March 2006

Appendix A –

Selected passages from the Florida Statutes, Florida Administrative Code, Federal Statutes and Other MFL-Related Correspondence

CONTENTS

Florida Statutes

Chapter 373 F.S. Water Resources Act

Excerpts from Florida Statutes,
Chapter 373, Water Resources Act

PART I STATE WATER RESOURCE PLAN (ss. 373.012-373.200)

373.042 Minimum flows and levels.—

(1) Within each section, or the water management district as a whole, the department or the governing board shall establish the following:

(a) Minimum flow for all surface watercourses in the area. The minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.

(b) Minimum water level. The minimum water level shall be the level of groundwater in an aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area.

(c) The minimum flow and minimum water level shall be calculated by the department and the governing board using the best information available. When appropriate, minimum flows and levels may be calculated to reflect seasonal variations. The department and the governing board shall also consider, and at their discretion may provide for, the protection of nonconsumptive uses in the establishment of minimum flows and levels.

(2) By November 15, 1997, and annually thereafter, each water management district shall submit to the department for review and approval a priority list and schedule for the establishment of minimum flows and levels for surface watercourses, aquifers, and surface waters within the district. The priority list shall also identify those water bodies for which the district will voluntarily undertake independent scientific peer review. By March 1, 2006, and annually thereafter, each water management district shall include its approved priority list and schedule in the consolidated annual report required by s. 373.036(7). The priority list shall be based upon the importance of the waters to the state or region and the existence of or potential for significant harm to the water resources or ecology of the state or region, and shall include those waters which are experiencing or may reasonably be expected to experience adverse impacts. Each water management district's priority list and schedule shall include all first magnitude springs, and all second magnitude springs within state or federally owned lands purchased for conservation purposes. The specific schedule for establishment of spring minimum flows and levels shall be commensurate with the existing or potential threat to spring flow from consumptive uses. Springs within the Suwannee River Water Management District, or second magnitude springs in other areas of the state, need not be included on the priority list if the water management district submits a report to the Department of Environmental Protection demonstrating that adverse impacts are not now occurring nor are reasonably expected to occur from consumptive uses during the next 20 years. The priority list and schedule shall

not be subject to any proceeding pursuant to chapter 120. Except as provided in subsection (3), the development of a priority list and compliance with the schedule for the establishment of minimum flows and levels pursuant to this subsection shall satisfy the requirements of subsection (1).

(3) Minimum flows or levels for priority waters in the counties of Hillsborough, Pasco, and Pinellas shall be established by October 1, 1997. Where a minimum flow or level for the priority waters within those counties has not been established by the applicable deadline, the secretary of the department shall, if requested by the governing body of any local government within whose jurisdiction the affected waters are located, establish the minimum flow or level in accordance with the procedures established by this section. The department's reasonable costs in establishing a minimum flow or level shall, upon request of the secretary, be reimbursed by the district.

(4) (a) Upon written request to the department or governing board by a substantially affected person, or by decision of the department or governing board, prior to the establishment of a minimum flow or level and prior to the filing of any petition for administrative hearing related to the minimum flow or level, all scientific or technical data, methodologies, and models, including all scientific and technical assumptions employed in each model, used to establish a minimum flow or level shall be subject to independent scientific peer review. Independent scientific peer review means review by a panel of independent, recognized experts in the fields of hydrology, hydrogeology, limnology, biology, and other scientific disciplines, to the extent relevant to the establishment of the minimum flow or level.

(b) If independent scientific peer review is requested, it shall be initiated at an appropriate point agreed upon by the department or governing board and the person or persons requesting the peer review. If no agreement is reached, the department or governing board shall determine the appropriate point at which to initiate peer review. The members of the peer review panel shall be selected within 60 days of the point of initiation by agreement of the department or governing board and the person or persons requesting the peer review. If the panel is not selected within the 60-day period, the time limitation may be waived upon the agreement of all parties. If no waiver occurs, the department or governing board may proceed to select the peer review panel. The cost of the peer review shall be borne equally by the district and each party requesting the peer review, to the extent economically feasible. The panel shall submit a final report to the governing board within 120 days after its selection unless the deadline is waived by agreement of all parties. Initiation of peer review pursuant to this paragraph shall toll any applicable deadline under chapter 120 or other law or district rule regarding permitting, rulemaking, or administrative hearings, until 60 days following submittal of the final report. Any such deadlines shall also be tolled for 60 days following withdrawal of the request or following agreement of the parties that peer review will no longer be pursued. The department or the governing board shall give significant weight to the final report of the peer review panel when establishing the minimum flow or level.

(c) If the final data, methodologies, and models, including all scientific and technical assumptions employed in each model upon which a minimum flow or level is based, have undergone peer review pursuant to this subsection, by request or by decision of the department or governing board, no further peer review shall be required with respect to that minimum flow or level.

(d) No minimum flow or level adopted by rule or formally noticed for adoption on or before May 2, 1997, shall be subject to the peer review provided for in this subsection.

(5) If a petition for administrative hearing is filed under chapter 120 challenging the establishment of a minimum flow or level, the report of an independent scientific peer review conducted under subsection (4) is admissible as evidence in the final hearing, and the administrative law judge must render the order within 120 days after the filing of the petition. The time limit for rendering the order shall not be extended except by agreement of all the parties. To the extent that the parties agree to the findings of the peer review, they may stipulate that those findings be incorporated as findings of fact in the final order.

History.—s. 6, part I, ch. 72-299; s. 2, ch. 73-190; s. 2, ch. 96-339; s. 5, ch. 97-160; s. 52, ch. 2002-1; s. 1, ch. 2002-15; s. 6, ch. 2005-36.
Note.—Former s. 373.036(7).

373.0421 Establishment and implementation of minimum flows and levels.—

(1) ESTABLISHMENT.—

(a) Considerations.—When establishing minimum flows and levels pursuant to s. 373.042, the department or governing board shall consider changes and structural alterations to watersheds, surface waters, and aquifers and the effects such changes or alterations have had, and the constraints such changes or alterations have placed, on the hydrology of an affected watershed, surface water, or aquifer, provided that nothing in this paragraph shall allow significant harm as provided by s. 373.042(1) caused by withdrawals.

(b) Exclusions.—

1. The Legislature recognizes that certain water bodies no longer serve their historical hydrologic functions. The Legislature also recognizes that recovery of these water bodies to historical hydrologic conditions may not be economically or technically feasible, and that such recovery effort could cause adverse environmental or hydrologic impacts. Accordingly, the department or governing board may determine that setting a minimum flow or level for such a water body based on its historical condition is not appropriate.
2. The department or the governing board is not required to establish minimum flows or levels pursuant to s. 373.042 for surface water bodies less than 25 acres in area, unless the water body or bodies, individually or cumulatively, have significant economic, environmental, or hydrologic value.
3. The department or the governing board shall not set minimum flows or levels pursuant to s. 373.042 for surface water bodies constructed prior to the requirement for a permit, or pursuant

to an exemption, a permit, or a reclamation plan which regulates the size, depth, or function of the surface water body under the provisions of this chapter, chapter 378, or chapter 403, unless the constructed surface water body is of significant hydrologic value or is an essential element of the water resources of the area.

The exclusions of this paragraph shall not apply to the Everglades Protection Area, as defined in s. 373.4592(2)(i).

(2) If the existing flow or level in a water body is below, or is projected to fall within 20 years below, the applicable minimum flow or level established pursuant to s. 373.042, the department or governing board, as part of the regional water supply plan described in s. 373.0361, shall expeditiously implement a recovery or prevention strategy, which includes the development of additional water supplies and other actions, consistent with the authority granted by this chapter, to:

(a) Achieve recovery to the established minimum flow or level as soon as practicable; or

(b) Prevent the existing flow or level from falling below the established minimum flow or level.

The recovery or prevention strategy shall include phasing or a timetable which will allow for the provision of sufficient water supplies for all existing and projected reasonable-beneficial uses, including development of additional water supplies and implementation of conservation and other efficiency measures concurrent with, to the extent practical, and to offset, reductions in permitted withdrawals, consistent with the provisions of this chapter.

(3) The provisions of this section are supplemental to any other specific requirements or authority provided by law. Minimum flows and levels shall be reevaluated periodically and revised as needed.

History.—s. 6, ch. 97-160; s. 36, ch. 2004-5.

373.043 Adoption and enforcement of rules by the department.—

The department has authority to adopt rules pursuant to ss. 120.536(1) and 120.54 to implement the provisions of this chapter.

History.—s. 8, part I, ch. 72-299; s. 5, ch. 74-114; s. 81, ch. 98-200.

373.044 Rules; enforcement; availability of personnel rules.—

The governing board of the district is authorized to adopt rules pursuant to ss. 120.536(1) and 120.54 to implement the provisions of this chapter. Rules and orders may be enforced by mandatory injunction or other appropriate action in the courts of the state. Rules relating to personnel matters shall be made available to the public and affected persons at no more than cost but need not be published in the Florida Administrative Code or the Florida Administrative Weekly.

History.—s. 4, ch. 29790, 1955; s. 25, ch. 73-190; s. 3, ch. 84-341; s. 82, ch. 98-200.

Note.—Former s. 378.151.

Florida Administrative Code

Chapter 40E - Rules of the South Florida Water Management District

Section 40E-8 Minimum Flows And Levels

PART I GENERAL

40E-8.011 Purpose and General Provisions.

(1) The purpose of this chapter is:

(a) To establish minimum flows for specific surface watercourses and minimum water levels for specific surface waters and specific aquifers with in the South Florida Water Management District, pursuant to Section 373.042, F.S.; and

(b) To establish the rule framework for implementation of recovery and prevention strategies, developed pursuant to Section 373.0421, F.S.

(2) Minimum flows are established to identify where further withdrawals would cause significant harm to the water resources, or to the ecology of the area. Minimum levels are established to identify where further withdrawals would cause significant harm to the water resources of the area. Specific minimum flows and levels (MFLs) are established in this rule for specified priority water bodies that have been designated pursuant to Section 373.042(2), F.S.

(3) The MFLs established herein are based on existing best available information, and will be periodically reviewed, at least every five years, based on new information and changing water resource conditions. Revisions to established MFLs will be peer reviewed as required by Section 373.042, F.S., prior to rule adoption. The minimum flow criteria for the Caloosahatchee River in subsection 40E-8.221(2), F.A.C., shall be reviewed within one year of the effective date of this rule, September 10, 2001, and amended, as necessary, based on best available information.

(4) The recovery and prevention strategies set forth in Rule 40E-8.421, F.A.C., the consumptive use permitting procedures described in paragraph 40E-2.301(1)(i), Rule 40E-8.431, F.A.C., Section 3.9 of the "Basis of Review for Water Use Permit Applications within the South Florida Water Management District – September 10, 2001," the water shortage plan implementation provisions specified in Rules 40E-8.441, 40E-21.531, and 40E-21.541, and Part III of Chapter 40E-22, F.A.C., September 10, 2001, are inseparable components of the minimum flows and levels established in Rules 40E-8.321 and 40E-8.331, F.A.C., September 10, 2001. The District would not have adopted the minimum flows and levels set forth in Rules 40E-8.321 and 40E-8.331, F.A.C., for Lake Okeechobee, the Everglades, the Biscayne Aquifer, the Lower West Coast Aquifers, and the Caloosahatchee River without simultaneously adopting their related implementation rules. If the rules cited above, as they pertain to a specified MFL water body, are found to be invalid, in whole or in part, such specified minimum flow(s) or level(s) in Rule 40E-8.321 or 40E-8.331, F.A.C., (including Lake Okeechobee, Everglades, Biscayne Aquifer, Lower West Coast Aquifers, Caloosahatchee River) (month, year) shall not be adopted, or if already in effect, shall not continue to be applied, until the District amends the applicable regional water supply plan(s), as necessary, and amends the subject rules, as necessary to address the reason for invalidity consistent with the requirements of Section 373.0421, F.S. This section shall be triggered after a rule is found to be invalid pursuant to a final order issued under Section 120.56, F.S., and after appellate review remedies have been exhausted.

(5) In concert with establishment of the MFL for the Northwest Fork of the Loxahatchee River in subsection 40E-8.221(5), F.A.C., the District commits to the following activities that are described in greater detail in the Recovery and Prevention Strategy section, subsection 40E-8.421(6), F.A.C.:

(a) Restore freshwater flows to the Northwest Fork of the Loxahatchee River beyond the MFL by developing programs and projects that will provide surface water flows as identified in a practical restoration goal and plan, to be developed with the Florida Department of Environmental Protection.

(b) Implement the restoration plan through structural and non-structural projects associated with the Comprehensive Everglades Restoration Plan and the regional water supply plan;

(c) Establish water reservations to deliver and protect water supplies for restoration of the Loxahatchee River; and

(d) Revise the MFL and the associated recovery and prevention strategy, as necessary, to be consistent with established restoration goals and future water reservations.

(e) Establish Minimum Flows and levels for other tributaries to the Northwest Fork of the Loxahatchee River including Loxahatchee Slough, Cypress Creek, Kitching

Creek and Hobe Grove Ditch as committed to in the District' s Priority Water Body List, as updated.
Specific Authority §§ 9, 10 P.L. 83-358, 373.044, 373.113, 373.171 FS. Law Implemented 373.016, 373.036, 373.0361, 373.042, 373.0421 FS.
History–New 9-10-01, Amended 4-1-03, 1-19-06.

40E-8.021 Definitions.
The terms set forth herein shall have the meanings ascribed to them, unless the context clearly indicates otherwise, and such meanings shall apply throughout the rules contained in this chapter. The terms defined in Rule 40E-8.021, F.A.C., shall apply throughout the District's consumptive use permit rules. In the event of a conflict or difference between the definitions contained in Rule 40E-8.021, F.A.C., and the definitions set forth in other District rules, the definitions in this Rule 40E-8.021, F.A.C., shall control for purposes of this chapter.

(1) Biscayne Aquifer – means the highly permeable surficial strata (hydraulic conductivities generally greater than 500 ft/day) that occur within Monroe, Miami-Dade (excluding those portions of coastal Monroe and Miami-Dade counties that discharge groundwater into Florida and Biscayne Bays), eastern Broward, and portions of eastern Palm Beach counties.

(2) Caloosahatchee River – means the surface waters that flow through the S-79 structure, combined with tributary contributions below S-79 that collectively flow southwest to San Carlos Bay.

(3) C&SF Project – means the project for Central and Southern Florida authorized under the heading 'CENTRAL AND SOUTHERN FLORIDA' in section 203 of the Flood Control Act of 1948 (Chapter 771).

(4) CERP – means the Comprehensive Everglades Restoration Plan contained in the 'Final Integrated Feasibility Report and Programmatic Environmental Impact Statement', dated April 1, 1999, as modified by the Water Resources Development Act of 2000.

(5) Certification or Certify – means the formal determination by the District, through a validation process consistent with state and federal law, of the total amount of water made available by a project or project phase of a recovery or prevention strategy, as appropriate, for natural systems and other uses.

(6) Direct Withdrawal means:

(a) A ground water withdrawal that causes a water table drawdown greater than 0.1 feet, as determined using a model accepted by the District, at any location beneath the MFL surface water body or aquifer, up through a 1 in 10 year drought; or

(b) A surface water withdrawal from facilities physically located within the boundaries of a MFL surface water body.

(7) Everglades – means the lands and waters included within Water Conservation Areas, the Holeyland/Rotenberger wildlife management areas, and the freshwater portions of the Everglades National Park.

(8) Harm – means the temporary loss of water resource functions, as defined for consumptive use permitting in Chapter 40E-2, F.A.C., that results from a change in surface or ground water hydrology and takes a period of one to two years of average rainfall conditions to recover.

(9) Indirect Withdrawal – means the withdrawal of water from a water source for a consumptive use that receives surface water or ground water from a MFL water body or is tributary to a MFL water body.

(10) Lake Istokpoga – means the lands and waters contained within the Lake below 40.0 feet NGVD, the top of the U.S. Army Corps of Engineers' regulation schedule.

(11) Lake Okeechobee – means the lands and waters contained within the perimeter of the Hoover Dike.

(12) LEC Plan – means the Lower East Coast Regional Water Supply Plan – May 2000, including all three volumes.

(13) Lower West Coast Aquifers – means the lower Tamiami aquifer, sandstone aquifer and the mid-Hawthorn aquifer that occur within Charlotte, Hendry, Glades, Lee and Collier counties.

(14) LWC Plan – means the Lower West Coast Regional Water Supply Plan – April 2000, including all three volumes.

(15) Minimum Flow – means a flow established by the District pursuant to Sections 373.042 and 373.0421, F.S., for a given water body and set forth in Parts II and III of this chapter, at which further withdrawals would be significantly harmful to the water resources or ecology of the area.

(16) Minimum Flow and Level Exceedance – means to fall below a minimum flow or level, which is established in Parts II and III of this chapter, for a duration greater than specified for the MFL water body.

(17) Minimum Flow and Level Violation – means to fall below a minimum flow or minimum level, which is established in Parts II and III of this chapter, for a duration and frequency greater than specified for the MFL water body. Unless otherwise specified herein, in determining the frequency with which water flows and levels fall below an established MFL for purposes of determining a MFL violation, a "year" means 365 days from the last day of the previous MFL exceedance.

(18) Minimum Level – means the level of groundwater in an aquifer or the level of surface water established by the District pursuant to Sections 373.042 and 373.0421, F.S., in Parts II and III of this chapter, at which further withdrawals would be significantly harmful to the water resources of the area.

(19) MFL Water Body – means any surface water, watercourse, or aquifer for which an MFL is established in Part II or III of this chapter.

(20) Northwest Fork of the Loxahatchee River: Means those areas defined below:

(a) Northwest Fork of the Loxahatchee River that has been federally designated as Wild, Scenic and Recreational uses (as defined in the Loxahatchee River Wild and Scenic River Management Plan 2000) (see Map 1, incorporated herein), including the river channel that extends from river mile 6.0 (latitude 26.9856, longitude 80.1426) located near the eastern edge of Jonathan Dickinson State Park and continues upstream to the G-92 structure (latitude 26.91014, longitude 80.17578), including the C-14 Canal. The river channel includes the physical water flow courses and adjacent floodplain up to the limits of the floodplain swamp and wetlands within Riverbend Park, as determined by state wetland delineation criteria;

(b) Cypress Creek which extends westward from river mile 10.6 to the intersection of Gulf Stream Citrus Road (latitude 26.96484, longitude 80.1855) located approximately one mile west of the Florida Turnpike and includes its natural river channels and contiguous floodplain as determined by state wetland delineation criteria;

(c) Kitching Creek which extends from river mile 8.1 (latitude 26.9908, longitude 80.1540) northward through Jonathan Dickinson State Park to north of Bridge Road (latitude 27.05513, longitude 80.17580), including its natural river channels and contiguous floodplain as determined by state wetland delineation criteria; and

(d) Hobe Grove Ditch which extends west from river mile 9.1 (latitude 26.9854, longitude 80.1594) westward to the Hobe-St. Lucie Conservancy District pump station outfall (latitude 26.5908, longitude 80.1031) including its natural river channels and contiguous floodplain as determined by state wetland delineation criteria.

(21) Operations – means activities taken by the District for the movement of surface water through works of the District pursuant to Chapter 373, F.S.

(22) Prevention Strategy(ies) – means the structural and non-structural actions approved by the District in regional water supply plans, pursuant to Section 373.0421, F.S., or by rule, for areas where MFLs are currently not violated, but are projected to be violated within twenty (20) years of the establishment of the minimum flow or level, if said prevention strategies are not implemented.

(23) Recovery Strategy(ies) – means the structural and non-structural actions approved by the District in regional water supply plans, pursuant to Section 373.0421, F.S., or by rule, for areas where MFLs are currently violated.

(24) Regional Water Supply Plan – means a plan approved by the District pursuant to Section 373.0361, F.S.

(25) St. Lucie River North Fork – means the surface waters that extend from the Gordy Road Bridge structure (state plane coordinates, x851212.831, y1116105.7470), combined with tributary contributions below Gordy Road and collectively flow south to the confluence with the C-24 canal (state plane coordinates, x873,712.20, y1064,390.41).

(26) St. Lucie River South Fork – means the surface waters that extend from the culverts located at state plane coordinates x902,512.67, y1,001,799.91, north to the confluence of the river and the St. Lucie Canal (C-44).

(27) St. Lucie Estuary – means the surface water body south of the confluence of the St. Lucie River North Fork and C-24, north of the confluence of the St. Lucie River South Fork and C-44, and west of the western boundary of the Intracoastal Waterway, exclusive of canals.

(28) Serious Harm – means the long-term loss of water resource functions, as addressed in Chapters 40E-21 and 40E-22, F.A.C., resulting from a change in surface or ground water hydrology.

(29) Significant Harm – means the temporary loss of water resource functions, which result from a change in surface or ground water hydrology, that takes more than two years to recover, but which is considered less severe than serious harm. The specific water resource functions addressed by a MFL and the duration of the recovery period associated with significant harm are defined for each priority water body based on the MFL technical support document.

Specific Authority §§ 9, 10 P.L. 83-358, 373.044, 373. 113, 373.119, 373.129, 373.136, 373.171 FS. Law Implemented 373.016, 373.036, 373.0361, 373.042, 373.0421, 373.175, 373.216, 373.219, 373.223, 373.246 FS. History–New 9-10-01, Amended 11-11-02, 4-1-03, 1-19-06.

PART II MFL CRITERIA FOR LOWER EAST COAST REGIONAL PLANNING AREA

40E-8.221 Minimum Flows and Levels: Surface Waters.

The MFLs contained in this Part identify the point at which further withdrawals would cause significant harm to the water resources, or ecology, of the area as applicable, pursuant to Sections 373.042 and 373.0421, F.S. It is the District's intent to correct or prevent the violation of these MFLs through management of the water resources and implementation of a recovery strategy.

(1) Lake Okeechobee. An MFL violation occurs in Lake Okeechobee when an exceedance, as defined herein, occurs more than once every six years. An "exceedance" is a decline below 11 feet NGVD for more than 80, non-consecutive or consecutive, days, during an eighteen month period. The eighteen month period shall be initiated following the first day Lake Okeechobee falls below 11 feet NGVD, and shall not include more than one wet season, defined as May 31st through October 31st of any given calendar year.

(2) Caloosahatchee River. A minimum mean monthly flow of 300 CFS is necessary to maintain sufficient salinities at S-79 in order to prevent a MFL exceedance. A MFL exceedance occurs during a 365 day period, when:

(a) A 30-day average salinity concentration exceeds 10 parts per thousand at the Ft. Myers salinity station (measured at 20% of the total river depth from the water surface at a location of latitude 263907.260, longitude 815209.296; or

(b) A single, daily average salinity exceeds a concentration of 20 parts per thousand at the Ft. Myers salinity station. Exceedance of either paragraph (a) or (b), for two consecutive years is a violation of the MFL.

(3) Everglades.

(a) Criteria for Peat-Forming Wetlands. Water levels within wetlands overlying organic peat soils within the water conservation areas, Rotenberger and Holey land wildlife management areas, and Shark River Slough (Everglades National Park) shall not fall 1.0 feet or more below ground surface, as measured at a key gage, for one or more days during a period in which the water level has remained below ground for a minimum of 30 days, at specific return frequencies as specified in Table 1, below.

(b) Criteria for Marl-Forming Wetlands. Water levels within marl-forming wetlands that are located east and west of Shark River Slough, the Rocky Glades, and Taylor Slough within Everglades National Park, shall not fall 1.5 feet below ground surface, as measured at a key gage, for one or more days during a period in which the water level has remained below ground for a minimum of 90 days, at specific return frequencies for different areas, as identified in Table 1, below. The MFL criteria listed in Table 1 are based on existing changes and structural alterations to the pre-drainage conditions of the Everglades. It is the District's intent through implementation of the LEC Plan and the CERP to achieve minimum hydropattern return frequencies that approximate CERP compatible pre-drainage conditions in the Everglades. As a result, as the existing structural changes and alterations are corrected, the MFL criteria contained herein will be modified through a rule amendment consistent with the LEC Plan and the CERP.

(4) Northwest Fork of the Loxahatchee River.

(a) An enhanced freshwater regime is necessary to prevent significant harm to the water resources and ecology of the Northwest Fork of the Loxahatchee River, pursuant to Sections 373.042 and 373.0421, F.S. By establishing the MFL set forth in paragraphs (b) and (c), along with implementation of the associated recovery strategy, it is the interim goal of the District to provide sufficient freshwater flows to create at River Mile 9.2 the freshwater regime found at River Mile 10.2.

(b) A MFL violation occurs within the Northwest fork of the Loxahatchee River when an exceedance, as defined in paragraph (c), occurs more than once in a six year period.

(c) A MFL exceedance occurs within the Northwest Fork of the Loxahatchee River when:

1. Flows over Lainhart Dam decline below 35 cfs for more than 20 consecutive days; or

2. The average daily salinity concentration expressed as a 20-day rolling average exceeds two parts per thousand. The average daily salinity will be representative of mid-depth in the water column (average of salinities measured at 0.5 meters below the surface and 0.5 meters above the bottom) at river mile 9.2 (latitude 26.9839, longitude 80.1609).

(d) In addition to this MFL, which is intended to achieve partial enhancement of the Northwest Fork of the Loxahatchee River to prevent significant harm, restoration of the Loxahatchee River beyond the MFL will be addressed pursuant to subsection 40E-8.421(6), F.A.C., and other applicable provisions of state law. This MFL will be reviewed within two years of adoption and revised, if necessary, to ensure consistency with the restoration goal and plan identified pursuant to Rule 40E-8.421, F.A.C., or other applicable provisions of state law.

Specific Authority §§ 9, 10 P.L. 83-358, 373.044, 373.113, 373.119, 373.129, 373.136, 373.171 F S. Law Implemented 373.016, 373.036, 373.0361, 373.042, 373.0421, 373.175, 373.216, 373.219, 373.223, 373.246 FS. History–New 9-10-01, Amended 4-1-03..

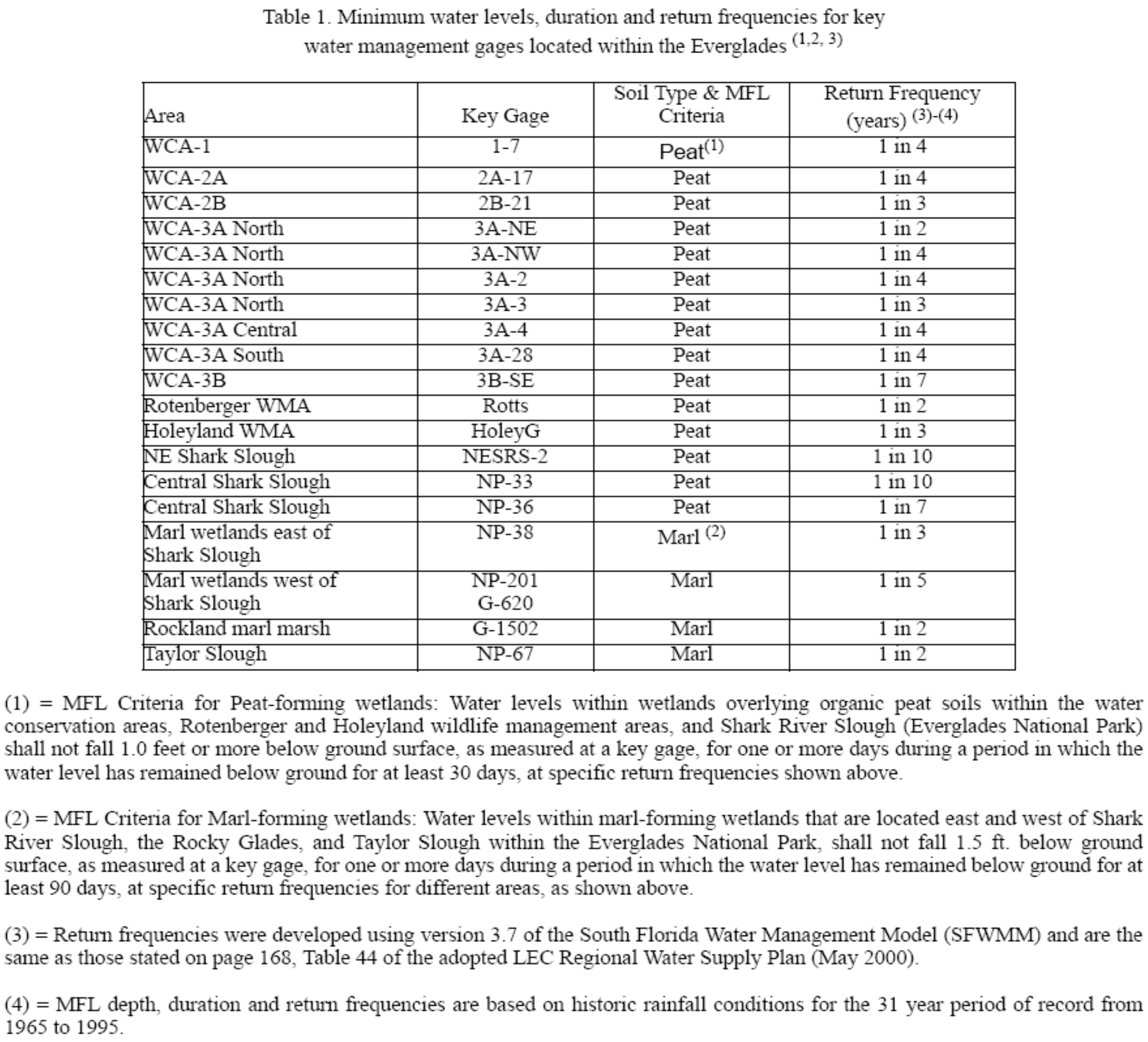


Table 1. Minimum water levels, duration and return frequencies for key water management gages located within the Everglades (1,2, 3)

Area	Key Gage	Soil Type & MFL Criteria	Return Frequency (years) (3)-(4)
WCA-1	1-7	Peat(1)	1 in 4
WCA-2A	2A-17	Peat	1 in 4
WCA-2B	2B-21	Peat	1 in 3
WCA-3A North	3A-NE	Peat	1 in 2
WCA-3A North	3A-NW	Peat	1 in 4
WCA-3A North	3A-2	Peat	1 in 4
WCA-3A North	3A-3	Peat	1 in 3
WCA-3A Central	3A-4	Peat	1 in 4
WCA-3A South	3A-28	Peat	1 in 4
WCA-3B	3B-SE	Peat	1 in 7
Rotenberger WMA	Rotts	Peat	1 in 2
Holeyland WMA	HoleyG	Peat	1 in 3
NE Shark Slough	NESRS-2	Peat	1 in 10
Central Shark Slough	NP-33	Peat	1 in 10
Central Shark Slough	NP-36	Peat	1 in 7
Marl wetlands east of Shark Slough	NP-38	Marl (2)	1 in 3
Marl wetlands west of Shark Slough	NP-201 G-620	Marl	1 in 5
Rockland marl marsh	G-1502	Marl	1 in 2
Taylor Slough	NP-67	Marl	1 in 2

(1) = MFL Criteria for Peat-forming wetlands: Water levels within wetlands overlying organic peat soils within the water conservation areas, Rotenberger and Holeyland wildlife management areas, and Shark River Slough (Everglades National Park) shall not fall 1.0 feet or more below ground surface, as measured at a key gage, for one or more days during a period in which the water level has remained below ground for at least 30 days, at specific return frequencies shown above.

(2) = MFL Criteria for Marl-forming wetlands: Water levels within marl-forming wetlands that are located east and west of Shark River Slough, the Rocky Glades, and Taylor Slough within the Everglades National Park, shall not fall 1.5 ft. below ground surface, as measured at a key gage, for one or more days during a period in which the water level has remained below ground for at least 90 days, at specific return frequencies for different areas, as shown above.

(3) = Return frequencies were developed using version 3.7 of the South Florida Water Management Model (SFWMM) and are the same as those stated on page 168, Table 44 of the adopted LEC Regional Water Supply Plan (May 2000).

(4) = MFL depth, duration and return frequencies are based on historic rainfall conditions for the 31 year period of record from 1965 to 1995.

40E-8.231 Minimum Levels: Aquifers.

Biscayne Aquifer – The minimum level for the Biscayne aquifer is the level that results in movement of the saltwater interface landward to the extent that ground water quality at an established withdrawal point is insufficient to serve as a water supply source. A MFL violation occurs when water levels within the aquifer produce this degree of saltwater movement at any point in time.

Specific Authority 373.044, 373.113, 373.171 FS. Law Implemented 373.016, 373.036, 373.0361, 373.042, 373.0421 FS. History–New 9-10-01.

PART III MFL CRITERIA FOR LOWER WEST COAST REGIONAL PLANNING AREA, MFL CRITERIA FOR KISSIMMEE BASIN REGIONAL PLANNING AREA, AND MFL CRITERIA FOR UPPER EAST COAST REGIONAL PLANNING AREA

40E-8.321 Minimum Flows and Levels: Surface Waters.

The MFLs contained in this Part identify the point at which further withdrawals would cause significant harm to the water resources or ecology, of the area, as applicable, pursuant to Sections 373.042 and 373.0421, F.S. It is the District's intent to correct or prevent the violation of these criteria through management of the water resources.
Specific Authority 373.044, 373.113, 373.119, 373.129, 373.136, 373.171 FS. Law Implemented 373.016, 373.036, 373.0361, 373.042, 373.0421, 373.175, 373.216, 373.219, 373.223, 373.246 FS. History–New 9-10-01.

40E-8.331 Minimum Levels: Aquifers.

The minimum levels for the lower Tamiami aquifer, the Sandstone aquifer and the mid-Hawthorn aquifer shall equal the structural top of the aquifer. A violation of this criteria occurs when the water levels drop below the top of the uppermost geologic strata that comprises the aquifer, at any point in time. Water level measurements that are made to monitor the conditions of the aquifers for the purpose of this rule shall be located no closer than 50 feet from any existing pumping well.
Specific Authority 373.044, 373.113, 373.171 FS. Law Implemented 373.016, 373.036, 373.0361, 373.042, 373.0421 FS. History–New 9-10-01.

40E-8.341 Minimum Flows and Levels: Surface Waters for Upper East Coast Regional Planning Area.

St. Lucie Estuary – mean monthly flows to the St. Lucie Estuary should not fall below 28cfs from the Gordy Road structure to the St. Lucie River North Fork for two consecutive months during a 365-day period, for two consecutive years.
Specific Authority 373.044, 373.113, 373.171 FS. Law Implemented 373.016, 373.036, 373.0361, 373.042, 373.0421 FS. History–New 11-11-02.

40E-8.351 Minimum Levels: Surface Waters for Kissimmee Basin Regional Planning Area.

Lake Istokpoga – An MFL violation occurs in Lake Istokpoga when surface water levels fall below 36.5 feet NGVD for 20 or more weeks, within a calendar year, more often than once every four years.
Specific Authority 373.044, 373.113, 373.171 FS. Law Implemented 373.016, 373.036, 373.0361, 373.042, 373.0421 FS. History–New 1-19-06.

PART IV IMPLEMENTATION

40E-8.421 Prevention and Recovery Strategies.

(1) At the time of adoption of this rule, the existing flow or level for certain specified water bodies is below, or within 20 years is projected to fall below, the applicable MFL. For this reason, Section 373.0361, F.S., requires regional water supply plans to contain recovery and prevention strategies, including water resource development and water supply development projects that are needed to achieve compliance with MFLs during the planning period. The implementation of such projects will allow for the orderly replacement or enhancement of existing water sources with alternative supplies in order to provide sufficient water for all existing and projected reasonable-beneficial uses, consistent with Section 373.0421, F.S.

(a) MFLs and recovery and prevention strategies will be implemented in phases with consideration of the District's missions in managing water resources, including water supply, flood protection, environmental enhancement and water quality protection, as required by Section 373.016, F.S.

(b) MFLs are implemented to prevent significant harm to the water resources and, where applicable, the ecology of the area due to further withdrawals (Sections 373.042 and 373.0421, F.S.). A consumptive use permitting program is implemented to prevent harm to the water resource (Section 373.219, F.S.). A water shortage program is implemented to prevent serious harm to the water resource (Sections 373.175 and 373.246, F.S.). Additionally, the protection of water resources will, in part, be achieved through the reservation of water for fish and wildlife or public health and safety (Section 373.223(4), F.S.). The conceptual model identifying the relationships between these water resource protection requirements is set forth in Figure I in this Part.

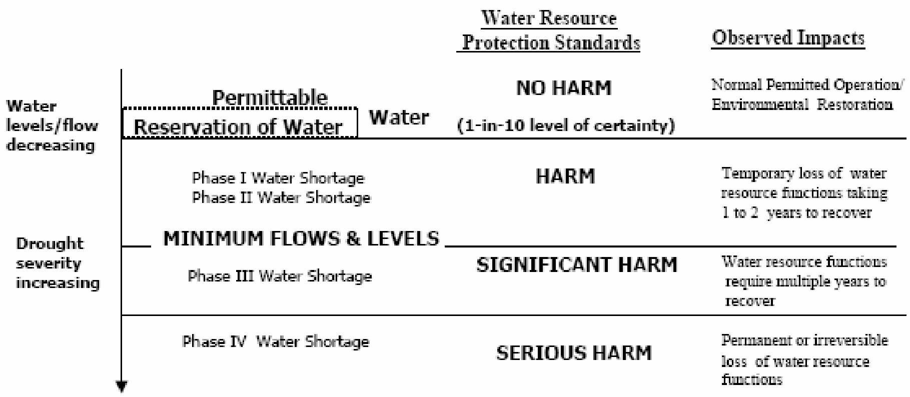
(c) The rules implementing water resource protection tools, including Chapters 40E-2, 40E-8, 40E-20, 40E-21, and 40E-22, F.A.C., identify the specific factors and conditions that will be applied and considered in implementing the conceptual model. Due to the extreme variations in water resource conditions, climatic conditions, hydrologic conditions, and economic considerations that will be faced when implementing these rules, it is critical to apply such criteria flexibly and to reserve for the governing board the ability to implement water resource protection and allocation programs considering all of the District's missions under Chapter 373, F.S., and to balance water supply, flood protection, resource protection and water quality protection needs. Implementation of the recovery and prevention strategies will be achieved in compliance with the assurances to consumptive users and to natural systems contained in the LEC Plan and the LWC Plan.

(d) The phasing and timetables for implementation of structural components in recovery and prevention strategies contained in approved regional water supply plans are found to meet the requirements in Section 373.0421(2), F.S., for the expeditious and practicable recovery of the MFLs.

(e) Upon completion of each project or project phase of a recovery or prevention plan the District will certify the availability of water, as defined in Rule 40E- 8.021(5), F.A.C.

(f) In order to ensure that the actual and projected performance of prevention and recovery strategies approved in the regional waters supply plans is sufficient to meet water resource needs, including MFLs, and the existing and projected reasonable-beneficial uses, the District will update recovery and prevention strategies on a periodic basis, based on new information and system performance. The performance of the recovery and prevention strategies in comparison to the performance projected in the regional water supply plans, will be assessed by the District for each recovery or prevention strategy phase. Based on the actual performance and new information obtained regarding the water resources, the District will review and revise, if necessary, recovery and prevention strategies through the regional water supply plan update process every five years, or sooner, as required by Section 373.0361, F.S. At that time, the governing board will determine if rule modifications to the MFL or recovery and prevention strategies are necessary to continue to meet the requirements of Sections 373.042 and 373.0421, F.S.

Figure 1: Conceptual Relationship Among the Harm, Serious Harm and Significant Harm Standards



(2) The Everglades and the Caloosahatchee River.

(a) As the effective date of this rule, September 10, 2001, the Everglades and Caloosahatchee River have experienced MFL violations. As a result, the LEC Plan and the LWC Plan contain approved recovery strategies, pursuant to Section 373.0421, F.S. Included in these recovery and prevention strategies is the CERP.

(b) MFLs for many areas within the Everglades and the Caloosahatchee River, served by the C&SF Project, will not be achieved immediately upon adoption of this rule largely because of the lack of adequate regional storage or ineffective water drainage and distribution infrastructure. Although not all locations within the Everglades are currently in violation of the proposed MFL, the Everglades, as a whole, is subject to a recovery strategy. The LEC Plan identifies the structural and non-structural remedies necessary for the recovery of MFL water bodies. These structural and non-structural remedies are also intended to restore the Everglades and the Caloosahatchee River above the MFLs, through Chapter 373, F.S., authorities of the District. The projected long-term restoration of flows and levels in the Everglades resulting from implementation of the LEC Plan and the CERP is documented in the LEC Plan, and are intended to more closely approximate "pre-drainage" conditions. The planned components include implementing consumptive use and water shortage programs, removing conveyance limitations, implementing revised C&SF Project operational programs, storing additional freshwater, reserving water for the protection of fish and wildlife, and developing alternative sources for water supply. These components will be implemented over the next 20 years, resulting in a phased restoration of the affected areas.

(c) The District, as the U.S. Army Corps of Engineers' local sponsor of the C&SF Project, is charged with implementing the CERP, in accordance with the Water Resources Development Act of 2000 (WRDA), Title VI entitled "Comprehensive Everglades Restoration," and in accordance with State law. Assurances regarding water availability for consumptive uses and protection of natural systems are set forth in WRDA, Chapter 373, F.S., CERP and the LEC Plan, which will be followed by the District in implementing this chapter. Additional quantities of water for both consumptive uses and the natural systems made available from the CERP and other water resource development projects will be documented and protected on a project basis. For project components implemented under CERP, the additional quantity, distribution and timing of delivery of water that is made available for the natural system for consumptive use, will be identified consistent with purposes of the CERP. Under State law, water reservations and water allocations to consumptive uses will be utilized to protect water availability for the intended purposes.

(3) Lake Okeechobee. The LEC Plan contains an approved prevention strategy for Lake Okeeechobee pursuant to Section 373.0421, F.S. The prevention strategy consists of implementing the District's water shortage plan, including supply side management, as simulated in the LEC Plan, and constructing and operating water supply and resource development projects.

(4) Biscayne Aquifer. The LEC Plan contains an approved prevention strategy for the Biscayne Aquifer pursuant to Section 373.0421, F.S., which consists of the following:

(a) Maintain coastal canal stages at the minimum operation levels shown in Table J-2 of the LEC Plan;

(b) Apply conditions for permit issuance in Chapter 40E-2 or 40E-20, F.A.C., to prevent the harmful movement of saltwater intrusion up to a 1-in-10 year level of certainty;

(c) Maintain a ground water monitoring network and utilize data to initiate water shortage actions pursuant to Rule 40E-8.441, F.A.C. and Chapters 40E-21 and 40E-22, F.A.C.;

(d) Construct and operate water resource and water supply development projects; and

(e) Conduct research in high risk areas to identify where the portions of the saltwater front is adjacent to existing and future potable water sources.

(5) Lower West Coast Aquifers. The LWC Plan identifies a prevention strategy for the LWC Aquifers, pursuant to Section 373.0421, F.S., as follows:

(a) Establish "no harm" maximum permittable levels for each aquifer (regulatory levels) for a 1-in-10 year level of certainty;

(b) Implement rule criteria to prevent harm through the consumptive use permitting process, including conditions for permit issuance in Rule 40E-2.301, F.A.C.;

(c) Construct and operate water resource and supply development projects; and

(d) Implement the water shortage plan in Chapter 40E-21, F. A.C., as needed to prevent serious harm during drought conditions in excess of a 1-in -10 year level of certainty.

(6) St. Lucie River and Estuary. The following is the prevention strategy for the St. Lucie River and Estuary:

(a) Discharges from the North Fork will be managed within the operational protocols of the Ten Mile Creek Project scheduled to be completed by 2004. Flow targets will be consistent with the CERP performance requirements for Indian River Lagoon.

(b) A research and monitoring strategy for the North and South Forks of the St. Lucie River will be developed and implemented in coordination with the Upper East Coast Regional Water Supply Plan update.

(7) Northwest Fork of the Loxahatchee River Recovery Strategy: Purpose and Intent.

(a) The Northwest Fork of the Loxahatchee River is currently not meeting the MFL and requires implementation of a recovery strategy to achieve the MFL as soon as practicable, consistent with Section 373.0421, F.S. The recovery strategy consists of projects contained within the following approved plans: the Lower East Coast Regional Water Supply Plan (LEC Plan), the Comprehensive Everglades Restoration Plan (CERP), and the Northern Palm Beach County Comprehensive Water Management Plan (NPBCCWMP). Four phases of recovery are identified in the Technical Documentation to Support Development of Minimum Flows and Levels for the Northwest Fork of the Loxahatchee River, November 2002, which are projected to increase flows to meet the MFL for the Northwest Fork of the Loxahatchee River. As part of the recovery strategy, as provided in this rule, the consumptive use permitting and water shortage requirements in this Chapter and Chapters 40E-2 and 40E-21, F.A.C., shall apply to consumptive use direct and indirect withdrawals from surface and groundwater sources from the Northwest Fork of the Loxahatchee River and those areas directly tributary to the Northwest Fork.

(b) In addition to implementation of this MFL recovery strategy, the District commits to restore freshwater flows to the Northwest Fork of the Loxahatchee River above the MFL through Chapter 373, F. S., and the Comprehensive Everglades Restoration Plan and its associated authorities. The District will continue to partner with the Florida Department of Environmental Protection in establishing a practical restoration goal and plan for the Loxahatchee River watershed. Recognizing that natural seasonal fluctuations in water flows are necessary to ensure that the functions of the Loxahatchee River are protected, this restoration goal and plan will include a more complete set of seasonally managed flow criteria for the river that are driven primarily by natural rainfall and runoff patterns within the watershed.

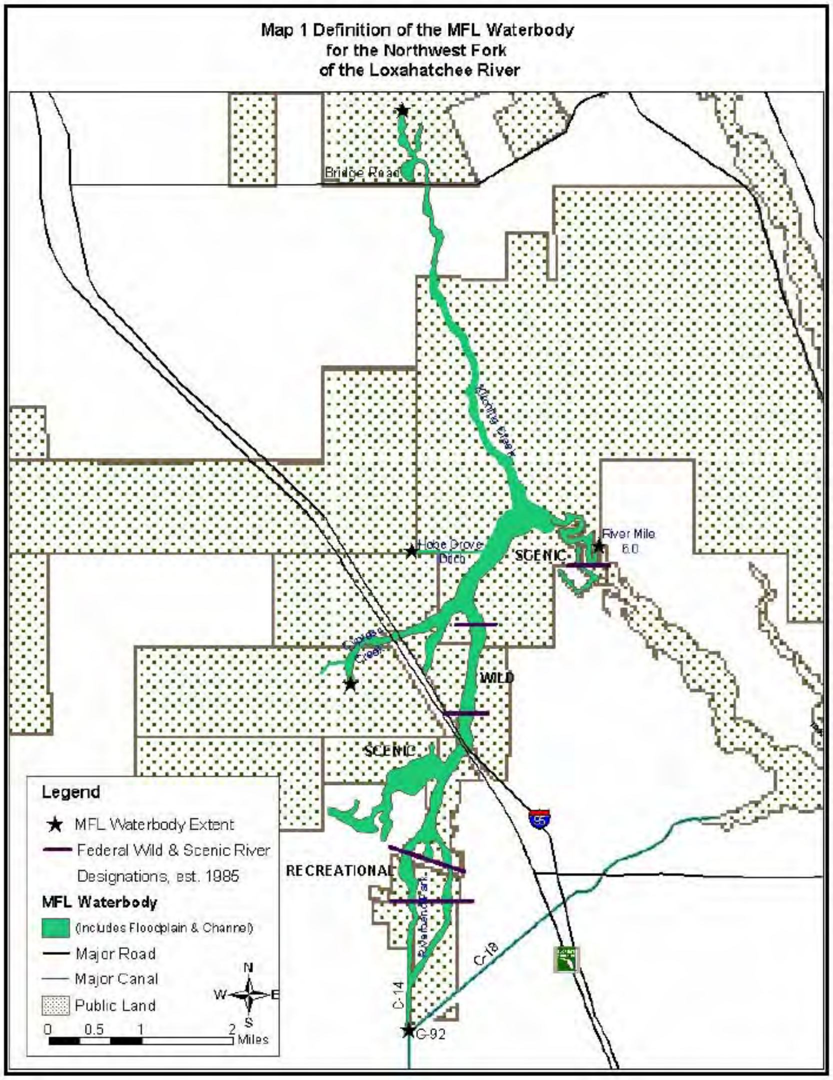
(c) The District shall continue to operate the G-92 structure and associated structures to provide approximately 50 cfs or more over Lainhart Dam to the Northwest Fork of the Loxahatchee River, when the District determines that water supplies are available.

(d) Additionally, it is the intent of the District to continue the current operational protocols of the G-92 structure so as not to reduce the historical high, average and low flows as estimated over the 30 year period of rainfall record used as the basis for the MFL for the Northwest Fork of the Loxahatchee River.

(e) It is the District's intent to implement, along with other partners, projects to meet the practical restoration goal developed according to paragraph (b). Projects contained in the Comprehensive Everglades Restoration Plan, the LEC Plan and the NPBCCWMP will provide increased storage and conveyance within the basin with a goal of providing more water for restoration of the Northwest Fork of the Loxahatchee River.

(f) To protect water made available for the recovery and restoration of the Loxahatchee River through implementation of these associated projects, the District intends to adopt water reservations for the Loxahatchee River , pursuant to Section 373.223(4), F.S., on a project by project basis over the next 20 years. In addition, the SFWMD intends to adopt an initial reservation to protect existing water used for protection of fish and wildlife, consistent with the practical restoration goal identified for the Loxahatchee River, by 2004. Future reservations related to the Loxahatchee River will be consistent with the reservations being developed for restoration of the Everglades under CERP, and will reflect the needs of the natural system through a range of hydrologic conditions. These water reservations are intended to prevent the future allocation to consumptive uses the freshwater intended for restoration of the Loxahatchee River. The reservations will be implemented through the consumptive use permit program, operational protocols, water shortage rules, and other appropriate provisions in Chapter 373, F.S.

(g) As reservations are adopted to restore the Loxahatchee River beyond that to be achieved by the MFL, the District shall revise the minimum flow and level and associated prevention and recovery strategy, as appropriate, under Sections 373.042 and 373.0421, F.S., to be consistent with the reservation.



Map 1 Definition of the MFL Waterbody
for the Northwest Fork
of the Loxahatchee River

(8) Lake Istokpoga. The water levels in Lake Istokpoga are controlled by operation of water control structures (G-85 and, primarily, S-68) as guided by a regulation schedule adopted by the U. S. Army Corps of Engineers and implemented by the District. The existing regulation schedule, typical regional weather patterns, and present levels of inflows from area creeks make violation of the Lake's minimum level unlikely; no such events have occurred since implementation of the Lake regulation schedule. Analysis of the current regulation schedule and operational policies for the Lake indicate the proposed Lake Istokpoga minimum level will be met for the foreseeable future. Therefore, the prevention strategy for Lake Istokpoga consists of continuation of the current operational plan and regulation schedule. The District, in coordination with other appropriate agencies, should also plan and operate extreme Lake drawdowns for

environmental purposes in a manner that, to the greatest extent possible, avoids a MFL violation. If significant changes to the Lake's water level management occurs due to new information, altered operational plans, or regulation schedule, a re-evaluation of the minimum level criteria will be conducted. This re-evaluation will occur as part of the next Lake Istokpoga MFL update which is scheduled to occur in 2010, or sooner, if significant changes to Lake management are proposed.
Specific Authority §§ 9, 10 P.L. 83-358, 373.044, 373.113, 373.171 FS. Law Implemented 373.016, 373.036, 373.0361, 373.042, 373.0421, 373.175, 373.216, 373.219, 373.223, 373.246 FS. History–New 9-10-01, Amended 11-11-02, 4-1-03, 1-19-06.

40E-8.431 Consumptive Use Permits.

(1) Consumptive use permit applications that propose to withdraw water directly or indirectly from a MFL water body, that meet the conditions for permit issuance in Part II of Chapter 373, F.S., (including implementing rules in this chapter, Chapter 40E-2, F.A.C., the Water Use Basis of Review, and Chapter 40E-20, F.A.C., as applicable), and are consistent with the approved recovery and prevention strategies under Section 373.0421, F.S., will be permitted. Consumptive use permit applications will be reviewed based on the recovery and prevention strategy approved at the time of permit application review.

(2) An existing permit will not be subject to revocation or modification by the District, prior to permit expiration, based on its impact on a MFL water body , unless the District has determined in the regional water supply plan that the reasonable-beneficial use served by the existing permitted allocation can otherwise be met from new or alternative water sources available (in place and operational) concurrent with such revocation or modification.

(3) A permittee must comply with the requirements of Rule 40E-2.351, F.A.C., in order to obtain a permit transfer to a new permittee.
Specific Authority 373.044, 373.113, 373.171 FS. Law Implemented 373.016, 373.036, 373.0361, 373.042, 373.0421 FS. History–New 9-10-01.

40E-8.441 Water Shortage Plan Implementation.

(1) Water shortage restrictions will be imposed as required by District rules on the direct or indirect withdrawals from a MFL water body if a MFL exceedance occurs or is projected to occur during climatic conditions more severe than a 1 in 10 year drought, to the extent consumptive uses contribute to such exceedance. Under these circumstances, the District will equitably distribute available supplies to prevent serious harm to the water resources, pursuant to Sections 373.175 and 373.246, F.S., and the District's Water Shortage Plan, Chapter 40E-21, F. A.C. The Water Shortage Plan utilizes a phased cutback approach with the severity of use restrictions increasing commensurate with increased potential for serious harm to the water resources.

(2) Water shortage restrictions will not be used in place of a component in an approved recovery plan to provide hydrologic benefits that are ultimately to be provided by such recovery strategy.

(3) MFL criteria will not be utilized to trigger water shortage restrictions during climatic conditions less severe than a 1 in 10 year level of drought.

(4) Water shortage restrictions will be implemented considering the factors in Chapter 40E-21, F.A.C., and this rule. In declaring a water shortage to protect a MFL water body, the governing board shall give consideration to:

(a) The level of drought;

(b) Whether the MFL criteria will be or is being exceeded due to direct or indirect withdrawals;

(c) The magnitude of the impact on the MFL water body, including water resource functions addressed by the MFL, from such withdrawals;

(d) The magnitude of the regional hydrologic improvements projected to be derived from the proposed cutbacks;

(e) Water management actions significantly contributing to the MFL exceedance; and

(f) The practicality of using other methods, such as deliveries of water from the regional system, to reduce MFL exceedances.

(5) The establishment and implementation of MFLs shall not limit the District's ability to impose water shortage restrictions pursuant to Sections 373.175 and 373.246, F.S., and the District's Water Shortage Plan, Chapter 40E-21, F.A.C., when water levels in a MFL water body are above an established MFL, nor shall it limit the District's ability to allow for the discharge or withdrawal of water from a MFL water body, when water levels are below an established MFL.

(6) Phase III water shortage restrictions may be imposed, consistent with the factors herein, when a MFL criteria exceedance or violation is imminent. Phase III or greater water shortage restrictions shall be implemented allowing for a shared adversity between continuing consumptive use and water resource needs.

Specific Authority 373.044, 373.113 FS. Law Implemented 373.042, 373.0421, 373.175, 373.246 FS. History–New 9-10-01.

Excerpts from Florida Administrative Code. Chapter 62, Rules of the FDEP,

Section 62-302.700.Special Protection, Outstanding Florida Waters, Outstanding National Resource Waters.

a It shall be the Department policy to afford the highest protection to Outstanding Florida Waters and Outstanding National Resource Waters. No degradation of water quality, other than that allowed in subsections 62-4.242(2) and (3), F.A.C., is to be permitted in Outstanding Florida Waters and Outstanding National Resource Waters, respectively, notwithstanding any other Department rules that allow water quality lowering.

b A complete listing of Outstanding Florida Waters and Outstanding National Resource Waters is provided in subsections (9) and (10). Outstanding Florida Waters generally include the following surface waters (unless named as Outstanding National Resource Waters):

- (a) Waters in National Parks, Preserves, Memorials, Wildlife Refuges and Wilderness Areas;
- (b) Waters in the State Park System and Wilderness Areas;
- (c) Waters within areas acquired through donation, trade, or purchased under the Environmentally Endangered Lands Bond Program, Conservation and Recreation Lands Program, Land Acquisition Trust Fund Program, and Save Our Coast Program;
- (d) Rivers designated under the Florida Scenic and Wild Rivers Program, federal Wild and Scenic Rivers Act of 1968 as amended, and Myakka River Wild and Scenic Designation and Preservation Act;
- (e) Waters within National Seashores, National Marine Sanctuaries, National Estuarine Research Reserves, and certain National Monuments;
- (f) Waters in Aquatic Preserves created under the provisions of Chapter 258, F.S.;
- (g) Waters within the Big Cypress National Preserve;
- (h) Special Waters as listed in paragraph 62-302.700(9)(i), F.A.C.; and
- (i) Certain Waters within the Boundaries of the National Forests.

c Each water body demonstrated to be of exceptional recreational or ecological significance may be designated as a Special Water.

d The following procedure shall be used in designating an Outstanding National Resource Water as well as any Special Water:

- (a) Rulemaking procedures pursuant to Chapter 120, F.S., and Chapter 62-102, F.A.C., shall be followed;
- (b) At least one fact-finding workshop shall be held in the affected area;
- (c) All local county or municipal governments and state legislators whose districts or jurisdictions include all or part of the water shall be notified at least 60 days prior to the workshop in writing by the Secretary;

(d) A prominent public notice shall be placed in a newspaper of general circulation in the area of the proposed water at least 60 days prior to the workshop; and

(e) An economic impact analysis, consistent with Chapter 120, F.S., shall be prepared which provides a general analysis of the impact on growth and development including such factors as impacts on planned or potential industrial, agricultural, or other development or expansion.

e The Commission may designate a water of the State as a Special Water after making a finding that the waters are of exceptional recreational or ecological significance and a finding that the environmental, social, and economic benefits of the designation outweigh the environmental, social, and economic costs.

f The Commission may designate a water as an Outstanding National Resource Water after making all of the following findings:

(a) That the waters are of such exceptional recreational or ecological significance that water quality should and can be maintained and protected under all circumstances other than temporary degradation and the lowering allowed by Section 316 of the Federal Clean Water Act; and

(b) That the level of protection afforded by the designation as Outstanding National Resource Waters is clearly necessary to preserve the exceptional ecological or recreational significance of the waters; and

(c) That the environmental, social, and economic benefits of the designation outweigh the environmental, social, and economic costs.

g The policy of this section shall be implemented through the permitting process pursuant to Rule 62-4.242, F.A.C.

h For each Outstanding Florida Water listed under subsection 62-302.700(9), F.A.C., the last day of the baseline year for defining the existing ambient water quality (paragraph 62-4.242(2)(c), F.A.C.) is March 1, 1979, unless otherwise indicated. Where applicable, Outstanding Florida Water boundary expansions are indicated by date(s) following “as mod.” under subsection 62-302.700(9), F.A.C. For each Outstanding Florida Water boundary which expanded subsequent to the original date of designation, the baseline year for the entire Outstanding Florida Water, including the expansion, remains March 1, 1979, unless otherwise indicated.

i Outstanding Florida Waters:

(a) Waters within National Parks and National Memorials.

National Park or National Memorial	County
3. Everglades National Park (as mod. 8-8-94)	Monroe/Dade/ Collier

(b) Waters within National Wildlife Refuges.

Wildlife Refuge	County
6. Crocodile Lake (12-1-82; as mod. 5-14-86, 4-19-88, 8-8-94)	Monroe
10. Great White Heron (as mod. 5-14-86, 4-19-88)	Monroe

(c) (c) Waters within State Parks, State Wildlife Parks, and State Recreation Areas.

State Park or State Recreation Area	County
4. Bahia Honda State Park (as mod. 5-14-86)	Monroe
41. John Pennekamp Coral Reef State Park (as mod. 5-14-86, 4-19-88)	Monroe
53. Long Key State Recreation Area	Monroe

(d) Waters within State Ornamental Gardens, State Botanical Sites, State Historic Sites, and State Geological Sites.

State Ornamental Gardens, State Botanical Site, State Historic Site, or State Geological Site	County
4. Fort Zachary Taylor State Historic Site (10-4-90)	Monroe
5. Indian Key State Historic Site (10-4-90)	Monroe
6. Key Largo Hammock State Botanical Site (5-14-86)	Monroe
15. Windley Key Fossil Reef State Geological Site (10-4-90)	Monroe

(e) Waters within State Preserves, State Underwater Archaeological Preserves, and State Reserves.

State Preserve or State Reserve	County
15. San Pedro State Underwater Archaeological Preserve (10-4-90)	Monroe

(f) Waters within Areas Acquired through Donation, Trade, or Purchased Under the Environmentally Endangered Lands Bond Program, Conservation and Recreation Lands Program, Land Acquisition Trust Fund Program, and Save Our Coast Program.

Program Area	County
13. Coupon Bight (10-4-90; as mod. 8-8-94)	Monroe
15. Curry Hammock (8-8-94)	Monroe
42. North Key Largo Hammock (5-14-86; as mod. 4-19-88, 10-4-90, 8-8-94)	Monroe

(g) Waters within National Seashores.

(h) Waters within State Aquatic Preserves.

Aquatic Preserves	County
23. Lignumvitae Key	Monroe

(i) Special Waters.

(j) Waters within Rivers Designated Under the Florida Scenic and Wild Rivers Program, Federal Wild and Scenic Rivers Act of 1968 as amended, and Myakka River Wild and Scenic Designation and Preservation Act

(k) Waters within National Preserves

(l) Waters within National Marine Sanctuaries

Marine Sanctuary	County
1. Key Largo	Monroe
2. Looe Key (12-1-82)	Monroe

(m) Waters within National Estuarine Research Reserves

(n) Certain Waters within the Boundaries of the National Forests

(10) Outstanding National Resource Waters:

(a) The Commission designates the following waters as Outstanding National Resource Waters:

1. Biscayne National Park, as described in the document entitled “Outstanding National Resource Waters Boundary Description and Map for Biscayne National Park”, dated June 15, 1989, herein adopted by reference.
2. Everglades National Park, as described in the document entitled “Outstanding National Resource Waters Boundary Description and Map for Everglades National Park”, dated June 15, 1989, herein adopted by reference.

(b) It is the intent of the Commission that water bodies designated as Outstanding National Resource Waters shall be protected and maintained to the extent required by the federal Environmental Protection Agency. Therefore, the designations set forth in paragraph 62-302.700(10)(a), F.A.C., shall not be effective until the Florida Legislature enacts legislation specifically authorizing protection and maintenance of Outstanding National Resource Waters to the extent required by the federal Environmental Protection Agency pursuant to 40 C.F.R. 131.12.

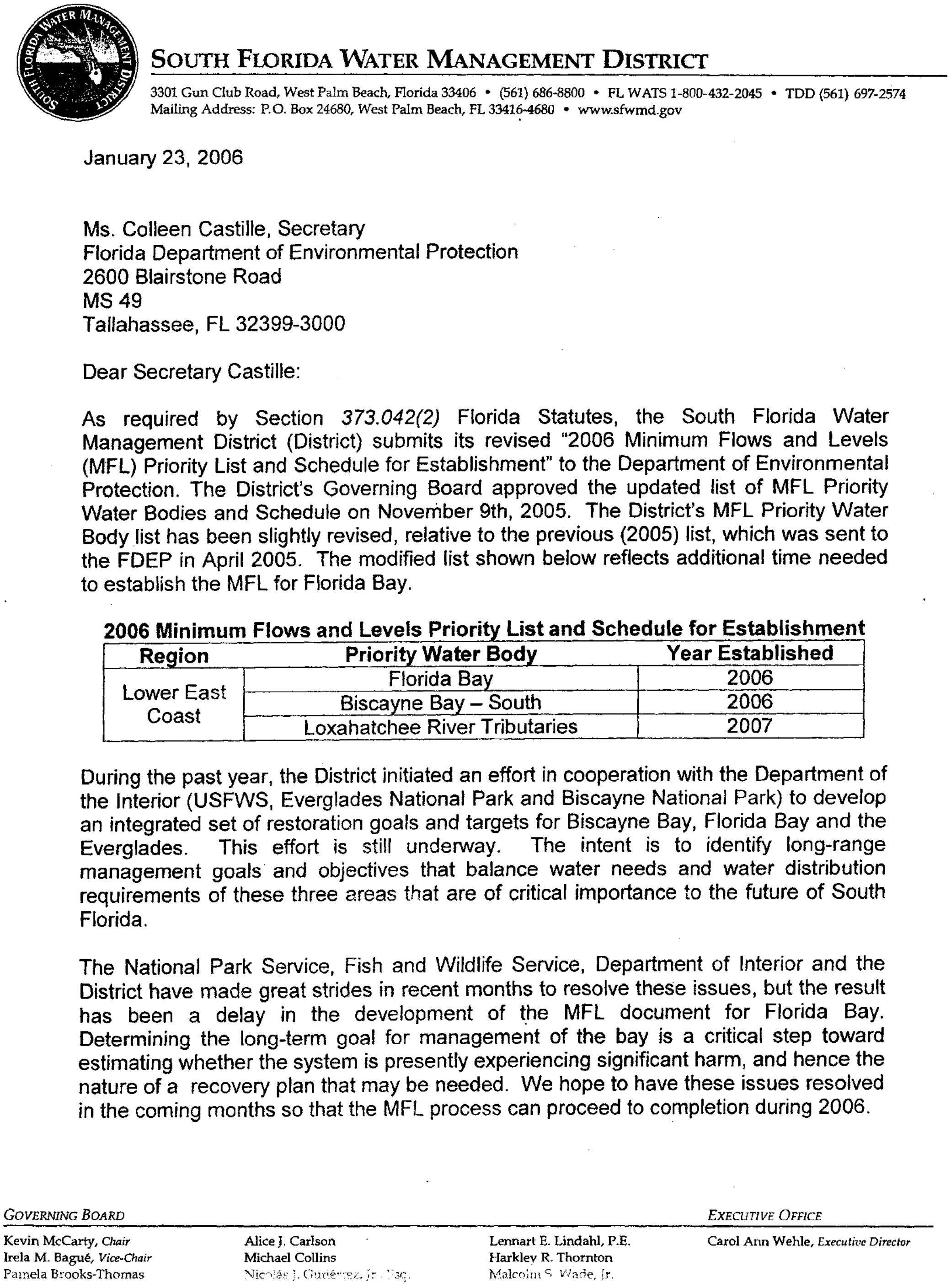
(c) It is also the intent of the Commission to utilize the Surface Water Improvement and Management Act planning process, as outlined in Section 373.451, F.S., and Chapter 62-43, F.A.C., to establish the numerical standards for water quality parameters appropriate for Everglades and Biscayne National Parks’ status as outstanding National Resource Waters.

(d) The baseline for defining the existing ambient water quality (paragraph 62-4.242(2)(c), F.A.C.) in Outstanding National Resource Waters is a five year period from March 1, 1976 to March 1, 1981, unless otherwise indicated.

Specific Authority 403.061, 403.087, 403.088, 403.804, 403.805 FS. Law Implemented 403.021, 403.061, 403.062, 403.087, 403.088, 403.101, 403.141, 403.182, 403.502, 403.702, 403.708, 403.918 FS. History–New 3-1-79, Amended 8-10-80, 8-24-82, 9-30-82, 11-30-82, 2-1-83, 6-1-83, 3-1-84, 8-16-84, 12-11-84, 1-17-85, 5-8-85, 4-29-86, 5-14-86, 5-22-86, 5-28-86, 10-29-86, 2-18-87, 4-9-87, 11-24-87, 12-15-87, 1-26-88, 4-19-88, 12-28-88, 4-10-89, 9-13-89, 10-4-89, 12-20-89, 1-28-90, Formerly 17-3.041, Amended 10-4-90, 11-8-90, 7-11-91, 8-18-91, 12-11-91, 6-18-92, 1-5-93, 8-8-94, Formerly 17-302.700, Amended 1-23-95, 4-3-95, 4-12-95, 7-16-96, 4-4-01, 12-11-03, 1-9-06.

Other Related Correspondence

2006 Update Minimum Flows and Levels Priority List and FDEP Transmittal Letter



SOUTH FLORIDA WATER MANAGEMENT DISTRICT
3301 Gun Club Road, West Palm Beach, Florida 33406 • (561) 686-8800 • FL WATS 1-800-432-2045 • TDD (561) 697-2574
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January 23, 2006

Ms. Colleen Castille, Secretary
Florida Department of Environmental Protection
2600 Blairstone Road
MS 49
Tallahassee, FL 32399-3000

Dear Secretary Castille:

As required by Section *373.042(2)* Florida Statutes, the South Florida Water Management District (District) submits its revised "2006 Minimum Flows and Levels (MFL) Priority List and Schedule for Establishment" to the Department of Environmental Protection. The District's Governing Board approved the updated list of MFL Priority Water Bodies and Schedule on November 9th, 2005. The District's MFL Priority Water Body list has been slightly revised, relative to the previous (2005) list, which was sent to the FDEP in April 2005. The modified list shown below reflects additional time needed to establish the MFL for Florida Bay.

2006 Minimum Flows and Levels Priority List and Schedule for Establishment

Region	Priority Water Body	Year Established
Lower East Coast	Florida Bay	2006
	Biscayne Bay – South	2006
	Loxahatchee River Tributaries	2007

During the past year, the District initiated an effort in cooperation with the Department of the Interior (USFWS, Everglades National Park and Biscayne National Park) to develop an integrated set of restoration goals and targets for Biscayne Bay, Florida Bay and the Everglades. This effort is still underway. The intent is to identify long-range management goals and objectives that balance water needs and water distribution requirements of these three areas that are of critical importance to the future of South Florida.

The National Park Service, Fish and Wildlife Service, Department of Interior and the District have made great strides in recent months to resolve these issues, but the result has been a delay in the development of the MFL document for Florida Bay. Determining the long-term goal for management of the bay is a critical step toward estimating whether the system is presently experiencing significant harm, and hence the nature of a recovery plan that may be needed. We hope to have these issues resolved in the coming months so that the MFL process can proceed to completion during 2006.

We look forward to the Department's approval of this revised list so that it can be published in the Florida Administrative Weekly. If you have any questions, please contact Carlyn Kowalsky, Director, Water Supply Department, at 561-682-6240.

Sincerely,

Carol Ann Wehle

Carol Ann Wehle
Executive Director
South Florida Water Management District

CW/jl

c: Janet Llewellyn, FDEP

Appendix B

The Use of Conceptual Ecological Models to Guide Ecosystem Restoration in South Florida (Ogden 2005)

A Conceptual Ecological Model of Florida Bay (Rudnick 2005)

A Conceptual Model of Ecological Interactions in the Mangrove Estuaries of the Florida Everglades (Davis 2005)

WETLANDS, Vol. 25, No. 4, December 2005, pp. 795–809

THE USE OF CONCEPTUAL ECOLOGICAL MODELS TO GUIDE ECOSYSTEM RESTORATION IN SOUTH FLORIDA

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Abstract: Conceptual ecological models, as used in the Everglades restoration program, are non-quantitative planning tools that identify the major anthropogenic drivers and stressors on natural systems, the ecological effects of these stressors, and the best biological attributes or indicators of these ecological responses. Conceptual ecological models can be used with any ecological restoration and conservation program and can become the primary communication, planning, and assessment link among scientists and policy-makers. A set of conceptual ecological models has been developed for South Florida restoration as a framework for supporting integration of science and policy and are key components of an Adaptive Management Program being developed for the Comprehensive Everglades Restoration Plan. Other large-scale restoration programs also use conceptual ecological models. This special edition of Wetlands presents 11 South Florida regional models, one total system model for South Florida, and one international regional model. This paper provides an overview of these models and defines conceptual ecological model components. It also provides a brief history of South Florida's natural systems and summarizes components common to many of the regional models.

Key Words: South Florida, Everglades, ecosystem restoration, conceptual ecological models, applied science strategy, adaptive management, sea-level rise, water management, urban development, agricultural development

INTRODUCTION

The rapid expansion of human impacts on entire natural ecosystems, and the resulting increasing scales of degradation of these environments, has created new challenges for the natural resource managers who are responsible for protecting and restoring the wild lands of the United States. Chesapeake Bay's waters are greatly degraded, Louisiana's coastline is receding into the Gulf of Mexico, and the Florida Everglades are both hydrologically altered and spatially fragmented. Programs designed to reverse these undesirable trends require integration of science and policy at scales not previously attempted in order to establish agreement on restoration objectives as the basis for restoration planning and to create the foundation for experimentation and monitoring for adaptive management. The challenge of organizing and applying good scientific understandings is especially great given the large spatial and temporal scales at which regional ecosystems operate and at which restoration plans must be designed and implemented to resolve these issues. Yet, current understanding of large, regional ecosystems is often substantially incomplete, and existing knowledge is widely scattered in place and time (and all too often unpublished). Despite these challenges, resource agencies and institutions must move forward with planning and implementing complex restoration programs before further degradation occurs. The need is for a logical process for synthesizing, organizing, and prioritizing existing knowledge of these ecosystems as a basis for maximizing an effective role for science in supporting the planning and assessment of regional restoration programs.

Since 1995, teams that have been planning and implementing restoration programs in South Florida have developed a set of non-quantitative conceptual ecological models as a framework for supporting this integration of science and policy. These conceptual models identify where there is broad agreement about major anthropogenic stressors on natural systems, ecological effects of these stressors, and best biological attributes or indicators of these ecological responses. In short, the models provide qualitative explanations of how natural systems have been altered by human stressors, which in turn provides planners with the information needed to focus on the best design and assessment strategy for the regional restoration program. In South Florida, these models have become powerful tools for developing consensus and communicating prevalent views of the major "working hypotheses" that explain what we know and don't know about the stressor linkages and effects in the greater Everglades basin, as a basis for developing an evolving set of performance measures, monitoring programs, and an adaptive management strategy for dealing with numerous uncertainties in ecosystem responses. It is important to emphasis that these conceptual models are non-quantitative, and have been designed primarily as planning tools for Everglades restoration. Secondarily, these models have contributed to discussions of research priorities in the context of the science needed to support Everglades restoration.

This initial paper describes the development and principal application of conceptual models. The following papers provide the scientific framework and underpinnings for 11 South Florida regional models, one total system model for South Florida, and one international regional model. Conceptual ecological models can be used with any ecological restoration and conservation program and, when developed and applied appropriately, can become the primary communication, planning, and assessment link among scientists and policy-makers.

HISTORY OF THE GREATER FLORIDA EVERGLADES ECOSYSTEM

South Florida was once a diverse mosaic of hydrologically interconnected landscapes and communities (Beard 1938, Davis 1943, Douglas 1947, Davis and Ogden 1994, Gunderson 1994, Browder and Ogden 1999). The expansive freshwater Everglades covered an area of about 1.2 million ha (Davis et al. 1994) and was the heart of a 3.6 million ha wetland system (Davis and Ogden 1994). The pre-drainage South Florida ecosystem has been characterized as a hydrologically interconnected, slow flowing system that extended from the Kissimmee River and Lake Okeechobee southward over low-gradient lands to the estuaries of Biscayne Bay, Ten Thousand Islands, and Florida Bay and eastward and westward to the northern estuaries (Figure 1). Excess water flowed overland to the Caloosahatchee Estuary and into the Gulf of Mexico, overland to the St. Lucie and Loxahatchee River Estuaries and Indian River and Lake Worth Lagoons into the Atlantic Ocean, and spilled over the low southern shore of Lake Okeechobee into the Everglades and south to Florida Bay (Obeysekera et al. 1999). Lake Okeechobee had no direct connection to the Atlantic Ocean or the Gulf of Mexico.

The South Florida natural ecosystem is the product of a unique combination of climate, soil, and topography (Obeysekera et al. 1999). Water depth and distribution, temporally and spatially, were largely determined by seasonal and annual rainfall, evaporation, transpiration, natural topography, outflow through natural streams into the ocean, and the system's capacity for surface- and ground-water storage (SFWMD 1992, Fennema et al. 1994). This large water-storage capacity resulted in a system much wetter, but not necessarily deeper, than the current system. Alternating high and low water depths and distribution patterns of surface water and ground water in the freshwater wetlands, as well as variations in water flow volumes and rates through wetlands and into estuaries largely determined soil and vegetation patterns. Hydrology also determined the distribution, abundance, and seasonal movements and reproductive dynamics of all aquatic and many terrestrial animals in the Everglades (Powell 1987, Kushlan 1989, Davis and Ogden 1994, Fennema et al. 1994, Holling et al. 1994, Walters and Gunderson 1994). The effects of this slow-moving sheet of water, in concert with natural climatic events such as fires, freezes, storms, hurricanes, floods, droughts, and sea-level change (Craighead 1964, Wanless et al. 1994, Browder and Ogden 1999) created and sustained a mosaic of ponds, marshes, hardwood hammocks, and forested wetlands. Local topographic and substrate differences were responsible for fine-scale vegetation patterns (Browder and Ogden 1999). The large spatial extent and connectivity of the Everglades were essential for sustaining populations of species with narrow habitat requirements or large feeding ranges and sustaining regional levels of aquatic production necessary to support large numbers of higher vertebrates (Harshberger 1914, Harper 1927, Ogden et al. 1999).

South Florida's rapidly increasing population has impacted the South Florida ecosystem. By the late 1990s, almost 6 million people were living along the coast of South Florida (Gannon 1996). Given the large numbers of people living in former low-lying wetlands, water management has been a constant and necessary practice for South Florida. Land was drained for urban and agricultural development, and canals and conservation areas were constructed for flood control, water retention, water supply, irrigation, and transport. South Florida now contains one of the largest water-management systems in the world, the Central and Southern Florida (C&SF) Project (USACE 1960, Light and Dineen 1994, USACE 1998) that was authorized by the US Congress in 1948 and constructed during the 1950s–1970s. This infrastructure was designed for a projected population of only 2 million people in

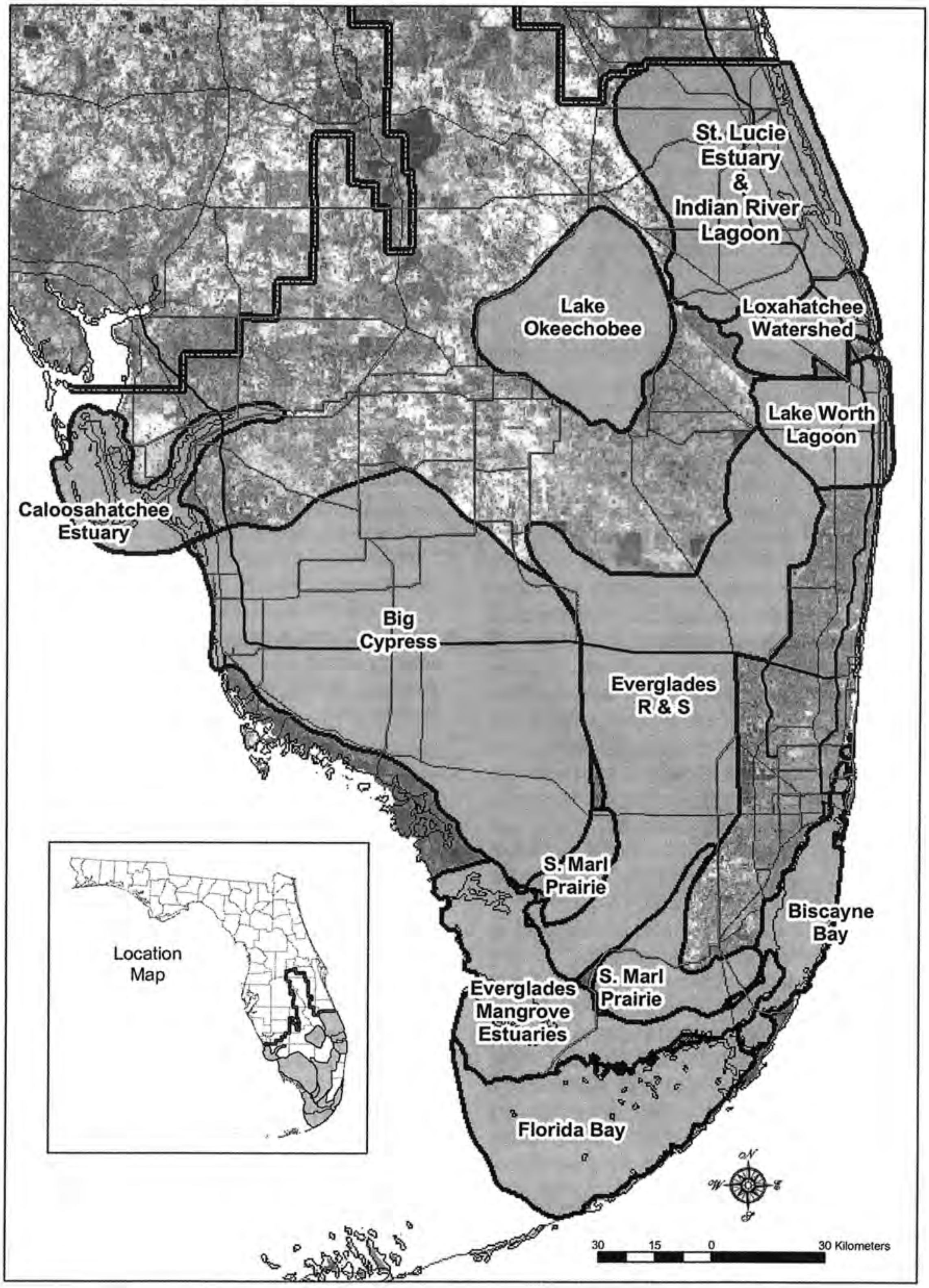

Figure 1. Map of South Florida with conceptual ecological model boundaries.

2000 (USACE and SFWMD 2004). Population in South Florida is now projected to increase to 8–15 million people by 2050 (USACE 1998, Harwell et al. 1999, National Park Service 2000, US Army Corp of Engineers 2003).

At present, approximately one-third of the original extent of the greater wetland system in South Florida has been lost or converted to other land uses, including about one-half of the true Everglades (Tebeau 1990, Chapman 1991, Davis et al. 1994, Harwell et al. 1996, Harwell 1997, Harwell 1998, M. Duever, South Florida Water Management District, pers. comm. 2002). Remaining wetlands have been increasingly impacted by water-management practices. The Everglades has lost 50% of its habitat, and 70% less water flows through the system (USFWS 1999). Around 6.4 billion kilograms of water are lost into the ocean every day for flood control, and water demand for human consumption increases daily. Large flood control releases from Lake Okeechobee and major canals during the wet season and water demand withdrawals during the dry season have altered habitat conditions in northern estuaries. Disruption of sheet flow through the Everglades has reduced the amount of fresh water flowing into southern estuaries. In both Florida and Biscayne Bays salinity levels have risen, water clarity and seagrass habitat have been reduced, algal blooms have occurred, and fish and invertebrate populations have decreased as fresh water flowing from the Everglades has decreased. Many hectares of habitat have been affected by phosphorous. Nesting wading bird population has been reduced 90–95% since the 1930s, and 68 plant and animal species are now listed as threatened or endangered, while nearly 600,000 hectares are being invaded by exotic species (USFWS 1999).

As a result of Everglades habitat degradation and an increasing human population, Congress authorized the Comprehensive Everglades Restoration Plan (CERP) in 2000 (USACE and SFWMD 1999, Water Resources Development Act of 2000) to assist in the restoration of South Florida's natural systems (SFERTF 2000). Estimated to cost $8.2 billion (in 1999 dollars), the project will span over thirty-five years. It may be the largest environmental restoration project ever authorized. The main restoration objectives of the plan are to increase water storage capacity of the system substantially and distribute water in a manner to reestablish ecologically desirable patterns of depth, distribution, and flow in freshwater wetlands and desirable salinity regimes in estuaries (Ogden et al. 2003). It is expected that these improvements in hydrologic patterns will result in substantial improvements in the system's ecological condition (Ogden et al. 2003). The plan specifies that it will be based on the ''best available science'' and the concept of ''adaptive assessment,'' which will allow the plan to be flexible so modifications can be made based on new information (Ogden et al. 2003). Modifications will be made as needed through the adaptive management process discussed below.

ROLE OF SCIENCE IN SUPPORTING EVERGLADES RESTORATION

Applied Science Strategy

An ''applied science strategy'' was developed in South Florida as a process for linking science and management during the planning and implementation of the South Florida ecosystem restoration programs (Ogden et al. 1997, Science Coordination Team 1997, Ogden and Davis 1999). The purpose of the strategy has been to organize and convert large amounts of existing scientific and technical information into planning and assessment tools that would support restoration. An organizing process is required for large-scale restoration planning because information from many disciplines is widely scattered in time and place, focused efforts are needed to include ''best professional opinion,'' and a large degree of consensus regarding major cause-and-effect relationships is necessary. Ogden et al. (2003) described the applied science strategy in more detail.

Role of Conceptual Ecological Models

The principle organizing component in the applied science strategy is a set of non-quantitative, conceptual ecological models of 11 major physiographic regions in South Florida. These conceptual models are being used as planning tools to guide and focus scientific support for the South Florida ecosystem restoration initiatives and to build understanding and consensus among scientists and managers regarding the set of working hypotheses that explain the sources and effects of major anthropogenically induced changes in the natural systems of South Florida. The hypotheses identify specific, large-scale stressors on the natural systems, ecological effects of these stressors, and recommended biological and ecological attributes of the natural systems that can best serve as indicators of the effectiveness of restoration programs designed to reduce or eliminate the effects of the identified stressors. In other words, each hypothesis describes ecological linkages between a stressor and a key attribute of the natural system that has been altered due to effects of that stressor.

Conceptual ecological models have become an essential part of South Florida's restoration planning process because both scientists and managers now depend on the models to help build scientific consensus regarding ecosystem linkages and responses, as a framework for creating performance measures used both to plan the design of the restoration programs and assess responses of the natural systems during implementation of each program, and to identify research needs. Managers appreciate these models because of their role in organizing effective application of existing science in support of decision-making during the restoration planning process. Scientists value the intellectual and integrative processes of developing working hypotheses and laying out linkages in conceptual models as a basis for identifying gaps in knowledge and setting research priorities. Specific hydrologic, water quality, biological, and ecological performance measures derived from stressors and attributes in the models (RECOVER 2004), in addition to focusing restoration planning on quantitative objectives, also define the content of system-wide monitoring programs designed to measure system responses to restoration efforts.

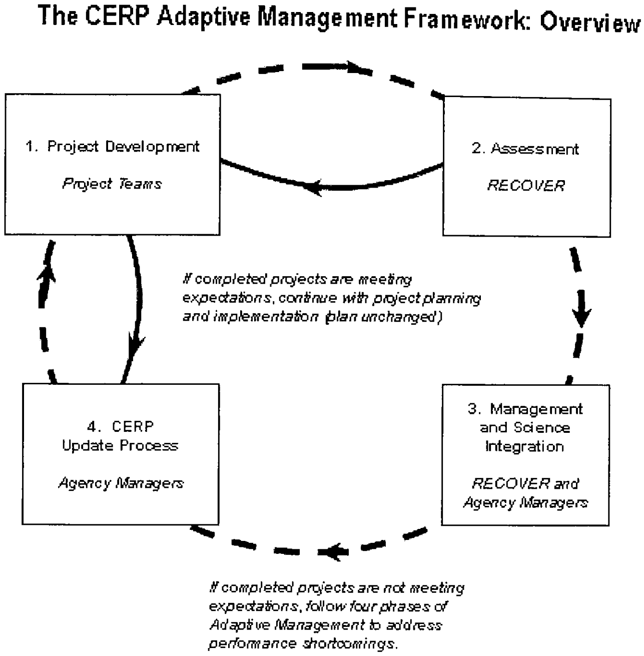

Figure 2. The CERP Adaptive Management Process.

Adaptive Management

Conceptual ecological models are key components of an Adaptive Management Program that is described in the Programmatic Regulations for the Comprehensive Everglades Restoration Plan (Department of Defense 2003). Adaptive management is a continuous process of seeking a better understanding of the interactions between the natural and human systems and refining and improving a restoration plan to respond to changes or unforeseen circumstances and new scientific and technical information.

The CERP Adaptive Management Program is currently being designed to anticipate future uncertainties and respond to system responses for success. These uncertainties include unanticipated and undesired responses and events in natural and human systems of South Florida that result from CERP implementation or from non-CERP influences, including external drivers in conceptual ecological models. A successful adaptive management program will provide early warnings of undesired impacts and allow decision-makers to integrate science and management effectively as a basis for providing on-going refinements in the plan to ensure that its goals are achieved.

A draft framework for the strategy to be used to implement adaptive management is presented in Figure 2. The conceptual ecological models, as the source for performance measures, serve tasks in Box 2: Performance Assessment. Performance assessments are based on information obtained through a system-wide monitoring program that focuses on physical and biological elements identified by assessment performance measures. Response of the system to restoration efforts is determined by applying monitoring data to performance measures and assessment protocols. Results of these analyses will determine what portions of the restoration plan are successful or not. Conceptual ecological models will be revised to the extent that monitoring and assessment activities result in improvements in our understanding of cause-and-effect relationships in the natural systems.

SUMMARY OF SOUTH FLORIDA CONCEPTUAL ECOLOGICAL MODELS

This paper introduces a Total Systems Model and eleven regional conceptual ecological models: 1) Everglades Ridge and Slough, 2) Everglades Southern Marl Prairies, 3) Everglades Mangrove Estuaries, 4) Big Cypress Regional Ecosystem, 5) Florida Bay, 6) Biscayne Bay, 7) Lake Okeechobee, 8) Caloosahatchee Estuary, 9) St. Lucie Estuary, 10) Loxahatchee Watershed, and 11) Lake Worth Lagoon (Figure 1).

Development of the Conceptual Ecological Models

Through workshops, participants identified causal hypotheses that best explain major anthropogenically-driven alterations in each landscape. Participants then created lists of appropriate stressors, ecological effects, and attributes (indicators) for each region. The objective was to identify physical and biological components and linkages in each landscape that best characterized changes explained by hypotheses. Each preparer (model lead) used hypotheses and lists of components to draft a model and prepare a supporting narrative to explain organization of the model and supporting science for hypotheses (RECOVER 2001, 2003).

In addition to the set of regional conceptual models developed, a Total System Model for South Florida has been created for several purposes beyond the scope of regional models. The Total System Model is used to identify working hypotheses that are relevant to all or a substantial subset of regional models, as a basis for determining stressors, ecological linkages, and attributes that are associated with the most important changes that have occurred over much of the natural areas of South Florida. Inclusion of working hypotheses at total system scales elevates the significance of these hypotheses in overall planning for restoration. The Total System Model also allows for a better characterization of stressors and ecological linkages that are operating at larger scales than can be presented adequately in regional models (e.g., altered nesting and foraging patterns by wading birds) and of altered hydrologic conditions having ecological effects across boundaries of adjacent regional models (e.g., altered nutrient and sediment transport between freshwater and estuarine regions). Unlike most regional models, the Total System Model includes consideration of working hypotheses that address changes that have occurred in upland landscapes in South Florida (e.g., pinelands).

SUMMARY OF THE INTERNATIONAL MODEL

Located on the Caribbean Coast in the state of Quintana Roo, the Sian Ka'an Reserve and South Florida, USA are remarkably similar. Valuable lessons in ecosystem ecology are being learned from the South Florida Ecosystem Restoration Initiative that can and should be applied to the Sian Ka'an Biosphere Reserve. The conceptual ecological model for the Sian Ka'an Reserve does not explain effects that have already occurred on ecological habitats and linkages between hypotheses but, rather, predicts effects that will occur due to current human pressures. The model predicts linkages allowing scientists to measure and protect precious attributes. The purpose of this conceptual ecological model is to identify important attributes and conditions required for their success. Sian Ka'an has the opportunity to test conceptual ecological models in a system that has not been extensively or intensively developed or degraded as South Florida ecosystems.

The Sian Ka'an Conceptual Ecological Model is analogous to the Everglades Total System model in scope and scale. The process for constructing the Sian Ka'an Biosphere Reserve model was modified slightly from that of Everglades' conceptual ecological models. Drivers, stressors, attributes, and effects/linkages were initially identified from a series of local workshops with area experts, primarily from Amigos de Sian Ka'an (ASK) and the National Commission for Protected Natural Areas (CONANP) staff in November 1999 in Cancún.

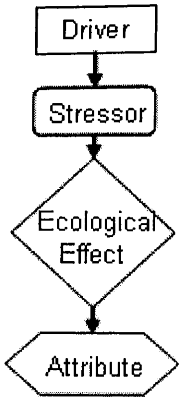

Figure 3. Simplified diagram of a conceptual ecological model.

MODEL COMPONENTS

The models include all major external drivers, stressors, ecological effects, and attributes that illustrate the major cause-and-effect linkages in each modeled region, regardless of their connection to the CERP. A schematic diagram of a conceptual ecological model is presented in Figure 3. Models depict general pathways by which driving forces (in rectangles) affect attributes of the ecosystem (in hexagons) that are important to ecosystem function and those viewed by people in south Florida as valuable and important to maintain. External drivers create internal stressors (ovals) that have various effects (diamonds) on the ecosystem, which are reflected in changes to ecosystem attributes (hexagons). To help illustrate the actual nature of the model components, examples of a working hypothesis as diagramed in a conceptual model are shown in Figure 4.

These major components of the models are defined as follows:

- Drivers—major driving forces that occur outside the natural system, which have large-scale influences on natural systems. Drivers are natural forces (e.g., sea-level rise) or anthropogenic (e.g., water management).
- Stressors—physical or chemical changes that occur within natural systems that are brought about by drivers, causing significant changes in biological

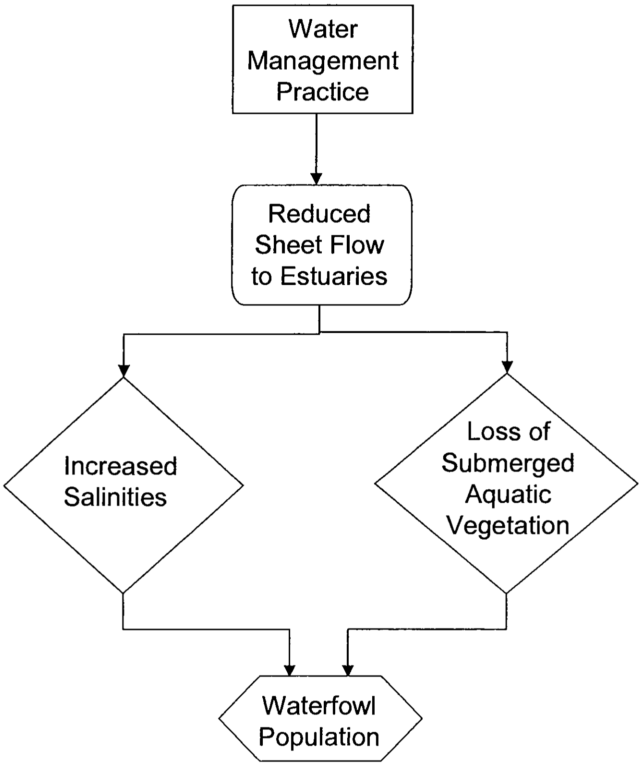

Figure 4. An example of an Everglades working hypothesis as diagramed in a conceptual model.

components, patterns and relationships in natural systems.

- Ecological Effects—physical, chemical, and biological responses caused by stressors.
- Attributes—a parsimonious subset of all potential biological elements or components of natural systems that are representative of overall ecological conditions of the system. Attributes typically are populations, species, guilds, communities, or processes. Attributes, also known as indicators or endpoints, are selected to represent known or hypothesized effects of stressors (e.g., nesting wading bird numbers) and elements of systems that have important human values (e.g., endangered species, sports fishing).

In the text for the models, attributes are discussed before ecological effects even though they are at the end of the pathway in the diagrams. Chapters are organized in this manner to provide the reader with background information on stressors and attributes prior to reading the discussion of ecological effects and critical linkages that are the basis for causal hypotheses.

As we learn more about how the ecosystem functions, it is possible that additional pathways could be added to the models or adjustments made to existing pathways. Models are flexible planning tools that, at any given time, reflect the current state of scientific knowledge about the regional or total system.

Although each regional model has a specific set of components, many key components overlap among models. Below is a generalized discussion of the more widespread drivers, stressors, and attributes that are common to most or all of the regional models. The information is presented here once, rather than repetitively within each regional model paper. Because ecological effects and critical linkages are more likely to vary among regional models, all effect discussions are retained in narratives for each model and are not summarized in the following general discussion.

Drivers

Each model lists or implies three major drivers: sea-level rise, water management, and urban and agricultural development. These drivers affect many attributes, but most frequently water quality, water levels, water patterns, water flow, toxin concentrations, habitat, and species composition.

Sea-Level Rise. There is strong evidence that present rates of sea-level rise in South Florida, which are attributed to global climate change, will massively reconfigure the geomorphology, circulation patterns, salinity patterns, and ecological processes during the Twenty-First Century (Wanless et al. 1994). The entire South Florida ecosystem is dependent on water flow and habitat area. Given that Florida is characterized by very small topographic relief, a conservatively estimated sea-level rise of 0.75 m over the next century (Wanless et al. 1994) will reduce shoreline habitat, overall habitat extent, and mix sediments and salinities altering water composition. Effects are further explained in the following attributes and linkages and within each model.

Water Management. Since the mid-1800s, water management has been designed to accommodate and support an influx of population. Water supply and flood control have been achieved by a complex system of structural and operational modifications to the natural system. Alterations affecting hydrology include construction of canals, channelization of natural waterways, filling, draining, and/or impoundment of wetlands, and creation of new inlets to the Atlantic Ocean. These modifications have 1) contributed to substantial reduction in spatial extent, 2) provided a network of canals and levees that have accelerated spread of degraded water and exotic species, 3) greatly reduced water storage capacity within remaining natural systems, 4) created an unnatural mosaic of impounded and overdrained marshes in the Water Conservation Areas, and 5) substantially disrupted natural patterns of sheet-flow direction, location, and volume (SFWMD 1992, Science Subgroup 1993, Davis and Ogden 1994, Fennema et al. 1994, Light and Dineen 1994). Declines in many ecological attributes correspond to development of the water management system.

Urban and Agricultural Development. Increasing population forced engineers to drain extensive areas of wetlands, both large and small, to provide space for development, provide flood protection, and to accommodate increasing urban and agricultural water demands. Clearing and paving of land prevents precipitation drainage and water-table replenishment.

Agricultural runoff contaminates water with nitrogen, phosphorus, pesticides, herbicides, and fungicides. Citrus farms, vegetable fields, cattle ranchers, and sugarcane fields now reside where flowing water once nourished native vegetation and animal species. This rapid, mass development resulted in fragmented habitats, degraded shoreline and coastal habitats, and contaminated water supplies.

Stressors

Stressors common to all or many of the models include altered hydrology, degraded water quality, reduced spatial extent, physical alterations, increases in exotic species, and boating and fishing pressure.

Altered Hydrology. Change in direction, volume, and timing of freshwater flow has altered hydrology in South Florida. Water-management practices for flood control and water supply have resulted in unnatural discharges of water to prevent flooding and water withdrawals for irrigation and consumption that reduce flow volumes during drought conditions. For inland models (Everglades Ridge and Slough, Southern Marl Prairies and Big Cypress Regional Ecosystem), altered hydrology takes the form of altered hydropatterns, especially altered hydroperiods (period of inundation). For Lake Okeechobee, lake stages are often too high or too low. Salinity regimes of all estuaries (Everglades Mangrove Estuaries, Caloosahatchee Estuary, St. Lucie and Indian River Lagoon, Loxahatchee Watershed, and Lake Worth Lagoon Conceptual Ecological Models) have been altered from changes in location, volume, and timing of fresh water.

The South Florida wetland ecosystems relied on a continuous and slow-moving sheet of water. Any interruption in that flow of water results in altered hydropatterns. Hydropattern includes depth, period of inundation, and sheet flow. Many species are dependent on specific hydropatterns, including fish, alligators (*Alligator mississippiensis* Daudin), benthic communities, submerged aquatic vegetation (SAV), and wading birds. With a shortened hydroperiod, the amount of water and duration of surface-water flooding in natural wetlands dramatically decreases, reducing the extent and quality of habitat and food supply for many species. Drier conditions can facilitate major shifts in the composition of affected wetland plant communities to a composition similar to upslope communities. An altered and less hospitable landscape allows for invasion of exotic species and a drier community opens the area up to more frequent and damaging fires.

Estuarine environments are sensitive to freshwater inputs. Modifications to natural patterns of volume, distribution, circulation, or timing of freshwater discharges can alter an estuary's salinity regime (Haunert et al. 1994). During the wet season, rainfall that was historically retained within the undeveloped watershed now reaches estuaries faster and in greater volume. During the dry season, less fresh water flows into estuaries, allowing encroachment of saltwater upstream. A heightened sea level will also continue to mix more saltwater with areas previously filled with fresh water, altering water quality and habitat conditions. The salinity regime of an estuary is a primary determinant of the species composition of communities, as well as strongly influencing functions of these communities (Kennish 1990, Sklar and Browder 1998). All estuarine biota have adapted to a given salinity range and a given degree of salinity variability. Rapid and unnatural fluctuations in salinity have contributed to major impacts on SAV abundance and distribution, productivity, community composition, predator-prey relationships, and food-web structure. It is a major factor limiting the distribution and abundance of alligators (Dunson and Mazzotti 1989, Mazzotti and Dunson 1989) and survival of juvenile crocodiles (*Crocodylus acutus* Cuvier) (Mazzotti et al. 1988, Mazzotti 1989, Mazzotti and Dunson 1989, Moler 1991).

Degraded Water Quality. Water quality throughout South Florida has been degraded by elevated nutrient loads, inputs of contaminants, and elevated suspended solids. Phosphorus increases can be traced back to application of fertilizers to urban and agricultural lands and processing of human and agricultural waste products, run off of which is facilitated by water-management practices (Drew and Schomer 1984, Post et al. 1999). Absence of adequate storage and treatment facilities requires delivering flood waters rapidly into wetlands and receiving water bodies with little potential for amelioration of nutrient and dissolved organic matter loads. High peak flow rates also scour canal bottoms and erode canal banks, elevating suspended solid loads during sporadic rain-driven events.

Productivity and food web structure of all ecosystems are strongly influenced by patterns of nutrient cycling and transport. Increased input of nutrients to the Everglades has resulted in adverse effects and a dramatic shift from diverse herbaceous communities to communities dominated by a few invasive exotic and native species (Davis 1994, David 1996, Porter and Porter 2002). Nutrient enrichment in estuarine systems has resulted in loss of seagrasses, algal blooms, and lethal low oxygen levels or anoxic events. Increases in areas of low dissolved oxygen and shifts in species composition of benthic invertebrates to more pollution-tolerant organisms are linked to increased nutrient levels (Barbour et al. 1996).

Contaminants include pesticides, fungicides, herbicides, microorganisms from sewage treatment plants, oils, greases, mercury, and other heavy metals such as copper and zinc. They can be introduced into the system from boating, as well as urban development and agricultural practices. Zooplankton and fish show direct toxic effects of these contaminants. Indirect effects can occur through the process of bioaccumulation or biomagnification through the food web, increasing toxic load to top predators (Day et al. 1989). Influx of contaminants and toxins is also altering water quality for human consumption.

Water clarity is affected by increased phytoplankton production, suspended solid loading, and sediment suspension. Phytoplankton production, which is stimulated by elevated nutrients, increases water color. Suspended solids that result from erosion and sediment suspension increase turbidity. Increased turbidity and water color can lead to SAV reduction.

Reduced Spatial Extent and Fragmentation. Drainage of wetlands and subsequent conversion of land into agricultural and urban uses have reduced total spatial extent of natural habitat and fragmented existing habitat within inland Everglades regions. Space was one physical characteristic that was necessary for all other physical and ecological components of these systems to be in place; it is the foundation of the mosaic of habitats in a low profile terrain (Craighead 1971, DeAngelis and White 1994). Loss of spatial extent has reduced the range of habitat options available for faunal populations (DeAngelis and White 1994). Extensive space was necessary for supporting robust numbers of higher vertebrates, such as wading birds and alligators, requiring large feeding and hunting ranges during different seasons and a range of hydrologic conditions in the nutrient-poor system (Browder 1976, Mazzotti and Brandt 1994). Fragmentation and habitat loss affects populations by reducing spatial extent of their prey base where it no longer supports viable populations. In many cases, due to development, lost spatial extent and connectivity of habitat cannot be restored on a large scale and must influence expectations for ecosystem restoration.

Physical Alterations. Construction of water-management canals and structures and resulting compartmentalization have affected both inland and estuarine regions. Compartmentalization by the system of canals and levees in inland regions has substantially disrupted natural patterns of sheet-flow direction, location, timing, and volume. Natural vegetation mosaic and habitat ranges of native animal species have been affected. Construction of canals has altered freshwater flow to estuaries and increased transport of nutrients, contaminants, and suspended solids. Water-control structures have decreased spatial extent of some estuaries and interfered with migration patterns of many estuarine species by acting as a barrier between the freshwater and saltwater habitats. Physical alterations have been made to the estuaries, including opening and widening of inlets, dredging and maintenance of navigation channels, development of shoreline and interior basins, and draining and filling of wetlands. Construction and dredging of canals stirs up sediments, reducing water clarity, and severely disrupts benthic communities.

Exotic Species. Introduction, both intended and unintended, of non-native species of plants and animals has resulted in a dramatic shift in plant community structure, loss of tree island habitat, and localized shifts in animal community structure, especially fish communities. Spread of these non-native species has been facilitated by stressors on the system.

Alterations in habitat, hydrology, and water quality have facilitated spread of exotic vegetation. Exotic species invade areas where dominant native vegetation has been damaged or stressed, allowing light penetration for exotic species germination. Lowered water tables result in transition from wetland to upland environments, and corresponding stress allows plants such as *Melaleuca* (*Melaleuca quinquenervia* (Cav.) Blake) to become established. Tree islands have been invaded with Brazilian pepper (*Schinus terebinthifolius* Raddi), *Melaleuca*, and Old World climbing fern (*Lygodium microphylla* (Cav.) R.Br.). Increased nutrient concentrations can produce dramatic shifts from diverse herbaceous communities to communities dominated by a few invasive exotic and nuisance native species, such as cattails (*Typha* spp.) and willows (*Salix* spp.). Introduction of nutrients also allows *Hydrilla* sp., water hyacinths (*Eichhornia crassipes* (Mart.) Solms) and water lettuce (*Pistia stratiotes* Linnaeus) to expand in open waters. *Melaleuca* and torpedograss (*Panicum repens* Linnaeus), have expanded over large areas of Lake Okeechobee, displacing native plants.

Animal communities most affected by exotic species invasion are fish communities (Trexler et al.

2001). Canals provide corridors of permanently flooded, deep-water habitat that would not otherwise occur and allow expansion of exotic and higher trophic level fishes into areas where they could not survive naturally (Howard et al. 1995). Introduction and spread of nonnative fishes may alter dynamics of marsh fish communities, foraging behavior of wading birds, or genetic biodiversity. Prevalence of higher trophic fishes in canals may diminish the value of this habitat, which might serve as a dry season refugium for aquatic and amphibious fauna. Exotic fish and amphibian species prey on native species and compete with them for resources (Dineen 1984, Duever et al. 1986).

Boating and Fishing Pressure. As the population of South Florida has increased, so has recreational and commercial boating and fishing pressure. Boats traversing shallow flats and running aground result in seagrass scarring and sediment resuspension. Boat wakes erode banks of waterways, releasing solids into the waterway and damaging shoreline habitat. Dredging to increase navigation eliminates benthic organisms and SAV and increases suspended solids. Suspended solids created by wake erosion and dredging may cover productive adjacent bottom communities, suffocating residing organisms. Boat collisions are the leading cause of human-related manatee (*Trichechus manatus* Linnaeus) deaths (W. Dexter Render and Assoc. 1995). Fishing pressure from sport and commercial fisheries impacts standing stocks of many species (Post et al. 1999).

Attributes

The inland models and estuarine models require different attributes, but among the inland models and among the estuarine models, many similar attributes are used. Attributes that are used in most models, whether for an inland or an estuarine region, include wading birds and endangered and keystone species. Attributes common to only inland models include vegetation mosaic, periphyton mats, small aquatic fauna, and freshwater fish communities. Attributes common to only estuarine models include benthic communities, oysters, SAV, shoreline herbaceous wetlands, and mangrove habitats, fisheries, and nearshore reefs.

Wading Birds. Wading birds are good biological indicators throughout South Florida because of their close association with hydropattern. The current managed system has reduced nesting birds from 75 to 90 % compared to the 1930s. Numbers of snowy egrets (*Egretta Thula* Molina), tri-colored herons (*Egretta tricolor* Muller), white ibis (*Eudocimus albus* Linnaeus), and wood storks (*Mycteria Americana* Linnaeus) have relocated away from estuaries and into impounded central and northern Everglades. Also, white ibis and wood storks have altered the timing of nesting compared to historical patterns (Ogden 1994). It is hypothesized that the reduction in nesting birds correlates to a substantial decline in abundance and availability of aquatic prey base caused by water-management practices. For animals such as wading birds that operate over large spatial scales, compartmentalization and peripheral drainage have converted a single, expansive wetland system into several, smaller, hydrologically independent systems. Levees and canals have replaced shallowly flooded marsh edges with either overdrained or more deeply flooded marsh along levee slopes.

Endangered and Keystone Species. Many species are either unique to the South Florida ecosystem or are keystone animals at landscape and regional scales, and they are classified as attributes to the area, including the West Indian manatee, Florida panther (*Puma concolor coryi* Bangs), Everglades snail kite (*Rostrhamus sociabilis* Vieillot), Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis* Howell), American alligator, American crocodile, and pink shrimp (*Penaeus duorarum* Burkenroad). The manatee, panther, snail kite, seaside sparrow, and crocodile are listed on the endangered species list. Keystone species are those important to the overall health of the region. For example, alligators and crocodiles are often considered keystone species since their holes and trails provide important refugia for aquatic fauna during dry periods (Craighead 1968). They are top predators that greatly influence size, classes, distribution, and abundance of marsh animals.

Vegetation Mosaic. The vegetation mosaic in a given locale is primarily a function of climate, soil type, and suitable water conditions, including depth of water table, length and frequency of inundation, flow, and water quality. These plant communities, in turn, provide food and/or habitat for wildlife. Thus, changes in distribution, abundance, and species composition of plant communities have a direct effect upon type and quality of associated animal communities (Alexander and Crook 1975, McPherson et al. 1982, Sharitz and Gibbons 1989). Habitat loss directly impacts availability of resources required by organisms that use these areas. However, distribution of these habitats across the landscape is even more important because few organisms use only one habitat type, particularly in a seasonally fluctuating landscape. Models often target specific types of vegetation such as tree islands, marsh plant communities, and upland and wetland habitats as attributes.

Periphyton Mats. Periphyton is important as a food-web base, as habitat structure for fishes and invertebrates (Geddes and Trexler 2003), for oxygenating the water column, and in forming marl soils. Communities of green algae and diatoms may be especially important to periphyton grazers. Water-management practices and changes in water chemistry, including increased levels of total phosphorus, have changed spatial distribution and species composition of periphyton mats (Browder et al. 1994, Davis 1994). Shortened hydroperiods cause a reduction in proportion of diatoms and green algae and an increase in calcareous blue-green algae, thus reducing food value of periphyton and affecting productivity of the Everglades. In nutrient-enriched areas, species characteristic of low-nutrient waters are replaced by filamentous species.

Small Aquatic Fauna. Aquatic fauna of freshwater Everglades' marshes include myriad small fishes, amphibians, reptiles, crustaceans, snails, and other invertebrates that play enormously important roles in food webs, nutrient cycles, and energy transfers from primary consumers to the highest trophic levels in the ecosystem. Total abundance of aquatic fauna in the system has been greatly reduced due to combined effects of reduced spatial extent of wetlands, shortened hydroperiods, altered water recession rates, compartmentalization, and possible reductions in secondary production associated with shifts in periphyton composition (Dalrymple 1987, Browder et al. 1994, Davis et al. 1994, Loftus and Eklund 1994, Howard et al. 1995, Trexler and Jordan 1999, Turner et al. 1999, Trexler and Loftus 2000, Diffendorfer et al. 2001, Kobza et al. 2004, Trexler et al. 2005).

Freshwater Fish Communities. Population density of small marsh fishes in the Everglades is directly related to duration of uninterrupted flooding (Trexler and Loftus 2000), and maximum densities are reached only after multiple years of continual surface water (Loftus et al. 1990, Loftus and Eklund 1994, Turner et al. 1999). These small fishes are important links in the ecosystem, as they are a primary source of food for wading birds such as wood storks and roseate spoonbills (*Ajaia ajaja* Linnaeus) (Bjork and Powell 1994, Ogden 1994). Marsh fish are impacted by water flow, shortened hydroperiods, and reduced habitat.

Coastal Attributes

Benthic Communities. Benthic organisms provide essential ecological and biological functions in estuaries and can influence environmental quality. They are often used as water-quality indicators because they are primarily sedentary and, thus, have limited escape mechanisms to avoid disturbances (Bilyard 1987). They can provide an easily monitored record of effects of short- and long-term environmental changes through species composition and abundance changes. They have been used extensively as indicators of pollution and natural fluctuation impacts in estuarine environments (Gaston et al. 1985, Bilyard 1987, Holland et al. 1987, Boesch and Rabalais 1992).

Oysters. Oysters are an important component of benthic invertebrate communities and are treated as a separate attribute by most estuarine models. The Eastern oyster (*Crassostrea virginica* Gmelin) is the dominant species in oyster reef communities in South Florida. Oyster bars provide habitat and food for other species, including the oyster catcher (*Haematopus palliates* Temminck). Under natural conditions, oyster reefs can be very large and provide extensive attachment area for oyster spat and numerous associated species such as mussels, tunicates, bryozoans, and barnacles (Woodward-Clyde 1998). Over 40 species of macrofauna may be living in oyster beds (Bahr and Lanier 1981), with the total number of species exceeding 300 (Wells 1961). Oysters also create substrate to support other species and filter water to remove suspended materials. Individual oysters filter 4 to 34 liters of water per hour, removing phytoplankton, particulate organic carbon, sediments, pollutants, and microorganisms from the water column. This process results in greater light penetration, promoting growth of SAV immediately downstream from oyster bars.

Distribution and abundance of oysters are influenced by availability of planktonic food, water quality and clarity, salinity, and the presence of a suitable substrate for attachment of veliger larvae. They require salinity levels above 3–5 ppt, with an optimal salinity range between 12 and 28 ppt varying with geographical region (Loosanoff 1932, Chanley 1958, Galtsoff 1964, Woodward-Clyde 1998). Increased oligohaline conditions have limited distribution of oysters in South Florida estuaries. Also, higher salinity levels increase negative effects from saltwater predators such as oyster drills (*Stramonita* sp.) (Hofstetter 1977, White and Wilson 1996) and the protozoan parasite dermo (*Perkinsus marinus* Dermo), which is limited to salinities greater than 9 ppt and has been implicated as a cause of 50 percent of adult oyster mortality in Florida (Mackin 1962, Quick and Mackin 1971, Volety 1995). Thus, oyster distribution, health, and abundance reflect water quality, salinity, and substrate quality of an estuary (Andrews et al. 1959, Sellers and Stanley 1984, Lenihan 1999, Livingston et al. 2000).

Submerged Aquatic Vegetation. SAV is a critical food source for many species and foraging and hiding ground for others. It provides habitat for myriad animals, including juveniles of many commercially and recreationally valuable species (Zieman 1982). Seagrasses affect water quality through nutrient uptake and storage, binding of sediments by their roots, and trapping of particles within their leaf canopy. With growth of lush seagrass beds, these mechanisms drive the area towards a condition of clear water, lowering nutrients for algae growth and concentrations of suspended sediment in the water column. SAV requires sunlight to photosynthesize, thus murky water caused by silt, turbidity, color, or phytoplankton is stressful. SAV is intolerant of changes in salinity, toxicity, and water clarity and can be used to document changes within the ecosystem.

Shoreline Herbaceous Wetlands and Mangrove Habitats. Mangrove communities provide habitat for marine organisms, protect shorelines from erosion, and enhance water quality (Savage 1972). Detritus produced by mangroves is the basis of the food chain for South Florida's marine and estuarine ecosystems. Mangroves provide nursery grounds for sport and commercial fisheries, including spotted seatrout (*Cynoscion nebulosus* Cuvier), common snook (*Centropomus undecimulis* Bloch), and pink shrimp (Lindall 1973, Harris et al. 1983). Mangrove roots act to trap sediments and prevent shoreline erosion and provide attachment surfaces for various marine organisms. Additionally, mangrove forests provide habitat for a highly diverse population of birds (Odum et al. 1982). Also, these coastal wetlands help maintain water and habitat quality by filtering sediments and nutrients from inflowing waters.

Shoreline herbaceous wetlands and mangrove habitats have lost much of their spatial extent, connectivity, and ecological function through dredge-and-fill and drainage activities (Estevez 1998, National Safety Council 1998). In some areas, drainage for agricultural and urban development has reduced overland flows of fresh water to mangroves, and channelization has diverted fresh water away from coastal feeder streams and creeks, resulting in greater concentrated runoff that changes salinity balance, reduces flushing of detritus, and washing of nutrients directly into the estuary without the benefit of mangrove filtration (Estevez 1998).

Fisheries. Diversity and dimensions of stable fisheries are good indicators of the state of an ecosystem. At least 70 percent of Florida's recreationally and commercially sought fishes depend on estuaries for part of their life histories (Lindall 1973, Harris et al. 1983, Estevez 1998). Within the estuary, seagrass communities, mangroves, oyster reefs, and stable benthic communities provide critical refugia and food sources for juvenile fish such as redfish (*Sciaenops ocellatus* Linnaeus), grouper, snook and spotted seatrout. Decline in juvenile abundance and distribution of these and other species, along with overall decline in species richness may be related to fishing pressure and a decrease in suitable habitat and/or a result of alterations in salinity regime and timing of freshwater discharges (Christensen 1965, Browder and Moore 1981, M. Hedgepeth, South Florida Water Management District, pers. comm.).

Nearshore Reefs. Nearshore reefs form bands of unique marine habitat offshore of the Atlantic Coast and are included as attributes in eastern northern estuarine models. Reef development is typically slow and occurs over geologic time scales, so impacts to reefs may cause ecological problems that require long time frames for recovery. Nearshore reefs are adversely affected by high level discharges, resulting silt and salinity plumes, and possibly changes due to nutrient enrichment. Reefs provide habitat for many marine species of socio-economic value to tourism and local fisheries. Continental shelf fish biodiversity is influenced by various reef structures and is also susceptible to sedimentation.

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A CONCEPTUAL ECOLOGICAL MODEL OF FLORIDA BAY

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Abstract: Florida Bay is a large and shallow estuary that is linked to the Everglades watershed and is a target of the Greater Everglades ecosystem restoration effort. The conceptual ecological model presented here is a qualitative and minimal depiction of those ecosystem components and linkages that are considered essential for understanding historic changes in the bay ecosystem, the role of human activities as drivers of these changes, and how restoration efforts are likely to affect the ecosystem in the future. The conceptual model serves as a guide for monitoring and research within an adaptive management framework. Historic changes in Florida Bay that are of primary concern are the occurrence of seagrass mass mortality and subsequent phytoplankton blooms in the 1980s and 1990s. These changes are hypothesized to have been caused by long-term changes in the salinity regime of the bay that were driven by water management. However, historic ecological changes also may have been influenced by other human activities, including occlusion of passes between the Florida Keys and increased nutrient loading. The key to Florida Bay restoration is hypothesized to be seagrass community restoration. This community is the central ecosystem element, providing habitat for upper trophic level species and strongly influencing productivity patterns, sediment resuspension, light penetration, nutrient availability, and phytoplankton dynamics. An expectation of Everglades restoration is that changing patterns of freshwater flow toward more natural patterns will drive Florida Bay's structure and function toward its pre-drainage condition. However, considerable uncertainty exists regarding the indirect effects of changing freshwater flow, particularly with regard to the potential for changing the export of dissolved organic matter from the Everglades and the fate and effects of this nutrient source. Adaptive management of Florida Bay, as an integral part of Everglades restoration, requires an integrated program of monitoring, research to decrease uncertainties, and development of quantitative models (especially hydrodynamic and water quality) to synthesize data, develop and test hypotheses, and improve predictive capabilities. Understanding and quantitatively predicting changes in the nature of watershed-estuarine linkages is the highest priority scientific need for Florida Bay restoration.

Key Words: ecosystem restoration, estuaries, Florida Bay, Everglades, adaptive management, seagrass, freshwater flow, salinity effects

BACKGROUND

Florida Bay is a triangularly shaped estuary, with an area of about 2200 km^2 that lies between the southern tip of the Florida mainland and the Florida Keys (Figure 1). About 80% of this estuary is within the boundaries of Everglades National Park and much of the remainder is within the Florida Keys National Marine Sanctuary. A defining feature of the bay is its shallow depth, which averages about 1 m (Schomer and Drew 1982). Light sufficient to support photosynthesis can reach the sediment surface in almost all areas of the bay, resulting in dominance of seagrass beds as both a habitat and a source of primary production. The shallowness of Florida Bay also affects its circulation and salinity regime. Except for basins near the northern coast (near freshwater sources), the bay's water column is vertically well-mixed and usually isohaline. In contrast, its complex network of shallow mud banks restricts horizontal water exchange among the bay's basins and between these basins and the Gulf of Mexico (Smith 1994, Wang et al. 1994). In areas with long residence times, the salinity of Florida Bay water can rise rapidly during drought periods due to excess of evaporation over precipitation and freshwater inflow (Nuttle et al. 2000). Salinity levels as high as twice that of seawater have been measured (McIvor et al. 1994). Another defining feature of the bay is that its sediments are primarily composed of carbonate mud, which can scavenge inorganic phosphorus from bay waters (DeKanel and Morse 1978).

Until the 1980s, Florida Bay was perceived by the public and environmental managers as being a healthy and stable system, with clear water, lush seagrass beds, and highly productive fish and shrimp populations. In the mid-1980s, however, catches of pink shrimp decreased dramatically (Browder et al. 1999), and in 1987, a mass mortality of turtle grass (*Thalassia testudinum* Banks & Soland ex. Koenig) beds began (Robblee et al. 1991). By 1992, the ecosystem appeared to change from a clear water system, dominated by benthic primary production, to a turbid water system, with algae blooms and resuspended sediments in the water column. The conceptual ecological model presented here focuses on these changes in seagrass communities and water quality as central issues to be considered by environmental managers.

The Florida Bay Conceptual Ecological Model is one of eleven regional models that are being used as tools for synthesis, planning, assessment, and communication within the adaptive management framework of the Everglades Restoration Plan. This framework and a summary of all of the conceptual ecological models are described in Ogden et al. (2005). Overviews of the history and challenges of Everglades restoration are presented in Ogden et al. (2005) and Sklar et al. (2005). The format and symbols of the Florida Bay model follows that of Ogden et al. (2005) and the other conceptual models published in this issue of *Wetlands*. Furthermore, the organization of this paper follows the conceptual model diagram, with major sections on drivers and stressors, and ecological attributes (generally structural components of the ecosystem) and their links to stressors. A final section considers expectations and uncertainties regarding future responses to restoration efforts.

This simple model does not address spatial complexity in Florida Bay. Florida Bay is, indeed, not so much a singular estuary, but a complex array of more than forty basins, with distinct characteristics, that are partitioned by a network of mud banks and islands (Schomer and Drew 1982, Fourqurean and Robblee 1999). The structure of vegetative habitats, as well as water quality and ecosystem processes, vary distinctly with this spatial variation. Nevertheless, only a single, generic model is described and intended to summarize the main characteristics and trends of the bay. While the structure of this model is appropriate for most areas of the bay, the relative importance of model components differ considerably among subregions. Any application of this model (e.g., recommendations for a specific set of monitoring parameters and guidelines) must accommodate the degree of spatial variability of the bay.

EXTERNAL DRIVERS AND ECOLOGICAL STRESSORS

Following observations of Florida Bay's dramatic ecological changes in the 1980s, it was commonly assumed that a direct cause of these changes was a long-term increase in salinity, which in turn was caused by the diversion of freshwater away from Florida Bay via South Florida Water Management District canals. However, subsequent research has indicated that these ecological changes may not be attributable to a single cause. While decreased freshwater inflow and resultant increased salinity have been part of the problem, it appears that other human activities, as well as natural forces, may have also played a role (Boesch et al. 1993, Armentano et al. 1997, Fourqurean and Robblee 1999). The conceptual ecological model presented here includes both natural and anthropogenic sources of stress (Figure 2). The discussion of external drivers and ecological stressors below is organized by stressor (ovals in Figure 2), with consideration of the main drivers (rectangles in Figure 2) that influence each stressor.

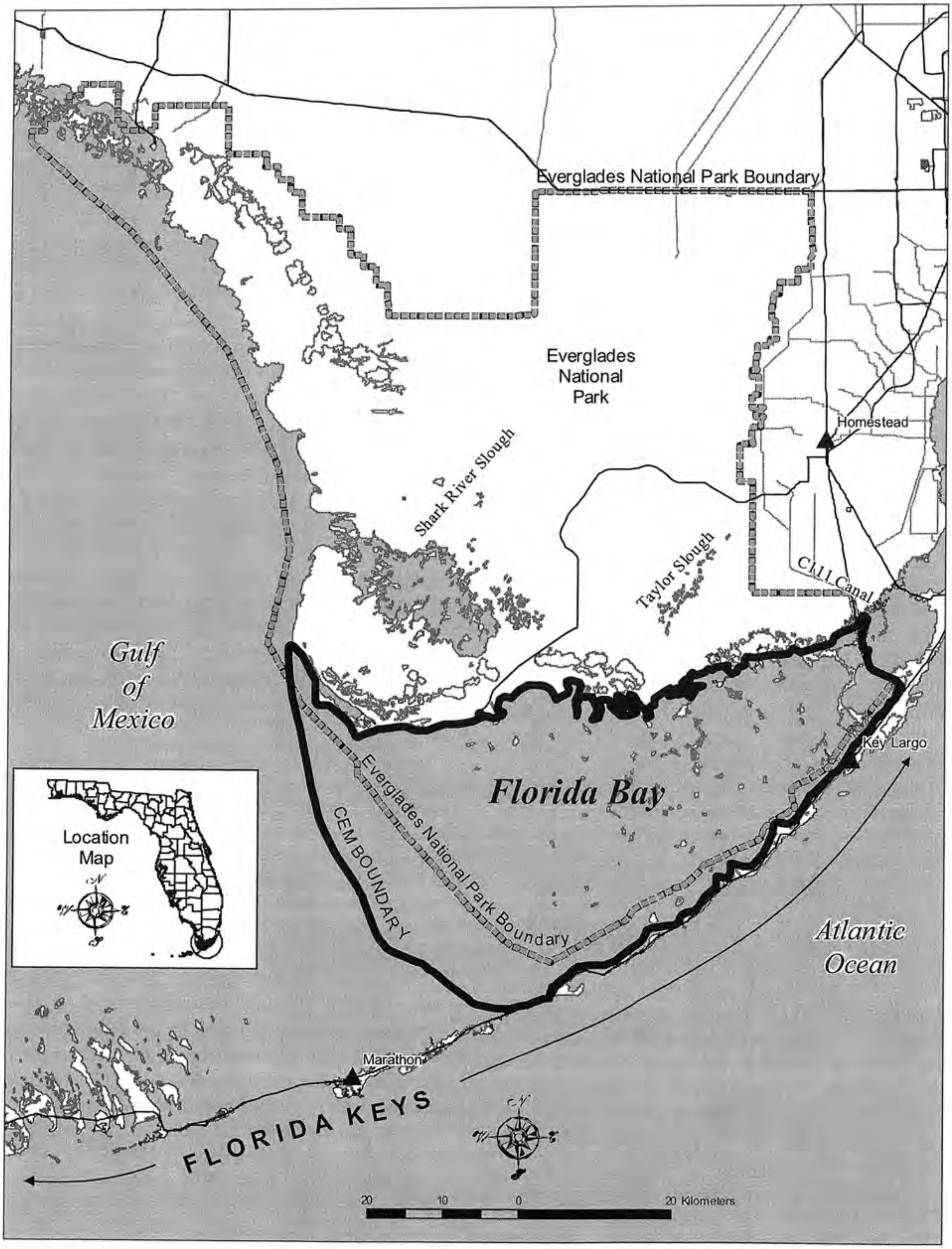

Figure 1. Geographic setting and boundary of the Florida Bay Conceptual Ecological Model (CEM).

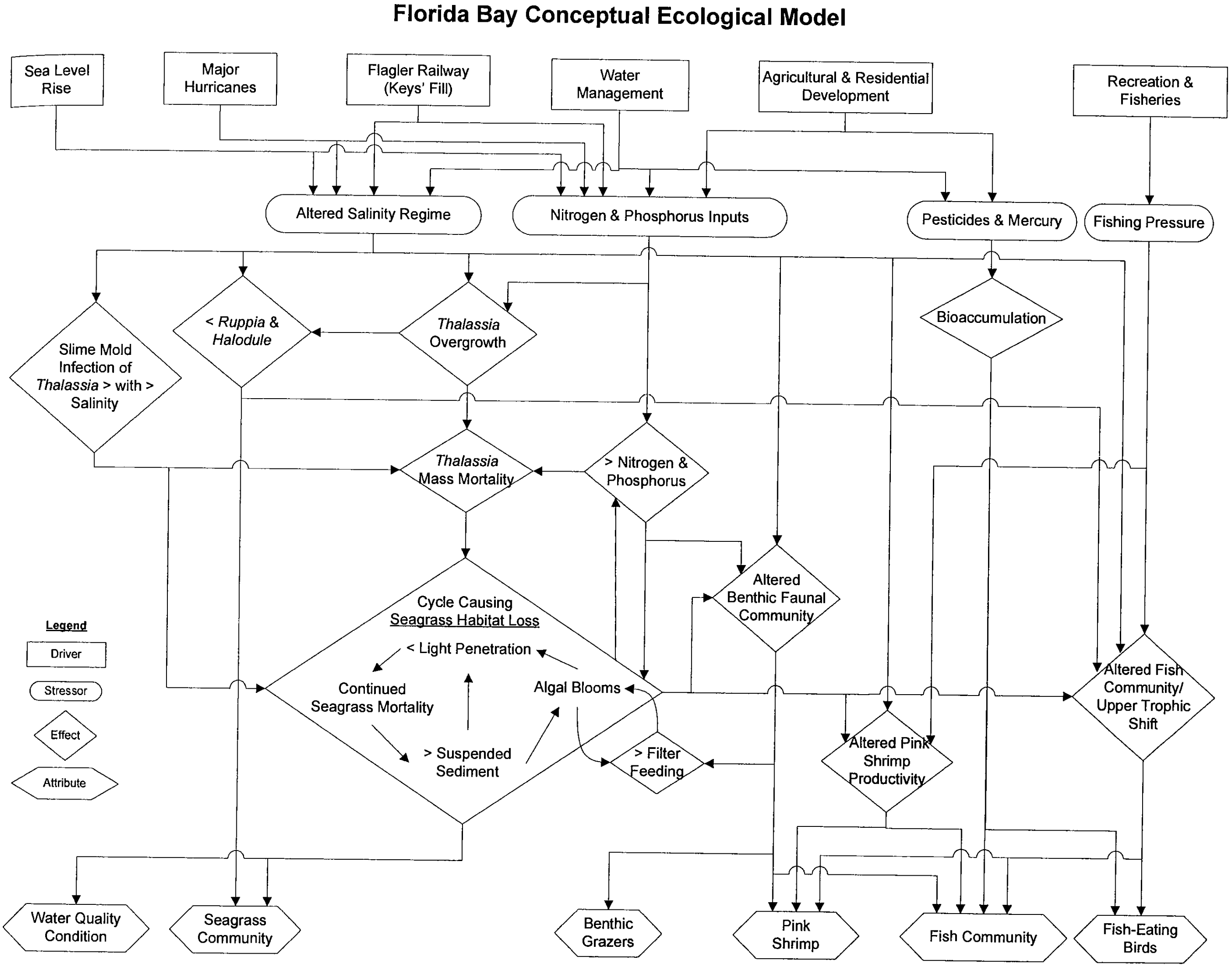

Figure 2. Florida Bay Conceptual Ecological Model Diagram. The format of this figure follows Ogden et al. (2005). Rectangles represent major external drivers of ecological change, ovals represent ecological stressors, diamonds represent ecological linkages and functions that mediate the effect of stressors on attributes, and hexagons represent ecosystem attributes to be monitored as part of the adaptive assessment process. Increases or decreases noted in diamonds with "< *Ruppia* and *Halodule*" and "> Nitrogen and Phosphorus" refer to pre-restoration changes.

Altered Salinity Regime

Florida Bay's salinity regime varies greatly over time and space. This variation ranges from coastal areas that can be nearly fresh during the wet season, to large areas of the central bay that can have salinity levels near 70 psu during prolonged droughts, to nearly stable marine conditions (about 35 psu) on the western boundary of the bay or near Florida Keys' passes. The main factors that determine the salinity regime in the bay are the inflow of freshwater from the Everglades, the difference between rainfall and evaporation over the bay, and exchange with marine waters of the Gulf of Mexico and Atlantic Ocean. Both freshwater inflow and exchange with the Atlantic have changed drastically in the past hundred years, resulting in an alteration of the bay's salinity regime (Swart et al. 1999, Brewster-Wingard et al. 2001, Dwyer and Cronin 2001).

Freshwater inflow to Florida Bay decreased in volume and changed in timing and distribution during the twentieth century because of water management. Hydrologic alteration began in the late 1800s but accelerated with construction of drainage canals by 1920, the Tamiami Trail by 1930, and the Central and South Florida (C&SF) Project and the South Dade Conveyance System from the early 1950s through 1980 (Light and Dineen 1994). With diversion of freshwater to the Atlantic and Gulf of Mexico coasts to the north, the bay's mean salinity inevitably increased. Isotopic studies of carbonate preserved in coral skeletons and buried ostracod shells confirmed this trend (Swart et al. 1999, Dwyer and Cronin 2001). Paleoecological studies also indicated that salinity variability within the bay also changed during the twentieth century, with an increase in variability in the northeastern bay, where freshwater inflows are channelized (Brewster-Wingard et al. 2001), and a decrease in variability in the southern bay (Swart et al. 1999).

Paleoecological studies indicated that a cause of salinity changes in the southern bay was construction of the Flagler Railway across the Florida Keys from 1905 to 1912 (Swart et al. 1996, 1999). In the nineteenth century, prior to railway construction and water management, southern Florida Bay had a lower mean salinity and more frequent periods of low (10 psu–20 psu) salinity than during the twentieth century. The extent and frequency of high salinity events in the southern bay does not appear to have changed between centuries. The bay's salinity regime changed abruptly around 1910 because passes between the Keys were filled to support the railway. Thus, water exchange between Florida Bay and the Atlantic Ocean was decreased, and this probably caused an increase in water residence time and a change in water circulation patterns within the bay.

Two important natural controls of salinity, sea-level rise and the frequency of major hurricanes, must also be considered. Florida Bay is a very young estuary, the product of sea level rising over the shallow slope of the Everglades during the past 4,000 years (Wanless et al. 1994). With rising sea level, the bay not only became larger but also became deeper. With greater depth, exchange of water between the ocean and the bay increased. All else being equal, this would result in a more stable salinity regime with salinity levels increasingly similar to the ocean. However, a factor that has counteracted rising sea level is accumulation of sediment, which makes the bay shallower. Most sediment that accumulates in Florida Bay is carbonate precipitated from water by organisms living in the bay (Bosence 1989). The extent to which these sediments accumulate is a function of the biology of these organisms (including skeletal carbonate production), chemical dynamics in the water column and sediments, and the physical energy available to transport some of these sediments from the bay. Major hurricanes are thought to be important high-energy events that can flush the bay of accumulated sediments. However, since 1965, no major hurricane has directly affected Florida Bay. Resultant sediment accumulation, with associated alteration of depth, circulation patterns, residence time, salinity, and nutrient storage may have influenced ecological changes in recent decades.

Nitrogen and Phosphorus Inputs

Productivity and food-web structure in all ecosystems are strongly influenced by internal nutrient cycling and import and export of these nutrients. Throughout the world, estuarine ecosystems have undergone dramatic ecological changes because they have been markedly enriched by nutrients derived from human activity (National Research Council 2000). These changes have often been catastrophic, with loss of seagrasses, increased algal blooms, and increased incidence of hypoxic and anoxic events. Augmentation of nitrogen and phosphorus inputs to an estuary is a potentially important stressor.

The degree to which nitrogen and phosphorus inputs have stressed Florida Bay is unclear. In general, the bay is relatively rich in nitrogen and poor in phosphorus, especially towards the eastern region of the bay (Boyer et al. 1997). This spatial pattern is at least partly a function of natural biogeochemical processes (e.g., P retention by the bay's carbonate sediments and relatively low N in adjacent marine waters) and thus may have existed prior to recent human influences. Little direct evidence confirms that nutrient inputs to the bay or concentrations within the bay have increased during the past century, but with expanding agricultural and residential development in South Florida, and particularly development of the Florida Keys, some nutrient enrichment almost certainly has occurred (Lapointe and Clark 1992, Orem et al. 1999). Anthropogenic nutrients that enter Florida Bay are derived not only from local sources (fertilizers and other wastes from agricultural and residential areas), but also from remote sources. Contributions of nutrients from atmospheric deposition and from the Gulf of Mexico, which may include nutrients from the phosphate fertilizer industry of the Tampa-Port Charlotte area and residential development from Tampa to Naples, are significant external nutrient sources (Rudnick et al. 1999).

Different sub-regions of the bay are differentially influenced by these local or remote sources, depending on the magnitude of inputs, relative abundance of different nutrients, internal cycling pathways and rates, and water residence time (Boyer et al. 1997, Rudnick et al. 1999, Childers et al. 2005). Algal bloom occurrence in the central and western bay is influenced by a combination of these factors (Tomas et al. 1999, Brand 2002). Despite the lack of definitive data, it is, nevertheless, a reasonable hypothesis that a chronic increase in nutrient inputs occurred in Florida Bay in the twentieth century and that this increase contributed to the bay's recent ecological changes. Development of a water quality model driven by appropriately scaled hydrodynamic and hydrologic models is essential to understand and evaluate quantitatively the potential effects of past nutrient inputs and predict the effects of future management scenarios.

Water management is a driver of nutrient stress in that the canal system can transport materials through wetlands toward the bay, decreasing nutrient retention by wetlands and thereby increasing inputs to the bay. Altered nutrient transport via canals may also alter the chemical composition of nutrients entering the bay. These inputs from the Everglades and the Gulf of Mexico are affected not only by changes of freshwater flowing from Taylor Slough and Shark River Slough, but also by changes in the bay's circulation. Nutrient cycling and retention within the bay are sensitive in particular to changes in residence time (a function of circulation) that were caused by Flagler Railway construction, as well as the balance of sea-level rise and sedimentation or sediment removal by major hurricanes. Hurricanes may be particularly important, as nutrients (organic and inorganic) can accumulate in sediments, and the absence of major hurricanes during the past few decades may have resulted in an accumulation of nutrients.

Pesticides and Mercury

With the widespread agricultural and residential development of South Florida, application and release of pesticides and other toxic materials has increased. Deposition of mercury from local and global sources has also increased in the past century and is of particular concern because of high concentrations of methylmercury in upper trophic level species (Cleckner et al. 1998). Altered biogeochemistry resulting from changes in water quality (e.g., sulfate availability), which in turn affects methylation rates, has also played a role in increased mercury bioaccumulation (Cleckner et al. 1999). Pesticides and mercury are of concern because they can affect human health through consumption of fish or other biota with high concentrations of these toxins and because other species also may be adversely affected by these compounds. To date, no evidence links observed ecological changes in Florida Bay to inputs of toxic compounds. Nevertheless, endocrine-disrupting endosulfans, with concentrations that could have biological effects, have been found in upstream canals and the biota of associated lakes (Scott et al. 2002, G. Graves, personal communication). Additionally, mercury levels remain elevated in fish in eastern Florida Bay despite decreases observed elsewhere (Strom and Graves 2001, Evans et al. 2003). Water management affects the distribution of these toxic materials and potentially their transport to Florida Bay (Scott et al. 2002, Rumbold et al. 2003). Controlling water levels in wetlands may also influence the decomposition of pesticides and mercury methylation rates because these processes are sensitive to the presence of oxygen and sulfate in soils, which are affected by water levels.

Fishing Pressure

For any species that is the target of recreational or commercial fishing, fishing pressure directly affects population dynamics and community structure. Commercial fishing has been prohibited within Everglades National Park since 1985, but populations that live outside of the Park boundaries for at least part of their life cycle, including most of Florida Bay's sportfish species, are affected by fisheries (Tilmant 1989). Recreational fishing pressure within the Park also affects these populations (e.g., the size structure of the gray snapper assemblages [Faunce et al. 2002]).

ECOLOGICAL ATTRIBUTES

The set of Florida Bay's attributes presented here (hexagons in Figure 2) includes both indicators of ecosystem condition and attributes deemed to be intrinsically important to society. Attributes, in most cases, are biological components of the ecosystem, including seagrass, mollusks, shrimp, fish, and birds, but also an aggregated attribute (water-quality condition) that includes phytoplankton blooms, turbidity, and nutrient concentrations. While the list of biological components is broad, it is clear from their links to stressors (see diamonds and associated arrows, linking to stressors in ovals, in Figure 2) that these attributes are not equally weighted; the most significant and causally interconnected attribute of this conceptual ecological model is the seagrass community. Details of each attribute and its linkages to the conceptual model's set of stressors are given below.

Seagrass Community

The structural and functional foundation of the Florida Bay ecosystem is its seagrass community (Zieman et al. 1989, Fourqurean and Robblee 1999). These plants are not only a highly productive base of the food web, but are also a principal habitat for higher trophic levels and strongly influence the physical and chemical nature of the bay. Understanding how seagrasses affect water quality is essential to understanding the bay's current status and predicting its response to restoration and other human activities.

Seagrasses affect water quality by three mechanisms: nutrient uptake and storage, binding of sediments by their roots, and trapping of particles within their leaf canopy. With growth of dense seagrass beds, these mechanisms drive the bay towards a condition of clear water, with low nutrient availability for algae growth within the water column and low concentrations of suspended sediment in the water. Paleoecological studies and historic observations suggest that *T. testudinum* in Florida Bay proliferated and increased in density during the mid-twentieth century (Brewster-Wingard and Ishman 1999, Zieman et al. 1999, Cronin et al. 2001), while other common species (*Halodule wrightii* Aschers and *Ruppia maritima* Linnaeus) likely decreased in distribution and density. From the 1960s through the mid-1980s, dense *T. testudinum* beds expanded throughout central and western Florida Bay, and the water column was reported to be crystal clear (Zieman et al. 1999). Largely following the conceptual model of Zieman et al. (1999), we hypothesize that with the onset of a *T. testudinum* mass-mortality event in 1987 (Robblee et al. 1991), the three mechanisms given above reversed, initiating a cycle (large diamond in Figure 2) that contributed to additional seagrass habitat loss (or at least inhibited recolonization) and favored the persistence of more turbid water with episodic algal blooms (Stumpf et al. 1999).

Causes of the 1987 mass-mortality event can be considered at two time scales—a multi-decadal period that poised *T. testudinum* beds for collapse and a short-term period (of days–months) in 1987 when proximate factors triggered mortality (Zieman et al. 1999). We hypothesize that changes in two stressors, salinity and a chronic and low-level increase in nutrient availability, occurred over several decades and caused *T. testudinum* beds to grow to an unsustainable density (designated "overgrowth" in Figure 2) by the mid-1980s. It is also likely that a decrease in shoal grass (*Halodule wrightii*) and widgeon grass (*Ruppia maritima*) occurred with the *T. testudinum* increase. *Thalassia testudinum* overgrowth may have occurred because the species had a competitive advantage over other seagrass species when the bay's salinity regime was stabilized, with few periods of low salinity (Zieman et al. 1999). Nutrient enrichment also may have played a role, with a chronic accumulation of nutrients caused by increased inputs over decades or decreased outputs because of the absence of major hurricanes or closure of Florida Keys' passes. Once *T. testudinum* beds were poised for collapse, multiple factors that acted over a short time scale are hypothesized to have been a proximate cause of mortality in 1987. These factors are thought to be related to high respiratory demands of dense grass beds and accumulated organic matter. During the summer of 1987, with high temperatures and hypersaline water, respiratory demand may have exceeded photosynthetic production of dissolved oxygen, causing sulfide concentrations to increase to lethal concentrations (diagram from Durako et al. in McIvor et al. 1994, Carlson et al. 1994). This hypothesis regarding the proximate cause of seagrass mass mortality is supported by a recent *in situ* study in Florida Bay (Borum et al. 2005) that showed the importance of anoxia and sulfide in surficial sediments as a potential cause of *T. testudinum* mortality.

Regardless of the cause of the mass-mortality event, once this event was initiated, the ecology of Florida Bay changed. A cycle resulting in continuing seagrass habitat loss is depicted in the conceptual ecological model. Continued seagrass mortality results in increased sediment resuspension (Prager and Halley 1999, Stumpf et al. 1999) and increased nutrient (nitrogen and phosphorus) release from sediments, stimulating phytoplankton growth in the water column. The presence of both phytoplankton and suspended sediment result in decreased light penetration to seagrass beds. This decreased light can limit seagrass growth and sustain the feedback loop.

Dynamics of this feedback loop are probably not independent of the salinity regime. Seagrass wasting disease, caused by a slime mold (*Labyrinthula* sp.) infection, is more common at salinities near or greater than seawater ($\geq$ 35 psu) than at low (15 to 20 psu) salinities (Blakesley et al. 2003). High salinity may have played a role in the initial seagrass mass mortality event but more likely has served to promote seagrass re-infection since that event. Incidence of this disease may therefore be directly affected by water management actions.

If the state of the seagrass community is to be used as a criterion to decide success of environmental restoration efforts, scientists and managers must specify the desirability of alternative states. Based on studies of historic changes of seagrass communities in Florida Bay and anecdotal information (Brewster-Wingard and Ishman 1999, Zieman et al. 1999, Cronin et al. 2001), it is likely that the Florida Bay of the 1970s and early 1980s, with lush *T. testudinum* and clear water, was probably a temporary and atypical condition. From an ecological perspective, restoration should generally strive for a more diverse seagrass community with lower *T. testudinum* density and biomass than during that anomalous period. A diversity of seagrass habitat is expected to be beneficial to many upper trophic level species (Thayer et al. 1999).

Water Quality Condition

Water quality condition reflects the light field, nutrient availability in the ecosystem, and algal blooms in the water column. All of these characteristics are closely related to the condition of seagrasses and food web structure and dynamics of the bay. While these characteristics have been monitored and researched since the early 1990s, earlier information is scarce for salinity and almost non-existent for the above water quality characteristics. Thus, at the present time, we do not know whether nutrient inputs to the bay have actually increased in recent decades or whether periods with sustained algal blooms and high turbidity occurred in the past.

Studies of nutrient export from southern Everglades canals and creeks flowing into Florida Bay have provided insights regarding the relationship between patterns of freshwater discharge, nutrient dynamics, and output to Florida Bay (Rudnick et al. 1999, Davis et al. 2003, Sutula et al. 2003). Results show that phosphorus loads to the bay do not greatly increase with increased freshwater inputs to the bay, but given the phosphorus limitation of the eastern bay, any increase in phosphorus availability is likely to affect productivity patterns. Unlike phosphorus, total nitrogen loads probably do increase with more freshwater flow (Rudnick et al. 1999), and algal growth in western and sometimes central Florida Bay can be nitrogen limited (Tomas et al. 1999). The potential thus exists for hydrologic restoration to increase nitrogen loading and stimulate phytoplankton blooms (Brand 2002). Because most of the nitrogen that is exported from the Everglades to the bay is in the form of organic compounds (Rudnick et al. 1999), the fate of these compounds within the bay is a critical unknown; if these compounds are easily decomposed and their nitrogen becomes available to algae, then increased freshwater flow could stimulate algal growth. In addition to organic nitrogen decomposition rates, other critical unknowns regarding the availability of nitrogen for algal productivity include rates of nitrogen fixation and denitrification within the bay and the residence time of water in bay's sub-basins.

Finally, as emphasized earlier, light penetration through Florida Bay waters is a key to the health of seagrasses. Light penetration is largely a function of turbidity from algae and suspended sediment. Although light levels were potentially limiting to seagrass growth during the early and mid-1990s, in more recent years, only the northwest corner of the bay is potentially light-limiting (Kelble et al. 2005). For successful restoration of Florida Bay, light penetration must be sufficient to ensure viable seagrass habitat. Such a light-penetration criterion has been used in other estuaries (Dennison et al. 1993) and is an important success criterion for Florida Bay.

Benthic Grazers

Consumption of phytoplankton by bivalves and other benthic filter feeders and suspension feeders (especially sponges and tunicates) may have significant impacts on the distribution, magnitude, and duration of algal blooms. Increases or decreases in algal blooms may be related to significant increases or decreases in grazer abundance and biomass. Decreased grazing may have occurred in the 1990s because of seagrass habitat loss, which could have decreased grazer abundance. Additionally, grazers may have been negatively affected by cyanobacterial blooms (*Synechococcus* sp., the dominant phytoplankter in central Florida Bay's blooms [Phlips and Badylak 1996]). These blooms may have played a role in the large-scale mortality of sponges in southern Florida Bay in the early 1990s (Butler et al. 1995). Such a loss of grazers would have enabled larger blooms to occur, decreasing light penetration, and thereby reinforcing the feedback loop of seagrass mortality and algal blooms.

Benthic grazers abundance, biomass, species composition, and distribution are valuable in a monitoring program not only because of their functional link with phytoplankton blooms, but also because these grazers are ecological indicators. Paleoecological and recent studies of the bay have inferred that long-term changes in molluscan species composition are largely a function of salinity and seagrass habitat availability (Brewster-Wingard and Ishman 1999).

Pink Shrimp

Pink shrimp (*Farfantepenaeus duorarum* Burkenroad) are economically important to society as a highly valued fishery species and are also ecologically important as a major dietary component of game fish and wading birds. Furthermore, pink shrimp are an indicator of Florida Bay's productivity because the bay and nearby coastal areas are primary shrimp nursery grounds. This nursery supports the shrimp fishery of the Tortugas grounds (Ehrhardt and Legault 1999). Hydrologic and ecological changes in the Everglades and Florida Bay may have impacted this fishery, which experienced a decrease in annual harvest from about 4.5 million kg per year in the 1960s and 1970s to only about 0.9 million kg per year in the late 1980s (Ehrhardt and Legault 1999). This decrease may have been associated with seagrass habitat loss or high salinity (50 to 70 psu) during the 1989–1990 drought; experiments have shown that pink shrimp mortality rates increase with salinities above about 35 psu, and growth rates are optimal at 30 psu (Browder et al. 2002). Shrimp harvest statistics indicate that shrimp productivity increases with increasing freshwater flow from the Everglades (Browder 1985). This may be because greater freshwater inflows reduce the frequency, duration, and spatial coverage of hypersaline events in Florida Bay (Browder et al. 1999, 2002). The statistical relationship between indices of freshwater flow and shrimp productivity is sufficiently robust to be used by the National Marine Fisheries Service in management of the offshore fishery (Sheridan 1996).

Fish Community

The health of Florida Bay's fish populations is of great importance to the public; sport fishing is a major economic contributor to the region (Tilmant 1989). Recruitment, growth, and survivorship of these fish populations are affected by many factors, including salinity, habitat quality and availability, food-web dynamics, and fishing pressure. Changes in mangrove and seagrass habitats are likely to influence the structure and function of the fish community. However, seagrass mass mortality appears to have had a greater influence on fish community structure than on the absolute abundance of fish; no dramatic bay-wide decreases in fish abundance were observed along with seagrass mass mortality (Thayer et al. 1999). Rather, a shift in fish species composition occurred as a result of seagrass habitat loss and sustained algal blooms. When demersal fish markedly declined, pelagic fish such as the bay anchovy, which feed on phytoplankton, increased (Thayer et al. 1999). More recently, changes in the opposite direction have been observed (Powell et al. 2001). While causes of these changes are not well-established, there is no question that stressors, such as altered salinity regimes, not only affect upper trophic level populations directly but also affect them indirectly through habitat and food-web changes.

Another important stressor that needs to be considered with regard to fish populations is the impact of pesticides and mercury. As concentrations of mercury and some pesticides greatly increase in upper trophic level species, such as sport fish (via the process of bioaccumulation) that people eat, a human health issue potentially exists. Pesticides and mercury can also have ecological impacts by physiologically stressing organisms (particularly reproductive functions). While toxic contaminant inputs to Florida Bay do not appear to be associated with recent large-scale changes in the bay ecosystem, biotic exposure to toxicants could change in association with restoration-related changes in upstream water management.

Among the many fish species that could be used as indicators of the health of the ecosystem's upper trophic level, the spotted sea trout (*Cynoscion nebulosus* Cuvier in Cuvier and Valenciennes) is unique because it is the only major sport fish species that spends its entire life in the bay (Rutherford et al. 1989). Changes in the bay's sea trout population and toxic residues in this species thus reflect changes in the bay itself, as well as upstream restoration actions that affect the quantity and quality of water entering the bay. Sea trout are a particularly good restoration indicator for central Florida Bay, where they are commonly found and where prolonged periods of hypersalinity are common. This species is known to be sensitive to hypersalinity; density of post-larvae has been found to be greatest at an intermediate salinity range of 20–40 psu (Alsuth and Gilmore 1994). For northeastern Florida Bay, the abundance of common snook (*Centropomus undecimalis* Bloch), red drum (*Sciaenops ocellatus* Linnaeus, 1766), crevalle jack (*Caranx hippos* Linnaeus), and mullet are also being considered as potential restoration indicators.

Fish-Eating Birds

Florida Bay and its mangrove coastline are important feeding and breeding grounds for waterfowl and wading birds. Conceptual ecological models for other regions of the Everglades, particularly the Everglades Mangrove Estuaries Conceptual Ecological Model (Davis et al. 2005), present more detailed descriptions of the use of bird populations as ecological indicators and consider a wide variety of birds. For the Florida Bay Conceptual Ecological Model, we consider only fish-eating birds that are characteristic of the marine environment, such as great white herons, reddish egrets, osprey, brown pelicans, and cormorants. These birds are important predators within the bay and are potentially impacted by any stressors that affect their prey base, including salinity changes, nutrient inputs, toxic compounds, and fishing pressure. As with other top predators, these bird species may also be especially vulnerable to toxic contaminants.

RESTORATION RESPONSES: EXPECTATIONS AND UNCERTAINTIES

In this section, we present a prospective view of Everglades restoration. The Conceptual Ecological Model, while largely based on past ecological dynamics, still serves as a guide. The foremost purpose of this section is to identify those components and linkages (with associated ecological processes) that are most sensitive to changing watershed management, have a strong effect on the entire estuarine ecosystem, and yet are poorly understood relative to the information needs of the adaptive management process. This includes consideration of salinity and hydrodynamics, nutrient inputs and phytoplankton blooms, and benthic habitat and higher trophic level responses to restoration. Working hypotheses regarding each of these high priority aspects of the Florida Bay conceptual model are also presented here. We use the term ''working hypothesis'' in the sense that the described predictions and relationships, while generally not test-able with strict experimental control, can be assessed as part of a long-term adaptive management program.

Salinity Responses

The conceptual model explicitly illustrates the central importance of water management on the Florida Bay ecosystem, largely mediated through changing salinity. An expectation of the Everglades restoration plan is that salinity in the bay will decrease, expanding the spatial extent and duration of oligohaline to polyhaline conditions, while decreasing the extent and duration of hypersaline conditions. However, a quantitative understanding of the relationship between wetland hydrologic conditions, freshwater flow, and resultant salinity throughout the bay is still lacking. An important step toward gaining this understanding and a predictive capability for environmental management is the synthesis of a broad array of available hydrologic, hydrodynamic, and salinity information within a hydrodynamic model. Development of such a model is challenging, given the shallow and complex morphology of Florida Bay. To date, restoration planning has only used simple statistical estimates of salinity, largely as a function of wetland water stages, and these estimates have been limited to near-shore embayments. Predicting salinity change within the entire bay requires understanding of changing water inputs, exchanges, and circulation. The effects of restoration efforts thus will be strongly influenced not only by changing freshwater flow, but also by sea-level rise and changing bay morphology.

Working Hypotheses: Relationships of Mud Bank Dynamics, Sea-Level Rise, and Circulation. Circulation and salinity patterns, and thus ecological patterns, are strongly influenced by Florida Bay's mud banks, which are dynamic features. The response of these banks to sea-level rise and the changing frequency and intensity of tropical storms cannot confidently be predicted. Based on the persistence of mud-bank spatial distributions over centuries and past patterns of accretion (Wanless and Tagett 1989), we hypothesize that sediments will accrete on banks at rates comparable to rates of sea-level rise and that the spatial pattern of banks and basins will remain largely unchanged in future decades, despite the likelihood that tropical storm activity will increase during the coming decade (Goldenberg et al. 2001). If these hypotheses are true, then water circulation within the bay will continue to be restricted by mud banks, even with sea-level rise, and exchange of bay water with seawater of the Atlantic Ocean and Gulf of Mexico will not markedly increase. However, as the depth of basins increases (historic sediment accretion of banks has greatly exceeded sediment accretion in basins; Wanless and Tagett (1989)), the residence time of water in basins and the potential for stratification and oxygen stress would also increase. Moreover, with increased depth, light penetration to seagrass communities would decrease. Alternatively, if mud bank accretion does not keep up with sea-level rise, the exchange and circulation of Gulf of Mexico and Atlantic water in Florida Bay will increase, shifting the bay from an estuarine to a more marine system and minimizing the influence of any watershed restoration actions. Such increased circulation could also ameliorate the historic effect of the Flagler Railway and Keys Highway, which decreased water exchange between the bay and Atlantic, increased water residence time in the bay, and probably changed circulation and salinity patterns. Finally, with rising sea level, the mangrove shoreline along the northern bay will likely move inland.

Water Quality Responses

Restoration of the Everglades will have effects on the watershed's estuaries beyond changing freshwater input and salinity. Restoration will also affect material (particularly dissolved nutrient) inputs as stormwater treatment areas decrease nutrient inputs to the Everglades (Chimney and Goforth 2001) and changing hydrologic conditions modify biogeochemical cycles and transport within the wetlands. Changing flow and salinity will affect biogeochemical cycling within the estuaries via direct effects of salinity on abiotic processes (e.g., phosphorus sorption-desorption) and indirect effects of changing community structure and associated physical and biogeochemical characteristics (e.g., sediment stabilization and resuspension with changing seagrass cover). The ecological consequences of these changes are uncertain, but one concern is that phytoplankton blooms could be stimulated by Everglades restoration because of potential increases in nitrogen inputs (Brand 2002). Nevertheless, an expectation of Everglades restoration is that such a change in Florida Bay water quality will not occur. Development of a coupled hydrodynamic-water quality model of the bay, combined with monitoring and research of biogeochemical processes will improve understanding and adaptive management responses to this and other aspects of the restoration.

Working Hypotheses: Relationships of Water Quality and External Nutrient Sources. Changing the flow of water through the Everglades and resultant changes in the structure and function of these wetlands will alter the delivery of materials to downstream coastal ecosystems, including Florida Bay. Quantitative predictions of these changes are not possible at this time, but it is reasonable to expect that phosphorus outputs from the Everglades, which are very low, will not change, and nitrogen outputs from the Everglades, which are much greater (Rudnick et al. 1999), could change. Given that most nitrogen output is in the form of dissolved organic matter (DOM), a major uncertainty is the extent to which this DOM can be decomposed by heterotrophic bacteria and phytoplankton and provide nutrients (particularly nitrogen) for phytoplankton. Depending upon the proportion of this bioavailable DOM and the relationship of DOM quality and quantity to freshwater flow, restoration of natural water inflows from the Everglades could affect the composition, magnitude, duration, and distribution of phytoplankton blooms.

Hydrologic restoration of the Everglades could also affect Florida Bay water quality by changing water circulation and water residence time in the bay. Increased freshwater inputs from the Everglades, with lower phosphorus concentrations than in Gulf of Mexico waters, could decrease phosphorus inputs from the Gulf (moving the zone of influence of P-limiting Everglades water westward in the bay) and thus decrease the density and prevalence of *Synechococcus* blooms in central Florida Bay (Boyer and Jones 1999). Furthermore, the magnitude of phytoplankton blooms varies as a function of the residence time of waters within the bay's basins and exchange of these waters with adjacent marine waters. Increased freshwater flow, along with the potential restoration of passes through the Florida Keys, could decrease bay water residence time and phytoplankton blooms.

Working Hypotheses: Relationships of Water Quality and Changing Internal Bay Structure and Function. Everglades restoration will affect Florida Bay water quality via changes in the bay's internal biogeochemical cycles. These internal changes will likely be mediated through changing seagrass community structure and function. An expectation of the restoration is that changing salinity will increase seagrass species diversity and spatial heterogeneity such that large scale *T. testudinum* die-off events will be prevented. In turn, water-quality degradation associated with such events will be prevented. Die-off events can increase phytoplankton growth because of increased sedimentary nutrient mobilization, decreased benthic uptake of nutrients and resultant reduction in competition for water-column nutrients, and decreased grazing pressure from benthic filter feeders (due to loss of their habitat). Sediment resuspension due to seagrass die-off can supply additional water-column nutrients via both porewater advection and desorption of surface-bound nutrients from resuspended particles. The latter process is salinity dependent and will be affected by hydrologic restoration, which may thus influence phosphorus availability for phytoplankton (with lower phosphorus availability as a function of lower salinity).

Nitrogen cycling and availability within the bay are likely to change with restoration, and these internal changes are likely to have greater effects on phytoplankton production than those derived from changing nitrogen inputs from the Everglades. Recent studies found that rapid and variable rates of nitrogen fixation and denitrification occur within bay sediments (particularly benthic microbial mats) and seagrass beds (Nagel 2004, Evans 2005). There is high uncertainty regarding the magnitude of large-scale (space and time), integrated rates of nitrogen cycling, and changes that may occur with restoration.

Seagrass Community and Trophic Web Response

An expectation of Everglades restoration is that changing patterns of freshwater flow toward more natural patterns will drive Florida Bay's seagrass community and trophic web toward its pre-drainage condition.

Working Hypotheses: Multiple Factors Affect the Florida Bay Seagrass Community. Spatial coverage, biomass, production, and taxonomic composition of seagrass beds in Florida Bay are controlled by the combined and inter-related effects of light penetration, epiphyte biomass, nutrient availability, sediment depth, salinity, temperature, sulfide toxicity, and disease. Decreased salinity caused by increasing freshwater flow will have a direct effect on seagrass communities through physiological mechanisms, resulting in greater spatial heterogeneity of seagrass beds, a decrease in the dominance of *T. testudinum*, and an increase in coverage by other seagrass species (*H. wrightii* through much of the bay and *R. maritima* near the northern coast of the bay). Decreased salinity will also decrease the infection of *T. testudinum* by the slime mold, *Labyrinthula*. Light availability will depend upon phytoplankton growth and sediment resuspension, which depend both on nutrient availability, grazing, and stabilization of sediments by seagrass beds.

Working Hypotheses: Changing Salinity and Seagrass Habitat Will Alter Fish Community Structure. Fish and invertebrate species in Florida Bay are expected to be affected by Everglades restoration efforts via responses to changing salinity and habitat. Decreasing salinity, and especially reducing the frequency and duration of hypersaline events, will increase the growth and survival of estuarine species (especially juvenile pink shrimp and juvenile spotted seatrout) and enhance the use of Florida Bay as a nursery. Increased seagrass habitat diversity and heterogeneity (with less area covered by high density *T. testudinum*) and minimizing large-scale *T. testudinum* die-off events will increase the survivorship and population size of these and other higher trophic level species. Both recreational and commercial fisheries are thus expected to benefit from Everglades restoration.

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A CONCEPTUAL MODEL OF ECOLOGICAL INTERACTIONS IN THE MANGROVE ESTUARIES OF THE FLORIDA EVERGLADES

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Abstract: A brackish water ecotone of coastal bays and lakes, mangrove forests, salt marshes, tidal creeks, and upland hammocks separates Florida Bay, Biscayne Bay, and the Gulf of Mexico from the freshwater Everglades. The Everglades mangrove estuaries are characterized by salinity gradients that vary spatially with topography and vary seasonally and inter-annually with rainfall, tide, and freshwater flow from the Everglades. Because of their location at the lower end of the Everglades drainage basin, Everglades mangrove estuaries have been affected by upstream water management practices that have altered the freshwater heads and flows and that affect salinity gradients. Additionally, interannual variation in precipitation patterns, particularly those caused to El Niño events, control freshwater inputs and salinity dynamics in these estuaries. Two major external drivers on this system are water management activities and global climate change. These drivers lead to two major ecosystem stressors: reduced freshwater flow volume and duration, and sea-level rise. Major ecological attributes include mangrove forest production, soil accretion, and resilience; coastal lake submerged aquatic vegetation; resident mangrove fish populations; wood stork (*Mycteria americana*) and roseate spoonbill (*Platelea ajaja*) nesting colonies; and estuarine crocodilian populations. Causal linkages between stressors and attributes include coastal transgression, hydroperiods, salinity gradients, and the ''white zone'' freshwater/estuarine interface. The functional estuary and its ecological attributes, as influenced by sea level and freshwater flow, must be viewed as spatially dynamic, with a possible near-term balancing of transgression but ultimately a long-term continuation of inland movement. Regardless of the spatio-temporal timing of this transgression, a salinity gradient supportive of ecologically functional Everglades mangrove estuaries will be required to maintain the integrity of the South Florida ecosystem.

Key Words: Everglades, South Florida, ecosystem restoration, conceptual ecological model, mangrove forest, tidal creeks, estuaries, salinity gradients, water management, sea-level rise, estuarine geomorphology, fish communities, wood stork, roseate spoonbill, American crocodile

BACKGROUND

A brackish water ecotone of coastal bays and lakes, mangrove and buttonwood forests, salt marshes, tidal creeks, and upland hammocks separates Florida Bay, southern Biscayne Bay, and the Gulf of Mexico from the freshwater Everglades. The model boundary from Turkey Point west to Lostman's River delineates the interface of Biscayne and Florida Bays and the Gulf of Mexico that is affected by freshwater flows from the Everglades (Figure 1). The Everglades mangrove estuaries are characterized by salinity gradients that vary spatially with topography and seasonally and inter-annually with rainfall, tide, and freshwater flow from the Everglades. Because of their location at the lower end of the Everglades drainage basin, Everglades mangrove estuaries are particularly vulnerable to changes in sea level and freshwater flow.

Everglades mangrove estuaries and their ecological attributes, as influenced by sea-level rise and increased freshwater flow (in both volume and duration), must be viewed as spatially dynamic, with a possible near-term balancing of transgression but ultimately a long-term continuation of inland movement. Regardless of the spatio-temporal timing of this transgression, a salinity gradient supportive of ecologically functional Everglades mangrove estuaries will be required to maintain the integrity of the South Florida ecosystem.

EXTERNAL DRIVERS AND ECOLOGICAL STRESSORS

All ecological processes and attributes in the mangrove coastline of the southern Everglades are hydrologically controlled by sheet flow from the freshwater wetlands to the north interacting with sea level in the Gulf of Mexico and Florida Bay (Figure 2). Responses to changes in freshwater flow from the implementation of CERP are relatively short term in comparison to the longer-term, progressively increasing changes resulting from relative sea-level rise.

Freshwater Flow

Construction and operation of South Florida's water management system during the Twentieth Century has depleted freshwater flow to the Everglades mangrove estuaries and has altered its timing and distribution (McIvor et al. 1994, VanZee 1999). There are numerous examples of how ecological patterns and processes in the mangrove estuaries are closely linked to patterns of hydrology, salinity, and supply of marine-derived phosphorus, all of which have been altered by reduced freshwater flow (Chen and Twilley 1999, Ross et al. 2000). Because the upstream freshwater Everglades system is so oligotrophic and phosphorus-limited (Noe et al. 2001), the ocean is the source of the limiting nutrient to these estuaries. This "upside-down" characteristic of Everglades estuaries is a defining feature and plays a strong role in the interaction of geomorphology and productivity (Childers et al. 2005).

Additionally, Childers et al. (2005) suggested that water residence time, particularly during the dry months, plays a key role in phosphorus cycling in Everglades mangrove estuaries. Along west coast systems, such as Shark River, low freshwater inflows at this time allow salinity incursions up-estuary, extending the influence of the marine phosphorus source to the oligohaline ecotone. In the Florida Bay mangrove zone, though, the loss of freshwater inflow effectively eliminates flushing, and water residence times are long. During this time, Childers et al. (2005) hypothesized that internal recycling of phosphorus (primarily via subtidal and open water processes) and nitrogen (primarily mediated by the mangrove wetlands) dominate dry season dynamics.

Sea-Level Rise

The rate of relative sea-level rise for South Florida increased above recent decadal rates beginning about 1930. Since that time, South Florida has had a relative sea-level rise of about 23 cm (Wanless et al. 1994). This is a rate of 30 cm per century. Anticipated response to global warming is projected to result in a global increase in sea level of about 60 cm in the coming century. Sea-level rise may massively reconfigure geomorphology, circulation patterns, salinity patterns, and ecological processes during the Twenty-First Century (Wanless et al. 1994).

Non-Native Plants and Fishes

The introduction and spread of non-native plants and fishes are additional drivers and stressors on the Everglades mangrove estuaries, although they are not included in this model because of the overwhelming influences of sea level and hydrology. The Mayan cichlid presently dominates the fish community in mangrove wetlands east of Taylor Slough (Trexler et al. 2001), and the non-native plants Brazilian pepper (*Schinus terebinthifolius* Raddi) and common colubrine (*Colubrina asiatica* (L.) Brongn) have invaded mangrove forests. Although less pervasive than sea level and freshwater flow, potential impacts from the spread of non-native plants and fishes merit a better understanding of their ecological roles and potentials for control.

ECOLOGICAL ATTRIBUTES

Mangrove Forest Production, Soil Accretion, and Resilience

Mangrove forests (red mangroves [*Rhizophora mangle* Linnaeus], black mangroves [*Avicennia germinans* (L.) Linnaeus], white mangroves [*Laguncularia racemosa* (L.) Gaertn.f.)], and buttonwood [*Conocarpus erectus*]) dominate primary productivity and soil accretion within the Everglades mangrove estuaries

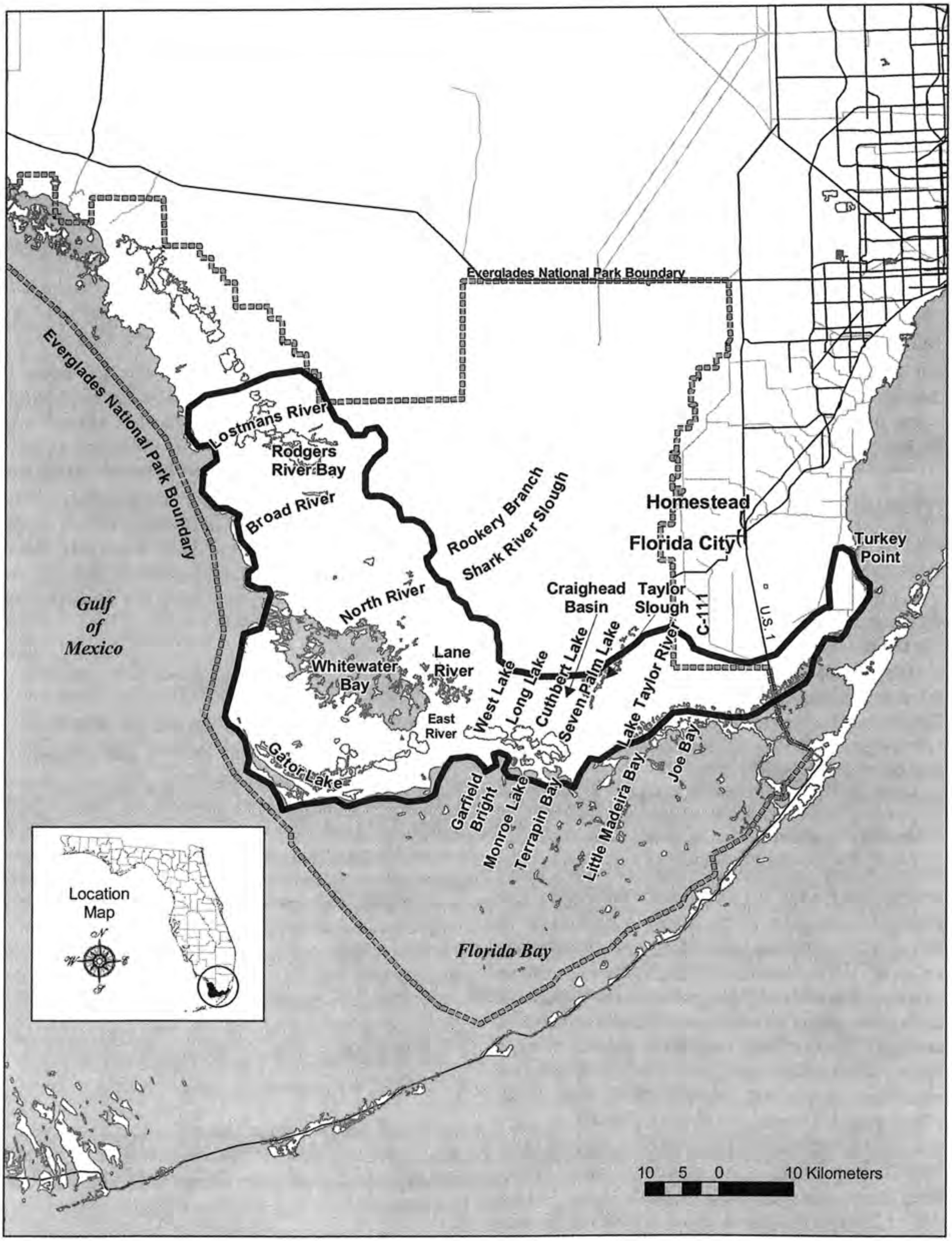

Figure 1. Boundary of the Everglades Mangrove Estuaries Conceptual Ecological Model.

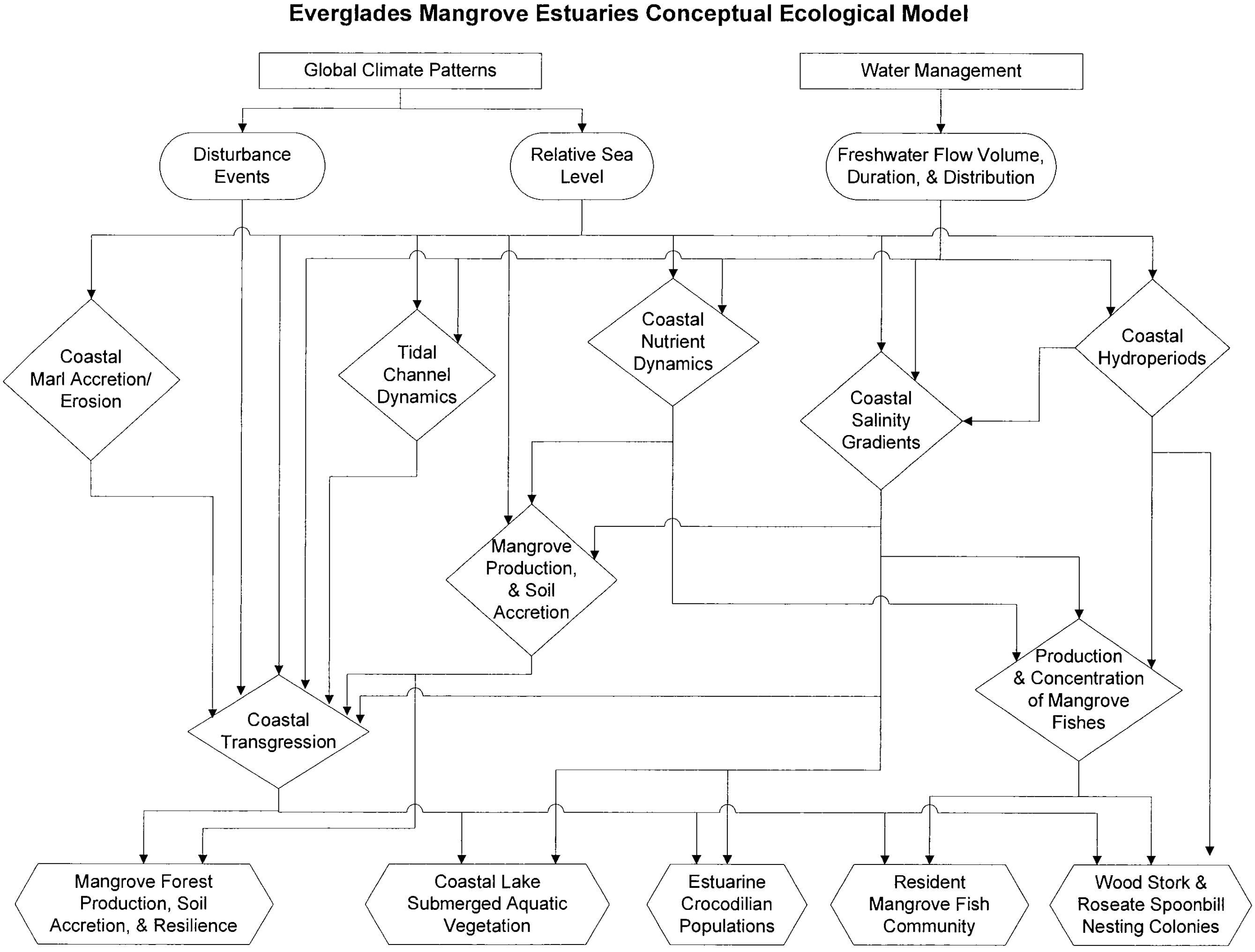

Figure 2. Everglades Mangrove Estuaries Conceptual Ecological Model diagram.

(Twilley 1998, Chen and Twilley 1999, Childers et al. 1999, Davis et al. 2004). That productivity appears to reflect the nutrient status of the estuarine interface, which is related to mixing of phosphorus-poor water from the freshwater Everglades with relatively phosphorus-rich water from the Gulf of Mexico (Davis et al. 2001 a, b, Davis et al. 2003, Childers et al. 2005).

Aboveground biomass and production in the mangrove forests of Shark River Slough and other Gulf estuaries increase from the ecotone toward the Gulf of Mexico, reflecting the direct connection of these systems to the marine phosphorus source (Chen and Twilley 1999, Rudnick et al. 1999, Childers et al. 2005). Trees in the forests near the Gulf are able to allocate more biomass to aboveground growth. The dwarf mangrove forests along the northern margin of Florida Bay reflect suppressed levels of aboveground productivity and seedling development, as influenced by minimal P supply from either the oligotrophic marshes of the southern Everglades or Florida Bay (Koch 1997, Koch and Snedaker 1997, Satula et al. 2003, Childers et al 2005). High belowground production rates in the dwarf mangrove forests appear to be a biomass allocation phenomenon in which mangroves in the oligotrophic southern Everglades are foraging for nutrients (Krauss et al. 2003). The counter-intuitive expectation is that maintenance of oligotrophic conditions in the southern Everglades [by increased freshwater inflows] may promote peat accretion in these mangroves.

Red mangrove forests in South Florida can potentially accrete organic peat substrate at 2–6 mm/year. Disturbances (major hurricanes, fire, freeze, and changing flushing) disrupt that rate and commonly result in phases of substrate subsidence from decay (Smith et al. 1994, Cahoon and Lynch 1997). Nutrient limitation and salinity stress also reduce that rate.

An important feature for maintenance of an existing wetland environment, its recovery following disturbance events such as hurricanes, freezes, fires, or salinity changes, or the successful shift from one wetland type to another is maintenance of good flushing by either fresh or saline waters (Wanless et al. 1995).

Where flow and flushing diminish, wetland communities collapse (Wanless and Vlaswinkel 2005). This is true for long-term maintenance of mangrove communities and for mangrove communities invading former sawgrass wetlands.

Terrestrial communities embedded in the mangrove forests include tropical forest communities and halophytic prairies. Midden forests, thatch palm (*Thrinax* spp.) hammocks, mixed coastal hammocks, and buttonwood hammocks contribute to local and landscape species diversity within the mangrove zone (including providing substrate for epiphytes) and are able to persist because of the presence of elevated substrates like storm berms and human-originated deposits (Craighead and Gilbert 1962, Craighead 1971). Halophytic prairies dominated by *Batis maritima* Linnaeus, *Salicornia* spp., and *Blutaparon vermiculare* (L.) Mears) appear to represent a long-term landscape element that becomes established where tropical storms alter coastal soils in such a way that mangrove and buttonwood forests are killed (Craighead and Gilbert 1962, Craighead 1971, Armentano et al. 1995).

Coastal Lake Submerged Aquatic Vegetation Communities

Coastal lakes such as Seven Palm Lake, Cuthbert Lake, Long Lake, West Lake, Lake Monroe, and the Taylor River ponds support seasonal beds of SAV under oligohaline to mesohaline conditions. Species richness and total and species-specific percent cover of SAV found in the lakes, ponds, and bays that make up this aquatic network vary both seasonally and interannually in patterns that are related to salinity (Morrison and Bean 1997). Salinity ranges for the suite of 10–12 species, including bladderwort (*Utricularia* spp.) and naiads (*Najas* spp.) are well-documented, with an upper limit of approximately 5–8 ppt, muskgrass (*Chara* spp.) under mesohaline salinities of approximately 15–20 ppt, and widgeon grass (*Ruppia maritima* Linnaeus) under mesohaline salinities of 10–25 ppt.

Waterfowl species that once occurred in large numbers in coastal lakes and basins of the mangrove zone (Kushlan et al. 1982) are dependent on SAV as their primary food resource. The local declines of American coot (*Fulica americana* J.F. Gmelin), lesser scaup (*Aythya affinis* Eyton, 1838), American widgeon (*Anas americana* J.F. Gmelin), and white-cheeked pintail (*Anas bahamensis* Linnaeus) correspond to decline in that food resource, despite overall resurgence of populations in other parts of North America. Recent high-rainfall years have witnessed an increase in coot numbers on West Lake to approximately 2,000 during winter 1996–1997 (O.L. Bass, Jr., Everglades National Park, pers. comm.) but not to the population size of approximately 50,000 that over-wintered there until the 1960s (Kushlan et al. 1982).

Resident Mangrove Fish Populations

Oligohaline wetlands of the mangrove estuary support a resident community of small fishes that is functionally important as an intermediate trophic level supporting wading birds and other higher consumers (Lorenz 2000). Density and seasonal concentration of small marsh fishes in the mangrove zone like sheepshead minnows (*Cyprinodon variegatus* Lacepede), sailfin mollies (*Poecilia latipinna* Lesueur), topminnows (*Fundulus chrysotus* Guenther), rainwater killifish (*Lucania parva* Baird and Girard), and sunfish (*Lepomis marginatus* Holbrook) reflect estuarine salinity, nutrient status, hydroperiod, and drying patterns (Lorenz 2000, Trexler and Loftus 2000), all of which are controlled by freshwater flow and sea level.

The resident fish assemblage decreases in density and size distribution when salinity exceeds 5–8 ppt (Lorenz 1997, 1999, 2000). This relationship has been demonstrated for Florida Bay mangrove wetlands, but not for Gulf of Mexico estuaries. Furthermore, salinity is inversely auto-correlated with hydroperiod in Florida Bay mangrove wetlands, and the relative contribution of each of these variables is not known.

Densities of small fishes in Shark River Slough are approximately 50 percent greater at Rookery Branch, near the interface with the Gulf of Mexico, in comparison to more upstream sites (Trexler and Loftus 2000). Greater fish densities at Rookery Branch hypothetically correspond to enhanced nutrient status and productivity in that area (Childers et al. 1999). In contrast, lower fish densities at the estuarine interface of Taylor Slough relative to sites upstream (Lorenz 1999, 2000, Trexler and Loftus 2000) correspond to low nutrient status and productivity there. Receding water levels following an extended annual hydroperiod can concentrate small fishes in Craighead Basin, at the estuarine interface of Taylor Slough, to densities comparable to the estuarine interface of Shark River Slough (Lorenz 2000).

Relationships of fish populations to hydrology in gulf estuaries are unknown. Populations of small marsh fishes in gulf estuaries may respond to hydroperiod and water recession patterns very differently than Everglades marsh fish communities because of more complex topography created by a dendritic pattern of tidal creeks. Tidal creeks may further influence the resident mangrove fish community as corridors for immigration of juveniles of more marine species.

Wood Stork and Roseate Spoonbill Nesting Colonies

Large nesting colonies of wood storks (*Mycteria americana*, Linnaeus) and great egrets (*Ardea alba*, Linnaeus) in the Everglades during the early 1900s were concentrated in Everglades mangrove estuaries (Ogden 1994). East River, Lane River, Rookery Branch, Broad River, and Rodgers River Bay colonies, in the headwaters of the tidal rivers entering the Gulf of Mexico, supported approximately 90 percent of the total nesting population of these and other wading bird species in the Everglades during the period 1931–1946. Additional colonies along the southern mainland of Florida Bay included Gator Lake, Mud Lake, Mud Hole (located east of Gator Lake), Cuthbert Lake, and Madeira Rookery. All of these coastal nesting colonies collapsed during the second half of the Twentieth Century (Ogden 1994). Larger fishes, such as sunfish and topminnows that grow to 10 cm in length, are considered to be particularly important in the diets of wood storks due to their higher vulnerability to capture (Ogden et al. 1978).

A decrease in roseate spoonbill (*Platelea ajaja*, Linnaeus) nesting in northeast Florida Bay and a shift of nesting distribution from eastern to western Florida Bay accompanied the collapse of the wood stork nesting colonies (Powell et al. 1989, Bjork and Powell 1994, Lorenz et al. 2002). Small fishes have been reported to be the primary diet of roseate spoonbills in Florida Bay (Allen 1942, Powell and Bjork 1990, Dumas 2000). Relatively sparse populations of marsh fishes along the estuarine interface of northeast Florida Bay today require very specific wetland drying patterns to concentrate them and make them available in densities adequate to support spoonbill nesting. Lorenz (2000) reported a water-depth threshold of 12 cm, averaged over the 21-day post-hatching period of roseate spoonbills, that is necessary to concentrate the fish prey base in Taylor Slough coastal sites. Water-level recession to 12-cm depth during that period can concentrate normally low fish density in that region to 85 fish per square meter in remaining pockets of water. The 12-cm depth threshold fits well with success or failure of spoonbill nesting in northeast Florida Bay colonies.

Collapse of coastal wood stork and great egret colonies, and of northeast Florida Bay roseate spoonbill colonies, corresponded to construction of the Central and South Florida (C&SF) Project and the resulting reduction of freshwater flow to the estuarine interface compared to Natural Systems Model (NSM) simulations (VanZee 1999).

Estuarine Crocodilian Populations

The American alligator (*Alligator mississippiensis* Daudin) was historically abundant and nested in freshwater mangrove areas of the Everglades (Craighead 1968). Today, nesting is limited, and few juveniles are observed. Salinity is a major factor limiting distribution and abundance of alligators in estuarine habitats (Dunson and Mazzotti 1989, Mazzotti and Dunson 1989). Alligators lose the capacity to we estuarine habitats for feeding, growth, and reproduction when salinity exceeds oligohaline levels (Joanen 1969). When alligators occur in salt water, it is usually to feed, and there is always a freshwater refugium in close proximity (Jacobsen 1983, Tamarack 1988). In a natural experiment in North Carolina, alligators that were exposed to diversion of freshwater flows due to construction of a power plant relocated to the diversion canal to maintain access to fresh water.

Small alligators are especially vulnerable to exposure to salt water. In laboratory experiments, small alligators ceased feeding and should signs of stress when exposed to salinities greater than 10 ppt (Lauren 1985). Alligators do feed and gain mass at 4 ppt (Mazzotti and Dunson 1984). For these reasons, alligators are good indicators of restoring freshwater flows to estuarine systems and the subsequent reestablishment of an extensive freshwater/brackish water zone.

The American crocodile (*Crocodylus acutus* Cuvier) dwells in ponds and creeks of the mangrove estuaries of Florida Bay (Ogden 1976, Mazzotti 1983). American crocodiles are tolerant of a wide salinity range as adults because of their ability to osmoregulate (Mazzotti 1989). Juvenile crocodiles lack this ability (Mazzotti 1989), however, and their growth and survival decrease at salinities exceeding 20 ppt (Mazzotti and Dunson 1984, Mazzotti et al. 1988, Moler 1991). Juvenile crocodiles tend to seek freshwater pockets, such as black mangrove stands, when those choices are available.

ECOLOGICAL EFFECTS: LINKAGES BETWEEN STRESSORS AND ATTRIBUTES

Coastal Transgression

The stability/instability of the shoreline and coastal wetlands in the southern Everglades is manifest through the dynamic interaction of freshwater outflows, sea-level rise, and saline water inflow, the rate of import/export of sediment, and the capability of the sedimentary environment or bio-sedimentary substrate level to respond to changes in water level. In this time of rapidly rising sea level (Wanless et al. 1997), most mangrove communities are presently losing area of coverage (Wanless et al. 2000). In the coming century, the coastal mangrove community can be expected to become increasingly dissected. Sustained rates of accretion of coastal marl shorelines of Florida Bay probably are also incapable of keeping up with predicted rates of sea-level rise, and over-topping and breaching of embankments during storm events are likely under future scenarios of rising sea level.

Where rates of peat or marl elevation buildup do not keep up with rates of sea-level rise, shoreline transgression and landward salinity intrusion will lead to mangrove erosion along shorelines and mangrove movement into interior landscapes. Saline intrusion into freshwater wetlands underlain by peat substrate may lead to wetland collapse and transformation to open, saline ponds and estuaries (Wanless and Vlaswinkel 2005). Saline intrusion into marl substrate wetlands results in an advancing zone of diminished productivity (white zone) (Ross et al. 2002). Restoration of freshwater flow volume, timing, and distribution may slow the inland movement but will not change the rate of erosion along the shoreline.

The coastal Everglades have also been re-configured during the past century by filling in of tidal creeks. Siltation and mangrove encroachment of tidal creeks (Craighead 1971, Meeder et al. 1996) has progressed to the extent that open water courses that were described earlier this century are no longer recognizable (G. Simmons, gladesman, pers. comm.). Reduced freshwater flow volume and rising sea level are probable contributing factors.

Coastal Hydroperiods and Salinity Gradients

Pre-drainage hydrologic conditions in the southern Everglades produced prolonged pooling of freshwater just upstream from the mangrove estuaries and prolonged durations of freshwater flow into the estuaries (VanZee 1999). The freshwater pooling and inflow supported wide salinity gradients, including a broad oligohaline zone, in the mangrove estuaries.

A combination of reduced freshwater flow and increased relative sea-level rise has resulted in higher salinities in the formerly oligohaline mangrove zone and significant saline intrusion into former freshwater marshes of the lower Everglades (Ross et al. 2000, Ross et al. 2002). Although surface-water salinities fluctuate laterally through wet and dry seasons, saline ground-water intrusion has moved and remains far inland of the position prior to drainage.

White Zone

At the landward interface of the mangrove estuaries with marl wetlands, a ‘‘white zone’’ band of sparse, mixed mangrove and graminoid vegetation that appears white on color infrared or black-and-white aerial photos. As with any upper bound on an oligohaline ectone, this zone integrates the balance between freshwater flow and sea-level rise (Ross et al. 2002). Egler (1952) described the white zone as a band of low, open vegetation separating mangrove swamps adjacent to the southeast saline Everglades coast (Taylor Slough to Turkey Point) from sawgrass marshes of the interior. Its composition included a mixture of sawgrass (*Cladium jamaicense* Crantz), spikerush (*Eleocharis* spp.), and red mangrove. He considered the inner edge to mark the farthest extent of storm tides. Ross et al. (2000) documented changes in extent and plant species composition of the white zone since Eglers work. They found movement toward the interior of less than 1 km up to about 4 km throughout the region over about 50 years. Movement was maximal in areas where virtually all freshwater has been blocked by canals and management (wetlands east of US 1), and minimal in wetlands where water flow was less impacted by canals, levees, and management (wetlands west of US 1 and directly south of the C-111 Canal). These patterns suggest that freshwater inflows [at least] partially counteract transgression driven by sea-level rise. Working along a hydrologically isolated coastal transect south of Turkey Point, Meeder et al. (1996) documented an inland movement of the interior boundary of the white zone of 1.9 km during 1940–1994. This distance equated to a vertical shift of 13 cm during a period in which sea level rose by only 11 cm.

WORKING HYPOTHESES FOR RESTORATION

Coastal Transgression

Sustained buildup of substrate by physical and biological processes in many coastal marl and mangrove environments of South Florida will not be capable of keeping up with rates of sea-level rise during the twenty-first century. Where rates of peat or marl elevation do not keep up with rates of sea-level rise, shoreline transgression and landward salinity intrusion into mangrove and freshwater wetlands will occur.

White Zone

If sea level continues to rise at its current rate or faster, the leading edge of the white zone will continue to move toward the interior, except along tidal creeks or major drainages. These changes will be least evident in areas in which freshwater input is augmented and greatest in areas cut off from freshwater flow.

Coastal Tidal Channel Characteristics

The dendritic pattern, channel width and depth, flow volume, and material transport of tidal watercourses through the coastal mangrove estuaries are controlled by sea level interacting with the volume, timing, and distribution of sheet flow and channel flow from the southern Everglades. Many tidal creeks through coastal wetlands of the Everglades have disappeared entirely during the past century because they have been filled in with sediments and with the vegetation of surrounding landscapes. Reduced freshwater flow volume and rising sea level are probable contributing factors. Restored freshwater inflow from the Everglades is expected to help sustain open watercourses through the estuary that will more closely resemble historic patterns, yet sea-level rise is expected to modify the patterns of connectivity through the coastal wetlands and create increased sediment loads.

Coastal Hydroperiod and Depth Patterns

Sheet flow in the southern Everglades prior to drainage produced persistent pooling of fresh water upstream from the mangrove estuaries and prolonged freshwater flow into the mangrove estuaries. Reduced volume and duration of freshwater flow have shortened hydroperiods in the southern Everglades, disrupted in sheet flow, and reduced duration of pooling along the sawgrass/mangrove ecotone. Restoration of pre-drainage volume, distribution, and duration of sheet flow in the southern Evergladeds will prolong pooling of fresh water along the sawgrass/mangrove interface and increase volumes and durations of freshwater flow to the estuaries.

Coastal Salinity Gradients

Prolonged pooling of fresh water upstream of the mangrove estuaries and prolonged patterns of freshwater flow supported a wide salinity gradient, including a broad oligohaline zone, in the mangrove estuary. A combination of historical reduced freshwater flow and increased relative sea-level rise have resulted in higher salinities in the formally estuarine mangrove zone and significant saline intrusion into former freshwater marshes of the lower Everglades. Increasing seasonal freshwater sheet flow to the lower Everglades is expected to provide a broader zone of salinity gradients in the lower Everglades and coastal wetlands and should, in the short term, re-establish an oligohaline zone in the coastal wetlands. Over a long-term period, rising sea level is expected to result in high tides overtopping coastal marl ridges and saline waters penetrating more deeply through tidal channels and mangrove forests, shifting the areas of fresh and lower salinity waters inland.

Production and Organic Soil Accretion of Coastal Mangrove Forests

Production and organic soil accretion in the mangrove forests of the coastal Everglades are controlled by phosphorus availability, with relatively large inputs from marine sources and small inputs from freshwater sources. Increased freshwater sheet flow caused by implementation of CERP projects is expected to maintain low nutrient conditions in the southern Everglades mangrove estuaries and in the oligohaline ecotone forests of the western mangrove estuaries. Low nutrient conditions are expected to enhance belowground productivity by mangroves, which will maintain peat production and soil elevation increases—ultimately enhancing the ability of these low salinity forests to maintain themselves against sea-level rise.

Resilience of Coastal Mangrove Forests

Resilience of the mangrove forests of the coastal Everglades after disturbance is dependent on hydrologic flushing by either fresh or saline water, which is driven by sea level and sheet flow from the Everglades. Resilience also varies with soil fertility. Improved freshwater flow and flushing through the lower Everglades and coastal wetlands (through both channel and sheet flow) are expected to aid in recovery of wetlands from catastrophic setbacks (from hurricanes, fire, freeze, and salinity changes).

Coastal Lake Submerged Aquatic Vegetation and Waterfowl

Prolonged periods of elevated salinity in coastal lakes and basins, resulting from diminished freshwater flow volume and duration, have reduced seasonal duration and cover of communities of SAV along shorelines and in tributaries. SAV communities will persist in larger beds, longer into the dry season, and lower in the estuarine system when oligohaline to mesohaline conditions are restored upon resumption of natural freshwater flow volume and duration.

Resident Mangrove Fish Populations

The wet-season density, size structure, and relative abundance of resident mangrove fish populations are directly related to the time since the last dry-down, the length of time the marsh was dry, and salinity in coastal ecotones. Responses of fishes are non-linear and species-specific. The concentration of resident mangrove fishes into high-density patches where wading birds can feed effectively is controlled by the rate of dry-season water-level recession and local topography/

habitat heterogeneity. Restoration of persistent pools of fresh-to-oligohaline water along the interface where mangrove forests meet the Everglades will support increased densities, size distributions, and seasonal concentrations of resident mangrove fishes due to combined effects of prolonged hydroperiod, enhanced drying patterns, and extended periods of freshwater to oligohaline salinity.

Wood Stork and Roseate Spoonbill Nesting Colonies

The collapse of coastal wood stork and great egret nesting colonies in the tributary headwaters and southern mainland of the Everglades mangrove estuary, and the abandonment of roseate spoonbill nesting colonies in islands of northeast Florida Bay, are attributed to declines in population densities and seasonal concentrations of marsh fishes and other wading bird prey in the southern Everglades. Restoration of densities and seasonal concentrations of resident mangrove fishes in persistent pools of fresh-to-oligohaline water immediately upstream from the mangrove forests will provide the necessary prey base in juxtaposition to nesting habitats to re-establish coastal nesting colonies of wood stork and great egret and northeast Florida Bay nesting colonies of roseate spoonbill.

American Alligator

American alligator distribution, abundance, reproduction, and body condition in the Everglades mangrove estuaries are controlled by salinity. Reduced freshwater flow into the mangrove estuaries of the southern Everglades has resulted in succession of former freshwater mangrove areas to saltwater systems, reducing American alligator populations in tidal rivers and tributaries. With the resumption of natural patterns of volume, timing, and distribution of flow to the Everglades, the American alligator is expected to repopulate and resume nesting in the freshwater reaches of tidal rivers in the mangrove estuaries.

American Crocodile

American crocodile relative density and juvenile growth, survival, and condition increase when salinity fluctuates below 20 ppt in shoreline, pond, and creek habitats in Everglades mangrove estuaries. Alteration of location and quantity of freshwater flow to the mangrove estuaries has lowered the relative density of crocodiles in areas where freshwater has been diverted and decreased growth and survival of juvenile crocodiles throughout the estuary in areas of higher salinities. Restoration of Volume, timing, and distribution of freshwater flow will result in an increase in relative density of crocodiles in areas of restored flow, such as Taylor Slough/Taylor River drainage. Reestablishing the salinity gradient in the estuary will increase growth and survival of juvenile crocodiles throughout the estuary.

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March 2006

Appendix C

Final Report
Fathom Enhancements and Implementation to Support Development of Minimum Flows and Levels for Florida Bay

USING STATISTICAL MODELS TO SIMULATE SALINITY VARIATION AND OTHER PHYSICAL PARAMETERS IN NORTH FLORIDA BAY

Cooperative Agreement Number 1443CA528001020 Amendment/ Modification 0004
Between
The United States Department of the Interior National Park Service
Everglades National Park
And
Cetacean Logic Foundation, Inc.

FINAL PROJECT REPORT

Project Period October 1, 2002 through April 30, 2004

Frank E. Marshall, III
Principal Investigator

DeWitt Smith
Project Coordinator

David Nickerson
Review

April 30, 2004

USING STATISTICAL MODELS TO SIMULATE SALINITY VARIATION AND OTHER PHYSICAL PARAMETERS IN NORTH FLORIDA BAY

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USING STATISTICAL MODELS TO SIMULATE SALINITY VARIATION AND OTHER PHYSICAL PARAMETERS IN NORTH FLORIDA BAY

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FINAL REPORT
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I. Introduction

This report describes the activities of the second year of Critical Ecosystem Studies Initiative (CESI) research into the use of statistical models to simulate salinity in Florida Bay. The activities of the first year of CESI work are presented in *Salinity Simulation Models for North Florida Bay Everglades National Park* (Marshall, et al 2003a). Because this report describes follow-on activities, reference to the first year report may be needed to understand all of the background for the second year of work. During the first year of this investigation, two types of statistical modeling procedures were found to be well-suited for use with time series data – SARIMA models (seasonal autoregressive integrated moving average models) and multivariate linear regression models (MLR models). SARIMA models were found to be useful for one-step forward predictions, but for other simulation purposes, MLR models were found to be much easier to use and almost as robust to the idiosyncrasies of time series data. Since the models are intended for use with the output from the South Florida Water Management District (SFWMD) Everglades watershed model (South Florida Water Management Model, or 2X2 model), which simulates hydrologic conditions in south Florida beginning in 1965, MLR models were selected for further development.

Tasks in the original Project Description for the Year 2 work are summarized as follows:

1. Coordinate with SFWMD to obtain 2X2 model data and evaluate the uncertainty in the 2X2 model simulations;
2. Obtain any other data that may be needed to use MLR models with 2X2 model data;
3. In conjunction with ENP staff, prepare MLR models of salinity, water level, or flow;
4. Simulate salinity, water level, or flow using the 2X2 Natural System Model and other appropriate input parameters;
5. Decode a previously prepared SARIMA model; and
6. Prepare draft and final reports.

As the project progressed considerable experience and feedback were gained using MLR salinity models. Additionally, when the uncertainty in the 2X2 model output was evaluated, the structure of the MLR salinity models was modified, as described further in the following sections of this report.

From the onset of the CESI work on statistical models, it was hoped that they would prove useful for simulating salinity in Florida Bay for the Initial CERP (Comprehensive Everglades Restoration Plan) Update (ICU) evaluations. However, when the Year 2 work began, it did not appear that the MLR models would be ready for this purpose, and the scope of the Year 2 project was made intentionally broad to investigate the use of MLR models to simulate other parameters besides salinity, such as water level or flow. As the project progressed it became clear that MLR models were capable of making acceptable simulations of salinity such that different water management schemes could be evaluated, and that the revised schedule for the ICU evaluations was going to make it possible for MLR models to be used for the evaluations. Therefore, the work being done was concentrated on the development of MLR models for that purpose (ICU evaluations).

The first tasks were completed as scheduled. Residual plots were examined and the updated dataset was assembled. In the midst of completing the project tasks, a need for the MLR models developed at Everglades National Park for use with the Interim Operational Plan (IOP) evaluation Congressional Report. ENP was tasked with analyzing the water management regimes that had been modified to lessen the impact of flow diversions on the Cape Sable seaside sparrow. MLR models were developed for use with these evaluations, and valuable experience was gained that has benefited the CESI project. In order to complete the IOP evaluations, a six-month extension of this CESI project was requested and granted. The IOP evaluation model development procedure also allowed the project dataset used for model development to be lengthened.

One committee that is charged with completing the ICU evaluations is the Southern Estuaries Sub-team of RECOVER. Beginning in the spring of 2003, the Principal Investigator has been coordinating with the Sub-team, preparing to use the models developed by this CESI project for evaluating the established salinity performance measures for Florida Bay and the southwest coast. At the time of preparation of this report, the models presented herein are intended to be used by the Sub-team in this manner.

When work re-started on this CESI project following the IOP evaluation activities, the tasks to be completed were officially modified to take into account the focus on modeling for ICU evaluation purposes. The revised Project Description included the following revised list of tasks:

1. Contact / meet with SFWMD staff to coordinate the acquisition of 2X2 model output and additional information about the modeling procedure.
2. Acquire the other data needed to create a complete input data set for running the multivariate linear regression models with 2X2 model output, including the historical record for wind at Key West and Miami weather stations.

3. Eliminate flow parameters from MLR salinity models.
4. Meet with the Southern Estuaries Sub-team to obtain their needs for MLR salinity models for ICU performance measure evaluations.
5. Prepare MLR salinity models for Joe Bay, Little Madeira Bay, Terrapin Bay, Garfield Bight and North River using 2X2 model output to calibrate the MLR salinity models. This task was completed. However, because the SFWMD updated the 2X2 model output subsequent to their development, these models were rendered obsolete. All future MLR salinity models will be developed from real (observed) data.
6. Adapt the IOP models prepared from observed data for use with the Southern Estuaries Sub-team performance measure evaluations by expanding the data used for model development, where possible for Little Madeira Bay, Terrapin Bay, Whipray Basin, Butternut Key, and Duck Key.
7. Prepare new MLR models using the longest period of record available for Taylor River, Little Blackwater Sound, Highway Creek, and Bob Allen Key.
8. Run simulations at all stations using the following 2X2 model runs: NSM 4.5, NSM 4.6, 95 Restudy, and 2000 CERP. These are the same runs being made by the Southern Estuaries Sub-team at other stations.
9. Evaluate the level of uncertainty in the models and in the simulations. Some statistical tests that may be used include the mean error, mean absolute error, root mean square error, maximum absolute error, relative mean error and relative absolute mean error.
10. Prepare draft and final Project Reports describing the activities that were completed and present the findings.

Details on the activities of these revised tasks are presented in this report.

II. Study Area and Data Set

The study area for this CESI project encompasses northeastern, north, and central Florida Bay; the extreme southwestern coast of the Florida; and the Everglades watershed within Everglades National Park. This modeling effort utilized data that have been collected at 15 to 60 minute increments and averaged to daily and monthly values. Salinity data is taken from the ENP Marine Monitoring Network (MMN) data base. The stage data are ENP Physical Monitoring Network Everglades water levels. Details about these data can be found in Everglades National Park (1997a and 1997b), and Smith (1997, 1998, 1999, and 2001). To these data other time series data were added, including wind data from the National Weather Service (Southeast Regional Climate Center), and water level data collected at Key West from the National Ocean Service. Wind data from Key West and Miami were used as these locations had the longest continuous records for wind and were considered to be representative of the regional wind patterns. Sea level data from Key West were considered to be representative of the average effect of oceanic water level influences, and, to some extent, the average water level patterns within Florida Bay.

The locations of each of the monitoring stations where water level and salinity data were collected are presented in Figure 1. The salinity monitoring stations for which MLR salinity models were prepared as part of this CESI study or the IOP evaluation (shown on Figure 1) are as follows:

1. Joe Bay
2. Little Madeira Bay
3. Terrapin Bay
4. North River
5. Whipray Basin
6. Duck Key
7. Butternut Key
8. Taylor River
9. Highway Creek
10. Little Blackwater
11. Bob Allen Key
12. Long Sound.

Continuous water level records in the Everglades begin in the 1950's in some locations, but most stage records date from the 1990's. Continuous salinity data extend back to 1988 at several locations in northeast Florida Bay. Because the shortest data record (for E146) begins on March 24, 1994, the period of data used for most of these modeling activities begins on this date. The period of record extends through October 31, 2002, which means that there are 3143 daily values in a record with no missing data. In reality, most data sets contained some missing values. Information on the parameters that were used for the modeling activities is presented in Table 1.

III. Residuals Analysis and Variable Significance Level Evaluation

The first task of the second year of this CESI project was to evaluate the residuals from the models that were developed in the first years work. Residuals (observed values minus simulated values, or deviations) were computed for all MLR salinity models including:

1. Residuals versus predicted values
2. Residuals versus time
3. Residual / probability / normal quartile.

Residual plots are presented in Appendix A. From the analysis of these diagnostic plots, it was determined that the preliminary MLR salinity models do not significantly violate any of the assumptions of linear regression model development, namely that the residuals are approximately normally distributed with a mean of 0 and a constant variance. However, the relatively large variability of the residuals indicates that there may be other significant predictor (independent) variables that are currently not in the models. The obvious example of a factor that is not currently included in the model is evaporation, and evaporation is an important process in salinity variation. However, direct measurements of evaporation on a daily basis are not available for use. Work by Nuttle (2003) has produced monthly estimates for evaporation in Florida Bay. Use of a spline-curve

Figure 1. The Everglades and Florida Bay Study Area Showing Monitoring Stations

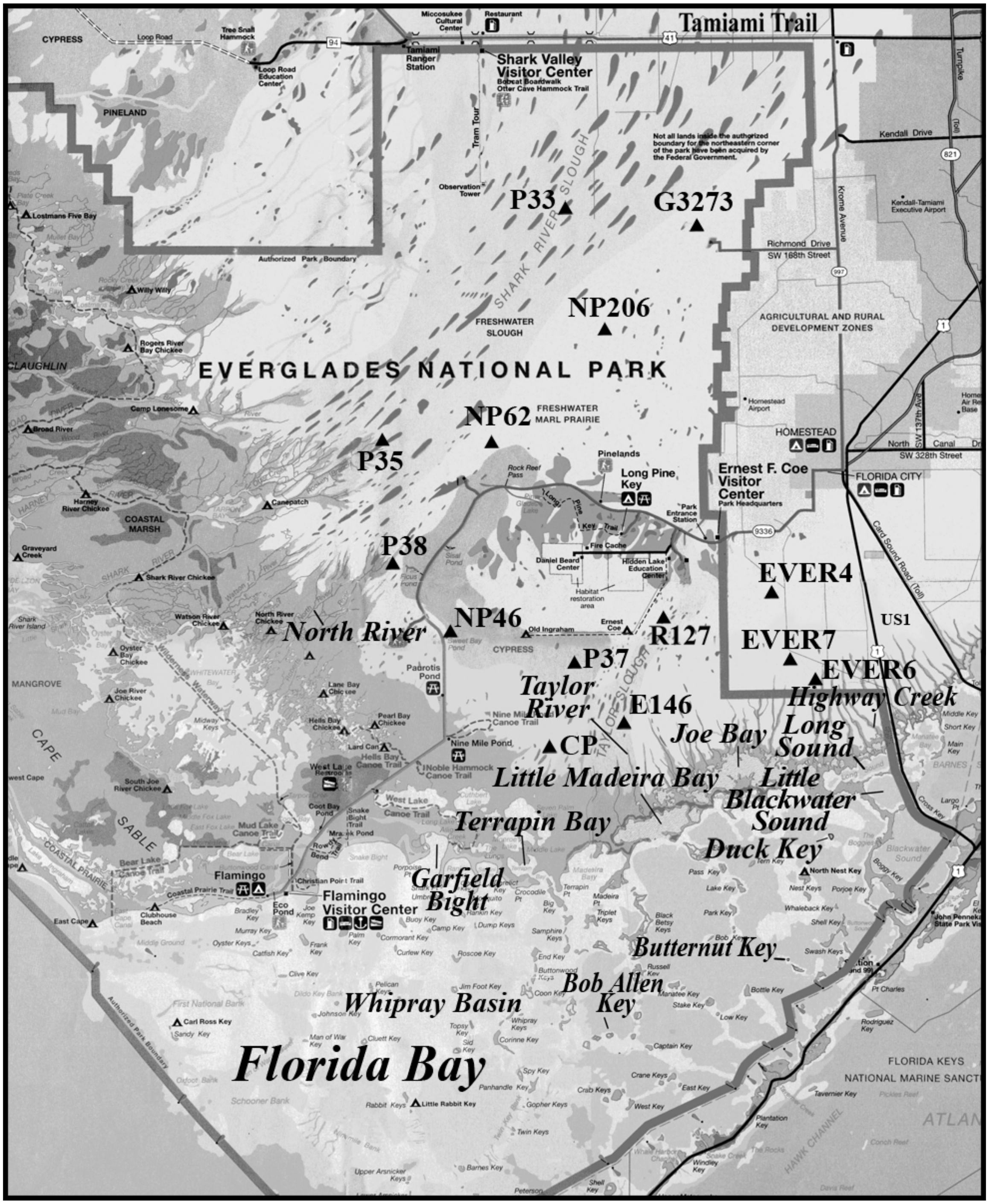


Table 1. Summary of information about the dependent and independent variables used in model development and verification, and in simulations.

Variable Name	Dependent or Independent	Variable Type	Units	Data Source	Location
Little Madeira Bay	Dependent	Salinity	PSU	ENP	Near-shore Florida Bay
Terrapin Bay	Dependent	Salinity	PSU	ENP	Near-shore Florida Bay
Long Sound	Dependent	Salinity	PSU	ENP	Near-shore Florida Bay
Joe Bay	Dependent	Salinity	PSU	ENP	Near-shore Florida Bay
Little Blackwater Sound	Dependent	Salinity	PSU	ENP	Near-shore Florida Bay
North River	Dependent	Salinity	PSU	ENP	Southwest Coast
Taylor River	Dependent	Salinity	PSU	ENP	Mangrove Zone
Highway Creek	Dependent	Salinity	PSU	ENP	Mangrove Zone
Whipray Basin	Dependent	Salinity	PSU	ENP	Open Water Florida Bay
Duck Key	Dependent	Salinity	PSU	ENP	Open Water Florida Bay
Butternut Key	Dependent	Salinity	PSU	ENP	Open Water Florida Bay
Bob Allen Key,	Dependent	Salinity	PSU	ENP	Open Water Florida Bay
Cp	Independent	Water Level	Ft, NGVD 29	ENP	Craighead Pond
E146	Independent	Water Level	Ft, NGVD 29	ENP	Taylor Slough
Ever4	Independent	Water Level	Ft, NGVD 29	ENP	So. Of FL City
Ever6	Independent	Water Level	Ft, NGVD 29	ENP	So. Of FL City
Ever7	Independent	Water Level	Ft, NGVD 29	ENP	So. Of FL City
G3273	Independent	Water Level	Ft, NGVD 29	ENP	East of S.R. Slough
NP206	Independent	Water Level	Ft, NGVD 29	ENP	East of S.R. Slough
NP46	Independent	Water Level	Ft, NGVD 29	ENP	Rocky Glades
NP62	Independent	Water Level	Ft, NGVD 29	ENP	East of S.R. Slough
P33	Independent	Water Level	Ft, NGVD 29	ENP	Shark River Slough
P35	Independent	Water Level	Ft, NGVD 29	ENP	Shark River Slough
P37	Independent	Water Level	Ft, NGVD 29	ENP	Taylor Slough
P38	Independent	Water Level	Ft, NGVD 29	ENP	Shark River Slough
R127	Independent	Water Level	Ft, NGVD 29	ENP	Taylor Slough
uwndkw	Independent	E-W Wind	N/A	NWS	Key West
vwndkw	Independent	N-S Wind	N/A	NWS	Key West
uwndmia	Independent	E-W Wind	N/A	NWS	Miami
vwndmia	Independent	N-S Wind	N/A	NWS	Miami
Kwwatlev	Independent	Tide Elevation	Ft, NGVD 29	NOS	Key West

method of interpolation to produce daily estimates did not create a time series that was significant as a predictor variable when tested.

Other predictor variables that were not included in the preliminary MLR salinity models that were investigated include the use of some measure of the hydraulic gradient in Shark River Slough, Taylor Slough, and in the eastern panhandle area. The following gradient independent variables were defined and evaluated:

R127 - E146
R127 - P37
P33 - P37
P33 – NP206
EVER4 - EVER6
EVER7 - EVER4.

Feedback on the preliminary models prepared during the first year of the project indicated that there was concern with the high number of independent variables in some of the models. An evaluation of the models (including gradient variables) showed that the significance level threshold for keeping a parameter in a model could be raised as high as 0.999 and there would still be 5-10 independent variables in each model, and the R^2 value remained high. This means that there was not much loss in explanatory power when the lesser significant parameters were dropped from the models, many of which were expressions of cross-correlation in the data.

IV. Observed Versus Model-Produced Data for Model Development

During April, 2003 visits were made to the SFWMD to coordinate obtaining the 2X2 model output for the ICU runs when it becomes available. From these meetings, it was learned that the 2X2 model output flow data may have a higher level of uncertainty compared to the water level simulations. Additionally, some of the water management structures have not been in place for the full 36-year period of the evaluations. Because of this and the fact that the correlation analysis showed that flow data are not as highly correlated to salinity at the locations in this study as water level in the Everglades (stage), a decision was made not to include any structure flows in the updated models.

When 2X2 model output data are compared to observed data, the 2X2 data frequently show a bias, greater at some stations than at others. A decision was made to adjust the 2X2 model data before they are input to the MLR salinity models in order to obtain a "best" simulation. When this is done, a higher Pearson's correlation coefficient value is obtained for 2X2 stage output and observed data. Initially, the bias was computed from the overlap period of 1995. When 2X2 model version 5.0 became available, this period of comparison was increased to 1996-2000. The bias between the two series' is then added or subtracted to/from the 2X2 model data.

The Southern Estuaries Sub-team is charged with the development of tools for Interim CERP Update (ICU) evaluations. They have developed performance measures for salinity in the embayments of Florida Bay. MLR salinity models were considered for use with the ICU performance measure evaluations at their July 2003 meeting. A recommendation was made by the Sub-team to use the CESI MLR salinity models for their performance measure evaluations for Florida Bay salinity. When the choice was made between models developed from observed stage data and models developed from 2X2 model stage data, the decision was made to develop the models to be used for ICU evaluations from the 2X2 model calibration/verification stage values, assuming that the 2X2 model would not be updated again for ICU evaluations.

However, the 2X2 model was subsequently re-calibrated, leading to the finding that observed data are the appropriate data for model development are observed data. Additionally, there is a strong aversion within the scientific community to using models that were developed from other modeled data, despite the fact that they have the ability to provide more accurate predictions, and are statistically sound.

Nonetheless, the models that were developed from 2X2 model output are presented below. These models should only be used with 2X2 model version 5.0.19 stage data, and historical wind and sea level data.

JOE BAY = 68.2 - 6.6 (P33 –P35) + 3.2 (EVER4 – EVER6) - 6.7 E146[lag2]
 - 6.3 EVER6[lag6] - 5.7 P35[lag7] - 0.094 uwndkw + 0.074 uwndkw[lag2]
 - 0.155 uwndmia[lag1] - 0.161 vwndmia[lag1]+ 7.0 kwwatlev[lag2]

LITTLE MADEIRA BAY = 34.6+ 2.2 (P33-P35) - 1.44 CP - 4.4 CP[lag21]
 + 1.9 NP46[lag17] - 2.4 R127[lag8] - 2.9 P33 - 0.15 vwndmia[lag1]
 + 3.8kwwatlev

TERRAPIN BAY = 32.5 - 4.0 (EVER4 – EVER6) - 8.7 CP[lag1] - 4.5 E146
 + 4.4 G3273[lag2] + 2.2 NP206[lag1] - 5.1 P33[lag2] - 4.4 P35[lag6]
 - 0.31 uwndkw[lag1] - 0.24 vwndkw[lag2] + 2.8 kwwatlev + 5.2 kwwatlev[lag2]

GARFIELD BIGHT = 4.5 + 5.9 (P33-P35)[lag1] - 4.3 CP - 8.0 E146[lag1]
 - 7.8 EVER4 - 6.0 NP46[lag1] + 4.4 P37[lag1] + 10.2 R127 - 0.19 uwndkw
 - 0.14 uwndkw[lag2] + 0.09 vwndmia + 3.8 kwwatlev[lag1]

NORTH RIVER = 18.3 + 4.6 (P33-P35)[lag3] + 2.9 (EVER4-EVER6) - 4.3 CP
 + 4.8 E146[lag2] - 4.9 NP206[lag3] - 2.4 NP46[lag2] - 2.8 P37[lag2]
 + 1.8 kwwatlev [lag2]

In all of the models that are presented in this report, the following naming conventions have been adopted: kwwatlev is the water level measured at Key West; uwndmia and vwndmia are the *U* and *V* vectors of wind as measured at the Miami weather station; uwndkw and vwndkw are the *U* and *V* vectors of wind measured at Key West. These components are computed as follows:

U = (Resultant wind speed) * Cosine (Resultant direction)
V = (Resultant wind speed) * Sine (Resultant direction).

Resultant wind speed and direction are the daily average values as reported in the National Weather Service data archives. "Lag" refers to the value of the independent variable at the day in the past to be used in the model with the present day values of the other parameters.

The adjusted-R^2 values for these models prepared from 2X2 model output are as follows:

Joe Bay Salinity – 0.87
Little Madeira Bay Salinity – 0.79
Terrapin Bay Salinity – 0.81
Garfield Bight Salinity – 0.74
North River Salinity – 0.88.

V. MLR Salinity Models for the IOP Evaluation

At a CESI project progress meeting in early August 2003, it was decided that MLR salinity models would be used for the ENP IOP evaluations. The IOP evaluations were deemed a priority by ENP. To complete them, a 6-month extension to this CESI project was requested and granted. In the end, the IOP evaluation project was instrumental in showing that MLR salinity models could be used to compare various operational alternatives. It was also instrumental in determining the final activities for the second year CESI project. After the IOP evaluation project started, it became clear that some of the IOP models, prepared using observed data, could also be used for the ICU evaluations.

Updated MLR salinity models were prepared for the IOP evaluation. These models are physically defensible (see the Discussion section below) with terms in each model that are reasonable. Examination of each model shows that the most important Everglades water level station is Craighead Pond (CP), which appeared in all of the near shore models. Some combination of wind vectors also appeared in all models except the North River model (including all open water locations), which is as expected. Sea level (tide) appeared in most models, but not all. Because the significance level was set at a very high level for inclusion of a parameter in a model (0.999), it is expected that there are other parameters that would have been significant had the significance level been specified at a lower level more typically seen in other statistical evaluations (say 0.95 or 0.90). However, the fact that the significance level is so high means that there is little doubt as to the importance of the parameters in the models in explaining the variation in salinity when all of the other parameters are also being included.

Comparisons of water management operational scenarios were made using salinity estimated by the IOP models. Stage simulations for 31 years of data from the 2X2 model (ver. 4.5) for IOP, ISOP, Base 95 (same as 95 Restudy) and Natural Systems Model (NSM 4.5) operational conditions were used with historical wind and sea level data to simulate salinity with the IOP MLR salinity models. Comparative statistics prepared from the time series simulations were then evaluated, and statistically significant differences in salinity can be detected at most of the stations. This application showed that the MLR models have done their job, simulating salinity and providing consistent results that are supported by the current level of knowledge in hydrology and physiography of Florida Bay. The operational comparisons show that the MLR salinity models can adequately estimate salinity in a manner that will allow the comparisons to be made.

The conclusions of the IOP evaluation study can be summarized as follows (Marshall, 2003b):

1. Statistical models can be used for the reasonable simulation of salinity using multivariate linear regression techniques.
2. The evaluation procedure using the MLR salinity models with 2X2 model output for Everglades water levels and historical data for wind and sea level to simulate

long-term operations for Base95 and IOP / ISOP water delivery scenarios show an increase in salinity values at the following locations, primarily during the dry season, for monthly average values (80% significance level):

- Little Madeira Bay
- Terrapin Bay
- North River
- Whipray Basin
- Duck Key
- Butternut Key

3. No effect of IOP / ISOP operations compared to Base95 31-year simulations was seen in the salinity regime of Joe Bay and Long Sound.

The IOP salinity models that were developed are as follows and plots are presented in Figures 2 - 9:

JOE BAY = 37.1 - 3.1CP - 3.5EVER6[lag6] - 10.5E146[lag6] - 0.19uwndkw - 0.09uwndkw[lag2] - 0.1vwndkw - 0.16vwndmia[lag1], Adj-R^2 = 0.74

LITTLE MADEIRA BAY = 66.4 – 3.6CP[lag2] - 6.3P33[lag2] - 0.83(P33-NP206) – 0.21uwndkw + 0.15uwndmia - 0.14vwndmia[lag1] + 0.8kwwatlev[lag2], Adj-R^2 = 0.56

TERRAPIN BAY = 106.9 - 6.3CP[lag1] - 11.1P33[lag2] - 0.45uwndkw - 0.23uwndkw[lag1] - 0.2uwndkw[lag2] - 0.14vwndkw[lag2] + 0.46uwndmia + 1.9kwwatlev[lag2], Adj-R^2 = 0.76

LONG SOUND = 42.2 - 9.5CP[lag4] - 5.2EVER7[lag2] - 1.7EVER6[lag2] - 0.04vwndmia[lag1], Adj-R^2 = 0.80

NORTH RIVER = 36.7 - 4.3CP - 3.8CP[lag3] - 3.4NP206[lag3] + 0.6kwwatlev[lag2], Adj-R^2 = 0.86

WHIPRAY BASIN = 21.1 + 0.24ltmad[lag3] + 0.2terbay + 0.15terbay[lag3] - 0.04vwndkw[lag2] - 0.5kwwatlev[lag2], Adj-R^2 = 0.80

DUCK KEY = 10.2 + 0.3ltmad[lag1] + 0.4ltmad[lag3] + 0.10uwndkw[lag1] + 0.13vwndkw[lag2] + 0.5kwwatlev, Adj-R^2 = 0.70

BUTTERNUT KEY = 15.4 + 0.14ltmad[lag1] + 0.44ltmad[lag3] + 0.03terbay[lag3] - 0.08uwndkw - 0.10uwndkw[lag2] + 0.4kwwatlev, Adj-R^2 = 0.65

Figure 2. Joe Bay salinity model development plot (IOP) – Calibration is March 24, 1995– October 31, 2002; Verification is March 24, 1994 – March 23, 1995.

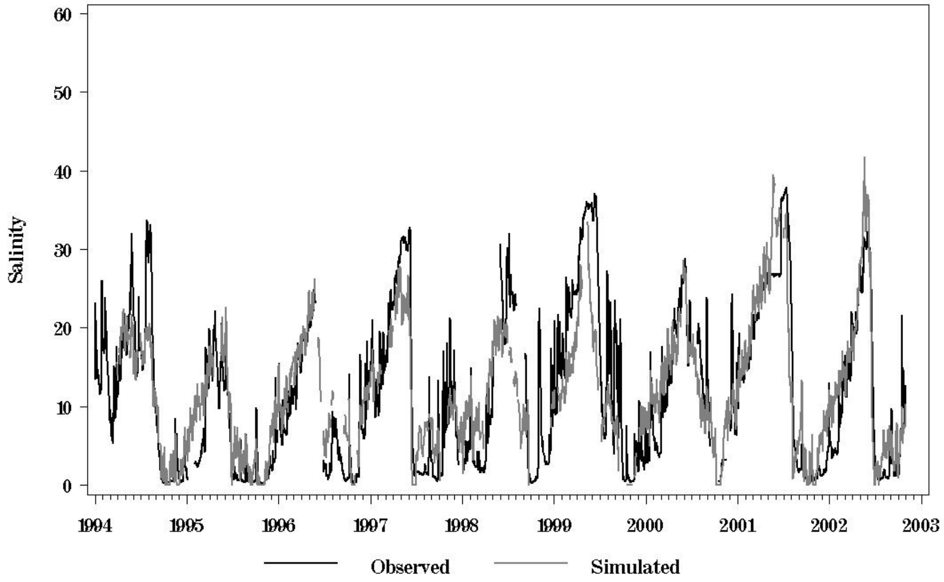


Figure 3. Little Madeira Bay salinity model development plot (IOP) – Calibration is March 24, 1995– October 31, 2002; Verification is March 24, 1994 – March 3, 1995.

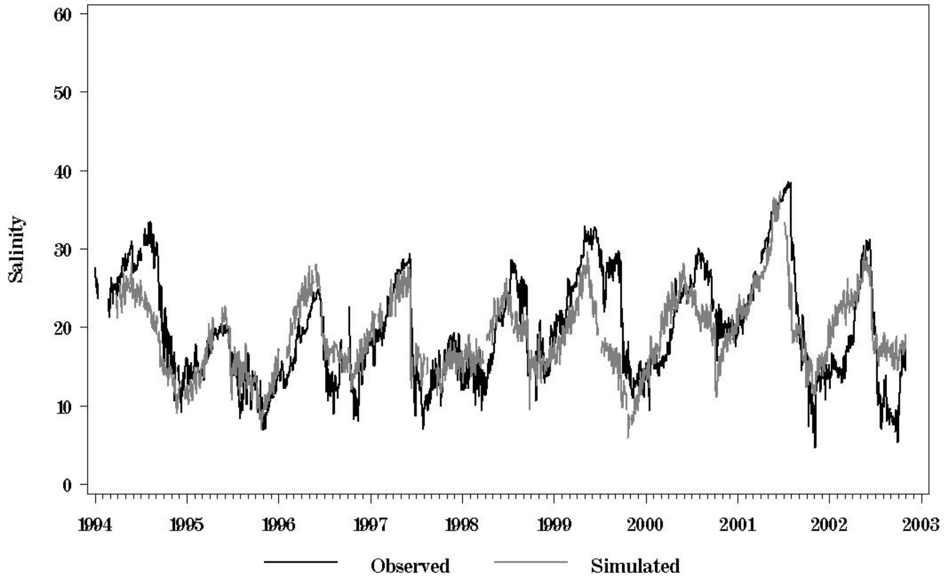


Figure 4. Terrapin Bay salinity model development plot (IOP) – Calibration is March 24, 1995– October 31, 2002; Verification is March 24, 1994 – March 3, 1995.

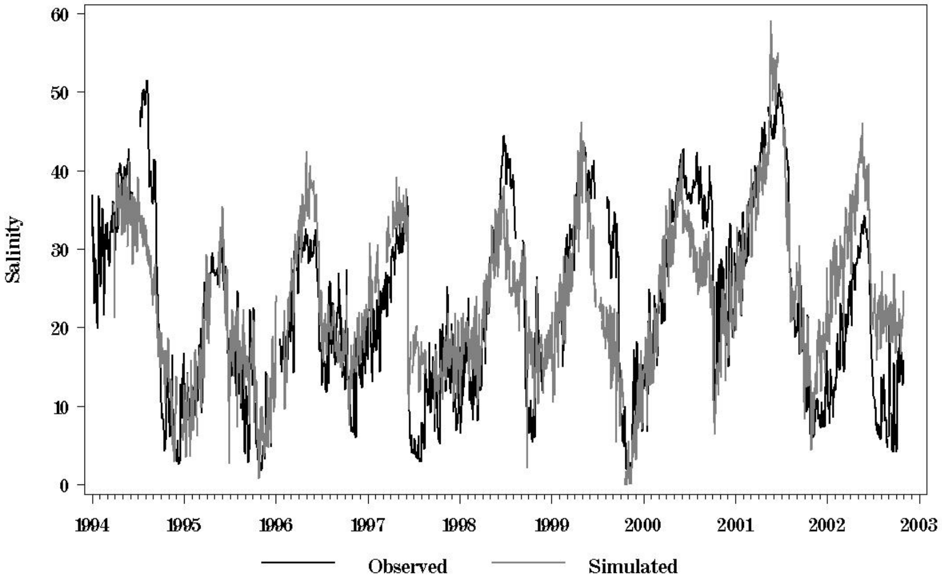


Figure 5. Long Sound salinity model development plot (IOP) – Calibration is March 24, 1995– October 31, 2002; Verification is March 24, 1994 – March 3, 1995.

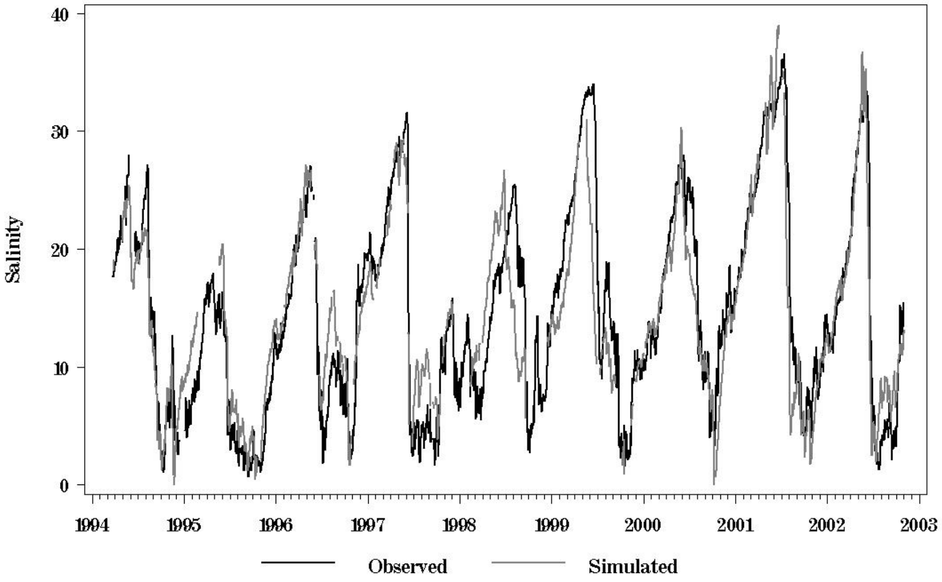


Figure 6. North River salinity model development plot (IOP) – Calibration is March 24, 1995– October 31, 2002; Verification is March 24, 1994 – March 3, 1995.

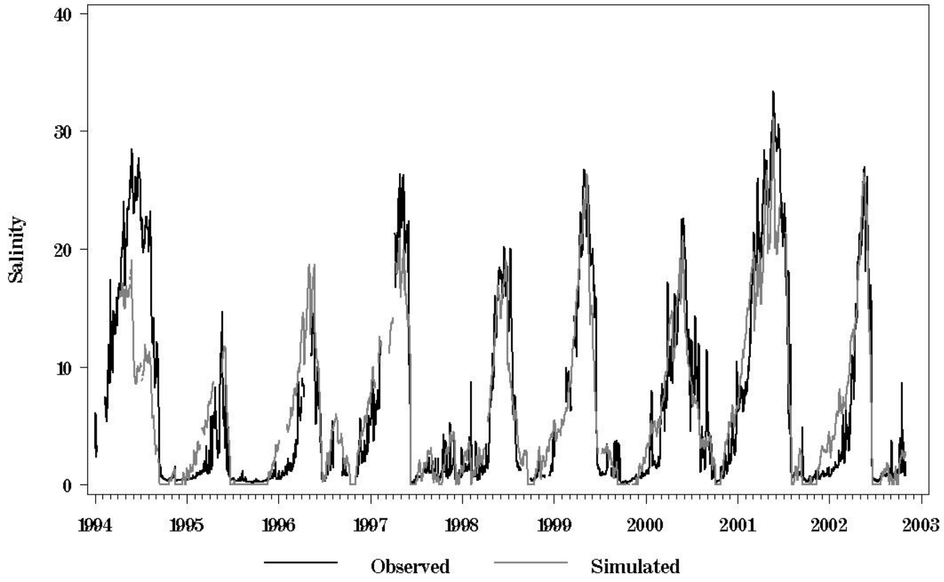


Figure 7. Whipray Basin salinity model development plot (IOP) – Calibration is March 24, 1995– October 31, 2002; Verification is March 24, 1994 – March 3, 1995.

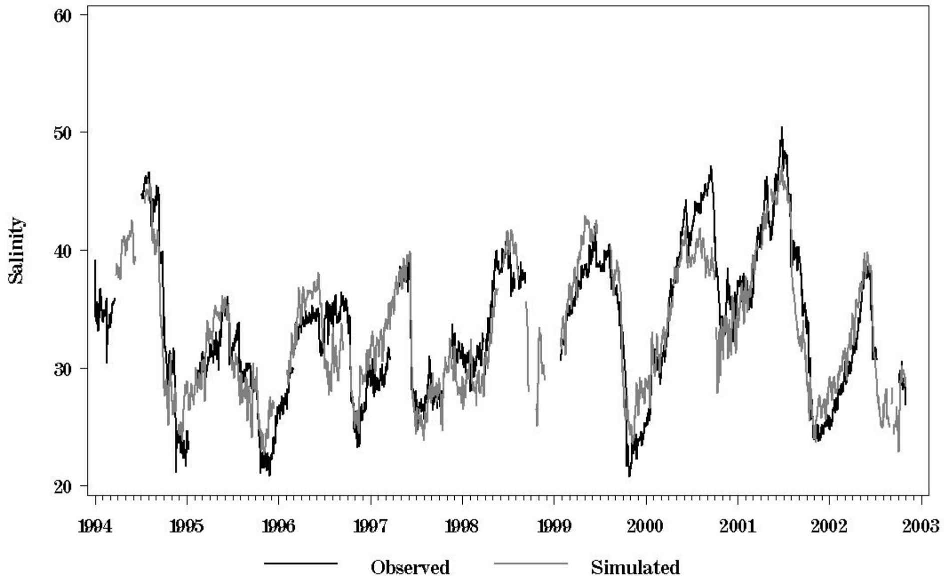


Figure 8. Duck Key salinity model development plot (IOP) – Calibration is March 24, 1995– October 31, 2002; Verification is March 24, 1994 – March 3, 1995.

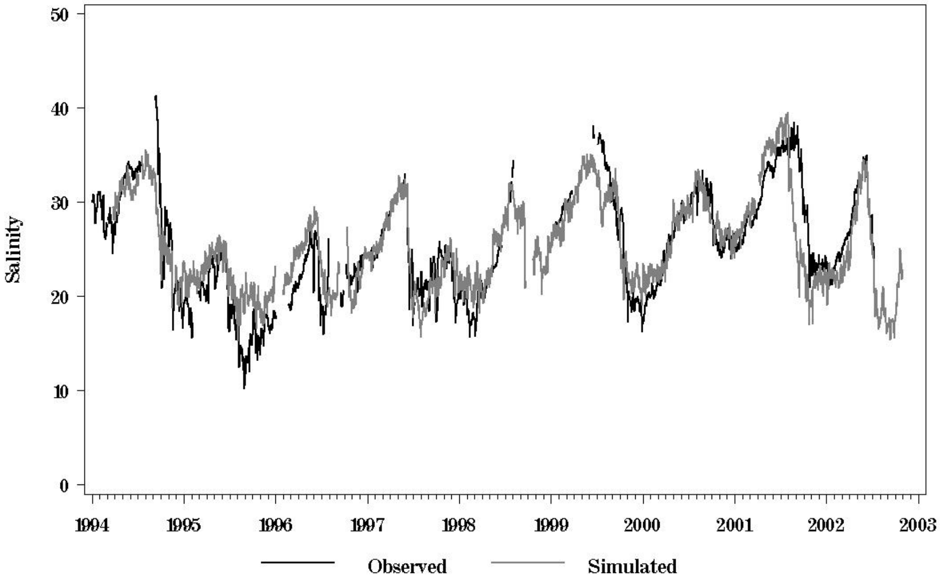
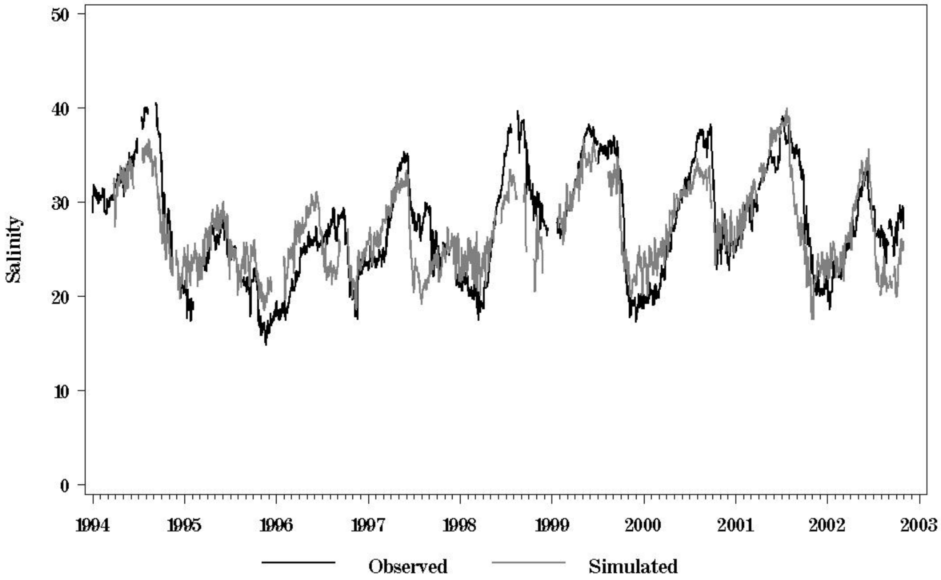


Figure 9. Butternut Key salinity model development plot (IOP) – Calibration is March 24, 1995– October 31, 2002; Verification is March 24, 1994 – March 3, 1995.



VI. Additional MLR Salinity Models

New MLR salinity models were prepared from observed data as part of this second year CESI project for Taylor River, Highway Creek, Little Blackwater Sound, and Bob Allen Key. The models are as follows:

TAYLOR RIVER = 83.2 - 15.1CP[lag4] + 0.8kwwatlev - 7.8(P33-P37)[lag1] - 4.4srsdiff1[lag4], Adj-R^2 = 0.78

HIGHWAY CREEK = 71.0 - 4.6E146[lag1] - 13.1EVER6[lag3] - 3.4R127[lag3] + 0.15uwndkw[lag1] + 0.1vwndkw[lag2] + 0.2uwndmia[lag3] - 4.4(P33-P37), Adj-R^2 = 0.81

LITTLE BLACKWATER SOUND = 42.5 -7.65CP[lag6] - 6.3EVER7[lag5] + 0.1vwndkw, Adj-R^2 = 0.75

BOB ALLEN KEY = 19.4 - 0.04uwndkw - 0.07uwndkw[lag2] - 0.06vwndkw[lag2] + 0.3ltmad + 0.25ltmad[lag3] + 0.08terbay[lag3], Adj-R^2 = 0.75.

Plots of the model simulations compared to the observed data for the model development and verification periods are presented as Figures 10 -13.

Figure 10. Comparison of Observed and Simulated Data for the Taylor River MLR Model – Calibration is March 24, 1995 – October 31, 2002; Verification is March 24, 1994 – March 3, 1995.

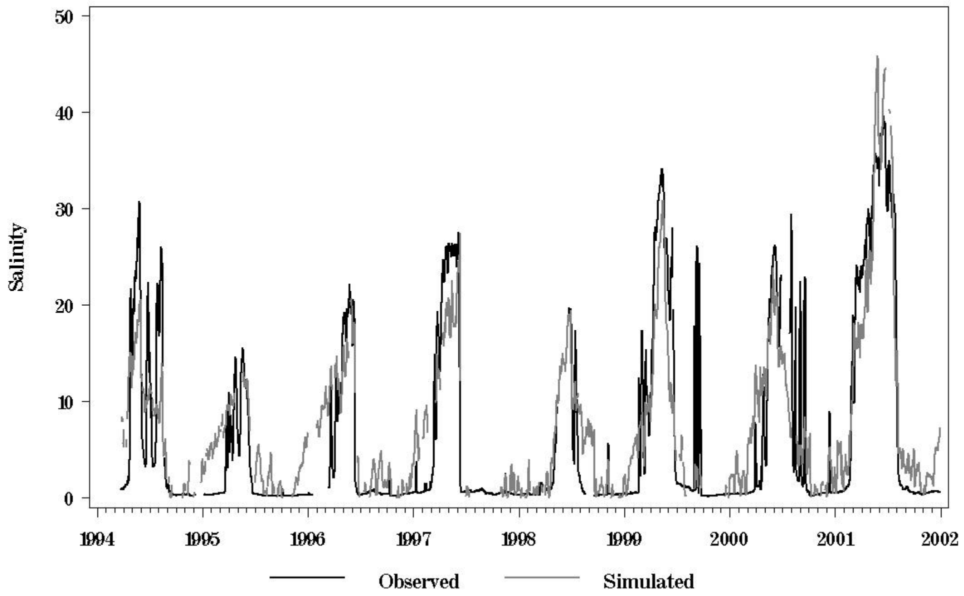


Figure 11. Comparison of Observed and Simulated Data for the Highway Creek MLR Model – Calibration is March 24, 1995 – October 31, 2002; Verification is March 24, 1994 – March 3, 1995.

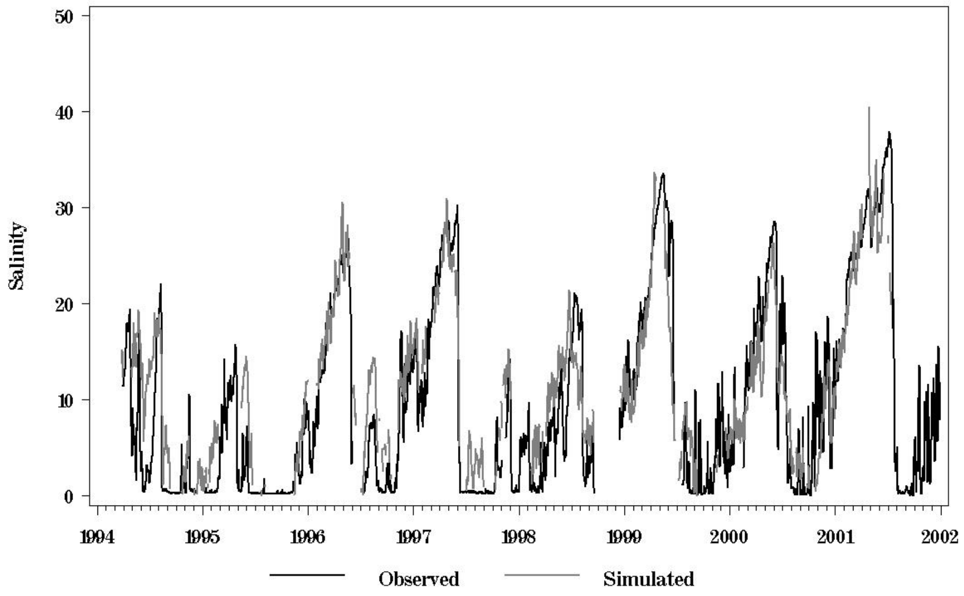


Figure 12. Comparison of Observed and Simulated Data for the Little Blackwater Sound MLR Model – Calibration is March 24, 1995 – October 31, 2002; Verification is March 24, 1994 – March 3, 1995.

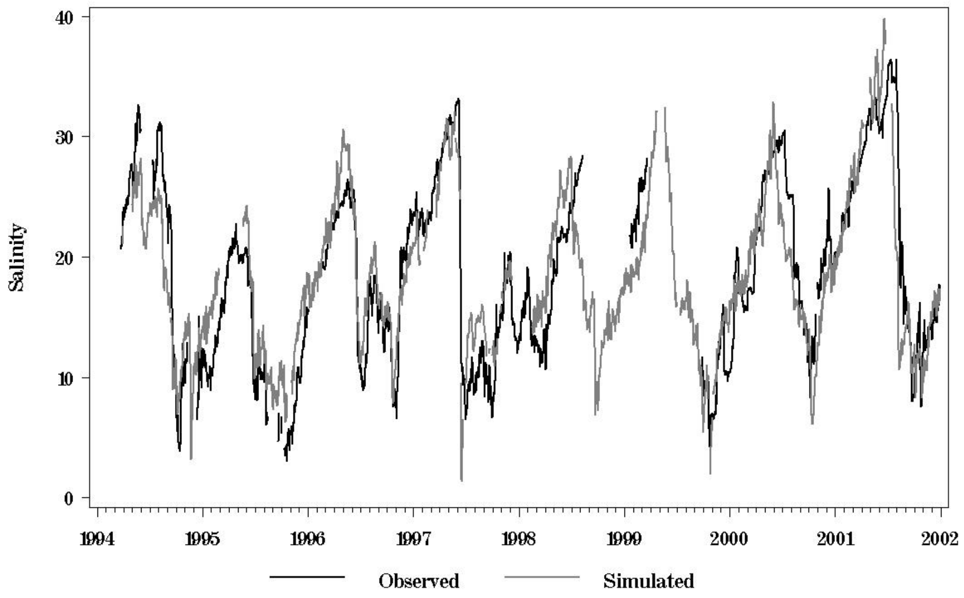
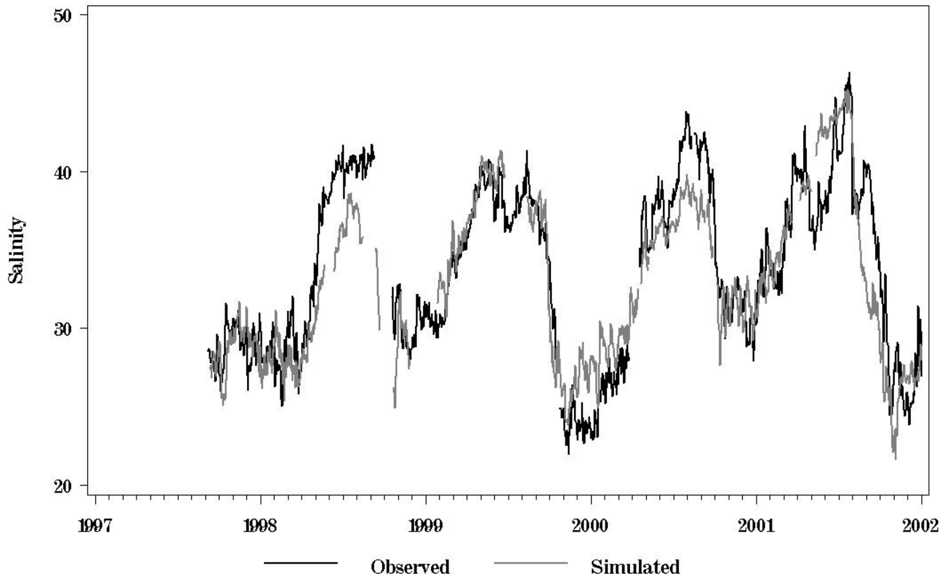


Figure 13. Comparison of Observed and Simulated Data for the Bob Allen Key MLR Model – Calibration is September 9, 1998– October 31, 2002; Verification is September 9, 1997 – September 8, 1998.



VII. Extended Period Models

The period of record for salinity and Everglades water level data at several stations extends back in time beyond March 24, 1994 (the beginning date for the this CESI / IOP dataset). For salinity, the period of record in the data available to the PI for Little Madeira Bay extends to August 25, 1988, and the period of record for Terrapin Bay extends to September 12, 1991. The period of record for the stage stations in the Little Madeira Bay and Terrapin Bay models covers the extended periods. In addition, the salinity models of Whipray Basin, Duck Key, and Butternut Key are a function of Little Madeira Bay and Terrapin Bay salinity (in addition to wind and sea level parameters), and the record at each of these open-water salinity stations extends at least as far as the Terrapin Bay salinity data. Therefore, extended period models can also be developed for these three open-water stations for the period extending to September 12, 1991. For these five extended period models, the model development data continues through September 31, 2001. The period from October 1, 2001 through September 31, 2002 was used for verification purposes in order to use the data from the start of the period for model development because the late 1980's was a period of relatively severe drought.

There were several objectives for preparing MLR salinity models with an extended period of data. Although there have been several short duration dry periods during the period of record used for development of the IOP/CESI models, there have been questions as to how well the MLR salinity models will perform during extended periods of drought, such as the severe drought experienced by south Florida in the mid-1980's. Therefore, one of the reasons for preparing the extended period models is to determine the effect on the models of including this additional data.

The MLR salinity models developed with the extended period of data are as follows:

LITTLE MADEIRA BAY = 106.1 - 0.3CP[lag2] - 12.5P33[lag2] - 1.7(P33-NP206) - 0.25uwndkw + 0.13uwndmia - 0.19vwndmia[lag1] + .95kwwatlev[lag2], Adj-R^2 = 0.65

TERRAPIN BAY = 101.2 - 7.4CP[lag1] – 10.0P33[lag2] - 0.36[uwndkw] - 0.20uwndkw[lag1] - 0.21uwndkw[lag2] - 0.19vwndkw[lag2] + 0.31uwndmia + 1.4kwwatlev[lag2], Adj-R^2 = 0.71

WHIPRAY BASIN = 21.0 + 0.0004vwndkw[lag2] + 0.21kwwatlev[lag2] + 0.2ltmad[lag3] + 0.20terbay + 0.19terbay[lag3], Adj-R^2 = 0.77

DUCK KEY = 9.6 + 0.06uwndkw[lag1] + 0.15vwndkw[lag2] + 1.1kwwatlev + 0.33ltmad[lag1] + 0.45ltmad[lag3], Adj-R^2 = 0.70

BUTTERNUT KEY = 14.6 + -0.06uwndkw - 0.09uwndkw[lag2] + 0.96kwwatlev + 0.13ltmad[lag1] + 0.47ltmad[lag3] + 0.06terbay[lag3], Adj-R^2 = 0.66

Plots of these extended periods models showing the comparison between observed and simulated data are presented in Figures 14 – 18.

Figure 14. Comparison of Observed and Simulated Data for the Little Madeira Bay Extended Period MLR Model – Calibration is August 25, 1988 – October 31, 2001; Verification is November 1, 2001 – October 31, 2002.

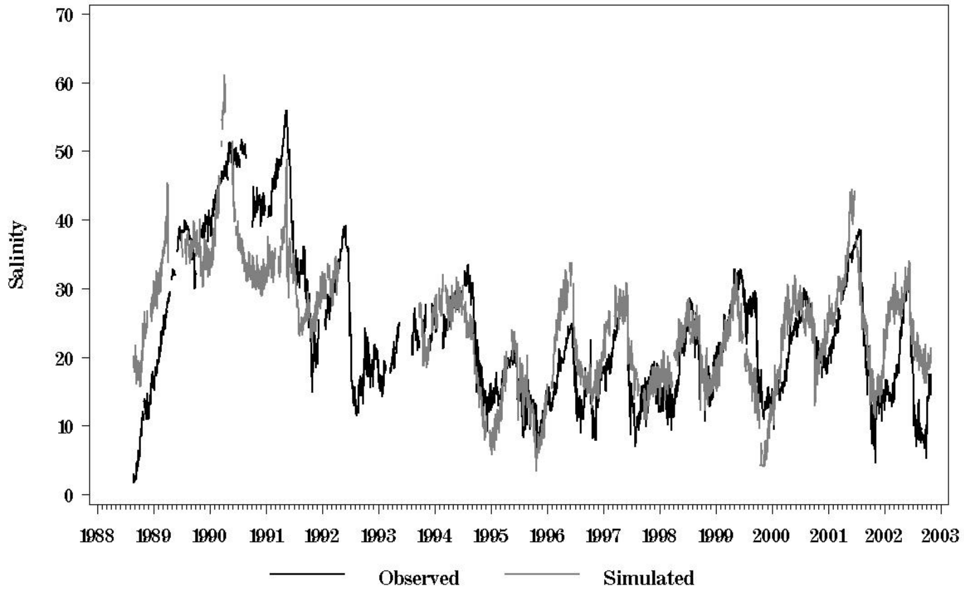


Figure 15. Comparison of Observed and Simulated Data for the Terrapin Bay Extended Period MLR Model – Calibration is September 12, 1991 – October 31, 2001; Verification is November 1, 2001 – October 31, 2002.

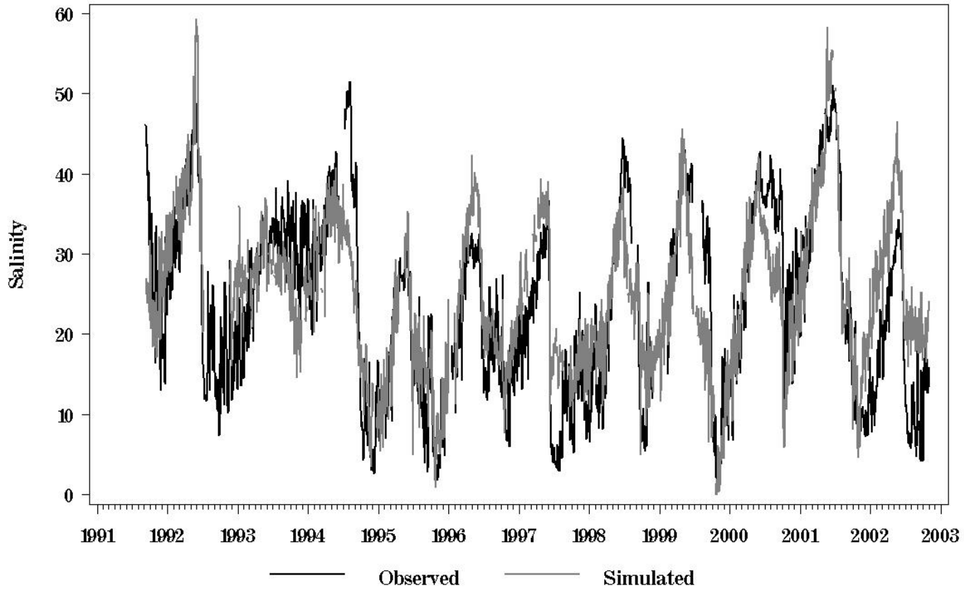


Figure 16. Comparison of Observed and Simulated Data for the Whipray Basin Extended Period MLR Model – Calibration is September 12, 1991 – October 31, 2001; Verification is November 1, 2001 – October 31, 2002.

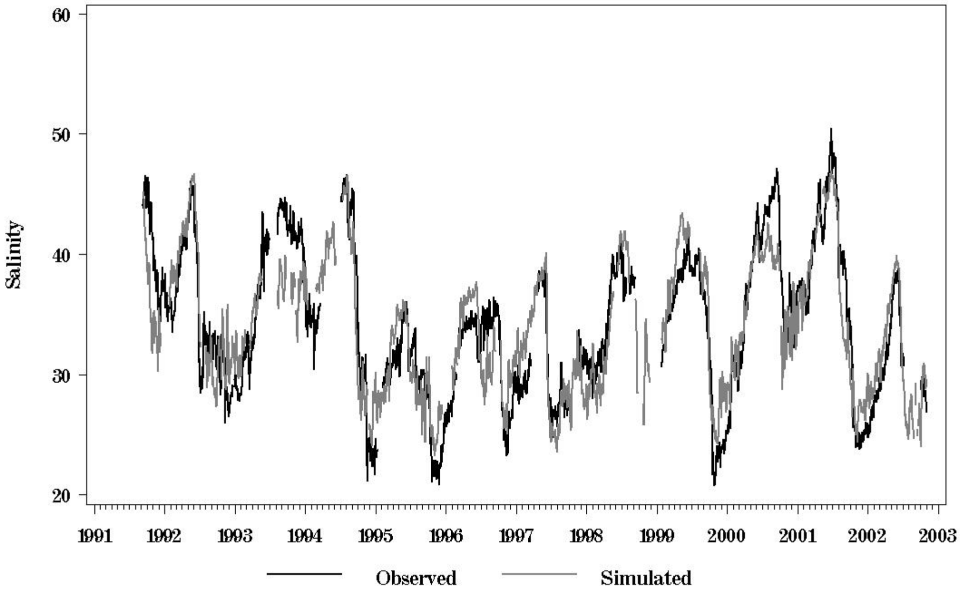


Figure 17. Comparison of Observed and Simulated Data for the Duck Key Extended Period MLR Model – Calibration is September 12, 1991 – October 31, 2001; Verification is November 1, 2001 – October 31, 2002.

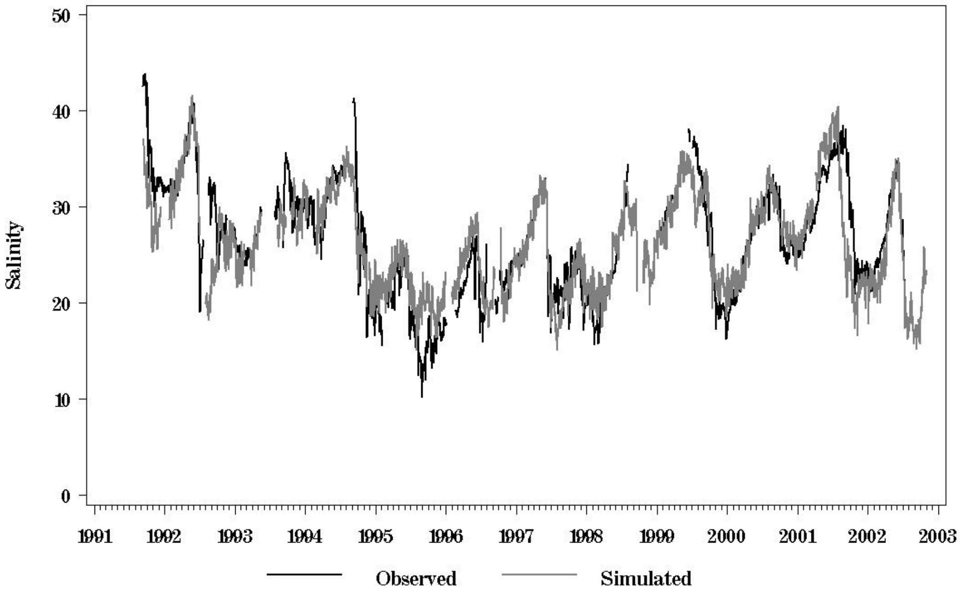
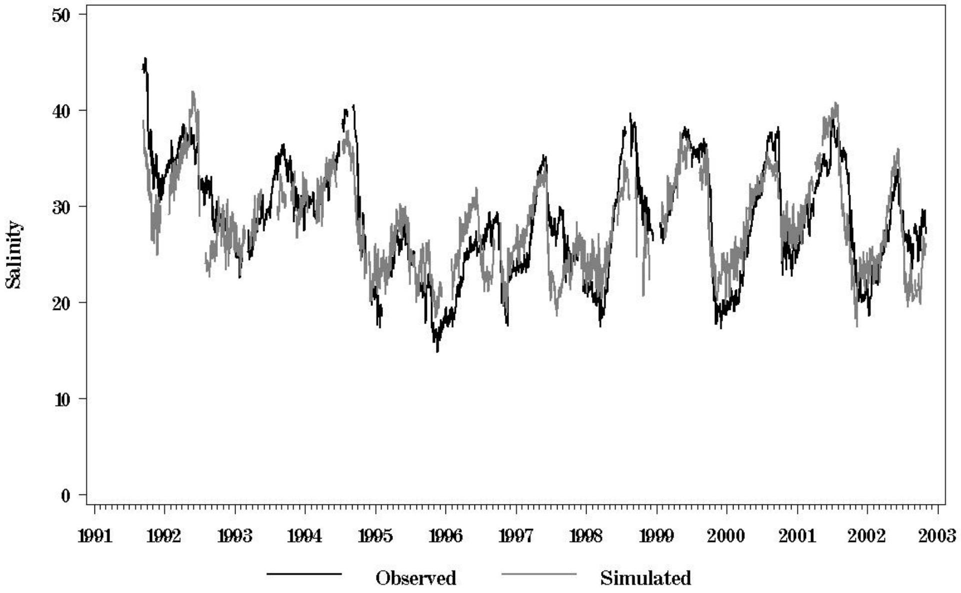


Figure 18. Comparison of Observed and Simulated Data for the Butternut Key Extended Period MLR Model – Calibration is September 12, 1991 – October 31, 2001; Verification is November 1, 2001 – October 31, 2002.



VIII. Coupling the 2X2 Model and MLR Salinity Models for Salinity Simulations

The ICU evaluations for salinity performance measures will include the analysis of simulations made using the MLR salinity models coupled with output from the 2X2 model for Everglades water level, and historic wind and sea level data. At the time of preparation of this report, the only 2X2 model ICU output available on the SFWMM (2X2) model version 5.0 website (accessed through www.evergladesplan.org) are 95 Restudy, 2000 CERP, NSM 4.5, and NSM 4.6. These 31- and 36-year stage simulations were used to simulate salinity at the following stations:

1. Joe Bay
2. Little Madeira Bay
3. Terrapin Bay
4. Whipray Basin
5. Duck Key
6. Butternut Key
7. Taylor River
8. Highway Creek
9. Little Blackwater Sound
10. Bob Allen Key
11. North River
12. Long Sound.

Before using the 2X2 model stage data for salinity simulations, the calibration / verification run was evaluated to determine how well the most recent update to the 2X2 model simulated the stage records. The average value of the 2X2 model stage estimates was compared to the average value of the observed time series for the 2X2 model verification period of January 1, 1996 through December 31, 2000 to compute the bias of the 2X2 model data. Then the 2X2 model data were adjusted by adding or subtracting the value of the bias (as appropriate) before being used for salinity simulations in the MLR salinity models. Comparison plots for each stage station are presented in Appendix B. These figures show that the 2X2 model stage data is very close to the observed data at some stations (P33 and EVER4 are examples) but not very close at others (P35 and R127 are examples). At R127 the deviation across the time series is almost perfectly constant as evidenced in a Pearson's correlation coefficient of almost 1.0 between the observed and 2X2 model data, though the 2X2 model data are offset from the observed by about 1.7 feet, which is possibly a datum problem. At most locations the deviation is similar through time, while at other locations the deviation varies over the time series. Therefore, it can be expected that the adjustment of the 2X2 model data using the bias in the 2X2 model data will improve the simulative capability for some of the 2X2 model series' more than others.

The plots of the simulations made with adjusted 2X2 model output for the 95 Restudy, 2000 CERP, NSM 4.5, and NSM 4.6, and historical wind and sea level data are presented in the Appendices. In a similar manner, the Southern Estuaries Sub-team work will produce new models for Garfield Bight, Shark River Slough, North River, Whitewater Bay, and Manatee Bay/Barnes Sound. The simulations presented herein are intended to be used as appropriate with the simulations produced by the new models, to compare the various operational scenarios, and to assist in the interpretation of performance measures.

IX. Model Error Statistics

The ability of the MLR salinity models to simulate the observed conditions can be evaluated using a number of error statistics. For this project, the statistics that were computed are described below.

1. Mean Square Error

The Mean Square Error, or MSE, is defined as the square of the mean of the squares of all the errors, as follows:

$$MSE = \frac{1}{N}\sum_{n=1}^{N}(O-P)^{2}$$

2. Root Mean Square Error

The Root Mean Square Error is defined as:

$$RMS = \sqrt{\frac{1}{N}\sum_{n=1}^{N}\left(O^{(n)} - P^{(n)}\right)^2}$$

The Root Mean Square Error is a weighted measure of the error where the largest deviations between observed and predicted values contribute most to this uncertainty statistic. This statistic has units that are the same as the observed and predicted values. It is thought to be the most rigorous tests of absolute error (Hamrick, 2003).

3. Adjusted – R^2

The Coefficient of Multiple Determination (R^2) is the most common measure of the explanatory capability of a model. It is defined as:

R^2 = Sum of Squares Regression/Sum of Squares Total, or
= 1- (Sum of Squares Error/Sum of Squares Total)

R^2 measures the percentage reduction in the total variation of the dependent variable associated with the use of the set of independent variables that comprise the model (Neter, et al; 1990). When there are many variables in the model, it is common to use the Adjusted Coefficient of Multiple Determination, which is R^2 divided by the associated degrees of freedom.

4. Mean Error

The Mean Error is another measure of model uncertainty. It is defined as:

$$ME = \frac{1}{N}\sum_{n=1}^{N}\left(O^{(n)} - P^{(n)}\right)$$

where O=observed values, P=predicted values, and N= number of observations used to develop the model. Positive values of the mean error indicate that the model tends to over-predict, and negative values indicated that the model tends to under-predict (Hamrick, 2003.)

5. Mean Absolute Error

The Mean Absolute Error is defined as:

$$MAE = \frac{1}{N}\sum_{n=1}^{N}\left|O^{(n)} - P^{(n)}\right|$$

Although the Mean Absolute Error tells nothing about over- or under-prediction, it is considered as another measure of the agreement between observed values and predicted values. It is preferred by some because it tends to cancel the effects of negative and positive errors, and is therefore less forgiving compared to the Mean Error (Hamrick, 2003).

6. Maximum Absolute Error

The Maximum Absolute Error is defined as:

$$MAX = \max\left|O^{(n)} - P^{(n)}\right| \quad : \quad n = 1, N$$

The Maximum Absolute Error is the largest deviation between observed and predicted values.

7. Nash-Sutcliffe Efficiency

The Nash-Sutcliffe Efficiency is a measure of model performance that is similar to R^2. It was first proposed for use with models in 1970 (Nash and Sutcliffe, 1970). It is defined as:

$$NSE = 1 - \frac{\sum_{n=1}^{N}(P - O)}{\sum_{n=1}^{N}(O - \overline{O})}$$

The value of the NSE roughly corresponds to the percentage of variation that is explained by a model.

8. Relative Mean Error

Relative measures of error are not as extreme as the absolute measures presented above. Relative error statistics provide a measure of the error relative to the observed value. The Relative Mean Error is defined as:

$$RME = \frac{\sum_{n=1}^{N}\left(O^{(n)} - P^{(n)}\right)}{\sum_{n=1}^{N} O^{(n)}}$$

9. Relative Mean Absolute Error

The Relative Mean Absolute Error is defined as:

$$RMA = \frac{\sum_{n=1}^{N}\left|O^{(n)} - P^{(n)}\right|}{\sum_{n=1}^{N} O^{(n)}}$$

Caution must be applied in the use of these two statistics when there can be small values of the observed and predicted variable, and when they can have both positive and negative signs (Hamrick, 2003).

10. Relative Mean Square Error

The Relative Mean Square Error is not as prone to fouling by small values and/or the presence of both positive and negative values and is defined as (Hamrick, 2003):

$$RSE = \frac{\sum_{n=1}^{N}\left(O^{(n)} - P^{(n)}\right)^2}{\sum_{n=1}^{N}\left(\left(O^{(n)} - \overline{O}\right)^2 + \left(P^{(n)} - \overline{O}\right)^2\right)}$$

The Relative Mean Square Error has values between zero and one, with a model that predicts well having a Relative Mean Square Error close to zero. According to this measure, the most reliable models are the Whipray Basin and Bob Allen Key models, but all models are considered by this measure to be very reliable.

Table 2 presents a summary of the values of these statistics for the various models.

Table 2. Comparison of Model Uncertainty Statistics for MLR Salinity Models

station	mean sq error (mse), psu^2	root mse (rmse), psu	adj R-sq	mean error, psu	mean abs error, psu	max abs error, psu	Nash-Sutcliffe Efficiency
Joe Bay	25.8	5.1	0.75	-0.14	3.7	20.6	0.76
Little Madeira Bay	20.3	4.5	0.56	0.56	3.5	15.4	0.55
Terrapin Bay	32.6	5.7	0.75	-0.99	5.4	5.4	0.67
Whipray Basin	7.2	2.7	0.8	0.11	2.2	10.1	0.77
Duck Key	9.7	3.1	0.71	-0.18	2.27	14.4	0.71
Butternut Key	10.7	3.3	0.65	0.1	2.7	11.3	0.66
Long Sound	15	3.9	0.8	0.31	2.7	18.9	0.81
Taylor River	21.4	4.62	0.78	-0.49	3.6	22.9	0.78
Highway Creek	18.2	4.3	0.81	-0.95	3.7	17.7	0.76
Little Blackwater Sound	14	3.75	0.75	-0.14	2.9	15.7	0.76
North River	8.9	3.0	0.86	0.19	2.3	18.1	0.78
Bob Allen Key	7.2	2.7	0.79	0.3	2.1	9.2	0.81

Table 2., continued.

station	rel mean error	rel mean abs error	rel mean sq error
Joe Bay	0.012 0.32		0.14
Little Madeira Bay	0.027 0.18		0.29
Terrapin Bay	0.044 0.24		0.2
Whipray Basin	0.034 0.07		0.12
Duck Key	-0.007 0.09		0.17
Butternut Key	0.003 0.1		0.21
Long Sound	0.021 0.18		0.11
Taylor River	-0.06 0.47		0.13
Highway Creek	-0.08 0.31		0.14
Little Blackwater Sound	-0.007 0.16		0.14
North River	0.03 0.35		0.11
Bob Allen Key	0.01 0.065 0.12		

When taken as a whole, these error statistics show that the MLR models are good to very good at simulating salinity values.

X. Presentations

A poster presentation was made at the joint conference of the Florida Bay Science Program and the Greater Everglades Ecosystem Restoration in April 2003. In this poster, SARIMA models and MLR models were discussed, including the reasoning behind the choice of MLR salinity models for the 2X2 model evaluations. The newly developed models with gradients included were presented, along with the Whipray Basin transfer model prepared from Joe Bay, Little Madeira Bay, and Terrapin Bay salinity.

A presentation was made by the PI to the Southern Estuaries Sub-team of RECOVER at their July 11, 2003 meeting on the progress that has been made with MLR salinity modeling.

On September 16-18, a poster was presented at the 2004 Estuarine Research Federation Meeting in Seattle, Washington, detailing the progress in the development of MLR salinity models and discussing the use of the models to simulate hypersaline conditions in Florida Bay.

On October 31, 2003, a presentation was made at the Estuarine Indicators Workshop at Sanibel Island, Florida. The current status of MLR salinity models was presented.

XI. Discussion

The second year CESI activities have shown that the MLR salinity models presented herein are capable of making reasonable and reliable simulations of salinity in the near-shore embayments, the mangrove zone, and the open water of Florida Bay over a wide range of hydrologic, meteorological, and sea level conditions. During this second year of the project, the models of the near-shore embayments and mangrove zone evolved into salinity relationships that have a physical basis in the parameters of the model, which are:

1. the variation of the elevation of the freshwater in the Everglades,
2. the variation in the elevation of sea level, and
3. the effect of wind direction and speed.

The MLR salinity modeling procedure relates them using a least squares method and step-wise regression for parameter selection at a significance level of 0.999, which is a very high threshold. The result is a weighting for each independent variable when used in combination with the other independent variables in a linear combination model.

The range of salinity measured at the MMN stations varies widely. At stations in the near-shore embayments and the mangrove zone (Joe Bay, Little Madeira Bay, Terrapin Bay, Garfield Bight, North River, Long Sound, Taylor River, Highway Creek, Little Blackwater Sound) the salinity varies between 0 psu and 35-55 psu. Depending on the location, the salinity may only approach 0 psu (Little Madeira Bay and Terrapin Bay), while at other near-shore locations the salinity remains at 0 psu for longer periods (weeks in the case of Highway Creek and Taylor River). At most locations the transition from high salinity values to low salinity values is more rapid (being described as “flashy” by some) than the transition from low to high salinity values.

To be applied with confidence MLR salinity models must be developed considering the physical phenomena that affect the salinity at a particular location and time in the estuary. The Everglades and the near-shore embayments of Florida Bay are a coastal aquifer system, with the fresh water body and the salt water body competing with each other as other factors (wind, evaporation, direct rainfall) act to reinforce the effects of one or the other or to provide mixing and translocation energy. Coastal aquifers have been studied in other estuarine areas of Florida. Pandit, et al (1991) studied the coastal aquifer and the interface of the surficial aquifer with the Indian River Lagoon in east central Florida. Beneath the barrier islands / peninsulas and coastal plain mainland of the Indian River Lagoon watershed the freshwater surficial aquifer is stored in porous sandy soils at a higher elevation than the saline lagoon or ocean. The location within the soil strata of the interface between the freshwater surficial aquifer and the denser saline water body can be mapped using the Ghyben-Herzberg principle (Pandit et al, 1991). According to this principle, if the elevation of the surficial aquifer is raised sufficiently by recharge, the interface will move towards the coast. If the elevation of sea level is raised, the interface moves towards the mainland (away from the coast) as the salt water intrudes. Because of the density difference between the salt water mass and the freshwater mass, a larger volume of freshwater (compared to salt water) is needed to cause the interface to move an equal distance. In addition, the interface between the surficial aquifer and the saltwater body is known to be a zone of salinity gradient that moves in response to climatic conditions. In south Florida, the U. S. Geological Survey (USGS) has prepared a ground and surface water model that simulates the regional aquifers. Information on the USGS model can be found on the SOFIA website.

In the Everglades, the water table (surficial aquifer) emerges above the ground most wet seasons and freshwater flows as sheet flow towards Florida Bay and the southwest coast of the Gulf of Mexico creating the unique ecosystems that exist in Everglades National Park. While overland flow has less resistance than flow through the substrate, the porous nature of the substrate means that freshwater is still flowing to the coast during the dry season, as evidenced by the continued decline in stage levels at all locations in the Everglades as the dry season evolves. During the dry season, evaporation may also be contributing to the decline of water levels.

Confined to a soil matrix, the interface zone is not affected by other factors that can affect a surface water body. In the absence of wind, direct rainfall, and evaporation, the change in salinity gradient over distance is large within the interface zone, and the “width” of the zone is relatively small. In an open estuary, the conditions are somewhat different. Direct rainfall can dilute the upper layer of the salt water body. Evaporation works in the opposite manner, reducing water mass in both bodies of water. Wind works to move the fluid water bodies in translocation fashion as well as to mix horizontally and vertically the different water masses. The result in estuarine surface water bodies is a relatively wide interface with a relatively gradual salinity change over distance. Because the conductivity probe at a monitoring station is fixed both vertically and horizontally, a particular observation in the near-shore embayments and mangrove zone may be the conductivity (salinity) of the freshwater lens, the interface zone, or the saltwater body, depending on the location of the interface zone. With the exception of the most upstream stations (North River, Highway Creek, and Taylor River), the salinity record shows that the most of the monitoring stations in the near-shore embayments are usually monitoring the salinity in the transition zone. Estuaries by definition are water bodies where a transition zone can exist. In the mangrove zone, the stations are measuring the salinity of the freshwater lens for a longer time.

Therefore, based on the coastal aquifer model presented above, it can be hypothesized that the salinity at a near-shore location is correlated in some manner to elevation of freshwater in the Everglades, sea level elevation, wind, and the watershed hydraulic gradient. Salinity may also be correlated to evaporation and direct rainfall, but those two parameters were not able to be investigated in this study. The results of the correlation analysis using the SARIMA correlation coefficient plot evaluation procedure (see Marshall, 2003) shows that the hypothesis is supported, in general, at the 95% significance level. What is meant by “in general” is that salinity at all locations was correlated with the stage measured at one or more stations in the Everglades, sea level, wind parameters, and hydraulic gradient in the Everglades. At all locations, lagged values of some of the independent variables were also correlated with salinity. However, the salinity at various locations was not always correlated to the same stage observations, but salinity was always correlated with stage in some manner. This means, there are a multitude of simple (univariate) linear regression models that could be prepared from this dataset with a wide range of R^2 values. Substantially improved models can be prepared by taking advantage of cross-correlation relationships in the stage data, and by including wind and sea level.

In this study more than one correlated independent variable is used to improve the fit of the models. The decision as to which independent variable to include in the models was, at first, left to the canned step-wise regression process. The step-wise regression procedure in SAS© begins by evaluating all independent variables that were identified as candidate variables from the correlation evaluation, and then a simple linear regression model is prepared from the candidate variable that produces a model with the highest R^2 value. Then the other candidate independent variables are added to the model one by one. For an independent variable to be kept in the model it must be significant at the 0.999 level using an F-test. If not, that independent variable is dropped from further consideration. Using a lower significance level than 0.999 resulted in models with many independent variables. Setting the selection threshold this high ensured that the parameters in the final models are as highly significant as possible, and reduces the overall Type I error rate.

If this canned step-wise regression process is left to its own devices, it may choose some independent variables for the model that are not physically defensible, but were selected by the program because of statistically advantageous cross-correlation relationships. In particular, there were cases where the step-wise procedure kept a stage variable that would seemingly be increasing salinity with increasing stage, i.e. the stage variable would be in the model with a + sign instead of a – sign. Therefore, the step-wise procedure was modified by eliminating the stage terms that were positive, or sea level terms that were negative.

It was at this point in developing the procedure for building MLR salinity models that the IOP evaluation began, and models using the above described procedure from this CESI project were prepared and used. After the IOP work was completed, there were some comments received regarding the inclusion in some models of stage stations that were not thought to influence salinity at a certain location. The best example of this is the North River IOP model, which includes stage at Craighead Pond (CP). Even though there is a correlative relationship between CP stage and North River salinity, a cause-and-effect relationship is not thought to be possible, because they are many miles apart and there are physical barriers that will not allow a simple raising of the CP elevation (such as by local rainfall) to decrease the salinity at North River. The Southern Estuaries Sub-team will be modifying the IOP model of North River so that it includes primarily stage stations that are directly upstream of the station in Shark River Slough.

Additionally, many of the models include P33, which is in Shark River Slough. The presence of P33 in the models is seen as an expression of the regional nature of the hydrology of the Everglades. There is known to be connectivity between Shark River Slough and Taylor Slough, though there is thought to be less connectivity between the water in Shark River Slough and the mangrove zone of the eastern panhandle of ENP. All models also include wind parameters, and most include sea level. Therefore, the new models for Taylor River, Highway Creek, and Little Blackwater Sound were developed using the concept of a combination of variables that represent the regional hydrology, the local hydrology, wind and sea level elevation, using the step-wise selection method to choose the appropriate independent variables at the 0.999 significance level.

At the open-water stations (Whipray Basin, Duck Key, Butternut Key, and Bob Allen Key), the salinity rarely drops below 20 psu and frequently reaches above 40 psu. The relationship between salinity at the open-water stations and the hydrology of the Everglades is weaker than at the near-shore areas. However, there is a very strong relationship between the salinity in the near-shore embayments and the salinity at the open-water stations. The relationship is particularly strong for Terrapin Bay and Little Madeira Bay. Therefore, the MLR salinity models for the open-water stations were developed using the salinity at Terrapin Bay and Little Madeira Bay along with sea level elevation and wind factors. This means that simulation of open-water salinity is made using a two-step transfer function relationship (using Everglades stage to estimate Little Maderia Bay and Terrapin Bays salinities, then using these salinities to estimate open-water salinity). When Pearson correlation coefficients were compared, the two-step process was found to provide a better simulation than open-water simulations from only Everglades water levels. Therefore, the use of another transfer function to simulate open-water salinity provides improved predictions.

In terms of deliverables, this second year activity produced the following products:

1. A set of salinity models that were developed from 2X2 model output that became obsolete when the 2X2 model was re-calibrated;
2. New MLR salinity models for Taylor River, Highway Creek, Little Blackwater Sound, and Bob Allen Key;
3. New models using an extended period of data for Little Madeira Bay, Terrapin Bay, Whipray Basin, Duck Key, and Butternut Key;
4. 31- or 36-year simulations of salinity at Joe Bay, Little Madeira Bay, Terrapin Bay, Whipray Basin, Duck Key, Long Sound, Butternut Key, Taylor River, Highway Creek, Little Blackwater Sound, and Bob Allen Key for use with ICU evaluations; and
5. A detailed uncertainty analysis.

From the models that became obsolete it was learned that the improvement to fit using 2X2 model data for model development was not worth the benefit when the 2X2 model was unknowingly re-calibrated, an exercise that is likely to happen again in the future.

The new models that were developed for Taylor River, Highway Creek, Little Blackwater Sound, and Bob Allen Key have been added to the IOP models for Joe Bay, Little Madeira Bay, Terrapin Bay, Long Sound, Whipray Basin, Duck Key, and Butternut Key for the ICU evaluations that will be performed by the Southern Estuaries Sub-team of RECOVER. A revised model for North River and (perhaps) Joe Bay will be developed by the USACOE, along with new models for Barnes Sound / Manatee Bay, Garfield Bight, Whitewater Bay, Shark River Slough, and one other station not yet identified (Buckingham, per. com.). The 31- or 36-year simulations in this CESI report will be added to new simulations for four other water management scenarios (D13R Restudy, D13R CERP, 2050 CERP, 2050 Restudy) and used directly for ICU performance measure evaluations. New 31- or 36-year simulations will be generated by the USACOE contractor for the new models that they will be developing.

Therefore, this CESI project has significantly extended the spatial coverage for the ICU evaluations from five near-shore stations (Joe Bay, Little Madeira Bay, Terrapin Bay, Garfield Bight, and North River) to include four open-water stations (Whipray Basin, Duck Key, Butternut Key, and Bob Allen Key), another important near-shore station (Little Blackwater Sound), and two stations in the mangrove zone (Taylor River and Highway Creek). This will allow a more spatially comprehensive look at the operational scenarios, particularly as it relates to the potential for hypersaline events in the open-water areas of Florida Bay.

For the extended period of data the Little Madeira Bay model differed more from the IOP model than the other stations. The R^2 value for the extended period Little Madeira Bay model (0.65) is a substantial improvement over the R^2 value for the IOP model (0.56). For Terrapin Bay, the extended period model coefficients are closer to the IOP model than for Little Madeira Bay, and the R^2 value is less (0.71) than the R^2 value for the IOP model (0.76). The Whipray Basin extended period model also had a slightly improved R^2 value, but the values for the Duck Key and Butternut Key extended period models, and the model coefficients were virtually the same as the IOP models. Therefore, this evaluation of the use of the extended period to produce better models is inconclusive. However, at all stations that the range of the data used for model development has been extended, and there is greater confidence in the use of the models to estimate hypersaline conditions because the model development data included a large number of high salinity values.

The uncertainty evaluation produced a number of measures of the ability of the new models developed by this study to simulate salinity. The error statistics show that all of the MLR salinity models are good to very good in their ability to simulate salinity. The highest relative mean error for the MLR salinity models developed by this study is about 3.5%, but there are several models with absolute relative mean error higher than 25%. However, the relative absolute mean error is known to be highly affected when observed and predicted quantities can have small values or values that have both positive and negative signs, as is the case with the salinity in the near-shore waters and the mangrove zone. It is the models for the stations in these areas that that have the highest values of the relative absolute mean error.

All models also have a relative mean square error of close to 0, which means that the models are rated as highly skilled according to this statistic, except for the Little Madeira Bay model. In general, the uncertainty analysis shows that only the Little Madeira Bay model would benefit from additional model modifications using the initial data set. The extended period Little Madeira Bay model is a substantial improvement over the IOP model, and should be considered for use with the ICU evaluations.

XII. Summary and Findings

This second year CESI project has evolved as the project period passed, and the end product was a broader and more accurate set of MLR salinity models with a better handle on model uncertainty than was possible with the original model scope. The IOP evaluation for the Congressional Report provided an important opportunity to use the initial second year project tasks in an application mode, which accomplished some of the original objectives for the project. In turn this allowed additional salinity models to be developed and simulations to be prepared which can now be used to provide a wider spatial analysis in the ICU evaluations.

The following findings were produced by this project:

1. MLR salinity models that can reasonably simulate observed conditions at a daily time step can be prepared from observed daily average values of Everglades water levels, average daily sea level elevation, and average daily wind speed and direction.
2. Other factors that were identified as potentially able to explain some of the remaining error are evaporation and direct rainfall.
3. Craighead Pond is the stage station that shows up most frequently in the MLR salinity models. The next most frequent stage station in model development is P33.
4. A modification of the canned SAS© step-wise linear regression procedure for parameter selection is needed to produce models with a physically defensible basis.
5. A hydrologic model that shows promise in application to the Everglades / Florida Bay system is the coastal aquifer model with fresh water and salt water masses and an interface zone that can be affected by wind and LOCAL evaporation factors.
6. The Little Madeira Bay MLR model prepared from an extended period of data that included data from the severe drought conditions in the late 1980's and early 1990's was improved as measured by the Adjusted-R^2 value, compared to the model prepared for the IOP evaluation that began in 1995. For the other stations, there was minimal improvement using the extended period data.
7. According to a number of error statistics, the MLR salinity models prepared for this study can be considered as good to excellent for simulation purposes. However, a relatively high maximum absolute error for most of the models may mean that a measure of local evaporation and rainfall would improve this statistic and further improve the MLR salinity models.
8. The simulations produced by this project are ready to be used for the ICU evaluations in a much broader fashion than was envisioned when this project began.

This work has shown that statistical models can be used when there is not enough physical data to develop and implement detailed hydrodynamic models. In the case of the Everglades and Florida Bay, not enough is known about the distribution of freshwater flows into the Bay outside of the gauged creeks. Because of this and the lack of detailed bathymetry needed to accurately describe the banks within the bay, a "traditional" hydrodynamic model has not yet been developed that can adequately simulate salinity. Therefore, MLR salinity models can be used in place of hydrodynamic models for analysis of water management alternatives, and to serve as input to ecological models as the next step of MLR salinity model utilization. MLR salinity models are relatively easy and inexpensive to develop and utilize, and the concept of linear regression and analysis of variance are familiar to most scientists and engineers. In the future, the more sophisticated SARIMA models may be able to be used for system control using the very accurate one-step forward predictions that can be made by these models, so that changes to water delivery patterns can be evaluated in real-time.

The strength of the MLR salinity models presented herein is that they are physically based, they have shown to be adaptable to changes in hydrology by simulating salinity well for both wet and dry conditions (including severe drought), and they are capable of being used to evaluate different flow scenarios by simulating salinity conditions from a given set of input data (in this case 2X2 model data) and historical climatology. The error statistics show that the models simulate good to very good, though there is an occasional large residual.

However, there is work that still remains to be done on the MLR salinity models. For example, a surrogate for evaporation is needed to determine if a measure of evaporation will improve the simulative capability of the models. When it is considered how the MLR salinity models are being used (i.e. with 2X2 model output over 31- and 36-year periods), the surrogate must be a quantity that has been continuously measured since 1965. The only set of data that fits that requirement is the meteorological data available from the National Weather Service, and the National Ocean Service records. Fortunately, parameters that are used to estimate evaporation such air temperature and sea water temperature are amongst the data that are available. Because the evaluation of extended period models was somewhat inconclusive, additional evaluation of model performance during wet and dry periods is also needed.

Now that it has been shown that MLR salinity models are capable of adequately simulating salinity, they can be coupled with ecological models at the daily, weekly, or monthly time scales. Though not shown in this report, simulated monthly average values track observed monthly average values very well, and the output from the daily MLR salinity models are easily transformed into weekly or monthly values, with the statistical power that comes from preparing simulations at the daily level and aggregating to develop less frequent simulations. Since the extended period models showed that the MLR salinity models were capable of simulating drought conditions as well as wet periods, MLR salinity models can be used with ecological models to evaluate the effect of hypersaline conditions. To assist with those evaluations, the preparation of MLR salinity models for the remaining MMN stations should be accomplished to increase the spatial resolution of the simulations.

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March 2006

Appendix D

Correspondence Regarding the Historical Reconstruction of the Salinity Time Series for the Taylor River for the Period 1970 – 2000

July 11, 2005

Ms. Melody Hunt, PhD
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33406

Subject: Extension of Taylor River Salinity Historical Reconstruction (1970-2005)

Dear Ms. Hunt:

Environmental Consulting & Technology, Inc. (ECT) has previously prepared a historical reconstruction of the salinity time series for the Taylor River monitoring station (also known as Argyle Hendry and TR) located in Taylor Slough in Everglades National Park (ENP). The Taylor River station is a part of the ENP Marine Monitoring Network, and salinity has been measured there since July 14, 1988. As part of the Minimum Flows and Levels modeling work, ECT developed a historical reconstruction of the salinity time series for Taylor River for the period 1970 through 2000. It was requested that the historical reconstruction be extended to the most recent date possible, given the limitations of the data, and that the dataset be "refreshed".

To begin this task, a new reconstruction data set was prepared, which is comprised as follows:

- Craighead Pond stage (CP) data are the original data obtained from DeWitt Smith of Everglades National Park from beginning of record on October 1, 1978 through October 31, 2002, with data from November 1, 2002 through November 3, 2003 obtained from the South Florida Natural Resources Center website, www.sfnrc.ever.nps.gov (see note below), and evaluated for completeness;
- P33 stage data were obtained fresh from the SFWMD DBHYDRO database website, www.sfwmd.gov/org/ema/dbhydro;
- P35 stage data were obtained fresh from the SFWMD DBHYDRO database website;
- P37 stage data were obtained fresh from the SFWMD DBHYDRO database website;
- Key West water level (kwwatlev) data were the data originally assembled for the Critical Ecosystems Studies Initiative (CESI) multivariate linear regression modeling project (Marshall, 2003) from January 1, 1970 through October 31, 2002, and for November 1, 2002 through November 3, 2003 new data were obtained from the National Ocean Service (NOS) website. http://tidesonline.nos.noaa.gov/ ; and
- Taylor River salinity (TR) data were the original data obtained from DeWitt Smith of Everglades National Park from beginning of record on July 14, 1988 through October 31, 2002, with data from November 1, 2002 through May 22, 2005 obtained from SFWMD and compared to the incomplete data available from the South Florida Natural Resources Center website (see note below).

The available data in DBHYDRO for P33, P35, and P37 ends on November 3, 2003, which is the limit as to how recent this data can be used in the MLR salinity model for Taylor River.

For the CP stage data, the original data were directly downloaded from the ENP validated database, and are known to be a complete series, with missing values included. Data that were downloaded from the SFNRC website are known to contain missing values along with missing dates that are not represented in the downloaded time series. Therefore, for the approximate two-year period of data obtained from this site, the data were evaluated visually and an appropriate symbol for missing values entered where needed.

For the National Ocean Service Key West water level data, data can only be downloaded for a year at a time, in hourly values that must be averaged to daily average values. This laborious process had been completed previously for the data from1970 through 2000. It was beyond the scope of this project to freshen this data. However, new data were downloaded and processed into daily average values for the period January 1, 2001 through November 3, 2003.

As was presented in the December 7, 2004 letter report, the model that was used to fill the period January 1, 1970 through July 13, 1988 and missing values in the observed Taylor River data was the CESI Taylor River multivariate linear regression (MLR) salinity model originally developed from observed salinity data for ENP (Marshall, 2004). The daily value salinity model is:

Taylor River salinity = 83.17 - 15.09CP[lag4] + 0.835Kwwatlev - 7.83(P33-P35)[lag1] - 4.34(P33-P35)[lag4]

where:

CP = stage (NGVD) at Craighead Pond
Kwwatlev = Key West water level (MSL)
P33 = stage (NGVD) at P33
P35 = stage (NGVD) at P35
Lag1 = one-day lag
Lag4 = four-day lag.

Details on model development can be found in Marshall, 2004. For historical reconstruction modeling purposes the Craighead Pond record had to be extended into the past before the beginning of the period of available CP data of October 1, 1978 using the following model:

Craighead Pond (CP) water level = -0.165 + 0.47 P37 + 0.49 P37[lag3], $R^2 = 0.87$.

For the extended Taylor River salinity historical reconstruction, the daily values for CP were simulated by this model for January 1, 1970 through September 30, 1978.

The extended daily Taylor River salinity reconstruction is presented as Figure 1 which shows that this reconstruction is a mix of modeled and observed data. For the period January 1, 1970 through September 30, 1978 CP input was simulated by the P37 model presented above. Then this simulated CP data were used with observed data for P33, P35, and kwwatlev in the TR MLR salinity model presented above for January 1, 1978 through September 30, 1978. The values on Figure 1 simulated in this manner are shown in blue. From October 1, 1978 through July 13, 1988 (magenta-colored line on Figure 1) all input data to the TR MLR salinity model were observed data, and the Taylor River salinity for this period is produced by the model using observed input values. From July 14, 1988 through May 22, 2005 all data (yellow line) observed Taylor River data are available and are utilized. Any gaps in the observed Taylor River salinity data were filled by the MLR salinity model, assuming that all input data to the model were available for that day. To summarize, the reconstructed Taylor River salinity time series consists of data that were generated from CP and Taylor River models from January 1, 1970 through September 30, 1978; using the Taylor River model only from October 1, 1978 through July 12, 1988; and from observed data from July 13, 1988 through May 22, 2005.

Because it is desired that the historical reconstruction be utilized at a monthly time scale, the daily values in the Taylor River mixed reconstruction presented above were averaged to monthly values. There were several months that contained missing values for more than 15 days out of the month, and these monthly averages were not retained in the monthly mixed reconstruction time series, instead being replaced with a missing value for that month. The months with more than 15 missing observed salinity values are as follows:

- 1975 – June
- 1978 – November
- 1979 – December
- 1982 – November
- 1983 – April, May, June, October, December
- 1984 – September
- 1988 – January, June
- 1992 – September, November
- 1993 – July
- 1994 – December
- 2003 - December
- 2004 - January, February, March, April.

Examination of the daily and monthly plots and the daily uncertainty statistics from the previous reconstruction show that the daily simulated values have a tolerance of about +/- 4.5 psu. However, some daily values may be as much as 10-15 psu in error during the month of May, and, to a lesser extent, April, June, August, and September. Monthly average values are generally within about 4 psu but individual averages may have an error of about 9 psu. Because of the potential for large residuals, particularly at the daily level, the following model limitations were previously presented and are repeated here:

- The highest variability is associated with the relatively short periods when the dry season is ending and the wet season is beginning; however, the exact date or period that this happens is not predictable.
- Because flow in Taylor Slough can cease for relatively long periods of time during extended drought periods, salinity simulations have the potential for high variability during extended droughts.

Even with these limitations, plots of the reconstructed salinity look reasonable, except for the maximum values during the 1970-1974 drought when CP is estimated indirectly from the P37 model.

Should you have any questions regarding this extension of the Taylor River historical salinity reconstruction, please give me a call.

Respectfully,

Frank E. Marshall III, PhD, P.E.

Figure 1. Extended Taylor River (TR) salinity daily historical reconstruction, 1970-2005 using a mix of simulated and observed data.

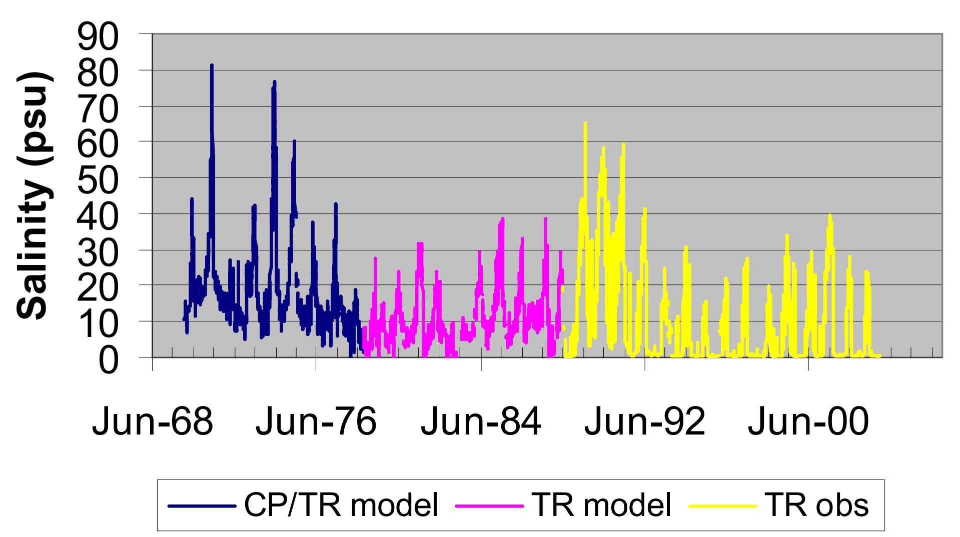
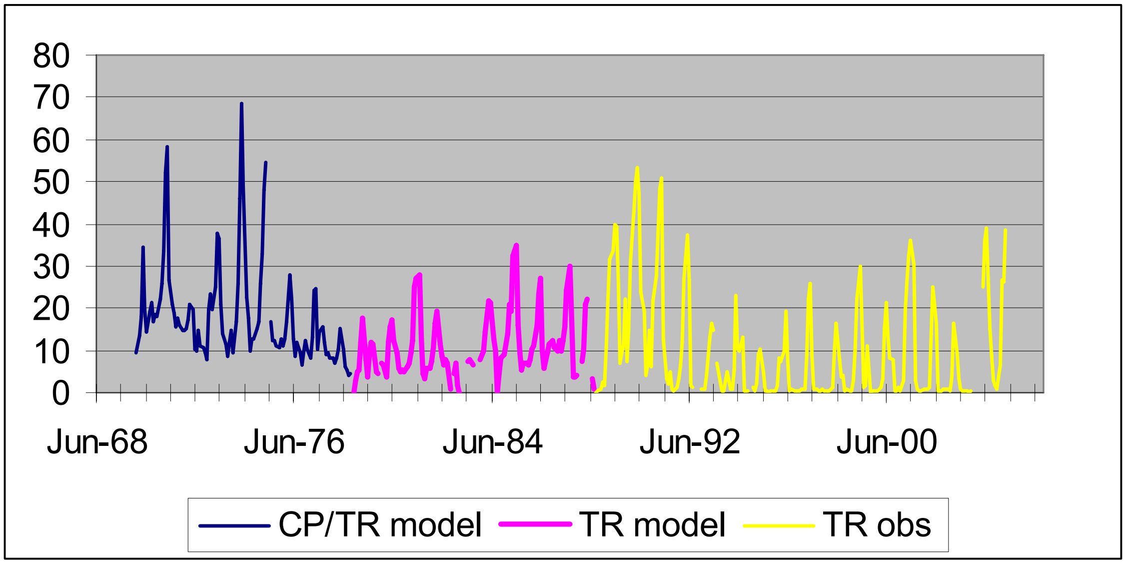


Figure 2. Extended Taylor River (TR) salinity monthly historical reconstruction, 1970-2005 using a mix of simulated and observed data.



Appendix E

Influence of Net Freshwater Supply on Salinity in Florida Bay (Nuttle 2000)

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Influence of net freshwater supply on salinity in Florida Bay

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Abstract. An annual water budget for Florida Bay, the large, seasonally hypersaline estuary in the Everglades National Park, was constructed using physically based models and long-term (31 years) data on salinity, hydrology, and climate. Effects of seasonal and interannual variations of the net freshwater supply (runoff plus rainfall minus evaporation) on salinity variation within the bay were also examined. Particular attention was paid to the effects of runoff, which are the focus of ambitious plans to restore and conserve the Florida Bay ecosystem. From 1965 to 1995 the annual runoff from the Everglades into the bay was less than one tenth of the annual direct rainfall onto the bay, while estimated annual evaporation slightly exceeded annual rainfall. The average net freshwater supply to the bay over a year was thus approximately zero, and interannual variations in salinity appeared to be affected primarily by interannual fluctuations in rainfall. At the annual scale, runoff apparently had little effect on the bay as a whole during this period. On a seasonal basis, variations in rainfall, evaporation, and runoff were not in phase, and the net freshwater supply to the bay varied between positive and negative values, contributing to a strong seasonal pattern in salinity, especially in regions of the bay relatively isolated from exchanges with the Gulf of Mexico and Atlantic Ocean. Changes in runoff could have a greater effect on salinity in the bay if the seasonal patterns of rainfall and evaporation and the timing of the runoff are considered. One model was also used to simulate spatial and temporal patterns of salinity responses expected to result from changes in net freshwater supply. Simulations in which runoff was increased by a factor of 2 (but with no change in spatial pattern) indicated that increased runoff will lower salinity values in eastern Florida Bay, increase the variability of salinity in the South Region, but have little effect on salinity in the Central and West Regions.

1. Introduction

Florida Bay, a broad (2000 km^2), shallow (approximately 1 m) estuarine lagoon nestled between the south Florida mainland and the Florida Keys (Figure 1), occupies a large portion of Everglades National Park and is contiguous with the Florida Keys National Marine Sanctuary. It is bounded by the mangrove wetlands of the mainland, the open marine systems of the Gulf of Mexico, and the islands that compose the Florida Keys. Bay waters support a valuable recreational fishery within the bay itself [*Tilmant*, 1989] and a commercial shrimp fishery in the Gulf of Mexico [*Costello and Allen*, 1966]. Beginning in 1987, sudden and extensive die-off in the sea grass beds that cover 95% of the bottom signaled a rapid, general decline in the ecological health of the bay [*Robblee et al.*, 1991; *Fourqurean et al.*, 1993; *Phlips et al.*, 1995]. Increased turbidity followed die-off in the grass beds [*Boyer et al.*, 1999], and recurrent blooms of cyanobacteria in the winters of 1991–1992 and 1992–1993 decimated the sponge population [*Butler et al.*, 1995]. The resulting changes in water quality and the long-term structural changes in the bay's ecosystems have also affected the health of adjacent coastal systems, such as the coral reefs of the Florida Keys.

Ecological decline in Florida Bay is widely considered to be the result of long-term regional water management in south Florida. Although there is general agreement about the nature and extent of the impacts of water management in the extensive wetlands of the Everglades, which lie immediately upstream of Florida Bay, the chain of cause and effect linking water management to sea grass die-off and plankton blooms in the bay has not yet been fully established. Because of management practices, discharge of freshwater directly into the Atlantic Ocean and farther north into the Gulf of Mexico has increased up to a factor of 10, while the discharge of freshwater into Florida Bay and along the southwest coast of Florida has decreased by an unknown but important amount [*Light and Dineen*, 1994]. Because we do not know the sensitivity of the Florida Bay ecosystem, primarily the extensive sea grass communities, to variations in freshwater runoff, we cannot tell what benefits restoring the historical runoff would have. Even without this knowledge, plans for water management and ecosystem restoration in south Florida [*U.S. Army Corps of Engineers*, 1998] are progressing, based, at least in part, on the assump-

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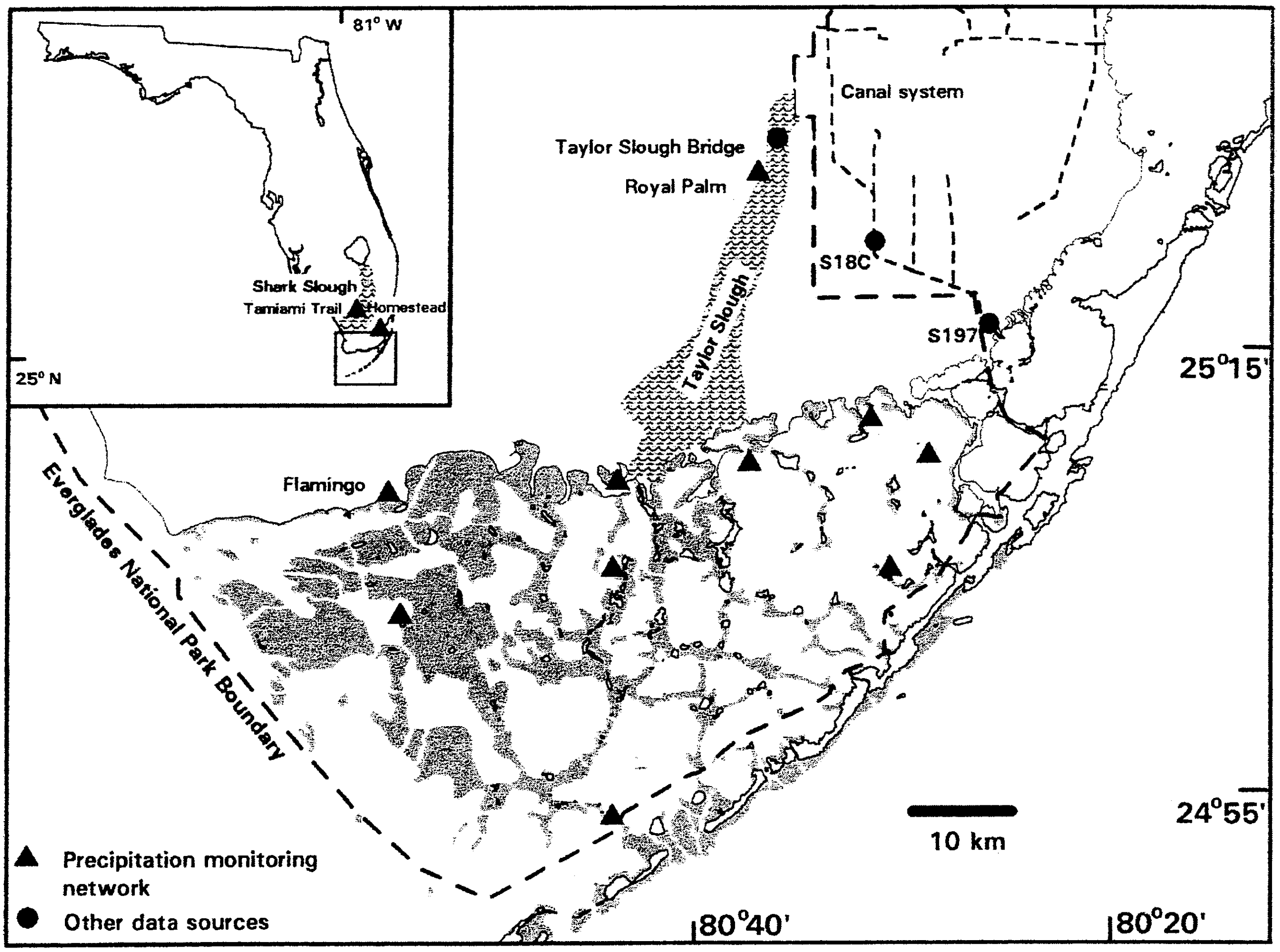

Figure 1. Broad, shallow (<30 cm) seagrass-covered mudbanks (shaded area) restrict water exchange between Florida Bay and the coastal ocean. Freshwater enters the bay as runoff through Taylor Slough and as diffuse flow from the wetlands to the east. Regional discharge through Shark Slough (inset) also influences salinity in the Gulf of Mexico on the western boundary of the bay. Locations are shown for sources of data on rainfall (points in the bay), pan evaporation (Flamingo), and runoff (Taylor Sough Bridge and the control structures S18C and S197 on the C111 canal).

tion that the ecological health of Florida Bay will be restored by increasing the freshwater runoff to the bay to as near to historic levels as possible.

Salinity is an intermediate link in the chain of cause and effect that connects water-management activities to the structure and functions of the bay's ecosystem. In Florida Bay, salinity varies markedly in time and space (Figure 2). Hypersaline conditions (>40) (salinity values given in practical salinity units) in one part of the bay frequently coexist with more estuarine conditions (<30) in another. At some interior locations, salinity regularly fluctuates between hypersaline and nearly freshwater conditions [*Frankovich and Fourqurean*, 1997]. Only within the confines of a few, semienclosed basins along the north shore of the bay do salinity fluctuations closely follow changes in canal discharge. The degree to which water management and, consequently, runoff from south Florida influence salinity fluctuations in Florida Bay cannot be ascertained without a detailed analysis. Therefore we have used salinity, hydrology, and climate data from 1965 through 1995 to investigate how the annual water balance and the variations in freshwater fluxes have influenced the salinity in Florida Bay.

2. Background

2.1. Factors Affecting Estuarine Salinity

Variation in estuarine salinity can be attributed to the intensity of the two-way exchange between the estuary and the coastal ocean, the net supply of freshwater that flows through the estuary to the coastal ocean, and the salinity of the coastal ocean at the estuary's mouth. The two-way exchange between estuary and ocean is driven by several physical processes, including density differences, astronomical tides, and wind. The net freshwater supply is the sum of runoff and direct rainfall minus any evaporation from the estuary. The patterns of salinity in estuaries result from a dynamic steady state in which the advective flux of salt into or out of the estuary, which is driven by the net freshwater supply, is balanced by a dispersive flux from the two-way water exchange created by tides and other hydrodynamic mixing processes.

In a classical estuary a positive net freshwater supply, usually from heavy runoff delivered by river discharge, dilutes the salinity in the estuary to below that of ocean water. Salinity ranges from zero at the head of the estuary to the salinity of the coastal ocean near the mouth.

Other estuaries may experience hypersaline conditions. Many coastal bays and lagoons, like Shark Bay, Western Australia [*Smith and Atkinson*, 1983]; Laguna Madre, Texas, United States of America [*Smith*, 1988]; and Lagoa de Araruama, Brazil [*Kjerfve et al.*, 1996], have higher average salinities near their mouths than the coastal ocean for most or all of the year. Because these inverse estuaries have a negative freshwater supply caused by evaporation rates higher than both rainfall and runoff rates, salt concentrates to hypersaline conditions. Salinities in these inverse estuaries can range from zero near freshwater discharge to a greater-than-coastal salinity in the main body of the estuary.

Seasonally hypersaline estuaries form a third class of estuary characterized by their episodic hypersalinity [*Largier et al.*, 1997]. These estuaries experience limited exchange with the coastal ocean, and net freshwater supply fluctuates on the positive and negative side of zero in response to climatic variations. Estuaries in this class are found in both temperate, Mediterranean climates (e.g., Tomales, Mission, and San Diego Bays, California, United States of America [*Largier et al.*, 1997]) and tropical, monsoonal areas (e.g., northern Australia [*Wolanski*, 1986], Kenya [*Kitheka*, 1998], and Sri Lanka [*Arulananthan et al.*, 1995]). Since the net annual freshwater balance of seasonally hypersaline estuaries is close to zero, small perturbations in the freshwater supply may lead to large changes in the salinity of the estuary. Diversions of freshwater runoff for urban or agricultural use, as in the Colorado River Estuary, Mexico, can drastically change the salinity regime. Small climactic variations can also have large impacts on salinity: For example, a multidecadal trend of decreasing rainfall has changed the Casamance River Estuary in Senegal from a seasonally hypersaline estuary to a permanently inverse estuary [*Debenay et al.*, 1994]. In Laguna Madre, Texas, prolonged and intense hypersaline conditions associated with droughts may trigger the "brown tide" phenomenon by changing the structure of the plankton community [*Rhudy et al.*, 1999].

Florida Bay is a seasonally hypersaline estuary (Figure 2a). In the bay a network of broad, shallow mud banks and the lack of density stratification limit the magnitude of tidally driven and baroclinic exchange flows. The influence of the south Florida climate is evident in runoff, rainfall, wind-driven tides, and the salinity of the coastal ocean. Wet and dry periods fluctuate seasonally and from year to year. Tides and currents in the bay are particularly influenced by the sustained winds associated with the passage of fronts characteristic of the subtropical winter weather [*Wang et al.*, 1994]. Patterns of local runoff from the Everglades directly affect salinity in the bay (Figure 2b). Variations in runoff from all of south Florida, including Lake Okeechobee, influence the salinity of the Gulf of Mexico along its border with Florida Bay thereby indirectly linking regional patterns of runoff to salinity variations in the bay.

2.2. Regional Patterns in Florida Bay

Florida Bay lacks the clearly defined upstream/downstream axis that, in most estuaries, organizes spatial variations in salinity. However, several analyses of water-quality parameters, for example, salinity, nutrient, chlorophyll, etc., have shown a consistent pattern. For example, *Boyer et al.* [1997] identified three zones of similar water quality in Florida Bay: a core region, a western region, and an eastern region. Other authors have suggested dividing the bay into similar zones based on bank morphology and dynamics [*Wanless and Tagett*, 1989], benthic mollusk communities [*Turney and Perkins*, 1972], salinity and nitrogen [*Fourqurean et al.*, 1993], and benthic plant communities [*Zieman et al.*, 1989]. These schemes all suggest that the primary axis of differentiation runs from northeast to southwest, and most schemes include a separate, distinct region (of varying size) in the upper central part of the bay adjacent to the Everglades.

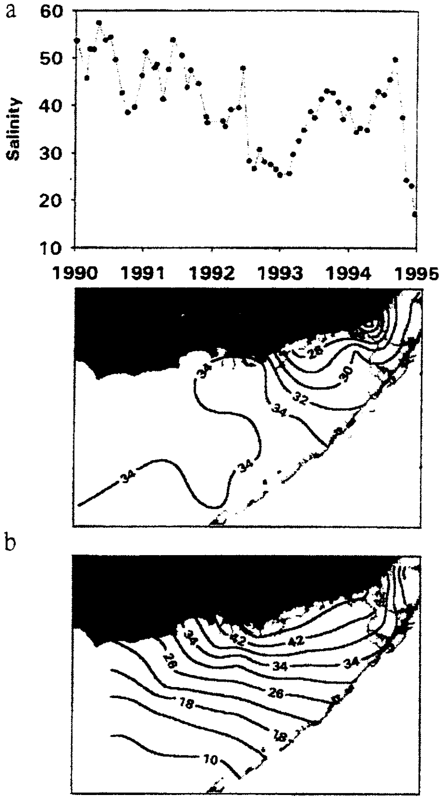

Figure 2. Salinity varies widely in time and space in Florida Bay. (top) Temporal patterns in the Central Region reflect the influence of sources of variation operating on seasonal and interannual timescales. (middle) Spatial patterns in mean salinity from February to March 1994 and (bottom) range of salinity variation from 1990 to 1994 over the whole bay reveal the influence of exchange with ocean waters and the localized effect of runoff into the bay.

On the basis of the work summarized above, for this study we divided the bay into four regions (Figure 3) that differ in their proximity to the Gulf of Mexico, areas of water flow through the Florida Keys, and sources of freshwater runoff from the mainland. In the Central Region, broad, shallow banks (Figure 1) restrict exchange with the Gulf and the Atlantic, and there is little freshwater runoff. Residence times are high and hypersaline conditions are frequent and persistent (Figure 2a). The East Region resembles the Central Region with its limited oceanic exchange and long residence times; however, it receives most of the bay's freshwater runoff primarily from the C111 canal and Taylor Slough (Figure 1). Salinity in the East Region varies widely between nearly fresh and hypersaline conditions (Figure 2b). In the South and West Regions, salinity variations are less extreme (Figure 2b). Greater exchange with the Gulf of Mexico and the Atlantic

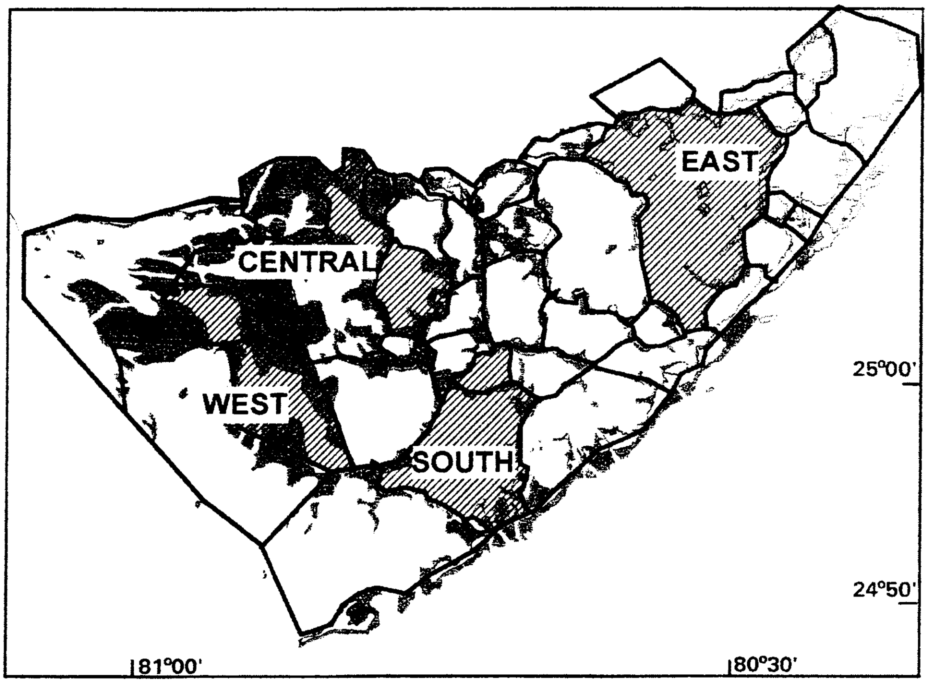

Figure 3. Subtidal banks and islands divide Florida Bay into 44 basins used to categorize the location of salinity observations. On a larger scale, studies of water quality, sediment type, faunal communities, and benthic plant communities generally divide the bay into four regions of similar character. This study uses data from an aggregation of basins within each of these four regions (hatched area) to characterize the spatial and temporal variations in Florida Bay.

Ocean and a lack of direct runoff result in salinities nearer to that of the coastal waters.

3. Methods

The main objectives of this study were (1) to establish the annual and seasonal water balances and net freshwater supplies for Florida Bay and (2) to evaluate the degree to which the amounts of and variations in rainfall and runoff contribute to the observed salinity variations in Florida Bay. The influence on salinity of any of the components of the net freshwater supply could not be demonstrated simply by searching for correlations with salinity. Most factors controlling estuarine salinity share climate as a common source of variation, and each can be expected to exhibit similar patterns of variation. The only way to understand the influence of a particular component of the net freshwater supply on salinity in Florida Bay was to isolate that component and quantify directly its effect on salinity.

This approach required spatially and temporally extensive measurements of freshwater fluxes and salinity in the bay, salinity models that incorporated different temporal and spatial scales, and a framework for interpreting the simulated and observed salinity variations. We assembled rainfall, runoff, and evaporation data and a database of published and unpublished salinity measurements in Florida Bay (see the appendix) that spans the 31 years from 1965 through 1995. We used the annual and monthly means of these data to establish the yearly and seasonal water balances for Florida Bay. We then used the data with physically based, mass balance salinity models in comparative analyses to examine the effects of spatial and temporal variations in net freshwater supply on the observed salinity variations.

3.1. Framework for the Comparative Analyses

In general, physically based models treat salinity, S, as a function of coastal ocean salinity, S_{ocn}, exchange fluxes with the coastal ocean, Q_T, and the fluxes of freshwater (rainfall, Q_P, runoff, Q_R, and evaporation, Q_E), all of which vary in time and space:

$$S|^{i}_{j,k} = f(S_{\text{ocn}}|^{i}_{j,k},\ Q_T|^{i}_{j,k},\ Q_E|^{i}_{j,k},\ Q_P|^{i}_{j,k},\ Q_R|^{i}_{j,k}) + R|^{i}_{j,k}, \qquad (1)$$

where the superscript and subscripts identify location (i), year (j), and month (k). The residual errors, R, are the differences between measured and simulated salinity and represent noise in the data and salinity variations not explained by the processes or assumptions inherent in the model formulations. We employed models that differed in their spatial and temporal resolution and compared the successes of the models in reproducing observed salinity variations in order to draw inferences about the importance for salinity variations of (1) interannual and seasonal variations in net freshwater supply and (2) location within the bay.

We used a measure of model efficiency, eff, to assess how successfully each model reproduced the patterns of variation in observed salinity data:

$$\text{eff} = 100\left[1 - \frac{\sum\limits_{i}\sum\limits_{j}\sum\limits_{k} (R|^{i}_{j,k})^2}{n\ \text{Var}\ (S|^{i}_{j,k})}\right], \qquad (2)$$

where R are the residual errors, Var (S) is the total variance of the salinity measurements, and n is the number of observations. A model's efficiency score (unitless) can be broadly interpreted as the proportion of the variance in the data explained by the model. In this sense, model efficiency is similar to the coefficient of determination r^2. In contrast to r^2 the efficiency score can take on negative values if, for example, the model produces a biased estimate of the data or if fluctuations in the model are out of phase with fluctuations in the data. If the efficiency score was zero, then the model explained the variation in the data no better than did the mean of the data. If the efficiency score was 100%, then the residuals were zero, and the model explained all of the variance in the data.

Any measure of model success is most useful if comparatively applied. That is, by examining the increase (or decrease) in explanatory power between a null model and an alternative, the power of the processes included in the alternative model to explain variance in the data can be assessed. The null model implicitly included in eff was the mean of the observed salinity across all observations and all regions in Florida Bay (i.e., a model with no temporal or spatial resolution). We developed three alternative salinity models that contained increasing spatial and temporal complexities. By comparing the efficiencies of the alternative models, we were able to estimate the relative contributions of two temporal components (interannual and seasonal variations in freshwater fluxes) and one spatial component (location of the salinity measurements) to the overall variation of salinity in Florida Bay.

The first type of model, a static location model, only accounted for the effects on salinity of position within the bay. This model was simply defined as the average of the observed salinity data, S_{av}, for all months and years in each region of the bay:

$$S|^i_{j,k} = S_{\mathrm{av}}|^i + R|^i_{j,k}. \tag{3}$$

The location model was applied to each of the four regions in Figure 3. The model did not contain a temporal component and could not explain any of the interannual or seasonal variations of salinity within any of the regions. The notation denotes that the model simulated a salinity value S for each region (i), every year (j), and every month (k), but the predicted salinity for all months and years in a region was the same value. Because the model has no temporal component (only the spatial means are used), the residuals were expected to contain all of the temporal variance in the data, and the efficiency was expected to be low.

The second type of model, a steady state, spatially aggregated "box" model, quantified the effects of location as well as the effects of long-term, interannual variations in rainfall and runoff on salinity within the bay:

$$S|^i_{j,k} = f(S_{\mathrm{ocn}}, Q_T|^i, Q_E|^i, Q_P|_j, Q_R|_j) + R|^i_{j,k}. \tag{4}$$

The box model was implemented using annual time steps and annual values of freshwater and exchange fluxes. Rainfall and runoff were uniformly distributed over the bay (no spatial component) and varied from year to year. Spatially explicit but temporally constant estimates of evaporation and dispersive exchange with the coastal ocean were derived for the model during calibration. This model was applied to all four regions in the bay (Figure 3). The residuals were expected to contain all of the seasonal variance, and the efficiency was expected to increase over that of the location model.

The third type of model, a dynamic, spatially explicit model, simulated the effects on salinity of location and both interannual and seasonal variations in freshwater and exchange fluxes:

$$S|^i_{j,k} = f(S_{\mathrm{ocn}}, Q_T|^i_{j,k}, Q_E|_k, Q_P|_{j,k}, Q_R|^i_{j,k}) + R|^i_{j,k}. \tag{5}$$

The dynamic model was based on the basin and bank geomorphology of Florida Bay and was driven by monthly values of rainfall, runoff, and evaporation. Rainfall and evaporation were applied uniformly across the bay, but runoff was added at appropriate locations on the boundaries of the bay. Hourly tides generated advective exchanges among 44 basins within the bay. We expected this model, with the greatest spatial and temporal complexity, to have the highest efficiency and explanatory power.

3.2. Salinity Data

We drew our salinity observations for this study from an historical salinity database for Florida Bay and the west coast of south Florida consisting of over 34,000 individual observations dating from 1947 (see the appendix). This database was assembled from the results of many field studies and from systematic, water-quality monitoring programs initiated in response to the ecological crises of the late 1980s and early 1990s. Data from within Florida Bay are categorized according to their location in a grid of 44 numbered basins. Boundaries of the basins follow the geometry of the system of anastomosing banks that physically subdivide the bay (Figure 3). This database provides excellent spatial and temporal coverage beginning with 1989 when mounting concern about conditions in the bay resulted in the establishment of regular water-quality monitoring surveys. However, the data from before 1989 are discontinuous and uneven with the highest number of observations clustered in the East Region of the bay. Because the data available from before 1965 are extremely spotty, they were not used in this study.

We aggregated the salinity data by subsampling and processing data from the historical database to assure an unbiased sampling of the interannual and seasonal salinity variations and to provide a balanced representation of the regional variations in the bay. First, the data were aggregated in time by computing the individual monthly average salinity in each basin for each month of record. Second, the data in each basin were screened to assure they consistently represented seasonal variations by excluding calendar years with data reported in fewer than 11 months. Third, in all but the East Region, data from two adjacent basins were combined to provide the most continuous salinity record possible (maximum number of years) over the 31 years (Figure 3). The resulting set of monthly averaged salinity data characterized the interannual and seasonal variations in salinity in each region of the bay for 1965 through 1995 (Figures 4 and 5). The nine years from 1987 to 1995 contain 34 station years (54%) of the data. We used this data subset, the evaluation period subset, for our detailed comparisons of the model results because it provided the most complete temporal and spatial coverage of the bay. Our evaluation of the influence of the net freshwater supply on salinity was primarily based on our analysis of these data. We used the additional data in the complete 31-year record to evaluate the predictive ability of the models. The distribution of salinity data in the 9-year evaluation period was similar to that of the complete 31-year record (Table 1).

3.3. Freshwater Flux Data

3.3.1. Runoff. Freshwater runoff into Florida Bay was estimated as the sum of monthly volume discharges in Taylor Slough and the C111 canal (Figure 6a). Data for Taylor Slough are available for the entire period from 1965 through 1995; data for the C111 canal are only available beginning in 1970.

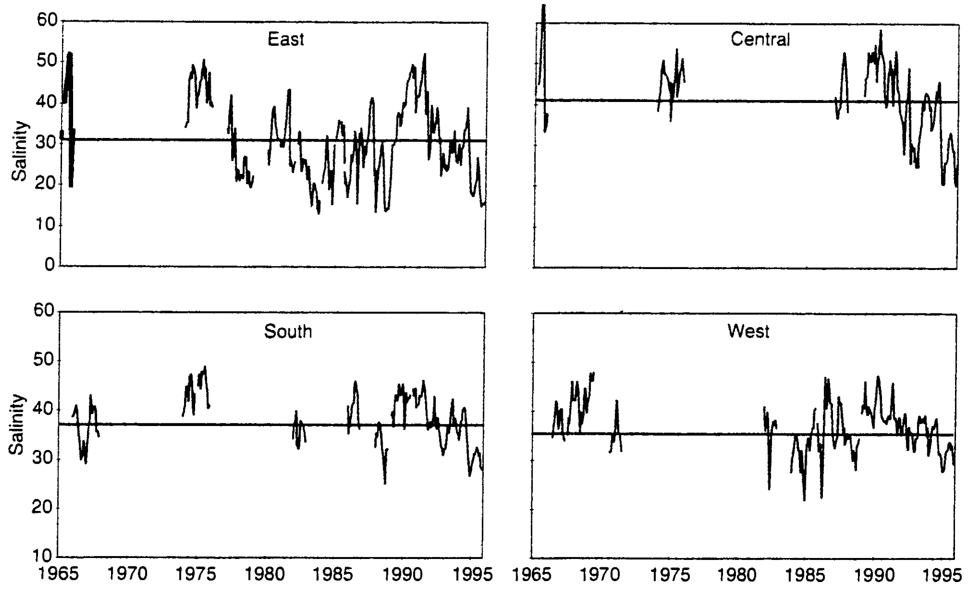

Figure 4. Monthly salinity values for 1965 to 1995 for each of four aggregated basins in Florida Bay show the combined influence of a strong seasonal cycle superimposed on interannual variation. The straight lines indicate the average salinity in each region for the period.

Discharge in Taylor Slough is measured as it crosses the main road through Everglades National Park (Figure 1). The flow down Taylor Slough discharges into a complex of ponds north of the bay and is distributed from there into the bay through several, smaller channels. Discharge in the C111 canal is measured at the S18C and the S197 control structures (Figure 1). The C111 canal conveys water from a regional network of drainage canals. Most water that leaves the C111 canal discharges into the mangrove wetlands between the S18C and the S197 structures. This freshwater then flows south into the East Region of the bay. During infrequent periods of extremely high flow, water is allowed to pass through the S197 structure and discharge directly into the extreme eastern end of Florida Bay. These runoff data do not account for the net gain (or loss) of freshwater from precipitation and evaporation over the area between the flow-monitoring points and the coast. The contribution of (ungauged) groundwater flow to the coast is also not accounted for in these data. Evidence from natural groundwater tracers suggests that submarine groundwater discharge into Florida Bay contributes only slightly to the net freshwater supply [*Corbett et al.*, 1999].

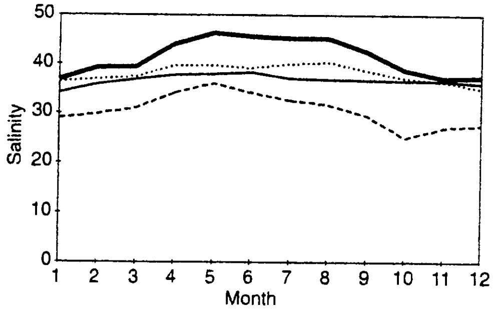

Figure 5. Regional salinity averaged by month over all 31 years illustrates similarities and differences in the seasonal patterns of variation. In all regions, salinity increases during the dry season and decreases during the wet season. The amplitude of seasonal variation is greater in the Central and East Regions (bold and dashed lines), which are isolated from active exchange with the coastal ocean, which moderates the seasonal variation in the South and West Regions (dotted and fine lines).

3.3.2. Rainfall. The available long-term rainfall records for land-based sites in south Florida do not provide reliable estimates of rain falling directly onto the bay. Convective storms form primarily along the coast early in the wet season but do not form over the open water of the bay until late in the wet season [*Schomer and Drew*, 1982]. This produces higher rainfall measurements at mainland stations just inland from the Florida Bay coast than actually occur in the bay. Therefore, to construct a long-term precipitation record for the bay, we had to correct for this bias in the land-based records. We did this by correlating land-based records with recently available rainfall measurements from stations within the bay and using this correlation to reconstruct rainfall for periods when no rainfall data for the bay were available.

Rainfall is currently being measured at several marine-monitoring network stations maintained in Florida Bay (D.

Table 1. Summary of the Monthly Average Salinity Observations in Each Region of Florida Bay

	1987–1995		1965–1995	
Basin	Mean	SD	Mean	SD
East	30.8	9.8	30.6	9.6
South	37.0	5.2	38.1	5.2
Central	39.6	9.4	41.4	9.2
West	36.4	4.2	36.7	5.0
All basins	35.8	8.2	35.8	8.6

SD is standard deviation.

Smith, Annual Data Reports: 1993–1996, Everglades National Park, Homestead, Florida). We used the monthly totals for 1993 through 1996 from eight of these stations (Figure 1) to estimate monthly bay-wide average rainfall for 1993 through 1996. We chose these stations because they reported at least 12 months of data within this period. We used linear regression to identify relationships between the monthly totals at each of the eight marine monitoring stations and monthly rainfall amounts from long-term records (National Weather Service, National Oceanic and Atmospheric Administration (NOAA), data available from the National Climatic Data Center, Asheville, North Carolina) for Flamingo, Royal Palm, Tamiami Trail, and Homestead (Figure 1). These relations, which have r^2 generally greater than 0.5, provided the means of extrapolating the recent record of rainfall in the bay back in time over the period 1965 through 1995. We calculated a bay-wide average rainfall from the extrapolated records, using area weights based on Thiessen polygons, to estimate annual and monthly, bay-wide average rainfall (Figure 6b).

3.3.3. Evaporation. Evaporation has not been directly measured in Florida Bay, and as yet little effort has been made to evaluate the long-term evaporation rate or its seasonal or regional variations. Several years (1965 through 1970) of pan evaporation observations are available from a National Weather Service cooperative observing station (data available from the National Climatic Data Center) at Flamingo on the southwest Florida mainland (Figure 1). The annual average of these data (approximately 210 cm yr^{-1}) appeared to be too high to be accepted as direct estimates of evaporation in Florida Bay. By comparison, *Morton* [1986] estimates annual evaporation from Lake Okeechobee is 162 cm based on a calculation of its water budget. Recently, *Pratt and Smith* [1999] estimated an annual evaporation rate of about 73 cm by using a Dalton law formula and data collected at three sites in the bay. However, since some data needed to apply this formula were obtained from a fourth station outside of the bay, it is not known what magnitude of error might have been introduced into their estimate. Because of the lack of reliable evaporation estimates we derived our own estimate of the long-term, bay-wide, annual average evaporation rate, E_B, from our calibration of the steady state box model using the annual averages of the observed salinity data (see section 3.4.1). Then, we estimated monthly values of evaporation, Q_E, by multiplying the long-term, annual rate by monthly weights, w_k, derived from the seasonal pattern in the pan data from Flamingo:

$$Q_E = E_B w_k, \tag{6}$$

where

$$\sum_{k=1}^{12} w_k = 1.$$

3.4. Salinity Models

3.4.1. Steady state box model. The steady state box model served two purposes. It allowed us (1) to estimate the unknown evaporation flux and (2) to investigate what effect year-to-year variations in net freshwater supply has had on bay salinity. We formulated the box model following the approach of *Miller and McPherson* [1991] at Charlotte Harbor. In this approach the net effects of residual circulation and hydrodynamic mixing were accounted for by a (unknown) net exchange flux, Q_T, for each region of the bay that represented the cumulative influx of seawater flowing into that region. These exchange fluxes, expressed in cm yr^{-1}, were assumed to be constant with respect to season and year. Each region also received a net supply of freshwater, Q_F, as a result of runoff, direct rainfall, and evaporation. Invoking mass conservation for both water and salt led to an expression for the steady state salinity in each region. On an annual average basis a flux of water, Q_T, with salinity, S_{ocn}, entered each basin from the ocean and a flux of water, Q_T plus Q_F, returned to the ocean with the salinity in the basin. Equating the inflow and outflow, advected fluxes of salt led to an expression for the annual average, steady state salinity in the efflux (S_{ann}, i.e., an estimate of the annual average salinity in a given region of the bay):

$$S_{\text{ann}} = S_{\text{ocn}} \frac{Q_T}{Q_T + Q_F}, \tag{7}$$

where $Q_F = Q_P + Q_R - Q_E$ and the rainfall, runoff, and evaporation fluxes are annual average values.

We applied the box model separately to each of the four regions in the bay (Figure 3). Annual runoff and rainfall volumes (Figure 6) were uniformly distributed over the entire area of the bay. In the case of runoff we assumed that mixing within the bay was vigorous enough to redistribute runoff throughout the bay from its localized points of discharge in less than a year. In the case of rainfall the available records from points within the bay were insufficient to characterize any spatial distribution that was not uniform. We thus applied the same rainfall, Q_P, and runoff, Q_R, to each region, and we

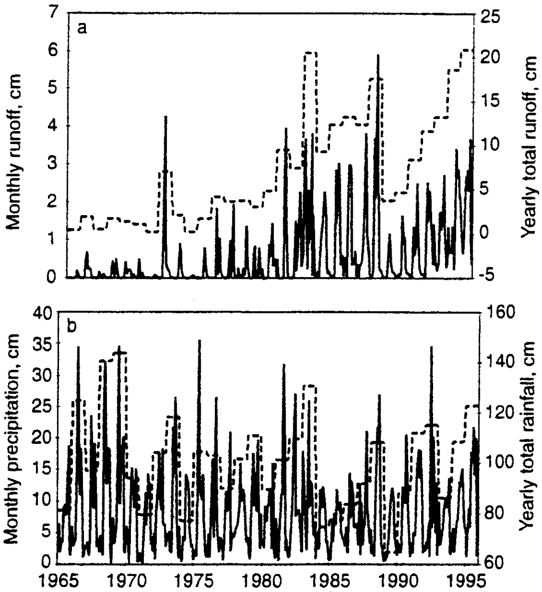

Figure 6. (a) Monthly runoff into Florida Bay was estimated from measured discharges in Taylor Sough (1965 to 1995) and in the C111 canal (1970 to 1995). The volumetric fluxes were divided by the surface area of Florida Bay (200 km^2) to yield an equivalent bay-wide depth for runoff. The dashed line is the total runoff for each calendar year. (b) Monthly rainfall onto Florida Bay for 1965 to 1995 was estimated from relationships between long-term rainfall data in the Everglades and more recent (short term) rainfall data in Florida Bay. The dashed line is the total rainfall for each calendar year.

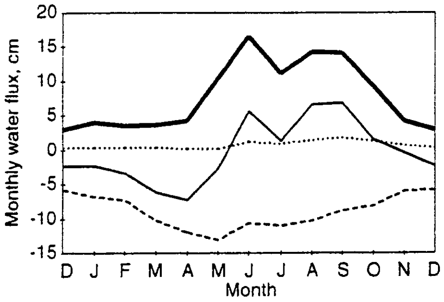

Figure 7. Average monthly freshwater fluxes to Florida Bay for 1970 to 1995. The net freshwater supply (fine line) fluctuates between deficit and surplus because peaks in monthly patterns of rainfall and runoff (bold and dotted lines) lag the peak in monthly evaporation (dashed line) by about 4 months.

calibrated the unknown annual exchange fluxes, Q_T, and annual evaporation fluxes, Q_E, for each region by individually fitting the model to the observed salinity data (using least squares minimization of the residuals). Following calibration for each region, we calculated the annual, bay-wide evaporation rate, E_B, as the average of the four regional values of Q_E (see (6)).

3.4.2. Dynamic, spatially explicit model. We used a dynamic, spatially explicit mass balance model to investigate the combined influence of seasonal and interannual variations in net freshwater supply for two reasons. We needed a dynamic model because residence times in the bay exceed 1 month and we could not assume a steady state salinity response on a seasonal or monthly timescale. We needed a spatially explicit model to examine whether the influence of runoff on a monthly scale would be confined to basins near the inflow along the Everglades coast. We developed a model for this purpose that maintains a running account of the water and salt budgets in each of 44 well-mixed basins within the bay (Figure 3). The boundaries of these basins follow the system of the anastomosing banks that dissect the bay. This geometry was chosen because the banks are the primary controls on fluxes within the bay and the basins offer a natural framework for mass balance accounting. This approach traces its roots to the *Keulegan*'s [1967] model for the response of a coastal lagoon to forcing by ocean tides acting through an inlet. Tidal exchange through the inlet is modeled using Manning's equation and the head difference between zero-velocity water bodies at either end of the inlet channel. We adapted this approach to conditions in Florida Bay where exchange is governed by the constriction of shallow banks, not narrow inlets, and we extended it to a network of basins interconnected by flows over banks.

The dynamic mass balance model (Flux Accounting and Tidal Hydrology at the Ocean Margin (FATHOM)) calculates exchange with a coastal ocean and mixing among basins in a bay as the results of tidally driven water fluxes across shallow banks. At each hourly time step the model solves for uniform, hydraulic flow across each bank based on the depth, width, and frictional roughness of the bank and water levels in upstream and downstream basins. Manning's equation for friction flow in channels [see *Henderson*, 1966] is used to calculate water velocity as a function of depth with a vertical resolution of 0.3 m. These velocities are used with cross-sectional areas of banks to calculate water fluxes. Salt fluxes are then calculated from water fluxes and the salinity of an "upstream" basin. Details of the banks' representation and the hydraulic-equation solutions are given by *Cosby et al.* [1999]. Basically, FATHOM simulates mixing of salt between adjacent basins as tidally driven flows over a series of weirs.

In addition to the climate data needed for the box model, FATHOM requires tide data to set the open-water boundary conditions for the bay. Hourly tide stages along the Gulf of Mexico and Atlantic boundaries of Florida Bay were interpolated from NOAA tide tables for locations along the southern Florida coast and along the Florida Keys. We used semidiurnal tides and applied the same annual pattern for all years from 1965 to 1995. The effects of wind tides and wind mixing were not included in this application of FATHOM. We assumed the Gulf of Mexico and Atlantic salinity to be constant at 35. The seasonal estimates of evaporation derived from the box model (equation (6)) were applied using the same total evaporation and seasonal pattern for all basins and all years simulated. Our estimated monthly rainfall for the bay (Figure 6b) was evenly distributed over the 44 basins, and monthly runoff (Figure 6a) was added at five inflow points along the north shore of the East Region. Runoff distribution among the inflow points was determined by the proportions of the total runoff contributed by measured flows in Taylor Slough and the C111 canal. Generally, the influence of the C111 canal has been to redistribute runoff to the easternmost parts of the northern boundary [*Lorenz*, 1999] relative to historical conditions. We derived the length/depth distribution of each bank and the volume/depth distribution of each basin from Geographic Information System (GIS) data that had a resolution of 20 m. On the basis of this GIS data we assigned to each bank one of four widths (300, 1000, 3000, or 4000 m). We applied a value of 0.1 for Manning's n, the friction coefficient, for all banks (based on the literature for sediments and substrates similar to those on the banks in Florida Bay [e.g., *Henderson*, 1966]).

FATHOM calculates hourly values of water level and mean salinity for each basin; monthly average salinity was calculated for each basin based on these hourly values. Because of the simplifying assumptions inherent in the representation of tidal exchange in the model, the variation of salinity is not correctly represented at timescales less than that represented in the variation of monthly average salinity. For all but the East Region (which consists of a single basin), simulated monthly salinity values from two adjacent basins were averaged to provide regional salinity estimates that corresponded to the observed data (Figure 3). We did not calibrate FATHOM in any formal sense (e.g., optimization by least squares to fit the salinity data). The inputs described above were applied to the model, and the simulated salinity values were used without further adjustment.

4. Results and Discussion

4.1. Water Balance for Florida Bay

Using the annual averages of rainfall and runoff for 1970 to 1995 estimated from our data for these inputs (Figure 6) and the annual evaporation estimated from the application of the box model to the salinity data for 1987 through 1995 (see section 4.1.2), we derived an annual water balance for Florida Bay for rainfall of 98 cm yr^{-1}, for runoff of 9 cm yr^{-1}, for evaporation of 110 cm yr^{-1}, and for net freshwater supply to the bay of -3 cm yr^{-1}. We averaged the freshwater fluxes for each month from 1970 through 1995 to derive an average seasonal cycle of the water balance for Florida Bay (Figure 7).

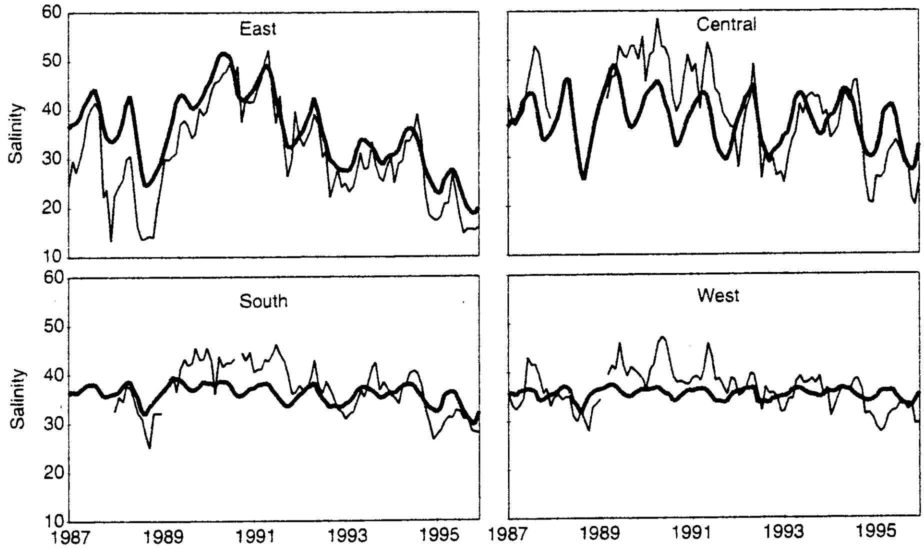

Figure 9. The simulated salinity values from the Flux Accounting and Tidal Hydrology at the Ocean Margin (FATHOM) model (bold line) when compared to the observed salinity data (fine line) for 1987 to 1995 revealed the magnitude of salinity variations associated with both interannual and seasonal variations in rainfall and runoff for each aggregated basin in Florida Bay. FATHOM was driven by monthly rainfall and runoff and simulated the salinity for all four basins over the 9 years with an efficiency of 51%.

component to runoff in FATHOM; all runoff was applied to the small bays along the northeastern margin of the bay that border the East Region (Figure 3), and no runoff was applied directly to the Central Region. This agreed with the location of the sources of runoff (Figure 1) and contrasted to the way runoff was applied in the box model (uniformly to all regions). Because of the increased spatial resolution and seasonal nature of the inputs, FATHOM simulated salinity in the East and Central Regions much more successfully than did the box model. However, FATHOM did not simulate the salinity variations observed in the West Region with the same success. The West Region is adjacent to the boundary with the Gulf of Mexico where salinity in the model was assumed to be constant. However, salinity does vary in the gulf adjacent to the bay, and the lack of this source of variation in the model contributed to the discrepancy.

Taken together, these seasonal results and the results from the annual analysis of net freshwater supply suggested that variations in the net freshwater supply influenced salinity in Florida Bay at both the seasonal and interannual timescales. Three factors, (1) location within the bay, (2) interannual variation of rainfall and runoff, and (3) seasonal variation of runoff and precipitation, accounted for approximately 51% of the observed salinity variation in the bay, each component contributing approximately equally (16%, 21%, and 14%, respectively). Other important sources of variation not included in these analyses, but which might have explained much of the remaining 49% of salinity variation, were temporal and spatial patterns of evaporation, wind-driven mixing and exchange with the coastal ocean, spatial patterns of rainfall over the bay, and variations of salinity at the Gulf of Mexico and Atlantic boundaries of the bay.

4.3. Model Reconstructions of Long-Term Salinity Variations (1965–1995)

We compared simulation results from each model with salinity observations from the complete 31-year (1965–1995) database to assess the predictive ability of the models. The 31-year record contains the temporally dense data used to calibrate the models (9 years from 1987 to 1995 comprising approximately 50% of the observations) and a sparser record that contains approximately the same number of observations over a longer period (22 years). Our purpose was not so much to formally test the models (that would have required that we evaluate only that data not used in calibration) as it was to extend the models to identify critical areas in which improvements could be made to both models and the supporting data.

The location model, based on regional means of the evaluation period (1987 through 1995), attained an efficiency of 20% when applied to the complete 31-year record (Table 4). This was not much different from the 16% efficiency achieved for the evaluation period and suggested that the effects of location have not changed much over the 3 decades under consideration. Likewise, efficiency for the steady state box model applied to all of the data was not significantly different from the box model efficiency achieved on the evaluation period (Table 4). We inferred from this that patterns of interannual variations in freshwater fluxes and the patterns of response in annual average salinity were relatively uniform over the period.

However, the efficiency score for FATHOM decreased from 51% when applied to the shorter evaluation period to 28% for the complete 31-year period probably because of the data used to drive the models and the salinity data itself. Since the efficiency for FATHOM declined even though the efficiencies of the other models did not, the quality and quantity of the data for the earlier period specific to FATHOM must have differed from that in the later evaluation period. These kinds of data include spatially explicit patterns of rainfall and runoff, monthly patterns of freshwater fluxes, and temporal and spatial variations in salinity values along the Gulf of Mexico and Atlantic Ocean boundaries. Given that FATHOM was the most spatially and temporally complex of the models, it should

Monthly rainfall varied from about 4 cm month^{-1} during the dry season to greater than 15 cm month^{-1} at the peak of the rainy season. Estimated evaporation was lowest in winter (about 6 cm month^{-1}) and reached a peak in early summer (13 cm month^{-1}). Monthly runoff under the management practices in place during the period was uniformly low (less than 2 cm month^{-1} for all months), but there appeared to be a tendency toward slightly higher runoff in late summer (Figure 7).

4.1.1. Importance of rainfall. Under water-management practices from 1970 through 1995 the average annual volume of runoff into Florida Bay was less than one tenth of the average annual volume of direct rainfall onto the bay. This distinguishes Florida Bay from other nearby estuarine areas where the ratio of runoff to direct rainfall was 1 to 2 orders of magnitude greater (Table 2). Within the bay the effects of runoff can be locally more important. For instance, in the East Region where almost all direct runoff actually entered the bay, the ratio of runoff to rainfall was larger (approximately 0.5). Comparing salinity conditions in the East Region with those in the Central Region provided an indication of the spatial variation in the magnitude of the effect of runoff to rainfall ratios on salinity within the bay. Both regions were relatively isolated from exchange with the ocean, but the Central Region received little freshwater inflow from runoff. Salinity variations in the two regions were similar (and high compared to other areas of the bay), but the mean salinity in the Central Region (no runoff) was 10 higher than that in the East Region (Table 1).

4.1.2. Estimated evaporation. The calibration of the box model for each region in the bay provided an estimate of annual average evaporation in each region for 1987 through 1995 (Table 3). We averaged the evaporation rates for each region to estimate the annual evaporation rate for Florida Bay as a whole. This average annual, bay-wide evaporation rate was approximately 110 cm yr^{-1}, significantly lower than the estimates derived from the pan data at Flamingo (210 cm yr^{-1}) and the water budget for Lake Okeechobee (162 cm yr^{-1}). Within the bay the estimates of annual evaporation varied spatially (Table 3). The estimated rates were almost identical in the Central, South, and West Regions (approximately 130 cm yr^{-1}), but the estimated rate for the East Region was more than 30% lower. A spatial pattern in evaporation over the bay (related to water depth, bottom cover, etc.) was expected, and, theoretically, the calibration of the box model could recover some of that pattern (to the degree to which the pattern is reflected in the annual average salinities used to calibrate the model).

Table 2. Comparison of Annual Freshwater Input Fluxes for Florida Bay With Other Florida Estuaries

Estuary	Area, km^2	Runoff,[a] cm	Rainfall,[a] cm	Inflow,[a] cm	Runoff/ Rainfall
Florida Bay[b]	2000	9[c]	98	107	0.1
Charlotte Harbor[d]	700	430	143	573	3.0
Indian River Lagoon[e]	568	635	131	766	4.8

[a] Annual volume is divided by area of estuary.

[b] Runoff and rainfall are annual averages for 1970 through 1995.

[c] This is the sum of gauged flows in Taylor Slough and in the C111 canal at S18C.

[d] Source is *Miller and McPherson* [1991].

[e] Source is *Smith* [1993].

Table 3. Summary of the Box Model Calibration for 1987–1995

Basin	Tide,[a] cm	Q_T,[b] cm yr^{-1}	Q_E,[b] cm yr^{-1}	r^2
East	0	172	83	0.25
South	6	339	128	0.48
Central	1	198	129	0.67
West	8	345	122	0.63

[a] Source is N. P. Smith and P. A. Pitts (Harbor Branch Oceanographic Institution, unpublished report, 1996).

[b] Values of Q_T and Q_E were estimated during calibration by nonlinear regression using observed annual average salinity.

The box model explained a much smaller proportion of the variation in the annual average salinity values in the East Region than elsewhere in the bay (based on the r^2 values, Table 3). The lower estimated evaporation and the lower explained variance in the east may reflect an underestimation of the freshwater fluxes either from runoff or direct rainfall into this region. This underestimation probably resulted, at least in part, from our decisions (1) to apply annual runoff uniformly to each region under the assumption that mixing of runoff throughout the bay was complete within a year and (2) to ignore the effect of rainfall contributions from the Taylor Slough area below the discharge gauge. If most of the runoff (and some additional rainfall) had been added to the simulations for the East Region, the estimated evaporation (and perhaps the explained variance) would have been higher in that region. Adding less runoff to the other regions would have resulted in lower estimated evaporation rates. Lacking observations on distribution and mixing of runoff in the bay (and the necessary resolution in the steady state, spatially aggregated box model structure), we could not evaluate these potential biases in the regional evaporation estimates. We therefore averaged the annual evaporation rates from all four regions to provide our best, unbiased estimate of the bay-wide annual evaporation rate.

4.2. Influence of Net Freshwater Supply on Salinity

4.2.1. Sources of interannual variation. The average annual net freshwater supply to Florida Bay is essentially zero. However, there have been large fluctuations in both the annual rainfall and annual runoff to the bay (Figure 6). From 1965 to 1995, annual direct rainfall onto the bay varied from about 75 cm yr^{-1} to about 140 cm yr^{-1}, a range of interannual variation of 65 cm yr^{-1} (range is 65% of mean value). For the same period the range of interannual variation of runoff into the bay was only 23 cm yr^{-1} (from 0 to 23 cm yr^{-1} with a range of 250% of mean value). Given the absolute magnitudes and ranges of interannual variations of rainfall and runoff, it seems likely that annual variations of salinity in Florida Bay for the last 3 decades have been primarily affected by variations in annual rainfall and only to a lesser extent by changes in annual runoff even though the percentage of changes in runoff have been greater.

4.2.2. Results of the steady state model. A comparison of the annual average salinity values simulated by the steady state box model with the observed monthly salinity data supported our conclusion that interannual variations in rainfall and runoff explained much of the variation of salinity in all regions of the bay (Figure 8). The box model, which was applied to each

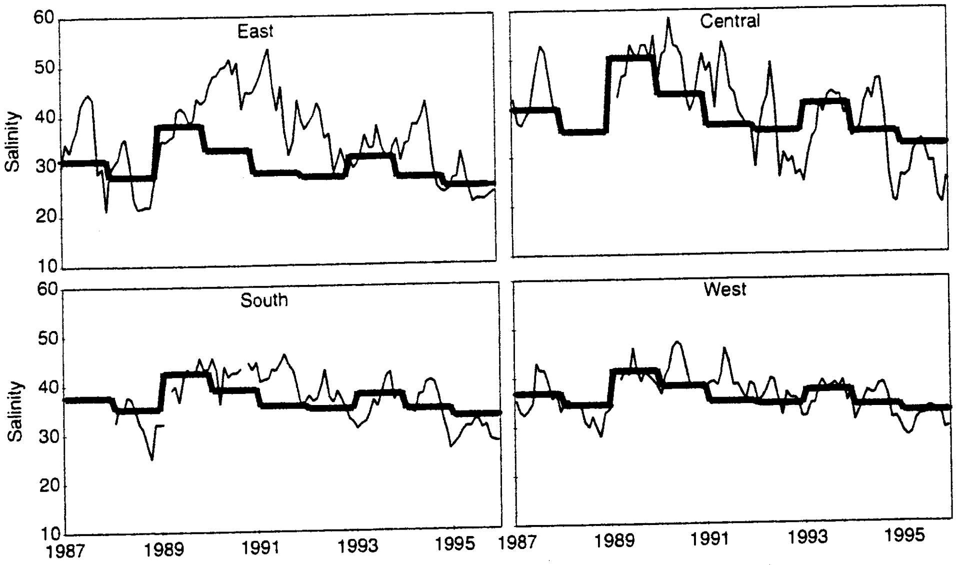

Figure 8. The simulated salinity values from the box model (bold line) when compared to the observed salinity data (fine line) for 1987 to 1995 revealed the magnitude of salinity variations associated with interannual variations in rainfall and runoff for each aggregated basin in Florida Bay. The box model was driven only by annual rainfall and runoff and simulated the salinity of all four basins over the 9 years with an efficiency of 37%.

region using annual fluxes, attained an efficiency of 37% for 1987 through 1995 (Table 4). (For each region the simulated average salinity for a given year was used for all months within that year when calculating the efficiency by (2).) By contrast, the efficiency score for the location model, the long-term mean salinity for each region, was just 16% (Table 4). (For each region the mean salinity was used for all months in all years when calculating the efficiency by (2).) The difference in efficiency can be attributed to the influence on salinity of interannual fluctuations in rainfall and runoff. That is, approximately 21% of the variance of salinity in Florida Bay resulted from interannual variations of freshwater fluxes.

The values of the exchange flux, Q_T, in the box model can be interpreted as the water renewal rate, a function of tidal exchange with the Gulf of Mexico and the Atlantic. We compared the magnitudes of the calibrated exchange fluxes with observed tidal amplitudes in each region of the bay (Table 3) and found a strong correlation, providing partial, qualitative corroboration of the model calibration. The calibrated values of Q_T (Table 3) were used to estimate residence times in each region of the bay. Assuming that the average water depth in each region is 100 cm, residence times in years were defined as $100/Q_T$. These estimates of residence times ranged from 0.3 to 0.6 years and indicated that water in the East and Central Regions would require over a year to be completely replaced by exchange flux. The results of the residence time analysis and the fact that observed fluctuations in the salinity data appear to lag the simulated salinity (Figure 8) for all regions suggested that annual average salinity was not in steady state with annual variations in the net freshwater supply anywhere within the bay.

4.2.3. Seasonal effects. On a monthly basis the average net freshwater supply fluctuated considerably between negative and positive values (Figure 7). The average net supply of freshwater was positive during the rainy season (from June through October) and was negative in the winter and spring. Generally, salinity values during winter and spring exceeded the salinity of the adjacent ocean; during the rainy season, salinity values dropped to below ocean salinity (Figure 5). Although annual runoff was small compared to annual rainfall, the seasonal variation in runoff was an important component of the seasonal variation in net freshwater supply. For example, total net freshwater supply during the rainy season was about 22 cm, of which more than 30% was contributed by runoff from Taylor Slough and the C111 canal. This implies that changes in the amount or the timing of the seasonal components of runoff may have greater impact than changes in annual totals alone.

4.2.4. Results from the dynamic model. FATHOM attained an efficiency score of 51% when compared to salinity observations for 1987 through 1995, compared to 37% attained by the steady state box model (Table 4). This suggested that approximately 14% of the variance in observed salinity in Florida Bay was related to seasonal variations in net freshwater supply. The increased efficiency largely resulted because FATHOM very successfully simulated both the seasonal fluctuations and interannual trends in salinity observations in the East and Central Regions (Figure 9). There was a spatial

Table 4. Types of Variability in Salinity Derived From Comparison of Model Results

Types of Variability[a]	Model	Efficiency (Eff), %	
		1987–1995	1965–1995
Spatial	basin means	16	20
Spatial and interannual	box model	37	38
Location, interannual and seasonal	FATHOM	51	29

FATHOM is Flux Accounting and Tidal Hydrology at the Ocean Margin model.

[a] Variability categorized as spatial (among basins, interannual), based on annual averages, and seasonal, based on monthly averages.

Table 5. Sensitivity of Monthly Average Salinity Simulated by FATHOM to Increased Runoff From 1987 to 1995

	Reference Simulation		Runoff Doubled	
Basin	Mean	SD	Mean	SD
East	35.4	8.0	26.1	8.9
South	36.0	2.0	35.0	2.8
Central	37.5	5.3	37.2	5.7
West	35.3	1.1	35.3	1.2

SD is standard deviation.

not have been surprising that its efficiency declined as it was applied to the earlier periods where the salinity data were sparse and flux data were increasingly uncertain. For example, a program of regular salinity monitoring has only been in place since about 1990; data from before this date are largely compilations of incidental measurements. Also, rainfall measurements from in the bay were only available from 1991. Before that, monthly values of rainfall were extrapolated from land-based stations based on regression equations calibrated on the 4 years of recent data in the bay. The exact cause(s) of the salinity variations in Florida Bay in the 1960s and 1970s may never be known.

4.4. Critical Gaps in Knowledge

Our analyses of net freshwater supply and our model reconstructions of long-term salinity variations have identified several areas where better information would improve our understanding of and ability to predict salinity variations in Florida Bay. Generally, these areas can be grouped as uncertainties relating to (1) complete lack of direct information about the magnitude and the spatial and temporal variations in evaporation in the bay; (2) insufficient long-term and seasonal data on both terrestrial and oceanic boundary conditions of the bay; and (3) the poor temporal and spatial coverage by currently available measurements of direct rainfall into the bay.

For example, the first two of these relate to the unknown causes of the lower evaporation rate estimated by the box model for the East Region (Table 3). Using the available information, we could not ascertain if the lower rate simply reflected the spatial variations in evaporation that we knew must be present in the bay (but which had not been quantified) or if the lower rate arose because we did not account for direct rainfall onto and runoff from the wetlands south of the Taylor Slough and C111 canal discharge measurement points. In either case a significant freshwater flux pertinent to the northeastern bay remains unquantified. The results of *Corbett et al.* [1999] rule out the possibility that this unknown source could be submarine groundwater discharge.

Another area of uncertainty about boundary conditions relates to salinity variations along the Gulf of Mexico and Atlantic boundaries of Florida Bay. In our models we assumed this salinity was constant and equal to 35. However, freshwater discharge from Shark Slough (Figure 1) joins a southward flowing coastal current just north of Florida Bay and contributes to salinity variation at the northwestern boundary of the bay. Recent data from this area have documented salinity fluctuations of 26 to 39 [e.g., *Boyer et al.*, 1999; *Wang*, 1998].

4.5. Simulated Response to Increased Runoff

Even with the limitations of the data and the current model, FATHOM simulated salinity variations for 1987 to 1995 reasonably well (Figure 9). We therefore decided to use this FATHOM application as a reference case and to investigate the sensitivity of salinity in Florida Bay to changes in runoff from Taylor Slough and the C111 canal. The experiment reported here was relatively simple and is presented only to demonstrate the usefulness of the model in such exercises and to provide a rough measure of the responses of salinity in Florida Bay to changes in the management of freshwater runoff into the bay.

We conducted a model simulation in which monthly runoff rates for every month from 1987 through 1995 were doubled. Monthly rainfall and evaporation rates were not changed. The increased runoff was applied to the model in the same locations (i.e., only the volume of runoff was increased, the spatial distribution of runoff was not changed). The results of this experiment were compared to the reference simulation (Table 5). In the East Region the increased runoff depressed the mean salinity value by 9.3 below the mean for the reference simulation. In the south, although the mean salinity was little changed, the standard deviation of monthly salinity values increased 40% (Table 5). Rather importantly for some management options under consideration, doubling runoff without changing its distribution along the northern boundary of the bay had little effect on salinity in the Central Region. This is significant because salinity in excess of 60, which occurs for short periods in the Central Region [*Fourqurean et al.*, 1993] even though monthly means do not show it (Figure 8), is often implicated in the ecological decline in the bay. Our experiment simply doubled the runoff for all months. Our analysis of the seasonal patterns in net freshwater fluxes suggested that the same total annual volume of runoff increase, if applied in just a few properly chosen months (instead of in all months), would have a much larger effect on salinity in the bay. Management options for ecosystem restoration in the Everglades and Florida Bay could certainly include changes in the timing as well as amount of runoff. Our analysis of the effects of location in the application of runoff also suggested that changing the runoff points along the Everglades boundary would affect the distribution of the freshwater within the bay. For instance, the redistribution of runoff westward from the C111 canal into Taylor Slough should bring larger salinity changes in the Central Region. We plan to continue to use FATHOM to investigate the projected effects of various changes in runoff amount, location, and timing on salinity distributions in Florida Bay.

5. Conclusions

The annual average water balance for Florida Bay from 1970 to 1995 was dominated by rainfall and evaporation, which were approximately equal. Annual runoff was less than one tenth of rainfall. Annually, the variations of salinity in Florida Bay for the last 3 decades have been primarily affected by interannual variations in rainfall volumes and somewhat less by changes in annual runoff even though the relative changes in runoff over the period have been greater.

Variations in the net freshwater supply influence salinity in Florida Bay seasonally and interannually. Three factors (location within the bay, interannual variation of rainfall and runoff, and seasonal variations of runoff and precipitation) accounted for approximately 51% of the observed salinity variation in the bay from 1987 to 1995, each component contributing approximately equally (16%, 21%, and 14%, respectively). Other important sources of variation not in these analyses but that might have explained much of the remaining 49% of the salinity variation were temporal and spatial patterns of evaporation, wind-driven mixing and exchange with the coastal ocean, spatial patterns of rainfall over the bay, and variations of salinity at the Gulf of Mexico and Atlantic boundaries of the bay.

We identified several areas where better information would improve our understanding of and ability to predict salinity variations in Florida Bay. Generally, these areas could be grouped as uncertainties relating to (1) complete lack of direct information about the magnitude and the spatial and temporal variations in evaporation in the bay; (2) insufficient long-term and seasonal data on both terrestrial and oceanic boundary conditions of the bay; and (3) poor temporal and spatial coverage by currently available measurements of direct rainfall into the bay.

Appendix: Florida Bay Historical Salinity Database

Salinity measurements for Florida Bay are numerous but scattered, reflecting the diverse character of the biologic, geologic, and hydrologic studies that generated the data. The available salinity record for Florida Bay began in 1936. Prior to this, salinity observations were extremely rare, and references to salinity conditions in the Florida Bay were mostly qualitative. By the mid-1950s, spatially and temporally intensive data were becoming available, but they were scattered in space and time. In 1981 the National Park Service inaugurated routine salinity monitoring in Florida Bay; by 1988 this network had become sufficiently dense to meet many of the needs of management and science.

We compiled into a single database what we feel are the most reliable salinity data for Florida Bay available in both published and unpublished sources. Temporal coverage of the database was reasonable, with a number of studies available in each decade since 1940 (Table A1). Spatial coverage was reasonable in most areas, but in some areas no data were available. For instance, few data were available covering the extensive shallow water banks in western Florida Bay primarily because the area is inaccessible by boat. We searched extensively for any source of data prior to 1990. For the data since 1990 we limited our sources to several spatially and temporally intensive monitoring studies in the bay. Regardless of the source, a salinity measurement was only included in the database if it met the following criteria: (1) The observation was made within Florida Bay or in waters immediately adjacent to the bay. (2) The measurement was a discrete observation (i.e., the observation was not part of a high-frequency time series or an average value taken over time or space). (3) The date and time of the observation were known. (4) The latitude and longitude of the location of the observation were available or could be estimated. (5) The depth at which the observation was made could be determined (i.e., surface, bottom, or intermediate depth).

Currently, the database contains over 34,000 salinity observations covering 1947 to 1995. Data sources in this compilation are organized by "study numbers" from 1 to 60. Each study consists of salinity measurements drawn from a single or a few closely related sources. Table A2 summarizes the number of stations, number of measurements, location, and duration (dates) of each study and includes references to the published or unpublished literature from which the data were extracted.

Table A1. Chronology of the Studies Included in the Historical Database for Florida Bay

	Decade					
Study	1940	1950	1960	1970	1980	1990
2	x					
4		x				
7		x				
8		x				
28		x	x			
34		x	x			
5			x			
6			x			
16			x			
22			x		x	
26			x			
29			x			
35			x			
41			x			
43			x			
55			x			
59			x			
3				x		
9				x		
12				x		
13				x	x	
14				x	x	
19				x	x	
21				x		
42				x		
45				x		
49				x	x	x
51				x		
54				x	x	
57				x		
1					x	
10					x	
15					x	
17					x	
20					x	
23					x	x
24					x	
25					x	x
27					x	x
30					x	x
31					x	x
32					x	x
33					x	x
36					x	
38					x	
46					x	x
47					x	x
48					x	
50					x	
52					x	x
58					x	x
18						x
37						x
39						x
60						x

Table A2. Annotated Bibliography

Study	Location	Number of Stations	Number of Observations	Period Sampled	Reference
1	NW Florida Bay, Shark River	8	50	Mar. 1984 to Sept. 1985	Powell, A. B., D. E. Hoss, W. F. Hettler, D. S. Peters, L. Simoneaux, and S. Wagner, Abundance and distribution of ichthyoplankton in Florida Bay and adjacent waters, *SFRC-87/01*, 45 pp., S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1987.
2	west coast estuaries, north, central, NE Florida Bay	31	31	June 1947 to May 1948	Davis, C. C., Notes on the plankton of Long Lake, Dade County, Florida, with descriptions of two new copepods, *Q. J. Fla. Acad. Sci.*, *10*, 79–88, 1948.
3	Long Sound, Manatee Bay	14	30	Jan. 1977 to March 1977	Creamer, D., Salinity observations east and west of U.S. Highway 1, unpublished report, Fish and Wildl. Serv., Vero Beach, Fla., 1977.
4	nearshore Gulf of Mexico, west coast estuaries, NW Florida Bay, Whitewater Bay	48	1225	Mar. 1954 to June 1958	Dragovitch, A., J. H. Finucane, and B. Z. May, Counts of red tide organisms, *Gymnodinium breve*, and associated oceanographic data from Florida west coast, 1957–1959, *Spec. Rep. Fish 369*, pp. 1–102, U.S. Fish and Wildl. Serv., Vero Beach, Fla., 1961. Finucane, J. H., and A. Dragovitch, Counts of red tide organisms, *Gymnodinium breve*, and associated oceanographic data from Florida west coast, 1957–1959, *Spec. Rep. Fish 289*, pp. 202–295, U.S. Fish and Wildl. Serv., Vero Beach, Fla., 1959. Finucane, J. H., Distribution and seasonal occurrence of *Gymnodinium breve* on the west coast of Florida, 1954–57, *Spec. Sci. Rep. Fish 487*, 14 pp., U.S. Fish and Wildl. Serv., Vero Beach, Fla., 1964.
5	Buttonwood Sound	19	75	Aug. 1962 to Feb. 1963	Lynts, G. W., Relationship of sediment-size distribution to ecological factors in Buttonwood Sound, Florida Bay, *J. Sediment Petrol.*, *36*(1), 66–74, 1966.
6	Florida Bay, Florida Keys	8	2140	Mar. 1960 to Jan. 1961	Goodell, H. G., and D. S. Gorsline, Data report on the hydrography of Apalachicola and Florida Bays, *Fla. St. Univ. Sed.Res. Lab. Contrib. 1*, 316 pp., Fla. State Univ., Tallahassee, 1961.
7	Florida Bay, Florida Keys	32	54	Aug. 1958 to Jan. 1959	Lloyd, R. M., Variation in oxygen and carbon isotope ratios of Florida Bay mollusks and their environmental significance, *J. Sediment Petrol.*, *36*(1), 84–111, 1964.
8	central, east Florida Bay	76	615	Dec. 1956 to April 1958	McCallum, J. S., and K. S. Stockman, Salinity in Florida Bay, *Geol. Misc. 21*, 14 pp., Explor. and Prod. Res. Div., Shell Dev. Co., Houston, Tex., 1959.
9	east, central Florida Bay, Barnes Sound, Manatee Bay	166	1760	Jan. 1977 to Feb. 1979	Coleman, R. A., T. W. Schmidt, R. E. Hermance, P. W. Rose, P. C. Patty, W. B. Robertson Jr., Some hydrographic aspects of the estuarine area from northeastern Florida Bay to Barnes Sound, especially in restoring historical water conditions, unpublished management report, 41 pp., S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1979.
10	west, central Florida Bay	5	40	Nov. 1982 to Dec. 1986	Powell, G. V. N., S. M. Sogard, and J. G. Holmquist, Ecology of shallow water bank habitats in Florida Bay, final report to S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 406 pp., Ornithol. Res. Unit, Natl. Audubon Soc., Tavernier, Fla., 1987.
11	NE Florida Bay	67	77	Feb. 1967 to Mar. 1967	Tabb, D. C., T. R. Alexander, T. M. Thomas, and N. Maynard, The physical, biological, and geological character of the area south of the C-111 Canal in extreme southeastern Everglades National Park, Homestead, Fla., final report, (contract 14-10-1-160-11), S. Fla. Res. Cent., Natl. Park Serv., Homestead, Fla., 1967. (Available as *ML 67103*, Rosenstiel Sch. of Mar. and Atmos. Sci., Univ. of Miami, Miami, Fla.)
12	Florida Bay	49	1665	April 1973 to Sept. 1976	Schmidt, T. W., Ecological study of fishes and the water quality characteristics of Florida Bay, Everglades National Park, Florida, final report, 144 pp., S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1979.
13	east, north, central Florida Bay	262	3070	July 1978 to Sept. 1983	White, D. A., Oceanographic monitoring study, October 1980 to October 1983, unpublished report, S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1983.
14	Florida Bay	13	275	Mar. 1977 to June 1980	Bert, T. M., J. T. Tilmant, J. W. Dodrill, and G. E. Davis, Aspects of the population dynamics and biology of the stone crab (*Menippe mercenaria*) in Everglades and Biscayne National Parks as determined by trapping, *Tech. Rep. SFRC-86/04*, 77 pp., S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1986.
15	east, NW Florida Bay, Whitewater Bay	30	160	Feb. 1982 to Dec. 1983	Rutherford, E. S., Larval and juvenile gamefish study, February 1982 to December 1983, unpublished report, S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1983.
16	NW Florida Bay	1	16	Jan. 1963 to Dec. 1964	Overstreet, R. M., Parasites of the inshore lizardfish, *Synodus foetens*, from south Florida, M.S. thesis, 69 pp., Univ. of Miami, Miami, Fla., 1966.

Table A2. (continued)

Study	Location	Number of Stations	Number of Observations	Period Sampled	Reference
17	NE Florida Bay	12	221	Mar. 1986 to Sept. 1987	Montague, C. L., R. D. Bartleson, and J. A. Ley, Assessment of benthic communities along salinity gradients in northeastern Florida Bay, *Final Rep. CA5280-5-8004*, S. Fla. Res. Cent., Natl. Park Serv., Homestead, Fla., 1989. (Available from Rosenstiel Sch. of Mar. and Atmos. Sci., Univ. of Miami, Miami, Fla.)
18	west, central Florida Bay, Sunset Cove	50	350	June 1990 to Nov. 1991	Robblee, M. B., Salinity and temperature data collected at swim-over stations associated with sea-grass die-off monitoring, 1990 to 1991, unpublished data, S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1991.
19	east Florida Bay	7	96	Oct. 1979 to Nov. 1980	Evink, G. L., Hydrological study in the area of Cross Key, Florida, *Environ. Res. FL-ER-16-81*, 31 pp., Fla. State Dep. of Transp., Bur. of Environ., Tallahassee, Fla., 1981.
20	west, central, south Florida Bay, Whitewater Bay	205	274	May 1984 to June 1985	Thayer, G. W., W. F. Hettler Jr., A. J. Chester, D. R. Colby, and P. T. McElhaney, Distribution and abundance of fish communities among selected estuarine and marine habitats in Everglades National Park, *Tech. Rep. SFRC-87/02*, 166 pp., S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1987.
21	central, east Florida Bay	43	75	June 1970 to Sept. 1973, Mar. 1977	Ogden, J. C., Field notes associated with Florida Bay field trips from Tavernier, Florida, 1971 to 1973, 1977, Ornithol. Res. Unit, Natl. Audubon Soc., Tavernier, Fla., 1977.
22	Florida Bay, Barnes Sound, Manatee Bay	312	312	May 1966, Jan. 1984 to June 1984	Shaw, A. B., Salinity data collected from across Florida Bay associated with studies of the distribution of mollusk shells, maps, Amoco Oil, Chicago, Ill., 1984.
23	west, central Florida Bay	47	230	May 1989 to Dec. 1991	Robblee, M. B., Salinity and temperature data associated with benthic animal sampling of seagrass die-off impacted areas in Florida Bay, 1989 to 1991, unpublished data, S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1992.
24	east, central, west Florida Bay, Manatee Bay	96	180	Aug. 1988 to Oct. 1988	Robblee, M. B., and J. W. Fourqurean, Field notes associated with the August 1988 C-111 canal water release, unpublished data, S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1988.
25	Florida Bay, Whitewater Bay, west coast estuaries	38	3190	May 1981 to Dec. 1995	Smith, D. T., Surface refractometer measurements made at marine monitoring stations, 1981 to 1995, unpublished data, S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1995.
26	Florida Bay, Florida Keys	61	610	Aug. 1963 to Feb. 1969	Costello, T. J., D. M. Allen, and J. H. Hudson, Distribution, seasonal abundance, and ecology of juvenile northern pink shrimp, *Penaeus duorarum*, in Florida Bay area, *NOAA Tech. Memo. NMFS-SEFC-161*, 84 pp., Natl. Oceanic and Atmos. Admin., Miami, Fla., 1986. Hudson, J. H., D. M. Allen, and T. J. Costello, The flora and fauna of a basin in central Florida Bay, U.S. Fish Wildl. Serv., *Spec. Sci. Rep. Fish 604*, 14 pp., Washington, D. C., 1970.
27	Florida Bay, Whitewater Bay	163	815	Oct. 1981 to Oct. 1987	Robblee, M. B., and T. W. Schmidt, Environmental data collected in association with collections of pink shrimp, caridean shrimp, and fishes in Florida Bay and Whitewater Bay, 1981 to 1987, unpublished report, S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1987.
28	NW Florida Bay, Whitewater Bay	36	1540	May 1957 to May 1962	Tabb, D. C., D. L. Dubrow, and R. B. Manning, Hydrographic data from the inshore bays and estuaries of Everglades National Park, Florida, 1957–1959, *ML 59253*, 26 pp., The Mar. Lab., Univ. of Miami, Miami, Fla., 1959. Tabb, D. C., and D. L. Dubrow, Hydrographic data, supplement I, from the inshore bays and estuaries of Everglades National Park, Florida, 1959–1962, *ML 62245*, 22 pp., The Mar. Lab., Univ. of Miami, Miami, Fla., 1962.
29	Florida Bay, Whitewater Bay	57	840	Sept. 1964 to July 1967	Tabb, D. C., Prediction of estuarine salinities in Everglades National Park, Florida, by the use of ground water records, Ph.D. dissertation, 107 pp., Univ. of Miami, Coral Gables, Fla., 1967.
30	Long Key	1	4215	Jan. 1981 to Dec. 1995	Swanson, J. W., Salinity, temperature, pH, DO monitoring data from the Keys Marine Laboratory, unpublished data, Fla. Dep. of Environ. Prot., Long Key, 1995 (Sea World, Orlando, Fla., collected data during the period 1981 to 1987.)
31	Florida Bay	30	190	June 1989 to July 1990	Fourqurean, J. W., R. D. Jones, and J. C. Zieman, Processes influencing water column nutrient characteristics and phosphorus limitation of phytoplankton biomass in Florida Bay, Florida, USA: Inferences from the spatial distributions, *Estuarine Coastal Shelf Sci.*, *36*, 295–314, 1993. Fourqurean, J. W., R. D. Jones, and J. C. Zieman, Water quality observations from across Florida Bay (June 1989 to April 1990), report (contracts CA5280-9-8001, CA5280-9-8008, CA5280-0-9009, CA5280-0-9010 and CA5280-8-8007), Univ. of Va., Charlottesville, Fla. Int. Univ., Miami, and S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1991.

Table A2. (continued)

Study	Location	Number of Stations	Number of Observations	Period Sampled	Reference
32	NE, NW Florida Bay	4	203	Dec. 1989 to Nov. 1991	Lorenz, J., Observations made during Ph.D. research in Florida Bay, 1989 to 1991, Univ. of Fla., Gainesville, 1991.
33	east, central Florida Bay, Whitewater Bay, Shark River	44	220	June 1989 to Mar. 1990	Ley, J. A., and C. L. Montague, Influence of changes in freshwater flow on the use of mangrove prop root habitat by fish, report to S. Fla. Water Manage. Dist., 220 pp., Dep. of Environ. Eng. Sci., Univ. Fla., Gainesville, 1991.
34	NW Florida Bay, Buttonwood Canal, Whitewater Bay, nearshore Gulf of Mexico	9	110	Sept. 1957 to Mar. 1962	Tabb, D. C., and D. L. Dubrow, Biological data on pink shrimp, *Penaeus duorarum*, of north Florida Bay and adjacent estuaries in Monroe County, Florida, September 1957–March 1962, unpublished data, *ML 62239*, 89 pp., The Mar. Lab., Univ. of Miami, Miami, Fla., 1962.
35	Florida Bay, Florida Keys	18	355	Jan. 1962 to Dec. 1962	Gorsline, D. S., Final data report marine geology and oceanography of Florida Bay, Apalachicola Bay and vicinity, Florida, observation period January to December 1962, *Rep. USC Geol. 65-1*, Fla. State Univ., Tallahassee, 1965.
36	West, central, east Florida Bay	179	179	Oct. 1987	Robblee, M. B., Salinity observations following Hurricane Floyd in October 1987, unpublished report, S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1987.
37	Florida Bay	31	80	June 1991 to Feb. 1992	Frankovitch, T. A., Epiphyte loads and production on the seagrass, *Thalassia testudinum*, M.S. thesis, 136 pp., Dep. of Environ. Sci., Univ. of Va., Charlottesville, 1996.
38	central Florida Bay	9	9	Oct. 1980	Gaby, R., Environmental observations along a transect across Florida Bay, October 1, 1980, report to Don Miller, Everglades Prot. Assoc., Islamorada, Fla., 3 pp., Connell, Metcalf and Eddy, Inc., Coral Gables, Fla., 1980.
39	Florida Bay, Barnes Sound	13	230	Jan. 1990 to June 1991	Bugden, J., Water quality observations made in Florida Bay, 1990 to 1991, as part of a M.S. thesis on seagrass die-off, Fla. Int. Univ., Miami, 1991.
41	west coast estuaries, Whitewater Bay	40	1495	April 1962 to Mar. 1967	Marshall, A., and R. Jones, Salinity data from Big Cypress and Everglades west coast estuaries, 1962 to 1967, unpublished data, Branch of River Basin Stud., Fish and Wildl. Serv., Vero Beach, Fla., 1967.
42	Card Sound	5	60	Oct. 1971 to Oct. 1972	Smith, R., Abundance and diversity of sponges and growth rates of *Spongia graminea* in Card Sound, Florida, M.S. thesis, 56 pp., Univ. of Miami, Coral Gables, Fla., 1973.
43	Buttonwood Canal Bridge	1	24	Jan. 1963 to Dec. 1964	Waldinger, F. J., Relationships of environmental parameters and catch of three species of the mojarra family (Gerridae), *Eucinostomus gula*, *Eucinostomus argenteus*, and *Diapterus plumeri*, collected in 1963 and 1964 in Buttonwood Canal, Everglades National Park, Florida, M.S. thesis, 68 pp., Univ. of Miami, Coral Gables, Fla., 1968.
44	Little Blackwater Sound, Long Sound	17	50	Feb. and Mar. 1966	Lee, C. C., The decomposition of organic matter in some shallow water, calcareous sediments of Little Blackwater Sound, Florida Bay, Ph.D. dissertation, 106 pp., Univ. of Miami, Coral Gables, Fla., 1969.
45	Florida Keys	5	21	April 1976 to June 1977	Helbling, R. J., Water quality data collected for Permanent Network Monitoring Program, unpublished data, Fla. Dep. of Environ. Regul., Marathon, Fla., 1978.
46	Florida Bay	50	132	June 1989 to Mar. 1991	Zieman, J. C., and J. W. Fourqurean, Water quality observations associated with seagrass die-off research, 1989 to 1990, unpublished data, Univ. of Va., Charlottesville, 1991.
47	Florida Bay, Whitewater Bay, west coast estuaries	75	2800	Jan. 1991 to Dec. 1995	Jones, R. D., Water quality observations in Florida and Manatee Bays and Barnes Sound, 1991 to 1995, unpublished data, (contract MA5280-0-9015), Fla. Int. Univ., Miami, and the S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1991–1995.
48	NE Florida Bay, C-111 canal	28	125	Oct. 1985 to Aug. 1986	Swift, D., Water quality measurements taken in the marshes and bays below the C-111 Canal in southwestern Dade County, unpublished data, S. Fla. Water Manage. Dist., West Palm Beach, 1988.
49	NE Florida Bay, Florida Keys	8	78	July 1975 to Sept. 1991	Rich, E., Environmental data collected in Florida Bay, unpublished data, Univ. of Miami, Coral Gables, Fla., 1991.
50	West coast estuaries, Whitewater Bay	19	65	April 1986 to Sept. 1989	Bancroft, G. T., S. D. Jewell, and A. M. Strong, Foraging and nesting ecology of herons in the lower Everglades relative to water conditions, *Final Rep. 202-M86-0254-R*, to S. Fla. Water Manage. Dist., 156 pp. and appendix, Natl. Audubon Soc., Tavernier, Fla., 1990.

Table A2. (continued)

Study	Location	Number of Stations	Number of Observations	Period Sampled	Reference
51	nearshore Gulf of Mexico, west coast estuaries, Whitewater Bay	35	140	May 1971 to Feb. 1972	Lindall, W. N., Jr., J. R. Hall, W. A. Fable Jr., and L. A. Collins, Fishes and commercial invertebrates of the nearshore and estuarine zone between Cape Romano and Cape Sable, Florida, South Florida Ecological Study Appendix E, Estuarine-Dependent Marine Fishes, Part II, Sect. II, 59 pp., Gulf Coastal Fish. Cent., St. Petersburg Beach Lab., Natl. Mar. Fish. Serv., St. Petersburg Beach, Fla., 1973.
52	west, central Florida Bay	52	90	June 1988 to Sept. 1990	Durako, M. J., Environmental data collected in association with seagrass die-off studies in Florida Bay, unpublished data, (contract CA5280-9-8002 to Fla. Mar. Res. Inst., Dep. of Nat. Resour., St. Petersburg, Fla.) S. Fla. Res. Cent., Everglades Natl. Park, Homestead, Fla., 1990.
53	west Florida Bay, Florida Keys	191	191	1972	Davies, T. D., Peat formation in Florida Bay and its significance in interpreting the recent vegetation and geological history of the bay area, Ph.D. dissertation, 338 pp., Pa. State Univ., University Park, 1980.
54	NE Florida Bay	119	440	Jan. 1978 to Sept. 1989	Mazzotti, F. J., The ecology of *Crocodylus acutus* in Florida, Ph.D. dissertation, 161 pp., Pa. State Univ., University Park, 1983.
55	Buttonwood Canal Bridge	1	150	June 1964 to June 1965	Beardsley, G. L., Jr., Distribution in the water column of migrating juvenile pink shrimp, *Penaeus duorarum*, Burkenroad in Buttonwood Canal, Everglades National Park, Florida, Ph.D. dissertation, 91 pp., Univ. of Miami, Coral Gables, Fla., 1967.
56	Largo Sound, nearshore Atlantic Ocean	5	250	Nov. 1982 to Dec. 1986	Skinner, R. H., Salinity observations from the water quality monitoring program of John Pennekamp Coral Reef State Park, unpublished data, 1982–1986.
57	nearshore Gulf of Mexico, west-coast estuaries, Whitewater Bay	35	140	May 1971 to Feb. 1972	Collins, L. A., and J. H. Finucane, Ichthyoplankton survey of the estuarine and inshore waters of the Florida Everglades, May 1971 to February 1972, *NOAA Tech. Rep. NMFS 6*, 75 pp., Natl. Oceanic Atmos. Admin., Miami, Fla., 1984.
58	west, central Florida Bay	5	115	June 1989 to June 1990	Sheridan, P. F., Environmental observations associated with seagrass die-off studies conducted in Florida Bay by the National Marine Fisheries Service, unpublished data, Galveston Lab., Galveston, Tex., 1990.
59	Whitewater Bay	8	120	Jan. 1968 to June 1969	Clark, S. H., Factors affecting the distribution of fishes in Whitewater Bay, Everglades National Park, Florida, Ph.D. dissertation, 100 pp., Univ. of Miami, Coral Gables, Fla., 1970.
60	Florida Bay	30	670	Sept. 1993 to Dec. 1995	Colvocoresses, J., Data from the Florida Marine Fisheries-Independent Monitoring Program in Florida Bay, unpublished data, Fla. Mar. Res. Inst., Marathon Lab., Marathon, Fla., 1995.

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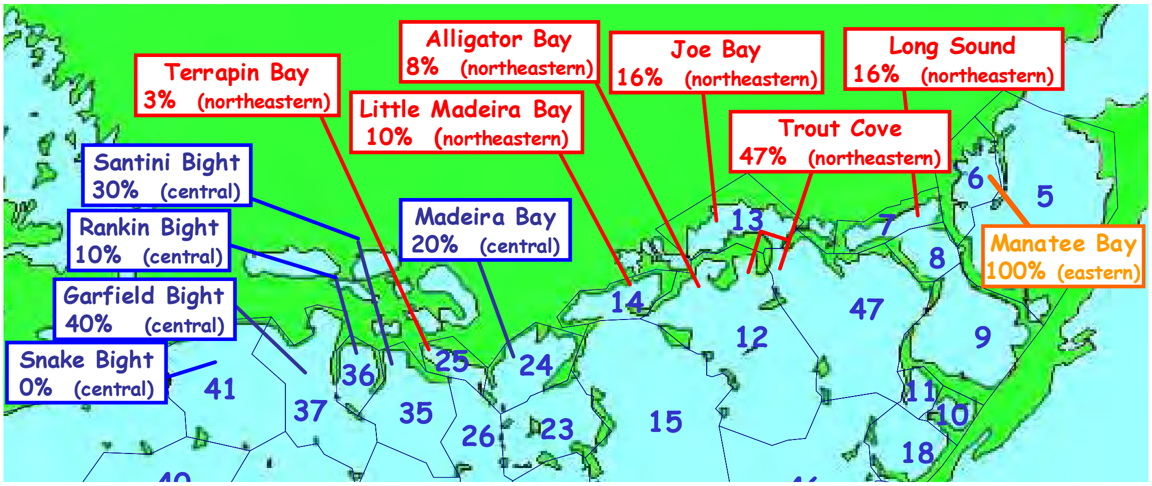
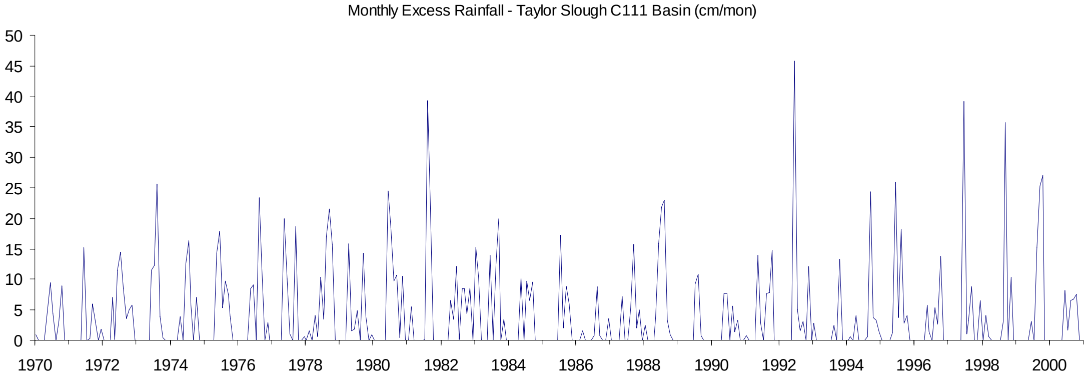
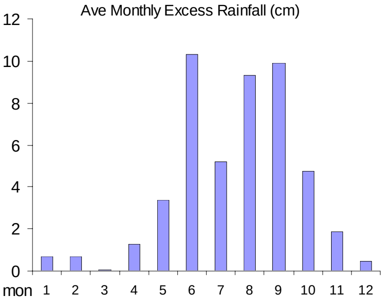
Appendix F

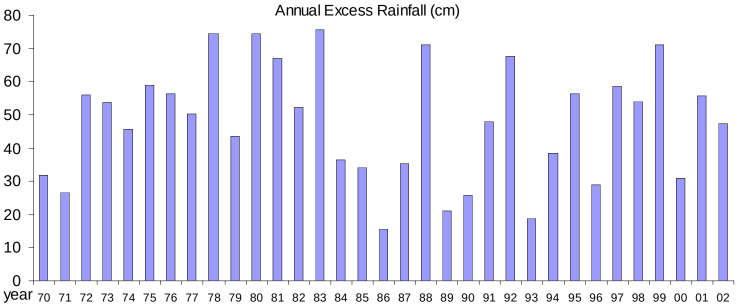
Excerpt from FATHOM Model Report Appendix C: Methodology to Determine Flows to Florida Bay

Figure 3.10: FATHOM inflow groups showing the distribution of flow among the basins in each group; percentages give distribution of total inflow within each group









FROM FATHOM FINAL REPORT, OCTOBER 2005, pp. 65-70

The **distribution** of inflow into the FATHOM basins always remains the same within each inflow group. However, the distribution of inflow among the inflow groups changes between MFL base case and the inflow alternatives examined in the sensitivity analysis. The eastern inflow group provides inflow only to Manatee Bay. The distribution of inflow from the northeastern inflow group into the FATHOM basins matches the distribution of inflow measured at the USGS monitoring sites, (Figure 3.4). The distribution of inflow from the central inflow group into the FATHOM basins is determined so that each basin receives the same depth of inflow, distributed over the surface of the basin With the exception of FATHOM basin 41. Basin 41 (Snake Bight) receives no inflow in any of the inflow alternatives examined.

The **magnitude** of inflow assigned to the inflow groups varies depending on what assumptions are made about how much the total inflow exceeds the amount measured at the USGS monitoring stations and how this additional inflow is distributed between the central and northeastern inflow groups, (Table 3.4). The inflow measured at the USGS monitoring stations from February 1996 through September 2000 provides the basis for calibrating estimates of inflow for the long-term period 1970 through 2002. It also serves as the basis for characterizing the magnitude of additional, “ungauged” flow included in the estimated inflow. The detailed description (below) of how the MFL base case inflow is constructed will illustrate the approach used to construct four alternative inflow data sets, (Table 3.5). A fifth alternative inflow data set is based on inflow calculated by the enhanced PHAST wetland hydrology model.

The inflow data for the MFL base case is compiled from remote data on surface flows, rainfall and evaporation in the Taylor Slough C111 wetland sub-basin by the following detailed procedure:

- Monthly volumes of flow assigned to the **eastern inflow group** (Manatee Bay) are equal to the monthly flows measured at the S197 control structure.

- Monthly volumes of flow assigned to the **northeastern inflow group** are the sum of two components.
    - The first component consists of the monthly volumes of the surface water discharge into the Taylor Slough C111 wetland sub-basin after accounting for the discharge into the eastern inflow group through S197. This first component is the sum of measured flows in Taylor Slough (TSB) and the C111 canal (S18C) minus the flow measured at the S197 control structure.
    - The second component accounts for the additional inflow to Florida Bay generated by rainfall over the Taylor Slough C111 wetland sub-basin in excess of evapotranspiration. For the MFL base case, the inflow assigned to the northeastern inflow group is calculated as the sum of all of the surface flow (TSB + S18C – S197) and 12 percent of the calculated excess rainfall. Adding 12 percent of the excess rainfall calibrates the total inflow assigned to the northeast inflow group so that it equals the total

inflow measured at the USGS monitoring stations for the period February 1996 through September 2000.

In the calculation of excess rainfall, evapotranspiration is calculated as a fraction (53 percent) of estimated total solar radiation by the method described by Abtew (1996) for South Florida. Total solar radiation is estimated from radiation incident at the top of the atmosphere, for given time of year, reduced by an amount to account for attenuation by moisture in the air. The attenuation factor is estimated from the daily range of temperatures measured at Royal Palm using the method developed by the SFWMD (2003). Monthly values of excess rainfall volume are calculated from the difference of Royal Palm rainfall minus estimated evapotranspiration and multiplied by the area of the Taylor Slough C111 wetland sub-basin (620 million square meters). Values of excess rainfall are set equal to zero in months when evapotranspiration exceeds rainfall.

- The magnitude of inflow assigned to the **central inflow group** in the MFL base case is equal to 20 percent of the gauged flow measured by the USGS at their estuarine creek monitoring stations, (Figure 1.4), for the period February 1996 through September 2000. The USGS data are the only direct estimates of inflow to Florida Bay, and the total volume of measured inflow provides a logical reference in reporting the volume of "ungauged" flow included in the estimated inflow data. The 20 percent of additional inflow included in the MFL base case as ungauged-flow is comparable to the magnitude of inflow estimated by the USGS in four ungauged creeks (Hittle et al. 2001) for the same period. For the historical reconstruction, creek flows are not available prior to 1996. Therefore, the monthly values for inflow assigned to the central inflow group are calculated as the measured monthly flow into Taylor Slough (TSB) multiplied by 0.67, which is approximately equal to 20% of the USGS creek flows. Of the two major sources of surface discharge into the Taylor Slough C111 wetland sub-basin, the flow measured at TSB is closer to the central region of Florida Bay, and thus it is considered to characterize better the temporal variation in the availability of surface water for inflow to Florida Bay from the western portion of the wetland basin. (Note that the addition of ungauged flow to the estimated inflow occurs only in the reconstruction of the historical inflow; no additional ungauged flow is included when inflow data are taken from output of the SFWMM)

Table 3.5: Summary of inflow alternatives

Data Set	Description
MFL Base Case	***Eastern Inflow Group*** - Monthly inflow was measured discharge at the S197 structure. All inflow was applied to Manatee Bay. ***Northeastern Inflow Group*** - Monthly inflow was calculated from measured discharge in Taylor Slough (TSB) and in the C-111 canal (difference in measured discharge between the S18C and S197 structures). Excess rainfall from the wetland basin was added in the amount needed for the total amount of inflow for the period 1996-2000 (surface flow plus excess rainfall) to equal the total discharge measured by the USGS from 1996-2000 in five creeks (McCormick C., Taylor R., Mud C., Trout C., West Highway C.) The monthly simulated inflow was applied to the FATHOM basins in this group based on the observed USGS discharge proportions in the five creeks for 1996-2000. (USGS estimates of un-gauged discharges into this group are not included). ***Central Inflow Group*** - Monthly inflow added to the central inflow group was proportional to the monthly measured discharge in Taylor Slough (TSB). The total amount added in the period 1996 through 2000 is equal to 20% of the flow in the Northeastern group. Central group inflow was added to Madeira Bay, Santini Bight, Garfield Bight and Rankin Lake. There is no inflow to Snake Bight *(The MFL base case inflow data set is the same as the RN-a alternative in Progress Report II and Progress Report III.)*

1 MFL BASE CASE CALCULATED SALINITY RECONSTRUCTION - 1970 THROUGH 2002

The MFL base case input data represent the “best available” information on the fresh water budget for Florida Bay in the period 1970 through 2002. Salinity calculations based on the MFL base case input data and parameter values are the best estimate of salinity conditions that occurred historically in Florida Bay. This section describes the input data and parameter values that comprise the MFL base case, and it summarizes the simulated salinity and calculated residence times based on these inputs. The fresh water input from the upstream wetland basins is described in detail in the previous section.

The input data consist of the following time series of monthly data:

- Rainfall,
- Evaporation,
- Inflow,
- Boundary Salinity, and
- Sea level.

The model parameters include:

- Tides (semi-diurnal, diurnal, and the spring-neap cycle),
- Bathymetry, and
- Bottom Friction (in flow over banks).

Table 4.1: Sources of input data to FATHOM for the MFL base case. Input data cover the period 1970 through 2002. Sources of the data are indicated in parentheses.

FATHOM Input	Indirect Data (Regional Index)
Rainfall	Flamingo, Royal Palm, Tavernier (NCDC)
Evaporation	Air temperature (mean and range) from Flamingo, Royal Palm and Tavernier (NCDC), relative humidity and wind speed (seasonal pattern) from Joe Bay (DBHYDRO)
Boundary salinity	S12T flow, P33 level (DBHYDRO)
Inflow	TSB flow, S18c flow, S197 flow, S175 flow (DBHYDRO)
Sea level	Key West sea level (NOAA)

FATHOM MODEL CALCULATIONS

	MFL base Case wetland inflow
tsb	Taylor Slough Bridge flow data
s18c	S18C canal flow data
s197	S197 canal flow data
rpl	Royal Palm rainfall
evap	Evap calculated after Abtew (1996) using SFWMD simple method for estimating radiation input
usgs tot	total measured USGS flows (McCormick Creek, Taylor River, Mud Creek, Trout Cove, West Highway Creek)
tsb+s18c-s197	Estimated surface input to Taylor Slough C111 wetland basin
excess rain	Estimated excess rainfall in Taylor Slough C111 wetland basin (including Long Pine)
central	Inflow assigned to FATHOM Central inflow group
ne	Inflow assigned to FATHOM Northeastern inflow group
east	Inflow assigned to FATHOM Eastern inflow group
Calculations:	
central	=0.67 * tsb
ne	= tsb+s18c-s197+ 0.12*excess rain
east	= s197

Conversion: 1 x 10^6 cubic meters = 811 acre-ft

MONTHLY DATA

	Input data - regional index data						**Intermediate calc.**		**FATHOM input**		
	106 m3**	**10**6 m3**	**10**6 m3**	**cm/mo**	**cm/mo**	**10**6 m3**	**10**6 m3**	**10**6 m3**	**10**6 m3**	**10**6 m3**	**10**6 m3**
month	**tsb**	**s18c**	**s197**	**rpl**	**evap u**	**sgs tot**	**tsb+s18c-s197**	**excess rain**	**central**	**ne**	**east**
1	1.69	5.60	0.36	4.84	8.76		6.93	4.21	1.13	7.44	0.36
2	1.19	5.34	0.89	4.41	9.34		5.65	4.19	0.80	6.15	0.89
3	0.55	5.19	1.16	5.13	12.07		4.58	0.41	0.37	4.63	1.16
4	0.30	3.51	0.18	7.01	12.85		3.64	7.81	0.20	4.58	0.18
5	0.69	4.46	0.38	14.17	13.95		4.77	20.94	0.46	7.28	0.38
6	4.71	21.74	6.19	21.31	12.60		20.26	63.97	3.15	27.94	6.19
7	5.33	16.38	1.82	17.12	13.00		19.89	32.37	3.57	23.77	1.82
8	6.84	24.85	5.09	21.48	12.22		26.60	57.82	4.58	33.54	5.09
9	9.12	30.43	5.70	20.30	10.53		33.85	61.52	6.11	41.23	5.70
10	8.23	24.85	6.82	12.51	9.44		26.27	29.35	5.51	29.79	6.82
11	3.42	11.56	1.62	6.53	8.03		13.36	11.69	2.29	14.76	1.62
12	2.01	6.37	0.05	3.97	7.94		8.33	2.85	1.35	8.67	0.05
annual ave	44.07	160.28	30.24	138.78	130.72		174.11	297.11	29.53	209.76	30.24

FATHOM MODEL CALCULATIONS

YEARLY TOTAL DATA

	10**6 m3	10**6 m3	10**6 m3	cm/yr	cm/yr	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3
Year	**tsb**	**s18c**	**s197**	**rpl**	**evap u**	**sgs tot**	**tsb+s18c-s197**	**excess rain**	**central**	**ne**	**east**
1970	13.06	16.37	0.00	117.17	113.98	0.00	29.43	196.32	8.75	52.99	0.00
1971	0.84	4.05	0.00	94.69	118.25	0.00	4.88	164.59	0.56	24.64	0.00
1972	27.49	125.83	14.07	151.54	112.37	0.00	139.25	348.17	18.42	181.03	14.07
1973	19.33	31.45	0.28	134.95	114.45	0.00	50.50	333.80	12.95	90.56	0.28
1974	8.51	0.02	0.00	115.47	110.92	0.00	8.53	283.33	5.70	42.53	0.00
1975	9.18	28.79	0.37	135.00	122.42	0.00	37.60	365.22	6.15	81.42	0.37
1976	39.71	63.41	0.00	146.46	125.84	0.00	103.13	348.41	26.61	144.94	0.00
1977	34.97	55.59	5.82	147.50	128.20	0.00	84.74	312.37	23.43	122.22	5.82
1978	24.93	63.14	3.26	188.85	127.46	0.00	84.81	462.05	16.70	140.26	3.26
1979	14.19	54.59	12.22	138.43	126.30	0.00	56.56	269.83	9.51	88.94	12.22
1980	25.24	83.18	39.89	185.45	139.92	0.00	68.52	461.47	16.91	123.90	39.89
1981	49.37	164.27	69.22	154.20	147.64	0.00	144.42	416.17	33.08	194.36	69.22
1982	50.74	122.95	39.76	162.10	138.40	0.00	133.92	323.55	33.99	172.75	39.76
1983	29.83	395.31	142.29	186.84	139.28	0.00	282.85	469.13	19.99	339.15	142.29
1984	26.08	172.28	23.34	117.86	146.03	0.00	175.02	225.54	17.48	202.09	23.34
1985	23.94	234.62	14.48	125.76	138.28	0.00	244.08	211.48	16.04	269.46	14.48
1986	10.73	259.00	35.76	96.29	126.26	0.00	233.98	96.73	7.19	245.59	35.76
1987	17.34	237.59	33.29	110.11	125.96	0.00	221.65	218.00	11.62	247.81	33.29
1988	37.71	330.78	104.63	155.93	122.56	0.00	263.86	441.26	25.26	316.81	104.63
1989	9.46	71.23	0.00	92.71	133.71	0.00	80.69	129.99	6.34	96.29	0.00
1990	13.33	85.60	0.00	109.04	124.44	0.00	98.93	159.76	8.93	118.10	0.00
1991	28.75	153.05	3.49	138.40	116.92	0.00	178.31	298.09	19.26	214.08	3.49
1992	39.73	212.22	55.66	146.43	125.36	0.00	196.29	418.82	26.62	246.55	55.66
1993	67.20	230.68	3.18	114.07	134.68	0.00	294.69	116.50	45.02	308.67	3.18
1994	104.25	319.98	37.14	138.89	136.09	0.00	387.10	237.28	69.85	415.57	37.14
1995	101.72	366.35	117.00	155.52	130.64	0.00	351.06	348.64	68.15	392.90	117.00
1996	64.04	168.93	33.03	121.11	148.07	292.25	199.94	179.39	42.91	221.47	33.03
1997	100.65	217.33	44.44	165.46	145.60	327.93	273.54	364.29	67.44	317.26	44.44
1998	77.17	214.83	36.73	155.96	137.83	280.19	255.27	334.32	51.70	295.39	36.73
1999	102.11	201.70	51.64	164.67	141.66	370.79	252.16	439.70	68.41	304.93	51.64
2000	104.36	232.54	31.45	126.67	142.91	103.21	305.45	191.14	69.92	328.39	31.45
2001	102.40	198.05	25.69	152.20	136.60	0.00	274.76	345.37	68.61	316.20	25.69
2002	76.01	173.59	19.91	134.09	134.89	0.00	229.70	294.05	50.93	264.98	19.91
annual ave	44.07	160.28	30.24	138.78	130.72		174.11	297.11	29.53	209.76	30.24
12-year total	968.39	2689.25	459.37	1713.46	1631.25		3198.27	3567.58	648.82	3626.38	459.37
33-year total	1454.37	5289.31	998.05	4579.80	4313.92		5745.64	9804.75	974.43	6922.21	998.05
average for period mar 96 - oct 00	7.35	17.12	2.99	12.62	12.14	24.54	21.48	26.10	4.93	24.61	2.99
								percent of usgs gauged flows:	**0.20**	**1.00**	**0.12**

FATHOM MODEL CALCULATIONS

MONTHLY FLOW BY YEAR

			10**6 m3	10**6 m3	10**6 m3	cm/mo	cm/mo	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3
dec year	Year	Mon	tsb	s18c	s197	rpl	evap u	sgs tot	tsb+s18c-s197	excess rain	central	ne	east
1970.04	1970	1	0.06	2.05	0.00	9.2	8.2		2.10	6.07	0.04	2.83	0.00
1970.13	1970	2	0.06	1.24	0.00	6.0	8.1		1.29	0.00	0.04	1.29	0.00
1970.21	1970	3	0.00	0.33	0.00	6.3	9.4		0.33	0.00	0.00	0.33	0.00
1970.29	1970	4	0.00	0.00	0.00	0.2	10.1		0.00	0.00	0.00	0.00	0.00
1970.38	1970	5	0.00	0.00	0.00	16.4	11.7		0.00	29.39	0.00	3.53	0.00
1970.46	1970	6	3.87	1.66	0.00	20.6	11.2		5.53	58.09	2.59	12.50	0.00
1970.54	1970	7	6.44	6.95	0.00	15.7	11.3		13.39	27.54	4.32	16.70	0.00
1970.63	1970	8	0.18	0.60	0.00	10.9	10.9		0.79	0.31	0.12	0.82	0.00
1970.71	1970	9	0.80	0.68	0.00	12.6	9.5		1.48	19.81	0.54	3.85	0.00
1970.79	1970	10	1.26	2.02	0.00	17.3	8.4		3.28	55.11	0.85	9.90	0.00
1970.88	1970	11	0.38	0.85	0.00	1.6	7.9		1.23	0.00	0.25	1.23	0.00
1970.96	1970	12	0.00	0.00	0.00	0.4	7.5		0.00	0.00	0.00	0.00	0.00
1971.04	1971	1	0.00	0.00	0.00	1.5	8.3		0.00	0.00	0.00	0.00	0.00
1971.13	1971	2	0.00	0.00	0.00	2.2	8.0		0.00	0.00	0.00	0.00	0.00
1971.21	1971	3	0.00	0.00	0.00	1.0	11.4		0.00	0.00	0.00	0.00	0.00
1971.29	1971	4	0.00	0.00	0.00	0.5	11.7		0.00	0.00	0.00	0.00	0.00
1971.38	1971	5	0.00	0.00	0.00	4.7	12.5		0.00	0.00	0.00	0.00	0.00
1971.46	1971	6	0.03	0.06	0.00	27.2	11.9		0.09	94.64	0.02	11.44	0.00
1971.54	1971	7	0.01	0.24	0.00	7.3	11.8		0.25	0.00	0.01	0.25	0.00
1971.63	1971	8	0.00	0.06	0.00	11.7	11.4		0.06	2.02	0.00	0.31	0.00
1971.71	1971	9	0.55	1.47	0.00	15.5	9.5		2.01	37.22	0.37	6.48	0.00
1971.79	1971	10	0.15	1.14	0.00	11.5	8.5		1.29	18.53	0.10	3.51	0.00
1971.88	1971	11	0.11	0.97	0.00	3.3	6.9		1.07	0.00	0.07	1.07	0.00
1971.96	1971	12	0.00	0.10	0.00	8.3	6.4		0.10	12.18	0.00	1.56	0.00
1972.04	1972	1	0.00	0.01	0.00	2.9	6.8		0.01	0.00	0.00	0.01	0.00
1972.13	1972	2	0.00	0.01	0.00	6.9	8.1		0.01	0.00	0.00	0.01	0.00
1972.21	1972	3	0.00	0.00	0.00	3.6	10.4		0.00	0.00	0.00	0.00	0.00
1972.29	1972	4	0.00	0.12	0.00	18.0	10.9		0.12	44.21	0.00	5.43	0.00
1972.38	1972	5	1.01	19.51	1.46	12.1	11.8		19.05	1.39	0.67	19.22	1.46
1972.46	1972	6	9.54	80.55	7.10	22.1	10.7		82.98	70.84	6.39	91.48	7.10
1972.54	1972	7	9.00	13.51	3.40	25.5	11.1		19.10	89.24	6.03	29.81	3.40
1972.63	1972	8	2.08	5.27	1.17	19.4	10.9		6.18	52.63	1.39	12.50	1.17
1972.71	1972	9	3.61	2.43	0.63	13.1	9.5		5.41	22.34	2.42	8.10	0.63
1972.79	1972	10	1.69	2.85	0.31	13.7	8.6		4.23	31.47	1.13	8.01	0.31
1972.88	1972	11	0.57	1.44	0.00	11.9	6.1		2.01	36.04	0.38	6.33	0.00
1972.96	1972	12	0.00	0.14	0.00	2.4	7.4		0.14	0.00	0.00	0.14	0.00
1973.04	1973	1	0.00	0.11	0.00	4.9	7.5		0.11	0.00	0.00	0.11	0.00
1973.13	1973	2	0.00	0.00	0.00	5.1	8.3		0.00	0.00	0.00	0.00	0.00
1973.21	1973	3	0.00	0.00	0.00	2.7	9.9		0.00	0.00	0.00	0.00	0.00
1973.29	1973	4	0.00	0.00	0.00	1.2	10.4		0.00	0.00	0.00	0.00	0.00
1973.38	1973	5	0.00	0.00	0.00	7.8	11.8		0.00	0.00	0.00	0.00	0.00
1973.46	1973	6	0.00	0.01	0.00	23.1	11.6		0.01	71.41	0.00	8.58	0.00
1973.54	1973	7	1.53	2.51	0.28	22.6	10.4		3.77	75.72	1.03	12.85	0.28
1973.63	1973	8	6.16	15.47	0.00	36.6	11.0		21.63	159.03	4.12	40.71	0.00
1973.71	1973	9	8.79	9.43	0.00	13.2	9.2		18.21	24.57	5.89	21.16	0.00
1973.79	1973	10	2.81	3.06	0.00	9.8	9.3		5.87	3.07	1.88	6.24	0.00
1973.88	1973	11	0.04	0.48	0.00	1.0	7.5		0.53	0.00	0.03	0.53	0.00
1973.96	1973	12	0.00	0.38	0.00	6.8	7.4		0.38	0.00	0.00	0.38	0.00
1974.04	1974	1	0.00	0.02	0.00	0.8	6.9		0.02	0.00	0.00	0.02	0.00

FATHOM MODEL CALCULATIONS

MONTHLY FLOW BY YEAR

			10**6 m3	10**6 m3	10**6 m3	cm/mo	cm/mo	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3
dec year	**Year**	**Mon**	**tsb**	**s18c**	**s197**	**rpl**	**evap u**	**sgs tot**	**tsb+s18c-s197**	**excess rain**	**central**	**ne**	**east**
1974.13	1974	2	0.00	0.00	0.00	0.2	8.8		0.00	0.00	0.00	0.00	0.00
1974.21	1974	3	0.00	0.00	0.00	0.3	8.5		0.00	0.00	0.00	0.00	0.00
1974.29	1974	4	0.00	0.00	0.00	13.5	9.7		0.00	24.07	0.00	2.89	0.00
1974.38	1974	5	0.00	0.00	0.00	5.8	11.1		0.00	0.00	0.00	0.00	0.00
1974.46	1974	6	0.00	0.00	0.00	23.6	11.1		0.00	77.74	0.00	9.33	0.00
1974.54	1974	7	1.78	0.00	0.00	27.3	11.0		1.78	101.41	1.19	13.95	0.00
1974.63	1974	8	2.99	0.00	0.00	16.1	10.3		2.99	36.13	2.00	7.33	0.00
1974.71	1974	9	3.13	0.00	0.00	6.4	9.5		3.13	0.00	2.10	3.13	0.00
1974.79	1974	10	0.60	0.00	0.00	15.2	8.1		0.60	43.99	0.40	5.88	0.00
1974.88	1974	11	0.00	0.00	0.00	5.4	8.6		0.00	0.00	0.00	0.00	0.00
1974.96	1974	12	0.00	0.00	0.00	0.8	7.4		0.00	0.00	0.00	0.00	0.00
1975.04	1975	1	0.00	0.00	0.00	0.4	7.7		0.00	0.00	0.00	0.00	0.00
1975.13	1975	2	0.00	0.00	0.00	2.1	8.1		0.00	0.00	0.00	0.00	0.00
1975.21	1975	3	0.00	0.00	0.00	0.6	11.0		0.00	0.00	0.00	0.00	0.00
1975.29	1975	4	0.00	0.00	0.00	0.2	11.2		0.00	0.00	0.00	0.00	0.00
1975.38	1975	5	0.00	0.00	0.00	26.3	12.0		0.00	88.62	0.00	10.63	0.00
1975.46	1975	6	0.35	5.92	0.00	30.1	12.2		6.26	111.53	0.23	19.65	0.00
1975.54	1975	7	3.93	14.06	0.00	18.0	12.6		18.00	33.61	2.64	22.03	0.00
1975.63	1975	8	1.20	8.81	0.37	22.1	12.4		9.64	60.40	0.81	16.89	0.37
1975.71	1975	9	2.23	0.00	0.00	17.7	10.2		2.23	46.34	1.49	7.79	0.00
1975.79	1975	10	1.21	0.00	0.00	13.5	9.5		1.21	24.72	0.81	4.17	0.00
1975.88	1975	11	0.26	0.00	0.00	2.6	7.8		0.26	0.00	0.17	0.26	0.00
1975.96	1975	12	0.00	0.00	0.00	1.3	7.7		0.00	0.00	0.00	0.00	0.00
1976.04	1976	1	0.00	0.00	0.00	2.4	9.6		0.00	0.00	0.00	0.00	0.00
1976.13	1976	2	0.00	0.00	0.00	5.4	8.8		0.00	0.00	0.00	0.00	0.00
1976.21	1976	3	0.00	0.00	0.00	0.5	10.6		0.00	0.00	0.00	0.00	0.00
1976.29	1976	4	0.00	0.00	0.00	9.8	12.5		0.00	0.00	0.00	0.00	0.00
1976.38	1976	5	0.25	1.02	0.00	20.7	12.3		1.27	52.22	0.17	7.54	0.00
1976.46	1976	6	13.20	30.03	0.00	20.7	11.5		43.23	57.02	8.84	50.07	0.00
1976.54	1976	7	3.87	0.00	0.00	10.0	12.9		3.87	0.00	2.59	3.87	0.00
1976.63	1976	8	5.77	14.76	0.00	35.4	11.9		20.53	145.73	3.86	38.02	0.00
1976.71	1976	9	12.54	14.86	0.00	22.4	10.4		27.40	74.52	8.40	36.34	0.00
1976.79	1976	10	2.95	2.74	0.00	5.5	9.6		5.68	0.00	1.97	5.68	0.00
1976.88	1976	11	1.14	0.00	0.00	10.7	7.7		1.14	18.92	0.76	3.41	0.00
1976.96	1976	12	0.00	0.00	0.00	3.0	8.1		0.00	0.00	0.00	0.00	0.00
1977.04	1977	1	0.00	0.00	0.00	5.0	9.5		0.00	0.00	0.00	0.00	0.00
1977.13	1977	2	0.00	0.00	0.00	4.2	9.0		0.00	0.00	0.00	0.00	0.00
1977.21	1977	3	0.00	0.00	0.00	1.8	10.6		0.00	0.00	0.00	0.00	0.00
1977.29	1977	4	0.00	0.00	0.00	1.6	11.6		0.00	0.00	0.00	0.00	0.00
1977.38	1977	5	1.22	3.70	0.00	32.5	12.6		4.92	123.40	0.81	19.72	0.00
1977.46	1977	6	9.54	14.88	5.82	22.0	12.0		18.61	62.18	6.39	26.07	5.82
1977.54	1977	7	0.81	0.00	0.00	14.0	12.9		0.81	7.05	0.54	1.66	0.00
1977.63	1977	8	2.11	2.46	0.00	11.3	12.4		4.57	0.00	1.41	4.57	0.00
1977.71	1977	9	16.44	31.00	0.00	29.7	11.0		47.44	115.94	11.02	61.35	0.00
1977.79	1977	10	3.43	3.55	0.00	9.0	10.2		6.98	0.00	2.30	6.98	0.00
1977.88	1977	11	0.58	0.00	0.00	7.3	8.0		0.58	0.00	0.39	0.58	0.00
1977.96	1977	12	0.83	0.00	0.00	9.1	8.5		0.83	3.80	0.56	1.29	0.00
1978.04	1978	1	0.23	0.00	0.00	8.4	9.7		0.23	0.00	0.15	0.23	0.00
1978.13	1978	2	0.42	5.14	0.00	11.7	10.0		5.56	10.20	0.28	6.79	0.00
1978.21	1978	3	0.39	0.00	0.00	7.1	13.0		0.39	0.00	0.26	0.39	0.00

FATHOM MODEL CALCULATIONS

MONTHLY FLOW BY YEAR

			10**6 m3	10**6 m3	10**6 m3	cm/mo	cm/mo	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3
dec year	Year	Mon	tsb	s18c	s197	rpl	evap u	sgs tot	tsb+s18c-s197	excess rain	central	ne	east
1978.29	1978	4	0.13	1.67	0.00	16.0	12.0		1.80	25.25	0.09	4.83	0.00
1978.38	1978	5	0.40	0.00	0.00	12.9	12.2		0.40	4.17	0.27	0.90	0.00
1978.46	1978	6	1.15	0.00	0.00	22.1	11.7		1.15	64.79	0.77	8.93	0.00
1978.54	1978	7	2.15	4.36	0.00	15.9	12.4		6.51	21.26	1.44	9.06	0.00
1978.63	1978	8	2.62	0.00	0.00	29.0	12.0		2.62	105.59	1.76	15.29	0.00
1978.71	1978	9	13.46	18.97	1.95	32.1	10.5		30.49	133.75	9.02	46.54	1.95
1978.79	1978	10	3.65	25.68	1.31	24.5	8.9		28.02	97.04	2.44	39.66	1.31
1978.88	1978	11	0.34	7.31	0.00	3.4	7.6		7.65	0.00	0.22	7.65	0.00
1978.96	1978	12	0.00	0.00	0.00	5.8	7.5		0.00	0.00	0.00	0.00	0.00
1979.04	1979	1	0.00	0.00	0.00	4.7	8.4		0.00	0.00	0.00	0.00	0.00
1979.13	1979	2	0.00	0.00	0.00	1.1	10.2		0.00	0.00	0.00	0.00	0.00
1979.21	1979	3	0.00	0.00	0.00	0.7	11.8		0.00	0.00	0.00	0.00	0.00
1979.29	1979	4	0.85	12.95	0.00	27.1	11.2		13.80	98.05	0.57	25.57	0.00
1979.38	1979	5	3.37	15.36	4.96	13.3	11.6		13.78	10.18	2.26	15.00	4.96
1979.46	1979	6	1.45	0.10	0.00	14.4	12.4		1.55	11.83	0.97	2.97	0.00
1979.54	1979	7	1.27	2.91	0.00	17.0	12.1		4.18	30.47	0.85	7.83	0.00
1979.63	1979	8	0.87	0.00	0.00	11.0	11.6		0.87	0.00	0.58	0.87	0.00
1979.71	1979	9	2.61	14.98	3.48	25.1	10.8		14.12	88.75	1.75	24.77	3.48
1979.79	1979	10	3.15	3.55	3.79	12.9	8.9		2.92	24.61	2.11	5.87	3.79
1979.88	1979	11	0.13	0.02	0.00	1.7	8.6		0.15	0.00	0.09	0.15	0.00
1979.96	1979	12	0.48	4.72	0.00	9.5	8.5		5.20	5.93	0.32	5.91	0.00
1980.04	1980	1	0.07	0.00	0.00	7.3	10.0		0.07	0.00	0.05	0.07	0.00
1980.13	1980	2	0.03	0.00	0.00	3.4	9.3		0.03	0.00	0.02	0.03	0.00
1980.21	1980	3	0.03	0.00	0.00	3.3	14.0		0.03	0.00	0.02	0.03	0.00
1980.29	1980	4	0.03	0.04	0.00	11.0	12.0		0.07	0.00	0.02	0.07	0.00
1980.38	1980	5	0.04	0.25	0.00	12.8	15.8		0.29	0.00	0.03	0.29	0.00
1980.46	1980	6	5.62	14.89	0.00	37.1	12.6		20.51	151.77	3.77	38.73	0.00
1980.54	1980	7	5.50	8.25	5.80	31.4	12.9		7.94	115.06	3.68	21.75	5.80
1980.63	1980	8	2.72	11.51	5.94	23.5	13.7		8.28	60.56	1.82	15.55	5.94
1980.71	1980	9	7.20	25.32	17.63	22.4	11.7		14.89	66.26	4.83	22.84	17.63
1980.79	1980	10	2.28	5.40	2.25	11.2	10.7		5.43	2.66	1.53	5.75	2.25
1980.88	1980	11	1.53	7.51	8.27	18.7	8.2		0.77	65.16	1.02	8.59	8.27
1980.96	1980	12	0.18	10.02	0.00	3.4	9.1		10.20	0.00	0.12	10.20	0.00
1981.04	1981	1	0.00	0.00	0.00	0.8	10.8		0.00	0.00	0.00	0.00	0.00
1981.13	1981	2	0.77	9.65	3.62	15.5	10.0		6.80	34.33	0.52	10.92	3.62
1981.21	1981	3	0.07	0.00	0.00	5.2	13.7		0.07	0.00	0.05	0.07	0.00
1981.29	1981	4	0.00	0.00	0.00	0.3	14.5		0.00	0.00	0.00	0.00	0.00
1981.38	1981	5	0.00	0.00	0.00	12.5	16.5		0.00	0.00	0.00	0.00	0.00
1981.46	1981	6	0.00	0.00	0.00	8.8	14.4		0.00	0.00	0.00	0.00	0.00
1981.54	1981	7	0.15	0.00	0.00	15.4	15.1		0.15	1.41	0.10	0.32	0.00
1981.63	1981	8	19.41	56.89	18.20	52.0	12.7		58.10	243.77	13.01	87.35	18.20
1981.71	1981	9	15.73	71.63	39.40	33.0	11.0		47.97	136.67	10.54	64.37	39.40
1981.79	1981	10	10.73	26.10	7.99	4.4	10.3		28.83	0.00	7.19	28.83	7.99
1981.88	1981	11	2.50	0.00	0.00	4.7	9.4		2.50	0.00	1.67	2.50	0.00
1981.96	1981	12	0.00	0.00	0.00	1.6	9.2		0.00	0.00	0.00	0.00	0.00
1982.04	1982	1	0.00	0.00	0.00	0.7	9.9		0.00	0.00	0.00	0.00	0.00
1982.13	1982	2	0.00	0.00	0.00	2.3	10.2		0.00	0.00	0.00	0.00	0.00
1982.21	1982	3	0.00	0.00	0.00	7.0	12.8		0.00	0.00	0.00	0.00	0.00
1982.29	1982	4	0.26	0.16	0.00	20.3	13.7		0.43	40.66	0.18	5.31	0.00
1982.38	1982	5	1.10	0.00	0.00	18.5	15.0		1.10	21.76	0.74	3.71	0.00

FATHOM MODEL CALCULATIONS

MONTHLY FLOW BY YEAR

			10**6 m3	10**6 m3	10**6 m3	cm/mo	cm/mo	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3
dec year	Year	Mon	tsb	s18c	s197	rpl	evap u	sgs tot	tsb+s18c-s197	excess rain	central	ne	east
1982.46	1982	6	12.53	24.16	12.50	24.7	12.6		24.20	75.01	8.40	33.20	12.50
1982.54	1982	7	3.06	2.02	2.20	14.0	13.8		2.89	0.86	2.05	2.99	2.20
1982.63	1982	8	4.91	7.68	0.00	21.7	13.3		12.59	52.63	3.29	18.91	0.00
1982.71	1982	9	6.65	17.36	4.66	19.9	11.5		19.35	52.53	4.45	25.65	4.66
1982.79	1982	10	10.66	40.32	9.79	14.0	9.7		41.19	26.90	7.14	44.42	9.79
1982.88	1982	11	7.93	27.17	10.61	16.5	7.9		24.49	53.21	5.31	30.87	10.61
1982.96	1982	12	3.62	4.06	0.00	2.4	8.0		7.69	0.00	2.43	7.69	0.00
1983.04	1983	1	5.04	10.21	7.32	24.0	8.7		7.92	94.73	3.37	19.29	7.32
1983.13	1983	2	5.57	60.58	25.61	19.5	9.2		40.54	64.20	3.73	48.24	25.61
1983.21	1983	3	0.38	73.23	34.29	9.2	12.3		39.33	0.00	0.26	39.33	34.29
1983.29	1983	4	0.07	38.85	5.82	7.4	13.7		33.09	0.00	0.04	33.09	5.82
1983.38	1983	5	0.00	4.77	0.00	1.8	15.3		4.77	0.00	0.00	4.77	0.00
1983.46	1983	6	3.15	44.68	24.52	27.7	13.6		23.31	87.20	2.11	33.77	24.52
1983.54	1983	7	3.12	16.65	7.65	12.4	14.6		12.11	0.00	2.09	12.11	7.65
1983.63	1983	8	2.16	38.98	11.98	26.2	13.7		29.16	77.70	1.45	38.49	11.98
1983.71	1983	9	5.21	73.50	24.14	30.9	10.9		54.57	123.61	3.49	69.40	24.14
1983.79	1983	10	3.19	0.00	0.95	7.8	9.8		2.24	0.00	2.14	2.24	0.95
1983.88	1983	11	1.79	32.68	0.00	12.3	8.8		34.47	21.69	1.20	37.07	0.00
1983.96	1983	12	0.16	1.19	0.00	7.6	8.7		1.35	0.00	0.11	1.35	0.00
1984.04	1984	1	0.00	0.00	0.00	0.5	9.8		0.00	0.00	0.00	0.00	0.00
1984.13	1984	2	0.00	0.00	0.00	2.9	10.4		0.00	0.00	0.00	0.00	0.00
1984.21	1984	3	0.00	3.49	3.90	7.6	13.5		-0.41	0.00	0.00	-0.41	3.90
1984.29	1984	4	0.00	0.00	0.00	0.8	14.5		0.00	0.00	0.00	0.00	0.00
1984.38	1984	5	1.15	9.83	6.24	25.6	15.4		4.75	63.66	0.77	12.38	6.24
1984.46	1984	6	6.59	15.80	0.00	9.2	14.4		22.39	0.00	4.41	22.39	0.00
1984.54	1984	7	6.70	26.78	8.84	24.0	14.1		24.64	60.88	4.49	31.94	8.84
1984.63	1984	8	2.24	36.89	3.31	20.0	13.3		35.81	41.38	1.50	40.78	3.31
1984.71	1984	9	5.25	42.91	1.04	21.1	11.5		47.12	59.62	3.52	54.28	1.04
1984.79	1984	10	4.11	29.22	0.00	1.2	10.9		33.32	0.00	2.75	33.32	0.00
1984.88	1984	11	0.04	4.95	0.00	4.3	9.2		4.99	0.00	0.03	4.99	0.00
1984.96	1984	12	0.00	2.41	0.00	0.7	9.2		2.41	0.00	0.00	2.41	0.00
1985.04	1985	1	0.00	3.52	0.00	0.8	10.5		3.52	0.00	0.00	3.52	0.00
1985.13	1985	2	0.00	1.51	0.00	0.7	10.7		1.51	0.00	0.00	1.51	0.00
1985.21	1985	3	0.00	1.25	0.00	6.8	14.5		1.25	0.00	0.00	1.25	0.00
1985.29	1985	4	0.00	0.71	0.00	6.1	15.5		0.71	0.00	0.00	0.71	0.00
1985.38	1985	5	0.00	0.28	0.00	14.6	16.4		0.28	0.00	0.00	0.28	0.00
1985.46	1985	6	0.97	1.12	0.00	9.2	13.7		2.10	0.00	0.65	2.10	0.00
1985.54	1985	7	7.78	52.96	4.57	30.0	12.7		56.17	107.56	5.21	69.07	4.57
1985.63	1985	8	4.54	26.49	0.00	13.5	11.4		31.03	12.87	3.04	32.57	0.00
1985.71	1985	9	5.87	57.62	9.91	18.5	9.7		53.58	54.35	3.94	60.11	9.91
1985.79	1985	10	3.57	53.40	0.00	14.2	8.3		56.97	36.70	2.40	61.38	0.00
1985.88	1985	11	1.04	28.94	0.00	7.0	7.4		29.98	0.00	0.70	29.98	0.00
1985.96	1985	12	0.16	6.83	0.00	4.4	7.4		6.99	0.00	0.11	6.99	0.00
1986.04	1986	1	0.37	11.57	0.00	4.1	8.2		11.94	0.00	0.25	11.94	0.00
1986.13	1986	2	0.07	0.85	0.00	3.9	9.4		0.92	0.00	0.05	0.92	0.00
1986.21	1986	3	0.16	10.82	0.00	12.9	11.3		10.98	9.92	0.11	12.17	0.00
1986.29	1986	4	0.08	9.77	0.00	4.2	13.8		9.85	0.00	0.05	9.85	0.00
1986.38	1986	5	0.00	0.00	0.00	1.2	13.3		0.00	0.00	0.00	0.00	0.00
1986.46	1986	6	3.00	32.84	4.46	8.1	11.6		31.38	0.00	2.01	31.38	4.46
1986.54	1986	7	3.02	57.96	0.00	13.1	12.3		60.99	4.61	2.03	61.54	0.00

FATHOM MODEL CALCULATIONS

MONTHLY FLOW BY YEAR

			10**6 m3	10**6 m3	10**6 m3	cm/mo	cm/mo	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3
dec year	Year	Mon	tsb	s18c	s197	rpl	evap u	sgs tot	tsb+s18c-s197	excess rain	central	ne	east
1986.63	1986	8	0.90	58.88	22.03	20.1	11.2		37.74	55.00	0.60	44.34	22.03
1986.71	1986	9	2.05	52.72	8.07	11.5	10.7		46.70	4.73	1.37	47.27	8.07
1986.79	1986	10	0.99	6.19	0.00	2.8	9.9		7.18	0.00	0.66	7.18	0.00
1986.88	1986	11	0.06	10.20	0.66	4.2	7.6		9.61	0.00	0.04	9.61	0.66
1986.96	1986	12	0.03	7.20	0.53	10.3	6.7		6.69	22.46	0.02	9.39	0.53
1987.04	1987	1	0.13	14.27	4.40	3.1	8.6		10.00	0.00	0.09	10.00	4.40
1987.13	1987	2	0.00	1.10	0.00	1.5	8.6		1.10	0.00	0.00	1.10	0.00
1987.21	1987	3	0.10	7.15	0.00	4.8	10.6		7.25	0.00	0.07	7.25	0.00
1987.29	1987	4	0.02	0.21	0.00	0.4	13.9		0.23	0.00	0.02	0.23	0.00
1987.38	1987	5	0.14	5.91	0.00	20.6	13.4		6.05	44.39	0.09	11.37	0.00
1987.46	1987	6	0.02	7.96	0.00	3.3	12.7		7.98	0.00	0.01	7.98	0.00
1987.54	1987	7	1.58	9.03	0.00	10.5	12.8		10.61	0.00	1.06	10.61	0.00
1987.63	1987	8	3.50	14.14	0.00	17.3	12.1		17.64	32.18	2.34	21.50	0.00
1987.71	1987	9	2.90	25.31	3.07	26.0	10.3		25.14	97.18	1.95	36.80	3.07
1987.79	1987	10	7.40	72.63	18.99	10.4	8.3		61.04	12.64	4.96	62.56	18.99
1987.88	1987	11	1.40	56.58	6.82	12.1	7.0		51.16	31.62	0.94	54.96	6.82
1987.96	1987	12	0.16	23.30	0.00	0.1	7.6		23.46	0.00	0.10	23.46	0.00
1988.04	1988	1	0.10	12.58	0.00	9.8	7.4		12.67	15.18	0.07	14.50	0.00
1988.13	1988	2	0.03	2.06	0.00	2.3	8.9		2.08	0.00	0.02	2.08	0.00
1988.21	1988	3	0.00	0.49	0.00	2.0	11.3		0.49	0.00	0.00	0.49	0.00
1988.29	1988	4	0.00	0.00	0.00	3.7	13.6		0.00	0.00	0.00	0.00	0.00
1988.38	1988	5	0.11	3.09	0.00	17.4	13.5		3.20	23.86	0.08	6.06	0.00
1988.46	1988	6	7.54	70.20	25.11	26.9	11.0		52.63	98.56	5.05	64.46	25.11
1988.54	1988	7	8.36	37.68	0.00	33.5	11.7		46.03	135.42	5.60	62.28	0.00
1988.63	1988	8	12.34	112.06	69.54	33.5	10.6		54.87	141.84	8.27	71.89	69.54
1988.71	1988	9	4.49	44.04	2.93	13.2	9.8		45.60	20.92	3.01	48.11	2.93
1988.79	1988	10	4.22	40.08	7.05	10.5	9.7		37.25	5.48	2.83	37.90	7.05
1988.88	1988	11	0.50	4.53	0.00	2.7	7.4		5.03	0.00	0.33	5.03	0.00
1988.96	1988	12	0.02	3.99	0.00	0.3	7.7		4.00	0.00	0.01	4.00	0.00
1989.04	1989	1	0.00	2.79	0.00	2.2	8.8		2.79	0.00	0.00	2.79	0.00
1989.13	1989	2	0.00	1.06	0.00	0.0	9.4		1.06	0.00	0.00	1.06	0.00
1989.21	1989	3	0.00	0.43	0.00	3.4	12.5		0.43	0.00	0.00	0.43	0.00
1989.29	1989	4	0.00	0.22	0.00	5.7	13.2		0.22	0.00	0.00	0.22	0.00
1989.38	1989	5	0.00	0.25	0.00	4.7	14.5		0.25	0.00	0.00	0.25	0.00
1989.46	1989	6	0.00	0.90	0.00	10.6	12.7		0.90	0.00	0.00	0.90	0.00
1989.54	1989	7	1.93	14.23	0.00	22.0	12.7		16.16	57.95	1.30	23.12	0.00
1989.63	1989	8	2.09	22.21	0.00	23.4	12.5		24.29	67.34	1.40	32.38	0.00
1989.71	1989	9	3.20	16.74	0.00	12.0	11.3		19.94	4.70	2.15	20.50	0.00
1989.79	1989	10	2.01	6.59	0.00	4.5	9.2		8.60	0.00	1.35	8.60	0.00
1989.88	1989	11	0.21	2.77	0.00	3.1	8.5		2.99	0.00	0.14	2.99	0.00
1989.96	1989	12	0.01	3.04	0.00	1.0	8.4		3.05	0.00	0.01	3.05	0.00
1990.04	1990	1	0.00	2.30	0.00	0.0	8.3		2.30	0.00	0.00	2.30	0.00
1990.13	1990	2	0.00	0.94	0.00	2.0	9.0		0.94	0.00	0.00	0.94	0.00
1990.21	1990	3	0.00	0.50	0.00	3.2	11.2		0.50	0.00	0.00	0.50	0.00
1990.29	1990	4	0.00	0.19	0.00	5.3	12.4		0.19	0.00	0.00	0.19	0.00
1990.38	1990	5	0.14	2.13	0.00	20.3	12.5		2.27	48.22	0.09	8.06	0.00
1990.46	1990	6	1.37	0.59	0.00	20.4	12.7		1.96	47.94	0.92	7.72	0.00
1990.54	1990	7	2.71	2.83	0.00	11.6	12.5		5.54	0.00	1.81	5.54	0.00
1990.63	1990	8	2.27	31.72	0.00	17.3	11.6		33.99	35.16	1.52	38.21	0.00
1990.71	1990	9	2.79	16.36	0.00	11.6	10.2		19.16	8.39	1.87	20.17	0.00

FATHOM MODEL CALCULATIONS

MONTHLY FLOW BY YEAR

			10**6 m3	10**6 m3	10**6 m3	cm/mo	cm/mo	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3
dec year	Year	Mon	tsb	s18c	s197	rpl	evap u	sgs tot	tsb+s18c-s197	excess rain	central	ne	east
1990.79	1990	10	3.24	19.86	0.00	12.2	8.9		23.10	20.05	2.17	25.51	0.00
1990.88	1990	11	0.78	5.20	0.00	3.3	7.7		5.98	0.00	0.52	5.98	0.00
1990.96	1990	12	0.02	2.97	0.00	1.8	7.4		2.99	0.00	0.01	2.99	0.00
1991.04	1991	1	0.01	2.48	0.00	8.2	7.4		2.49	5.07	0.00	3.10	0.00
1991.13	1991	2	0.00	2.28	0.00	3.1	8.8		2.28	0.00	0.00	2.28	0.00
1991.21	1991	3	0.01	1.13	0.00	8.1	11.2		1.13	0.00	0.00	1.13	0.00
1991.29	1991	4	0.00	0.13	0.00	7.8	11.5		0.13	0.00	0.00	0.13	0.00
1991.38	1991	5	1.01	10.56	0.00	25.9	11.9		11.57	86.33	0.67	21.93	0.00
1991.46	1991	6	4.83	24.70	0.00	14.1	11.2		29.53	18.01	3.24	31.69	0.00
1991.54	1991	7	3.37	10.21	0.00	7.9	11.5		13.58	0.00	2.26	13.58	0.00
1991.63	1991	8	2.67	15.14	0.00	19.3	11.6		17.81	47.91	1.79	23.55	0.00
1991.71	1991	9	4.56	47.76	0.00	17.5	9.5		52.32	49.16	3.06	58.22	0.00
1991.79	1991	10	8.90	30.28	3.49	22.9	8.1		35.69	91.61	5.96	46.68	3.49
1991.88	1991	11	3.28	4.98	0.00	1.0	7.0		8.26	0.00	2.20	8.26	0.00
1991.96	1991	12	0.12	3.41	0.00	2.6	7.1		3.53	0.00	0.08	3.53	0.00
1992.04	1992	1	0.11	2.36	0.00	2.9	8.1		2.47	0.00	0.07	2.47	0.00
1992.13	1992	2	1.10	1.25	0.00	3.1	8.6		2.36	0.00	0.74	2.36	0.00
1992.21	1992	3	0.62	2.08	0.00	9.0	11.8		2.70	0.00	0.41	2.70	0.00
1992.29	1992	4	0.36	0.42	0.00	6.2	11.7		0.78	0.00	0.24	0.78	0.00
1992.38	1992	5	0.01	0.17	0.00	2.1	14.8		0.18	0.00	0.01	0.18	0.00
1992.46	1992	6	6.45	47.49	33.72	56.6	10.8		20.22	283.98	4.32	54.29	33.72
1992.54	1992	7	8.87	25.44	7.13	17.0	12.0		27.17	31.16	5.94	30.91	7.13
1992.63	1992	8	7.87	39.72	8.78	11.3	9.8		38.82	9.26	5.28	39.93	8.78
1992.71	1992	9	9.46	41.00	6.02	13.9	10.7		44.44	19.53	6.34	46.78	6.02
1992.79	1992	10	2.19	25.28	0.00	4.2	10.8		27.47	0.00	1.47	27.47	0.00
1992.88	1992	11	2.12	20.11	0.00	19.9	7.8		22.23	74.87	1.42	31.22	0.00
1992.96	1992	12	0.57	6.89	0.00	0.2	8.5		7.46	0.00	0.38	7.46	0.00
1993.04	1993	1	2.48	27.02	0.00	11.0	8.1		29.49	17.89	1.66	31.64	0.00
1993.13	1993	2	2.25	5.80	0.00	3.6	9.8		8.05	0.00	1.51	8.05	0.00
1993.21	1993	3	2.35	6.53	0.00	6.5	12.5		8.88	0.00	1.58	8.88	0.00
1993.29	1993	4	2.23	2.41	0.00	6.8	13.8		4.64	0.00	1.49	4.64	0.00
1993.38	1993	5	1.80	6.72	0.00	12.0	14.4		8.52	0.00	1.20	8.52	0.00
1993.46	1993	6	4.27	33.14	0.00	10.9	12.7		37.40	0.00	2.86	37.40	0.00
1993.54	1993	7	9.20	21.62	0.00	12.7	14.0		30.82	0.00	6.17	30.82	0.00
1993.63	1993	8	9.46	20.91	0.00	15.6	13.1		30.37	15.61	6.34	32.25	0.00
1993.71	1993	9	11.18	35.00	0.00	8.7	10.5		46.18	0.00	7.49	46.18	0.00
1993.79	1993	10	12.82	48.27	3.18	22.7	9.3		57.90	83.00	8.59	67.86	3.18
1993.88	1993	11	6.51	19.22	0.00	2.8	8.4		25.73	0.00	4.36	25.73	0.00
1993.96	1993	12	2.65	4.04	0.00	0.6	8.0		6.69	0.00	1.77	6.69	0.00
1994.04	1994	1	3.30	5.93	0.00	7.6	8.5		9.22	0.00	2.21	9.22	0.00
1994.13	1994	2	2.96	25.69	0.00	9.2	8.6		28.65	4.30	1.98	29.16	0.00
1994.21	1994	3	5.37	11.38	0.00	3.7	12.9		16.74	0.00	3.60	16.74	0.00
1994.29	1994	4	1.65	12.54	0.00	17.7	13.6		14.18	25.38	1.10	17.23	0.00
1994.38	1994	5	3.13	12.51	0.00	8.9	15.2		15.64	0.00	2.10	15.64	0.00
1994.46	1994	6	4.03	25.62	0.00	1.7	13.8		29.65	0.00	2.70	29.65	0.00
1994.54	1994	7	0.55	4.41	0.00	7.6	14.7		4.96	0.00	0.37	4.96	0.00
1994.63	1994	8	16.19	31.63	0.00	13.9	13.2		47.82	4.38	10.85	48.34	0.00
1994.71	1994	9	21.35	57.84	5.45	34.4	10.0		73.73	151.13	14.30	91.87	5.45
1994.79	1994	10	19.40	43.60	7.25	14.2	10.4		55.75	23.14	13.00	58.52	7.25
1994.88	1994	11	15.58	49.65	24.44	10.4	7.2		40.80	20.07	10.44	43.21	24.44

FATHOM MODEL CALCULATIONS

MONTHLY FLOW BY YEAR

			10**6 m3	10**6 m3	10**6 m3	cm/mo	cm/mo	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3
									tsb+s18c-	excess			
dec year	Year	Mon	tsb	s18c	s197	rpl	evap u	sgs tot	s197	rain	central	ne	east
1994.96	1994	12	10.76	39.20	0.00	9.5	8.1		49.96	8.88	7.21	51.03	0.00
1995.04	1995	1	9.17	36.87	0.00	6.7	8.9		46.03	0.00	6.14	46.03	0.00
1995.13	1995	2	6.40	18.11	0.00	0.8	8.9		24.51	0.00	4.29	24.51	0.00
1995.21	1995	3	1.66	13.47	0.00	8.8	13.8		15.13	0.00	1.11	15.13	0.00
1995.29	1995	4	0.34	12.69	0.00	6.8	13.9		13.03	0.00	0.23	13.03	0.00
1995.38	1995	5	3.02	19.91	0.00	15.9	14.7		22.93	7.40	2.02	23.82	0.00
1995.46	1995	6	9.45	49.68	25.09	38.6	12.6		34.04	161.30	6.33	53.40	25.09
1995.54	1995	7	15.53	38.76	9.51	16.6	12.8		44.78	23.22	10.40	47.57	9.51
1995.63	1995	8	13.72	50.63	20.43	30.0	11.8		43.92	113.20	9.19	57.50	20.43
1995.71	1995	9	12.39	39.35	9.02	12.6	9.7		42.71	17.95	8.30	44.87	9.02
1995.79	1995	10	15.07	65.86	52.34	11.9	7.8		28.59	25.57	10.09	31.65	52.34
1995.88	1995	11	8.40	16.99	0.61	2.4	8.3		24.78	0.00	5.62	24.78	0.61
1995.96	1995	12	6.59	4.02	0.00	4.3	7.5		10.62	0.00	4.42	10.62	0.00
1996.04	1996	1	3.98	5.77	0.00	4.1	8.2		9.74	0.00	2.66	9.74	0.00
1996.13	1996	2	1.55	1.77	0.00	1.8	11.1	3.64	3.32	0.00	1.04	3.32	0.00
1996.21	1996	3	0.48	0.88	0.00	4.2	13.2	0.23	1.37	0.00	0.32	1.37	0.00
1996.29	1996	4	0.06	0.59	0.00	4.9	13.9	1.62	0.65	0.00	0.04	0.65	0.00
1996.38	1996	5	1.85	9.58	0.00	20.0	14.3	0.68	11.43	35.88	1.24	15.73	0.00
1996.46	1996	6	8.44	48.67	18.87	15.3	13.8	43.79	38.23	9.07	5.65	39.32	18.87
1996.54	1996	7	6.91	16.84	0.62	8.4	15.8	41.40	23.13	0.00	4.63	23.13	0.62
1996.63	1996	8	7.78	13.40	0.00	20.2	14.9	12.40	21.18	32.71	5.21	25.11	0.00
1996.71	1996	9	9.98	21.04	0.00	15.6	13.0	48.11	31.02	16.42	6.69	32.99	0.00
1996.79	1996	10	18.77	42.32	13.54	23.9	10.1	100.55	47.55	85.32	12.58	57.79	13.54
1996.88	1996	11	3.77	5.15	0.00	0.8	9.6	33.11	8.91	0.00	2.52	8.91	0.00
1996.96	1996	12	0.46	2.94	0.00	1.9	10.1	6.72	3.40	0.00	0.31	3.40	0.00
1997.04	1997	1	0.04	2.12	0.00	5.9	10.5	9.93	2.16	0.00	0.02	2.16	0.00
1997.13	1997	2	0.00	1.25	0.00	1.5	10.7	1.79	1.25	0.00	0.00	1.25	0.00
1997.21	1997	3	0.03	0.84	0.00	4.2	14.6	0.87	0.86	0.00	0.02	0.86	0.00
1997.29	1997	4	0.01	0.66	0.00	5.2	11.0	0.09	0.68	0.00	0.01	0.68	0.00
1997.38	1997	5	1.50	1.84	0.00	12.8	16.8	1.38	3.33	0.00	1.00	3.33	0.00
1997.46	1997	6	26.73	61.87	37.12	53.1	14.0	78.02	51.48	242.56	17.91	80.59	37.12
1997.54	1997	7	11.86	28.23	0.00	16.8	15.7	55.74	40.10	6.80	7.95	40.91	0.00
1997.63	1997	8	17.64	36.08	0.00	17.4	14.2	26.39	53.72	20.05	11.82	56.13	0.00
1997.71	1997	9	20.89	41.86	6.04	20.4	11.7	62.13	56.70	54.17	14.00	63.20	6.04
1997.79	1997	10	5.27	16.59	0.00	9.2	11.8	37.98	21.86	0.00	3.53	21.86	0.00
1997.88	1997	11	0.92	1.66	0.00	6.0	8.4	10.74	2.58	0.00	0.61	2.58	0.00
1997.96	1997	12	15.76	24.34	1.27	12.9	6.3	42.87	38.82	40.72	10.56	43.71	1.27
1998.04	1998	1	6.71	4.53	0.00	5.6	8.2	19.55	11.24	0.00	4.50	11.24	0.00
1998.13	1998	2	5.81	19.98	0.00	13.2	9.1	38.19	25.79	25.35	3.89	28.83	0.00
1998.21	1998	3	6.02	28.64	0.00	12.6	12.1	36.55	34.66	3.50	4.03	35.08	0.00
1998.29	1998	4	2.84	13.70	0.00	0.1	13.9	1.49	16.55	0.00	1.90	16.55	0.00
1998.38	1998	5	1.16	15.40	0.00	15.6	15.6	0.12	16.57	0.00	0.78	16.57	0.00
1998.46	1998	6	0.51	6.93	0.00	5.8	14.8	0.00	7.44	0.00	0.34	7.44	0.00
1998.54	1998	7	2.95	7.30	0.00	13.4	14.1	0.39	10.25	0.00	1.98	10.25	0.00
1998.63	1998	8	7.93	21.83	0.00	16.2	13.0	15.55	29.76	19.88	5.31	32.14	0.00
1998.71	1998	9	15.39	50.65	34.68	46.1	10.4	64.40	31.36	221.41	10.31	57.93	34.68
1998.79	1998	10	17.54	22.92	0.00	7.2	9.6	53.12	40.46	0.00	11.75	40.46	0.00
1998.88	1998	11	8.63	19.60	2.05	18.7	8.3	41.17	26.18	64.17	5.78	33.88	2.05
1998.96	1998	12	1.68	3.33	0.00	1.5	8.6	9.66	5.01	0.00	1.12	5.01	0.00
1999.04	1999	1	4.12	6.77	0.00	8.0	9.0	9.19	10.89	0.00	2.76	10.89	0.00

FATHOM MODEL CALCULATIONS

MONTHLY FLOW BY YEAR

			10**6 m3	10**6 m3	10**6 m3	cm/mo	cm/mo	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3	10**6 m3
dec year	Year	Mon	tsb	s18c	s197	rpl	evap u	sgs tot	tsb+s18c-s197	excess rain	central	ne	east
1999.13	1999	2	2.10	1.05	0.00	0.7	10.7	0.32	3.15	0.00	1.41	3.15	0.00
1999.21	1999	3	0.01	0.86	0.00	1.8	14.6	0.83	0.88	0.00	0.01	0.88	0.00
1999.29	1999	4	0.00	0.23	0.00	2.1	15.3	0.00	0.23	0.00	0.00	0.23	0.00
1999.38	1999	5	0.02	0.60	0.00	14.5	16.0	0.00	0.62	0.00	0.01	0.62	0.00
1999.46	1999	6	2.90	18.73	0.00	16.4	13.2	6.66	21.63	19.48	1.94	23.97	0.00
1999.54	1999	7	3.74	21.09	0.00	10.6	14.0	38.39	24.83	0.00	2.50	24.83	0.00
1999.63	1999	8	10.27	22.01	0.00	28.4	13.1	32.63	32.27	94.95	6.88	43.67	0.00
1999.71	1999	9	18.06	31.31	5.49	36.0	10.6	61.37	43.88	157.33	12.10	62.76	5.49
1999.79	1999	10	34.27	65.33	46.15	35.9	8.8	129.64	53.45	167.94	22.96	73.60	46.15
1999.88	1999	11	15.51	19.06	0.00	6.5	8.1	68.69	34.57	0.00	10.39	34.57	0.00
1999.96	1999	12	11.11	14.66	0.00	3.7	8.0	23.06	25.77	0.00	7.44	25.77	0.00
2000.04	2000	1	15.35	19.26	0.00	1.4	9.1	16.85	34.61	0.00	10.28	34.61	0.00
2000.13	2000	2	9.86	12.15	0.00	3.8	10.0	16.78	22.00	0.00	6.60	22.00	0.00
2000.21	2000	3	0.33	7.02	0.00	8.6	13.3	0.49	7.35	0.00	0.22	7.35	0.00
2000.29	2000	4	1.03	7.18	0.00	10.7	14.5	0.31	8.21	0.00	0.69	8.21	0.00
2000.38	2000	5	0.00	0.76	0.00	3.5	15.9	0.00	0.76	0.00	0.00	0.76	0.00
2000.46	2000	6	0.60	11.10	0.00	22.2	14.0	0.00	11.70	51.09	0.40	17.83	0.00
2000.54	2000	7	5.29	26.06	0.00	16.0	14.2	1.50	31.35	10.75	3.54	32.64	0.00
2000.63	2000	8	20.16	38.57	0.00	19.5	12.9	21.11	58.73	40.66	13.51	63.61	0.00
2000.71	2000	9	19.20	39.36	1.57	18.0	11.3	46.18	57.00	41.47	12.87	61.97	1.57
2000.79	2000	10	28.23	57.21	29.88	17.6	9.9		55.56	47.18	18.91	61.22	29.88
2000.88	2000	11	3.97	5.29	0.00	0.7	9.4		9.26	0.00	2.66	9.26	0.00
2000.96	2000	12	0.34	8.58	0.00	4.8	8.5		8.92	0.00	0.23	8.92	0.00
2001.04	2001	1	0.03	0.19	0.00	1.1	10.6		0.22	0.00	0.02	0.22	0.00
2001.13	2001	2	0.00	0.00	0.00	0.0	10.2		0.00	0.00	0.00	0.00	0.00
2001.21	2001	3	0.00	0.00	0.00	7.6	11.1		0.00	0.00	0.00	0.00	0.00
2001.29	2001	4	0.00	0.26	0.00	7.8	14.9		0.26	0.00	0.00	0.26	0.00
2001.38	2001	5	0.09	1.34	0.00	11.7	14.9		1.43	0.00	0.06	1.43	0.00
2001.46	2001	6	0.54	4.95	0.00	22.1	14.5		5.49	47.03	0.36	11.13	0.00
2001.54	2001	7	4.90	24.29	0.00	17.0	13.8		29.19	20.05	3.28	31.59	0.00
2001.63	2001	8	16.55	37.20	6.09	32.7	12.2		47.66	127.05	11.09	62.91	6.09
2001.71	2001	9	19.86	36.23	2.97	28.3	10.7		53.12	109.33	13.31	66.24	2.97
2001.79	2001	10	29.25	49.02	16.63	15.2	8.4		61.64	41.91	19.60	66.67	16.63
2001.88	2001	11	22.54	26.02	0.00	3.3	7.7		48.56	0.00	15.10	48.56	0.00
2001.96	2001	12	8.65	18.53	0.00	5.4	7.6		27.19	0.00	5.80	27.19	0.00
2002.04	2002	1	4.58	11.95	0.00	3.5	9.0		16.53	0.00	3.07	16.53	0.00
2002.13	2002	2	0.20	2.89	0.00	5.7	9.4		3.09	0.00	0.13	3.09	0.00
2002.21	2002	3	0.10	0.61	0.00	4.1	12.6		0.71	0.00	0.06	0.71	0.00
2002.29	2002	4	0.02	0.26	0.00	1.9	14.0		0.28	0.00	0.02	0.28	0.00
2002.38	2002	5	0.11	1.80	0.00	22.4	14.3		1.91	50.00	0.08	7.91	0.00
2002.46	2002	6	6.67	38.25	9.86	34.4	12.1		35.05	137.95	4.47	51.60	9.86
2002.54	2002	7	28.14	43.20	10.04	29.7	12.6		61.30	106.10	18.85	74.03	10.04
2002.63	2002	8	14.27	28.08	0.00	12.1	12.7		42.35	0.00	9.56	42.35	0.00
2002.71	2002	9	13.19	25.41	0.00	10.5	10.7		38.60	0.00	8.84	38.60	0.00
2002.79	2002	10	6.58	9.06	0.00	2.1	10.6		15.64	0.00	4.41	15.64	0.00
2002.88	2002	11	0.21	2.13	0.00	5.0	8.8		2.34	0.00	0.14	2.34	0.00
2002.96	2002	12	1.94	9.95	0.00	2.7	8.2		11.90	0.00	1.30	11.90	0.00

March 2006

Appendix G

Description, Features and Assumptions Used in 2000 Base, 2050 Base, CERP1, and NSM Model Runs

Summary Table

Effects of Future CERP Scenarios on Salinity Conditions at the Taylor River Site and Northeastern Florida Bay

Description, Features and Assumptions used in 2000 Base, 2050 Base, CERP1, and NSM Model Runs

Contents

Model Run Name : 2000B1

Description :

The 2000B1 Existing condition represents conditions that existed in South Florida in 2000, when CERP was approved. In general, assumptions in the 2000B1 represent structures, operations, system demands and land use that were in place in the year 2000. Where emergency operations were in place at that time, operations more representative of "normal" operations have been used in the 2000 existing condition for long-term simulation. The 2000 existing condition is a planning base, and since planning by nature is iterative the simulation is labeled 2000B1, with the expectation that it will be updated as assumptions change over time through the review process.

The Initial CERP Update is being undertaken by an interagency, interdisciplinary team of the RECOVER program in CERP. The purpose of the update is to incorporate new information gained since the C&SF Comprehensive Review Study was released (July 1999). The scope of this effort is to:

- update planning conditions from the 1995 data used in the Restudy to 2000 data, such as land use, population, and water use
- update structural, operational and regulation schedule changes to the water management system
- update forecasts of 2050 conditions based on new data since the Restudy
- evaluate the performance of the Comprehensive Plan using the latest updated versions of the South Florida Water Management Model (SFWMM) and the Natural System Model (NSM)
- document all findings in a technical report

Planning for water resources purposes in South Florida relies strongly upon a computer simulation tool called the South Florida Water Management Model, which is capable of simulating the daily hydrology and operations of the water management system. The model requires input data, termed “assumptions”, that govern the results, or outputs, of a given model simulation. Use of this modeling tool allows informed discussion as to what assumptions appear reasonable as input data. In addition to the use of new data, the SFWMM and NSM have undergone updating and improvements to increase accuracy of predictions.

The first updated model run for the 2000 Existing Condition will be posted on the web at http://modeling.cerpzone.org/cerp_recover/pmviewer/pmviewer.jsp for agency and public review. In the planning process, conditions that exist at the time of the investigation, or study, are collectively called the “existing condition.” The existing condition is a reasonable depiction of current, relevant circumstances in the planning area.

Planning by its nature is iterative. This web posting begins the review and discussion of the assumptions for the 2000 Existing Condition. These assumptions may change over time, as the review process proceeds. Additionally, as external review of the calibration/verification of the SFWMM goes forward, there is the potential that the outputs (results) of the model may be refined as well.

The assumptions for the 2000 Existing Condition as currently modeled for the Initial CERP Update are to be used for planning purposes only and are presented in the table below.

The assumptions for the proposed 2000 Existing Condition should not be construed as those that will necessarily be contained within the "Pre-CERP Baseline" as called for in the draft Programmatic Regulations (August 2002). The definition of the assumptions to be used in the Pre-CERP Baseline will be coordinated through an interagency process as required by sub-part 385.35 of the draft Programmatic Regulations.

Feature Assumptions

Regional Input Data

Climate

- The climatic period of record is from 1965 to 2000.
- Rainfall estimates have been revised and updated for 1965-2000.
- Revised evapotranspiration methods have been used for 1965-2000.

Topography

Updated November 2001 and September 2003 using latest available information (in NGVD 29 datum). Nov 2001 update (Documented in November 2001 SFWMD memorandum from M. Hinton to K. Tarboton) includes:

- USGS High Accuracy Elevation data from helicopter surveys collected 1999-200 0for Everglades National Park and Water Conservation Area (WCA) 3 south of Alligator Alley
- USGS Lidar data (May 1999) for WCA-3A north of Alligator Alley
- Lindahl, Browning, Ferrari & Helstrom 1999 survey for Rotenberger Wildlife Management Area.
- Stormwater Treatment Area surveys from 1990s
- Aerometric Corp. 1986 survey of the 8-1/2 square mile area
- Includes estimate of Everglades Agricultural Area subsidence
- Other data as in SFWMM v3.7
- FWC survey 1992 for the Holey Land Wildlife Management Area.

September 2003 update includes:

- Reverting to FWC 1992 survey data for Rotenberger Wildlife Management Area.
- DHI gridded data from Kimley –Horn contracted survey of EAA, 2002-2003. Regridded to 2x2 scale for EAA outside of STAs and WMAs.

Sea Level

- Sea level data from six long-term NOAA stations were used to generate a historic record to use as sea level boundary conditions for the 1965 to 2000 evaluation period.

Land Use

- All land use has been updated using most recent FLUCCS data (1995), modified in the Lower East Coast urban areas using 2000 aerial photography (2x2 scale).

(Documented in August 2003 SFWMD memorandum from J. Barnes and K. Tarboton to J. Obeysekera).

Natural Area Land Cover (Vegetation)

Vegetation classes and their spatial distribution in the natural areas comes from the following data:

- Walsh 1995 aerial photography in Everglades National Park
- Rutchey 1995 classification in WCA-3B, WCA-3A north of Alligator Alley and the Miami Canal, WCA-2A & 2B
- Richardson 1990 data for Loxahatchee National Wildlife Refuge
- FLUCCS 1995 for Big Cypress National Preserve, Holey Land & Rotenberger Wildlife Management Areas & WCA-3A south of Alligator Alley and the Miami Canal.

(Documented in August 2003 SFWMD memorandum from J. Barnes and K. Tarboton to J. Obeysekera).

Lake Okeechobee Service Area

LOSA Basins

- Lower Istokpoga, S-4, North Lake Shore and Northeast Lake Shore demands and runoff based on AFSIRS modeling.

Lake Okeechobee

- Lake Okeechobee Regulation Schedule WSE according to WSE decision trees.

- Lake Okeechobee Supply Side management policy for Lake Okeechobee Service Area water restriction cutbacks as per rule 40E-21 and 40E-22 (13.5 – 11.0 ft. trigger line). A 67% maximum cutback will be implemented.
- Emergency flood control backpumping to Lake Okeechobee from the Everglades Agricultural Area.
- Kissimmee River inflows based on interim schedule for Kissimmee Chain of Lakes using the UKISS model.
- Best Management Practices runoff reduction assumed to be 0%. BMP Makeup water (Replacement Water Rule) target has an average of 102 KAF per year for the 36-yr period. Actual deliveries can be less due to conveyance limitations, WCAs above schedule and suspension of makeup water deliveries due to SSM.

Caloosahatchee River Basin

- Caloosahatchee River Basin irrigation demands and runoff were estimated using the AFSIRS method based on existing planted acreage.
- Public water supply daily intake from the river is included in the analysis.

St. Lucie Canal Basin

- St. Lucie Canal Basin demands estimated using the AFSIRS method based on existing planted acreage.
- Basin demands include the Florida Power & Light reservoir at Indiantown.

Seminole Brighton Reservation

- Brighton Reservation demands were estimated using the AFSIRS method based on existing planted acreage.
- Demands are in agreement with the entitlement quantities as per Table 7, Agreement 41-21 (Nov 92).
- Supply-side management applies to this agreement.

Seminole Big Cypress Reservation

- Big Cypress Reservation irrigation demands and runoff were estimated using the AFSIRS method based on existing planted acreage.
- The 1 in 5 demand is in agreement with the Seminole Compact (Work Plan = 2606 MGM, Model = 2659 MGM) .
- Supply-side management applies to the Compact.

Everglades Agricultural Area

- Everglades Agricultural Area irrigation demands are simulated using climatic data for the 36 year period of record and a soil moisture accounting algorithm, with parameters calibrated to match historical regional supplemental deliveries from Lake Okeechobee.

- Best Management Practices assumed to reduce runoff 0% annually.

Everglades Construction Project Stormwater Treatment Areas

- Stormwater Treatment Areas 1W, 5 & 6 operational.
- Stormwater Treatment Area 2 complete but not connected to the regional system.
- Operation of Stormwater Treatment Areas assumes 6" minimum depth during periods of drought.

Holey Land Wildlife Management Area

- As per Memorandum of Agreement between the FWC and the District.

Rotenberger Wildlife Management Area

- Interim Operational Schedule as defined in the Operation Plan for Rotenberger (SFWMD Jan 2001).

Water Conservation Areas

Water Conservation Area 1 (ARM Loxahatchee National Wildlife Refuge)

- Current C&SF Regulation Schedule. Includes regulatory releases to tide through LEC canals.
- No net outflow to maintain minimum stages in the LEC Service Area canals (salinity control), if water levels are less than minimum operating criteria of 14 ft.
- The bottom floor of the schedule (Zone C) is the area below 14 ft. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.

Water Conservation Area 2 A&B

- Current C&SF regulation schedule. Includes regulatory releases to tide through LEC canals.
- No net outflow to maintain minimum stages in the LEC Service Area canals (salinity control), if water levels in WCA-2A are less than minimum operating criteria of 10.5 ft. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.

Water Conservation Area 3 A&B

- Current C&SF regulation schedule. Includes regulatory releases to tide through LEC canals.
- No net outflow to maintain minimum stages in the LEC Service Area canals (salinity control), if water levels are less than minimum operating criteria of 7.5 ft in WCA-3A. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee.

Lower East Coast Service Areas

Public Water Supply and Irrigation

- Public water supply wellfield pumpages and locations are based on actual pumpage data for calendar year 2000 (includes Miami-Dade County Water and Sewer Department West Wellfield Aquifer Storage and Recovery system).
- Irrigation demands are based upon existing land use and calculated using AFSIRS, reduced to account for landscape and golf course areas irrigated using reuse waterand landscape areas irrigated using public water supply.

Seminole Hollywood Reservation

- Hollywood Reservation demands are set forth under VI.C of the Water Rights Compact.

Natural Areas

- For the Northwest Fork of the Loxahatchee River, the District operates the G-92 structure and associated structures to provide approximately 50 cfs over Lainhart Dam to the Northwest Fork, when the District determines that water supplies are available.
- Flows to Pond Apple Slough through S-13A are adjusted in the model to approximate measured flows at the structure.
- Flows to Biscayne Bay are simulated through Snake Creek, North Bay, the Miami River, Central Bay and South Bay.

Canal Operations

- C&SF system and operating rules in effect in 2000.
- Includes operations to meet control elevations in the primary coastal canals for the prevention of saltwater intrusion.
- Includes existing secondary drainage/water supply system.
- Excludes portions of the South Dade Conveyance System that follow rules for Test 7 Phase 1 water deliveries to Everglades National Park, as per Restudy 1995 Existing Condition.

Western Basins and Big Cypress National Preserve

Western Basins

- Estimated and updated historical inflows from western basins at two locations: G- 136 and G-406. The G-406 location represents potential inflow from the C-139 Basin into STA 5. Data for the period 1978 - 2000 is the same as the data used for the C-139 Basin Rule development.

(Documented in June 2002 SFWMD memorandum from L. Cadavid and L. Brion to J. Obeysekera).

Big Cypress

- The northern end of Big Cypress receives flows from S-190.
- Tamiami Trail culverts are not modeled in SFWMM due to the coarse (2x2 mile) model resolution.

Everglades National Park and Florida Bay

Everglades National Park

- Water deliveries to Everglades National Park are based on Test 7 Phase 1 as per Restudy 1995 Existing Condition.

Region-wide Water Management and Related Operations

Water Management Rules

- The existing condition reflects the existing water shortage policies in 2000 as reflected in South Florida Water Management District rule 40E-21.
- The impacts of declarations of water shortages on utility water use reflect assumpti

Model Run Name : 2050B1 - CERP Future Without Project (2050) Condition

Description

The 2050B1 future without project condition represents predicted conditions that will exist in South Florida in 2050, without the implementation of CERP projects. In general assumptions in the 2050B1 represent structures, operations, system demands and land use that are projected to be in place in the year 2050. The 2050 future without project condition is used for planning purposes, and since planning by nature is iterative the simulation is labeled 2050B1, with the expectation that it will be updated as assumptions change over time. It is the 2050 future without project condition that we use in planning to measure the benefits of the implementation of CERP.
Link to the 2050 future without project condition assumptions table:
http://pmviewer.cerpzone.org/cerp_recover/showDocument.do?documentID=153

Feature Assumptions

Regional Input Data

Climate

- The climatic period of record is from 1965 to 2000.
- Rainfall estimates have been revised and updated for 1965-2000.
- Revised evapotranspiration methods have been used for 1965-2000.

These data are the same as the existing condition.

Topography

Updated November 2001 and September 2003 using latest available information (in NGVD 29 datum). This update iincorporates the Nov 2001 update (Documented in November 2001 SFWMD memorandum from M. Hinton to K. Tarboton) includes:

- USGS High Accuracy Elevation data from helicopter surveys collected 1999-2000 for Everglades National Park and Water Conservation Area (WCA) 3 south of Alligator Alley.
- USGS Lidar data (May 1999) for WCA-3A north of Alligator Alley
- Lindahl, Browning, Ferrari & Helstrom 1999 survey for Rotenberger Wildlife Management Area (WMA).
- Stormwater Treatment Area (STA) surveys from 1990s

- Aerometric Corp. 1986 survey of the 8.5 square mile area
- Includes estimate of Everglades Agricultural Area (EAA) subsidence
- Other data as in SFWMM v3.7
- FWC survey 1992 for the Holey Land Wildlife Management Area.

September 2003 update includes

- Reverting to FWC 1992 survey data for Rotenberger Wildlife Management Area.
- DHI gridded data from Kimley –Horn contracted survey of EAA, 2002-2003. Regridded to 2x2 scale for EAA outside of STAs and WMAs.

These data are the same as the existing condition. No subsidence will be addressed;subsidence in the EAA and other areas may be addressed in the next CERP Update.

Sea Level

- Sea level data from six long-term NOAA stations were used to generate a historic record to use as sea level boundary conditions for the 1965 to 2000 evaluation period.
- A sensitivity analysis will be performed utilizing an 0.8 foot rise in sea level so that the impacts of such a change on the performance of the water management system can be assessed.

Land Use

- Lands not developed in the existing condition are assigned land use codes crosswalked from county comprehensive plans (future land use).

Natural Area

Vegetation classes and their spatial distribution in the natural areas comes from the following data:

- Walsh 1995 aerial photography in Everglades National Park
- Rutchey 1995 classification in WCA-3B, WCA-3A north of Alligator Alley and the Miami Canal, WCA-2A & 2B
- Richardson 1990 data for Loxahatchee National Wildlife Refuge
- FLUCCS 1995 for Big Cypress National Preserve, Holey Land & Rotenberger Wildlife Management Areas & WCA-3A south of Alligator Alley and the Miami Canal. (Documented in August 2003 SFWMD memorandum from J. Barnes and K. Tarboton to J. Obeysekera).

These data are the same as in the existing condition.

Lake Okeechobee Service Area

LOSA Basins

• Lower Istokpoga, S-4, North Lake Shore and Northeast Lake Shore demands and runoff are based on AFSIRS modeling using 2050 land use projections.

Lake Okeechobee

- Lake Okeechobee Regulation Schedule WSE according to WSE decision trees.
- Lake Okeechobee Supply Side Management policy for Lake Okeechobee Service Area water restriction cutbacks as per rule 40E-21 and 40E-22 (as amended in September, 2001) (13.0 – 10.5 ft. SSM trigger line). .
- Adaptive Protocols are included.
- Kissimmee River Restoration and Headwaters Revitalization Project is complete.
- Average annual environmental deliveries to the WCAs equal the annual average Best Management Practices (BMP) Replacement Water Rule volumes (102 ,000 ac-ft/year).
- BMP runoff reduction is assumed to be 0%; there are no makeup water deliveries.

Caloosahatchee River Basin

- • Caloosahatchee River Basin irrigation demands and runoff were estimated using the AFSIRS method based on projected acreage as per the 2000 Caloosahatchee Water Management Plan projections for 2020.
- • Public water supply daily intake from the river is ~10 MGD.

St. Lucie Canal Basin

- • St. Lucie Canal Basin demands were based on the Indian River Lagoon draft feasibility study future without project condition projected acreages for 2050.
- • Basin demands include the Florida Power & Light reservoir at Indiantown.

Seminole Brighton Reservation

- • Brighton Reservation demands were estimated using the AFSIRS method based on existing planted acreage.

- • Demands are in agreement with the entitlement quantities as per Table 7, Agreement 41-21 (Nov 92).
- • Supply-side management applies to this agreement.

Seminole Big • Big Cypress Reservation

- irrigation demands and runoff were estimated using the AFSIRS method based on existing planted acreage.
- • Demands are in agreement with the Seminole Compact.
- • Supply-side management applies to the Compact.

Everglades Agricultural Area

- • Everglades Agricultural Area irrigation demands are simulated using climatic data for the 36 year period of record and a soil moisture accounting algorithm, with parameters calibrated to match historical regional supplemental deliveries from Lake Okeechobee.
- • BMPs are assumed to reduce runoff 0% annually.
- • Demands reflect the construction of STA 3/4.

Everglades Construction Project Stormwater Treatment Areas

- • All Stormwater Treatment Areas are maintained at a 6" minimum depth duringperiods of drought.
- • As compared to the existing condition:
    - STA-2 is connected to the regional system
    - STA 3/4 and STA 1E are constructed and operational
    - STA-6 area increased from 870 to 2421 acres due to Phase 2 construction.

Holey Land Wildlife Management Area

- • Operations are similar to the existing condition as in the 1995 base simulation for the Lower East Coast Regional Water Supply Plan (LECRWSP, May 2000).

Rotenberger Wildlife Management Area

- • Interim Operational Schedule as defined in the Operation Plan for Rotenberger (SFWMD July 2002).

Water Conservation Areas

Water Conservation Area 1 (ARM Loxahatchee National Wildlife Refuge)

- • Current C&SF Regulation Schedule. Includes regulatory releases to tide through lower east coast (LEC) canals.
- • No net outflow to maintain minimum stages in the LEC Service Area canals (salinity control), if water levels are less than minimum operating criteria of 14 ft. The bottom floor of the schedule (Zone C) is the area below 14 ft. and reads: "No net releases from WCA-1. Any water supply releases below the floor will be matched by an equivalent volume of inflow from Lake Okeechobee."
- • Operations are the same as the existing condition.

Water Conservation Area 2 A&B

- • Rainfall driven operational criteria for determining timing of deliveries to and discharges from WCA-2A.

Water Conservation Area 3 A&B

- • Rainfall driven operational criteria for determining timing of deliveries to and discharges from WCA-3A.
- • Structural and operational modifications for L-67 canal conveyance and S-355 structures as in the federally authorized Modified Water Delivery Project. Refer to separate Modified Water Deliveries (MWD), 8.5 square mile area, and C-111 table for details.

Lower East Coast Service Areas

Public Water Supply and Irrigation

- • Projections are based upon IWR MAIN methodologies (September 2003 final report). The focus will be on changes in population / economic projections and water conservation effectiveness.
- • Projections take into account a 15% across the board increase in demand to account for alternative treatment technologies.
- • Wellfield distribution as in the LECRWSP for 2020 (LEC1).
- • Irrigation demands are based on projected land use and calculated in the same manner as the existing condition.
- • Miami-Dade aquifer storage and recovery (ASR) West Wellfield is 15 MGD, Northwest and Southwest Wellfields are 10 MGD each.
- • Wastewater reuse has been incorporated in the estimation of landscape irrigation demands for each county.

Seminole Hollywood Reservation

- • Hollywood Reservation demands are set forth under VI.C of the Water Rights Compact.

Natural Areas

- • For the Northwest Fork of the Loxahatchee River, the District operates the G-92 structure and associated structures to provide approximately 50 cfs over Lainhart Dam to the Northwest Fork, when the District determines that water supplies are available.
- • Flows to Pond Apple Slough through S-13A are adjusted in the model to approximate measured flows at the structure.
- • Flows to Biscayne Bay are simulated through Snake Creek, North Bay, the Miami River, Central Bay and South Bay.

These data are the same as the existing condition.

Canal Operations

- • C-11 Water Quality Treatment Critical Project constructed (S-381 Ogee Gated Spillway and Pumping Station S-9A).
- • Western C-4 Structure (S-380) Critical Project constructed.
- • C-4 Flood Mitigation Project includes 440 and 434 +/- acre impoundments to store stormwater from the C-4 Basin.
- • Recently completed S-25B and S-26 pumps will not be modeled since they would be used very rarely during high tide conditions and the SFWMM uses a long-term average daily tidal boundary.
- • Operational adjustments to maintain water levels in the coastal canals to meet minimum levels in the Biscayne Aquifer as proposed in the LECRWSP.
- • Northwest Dade Lake Belt area assumes that the conditions caused by currently permitted mining exist and that the effects of any future mining are fully mitigated by industry.
- • Eastern Hillsboro Utility ASR is 5 MGD.
- • ACME Basin A flood control discharges are sent to C-51, west of the S-155A structure, to be pumped into STA-1E. ACME Basin B flood control discharges are no longer sent into the Loxahatchee National Wildlife Refuge, but instead to C-51 East through the S-155A structure.

Western Basins and Big Cypress National Preserve

Western Basins

- • Estimated and updated historical inflows from western basins at two locations: G- 136 and G-406. The G-406 location represents potential inflow from the C-139 Basin into STA 5. Data for the period 1978 - 2000 is the same as the data used for the C-139 Basin Rule development.

(Documented in June 2002 SFWMD memorandum from L. Cadavid and L. Brion to J. Obeysekera). Data are the same as the existing condition.

Big Cypress

- • The northern end of Big Cypress receives flows from S-190.
- • No Tamiami Trail culverts are modeled in the SFWMM due to the coarse (2x2 mile) model resolution.

Everglades National Park and Florida Bay

- • Structural and operational modifications for L-67 extension canal as in the federally authorized Modified Water Delivery Project.
- • 8.5 SMA as per the federally authorized Alternative 6D of the 8.5 SMA project.
- • C-111 project features and operations as per Restudy 2050 Base.

Refer to separate MWD, 8.5.SMA, C-111 table for details.

Region-wide Water Management and Related Operations

- • The future without project condition reflects the existing water shortage policies in 2000 as reflected in South Florida Water Management District rule 40E-21.
- • The impacts of declarations of water shortages on utility water use reflect assumptions contained in the LECRWSP.

These data are the same as in the existing condition.

Model Run Name : CERP1

Description :

CERP1 is a simulation of the "with project" condition which incorporates new information into modeling of the CERP with the latest version of the South Florida Water Management Model (SFWMMv5.4). An alternative "with project" simulation named CERP0 has also been posted.

The major differences between the two alternative "with project" simulations are:

- **CERP1** uses updated public water supply demands in the LEC (as in the 2050 future without project condition) and updated agricultural water supply demands in the Caloosahatchee Basin (also in the 2050 future without) but limits average annual water supply deliveries from Lake Okeechobee to the Caloosahatchee Basin to be the same as annual average D13R volumes (consistent with the Caloosahatchee Water Management Plan and Lower East Coast Regional Water Supply Plan).
- **CERP0** uses D13R public water supply demands in the LEC and "D13R-like" demands in the Caloosahatchee (C-43) Basin.

Modeling specification differences between CERP0 & CERP1 and D13R were arrived at through discussion with RECOVER project leaders and the Interagency Modeling Center, CERP1 Modeling Team.

Comparison of Various CERP Model Runs

The Initial CERP Update (ICU) is being undertaken by the interagency, interdisciplinary RECOVER Team. One purpose of the update is to incorporate new information into the planning process that has been gained since the C&SF Comprehensive Review Study was completed in July 1999. A second purpose is to simulate the Comprehensive Everglades Restoration Plan (CERP) using the latest versions of the South Florida Water Management Model (SFWMM) and the Natural System Model (NSM). A set of principles was provided by RECOVER project leaders to guide the simulation of the Comprehensive Plan with the new data and updated tools. Those principles were:

- to use 2050 future without project assumptions for all non-CERP components (as documented in the 2050 future without project condition, see link below)
- for all CERP projects, use project definitions as defined in C&SF Project Comprehensive Review Study (July 1999, aka the “Yellow Book”) and modeled in D13R (Nov. 98 version) , i.e., do not make changes to the Plan
- seek guidance from RECOVER project leaders should differences between project definitions and modeled project assumptions occur

Two model simulations for the Initial CERP Update have previously been completed – a simulation of the 2000 existing condition and the 2050 without project condition. Two additional model simulations have now been completed and are being presented for review and evaluation by RECOVER's Regional Evaluation Team (RET) and the ICU Team. The nomenclature on the performance measure graphics for these two additional simulations is "CERP0" and "CERP1". CERP0 & CERP1 are simulations of the "with project" condition that incorporate new information into modeling of the CERP with the latest version of the SFWMM (version 5.4). Differences between CERP0 & CERP1 are:

- CERP0 uses D13R public water supply demands in the Lower East Coast and "D13R-like" demands in the Caloosahatchee (C-43) Basin
- CERP1 uses updated public water supply demands in the Lower East Coast (as in the 2050 future without project condition) and updated agricultural water supply demands in the Caloosahatchee Basin (also in the 2050 future without) but limits average annual water supply deliveries from lake Okeechobee to the Caloosahatchee Basin to be the same as annual average D13R volumes (consistent with the Caloosahatchee Water Management Plan and Lower East Coast Regional Water Supply Plan)

Modeling specification differences between CERP0 & CERP1 and D13R

All modeling specification differences between CERP0 & CERP1 and D13R were arrived at through discussion with RECOVER project leaders and the Interagency Modeling Center, CERP1 Modeling Team. Modeling specifications not listed here are consistent with those specified for D13R in the Yellow Book. Some of the differences below are non-CERP project changes (e.g., implementation of the WSE schedule for Lake Okeechobee), and are listed separately.

Modeling specification differences in CERP

Lake Okeechobee operations

- ASR injection at the bottom of Zone D of WSE (CERP0 & CERP1 injection begins ~ ½' lower than D13R, hence puts water into ASR sooner); becomes highest priority for injection
- ASR recovery follows new SSM line + ¼' and is ~ 1' lower than D13R
- Injection for North of Lake Storage and EAA Reservoir now second in priority; CERP0 & CERP1 injection ~ ¼' higher than D13R; shape of line is parallel to Zone D of WSE
- North of Lake Storage seepage losses assumed to be 50% in CERP0 & CERP1 (consistent with LECRWSP) compared to 100% in D13R

Other operational adjustments

- Shift in STA 3-4 discharge priorities for hydropattern enhancement
- Flows allowed to Pond Apple Slough
- NSM stage targets based on NSMv4.6.2 ponding depths and adjusted due to changes in topo; D13R used NSMv4.5 ponding depths
- L-67 weir heights adjusted due to changes in topo to enhance flows to ENP

Public water supply

- CERP1 includes a 15% conservation assumption compared to the D13R assumption of 12%; D13R component AAA LEC Utility Water Conservation (6%) is not included in CERP1
- CERP1 wellfield locations are the same as D13R with demands higher in some wellfields (based on data from Gulf Engineering M&I Report and bulk sales) and lower in others (use of alternative sources, bulk purchasers)

Modeling specification differences for non-CERP projects (also included in 2050 future without project condition)

Lake Okeechobee operations

- WSE operation schedule for CERP0 & CERP1; D13R used Run 25

Caloosahatchee and St. Lucie basins

- Revised time series hydrologic data created revised demands and runoff and targets for environmental deliveries to the estuaries

Other operational adjustments

- BMP runoff reduction from the EAA calculated to be 0% in CERP0 & CERP1; D13R had 18% runoff reduction
- STAs to maintain 6” min depth in times of mild to moderate drought

Public water supply

- Includes updated M&I demand projections for the Lower East Coast based on Gulf Engineering M&I Report

Inclusion of additional utility ASR changes seasonality of wellfield withdrawals

- Raw water withdrawals by utility increased by 15% to account for anticipated conversion to advanced treatment technologies with reject water lost to system due to current unpermittability for reuse (canal recharge)

Model Run Name : NSM4.6.2

Description

The Natural System Model (NSM) simulates the hydrologic response of an Everglades watershed in its pre-drainage condition. Recent climatic data is used to simulate the pre-drainage hydrologic response to current hydrologic input allowing for meaningful comparisons between SFWMM simulations and NSM simulations. Vegetation, topography, and river courses used by the NSM are based on pre-drainage conditions.

NSM Version 4.6.2 uses the same climatic input, computational methods, and model parameters calibrated and verified by the SFWMMv5.4 (e.g. ET, Manning's "n") including:

- updated tidal boundary stations
- new rainfall based on "10-tin" interpolation
- reformulated PET dataset
- modified landscape coverage
- updated soil storage coefficients
- updated et and manning's coefficients
- revised topography
- updated inflow boundary flows into Lake Okeechobee and Lake Istokpoga (dbhydro changes)
- expanded period of record through 2000

Joel,

The 2X2 runs coupled to FATHOM model (shown in MFL document for Little Madeira Bay) were received for our use on May 5, 2005. They are referenced by Danielle Lyons in an August 2004 email as :**2000B2, 2050B2, and** CERP1. NSM was not referenced.

The runs coupled with the Taylor River Model were received by Frank Marshall August 25, 2004 and (used for RECOVER modeling work). They are referenced by Xu Hong in an August 26,2004 email as: **2000CERP and 2050CERP.** Also referenced by Frank Marshall in that exchange were CERP1 and NSM4.6.2.

Features of some of these runs are summarized in the table below.

EXISTING CONDITIONS	FUTURE WITHOUT PROJECT CONDITIONS	FUTURE WITH PROJECT CONDITIONS
2000B1 (SFWMM 5.0) The 2000B1 Existing condition represents conditions that existed in South Florida in 2000, when CERP was approved. In general, assumptions in the 2000B1 represent structures, operations, system demands and land use that were in place in the year 2000. Where emergency operations were in place at that time, operations more representative of "normal" operations have been used in the 2000 existing condition for long-term simulation. The 2000 existing condition is a planning base, and since planning by nature is iterative the simulation is labeled 2000B1, with the expectation that it will be updated as assumptions change over time through the review process.	**2050B1 (SFWMM 5.0) (rainfall driven ops)** The 2050 future without project condition represents predicted conditions that will exist in South Florida in 2050, without the implementation of CERP projects. In general, assumptions in the 2050 represent structures, operations, and land use projected to be in place in the year 2050.	**D13R (SFWMM 3.5.7)** Describes conditions that are expected to exist in 2050 if the Comprehensive Everglades Restoration Plan (CERP) is implemented subject to 1965-1995 climatic conditions. Alternative D13R is the plan selected by the full Restudy Team as the initial draft plan. The components contained in Alternative D13R are derived from components which were developed in earlier Alternatives. Some components have been modified from their original design in order to meet the environmental objectives of restoration of historic sheetflow and ecological connectivity.
2000B2 (SFWMM 5.4) The 2000B2 Existing condition simulation is an improved version of the previously posted 2000B1. The 2000B2 inherits most of the assumptions, data and properties from the 2000B1. Modifications to the 2000B1 were made following RECOVER review and other minor changes to be consistent	**2050B2 (SFWMM 5.4) (rainfall driven ops)** The 2050B2 Future without project condition simulation is an improved version of the previously posted 2050B1. The 2050B2 inherits most of the assumptions, data and properties from the 2050B1. Modifications to the 2050B1 were made following	**CERP1 (SFWMM 5.0)** CERP1 is a simulation of the "with project" condition which incorporates new information into modeling of the CERP with the latest version of the South Florida Water Management Model (SFWMMv5.4). CERP1 uses updated public water supply demands in the LEC (as in the 2050 future without project condition) and updated agricultural

EXISTING CONDITIONS	FUTURE WITHOUT PROJECT CONDITIONS	FUTURE WITH PROJECT CONDITIONS
with the new version of the SFWMM (v5.4).	RECOVER review and other minor changes to be consistent with the new version of the SFWMM (v5.4).	water supply demands in the Caloosahatchee Basin (also in the 2050 future without) but limits average annual water supply deliveries from Lake Okeechobee to the Caloosahatchee Basin to be the same as annual average D13R volumes (consistent with the Caloosahatchee Water Management Plan and Lower East Coast Regional Water Supply Plan).
2000B3 (SFWMM 5.4.3) The 2000B3 existing condition simulation is an improved version of the previously posted 2000B2. The 2000B3 inherits most of the assumptions, data and properties from the 2000B2. Modifications to the 2000B2 were made to be consistent with the new version of the SFWMM (v5.4.3). These changes only affect the way in which structure flows in the Stormwater Treatment Areas are simulated.	**2050B0 (SFWMM 5.4) (rainfall driven ops)** Public water supply demands are those that were projected during the development of the CERP (the Restudy), as are agricultural demands in the Caloosahatchee River basin.	**CERP0 (SFWMM 5.4)** CERP0 is a simulation of the "with project" condition which incorporates new information into modeling of the CERP with the latest version of the South Florida Water Management Model (SFWMMv5.4). CERP0 uses D13R public water supply demands in the LEC and "D13R-like" demands in the Caloosahatchee (C-43) Basin.
	2050B3 (SFWMM5.4.3) (NO rainfall driven ops) Public water supply demands are those that were projected during the development of the CERP (the Restudy), as are agricultural demands in the Caloosahatchee River basin.	**CERPA (SFWMM 5.4.3)** CERPA is the latest simulation of the CERP (D13R), using version 5.4.3 of the SFWMM. CERPA modeling mimics closely the structural and operational intent of D13R, using the new tool. It was adapted from the CERP0 scenario with the following differences: Expanded storm water treatment areas associated with the Acceler8 Everglades Construction Project configuration (as in the 2050B3) Updated climate forecasts as in 2050B3 Lake Okeechobee operational lines for ASR injection and deliveries to North of Lake Storage and EAA Reservoir the same as in D13R ASR recovery line modified due to changes in the supply side management line Offsets, translations, and truncations to NSM targets use same logic as D13R C-9 reservoir modeled as a physical feature and ACME Basin B project incorporated Updated Caloosahatchee and St.
	50B3S4 (SFWMM5.4.3) (rainfall driven ops) 50B3S4 uses Everglades rainfall driven operations (similar to the previously posted 2050B0 and 2050B2 scenarios) based on NSMS4 targets to operate WCA2A, WCA2B, WCA3A, WCA3B and ENP. Public water supply demands are those that were projected during the development of the CERP (the Restudy), as are agricultural demands in the Caloosahatchee River basin.	

EXISTING CONDITIONS	FUTURE WITHOUT PROJECT CONDITIONS	FUTURE WITH PROJECT CONDITIONS
		Lucie estuary targets

EFFECTS OF FUTURE RESTORATION PROJECTS ON FRESHWATER FLOW AND SALINITY CONDITIONS

Regional modeling was performed to determine the relative impact of the future CERP projects on the proposed MFL criteria. Using flow input from the South Florida Water Management Model (SFWMM), salinity predictions were produced for Little Madeira Bay using the FATHOM model (Environmental Consulting and Technology, Inc. 2005) and for the Taylor River site using the Taylor River MLR Model (Marshall, 2005). The input data set in each model was extended to 36 years to span 1965 - 2000. Salinity simulations were then produced for each of the following water management scenarios: 2000B (base case 2000 which assumes 2000 operations), 2050 (future with no project), CERP1 (future with CERP project), and NSM 4.6.2 (natural system).

Taylor River Site

The regional modeling salinity predictions using the SFWMM for the Taylor River site (Marshall, 2005) show differences between the 4 scenarios over the 36 year simulations relevant to the proposed MFL **(Figure 5-9)**

Base case (2000B): Significant harm occurred 5 times in the 36 year simulation period. That equates to a return frequency of 1:7 years.

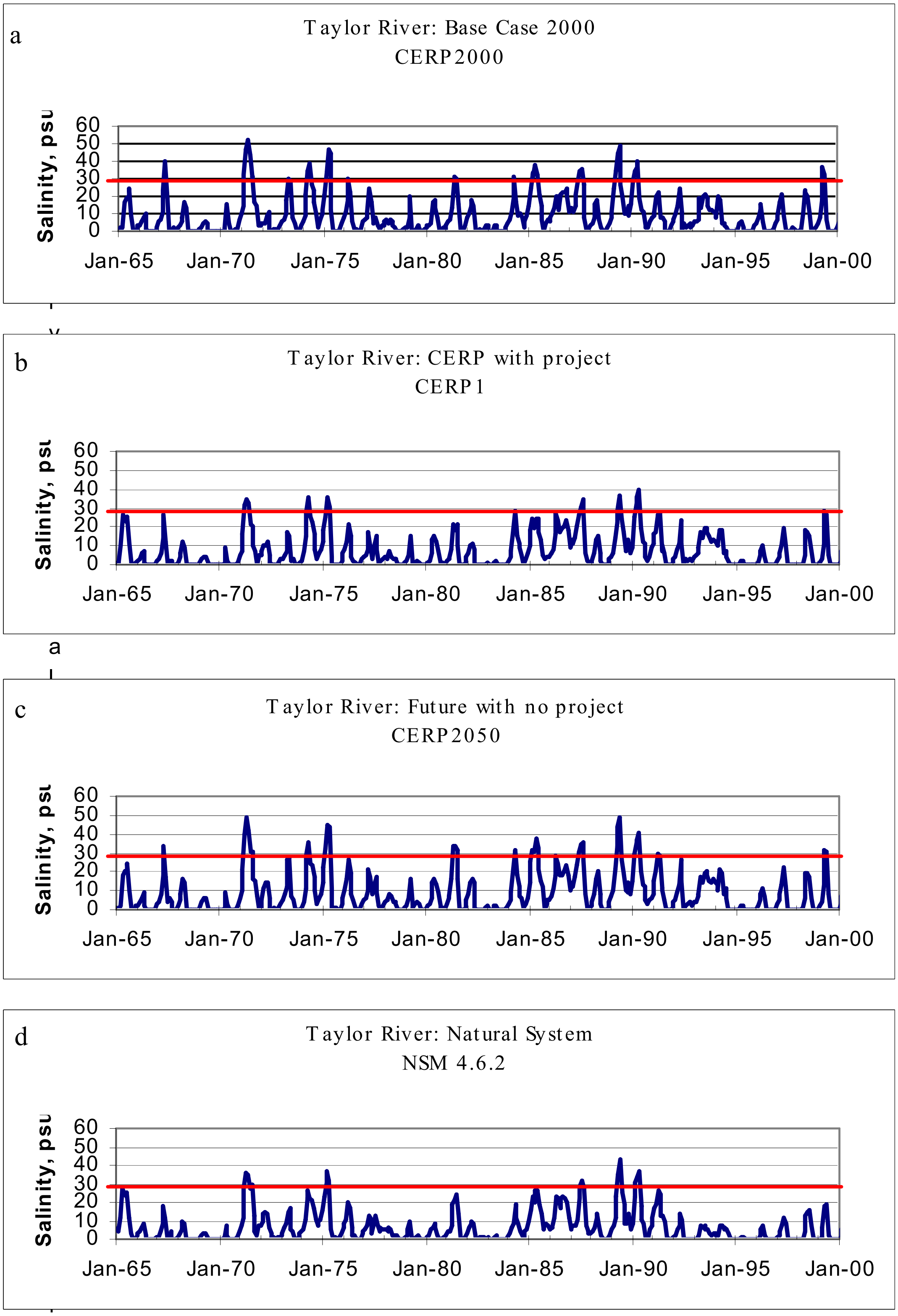
Future with no project (2050): Significant harm occurred 4 times in the 36 year simulation period. That equates to a return frequency of 1: 9 years.

Future with CERP Project (CERP1): Significant harm occurred 2 times in the 36 year simulation period. That equates to a return frequency of 1:18 years.

Natural System (NSM): Significant harm occurred 1 time in the 36 year simulation period. That equates to a return frequency of 1:36 years.

In summary, significant harm in the NSM scenario occurred only during two consecutive drought years for Florida Bay 1989 and 1990. There is no significant difference between the current base case 2000 and the future with no project (2050). The CERP1 scenario predicts an improvement relative to current and future with no project.

Figure



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om Marshall 2005) for (a) base case (2000) (b) future no project (2050) (c) future with project (CERP1) (d) natural system (NSM 4.6.2). Markers denote occurrences of significant harm.

Northeastern Florida Bay

Results from the regional modeling scenarios described above were also run with outputs provided for the FATHOM model and salinity throughout Florida Bay was calculated (Environmental Consulting and Technologies, Inc., 2005). A comparison of these results for Little Madeira Bay, with the FATHOM historic base case **(Figure 5-10),** showed that this base case markedly differed from all SFWMM alternatives, but there was little difference among these alternatives. The base case likely differs in the historic predictions (1965 – 1990) because it includes actual operations of a given year (i.e. it is based on empirical conditions), while each SFWMM alternative entails an assumption of constant operations (either given as a recent historic year or as a future plan). As documented in the water budget substantially less inflow was directed to northeast Florida Bay during the historic periods due to water management activities in the watershed (Environmental Consulting and Technology, Inc. 2005). However, this generality does not entirely explain why predictions in recent years for the 2000B (CERP2000), which has similar operations in recent years to the FATHOM historical base case, are lower. Predictions for all SFWMM scenarios for Little Madeira Bay appear to be biased low relative to the FATHOM base case, a calibrated and verified model, shown to provide reasonable salinity predictions in Little Madeira Bay compared to observed data (Environmental Consulting and Technology, Inc. 2005). The Taylor River runs **(Figure 5-9)** have a correction for bias which appear to represent more realistically the historic salinity reconstruction (**Figure 5-1)**. A similar bias correction when interfacing FATHOM and SFWMM may be warranted for future comparisons. The drought period of 1989 – 1990 indicates prolonged elevated salinities with all scenarios. The only difference between the input data sets among the SFWMM scenarios is the wetland inflow data. Average annual inflow to the northeast portion of Florida Bay for the NSM scenario (which includes Little Madeira Bay), is 23 % less than the average inflow in the northeast Bay for the 2000B scenario **(Table 5-2)**. However, the NSM scenario has higher inflow directed into the central region than the other three scenarios. Average annual inflow for the 2000B scenario is comparable to the average annual inflow for the FATHOM base case, although the timing and relative variation in magnitude of flows is different with the different alternatives.

Table 5-1. Summary of fresh water inflow defined by each of the SFWMM scenarios (from Environmental Consulting Technologies, Inc., 2004) . Units are 1000 acre-feet per year, averaged over the period 1965 through 2000. Summary of the FATHOM base case inflow for the period 1970 through 2000 are provided for reference.

SCENARIO	CENTRAL	NORTHEAST	TOTAL
2000B	30	200	230
2050	31	179	210
CERP1	34	152	186
NSM	61	117	178
FATHOM base (1970-2000)	28	204	232

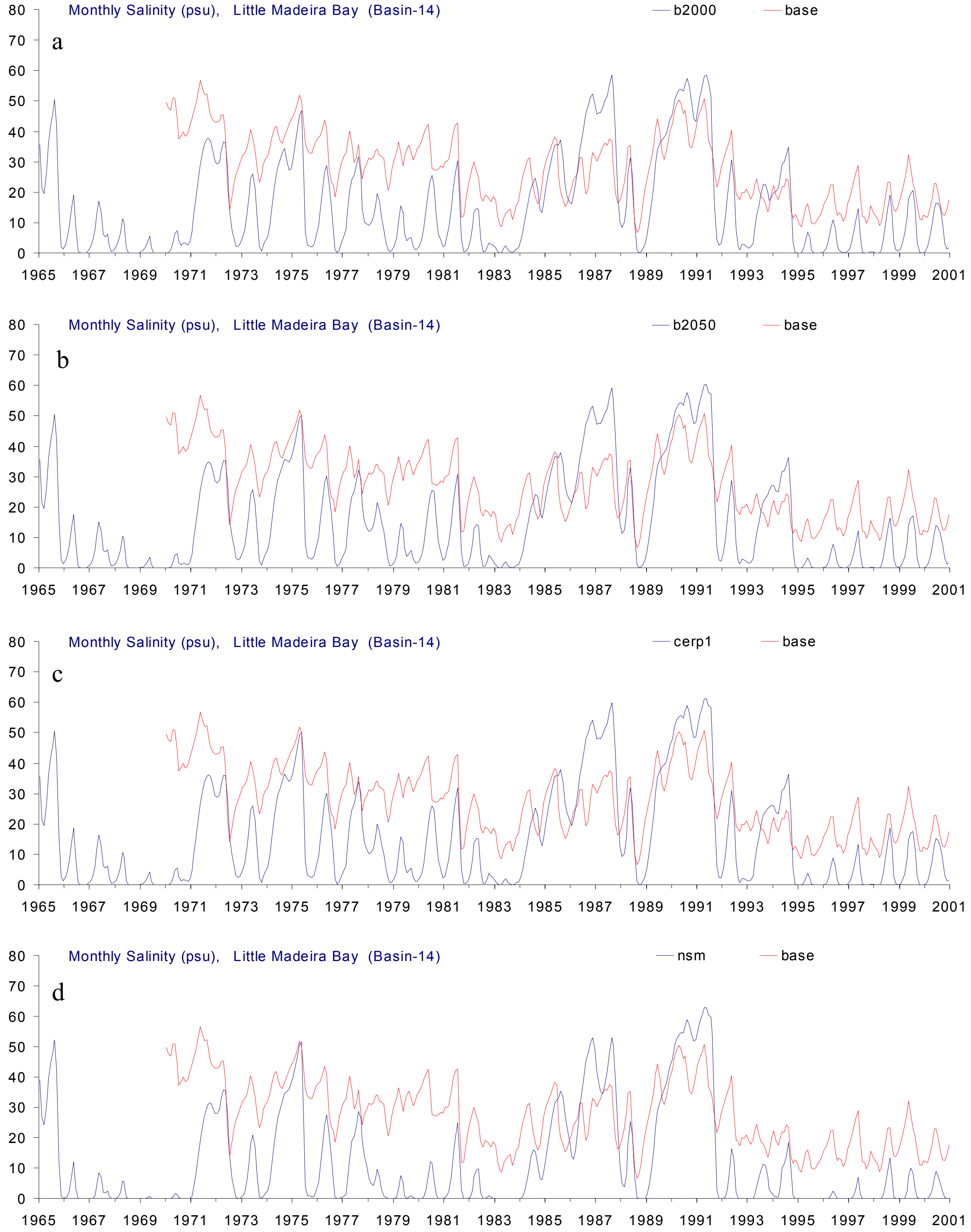


Figure 5-2. Little Madeira regional modeling results for (a) base case (2000) (b) future no project (2050) (c) future with project (CERP1) (d) natural system (NSM 4.6.2). The salinity time series obtained for the FATHOM historical base case is shown on all plots (red lines) for point of reference (ECT, Inc., 2005). There are no discernable differences among alternatives for Little Madeira Bay.

March 2006

Appendix H

Correspondence Regarding Monthly Salinity Simulations for Taylor River Interim CERP Update Runs

June 27, 2005
Revised September 25, 2005

Ms. Melody Hunt, PhD
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33406

Subject: Monthly Salinity Simulations for Taylor River Interim CERP Update Runs

Dear Ms. Hunt:

Environmental Consulting & Technology, Inc. (ECT) is currently providing professional services associated with salinity modeling for the South Florida Water Management District's Minimum Flows and Levels project for Florida Bay. As part of that work, ECT was requested to prepare simulations of monthly salinity at the Taylor River monitoring station (Everglades National Park Marine Monitoring Network) for the following Interim CERP Update (ICU) alternatives:

- 2000CERP
- 2050CERP
- CERP1
- NSM 4.6.2.

The salinity model that was used was the multivariate linear regression (MLR) model that was developed for the Park by Marshall (2004). The Taylor River MLR salinity model (daily resolution) is:

Taylor River salinity = 83.17 - 15.09CP[lag4] + 0.835Kwwatlev - 7.83(P33-P35)[lag1] - 4.34(P33-P35)[lag4]

where:

CP = stage (NGVD) at Craighead Pond
Kwwatlev = Key West water level (MSL)
P33 = stage (NGVD) at P33
P35 = stage (NGVD) at P35
Lag1 = one-day lag
Lag4 = four-day lag.

Details on model development can be found in Marshall, 2004.

These data used for CERP alternative simulations was obtained on August 25, 2004 from the Interagency Modeling Center for performance measure modeling being performed by this investigator for the Southern Estuaries Sub-team of RECOVER and the U.S. Army Corps of Engineers. The e-mail communication included as Appendix A to this letter report, following the text and plots, provides the information needed to document the source of the CERP alternatives input data. These data are known to be the most up-to-date simulations from the South Florida Water Management Model at the time that this Taylor River modeling effort was conducted. The values of the Key West water level were obtained from the NOS website (http://tidesonline.nos.noaa.gov/).

The daily simulation values produced by the model were averaged to monthly values for this task. Because there are missing values in the Key West water level time series, some of the monthly averaged values were computed from less than 30, 31, or 28 day values. The PROC EXPAND SAS routine that averages the values assigns the monthly value to the first day of the month. The routine also begins the averaging procedure with the first month that has a daily value on the first day of the month. Because there are lagged values in the salinity model, the first month that satisfies this requirement is February 1965, so there is no monthly value for January 1965.

A plot of each monthly simulation is included below as Figures 1, 2, 3, and 4. Figure 5 presents a comparison of the salinity simulations for all four ICU alternatives runs. While it is difficult to make out the details of the differences in the simulations, Figure 5 indicates that the highest salinity values are, in general, produced by the CERP2000 and CERP 2050 runs, with CERP1 having lower values, and NSM 4.6.2 producing the lowest salinity values overall. This is similar to the results published by Marshall (2005) for the Southern Estuaries Sub-team of RECOVER at this station for daily values.

It is noted that there are times when the 2000CERP monthly simulation value is equal to or higher than the 2050CERP monthly simulation, which is seemingly contrary to results that are presented in Marshall (2005) for a number of other stations in Florida Bay. This is because the observed salinity at the Taylor River station is at or near 0 psu for most wet season months, which is also seen in the 2000CERP and 2050CERP simulations. Plots shown in Marshall (2005) have been included in this report as Figures 6, 7, and 8. As can be seen there is no difference in the 25th quartile value for both runs, and the 25th quartile value is 0. However, the annual mean and 75th quartile values are both greater for 2050CERP compared to 2000CERP, confirming that the model is performing as expected at this station. Additionally, the monthly average time series for both of these CERP alternative runs contain values that may have been computed in months with a substantial number of missing daily values, at times greater than 15 values. Though these monthly values were removed from monthly reconstruction previously completed, theses monthly values have not been eliminated from the CERP alternative simulations.

Several files with all of the data that were generated and copies of the plots are provided as deliverables. Should you have any questions regarding any of this, please give me a call.

Respectfully,

Frank E. Marshall III, PhD, P.E.

References Used:

Marshall III, F. E.; D. Smith; and D. Nickerson. 2004. Using Statistical Models to Simulate Salinity Variation and Other Physical Parameters in North Florida Bay. Cetacean Logic Foundation, Inc. New Smyrna Beach, Florida.

Marshall III, F.E. 2005. RECOVER Southern Estuaries Performance Measues: Identification of Hydrology-Salinity Relationships for Coastal Estuaries and Analysis of Interim CERP Update Scenarios. Environmental Consulting & Technology, Inc. New Smyrna Beach, Florida.

Figure 1. Taylor River monthly average salinity simulation for the CERP 2000 alternative.

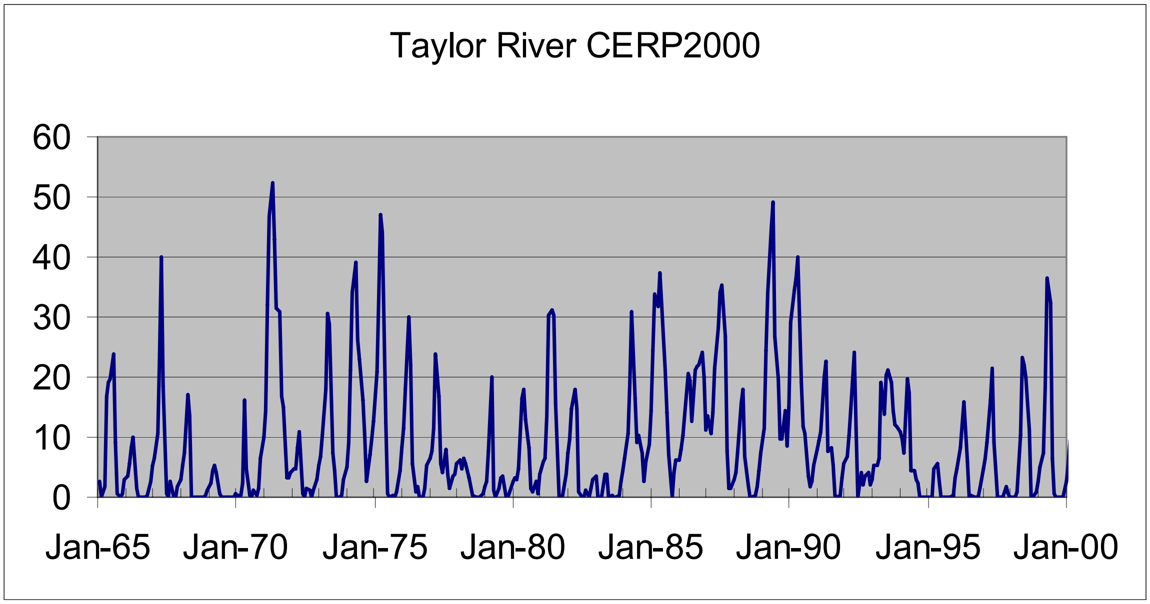


Figure 2. Taylor River monthly average salinity simulation for the CERP 2050 alternative.

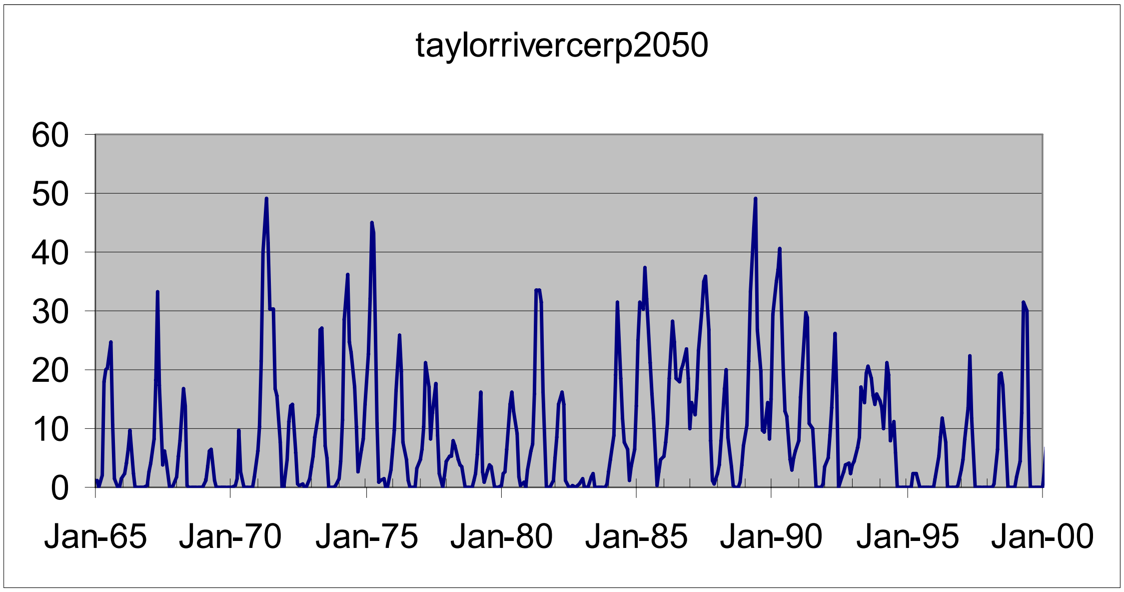


Figure 3. Taylor River monthly average salinity simulation for the CERP 1 alternative.

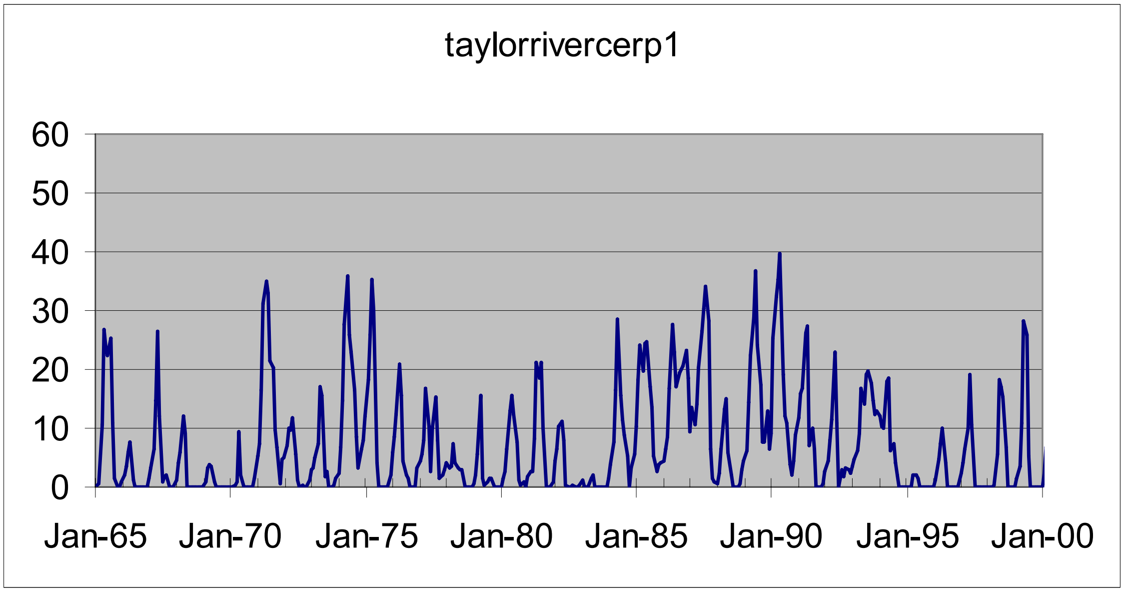


Figure 4. Taylor River monthly average salinity simulation for the NSM 4.6.2 alternative.

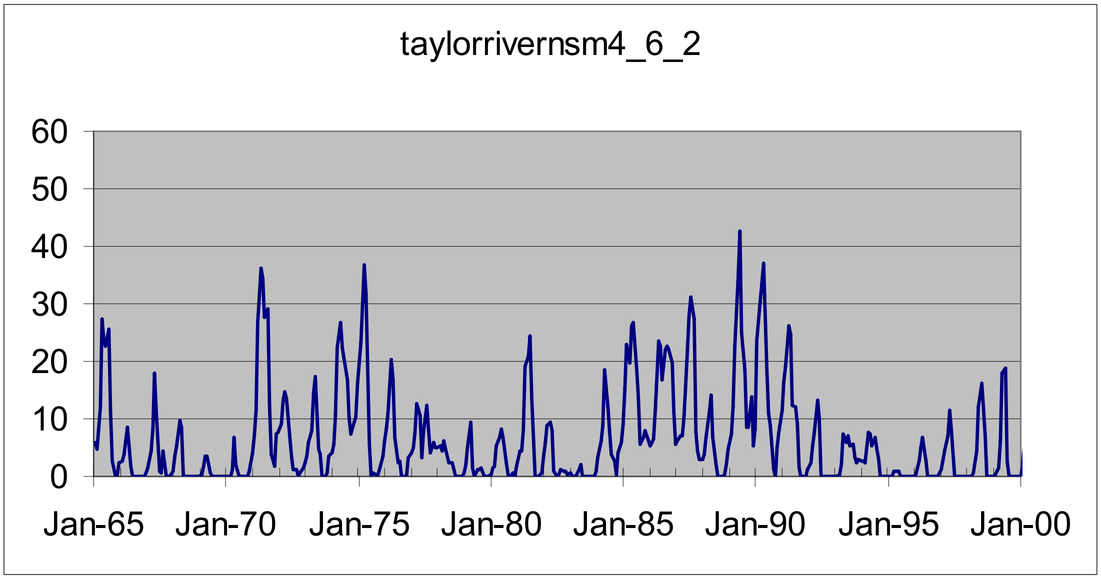


Figure 5. Comparison of all Taylor River monthly average salinity ICU simulations.

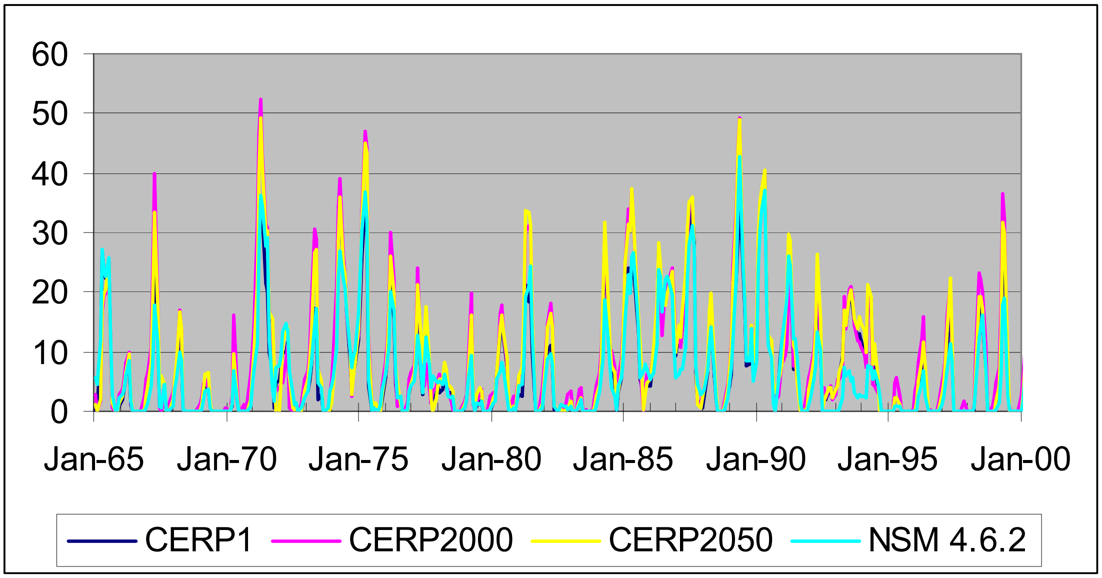


Figure 6. Annual mean value comparison from Marshall (2005). Values were computed from daily values, and results for simulations not included in this letter report are shown.

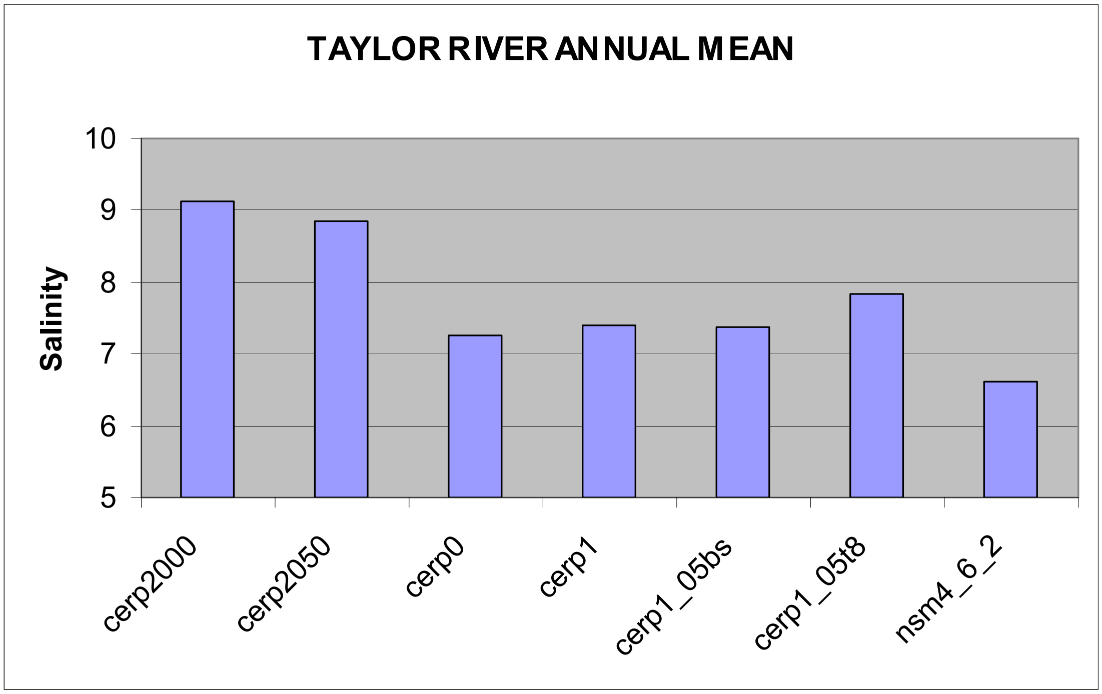


Figure 7. 25th quartile value comparison from Marshall (2005). All values are 0. Values were computed from daily values, and results for simulations not included in this letter report are shown.

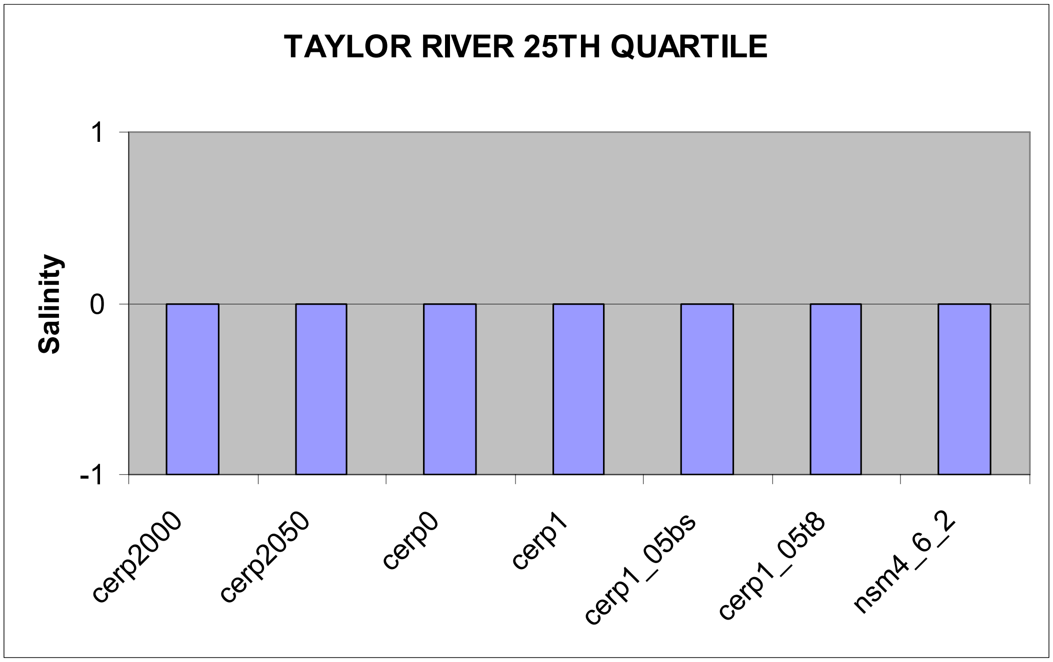
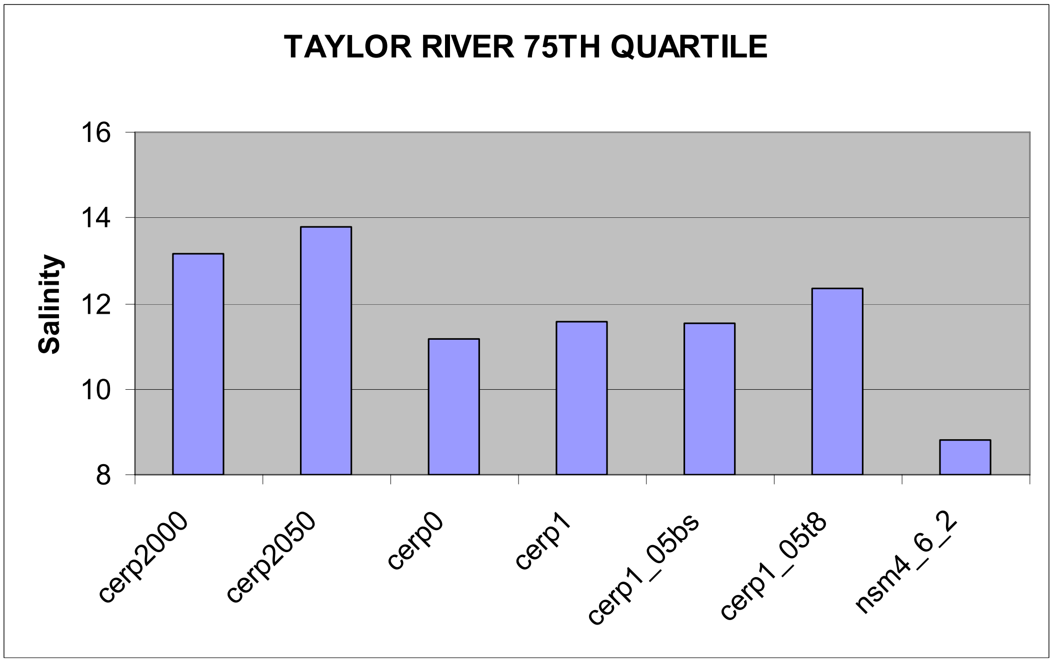


Figure 8. 75th quartile value comparison from Marshall (2005). Values were computed from daily values, and results for simulations not included in this letter report are shown.



Appendix A.

The following e-mail message documents the source of the data used for the CERP alternative simulations.

From: Xu, Hong [hxu@sfwmd.gov]
Sent: Thursday, August 26, 2004 7:58 AM
To: fmarshall@ectinc.com; Otero, Jose; Wilcox, Walter; Xu, Hong
Subject: RE: 2X2 Output

Frank,

Attached are the data for the following cells as you requested:

CERP1.05BS
D13R
Cell list (row,column):
5 21 - E146
6 26 - EVER6
7 17 - NP46
11 17 - NP62
12 15 - P35
4 20 - CP
17 20 - P33
6 20 - P37
8 23 - R127
17 24 - G3273
8 25 - EVER4
6 25 - EVER7
15 21 - NP206
9 16 - P38
8 28 - EVER1

row 8 column 28 for CERP0, CERP1.05t8, 2000CERP, and 2050CERP runs.

If you have any questions, please let me know. Thanks!

Hong

-----Original Message-----

From: Wilcox, Walter
Sent: Wednesday, August 25, 2004 2:51 PM
To: Xu, Hong
Subject: FW: 2X2 Output

This is request #2 that we discussed...

-----Original Message-----
From: Frank E. Marshall, III [mailto:fmarshall@ectinc.com]
Sent: Wednesday, August 25, 2004 11:29 AM
To: Wilcox, Walter
Subject: RE: 2X2 Output

Walter -

Sorry to bother you again, but I see a mistake in my original message to you. I requested CERP0, CERP1.05t8, 2000CERP, and 2050CERP for the wrong cell. EVER1 is in row 8 column 28, NOT ROW 8 COLUMN 25.

I hope that this error didn't cause a problem.

Frank E. Marshall III, PhD, P.E.
Environmental Consulting & Technology, Inc
340 North Causeway
New Smyrna Beach, Florida 32169
(386) 427-0694
(386) 427-0889 - FAX
(386) 451-9381 - CELL

-----Original Message-----
From: Frank E. Marshall, III [mailto:fmarshall@ectinc.com]
Sent: Wednesday, August 25, 2004 10:24 AM
To: 'wwilcox@sfwmd.gov'
Cc: 'Buckingham, Cheryl A SAJ'
Subject: RE: 2X2 Output

Hey Walter -

I was just checking-in to see if you received my message below. If these data are available to me on a website and I can access it without bothering you, just let me know.

Frank E. Marshall III, PhD, P.E.
Environmental Consulting & Technology, Inc

340 North Causeway
New Smyrna Beach, Florida 32169
(386) 427-0694
(386) 427-0889 - FAX
(386) 451-9381 - CELL

-----Original Message-----
From: Frank E. Marshall, III [mailto:fmarshall@ectinc.com]
Sent: Thursday, August 19, 2004 10:50 AM
To: 'wwilcox@sfwmd.gov'
Cc: 'Buckingham, Cheryl A SAJ'
Subject: 2X2 Output

Walter -

Cheryl Buckingham has asked me to produce simulations for a couple of new runs. I have all of the data except the following:

CERP1.05BS
    D13R (I thought that I had this, but I don't)
    Cell list (row,column):
        5 21 - E146
        6 26 - EVER6
        7 17 - NP46
        11 17 - NP62
        12 15 - P35
        4 20 - CP
        17 20 - P33
        6 20 - P37
        8 23 - R127
        17 24 - G3273
        8 25 - EVER4
        6 25 - EVER7
        15 21 - NP206
        9 16 - P38
        8 28 - EVER1
    For cell 8, 25 (row/column), EVER1:
        CERP0
CERP1.05t8
2000CERP
2050CERP

Could you please send me the daily_stage_minus_lsel for the above. Note that the cell list above has the EVER1 cell (8, 25) added, so it is slightly different than the last cell list that I sent you several weeks ago. That is why I had to also request the data for that cell for the other runs.

If you have any questions or if I need to send this request to someone else, please let me know.

Thank you for your help. Thanks also for taking the time earlier this week to meet with me.

Frank E. Marshall III, PhD, P.E.
Environmental Consulting & Technology, Inc
340 North Causeway
New Smyrna Beach, Florida 32169
(386) 427-0694
(386) 427-0889 - FAX
(386) 451-9381 - CELL

March 2006

Appendix I

Seagrass Model Documentation and Uncertainty Analysis

An Ecological Model of the Florida Bay Seagrass Community

Model Documentation

Version II

By

Christopher J. Madden
Amanda A. McDonald

South Florida Water Management District
Coastal Ecosystems Division

January 31, 2006

Ecological Model of the Florida Bay Seagrass Community

Introduction

Within the past two decades, the Florida Bay ecosystem has undergone profound changes indicative of environmental degradation. In particular, a dramatic die-off of the seagrass *Thalassia testudinum,* reductions in water clarity, phytoplankton blooms and loss of several important fish species (Robblee et al. 1991) has occurred since the late 1980s. Because of the importance of the seagrass community as a keystone component of the ecosystem, it is imperative to understand the mechanism of seagrass growth and succession, as well as reasons for its degradation and die-off in Florida Bay. Several hypotheses have been advanced to explain seagrass die-off and other changes in the seagrass community, including an altered salinity regime resulting from reduced freshwater flows, changes in circulation patterns, changes in sediment chemistry, disease, over-maturation of the seagrass beds, and increased nutrient inputs. ***The Florida Bay Seagrass Model*** was developed to investigate these potential mechanisms as they may relate to seagrass die-off and to evaluate their effects on seagrass community processes, distribution and survival.

Development of an ecological model of the Florida Bay seagrass community was initiated in 2001 and has produced a dynamic numerical simulation of the *Thalassia-Halodule* seagrass community (Madden and McDonald 2005). This modeling effort was conceived as a means of enhancing scientific understanding and improving coastal management of seagrass systems in general and of the Florida Bay community in particular. The project has produced an operational mechanistic unit model of the *Thalassia-Halodule* community, calibrated for six basins that represent a large part of Florida Bay. Additional basin models are in continuing development and modules for the seagrasses *Ruppia maritima* and *Syringodium filiformi* are being initiated. The model code was developed in STELLA, MATLAB and FORTRAN platforms and the model can be run on a desktop PC. Initial development is being finalized for representative basins in all major areas of Florida Bay, such that linkage of the model to a hydrodynamic or water balance framework is possible, with a subsequent goal of inserting the kernel of the mechanistic biological model into a spatially explicit landscape-based model operating on a geospatial platform. Currently, model runs for all operational basin versions are done in parallel using data or model-driven forcing to provide salinity and nutrient input files. When in spatially explicit mode, the model will generate water quality information enabling full interaction of the seagrass, phytoplankton and algal community model components.

Ecology of the Florida Bay Seagrass Community

The seagrass community covers an estimated 5,500 km^2 of the greater Florida Bay and Keys area, and is one of the most extensive seagrass resources in the world (Zieman 1982). Seagrasses are a keystone community of this ecosystem, playing roles in many important physico-chemical (Stumpf et al. 1999, Matheson et al. 1999), autotrophic (Fourqurean et al. 2002) and higher trophic (Ley and McIvor 2002, Lorenz et al. 2002) functions of the bay's ecology. Dominated by the turtle grass *Thalassia testudinum*, seagrasses stabilize sediment and sequester nutrients, processes that help reduce epiphyte and phytoplankton blooms (Zieman 1982). The sediment-binding capacity of the rhizomatous macrophytes also serves to ameliorate turbid resuspension events, reduce scouring, promote a clear water column, and contribute to high rates of primary and secondary productivity (Zieman 1982).

Seagrasses provide refuge, spawning areas and a food source for numerous important fish and invertebrate species (Zieman 1982, Sogard et al. 1989, McIvor et al. 1994, Thayer et al. 1999). Fish densities tend to be greater in the seagrass beds than outside the beds (Weinstein et al. 1977), and mixed communities of *Thalassia* and *Halodule wrightii* appear to support higher densities of desirable fauna (Johnson et al. 2005). In Rookery Bay to the west of Florida Bay, Yokel (1975) reported trawl catches in seagrass beds that were 3.5 times greater than those in other habitat types. Pink shrimp favor seagrass habitat (Sheriden 1992), and initiate their development in the protected confines of Florida Bay before moving to the Dry Tortugas. There, the shrimp production supports one of the largest commercial shrimp fisheries in the Gulf of Mexico (Ehrhardt and Legault 1999). As juveniles, spiny lobsters develop in Florida Bay before moving across the Keys to take residence in the reef extending from the Dry Tortugas to Pacific Reef near Miami (Davis and Dodrill 1989). The highest growth rates of juvenile spiny lobsters in the world have been measured in Florida Bay, which is considered to be an optimum habitat for this species (Davis and Dodrill 1989).

The seagrass community is demonstrably vulnerable to system-wide perturbation, and the *Thalassia* population underwent a catastrophic die-off in 1987 (Carlson et al. 1990a,b; Robblee et al. 1991, Durako et al. 2002). Following this die-off event, multiple systemic changes began to occur throughout the bay, including the development of large and persistent phytoplankton blooms, the loss of other seagrass habitat, decreasing water clarity and disappearance of key fauna (Robblee et al. 1991). Subsequently, additional cases of die-off, the development of harmful algal blooms (Phlips and Badylak 1996) and fish, plant and animal kills have occurred since the initial *Thalassia* die-off (Anderson 2005).

The Florida Bay system continues to exhibit signs of impairment, and is subject to smaller-scale "secondary seagrass die-off" and continuing related habitat degradation (Hall et al. 1999, Durako et al. 2002). These events have caused concern about wholesale restructuring or loss of biological communities, degradation of habitat quality, declines in biodiversity and in fish landings, and possible irreversible damage to the ecology of the bay (Durako et al. 2002). Because of their central ecological position in the Florida Bay system, healthy seagrasses are critical to several key biogeochemical cycles and processes and are important in maintaining water quality. A comprehensive research plan, with emphasis on seagrass research and modeling, was recommended in order to increase understanding and our ability to maintain and restore this critical living resource (Florida Bay Science Oversight Panel Report 1999, 2001).

Context for Model Development

Despite vigorous research on and monitoring of Florida Bay seagrasses, synthesis of information into useful forms for interpretation and science-based management has been lacking. Often, the time and space scales of research outputs are not compatible. System components studied in isolation cannot always be counted on to behave predictably in an ecosystem where strong ecological feedbacks are so prevalent. In an ecological system with the biological, spatial and temporal complexity of Florida Bay, we propose that meaningful synthesis can *only* be effectively achieved through dynamic simulation modeling techniques. Simulation models enable the simultaneous numerical description of state variables, major material flows and forcing functions in the target domain, permitting the full interpretation of ecological relationships, prediction of system behavior and hypothesis-testing. Furthermore, the capability to invoke multiple environmental stresses simultaneously is needed to accurately assess the cumulative effects of forcings that impact seagrasses *in situ*. Thus, there is a need for a modeling tool that can track multiple non-linear relationships simultaneously. Unlike studies in nature, the simulation model provides a means to determine the mechanism and the magnitude of each potential stress or limitation in controlled isolation and in interaction with other factors.

This modeling tool describes the growth, ecology, community composition, physical structure and nutrient dynamics of the seagrass community, and will guide decisions about the restoration of Florida Bay. Several South Florida Water Management District (SFWMD) mandates are served by this model initiative, including rules development for Minimum Flows and Levels for Florida Bay (Hunt et al. 2005), the Modified Waters Project, and several Acceler8 projects under the CERP program, most notably the C111 Spreader Canal Project and the Florida Bay and Florida Keys Feasibility Study. Development of management strategies and infrastructure components require a model framework that can be used to assess alternative formulation.

The process-level and landscape-scale seagrass models currently being developed for Florida Bay will require a close coupling of research and modeling. Throughout the modeling effort, open communication and data sharing between modelers and the wider bay research community has facilitated model development. There is a strong recognition that this model will need to link with other modeling efforts (hydrodynamic, water quality, upper trophic level) in order to access existing and new ecological data. Linked physical-biological models will address the bay’s physical and hydrological architecture and, additionally, will synthesize information on nutrients and water quality, basin and bank geomorphology, water turnover rates in basins and salinity structure.

Model Goals, Purpose and Objectives

The goal of the seagrass modeling effort is to accurately simulate the effects of physical and biogeochemical conditions on the growth and survivorship of seagrasses in a tropical/subtropical carbonate-based system. Specifically, the purpose of the resulting model will be to simulate seagrass community growth, species composition and succession and to provide a tool for testing hypotheses about seagrass die-off and response in Florida Bay. The seagrass unit model will be incorporated within a landscape model framework and linked to process-level models of higher trophic levels. The effort to develop the seagrass models will include empirical studies needed to develop information for the models, evaluation of the assumptions of the models, and the calibration and verification of model outputs. The models will be used in the restoration program for predicting the effects of water management within a landscape model framework.

The objective of these efforts is to use the seagrass model to better understand mechanisms for recent changes in the seagrass community and assist in making management decisions relevant to seagrasses. Specific objectives of the modeling effort include an improved understanding of the physiology and ecology of Florida Bay seagrass communities, their growth, survival and species succession, as well as determination of the factors controlling seagrass productivity, abundance, and distribution in different areas of Florida Bay.

The model currently includes two seagrass species: *Thalassia*, a long term, stable form, and *Halodule*, a rapidly propagating, opportunistic form. *Ruppia*, a generally less halophytic form expected to expand in distribution with additional fresh water introduction to the system, and *Syringodium*, which is generally found in the more saline southern and western areas of the bay, will be added to the model. The model provides a conceptual framework which guides seagrass research priorities and a computational framework that will yield answers to specific questions about how components of the system interact, and which can test the degree to which environmental factors induce changes in seagrasses. Specifically it will:

- Allow quantitative testing and improved planning of field, mesocosm and laboratory experiments in an inexpensive and controllable model environment
- Provide a means for developing management strategies and for testing hypotheses about how the seagrass community will respond to environmental changes, both natural and anthropogenic
- Provide a means to determine small scale spatial factors responsible for differences in seagrass community recruitment, productivity, structure, and composition, including patch dynamics and bed structure
- Provide a means for testing hypotheses about causes of die-off, including salinity, sulfide, temperature, light, diseases and the possible interactions of these components (the multiple stressor hypothesis)

- Develop a predictive capability that will provide long-term simulations, giving insight to impacts on seagrasses due to nutrient enrichment, changes in freshwater flow and salinity regime, eustatic sea level rise, climate change and episodic impacts such as hurricanes and drought events.

The Unit Model Approach

The basis of the unit model approach is to emphasize a detailed mathematical description of internal seagrass processes and their interactions with the environment which produce changes in biomass per unit area. We have modeled the seagrass community at a point in space that represents average conditions for a given relatively homogeneous area of the system. We have developed separate unit models for different regions of the bay. This approach was chosen because of the lack of spatially explicit data on both seagrasses and environmental variables with which to calibrate the model at spatial scales sufficiently resolved to be meaningful. Modeling spatially averaged units for several representative areas of the bay (Figure 1) has a low spatial resolution but yields important information on general trends in space in response to different environmental contexts (see Spatial Domain section below). The time domain of the model is more highly resolved (see Time Domain section below) because significantly more time series data are available on processes affecting seagrasses and on the physiology of the seagrasses themselves, enabling a more precise accounting of the behavior of these units at small temporal scales.

The initial stage of model development has produced a carbon-based seagrass unit model, calibrated for the Florida Bay *Thalassia testudinum* community in seven basins (from east to west): Duck Key, Trout Cove, Little Madeira Bay, Eagle Key Basin, Whipray Basin, Rankin Lake, and Rabbit Key Basin. Subsequently a module for the seagrass *Halodule wrightii* was implemented and fully integrated into the primary model, invoking inter-specific competition between the two seagrass species. Our approach was to utilize field monitoring data and *in situ* process measurements, augmented by targeted mesocosm studies that accurately measured specific processes and variables (see section on Data Sources below). The model includes information about the physical architecture of seagrass beds as well as interactions of light, nutrients, salinity and sediment properties influencing the growth, survival and succession of seagrasses. This level of detail is achieved at a spatially averaged scale (regional or basin-wide), and although at the expense of detail about landscape processes or high-resolution spatial variability. The model yields average seagrass biomass, distribution, productivity and species composition per basin. It is important to note that the unit model is not able to predict the dynamics of seagrass population at a particular point in the bay at the sub-basin scale, only the average behavior within a basin. However, the model can be used to explore the environmental characteristics required to produce sub-basin scale spatial variability.

The customization of the unit model for several representative regions of Florida Bay is accomplished through exploitation of publicly available databases at SFWMD as well as from other sources, communication with research scientists, and strong feedback of information requests to the research community.

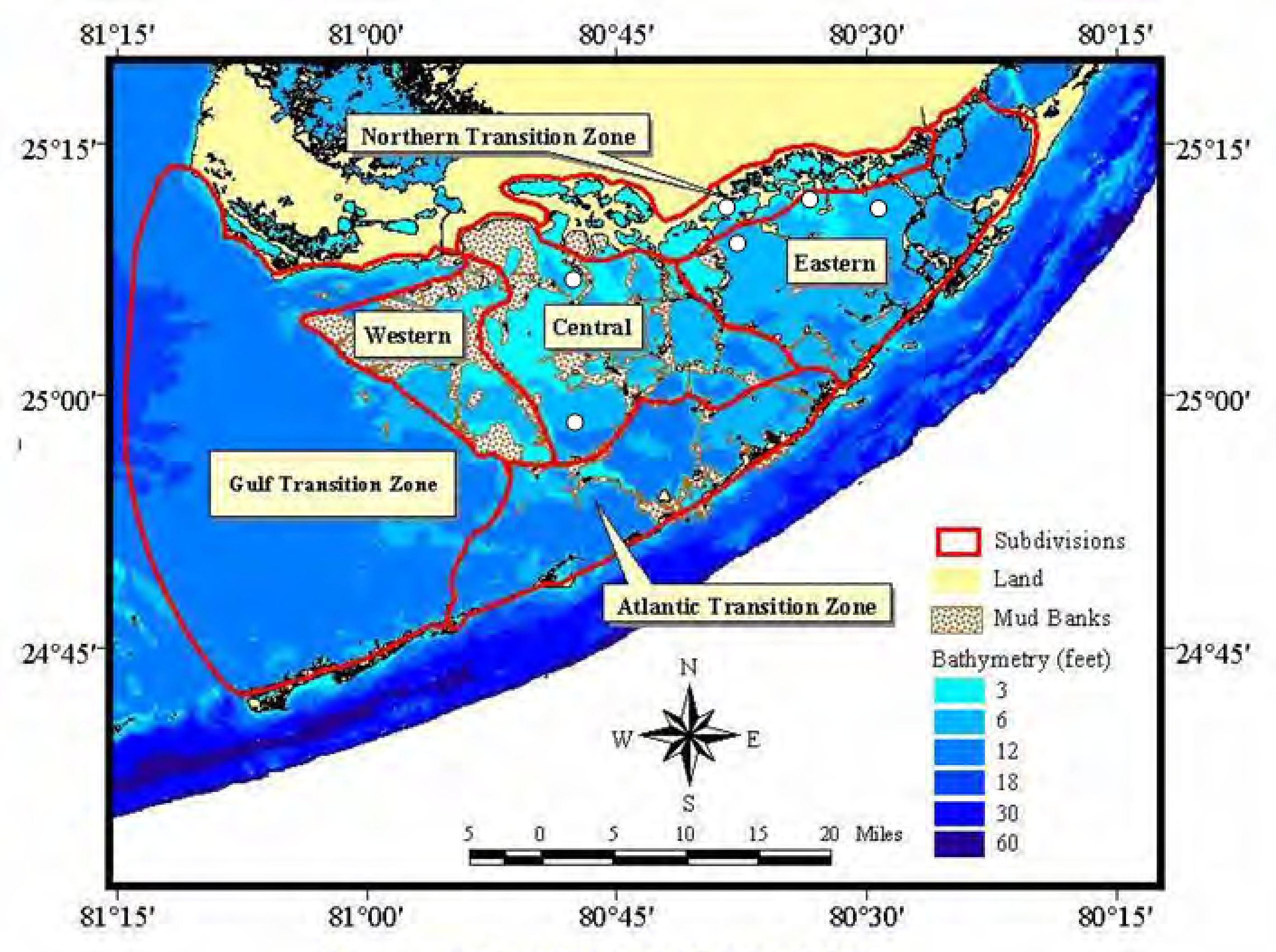


Figure 1. Florida Bay regions divided into representative areas. The seagrass model calibration emphasizes sites (white dots) in the northern transition zone, the eastern bay and the central bay where land run-off has greatest impact on the system.

Processes specific to sub-tropical Florida Bay that are integrated into the model include: episodic high water temperatures, hypersalinity events, freshwater pulses, carbonate chemistry, diffuse and point source surface and subsurface freshwater inputs, the influence of nutrient inputs from the Gulf of Mexico, the influence of Everglades sheet flow and nutrient inputs, dissolved organic nutrient inputs, bank-basin morphology and depth gradients, organic material inputs, hydrogen sulfide production in sediments, and effects of episodic storms and hurricanes. The totality of the high organic, high sulfide, hypersalinity and high temperature effects, which we refer to as the multiple stressor suite, is likely implicated in the seagrass die-off phenomenon and certainly responsible for sub-lethal effects on seagrass population dynamics. These elements form the basis for several hypotheses regarding seagrass die-off that we use the model to investigate.

Conceptual Model

Model development began with the design of a conceptual model depicting the relevant variables, interactions and processes that are considered important in Florida Bay seagrass ecology (Figure 2). The conceptual model underlies the numerical model, providing a high-level, object-oriented map of the interactions that have been measured in the system or the expected relationships based on scientific literature and expert knowledge. The conceptual model provides a means of showing model variables and their relationships and organizing the structure of the numerical model. This model has also been instrumental in pointing to additional research needs required to fill important gaps in the existing knowledge base. In Figure 2 the blue (lighter shaded) components are fully implemented state variables and forcing functions. The green (darker shaded) components are included in the model but are data driven variables that are not impacted by other model process, although they do impact other variables. Forcing functions in the numerical model are listed along the left side of the conceptual model and include light, dissolved N and P, organic material, temperature and salinity. Along the right side of the diagram are depicted processes such as vegetative and seed propagation, spatial distribution of the population and GIS inputs that are being experimentally implemented in the expansion of a unit model to a spatially articulated landscape model.

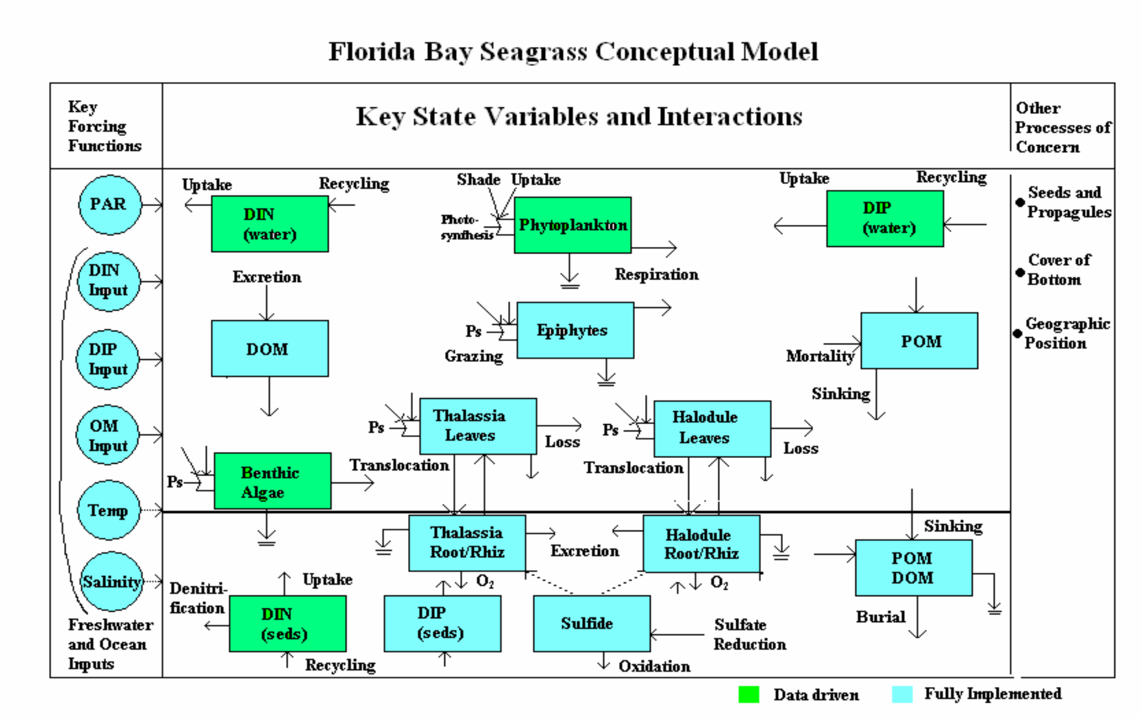


Figure 2. Conceptual model of Florida Bay seagrass community showing state variables, forcing functions and interactions.

In the conceptual model, two seagrass species are the main response variables, regulated by the nutrient cycles, light regime, geology and biology of the bay. The primary seagrass state variables are aboveground (leaves) and belowground (root/rhizome) *Thalassia* compartments and above- and belowground *Halodule* compartments. A state variable representing a generalized community of epiphytes grows on the seagrass aboveground material. We initially conceptualized the seagrass system to most strongly respond to nutrient (positively) and sulfide (negatively) concentrations in the sediment compartment and to light, salinity and temperature in the water column compartment. Epiphytes respond most strongly to nutrients, temperature and light in the water column. Phytoplankton and benthic algae are represented in the model by data functions; they interact with the light regime and nutrients in the water column. Although at present these two variables are fitted with empirical data, they will be converted to state variables following additional conditioning of the data.

Particulate and dissolved organic matter (POM and DOM) pools are partitioned in the water column and sediment pools, whose sizes are influenced by external inputs and detritus formation from plant components and losses to breakdown and remineralization and burial. The dissolved inorganic phosphorus (DIP) pool in the sediments is largely responsible for regulating seagrass growth as P is the limiting nutrient for autotrophy in Florida Bay (Fourqurean et al. 2002). This pool is increased by a breakdown of sediment organic material (POM, DOM) and small bi-directional diffusive flux between the sediment and water column compartments. Losses from this sediment P pool are from nutrient uptake by seagrasses, buffered by an equilibrium between the dissolved P pool and the solid phase pool of sorbed phosphorus. Dissolved nitrogen (DIN) in sediments is a data-driven variable that we consider to be rarely limiting to seagrass production. Due to the carbonate geochemistry of the system and affinity for P to bind and adsorb to carbonate compounds (forming apatite and oxyhydroxides), P is generally low in concentration throughout the system. However, root exudates released during active seagrass growth can cause dissolution of the carbonate sediments (Madden et al. 2001), which in turn releases the solid-phase phosphate back into the porewater where it can be utilized by seagrasses for growth. N, mostly in the form of ammonium, is generally readily available in sediment pools. The dynamic N state variables will be implemented following full calibration of the P-based model.

Spatial Domain of the Numerical Model

The spatial domain encompasses Florida Bay from the northern transitional bays bordering the southern Everglades to the Gulf of Mexico, vertically including the non-stratified water column (1-3 m) and sediments to a depth of 5-15 cm. The horizontal spatial unit is 1 m^2. Because of the spatial coarseness of empirical data and lack of full understanding of the causes of patchiness in seagrass beds, only a moderate amount of spatial information is captured in each of the six basin models in the northeast and central bay (Figure 3). There is a basin and bank version of each unit model, which imparts some degree of spatial heterogeneity to each. Much of the biomass data available is generally obtained in viable seagrass beds, meaning that many datasets are biased toward the higher biomass areas of each basin. Due to the inadequacy of field data alone in defining cause-effect relationships in seagrass growth, the field data are supplemented with mesocosm studies of processes that can be manipulated to produce specific physiological and demographic patterns in seagrass populations (Koch and Durako 2005).

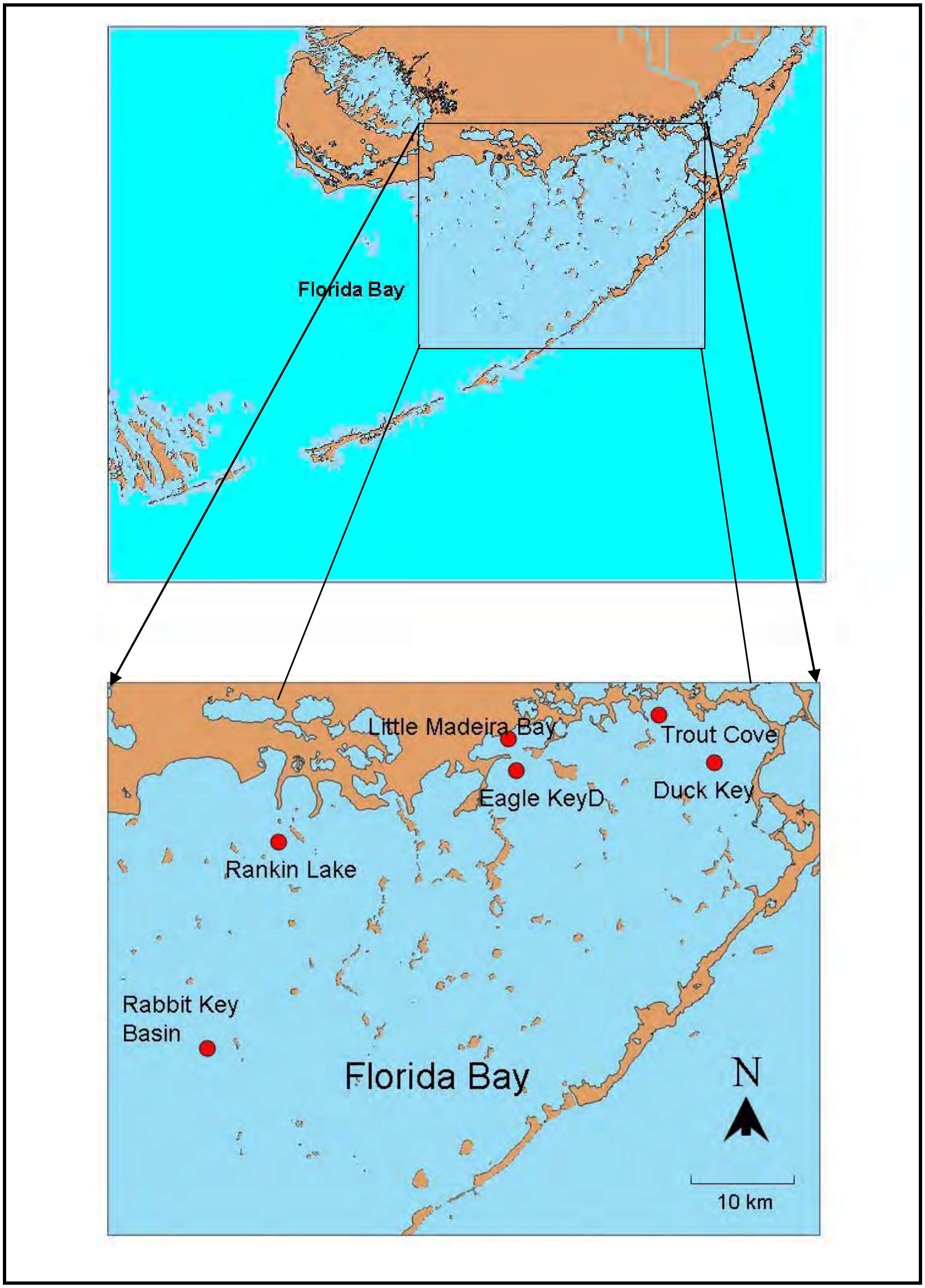


Figure 3. Detailed site locations of unit model basins in Florida Bay.

The unit model approach yields a spatially averaged output, and the models are calibrated and parameterized with distinctive physical, ecological and geomorphological conditions of water quality parameters, water depth, sediment depth and seagrass initial conditions. Combined, all of the unit models offer a means of examining large-scale spatial heterogeneity of seagrass distribution in Florida Bay. Nonetheless, the model is also valuable in that it can simulate variations in conditions each the specific basins of the bay, based solely on ambient nutrient concentrations and salinity levels. Each unit model explicitly incorporates bank and basin morphology and hypsometric characterization via water and sediment depth parameters. External forcings vary among different basins, including nutrient levels in water and sediments, organic material inputs, water depth, sediment depth, basin exchange rates, water turnover time, PAR, turbidity and salinity.

Temporal Domain of the Numerical Model

The temporal domain of the model covers the recent ecological history of Florida Bay for which there are environmental and seagrass data available, about 1960 to the present (Phillips 1960; Tabb and Manning 1961). Standard simulation length is one year, and simulations of two-, five-, ten- and 30-year periods are typically run. The choice of a model timestep of dt=3 hours is based on expert knowledge of the biological and physico-chemical processes important in determining seagrass function and growth patterns. The dt selected represents the timescale of the most rapidly varying processes that materially impact functioning of the seagrass community. The timestep interval represents a compromise between the computational requirements for accurately reproducing the patterns in nature and both the timescale of the available data and computer processing time. The upper limit for the timestep was determined by successively reducing the dt until the model converged on a constant solution.

The model indicates that sediment nutrient pools are drawn down to very low levels during daily productivity processes, below nutrient half-saturation locally around the roots of the seagrass. This emergent property is relevant to P self-limitation in the *Thalassia* state variable itself and is likely for *Halodule* as well. Therefore, a small dt is required to capture biogeochemical interactions operating in such small tolerances. A large dt would generate large productivity rates per timestep and cause the model to “overshoot” available nutrients leading to a negative solution. Other important processes that operate on subdaily timescales are sediment redox potential (not yet implemented), sediment oxygen concentration (partially implemented), and variations in light regime (implemented). Processes that act on longer timescales that affect seagrass processes include salinity distribution (days to weeks), mean temperature (weeks to months), epiphyte cover (days to weeks), and sulfide production (days to weeks).

Model Specifications

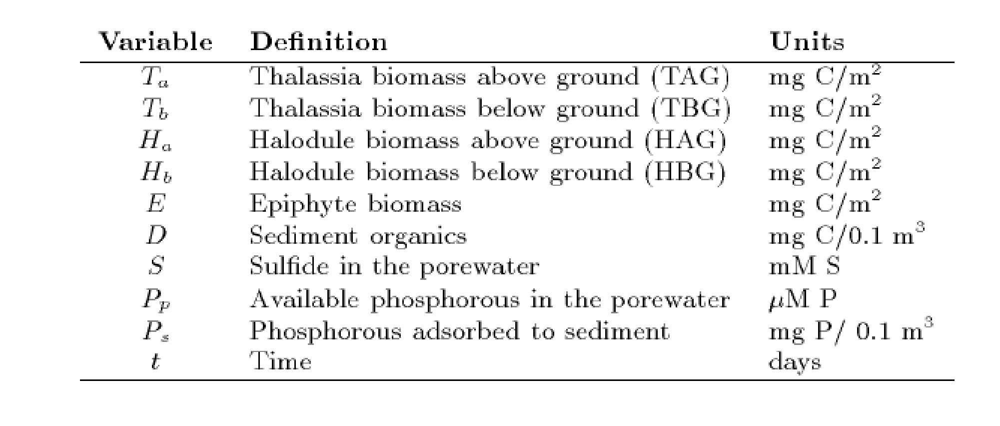
The model is comprised of a system of simultaneous ordinary differential (finite-difference) equations, solved using a second-order Runga-Kutta numerical integration scheme at a dt of 3 hr. Rate equations were derived using information from several sources, including existing models (Madden and Kemp 1996, Cerco 2002), literature values, and empirical relationships derived from field and mesocosm research for this study (Erskine and Koch 1999, Gras et al. 2003, Koch and Durako 2005). The base model describes a non-stratified water column, nominally 1m deep, overlaying a benthic system with which it interacts through sedimentation, diffusive flux, and nutrient translocation. The model tracks biomass in units of organic carbon: seagrass, epiphyte, and detritus stocks are accounted in mg C m^{-2}. Nitrogen and phosphorus are accounted in the model by stoichiometric relationship to carbon. The atom ratio of 280:16:1 for C:N:P (Fourqurean et al. 1992) is fixed for plant tissue and used to index nutrient uptake to carbon flow. N and P in biota and in the nutrient pools are reported on a mg m^{-2} basis.

The base model configuration simulates annual patterns for *Thalassia* and *Halodule*, and will be expanded to include state variables for benthic algae, phytoplankton and other seagrasses. The model has been developed and optimized to elucidate the dynamics of seagrass community growth and species composition. The number of state variables has been kept to the minimum required to realistically model photosynthesis and productivity dynamics without introducing unnecessary and unconstrained error. For example, there is no grazing term in the model for seagrasses, although some small degree of grazing may occur in nature. Groundwater seepage may be important as a nutrient source, but data are too few to accurately quantify this potential input. Thus, this nutrient input is aggregated in the water column nutrient forcing function data.

The baseline period for the dual-species model has been established as 1996-2000 and the unit model provides the following output parameters: specific photosynthetic rate, specific growth rate of aboveground material, total leaf area, mean canopy height, biomass density, biomass turnover rate, detritus production, epiphyte load, belowground biomass, dissolved nitrogen and phosphorus utilization rate, dissolved nitrogen and phosphorus concentration, deposition of organic matter, hydrogen sulfide concentration, sulfate reduction rate and decomposition rate.

Model Variables

The unit model includes the following state variables: *Thalassia* aboveground biomass (T_a), *Thalassia* below ground biomass (T_b), *Halodule* above ground biomass (H_a), *Halodule* below ground biomass (H_b), epiphyte biomass (E), sediment organic matter (D), porewater hydrogen sulfide (S), porewater phosphate (P_p), sediment adsorbed phosphate (P_s). Units for each of the state variables are as follows:



Variable	Definition	Units
T_a	Thalassia biomass above ground (TAG)	mg C/m^2
T_b	Thalassia biomass below ground (TBG)	mg C/m^2
H_a	Halodule biomass above ground (HAG)	mg C/m^2
H_b	Halodule biomass below ground (HBG)	mg C/m^2
E	Epiphyte biomass	mg C/m^2
D	Sediment organics	mg C/0.1 m^3
S	Sulfide in the porewater	mM S
P_p	Available phosphorous in the porewater	μM P
P_s	Phosphorous adsorbed to sediment	mg P/ 0.1 m^3
t	Time	days

Forcing Functions and Input Data

Forcing functions are energy or materials inputs from outside the model boundaries, such as light and salinity, whose input rates are not influenced by processes occurring within the model boundaries. Data are gathered from the following primary sources as well as from those described in the section Data Sources. Salinity and temperature (Figures 4 and 5) are from USGS instrument deployments at fixed platforms in the basins indicated. These data are collected every 15 min. and averaged per day in the model input files. Data for inorganic as well as dissolved organic nutrients (N_w, P_w) are from the FIU SERC monthly monitoring program at stations in each indicated basin (Figure 6). Subsurface PAR (photosynthetically active radiation) data (not pictured) are from the USGS-funded monitoring of daily light regime at surface- and bottom-sensor deployments at platforms in each basin.

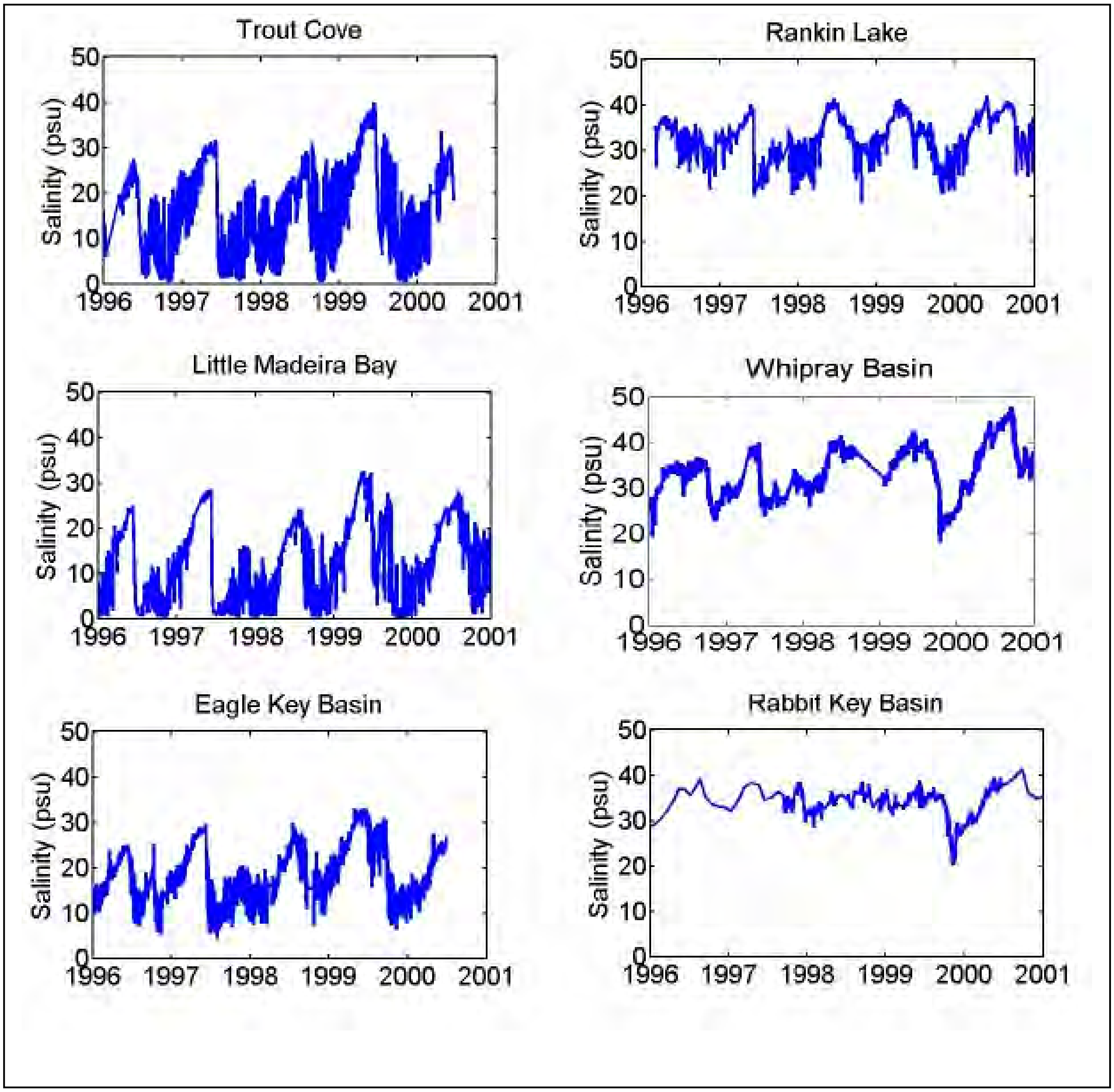


Figure 4. Hourly salinity input data from long-term, platform-based instrument deployments for six unit models (USGS).

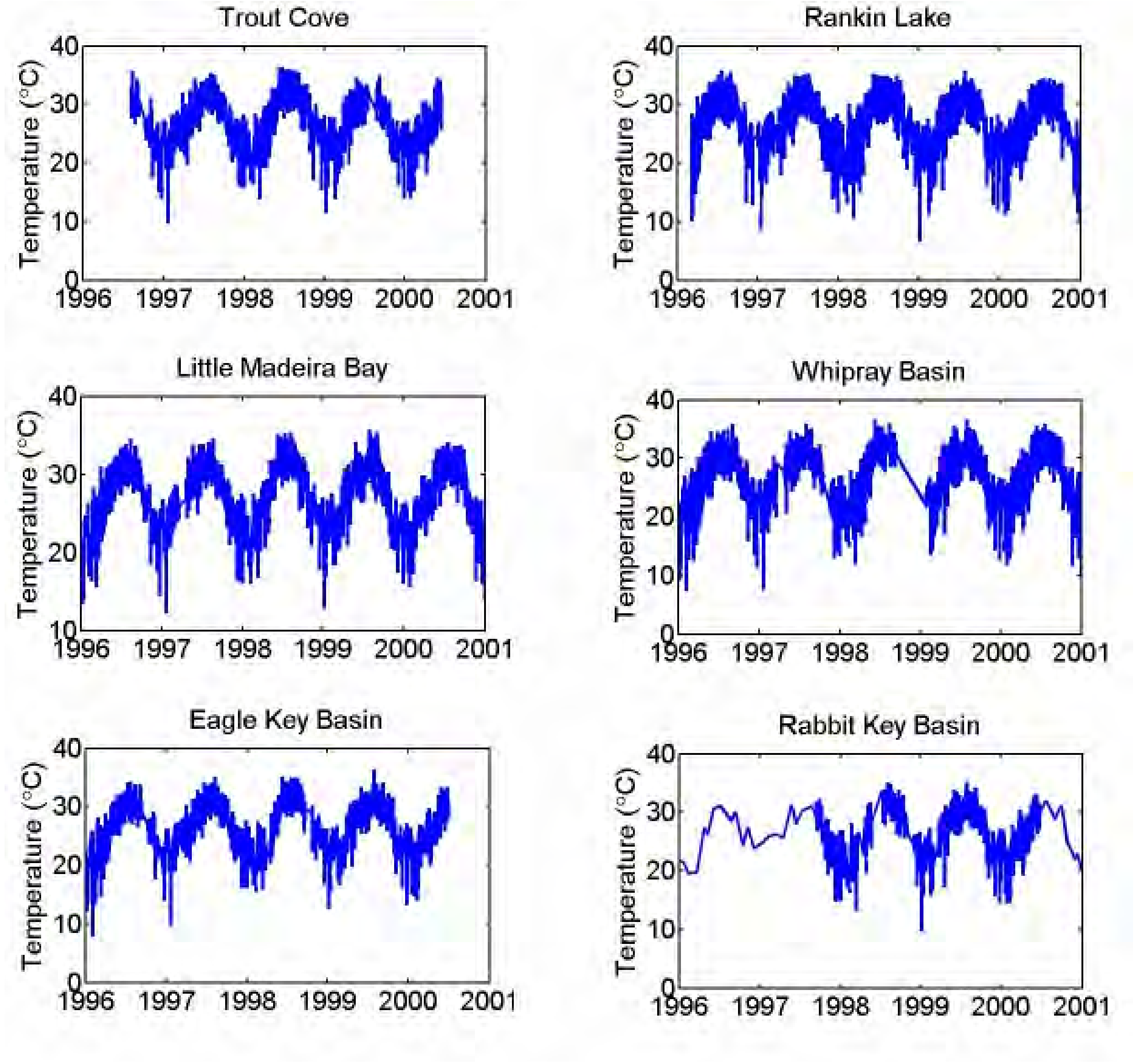


Figure 5. Hourly temperature input data from permanent, platform-deployed instruments for six unit models (USGS).

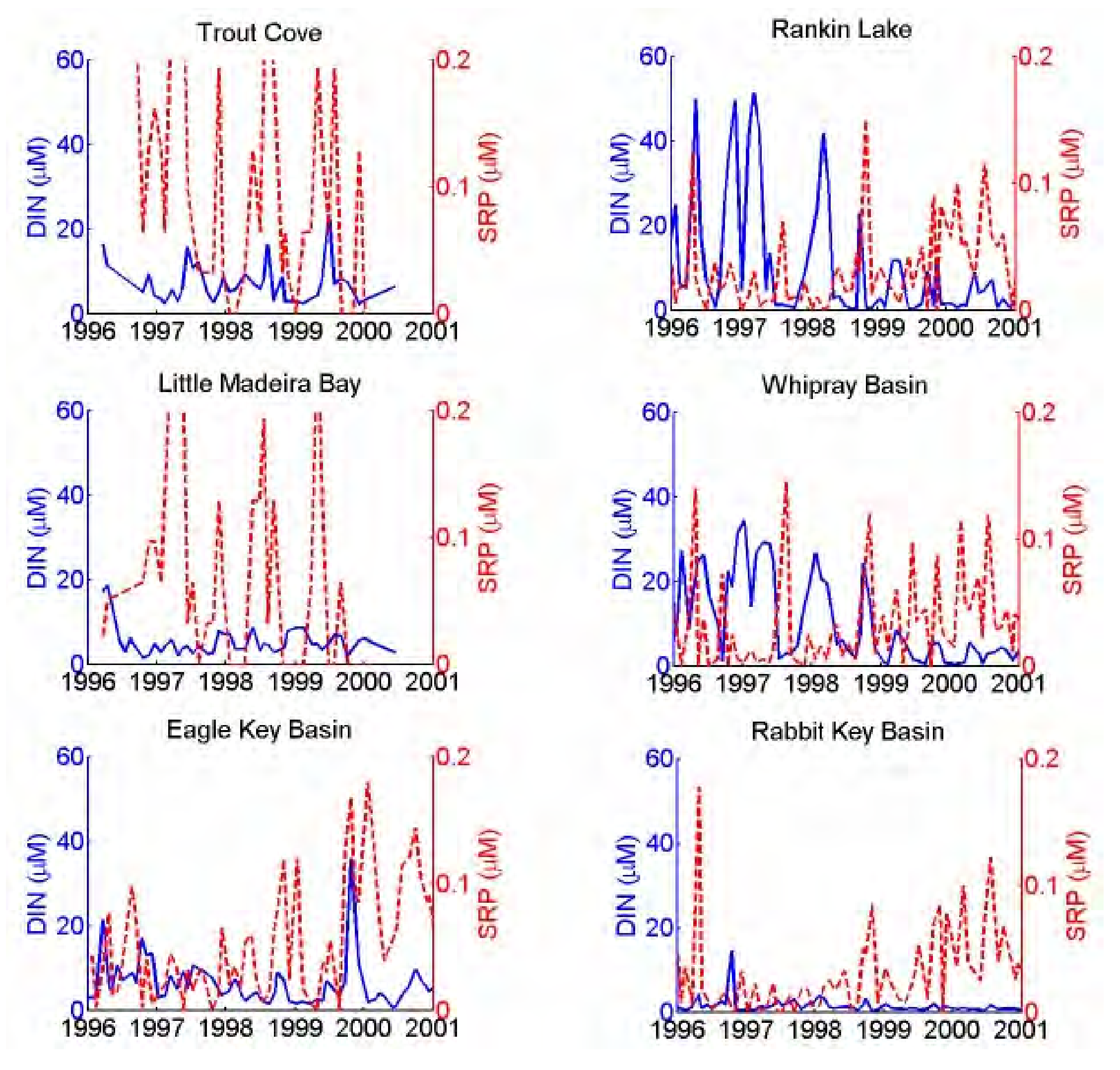


Figure 6. Monthly nutrient (DIN, DIP) input data from ship-based water quality surveys for six unit models (FIU-SERC).

Salinity response curves for both species used in the model show that *Halodule* has a broader range of optimal salinities. The curve for *Halodule* has a plateau because the data used to build the curve showed no significant differences between 10 and 35 psu.

Numerical Model Description

Growth in autotrophic compartments is controlled by maximum photosynthetic rates for both seagrass species and epiphytes. Maximum potential growth is modified by dimensionless terms called primary growth factors characterizing light sufficiency, nutrient sufficiency, salinity, sulfide concentration and temperature relative to optimal or saturating requirements. The relationships between these growth factors and photosynthesis are described by mathematical functions of the forms depicted in Figure 7. Secondary factors that act to influence the level of the primary growth factors include turbidity from phytoplankton, epiphytes and suspended particulates which all reduce PAR at the seagrass leaf surface, and nutrients in the water column and from recycled nutrients that support seagrass and phytoplankton growth. Inorganic nutrient concentrations regulate photosynthesis in accordance with Michaelis-Menten kinetics. Biomass change in the autotrophic components of the model is calculated through environmental inputs and species-specific response curves created to fit experimental data. The effects of environmental influences on photosynthesis are multiplicative, and they attenuate the maximum growth rate of 0.7 d^{-1} for epiphytes, 0.3 d^{-1} for *Thalassia* and 0.3 d^{-1} for *Halodule*. Total biomass change for each state variable for each time step is calculated as the sum of gain and loss terms to yield a new biomass at time t+1.

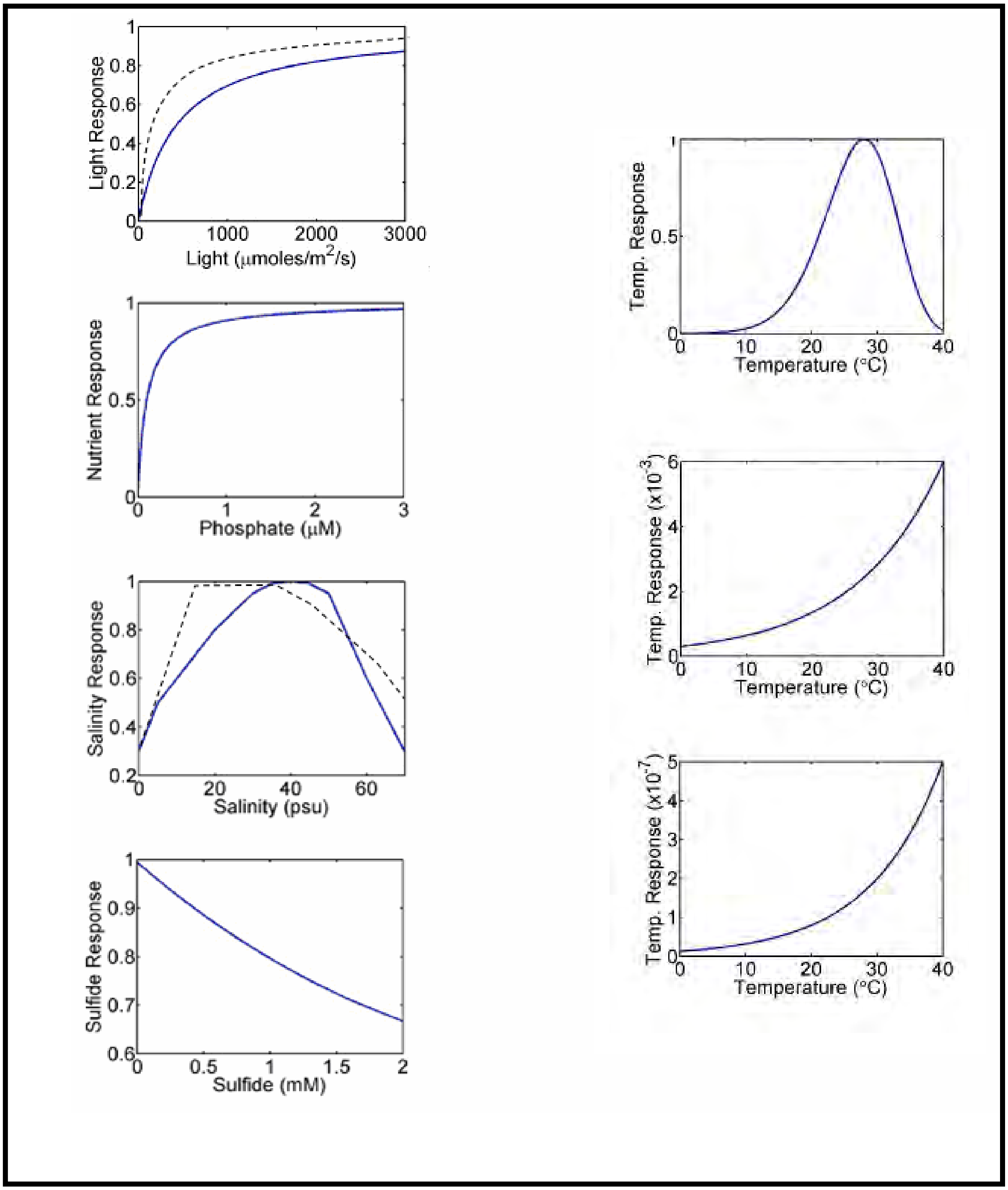


Figure 7. Graphical depictions of seagrass response functions to environmental factors. In the left column are four functions that affect the rate of photosynthesis (Ps): light, phosphorus concentration, salinity and sulfide concentration. Where two lines are shown, dashed line is for *Halodule*, solid for *Thalassia*. *Halodule* is not affected by H_2S in the model. In the right column, top shows the temperature optimum function effect on Ps, and temperature functions for carbon losses due to respiration rate and mortality rate. All Ps response functions are relative to the maximum Ps rate. Loss functions are specific rates in units of mg per mg carbon.

Seagrass State Variables

The state variable for aboveground *Thalassia* biomass is represented by the differential equation:

$$\frac{dT_a}{dt} = (1-\chi_{T_a})g_T T_a - r_{T_a}T_a - m_{T_a}T_a + \chi_{T_b}T_b \qquad (1)$$

The terms are: increase due to photosynthetic growth, loss from respiration, loss from mortality and increase from carbon translocated from belowground tissue. Mortality includes plant death as well as leaf sloughing but does not include a grazing term. Direct grazing on seagrasses is not widely observed in Florida Bay and is likely a second-order process.

The photosynthetic production equation for *Thalassia* is:

$$g_T = V_T \xi_T \left(\tanh \frac{I_T}{l_T}\right) \eta_T \left(1 - \left(\frac{T_a}{\kappa_T} + \frac{H_a}{\kappa_H}\right)^2\right) R_T \psi_T \qquad (2)$$

Growth of the seagrasses is controlled by light and nutrient availability, water column salinity, porewater sulfide concentration, self-limiting density and water temperature with parameters as detailed in Table 1. Light available for seagrass use is determined by the amount of light reaching the seagrass canopy (data-driven forcing function) as modified by epiphyte density on the surface of seagrass blades. The reduction of light (PAR) at the SAV leaf surface in the model is characterized by the expression from Frankovich and Zieman (2005):

$$I_e e^{-0.11 \frac{E \delta_e}{\phi_T}} \qquad (3)$$

The light-coupled term governing photosynthetic rate uses the hyperbolic tangent function (Jassby-Platt 1976). Nutrient uptake is governed by a Michaelis-Menten function for P and N of the form:

$$G=KnC/K+C$$

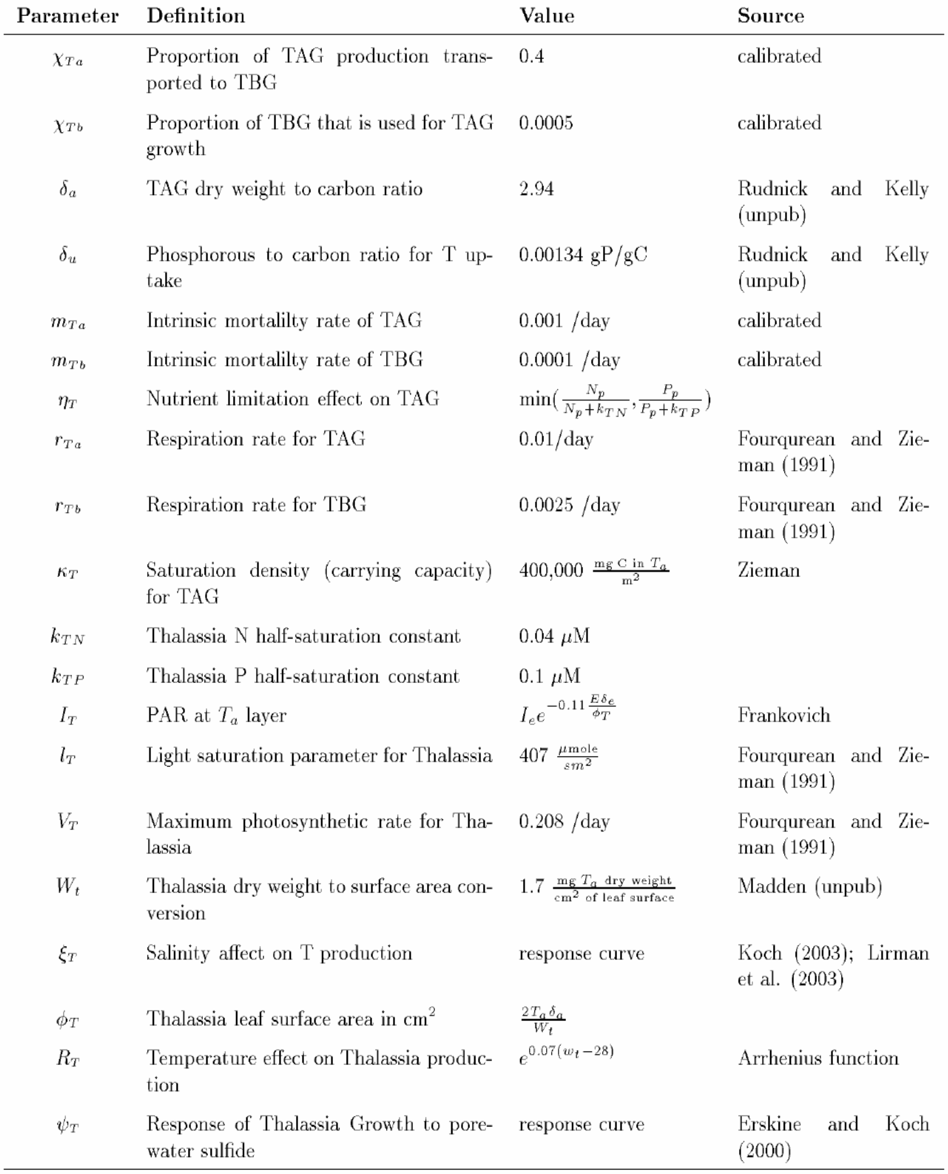
where G=nutrient-based growth rate, K is the half saturation coefficient for a particular nutrient form, n, and C is the concentration of the nutrient. Uptake is calculated using the minimum of a separate uptake velocity calcuation for each nutrient concentration, N and P, as detailed in Table 1. The model assumes that plants acquire phosphorus from the sediment porewater since water column phosphorus concentrations are generally low (less than 0.1 uM) and epiphytes generally have higher nutrient uptake affinities than seagrass leaves out-competing seagrasses for water column nutrients. This also represents a simplifying assumption to reduce error as the effect of surface epiphytes presents an unknown boundary layer effect on nutrient uptake via seagrass leaves. The effects of sulfide toxicity, temperature and salinity on seagrass production are expressed as response curves whose development is described further in the section entitled Parameterization of the Biological Model.

The density limiting function (Table 1) is described as a simple inverse logarithm with variable species-specific density maxima (L). For *Thalassia*, we employ a critical value of δ_{maxTA}=400 g C m^{-2}, which yields minimal effect on photosynthesis at densities from 0-50 g C m^{-2}, progressing to a 50% reduction in photosynthesis between 50-150, and about a 80% reduction above 200 g C m^{-2}.

Thalassia above ground losses occur in the form of temperature-dependent mortality and respiration, as well as translocation to the below ground compartment. Below ground *Thalassia* material accrues solely from downward translocation (Equation 4). Losses occur from mortality, respiration and the fractions of below ground material from the root/rhizome biomass compartment that is transported upward to support growth of shoots.

$$\frac{dT_b}{dt} = \chi_{T_a} g_T T_a - m_{T_b} T_b - r_{T_b} T_b - \chi_{T_b} T_b \qquad (4)$$

Table 1: *Thalassia testudinum* parameters



Parameter	**Definition**	**Value**	**Source**
χ_{Ta}	Proportion of TAG production transported to TBG	0.4	calibrated
χ_{Tb}	Proportion of TBG that is used for TAG growth	0.0005	calibrated
δ_a	TAG dry weight to carbon ratio	2.94	Rudnick and Kelly (unpub)
δ_u	Phosphorous to carbon ratio for T uptake	0.00134 gP/gC	Rudnick and Kelly (unpub)
m_{Ta}	Intrinsic mortalilty rate of TAG	0.001 /day	calibrated
m_{Tb}	Intrinsic mortalilty rate of TBG	0.0001 /day	calibrated
η_T	Nutrient limitation effect on TAG	$\min(\frac{N_p}{N_p+k_{TN}}, \frac{P_p}{P_p+k_{TP}})$	
r_{Ta}	Respiration rate for TAG	0.01/day	Fourqurean and Zieman (1991)
r_{Tb}	Respiration rate for TBG	0.0025 /day	Fourqurean and Zieman (1991)
κ_T	Saturation density (carrying capacity) for TAG	400,000 $\frac{\text{mg C in } T_a}{\text{m}^2}$	Zieman
k_{TN}	Thalassia N half-saturation constant	0.04 μM	
k_{TP}	Thalassia P half-saturation constant	0.1 μM	
I_T	PAR at T_a layer	$I_e e^{-0.11 \frac{E \delta_e}{\phi_T}}$	Frankovich
l_T	Light saturation parameter for Thalassia	407 $\frac{\mu\text{mole}}{sm^2}$	Fourqurean and Zieman (1991)
V_T	Maximum photosynthetic rate for Thalassia	0.208 /day	Fourqurean and Zieman (1991)
W_t	Thalassia dry weight to surface area conversion	1.7 $\frac{\text{mg } T_a \text{ dry weight}}{\text{cm}^2 \text{ of leaf surface}}$	Madden (unpub)
ξ_T	Salinity affect on T production	response curve	Koch (2003); Lirman et al. (2003)
ϕ_T	Thalassia leaf surface area in cm^2	$\frac{2T_a\delta_a}{W_t}$	
R_T	Temperature effect on Thalassia production	$e^{0.07(w_t-28)}$	Arrhenius function
ψ_T	Response of Thalassia Growth to porewater sulfide	response curve	Erskine and Koch (2000)

Above ground and below ground *Halodule* equations (Eqn 5, 6) function exactly as for *Thalassia* but with coefficients as listed in Table 2.

$$\frac{dH_a}{dt} = (1-\chi_{Ha})g_H - r_{Ha}H_a - m_{Ha}H_a + \chi_{Hb}H_b \quad (5)$$

$$\frac{dH_b}{dt} = \chi_{Ha}g_H H_a - m_{Hb}H_b - r_{Hb}H_b - \chi_{Hb}H_b \quad (6)$$

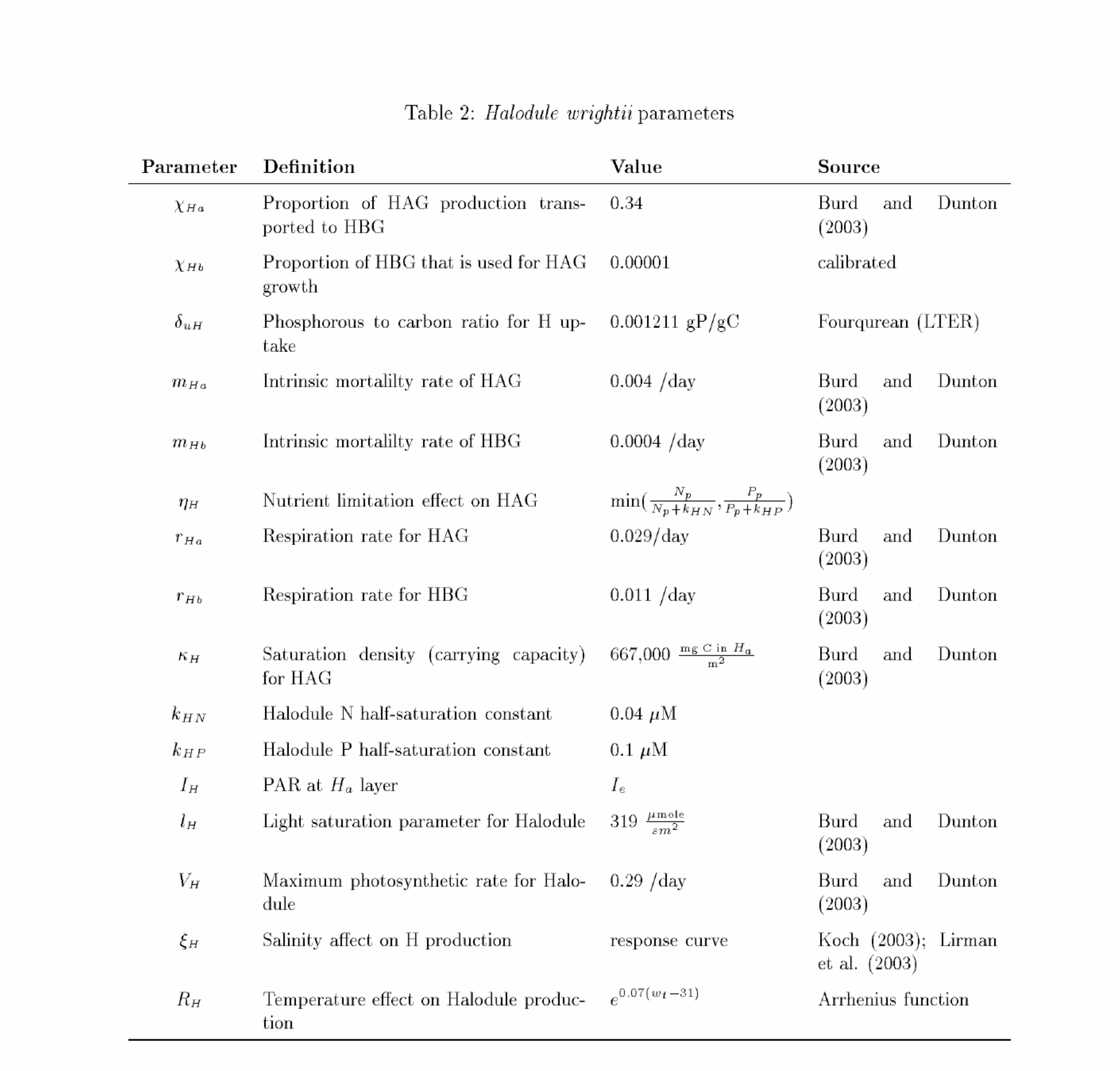


Table 2: *Halodule wrightii* parameters

Parameter	Definition	Value	Source
χ_{Ha}	Proportion of HAG production transported to HBG	0.34	Burd and Dunton (2003)
χ_{Hb}	Proportion of HBG that is used for HAG growth	0.00001	calibrated
δ_{uH}	Phosphorous to carbon ratio for H uptake	0.001211 gP/gC	Fourqurean (LTER)
m_{Ha}	Intrinsic mortalilty rate of HAG	0.004 /day	Burd and Dunton (2003)
m_{Hb}	Intrinsic mortalilty rate of HBG	0.0004 /day	Burd and Dunton (2003)
η_H	Nutrient limitation effect on HAG	$\min(\frac{N_p}{N_p+k_{HN}}, \frac{P_p}{P_p+k_{HP}})$	
r_{Ha}	Respiration rate for HAG	0.029/day	Burd and Dunton (2003)
r_{Hb}	Respiration rate for HBG	0.011 /day	Burd and Dunton (2003)
κ_H	Saturation density (carrying capacity) for HAG	667,000 $\frac{\text{mg C in } H_a}{\text{m}^2}$	Burd and Dunton (2003)
k_{HN}	Halodule N half-saturation constant	0.04 μM	
k_{HP}	Halodule P half-saturation constant	0.1 μM	
I_H	PAR at H_a layer	I_e	
l_H	Light saturation parameter for Halodule	319 $\frac{\mu\text{mole}}{sm^2}$	Burd and Dunton (2003)
V_H	Maximum photosynthetic rate for Halodule	0.29 /day	Burd and Dunton (2003)
ξ_H	Salinity affect on H production	response curve	Koch (2003); Lirman et al. (2003)
R_H	Temperature effect on Halodule production	$e^{0.07(w_t-31)}$	Arrhenius function

Epiphyte State Variable

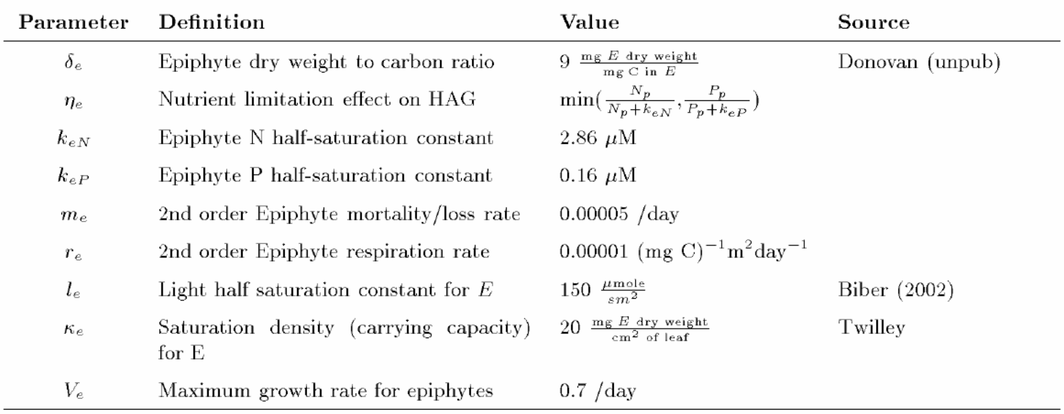
Epiphytes colonize SAV leaf surfaces, intercepting light and reducing SAV productivity. They obtain nutrients and light directly from the water column and SAV provides a substrate on which to grow. The epiphyte community is actually a consortium of plant, animal, bacterial and abiotic components. The abiotic parts include sediments, mucous and detritus. Photosynthetic rates of the autotrophic component are characterized similarly as for SAV: a temperature-related potential growth rate defines maximum specific growth rate of 0.7 per day, modified by the product of P-I based and nutrient-based growth rates. A density-dependent function limits epiphyte growth from self-shading, and with increasing epiphyte density per area of SAV leaf, an exponential decline in growth rate is invoked, using a maximum of δ_{maxE}=20 mg cm^{-2}. Growth is reduced by 50% per 0.5 mg cm^{-1} increase in density, and at 5.0 mg cm^{-1}, growth rate is 30% of the maximum potential rate. If no seagrass is present as a substrate for growth, the density limiting function goes to zero, and production ceases.

Epiphyte biomass is represented by the differential equation:

$$\frac{dE}{dt} = V_e\left(1-\left(\frac{E\delta_e}{\kappa_e\phi_T}\right)^2\right)\left(\frac{I_e}{I_e+l_e}\right)\eta_e E - m_{T_a}E - r_e E^2 - m_e E^2 \tag{7}$$

Loss pathways from epiphytes are respiration, grazing and mortality, applying coefficients listed in Table 3. Additionally, a quantum loss of epiphyte material is associated with substrate losses via seagrass leaf sloughing, calculated as the product of leaf death rate and epiphyte density. A constant relates mortality to the square of biomass, simulating natural mortality, stripping by wave action, and sedimentation such that 2-6% of the biomass is removed by this pathway daily.

Table 3: Epiphyte parameters



Parameter	Definition	Value	Source
δ_e	Epiphyte dry weight to carbon ratio	$9\ \frac{\text{mg } E \text{ dry weight}}{\text{mg C in } E}$	Donovan (unpub)
η_e	Nutrient limitation effect on HAG	$\min(\frac{N_p}{N_p+k_{eN}}, \frac{P_p}{P_p+k_{eP}})$	
k_{eN}	Epiphyte N half-saturation constant	2.86 μM	
k_{eP}	Epiphyte P half-saturation constant	0.16 μM	
m_e	2nd order Epiphyte mortality/loss rate	0.00005 /day	
r_e	2nd order Epiphyte respiration rate	0.00001 (mg C)$^{-1}$m^{2}day^{-1}	
l_e	Light half saturation constant for E	$150\ \frac{\mu\text{mole}}{sm^2}$	Biber (2002)
κ_e	Saturation density (carrying capacity) for E	$20\ \frac{\text{mg } E \text{ dry weight}}{\text{cm}^2 \text{ of leaf}}$	Twilley
V_e	Maximum growth rate for epiphytes	0.7 /day	

Mortality losses from seagrass and epiphyte compartments enter the organic matter pool (D) in the sediments. Other sources of organic matter are detritus from benthic algae and of planktonic organisms, fixed as a constant.

$$\frac{dD}{dt} = m_{T_a}E + m_{T_a}T_a + m_{T_b}T_b + m_{H_a}H_a + m_{H_b}H_b + m_B B + m_z Z + \chi_w - \sigma\tau_D D - \chi_D D \qquad (8)$$

A proportion of the sediment organic matter is lost through export and burial, while another portion is remineralized to release nutrients into the porewater. The remineralization process releases inorganic nutrients and produces hydrogen sulfide (S) as a byproduct of sulfate reduction, accumulating sulfide in the porewater. Some of the sulfide is oxidized through seagrass oxygen production and exudation from the roots and via natural diffusion of oxygen from overlying water.

$$\frac{dS}{dt} = \left(r_s \delta_s \sigma \tau_D D - K_s S \nu_S\right) / \nu_S \qquad (9)$$

Phosphate released during remineralization accumulates in the porewater fraction (P_p) as dissolved inorganic phosphorus DIP and sorbs to the calcium carbonate sediment matrix (P_s) that is a major component in Florida Bay sediments (Table 4). A portion of the sorbed phosphate is incorporated into the sediment matrix, sequestration that effectively makes the P unavailable to plants. Seagrass growth can lower pH in the sediments via acid excretion, causing dissolution of the carbonate sediments (Jensen et al. 1998) and releasing phosphorus from the solid phase into the porewater where it can be utilized by seagrass for growth. Phosphate released during remineralization accumulates in the porewater and adsorbs to the calcium carbonate sediment matrix. A portion of the adsorbed phosphate is incorporated into the sediment matrix allowing more phosphate to adsorb to the sediment surface.

$$\frac{dP_p}{dt} = \left(\sigma\tau_D \delta_p D + (K_d - \delta_{uT}) g_T T_a - \delta_{uH} g_H H_a + (P_s K_p - P_p \nu_p)\right) / \nu_p \qquad (10)$$

$$\frac{dP_s}{dt} = -\left(P_s K_p - P_p \nu_p\right) - \beta_p P_s \qquad (11)$$

Parameterization of the Biological Model

In addition to light and nutrient control of photosynthesis, three mechanisms are critical to plant response: sediment sulfide concentration, salinity and temperature. The effect of sulfide concentration is to limit *Thalassia* photosynthesis. Erskine and Koch (1999) determined that higher sulfide concentrations had a negative effect on growth. While there was a sharp decline in leaf elongation to approximately 50% of maximum when sulfide concentration increased from 0 uM to 2 uM, there was no further decrease in elongation rate between 2 uM and 6 uM. At 10 uM, there was again a large decrease in elongation rate. A response curve was created to exhibit this relationship in the model. Because *Halodule* belowground biomass is positioned

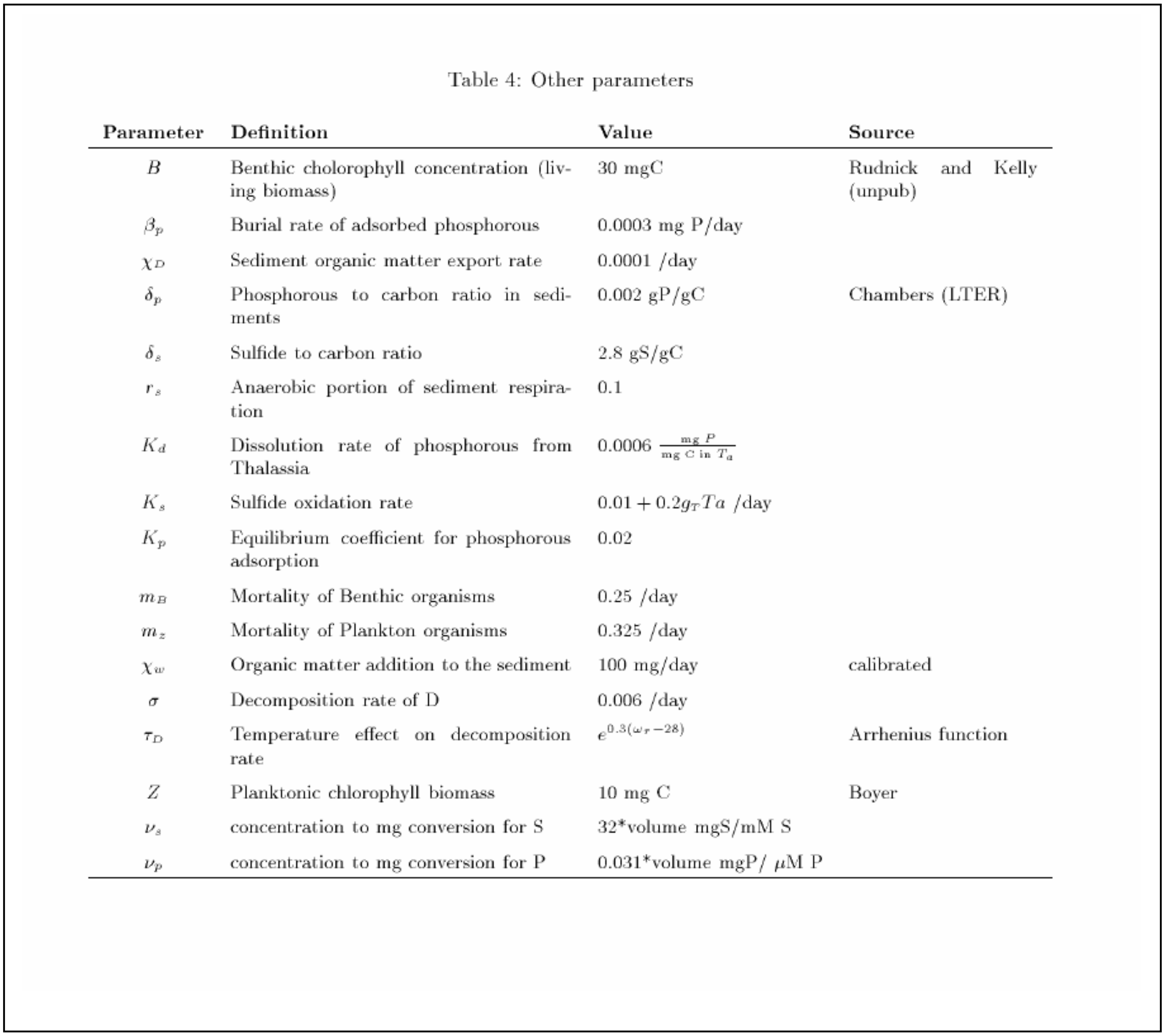


Table 4: Other parameters

Parameter	**Definition**	**Value**	**Source**
B	Benthic cholorophyll concentration (living biomass)	30 mgC	Rudnick and Kelly (unpub)
β_p	Burial rate of adsorbed phosphorous	0.0003 mg P/day	
χ_D	Sediment organic matter export rate	0.0001 /day	
δ_p	Phosphorous to carbon ratio in sediments	0.002 gP/gC	Chambers (LTER)
δ_s	Sulfide to carbon ratio	2.8 gS/gC	
r_s	Anaerobic portion of sediment respiration	0.1	
K_d	Dissolution rate of phosphorous from Thalassia	$0.0006 \frac{\text{mg } P}{\text{mg C in } T_a}$	
K_s	Sulfide oxidation rate	$0.01 + 0.2 g_T Ta$ /day	
K_p	Equilibrium coefficient for phosphorous adsorption	0.02	
m_B	Mortality of Benthic organisms	0.25 /day	
m_z	Mortality of Plankton organisms	0.325 /day	
χ_w	Organic matter addition to the sediment	100 mg/day	calibrated
σ	Decomposition rate of D	0.006 /day	
τ_D	Temperature effect on decomposition rate	$e^{0.3(\omega_T - 28)}$	Arrhenius function
Z	Planktonic chlorophyll biomass	10 mg C	Boyer
ν_s	concentration to mg conversion for S	32*volume mgS/mM S	
ν_p	concentration to mg conversion for P	0.031*volume mgP/ μM P	

superficially in the sediments, primarily in the oxidized microzone and is less affected by sulfide, there is no sulfide effect on *Halodule* growth conceptualized in the model.

Salinity data were compiled from multiple sources to produce a response curve for *Thalassia* that has optimal growth centered at 40 psu (Koch and Durako 2004; Lirman and Cropper 2003; McMillan and Moseley 1967). Literature suggests that *Thalassia* is more sensitive to higher salinities than lower salinities, which would imply a sharper slope above 40 psu. However, Koch and Durako (2005) showed that *Thalassia* can be more productive in higher salinities if the salinity increase is gradual (0.5 psu d^{-1}), thus producing the flatter response curve in the upper limb, which is used in the model. *Halodule* has a broader optimum and better tolerance for lower salinities Lirman and Cropper (2003), yielding a flattened curve centered at 25 psu, with optimum salinity range extending from 15-35 psu. While McMillan and Mosely (1967) found that *Halodule* was more resilient at high salinities, Lirman and Cropper (2003) showed a decline that began at around 40 psu, and evidence from multiple Florida Bay researchers suggest that *Thalassia* is more resilient than *Halodule* at high salinities.

Temperature influences several processes in the model, including photosynthesis, mortality and respiration of seagrasses as well as decomposition rate of sediment organic matter through the metabolism of microorganisms. Arrhenius functions were used to model the temperature effects with an Arrhenius parameter of 0.07. The reference temperature was set to the temperature condition under which the rates were measured (ranged from 25ºC to 28ºC).

Basin and Bank Model Versions

For the standard model formulation developed for the deeper parts of each of the targeted basins of Florida Bay, selected parameters are adjusted to yield a "bank" version for each unit model. Banks are found throughout Florida Bay and are shoal areas that tend to have thicker sediment layers over bedrock, shallower water columns, higher water temperatures, increased light, and often higher salinity relative to the adjacent deeper waters of the basin. These conditions can result in a more lush seagrass biomass (Zieman 1982). For the bank versions of the unit models, we are incorporating an active root zone that is on average 2.5 times deeper than the basin version, yielding a larger nutrient pool from which roots can draw, higher % organic matter in the sediments, 50% more light reaching the epiphyte surface and seagrass canopy, increased variance of salinity around a 30% higher mean salinity value and increased variance of temperature around a 20% higher mean temperature value. Development of these bank versions is in progress, but preliminary model runs indicate that stable, viable seagrass populations result, with greater average biomass. The biomass increase is due largely to the deeper sediment depth, providing access to larger phosphorus porewater volume and higher mean light and temperature regimes (Figure 8).

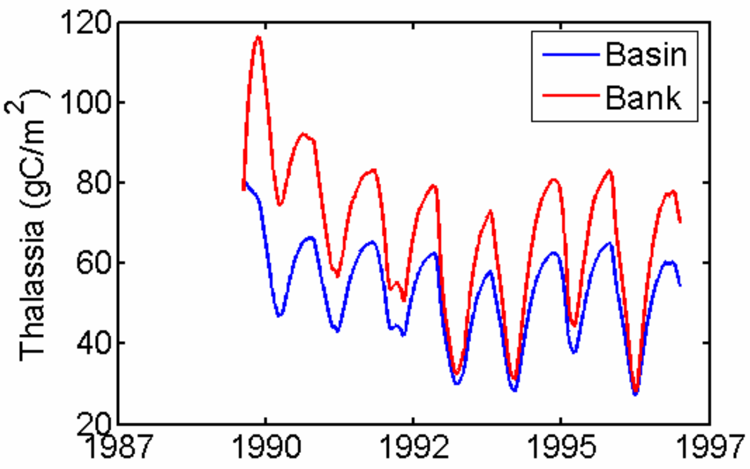


Figure 8. Bank and basin proof-of-concept model run for Rabbit Key Basin *Thalassia* population.

Interspecific Competition

The two target seagrass species in the current version of the model, *Thalassia* and *Halodule*, can be found coincident in space at the spatial resolution (1 m^2) represented by the model. The model reproduces the competitive interaction of these species for nutrients, light and space within the same parameter space. Allelopathy is not considered, as no evidence of this process is noted in the literature. Both modeled species draw from the same pool of sediment nutrients for growth and are thus competing for the same resources. Both have the same nutrient kinetics parameters, meaning that nutrient affinities are identical. However, due to the architecture of *Thalassia*, with greater belowground biomass and occupation of a deeper zone in the sediment compartment, there is a larger volume of nutrient porewater available to this species. Each species can compete for nutrients equally on a local concentration basis, but *Thalassia* occupies a larger physical space. Secondarily, *Halodule* is more tolerant of lower and mid salinities, while *Thalassia* is slightly more tolerant of high salinities. Therefore when hypersaline conditions persist, *Thalassia* is favored.

In terms of density, *Halodule* presents a lower and smaller profile and, thereby, reduced shading influence on *Thalassia* per unit biomass than *Thalassia* on *Halodule*. Furthermore, *Halodule* is more efficient at photosynthesizing at lower light intensities due to its lower saturation onset parameter (Ik). Thus, *Halodule* can tolerate the presence of shading and crowding by *Thalassia* to some degree, but the massive profile of *Thalassia* can and does present a competitive challenge for *Halodule* at some "tipping" point beyond which a positive feedback loop is generated, maintaining *Thalassia* in a dominant configuration.

Calibration of the Seagrass Community Model

Calibration of the single-species model

Initially, we developed the *Thalassia* single-species model, including all state variables described above, excluding *Halodule*. Calibration for each basin unit model was achieved through least-squares optimization of the summed squared error for *Thalassia* aboveground biomass. The free parameters allowed to vary during the optimization routines were:

- Rate of translocation of carbon between above and below biomass portions
- Mortality rate for aboveground *Thalassia* biomass
- Mortality rate for belowground *Thalassia* biomass
- Import rate of organic matter

The calibration period was selected to cover a period of record where data for all variables were available, which for sites in northeast Florida Bay (Duck Key, Trout Cove, Little Madeira Bay and Eagle Key Basin) was from 1989 to 1995. Figure 9 shows the calibrated *Thalassia* output for Rankin Lake and Rabbit Key Basin. The general decline of *Thalassia* in the Rabbit Key Basin data after 1992 was not captured by the model initially, and the model required an adjustment of the chlorophyll data to reflect the initiation of blooms in that year. A validation exercise was performed using the calibrated models extended until 2000 (Figure 10), and model output tracked the empirical data reasonably well.

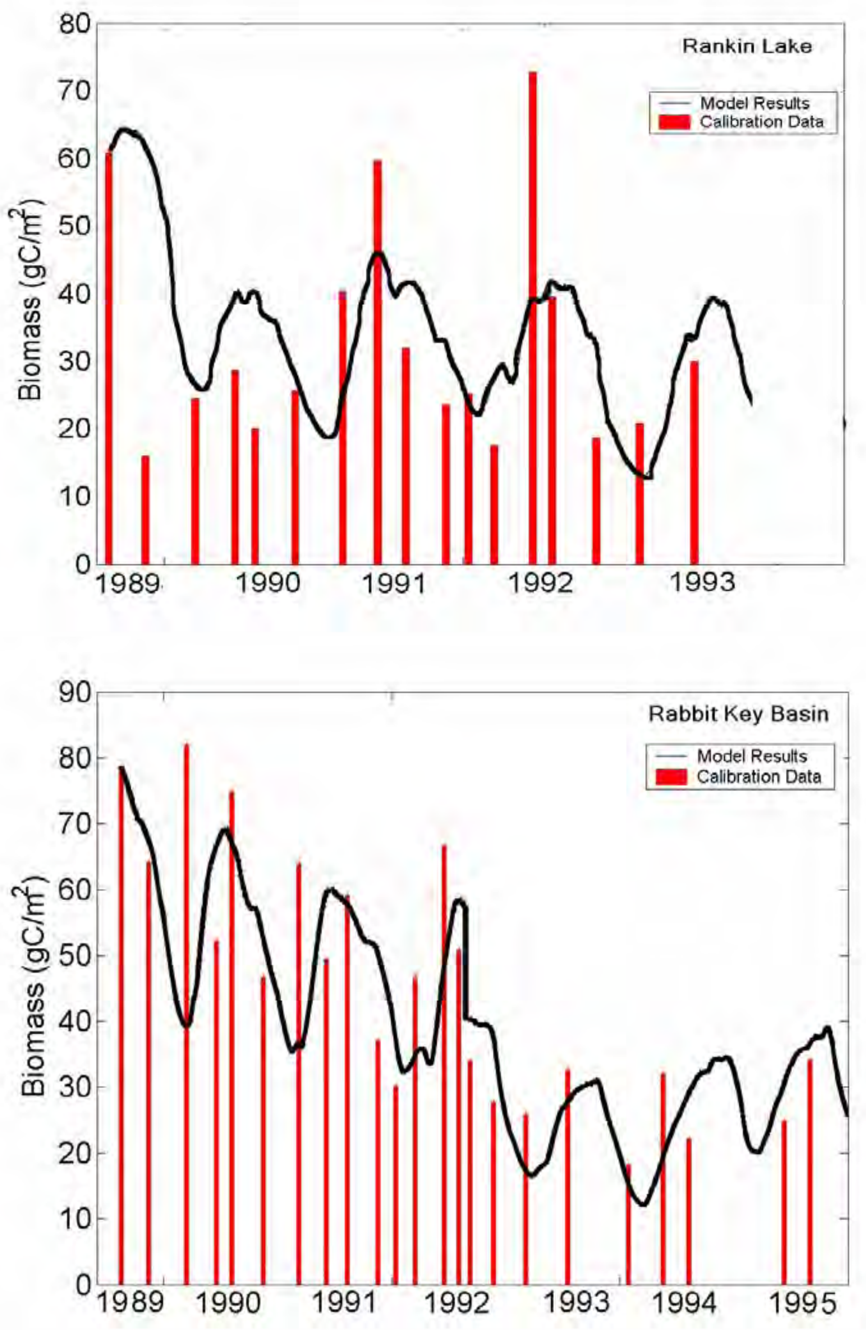


Figure 9. Calibration of single-species *Thalassia* model for Rankin Lake and Rabbit Key Basin. Red columns represent field biomass data.

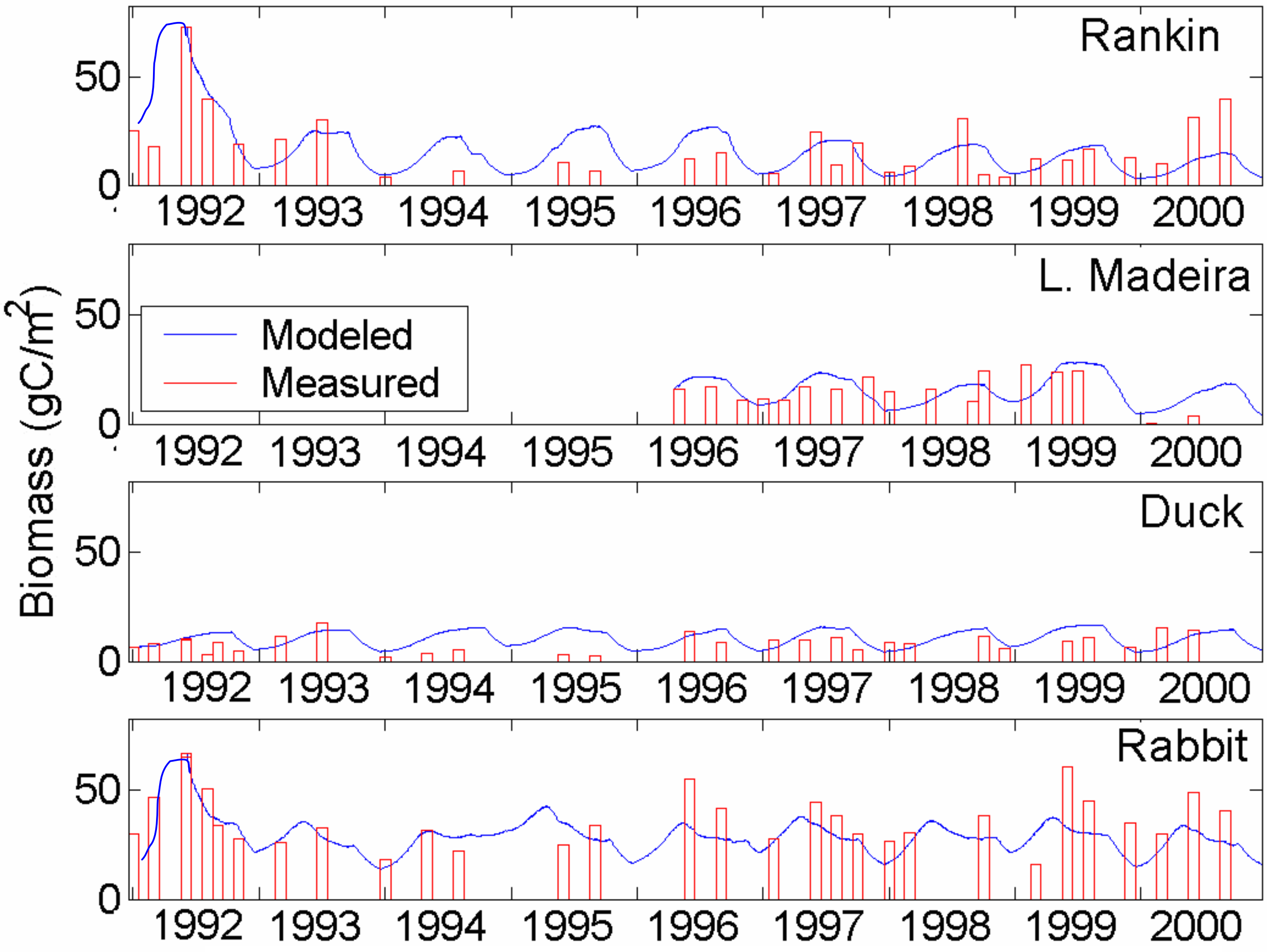


Figure 9. Validation model runs for four basins for single-species *Thalassia* model.

Calibration of the dual-species model

A dual-species version of the Florida Bay seagrass model was calibrated for four northeastern basins using biomass data collected by Miami-Dade Department of Environmental Resources Management (Miami-Dade DERM) from fall 1996 to spring 2000 (M-D DERM 2004). Calibration runs were done for *Halodule* and *Thalassia* in Little Madeira Bay, Eagle Key Basin, Whipray Basin and Trout Cove against empirical data from those sites between 1997 and 2000 or 2001 (Figure 11). Calibration for each basin unit model was achieved through least-squares optimization of the summed squared error for both *Thalassia* and *Halodule*. Model output (solid lines) for *Halodule* is total plant biomass and for *Thalassia* is aboveground biomass, in g C m^{-2}.

Thalassia biomass data were compartmentalized into three components: leaf, shoot/sheath and root/rhizome. The shoot/sheath and root/rhizome data were aggregated as belowground biomass. For *Thalassia* only the above ground biomass was assessed in the calibration routine. Because belowground biomass is collected to a depth of 30 cm (which is outside of the active layer in the model), it is not possible to calibrate the model for belowground biomass without a depth distribution for biomass. However, the overall visible trend was noted (decrease, increase or stable).

Halodule biomass is not apportioned at collection so the *Halodule* state variable is calibrated as total (aboveground plus belowground) biomass. This could introduce errors, as belowground biomass for *Halodule* was also sampled to 30 cm, which is deeper than the active zone in the model. However, in model development, we assume that *Halodule* does not reside in deep sediments, and that this error is likely to be minimal. Parameters assigned from literature values or calculated from empirical data were not allowed to vary.

Because *Halodule* is a small-biomass component occupying a distinct niche, competition with *Thalassia* for resources, particularly light, may be considered to be minor, and indeed, *Thalassia* parameters changed little with the introduction of the *Halodule* state variable. However, *Thalassia* has a strong influence on *Halodule* in a mixed community and a competitive advantage under stable, undisturbed situations.

The free parameters allowed to vary during the optimization routines were:

- Rate of translocation of carbon between above and below biomass portions
- Mortality rate for aboveground *Thalassia* biomass
- Mortality rate for belowground *Thalassia* biomass
- Mortality rate for total *Halodule* biomass
- Import rate of organic matter

The calibration output in Figure 11 shows that the model intersects the data at a number of points for both species. Although the model undergoes seasonal oscillations, the actual data are not sufficiently temporally resolved to show seasonal patterns. In general, the level of biomass is appropriate for each species, and the biomass level predicted by the model conforms ordinally to the biomass abundance at each calibration site. Only where there is a highly variable "unexpected" change in the biomass data did the model fail to capture the pattern, probably indicating a process that is not anticipated in the model. This might be most prevalent at highly variable sites such as Little Madeira Bay, near the Taylor River discharge. Nonetheless, the model shows stability and the ability to track some long term trends (e.g. *Halodule* decline in Trout Cove, *Thalassia* increase in Whipray Basin). The error analysis in Table 5 reflects that the model tracks data reasonably well, and the coefficient of determination for the regression analysis in Figure 12 indicates a relatively high predictive ability.

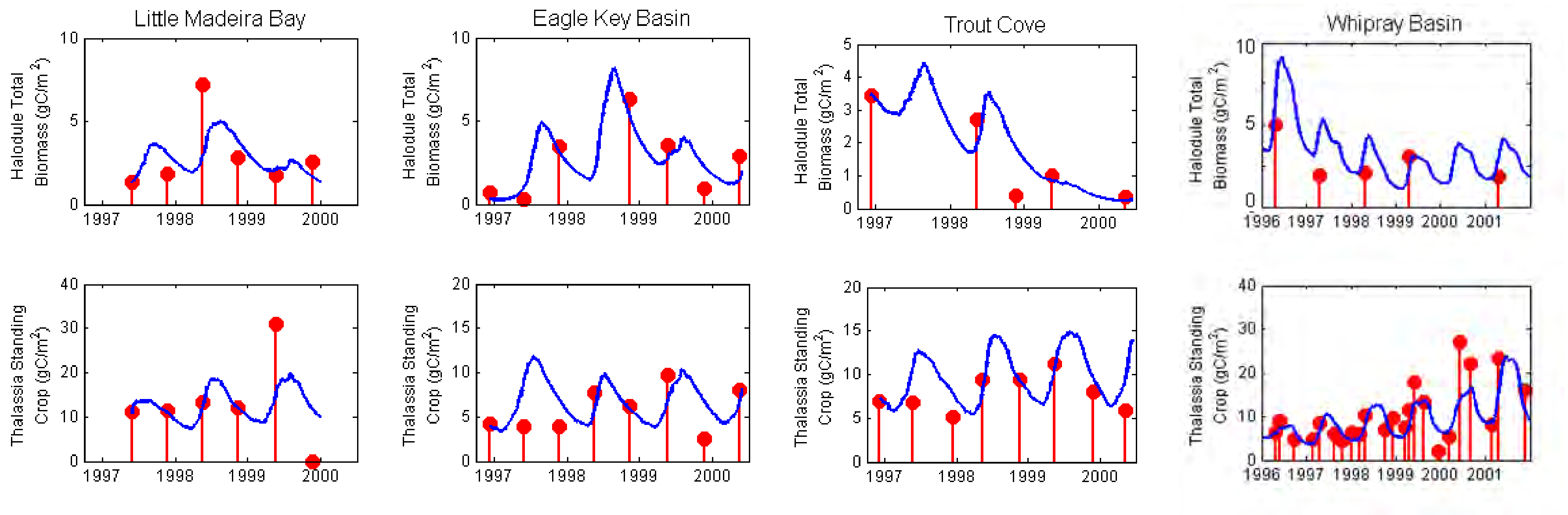


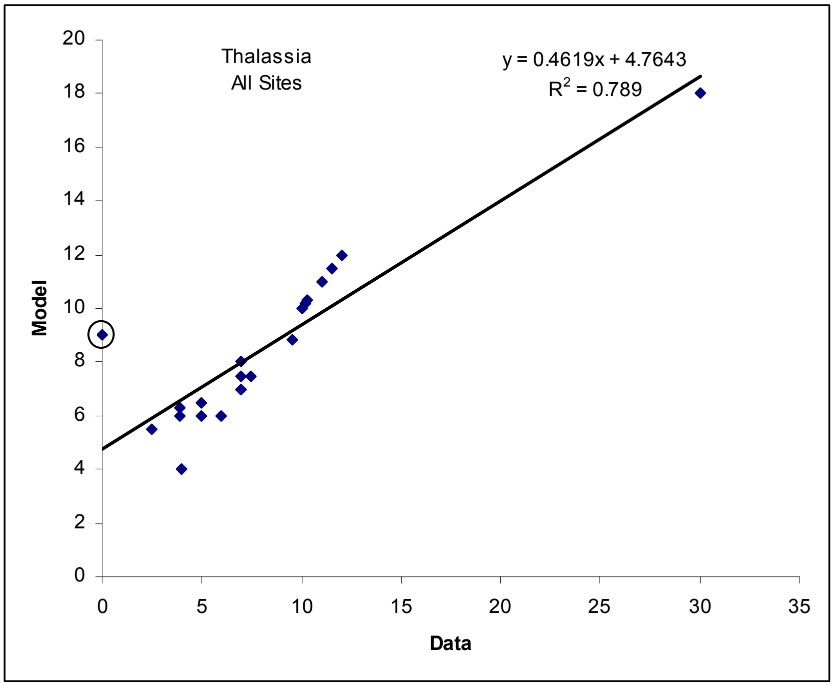
Figure 11. Calibration runs for *Halodule* (top) and *Thalassia* (bottom) species in the SAV model for the inner Little Madeira Bay, Eagle Key Basin, Trout Cove and Whipray Basin. Model output (solid lines) for *Halodule* is total plant biomass, and output for *Thalassia* is aboveground biomass, both in g C m^{-2}. Note scale differences for locations. Solid circles represent data from field measurements.

Error Analysis

Model uncertainty was examined using Root Mean Squared Error (RMSE) calculation for multi-year runs during the calibration period. RMSE values for *Halodule* were 1.9 g C m^{-2} in Little Madeira Bay, 1.0 in Eagle Key Basin and 0.8 in Trout Cove. RMSE values for *Thalassia* biomass were 7.9 g C m^{-2} in Little Madeira Bay, 3.1 g C m^{-2} in Eagle Key Basin and 2.7 in Trout Cove. The r^2 values are low in some cases due to the sparseness of biomass calibration data taken for both species concurrently. The *Thalassia* r^2 value is reduced due to the inability to capture the extremes that occurred in 1999. The model is used as a predictive tool, but we are careful in interpreting results due to the uncertainties in both the model and the data that are used in calibration. We have confidence that the model faithfully represents the major processes and interactions in the seagrass community, though components are still in the process of being refined.

Table 5. Calibration statistics for the three northeastern Florida Bay transition zone sites. SSE = summed squared error; RMSE = root mean squared error; r^2 = coefficient of determination. n=18 for *Halodule* and n=22 for *Thalassia*; *= linear regression recalculated excluding one extreme outlier (circled in Figure 12) in the empirical data for each species.

Statistic	Little Madeira Bay	Eagle Key Basin	Trout Cove	ALL	ALL*
Halodule wrightii					
SSE	17.8	6.1	2.7		
RMSE	1.9	1.0	0.8		
r^2	0.50	0.87	0.75	0.68	0.83
Thalassia testudinum					
SSE	311.3	68.6	38.1		
RMSE	7.9	3.1	2.3		
r^2	0.93	0.70	0.97	0.79	0.90



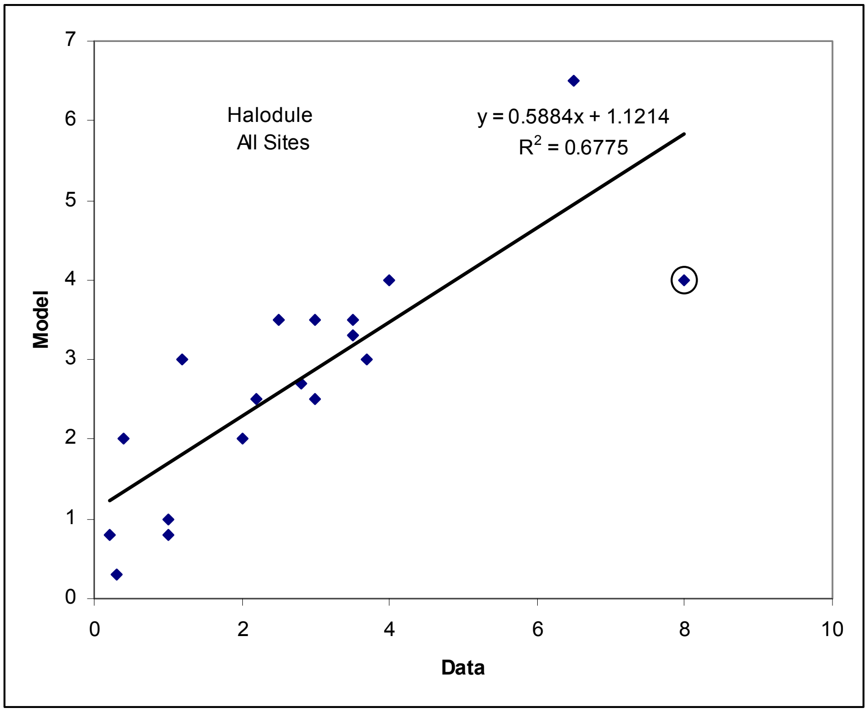


Figure 12. Regression of dual-species model output versus data for all sites.

Sensitivity Analysis

The sensitivity of the model was assessed by varying selected parameters and measuring changes in model output of biomass for both species (Tables 6 and 7). Sensitivity of response variables *Thalassia* and *Halodule* aboveground biomass were measured for the calibration period May 1997 – February 2000. The protocol for sensitivity testing of the two species running in dual-species mode involved systematic adjustment of all 56 model parameters individually by 10% and 5% in both positive and negative directions. The resulting change in the model output was compared to the baseline calibration value. The average absolute deviation from baseline was divided by the average baseline value to determine relative per cent deviation. This value was then normalized to the percent change in the input parameter (-10%, -5%, +5%, +10%), giving as a result the per cent change in output per change in input. A values that is greater than 100% (in red) indicates an amplification response, and a value in black represents a damping of the input perturbation. Parameters that produced a change less than half of the input parameter change are not presented.

The model proved to be robust and resistant to changes in most parameters, as is often the case in complex models with a large number of variables. Only eight of the 56 parameters met the threshold for significance for *Thalassia* and 16 met the threshold for *Halodule*. Changes in *Thalassia* were generally less than the input perturbation. *Thalassia* was most sensitive to the rate of translocation from the belowground to aboveground compartment and to respiration. Interestingly, increases in epiphyte growth evoked a positive response in *Thalassia*, possibly as a mechanism for increasing organic matter and nutrient input to the sediments via mortality and decay.

Halodule was far more sensitive to input perturbations, attributable to the relatively low biomass of *Halodule* and to the higher growth, respiration and mortality rates. *Halodule* was most sensitive to respiration, organic accumulation in the sediments and a number of *Thalassia* parameters. This latter effect demonstrates the importance of *Thalassia* processes in the ecosystem and the inherently dominant role of *Thalassia* in limiting *Halodule* productivity when both are present.

Table 6. Sensitivity of *Thalassia* biomass to variation in parameter values.

% CHANGE

Parameter	**-10%**	**-5%**	**+5%**	**+10%**
Epi mx Ps V_e	-69%	-70%	+73%	+75%
Thal transloc χ_{Tb}	+112%	+113%	-116%	-118%
Thal mx Ps V_T	-101%	-92%	+75%	+67%
Hal resp r_{Ha}	-50%	-54%	+49%	+46%
Hal mx Ps V_H	+60%	+67%	-77%	-80%
Sed P:C δ_p	-91%	-91%	+92%	+92%
Thal P stoich δ_{uT}	+86%	+81%	-75%	-72%
Thal resp r_{Ta}	+151%	+150%	-145%	-142%

Table 7. Sensitivity of *Halodule* biomass to variation in parameter values.

% CHANGE

Parameter	**-10%**	**-5%**	**+5%**	**+10%**
Epi P sat k_{eP}	+75%	+72%	-65%	-61%
Epi mx Ps V_e	-103%	-106%	+110%	+112%
Thal transloc χ_{Tb}	-248%	-264%	+298%	+315%
Thal P sat k_{TP}	-240%	-244%	+250%	+250%
Light I_T	-169%	-172%	+177%	+179%
Thal Ps V_T	+575%	+536%	-450%	-406%
Hal transloc χ_{Hb}	+295%	+291%	-276%	-266%
Hal mortality m_H	+57%	+55%	-52%	-51%
Hal P sat k_{HP}	+295%	+280%	-251%	-237%
Hal light I_H	+163%	+159%	-151%	-147%
Hal resp r_{Ha}	+517%	+496%	-443%	-410%
Hal mx Ps V_H	-471%	-501%	+555%	+566%

Sed org accum χ_w	-585%	-584%	+581%	+580%
Sed P:C δ_p	-139%	-139%	+138%	+138%
Thal P stoich δ_{uT}	+117%	+112%	-103%	-99%
Thal resp r_{Ta}	-307%	-326%	+358%	+371%

Sensitivity to salinity averaging

Because salinity is the primary forcing function used to determine many management alternatives, we also focused an analysis on the sensitivity of the model to changes in the resolution of the salinity data used in the forcing function. This will be useful in determining how the SAV components will interact with the water quality model in the fully integrated hydrodynamic framework of the EFDC model. The baseline calibration of the SAV model interpolates instantaneous salinity from salinity data measured at 15-minute intervals. We developed alternative salinity formulations by exploring five averaging schemes: daily, 7-day moving average, 14-day moving average, 30-day moving average and a monthly average (Figure 13). Sensitivity runs were compared to baseline averages for *Thalassia* and *Halodule* biomass (Figure 14) and absolute deviations from the average were quantified as both summed squared error and root mean squared error.

All of the alternatives degraded model performance for *Thalassia* based on SSE and RMSE (Table 8) by increasing *Thalassia* productivity above the base case. Monthly running averaging reduced variability by about 14% (salinity standard deviation) and allows modeled plants to grow at more constant salinity, which particularly favors *Thalassia* at the expense of *Halodule*. Monthly averaging actually slightly improved the fit for *Halodule* by a very small margin compared to 15-minute empirical data, although other smoothing schemes reduced both model fit and *Halodule* production. Lengthening the averaging period has two effects on the salinity input data: it increases salinity, and it diminishes variability, notably the frequency of extreme salinity spikes. Both of these factors increase *Thalassia* growth, accounting for an enhancement of biomass relative to the base case. Smoothing has a net effect of slightly raising the average, minimum and maximum salinity. By smoothing the data, salinity values are centered more within the optimal salinity envelope for *Thalassia*. The 30-day moving average resulted in a maximum daily increase in *Thalassia* of 1.5 g, or 12.4 % of the mean *Thalassia* baseline biomass of 12.4 g and reducing *Halodule* by 0.27 g, which is 27 % of the mean baseline biomass of 0.99 g. Long-term, 30-day smoothing elevated the *Thalassia* standing crop by about 80 mg C yr^{-1} and reduced *Halodule* by 25 mg C y^{-1}.

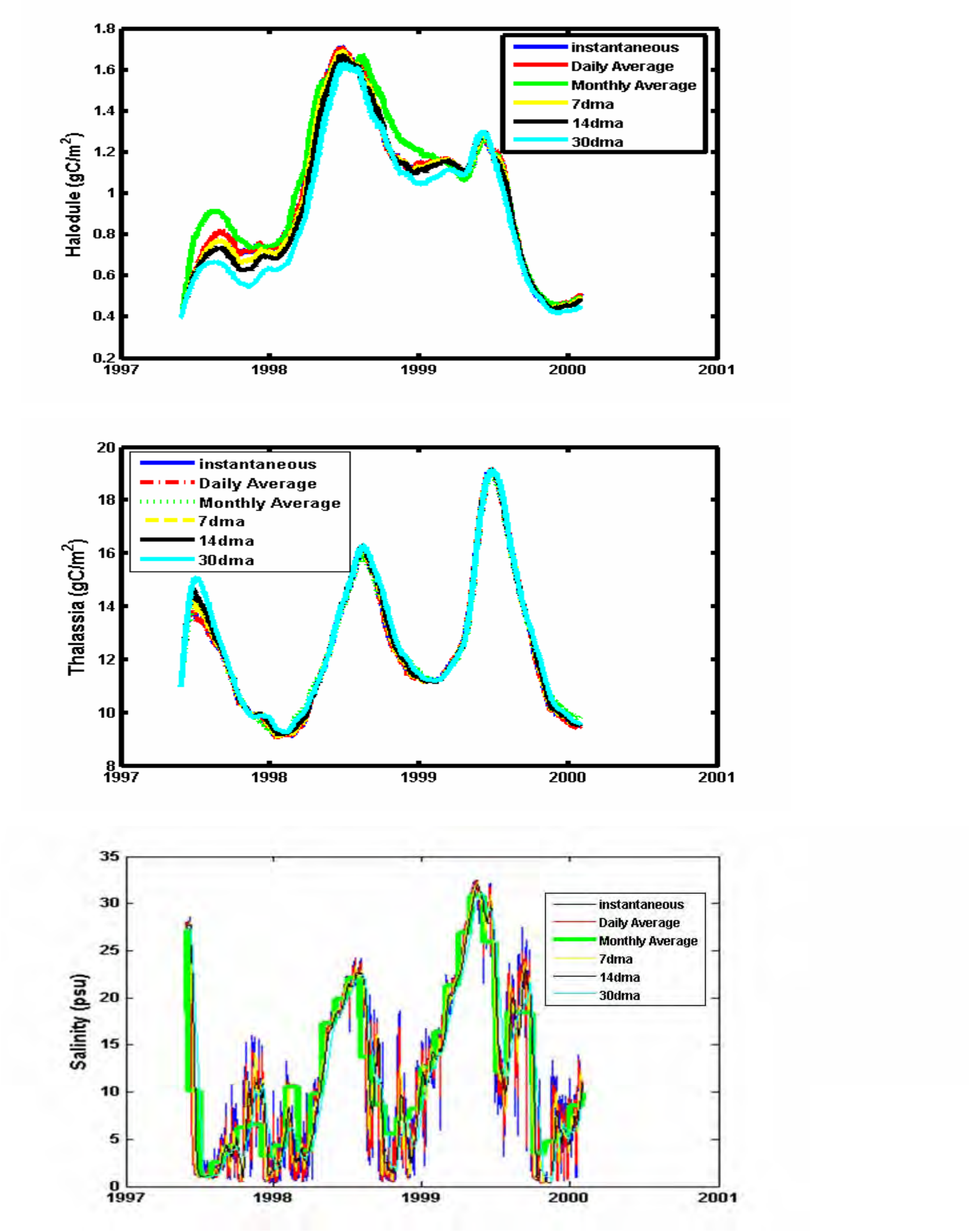


Figure 13. Salinity smoothing analysis and influence on seagrass biomass calculations.

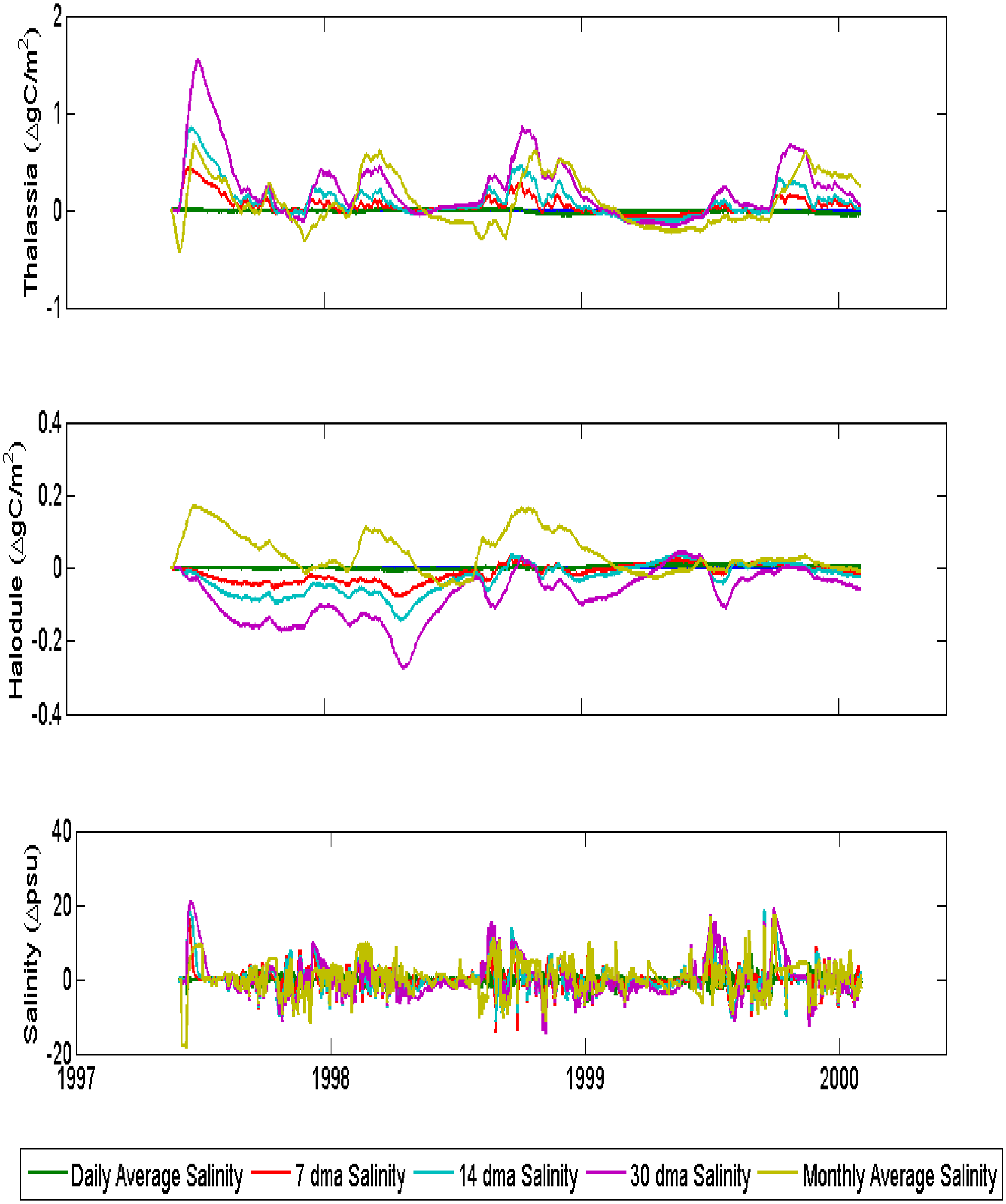


Figure 14. Deviations of SAV biomass and salinity from the baseline calibration values caused by differential smoothing of the salinity input function.

Table 8. Model fit to data with the smoothed salinity inputs. All numbers are reported in gC m^{-2}. DMA = day moving average, SSE = summed squared error, RMSE = root mean squared error.

Smoothing Applied	Thalassia SSE	Thalassia RMSE	Halodule SSE	Halodule RMSE
Instantaneous	311	7.89	17.8	1.89
Daily Average	311	7.89	17.9	1.89
7 DMA	313	7.91	18.9	1.94
14 DMA	316	7.94	19.7	1.99
30 DMA	323	8.04	21.8	2.09
Monthly Average	328	8.10	17.7	1.88

Table 9. Net effects of different smoothing in the salinity input function. Values are the integrated difference from the calibration baseline using instantaneous data across the entire calibration period.

Smoothing Applied	Thalassia (mg C m^{-2})	Halodule (mg C m^{-2})	Salinity (psu)	Std Dev Salinity
Instantaneous	n/a	n/a	n/a	9.2
Daily Average	-11	3	0.00	9.1
7 DMA	46	-13	0.06	8.9
14 DMA	100	-29	0.12	8.8
30 DMA	224	-73	0.26	8.5
Monthly Average	92	39	0.34	7.9

Model System Physiology

Several key physiological indicator variables were monitored to assess realism of model processes and to diagnose mechanisms by which environmental perturbations effect changes in the plant community. We are careful to assess carbon flows in the model, because it is possible to generate apparently reasonable output for state variables that integrate several underlying processes with offsetting errors. For example, seagrass biomass integrates flows of production, mortality, translocation and respiration and an overestimate of respiration could be offset by an overestimate of production. By routinely monitoring carbon dynamics in this model, such spurious results are identified and avoided.

Indicator variables were also used to track key model processes, which were responsible for observed patterns of seagrass and epiphyte biomass. By quantifying the flow and fate of carbon on a normalized basis, assessment of the velocity of carbon and nutrient movement through state variables could be made. Carbon flows showed that under baseline conditions, seagrass photosynthesis was highest in the mid growing season (Figure 15), and gross photosynthetic rates peaked at above 400 mg C m^{-2} d^{-1} during summer of each year. The respiration term, which is expressed as a negative carbon flow, combines active and basal metabolism and ranged from about 20-25 of gross photosynthesis throughout the year, peaking at about 75 mg C $m^{-2}d^{-1}$ during mid-summer. Losses to leaf mortality were slightly greater than respiratory losses and similarly expressed as a negative. Together, both loss terms combine to represent about 45 mg C^{-1} $m^{-2}d^{-1}$ in winter to 160 in summer or about 30%-50% of the gross normalized production. As an example, this corresponds to a complete biomass turnover time of about 150 d in summer for the average square meter of bay bottom containing 30 g *Thalassia* plant material.

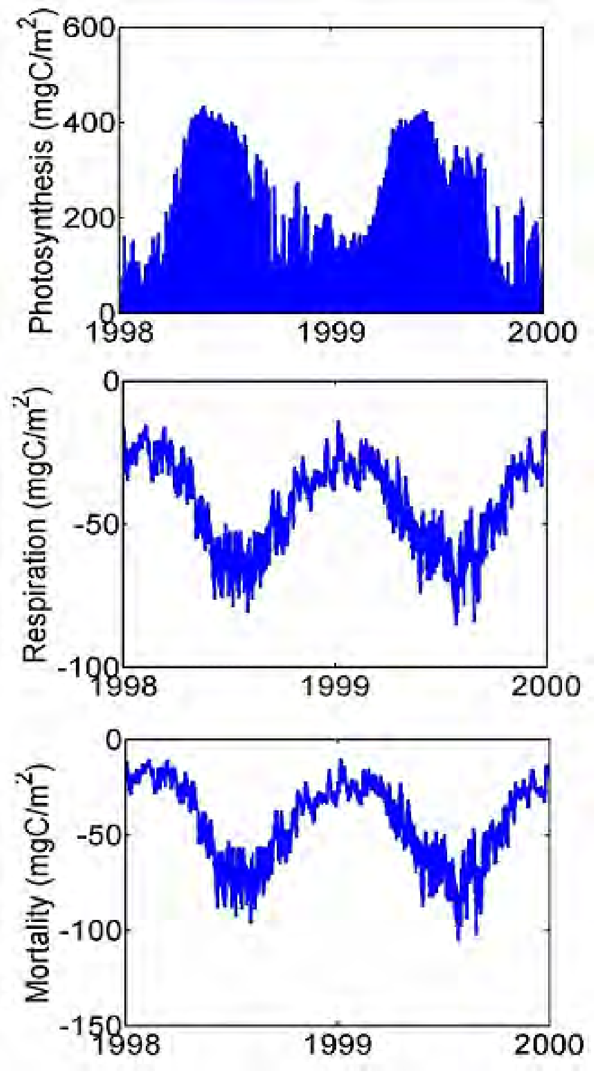


Figure 15. Internal carbon flow in a *Thalassia* bed permitting calculation of turnover time for biomass.

Model Applications

A multitude of major management and research questions can be addressed using the model. The following issues are being actively investigated for Florida Bay using the seagrass model:

- What is the appropriate salinity level, range and timing of salinity for a healthy seagrass community?
- What are the recovery periods to differential levels of seagrass loss or community change, and what salinity conditions are optimal for recovery?
- How does salinity regime affect species composition, reproduction and plant vigor?
- How will strong pulses of low-salinity water affect plant health?
- What is the effect of differential schedules of fresh water input on plant health?
- How is sediment sulfide implicated in seagrass health?
- How does the light regime affect seagrass health and species composition? Which species dominates under low and high light regimes?
- How does the nutrient regime affect seagrass health and species composition? Which species dominates under low and high nutrient regimes?
- What are the responses of epiphytes, and what are the tolerances of seagrasses to nutrient enrichment?
- How does the oxygen regime contribute to die-off?
- How might sea level rise affect the interaction of environmental factors and seagrass community health?
- What are the effects of multiple stressors: hypersalinity, hyposalinity, thermal stress, hypoxia, hydrogen sulfide, low light and interspecific competition on seagrass community health and species composition?

Two applications of the model are presented here as examples of its utility as a tool for retrospective data exploration and hypothesis testing.

Case #1: Long-Term Historical Retrospective Model Analysis

We applied the model to do 30- year retrospective simulations of seagrass trends using the calibrated model combined with salinity input from the FATHOM model's base case. FATHOM salinity output for Basin #14 (Little Madeira Bay) and Basin #15 (Eagle Key Basin) was used for the two simulation runs in the downstream reach of Taylor River outflow. FATHOM output from Basin #34, Whipray Basin, was used to run the model for an area that is relatively isolated from freshwater inflow in the central bay. Output from FATHOM Basin # 47, Trout Cove, was used to reconstruct plant dynamics for an area that receives a large volume of freshwater input from Trout Creek, but that is extremely P-limited (Fourqurean et al. 1992). This reconstructive analysis enabled the evaluation of probable effects of droughts and other low flow conditions on the seagrass community in different parts of the bay over long periods and during a time when no seagrass or salinity data were collected. The analysis enables us to provide a best estimate of seagrass biomass and composition response to historically high salinity conditions.

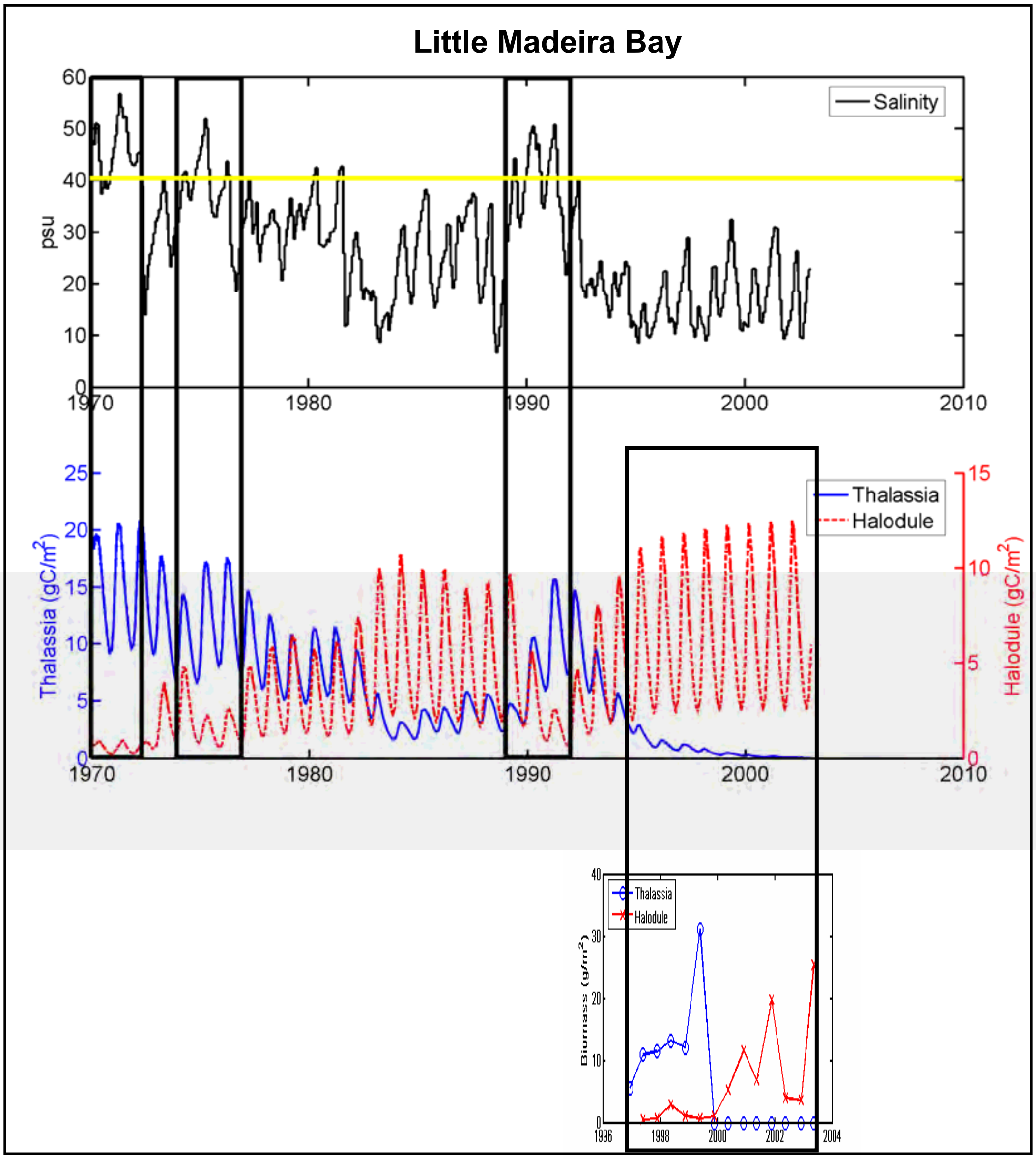


Figure 16. 30-year retrospective simulation of *Thalassia* (blue) and *Halodule* (red) using modeled salinity reconstruction (black) from FATHOM in Little Madeira Bay. Inset: Data (M-DDERM 2004) from field measurements south of Taylor River.

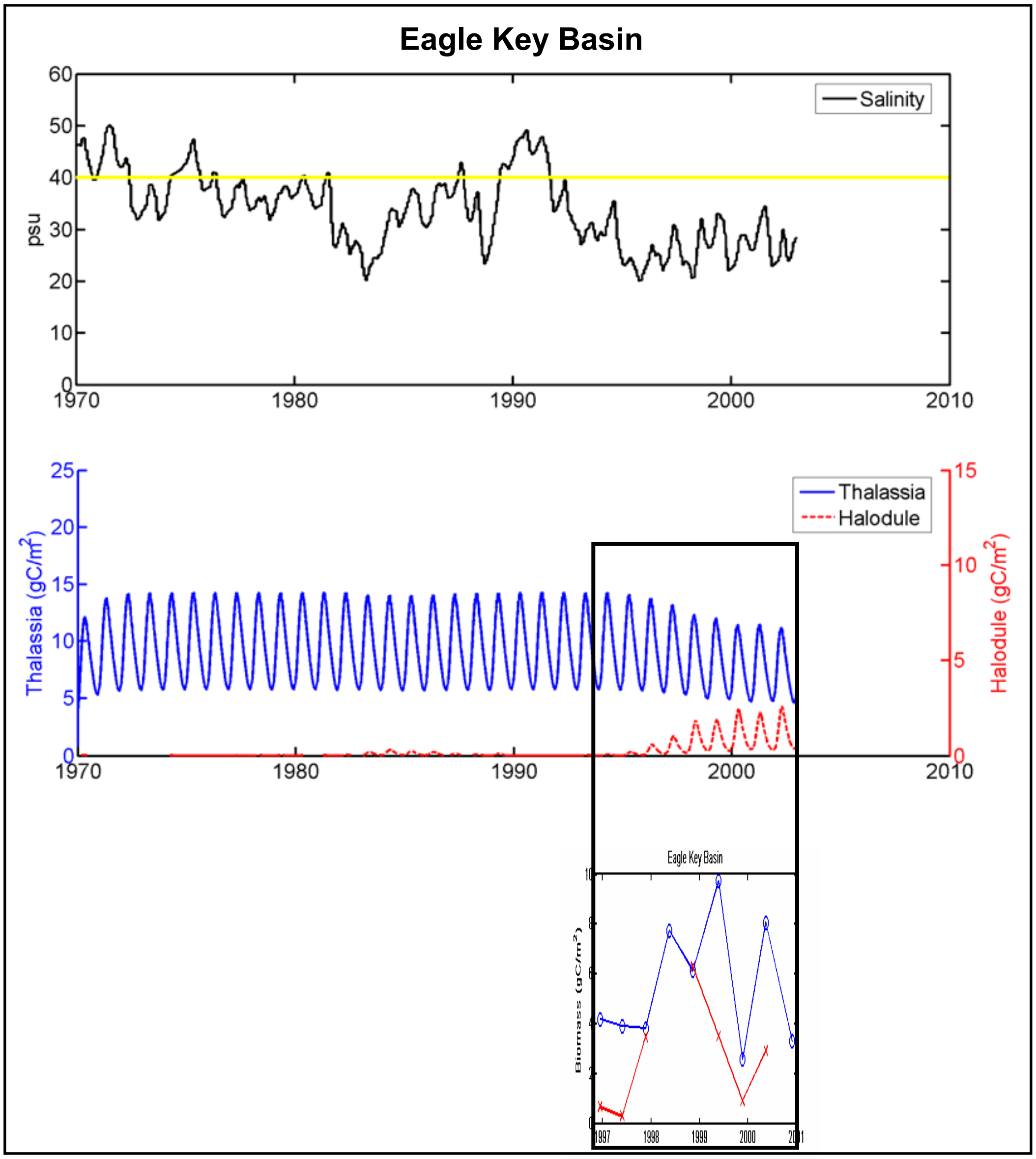


Figure 17. 30-year retrospective simulation of *Thalassia* (blue) and *Halodule* (red) using modeled salinity reconstruction (black) from FATHOM in Eagle Key Basin. Inset: Data (M-DDERM 2004) from field measurements in Eagle Key Basin south of Little Madeira Bay.

The Florida Bay seagrass model was initially used to reconstruct Little Madeira Bay (Figure 16) and Eagle Key Basin (Figure 17) SAV populations using FATHOM predictions as input salinity datafiles. Values for other environmental variables (nutrients, temperature, light) throughout the 30-year simulation were from data from 1995-2001, averaged monthly to produce a standard annual curve and repeated for each year of the 30-year simulation. The time series for salinity from the FATHOM model and biomass for *Thalassia* and *Halodule* are shown for the period 1970-2000. In Little Madeira Bay (Figure 16), three periods correspond to loss of *H. wrightii* at the inner site shown in the boxed area: (1) 1970-1971 drought, (2) mid 1970s and (3) 1989-1990 drought. In all cases, marine to hypersaline conditions prevailed for > 1 year. Note the development of monospecific *Thalassia* beds in the early 1990s at the inner site in the early 1990s and then decline in wetter years mid 1990s. At the outer site in Eagle Key Basin (Figure 17), *Thalassia* dominated the seagrass community from 1970 through the mid 1990s when a mixed bed appears during wetter period in the mid 1990s. During the simulation period, the same drought and hypersalinity conditions were evident in Eagle Key Basin, but the salinity peaks were not as extreme (none above 50 psu) nor as persistent as in the Little Madeira Bay simulation.

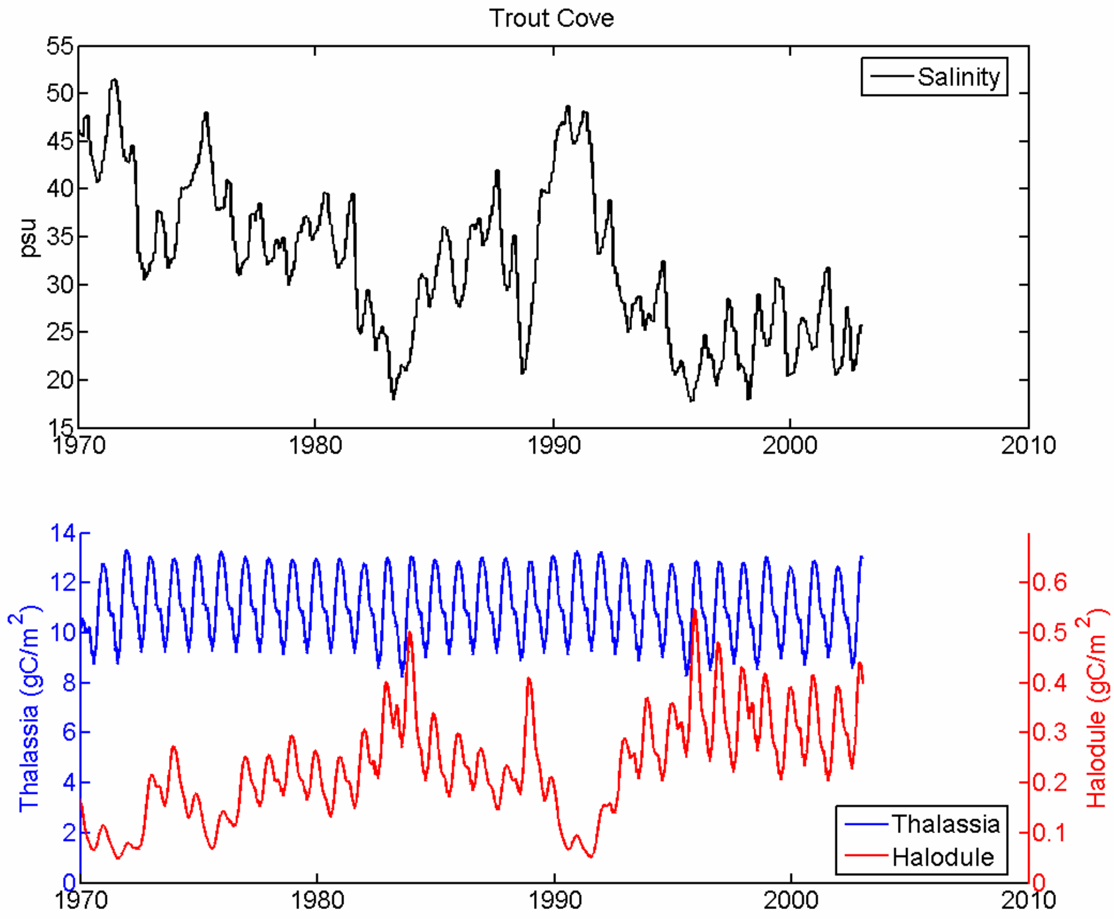


Figure 18. 30-year retrospective simulation of *Thalassia* (blue) and *Halodule* (red) using modeled salinity reconstruction (black) from FATHOM in Trout Cove.

In the Trout Cove historical reconstruction (Figure 18), higher freshwater input maintained salinities generally in the range supportive of healthy populations of both *Thalassia* and *Halodule*, resulting in a mixed community throughout the simulation. The oligotrophic nature of the water and sediments at this site is reflected in the generally lower productivity of both species. In Whipray Basin (Figure 19), salinity was generally high and more constant than in other basins. Levels of salinity were above 40 psu for prolonged periods during the 30-year simulation. This mean salinity level may be erroneously lower than the true salinities experienced in this part of the bay, as based on the data available and anecdotal information. The result was a very productive and stable mixed seagrass community.

Results from the first three of these model runs, which had highly variable salinity patterns, showed clear responses of seagrasses to salinity (boxes) as *Thalassia* became dominant during periods when salinity was elevated above 40 psu for extended periods. This dynamic differs from what would be expected based on the mesocosm experiments previously described, which indicated that *Halodule* is at least as tolerant of high salinity as *Thalassia*. This pattern was reflected in the fourth simulation, reconstructing a stable salinity regime in Whipray Basin. During the periods when salinity remained above 40 psu for two or more consecutive years at the inner Little Madeira site, *Thalassia* growth was favored at the expense of *Halodule.* Immediately following extended periods of elevated salinity, increased freshwater flow from Taylor River resulted in lowered salinities, and by the late 1990's, *Thalassia* was nearly eliminated from the Little Madeira Bay site. At the Eagle Key Basin site, about 5 km from Taylor River mouth, salinity was less variable and remained at higher levels, favoring *Thalassia* and suppressing *Halodule* growth throughout the period 1970 - 1997. Briefly during the mid 1980s, and then persistently beginning in the mid 1990s, the onset of reduced salinities corresponded with increased *Halodule* biomass at Eagle Key, resulting in the development of a mixed *Thalassia-Halodule* assemblage. The results discussed here and earlier have pointed to the importance of competitive interaction for nutrients and light between plants *in situ* and that a competitive advantage appears to be strongly influenced by salinity.

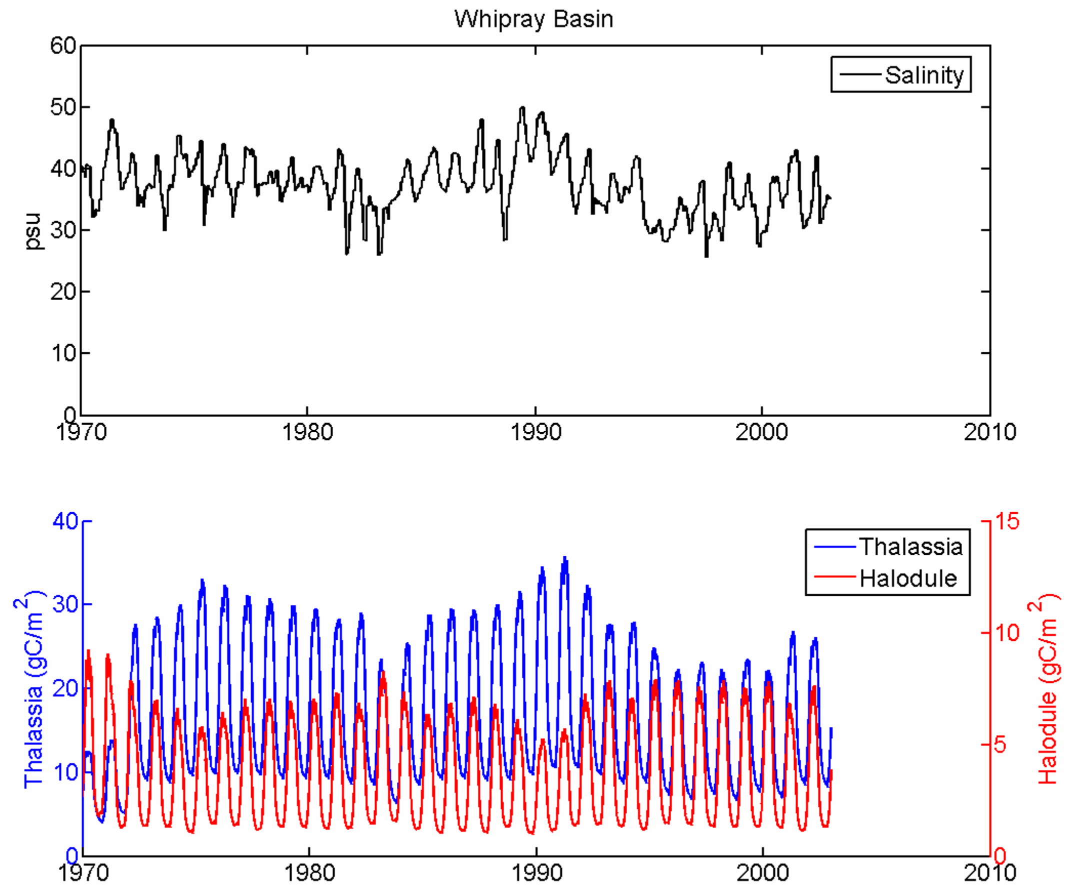


Figure 19. 33-year retrospective simulation of *Thalassia* (blue) and *Halodule* (red) using modeled salinity reconstruction (black) from FATHOM in Whipray Basin.

Because mesocosm studies demonstrated that elevated salinities alone caused internal, physiological stress in the seagrass plants- even though growth continued in the otherwise ideal conditions of light, nutrient, oxygen- we suspect that the dynamics of interspecific competition are shifted by high salinity *in situ* (and in the model), where *Thalassia* could out-compete *Halodule*, particularly for nutrients, but also for light and space. In the bay, sulfide-rich sediments and interspecific competition appear to result in cumulative stresses that could provoke a decline in the vigor of both species at elevated salinity levels (Madden et al. 2003). The model prediction is due to the reduced ability of *Halodule* to compensate for hypersalinity in the face of such multiple environmental stresses and to successfully compete with *Thalassia* for limited resources.

These modeling results reflect species composition changes of *Thalassia* and *Halodule* that have been observed in Little Madeira Bay and Eagle Key Basin. It is instructive to look at the longer term field dataset for the two calibration sites above. Empirical data for biomass, shown in the inset for both species was collected from 1997-2004 (Figures 16-17), extending three years beyond the calibration period of the model. The 30-year model run does not incorporate these data in its calibration dataset meaning that these data can be considered a validation dataset. The changes in biomass in the field, though delayed, are consistent with the model prediction at both sites. As flow increased in the late 1990s, *Thalassia* declined to zero, and *Halodule* became the dominant species in the Little Madeira site, while at Eagle Key Basin, a mixed assemblage develops.

Case #2: Multiple Stressor Evaluation

The model has been effectively used to test the response of plant biomass to individual stress and simultaneous multiple stressors, as more realistically occurs *in situ*. Simulations were performed to investigate influences of different stresses common to plants in Florida Bay on the performance of *Thalassia*: high salinity, high sulfide concentrations and elevated nutrient levels (Figure 20). For this application, stresses were applied in combination at the levels they had been applied individually. Interestingly, whereas individually neither salinity nor nutrient increases alone caused much response in the *Thalassia* growth profile, together these stresses caused a strong reduction in spring initial growth rate and the spring-summer biomass level. The model community did recover to ‘normal’ peak biomass levels by fall, but overall, annual production was reduced by half in response to elevated nutrients and salinity.

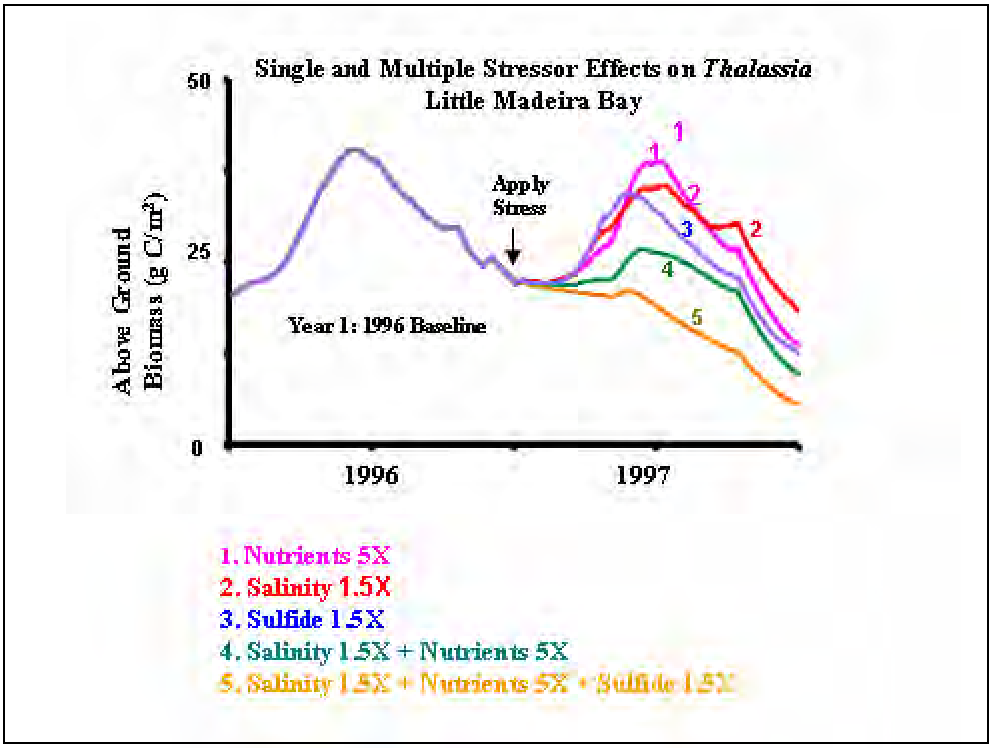


Figure 20. Single-species model scenario test of individual and simultaneous stressors on *Thalassia* growth. See text for explanation.

Application of a multiple stress condition involving elevated nutrients, salinity and elevated sulfide concentrations produced more dramatic results in the *Thalassia* growth profile. The level of nutrient ‘stress’ (inorganic N and P) applied in the model, a quintupling of baseline observed levels, has not been observed in Florida Bay. However, given the low concentrations of each of these nutrients currently measured, an increase by a factor of five is not very extreme and still places the modeled concentrations of these nutrients well below the levels commonly observed in many estuaries, and within the range that could occur under certain conditions in the bay. In fact, the nutrient treatment increased seagrass biomass slightly.

When three relatively benign stresses were applied simultaneously (run #5), biomass declined continuously from the point of stress application in January throughout the growing season, as *Thalassia* rapidly died off. Examination of processes underlying this model behavior revealed that photosynthesis, though operational, was impaired and functioning at such a low level that the net daily production was negative throughout the growing season. Interaction of the above- and belowground compartments plays a strong role in the trajectory of the seasonal biomass curve in the model. Exchanges of organic carbon and nutrients between leaf and root compartments are seasonally variable and critical for survival of submersed plants. The modeled plants can mobilize belowground resources to supplement carbon input to the aboveground compartment, should autotrophic assimilation become deficient. The amount of carbon in the root/rhizome material available for growth supplementation can control the outcome of plants subjected to stress conditions. Therefore, the status of the belowground compartment can determine the survival of the entire plant. Conversely, when conditions are unfavorable to growth, and belowground resources are depleted, the existence of aboveground plant material can mask a plant community in fragile condition. We believe that this model conceptualization is realistic and is likely close to the physiological and community behavior that occurs in the real system, emphasizing the importance of thresholds and non-linear behaviors, which can be tracked and revealed by model analysis.

Data sources and description

A large and varied set of data sources were used in developing this model, reflecting the synthetic nature of the process and the importance of creating linkages among the various research programs (Table 10). The ongoing acquisition of data will continue to require collaboration with research scientists and managers active in Florida Bay. One of the benefits of this model is its emerging role as a tool for synthesis of the myriad data types, formats and scales being sampled in Florida Bay. By continuing to locate new data sources and updating current data sources, the resolution and range of the calibration data set increases, allowing for increasingly greater confidence and accuracy in model predictions. Data included in the calibration data set are: bathymetry, salinity pattern, nutrient inputs, water column light dynamics, sediment characteristics and depth, chemistry conditions, hydrology and seagrass distributions. This database will enable calculation of conditions and seagrass distributions across representative areas of the bay.

Table 10. Data sources utilized directly or in development of the conceptual understanding and model of the bay. Sources marked by an asterisk (*) were not used directly in the model but did provide background and supporting information during model development.

Data Type and Org.	Comments and Source
Seagrass biomass and cover monitoring program. Miami-Dade DERM	As part of a monitoring program from 1996 to 2005, bimonthly assessments of seagrass cover were conducted using a modified Braun-Blanquet index as well as measurements of short shoot density and compartmentalized biomass for Biscayne Bay and northeast Florida Bay. From 2005, sampling was reduced to twice a year. Biomass data is used as calibration data for northeastern Florida Bay while the Braun-Blanquet and short shoot density data were used to determine regional differences in biomass per shoot and to develop relationships between biomass and cover.
Seagrass biomass and cover monitoring program. Seagrass cover monitoring and change analysis FHAP (Fish Habitat Assessment Program)	Sampling was done in spring and fall of every year from 1996 to 2004 of Braun-Blanquet cover analysis and short shoot density. Cores for compartmentalized biomass were taken during spring sampling. The spatial extent of this sampling is distinct from the DERM sampling with most of the sampling in central and western Florida Bay. Beginning 2005, sampling was reduced to once a year Braun-Blanquet and short shoot density, but spatial extent was increased from Biscayne Bay to the Southwest Florida coast. Coring was discontinued. Biomass data is used as calibration data for central and western Florida Bay while the Braun-Blanquet and short shoot density data were used to determine regional differences in biomass per shoot and to develop relationships between biomass and cover.
FATHOM model output of salinity distributions	The Fathom mass balance model for Florida Bay provides monthly salinity distributions for 42 basins in the bay (Cosby et al. 1999).
*PHAST Model	Fresh water flow calculations were used as inputs for the FATHOM

	hydrologic model. (Marshall et al. 2004a, b).
DERM seagrass monitoring	As part of a monitoring program from 1996 to 2005, bimonthly assessments of seagrass cover were conducted using a modified Braun-Blanquet index as well as measurements of short shoot density and compartmentalized biomass for Biscayne Bay and northeast Florida Bay. From 2005, sampling was reduced to twice a year. Biomass data is used as calibration data for northeastern Florida Bay while the Braun-Blanquet and short shoot density data were used to determine regional differences in biomass per shoot and to develop relationships between biomass and cover. (M-D DERM 2004)
Seagrass monitoring, nutrient status	Collection of seagrass nutrient composition in 2002 at FCE-LTER sites. Used to calculate C:P ratios for phosphorus uptake in model. (Fourqurean et al. 2002, 2005). LTER
Subsurface light regime data.	Measurements of photosynthetically active radiation (PAR) using spherical (4pi) sensors for bottom reading (submerged to just above substrate) and flat (2pi) sensors above water surface at 15 minute intervals from 1998-2002. Sensors are established near water quality platforms in seven basins. Light – Paul Carlson (FWCC) – daily average light on bottom (Julian day average that includes nighttime 0's) Carlson 2003. Florida Marine Research Institute.
Seagrass and epiphyte monitoring	Seagrasses were monitored for biomass and morphology and epiphyte load during the period from 1989 to 2001 for several basins across Florida Bay. This data is used in calibration of the model development and calculation of biomass to surface area ratio for *Thalassia*. Frankovich, Zieman, Bricker, Schwarzschild Univ. of VA. Frankovich and Zieman (2005).
Water quality monitoring network	Since 1990, multiple point stations throughout the bay have been sampled monthly for water quality, including salinity, temperature,

	turbidity, chlorophyll a concentration, and inorganic macronutrients. This data is used as the water column nutrient forcing for the calibration of the model. J. Boyer et al. FIU, under SFWMD contract. http://serc.fiu.edu/wqmnetwork/
*Salinity and temperature – USGS.	Mouth of Taylor River and ENP for the mouth of Little Madeira Bay platform data at 15 minute intervals which is linearly interpolated to provide instantaneous salinity. http://www.evergladesplan.org/facts_info/science_maps.cfm
Water column nutrient inputs	Mouth of Taylor River and Joe Boyer (FIU) for the mouth of Little Madeira Bay. (monthly grab samples that serve as anchor points for linear interpolation of a daily time series.)
*Water column nutrient concentrations in north and central bay	Quarterly to monthly synoptic sampling was performed by SFWMD using a high-speed mapping platform (Madden and Day 1993) to develop snapshots of salinity distributions in the bay. Madden SFWMD
Salinity at inflows	Monitoring of salinity and nutrient inputs at major flow points using permanent instrument deployments. USGS Hittle & Zucker
*Organic and inorganic nutrients	Measured from grab samples taken on a monthly basis at the platforms for monitoring salinity and flow during the time period of 1996 to 2000. After 2000, nutrient sampling at the northeastern Florida Bay sites was continued by a team from. Childers FIU
Total nutrients at inflow points	Automatic samplers at major input flows. Childers FIU
Thalassia growth	In situ chamber studies of nutrients and sediment effects on growth. Koch FAU
*Photosynthetic efficiency and stress	PAM fluorometery: in situ measurements of plant stress, efficiency, P vs I. Durako UNC-W
Thalassia biomass and growth	In situ measurements of growth, leaf elongation, tissue content Fourqurean- tissue content relative to environmental N:P, respiration rates. Madden SFWMD
*Multiple stress effects	Mesocosm studies of 3 seagrass species responses to multiple

	stresses. Koch and Durako 2005
*Seed survival	Seed germination and seedling growth and survival. Durako FMRI
Plant metabolism	Incubation of plant and community components. Madden SFWMD
*Sediment profiles of H2S, and oxygen metabolism	O2 measured the micro structure of oxygen and sulfide distribution vertically in the sediments using micro electrodes. The study was conducted at one site on two occasions. Borum et al. 2005
Epiphyte loading and light absorption	Data on the distribution of epiphyte species on Thalassia leaves and density and light absorption. Frankovich and Zieman (2005) UVA
Tissue N and P in Thalassia. Limiting nutrients.	a survey of tissue content, limiting nutrients, sediment depth, seagrass distribution, seagrass health, photosynthesis and respiration rates. Fourqurean 1992

The seagrass modeling effort is linked to, and part of, the overall Scientific Program for the Restoration of Florida Bay (Table 11), and this Program is organized around five central research and modeling areas. The importance of model linkages within the program is presented in the following tabular organization showing how the various models being developed might be integrated.

Table 11. Linkage of the seagrass model with other models to be developed for Florida Bay.

Linked Model	**Linked model output to Seagrass Model**	**Seagrass Model output to linked model:**
PHYSICAL MODEL	Velocity Turbulence & Wave energy Water depth Salinity Temperature Fetch Sediment resuspension Residence Time	Total Leaf Area Specific Growth Biomass Canopy height Shoot Density/m^2
	Light Penetration N and P	N and P uptake Productivity and turnover

WATER QUALITY MODEL	Chl *a* Light quality Turbidity Color	Stabilized sediments Sedimentation
SEDIMENT MODEL	Depth Characteristics - texture N and P Organic content	Cover Shoot Density/m^2 Below-ground biomass Redox (H_2S) Deposition OM and $CaCO_3$ Resuspension
CONSUMER MODELS	Herbivory Decreased standing crop Recruitment Migration Bioturbation Filtration	Species Composition LAI, ss/m^2 Canopy height Litter Epiphytes

Conclusion

The seagrass model project has produced an operational mechanistic dual-species unit model of the *Thalassia-Halodule* community distribution, calibrated for six representative basins in Florida Bay. Under this proposed project expansion, the model code for phytoplankton will be initially developed in STELLA, running on a desktop PC, then ported to MATLAB so as to be compatible with, and to facilitate incorporation into the existing Florida Bay Seagrass Model. Code has been ported to a FORTRAN platform for compatibility with the emerging 3-D hydrodynamic water quality model at a landscape scale to be developed for Florida Bay (Hamrick and Moustafa 2003; Cerco 2000).

The seagrass model is a proven tool in active use in the development of management strategies of the state-mandated Florida Bay Minimum Flows and Levels program (Madden and McDonald 2005; Hunt et al. 2005). The integrated seagrass-phytoplankton model will provide a powerfully upgraded tool for addressing community health and restoration issues involving water column processes and Harmful Algal Blooms (HAB). It will incorporate mechanisms for nutrient inputs and community transformations into the model and predict their outcome under a variety of natural and management scenarios. The model is actively being used to test hypotheses and alternative management strategies for Everglades and Florida Bay restoration.

Linkage of the seagrass model to a hydrodynamic transport framework, landscape model based on a geospatial platform is currently planned under an existing SFWMD project. This proposed project will leverage the incorporation of the phytoplankton module into the water quality model as well. The seagrass unit model has already been successfully integrated with higher trophic General Additive Models (GAM) to produce predictions of the density of important fish species and pink shrimp in response to habitat type and quality (Bennett et al. 2005). By integrating these bottom-up components into the model, the predictive capability of the GAM models supported by the seagrass parameters of species composition and density will be enhanced (Johnson et al. 2005).

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Appendix J

Statistical Models of Florida Bay Fishes and Crustaceans to Evaluate Minimum Flows and Levels in Florida Bay

Statistical Models of Florida Bay Fishes and Crustaceans to Evaluate Minimum Flow Levels in Florida Bay

March 10, 2005

Final Report on

Project No. OT040326

To the

South Florida Water Management District

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Statistical Models of Florida Bay Fishes and Crustaceans to Evaluate Minimum Flow Levels in Florida Bay

Darlene Johnson and Joan Browder

Introduction

PROJECT GOALS AND OBJECTIVES

Statistical models to predict the response of fish populations to changes in salinity and submergent vegetation (SAV) were developed to help the South Florida Water Management District (SFWMD) determine the minimum flows and levels (MFL) that must be retained to avoid significant harm to the Florida Bay ecosystem. The models were used to predict fish densities under scenarios of salinity and SAV related by other models to freshwater inflows for wet, dry, and mean rainfall years. Relative fish abundance under the various scenarios will be used to indicate the ecological response of Florida Bay to water management changes as reflected by other models that relate salinity and submergent vegetation to freshwater flow.

This effort was made possible by a series of models that simulated hydrologic, salinity, and SAV responses under various water management scenarios. We extended predictive power to include the response of faunal communities to water management scenarios in help ensure that biological systems will not be significantly harmed by future water management decisions. Few models have been available to predict ecological responses to proposed water management changes. This project developed a set of models to collectively provide an estimate of the response of Florida Bay's forage fish community and juvenile sportfish to changes in salinity and submerged vegetation (SAV).

The forage community in Florida Bay is a useful indicator of ecological response to changes in water management for several reasons. This group consists of small species that are easily sampled and, because they have relatively short-life cycles, respond quickly to environmental conditions. The abundance of forage species may indicate the relative abundance of the larger fish, including many sought-after gamefish, that prey upon them, but whose abundance cannot be as accurately determined.

Models of the forage species provide a means to evaluate ecological responses to salinity and SAV through correlative relationships extracted from an extensive database compiled from several studies. The models demonstrate a link between salinity and biological responses and identify salinity optima (as reflected by relative abundance) for individual species and the forage community as a whole. These models of forage fish density were developed based on four decades of historic data. The data include wet and dry periods and years of moderate conditions and provided a broadly representative baseline from which to evaluate species responses. These models examine links between seagrass communities and forage species. Because seagrass type and seagrass density were included in the models as variables, the models can be used to evaluate secondary effects on fish communities of water management and subsequent changes in salinity regime that may affect seagrass communities.

A general additive modeling (GAM) approach was used to develop models that include, as independent variables, region (northeast, interior, Gulf, and Atlantic) salinity, submerged vegetation (*Thalassia, Halodule,* and *Syringodium* density or cover), depth, temperature, Julian date, and habitat type (bank, basin, channel, island shoreline, and mainland shoreline) to predict the densities of major forage species.

Methods

STUDY AREA

Florida Bay was divided into four regions (as prescribed by the SFWMD) comprised of FATHOM basins as described by Cosby et al. (1999). The regions were- Gulf/western (FATHOM basins 38, 39, 40, 42, 43, 32), interior (FATHOM basins 22, 23, 24, 26, 27, 28, 33, 34, 35, 36, 37, 44, 41, 25), northeastern (FATHOM basins 7, 8, 9, 10, 11, 12, 15, 16, 17, 18, 19, 45, 46, 47, 13, 14) and Atlantic (FATHOM basins 20, 21, 29, 30, 31) (Figure 1). Samples were assigned to basin number from latitude/longitude using GIS.

DATA SOURCES

Table 1 shows the sources of fish and shrimp data used in this study. Faunal models were developed separately for throw-trap gear and the combined trawl and seine gears. These sets of models are referred to throughout the text as trawl/seine models and throw-trap models. The trawl and seine data were adjusted by the area that was sampled and numbers were standardized to number per hectare. The throw-trap sampled an area of 1 m^2 and data were kept in per m^2 units. Both biological and physical data were examined for obvious errors and outliers prior to analyses.

Fish data for the seine and trawl gears were obtained from Tom Schmidt (ENP), Allyn Powell (NOAA/NOS), and James Colvocoresses (FMRI/FWC). Seine data were available for the periods 1974-1976 and 1994-1997, and trawl data covered the time periods of 1974-1976, 1984-1986, and 1994-2001. Throw-trap data used in model development came from Mike Robblee (USGS) and was available from 1986-2001. Throw-trap data from Sogard (1984-1986) and Matheson (1994-1996) were used for the throw-trap model validation.

PRELIMINARY EVALUATION OF THE DATA

In order to determine which species to use as indicators, we summarized the number of the most common species by region for each gear type. Table 2 shows the ten most common species in the Robblee throw-trap data, and Table 3-6 shows the most common species by region in the trawl/seine data. The data were used to identify which species were found in northeastern and interior regions of Florida Bay (areas thought to be most impacted by water management).

Throw-trap

The major species in throw-trap samples (Robblee 1986-2003) for Johnson Key Basin included six of the nine species that were modeled in a previous study (Johnson et al. 2002a, 2002b)– *Farfantepenaeus duorarum, Lucania parva, Gobiosoma robustum, Floridichthys carpio, Opsanus beta, and Syngnathus scovelli* and made up 90% of the macrofauna. Throw-trap models (models using only throw-trap data) were developed for the six commonest forage species. Two additional throw-trap models for caridean shrimp, grouping the two major *Thor* species and the two major *Hippolyte* species, were also developed. Thus, a total of eight taxa models were developed for the throw-trap. All *Thor* were identified as *Thor floridanus* during earlier studies, and the two species were only differentiated in 1990's data (when it became apparent that *Thor manningi* is actually the more abundant species), which would prevent us from using 1980's data if we were to develop separate models. Table 7 summarizes the species composition data from Matheson and Sogard's studies from their 1999 publication (Matheson et al. 1999). Only *Hippolyte zostericola* was identified in Sogard's and Matheson's studies, suggesting they may not have differentiated the two *Hippolyte* species. Data for only 24 selected species were available in the Matheson data set). Robblee's top ten species made up 90% of Sogard's and 89% of Matheson's collections in their bank studies. Robblee's data consists of 3 habitat types- bank, basin, and near-key, whereas Matheson and Sogard's studies focused only on banks. Table 8 updates the number/m^2 by region for these species. These numbers include the additional data received from Robblee.

Table 9 shows the yearly sample size for Robblee's throw-trap data and the number of samples for the Sogard and Matheson data sets, which were used to validate models based on Robblee's data. Data records were sorted by total annual rainfall from Royal Palm so dry and wet years could be evaluated. The wettest (1995) and driest years (1986) were used as the boundaries in the models and the samples nearest to the boundaries were used for validation of wet and dry years. Table 10A shows the number/m^2 of modeled species in the throw-trap data. Table 11A shows the number of positive catches per sample for each species. The throw-trap was a more efficient gear, according to Robblee et al. (1991), and also had a higher proportion of nonzero values (positive catches), compared to the other gear. A new trawl/seine model for the code goby (*Gobiosoma robustum*) was not prepared, as it was only common in trawl samples from the interior region.

Trawl/seine

The northeastern and interior parts of Florida Bay are the areas that will be most directly impacted by changes in freshwater flow and resultant salinity. Occurrence in these areas was one criterion used to select species to model. Nine species made up 90% of the trawl catches in the northeastern region of the Bay (Table 6). Models were previously developed for six of these species (*Floridichthys carpio, Lucania parva, Eucinostomus spp., Opsanus beta, Hippocampus zosterae, and Microgobius gulosus*). Three additional species common to the NE region, *Microgobius microlepis* (banner goby), *Syngnathus floridae* (dusky pipefish), and *Anarchopterus criniger* (fringed pipefish), were added. Table 10B shows number/hectare for trawl/seine samples for each of the modeled species. Sufficient trawl data was available to model spotted seatrout (*Cynoscion nebulosus*) in the Gulf and interior regions and gray snapper (*Lutjanus griseus*) in the Gulf region. The modeling team evaluated whether to include the Atlantic region in the analyses that consisted primarily of marine and reef species other than those for species that are sufficiently abundant there, (i.e. pinfish (*Lagodon rhomboides),* mojarras (*Eucinostomus spp*.), and pink shrimp (*Farfantepenaeus duorarum*)). Table 11B shows the number of positive catches per sample for each species. The throw-trap was a more efficient gear in terms of frequency (positive catches). The inclusion of the Atlantic region did not adversely affect the model fit for any species, but rather produced a higher r^2 and so was included in all of the analyses. Perhaps the improvement resulting from including the Atlantic region was due to the expansion it afforded on the lower end of the range of densities and associated conditions. Table 12 shows the annual number of trawl and seine samples and provide information for two groupings in the NE region. Table 13 shows the samples sorted by annual rainfall.

Table 14 shows, for each gear, the mean salinity, along with standard deviation and range, observed for positive catches for each species that was modeled. Most species were collected over a wide range of salinity. The trawl/seine samples were collected over a wider range in salinities (0.5-66.6 psu) compared to the throw-trap (5-52 psu). Mean salinity was slightly less for the trawl/seine (31.5 psu) than the throw-trap (33.4 psu).

DATABASE EXPANSION AND MODIFICATION

An expanded database was prepared for model development. Faunal models were previously developed for 11 species of forage species using data from 1974-1976, 1984-1986, and 1994-1997 (Johnson et al. 2002). The database was expanded by adding trawl data for the years 1998-2001 and throw- trap data for the years 1986-2003. The expanded database increased the predictive capability of the faunal models by increasing the sampling size, expanding the salinity range covered by the data, and increasing the number of species represented in sufficient number to be modeled. The species models developed, by gear, are presented in Table 15.

Seagrass Data Treatment

Two sets of faunal models were developed, one based on data from throw-trap studies and the other based on data from trawl or trawl/seine studies. The throw-trap studies collected seagrass biomass data, and this was used as an indicator of seagrass density in the throw-trap models. Short-shoot seagrass data were collected in the trawl studies by the National Marine Fisheries Service/National Oceanographic Services (NMFS/NOS) Beaufort (NC) Laboratory. Trawl/seine studies by Everglades National Park and Fish and the Fish and Wildlife Research Institute/Florida Fish and Wildlife Conservation Commission (FWRI/FFWCC) fixed station studies did not collect seagrass density data with samples, but reported dominant vegetation types and relative densities (sparse, moderately sparse, moderate, moderately dense, and dense) of seagrass for each station. To integrate the two data types (shoot and relative density), both types of information were converted to a common index of seagrass density, the Braun-Blanquet Cover Abundance Index (BBCA) (Mueller-Dombois and Ellenberg 1974, Durako et al. 2002).

FWRI random trawl stations did not have any associated seagrass density, so a BBCA index was predicted separately for these stations.

Trawl/Seine Models

The trawl/seine models used fishery data from three studies (Schmidt, ENP, 1974-1976; Colvocoresses, FWRI, 1994-1997; Powell, NMFS/NOS, 1984-86, 1994-2001). Only the Powell study provided seagrass shoot density, so we used the Braun-Blanquet Cover Abundance index (BBCA)) to represent seagrass density in association with faunal data from all three studies.

The Everglades National Park study of the 1970's recorded seagrass density at each station as sparse, moderate, and dense. The dominant seagrass type at each station was also recorded. The SAV information was associated with a station and not a particular sample, so the data were not temporal. These data were converted to a Braun-Blanquet classification system where sparse=1, moderately sparse=2, moderate=3, moderately dense=4, and dense=5.

FWRI fixed-station seagrass density was available for each station as sparse, moderately sparse, moderate, moderately dense, and dense. Seagrass type was available for 9.6% of the FWRI fixed-station samples (all stations were sampled monthly), and we assigned, as the seagrass type for other samples, the most frequent seagrass type for that station. SFWMD personnel Amanda McDonald and Robin Bennett used a combination of the narrative site descriptions, dominant SAV type, and best judgment of SAV density in various basins to assign BBCA values for each site. They also conducted the seagrass assignments for the FWRI random sites and developed the seagrass conversions as follows.

For the 264 random FWRI stations collected in 1997, 65.3% of the samples had seagrass type information but no seagrass density information. Average 1997 shoot densities from data collected by DERM, NMFS, and FMRI (FHAP program Durako and Hall, spring only) for each FATHOM basin was used to assign seagrass density to each sample (Table 16). Shoot count was converted to BBCA value using conversions described below. For a few FATHOM basins (16, 19, 25, 45, and 46) there were no 1997 SAV samples; therefore, basin-wide averaging was done across a longer POR using only NMFS data (DERM and FMRI had no stations in these areas).

Data to develop these conversions came from the FHAP data set only because these were the only datasets containing BBCA, short shoot (SS) and standing crop (SC) data (all of which were needed to coordinate with output from the Florida Bay SAV model during the model application phase of this project). BBCA values from the DERM data set were consistently higher than those from the FHAP dataset for a given shoot data. SS to BBCA data were converted as follows:

- Halodule (baywide, did not have sufficient data to do by region):
  BBCA = 0.0642047 * Sqrt(SS)

- Syringodium (baywide, did not have sufficient data to do by region):
  BBCA = 0.0754643 * Sqrt(SS)

- Thalassia (by region):
    - Atlantic: BBCA = 0.1008254 * Sqrt(SS)
    - Gulf: BBCA = 0.1212976 * Sqrt(SS)
    - Interior: BBCA = .1105065 * Sqrt(SS)
    - Northeast: BBCA = .10010718 * Sqrt(SS)

Throw-trap Models

The throw-trap models used seagrass standing crop biomass (grams dry weight/m^2-above ground biomass only) which was collected with three of Robblee's studies (6-Basin Study (1986), 30-Station Study (every 5 years-1985, 1990, 1995, 2000), and Salinity Gradient Study (1998-2000) and Sogard's throw-trap studies (1984-1986). Vegetation information for the throw-trap database was missing only from Johnson Key study. Robblee's 6-Week Study (Johnson Key, 1985-2004) had 9 fixed stations that overlapped with the 30-Station Study, so provided vegetation biomass data for Johnson Key fixed stations for every 5 years. Seagrass biomass was missing for 81% of the Johnson Key fixed stations, which represented 61% of the total throw-trap model data. All of Sogard's samples contained associated seagrass biomass data.

Missing seagrass biomass data were imputed using the *transcan* impute program (a function in the HMISC library of SPLUS). *Transcan* is a nonlinear additive transformation and imputation function that automatically transforms continuous and categorical variables to have maximum correlation with the best linear combination of the other variables (Harrell, SPLUS HMISC Help library). Continuous variables were expanded as restricted cubic spines, and categorical variables were expanded as contrasts (i.e. dummy variables). By default, the first canonical variate was used to find optimum linear combinations of component columns. When a variable had missing values, transformed scores for that variable were imputed using least squares multiple regression incorporating optimum transformations. By default, *transcan* imputes missing values with "best guess" expected values of transformed variables, back transformed to the original scale. Imputed values are most like conditional medians, assuming the transformations make variables' distributions symmetric (imputed values are most like conditional modes for categorical variables).

Missing biomass of *Thalassia* was imputed from year, season, fixed station number, basin number, salinity, depth, and habitat type (r^2=0.78). Besides the 5-year data fixed station data, the seagrass impute model for *Thalassia* also used biomass data for Johnson Key Basin provided by Zieman and Frankovich (University of Virginia, 1991-2000). This was essential because Robblee had collected no vegetation data during the seagrass dieoff of the early 1990's. Basin number was included as an independent variable in the imputation in order to artificially assign to Johnson Key Basin some Robblee stations that actually were located slightly outside of the Johnson Key Basin so that the Zieman and Frankovich seagrass information for Johnson Key Basin would apply. Missing *Halodule* was imputed from actual and imputed *Thalassia* biomass, year, season, station number, and depth (r^2=0.30). Missing *Syringodium* was computed from *Thalassia* biomass, *Halodule* biomass, year, season, station number, basin number, depth, and temperature (r^2=0.74). Missing seagrass type was calculated from the percent of *Thalassia, Halodule,* and *Syringodium* predicted from the impute models, and the treatment was the same as calculated for the samples.

The Matheson validation data set contained shoot counts for SAV that were converted to standing crop using the below conversions. About one fifth of the calculated standing crop values for the Matheson validation data were higher than the highest value for the Robblee model data set and the maximum estimated Matheson standing crop value was 5 times higher than the maximum value for Robblee's standing crop.

- Halodule (baywide, did not have sufficient data to do by region):
  SS = 321.50546 Sqrt(SC)

- Syringodium (baywide, did not have sufficient data to do by region):
  SS = 183.74297 Sqrt(SC)

- Thalassia (by region):
  - Atlantic: SS = 100.46357 Sqrt(SC)
  - Gulf: SS = 66.867834 Sqrt(SC)
  - Interior: SS = 82.974514 Sqrt(SC)
  - Northeast: BB = SS = 66.618175 Sqrt(SC)

MODEL DEVELOPMENT

General additive models (GAM) are a relatively recent development in statistical modeling approaches but have been used in a number of ecological and fishery population studies. A generalized additive model was developed by Kupschus (2004) to describe the relationship between spotted seatrout (*Cynoscion nebulosus*) reproduction and local environmental conditions in the Indian River. The GAM approach was applied by Swartzman et al. (1992) to improve abundance estimates by using depth and temperature in trawl survey data to examine Bering Sea groundfish trends and distribution. Ciannelli et al. (2004) used the GAM's to simulate climatic effects on recruitment in walleye pollock in Alaska, while Augustin et al. (1998) used GAM's for spatiotemporal modeling of egg abundance for stock assessment of Atlantic mackerel. Clarke et al. (2003) used GAM modeling to account for bird movement relative to the ship in seabird populations, and Fewster et al. (2000) used it to account for environmental differences in analyzing population trends in farmland birds.

GAM is a nonlinear generalization of multiple linear regression. Both methods relate the dependent variable to possibly important covariates. However, in the GAM, the covariates are assumed to affect the dependent variable through additive unspecified (not necessarily linear but can be) functions. The GAM approach allows changes in abundance to be related to covariates, without restricting the functional form of the relationship (Hastie and Tibshirani 1990). An additive model extends the notion of a linear model by allowing some or all of the relationships to be linear functions of the predictors or to be replaced by arbitrary smooth functions of the predictors. The linear model is a simple case of the additive model where all the terms are linear. In this study we used the restricted cubic spline function as our designated smoother. It works well for our purposes because it performs better in the tails (forcing linearity) than other smoothers and is parsimonious in terms of degrees of freedom (for small sample sizes).

Models were run in SPLUS version 6.0. An ordinary linear model (OLS from the SPLUS Design Library) was used and the restricted-cubic spline functions algorithm was used for continuous terms. The OLS procedure fits the linear regression model using the same fitting routines used by the linear model but also stores the variance-covariance matrix and uses traditional dummy-variable coding for categorical factors. It fits unweighted models using penalized least squares and weighted additive models by backfitting. The backfitting algorithm is a Gauss-Seidel method for fitting additive models by iteratively smoothing partial residuals. The algorithm separates the parametric from the nonparametric part of the fit, and fits the parametric part using weighted linear least squares within the backfitting algorithm. The DESIGN library in SPLUS is a package of 200 linked functions written by Frank Harrell (2001) and is designed for model fitting, testing, estimation, validation, graphics, and prediction, and facilitates the regression process. Bootstrapping is included as part of many of the procedures.

Seventeen new species models were identified development with the combined trawl/seine data. These were developed for 10 of the original 11 forage species (with the exception of *Gobiosoma robustum*, the code goby) and seven additional species: *Syngnathus floridae* (dusky pipefish), *Atherinomorus stipes* (hardhead silverside), *Opisthonema oglinum* (Atlantic thread herring), *Anarchopterus criniger* (fringed pipefish), *Microgobius microlepis* (banner goby), juvenile *Lutjanus griseus* (gray snapper), and juvenile *Cynoscion nebulosus* (spotted seatrout).

Models based on throw-trap data were developed for two groups of caridean shrimps that are very abundant in throw-trap samples, *Thor spp*. (*dobkini* and *manningi*) and *Hippolyte spp*. (*coerulescens, obliquirmanus,* and *pleuracanthus*). Models also were developed for the six other species that make up 90% of the rest of the throw-trap collections, *Farfantepenaeus duorarum* (pink shrimp), *Lucania parva* (rainwater killifish), *Gobiosoma robustum* (code goby), *Floridichthys carpio* (gold-spotted killifish), *Opsanus beta* (gulf toadfish), and *Syngnathus scovelli* (gulf pipefish).

The entire data set was modeled repetitively to compare model sensitivity to various data transformations (log, square root) and to determine the best constant to use with the data (since zero values cannot be transformed to log). ANOVA (analysis of variance) was used to determine whether to assume a linear fit or use a nonlinear transformation for each continuous variable. The Design Library ANOVA tests both the linear and spline fits of a continuous variable when a natural spline function for the variable in the model is selected. The F-statistic from the ANOVA was used to rank the importance of model variables. Significance of each model variable was based on a p-value of 0.05. Insignificant variables were retained in the model except in those cases where the convergence of the model was adversely affected.

For ordinary multiple regression models, the r^2 is a good index of the model's predictive ability, especially for quantifying drop-off in predictive ability when applying the model to other data sets (Harrell 2001). R^2 can be biased, especially for small sample sizes, where over-fitting can occur. The adjusted r^2 from bootstrapping helps identify the occurrence of over-fitting and was the r^2 reported for all analyses. Harrell (2001) said that the pre-described full model (rather than the model with insignificant variables removed) is the best model to use and has the least amount of bias. The F-statistic was used to evaluate the model r^2, and determination of model significance was based on $p \leq 0.05$ of F.

MODEL VALIDATION

Model validation is conducted to ascertain whether a model is likely to accurately predict future responses on responses based on data other than that used to develop the model. Three major causes of failure of a model are over-fitting, changes in measurement methods or definition of categorical variables, and major changes in subject inclusion criteria (Harrell 2001).

Harrell (2001) described two major modes of model validation, one in which a subset of data (at least 100 observations) is excluded from the model and used solely for validation (which results in a reduction in sample size) and the other in which the data are repeatedly re-sampled (via bootstrapping, jackknifing, or some other resampling routine) to obtain nearly unbiased estimates of model performance without sacrificing sample size. Harrell (2001) commented that validation with a subset of data is frequently favored by non-statisticians but is problematic because eliminating data from the model-fitting phase results in lower precision and power. Data splitting reduces the sample size for both model development and model testing, and Roecker (1991) found this a costly approach in terms of predictive accuracy of the fitted model and the precision of the estimate of its accuracy.

We used a two-step process to validate the faunal models. In the first step, we excluded a portion of the data from the model and used it to validate the model produced from the remainder of the data. Then, based on Harrell's (2001) and Roecker's (1991) concerns about loss of predictive accuracy and power when data are removed, we recombined the data and refit the model to the larger sample. Because the model then was not identical to the one initially validated, we used Harrell's (2001) recommended bootstrapping approach to validate the final models. Recombining the validation data with the model data applied to the trawl/seine models only; in the validation process with the throw-trap data we did not combine the validation data with the data used to develop the model because the validation data were from different studies than the model data (which was not the case with the trawl/seine validation data). We did, however, perform the bootstrapping validation process with the throw-trap as well as the trawl/seine models.

In the context of model validation, bootstrapping involves repeated random sampling (with replacement) of the original data set to create data sets (at least 100 is recommended) of the same sample size for use in evaluating the performance (i.e., predictive accuracy) of the model developed from the original sample. One repeatedly fits the model to a bootstrap sample and evaluates the performance of the model on the original sample. In the simple bootstrap, the likely performance of the final model on future data is estimated by the average of all the indexes computed on the original sample (Harrell 2001). The enhanced bootstrap of Efron (1986) estimates future model performance more accurately than the simple bootstrap but in a more indirect way, described by Harrell (2001).

We used pre-determined data that had not been used in model development to validate the initial faunal models. The initial validation used at least three years (a dry year, a wet year, and an average year) of data that we excluded from the datasets used to develop the models. Each included separate dry season and wet season analyses. The wettest and driest years (based on Royal Palm rainfall) were used to develop the model (to analyze the data across the broadest range of salinity and freshwater inflow available) and the next wettest and driest years (with sufficient data) for validation. A year with rainfall closest to the mean for 1972-2002 was used for the mean validation. Table 13 shows the years that were used for the trawl validation. No validation was conducted for the seine gear, which was not used for predictions. The validation data set for the throw-trap was the bank throw-trap data from Sogard (1984-1986) and Matheson (1984-1986). The best candidate years for independent data from throw-trap sampling were Matheson's 1994 and 1995 data for the wet years (will use both due to small sample size) and Sogard's 1986 data for the dry year. Matheson had an average year in 1996 and Sogard an average year in 1984. Throw-trap data had 4-6 replicates for each site. External validation data for only the trawl was used to validate the trawl/seine models and was predetermined: 1984 was the dry year (265 samples), 1995 was the wet year (66 samples), and 1985-1986 (860 samples) and 1996 (99 samples) were average years. After validation of the initial throw-trap models, the data were added back into the data set and the models refit. Validation using the bootstrapping procedure recommended by Harrell (2001) was then conducted on final models built from the full data set. The criteria for validation of the initial models were $r^2 \geq 0.1$ and significance at $p \leq 0.1$ on the linear regressions of model predictions with validation data sets. All model r^2's given in this report represent the adjusted r^2 that was obtained from bootstrapping 100 times and represent results of the final model validation.

MODEL APPLICATION

The models were applied to evaluate the response of the forage fauna assemblage to environmental variables relevant to MFL determination. The output for individual species (or species groups) was combined for evaluations at the assemblage level because higher trophic level consumers may respond to changes in the forage base as a whole rather than change in one or two forage species. For MFL work, analysis of the effect of the duration, and timing of high salinity events was needed.

The two major habitat types in Florida Bay are the basin and bank habitats, which make up 78% and 21% of the area of the bay, as calculated in a previous study using GIS techniques (Johnson et al. 2002). While channel, near key, and mainland shoreline habitats were used in model development in order to extend the range of the physical variables to be evaluated, these areas make up about 1% of habitat area and were not used for model predictions.

Models predicted forage species density in response to varying environmental regimes including salinity, SAV densities and temperature. Only the basin habitat type was used for the trawl/seine models and the bank habitat was used for the throw-trap models. Input data for model scenarios came from a range of sources, including existing hydrologic datasets and model output from a predictive SAV model.

Assemblage Evaluation:

Model results and reporting include evaluations that aggregate the individual species' results to the assemblage level (total fish, total forage fish, and total predators). Response variables addressed in model application and discussion of results include density, species evenness, presence/absence, and biomass. Results are presented for each region.

As an index of community composition, we adapted the evenness measure to our use. As described by Krebs (1989), evenness is as follows:

$$J' = H'/H'max.$$

where H' is the Shannon-Wiener function, $H' = 3p_i \log p_i$, where $p = n_i/N$, n is the number of individuals of species i and N is the total number of individuals of all species. $H'max = \log_e S$, where S is the number of species. H'max is the maximum possible H'. We calculated this index based on the output of the models for 16 trawl/seine species and 8 throw-trap species (an index for each set of species), and S was limited to the number of models for each gear. As we have applied it, this index can only be used to compare the predicted distributions of the number of modeled species among the strata of our models and under the various conditions examined with the 16 models for the trawl/seine and 8 models for the throw-trap. It seems useful for this purpose, as we see variation that provides perspective on the influence of environmental variation on species composition, but our results with respect to this evenness measure should not be used to compare Florida Bay with other systems.

Biomass

Numbers of each species were converted to biomass using monthly median weights for each species using data from Schmidt (1970's) for pink shrimp and from Powell et al. (1980's and 1990's) for the fish species (Table 17). Caridean average biomass per shrimp was calculated from the monthly total abundance and total biomass of carideans shrimp from Biscayne Bay by Browder (June-2003-January 2004). No data were available for February-May. An interpolation developed from the relationship for the months from October/November/December (smallest size) to June/July (largest size) was used to predict average weight for February-May (Figure 2). Minimum weights (an indicator of recruitment) of select species are in Table 18.

Florida Bay Seagrass Model Scenario Initialization

Seagrass data used as input to the faunal models came from the Florida Bay Seagrass Model, which has been calibrated for four basins in Florida Bay: Trout Cove, Little Madeira Bay (site near the mouth of Taylor River), Rankin Lake, and Whipray Basin. All four calibrations had an r^2 value of >0.80 and a root mean square error of less than 10 g/m^2 for *Thalassia* above ground biomass and for *Halodule* total biomass. The base case for the scenario analysis was established using an averaged salinity, temperature and nutrient (dissolved N and P) dataset from the years 1996-2001 (the calibration period of the model) to produce a single "average year" base case input file. Salinity and temperature data are expressed as daily mean values from sub-daily measurements taken by *in situ* sensors (USGS and ENP) in each basin; water column nutrient concentrations are expressed monthly, from grab samples in each modeled basin (Florida Bay Monitoring Program). Initial *Thalassia* and *Halodule* levels were established using data from Zieman et al. (unpub), Durako et al. (unpub), and the Miami-DERM monitoring database (unpub).

The scenarios were simulated by repeating the averaged annual physical forcings (salinity, temperature, and nutrients) under the treatments described below for five consecutive years. All scenarios for all basins were initialized by running the base case for 10 years to stabilize the annual dynamics of the seagrass state variables and to remove transient effects of initial conditions on the simulations. Both *Thalassia* and *Halodule* reached equilibrium for all basins, except Trout Cove, well within the ten-year model stabilization period. For Trout Cove, *Halodule* was in decline for the duration of the ten-year stabilization runs, reflecting the actual decline in *Halodule* noted in the empirical data from that site. Nevertheless, *Halodule* was present at the end of the stabilization period for Trout Cove and all scenario runs were initiated for all modeled basins beginning at the 10-year mark, to be run for a period of 5 years.

The scenario matrix consisted of all permutations of the following salinity and salinity lags:

Salinity:

- Base
- 10% decrease in the annual salinity curve
- 10% increase in the annual salinity curve
- 30% increase in the annual salinity curve
- 10-psu increase in the annual salinity curve
- 20-psu increase in the annual salinity curve

Lags:

- Base
- 30 day lag in salinity (annual salinity curve shifted so that the peak is 30 days later)

Output (response) variables from the Florida Bay Seagrass Model included: *Thalassia* standing crop, *Halodule* standing crop in biomass in g C m^{-2} and calculated conversions of both variables to Braun-Blanquet coverage equivalents. These output variables, along with the monthly mean temperature and salinity input functions, were provided to the trophic modeling team as input to the GAM models.

Results

SUMMARY OF MODEL RESULTS

Models were developed from trawl/seine data for 17 species and from throw-trap data for eight species. Two models were produced for each of the five species in common to both gear types. All of the models were significant at a $p \leq 0.0001$. All validations of initial models were significant at $p \leq 0.05$.

Throw-trap Models

Throw-trap models were developed for eight species of forage fish and shrimp. Models were run using region (Atlantic, gulf, interior, and northeast) and habitat type (bank, basin, and nearkey) as categorical variables, and depth, Julian date, salinity, water temperature, *Thalassia* standing crop, *Halodule* standing crop, and *Syringodium* standing crop as continuous variables (Table 19). The Sogard and Matheson validation data sets were based on samples collected only in the bank habitat.

Table 20 shows the model and validation results from the throw-trap models.. Validation regressions were using separate validation data files from Sogard and Matheson. The faunal model predictions based on Robblee data were compared to Sogard's "all years", "average year" and "dry year" and to Matheson's "all years", "average year", and "wet year". In addition, a linear regression was performed between model predictions and the Robblee data used to produce the model.

In the initial validation, a linear regression was performed between the model-predicted values and the validation data sets. To provide perspective on these results, a linear regression was also performed between the observed and predicted values of the model. In most cases the regression met the criterion of $r^2 \geq 0.1$ and $p \leq 0.1$ that we defined as "adequate" (Table 20). Three of the eight species (*Lucania*, *Opsanus*, and *Thor*) performed adequately for the dry year (*Farfantepenaeus*, six if region was considered), four species (*Farfantepenaeus, Gobiosoma, Hippolyte,* and *Thor*) performed adequately for the wet year, three species (*Farfantepenaeus, Gobiosoma,* and *Lucania*) performed adequately for the 1980's average year and two models (*Farfantepenaeus* and *Floridichthys*) performed adequately for the 1990's average year. The r^2 values for the 1980's average-year predictions vs. validation data were higher for seven of the eight species. This was probably because the 1980's average-year-validation data set was nine times larger than the 1990's validation set. In general, all fits between model predictions and the validation data were improved when the categorical variable 'region' was added to the regression equation, suggesting that the linear relationships between the predictions and the validation data for the various regions, while having similar slopes, had different intercepts.

The optimism of the models, expressed as an index of optimism effects (bootstrap-adjusted r^2/unadjusted r^2), varied from 0.908 for *Syngnathus scovelli* to 0.996 for *Lucania parva*, higher values indicating the best models or models least affected by over-fitting (Table 20). The index was also high for the *Farfantepenaeus duorarum* model. We have used IO≥0.900 as the criterion for model acceptance.

The F-statistic and associated p-values for each model and the model variables are presented in Table 21. The best throw-trap models in terms of r^2 were for *Farfantepenaeus*, followed by *Lucania*. The *Farfantepenaeus* model was the most consistent model and did well for the wet and average years, but it only did well for the dry year when region was taken in consideration.

Highest faunal densities were related to reproduction and/or recruitment into Florida Bay, according to Table 18, which shows the minimum size collected in the trawl by month. Many of the species had a protracted spawning period, although the temporal pattern of predicted densities of most species suggested concentrated spawning during certain times of the year. Small individuals of *Lucania, S. scovelli,* and *Gobiosoma,* were collected through much of the year.

Ranked values derived from the F-statistic are presented in Table 22. The most important variable for five of the eight throw-trap species was Julian date. The second ranked variables were habitat (3 species), *Halodule* (3 species), depth (3 species), and salinity (3 species). *Syringodium* and *Thalassia* density ranked third (2 species). It was necessary to remove *Syringodium* from two of the models (*Floridichthys* and *Gobiosoma*) so that the models would converge. *Syringodium*, which typically grows in deeper waters than the other two seagrass species, was not common in the throw-trap samples (especially on the banks) and was found in only 6.5% of the samples. Temperature was the least important model variable.

Trawl/Seine Models

Seventeen trawl/seine models were developed (Table 13). Models were run using region (Atlantic, Gulf, interior, and northeast) and habitat type (bank, basin, channel, island shoreline, and mainland shoreline) as categorical variables, and depth, Julian date, salinity, water temperature, *Thalassia* BB index, *Halodule* BB index, and *Syringodium* BB index as continuous variables (Table 23). Braun-Blanquet values were used as indices of seagrass density in these models.

For the validation of the faunal models based on trawl/seine data, single years of data to represent a wet, a dry, and an average year were removed from the data set one at a time and the remaining data (minus whichever year of data was used for the particular validation) was used in the model to predict faunal densities to compare with the appropriate validation data. The data were then recombined to produce a model based on all of the data, which was then validated via the bootstrap method.

Four trawl/seine species validated adequately for the dry year: *Farfantepenaeus, S. floridae, M. microlepis,* and *Lutjanus* (Table 24). Ten species predicted adequately (with $r^2 \geq 0.1$ and $P \leq 0.1$) for the wet year, and nine species predicted adequately for the average year. Seven species performed adequately for two of the three validation years, and three species performed adequately for one validation year. Only two species performed adequately for all validation years: *Farfantepenaeus* and *Lutjanus*.

There were five models (*Anchoa, Atherinomorus, Hippocampus, Opisthonema,* and *Opsanus*) that did not validate with an $r^2 \geq 0.1$ for any of the validation years or predict the model data well. Three of these species (*Anchoa, Atherinomorus*, and *Opisthonema*) are schooling species that are probably difficult to quantify as their occurrence is highly patchy, and sampling them depends on the quantity of sampling within any time period; they may be present in a habitat but not collected unless sampling occurs where they happen to be. The other two species have behavioral mechanisms that may reduce their rate of capture. *Hippocampus* is capable of wrapping its tail around a seagrass blade and *Opsanus* (like the gobies) burrows in the mud and/or sand. Sheridan et al. (1997) found that, in mark-recapture studies, *Opsanus* would often remain burrowed for 5-10 minutes after water was removed from a drop net, resulting in low sampling efficiency. Gobies are also probably underestimated in sampling.

The index of optimism for the 17 faunal models based on trawl/seine data is shown in Table 24. All of the trawl models passed the test of $OI \geq 0.900$, however one model, that for *Opistonema oglinum*, was marginal. Otherwise, the range varied from 0.926 for *Atherinomorus stipes* to 0.987 for *Floridichthys carpio*.

Table 25 has the F-statistic and p-values (from ANOVA) associated with each model variable. The most important model variables as reflected in the top three ranked values (Table 26) were *Syringodium* (9 species), region (9 species), sampling depth (8 species), salinity (7 species), and the other two seagrasses, *Thalassia* and *Halodule* (6 species). The least important variables were temperature, Julian date, gear type and habitat type.

Comparison of Trawl/seine and Throw-trap Models

Models for both gears (throw-trap and trawl/seine) were developed for five species, *Farfantepenaeus, Floridichthys, Lucania, Opsanus,* and *S. scovelli* (Table 27). The higher model r^2 values for the throw-trap models for these species suggest that the throw-trap models were stronger predictors of *Farfantepenaeus duorarum* densities than the trawl/seine models. The trawl/seine models were stronger predictors of the densities of the fishes except *Opsanus beta*, which by all comparisons, was better predicted with throw-trap models.

The throw-trap models predicted the validation data for the dry year better than the trawl/seine models for *Floridichthys, Lucania,* and *Syngnathus.* The throw-trap models predicted the validation data for *Farfantepenaeus, Floridichthys*, and *Opsanus* better than the trawl/seine. The throw-trap models predicted the validation data for the 1990's average years better than the trawl/seine models for all of the species but *Floridichthys*. Six of the eight throw-trap species (75%) predicted the validation set adequately ($r^2 > 0.1$) for the dry year, seven performed adequately for the wet year, and two species performed adequately for the average year. Only the *Farfantepenaeus* model performed adequately for the wet, dry, and two average year data sets. Four (24%) of the 17 trawl/seine species (*Farfantepenaeus, S. floridae, M. microlepis,* and *Lutjanus*) validated adequately for the dry year, ten species validated adequately (with an $r^2 \geq 0.1$) for the wet year, and nine species validated adequately for the average year. Only two trawl/seine species (*Farfantepenaeus* and *Lutjanus*) predicted the validation set with an $r^2 \geq 0.1$ for all validation years.

The throw-trap is a more precise gear and has a lower variability associated with samples and because of this, under normal conditions would be the preferred gear type. However, the broader coverage in time and space of samples in which the trawl/seine gear was used and the greater number of species (including juvenile sport fish) that it collected made models based on throw-trap data better predictor over of a wider range of conditions. The use of data from both gears is vital to predicting the impact of salinity and SAV on the forage and juvenile fish community in Florida Bay.

The most important variables in the eight throw-trap models were Julian date (5 species), habitat (3 species), *Halodule* standing crop (3 species), depth (3 species), and salinity (3 species), and in the seventeen trawl/seine models: region (9 species), *Syringodium* (9 species), depth (8 species), salinity (7 species), and *Thalassia* and *Halodule* (6 species each). S*yringodium* was unimportant in the throw-trap models because it grows in deeper water than *Thalassia* or *Halodule* and was uncommon in throw-trap samples; moreover, sometimes *Syringodium* had to be removed from a model in order for the model to converge (because no positive catches were observed).

MODELS BY SPECIES

Anarchopterus criniger–Fringed pipefish

The *Anarchopterus* trawl/seine model had an adjusted $r^2 = 0.14$ (Table 24). No validation for the dry year was possible because the validation data set did not contain any *Anarchopterus*. For the wet year, a linear regression between the observed and predicted values had an $r^2 = 0.15$ and the average year had an $r^2 = 0.10$. The most important predictors for the model were region, salinity, habitat, and gear (Table 25-26). Temperature was insignificant in the model (p=0.32). Highest density was predicted in the northeast region. The model suggested a negative relationship with salinity (especially at salinities greater than 30 psu), a hyperbolic relationship to *Thalassia* BB coverage index, and a positive relationship to the BB coverage index of other seagrasses, *Halodule* and *Syringodium* (Figure 3). Highest density was in the early summer. Higher numbers were found in *Thalassia* than in *Halodule* in western Florida Bay by Sheridan et al. (1997) and Sogard (1987). Numbers were higher in the 1980’s than the 1990’s (Sheridan et al. 1997).

Anchoa mitchilli- Bay anchovy

The *Anchoa* trawl/seine model had an adjusted model r^2 =0.21 (Table 24). None of the validation years were predicted well: dry year (r^2 =0.02), wet year (r^2 =0.03), and average year (r^2 =0.09). For comparison a linear model of the observed model input data vs. model-predicted values also had a low r^2 (0.01). The best predictors were *Thalassia* BB coverage index (negatively correlated), region, salinity (negatively correlated), and *Halodule* BB coverage index (positively correlated) (Figure 4, Tables 25-26). Gear (p=0.05) and *Syringodium* (negatively correlated, p=0.03) were the least important variables. In a previous study using a subset of the data in this study, we found a strong relationship between *Anchoa* density and chlorophyll and salinity standard deviation, two variables that were not available for most of the samples in the present study (Johnson et al. 2002).

The literature is divided on the effect of salinity on the abundance and distribution of bay anchovy. The relationship is likely complex and varies by life stage. Tabb and Manning (1961) reported that bay anchovy was the most abundant fish of brackish water in Everglades National Park. Tabb and Manning (1961) and Tabb et al. (1962) noted that anchovies were dominant in trawl collections in Florida Bay, Whitewater Bays, Clearwater Pass, Oyster Bay, and the Shark River estuary, areas strongly influenced by freshwater inflow from the Everglades. The bay anchovy was the dominant species in Coot Bay, southeast Whitewater Bay, and western Whitewater Bay in low (5-18 psu) and moderate (18-35 psu) salinities (Tabb et al. 1962). This species was collected during all months in Coot and Whitewater Bays: juveniles September-November, adults March-November. Surprisingly, Clarke (1971) found reduced numbers of bay anchovies (<1 %) in a trawl study in Whitewater Bay a few years after the Tabb et al. (1962) study. Salinities (7-20-psu) were reduced during his study due to heavy rainfall during that year. In recent (2000-2001) trawl sampling, Powell (NMFS, Beaufort Lab, unpublished data) found juvenile bay anchovy were absent from the western zone of Florida Bay and abundant in the vicinity of Roscoe Key in the central Zone and in the Northern Transition Zone. In Matagorda Bay, TX, juveniles and adults were collected at 1-32 psu (Ward and Armstrong 1980). Cornelius reports juveniles from 11-40 psu in Alazan Bay, TX. Juveniles and adults have been reported to move to deeper and more saline waters as they grow (Gunter 1945; Hoese 1965; Edwards 1967; Killam et al. 1992; Pattillo et al. 1997). Hellier (1962) found that bay anchovy was the most abundant species in drop net samples (>25 mm) and fourth in terms of biomass in Laguna Madre. Salinity ranged from 18-56 psu during the study, but Hellier observed that larger individuals left the area in the summer months (when salinities were highest).

A. mitchilli is a schooling planktivore throughout its entire life history, consuming molluscan larvae and copepods (Carr and Adams 1973; Houde and Lovdall 1984; Thayer et al. 1999), and increased phytoplankton blooms could potentially contribute to *A. mitchilli* increased densities. Thayer et al. (1999) observed an increase in *A. mitchilli* between their 1984-85 and 1995-1996 samplings. They concluded that the seagrass dieoff that started in the late 1980's created an environment favoring pelagic (water column) species over demersal (seagrass canopy) species. Observations in the late 1990's caused them to reject this conclusion (A. Powell, personal communication). Salinities in the mid-1990's were lower than in the 1980's, but increased in the late 1990's, and *A. mitchilli* densities were observed to increase as salinities declined and decrease when salinities rose.

Previous statistical models developed by Johnson et al. (2002) suggested that bay anchovy were more abundant over bare bottom than vegetated bottom. Griffith and Bechler (1995) in Louisiana reported that heavily vegetated backwaters (*Ruppia maritima* and filamentous algae) were associated with reduced anchovy numbers. This was a pattern that was also observed by Herke (1971) in Louisiana, and Cornelius (1984) in Texas. Tolan et al. (1997) reported that highest larval densities were at sites without seagrass, although significant numbers were found at all sites. Rydene and Matheson (2003) found no clear relationship with seagrass density.

Atherinomorus stipes- Hardhead silverside

The *Atherinomorus* trawl/seine model had an adjusted r^2 =0.11 (Table 24). The model validation was also poor. Predicted and observed values were poorly correlated in wet and average year validations (r^2 =0.02), and the dry-year validation data set had no *A. stipes* catches. For perspective, the r2 of a linear regression of the observed model input data vs. model-predicted values also was low (r^2 =0.04). The most important variables in the model were region, salinity (positively correlated), and *Halodule* (positively correlated) and *Thalassia* BB coverage indices (Figure 5, Tables 25-26). The least important variables were *Syringodium* (p=0.95) and depth (p=0.19). The model suggested that numbers would be higher in the northeast when salinities were high; however, none were caught in the dry validation set. Catches in the seine gear were higher than the trawl. Since the trawl was the only gear in the validation data set, this probably affected the quality of the validation. *Atherinomorus* is a tropical species commonly found in the Caribbean and South America, and no information on its relationship to salinity or seagrass preferences was found.

Cynoscion nebulosus- spotted seatrout

The *Cynoscion* trawl/seine model had an adjusted r^2 = 0.11 (Table 24). A linear regression of the predicted vs. the model data also had an r^2 =0.11. The model predicted the values of the validation data sets fairly well, wet year (r^2 =0.24), dry year (r^2 =0.15), and average years (r^2 =0.18). The most important model variables were *Syringodium* and *Halodule* BB coverage indices (positive relationship), region, *Thalassia* BB coverage index (hyperbolic relationship), and salinity (negative relationship) (Figure 6, Tables 25-26). The least important variables were habitat (p=0.25) and temperature (p=0.62). Highest densities were predicted in the Gulf and interior regions. Highest numbers of fish were predicted in early summer, which coincided with reproduction (Table 18).

In Florida Bay, the spatial distribution of seatrout larvae and juveniles suggest, based on both spawning and the early life history, that spotted seatrout occur mainly in the northwestern Bay and adjacent estuaries waters (Thayer et al 1987; Powell et al. 1989, Rutherford et al. 1989). The Rutherford et al. study suggested some spawning activity in the northeastern Bay, while Thayer et al. found highest numbers in passes leading into Florida Bay. Powell (2003) reported spotted seatrout preflexion larvae at the entrance to Little Madeira Bay (at salinities as low as 12 psu), indicating spawning had also occurred in the northeastern Bay. Powell noted that, in general, larval spotted seatrout were absent or rarely collected in the eastern, Atlantic transition, and northern transition zones of Florida Bay and parts of the central zone, although larvae were consistently collected in the central zone at Whipray Basin in years of moderate salinity. Juveniles were found every month sampled except May and January, and smallest juveniles were found in Whitewater Bay in June (Thayer et al. 1987). The smallest juveniles in Florida Bay were also caught in June and July, and were associated with seagrass meadows. Larval and juvenile spotted seatrout were collected in similar areas, primarily in northwestern Florida Bay, in areas with mixed *Thalassia*, *Syringodium* and *Halodule* meadows having lush growth of *Syringodium* rather than any single monotypic seagrass type (Thayer et al. 1987).

Killam et al. (1992) reported that spotted seatrout larvae tolerate brackish water or salinities lower than seawater better than hypersaline conditions. Banks et al. (1991) noted that salinity tolerance of seatrout larvae was age-linked. Laboratory studies showed that the range of salinities tolerated by larvae spawned at 32 psu decreased initially from day 1 (4-40 psu) to day 3 (8-32 psu) but increased after day 3. For larvae spawned at low salinity (24 psu), the highest salinity tolerated decreased with time; it was 37 psu on day 1 and 27 psu on day 3. It was possible to acclimate larvae to lower salinity but not higher salinity. This suggests a parental or habitat influence on salinity tolerance in newly hatched larvae.

Brown-Peterson et al. (2002) suggested that salinities from 20-29 psu should be optimal for spotted seatrout growth, maturation, spawning, and survival of larvae, and be the least energetically costly. Powell (2003) reported collection of spotted seatrout larvae mainly at salinities between 25 and 40 psu, although larvae were collected in salinities as low as 12 psu at the Little Madeira Bay entrance.

In Florida Bay, juvenile spotted seatrout were caught in salinities 24-48 psu (Rutherford et al. 1989). In the summer, when spotted seatrout are 10-15 mm SL (standard length), they are more easily collected in shallow vegetation and grassbeds in bays and lagoons (Tabb 1966). Spotted seatrout juveniles have been collected in waters with salinities from 0-48 psu (Gunter 1945; Wang and Raney 1971; Peterson 1986; Rutherford et al. 1989a; Killam et al. 1992). Juveniles seem to prefer mesohaline and polyhaline waters where salinities range from 8-25 psu (Peterson 1986). However, Chester and Thayer (1990) reported that salinity was not a significant factor in the distribution of juveniles among sites throughout Florida Bay. However, the distribution of spotted seatrout expanded into the central and northeastern portions of Florida Bay in the 1990's when average salinities throughout the Bay were 4 psu lower (Thayer et al 1999) than during their sampling in the 1980s, when conditions were hypersaline.

Powell (2003) determined that central Florida Bay is a major spawning ground for spotted seatrout. However, bioenergetic models suggest that at salinities >45 psu survival and growth of larval and juvenile spotted seatrout could be diminished (Wuenschel 2002). Furthermore, Thayer et al. (1999) found young juvenile spotted seatrout occurred in central Florida Bay only in 1994-1995 when high rainfall eliminated the hypersaline conditions often found there. The frequency and duration of hypersaline events in the central Bay might, therefore, affect survival and growth of young seatrout and, consequently, the abundance of this species. Powell (2003) noted that densities of the postlarvae of many species collected with an epibenthic sled were higher in the central Bay; therefore, many species may be disproportionately exposed to hypersaline conditions in an otherwise favorable nursery area. However, in Laguna Madre, Gunter (1967) listed spotted seatrout as a fish normally caught in hypersaline waters based on work of Simmons (1957) and Breuer (1957) and noted that small seatrout were taken up to 60 psu. Nevertheless, hypersaline conditions may restrict the distribution of juvenile spotted seatrout in Florida Bay. Thayer et al. (1999) reported an expansion of juvenile spotted seatrout within Florida Bay during 1994-1996 and attributed the expansion to more favorable salinities and greater vulnerability of prey due to reduced seagrass densities.

Eucinostomus spp. – Mojarras

The mojarras consist of several species, but the two main species are *E. gula*, which is the most common, and *E. argenteus*. The *Eucinostomus* trawl/seine model had an adjusted r^2 = 0.327 (Table 24). A linear regression of the predicted vs. the model input data had an r^2 of 0.07. The model predicted the average year validation set best (r^2 =0.14), but the dry year (r^2 =0.02) and wet year (r^2 =0.07) poorly. The most important model variables were *Syringodium* and *Halodule* BB coverage indices, Julian date, depth, and *Thalassia* BB coverage index (Figure 7, Tables 25-26). The least important model variables were gear (p=0.12) and temperature (p=0.11). There was a positive correlation of *Eucinostomus* density to all the seagrass species. Densities were predicted to increase at salinities greater than 30 psu. Density was predicted to be lowest in the Atlantic region and highest in the interior region. Densities were predicted to be highest in the summer, corresponding to the time of the year when minimum sizes are collected (Table 18).

Weinstein et al. (1977) considered the silver jenny a permanent resident of the Florida Bay ecosystem and suggested that the species does not migrate seasonally into the open Gulf of Mexico, but several researchers have documented adults in Gulf of Mexico offshore waters and suggested they are offshore spawners (Hildebrand 1995; Springer and Bullis 1956). The occurrence of gravid females, and the collection of larvae have suggested both spring and fall spawning (Charles 1975; Powell 1993; Schmidt) Highest numbers in Florida Bay have been reported in summer and fall (Tabb and Manning 1961; Roessler 1967; Waldinger 1968)

The most common mojarra in Florida Bay, *Eucinostomus gula* (silver jenny), has been associated with higher estuarine salinities in most studies. Thayer et al. (1999) reported density in the 1990's, when salinities were reduced 4 psu, were one third that for the 1980's when salinities were higher. Waldinger (1968) reported a negative correlation of *E. gula* to salinity during some years but not others. Schmidt (1993) found mean size in the Whitewater Bay complex decreased with decreasing salinity and with distance and from the opening to the Gulf of Mexico. Similarly, peaks in abundance of Marco Island fish coincided with maximum salinity and water temperatures (Rydene and Matheson 2003).

On the other hand, at least two studies suggest that Eucinostomus is tolerant of low salinity. Serafy et al. (1997a), based on laboratory trials, categorized *Eucinostomus gula* as tolerant of rapid salinity changes (seawater to fresh). Browder and Wang (2004), based on a statistical analysis, concluded that lower salinities favored *Eucinostomus* sp. in Faka Union Bay.

At least one study suggests Eucinostomus is favored by intermediate salinities. Sogard et al. (1987) reported that, in Florida Bay, highest numbers were at stations nearest to the Gulf of Mexico followed by those closest to the Atlantic Ocean, and then, interior sites (where salinities were hypersaline during the Sogard et al. study).

Other studies suggest that there is no relationship of *Eucinostomus* to salinity. Clarke (1970) reported that there was little relation between catch rates and changes in environmental factors for Whitewater Bay fish, including *Eucinostomus* sp. Serafy et al. (2004) found no difference in *Eucinostomus* densities in Biscayne Bay between mainland sites and barrier island sites for three of the four seasons, even though there are large differences in mean seasonal salinities in the two areas (mainland always has lower salinities).

There may be size/age differences in the relationship of *E. gula* to salinity that affect consistency among observations. Serafy et al. (2004) found larger *Eucinostomus* at the barrier island sites of Biscayne Bay (>60 mm) than at the mainland sites (20-60 mm), suggesting that size classes may experience different salinities. Alternatively, the inability to distinguish between *E. gula* and *E. argenteus*, particularly at smaller sizes, may lead to observational differences among investigators or confound the results of any one investigation regarding the relationship of *Eucinostomus* to salinity.

Our models suggested that *Syringodium* and *Halodule* were more important to the silver jenny than *Thalassia*. This is supported by other studies. Kerchschner et al. (1985) reported that, in the Indian River, the silver jenny was most frequently taken in *Halodule* (size range 10-109 mm). Smaller fish were more abundant in seagrass and larger fish were more abundant near the inlet. Sheridan et al. (1997) reported that highest densities in Florida Bay were in *Halodule*, followed by mud and algae habitats, and densities were lowest in *Thalassia.* In the Indian River, Stoner (1983) also found highest density associated with *Halodule*, followed by *Syringodium*, and lowest density in *Thalassia*.

Farfantepenaeus duorarum-Pink shrimp

1.Throw-trap

The most important variables were Julian date, region, *Halodule* density, depth, and salinity (Tables 19 and 20). Habitat (i.e., bank, basin, near-key, near mainland) was the least important variable and was insignificant (p=0.75). Figure 8 shows a plot of the standardized variables. Density was highest in the Gulf region and lowest in the northeast. There was little difference in density by habitat type. Shrimp density showed a hyperbolic relationship with salinity. Shrimp density was negatively related to depth and positively related to temperature.

The model predicted both the Matheson and the Sogard validation data sets fairly well (Tables 20, 28). Wet and average years were predicted best. Dry years were not predicted well but were better when 'region' was taken into consideration.

2. Trawl/Seine

The most important model variables in the trawl/seine model were *Halodule* BB coverage index, region, depth, and *Syringodium* BB coverage index (Table 25-26). All of the variables were significant but temperature ($p=0.53$) (Figure 9). Highest density of *Farfantepenaeus* was predicted in the Gulf and lowest in the northeast. Highest densities were predicted for the three shallowest habitats: bank, island shoreline, and mainland shoreline. Gear was a significant factor, and higher density was predicted for the trawl versus the seine. Highest density was around Julian Day 300 (late October).

All of the validation years were well predicted (Table 24). The dry year had the highest correlation between observed and predicted values ($r^2 =0.37$) followed by the wet year ($r^2=0.23$) and average year ($r^2=0.14$).

3. Comparison of Trawl/seine and Throw-trap Models

Both models performed well and validated fairly well (Table 27). The throw-trap model had a higher adjusted r^2 than the trawl/seine model (0.42 vs. 0.27). In the dry year validation, the throw-trap model linear regression between predicted and observed values ($r^2=0.42$) outperformed the trawl/seine ($r^2=0.39$). In the wet year, the throw-trap was better ($r^2=0.62$) than the trawl/seine ($r^2=0.16$). Predictability was similar for the two throw-trap validation average years ($r^2=0.43$ for Matheson and $r^2=0.43$ for Sogard), which were higher than for the trawl/seine average year validation ($r^2=0.25$). The predicted relationships between density and the physical variables were also similar. Both model types predicted an optimum salinity around 30 psu.

Laboratory survival studies of pink shrimp in relationship to salinity suggested that optimum salinity for pink shrimp was 30 psu (Browder et al. 1999, 2002). Juvenile pink shrimp have occurred in salinities ranging between 0 psu and 70 psu in Florida Bay and other south Florida waters with highest abundance from 25 psu to 40 psu and in temperatures from 11^{o} C to 40^{o} C (Tabb et al 1962a; Tabb et al 1962b; Costello et al 1986; Robblee et al 1991; Robblee unpublished data). Large shrimp (28-32 mm CL) may exhibit a preference for higher salinities, 25 to 45 psu (Tabb et al 1962a). Costello et al (1986) suggested that maximum recruitment and survival, but not necessarily optimum osmoregulation, occurred during periods of highest salinity in Florida Bay and adjacent waters. Highest juvenile densities at salinities were reported from 30 psu to 50 psu in Florida Bay (Costello et al. 1986; Tabb, as cited in Costello and Allen 1970). In Johnson Key Basin, western Florida Bay, where a 16-year record of juvenile pink shrimp annual peak abundance exists, lowest peak annual shrimp abundance has occurred in 2 of 3 years when basin salinities were above 40 psu (Robblee et al 1991; Robblee unpublished data).

The effects of temperature and salinity on pink shrimp should be evaluated together. At low temperatures, all shrimp species have difficulty adjusting to changes in salinity. Survival rates are higher at moderate to high salinities under conditions of low water temperatures (Williams 1960). In the laboratory Browder et al. (2002) found survival was low at high (>45 psu) and low (<15 psu) salinities, especially at low temperatures. Conditioning did not improve survival at low salinities. Survival showed a strong salinity-temperature interaction. Postlarvae and juvenile pink shrimp can survive in waters having a wide salinity range (e.g. 12-43 psu and 0-70 psu, respectively, Tabb et al 1962a), although the optimum salinity range is narrower and relatively high compared with those of white and brown shrimp (Gunter 1961; Gunter et al 1964). Dall (1981) concluded that nursery ground selection is unlikely to be related to a salinity optimum determined by osmoregulatory ability. In the laboratory, Browder et al (2002) established for juvenile pink shrimp that optimal growth occurred at 30 psu although the response curve of survival was broad and nearly flat between 20 psu and 40 psu. Juvenile production and potential harvests from regions of Florida Bay were simulated using these laboratory developed salinity-temperature relationships and observed daily temperature and salinity. These simulations predicted that juvenile production and potential harvests might differ among years, seasons and regions of Florida Bay based solely on observed salinity and temperature (Browder et al, 2002).

Laboratory experiments (Hughes 1969a; 1969b) suggest that the mechanism used by postlarvae and juveniles to discriminate between the tides is based on respective responses of postlarvae and juveniles to changes in salinity. Postlarvae drop to the substrate and become inactive in response to decreasing salinity thus avoiding displacement out of the estuary by the ebb tide; postlarvae reenter the water column on the flood tide with rising salinities moving into the estuary. In contrast, juvenile pink shrimp, which are positively rheotactic (swim into the current), will switch and swim downstream when they sense salinities are decreasing, thus ensuring that they will be moved out of the estuary by the ebb tide. The salinity pattern in Florida Bay is typically that of a marine lagoon (broad marine salinities throughout), however, within the wet/dry cycle in south Florida the Bay ranges between two extremes, a positive estuary (increasing salinities toward the Gulf of Mexico) in extremely wet years and a hypersaline lagoon (negative estuary, increasing salinities eastward into the bay, hypersaline central bay) during severe drought (Fourqueran and Robblee 1999). Because, migration is facilitated by salinity-based cues (Hughes 1969a, 1969b), Florida Bay might operate more effectively as a nursery ground for pink shrimp when it acts as a positive estuary (salinity gradient with lower salinity towards shore and higher salinity offshore). The negative salinity gradient that occurs in the bay when it is in a hypersaline state might disrupt both postlarval immigration and juvenile recruitment to the offshore fishery.

The association of juvenile pink shrimp with seagrass suggested in this study has been observed (Hildebrand 1955; Tabb et al. 1962b; Costello et al. 1986; Hudson et al. 1970; Eldred et al.1962; Idyll and Yokel 1970). Seagrass is critical for providing shelter and foraging habitat (Fry et al. 1999). Higher densities of pink shrimp are associated with seagrass habitats rather than algal, red mangrove prop root or non-vegetated habitats (Sheridan 1992). The geographic distribution of pink shrimp may follow closely the distribution of seagrasses according to Hoese and Jones (1963), who noted that there are no pink shrimp fisheries near areas where seagrasses are rare or absent. Seagrass die-off in Florida Bay is thought to have impacted the Tortugas shrimp fishery (Fourqurean and Robblee 1999). The spatial pattern of juvenile pink shrimp abundance in Florida Bay coincides with the distribution and development of the seagrass community (Robblee et al 1991; Costello et al 1986; Holmquist et al 1989; Zieman et al 1989), although the distribution of pink shrimp may also reflect gradients of environmental conditions such as salinity and temperature as explored with modeling by Browder et al. (1999, 2002) or larval accessibility

Both the throw-trap and trawl/seine models for pink shrimp confirmed the importance of *Halodule* and agreed with Costello et al. (1986), who postulated that postlarval pink shrimp actively select shoal grass habitat in preference to turtle grass habitat for initial settling. Costello et al (1986) characterized optimum habitat for early juvenile pink shrimp as relatively open marine water circulation with daily tidal exchange, and extensive intertidal or subtidal beds of shoal grass with high blade density. Eldred et al. (1962) reported that in inshore waters, small juvenile pink shrimp were near shore in beds of *Halodule* and large juveniles were in deeper waters in *Thalassia*. Sheridan et al. (1997) reported that pink shrimp were irregularly related to plant type, but their table of shrimp density on banks (which includes Sogard 1987) suggests higher densities in *Halodule* compared to *Thalassia* for the 1980's and 1990's. They stated that densities of pink shrimp were significantly greater in moderately dense and dense seagrass cover than sparse cover. In our models, there was no significant difference in density between sparse and moderately sparse or moderate seagrass densities.

Floridichthys carpio- Gold-spotted killifish

1. Throw-trap

The most important variables in the throw-trap model were depth (negative correlation), Julian date, salinity (U-shaped correlation), and habitat type (Tables 19 and 20). The least important variables were *Halodule* (p=0.31) and *Syringodium* (p=0.25). Figure 10 shows a plot of the standardized variables. The full throw-trap model showed little difference between habitat types.

The model predicted the Matheson validation data set well for all years (r^2 =0 .18) and average years (r^2 =0 .23) but poorly for the wet years (r^2 =0.09) (Tables 20, 29). The Sogard validation data set was poorly predicted for average, dry, and wet years.

2. Trawl/seine

The *Floridichthys* model had the highest r^2 of all of the trawl/seine models, r^2=0.445, and also the highest index of optimism (Tables 24, 29). However, the model predicted its own data poorly (r^2 = 0.01). The model predicted the dry year validation poorly (r^2 = 0.01), but did better for the wet (r^2 = 0.11) and average (r^2 =0.18) years. The most important variables in the model were region, depth, and salinity (U-shaped relationship) (Figure 11, Tables 25-26). The least important model variables were *Halodule* (p=0.20) and gear (p=0.10). Smallest sizes were collected in July (Table 18) while highest numbers were predicted by the model to occur around Julian date 250 (~beginning September; Figure 11).

3. Comparison of Trawl/seine and Throw-trap Models

The trawl/seine model r^2 was higher than that for the throw-trap model (Table 27). In model validations, both models performed better for wet years and neither did well for dry years. Average years were predicted well for the trawl/seine model and the Matheson throw-trap. Both the trawl/seine and throw-trap models suggested similar responses of *F. carpio* density to depth, Julian date, and salinity. Neither model found strong effects of seagrass density. Trawl/seine models suggested that the northeast region had higher densities and the Atlantic lower densities, while the throw-trap model suggested lower densities in the Gulf. The trawl/seine models predicted higher densities in the bank and mainland shoreline habitats and lowest densities in the basin habitat.

Lorenz (1997) reported that *F. carpio* was among the most abundant species collected in the coastal dwarf mangroves of the southern Everglades. He later classified this species as polyhaline (18-30 psu) based on the mean salinity (2-31.5 psu) for 30 days prior to sampling (Lorenz 2000). Sheridan et al. (1997) reported that mean densities of *F. carpio* on banks were lower in *Thalassia* than other vegetation types.

Gobiosoma robustum- Code goby

The throw-trap *Gobiosoma* model predicted the wet years best (Tables 20, 30). However, the dry years were not predicted well. The best predictors were region, habitat, Julian date, and *Thalassia* and the least important predictors were *Syringodium* (p=0.95) and salinity (p=0.04) (Tables 19 and 20). Predicted numbers were highest in the interior and gulf regions and lowest in the northeast region (Figure 12). While not significantly different, predicted densities were highest for the basin habitats and lowest for near-key habitats. Optimum salinities were 35-45 psu. A peak in numbers of fish was associated with *Thalassia* standing crop of around 60 g/m2. There are differences in patterns of abundance as to salinity, temperature, and Julian date, which may suggest changes in habitat utilization. Our findings disagree with Stoner's (1983) who found *G. robustum* only abundant in *Syringodium* compared to other seagrasses in the Indian River. Our models predicted that *Thalassia* was the most important seagrass and *Syringodium* was unimportant.

G. robustum has been characterized as an annual fish that spawns year-round with peak spawning in May. Sexual maturity is achieved within only a few months (Pattillo et al. 1997). Our models suggested that numbers rise in the spring, peaking in late May. Pattillo et al. (1997) suggested based on a review of the literature that, although adults are found from 2-38 psu, this species seems to prefer intermediate to moderate salinities (22-32 psu). Our model in contrast predicted that optimum salinities were 35-45 psu, but salinity was the least important variable in our models. Sheridan et al. (1997) reported that the abundance of *G. robustum* (western Florida Bay) was never related to plant type. The Pattillo et al (1997) review of the literature suggests that *G. robustum* is found in a variety of shallow-water habitats, especially *Thalassia* beds, but is uncommon in deep habitats. However, in a comparison of *Halodule* and *Thalassia* meadows in Redfish bay, Texas, *Gobiosoma* was reported as one of the commonest fish in deeper turtlegrass meadows (Huh 1984). Kulcycki et al. (1981) found a significant relationship between Gobiosoma and drift algae biomass. Schofield (2003a) found that *Gobiosoma* was more abundant in seagrass than bare areas in the field and in laboratory experiments. Rydene and Matheson (2003) found that highest densities of *Gobiosoma* in the Little Manatee River were in dense vegetation and also related to the amount of drift algae at a site. In experiments with salinity tolerance, Scofield (2003b), according to plotted percent survival with elapsed time) found strong but latent intolerance (less than 10% survival within ~144 hours and stable thereafter) of *Gobiosoma* to rapid salinity decreases to 0 psu, and a more rapid but less intense response (~50% survival within 24 hrs and stable thereafter) to 60 psu.

Hippocampus zosterae- Dwarf seahorse

The *Hippocampus* trawl/seine model was one of the poorer models (r^2=0.10) and did not validate well (r^2 = 0.04-0.05) (Table 24). The most important model variables were *Thalassia* and *Syringodium* density, depth, and salinity (Table 25-26). The least important variables were temperature, which was not significant (p=0.65), and *Halodule* (p=0.03). The model predicted higher densities in the northeast and interior regions and lowest densities in the Atlantic region (Figure 13). Densities were positively correlated with *Syringodium* and *Halodule*. Density showed a hyperbolic relationship with salinity and with *Thalassia* density (highest fish density at moderate seagrass density). Highest densities were captured around island shorelines and in the summer. Smallest individuals were collected from May-September (Table 18). Rydene and Matheson (2003) reported that densities in Tampa Bay were highest in dense and moderate seagrass.

Hippolyte spp.- Caridean shrimp

The *Hippolyte* throw-trap model validated the wet year well but performed poorly for the average or dry years (Tables 20, 31). The most important model variables were *Syringodium,* depth (hyperbolic with an optimum at 100 cm), *Halodule,* and habitat (Table 19 and 20). The least important, but still highly significant, variables were temperature (p=0.0002) and salinity (p=<0.0001). The model predicted lowest densities in the northeast and highest densities in the Atlantic regions (Figure 14). The basin habitat was predicted to have highest densities and the near-key habitat the lowest. Density was predicted to be lowest in the summer with spring and fall peaks.

The model suggested a negative correlation with salinity and temperature. Highest catch/m^2 (from the raw data) was in the Gulf region (21.3/m^2) and lowest (3.0/m^2) was in northeast region (Table 9B). Holmquist et al. (1989a, 1989b) noted an increase in hippolytids at their northeast site following a rise in salinity from 24 to 30 psu.

Hippolyte density was positively correlated with all seagrass species densities. Sheridan (1992) reported that *Hippolyte* densities in Rookery Bay were higher in seagrass habitats compared to open water or adjacent flooded mangrove habitat (none were collected in the mangrove habitat) at salinities from 31-37 psu. In another study in western Florida Bay during the period of 1990-1993, Sheridan et al. (1997) found higher numbers in *Thalassia* beds and lower numbers in *Halodule* beds than what was caught by Sogard et al. (1987) during the period of 1984-1985.

Lagodon rhomboides- Pinfish

The *Lagodon* model was the second best trawl/seine model with an r^2 = 0.38 (Table 24). The model predicted its input data with an r^2 =0.13. It validated adequately (similar to model data) the wet (r^2 =0.16) and average validation years (r^2 =0.14), but did poorly for the dry year validation (r^2 =0.02). The best model variables were *Syringodium* (positive relationship), region, depth (negative relationship), and *Thalassia* (positive relationship) (Table 25-26). The least important variables were temperature (p=0.07) and Julian date (p=<0.0001). The model predicted lowest catches on banks and highest around island and mainland shorelines (Figure 15). Highest densities were predicted in the Gulf and lowest in the interior and northeast regions. Trawl catches were higher than seine. A positive relationship was predicted for all seagrasses. A bimodal peak in density was predicted with a dip in the summer. Minimum size was taken in January (Table 18). Abundance was positively related to salinity, with density increasing with salinity particularly above 30 psu.

Serafy et al. (1997a) categorized *L. rhomboides* as tolerant of rapid salinity changes (seawater to fresh). Nelson (1998) reported that young-of the-year pinfish (in a study of Tampa Bay, Charlotte Harbor, Choctawhatchee Bay, and Santa Rosa Sound) are found in seagrass beds <3.5 m with smallest fish in shallower areas and movement to deeper waters as they grew. Highest abundances were in bays dominated by *Halodule*. Pattillo et al. 1997 described *L. rhomboides* as euryhaline, tolerating salinities from 0-43.8 psu. Vegetation rather than salinity is thought to have a greater affect on its distribution (Weinstein 1979). However, Cameron (1969b) reported that when heavy rains reduced salinity to 4 psu, juvenile abundance decreased in a shallow seagrass bed. A positive correlation was reported between abundance and salinity by Subrahmanyam and Coultas (1980). Adults have been reported to prefer higher salinity waters (Wang and Raney 1971). Browder and Wang (1988) found that the abundance of *Lagodon* in Faka Union Bay was correlated over time with the surface area of the bay between 24-27 psu.

Lucania parva- Rainwater killifish

1. Throw-trap

In the *Lucania* throw-trap model, all of the variables were significant at $p \leq 0.0001$ (Table 19). The most important variables were depth (negative correlation), *Syringodium* density (positive correlation), salinity (U-shaped), and *Thalassia* density (positive correlation, Tables 19-20). Figure 16 shows a plot of the standardized variables. In general, in model validation (taking region in account), the best predictions were for the dry year, followed by the 1990’s average year, and 1980’s average year (Tables 20, 32). All years had an r^2 greater than 0.1.

2. Trawl/seine model

The *Lucania* model was the third best trawl/seine model in terms of explained variance (r^2 =0.37, Table 24). The correlation between the observed model data and the predicted had an r^2 = 0.10. Taking region into account, the model predicted the dry year validation set poorly (r^2 = 0.05), but predicted the wet year (r^2 =0.2) and the average year (r^2 =0.34) fairly well. The best model variables were density of *Syringodium* and *Thalassia* (positive correlations), habitat, and depth (negative correlation) (Table 25-26, Figure 16). The least important variables were *Halodule* (p=0.69) and temperature (p=0.06) and salinity (p=0.02). Density was negatively related to salinity. Smallest sizes were collected in March-May and November, which suggests either a bimodal spawning peak. The model suggested bimodal peaks in abundance in early winter and fall (Figure 16).

3. Comparison of the Trawl/seine and Throw-trap Models

While both models had higher r^2 values (compared to other species), the trawl/seine model was better explained by the set of variables (Table 27). Both models also predicted the model input data adequately. Both models predicted the validation sets for wet and average years adequately, but only the throw-trap validated the dry year adequately ($r^2 > 0.1$). The relationship of density to salinity in the two models seems at first glance to show an opposite effect. The throw-trap model had a stronger and positive relationship to salinity than the trawl/seine model, which seems to have a negative relationship to salinity. However, the trawl/seine model data extends to nearly zero psu while the throw-trap model data starts at about 10-psu. A U-shaped curve seems more probable with lowest densities around 30 psu. Both gear models show a positive relationship to *Syringodium* and *Thalassia*. The throw-trap model suggests a positive relationship to *Halodule* where the trawl/seine model predicted no relationship. However, next to temperature, *Halodule* was the second least important variable in the throw-trap model. The trawl/seine model predicted higher densities in the northeast region, while the throw-trap model did not. However, throw-trap samples in the northeast region were underrepresented. Both models suggest lowest densities in the Atlantic region. The data for the throw-trap was more limited in time and space and may not have collected *Lucania* in the northeast during peak periods. The model predicted moderate numbers at mainland shoreline habitats.

Matheson et al. (1999) suggest that the life history of *L. parva* (small size at maturity, 23 mm or less than 2 months, year around spawner) makes it well suited to function as an opportunistic species that can rapidly colonize hypersaline environments where they occur. Serafy et al. (1997a) categorized *L. parva* as intolerant of rapid salinity changes (seawater to fresh). However, Lorenz (1997) reported that *Lucania* was the most abundant species caught in upstream sites of Florida Bay at salinities from 0.5-28 psu, and classified *Lucania* as oligohaline. Jordan (2002) reported that *Lucania* in the St. Johns River estuary was positively correlated with salinity as long as vegetated habitat was available, but not correlated to plant biomass or water depth within an area. The importance of seagrass as protection from predators was emphasized by previous investigators. Sheridan et al. (1997) reported that mean densities were always higher in *Thalassia* beds than in *Halodule,* algae, or mud patches. Both models suggested that depth was very important in our study (in the throw-trap model it was the most important variable). Submerged seagrasses were also very important. Our models predicted that Lucania had a U-shaped distribution with lowest distribution at 30 psu but high densities at low and high salinities. Serafy et al. (1997a), however, classified this species as intolerant of salinity variation when they observed mean abundances higher at stable salinity sites and found a 50% mortality rate when subjected to a 2-hour rapid pulse event where the salinity changed from 33 to 0 psu. What this seems to indicate is that the *L. parva,* while intolerant of freshwater or rapid freshwater pulses, probably still has the ability to tolerate a wide range of salinities and is able to colonize areas that have been subject to these extremes (both high and low), where potential competitors and predators are excluded. Crawford and Balon (1994) consider *Lucania parva* a small r-selected species that produces many low quality eggs (little yolk investment). They observed that it reproduced year-round. They also stated that while it is able to tolerate full seawater, it loses its competitive advantage and may even, because of its small size, be subject to high predation rates in full seawater.

Lutjanus griseus – Gray snapper

The L*utjanus* trawl/seine model was only for juvenile stages. The model variables did not explain the variance well and this model had one of the lower r^2 values (0.12) (Table 24). The model output data did not fit well with its input data (r^2=0.05). However, the model validation was better, close to the model r^2, for the dry year (r^2=0.10), wet year (r^2=0.10), and average year (r^2=0.10). This apparent discrepancy may be due to the fact that the model predicts trawl data well but not seine data and the validation data sets were only for the trawl. The most important model variables were *Syringodium*, depth (negative relationship), *Halodule,* and habitat (Tables 25-26, Figure 18). The least important variables were temperature (p=0.0028) and Julian date (p=<0.0001). *Lujanus* density was positively related to all of the seagrasses. Higher densities were found in the trawl and in the Atlantic and northeast regions. Density increased as salinity increased to an optimum (around 35 psu) and decreased slightly thereafter.

There is no evidence of spawning within the Bay for this species. The presence of large juvenile gray snapper in July and August in northwestern Florida Bay (Hettler 1989, Starck 1970) but the absence of larvae and small juveniles suggests that gray snapper in northwestern Florida Bay may be recruited from adults spawning in June-July over reef areas south and east of northwestern Florida Bay (Powell et al. 1989). Thayer et al. (1987) reported catching juveniles during 1984-1985 in every sampling trip with largest numbers in September, March, and May, suggesting that spawning may occur in late spring and extend into the fall. Rutherford et al. (1989b) suggested that reefs off the middle and lower Florida Keys probably supply much of the recruitment. McIvor et al. (1994) stated that enhanced recruitment occurs in years of higher salinity in Florida Bay.

Authors are divided on the most importance of submerged vegetation and physical habitat for gray snapper. Rutherford et al. (1989b) reported that numbers (combined for two studies) were higher in the basin habitats than in channels. Most successful catches were in *Halodule* and *Syringodium*-dominated grassbeds. On the other hand, in a cluster analysis by Thayer et al. (1987), gray snapper were grouped with fishes taken in large numbers in the northwestern part of the Bay associated with channels in areas where mixtures of S*yringodium* and *Thalassia* or *Syringodium* and *Halodule* were prevalent. These authors suggested that smaller juveniles used seagrass beds and larger juveniles were more characteristic in channels in the southeastern Bay that contained mixtures of *Thalassia* and *Halodule*. Thayer et al. also suggested that the channels might be the only suitable habitat (open areas contain sparse monotypic *Thalassia*) for larger juvenile gray snapper in the bay besides the mangrove prop root habitats.

Gray snapper juveniles in Florida Bay were taken at salinities 8-44 psu (mean =35.6 ± 2.2 psu (95% confidence intervals)) in 1973-1976 and 23.7-48 psu (mean=32.6 ± 2.1 (95% confidence intervals)) in 1982-1984 (based on 12 fish; Rutherford et al. 1989b). Thayer et al. (1987) reported that juveniles were taken in greatest numbers in higher salinity areas in the western bay, with only two collected in the low salinity stratum. These findings agree with the model predicted optimum salinity of 35 psu.

Rutherford et al. (1989a) found gray snapper density to be highest during the season of highest rainfall each year, but they did not find a correlation between high rainfall years and gray snapper production. They suggested a 3-year lag between rainfall (or water levels) and catch rates. They reported that recruitment levels of 1-year-old fish were inversely correlated with water levels in Taylor Slough marshes. They suggested that, during low rainfall years and higher salinity conditions in the estuaries, sub-adult fish might remain within the estuaries longer.

Microgobius gulosus- Clown goby

The *M. gulosus* trawl/seine model was one of the better models with an r^2=0.36 (Table 24). The model predicted the model data adequately (r^2=0.14) and the validation data for the wet and average years. It did not predict the dry year well (r^2=0.01). The best variables for the model were salinity (negative correlation), habitat type, *Thalassia* BB coverage index (negatively correlated), and region (Table 25-26) and the least important were *Halodule*, *Syringodium*, and temperature. Highest numbers were predicted for the interior and northeast regions (Figure 19). Schofield (2003) reported that, in the field, *M. gulosus* was most abundant in bare mud but appeared to prefer seagrass in laboratory experiments. Laboratory experiments with and without the presence of *Gobiosoma robustum* suggested that aggression from the larger goby species may discourage *M. gulosus* from using seagrass habitat in the field (Schofield, pers. comm.). Rydene and Matheson (2003) found in Little Manatee River using a long-haul seine and roving dropnet, that highest densities of *Microgobius* were in dense vegetation and were significantly related to drift algae cover in the seine gear. However, Duffy and Balz (1998) also found this species more abundant in seagrass areas over bare substrate.

In comparing the salinity responses of *M. gulosus* and *G. robustum*, to abrupt changes in salinity, Schofield (2003b) (according to plots on graphs) found that mortality (as reflected in percent surviving) at 0 psu was more immediate than that of *G. robustum* but less drastic. On the other hand, mortality at 60 psu was both immediate and greater (survival less than 10%) for *M. gulosus*. These survival results relative to salinity support the reported contrasting distributions of *M. gulosus* and *G. robustum* in Florida Bay.

Microgobius microlepis- Banner goby

The *M. microlepis* trawl/seine model had an r^2=0.13 (Table 24). The model did not predict the model input data well. Although it predicted the dry year (r^2=0.16) well, it performed poorly in the wet and average years. The best variables in the model were region, salinity (negative correlation), depth, and temperature (Table 25-26). The poorest model variables were *Syringodium* (p=0.61), *Thalassia* (p=0.08), and gear (p=0.12). The model predicted higher densities in the interior and northeast regions especially along mainland shorelines (Figure 20).

Opisthonema oglinum- Atlantic thread herring

The *Opisthonema* model was the worst model (r^2=0.08) (Table 24). It did not predict itself or any of the validation sets well. The most important model variables were *Thalassia*, habitat, and *Syringodium* (Tables 25-26). The worst variables were temperature (p=0.74), salinity (p=0.25), and *Halodule* (p=0.15). The model predicted a negative relationship with seagrasses (Figure 21). No distinct relationship was observed with salinity. Paperno et al. (2001) characterized *Opisthonema* near Ponce de Leon Inlet as a species associated with higher salinity. *Opisthonema* was not used in any of the scenarios due to the poor model fit. This species is a schooling species with a patchy distribution, which probably makes its density difficult to estimate or correlate with habitat variables.

Opsanus beta-Gulf toadfish

1. Throw-trap

Opsanus beta density was not strongly predicted by the model variables in the throw-trap model, which had an r*2* =0.12 (Table 18). The most important variables were *Thalassia* density, salinity, Julian date, depth, and *Syringodium* density (Table 19 and 20). The weakest variables were habitat (p=0.0064) and temperature (p<0.0001), although both were highly significant. Figure 22 shows a plot of the standardized variables. The model performed adequately predicting the 1980's validation data (dry and average years (Table 20, 33). The 1990's validation data (wet and average years) were not well validated. The dry year was best predicted by the model. Smallest fish were collected in May (Table 18). The model suggested a peak in abundance around the end of May (Figure 22).

2. Trawl/Seine

The *Opsanus* trawl/seine model had an r^2=0.12 (Table 24). It did not predict the model input data well or the validation data. The most important variables were *Syringodium*, gear, Thalassia, and region (Tables 25-26, Figure 23). The least important variables were *Halodule* (p=0.14) and Julian date (p=0.07). A positive relationship was found with Syringodium and a positive relationship was found with *Thalassia* up to moderate seagrass densities where it leveled off or declined slightly. Density was positively correlated with salinity up to an optimum of 30 psu and declined thereafter. Smallest fish were collected in May (Table 18). The model suggested a broad mid-year peak in abundance (Figure 23).

3. Comparison of the Trawl/seine and Throw-trap Models

The two models had similar model r2 values (0.12), but the throw-trap model performed better (especially when region was considered) when predicting the model input data and the validation sets, especially the wet and dry years (Table 27). Both models predicted bank habitats with higher fish densities, which may explain why the throw-trap (with more data on banks) performed better. Both models predicted similar responses to depth, and seagrass. The two models differed in their predicted response to salinity. The throw-trap model predicted an even distribution from 20-35 psu with an increase in density thereafter, while the trawl/seine predicted no change or only a slight increase to about 30 psu and a decline thereafter. The input data of the trawl/seine model has a broader salinity range (0-60 psu) than the throw-trap model (10-50 psu). The trawl/seine model may be more realistic because its input data extended beyond 50 psu, and sharp declines in *Opsanus* densities were noted between 50 and 60 psu. The throw-trap models had baywide samples for only several years in contrast to trawl/seine models that had baywide data for all years.

Serafy et. al. (1997a) reported that *O. beta* was tolerant of fresh water pulses and found that abundance was higher in areas with higher salinity variation than in areas with more stable salinities. Serafy et al. (1997b) reported densities of *O. beta* in all vegetation types, with slightly higher densities in *Thalassia* than *Halodule* vegetation in Biscayne Bay, although density was also related to a north-south distribution (higher in the southern bay). Sheridan et al. (1997) also reported mean densities of *O. beta* were significantly higher in *Thalassia* beds than in *Halodule*. Sogard et al. (1987) reported abundance in Florida Bay was related only to *Thalassia* density, not total seagrass shoot density. Serafy et al. (1997a) reported that *O. beta* related to *Thalassia* biomass, while Matheson et al. (1999) reported increases in the benthic predatory *O. beta* when the above ground standing crop of lush seagrass meadows declined. Our models predicted that *Opsanus* density was related to *Thalassia* (and *Syringodium*) density. Trawl/seine models predicted, however, that moderate seagrass densities were optimal for this species. Salinity variability was not a component of our models, however we might have expected that the distribution of *Opsanus* would not be restricted by the highly variable salinities in northeastern Florida Bay. Other factors, such as sparse seagrass coverage in the northeastern bay, would be the more likely inhibit abundance there.

Relationships to variables may be masked by seasonal movements of *Opsanus*. Serafy et al. (1997b) found changes in seasonal abundance by site in Biscayne Bay, and suggested that cool season increases of toadfish in shallow *Thalassia* beds may reflect a seasonal movement of reproductive individuals to these areas (where the males create nesting sites and sing to attract females). Perhaps the dense seagrass prevents burrowing in the substrate of this species, while seasonal (winter) declines in seagrass coverage in shallow seagrass areas provide a place both where mating burrows can be dug and vulnerability to predators is reduced. This species may be subject to high predation by diving birds, dolphins, and sharks (Schmidt 1986; Barros 1987; Cummings 1987).

Syngnathus floridae- Dusky pipefish

The *S. floridae* trawl/seine model had a model r^2=0.22 and predicted the model data with an r^2=0.15. However, the validation sets were predicted very well for both the dry (r^2=0.30) and wet (r^2=0.33) years (Table 24). The average year was predicted poorly (r^2=0.08). The most important variables were *Syringodium*, region, and depth (negative correlation) (Tables 25-26, Figure 24). The least important variables were temperature (p=0.15) and *Halodule* (p=0.0002). The model predicted higher densities in the gulf and northeast regions. Fish density was positively related to all of the seagrass densities. Density showed a hyperbolic relationship with salinity with an optimum at about 30 psu. Density was predicted to be lowest in the spring with highest numbers in the summer and fall.

Syngnathus scovelli- Gulf pipefish

1. Throw-trap

The model r^2 for *Syngnathus scovelli* was 0.11 (Tables 20, 34). The model predicted the model data poorly (r2=0.09). The wet and average validation data were predicted better than the model input data by the models (r^2=0.20 and 0.25 respectively). In general, the model poorly predicted the dry year validation data. The most important model variables were Julian date, habitat type, *Halodule* standing crop, and *Thalassia* standing crop (Tables 19-20, Figure 25). The least important variables were *Syringodium* standing crop (p=0.29), temperature (p=0.13), and depth (p=0.08). The model suggested a positive relationship with *Halodule* and *Thalassia* and a negative relationship with salinity.

2. Trawl/seine

The *S. scovelli* trawl/seine model had an r^2=0.23 (Table 24). The model predicted the model data at less than 0.1. The model performed well in predicting the wet (r^2=0.24) and average (r^2=0.16) validation years but not the dry year (r^2=0.06). The best model variables were depth (negative correlation), *Halodule*, and salinity (negative correlation), and the poorest model variables were Julian date (p=0.16) and habitat (p=0.0003) (Table 25-26, Figure 26). In general, the model predicted a positive relationship with *Halodule* and *Syringodium* and a negative relationship with salinity. Smallest fish were collected in spring and fall (Table 18). The model suggested that densities increased until July (Figure 26).

3. Comparison of Trawl/seine and Throw-trap Models

The *S. scovelli* trawl/seine model (Table 24) performed better than the throw-trap model (Tables 20, 34). Both models suggested highest densities around shoreline habitats. Both models also suggested higher densities in the Gulf and interior regions. The best predictors in the throw-trap models were the least important in the trawl/seine models (Julian date and habitat). The annual pattern in densities differed between the two models as the throw-trap model suggested peak abundance around 130 Julian day (spring) but the trawl/seine model suggested a 200 day (summer) peak. Minimum-size data suggests that smallest sizes occur in both seasons (Table 24). In both gear models, densities had a negative relationship to depth. The trawl/seine model suggested a sharper slope in the relationship of density to depth than the throw-trap model, perhaps because this gear samples much deeper areas. Both gear models suggested that densities were related to seagrass density, although the trawl/seine model suggested a hyperbolic relationship to *Thalassia*. *Syringodium* was not an important variable in the throw-trap model.

Sheridan et al. (1997) reported that *S. scovelli* on banks was most abundant from April-June in Florida Bay, similar to findings from our models. In the Indian River, they were most abundant in the spring during spring/fall sampling (Tremain and Adams 1993) and during the summer during seasonal sampling (Brown-Peterson et al. 1993). In Alazon Bay, Texas, Dokken et al. (1984) reported, based on larvae collections, that spawning occurred in summer and fall, but they did not collect larvae in the winter.

Highest densities in the Laguna Madre (Texas), Indian River, and Florida Bay have been reported in *Syringodium* and *Halodule* (Tolan et al. 1997; Stoner 1983; Sheridan et al. 1997). Several studies in the Indian River have found them positively associated with drift algae biomass (Snelson 1980; Kulczychi et al. 1981; Rydene and Matheson 2002). A shift in habitat may occur seasonally or by life stage. In Laguna Madre, Tolan et al. (1997) found that in winter and fall, densities were higher in *Syringodium*-dominated/mixed seagrass beds (compared to *Halodule* or unvegetated sites), but in the summer, highest numbers were in *Halodule*. Sheridan et al. (1997) reported that they are found in *Thalassia* and in mud habitats. They were reported absent in mangrove areas of Florida Bay (Sheridan 1992; Lorenz 1999). Ley et al. (1999) reported catching them in the northeast part of the Bay, but they were not one of the dominant species of this area.

S. scovelli has been reported common in fresh to hypersaline waters up to 45 psu (Whatley 1962; Simmons 1957; Roessler 1967). An isolated population has even been reported from Lake St. John, a freshwater lake 150 miles inland from the Louisiana coast by Whatley (1962; 1969) and has been found in the St. Johns River in northern Florida (McLane 1955). In a survey by Carter et al. (1973) of the Ten Thousand Islands/Fakhatchee Strand, they were reported in four habitats that include beaches and adjacent bays, tidal streams, and tidal canals, but they were not found in freshwater canals or freshwater lakes. Quast and Howe (1980) reported the brood pouch osmolality is regulated near the osmolality of the father through incubation, perhaps to protect developing embryos from osmotic extremes. This allows the larvae to develop efficiently in any aquatic environment acceptable to the adults.

In the Indian River, Snodgrass (1992) reported that *S. scovelli* density was determined by (in order of importance) vegetation biomass, depth, dissolved oxygen, pH, and salinity. Rydene and Matheson (2003) reported that in the Little Manatee River, *S. scovelli* density was highest in a seagrass habitat with moderate to dense seagrass and significantly more individuals were collected when drift algae cover was present. Clark (1970) reported that abundance was higher in higher salinity areas and that the most important variables in predicting abundance were runoff, temperature, rainfall, and vegetation.

Thor spp. – Caridean shrimp

The *Thor spp.* was the third best throw-trap model in terms of r^2 (0.20) (Tables 20, 35). However, the model predicted the model data poorly (r^2=0.04). The model predicted the wet and dry year validation data better than the model data (Table 18). Both average validation years were predicted poorly (even when taking in account region). All of the model variables were significant but the best, in order of importance, were: habitat, *Syringodium*, *Thalassia*, and *Halodule*, which suggests the importance of vegetation (Tables 19 and 20, Figure 27). Highest predicted densities were in the early part of the year when the smallest carideans are found, suggesting that abundance was related to reproduction (Table 17).

Holmquist et al. (1989) found *Thor* densities were lowest in the northeast sites and highest in the Gulf sites of Florida Bay. Based on 1980's data from Sogard et al. (1987) and bank sampling for the 1990's, Sheridan et al. (1997) reported that mean densities of *Thor floridanus* on banks were higher in *Thalassia* beds than in *Halodule*. They reported that 1990-1993 densities were higher than 1984-1985 densities.

Scenarios

Summary

Trawl/seine and throw trap models predicted outcomes of 12 scenarios. Including the baseline scenarios, there were six scenarios with a lag and six without a lag. The lagged scenarios shifted the annual salinity curve 30 days later in the year, approximating a change in the seasonal timing of the salinity pattern. The output of the SFWMD seagrass model provided the input to the trawl/seine and throw-trap models. There were 16 species-specific trawl/seine models (*Opisthonema oglinum* was not used in the trawl/seine scenarios because the model was so poor) and eight throw-trap models that were developed in this project. The models were used to predict the response of forage species at two sites in the Northeast region and two sites in the Interior region.

The base scenario was simulated as the average salinity and temperature conditions for the years 1996-2001 (the calibration period of the seagrass model) to produce a single "average year" base case input file. The same salinity and temperature curves were used as input to both the SAV and forage fish models. SAV and forage fish model predictions were made for July and October for year 1 and January, May, July, and October for years 2 and 3. The 90% scenario refers to a 10% decrease in the annual salinity curve. The 110% scenario refers to a 10% increase, and the 130% scenario refers to a 30% increase in the annual salinity curve. The 10-psu scenario refers to a 10 psu increase in the annual salinity curve and the 20-psu scenario refers to a 20 psu increase. The lagged scenarios shifted the annual salinity curve 30 days later in the year.

Changes are described in the text as follows:

- small refers to changes less than 50%
- major refers to changes from 50% to 150% (about double)

- huge refers to changes greater than 200% (triple or more)

Besides output for individual species responses and total abundance of all species, several groupings were made to determine trophic response. Three species (*Cynoscion, Lutjanus,* and *Opsanus*) are predatory even as juveniles and were grouped together in a predator category. The rest of the species were grouped together in a forage species category. Total biomass for each species was calculated from average weight per individual by month multiplied by the predicted abundance (Table 17). Total biomass was estimated by summing the total biomass for each species.

The trawl/seine models predicted more dramatic and consistent changes for the majority of species than the throw-trap models. Data used for the trawl/seine models covered a wider range of conditions and were more evenly distributed throughout Florida Bay than the throw-trap models, where at least 84% of the data came from for the Gulf region (most of it from Johnson Key; Table 8).

Of all the scenarios, the greatest changes were predicted in the 20-psu scenario, which was the most extreme scenario in terms of salinity change. Of the 16 trawl/seine model species, dramatic declines were predicted from this scenario for eight species in Rankin Lake, six in Whipray Basin (both interior region sites), and seven species in both northeast region sites, Little Madeira Bay and Trout Cove. The number of species that increased in density in the interior salinity reduction scenarios was less than in the northeast scenarios. Thirteen species declined dramatically in at least one site in the 20-psu scenario, including *Anarchopterus, Anchoa, Atherinomorus, Cynoscion, Eucinostomus, Farfantepenaeus, Floridichthys, Hippocampus, M. gulosus, M. microlepis, Opsanus, S. floridae,* and *S. scovelli*. Small declines were also predicted for *Lucania* and *Lutjanus* in at least one scenario. *Lagodon* was the only species that did not exhibit a definite decline, however at two sites, there were both increases and decreases (from the baseline) depending on the season.

Total SAV (standing crop) increased with salinity at the two northeast sites, but at the interior sites, SAV increased up to the 130% (30%-increase in salinity) scenario, but declined in the 10-psu and 20-psu scenarios. However, both 10-psu and 20-psu SAV levels were still higher than the baseline. Total SAV increases were due to increases in *Thalassia*, as *Halodule* decreased. Highest seasonal seagrass densities predicted from the trawl/seine scenario were, from highest to lowest - Whipray Basin (86.6 g/m2, 130% scenario), Little Madeira Bay (69 g/m2, 20- psu scenario), Rankin Lake (55.3 g/m2, 130 scenario), and Trout Cove (43.3 g/m2, 20-psu scenario). Maximum predicted change in total seagrass density (maximum value minus highest predicted in the baseline scenario) was Whipray (30.8 g/m2), Little Madeira Bay (20 g/m2), Rankin Lake (13.2 g/m2), and Trout Cove (5 g/m2). Total SAV decreased in the 90% (10%-decrease in salinity) scenario, although *Halodule* was predicted to increase. The Braun-Blanquet Cover Abundance index that was used for the throw-trap models showed similar patterns for *Thalassia* and *Halodule*.

The eight species throw-trap model group gave a slightly different response in the 20-psu scenarios. Two species were predicted to decline drastically in Rankin Lake, two in Whipray

Basin, four in Little Madeira Bay, and three in Trout Cove. Large decreases in *Farfantepenaeus, Floridichthys, Hippolyte,* and *S. scovelli* were predicted for at least one site. Small decreases were predicted for *Gobiosoma* in one region in the 20-psu scenario. *Lucania* and *Thor* showed both increases and decreases depending upon the season. *Opsanus* was the only species that did not exhibit a decrease in this scenario. Major increases in total abundance were predicted at all sites (except at Little Madeira which had mixed results-higher abundance than the baseline in the spring and lower than base abundance in the winter and summer). Major declines in overall fish/crustacean biomass were predicted for the northeast sites.

In the 10-psu scenario, there were major predicted declines in trawl/seine model predictions for five species in Little Madeira Bay, three species in Trout Cove, seven in Whipray Basin, and five in Rankin Lake. A decline was predicted for all species in at least one site. Twelve species were predicted to decline drastically (major or huge as defined above) for at least one site. These species were *Anarchopterus, Anchoa, Atherinomorus, Cynoscion, Eucinostomus, Farfantepenaeus, Hippocampus, M. gulosus, M. microlepis, Opsanus, S. floridae,* and *S. scovelli*. Small declines were also predicted for *Lagodon, Lutjanus, Lucania,* and *Floridichthys*.

In the 10-psu scenario using the throw-trap models, there were four predicted species' declines in the northeast sites, and two species' declines for the interior sites. Five species were predicted to decline dramatically at least at one site; these species include *Farfantepenaeus, Floridichthys, Gobiosoma, Hippolyte,* and *S. scovelli.* Major increases were predicted for *Farfantepenaeus* and *Gobiosoma* at the northeast Little Madeira Bay site (small increase for pink shrimp at Trout Cove sites) but major declines were predicted at the interior sites. Highest predicted salinity in this scenario for the Little Madeira Bay site was 32.5 psu compared to the baseline of 22.6 psu. This scenario brought the predicted salinity closer to the optimum salinity (as defined by relative abundance in the models) of these two species (~30 psu and 38 psu respectively). Neither species was found to be common in the raw data at the northeast site. Major increases were predicted for *Opsanus* at all sites. Substantial (major and huge) declines at all sites were predicted for *Hippolyte*. Major declines for *Floridichthys* were predicted at the northeast sites, but major increases at the interior sites. Small declines for *Lucania* were predicted at the northeast sites but major increases were predicted at interior sites. Similarly, small to major declines for *S. scovelli* were predicted at the northeast sites, but small increases were predicted at the interior sites. *Thor* had little change at the northeast sites, but a predicted increase at the interior sites.

In the 130% (30% increase) scenario using the trawl/seine models, there were no major predicted declines in the northeast sites (although there were small declines). There were four species in Rankin Lake and five species in Whipray Basin in which major declines were predicted. All sixteen species were predicted to decline in at least one site. Six species that were predicted to exhibit notable declines at one of the sites were *Cynoscion, Farfantepenaeus, M. microlepis, Opsanus, S. floridae,* and *S. scovelli.* Small declines were also predicted for *Anarchopterus, Anchoa, Atherinomorus, Hippocampus, Lutjanus, Floridichthys, Eucinostomus, Lagodon, Lucania,* and *M. gulosus.*

In the 130% scenario using the throw-trap models, there were no major changes predicted for the northeast. Small declines were predicted for four species. In the interior, there were two major predicted declines in the interior sites, *Farfantepenaeus* and *Hippolyte*. Major increases were predicted in at least one interior site for *Floridichthys, Lucani*a, *Opsanus*, and *Thor*.

In the 110% (10% increase) scenario *M. microlepis* at Whipray Basin was the only species to exhibit considerable change from baseline trawl/seine scenarios. Small declines were predicted for all species in at least one site, with the exception of *S. scovelli*. Decreases at the four sites ranged from 8-11 species. Increases at the four sites ranged from 1-5 species.

Throw-trap model predictions for the 110% scenario included no major changes from baseline conditions for any species. Small declines were predicted for *Floridichthys, Hipploye, Lucania* (only Madeira Bay), and *S. scovelli* at the northeast sites and small declines in *Hippolyte* and *Farfantepenaeus* were predicted at Whipray Basin. No declines were predicted for Rankin Lake, only increases.

In the 90% (10% reduction) scenario using the trawl/seine models, there were more predicted increases than decreases for all sites but Whipray Basin. The number of species that increased was greatest at the northeast sites. However, most of the increases were small, except for a major predicted increase in *M. microlepis* in Whipray Basin. There was one predicted major decline, *Lucania* in Whipray Basin. All species were predicted to increase in at least one site except *Lutjanus,* which did not change.

In the 90% scenario using the throw-trap models, two species were predicted to increase and two species were predicted to decrease in the interior sites. In the northeast, four species increased and decreased at Little Madeira Bay and three increased and one decreased at Trout Cove. No major changes were predicted. Decreased salinities were predicted to benefit *Floridichthys, Hippolyte, Lucania,* and *S. scovelli* in the northeast sites and *Hippolyte, Farfantepenaeus,* and *S. scovelli* in the interior sites.

In the northeast scenarios, predicted total abundance from the throw-trap models was constant in all scenarios except there was an increase in the 20-psu scenarios for Trout Cove. Total throw-trap abundance was heavily dominated by *Thor spp.* In the trawl/seine models, there was a predicted decrease in abundance in all of the northeast salinity increase scenarios. Trawl/seine total predicted abundance was heavily dominated by predicted numbers of *Eucinostomus spp.* In the interior scenario, predicted total abundance for the throw-trap models was constant for the 90% and 110% scenarios, and increased progressively in the salinity increase scenarios. Trawl /seine models predicted small decreased abundance in the interior sites for all salinity increase scenarios and an increase in the 90% scenario.

Biomass decreased in the northeast for all throw-trap scenarios except the salinity reduction scenario (which remained constant), indicating that increased salinity leads to an increase in smaller species (as abundance went up) and a decrease in average size. Small decreases in forage fish biomass were also predicted from the trawl/seine models. In the interior, the predicted biomass from the throw-trap models suggested a progressive increase with salinity (no change in the 90% and 110% scenarios). The trawl/seine forage assemblage also was predicted to increase in number in Whipray Basin. Rankin Lake biomass did not change in any scenario but the 20-psu, where it increased. Predator biomass was predicted to increase with increased salinity in the northeast and decrease in the interior in the trawl/seine models.

In the salinity reduction scenario (trawl/seine models), evenness was predicted to decrease in both northeast sites and Rankin Lake (Whipray no change). Decreased evenness was predicted for the interior sites and increased evenness was predicted for the northeast sites (except a decline in the 20-psu for Trout Cove).

Across all throw-trap scenarios, average confidence intervals on predictions were smallest for *S. scovelli, Opsanus,* and *Gobiosoma* and greatest for *Thor, Lucania* and *Hippolyte*. Confidence limits were somewhat related to predicted density. Thor and Lucania had the highest predicted densities and broadest confidence intervals and *S. scovelli, Opsanus*, and *Gobiosoma* had the smallest predicted densities and smallest confidence intervals. *Hippolyte* did not fit this pattern. The northeast sites had lower predicted values and smaller confidence limits than the interior sites for most species, except for *Hippolyt*e, which was predicted to be higher with broader confidence limits and *S. scovelli*, for which confidence intervals were similar for the two regions.

Across all trawl/seine scenarios, average confidence intervals were smallest for *Cynoscion, Lutjanus, M. microlepis,* and *Anchoa* and greatest for *Eucinostomus, Floridichthys,* and *Lucania*. Like the throw-trap, the magnitude of the confidence interval was also related to density. *Opsanus* was an exception with very low predicted densities but large confidence intervals from trawl/seine models, unlike those from the throw-trap models.

Northeast Region

Huge to major declines in one or more of the northeast sites were predicted for *Anchoa, Anarchopterus, Cynoscion, Eucinostomus, Floridichthys, M. gulosus*, and *S. scovelli* in the trawl/seine models for the 20-psu scenario. Huge declines in *Floridichthys* and *Hippolyte* were predicted in throw-trap models for the 20-psu scenarios in Little Madeira Bay and major declines in *Floridichthys, Hippolyte*, and *S. scovelli* (only 10-psu) in Trout Cove. The number of species that declined in the trawl/seine models in the salinity increase scenarios ranged from 10 to12 in Little Madeira Bay and 8 to 10 in Trout Cove. Little Madeira had a higher baseline maximum seasonal biomass of both seagrass species than Trout Cove. The maximum seasonal baseline biomass of *Halodule* was low in Trout Cove (0.45 g/m^2) compared to the biomass of *Thalassia* (41.6 g/ m^2). In Little Madeira, both seagrass species had a higher baseline maximum seasonal density than Trout Cove; maximum seasonal biomass of *Halodule* was 5.6 g/m^2 and Thalassia was 54.7 g/m^2. For both northeast sites, the maximum SAV biomass increased most in the 20 psu scenario-Trout Cove increased 3% and Little Madeira Bay increased 14%. Highest predicted salinity was in the 20-psu scenario- 47.4 psu in Trout Cove and 42.6 psu in Little Madeira Bay. The BBCA index used in the trawl models showed similar patterns as the standing crop, although the increase in Little Madeira Bay showed a more dramatic increase in the 90% scenario.

Trout Cove

Figures 28-43 show by-species plots of abundance for Trout Cove trawl/seine models-total fish abundance and biomass (Figures 44-45), evenness (Figure 46), salinity and SAV (Figure 47). Figures 48-55 show by-species plots of abundance and biomass for the Trout Cove models for each of the scenarios, total fish abundance and biomass (Figures 56-57), evenness (Figure 58), salinity and SAV (Figure 59) for the throw-trap models. Tables 36 and 37 summarize the abundance and biomass results from the trawl/seine model for the 16 trawl/seine species, and Tables 38 and 39 summarize the abundance and biomass results from the throw-trap model for the eight species.

In general, when salinities were reduced to 90% of the baseline, there was an increase in the *Halodule* BBCA index (0.9 to 1.2), but no change in the *Thalassia* BBCA index (Figure 47). In the 30-day-lagged scenario (in which the salinity curve shifted so that the peak is 30 days later in the year), the increase in *Halodule* was less dramatic and there was little change in *Thalassia*. The abundance of 10 trawl/seine species in Trout Cove went up and one went down (Table 36). Ten species increased in both abundance and biomass. *Atherinomorus* was the only species that exhibited a decreased abundance and biomass. There were small predicted increases in total fish abundance, total biomass, forage fish biomass, and predator biomass (Figure 44-45). Evenness was reduced (Figure 46). The number of species that increased changed from 10 (unlagged) to 9 (lagged) (Table 36). The same pattern was observed with evenness, total fish abundance, total fish biomass, and forage fish biomass (Tables 36 and 37). In the lagged scenarios, there was no increase in predator biomass (Table 41).

In the 90% reduction scenario, the *Halodule* standing crop nearly tripled while *Thalassia* decreased 4.8% (Figure 59). For the eight throw-trap models, three species were predicted to increase and one to decrease in Trout Cove (Table 38 and 39). Predicted changes were small. In the lagged scenario, five species increased and three decreased, though changes were small. Evenness (Figure 58), total abundance, total fish biomass, and forage fish biomass (Figure 56-57) were not predicted to change, in contrast to the small changes predicted with the trawl/seine models. Throw-trap models (both lagged and non-lagged salinity) were consistent with the trawl/seine models in predicting a decrease in evenness.

The *Thalassia* BBCA index did not change much in any of the salinity increase scenarios for Trout Cove, but the *Halodule* BBCA index decreased a little in the 110% scenario (0.95 to 0.7) and drastically in the 130% (0.4), 10-psu (0.2), and 20-psu (0.03) scenarios. In the 10-psu and 20-psu increase scenarios, the predicted numbers of decreased trawl/seine faunal species were 10 and nine respectively. The faunal changes predicted under the percent salinity scenarios (90%-130% salinity) were small. In the 110% salinity scenarios (salinities were increased to 110% of the base), the trawl/seine model predicted an increased density of one species and a decreased density of eight species in Trout Cove (Table 36). In the 130% salinity scenario, nine species were predicted to decrease in abundance. The trawl/seine models suggested stronger negative responses of faunal species as the salinity increased and *Halodule* decreased. Major to huge declines in *Anchoa, Anarchopterus, Cynoscion, Eucinostomus, Floridichthys, M. gulosus,* and *S. scovelli* were predicted in the 20-psu scenarios. A major increase was predicted in

Atherinomorus and small increases were predicted for *Lutjanus*, and *S. floridae* with increased salinity. Total abundance, total fish biomass, and forage fish biomass were predicted to decrease with salinity increases (Tables 36 and 37). Small increases in evenness and predator biomass were predicted.

SAV standing crop increased as salinity increased in the Trout Cove scenarios. However, increases were small (the least responsive of all of the sites) - 1.1% in the 110% scenario up to 2.9% in the 20-psu scenario. The throw-trap models predicted major declines in *Floridichthys, Hippolyte*, and *S. scovelli* (only10-psu) for the 10-psu and 20-psu (Table 38) and major increases in densities of *Farfantepenaeus, Gobiosoma*, *Lucania* (only 20-psu), *Opsanus* (only 20-psu), and *Thor* (only 20-psu) in the stepped-up salinities. *Farfantepenaeus* was not found to be common in the raw data at the northeast region. An increase only in the 20-psu scenario suggests a response to both salinity and *Thalassia*. *Lucania* declined in the 130 % and 10-psu scenarios (no change at the 90% and 110%) but showed a major increase in the 20-psu scenario. This increase is likely a salinity response rather than a response to SAV as there was little difference in SAV between the 10-psu and 20-psu scenarios (43.1 vs. 43.3 g/m2). *Opsanus* and *Thor* exhibited no change except a major increase in the 20-psu scenario. Holmquist et al. (1989a and 1989b) reported that *Thor* densities in the northeast part of Florida Bay went from zero to dense during a 3-year rise in salinities in the 1980's. They also reported that *Hippolyte* colonized the northeast site during this period, which the throw-trap model did not predict.

Both gear models predicted an increase in Trout Cove densities of *S. scovelli* and *Floridichthys* in the 90% scenarios and small declines in the 110% and 130% scenarios (Tables 36 and 38) that were probably due to changes in *Halodule*. The trawl/seine models predicted small declines in the 10-psu scenario, while the throw-trap predicted major declines for both species. In the 20-psu scenario, the trawl/seine models predicted major declines for both species, but the throw-trap predicted a major decline for *Floridichthys* and a smaller decline for *S. scovelli.*

There were differences in the response of three species in Trout Cove between the throw-trap and trawl/seine predictions. In the 90% scenario, the throw-trap models predicted no change for *Lucania* and *Opsanus* and a decrease for *Farfantepenaeus*. *Farfantepenaeus* was not common in the raw data of the northeast region. The throw-trap models predicted no change at 110%, small increase at 130%, and major increases at the 10 and 20-psu scenarios for *Farfantepenaeus*. The trawl/seine predicted small increase at 90%, and small decreases in *Farfantepenaeus* densities for the 110%, 130%, and 10-psu scenarios and a major increase at the 20-psu scenario.

The trawl/seine model predicted a small increase in Trout Cove densities of *Lucania* for the 90% scenarios but the throw-trap model predicted no change for this species. Both models for the 110% scenario predicted no change. No change was predicted by the trawl/seine model for the 130% scenario but a small decrease was predicted by the throw-trap model. Both models predicted a small decline in the 10-psu salinity scenario. The trawl/seine model predicted a decrease in density (but not biomass) in the 20-psu scenario, while the throw-trap predicted a huge increase in density. The differences (which affected assignment) in the relative increase in May *Thalassia* by the two models.

Both Trout Cove models predicted no change in *Opsanus* density for the 90% and 110% salinity scenarios. The throw-trap model predicted no change for the 130% and 10-psu scenarios and a major increase in the 20-psu scenario, while the trawl/seine predicted both increased and decreased densities within a scenario depending up the season. The differences in the two models for *Opsanus* may be related to the size collected in throw-trap that samples smaller-size classes. Serafy et al. (1997b) observed movements of *Opsanus* in Biscayne Bay between habitats on a seasonal basis associated with reproductive activities. If seasonal movement occurs between Florida Bay habitats, this could introduce error in the *Opsanus* models.

Little Madeira Bay (inner)

Figures 60-75 show by-species plots of abundance and biomass for the Little Madeira Bay models for each of the scenarios, total fish abundance and biomass (Figures 76-77), evenness (Figure 78), salinity and SAV (Figure 79) for the trawl/seine models. Figures 80-88 show by-species plots of abundance and biomass for the Little Madeira Bay models for each of the scenarios, total fish abundance and biomass (Figures 89-90), evenness (Figure 91), salinity and SAV (Figure 92) for the throw-trap models. Tables 40 and 41 summarizes the abundance and biomass results from the trawl/seine models, and Tables 42 and 43 summarizes the abundance and biomass results from the throw-trap models.

In the salinity reduction scenario for Little Madeira Bay, the *Halodule* BBCA index increased slightly (1.8 to 1.9) but there was no change in the *Thalassia* BBCA index (Figure 79). Out of 16 trawl/seine models, the abundance of 10 species went up and three went down (Table 40). Three species showed no response: *Farfantepenaeus, Hippocampus,* and *Lagodon*. Most of the species exhibited small increases in abundance and biomass. *Atherinomorus, Lutjanus, Opsanus*, and *S. floridae* exhibited small decreases in abundance and biomass. There were small increases of total fish abundance, total fish biomass, and forage fish biomass. No change was predicted for predator biomass and evenness. In the 30-day lagged scenario, the number of species that increased was the same as the unlagged, but four species were predicted to decrease (Table 40). The same pattern as the unlagged (small increase) was predicted for total fish abundance, total fish biomass, and forage fish biomass (Tables 40 and 41). Unlike at Trout Cove, a small decrease in evenness and predator biomass was predicted (Tables 40 and 41).

In the salinity increase scenarios for Little Madeira Bay, the *Halodule* BBCA index decreased from 1.8 to 1.7 (110%), 1.4 (130%), 0.5 (10-psu), and 0.1 (20-psu) and the *Thalassia* BBCA index increased slightly with increased salinity (2.2 for the baseline to 2.4 for the 20-psu scenario). In the 110% salinity change scenario, 10 species were predicted to decline in the trawl/seine model and three were predicted to increase, while in the 130% scenario, 12 species declined and four increased (Table 40). The 10-psu scenario had 12 species declining and three species increasing. In the 20-psu scenario, 11 species declined and two species increased. In the lagged scenarios for 110% and 20-psu, a greater number of species declined. Evenness and predator fish increased. Huge declines in *Anchoa, Atherinomorus,* and *Cynoscion*, were predicted in the 20-psu scenarios.

Halodule standing crop in the salinity reduction scenario for Little Madeira Bay increased 9%, and *Thalassia* decreased 2.6%. In the eight throw-trap models, four species increased and one decreased (Tables 42 and 43). A very small increase in *Lucania* was predicted with the throw-trap but no change was predicted in the trawl/seine model. *Opsanus* was predicted to decrease slightly by the trawl/seine model but the throw-trap model predicted no change. No change was predicted for evenness, total abundance, total fish biomass, forage fish biomass, and predator biomass.

In the salinity increase scenarios for Little Madeira Bay, Thalassia increased and Halodule decreased. Thalassia standing crop increased with salinity (5% in the 110% scenario to 14% in the 20-psu scenario). Halodule decreased 21% (110% scenario), 63% (130% scenario), 99% (10-psu scenario), and 100% (20-psu scenario). The throw-trap models predicted that four species would decrease in the 110%, 130%, and 10-psu scenarios and three species would increase in the 20-psu scenario (Table 42 and 43). In the 110% scenario, no change was predicted for evenness, total fish abundance, total biomass, and forage fish biomass. Small changes were predicted for evenness in the other scenarios. Total abundance did not change except in the 20-psu scenario where there were increases and decreases by season. Total biomass was predicted to increase slightly in the 130% scenario and fluctuate in the 10-psu and 20-psu scenarios. Small decreases in forage fish biomass were predicted for the 130% and 10-psu scenarios and major decreases in the 20-psu scenario. Huge declines in *Floridichthys* and *Hippolyte* and a huge increase in *Gobiosoma* (although relative numbers were small compared to the other species) were predicted in the 20-psu scenario.

Both models predicted declines in *Floridichthys* and *S. scovelli* for Little Madeira Bay with major declines in *S. scovelli* in the 20-psu scenarios. The magnitude of decline varied between the models for *Floridichthys*, minor decline was predicted with the trawl/seine model but major declines for the throw-trap were predicted for the 10-psu and 20-psu scenarios. The models did not agree for *Farfantepenaeus*; the throw-trap predicted a small increase, while the trawl/seine predicted a small decrease but varied by season in the 20-psu scenario. In the throw tap model *Opsanus* increased with salinity, while the trawl/seine predicted both increases and decreases depending upon season. *Lucania* predicted small declines for the trawl/seine model in the 130% salinity scenario and 10-psu and 20-psu salinity increase scenarios, while the throw-trap predicted no change in the 110-130% scenarios, small decrease in the 10-psu scenario, and both increases and decreases (depending upon season) in the 20-psu scenario depending upon season.

Interior Region

The trawl/seine models predicted major declines for Rankin Lake in all of the salinity increase scenarios for one species (*M. microlepis*). Major declines were predicted in Whipray Basin in the 130% scenario for four species (*Cynoscion*, *M. microlepis*, *Opsanus*, and *S. scovelli*). Six species were predicted to decline drastically in the 130% and 10-psu Rankin Lake scenarios and eight declined drastically in the 20-psu scenario. The species that declined drastically in at least one Rankin Lake salinity increase scenario were *Anarchopterus, Cynoscion,* *Farfantepenaeus, Hippocampus, S. floridae, S. scovelli, M. microlepis* and *Opsanus*. Small declines also were predicted for *Anchoa, Floridichthys, Lucania,* and *Lutjanus*. In Whipray Basin, there were seven species that were predicted to exhibit huge to major declines in the 20-psu scenario and three that exhibited small declines. The same species that were predicted to decline drastically in Whipray Basin also declined similarly in Rankin Lake. In the salinity increase scenarios, 1-5 species increased in Rankin Lake and 5-6 species increased in Whipray. Increases in Whipray Basin were associated with major increases in *Thalassia* but not *Halodule*. Total seagrass density declined in the 20-psu scenario compared to the 130% and 10-psu scenarios.

Both interior (Whipray Basin and Rankin Lake) throw-trap scenarios predicted small changes (2-3 species increased and two decreased) even though *Thalassia* was reduced drastically (94%) in the Whipray scenario. *Halodule* increased in both scenarios. In both scenarios, *Gobiosoma* and *Floridichthys* were predicted to decrease and *S. scovelli* was predicted to increase. In Whipray Basin, *Farfantepenaeus* was predicted to increase and in Rankin Lake, *Hippolyte* was predicted to increase.

In the salinity reduction scenarios, small changes were associated with the 110% scenario and large changes in the 130%, 10-psu boost, and 20-psu boost scenarios. In the higher salinity scenarios, 4-5 species increased and 1-2 declined. *Hippolyte* decreased and *Lucania, Opsanus, Thor,* and *Floridichthys* increased in both regions. Declines occurred in *Farfantepenaeus* in Whipray Basin.

Fewer species increased in the Rankin Lake and Whipray Basin salinity reduction scenarios than in the northeast scenarios.

Whipray Basin

Figures 93-108 show by-species plots of abundance and biomass for the Whipray Basin models for each of the scenarios, total fish abundance and biomass (Figures 109-110), evenness (Figure 111), salinity and SAV (Figure 112) for the trawl/seine models. Figures 113-120 show by-species plots of abundance and biomass for the Whipray Basin models for each of the scenarios, total fish abundance and biomass (Figures 121-122), evenness (Figure 123), salinity and SAV (Figure 124) for the throw-trap models. Table 44 and 45 summarize the abundance and biomass results from the trawl/seine model, and Table 46 and 47 summarize the abundance and biomass results from the throw-trap.

In the salinity reduction Whipray Basin scenario for the trawl/seine, the *Thalassia* BBCA declined from 2.5 (maximum baseline in July,Year 3) to 1.2 and *Halodule* BBCA increased from 2.3 to 2.7 (Figure 112). In the Whipray Basin trawl/seine 90% salinity scenarios, eight species increased and eight species (out of 16) decreased. Small increases were predicted for seven species, a major increase was predicted for one species (*M. microlepis*), and declines were predicted in eight species (Table 44). Major declines were predicted for *Lucania*. No change was predicted for total fish abundance or predator biomass. Declines were predicted for total fish biomass, and forage fish biomass. Evenness was predicted to increase slightly. The results for the lagged scenario were similar to the unlagged scenario except *Lagodon* declines went from major to small, evenness went from a small increase to a small decrease, and total abundance went from no change to a small decrease.

In the salinity increase scenarios for Whipray Basin, Thalassia BBCA increased from 2.5 to 2.7 (110%) and 3.0 in 130%, 10-psu, and 20-psu scenarios (Figure 112). Lagged scenarios did not change vegetation significantly. In most of the salinity increase scenarios for Whipray Basin using the trawl/seine models, there were declines in 10 (nine in the 110% scenarios) species and increases in six species (Table 44). However, as the salinity in the scenarios increased, more dramatic declines or increases were predicted. In the 110% scenario, small declines were predicted for eight species and a major decline was predicted for one species (*M. microlepis*), although relative predicted numbers were small. One species showed no change (*Lutjanus*), and five species were predicted to experience small increases. Predictions for the 130% and 10-psu scenarios were similar: there were huge declines in one species (*M. microlepis*), major declines in seven species, and small declines in four species. Major increases were predicted for two species and small increases for four species. In the 20-psu scenario, five species declined extremely, two declined greatly, and three that declined slightly. Huge increases were predicted for *Floridichthys*; major increases were predicted for three species (*Atherinomorus*, *Lagodon*, and *M. gulosus*).

In the 90% salinity scenario for Whipray Basin for input to the throw-trap models, the maximum predicted *Thalassia* declined from 38.6 g/m2 to 2.0 g/m2 and *Halodule* increased from 17.2 to 32.8 g/m2 (Figure 124). Throw-trap models predicted that two species increased and two species decreased in Whipray Basin (Table 46). Four species did not change. The lagged scenario was similar except that *Hippolyte* density went from no change to a small increase. No change was predicted for total fish abundance, total fish biomass, or forage fish biomass (Tables 46 and 47). Evenness increased slightly (Table 46).

In all of the Whipray Basin salinity increase scenarios for the throw-trap, *Thalassia* increased and *Halodule* decreased (Figure 124). The greatest change in the SAV standing crop was predicted for the 130% scenario, an increase of 55.2% from the maximum baseline. In the 110% Whipray Basin scenario for the throw-trap, three species increased in abundance and two declined. The increase in the number of forage species responding to increased salinity was related to the positive increase in total seagrass standing crop. Maximum standing crop was associated with the 130% scenario. Huge increases in total fish abundance and biomass were associated with the higher salinity scenarios. However, only small changes in forage fish biomass were associated with these scenarios. Largest changes occurred in *Lucania, Floridichthys*, *Thor,* and *Opsanus*. The first three species are all very small and while even when numerous contribute little to forage fish biomass. *Opsanus* is a relatively large species compared to the forage species and dominates the biomass even when relative numbers are small. Evenness declined in all of the salinity increase scenarios and in the salinity reduction scenario.

Rankin Lake

Figures 125-140 show by-species plots of abundance and biomass for Rankin Lake for each of the scenarios, total fish abundance and biomass (Figures 141-142), evenness (Figure 143), salinity and SAV (Figure 144) from the trawl/seine models. Figures 145-152 show by-species plots of abundance and biomass for the Rankin Lake models for each of the scenarios, total fish abundance and biomass (Figures 153-154), evenness (Figure 155), salinity and SAV (Figure 156) for the throw-trap models. Tables 48 and 49 summarizes the abundance and biomass results from the trawl/seine model, and Tables 50 and 51 summarizes the abundance and biomass results from the throw-trap.

In the 90% salinity reduction scenario for Rankin Lake, the *Thalassia* BBCA index declined from 2.5 to 2.3, while the *Halodule* BBCA index increased from 1.8 to 2.0 (Figure 157). The trawl/seine models predicted that, when salinities were reduced to 90% of the baseline, the abundance of seven (out of 16) species increased and three decreased (Table 48). Five species showed no response and one species responded both positively and negatively depending on the season. All of the species exhibited only small increases in abundance and biomass (Table 48 and 49). Total fish abundance and evenness increased (Table 48). Total fish biomass and forage fish biomass showed no change and predator biomass showed variable increases and decreases depending on season (Table 49). In the lagged scenario, nine species exhibited small increases compared to seven in the baseline.

In the salinity increase scenarios for Rankin Lake, small changes in *Thalassia* BBCA index values were predicted (2.5 for baseline to 2.7) (Figure 156). Highest *Thalassia* BBCA index values were predicted for the 130% and 10-psu scenarios. *Halodule* BBCA index values decreased from 1.8 in the baseline to 1.6 (110%), 1.0 (130%), 0.9 (10-psu), and increased again to 1.6 in the 20-psu scenario. The increase in *Halodule* in the 20-psu scenario was associated with a slight decrease in *Thalassia* to 2.5. In the 110% scenario for Rankin Lake, trawl/seine models predicted small decreases in densities of 11 species exhibited small decreases and a small increase in the density of one species (Table 50). In the 130% scenario, small decreases were predicted for seven species, and major decreases were predicted for four species (*Cynoscion, M. microlepis, S. scovelli,* and *Opsanus*). A major increase in *Atherinomorus* was predicted. The 10-psu scenario was similar to the 130% scenario except that a small change was predicted in *M. gulosus*. The 20-psu scenario predicted small declines in four species, major declines in six species (*Anarchopterus, Cynoscion, Farfantepenaeus, Hippocampus, S. floridae*, and *S. scovelli*), and huge declines in *M. microlepis* and *Opsanus*. Small increases were predicted for two species, major increases were predicted for *Lagodon* and *M. gulosus*, and huge increases were predicted for *Atherinomorus*. The trawl/seine models predicted that the salinity-increase scenarios would result in small decreases in total fish abundance, evenness, and predator biomass, except for total fish abundance in the 20-psu scenario, for which a small increase was predicted. No changes were predicted in forage fish biomass except for an increase in the 20-psu scenario (Table 49).

In the 90% reduction scenarios, standing crop of *Halodule* increased 13% and *Thalassia* decreased 15% (Figure 156). The throw-trap models for Rankin Lake predicted that two species (out of 8 modeled) exhibited small increases and two species exhibited small declines (Tables 50 and 51). No change was predicted for total fish abundance, total fish biomass, and forage fish biomass (Tables 50 and 51). Evenness was predicted to increase (Table 50).

In the salinity increase scenarios for Rankin Lake, Thalassia standing crop increased from the baseline 21% (110% scenario), 50% (130% scenario), 53% (10-psu scenario), and 14% (20-psu scenario) (Figure 156). Halodule standing crop decreased 42% (110% scenario), 46% (130%), 88%(10-psu scenario), and 42% (20-psu scenario). Maximum total seagrass standing crop for all of the Rankin Lake salinity increase scenarios (47.1-55.3 g/m^2) was greater than the baseline (42.1 g/m^2). Maximum total seagrass standing crop declined slightly in the 20-psu scenario compared to the 130% (which was the highest) and 10-psu scenarios. The lagged scenario predicted vegetation results were similar to the no-lag scenarios.

No species were predicted to decline in the Rankin Lake throw-trap models for the 110% scenario (Table 50). Two species were predicted to decline for the other scenarios. Four species increased in the 110% and 130% scenarios and five increased in the base+10-psu and base+20-psu scenarios. The amount of change was small in the percent increase scenarios and major to huge in the 10-psu and 20-psu scenarios. The species that were predicted to increase were *Floridichthys, Gobiosoma, Lucania, Opsanus, S. scovelli,* and *Thor.* The species that were predicted to decline were *Farfantepenaeus* and *Hippolyte*. Total fish abundance, total fish biomass, and forage fish biomass were all predicted to increase dramatically. The increase in total fish abundance was determined by three of the species (*Lucania*, *Floridichthys*, and *Thor*) that are small in size and numerically abundant. Total fish biomass was most affected by the abundance of one species- *Opsanus*. Evenness was predicted to decline.

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Table 1. Data Sources for Fish and Shrimp

Source	Type of Data	Time Frame	Sampling Interval	Comments
Tom Schmidt Everglades National Park	Small and juvenile fish and macro-invertebrates-trawl and seine	1974-1976	fixed stations 10 monthly 17 quarterly	
Susan Sogard NMFS/Hatfield Marine Institute	Small and juvenile fish and macro-invertebrates-throw trap	1984-1986	dry, early wet, late wet fixed sites (5 replicates) 3 seasons	Validation set
Allyn Powell and Gordon Thayer NOAA/NOS Beaufort	Small and juvenile fish and macro-invertebrates-trawl	1984-1985, 1994-2001	fixed and random sampling	
James Colvocoresses FMRI/FWC	Small and juvenile fish and macro-invertebrates-trawl and seine	1994-1997	monthly- fixed and random sites	
Richard Matheson FMRI/FWC	Small and juvenile fish and macro-invertebrates-throw trap	1994-1996	early wet, late wet fixed sites 2 seasons	Validation set
Michael Robblee ENP/USGS	throw trap	1984-2003	fixed sites	

Table 2. Top 10 Macrofaunal Species and Top 6 Caridean Species Collected in Throw-Trap samples from 1986-2003 (Michael Robblee, USGS). Totals are for all samples.

	Macrofauna	Total	#/m2	Percent	Cumulative percent catch
1	Farfantepenaeus duorarum	27658	7.11	39.34	39.34
2	Lucania parva	21706	5.58	30.87	70.21
3	Gobiosoma robustum	5042	1.30	7.17	77.38
4	Floridichthys carpio	3776	0.97	5.37	82.75
5	Opsanus beta	3282	0.84	4.67	87.42
6	Syngnathus scovelli	1590	0.41	2.26	89.68
7	Anchoa mitchilli	1390	0.36	1.98	91.66
8	Symphurus plagiusa	719	0.18	1.02	92.68
9	Hippocampus zosterae	713	0.18	1.01	93.69
10	Eucinostomus gula	640	0.16	0.91	94.60
	totfish	42596	10.95		
	Caridean Shrimp				
1	Thor floridanus	182385	46.90	41.92	41.92
2	Thor manningi	113960	29.30	26.19	68.11
3	Hipployte zostericola	65883	16.94	15.14	83.25
4	Hipployte pleuracanthus	24616	6.33	5.66	88.91
5	Periclimenes longicaudatus	17847	4.59	4.10	93.01
6	Periclimenes americanus	8307	2.14	1.91	94.92
	Total	435119	111.88	100.00	

Table 3. Top 17 species in Atlantic trawl and seine (FMRI data 1994-97). Number is total caught in all samples.

	Species	Number	Percent catch	Cumulative percent catch	
1	Eucinostomus spp.- mojarras	14138	31.54	31.54	
2	**Atherinomorus stipes-hardhead silverside**	5887	13.13	44.67	not common in trawl
3	**Anchoa hepsetus-striped anchovy**	3917	8.74	53.41	not common in trawl
4	**Hypoatherina harringtonensis-reef silverside**	3211	7.16	60.58	not common in trawl
5	**Orthopristis chrysoptera-pigfish**	2419	5.40	65.97	
6	Anchoa mitchelli-bay anchovy	2036	4.54	70.51	
7	**Harengula jaguana-scaled sardine**	1274	2.84	73.36	not common in trawl
8	Floridichthys carpio-gold-spotted killifish	1160	2.59	75.94	
9	**Opisthonema oglinum-Atlantic Thread Herring**	1123	2.51	78.45	not common in trawl
10	**Haemulon sciurus-blue striped grunt**	950	2.12	80.57	
11	**Monacanthus ciliatus-fringed filefish**	760	1.70	82.26	
12	Lagodon rhomboides-pinfish	662	1.48	83.74	
13	**Anchoa spp.- anchovies**	590	1.32	85.06	not common in trawl
14	**Strongylura notata-redfin needlefish**	387	0.86	85.92	not common in trawl
15	**Panulirus argus- spiny lobster**	346	0.77	86.69	
16	**Nicholsina usta-emerald parrotfish**	339	0.76	87.45	
17	Lucania parva- rainwater killifish	332	0.74	88.19	
	Additional species				
	Lutjanus griseus- gray snapper	94	0.21		
	Cynosion nebulosus- spotted seatrout	0			
	Farfantepenaeus duorarum- pink shrimp	150	0.33		

Bold indicates those species that no previous models were developed

Table 4. Top 15 species in Gulf trawl and seine (FMRI data 1994-97). Number is total caught in all samples.

	Species	Number	Percent catch	Cumulative percent catch	
1	Eucinostomus spp.- mojarras	14895	24.08	24.08	
2	Anchoa mitchelli-bay anchovy	14575	12.60	36.68	
4	Farfantepenaeus duorarum- pink shrimp	10659	9.21	45.89	
3	Lagodon rhomboides-pinfish	10628	9.19	55.08	
5	**Haemulon plumieri - white grunt**	5797	5.01	60.09	
6	**Orthopristis chrysoptera- pigfish**	4816	4.16	64.25	
7	**Bairdiella chrysoura-silver perch**	4685	4.05	68.30	
8	Lucania parva- rainwater killifish	4479	3.87	72.17	
9	**Opisthonema oglinum-Atlantic thread herring**	3956	3.42	75.59	not common in trawl
10	**Harengula jaguana - scaled sardine**	3767	3.26	78.85	not common in trawl
11	Syngnathus scovelli- gulf pipefish	3033	2.62	81.47	
12	**Monacanthus ciliatus- fringed filefish**	2490	2.15	83.62	
13	**Lutjanus synagris- lane snapper**	2088	1.80	85.43	
14	**Syngnathus floridae- dusky pipefish**	1879	1.62	87.05	
15	Floridichthys carpio-gold-spotted killifish	1458	1.26	88.31	
	Additional species				
	Lutjanus griseus- gray snapper	319	0.28		
	Cynosion nebulosus- spotted seatrout	678	0.59		

Bold indicates those species that no previous models were developed

Table 5. Top 14 species in Interior trawl and seine (FMRI data 1994-97). Number is total caught in all samples.

	Species	Number	Percent catch	Cumulative percent catch	
1	Eucinostomus spp.- mojarras	17372	29.38	29.38	
2	Anchoa mitchelli-bay anchovy	15639	26.45	55.83	
3	Lucania parva- rainwater killifish	6494	10.98	66.81	
4	Floridichthys carpio-gold-spotted killifish	5196	8.79	75.60	
5	Syngnathus scovelli- gulf pipefish	2369	4.01	79.60	
6	Farfantepenaeus duorarum- pink shrimp	1794	3.03	82.64	
7	**Atherinomorus stipes-hardhead silverside**	1626	2.75	85.39	not common in trawl
8	**Opisthonema oglinum-Atlantic thread herring**	1575	2.66	88.05	not common in trawl
9	Lagodon rhomboides-pinfish	929	1.57	89.62	
10	Microgobius gulosus- clown goby	663	1.12	90.74	
11	Gobiosoma robustum- code goby	630	1.07	91.81	
12	Hippocampus zostera- dwarf seahorse	518	0.88	92.68	
13	Opsanus beta- gulf toadfish	487	0.82	93.51	
14	**Cynosion nebulosus- spotted seatrout**	410	0.69	94.20	
	Additional species				
	Lutjanus griseus- gray snapper	27			Not enough for analysis

Bold indicates those species that no previous models were developed

Table 6. Top 14 species in NE trawl and seine (FMRI data 1994-97). Number is total caught in all samples.

	Species	Number	Percent catch	Cumulative percent catch	
1	Lucania parva- rainwater killifish	29501	21.12	21.12	
2	Floridichthys carpio-gold-spotted killifish	25580	18.31	39.43	
3	Anchoa mitchelli-bay anchovy	24715	17.69	57.13	
4	Eucinostomus spp.- mojarras	20568	14.72	71.85	
5	**Atherinomorus stipes-hardhead silverside**	19550	14.00	85.85	not common in trawl
6	Microgobius gulosus- clown goby	4870	3.49	89.33	
7	**Opisthonema oglinum-Atlantic thread herring**	2088	1.49	90.83	not common in trawl
8	Syngnathus scovelli- gulf pipefish	1445	1.03	91.86	
9	**Anarchopterus criniger-Fringed pipefish**	1163	0.83	92.69	
10	**Syngnathus floridae-dusky pipefish**	1154	0.83	93.52	
11	Opsanus beta- gulf toadfish	919	0.66	94.18	
12	**Microgobius microlepis-banner goby**	895	0.64	94.82	
13	**Strongylura notata-redfin needlefish**	886	0.63	95.45	not common in trawl
14	Hippocampus zostera- dwarf seahorse	688	0.49	95.95	
	Additional species				
	Lutjanus griseus- gray snapper	85	0.06		
	Cynosion nebulosus- spotted seatrout	103	0.07		
	Farfantepenaeus duorarum- pink shrimp	322	0.23		

Bold indicates those species that no previous models were developed

Table 7. Top 10 macrofaunal species and top 6 caridean shrimp species collected in throw-trap by Sogard and Matheson (6 sites in Florida Bay); bank habitat only (summarized from Matheson et al. 1999). Number is from all samples.

		Sogard	Sogard	Sogard	Matheson	Matheson	Matheson
		Number 1984-1986	Percent	Cumulative percent catch	Number 1994-1996	Percent	Cumulative percent catch
	Macrofauna						
1	Lucania parva- rainwater killifish	1061	28.02	28.02	259	11.39	11.39
2	Gobiosoma robustum- code goby	558	14.74	42.76	404	17.77	29.17
3	Opsanus beta- gulf toadfish	427	11.28	54.04	607	26.70	55.87
4	Farfantepenaeus duorarum- pink shrimp	412	10.88	64.92	307	13.51	69.38
5	Floridichthys carpio-gold-spotted killifish	372	9.83	74.75	148	6.51	75.89
6	Anarchopterus criniger-fringed pipefish	324	8.56	83.31	127	5.59	81.48
7	Hippocampus zostera- dwarf seahorse	116	3.06	86.37	61	2.68	84.16
8	Syngnathus scovelli- gulf pipefish	113	2.98	89.36	82	3.61	87.77
9	Lagodon rhomboides-pinfish	53	1.40	90.76	9	0.40	88.17
10	Eucinostomus spp.- mojarras	45	1.19	91.94	29	1.28	89.44
	Total Caridean						
1	Thor floridanus	41249	90.57	90.57	13492	90.45	90.45
2	Hippolyte zostericola	1745	3.83	94.40	809	5.42	95.88
3	Periclimenes americanus	1482	3.25	97.66	336	2.25	98.13
4	Periclimenes longicaudatus	849	1.86	99.52	141	0.95	99.07
5	Tozeuma carolinese	124	0.27	99.79	91	0.61	99.68
6	Latreutes fucorum	62	0.14	99.93	42	0.28	99.97
7	other	32	0.07	100.00	5	0.03	100.00

Table 8. Mean number per m2 of each species caught in throw-trap samples by region and number of samples.

Region	Number of Samples	Floridichthys carpio	Gobiosoma robustum	Lucania parva	Opsanus beta	Syngnathus scovelli	Farfantepenaeus duorarum	Hippolyte spp.	Thor spp.
Atlantic	158	1.13	1.17	0.91	0.66	0.13	1.78	7.94	1.13
Gulf	4470	1.09	1.38	5.62	0.87	0.44	6.65	21.28	74.62
Interior	262	1.44	2.13	0.76	0.97	0.29	1.41	9.26	66.61
Northeast	423	0.93	0.02	0.43	0.63	0.13	0.06	2.99	25.48

Table 9. Annual number of throw-trap samples sorted by annual Royal Palm rainfall (inches). Bold = validation data

Researcher		Robblee	Robblee	Robblee	Robblee, Matheson, and Powell		Sogard	Matheson	
Study		Johnson Key Basin 6-week	30-Station Study*	6-Basin Study*	Salinity Gradient	Model Development Data	1984-1986	1994-1996	
habitat		bank, basin, near key	bank, basin, near key	bank, basin,near key	bank, basin, near-key	Total	bank	bank	
Year	Annual Royal Palm Rainfall	Number of Samples	Number of Samples	Number of Samples	Number of Samples	Number of Samples	Number of Samples	Number of Samples	
1989	36.50	72	84			156			driest year for model
2002	37.13**	0							
1990	42.93	212	64			276			
1986	43.20	280		180		460	**271 (90 JKB)**		dry validation
1987	43.35	108				108			
1993	43.95	0				0			
1985	45.29	288	164			452	**446 (90 JKB)**		
1984	46.18	80				80	**414 (90 JKB)**		
2001	47.61**	324				324			
2000	50.1	316			255	571			
1996	55.49	288				288		**30 (12 JKB)**	mean validation
	55.57								MEAN 1972-2002
2003	56.32	252				252			
1988	58.51	0				0			
1991	60.23	144				144			
1998	61.20	312			170	482			
1994	61.21	0				0		**69 (12 JKB)**	
1999	63.36	288			550	838			
1995	63.54	284	174			458		**66 (12 JKB)**	wet validation
1997	65.93	288				288			wettest year for model
1992	67.13	0				0			

*Duplicate samples for Johnson Key in data bases (have been subtracted)
**Rainfall-mean of 5 northern Florida Bay stations

Table 10A. Average catch/m2 of selected throw-trap species by region.

	Atlantic	Gulf Interior		Northeast	All samples
Farfantepenaeus duorarum	1.8	6.6	1.4	0.1	5.7
Floridichthys carpio	1.1	1.1	1.4	0.9	1.1
Gobiosoma robustum	1.2	1.4	2.1	0.0	1.3
Hippolyte spp.	7.9	21.3	9.3	3.0	18.8
Lucania parva	0.9	5.6	0.8	0.4	4.8
Opsanus beta	0.7	0.9	1.0	0.6	0.9
Syngnathus scovelli	0.1	0.4	0.3	0.1	0.4
Thor spp.	47.6	74.6	66.6	25.5	69.5

Table 10B. Average catch/hectare of selected trawl/seine species by region

	Atlantic	Gulf	Interior	Northeast	All samples
Anarchopterus criniger	1.9	4.2	3.6	15.6	6.6
Anchoa mitchelli	92.3	861.4	543.4	589.2	623.6
Atherinomorus stipes	49.3	0.1	1.6	904.8	232.0
Cynoscion nebulosus	0.8	12.0	8.1	2.4	7.3
Eucinostomus spp.	679.5	1011.1	551.3	658.0	783.2
Farfantepenaeus duorarum	7.8	498.4	123.5	6.4	231.9
Floridichthys carpio	191.9	623.4	134.4	875.7	526.4
Hippocampus zosterae	6.0	18.5	21.2	17.3	17.1
Lagodon rhomboides	53.7	274.5	36.7	13.5	130.5
Lucania parva	64.6	430.9	205.8	649.9	389.1
Lutjanus griseus	6.2	5.7	1.8	2.4	4.1
Microbius gulosus	0.7	1.1	18.7	126.5	35.5
Microgobius microlepis	0.9	0.5	4.7	11.9	4.3
Opisthonema oglinum	16.0	12.2	3.5	5.0	9.1
Opsanus beta	5.8	15.4	15.5	15.4	14.1
Syngnathus floridae	15.8	50.9	6.7	19.9	29.3
Syngnathus scovelli	13.4	68.8	71.2	41.4	55.0

Table 11A. Fraction of positive catches for selected throw-trap species by region

	Atlantic	Gulf	Interior	Northeast	All samples
Farfantepenaeus duorarum	0.53	0.82	0.45	0.02	0.73
Floridichthys carpio	0.42	0.24	0.35	0.36	0.26
Gobiosoma robustum	0.37	0.52	0.56	0.01	0.48
Hippolyte spp.	0.75	0.72	0.68	0.50	0.70
Lucania parva	0.16	0.50	0.22	0.13	0.45
Opsanus beta	0.28	0.39	0.43	0.32	0.38
Syngnathus scovelli	0.11	0.26	0.22	0.11	0.24
Thor spp.	0.88	0.76	0.82	0.66	0.76

Table 11B. Fraction of positive catches for selected trawl/seine species by region

	Atlantic	Gulf	Interior	Northeast	All samples
Anarchopterus criniger	0.06	0.09	0.09	0.23	0.12
Anchoa mitchelli	0.08	0.21	0.29	0.24	0.21
Atherinomorus stipes	0.08	0.01	0.01	0.11	0.04
Cynoscion nebulosus	0.01	0.17	0.17	0.03	0.11
Eucinostomus spp.	0.70	0.84	0.85	0.82	0.82
Farfantepenaeus duorarum	0.16	0.49	0.38	0.13	0.33
Floridichthys carpio	0.16	0.15	0.26	0.66	0.30
Hippocampus zosterae	0.14	0.24	0.35	0.30	0.27
Lagodon rhomboides	0.31	0.63	0.27	0.09	0.38
Lucania parva	0.07	0.26	0.21	0.49	0.28
Lutjanus griseus	0.15	0.15	0.06	0.06	0.11
Microbius gulosus	0.02	0.02	0.22	0.38	0.15
Microgobius microlepis	0.03	0.02	0.10	0.21	0.09
Opisthonema oglinum	0.05	0.04	0.06	0.05	0.04
Opsanus beta	0.18	0.32	0.27	0.29	0.28
Syngnathus floridae	0.34	0.48	0.14	0.28	0.34
Syngnathus scovelli	0.23	0.42	0.56	0.46	0.44

Table 12. Trawl/seine samples by year (ENP (1973-1976), Powell (1984-1985, 1994-1996, 2000, 2001), FMRI (1994-1997)

Year	Gulf	Interior	NE	NE1	NE2	Atlantic	Total
1973	89	0	0	0	0	0	89
1974	200	46	0	0	0	0	246
1975	137	80	40	12	10	3	282
1976	22	14	58	11	21	4	130
1984	40	46	7	0	2	15	110
1985	29	40	9	0	4	18	100
1994	295	217	287	60	71	122	1052
1995	394	309	369	69	180	195	1516
1996	157	146	127	24	58	83	595
1997	209	181	159	16	90	105	760
1998	70	102	16	0	0	20	208
1999	12	8	37	7	30	0	94
2000	36	49	52	7	34	37	215
2001	7	11	11	1	4	7	41*

NE1=basins 7, 13, 14
NE2=basins 12, 15, 47
*January only

Table 13. Number of trawl and seine samples by year and sorted by annual rainfall (FMRI 1994-1997, Beaufort 1984-1985, 1994-2001, ENP 1973-1976)

Year	Number of TrawlSamples	Number of Seine Samples	Rainfall		
1989	0	0	36.50	very dry	no sample
2002	0	0	37.13*	very dry	no sample
1990	0	0	42.93	dry	no sample
1986	0	0	43.20	dry	no sample
1987	0	0	43.35	dry	no sample
1993	0	0	43.95	dry	no sample
1985	96	0	45.29	dry	dryest year for model
1984	96	0	46.18		validation dry year
2001	36	0	47.60*		january only
1974	192	54	48.58		
2000	180	0	50.10		
1973	30	59	52.54	mean	one month
1975	229	32	53.45	mean	
1979	0	0	54.50	mean	no sample
1996	321	192	55.49	mean	validation mean-split
			55.57	MEAN 1972-2002	
1976	58	0	57.66	mean	
1977	0	0	58.07	mean	no sample
1988	0	0	58.51	mean	no sample
1972	0	0	59.66	mean	no sample
1991	0	0	60.23		no sample
1981	0	0	60.71		no sample
1998	208	0	61.20		
1994	471	450	61.21		
1999	199	0	63.36		
1995	691	576	63.54	wet	validation wet year-split
1982	0	0	63.82	wet	no sample
1997	377	277	65.93	wet	wettest year for model
1992	0	0	67.13	wet	no sample
1980	0	0	73.01	verywet	no sample
1983	0	0	73.56	verywet	no sample
1978	0	0	74.35	verywet	no sample

* grouped station data

Table 14. Salinity mean, standard deviation, minimum and maximum of positive catches of selected forage and juvenile species collected in trawl/seine and throw trap in Florida Bay (from raw data)

Species	Salinity Min	Salinity Max	Salinity Mean	Salinity SD
All trawl/seine samples	0.5	66.6	31.5	8.2
Anarchopterus criniger	2.1	44.0	29.2	7.0
Anchoa mitchelli	0.5	50.0	27.9	9.7
Atherinomorus stipes	4.3	52.1	29.2	9.7
Cynoscion nebulosus	0.5	46.7	31.9	8.3
Eucinostomus spp.	0.5	66.6	31.3	8.4
Farfantepenaeus duorarum	6.0	66.6	32.6	6.0
Floridichthys carpio	0.5	57.3	28.0	10.7
Hippocampus zosterae	0.5	59.7	31.2	7.4
Lagodon rhomboides	8.0	60.0	34.7	5.7
Lucania parva	0.5	57.3	28.8	10.4
Lutjanus griseus	4.3	66.6	34.2	6.5
Microbius gulosus	0.5	52.1	24.3	10.8
Microgobius microlepis	2.6	47.0	27.1	7.6
Opisthonema oglinum	0.9	48.0	29.3	9.2
Opsanus beta	0.8	59.7	32.1	7.5
Syngnathus floridae	6.0	50.1	32.4	6.0
Syngnathus scovelli	0.5	59.7	30.0	8.6
All throw trap samples	5.0	52.0	33.4	5.8
Farfantepenaeus duorarum	15.0	52.0	33.7	5.1
Floridichthys carpio	5.0	52.0	33.8	6.6
Gobiosoma robustum	15.0	52.0	34.0	5.1
Hippolyte spp.	6.0	52.0	33.1	5.5
Lucania parva	6.0	52.0	34.7	5.6
Opsanus beta	6.0	52.0	34.1	5.8
Syngnathus scovelli	6.0	52.0	33.6	5.7
Thor spp.	6.0	52.0	33.6	5.7

Table 15. Scientific and common name of species and gear-specific models developed.

Species	Common name	Throw-trap	Trawl/seine
Anarchopterus criniger (formerly *Micrognathus*)	Fringed pipefish		X
Anchoa mitchelli	Bay anchovy		X
Atherinomorus stipes	Hardhead silverside		X
Cynoscion nebulosus	Spotted seatrout		X
Eucinostomus spp. (gula, argenteus, lefroyi, and harengulus)	Mojarras		X
Farfantepenaeus duorarum (formerly *Penaeus*)	Pink shrimp	X	X
Floridichthys carpio	Gold-spotted killifish	X	X
Gobiosoma robustum	Code goby	X	
Hippocampus zosterae	Dwarf seahorse		X
Hippolyte spp. (coerulescens, zostericola, obliquirmanus, and *pleuracanthus)*	Caridean shrimp	X	
Lagodon rhomboides	Pinfish		X
Lucania parva	Rainwater killifish	X	X
Lutjanus griseus	Gray snapper		X
Microbius gulosus	Clown goby		X
Microgobius microlepis	Banner goby		X
Opisthonema oglinum	Atlantic thread herring		X
Opsanus beta	Gulf toadfish	X	X
Syngnathus floridae	Dusky pipefish		X
Syngnathus scovelli	Gulf pipefish	X	X
Thor spp. (dobkini, floridanus, and *manningi)*	Caridean shrimp	X	

Table 16. Additional Seagrass Data Sources

Source	Type of Data	Time Frame	Sampling Interval	Comments
Michael Durako, Margaret Hall UNC/FMRI/FWC	Seagrass density and type	1997-1998	Spring and Fall Spring	Braun-Blanquet Shoot counts
DERM	Seagrass density and type for NE region	1995-2003		Braun-Blanquet and shoot counts
Zieman and Frankovich Univ. of Virginia	Thalassia	1995-2003		Braun Blanquet an shoot counts

Table 17. Estimated monthly individual weights (grams) for species used in scenarios. Weights used to calculate biomass. Data from NMFS Beaufort Laboratory, Schmidt (ENP), and Robblee (USGS).

MONTH	Interpolated from adjacent months	Beaufort trawl Lucania wt	Beaufort trawl Floridichthys wt	Beaufort trawl Lagodon wt	Beaufort trawl Anchoa wt	Beaufort trawl S.scovelli wt	Beaufort trawl S.floridae wt	Beaufort trawl Micrognathus wt	Beaufort trawl Opsanus wt	Beaufort trawl Hippocampus wt	Beaufort trawl Gobiosoma wt	Beaufort trawl Microgobius gulosus wt	Beaufort trawl Microgobius microlepis wt	Beaufort Eucinostomus spp	Beaufort trawl Cynoscion wt	Beaufort trawl Lutjanus wt	Beaufort trawl Opisthonema wt	Schmidt trawl Farfantepenaeus wt	Robblee throw trap caridean
1		0.104	0.304	11.121	0.181	1.366	1.501	0.207	2.476	0.077	0.156	0.183	0.048	1.955	14.980	17.785	16.745	0.122	0.025
2	*	0.072	0.185	6.211	0.314	1.133	1.647	0.207	1.987	0.084	0.189	0.183	0.118	1.497	15.221	10.496	9.129	0.370	0.052
3		0.041	0.066	1.302	0.447	0.900	1.793	0.207	1.498	0.091	0.222	0.183	0.188	1.039	15.463	3.207	1.513	0.550	0.063
4	*	0.042	0.124	1.493	0.435	0.769	1.361	0.193	2.852	0.084	0.235	0.191	0.251	0.804	7.850	18.890	18.262	0.139	0.077
5		0.042	0.182	1.685	0.422	0.638	0.929	0.178	4.206	0.076	0.249	0.199	0.315	0.568	0.237	34.573	35.011	0.415	0.092
6		0.006	0.091	0.844	0.328	0.306	1.602	0.102	0.635	0.047	0.143	0.019	0.249	0.224	0.081	18.089	19.055	0.297	0.163
7		0.018	0.058	2.764	0.527	0.485	2.250	0.151	2.357	0.027	0.098	0.139	0.184	0.536	0.387	108.174	3.100	0.707	0.116
8	*	0.077	0.167	11.696	0.452	0.507	2.279	0.143	3.351	0.053	0.162	0.146	0.167	1.432	0.943	79.778	1.800	0.467	0.046
9		0.136	0.276	20.628	0.378	0.528	2.308	0.136	4.346	0.079	0.227	0.154	0.150	2.328	1.499	51.382	0.501	0.115	0.052
10	*	0.078	0.175	17.400	0.281	0.498	2.457	0.146	6.490	0.071	0.212	0.166	0.133	2.077	7.999	37.769	1.701	0.224	0.030
11		0.020	0.074	14.173	0.184	0.468	2.605	0.156	8.633	0.062	0.196	0.178	0.115	1.826	14.499	24.155	2.901	0.103	0.034
12	*	0.062	0.189	12.647	0.183	0.917	2.053	0.182	5.555	0.070	0.176	0.180	0.082	1.890	14.739	20.970	9.823	0.453	0.035
ave		0.050	0.161	5.170	0.353	0.604	1.865	0.174	3.216	0.059	0.188	0.154	0.158	1.371	4.217	33.761	1.968	0.237	0.065

Table 18. Minimum weight (grams) of selected forage species (NMFS Beaufort laboratory data 1984-1985, 1994-1996)

MONTH	Lucania	Floridichthys	Lagodon	Anchoa	Opsanus	S.scovelli	Hippocampus	Gobiosoma	Microgobius gulosus	Cynoscion	Lutjanus	Eucinstomus argenteus	Eucinostomus gula
1	0.171	0.571	**0.048**	0.062	0.780	0.244	0.075	0.145			9.095	2.181	**0.560**
3	**0.059**	0.201	0.125	0.050	1.072	**0.074**	0.107	**0.047**	0.250	16.617	**2.231**		1.277
5	**0.059**	0.084	1.982	0.049	**0.067**	0.158	**0.030**	0.166	**0.040**	**0.028**	15.007	0.606	3.451
6	0.086	0.065	9.208	**0.034**	0.126	0.171	**0.030**	0.138	0.097	0.297	11.230	**0.515**	**0.557**
7	0.091	**0.029**	11.151	0.037	0.213	**0.071**	**0.033**	**0.048**	**0.063**	2.322	53.496	1.401	0.695
9	0.126	0.068	12.239	0.054	0.584	**0.070**	**0.028**	0.056	0.079	0.067	4.898	**0.460**	0.822
11	**0.054**	0.120	8.383	**0.029**	0.508	0.169	0.052	0.045	0.100	**0.039**	3.355	0.899	0.910

Table 19. Final variables used in throw-trap models (Cat= categorical; Cont= continuous)

Species	Region	Habitat	TtSC	HwSC	SfSC	Depth	Julian date	Temperature	Salinity
Type	Cat	Cat	Cont	Cont	Cont	Cont	Cont	Cont	Cont
Farfantepenaeus duorarum	x	x	x	x	x	x	x	x	x
Floridichthys carpio	x	x	x	x		x	x	x	x
Gobiosoma robustum	x	x	x	x		x	x	x	x
Hippolyte spp.	x	x	x	x	x	x	x	x	x
Lucania parvae	x	x	x	x	x	x	x	x	x
Opsanus beta	x	x	x	x	x	x	x	x	x
Syngnathus scovelli	x	x	x	x	x	x	x	x	x
Thor spp.	x	x	x	x	x	x	x	x	x

Table 20. Throw-trap validation results model r^2, optimism, and p-value and r^2 and p-value (from linear regression between predicted and observed with and without region) for model and validation years

	Model			Model			
	Adjusted model r^2	Optimism[1]	p-val.	r^2	p-val.	r^2	p-val.
				without region		with region	
Species							
Number of Samples							
Farfantepenaeus duorarum	0.419	0.98	<.0001	0.440	<.0001	0.440	<.0001
Floridichthys carpio	0.182	0.943	<.0001	0.105	<.0001	0.114	<.0001
Gobiosoma robustum	0.108	0.915	<0.0001	0.078	<0.0001	0.081	<0.0001
Hippolyte spp.	0.165	0.948	<0.0001	0.004	<0.0001	0.023	<0.0001
Lucania parva	0.248	0.996	<.0001	0.161	<.0001	0.168	<.0001
Opsanus beta	0.122	0.924	<.0001	0.100	<.0001	0.100	<.0001
Syngnathus scovelli	0.108	0.908	<.0001	0.091	<.0001	0.091	<.0001
Thor spp.	0.195	0.961	<.0001	0.035	<.0001	0.041	<.0001

	Dry Year Validation				Wet Year Validation			
	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.
	without region		with region		without region		with region	
Species								
Number of Samples								
Farfantepenaeus duorarum	0.020	0.040	0.390	<.0001	0.549	<.0001	0.622	<.0001
Floridichthys carpio	0.016	0.016	0.046	0.014	0.090	0.015	0.228	0.003
Gobiosoma robustum	0.007	0.160	0.294	<0.0001	0.397	<0.0001	0.496	<0.0001
Hippolyte spp.	0.037	<0.0001	0.267	<0.0001	0.165	<0.0001	0.325	<0.0001
Lucania parva	0.114	<.0001	0.208	<.0001	0.047	0.019	0.145	0.003
Opsanus beta	0.184	<.0001	0.311	<.0001	0.010	0.426	0.249	0.002
Syngnathus scovelli	0.036	0.002	0.060	0.002	0.059	0.051	0.203	0.008
Thor spp.	0.104	<.0001	0.170	<.0001	0.138	0.002	0.197	0.009

	1980 Average Validation				1990 Average Year Validation			
	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.
	without region		with region		without region		with region	
Species								
Number of Samples								
Farfantepenaeus duorarum	0.426	<.0001	0.456	<.0001	0.170	<.0001	0.427	<.0001
Floridichthys carpio	0.038	<.0001	0.067	<.0001	0.230	<.0001	0.276	<.0001
Gobiosoma robustum	0.108	<0.0001	0.189	<0.0001	0.018	0.182	0.208	0.0002
Hippolyte spp.	0.037	<0.0001	0.267	<0.0001	0.003	0.608	0.212	<0.0001
Lucania parva	0.109	<.0001	0.151	<.0001	0.007	0.238	0.177	0.001
Opsanus beta	0.079	<.0001	0.142	<.0001	0.035	0.118	0.075	0.062
Syngnathus scovelli	0.066	<.0001	0.112	<.0001	0.005	0.500	0.250	0.001
Thor spp.	0.052	<.0001	0.072	<.0001	0.011	0.300	0.091	0.059

Table 21. F-statistic and P-values of final models and model variables (from ANOVA of whole model) in throw-trap models

Species	Final Model		Region		Habitat		TtSC		HwSC		SfSC		Depth		Julian date		Temperature		Salinity	
	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value
Farfantepenaeus duorarum	130.4	<.0001	162.9	<.0001	0.3	0.7542	10.5	<.0001	62.0	<.0001	28.3	0.0007	15.7	<.0001	222.5	<.0001	8.9	<.0001	13.6	<.0001
Floridichthys carpio	42.0	<.0001	9.8	<.0001	10.1	<.0001	3.3	0.0197	1.2	0.305	1.34*	0.2463	171.7	<.0001	27.8	<.0001	2.7	0.0285	15.3	<.0001
Gobiosoma robustum	23.5	<.0001	62.4	<.0001	21.5	<.0001	12.1	<.0001	7.4	0.0001	0*	0.9466	6.0	0.0024	14.4	<.0001	6.0	0.0001	2.3	0.0419
Hippolyte spp.	37.0	<.0001	20.1	<.0001	39.5	<.0001	19.5	<.0001	47.4	<.0001	67.5	<.0001	54.5	<.0001	35.6	<.0001	4.1	0.0002	17.5	<.0001
Lucania parvae	60.4	<.0001	15.8	<.0001	33.2	<.0001	44.3	<.0001	12.1	<.0001	57.2	<.0001	93.5	<.0001	25.6	<.0001	5.8	<.0001	66.5	<.0001
Opsanus beta	26.7	<.0001	8.2	<.0001	5.1	0.0064	35.1	<.0001	16.3	<.0001	24.1	<.0001	25.6	<.0001	25.7	<.0001	6.0	<.0001	26.0	<.0001
Syngnathus scovelli	23.8	<.0001	3.8	0.0093	32.0	<.0001	7.1	<.0001	27.5	<.0001	1.1	0.2902	2.5	0.0819	63.4	<.0001	1.7	0.1258	4.6	0.0003
Thor spp.	44.8	<.0001	16.1	<.0001	190.0	<.0001	68.2	<.0001	31.2	<.0001	117.8	<.0001	22.3	<.0001	5.6	0.0002	4.6	0.001	26.1	<.0001

*eliminated from final model

Table 22. Ranked importance of variables in throw-trap models (NS=not significant, p<0.05). Ranks were based on the F-statistic generated from the ANOVA (Table 21).

Species	Region	Habitat	TtSC	HwSC	SfSC	Depth	Julian date	Temperature	Salinity
Farfantepenaeus duorarum	2	NS	7	3	6	4	1	8	5
Floridichthys carpio	5	4	6	NS	*	1	2	7	3
Gobiosoma robustum	1	2	4	5	*	6	3	7	8
Hippolyte spp.	6	4	7	3	1	2	5	9	8
Lucania parvae	7	5	4	8	3	1	6	9	2
Opsanus beta	7	9	1	6	5	4	3	8	2
Syngnathus scovelli	6	2	4	3	NS	7	1	NS	5
Thor spp.	7	1	3	4	2	6	8	9	5
Most important variable	1	1	1	0	1	2	2	0	0
Top 2	2	3	1	0	2	3	3	0	2
Top 3	2	3	2	3	2	3	5	0	3

*eliminated from final model

Table 23. Final variables used in trawl/seine models (Cat= categorical; Cont= continuous)

	Region	Habitat	Gear	BB.Tt	BB.Hw	BB.Sf	Depth	Julian date	Temperature	Salinity
Type of Variable	Cat	Cat	Cat	Cont	Cont	Cont	Cont	Cont	Cont	Cont
Anarchopterus criniger	x	x	x	x	x	x	x	x	x	x
Anchoa mitchelli	x	x	x	x	x	x	x	x	x	x
Atherinomorus stipes	x	x	x	x	x	x	x	x	x	x
Cynoscion nebulosus	x	x	x	x	x	x	x	x	x	x
Eucinostomus spp.	x	x	x	x	x	x	x	x	x	x
Farfantepenaeus duorarum	x	x	x	x	x	x	x	x		x
Floridichthys carpio	x	x	x	x	x	x	x	x	x	x
Hippocampus zostera	x	x	x	x	x	x	x	x	x	x
Lagodon rhomboides	x	x	x	x	x	x	x	x	x	x
Lucania parvae	x	x	x	x	x	x	x	x	x	x
Lutjanus griseus	x	x	x	x	x	x	x	x	x	x
Microbius gulosus	x	x	x	x	x	x	x	x	x	x
Microgobius microlepis	x	x	x	x	x	x	x	x	x	x
Opisthonema oglinum	x	x	x	x	x	x	x	x	x	x
Opsanus beta	x	x	x	x	x	x	x	x	x	x
Syngnathus floridae	x	x	x	x	x	x	x	x	x	x
Syngnathus scovelli	x	x	x	x	x	x	x	x	x	x

Table 24. Seine/trawl model and validation results: unadjusted model r^2 adjusted r2 and bootstrapped r^2 (adjusted), computed optimism index from bootstrapping; and r2 and p-values of linear regressions between predicted and observed, with and without region.

Species	Model r^2	Adjusted Model r^2	Optimism	P-value	Full model observed vs predicted r^2	Full model observed vs predicted p-value	Full model observed vs predicted with region r^2	Full model observed vs predicted with region p-value	Dry year 1984 observed vs predicted r^2	Dry year 1984 observed vs predicted p-value	Dry year 1984 with region observed vs predicted r^2	Dry year 1984 with region observed vs predicted p-value	Wet year 1995 observed vs predicted r^2	Wet year 1995 observed vs predicted p-value	Wet year 1995 with region observed vs predicted r^2	Wet year 1995 with region observed vs predicted p-value	Average year 1996 observed vs predicted r^2	Average year 1996 observed vs predicted p-value	Average year 1996 with region observed vs predicted r^2	Average year 1996 with region observed vs predicted p-value
Number of Samples	3900	3900			3900		3900		96		96		1267		1267		513		513	
Anarchopterus crinigerus	0.148	0.141	0.953	<.0001	0.077	<.0001	0.077	<.0001	NE	NE	NE	NE	0.150	<.0001	0.153	<.0001	0.097	<.0001	0.102	<.0001
Anchoa mitchelli	0.221	0.212	0.960	<.0001	0.014	<.0001	0.016	<.0001	0.016	0.2200	0.022	0.7220	0.026	<.0001	0.029	<.0001	0.085	<.0001	0.089	<.0001
Atherinomorus stipes	0.1220	0.113	0.926	<.0001	0.043	<.0001	0.046	<.0001	NE	NE	NE	NE	0.017	<.0001	0.020	<.0001	0.017	0.003	0.034	0.001
Cynoscion nebulosus	0.136	0.127	0.934	<.0001	0.114	<.0001	0.115	<.0001	0.039	0.0540	0.152	0.0040	0.222	<.0001	0.250	<.0001	0.183	<.0001	0.192	<.0001
Eucinostomus spp.	0.332	0.327	0.985	<.0001	0.073	<.0001	0.074	<.0001	0.023	0.1410	0.043	0.4330	0.068	<.0001	0.088	<.0001	0.139	<.0001	0.184	<.0001
Farfantepenaeus duorarum	0.279	0.270	0.968	<.0001	0.054	<.0001	0.054	<.0001	0.368	<.0001	0.424	<.0001	0.140	<.0001	0.156	<.0001	0.234	<.0001	0.247	<.0001
Floridichthys carpio	0.451	0.445	0.987	<.0001	0.011	<.0001	0.013	<.0001	0.012	0.2900	0.041	0.4230	0.175	<.0001	0.191	<.0001	0.114	<.0001	0.145	<.0001
Hippocampus zosterae	0.107	0.100	0.935	<.0001	0.047	<.0001	0.048	<.0001	0.050	0.0290	0.072	0.1430	0.043	<.0001	0.046	<.0001	0.047	<.0001	0.070	<.0001
Lagodon rhomboides	0.387	0.380	0.982	<.0001	0.126	<.0001	0.130	<.0001	0.017	0.2100	0.120	0.0190	0.161	<.0001	0.170	<.0001	0.141	<.0001	0.157	<.0001
Lucania parva	0.381	0.374	0.982	<.0001	0.108	<.0001	0.113	<.0001	0.007	0.4280	0.050	0.3150	0.225	<.0001	0.239	<.0001	0.335	<.0001	0.337	<.0001
Lutjanus griseus	0.133	0.124	0.932	<.0001	0.052	<.0001	0.054	<.0001	0.105	0.0010	0.120	0.0200	0.102	<.0001	0.108	<.0001	0.102	<.0001	0.119	<.0001
Microgobius gulosus	0.364	0.357	0.981	<.0001	0.138	<.0001	0.138	<.0001	0.013	0.2650	0.054	0.2760	0.249	<.0001	0.256	<.0001	0.196	<.0001	0.198	<.0001
Microgobius microlepis	0.14	0.132	0.943	<.0001	0.078	<.0001	0.078	<.0001	0.155	0.0001	0.219	0.0001	0.084	<.0001	0.087	<.0001	0.059	<.0001	0.083	<.0001
Opisthonema oglinum	0.09	0.081	0.900	<.0001	0.002	0.002	0.003	0.0120	0.001	0.7883	0.017	0.8183	0.031	<.0001	0.036	<.0001	0.031	<.0001	0.033	0.002
Opsanus beta	0.127	0.119	0.937	<.0001	0.033	<.0001	0.038	<.0001	0.096	0.0022	0.154	0.0040	0.064	<.0001	0.084	<.0001	0.056	<.0001	0.067	<.0001
Syngnathus floridae	0.225	0.217	0.964	<.0001	0.148	<.0001	0.148	<.0001	0.299	<.0001	0.329	<.0001	0.227	<.0001	0.257	<.0001	0.076	<.0001	0.084	<.0001
Syngnathus scovelli	0.235	0.229	0.974	<.0001	0.093	<.0001	0.095	<.0001	0.057	0.0193	0.083	0.0911	0.239	<.0001	0.247	<.0001	0.155	<.0001	0.168	<.0001

NE=not estimatable-
validation data=zero catches

Table 25. F-statistic and P-value of final model and model variables (from ANOVA of models from full trawl/seine data set)

Species	Model		Region		Habitat		Gear		BB.Tt		BB.Hw		BB.Sf	
	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value
Anarchopterus criniger	36.9	<0.0001	105.8	<0.0001	27.8	<0.0001	27.4	<0.0001	25.5	<0.0001	5.7	0.0170	7.0	0.0081
Anchoa mitchelli	60.2	<0.0001	53.2	<0.0001	17.7	<0.0001	3.7	0.0532	100.1	<0.0001	22.5	<0.0001	4.5	0.0340
Atherinomorus stipes	29.5	<0.0001	100.9	<0.0001	10.2	<0.0001	4.7	0.0305	32.5	<0.0001	35.8	<0.0001	0.0	0.9526
Cynoscion nebulosus	33.3	<0.0001	53.6	<0.0001	1.3	0.2508	3.3	0.0684	21.5	<0.0001	71.6	<0.0001	121.3	<0.0001
Eucinostomus spp.	105.5	<0.0001	15.0	<0.0001	12.4	<0.0001	2.4	0.1173	40.1	<0.0001	147.5	<0.0001	239.8	<0.0001
Farfantepenaeus duorarum	89.6	<0.0001	110.5	<0.0001	5.5	0.0002	25.8	<0.0001	37.6	<0.0001	199.2	<0.0001	64.1	<0.0001
Floridichthys carpio	174.1	<0.0001	210.7	<0.0001	15.5	<0.0001	2.7	0.0989	20.1	<0.0001	1.7	0.1960	10.4	0.0012
Hippocampus zostera	25.3	<0.0001	28.7	<0.0001	15.6	<0.0001	5.7	0.0167	24.7	<0.0001	44.8	0.0289	37.9	<0.0001
Lagodon rhomboides	133.6	<0.0001	206.0	<0.0001	10.4	<0.0001	22.1	<0.0001	88.2	<0.0001	61.6	<0.0001	495.6	<0.0001
Lucania parvae	130.4	<0.0001	80.2	<0.0001	142.5	<0.0001	12.2	0.0005	160.4	<0.0001	0.2	0.6936	348.1	<0.0001
Lutjanus griseus	32.4	<0.0001	14.4	<0.0001	16.6	<0.0001	10.6	<0.0001	10.6	<0.0001	24.7	<0.0001	286.3	<0.0001
Microgobius gulosus	121.1	<0.0001	31.8	<0.0001	67.6	<0.0001	6.4	0.0114	36.4	<0.0001	2.2	0.1361	0.1	0.7855
Microgobius microlepis	34.4	<0.0001	30.2	<0.0001	10.1	<0.0001	0.3	0.6043	1.5	0.2221	11.2	0.0008	1.0	0.3265
Opisthonema oglinum	23.0	<0.0001	9.3	<0.0001	20.1	<0.0001	12.2	0.0005	45.9	<0.0001	2.1	0.1463	14.8	0.0001
Opsanus beta	31.0	<0.0001	25.4	<0.0001	6.0	<0.0001	35.5	<0.0001	32.8	<0.0001	2.2	0.1370	124.1	<0.0001
Syngnathus floridae	61.4	<0.0001	106.5	<0.0001	27.4	<0.0001	23.8	<0.0001	48.2	<0.0001	14.1	0.0002	294.0	<0.0001
Syngnathus scovelli	65.3	<0.0001	53.6	<0.0001	5.4	0.0030	16.9	<0.0001	16.4	<0.0001	122.2	<0.0001	54.6	<0.0001

Species	Depth		Julian date		Temperature		Salinity	
	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value	F-statistic	P-value
Anarchopterus criniger	7.3	0.0007	3.3	0.0092	1.0	0.3221	48.4	<0.0001
Anchoa mitchelli	5.3	0.0049	7.4	<0.0001	8.8	<0.0001	37.1	<0.0001
Atherinomorus stipes	1.6	0.1895	2.7	0.0303	4.3	0.0138	61.3	<0.0001
Cynoscion nebulosus	10.7	<0.0001	6.9	<0.0001	0.5	0.6228	16.4	<0.0001
Eucinostomus spp.	58.3	<0.0001	120.3	<0.0001	2.6	0.1060	16.2	<0.0001
Farfantepenaeus duorarum	97.5	<0.0001	19.4	<0.0001	0.4	0.5265	56.4	<0.0001
Floridichthys carpio	94.7	<0.0001	19.8	<0.0001	9.5	0.0001	66.3	<0.0001
Hippocampus zostera	31.7	<0.0001	13.5	<0.0001	0.2	0.6496	30.4	<0.0001
Lagodon rhomboides	96.6	<0.0001	8.2	<0.0001	3.9	0.0495	20.4	<0.0001
Lucania parvae	131.6	<0.0001	12.6	<0.0001	2.9	0.0573	4.2	0.0155
Lutjanus griseus	43.5	<0.0001	9.8	<0.0001	5.9	0.0028	10.9	<0.0001
Microgobius gulosus	3.3	0.0672	3.6	0.0060	2.3	0.1039	150.0	<0.0001
Microgobius microlepis	12.9	<0.0001	3.1	0.0153	12.0	0.0005	14.0	<0.0001
Opisthonema oglinum	2.1	0.1461	2.7	0.0275	0.3	0.7299	1.3	0.2539
Opsanus beta	19.9	<0.0001	2.2	0.0706	9.6	0.0001	18.2	<0.0001
Syngnathus floridae	59.1	<0.0001	20.1	<0.0001	2.1	0.1487	40.9	<0.0001
Syngnathus scovelli	124.6	<0.0001	44.2	0.1562	8.4	0.0524	56.3	0.0035

*eliminated in final model

Table 26. Ranked importance of variables in trawl/seine models (NS=not significant, p<0.05). Ranks were based on the F-statistic generated from the ANOVA (Table 25).

Species	Region	Habitat	Gear	BB.Tt	BB.Hw	BB.Sf	Depth	Julian date	Temperature	Salinity
Anarchopterus criniger	1	3	4	5	8	7	6	9	NS	2
Anchoa mitchelli	2	5	10	1	4	9	8	7	6	3
Atherinomorus stipes	1	5	6	4	3	NS	9	8	7	2
Cynoscion nebulosus	3	NS	8	4	2	1	6	7	NS	5
Eucinostomus spp.	6	8	NS	5	2	1	4	3	NS	7
Farfantepenaeus duorarum	2	9	7	6	1	4	3	8	NS	5
Floridichthys carpio	1	6	9	4	NS	7	2	5	8	3
Hippocampus zostera	5	6	8	1	9	2	3	7	NS	4
Lagodon rhomboides	2	8	6	4	5	1	3	9	10	7
Lucania parvae	5	3	8	2	NS	1	4	6	9	8
Lutjanus griseus	5	4	8	7	3	1	2	9	10	6
Microbius gulosus	4	2	5	3	NS	NS	7	6	NS	1
Microgobius microlepis	1	6	NS	NS	5	NS	3	7	4	2
Opisthonema oglinum	5	2	4	1	8	3	NS	6	NS	NS
Opsanus beta	4	7	2	3	NS	1	5	9	8	6
Syngnathus floridae	2	7	9	4	10	1	3	8	NS	5
Syngnathus scovelli	5	9	6	7	2	4	1	NS	8	3
Most important variables	4	0	0	3	1	7	1	0	0	1
Top 2	8	2	1	3	5	8	4	0	0	5
Top 3	9	4	1	6	6	9	8	1	0	7

Table 27.Comparison of trawl/seine and throw-trap models (linear regression between predicted and observed) model r2, prediction of model data, dry year validation, wet year validation, average year validation

Species	Number of Samples	*Farfantepenaeus duorarum*	*Floridichthys carpio*	*Lucania parva*	*Opsanus beta*	*Syngnathus scovelli*
Throw-trap Model r2	6082	0.419	0.182	0.248	0.122	0.108
Trawl/seine Model r^2	3900	0.270	0.445	0.374	0.119	0.229
Throw-trap full model observed vs predicted	6082	0.440	0.105	0.161	0.100	0.091
Trawl/seine full model observed vs predicted	3900	0.054	0.011	0.108	0.033	0.093
Throw-trap dry year 1984	265	0.390	0.016	0.208	0.311	0.060
Trawl/seine dry year 1984	96	0.368	0.012	0.007	0.096	0.057
Throw-trap wet year 1995	59	0.622	0.090	0.145	0.249	0.203
Trawl/seine wet year 1995	1267	0.140	0.175	0.225	0.064	0.239
Throw-trap average year 80's	856	0.426	0.038	0.109	0.079	0.066
Throw-trap average year 90's	93	0.170	0.230	0.007	0.035	0.005
Trawl/seine average year 90's	513	0.234	0.114	0.335	0.056	0.155

Table 28. Farfantepenaeus (pink shrimp) model validation results throw-trap.

Final model				Observed vs. predicted by final model		Observed vs predicted by final model (with 'region')[2]		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region	
Model r^2	Adjusted model r^2	Optimism[1]	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.
Robblee data				Robblee data				Matheson's data				Matheson's data				Matheson's data			
All Years				All Years				All Years				Average Year				Wet Year			
0.426	0.419	0.98	<.0001	0.440	<.0001	0.440	<.0001	0.165	<.0001	0.454	<.0001	0.170	<.0001	0.427	<.0001	0.549	<.0001	0.622	<.0001
								Sogard's data				Sogard's data				Sogard's data			
								All Years				Average Year				Dry Year			
								0.209	<.0001	0.331	<.0001	0.426	<.0001	0.456	<.0001	0.020	0.040	0.390	<.0001

[1] Optimism is expressed as the ratio of the bootstrap-adjusted r2 (column 2 to the unadjusted model r2 (column 1)

[2] The categorical variable 'region' is used in the regression equation to take into account regional differences in the relationship of predicted to observed data.

Table 29. Floridichthys carpio validation results throw-trap

Final model				Observed vs. predicted by final model		Observed vs predicted by final model (with 'region')[2]		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region	
Model r^2	Adjusted model r^2	Optimism[1]	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.
Robblee data				Robblee data				Matheson's data				Matheson's data				Matheson's data			
All Years				All Years				All Years				Average Year				Wet Year			
0.193	0.182	0.943	<.0001	0.105	<.0001	0.114	<.0001	0.179	<.0001	0.233	<.0001	0.230	<.0001	0.276	<.0001	0.090	0.015	0.228	0.003
								Sogard's data				Sogard's data				Sogard's data			
								All Years				Average Year				Dry Year			
								0.032	<.0001	0.046	<.0001	0.038	<.0001	0.067	<.0001	0.016	0.016	0.046	0.014

[1] Optimism is expressed as the ratio of the bootstrap-adjusted r2 (column 2 to the unadjusted model r2 (column 1)

[2] The categorical variable 'region' is used in the regression equation to take into account regional differences in the relationship of predicted to observed data.

Table 30. Gobiosoma robustum validation results throw-trap

Final model				Observed vs. predicted by final model		Observed vs predicted by final model (with 'region')[2]		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region	
Model r^2	Adjusted model r^2	Optimism [1]	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.
Robblee data				Robblee data				Matheson's data				Matheson's data				Matheson's data			
All Years				All Years				All Years				Average Year				Wet Year			
0.118	0.108	0.915	<0.0001	0.078	<0.0001	0.081	<0.0001	0.019	0.079	0.233	<0.0001	0.018	0.182	0.208	0.0002	0.397	<0.0001	0.496	<0.0001
								Sogard's data				Sogard's data				Sogard's data			
								All Years				Average Year				Dry Year			
								0.015	<0.0001	0.217	<0.0001	0.108	<0.0001	0.189	<0.0001	0.007	0.160	0.294	<0.0001

[1] Optimism is expressed as the ratio of the bootstrap-adjusted r2 (column 2 to the unadjusted model r2 (column 1)

[2] The categorical variable 'region' is used in the regression equation to take into account regional differences in the relationship of predicted to observed data.

Table 31. Hippolyte spp. validation results throw-trap

Final model				Observed vs. predicted by final model		Observed vs predicted by final model (with 'region')[2]		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region	
Model r^2	Adjusted model r^2	Optimism[1]	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.
Robblee data				Robblee data				Matheson's data				Matheson's data				Matheson's data			
All Years				All Years				All Years				Average Year				Wet Year			
0.174	0.165	0.948	<0.0001	0.004	<0.0001	0.023	<0.0001	0.002	0.565	0.222	<0.0001	0.003	0.608	0.212	<0.0001	0.165	<0.0001	0.325	<0.0001
								Sogard's data				Sogard's data				Sogard's data			
								All Years				Average Year				Dry Year			
								0.003	0.065	0.203	<0.0001	0.037	<0.0001	0.267	<0.0001	0.037	<0.0001	0.267	<0.0001

[1] Optimism is expressed as the ratio of the bootstrap-adjusted r2 (column 2 to the unadjusted model r2 (column 1)

[2] The categorical variable 'region' is used in the regression equation to take into account regional differences in the relationship of predicted to observed data.

Table 32. Lucania parva model validation results throw-trap

Final model				Observed vs. predicted by final model		Observed vs predicted by final model (with 'region')[2]		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region	
Model r^2	Adjusted model r^2	Optimism[1]	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.
Robblee data				Robblee data				Matheson's data				Matheson's data				Matheson's data			
All Years				All Years				All Years				Average Year				Wet Year			
0.249	0.248	0.996	<.0001	0.161	<.0001	0.168	<.0001	0.006	0.104	0.075	0.004	0.007	0.238	0.177	0.001	0.047	0.019	0.145	0.003
								Sogard's data				Sogard's data				Sogard's data			
								All Years				Average Year				Dry Year			
								0.134	<.0001	0.218	<.0001	0.109	<.0001	0.151	<.0001	0.114	<.0001	0.208	<.0001

[1] Optimism is expressed as the ratio of the bootstrap-adjusted r2 (column 2 to the unadjusted model r2 (column 1)

[2] The categorical variable 'region' is used in the regression equation to take into account regional differences in the relationship of predicted to observed data.

Table 33. Opsanus beta model validation results throw-trap

Final model				Observed vs. predicted by final model		Observed vs predicted by final model (with 'region')[2]		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region	
Model r^2	Adjusted model r^2	Optimism[1]	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.
Robblee data				Robblee data				Matheson's data				Matheson's data				Matheson's data			
All Years				All Years				All Years				Average Year				Wet Year			
0.132	0.122	0.924	<.0001	0.100	<.0001	0.100	<.0001	0.033	0.021	0.100	0.002	0.035	0.118	0.075	0.062	0.010	0.426	0.249	0.002
								Sogard's data				Sogard's data				Sogard's data			
								All Years				Average Year				Dry Year			
								0.193	<.0001	0.227	<.0001	0.079	<.0001	0.142	<.0001	0.184	<.0001	0.311	<.0001

[1] Optimism is expressed as the ratio of the bootstrap-adjusted r2 (column 2 to the unadjusted model r2 (column 1)

[2] The categorical variable 'region' is used in the regression equation to take into account regional differences in the relationship of predicted to observed data.

Table 34. Syngnathus scovelli validation results throw trap

Final model				Observed vs. predicted by final model		Observed vs predicted by final model (with 'region')[2]		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region	
Model r^2	Adjusted model r^2	Optimism[1]	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.
Robblee data				Robblee data				Matheson's data				Matheson's data				Matheson's data			
All Years				All Years				All Years				Average Year				Wet Year			
0.119	0.108	0.908	<.0001	0.091	<.0001	0.091	<.0001	0.008	0.246	0.109	0.001	0.005	0.500	0.250	0.001	0.059	0.051	0.203	0.008
								Sogard's data				Sogard's data				Sogard's data			
								All Years				Average Year				Dry Year			
								0.022	<.0001	0.081	<.0001	0.066	<.0001	0.112	<.0001	0.036	0.002	0.060	0.002

[1] Optimism is expressed as the ratio of the bootstrap-adjusted r2 (column 2 to the unadjusted model r2 (column 1)

[2] The categorical variable 'region' is used in the regression equation to take into account regional differences in the relationship of predicted to observed data.

Table 35. Thor spp. model validation results throw-trap.

Final model				Observed vs. predicted by final model		Observed vs predicted by final model (with 'region')[2]		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region		Validation linear regression observed vs. predicted		Validation linear regression observed vs predicted with region	
Model r^2	Adjusted model r^2	Optimism[1]	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.	r^2	p-val.
Robblee data				Robblee data				Matheson's data				Matheson's data				Matheson's data			
All Years				All Years				All Years				Average Year				Wet Year			
0.203	0.195	0.961	<.0001	0.035	<.0001	0.041	<.0001	0.003	0.455	0.073	0.016	0.011	0.300	0.091	0.059	0.138	0.002	0.197	0.009
								Sogard's data				Sogard's data				Sogard's data			
								All Years				Average Year				Dry Year			
								0.100	<.0001	0.236	<.0001	0.052	<.0001	0.072	<.0001	0.104	<.0001	0.170	<.0001

[1] Optimism is expressed as the ratio of the bootstrap-adjusted r2 (column 2 to the unadjusted model r2 (column 1)

[2] The categorical variable 'region' is used in the regression equation to take into account regional differences in the relationship of predicted to observed data.

Table 36. Summary of scenario responses for Trout Cove (Northeast region)-abundance in trawl/seine

			Treatment No lag						Treatment 30 day lag		
Factors	90% base	110% base	130% base	10 psu increase	20 psu increase	change in base	90% base	110% base	130% base	10 psu increase	20 psu increase
Salinity	-1	0	1	1	2	0	-1	0	1	1	2
Thalassia BB	0	0	0	1	2	0	0	0	1	2	2
Halodule BB	2	-1	-2	-2	-2	-1	2	-1	-2	-2	-2
Anarchopterus crinigerus	1	-1	-1	-2	-2	-1	1	-1	-1	-2	-2
Anchoa mitchelli	1	-1	-1	-2	-3	-1	1	-1	-1	-2	-3
Atherinomorus stipes	-1	1	2	2	3	-1	-1	1	2	2	3
Cynoscion nebulosus	1	-1	-1	-1	-2	-1	1	-1	-1	-1	-2
Eucinostomus spp.	1	-1	-1	-2	-2	-1	1	-1	-1	-2	-2
Farfantepenaeus duorarum	1	-1	-1	-1	1	1	1	-1	-1	0	both
Floridichthys carpio	1	0	-1	-1	-2	-1	1	-1	-1	-1	both
Hippocampus zosterae	0	0	0	both	both	1	0	0	0	both	both
Lagodon rhomboides	1	-1	both	both	both	-1	1	0	-1	both	both
Lucania parvae	1	0	-1	-1	-1	-1	1	-1	-1	-1	-1
Lutjanus griseus	0	0	0	1	1	0	0	0	1	1	1
Microgobius gulosus	1	-1	-1	-2	-3	-1	1	-1	-1	-2	-3
Microgobius microlepis	0	0	0	-1	-1	-1	0	0	-1	-1	-2
Opsanus beta	0	0	both	both	both	1	0	0	both	both	both
Syngnathus floridae	0	0	0	0	1	-1	0	0	1	1	1
Syngnathus scovelli	1	-1	-1	-1	-2	-1	-1	-1	-1	-1	-2
Species up	10	1	1	2	3		9	1	3	3	3
Species down	1	8	9	10	9		1	9	11	9	8
Total fish abundance	1	-1	-1	-1	-2	-1	1	-1	-1	-1	-1
Evenness	-1	1	1	1	both	1	-1	1	1	1	-1

0=no difference
1=less than 50% increase
2=50% to 150% increase (about double)
3=greater than 200% increase (triple or more)
(-1)=less than 50% decrease
(-2)=50% to 150% decrease (about double)
(-3)=greater than 200% decrease (triple or more)
both- increase and decrease by season

Table 37. Summary of scenario responses for Trout Cove (Northeast region)-biomass in trawl/seine

	Treatment No lag						Treatment 30 day lag				
Factors	90% base	110% base	130% base	10 psu increase	20 psu increase	change in base	90% base	110% base	130% base	10 psu increase	20 psu increase
Salinity	-1	0	1	1	2	0	-1	0	1	1	2
Thalassia BB	0	0	0	1	2	0	0	0	1	2	2
Halodule BB	2	-1	-2	-2	-2	-1	2	-1	-2	-2	-2
Anarchopterus crinigerus	1	-1	-1	-2	-2	-1	1	-1	-1	-2	-2
Anchoa mitchelli	1	-1	-1	-2	-3	-1	1	-1	-1	-2	-3
Atherinomorus stipes	-1	1	2	2	3	-1	-1	1	2	2	3
Cynoscion nebulosus	1	-1	-1	-1	-2	-1	1	-1	-1	-1	-3
Eucinostomus spp.	1	-1	-1	-2	-2	-1	1	-1	-1	-2	-2
Farfantepenaeus duorarum	1	-1	-1	-1	1	1	1	-1	-1	-1	both
Floridichthys carpio	1	0	-1	-1	-2	-1	1	-1	-1	-1	both
Hippocampus zosterae	0	0	0	both	both	1	0	0	1	both	both
Lagodon rhomboides	1	0	-1	both	both	-1	1	0	-1	both	both
Lucania parvae	1	0	-1	-1	-1	1	1	-1	-1	-1	-1
Lutjanus griseus	0	0	0	1	1	0	0	0	1	1	1
Microgobius gulosus	1	-1	-1	-2	-3	-1	1	-1	-1	-2	-3
Microgobius microlepis	0	0	0	-1	-1	-1	0	0	-1	-1	-2
Opsanus beta	0	0	both	both	both	1	0	0	both	both	both
Syngnathus floridae	0	0	0	1	1	-1	0	0	1	1	1
Syngnathus scovelli	1	-1	-1	-1	-2	-1	-1	-1	-1	-1	-2
Total fish biomass	1	-1	-1	-1	-1	0	1	-1	-1	-1	-1
Predator biomass	1	0	1	1	1	1	0	0	1	1	1
Forage fish biomass	1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1

0=no difference
1=less than 50% increase
2=50% to 150% increase (about double)
3=greater than 200% increase (triple or more)
(-1)=less than 50% decrease
(-2)=50% to 150% decrease (about double)
(-3)=greater than 200% decrease (triple or more)
both- increase and decrease by season

Table 38. Summary of scenario responses for Trout Cove (Northeast region)-abundance in throw-trap

Treatment	Salinity	Thalassia	Halodule	Total Seagrass SC	Farfantepenaeus duorarum	Floridichthys carpio	Gobiosoma robustum	Hippolyte spp.	Lucania parvae	Opsanus beta	S. scovelli	Thor spp.	Species up	Species down	Evenness	Total Abundance
No lag																
90% base	-1	0	2	0	-1	1	0	1	0	0	1	0	3	1	0	0
110% base	0	0	-1	0	0	-1	1	-1	0	0	-1	0	1	3	0	0
130%base	1	0	-2	0	1	-1	1	-1	-1	0	-1	0	2	4	0	0
10 psu increase	1	1	-2	0	2	-2	3	-2	-1	0	-2	0	2	4	0	0
20 psu increase	2	2	-2	0	2	-2	3	-2	2	2	-1	2	5	3	-1	2
30 day lag																
baseline	0	0	-1	0	1	-1	1	-1	-1	0	1	-1	5	3	0	0
90% base	-1	0	2	0	0	1	0	1	1	0	1	0	4	0	0	0
110% base	0	0	-1	0	0	-1	1	-1	-1	0	-1	0	1	4	0	0
130%base	1	1	-2	0	0	-1	1	-1	-1	0	-1	0	1	4	0	0
10 psu increase	1	2	-2	2	1	-2	3	-2	1	0	-2	0	3	3	-1	0
20 psu increase	2	2	-2	2	2	-2	3	-2	2	2	-2	2	3	3	-1	1

0=no difference

1=less than 50% increase

2=50% to 150% increase (about double)

3=greater than 200% increase (triple or more)

(-1)=less than 50% decrease

(-2)=50% to 150% decrease (about double)

(-3)=greater than 200% decrease (triple or more)

both- increase and decrease by season

Table 39. Summary of scenario responses for Trout Cove (Northeast region)-biomass in throw- trap

Treatment	Salinity	Thalassia	Halodule	Total Seagrass SC	Farfantepenaeus duorarum	Floridichthys carpio	Gobiosoma robustum	Hippolyte spp.	Lucania parvae	Opsanus beta	S. scovelli	Thor spp.	Total fish Biomass	Forage Fish Biomass
No lag														
90% base	-1	0	2	0	-1	1	0	1	1	0	1	1	0	0
110% base	0	0	-1	0	0	-1	1	-1	-1	0	-1	-2	0	-1
130%base	1	0	-2	0	1	-1	1	-1	-1	0	-1	-2	0	-1
10 psu increase	1	1	-2	0	2	-2	3	-2	-1	0	-2	0	1	-1
20 psu increase	2	2	-2	0	3	-2	3	-2	2	2	-2	0	2	-2
30 day lag														
baseline	0		-1	0	-1	1	1	-1	-1	0	1	-1	0	1
90% base	-1	0	2	0	1	1	0	1	1	0	-1	1	0	-1
110% base	0	0	-1	0	2	-1	1	-1	-1	0	-1	-2	0	-1
130%base	1	1	-2	0	3	-1	1	-1	-1	1	-1	-2	0	-1
10 psu increase	1	2	-2	2	2	-2	3	-1	-1	1	-2	0	1	-1
20 psu increase	2	2	-2	2	1	-2	3	-2	2	2	-2	0	1	-1

0=no difference

1=less than 50% increase

2=50% to 150% increase (about double)

3=greater than 200% increase (triple or more)

(-1)=less than 50% decrease

(-2)=50% to 150% decrease (about double)

(-3)=greater than 200% decrease (triple or more)

both- increase and
decrease by
season

Table 40. Summary of scenario responses for Inner Madeira Bay (Northeast region)-abundance in trawl/seine

	Treatment No lag						Treatment 30 day lag				
Factors	90% base	110% base	130% base	10 psu increase	20 psu increase	change in base	90% base	110% base	130% base	10 psu increase	20 psu increase
Salinity	-1	0	1	1	2	0	-1	0	1	1	2
Thalassia BB	0	0	1	1	2	-1	0	0	1	1	2
Halodule BB	1	-1	-2	-3	-3	-1	1	-1	-2	-3	-3
Anarchopterus crinigerus	1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1
Anchoa mitchelli	1	-1	-1	-2	-3	-1	1	-1	-1	-2	-3
Atherinomorus stipes	1	-1	-1	-2	-3	-1	1	-1	-1	-2	-3
Cynoscion nebulosus	1	-1	-1	-2	-3	-1	1	-1	-1	-2	-3
Eucinostomus spp.	1	-1	-1	-2	-2	0	1	-1	-1	-2	-2
Farfantepenaeus duorarum	0	0	-1	-1	-1	1	0	-1	-1	-1	-1
Floridichthys carpio	1	-1	-1	-1	-2	-1	1	-1	-1	-1	-2
Hippocampus zosterae	0	0	1	both	both	1	-1	1	1	1	1
Lagodon rhomboides	0	0	-1	-1	both	-1	0	0	-1	-1	-1
Lucania parvae	1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1
Lutjanus griseus	-1	1	1	1	1	1	-1	1	1	1	1
Microgobius gulosus	1	-1	-1	-1	-2	-1	1	-1	-1	-1	-2
Microgobius microlepis	1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1
Opsanus beta	-1	1	1	1	both	0	-1	1	1	1	both
Syngnathus floridae	-1	1	1	1	1	1	-1	1	1	1	1
Syngnathus scovelli	1	-1	-1	-2	-2	-1	1	-1	-1	-2	-2
Species up	10	3	4	3	2	3	10	4	4	4	3
Species down	3	10	12	12	11	10	4	11	12	12	12
Total fish abundance	1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1
Evenness	0	0	0	1	1	0	-1	0	1	1	1

0=no difference

1=less than 50% increase

2=50% to 150% increase (about double)

3=greater than 200% increase (triple or more)

(-1)=less than 50% decrease

(-2)=50% to 150% decrease (about double)

(-3)=greater than 200% decrease (triple or more)

both- increase and decrease by season

Table 41. Summary of scenario responses for Inner Madeira Bay (Northeast region)-biomass in trawl/seine

	Treatment No lag						Treatment 30 day lag				
Factors	90% base	110% base	130% base	10 psu increase	20 psu increase	change in base	90% base	110% base	130% base	10 psu increase	20 psu increase
Salinity	-1	0	1	1	2	0	-1	0	1	1	2
Thalassia BB	0	0	1	1	2	-1	0	0	1	1	2
Halodule BB	1	-1	-2	-3	-3	-1	1	-1	-2	-3	-3
Anarchopterus crinigerus	1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1
Anchoa mitchelli	1	-1	-1	-2	-3	-1	1	-1	-1	-2	-3
Atherinomorus stipes	1	-1	-1	-2	-3	-1	1	-1	-1	-2	-3
Cynoscion nebulosus	1	-1	-1	-2	-3	-1	1	-1	-1	-2	-3
Eucinostomus spp.	1	-1	-1	-2	-2	0	1	-1	-1	-2	-2
Farfantepenaeus duorarum	0	0	-1	-1	-1	1	0	0	-1	-1	-1
Floridichthys carpio	1	-1	-1	-1	-2	0	1	-1	-1	-1	-2
Hippocampus zosterae	-1	1	1	both	both	-1	-1	1	1	1	1
Lagodon rhomboides	0	0	-1	-1	-1	0	0	0	-1	-1	-1
Lucania parvae	0	-1	-1	-1	-1	-1	1	0	-1	-1	-1
Lutjanus griseus	-1	1	1	1	1	-1	-1	1	1	1	1
Microgobius gulosus	1	-1	-1	-1	-2	-1	1	-1	-1	-1	-2
Microgobius microlepis	1	-1	-1	-1	-1	1	1	-1	-1	-1	-1
Opsanus beta	-1	1	1	1	both	0	-1	1	1	1	both
Syngnathus floridae	-1	1	1	1	1	1	-1	1	1	1	1
Syngnathus scovelli	1	-1	-1	-2	-2	0	1	-1	-1	-2	-2
Total fish biomass	1	-1	-1	-1	-2	0	1	-1	-1	-1	-2
Predator biomass	0	0	0	both	both	1	-1	1	1	1	1
Forage fish biomass	1	-1	-1	-1	-1	0	1	-1	-1	-1	-1

0=no difference
1=less than 50% increase
2=50% to 150% increase (about double)
3=greater than 200% increase (triple or more)
(-1)=less than 50% decrease
(-2)=50% to 150% decrease (about double)
(-3)=greater than 200% decrease (triple or more)
both- increase and decrease by season

Table 42. Summary of scenario responses for Inner Little Madeira Bay (Northeast region)-abundance in throw-trap

Treatment	Salinity	Thalassia	Halodule	Total Seagrass SC	Farfantepenaeus duorarum	Floridichthys carpio	Gobiosoma robustum	Hippolyte spp.	Lucania parvae	Opsanus beta	S. scovelli	Thor spp.	Species up	Species down	Evenness	Total Abundance
No lag																
90% base	-1	0	1	0	0	1	-1	1	1	0	1	0	4	1	0	0
110% base	0	0	-1	0	0	-1	1	-1	-1	0	-1	0	1	4	0	0
130%base	1	1	-2	0	0	-1	1	-1	-1	1	-1	0	2	4	-1	0
10 psu increase	1	1	-3	1	1	-2	2	-2	-1	1	-1	both	3	4	-1	0
20 psu increase	2	2	-3	1	2	-3	3	-3	both	2	-2	both	3	3	-1	both
30 day lag																
baseline	0	-1	-1	-1	1	0	-1	-1	-1	0	1	-1	2	4	0	-1
90% base	-1	0	1	0	0	1	-1	1	1	0	1	0	4	1	-1	0
110% base	0	0	-1	0	0	-1	1	-1	-1	0	-1	0	1	4	0	0
130%base	1	1	-2	0	0	-1	1	-1	-1	1	-1	0	2	4	-1	0
10 psu increase	1	1	-3	1	1	-2	2	-2	-1	1	-1	-1	3	4	-1	both
20 psu increase	2	2	-3	1	2	-3	3	-3	-1	1	-2	-1	3	5	-1	both

0=no difference
1=less than 50% increase
2=50% to 150% increase (about double)
3=greater than 200% increase (triple or more)
(-1)=less than 50% decrease
(-2)=50% to 150% decrease (about double)
(-3)=greater than 200% decrease (triple or more)
both- increase and decrease by season

Table 43. Summary of scenario responses for Inner Little Madeira Bay (Northeast region)-biomass in throw-trap

Treatment	Salinity	Thalassia	Halodule	Total Seagrass SC	Farfantepenaeus duorarum	Floridichthys carpio	Gobiosoma robustum	Hippolyte spp.	Lucania parvae	Opsanus beta	S. scovelli	Thor spp.	Total fish Biomass	Forage Fish Biomass
No lag														
90% base	-1	0	1	0	0	1	-1	1	1	0	1	0	0	0
110% base	0	0	-1	0	0	-1	1	-1	0	1	-1	-1	0	-1
130%base	1	1	-2	0	0	-1	2	-1	0	1	-1	-1	1	-1
10 psu increase	1	1	-3	1	1	-2	2	-2	-1	1	-1	-1	both	-1
20 psu increase	2	2	-3	1	2	-3	3	-3	both	2	-2	-1	both	-2
30 day lag														
baseline	0	-1	-1	-1	1	both	-1	2	both	-1	1	-1	-1	1
90% base	-1	0	1	0	0	1	-1	1	1	0	1	1	0	-1
110% base	0	0	-1	0	0	-1	1	-1	0	1	-1	-1	0	-1
130%base	1	1	-2	0	0	-1	1	-1	0	1	-1	-1	1	-1
10 psu increase	1	1	-3	1	1	-2	2	-2	-1	1	-1	1	both	1
20 psu increase	2	2	-3	1	1	-3	3	-3	both	2	-1	both	both	both

0=no difference
1=less than 50% increase
2=50% to 150% increase (about double)
3=greater than 200% increase (triple or more)
(-1)=less than 50% decrease
(-2)=50% to 150% decrease (about double)
(-3)=greater than 200% decrease (triple or more)
both- increase and
decrease by season

Table 44. Summary of scenario responses for Whipray Basin (Interior region)-abundance in trawl/seine

	Treatment No lag						Treatment 30 day lag				
Factors	90% base	110% base	130% base	10 psu increase	20 psu increase	change in base	90% base	110% base	130% base	10 psu increase	20 psu increase
Salinity	-1	1	2	2	3		-1	1	2	2	3
Thalassia BB	-1	1	2	2	2		-1	1	2	2	2
Halodule BB	3	-1	-2	-2	-2		3	-1	-2	-2	-2
Anarchopterus crinigerus	1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1
Anchoa mitchelli	1	-1	-1	-1	-1	0	1	-1	-1	-1	-1
Atherinomorus stipes	-1	1	2	2	2	1	-1	1	2	2	2
Cynoscion nebulosus	1	-1	-2	-2	-2	0	1	-1	-2	-2	-2
Eucinostomus spp.	-1	1	1	1	1	1	-1	1	1	1	1
Farfantepenaeus duorarum	1	-1	-2	-2	-3	-1	1	-1	-2	-2	-3
Floridichthys carpio	-1	1	2	2	3	0	-1	1	2	2	3
Hippocampus zosterae	1	-1	-1	-2	-2	0	1	-1	-2	-2	-2
Lagodon rhomboides	-1	1	1	1	2	-1	-1	1	1	1	2
Lucania parva	-2	1	1	1	1	0	-1	1	1	1	1
Lutjanus griseus	-1	0	-1	-1	-1	0	-1	-1	-1	-1	-1
Microgobius gulosus	1	1	1	1	2	-1	1	1	1	1	2
Microgobius microlepis	2	-2	-3	-3	-3	-1	2	-2	-3	-3	-3
Opsanus beta	-1	-1	-2	-2	-3	-1	-1	-1	-2	-2	-3
Syngnathus floridae	-1	-1	-2	-2	-3	0	-1	-1	-2	-2	-3
Syngnathus scovelli	1	-1	-2	-2	-3	0	1	-1	-2	-2	-3
Species up	8	5	6	6	6		8	6	6	6	6
Species down	8	9	10	10	10		8	10	10	10	10
Total fish abundance	0	1	1	1	2	1	-1	1	1	1	2
Evenness	1	-1	-1	-1	-2	1	0	-1	-1	-1	-2

0=no difference
1=less than 50% increase
2=50% to 150% increase (about double)
3=greater than 200% increase (triple or more)
(-1)=less than 50% decrease
(-2)=50% to 150% decrease (about double)
(-3)=greater than 200% decrease (triple or more)
both- increase and decrease by season

Table 45. Summary of scenario responses for Whipray Basin (Interior region)-biomass in trawl/seine

	Treatment No lag						Treatment 30 day lag				
Factors	90% base	110% base	130% base	10 psu increase	20 psu increase	change in base	90% base	110% base	130% base	10 psu increase	20 psu increase
Salinity	-1	1	2	2	3		-1	1	2	2	3
Thalassia BB	-1	1	2	2	2		-1	1	2	2	2
Halodule BB	3	-1	-2	-2	-2		3	-1	-2	-2	-2
Anarchopterus crinigerus	1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1
Anchoa mitchelli	1	-1	-1	-1	-1	0	1	-1	-1	-1	-1
Atherinomorus stipes	-1	1	2	2	2	0	-1	1	2	2	2
Cynoscion nebulosus	1	-1	-2	-2	-2	0	1	-1	-2	-2	-2
Eucinostomus spp.	-1	1	1	1	1	1	-1	1	1	1	1
Farfantepenaeus duorarum	1	-1	-2	-2	-3	-1	1	-1	-2	-2	-3
Floridichthys carpio	-1	1	2	2	3	0	-1	1	2	2	3
Hippocampus zosterae	1	-1	-1	-2	-2	0	1	-1	-2	-2	-2
Lagodon rhomboides	-1	1	1	1	2	-1	-1	1	1	1	2
Lucania parva	-1	1	1	1	1	0	-1	1	1	1	1
Lutjanus griseus	-1	-1	-1	-1	-2	0	0	-1	-1	-1	-2
Microgobius gulosus	1	1	1	1	2	-1	1	1	1	1	2
Microgobius microlepis	2	-2	-3	-3	-3	-1	2	-2	-3	-3	-3
Opsanus beta	-1	-1	-2	-2	-3	-1	-1	-1	-2	-2	-3
Syngnathus floridae	-1	-1	-2	-2	-3	-1	-1	-1	-2	-2	-3
Syngnathus scovelli	1	-1	-2	-2	-3	0	1	-1	-2	-2	-3
Total fish biomass	-1	1	1	1	2	0	-1	1	1	1	2
Predator biomass	0	-1	-1	-1	-1	0	0	-1	-1	-1	-1
Forage fish biomass	-1	1	1	1	2	0	-1	1	1	1	2

0=no difference

1=less than 50% increase

2=50% to 150% increase (about double)

3=greater than 200% increase (triple or more)

(-1)=less than 50% decrease

(-2)=50% to 150% decrease (about double)

(-3)=greater than 200% decrease (triple or more)

both- increase and decrease by season

Table 46. Summary of scenario responses for Whipray Basin (Interior region)-abundance in throw-trap

Treatment	Salinity	Thalassia	Halodule	Total Seagrass SC	Farfantepenaeus	Floridichthys	Gobiosoma	Hippolyte	Lucania	Opsanus	S. scovelli	Thor	Species up	Species down	Evenness	Total Abundance
No lag																
90% base	-1	-1	3	-1	1	-1	-1	0	0	0	1	0	2	2	1	0
110% base	1	1	-1	1	-1	1	1	-1	0	1	0	0	3	2	-1	0
130%base	2	2	-2	2	-2	2	1	-2	1	2	1	2	5	2	-1	1
10 psu increase	2	2	-2	2	-2	2	0	-3	2	2	1	2	5	2	-1	2
20 psu increase	3	2	-2	2	-3	3	-1	-3	3	3	1	3	5	3	-1	3
30 day lag																
baseline				1	-1	0	1	-1	0	0	0	0				
90% base	-1	-1	3	-1	1	-1	-1	1	0	0	1	0	3	2	0	0
110% base	1	1	-1	1	-1	1	1	-1	0	1	0	0	3	2	-1	0
130%base	2	2	-2	2	-2	2	1	-2	1	2	1	2	5	2	-1	1
10 psu increase	2	2	-2	2	-2	2	0	-3	2	2	1	2	5	2	-1	2
20 psu increase	3	2	-2	2	-3	3	-1	-3	3	3	1	3	5	2	-1	3

0=no difference
1=less than 50% increase
2=50% to 150% increase (about double)
3=greater than 200% increase (triple or more)
(-1)=less than 50% decrease
(-2)=50% to 150% decrease (about double)
(-3)=greater than 200% decrease (triple or more)
both- increase and decrease by season

Table 47. Summary of scenario responses for Whipray Basin (Interior region)-biomass in throw-trap

Treatment	Salinity	Thalassia	Halodule	Total Seagrass SC	Farfantepenaeus	Floridichthys	Gobiosoma	Hippolyte	Lucania	Opsanus	S. scovelli	Thor	Total fish Biomass	Forage Fish Biomass
No lag														
90% base	-1	-1	3	-1	1	-1	-1	0	0	0	1	0	0	0
110% base	1	1	-1	1	-1	1	1	-1	0	1	0	0	0	0
130%base	2	2	-2	2	-2	2	0	-2	1	2	1	2	1	1
10 psu increase	2	2	-2	2	-3	2	1	-3	2	2	1	2	2	1
20 psu increase	3	2	-2	2	-3	3	0	-3	3	3	1	3	3	1
30 day lag														
baseline				1	-1	0	1	-1	0	0	0	0		
90% base	-1	-1	3	-1	1	-1	-1	1	0	0	1	0	0	0
110% base	1	1	-1	1	-1	1	0	-1	0	1	0	0	0	0
130%base	2	2	-2	2	-2	2	0	-2	1	2	1	2	1	1
10 psu increase	2	2	-2	2	-3	2	0	-3	2	2	1	2	2	1
20 psu increase	3	2	-2	2	-3	3	-1	-3	3	3	1	3	3	1

0=no difference

1=less than 50% increase

2=50% to 150% increase (about double)

3=greater than 200% increase (triple or more)

(-1)=less than 50% decrease

(-2)=50% to 150% decrease (about double)

(-3)=greater than 200% decrease (triple or more)

both- increase and
decrease by season

Table 48. Summary of scenario responses for Rankin Lake (Interior region)-abundance in trawl/seine

	Treatment No lag						Treatment 30 day lag				
Factors	90% base	110% base	130% base	10 psu increase	20 psu increase	change in base	90% base	110% base	130% base	10 psu increase	20 psu increase
Salinity	-1	1	2	2	3	0	-1	1	2	2	3
Thalassia BB	-1	1	2	2	1	-1	-1	1	2	2	1
Halodule BB	1	-1	-2	-2	-3	-1	1	-1	-2	-2	-3
Anarchopterus crinigerus	-1	-1	-1	-1	-2	-1	-1	-1	-1	-1	-2
Anchoa mitchelli	1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1
Atherinomorus stipes	-1	1	2	2	3	0	-1	1	2	2	3
Cynoscion nebulosus	1	-1	-2	-2	-2	-1	1	-1	-2	-2	-2
Eucinostomus spp.	0	0	0	0	1	0	0	0	0	0	2
Farfantepenaeus duorarum	0	-1	-1	-2	-2	0	1	-1	-2	-2	-2
Floridichthys carpio	0	-1	-1	-1	-1	0	1	-1	-2	-2	-2
Hippocampus zosterae	1	-1	-1	-1	-2	-1	1	-1	-1	-1	-2
Lagodon rhomboides	-1	1	1	1	2	0	-1	1	1	1	2
Lucania parvae	0	0	1	1	-1	0	0	0	1	1	-1
Lutjanus griseus	0	0	-1	-1	-1	0	0	0	-1	-1	-1
Microgobius gulosus	1	both	both 1		2	both	1	both	both	1	2
Microgobius microlepis	1	-1	-2	-2	-3	-1	1	-1	-3	-3	-3
Opsanus beta	1	-1	-2	-2	-3	-1	1	-1	-2	-2	-3
Syngnathus floridae	both	-1	-1	-1	-2	0	both	both	-1	-1	-2
Syngnathus scovelli	1	-1	-2	-2	-2	-1	1	-1	-2	-2	-2
Species up	7	1	3	4	4	0	9	2	3	4	4
Species down	3	11	11	11	12	7	3	9	11	11	12
Total fish abundance	1	-1	-1	-1	1	0	1	-1	-1	-1	1
Evenness	1	-1	-1	-1	-1		-1	-1	-1	-1	-1

0=no difference
1=less than 50% increase
2=50% to 150% increase (about double)
3=greater than 200% increase (triple or more)
(-1)=less than 50% decrease
(-2)=50% to 150% decrease (about double)
(-3)=greater than 200% decrease (triple or more)
both- increase and decrease by season

Table 49. Summary of scenario responses for Rankin Lake (Interior region)-biomass in trawl/seine

			Treatment No lag						Treatment 30 day lag		
Factors	90% base	110% base	130% base	10 psu increase	20 psu increase	change in base	90% base	110% base	130% base	10 psu increase	20 psu increase
Salinity	-1	1	2	2	3	0	-1	1	2	2	3
Thalassia BB	-1	1	2	2	1	-1	-1	1	2	2	1
Halodule BB	1	-1	-2	-2	-3	-1	1	-1	-2	-2	-3
Anarchopterus crinigerus	-1	-1	-1	-1	-2	-1	-1	-1	-1	-1	-2
Anchoa mitchelli	1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1
Atherinomorus stipes	-1	1	2	2	3	0	-1	1	2	2	3
Cynoscion nebulosus	1	-1	-2	-2	-2	-1	1	-1	-2	-2	-2
Eucinostomus spp.	0	0	0	0	1	0	0	0	0	0	2
Farfantepenaeus duorarum	0	-1	-2	-2	-2	0	1	-1	-2	-2	-2
Floridichthys carpio	1	-1	-1	-1	-1	0	1	-1	-2	-2	-2
Hippocampus zosterae	1	-1	-2	-2	-2	-1	1	-1	-1	-1	-2
Lagodon rhomboides	0	1	1	1	2	0	-1	1	1	1	2
Lucania parvae	0	0	1	1	-1	0	1	0	1	1	-1
Lutjanus griseus	0	0	-1	-1	-1	0	0	-1	-1	-1	-1
Microgobius gulosus	1	both	both 1		2	both	1	both	both	1	2
Microgobius microlepis	1	-1	-2	-3	-3	-1	1	-1	-3	-3	-3
Opsanus beta	1	-1	-2	-2	-3	-1	1	-1	-2	-2	-3
Syngnathus floridae	both	-1	-1	-1	-2	0	both	-1	-1	-1	-2
Syngnathus scovelli	1	-1	-1	-2	-2	-1	1	-1	-1	-2	-2
Total fish biomass	0	0	0	0	1	0	0	0	0	0	1
Predator biomass	both	-1	-1	-1	-1	0	1	-1	-1	-1	-1
Forage fish biomass	0	0	0	0	1	0	0	0	0	0	1

0=no difference

1=less than 50% increase

2=50% to 150% increase (about double)

3=greater than 200% increase (triple or more)

(-1)=less than 50% decrease

(-2)=50% to 150% decrease (about double)

(-3)=greater than 200% decrease (triple or more)

both- increase and decrease by season

Table 50. Summary of scenario responses for Rankin Lake (Interior region)-abundance in throw-trap

Treatment	Salinity	Thalassia	Halodule	Total Seagrass SC	Farfantepenaeus duorarum	Floridichthys carpio	Gobiosoma robustum	Hippolyte spp.	Lucania parvae	Opsanus beta	S. scovelli	Thor spp.	Species up	Species down	Evenness	Total Abundance
No lag																
90% base	-1	-1	1	-1	0	-1	-1	1	0	0	1	0	2	2	1	0
110% base	1	1	-1	1	0	1	1	1	0	1	both	0	4	0	-1	0
130%base	2	2	-2	2	-1	2	2	-1	2	2	both	2	4	2	-1	2
10 psu increase	2	2	-2	2	-2	2	2	-2	2	2	1	2	5	2	-1	2
20 psu increase	3	1	-3	1	-3	3	0	-3	3	3	2	3	5	2	-1	3
30 day lag																
baseline	0	-1	-1	-1	1	0	0	1	0	0	0	0	2	0		
90% base	-1	-1	1	-1	0	-1	-1	both	0	0	1	0	1	2	0	0
110% base	1	1	-1	1	0	1	1	both	0	1	both	0	3	0	-1	0
130%base	2	2	-2	2	-1	2	2	-1	2	2	both	2	5	2	-1	2
10 psu increase	2	2	-2	2	-2	2	2	-2	2	2	1	2	6	2	-1	2
20 psu increase	3	1	-3	1	-3	3	0	-3	3	3	2	3	5	2	-1	3

0=no difference
1=less than 50% increase
2=50% to 150% increase (about double)
3=greater than 200% increase (triple or more)
(-1)=less than 50% decrease
(-2)=50% to 150% decrease (about double)
(-3)=greater than 200% decrease (triple or more)
both- increase and decrease by season

Table 51. Summary of scenario responses for Rankin Lake (Interior region)-biomass in throw-trap

Treatment	Salinity	Thalassia	Halodule	Total Seagrass SC	Farfantepenaeus duorarum	Floridichthys carpio	Gobiosoma robustum	Hippolyte spp.	Lucania parvae	Opsanus beta	S. scovelli	Thor spp.	Total fish Biomass	Forage Fish Biomass
No lag														
90% base	-1	-1	1	-1	1	-1	-1	1	0	0	1	0	0	0
110% base	1	1	-1	1	-1	1	1	-1	0	1	0	0	0	0
130%base	2	2	-2	2	-2	2	2	-2	2	2	both	2	2	2
10 psu increase	2	2	-2	2	-2	2	2	-2	2	2	1	2	2	2
20 psu increase	3	1	-3	1	-3	3	0	-3	3	3	2	3	3	3
30 day lag														
baseline	0	-1	-1	-1	-1	-1	0	1	0	0	0	0		
90% base	-1	-1	1	-1	1	-1	-1	1	0	0	1	0	0	0
110% base	1	1	-1	1	-1	1	1	-1	0	1	0	0	0	0
130%base	2	2	-2	2	-2	2	2	-2	2	2	both	2	2	2
10 psu increase	2	2	-2	2	-2	2	2	-2	2	2	1	2	2	2
20 psu increase	3	1	-3	1	-3	3	0	-3	3	3	2	3	3	3

0=no difference
1=less than 50% increase
2=50% to 150% increase (about double)
3=greater than 200% increase (triple or more)
(-1)=less than 50% decrease
(-2)=50% to 150% decrease (about double)
(-3)=greater than 200% decrease (triple or more)
both- increase and
decrease by season

Figure 1. Map of Florida Bay with regions.

Figure 1. Map of Florida Bay regions and basin numbers

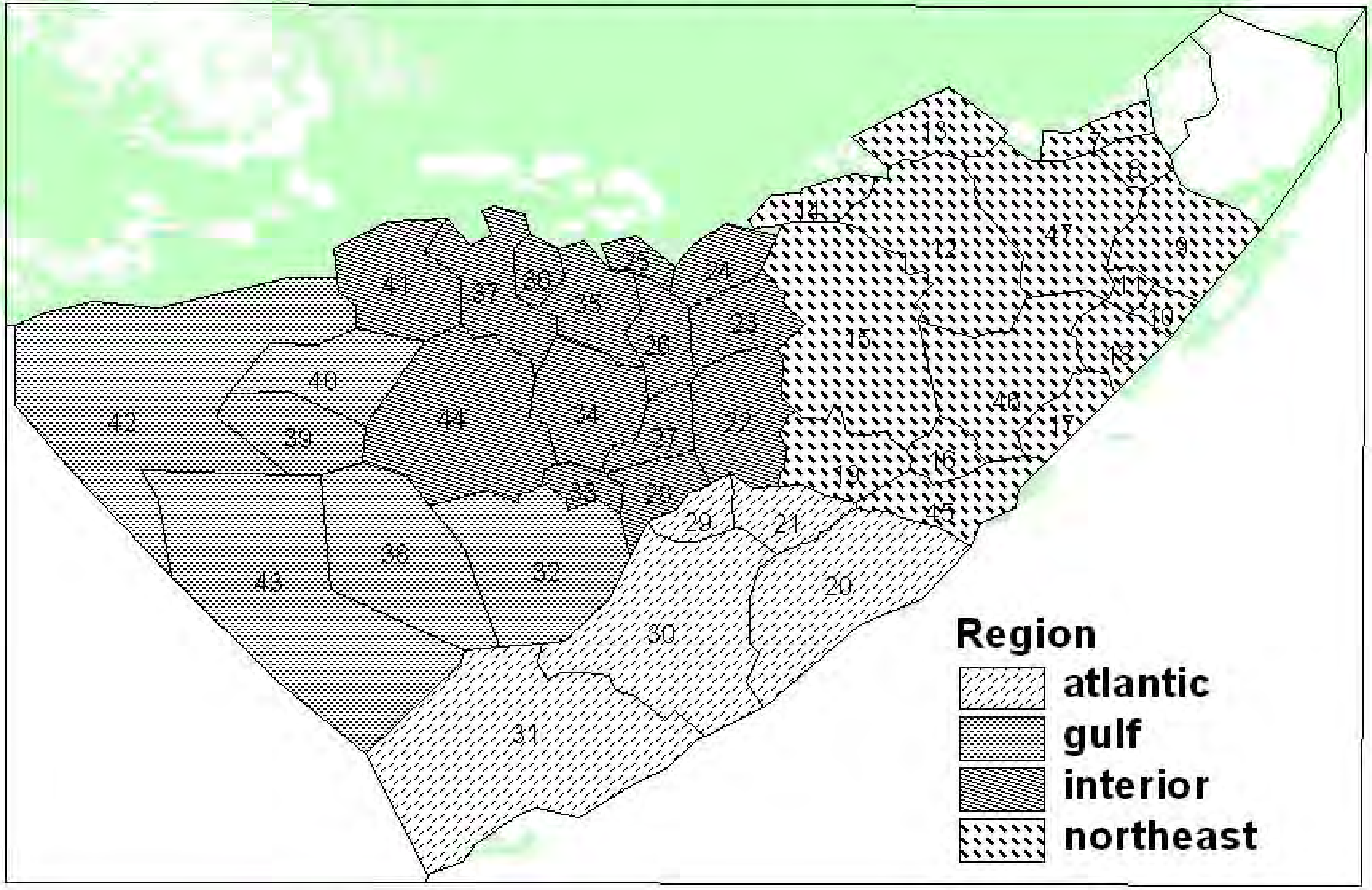


Figure 2. Caridean shrimp weight by month.

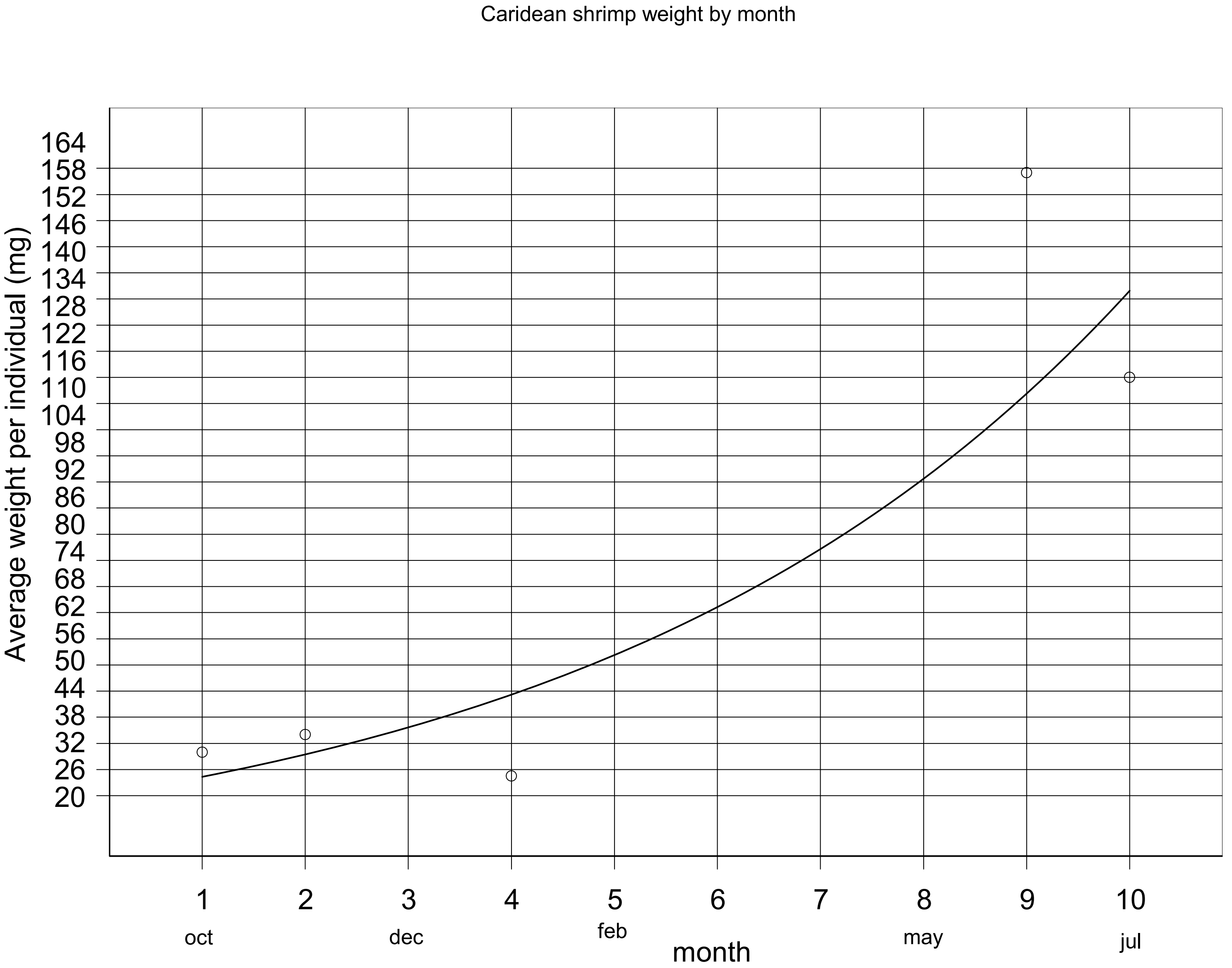

Caridean shrimp weight by month
Average weight per individual (mg)
164
158
152
146
140
134
128
122
116
110
104
98
92
86
80
74
68
62
56
50
44
38
32
26
20
1
2
3
4
5
6
7
8
9
10
oct
dec
feb
may
jul
month

Figure 2

Figure 3. Standardized catch (on a log scale) of *Anarchopterus criniger* from the trawl/seine model showing model variables with 95% confidence levels.

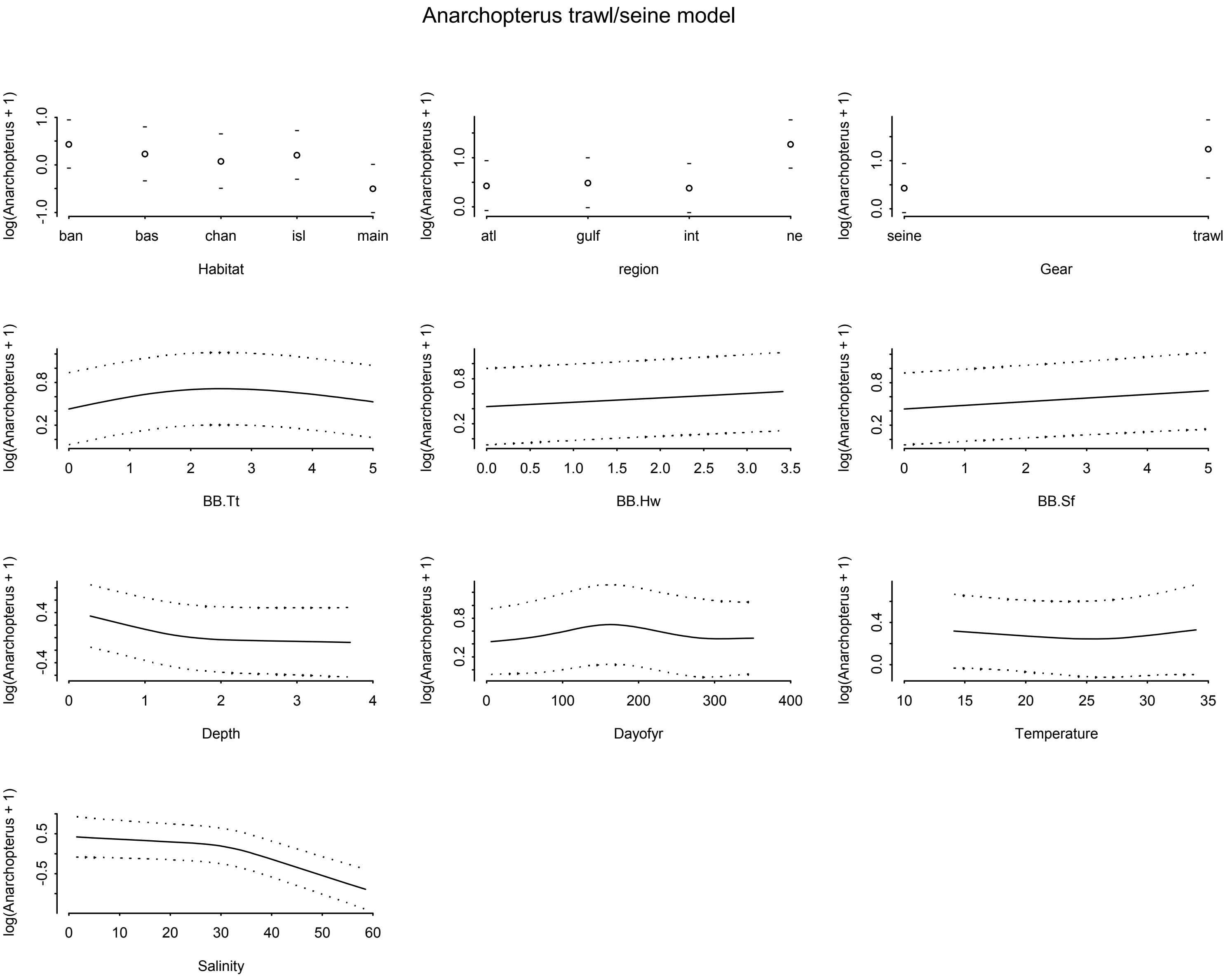

Anarchopterus trawl/seine model
log(Anarchopterus + 1)
Habitat
ban
bas
chan
isl
main
region
atl
gulf
int
ne
Gear
seine
trawl
BB.Tt
BB.Hw
BB.Sf
Depth
Dayofyr
Temperature
Salinity

Figure 3

Figure 4. Standardized catch (on a log scale) of *Anchoa mitchelli* from the trawl/seine model showing model variables with 95% confidence levels.

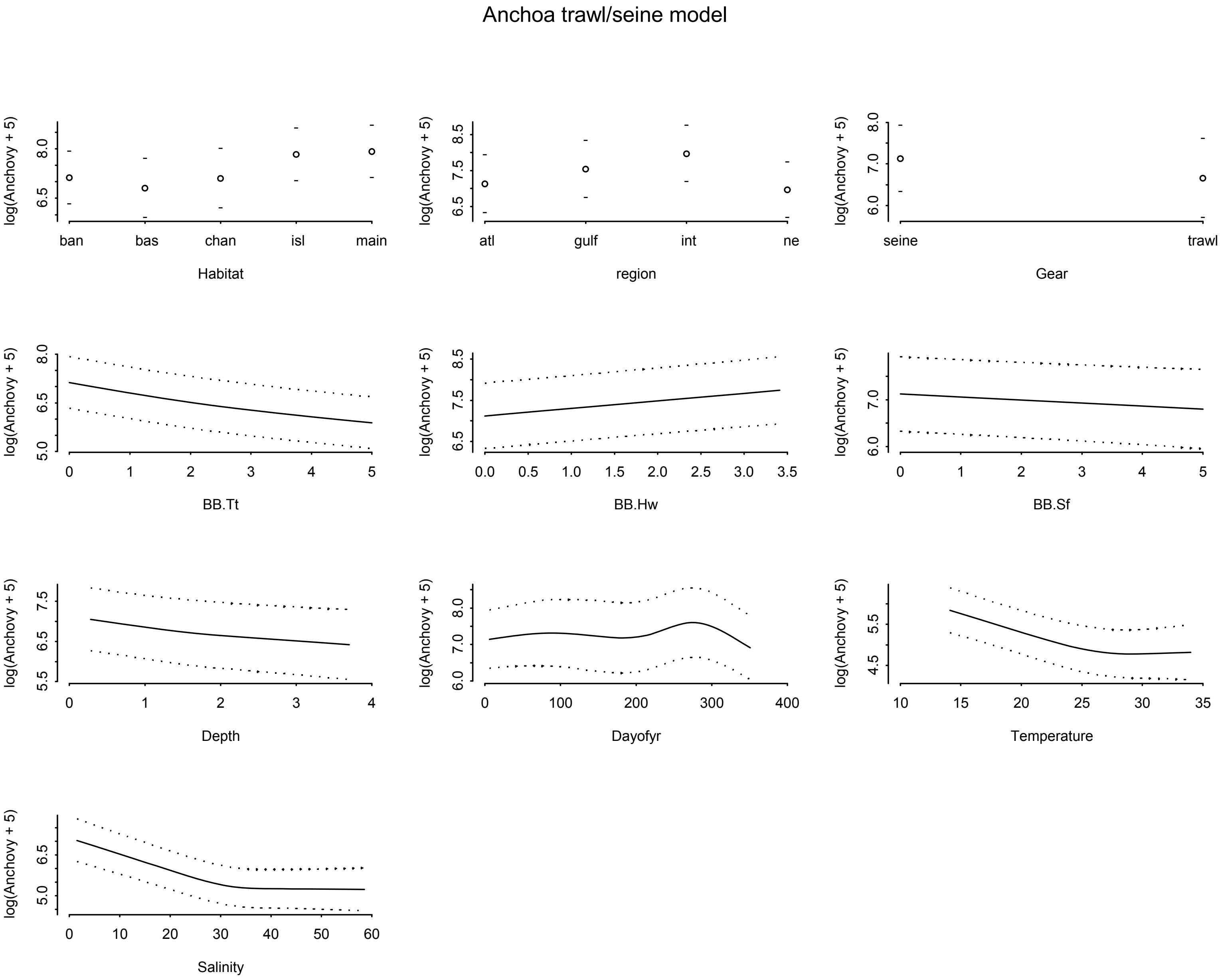

Anchoa trawl/seine model
log(Anchovy + 5)
6.5
8.0
ban
bas
chan
isl
main
Habitat
log(Anchovy + 5)
6.5
7.5
8.5
atl
gulf
int
ne
region
log(Anchovy + 5)
6.0
7.0
8.0
seine
trawl
Gear
log(Anchovy + 5)
5.0
6.5
8.0
0
1
2
3
4
5
BB.Tt
log(Anchovy + 5)
6.5
7.5
8.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
BB.Hw
log(Anchovy + 5)
6.0
7.0
0
1
2
3
4
5
BB.Sf
log(Anchovy + 5)
5.5
6.5
7.5
0
1
2
3
4
Depth
log(Anchovy + 5)
6.0
7.0
8.0
0
100
200
300
400
Dayofyr
log(Anchovy + 5)
4.5
5.5
10
15
20
25
30
35
Temperature
log(Anchovy + 5)
5.0
6.5
0
10
20
30
40
50
60
Salinity

Figure 4

Figure 5. Standardized catch (on a log scale) of *Atherinomorus stipes* from the trawl/seine model showing model variables with 95% confidence levels.

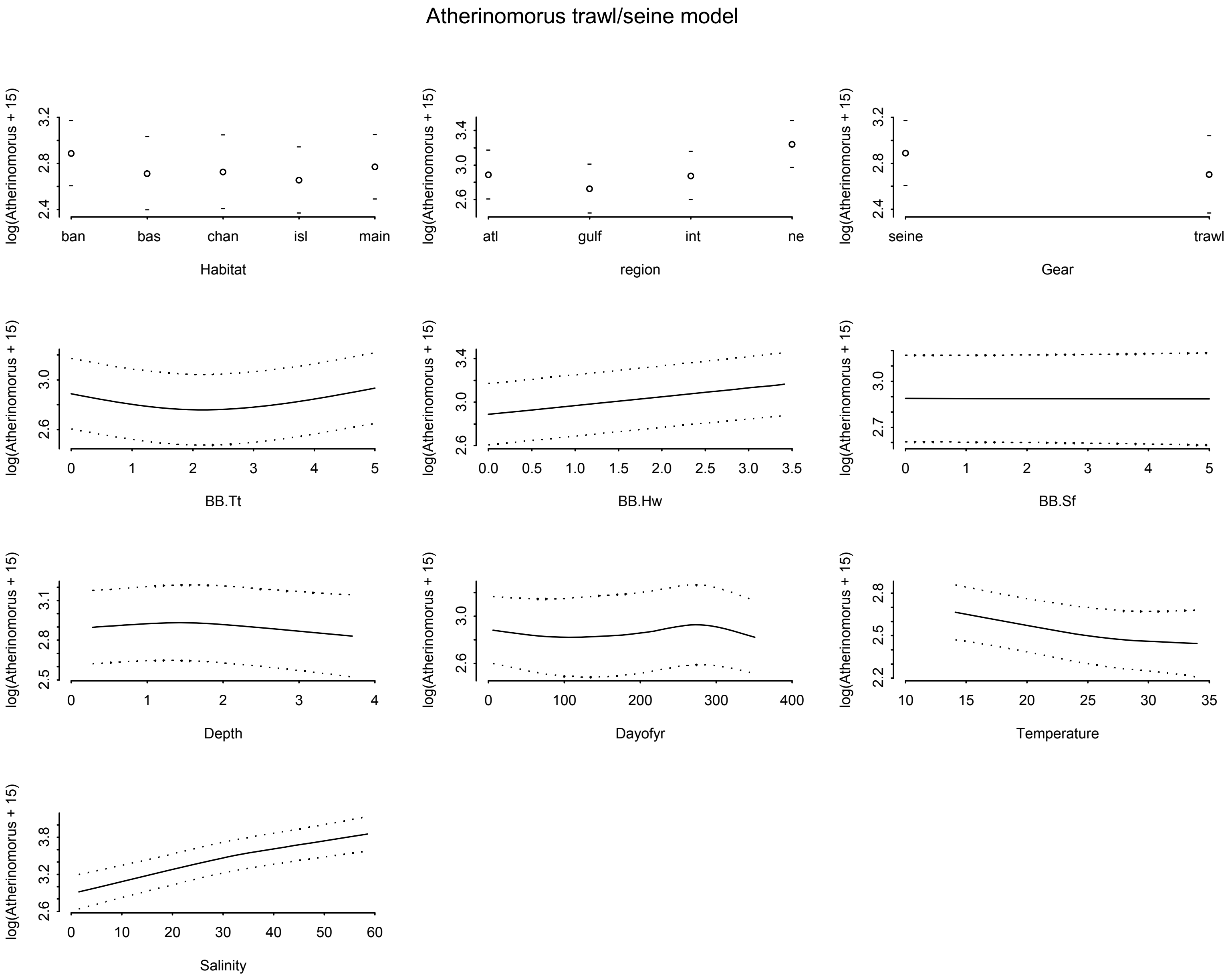

Atherinomorus trawl/seine model
log(Atherinomorus + 15)
2.4
2.8
3.2
ban
bas
chan
isl
main
Habitat
2.6
3.0
3.4
atl
gulf
int
ne
region
seine
trawl
Gear
BB.Tt
BB.Hw
BB.Sf
Depth
Dayofyr
Temperature
Salinity

Figure 5

Figure 6. Standardized catch (on a log scale) of *Cynoscion nebulosus* from the trawl/seine model showing model variables with 95% confidence levels.

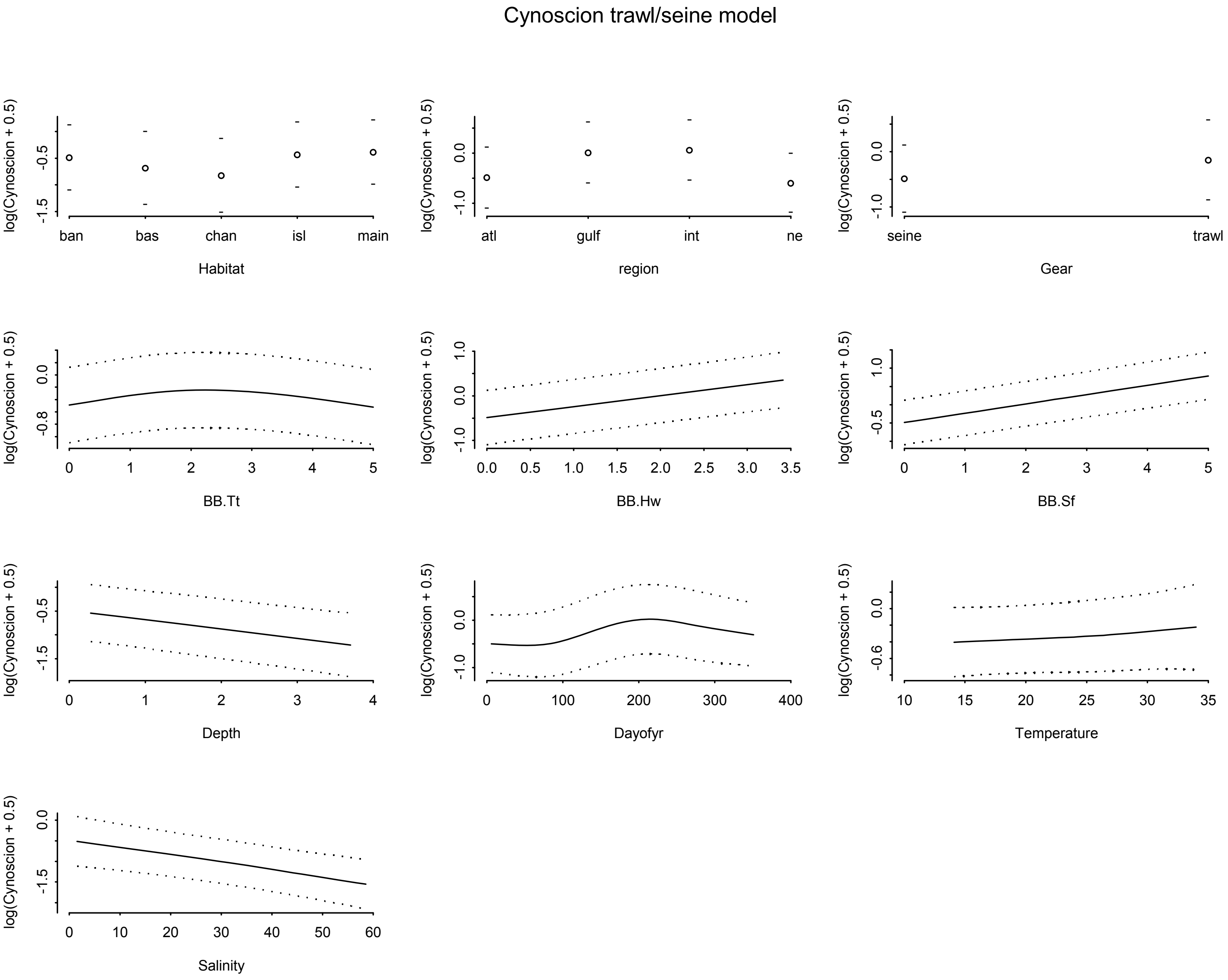

Cynoscion trawl/seine model
log(Cynoscion + 0.5)
-1.5
-0.5
ban
bas
chan
isl
main
Habitat
log(Cynoscion + 0.5)
-1.0
0.0
atl
gulf
int
ne
region
log(Cynoscion + 0.5)
-1.0
0.0
seine
trawl
Gear
log(Cynoscion + 0.5)
-0.8
0.0
0
1
2
3
4
5
BB.Tt
log(Cynoscion + 0.5)
-1.0
0.0
1.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
BB.Hw
log(Cynoscion + 0.5)
-0.5
1.0
0
1
2
3
4
5
BB.Sf
log(Cynoscion + 0.5)
-1.5
-0.5
0
1
2
3
4
Depth
log(Cynoscion + 0.5)
-1.0
0.0
0
100
200
300
400
Dayofyr
log(Cynoscion + 0.5)
-0.6
0.0
10
15
20
25
30
35
Temperature
log(Cynoscion + 0.5)
-1.5
0.0
0
10
20
30
40
50
60
Salinity

Figure 6

Figure 7. Standardized catch (on a log scale) of *Eucinostomus spp*. from the trawl/seine model showing model variables with 95% confidence levels.

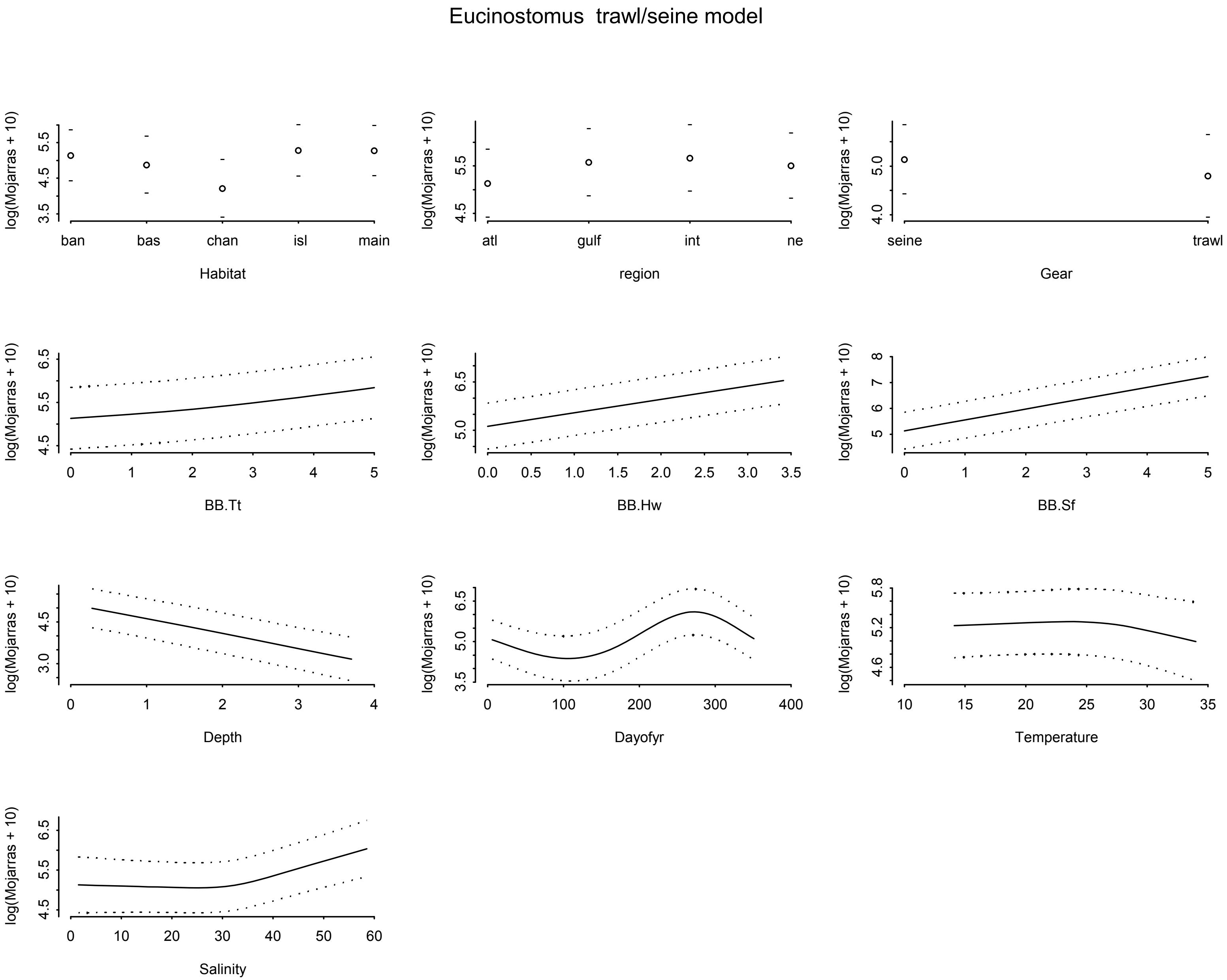

Eucinostomus trawl/seine model
log(Mojarras + 10)
3.5
4.5
5.5
ban
bas
chan
isl
main
Habitat
4.5
5.5
atl
gulf
int
ne
region
4.0
5.0
seine
trawl
Gear
4.5
5.5
6.5
0
1
2
3
4
5
BB.Tt
5.0
6.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
BB.Hw
5
6
7
8
0
1
2
3
4
5
BB.Sf
3.0
4.5
0
1
2
3
4
Depth
3.5
5.0
6.5
0
100
200
300
400
Dayofyr
4.6
5.2
5.8
10
15
20
25
30
35
Temperature
4.5
5.5
6.5
0
10
20
30
40
50
60
Salinity

Figure 7

Figure 8. Standardized catch (on a log scale) of *Farfantepenaeus duorarum* from the throw-trap model showing model variables with 95% confidence levels.

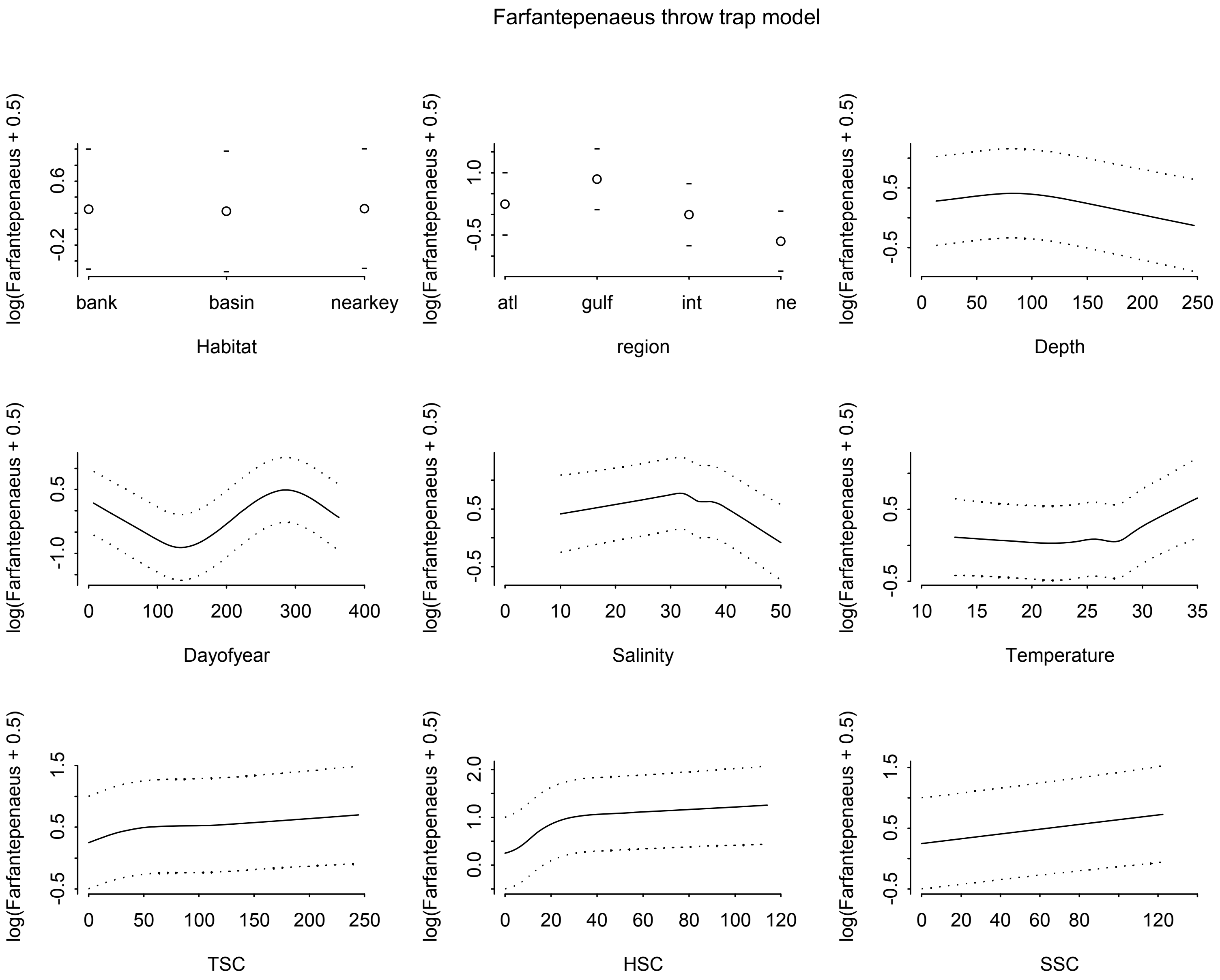

Farfantepenaeus throw trap model
log(Farfantepenaeus + 0.5)
-0.2
0.6
bank
basin
nearkey
Habitat
-0.5
1.0
atl
gulf
int
ne
region
-0.5
0.5
0
50
100
150
200
250
Depth
-1.0
0.5
0
100
200
300
400
Dayofyear
-0.5
0.5
0
10
20
30
40
50
Salinity
-0.5
0.5
10
15
20
25
30
35
Temperature
-0.5
0.5
1.5
0
50
100
150
200
250
TSC
0.0
1.0
2.0
0
20
40
60
80
100
120
HSC
-0.5
0.5
1.5
0
20
40
60
80
120
SSC

Figure 8

Figure 9 . Standardized catch (on a log scale) of *Farfantepenaeus duorarum* from the trawl/seine model showing model variables with 95% confidence levels.

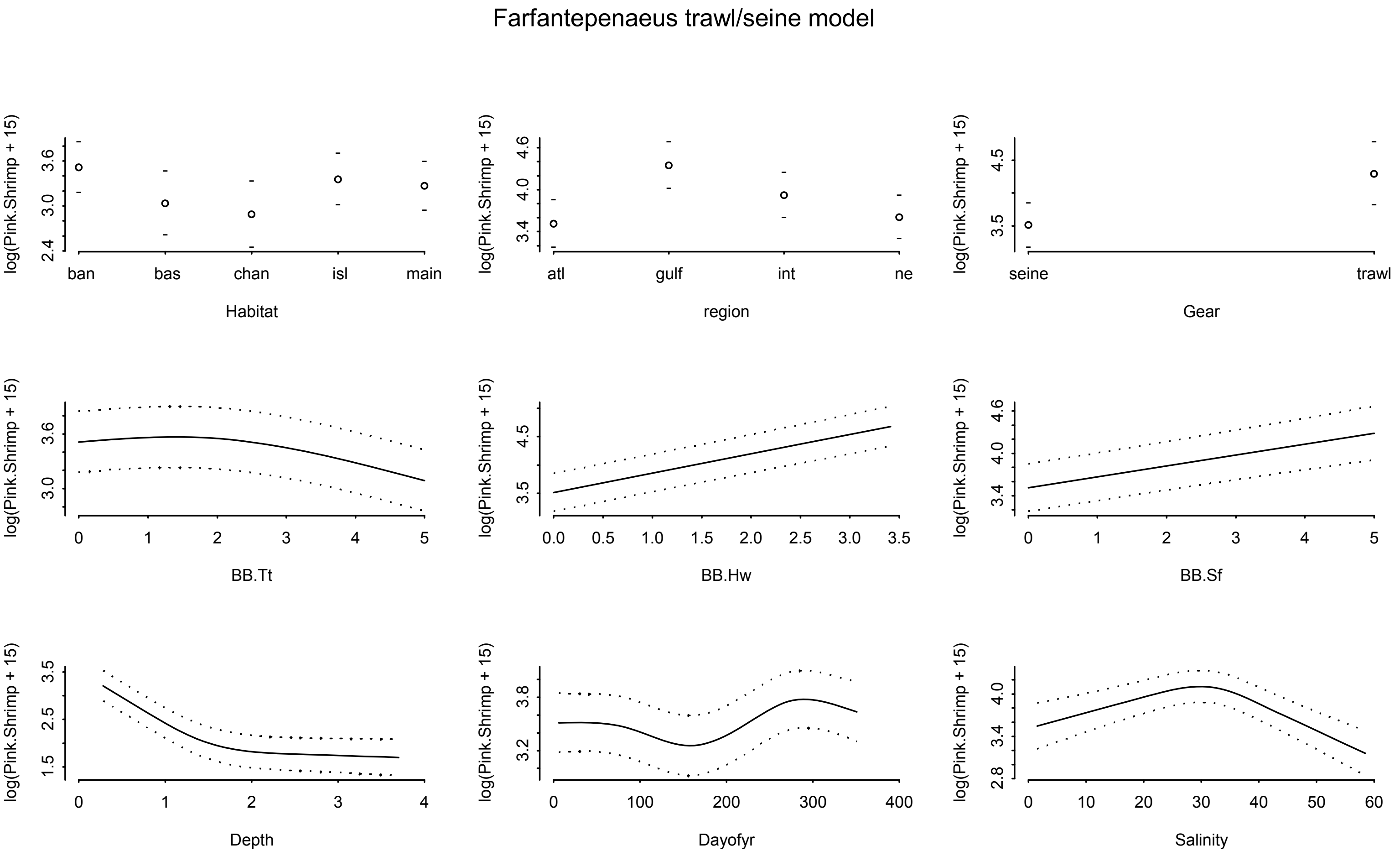

Farfantepenaeus trawl/seine model
log(Pink.Shrimp + 15)
2.4
3.0
3.6
ban
bas
chan
isl
main
Habitat
3.4
4.0
4.6
atl
gulf
int
ne
region
3.5
4.5
seine
trawl
Gear
3.0
3.6
0
1
2
3
4
5
BB.Tt
3.5
4.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
BB.Hw
3.4
4.0
4.6
BB.Sf
1.5
2.5
3.5
Depth
3.2
3.8
0
100
200
300
400
Dayofyr
2.8
3.4
4.0
0
10
20
30
40
50
60
Salinity

Figure 9

Figure 10. Standardized catch (on a log scale) of *Floridichthys carpio* from the throw-trap model showing model variables with 95% confidence levels

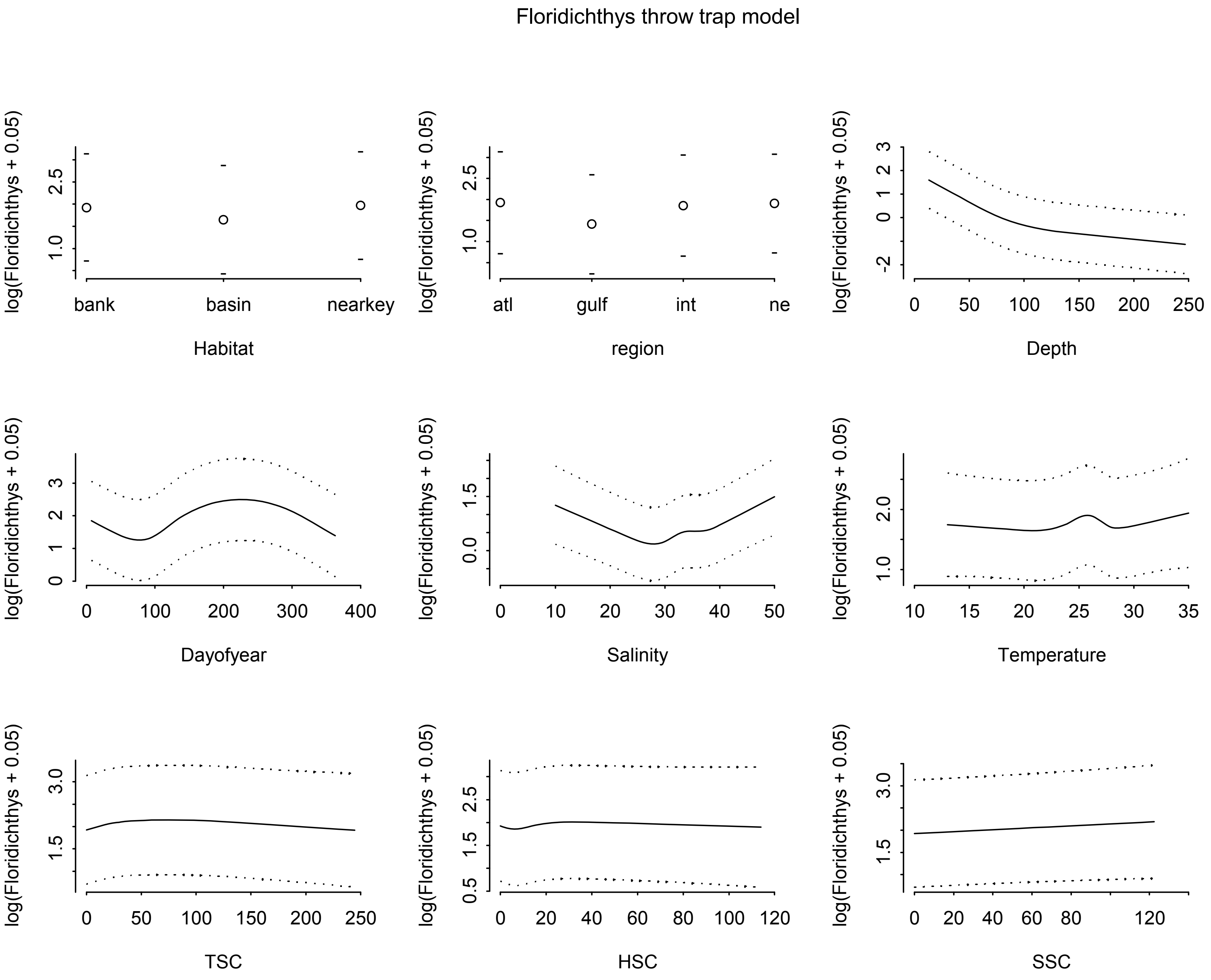

Floridichthys throw trap model
log(Floridichthys + 0.05)
2.5
1.0
bank
basin
nearkey
Habitat
log(Floridichthys + 0.05)
2.5
1.0
atl
gulf
int
ne
region
log(Floridichthys + 0.05)
3
2
1
0
-2
0
50
100
150
200
250
Depth
log(Floridichthys + 0.05)
3
2
1
0
0
100
200
300
400
Dayofyear
log(Floridichthys + 0.05)
1.5
0.0
0
10
20
30
40
50
Salinity
log(Floridichthys + 0.05)
2.0
1.0
10
15
20
25
30
35
Temperature
log(Floridichthys + 0.05)
3.0
1.5
0
50
100
150
200
250
TSC
log(Floridichthys + 0.05)
2.5
1.5
0.5
0
20
40
60
80
100
120
HSC
log(Floridichthys + 0.05)
3.0
1.5
0
20
40
60
80
120
SSC

Figure 10

Figure 11. Standardized catch (on a log scale) of *Floridichthys carpio* from the trawl/seine model showing model variables with 95% confidence levels.

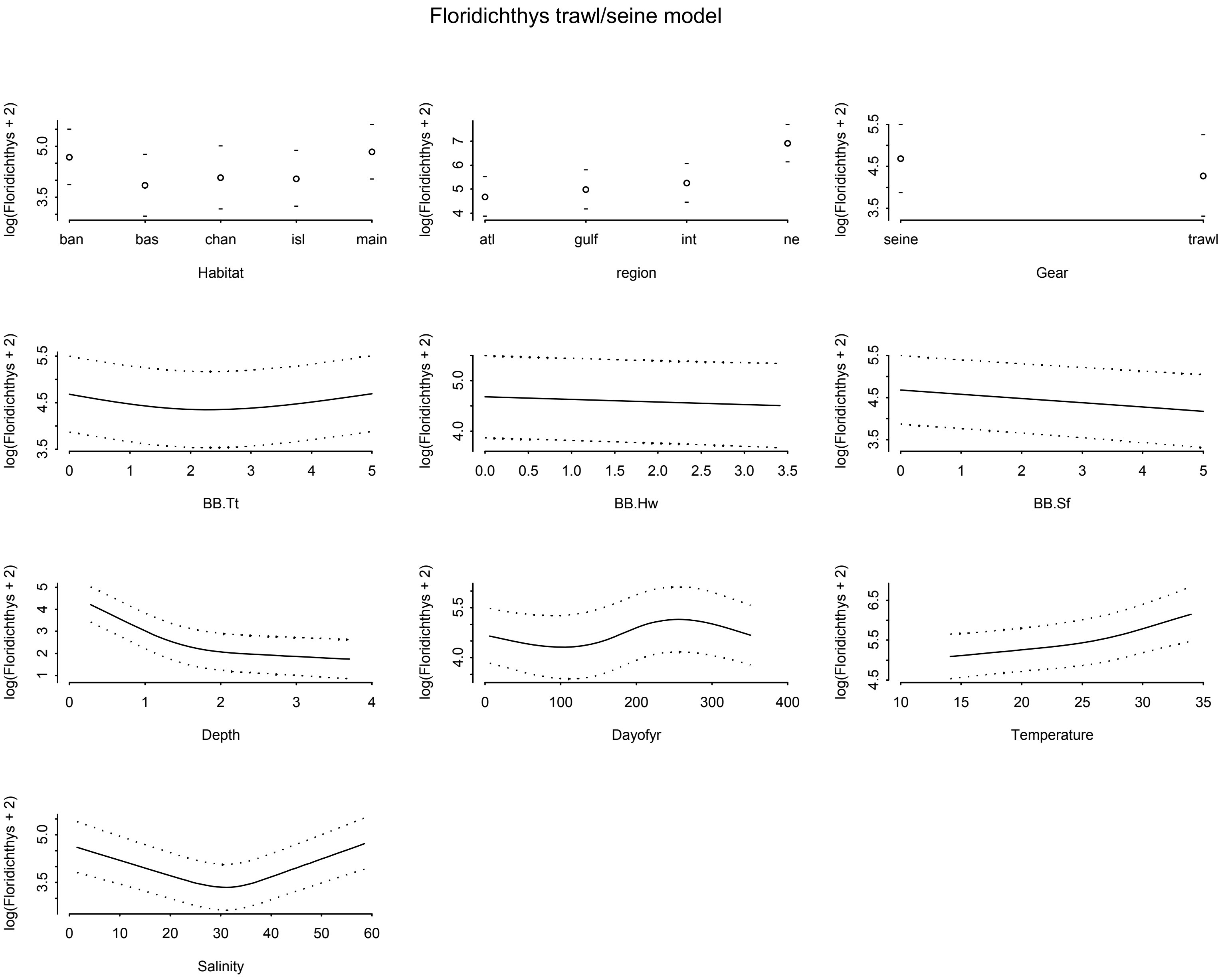
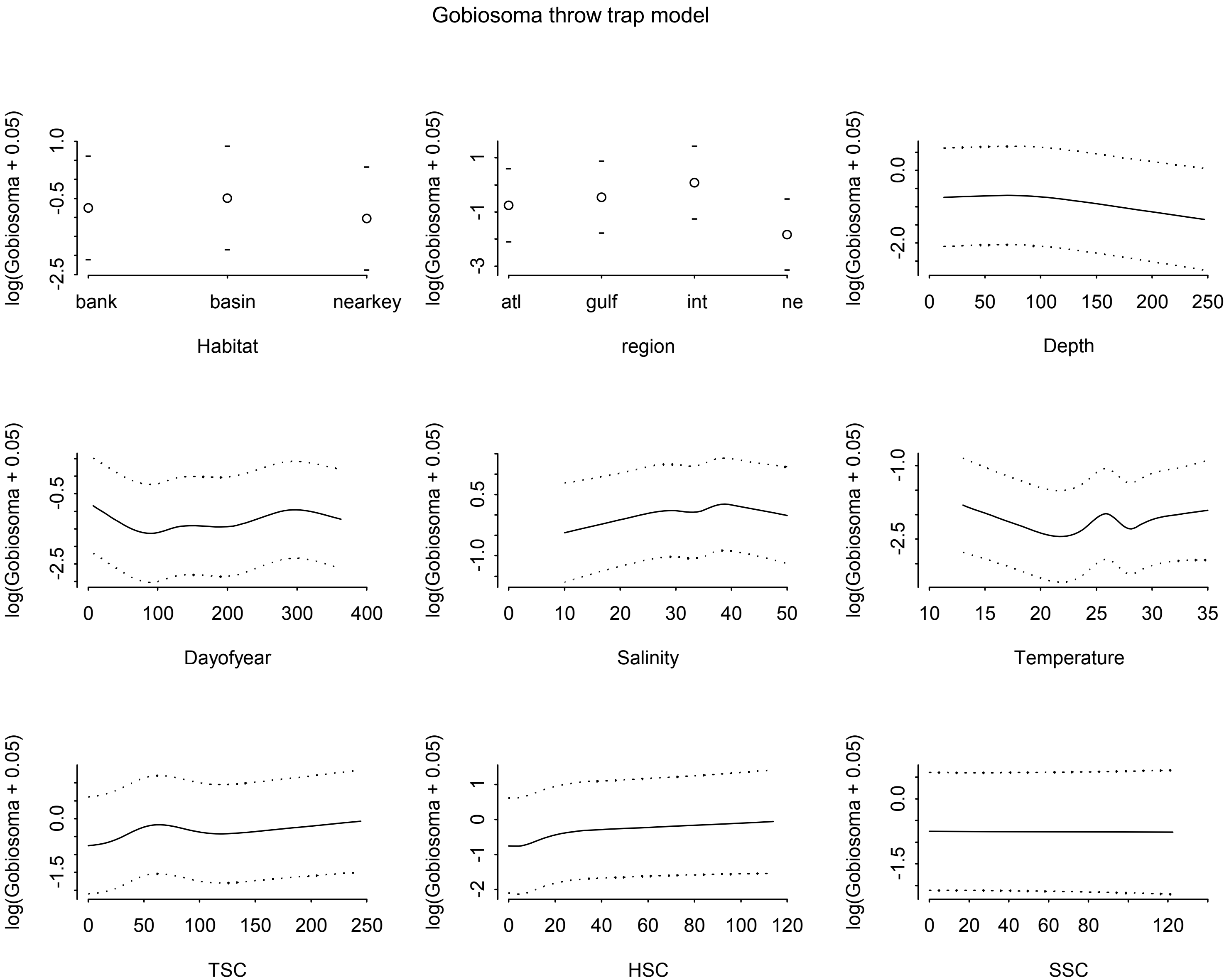

Floridichthys trawl/seine model
log(Floridichthys + 2)
Habitat
ban
bas
chan
isl
main
region
atl
gulf
int
ne
Gear
seine
trawl
BB.Tt
BB.Hw
BB.Sf
Depth
Dayofyr
Temperature
Salinity

Figure 11

Figure 12. Standardized catch (on a log scale) of *Gobiosoma robustum* from the throw-trap model showing model variables with 95% confidence levels.



Gobiosoma throw trap model
log(Gobiosoma + 0.05)
1.0
-0.5
-2.5
bank
basin
nearkey
Habitat
1
-1
-3
atl
gulf
int
ne
region
0.0
-2.0
0
50
100
150
200
250
Depth
-0.5
-2.5
0
100
200
300
400
Dayofyear
0.5
-1.0
0
10
20
30
40
50
Salinity
-1.0
-2.5
10
15
20
25
30
35
Temperature
0.0
-1.5
0
50
100
150
200
250
TSC
1
0
-1
-2
0
20
40
60
80
100
120
HSC
0.0
-1.5
0
20
40
60
80
120
SSC

Figure 12

Figure 13. Standardized catch (on a log scale) of *Hippocampus zosterae* from the trawl/seine model showing model variables with 95% confidence levels.

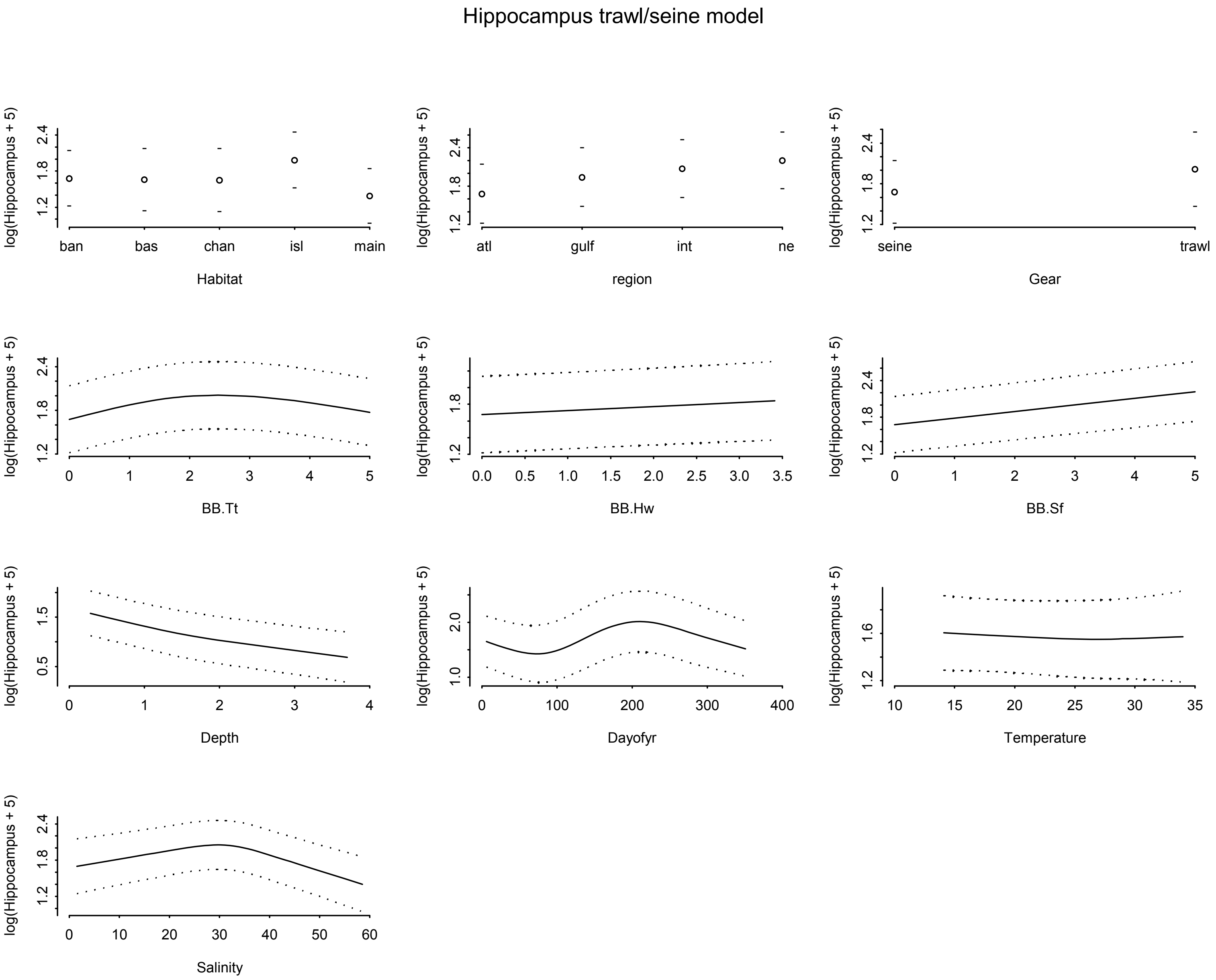

Hippocampus trawl/seine model
log(Hippocampus + 5)
1.2
1.8
2.4
ban
bas
chan
isl
main
Habitat
atl
gulf
int
ne
region
seine
trawl
Gear
0
1
2
3
4
5
BB.Tt
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
BB.Hw
BB.Sf
0.5
1.5
Depth
1.0
2.0
0
100
200
300
400
Dayofyr
1.6
10
15
20
25
30
35
Temperature
0
10
20
30
40
50
60
Salinity

Figure 13

Figure 14 . Standardized catch (on a log scale) of *Hippolyte spp*. from the throw-trap model showing model variables with 95% confidence levels.

Hippolyte throw trap model

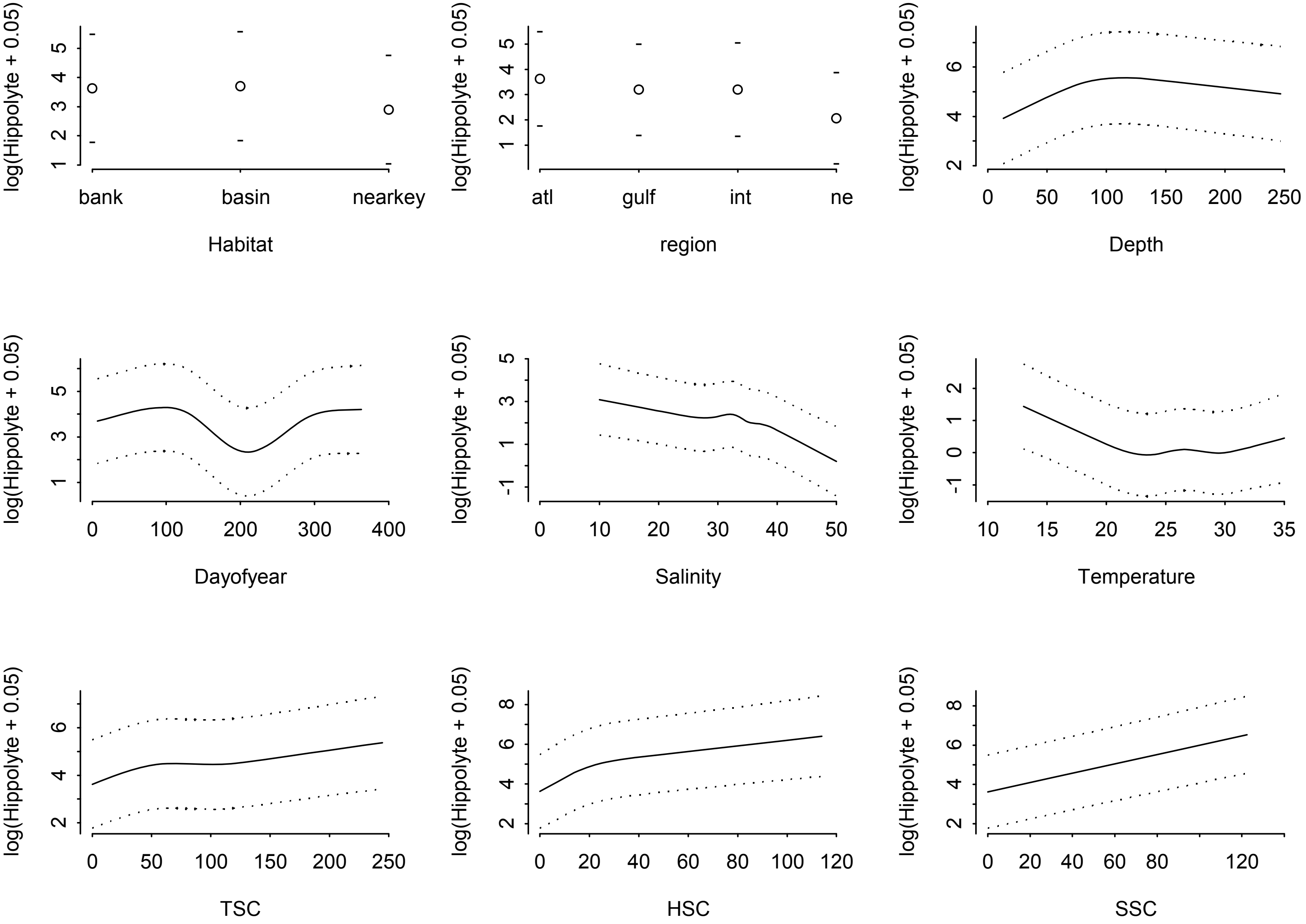


Figure 14

Figure 15. Standardized catch (on a log scale) of *Lagodon rhomboides* from the trawl/seine model showing model variables with 95% confidence levels.

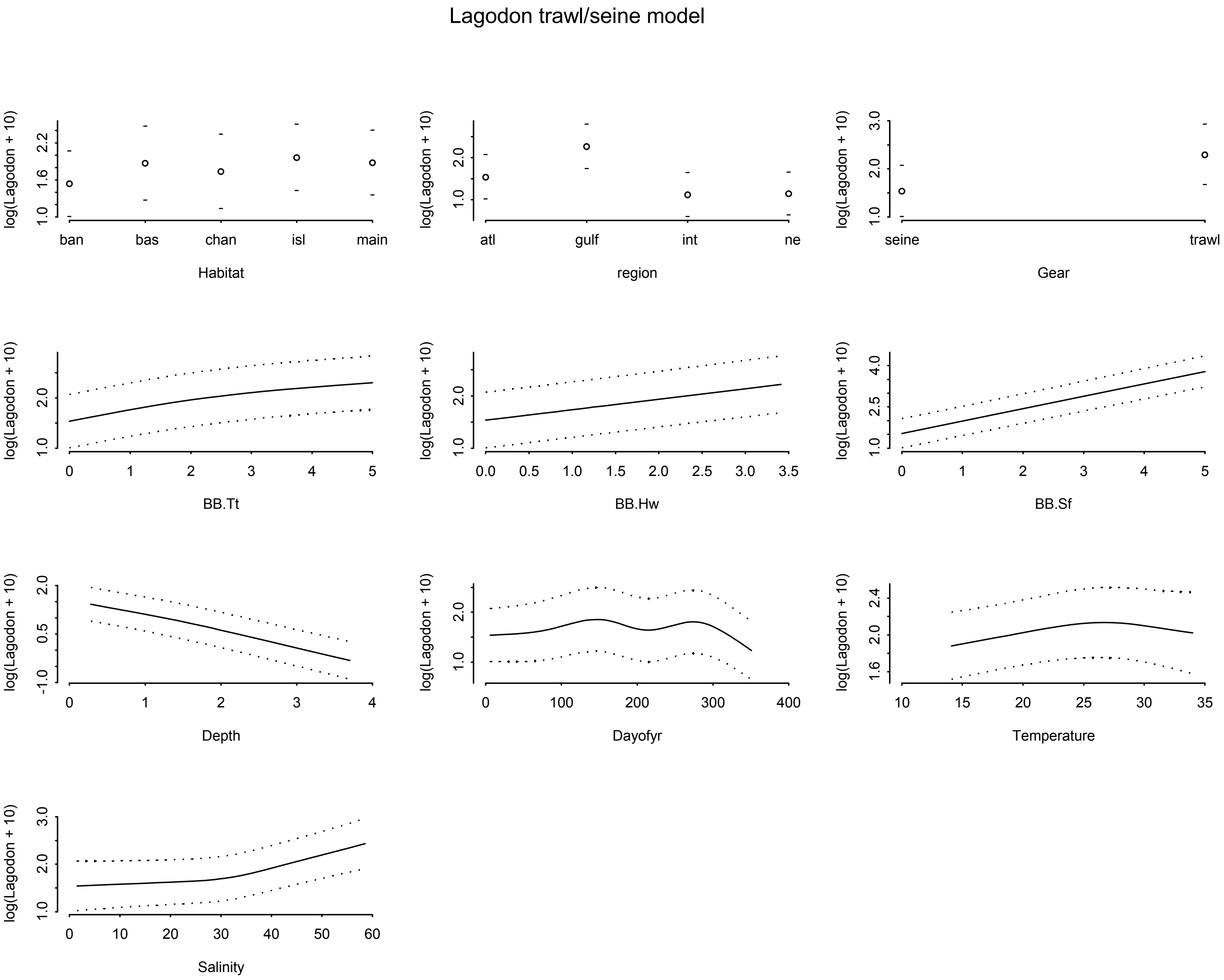

Lagodon trawl/seine model
log(Lagodon + 10)
1.0
1.6
2.2
ban
bas
chan
isl
main
Habitat
log(Lagodon + 10)
1.0
2.0
atl
gulf
int
ne
region
log(Lagodon + 10)
1.0
2.0
3.0
seine
trawl
Gear
log(Lagodon + 10)
1.0
2.0
0
1
2
3
4
5
BB.Tt
log(Lagodon + 10)
1.0
2.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
BB.Hw
log(Lagodon + 10)
1.0
2.5
4.0
0
1
2
3
4
5
BB.Sf
log(Lagodon + 10)
-1.0
0.5
2.0
0
1
2
3
4
Depth
log(Lagodon + 10)
1.0
2.0
0
100
200
300
400
Dayofyr
log(Lagodon + 10)
1.6
2.0
2.4
10
15
20
25
30
35
Temperature
log(Lagodon + 10)
1.0
2.0
3.0
0
10
20
30
40
50
60
Salinity

Figure 15

Figure 16. Standardized catch (on a log scale) of *Lucania parva* from the throw-trap model showing model variables with 95% confidence levels.

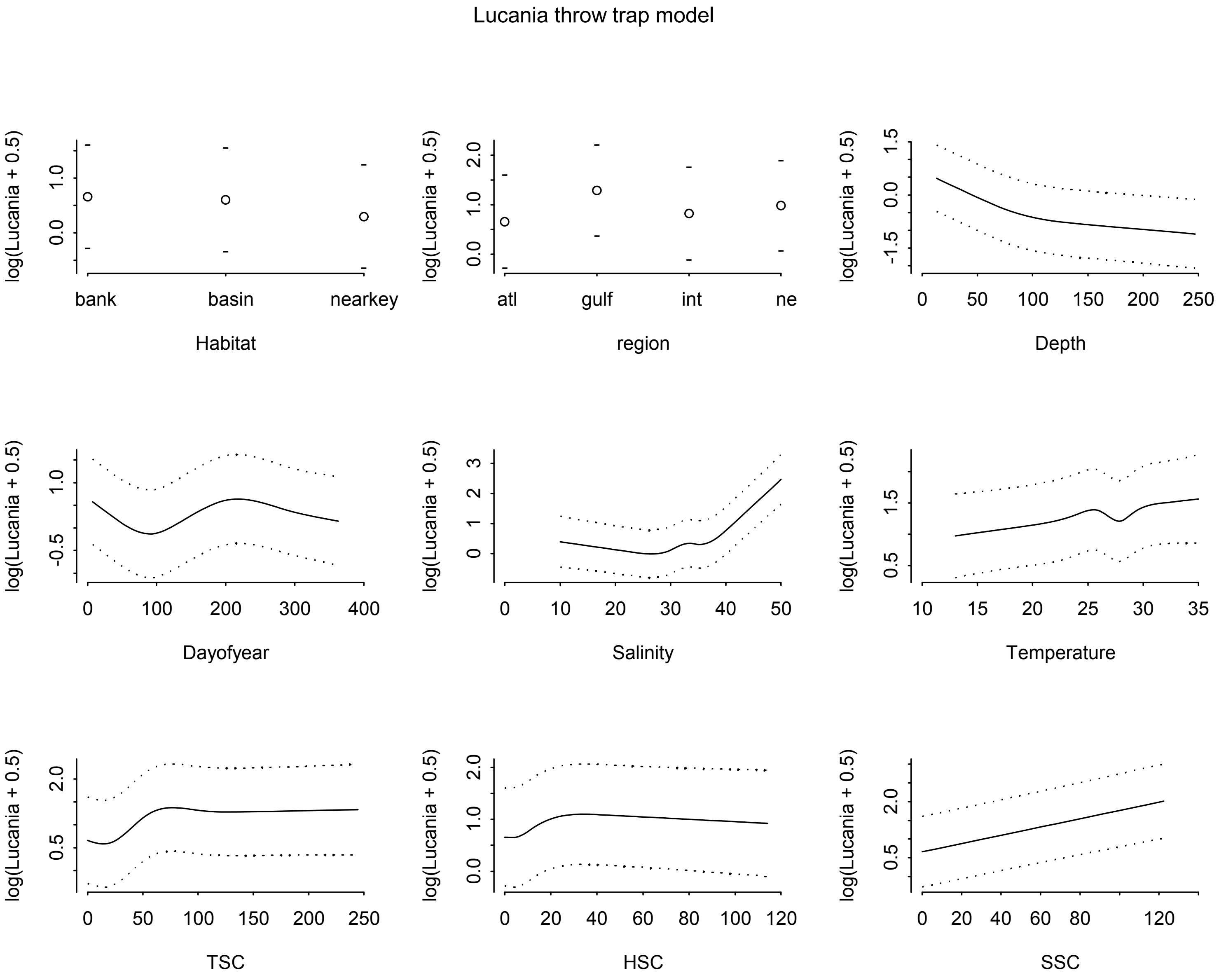

Lucania throw trap model
log(Lucania + 0.5)
1.0
0.0
bank
basin
nearkey
Habitat
2.0
1.0
0.0
atl
gulf
int
ne
region
1.5
0.0
-1.5
0
50
100
150
200
250
Depth
1.0
-0.5
0
100
200
300
400
Dayofyear
3
2
1
0
0
10
20
30
40
50
Salinity
1.5
0.5
10
15
20
25
30
35
Temperature
2.0
0.5
0
50
100
150
200
250
TSC
2.0
1.0
0.0
0
20
40
60
80
100
120
HSC
2.0
0.5
0
20
40
60
80
120
SSC

Figure 16

Figure 17. Standardized catch (on a log scale) of *Lucania parva* from the trawl/seine model showing model variables with 95% confidence levels.

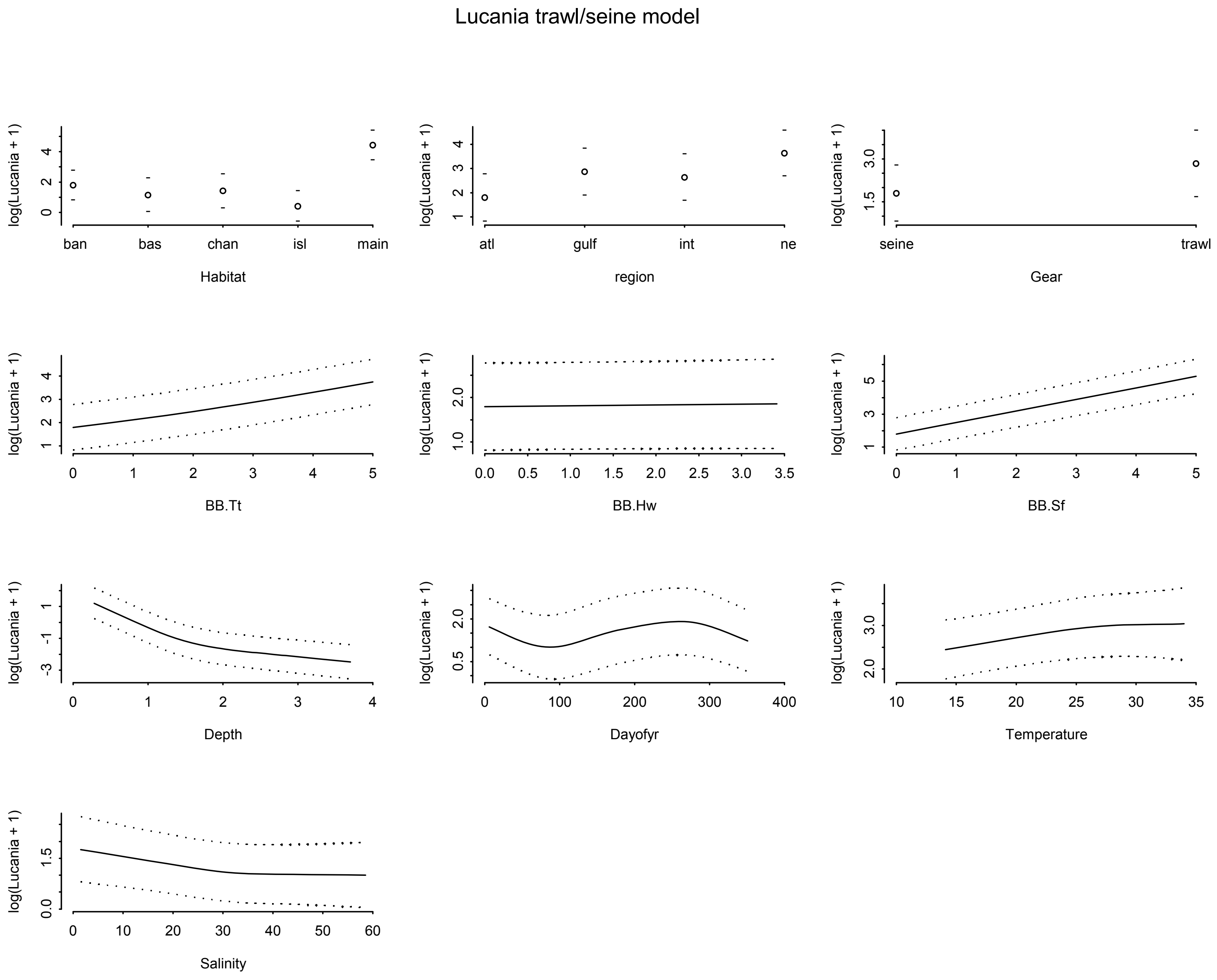

Lucania trawl/seine model
log(Lucania + 1)
0
2
4
ban
bas
chan
isl
main
Habitat
1
2
3
4
atl
gulf
int
ne
region
1.5
3.0
seine
trawl
Gear
1
2
3
4
0
1
2
3
4
5
BB.Tt
1.0
2.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
BB.Hw
1
3
5
0
1
2
3
4
5
BB.Sf
-3
-1
1
0
1
2
3
4
Depth
0.5
2.0
0
100
200
300
400
Dayofyr
2.0
3.0
10
15
20
25
30
35
Temperature
0.0
1.5
0
10
20
30
40
50
60
Salinity

Figure 17

Figure 18. Standardized catch (on a log scale) of *Lutjanus griseus* from the trawl/seine model showing model variables with 95% confidence levels.

Lutjanus trawl/seine model

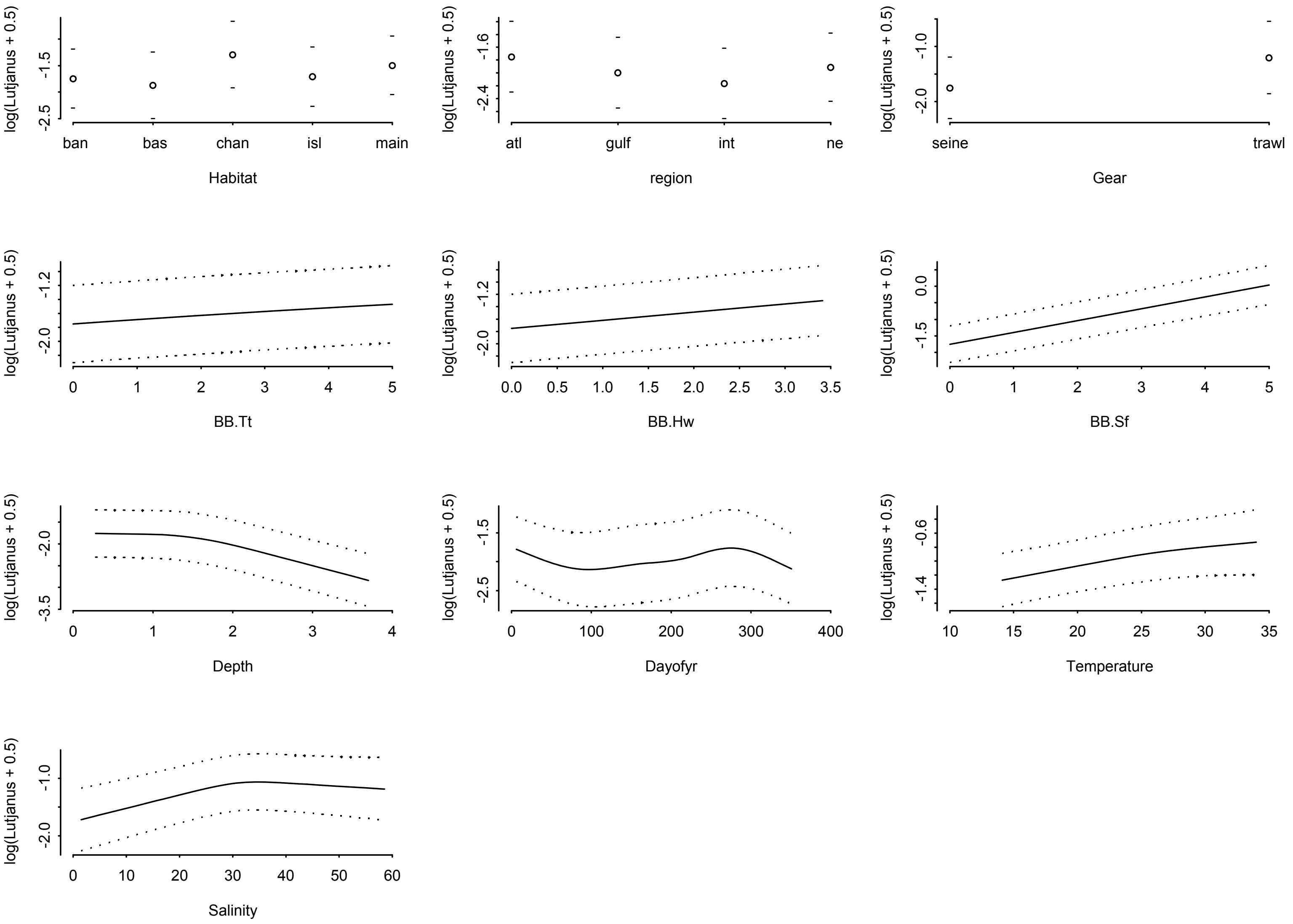


Figure 18

Figure 19. Standardized catch (on a log scale) of *Microgobius gulosus* from the trawl/seine model showing model variables with 95% confidence levels.

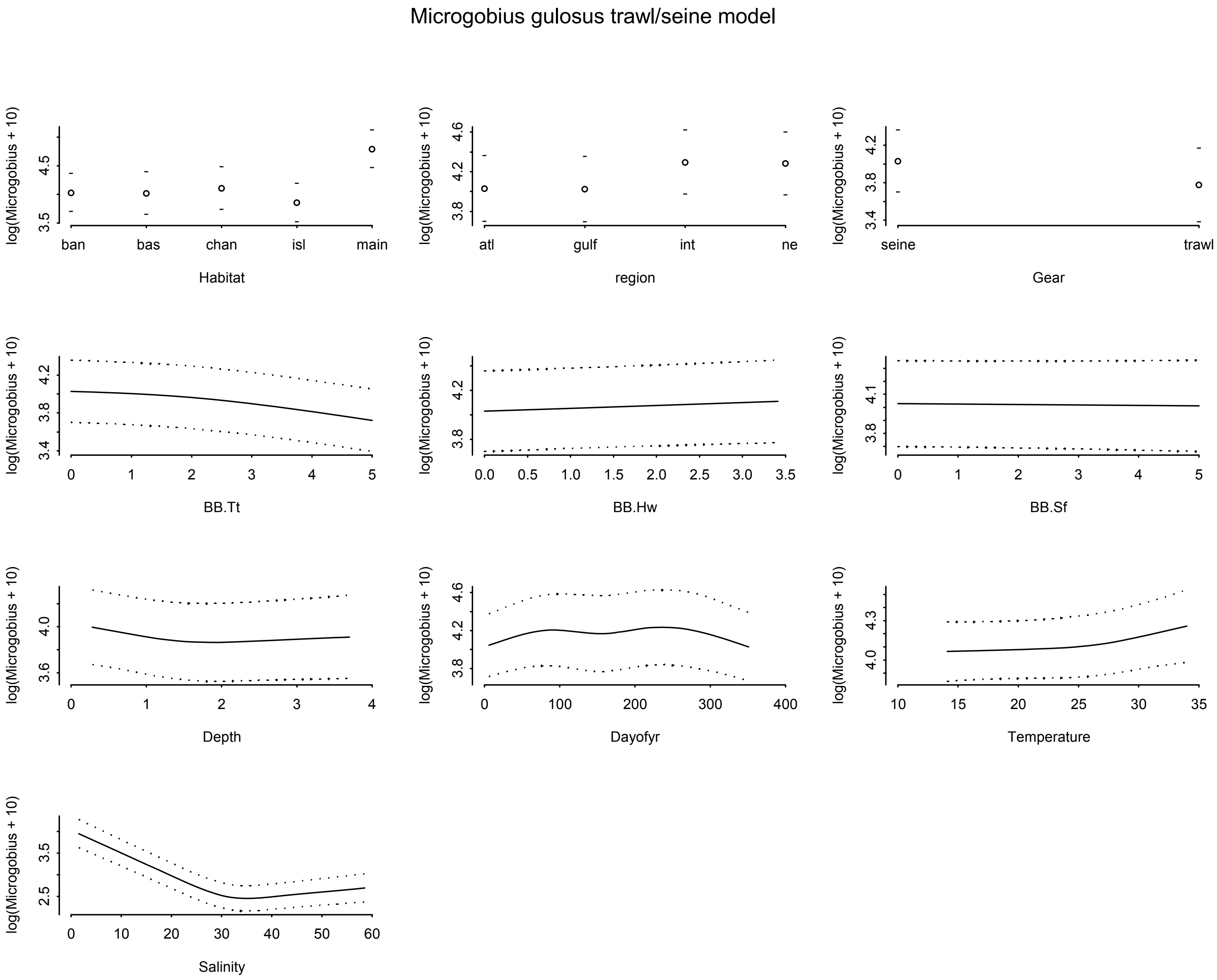

Microgobius gulosus trawl/seine model
log(Microgobius + 10)
3.5
4.5
ban
bas
chan
isl
main
Habitat
3.8
4.2
4.6
atl
gulf
int
ne
region
3.4
3.8
4.2
seine
trawl
Gear
3.4
3.8
4.2
0
1
2
3
4
5
BB.Tt
3.8
4.2
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
BB.Hw
3.8
4.1
0
1
2
3
4
5
BB.Sf
3.6
4.0
0
1
2
3
4
Depth
3.8
4.2
4.6
0
100
200
300
400
Dayofyr
4.0
4.3
10
15
20
25
30
35
Temperature
2.5
3.5
0
10
20
30
40
50
60
Salinity

Figure 19

Figure 20. Standardized catch (on a log scale) of *Microgobius microlepis* from the trawl/seine model showing model variables with 95% confidence levels.

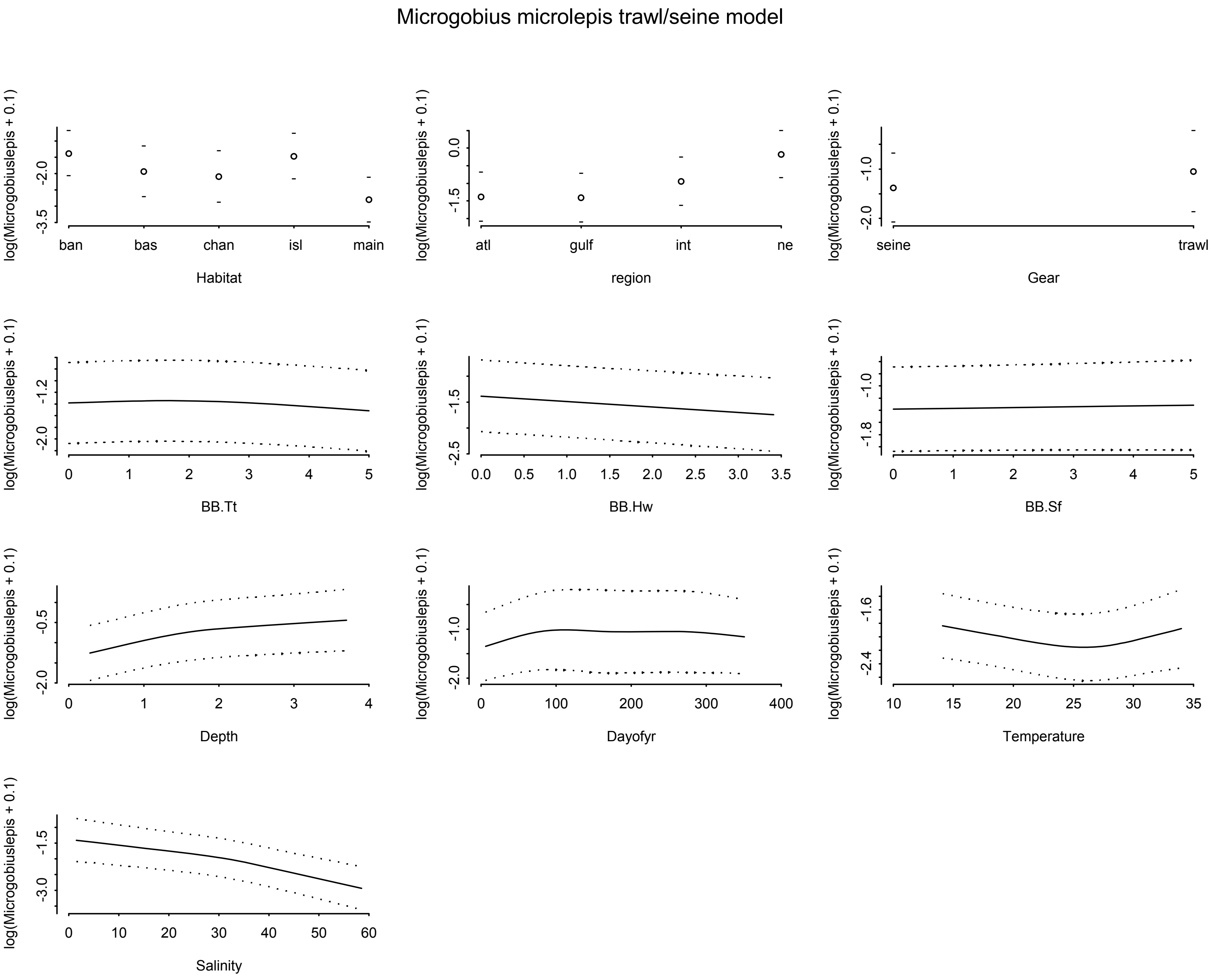

Microgobius microlepis trawl/seine model

Figure 20

Figure 21. Standardized catch (on a log scale) of *Opisthonema oglinum* from the trawl/seine model showing model variables with 95% confidence levels.

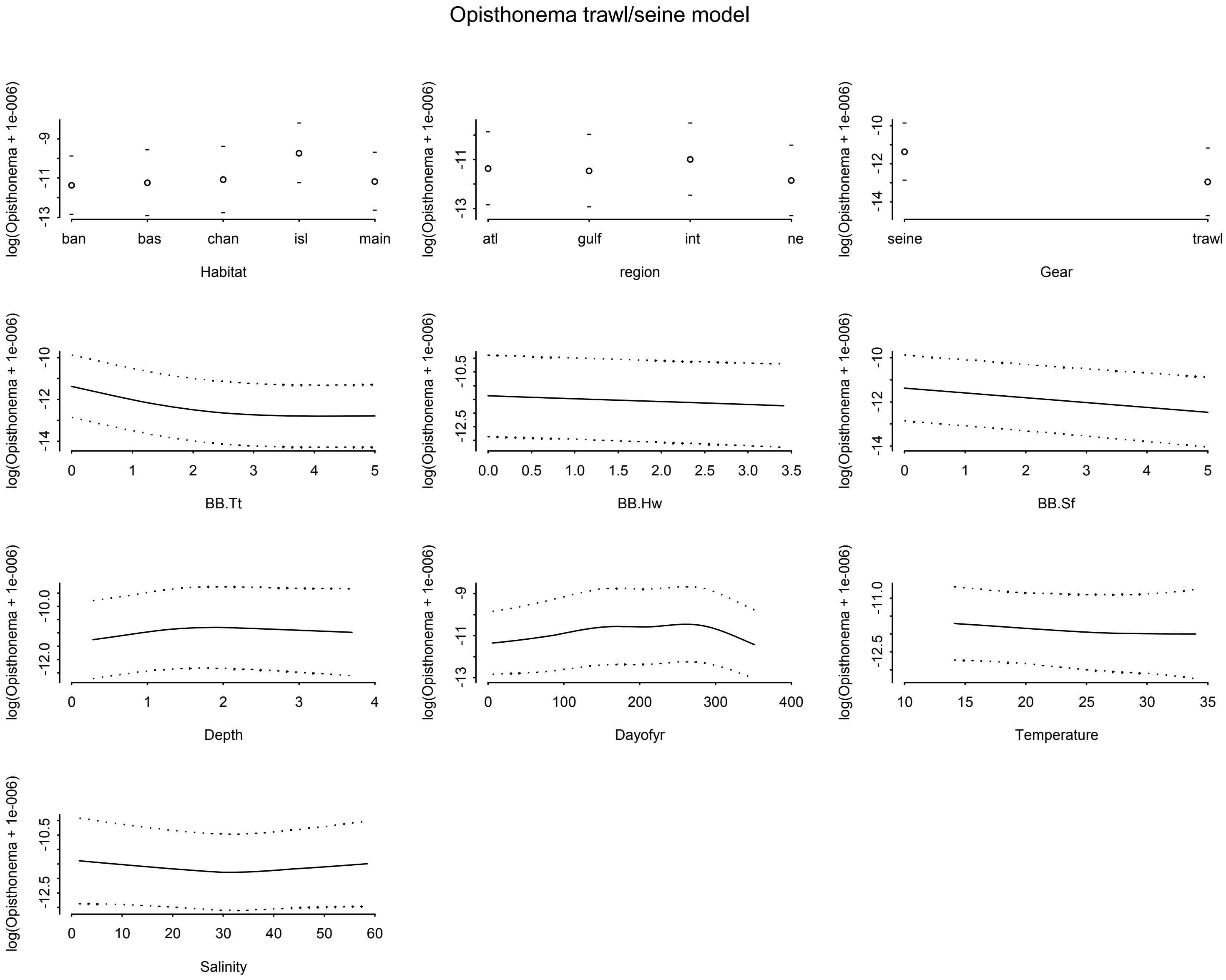

Opisthonema trawl/seine model

Figure 21

Figure 22. Standardized catch (on a log scale) of *Opsanus beta* from the throw-trap model showing model variables with 95% confidence levels.

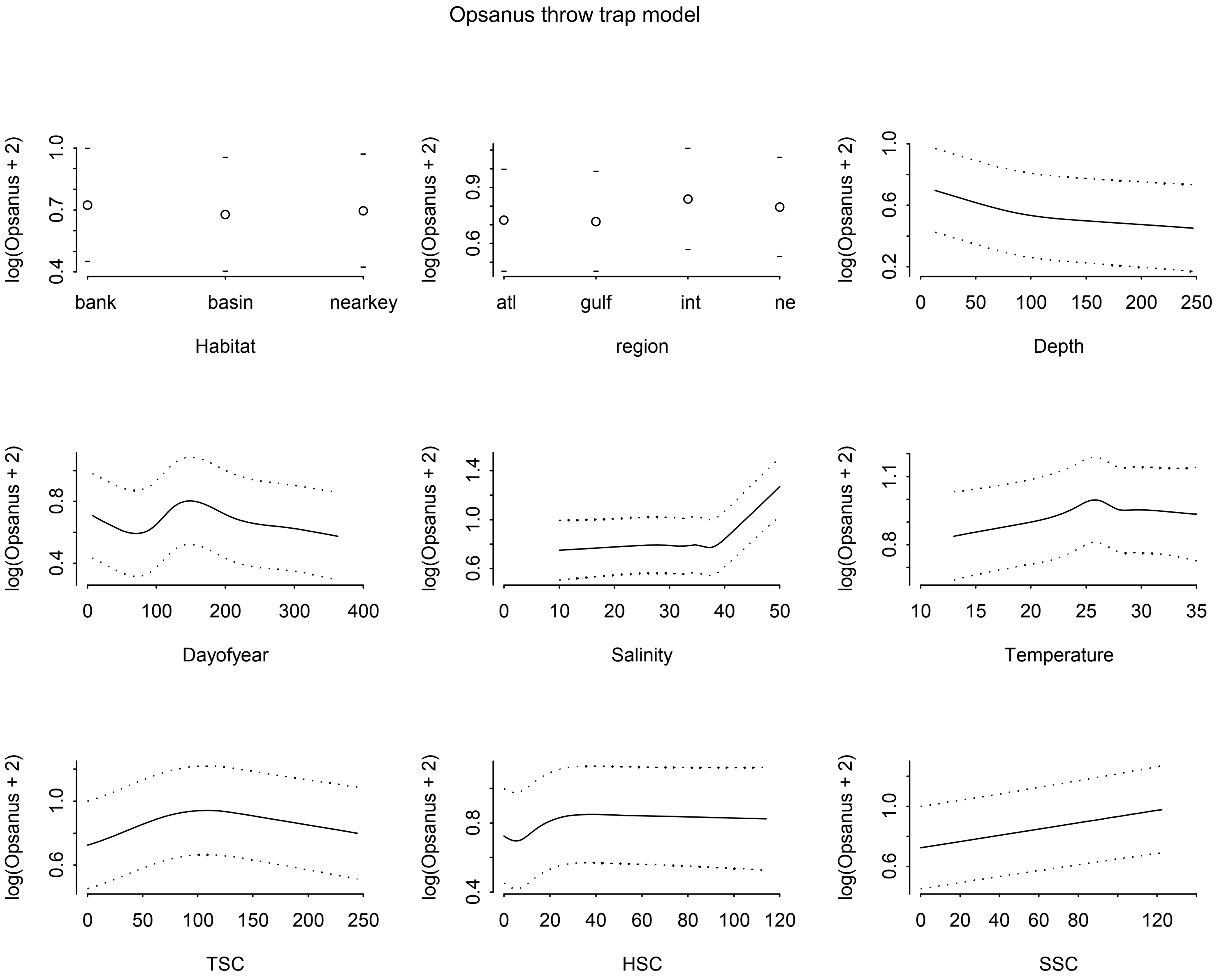

Opsanus throw trap model
log(Opsanus + 2)
0.4
0.7
1.0
bank
basin
nearkey
Habitat
0.6
0.9
atl
gulf
int
ne
region
0.2
0.6
1.0
0
50
100
150
200
250
Depth
0.4
0.8
0
100
200
300
400
Dayofyear
0.6
1.0
1.4
0
10
20
30
40
50
Salinity
0.8
1.1
10
15
20
25
30
35
Temperature
0.6
1.0
0
50
100
150
200
250
TSC
0.4
0.8
0
20
40
60
80
100
120
HSC
0.6
1.0
0
20
40
60
80
120
SSC

Figure 22

Figure 23. Standardized catch (on a log scale) of *Opsanus beta* from the trawl/seine model showing model variables with 95% confidence levels.

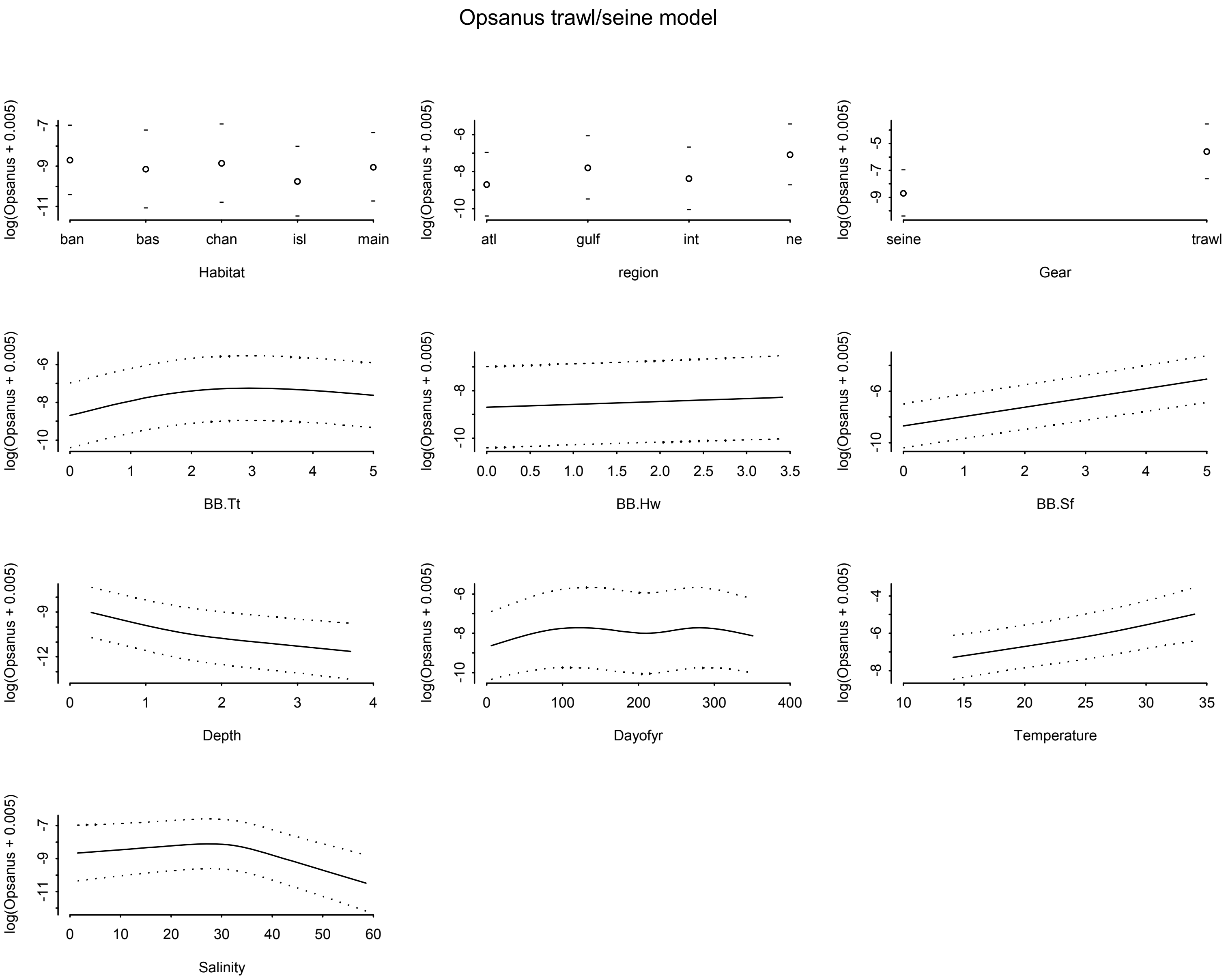
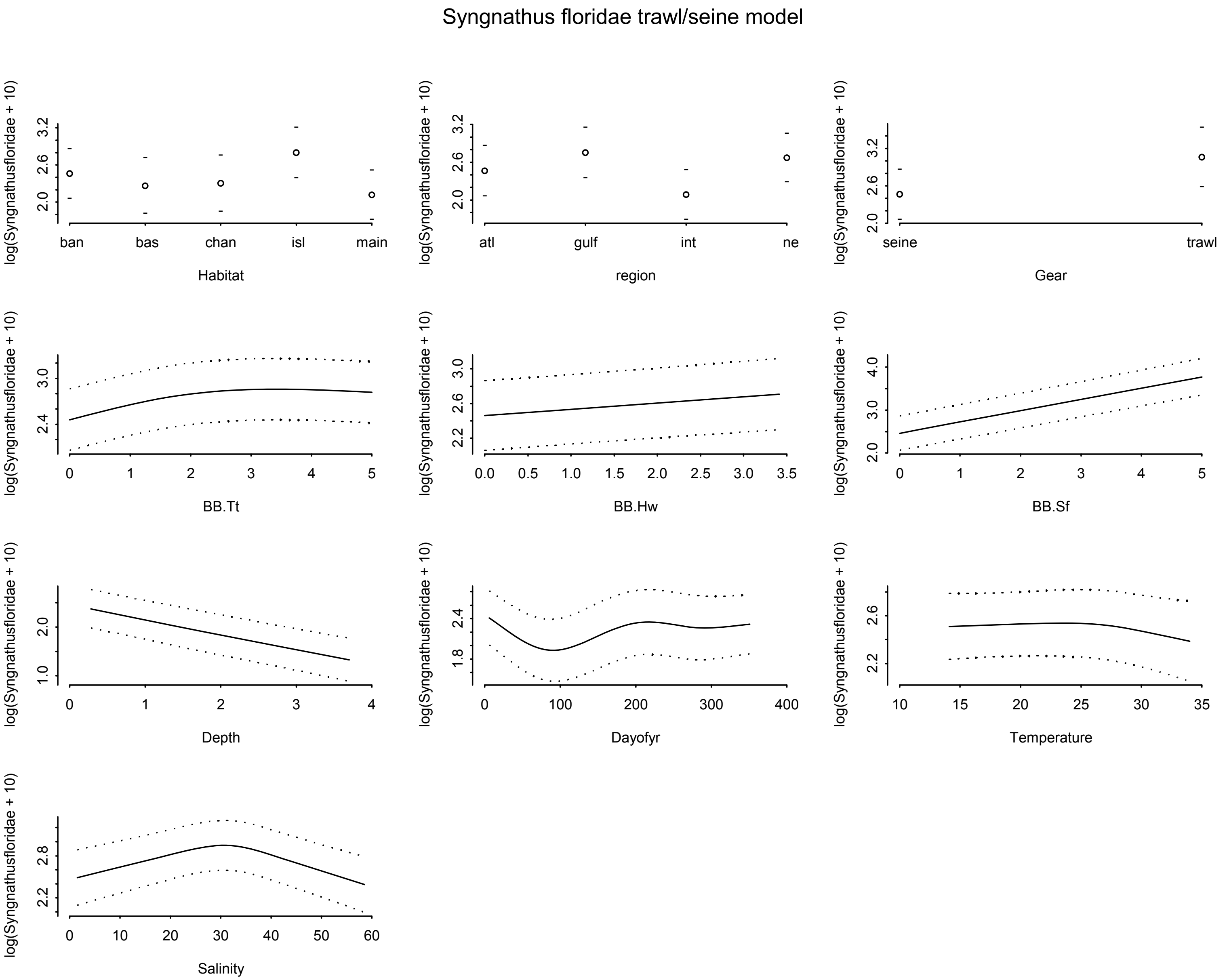

Opsanus trawl/seine model
log(Opsanus + 0.005)
-7
-9
-11
ban
bas
chan
isl
main
Habitat
-6
-8
-10
atl
gulf
int
ne
region
-5
-7
-9
seine
trawl
Gear
-6
-8
-10
0
1
2
3
4
5
BB.Tt
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
BB.Hw
BB.Sf
-9
-12
Depth
0
100
200
300
400
Dayofyr
-4
-6
-8
10
15
20
25
30
35
Temperature
0
10
20
30
40
50
60
Salinity

Figure 23

Figure 24. Standardized catch (on a log scale) of *Syngnathus floridae* from the trawl/seine model showing model variables with 95% confidence levels.



Syngnathus floridae trawl/seine model

Figure 24

Figure 25. Standardized catch (on a log scale) of *Syngnathus scovelli* from the throw-trap model showing model variables with 95% confidence levels.

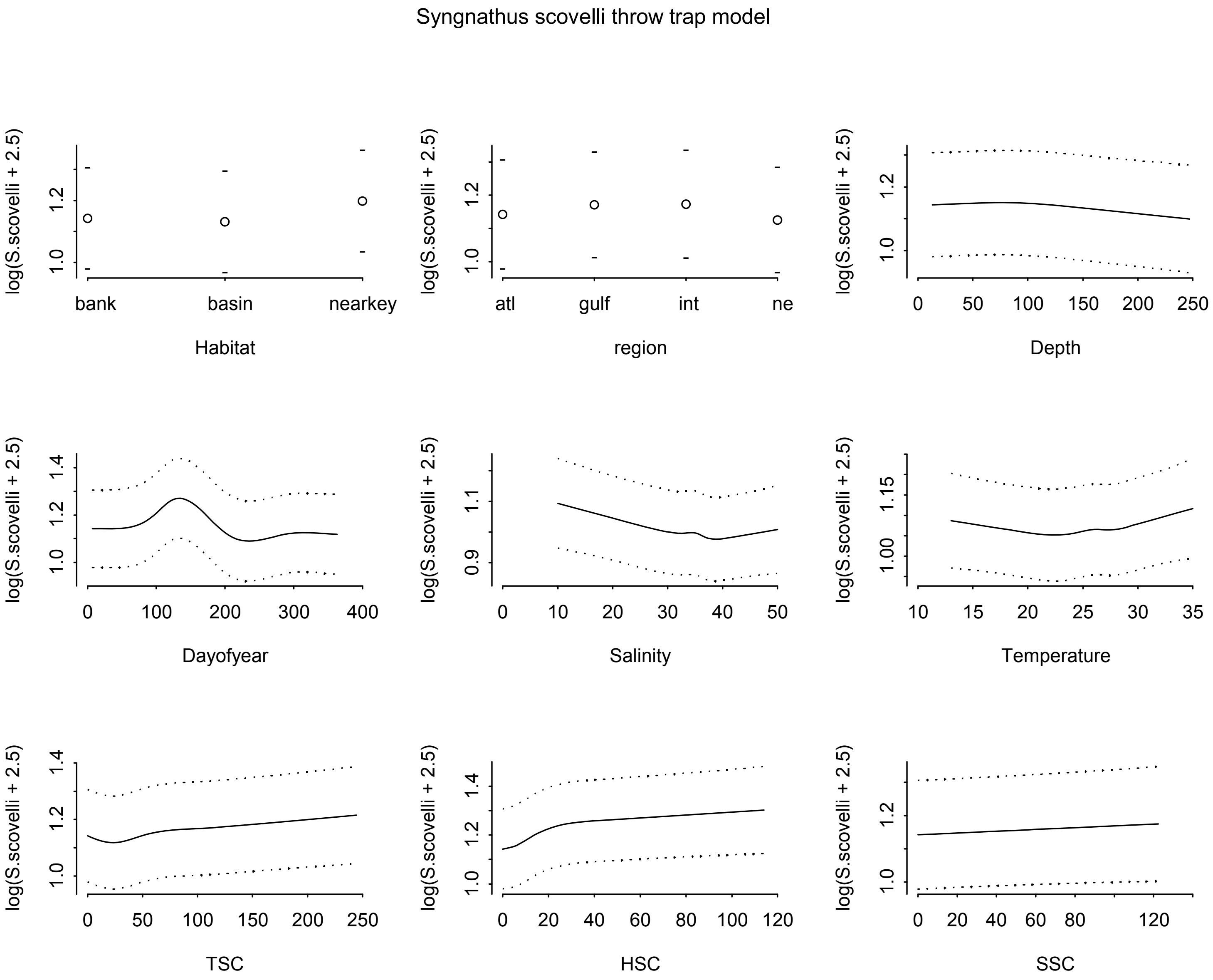

Syngnathus scovelli throw trap model
log(S.scovelli + 2.5)
1.0
1.2
bank
basin
nearkey
Habitat
atl
gulf
int
ne
region
0
50
100
150
200
250
Depth
1.4
0
100
200
300
400
Dayofyear
0.9
1.1
0
10
20
30
40
50
Salinity
1.00
1.15
10
15
20
25
30
35
Temperature
TSC
20
40
60
80
120
HSC
SSC

Figure 25

Figure 26. Standardized catch (on a log scale) of *Syngnathus scovelli* from the trawl/seine model showing model variables with 95% confidence levels.

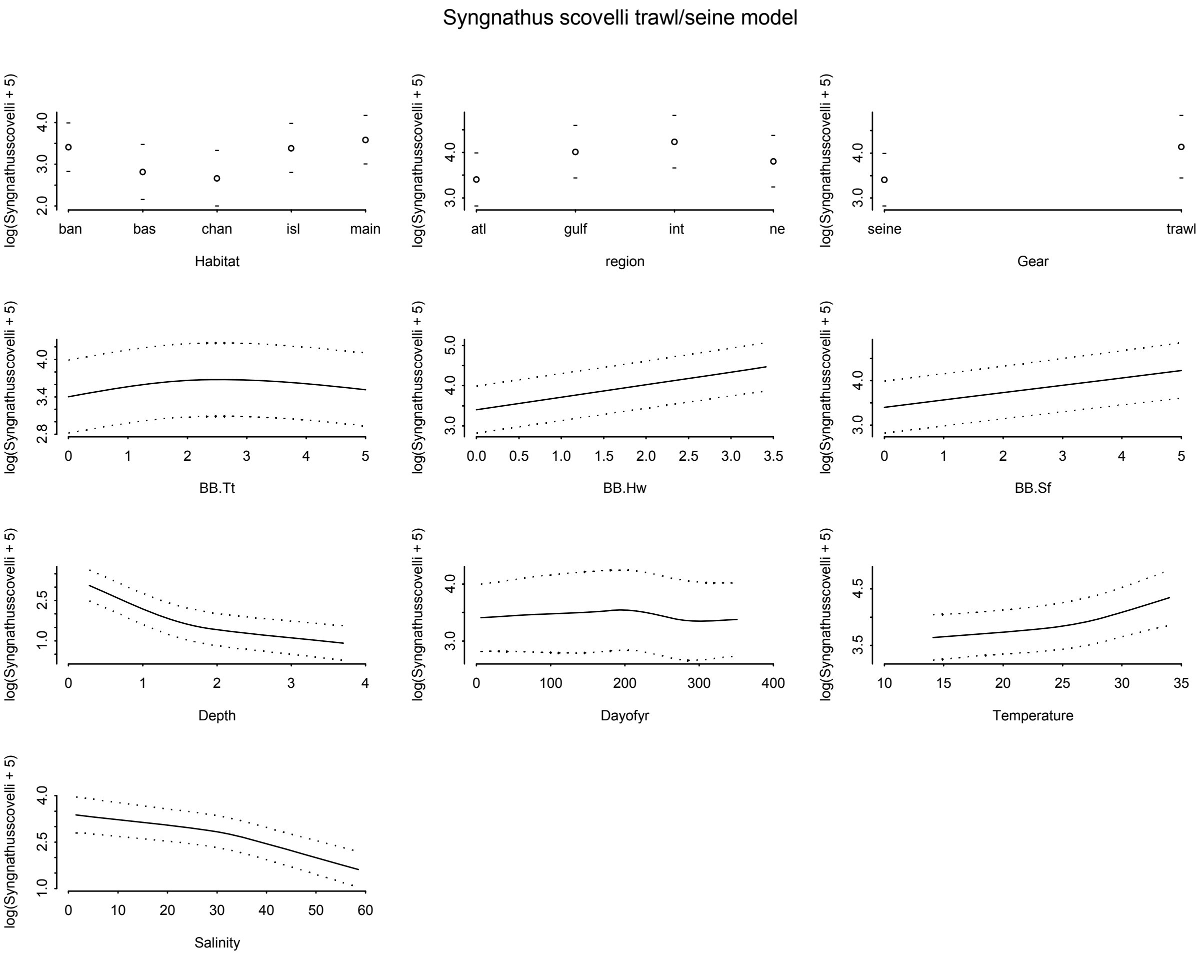

Syngnathus scovelli trawl/seine model
log(Syngnathusscovelli + 5)
2.0
3.0
4.0
ban
bas
chan
isl
main
Habitat
3.0
4.0
atl
gulf
int
ne
region
seine
trawl
Gear
2.8
3.4
4.0
0
1
2
3
4
5
BB.Tt
5.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
BB.Hw
BB.Sf
1.0
2.5
Depth
100
200
300
400
Dayofyr
3.5
4.5
10
15
20
25
30
35
Temperature
10
20
30
40
50
60
Salinity

Figure 26

Figure 27. Standardized catch (on a log scale) of *Thor spp.* from the throw-trap model showing model variables with 95% confidence levels.

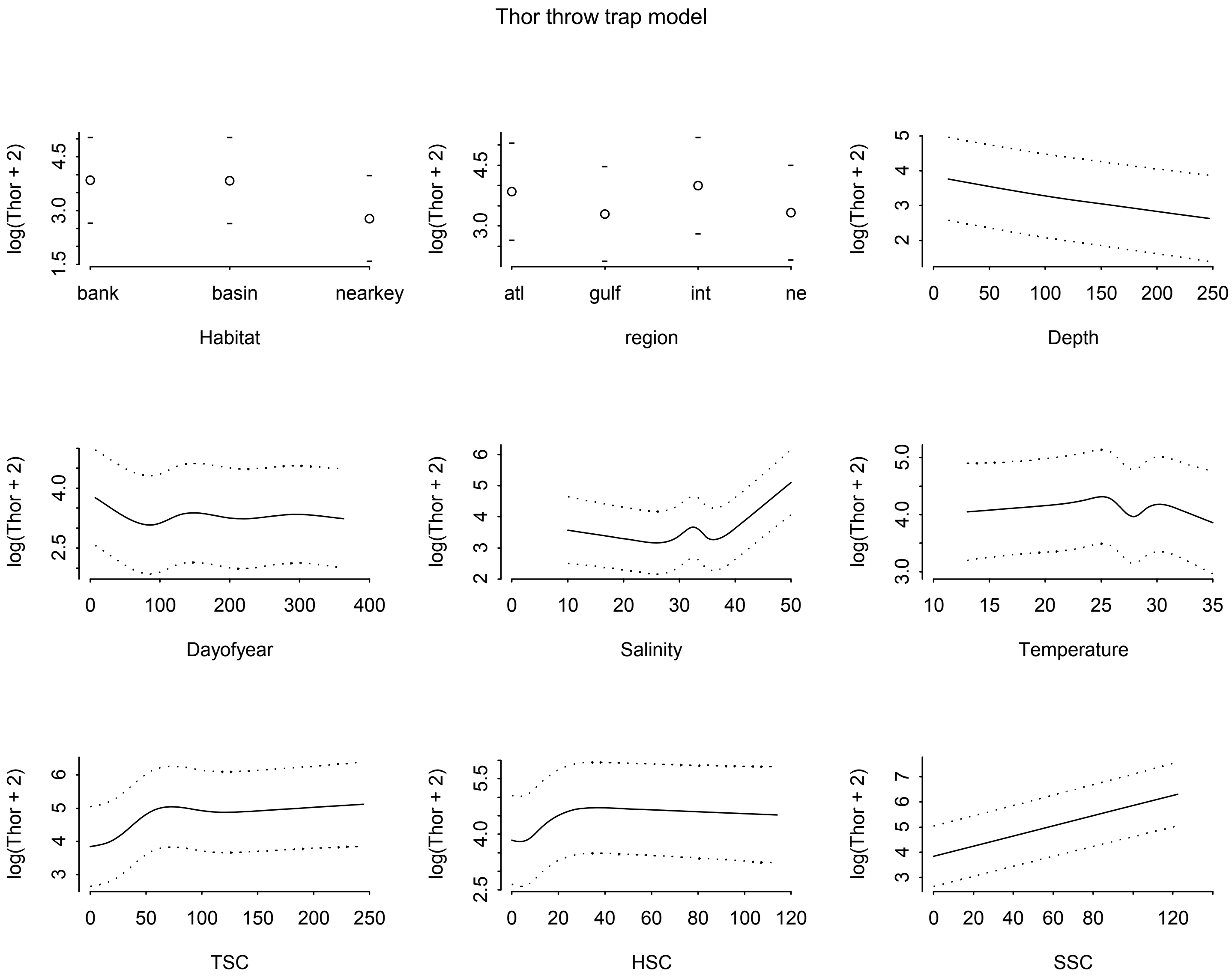
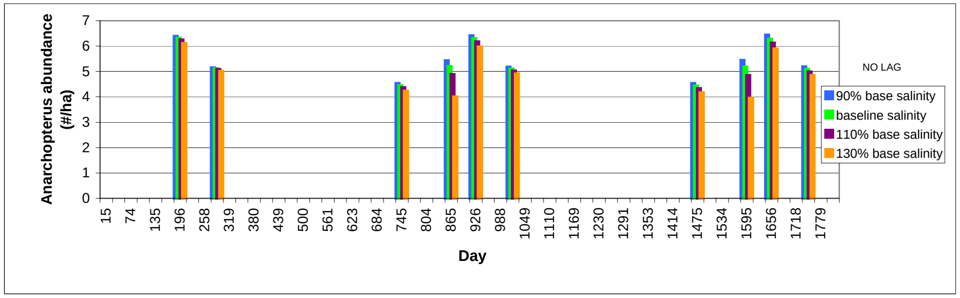
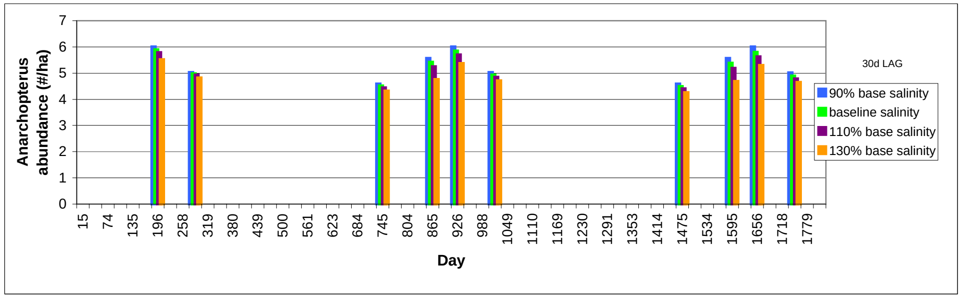

Thor throw trap model
log(Thor + 2)
1.5
3.0
4.5
bank
basin
nearkey
Habitat
log(Thor + 2)
3.0
4.5
atl
gulf
int
ne
region
log(Thor + 2)
2
3
4
5
0
50
100
150
200
250
Depth
log(Thor + 2)
2.5
4.0
0
100
200
300
400
Dayofyear
log(Thor + 2)
2
3
4
5
6
0
10
20
30
40
50
Salinity
log(Thor + 2)
3.0
4.0
5.0
10
15
20
25
30
35
Temperature
log(Thor + 2)
3
4
5
6
0
50
100
150
200
250
TSC
log(Thor + 2)
2.5
4.0
5.5
0
20
40
60
80
100
120
HSC
log(Thor + 2)
3
4
5
6
7
0
20
40
60
80
120
SSC

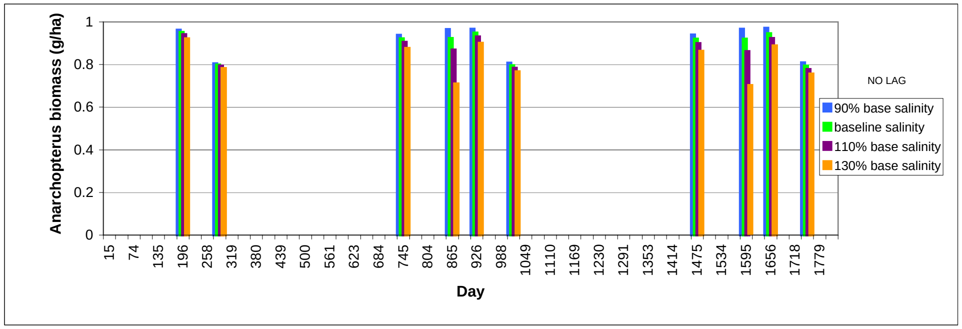
Figure 27

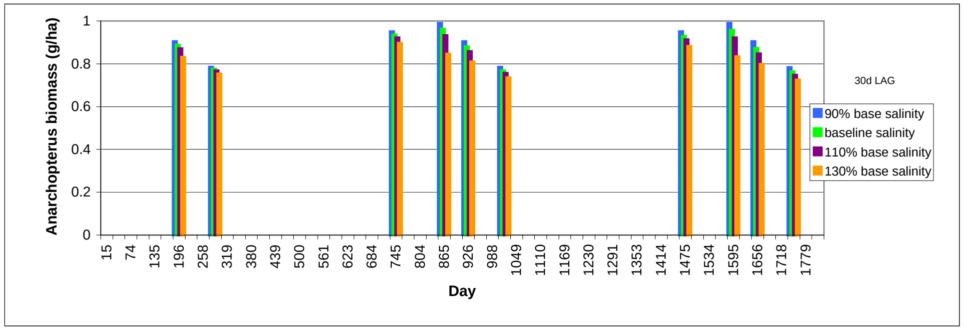
Figure 28. Trout Cove Scenario – *Anarchopterus criniger* abundance and biomass-trawl/seine

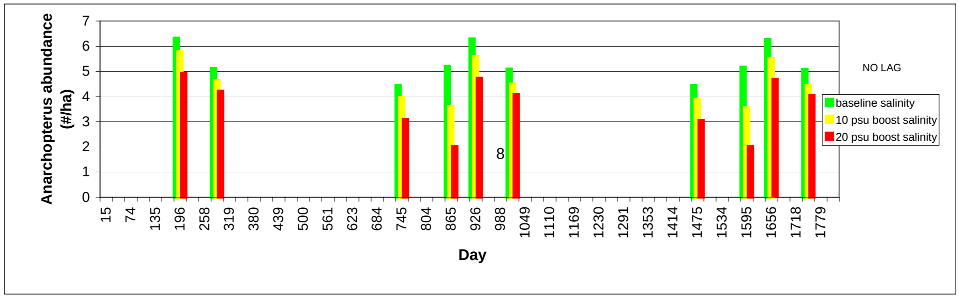
TROUT COVE- TRAWL/SEINE

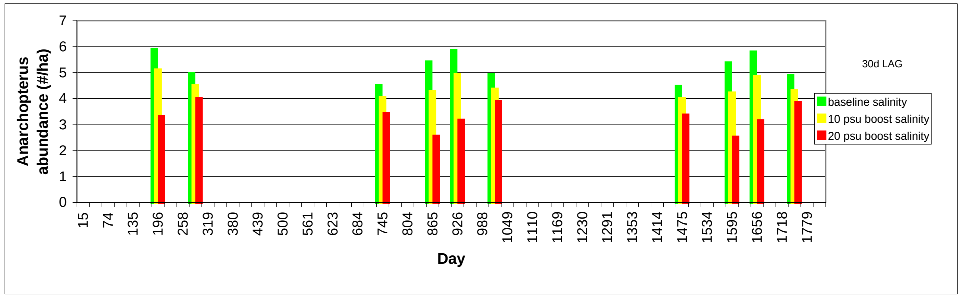


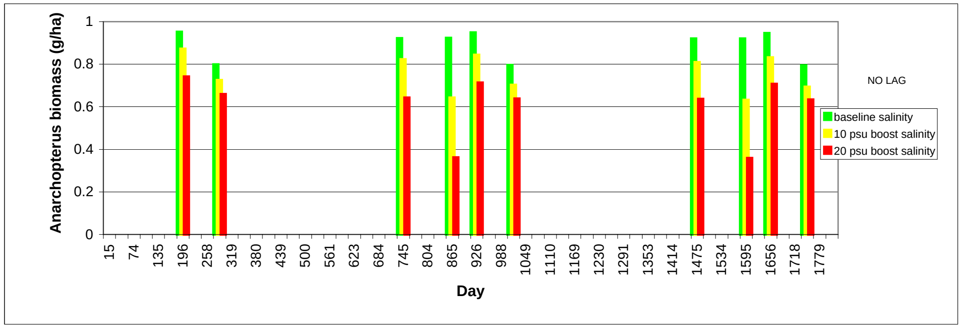












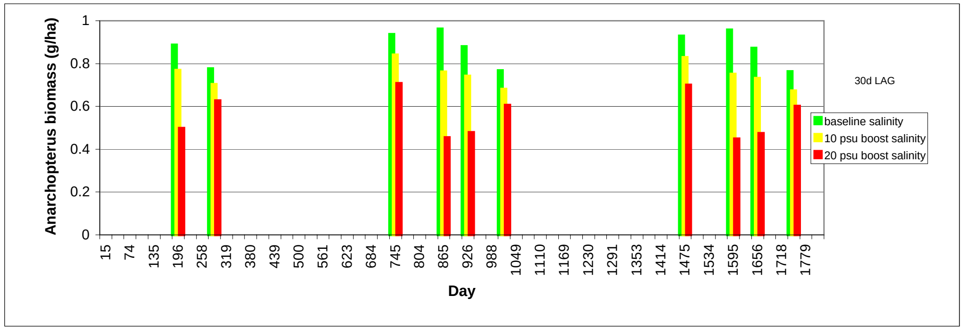
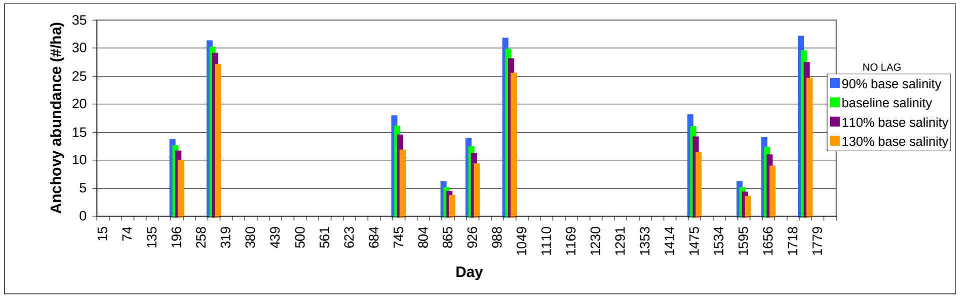
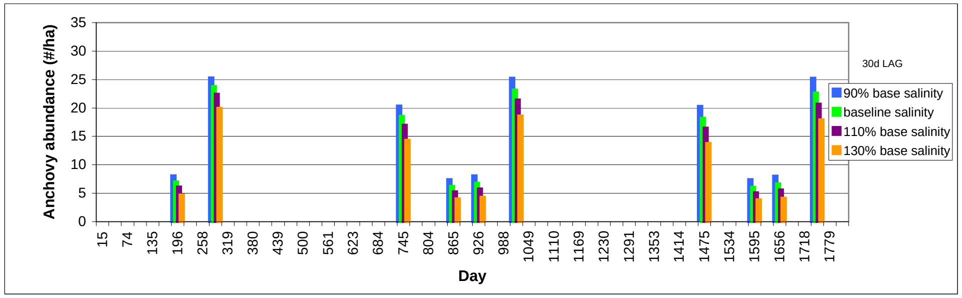
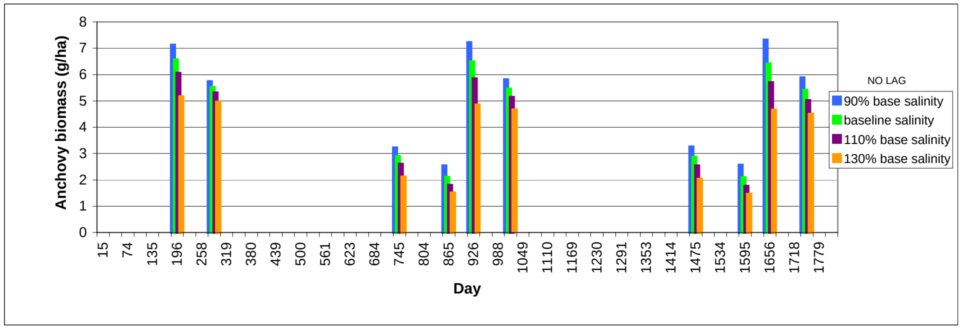


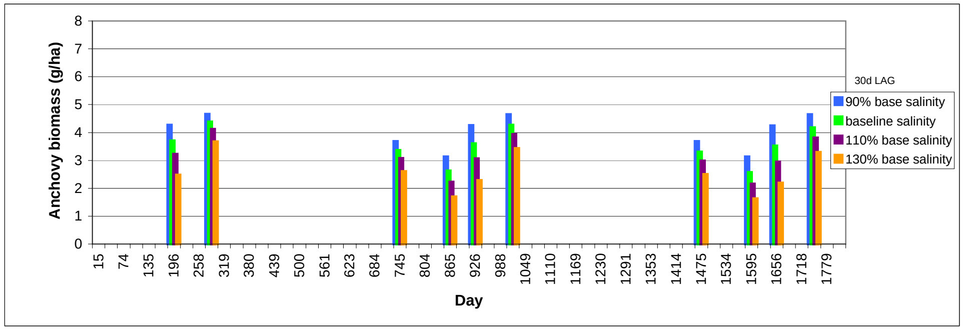
Figure 29. Trout Cove Scenario – *Anchoa mitchelli* abundance and biomass- trawl/seine

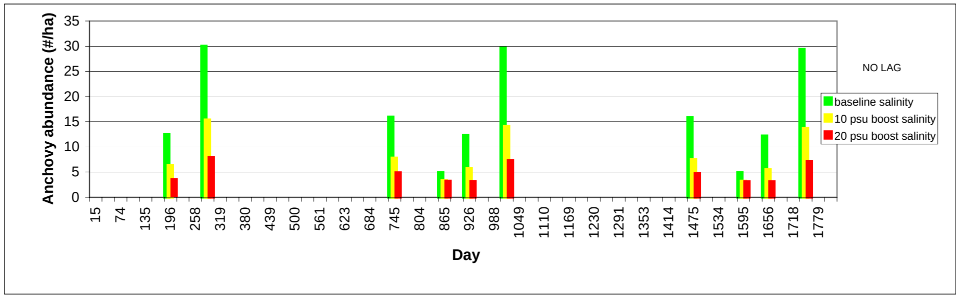
TROUT COVE- TRAWL/SEINE

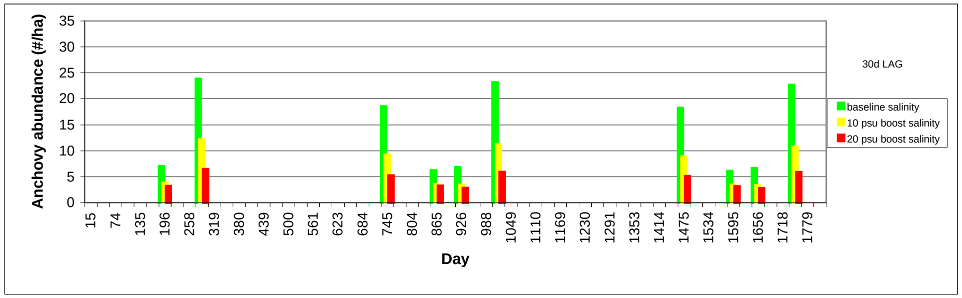


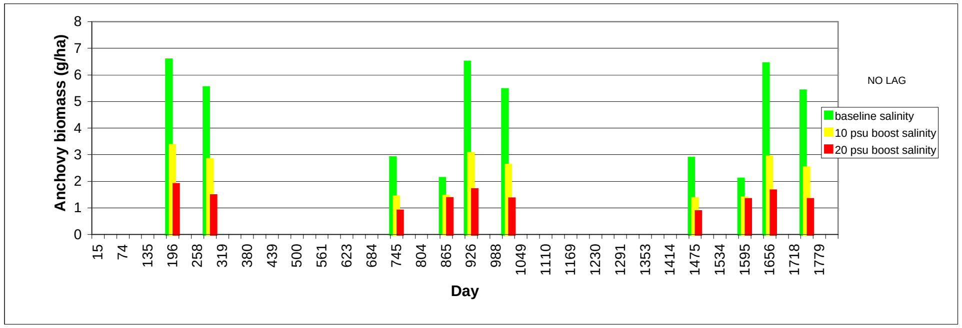












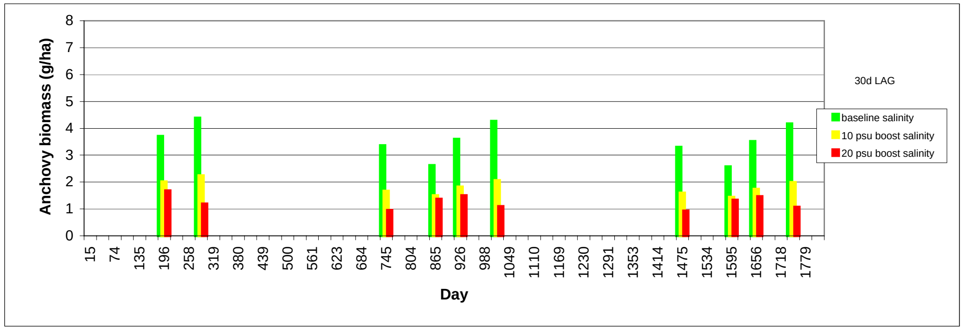
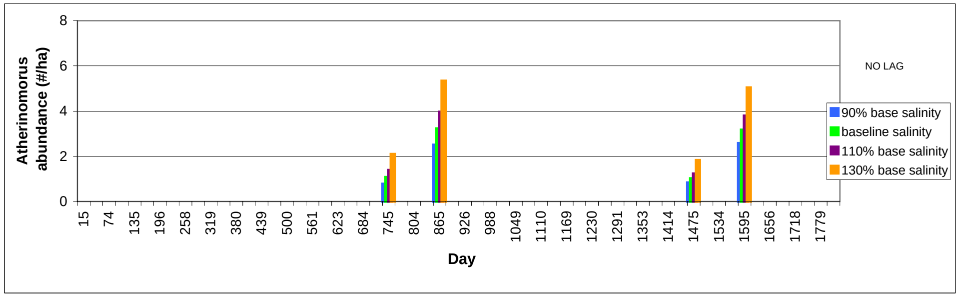
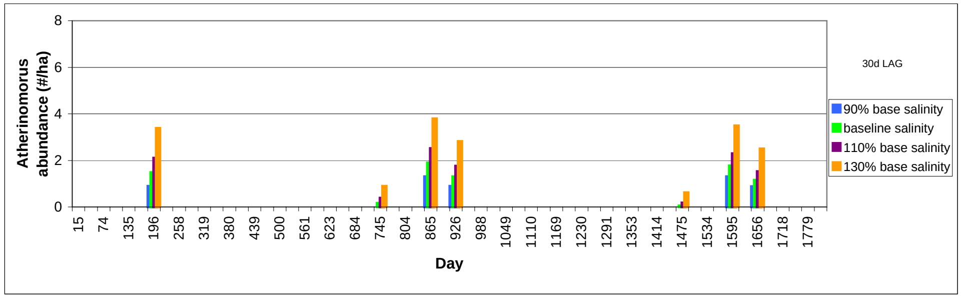
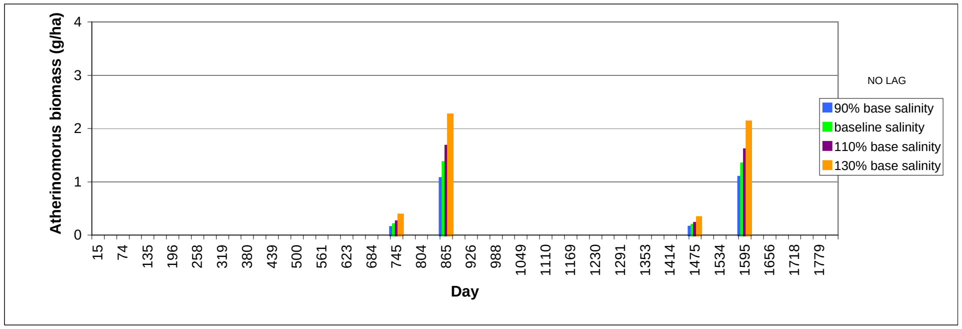


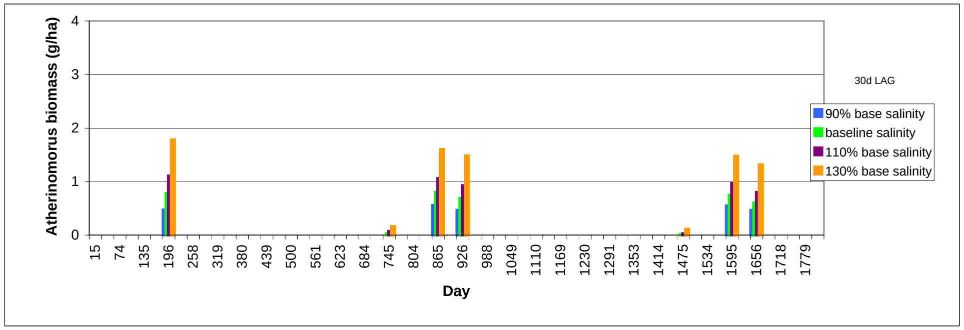
Figure 30. Trout Cove Scenario – *Atherinomorus stipes* abundance and biomass-trawl/seine

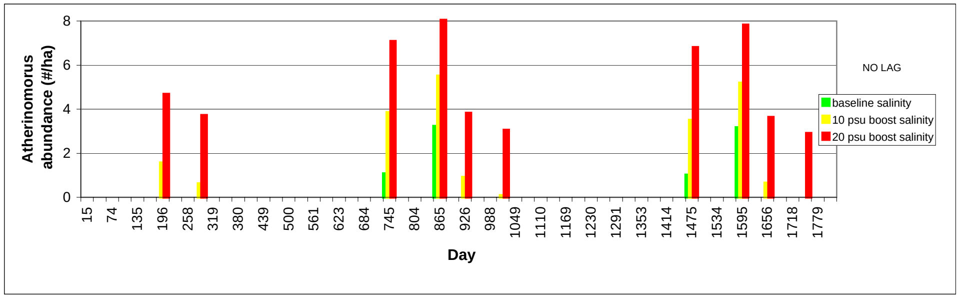
TROUT COVE-TRAWL/SEINE

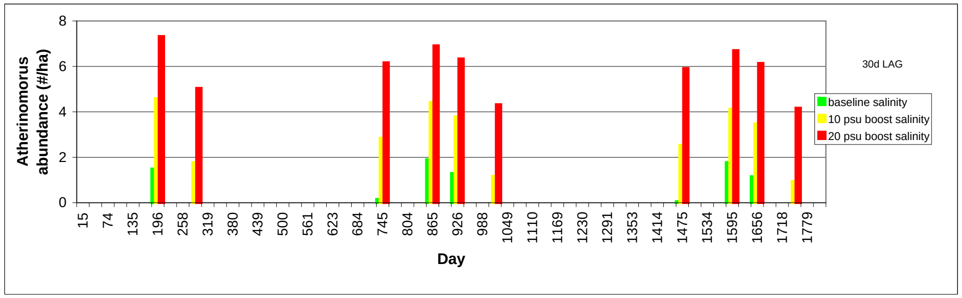


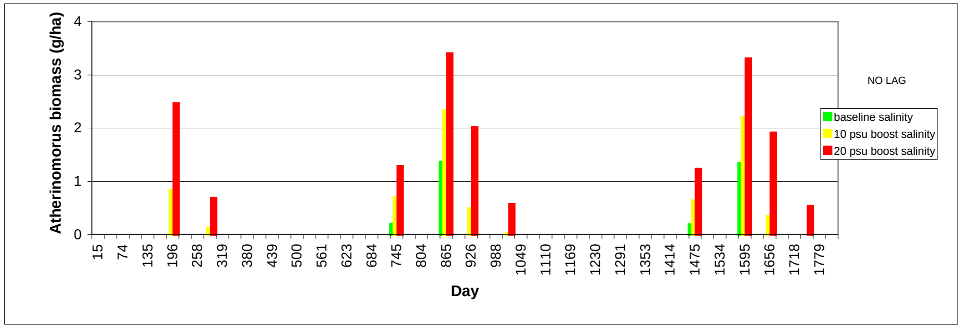












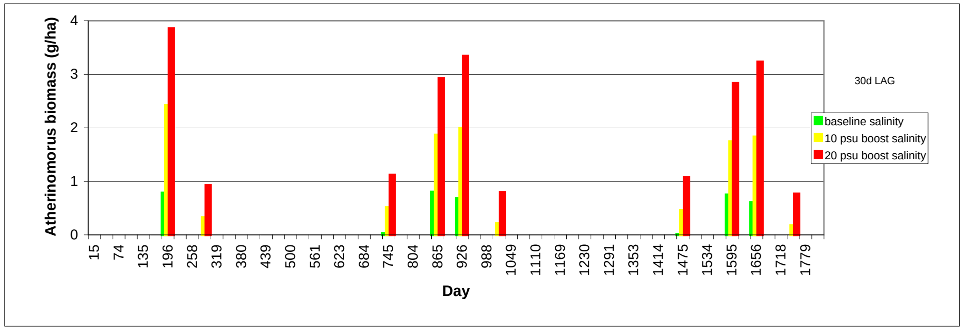
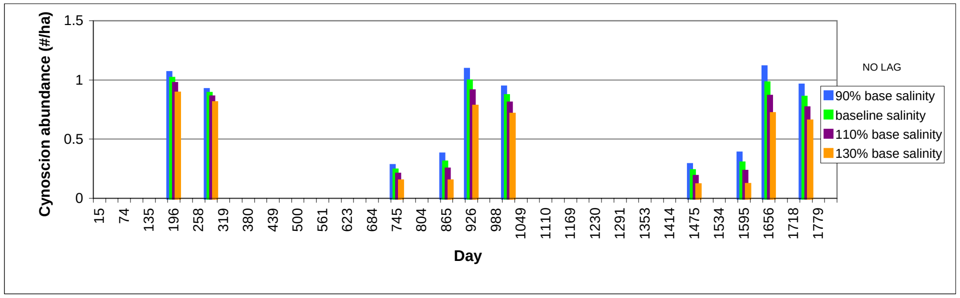
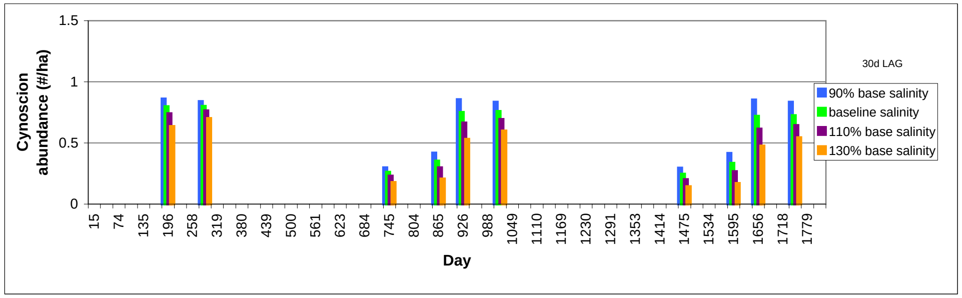
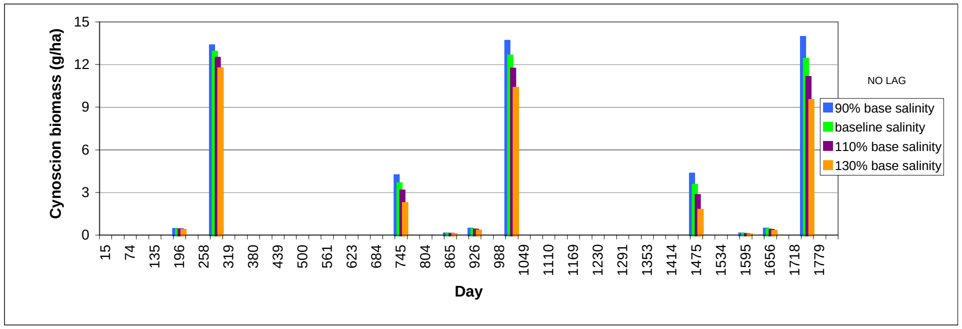


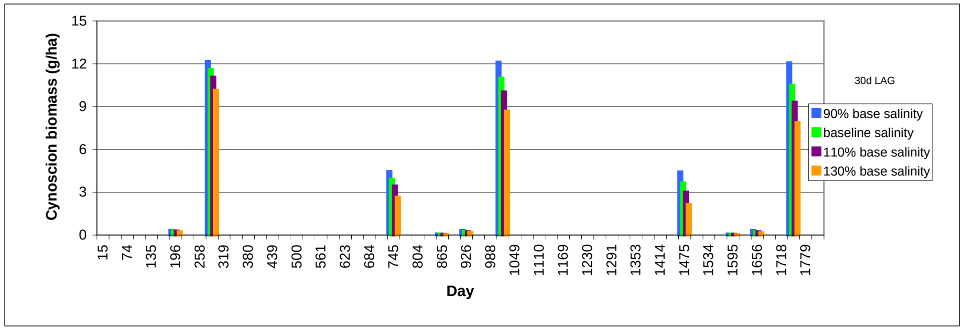
Figure 31. Trout Cove Scenario – *Cynoscion nebulosus* abundance and biomass-trawl/seine

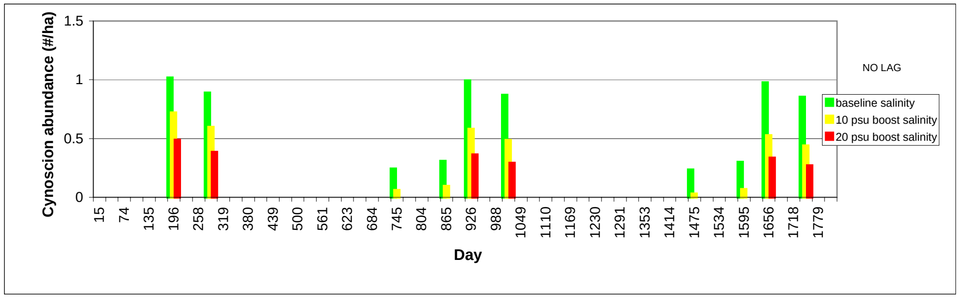
TROUT COVE-TRAWL/SEINE

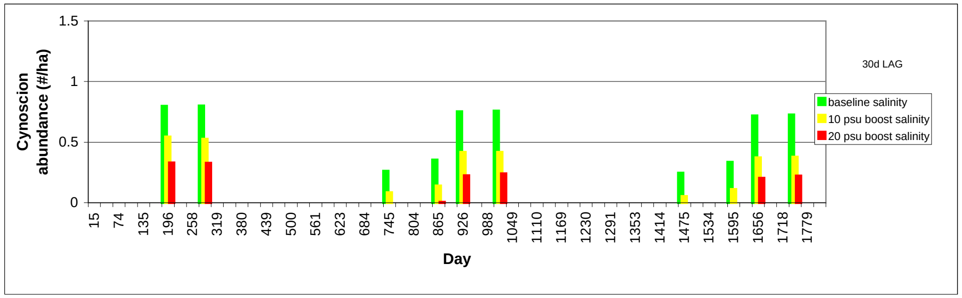


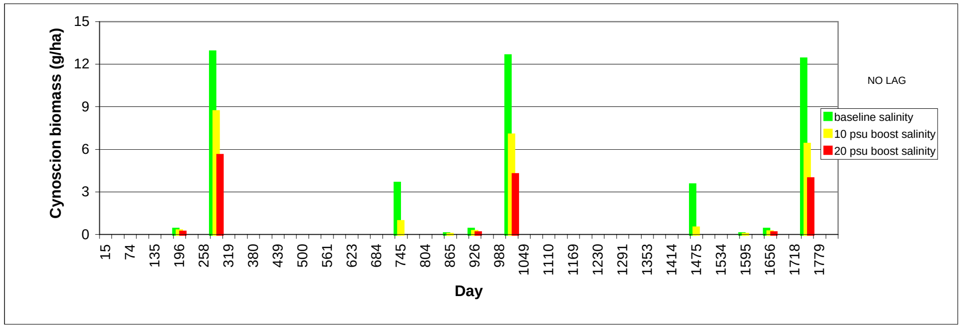












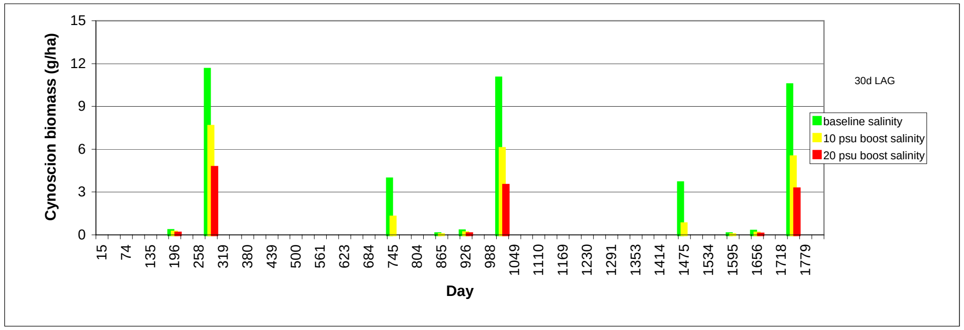
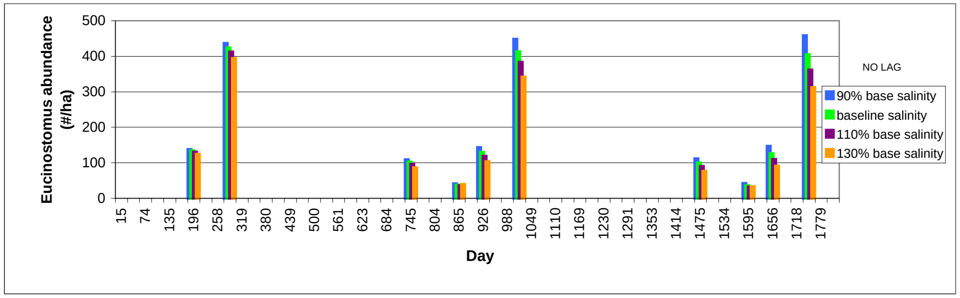
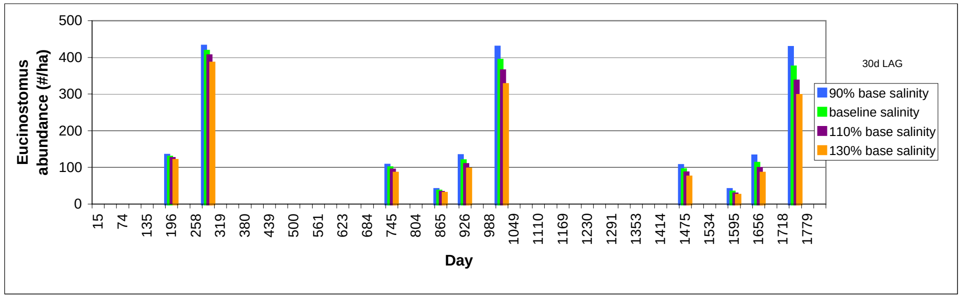
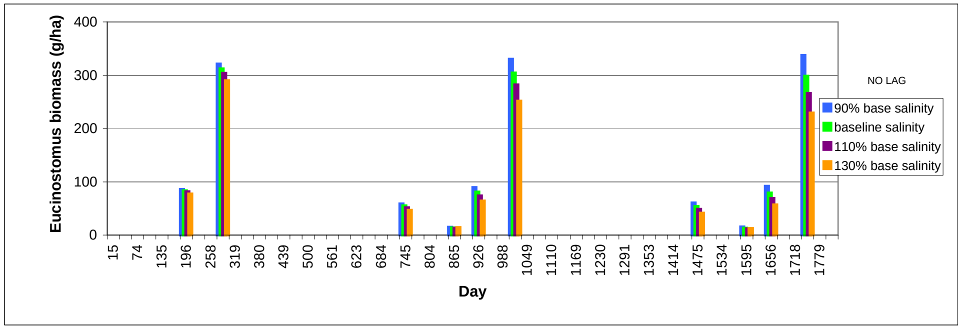


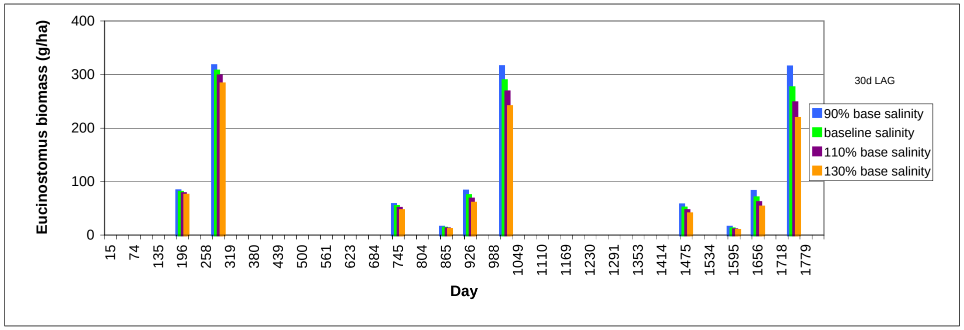
Figure 32. Trout Cove Scenario – *Eucinostomus spp*. abundance and biomass- trawl/seine

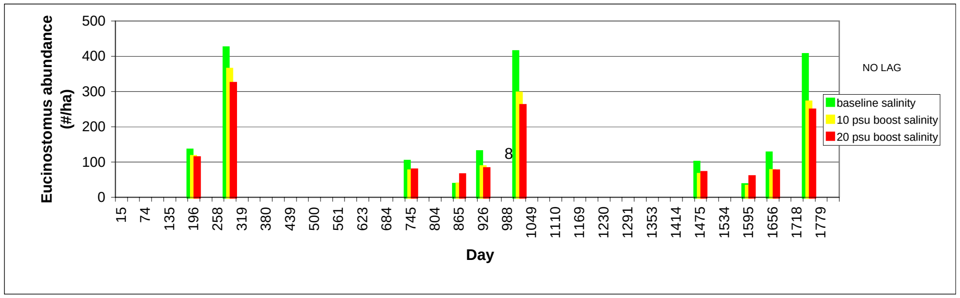
TROUT COVE-TRAWL/SEINE

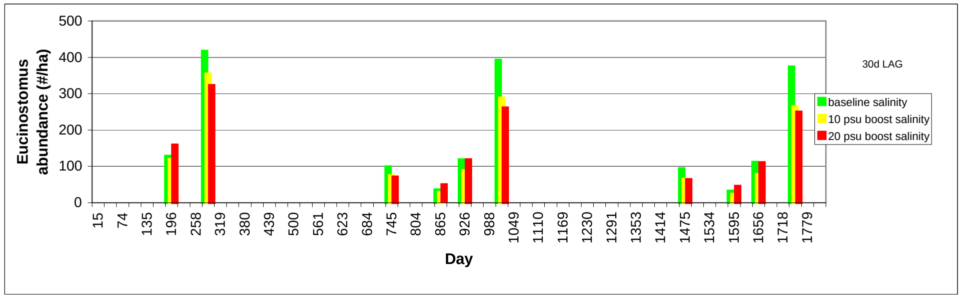


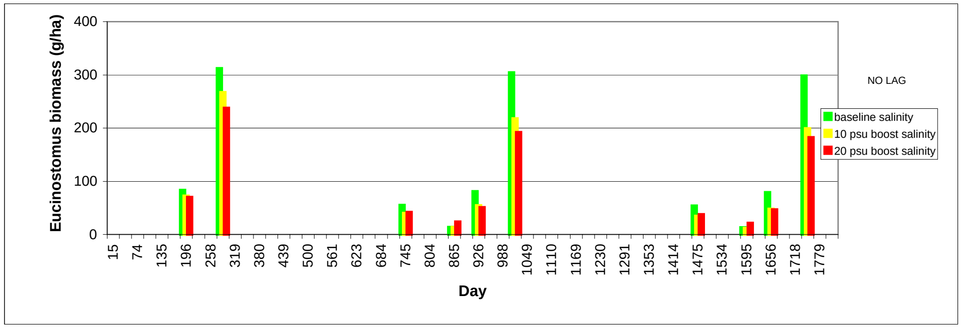












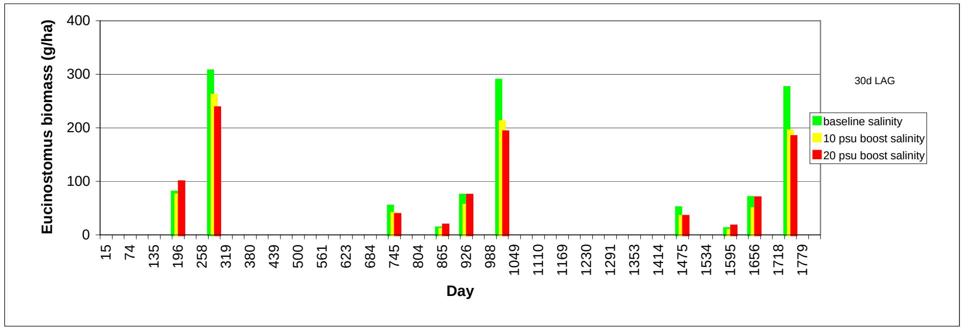
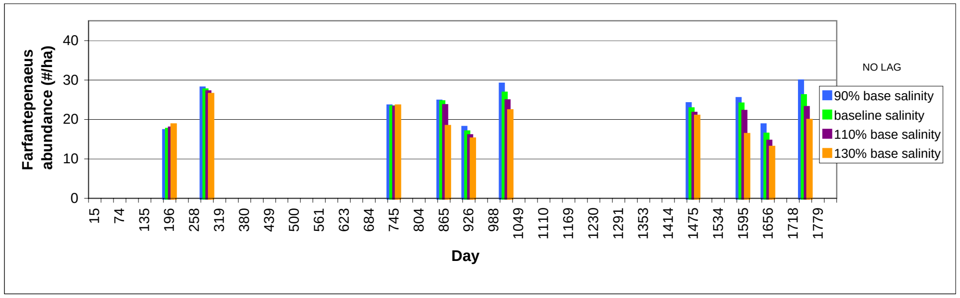
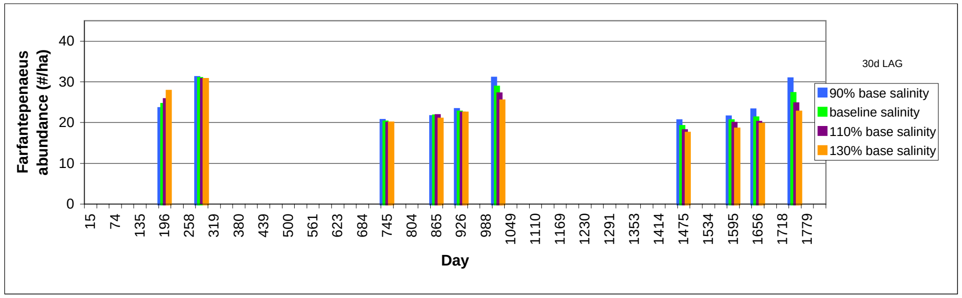
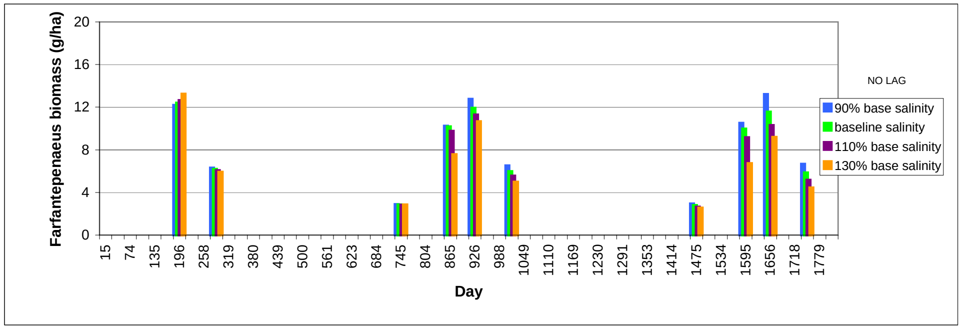


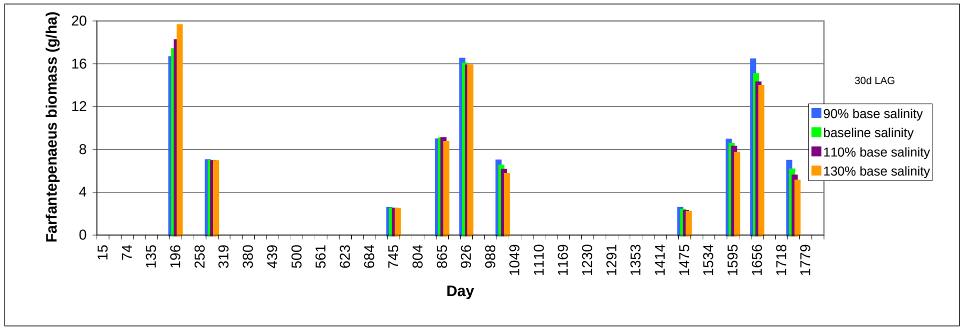
Figure 33. Trout Cove Scenario – *Farfantepenaeus duorarum* abundance and biomass-trawl/seine

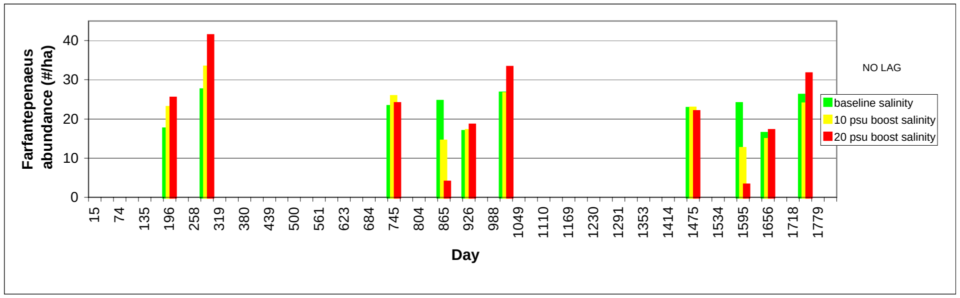
TROUT COVE-TRAWL/SEINE

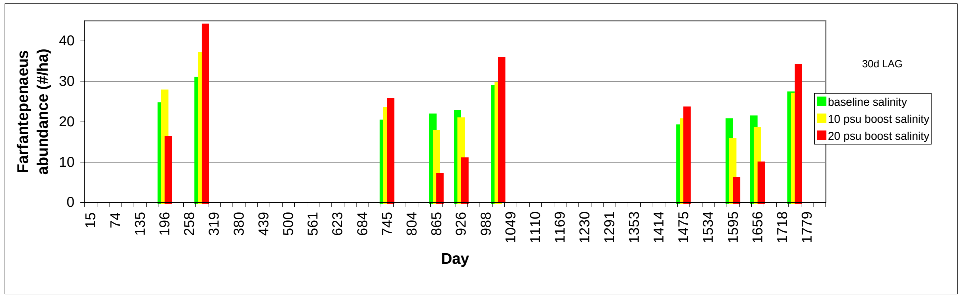


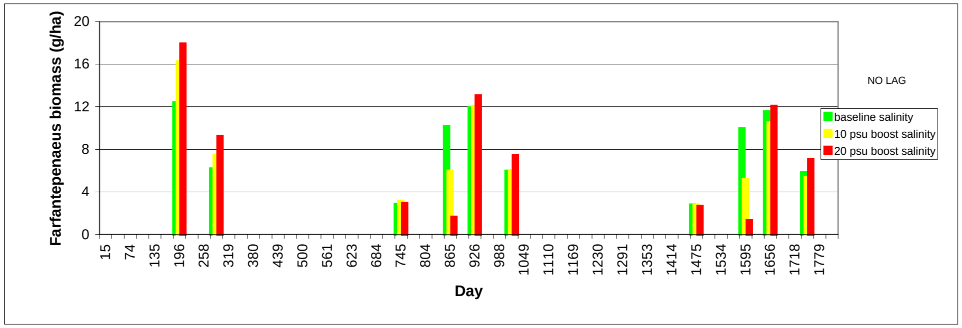












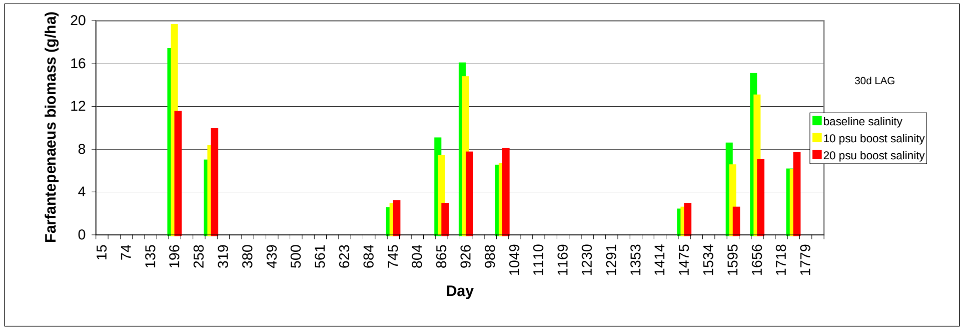
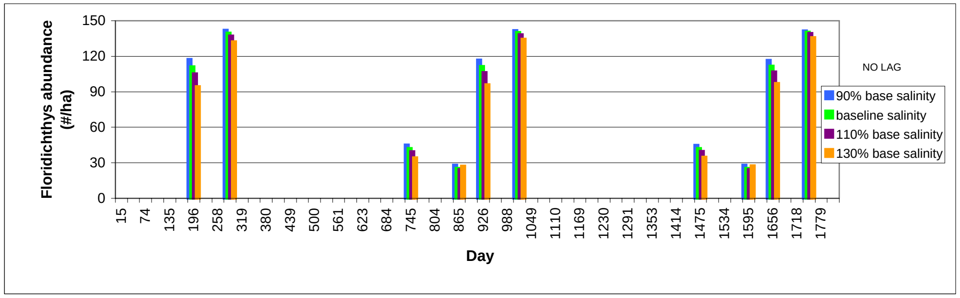
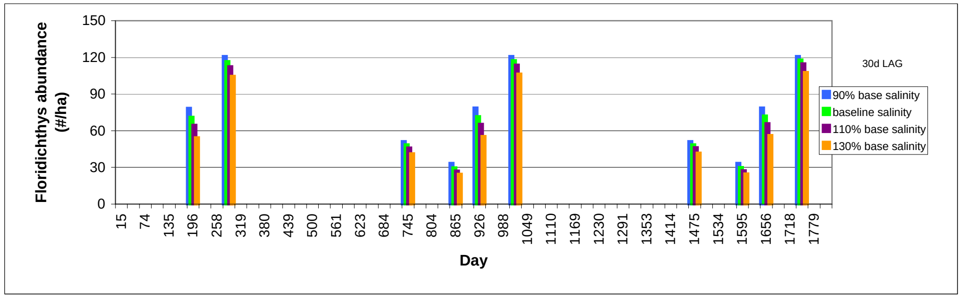
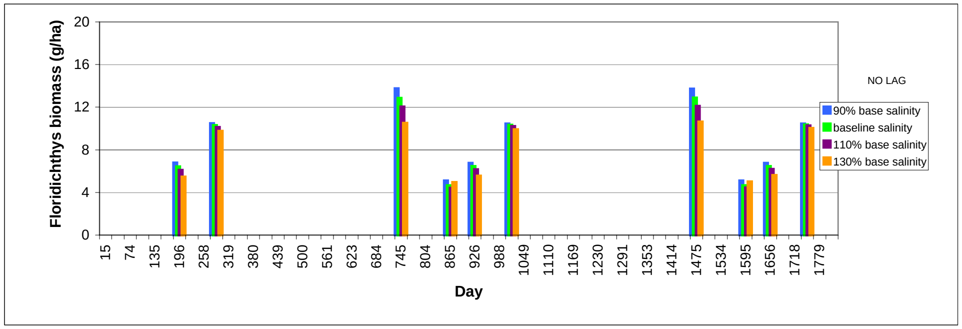


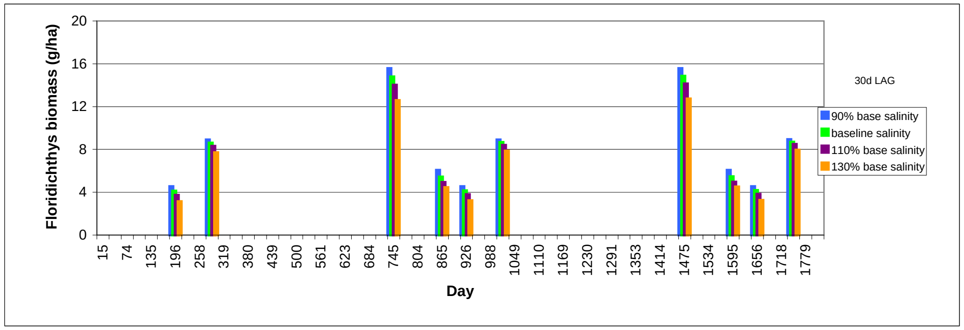
Figure 34. Trout Cove Scenario – *Floridichthys carpio* abundance and biomass-trawl/seine

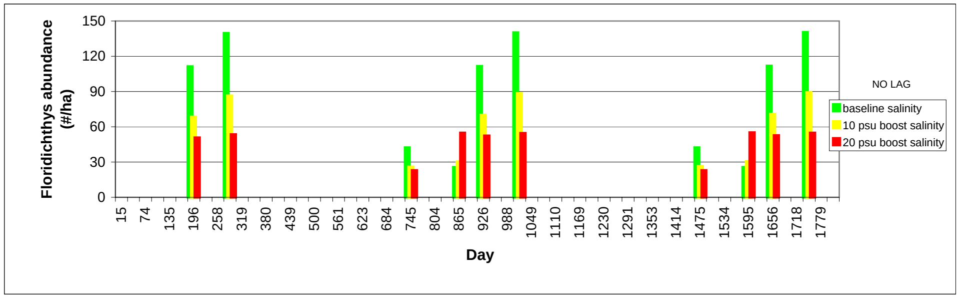
TROUT COVE- TRAWL/SEINE

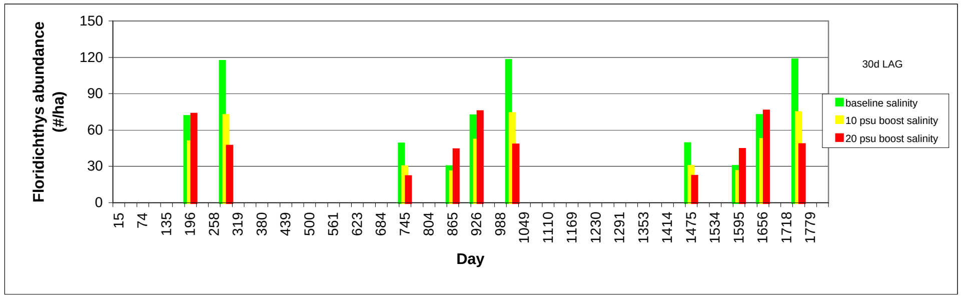


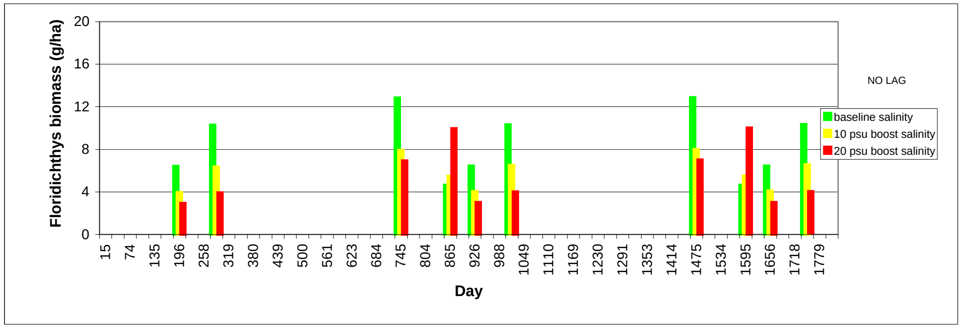












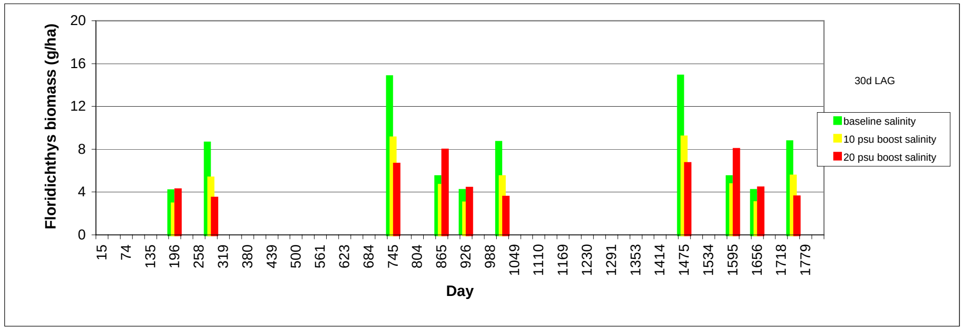
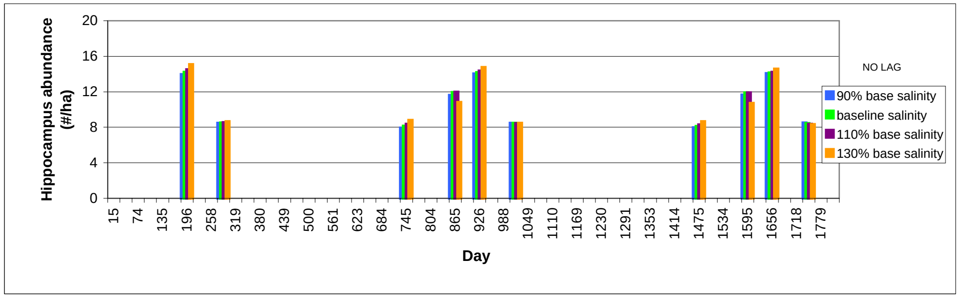
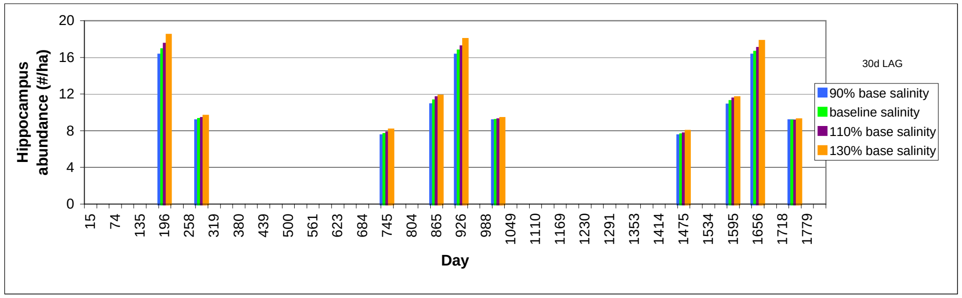
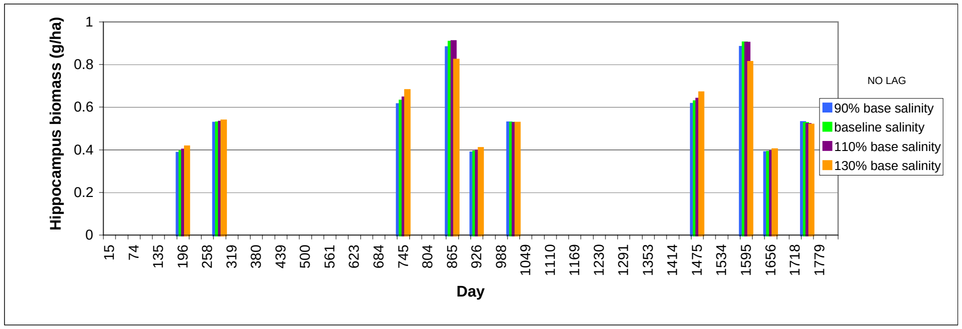


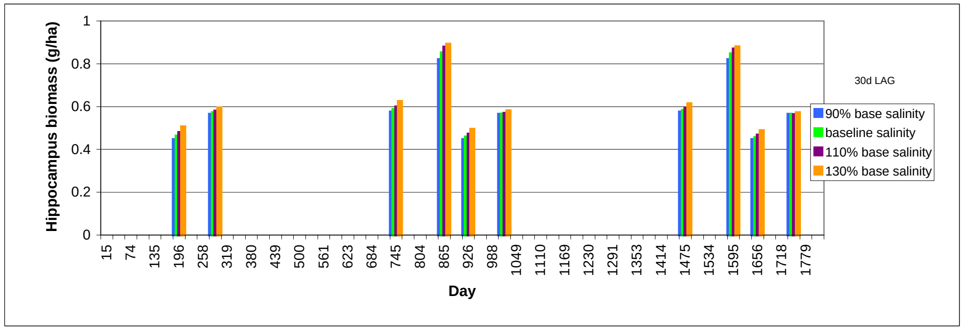
Figure 35. Trout Cove Scenario – *Hippocampus zosterae* abundance and biomass-trawl/seine

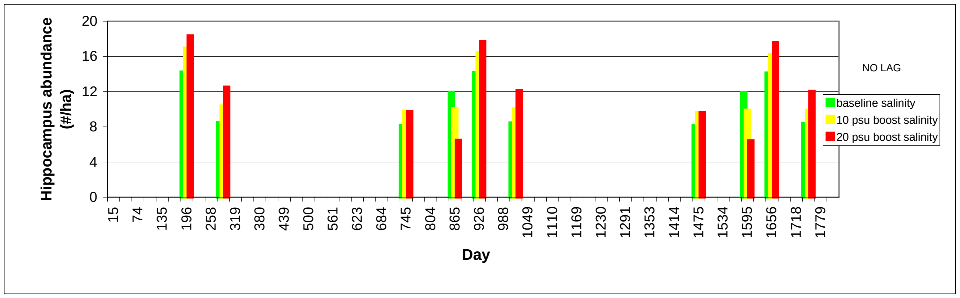
TROUT COVE- TRAWL/SEINE

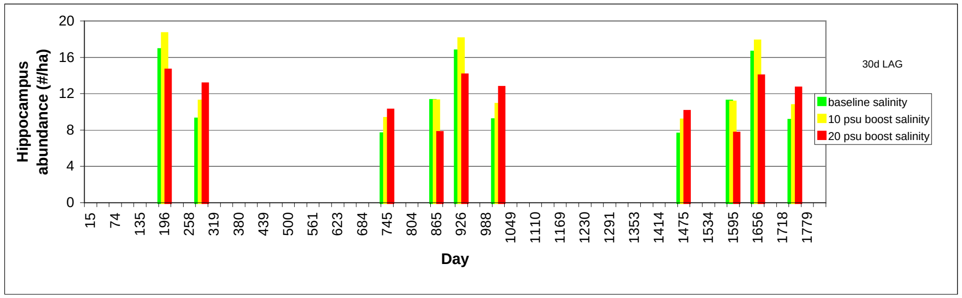


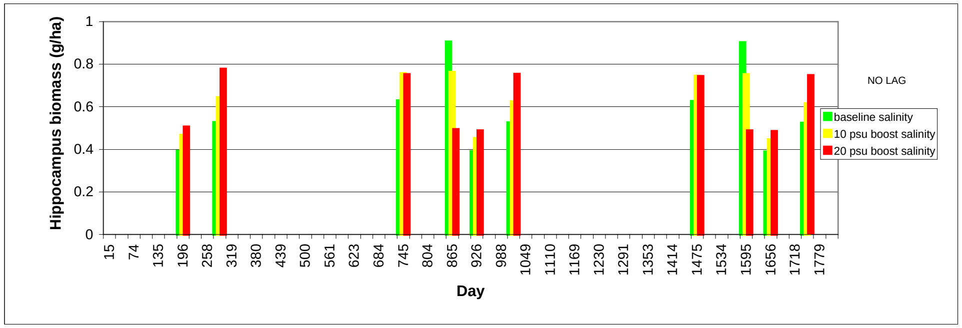












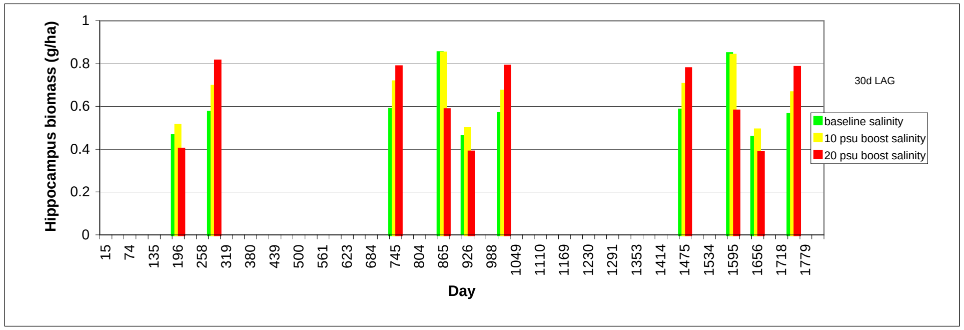
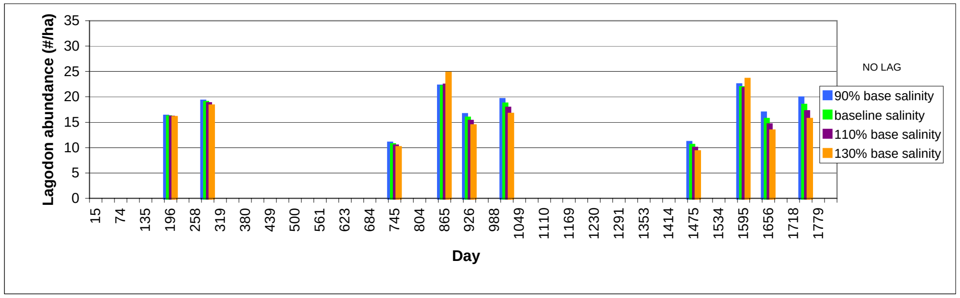
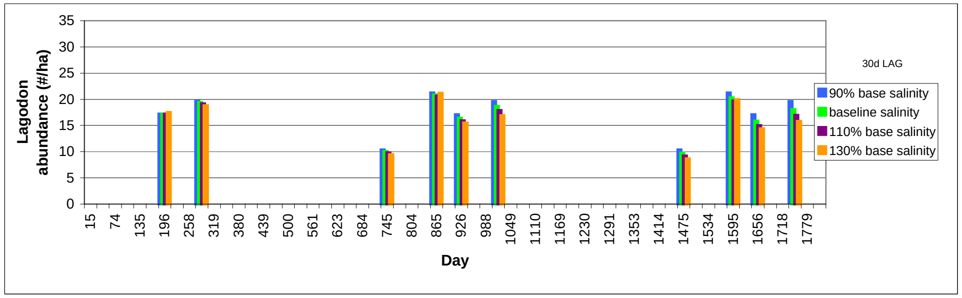
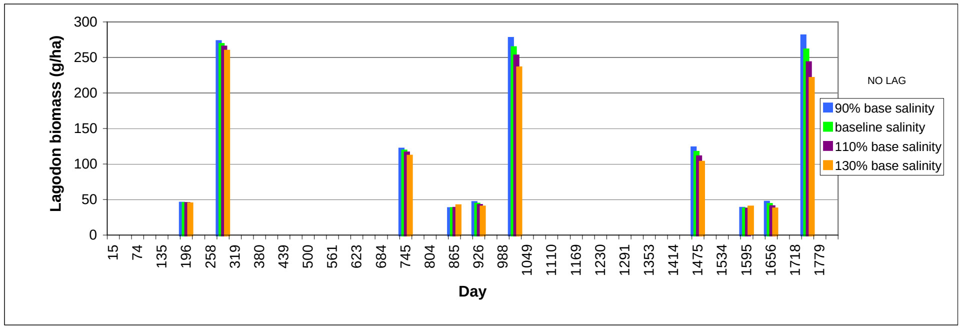


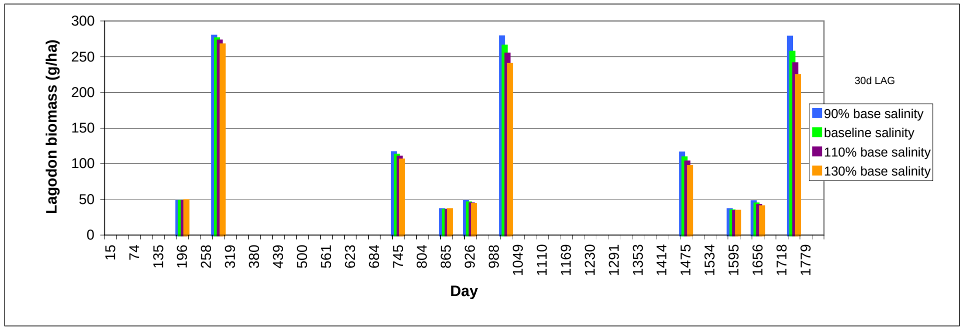
Figure 36. Trout Cove Scenario – *Lagodon rhomboides* abundance and biomass-trawl/seine

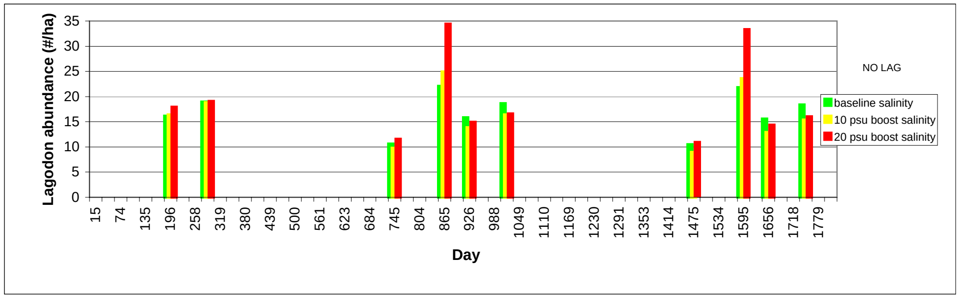
TROUT COVE-TRAWL/SEINE

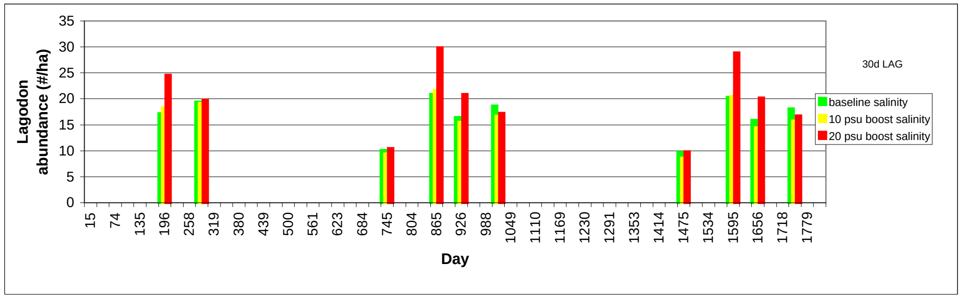


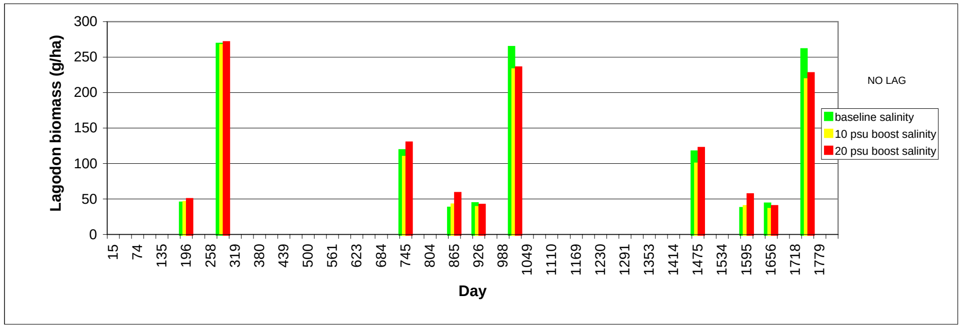












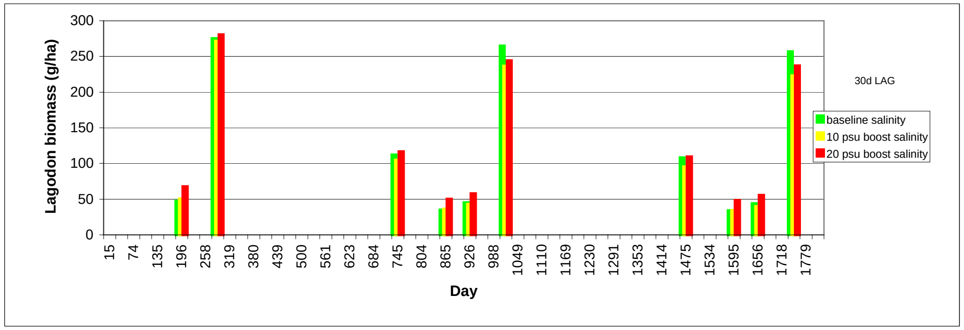
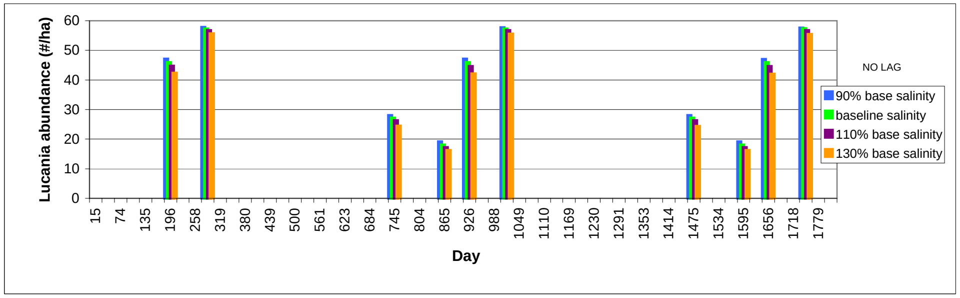
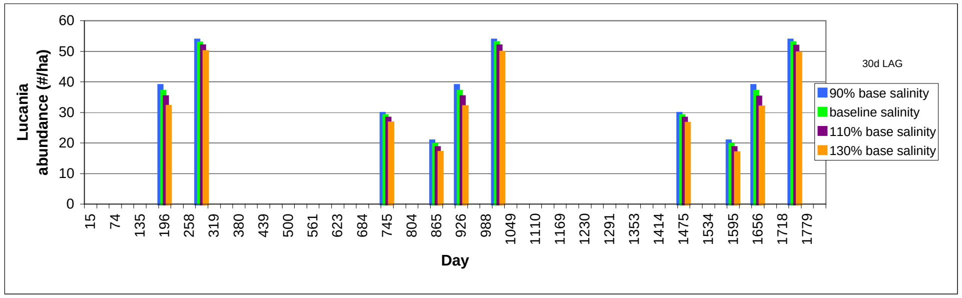
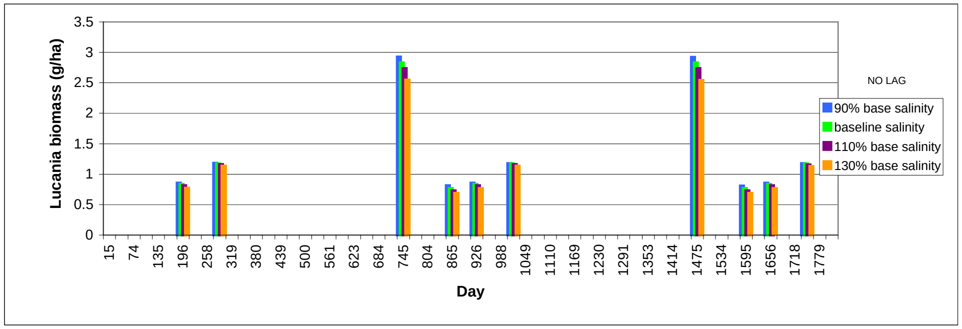


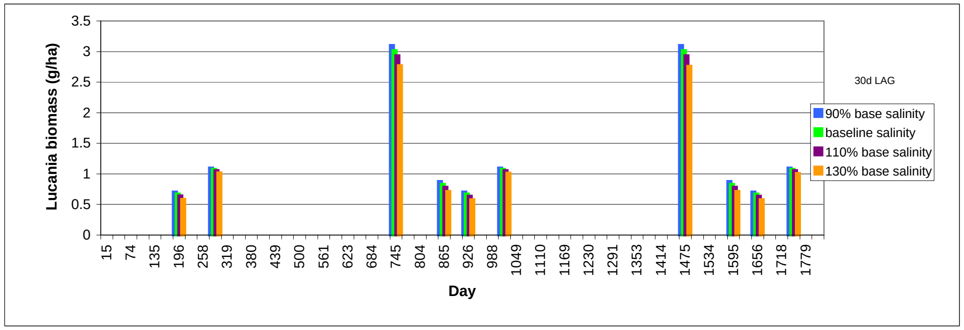
Figure 37. Trout Cove Scenario – *Lucania parva* abundance and biomass- trawl/seine

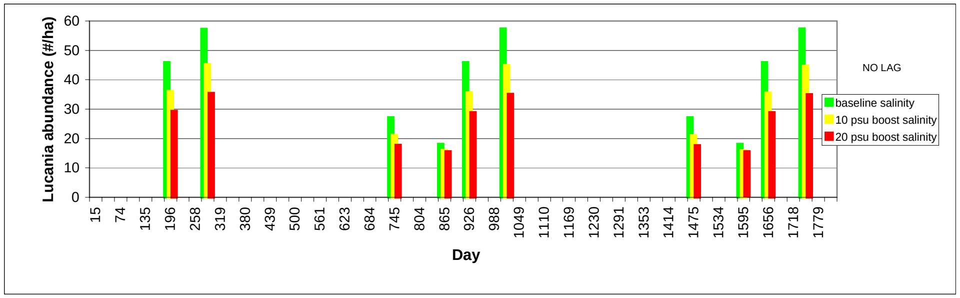
TROUT COVE- TRAWL/SEINE

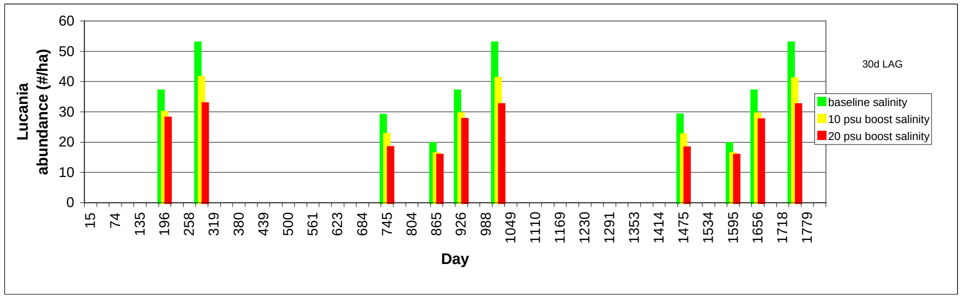


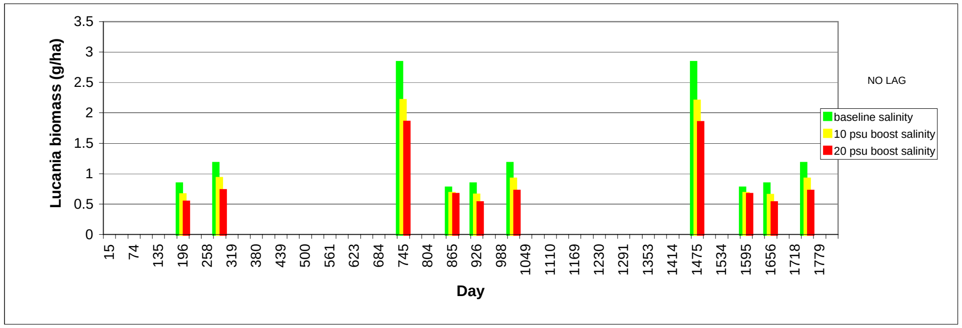












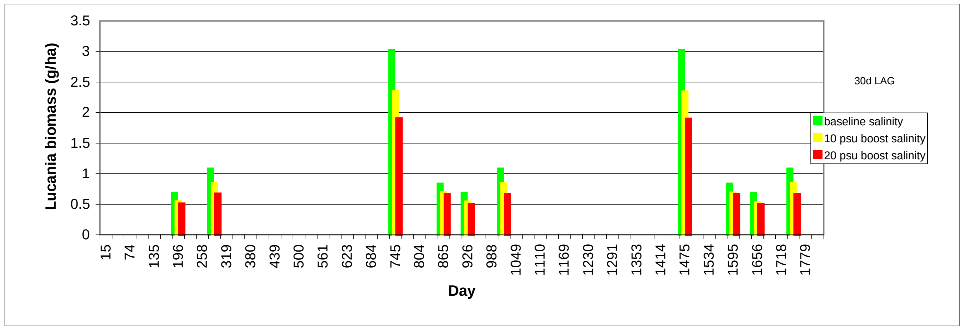
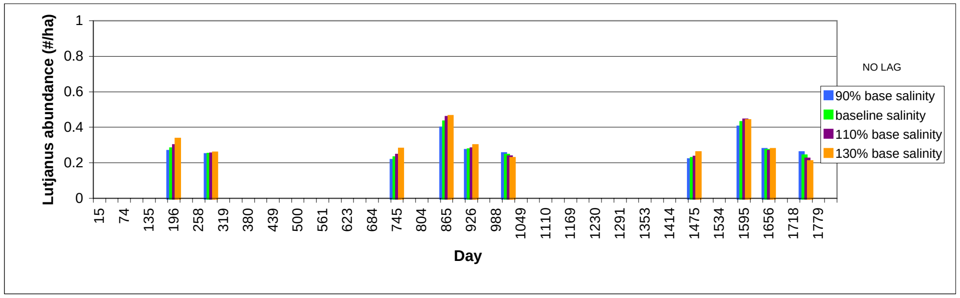
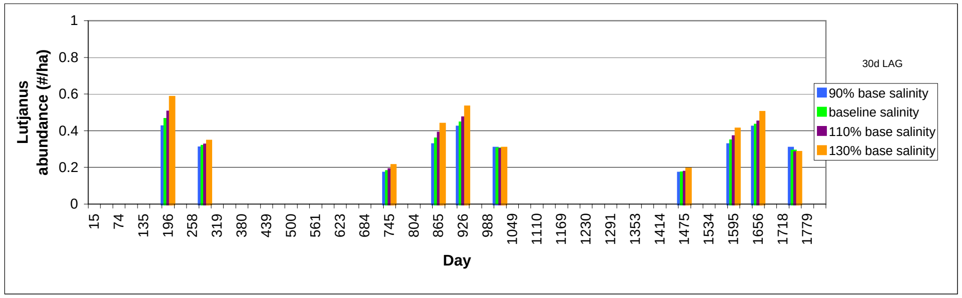
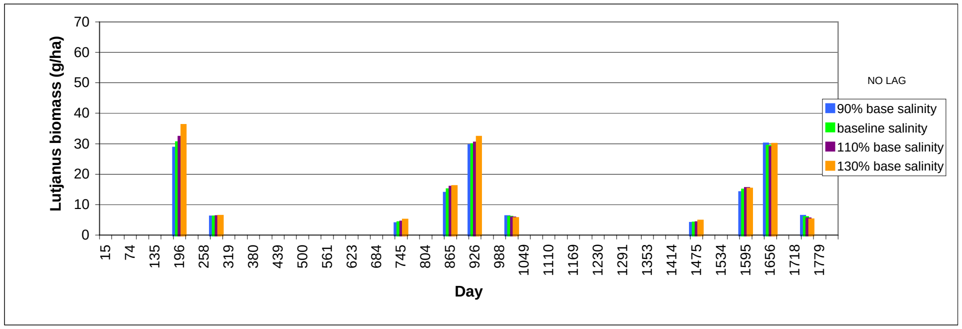


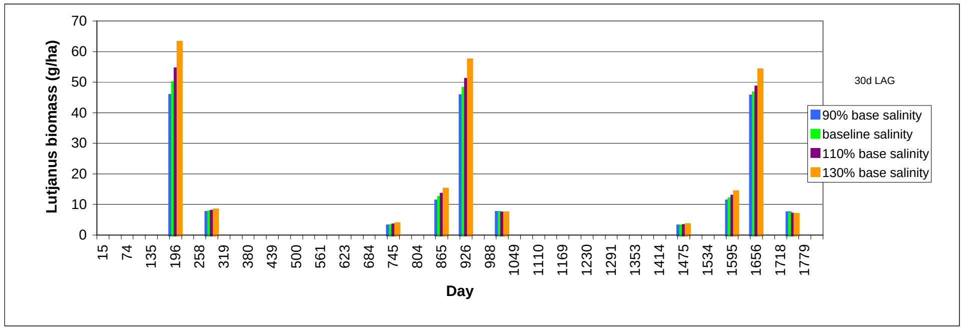
Figure 38. Trout Cove Scenario – *Lutjanus griseus* abundance and biomass- trawl/seine

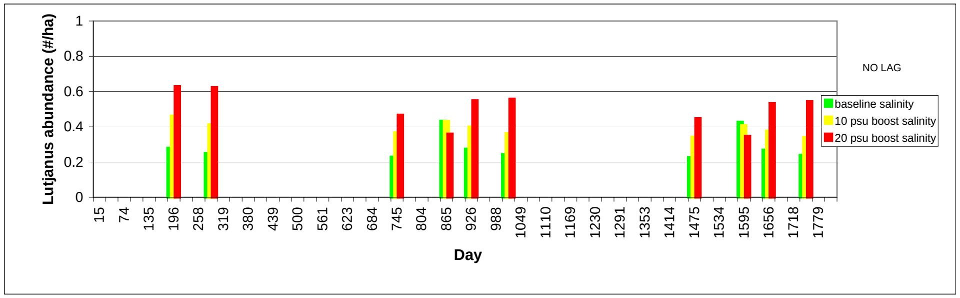
TROUT COVE- TRAWL/SEINE

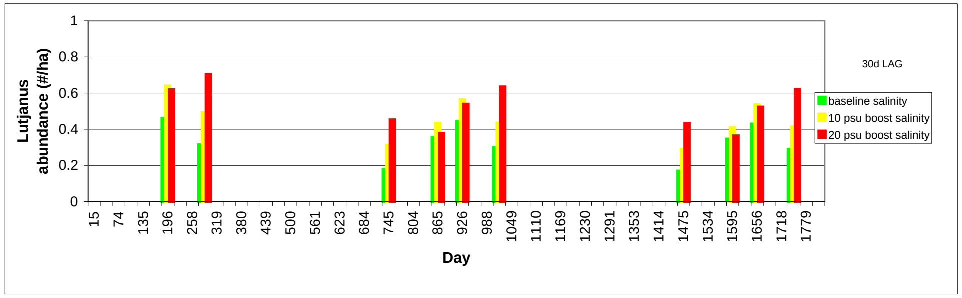


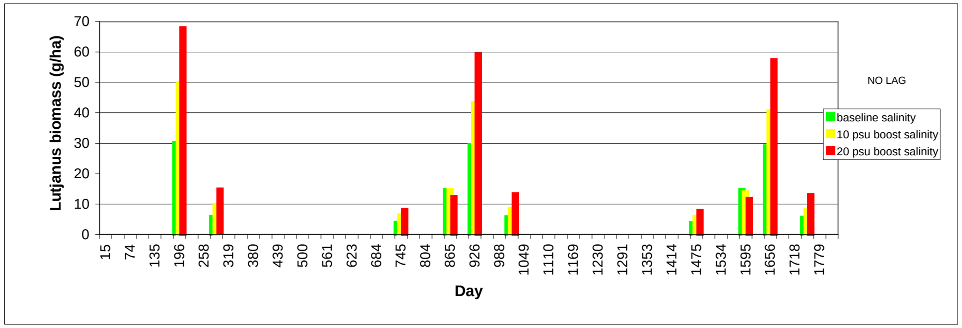












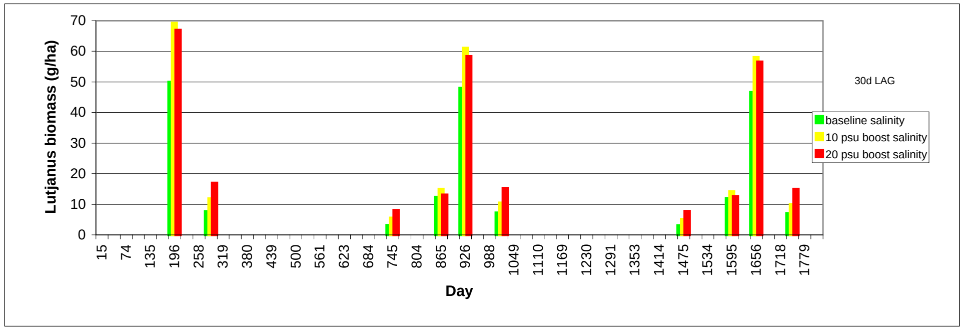
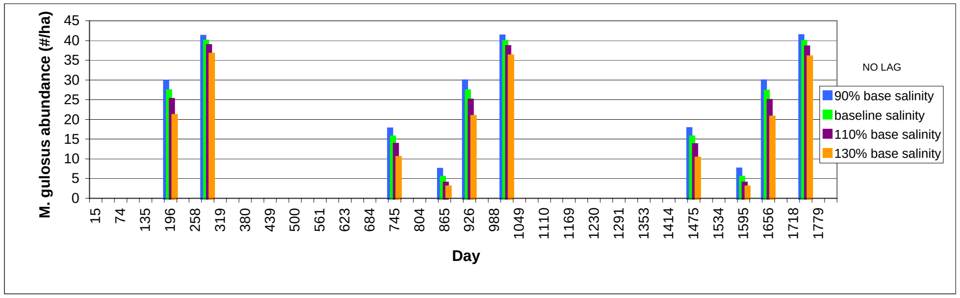
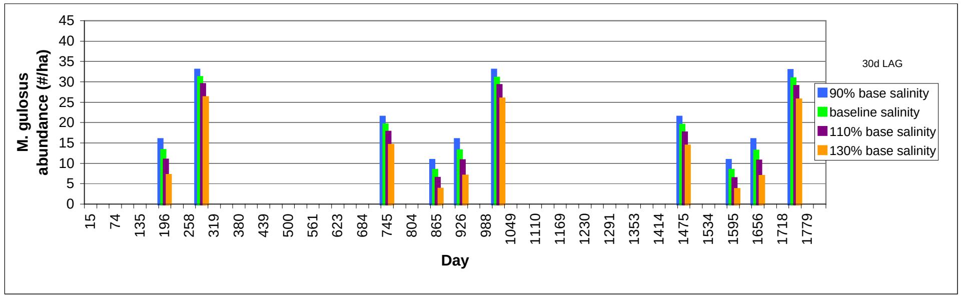
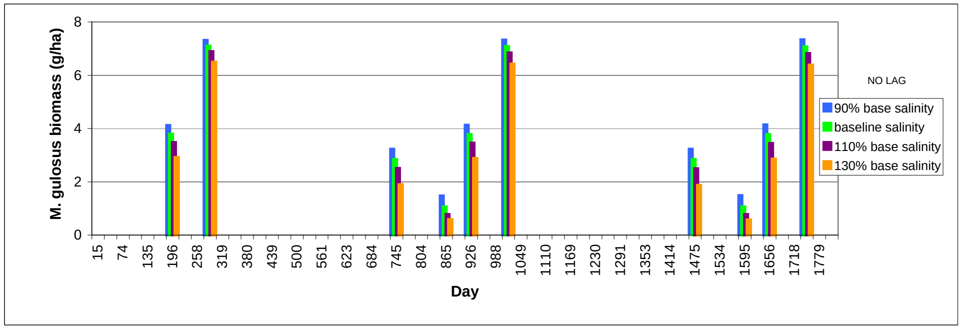


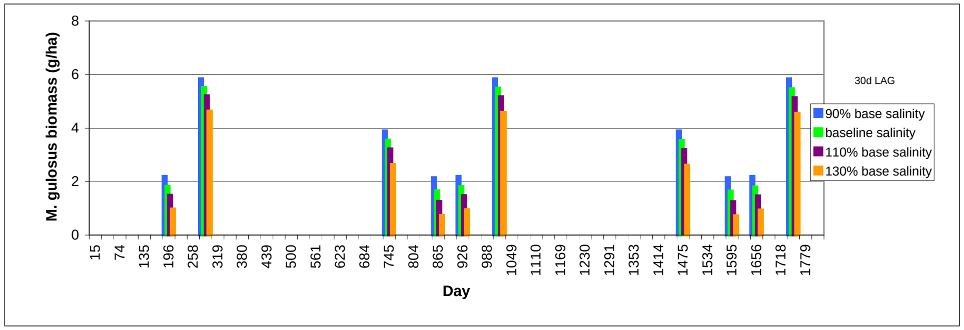
Figure 39. Trout Cove Scenario – *Microgobius gulosus* abundance and biomass-trawl/seine

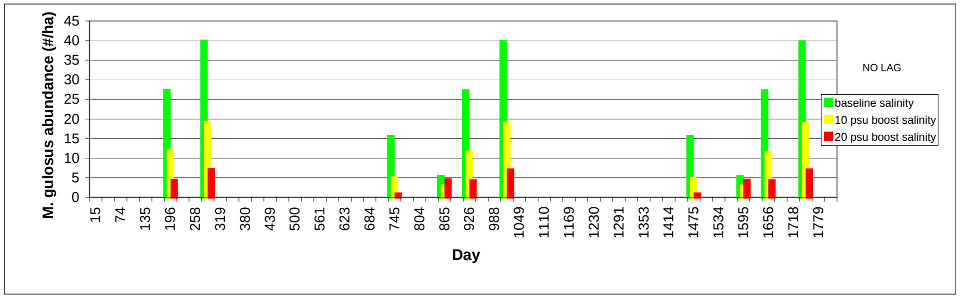
TROUT COVE- TRAWL/SEINE

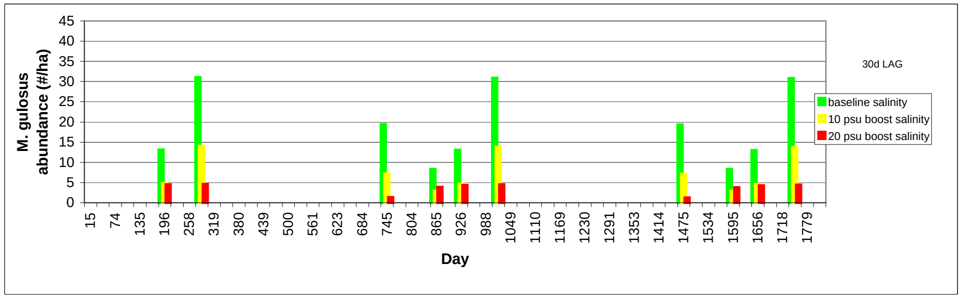


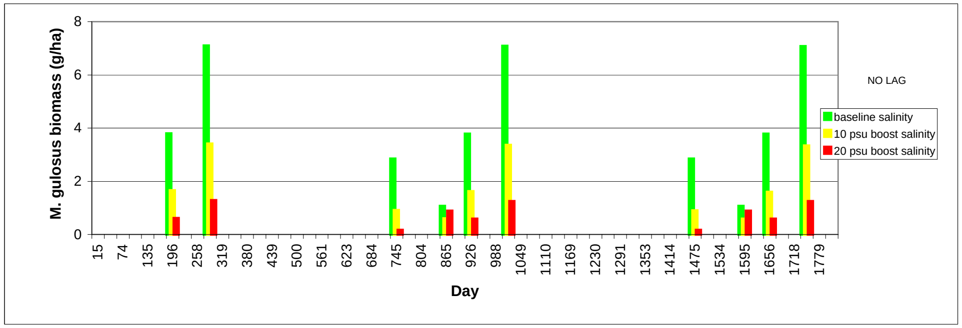












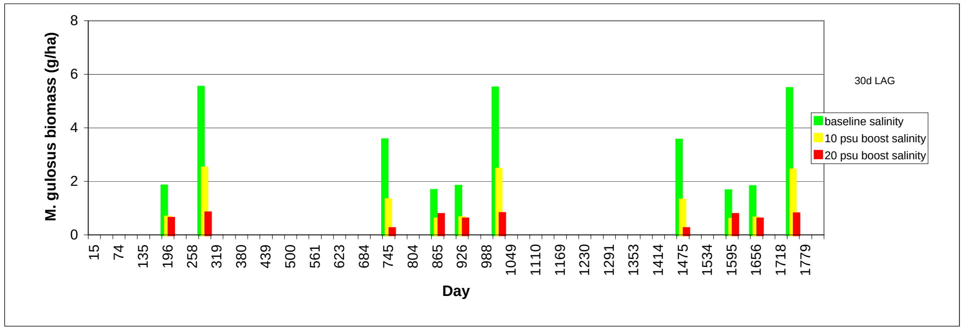
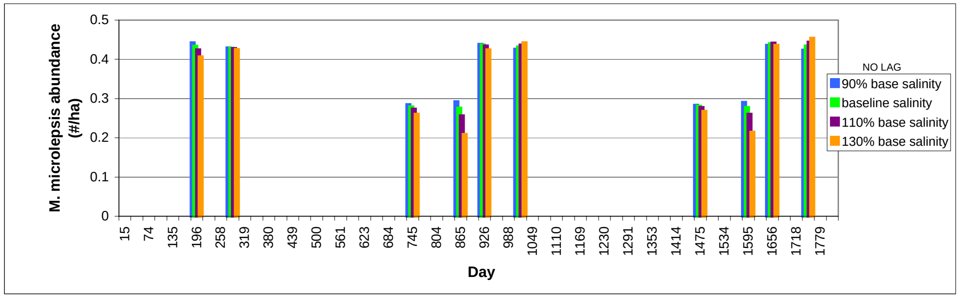
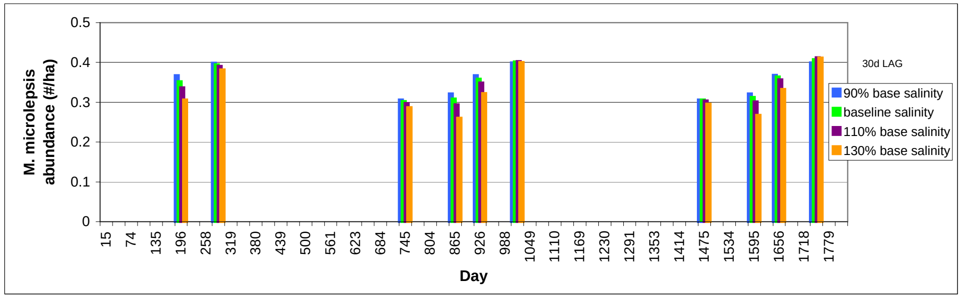
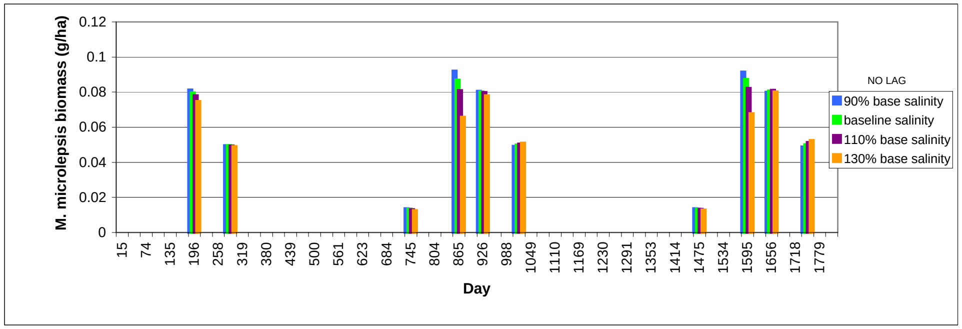


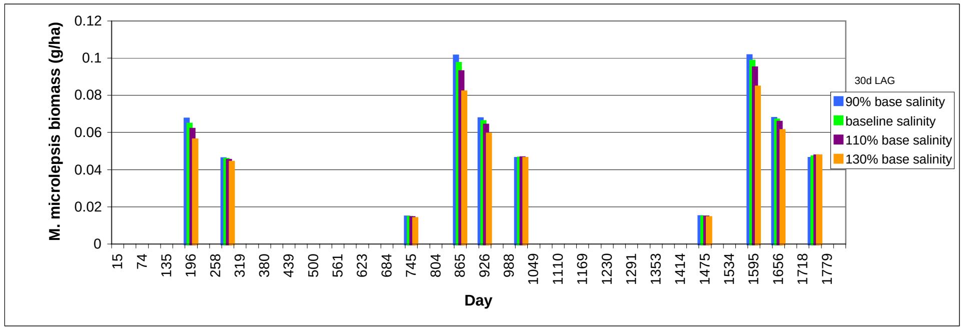
Figure 40. Trout Cove Scenario – *Microgobius microlepis* abundance and biomass-trawl/seine

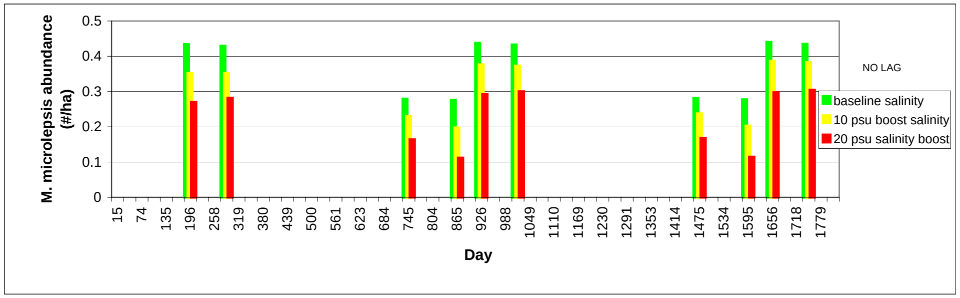
TROUT COVE-TRAWL/SEINE

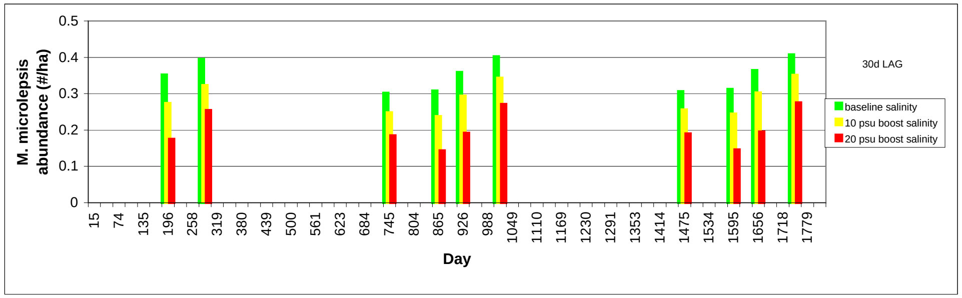


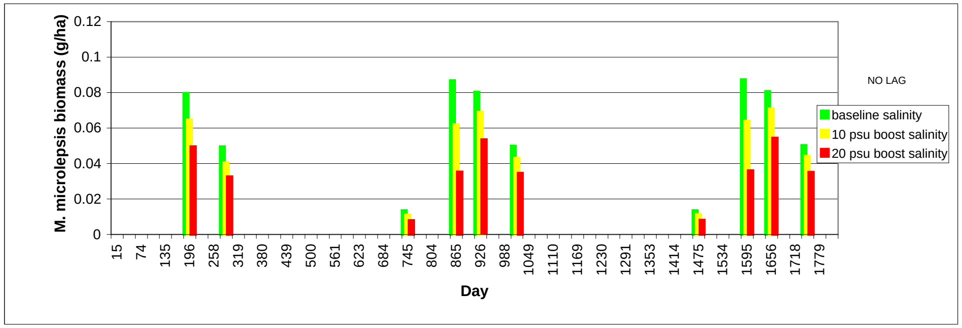












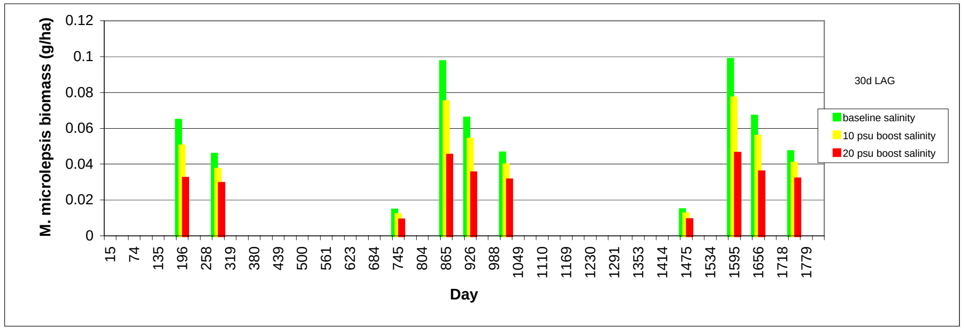
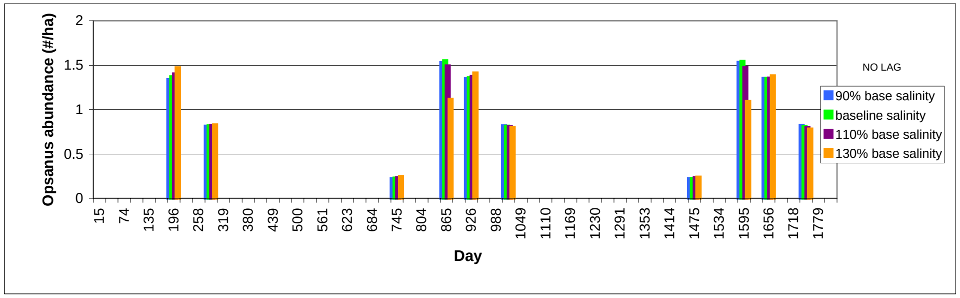
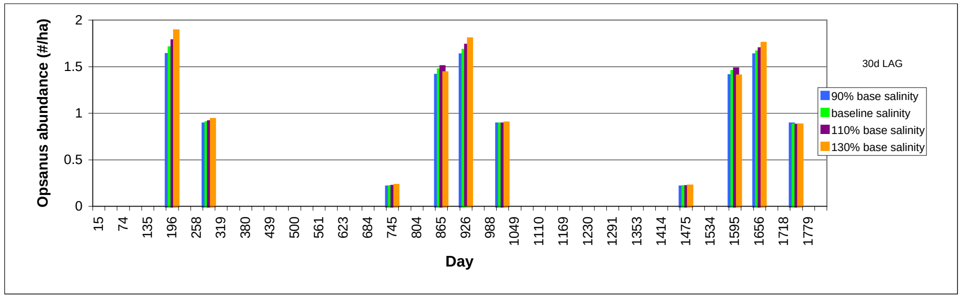
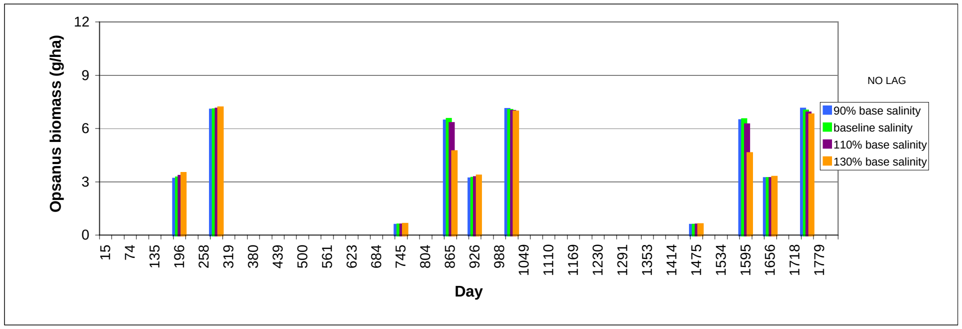


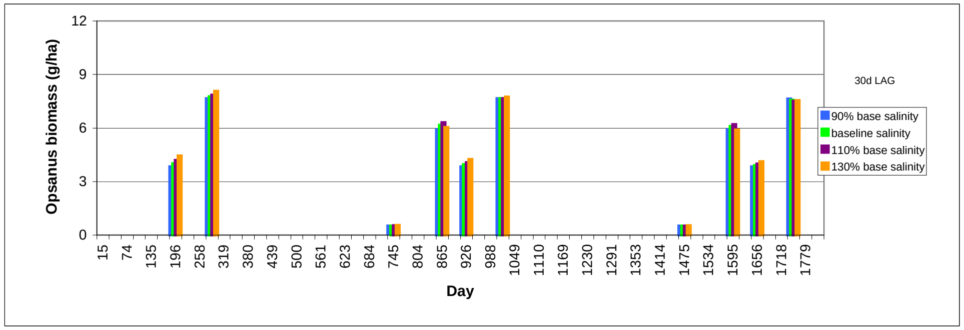
Figure 41. Trout Cove Scenario – *Opsanus beta* abundance and biomass- trawl/seine

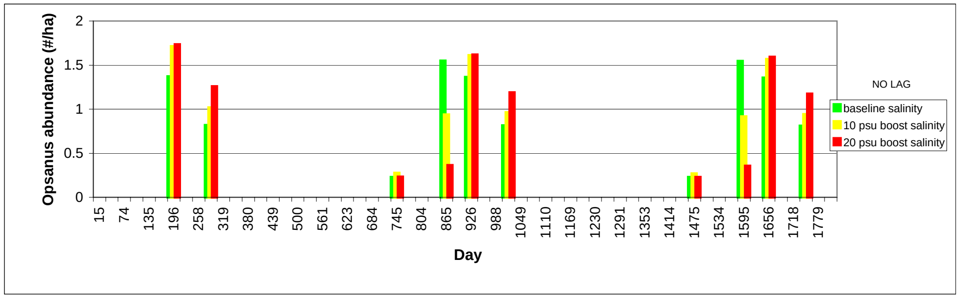
TROUT COVE-TRAWL/SEINE

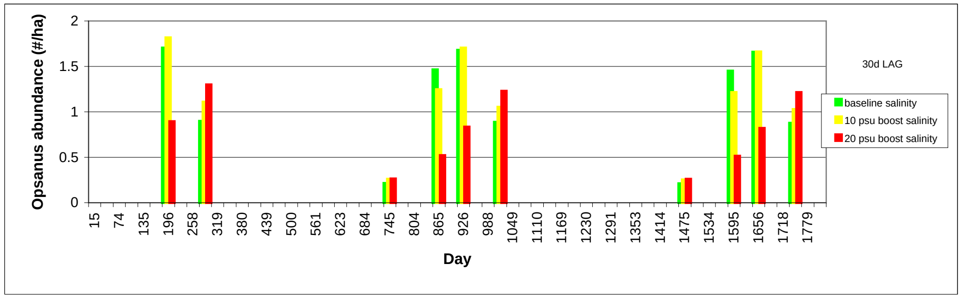


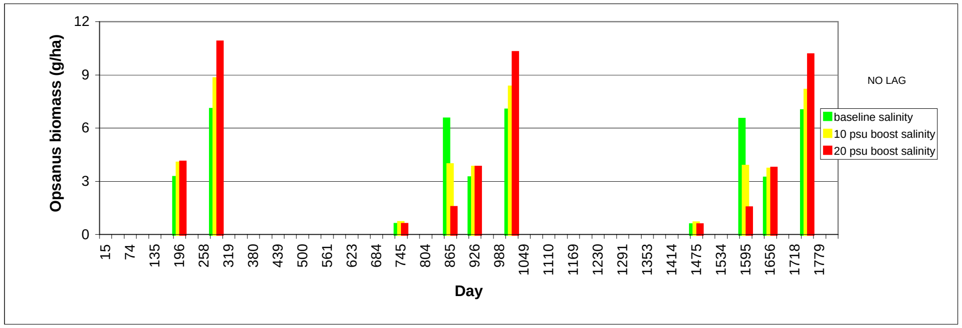












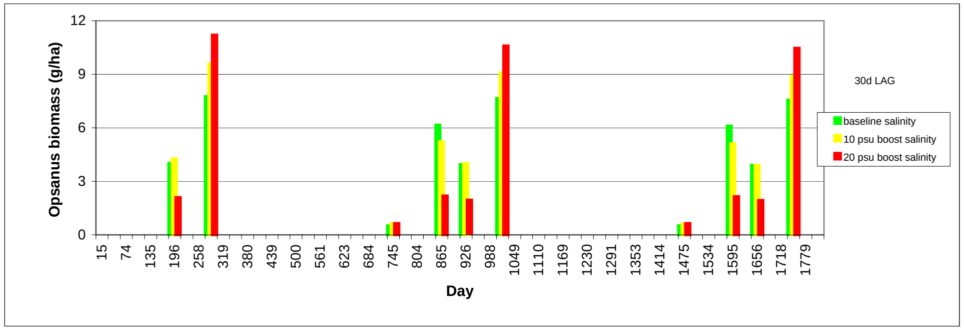
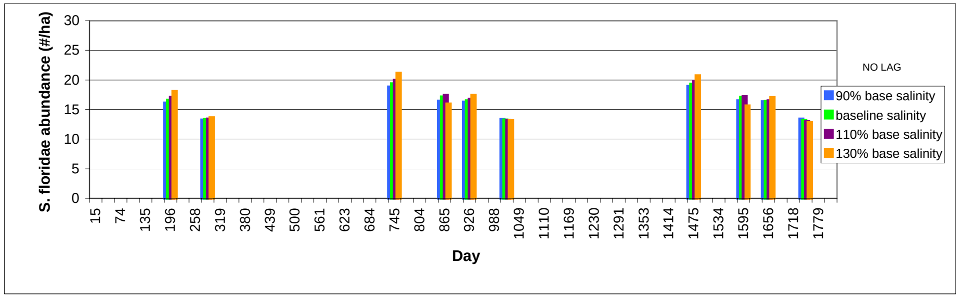
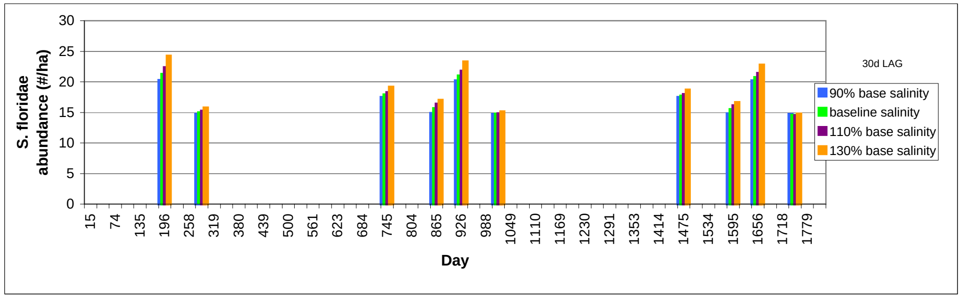
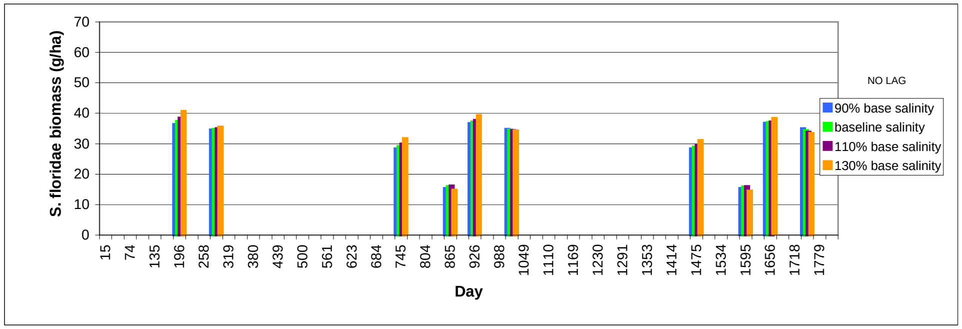


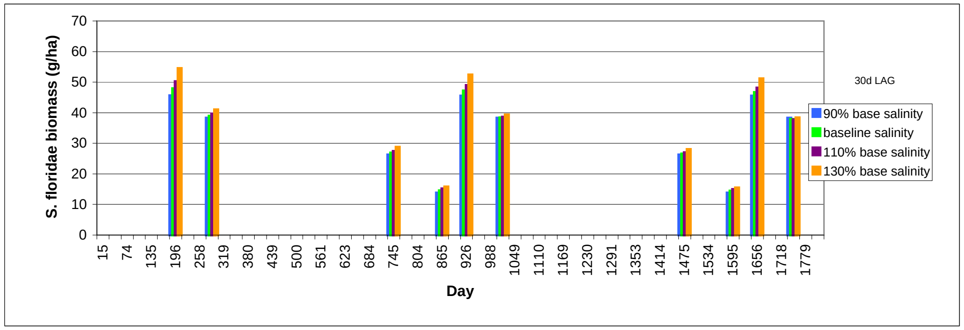
Figure 42. Trout Cove Scenario – *Syngnathus floridae* abundance and biomass-trawl/seine

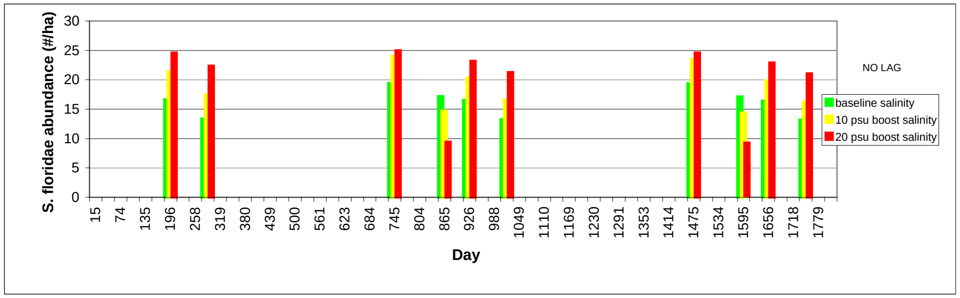
TROUT COVE-TRAWL/SEINE

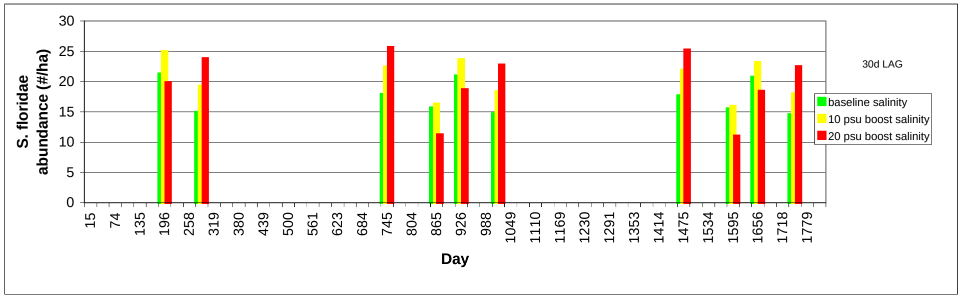


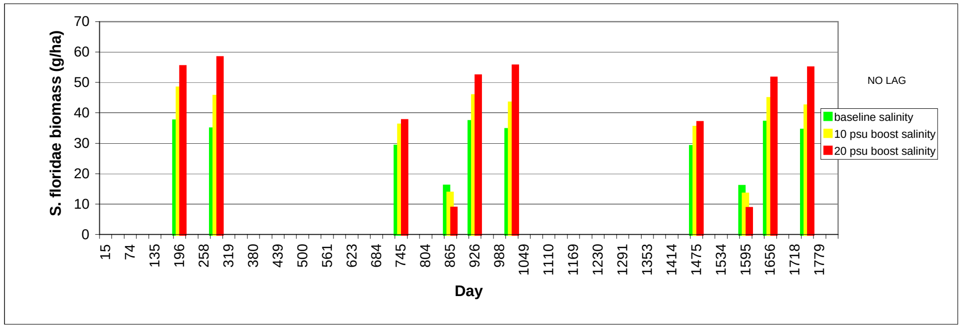












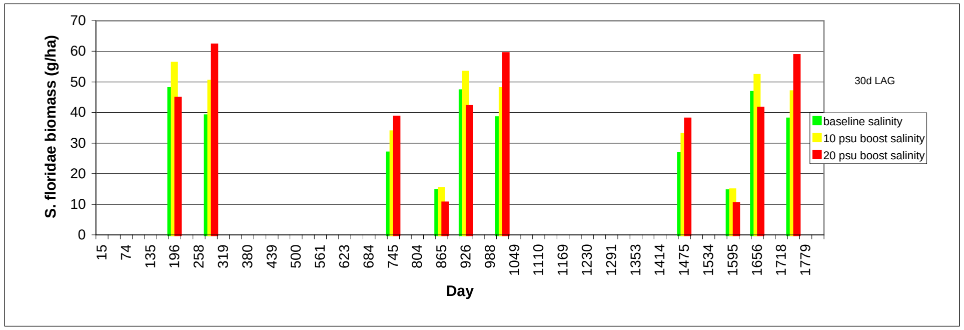
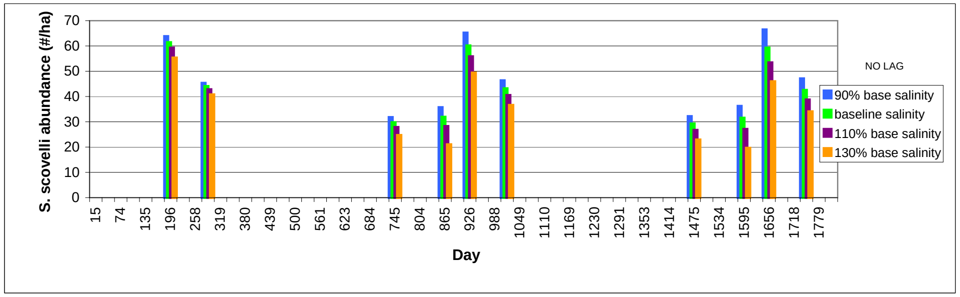
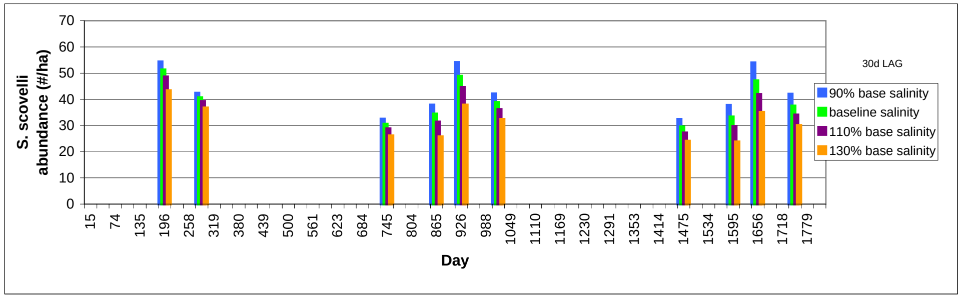
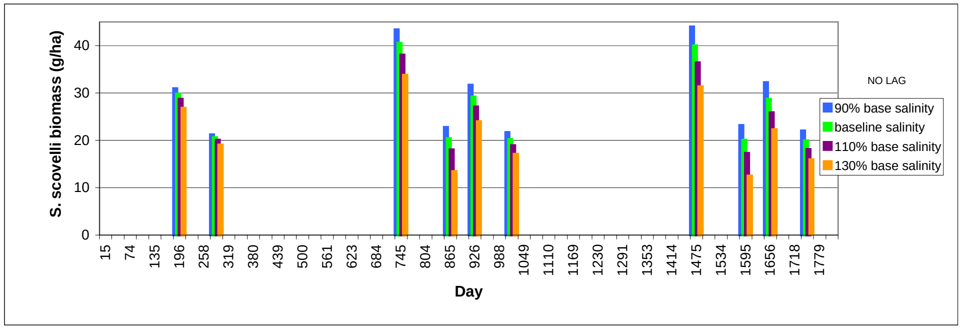


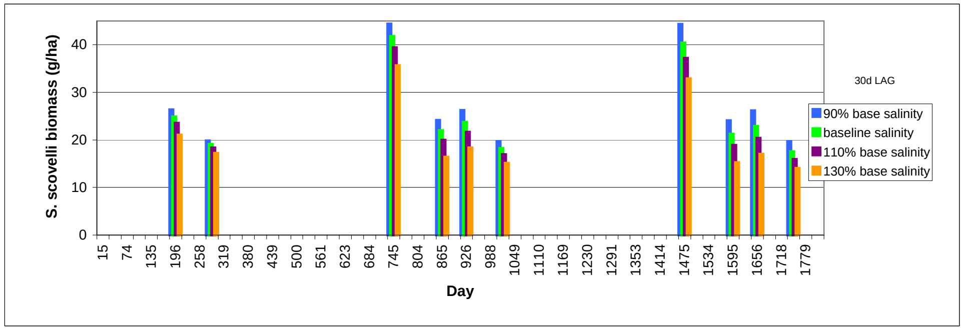
Figure 43. Trout Cove Scenario – *Syngnathus scovelli* abundance and biomass-trawl/seine

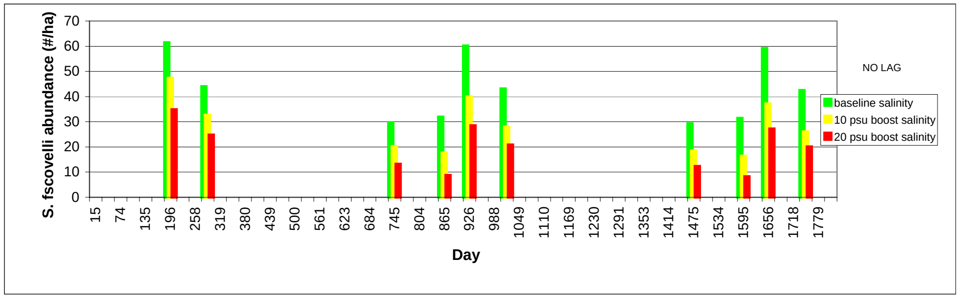
TROUT COVE-TRAWL/SEINE

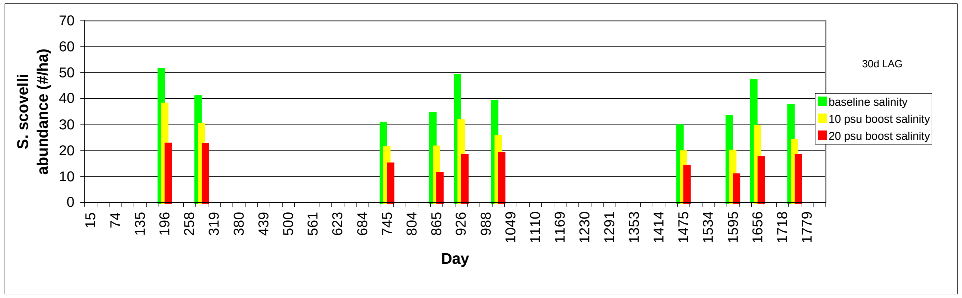


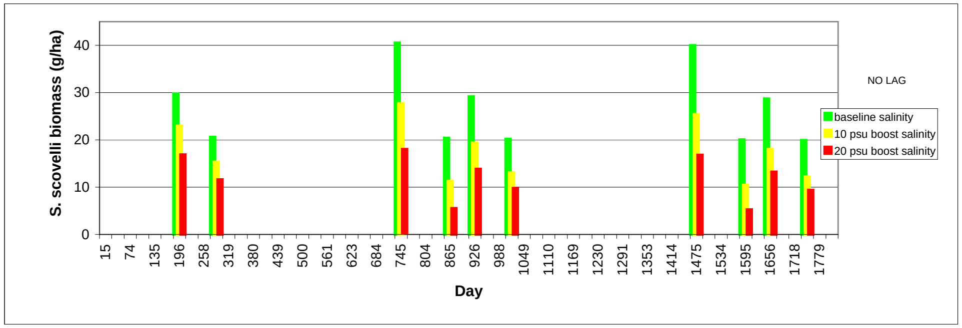












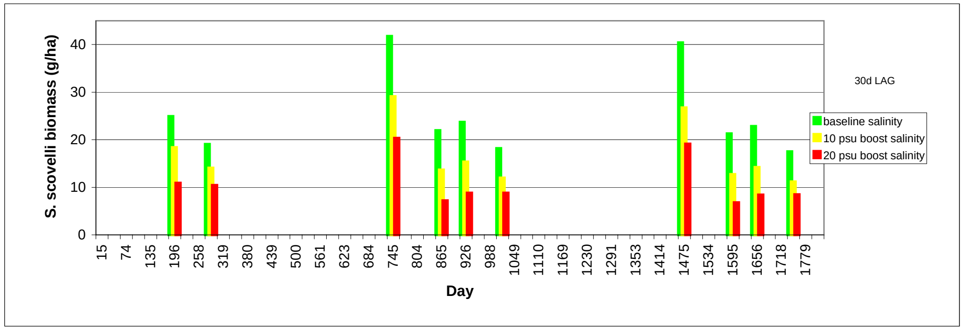
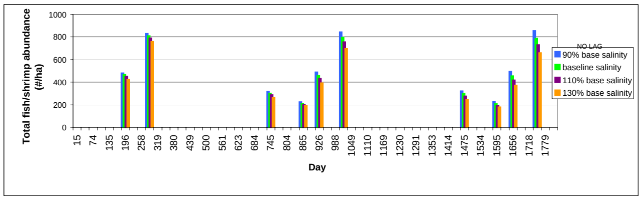
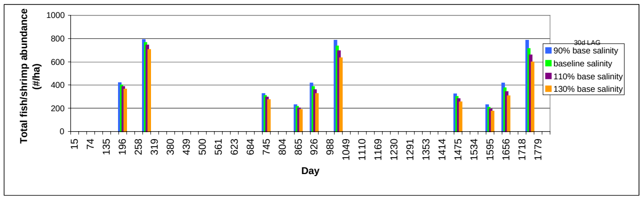
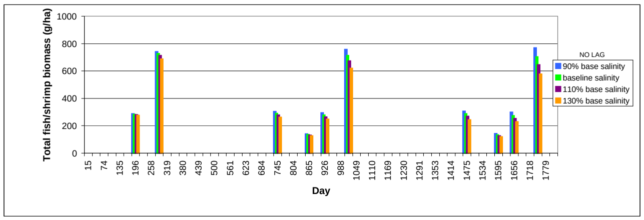


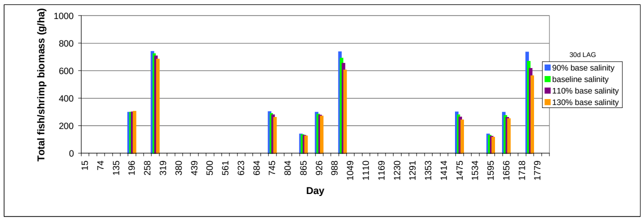
Figure 44. Trout Cove Scenario – Total fish/shrimp abundance, Total fish/shrimp biomass, Forage fish/shrimp biomass, Predator fish biomass- trawl/seine

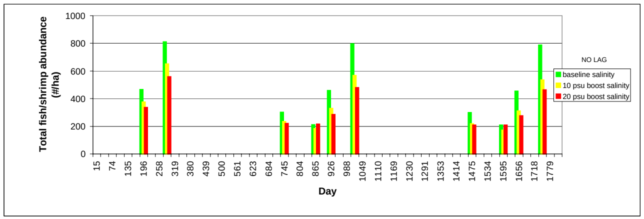
TROUT COVE- TRAWL/SEINE

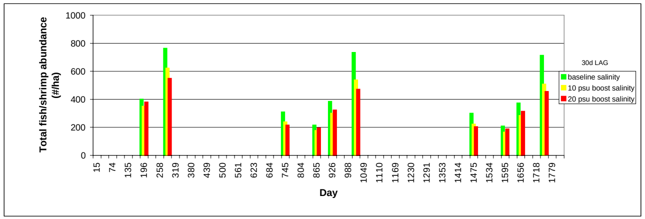


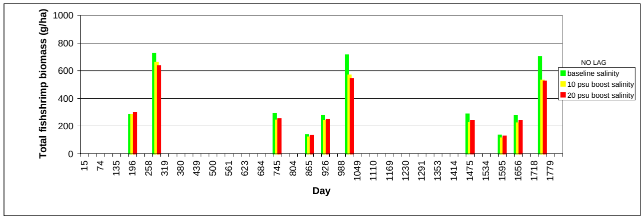


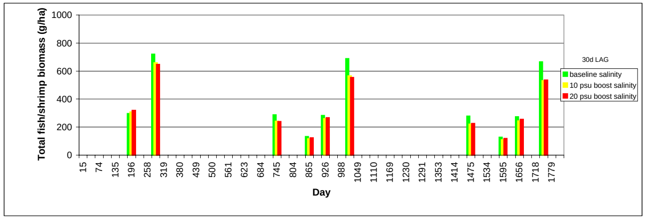


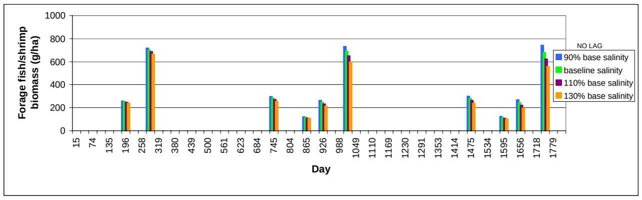


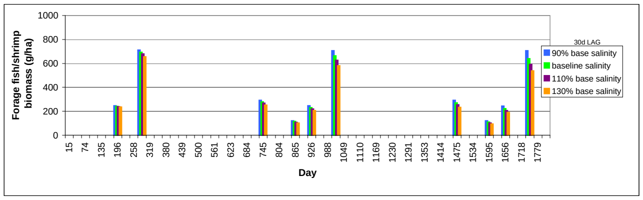


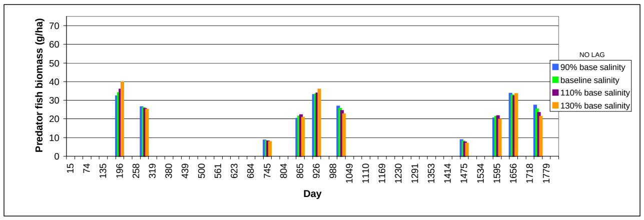


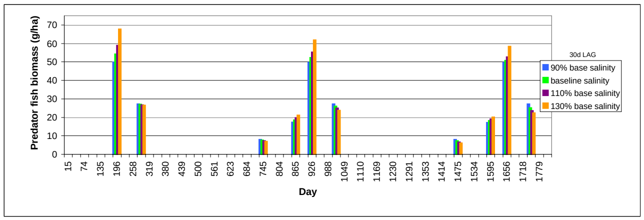


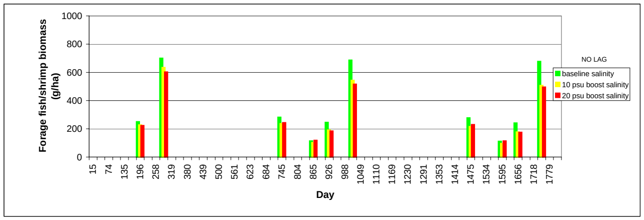


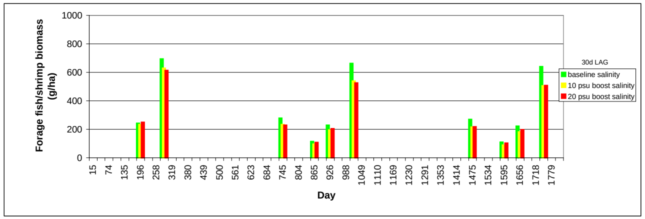


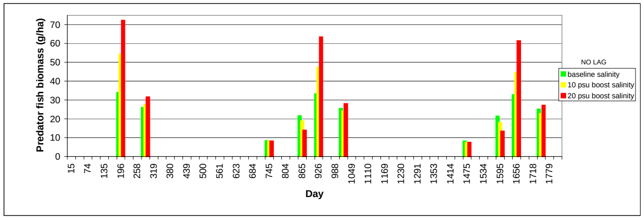












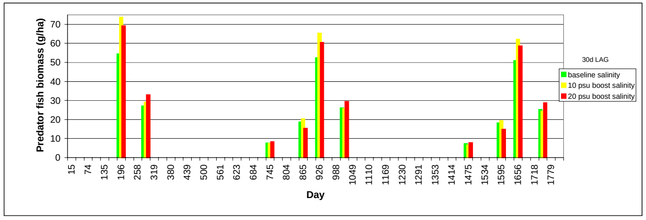
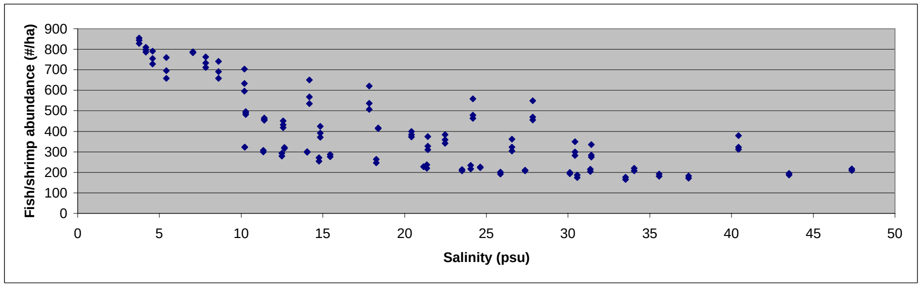
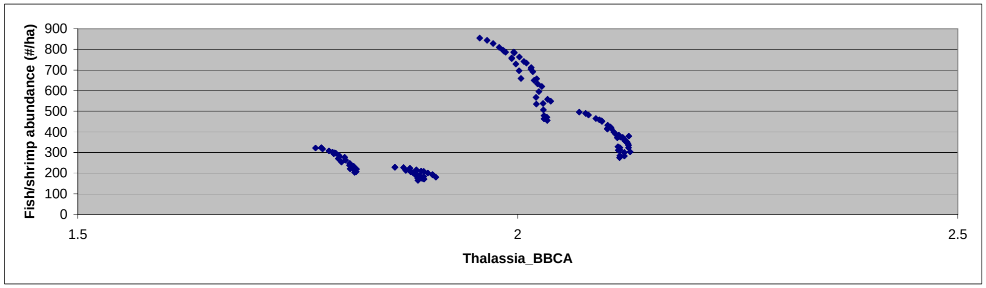
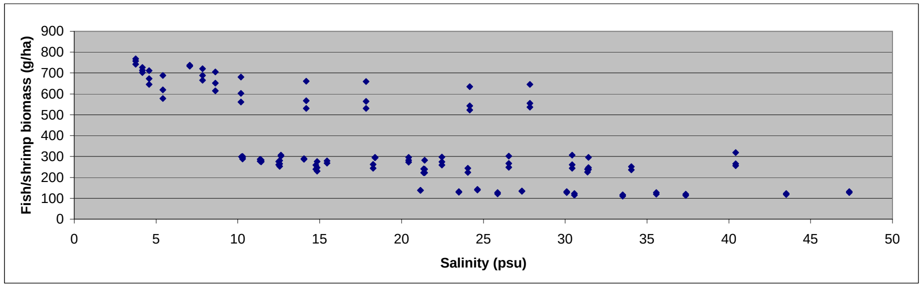


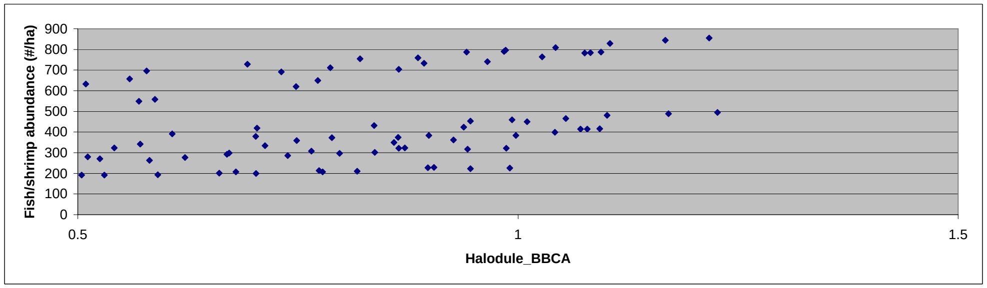
Figure 45. Trout Cove Scenario - Fish/shrimp abundance vs. Salinity, Fish/shrimp biomass vs. salinity, Predator fish biomass vs. Salinity, Fish/shrimp abundance vs. Thalassia BBCA, Fish/shrimp abundance vs. Halodule BBCA- trawl seine.

TROUT COVE- TRAWL/SEINE









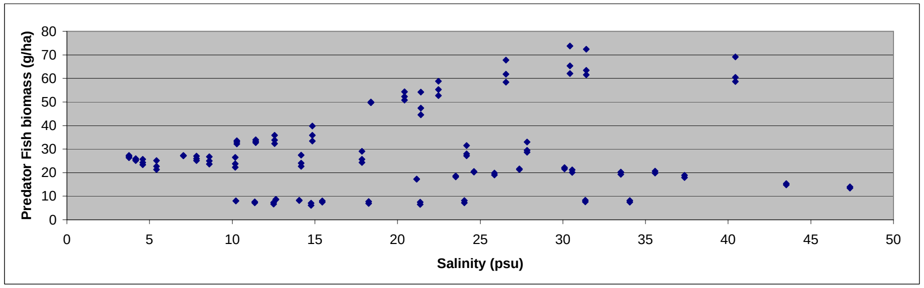
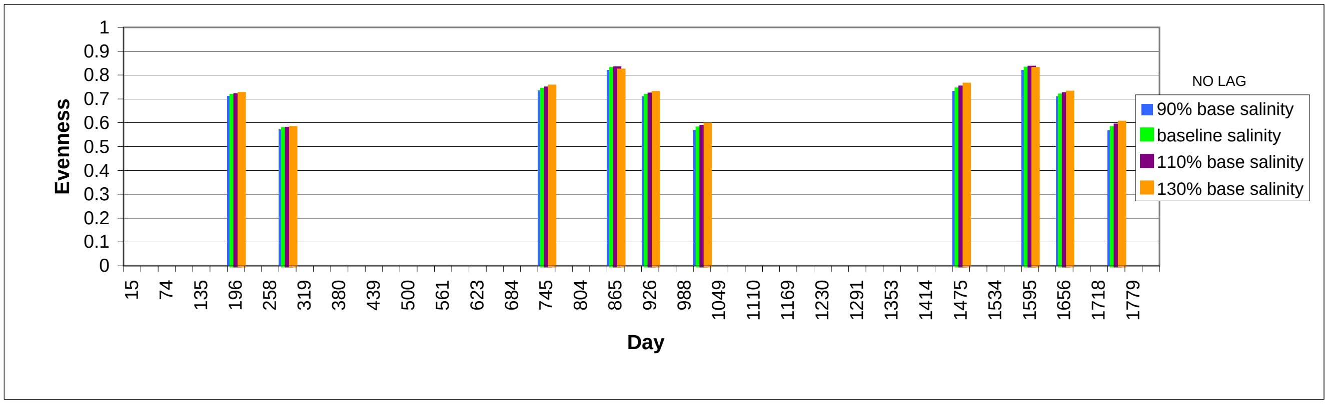
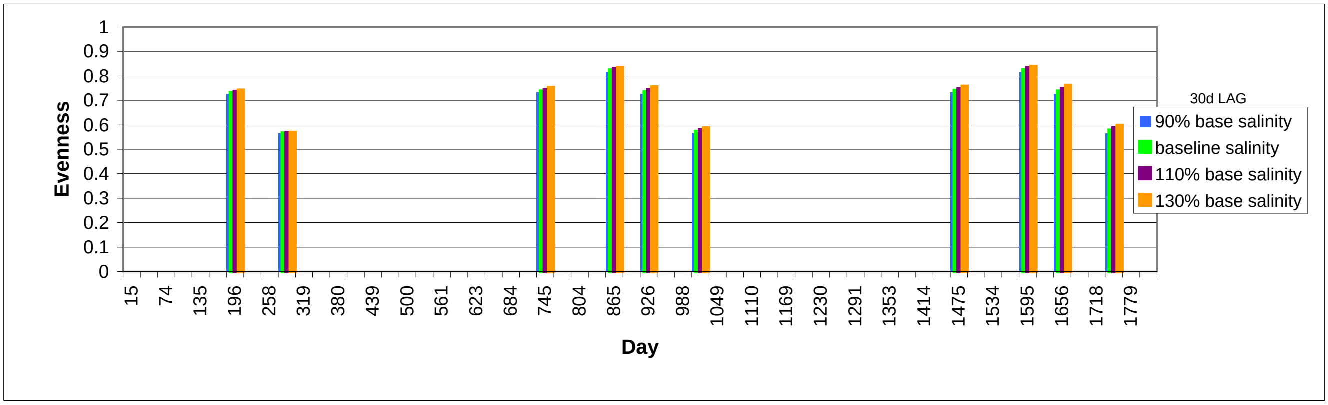
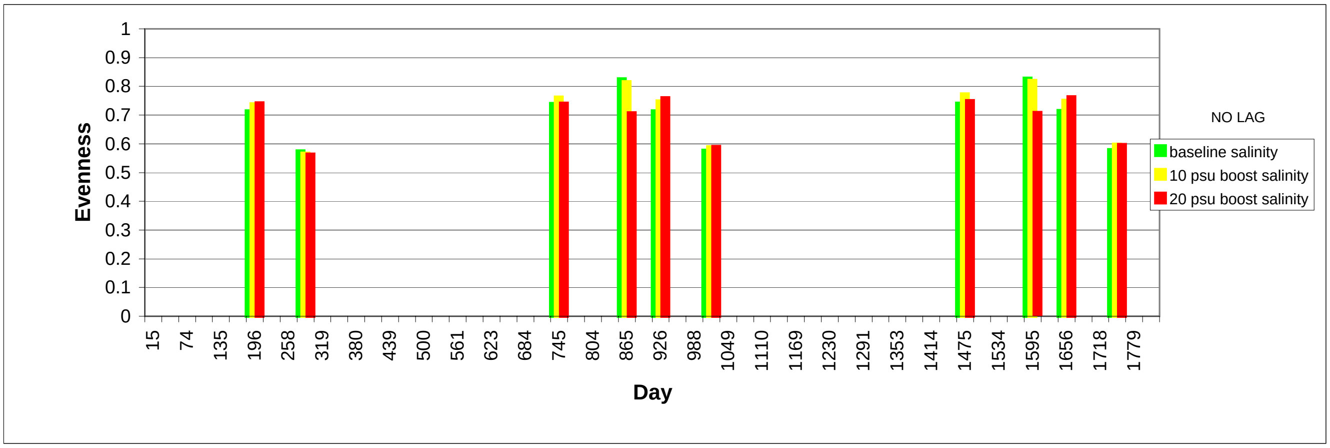


Figure 46. Trout Cove Scenario – Evenness trawl/seine

TROUT COVE- TRAWL/SEINE







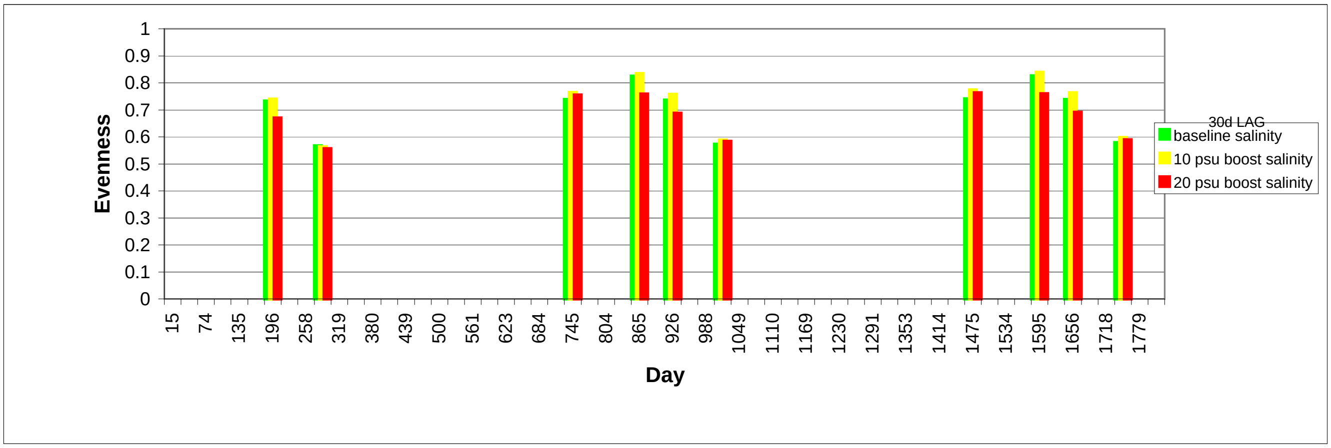
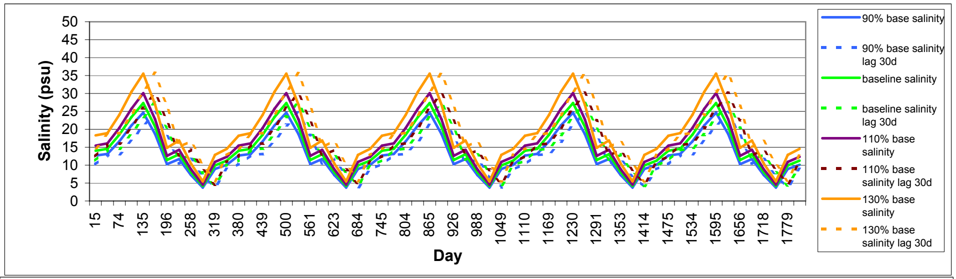
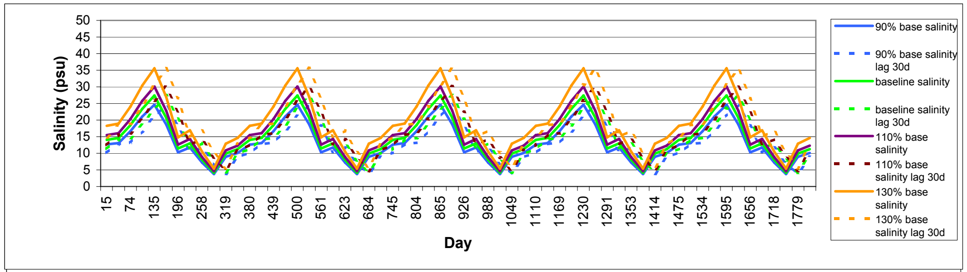
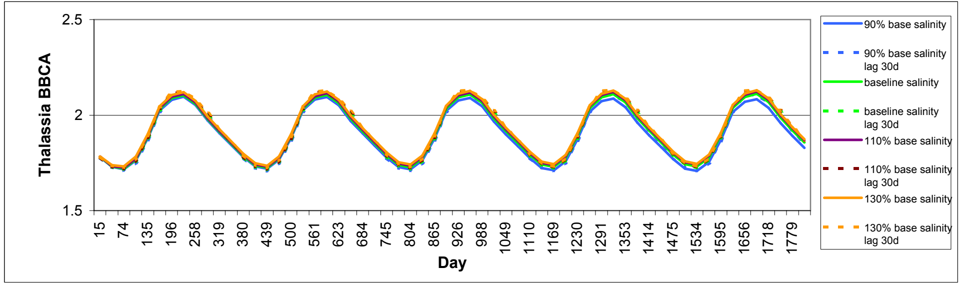


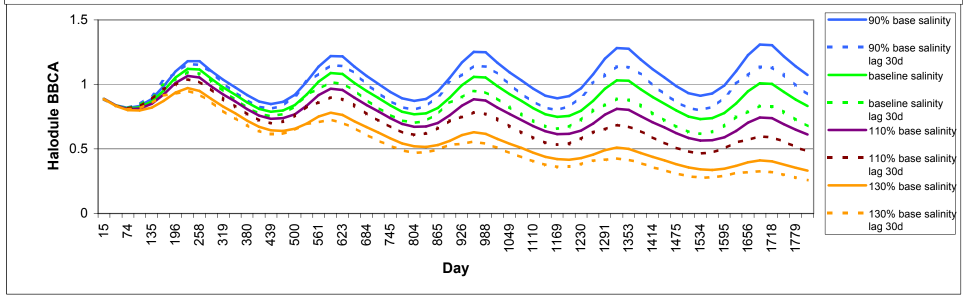
Figure 47. Trout Cove Scenario – Salinity and SAV- trawl/seine

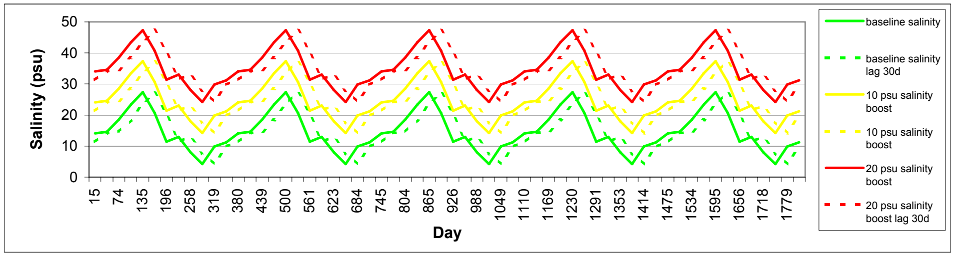
TROUT COVE- TRAWL/SEINE

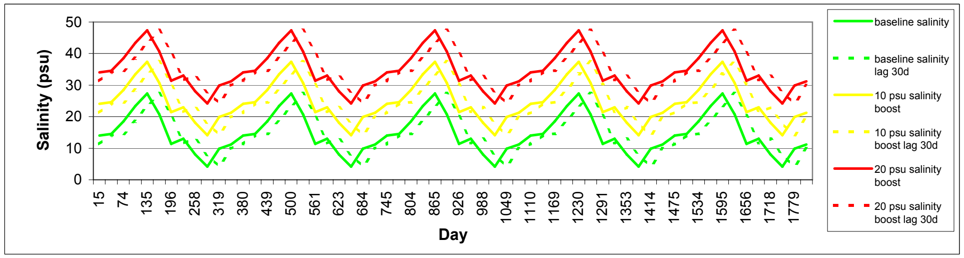


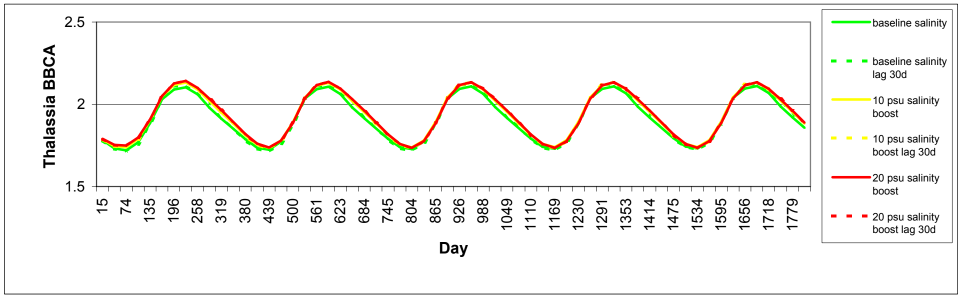












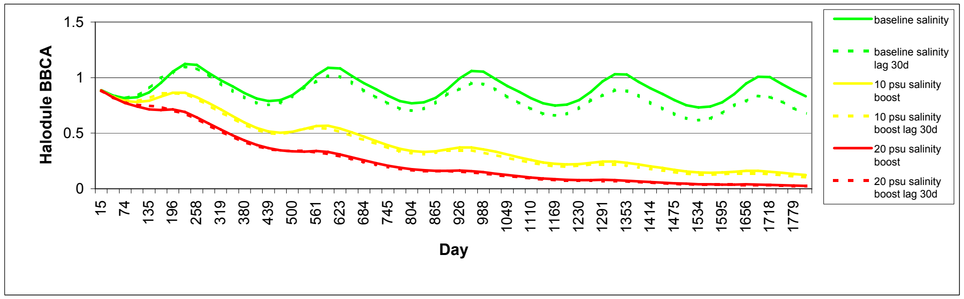
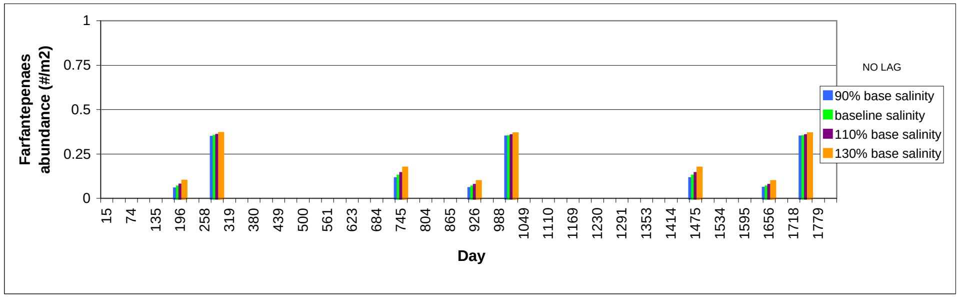
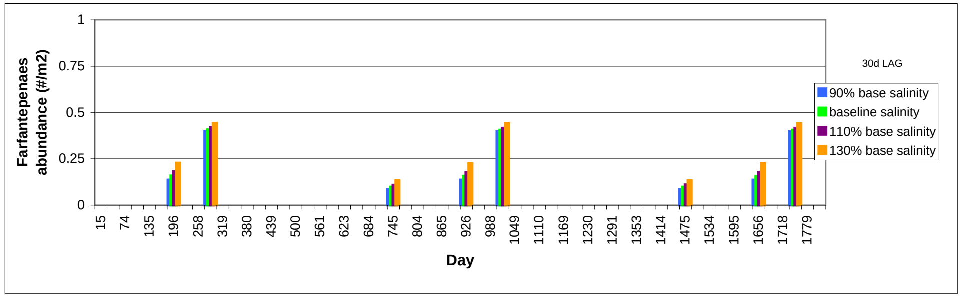
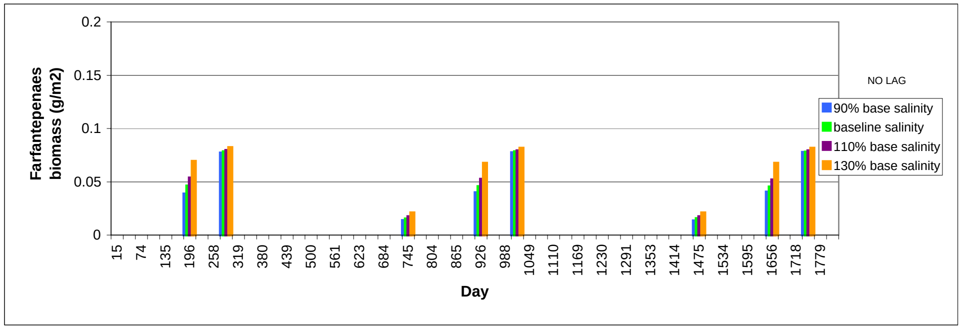


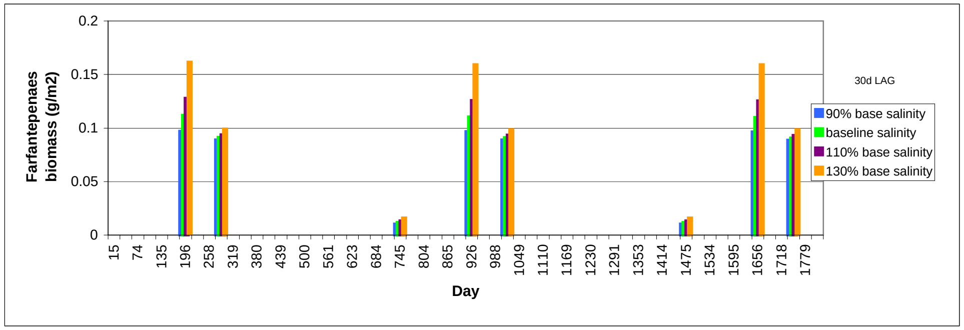
Figure 48. Trout Cove Scenario – *Farfantepenaeus duorarum* abundance and biomass-throw-trap

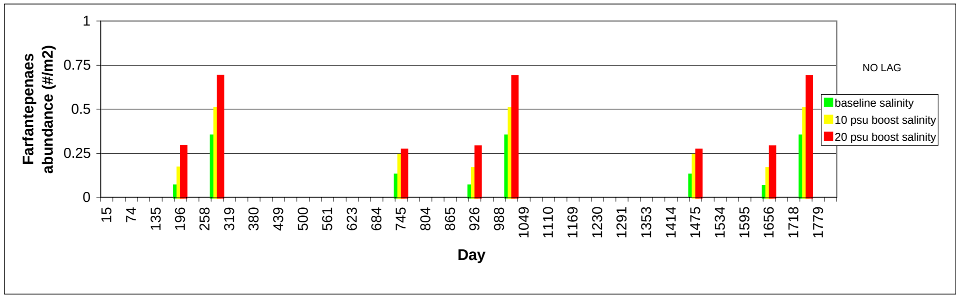
TROUT COVE- THROW TRAP

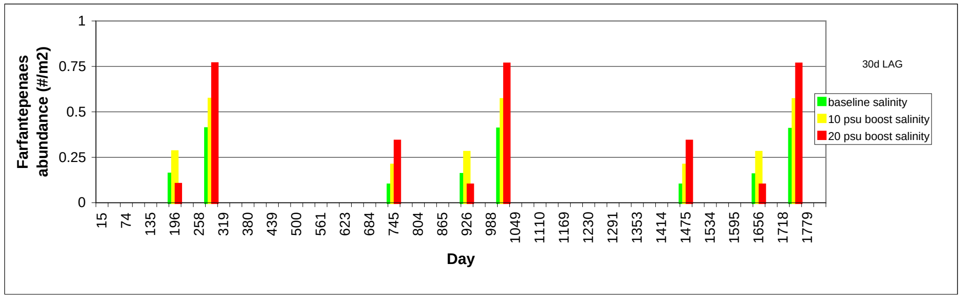


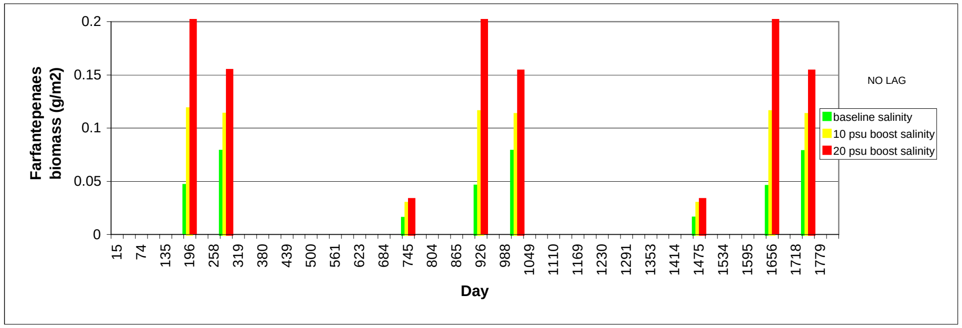












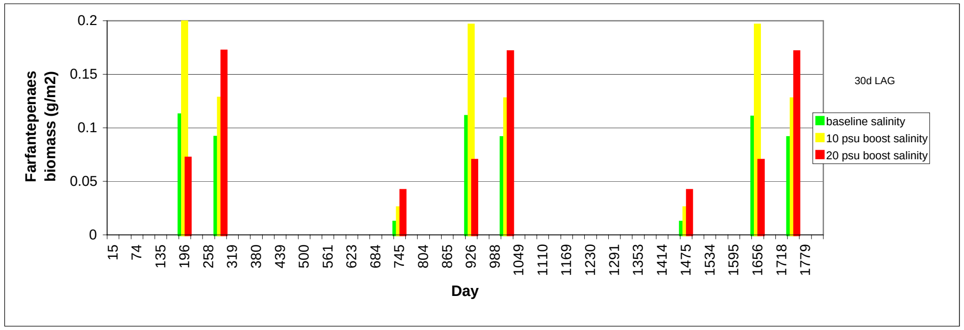
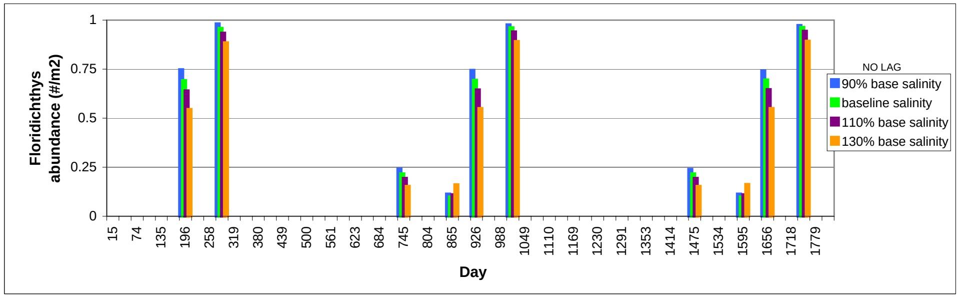
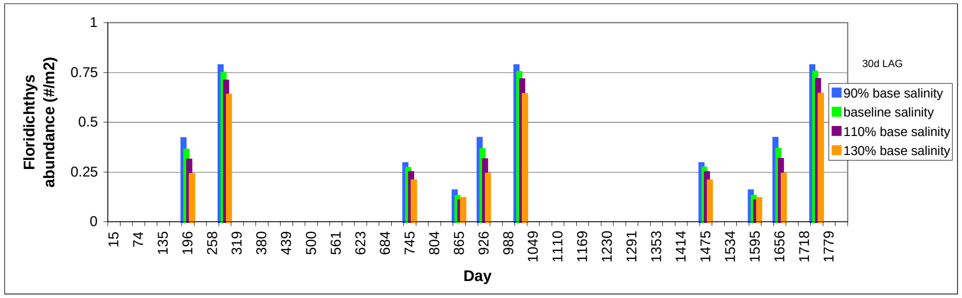
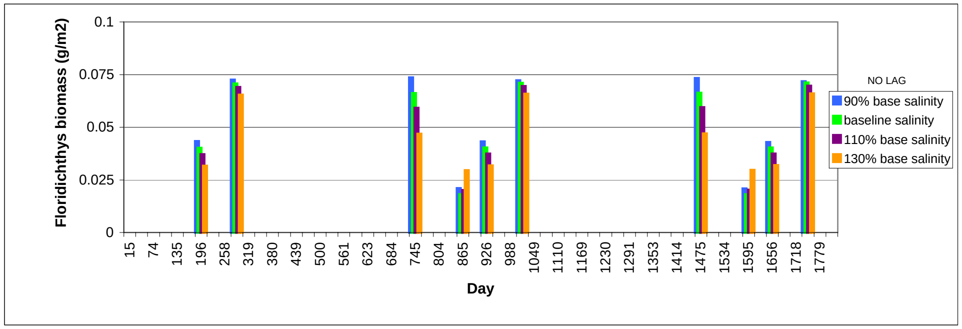


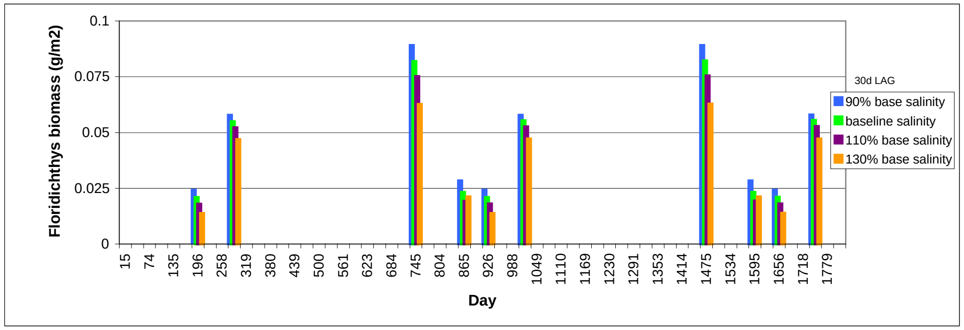
Figure 49. Trout Cove Scenario – *Floridichthys carpio* abundance and biomass- throw-trap

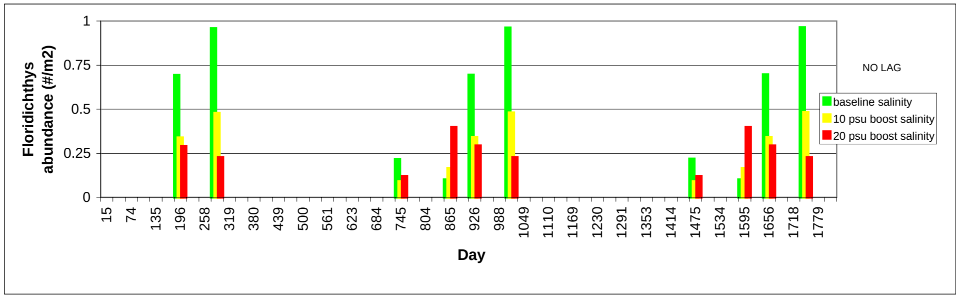
TROUT COVE- THROW TRAP

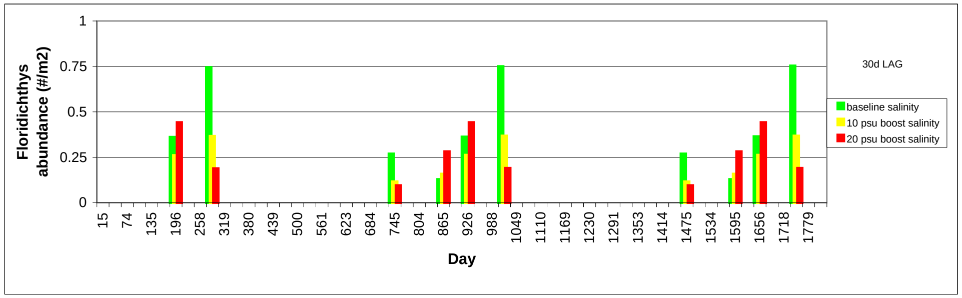


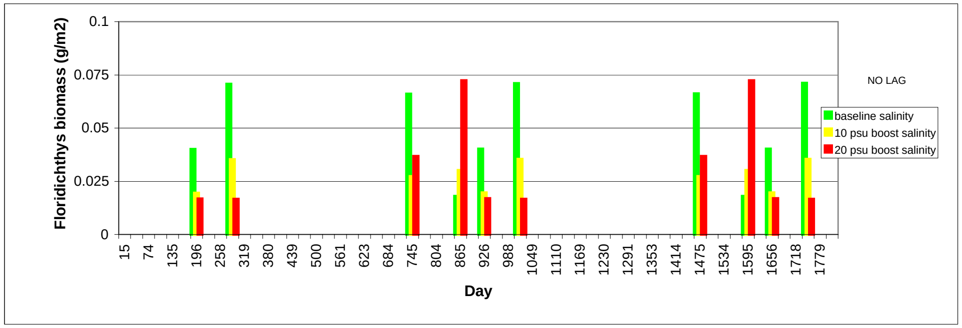












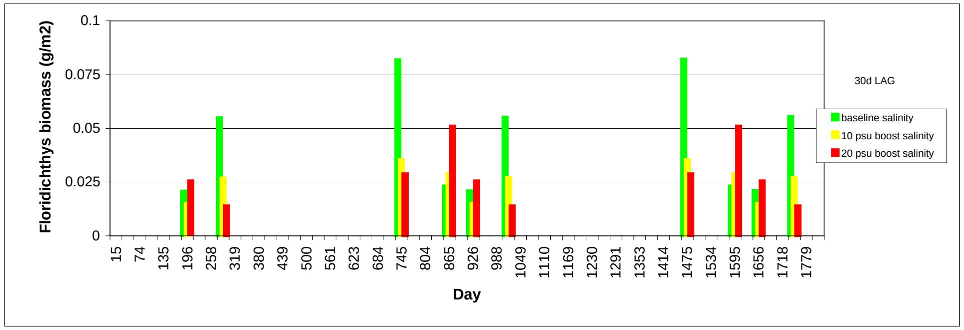
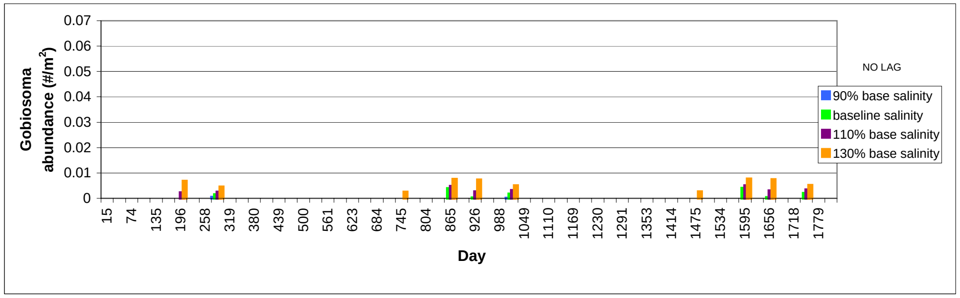
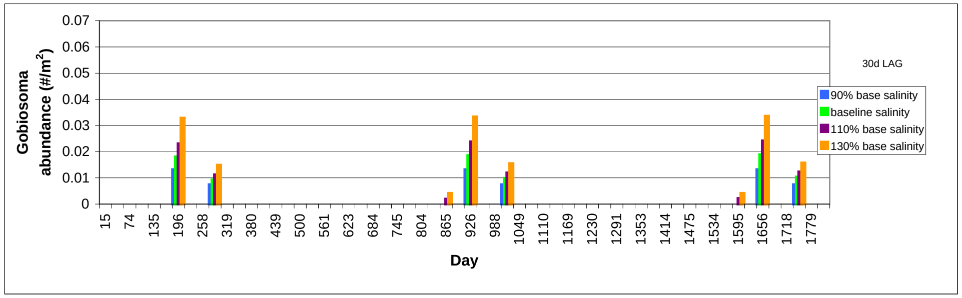
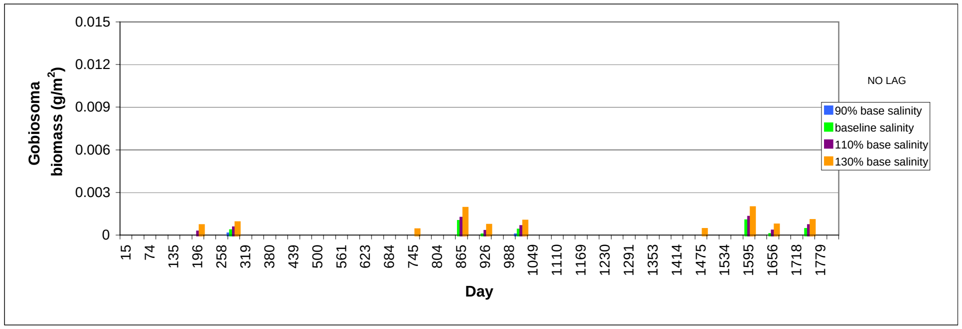


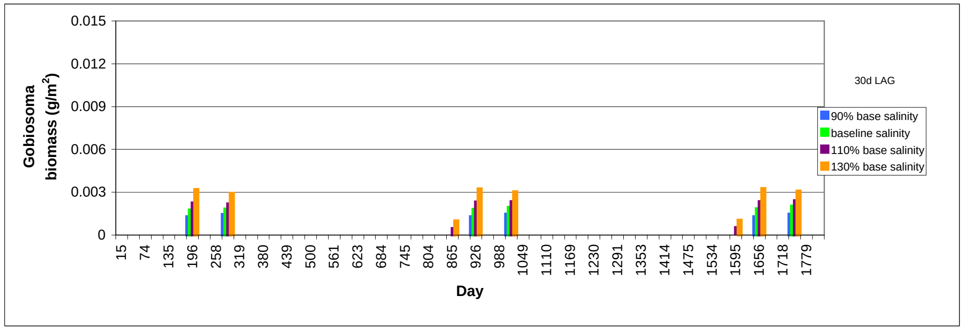
Figure 50. Trout Cove Scenario – *Gobiosoma robustum* abundance and biomass- throw-trap

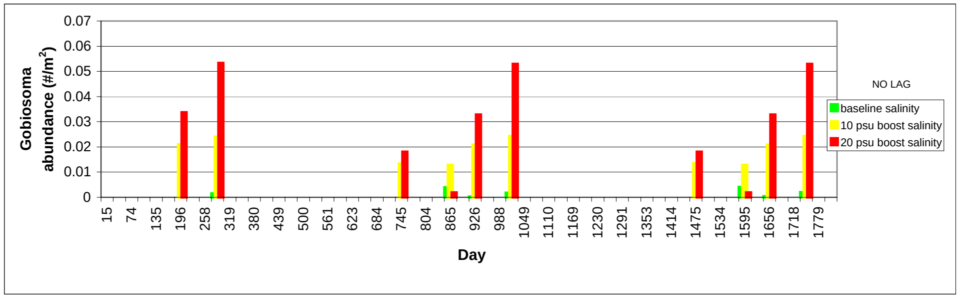
TROUT COVE- THROW TRAP

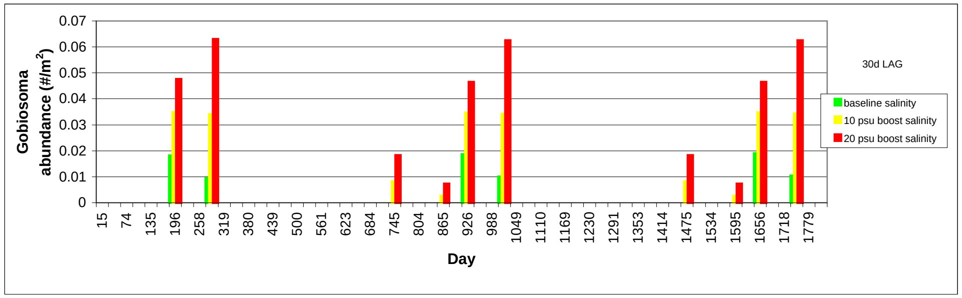


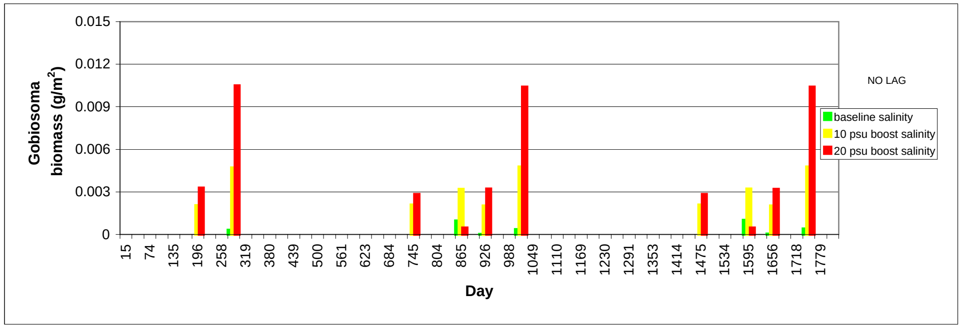












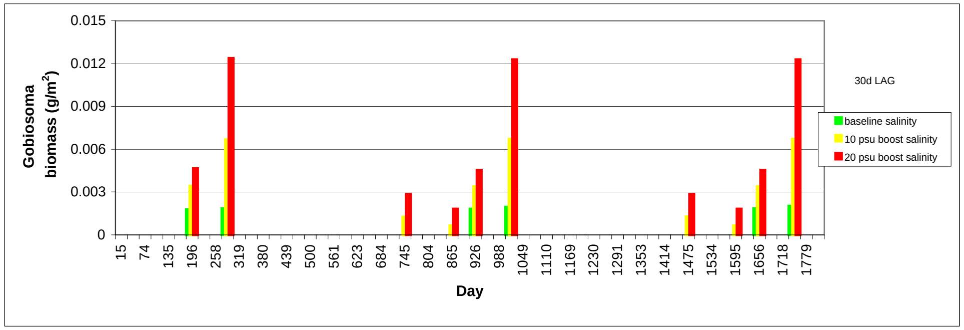
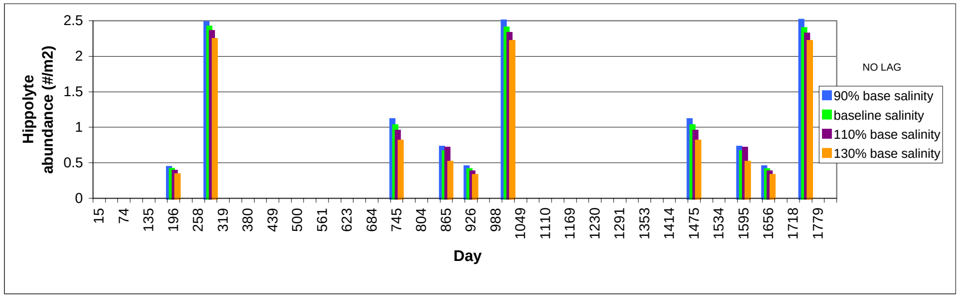
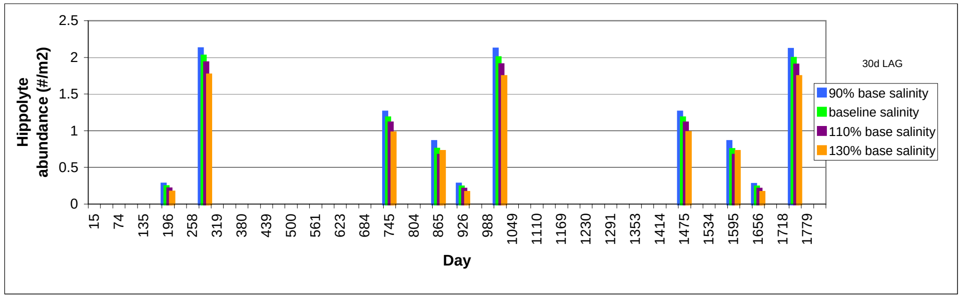
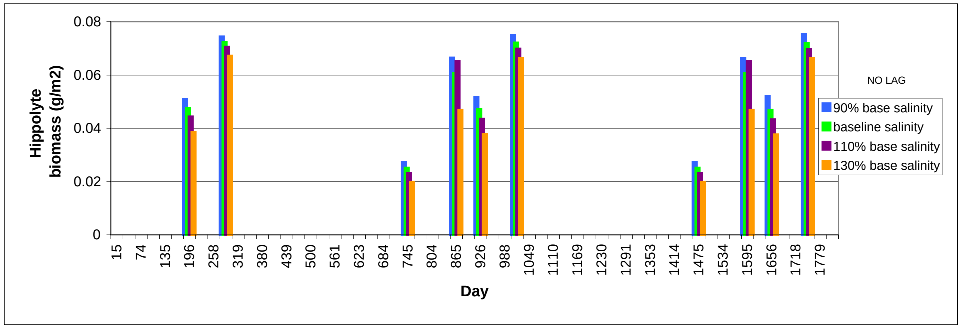


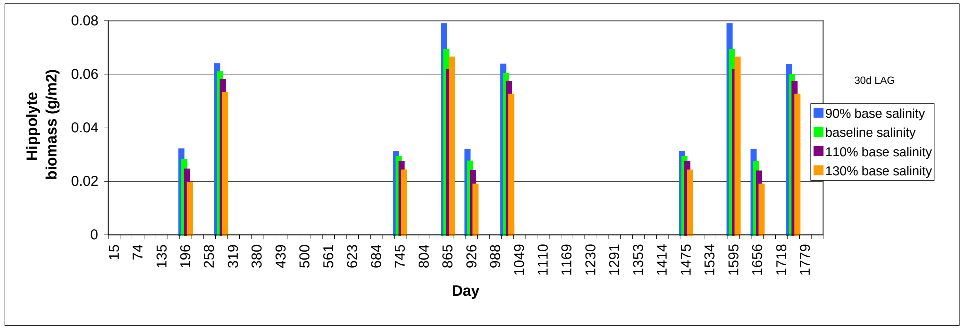
Figure 51. Trout Cove Scenario – *Hippolyte spp.* abundance and biomass- throw-trap

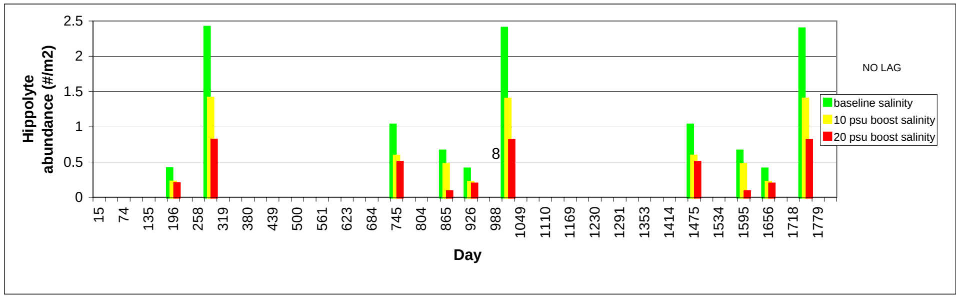
TROUT COVE- THROW TRAP

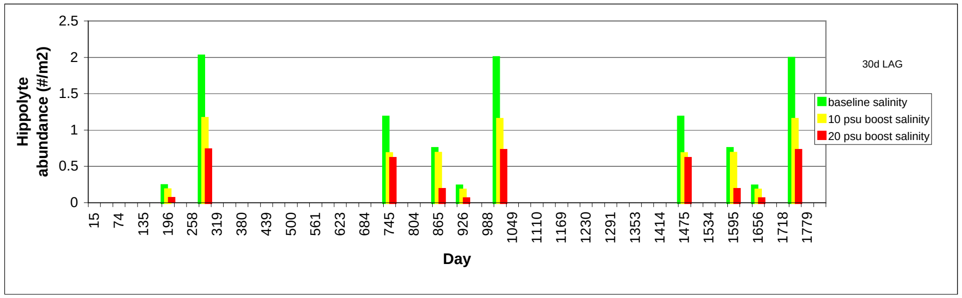


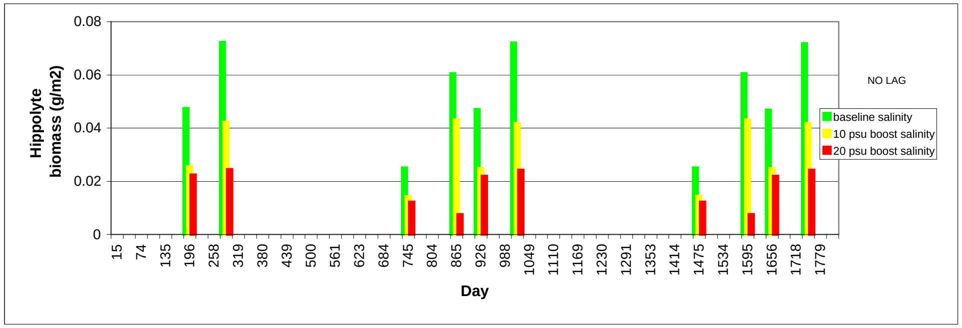












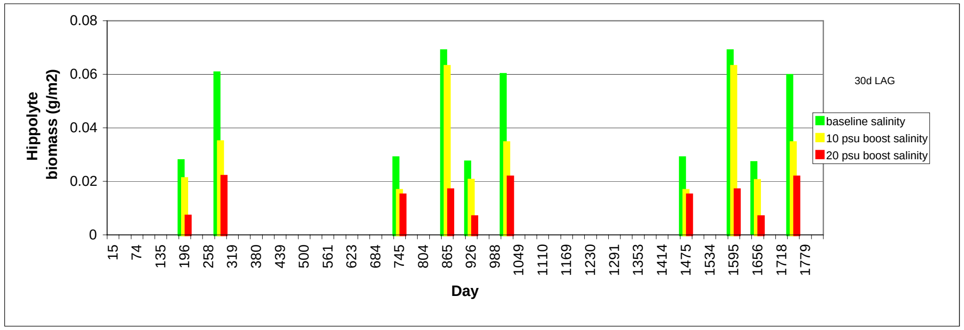
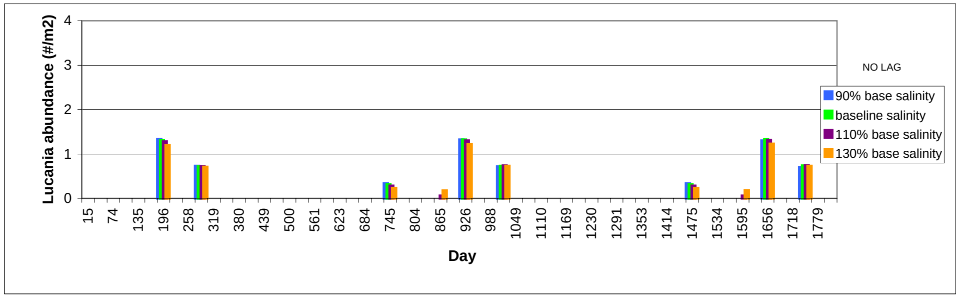
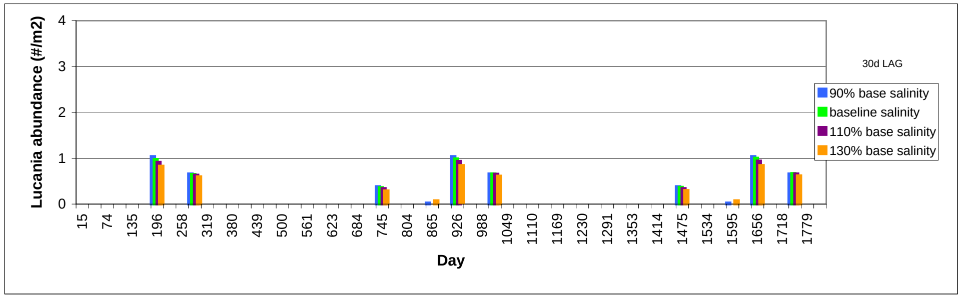
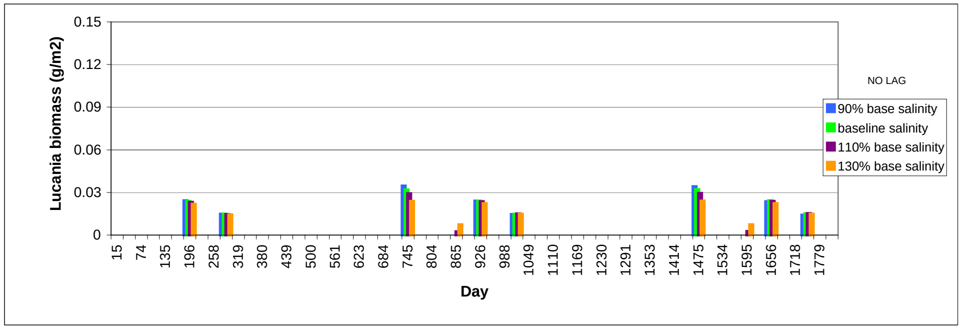


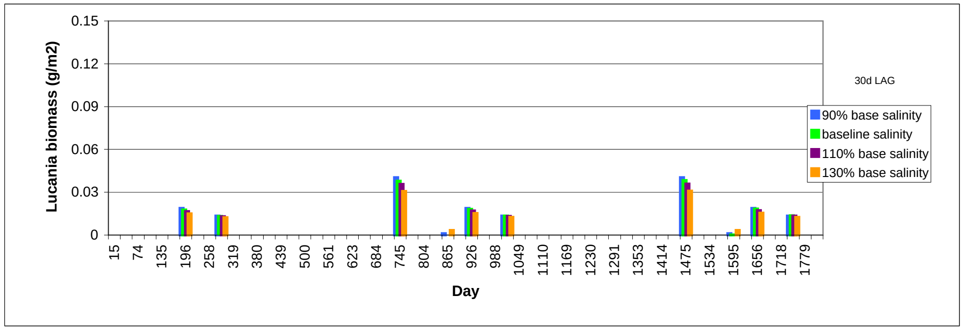
Figure 52. Trout Cove Scenario – *Lucania parva* abundance and biomass- throw-trap

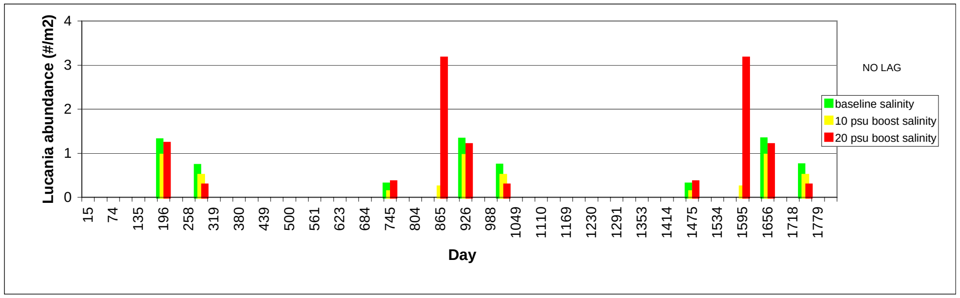
TROUT COVE- THROW TRAP

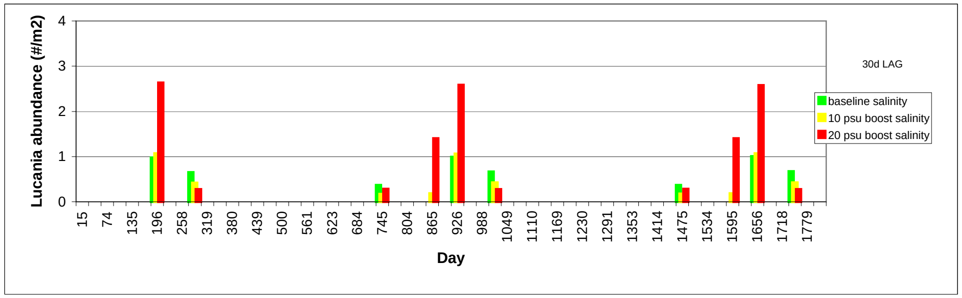


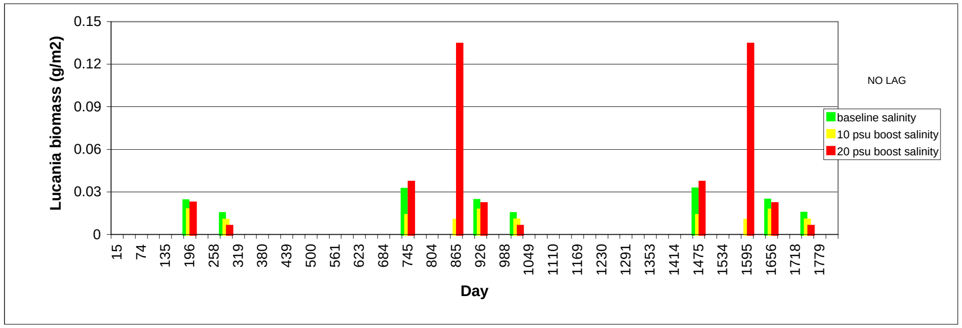












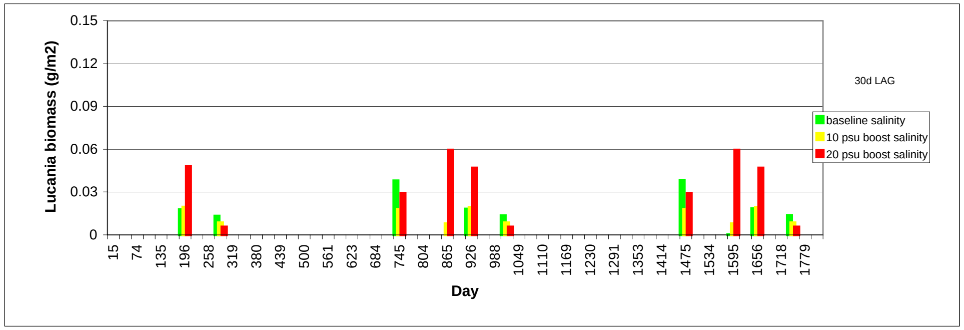
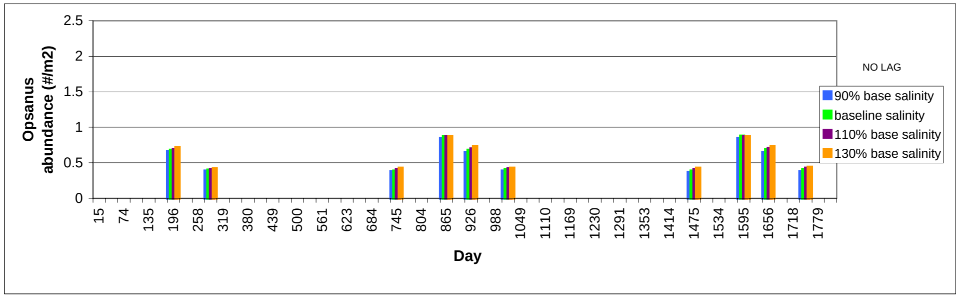
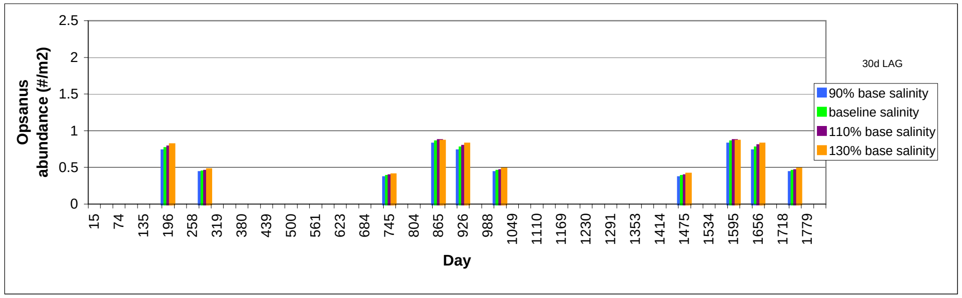
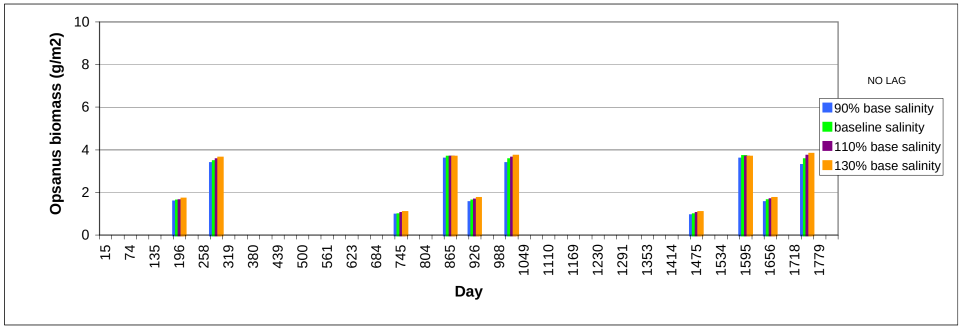


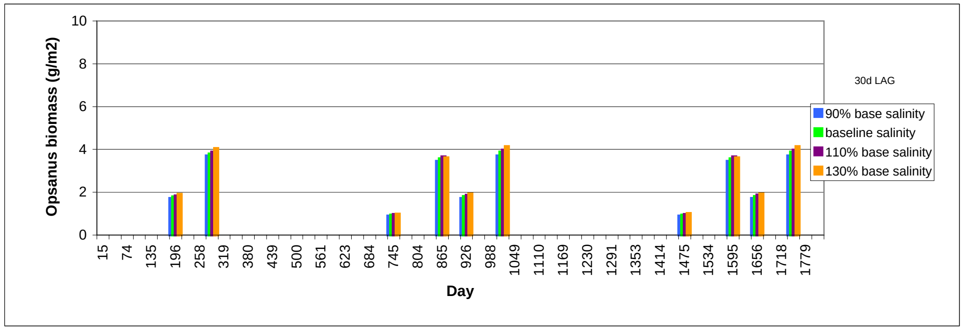
Figure 53. Trout Cove Scenario – *Opsanus beta* abundance and biomass- throw-trap

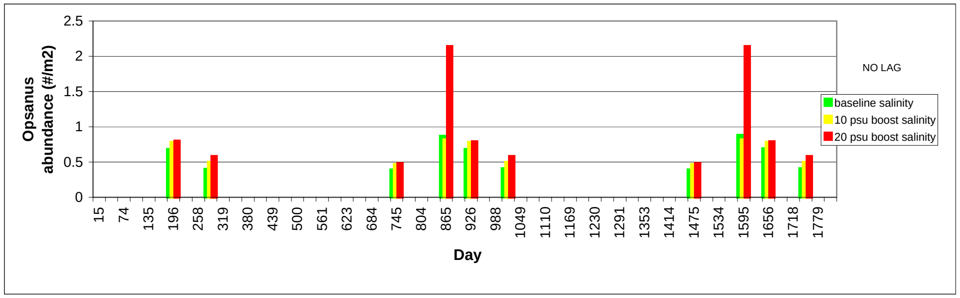
TROUT COVE- THROW TRAP

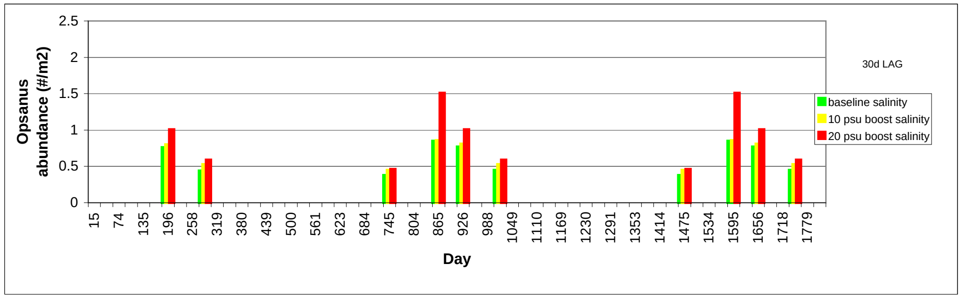


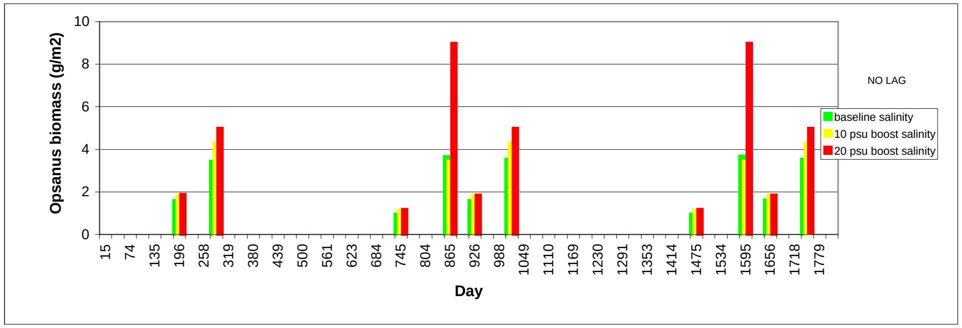












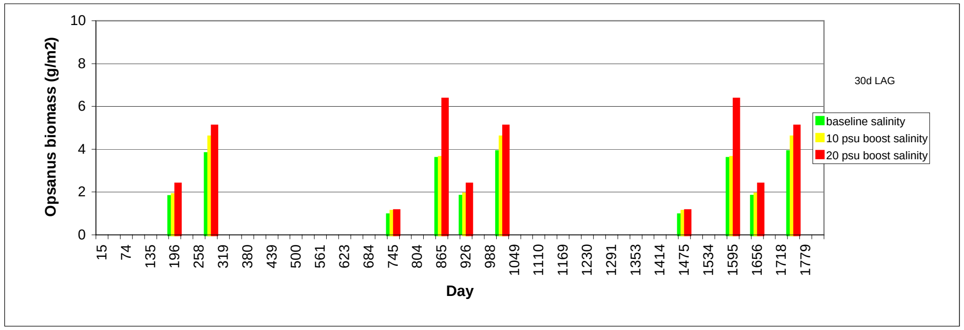
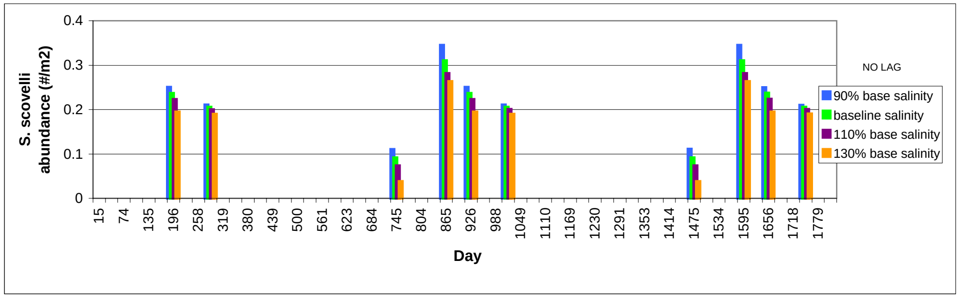
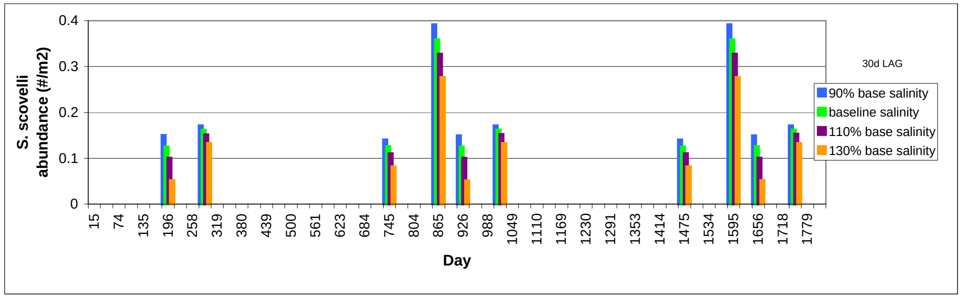
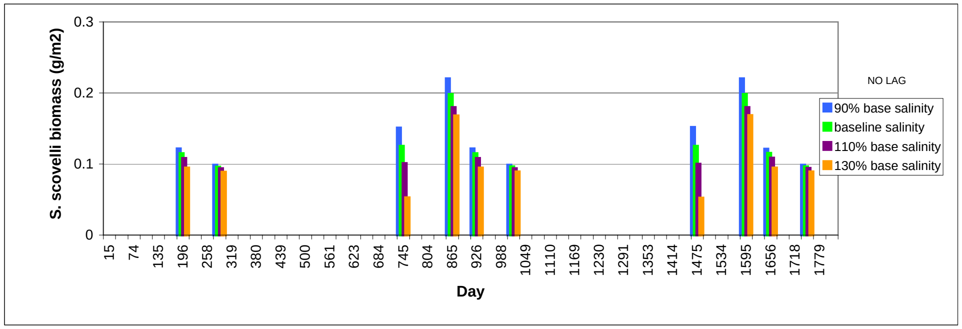


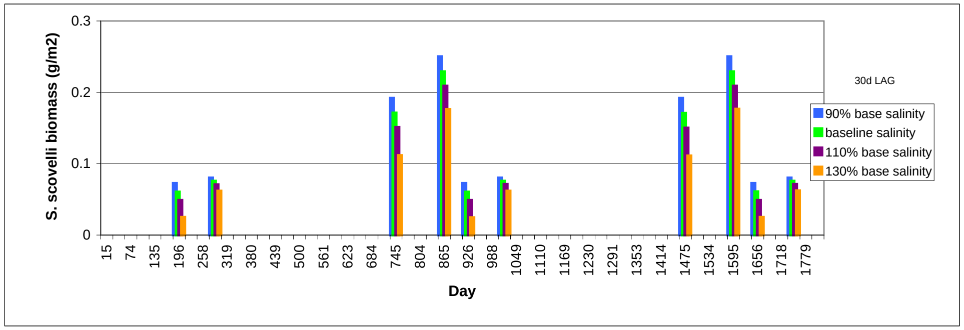
Figure 54. Trout Cove Scenario – *Syngnathus scovelli* abundance and biomass- throw-trap

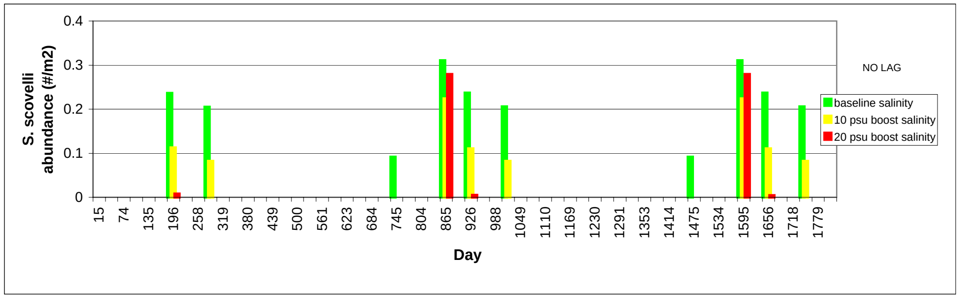
TROUT COVE- THROW TRAP

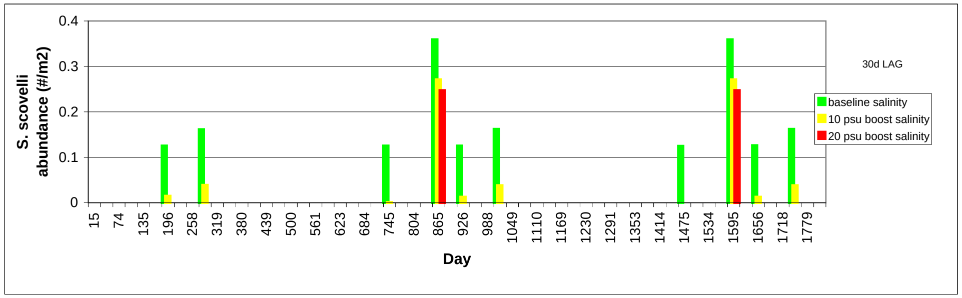


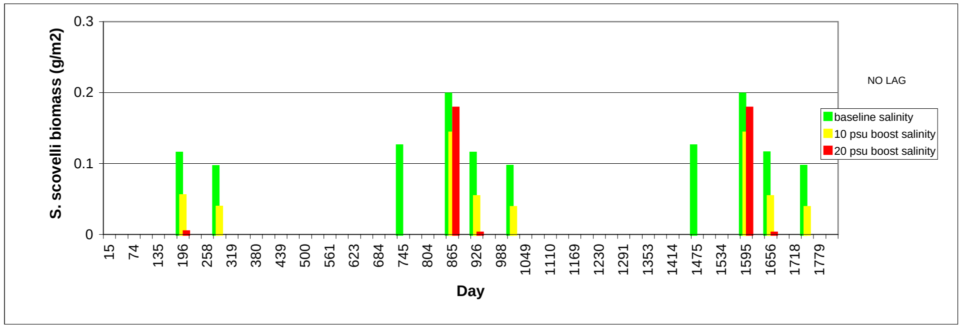












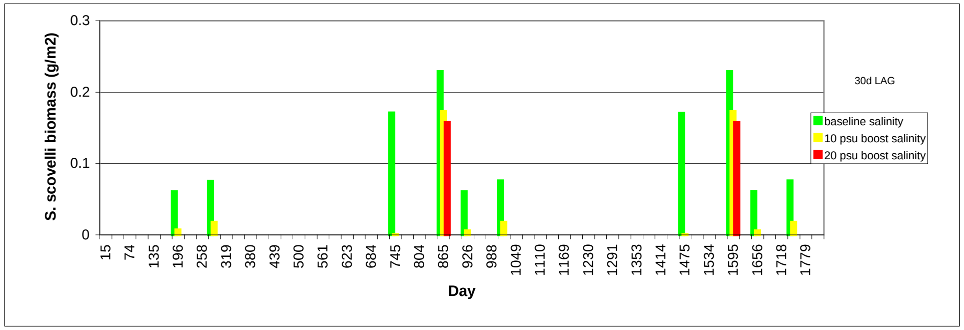
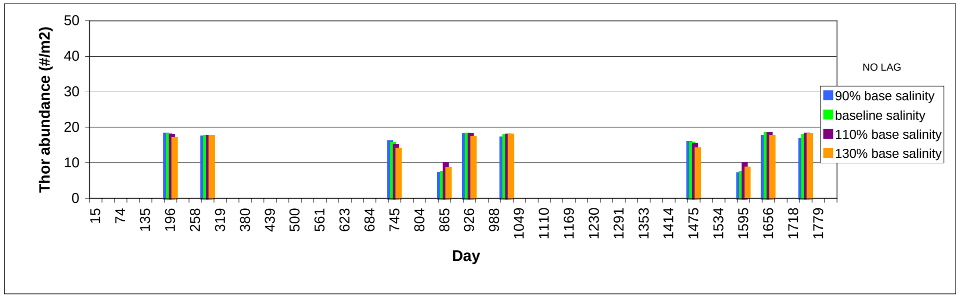
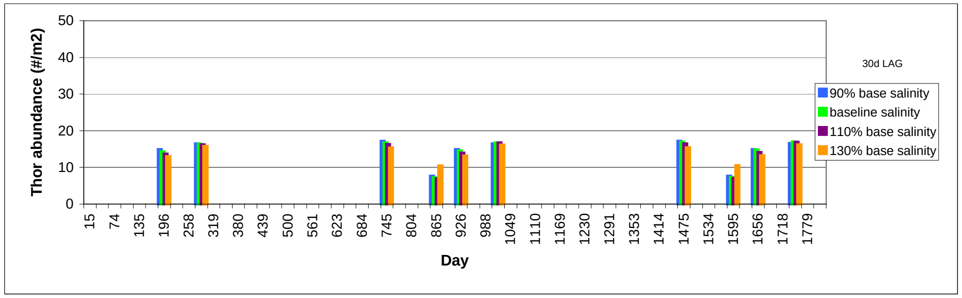
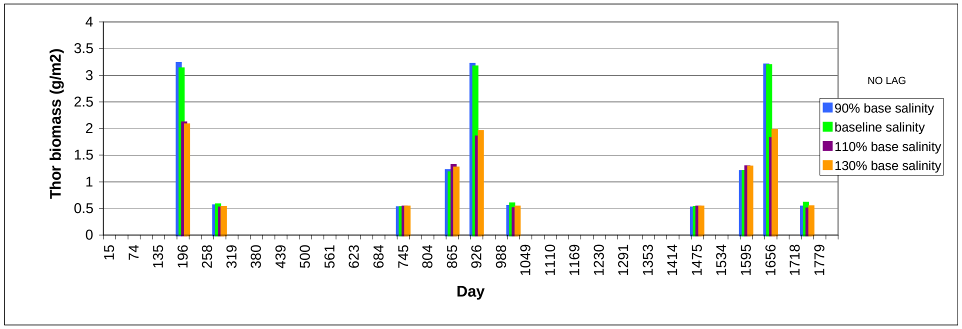


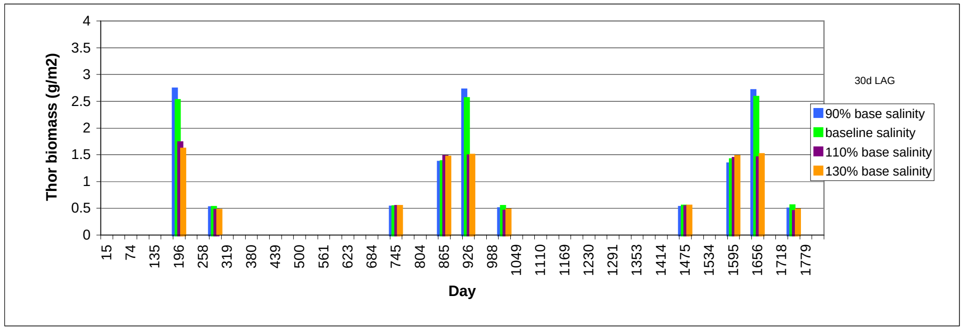
Figure 55. Trout Cove Scenario – *Thor spp.* abundance and biomass- throw-trap

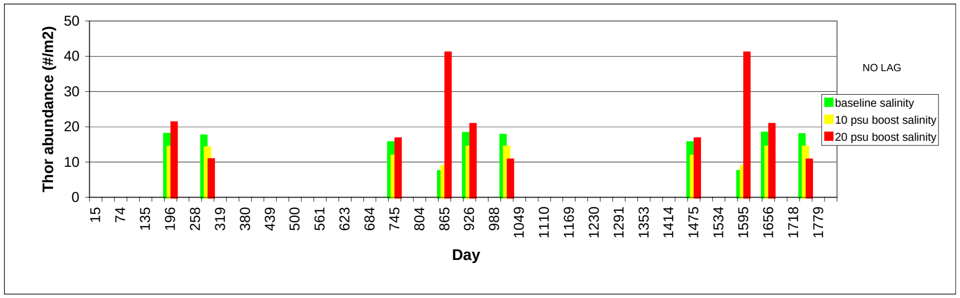
TROUT COVE- THROW TRAP

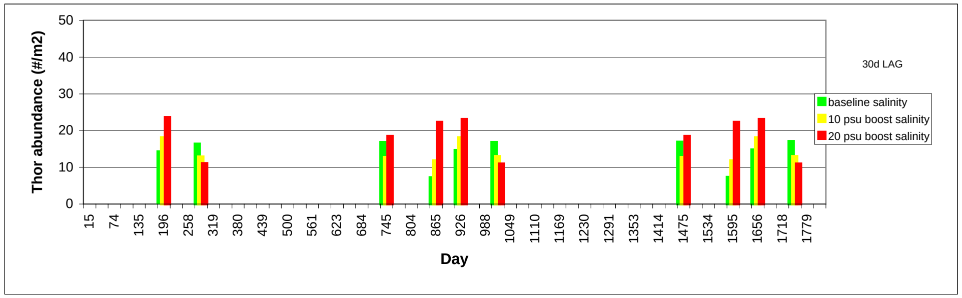


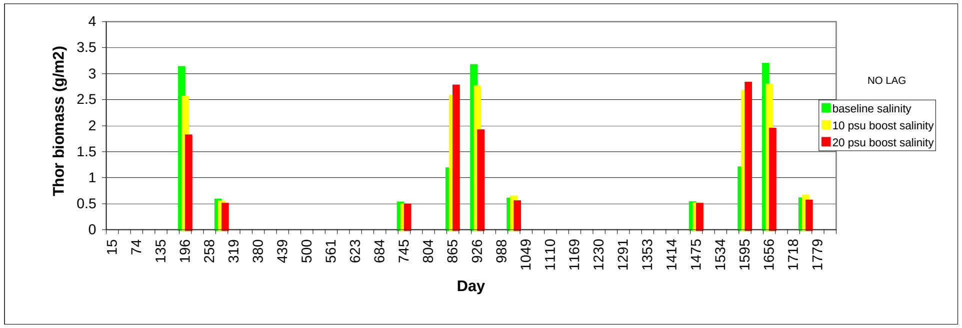












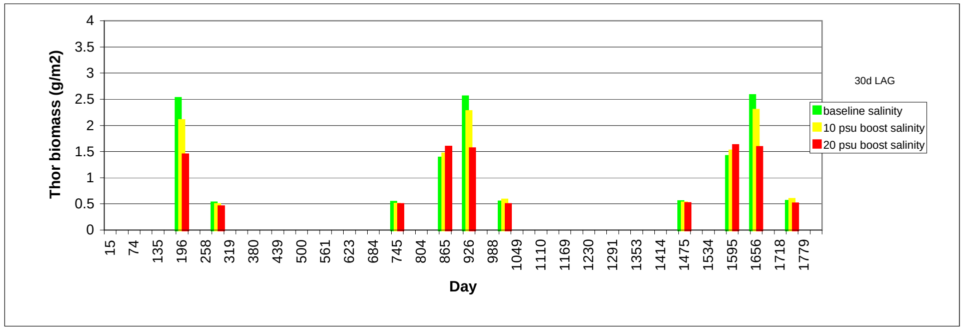
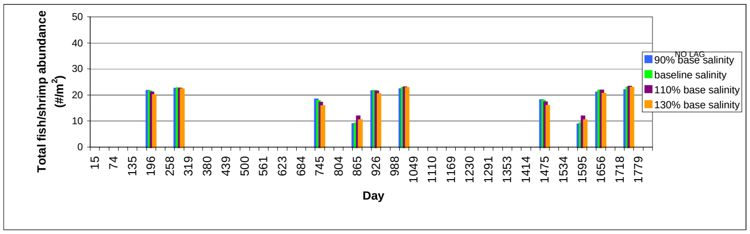
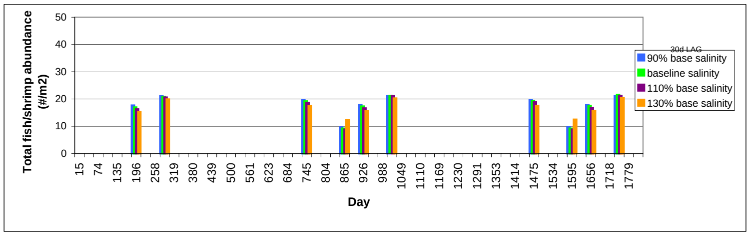
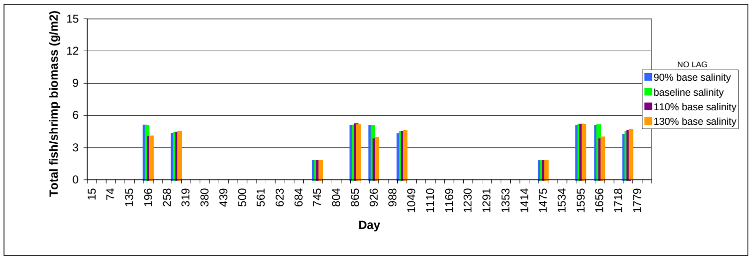


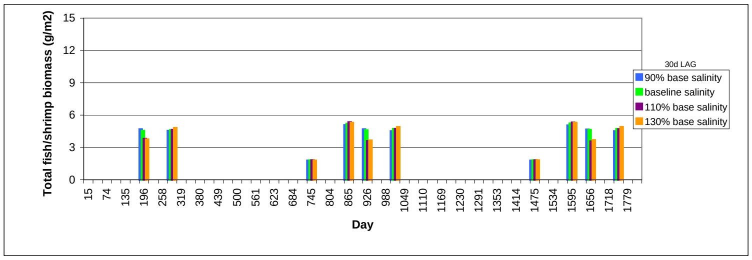
Figure 56. Trout Cove Scenario – Total fish/shrimp abundance, Total fish/shrimp biomass, Forage fish/shrimp biomass, Predator fish biomass- throw-trap

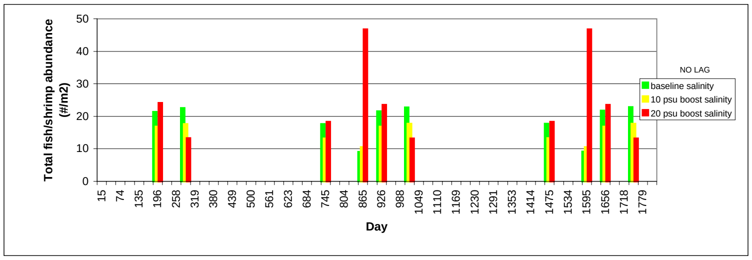
TROUT COVE -THROW TRAP

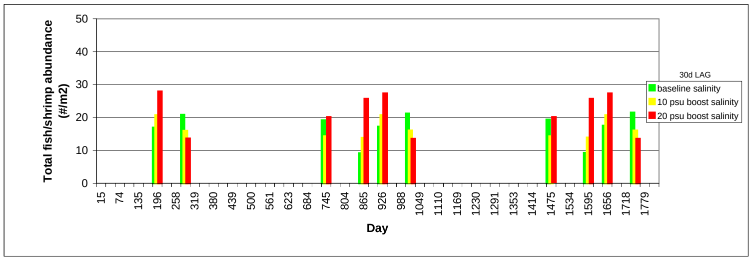


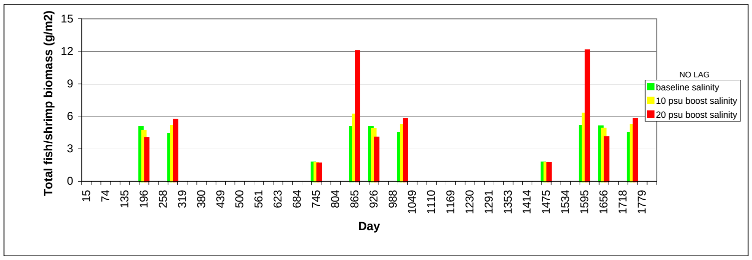


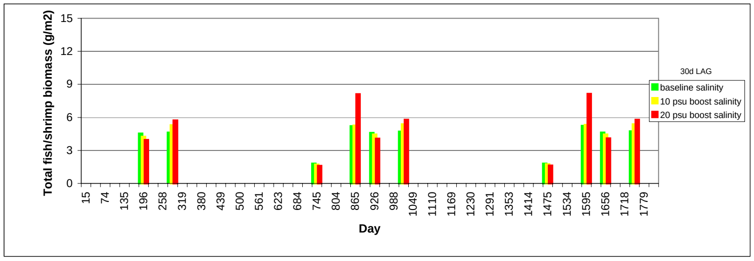


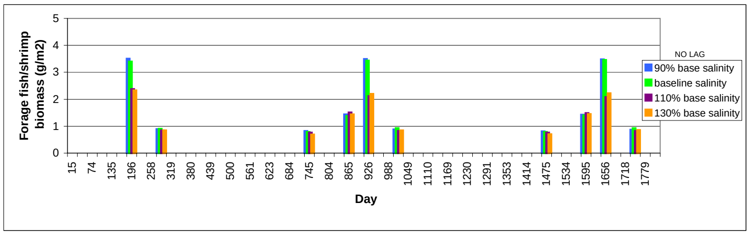


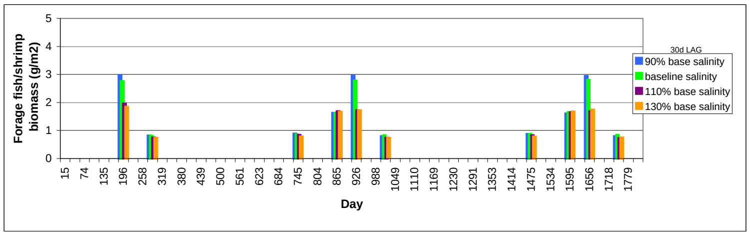


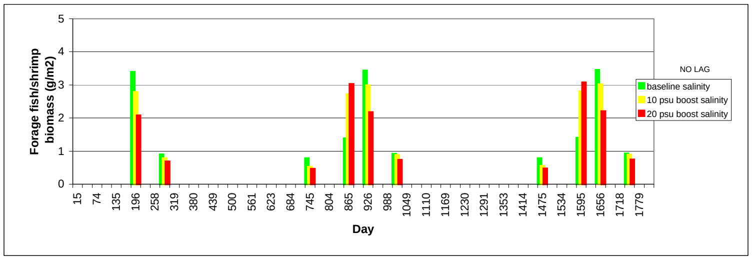












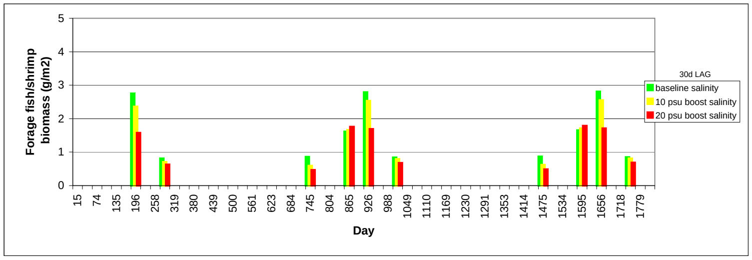
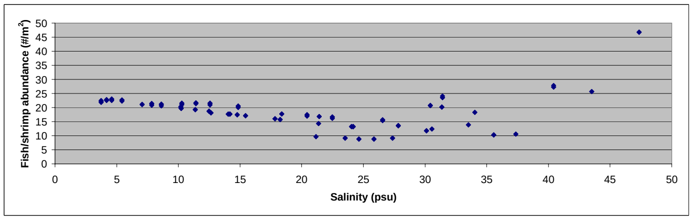
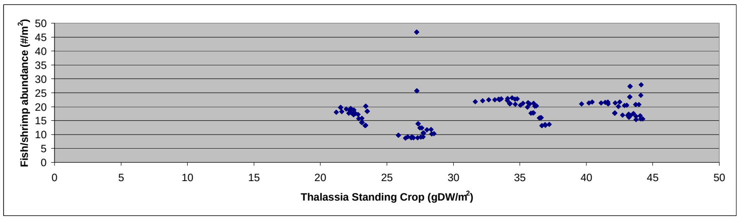
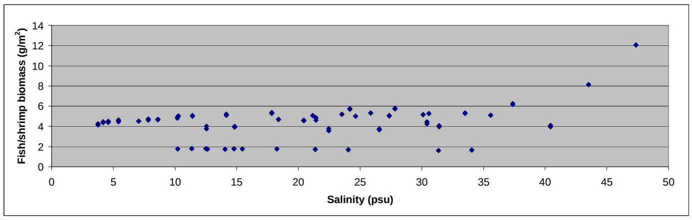


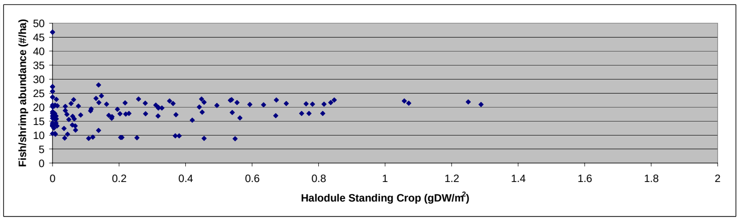
Figure 57. Trout Cove Scenario - Fish/shrimp abundance vs. Salinity, Fish/shrimp biomass vs. salinity, Predator fish biomass vs. Salinity, Fish/shrimp abundance vs. Thalassia BBCA, Fish/shrimp abundance vs. Halodule BBCA- throw-trap

TROUT COVE -THROW TRAP









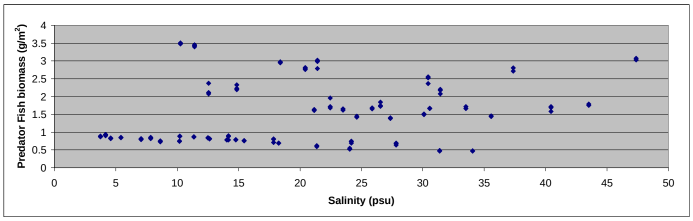
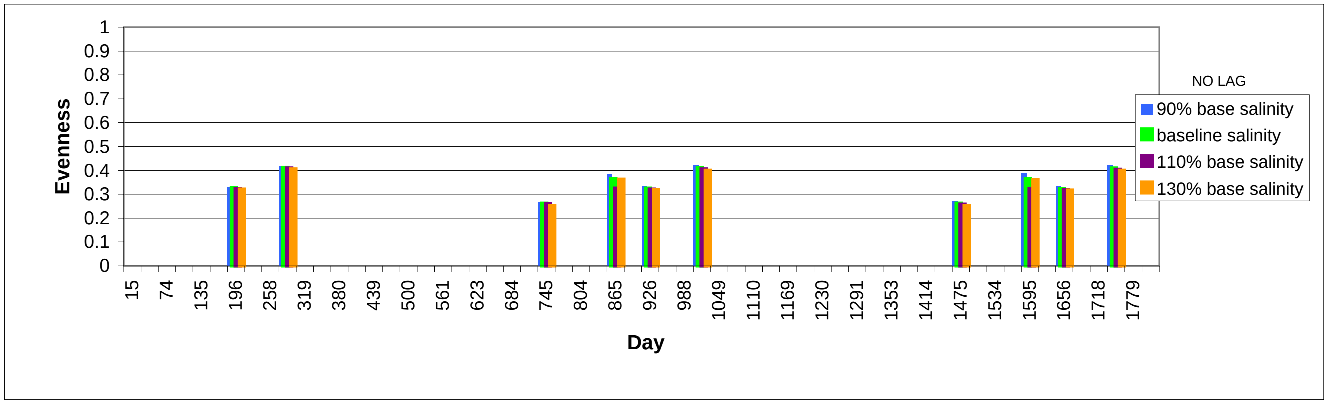
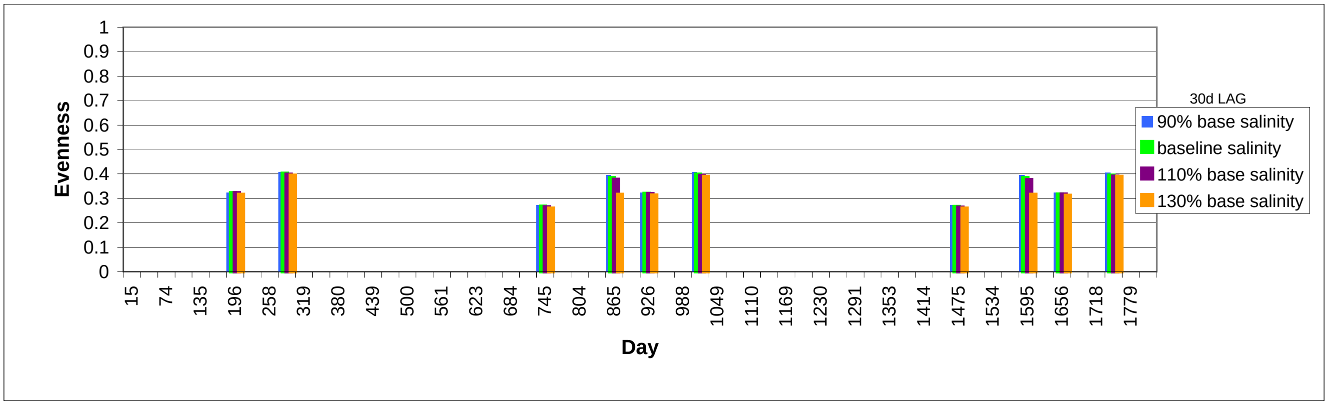
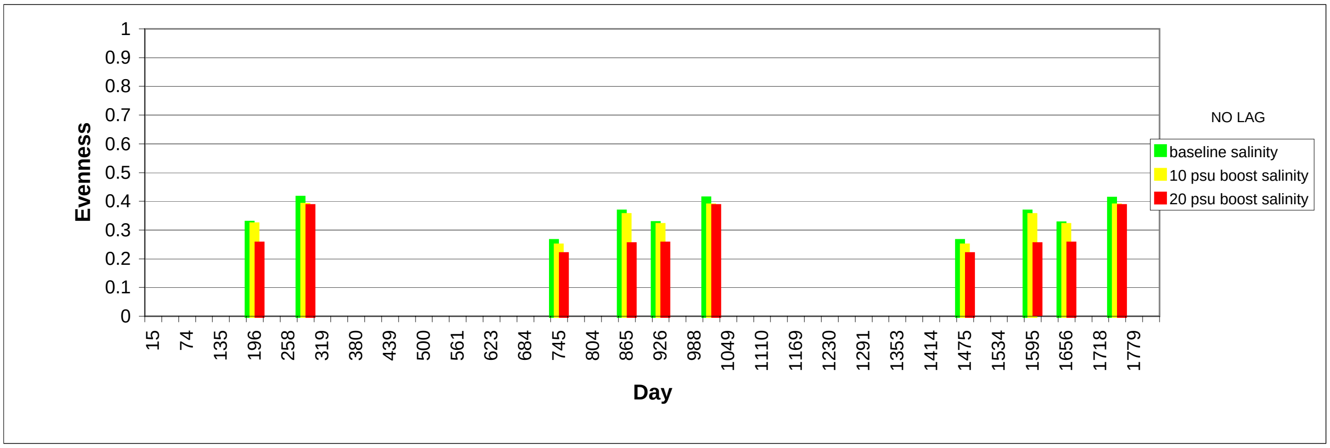


Figure 58. Trout Cove Scenario – Evenness throw-trap

TROUT COVE -THROW TRAP







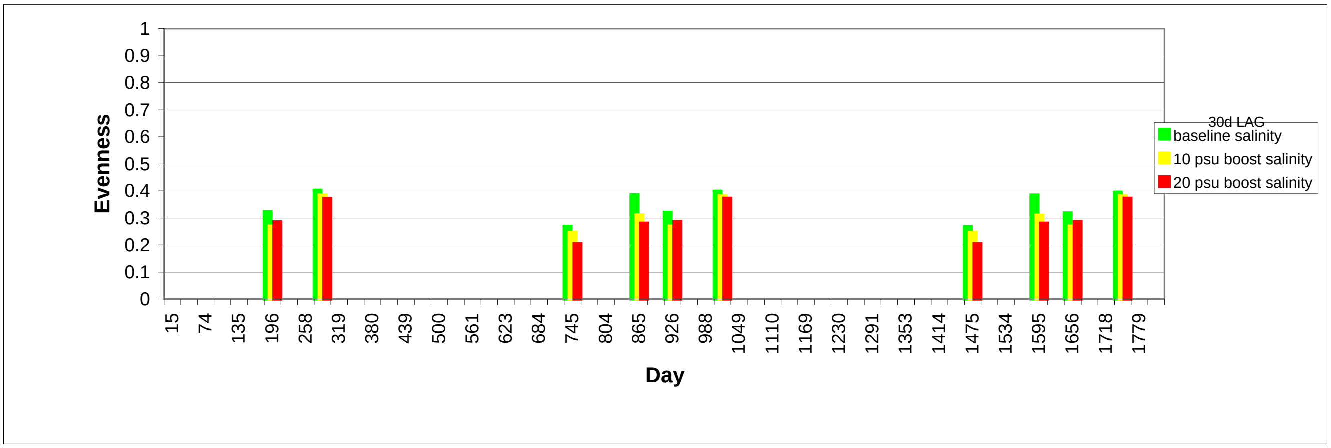
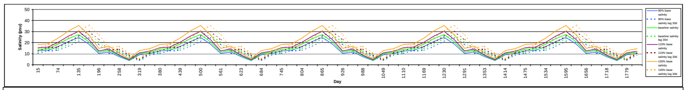
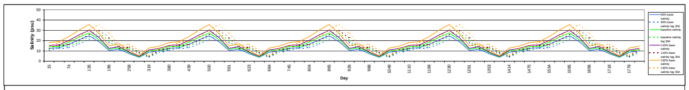
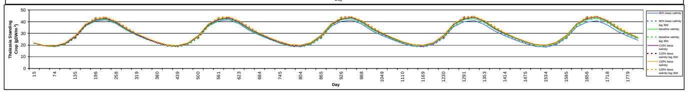


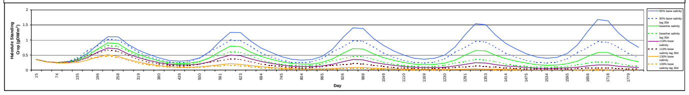
Figure 59. Trout Cove Scenario – Salinity and SAV- throw-trap

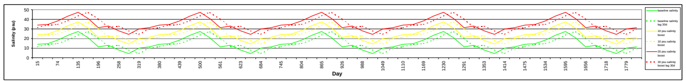
TROUT COVE -THROW TRAP

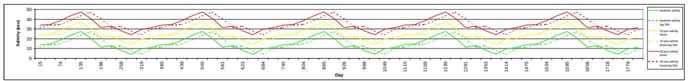


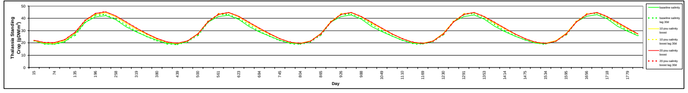


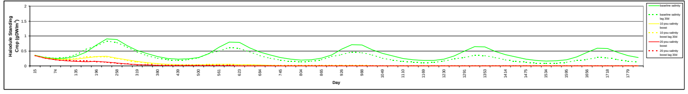


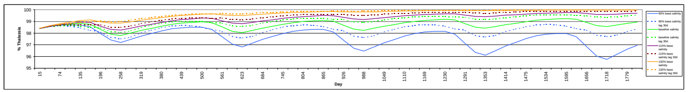


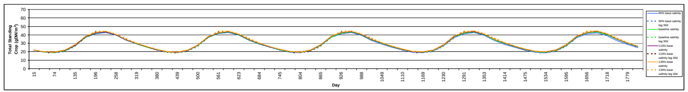


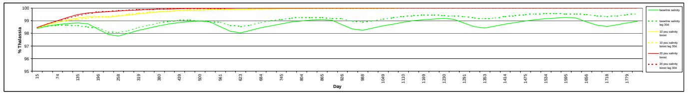












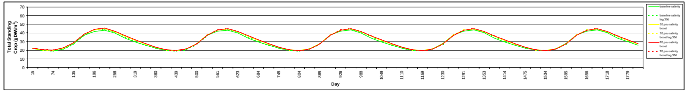
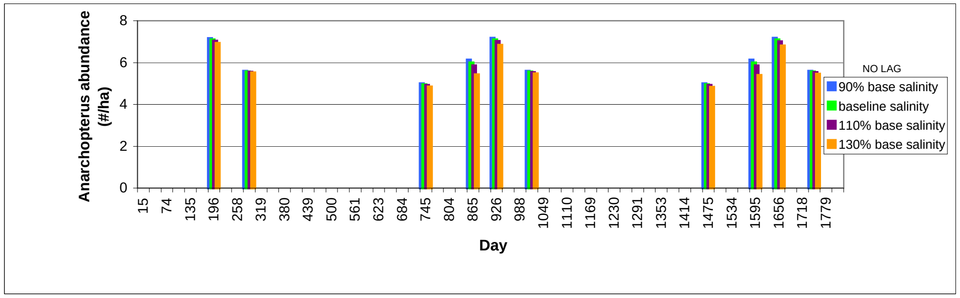
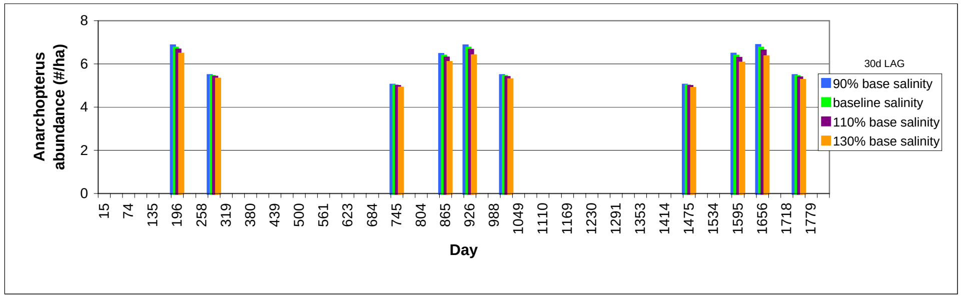
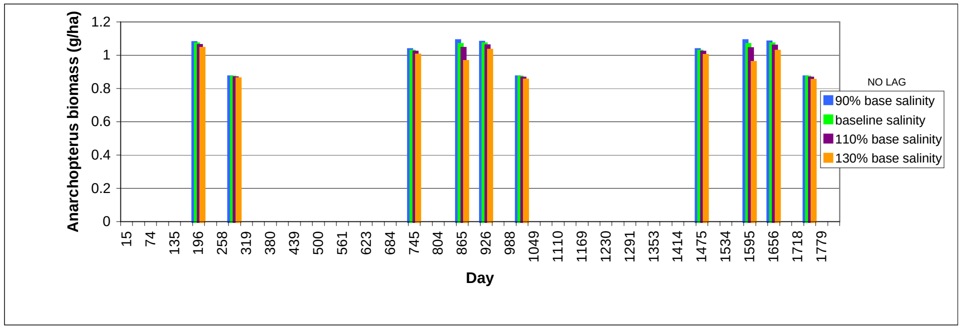


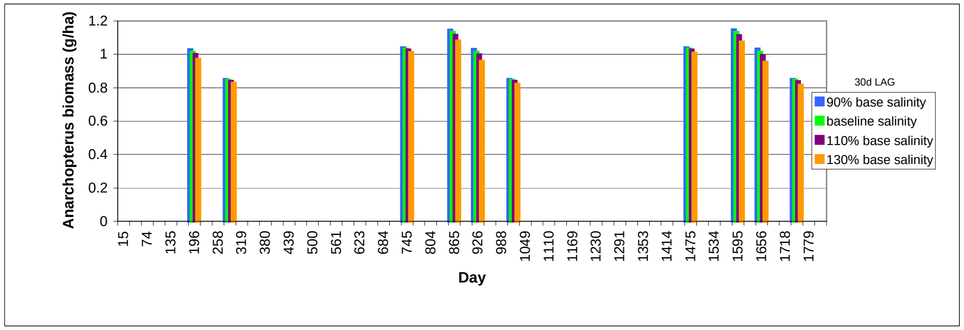
Figure 60. Little Madeira Bay Scenario – *Anarchopterus criniger* abundance and biomass- trawl/seine

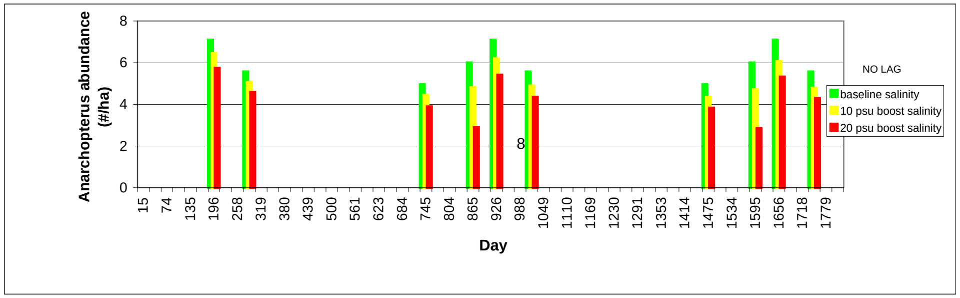
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

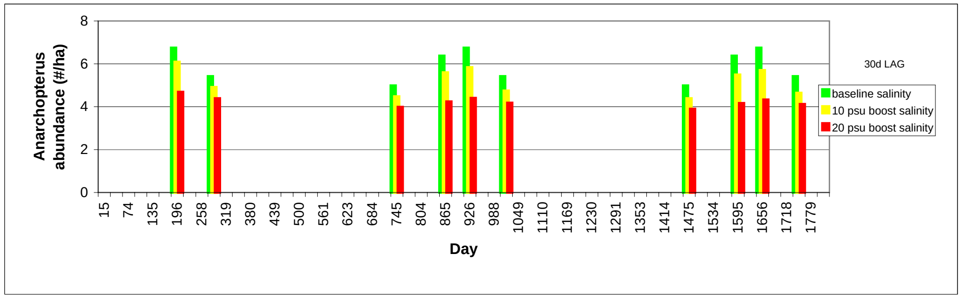


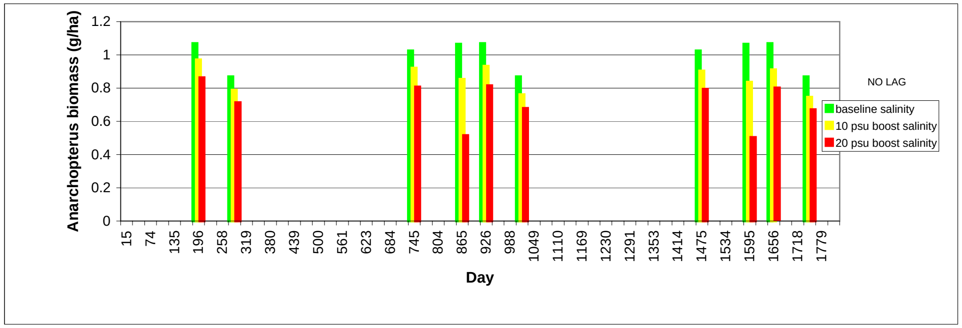












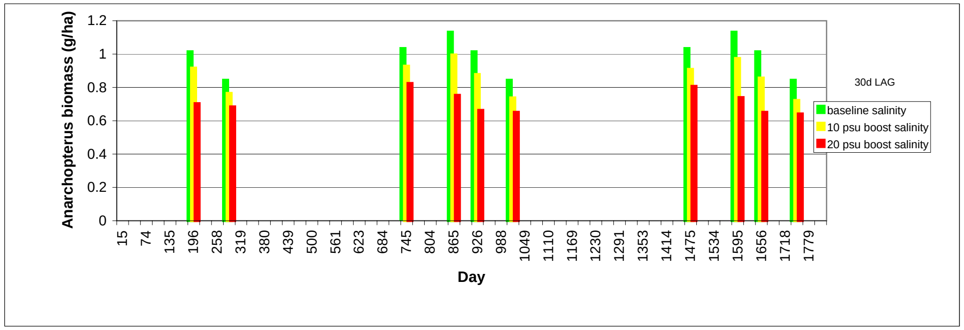
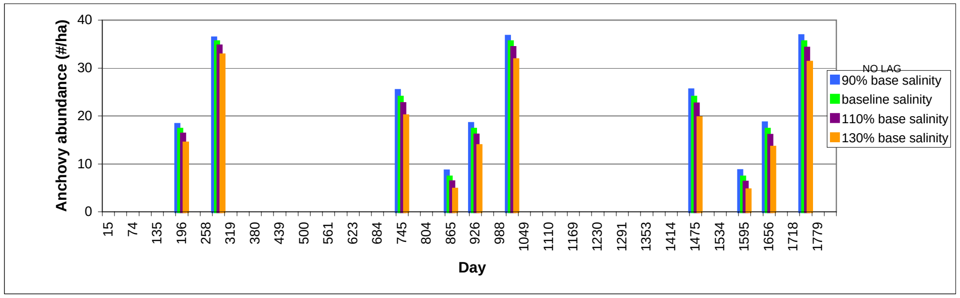
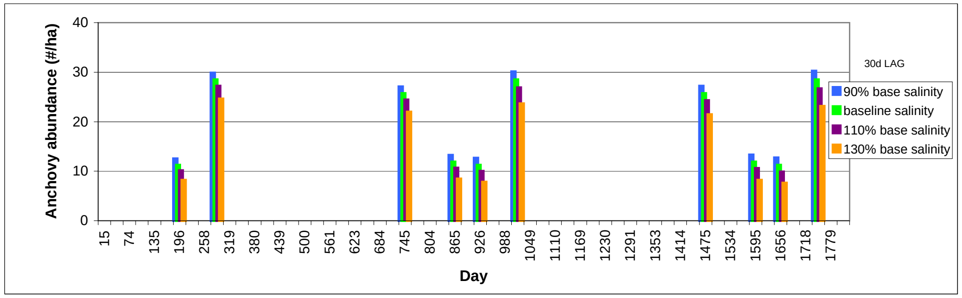
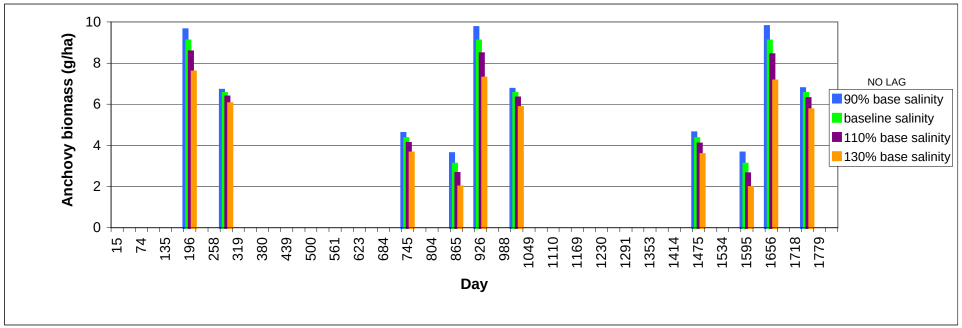


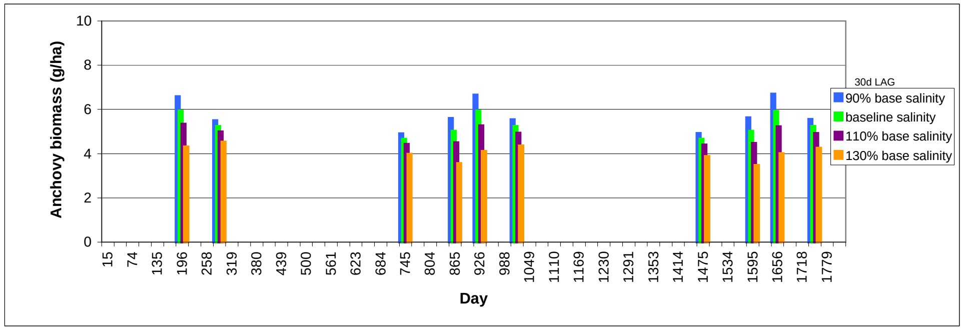
Figure 61. Little Madeira Bay Scenario – *Anchoa mitchelli* abundance and biomass-trawl/seine

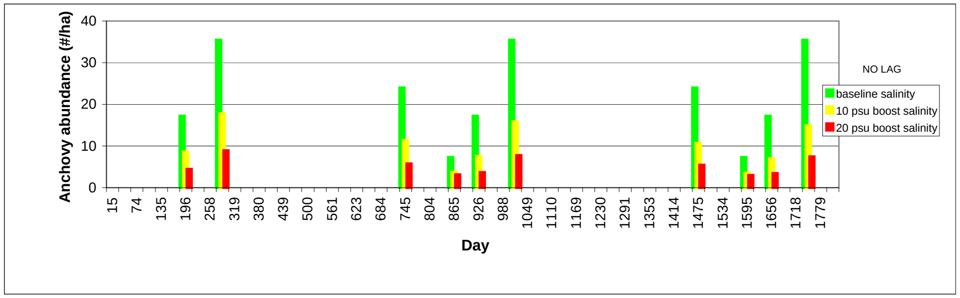
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

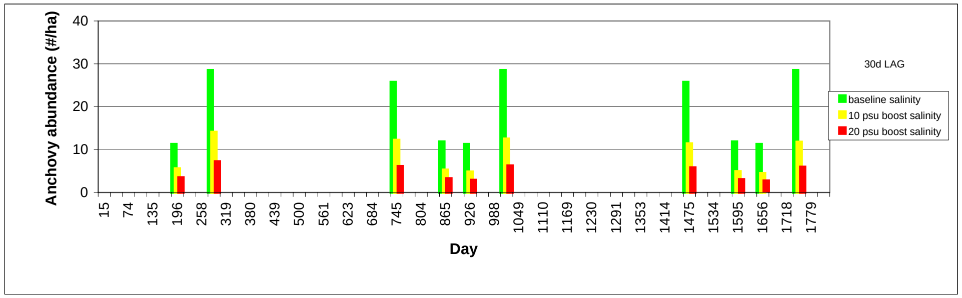


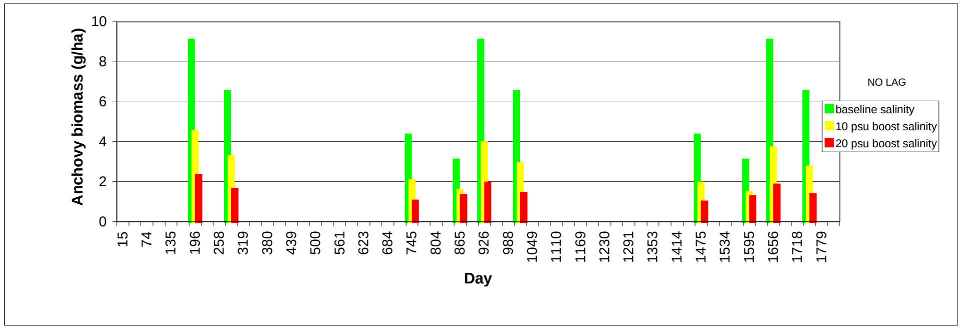












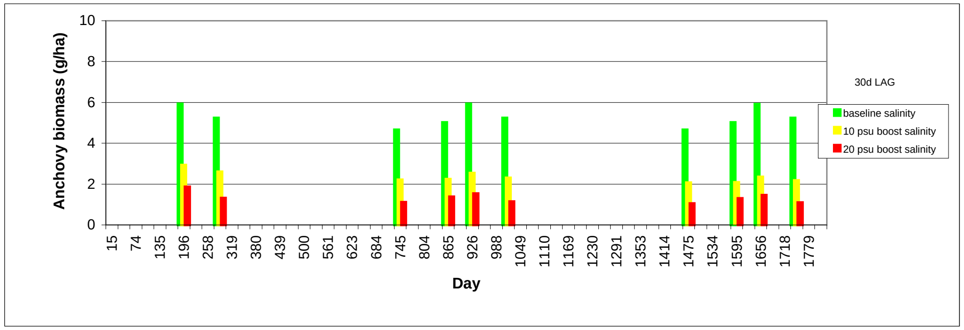
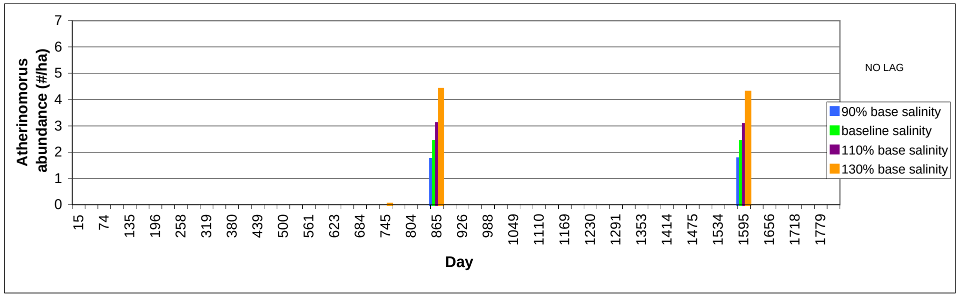
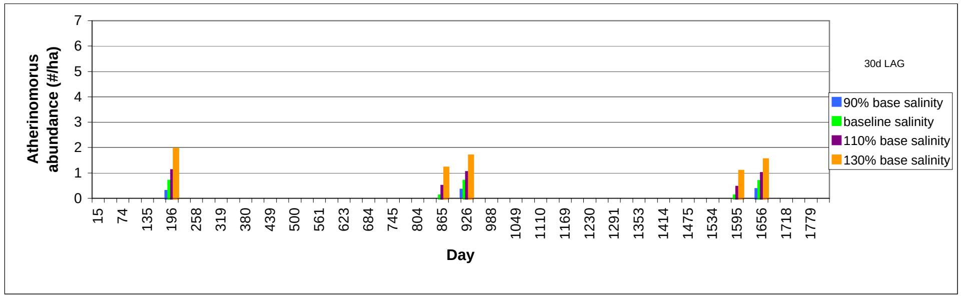
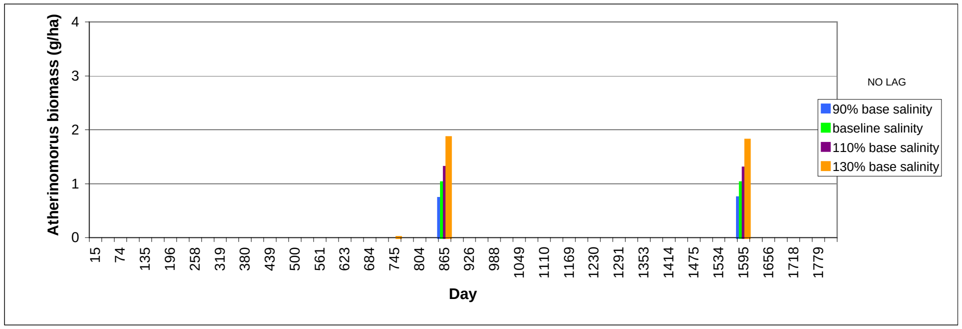


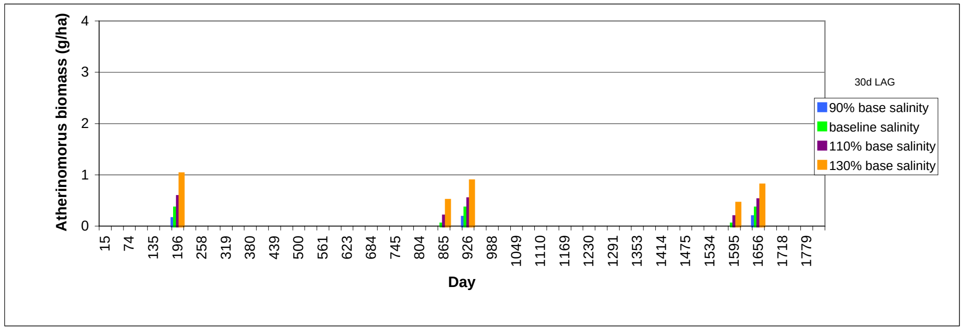
Figure 62. Little Madeira Bay Scenario – *Atherinomorus stipes* abundance and biomass-trawl/seine

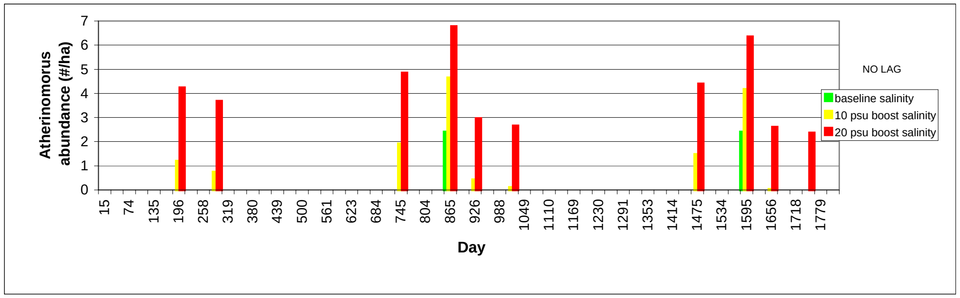
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

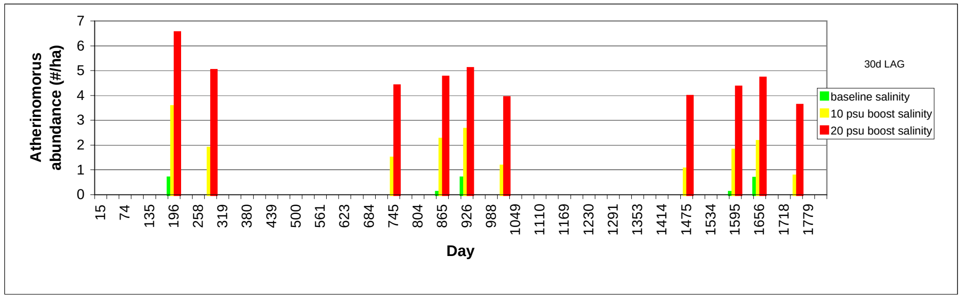


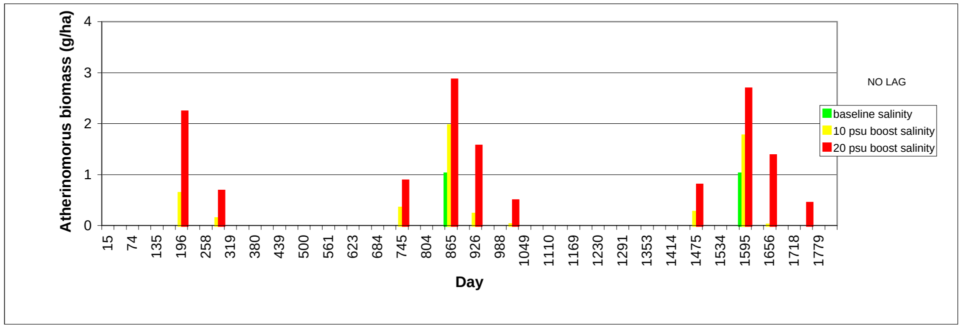












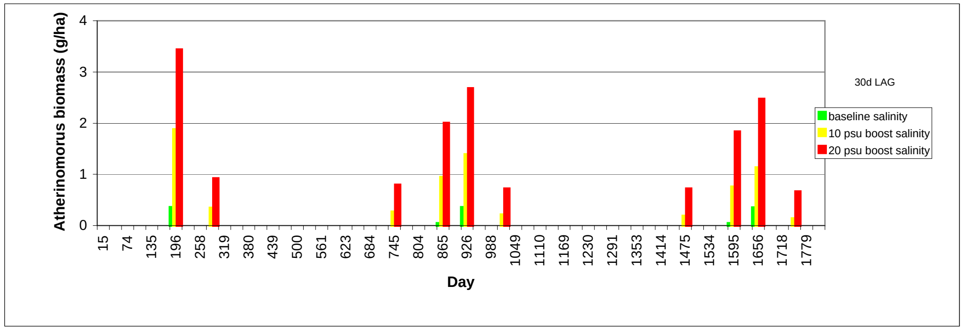
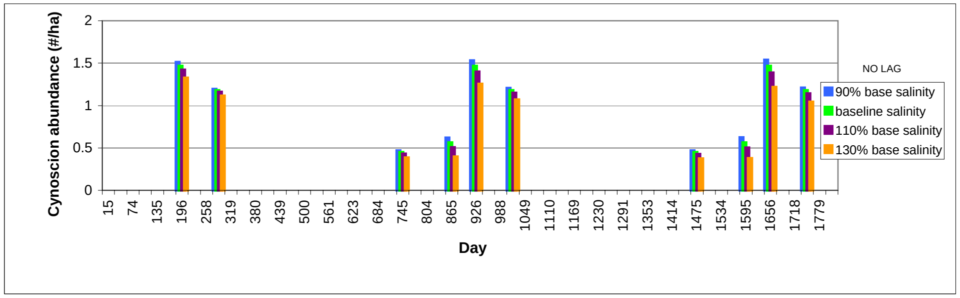
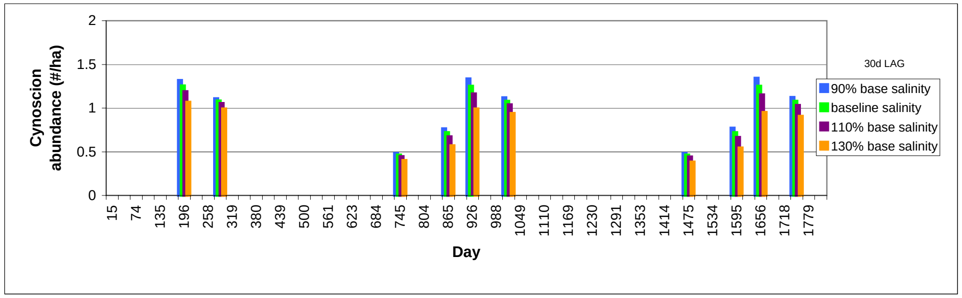
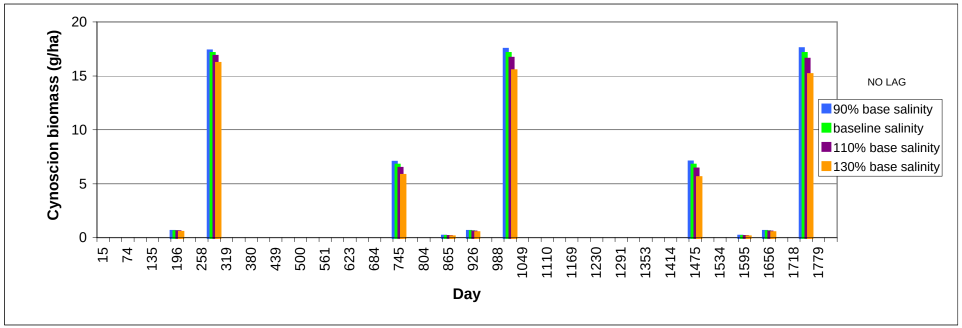


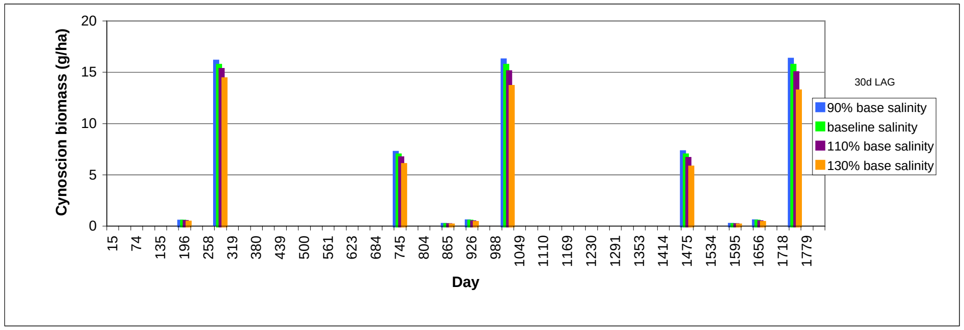
Figure 63. Little Madeira Bay Scenario – *Cynoscion nebulosus* abundance and biomass-trawl/seine

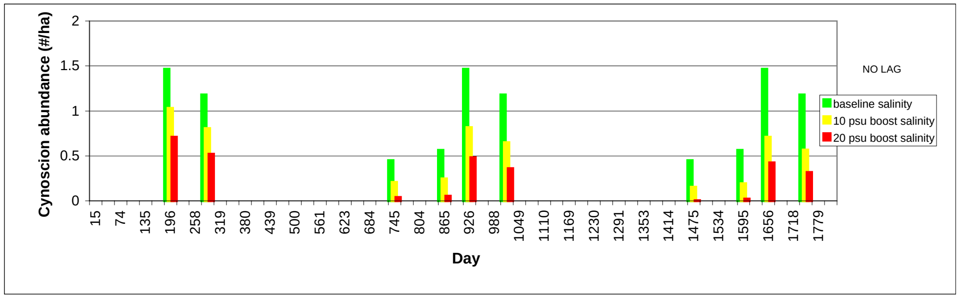
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

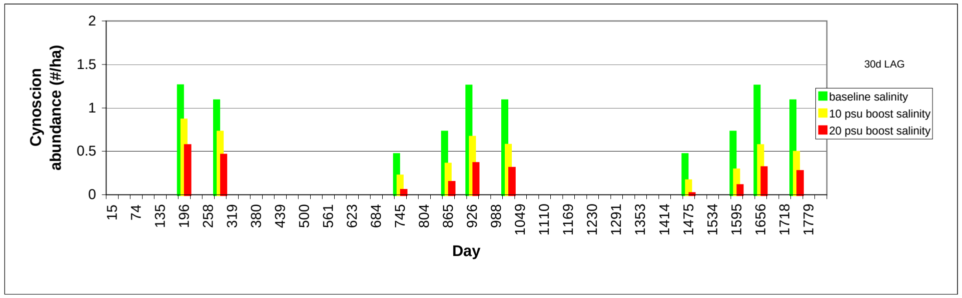


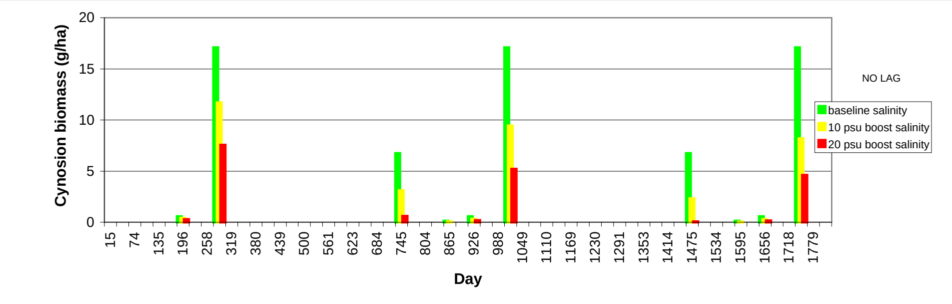












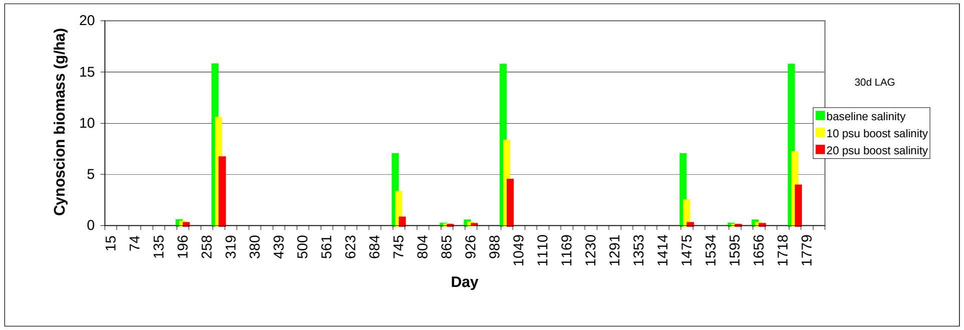
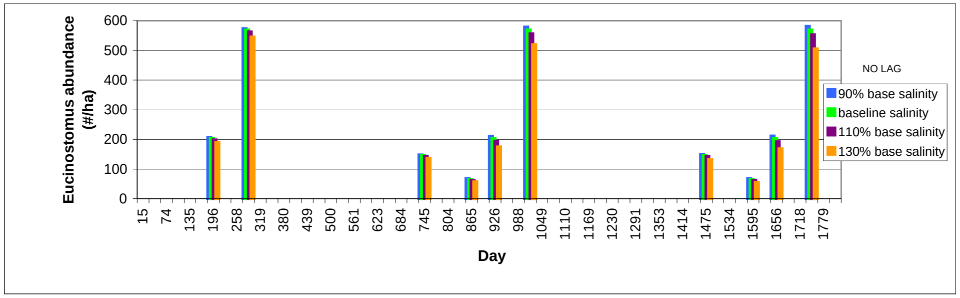
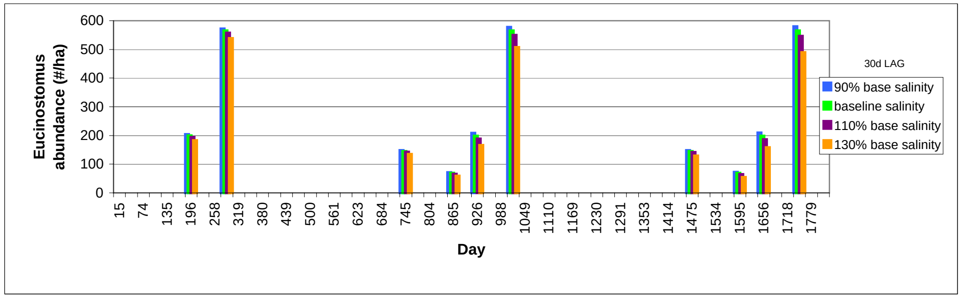
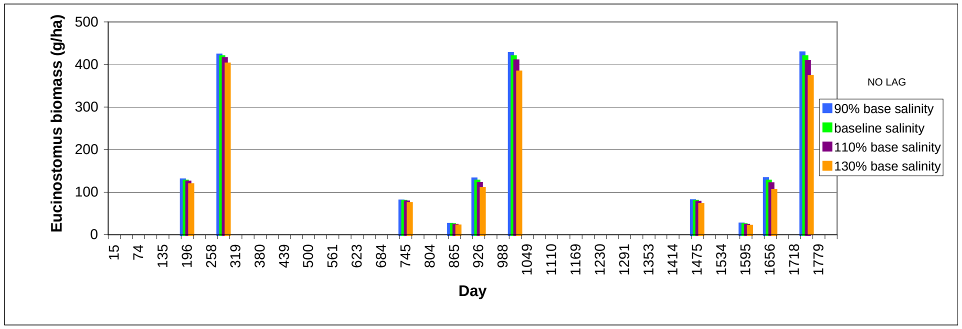


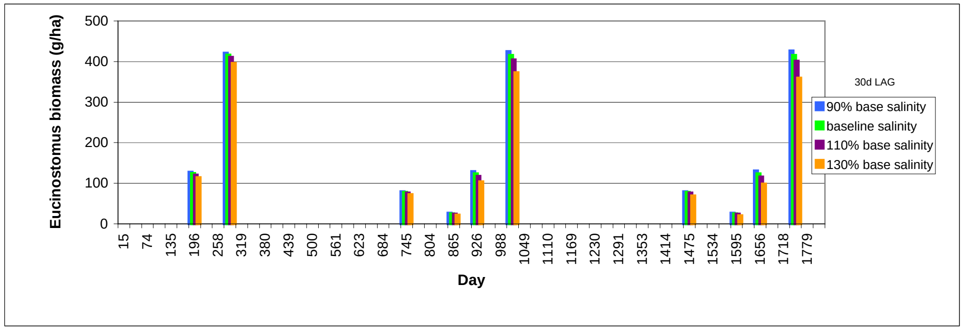
Figure 64. Little Madeira Bay Scenario – *Eucinostomus spp*. abundance and biomass-trawl/seine

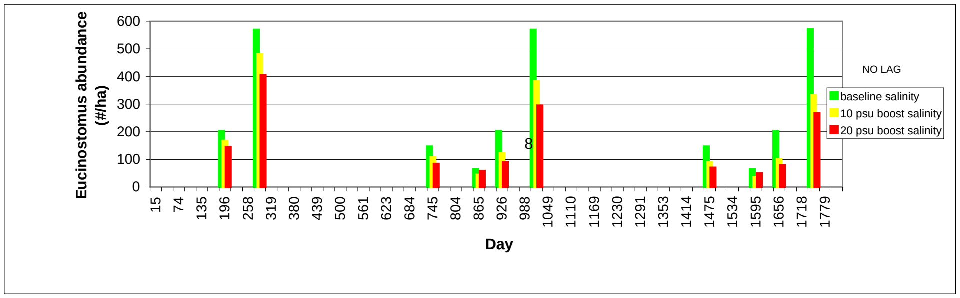
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

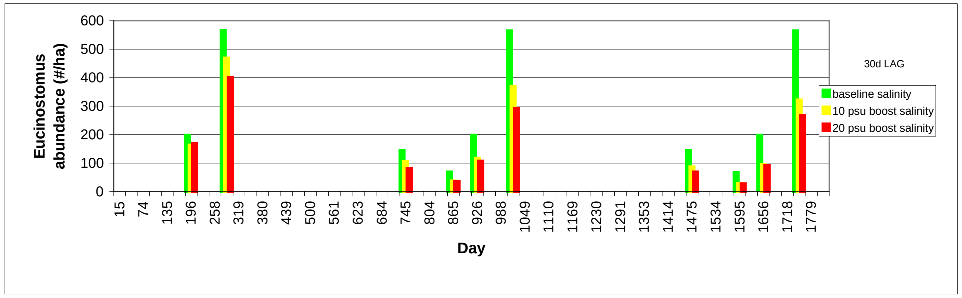


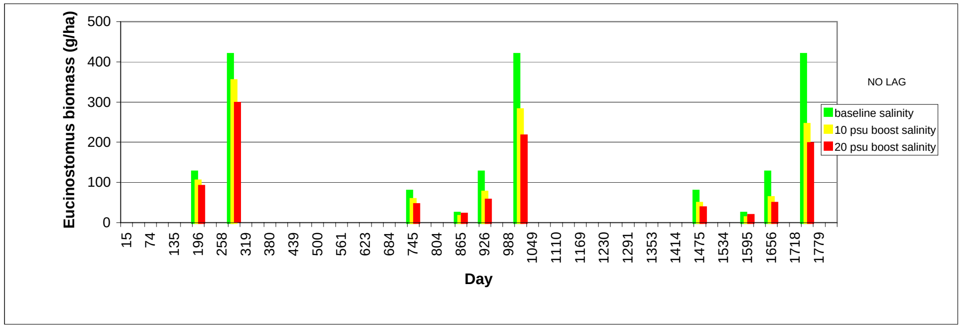












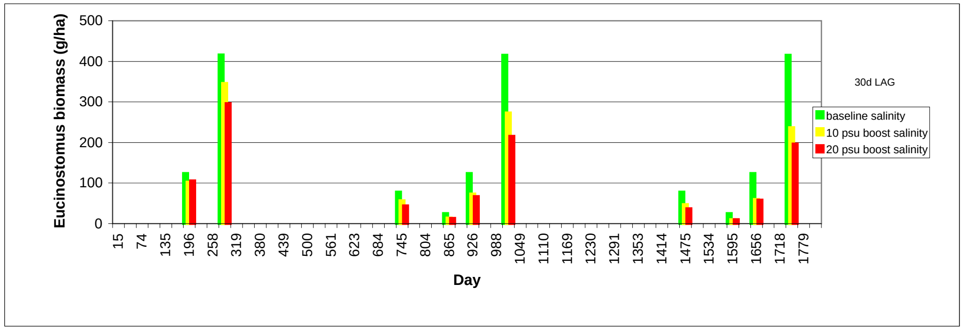
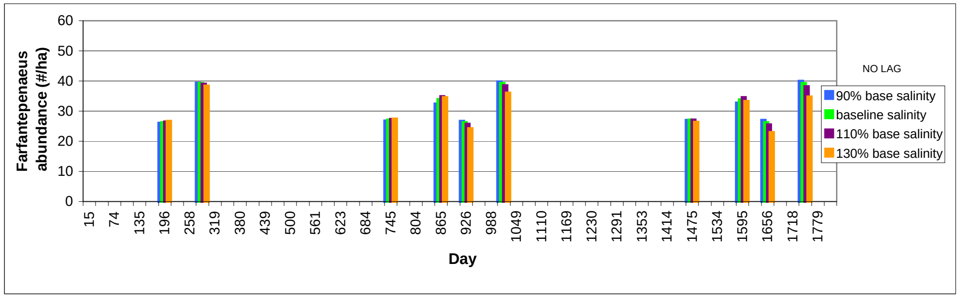
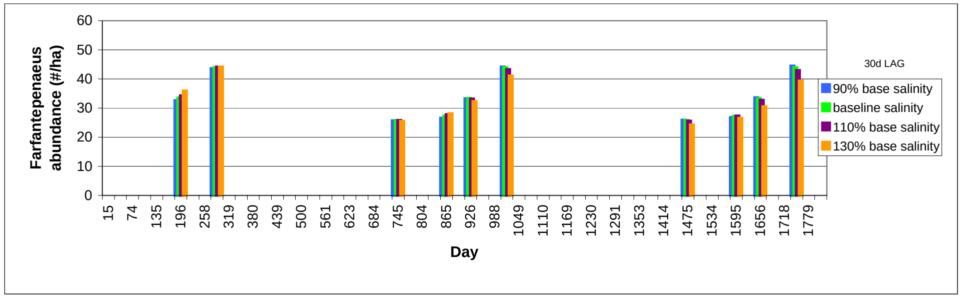
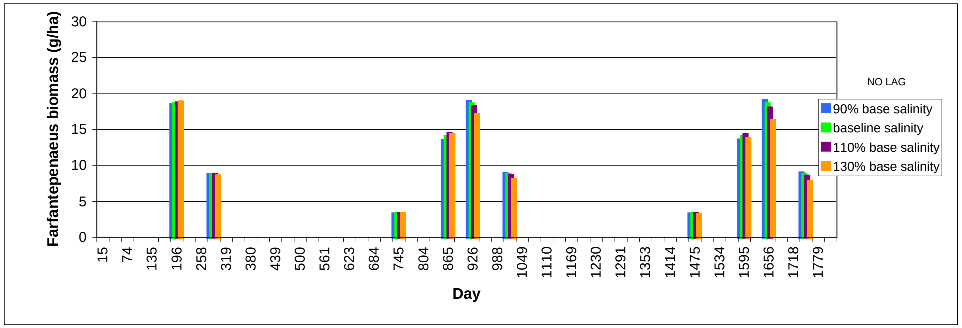


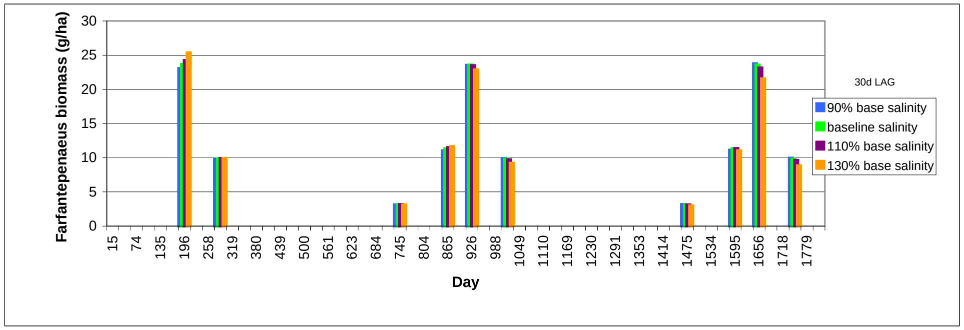
Figure 65. Little Madeira Bay Scenario – *Farfantepenaeus duorarum* abundance and biomass- trawl/seine

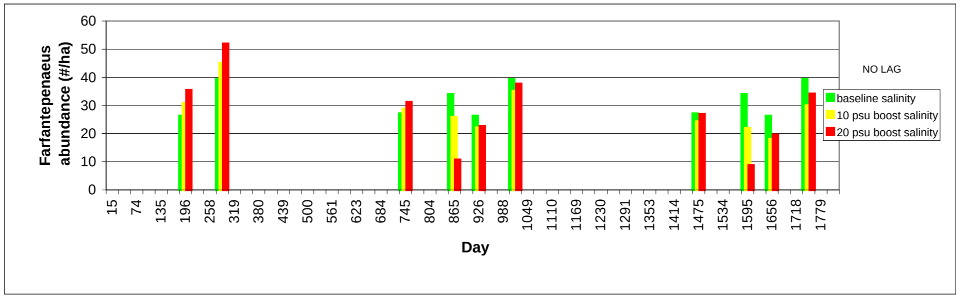
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

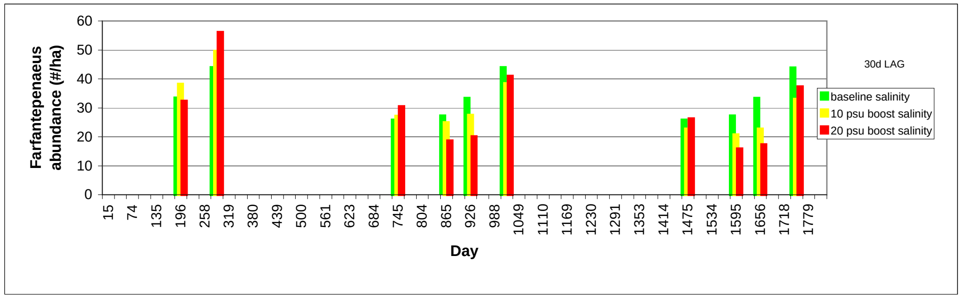


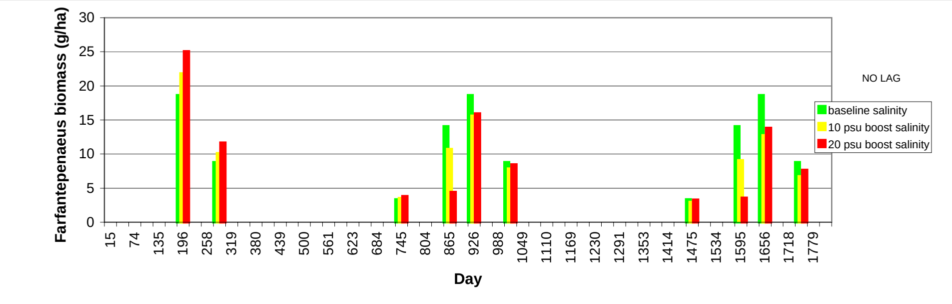












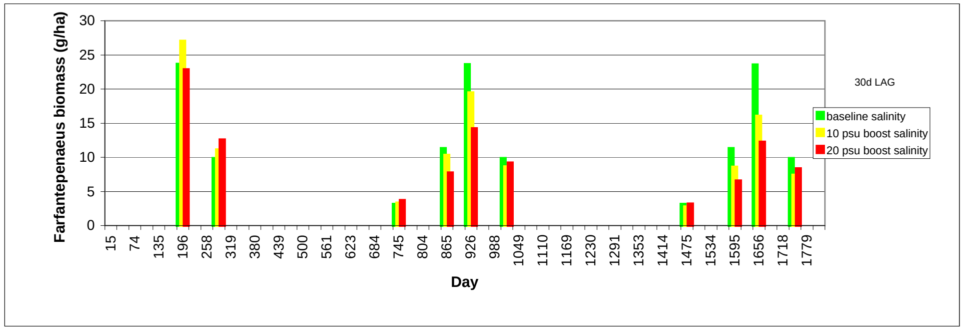
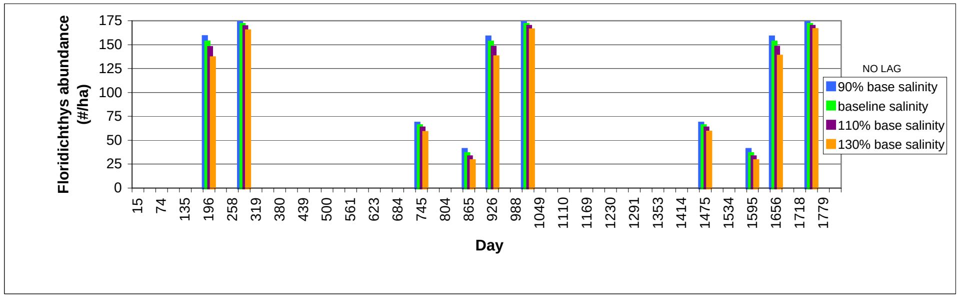
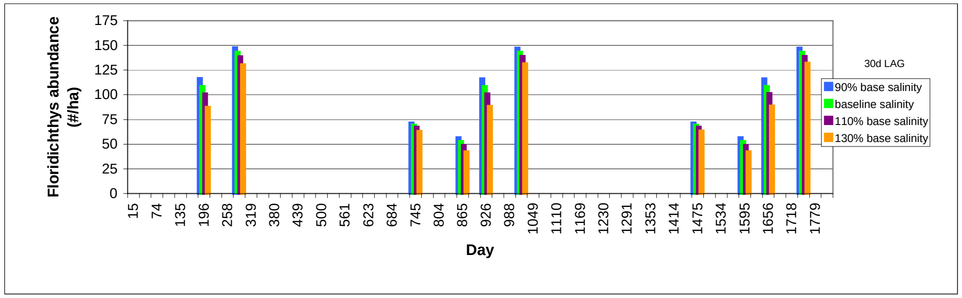
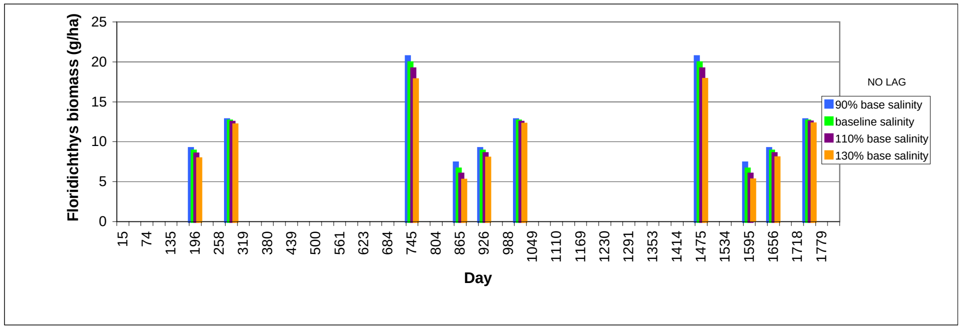


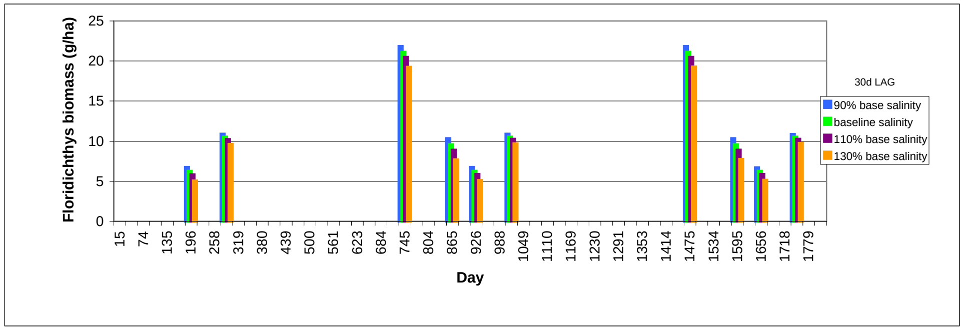
Figure 66. Little Madeira Bay Scenario – *Floridichthys carpio* abundance and biomass-trawl/seine

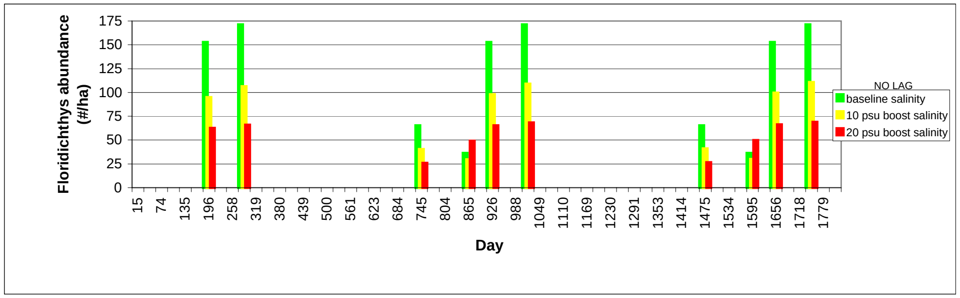
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

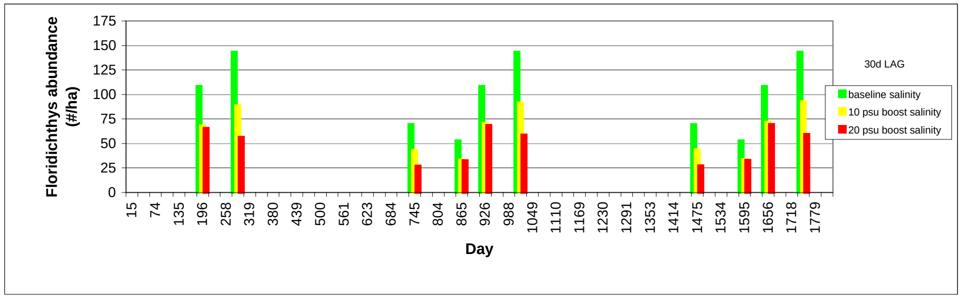


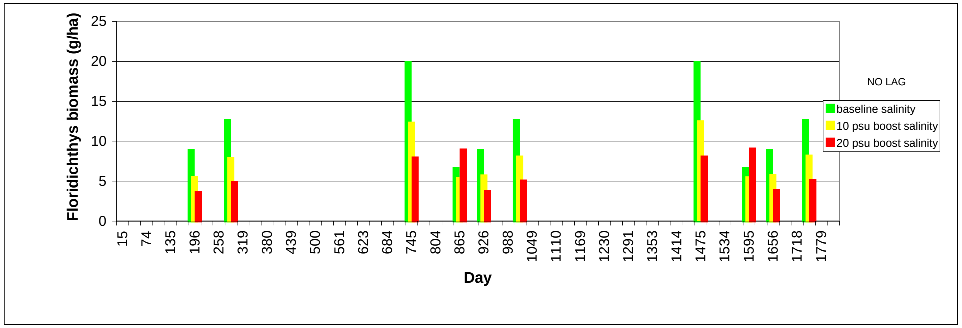












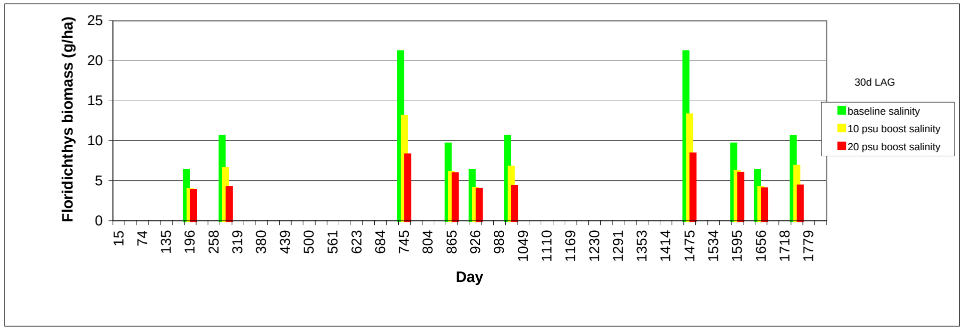
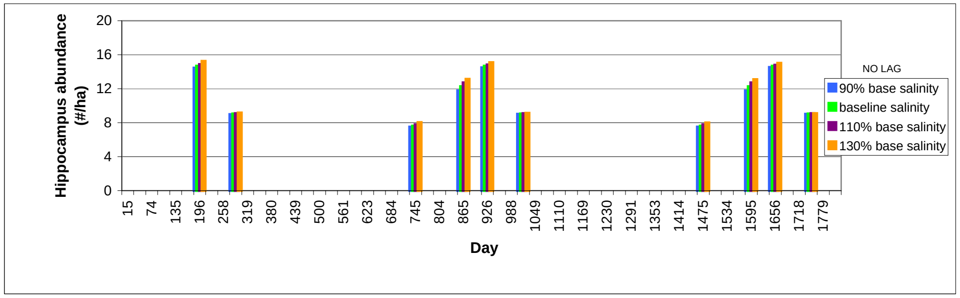
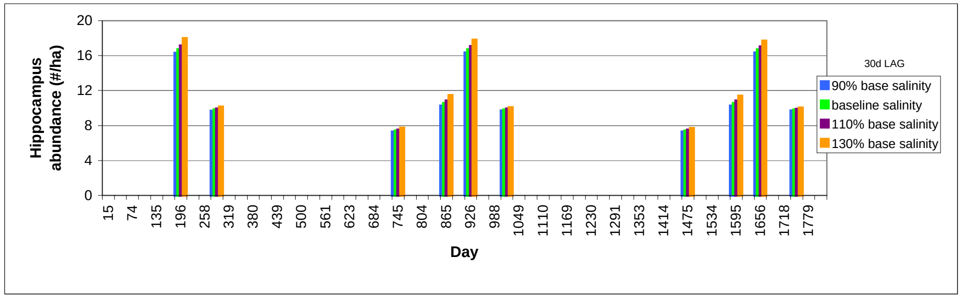
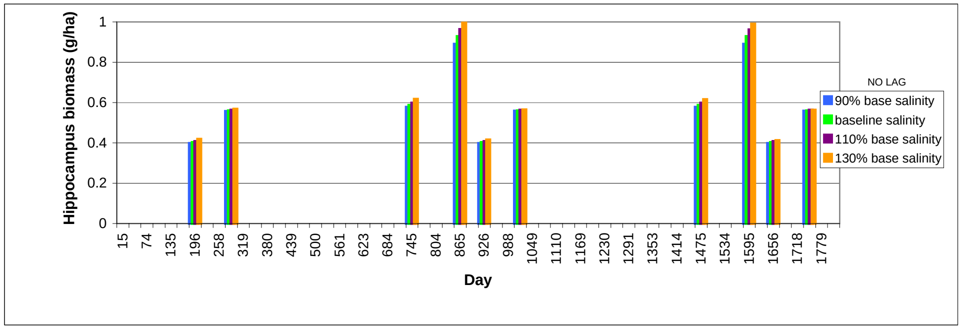


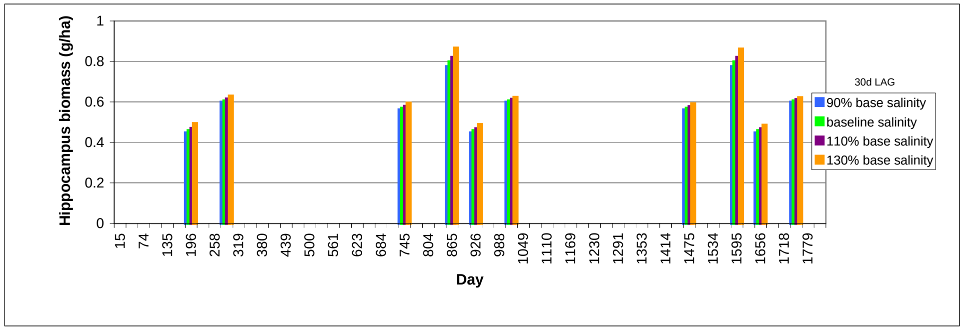
Figure 67. Little Madeira Bay Scenario – *Hippocampus zosterae* abundance and biomass-trawl/seine

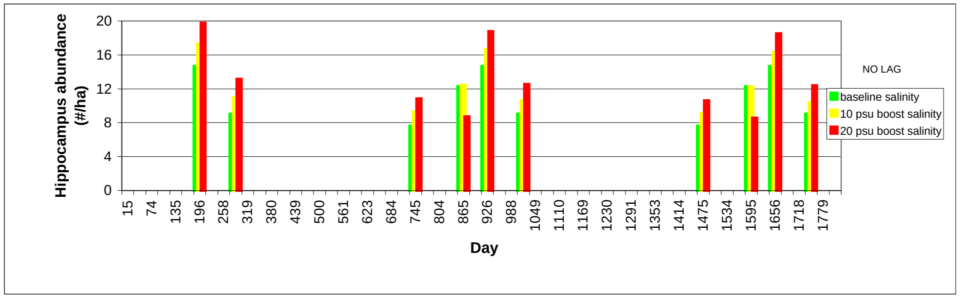
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

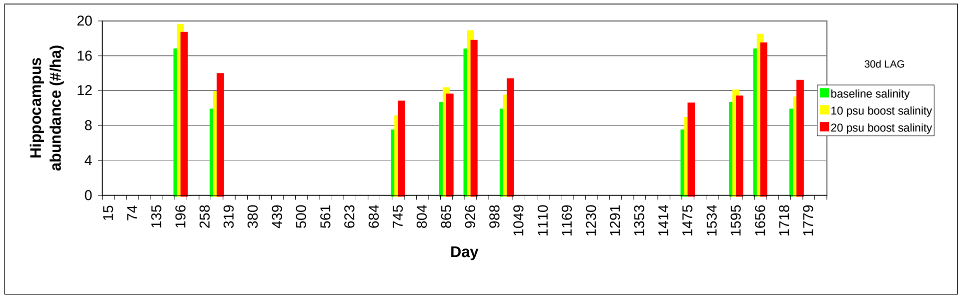


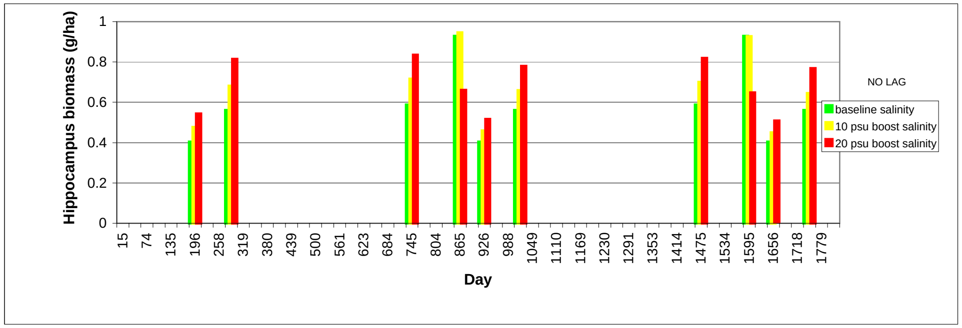












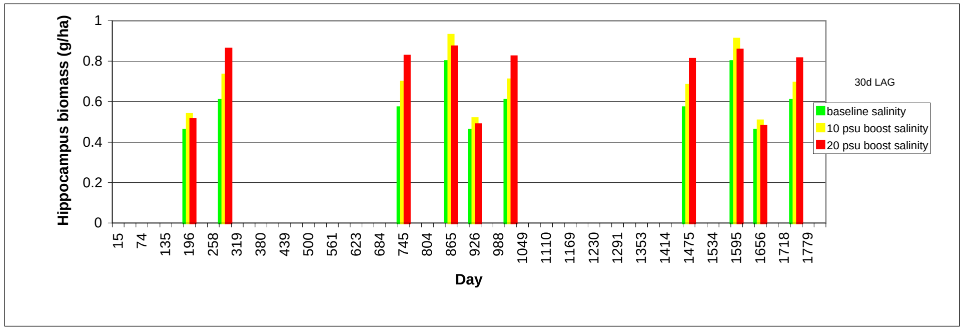
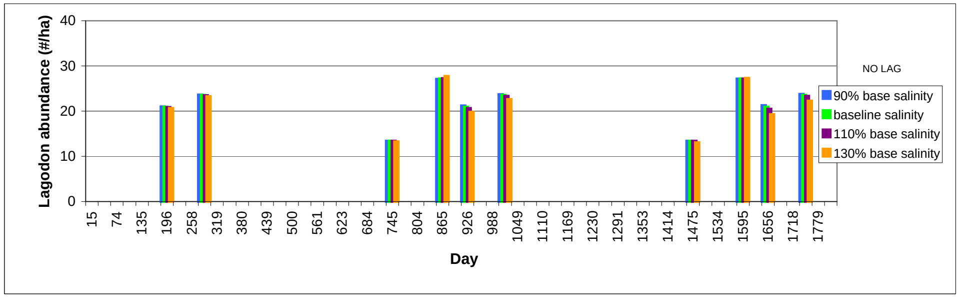
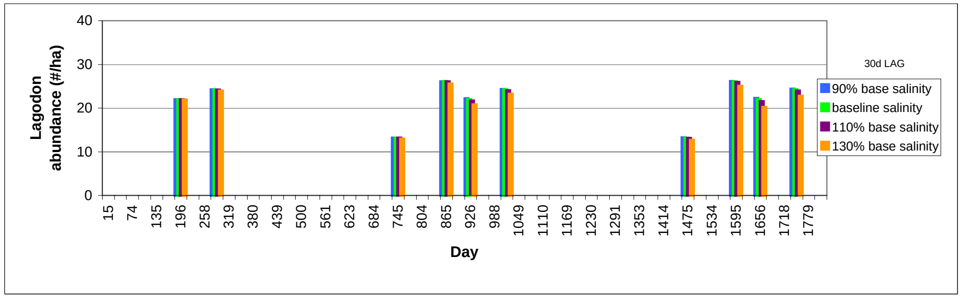
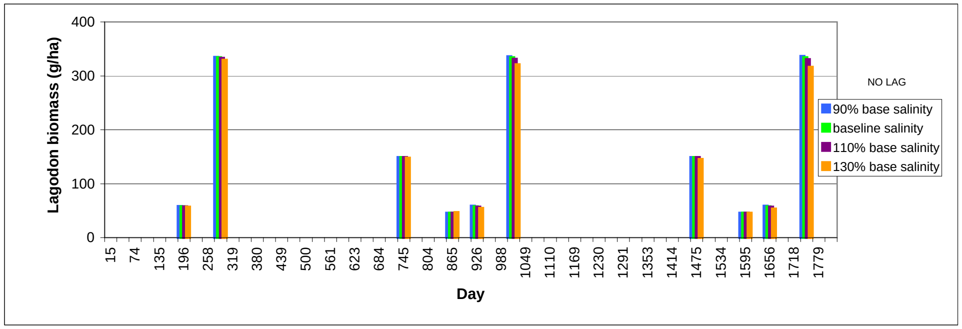


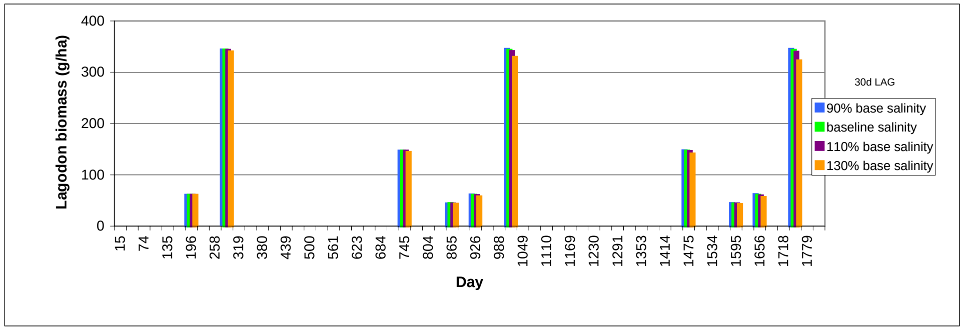
Figure 68. Little Madeira Bay Scenario – *Lagodon rhomboides* abundance and biomass-trawl/seine

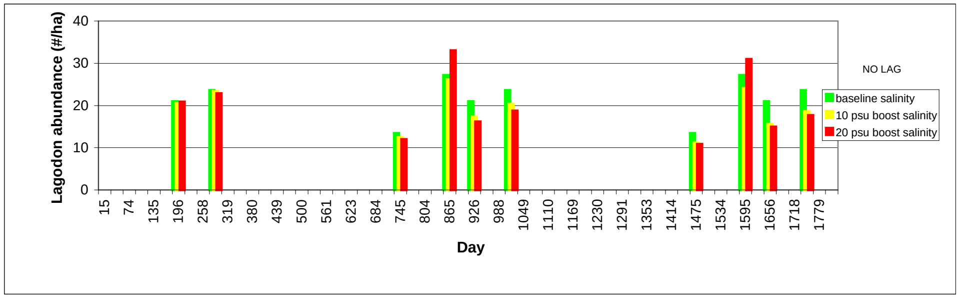
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

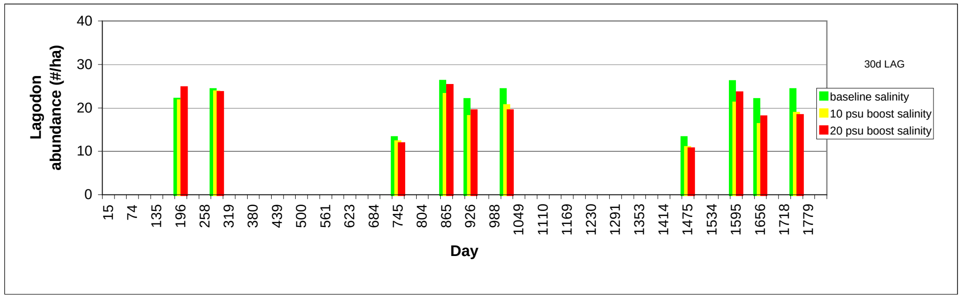


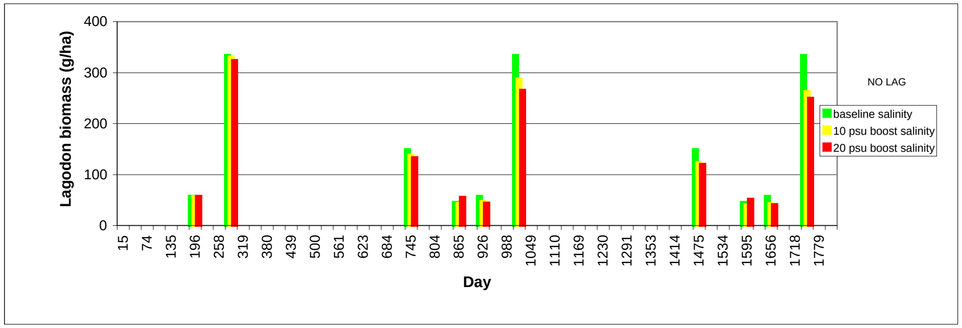












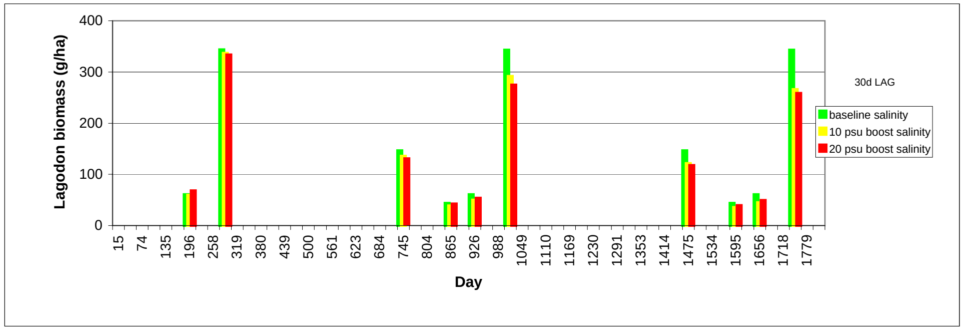
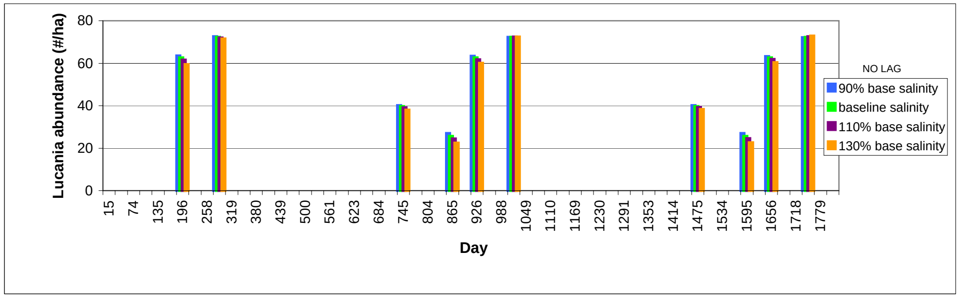
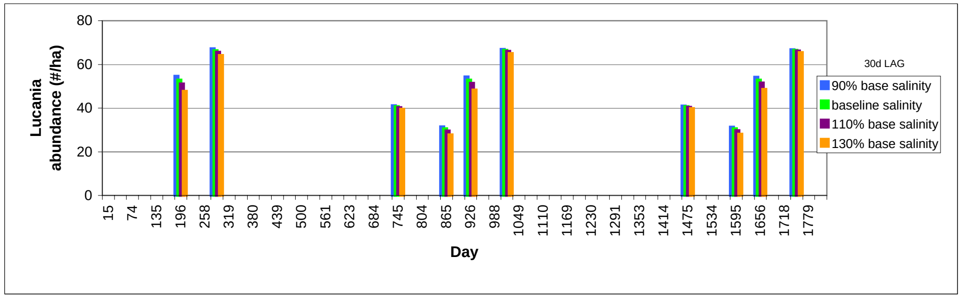
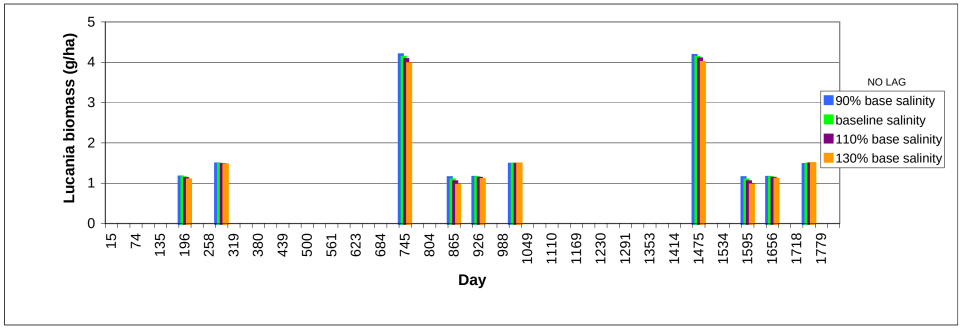


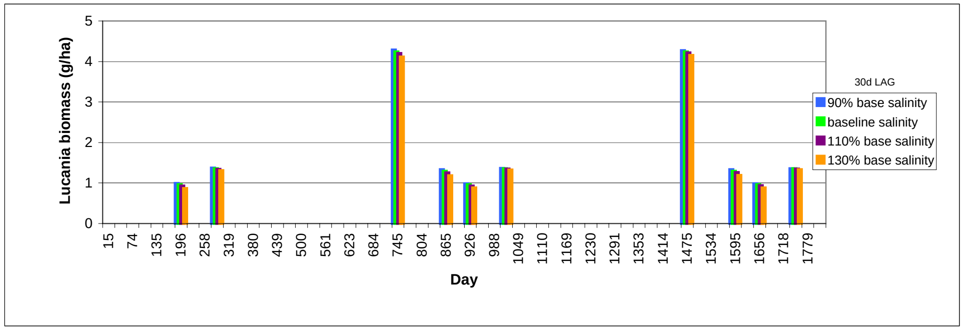
Figure 69. Little Madeira Bay Scenario – *Lucania parva* abundance and biomass-trawl/seine

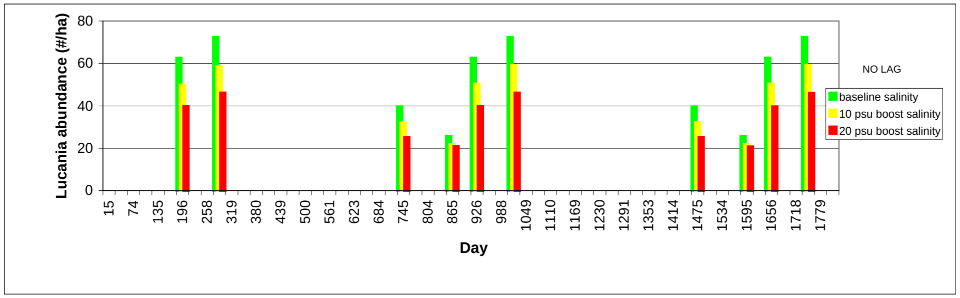
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

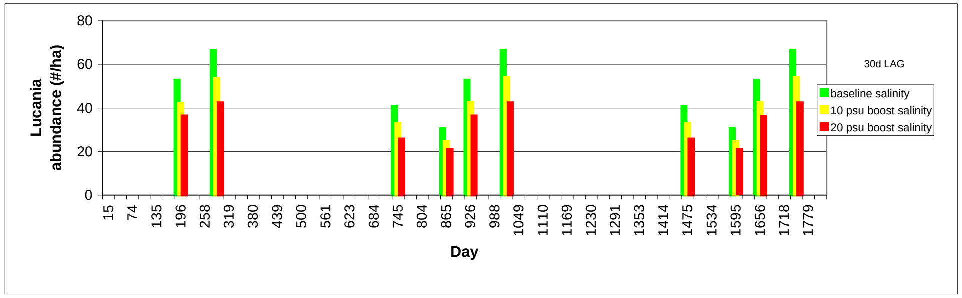


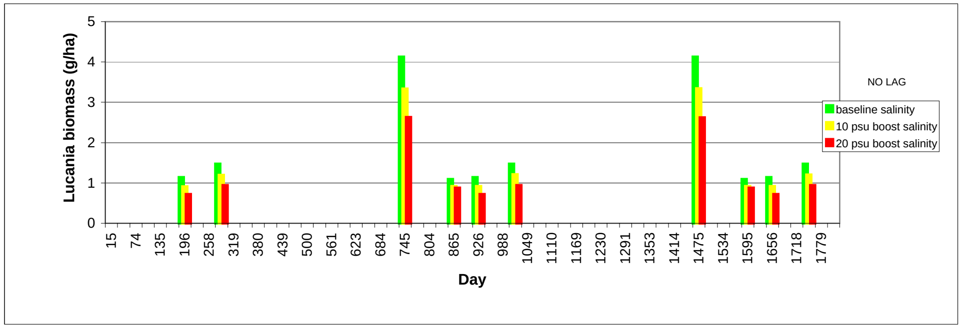












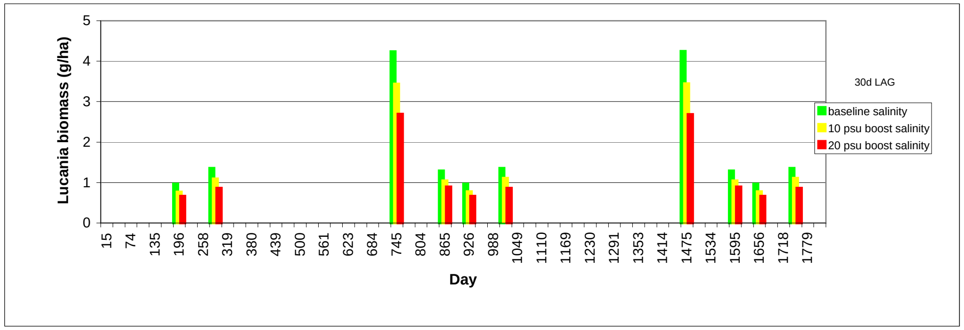
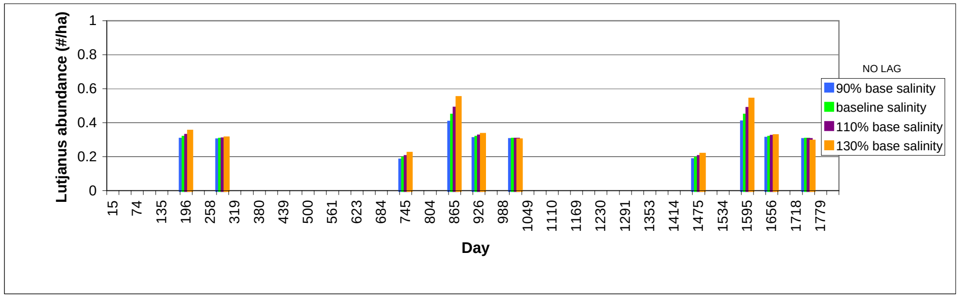
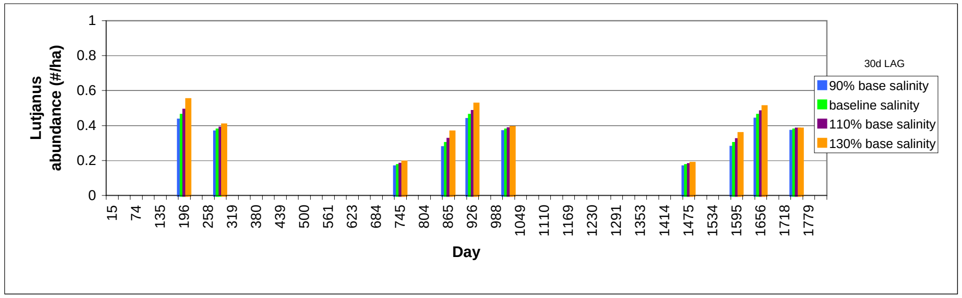
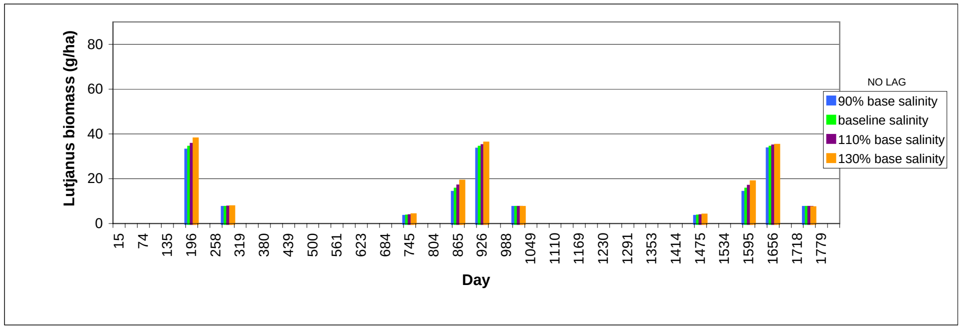


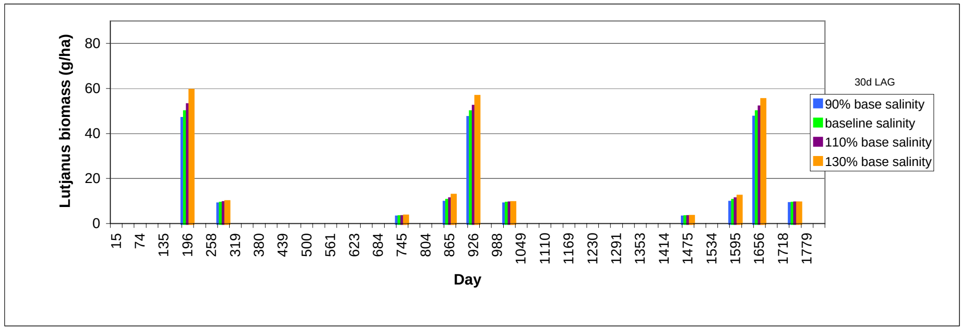
Figure 70. Little Madeira Bay Scenario – *Lutjanus griseus* abundance and biomass-trawl/seine

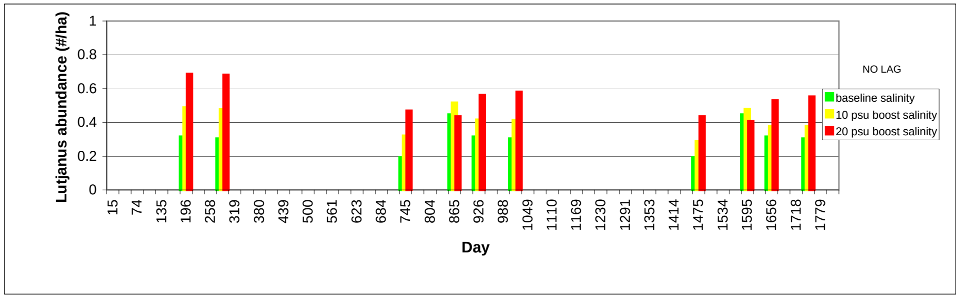
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

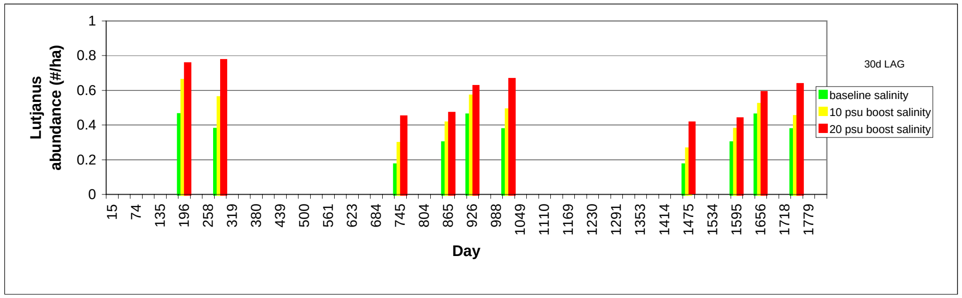


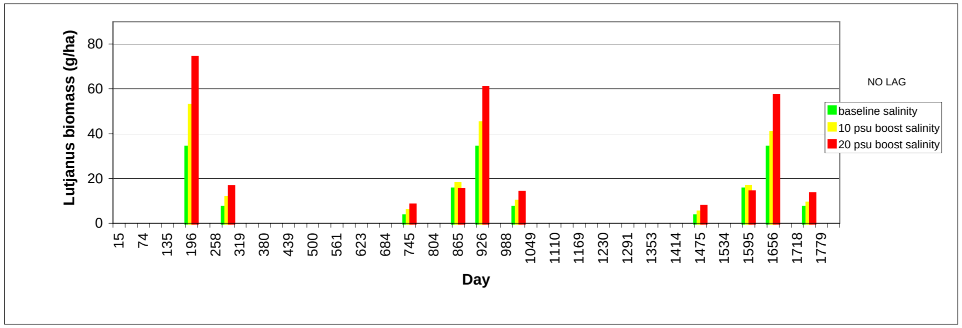












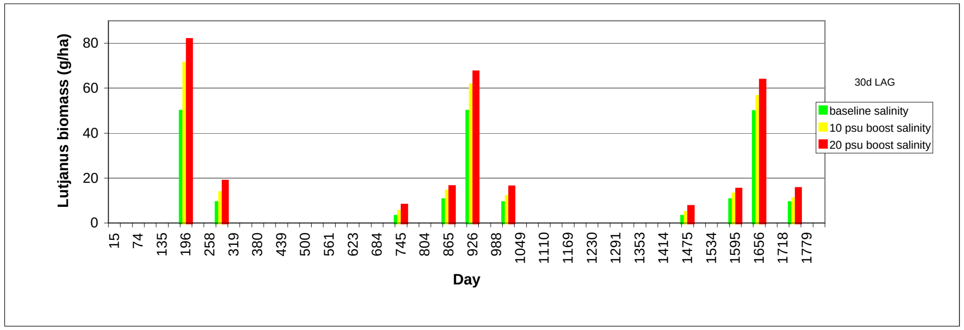
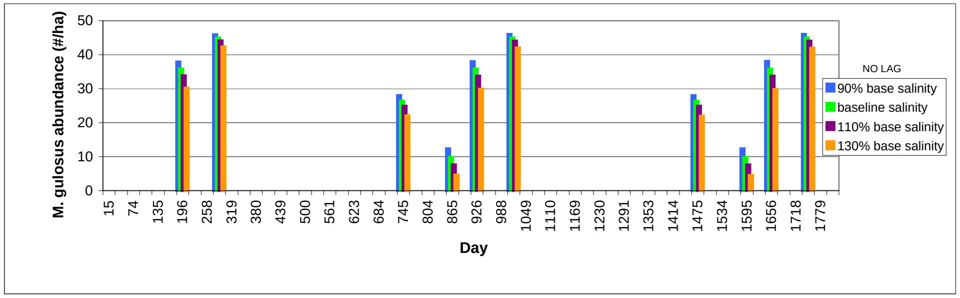
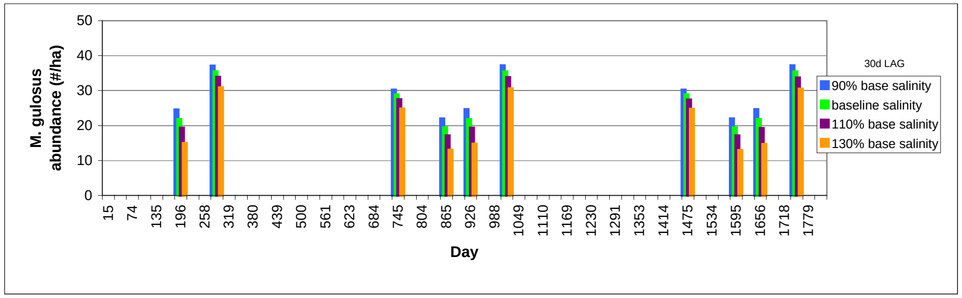
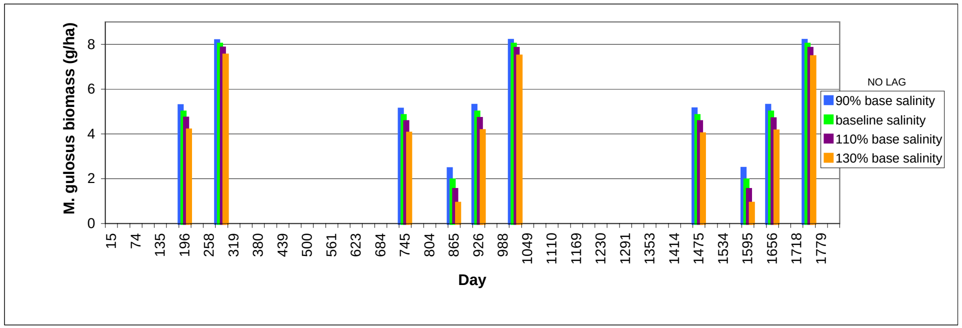


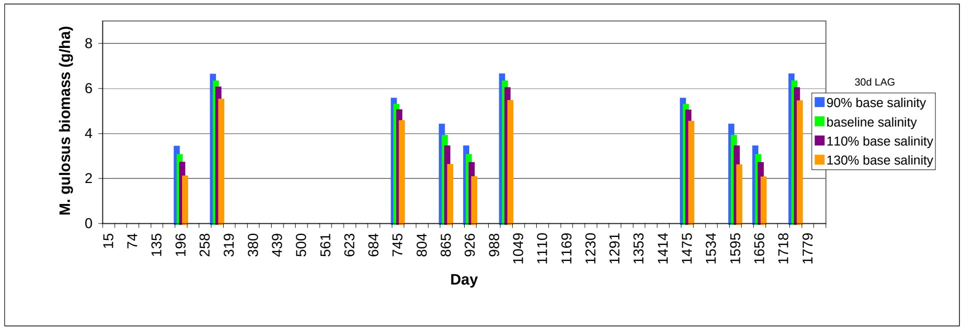
Figure 71. Little Madeira Bay Scenario – *Microgobius gulosus* abundance and biomass-trawl/seine

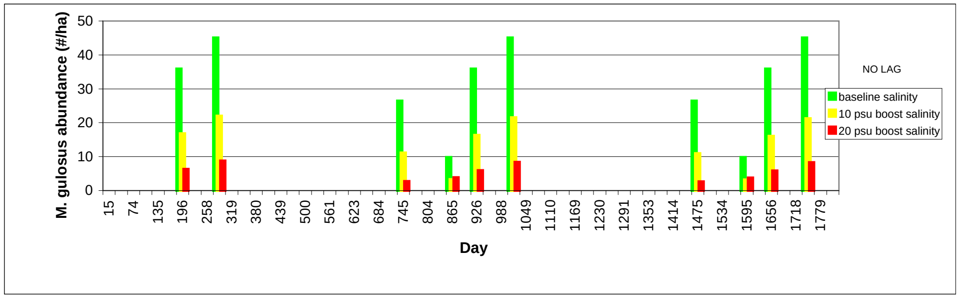
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

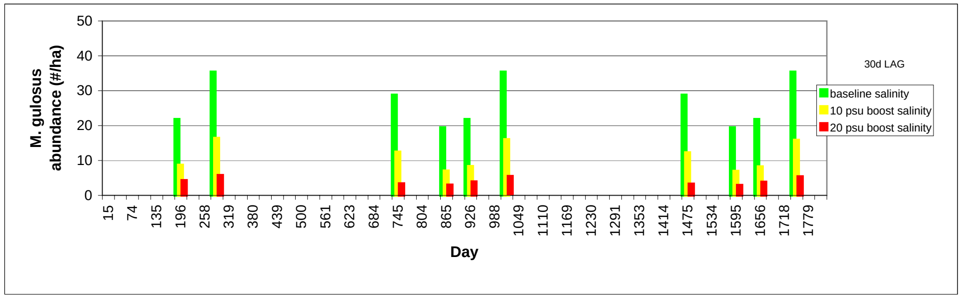


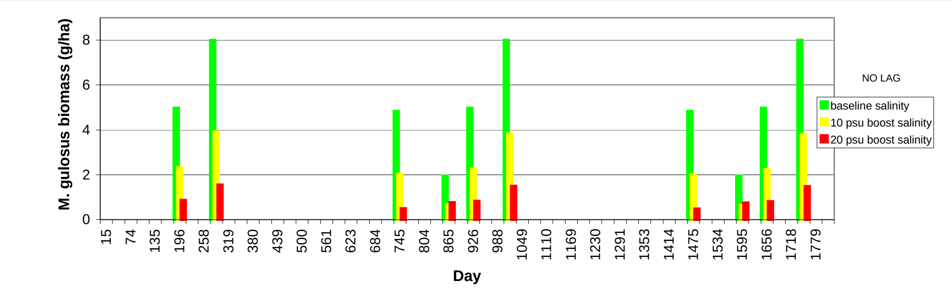












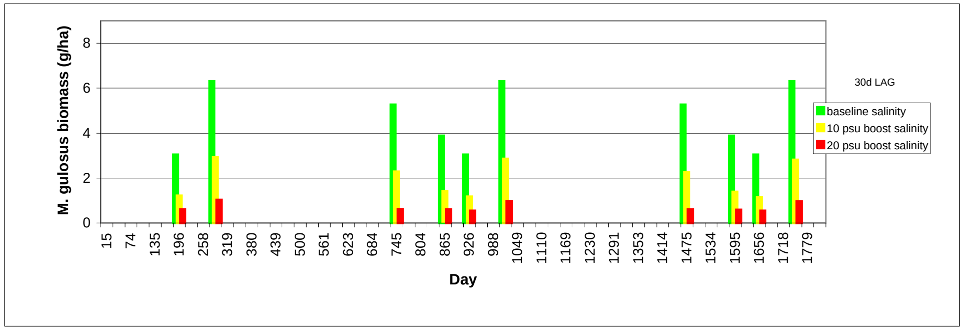
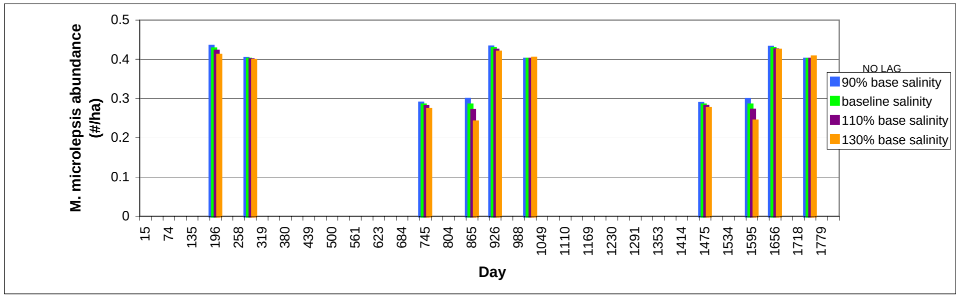
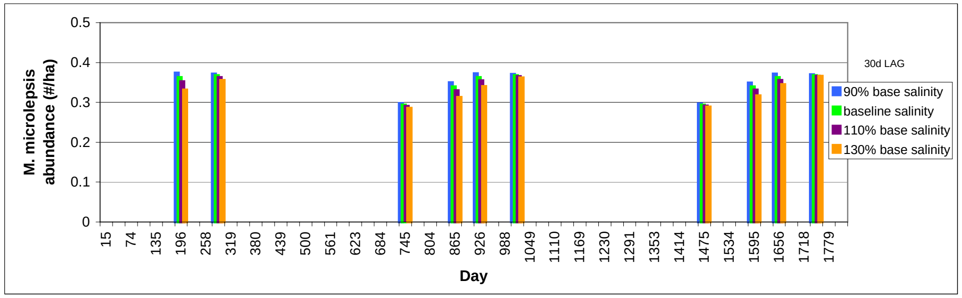
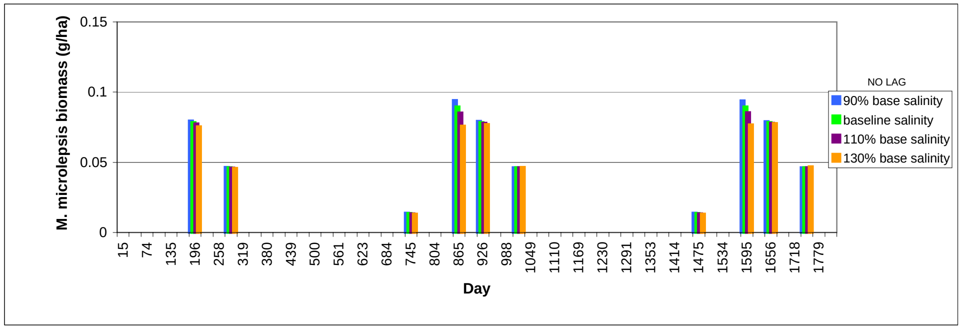


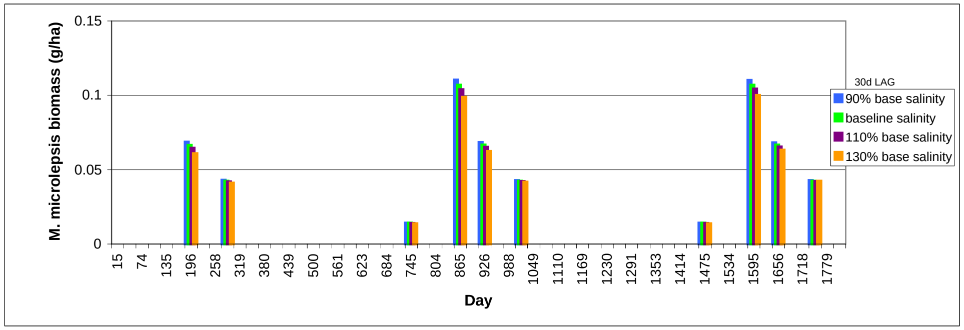
Figure 72. Little Madeira Bay Scenario – *Microgobius microlepis* abundance and biomass- trawl/seine

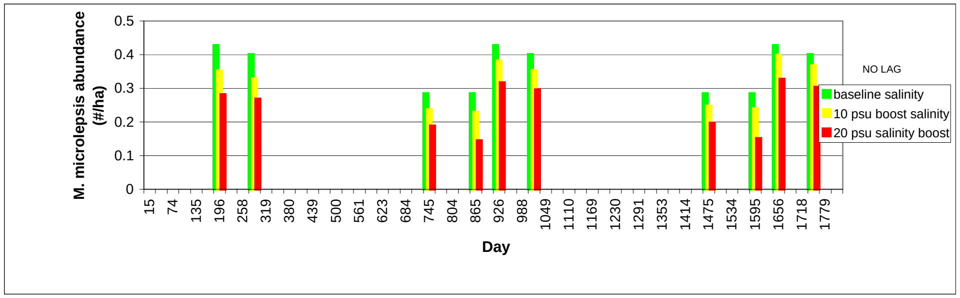
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

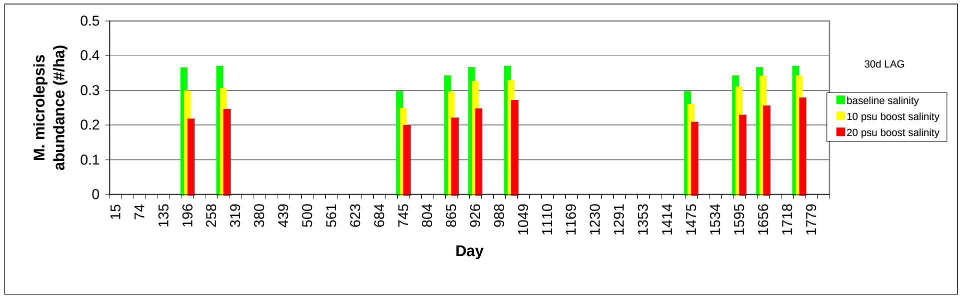


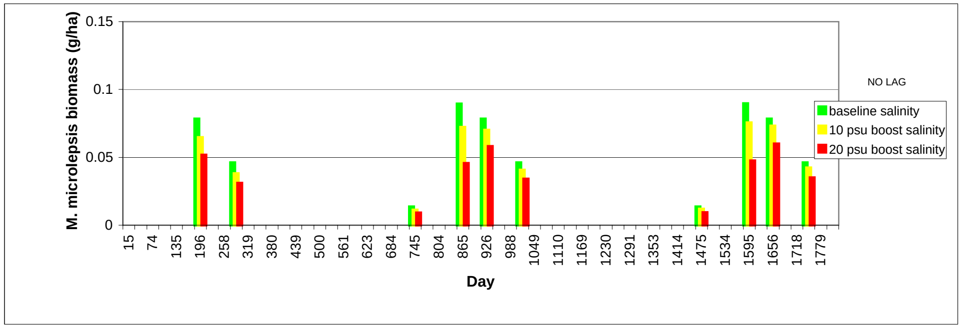












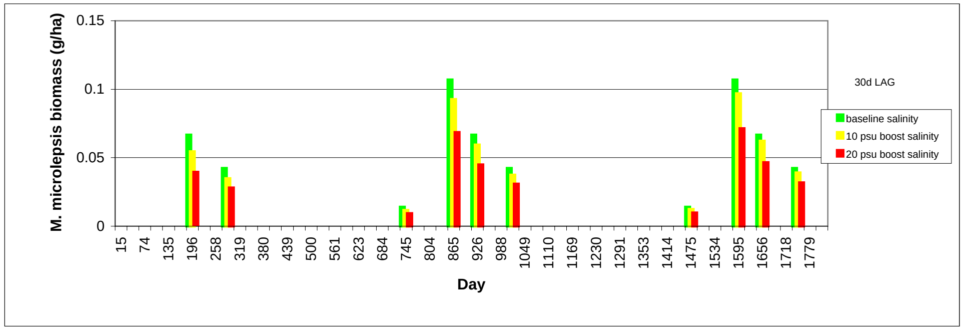
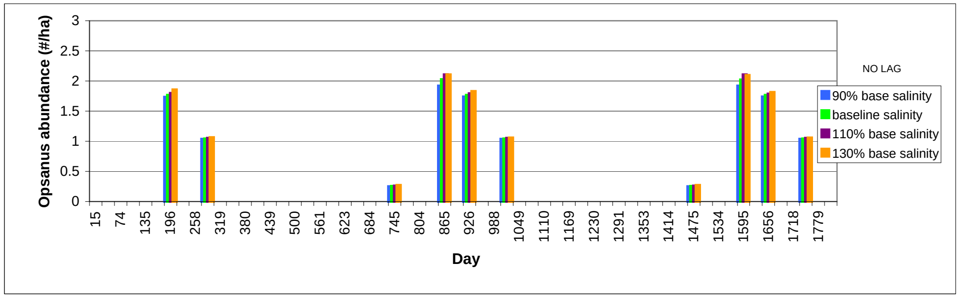
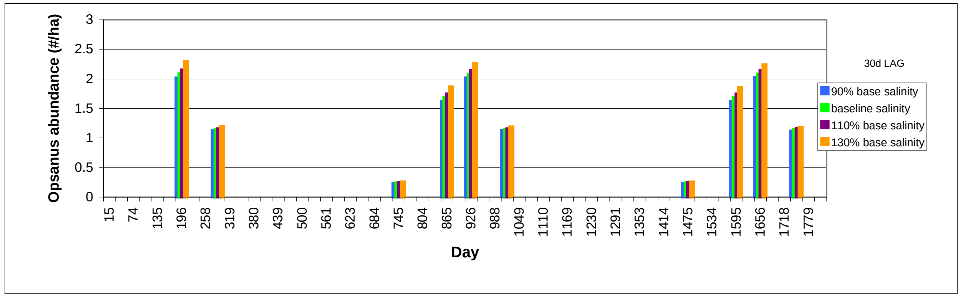
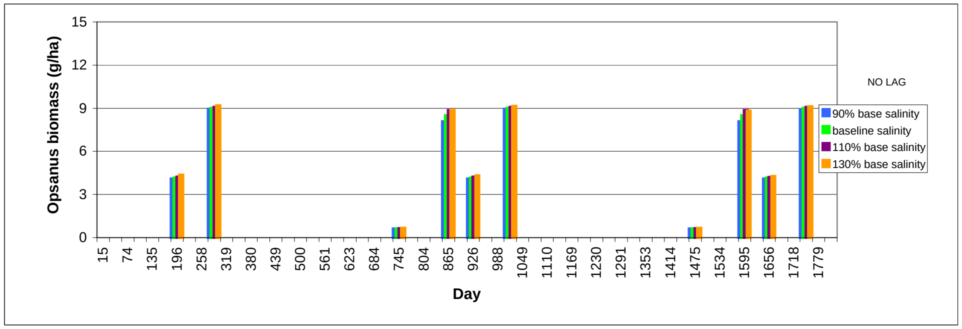


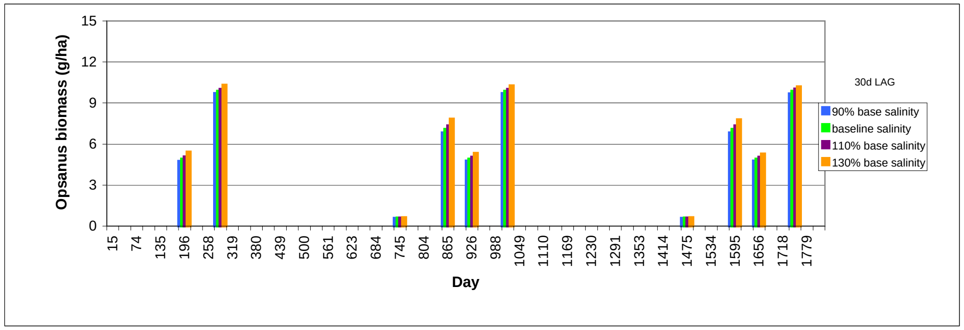
Figure 73. Little Madeira Bay Scenario – *Opsanus beta* abundance and biomass-trawl/seine

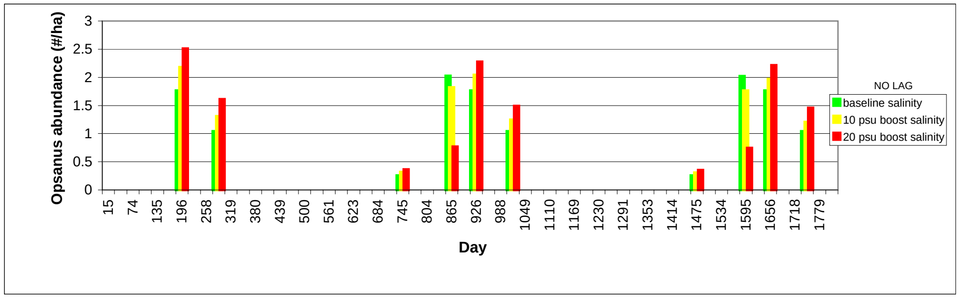
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

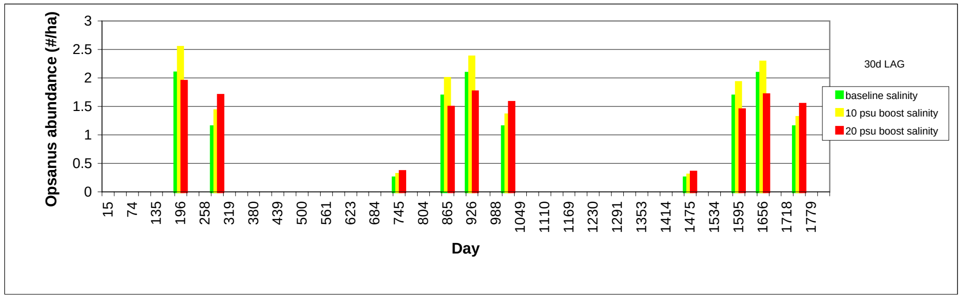


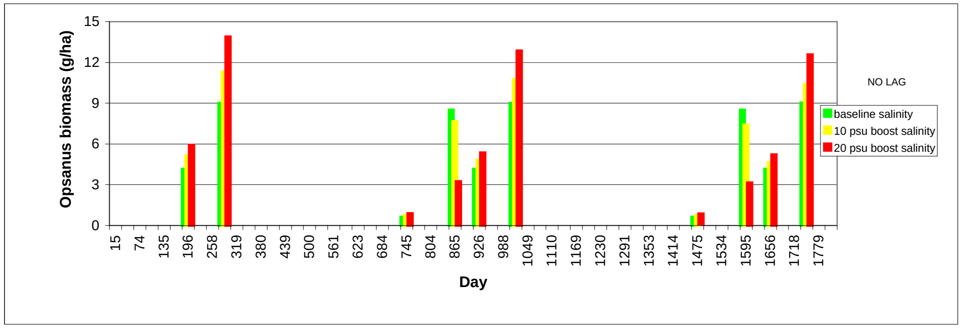












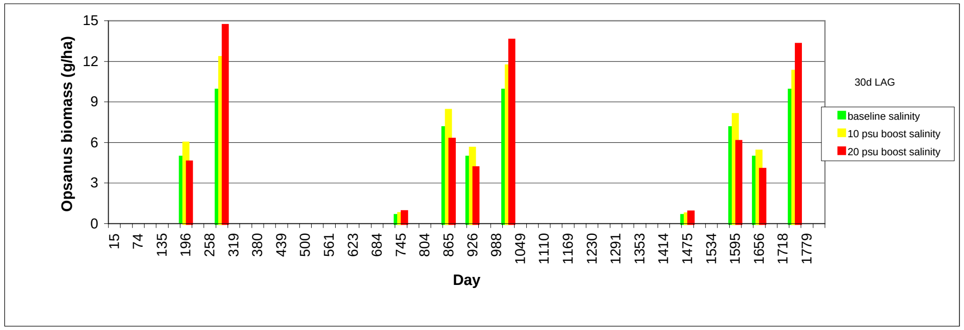
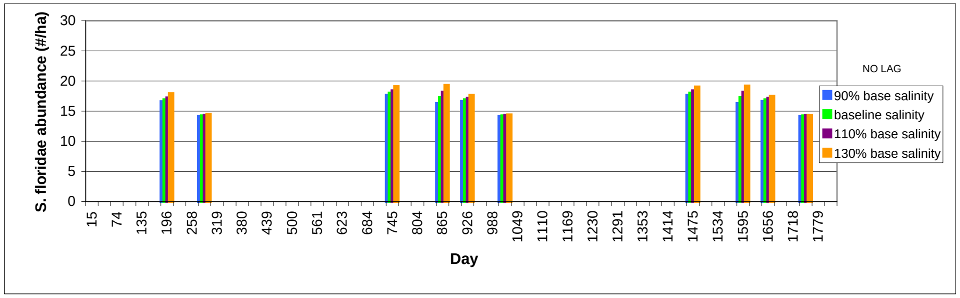
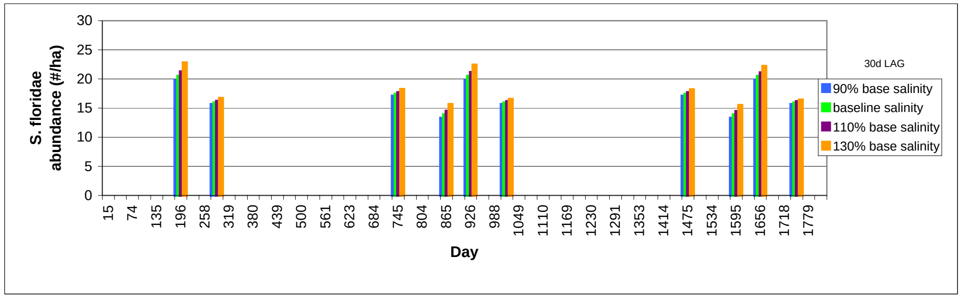
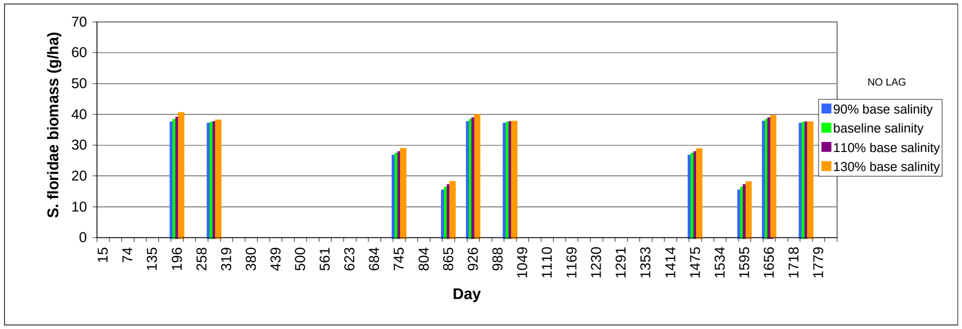


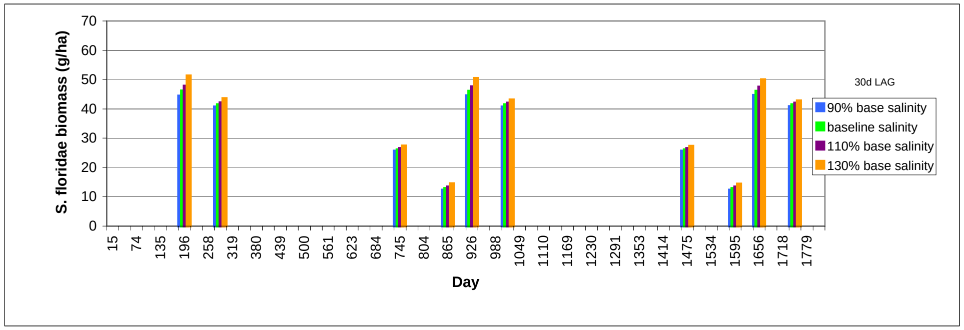
Figure 74. Little Madeira Bay Scenario – *Syngnathus floridae* abundance and biomass-trawl/seine

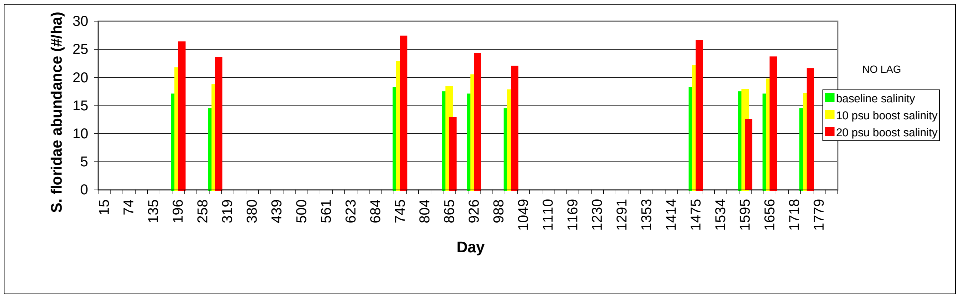
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

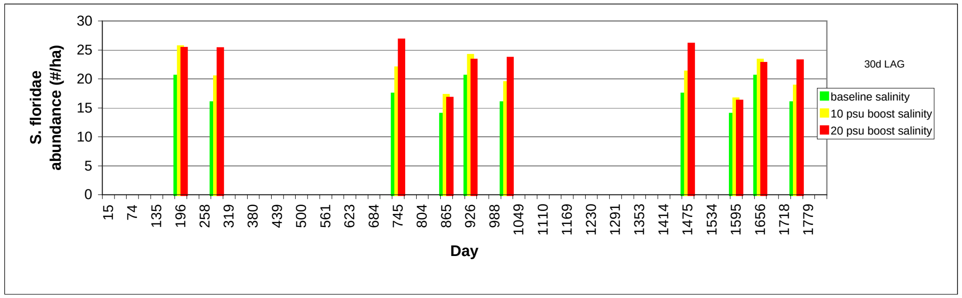


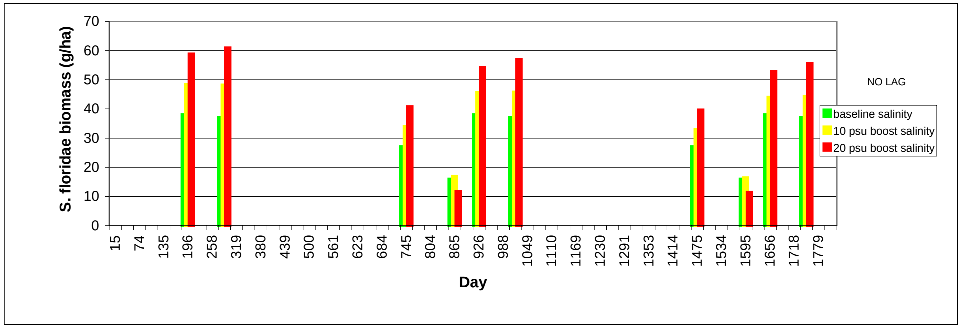












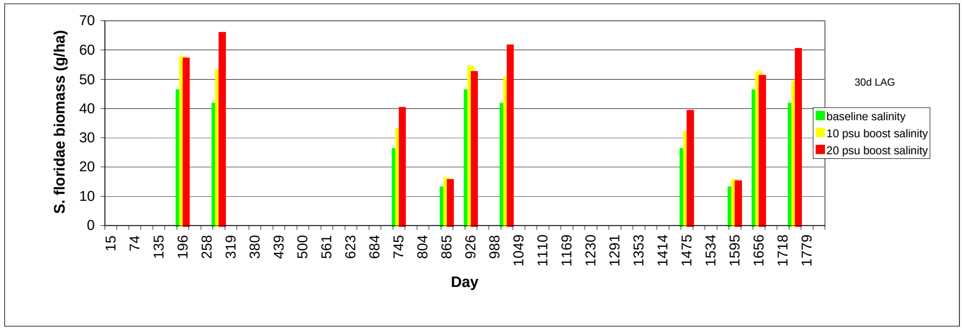
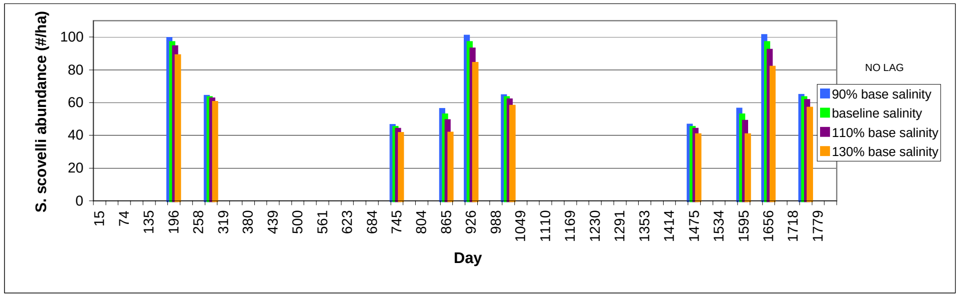
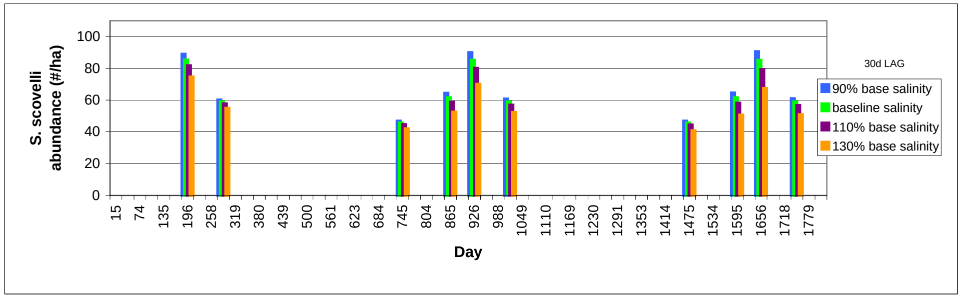
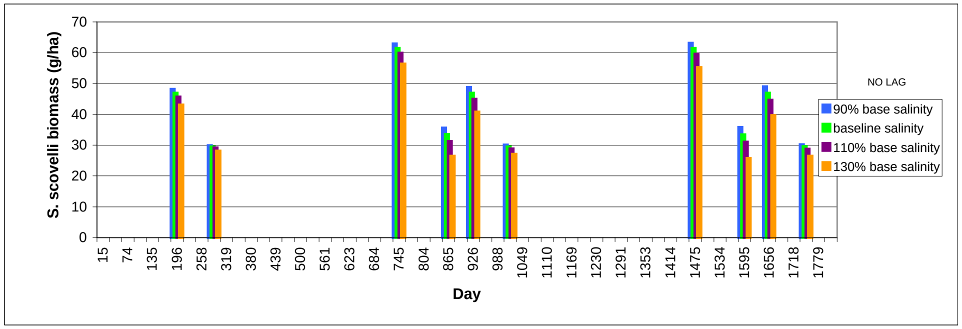


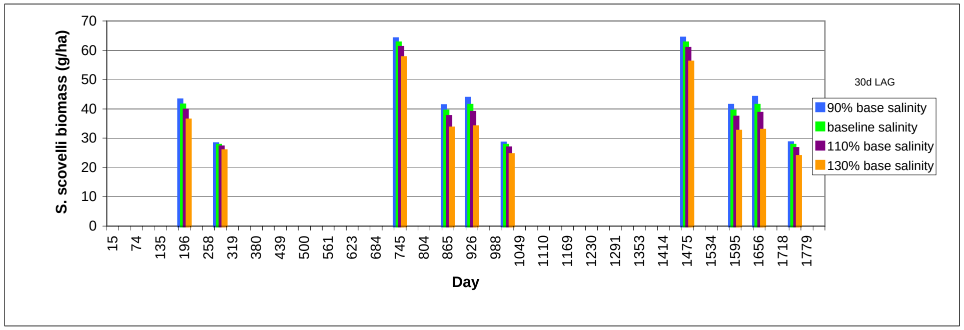
Figure 75. Little Madeira Bay Scenario – *Syngnathus scovelli* abundance and biomass-trawl/seine

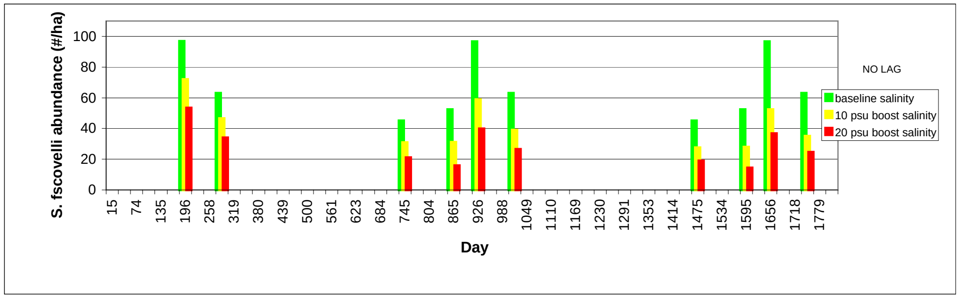
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

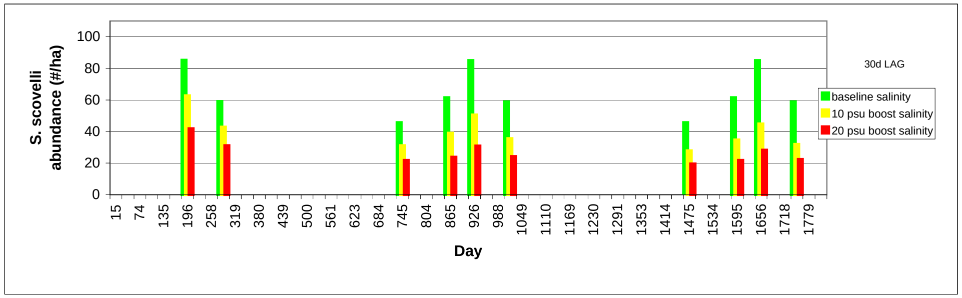


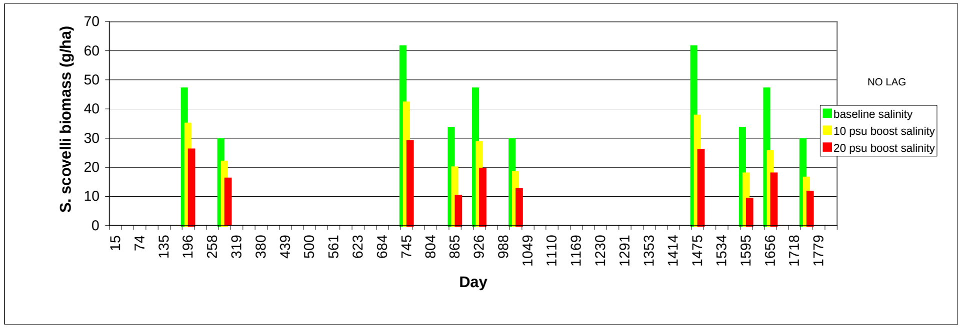












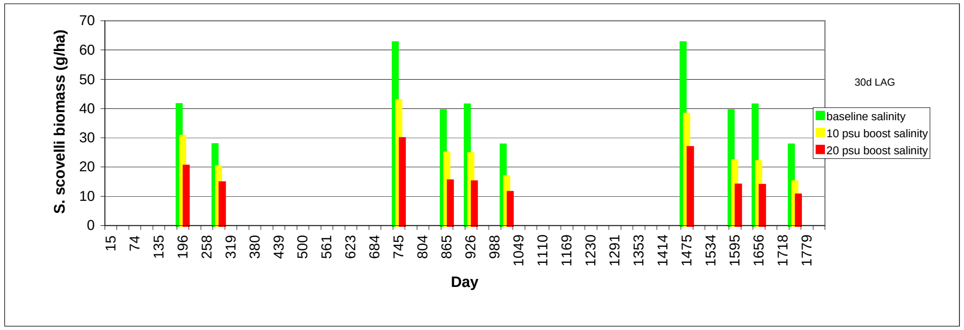
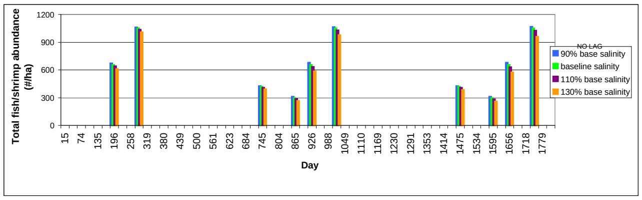
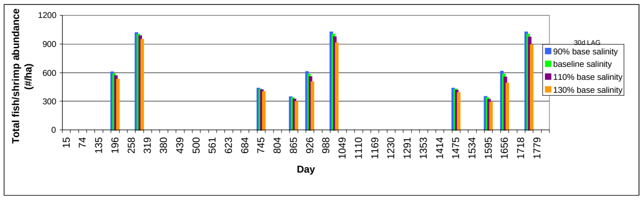
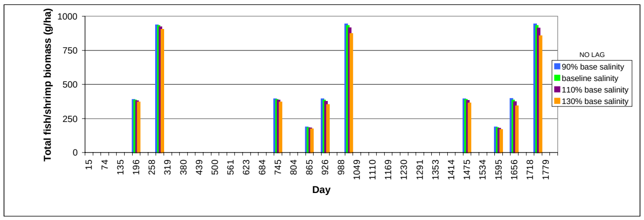


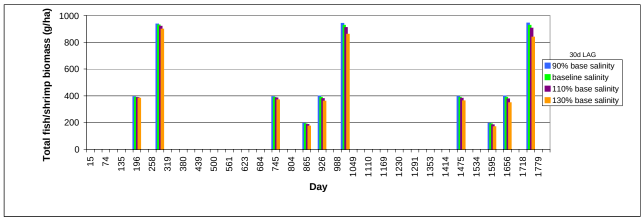
Figure 76. Little Madeira Bay Scenario – Total fish/shrimp abundance, Total fish/shrimp biomass, Forage fish/shrimp biomass, Predator fish biomass- trawl/seine

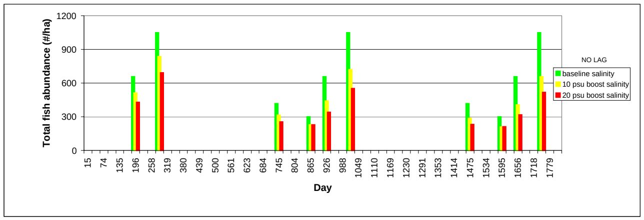
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

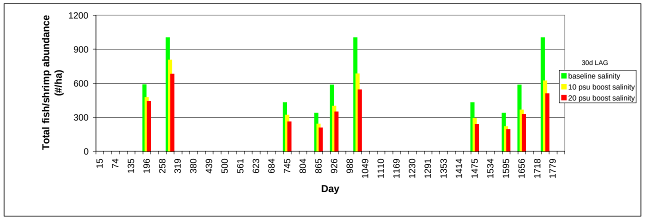


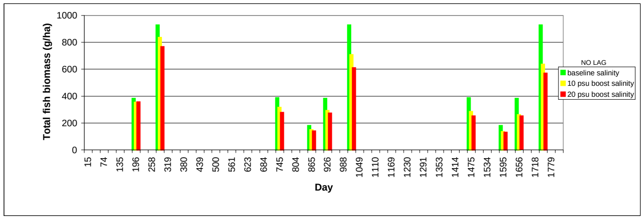


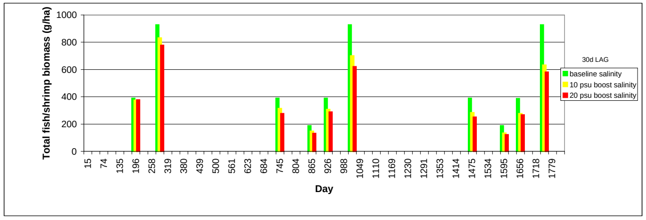


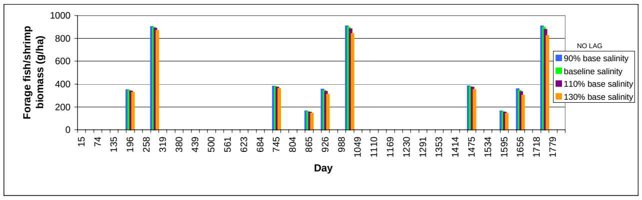


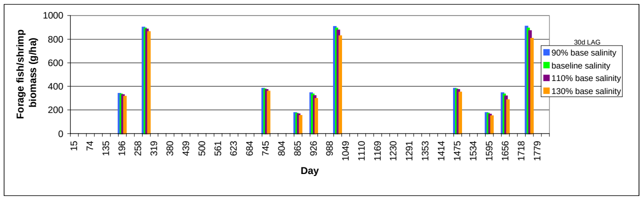


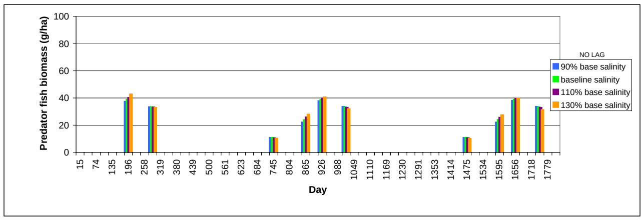


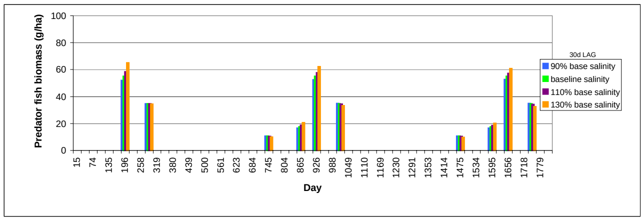


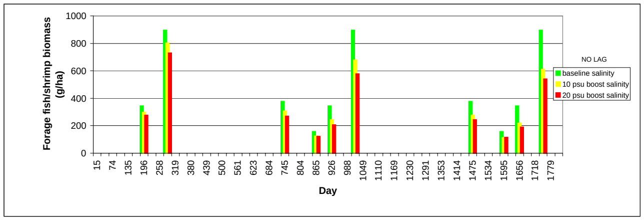


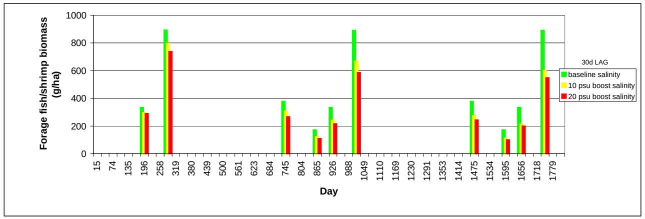


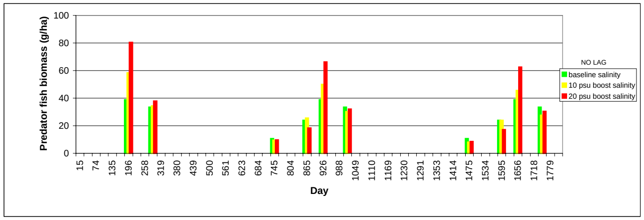












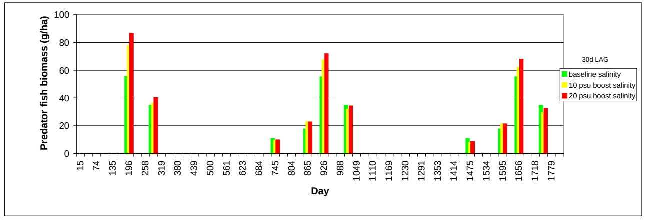
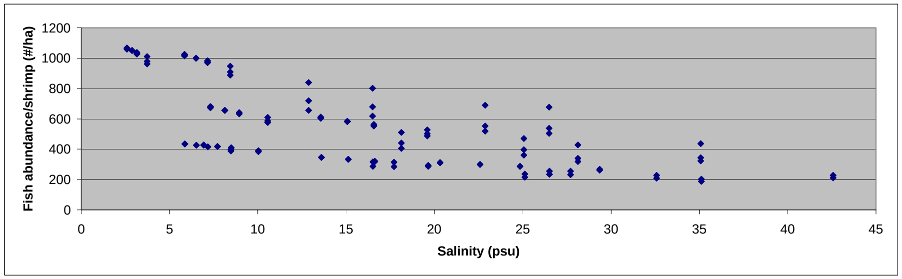
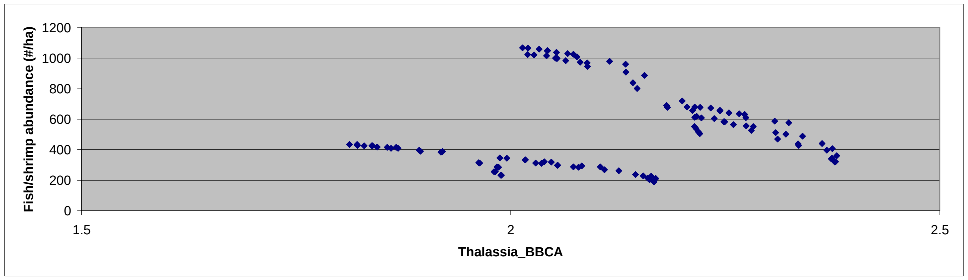
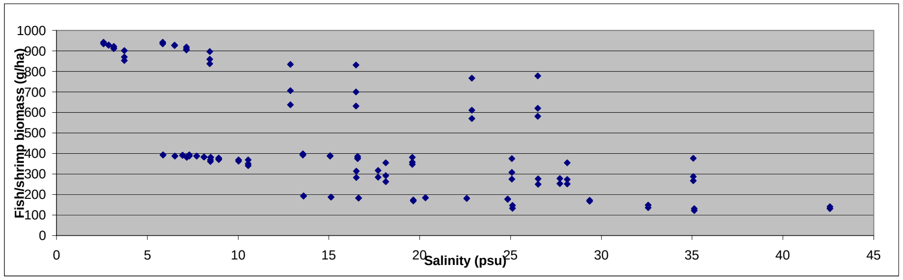


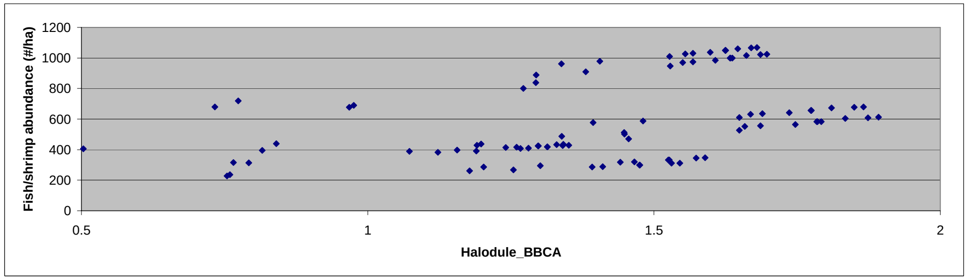
Figure 77. Little Madeira Bay Scenario - Fish/shrimp abundance vs. Salinity, Fish/shrimp biomass vs. salinity, Predator fish biomass vs. Salinity, Fish/shrimp abundance vs. Thalassia BBCA, Fish/shrimp abundance vs. Halodule BBCA- trawl seine.

INNER LITTLE MADEIRA BAY- TRAWL/SEINE









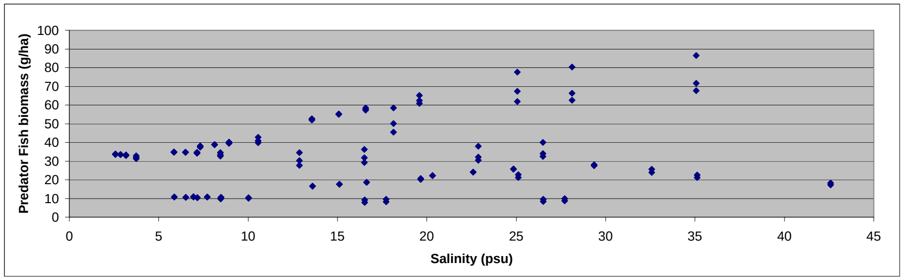
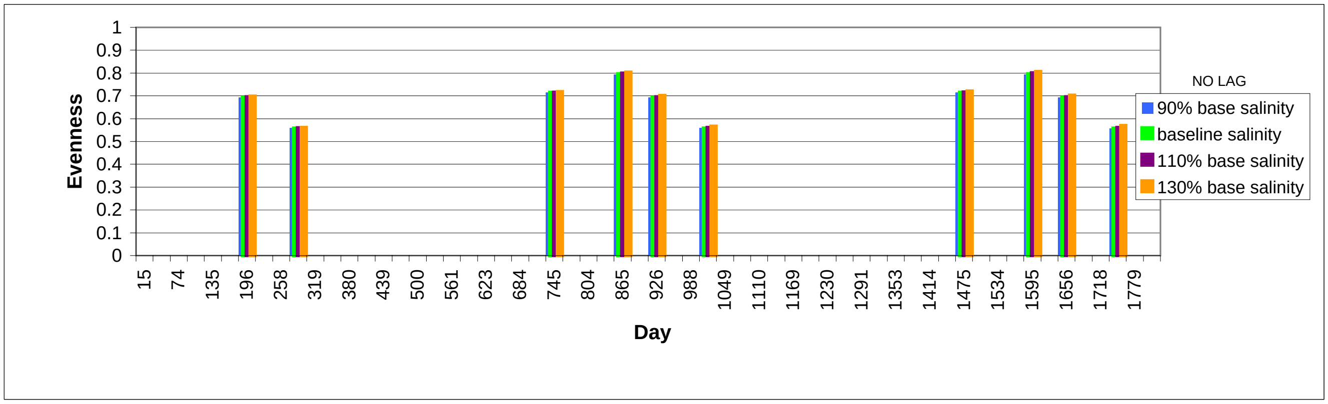
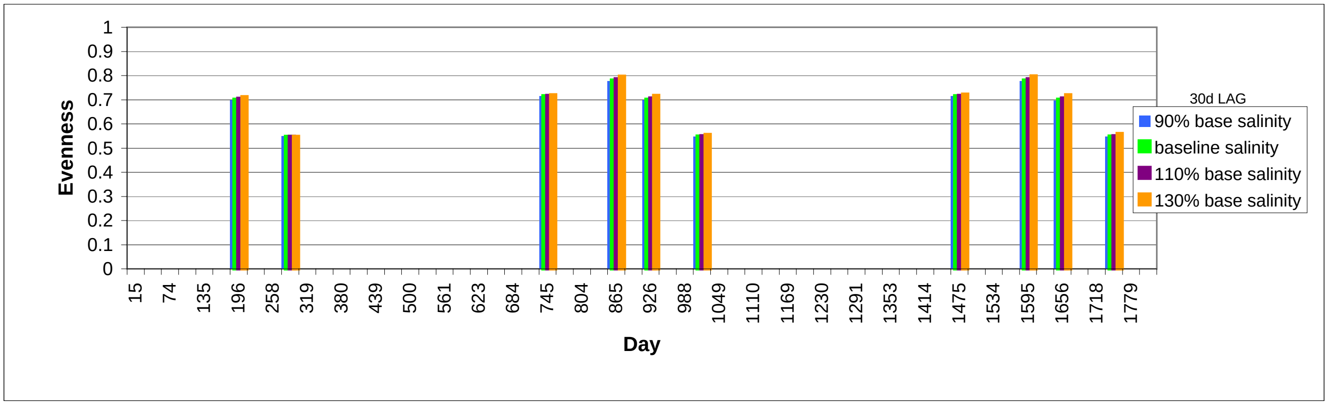
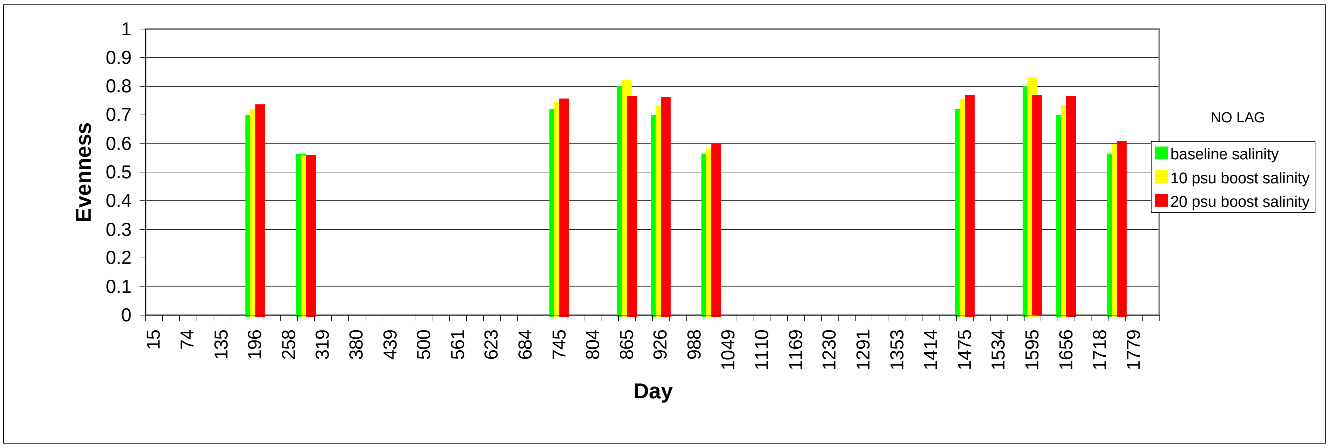


Figure 78. Little Madeira Bay Scenario – Evenness trawl/seine

INNER LITTLE MADEIRA BAY- TRAWL/SEINE







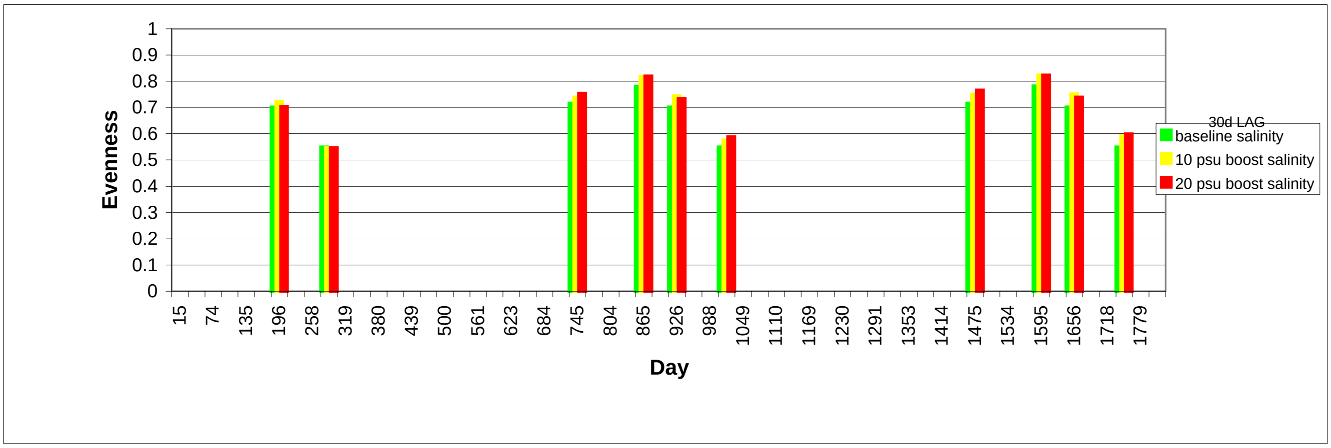
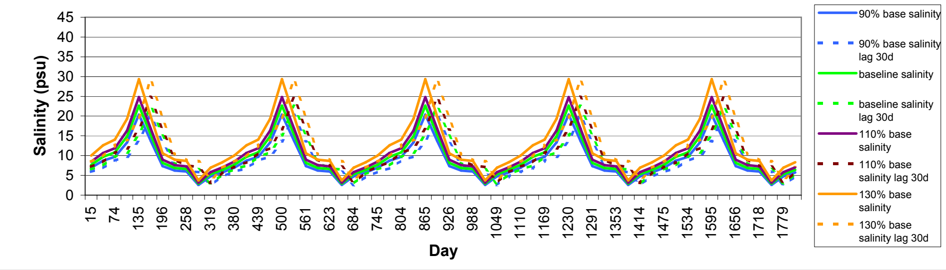
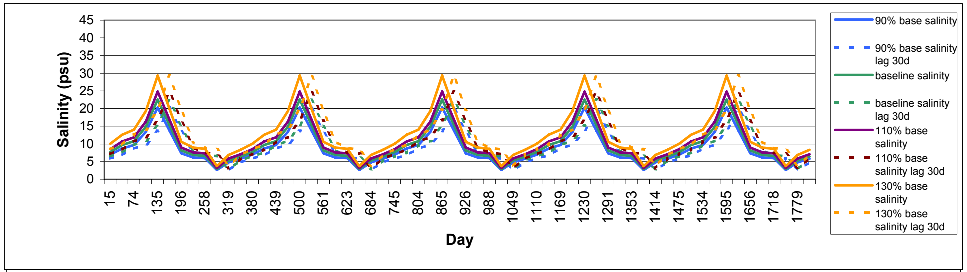
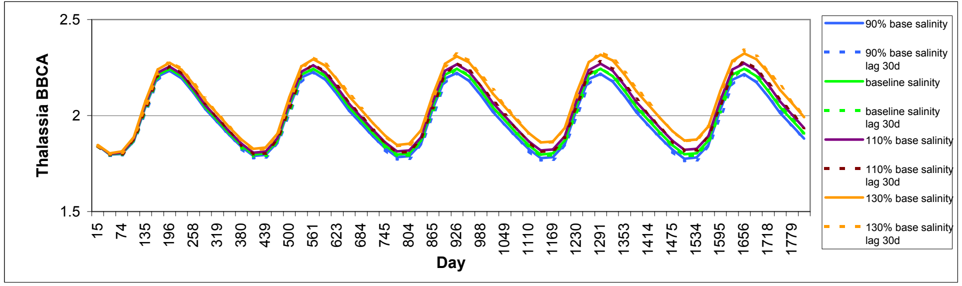


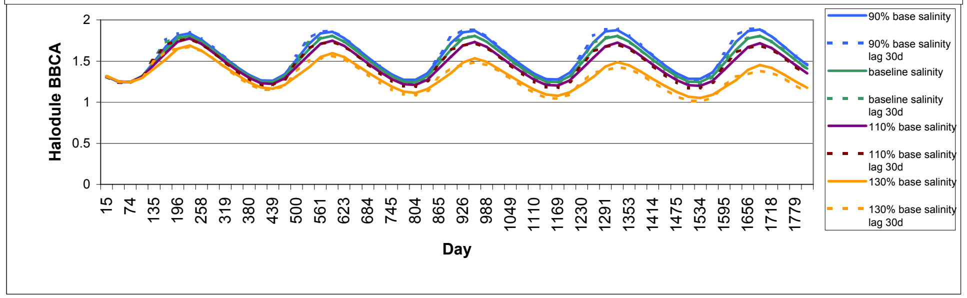
Figure 79. Little Madeira Bay Scenario – Salinity and SAV- trawl/seine

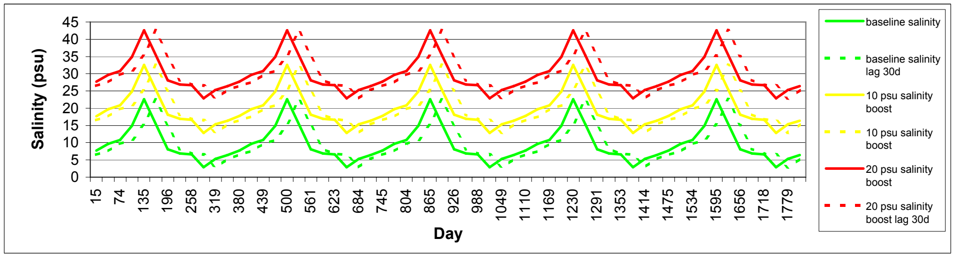
INNER LITTLE MADEIRA BAY

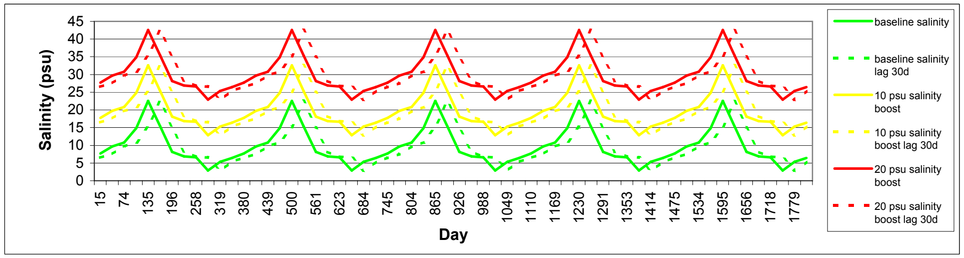


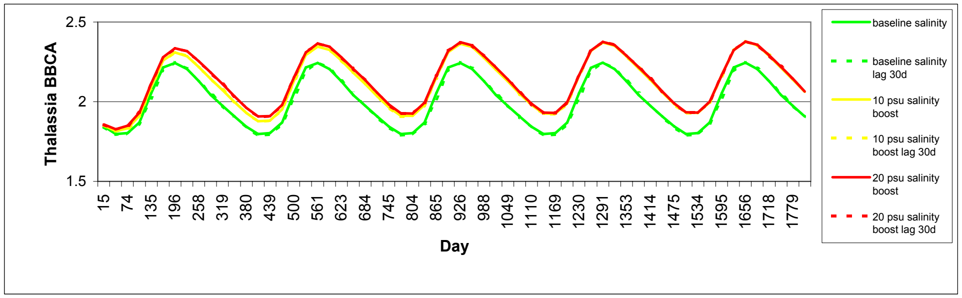












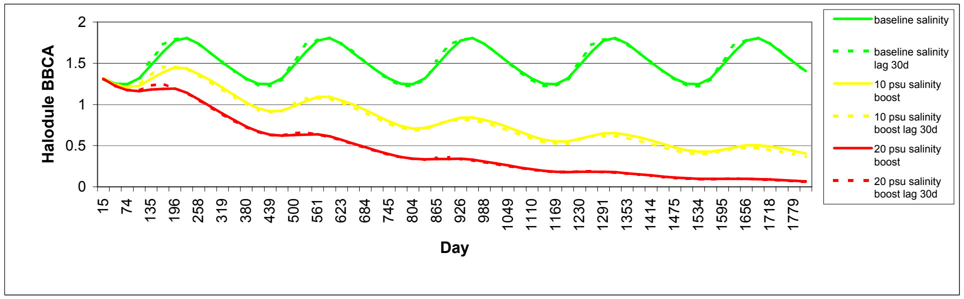
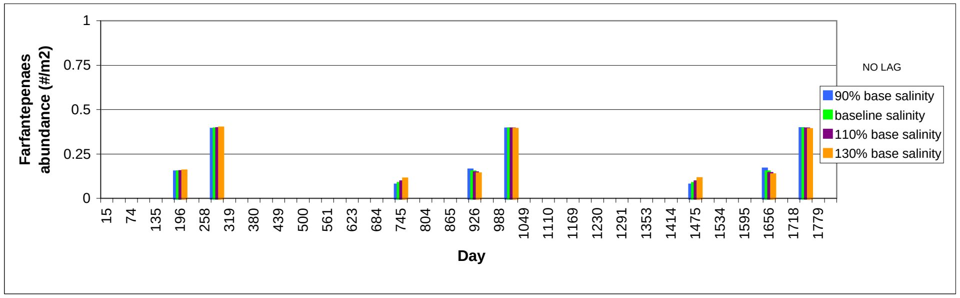
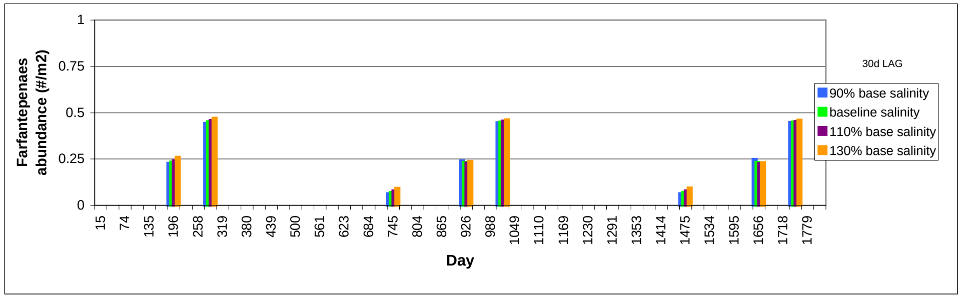
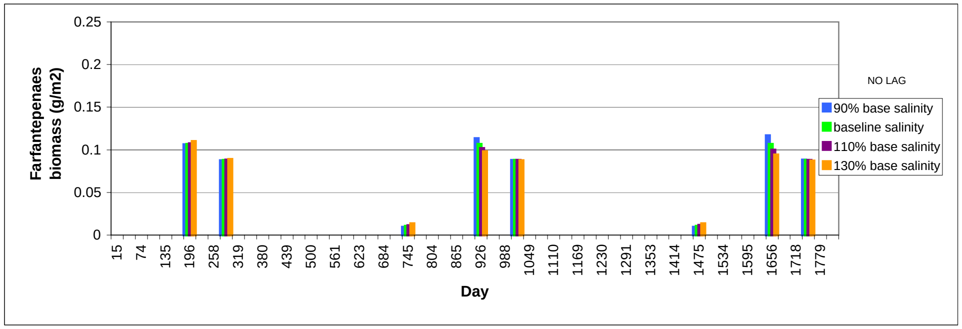


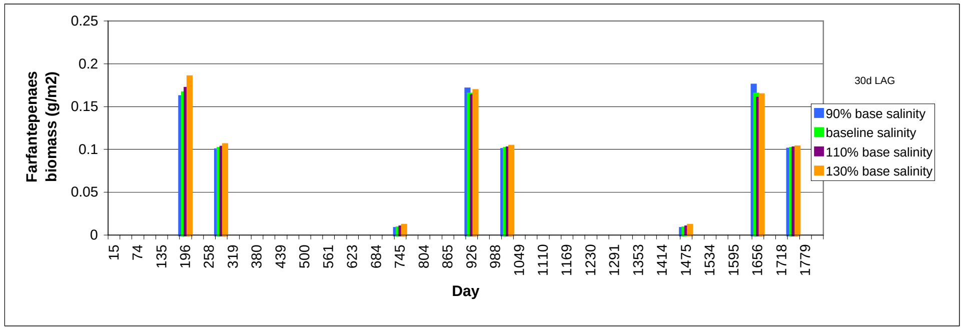
Figure 80. Little Madeira Bay Scenario – *Farfantepenaeus duorarum* abundance and biomass- throw-trap

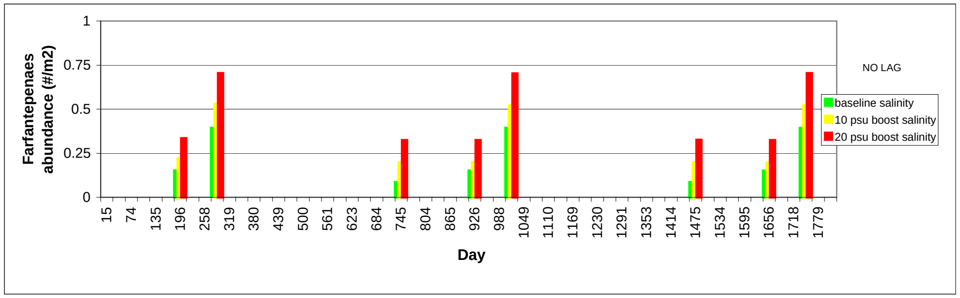
INNER LITTLE MADEIRA BAY- THROW TRAP

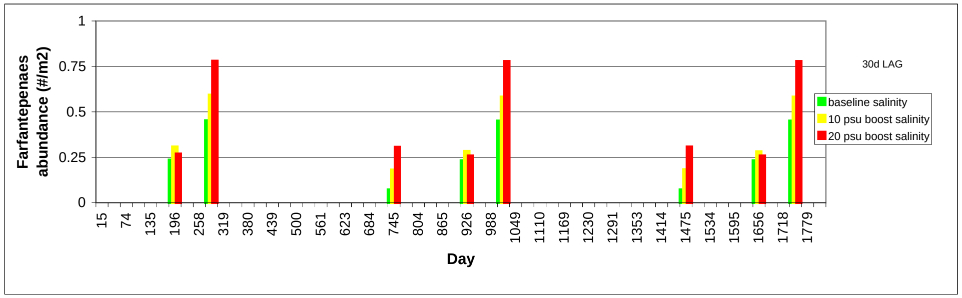


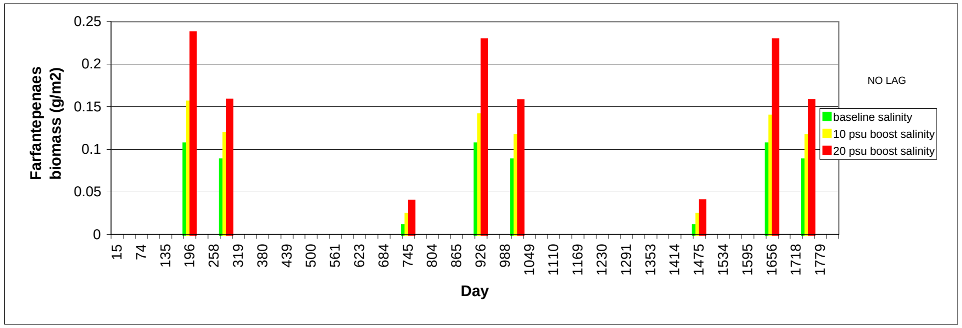












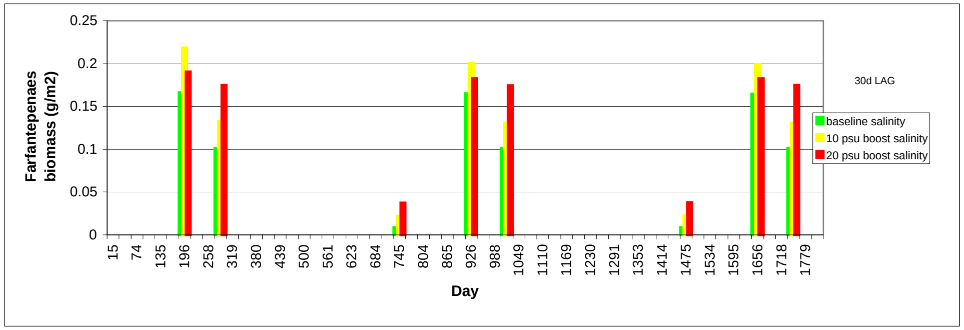
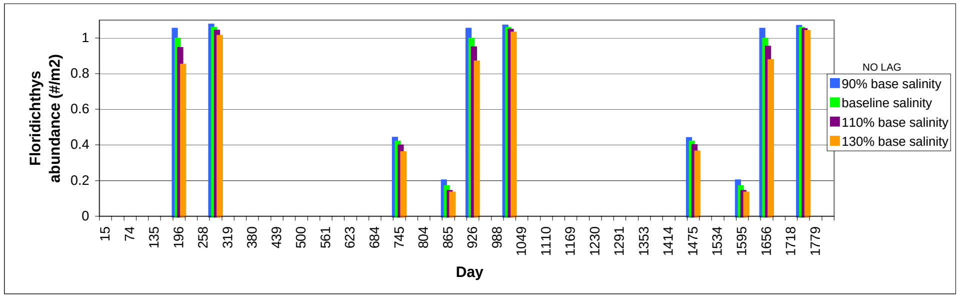
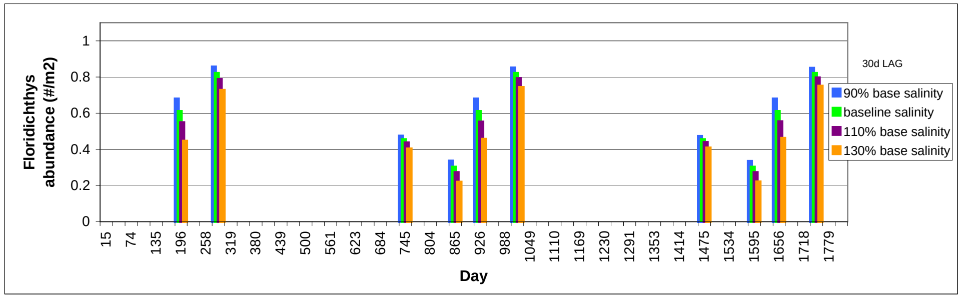
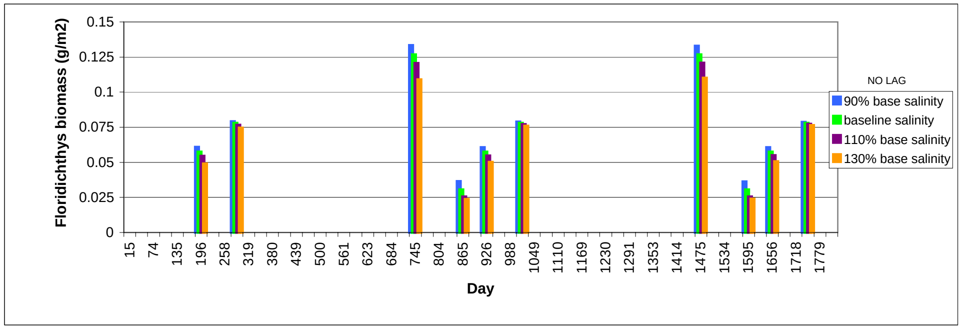


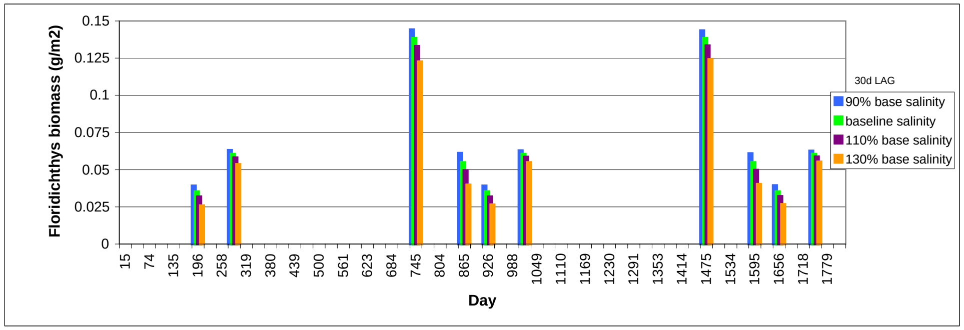
Figure 81. Little Madeira Bay Scenario – *Floridichthys carpio* abundance and biomass-throw-trap

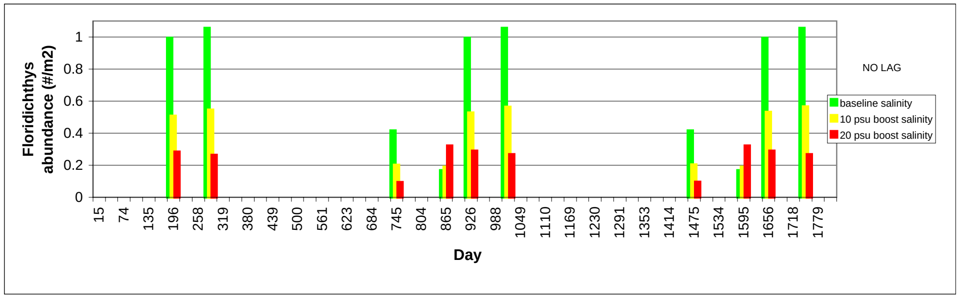
INNER LITTLE MADEIRA BAY- THROW TRAP

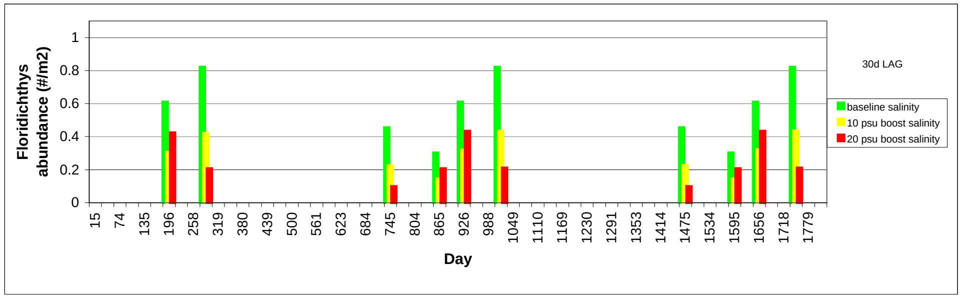


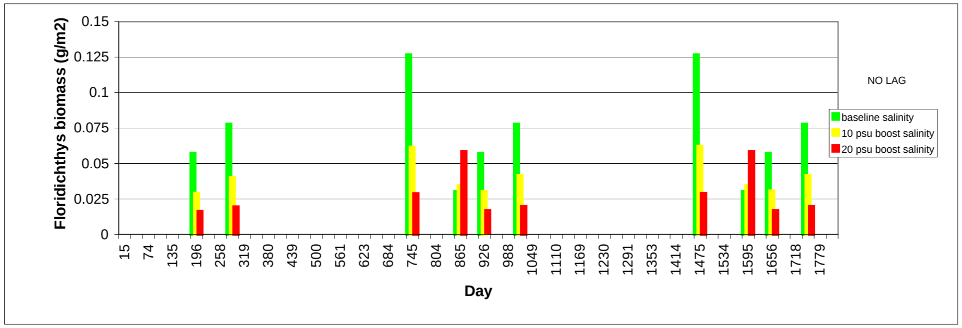












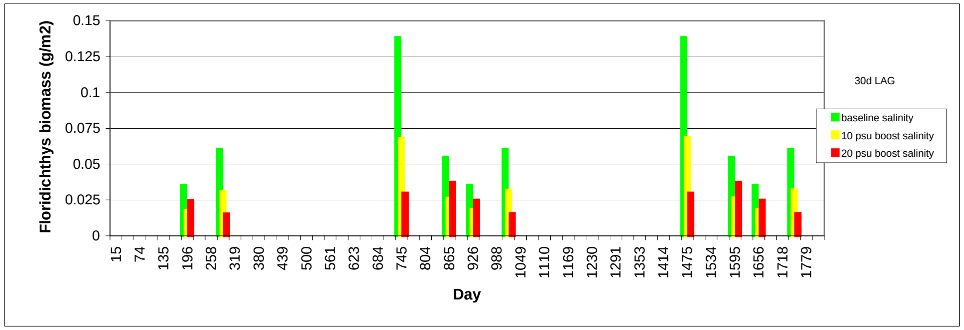
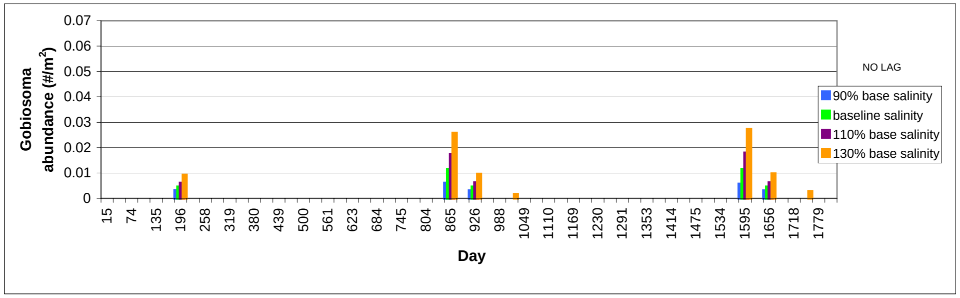
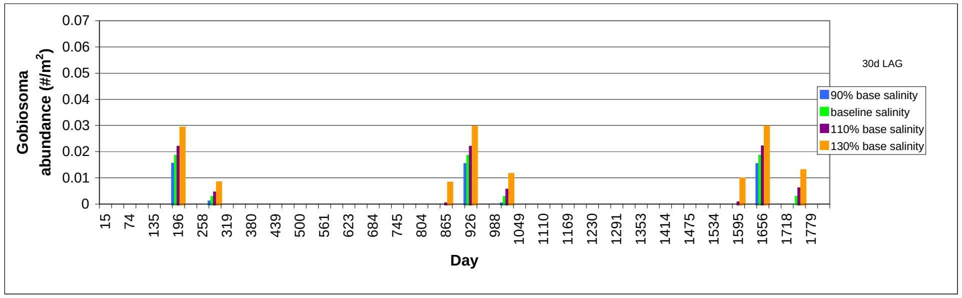
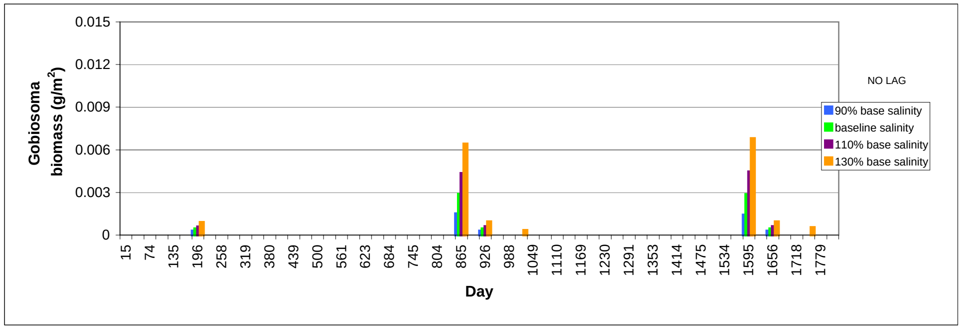


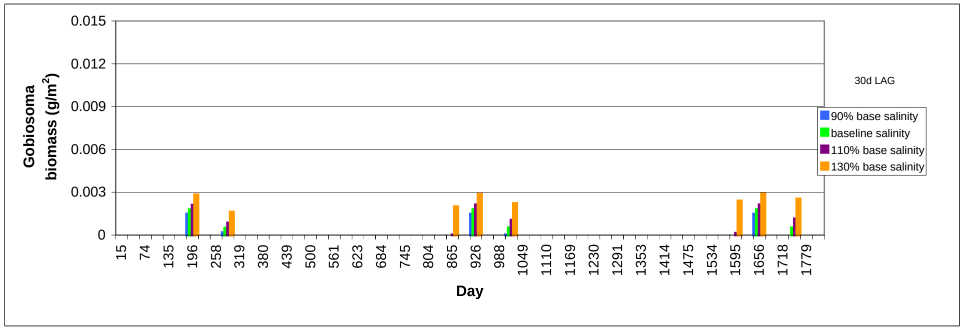
Figure 82. Little Madeira Bay Scenario – *Gobiosoma robustum* abundance and biomass-throw-trap

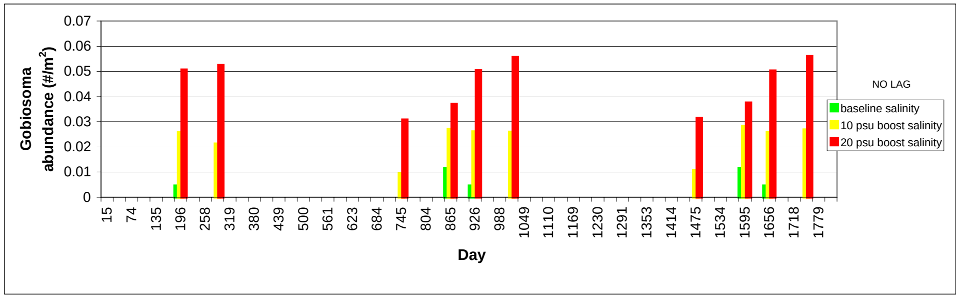
INNER LITTLE MADEIRA BAY- THROW TRAP

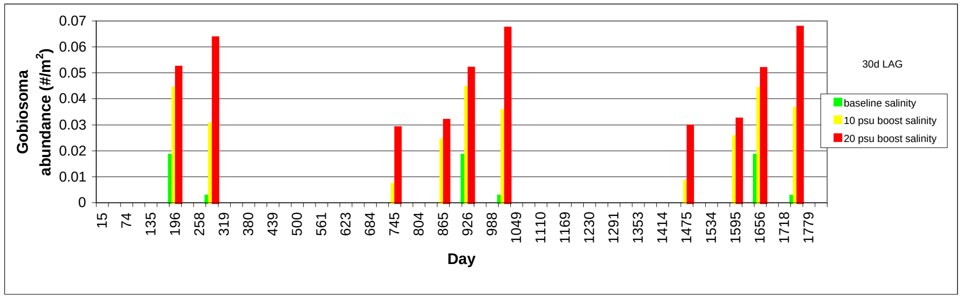


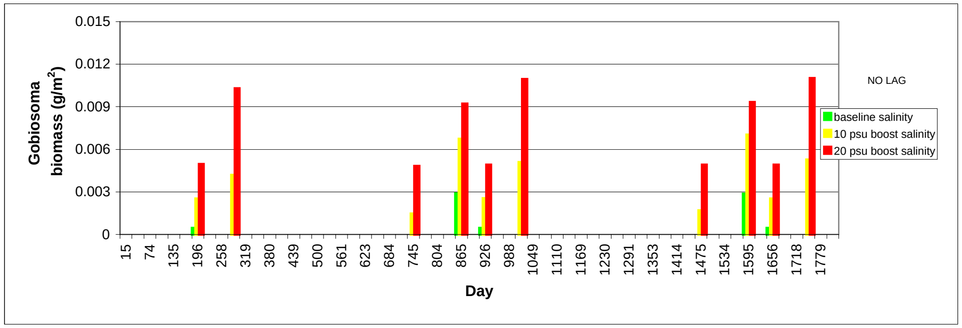












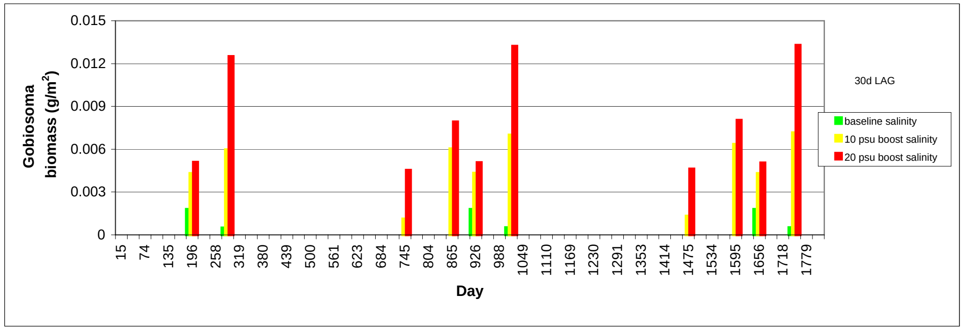
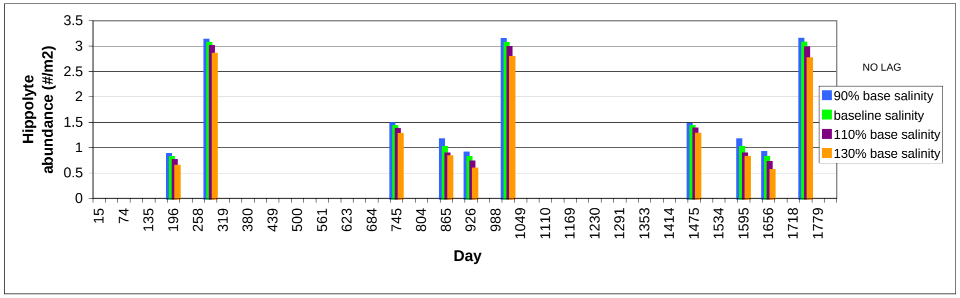
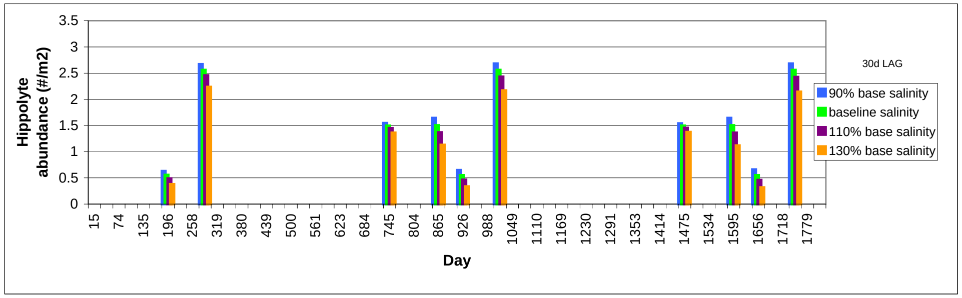
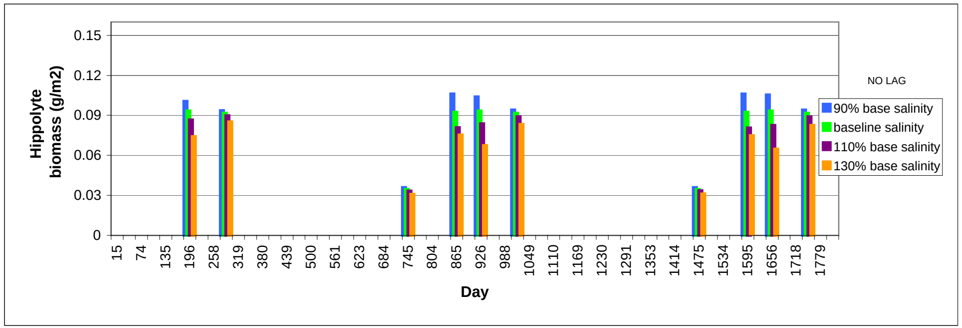


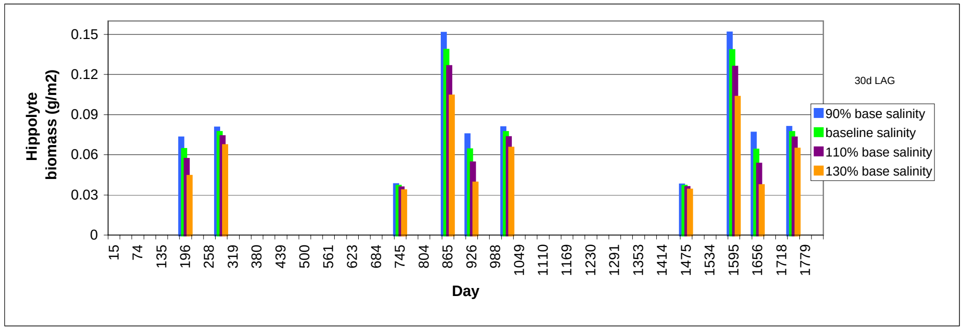
Figure 83. Little Madeira Bay Scenario – *Hippolyte spp*. abundance and biomass- throw-trap

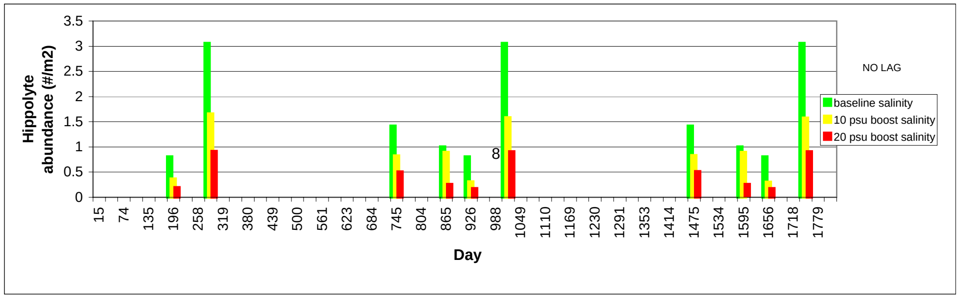
INNER LITTLE MADEIRA BAY- THROW TRAP

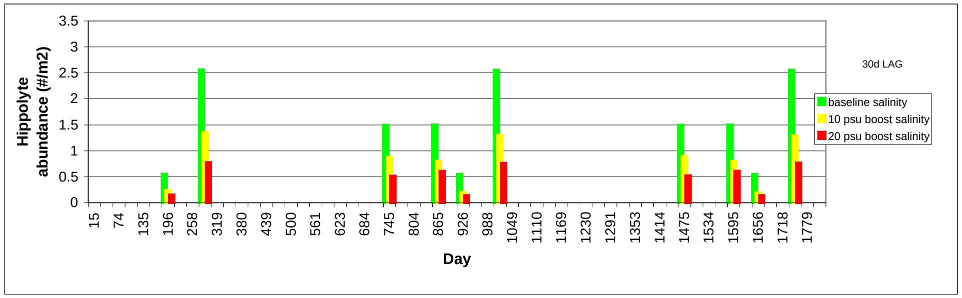


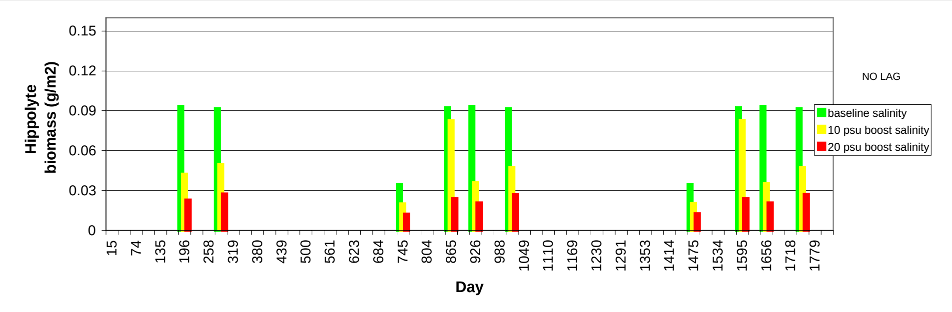












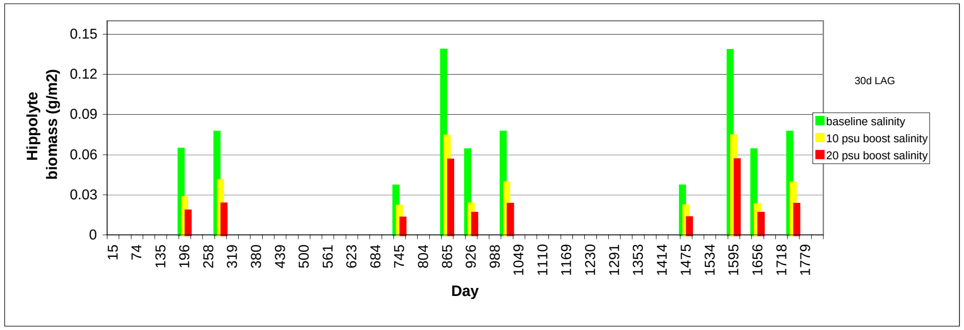
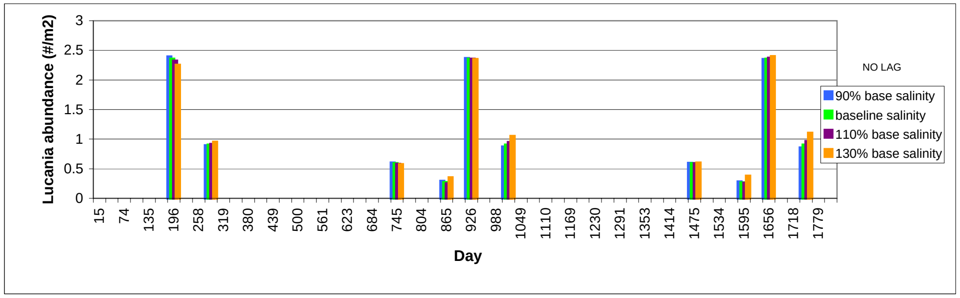
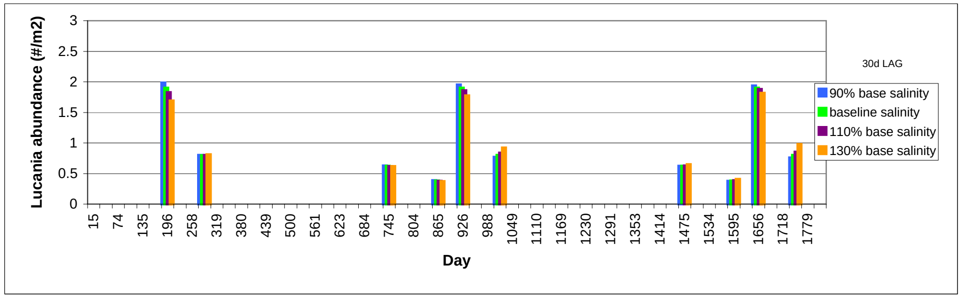
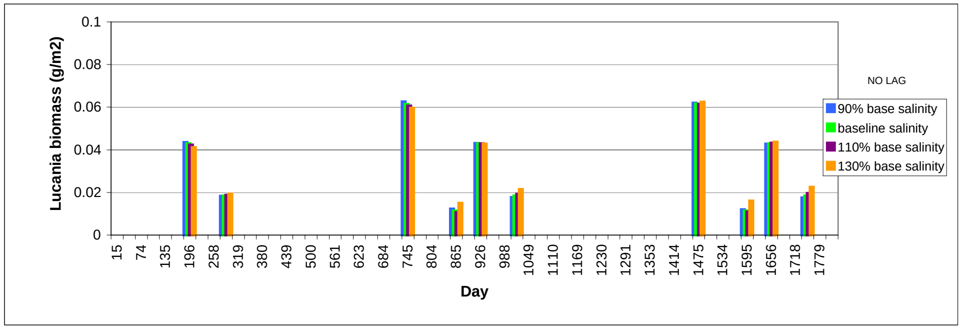


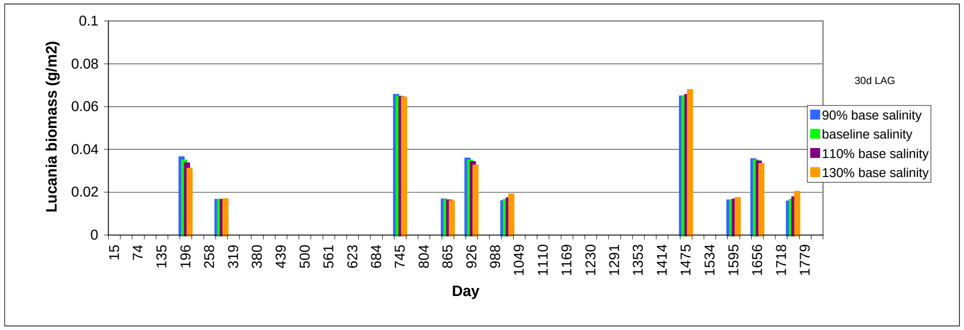
Figure 84. Little Madeira Bay Scenario – *Lucania parva* abundance and biomass- throw-trap

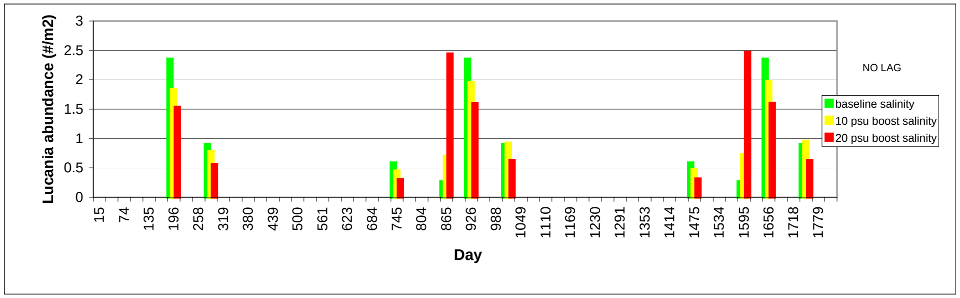
INNER LITTLE MADEIRA BAY- THROW TRAP

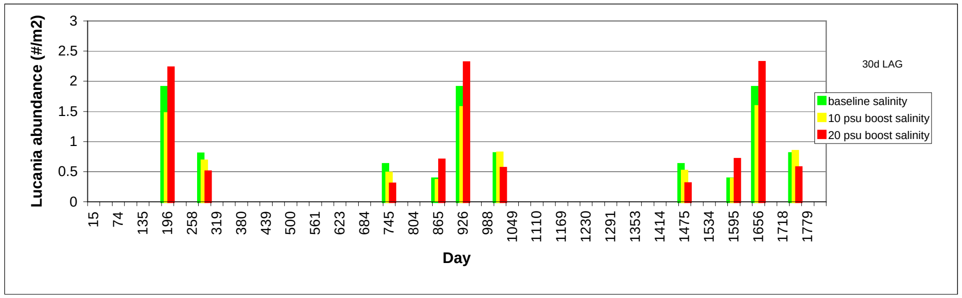


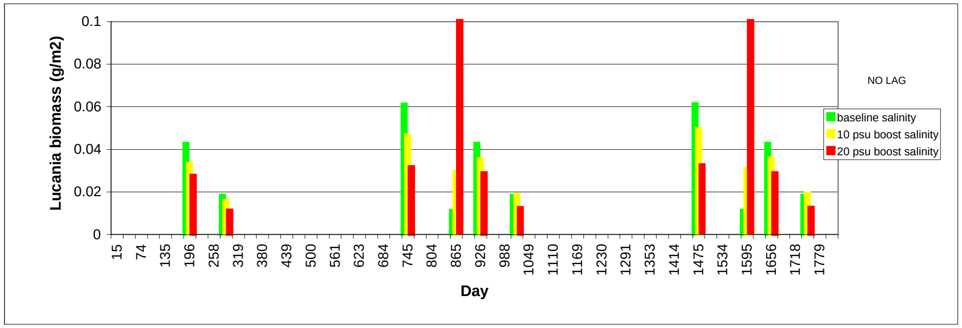












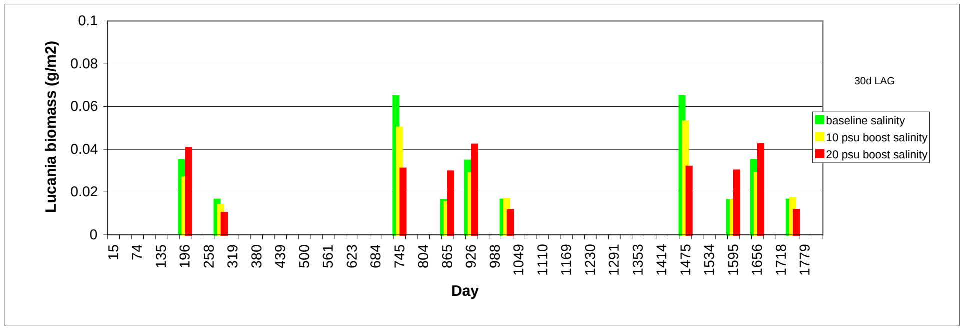
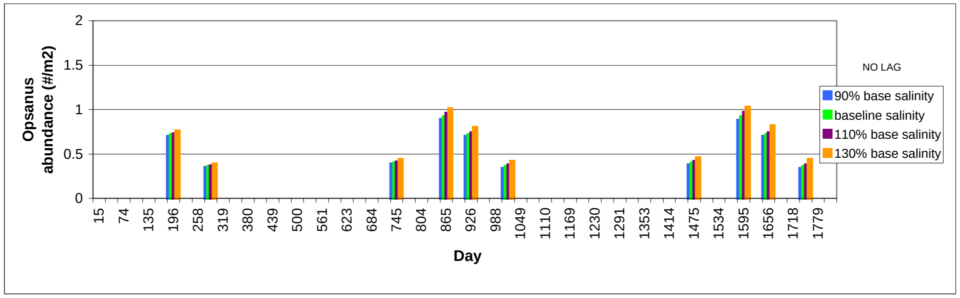
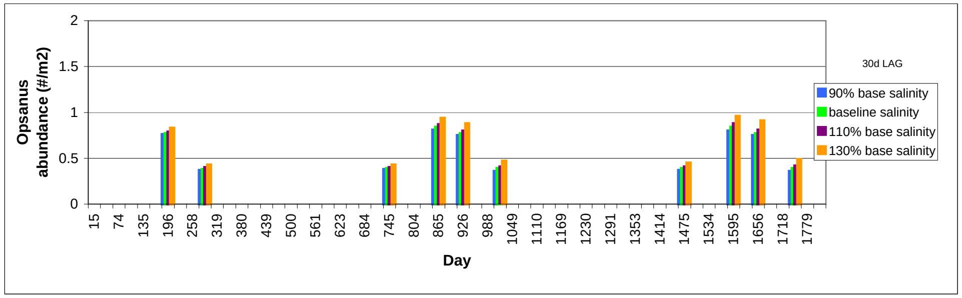
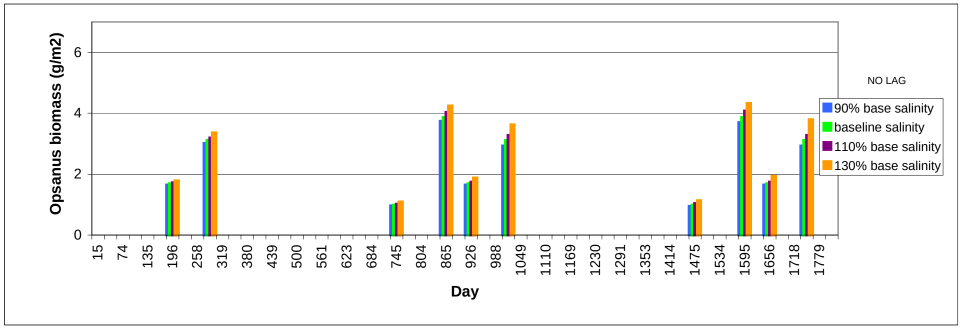


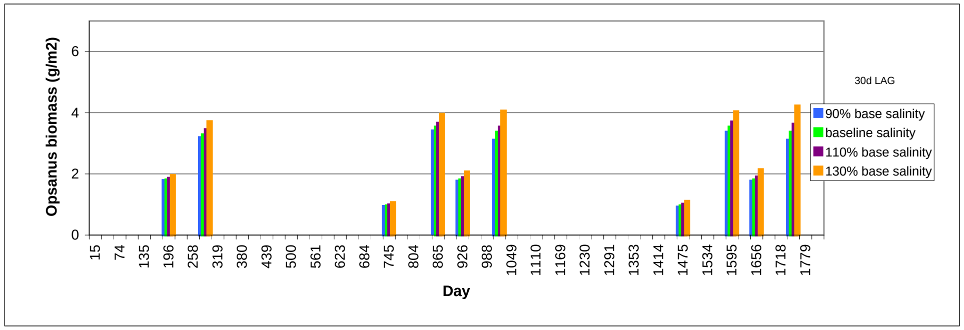
Figure 85. Little Madeira Bay Scenario – *Opsanus beta* abundance and biomass- throw-trap

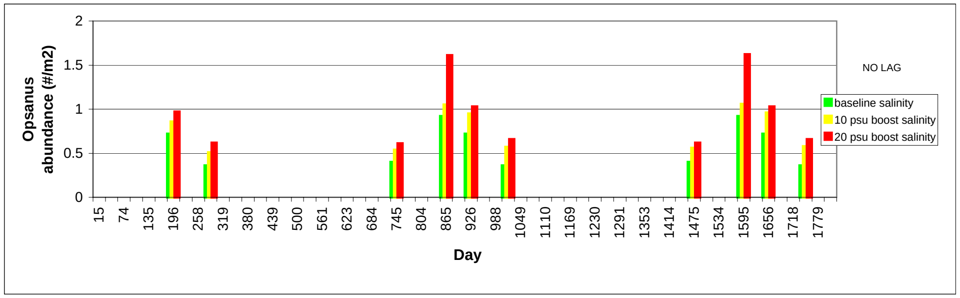
INNER LITTLE MADEIRA BAY- THROW TRAP

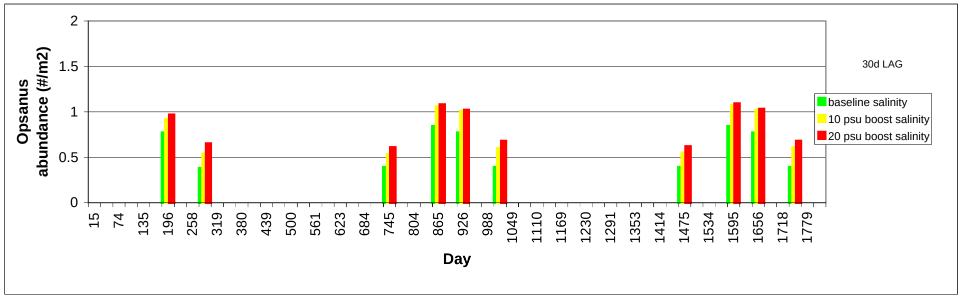


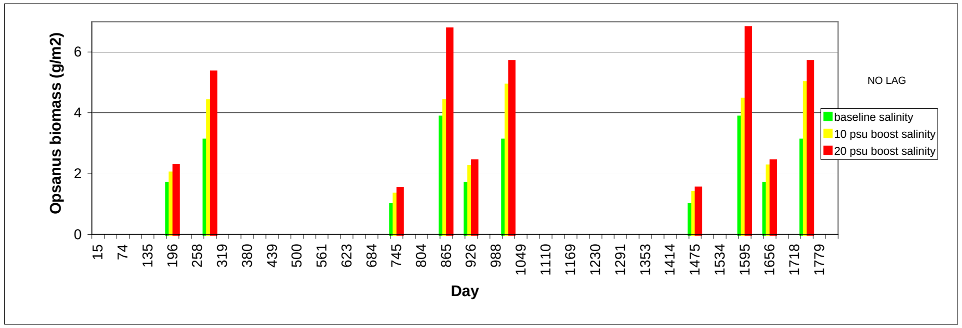












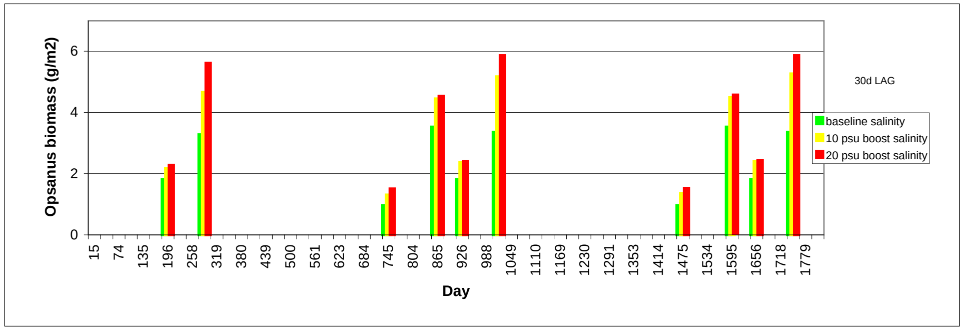
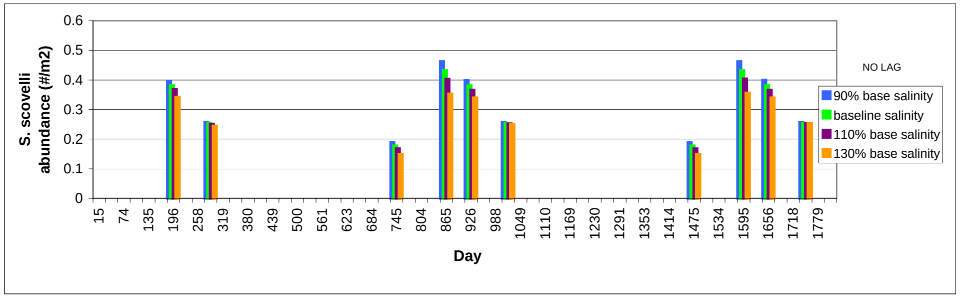
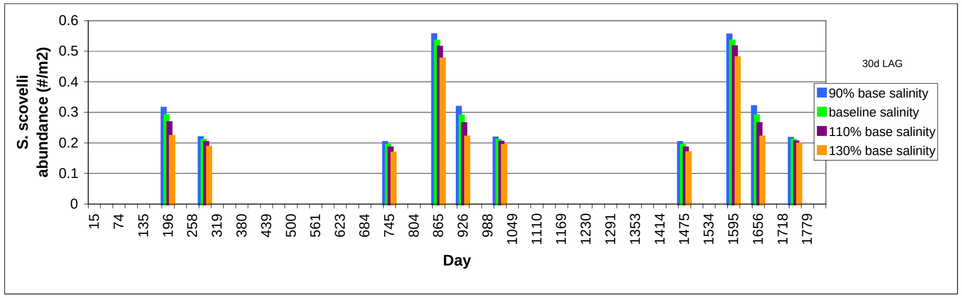
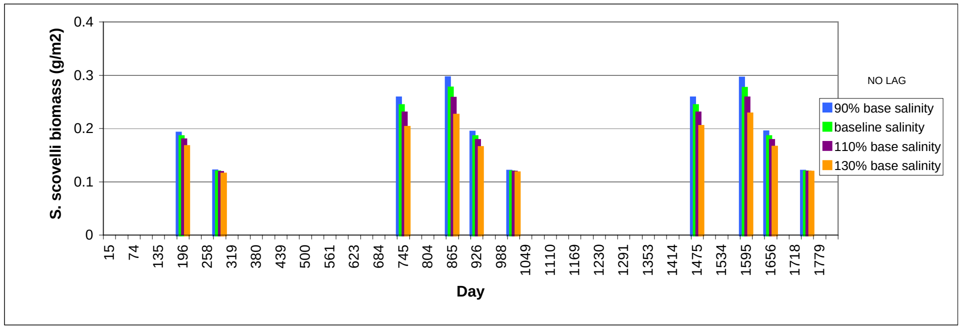


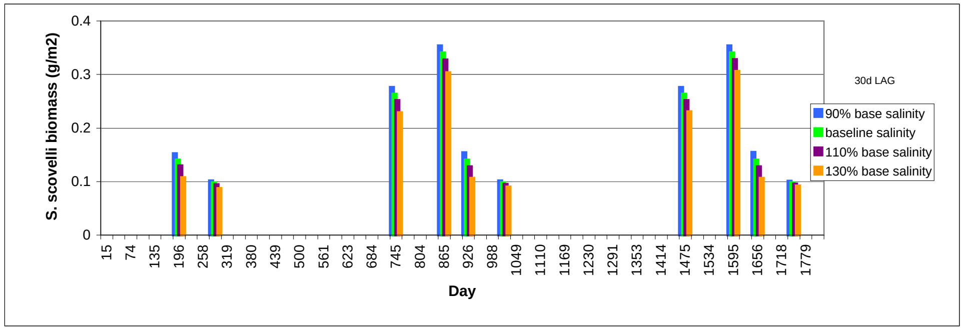
Figure 86. Little Madeira Bay Scenario – *Syngnathus scovelli* abundance and biomass-throw-trap

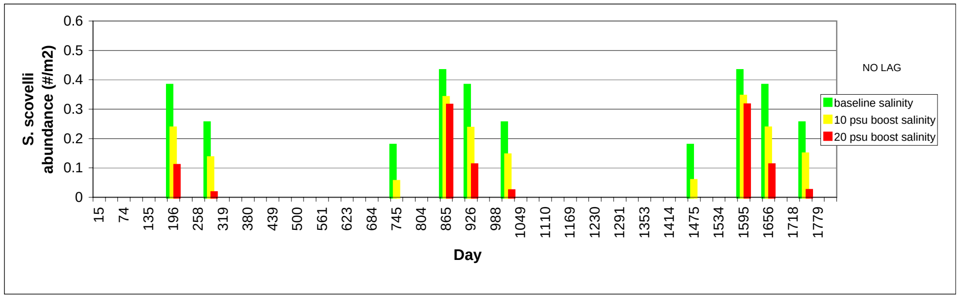
INNER LITTLE MADEIRA BAY- THROW TRAP

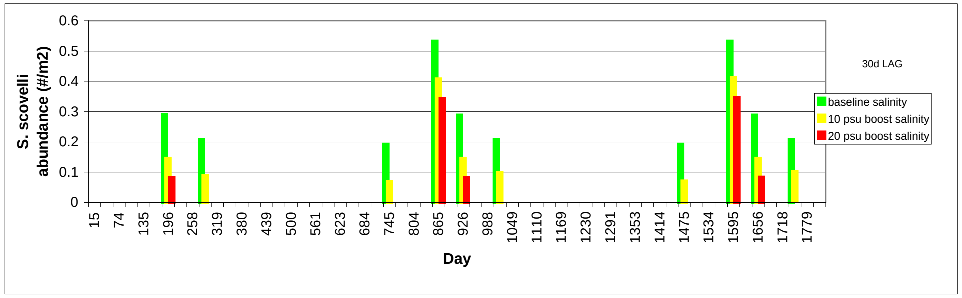


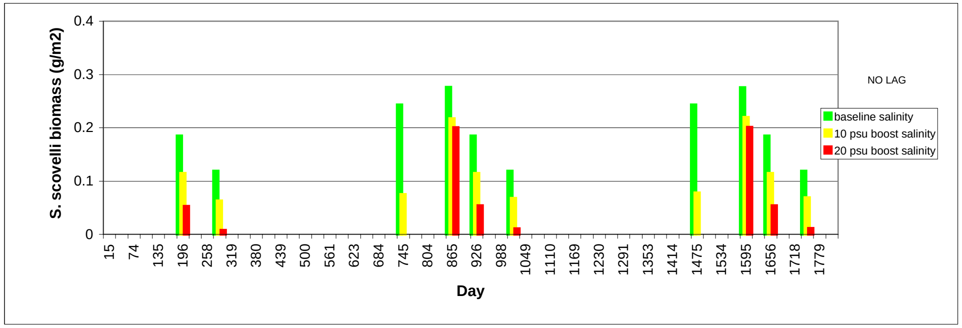












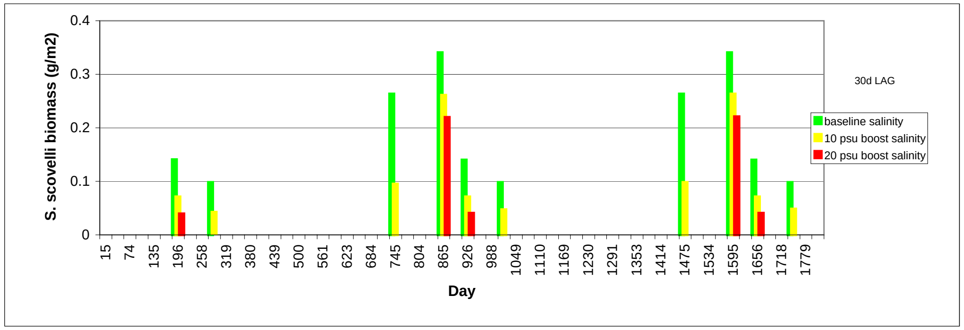
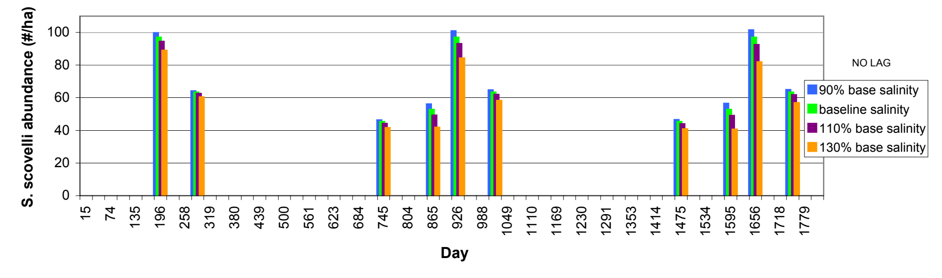
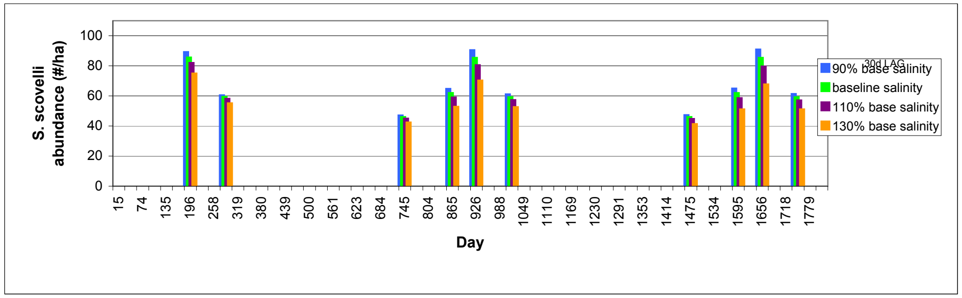
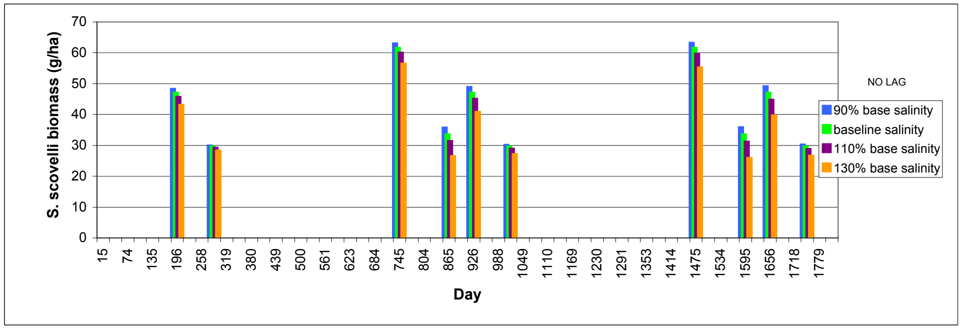


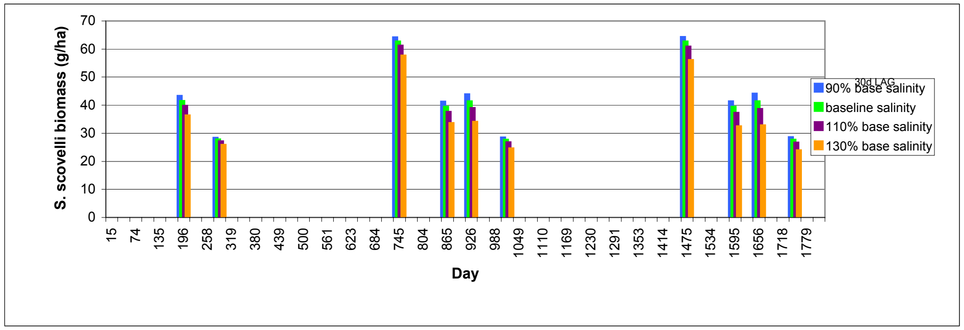
Figure 87. Little Madeira Bay Scenario – *Syngnathus scovelli* abundance and biomass-throw-trap

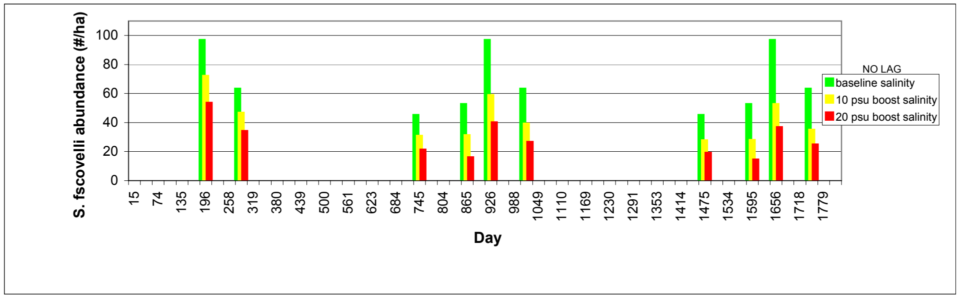
INNER LITTLE MADEIRA BAY- TRAWL/SEINE

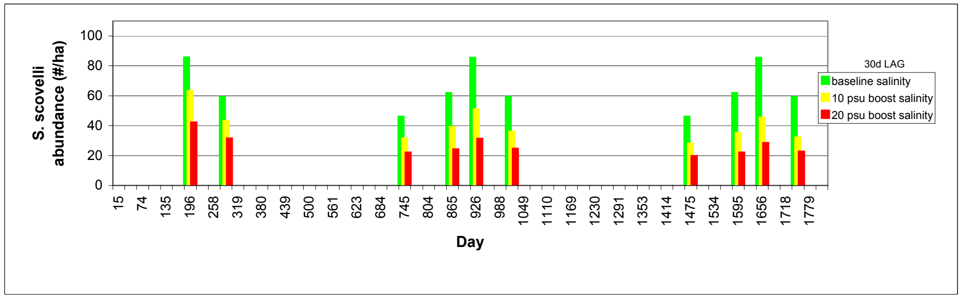


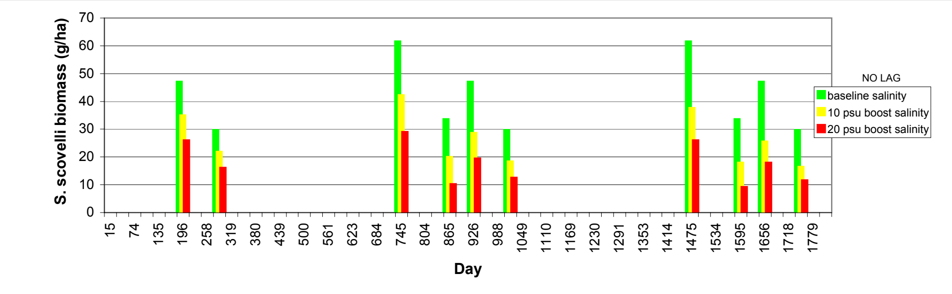












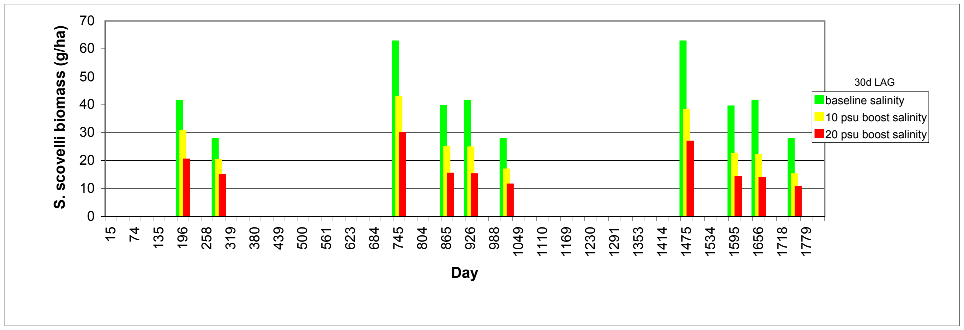
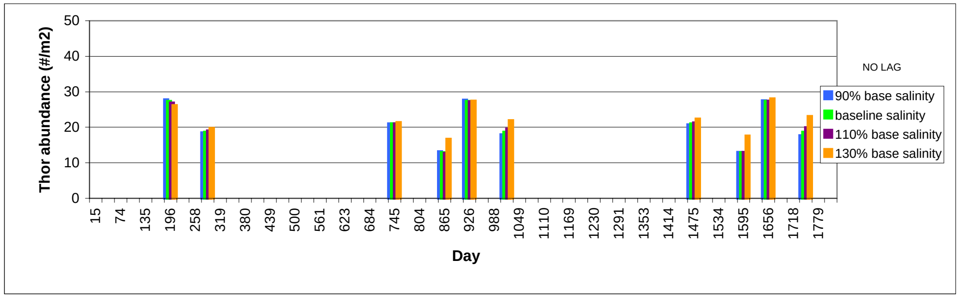
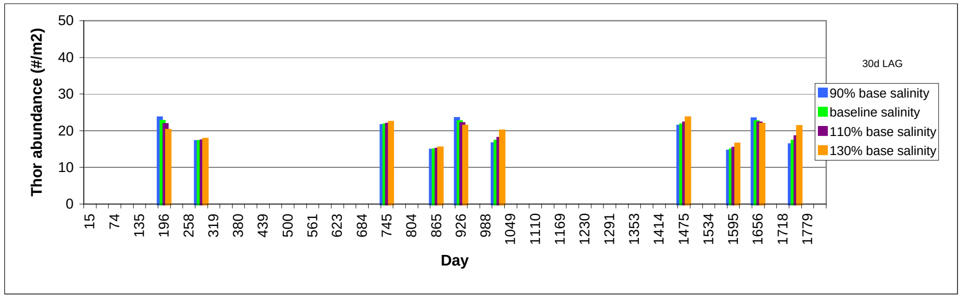
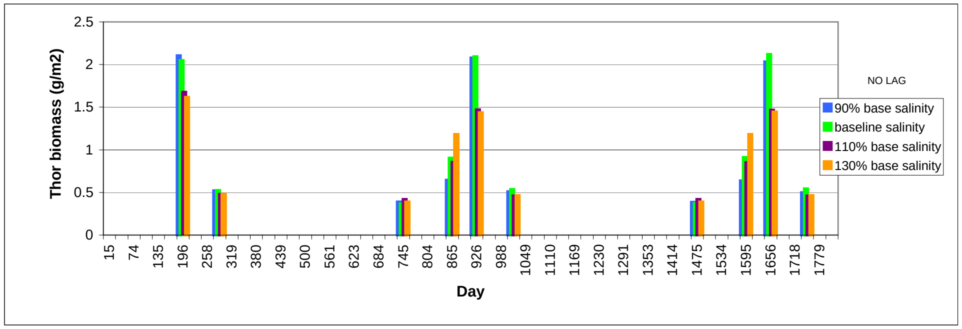


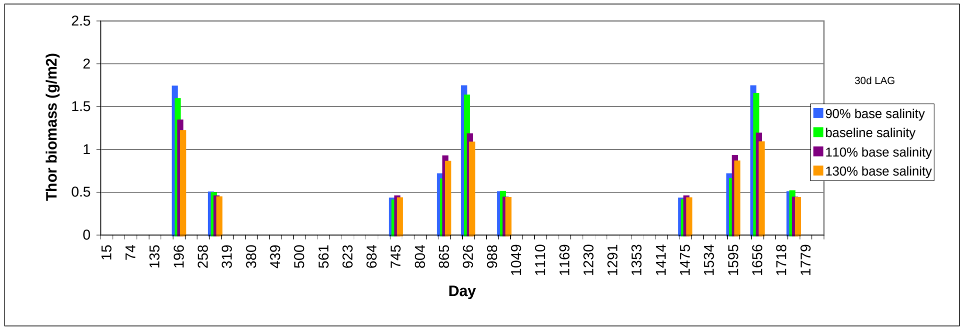
Figure 88. Little Madeira Bay Scenario – *Thor spp.* abundance and biomass- throw-trap

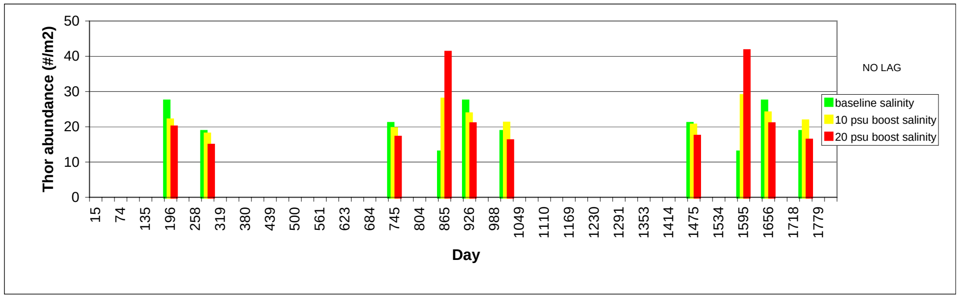
INNER LITTLE MADEIRA BAY- THROW TRAP

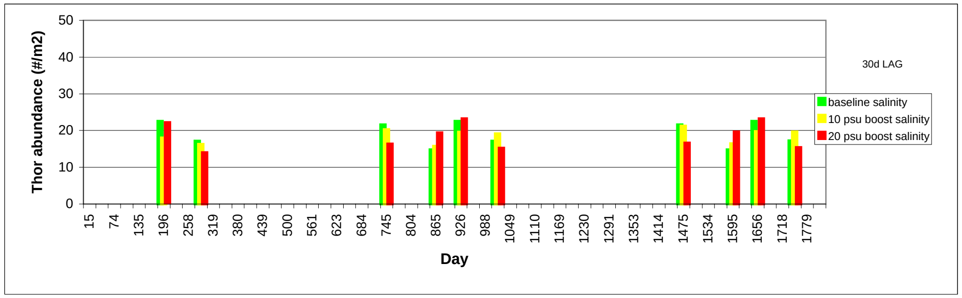


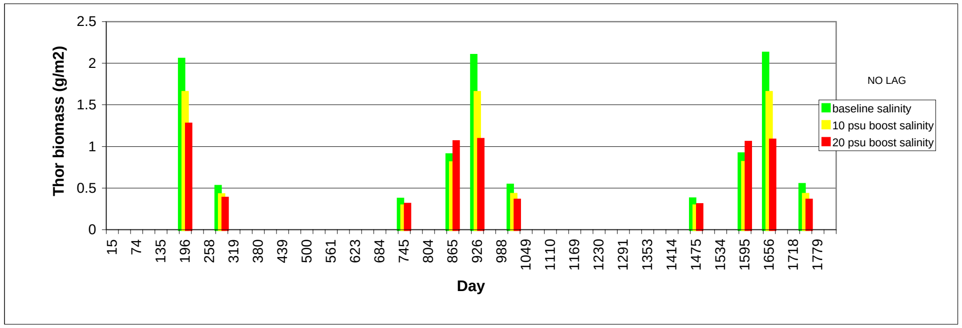












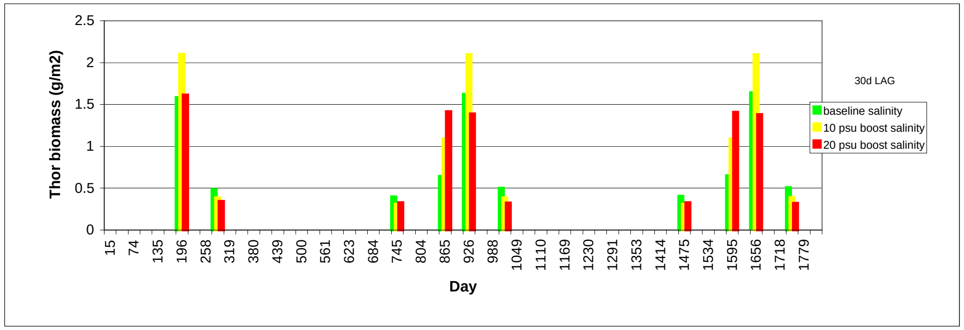
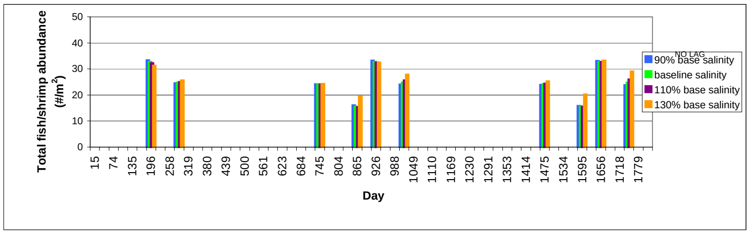
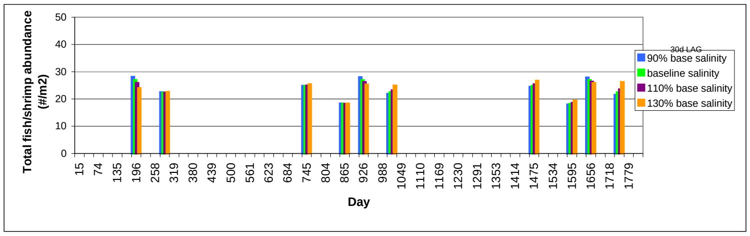
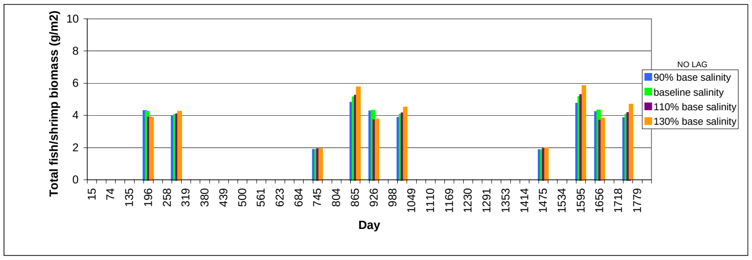


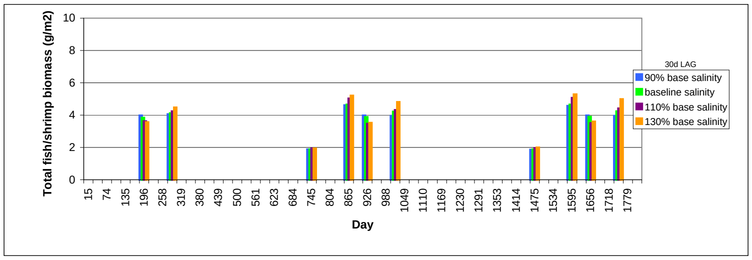
Figure 89. Little Madeira Bay Scenario – Total fish/shrimp abundance, Total fish/shrimp biomass, Forage fish/shrimp biomass, Predator fish biomass- throw-trap

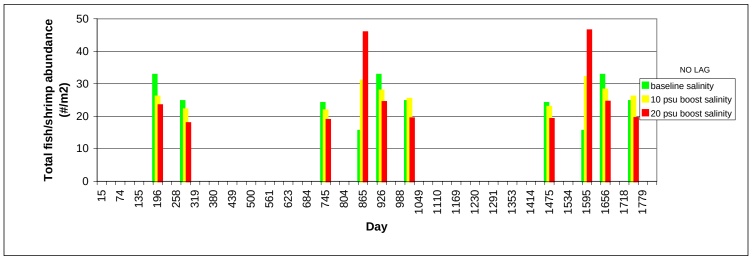
INNER LITTLE MADEIRA BAY- THROW TRAP

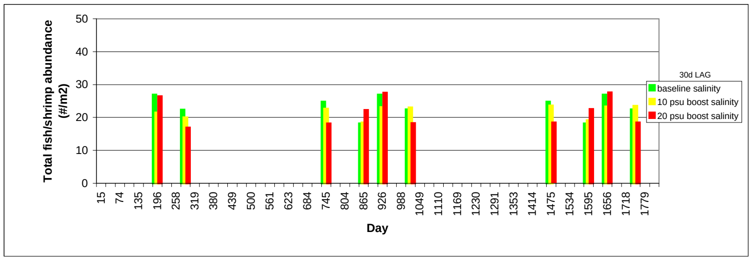


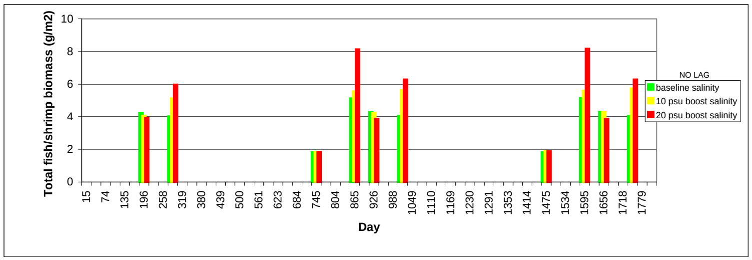


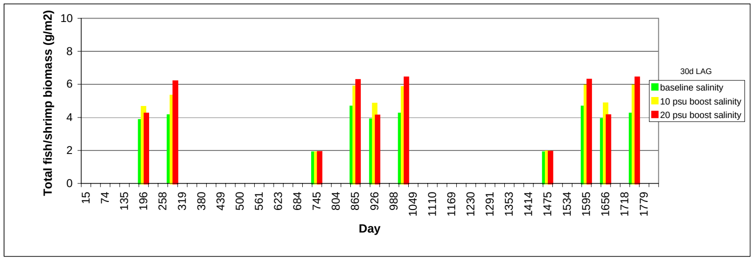


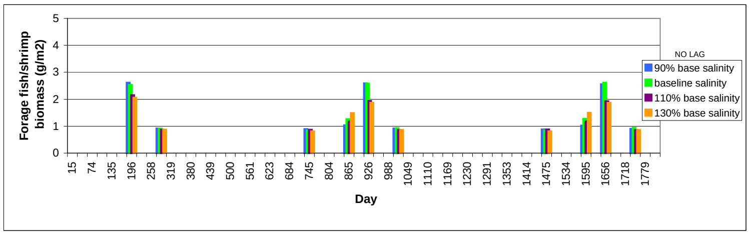


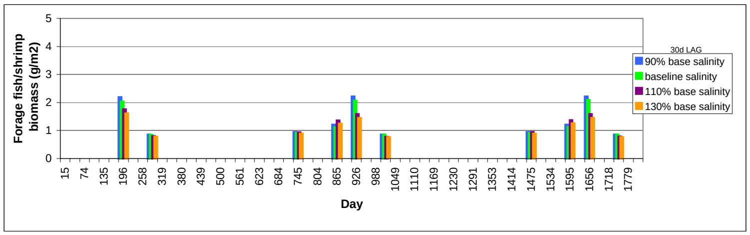


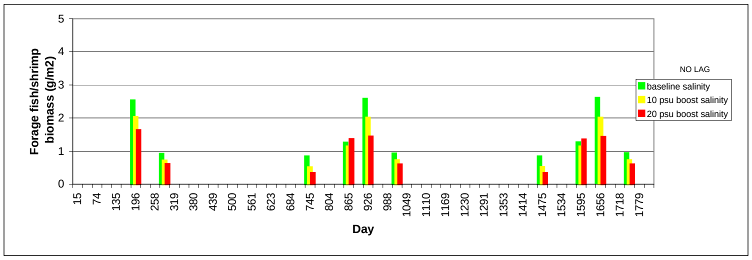


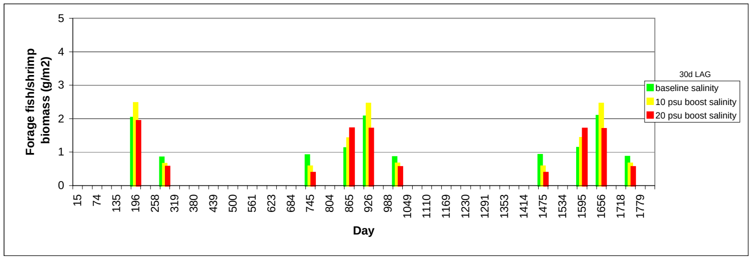






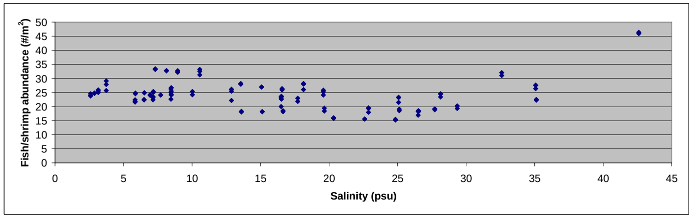


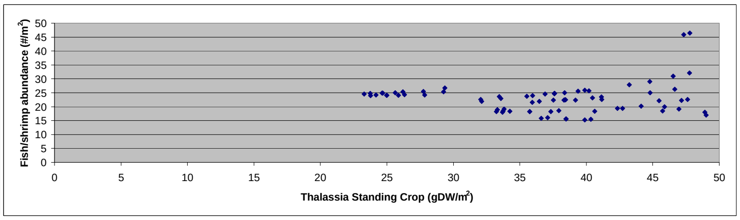


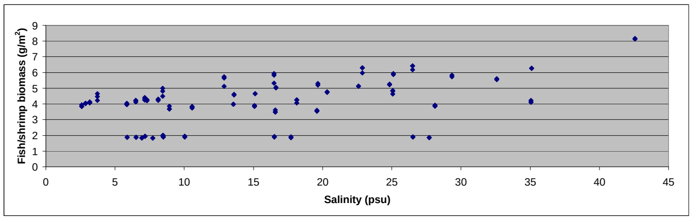


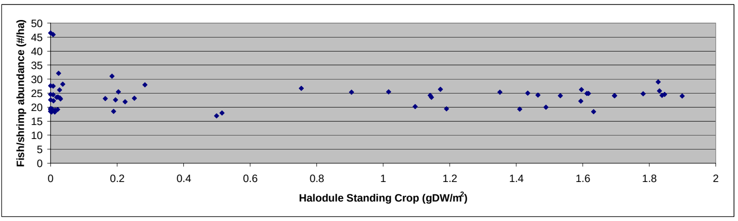
90. Little Madeira Bay Scenario - Fish/shrimp abundance vs. Salinity, Fish/shrimp biomass vs. salinity, Predator fish biomass vs. Salinity, Fish/shrimp abundance vs. Thalassia BBCA, Fish/shrimp abundance vs. Halodule BBCA- throw-trap

INNER LITTLE MADEIRA BAY- THROW TRAP









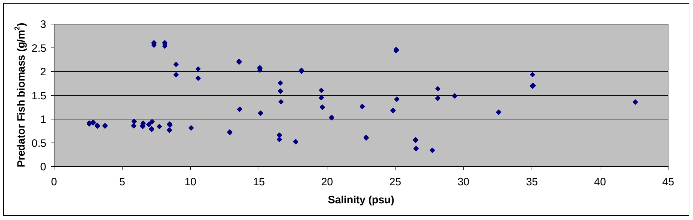
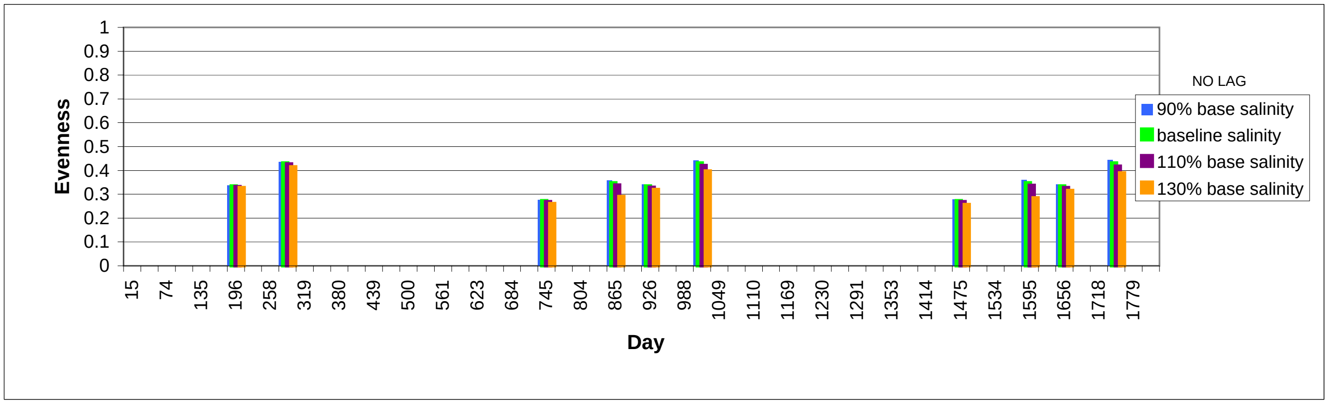
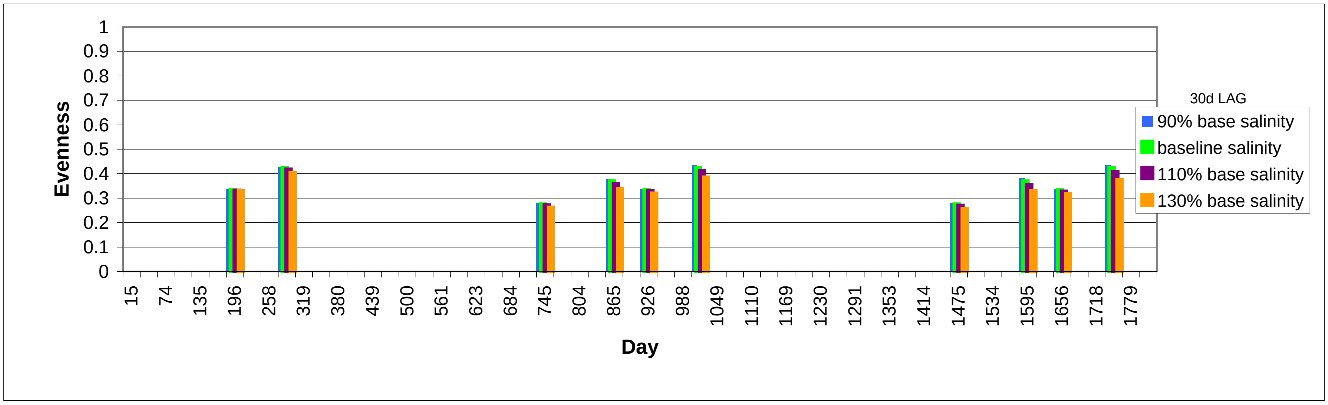
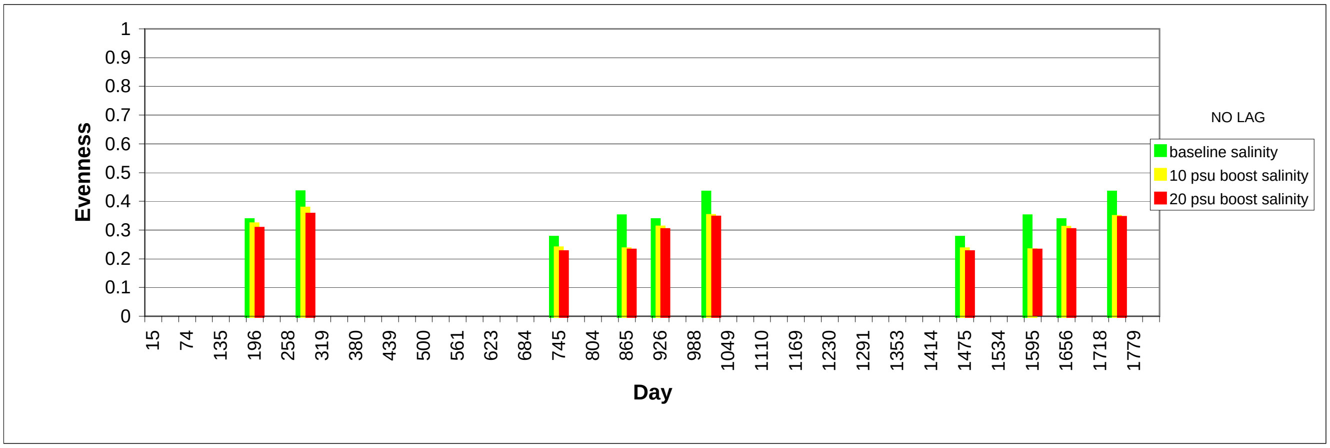


Figure 91. Little Madeira Bay Scenario – Evenness throw-trap

INNER LITTLE MADEIRA BAY- THROW TRAP







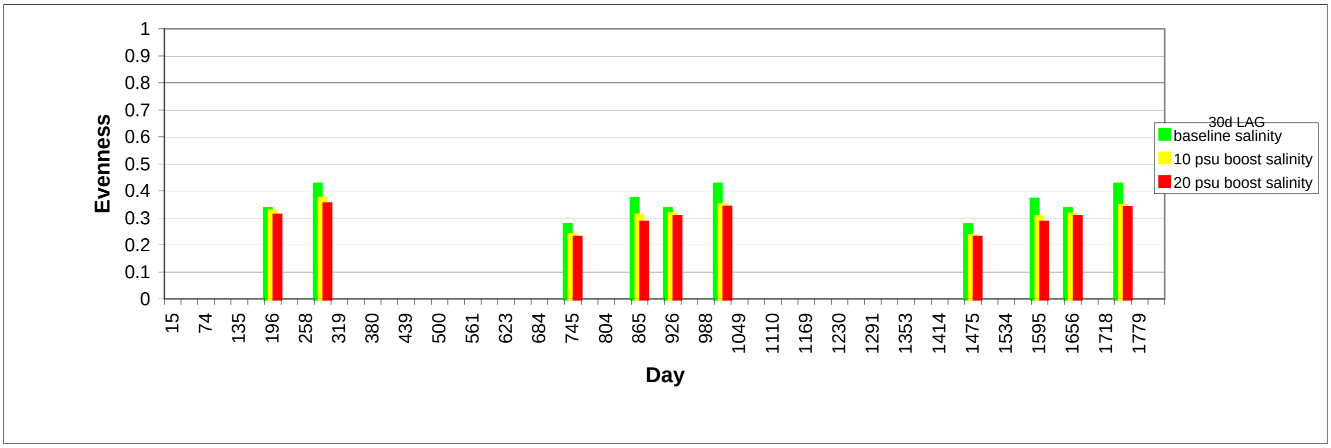
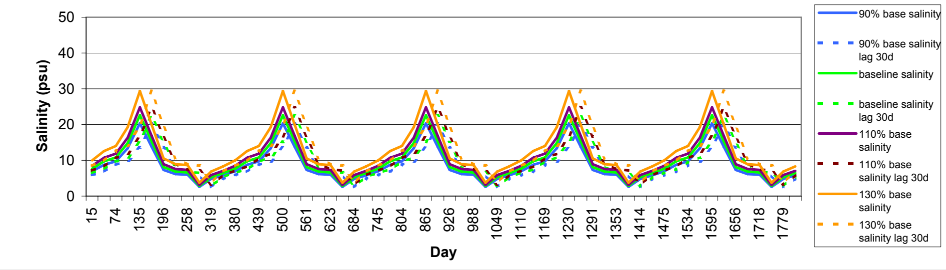
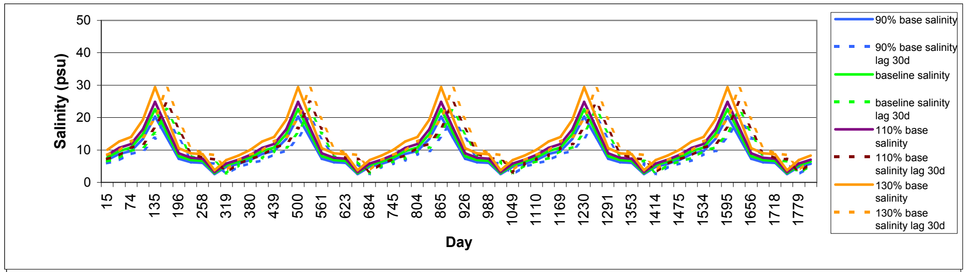
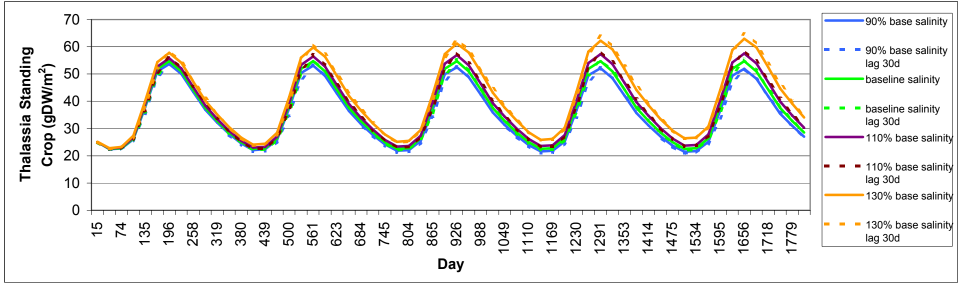


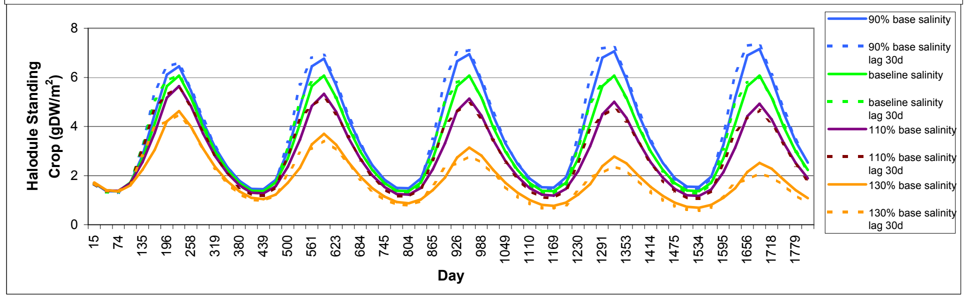
Figure 92. Little Madeira Bay Scenario – Salinity and SAV- throw-trap

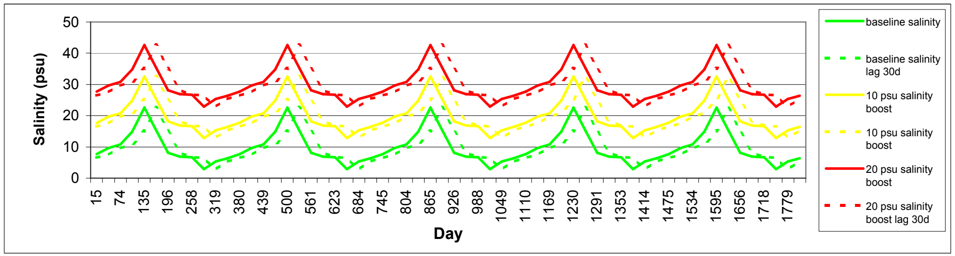
INNER LITTLE MADEIRA BAY

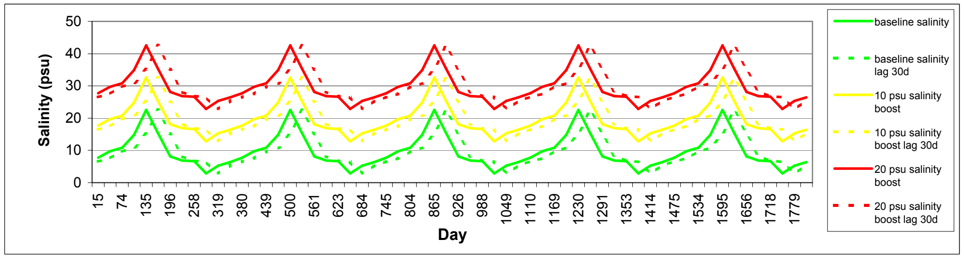


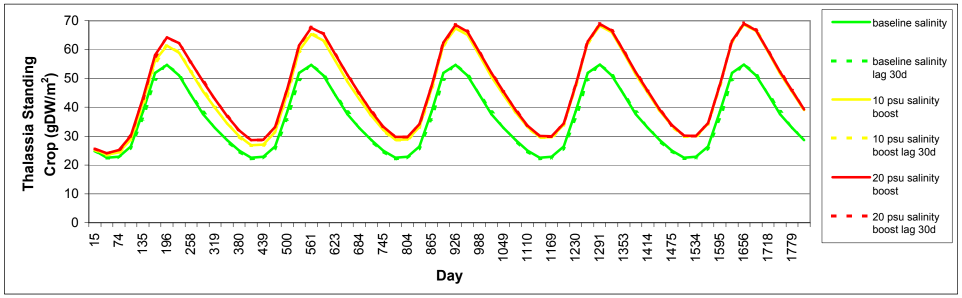












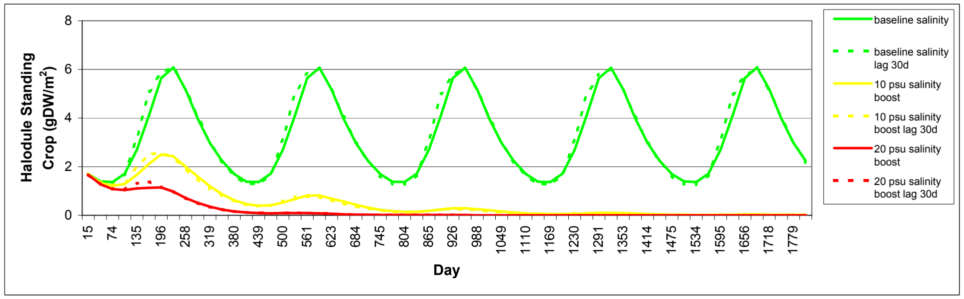
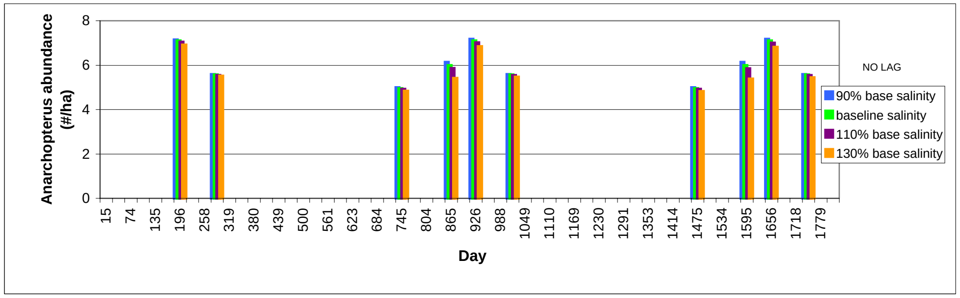
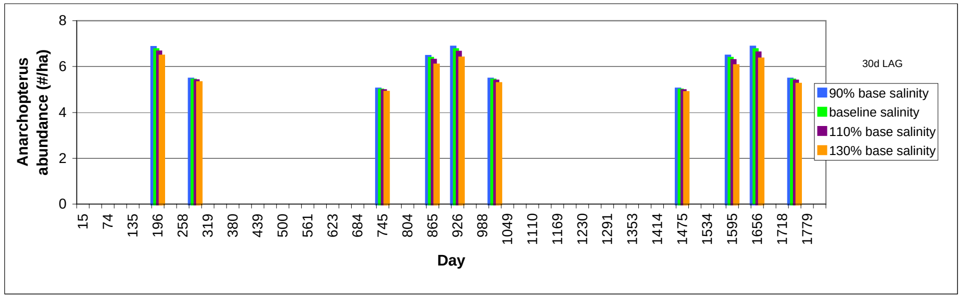
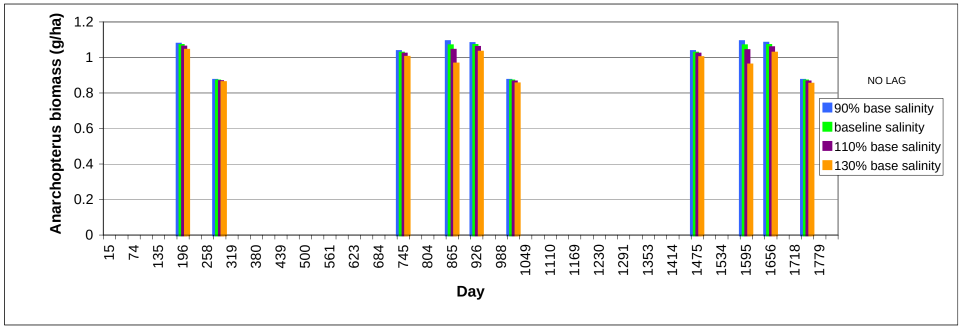


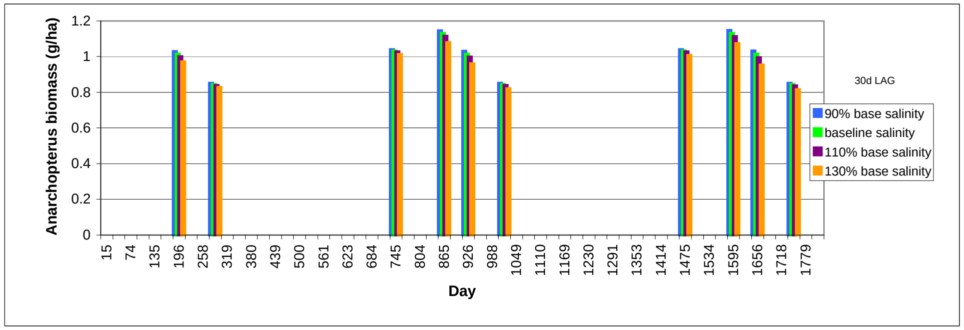
Figure 93. Whipray Basin Scenario – *Anarchopterus criniger* abundance and biomass-trawl/seine

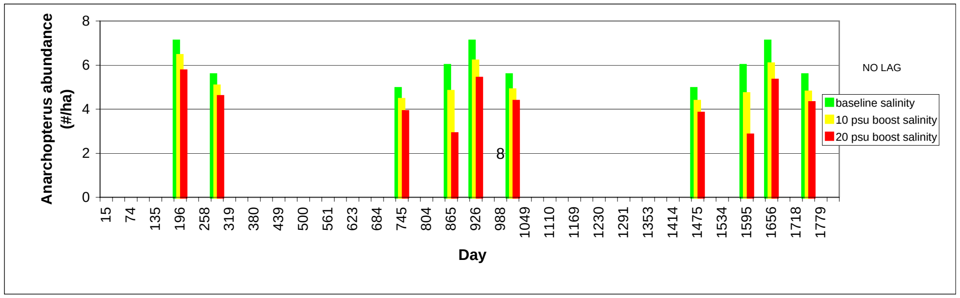
WHIPRAY- TRAWL/SEINE

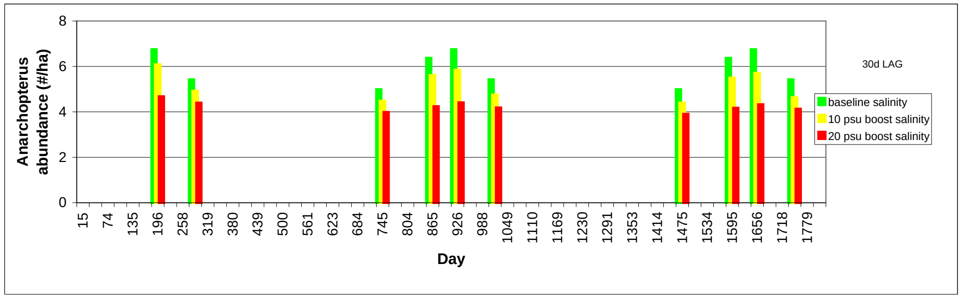


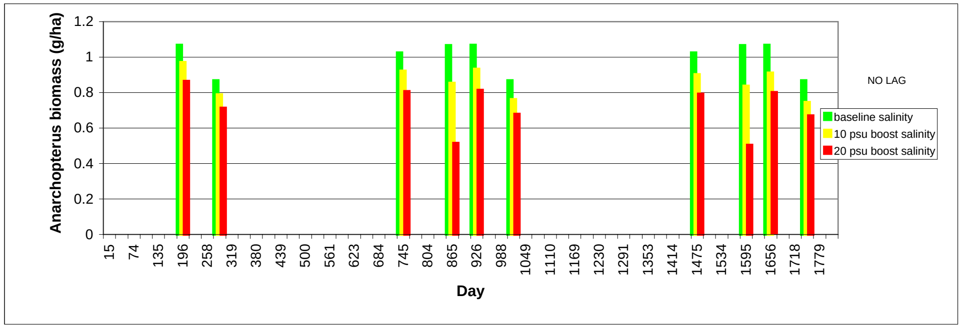












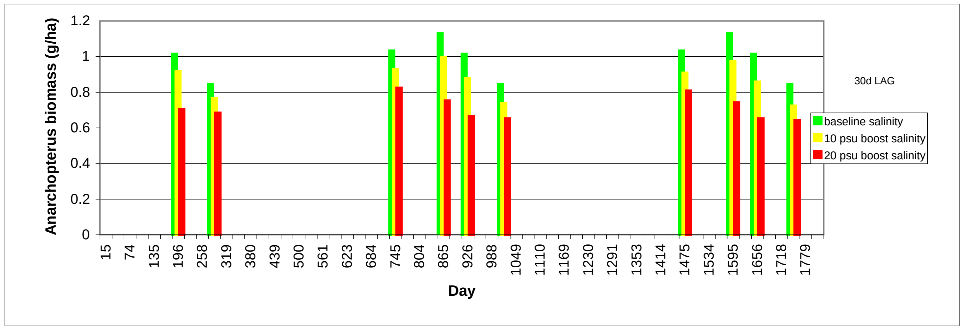
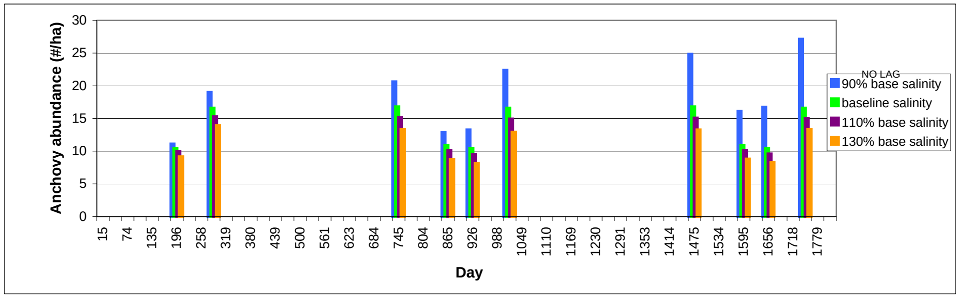
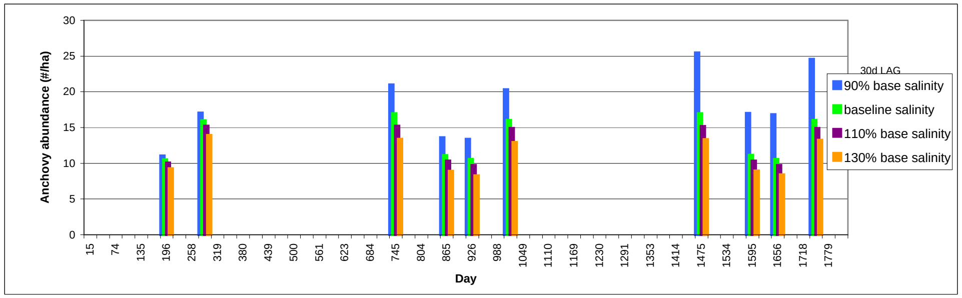
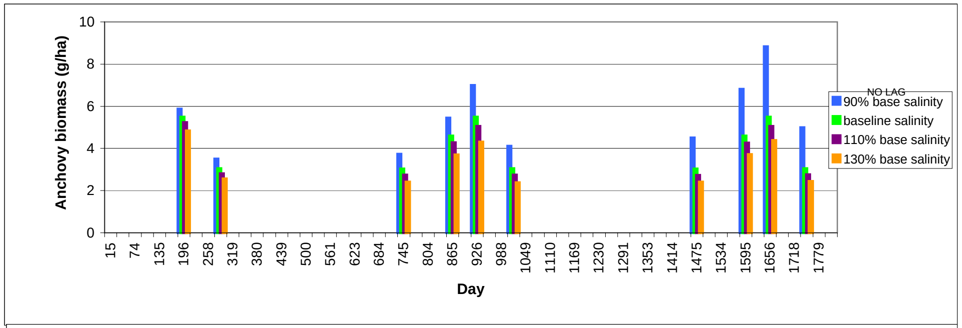


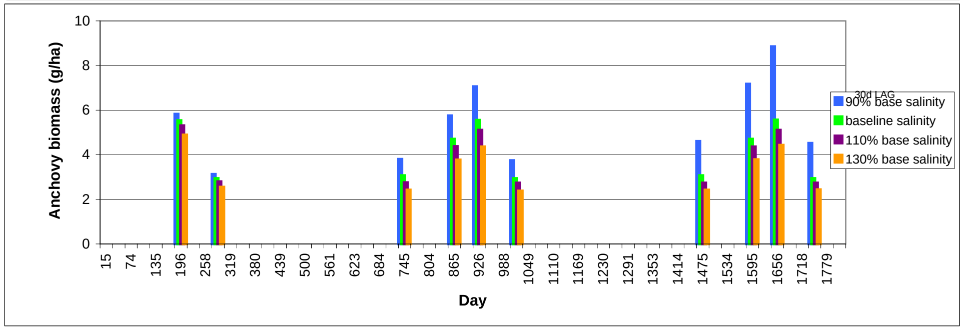
Figure 94. Whipray Basin Scenario – *Anchoa mitchelli* abundance and biomass-trawl/seine

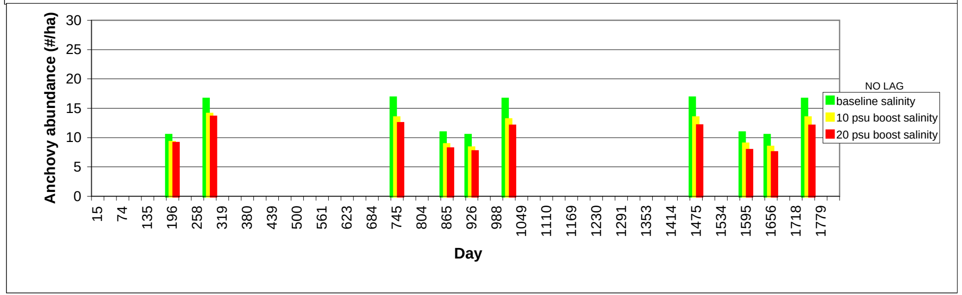
WHIPRAY- TRAWL/SEINE

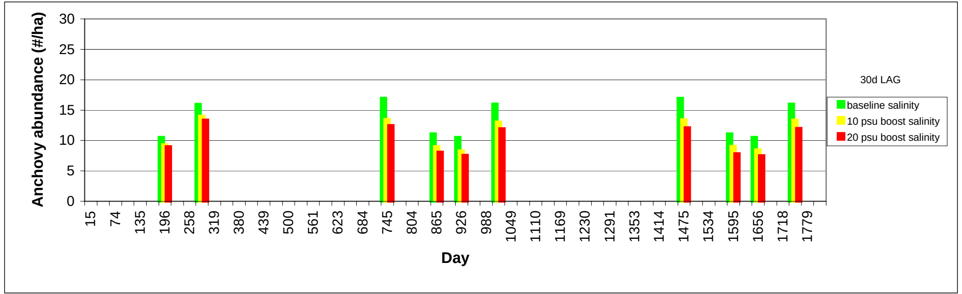


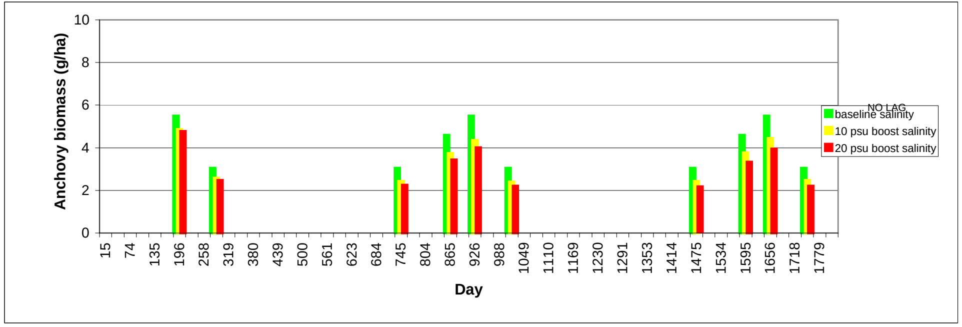












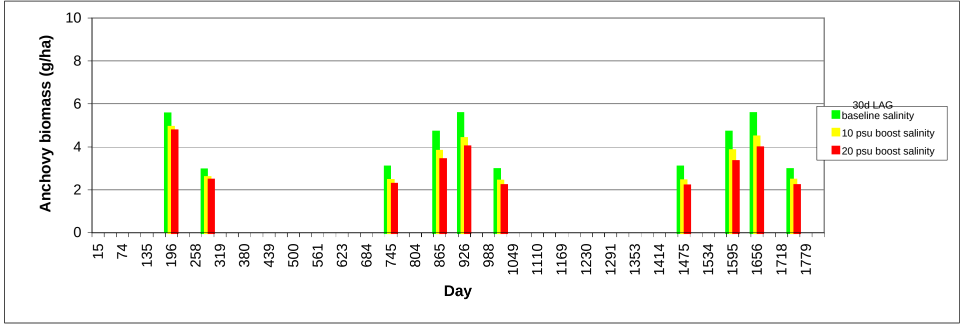
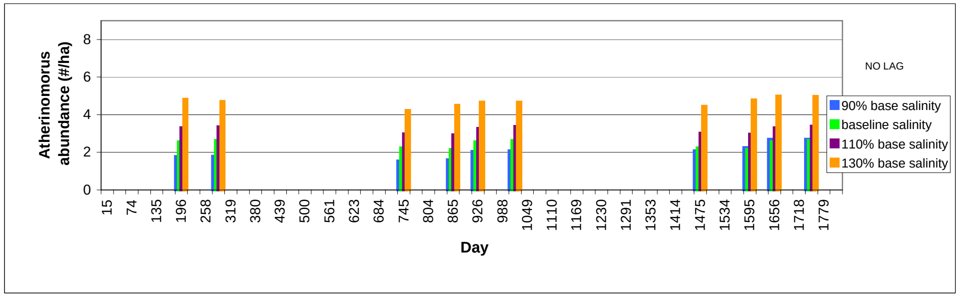
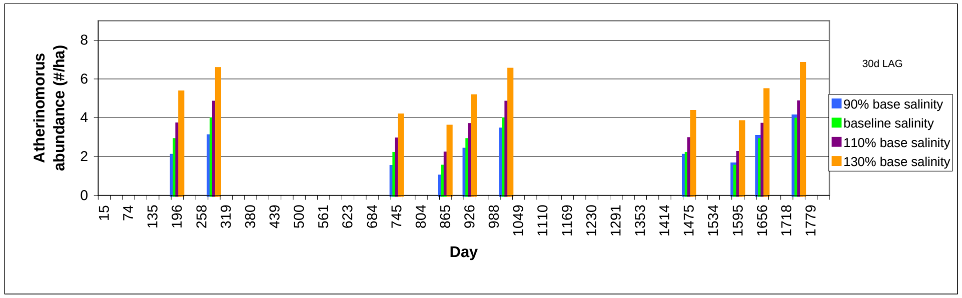
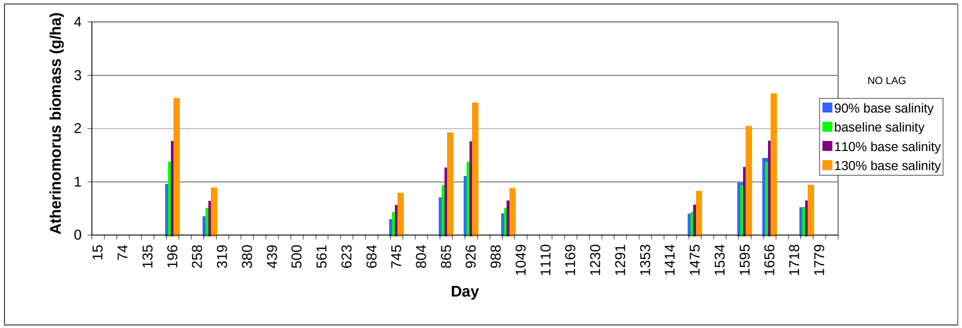


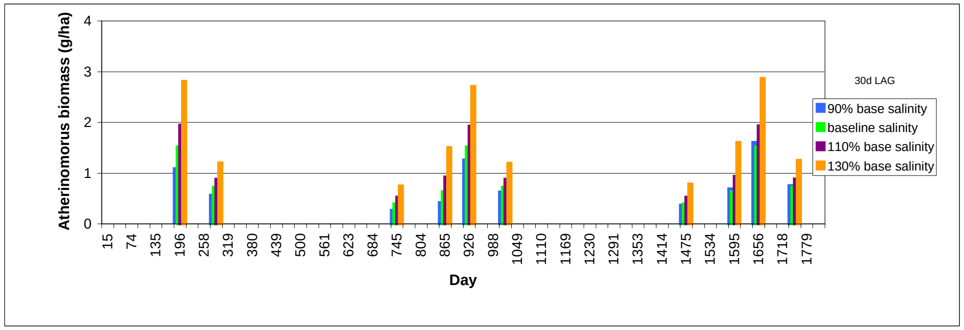
Figure 95. Whipray Basin Scenario – *Atherinomorus stipes* abundance and biomass-trawl/seine

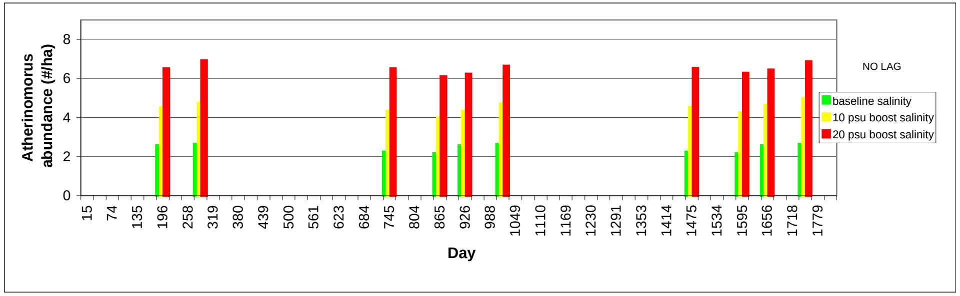
WHIPRAY- TRAWL/SEINE

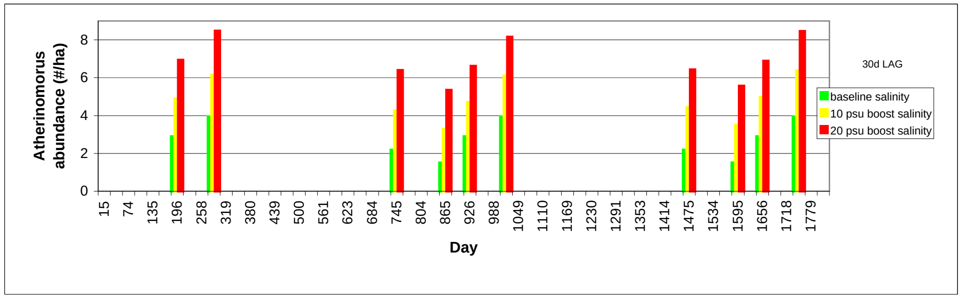


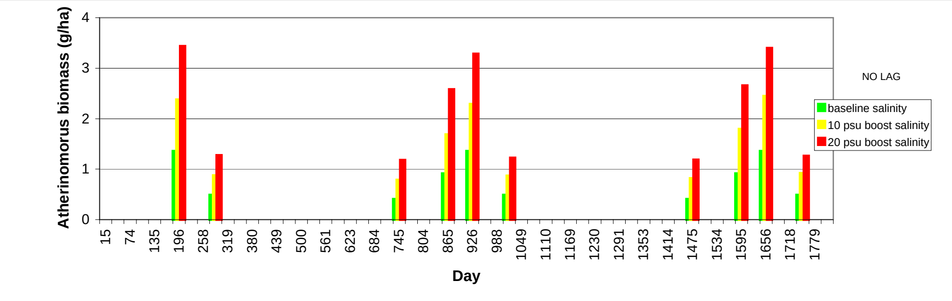












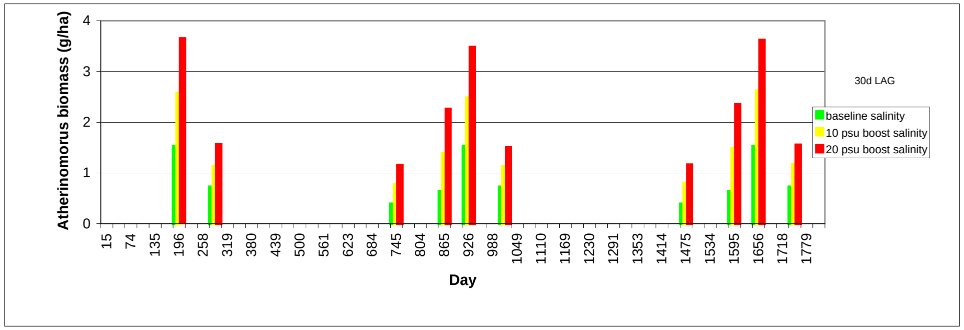
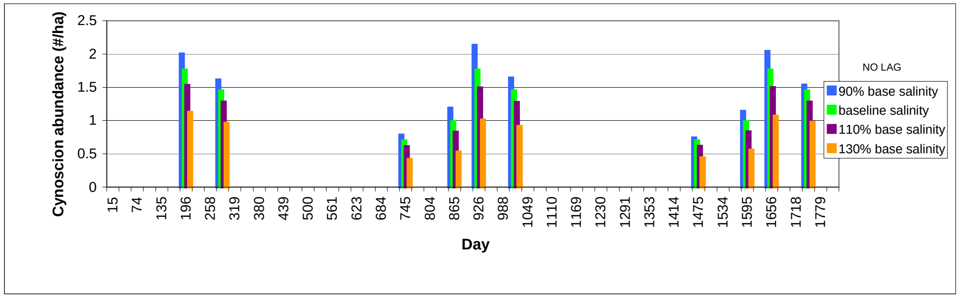
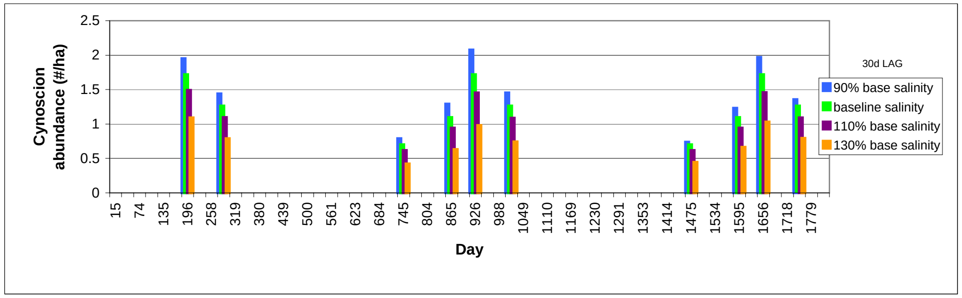
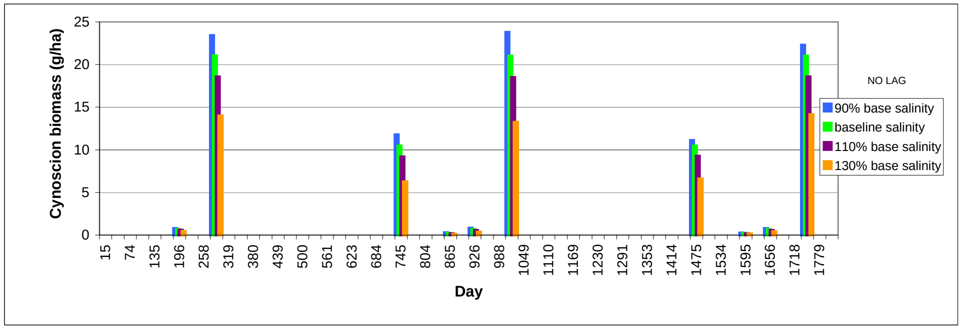


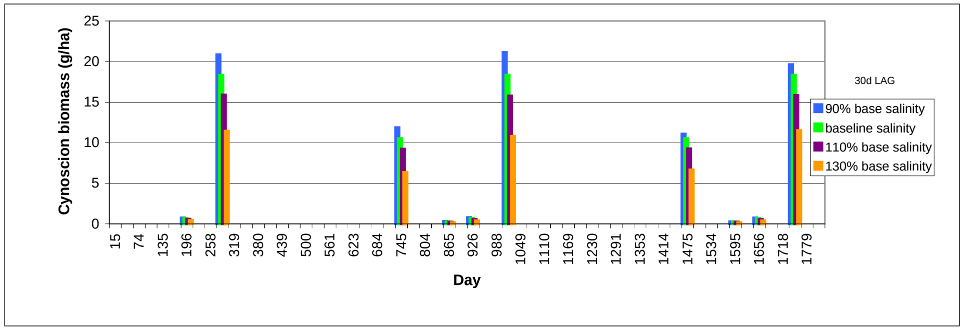
Figure 96. Whipray Basin Scenario – *Cynoscion nebulosus* abundance and biomass-trawl/seine

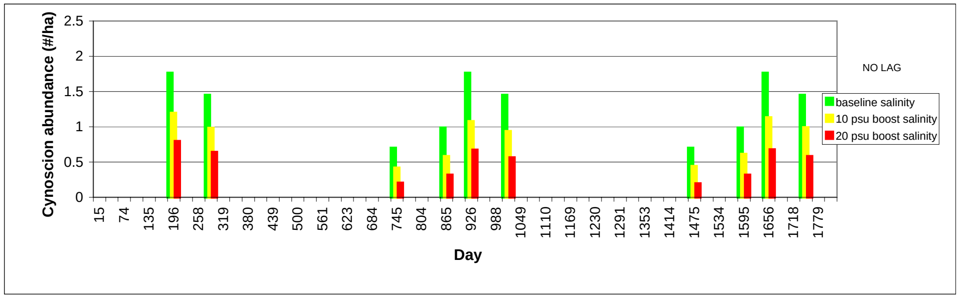
WHIPRAY- TRAWL/SEINE

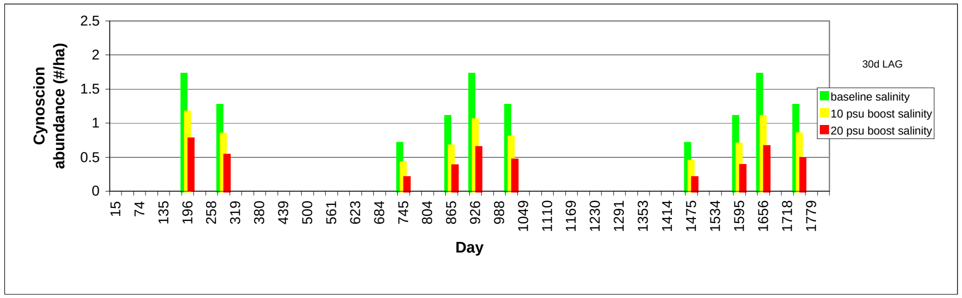


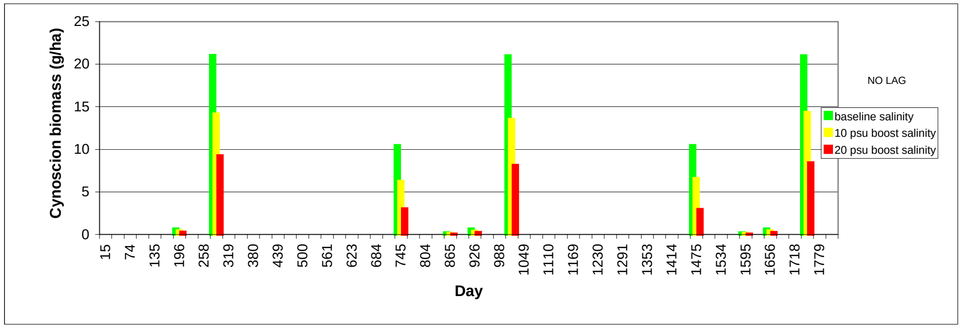












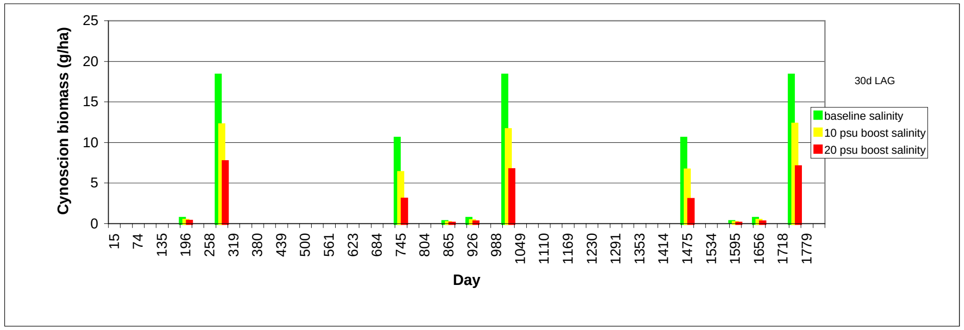
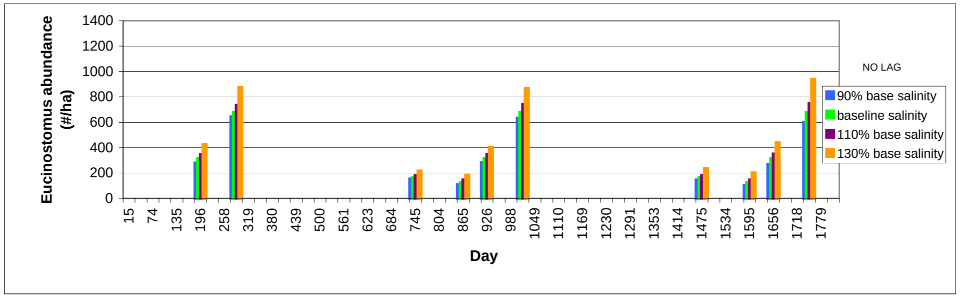
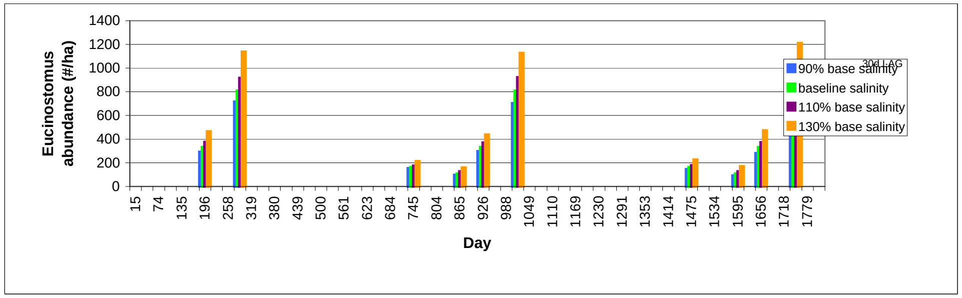
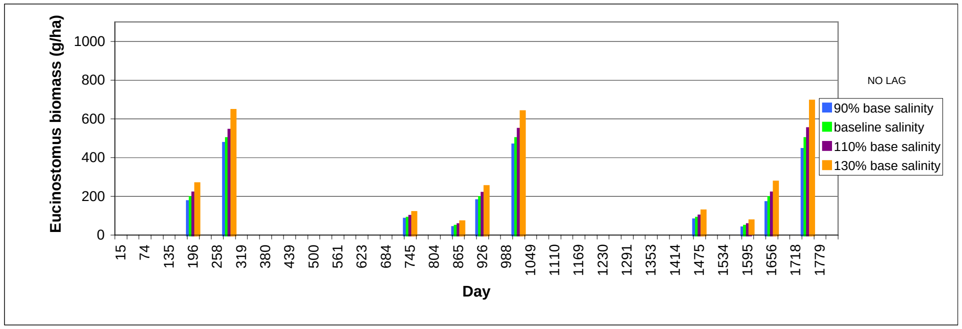


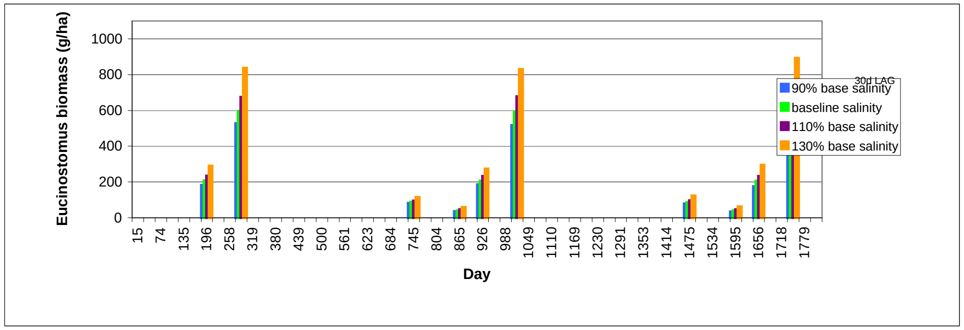
Figure 97. Whipray Basin Scenario – *Eucinostomus spp*. abundance and biomass-trawl/seine

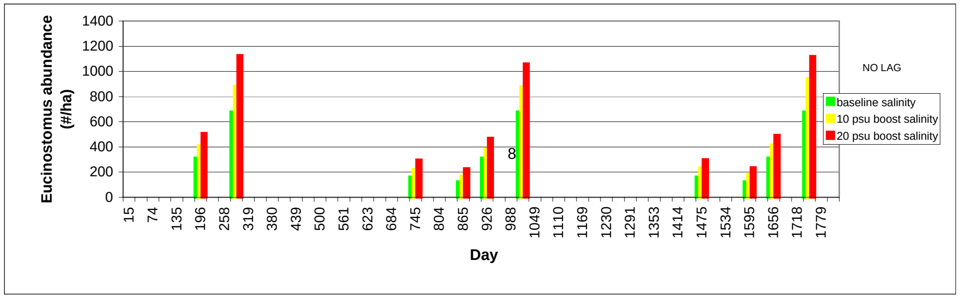
WHIPRAY- TRAWL/SEINE

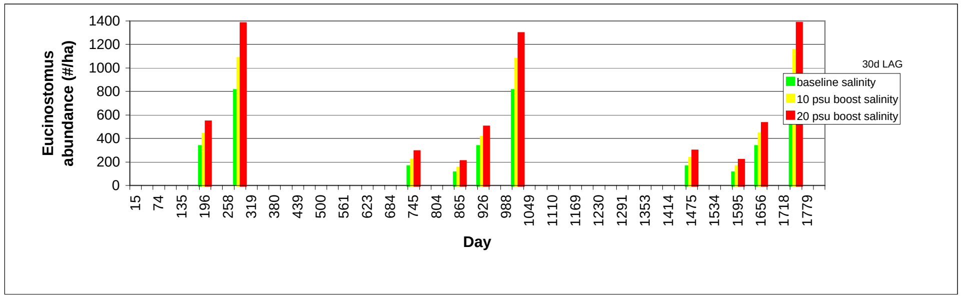


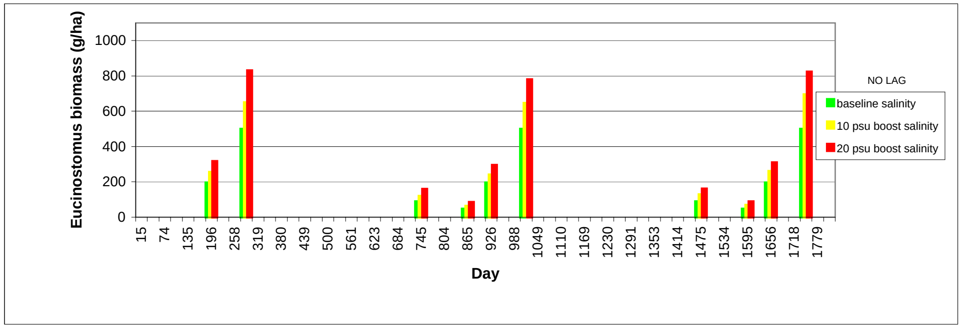












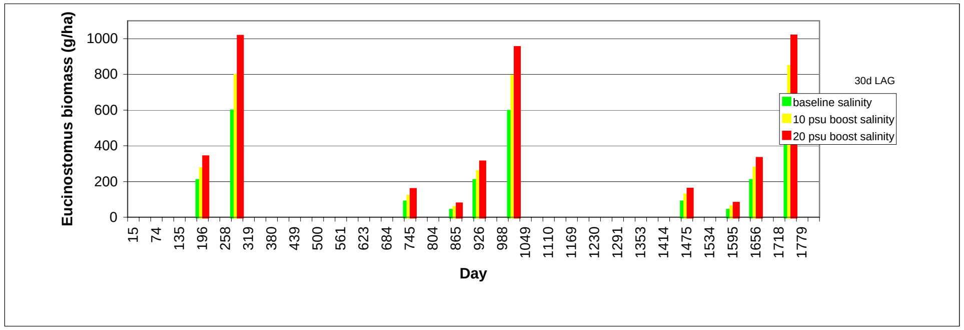
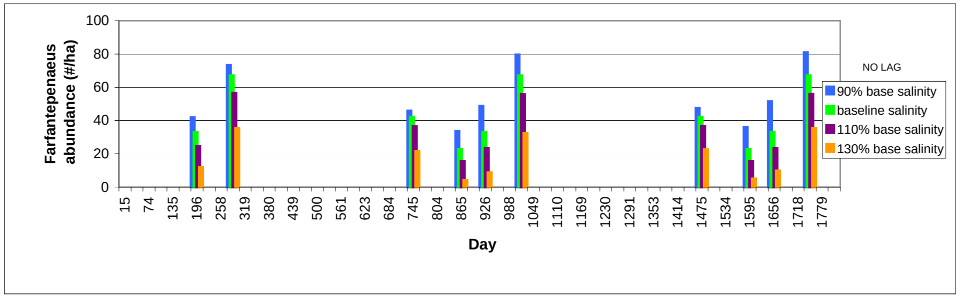
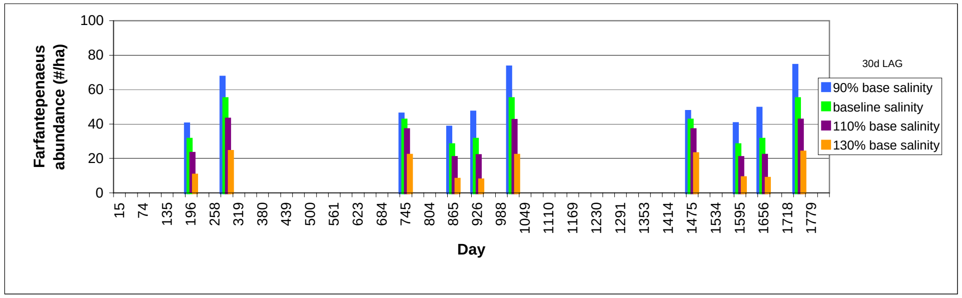
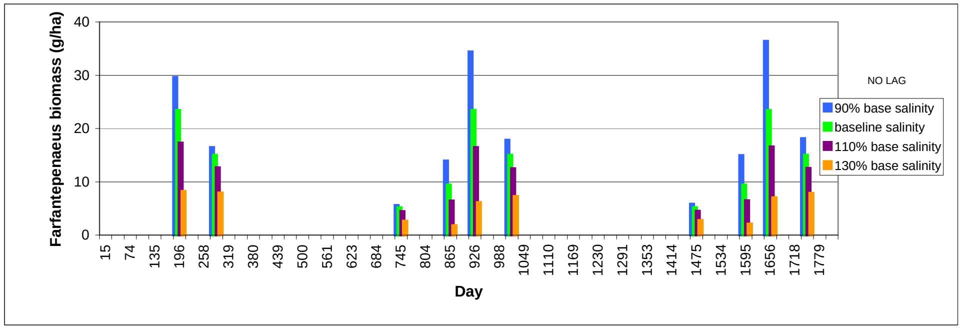


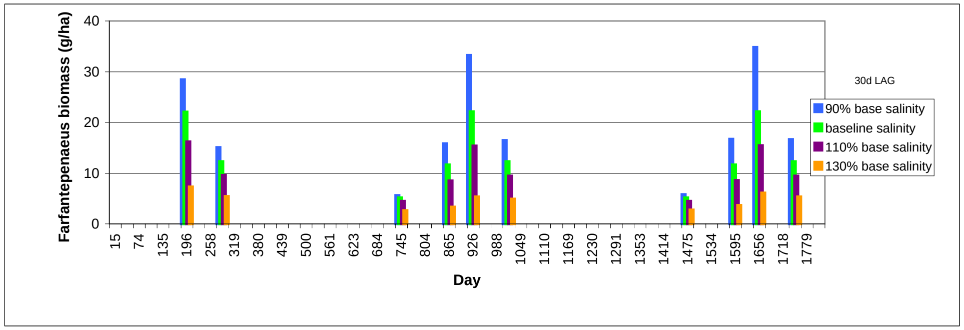
Figure 98. Whipray Basin Scenario – *Farfantepenaeus duorarum* abundance and biomass- trawl/seine

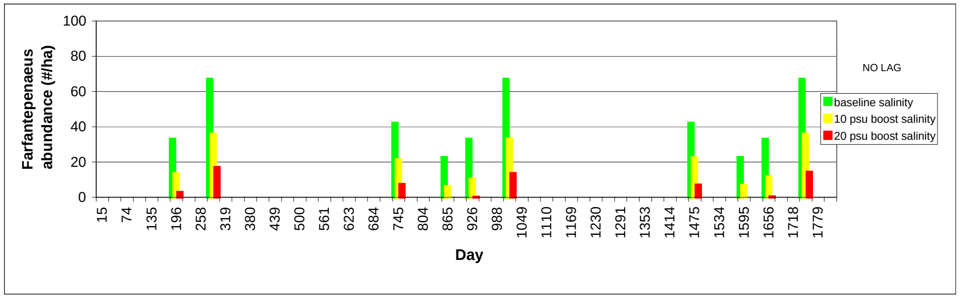
WHIPRAY- TRAWL/SEINE

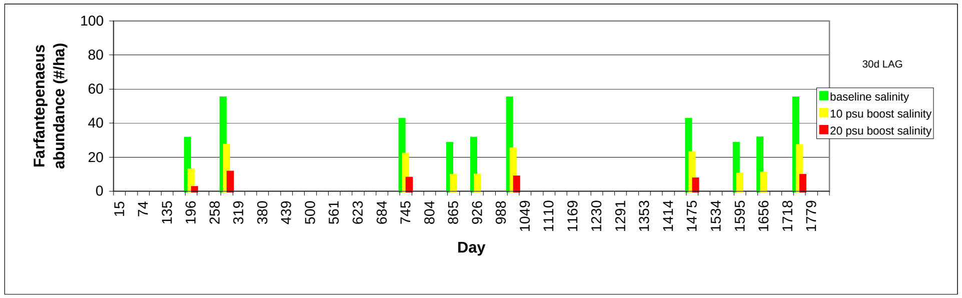


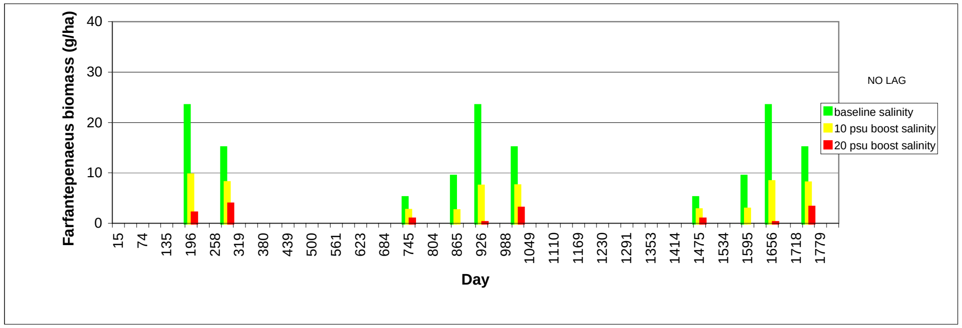












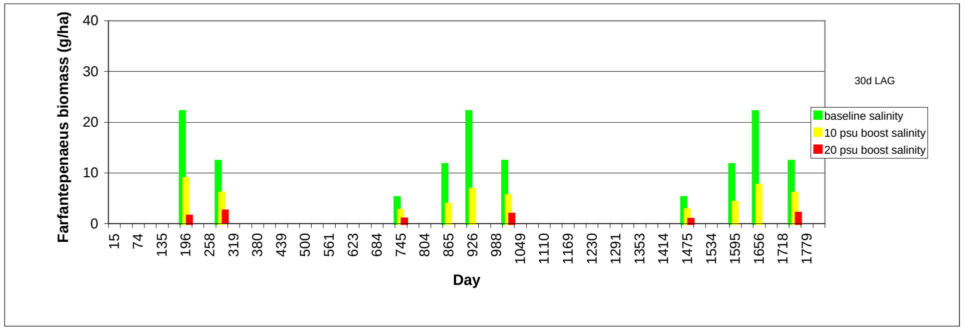
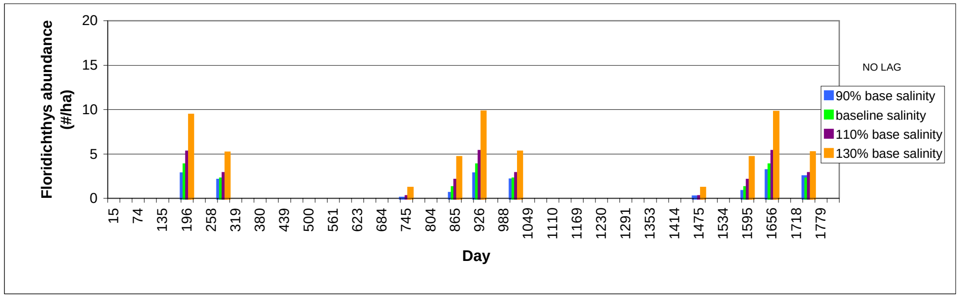
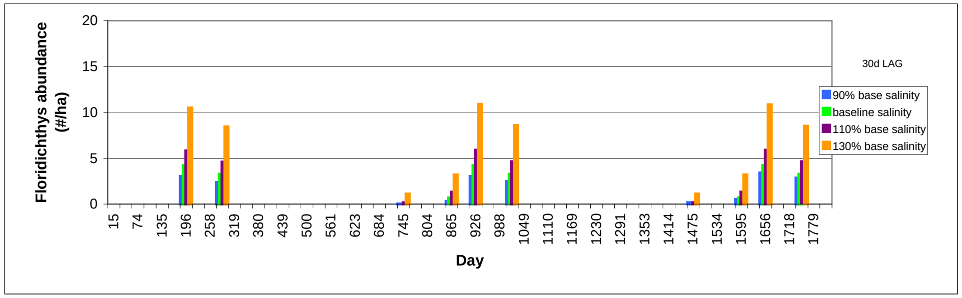
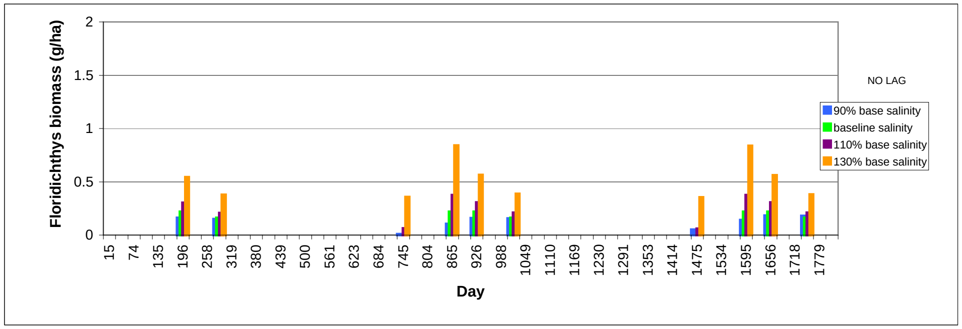


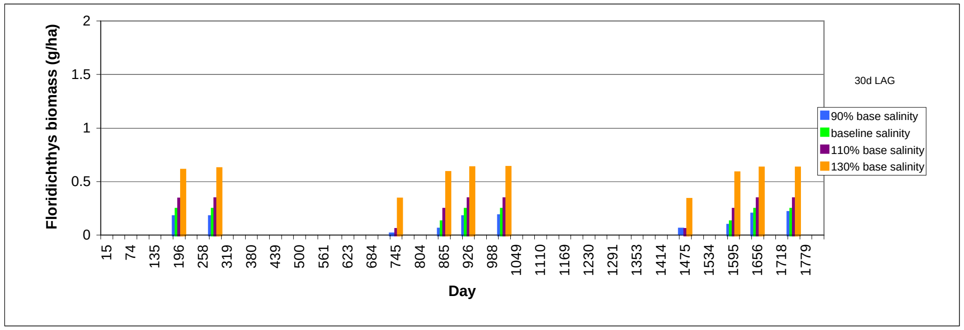
Figure 99. Whipray Basin Scenario – *Floridichthys carpio* abundance and biomass-trawl/seine

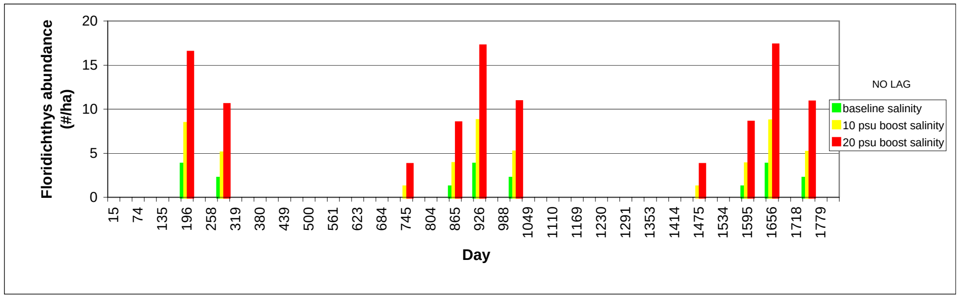
WHIPRAY- TRAWL/SEINE

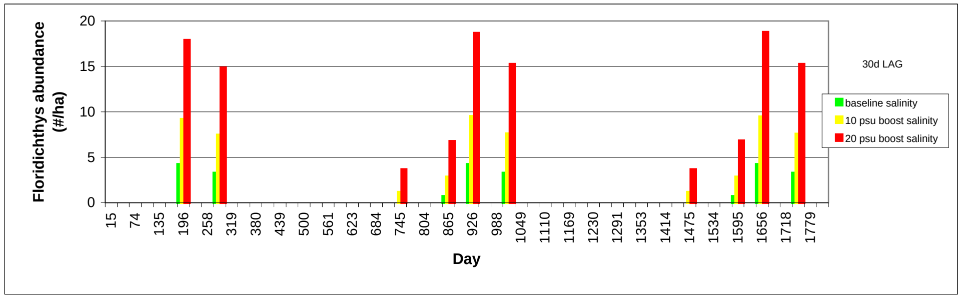


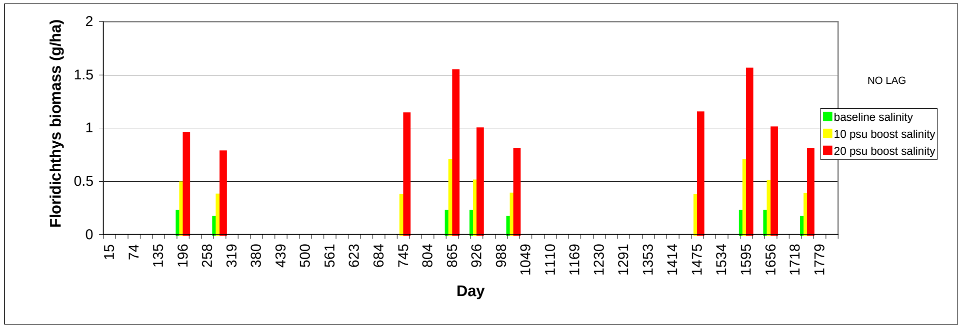












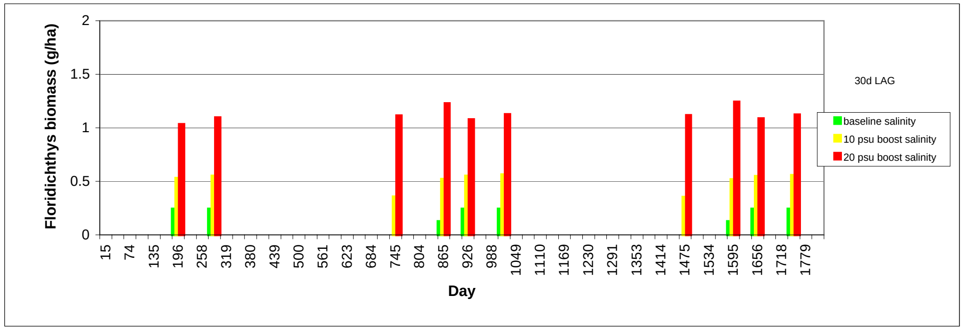
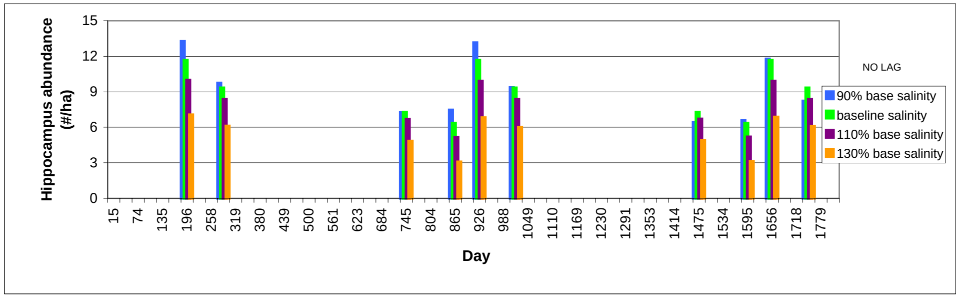
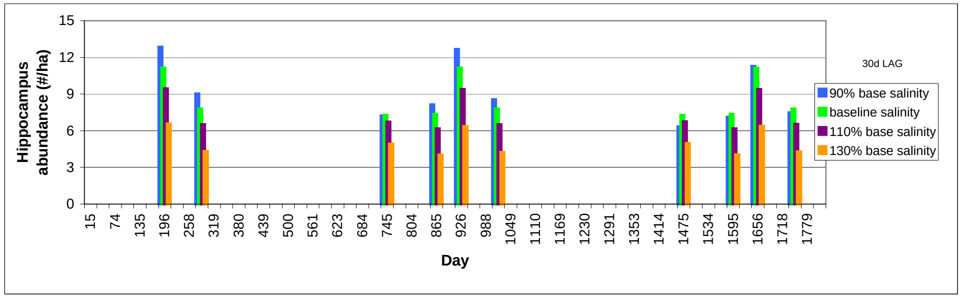
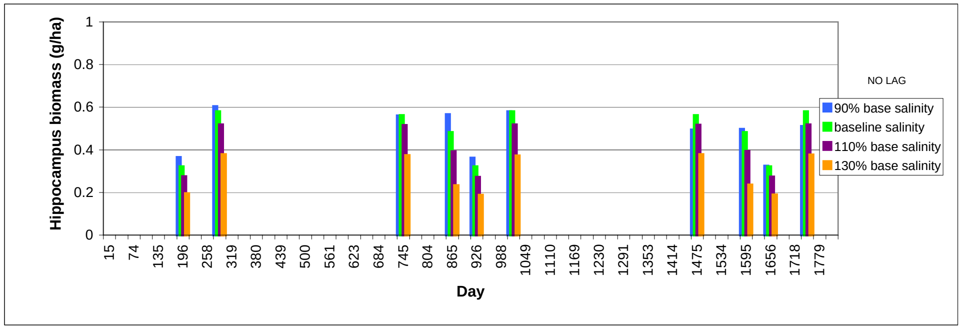


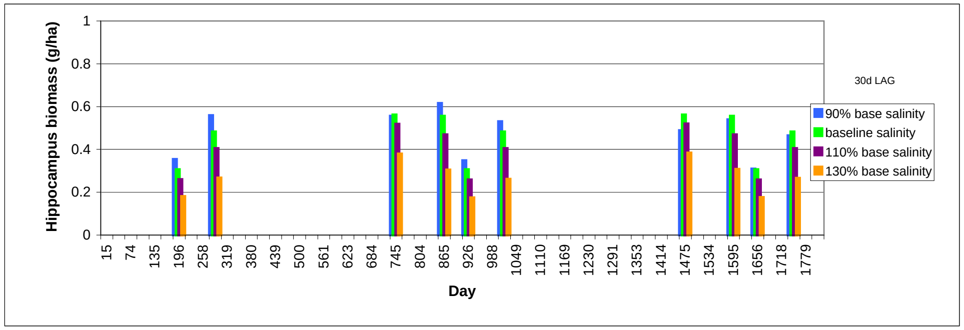
Figure 100. Whipray Basin Scenario – *Hippocampus zosterae* abundance and biomass-trawl/seine

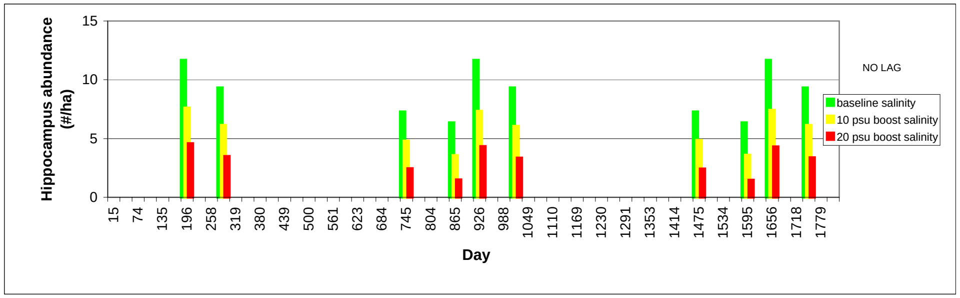
WHIPRAY- TRAWL/SEINE

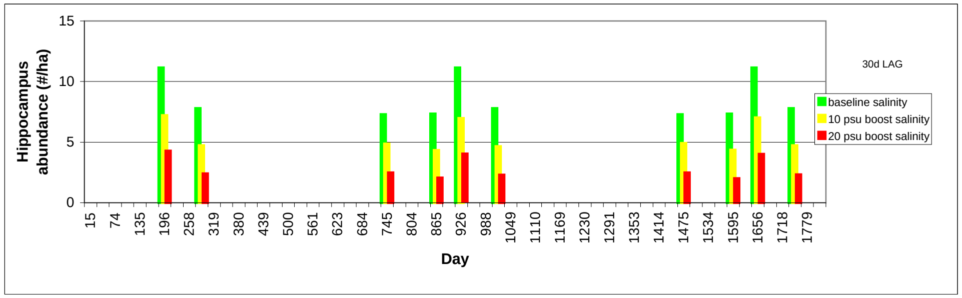


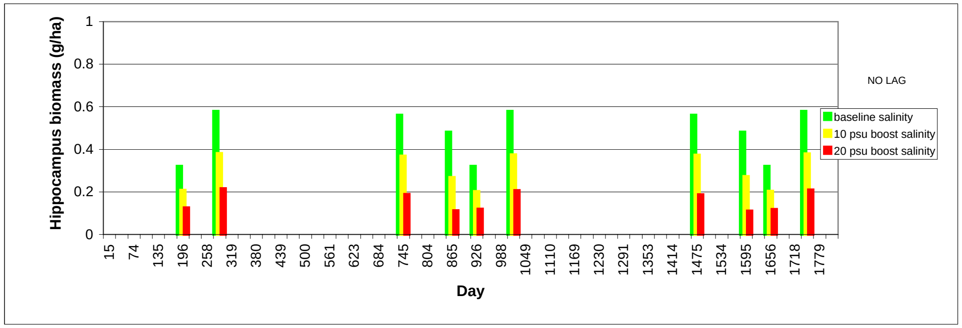












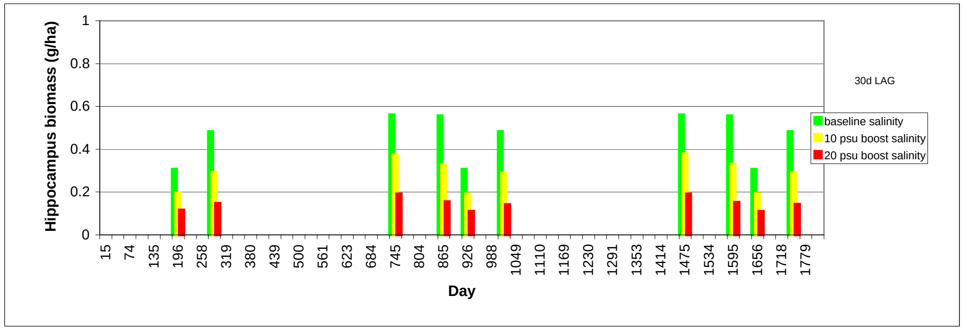
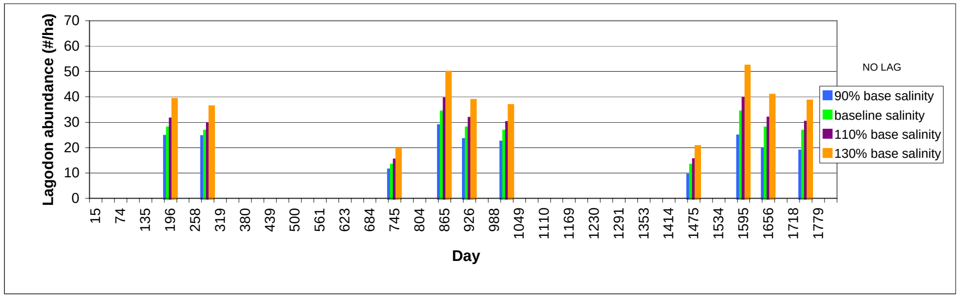
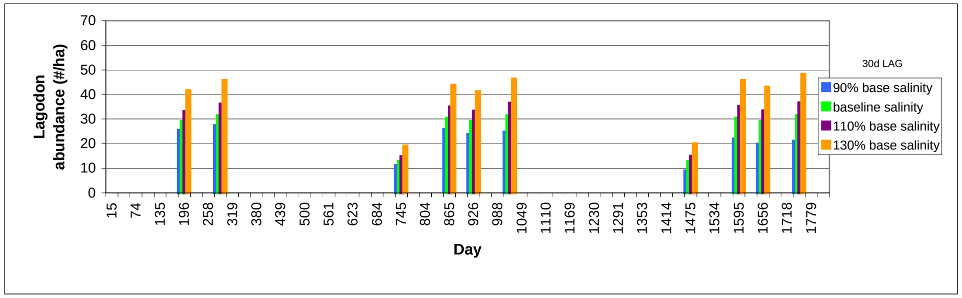
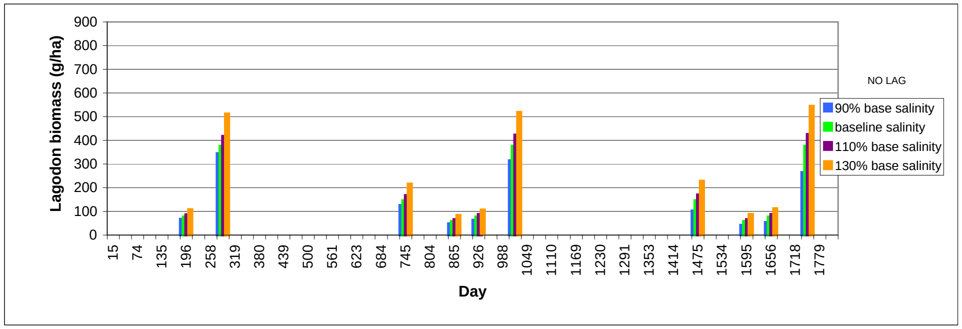


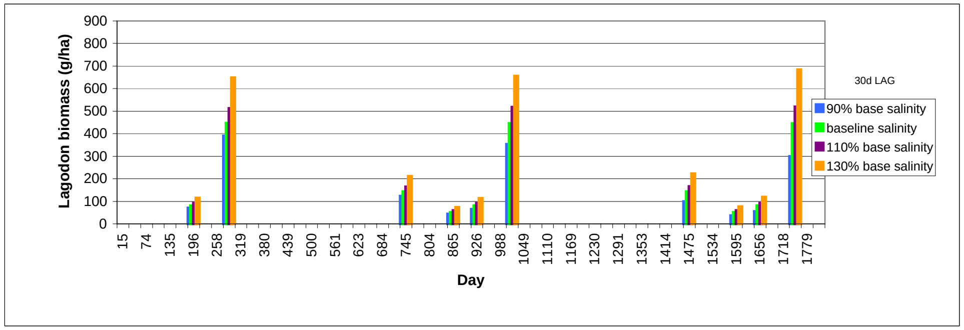
Figure 101. Whipray Basin Scenario – *Lagodon rhomboides* abundance and biomass-trawl/seine

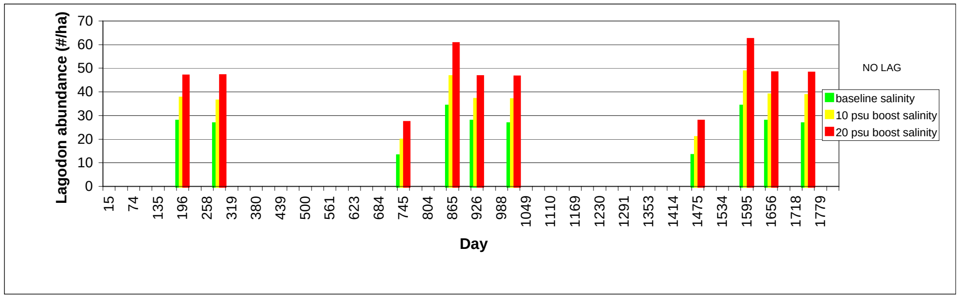
WHIPRAY- TRAWL/SEINE

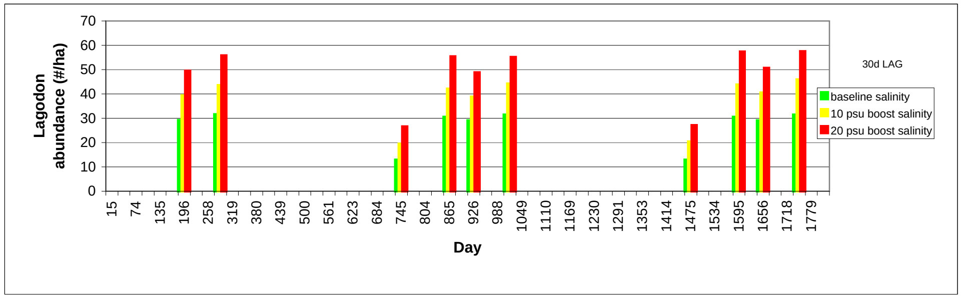


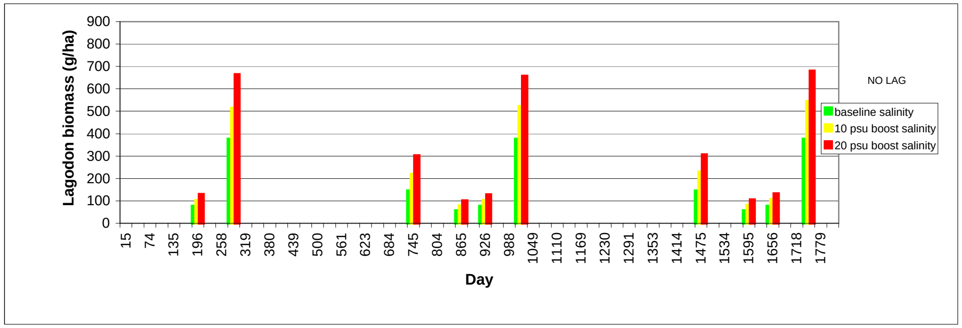












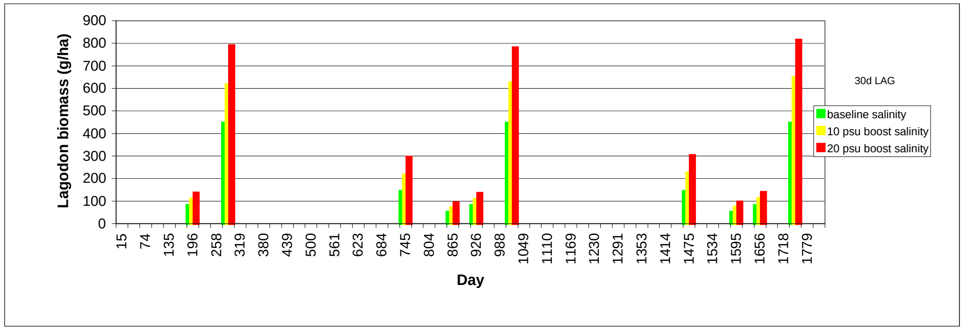
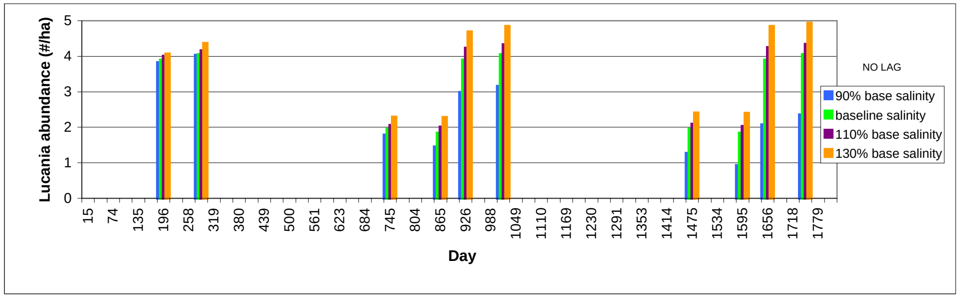
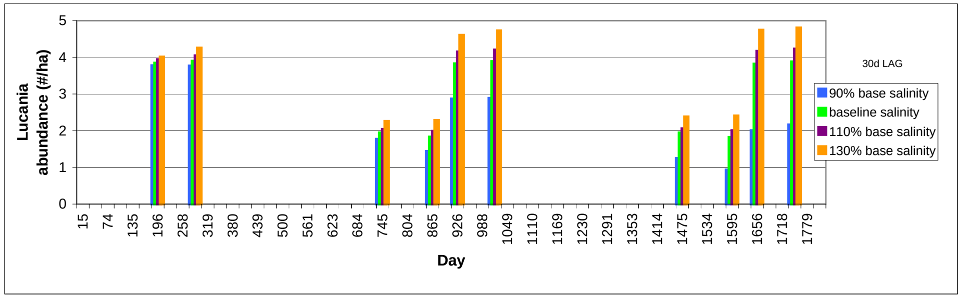
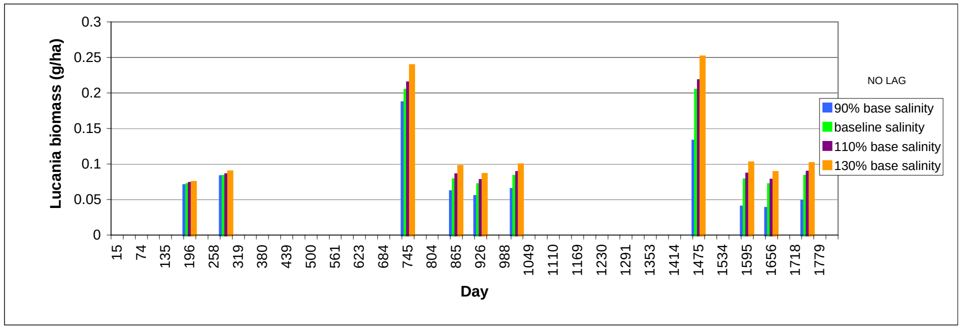


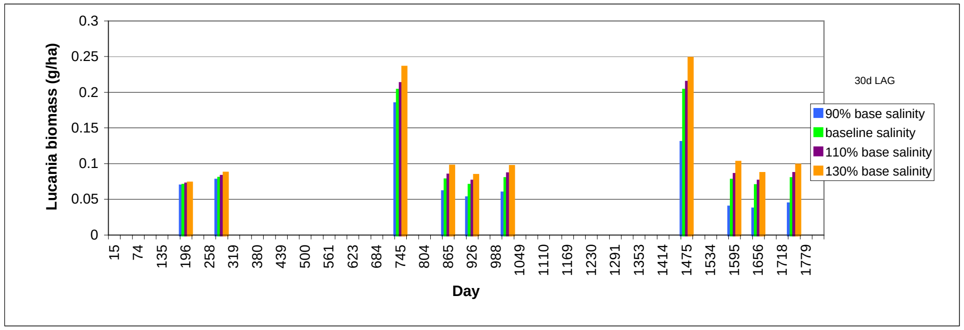
Figure 102. Whipray Basin Scenario – *Lucania parva* abundance and biomass-trawl/seine

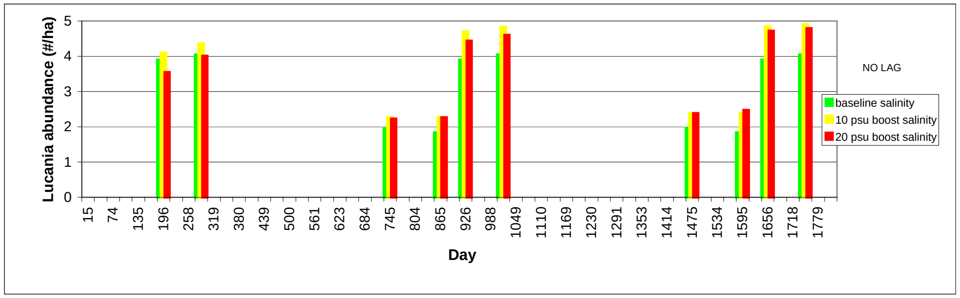
WHIPRAY- TRAWL/SEINE

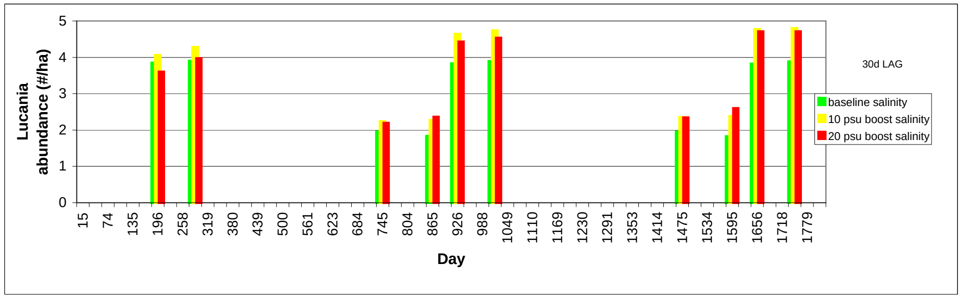


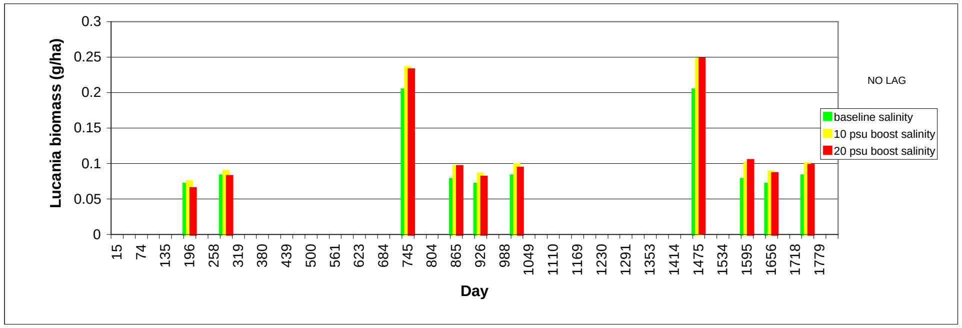












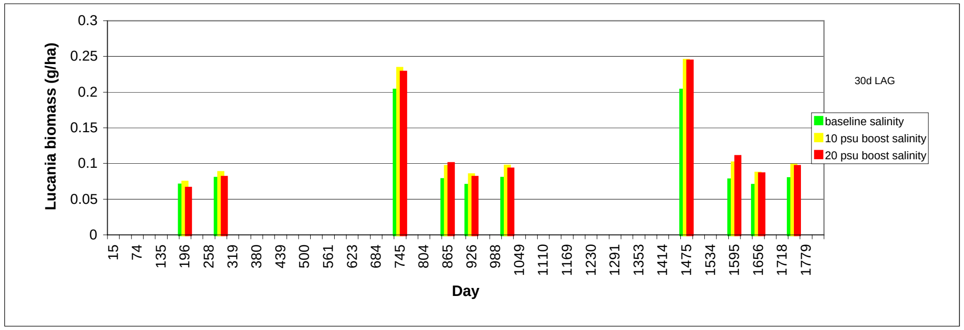
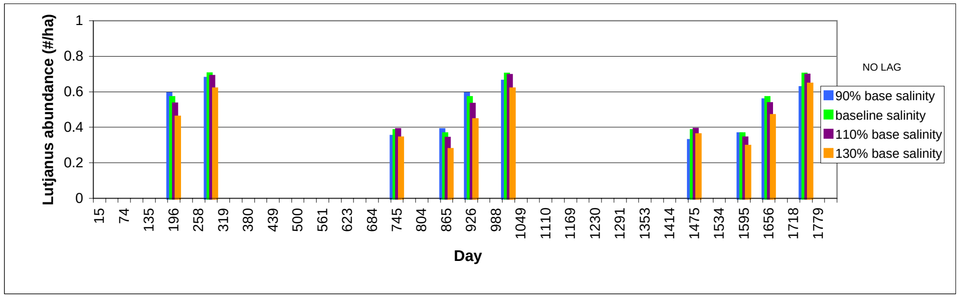
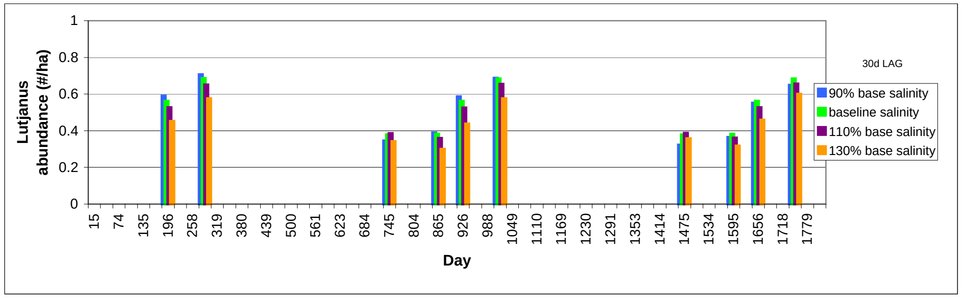
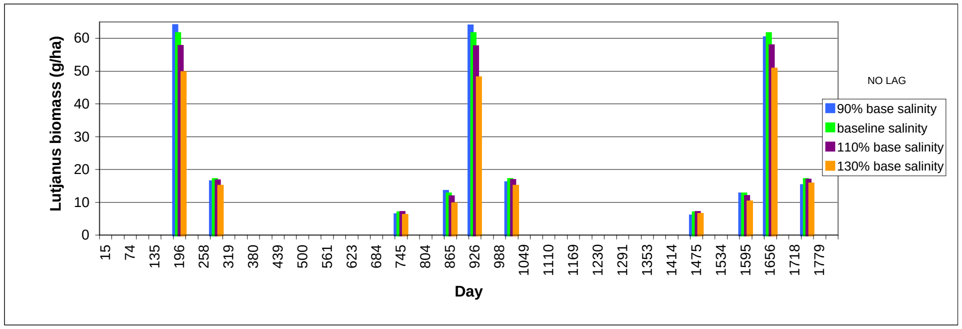


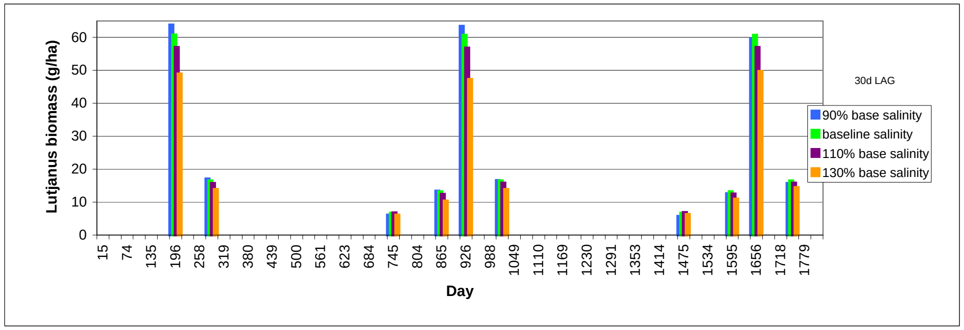
Figure 103. Whipray Basin Scenario – *Lutjanus griseus* abundance and biomass-trawl/seine

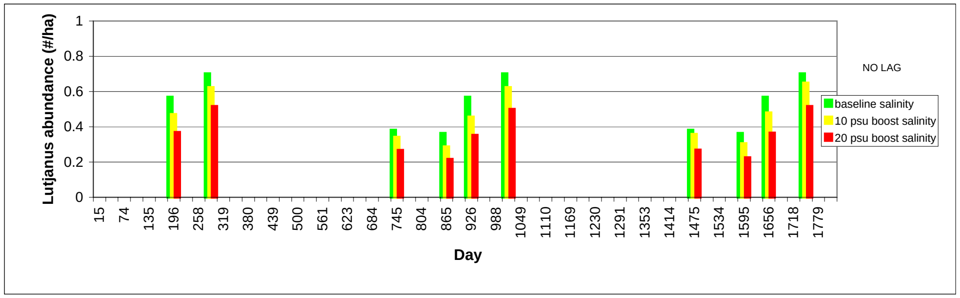
WHIPRAY- TRAWL/SEINE

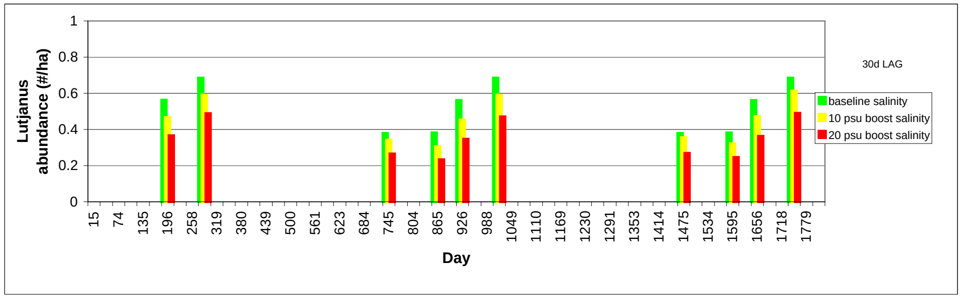


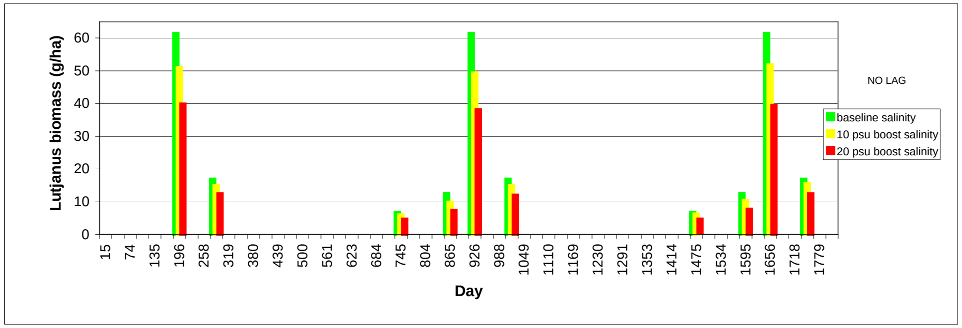












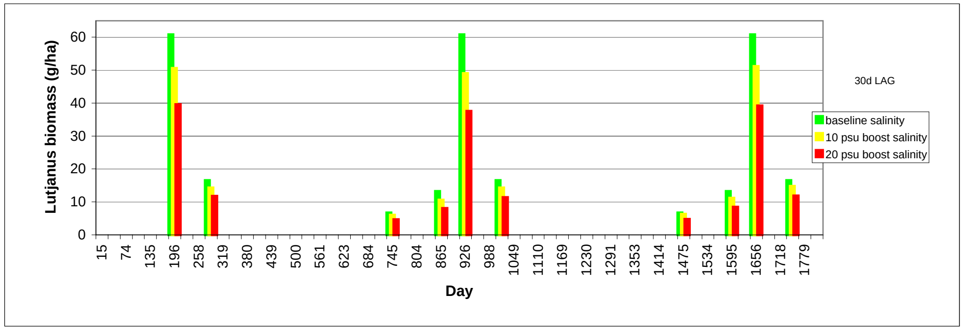
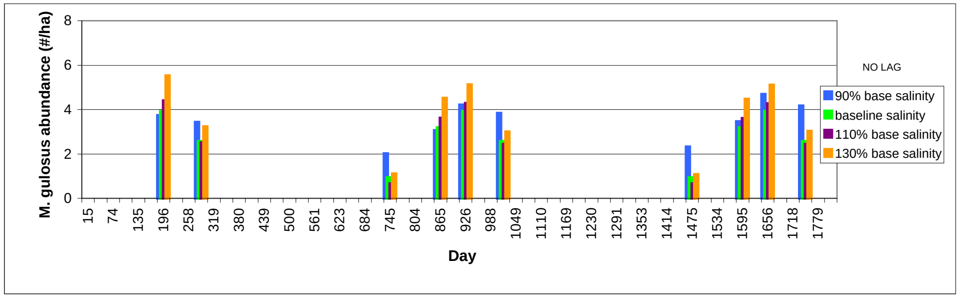
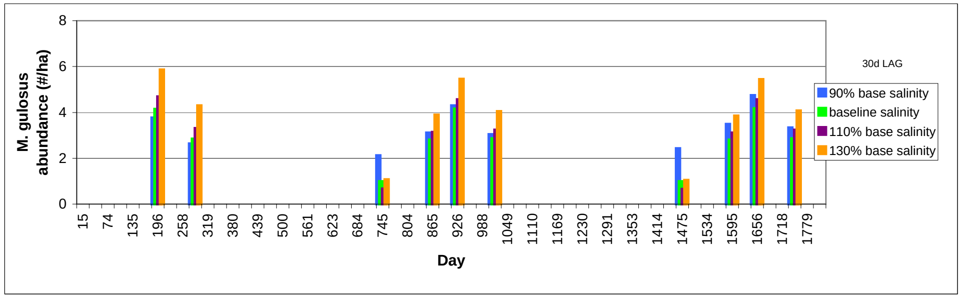
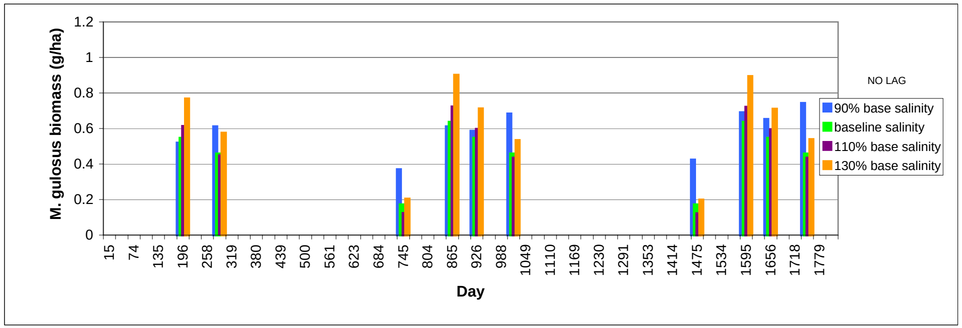


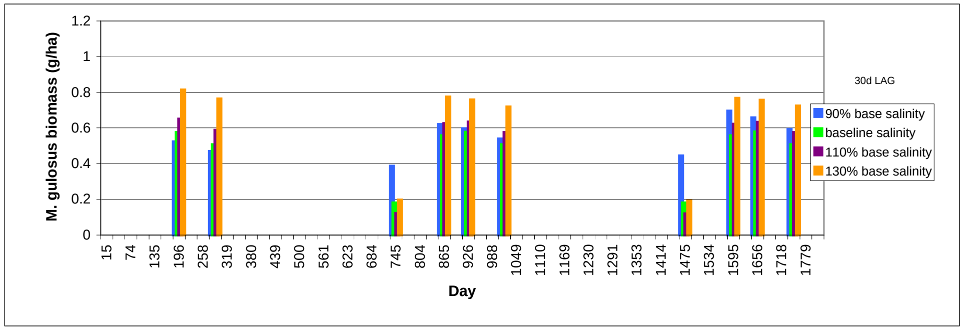
Figure 104. Whipray Basin Scenario – *Microgobius gulosus* abundance and biomass-trawl/seine

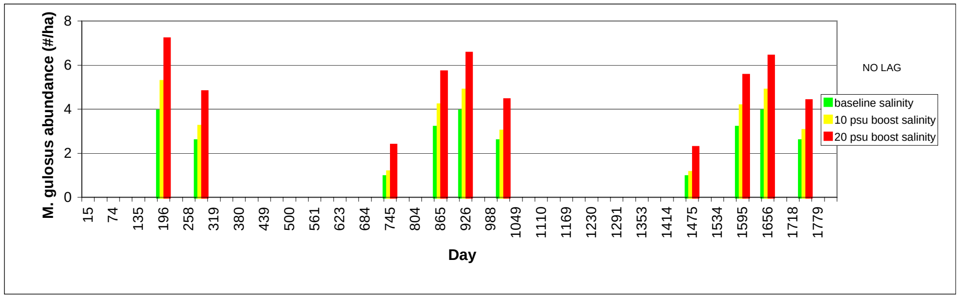
WHIPRAY- TRAWL/SEINE

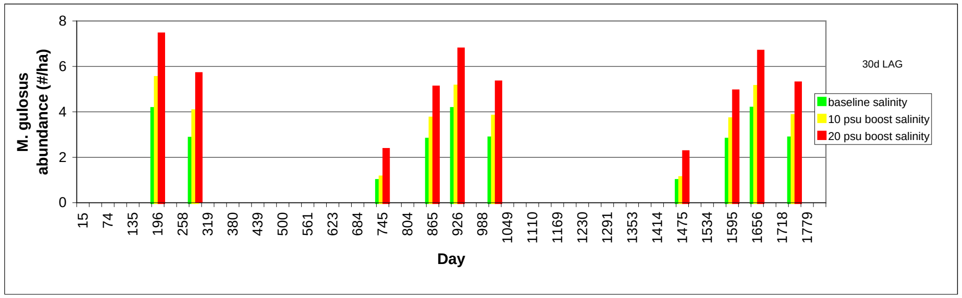


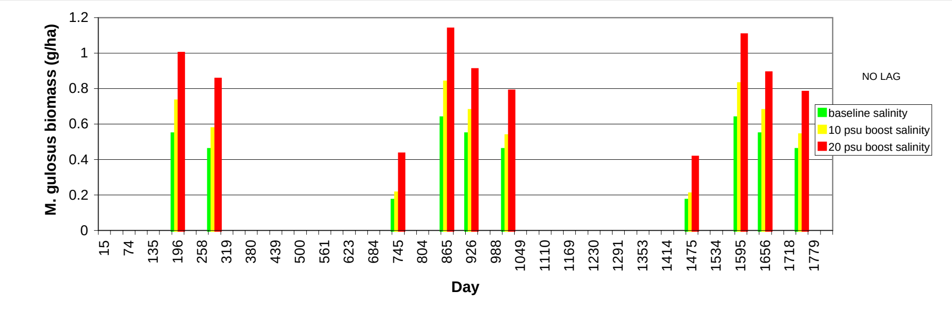












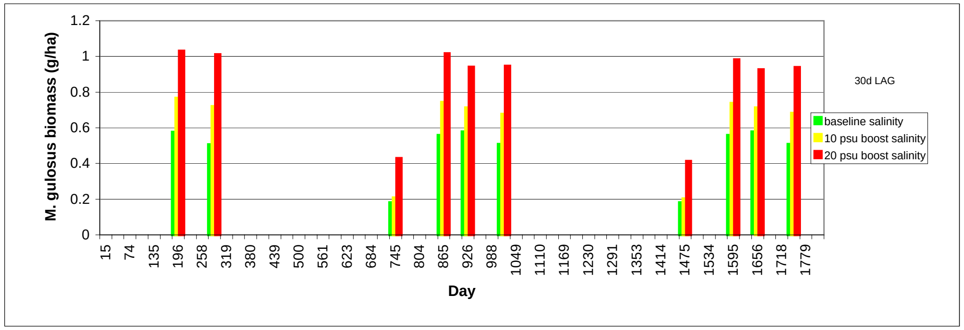
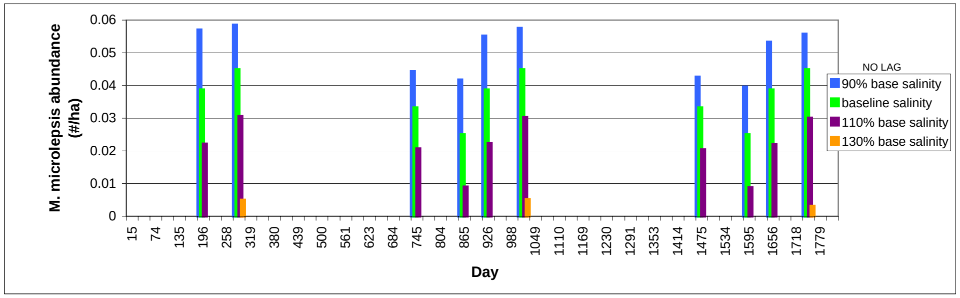
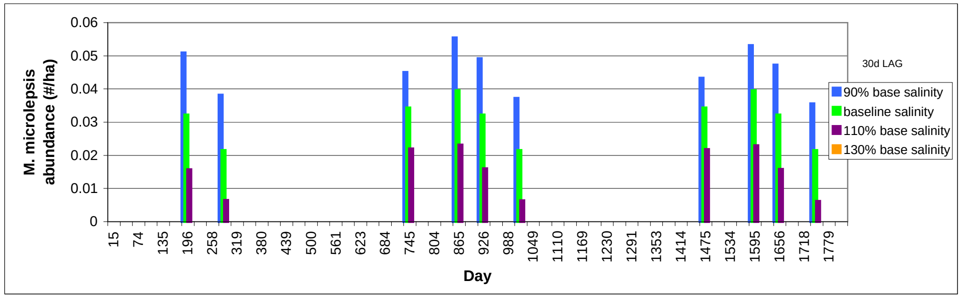
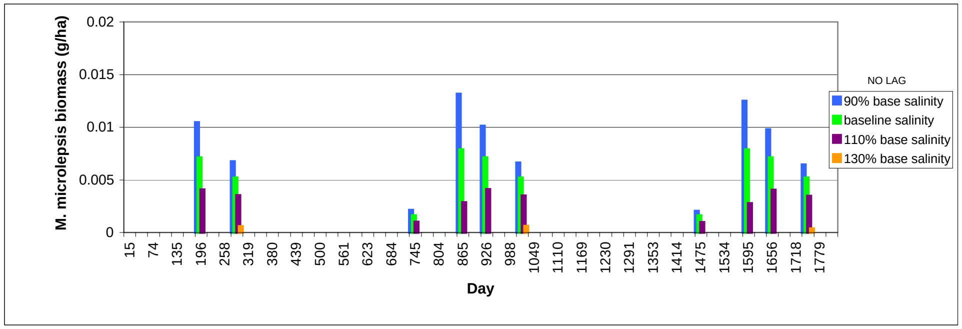


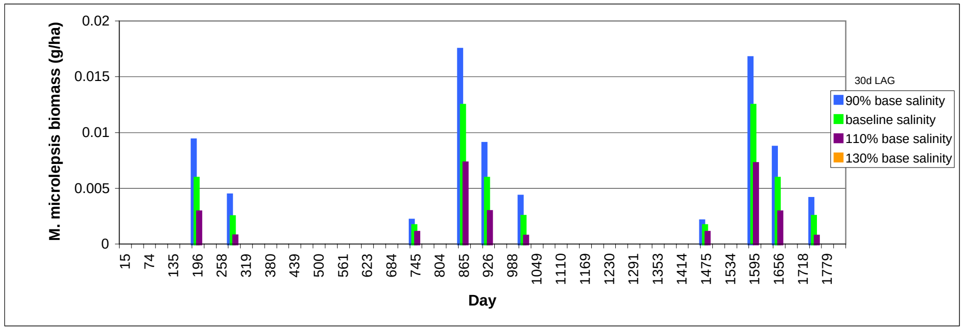
Figure 105. Whipray Basin Scenario – *Microgobius microlepis* abundance and biomass-trawl/seine

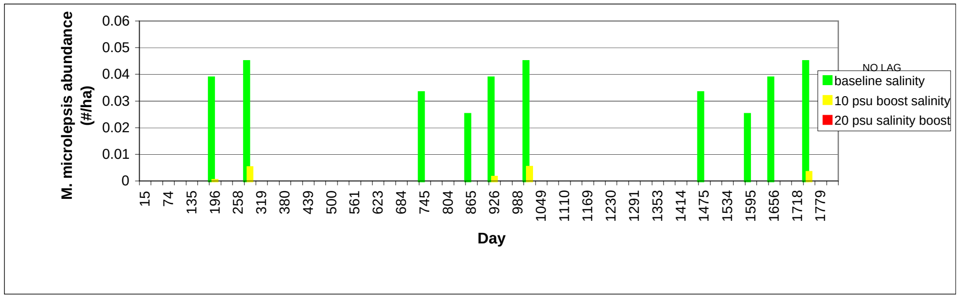
WHIPRAY- TRAWL/SEINE

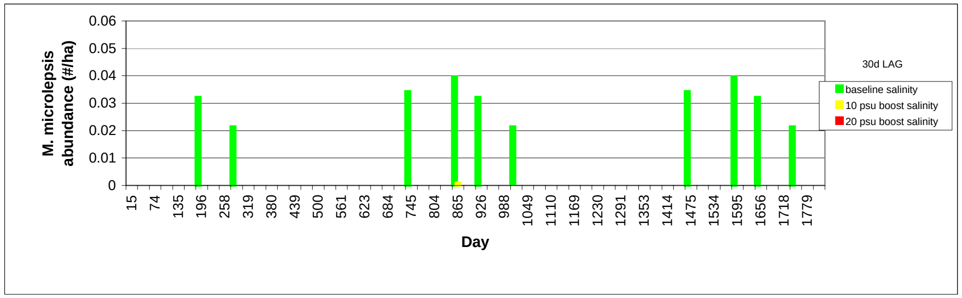


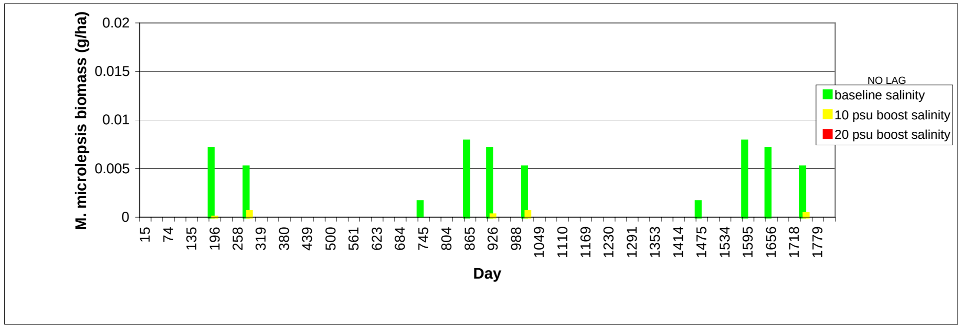












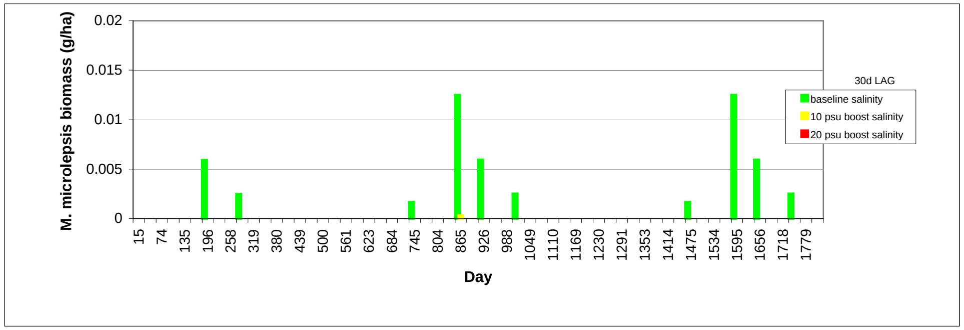
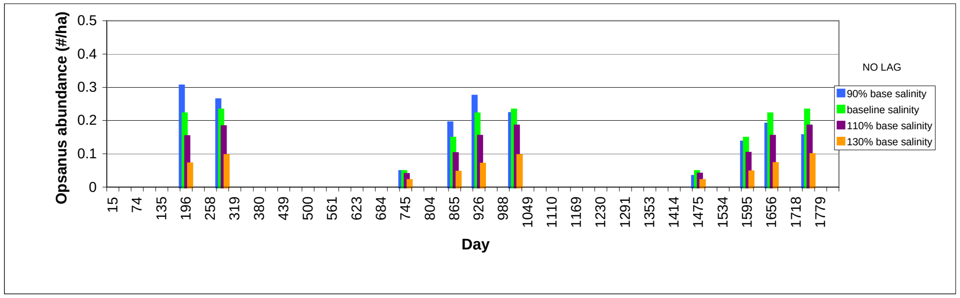
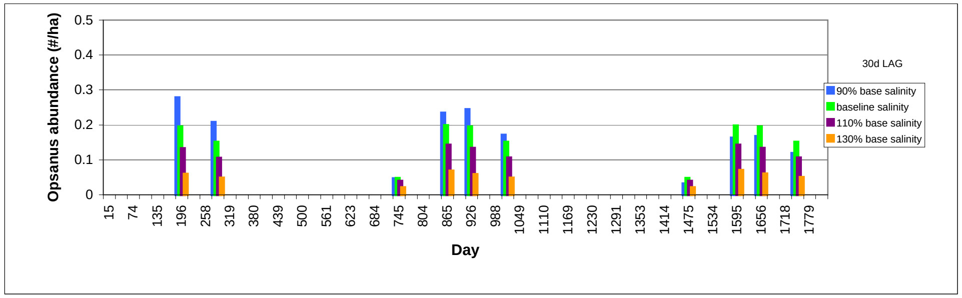
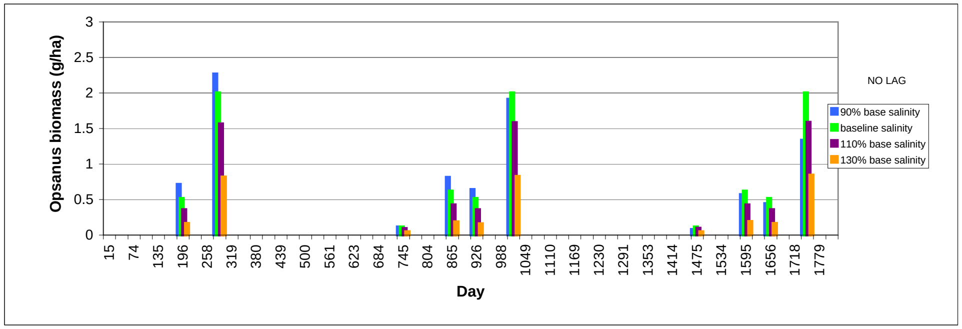


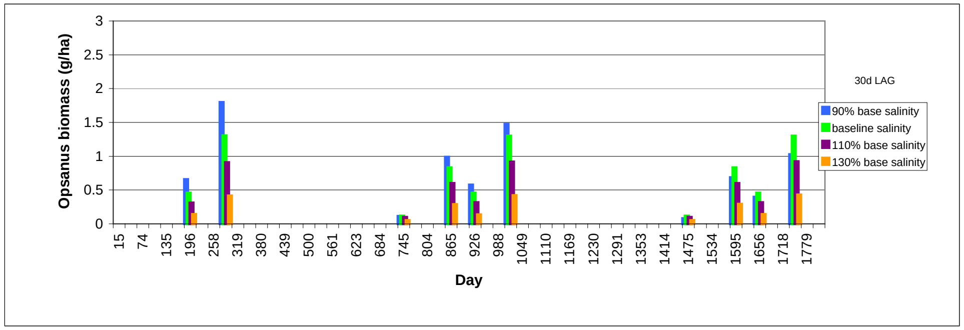
Figure 106. Whipray Basin Scenario – *Opsanus beta* abundance and biomass- trawl/seine

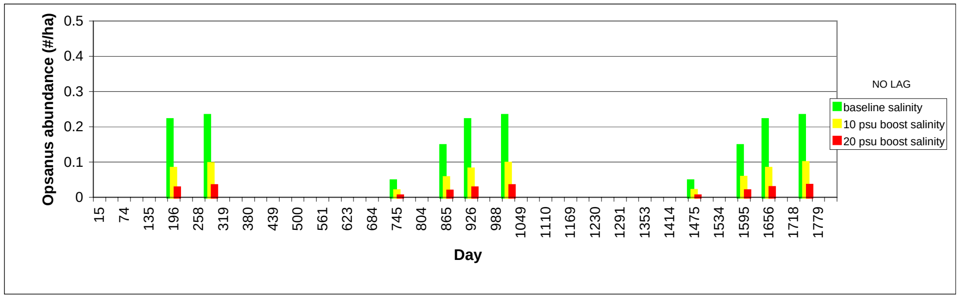
WHIPRAY- TRAWL/SEINE

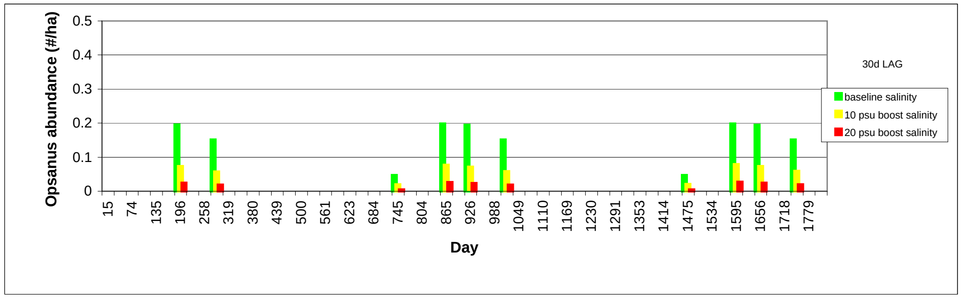


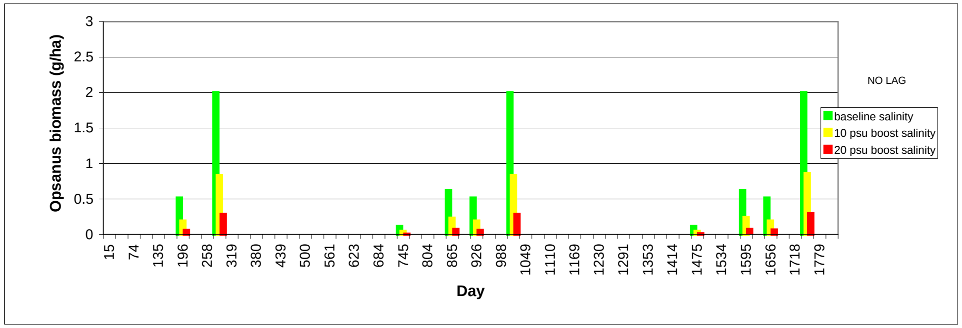












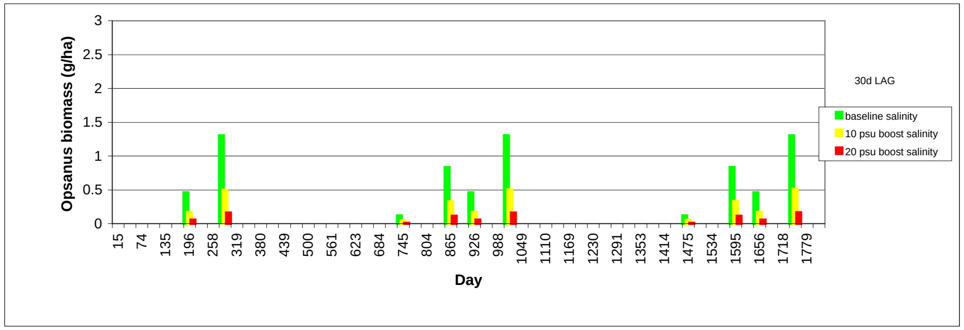
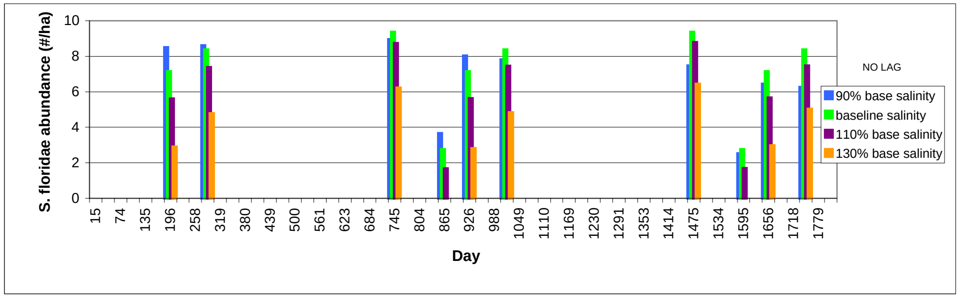
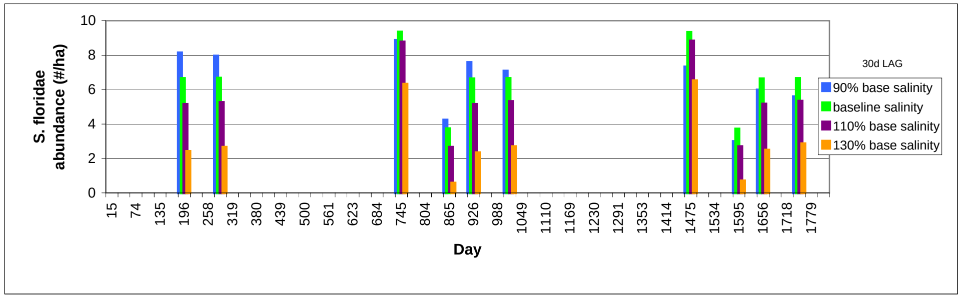
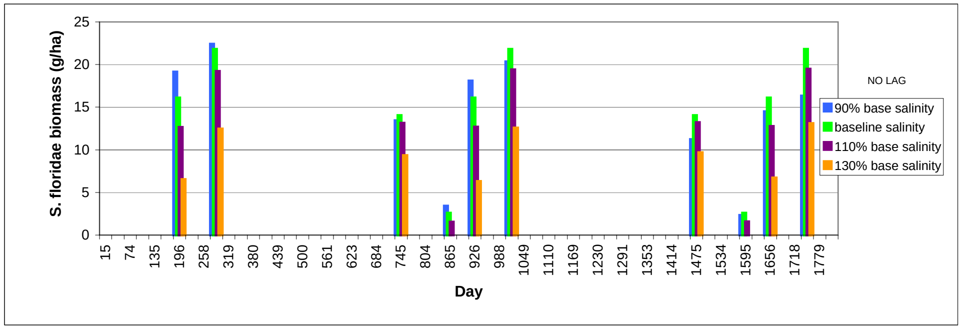


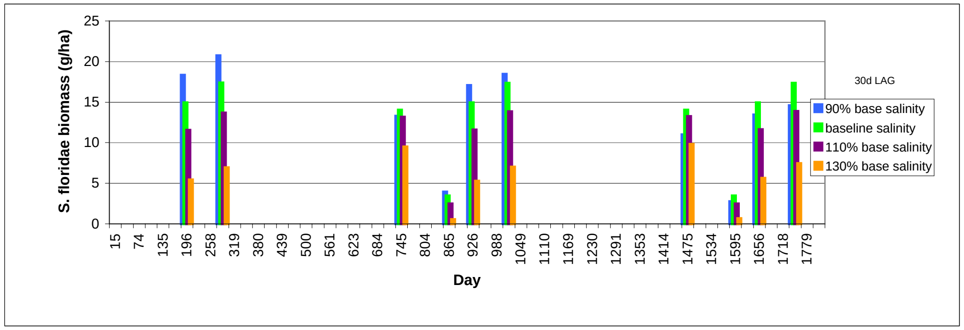
Figure 107. Whipray Basin Scenario – *Syngnathus floridae* abundance and biomass-trawl/seine

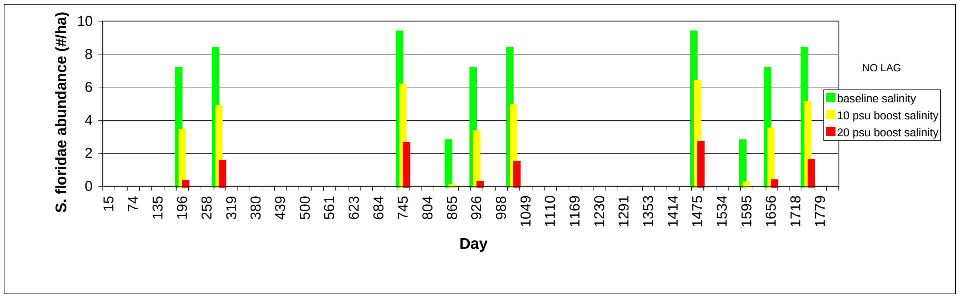
WHIPRAY- TRAWL/SEINE

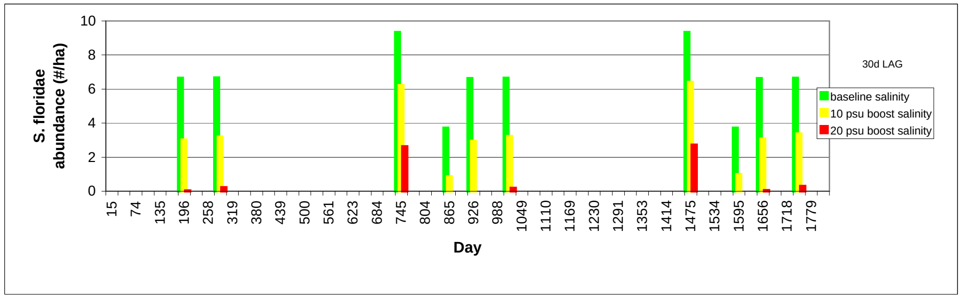


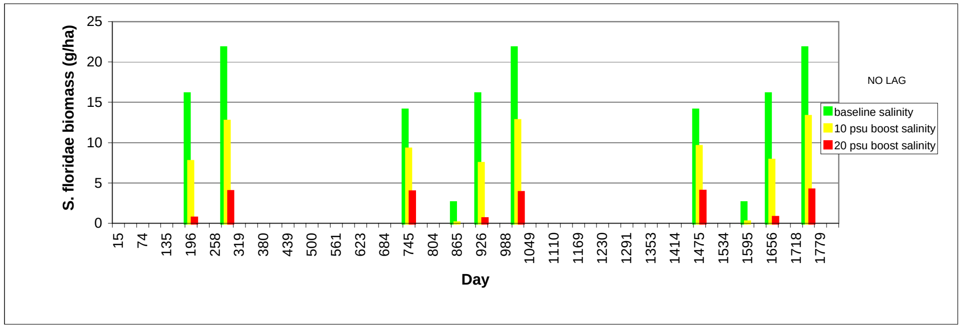












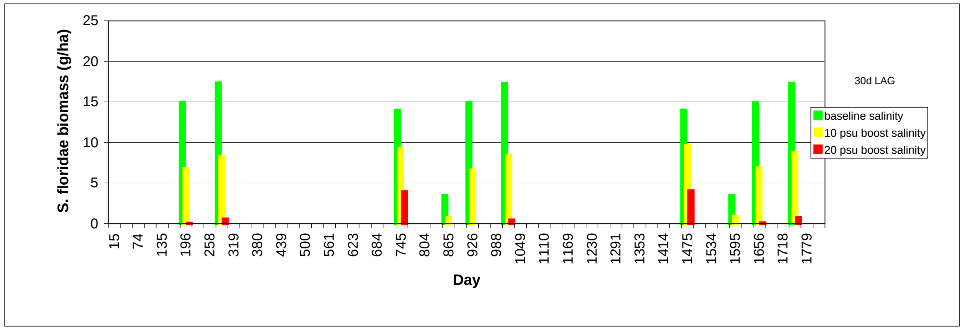
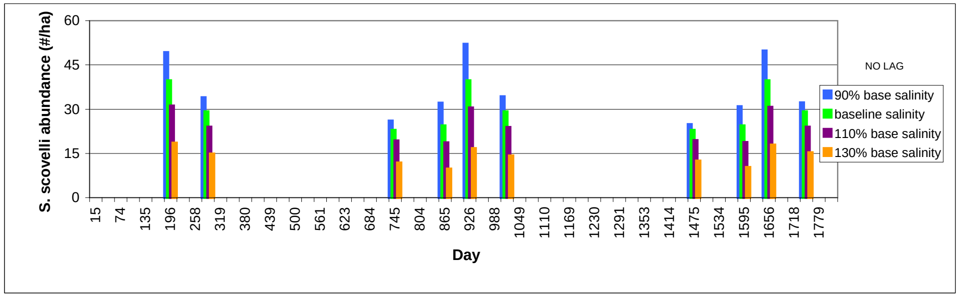
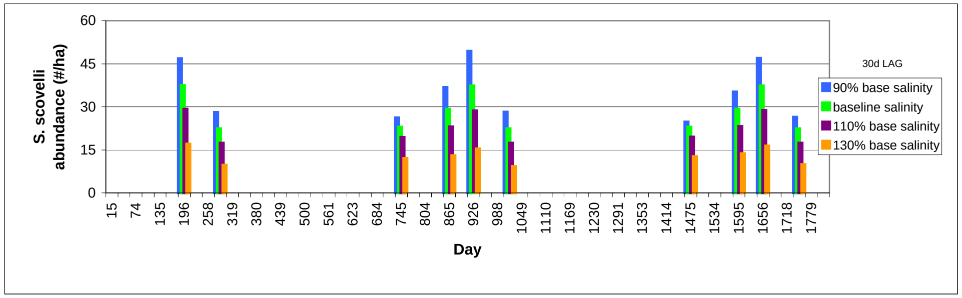
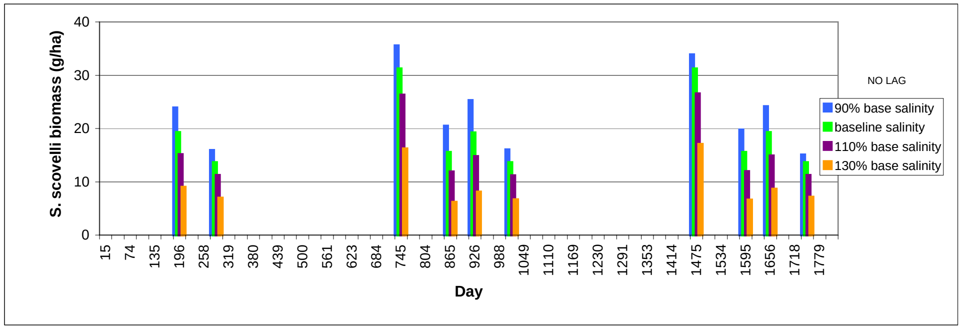


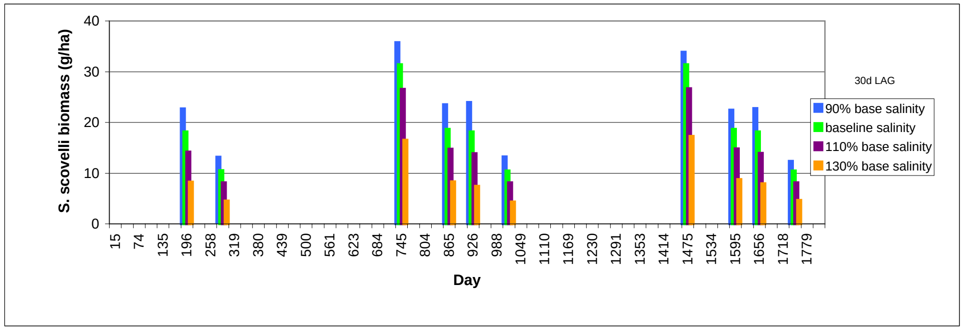
Figure 108. Whipray Basin Scenario – *Syngnathus scovelli* abundance and biomass-trawl/seine

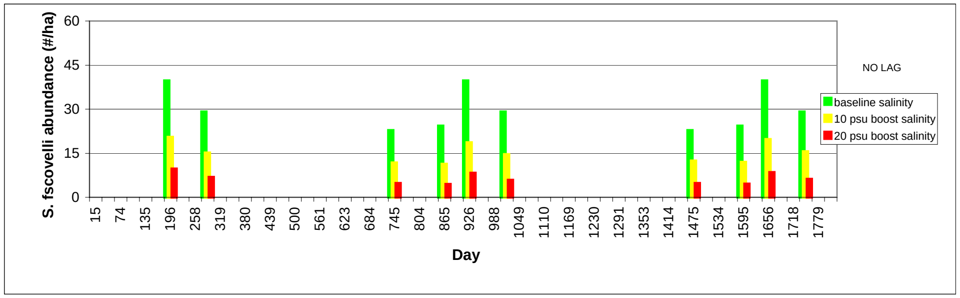
WHIPRAY- TRAWL/SEINE

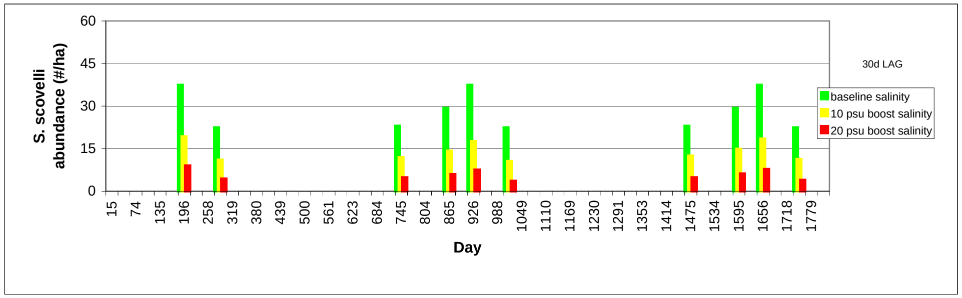


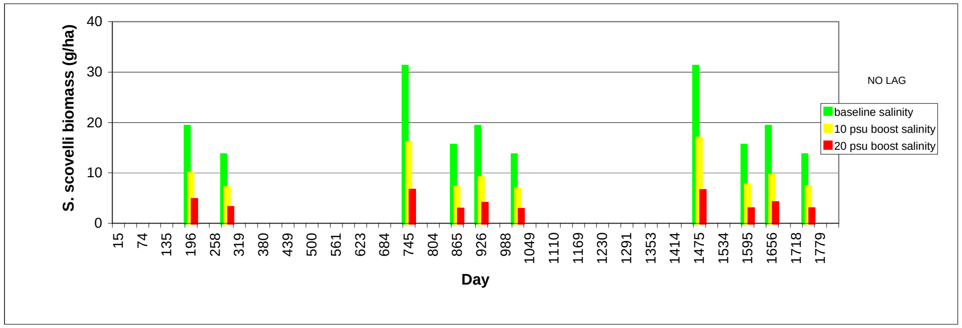












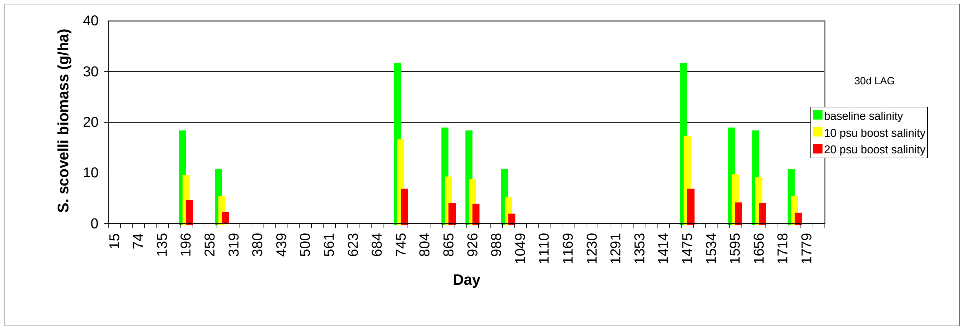
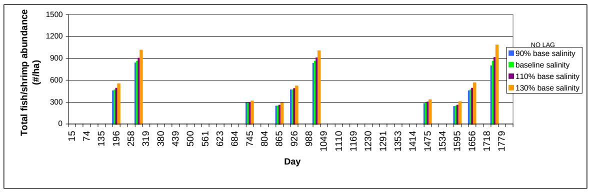
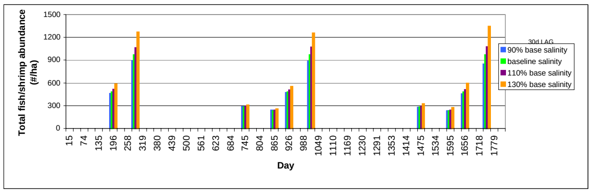
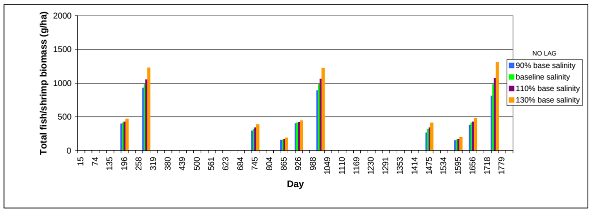


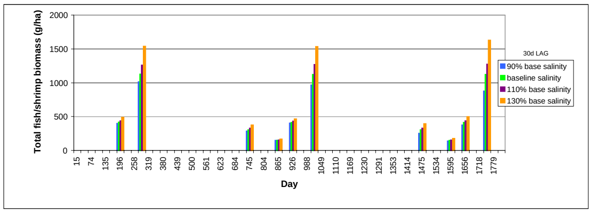
Figure 109. Whipray Basin Scenario – Total fish/shrimp abundance, Total fish/shrimp biomass, Forage fish/shrimp biomass, Predator fish biomass- trawl/seine

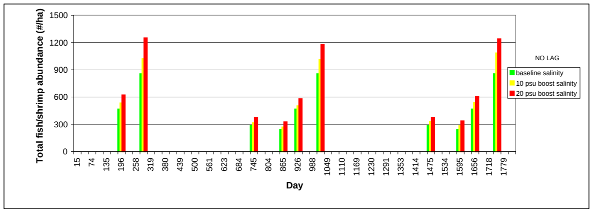
WHIPRAY- TRAWL/SEINE

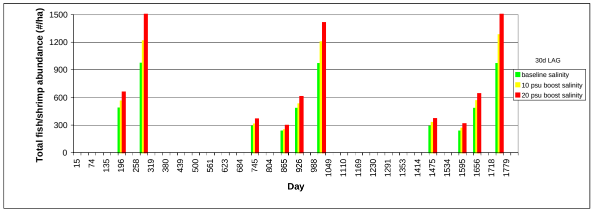


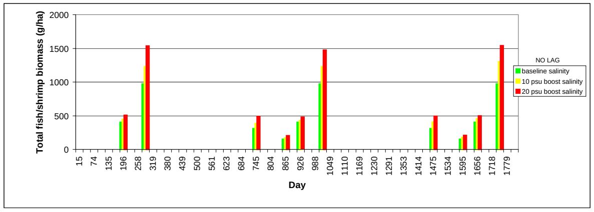


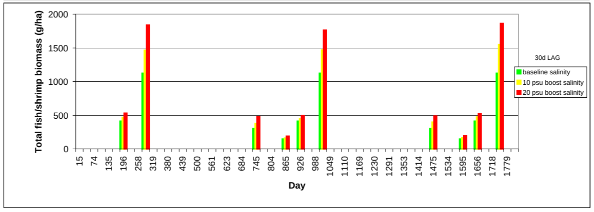


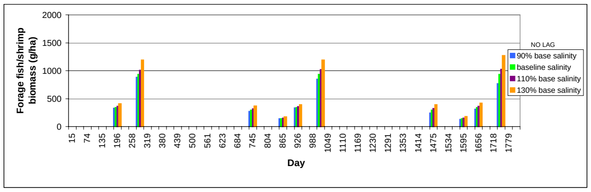


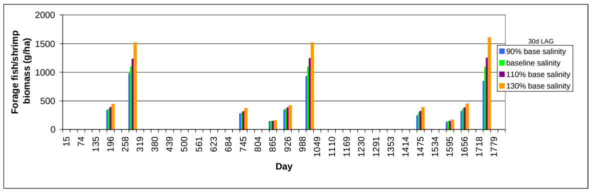


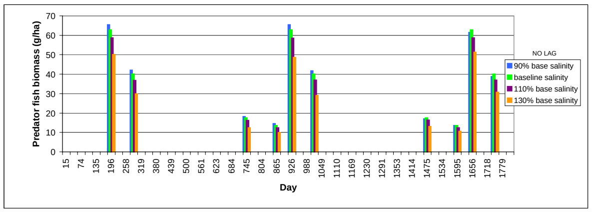


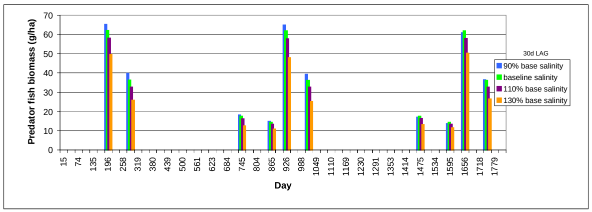


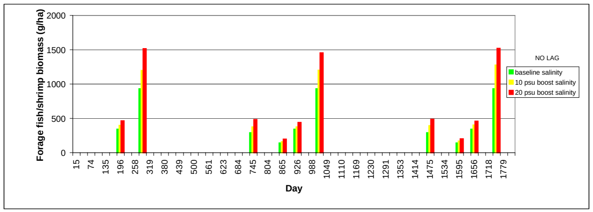


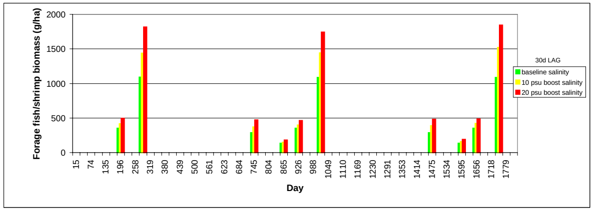


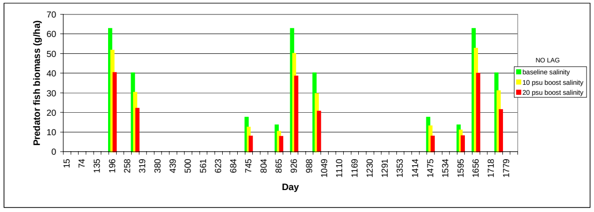












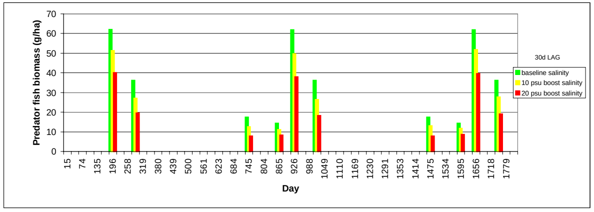
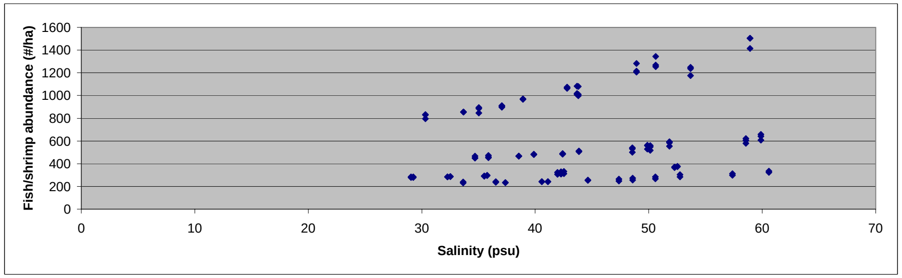
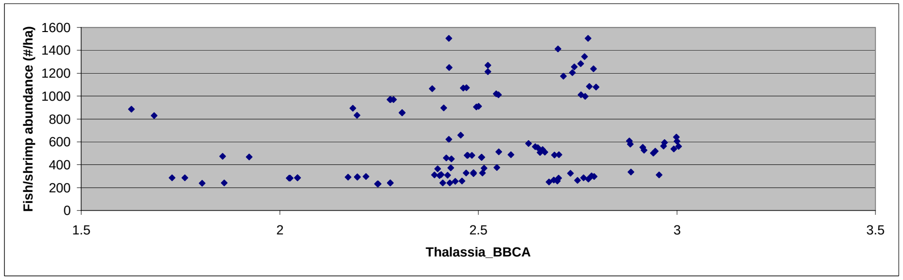
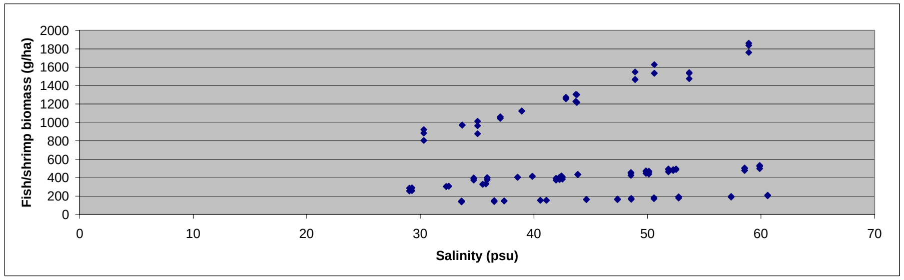


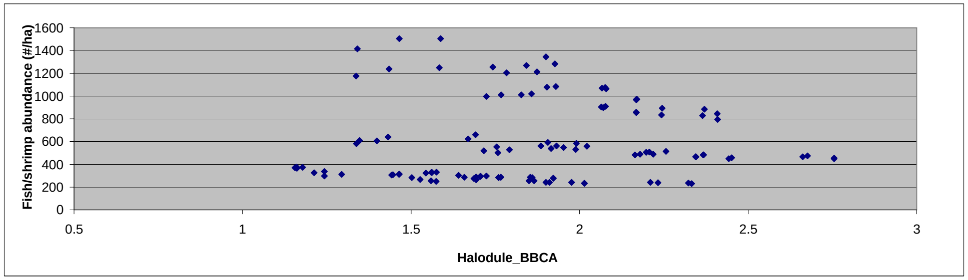
Figure 110. Whipray Basin Scenario - Fish/shrimp abundance vs. Salinity, Fish/shrimp biomass vs. salinity, Predator fish biomass vs. Salinity, Fish/shrimp abundance vs. Thalassia BBCA, Fish/shrimp abundance vs. Halodule BBCA- trawl seine.

WHIPRAY- TRAWL/SEINE









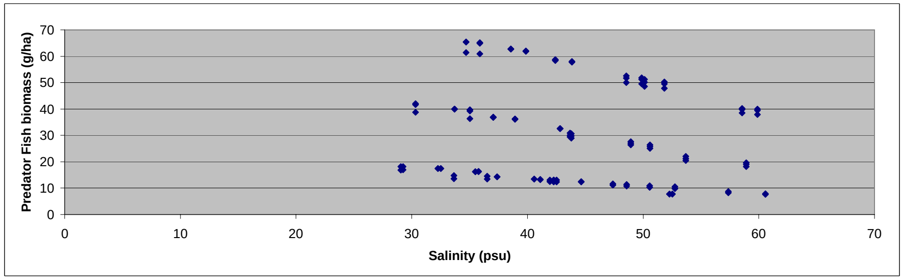
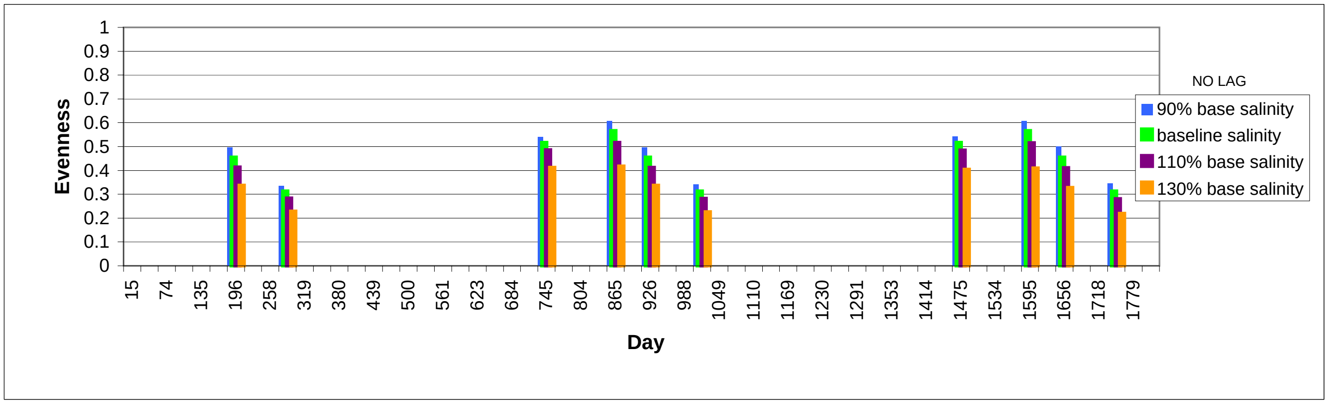
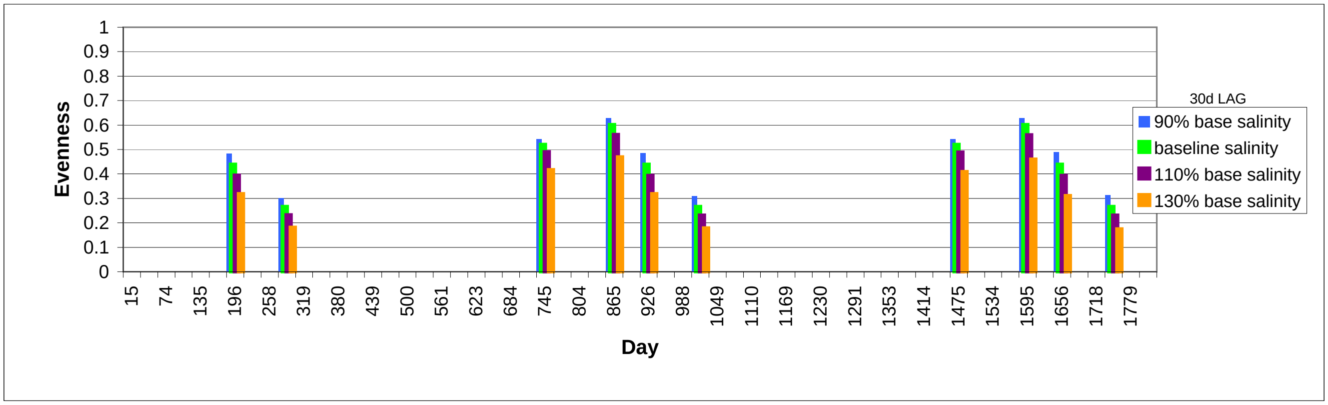
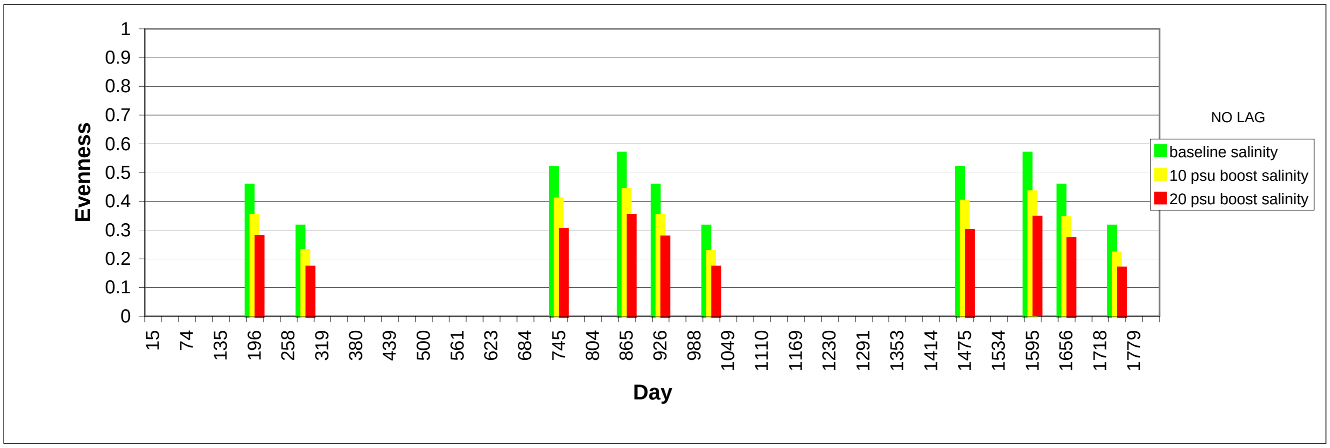


Figure 111. Whipray Basin Scenario – Evenness trawl/seine

WHIPRAY- TRAWL/SEINE







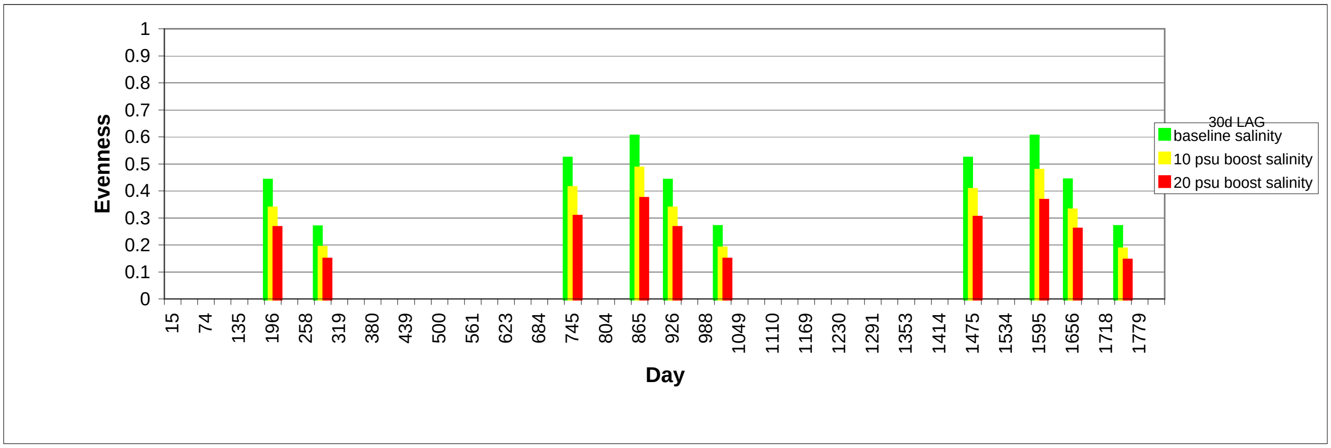
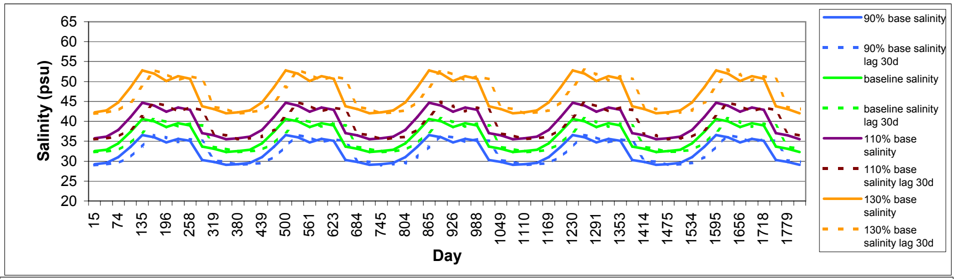
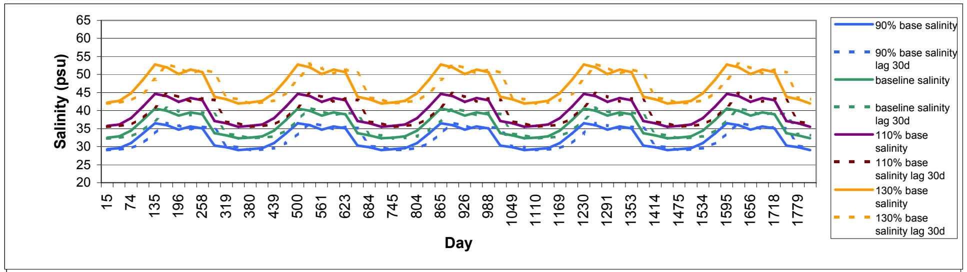
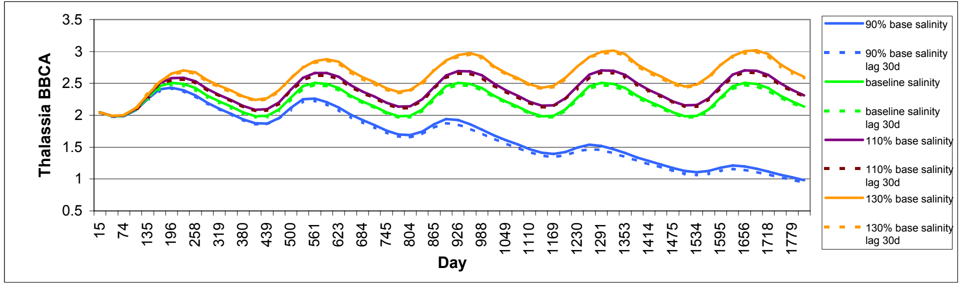


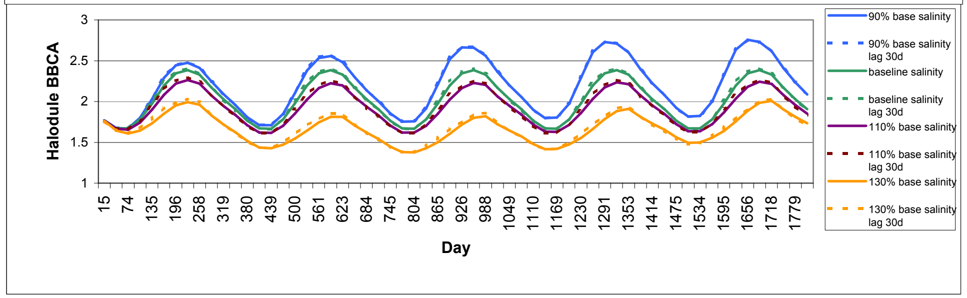
Figure 112. Whipray Basin Scenario – Salinity and SAV- trawl/seine

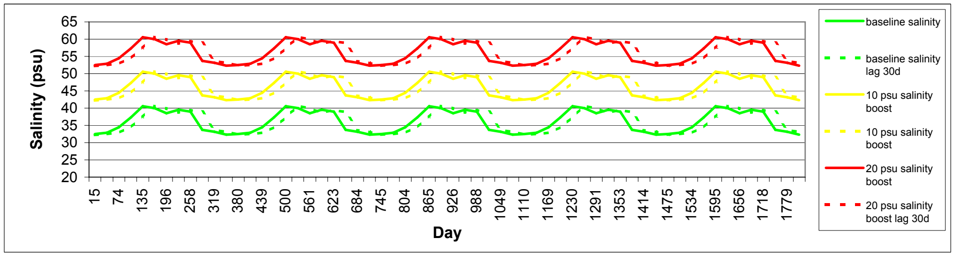
Whipray Basin

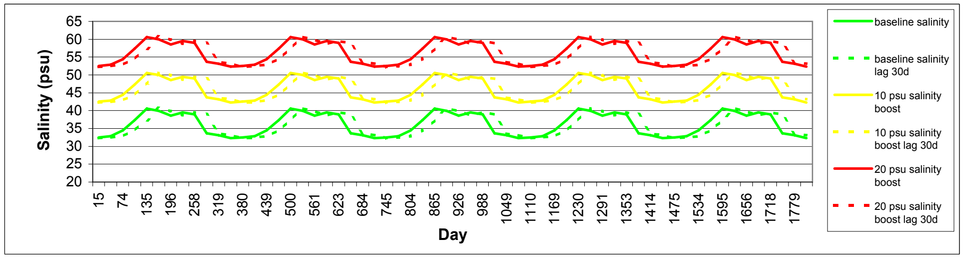


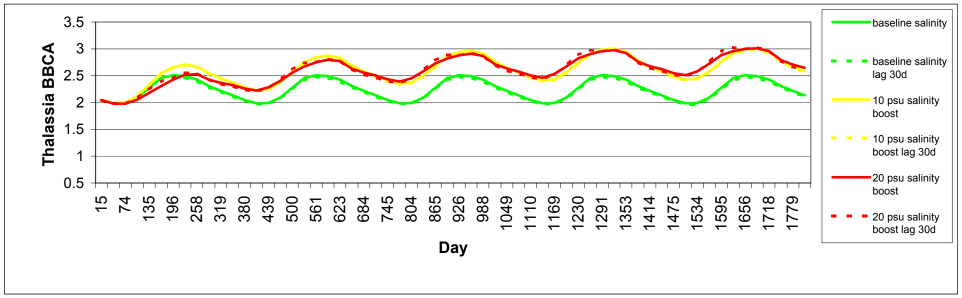












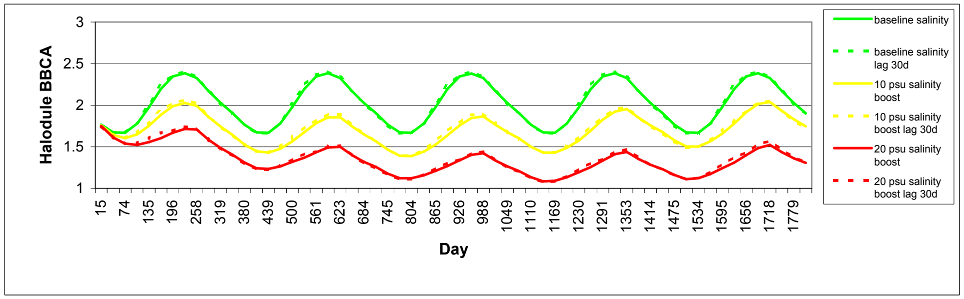
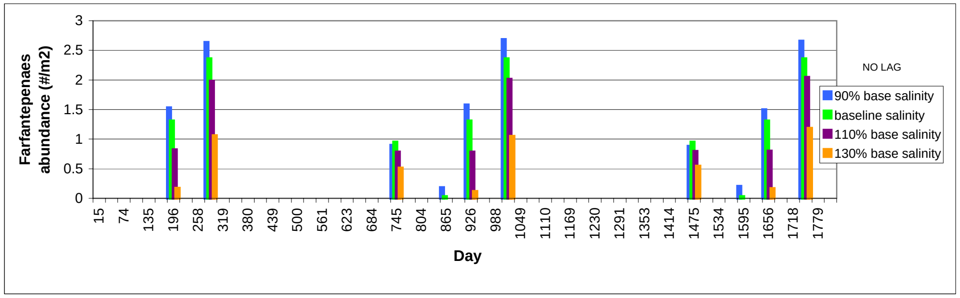
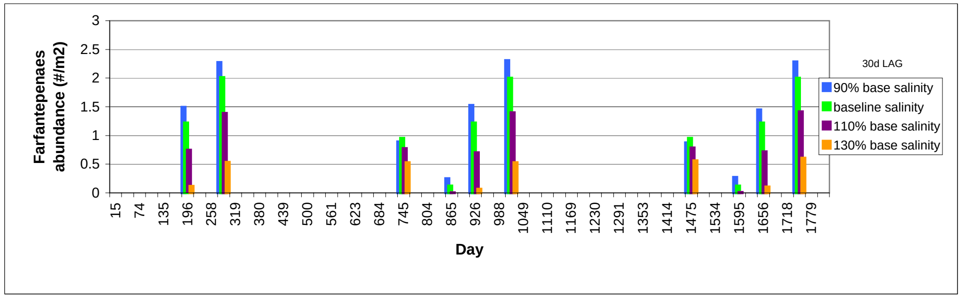
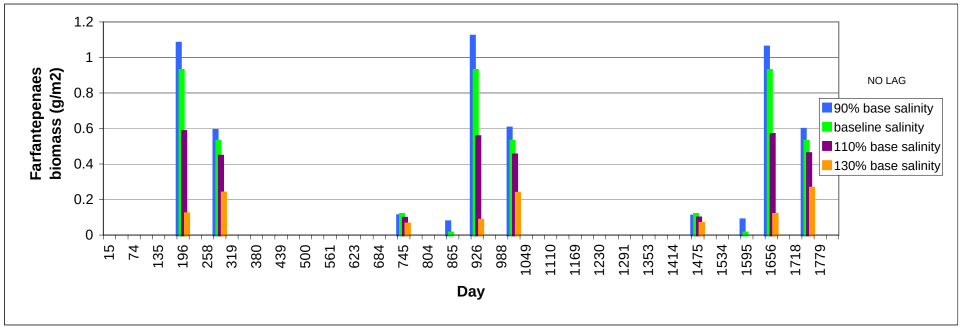


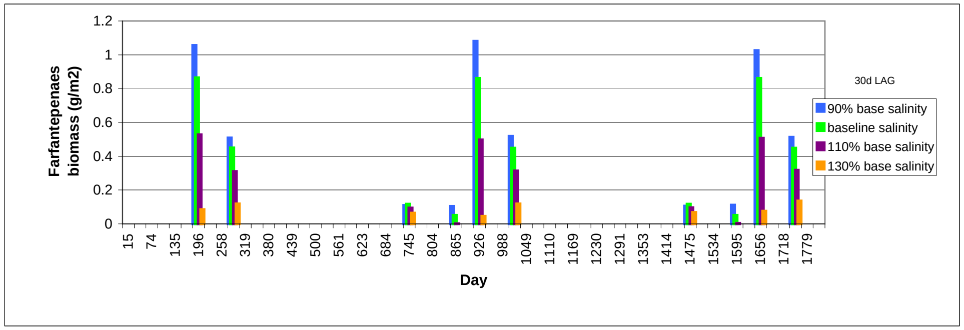
Figure 113. Whipray Basin Scenario – *Farfantepenaeus duorarum* abundance and biomass- throw-trap

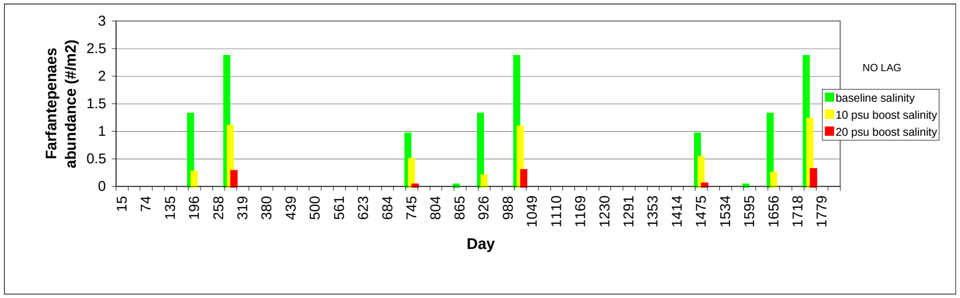
WHIPRAY- THROW TRAP

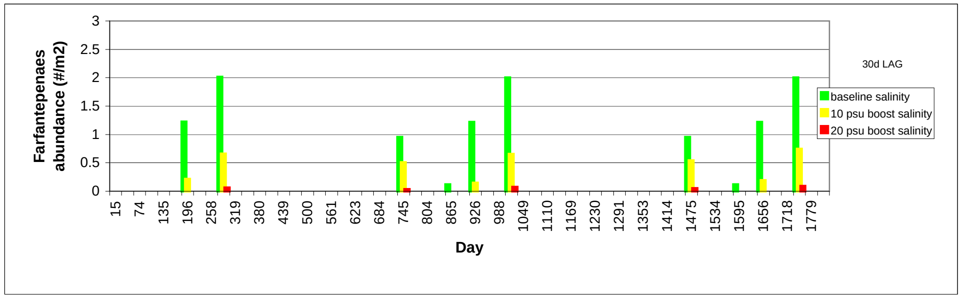


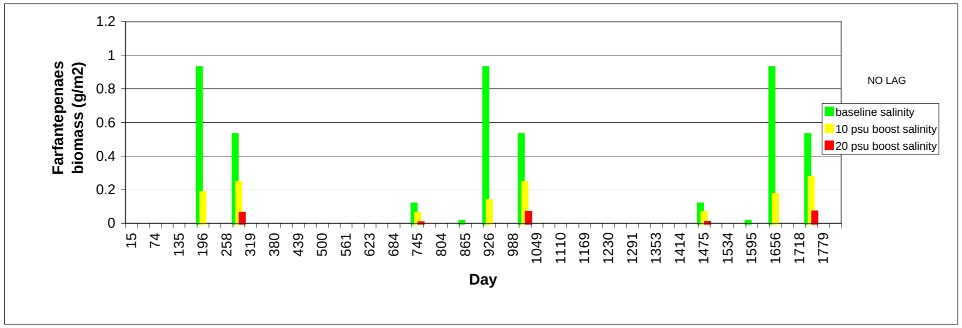












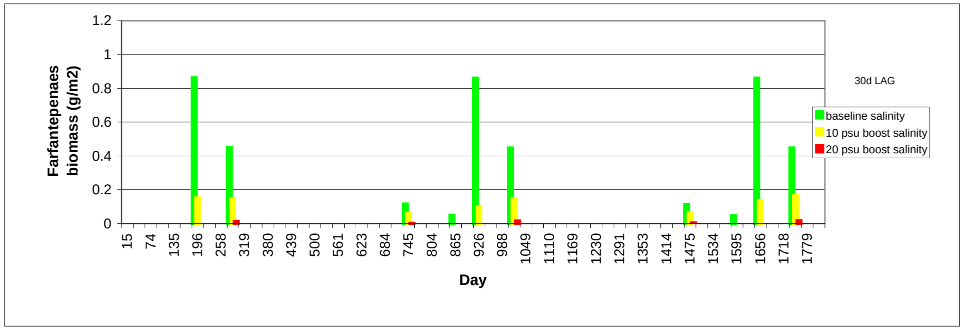
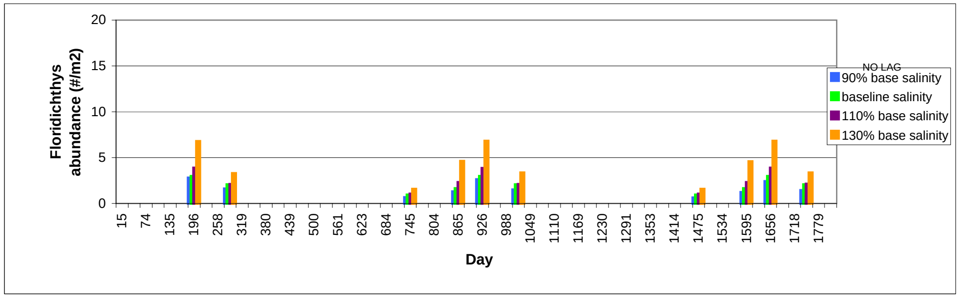
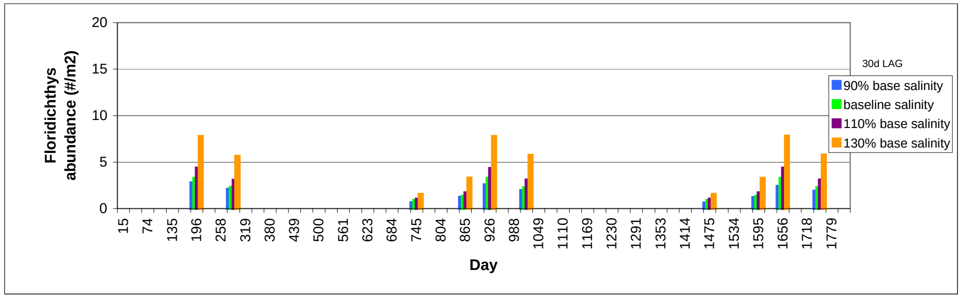
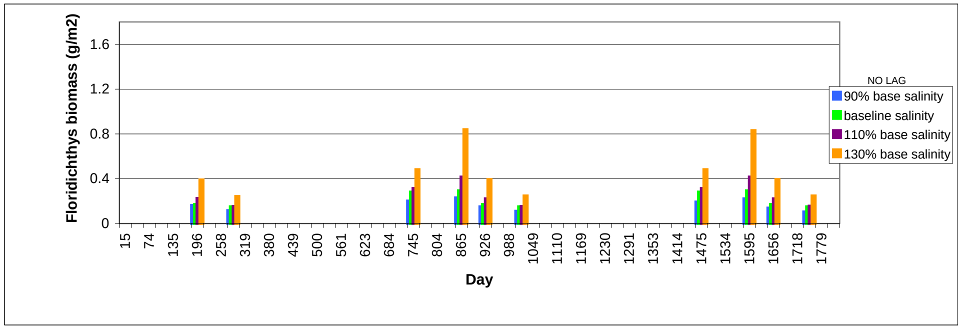


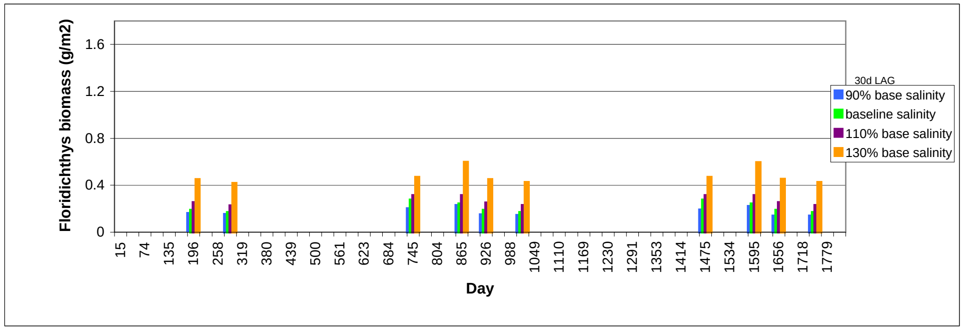
Figure 114. Whipray Basin Scenario – *Floridichthys carpio* abundance and biomass-throw-trap

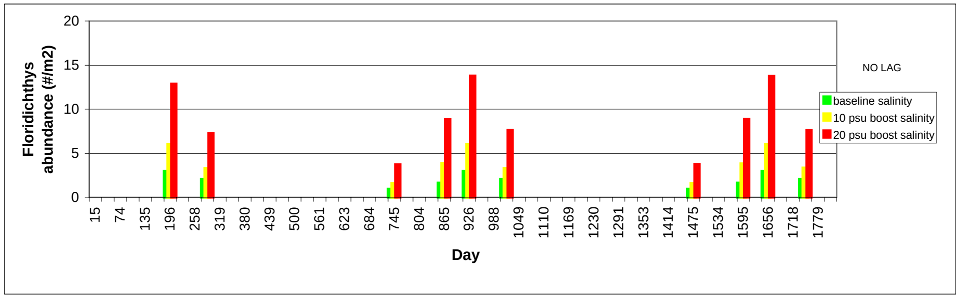
WHIPRAY- THROW TRAP

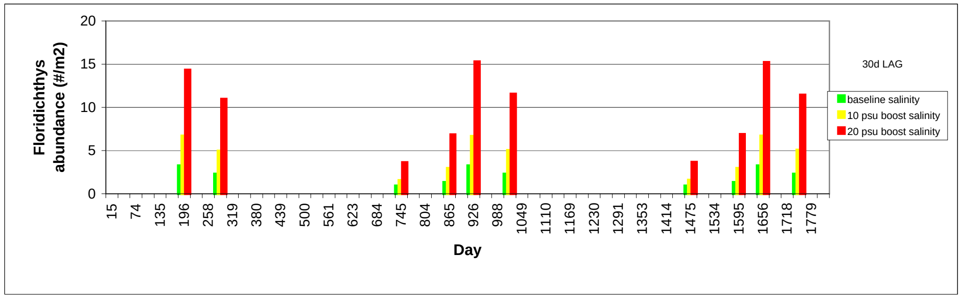


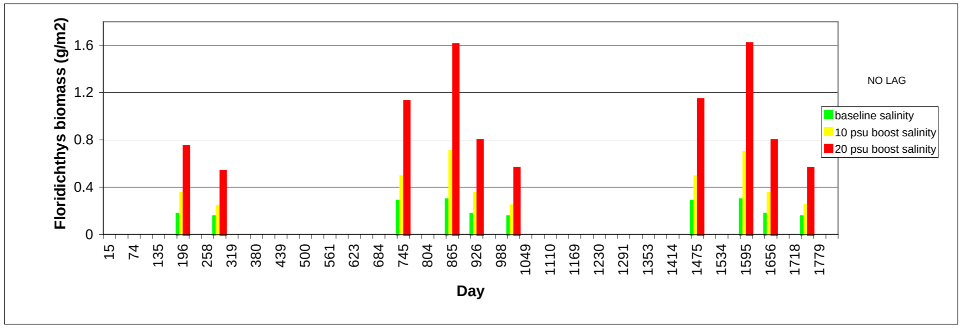












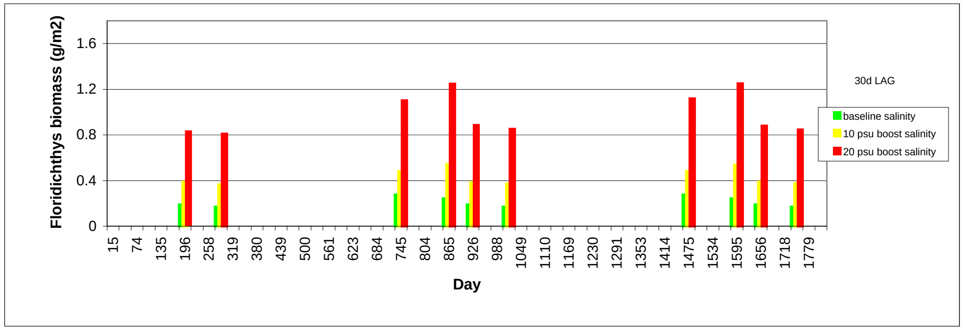
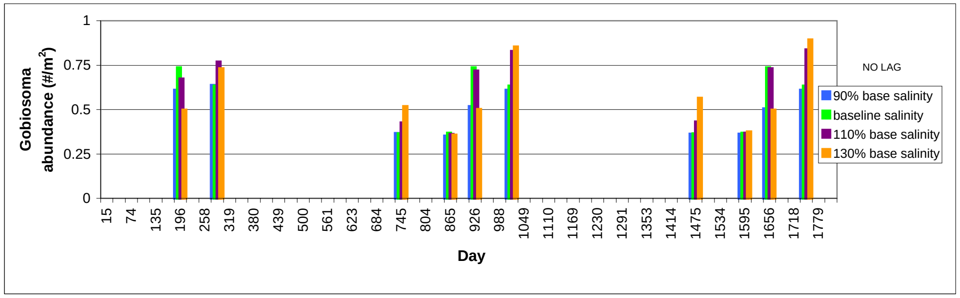
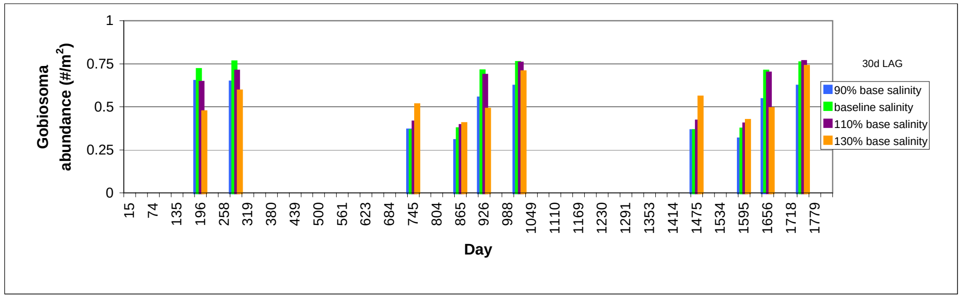
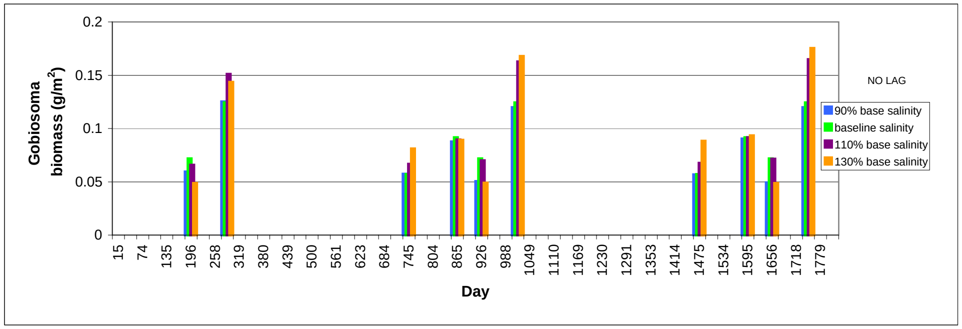


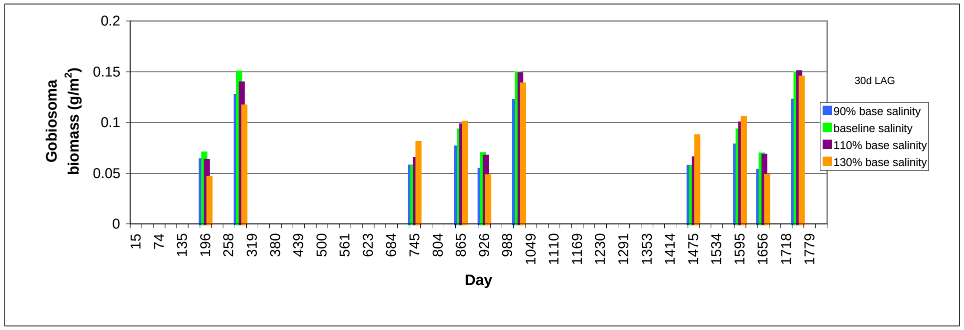
Figure 115. Whipray Basin Scenario – *Gobiosoma robustum* abundance and biomass-throw-trap

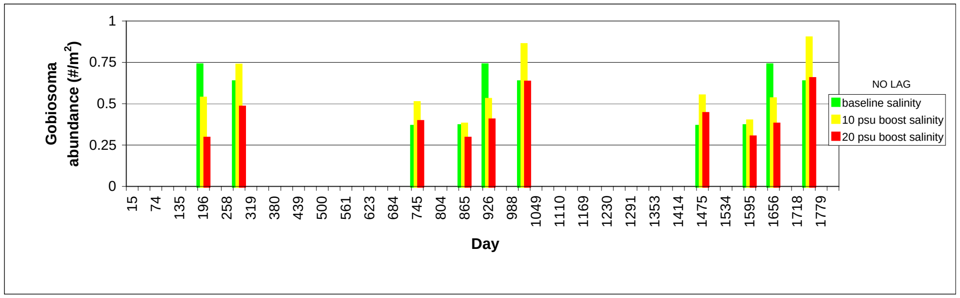
WHIPRAY- THROW TRAP

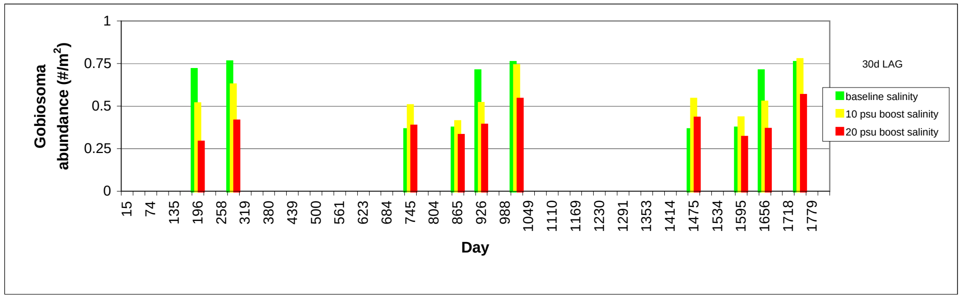


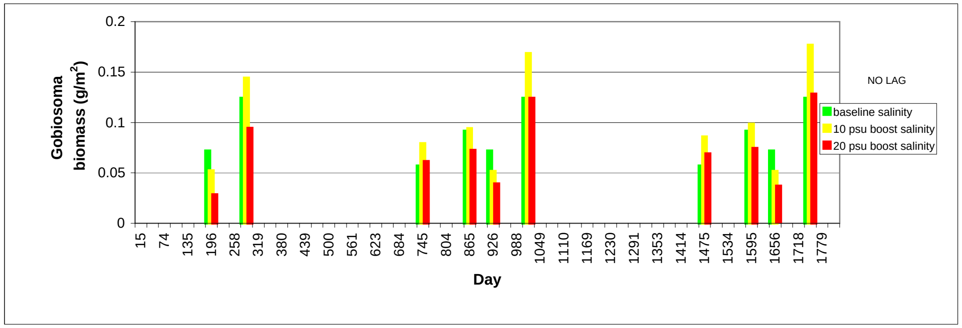












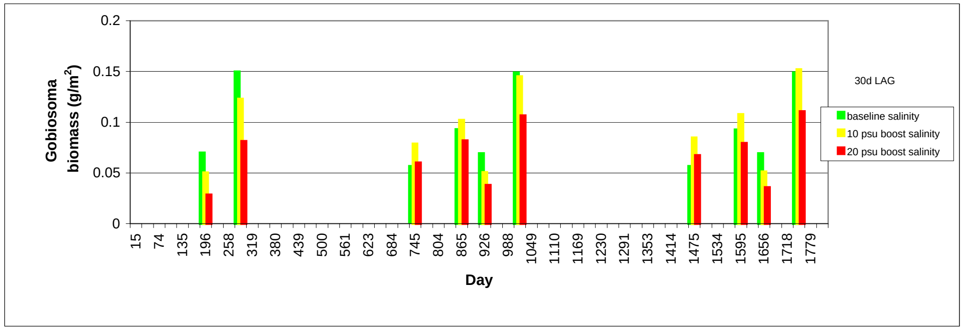
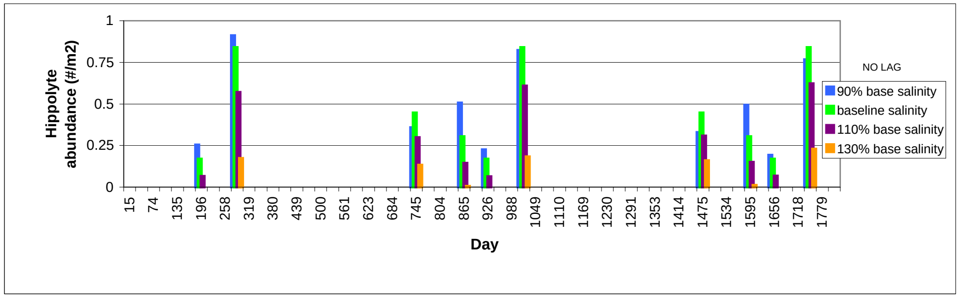
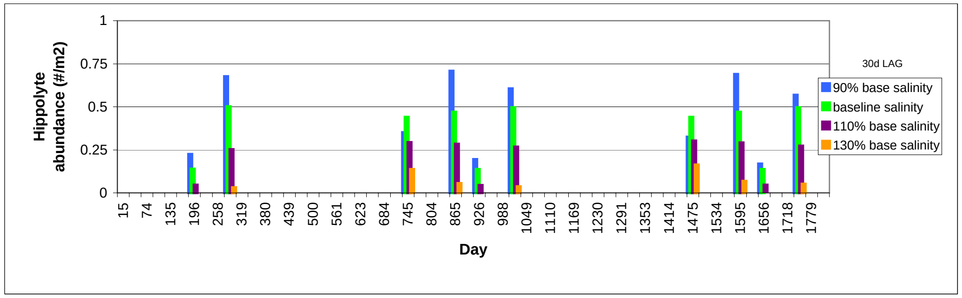
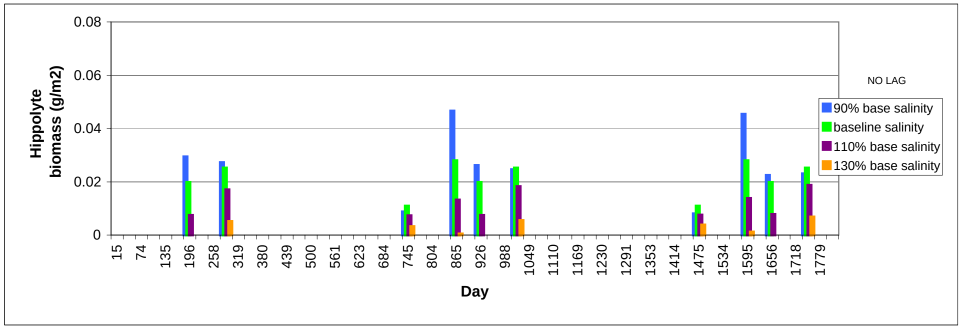


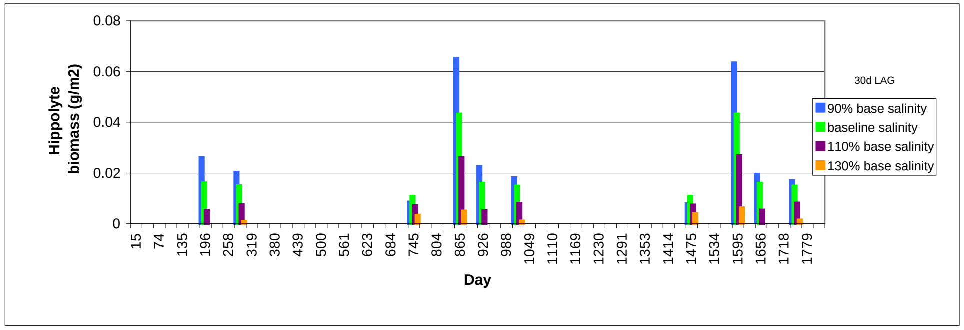
Figure 116. Whipray Basin Scenario – *Hippolyte spp.* abundance and biomass- throw-trap

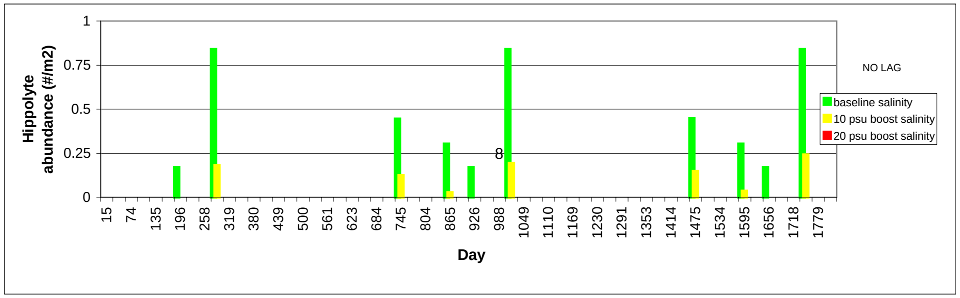
WHIPRAY- THROW TRAP

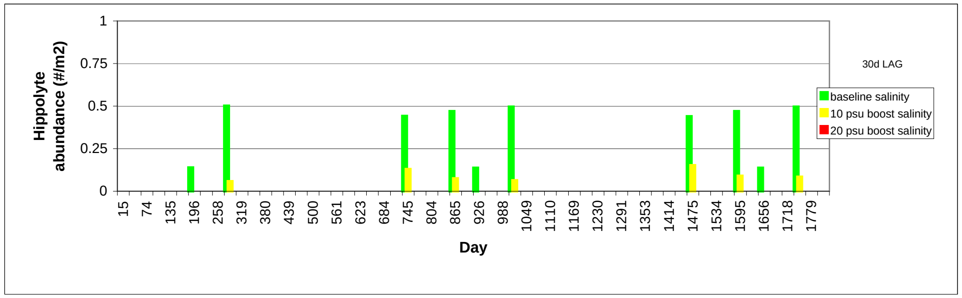


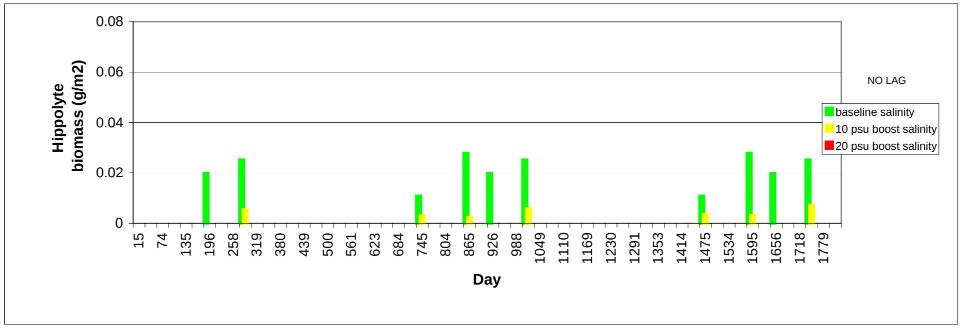












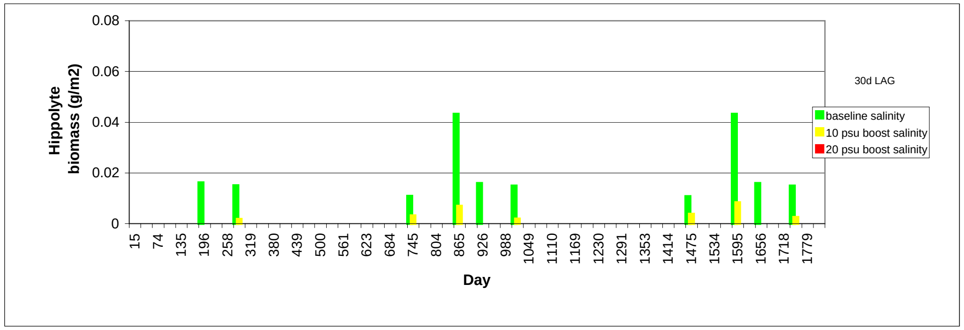
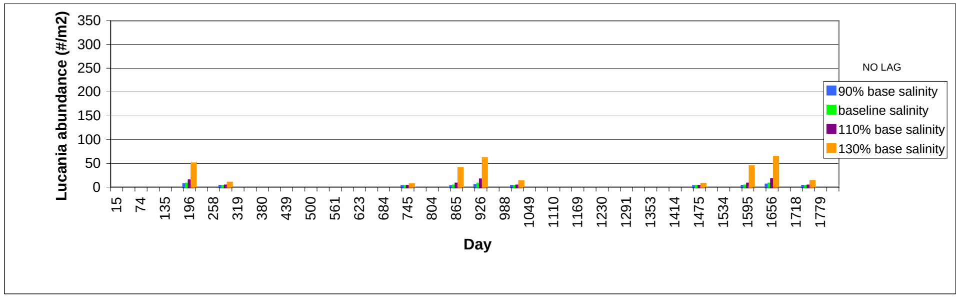
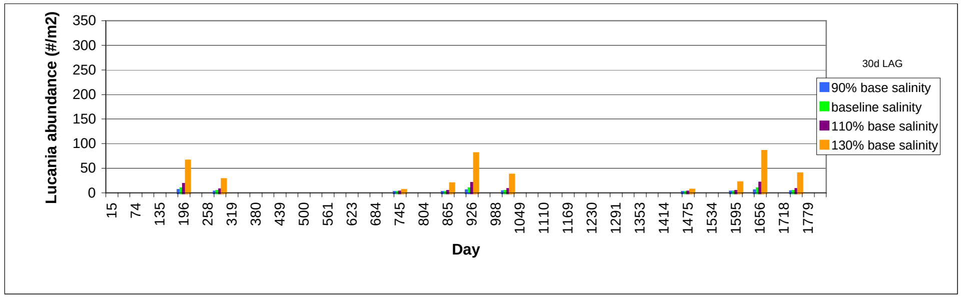
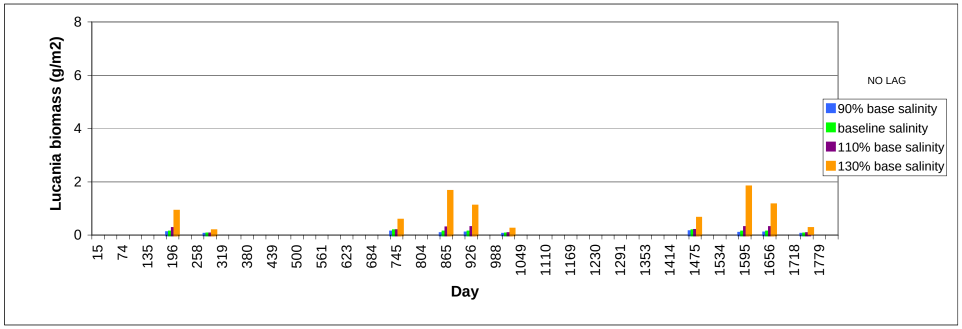


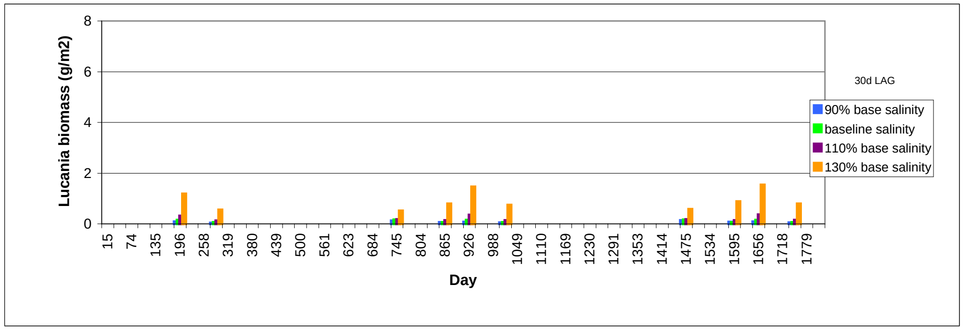
Figure 117. Whipray Basin Scenario – *Lucania parva* abundance and biomass- throw-trap

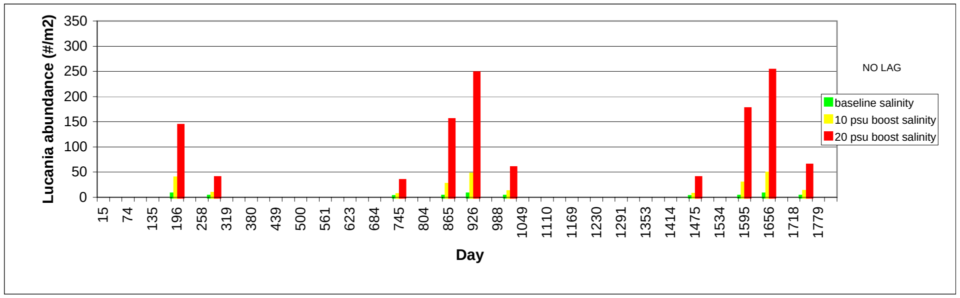
WHIPRAY- THROW TRAP

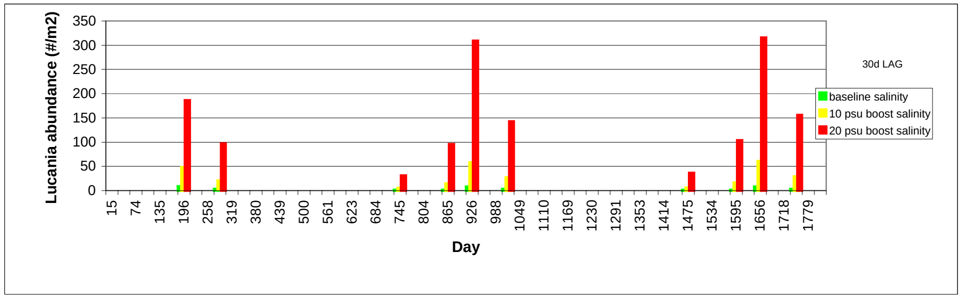


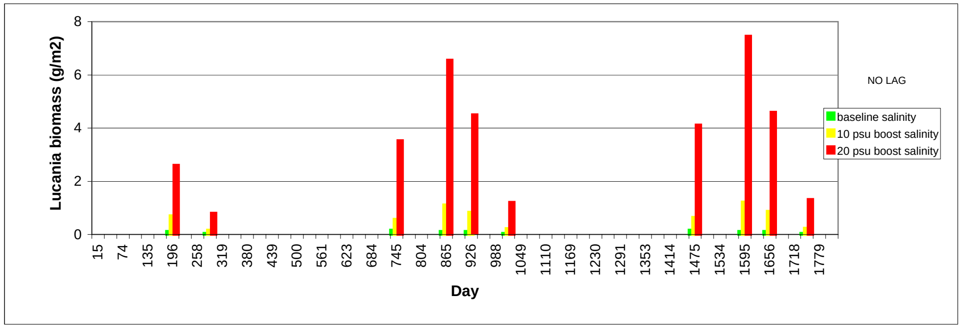












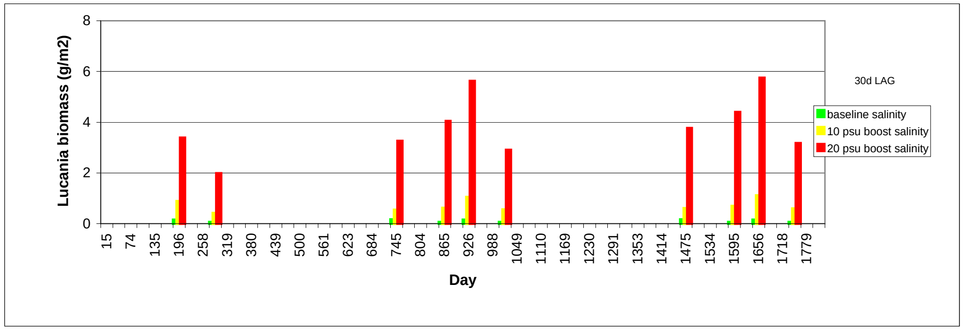
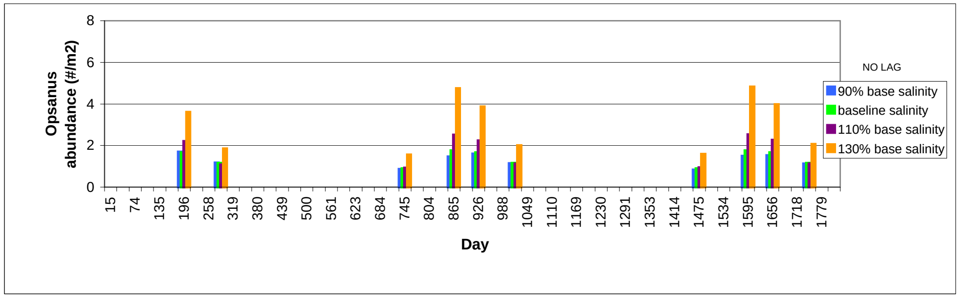
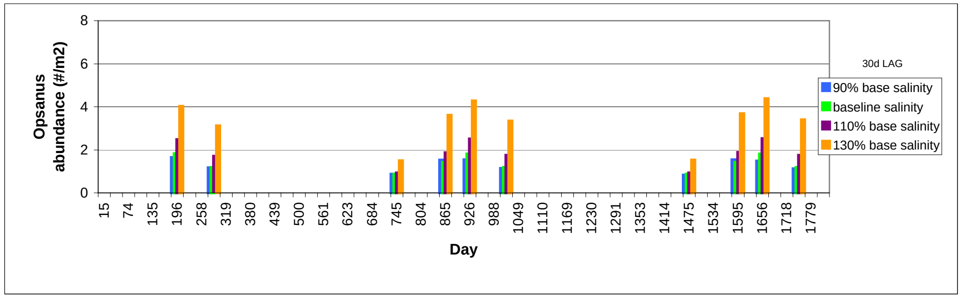
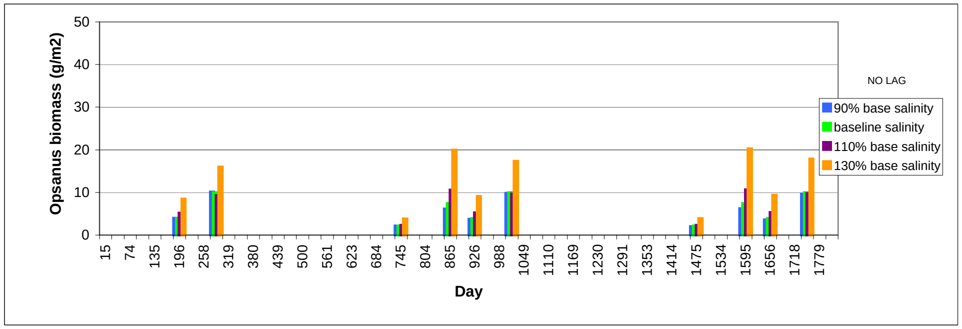


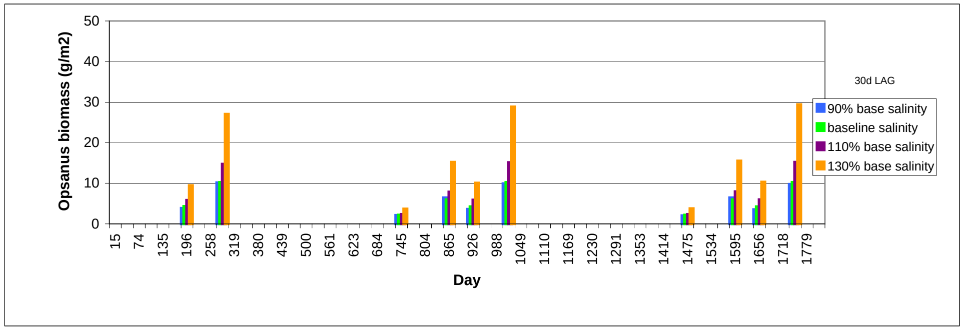
Figure 118. Whipray Basin Scenario – *Opsanus beta* abundance and biomass- throw-trap

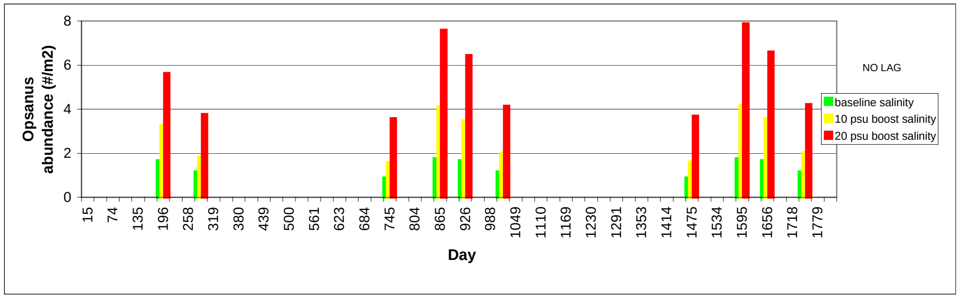
WHIPRAY- THROW TRAP

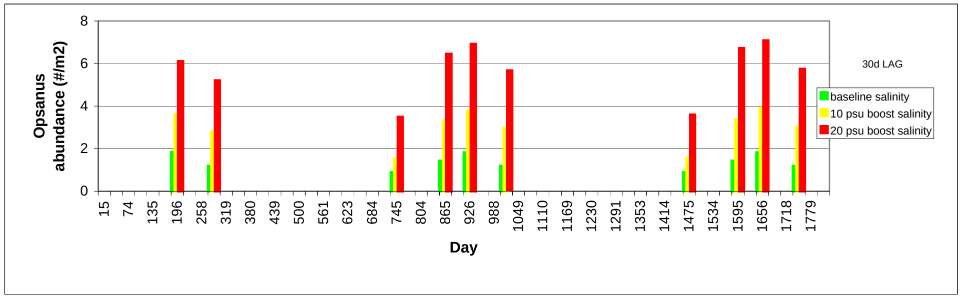


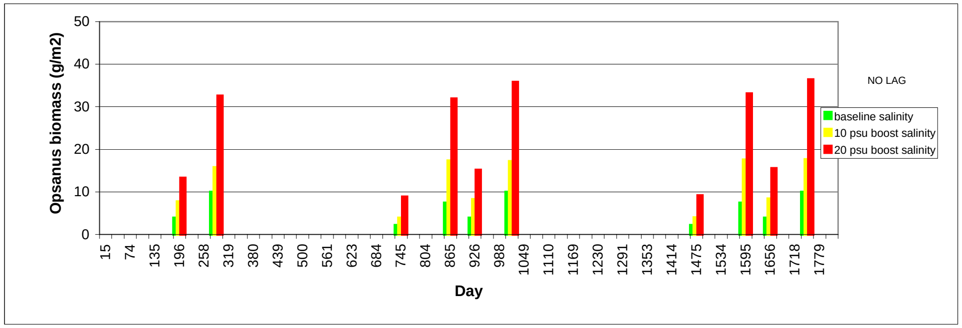












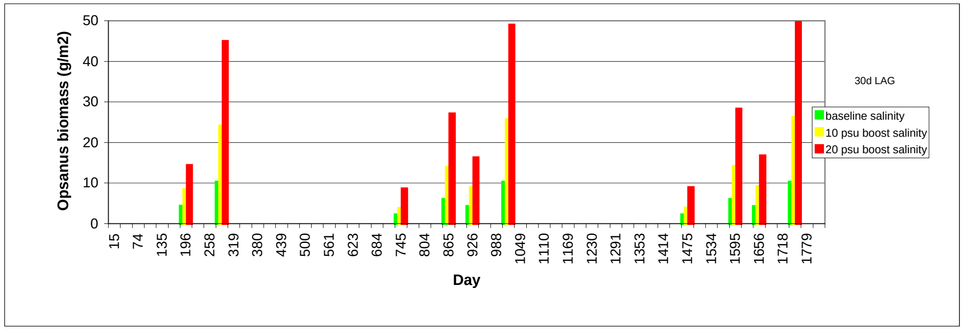
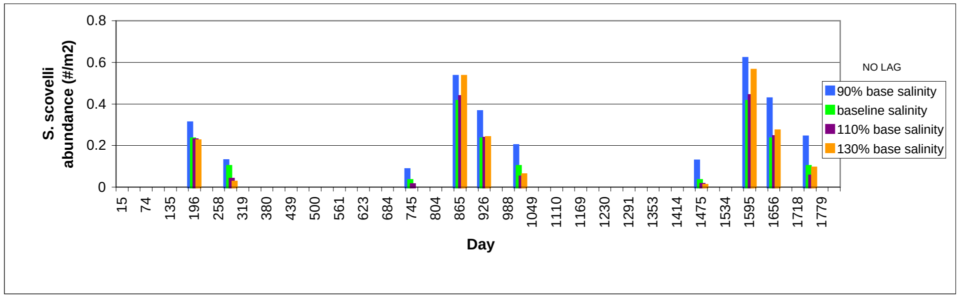
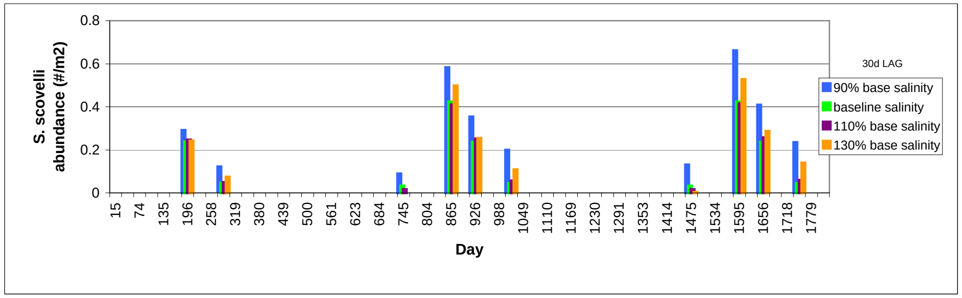
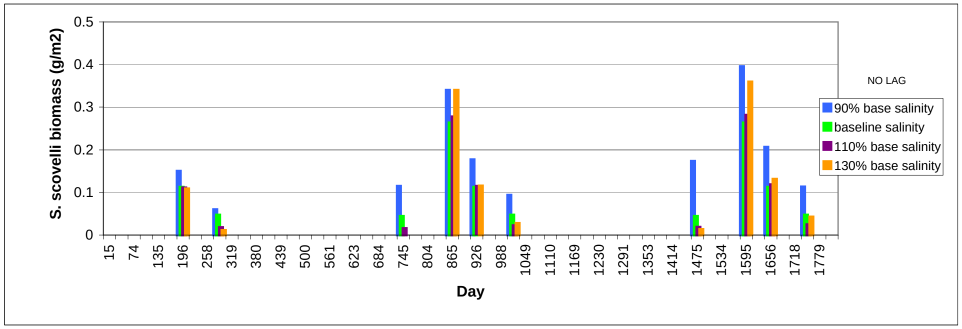


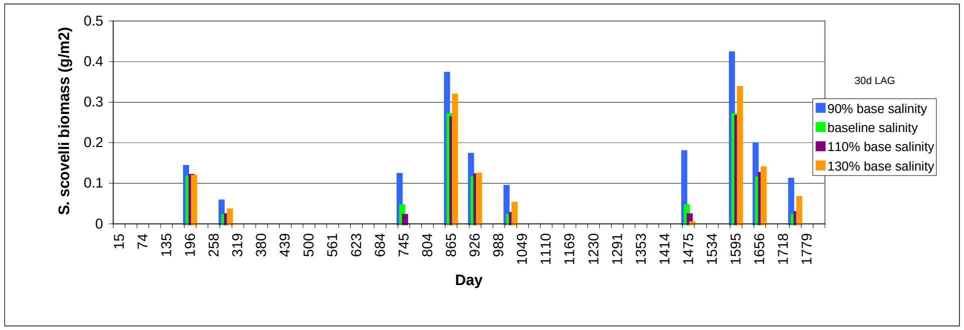
Figure 119. Whipray Basin Scenario – *Syngnathus scovelli* abundance and biomass-throw-trap

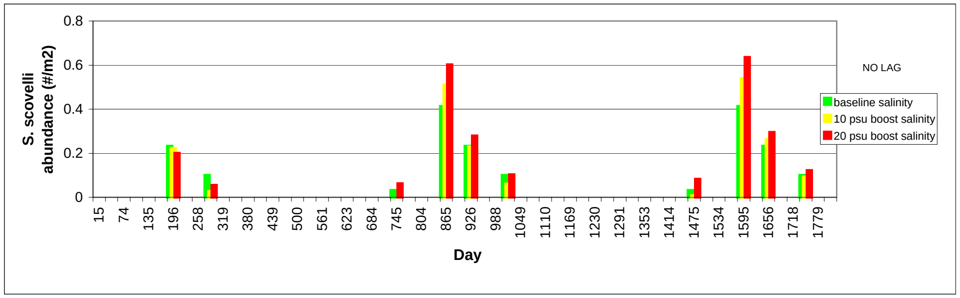
WHIPRAY- THROW TRAP

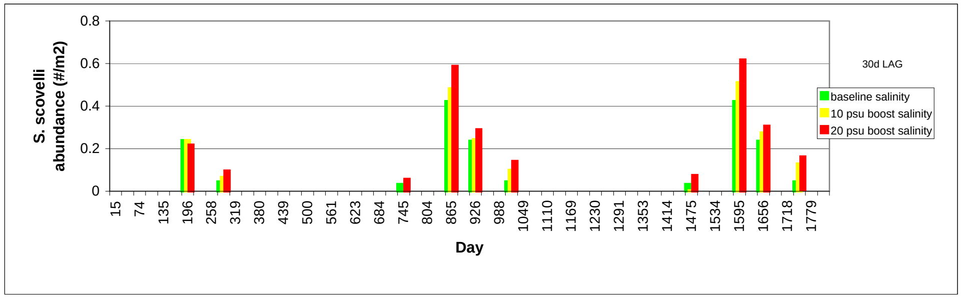


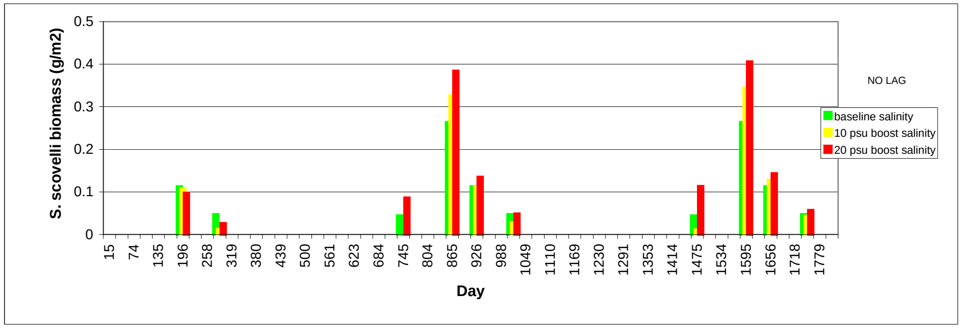












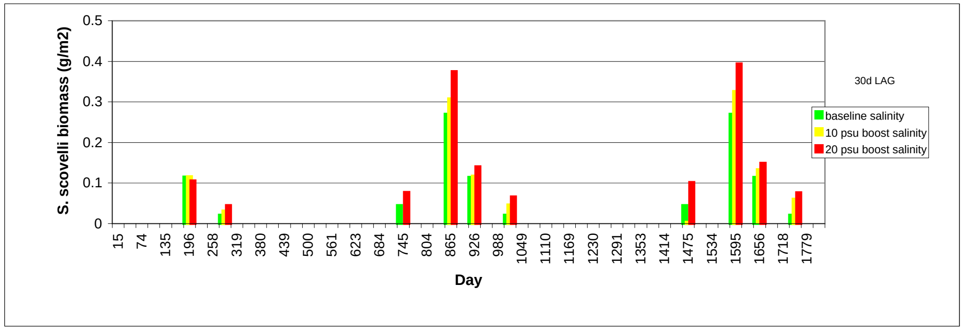
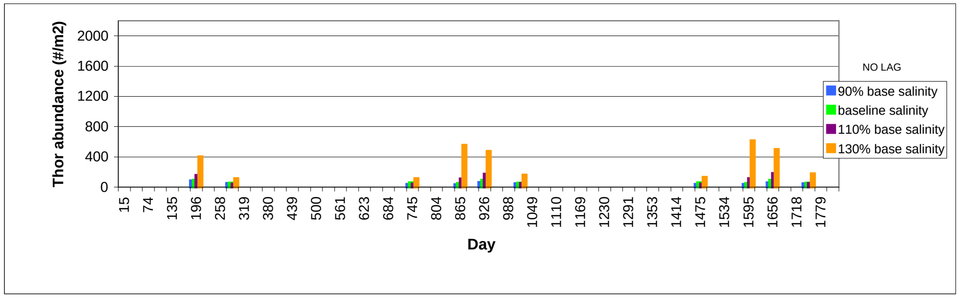
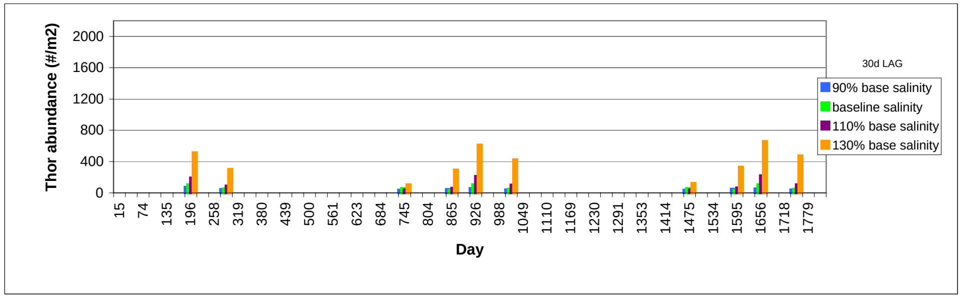
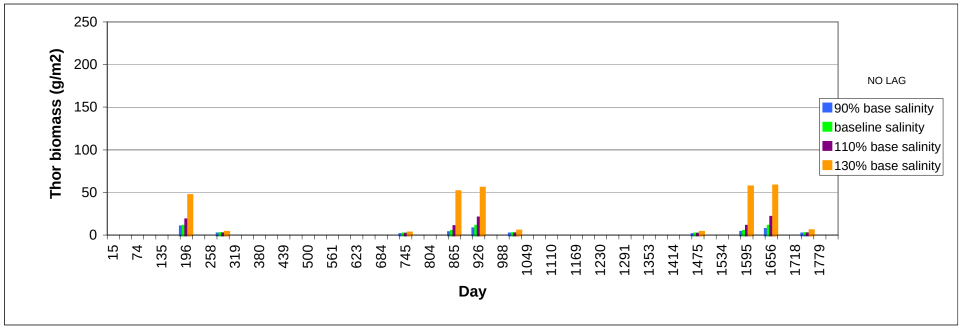


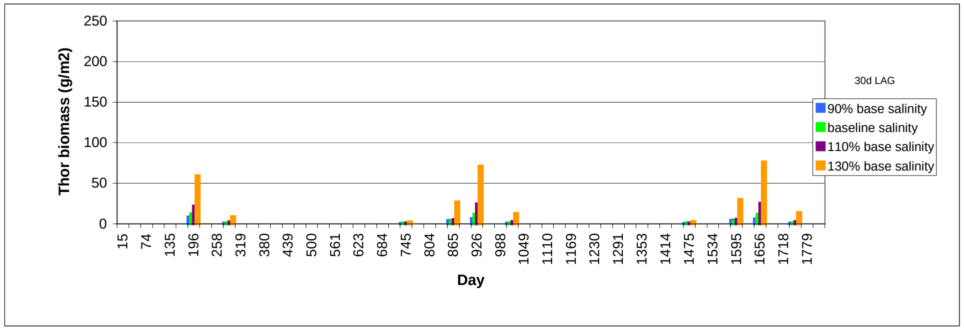
Figure 120. Whipray Basin Scenario – *Thor spp.* abundance and biomass- throw-trap

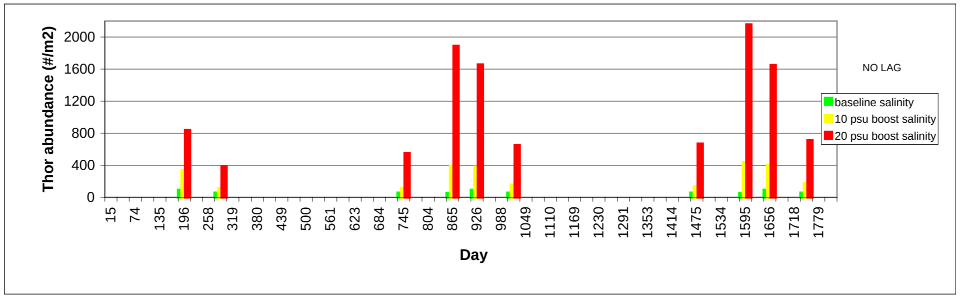
WHIPRAY- THROW TRAP

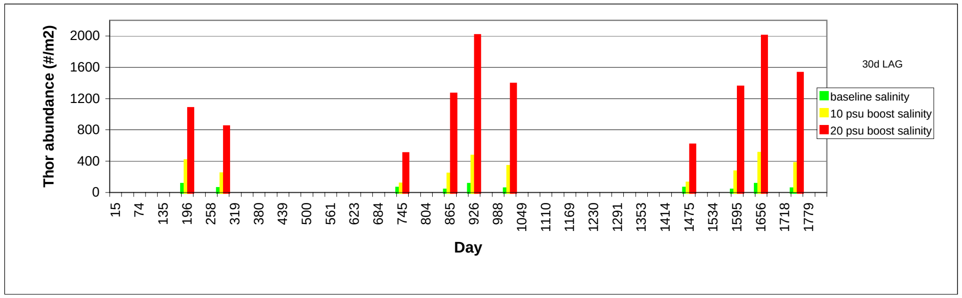


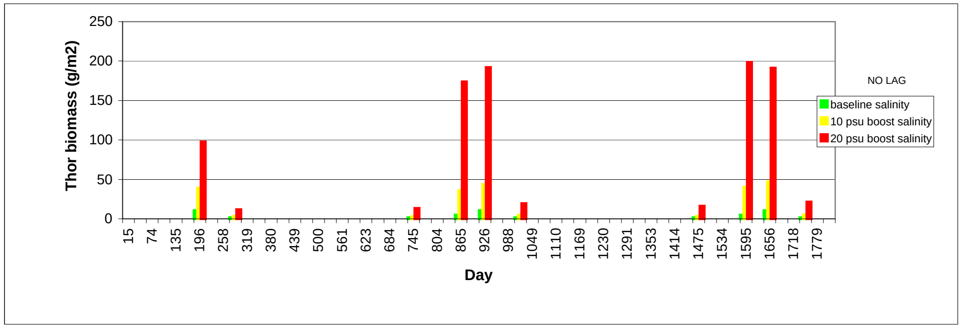












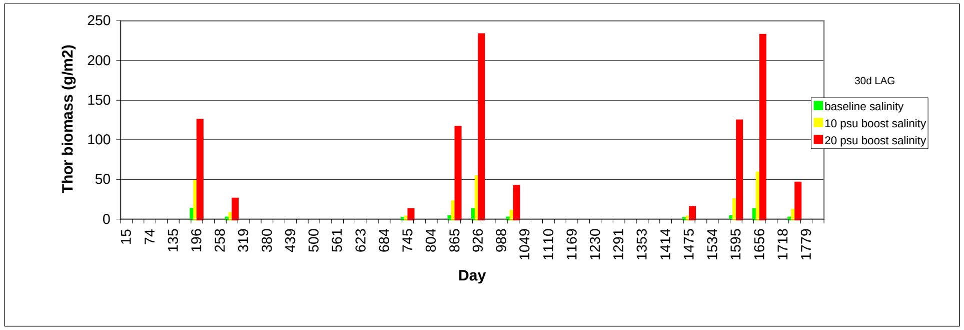
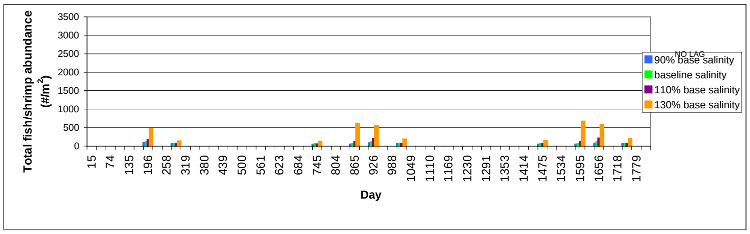
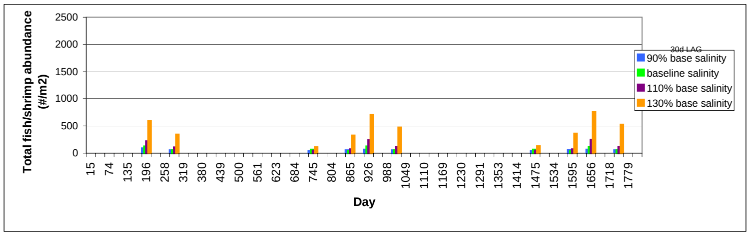
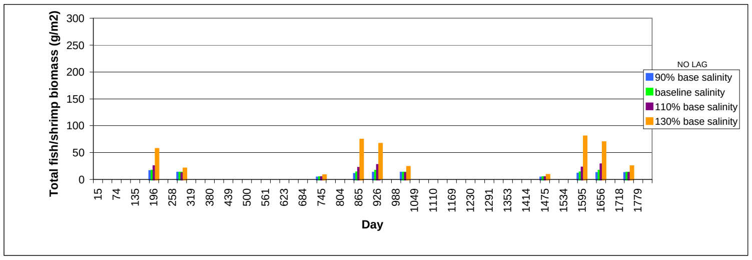


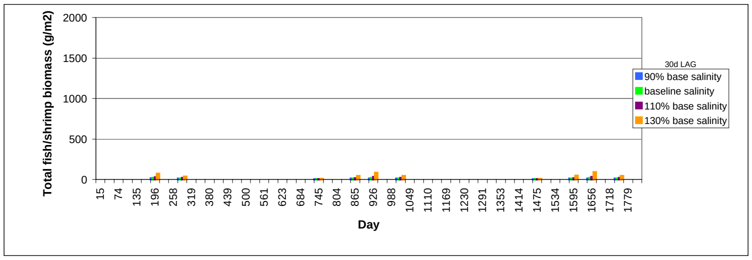
Figure 121. Whipray Basin Scenario – Total fish/shrimp abundance, Total fish/shrimp biomass, Forage fish/shrimp biomass, Predator fish biomass- throw-trap

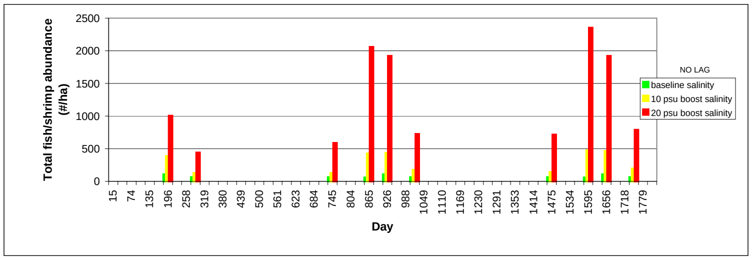
WHIPRAY- THROW TRAP

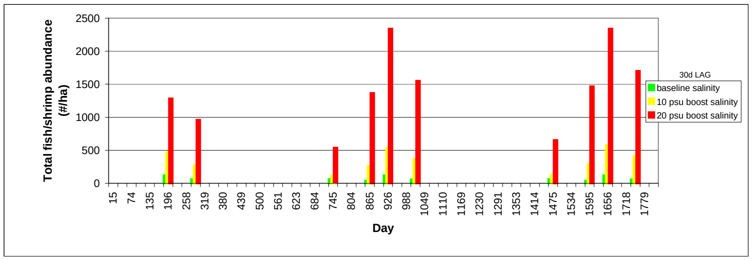


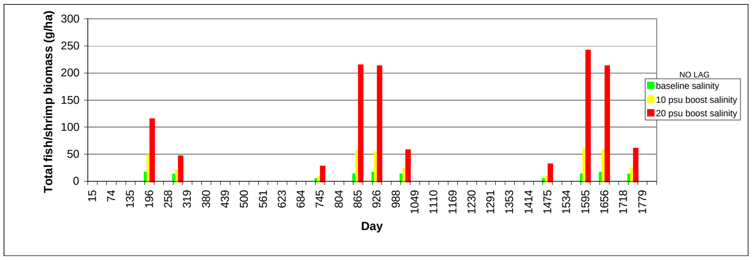


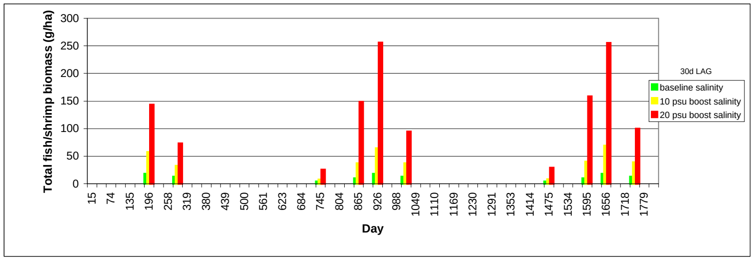


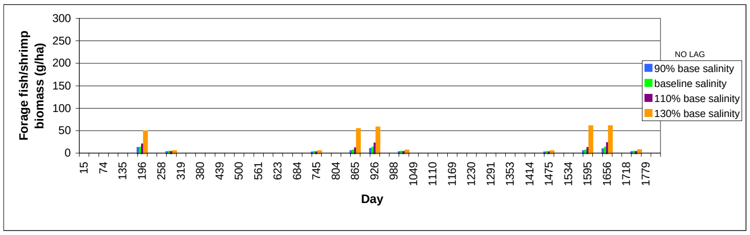


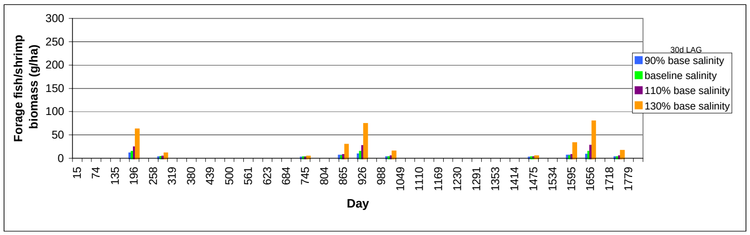


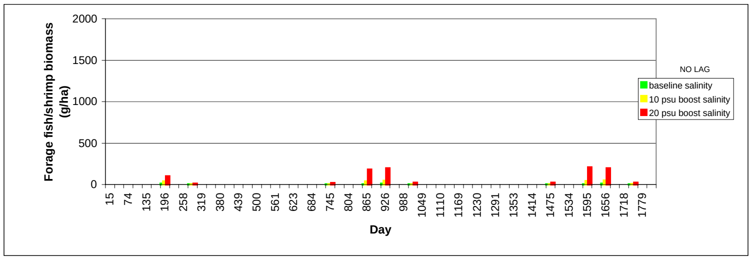












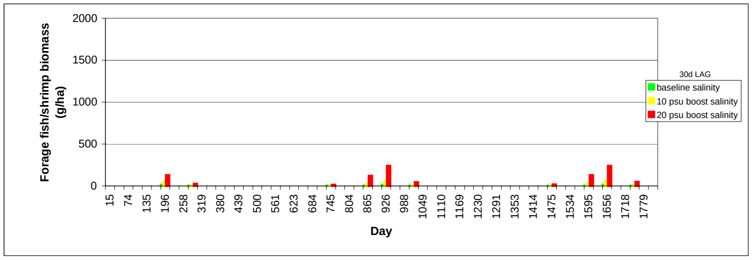
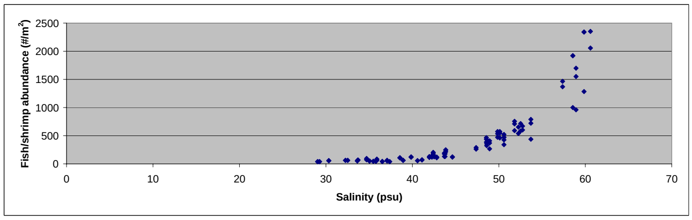
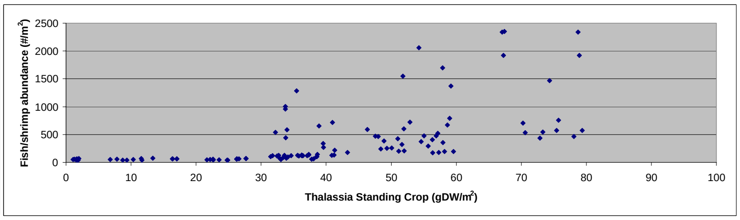
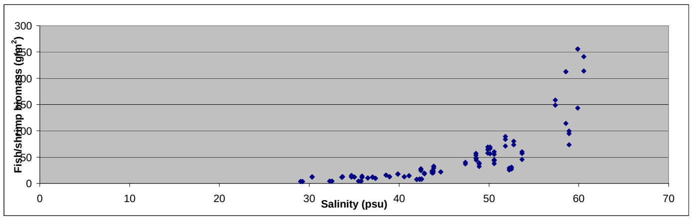


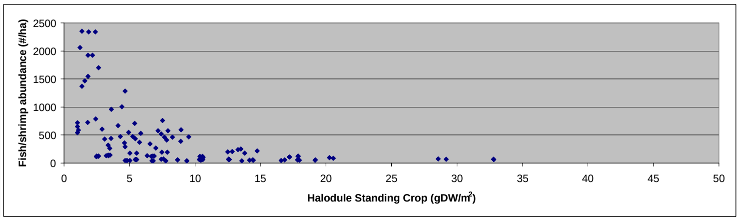
Figure 122. Whipray Basin Scenario - Fish/shrimp abundance vs. Salinity, Fish/shrimp biomass vs. salinity, Predator fish biomass vs. Salinity, Fish/shrimp abundance vs. Thalassia BBCA, Fish/shrimp abundance vs. Halodule BBCA- throw-trap

WHIPRAY- THROW TRAP









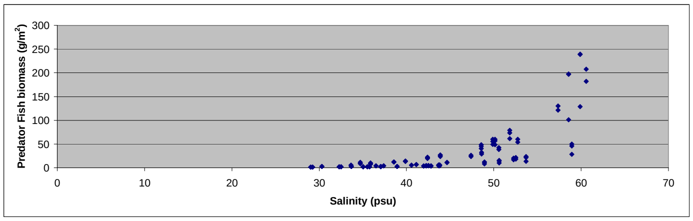
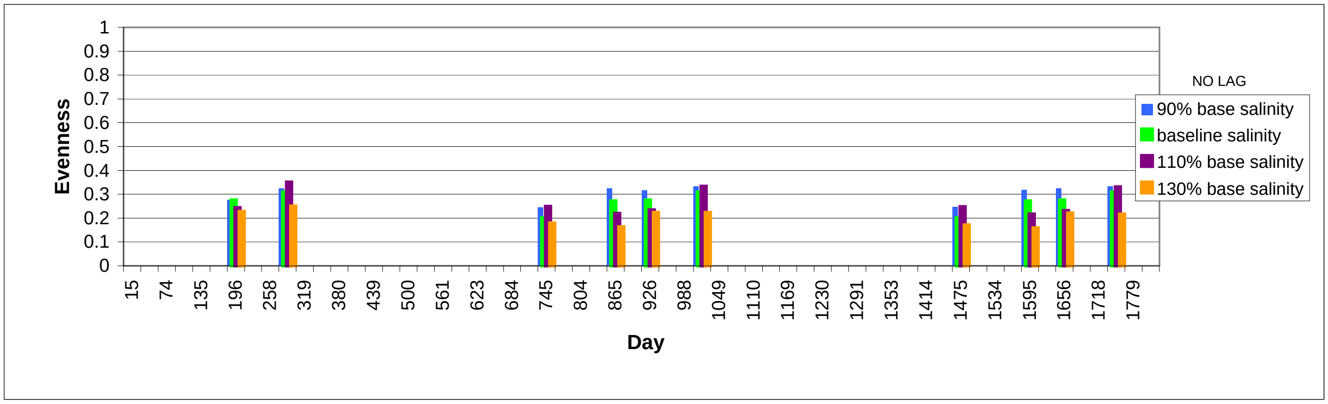
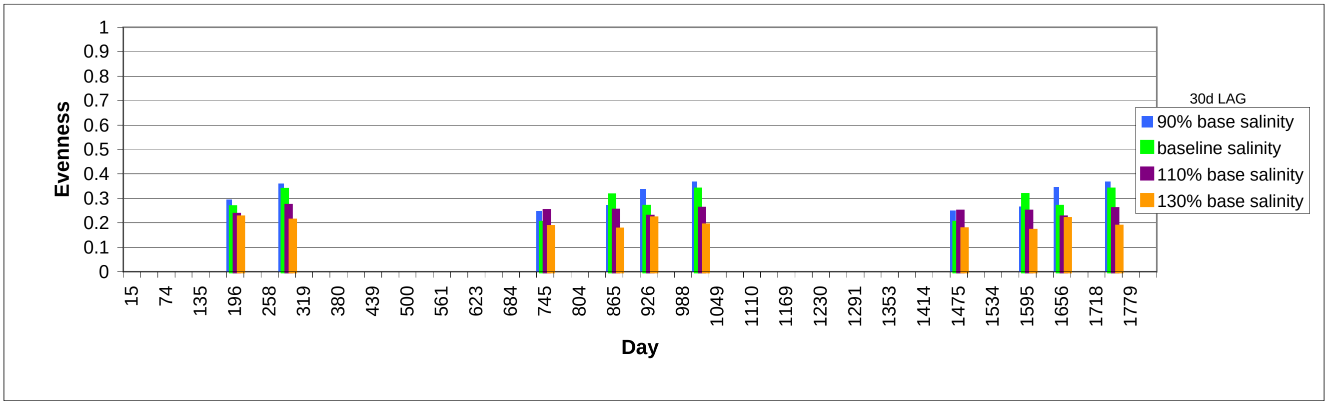
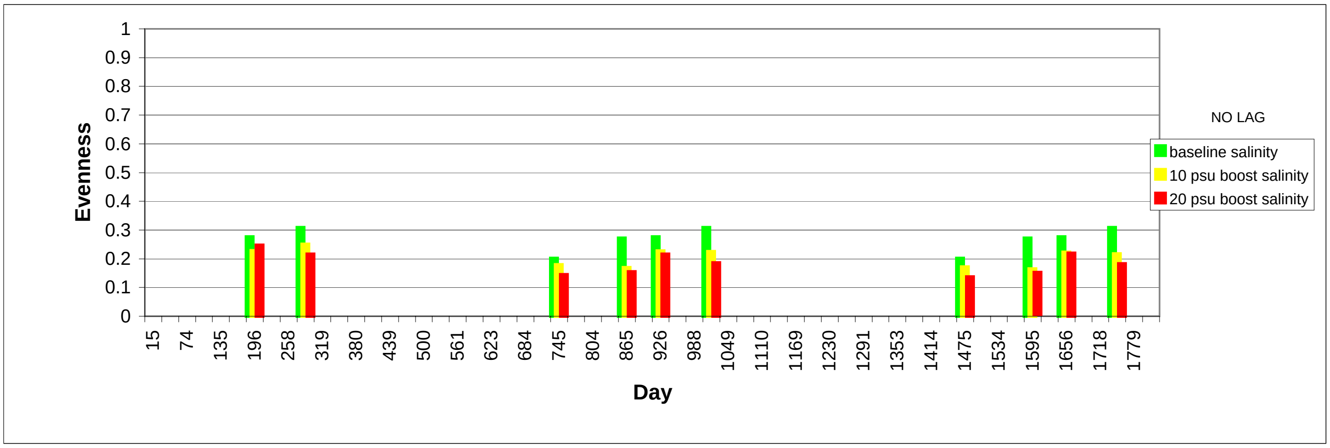


Figure 123. Whipray Basin Scenario – Evenness throw-trap

WHIPRAY- THROW TRAP







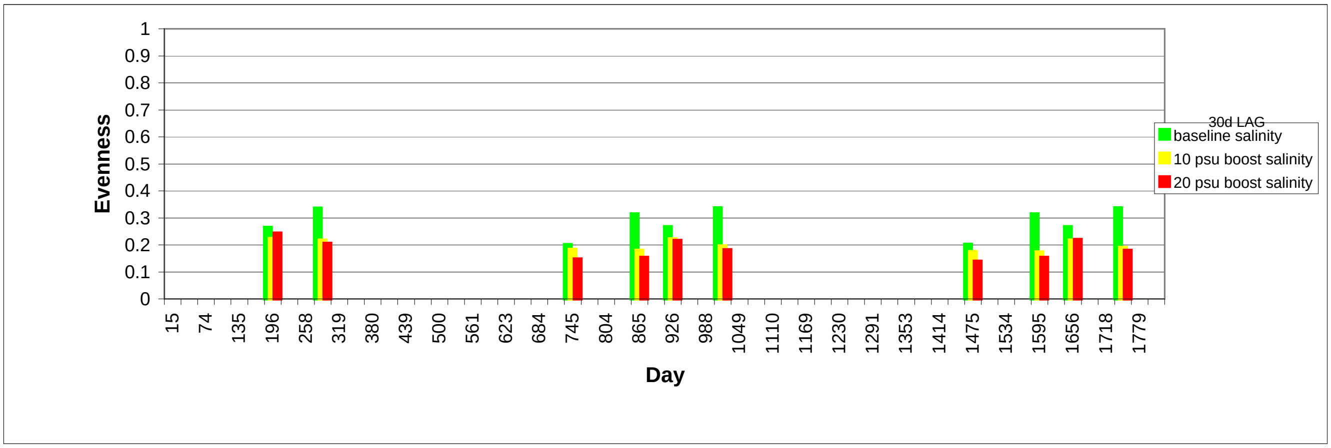
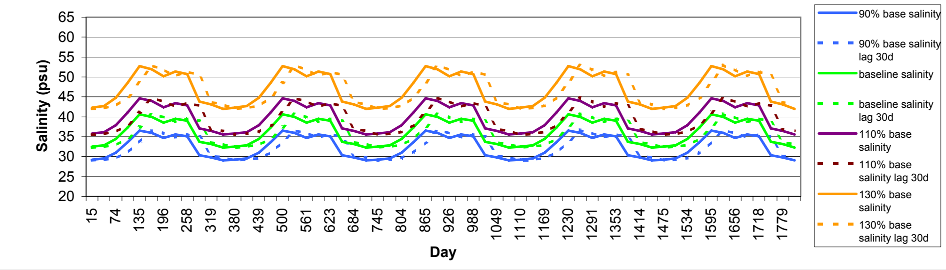
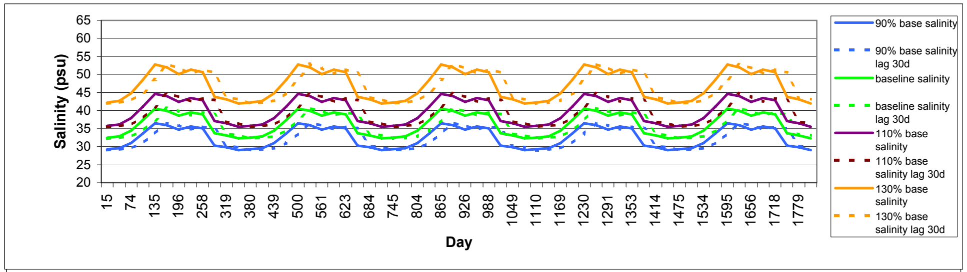
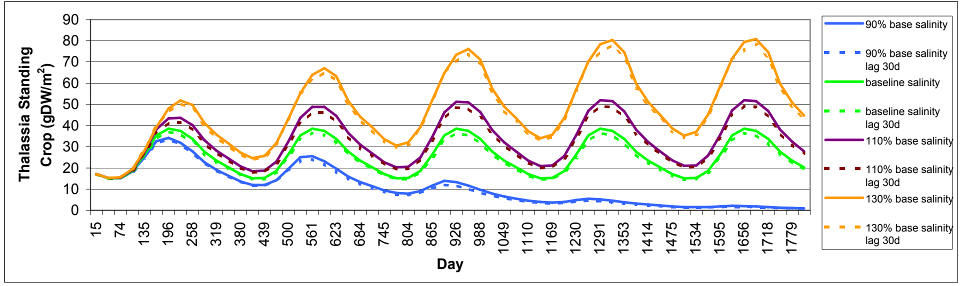


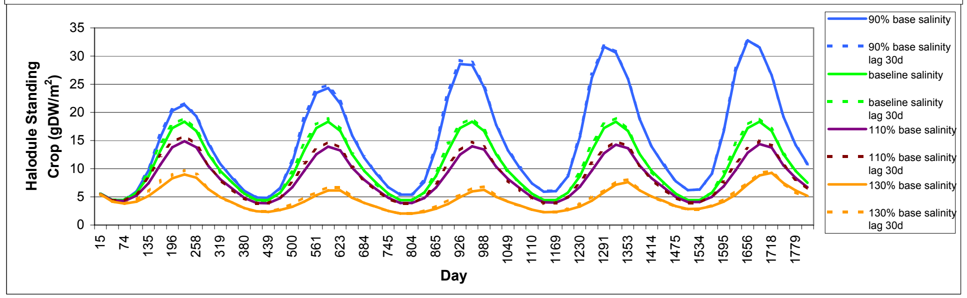
Figure 124. Whipray Basin Scenario – Salinity and SAV- throw-trap

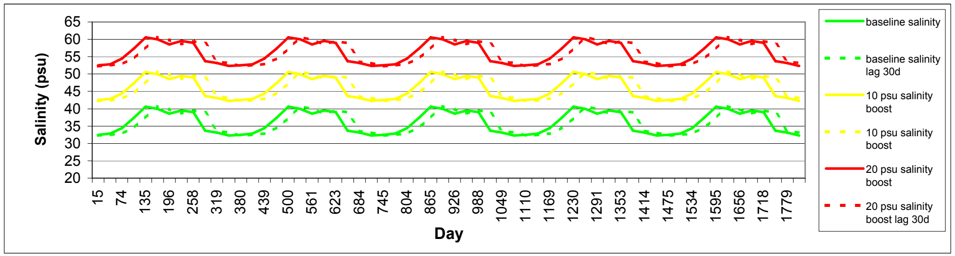
WHIPRAY BASIN

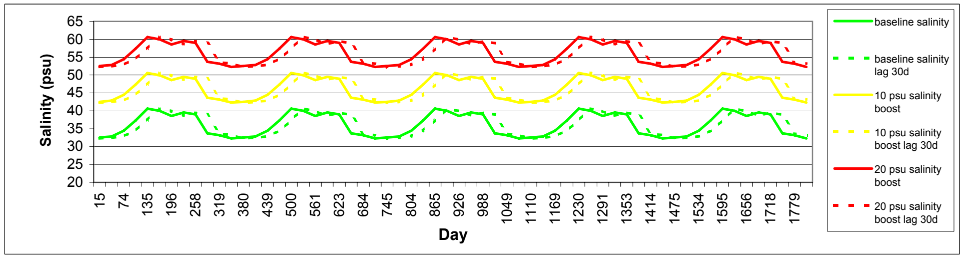


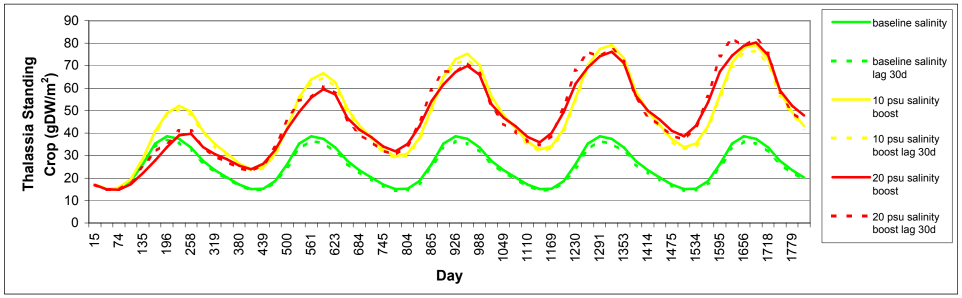












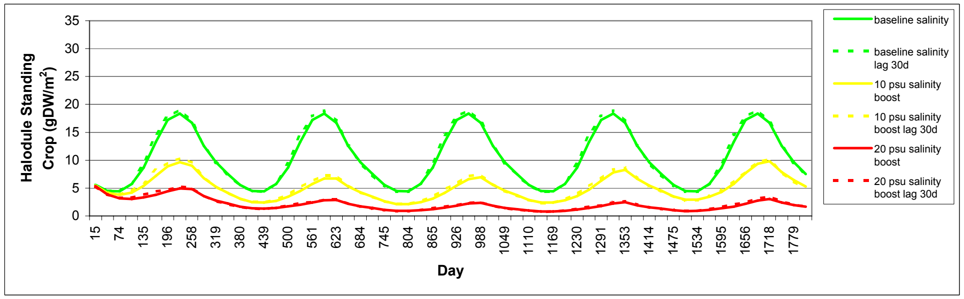
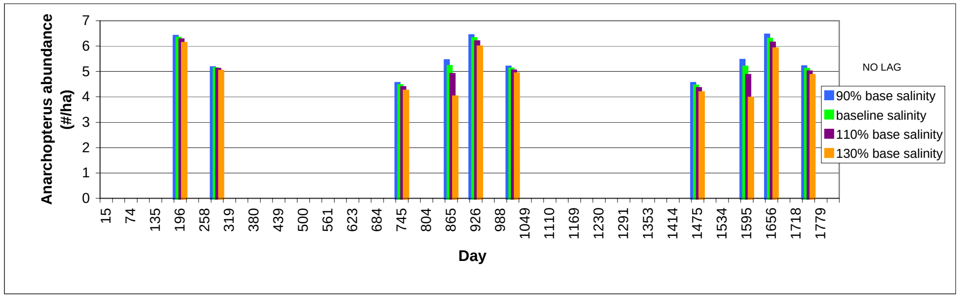
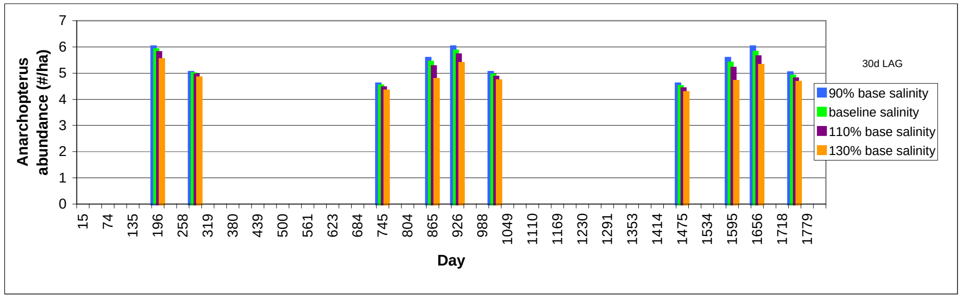
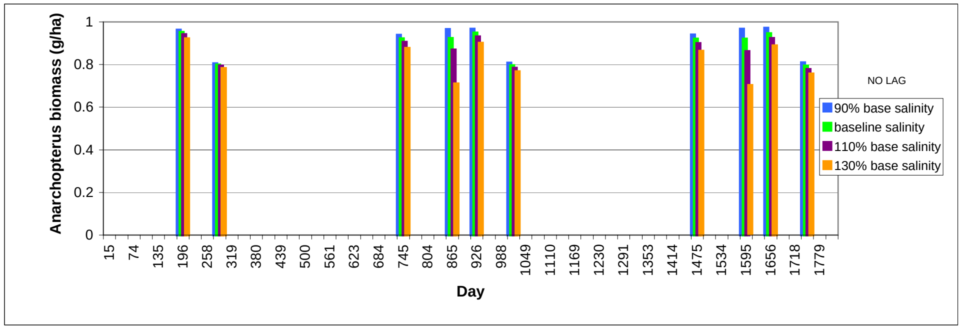


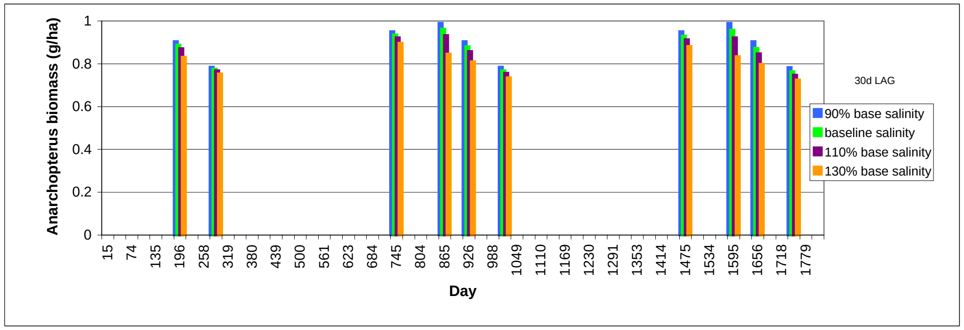
Figure 125. Rankin Lake Scenario – *Anarchopterus criniger* abundance and biomass-trawl/seine

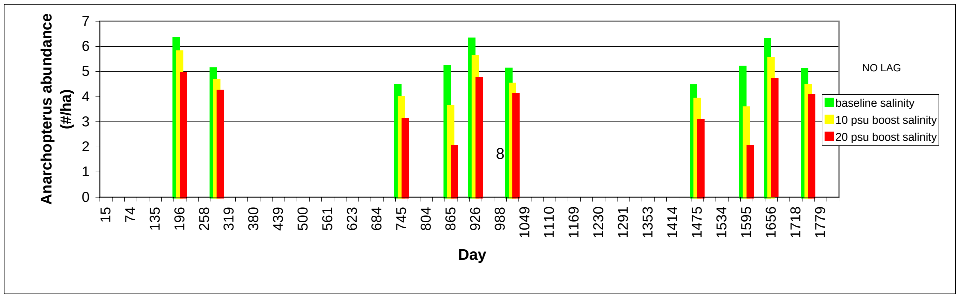
RANKIN LAKE- TRAWL/SEINE

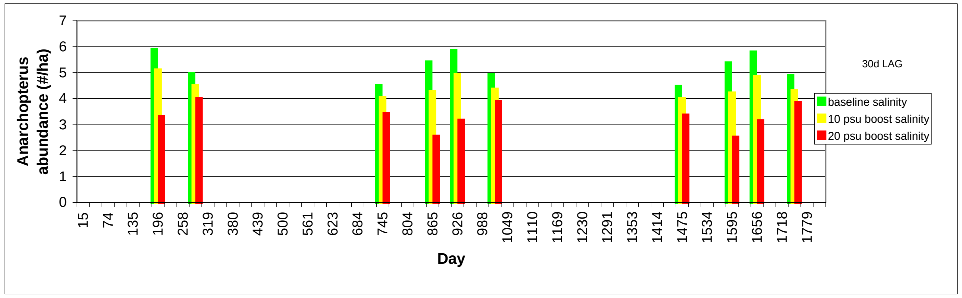


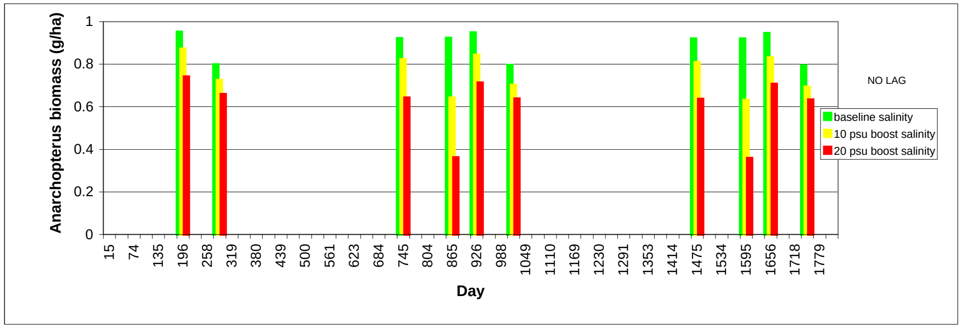












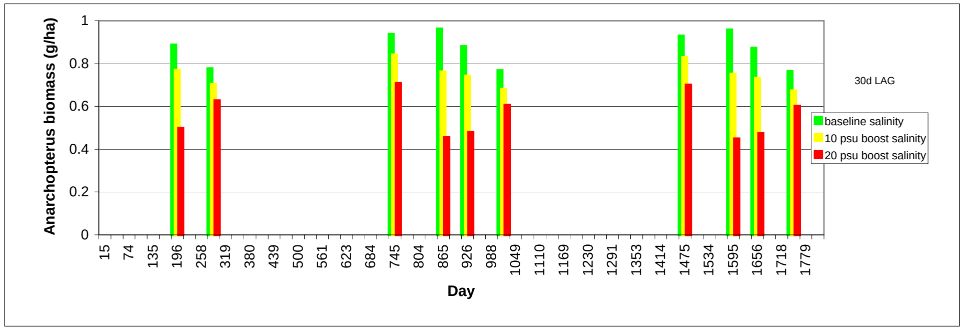
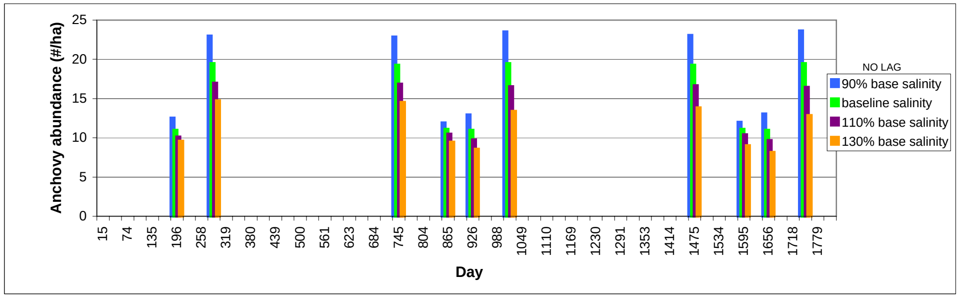
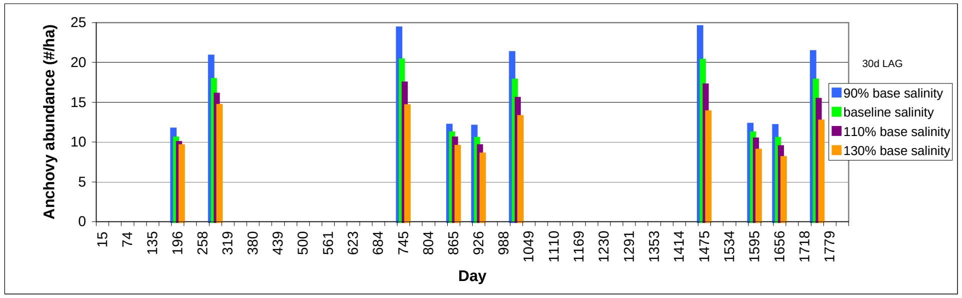
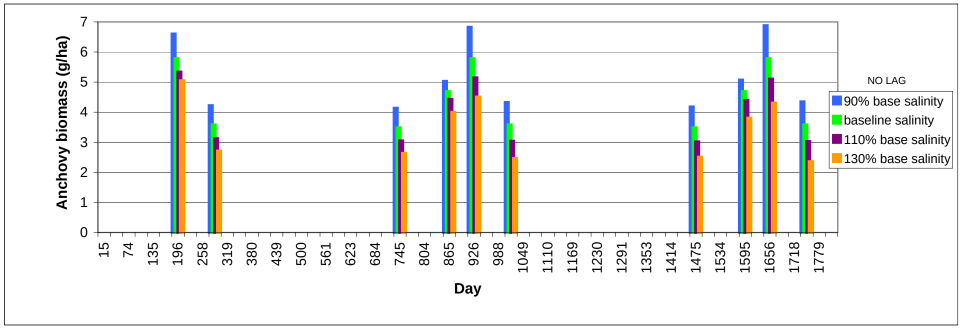


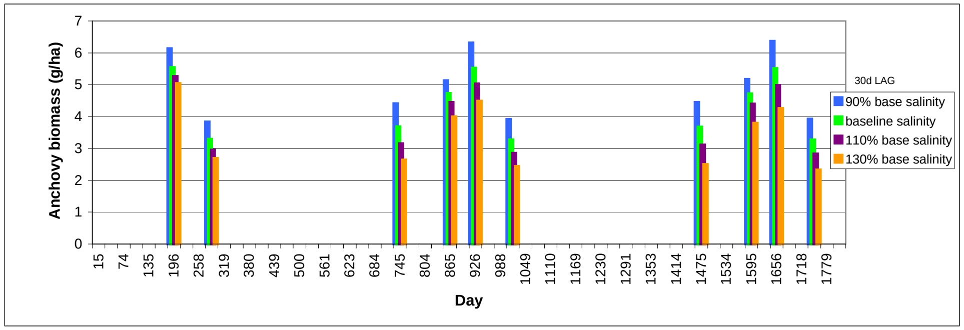
Figure 126. Rankin Lake Scenario – *Anchoa mitchelli* abundance and biomass-trawl/seine

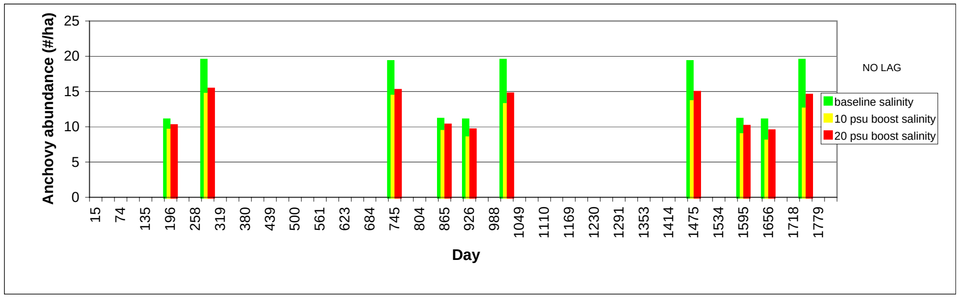
RANKIN LAKE- TRAWL/SEINE

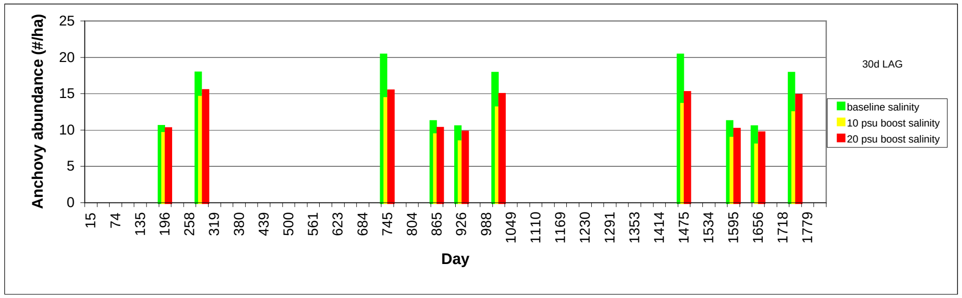


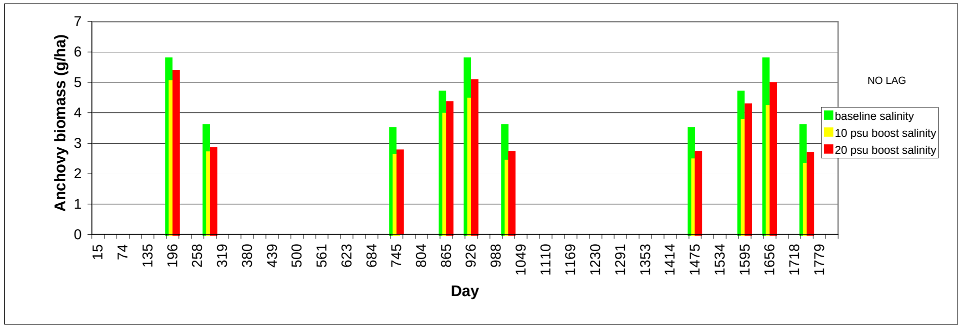












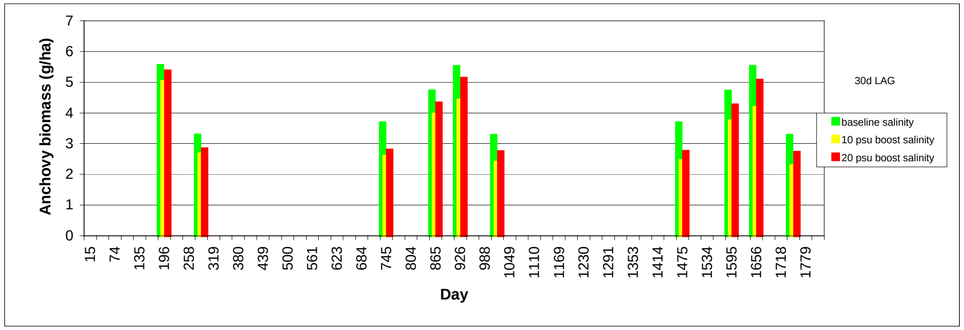
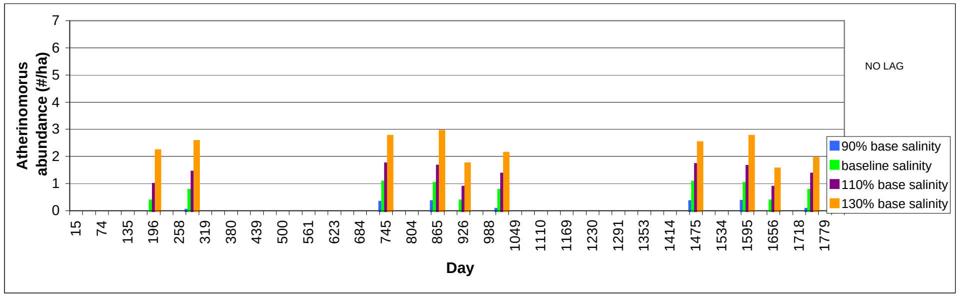
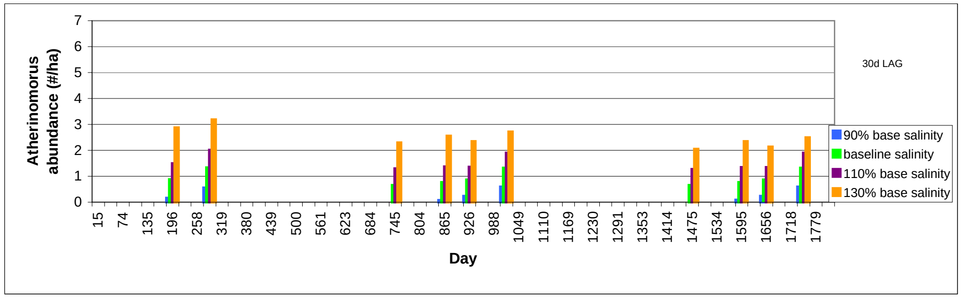
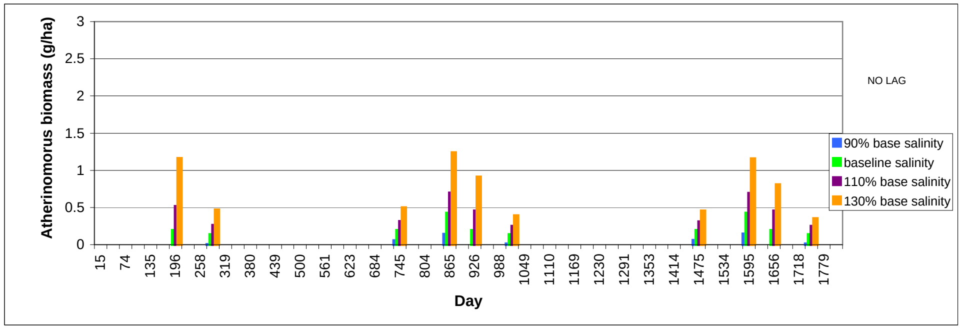


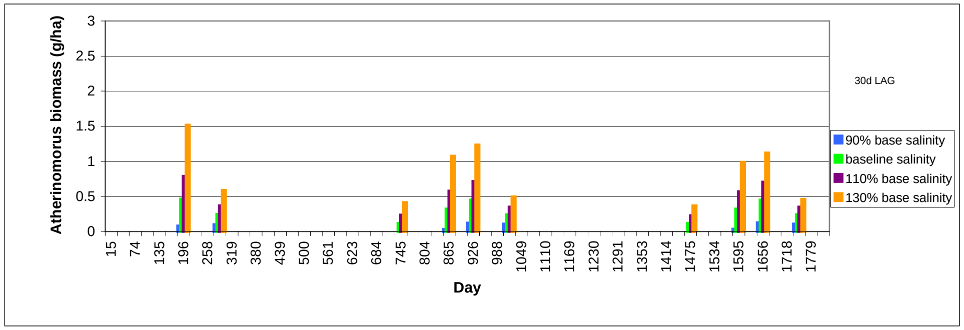
Figure 127. Rankin Lake Scenario – *Atherinomorus stipes* abundance and biomass-trawl/seine

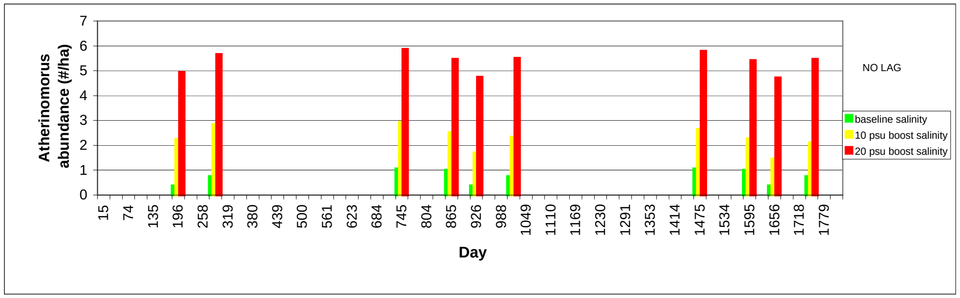
RANKIN LAKE- TRAWL/SEINE

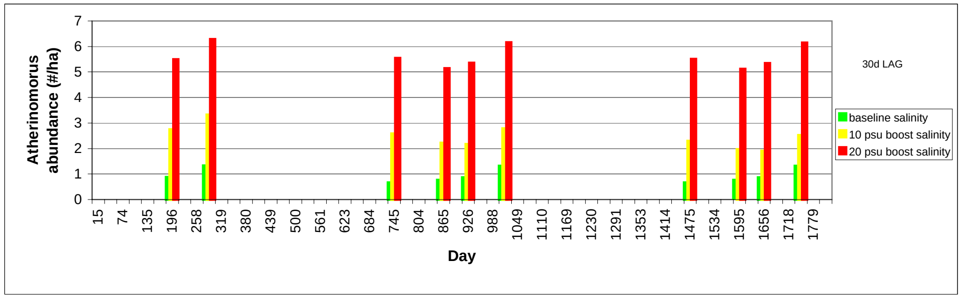


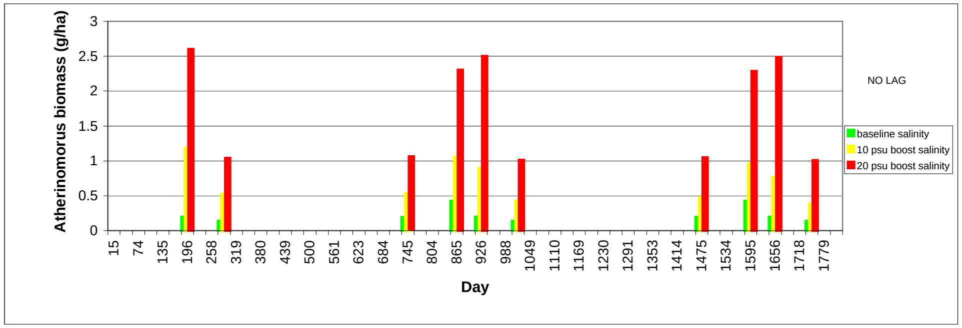












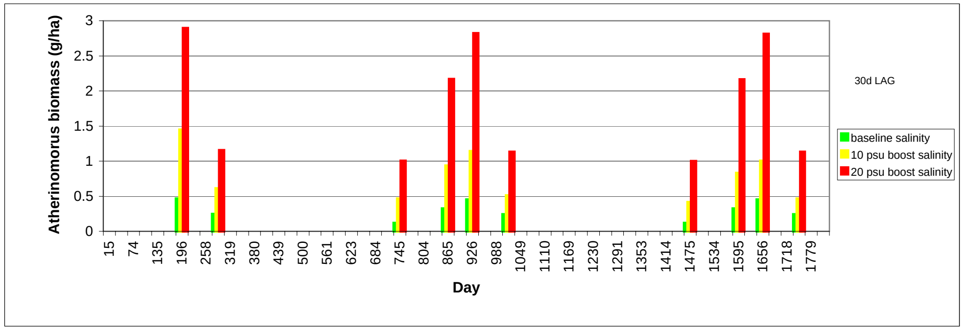
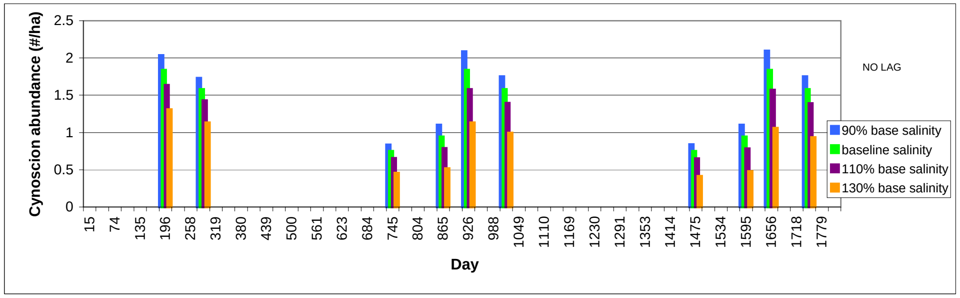
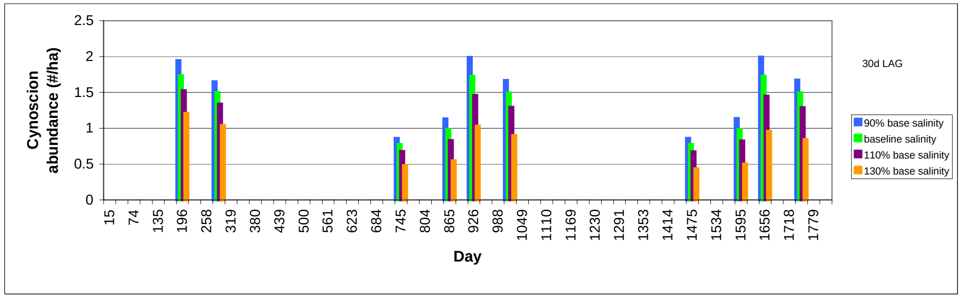
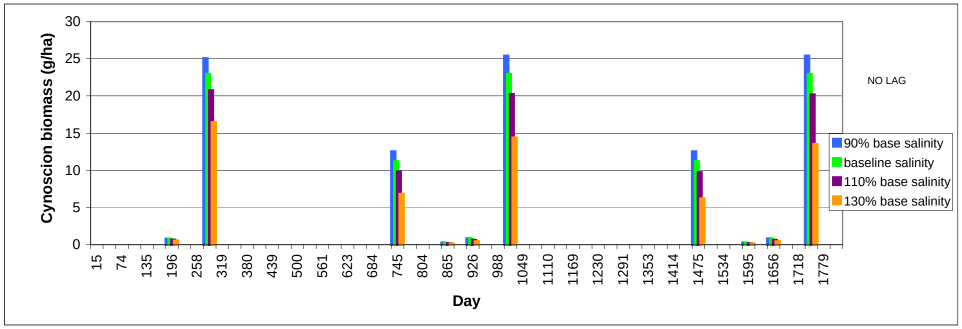


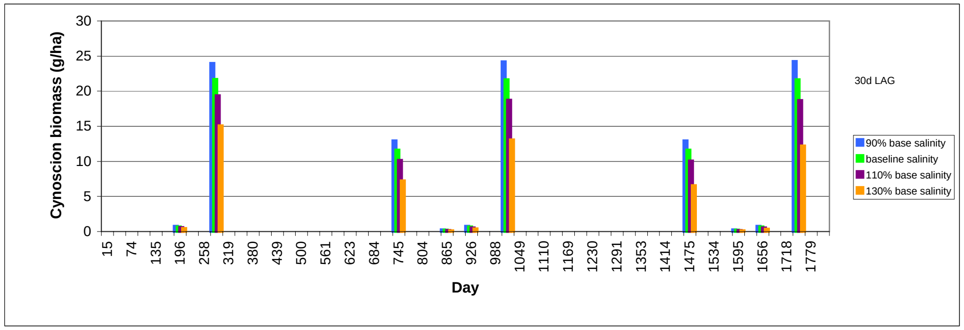
Figure 128. Rankin Lake Scenario – *Cynoscion nebulosus* abundance and biomass-trawl/seine

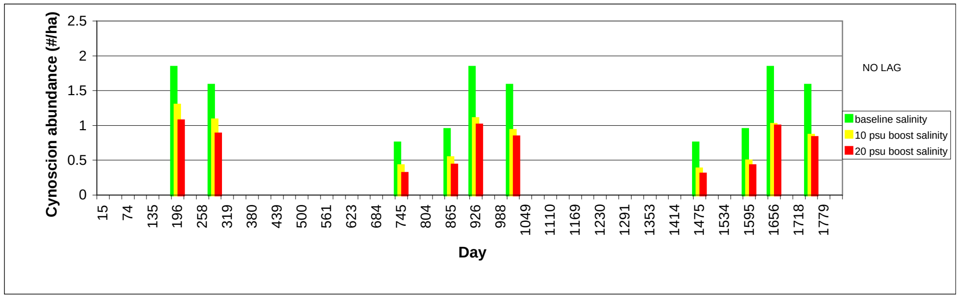
RANKIN LAKE- TRAWL/SEINE

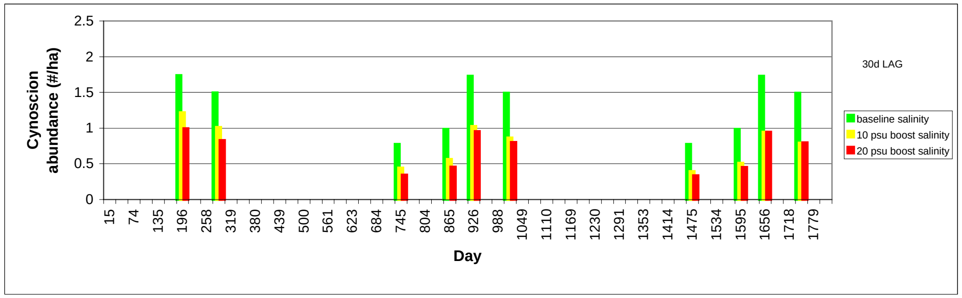


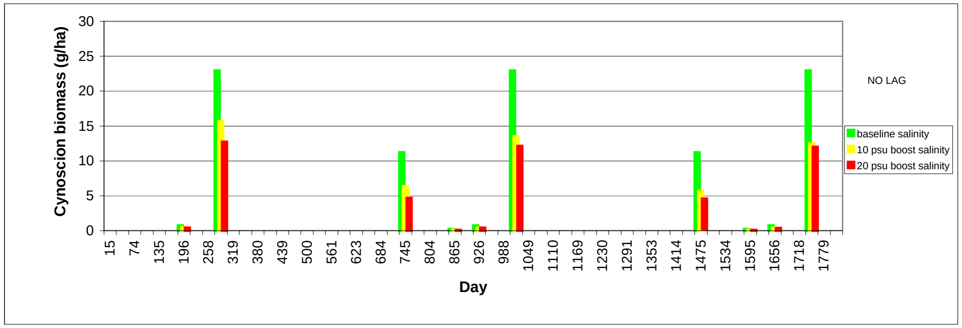












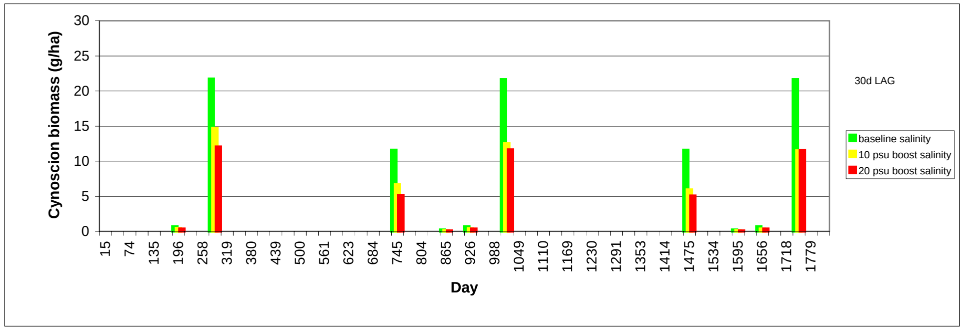
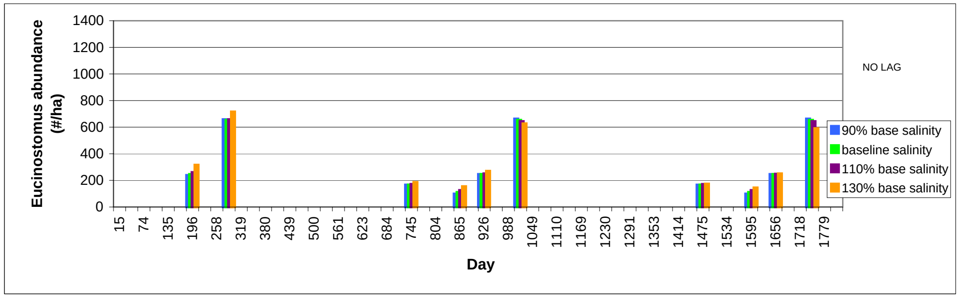
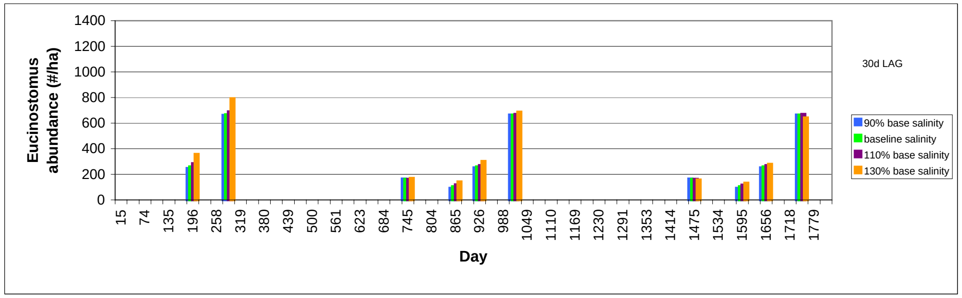
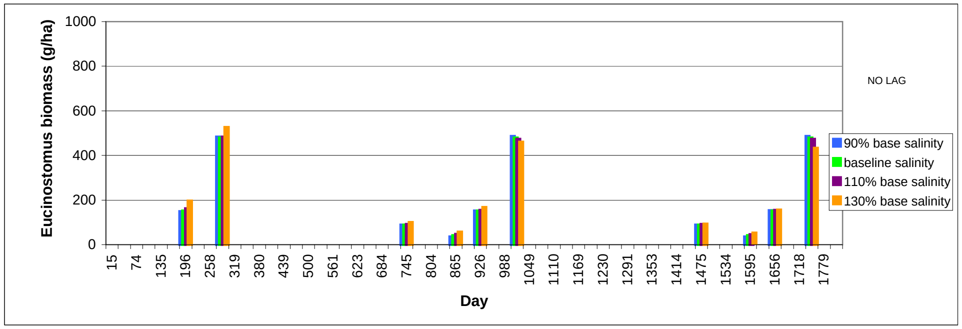


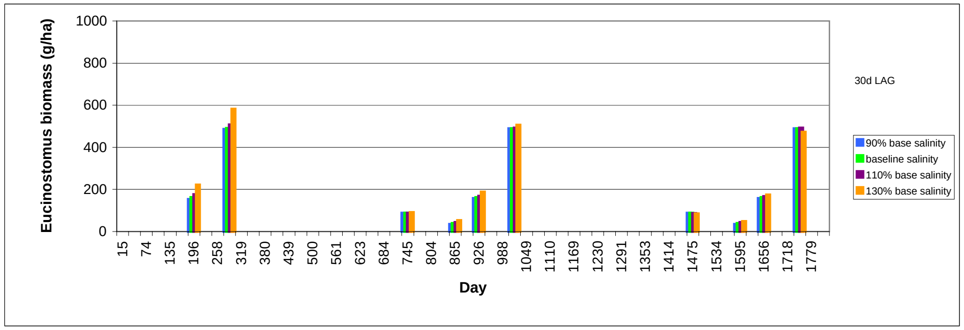
Figure 129. Rankin Lake Scenario – *Eucinostomus spp*. abundance and biomass-trawl/seine

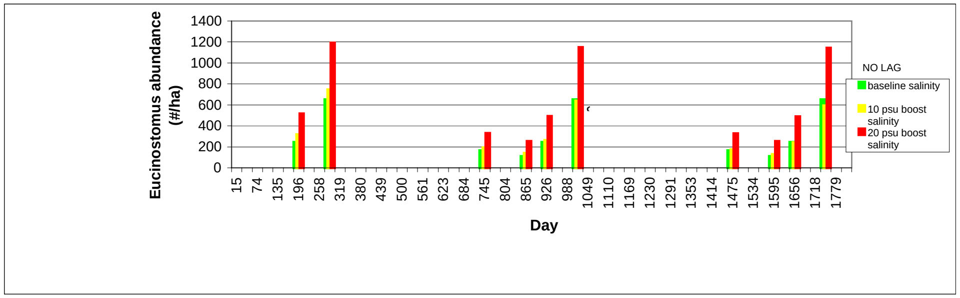
RANKIN LAKE- TRAWL/SEINE

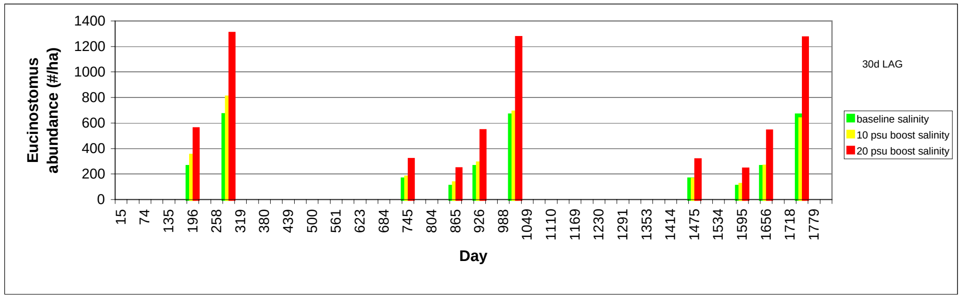


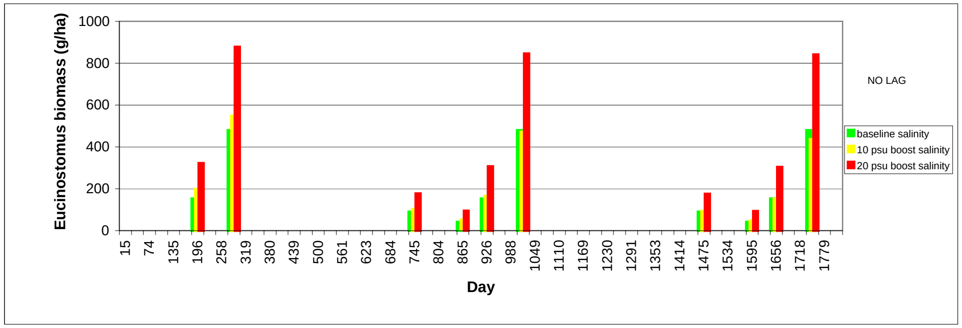












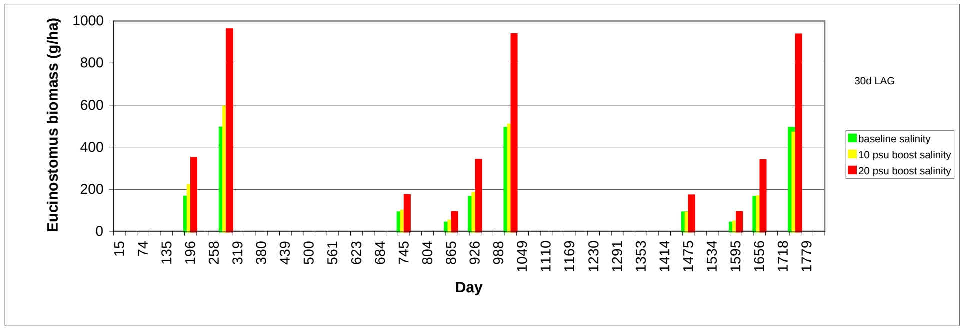
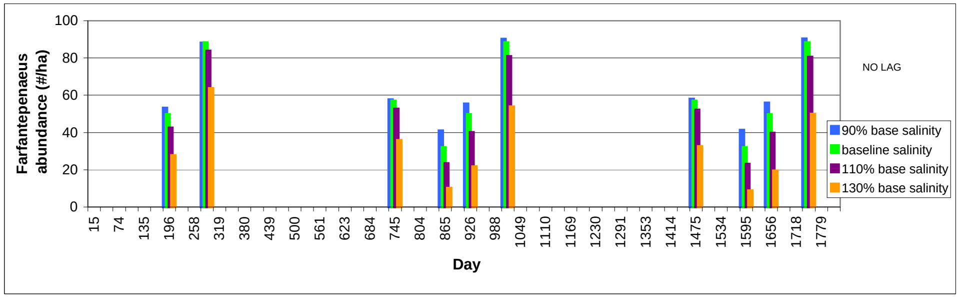
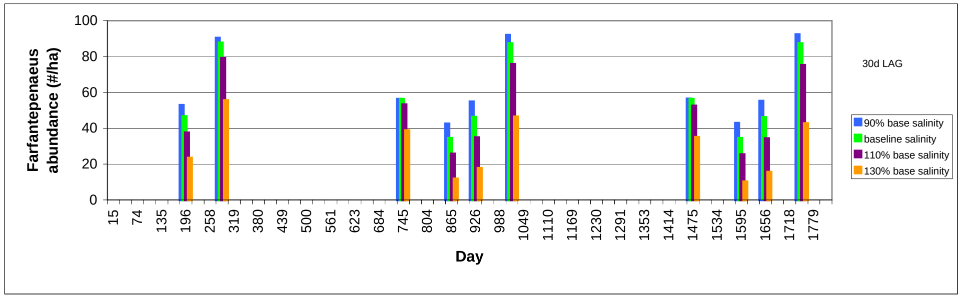
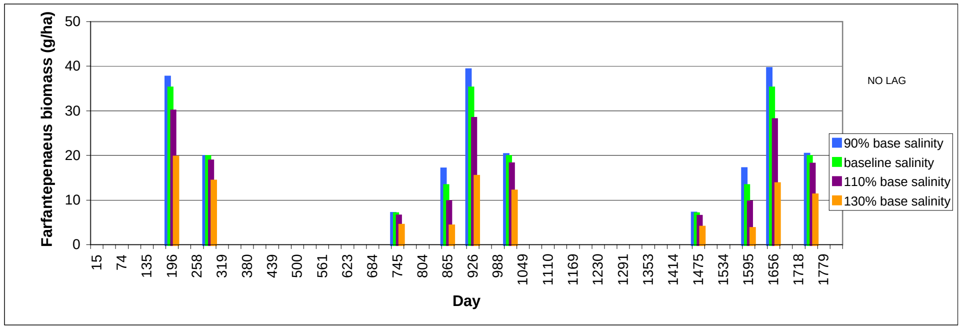


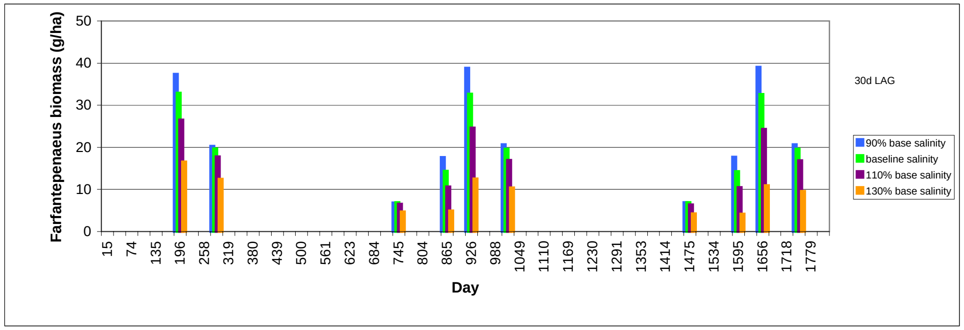
Figure 130. Rankin Lake Scenario – *Farfantepenaeus duorarum* abundance and biomass-trawl/seine

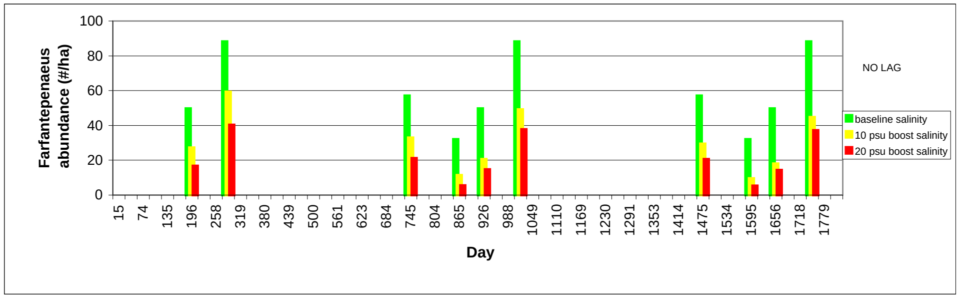
RANKIN LAKE- TRAWL/SEINE

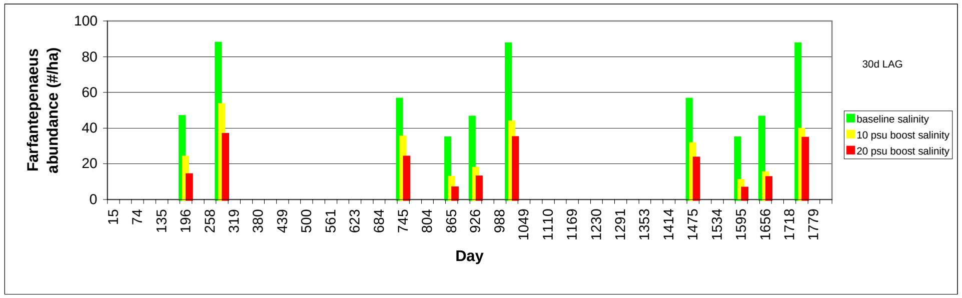


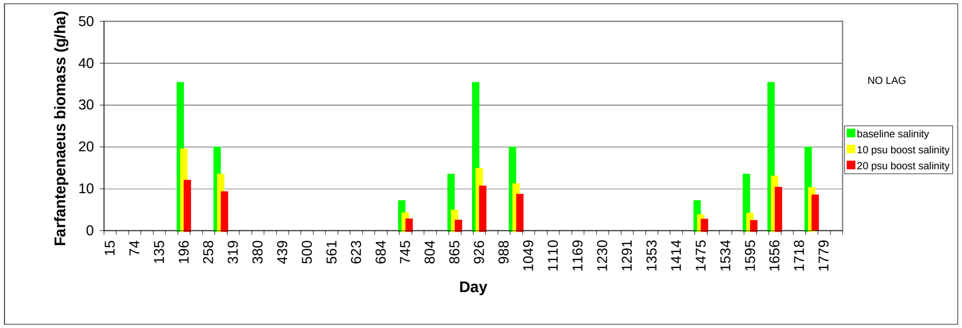












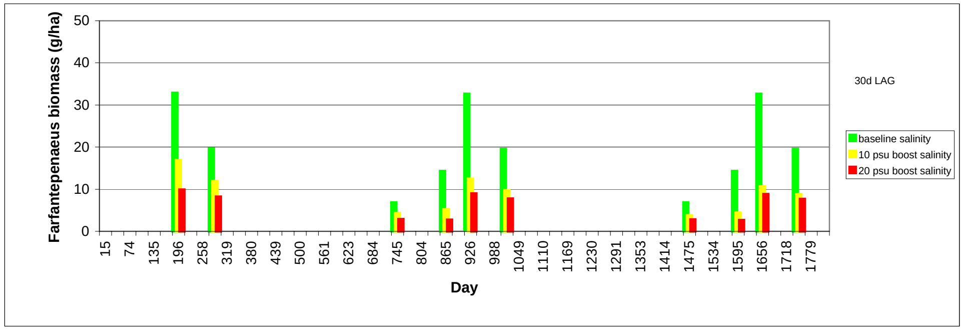
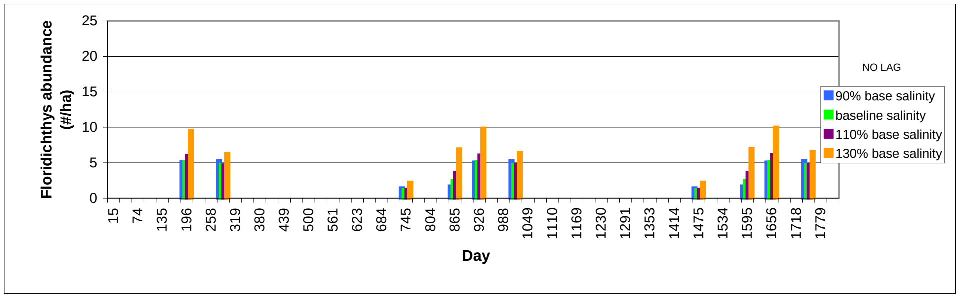
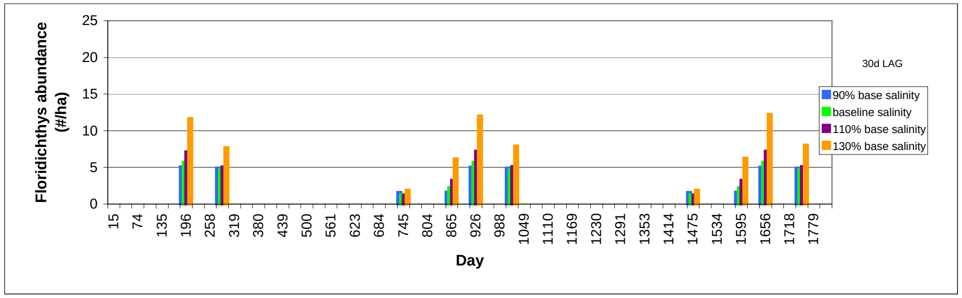
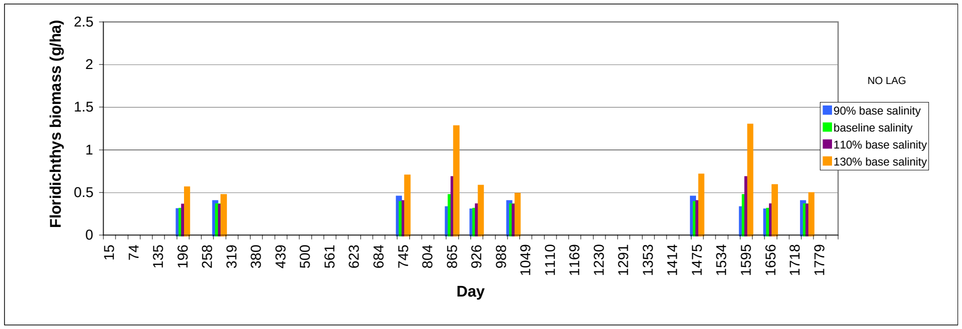


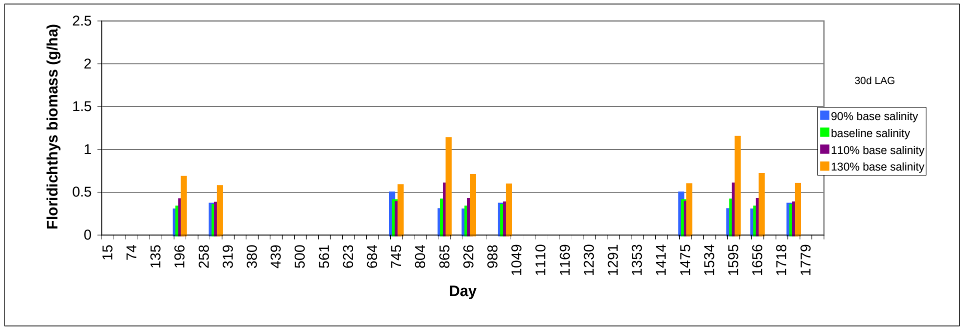
Figure 131. Rankin Lake Scenario – *Floridichthys carpio* abundance and biomass-trawl/seine

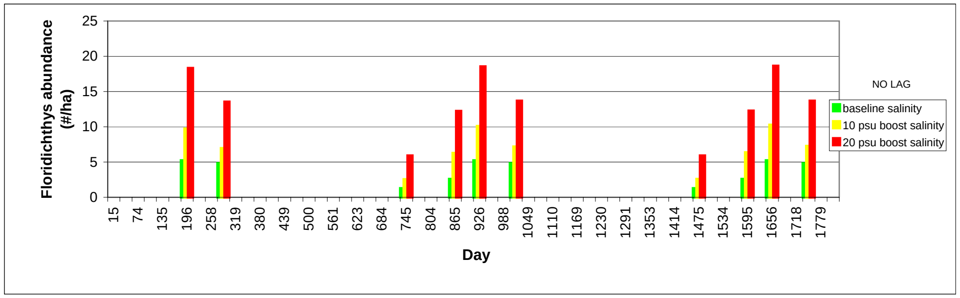
RANKIN LAKE- TRAWL/SEINE

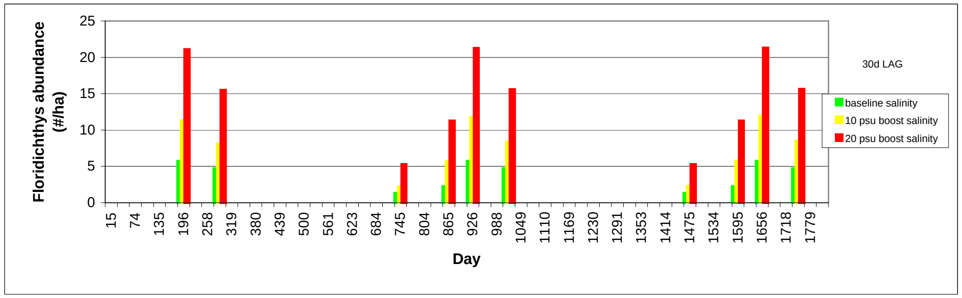


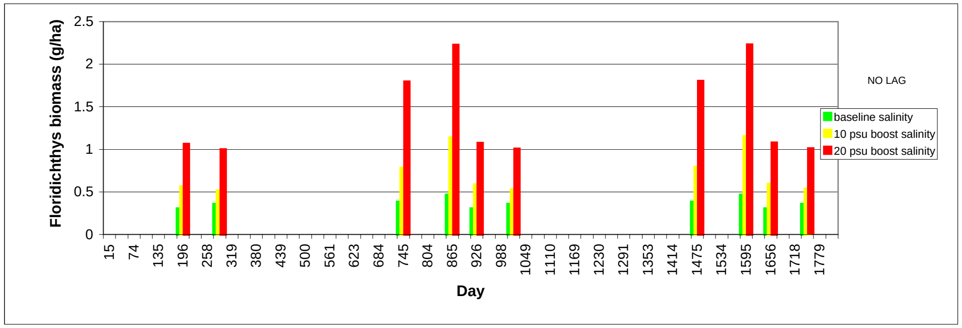












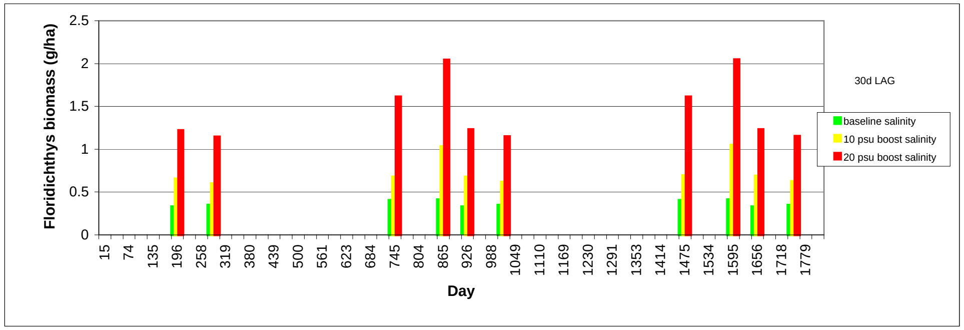
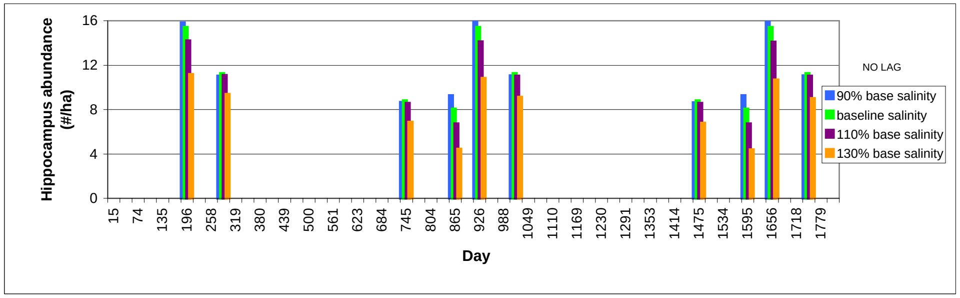
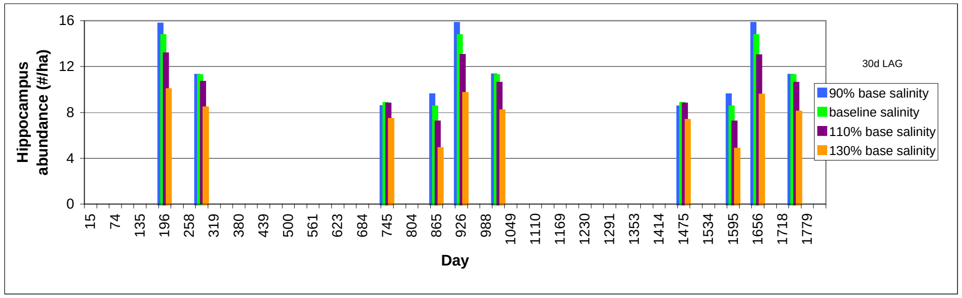
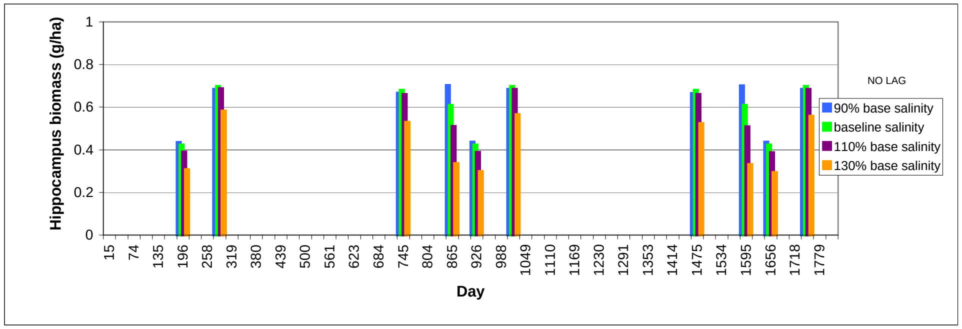


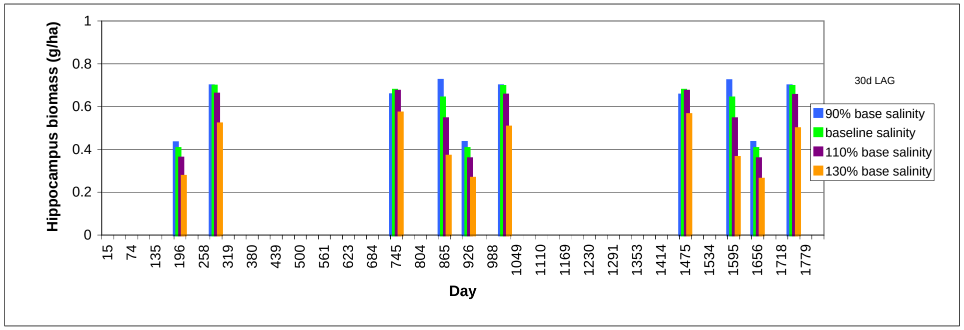
Figure 132. Rankin Lake Scenario – *Hippocampus zosterae* abundance and biomass-trawl/seine

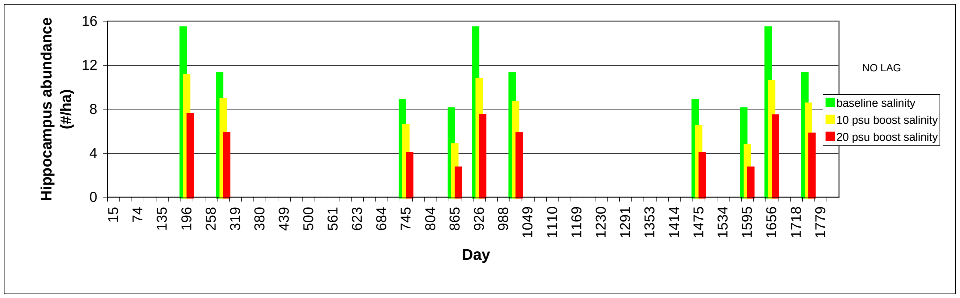
RANKIN LAKE- TRAWL/SEINE

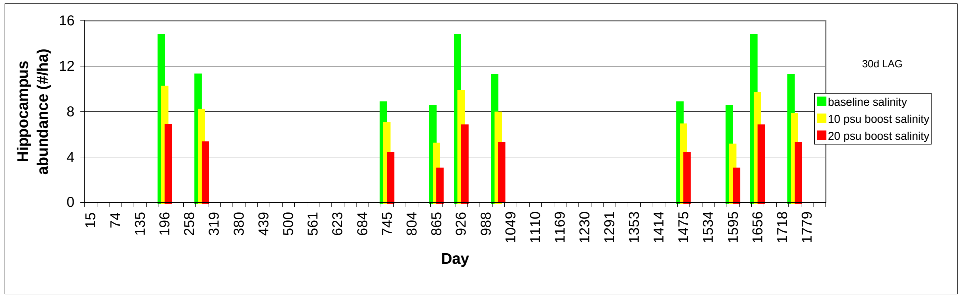


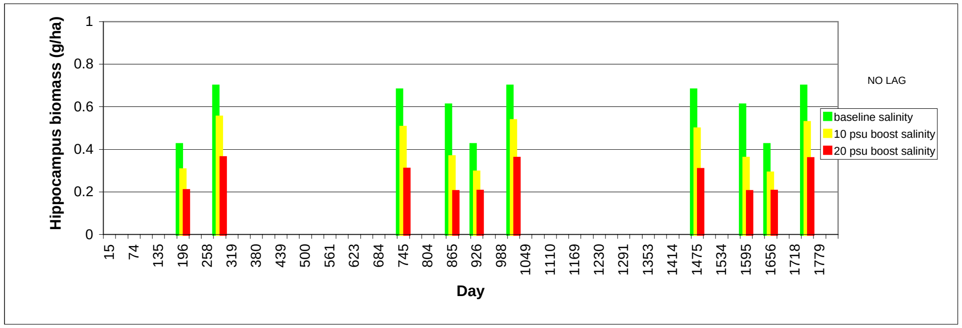












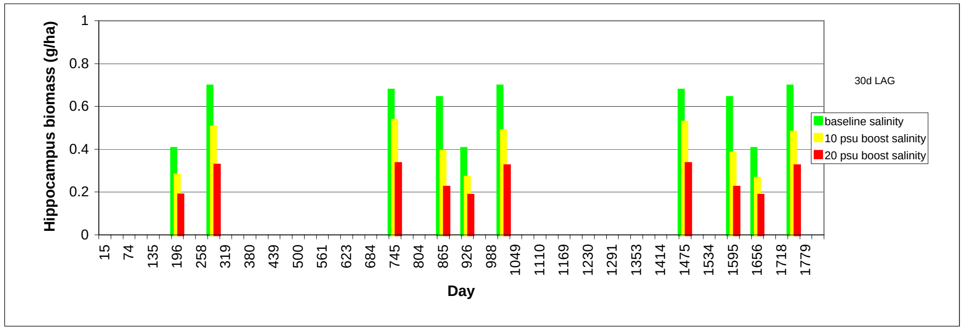
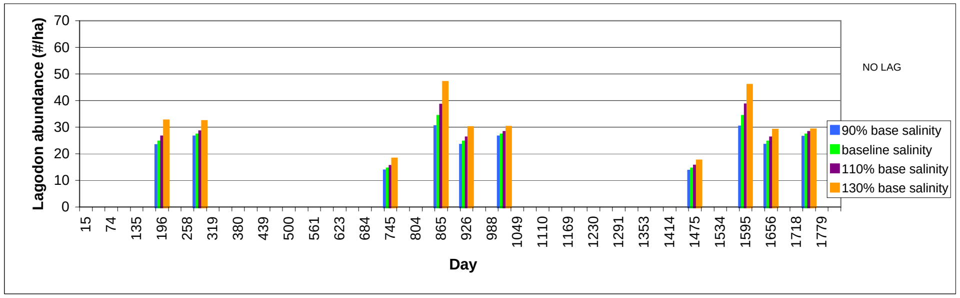
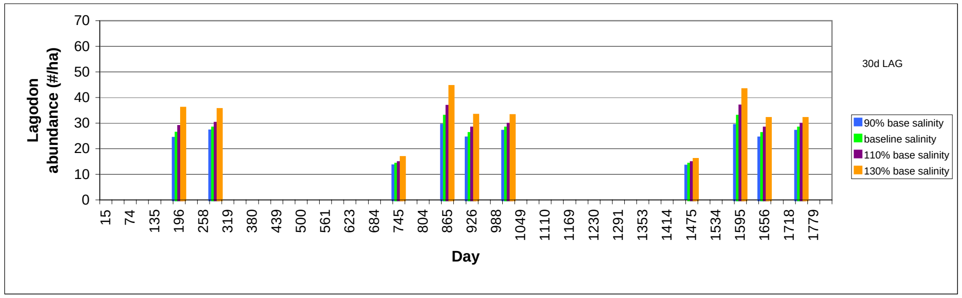
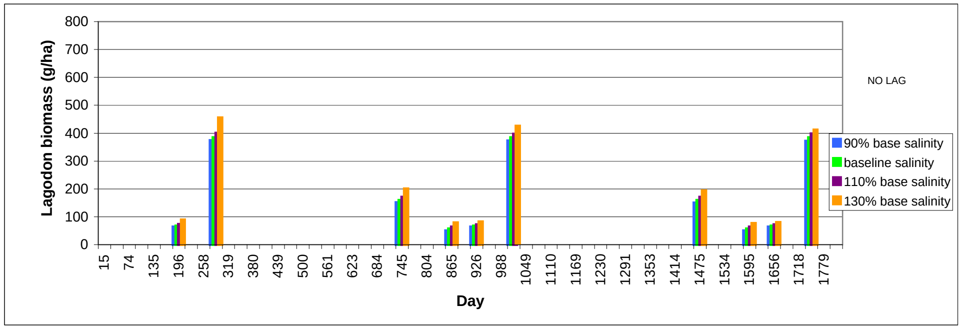


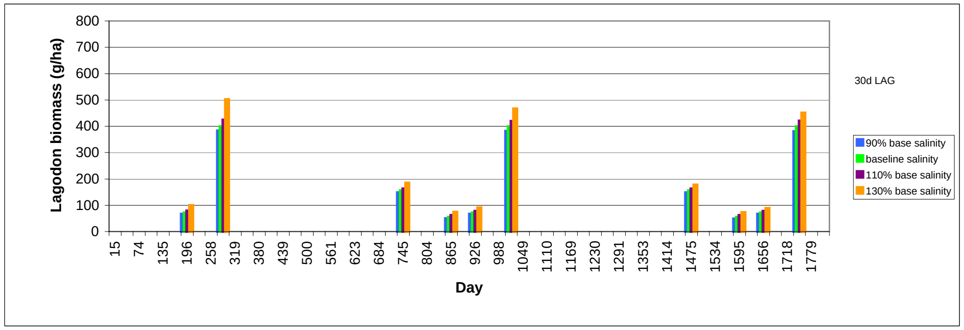
Figure 133. Rankin Lake Scenario – *Lagodon rhomboides* abundance and biomass-trawl/seine

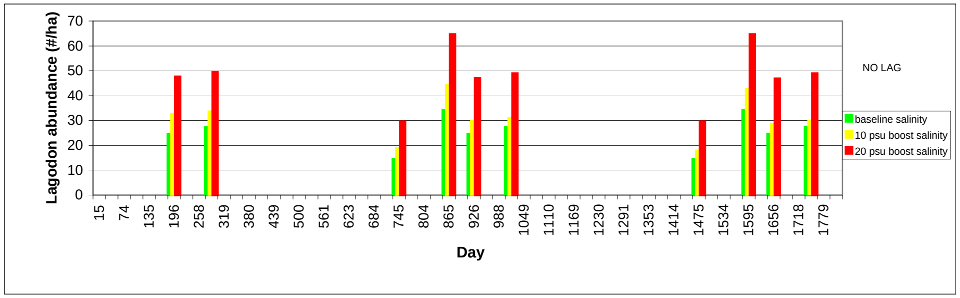
RANKIN LAKE- TRAWL/SEINE

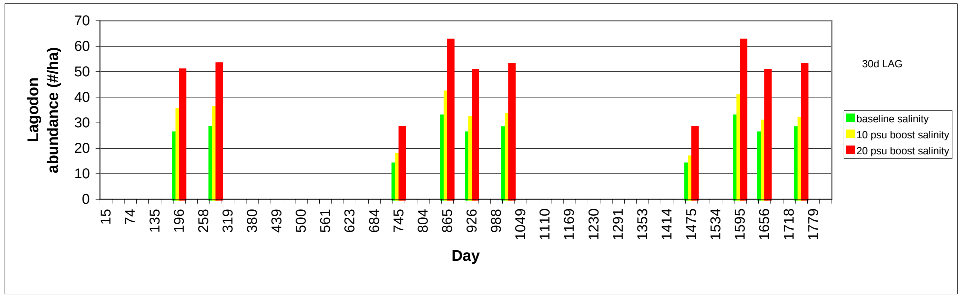


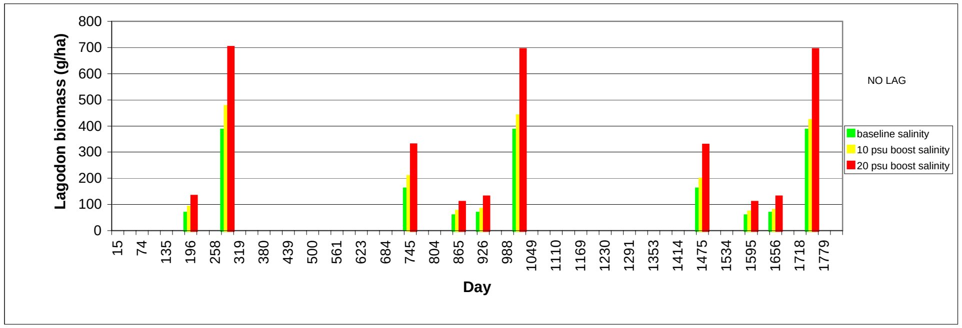












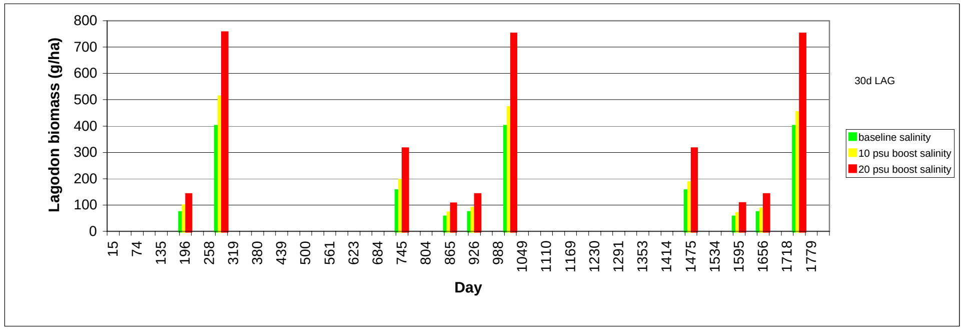
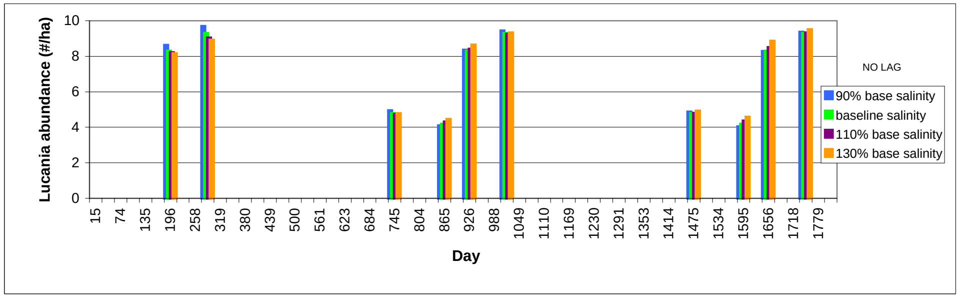
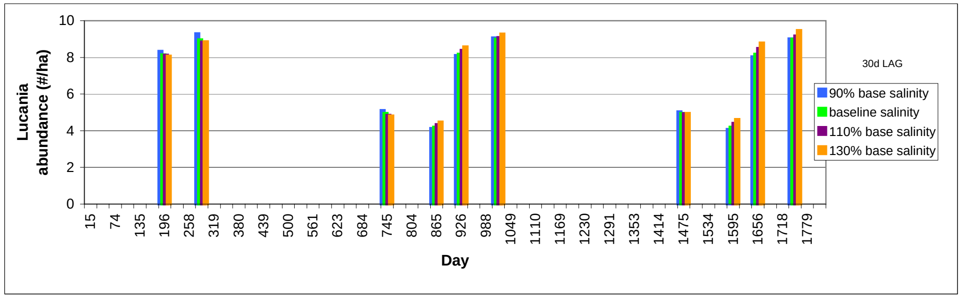
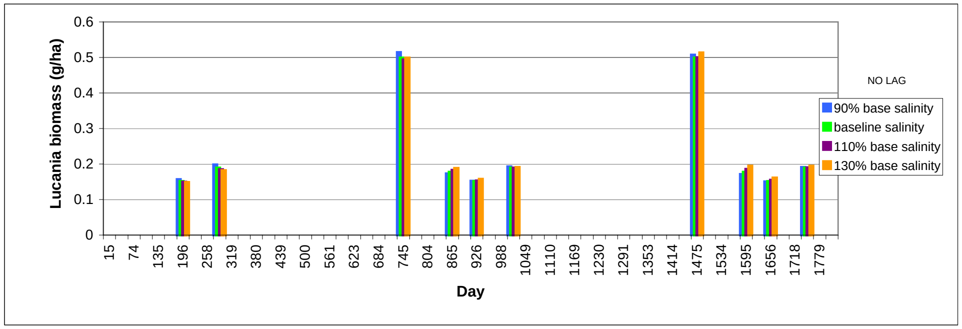


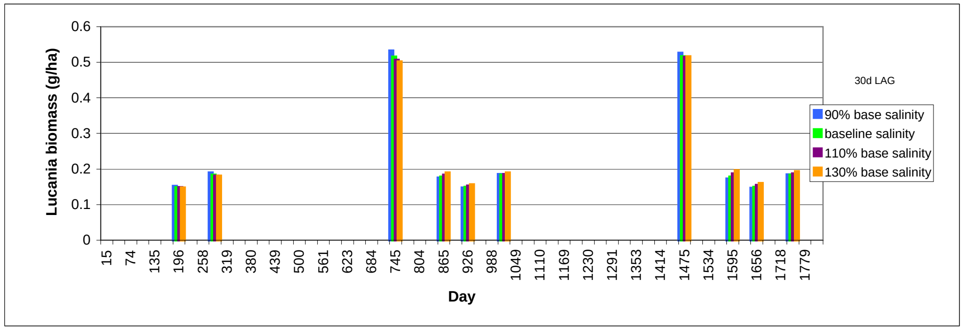
Figure 134. Rankin Lake Scenario – *Lucania parva* abundance and biomass- trawl/seine

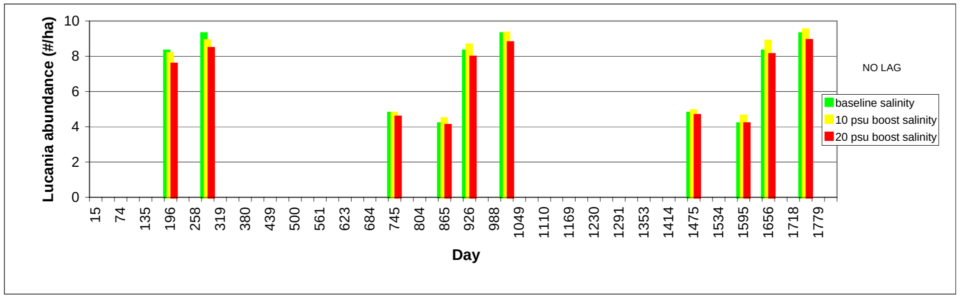
RANKIN LAKE- TRAWL/SEINE

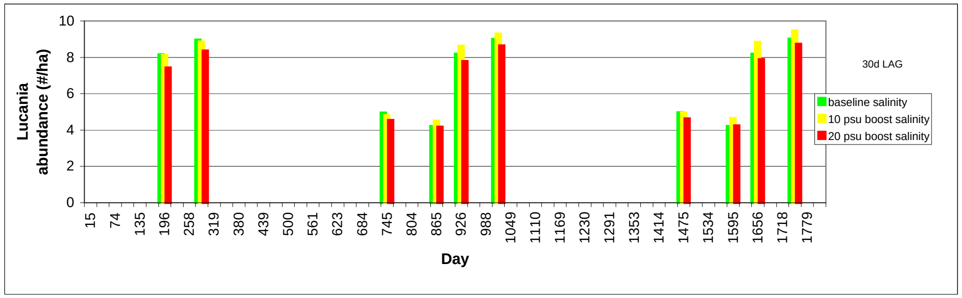


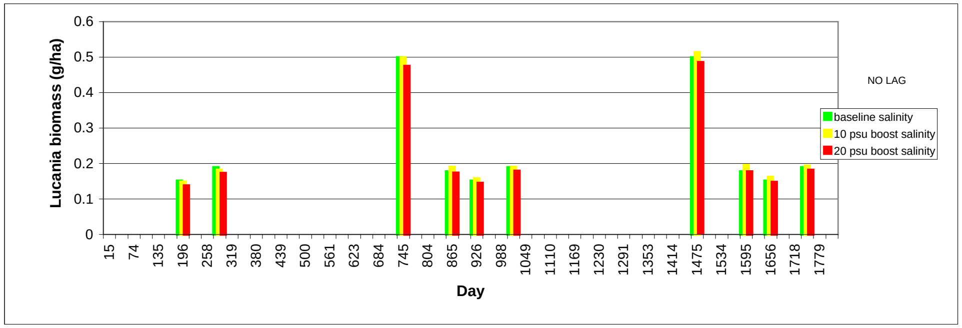












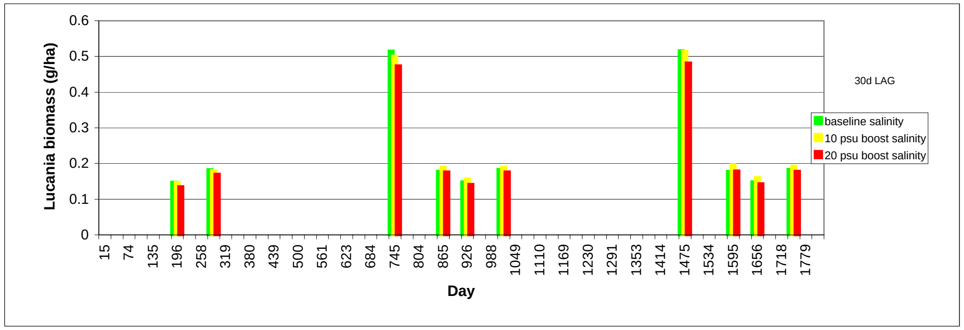
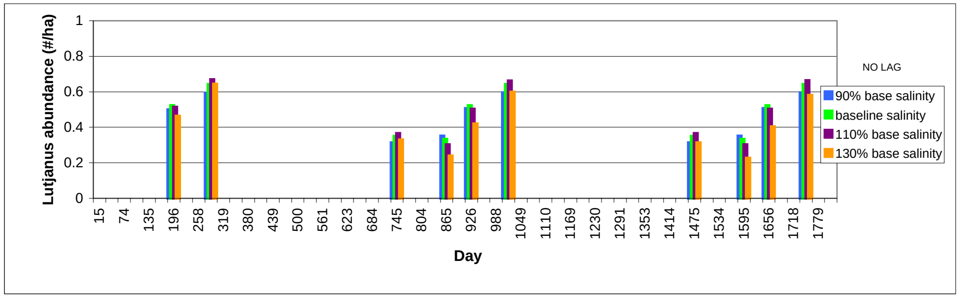
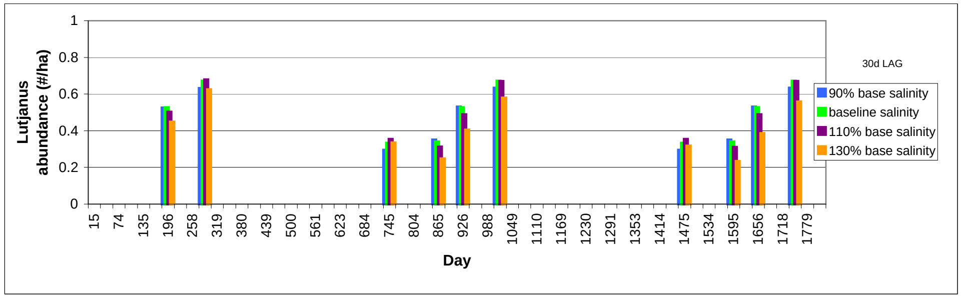
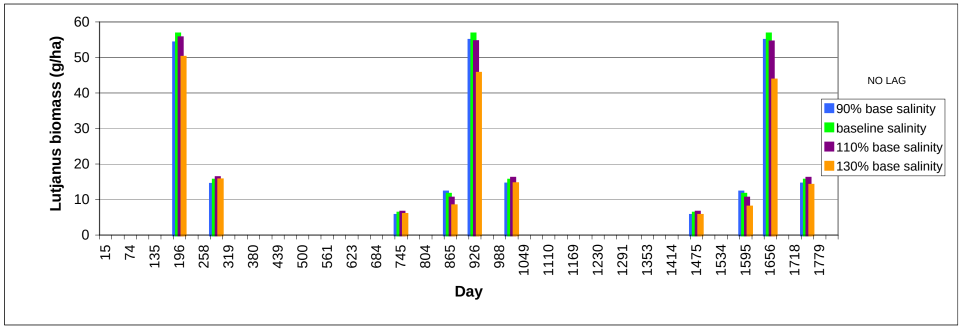


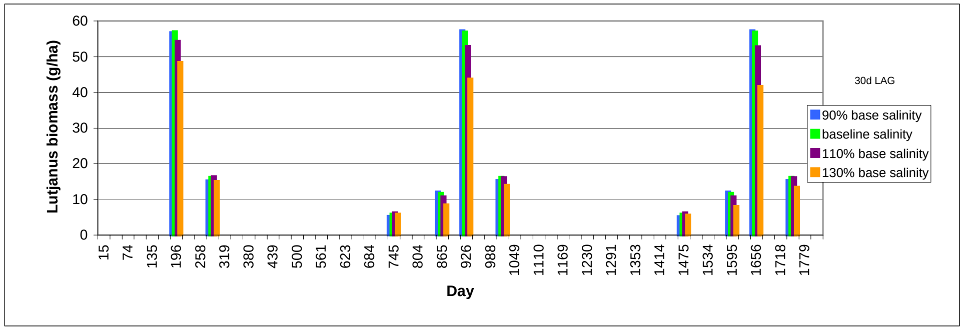
Figure 135. Rankin Lake Scenario – *Lutjanus griseus* abundance and biomass-trawl/seine

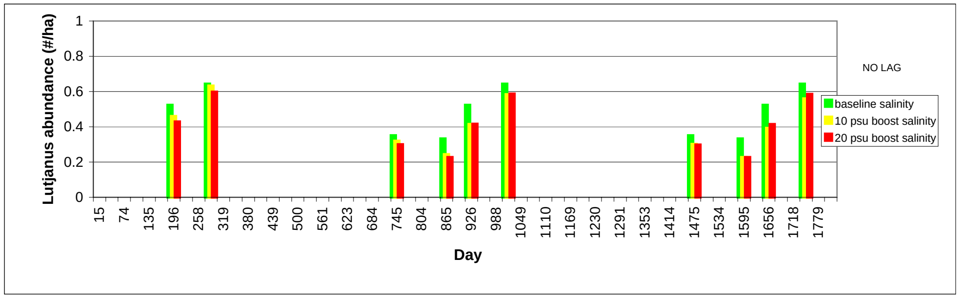
RANKIN LAKE- TRAWL/SEINE

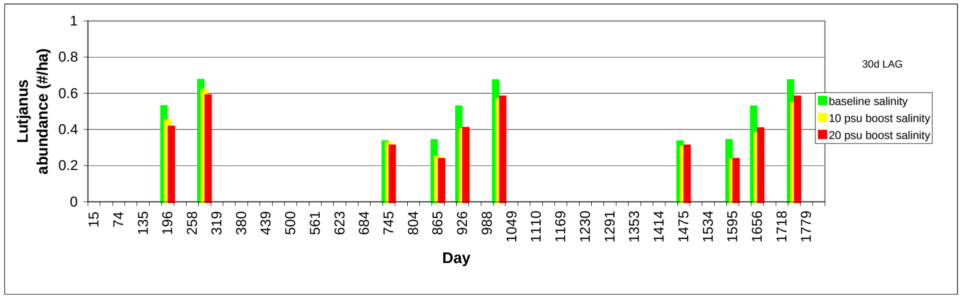


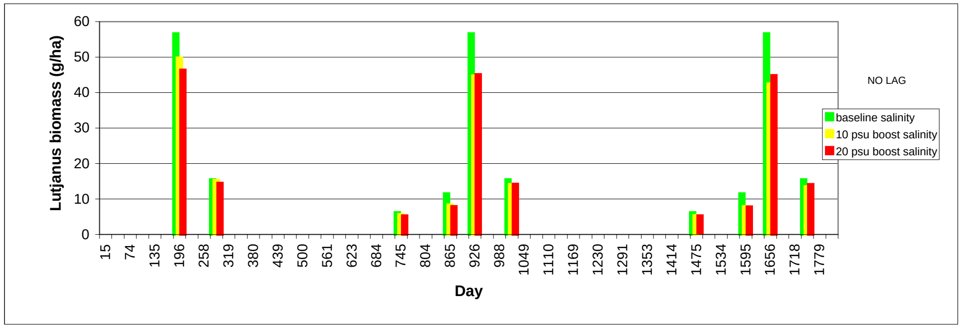












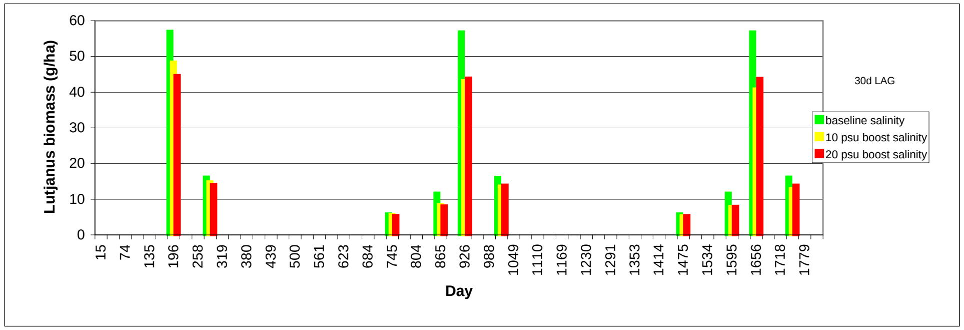
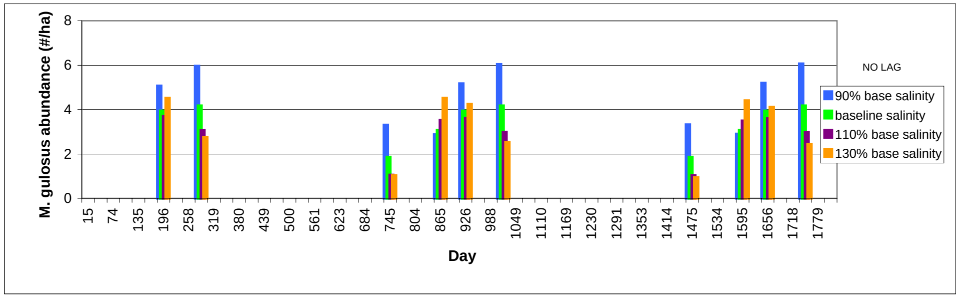
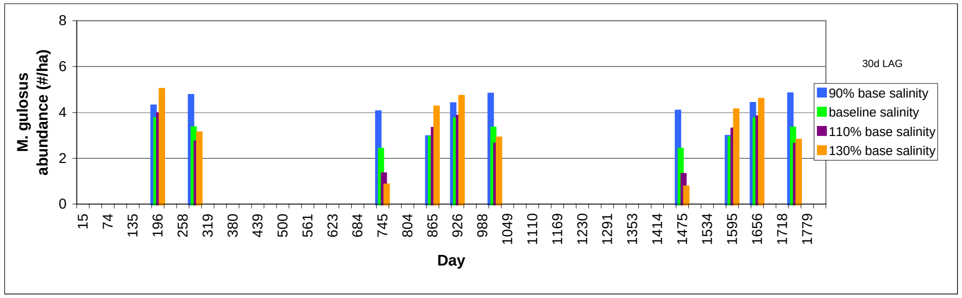
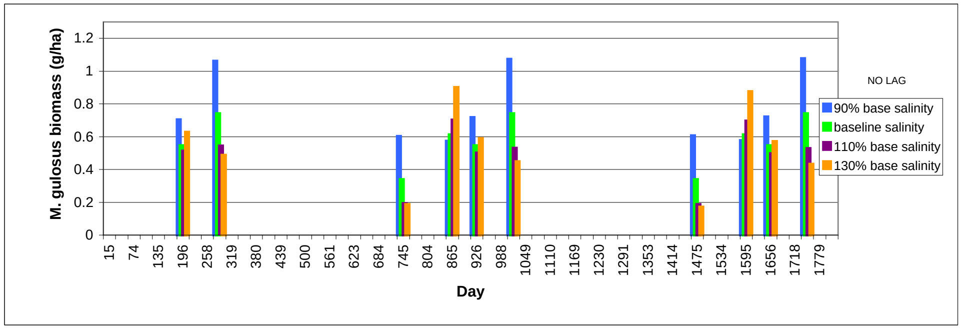


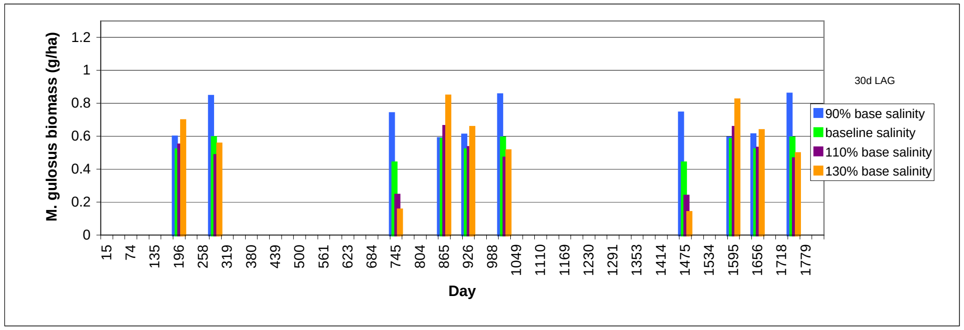
Figure 136. Rankin Lake Scenario – *Microgobius gulosus* abundance and biomass-trawl/seine

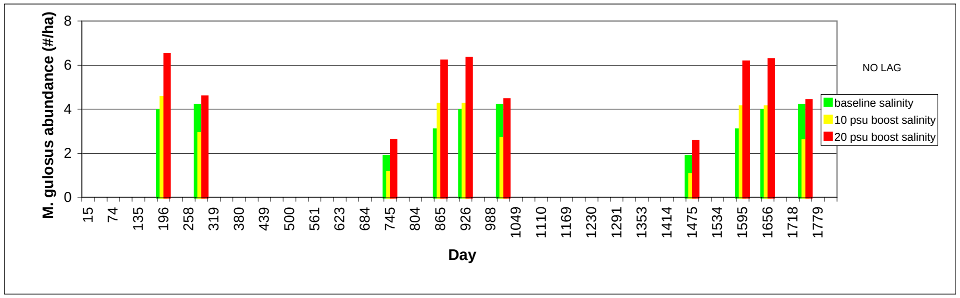
RANKIN LAKE- TRAWL/SEINE

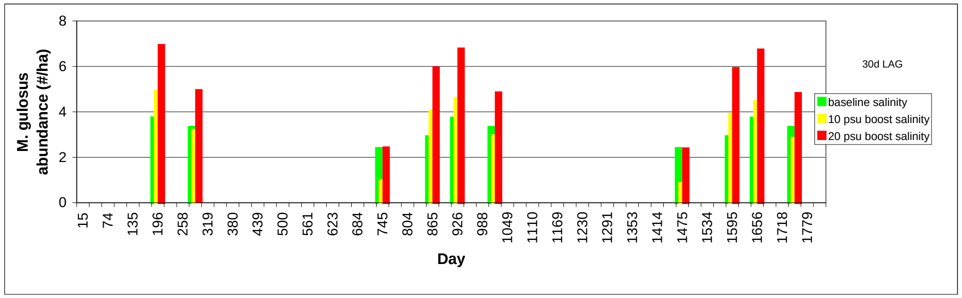


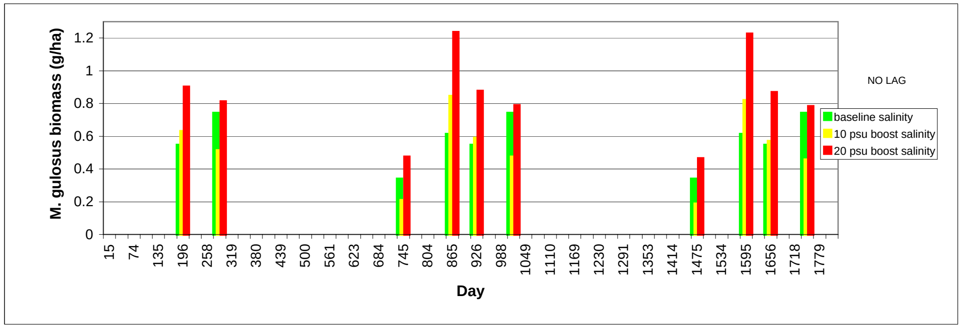












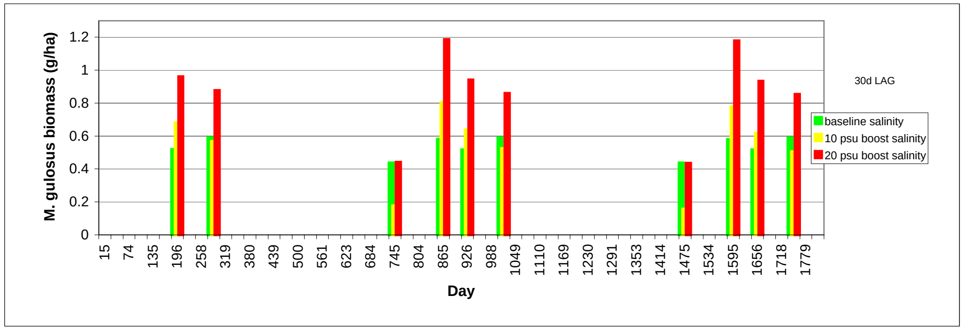
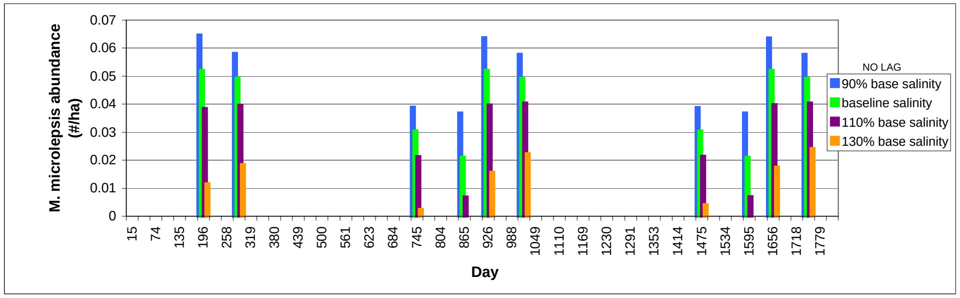
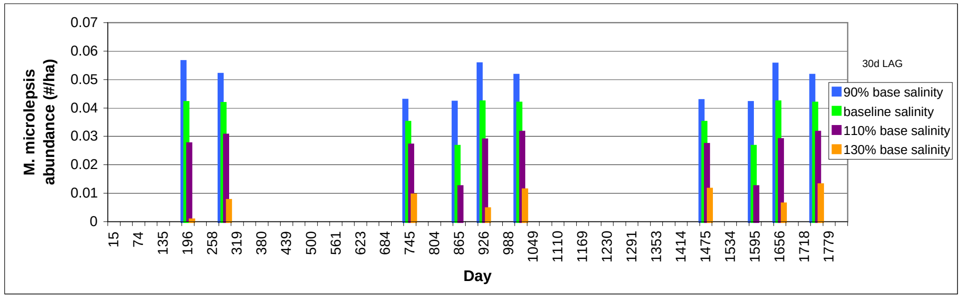
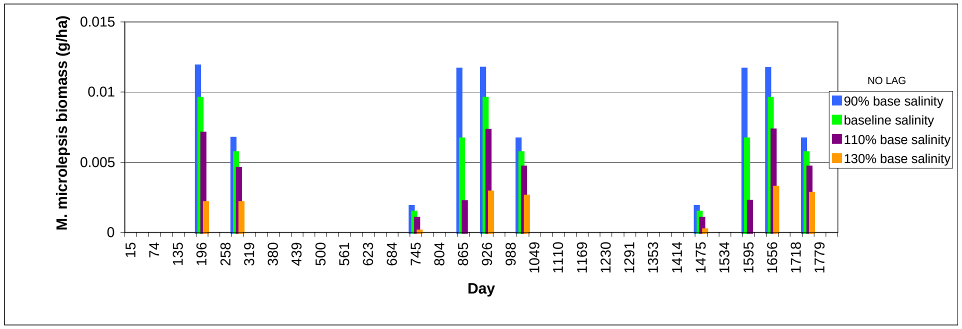


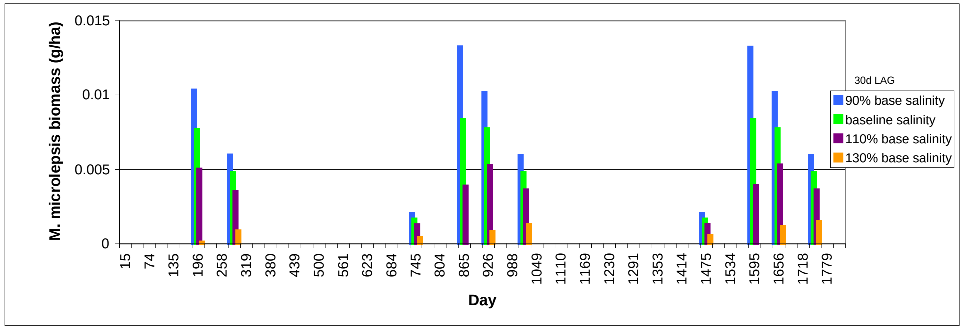
Figure 137. Rankin Lake Scenario – *Microgobius microlepis* abundance and biomass-trawl/seine

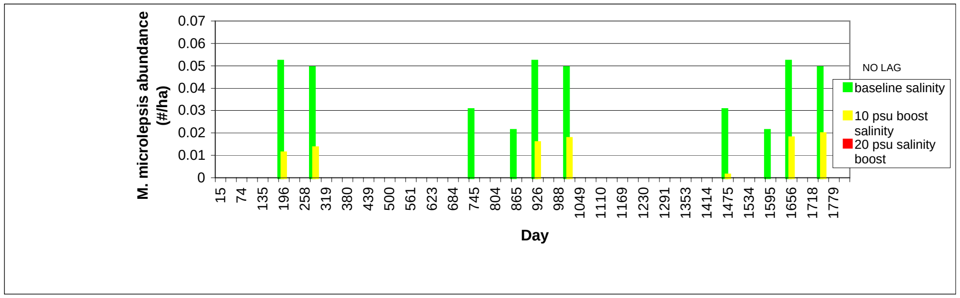
RANKIN LAKE- TRAWL/SEINE

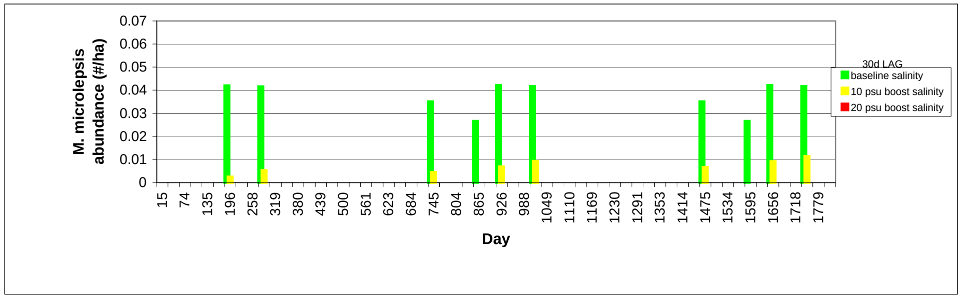


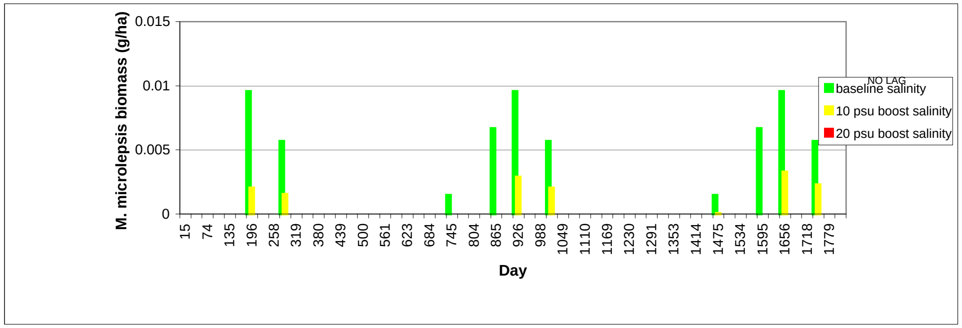












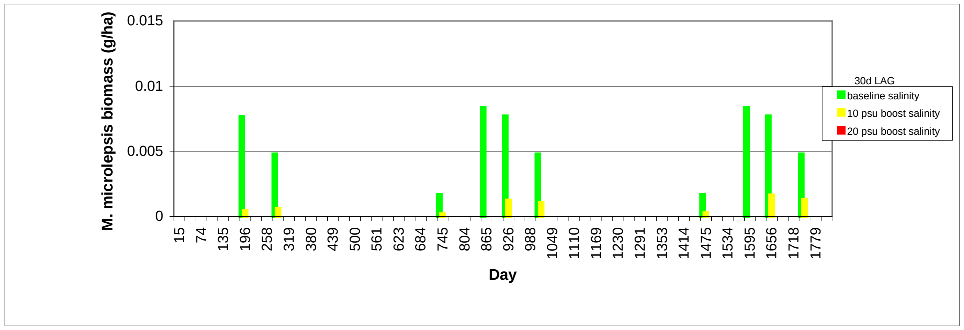
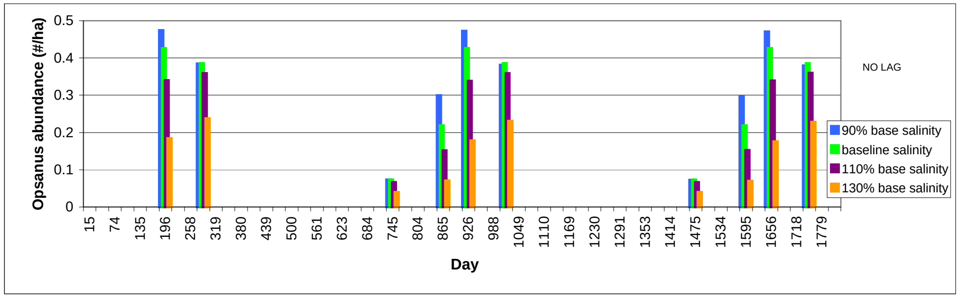
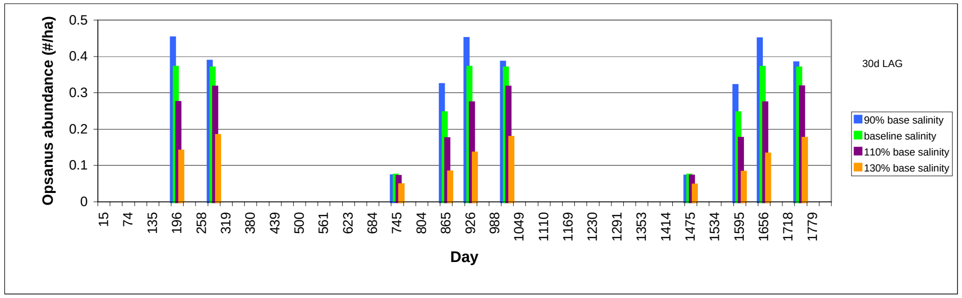
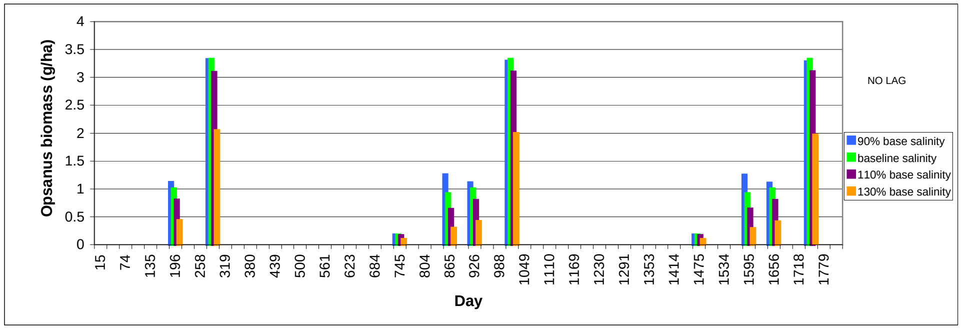


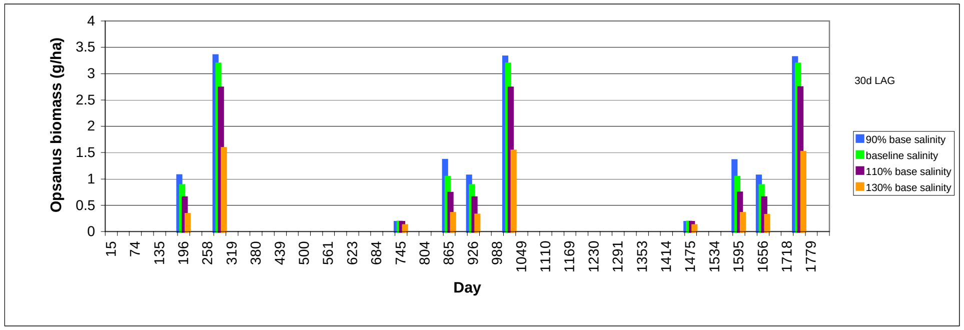
Figure 138. Rankin Lake Scenario – *Opsanus beta* abundance and biomass- trawl/seine

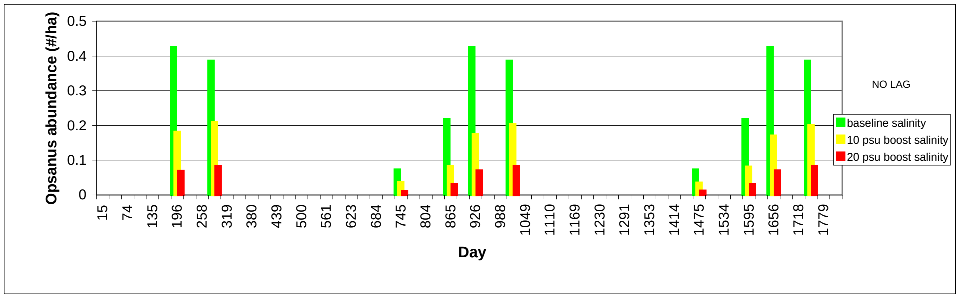
RANKIN LAKE- TRAWL/SEINE

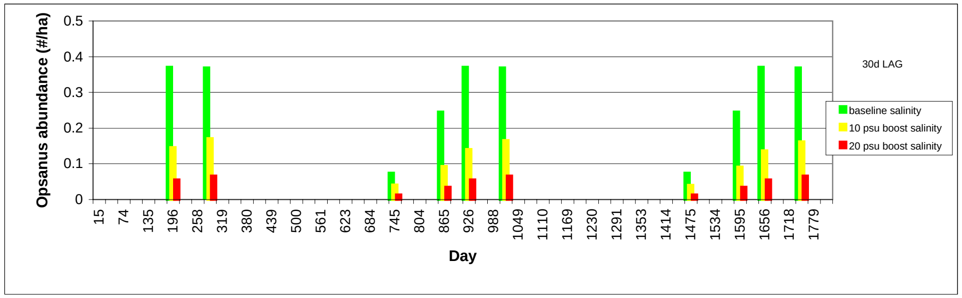


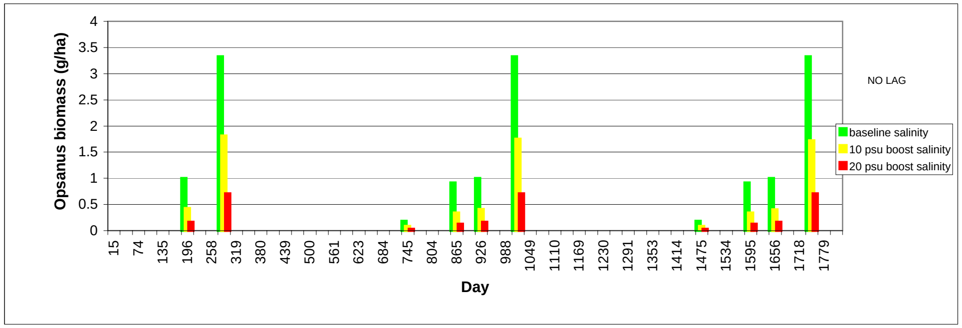












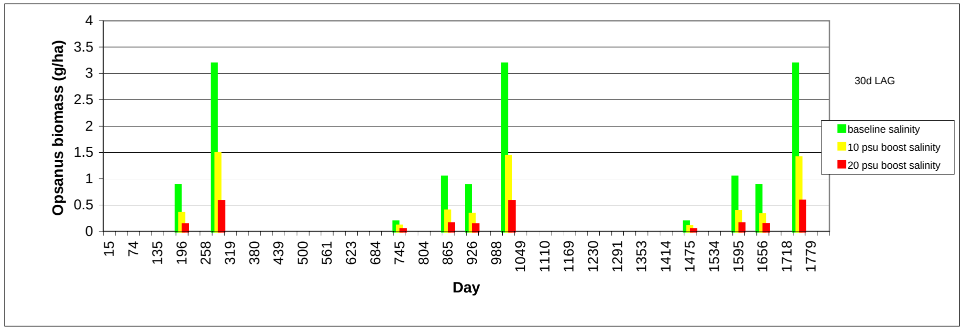
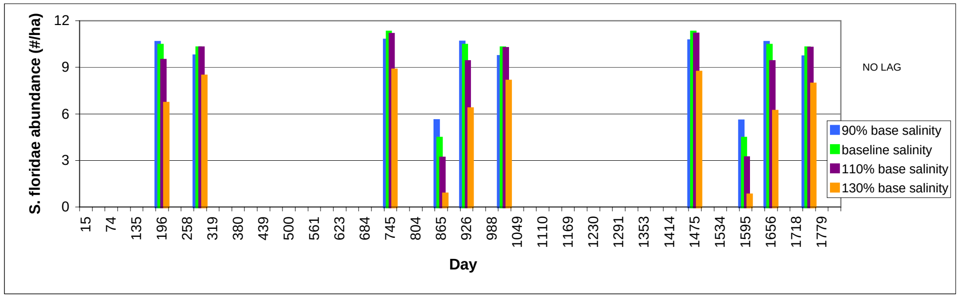
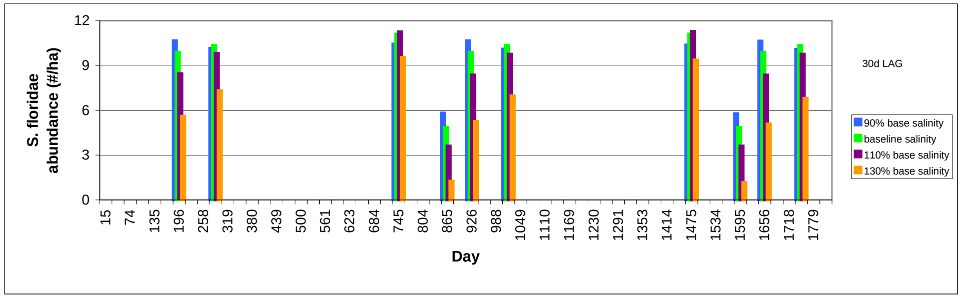
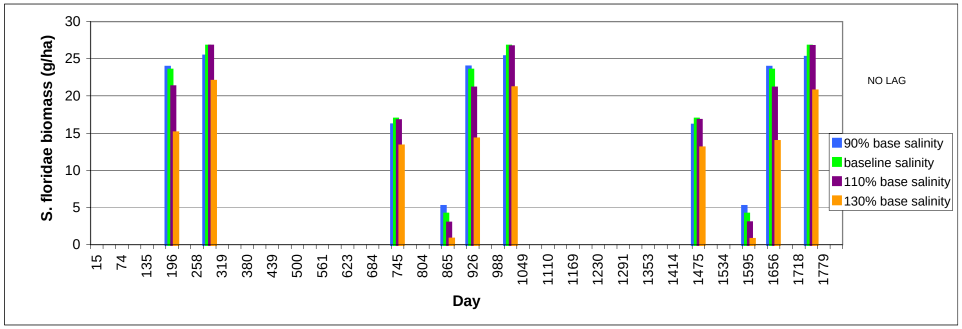


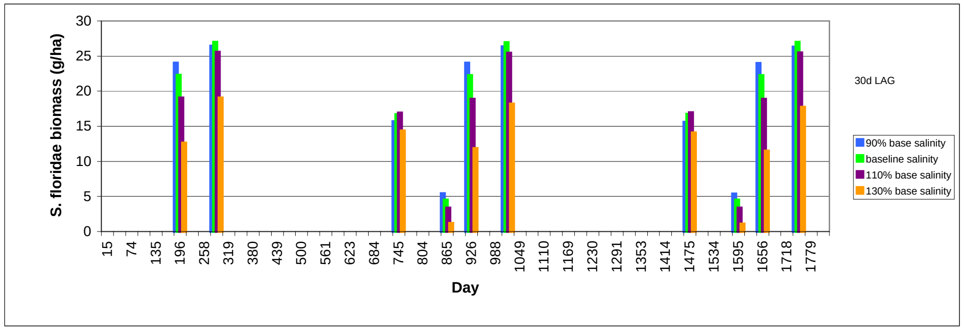
Figure 139. Rankin Lake Scenario – *Syngnathus floridae* abundance and biomass-trawl/seine

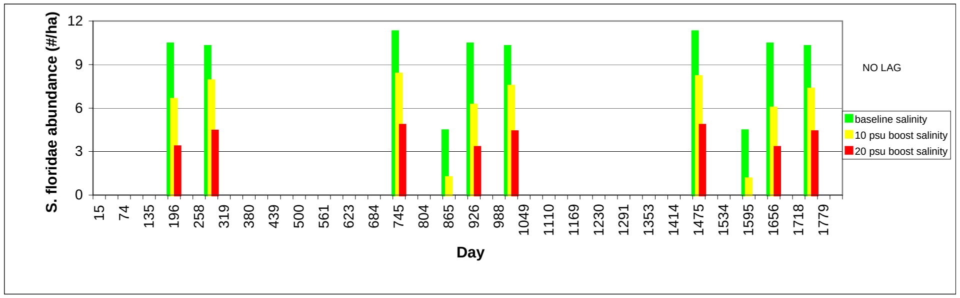
RANKIN LAKE- TRAWL/SEINE

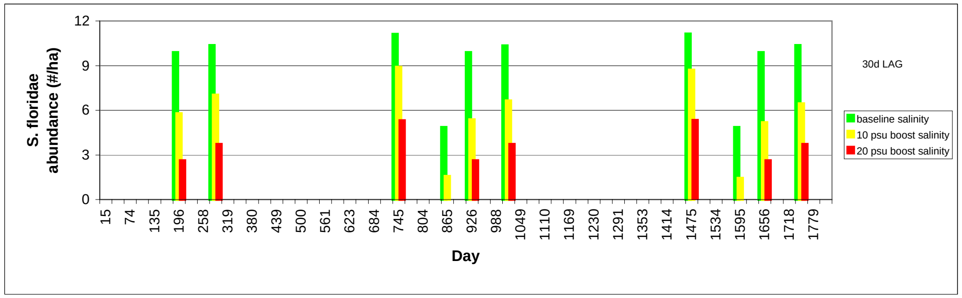


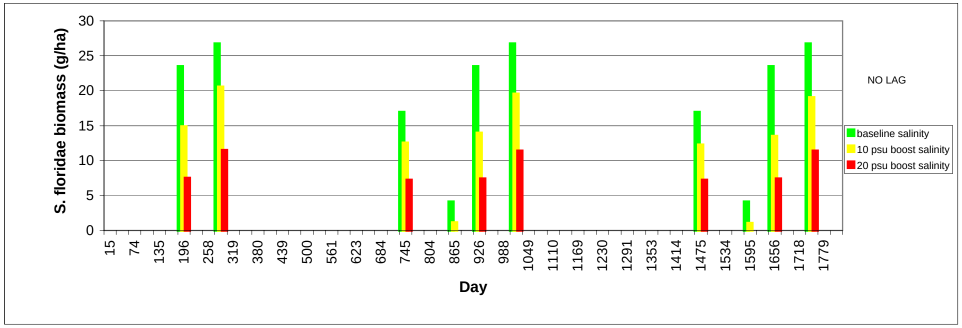












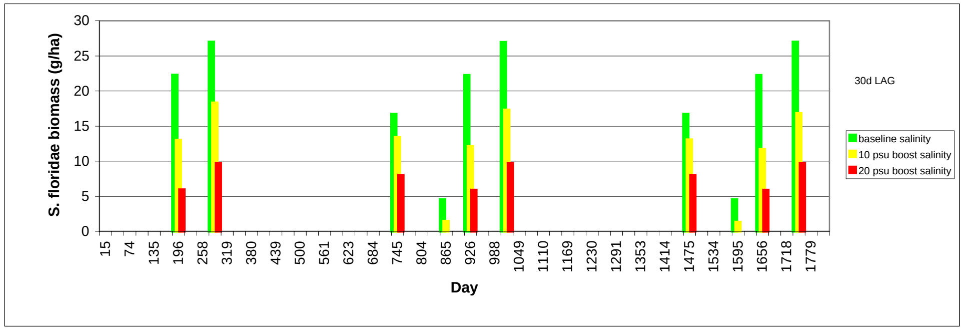
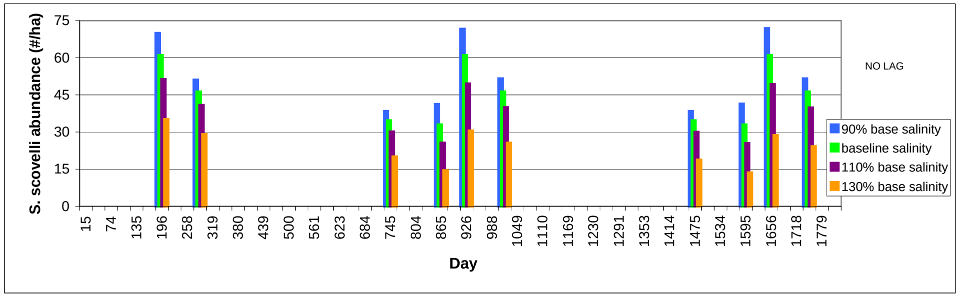
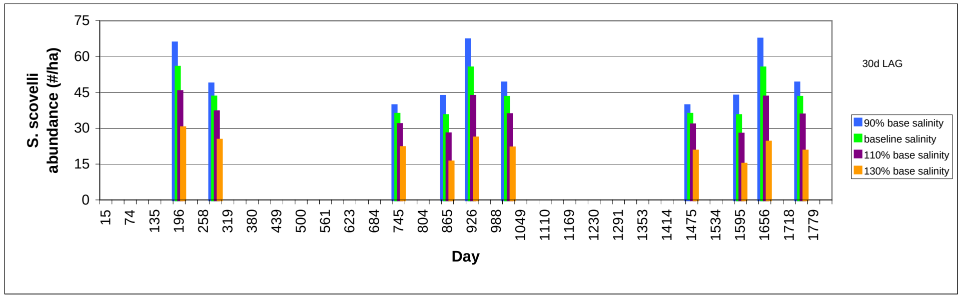
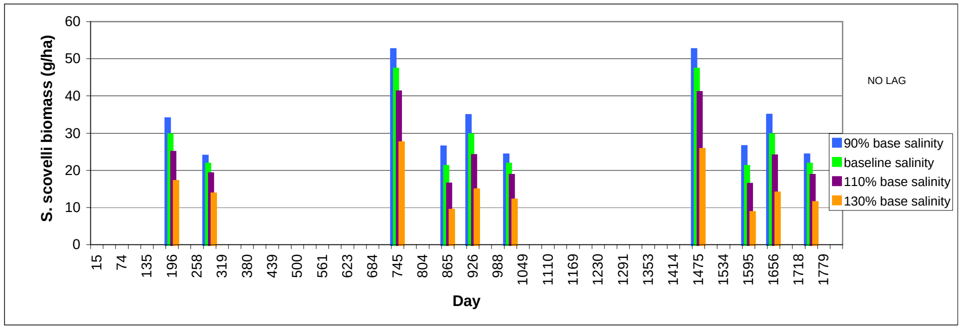


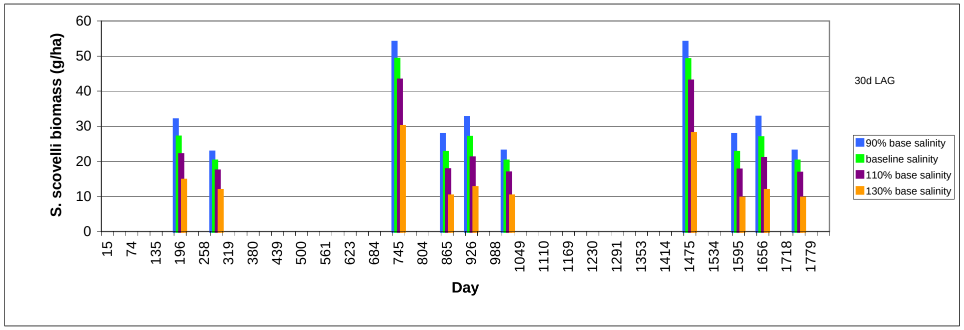
Figure 140. Rankin Lake Scenario – *Syngnathus scovelli* abundance and biomass-trawl/seine

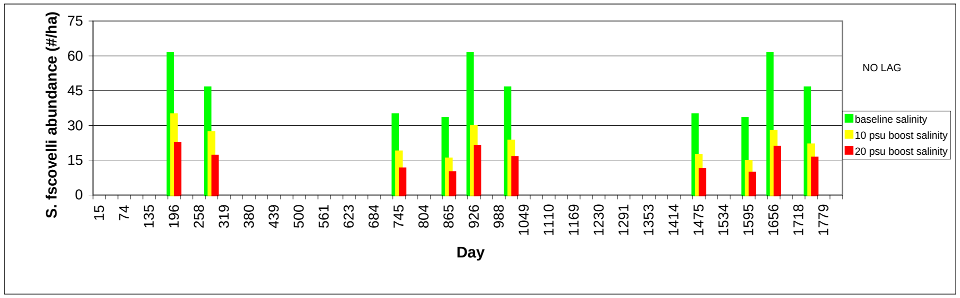
RANKIN LAKE- TRAWL/SEINE

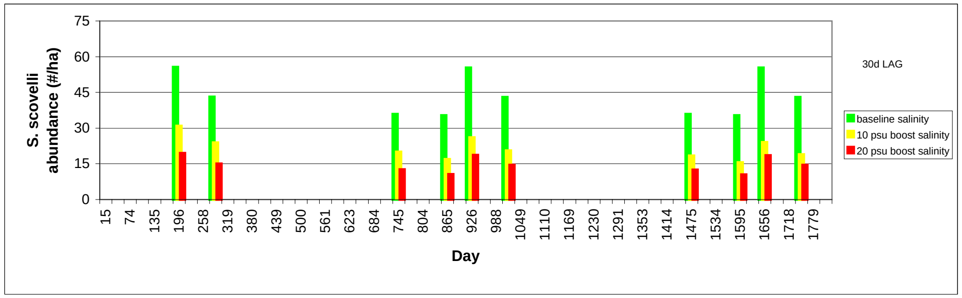


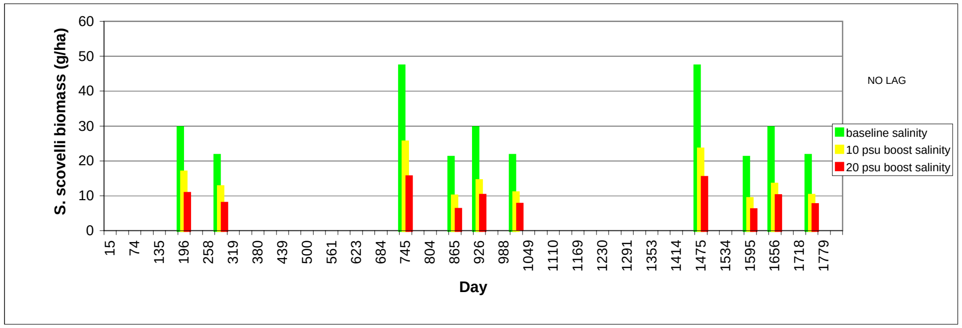












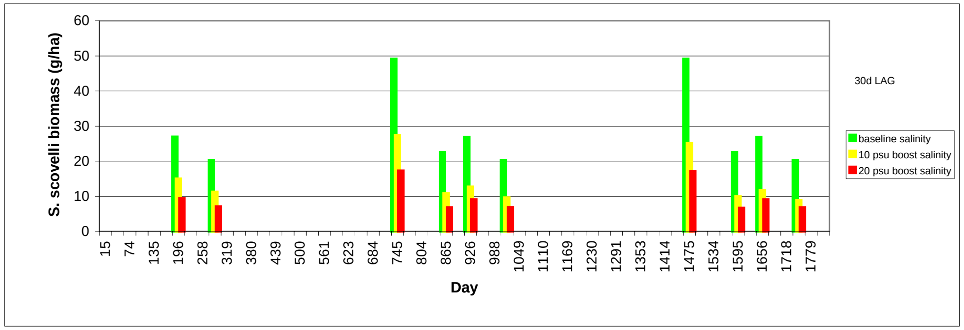
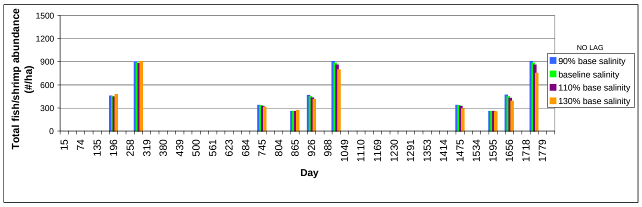
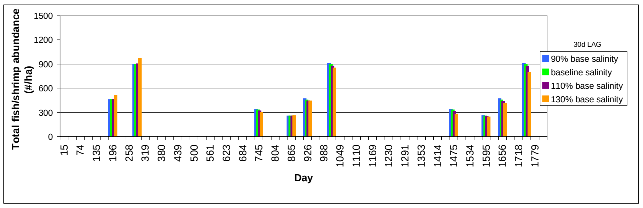
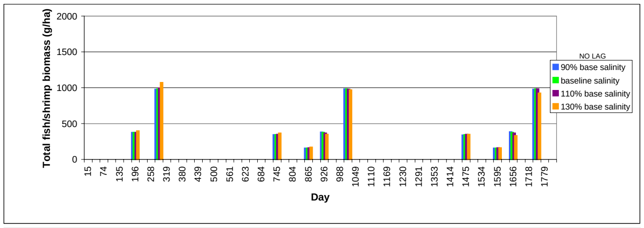


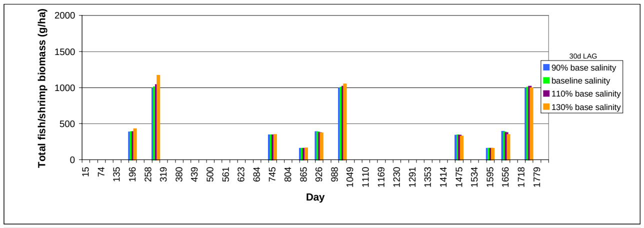
Figure 141. Rankin Lake Scenario – Total fish/shrimp abundance, Total fish/shrimp biomass, Forage fish/shrimp biomass, Predator fish biomass- trawl/seine

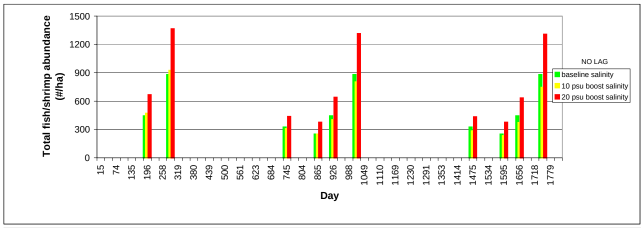
RANKIN LAKE- TRAWL/SEINE

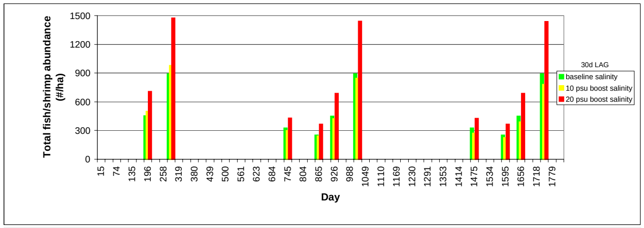


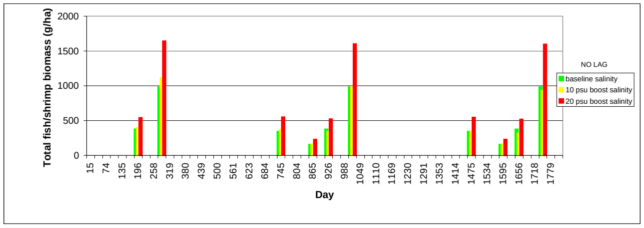


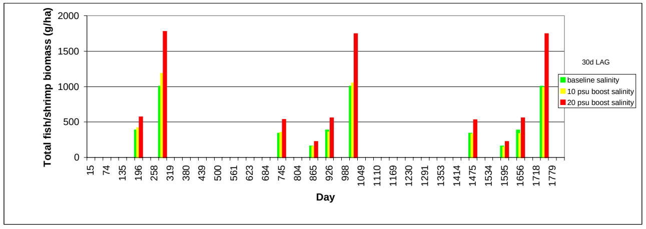


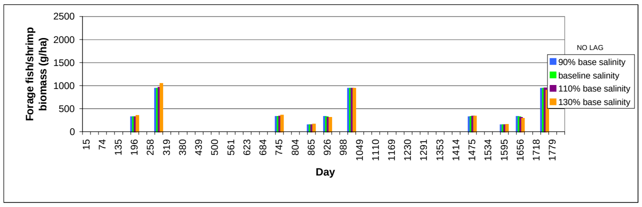


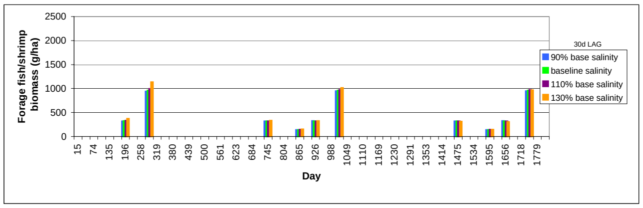


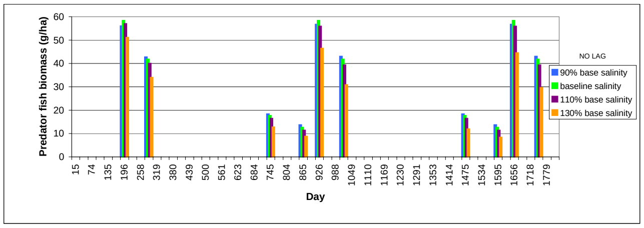


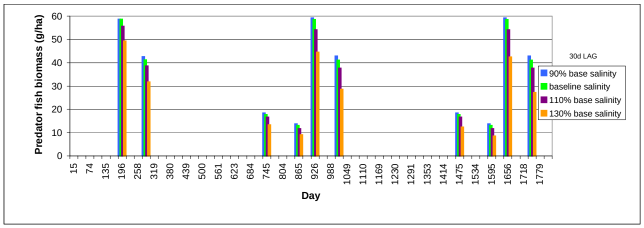


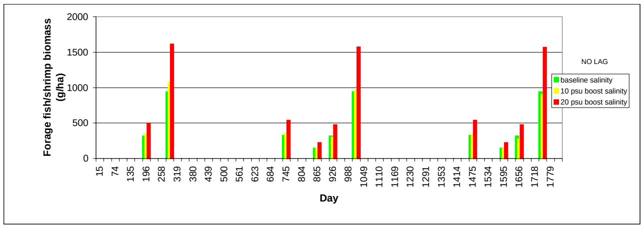


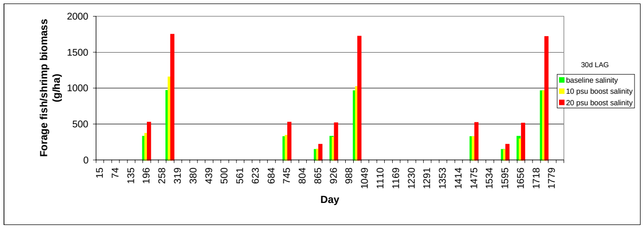


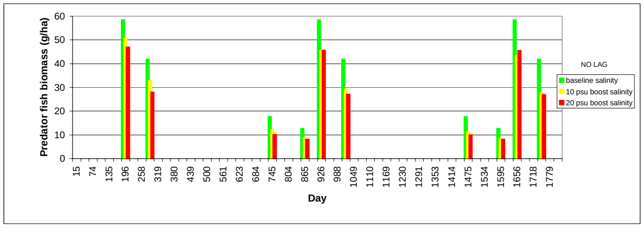












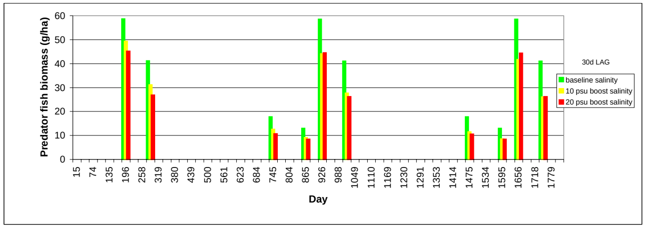
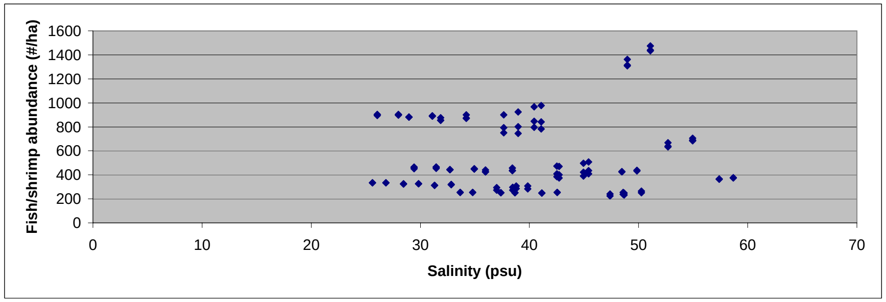
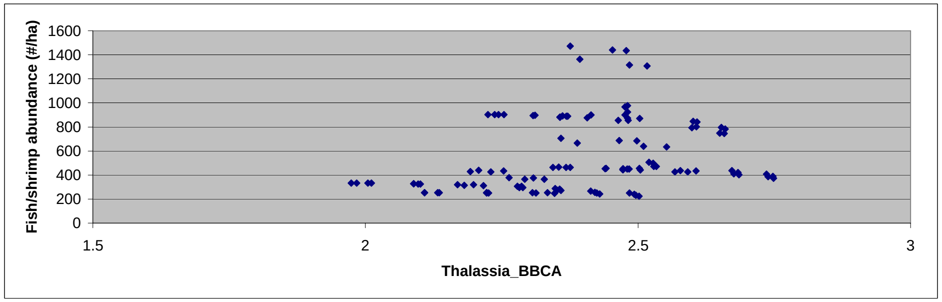
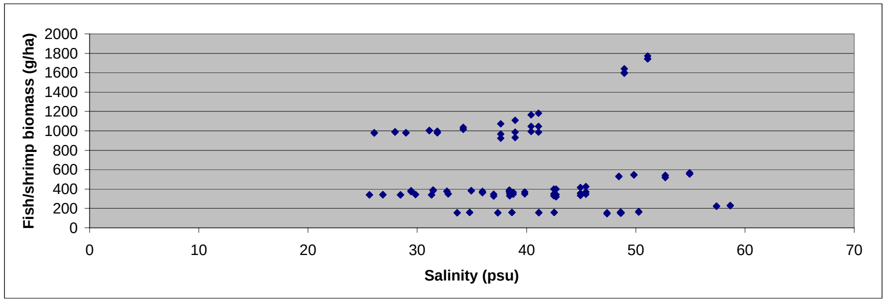


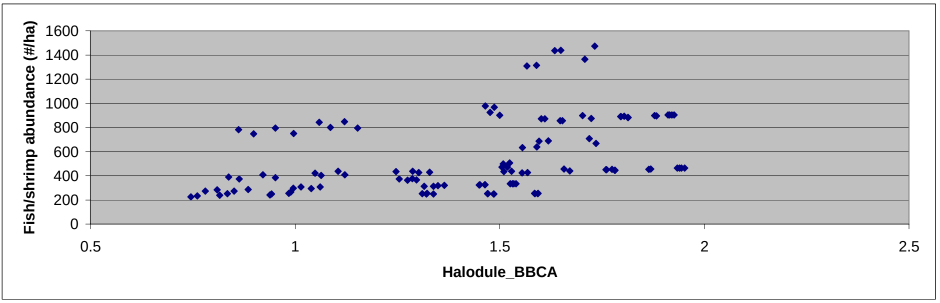
Figure 142. Rankin Lake Scenario - Fish/shrimp abundance vs. Salinity, Fish/shrimp biomass vs. salinity, Predator fish biomass vs. Salinity, Fish/shrimp abundance vs. Thalassia BBCA, Fish/shrimp abundance vs. Halodule BBCA- trawl seine.

RANKIN LAKE- TRAWL/SEINE









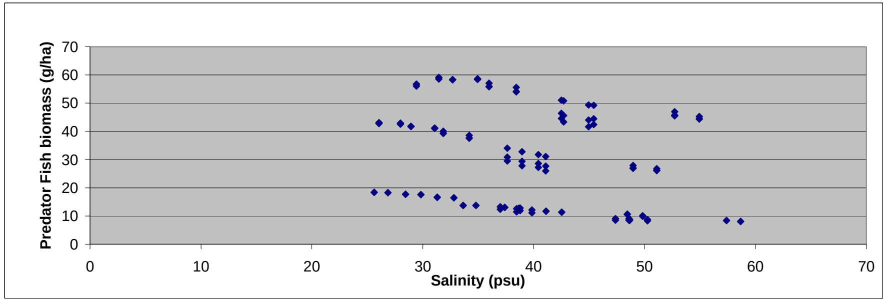
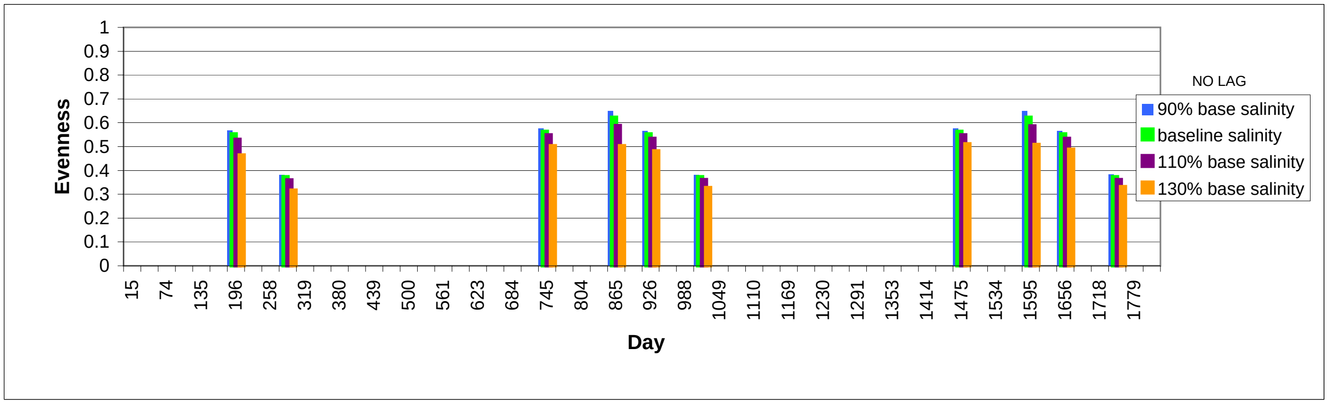
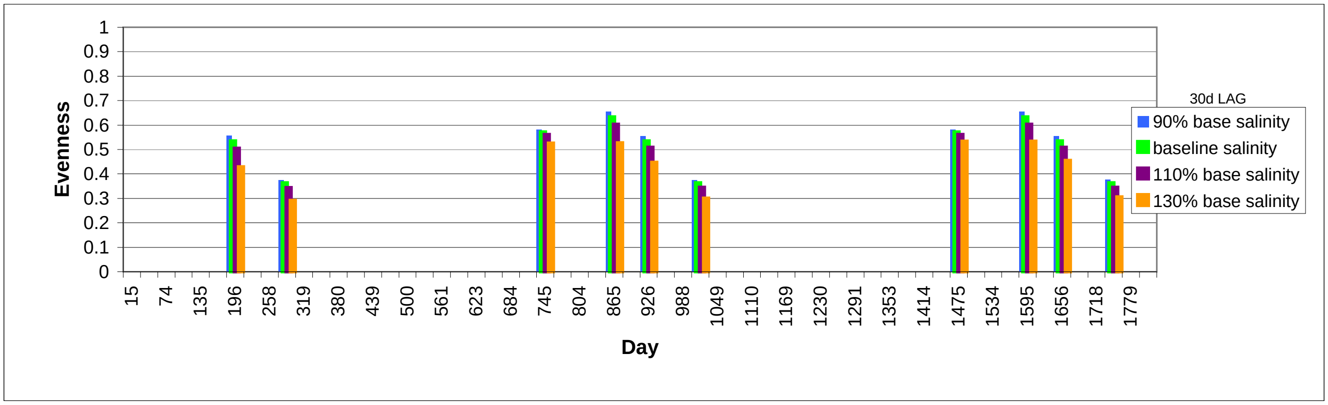
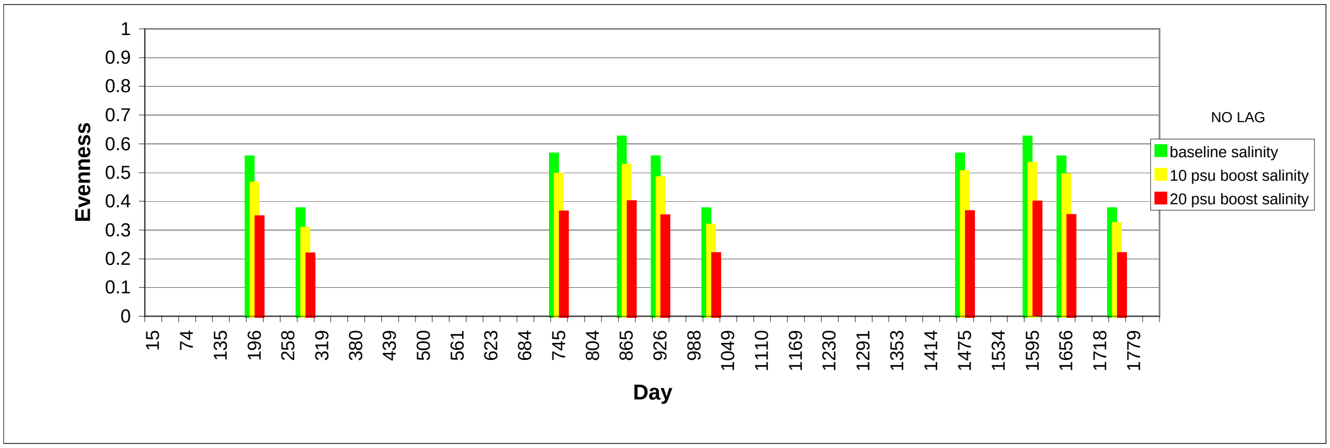


Figure 143. Rankin Lake Scenario – Evenness trawl/seine

RANKIN LAKE- TRAWL/SEINE







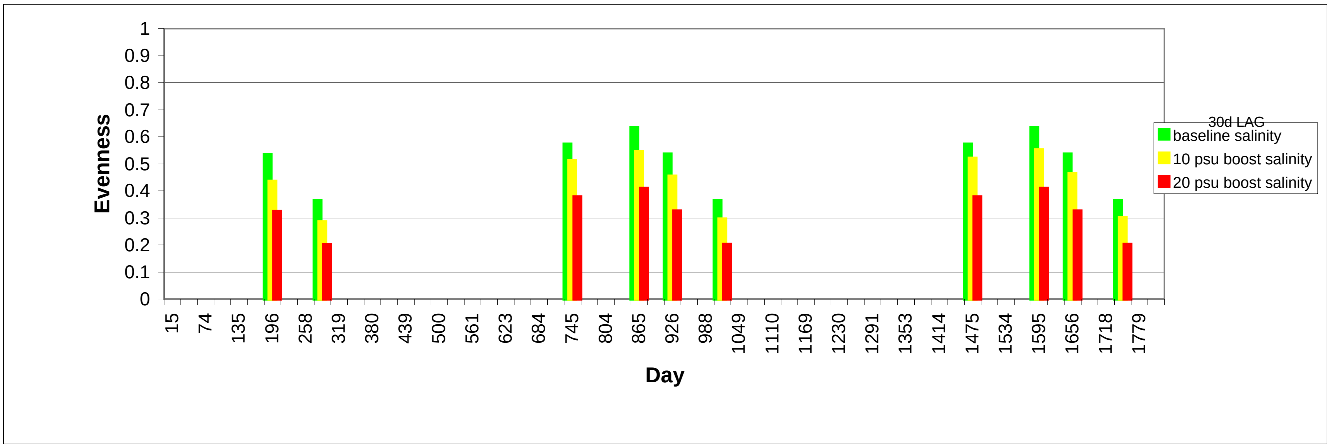
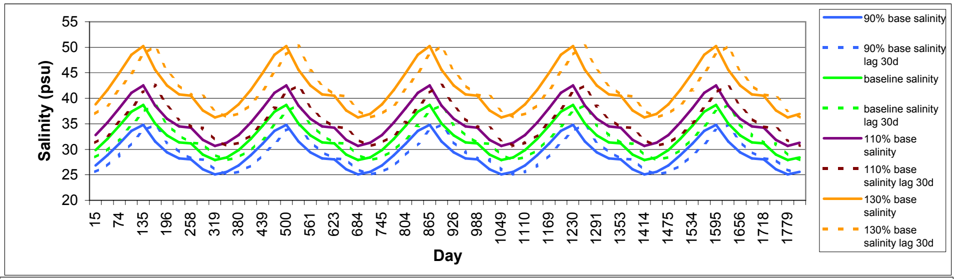
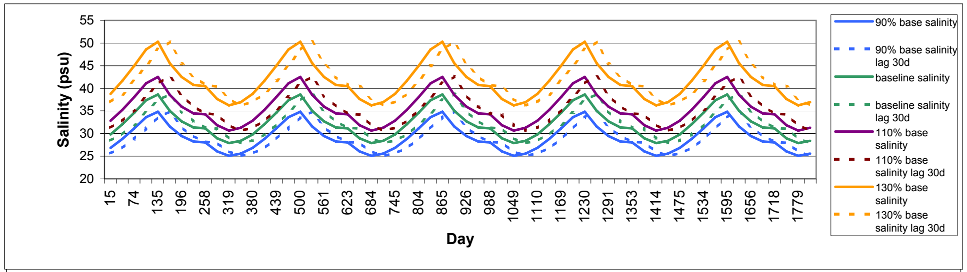
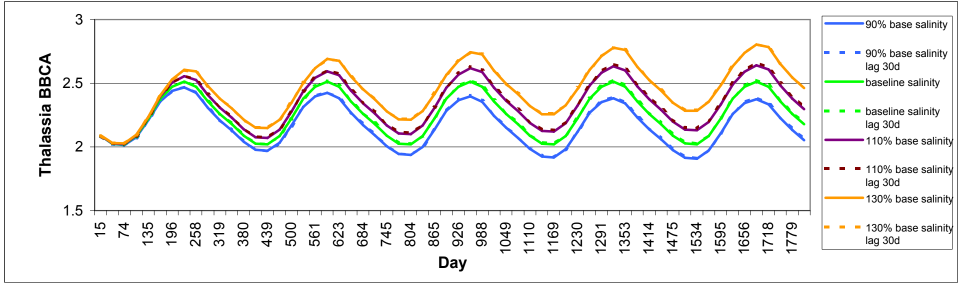


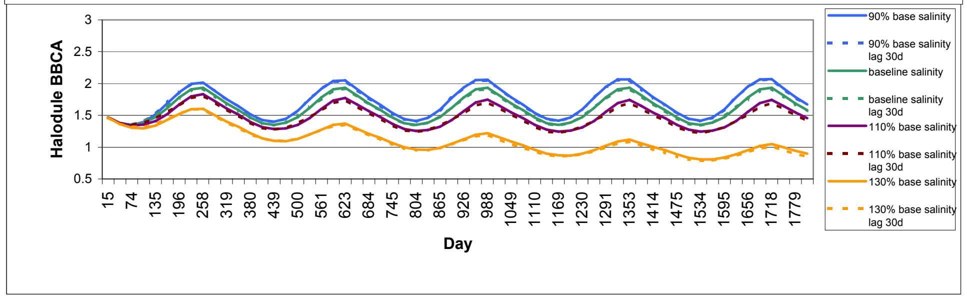
Figure 144. Rankin Lake Scenario – Salinity and SAV- trawl/seine

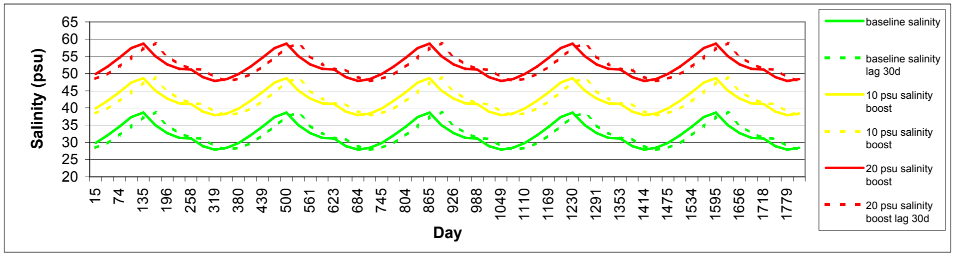
RANKIN LAKE

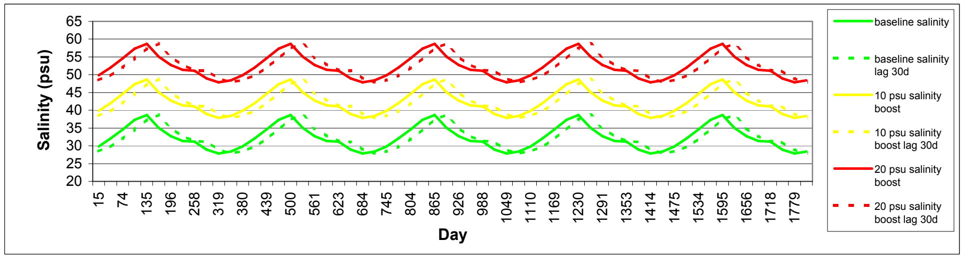

Salinity (psu)
55
50
45
40
35
30
25
20
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
90% base salinity
90% base salinity lag 30d
baseline salinity
baseline salinity lag 30d
110% base salinity
110% base salinity lag 30d
130% base salinity
130% base salinity lag 30d

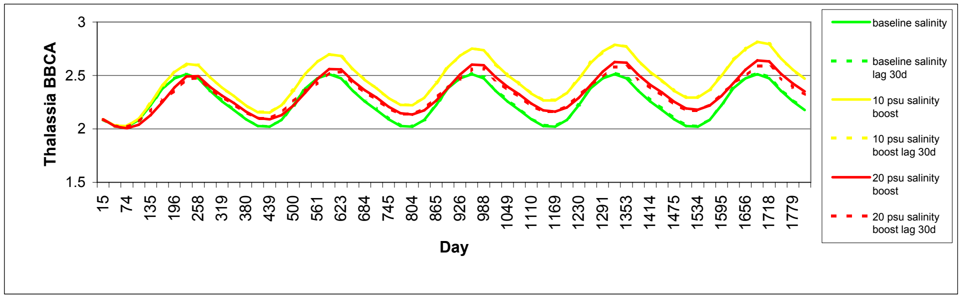

Salinity (psu)
55
50
45
40
35
30
25
20
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
90% base salinity
90% base salinity lag 30d
baseline salinity
baseline salinity lag 30d
110% base salinity
110% base salinity lag 30d
130% base salinity
130% base salinity lag 30d


Thalassia BBCA
3
2.5
2
1.5
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
90% base salinity
90% base salinity lag 30d
baseline salinity
baseline salinity lag 30d
110% base salinity
110% base salinity lag 30d
130% base salinity
130% base salinity lag 30d


Halodule BBCA
3
2.5
2
1.5
1
0.5
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
90% base salinity
90% base salinity lag 30d
baseline salinity
baseline salinity lag 30d
110% base salinity
110% base salinity lag 30d
130% base salinity
130% base salinity lag 30d


Salinity (psu)
65
60
55
50
45
40
35
30
25
20
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
baseline salinity
baseline salinity lag 30d
10 psu salinity boost
10 psu salinity boost
20 psu salinity boost
20 psu salinity boost lag 30d


Salinity (psu)
65
60
55
50
45
40
35
30
25
20
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
baseline salinity
baseline salinity lag 30d
10 psu salinity boost
10 psu salinity boost lag 30d
20 psu salinity boost
20 psu salinity boost lag 30d


Thalassia BBCA
3
2.5
2
1.5
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
baseline salinity
baseline salinity lag 30d
10 psu salinity boost
10 psu salinity boost lag 30d
20 psu salinity boost
20 psu salinity boost lag 30d

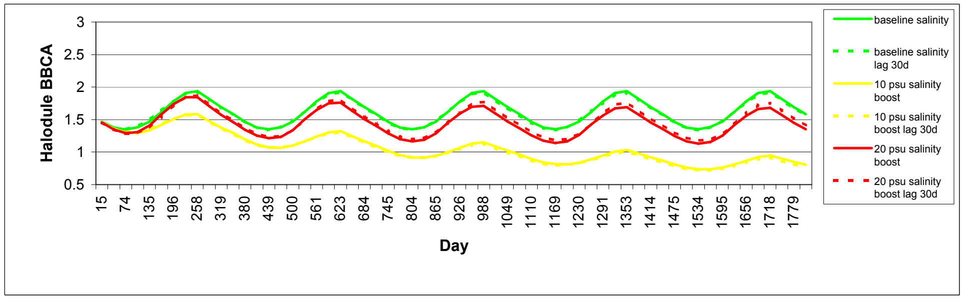
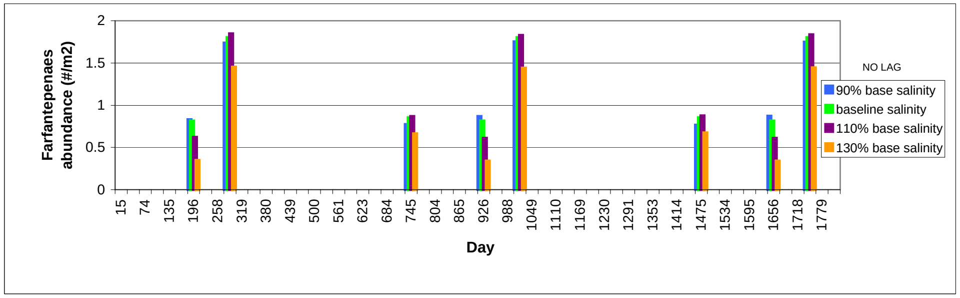
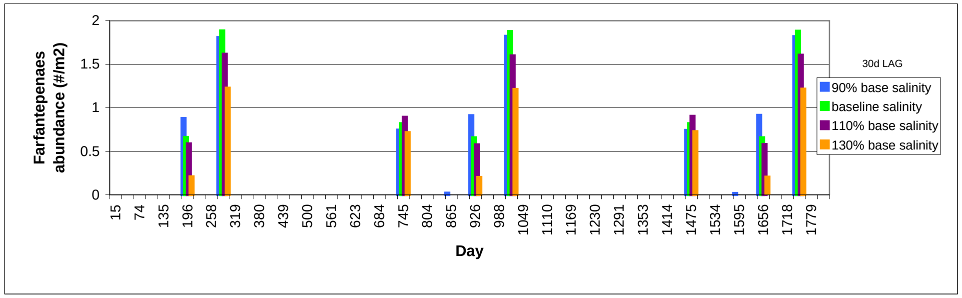
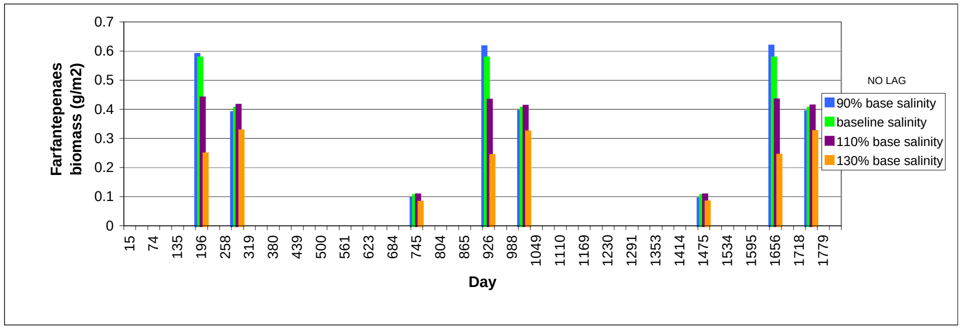

Halodule BBCA
3
2.5
2
1.5
1
0.5
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
baseline salinity
baseline salinity lag 30d
10 psu salinity boost
10 psu salinity boost lag 30d
20 psu salinity boost
20 psu salinity boost lag 30d

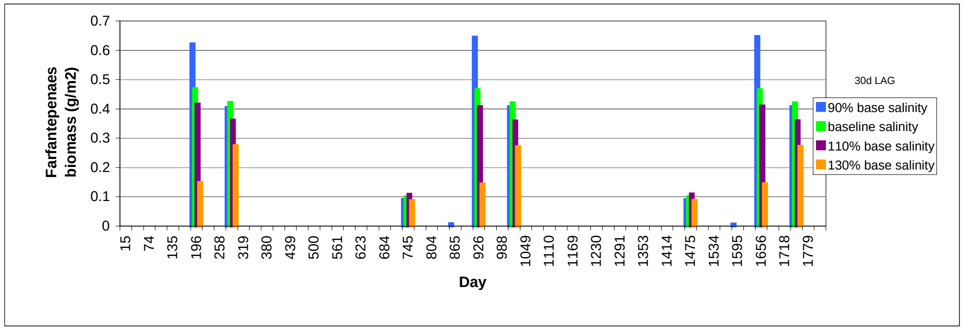
Figure 145. Rankin Lake Scenario – *Farfantepenaeus duorarum* abundance and biomass-throw-trap

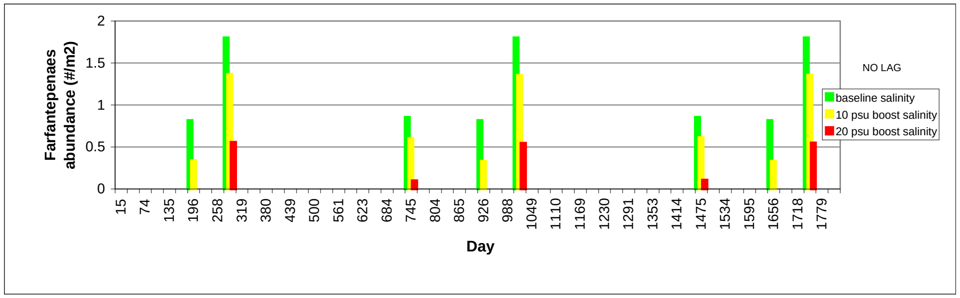
RANKIN LAKE- THROW TRAP

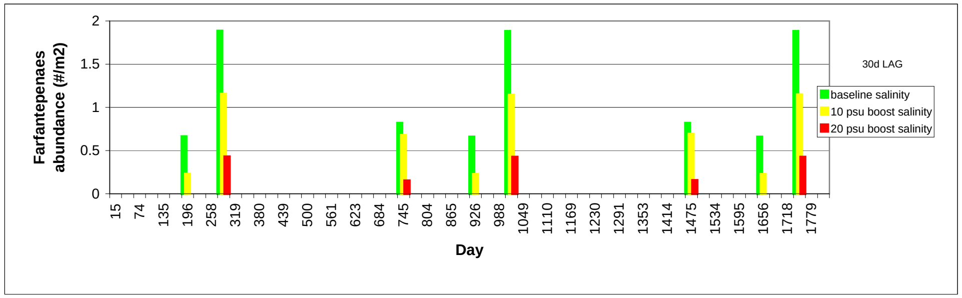


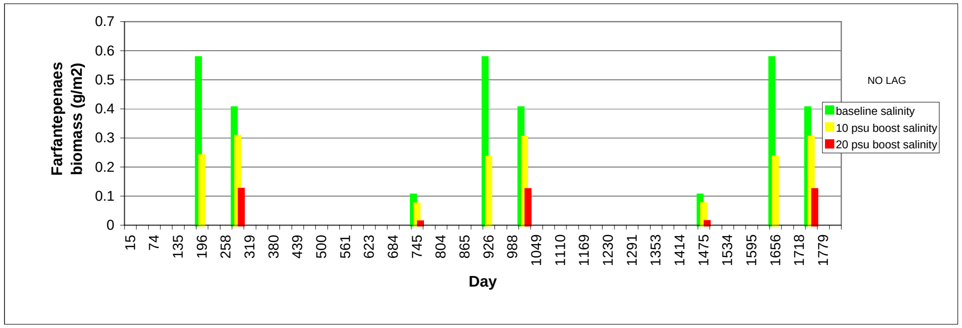












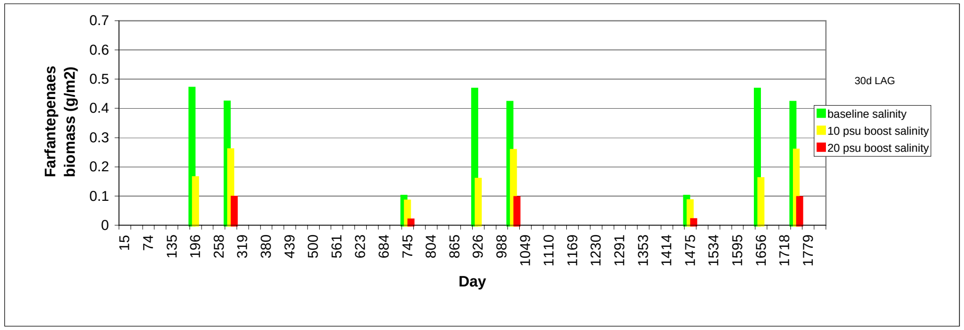
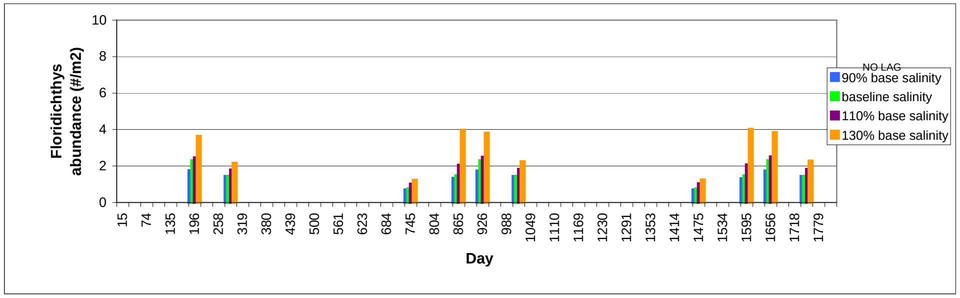
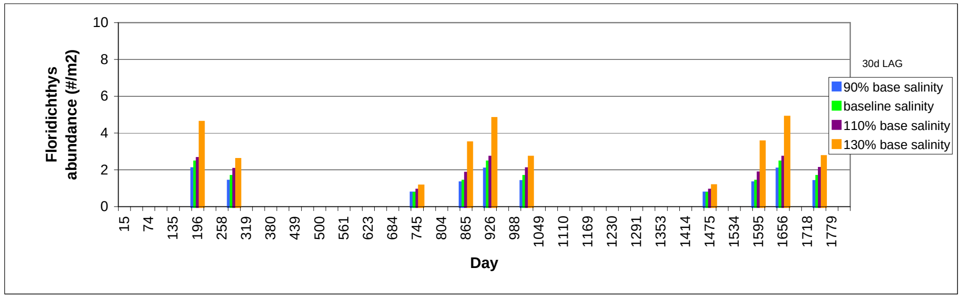
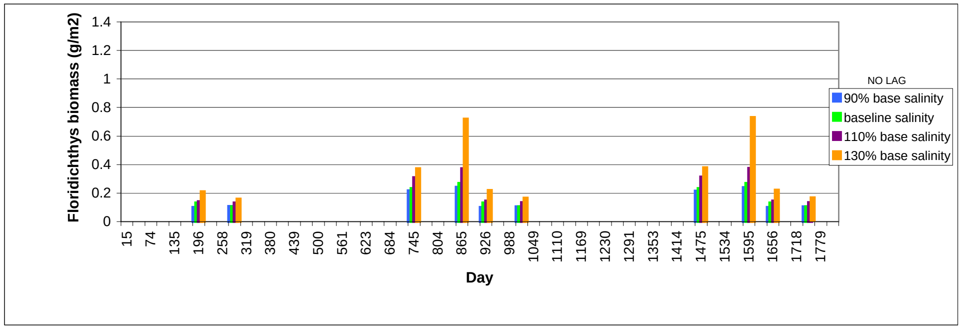


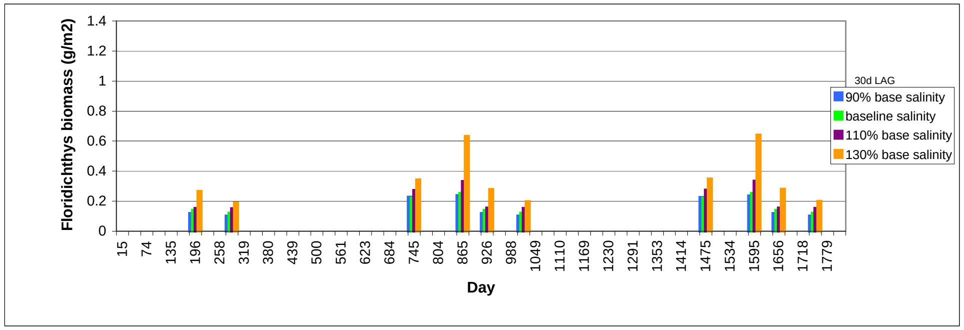
Figure 146. Rankin Lake Scenario – *Floridichthys carpio* abundance and biomass- throw-trap

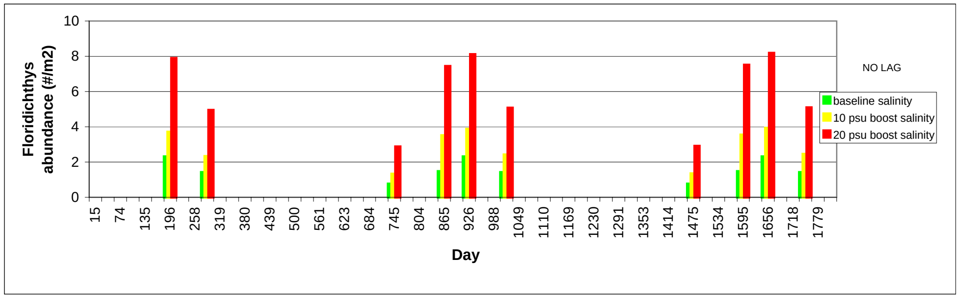
RANKIN LAKE- THROW TRAP

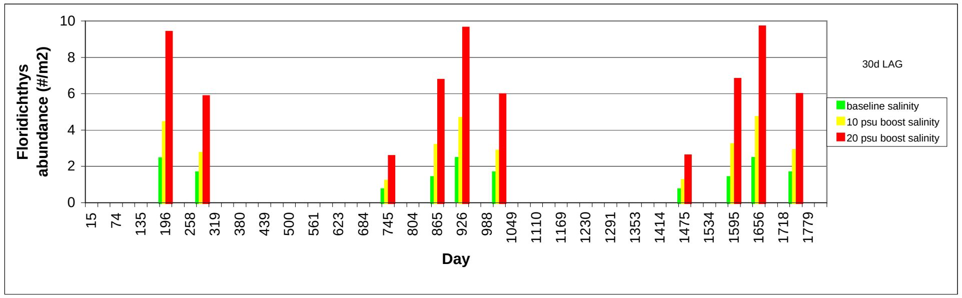


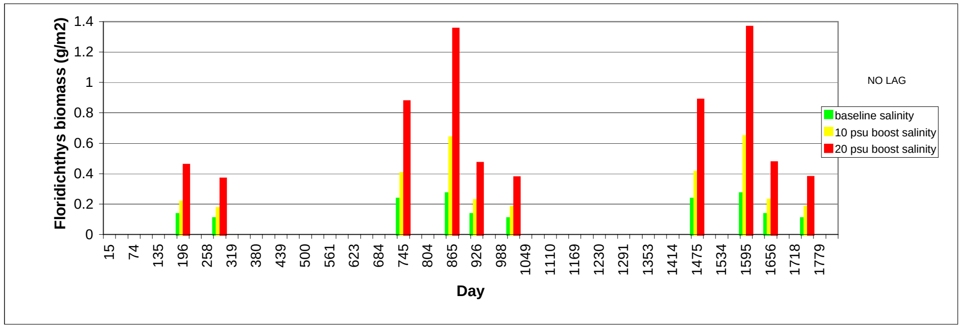












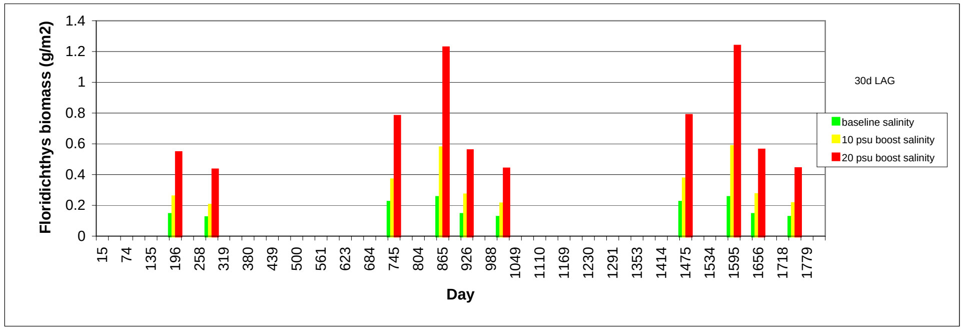
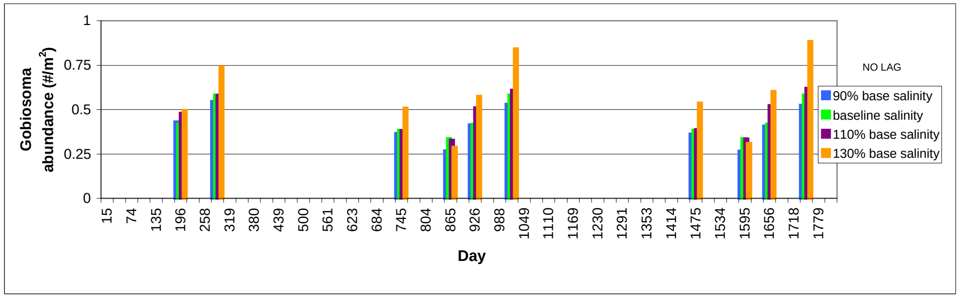
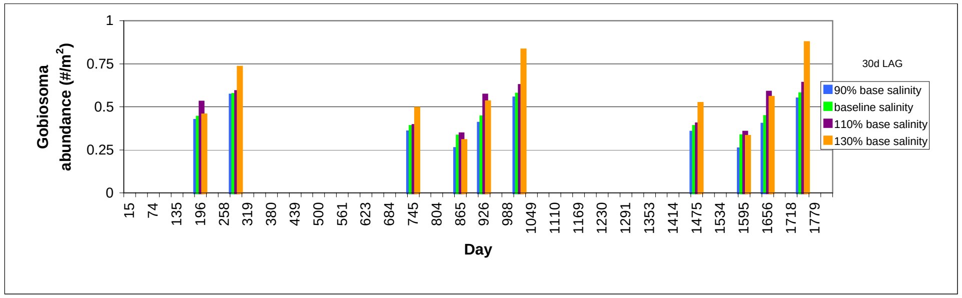
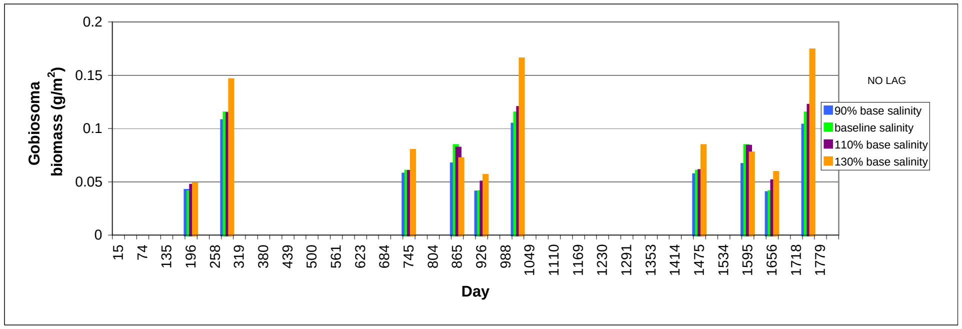


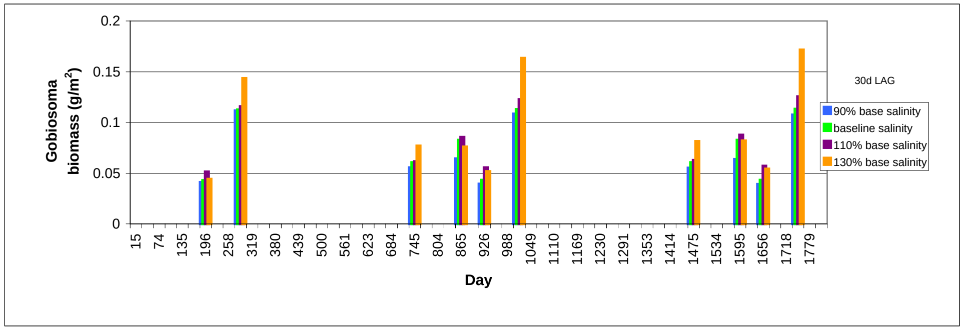
Figure 147. Rankin Lake Scenario – *Gobiosoma robustum* abundance and biomass-throw-trap

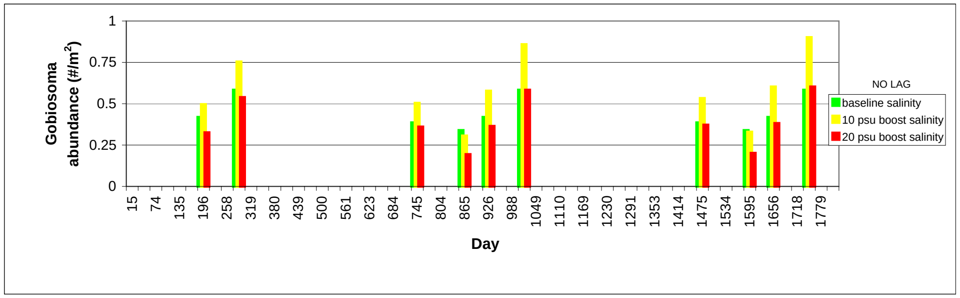
RANKIN LAKE- THROW TRAP

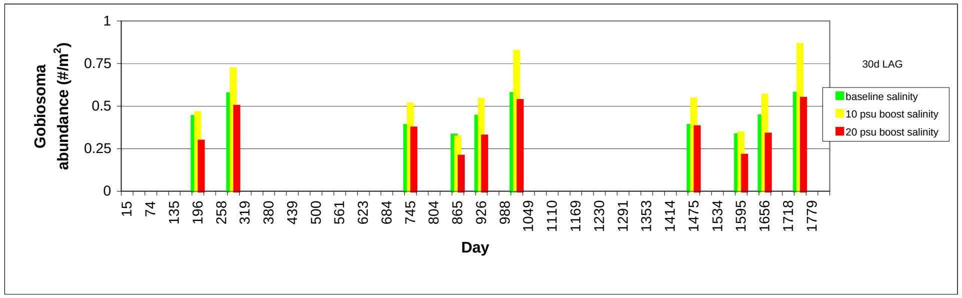


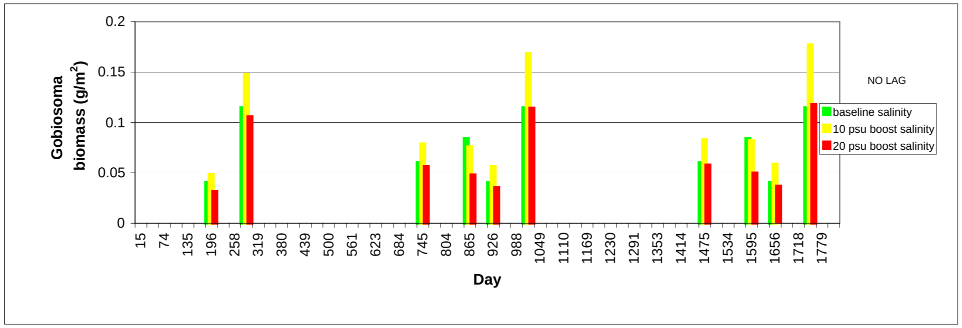












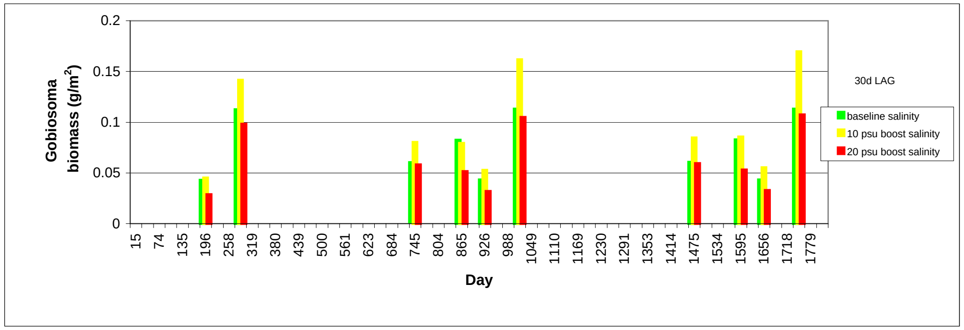
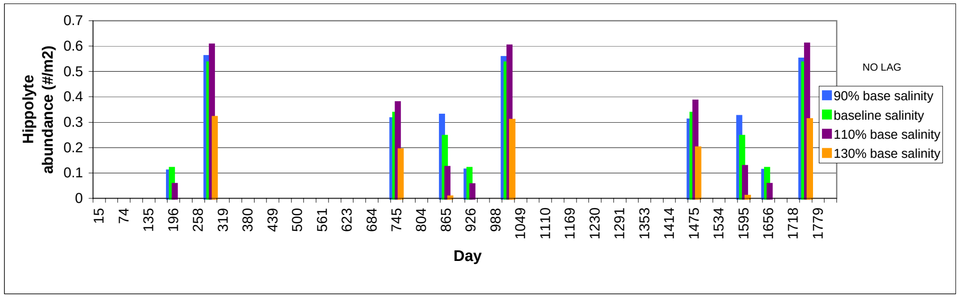
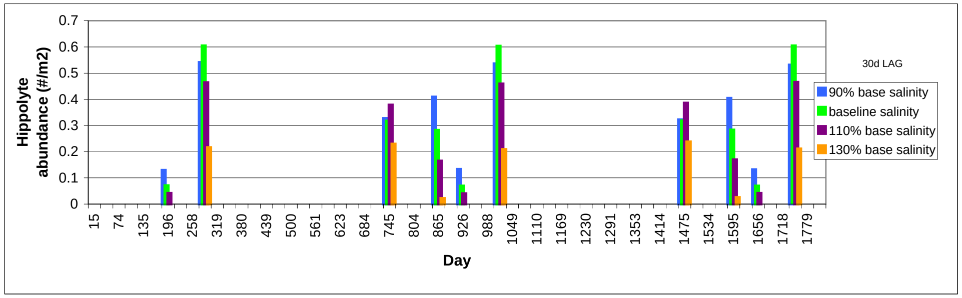
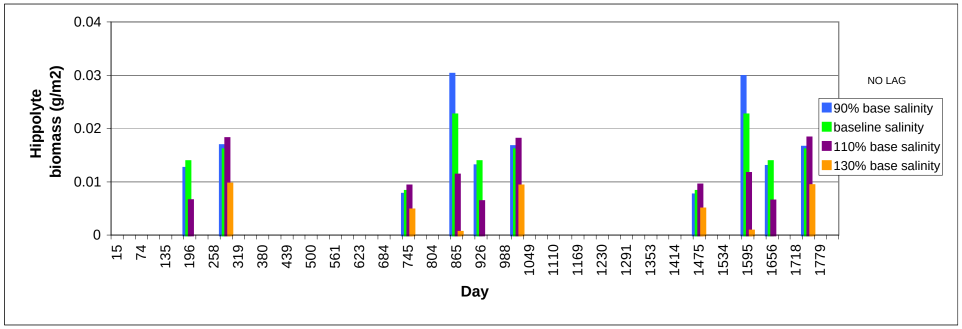


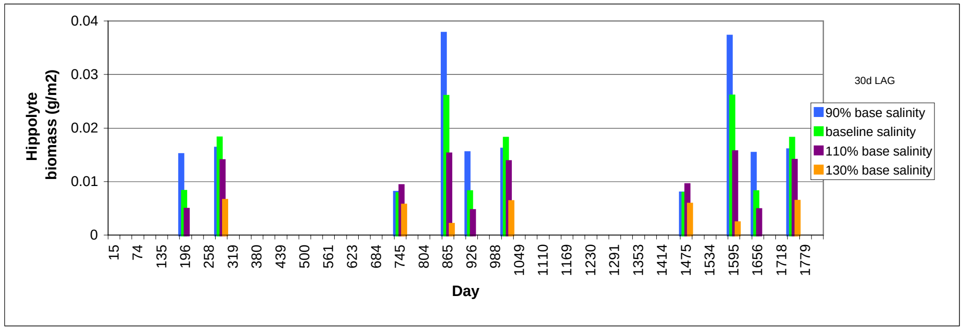
Figure 148. Rankin Lake Scenario – *Hippolyte spp.* abundance and biomass- throw-trap

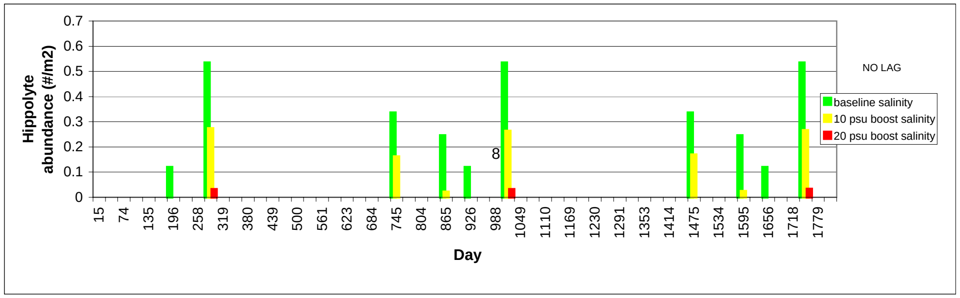
RANKIN LAKE- THROW TRAP

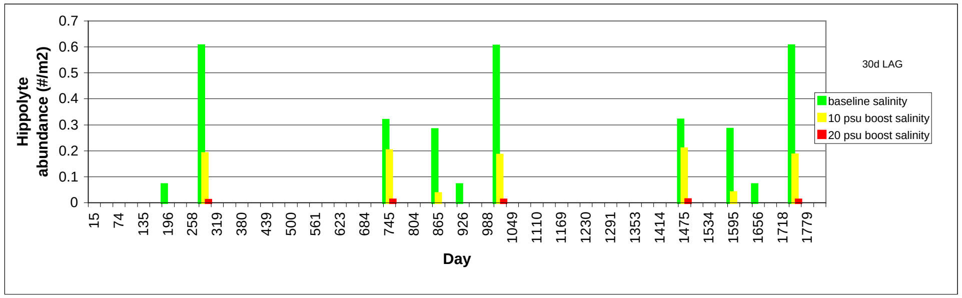


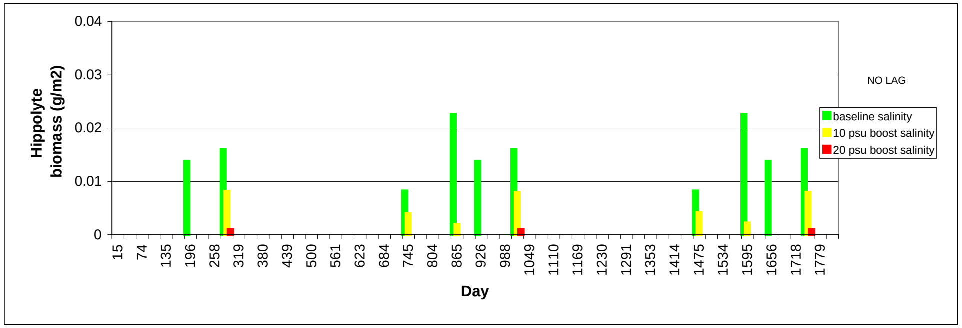












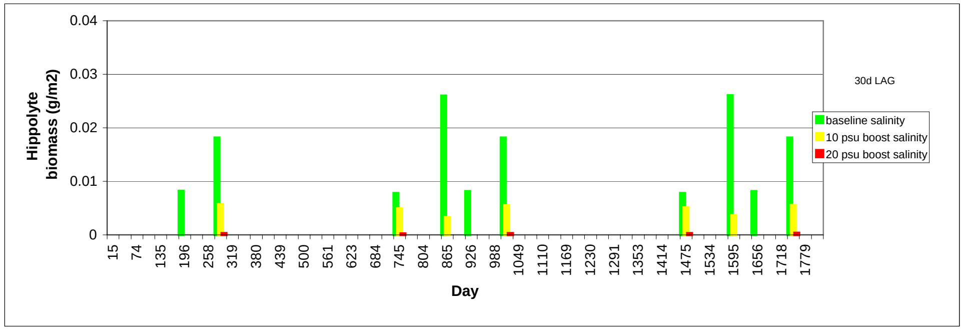
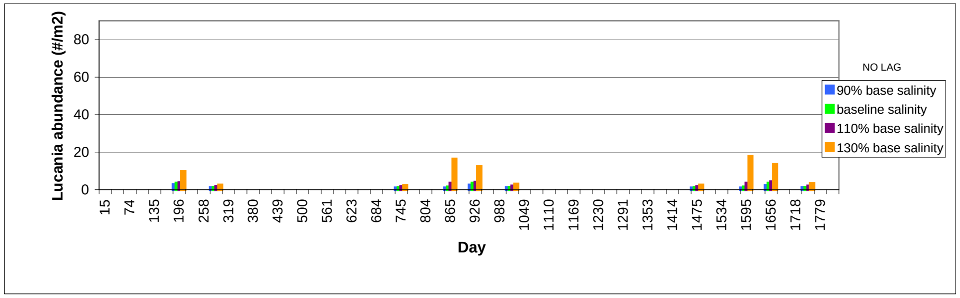
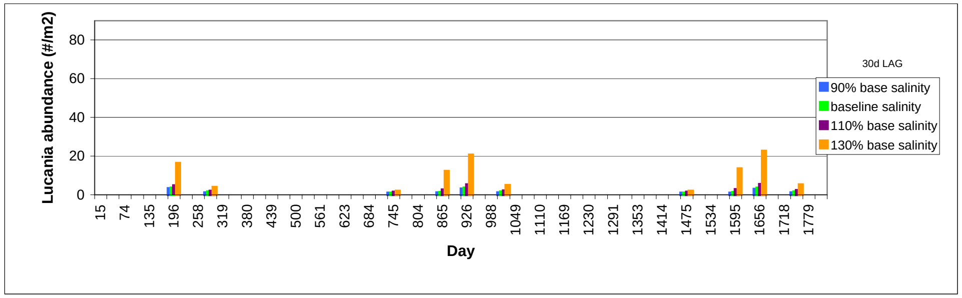
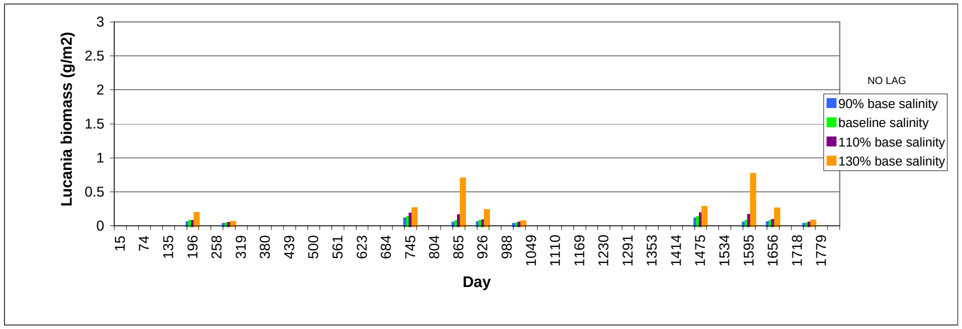


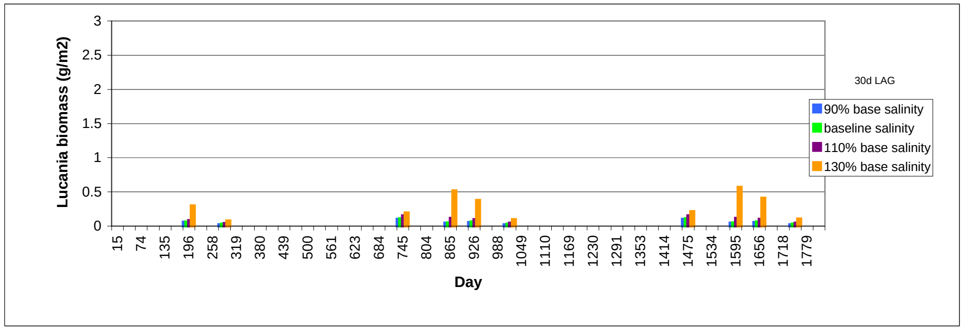
Figure 149. Rankin Lake Scenario – *Lucania parva* abundance and biomass- throw-trap

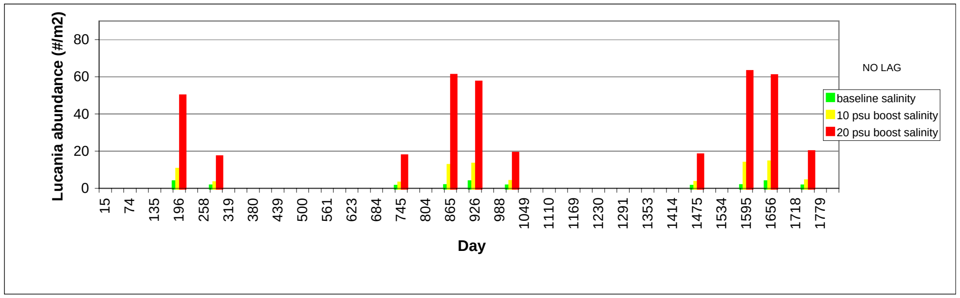
RANKIN LAKE- THROW TRAP

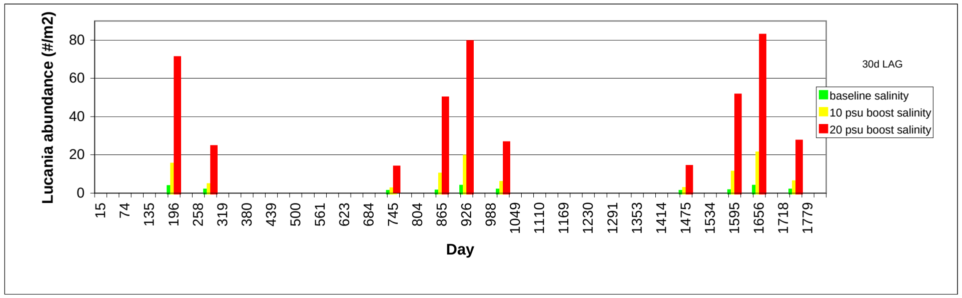


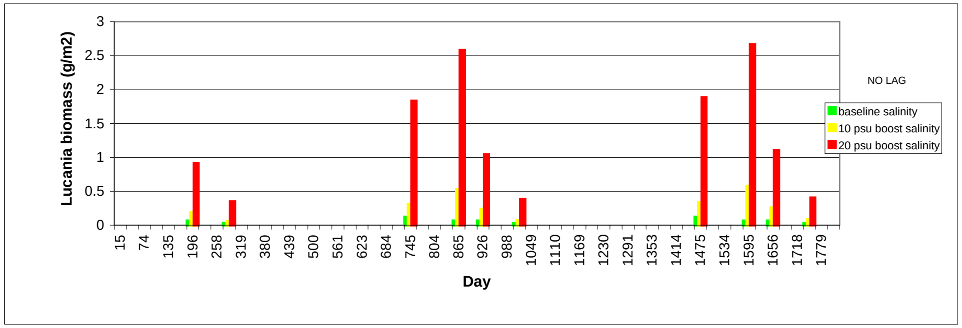












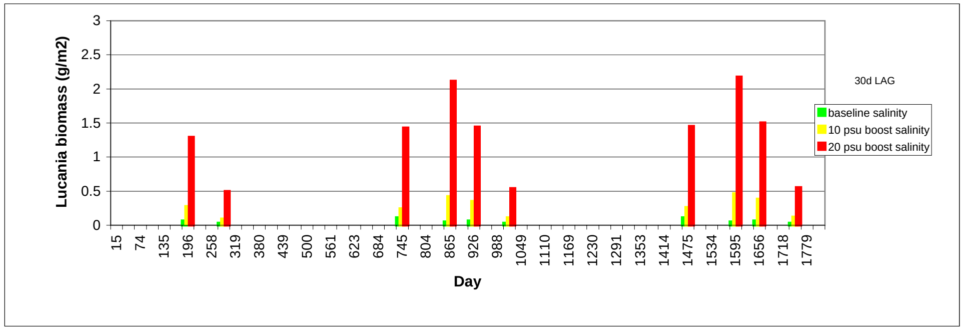
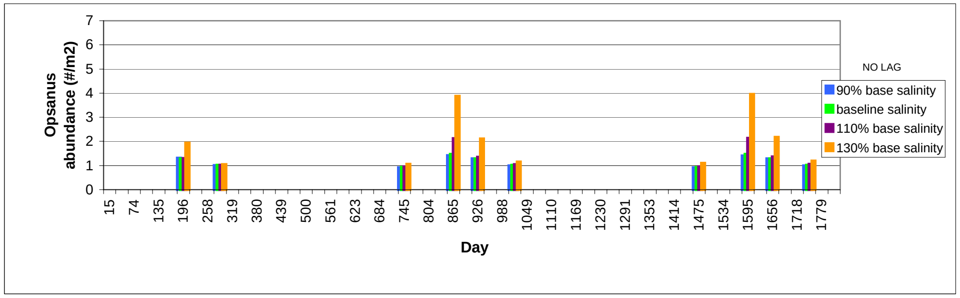
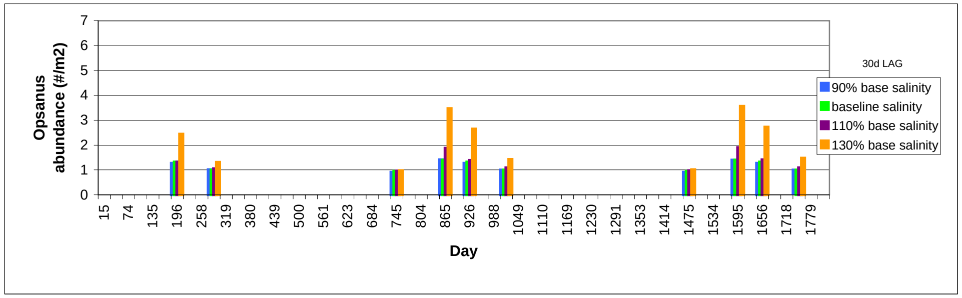
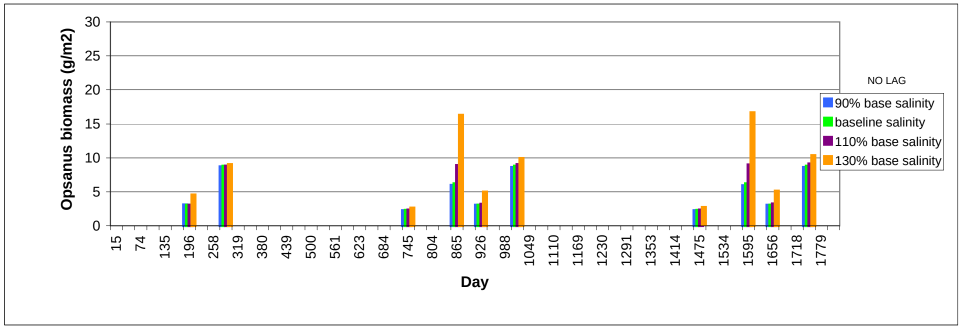


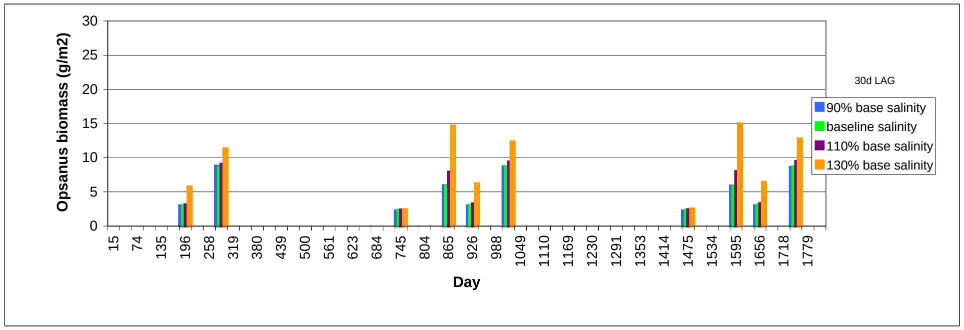
Figure 150. Rankin Lake Scenario – *Opsanus beta* abundance and biomass- throw-trap

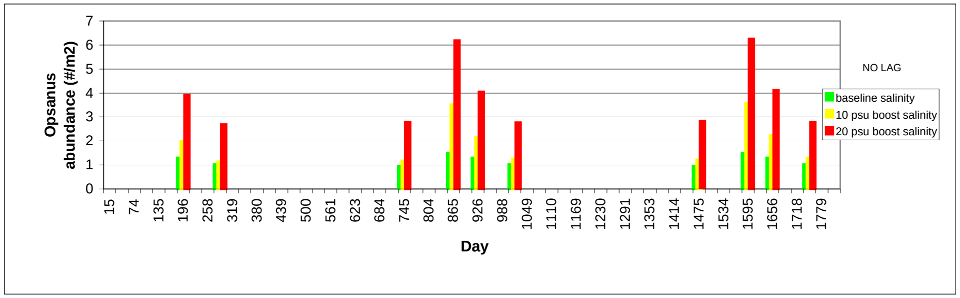
RANKIN LAKE- THROW TRAP

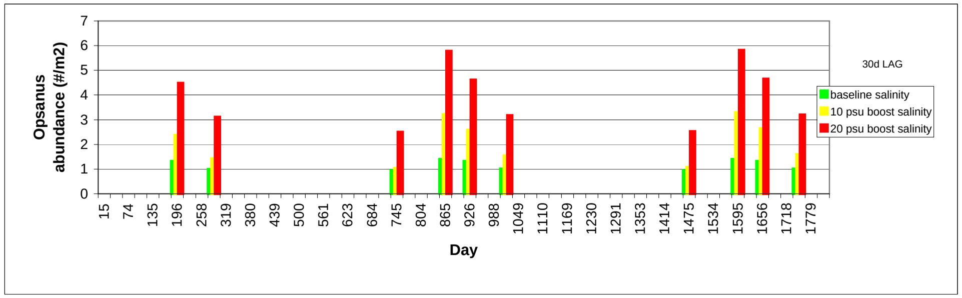


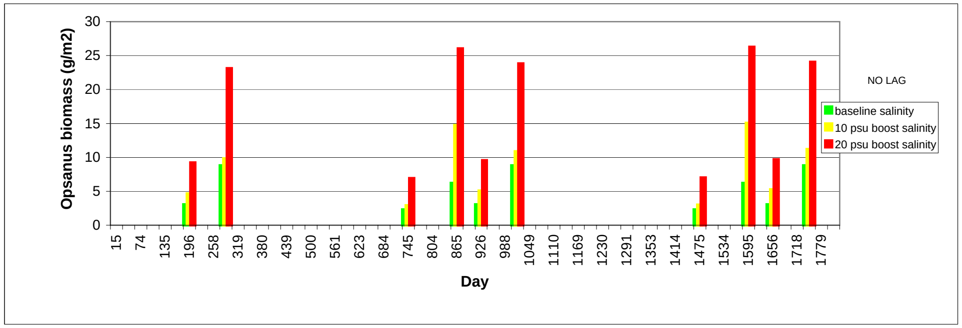












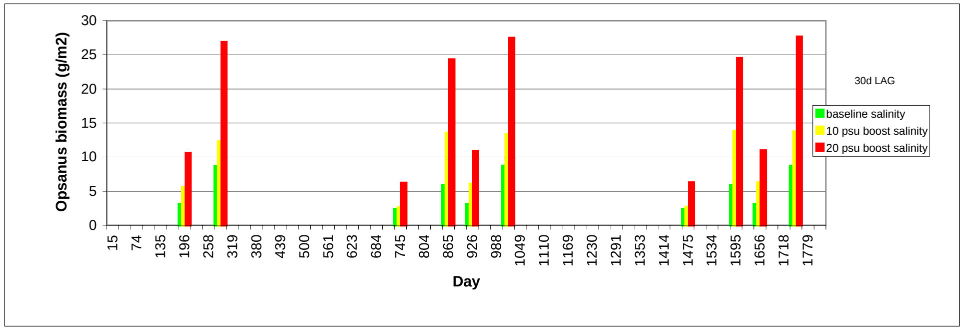
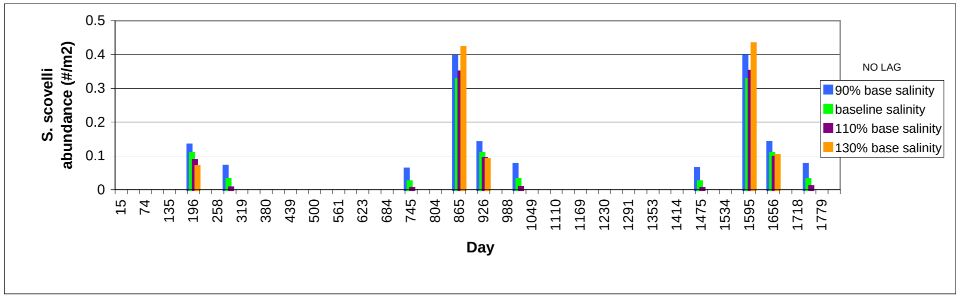
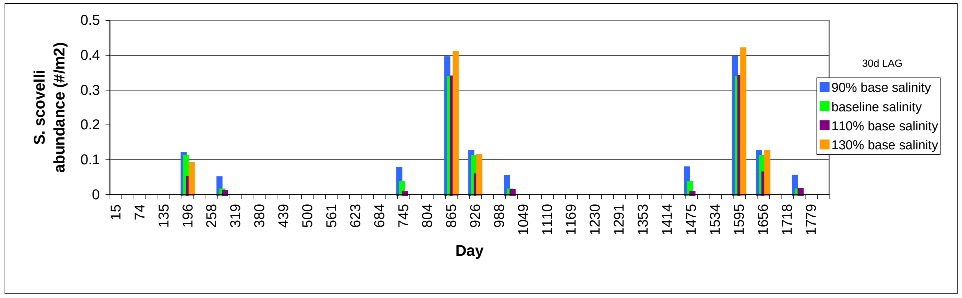
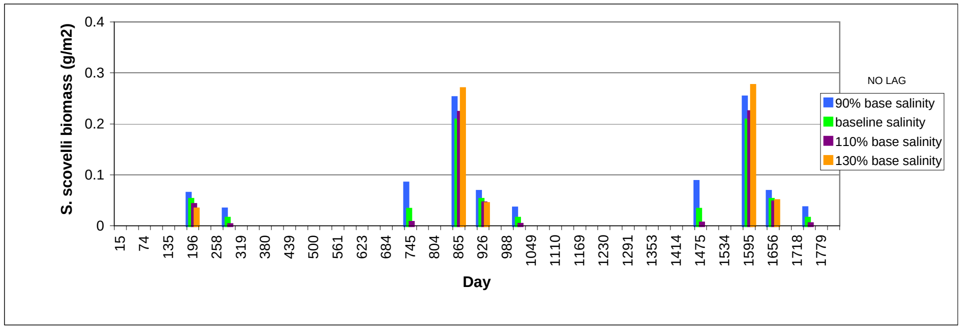


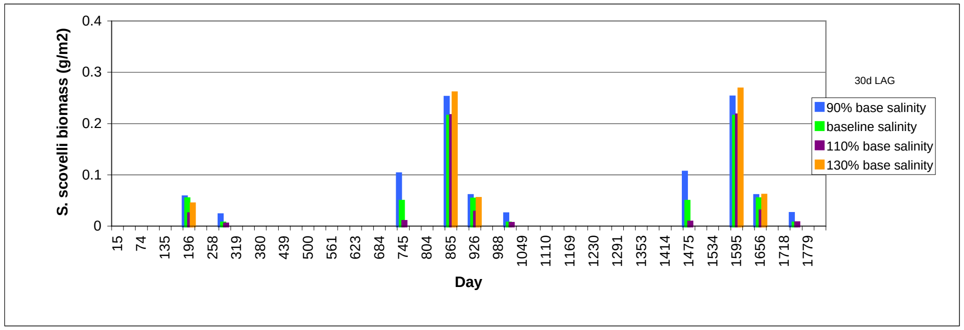
Figure 151. Rankin Lake Scenario – *Syngnathus scovelli* abundance and biomass- throw-trap

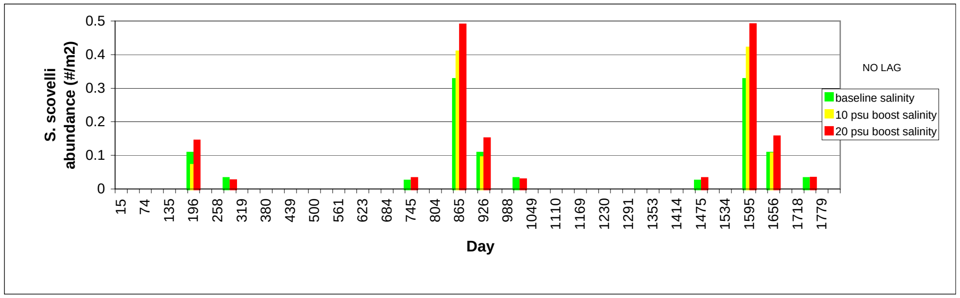
RANKIN LAKE- THROW TRAP

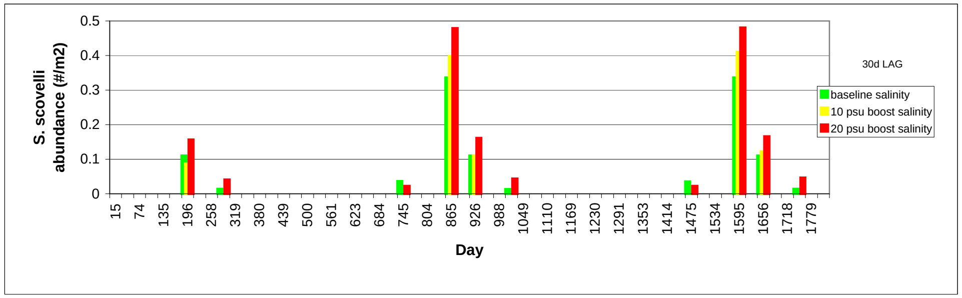


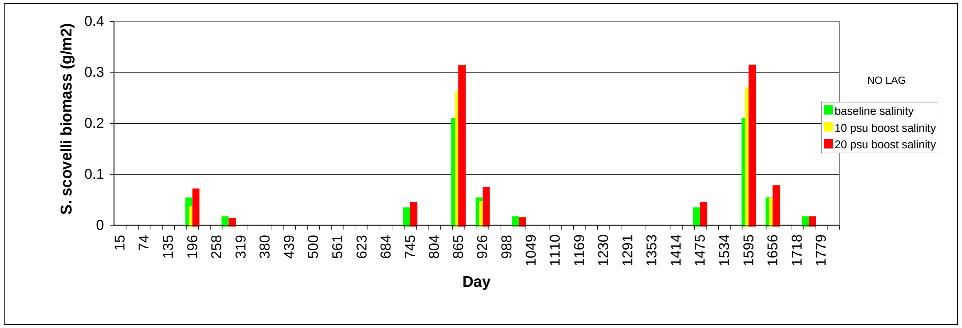












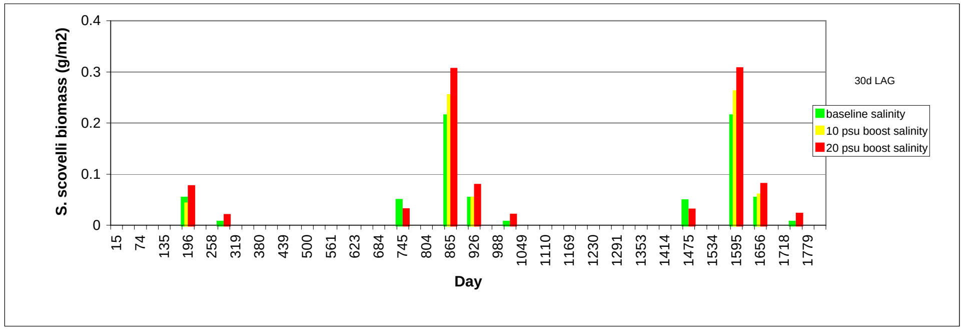
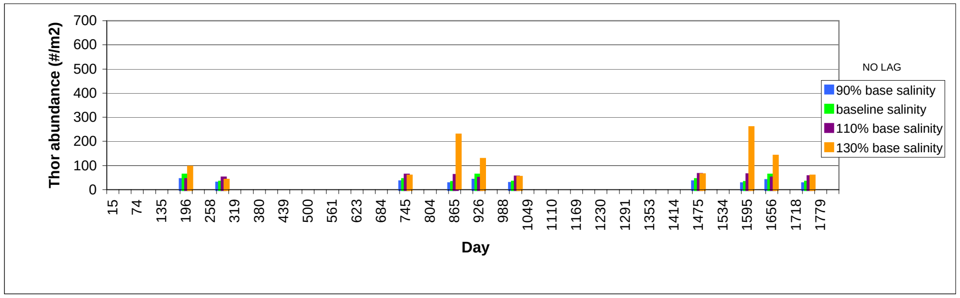
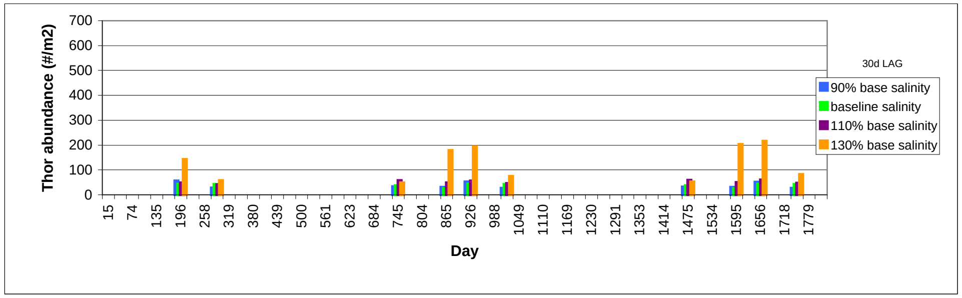
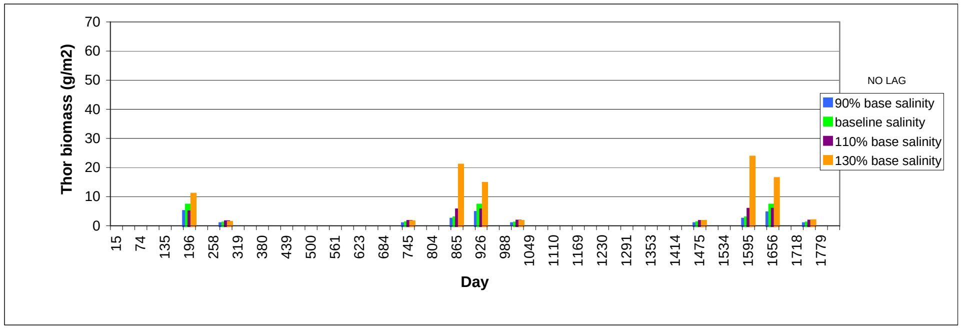


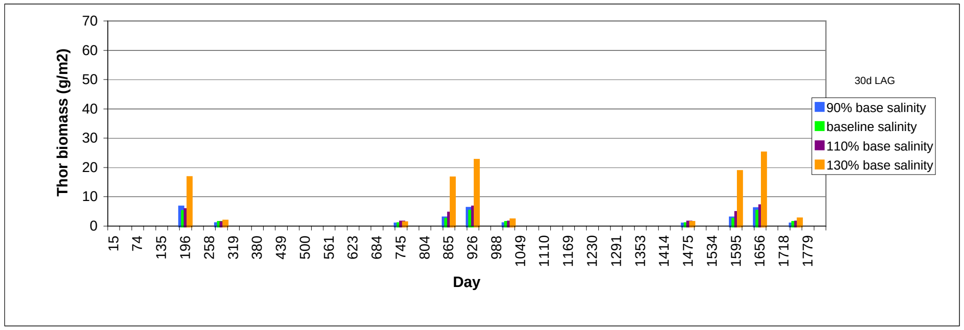
Figure 152. Rankin Lake Scenario – *Thor spp.* abundance and biomass- throw-trap

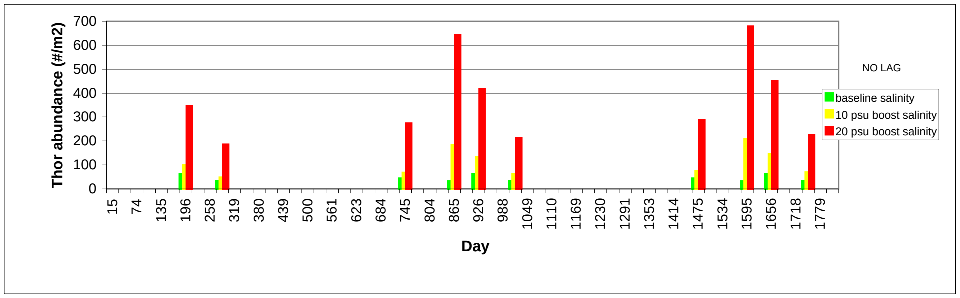
RANKIN LAKE- THROW TRAP

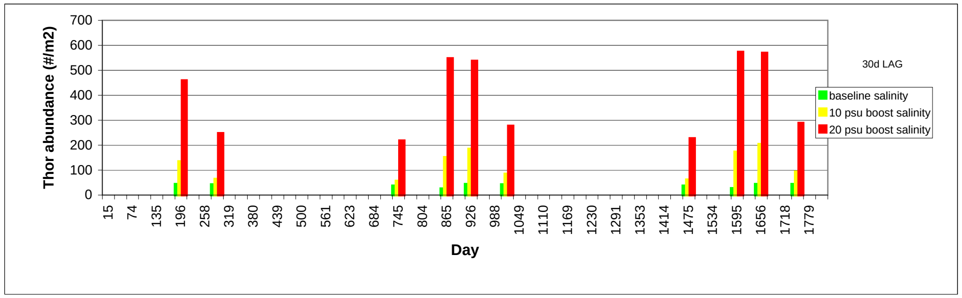


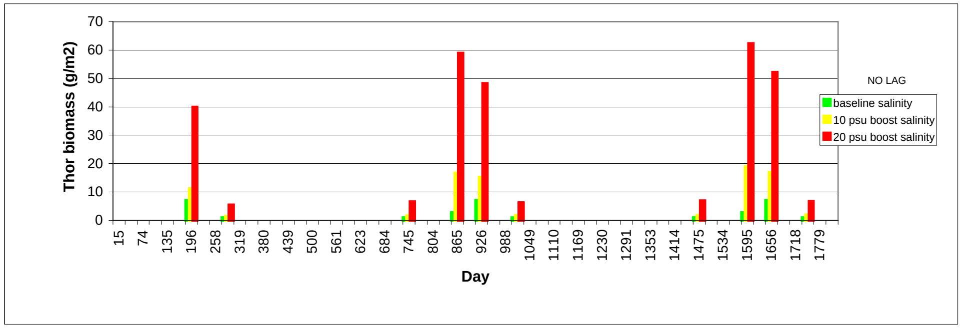












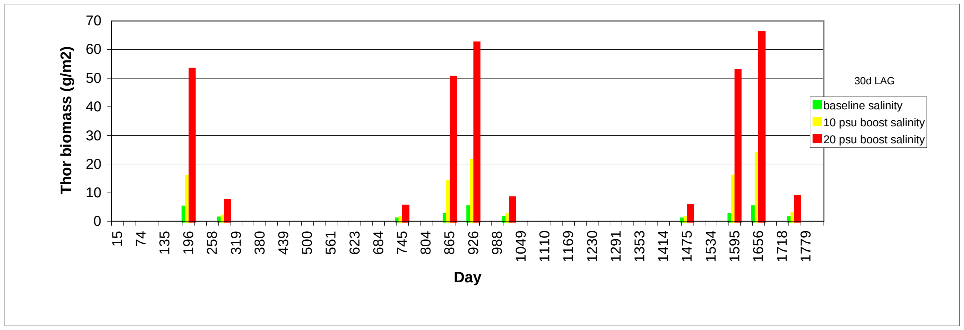
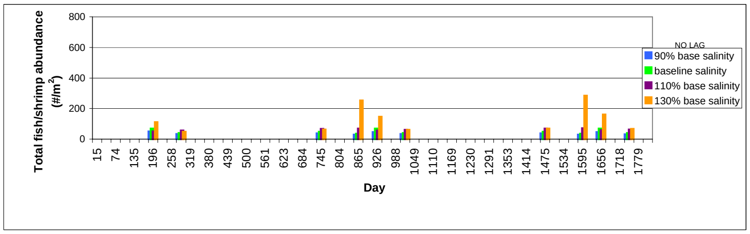
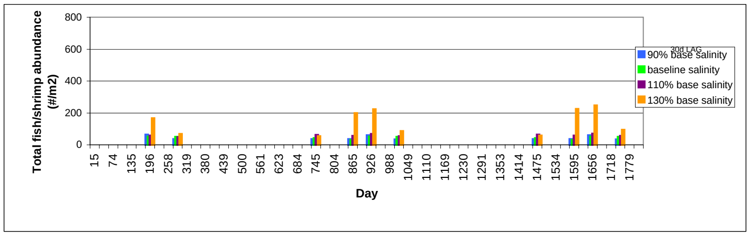
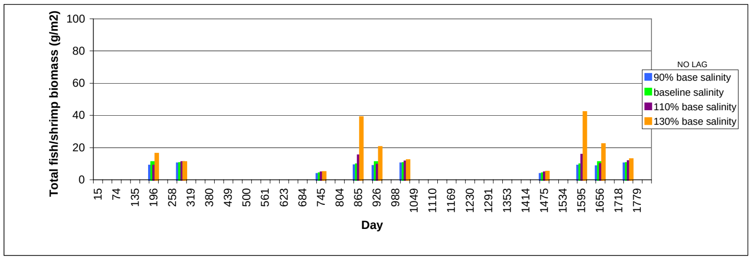


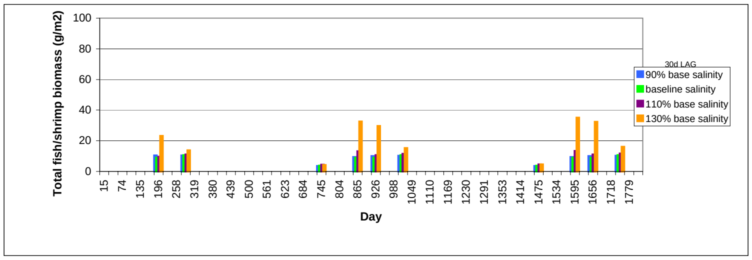
Figure 153. Rankin Lake Scenario – Total fish/shrimp abundance, Total fish/shrimp biomass, Forage fish/shrimp biomass, Predator fish biomass- throw-trap

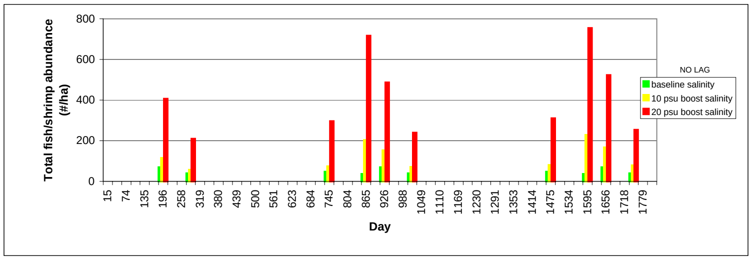
RANKIN LAKE- THROW TRAP

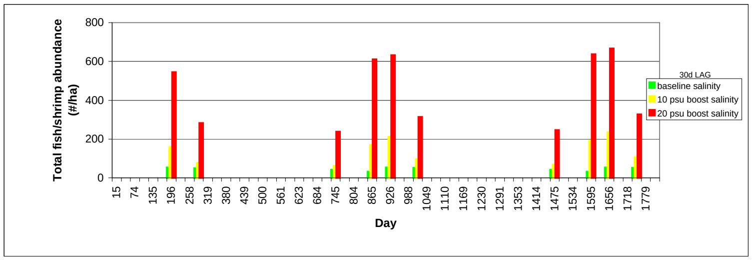


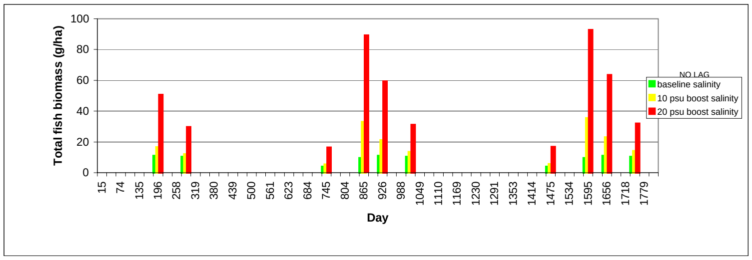


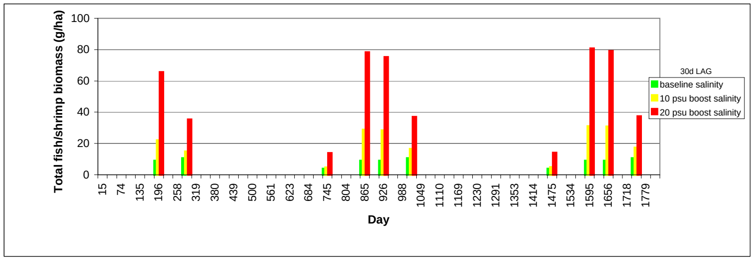


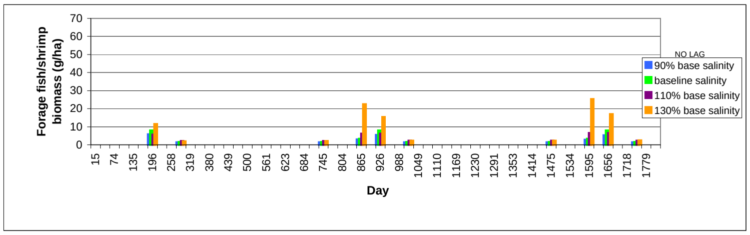


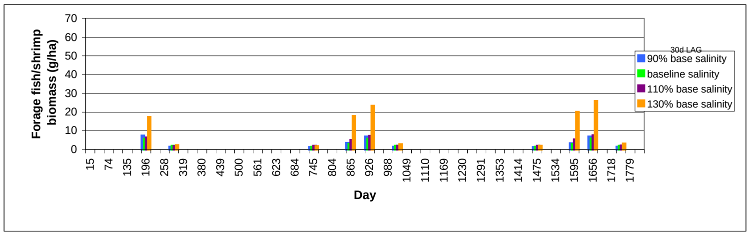


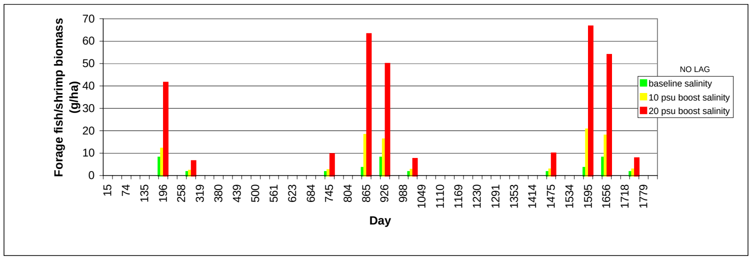












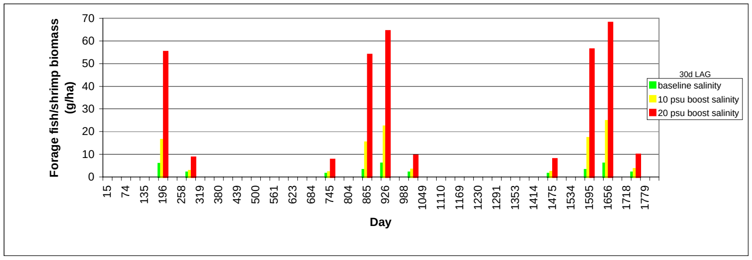
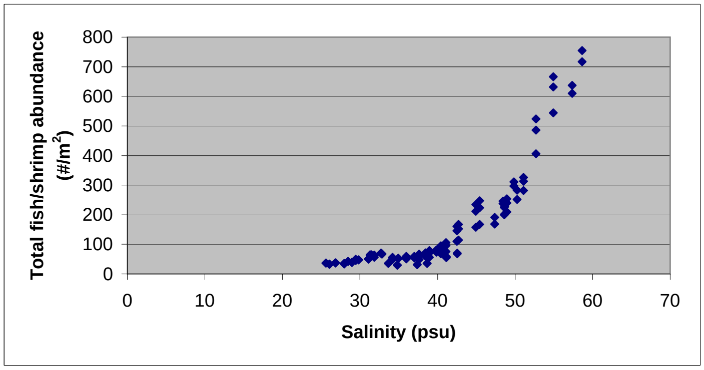
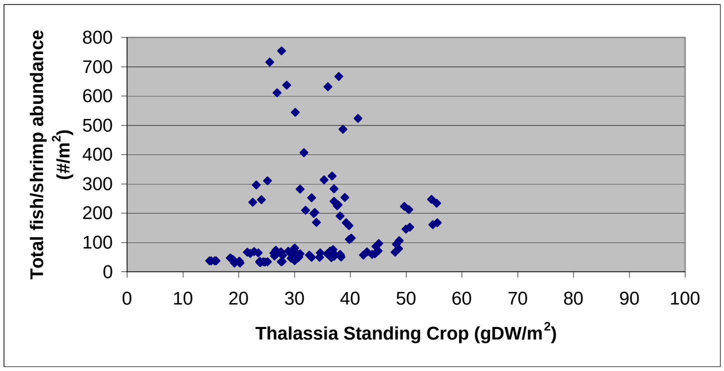
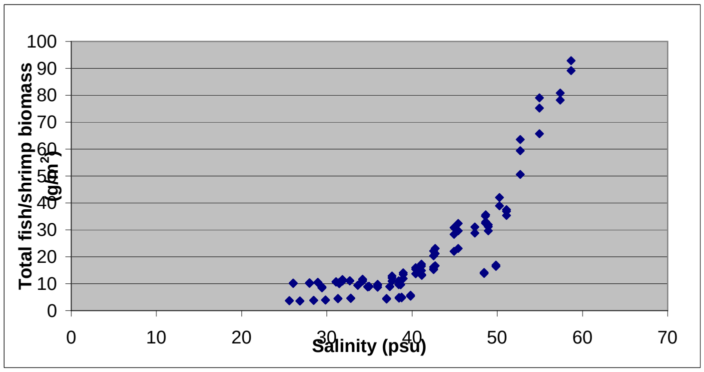


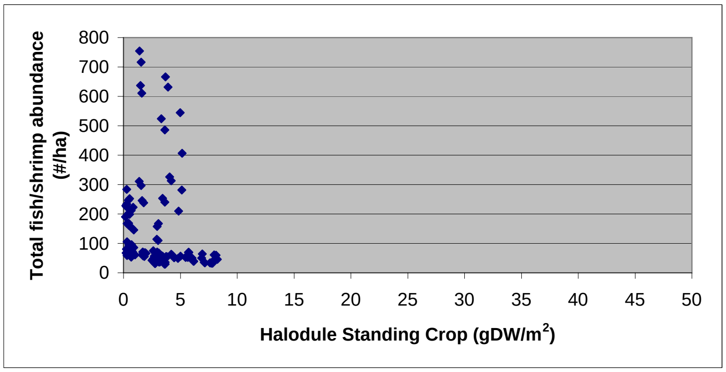
Figure 154. Rankin Lake Scenario - Fish/shrimp abundance vs. Salinity, Fish/shrimp biomass vs. salinity, Predator fish biomass vs. Salinity, Fish/shrimp abundance vs. Thalassia BBCA, Fish/shrimp abundance vs. Halodule BBCA- throw-trap

RANKIN LAKE- THROW TRAP









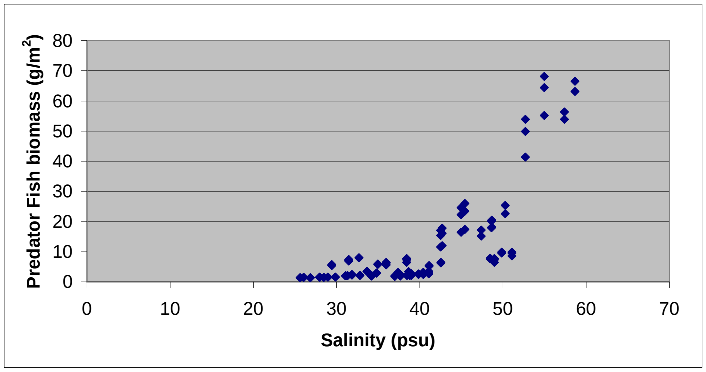
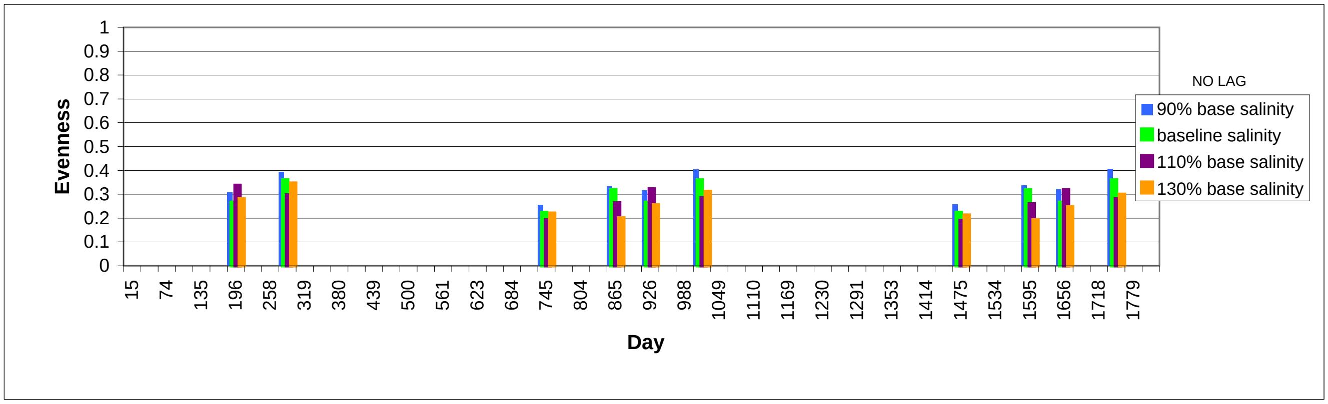
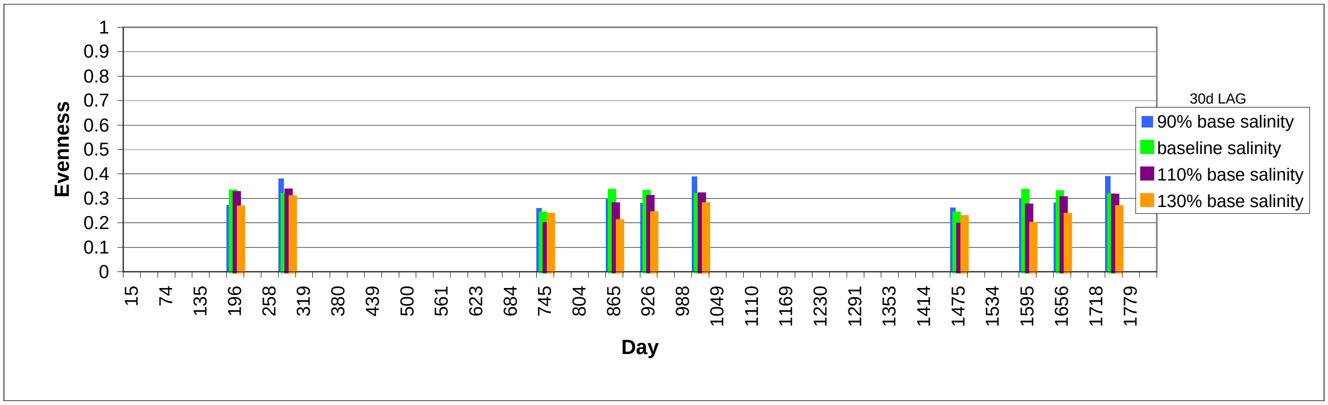
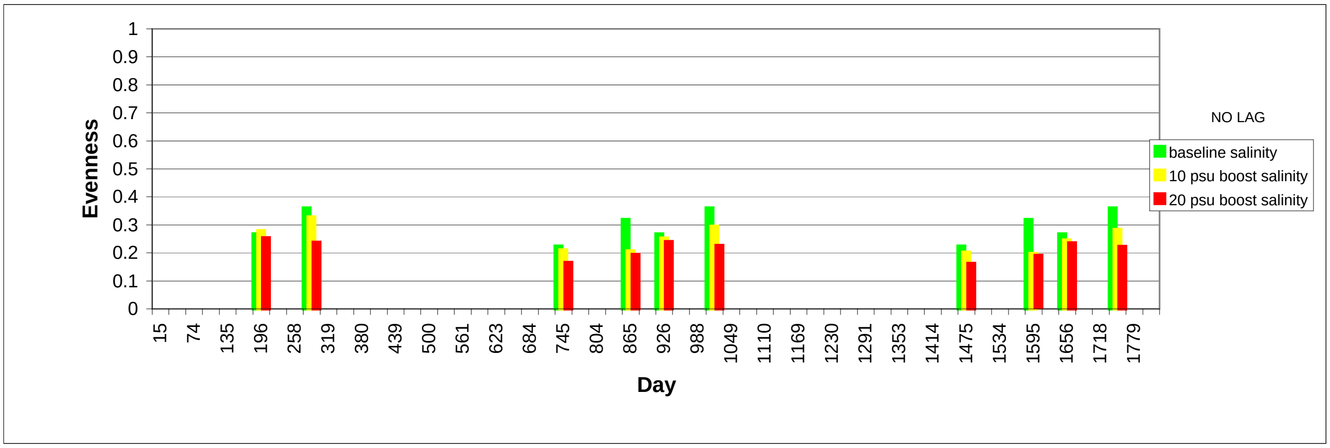


Figure 155. Rankin Lake Scenario – Evenness throw-trap

RANKIN LAKE- THROW TRAP







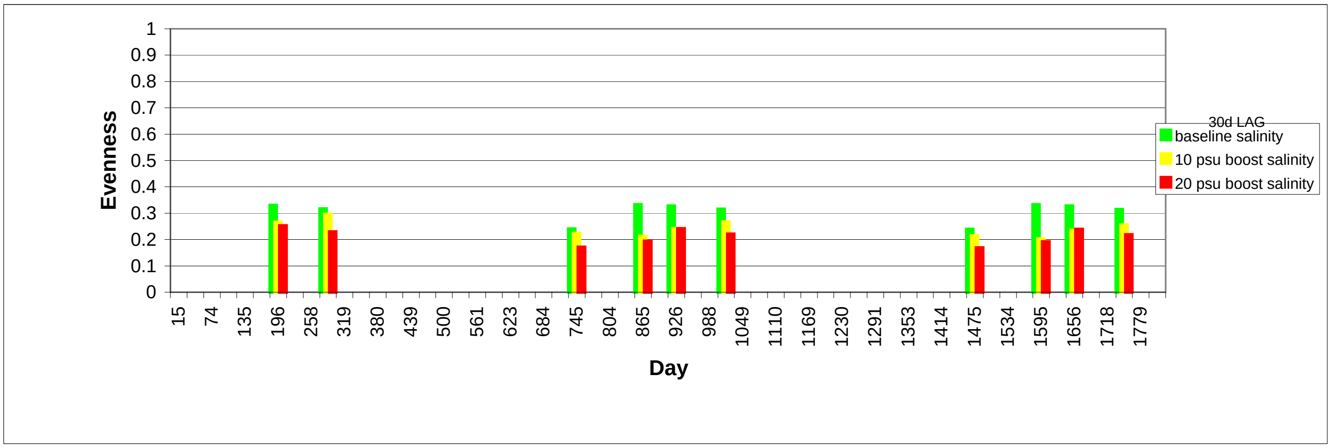
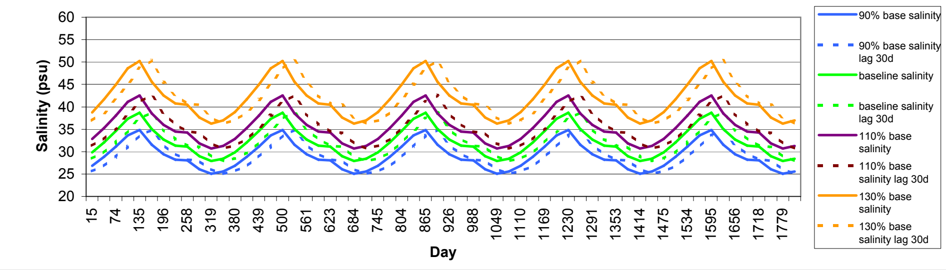
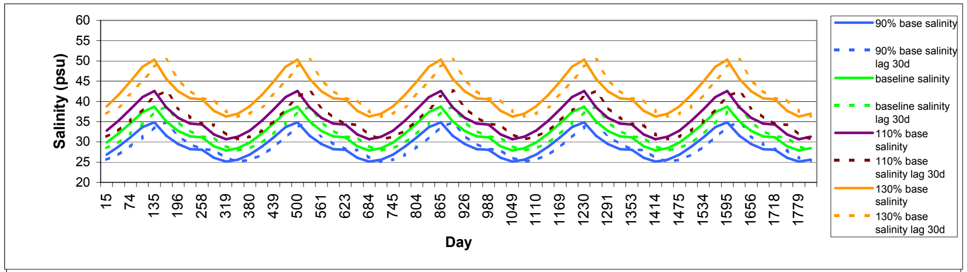
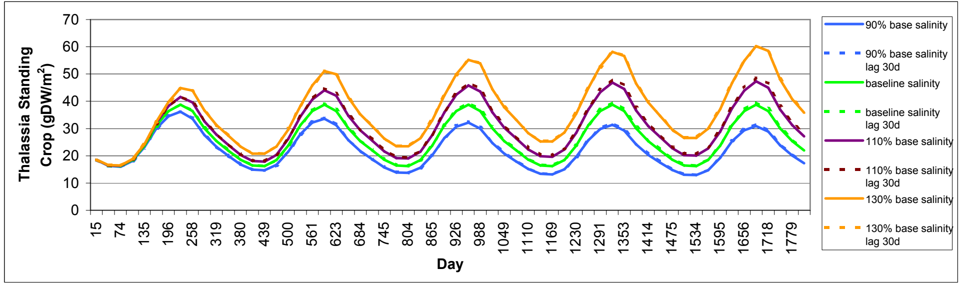


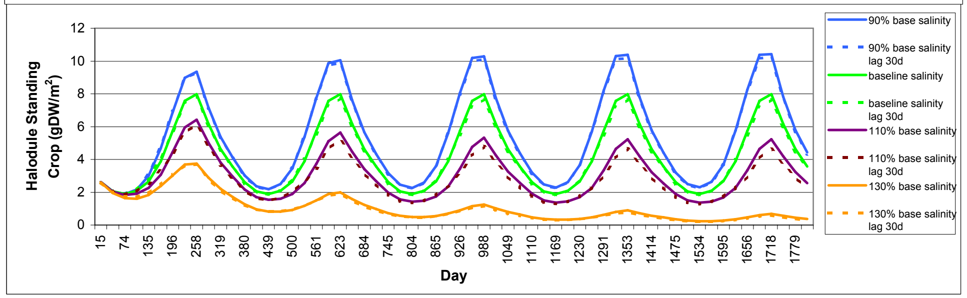
Figure 156. Rankin Lake Scenario – Salinity and SAV- throw-trap

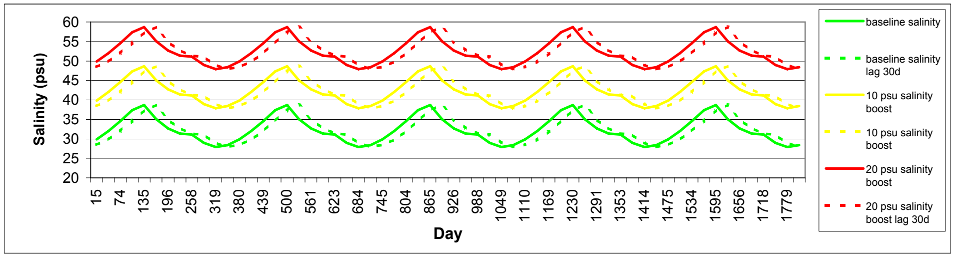
RANKIN LAKE

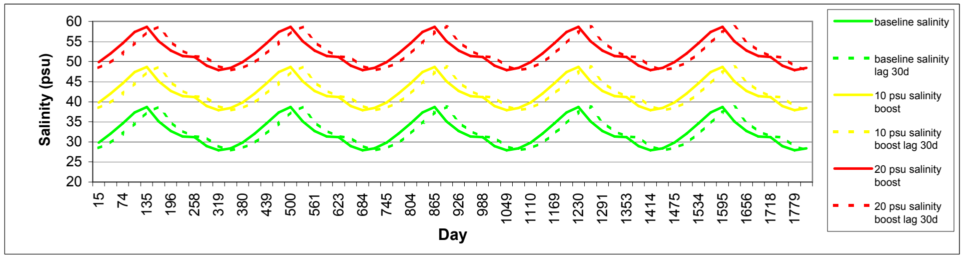

Salinity (psu)
60 55 50 45 40 35 30 25 20
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
90% base salinity
90% base salinity lag 30d
baseline salinity
baseline salinity lag 30d
110% base salinity
110% base salinity lag 30d
130% base salinity
130% base salinity lag 30d

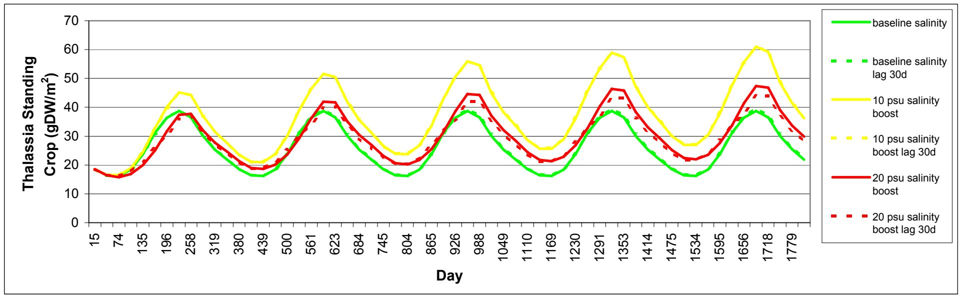

Salinity (psu)
60 55 50 45 40 35 30 25 20
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
90% base salinity
90% base salinity lag 30d
baseline salinity
baseline salinity lag 30d
110% base salinity
110% base salinity lag 30d
130% base salinity
130% base salinity lag 30d

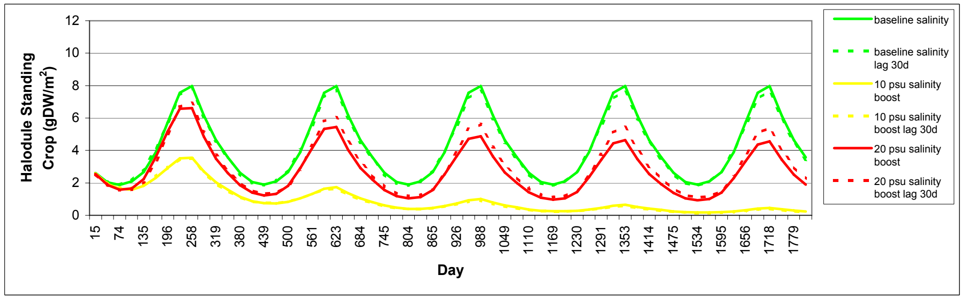

Thalassia Standing Crop (gDW/m²)
70 60 50 40 30 20 10 0
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
90% base salinity
90% base salinity lag 30d
baseline salinity
baseline salinity lag 30d
110% base salinity
110% base salinity lag 30d
130% base salinity
130% base salinity lag 30d


Halodule Standing Crop (gDW/m²)
12 10 8 6 4 2 0
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
90% base salinity
90% base salinity lag 30d
baseline salinity
baseline salinity lag 30d
110% base salinity
110% base salinity lag 30d
130% base salinity
130% base salinity lag 30d


Salinity (psu)
60 55 50 45 40 35 30 25 20
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
baseline salinity
baseline salinity lag 30d
10 psu salinity boost
10 psu salinity boost
20 psu salinity boost
20 psu salinity boost lag 30d


Salinity (psu)
60 55 50 45 40 35 30 25 20
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
baseline salinity
baseline salinity lag 30d
10 psu salinity boost
10 psu salinity boost lag 30d
20 psu salinity boost
20 psu salinity boost lag 30d


Thalassia Standing Crop (gDW/m²)
70 60 50 40 30 20 10 0
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
baseline salinity
baseline salinity lag 30d
10 psu salinity boost
10 psu salinity boost lag 30d
20 psu salinity boost
20 psu salinity boost lag 30d


Halodule Standing Crop (gDW/m²)
12 10 8 6 4 2 0
15 74 135 196 258 319 380 439 500 561 623 684 745 804 865 926 988 1049 1110 1169 1230 1291 1353 1414 1475 1534 1595 1656 1718 1779
Day
baseline salinity
baseline salinity lag 30d
10 psu salinity boost
10 psu salinity boost lag 30d
20 psu salinity boost
20 psu salinity boost lag 30d

Appendix
Predicted scenario data and confidence intervals.

Table A-1. Predictions for interior scenarios for throw trap with 95% confidence intervals

Table A-2. Predictions for northeast scenarios for throw trap with 95% confidence intervals

Table A-3. Predictions for interior scenarios for trawl/seine with 95% confidence intervals

Table A-4. Predictions for northeast scenarios for trawl/seine with 95% confidence intervals

Appendix Table A-1. Predictions for interior scenarios for throw-trap with 95% confidence intervals

Site	Salt Trmt	Lag	Year	Month	Julian Date	Salinity	Tempe r-ature	Depth	TSC	HSC	SSC	Habitat	Floridichthys	Floridichthys upper	Floridichthy s lower	Gobiosoma	Gobiosoma upper	Gobiosoma lower	Hippolyte	Hippolyte upper	Hippolyte lower
WHP	0.9	0	1	7	196	34.7	31.1	1.33	34.1	20.3	0.0	bank	2.8	70.1	0.1	0.6	23.9	0.0	0.3	41.5	0.0
WHP	0.9	0	1	10	288	30.3	27.3	1.33	22.6	14.4	0.0	bank	1.6	40.4	0.0	0.6	24.8	0.0	0.9	131.0	0.0
WHP	0.9	0	3	1	15	29.3	21.2	1.33	9.4	6.7	0.0	bank	0.7	17.7	0.0	0.4	15.1	0.0	0.4	55.7	0.0
WHP	0.9	0	3	5	135	36.5	28.5	1.33	11.7	13.6	0.0	bank	1.3	32.5	0.0	0.4	14.5	0.0	0.5	75.7	0.0
WHP	0.9	0	3	7	196	34.7	31.1	1.33	13.3	28.6	0.0	bank	2.6	65.9	0.1	0.5	20.6	0.0	0.2	37.7	0.0
WHP	0.9	0	3	10	288	30.3	27.3	1.33	7.8	17.8	0.0	bank	1.5	38.1	0.0	0.6	23.8	0.0	0.8	118.7	0.0
WHP	0.9	0	5	1	15	29.3	21.2	1.33	1.8	7.8	0.0	bank	0.6	16.8	0.0	0.4	14.9	0.0	0.3	51.9	0.0
WHP	0.9	0	5	5	135	36.5	28.5	1.33	1.9	16.6	0.0	bank	1.2	31.2	0.0	0.4	14.9	0.0	0.5	74.0	0.0
WHP	0.9	0	5	7	196	34.7	31.1	1.33	2.0	32.8	0.0	bank	2.4	60.9	0.1	0.5	20.1	0.0	0.2	33.3	0.0
WHP	0.9	0	5	10	288	30.3	27.3	1.33	1.3	19.2	0.0	bank	1.4	36.7	0.0	0.6	23.9	0.0	0.8	111.4	0.0
WHP	0.9	30	1	7	196	35.9	31.1	1.33	33.4	20.5	0.0	bank	2.8	69.9	0.1	0.6	25.3	0.0	0.2	37.5	0.0
WHP	0.9	30	1	10	288	35.0	27.3	1.33	22.1	14.5	0.0	bank	2.1	52.5	0.0	0.6	25.1	0.0	0.7	99.2	0.0
WHP	0.9	30	3	1	15	29.0	21.2	1.33	8.7	6.8	0.0	bank	0.7	17.4	0.0	0.4	15.0	0.0	0.4	54.9	0.0
WHP	0.9	30	3	5	135	33.6	28.5	1.33	10.3	14.1	0.0	bank	1.3	32.0	0.0	0.3	12.8	0.0	0.7	103.3	0.0
WHP	0.9	30	3	7	196	35.9	31.1	1.33	11.6	29.2	0.0	bank	2.6	65.0	0.1	0.6	21.8	0.0	0.2	33.5	0.0
WHP	0.9	30	3	10	288	35.0	27.3	1.33	6.8	18.0	0.0	bank	2.0	49.2	0.0	0.6	24.2	0.0	0.6	89.2	0.0
WHP	0.9	30	5	1	15	29.0	21.2	1.33	1.6	7.8	0.0	bank	0.6	16.6	0.0	0.4	14.9	0.0	0.3	51.3	0.0
WHP	0.9	30	5	5	135	33.6	28.5	1.33	1.6	16.8	0.0	bank	1.2	30.8	0.0	0.3	13.1	0.0	0.7	100.9	0.0
WHP	0.9	30	5	7	196	35.9	31.1	1.33	1.7	32.8	0.0	bank	2.4	60.6	0.1	0.5	21.4	0.0	0.2	29.9	0.0
WHP	0.9	30	5	10	288	35.0	27.3	1.33	1.1	19.2	0.0	bank	1.9	47.6	0.0	0.6	24.2	0.0	0.6	84.4	0.0
WHP	1	0	1	7	196	38.6	31.1	1.33	38.6	17.2	0.0	bank	3.0	74.3	0.1	0.7	28.5	0.0	0.2	30.1	0.0
WHP	1	0	1	10	288	33.7	27.3	1.33	27.7	12.6	0.0	bank	2.1	51.9	0.0	0.6	24.7	0.0	0.8	121.3	0.0
WHP	1	0	3	1	15	32.5	21.2	1.33	17.0	5.5	0.0	bank	0.9	24.1	0.0	0.4	15.0	0.0	0.4	68.0	0.0
WHP	1	0	3	5	135	40.6	28.5	1.33	26.2	8.7	0.0	bank	1.6	41.1	0.0	0.4	15.1	0.0	0.3	48.3	0.0
WHP	1	0	3	7	196	38.6	31.1	1.33	38.6	17.2	0.0	bank	3.0	74.3	0.1	0.7	28.5	0.0	0.2	30.1	0.0
WHP	1	0	3	10	288	33.7	27.3	1.33	27.7	12.6	0.0	bank	2.1	51.9	0.0	0.6	24.7	0.0	0.8	121.2	0.0
WHP	1	0	5	1	15	32.5	21.2	1.33	17.0	5.5	0.0	bank	0.9	24.1	0.0	0.4	15.0	0.0	0.4	68.0	0.0
WHP	1	0	5	5	135	40.6	28.5	1.33	26.2	8.7	0.0	bank	1.6	41.1	0.0	0.4	15.1	0.0	0.3	48.3	0.0
WHP	1	0	5	7	196	38.6	31.1	1.33	38.6	17.2	0.0	bank	3.0	74.3	0.1	0.7	28.5	0.0	0.2	30.1	0.0
WHP	1	0	5	10	288	33.7	27.3	1.33	27.7	12.6	0.0	bank	2.1	51.9	0.0	0.6	24.7	0.0	0.8	121.2	0.0
WHP	1	30	1	7	196	39.9	31.1	1.33	37.1	17.9	0.0	bank	3.3	81.4	0.1	0.7	27.8	0.0	0.1	25.9	0.0
WHP	1	30	1	10	288	38.9	27.3	1.33	26.6	12.6	0.0	bank	2.3	57.5	0.0	0.8	29.4	0.0	0.5	75.2	0.0
WHP	1	30	3	1	15	32.3	21.2	1.33	16.4	5.5	0.0	bank	0.9	23.5	0.0	0.4	14.9	0.0	0.4	67.3	0.0
WHP	1	30	3	5	135	37.4	28.5	1.33	24.9	9.4	0.0	bank	1.3	33.9	0.0	0.4	15.3	0.0	0.5	71.1	0.0
WHP	1	30	3	7	196	39.9	31.1	1.33	36.4	17.9	0.0	bank	3.3	81.2	0.1	0.7	27.5	0.0	0.1	25.6	0.0
WHP	1	30	3	10	288	38.9	27.3	1.33	26.3	12.6	0.0	bank	2.3	57.4	0.0	0.8	29.2	0.0	0.5	74.6	0.0
WHP	1	30	5	1	15	32.3	21.2	1.33	16.3	5.5	0.0	bank	0.9	23.5	0.0	0.4	14.9	0.0	0.4	67.2	0.0
WHP	1	30	5	5	135	37.4	28.5	1.33	24.8	9.4	0.0	bank	1.3	33.9	0.0	0.4	15.3	0.0	0.5	71.0	0.0
WHP	1	30	5	7	196	39.9	31.1	1.33	36.4	17.9	0.0	bank	3.3	81.2	0.1	0.7	27.5	0.0	0.1	25.6	0.0
WHP	1	30	5	10	288	38.9	27.3	1.33	26.2	12.6	0.0	bank	2.3	57.4	0.0	0.8	29.2	0.0	0.5	74.5	0.0
WHP	1.1	0	1	7	196	42.4	31.1	1.33	43.3	13.8	0.0	bank	3.9	96.5	0.1	0.7	26.2	0.0	0.1	15.6	0.0
WHP	1.1	0	1	10	288	37.1	27.3	1.33	33.0	10.5	0.0	bank	2.1	52.4	0.0	0.8	29.6	0.0	0.6	84.5	0.0
WHP	1.1	0	3	1	15	35.8	21.2	1.33	22.6	4.8	0.0	bank	1.0	26.6	0.0	0.4	17.2	0.0	0.3	47.6	0.0
WHP	1.1	0	3	5	135	44.6	28.5	1.33	34.6	6.7	0.0	bank	2.3	57.6	0.0	0.4	14.8	0.0	0.1	26.5	0.0
WHP	1.1	0	3	7	196	42.4	31.1	1.33	51.2	12.5	0.0	bank	3.9	95.8	0.1	0.7	27.8	0.0	0.1	15.6	0.0
WHP	1.1	0	3	10	288	37.1	27.3	1.33	37.8	10.3	0.0	bank	2.1	52.9	0.0	0.8	31.7	0.0	0.6	89.7	0.0
WHP	1.1	0	5	1	15	35.8	21.2	1.33	23.5	5.0	0.0	bank	1.0	26.7	0.0	0.4	17.5	0.0	0.3	49.0	0.0

Appendix Table A-1. Predictions for interior scenarios for throw-trap with 95% confidence intervals

Site	Salt Trmt	Lag	Year	Month	Julian Date	Salinity	Tempe r-ature	Depth	TSC	HSC	SSC	Habitat	Floridichthys	Floridichthys upper	Floridichthys lower	Gobiosoma	Gobiosoma upper	Gobiosoma lower	Hippolyte	Hippolyte upper	Hippolyte lower
WHP	1.1	0	5	5	135	44.6	28.5	1.33	35.6	6.9	0.0	bank	2.3	57.7	0.0	0.4	15.1	0.0	0.1	27.3	0.0
WHP	1.1	0	5	7	196	42.4	31.1	1.33	52.0	12.8	0.0	bank	3.9	96.3	0.1	0.7	28.3	0.0	0.1	16.0	0.0
WHP	1.1	0	5	10	288	37.1	27.3	1.33	38.1	10.6	0.0	bank	2.1	53.1	0.0	0.8	32.1	0.0	0.6	91.7	0.0
WHP	1.1	30	1	7	196	43.9	31.1	1.33	41.3	14.7	0.0	bank	4.4	109.1	0.1	0.6	25.2	0.0	0.0	13.1	0.0
WHP	1.1	30	1	10	288	42.8	27.3	1.33	31.5	10.6	0.0	bank	3.1	76.7	0.1	0.7	27.4	0.0	0.3	41.2	0.0
WHP	1.1	30	3	1	15	35.5	21.2	1.33	21.7	4.7	0.0	bank	1.0	26.5	0.0	0.4	16.8	0.0	0.3	47.0	0.0
WHP	1.1	30	3	5	135	41.1	28.5	1.33	32.9	7.4	0.0	bank	1.7	43.4	0.0	0.4	16.0	0.0	0.3	45.5	0.0
WHP	1.1	30	3	7	196	43.9	31.1	1.33	48.4	13.3	0.0	bank	4.4	108.2	0.1	0.7	26.6	0.0	0.0	12.9	0.0
WHP	1.1	30	3	10	288	42.8	27.3	1.33	35.8	10.4	0.0	bank	3.1	77.2	0.1	0.8	29.1	0.0	0.3	43.3	0.0
WHP	1.1	30	5	1	15	35.5	21.2	1.33	22.6	4.8	0.0	bank	1.0	26.6	0.0	0.4	17.0	0.0	0.3	48.2	0.0
WHP	1.1	30	5	5	135	41.1	28.5	1.33	33.9	7.6	0.0	bank	1.7	43.6	0.0	0.4	16.3	0.0	0.3	46.7	0.0
WHP	1.1	30	5	7	196	43.9	31.1	1.33	49.3	13.5	0.0	bank	4.4	108.6	0.1	0.7	27.0	0.0	0.0	13.2	0.0
WHP	1.1	30	5	10	288	42.8	27.3	1.33	36.2	10.6	0.0	bank	3.1	77.5	0.1	0.8	29.5	0.0	0.3	44.1	0.0
WHP	1.3	0	1	7	196	50.1	31.1	1.33	48.0	8.3	0.0	bank	6.8	170.1	0.2	0.5	20.2	0.0	0.0	3.7	0.0
WHP	1.3	0	1	10	288	43.8	27.3	1.33	41.2	6.3	0.0	bank	3.3	81.9	0.1	0.7	28.2	0.0	0.2	30.4	0.0
WHP	1.3	0	3	1	15	42.3	21.2	1.33	33.6	2.5	0.0	bank	1.6	40.2	0.0	0.5	20.6	0.0	0.1	25.0	0.0
WHP	1.3	0	3	5	135	52.8	28.5	1.33	51.9	2.9	0.0	bank	4.6	117.3	0.1	0.4	15.1	0.0	0.0	7.8	0.0
WHP	1.3	0	3	7	196	50.1	31.1	1.33	73.3	4.9	0.0	bank	6.8	171.6	0.2	0.5	20.3	0.0	0.0	3.2	0.0
WHP	1.3	0	3	10	288	43.8	27.3	1.33	57.3	5.0	0.0	bank	3.4	83.4	0.1	0.9	32.7	0.0	0.2	31.8	0.0
WHP	1.3	0	5	1	15	42.3	21.2	1.33	38.7	3.4	0.0	bank	1.6	40.1	0.0	0.6	22.3	0.0	0.2	28.6	0.0
WHP	1.3	0	5	5	135	52.8	28.5	1.33	58.6	4.1	0.0	bank	4.6	116.2	0.1	0.4	15.8	0.0	0.0	8.8	0.0
WHP	1.3	0	5	7	196	50.1	31.1	1.33	79.4	7.2	0.0	bank	6.8	171.3	0.2	0.5	20.2	0.0	0.0	3.7	0.0
WHP	1.3	0	5	10	288	43.8	27.3	1.33	59.6	7.5	0.0	bank	3.4	83.6	0.1	0.9	34.1	0.0	0.2	38.2	0.0
WHP	1.3	30	1	7	196	51.8	31.1	1.33	46.3	8.9	0.0	bank	7.8	196.7	0.3	0.5	19.4	0.0	0.0	3.0	0.0
WHP	1.3	30	1	10	288	50.6	27.3	1.33	39.6	6.6	0.0	bank	5.6	142.1	0.2	0.6	23.7	0.0	0.0	11.4	0.0
WHP	1.3	30	3	1	15	42.0	21.2	1.33	32.4	2.5	0.0	bank	1.5	39.1	0.0	0.5	20.4	0.0	0.1	25.7	0.0
WHP	1.3	30	3	5	135	48.6	28.5	1.33	51.7	3.4	0.0	bank	3.3	82.6	0.1	0.4	16.5	0.0	0.1	14.4	0.0
WHP	1.3	30	3	7	196	51.8	31.1	1.33	70.2	5.4	0.0	bank	7.8	197.0	0.3	0.5	19.9	0.0	0.0	2.6	0.0
WHP	1.3	30	3	10	288	50.6	27.3	1.33	55.1	5.2	0.0	bank	5.8	144.8	0.2	0.7	27.7	0.0	0.0	12.1	0.0
WHP	1.3	30	5	1	15	42.0	21.2	1.33	37.3	3.2	0.0	bank	1.5	39.1	0.0	0.6	22.0	0.0	0.2	29.1	0.0
WHP	1.3	30	5	5	135	48.6	28.5	1.33	57.9	4.6	0.0	bank	3.3	82.0	0.1	0.4	17.2	0.0	0.1	16.3	0.0
WHP	1.3	30	5	7	196	51.8	31.1	1.33	75.7	7.5	0.0	bank	7.8	197.5	0.3	0.5	20.0	0.0	0.0	3.0	0.0
WHP	1.3	30	5	10	288	50.6	27.3	1.33	57.1	7.4	0.0	bank	5.8	145.1	0.2	0.7	28.9	0.0	0.1	14.2	0.0
WHP	10	0	1	7	196	48.6	31.1	1.33	48.9	8.9	0.0	bank	6.0	150.5	0.2	0.5	21.4	0.0	0.0	4.9	0.0
WHP	10	0	1	10	288	43.7	27.3	1.33	40.9	6.8	0.0	bank	3.3	81.2	0.1	0.7	28.3	0.0	0.2	31.7	0.0
WHP	10	0	3	1	15	42.5	21.2	1.33	32.7	2.6	0.0	bank	1.6	40.8	0.0	0.5	20.2	0.0	0.1	24.0	0.0
WHP	10	0	3	5	135	50.6	28.5	1.33	51.0	3.1	0.0	bank	3.9	97.6	0.1	0.4	15.7	0.0	0.0	10.6	0.0
WHP	10	0	3	7	196	48.6	31.1	1.33	72.9	5.4	0.0	bank	6.0	150.5	0.2	0.5	21.1	0.0	0.0	4.2	0.0
WHP	10	0	3	10	288	43.7	27.3	1.33	56.4	5.5	0.0	bank	3.3	82.5	0.1	0.9	32.8	0.0	0.2	33.4	0.0
WHP	10	0	5	1	15	42.5	21.2	1.33	37.3	3.5	0.0	bank	1.6	40.8	0.0	0.5	21.7	0.0	0.1	27.3	0.0
WHP	10	0	5	5	135	50.6	28.5	1.33	56.9	4.3	0.0	bank	3.8	96.8	0.1	0.4	16.4	0.0	0.0	12.0	0.0
WHP	10	0	5	7	196	48.6	31.1	1.33	78.1	7.7	0.0	bank	6.0	151.0	0.2	0.5	21.2	0.0	0.0	4.8	0.0
WHP	10	0	5	10	288	43.7	27.3	1.33	58.2	7.9	0.0	bank	3.3	83.0	0.1	0.9	34.4	0.0	0.2	39.8	0.0
WHP	10	30	1	7	196	49.9	31.1	1.33	47.5	9.5	0.0	bank	6.7	168.4	0.2	0.5	20.8	0.0	0.0	4.2	0.0
WHP	10	30	1	10	288	48.9	27.3	1.33	39.6	7.0	0.0	bank	4.9	123.9	0.2	0.6	24.7	0.0	0.1	15.0	0.0
WHP	10	30	3	1	15	42.3	21.2	1.33	31.8	2.6	0.0	bank	1.6	39.9	0.0	0.5	20.0	0.0	0.1	24.5	0.0
WHP	10	30	3	5	135	47.4	28.5	1.33	50.1	3.5	0.0	bank	3.0	74.6	0.1	0.4	16.7	0.0	0.1	17.1	0.0

Appendix Table A-1. Predictions for interior scenarios for throw-trap with 95% confidence intervals

Site	Salt Trmt	Lag	Year	Month	Julian Date	Salinity	Tempe r-ature	Depth	TSC	HSC	SSC	Habitat	Floridichthys	Floridichthys upper	Floridichthy s lower	Gobiosoma	Gobiosoma upper	Gobiosoma lower	Hippolyte	Hippolyte upper	Hippolyte lower
WHP	10	30	3	7	196	49.9	31.1	1.33	70.6	5.9	0.0	bank	6.7	167.3	0.2	0.5	20.9	0.0	0.0	3.6	0.0
WHP	10	30	3	10	288	48.9	27.3	1.33	54.6	5.8	0.0	bank	5.0	125.8	0.2	0.7	28.8	0.0	0.1	15.8	0.0
WHP	10	30	5	1	15	42.3	21.2	1.33	36.2	3.4	0.0	bank	1.6	39.9	0.0	0.5	21.4	0.0	0.2	27.7	0.0
WHP	10	30	5	5	135	47.4	28.5	1.33	55.7	4.7	0.0	bank	3.0	74.2	0.1	0.4	17.5	0.0	0.1	19.3	0.0
WHP	10	30	5	7	196	49.9	31.1	1.33	75.4	7.9	0.0	bank	6.7	168.4	0.2	0.5	21.1	0.0	0.0	4.1	0.0
WHP	10	30	5	10	288	48.9	27.3	1.33	56.3	7.8	0.0	bank	5.1	126.6	0.2	0.8	30.2	0.0	0.1	18.5	0.0
WHP	20	0	1	7	196	58.6	31.1	1.33	33.7	4.4	0.0	bank	12.9	337.9	0.4	0.3	13.2	0.0	0.0	0.7	0.0
WHP	20	0	1	10	288	53.7	27.3	1.33	33.8	3.6	0.0	bank	7.2	184.4	0.2	0.5	19.8	0.0	0.0	5.5	0.0
WHP	20	0	3	1	15	52.5	21.2	1.33	34.0	1.1	0.0	bank	3.7	94.7	0.1	0.4	16.5	0.0	0.0	5.3	0.0
WHP	20	0	3	5	135	60.6	28.5	1.33	54.3	1.2	0.0	bank	8.8	234.1	0.3	0.3	13.3	0.0	0.0	2.4	0.0
WHP	20	0	3	7	196	58.6	31.1	1.33	67.2	1.8	0.0	bank	13.8	361.2	0.5	0.4	17.5	0.0	0.0	0.8	0.0
WHP	20	0	3	10	288	53.7	27.3	1.33	52.9	1.8	0.0	bank	7.6	194.1	0.3	0.6	25.5	0.0	0.0	6.1	0.0
WHP	20	0	5	1	15	52.5	21.2	1.33	41.0	1.0	0.0	bank	3.8	96.1	0.1	0.4	18.4	0.0	0.0	5.8	0.0
WHP	20	0	5	5	135	60.6	28.5	1.33	67.4	1.4	0.0	bank	8.9	235.1	0.3	0.3	13.6	0.0	0.0	2.5	0.0
WHP	20	0	5	7	196	58.6	31.1	1.33	78.9	2.2	0.0	bank	13.7	359.5	0.5	0.4	16.5	0.0	0.0	0.8	0.0
WHP	20	0	5	10	288	53.7	27.3	1.33	59.0	2.4	0.0	bank	7.6	193.1	0.3	0.7	26.3	0.0	0.0	6.5	0.0
WHP	20	30	1	7	196	59.9	31.1	1.33	35.4	4.7	0.0	bank	14.3	378.9	0.5	0.3	13.3	0.0	0.0	0.6	0.0
WHP	20	30	1	10	288	58.9	27.3	1.33	33.7	3.6	0.0	bank	11.0	287.4	0.4	0.4	18.0	0.0	0.0	2.7	0.0
WHP	20	30	3	1	15	52.3	21.2	1.33	32.2	1.0	0.0	bank	3.6	92.5	0.1	0.4	16.2	0.0	0.0	5.3	0.0
WHP	20	30	3	5	135	57.4	28.5	1.33	59.2	1.4	0.0	bank	6.9	178.0	0.2	0.3	14.4	0.0	0.0	3.8	0.0
WHP	20	30	3	7	196	59.9	31.1	1.33	67.1	1.9	0.0	bank	15.3	403.8	0.5	0.4	17.1	0.0	0.0	0.6	0.0
WHP	20	30	3	10	288	58.9	27.3	1.33	51.8	1.8	0.0	bank	11.5	302.2	0.4	0.5	22.9	0.0	0.0	2.9	0.0
WHP	20	30	5	1	15	52.3	21.2	1.33	38.9	1.0	0.0	bank	3.7	93.9	0.1	0.4	17.9	0.0	0.0	5.8	0.0
WHP	20	30	5	5	135	57.4	28.5	1.33	74.3	1.6	0.0	bank	6.9	178.2	0.2	0.3	14.0	0.0	0.0	3.9	0.0
WHP	20	30	5	7	196	59.9	31.1	1.33	78.7	2.4	0.0	bank	15.2	401.0	0.5	0.4	16.2	0.0	0.0	0.7	0.0
WHP	20	30	5	10	288	58.9	27.3	1.33	57.9	2.6	0.0	bank	11.5	299.9	0.4	0.6	23.7	0.0	0.0	3.2	0.0
RL	0.9	0	1	7	196	29.4	30.5	0.99	34.5	6.9	0.0	bank	1.8	44.3	0.0	0.4	17.4	0.0	0.1	21.6	0.0
RL	0.9	0	1	10	288	26.1	27.2	0.99	27.6	7.2	0.0	bank	1.4	36.8	0.0	0.5	21.6	0.0	0.6	83.4	0.0
RL	0.9	0	3	1	15	26.9	20.9	0.99	15.7	3.2	0.0	bank	0.7	18.7	0.0	0.4	15.0	0.0	0.3	49.7	0.0
RL	0.9	0	3	5	135	34.8	27.7	0.99	20.2	3.6	0.0	bank	1.3	33.8	0.0	0.3	11.5	0.0	0.3	51.6	0.0
RL	0.9	0	3	7	196	29.4	30.5	0.99	30.6	8.1	0.0	bank	1.7	44.1	0.0	0.4	16.8	0.0	0.1	22.2	0.0
RL	0.9	0	3	10	288	26.1	27.2	0.99	24.7	7.8	0.0	bank	1.4	36.5	0.0	0.5	21.0	0.0	0.6	82.8	0.0
RL	0.9	0	5	1	15	26.9	20.9	0.99	14.8	3.2	0.0	bank	0.7	18.5	0.0	0.4	14.9	0.0	0.3	49.0	0.0
RL	0.9	0	5	5	135	34.8	27.7	0.99	19.2	3.7	0.0	bank	1.3	33.5	0.0	0.3	11.4	0.0	0.3	51.0	0.0
RL	0.9	0	5	7	196	29.4	30.5	0.99	29.4	8.3	0.0	bank	1.7	44.0	0.0	0.4	16.6	0.0	0.1	22.0	0.0
RL	0.9	0	5	10	288	26.1	27.2	0.99	23.9	7.8	0.0	bank	1.4	36.4	0.0	0.5	20.8	0.0	0.6	82.0	0.0
RL	0.9	30	1	7	196	31.5	30.5	0.99	34.6	6.9	0.0	bank	2.1	51.9	0.0	0.4	17.1	0.0	0.1	24.6	0.0
RL	0.9	30	1	10	288	28.0	27.2	0.99	27.8	7.1	0.0	bank	1.4	35.4	0.0	0.6	22.4	0.0	0.5	80.8	0.0
RL	0.9	30	3	1	15	25.6	20.9	0.99	15.9	3.1	0.0	bank	0.7	19.6	0.0	0.4	14.6	0.0	0.3	51.5	0.0
RL	0.9	30	3	5	135	33.6	27.7	0.99	20.1	3.6	0.0	bank	1.3	33.3	0.0	0.3	11.1	0.0	0.4	62.7	0.0
RL	0.9	30	3	7	196	31.5	30.5	0.99	31.0	8.0	0.0	bank	2.1	51.6	0.0	0.4	16.5	0.0	0.1	25.0	0.0
RL	0.9	30	3	10	288	28.0	27.2	0.99	25.1	7.6	0.0	bank	1.4	35.1	0.0	0.6	21.8	0.0	0.5	80.2	0.0
RL	0.9	30	5	1	15	25.6	20.9	0.99	15.1	3.1	0.0	bank	0.7	19.5	0.0	0.4	14.6	0.0	0.3	50.8	0.0
RL	0.9	30	5	5	135	33.6	27.7	0.99	19.3	3.7	0.0	bank	1.3	33.1	0.0	0.3	11.0	0.0	0.4	61.9	0.0
RL	0.9	30	5	7	196	31.5	30.5	0.99	29.9	8.1	0.0	bank	2.0	51.5	0.0	0.4	16.3	0.0	0.1	24.9	0.0
RL	0.9	30	5	10	288	28.0	27.2	0.99	24.4	7.7	0.0	bank	1.4	35.0	0.0	0.5	21.6	0.0	0.5	79.5	0.0
RL	1	0	1	7	196	32.7	30.5	0.99	36.4	5.7	0.0	bank	2.3	57.8	0.0	0.4	17.0	0.0	0.1	23.1	0.0

Appendix Table A-1. Predictions for interior scenarios for throw-trap with 95% confidence intervals

Site	Salt Trmt	Lag	Year	Month	Julian Date	Salinity	Tempe r-ature	Depth	TSC	HSC	SSC	Habitat	Floridichthys	Floridichthys upper	Floridichthy s lower	Gobiosoma	Gobiosoma upper	Gobiosoma lower	Hippolyte	Hippolyte upper	Hippolyte lower
RL	1	0	1	10	288	29.0	27.2	0.99	30.0	6.2	0.0	bank	1.4	36.1	0.0	0.6	22.9	0.0	0.5	79.7	0.0
RL	1	0	3	1	15	29.8	20.9	0.99	18.5	2.6	0.0	bank	0.8	19.9	0.0	0.4	15.7	0.0	0.3	52.7	0.0
RL	1	0	3	5	135	38.7	27.7	0.99	23.8	2.7	0.0	bank	1.5	37.5	0.0	0.3	14.0	0.0	0.2	40.2	0.0
RL	1	0	3	7	196	32.7	30.5	0.99	36.4	5.7	0.0	bank	2.3	57.8	0.0	0.4	17.0	0.0	0.1	23.1	0.0
RL	1	0	3	10	288	29.0	27.2	0.99	30.0	6.2	0.0	bank	1.4	36.1	0.0	0.6	22.9	0.0	0.5	79.7	0.0
RL	1	0	5	1	15	29.8	20.9	0.99	18.5	2.6	0.0	bank	0.8	19.9	0.0	0.4	15.7	0.0	0.3	52.7	0.0
RL	1	0	5	5	135	38.7	27.7	0.99	23.8	2.7	0.0	bank	1.5	37.5	0.0	0.3	14.0	0.0	0.2	40.3	0.0
RL	1	0	5	7	196	32.7	30.5	0.99	36.4	5.7	0.0	bank	2.3	57.8	0.0	0.4	17.0	0.0	0.1	23.1	0.0
RL	1	0	5	10	288	29.0	27.2	0.99	30.1	6.2	0.0	bank	1.4	36.1	0.0	0.6	22.9	0.0	0.5	79.7	0.0
RL	1	30	1	7	196	34.9	30.5	0.99	36.4	5.6	0.0	bank	2.4	61.1	0.1	0.4	17.7	0.0	0.1	16.4	0.0
RL	1	30	1	10	288	31.1	27.2	0.99	30.3	6.0	0.0	bank	1.7	41.7	0.0	0.6	22.5	0.0	0.6	89.3	0.0
RL	1	30	3	1	15	28.5	20.9	0.99	18.8	2.5	0.0	bank	0.7	19.0	0.0	0.4	15.8	0.0	0.3	50.2	0.0
RL	1	30	3	5	135	37.4	27.7	0.99	23.8	2.8	0.0	bank	1.4	35.3	0.0	0.3	13.8	0.0	0.3	45.2	0.0
RL	1	30	3	7	196	34.9	30.5	0.99	36.9	5.5	0.0	bank	2.4	61.2	0.1	0.4	17.8	0.0	0.1	16.4	0.0
RL	1	30	3	10	288	31.1	27.2	0.99	30.7	5.9	0.0	bank	1.7	41.8	0.0	0.6	22.6	0.0	0.6	89.1	0.0
RL	1	30	5	1	15	28.5	20.9	0.99	19.0	2.5	0.0	bank	0.7	19.0	0.0	0.4	15.8	0.0	0.3	50.3	0.0
RL	1	30	5	5	135	37.4	27.7	0.99	23.9	2.8	0.0	bank	1.4	35.3	0.0	0.3	13.8	0.0	0.3	45.3	0.0
RL	1	30	5	7	196	34.9	30.5	0.99	37.1	5.5	0.0	bank	2.4	61.2	0.1	0.4	17.9	0.0	0.1	16.4	0.0
RL	1	30	5	10	288	31.1	27.2	0.99	30.8	5.9	0.0	bank	1.7	41.8	0.0	0.6	22.6	0.0	0.6	89.3	0.0
RL	1.1	0	1	7	196	36.0	30.5	0.99	38.3	4.4	0.0	bank	2.5	61.6	0.1	0.5	19.2	0.0	0.1	14.4	0.0
RL	1.1	0	1	10	288	31.8	27.2	0.99	32.7	5.0	0.0	bank	1.8	45.2	0.0	0.6	22.8	0.0	0.6	89.2	0.0
RL	1.1	0	3	1	15	32.8	20.9	0.99	21.6	2.0	0.0	bank	1.0	26.3	0.0	0.4	15.6	0.0	0.4	58.4	0.0
RL	1.1	0	3	5	135	42.5	27.7	0.99	27.6	1.7	0.0	bank	2.1	51.6	0.0	0.3	13.6	0.0	0.1	23.5	0.0
RL	1.1	0	3	7	196	36.0	30.5	0.99	42.3	3.4	0.0	bank	2.5	62.6	0.1	0.5	20.3	0.0	0.1	14.2	0.0
RL	1.1	0	3	10	288	31.8	27.2	0.99	35.9	4.2	0.0	bank	1.8	45.8	0.0	0.6	23.8	0.0	0.6	88.6	0.0
RL	1.1	0	5	1	15	32.8	20.9	0.99	22.8	1.9	0.0	bank	1.0	26.5	0.0	0.4	15.9	0.0	0.4	59.3	0.0
RL	1.1	0	5	5	135	42.5	27.7	0.99	28.9	1.7	0.0	bank	2.1	51.9	0.0	0.3	13.9	0.0	0.1	24.0	0.0
RL	1.1	0	5	7	196	36.0	30.5	0.99	43.9	3.3	0.0	bank	2.5	62.8	0.1	0.5	20.7	0.0	0.1	14.3	0.0
RL	1.1	0	5	10	288	31.8	27.2	0.99	37.0	4.2	0.0	bank	1.8	45.9	0.0	0.6	24.2	0.0	0.6	89.7	0.0
RL	1.1	30	1	7	196	38.4	30.5	0.99	38.2	4.3	0.0	bank	2.6	65.9	0.1	0.5	20.9	0.0	0.0	12.5	0.0
RL	1.1	30	1	10	288	34.2	27.2	0.99	33.1	4.8	0.0	bank	2.0	51.1	0.0	0.6	23.0	0.0	0.5	70.0	0.0
RL	1.1	30	3	1	15	31.3	20.9	0.99	22.0	1.8	0.0	bank	0.9	23.2	0.0	0.4	16.0	0.0	0.4	58.5	0.0
RL	1.1	30	3	5	135	41.1	27.7	0.99	27.9	1.8	0.0	bank	1.8	46.1	0.0	0.3	14.2	0.0	0.2	29.2	0.0
RL	1.1	30	3	7	196	38.4	30.5	0.99	43.0	3.1	0.0	bank	2.7	67.2	0.1	0.6	22.4	0.0	0.0	12.2	0.0
RL	1.1	30	3	10	288	34.2	27.2	0.99	36.9	3.8	0.0	bank	2.1	52.0	0.0	0.6	24.3	0.0	0.5	69.3	0.0
RL	1.1	30	5	1	15	31.3	20.9	0.99	23.5	1.7	0.0	bank	0.9	23.4	0.0	0.4	16.3	0.0	0.4	59.5	0.0
RL	1.1	30	5	5	135	41.1	27.7	0.99	29.5	1.7	0.0	bank	1.8	46.4	0.0	0.4	14.5	0.0	0.2	29.8	0.0
RL	1.1	30	5	7	196	38.4	30.5	0.99	45.0	3.0	0.0	bank	2.7	67.5	0.1	0.6	23.0	0.0	0.0	12.4	0.0
RL	1.1	30	5	10	288	34.2	27.2	0.99	38.3	3.7	0.0	bank	2.1	52.2	0.0	0.6	24.8	0.0	0.5	70.1	0.0
RL	1.3	0	1	7	196	42.5	30.5	0.99	39.9	3.0	0.0	bank	3.6	90.6	0.1	0.5	19.8	0.0	0.0	6.7	0.0
RL	1.3	0	1	10	288	37.6	27.2	0.99	36.6	2.9	0.0	bank	2.2	54.1	0.0	0.7	28.6	0.0	0.3	50.2	0.0
RL	1.3	0	3	1	15	38.8	20.9	0.99	26.3	0.7	0.0	bank	1.2	31.2	0.0	0.5	20.2	0.0	0.2	33.1	0.0
RL	1.3	0	3	5	135	50.3	27.7	0.99	33.0	0.5	0.0	bank	4.0	100.1	0.1	0.3	12.4	0.0	0.0	7.8	0.0
RL	1.3	0	3	7	196	42.5	30.5	0.99	50.0	0.9	0.0	bank	3.8	94.8	0.1	0.6	22.6	0.0	0.0	6.4	0.0
RL	1.3	0	3	10	288	37.6	27.2	0.99	44.4	1.0	0.0	bank	2.3	56.3	0.0	0.8	32.2	0.0	0.3	48.7	0.0
RL	1.3	0	5	1	15	38.8	20.9	0.99	29.6	0.4	0.0	bank	1.2	31.8	0.0	0.5	21.2	0.0	0.2	34.1	0.0
RL	1.3	0	5	5	135	50.3	27.7	0.99	37.1	0.3	0.0	bank	4.0	101.5	0.1	0.3	13.2	0.0	0.0	8.1	0.0

Appendix Table A-1. Predictions for interior scenarios for throw-trap with 95% confidence intervals

Site	Salt Trmt	Lag	Year	Month	Julian Date	Salinity	Temper-ature	Depth	TSC	HSC	SSC	Habitat	Floridichthys	Floridichthys upper	Floridichthys lower	Gobiosoma	Gobiosoma upper	Gobiosoma lower	Hippolyte	Hippolyte upper	Hippolyte lower
RL	1.3	0	5	7	196	42.5	30.5	0.99	54.8	0.5	0.0	bank	3.8	95.8	0.1	0.6	23.6	0.0	0.0	6.5	0.0
RL	1.3	0	5	10	288	37.6	27.2	0.99	48.0	0.6	0.0	bank	2.3	57.0	0.0	0.9	33.7	0.0	0.3	49.0	0.0
RL	1.3	30	1	7	196	45.4	30.5	0.99	39.3	3.1	0.0	bank	4.6	114.3	0.1	0.5	18.3	0.0	0.0	4.3	0.0
RL	1.3	30	1	10	288	40.4	27.2	0.99	36.6	2.8	0.0	bank	2.6	64.4	0.1	0.7	28.1	0.0	0.2	36.2	0.0
RL	1.3	30	3	1	15	37.0	20.9	0.99	26.4	0.7	0.0	bank	1.1	28.9	0.0	0.5	19.6	0.0	0.2	38.1	0.0
RL	1.3	30	3	5	135	48.6	27.7	0.99	33.5	0.5	0.0	bank	3.5	87.4	0.1	0.3	13.0	0.0	0.0	9.9	0.0
RL	1.3	30	3	7	196	45.4	30.5	0.99	49.7	0.9	0.0	bank	4.8	119.8	0.1	0.5	21.1	0.0	0.0	4.2	0.0
RL	1.3	30	3	10	288	40.4	27.2	0.99	44.6	0.9	0.0	bank	2.7	67.2	0.1	0.8	31.8	0.0	0.2	35.1	0.0
RL	1.3	30	5	1	15	37.0	20.9	0.99	29.8	0.3	0.0	bank	1.2	29.5	0.0	0.5	20.6	0.0	0.2	39.2	0.0
RL	1.3	30	5	5	135	48.6	27.7	0.99	37.6	0.3	0.0	bank	3.5	88.7	0.1	0.3	13.8	0.0	0.0	10.3	0.0
RL	1.3	30	5	7	196	45.4	30.5	0.99	54.6	0.4	0.0	bank	4.9	121.2	0.1	0.6	22.0	0.0	0.0	4.2	0.0
RL	1.3	30	5	10	288	40.4	27.2	0.99	48.3	0.5	0.0	bank	2.7	67.9	0.1	0.9	33.3	0.0	0.2	35.4	0.0
RL	10	0	1	7	196	42.7	30.5	0.99	40.1	2.9	0.0	bank	3.7	92.1	0.1	0.5	19.8	0.0	0.0	6.5	0.0
RL	10	0	1	10	288	39.0	27.2	0.99	36.9	2.7	0.0	bank	2.3	58.1	0.0	0.8	29.0	0.0	0.3	43.9	0.0
RL	10	0	3	1	15	39.8	20.9	0.99	26.6	0.6	0.0	bank	1.3	33.7	0.0	0.5	20.1	0.0	0.2	28.9	0.0
RL	10	0	3	5	135	48.7	27.7	0.99	33.7	0.4	0.0	bank	3.5	88.1	0.1	0.3	13.0	0.0	0.0	9.8	0.0
RL	10	0	3	7	196	42.7	30.5	0.99	50.7	0.7	0.0	bank	3.9	96.5	0.1	0.6	22.7	0.0	0.0	6.2	0.0
RL	10	0	3	10	288	39.0	27.2	0.99	45.0	0.8	0.0	bank	2.4	60.6	0.1	0.9	32.8	0.0	0.3	42.6	0.0
RL	10	0	5	1	15	39.8	20.9	0.99	30.0	0.2	0.0	bank	1.3	34.3	0.0	0.5	21.1	0.0	0.2	29.9	0.0
RL	10	0	5	5	135	48.7	27.7	0.99	37.8	0.2	0.0	bank	3.6	89.2	0.1	0.3	13.9	0.0	0.0	10.2	0.0
RL	10	0	5	7	196	42.7	30.5	0.99	55.6	0.3	0.0	bank	3.9	97.6	0.1	0.6	23.6	0.0	0.0	6.3	0.0
RL	10	0	5	10	288	39.0	27.2	0.99	48.6	0.4	0.0	bank	2.5	61.3	0.1	0.9	34.3	0.0	0.3	42.9	0.0
RL	10	30	1	7	196	44.9	30.5	0.99	39.8	2.9	0.0	bank	4.4	110.2	0.1	0.5	18.6	0.0	0.0	4.7	0.0
RL	10	30	1	10	288	41.1	27.2	0.99	36.9	2.6	0.0	bank	2.7	68.1	0.1	0.7	27.8	0.0	0.2	32.6	0.0
RL	10	30	3	1	15	38.5	20.9	0.99	26.7	0.6	0.0	bank	1.2	30.8	0.0	0.5	20.4	0.0	0.2	34.2	0.0
RL	10	30	3	5	135	47.4	27.7	0.99	33.9	0.4	0.0	bank	3.2	79.4	0.1	0.3	13.4	0.0	0.0	11.8	0.0
RL	10	30	3	7	196	44.9	30.5	0.99	50.5	0.7	0.0	bank	4.6	115.6	0.1	0.5	21.5	0.0	0.0	4.5	0.0
RL	10	30	3	10	288	41.1	27.2	0.99	45.1	0.7	0.0	bank	2.9	71.1	0.1	0.8	31.5	0.0	0.2	31.6	0.0
RL	10	30	5	1	15	38.5	20.9	0.99	30.2	0.2	0.0	bank	1.2	31.3	0.0	0.5	21.4	0.0	0.2	35.3	0.0
RL	10	30	5	5	135	47.4	27.7	0.99	38.2	0.2	0.0	bank	3.2	80.5	0.1	0.3	14.3	0.0	0.0	12.3	0.0
RL	10	30	5	7	196	44.9	30.5	0.99	55.5	0.3	0.0	bank	4.7	116.9	0.1	0.6	22.4	0.0	0.0	4.5	0.0
RL	10	30	5	10	288	41.1	27.2	0.99	48.8	0.3	0.0	bank	2.9	71.9	0.1	0.9	33.0	0.0	0.2	31.9	0.0
RL	20	0	1	7	196	52.7	30.5	0.99	31.7	5.2	0.0	bank	7.9	200.5	0.3	0.3	14.0	0.0	0.0	1.6	0.0
RL	20	0	1	10	288	49.0	27.2	0.99	32.0	4.8	0.0	bank	4.9	124.1	0.2	0.5	21.5	0.0	0.0	11.4	0.0
RL	20	0	3	1	15	49.8	20.9	0.99	23.1	1.6	0.0	bank	2.9	73.1	0.1	0.4	15.1	0.0	0.0	6.9	0.0
RL	20	0	3	5	135	58.7	27.7	0.99	25.6	1.6	0.0	bank	7.4	194.8	0.2	0.2	9.4	0.0	0.0	2.3	0.0
RL	20	0	3	7	196	52.7	30.5	0.99	38.7	3.6	0.0	bank	8.1	206.2	0.3	0.4	15.5	0.0	0.0	1.6	0.0
RL	20	0	3	10	288	49.0	27.2	0.99	37.1	3.6	0.0	bank	5.1	126.9	0.2	0.6	23.2	0.0	0.0	11.3	0.0
RL	20	0	5	1	15	49.8	20.9	0.99	25.1	1.4	0.0	bank	2.9	74.0	0.1	0.4	15.5	0.0	0.0	7.0	0.0
RL	20	0	5	5	135	58.7	27.7	0.99	27.7	1.4	0.0	bank	7.5	196.9	0.2	0.2	9.7	0.0	0.0	2.3	0.0
RL	20	0	5	7	196	52.7	30.5	0.99	41.4	3.3	0.0	bank	8.2	207.8	0.3	0.4	16.1	0.0	0.0	1.6	0.0
RL	20	0	5	10	288	49.0	27.2	0.99	39.1	3.4	0.0	bank	5.1	127.6	0.2	0.6	23.9	0.0	0.0	11.4	0.0
RL	20	30	1	7	196	54.9	30.5	0.99	30.2	5.0	0.0	bank	9.4	241.2	0.3	0.3	13.1	0.0	0.0	1.1	0.0
RL	20	30	1	10	288	51.1	27.2	0.99	31.0	5.1	0.0	bank	5.8	147.3	0.2	0.5	20.3	0.0	0.0	8.4	0.0
RL	20	30	3	1	15	48.5	20.9	0.99	22.5	1.8	0.0	bank	2.6	64.8	0.1	0.4	15.5	0.0	0.0	8.4	0.0
RL	20	30	3	5	135	57.4	27.7	0.99	26.9	1.6	0.0	bank	6.7	175.4	0.2	0.2	9.8	0.0	0.0	2.8	0.0
RL	20	30	3	7	196	54.9	30.5	0.99	36.0	3.9	0.0	bank	9.6	246.9	0.3	0.3	14.2	0.0	0.0	1.1	0.0

Appendix Table A-1. Predictions for interior scenarios for throw-trap with 95% confidence intervals

Site	Salt Trmt	Lag	Year	Month	Julian Date	Salinity	Temper-ature	Depth	TSC	HSC	SSC	Habitat	Floridichthys	Floridichthys upper	Floridichthys lower	Gobiosoma	Gobiosoma upper	Gobiosoma lower	Hippolyte	Hippolyte upper	Hippolyte lower
RL	20	30	3	10	288	51.1	27.2	0.99	35.3	4.2	0.0	bank	5.9	149.9	0.2	0.5	21.6	0.0	0.0	8.4	0.0
RL	20	30	5	1	15	48.5	20.9	0.99	24.1	1.6	0.0	bank	2.6	65.5	0.1	0.4	15.8	0.0	0.0	8.6	0.0
RL	20	30	5	5	135	57.4	27.7	0.99	28.6	1.5	0.0	bank	6.8	176.8	0.2	0.2	10.0	0.0	0.0	2.9	0.0
RL	20	30	5	7	196	54.9	30.5	0.99	37.9	3.7	0.0	bank	9.7	248.4	0.3	0.3	14.6	0.0	0.0	1.1	0.0
RL	20	30	5	10	288	51.1	27.2	0.99	36.8	4.1	0.0	bank	6.0	150.6	0.2	0.5	22.0	0.0	0.0	8.5	0.0

Appendix Table A-1

Site	Salt Trmt	Lag	Lucania	Lucania upper	Lucania lower	Opsanus	Opsanus upper	Opsanus lower	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Sscovelli	Sscovelli upper	Sscovelli lower	Thor	Thor upper	Thor lower	all species	All species upper	All species lower
WHP	0.9	0	5.1	67.6	0.0	1.7	5.6	-0.2	1.5	14.2	-0.2	0.3	1.8	-0.7	84	2052	2	95	2263	1
WHP	0.9	0	1.7	26.7	-0.3	1.2	4.5	-0.5	2.6	22.3	-0.1	0.1	1.6	-0.8	49	1222	0	56	1451	-1
WHP	0.9	0	1.2	20.0	-0.4	0.9	3.9	-0.6	0.9	9.7	-0.3	0.1	1.5	-0.8	38	954	0	42	1067	-2
WHP	0.9	0	1.5	24.1	-0.3	1.5	5.2	-0.3	0.2	4.5	-0.4	0.5	2.2	-0.5	34	847	-1	39	1001	-2
WHP	0.9	0	4.3	58.1	-0.1	1.6	5.4	-0.3	1.6	14.6	-0.2	0.4	1.9	-0.6	63	1560	1	73	1750	0
WHP	0.9	0	1.9	28.2	-0.3	1.1	4.5	-0.5	2.7	22.6	-0.1	0.2	1.7	-0.7	47	1176	0	54	1391	-2
WHP	0.9	0	1.3	21.5	-0.4	0.8	3.8	-0.6	0.9	9.5	-0.3	0.1	1.6	-0.8	38	949	0	41	1060	-2
WHP	0.9	0	1.8	27.4	-0.3	1.5	5.2	-0.3	0.2	4.6	-0.4	0.6	2.3	-0.5	37	918	0	43	1073	-2
WHP	0.9	0	4.7	62.2	-0.1	1.5	5.3	-0.3	1.5	14.0	-0.2	0.4	2.0	-0.6	60	1476	1	70	1660	0
WHP	0.9	0	2.0	30.2	-0.3	1.1	4.4	-0.5	2.7	22.4	-0.1	0.2	1.7	-0.7	48	1190	0	54	1399	-1
WHP	0.9	30	5.1	67.1	0.0	1.7	5.5	-0.2	1.5	14.0	-0.2	0.3	1.8	-0.7	75	1828	1	85	2036	0
WHP	0.9	30	2.1	31.4	-0.3	1.2	4.5	-0.5	2.3	19.6	-0.1	0.1	1.5	-0.8	43	1082	0	50	1296	-2
WHP	0.9	30	1.2	19.8	-0.4	0.9	3.9	-0.6	0.9	9.6	-0.3	0.1	1.5	-0.8	37	932	0	41	1044	-2
WHP	0.9	30	1.6	24.5	-0.3	1.5	5.3	-0.3	0.2	4.9	-0.4	0.6	2.3	-0.5	47	1155	0	52	1335	-1
WHP	0.9	30	4.4	58.7	-0.1	1.6	5.3	-0.3	1.5	14.2	-0.2	0.4	1.9	-0.6	56	1390	0	66	1576	-1
WHP	0.9	30	2.3	33.6	-0.3	1.2	4.5	-0.5	2.3	19.9	-0.1	0.2	1.7	-0.7	42	1046	0	49	1248	-2
WHP	0.9	30	1.3	21.3	-0.4	0.8	3.8	-0.6	0.9	9.5	-0.3	0.1	1.6	-0.8	37	929	0	41	1038	-2
WHP	0.9	30	1.8	27.5	-0.3	1.5	5.3	-0.3	0.3	5.1	-0.4	0.7	2.4	-0.4	50	1240	0	56	1420	-1
WHP	0.9	30	4.7	62.6	-0.1	1.5	5.2	-0.3	1.5	13.7	-0.2	0.4	2.0	-0.6	54	1328	0	63	1510	-1
WHP	0.9	30	2.5	35.8	-0.3	1.1	4.5	-0.5	2.3	19.7	-0.1	0.2	1.7	-0.7	42	1058	0	49	1256	-2
WHP	1	0	6.9	89.4	0.1	1.7	5.6	-0.2	1.3	12.7	-0.3	0.2	1.7	-0.7	92	2238	2	104	2467	1
WHP	1	0	2.3	33.1	-0.3	1.2	4.5	-0.5	2.4	20.3	-0.1	0.1	1.5	-0.8	57	1395	0	64	1631	-1
WHP	1	0	1.6	25.4	-0.3	0.9	4.0	-0.6	1.0	10.1	-0.3	0.0	1.4	-0.9	58	1432	1	62	1570	-1
WHP	1	0	2.7	38.4	-0.2	1.8	5.7	-0.2	0.0	3.4	-0.4	0.4	2.0	-0.6	51	1257	0	58	1407	-1
WHP	1	0	6.9	89.4	0.1	1.7	5.6	-0.2	1.3	12.7	-0.3	0.2	1.7	-0.7	92	2237	2	104	2467	1
WHP	1	0	2.3	33.1	-0.3	1.2	4.5	-0.5	2.4	20.3	-0.1	0.1	1.5	-0.8	57	1394	0	64	1631	-1
WHP	1	0	1.6	25.4	-0.3	0.9	4.0	-0.6	1.0	10.1	-0.3	0.0	1.4	-0.9	58	1432	1	62	1570	-1
WHP	1	0	2.7	38.4	-0.2	1.8	5.7	-0.2	0.0	3.4	-0.4	0.4	2.0	-0.6	51	1257	0	58	1408	-1
WHP	1	0	6.9	89.4	0.1	1.7	5.6	-0.2	1.3	12.7	-0.3	0.2	1.7	-0.7	92	2238	2	104	2467	1
WHP	1	0	2.3	33.1	-0.3	1.2	4.5	-0.5	2.4	20.3	-0.1	0.1	1.5	-0.8	57	1394	0	64	1631	-1
WHP	1	30	8.4	107.0	0.2	1.8	5.9	-0.1	1.2	12.0	-0.3	0.2	1.7	-0.7	107	2611	3	122	2860	2
WHP	1	30	3.0	42.5	-0.2	1.2	4.6	-0.5	2.0	17.7	-0.2	0.0	1.4	-0.8	51	1267	0	59	1478	-1
WHP	1	30	1.6	24.9	-0.3	0.9	3.9	-0.6	1.0	10.1	-0.3	0.0	1.4	-0.9	57	1411	0	61	1547	-1
WHP	1	30	1.5	24.2	-0.3	1.4	5.1	-0.3	0.1	4.0	-0.4	0.4	2.0	-0.6	34	856	0	40	1008	-2
WHP	1	30	8.2	105.5	0.2	1.8	5.9	-0.1	1.2	12.0	-0.3	0.2	1.7	-0.7	105	2563	2	120	2810	2
WHP	1	30	3.0	42.2	-0.2	1.2	4.6	-0.5	2.0	17.7	-0.2	0.0	1.4	-0.8	51	1254	0	58	1464	-1
WHP	1	30	1.6	24.9	-0.3	0.9	3.9	-0.6	1.0	10.1	-0.3	0.0	1.4	-0.9	57	1409	0	61	1545	-1
WHP	1	30	1.5	24.2	-0.3	1.4	5.1	-0.3	0.1	4.0	-0.4	0.4	2.0	-0.6	34	855	0	39	1006	-2
WHP	1	30	8.2	105.3	0.2	1.8	5.9	-0.1	1.2	12.0	-0.3	0.2	1.7	-0.7	105	2557	2	120	2804	2
WHP	1	30	3.0	42.2	-0.2	1.2	4.6	-0.5	2.0	17.7	-0.2	0.0	1.4	-0.8	51	1252	0	58	1462	-1
WHP	1.1	0	13.7	172.1	0.7	2.2	6.7	0.0	0.8	9.1	-0.3	0.2	1.7	-0.7	155	3751	5	176	4070	5
WHP	1.1	0	2.5	35.8	-0.3	1.1	4.3	-0.5	2.0	17.5	-0.2	0.0	1.4	-0.9	44	1099	0	51	1307	-2
WHP	1.1	0	1.7	25.8	-0.3	0.9	4.0	-0.6	0.8	8.8	-0.3	0.0	1.4	-0.9	42	1051	0	46	1173	-2
WHP	1.1	0	6.6	85.8	0.1	2.5	7.3	0.2	-0.1	2.4	-0.4	0.4	2.0	-0.6	108	2635	3	121	2829	2
WHP	1.1	0	15.6	194.7	0.8	2.2	6.7	0.1	0.8	8.8	-0.3	0.2	1.7	-0.7	175	4233	5	198	4576	6
WHP	1.1	0	2.8	39.4	-0.2	1.1	4.4	-0.5	2.0	17.7	-0.2	0.0	1.4	-0.8	51	1250	0	58	1470	-1
WHP	1.1	0	1.7	26.1	-0.3	0.9	4.1	-0.6	0.8	8.9	-0.3	0.0	1.4	-0.9	43	1074	0	47	1199	-2

Appendix Table A-1

Site	Salt Trmt	Lag	Lucania	Lucania upper	Lucania lower	Opsanus	Opsanus upper	Opsanus lower	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Sscovelli	Sscovelli upper	Sscovelli lower	Thor	Thor upper	Thor lower	all species	All species upper	All species lower
WHP	1.1	0	6.8	87.9	0.1	2.5	7.3	0.2	-0.1	2.4	-0.4	0.4	2.0	-0.6	112	2731	3	125	2928	2
WHP	1.1	0	16.0	199.5	0.9	2.3	6.8	0.1	0.8	9.0	-0.3	0.2	1.7	-0.7	182	4394	6	205	4743	6
WHP	1.1	0	2.8	40.0	-0.2	1.1	4.4	-0.5	2.0	18.0	-0.1	0.1	1.4	-0.8	52	1282	0	60	1505	-1
WHP	1.1	30	17.4	216.1	1.0	2.5	7.2	0.2	0.7	8.6	-0.3	0.2	1.7	-0.7	192	4626	6	217	4998	7
WHP	1.1	30	6.4	83.4	0.1	1.7	5.6	-0.2	1.4	13.2	-0.2	0.0	1.4	-0.8	92	2238	2	104	2474	1
WHP	1.1	30	1.6	25.4	-0.3	0.9	4.1	-0.6	0.8	8.8	-0.3	0.0	1.4	-0.9	42	1041	0	46	1163	-2
WHP	1.1	30	3.3	45.9	-0.2	1.9	6.0	-0.1	0.0	3.2	-0.4	0.4	2.0	-0.6	62	1527	1	70	1686	0
WHP	1.1	30	19.5	241.8	1.1	2.5	7.3	0.2	0.7	8.3	-0.3	0.3	1.7	-0.7	214	5159	7	241	5557	8
WHP	1.1	30	7.0	90.4	0.1	1.8	5.7	-0.2	1.4	13.3	-0.2	0.1	1.4	-0.8	103	2494	2	116	2741	1
WHP	1.1	30	1.7	25.7	-0.3	0.9	4.1	-0.6	0.8	8.8	-0.3	0.0	1.4	-0.9	43	1063	0	47	1186	-2
WHP	1.1	30	3.4	47.0	-0.2	1.9	6.0	-0.1	0.0	3.2	-0.4	0.4	2.0	-0.6	64	1582	1	73	1744	0
WHP	1.1	30	20.0	247.8	1.2	2.5	7.3	0.2	0.7	8.4	-0.3	0.3	1.8	-0.7	222	5340	7	249	5745	8
WHP	1.1	30	7.1	91.8	0.1	1.8	5.7	-0.2	1.4	13.4	-0.2	0.1	1.4	-0.8	105	2555	2	118	2805	2
WHP	1.3	0	49.2	609.9	3.6	3.6	9.6	0.7	0.2	4.4	-0.4	0.2	1.7	-0.7	402	9800	15	463	10615	18
WHP	1.3	0	8.5	108.6	0.2	1.9	5.9	-0.1	1.1	10.8	-0.3	0.0	1.4	-0.9	114	2761	3	128	3018	2
WHP	1.3	0	5.4	71.6	0.0	1.6	5.3	-0.3	0.5	6.9	-0.4	0.0	1.3	-0.9	114	2779	3	124	2943	2
WHP	1.3	0	38.8	484.7	2.7	4.7	12.0	1.3	-0.3	1.2	-0.5	0.5	2.2	-0.5	554	13558	21	603	14197	24
WHP	1.3	0	60.1	743.4	4.4	3.9	10.1	0.8	0.1	4.0	-0.4	0.2	1.7	-0.7	475	11551	18	546	12502	22
WHP	1.3	0	11.4	144.0	0.5	2.0	6.3	-0.1	1.1	10.8	-0.3	0.1	1.4	-0.8	159	3843	5	177	4143	4
WHP	1.3	0	6.1	79.9	0.0	1.6	5.4	-0.3	0.5	7.1	-0.4	0.0	1.4	-0.9	132	3204	4	142	3381	2
WHP	1.3	0	42.9	534.9	3.0	4.8	12.1	1.3	-0.3	1.3	-0.5	0.6	2.2	-0.5	617	15096	23	670	15786	27
WHP	1.3	0	62.5	771.7	4.6	4.0	10.3	0.9	0.2	4.4	-0.4	0.3	1.8	-0.7	500	12158	19	574	13137	24
WHP	1.3	0	12.3	154.0	0.6	2.1	6.4	0.0	1.2	11.7	-0.3	0.1	1.5	-0.8	177	4257	5	195	4575	5
WHP	1.3	30	64.9	805.5	4.8	4.0	10.5	0.9	0.1	4.1	-0.4	0.2	1.7	-0.7	515	12604	19	592	13640	24
WHP	1.3	30	27.2	339.8	1.8	3.1	8.6	0.5	0.5	7.1	-0.4	0.1	1.5	-0.8	303	7397	11	340	7924	12
WHP	1.3	30	5.0	66.3	0.0	1.5	5.2	-0.3	0.5	7.0	-0.4	0.0	1.3	-0.9	106	2568	3	114	2726	1
WHP	1.3	30	18.8	234.5	1.1	3.6	9.6	0.7	-0.2	1.7	-0.5	0.5	2.1	-0.6	295	7141	10	322	7501	12
WHP	1.3	30	80.3	995.4	6.1	4.3	11.0	1.0	0.1	3.7	-0.4	0.3	1.8	-0.7	615	15043	23	708	16270	30
WHP	1.3	30	36.4	452.3	2.5	3.3	9.0	0.6	0.5	7.0	-0.4	0.1	1.5	-0.8	427	10397	16	474	11044	18
WHP	1.3	30	5.6	73.5	0.0	1.5	5.3	-0.3	0.6	7.2	-0.4	0.0	1.4	-0.9	121	2939	3	131	3110	2
WHP	1.3	30	20.8	258.7	1.2	3.7	9.7	0.8	-0.2	1.8	-0.5	0.5	2.2	-0.5	330	7973	12	358	8359	13
WHP	1.3	30	84.3	1044.4	6.4	4.4	11.2	1.1	0.1	4.0	-0.4	0.3	1.8	-0.7	659	16122	25	756	17400	32
WHP	1.3	30	38.9	483.1	2.7	3.4	9.2	0.6	0.6	7.6	-0.3	0.1	1.6	-0.8	472	11492	18	521	12174	20
WHP	10	0	38.9	481.3	2.7	3.3	8.9	0.6	0.3	5.0	-0.4	0.2	1.7	-0.7	336	8155	12	385	8823	15
WHP	10	0	8.4	106.7	0.2	1.8	5.9	-0.1	1.1	11.1	-0.3	0.0	1.4	-0.9	113	2731	3	127	2987	2
WHP	10	0	5.6	73.4	0.0	1.6	5.4	-0.3	0.5	6.7	-0.4	0.0	1.3	-0.9	116	2807	3	125	2972	2
WHP	10	0	26.2	327.0	1.7	4.1	10.6	1.0	-0.2	1.4	-0.5	0.5	2.2	-0.6	392	9535	14	427	9998	16
WHP	10	0	46.2	569.5	3.3	3.5	9.3	0.7	0.2	4.5	-0.4	0.2	1.7	-0.7	379	9184	14	435	9940	17
WHP	10	0	11.1	140.6	0.5	2.0	6.2	-0.1	1.1	11.0	-0.3	0.1	1.4	-0.8	156	3768	5	174	4065	4
WHP	10	0	6.2	81.0	0.1	1.6	5.5	-0.2	0.5	7.0	-0.4	0.0	1.4	-0.9	132	3194	4	142	3372	2
WHP	10	0	28.9	359.9	1.9	4.2	10.8	1.0	-0.2	1.5	-0.5	0.5	2.2	-0.5	437	10609	16	474	11108	19
WHP	10	0	48.3	595.5	3.5	3.6	9.5	0.7	0.2	4.9	-0.4	0.3	1.8	-0.7	405	9825	15	464	10608	18
WHP	10	0	12.0	150.4	0.5	2.0	6.3	0.0	1.2	12.0	-0.3	0.1	1.5	-0.8	174	4200	5	193	4516	5
WHP	10	30	48.3	597.7	3.5	3.6	9.6	0.7	0.2	4.8	-0.4	0.2	1.7	-0.7	409	9962	15	469	10765	19
WHP	10	30	20.5	256.5	1.2	2.8	7.9	0.3	0.7	8.0	-0.3	0.1	1.5	-0.8	240	5833	8	269	6262	9
WHP	10	30	5.2	69.1	0.0	1.5	5.3	-0.3	0.5	6.8	-0.4	0.0	1.3	-0.9	108	2638	3	117	2798	1
WHP	10	30	14.8	185.0	0.8	3.3	9.0	0.6	-0.2	1.9	-0.5	0.5	2.1	-0.6	238	5748	8	260	6053	9

Appendix Table A-1

Site	Salt Trmt	Lag	Lucania	Lucania upper	Lucania lower	Opsanus	Opsanus upper	Opsanus lower	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Sscovelli	Sscovelli upper	Sscovelli lower	Thor	Thor upper	Thor lower	all species	All species upper	All species lower
WHP	10	30	57.8	714.1	4.3	3.8	9.9	0.8	0.1	4.2	-0.4	0.2	1.7	-0.7	464	11290	17	533	12207	22
WHP	10	30	27.3	338.4	1.8	3.0	8.3	0.4	0.7	7.9	-0.3	0.1	1.5	-0.8	334	8088	12	370	8606	13
WHP	10	30	5.8	75.8	0.0	1.6	5.4	-0.3	0.5	7.1	-0.4	0.0	1.4	-0.9	123	2984	3	133	3156	2
WHP	10	30	16.3	204.0	0.9	3.4	9.1	0.6	-0.2	1.9	-0.5	0.5	2.1	-0.5	266	6433	9	290	6759	10
WHP	10	30	60.8	751.1	4.5	3.9	10.2	0.8	0.2	4.6	-0.4	0.3	1.8	-0.7	502	12201	19	574	13157	24
WHP	10	30	29.1	361.1	1.9	3.0	8.4	0.4	0.7	8.6	-0.3	0.1	1.6	-0.8	370	8971	13	409	9518	15
WHP	20	0	143.3	1827.4	10.8	5.6	13.9	1.7	-0.2	2.1	-0.5	0.2	1.7	-0.8	841	21363	31	1003	23558	43
WHP	20	0	39.7	498.2	2.7	3.8	10.0	0.8	0.3	5.2	-0.4	0.1	1.5	-0.8	388	9579	14	439	10299	17
WHP	20	0	33.9	425.6	2.3	3.6	9.6	0.7	0.0	3.4	-0.4	0.1	1.5	-0.8	546	13444	20	588	13997	22
WHP	20	0	154.8	1985.0	11.6	7.6	18.1	2.6	-0.4	0.6	-0.5	0.6	2.3	-0.5	1888	48285	72	2060	50540	86
WHP	20	0	247.3	3145.4	19.0	6.4	15.6	2.0	-0.2	2.1	-0.5	0.3	1.8	-0.7	1654	41934	63	1922	45476	84
WHP	20	0	59.3	740.5	4.3	4.2	10.8	1.0	0.3	5.3	-0.4	0.1	1.5	-0.8	651	16040	25	723	17018	29
WHP	20	0	39.6	495.2	2.7	3.7	9.8	0.7	0.0	3.5	-0.4	0.1	1.5	-0.8	670	16465	25	717	17091	28
WHP	20	0	176.0	2255.2	13.3	7.9	18.7	2.7	-0.4	0.6	-0.5	0.6	2.4	-0.5	2157	55150	83	2351	57677	98
WHP	20	0	252.8	3213.0	19.5	6.6	16.0	2.1	-0.1	2.1	-0.5	0.3	1.8	-0.7	1649	41767	63	1923	45375	85
WHP	20	0	64.5	804.1	4.7	4.2	10.9	1.0	0.3	5.5	-0.4	0.1	1.6	-0.8	712	17516	27	789	18558	32
WHP	20	30	186.0	2386.9	14.1	6.1	15.0	1.9	-0.2	1.9	-0.5	0.2	1.7	-0.8	1075	27553	40	1282	30349	56
WHP	20	30	97.3	1242.2	7.2	5.2	13.1	1.5	0.1	3.8	-0.4	0.1	1.5	-0.8	844	21425	31	958	22989	39
WHP	20	30	31.3	393.6	2.1	3.5	9.4	0.7	0.0	3.5	-0.4	0.1	1.5	-0.8	501	12321	19	540	12839	20
WHP	20	30	95.5	1205.9	7.1	6.5	15.6	2.1	-0.3	0.8	-0.5	0.6	2.3	-0.5	1258	31514	48	1368	32934	57
WHP	20	30	308.8	3954.7	23.7	6.9	16.7	2.3	-0.2	1.9	-0.5	0.3	1.8	-0.7	2007	51319	77	2338	55714	102
WHP	20	30	142.5	1815.0	10.8	5.7	14.0	1.7	0.1	3.8	-0.4	0.1	1.6	-0.8	1388	35180	53	1548	37339	65
WHP	20	30	36.2	453.4	2.5	3.6	9.6	0.7	0.0	3.5	-0.4	0.1	1.5	-0.8	608	14949	23	652	15531	25
WHP	20	30	103.9	1311.5	7.8	6.7	16.1	2.2	-0.3	0.8	-0.5	0.6	2.3	-0.5	1350	33777	52	1468	35303	62
WHP	20	30	315.9	4042.1	24.3	7.1	17.0	2.3	-0.2	2.0	-0.5	0.3	1.9	-0.7	2000	51095	76	2339	55574	103
WHP	20	30	155.7	1980.8	11.8	5.8	14.2	1.7	0.1	3.9	-0.4	0.2	1.6	-0.8	1525	38628	58	1699	40951	71
RL	0.9	0	2.7	37.8	-0.2	1.3	4.8	-0.4	0.8	9.2	-0.3	0.1	1.6	-0.8	42	1056	0	49	1184	-2
RL	0.9	0	1.2	20.1	-0.4	1.0	4.2	-0.5	1.7	15.8	-0.2	0.1	1.5	-0.8	27	699	-1	32	866	-3
RL	0.9	0	1.0	17.6	-0.4	0.9	4.0	-0.6	0.8	8.8	-0.3	0.1	1.4	-0.8	33	838	-1	37	944	-2
RL	0.9	0	1.0	18.1	-0.4	1.4	5.1	-0.3	0.0	3.0	-0.4	0.4	2.0	-0.6	25	644	-1	30	766	-2
RL	0.9	0	2.5	36.0	-0.3	1.3	4.8	-0.4	0.9	9.5	-0.3	0.1	1.6	-0.8	40	997	0	46	1123	-2
RL	0.9	0	1.1	19.5	-0.4	1.0	4.2	-0.5	1.8	15.9	-0.2	0.1	1.5	-0.8	26	668	-1	31	833	-3
RL	0.9	0	1.0	17.6	-0.4	0.9	4.0	-0.6	0.8	8.7	-0.3	0.1	1.5	-0.8	33	828	-1	36	933	-2
RL	0.9	0	1.0	18.0	-0.4	1.4	5.0	-0.3	0.0	3.0	-0.4	0.4	2.0	-0.6	25	633	-1	29	754	-2
RL	0.9	0	2.5	35.4	-0.3	1.3	4.8	-0.4	0.9	9.5	-0.3	0.1	1.6	-0.8	39	974	0	45	1099	-2
RL	0.9	0	1.1	19.3	-0.4	1.0	4.2	-0.5	1.8	15.9	-0.2	0.1	1.5	-0.8	26	658	-1	30	822	-3
RL	0.9	30	3.3	45.2	-0.2	1.3	4.8	-0.4	0.9	9.5	-0.3	0.1	1.5	-0.8	56	1389	0	63	1534	-1
RL	0.9	30	1.2	20.5	-0.4	1.0	4.2	-0.5	1.8	16.3	-0.2	0.0	1.4	-0.8	29	736	-1	34	900	-3
RL	0.9	30	1.0	17.7	-0.4	0.9	4.0	-0.6	0.7	8.6	-0.3	0.1	1.5	-0.8	33	833	-1	36	942	-2
RL	0.9	30	1.1	18.6	-0.4	1.4	5.0	-0.3	0.0	3.3	-0.4	0.4	2.0	-0.6	31	790	-1	36	923	-2
RL	0.9	30	3.1	43.0	-0.2	1.3	4.7	-0.4	0.9	9.8	-0.3	0.1	1.5	-0.8	53	1312	0	60	1455	-1
RL	0.9	30	1.2	19.9	-0.4	1.0	4.2	-0.5	1.8	16.4	-0.2	0.1	1.4	-0.8	28	704	-1	32	867	-3
RL	0.9	30	1.0	17.7	-0.4	0.9	4.0	-0.6	0.7	8.5	-0.3	0.1	1.5	-0.8	33	824	-1	36	932	-2
RL	0.9	30	1.1	18.5	-0.4	1.4	5.0	-0.4	0.0	3.3	-0.4	0.4	2.0	-0.6	31	778	-1	36	910	-2
RL	0.9	30	3.0	42.4	-0.2	1.3	4.7	-0.4	0.9	9.8	-0.3	0.1	1.5	-0.8	52	1284	0	59	1426	-1
RL	0.9	30	1.2	19.7	-0.4	1.0	4.2	-0.5	1.8	16.4	-0.2	0.1	1.4	-0.8	27	695	-1	32	856	-3
RL	1	0	3.7	50.0	-0.2	1.3	4.8	-0.4	0.8	9.1	-0.3	0.1	1.5	-0.8	61	1506	1	69	1660	-1

Appendix Table A-1

Site	Salt Trmt	Lag	Lucania	Lucania upper	Lucania lower	Opsanus	Opsanus upper	Opsanus lower	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Sscovelli	Sscovelli upper	Sscovelli lower	Thor	Thor upper	Thor lower	all species	All species upper	All species lower
RL	1	0	1.3	21.7	-0.3	1.0	4.2	-0.5	1.8	16.2	-0.2	0.0	1.4	-0.9	32	809	-1	37	975	-2
RL	1	0	1.2	19.9	-0.4	0.9	4.0	-0.6	0.9	9.3	-0.3	0.0	1.4	-0.9	43	1072	0	47	1186	-2
RL	1	0	1.5	24.2	-0.3	1.5	5.2	-0.3	0.0	2.9	-0.4	0.3	1.9	-0.7	30	764	-1	36	887	-2
RL	1	0	3.7	50.0	-0.2	1.3	4.8	-0.4	0.8	9.1	-0.3	0.1	1.5	-0.8	61	1506	1	69	1660	-1
RL	1	0	1.3	21.7	-0.3	1.0	4.2	-0.5	1.8	16.2	-0.2	0.0	1.4	-0.9	32	809	-1	37	975	-2
RL	1	0	1.2	19.9	-0.4	0.9	4.0	-0.6	0.9	9.3	-0.3	0.0	1.4	-0.9	43	1072	0	47	1186	-2
RL	1	0	1.5	24.2	-0.3	1.5	5.2	-0.3	0.0	2.9	-0.4	0.3	1.9	-0.7	30	764	-1	36	887	-2
RL	1	0	3.7	50.1	-0.2	1.3	4.8	-0.4	0.8	9.1	-0.3	0.1	1.5	-0.8	61	1506	1	69	1660	-1
RL	1	0	1.3	21.7	-0.3	1.0	4.2	-0.5	1.8	16.2	-0.2	0.0	1.4	-0.9	32	809	-1	37	975	-2
RL	1	30	3.6	48.9	-0.2	1.3	4.8	-0.4	0.7	8.0	-0.3	0.1	1.5	-0.8	43	1083	0	51	1233	-1
RL	1	30	1.7	25.8	-0.3	1.0	4.2	-0.5	1.9	16.8	-0.2	0.0	1.4	-0.9	43	1061	0	48	1246	-2
RL	1	30	1.1	18.4	-0.4	1.0	4.1	-0.6	0.8	9.1	-0.3	0.0	1.4	-0.9	38	944	0	41	1053	-2
RL	1	30	1.3	20.7	-0.4	1.4	5.0	-0.4	0.0	3.0	-0.4	0.3	1.9	-0.7	26	672	-1	31	793	-2
RL	1	30	3.6	49.2	-0.2	1.3	4.8	-0.4	0.7	7.9	-0.3	0.1	1.5	-0.8	44	1093	0	52	1244	-1
RL	1	30	1.7	25.9	-0.3	1.0	4.2	-0.5	1.9	16.8	-0.2	0.0	1.4	-0.9	43	1069	0	48	1254	-2
RL	1	30	1.1	18.4	-0.4	1.0	4.1	-0.6	0.8	9.1	-0.3	0.0	1.4	-0.9	38	947	0	41	1056	-2
RL	1	30	1.3	20.8	-0.4	1.4	5.0	-0.4	0.0	3.0	-0.4	0.3	1.9	-0.7	26	674	-1	31	796	-2
RL	1	30	3.6	49.4	-0.2	1.3	4.9	-0.4	0.7	7.9	-0.3	0.1	1.5	-0.8	44	1099	0	52	1250	-1
RL	1	30	1.7	26.0	-0.3	1.0	4.2	-0.5	1.9	16.8	-0.2	0.0	1.4	-0.9	43	1073	0	49	1258	-2
RL	1.1	0	3.7	50.8	-0.2	1.3	4.8	-0.4	0.6	7.6	-0.3	0.1	1.5	-0.8	42	1048	0	50	1200	-2
RL	1.1	0	1.9	28.5	-0.3	1.0	4.2	-0.5	1.8	16.5	-0.2	0.0	1.4	-0.9	49	1210	0	55	1401	-2
RL	1.1	0	1.7	25.8	-0.3	1.0	4.1	-0.6	0.9	9.5	-0.3	0.0	1.4	-0.9	62	1515	1	66	1647	-1
RL	1.1	0	3.6	48.7	-0.2	2.1	6.5	0.0	-0.1	2.2	-0.4	0.3	1.9	-0.7	60	1466	1	68	1612	0
RL	1.1	0	4.1	55.4	-0.1	1.4	4.9	-0.4	0.6	7.6	-0.3	0.1	1.5	-0.8	47	1173	0	56	1332	-1
RL	1.1	0	2.0	30.3	-0.3	1.1	4.3	-0.5	1.8	16.4	-0.2	0.0	1.4	-0.9	53	1317	0	60	1511	-1
RL	1.1	0	1.7	26.1	-0.3	1.0	4.1	-0.6	0.9	9.5	-0.3	0.0	1.4	-0.9	63	1554	1	68	1687	-1
RL	1.1	0	3.7	49.9	-0.2	2.1	6.5	0.0	-0.1	2.2	-0.4	0.4	1.9	-0.7	62	1520	1	71	1668	0
RL	1.1	0	4.3	57.3	-0.1	1.4	4.9	-0.4	0.6	7.6	-0.3	0.1	1.5	-0.8	49	1225	0	58	1386	-1
RL	1.1	0	2.1	31.0	-0.3	1.1	4.3	-0.5	1.8	16.5	-0.2	0.0	1.4	-0.9	55	1358	0	61	1555	-1
RL	1.1	30	4.7	62.8	-0.1	1.3	4.9	-0.4	0.6	7.4	-0.4	0.0	1.4	-0.8	49	1223	0	59	1392	-1
RL	1.1	30	2.0	30.0	-0.3	1.1	4.3	-0.5	1.6	14.9	-0.2	0.0	1.4	-0.9	41	1024	0	47	1203	-2
RL	1.1	30	1.5	23.4	-0.3	1.0	4.1	-0.6	0.9	9.6	-0.3	0.0	1.4	-0.9	57	1413	0	61	1540	-1
RL	1.1	30	2.7	38.4	-0.2	1.9	6.0	-0.1	-0.1	2.5	-0.4	0.3	1.9	-0.7	48	1197	0	56	1333	-1
RL	1.1	30	5.3	69.6	0.0	1.4	5.0	-0.4	0.6	7.3	-0.4	0.1	1.4	-0.8	57	1402	0	67	1580	-1
RL	1.1	30	2.2	32.4	-0.3	1.1	4.4	-0.5	1.6	14.7	-0.2	0.0	1.4	-0.9	46	1136	0	52	1320	-2
RL	1.1	30	1.5	23.8	-0.3	1.0	4.1	-0.6	0.9	9.7	-0.3	0.0	1.4	-0.9	59	1460	1	63	1588	-1
RL	1.1	30	2.8	39.5	-0.2	1.9	6.0	-0.1	-0.1	2.5	-0.4	0.3	1.9	-0.7	51	1253	0	58	1391	-1
RL	1.1	30	5.5	72.7	0.0	1.4	5.0	-0.3	0.6	7.3	-0.4	0.1	1.4	-0.8	60	1480	1	70	1662	-1
RL	1.1	30	2.3	33.3	-0.3	1.1	4.4	-0.5	1.6	14.8	-0.2	0.0	1.4	-0.9	48	1182	0	54	1368	-2
RL	1.3	0	10.0	126.3	0.4	1.9	6.1	-0.1	0.3	5.7	-0.4	0.1	1.5	-0.8	94	2282	2	110	2533	1
RL	1.3	0	2.5	35.9	-0.3	1.1	4.3	-0.5	1.5	13.7	-0.2	0.0	1.3	-0.9	40	1005	0	47	1180	-2
RL	1.3	0	2.4	35.2	-0.3	1.1	4.3	-0.5	0.7	8.0	-0.3	0.0	1.3	-0.9	57	1414	0	63	1540	-1
RL	1.3	0	16.3	205.7	0.9	3.9	10.2	0.8	-0.3	1.2	-0.5	0.4	2.0	-0.6	227	5551	7	252	5889	9
RL	1.3	0	12.5	157.3	0.6	2.1	6.5	0.0	0.3	5.6	-0.4	0.1	1.5	-0.8	126	3053	3	145	3342	3
RL	1.3	0	3.1	42.9	-0.2	1.2	4.5	-0.5	1.4	13.6	-0.2	0.0	1.3	-0.9	52	1282	0	60	1468	-1
RL	1.3	0	2.6	37.3	-0.2	1.1	4.4	-0.5	0.7	8.0	-0.3	0.0	1.3	-0.9	63	1550	1	69	1680	-1
RL	1.3	0	17.8	224.3	1.0	4.0	10.3	0.9	-0.3	1.2	-0.5	0.4	2.0	-0.6	257	6267	9	284	6627	10

Appendix Table A-1

Site	Salt Trmt	Lag	Lucania	Lucania upper	Lucania lower	Opsanus	Opsanus upper	Opsanus lower	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Sscovelli	Sscovelli upper	Sscovelli lower	Thor	Thor upper	Thor lower	all species	All species upper	All species lower
RL	1.3	0	13.7	171.1	0.7	2.2	6.6	0.0	0.3	5.6	-0.4	0.1	1.5	-0.8	140	3387	4	160	3692	4
RL	1.3	0	3.4	46.4	-0.2	1.2	4.6	-0.4	1.4	13.6	-0.2	0.0	1.3	-0.9	58	1417	1	66	1609	-1
RL	1.3	30	16.5	205.6	0.9	2.5	7.2	0.2	0.2	4.7	-0.4	0.1	1.5	-0.8	143	3471	4	167	3822	4
RL	1.3	30	4.0	53.9	-0.1	1.3	4.8	-0.4	1.2	12.0	-0.3	0.0	1.3	-0.9	58	1418	1	66	1607	-1
RL	1.3	30	1.9	28.7	-0.3	1.0	4.1	-0.6	0.7	8.3	-0.3	0.0	1.3	-0.9	48	1198	0	53	1319	-2
RL	1.3	30	12.3	155.6	0.5	3.5	9.3	0.7	-0.2	1.4	-0.5	0.4	2.0	-0.6	179	4367	6	199	4644	6
RL	1.3	30	20.8	257.9	1.2	2.7	7.6	0.3	0.2	4.6	-0.4	0.1	1.5	-0.8	194	4696	6	223	5108	7
RL	1.3	30	4.9	64.6	-0.1	1.4	5.1	-0.3	1.2	11.9	-0.3	0.0	1.3	-0.9	75	1820	1	85	2025	0
RL	1.3	30	2.1	30.4	-0.3	1.0	4.2	-0.5	0.7	8.4	-0.3	0.0	1.3	-0.9	53	1315	0	58	1440	-1
RL	1.3	30	13.5	170.1	0.6	3.6	9.5	0.7	-0.2	1.4	-0.5	0.4	2.0	-0.6	204	4946	7	225	5241	7
RL	1.3	30	22.7	281.2	1.4	2.7	7.8	0.3	0.2	4.6	-0.4	0.1	1.5	-0.8	216	5224	7	247	5662	8
RL	1.3	30	5.3	69.9	0.0	1.5	5.2	-0.3	1.2	12.0	-0.3	0.0	1.3	-0.9	83	2013	2	93	2226	0
RL	10	0	10.4	131.3	0.4	2.0	6.2	-0.1	0.3	5.6	-0.4	0.1	1.5	-0.8	97	2368	2	114	2626	2
RL	10	0	3.1	42.8	-0.2	1.1	4.5	-0.5	1.4	13.0	-0.2	0.0	1.3	-0.9	47	1169	0	55	1349	-2
RL	10	0	3.0	41.7	-0.2	1.2	4.6	-0.5	0.6	7.5	-0.3	0.0	1.3	-0.9	67	1642	1	73	1773	-1
RL	10	0	12.5	158.0	0.6	3.5	9.4	0.7	-0.2	1.4	-0.5	0.4	2.0	-0.6	182	4439	6	203	4719	6
RL	10	0	13.1	164.7	0.6	2.2	6.6	0.0	0.3	5.5	-0.4	0.1	1.5	-0.8	132	3199	4	152	3497	3
RL	10	0	3.8	51.5	-0.1	1.3	4.7	-0.4	1.4	12.9	-0.2	0.0	1.3	-0.9	61	1505	1	70	1699	-1
RL	10	0	3.2	44.3	-0.2	1.2	4.6	-0.4	0.6	7.6	-0.3	0.0	1.3	-0.9	74	1805	1	80	1940	0
RL	10	0	13.7	172.8	0.7	3.6	9.5	0.7	-0.2	1.4	-0.5	0.4	2.0	-0.6	207	5027	7	228	5325	7
RL	10	0	14.3	178.9	0.7	2.2	6.7	0.0	0.3	5.6	-0.4	0.1	1.5	-0.8	146	3538	4	167	3853	4
RL	10	0	4.1	55.7	-0.1	1.3	4.8	-0.4	1.4	13.0	-0.2	0.0	1.3	-0.9	68	1663	1	77	1864	0
RL	10	30	15.3	191.3	0.8	2.4	7.0	0.1	0.2	4.8	-0.4	0.1	1.5	-0.8	135	3276	4	158	3609	4
RL	10	30	4.6	60.8	-0.1	1.4	5.0	-0.3	1.2	11.5	-0.3	0.0	1.3	-0.9	65	1581	1	74	1777	-1
RL	10	30	2.3	33.9	-0.3	1.0	4.3	-0.5	0.7	8.1	-0.3	0.0	1.3	-0.9	56	1379	0	61	1504	-1
RL	10	30	10.0	127.4	0.4	3.2	8.8	0.5	-0.2	1.5	-0.5	0.4	2.0	-0.6	152	3689	4	169	3932	5
RL	10	30	19.4	241.4	1.1	2.6	7.4	0.2	0.2	4.8	-0.4	0.1	1.5	-0.8	184	4464	6	212	4856	6
RL	10	30	5.6	73.3	0.0	1.5	5.3	-0.3	1.1	11.4	-0.3	0.0	1.3	-0.9	84	2044	2	95	2258	0
RL	10	30	2.5	36.0	-0.3	1.1	4.3	-0.5	0.7	8.2	-0.3	0.0	1.3	-0.9	62	1517	1	67	1646	-1
RL	10	30	11.0	139.6	0.4	3.3	8.9	0.6	-0.2	1.6	-0.5	0.4	2.0	-0.6	173	4185	5	191	4443	6
RL	10	30	21.1	262.5	1.3	2.7	7.6	0.3	0.2	4.8	-0.4	0.1	1.5	-0.8	204	4944	7	234	5359	7
RL	10	30	6.1	79.2	0.0	1.6	5.4	-0.3	1.1	11.4	-0.3	0.0	1.3	-0.9	93	2258	2	105	2481	1
RL	20	0	49.9	623.6	3.6	3.9	10.3	0.9	0.0	2.9	-0.4	0.1	1.6	-0.8	344	8496	12	406	9347	16
RL	20	0	17.1	214.3	0.9	2.7	7.7	0.3	0.6	7.2	-0.4	0.0	1.4	-0.9	184	4480	6	209	4860	6
RL	20	0	17.6	221.9	1.0	2.8	7.9	0.3	0.1	3.9	-0.4	0.0	1.4	-0.9	273	6675	9	297	7001	10
RL	20	0	60.9	778.5	4.3	6.2	15.1	1.9	-0.4	0.5	-0.5	0.5	2.1	-0.6	642	16271	23	717	17273	29
RL	20	0	57.2	714.4	4.2	4.1	10.6	0.9	0.0	2.9	-0.4	0.1	1.6	-0.8	416	10260	15	486	11209	20
RL	20	0	18.9	236.8	1.1	2.8	7.8	0.3	0.5	7.2	-0.4	0.0	1.4	-0.9	212	5156	7	239	5563	7
RL	20	0	18.1	227.6	1.0	2.8	8.0	0.3	0.1	3.9	-0.4	0.0	1.4	-0.9	286	7000	10	311	7334	10
RL	20	0	62.9	803.8	4.5	6.3	15.2	1.9	-0.4	0.5	-0.5	0.5	2.1	-0.6	677	17174	25	755	18204	31
RL	20	0	60.7	757.4	4.4	4.1	10.7	0.9	0.0	2.9	-0.4	0.2	1.6	-0.8	450	11084	16	524	12079	21
RL	20	0	19.8	247.0	1.2	2.8	7.9	0.3	0.5	7.2	-0.4	0.0	1.4	-0.9	224	5456	7	253	5875	8
RL	20	30	71.0	893.2	5.2	4.5	11.5	1.1	-0.1	2.5	-0.4	0.2	1.6	-0.8	459	11446	17	544	12608	22
RL	20	30	24.4	305.5	1.5	3.1	8.6	0.5	0.4	6.3	-0.4	0.0	1.4	-0.9	247	6060	8	281	6552	9
RL	20	30	13.7	173.4	0.7	2.5	7.3	0.2	0.2	4.3	-0.4	0.0	1.4	-0.9	218	5326	7	238	5597	7
RL	20	30	49.9	634.4	3.5	5.8	14.2	1.7	-0.3	0.6	-0.5	0.5	2.1	-0.6	548	13784	20	611	14623	25
RL	20	30	79.3	996.7	5.9	4.6	11.7	1.2	-0.1	2.5	-0.4	0.2	1.6	-0.8	538	13389	20	632	14661	26

Appendix Table A-1

Site	Salt Trmt	Lag	Lucania	Lucania upper	Lucania lower	Opsanus	Opsanus upper	Opsanus lower	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Sscovelli	Sscovelli upper	Sscovelli lower	Thor	Thor upper	Thor lower	all species	All species upper	All species lower
RL	20	30	26.4	330.4	1.7	3.2	8.7	0.5	0.4	6.3	-0.4	0.0	1.4	-0.9	277	6775	9	313	7295	11
RL	20	30	14.0	176.6	0.7	2.5	7.4	0.2	0.2	4.3	-0.4	0.0	1.4	-0.9	227	5523	7	246	5798	7
RL	20	30	51.3	652.3	3.6	5.8	14.3	1.8	-0.3	0.6	-0.5	0.5	2.1	-0.6	573	14419	21	638	15278	26
RL	20	30	82.7	1038.4	6.2	4.7	11.8	1.2	-0.1	2.5	-0.4	0.2	1.6	-0.8	569	14158	21	666	15474	28
RL	20	30	27.3	340.7	1.8	3.2	8.8	0.5	0.4	6.3	-0.4	0.0	1.4	-0.9	289	7064	10	326	7596	12

Appendix Table A-2. Predictions for northeast scenarios for throw-trap with 95% confidence intervals.

Site	Salt Trmt	Lag	Year	Month	Julian Date	Salinity	Temper-ature	Depth	TSC	HSC	SSC	Habitat	Floridichthys	Floridichthys upper	Floridichthys lower	Gobiosoma	Gobiosoma upper	Gobiosoma lower	Hippolyte	Hippolyte upper	Hippolyte lower
TR	0.9	0	1	7	196	7.3	31.9	0.76	53.7	6.1	0.0	bank	1.1	27.6	0.0	0.00	1.93	-0.05	0.9	130.1	0.0
TR	0.9	0	1	10	288	2.6	27.7	0.76	36.9	4.2	0.0	bank	1.1	28.5	0.0	0.00	1.66	-0.05	3.1	457.6	0.0
TR	0.9	0	3	1	15	6.9	22.4	0.76	24.2	1.8	0.0	bank	0.4	12.3	0.0	-0.01	1.35	-0.05	1.5	216.2	0.0
TR	0.9	0	3	5	135	20.3	29.3	0.76	37.1	3.1	0.0	bank	0.2	6.0	0.0	0.01	1.96	-0.05	1.2	161.8	0.0
TR	0.9	0	3	7	196	7.3	31.9	0.76	52.5	6.7	0.0	bank	1.0	27.6	0.0	0.00	1.93	-0.05	0.9	134.2	0.0
TR	0.9	0	3	10	288	2.6	27.7	0.76	36.0	4.4	0.0	bank	1.1	28.4	0.0	-0.01	1.64	-0.05	3.1	459.5	0.0
TR	0.9	0	5	1	15	6.9	22.4	0.76	23.8	1.9	0.0	bank	0.4	12.2	0.0	-0.01	1.34	-0.05	1.5	215.5	0.0
TR	0.9	0	5	5	135	20.3	29.3	0.76	36.6	3.2	0.0	bank	0.2	6.0	0.0	0.01	1.95	-0.05	1.2	162.0	0.0
TR	0.9	0	5	7	196	7.3	31.9	0.76	51.9	6.9	0.0	bank	1.0	27.6	0.0	0.00	1.92	-0.05	0.9	135.9	0.0
TR	0.9	0	5	10	288	2.6	27.7	0.76	35.5	4.5	0.0	bank	1.1	28.4	0.0	-0.01	1.63	-0.05	3.1	460.0	0.0
TR	0.9	30	1	7	196	13.6	31.9	0.76	54.1	6.4	0.0	bank	0.7	17.9	0.0	0.02	2.33	-0.05	0.6	92.9	0.0
TR	0.9	30	1	10	288	5.8	27.7	0.76	37.5	4.3	0.0	bank	0.9	22.7	0.0	0.00	1.84	-0.05	2.7	383.9	0.0
TR	0.9	30	3	1	15	5.9	22.4	0.76	23.7	1.8	0.0	bank	0.5	13.2	0.0	-0.01	1.30	-0.05	1.5	227.9	0.0
TR	0.9	30	3	5	135	13.6	29.3	0.76	34.2	3.5	0.0	bank	0.3	9.4	0.0	-0.01	1.52	-0.05	1.6	231.3	0.0
TR	0.9	30	3	7	196	13.6	31.9	0.76	52.6	7.0	0.0	bank	0.7	17.9	0.0	0.02	2.32	-0.05	0.6	95.9	0.0
TR	0.9	30	3	10	288	5.8	27.7	0.76	36.5	4.6	0.0	bank	0.9	22.6	0.0	0.00	1.81	-0.05	2.7	385.3	0.0
TR	0.9	30	5	1	15	5.9	22.4	0.76	23.3	1.8	0.0	bank	0.5	13.2	0.0	-0.01	1.29	-0.05	1.5	227.1	0.0
TR	0.9	30	5	5	135	13.6	29.3	0.76	33.7	3.6	0.0	bank	0.3	9.4	0.0	-0.01	1.51	-0.05	1.6	231.7	0.0
TR	0.9	30	5	7	196	13.6	31.9	0.76	51.9	7.3	0.0	bank	0.7	17.9	0.0	0.02	2.32	-0.05	0.7	97.2	0.0
TR	0.9	30	5	10	288	5.8	27.7	0.76	35.9	4.7	0.0	bank	0.8	22.5	0.0	0.00	1.80	-0.05	2.7	385.8	0.0
TR	1	0	1	7	196	8.1	31.9	0.76	54.7	5.6	0.0	bank	1.0	26.1	0.0	0.00	1.98	-0.05	0.8	120.7	0.0
TR	1	0	1	10	288	2.9	27.7	0.76	37.6	4.0	0.0	bank	1.1	28.0	0.0	0.00	1.69	-0.05	3.1	447.3	0.0
TR	1	0	3	1	15	7.7	22.4	0.76	25.0	1.7	0.0	bank	0.4	11.7	0.0	-0.01	1.39	-0.05	1.4	207.4	0.0
TR	1	0	3	5	135	22.6	29.3	0.76	38.5	2.7	0.0	bank	0.2	5.2	0.0	0.01	2.15	-0.05	1.0	141.7	0.0
TR	1	0	3	7	196	8.1	31.9	0.76	54.7	5.6	0.0	bank	1.0	26.1	0.0	0.00	1.98	-0.05	0.8	120.7	0.0
TR	1	0	3	10	288	2.9	27.7	0.76	37.6	4.0	0.0	bank	1.1	28.0	0.0	0.00	1.69	-0.05	3.1	447.3	0.0
TR	1	0	5	1	15	7.7	22.4	0.76	25.0	1.7	0.0	bank	0.4	11.7	0.0	-0.01	1.39	-0.05	1.4	207.4	0.0
TR	1	0	5	5	135	22.6	29.3	0.76	38.5	2.7	0.0	bank	0.2	5.2	0.0	0.01	2.15	-0.05	1.0	141.7	0.0
TR	1	0	5	7	196	8.1	31.9	0.76	54.7	5.6	0.0	bank	1.0	26.1	0.0	0.00	1.98	-0.05	0.8	120.7	0.0
TR	1	0	5	10	288	2.9	27.7	0.76	37.6	4.0	0.0	bank	1.1	28.0	0.0	0.00	1.69	-0.05	3.1	447.6	0.0
TR	1	30	1	7	196	15.1	31.9	0.76	55.2	5.9	0.0	bank	0.6	16.2	0.0	0.02	2.43	-0.05	0.6	82.4	0.0
TR	1	30	1	10	288	6.5	27.7	0.76	38.3	4.1	0.0	bank	0.8	21.7	0.0	0.00	1.89	-0.05	2.6	366.9	0.0
TR	1	30	3	1	15	6.5	22.4	0.76	24.6	1.6	0.0	bank	0.5	12.7	0.0	-0.01	1.34	-0.05	1.5	220.1	0.0
TR	1	30	3	5	135	15.1	29.3	0.76	35.7	3.1	0.0	bank	0.3	8.6	0.0	0.00	1.63	-0.05	1.5	211.1	0.0
TR	1	30	3	7	196	15.1	31.9	0.76	55.2	5.8	0.0	bank	0.6	16.2	0.0	0.02	2.43	-0.05	0.5	82.0	0.0
TR	1	30	3	10	288	6.5	27.7	0.76	38.4	4.1	0.0	bank	0.8	21.7	0.0	0.00	1.90	-0.05	2.6	366.5	0.0
TR	1	30	5	1	15	6.5	22.4	0.76	24.7	1.6	0.0	bank	0.5	12.7	0.0	-0.01	1.34	-0.05	1.5	220.2	0.0
TR	1	30	5	5	135	15.1	29.3	0.76	35.8	3.1	0.0	bank	0.3	8.6	0.0	0.00	1.63	-0.05	1.5	210.9	0.0
TR	1	30	5	7	196	15.1	31.9	0.76	55.3	5.8	0.0	bank	0.6	16.2	0.0	0.02	2.43	-0.05	0.5	81.9	0.0
TR	1	30	5	10	288	6.5	27.7	0.76	38.4	4.0	0.0	bank	0.8	21.7	0.0	0.00	1.90	-0.05	2.6	366.6	0.0
TR	1.1	0	1	7	196	8.9	31.9	0.76	55.8	5.2	0.0	bank	0.9	24.8	0.0	0.01	2.02	-0.05	0.7	112.0	0.0
TR	1.1	0	1	10	288	3.2	27.7	0.76	38.4	3.7	0.0	bank	1.0	27.6	0.0	0.00	1.73	-0.05	3.0	436.6	0.0
TR	1.1	0	3	1	15	8.5	22.4	0.76	25.9	1.5	0.0	bank	0.4	11.1	0.0	-0.01	1.44	-0.05	1.4	198.9	0.0
TR	1.1	0	3	5	135	24.8	29.3	0.76	39.9	2.3	0.0	bank	0.1	4.6	0.0	0.02	2.37	-0.05	0.9	124.9	0.0
TR	1.1	0	3	7	196	8.9	31.9	0.76	57.0	4.6	0.0	bank	0.9	24.9	0.0	0.01	2.03	-0.05	0.7	108.4	0.0
TR	1.1	0	3	10	288	3.2	27.7	0.76	39.4	3.4	0.0	bank	1.0	27.7	0.0	0.00	1.75	-0.05	3.0	434.0	0.0
TR	1.1	0	5	1	15	8.5	22.4	0.76	26.3	1.5	0.0	bank	0.4	11.2	0.0	-0.01	1.45	-0.05	1.4	199.6	0.0
TR	1.1	0	5	5	135	24.8	29.3	0.76	40.3	2.1	0.0	bank	0.1	4.6	0.0	0.02	2.38	-0.05	0.9	124.6	0.0
TR	1.1	0	5	7	196	8.9	31.9	0.76	57.6	4.4	0.0	bank	0.9	24.9	0.0	0.01	2.03	-0.05	0.7	107.1	0.0

Appendix Table A-2. Predictions for northeast scenarios for throw-trap with 95% confidence intervals.

Site	Salt Trmt	Lag	Year	Month	Julian Date	Salinity	Temper-ature	Depth	TSC	HSC	SSC	Habitat	Floridichthys	Floridichthys upper	Floridichthys lower	Gobiosoma	Gobiosoma upper	Gobiosoma lower	Hippolyte	Hippolyte upper	Hippolyte lower
TR	1.1	0	5	10	288	3.2	27.7	0.76	39.9	3.3	0.0	bank	1.0	27.8	0.0	0.00	1.77	-0.05	3.0	433.5	0.0
TR	1.1	30	1	7	196	16.6	31.9	0.76	56.3	5.3	0.0	bank	0.5	14.6	0.0	0.02	2.54	-0.05	0.5	73.2	0.0
TR	1.1	30	1	10	288	7.1	27.7	0.76	39.2	3.8	0.0	bank	0.8	20.9	0.0	0.00	1.95	-0.05	2.5	350.2	0.0
TR	1.1	30	3	1	15	7.2	22.4	0.76	25.6	1.4	0.0	bank	0.4	12.2	0.0	-0.01	1.39	-0.05	1.4	212.7	0.0
TR	1.1	30	3	5	135	16.6	29.3	0.76	37.3	2.6	0.0	bank	0.3	7.8	0.0	0.00	1.75	-0.05	1.4	192.1	0.0
TR	1.1	30	3	7	196	16.6	31.9	0.76	57.8	4.6	0.0	bank	0.6	14.7	0.0	0.02	2.55	-0.05	0.5	70.1	0.0
TR	1.1	30	3	10	288	7.1	27.7	0.76	40.5	3.4	0.0	bank	0.8	21.0	0.0	0.01	1.99	-0.05	2.4	347.2	0.0
TR	1.1	30	5	1	15	7.2	22.4	0.76	26.2	1.4	0.0	bank	0.4	12.3	0.0	-0.01	1.40	-0.05	1.5	213.6	0.0
TR	1.1	30	5	5	135	16.6	29.3	0.76	37.9	2.5	0.0	bank	0.3	7.8	0.0	0.00	1.77	-0.05	1.4	191.4	0.0
TR	1.1	30	5	7	196	16.6	31.9	0.76	58.6	4.3	0.0	bank	0.6	14.7	0.0	0.02	2.55	-0.05	0.5	69.0	0.0
TR	1.1	30	5	10	288	7.1	27.7	0.76	41.1	3.3	0.0	bank	0.8	21.0	0.0	0.01	2.01	-0.05	2.4	346.4	0.0
TR	1.3	0	1	7	196	10.6	31.9	0.76	57.8	4.2	0.0	bank	0.8	22.3	0.0	0.01	2.13	-0.05	0.6	96.1	0.0
TR	1.3	0	1	10	288	3.7	27.7	0.76	40.2	3.1	0.0	bank	1.0	26.8	0.0	0.00	1.80	-0.05	2.8	413.7	0.0
TR	1.3	0	3	1	15	10.0	22.4	0.76	27.8	1.1	0.0	bank	0.4	10.1	0.0	-0.01	1.55	-0.05	1.3	182.9	0.0
TR	1.3	0	3	5	135	29.4	29.3	0.76	42.7	1.4	0.0	bank	0.1	4.3	0.0	0.03	2.66	-0.05	0.8	116.7	0.0
TR	1.3	0	3	7	196	10.6	31.9	0.76	61.2	2.7	0.0	bank	0.9	22.7	0.0	0.01	2.14	-0.05	0.6	87.7	0.0
TR	1.3	0	3	10	288	3.7	27.7	0.76	43.2	2.2	0.0	bank	1.0	27.2	0.0	0.00	1.89	-0.05	2.8	404.1	0.0
TR	1.3	0	5	1	15	10.0	22.4	0.76	29.3	0.9	0.0	bank	0.4	10.2	0.0	-0.01	1.59	-0.05	1.3	184.2	0.0
TR	1.3	0	5	5	135	29.4	29.3	0.76	44.1	1.1	0.0	bank	0.1	4.4	0.0	0.03	2.72	-0.05	0.8	116.1	0.0
TR	1.3	0	5	7	196	10.6	31.9	0.76	63.0	2.1	0.0	bank	0.9	22.9	0.0	0.01	2.14	-0.05	0.6	84.6	0.0
TR	1.3	0	5	10	288	3.7	27.7	0.76	44.8	1.8	0.0	bank	1.0	27.4	0.0	0.00	1.93	-0.05	2.8	400.1	0.0
TR	1.3	30	1	7	196	19.6	31.9	0.76	58.4	4.2	0.0	bank	0.4	12.0	0.0	0.03	2.79	-0.05	0.4	58.0	0.0
TR	1.3	30	1	10	288	8.4	27.7	0.76	41.2	3.1	0.0	bank	0.7	19.3	0.0	0.01	2.09	-0.05	2.2	317.1	0.0
TR	1.3	30	3	1	15	8.5	22.4	0.76	27.8	1.0	0.0	bank	0.4	11.3	0.0	-0.01	1.48	-0.05	1.4	198.3	0.0
TR	1.3	30	3	5	135	19.6	29.3	0.76	40.6	1.6	0.0	bank	0.2	6.5	0.0	0.01	2.03	-0.05	1.1	158.6	0.0
TR	1.3	30	3	7	196	19.6	31.9	0.76	62.6	2.5	0.0	bank	0.5	12.3	0.0	0.03	2.81	-0.05	0.3	52.1	0.0
TR	1.3	30	3	10	288	8.4	27.7	0.76	44.8	2.1	0.0	bank	0.7	19.6	0.0	0.01	2.20	-0.05	2.2	308.1	0.0
TR	1.3	30	5	1	15	8.5	22.4	0.76	29.4	0.8	0.0	bank	0.4	11.4	0.0	-0.01	1.52	-0.05	1.4	200.0	0.0
TR	1.3	30	5	5	135	19.6	29.3	0.76	42.3	1.2	0.0	bank	0.2	6.6	0.0	0.01	2.09	-0.05	1.1	157.2	0.0
TR	1.3	30	5	7	196	19.6	31.9	0.76	64.7	1.8	0.0	bank	0.5	12.4	0.0	0.03	2.81	-0.05	0.3	49.9	0.0
TR	1.3	30	5	10	288	8.4	27.7	0.76	46.6	1.6	0.0	bank	0.8	19.8	0.0	0.01	2.26	-0.05	2.1	304.0	0.0
TR	10	0	1	7	196	18.1	31.9	0.76	61.3	2.5	0.0	bank	0.5	13.6	0.0	0.03	2.68	-0.05	0.4	56.3	0.0
TR	10	0	1	10	288	12.9	27.7	0.76	45.5	1.6	0.0	bank	0.5	14.6	0.0	0.02	2.53	-0.05	1.7	232.9	0.0
TR	10	0	3	1	15	17.7	22.4	0.76	32.1	0.2	0.0	bank	0.2	6.1	0.0	0.01	2.09	-0.05	0.8	118.9	0.0
TR	10	0	3	5	135	32.6	29.3	0.76	46.5	0.2	0.0	bank	0.2	5.8	0.0	0.03	2.71	-0.05	0.9	127.6	0.0
TR	10	0	3	7	196	18.1	31.9	0.76	67.3	0.3	0.0	bank	0.5	14.1	0.0	0.03	2.69	-0.05	0.3	48.8	0.0
TR	10	0	3	10	288	12.9	27.7	0.76	50.6	0.2	0.0	bank	0.6	15.0	0.0	0.03	2.70	-0.05	1.6	222.3	0.0
TR	10	0	5	1	15	17.7	22.4	0.76	33.6	0.0	0.0	bank	0.2	6.2	0.0	0.01	2.14	-0.05	0.8	120.0	0.0
TR	10	0	5	5	135	32.6	29.3	0.76	47.8	0.0	0.0	bank	0.2	5.8	0.0	0.03	2.76	-0.05	0.9	127.8	0.0
TR	10	0	5	7	196	18.1	31.9	0.76	68.7	0.0	0.0	bank	0.5	14.2	0.0	0.03	2.68	-0.05	0.3	48.0	0.0
TR	10	0	5	10	288	12.9	27.7	0.76	51.7	0.0	0.0	bank	0.6	15.1	0.0	0.03	2.73	-0.05	1.6	221.5	0.0
TR	10	30	1	7	196	25.1	31.9	0.76	61.6	2.6	0.0	bank	0.3	8.6	0.0	0.04	3.33	-0.05	0.2	39.2	0.0
TR	10	30	1	10	288	16.5	27.7	0.76	45.9	1.5	0.0	bank	0.4	11.4	0.0	0.03	2.84	-0.05	1.4	189.6	0.0
TR	10	30	3	1	15	16.5	22.4	0.76	32.1	0.2	0.0	bank	0.2	6.7	0.0	0.01	2.01	-0.05	0.9	126.7	0.0
TR	10	30	3	5	135	25.1	29.3	0.76	45.7	0.2	0.0	bank	0.1	4.7	0.0	0.02	2.61	-0.05	0.8	114.7	0.0
TR	10	30	3	7	196	25.1	31.9	0.76	68.0	0.3	0.0	bank	0.3	8.9	0.0	0.04	3.34	-0.05	0.2	33.7	0.0
TR	10	30	3	10	288	16.5	27.7	0.76	51.1	0.2	0.0	bank	0.4	11.7	0.0	0.04	3.03	-0.05	1.3	181.8	0.0
TR	10	30	5	1	15	16.5	22.4	0.76	33.4	0.0	0.0	bank	0.2	6.7	0.0	0.01	2.06	-0.05	0.9	127.9	0.0
TR	10	30	5	5	135	25.1	29.3	0.76	47.0	0.0	0.0	bank	0.1	4.7	0.0	0.03	2.65	-0.05	0.8	114.9	0.0

Appendix Table A-2. Predictions for northeast scenarios for throw-trap with 95% confidence intervals.

Site	Salt Trmt	Lag	Year	Month	Julian Date	Salinity	Temper-ature	Depth	TSC	HSC	SSC	Habitat	Floridichthys	Floridichthys upper	Floridichthys lower	Gobiosoma	Gobiosoma upper	Gobiosoma lower	Hippolyte	Hippolyte upper	Hippolyte lower
TR	10	30	5	7	196	25.1	31.9	0.76	69.3	0.0	0.0	bank	0.3	9.0	0.0	0.04	3.33	-0.05	0.2	33.2	0.0
TR	10	30	5	10	288	16.5	27.7	0.76	52.1	0.0	0.0	bank	0.4	11.8	0.0	0.04	3.06	-0.05	1.3	181.4	0.0
TR	20	0	1	7	196	28.1	31.9	0.76	64.2	1.1	0.0	bank	0.3	8.1	0.0	0.05	3.57	-0.05	0.2	33.5	0.0
TR	20	0	1	10	288	22.9	27.7	0.76	48.9	0.5	0.0	bank	0.3	7.6	0.0	0.05	3.61	-0.05	0.9	129.6	0.0
TR	20	0	3	1	15	27.7	22.4	0.76	33.3	0.0	0.0	bank	0.1	3.5	0.0	0.03	2.85	-0.05	0.5	75.7	0.0
TR	20	0	3	5	135	42.6	29.3	0.76	47.3	0.0	0.0	bank	0.3	9.0	0.0	0.04	3.07	-0.05	0.3	41.9	0.0
TR	20	0	3	7	196	28.1	31.9	0.76	68.5	0.0	0.0	bank	0.3	8.2	0.0	0.05	3.56	-0.05	0.2	31.1	0.0
TR	20	0	3	10	288	22.9	27.7	0.76	51.9	0.0	0.0	bank	0.3	7.7	0.0	0.06	3.73	-0.05	0.9	128.3	0.0
TR	20	0	5	1	15	27.7	22.4	0.76	33.8	0.0	0.0	bank	0.1	3.5	0.0	0.03	2.87	-0.05	0.5	76.2	0.0
TR	20	0	5	5	135	42.6	29.3	0.76	47.8	0.0	0.0	bank	0.3	9.0	0.0	0.04	3.09	-0.05	0.3	42.0	0.0
TR	20	0	5	7	196	28.1	31.9	0.76	69.0	0.0	0.0	bank	0.3	8.2	0.0	0.05	3.55	-0.05	0.2	31.1	0.0
TR	20	0	5	10	288	22.9	27.7	0.76	52.3	0.0	0.0	bank	0.3	7.7	0.0	0.06	3.74	-0.05	0.9	128.6	0.0
TR	20	30	1	7	196	35.1	31.9	0.76	64.2	1.2	0.0	bank	0.4	11.5	0.0	0.05	3.63	-0.05	0.2	27.7	0.0
TR	20	30	1	10	288	26.5	27.7	0.76	49.0	0.5	0.0	bank	0.2	6.2	0.0	0.06	4.02	-0.05	0.8	110.8	0.0
TR	20	30	3	1	15	26.5	22.4	0.76	33.2	0.0	0.0	bank	0.1	3.6	0.0	0.03	2.79	-0.05	0.5	76.8	0.0
TR	20	30	3	5	135	35.1	29.3	0.76	47.2	0.0	0.0	bank	0.2	6.2	0.0	0.03	2.88	-0.05	0.6	88.7	0.0
TR	20	30	3	7	196	35.1	31.9	0.76	68.6	0.0	0.0	bank	0.4	11.8	0.0	0.05	3.62	-0.05	0.1	25.7	0.0
TR	20	30	3	10	288	26.5	27.7	0.76	52.0	0.0	0.0	bank	0.2	6.3	0.0	0.07	4.15	-0.05	0.8	109.8	0.0
TR	20	30	5	1	15	26.5	22.4	0.76	33.7	0.0	0.0	bank	0.1	3.6	0.0	0.03	2.81	-0.05	0.5	77.4	0.0
TR	20	30	5	5	135	35.1	29.3	0.76	47.6	0.0	0.0	bank	0.2	6.2	0.0	0.03	2.90	-0.05	0.6	89.0	0.0
TR	20	30	5	7	196	35.1	31.9	0.76	69.1	0.0	0.0	bank	0.4	11.8	0.0	0.05	3.61	-0.05	0.1	25.6	0.0
TR	20	30	5	10	288	26.5	27.7	0.76	52.5	0.0	0.0	bank	0.2	6.3	0.0	0.07	4.17	-0.05	0.8	110.1	0.0
TC	0.9	0	1	7	196	10.3	31.1	0.83	40.4	0.8	0.0	bank	0.7	19.8	0.0	0.00	1.70	-0.05	0.4	67.8	0.0
TC	0.9	0	1	10	288	3.8	26.9	0.83	32.7	0.8	0.0	bank	1.0	26.1	0.0	0.00	1.84	-0.05	2.5	361.0	0.0
TC	0.9	0	3	1	15	12.6	21.5	0.83	21.6	0.4	0.0	bank	0.2	7.2	0.0	-0.01	1.53	-0.05	1.1	160.0	0.0
TC	0.9	0	3	5	135	24.6	28.5	0.83	26.8	0.5	0.0	bank	0.1	4.0	0.0	0.00	1.74	-0.05	0.7	103.4	0.0
TC	0.9	0	3	7	196	10.3	31.1	0.83	40.2	1.1	0.0	bank	0.7	19.7	0.0	0.00	1.69	-0.05	0.4	68.7	0.0
TC	0.9	0	3	10	288	3.8	26.9	0.83	32.2	1.1	0.0	bank	1.0	25.9	0.0	0.00	1.83	-0.05	2.5	363.6	0.0
TC	0.9	0	5	1	15	12.6	21.5	0.83	21.2	0.5	0.0	bank	0.2	7.1	0.0	-0.01	1.52	-0.05	1.1	159.8	0.0
TC	0.9	0	5	5	135	24.6	28.5	0.83	26.4	0.5	0.0	bank	0.1	3.9	0.0	0.00	1.73	-0.05	0.7	103.3	0.0
TC	0.9	0	5	7	196	10.3	31.1	0.83	39.6	1.3	0.0	bank	0.7	19.6	0.0	0.00	1.68	-0.05	0.4	69.2	0.0
TC	0.9	0	5	10	288	3.8	26.9	0.83	31.7	1.2	0.0	bank	1.0	25.8	0.0	0.00	1.81	-0.05	2.5	365.4	0.0
TC	0.9	30	1	7	196	18.4	31.1	0.83	42.1	0.8	0.0	bank	0.4	11.4	0.0	0.01	2.22	-0.05	0.3	43.7	0.0
TC	0.9	30	1	10	288	7.1	26.9	0.83	34.2	0.8	0.0	bank	0.8	20.8	0.0	0.01	2.07	-0.05	2.1	303.1	0.0
TC	0.9	30	3	1	15	10.2	21.5	0.83	21.5	0.3	0.0	bank	0.3	8.5	0.0	-0.01	1.42	-0.05	1.3	182.1	0.0
TC	0.9	30	3	5	135	21.2	28.5	0.83	25.9	0.4	0.0	bank	0.2	5.0	0.0	-0.01	1.53	-0.05	0.9	121.2	0.0
TC	0.9	30	3	7	196	18.4	31.1	0.83	42.1	0.8	0.0	bank	0.4	11.4	0.0	0.01	2.22	-0.05	0.3	43.6	0.0
TC	0.9	30	3	10	288	7.1	26.9	0.83	34.3	0.8	0.0	bank	0.8	20.8	0.0	0.01	2.07	-0.05	2.1	302.6	0.0
TC	0.9	30	5	1	15	10.2	21.5	0.83	21.5	0.3	0.0	bank	0.3	8.5	0.0	-0.01	1.42	-0.05	1.3	182.1	0.0
TC	0.9	30	5	5	135	21.2	28.5	0.83	25.9	0.4	0.0	bank	0.2	5.0	0.0	-0.01	1.53	-0.05	0.9	121.1	0.0
TC	0.9	30	5	7	196	18.4	31.1	0.83	42.1	0.7	0.0	bank	0.4	11.4	0.0	0.01	2.22	-0.05	0.3	43.5	0.0
TC	0.9	30	5	10	288	7.1	26.9	0.83	34.3	0.8	0.0	bank	0.8	20.8	0.0	0.01	2.07	-0.05	2.1	302.3	0.0
TC	1	0	1	7	196	11.4	31.1	0.83	41.1	0.7	0.0	bank	0.7	18.3	0.0	0.00	1.78	-0.05	0.4	63.4	0.0
TC	1	0	1	10	288	4.2	26.9	0.83	33.1	0.7	0.0	bank	1.0	25.4	0.0	0.00	1.88	-0.05	2.4	350.3	0.0
TC	1	0	3	1	15	14.0	21.5	0.83	22.1	0.3	0.0	bank	0.2	6.5	0.0	0.00	1.60	-0.05	1.0	147.4	0.0
TC	1	0	3	5	135	27.4	28.5	0.83	27.6	0.3	0.0	bank	0.1	3.6	0.0	0.00	1.88	-0.05	0.7	95.0	0.0
TC	1	0	3	7	196	11.4	31.1	0.83	41.4	0.6	0.0	bank	0.7	18.4	0.0	0.00	1.79	-0.05	0.4	63.0	0.0
TC	1	0	3	10	288	4.2	26.9	0.83	33.4	0.5	0.0	bank	1.0	25.5	0.0	0.00	1.89	-0.05	2.4	348.6	0.0
TC	1	0	5	1	15	14.0	21.5	0.83	22.3	0.2	0.0	bank	0.2	6.5	0.0	0.00	1.61	-0.05	1.0	147.4	0.0

Appendix Table A-2. Predictions for northeast scenarios for throw-trap with 95% confidence intervals.

Site	Salt Trmt	Lag	Year	Month	Julian Date	Salinity	Temper-ature	Depth	TSC	HSC	SSC	Habitat	Floridichthys	Floridichthys upper	Floridichthys lower	Gobiosoma	Gobiosoma upper	Gobiosoma lower	Hippolyte	Hippolyte upper	Hippolyte lower
TC	1	0	5	5	135	27.4	28.5	0.83	27.7	0.2	0.0	bank	0.1	3.6	0.0	0.00	1.89	-0.05	0.7	95.0	0.0
TC	1	0	5	7	196	11.4	31.1	0.83	41.6	0.5	0.0	bank	0.7	18.4	0.0	0.00	1.79	-0.05	0.4	62.7	0.0
TC	1	0	5	10	288	4.2	26.9	0.83	33.6	0.4	0.0	bank	1.0	25.5	0.0	0.00	1.89	-0.05	2.4	347.6	0.0
TC	1	30	1	7	196	20.4	31.1	0.83	42.7	0.7	0.0	bank	0.4	10.0	0.0	0.02	2.39	-0.05	0.2	39.0	0.0
TC	1	30	1	10	288	7.8	26.9	0.83	34.7	0.6	0.0	bank	0.7	19.7	0.0	0.01	2.13	-0.05	2.0	287.8	0.0
TC	1	30	3	1	15	11.4	21.5	0.83	21.9	0.2	0.0	bank	0.3	7.9	0.0	-0.01	1.48	-0.05	1.2	170.3	0.0
TC	1	30	3	5	135	23.5	28.5	0.83	26.6	0.2	0.0	bank	0.1	4.3	0.0	0.00	1.67	-0.05	0.7	106.9	0.0
TC	1	30	3	7	196	20.4	31.1	0.83	43.2	0.4	0.0	bank	0.4	10.0	0.0	0.02	2.41	-0.05	0.2	38.4	0.0
TC	1	30	3	10	288	7.8	26.9	0.83	35.2	0.4	0.0	bank	0.8	19.8	0.0	0.01	2.15	-0.05	2.0	284.9	0.0
TC	1	30	5	1	15	11.4	21.5	0.83	22.3	0.1	0.0	bank	0.3	7.9	0.0	-0.01	1.48	-0.05	1.2	170.3	0.0
TC	1	30	5	5	135	23.5	28.5	0.83	26.9	0.1	0.0	bank	0.1	4.3	0.0	0.00	1.68	-0.05	0.7	106.9	0.0
TC	1	30	5	7	196	20.4	31.1	0.83	43.5	0.2	0.0	bank	0.4	10.0	0.0	0.02	2.43	-0.05	0.2	38.2	0.0
TC	1	30	5	10	288	7.8	26.9	0.83	35.6	0.2	0.0	bank	0.8	19.9	0.0	0.01	2.17	-0.05	2.0	283.7	0.0
TC	1.1	0	1	7	196	12.6	31.1	0.83	41.6	0.6	0.0	bank	0.6	17.0	0.0	0.00	1.85	-0.05	0.4	59.3	0.0
TC	1.1	0	1	10	288	4.6	26.9	0.83	33.5	0.5	0.0	bank	0.9	24.8	0.0	0.00	1.91	-0.05	2.3	340.4	0.0
TC	1.1	0	3	1	15	15.4	21.5	0.83	22.5	0.2	0.0	bank	0.2	5.9	0.0	0.00	1.68	-0.05	0.9	136.0	0.0
TC	1.1	0	3	5	135	30.1	28.5	0.83	28.0	0.1	0.0	bank	0.1	3.9	0.0	0.00	1.91	-0.05	0.7	101.7	0.0
TC	1.1	0	3	7	196	12.6	31.1	0.83	42.2	0.3	0.0	bank	0.6	17.1	0.0	0.00	1.87	-0.05	0.4	58.4	0.0
TC	1.1	0	3	10	288	4.6	26.9	0.83	34.1	0.3	0.0	bank	0.9	24.9	0.0	0.00	1.93	-0.05	2.3	337.0	0.0
TC	1.1	0	5	1	15	15.4	21.5	0.83	22.8	0.1	0.0	bank	0.2	6.0	0.0	0.00	1.69	-0.05	0.9	136.0	0.0
TC	1.1	0	5	5	135	30.1	28.5	0.83	28.3	0.1	0.0	bank	0.1	3.9	0.0	0.01	1.92	-0.05	0.7	101.7	0.0
TC	1.1	0	5	7	196	12.6	31.1	0.83	42.5	0.1	0.0	bank	0.6	17.1	0.0	0.00	1.88	-0.05	0.4	58.1	0.0
TC	1.1	0	5	10	288	4.6	26.9	0.83	34.4	0.1	0.0	bank	0.9	25.0	0.0	0.00	1.94	-0.05	2.3	335.7	0.0
TC	1.1	30	1	7	196	22.5	31.1	0.83	43.2	0.6	0.0	bank	0.3	8.7	0.0	0.02	2.57	-0.05	0.2	34.9	0.0
TC	1.1	30	1	10	288	8.6	26.9	0.83	35.0	0.5	0.0	bank	0.7	18.7	0.0	0.01	2.19	-0.05	1.9	273.8	0.0
TC	1.1	30	3	1	15	12.5	21.5	0.83	22.2	0.1	0.0	bank	0.2	7.3	0.0	-0.01	1.53	-0.05	1.1	159.3	0.0
TC	1.1	30	3	5	135	25.9	28.5	0.83	27.0	0.1	0.0	bank	0.1	3.7	0.0	0.00	1.81	-0.05	0.7	96.3	0.0
TC	1.1	30	3	7	196	22.5	31.1	0.83	43.7	0.2	0.0	bank	0.3	8.8	0.0	0.02	2.60	-0.05	0.2	34.2	0.0
TC	1.1	30	3	10	288	8.6	26.9	0.83	35.7	0.2	0.0	bank	0.7	18.9	0.0	0.01	2.22	-0.05	1.9	270.4	0.0
TC	1.1	30	5	1	15	12.5	21.5	0.83	22.5	0.0	0.0	bank	0.2	7.3	0.0	-0.01	1.54	-0.05	1.1	159.4	0.0
TC	1.1	30	5	5	135	25.9	28.5	0.83	27.3	0.0	0.0	bank	0.1	3.7	0.0	0.00	1.82	-0.05	0.7	96.3	0.0
TC	1.1	30	5	7	196	22.5	31.1	0.83	44.1	0.1	0.0	bank	0.3	8.8	0.0	0.02	2.61	-0.05	0.2	34.0	0.0
TC	1.1	30	5	10	288	8.6	26.9	0.83	36.0	0.1	0.0	bank	0.7	18.9	0.0	0.01	2.23	-0.05	1.9	269.6	0.0
TC	1.3	0	1	7	196	14.8	31.1	0.83	42.4	0.4	0.0	bank	0.5	14.6	0.0	0.01	2.01	-0.05	0.3	52.1	0.0
TC	1.3	0	1	10	288	5.4	26.9	0.83	34.1	0.4	0.0	bank	0.9	23.4	0.0	0.00	1.97	-0.05	2.2	322.7	0.0
TC	1.3	0	3	1	15	18.3	21.5	0.83	22.9	0.1	0.0	bank	0.2	4.9	0.0	0.00	1.84	-0.05	0.8	116.3	0.0
TC	1.3	0	3	5	135	35.6	28.5	0.83	28.4	0.0	0.0	bank	0.2	5.1	0.0	0.01	2.01	-0.05	0.5	75.1	0.0
TC	1.3	0	3	7	196	14.8	31.1	0.83	42.9	0.1	0.0	bank	0.6	14.7	0.0	0.01	2.02	-0.05	0.3	51.1	0.0
TC	1.3	0	3	10	288	5.4	26.9	0.83	34.6	0.1	0.0	bank	0.9	23.6	0.0	0.01	1.99	-0.05	2.2	319.1	0.0
TC	1.3	0	5	1	15	18.3	21.5	0.83	23.1	0.0	0.0	bank	0.2	4.9	0.0	0.00	1.85	-0.05	0.8	116.4	0.0
TC	1.3	0	5	5	135	35.6	28.5	0.83	28.5	0.0	0.0	bank	0.2	5.1	0.0	0.01	2.02	-0.05	0.5	75.1	0.0
TC	1.3	0	5	7	196	14.8	31.1	0.83	43.0	0.0	0.0	bank	0.6	14.7	0.0	0.01	2.03	-0.05	0.3	50.9	0.0
TC	1.3	0	5	10	288	5.4	26.9	0.83	34.8	0.0	0.0	bank	0.9	23.6	0.0	0.01	2.00	-0.05	2.2	318.8	0.0
TC	1.3	30	1	7	196	26.6	31.1	0.83	43.7	0.4	0.0	bank	0.2	6.9	0.0	0.03	2.92	-0.05	0.2	29.0	0.0
TC	1.3	30	1	10	288	10.2	26.9	0.83	35.6	0.3	0.0	bank	0.6	16.9	0.0	0.01	2.32	-0.05	1.8	249.0	0.0
TC	1.3	30	3	1	15	14.8	21.5	0.83	22.5	0.0	0.0	bank	0.2	6.2	0.0	0.00	1.65	-0.05	1.0	140.0	0.0
TC	1.3	30	3	5	135	30.6	28.5	0.83	27.5	0.0	0.0	bank	0.1	4.0	0.0	0.00	1.89	-0.05	0.7	103.3	0.0
TC	1.3	30	3	7	196	26.6	31.1	0.83	44.1	0.0	0.0	bank	0.2	7.0	0.0	0.03	2.94	-0.05	0.2	28.4	0.0
TC	1.3	30	3	10	288	10.2	26.9	0.83	36.1	0.0	0.0	bank	0.6	17.0	0.0	0.02	2.34	-0.05	1.7	246.2	0.0

Appendix Table A-2. Predictions for northeast scenarios for throw-trap with 95% confidence intervals.

Site	Salt Trmt	Lag	Year	Month	Julian Date	Salinity	Temper-ature	Depth	TSC	HSC	SSC	Habitat	Floridichthys	Floridichthys upper	Floridichthys lower	Gobiosoma	Gobiosoma upper	Gobiosoma lower	Hippolyte	Hippolyte upper	Hippolyte lower
TC	1.3	30	5	1	15	14.8	21.5	0.83	22.6	0.0	0.0	bank	0.2	6.3	0.0	0.00	1.65	-0.05	1.0	140.1	0.0
TC	1.3	30	5	5	135	30.6	28.5	0.83	27.6	0.0	0.0	bank	0.1	4.0	0.0	0.00	1.89	-0.05	0.7	103.3	0.0
TC	1.3	30	5	7	196	26.6	31.1	0.83	44.2	0.0	0.0	bank	0.2	7.0	0.0	0.03	2.95	-0.05	0.2	28.3	0.0
TC	1.3	30	5	10	288	10.2	26.9	0.83	36.2	0.0	0.0	bank	0.6	17.0	0.0	0.02	2.34	-0.05	1.7	246.1	0.0
TC	10	0	1	7	196	21.4	31.1	0.83	43.3	0.3	0.0	bank	0.3	9.4	0.0	0.02	2.49	-0.05	0.2	36.3	0.0
TC	10	0	1	10	288	14.2	26.9	0.83	35.8	0.2	0.0	bank	0.5	12.9	0.0	0.02	2.62	-0.05	1.4	197.8	0.0
TC	10	0	3	1	15	24.0	21.5	0.83	23.4	0.0	0.0	bank	0.1	3.3	0.0	0.01	2.23	-0.05	0.6	85.6	0.0
TC	10	0	3	5	135	37.4	28.5	0.83	27.7	0.0	0.0	bank	0.2	5.2	0.0	0.01	2.20	-0.05	0.5	69.7	0.0
TC	10	0	3	7	196	21.4	31.1	0.83	43.1	0.0	0.0	bank	0.3	9.4	0.0	0.02	2.49	-0.05	0.2	35.5	0.0
TC	10	0	3	10	288	14.2	26.9	0.83	36.0	0.0	0.0	bank	0.5	12.9	0.0	0.02	2.63	-0.05	1.4	195.6	0.0
TC	10	0	5	1	15	24.0	21.5	0.83	23.4	0.0	0.0	bank	0.1	3.4	0.0	0.01	2.23	-0.05	0.6	85.6	0.0
TC	10	0	5	5	135	37.4	28.5	0.83	27.8	0.0	0.0	bank	0.2	5.2	0.0	0.01	2.20	-0.05	0.5	69.7	0.0
TC	10	0	5	7	196	21.4	31.1	0.83	43.1	0.0	0.0	bank	0.3	9.4	0.0	0.02	2.49	-0.05	0.2	35.5	0.0
TC	10	0	5	10	288	14.2	26.9	0.83	36.0	0.0	0.0	bank	0.5	12.9	0.0	0.02	2.63	-0.05	1.4	195.6	0.0
TC	10	30	1	7	196	30.4	31.1	0.83	44.0	0.3	0.0	bank	0.3	7.5	0.0	0.03	3.00	-0.05	0.2	31.1	0.0
TC	10	30	1	10	288	17.8	26.9	0.83	36.5	0.2	0.0	bank	0.4	10.1	0.0	0.03	2.96	-0.05	1.2	162.6	0.0
TC	10	30	3	1	15	21.4	21.5	0.83	23.1	0.0	0.0	bank	0.1	4.0	0.0	0.01	2.04	-0.05	0.7	98.2	0.0
TC	10	30	3	5	135	33.5	28.5	0.83	27.3	0.0	0.0	bank	0.2	5.0	0.0	0.00	1.84	-0.05	0.7	98.6	0.0
TC	10	30	3	7	196	30.4	31.1	0.83	43.7	0.0	0.0	bank	0.3	7.6	0.0	0.03	2.99	-0.05	0.2	30.4	0.0
TC	10	30	3	10	288	17.8	26.9	0.83	36.6	0.0	0.0	bank	0.4	10.1	0.0	0.03	2.96	-0.05	1.1	160.9	0.0
TC	10	30	5	1	15	21.4	21.5	0.83	23.2	0.0	0.0	bank	0.1	4.0	0.0	0.01	2.04	-0.05	0.7	98.2	0.0
TC	10	30	5	5	135	33.5	28.5	0.83	27.4	0.0	0.0	bank	0.2	5.0	0.0	0.00	1.84	-0.05	0.7	98.6	0.0
TC	10	30	5	7	196	30.4	31.1	0.83	43.7	0.0	0.0	bank	0.3	7.6	0.0	0.03	2.99	-0.05	0.2	30.4	0.0
TC	10	30	5	10	288	17.8	26.9	0.83	36.6	0.0	0.0	bank	0.4	10.1	0.0	0.03	2.96	-0.05	1.1	160.9	0.0
TC	20	0	1	7	196	31.4	31.1	0.83	44.1	0.1	0.0	bank	0.3	8.3	0.0	0.03	2.96	-0.05	0.2	32.9	0.0
TC	20	0	1	10	288	24.2	26.9	0.83	36.9	0.1	0.0	bank	0.2	6.6	0.0	0.05	3.64	-0.05	0.8	115.9	0.0
TC	20	0	3	1	15	34.0	21.5	0.83	23.5	0.0	0.0	bank	0.1	4.1	0.0	0.02	2.40	-0.05	0.5	74.2	0.0
TC	20	0	3	5	135	47.4	28.5	0.83	27.3	0.0	0.0	bank	0.4	11.0	0.0	0.00	1.83	-0.05	0.1	18.0	0.0
TC	20	0	3	7	196	31.4	31.1	0.83	43.3	0.0	0.0	bank	0.3	8.3	0.0	0.03	2.93	-0.05	0.2	32.2	0.0
TC	20	0	3	10	288	24.2	26.9	0.83	36.6	0.0	0.0	bank	0.2	6.6	0.0	0.05	3.63	-0.05	0.8	114.9	0.0
TC	20	0	5	1	15	34.0	21.5	0.83	23.5	0.0	0.0	bank	0.1	4.1	0.0	0.02	2.40	-0.05	0.5	74.2	0.0
TC	20	0	5	5	135	47.4	28.5	0.83	27.2	0.0	0.0	bank	0.4	11.0	0.0	0.00	1.83	-0.05	0.1	18.0	0.0
TC	20	0	5	7	196	31.4	31.1	0.83	43.3	0.0	0.0	bank	0.3	8.3	0.0	0.03	2.93	-0.05	0.2	32.2	0.0
TC	20	0	5	10	288	24.2	26.9	0.83	36.6	0.0	0.0	bank	0.2	6.6	0.0	0.05	3.63	-0.05	0.8	114.9	0.0
TC	20	30	1	7	196	40.4	31.1	0.83	44.1	0.1	0.0	bank	0.4	11.9	0.0	0.05	3.46	-0.05	0.1	14.9	0.0
TC	20	30	1	10	288	27.8	26.9	0.83	37.2	0.1	0.0	bank	0.2	5.8	0.0	0.06	4.00	-0.05	0.7	104.7	0.0
TC	20	30	3	1	15	31.4	21.5	0.83	23.4	0.0	0.0	bank	0.1	3.5	0.0	0.02	2.41	-0.05	0.6	89.1	0.0
TC	20	30	3	5	135	43.5	28.5	0.83	27.3	0.0	0.0	bank	0.3	8.0	0.0	0.01	2.01	-0.05	0.2	31.4	0.0
TC	20	30	3	7	196	40.4	31.1	0.83	43.3	0.0	0.0	bank	0.4	12.0	0.0	0.05	3.42	-0.05	0.1	14.6	0.0
TC	20	30	3	10	288	27.8	26.9	0.83	36.9	0.0	0.0	bank	0.2	5.8	0.0	0.06	3.98	-0.05	0.7	103.8	0.0
TC	20	30	5	1	15	31.4	21.5	0.83	23.4	0.0	0.0	bank	0.1	3.5	0.0	0.02	2.41	-0.05	0.6	89.1	0.0
TC	20	30	5	5	135	43.5	28.5	0.83	27.3	0.0	0.0	bank	0.3	8.0	0.0	0.01	2.01	-0.05	0.2	31.4	0.0
TC	20	30	5	7	196	40.4	31.1	0.83	43.3	0.0	0.0	bank	0.4	12.0	0.0	0.05	3.42	-0.05	0.1	14.6	0.0
TC	20	30	5	10	288	27.8	26.9	0.83	36.9	0.0	0.0	bank	0.2	5.8	0.0	0.06	3.98	-0.05	0.7	103.8	0.0

Appendix Table A-2. F

Site	Salt Trmt	Lag	Lucania	Lucania upper	Lucania lower	Opsanus	Opsanus upper	Opsanus lower	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Sscovelli	Sscovelli upper	Sscovelli lower	Thor	Thor upper	Thor lower	all species	All species upper	All species lower
TR	0.9	0	2.4	35.2	-0.3	0.7	3.6	-0.7	0.1	4.3	-0.4	0.4	2.0	-0.6	28	727	-1	33	927	-2
TR	0.9	0	0.9	16.9	-0.4	0.4	2.9	-0.9	0.4	6.1	-0.4	0.3	1.8	-0.7	18	504	-1	24	1013	-3
TR	0.9	0	0.6	13.1	-0.4	0.4	2.9	-0.8	0.1	3.8	-0.4	0.2	1.7	-0.8	21	562	-1	24	809	-3
TR	0.9	0	0.3	9.0	-0.4	0.9	3.9	-0.6	-0.2	2.0	-0.5	0.5	2.1	-0.6	13	357	-1	16	542	-3
TR	0.9	0	2.4	34.9	-0.3	0.7	3.6	-0.7	0.2	4.4	-0.4	0.4	2.0	-0.6	28	723	-1	33	927	-2
TR	0.9	0	0.9	16.6	-0.4	0.3	2.9	-0.9	0.4	6.1	-0.4	0.3	1.8	-0.7	18	491	-1	24	1002	-3
TR	0.9	0	0.6	13.0	-0.4	0.4	2.9	-0.9	0.1	3.7	-0.4	0.2	1.7	-0.8	21	556	-1	24	803	-3
TR	0.9	0	0.3	8.9	-0.4	0.9	3.9	-0.6	-0.2	2.0	-0.5	0.5	2.1	-0.6	13	352	-1	16	537	-3
TR	0.9	0	2.3	34.7	-0.3	0.7	3.6	-0.7	0.2	4.4	-0.4	0.4	2.0	-0.6	28	721	-1	33	926	-2
TR	0.9	0	0.9	16.4	-0.4	0.3	2.9	-0.9	0.4	6.1	-0.4	0.3	1.8	-0.7	18	485	-1	23	996	-3
TR	0.9	30	2.0	29.7	-0.3	0.8	3.7	-0.7	0.2	4.8	-0.4	0.3	1.8	-0.7	24	610	-1	28	758	-3
TR	0.9	30	0.8	15.5	-0.4	0.4	2.9	-0.9	0.4	6.5	-0.4	0.2	1.7	-0.7	17	462	-1	22	891	-3
TR	0.9	30	0.6	13.5	-0.4	0.4	2.9	-0.9	0.1	3.7	-0.4	0.2	1.7	-0.8	22	576	-1	25	836	-3
TR	0.9	30	0.4	10.3	-0.4	0.8	3.8	-0.6	-0.2	1.7	-0.5	0.6	2.2	-0.5	15	399	-1	19	658	-3
TR	0.9	30	2.0	29.3	-0.3	0.8	3.7	-0.7	0.2	4.9	-0.4	0.3	1.8	-0.7	23	607	-1	28	757	-3
TR	0.9	30	0.8	15.2	-0.4	0.4	2.9	-0.9	0.4	6.5	-0.4	0.2	1.7	-0.7	17	450	-1	21	879	-3
TR	0.9	30	0.6	13.4	-0.4	0.4	2.9	-0.9	0.1	3.7	-0.4	0.2	1.7	-0.8	21	570	-1	24	829	-3
TR	0.9	30	0.4	10.2	-0.4	0.8	3.8	-0.6	-0.2	1.7	-0.5	0.6	2.2	-0.5	15	393	-1	18	651	-3
TR	0.9	30	1.9	29.1	-0.3	0.8	3.7	-0.7	0.2	4.9	-0.4	0.3	1.8	-0.7	23	604	-1	28	757	-3
TR	0.9	30	0.8	15.0	-0.4	0.4	2.9	-0.9	0.4	6.5	-0.4	0.2	1.7	-0.7	16	443	-1	21	873	-3
TR	1	0	2.4	34.7	-0.3	0.7	3.6	-0.7	0.2	4.3	-0.4	0.4	2.0	-0.6	27	713	-1	33	902	-2
TR	1	0	0.9	17.0	-0.4	0.4	2.9	-0.9	0.4	6.1	-0.4	0.3	1.8	-0.7	19	509	-1	24	1007	-3
TR	1	0	0.6	12.9	-0.4	0.4	3.0	-0.8	0.1	3.8	-0.4	0.2	1.6	-0.8	21	560	-1	24	798	-3
TR	1	0	0.3	8.7	-0.4	0.9	4.0	-0.6	-0.1	2.1	-0.5	0.4	2.0	-0.6	13	350	-1	16	514	-3
TR	1	0	2.4	34.7	-0.3	0.7	3.6	-0.7	0.2	4.3	-0.4	0.4	2.0	-0.6	27	713	-1	33	902	-2
TR	1	0	0.9	17.0	-0.4	0.4	2.9	-0.9	0.4	6.1	-0.4	0.3	1.8	-0.7	19	509	-1	24	1007	-3
TR	1	0	0.6	12.9	-0.4	0.4	3.0	-0.8	0.1	3.8	-0.4	0.2	1.6	-0.8	21	560	-1	24	798	-3
TR	1	0	0.3	8.7	-0.4	0.9	4.0	-0.6	-0.1	2.1	-0.5	0.4	2.0	-0.6	13	350	-1	16	513	-3
TR	1	0	2.4	34.7	-0.3	0.7	3.6	-0.7	0.2	4.3	-0.4	0.4	2.0	-0.6	27	713	-1	33	902	-2
TR	1	0	0.9	17.0	-0.4	0.4	2.9	-0.9	0.4	6.1	-0.4	0.3	1.8	-0.7	19	509	-1	24	1008	-3
TR	1	30	1.9	28.6	-0.3	0.8	3.7	-0.7	0.2	4.8	-0.4	0.3	1.8	-0.7	23	585	-1	27	720	-3
TR	1	30	0.8	15.4	-0.4	0.4	2.9	-0.8	0.5	6.5	-0.4	0.2	1.7	-0.7	17	463	-1	22	874	-3
TR	1	30	0.6	13.4	-0.4	0.4	3.0	-0.8	0.1	3.7	-0.4	0.2	1.7	-0.8	22	577	-1	25	829	-3
TR	1	30	0.4	10.2	-0.4	0.8	3.8	-0.6	-0.2	1.8	-0.5	0.5	2.2	-0.5	15	399	-1	18	636	-3
TR	1	30	1.9	28.6	-0.3	0.8	3.7	-0.7	0.2	4.8	-0.4	0.3	1.8	-0.7	23	584	-1	27	718	-3
TR	1	30	0.8	15.5	-0.4	0.4	2.9	-0.8	0.5	6.5	-0.4	0.2	1.7	-0.7	17	464	-1	22	874	-3
TR	1	30	0.6	13.4	-0.4	0.4	3.0	-0.8	0.1	3.7	-0.4	0.2	1.7	-0.8	22	578	-1	25	830	-3
TR	1	30	0.4	10.2	-0.4	0.8	3.8	-0.6	-0.2	1.8	-0.5	0.5	2.2	-0.5	15	399	-1	18	636	-3
TR	1	30	1.9	28.6	-0.3	0.8	3.7	-0.7	0.2	4.8	-0.4	0.3	1.8	-0.7	23	584	-1	27	719	-3
TR	1	30	0.8	15.5	-0.4	0.4	2.9	-0.8	0.5	6.5	-0.4	0.2	1.7	-0.7	17	465	-1	22	875	-3
TR	1.1	0	2.3	34.2	-0.3	0.7	3.6	-0.7	0.2	4.3	-0.4	0.4	1.9	-0.6	27	700	-1	32	879	-3
TR	1.1	0	0.9	17.1	-0.4	0.4	2.9	-0.9	0.4	6.1	-0.4	0.3	1.8	-0.7	19	515	-1	25	1003	-3
TR	1.1	0	0.6	12.8	-0.4	0.4	3.0	-0.8	0.1	3.9	-0.4	0.2	1.6	-0.8	21	559	-1	24	788	-3
TR	1.1	0	0.3	8.5	-0.4	1.0	4.1	-0.6	-0.1	2.2	-0.4	0.4	2.0	-0.6	13	346	-1	15	493	-3
TR	1.1	0	2.4	34.6	-0.3	0.7	3.7	-0.7	0.1	4.2	-0.4	0.4	1.9	-0.6	27	708	-1	32	883	-2
TR	1.1	0	0.9	17.5	-0.4	0.4	2.9	-0.9	0.4	6.1	-0.4	0.3	1.8	-0.7	20	531	-1	25	1016	-3
TR	1.1	0	0.6	12.9	-0.4	0.4	3.0	-0.8	0.1	3.9	-0.4	0.2	1.6	-0.8	21	566	-1	24	796	-3
TR	1.1	0	0.3	8.6	-0.4	1.0	4.1	-0.6	-0.1	2.2	-0.4	0.4	2.0	-0.6	13	351	-1	16	498	-3
TR	1.1	0	2.4	34.8	-0.3	0.7	3.7	-0.7	0.1	4.2	-0.4	0.4	1.9	-0.6	27	713	-1	33	887	-2

Appendix Table A-2.

Site	Salt Trmt	Lag	Lucania	Lucania upper	Lucania lower	Opsanus	Opsanus upper	Opsanus lower	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Sscovelli	Sscovelli upper	Sscovelli lower	Thor	Thor upper	Thor lower	all species	All species upper	All species lower
TR	1.1	0	1.0	17.7	-0.4	0.4	2.9	-0.9	0.4	6.1	-0.4	0.3	1.8	-0.7	20	539	-1	26	1024	-3
TR	1.1	30	1.8	27.7	-0.3	0.8	3.7	-0.6	0.2	4.9	-0.4	0.3	1.8	-0.7	22	562	-1	26	686	-3
TR	1.1	30	0.8	15.4	-0.4	0.4	3.0	-0.8	0.5	6.5	-0.4	0.2	1.7	-0.8	17	465	-1	22	858	-3
TR	1.1	30	0.6	13.3	-0.4	0.4	3.0	-0.8	0.1	3.8	-0.4	0.2	1.7	-0.8	22	580	-1	25	824	-3
TR	1.1	30	0.4	10.1	-0.4	0.9	3.9	-0.6	-0.2	1.8	-0.5	0.5	2.1	-0.5	15	401	-1	18	619	-3
TR	1.1	30	1.9	28.0	-0.3	0.8	3.8	-0.6	0.2	4.8	-0.4	0.3	1.8	-0.7	22	569	-1	26	690	-3
TR	1.1	30	0.8	15.9	-0.4	0.4	3.0	-0.8	0.5	6.5	-0.4	0.2	1.7	-0.8	18	483	-1	23	873	-3
TR	1.1	30	0.6	13.4	-0.4	0.4	3.0	-0.8	0.1	3.8	-0.4	0.2	1.7	-0.8	22	589	-1	25	834	-3
TR	1.1	30	0.4	10.2	-0.4	0.9	3.9	-0.6	-0.2	1.8	-0.5	0.5	2.1	-0.5	15	409	-1	19	626	-3
TR	1.1	30	1.9	28.2	-0.3	0.8	3.8	-0.6	0.2	4.8	-0.4	0.3	1.8	-0.7	22	574	-1	26	694	-3
TR	1.1	30	0.9	16.1	-0.4	0.4	3.0	-0.8	0.5	6.5	-0.4	0.2	1.7	-0.7	18	492	-1	23	882	-3
TR	1.3	0	2.3	33.2	-0.3	0.8	3.7	-0.7	0.2	4.3	-0.4	0.3	1.9	-0.7	26	679	-1	31	838	-3
TR	1.3	0	1.0	17.5	-0.4	0.4	3.0	-0.8	0.4	6.1	-0.4	0.2	1.7	-0.7	20	534	-1	25	998	-3
TR	1.3	0	0.6	12.6	-0.4	0.4	3.0	-0.8	0.1	4.0	-0.4	0.1	1.6	-0.8	21	563	-1	24	775	-3
TR	1.3	0	0.4	9.7	-0.4	1.0	4.2	-0.5	-0.1	2.4	-0.4	0.4	1.9	-0.6	17	441	-1	19	580	-3
TR	1.3	0	2.4	34.4	-0.3	0.8	3.8	-0.6	0.1	4.2	-0.4	0.3	1.9	-0.7	27	708	-1	32	861	-2
TR	1.3	0	1.1	18.7	-0.4	0.4	3.0	-0.8	0.4	6.1	-0.4	0.3	1.8	-0.7	22	586	-1	27	1042	-3
TR	1.3	0	0.6	13.0	-0.4	0.5	3.1	-0.8	0.1	4.0	-0.4	0.1	1.6	-0.8	22	587	-1	25	800	-3
TR	1.3	0	0.4	10.1	-0.4	1.0	4.2	-0.5	-0.1	2.4	-0.4	0.4	1.9	-0.6	18	460	-1	20	599	-3
TR	1.3	0	2.4	34.9	-0.3	0.8	3.8	-0.6	0.1	4.1	-0.4	0.3	1.9	-0.7	28	723	-1	33	873	-2
TR	1.3	0	1.1	19.4	-0.4	0.4	3.1	-0.8	0.4	6.1	-0.4	0.3	1.8	-0.7	23	614	-1	29	1067	-3
TR	1.3	30	1.7	25.9	-0.3	0.8	3.8	-0.6	0.3	5.0	-0.4	0.2	1.7	-0.7	20	524	-1	24	628	-3
TR	1.3	30	0.8	15.5	-0.4	0.4	3.0	-0.8	0.5	6.6	-0.4	0.2	1.6	-0.8	18	473	-1	22	832	-3
TR	1.3	30	0.6	13.2	-0.4	0.4	3.0	-0.8	0.1	3.9	-0.4	0.2	1.6	-0.8	22	591	-1	25	820	-3
TR	1.3	30	0.4	10.0	-0.4	0.9	4.0	-0.6	-0.2	1.9	-0.5	0.5	2.1	-0.6	15	409	-1	19	592	-3
TR	1.3	30	1.8	26.9	-0.3	0.9	3.9	-0.6	0.2	4.8	-0.4	0.2	1.7	-0.7	21	550	-1	25	650	-3
TR	1.3	30	0.9	16.8	-0.4	0.5	3.1	-0.8	0.5	6.5	-0.4	0.2	1.7	-0.8	20	528	-1	24	880	-3
TR	1.3	30	0.6	13.6	-0.4	0.5	3.1	-0.8	0.1	3.9	-0.4	0.2	1.6	-0.8	24	619	-1	27	850	-3
TR	1.3	30	0.4	10.4	-0.4	1.0	4.1	-0.6	-0.2	1.9	-0.5	0.5	2.1	-0.6	16	432	-1	20	614	-3
TR	1.3	30	1.8	27.4	-0.3	0.9	4.0	-0.6	0.2	4.8	-0.4	0.2	1.7	-0.7	22	563	-1	26	661	-3
TR	1.3	30	1.0	17.6	-0.4	0.5	3.1	-0.8	0.5	6.5	-0.4	0.2	1.7	-0.8	21	558	-1	26	906	-3
TR	10	0	1.8	27.7	-0.3	0.9	3.9	-0.6	0.2	4.7	-0.4	0.2	1.7	-0.7	22	567	-1	26	673	-3
TR	10	0	0.8	15.0	-0.4	0.5	3.2	-0.8	0.5	7.0	-0.4	0.1	1.6	-0.8	18	473	-1	22	743	-3
TR	10	0	0.5	11.0	-0.4	0.5	3.2	-0.8	0.2	4.5	-0.4	0.1	1.4	-0.8	20	510	-1	22	653	-3
TR	10	0	0.7	13.9	-0.4	1.1	4.3	-0.5	-0.1	2.4	-0.4	0.3	1.9	-0.7	28	704	-1	31	861	-2
TR	10	0	2.0	29.2	-0.3	1.0	4.1	-0.6	0.2	4.6	-0.4	0.2	1.7	-0.7	24	609	-1	28	710	-3
TR	10	0	0.9	16.8	-0.4	0.6	3.3	-0.8	0.5	6.9	-0.4	0.1	1.6	-0.8	21	548	-1	25	810	-3
TR	10	0	0.5	11.3	-0.4	0.6	3.3	-0.8	0.2	4.6	-0.4	0.1	1.4	-0.8	21	534	-1	23	678	-3
TR	10	0	0.7	14.3	-0.4	1.1	4.3	-0.5	-0.1	2.4	-0.4	0.3	1.9	-0.7	29	729	-1	32	886	-2
TR	10	0	2.0	29.4	-0.3	1.0	4.1	-0.6	0.2	4.5	-0.4	0.2	1.7	-0.7	24	615	-1	28	715	-3
TR	10	0	1.0	17.2	-0.4	0.6	3.3	-0.7	0.5	6.9	-0.4	0.1	1.6	-0.8	22	563	-1	26	824	-3
TR	10	30	1.5	23.1	-0.3	0.9	4.0	-0.6	0.3	5.3	-0.4	0.1	1.6	-0.8	18	472	-1	21	552	-3
TR	10	30	0.7	13.7	-0.4	0.5	3.2	-0.8	0.6	7.4	-0.3	0.1	1.5	-0.8	16	431	-1	19	653	-3
TR	10	30	0.5	11.3	-0.4	0.5	3.2	-0.8	0.2	4.4	-0.4	0.1	1.5	-0.8	20	528	-1	22	679	-3
TR	10	30	0.4	9.8	-0.4	1.1	4.3	-0.5	-0.1	2.1	-0.4	0.4	2.0	-0.6	16	418	-1	19	556	-3
TR	10	30	1.6	24.4	-0.3	1.0	4.2	-0.5	0.3	5.2	-0.4	0.1	1.6	-0.8	20	508	-1	23	584	-3
TR	10	30	0.8	15.3	-0.4	0.6	3.4	-0.7	0.6	7.3	-0.4	0.1	1.5	-0.8	19	499	-1	22	715	-3
TR	10	30	0.5	11.7	-0.4	0.6	3.2	-0.8	0.2	4.5	-0.4	0.1	1.5	-0.8	21	551	-1	23	704	-3
TR	10	30	0.4	10.0	-0.4	1.1	4.3	-0.5	-0.1	2.1	-0.4	0.4	2.0	-0.6	16	433	-1	19	572	-3

Appendix Table A-2. F

Site	Salt Trmt	Lag	Lucania	Lucania upper	Lucania lower	Opsanus	Opsanus upper	Opsanus lower	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Sscovelli	Sscovelli upper	Sscovelli lower	Thor	Thor upper	Thor lower	all species	All species upper	All species lower
TR	10	30	1.6	24.6	-0.3	1.0	4.2	-0.5	0.3	5.1	-0.4	0.1	1.6	-0.8	20	512	-1	23	588	-3
TR	10	30	0.8	15.6	-0.4	0.6	3.4	-0.7	0.6	7.3	-0.4	0.1	1.5	-0.8	20	511	-1	23	728	-3
TR	20	0	1.5	24.0	-0.3	1.0	4.1	-0.6	0.3	5.5	-0.4	0.1	1.5	-0.8	20	518	-1	23	593	-3
TR	20	0	0.6	12.3	-0.4	0.6	3.4	-0.7	0.7	8.2	-0.3	0.0	1.4	-0.9	15	395	-1	17	552	-3
TR	20	0	0.3	9.2	-0.4	0.6	3.4	-0.7	0.3	5.5	-0.4	-0.1	1.3	-0.9	17	450	-1	19	546	-3
TR	20	0	2.4	34.9	-0.3	1.6	5.4	-0.2	-0.2	1.5	-0.5	0.3	1.8	-0.7	41	1018	0	46	1114	-1
TR	20	0	1.6	24.8	-0.3	1.0	4.2	-0.5	0.3	5.5	-0.4	0.1	1.5	-0.8	21	539	-1	24	613	-3
TR	20	0	0.6	13.0	-0.4	0.7	3.5	-0.7	0.7	8.2	-0.3	0.0	1.4	-0.9	16	425	-1	19	583	-3
TR	20	0	0.3	9.3	-0.4	0.6	3.4	-0.7	0.3	5.5	-0.4	-0.1	1.3	-0.9	17	456	-1	19	553	-3
TR	20	0	2.5	35.2	-0.3	1.6	5.4	-0.2	-0.2	1.5	-0.5	0.3	1.8	-0.7	42	1030	0	47	1126	-1
TR	20	0	1.6	24.8	-0.3	1.0	4.2	-0.5	0.3	5.5	-0.4	0.1	1.5	-0.8	21	540	-1	24	614	-3
TR	20	0	0.6	13.1	-0.4	0.7	3.5	-0.7	0.7	8.2	-0.3	0.0	1.4	-0.9	16	429	-1	19	587	-3
TR	20	30	2.2	32.4	-0.3	1.0	4.1	-0.6	0.3	5.1	-0.4	0.1	1.5	-0.8	22	572	-1	26	653	-3
TR	20	30	0.5	11.5	-0.4	0.7	3.4	-0.7	0.8	8.7	-0.3	0.0	1.3	-0.9	14	376	-1	16	513	-3
TR	20	30	0.3	9.1	-0.4	0.6	3.4	-0.7	0.3	5.3	-0.4	0.0	1.3	-0.9	16	434	-1	18	530	-3
TR	20	30	0.7	13.9	-0.4	1.1	4.3	-0.5	-0.1	2.1	-0.5	0.3	1.9	-0.7	19	505	-1	22	623	-3
TR	20	30	2.3	33.4	-0.3	1.0	4.2	-0.5	0.3	5.0	-0.4	0.1	1.5	-0.8	23	596	-1	27	676	-3
TR	20	30	0.6	12.2	-0.4	0.7	3.5	-0.7	0.8	8.7	-0.3	0.0	1.3	-0.9	15	405	-1	18	543	-3
TR	20	30	0.3	9.2	-0.4	0.6	3.4	-0.7	0.3	5.3	-0.4	0.0	1.3	-0.9	17	440	-1	18	538	-3
TR	20	30	0.7	14.0	-0.4	1.1	4.3	-0.5	-0.1	2.1	-0.5	0.3	1.9	-0.7	20	511	-1	23	629	-3
TR	20	30	2.3	33.5	-0.3	1.0	4.2	-0.5	0.3	5.0	-0.4	0.1	1.5	-0.8	23	597	-1	27	677	-3
TR	20	30	0.6	12.3	-0.4	0.7	3.5	-0.7	0.8	8.7	-0.3	0.0	1.3	-0.9	15	409	-1	18	547	-3
TC	0.9	0	1.3	21.9	-0.3	0.7	3.5	-0.7	0.1	3.6	-0.4	0.3	1.7	-0.7	18	484	-1	22	600	-3
TC	0.9	0	0.7	14.7	-0.4	0.4	3.0	-0.8	0.3	5.7	-0.4	0.2	1.7	-0.7	17	473	-1	22	881	-3
TC	0.9	0	0.3	9.6	-0.4	0.4	2.9	-0.8	0.1	4.0	-0.4	0.1	1.5	-0.8	16	428	-1	18	611	-3
TC	0.9	0	0.0	5.4	-0.5	0.9	3.9	-0.6	-0.2	1.8	-0.5	0.3	1.9	-0.7	7	211	-2	9	331	-3
TC	0.9	0	1.3	21.8	-0.4	0.7	3.5	-0.7	0.1	3.6	-0.4	0.3	1.7	-0.7	18	479	-1	21	596	-3
TC	0.9	0	0.7	14.5	-0.4	0.4	3.0	-0.8	0.3	5.8	-0.4	0.2	1.7	-0.7	17	466	-1	22	876	-3
TC	0.9	0	0.3	9.6	-0.4	0.4	2.9	-0.9	0.1	4.0	-0.4	0.1	1.5	-0.8	16	425	-1	18	607	-3
TC	0.9	0	0.0	5.3	-0.5	0.9	3.9	-0.6	-0.2	1.8	-0.5	0.3	1.9	-0.7	7	208	-2	9	328	-3
TC	0.9	0	1.3	21.5	-0.4	0.7	3.5	-0.7	0.1	3.6	-0.4	0.2	1.7	-0.7	18	470	-1	21	587	-3
TC	0.9	0	0.7	14.4	-0.4	0.4	2.9	-0.9	0.3	5.8	-0.4	0.2	1.7	-0.7	17	457	-1	21	869	-3
TC	0.9	30	1.0	18.0	-0.4	0.7	3.6	-0.7	0.1	4.1	-0.4	0.1	1.6	-0.8	15	399	-1	18	480	-3
TC	0.9	30	0.7	13.7	-0.4	0.4	3.0	-0.8	0.4	6.1	-0.4	0.2	1.6	-0.8	17	446	-1	21	790	-3
TC	0.9	30	0.4	10.4	-0.4	0.4	2.9	-0.9	0.1	3.8	-0.4	0.1	1.6	-0.8	17	461	-1	20	668	-3
TC	0.9	30	0.0	5.8	-0.5	0.8	3.8	-0.6	-0.2	1.6	-0.5	0.4	2.0	-0.6	8	226	-2	10	365	-3
TC	0.9	30	1.0	18.0	-0.4	0.7	3.6	-0.7	0.1	4.1	-0.4	0.1	1.6	-0.8	15	400	-1	18	480	-3
TC	0.9	30	0.7	13.7	-0.4	0.4	3.0	-0.8	0.4	6.1	-0.4	0.2	1.6	-0.8	17	447	-1	21	791	-3
TC	0.9	30	0.4	10.4	-0.4	0.4	2.9	-0.9	0.1	3.8	-0.4	0.1	1.6	-0.8	17	462	-1	20	668	-3
TC	0.9	30	0.0	5.8	-0.5	0.8	3.8	-0.6	-0.2	1.6	-0.5	0.4	2.0	-0.6	8	226	-2	10	365	-3
TC	0.9	30	1.0	18.0	-0.4	0.7	3.6	-0.7	0.1	4.1	-0.4	0.1	1.6	-0.8	15	400	-1	18	480	-3
TC	0.9	30	0.7	13.7	-0.4	0.4	3.0	-0.8	0.4	6.1	-0.4	0.2	1.6	-0.8	17	447	-1	21	791	-3
TC	1	0	1.3	21.5	-0.4	0.7	3.5	-0.7	0.1	3.6	-0.4	0.2	1.7	-0.7	18	477	-1	21	588	-3
TC	1	0	0.7	14.7	-0.4	0.4	3.0	-0.8	0.3	5.8	-0.4	0.2	1.7	-0.8	17	474	-1	22	871	-3
TC	1	0	0.3	9.3	-0.4	0.4	2.9	-0.8	0.1	4.1	-0.4	0.1	1.5	-0.8	16	417	-1	18	586	-3
TC	1	0	0.0	5.4	-0.5	0.9	3.9	-0.6	-0.2	1.9	-0.5	0.3	1.8	-0.7	7	218	-2	9	330	-3
TC	1	0	1.3	21.7	-0.4	0.7	3.5	-0.7	0.1	3.6	-0.4	0.2	1.7	-0.7	18	483	-1	22	593	-3
TC	1	0	0.7	14.8	-0.4	0.4	3.0	-0.8	0.3	5.8	-0.4	0.2	1.7	-0.8	18	479	-1	22	875	-3
TC	1	0	0.3	9.3	-0.4	0.4	2.9	-0.8	0.1	4.1	-0.4	0.1	1.5	-0.8	16	418	-1	18	588	-3

Appendix Table A-2.

Site	Salt Trmt	Lag	Lucania	Lucania upper	Lucania lower	Opsanus	Opsanus upper	Opsanus lower	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Sscovelli	Sscovelli upper	Sscovelli lower	Thor	Thor upper	Thor lower	all species	All species upper	All species lower
TC	1	0	0.0	5.4	-0.5	0.9	3.9	-0.6	-0.2	1.9	-0.5	0.3	1.8	-0.7	7	219	-2	9	331	-3
TC	1	0	1.3	21.8	-0.3	0.7	3.5	-0.7	0.1	3.6	-0.4	0.2	1.7	-0.7	18	486	-1	22	596	-3
TC	1	0	0.7	14.8	-0.4	0.4	3.0	-0.8	0.3	5.8	-0.4	0.2	1.7	-0.8	18	483	-1	23	877	-3
TC	1	30	1.0	17.3	-0.4	0.8	3.7	-0.7	0.2	4.3	-0.4	0.1	1.5	-0.8	14	384	-1	17	458	-3
TC	1	30	0.6	13.5	-0.4	0.4	3.0	-0.8	0.4	6.1	-0.4	0.2	1.6	-0.8	16	442	-1	20	770	-3
TC	1	30	0.4	10.1	-0.4	0.4	2.9	-0.8	0.1	3.9	-0.4	0.1	1.6	-0.8	17	451	-1	19	645	-3
TC	1	30	0.0	5.5	-0.5	0.9	3.9	-0.6	-0.2	1.7	-0.5	0.4	1.9	-0.6	7	216	-2	9	340	-3
TC	1	30	1.0	17.5	-0.4	0.8	3.7	-0.7	0.2	4.2	-0.4	0.1	1.5	-0.8	15	391	-1	17	464	-3
TC	1	30	0.7	13.7	-0.4	0.5	3.1	-0.8	0.4	6.1	-0.4	0.2	1.6	-0.8	17	452	-1	21	777	-3
TC	1	30	0.4	10.1	-0.4	0.4	2.9	-0.8	0.1	3.9	-0.4	0.1	1.6	-0.8	17	454	-1	19	648	-3
TC	1	30	0.0	5.5	-0.5	0.9	3.9	-0.6	-0.2	1.7	-0.5	0.4	1.9	-0.6	7	218	-2	9	342	-3
TC	1	30	1.0	17.6	-0.4	0.8	3.7	-0.7	0.2	4.2	-0.4	0.1	1.5	-0.8	15	396	-1	17	469	-3
TC	1	30	0.7	13.9	-0.4	0.5	3.1	-0.8	0.4	6.1	-0.4	0.2	1.6	-0.8	17	458	-1	21	782	-3
TC	1.1	0	1.3	21.1	-0.4	0.7	3.6	-0.7	0.1	3.7	-0.4	0.2	1.7	-0.7	18	469	-1	21	574	-3
TC	1.1	0	0.7	14.6	-0.4	0.4	3.0	-0.8	0.4	5.8	-0.4	0.2	1.7	-0.8	17	474	-1	22	861	-3
TC	1.1	0	0.3	9.0	-0.4	0.4	3.0	-0.8	0.1	4.2	-0.4	0.1	1.5	-0.8	15	403	-1	17	560	-4
TC	1.1	0	0.1	6.2	-0.5	0.9	3.9	-0.6	-0.2	2.0	-0.5	0.3	1.8	-0.7	10	277	-1	12	396	-3
TC	1.1	0	1.3	21.4	-0.4	0.7	3.6	-0.7	0.1	3.7	-0.4	0.2	1.7	-0.7	18	479	-1	21	583	-3
TC	1.1	0	0.7	14.8	-0.4	0.4	3.0	-0.8	0.4	5.8	-0.4	0.2	1.7	-0.8	18	485	-1	23	868	-3
TC	1.1	0	0.3	9.0	-0.4	0.4	3.0	-0.8	0.1	4.2	-0.4	0.1	1.5	-0.8	15	407	-1	17	564	-4
TC	1.1	0	0.1	6.2	-0.5	0.9	3.9	-0.6	-0.2	2.0	-0.5	0.3	1.8	-0.7	10	280	-1	12	399	-3
TC	1.1	0	1.3	21.5	-0.4	0.7	3.6	-0.7	0.1	3.7	-0.4	0.2	1.7	-0.7	18	484	-1	22	588	-3
TC	1.1	0	0.7	14.9	-0.4	0.4	3.0	-0.8	0.4	5.8	-0.4	0.2	1.7	-0.8	18	490	-1	23	873	-3
TC	1.1	30	0.9	16.5	-0.4	0.8	3.7	-0.6	0.2	4.4	-0.4	0.1	1.5	-0.8	14	368	-1	16	436	-3
TC	1.1	30	0.6	13.3	-0.4	0.5	3.1	-0.8	0.4	6.2	-0.4	0.2	1.6	-0.8	16	437	-1	20	750	-3
TC	1.1	30	0.3	9.7	-0.4	0.4	2.9	-0.8	0.1	3.9	-0.4	0.1	1.5	-0.8	16	438	-1	19	621	-3
TC	1.1	30	0.0	5.3	-0.5	0.9	3.9	-0.6	-0.2	1.8	-0.5	0.3	1.9	-0.7	7	210	-2	9	323	-3
TC	1.1	30	0.9	16.7	-0.4	0.8	3.7	-0.6	0.2	4.4	-0.4	0.1	1.5	-0.8	14	376	-1	16	444	-3
TC	1.1	30	0.7	13.6	-0.4	0.5	3.1	-0.8	0.4	6.2	-0.4	0.2	1.6	-0.8	17	449	-1	21	759	-3
TC	1.1	30	0.3	9.8	-0.4	0.4	2.9	-0.8	0.1	3.9	-0.4	0.1	1.5	-0.8	16	442	-1	19	624	-3
TC	1.1	30	0.0	5.3	-0.5	0.9	3.9	-0.6	-0.2	1.8	-0.5	0.3	1.9	-0.7	7	212	-2	9	325	-3
TC	1.1	30	0.9	16.9	-0.4	0.8	3.7	-0.6	0.2	4.4	-0.4	0.1	1.5	-0.8	14	380	-1	17	448	-3
TC	1.1	30	0.7	13.7	-0.4	0.5	3.1	-0.8	0.4	6.2	-0.4	0.2	1.6	-0.8	17	454	-1	21	763	-3
TC	1.3	0	1.2	20.1	-0.4	0.7	3.6	-0.7	0.1	3.8	-0.4	0.2	1.7	-0.8	17	449	-1	20	543	-3
TC	1.3	0	0.7	14.4	-0.4	0.4	3.0	-0.8	0.4	5.9	-0.4	0.2	1.7	-0.8	17	471	-1	22	838	-3
TC	1.3	0	0.2	8.3	-0.4	0.4	3.0	-0.8	0.2	4.4	-0.4	0.0	1.4	-0.9	14	375	-1	16	511	-4
TC	1.3	0	0.2	7.6	-0.4	0.9	3.9	-0.6	-0.2	1.7	-0.5	0.3	1.8	-0.7	8	245	-2	10	341	-3
TC	1.3	0	1.2	20.3	-0.4	0.7	3.6	-0.7	0.1	3.8	-0.4	0.2	1.7	-0.8	17	458	-1	20	551	-3
TC	1.3	0	0.7	14.6	-0.4	0.4	3.0	-0.8	0.4	5.9	-0.4	0.2	1.7	-0.8	18	481	-1	22	845	-3
TC	1.3	0	0.2	8.3	-0.4	0.4	3.0	-0.8	0.2	4.4	-0.4	0.0	1.4	-0.9	14	377	-1	16	513	-4
TC	1.3	0	0.2	7.6	-0.4	0.9	3.9	-0.6	-0.2	1.7	-0.5	0.3	1.8	-0.7	9	247	-2	11	342	-3
TC	1.3	0	1.2	20.4	-0.4	0.7	3.6	-0.7	0.1	3.8	-0.4	0.2	1.7	-0.8	17	460	-1	20	554	-3
TC	1.3	0	0.7	14.7	-0.4	0.4	3.0	-0.8	0.4	5.9	-0.4	0.2	1.7	-0.8	18	484	-1	22	848	-3
TC	1.3	30	0.8	15.5	-0.4	0.8	3.8	-0.6	0.2	4.8	-0.4	0.1	1.4	-0.8	13	352	-1	15	411	-3
TC	1.3	30	0.6	12.9	-0.4	0.5	3.1	-0.8	0.4	6.4	-0.4	0.1	1.6	-0.8	16	425	-1	19	710	-3
TC	1.3	30	0.3	9.1	-0.4	0.4	3.0	-0.8	0.1	4.1	-0.4	0.1	1.5	-0.8	15	412	-1	17	573	-3
TC	1.3	30	0.1	6.4	-0.5	0.9	3.9	-0.6	-0.2	2.0	-0.5	0.3	1.8	-0.7	10	293	-1	13	414	-3
TC	1.3	30	0.8	15.6	-0.4	0.8	3.8	-0.6	0.2	4.7	-0.4	0.1	1.4	-0.8	13	357	-1	15	417	-3
TC	1.3	30	0.6	13.1	-0.4	0.5	3.1	-0.8	0.4	6.3	-0.4	0.1	1.6	-0.8	16	434	-1	20	717	-3

Appendix Table A-2.

Site	Salt Trmt	Lag	Lucania	Lucania upper	Lucania lower	Opsanus	Opsanus upper	Opsanus lower	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Sscovelli	Sscovelli upper	Sscovelli lower	Thor	Thor upper	Thor lower	all species	All species upper	All species lower
TC	1.3	30	0.3	9.2	-0.4	0.4	3.0	-0.8	0.1	4.1	-0.4	0.1	1.5	-0.8	15	414	-1	17	575	-3
TC	1.3	30	0.1	6.4	-0.5	0.9	3.9	-0.6	-0.2	2.0	-0.5	0.3	1.8	-0.7	11	294	-1	13	415	-3
TC	1.3	30	0.8	15.7	-0.4	0.8	3.8	-0.6	0.2	4.7	-0.4	0.1	1.4	-0.8	13	359	-1	15	418	-3
TC	1.3	30	0.6	13.1	-0.4	0.5	3.1	-0.8	0.4	6.3	-0.4	0.1	1.6	-0.8	16	435	-1	20	719	-3
TC	10	0	1.0	17.1	-0.4	0.8	3.7	-0.6	0.2	4.3	-0.4	0.1	1.5	-0.8	14	382	-1	17	453	-3
TC	10	0	0.5	11.5	-0.4	0.5	3.1	-0.8	0.5	6.8	-0.4	0.1	1.5	-0.8	14	381	-1	17	610	-3
TC	10	0	0.1	7.1	-0.4	0.5	3.1	-0.8	0.2	4.8	-0.4	0.0	1.3	-0.9	12	323	-1	13	425	-4
TC	10	0	0.2	8.4	-0.4	0.8	3.8	-0.6	-0.2	1.7	-0.5	0.2	1.7	-0.7	9	253	-2	11	344	-3
TC	10	0	1.0	17.0	-0.4	0.8	3.7	-0.6	0.2	4.3	-0.4	0.1	1.5	-0.8	14	382	-1	17	451	-3
TC	10	0	0.5	11.6	-0.4	0.5	3.2	-0.8	0.5	6.8	-0.4	0.1	1.5	-0.8	14	384	-1	17	611	-3
TC	10	0	0.1	7.1	-0.4	0.5	3.1	-0.8	0.2	4.8	-0.4	0.0	1.3	-0.9	12	323	-1	13	426	-4
TC	10	0	0.2	8.4	-0.4	0.8	3.8	-0.6	-0.2	1.7	-0.5	0.2	1.7	-0.7	9	253	-2	11	344	-3
TC	10	0	1.0	17.0	-0.4	0.8	3.7	-0.6	0.2	4.3	-0.4	0.1	1.5	-0.8	14	382	-1	17	452	-3
TC	10	0	0.5	11.6	-0.4	0.5	3.2	-0.8	0.5	6.8	-0.4	0.1	1.5	-0.8	14	384	-1	17	611	-3
TC	10	30	1.1	18.4	-0.4	0.8	3.8	-0.6	0.3	5.1	-0.4	0.0	1.4	-0.9	18	474	-1	20	539	-3
TC	10	30	0.4	10.5	-0.4	0.5	3.2	-0.8	0.6	7.2	-0.4	0.0	1.4	-0.9	13	349	-1	15	539	-4
TC	10	30	0.2	7.6	-0.4	0.5	3.0	-0.8	0.2	4.6	-0.4	0.0	1.4	-0.9	13	345	-1	14	462	-4
TC	10	30	0.2	7.7	-0.4	0.9	3.9	-0.6	-0.2	1.9	-0.5	0.3	1.8	-0.7	12	325	-1	14	444	-3
TC	10	30	1.1	18.3	-0.4	0.8	3.8	-0.6	0.3	5.1	-0.4	0.0	1.4	-0.9	18	473	-1	20	537	-3
TC	10	30	0.4	10.6	-0.4	0.5	3.2	-0.8	0.6	7.2	-0.4	0.0	1.4	-0.9	13	351	-1	15	540	-4
TC	10	30	0.2	7.6	-0.4	0.5	3.0	-0.8	0.2	4.6	-0.4	0.0	1.4	-0.9	13	346	-1	14	462	-4
TC	10	30	0.2	7.7	-0.4	0.9	3.9	-0.6	-0.2	1.9	-0.5	0.3	1.8	-0.7	12	326	-1	14	445	-3
TC	10	30	1.1	18.3	-0.4	0.8	3.8	-0.6	0.3	5.1	-0.4	0.0	1.4	-0.9	18	473	-1	20	538	-3
TC	10	30	0.4	10.6	-0.4	0.5	3.2	-0.8	0.6	7.2	-0.4	0.0	1.4	-0.9	13	351	-1	15	540	-4
TC	20	0	1.2	20.3	-0.4	0.8	3.7	-0.6	0.3	5.2	-0.4	0.0	1.4	-0.9	21	547	-1	24	617	-3
TC	20	0	0.3	8.9	-0.4	0.6	3.3	-0.7	0.7	8.1	-0.3	0.0	1.3	-0.9	11	297	-1	13	437	-4
TC	20	0	0.4	9.8	-0.4	0.5	3.1	-0.8	0.3	5.1	-0.4	-0.1	1.2	-0.9	17	440	-1	18	535	-4
TC	20	0	3.2	43.9	-0.2	2.1	6.5	0.0	-0.3	0.8	-0.5	0.3	1.8	-0.7	41	1023	0	47	1107	-1
TC	20	0	1.2	20.0	-0.4	0.8	3.7	-0.6	0.3	5.2	-0.4	0.0	1.4	-0.9	21	537	-1	23	605	-3
TC	20	0	0.3	8.9	-0.4	0.6	3.3	-0.7	0.7	8.0	-0.3	0.0	1.3	-0.9	11	295	-1	13	434	-4
TC	20	0	0.4	9.8	-0.4	0.5	3.1	-0.8	0.3	5.1	-0.4	-0.1	1.2	-0.9	17	440	-1	18	535	-4
TC	20	0	3.2	43.9	-0.2	2.1	6.5	0.0	-0.3	0.8	-0.5	0.3	1.8	-0.7	41	1023	0	47	1106	-1
TC	20	0	1.2	19.9	-0.4	0.8	3.7	-0.6	0.3	5.2	-0.4	0.0	1.4	-0.9	21	536	-1	23	605	-3
TC	20	0	0.3	8.9	-0.4	0.6	3.3	-0.7	0.7	8.0	-0.3	0.0	1.3	-0.9	11	295	-1	13	434	-4
TC	20	30	2.6	37.3	-0.2	1.0	4.2	-0.5	0.1	3.8	-0.4	0.0	1.3	-0.9	24	605	-1	28	678	-3
TC	20	30	0.3	8.9	-0.4	0.6	3.3	-0.7	0.8	8.6	-0.3	-0.1	1.2	-0.9	11	307	-1	13	434	-4
TC	20	30	0.3	8.9	-0.4	0.5	3.1	-0.8	0.3	5.6	-0.4	-0.1	1.2	-0.9	18	483	-1	20	591	-3
TC	20	30	1.4	22.4	-0.3	1.5	5.2	-0.3	-0.3	1.1	-0.5	0.2	1.7	-0.7	22	573	-1	26	644	-2
TC	20	30	2.6	36.6	-0.2	1.0	4.2	-0.5	0.1	3.8	-0.4	0.0	1.3	-0.9	23	593	-1	27	665	-3
TC	20	30	0.3	8.8	-0.4	0.6	3.3	-0.7	0.8	8.6	-0.3	-0.1	1.2	-0.9	11	304	-1	13	431	-4
TC	20	30	0.3	8.9	-0.4	0.5	3.1	-0.8	0.3	5.6	-0.4	-0.1	1.2	-0.9	18	483	-1	20	591	-3
TC	20	30	1.4	22.4	-0.3	1.5	5.2	-0.3	-0.3	1.1	-0.5	0.2	1.7	-0.7	22	573	-1	26	644	-2
TC	20	30	2.6	36.6	-0.2	1.0	4.2	-0.5	0.1	3.8	-0.4	0.0	1.3	-0.9	23	592	-1	27	664	-3
TC	20	30	0.3	8.8	-0.4	0.6	3.3	-0.7	0.8	8.6	-0.3	-0.1	1.2	-0.9	11	304	-1	13	431	-4

Appendix Table A-3. Predictions for interior scenarios for trawl/seine with 95% confidence intervals

Site	Salt Trmt	Lag	Year	Month	Dayofyr	Salinity	Temper-ature	Depth	BB.Tt	BB.Hw	BB.Sf	Habitat	Gear	Anchoa	Anchoa upper	Anchoa lower	Floridichthys	Floridichthys upper	Floridichthys lower	Anarchopterus	Anarchopterus upper	Anarchopterus lower	Lutjanus	Lutjanus upper	Lutjanus lower	Hippocampus	Hippocampus upper
WHP	0.9	0	1	7	196	34.7	31.1	1.3	2.4	2.4	0.0	bas	trawl	11.1	352.9	-0.1	2.8	155.2	-1.9	7.2	71.4	-0.1	0.6	11.2	-0.4	13.3	126.7
WHP	0.9	0	1	10	288	30.3	27.3	1.3	2.2	2.2	0.0	bas	trawl	19.0	592.7	0.1	2.0	130.5	-1.9	5.6	57.6	-0.3	0.7	12.1	-0.4	9.8	101.3
WHP	0.9	0	3	1	15	29.3	21.2	1.3	1.8	1.9	0.0	bas	trawl	20.6	640.3	0.2	0.0	64.5	-1.9	5.0	52.1	-0.3	0.3	8.6	-0.4	7.3	83.3
WHP	0.9	0	3	5	135	36.5	28.5	1.3	1.9	2.2	0.0	bas	trawl	12.9	405.5	-0.1	0.6	82.7	-1.9	6.1	61.9	-0.2	0.4	9.0	-0.4	7.5	84.9
WHP	0.9	0	3	7	196	34.7	31.1	1.3	1.9	2.7	0.0	bas	trawl	13.3	418.3	0.0	2.8	154.8	-1.9	7.2	71.5	-0.1	0.6	11.2	-0.4	13.2	125.9
WHP	0.9	0	3	10	288	30.3	27.3	1.3	1.7	2.4	0.0	bas	trawl	22.4	694.5	0.3	2.1	133.1	-1.9	5.6	57.6	-0.3	0.7	12.0	-0.4	9.4	98.5
WHP	0.9	0	5	1	15	29.3	21.2	1.3	1.2	1.9	0.0	bas	trawl	24.9	769.8	0.3	0.2	69.3	-1.9	5.0	52.1	-0.3	0.3	8.4	-0.4	6.4	77.3
WHP	0.9	0	5	5	135	36.5	28.5	1.3	1.2	2.3	0.0	bas	trawl	16.1	504.1	0.0	0.8	89.1	-1.9	6.1	61.9	-0.2	0.4	8.8	-0.4	6.6	78.4
WHP	0.9	0	5	7	196	34.7	31.1	1.3	1.2	2.8	0.0	bas	trawl	16.8	524.1	0.1	3.1	166.8	-1.8	7.2	71.6	-0.1	0.6	10.9	-0.4	11.8	116.1
WHP	0.9	0	5	10	288	30.3	27.3	1.3	1.1	2.4	0.0	bas	trawl	27.2	839.9	0.4	2.5	144.4	-1.9	5.6	57.7	-0.3	0.6	11.6	-0.4	8.2	90.5
WHP	0.9	30	1	7	196	35.9	31.1	1.3	2.4	2.5	0.0	bas	trawl	11.0	350.1	-0.1	3.0	162.7	-1.8	6.8	68.3	-0.1	0.6	11.2	-0.4	12.9	123.7
WHP	0.9	30	1	10	288	35.0	27.3	1.3	2.2	2.2	0.0	bas	trawl	17.0	532.0	0.1	2.4	141.2	-1.9	5.5	56.3	-0.3	0.7	12.5	-0.4	9.0	96.1
WHP	0.9	30	3	1	15	29.0	21.2	1.3	1.7	1.9	0.0	bas	trawl	21.0	652.6	0.2	0.0	64.9	-1.9	5.0	52.5	-0.3	0.3	8.6	-0.4	7.2	83.1
WHP	0.9	30	3	5	135	33.6	28.5	1.3	1.8	2.2	0.0	bas	trawl	13.6	427.7	0.0	0.3	74.1	-1.9	6.5	64.9	-0.2	0.4	9.0	-0.4	8.1	89.7
WHP	0.9	30	3	7	196	35.9	31.1	1.3	1.9	2.7	0.0	bas	trawl	13.4	421.7	0.0	3.0	162.8	-1.8	6.9	68.5	-0.1	0.6	11.2	-0.4	12.7	122.4
WHP	0.9	30	3	10	288	35.0	27.3	1.3	1.6	2.4	0.0	bas	trawl	20.3	632.1	0.2	2.5	144.8	-1.9	5.5	56.3	-0.3	0.7	12.3	-0.4	8.6	92.9
WHP	0.9	30	5	1	15	29.0	21.2	1.3	1.1	1.9	0.0	bas	trawl	25.5	787.6	0.4	0.2	70.0	-1.9	5.0	52.5	-0.3	0.3	8.3	-0.4	6.3	76.7
WHP	0.9	30	5	5	135	33.6	28.5	1.3	1.1	2.3	0.0	bas	trawl	17.0	530.6	0.1	0.5	80.3	-1.9	6.5	64.9	-0.2	0.4	8.8	-0.4	7.1	82.4
WHP	0.9	30	5	7	196	35.9	31.1	1.3	1.1	2.8	0.0	bas	trawl	16.8	525.7	0.1	3.4	176.4	-1.8	6.9	68.5	-0.1	0.6	10.8	-0.4	11.3	112.4
WHP	0.9	30	5	10	288	35.0	27.3	1.3	1.0	2.4	0.0	bas	trawl	24.6	761.4	0.3	2.9	157.4	-1.9	5.5	56.3	-0.3	0.6	11.9	-0.4	7.5	85.1
WHP	1	0	1	7	196	38.6	31.1	1.3	2.5	2.3	0.0	bas	trawl	10.4	331.6	-0.1	3.8	187.8	-1.8	7.1	70.8	-0.1	0.6	11.0	-0.4	11.7	115.2
WHP	1	0	1	10	288	33.7	27.3	1.3	2.3	2.2	0.0	bas	trawl	16.6	518.5	0.1	2.2	135.4	-1.9	5.6	57.4	-0.3	0.7	12.4	-0.4	9.3	98.3
WHP	1	0	3	1	15	32.5	21.2	1.3	2.0	1.8	0.0	bas	trawl	16.8	524.4	0.1	0.0	63.6	-1.9	5.0	51.8	-0.3	0.4	9.0	-0.4	7.3	83.5
WHP	1	0	3	5	135	40.6	28.5	1.3	2.3	2.0	0.0	bas	trawl	10.9	344.3	-0.1	1.2	103.3	-1.9	6.0	60.8	-0.2	0.4	8.8	-0.4	6.4	76.8
WHP	1	0	3	7	196	38.6	31.1	1.3	2.5	2.3	0.0	bas	trawl	10.4	331.6	-0.1	3.8	187.8	-1.8	7.1	70.8	-0.1	0.6	11.0	-0.4	11.7	115.2
WHP	1	0	3	10	288	33.7	27.3	1.3	2.3	2.2	0.0	bas	trawl	16.6	518.5	0.1	2.2	135.4	-1.9	5.6	57.4	-0.3	0.7	12.4	-0.4	9.3	98.3
WHP	1	0	5	1	15	32.5	21.2	1.3	2.0	1.8	0.0	bas	trawl	16.8	524.4	0.1	0.0	63.6	-1.9	5.0	51.8	-0.3	0.4	9.0	-0.4	7.3	83.5
WHP	1	0	5	5	135	40.6	28.5	1.3	2.3	2.0	0.0	bas	trawl	10.9	344.3	-0.1	1.2	103.3	-1.9	6.0	60.8	-0.2	0.4	8.8	-0.4	6.4	76.8
WHP	1	0	5	7	196	38.6	31.1	1.3	2.5	2.3	0.0	bas	trawl	10.4	331.6	-0.1	3.8	187.8	-1.8	7.1	70.8	-0.1	0.6	11.0	-0.4	11.7	115.2
WHP	1	0	5	10	288	33.7	27.3	1.3	2.3	2.2	0.0	bas	trawl	16.6	518.5	0.1	2.2	135.4	-1.9	5.6	57.4	-0.3	0.7	12.4	-0.4	9.3	98.3
WHP	1	30	1	7	196	39.9	31.1	1.3	2.5	2.4	0.0	bas	trawl	10.5	334.2	-0.1	4.2	201.8	-1.8	6.7	67.5	-0.1	0.6	10.9	-0.4	11.1	111.3
WHP	1	30	1	10	288	38.9	27.3	1.3	2.3	2.2	0.0	bas	trawl	16.0	500.1	0.0	3.3	171.6	-1.8	5.4	56.0	-0.3	0.7	12.2	-0.4	7.8	87.3
WHP	1	30	3	1	15	32.3	21.2	1.3	2.0	1.8	0.0	bas	trawl	17.0	529.6	0.1	0.0	63.5	-1.9	5.0	52.2	-0.3	0.4	8.9	-0.4	7.3	83.6
WHP	1	30	3	5	135	37.4	28.5	1.3	2.2	2.0	0.0	bas	trawl	11.1	351.9	-0.1	0.7	86.1	-1.9	6.4	64.1	-0.2	0.4	9.0	-0.4	7.4	83.9
WHP	1	30	3	7	196	39.9	31.1	1.3	2.5	2.4	0.0	bas	trawl	10.6	335.0	-0.1	4.2	201.8	-1.8	6.7	67.4	-0.1	0.6	10.9	-0.4	11.1	111.3
WHP	1	30	3	10	288	38.9	27.3	1.3	2.3	2.2	0.0	bas	trawl	16.0	500.8	0.0	3.3	171.6	-1.8	5.4	55.9	-0.3	0.7	12.2	-0.4	7.8	87.2
WHP	1	30	5	1	15	32.3	21.2	1.3	2.0	1.8	0.0	bas	trawl	17.0	529.9	0.1	0.0	63.5	-1.9	5.0	52.2	-0.3	0.4	8.9	-0.4	7.3	83.6
WHP	1	30	5	5	135	37.4	28.5	1.3	2.2	2.0	0.0	bas	trawl	11.1	352.1	-0.1	0.7	86.1	-1.9	6.4	64.1	-0.2	0.4	9.0	-0.4	7.4	83.9
WHP	1	30	5	7	196	39.9	31.1	1.3	2.5	2.4	0.0	bas	trawl	10.6	335.1	-0.1	4.2	201.8	-1.8	6.7	67.4	-0.1	0.6	10.9	-0.4	11.1	111.3
WHP	1	30	5	10	288	38.9	27.3	1.3	2.3	2.2	0.0	bas	trawl	16.0	500.9	0.0	3.3	171.6	-1.8	5.4	55.9	-0.3	0.7	12.2	-0.4	7.8	87.2
WHP	1.1	0	1	7	196	42.4	31.1	1.3	2.6	2.2	0.0	bas	trawl	9.9	316.6	-0.2	5.3	235.9	-1.8	7.0	70.3	-0.1	0.5	10.6	-0.4	10.0	103.0
WHP	1.1	0	1	10	288	37.1	27.3	1.3	2.4	2.1	0.0	bas	trawl	15.3	478.7	0.0	2.8	156.1	-1.9	5.6	57.2	-0.3	0.7	12.3	-0.4	8.4	91.3
WHP	1.1	0	3	1	15	35.8	21.2	1.3	2.2	1.7	0.0	bas	trawl	15.1	473.9	0.0	0.2	70.4	-1.9	4.9	51.5	-0.3	0.4	9.0	-0.4	6.7	79.2
WHP	1.1	0	3	5	135	44.6	28.5	1.3	2.4	1.8	0.0	bas	trawl	10.1	321.6	-0.2	2.1	131.6	-1.9	5.9	59.5	-0.2	0.3	8.5	-0.4	5.2	68.3
WHP	1.1	0	3	7	196	42.4	31.1	1.3	2.7	2.2	0.0	bas	trawl	9.6	305.5	-0.2	5.3	237.8	-1.8	7.0	70.1	-0.1	0.5	10.6	-0.4	9.9	102.5
WHP	1.1	0	3	10	288	37.1	27.3	1.3	2.5	2.1	0.0	bas	trawl	15.0	468.9	0.0	2.8	156.5	-1.9	5.5	57.2	-0.3	0.7	12.3	-0.4	8.4	91.3
WHP	1.1	0	5	1	15	35.8	21.2	1.3	2.2	1.7	0.0	bas	trawl	15.1	472.8	0.0	0.2	70.3	-1.9	4.9	51.4	-0.3	0.4	9.1	-0.4	6.7	79.4
WHP	1.1	0	5	5	135	44.6	28.5	1.3	2.5	1.9	0.0	bas	trawl	10.1	321.2	-0.2	2.1	131.5	-1.9	5.9	59.4	-0.2	0.3	8.5	-0.4	5.2	68.4
WHP	1.1	0	5	7	196	42.4	31.1	1.3	2.7	2.2	0.0	bas	trawl	9.6	305.5	-0.2	5.3	237.7	-1.8	7.0	70.0	-0.1	0.5	10.6	-0.4	9.9	102.5
WHP	1.1	0	5	10	288	37.1	27.3	1.3	2.5	2.1	0.0	bas	trawl	15.0	469.4	0.0	2.8	156.4	-1.9	5.5	57.1	-0.3	0.7	12.3	-0.4	8.4	91.4
WHP	1.1	30	1	7	196	43.9	31.1	1.3	2.6	2.3	0.0	bas	trawl	10.1	320.5	-0.2	5.8	255.5	-1.8	6.7	66.6	-0.1	0.5	10.5	-0.4	9.5	99.2
WHP	1.1	30	1	10	288	42.8	27.3	1.3	2.4	2.1	0.0	bas	trawl	15.2	477.5	0.0	4.6	215.5	-1.8	5.4	55.6	-0.3	0.7	11.9	-0.4	6.5	78.2
WHP	1.1	30	3	1	15	35.5	21.2	1.3	2.2	1.7	0.0	bas	trawl	15.2	476.7	0.0	0.2	69.7	-1.9	5.0	51.9	-0.3	0.4	9.0	-0.4	6.7	79.6
WHP	1.1	30	3	5	135	41.1	28.5	1.3	2.4	1.9	0.0	bas	trawl	10.4	328.5	-0.1	1.3	107.0	-1.9	6.3	63.2	-0.2	0.4	8.7	-0.4	6.2	75.6

Appendix Table A-3. Predictions for interior scenarios for trawl/seine with 95% confidence intervals

Site	Salt Trmt	Lag	Year	Month	Dayofyr	Salinity	Tempe r-ature	Depth	BB.Tt	BB.Hw	BB.Sf	Habitat	Gear	Anchoa	Anchoa upper	Anchoa lower	Floridichthys	Floridichthys upper	Floridichthys lower	Anarch-opterus	Anarch-opterus upper	Anarch-opterus lower	Lutjanus	Lutjanus upper	Lutjanus lower	Hippo-campus	Hippo-campus upper
WHP	1.1	30	3	7	196	43.9	31.1	1.3	2.7	2.2	0.0	bas	trawl	9.7	309.4	-0.2	5.9	257.3	-1.8	6.6	66.4	-0.1	0.5	10.5	-0.4	9.4	98.8
WHP	1.1	30	3	10	288	42.8	27.3	1.3	2.5	2.1	0.0	bas	trawl	14.9	467.5	0.0	4.6	216.0	-1.8	5.4	55.5	-0.3	0.7	11.9	-0.4	6.5	78.1
WHP	1.1	30	5	1	15	35.5	21.2	1.3	2.2	1.7	0.0	bas	trawl	15.2	475.0	0.0	0.2	69.6	-1.9	5.0	51.9	-0.3	0.4	9.0	-0.4	6.8	79.7
WHP	1.1	30	5	5	135	41.1	28.5	1.3	2.4	1.9	0.0	bas	trawl	10.3	327.7	-0.1	1.3	107.0	-1.9	6.3	63.2	-0.2	0.4	8.7	-0.4	6.2	75.6
WHP	1.1	30	5	7	196	43.9	31.1	1.3	2.7	2.2	0.0	bas	trawl	9.7	309.1	-0.2	5.9	257.4	-1.8	6.6	66.3	-0.1	0.5	10.5	-0.4	9.4	98.8
WHP	1.1	30	5	10	288	42.8	27.3	1.3	2.5	2.1	0.0	bas	trawl	14.9	467.5	0.0	4.6	216.0	-1.8	5.4	55.5	-0.3	0.7	11.9	-0.4	6.5	78.2
WHP	1.3	0	1	7	196	50.1	31.1	1.3	2.6	2.0	0.0	bas	trawl	9.2	294.4	-0.2	9.4	373.1	-1.7	6.9	69.1	-0.1	0.5	9.8	-0.4	7.1	82.2
WHP	1.3	0	1	10	288	43.8	27.3	1.3	2.6	1.8	0.0	bas	trawl	13.9	437.5	0.0	5.1	231.8	-1.8	5.5	56.8	-0.3	0.6	11.5	-0.4	6.1	75.1
WHP	1.3	0	3	1	15	42.3	21.2	1.3	2.4	1.4	0.0	bas	trawl	13.3	419.2	0.0	1.2	102.2	-1.9	4.8	50.7	-0.3	0.3	8.5	-0.4	4.9	66.1
WHP	1.3	0	3	5	135	52.8	28.5	1.3	2.7	1.5	0.0	bas	trawl	8.8	281.8	-0.2	4.6	216.2	-1.8	5.4	55.6	-0.3	0.3	7.9	-0.4	3.1	53.4
WHP	1.3	0	3	7	196	50.1	31.1	1.3	2.9	1.7	0.0	bas	trawl	8.2	263.5	-0.2	9.8	384.8	-1.6	6.8	68.5	-0.1	0.4	9.7	-0.4	6.8	80.4
WHP	1.3	0	3	10	288	43.8	27.3	1.3	2.8	1.7	0.0	bas	trawl	13.0	408.0	-0.1	5.2	235.5	-1.8	5.5	56.5	-0.3	0.6	11.5	-0.4	6.0	74.3
WHP	1.3	0	5	1	15	42.3	21.2	1.3	2.5	1.6	0.0	bas	trawl	13.3	419.1	0.0	1.2	101.8	-1.9	4.8	50.6	-0.3	0.4	8.7	-0.4	4.9	66.5
WHP	1.3	0	5	5	135	52.8	28.5	1.3	2.8	1.6	0.0	bas	trawl	8.8	283.6	-0.2	4.6	215.8	-1.8	5.4	55.4	-0.3	0.3	8.1	-0.4	3.1	53.6
WHP	1.3	0	5	7	196	50.1	31.1	1.3	3.0	1.9	0.0	bas	trawl	8.3	268.4	-0.2	9.7	383.6	-1.6	6.8	68.1	-0.1	0.5	9.9	-0.4	6.9	80.8
WHP	1.3	0	5	10	288	43.8	27.3	1.3	2.8	1.9	0.0	bas	trawl	13.3	419.1	0.0	5.2	233.9	-1.8	5.5	56.3	-0.3	0.6	11.8	-0.4	6.1	74.9
WHP	1.3	30	1	7	196	51.8	31.1	1.3	2.6	2.0	0.0	bas	trawl	9.3	297.7	-0.2	10.5	410.3	-1.6	6.5	64.9	-0.2	0.5	9.8	-0.4	6.6	78.7
WHP	1.3	30	1	10	288	50.6	27.3	1.3	2.5	1.8	0.0	bas	trawl	13.9	439.0	0.0	8.4	342.3	-1.7	5.3	54.9	-0.3	0.6	11.1	-0.4	4.3	62.3
WHP	1.3	30	3	1	15	42.0	21.2	1.3	2.4	1.4	0.0	bas	trawl	13.4	421.1	0.0	1.1	100.3	-1.9	4.9	51.2	-0.3	0.3	8.5	-0.4	4.9	66.6
WHP	1.3	30	3	5	135	48.6	28.5	1.3	2.7	1.6	0.0	bas	trawl	8.9	285.8	-0.2	3.2	169.4	-1.8	6.1	61.4	-0.2	0.3	8.1	-0.4	4.0	60.1
WHP	1.3	30	3	7	196	51.8	31.1	1.3	2.9	1.8	0.0	bas	trawl	8.3	266.9	-0.2	10.9	422.6	-1.6	6.4	64.1	-0.2	0.4	9.6	-0.4	6.4	77.0
WHP	1.3	30	3	10	288	50.6	27.3	1.3	2.7	1.7	0.0	bas	trawl	12.9	409.6	-0.1	8.6	347.5	-1.7	5.3	54.5	-0.3	0.6	11.1	-0.4	4.2	61.7
WHP	1.3	30	5	1	15	42.0	21.2	1.3	2.5	1.5	0.0	bas	trawl	13.3	420.3	0.0	1.1	100.0	-1.9	4.9	51.0	-0.3	0.4	8.7	-0.4	5.0	67.0
WHP	1.3	30	5	5	135	48.6	28.5	1.3	2.8	1.7	0.0	bas	trawl	9.0	287.4	-0.2	3.2	169.1	-1.8	6.1	61.1	-0.2	0.3	8.3	-0.4	4.1	60.4
WHP	1.3	30	5	7	196	51.8	31.1	1.3	3.0	1.9	0.0	bas	trawl	8.4	271.2	-0.2	10.8	421.4	-1.6	6.3	63.7	-0.2	0.5	9.8	-0.4	6.4	77.4
WHP	1.3	30	5	10	288	50.6	27.3	1.3	2.8	1.9	0.0	bas	trawl	13.3	419.3	0.0	8.5	345.4	-1.7	5.2	54.3	-0.3	0.6	11.4	-0.4	4.3	62.2
WHP	10	0	1	7	196	48.6	31.1	1.3	2.7	2.0	0.0	bas	trawl	9.2	295.9	-0.2	8.4	340.5	-1.7	6.5	64.8	-0.2	0.5	10.0	-0.4	7.6	86.0
WHP	10	0	1	10	288	43.7	27.3	1.3	2.5	1.9	0.0	bas	trawl	14.0	440.6	0.0	5.1	230.0	-1.8	5.1	52.5	-0.3	0.6	11.6	-0.4	6.2	75.4
WHP	10	0	3	1	15	42.5	21.2	1.3	2.4	1.5	0.0	bas	trawl	13.4	422.2	0.0	1.2	103.5	-1.9	4.5	47.1	-0.4	0.3	8.5	-0.4	4.8	65.7
WHP	10	0	3	5	135	50.6	28.5	1.3	2.7	1.5	0.0	bas	trawl	8.9	284.3	-0.2	3.8	190.3	-1.8	4.8	50.2	-0.3	0.3	8.0	-0.4	3.6	56.8
WHP	10	0	3	7	196	48.6	31.1	1.3	2.9	1.8	0.0	bas	trawl	8.3	266.1	-0.2	8.7	350.7	-1.7	6.2	62.5	-0.2	0.5	9.8	-0.4	7.4	84.1
WHP	10	0	3	10	288	43.7	27.3	1.3	2.8	1.8	0.0	bas	trawl	13.1	412.4	-0.1	5.2	233.4	-1.8	4.9	51.0	-0.3	0.6	11.6	-0.4	6.1	74.7
WHP	10	0	5	1	15	42.5	21.2	1.3	2.5	1.6	0.0	bas	trawl	13.4	422.5	0.0	1.2	103.1	-1.9	4.4	46.3	-0.4	0.4	8.7	-0.4	4.9	66.1
WHP	10	0	5	5	135	50.6	28.5	1.3	2.8	1.7	0.0	bas	trawl	8.9	286.3	-0.2	3.8	189.9	-1.8	4.7	49.3	-0.4	0.3	8.2	-0.4	3.6	57.1
WHP	10	0	5	7	196	48.6	31.1	1.3	3.0	1.9	0.0	bas	trawl	8.4	270.9	-0.2	8.7	349.6	-1.7	6.1	61.3	-0.2	0.5	10.0	-0.4	7.4	84.5
WHP	10	0	5	10	288	43.7	27.3	1.3	2.8	1.9	0.0	bas	trawl	13.4	422.9	0.0	5.1	231.9	-1.8	4.8	50.1	-0.3	0.6	11.8	-0.4	6.1	75.3
WHP	10	30	1	7	196	49.9	31.1	1.3	2.6	2.0	0.0	bas	trawl	9.3	298.7	-0.2	9.2	366.2	-1.7	6.1	61.5	-0.2	0.5	9.9	-0.4	7.2	83.1
WHP	10	30	1	10	288	48.9	27.3	1.3	2.5	1.9	0.0	bas	trawl	14.0	442.0	0.0	7.5	310.3	-1.7	4.9	51.2	-0.3	0.6	11.3	-0.4	4.7	65.3
WHP	10	30	3	1	15	42.3	21.2	1.3	2.4	1.5	0.0	bas	trawl	13.5	424.0	0.0	1.2	102.0	-1.9	4.5	47.4	-0.4	0.3	8.6	-0.4	4.9	66.1
WHP	10	30	3	5	135	47.4	28.5	1.3	2.7	1.6	0.0	bas	trawl	9.0	288.3	-0.2	2.9	157.6	-1.9	5.6	57.2	-0.3	0.3	8.2	-0.4	4.3	62.3
WHP	10	30	3	7	196	49.9	31.1	1.3	2.9	1.8	0.0	bas	trawl	8.4	268.9	-0.2	9.5	376.9	-1.7	5.8	59.3	-0.2	0.5	9.8	-0.4	7.0	81.4
WHP	10	30	3	10	288	48.9	27.3	1.3	2.7	1.8	0.0	bas	trawl	13.1	413.8	-0.1	7.6	314.7	-1.7	4.7	49.6	-0.3	0.6	11.3	-0.4	4.7	64.8
WHP	10	30	5	1	15	42.3	21.2	1.3	2.5	1.6	0.0	bas	trawl	13.4	423.4	0.0	1.2	101.7	-1.9	4.4	46.6	-0.4	0.4	8.7	-0.4	4.9	66.5
WHP	10	30	5	5	135	47.4	28.5	1.3	2.7	1.7	0.0	bas	trawl	9.1	289.8	-0.2	2.9	157.4	-1.9	5.5	56.1	-0.3	0.3	8.3	-0.4	4.4	62.5
WHP	10	30	5	7	196	49.9	31.1	1.3	3.0	1.9	0.0	bas	trawl	8.5	273.0	-0.2	9.5	375.8	-1.7	5.7	58.1	-0.2	0.5	10.0	-0.4	7.0	81.8
WHP	10	30	5	10	288	48.9	27.3	1.3	2.8	1.9	0.0	bas	trawl	13.4	422.8	0.0	7.6	313.0	-1.7	4.6	48.7	-0.4	0.6	11.5	-0.4	4.7	65.2
WHP	20	0	1	7	196	58.6	31.1	1.3	2.4	1.7	0.0	bas	trawl	9.1	293.5	-0.2	16.5	610.8	-1.4	5.7	58.4	-0.2	0.4	8.9	-0.4	4.6	64.5
WHP	20	0	1	10	288	53.7	27.3	1.3	2.4	1.6	0.0	bas	trawl	13.5	427.8	0.0	10.6	413.3	-1.6	4.6	48.1	-0.4	0.5	10.5	-0.4	3.5	56.4
WHP	20	0	3	1	15	52.5	21.2	1.3	2.4	1.2	0.0	bas	trawl	12.4	395.4	-0.1	3.7	187.8	-1.8	3.9	42.3	-0.4	0.3	7.8	-0.4	2.5	48.9
WHP	20	0	3	5	135	60.6	28.5	1.3	2.7	1.2	0.0	bas	trawl	8.1	264.8	-0.2	8.5	346.2	-1.7	2.9	33.3	-0.6	0.2	7.3	-0.4	1.5	42.1
WHP	20	0	3	7	196	58.6	31.1	1.3	2.9	1.3	0.0	bas	trawl	7.6	248.3	-0.2	17.2	634.7	-1.4	5.4	55.5	-0.3	0.4	8.7	-0.4	4.4	62.8
WHP	20	0	3	10	288	53.7	27.3	1.3	2.7	1.3	0.0	bas	trawl	12.0	382.0	-0.1	10.9	423.0	-1.6	4.4	46.2	-0.4	0.5	10.3	-0.4	3.4	55.5
WHP	20	0	5	1	15	52.5	21.2	1.3	2.5	1.2	0.0	bas	trawl	12.0	383.2	-0.1	3.8	188.6	-1.8	3.8	41.6	-0.5	0.3	7.8	-0.4	2.4	48.9
WHP	20	0	5	5	135	60.6	28.5	1.3	2.9	1.2	0.0	bas	trawl	7.9	257.2	-0.2	8.6	349.2	-1.7	2.8	32.9	-0.6	0.2	7.4	-0.4	1.5	41.9

Appendix Table A-3. Predictions for interior scenarios for trawl/seine with 95% confidence intervals

Site	Salt Trmt	Lag	Year	Month	Dayofyr	Salinity	Tempe r-ature	Depth	BB.Tt	BB.Hw	BB.Sf	Habitat	Gear	Anchoa	Anchoa upper	Anchoa lower	Floridichthys	Floridichthys upper	Floridichthys lower	Anarch-opterus	Anarch-opterus upper	Anarch-opterus lower	Lutjanus	Lutjanus upper	Lutjanus lower	Hippo-campus	Hippo-campus upper
WHP	20	0	5	7	196	58.6	31.1	1.3	3.0	1.4	0.0	bas	trawl	7.5	244.6	-0.2	17.3	638.9	-1.4	5.3	54.7	-0.3	0.4	8.9	-0.4	4.3	62.6
WHP	20	0	5	10	288	53.7	27.3	1.3	2.8	1.4	0.0	bas	trawl	12.0	382.3	-0.1	10.9	422.9	-1.6	4.3	45.7	-0.4	0.5	10.5	-0.4	3.4	55.6
WHP	20	30	1	7	196	59.9	31.1	1.3	2.5	1.7	0.0	bas	trawl	9.0	292.5	-0.2	17.9	658.8	-1.4	4.7	49.1	-0.4	0.4	8.9	-0.4	4.3	62.3
WHP	20	30	1	10	288	58.9	27.3	1.3	2.4	1.6	0.0	bas	trawl	13.4	427.6	0.0	14.9	559.7	-1.5	4.4	46.5	-0.4	0.5	10.2	-0.4	2.4	48.8
WHP	20	30	3	1	15	52.3	21.2	1.3	2.4	1.2	0.0	bas	trawl	12.5	397.3	-0.1	3.7	185.2	-1.8	4.0	42.9	-0.4	0.3	7.8	-0.4	2.5	49.2
WHP	20	30	3	5	135	57.4	28.5	1.3	2.8	1.2	0.0	bas	trawl	8.1	262.7	-0.2	6.8	288.0	-1.7	4.2	45.2	-0.4	0.2	7.4	-0.4	2.1	46.1
WHP	20	30	3	7	196	59.9	31.1	1.3	2.9	1.3	0.0	bas	trawl	7.6	248.8	-0.2	18.7	684.4	-1.4	4.4	46.7	-0.4	0.3	8.7	-0.4	4.0	60.6
WHP	20	30	3	10	288	58.9	27.3	1.3	2.7	1.3	0.0	bas	trawl	12.0	383.0	-0.1	15.3	572.4	-1.5	4.2	44.7	-0.4	0.5	10.0	-0.4	2.3	48.0
WHP	20	30	5	1	15	52.3	21.2	1.3	2.5	1.2	0.0	bas	trawl	12.1	385.9	-0.1	3.7	185.8	-1.8	3.9	42.2	-0.4	0.3	7.8	-0.4	2.5	49.2
WHP	20	30	5	5	135	57.4	28.5	1.3	3.0	1.3	0.0	bas	trawl	7.9	255.7	-0.2	6.8	290.7	-1.7	4.2	44.5	-0.4	0.2	7.6	-0.4	2.0	45.9
WHP	20	30	5	7	196	59.9	31.1	1.3	3.0	1.4	0.0	bas	trawl	7.5	246.2	-0.2	18.8	688.1	-1.4	4.3	46.0	-0.4	0.4	8.8	-0.4	4.0	60.5
WHP	20	30	5	10	288	58.9	27.3	1.3	2.8	1.5	0.0	bas	trawl	12.0	385.1	-0.1	15.2	571.4	-1.5	4.1	44.2	-0.4	0.5	10.2	-0.4	2.3	48.2
RL	0.9	0	1	7	196	29.4	30.5	1.0	2.4	1.9	0.0	bas	trawl	12.5	395.5	-0.1	5.2	233.5	-1.8	6.4	64.4	-0.2	0.5	10.3	-0.4	15.8	145.0
RL	0.9	0	1	10	288	26.1	27.2	1.0	2.3	1.9	0.0	bas	trawl	23.0	712.4	0.3	5.3	239.0	-1.8	5.2	53.7	-0.3	0.6	11.3	-0.4	11.0	110.6
RL	0.9	0	3	1	15	26.9	20.9	1.0	2.0	1.5	0.0	bas	trawl	22.9	708.6	0.3	1.5	111.8	-1.9	4.5	47.9	-0.4	0.3	8.3	-0.4	8.7	93.4
RL	0.9	0	3	5	135	34.8	27.7	1.0	2.1	1.6	0.0	bas	trawl	11.9	376.0	-0.1	1.8	121.9	-1.9	5.4	55.6	-0.3	0.4	8.6	-0.4	9.3	97.8
RL	0.9	0	3	7	196	29.4	30.5	1.0	2.4	1.9	0.0	bas	trawl	13.0	408.2	-0.1	5.1	232.3	-1.8	6.4	64.7	-0.2	0.5	10.3	-0.4	15.9	145.5
RL	0.9	0	3	10	288	26.1	27.2	1.0	2.2	1.9	0.0	bas	trawl	23.5	728.8	0.3	5.3	238.5	-1.8	5.2	53.8	-0.3	0.6	11.3	-0.4	11.1	110.7
RL	0.9	0	5	1	15	26.9	20.9	1.0	2.0	1.5	0.0	bas	trawl	23.1	715.1	0.3	1.5	111.9	-1.9	4.5	47.9	-0.4	0.3	8.2	-0.4	8.6	93.3
RL	0.9	0	5	5	135	34.8	27.7	1.0	2.1	1.6	0.0	bas	trawl	12.0	379.2	-0.1	1.8	121.9	-1.9	5.4	55.7	-0.3	0.4	8.6	-0.4	9.3	97.8
RL	0.9	0	5	7	196	29.4	30.5	1.0	2.3	2.0	0.0	bas	trawl	13.1	411.5	-0.1	5.1	232.1	-1.8	6.5	64.9	-0.2	0.5	10.3	-0.4	15.9	145.6
RL	0.9	0	5	10	288	26.1	27.2	1.0	2.2	1.9	0.0	bas	trawl	23.7	733.0	0.3	5.3	238.5	-1.8	5.2	54.0	-0.3	0.6	11.3	-0.4	11.1	110.7
RL	0.9	30	1	7	196	31.5	30.5	1.0	2.4	1.9	0.0	bas	trawl	11.7	368.3	-0.1	5.1	231.1	-1.8	6.0	60.8	-0.2	0.5	10.5	-0.4	15.7	144.3
RL	0.9	30	1	10	288	28.0	27.2	1.0	2.3	1.9	0.0	bas	trawl	20.8	647.0	0.2	4.9	225.6	-1.8	5.0	52.4	-0.3	0.6	11.7	-0.4	11.3	112.2
RL	0.9	30	3	1	15	25.6	20.9	1.0	2.0	1.5	0.0	bas	trawl	24.3	753.1	0.3	1.6	116.8	-1.9	4.6	48.5	-0.4	0.3	8.0	-0.4	8.5	92.4
RL	0.9	30	3	5	135	33.6	27.7	1.0	2.1	1.6	0.0	bas	trawl	12.2	383.0	-0.1	1.7	117.5	-1.9	5.6	56.9	-0.3	0.4	8.6	-0.4	9.6	99.8
RL	0.9	30	3	7	196	31.5	30.5	1.0	2.4	1.9	0.0	bas	trawl	12.0	378.8	-0.1	5.1	230.0	-1.8	6.0	60.8	-0.2	0.5	10.6	-0.4	15.8	144.7
RL	0.9	30	3	10	288	28.0	27.2	1.0	2.3	1.9	0.0	bas	trawl	21.3	660.3	0.2	4.9	225.2	-1.8	5.0	52.4	-0.3	0.6	11.7	-0.4	11.3	112.2
RL	0.9	30	5	1	15	25.6	20.9	1.0	2.0	1.5	0.0	bas	trawl	24.5	759.2	0.3	1.6	116.9	-1.9	4.6	48.5	-0.4	0.3	8.0	-0.4	8.5	92.2
RL	0.9	30	5	5	135	33.6	27.7	1.0	2.1	1.6	0.0	bas	trawl	12.2	385.8	-0.1	1.7	117.5	-1.9	5.6	56.9	-0.3	0.4	8.6	-0.4	9.5	99.7
RL	0.9	30	5	7	196	31.5	30.5	1.0	2.4	1.9	0.0	bas	trawl	12.1	381.5	-0.1	5.1	229.9	-1.8	6.0	60.8	-0.2	0.5	10.6	-0.4	15.8	144.8
RL	0.9	30	5	10	288	28.0	27.2	1.0	2.2	1.9	0.0	bas	trawl	21.4	663.6	0.2	4.9	225.2	-1.8	5.0	52.3	-0.3	0.6	11.7	-0.4	11.3	112.2
RL	1	0	1	7	196	32.7	30.5	1.0	2.5	1.8	0.0	bas	trawl	11.0	347.8	-0.1	5.2	235.3	-1.8	6.3	63.7	-0.2	0.5	10.5	-0.4	15.4	142.1
RL	1	0	1	10	288	29.0	27.2	1.0	2.4	1.8	0.0	bas	trawl	19.5	605.6	0.2	4.8	221.8	-1.8	5.1	53.3	-0.3	0.6	11.8	-0.4	11.3	112.3
RL	1	0	3	1	15	29.8	20.9	1.0	2.1	1.5	0.0	bas	trawl	19.3	599.4	0.2	1.3	104.9	-1.9	4.5	47.1	-0.4	0.4	8.6	-0.4	8.8	94.6
RL	1	0	3	5	135	38.7	27.7	1.0	2.2	1.5	0.0	bas	trawl	11.1	351.2	-0.1	2.6	147.6	-1.9	5.2	53.6	-0.3	0.3	8.4	-0.4	8.1	88.9
RL	1	0	3	7	196	32.7	30.5	1.0	2.5	1.8	0.0	bas	trawl	11.0	347.8	-0.1	5.2	235.3	-1.8	6.3	63.5	-0.2	0.5	10.5	-0.4	15.4	142.1
RL	1	0	3	10	288	29.0	27.2	1.0	2.4	1.8	0.0	bas	trawl	19.5	605.6	0.2	4.8	221.8	-1.8	5.1	53.1	-0.3	0.6	11.8	-0.4	11.3	112.3
RL	1	0	5	1	15	29.8	20.9	1.0	2.1	1.5	0.0	bas	trawl	19.3	599.4	0.2	1.3	104.9	-1.9	4.4	47.0	-0.4	0.4	8.6	-0.4	8.8	94.6
RL	1	0	5	5	135	38.7	27.7	1.0	2.2	1.5	0.0	bas	trawl	11.1	351.2	-0.1	2.6	147.6	-1.9	5.2	53.5	-0.3	0.3	8.4	-0.4	8.1	88.9
RL	1	0	5	7	196	32.7	30.5	1.0	2.5	1.8	0.0	bas	trawl	11.0	347.8	-0.1	5.2	235.3	-1.8	6.3	63.3	-0.2	0.5	10.5	-0.4	15.4	142.1
RL	1	0	5	10	288	29.0	27.2	1.0	2.4	1.8	0.0	bas	trawl	19.5	605.6	0.2	4.8	221.8	-1.8	5.1	53.0	-0.3	0.6	11.8	-0.4	11.3	112.3
RL	1	30	1	7	196	34.9	30.5	1.0	2.5	1.8	0.0	bas	trawl	10.5	334.0	-0.1	5.7	250.6	-1.8	5.9	59.8	-0.2	0.5	10.5	-0.4	14.7	137.1
RL	1	30	1	10	288	31.1	27.2	1.0	2.4	1.8	0.0	bas	trawl	17.9	557.5	0.1	4.7	217.9	-1.8	5.0	51.9	-0.3	0.7	12.1	-0.4	11.2	112.0
RL	1	30	3	1	15	28.5	20.9	1.0	2.1	1.5	0.0	bas	trawl	20.3	631.9	0.2	1.3	107.3	-1.9	4.5	47.8	-0.4	0.3	8.4	-0.4	8.8	94.3
RL	1	30	3	5	135	37.4	27.7	1.0	2.2	1.5	0.0	bas	trawl	11.2	353.6	-0.1	2.3	137.6	-1.9	5.4	55.5	-0.3	0.3	8.5	-0.4	8.5	92.0
RL	1	30	3	7	196	34.9	30.5	1.0	2.5	1.8	0.0	bas	trawl	10.5	332.5	-0.1	5.7	250.8	-1.8	5.9	59.3	-0.2	0.5	10.5	-0.4	14.7	137.0
RL	1	30	3	10	288	31.1	27.2	1.0	2.4	1.8	0.0	bas	trawl	17.8	555.6	0.1	4.7	218.0	-1.8	4.9	51.5	-0.3	0.7	12.1	-0.4	11.2	111.9
RL	1	30	5	1	15	28.5	20.9	1.0	2.1	1.5	0.0	bas	trawl	20.3	631.1	0.2	1.3	107.3	-1.9	4.5	47.6	-0.4	0.3	8.4	-0.4	8.8	94.4
RL	1	30	5	5	135	37.4	27.7	1.0	2.2	1.5	0.0	bas	trawl	11.2	353.2	-0.1	2.3	137.6	-1.9	5.4	55.2	-0.3	0.3	8.5	-0.4	8.5	92.0
RL	1	30	5	7	196	34.9	30.5	1.0	2.5	1.8	0.0	bas	trawl	10.5	332.2	-0.1	5.7	250.9	-1.8	5.8	58.9	-0.2	0.5	10.5	-0.4	14.7	137.0
RL	1	30	5	10	288	31.1	27.2	1.0	2.4	1.8	0.0	bas	trawl	17.8	555.3	0.1	4.7	218.0	-1.8	4.9	51.2	-0.3	0.7	12.1	-0.4	11.2	111.9
RL	1.1	0	1	7	196	36.0	30.5	1.0	2.5	1.7	0.0	bas	trawl	10.1	321.9	-0.1	6.1	263.0	-1.8	6.3	63.1	-0.2	0.5	10.4	-0.4	14.2	133.4
RL	1.1	0	1	10	288	31.8	27.2	1.0	2.4	1.7	0.0	bas	trawl	17.0	530.9	0.1	4.8	219.6	-1.8	5.1	53.0	-0.3	0.7	12.1	-0.4	11.1	111.0

Appendix Table A-3. Predictions for interior scenarios for trawl/seine with 95% confidence intervals

Site	Salt Trmt	Lag	Year	Month	Dayofyr	Salinity	Temperature	Depth	BB.Tt	BB.Hw	BB.Sf	Habitat	Gear	Anchoa	Anchoa upper	Anchoa lower	Floridichthys	Floridichthys upper	Floridichthys lower	Anarchopterus	Anarchopterus upper	Anarchopterus lower	Lutjanus	Lutjanus upper	Lutjanus lower	Hippocampus	Hippocampus upper
RL	1.1	0	3	1	15	32.8	20.9	1.0	2.2	1.4	0.0	bas	trawl	16.9	525.9	0.1	1.3	106.3	-1.9	4.4	46.4	-0.4	0.4	8.8	-0.4	8.6	92.7
RL	1.1	0	3	5	135	42.5	27.7	1.0	2.3	1.3	0.0	bas	trawl	10.5	332.8	-0.1	3.7	185.4	-1.8	4.9	50.9	-0.3	0.3	8.1	-0.4	6.7	79.5
RL	1.1	0	3	7	196	36.0	30.5	1.0	2.6	1.6	0.0	bas	trawl	9.8	311.1	-0.2	6.2	264.9	-1.8	6.2	62.4	-0.2	0.5	10.3	-0.4	14.1	132.6
RL	1.1	0	3	10	288	31.8	27.2	1.0	2.5	1.7	0.0	bas	trawl	16.6	516.8	0.1	4.8	220.6	-1.8	5.0	52.5	-0.3	0.7	12.0	-0.4	11.0	110.6
RL	1.1	0	5	1	15	32.8	20.9	1.0	2.2	1.3	0.0	bas	trawl	16.7	520.5	0.1	1.3	106.3	-1.9	4.3	46.1	-0.4	0.4	8.8	-0.4	8.6	92.8
RL	1.1	0	5	5	135	42.5	27.7	1.0	2.3	1.3	0.0	bas	trawl	10.4	329.8	-0.1	3.7	185.5	-1.8	4.9	50.5	-0.3	0.3	8.1	-0.4	6.7	79.5
RL	1.1	0	5	7	196	36.0	30.5	1.0	2.6	1.6	0.0	bas	trawl	9.7	308.6	-0.2	6.2	265.4	-1.8	6.1	61.9	-0.2	0.5	10.3	-0.4	14.1	132.5
RL	1.1	0	5	10	288	31.8	27.2	1.0	2.5	1.6	0.0	bas	trawl	16.5	514.1	0.1	4.8	220.8	-1.8	5.0	52.1	-0.3	0.7	12.0	-0.4	11.0	110.6
RL	1.1	30	1	7	196	38.4	30.5	1.0	2.5	1.7	0.0	bas	trawl	10.0	317.3	-0.2	7.2	298.1	-1.7	5.8	58.8	-0.2	0.5	10.3	-0.4	13.1	125.5
RL	1.1	30	1	10	288	34.2	27.2	1.0	2.4	1.7	0.0	bas	trawl	16.1	501.8	0.0	5.1	230.6	-1.8	4.9	51.4	-0.3	0.7	12.2	-0.4	10.6	107.6
RL	1.1	30	3	1	15	31.3	20.9	1.0	2.2	1.3	0.0	bas	trawl	17.4	543.6	0.1	1.3	104.7	-1.9	4.5	47.2	-0.4	0.4	8.7	-0.4	8.7	93.9
RL	1.1	30	3	5	135	41.1	27.7	1.0	2.3	1.3	0.0	bas	trawl	10.5	333.8	-0.1	3.3	170.9	-1.8	5.3	54.0	-0.3	0.3	8.2	-0.4	7.2	82.7
RL	1.1	30	3	7	196	38.4	30.5	1.0	2.6	1.5	0.0	bas	trawl	9.6	304.4	-0.2	7.2	300.8	-1.7	5.7	58.0	-0.2	0.5	10.1	-0.4	13.0	124.6
RL	1.1	30	3	10	288	34.2	27.2	1.0	2.5	1.6	0.0	bas	trawl	15.5	485.5	0.0	5.1	232.0	-1.8	4.9	50.7	-0.3	0.7	12.1	-0.4	10.6	107.1
RL	1.1	30	5	1	15	31.3	20.9	1.0	2.2	1.3	0.0	bas	trawl	17.2	536.5	0.1	1.3	104.8	-1.9	4.4	46.7	-0.4	0.4	8.7	-0.4	8.7	93.9
RL	1.1	30	5	5	135	41.1	27.7	1.0	2.3	1.3	0.0	bas	trawl	10.4	330.0	-0.1	3.3	171.1	-1.8	5.2	53.5	-0.3	0.3	8.2	-0.4	7.2	82.7
RL	1.1	30	5	7	196	38.4	30.5	1.0	2.6	1.5	0.0	bas	trawl	9.5	301.3	-0.2	7.3	301.5	-1.7	5.6	57.4	-0.2	0.5	10.1	-0.4	13.0	124.4
RL	1.1	30	5	10	288	34.2	27.2	1.0	2.5	1.6	0.0	bas	trawl	15.4	482.0	0.0	5.1	232.2	-1.8	4.8	50.2	-0.3	0.7	12.1	-0.4	10.6	107.0
RL	1.3	0	1	7	196	42.5	30.5	1.0	2.5	1.5	0.0	bas	trawl	9.6	305.4	-0.2	9.6	378.5	-1.6	6.1	61.8	-0.2	0.5	9.8	-0.4	11.2	111.6
RL	1.3	0	1	10	288	37.6	27.2	1.0	2.5	1.5	0.0	bas	trawl	14.8	462.0	0.0	6.3	271.0	-1.7	5.0	52.4	-0.3	0.6	11.8	-0.4	9.4	98.7
RL	1.3	0	3	1	15	38.8	20.9	1.0	2.3	1.1	0.0	bas	trawl	14.6	456.2	0.0	2.3	138.5	-1.9	4.2	45.1	-0.4	0.3	8.4	-0.4	6.9	80.6
RL	1.3	0	3	5	135	50.3	27.7	1.0	2.4	1.0	0.0	bas	trawl	9.5	302.6	-0.2	7.0	294.3	-1.7	4.0	43.0	-0.4	0.2	7.5	-0.4	4.5	63.2
RL	1.3	0	3	7	196	42.5	30.5	1.0	2.7	1.1	0.0	bas	trawl	8.6	274.3	-0.2	9.9	388.4	-1.6	6.0	60.6	-0.2	0.4	9.4	-0.4	10.8	109.1
RL	1.3	0	3	10	288	37.6	27.2	1.0	2.6	1.2	0.0	bas	trawl	13.4	421.1	0.0	6.5	276.9	-1.7	4.9	51.4	-0.3	0.6	11.3	-0.4	9.1	96.8
RL	1.3	0	5	1	15	38.8	20.9	1.0	2.3	0.9	0.0	bas	trawl	13.8	434.3	0.0	2.3	139.8	-1.9	4.2	44.6	-0.4	0.3	8.2	-0.4	6.8	80.0
RL	1.3	0	5	5	135	50.3	27.7	1.0	2.5	0.8	0.0	bas	trawl	9.0	289.2	-0.2	7.1	297.1	-1.7	4.0	42.5	-0.4	0.2	7.3	-0.4	4.4	62.7
RL	1.3	0	5	7	196	42.5	30.5	1.0	2.7	1.0	0.0	bas	trawl	8.2	262.1	-0.2	10.1	393.0	-1.6	5.9	59.9	-0.2	0.4	9.2	-0.4	10.7	107.9
RL	1.3	0	5	10	288	37.6	27.2	1.0	2.6	1.0	0.0	bas	trawl	12.9	404.4	-0.1	6.6	279.7	-1.7	4.9	50.8	-0.3	0.6	11.1	-0.4	9.0	96.0
RL	1.3	30	1	7	196	45.4	30.5	1.0	2.5	1.5	0.0	bas	trawl	9.6	305.3	-0.2	11.7	446.8	-1.6	5.5	56.4	-0.3	0.4	9.7	-0.4	10.0	103.1
RL	1.3	30	1	10	288	40.4	27.2	1.0	2.5	1.5	0.0	bas	trawl	14.6	458.3	0.0	7.7	316.6	-1.7	4.8	50.6	-0.3	0.6	11.6	-0.4	8.4	91.5
RL	1.3	30	3	1	15	37.0	20.9	1.0	2.3	1.0	0.0	bas	trawl	14.6	456.7	0.0	1.9	125.9	-1.9	4.3	46.0	-0.4	0.3	8.5	-0.4	7.4	84.4
RL	1.3	30	3	5	135	48.6	27.7	1.0	2.4	1.0	0.0	bas	trawl	9.5	302.2	-0.2	6.2	267.6	-1.8	4.8	49.7	-0.3	0.2	7.5	-0.4	4.9	66.1
RL	1.3	30	3	7	196	45.4	30.5	1.0	2.7	1.1	0.0	bas	trawl	8.5	272.8	-0.2	12.1	459.0	-1.6	5.4	55.2	-0.3	0.4	9.2	-0.4	9.7	100.7
RL	1.3	30	3	10	288	40.4	27.2	1.0	2.6	1.1	0.0	bas	trawl	13.2	416.0	0.0	7.9	323.8	-1.7	4.7	49.5	-0.4	0.6	11.1	-0.4	8.2	89.7
RL	1.3	30	5	1	15	37.0	20.9	1.0	2.4	0.9	0.0	bas	trawl	13.8	433.7	0.0	1.9	127.1	-1.9	4.3	45.5	-0.4	0.3	8.3	-0.4	7.3	83.7
RL	1.3	30	5	5	135	48.6	27.7	1.0	2.5	0.8	0.0	bas	trawl	9.0	288.0	-0.2	6.3	270.3	-1.7	4.7	49.1	-0.4	0.2	7.4	-0.4	4.8	65.6
RL	1.3	30	5	7	196	45.4	30.5	1.0	2.7	0.9	0.0	bas	trawl	8.1	260.0	-0.2	12.2	464.8	-1.6	5.3	54.5	-0.3	0.4	9.0	-0.4	9.5	99.6
RL	1.3	30	5	10	288	40.4	27.2	1.0	2.7	1.0	0.0	bas	trawl	12.7	398.5	-0.1	8.1	327.3	-1.7	4.7	48.9	-0.4	0.6	10.9	-0.4	8.0	88.8
RL	10	0	1	7	196	42.7	30.5	1.0	2.5	1.5	0.0	bas	trawl	9.6	304.3	-0.2	9.7	382.9	-1.6	5.8	58.8	-0.2	0.5	9.8	-0.4	11.1	110.9
RL	10	0	1	10	288	39.0	27.2	1.0	2.5	1.5	0.0	bas	trawl	14.6	457.9	0.0	7.0	291.6	-1.7	4.7	48.9	-0.4	0.6	11.7	-0.4	8.9	95.2
RL	10	0	3	1	15	39.8	20.9	1.0	2.3	1.0	0.0	bas	trawl	14.4	450.7	0.0	2.6	147.4	-1.9	4.0	42.8	-0.4	0.3	8.3	-0.4	6.5	78.1
RL	10	0	3	5	135	48.7	27.7	1.0	2.4	0.9	0.0	bas	trawl	9.4	299.7	-0.2	6.3	269.1	-1.7	3.6	39.6	-0.5	0.2	7.5	-0.4	4.8	65.9
RL	10	0	3	7	196	42.7	30.5	1.0	2.7	1.1	0.0	bas	trawl	8.5	270.8	-0.2	10.1	393.9	-1.6	5.6	57.1	-0.3	0.4	9.3	-0.4	10.7	108.1
RL	10	0	3	10	288	39.0	27.2	1.0	2.6	1.1	0.0	bas	trawl	13.2	413.8	0.0	7.2	298.6	-1.7	4.5	47.6	-0.4	0.6	11.1	-0.4	8.6	93.2
RL	10	0	5	1	15	39.8	20.9	1.0	2.4	0.8	0.0	bas	trawl	13.6	426.8	0.0	2.6	149.0	-1.9	3.9	42.3	-0.4	0.3	8.1	-0.4	6.4	77.4
RL	10	0	5	5	135	48.7	27.7	1.0	2.5	0.8	0.0	bas	trawl	8.9	284.9	-0.2	6.4	272.1	-1.7	3.6	39.2	-0.5	0.2	7.3	-0.4	4.8	65.3
RL	10	0	5	7	196	42.7	30.5	1.0	2.7	0.9	0.0	bas	trawl	8.0	257.3	-0.2	10.3	399.3	-1.6	5.5	56.4	-0.3	0.4	9.1	-0.4	10.5	106.9
RL	10	0	5	10	288	39.0	27.2	1.0	2.7	0.9	0.0	bas	trawl	12.6	395.1	-0.1	7.3	302.1	-1.7	4.5	47.1	-0.4	0.6	10.9	-0.4	8.5	92.2
RL	10	30	1	7	196	44.9	30.5	1.0	2.5	1.5	0.0	bas	trawl	9.5	304.1	-0.2	11.3	435.0	-1.6	5.1	52.8	-0.3	0.4	9.7	-0.4	10.2	104.4
RL	10	30	1	10	288	41.1	27.2	1.0	2.5	1.5	0.0	bas	trawl	14.5	455.6	0.0	8.1	329.4	-1.7	4.5	47.6	-0.4	0.6	11.5	-0.4	8.2	89.7
RL	10	30	3	1	15	38.5	20.9	1.0	2.3	1.0	0.0	bas	trawl	14.4	450.0	0.0	2.2	136.4	-1.9	4.1	43.6	-0.4	0.3	8.4	-0.4	7.0	81.1
RL	10	30	3	5	135	47.4	27.7	1.0	2.4	0.9	0.0	bas	trawl	9.4	299.4	-0.2	5.7	250.1	-1.8	4.3	45.5	-0.4	0.2	7.5	-0.4	5.2	68.2
RL	10	30	3	7	196	44.9	30.5	1.0	2.7	1.0	0.0	bas	trawl	8.4	269.4	-0.2	11.7	448.0	-1.6	4.9	51.2	-0.3	0.4	9.2	-0.4	9.8	101.7
RL	10	30	3	10	288	41.1	27.2	1.0	2.6	1.1	0.0	bas	trawl	13.1	410.3	-0.1	8.4	337.6	-1.7	4.4	46.4	-0.4	0.6	11.0	-0.4	7.9	87.8

Appendix Table A-3. Predictions for interior scenarios for trawl/seine with 95% confidence intervals

Site	Salt Trmt	Lag	Year	Month	Dayofyr	Salinity	Tempe r-ature	Depth	BB.Tt	BB.Hw	BB.Sf	Habitat	Gear	Anchoa	Anchoa upper	Anchoa lower	Floridichthys	Floridichthys upper	Floridichthys lower	Anarch-opterus	Anarch-opterus upper	Anarch-opterus lower	Lutjanus	Lutjanus upper	Lutjanus lower	Hippo-campus	Hippo-campus upper
RL	10	30	5	1	15	38.5	20.9	1.0	2.4	0.8	0.0	bas	trawl	13.5	425.3	0.0	2.3	138.0	-1.9	4.0	43.0	-0.4	0.3	8.1	-0.4	6.8	80.3
RL	10	30	5	5	135	47.4	27.7	1.0	2.5	0.7	0.0	bas	trawl	8.9	284.1	-0.2	5.8	253.0	-1.8	4.2	45.0	-0.4	0.2	7.4	-0.4	5.1	67.6
RL	10	30	5	7	196	44.9	30.5	1.0	2.7	0.8	0.0	bas	trawl	7.9	255.5	-0.2	11.9	454.3	-1.6	4.9	50.6	-0.3	0.4	8.9	-0.4	9.6	100.4
RL	10	30	5	10	288	41.1	27.2	1.0	2.7	0.9	0.0	bas	trawl	12.4	391.0	-0.1	8.5	341.8	-1.7	4.3	45.9	-0.4	0.5	10.7	-0.4	7.8	86.8
RL	20	0	1	7	196	52.7	30.5	1.0	2.4	1.7	0.0	bas	trawl	10.2	325.7	-0.1	18.3	669.1	-1.4	4.9	51.2	-0.3	0.4	9.5	-0.4	7.5	85.6
RL	20	0	1	10	288	49.0	27.2	1.0	2.4	1.7	0.0	bas	trawl	15.4	482.6	0.0	13.5	509.7	-1.5	4.2	45.1	-0.4	0.6	11.3	-0.4	5.8	73.3
RL	20	0	3	1	15	49.8	20.9	1.0	2.2	1.3	0.0	bas	trawl	15.2	478.8	0.0	5.9	258.9	-1.8	3.1	35.2	-0.5	0.3	8.1	-0.4	4.0	60.0
RL	20	0	3	5	135	58.7	27.7	1.0	2.3	1.3	0.0	bas	trawl	10.3	330.3	-0.1	12.3	470.9	-1.6	2.0	25.8	-0.7	0.2	7.4	-0.4	2.7	50.7
RL	20	0	3	7	196	52.7	30.5	1.0	2.5	1.6	0.0	bas	trawl	9.6	307.9	-0.2	18.6	675.8	-1.4	4.7	49.6	-0.3	0.4	9.4	-0.4	7.5	85.0
RL	20	0	3	10	288	49.0	27.2	1.0	2.5	1.6	0.0	bas	trawl	14.7	462.0	0.0	13.7	513.6	-1.5	4.1	43.9	-0.4	0.6	11.2	-0.4	5.8	72.8
RL	20	0	5	1	15	49.8	20.9	1.0	2.3	1.2	0.0	bas	trawl	14.9	469.8	0.0	5.9	259.4	-1.8	3.1	34.8	-0.5	0.3	8.1	-0.4	4.0	60.0
RL	20	0	5	5	135	58.7	27.7	1.0	2.3	1.3	0.0	bas	trawl	10.1	324.7	-0.2	12.3	471.7	-1.6	2.0	25.6	-0.7	0.2	7.4	-0.4	2.7	50.7
RL	20	0	5	7	196	52.7	30.5	1.0	2.6	1.6	0.0	bas	trawl	9.4	302.9	-0.2	18.6	677.9	-1.4	4.7	49.2	-0.4	0.4	9.4	-0.4	7.4	84.8
RL	20	0	5	10	288	49.0	27.2	1.0	2.5	1.6	0.0	bas	trawl	14.5	456.5	0.0	13.7	514.7	-1.5	4.1	43.6	-0.4	0.6	11.2	-0.4	5.8	72.7
RL	20	30	1	7	196	54.9	30.5	1.0	2.4	1.7	0.0	bas	trawl	10.2	326.7	-0.1	21.1	761.7	-1.3	3.3	37.0	-0.5	0.4	9.4	-0.4	6.8	80.5
RL	20	30	1	10	288	51.1	27.2	1.0	2.4	1.7	0.0	bas	trawl	15.4	486.2	0.0	15.5	575.4	-1.5	4.0	43.2	-0.4	0.6	11.2	-0.4	5.3	69.2
RL	20	30	3	1	15	48.5	20.9	1.0	2.2	1.3	0.0	bas	trawl	15.4	484.8	0.0	5.3	238.6	-1.8	3.4	38.0	-0.5	0.3	8.2	-0.4	4.3	62.5
RL	20	30	3	5	135	57.4	27.7	1.0	2.3	1.3	0.0	bas	trawl	10.2	328.6	-0.1	11.3	437.0	-1.6	2.6	30.3	-0.6	0.2	7.5	-0.4	3.0	52.6
RL	20	30	3	7	196	54.9	30.5	1.0	2.5	1.6	0.0	bas	trawl	9.7	312.5	-0.2	21.3	766.9	-1.3	3.2	35.8	-0.5	0.4	9.3	-0.4	6.8	80.1
RL	20	30	3	10	288	51.1	27.2	1.0	2.5	1.6	0.0	bas	trawl	14.9	469.8	0.0	15.6	578.6	-1.5	3.9	42.1	-0.4	0.6	11.2	-0.4	5.2	68.9
RL	20	30	5	1	15	48.5	20.9	1.0	2.2	1.3	0.0	bas	trawl	15.2	477.9	0.0	5.3	238.9	-1.8	3.4	37.6	-0.5	0.3	8.2	-0.4	4.3	62.4
RL	20	30	5	5	135	57.4	27.7	1.0	2.3	1.3	0.0	bas	trawl	10.1	324.4	-0.2	11.3	437.5	-1.6	2.5	30.1	-0.6	0.2	7.4	-0.4	3.0	52.6
RL	20	30	5	7	196	54.9	30.5	1.0	2.5	1.6	0.0	bas	trawl	9.6	308.8	-0.2	21.3	768.5	-1.3	3.2	35.5	-0.5	0.4	9.3	-0.4	6.8	80.0
RL	20	30	5	10	288	51.1	27.2	1.0	2.5	1.6	0.0	bas	trawl	14.8	465.8	0.0	15.6	579.3	-1.5	3.9	41.9	-0.4	0.6	11.1	-0.4	5.2	68.8

Appendix Table A-3

Site	Salt Trmt	Lag	Hippocampus lower	Lucania	Lucania upper	Lucania lower	M. gulosus	M. gulosus upper	M. gulosus lower	M. microlepis	M. microlepis upper	M. microlepis lower	Eucinostomus	Eucinostomus upper	Eucinostomus lower	Opisthonema	Opisthonema upper	Opisthonema lower	Lagodon	Lagodon upper	Lagodon lower	Farfantepenaeus	Farfantepenaeus upper
WHP	0.9	0	-2.5	3.8	320.2	-0.9	3.7	46.4	-6.7	0.1	3.0	-0.1	279.3	6724.3	-24.9	0.0	0.0	0.0	24.5	325.5	-6.5	41.9	483.5
WHP	0.9	0	-3.0	4.0	333.3	-0.9	3.4	45.2	-6.7	0.1	3.0	-0.1	644.5	14457.6	-7.7	0.0	0.0	0.0	24.4	324.4	-6.5	73.3	759.0
WHP	0.9	0	-3.3	1.8	184.5	-1.0	2.0	39.4	-7.1	0.0	2.7	-0.1	153.6	4058.1	-30.9	0.0	0.0	0.0	11.3	197.3	-7.8	45.8	517.7
WHP	0.9	0	-3.3	1.5	162.0	-1.0	3.1	43.6	-6.8	0.0	2.7	-0.1	108.8	3107.4	-33.0	0.0	0.0	0.0	28.6	365.7	-6.0	33.7	411.3
WHP	0.9	0	-2.5	3.0	264.3	-0.9	4.2	48.4	-6.5	0.1	2.9	-0.1	286.1	6871.3	-24.6	0.0	0.0	0.0	23.2	313.4	-6.6	48.7	543.4
WHP	0.9	0	-3.0	3.2	275.9	-0.9	3.8	46.9	-6.6	0.1	3.0	-0.1	634.1	14239.0	-8.2	0.0	0.0	0.0	22.3	303.9	-6.7	79.6	813.9
WHP	0.9	0	-3.4	1.3	150.0	-1.0	2.3	40.6	-7.0	0.0	2.7	-0.1	146.2	3902.7	-31.2	0.0	0.0	0.0	9.2	177.0	-8.0	47.5	532.4
WHP	0.9	0	-3.4	0.9	127.3	-1.0	3.5	45.3	-6.7	0.0	2.6	-0.1	104.1	3009.5	-33.2	0.0	0.0	0.0	24.6	326.5	-6.4	36.0	431.7
WHP	0.9	0	-2.7	2.1	204.2	-1.0	4.7	50.4	-6.4	0.1	2.9	-0.1	271.4	6560.7	-25.3	0.0	0.0	0.0	19.4	276.4	-7.0	51.5	568.0
WHP	0.9	0	-3.2	2.4	222.6	-0.9	4.2	48.2	-6.5	0.1	2.9	-0.1	601.2	13544.4	-9.7	0.0	0.0	0.0	18.7	269.7	-7.0	80.9	826.1
WHP	0.9	30	-2.5	3.8	316.7	-0.9	3.8	46.6	-6.6	0.1	2.9	-0.1	291.6	6983.0	-24.3	0.0	0.0	0.0	25.5	335.1	-6.4	40.2	469.0
WHP	0.9	30	-3.1	3.8	316.4	-0.9	2.6	41.9	-6.9	0.0	2.6	-0.1	717.0	15990.5	-4.3	0.0	0.0	0.0	27.5	354.9	-6.1	67.4	706.8
WHP	0.9	30	-3.3	1.8	183.1	-1.0	2.1	39.8	-7.0	0.0	2.7	-0.1	152.9	4043.7	-30.9	0.0	0.0	0.0	11.2	195.8	-7.8	45.9	518.9
WHP	0.9	30	-3.2	1.4	161.4	-1.0	3.1	43.8	-6.8	0.1	2.9	-0.1	96.9	2857.4	-33.5	0.0	0.0	0.0	25.9	339.2	-6.3	38.2	451.2
WHP	0.9	30	-2.6	2.9	256.3	-0.9	4.3	48.7	-6.5	0.0	2.8	-0.1	297.1	7104.1	-24.1	0.0	0.0	0.0	23.9	319.7	-6.5	47.0	529.2
WHP	0.9	30	-3.1	2.9	257.6	-0.9	3.0	43.6	-6.8	0.0	2.6	-0.1	702.3	15682.3	-5.0	0.0	0.0	0.0	24.9	329.7	-6.4	73.3	759.1
WHP	0.9	30	-3.4	1.3	148.3	-1.0	2.4	41.0	-7.0	0.0	2.7	-0.1	145.0	3877.8	-31.3	0.0	0.0	0.0	9.0	174.8	-8.0	47.4	531.7
WHP	0.9	30	-3.3	0.9	127.2	-1.0	3.5	45.4	-6.7	0.1	2.9	-0.1	92.1	2755.8	-33.8	0.0	0.0	0.0	22.0	301.6	-6.7	40.3	469.7
WHP	0.9	30	-2.7	2.0	199.4	-1.0	4.7	50.6	-6.4	0.0	2.8	-0.1	281.1	6765.4	-24.9	0.0	0.0	0.0	19.9	281.5	-6.9	49.2	548.2
WHP	0.9	30	-3.3	2.2	209.1	-1.0	3.3	44.8	-6.8	0.0	2.6	-0.1	666.1	14917.4	-6.7	0.0	0.0	0.0	21.1	292.7	-6.8	74.2	767.1
WHP	1	0	-2.7	3.9	324.8	-0.9	3.9	47.2	-6.6	0.0	2.6	-0.1	312.4	7421.4	-23.4	0.0	0.0	0.0	27.7	357.2	-6.1	33.1	406.6
WHP	1	0	-3.0	4.1	334.5	-0.9	2.6	41.7	-6.9	0.0	2.7	-0.1	678.9	15182.6	-6.0	0.0	0.0	0.0	26.5	345.5	-6.2	67.1	704.3
WHP	1	0	-3.3	2.0	195.8	-1.0	0.9	34.9	-7.3	0.0	2.5	-0.1	163.2	4263.0	-30.4	0.0	0.0	0.0	13.1	214.7	-7.6	42.2	486.4
WHP	1	0	-3.4	1.8	187.6	-1.0	3.2	44.2	-6.8	0.0	2.3	-0.1	125.1	3450.8	-32.2	0.0	0.0	0.0	34.1	418.8	-5.5	22.7	315.0
WHP	1	0	-2.7	3.9	324.8	-0.9	3.9	47.2	-6.6	0.0	2.6	-0.1	312.4	7420.6	-23.4	0.0	0.0	0.0	27.7	357.2	-6.1	33.1	406.5
WHP	1	0	-3.0	4.1	334.5	-0.9	2.6	41.7	-6.9	0.0	2.7	-0.1	678.9	15181.8	-6.1	0.0	0.0	0.0	26.5	345.5	-6.2	67.1	704.3
WHP	1	0	-3.3	2.0	195.8	-1.0	0.9	34.9	-7.3	0.0	2.5	-0.1	163.2	4263.3	-30.4	0.0	0.0	0.0	13.1	214.7	-7.6	42.2	486.4
WHP	1	0	-3.4	1.8	187.6	-1.0	3.2	44.2	-6.8	0.0	2.3	-0.1	125.1	3451.1	-32.2	0.0	0.0	0.0	34.1	418.9	-5.5	22.7	315.0
WHP	1	0	-2.7	3.9	324.8	-0.9	3.9	47.2	-6.6	0.0	2.6	-0.1	312.4	7421.0	-23.4	0.0	0.0	0.0	27.7	357.2	-6.1	33.1	406.6
WHP	1	0	-3.0	4.1	334.5	-0.9	2.6	41.7	-6.9	0.0	2.7	-0.1	678.9	15182.2	-6.1	0.0	0.0	0.0	26.5	345.5	-6.2	67.1	704.3
WHP	1	30	-2.8	3.9	321.2	-0.9	4.2	48.1	-6.6	0.0	2.5	-0.1	331.8	7832.0	-22.4	0.0	0.0	0.0	29.2	371.1	-6.0	31.2	390.3
WHP	1	30	-3.2	3.9	324.7	-0.9	2.9	42.8	-6.9	0.0	2.3	-0.1	809.0	17938.8	0.1	0.0	0.0	0.0	31.6	394.3	-5.7	54.8	597.1
WHP	1	30	-3.3	2.0	194.9	-1.0	1.0	35.1	-7.3	0.0	2.5	-0.1	161.1	4218.3	-30.5	0.0	0.0	0.0	12.9	212.7	-7.6	42.3	487.4
WHP	1	30	-3.3	1.8	186.5	-1.0	2.8	42.5	-6.9	0.0	2.6	-0.1	108.7	3104.5	-33.0	0.0	0.0	0.0	30.5	383.8	-5.8	28.1	362.7
WHP	1	30	-2.8	3.8	319.8	-0.9	4.2	48.2	-6.6	0.0	2.5	-0.1	331.2	7818.6	-22.5	0.0	0.0	0.0	29.1	370.5	-6.0	31.3	390.7
WHP	1	30	-3.2	3.9	323.8	-0.9	2.9	42.8	-6.9	0.0	2.3	-0.1	807.6	17908.6	0.0	0.0	0.0	0.0	31.5	393.7	-5.7	54.8	597.1
WHP	1	30	-3.3	2.0	194.7	-1.0	1.0	35.2	-7.3	0.0	2.5	-0.1	161.0	4216.6	-30.5	0.0	0.0	0.0	12.9	212.6	-7.6	42.3	487.4
WHP	1	30	-3.3	1.8	186.4	-1.0	2.8	42.5	-6.9	0.0	2.6	-0.1	108.7	3103.9	-33.0	0.0	0.0	0.0	30.5	383.7	-5.8	28.1	362.8
WHP	1	30	-2.8	3.8	319.6	-0.9	4.2	48.2	-6.6	0.0	2.5	-0.1	331.1	7817.8	-22.5	0.0	0.0	0.0	29.1	370.4	-6.0	31.3	390.8
WHP	1	30	-3.2	3.9	323.7	-0.9	2.9	42.8	-6.9	0.0	2.3	-0.1	807.4	17904.8	0.0	0.0	0.0	0.0	31.5	393.6	-5.7	54.9	597.1
WHP	1.1	0	-2.9	4.0	331.9	-0.9	4.4	49.2	-6.5	0.0	2.3	-0.1	349.5	8206.6	-21.6	0.0	0.0	0.0	31.4	392.7	-5.7	24.5	331.0
WHP	1.1	0	-3.1	4.2	342.0	-0.9	2.5	41.4	-7.0	0.0	2.5	-0.1	736.3	16392.8	-3.3	0.0	0.0	0.0	29.5	373.9	-5.9	56.4	610.5
WHP	1.1	0	-3.4	2.1	202.5	-1.0	0.7	33.8	-7.4	0.0	2.3	-0.1	180.7	4632.8	-29.6	0.0	0.0	0.0	15.1	234.3	-7.4	36.5	435.8
WHP	1.1	0	-3.6	2.0	198.7	-1.0	3.6	45.9	-6.7	0.0	2.0	-0.1	146.1	3899.9	-31.2	0.0	0.0	0.0	39.3	470.0	-4.9	15.5	251.9
WHP	1.1	0	-2.9	4.2	346.6	-0.9	4.3	48.7	-6.5	0.0	2.3	-0.1	347.2	8157.0	-21.7	0.0	0.0	0.0	31.6	394.3	-5.7	23.3	320.4
WHP	1.1	0	-3.1	4.3	353.2	-0.9	2.4	41.1	-7.0	0.0	2.4	-0.1	743.7	16548.7	-3.0	0.0	0.0	0.0	29.9	378.1	-5.9	55.7	604.2
WHP	1.1	0	-3.4	2.1	204.3	-1.0	0.7	33.8	-7.4	0.0	2.3	-0.1	183.0	4680.8	-29.5	0.0	0.0	0.0	15.3	236.0	-7.4	36.7	437.8
WHP	1.1	0	-3.6	2.0	200.1	-1.0	3.6	45.9	-6.7	0.0	2.0	-0.1	147.8	3935.1	-31.1	0.0	0.0	0.0	39.6	472.7	-4.9	15.6	252.9
WHP	1.1	0	-2.9	4.3	348.3	-0.9	4.3	48.7	-6.5	0.0	2.3	-0.1	350.2	8221.2	-21.6	0.0	0.0	0.0	31.7	396.1	-5.7	23.4	321.7
WHP	1.1	0	-3.1	4.3	354.1	-0.9	2.4	41.1	-7.0	0.0	2.4	-0.1	748.5	16651.6	-2.8	0.0	0.0	0.0	30.0	379.4	-5.9	56.0	606.7
WHP	1.1	30	-3.0	3.9	327.7	-0.9	4.7	50.4	-6.4	0.0	2.2	-0.1	375.2	8755.8	-20.4	0.0	0.0	0.0	33.2	410.6	-5.6	23.0	318.0
WHP	1.1	30	-3.4	4.1	335.3	-0.9	3.3	44.7	-6.8	0.0	2.0	-0.1	916.2	20220.5	5.1	0.0	0.0	0.0	36.1	439.1	-5.3	42.9	492.3
WHP	1.1	30	-3.4	2.0	200.9	-1.0	0.7	33.8	-7.4	0.0	2.3	-0.1	176.9	4553.0	-29.8	0.0	0.0	0.0	14.8	231.2	-7.5	36.7	438.2
WHP	1.1	30	-3.4	2.0	197.2	-1.0	3.1	43.9	-6.8	0.0	2.3	-0.1	126.2	3475.8	-32.1	0.0	0.0	0.0	35.0	427.3	-5.4	20.6	296.4

Appendix Table A-3

Site	Salt Trmt	Lag	Hippocampus lower	Lucania	Lucania upper	Lucania lower	M. gulosus	M. gulosus upper	M. gulosus lower	M. microlepis	M. microlepis upper	M. microlepis lower	Eucinostomus	Eucinostomus upper	Eucinostomus lower	Opisthonema	Opisthonema upper	Opisthonema lower	Lagodon	Lagodon upper	Lagodon lower	Farfantepenaeus	Farfantepenaeus upper
WHP	1.1	30	-3.0	4.2	341.2	-0.9	4.6	49.8	-6.5	0.0	2.2	-0.1	371.5	8676.5	-20.6	0.0	0.0	0.0	33.3	411.7	-5.5	21.8	307.6
WHP	1.1	30	-3.4	4.2	345.8	-0.9	3.2	44.4	-6.8	0.0	2.0	-0.1	922.2	20348.3	5.4	0.0	0.0	0.0	36.6	443.2	-5.2	42.2	486.4
WHP	1.1	30	-3.4	2.1	202.7	-1.0	0.7	33.8	-7.4	0.0	2.3	-0.1	178.7	4590.7	-29.7	0.0	0.0	0.0	14.9	232.6	-7.4	36.8	439.3
WHP	1.1	30	-3.4	2.0	198.6	-1.0	3.1	43.9	-6.8	0.0	2.3	-0.1	127.4	3500.2	-32.1	0.0	0.0	0.0	35.2	429.4	-5.4	20.6	297.0
WHP	1.1	30	-3.0	4.2	343.0	-0.9	4.6	49.8	-6.5	0.0	2.2	-0.1	373.9	8727.3	-20.5	0.0	0.0	0.0	33.5	413.2	-5.5	21.9	308.2
WHP	1.1	30	-3.4	4.2	346.9	-0.9	3.2	44.4	-6.8	0.0	2.0	-0.1	927.0	20450.9	5.6	0.0	0.0	0.0	36.7	444.5	-5.2	42.3	487.7
WHP	1.3	0	-3.3	4.1	337.0	-0.9	5.5	53.9	-6.2	0.0	1.8	-0.1	427.8	9892.8	-18.0	0.0	0.0	0.0	39.1	468.5	-5.0	11.7	219.2
WHP	1.3	0	-3.5	4.4	356.0	-0.9	3.2	44.4	-6.8	0.0	2.0	-0.1	874.9	19340.4	3.2	0.0	0.0	0.0	36.2	439.4	-5.3	35.3	425.9
WHP	1.3	0	-3.6	2.3	217.7	-1.0	1.1	35.7	-7.3	0.0	1.8	-0.1	218.0	5427.3	-27.8	0.0	0.0	0.0	19.4	276.7	-7.0	21.4	304.3
WHP	1.3	0	-3.9	2.3	218.0	-1.0	4.5	49.8	-6.5	0.0	1.5	-0.1	185.7	4757.1	-29.4	0.0	0.0	0.0	49.8	573.7	-3.9	4.3	154.6
WHP	1.3	0	-3.4	4.7	378.5	-0.9	5.1	52.2	-6.3	0.0	1.8	-0.1	403.8	9379.2	-19.1	0.0	0.0	0.0	38.6	464.1	-5.0	8.7	193.0
WHP	1.3	0	-3.5	4.9	388.1	-0.9	3.0	43.4	-6.8	0.0	2.0	-0.1	866.0	19149.4	2.8	0.0	0.0	0.0	36.6	443.5	-5.2	32.3	399.9
WHP	1.3	0	-3.6	2.4	225.9	-0.9	1.1	35.5	-7.3	0.0	1.8	-0.1	234.0	5767.1	-27.1	0.0	0.0	0.0	20.5	287.1	-6.9	22.5	314.2
WHP	1.3	0	-3.9	2.4	226.2	-0.9	4.5	49.6	-6.5	0.0	1.5	-0.1	202.1	5108.7	-28.6	0.0	0.0	0.0	52.2	596.9	-3.6	5.0	161.1
WHP	1.3	0	-3.4	4.9	389.4	-0.9	5.1	52.2	-6.3	0.0	1.7	-0.1	440.7	10165.4	-17.4	0.0	0.0	0.0	40.7	484.2	-4.8	9.9	203.7
WHP	1.3	0	-3.5	4.9	394.0	-0.9	3.0	43.5	-6.8	0.0	1.9	-0.1	940.2	20729.2	6.3	0.0	0.0	0.0	38.5	461.9	-5.0	35.2	424.9
WHP	1.3	30	-3.4	4.0	333.8	-0.9	5.9	55.3	-6.1	0.0	1.7	-0.1	464.0	10676.2	-16.3	0.0	0.0	0.0	41.7	494.4	-4.7	10.4	208.1
WHP	1.3	30	-3.7	4.3	350.8	-0.9	4.3	48.9	-6.5	0.0	1.5	-0.1	1137.9	25013.0	15.4	0.0	0.0	0.0	45.8	534.3	-4.3	24.1	328.9
WHP	1.3	30	-3.6	2.3	216.0	-1.0	1.1	35.5	-7.3	0.0	1.8	-0.1	213.9	5339.4	-28.0	0.0	0.0	0.0	19.1	273.1	-7.0	21.9	308.4
WHP	1.3	30	-3.7	2.3	218.3	-1.0	3.9	47.1	-6.6	0.0	1.8	-0.1	158.2	4160.3	-30.7	0.0	0.0	0.0	43.9	514.4	-4.5	8.1	187.4
WHP	1.3	30	-3.4	4.6	373.7	-0.9	5.5	53.6	-6.2	0.0	1.7	-0.1	437.6	10109.5	-17.5	0.0	0.0	0.0	41.2	489.4	-4.8	7.6	183.5
WHP	1.3	30	-3.7	4.7	382.3	-0.9	4.1	47.8	-6.6	0.0	1.5	-0.1	1127.7	24791.4	14.9	0.0	0.0	0.0	46.3	539.6	-4.2	21.9	309.3
WHP	1.3	30	-3.6	2.4	223.9	-0.9	1.1	35.4	-7.3	0.0	1.8	-0.1	228.1	5642.4	-27.4	0.0	0.0	0.0	20.0	282.6	-6.9	22.9	317.1
WHP	1.3	30	-3.7	2.4	226.1	-0.9	3.9	46.9	-6.6	0.0	1.8	-0.1	171.5	4443.9	-30.0	0.0	0.0	0.0	45.8	533.7	-4.3	8.9	194.5
WHP	1.3	30	-3.4	4.8	383.6	-0.9	5.5	53.6	-6.2	0.0	1.6	-0.1	473.3	10871.6	-15.9	0.0	0.0	0.0	43.1	508.6	-4.6	8.6	192.7
WHP	1.3	30	-3.7	4.8	387.6	-0.9	4.1	48.0	-6.6	0.0	1.5	-0.1	1212.1	26594.9	18.9	0.0	0.0	0.0	48.3	559.4	-4.0	23.8	326.4
WHP	10	0	-3.3	4.1	339.2	-0.9	5.3	52.8	-6.3	0.0	1.9	-0.1	409.0	9485.0	-18.8	0.0	0.0	0.0	37.4	451.9	-5.1	13.6	236.2
WHP	10	0	-3.5	4.4	355.5	-0.9	3.2	44.4	-6.8	0.0	2.0	-0.1	882.3	19498.3	3.5	0.0	0.0	0.0	36.3	440.5	-5.2	36.1	432.6
WHP	10	0	-3.6	2.3	216.3	-1.0	1.2	35.9	-7.3	0.0	1.8	-0.1	221.8	5509.4	-27.6	0.0	0.0	0.0	19.7	279.1	-7.0	21.4	304.0
WHP	10	0	-3.8	2.3	217.2	-1.0	4.2	48.4	-6.5	0.0	1.7	-0.1	170.2	4420.3	-30.1	0.0	0.0	0.0	46.5	540.7	-4.2	6.2	170.9
WHP	10	0	-3.3	4.7	378.5	-0.9	4.9	51.2	-6.4	0.0	1.9	-0.1	386.0	8992.9	-19.9	0.0	0.0	0.0	36.9	447.2	-5.2	10.5	209.0
WHP	10	0	-3.5	4.8	386.8	-0.9	3.0	43.4	-6.8	0.0	2.0	-0.1	877.4	19390.9	3.3	0.0	0.0	0.0	36.8	445.5	-5.2	33.3	408.5
WHP	10	0	-3.6	2.4	224.0	-0.9	1.1	35.7	-7.3	0.0	1.8	-0.1	237.3	5839.9	-26.9	0.0	0.0	0.0	20.7	289.1	-6.8	22.5	313.7
WHP	10	0	-3.8	2.4	224.6	-0.9	4.2	48.3	-6.6	0.0	1.6	-0.1	184.5	4725.3	-29.4	0.0	0.0	0.0	48.6	561.1	-4.0	7.0	177.7
WHP	10	0	-3.3	4.8	388.0	-0.9	4.9	51.2	-6.4	0.0	1.8	-0.1	418.6	9687.3	-18.4	0.0	0.0	0.0	38.8	465.0	-5.0	11.8	219.9
WHP	10	0	-3.5	4.9	391.6	-0.9	3.0	43.6	-6.8	0.0	1.9	-0.1	944.7	20825.6	6.5	0.0	0.0	0.0	38.5	462.0	-5.0	35.9	431.7
WHP	10	30	-3.3	4.1	336.7	-0.9	5.5	53.8	-6.2	0.0	1.8	-0.1	436.4	10075.2	-17.6	0.0	0.0	0.0	39.4	471.3	-4.9	12.6	227.4
WHP	10	30	-3.7	4.3	351.3	-0.9	4.1	47.8	-6.6	0.0	1.6	-0.1	1081.8	23792.3	12.8	0.0	0.0	0.0	43.5	512.3	-4.5	27.2	355.2
WHP	10	30	-3.6	2.2	214.9	-1.0	1.1	35.8	-7.3	0.0	1.8	-0.1	218.7	5443.5	-27.8	0.0	0.0	0.0	19.4	276.4	-7.0	21.8	307.3
WHP	10	30	-3.7	2.3	216.7	-1.0	3.7	46.4	-6.7	0.0	1.9	-0.1	150.2	3988.2	-31.0	0.0	0.0	0.0	42.1	497.0	-4.6	9.4	198.5
WHP	10	30	-3.3	4.6	374.8	-0.9	5.1	52.2	-6.3	0.0	1.8	-0.1	411.7	9545.7	-18.7	0.0	0.0	0.0	38.9	466.3	-5.0	9.7	201.4
WHP	10	30	-3.7	4.7	382.0	-0.9	3.8	46.8	-6.6	0.0	1.6	-0.1	1076.0	23665.1	12.5	0.0	0.0	0.0	44.2	518.1	-4.4	24.9	335.5
WHP	10	30	-3.6	2.4	222.3	-0.9	1.1	35.6	-7.3	0.0	1.8	-0.1	232.5	5736.9	-27.1	0.0	0.0	0.0	20.3	285.5	-6.9	22.7	315.7
WHP	10	30	-3.7	2.4	223.8	-0.9	3.7	46.3	-6.7	0.0	1.8	-0.1	162.0	4239.0	-30.5	0.0	0.0	0.0	43.9	514.3	-4.5	10.1	205.5
WHP	10	30	-3.3	4.8	383.7	-0.9	5.1	52.2	-6.3	0.0	1.8	-0.1	442.5	10203.1	-17.3	0.0	0.0	0.0	40.6	482.9	-4.8	10.7	210.6
WHP	10	30	-3.7	4.8	386.5	-0.9	3.8	46.9	-6.6	0.0	1.6	-0.1	1148.1	25204.4	15.9	0.0	0.0	0.0	45.9	535.1	-4.3	26.8	352.3
WHP	20	0	-3.7	3.6	305.7	-0.9	7.2	61.0	-5.8	0.0	1.3	-0.1	508.2	11685.5	-14.4	0.0	0.0	0.0	46.8	546.7	-4.2	3.0	143.6
WHP	20	0	-3.8	4.0	335.3	-0.9	4.8	51.0	-6.4	0.0	1.4	-0.1	1128.3	24865.1	14.8	0.0	0.0	0.0	46.9	546.3	-4.2	17.2	268.1
WHP	20	0	-4.0	2.2	216.0	-1.0	2.4	41.0	-7.0	0.0	1.3	-0.1	296.8	7145.9	-24.2	0.0	0.0	0.0	27.1	353.5	-6.2	7.5	183.0
WHP	20	0	-4.1	2.3	219.4	-1.0	5.7	54.9	-6.2	0.0	1.2	-0.1	228.1	5704.1	-27.5	0.0	0.0	0.0	60.4	681.6	-2.8	-2.1	99.3
WHP	20	0	-3.7	4.4	365.3	-0.9	6.5	58.2	-6.0	0.0	1.4	-0.1	472.1	10905.6	-16.0	0.0	0.0	0.0	46.6	544.3	-4.2	0.2	119.4
WHP	20	0	-3.8	4.6	374.5	-0.9	4.4	49.5	-6.5	0.0	1.4	-0.1	1060.4	23407.5	11.6	0.0	0.0	0.0	46.4	541.0	-4.2	13.6	237.0
WHP	20	0	-4.0	2.4	226.3	-0.9	2.3	40.6	-7.0	0.0	1.3	-0.1	299.9	7213.1	-24.1	0.0	0.0	0.0	27.6	358.3	-6.2	7.1	179.4
WHP	20	0	-4.1	2.5	233.7	-0.9	5.5	54.2	-6.2	0.0	1.2	-0.1	237.9	5915.5	-27.0	0.0	0.0	0.0	62.3	699.7	-2.6	-2.2	98.2

Appendix Table A-3

Site	Salt Trmt	Lag	Hippocampus lower	Lucania	Lucania upper	Lucania lower	M. gulosus	M. gulosus upper	M. gulosus lower	M. microlepis	M. microlepis upper	M. microlepis lower	Eucinostomus	Eucinostomus upper	Eucinostomus lower	Opisthonema	Opisthonema upper	Opisthonema lower	Lagodon	Lagodon upper	Lagodon lower	Farfantepenaeus	Farfantepenaeus upper
WHP	20	0	-3.7	4.7	384.1	-0.9	6.4	57.7	-6.0	0.0	1.3	-0.1	495.0	11396.4	-15.0	0.0	0.0	0.0	48.1	559.4	-4.1	0.3	120.0
WHP	20	0	-3.8	4.8	387.0	-0.9	4.4	49.3	-6.5	0.0	1.4	-0.1	1119.5	24669.3	14.4	0.0	0.0	0.0	48.1	557.6	-4.1	14.3	243.3
WHP	20	30	-3.7	3.6	309.7	-0.9	7.4	62.0	-5.8	0.0	1.3	-0.1	543.2	12453.5	-12.8	0.0	0.0	0.0	49.4	573.2	-3.9	2.2	136.8
WHP	20	30	-4.0	4.0	335.3	-0.9	5.7	54.8	-6.2	0.0	1.1	-0.1	1377.9	30361.8	26.1	0.0	0.0	0.0	55.8	636.5	-3.3	11.4	218.1
WHP	20	30	-4.0	2.2	213.2	-1.0	2.4	40.9	-7.0	0.0	1.3	-0.1	289.8	6994.6	-24.5	0.0	0.0	0.0	26.6	348.0	-6.3	7.6	184.2
WHP	20	30	-4.0	2.4	224.8	-1.0	5.1	52.2	-6.3	0.0	1.3	-0.1	203.5	5157.5	-28.6	0.0	0.0	0.0	55.3	629.7	-3.3	-0.4	114.1
WHP	20	30	-3.8	4.4	365.2	-0.9	6.8	59.3	-5.9	0.0	1.3	-0.1	499.3	11506.1	-14.8	0.0	0.0	0.0	48.8	566.5	-4.0	-0.5	113.4
WHP	20	30	-4.0	4.5	372.6	-0.9	5.3	53.3	-6.3	0.0	1.2	-0.1	1293.4	28540.0	22.2	0.0	0.0	0.0	55.1	629.4	-3.4	8.5	193.0
WHP	20	30	-4.0	2.3	223.3	-1.0	2.3	40.5	-7.0	0.0	1.3	-0.1	294.6	7098.5	-24.3	0.0	0.0	0.0	27.2	353.7	-6.2	7.3	181.6
WHP	20	30	-4.0	2.6	240.8	-0.9	4.9	51.6	-6.4	0.0	1.3	-0.1	215.2	5407.9	-28.0	0.0	0.0	0.0	57.4	649.9	-3.1	-0.4	113.6
WHP	20	30	-3.8	4.7	384.2	-0.9	6.7	58.8	-6.0	0.0	1.3	-0.1	529.0	12143.2	-13.4	0.0	0.0	0.0	50.6	585.0	-3.8	-0.3	115.1
WHP	20	30	-4.0	4.7	385.3	-0.9	5.3	53.1	-6.3	0.0	1.1	-0.1	1380.8	30417.8	26.3	0.0	0.0	0.0	57.4	652.3	-3.1	9.3	200.1
RL	0.9	0	-2.1	8.6	638.4	-0.9	5.1	51.9	-6.3	0.1	3.1	-0.1	239.1	5868.1	-26.8	0.0	0.0	0.0	23.2	312.5	-6.6	53.2	582.6
RL	0.9	0	-2.8	9.7	709.9	-0.8	6.0	55.6	-6.1	0.1	3.0	-0.1	657.3	14724.0	-7.1	0.0	0.0	0.0	26.4	344.3	-6.3	88.2	889.5
RL	0.9	0	-3.1	4.9	393.4	-0.9	3.3	44.6	-6.8	0.0	2.6	-0.1	165.8	4317.1	-30.3	0.0	0.0	0.0	13.6	219.7	-7.6	57.7	621.9
RL	0.9	0	-3.0	4.1	337.1	-0.9	2.9	42.9	-6.9	0.0	2.6	-0.1	98.0	2878.0	-33.5	0.0	0.0	0.0	30.3	381.7	-5.9	41.0	475.0
RL	0.9	0	-2.1	8.4	621.5	-0.9	5.2	52.3	-6.3	0.1	3.1	-0.1	245.0	5995.1	-26.5	0.0	0.0	0.0	23.3	314.0	-6.6	55.5	602.6
RL	0.9	0	-2.8	9.4	693.2	-0.8	6.0	55.9	-6.1	0.1	3.0	-0.1	662.0	14825.9	-6.8	0.0	0.0	0.0	26.3	343.5	-6.3	90.1	906.2
RL	0.9	0	-3.1	4.9	388.9	-0.9	3.3	44.7	-6.8	0.0	2.6	-0.1	165.5	4310.2	-30.3	0.0	0.0	0.0	13.5	218.8	-7.6	58.0	624.3
RL	0.9	0	-3.0	4.0	333.6	-0.9	2.9	43.0	-6.9	0.0	2.6	-0.1	98.0	2877.8	-33.5	0.0	0.0	0.0	30.2	380.6	-5.9	41.2	477.4
RL	0.9	0	-2.1	8.3	615.9	-0.9	5.2	52.4	-6.3	0.1	3.1	-0.1	245.4	6004.2	-26.5	0.0	0.0	0.0	23.3	313.6	-6.6	55.9	606.4
RL	0.9	0	-2.8	9.4	688.1	-0.8	6.1	56.0	-6.1	0.1	3.0	-0.1	661.6	14816.4	-6.9	0.0	0.0	0.0	26.3	342.8	-6.3	90.4	909.2
RL	0.9	30	-2.1	8.4	620.0	-0.9	4.3	48.7	-6.5	0.1	3.0	-0.1	247.3	6041.3	-26.4	0.0	0.0	0.0	24.1	322.1	-6.5	52.9	580.1
RL	0.9	30	-2.7	9.3	683.9	-0.8	4.7	50.5	-6.4	0.1	2.9	-0.1	661.4	14810.6	-6.9	0.0	0.0	0.0	27.0	350.0	-6.2	90.3	908.0
RL	0.9	30	-3.1	5.1	404.8	-0.9	4.0	47.6	-6.6	0.0	2.7	-0.1	164.8	4294.7	-30.3	0.0	0.0	0.0	13.4	217.5	-7.6	56.2	609.0
RL	0.9	30	-3.0	4.1	339.4	-0.9	2.9	43.1	-6.8	0.0	2.7	-0.1	93.7	2787.6	-33.7	0.0	0.0	0.0	29.3	371.7	-6.0	42.5	488.8
RL	0.9	30	-2.1	8.1	604.9	-0.9	4.4	49.0	-6.5	0.1	2.9	-0.1	252.4	6150.8	-26.2	0.0	0.0	0.0	24.3	323.3	-6.5	54.9	597.5
RL	0.9	30	-2.7	9.1	669.3	-0.8	4.8	50.8	-6.4	0.1	2.9	-0.1	665.4	14896.7	-6.7	0.0	0.0	0.0	26.9	349.2	-6.2	92.0	923.0
RL	0.9	30	-3.1	5.1	400.7	-0.9	4.1	47.7	-6.6	0.0	2.7	-0.1	164.5	4288.4	-30.3	0.0	0.0	0.0	13.3	216.7	-7.6	56.5	611.0
RL	0.9	30	-3.0	4.1	336.4	-0.9	3.0	43.2	-6.8	0.0	2.7	-0.1	93.7	2786.7	-33.7	0.0	0.0	0.0	29.2	370.7	-6.0	42.8	490.9
RL	0.9	30	-2.1	8.0	600.1	-0.9	4.4	49.1	-6.5	0.1	2.9	-0.1	252.7	6157.7	-26.2	0.0	0.0	0.0	24.2	322.9	-6.5	55.3	600.7
RL	0.9	30	-2.7	9.0	665.0	-0.8	4.8	50.9	-6.4	0.1	2.9	-0.1	664.9	14886.8	-6.7	0.0	0.0	0.0	26.9	348.6	-6.2	92.3	925.6
RL	1	0	-2.2	8.3	617.4	-0.9	3.9	47.2	-6.6	0.1	2.9	-0.1	245.0	5991.8	-26.5	0.0	0.0	0.0	24.4	325.0	-6.5	49.7	552.2
RL	1	0	-2.7	9.3	683.1	-0.8	4.2	48.2	-6.5	0.0	2.8	-0.1	652.0	14611.9	-7.3	0.0	0.0	0.0	27.2	351.4	-6.2	88.2	889.5
RL	1	0	-3.1	4.8	384.0	-0.9	1.9	38.7	-7.1	0.0	2.4	-0.1	166.5	4330.5	-30.2	0.0	0.0	0.0	14.4	226.9	-7.5	57.0	615.8
RL	1	0	-3.2	4.2	343.1	-0.9	3.1	43.6	-6.8	0.0	2.3	-0.1	111.5	3162.2	-32.8	0.0	0.0	0.0	34.1	418.7	-5.5	32.1	396.8
RL	1	0	-2.2	8.3	617.5	-0.9	3.9	47.2	-6.6	0.1	2.9	-0.1	245.0	5992.1	-26.5	0.0	0.0	0.0	24.4	325.0	-6.5	49.7	552.2
RL	1	0	-2.7	9.3	683.1	-0.8	4.2	48.2	-6.5	0.0	2.8	-0.1	652.1	14612.3	-7.3	0.0	0.0	0.0	27.2	351.4	-6.2	88.2	889.5
RL	1	0	-3.1	4.8	384.0	-0.9	1.9	38.7	-7.1	0.0	2.4	-0.1	166.5	4330.6	-30.2	0.0	0.0	0.0	14.4	226.9	-7.5	57.0	615.8
RL	1	0	-3.2	4.2	343.1	-0.9	3.1	43.6	-6.8	0.0	2.3	-0.1	111.5	3162.4	-32.8	0.0	0.0	0.0	34.1	418.7	-5.5	32.1	396.8
RL	1	0	-2.2	8.3	617.5	-0.9	3.9	47.2	-6.6	0.1	2.9	-0.1	245.1	5992.5	-26.5	0.0	0.0	0.0	24.5	325.0	-6.5	49.7	552.2
RL	1	0	-2.7	9.3	683.1	-0.8	4.2	48.2	-6.5	0.0	2.8	-0.1	652.1	14612.8	-7.3	0.0	0.0	0.0	27.2	351.4	-6.2	88.2	889.5
RL	1	30	-2.3	8.2	606.8	-0.9	3.7	46.4	-6.7	0.0	2.7	-0.1	261.3	6333.3	-25.8	0.0	0.0	0.0	26.1	341.0	-6.3	46.5	524.0
RL	1	30	-2.7	9.0	661.9	-0.8	3.3	44.7	-6.8	0.0	2.7	-0.1	667.6	14941.8	-6.6	0.0	0.0	0.0	28.2	361.4	-6.1	87.7	884.9
RL	1	30	-3.1	5.0	394.3	-0.9	2.4	40.9	-7.0	0.0	2.5	-0.1	163.1	4257.7	-30.4	0.0	0.0	0.0	13.9	222.9	-7.5	56.3	609.8
RL	1	30	-3.1	4.2	344.2	-0.9	2.9	43.0	-6.9	0.0	2.4	-0.1	105.7	3039.5	-33.1	0.0	0.0	0.0	32.7	405.4	-5.6	34.6	418.7
RL	1	30	-2.3	8.2	608.4	-0.9	3.7	46.4	-6.7	0.0	2.7	-0.1	259.9	6304.6	-25.8	0.0	0.0	0.0	26.0	340.4	-6.3	46.2	521.1
RL	1	30	-2.7	9.0	663.7	-0.8	3.3	44.7	-6.8	0.0	2.7	-0.1	665.9	14905.6	-6.7	0.0	0.0	0.0	28.1	361.1	-6.1	87.3	881.7
RL	1	30	-3.1	5.0	394.9	-0.9	2.4	40.9	-7.0	0.0	2.5	-0.1	163.0	4257.1	-30.4	0.0	0.0	0.0	13.9	222.9	-7.5	56.3	609.3
RL	1	30	-3.1	4.2	344.7	-0.9	2.9	43.0	-6.9	0.0	2.4	-0.1	105.7	3039.5	-33.1	0.0	0.0	0.0	32.8	405.5	-5.6	34.5	418.4
RL	1	30	-2.3	8.2	609.2	-0.9	3.7	46.4	-6.7	0.0	2.7	-0.1	259.9	6303.3	-25.8	0.0	0.0	0.0	26.0	340.5	-6.3	46.2	520.6
RL	1	30	-2.7	9.0	664.3	-0.8	3.3	44.7	-6.8	0.0	2.7	-0.1	666.0	14907.1	-6.7	0.0	0.0	0.0	28.2	361.2	-6.1	87.3	881.3
RL	1.1	0	-2.3	8.2	610.0	-0.9	3.7	46.3	-6.7	0.0	2.6	-0.1	259.3	6290.1	-25.8	0.0	0.0	0.0	26.4	344.1	-6.3	42.5	488.1
RL	1.1	0	-2.8	9.0	666.1	-0.8	3.1	43.6	-6.8	0.0	2.6	-0.1	657.6	14727.1	-7.0	0.0	0.0	0.0	28.3	362.4	-6.1	83.9	851.2

Appendix Table A-3

Site	Salt Trmt	Lag	Hippocampus lower	Lucania	Lucania upper	Lucania lower	M. gulosus	M. gulosus upper	M. gulosus lower	M. microlepis	M. microlepis upper	M. microlepis lower	Eucinostomus	Eucinostomus upper	Eucinostomus lower	Opisthonema	Opisthonema upper	Opisthonema lower	Lagodon	Lagodon upper	Lagodon lower	Farfantepenaeus	Farfantepenaeus upper
RL	1.1	0	-3.1	4.7	380.3	-0.9	1.1	35.4	-7.3	0.0	2.3	-0.1	170.4	4413.3	-30.1	0.0	0.0	0.0	15.4	236.7	-7.4	52.7	577.7
RL	1.1	0	-3.4	4.3	351.6	-0.9	3.5	45.5	-6.7	0.0	2.0	-0.1	126.1	3471.8	-32.1	0.0	0.0	0.0	38.3	459.4	-5.0	23.3	320.7
RL	1.1	0	-2.3	8.4	624.3	-0.9	3.6	45.9	-6.7	0.0	2.6	-0.1	249.4	6079.5	-26.3	0.0	0.0	0.0	26.0	339.9	-6.3	40.1	467.2
RL	1.1	0	-2.8	9.3	680.4	-0.8	3.0	43.3	-6.8	0.0	2.6	-0.1	643.1	14418.2	-7.7	0.0	0.0	0.0	28.1	360.2	-6.1	81.0	825.7
RL	1.1	0	-3.1	4.8	384.5	-0.9	1.0	35.3	-7.3	0.0	2.3	-0.1	169.9	4402.7	-30.1	0.0	0.0	0.0	15.4	237.1	-7.4	52.2	573.3
RL	1.1	0	-3.4	4.4	355.4	-0.9	3.5	45.4	-6.7	0.0	2.0	-0.1	126.0	3468.8	-32.2	0.0	0.0	0.0	38.4	460.3	-5.0	23.1	318.5
RL	1.1	0	-2.3	8.5	630.0	-0.9	3.6	45.8	-6.7	0.0	2.6	-0.1	248.9	6067.6	-26.3	0.0	0.0	0.0	26.0	340.1	-6.3	39.7	463.8
RL	1.1	0	-2.8	9.3	685.3	-0.8	3.0	43.3	-6.8	0.0	2.6	-0.1	643.5	14426.6	-7.7	0.0	0.0	0.0	28.1	360.8	-6.1	80.6	822.7
RL	1.1	30	-2.5	8.1	605.0	-0.9	4.0	47.3	-6.6	0.0	2.4	-0.1	283.8	6807.0	-24.7	0.0	0.0	0.0	28.8	366.7	-6.0	37.5	444.8
RL	1.1	30	-2.8	8.9	653.1	-0.9	2.7	42.2	-6.9	0.0	2.4	-0.1	690.5	15420.0	-5.5	0.0	0.0	0.0	30.0	378.7	-5.9	79.2	810.2
RL	1.1	30	-3.1	4.9	388.5	-0.9	1.3	36.5	-7.2	0.0	2.4	-0.1	162.5	4245.6	-30.4	0.0	0.0	0.0	14.6	229.4	-7.5	53.2	582.3
RL	1.1	30	-3.3	4.3	353.2	-0.9	3.3	44.6	-6.8	0.0	2.1	-0.1	118.9	3319.1	-32.5	0.0	0.0	0.0	36.6	443.2	-5.2	25.7	340.8
RL	1.1	30	-2.5	8.4	621.8	-0.9	3.8	46.8	-6.6	0.0	2.4	-0.1	270.4	6522.5	-25.3	0.0	0.0	0.0	28.2	361.0	-6.1	34.9	421.5
RL	1.1	30	-2.8	9.1	669.4	-0.8	2.6	41.9	-6.9	0.0	2.5	-0.1	670.0	14985.1	-6.4	0.0	0.0	0.0	29.6	375.3	-5.9	75.7	779.3
RL	1.1	30	-3.1	4.9	393.7	-0.9	1.3	36.4	-7.2	0.0	2.4	-0.1	161.6	4225.5	-30.5	0.0	0.0	0.0	14.6	229.7	-7.5	52.5	576.0
RL	1.1	30	-3.3	4.4	357.9	-0.9	3.3	44.5	-6.8	0.0	2.1	-0.1	118.5	3310.7	-32.5	0.0	0.0	0.0	36.7	444.0	-5.2	25.3	337.6
RL	1.1	30	-2.5	8.5	628.8	-0.9	3.8	46.7	-6.6	0.0	2.4	-0.1	269.3	6498.4	-25.4	0.0	0.0	0.0	28.2	361.0	-6.1	34.4	417.2
RL	1.1	30	-2.8	9.2	675.4	-0.8	2.6	41.8	-6.9	0.0	2.5	-0.1	669.7	14977.2	-6.5	0.0	0.0	0.0	29.7	375.8	-5.9	75.2	774.9
RL	1.3	0	-2.8	8.2	606.4	-0.9	4.5	49.6	-6.5	0.0	2.1	-0.1	316.4	7496.9	-23.1	0.0	0.0	0.0	32.4	401.8	-5.6	27.8	359.6
RL	1.3	0	-3.0	8.9	656.8	-0.9	2.7	42.3	-6.9	0.0	2.2	-0.1	715.9	15950.8	-4.3	0.0	0.0	0.0	32.2	400.1	-5.7	63.6	673.5
RL	1.3	0	-3.4	4.8	383.5	-0.9	1.0	35.3	-7.3	0.0	1.9	-0.1	186.6	4754.5	-29.3	0.0	0.0	0.0	18.1	263.2	-7.1	35.7	429.5
RL	1.3	0	-3.7	4.5	362.1	-0.9	4.5	49.7	-6.5	0.0	1.5	-0.1	155.1	4098.9	-30.8	0.0	0.0	0.0	46.9	544.6	-4.2	10.2	206.4
RL	1.3	0	-2.8	8.6	638.1	-0.9	4.2	48.4	-6.5	0.0	2.2	-0.1	268.9	6488.8	-25.4	0.0	0.0	0.0	29.9	378.0	-5.9	21.7	306.6
RL	1.3	0	-3.0	9.3	684.9	-0.8	2.5	41.4	-6.9	0.0	2.3	-0.1	626.4	14048.7	-8.5	0.0	0.0	0.0	30.0	379.1	-5.9	53.9	588.2
RL	1.3	0	-3.4	4.9	392.6	-0.9	0.9	34.9	-7.3	0.0	1.9	-0.1	172.6	4459.2	-30.0	0.0	0.0	0.0	17.4	256.5	-7.2	32.5	400.9
RL	1.3	0	-3.7	4.6	371.3	-0.9	4.4	49.2	-6.5	0.0	1.6	-0.1	144.9	3881.4	-31.3	0.0	0.0	0.0	45.8	533.2	-4.3	8.8	193.5
RL	1.3	0	-2.8	8.9	652.3	-0.9	4.1	47.9	-6.6	0.0	2.2	-0.1	250.6	6100.2	-26.2	0.0	0.0	0.0	28.9	368.1	-6.0	19.4	286.1
RL	1.3	0	-3.1	9.5	697.0	-0.8	2.4	41.1	-7.0	0.0	2.3	-0.1	589.3	13262.3	-10.2	0.0	0.0	0.0	29.1	369.8	-6.0	49.9	553.4
RL	1.3	30	-2.9	8.1	602.4	-0.9	5.0	51.6	-6.3	0.0	1.9	-0.1	356.9	8362.6	-21.2	0.0	0.0	0.0	35.9	436.7	-5.3	23.4	321.4
RL	1.3	30	-3.1	8.9	653.7	-0.9	3.1	43.8	-6.8	0.0	2.0	-0.1	791.6	17556.0	-0.7	0.0	0.0	0.0	35.4	431.6	-5.3	55.6	602.9
RL	1.3	30	-3.3	4.8	385.2	-0.9	0.8	34.5	-7.4	0.0	2.0	-0.1	170.7	4418.5	-30.0	0.0	0.0	0.0	16.7	249.2	-7.3	38.7	455.4
RL	1.3	30	-3.6	4.5	363.5	-0.9	4.2	48.5	-6.5	0.0	1.6	-0.1	143.4	3846.2	-31.3	0.0	0.0	0.0	44.4	519.2	-4.4	11.8	220.1
RL	1.3	30	-3.0	8.6	635.0	-0.9	4.7	50.4	-6.4	0.0	1.9	-0.1	301.3	7180.2	-23.9	0.0	0.0	0.0	33.1	409.4	-5.6	17.7	271.5
RL	1.3	30	-3.2	9.3	682.2	-0.8	2.9	42.9	-6.9	0.0	2.1	-0.1	687.7	15348.4	-5.6	0.0	0.0	0.0	33.0	407.6	-5.6	46.4	522.7
RL	1.3	30	-3.3	5.0	394.4	-0.9	0.8	34.1	-7.4	0.0	2.1	-0.1	156.8	4122.5	-30.7	0.0	0.0	0.0	15.9	242.2	-7.3	35.0	423.3
RL	1.3	30	-3.6	4.6	372.8	-0.9	4.1	48.0	-6.6	0.0	1.7	-0.1	132.8	3620.8	-31.8	0.0	0.0	0.0	43.1	507.0	-4.5	10.1	205.3
RL	1.3	30	-3.0	8.8	649.3	-0.9	4.6	49.8	-6.4	0.0	2.0	-0.1	279.3	6712.4	-24.9	0.0	0.0	0.0	31.9	397.7	-5.7	15.5	251.9
RL	1.3	30	-3.2	9.5	694.2	-0.8	2.8	42.5	-6.9	0.0	2.1	-0.1	643.5	14412.1	-7.7	0.0	0.0	0.0	31.8	396.5	-5.7	42.6	489.4
RL	10	0	-2.8	8.2	607.2	-0.9	4.5	49.7	-6.5	0.0	2.1	-0.1	317.1	7513.1	-23.1	0.0	0.0	0.0	32.5	403.2	-5.6	27.3	355.1
RL	10	0	-3.1	8.9	656.0	-0.9	2.9	42.9	-6.9	0.0	2.1	-0.1	745.3	16572.4	-2.9	0.0	0.0	0.0	33.5	413.4	-5.5	59.3	635.4
RL	10	0	-3.4	4.8	383.8	-0.9	1.1	35.7	-7.3	0.0	1.8	-0.1	191.1	4851.4	-29.1	0.0	0.0	0.0	18.7	269.0	-7.1	33.0	405.1
RL	10	0	-3.6	4.5	363.7	-0.9	4.2	48.5	-6.5	0.0	1.6	-0.1	140.8	3789.9	-31.5	0.0	0.0	0.0	44.0	516.0	-4.5	11.4	216.1
RL	10	0	-2.8	8.7	639.6	-0.9	4.2	48.4	-6.5	0.0	2.2	-0.1	264.1	6386.4	-25.6	0.0	0.0	0.0	29.7	376.0	-5.9	20.7	297.6
RL	10	0	-3.1	9.3	684.5	-0.8	2.7	42.0	-6.9	0.0	2.2	-0.1	640.4	14345.0	-7.8	0.0	0.0	0.0	31.0	388.5	-5.8	49.1	546.2
RL	10	0	-3.4	4.9	392.8	-0.9	1.0	35.3	-7.3	0.0	1.9	-0.1	174.4	4496.6	-29.9	0.0	0.0	0.0	17.8	260.6	-7.1	29.4	374.2
RL	10	0	-3.6	4.6	372.9	-0.9	4.1	48.0	-6.6	0.0	1.7	-0.1	129.4	3548.7	-32.0	0.0	0.0	0.0	42.7	502.5	-4.6	9.6	200.6
RL	10	0	-2.8	8.9	653.6	-0.9	4.1	47.9	-6.6	0.0	2.2	-0.1	242.5	5930.2	-26.6	0.0	0.0	0.0	28.5	364.0	-6.0	18.1	274.7
RL	10	0	-3.1	9.5	696.3	-0.8	2.6	41.6	-6.9	0.0	2.2	-0.1	594.3	13368.3	-10.0	0.0	0.0	0.0	29.8	376.5	-5.9	44.8	508.2
RL	10	30	-2.9	8.1	604.4	-0.9	4.9	51.2	-6.4	0.0	1.9	-0.1	347.9	8169.2	-21.7	0.0	0.0	0.0	35.2	429.8	-5.4	23.9	325.5
RL	10	30	-3.2	8.9	654.1	-0.9	3.2	44.2	-6.8	0.0	2.0	-0.1	805.3	17847.3	-0.1	0.0	0.0	0.0	36.1	438.4	-5.3	53.2	582.5
RL	10	30	-3.3	4.8	384.7	-0.9	1.0	35.0	-7.3	0.0	1.9	-0.1	178.1	4574.8	-29.7	0.0	0.0	0.0	17.5	257.5	-7.2	35.2	424.6
RL	10	30	-3.6	4.5	364.7	-0.9	4.0	47.6	-6.6	0.0	1.7	-0.1	132.3	3608.7	-31.9	0.0	0.0	0.0	42.1	497.4	-4.6	12.6	227.1
RL	10	30	-2.9	8.6	637.5	-0.9	4.6	49.9	-6.4	0.0	2.0	-0.1	288.0	6897.6	-24.5	0.0	0.0	0.0	32.1	399.7	-5.7	17.6	270.7
RL	10	30	-3.2	9.3	682.8	-0.8	3.0	43.2	-6.8	0.0	2.0	-0.1	687.8	15353.1	-5.6	0.0	0.0	0.0	33.3	410.7	-5.5	43.6	497.7

Appendix Table A-3

Site	Salt Trmt	Lag	Hippocampus lower	Lucania	Lucania upper	Lucania lower	M. gulosus	M. gulosus upper	M. gulosus lower	M. microlepis	M. microlepis upper	M. microlepis lower	Eucinostomus	Eucinostomus upper	Eucinostomus lower	Opisthonema	Opisthonema upper	Opisthonema lower	Lagodon	Lagodon upper	Lagodon lower	Farfantepenaeus	Farfantepenaeus upper
RL	10	30	-3.4	4.9	393.7	-0.9	0.9	34.6	-7.4	0.0	2.0	-0.1	161.5	4222.5	-30.5	0.0	0.0	0.0	16.6	249.0	-7.3	31.3	390.9
RL	10	30	-3.6	4.6	373.9	-0.9	3.9	47.1	-6.6	0.0	1.8	-0.1	120.7	3362.1	-32.4	0.0	0.0	0.0	40.7	483.2	-4.8	10.7	210.0
RL	10	30	-3.0	8.8	651.5	-0.9	4.5	49.3	-6.5	0.0	2.0	-0.1	263.4	6375.6	-25.7	0.0	0.0	0.0	30.7	386.1	-5.8	15.1	248.7
RL	10	30	-3.2	9.5	694.4	-0.8	2.9	42.8	-6.9	0.0	2.1	-0.1	635.7	14247.5	-8.0	0.0	0.0	0.0	31.9	397.2	-5.7	39.4	461.3
RL	20	0	-3.3	7.6	571.9	-0.9	6.5	57.9	-6.0	0.0	1.4	-0.1	515.6	11778.0	-13.9	0.0	0.0	0.0	47.5	551.8	-4.1	16.7	263.7
RL	20	0	-3.5	8.5	630.8	-0.9	4.6	49.9	-6.5	0.0	1.4	-0.1	1192.8	26148.4	18.0	0.0	0.0	0.0	49.5	570.0	-3.9	40.4	471.7
RL	20	0	-3.8	4.6	371.5	-0.9	2.6	41.8	-6.9	0.0	1.2	-0.1	329.7	7829.3	-22.6	0.0	0.0	0.0	29.5	375.9	-6.0	21.2	303.5
RL	20	0	-3.9	4.1	342.9	-0.9	6.2	56.9	-6.1	0.0	1.1	-0.1	254.4	6254.4	-26.2	0.0	0.0	0.0	64.6	721.3	-2.4	5.6	166.4
RL	20	0	-3.3	8.0	598.3	-0.9	6.3	57.1	-6.0	0.0	1.4	-0.1	492.4	11281.6	-15.0	0.0	0.0	0.0	46.9	545.3	-4.2	14.8	247.0
RL	20	0	-3.5	8.8	652.4	-0.9	4.4	49.4	-6.5	0.0	1.4	-0.1	1149.5	25224.4	16.0	0.0	0.0	0.0	48.9	563.9	-4.0	37.8	448.3
RL	20	0	-3.8	4.7	377.9	-0.9	2.5	41.6	-7.0	0.0	1.2	-0.1	325.9	7747.4	-22.8	0.0	0.0	0.0	29.5	375.5	-6.0	20.6	297.9
RL	20	0	-3.9	4.2	348.8	-0.9	6.2	56.6	-6.1	0.0	1.1	-0.1	252.2	6209.0	-26.3	0.0	0.0	0.0	64.6	721.5	-2.4	5.3	163.7
RL	20	0	-3.3	8.1	608.1	-0.9	6.3	56.9	-6.1	0.0	1.4	-0.1	488.1	11189.5	-15.2	0.0	0.0	0.0	46.8	544.8	-4.2	14.3	242.7
RL	20	0	-3.5	8.9	660.5	-0.9	4.4	49.2	-6.5	0.0	1.4	-0.1	1143.4	25093.4	15.7	0.0	0.0	0.0	48.8	563.8	-4.0	37.2	443.0
RL	20	30	-3.4	7.4	564.7	-0.9	6.9	59.8	-5.9	0.0	1.3	-0.1	556.6	12675.7	-12.0	0.0	0.0	0.0	50.8	584.2	-3.8	14.0	240.5
RL	20	30	-3.6	8.4	626.1	-0.9	4.9	51.5	-6.4	0.0	1.3	-0.1	1303.4	28544.0	23.1	0.0	0.0	0.0	53.2	607.5	-3.5	36.6	438.7
RL	20	30	-3.7	4.6	369.9	-0.9	2.4	41.1	-7.0	0.0	1.3	-0.1	316.8	7546.1	-23.2	0.0	0.0	0.0	28.2	363.3	-6.1	23.8	325.6
RL	20	30	-3.9	4.2	346.9	-0.9	6.0	55.8	-6.1	0.0	1.1	-0.1	243.2	6006.9	-26.7	0.0	0.0	0.0	62.5	699.6	-2.6	6.6	175.5
RL	20	30	-3.4	7.8	587.8	-0.9	6.8	59.1	-5.9	0.0	1.3	-0.1	541.2	12345.1	-12.7	0.0	0.0	0.0	50.5	581.5	-3.8	12.8	229.3
RL	20	30	-3.6	8.7	644.6	-0.9	4.8	51.1	-6.4	0.0	1.3	-0.1	1272.5	27882.1	21.7	0.0	0.0	0.0	52.9	604.2	-3.6	34.8	422.6
RL	20	30	-3.7	4.6	375.1	-0.9	2.4	41.0	-7.0	0.0	1.3	-0.1	314.7	7501.3	-23.3	0.0	0.0	0.0	28.3	363.5	-6.1	23.3	321.5
RL	20	30	-3.9	4.2	351.5	-0.9	5.9	55.6	-6.1	0.0	1.1	-0.1	242.0	5981.6	-26.8	0.0	0.0	0.0	62.5	700.2	-2.6	6.4	173.5
RL	20	30	-3.4	7.9	595.2	-0.9	6.7	58.9	-5.9	0.0	1.3	-0.1	538.5	12287.3	-12.8	0.0	0.0	0.0	50.5	581.6	-3.8	12.5	226.7
RL	20	30	-3.6	8.7	650.9	-0.9	4.8	51.0	-6.4	0.0	1.3	-0.1	1269.5	27817.6	21.6	0.0	0.0	0.0	53.0	604.7	-3.6	34.4	419.4

Appendix Table A-3

Site	Salt Trmt	Lag	Farfantepenaeus lower	Cynoscion	Cynoscion upper	Cynoscion lower	Sfloridae	Sfloridae upper	Sfloridae lower	Atherinomorus	Atherinomorus upper	Atherinomorus lower	S.scovelli	S.scovelli upper	S.scovelli lower	Opsanus	Opsanus upper	Opsanus lower	all forage	all forage upper	all forage lower
WHP	0.9	0	-8.5	2.0	33.5	-0.3	8.5	93.6	-6.7	1.8	41.3	-10.0	49.2	658.6	-0.6	0.3	480.5	0.0	458.9	9886.6	-60.1
WHP	0.9	0	-4.9	1.6	28.2	-0.3	8.6	94.1	-6.7	1.8	41.4	-10.0	34.0	471.7	-1.8	0.3	415.5	0.0	842.7	17826.2	-41.0
WHP	0.9	0	-8.1	0.8	17.0	-0.4	9.0	96.0	-6.6	1.5	40.5	-10.1	26.0	374.4	-2.5	0.0	80.7	0.0	291.8	6416.8	-70.1
WHP	0.9	0	-9.4	1.2	22.5	-0.4	3.7	66.4	-7.6	1.6	40.8	-10.0	32.1	448.9	-2.0	0.2	307.5	0.0	248.9	5581.9	-72.1
WHP	0.9	0	-7.7	2.1	35.3	-0.3	8.0	91.0	-6.8	2.1	42.3	-9.9	52.1	693.5	-0.3	0.3	432.9	0.0	475.3	10078.1	-58.8
WHP	0.9	0	-4.2	1.6	28.6	-0.3	7.8	89.6	-6.8	2.1	42.4	-9.9	34.3	476.0	-1.8	0.2	352.0	0.0	838.3	17624.5	-41.0
WHP	0.9	0	-7.9	0.7	16.4	-0.4	7.5	87.8	-6.9	2.1	42.3	-9.9	24.8	359.6	-2.6	0.0	59.0	0.0	284.4	6305.1	-70.8
WHP	0.9	0	-9.2	1.1	21.8	-0.4	2.5	60.0	-7.8	2.3	42.9	-9.9	30.9	434.6	-2.1	0.1	218.2	0.0	242.2	5419.7	-72.7
WHP	0.9	0	-7.4	2.0	34.1	-0.3	6.4	82.0	-7.1	2.7	44.4	-9.7	49.8	666.3	-0.5	0.2	302.8	0.0	457.3	9637.4	-60.0
WHP	0.9	0	-4.1	1.5	27.2	-0.4	6.3	81.0	-7.1	2.7	44.4	-9.7	32.2	450.3	-2.0	0.2	248.3	0.0	802.7	16864.9	-43.1
WHP	0.9	30	-8.7	2.0	32.8	-0.3	8.2	91.6	-6.8	2.1	42.3	-9.9	46.8	629.1	-0.8	0.3	439.8	0.0	467.0	10062.6	-59.9
WHP	0.9	30	-5.6	1.4	25.8	-0.4	8.0	90.5	-6.8	3.1	45.7	-9.6	28.1	400.0	-2.3	0.2	330.5	0.0	902.3	19097.9	-38.9
WHP	0.9	30	-8.0	0.8	17.0	-0.4	8.9	95.5	-6.6	1.5	40.4	-10.1	26.2	376.4	-2.5	0.0	79.8	0.0	291.6	6414.4	-70.1
WHP	0.9	30	-8.9	1.3	23.9	-0.4	4.2	69.6	-7.5	1.0	38.7	-10.2	36.8	506.5	-1.6	0.2	371.3	0.0	245.8	5492.5	-71.8
WHP	0.9	30	-7.9	2.1	34.5	-0.3	7.6	88.4	-6.9	2.4	43.4	-9.8	49.4	660.9	-0.6	0.2	387.5	0.0	481.6	10218.7	-58.8
WHP	0.9	30	-4.9	1.5	26.1	-0.4	7.1	85.6	-6.9	3.4	46.9	-9.5	28.3	402.1	-2.3	0.2	273.4	0.0	892.5	18800.3	-39.2
WHP	0.9	30	-7.9	0.7	16.3	-0.4	7.3	86.9	-6.9	2.1	42.3	-9.9	24.8	359.7	-2.6	0.0	57.5	0.0	283.4	6292.0	-70.9
WHP	0.9	30	-8.7	1.2	23.0	-0.4	3.0	62.7	-7.7	1.6	40.9	-10.0	35.2	486.8	-1.7	0.2	260.2	0.0	238.3	5302.3	-72.4
WHP	0.9	30	-7.7	2.0	33.1	-0.3	6.0	79.5	-7.1	3.1	45.6	-9.6	46.9	630.6	-0.8	0.2	268.4	0.0	461.2	9753.4	-60.2
WHP	0.9	30	-4.8	1.4	24.7	-0.4	5.6	77.3	-7.2	4.1	49.1	-9.3	26.4	379.3	-2.4	0.1	192.2	0.0	852.7	17979.3	-41.6
WHP	1	0	-9.5	1.8	30.2	-0.3	7.2	85.9	-6.9	2.6	44.0	-9.8	39.7	541.6	-1.3	0.2	349.9	0.0	473.9	10283.9	-60.4
WHP	1	0	-5.6	1.5	26.0	-0.4	8.4	92.7	-6.7	2.6	44.2	-9.7	29.2	413.0	-2.2	0.2	368.2	0.0	864.5	18333.3	-40.6
WHP	1	0	-8.5	0.7	15.8	-0.4	9.4	98.3	-6.5	2.3	42.9	-9.9	22.8	335.6	-2.7	0.0	80.7	0.0	292.4	6460.0	-70.5
WHP	1	0	-10.7	1.0	19.7	-0.4	2.8	61.4	-7.7	2.2	42.6	-9.9	24.4	354.1	-2.6	0.1	235.8	0.0	248.4	5683.6	-73.0
WHP	1	0	-9.5	1.8	30.2	-0.3	7.2	85.9	-6.9	2.6	44.0	-9.8	39.7	541.5	-1.3	0.2	349.9	0.0	473.9	10282.9	-60.4
WHP	1	0	-5.6	1.5	26.0	-0.4	8.4	92.7	-6.7	2.6	44.2	-9.7	29.2	413.0	-2.2	0.2	368.2	0.0	864.4	18332.4	-40.6
WHP	1	0	-8.5	0.7	15.8	-0.4	9.4	98.3	-6.5	2.3	42.9	-9.9	22.8	335.6	-2.7	0.0	80.7	0.0	292.4	6460.4	-70.5
WHP	1	0	-10.7	1.0	19.7	-0.4	2.8	61.4	-7.7	2.2	42.6	-9.9	24.4	354.2	-2.6	0.1	235.8	0.0	248.4	5684.1	-73.0
WHP	1	0	-9.5	1.8	30.2	-0.3	7.2	85.9	-6.9	2.6	44.0	-9.8	39.7	541.6	-1.3	0.2	349.9	0.0	473.9	10283.4	-60.4
WHP	1	0	-5.6	1.5	26.0	-0.4	8.4	92.7	-6.7	2.6	44.2	-9.7	29.2	413.0	-2.2	0.2	368.2	0.0	864.5	18332.8	-40.6
WHP	1	30	-9.7	1.7	29.7	-0.3	6.7	83.1	-7.0	2.9	45.0	-9.7	37.4	514.0	-1.5	0.2	310.3	0.0	489.7	10628.1	-59.8
WHP	1	30	-7.0	1.3	23.5	-0.4	6.7	83.2	-7.0	4.0	48.6	-9.4	22.4	330.8	-2.8	0.2	242.3	0.0	977.5	20806.8	-36.4
WHP	1	30	-8.5	0.7	15.8	-0.4	9.4	98.2	-6.5	2.2	42.7	-9.9	23.0	337.4	-2.7	0.0	81.0	0.0	290.6	6421.2	-70.5
WHP	1	30	-10.1	1.1	21.2	-0.4	3.7	66.7	-7.5	1.5	40.4	-10.1	29.3	413.8	-2.2	0.2	314.4	0.0	240.8	5493.8	-72.8
WHP	1	30	-9.7	1.7	29.7	-0.3	6.6	83.1	-7.0	2.9	45.0	-9.7	37.4	513.9	-1.5	0.2	309.8	0.0	489.1	10613.2	-59.9
WHP	1	30	-7.0	1.3	23.5	-0.4	6.7	83.2	-7.0	4.0	48.6	-9.4	22.4	330.5	-2.8	0.2	241.9	0.0	976.0	20775.2	-36.5
WHP	1	30	-8.5	0.7	15.8	-0.4	9.3	98.2	-6.5	2.2	42.7	-9.9	23.0	337.3	-2.7	0.0	80.9	0.0	290.5	6419.4	-70.6
WHP	1	30	-10.1	1.1	21.2	-0.4	3.7	66.7	-7.5	1.5	40.4	-10.1	29.3	413.9	-2.2	0.2	314.3	0.0	240.8	5493.2	-72.8
WHP	1	30	-9.7	1.7	29.7	-0.3	6.6	83.1	-7.0	2.9	45.0	-9.7	37.4	513.9	-1.5	0.2	309.7	0.0	489.1	10612.3	-59.9
WHP	1	30	-7.0	1.3	23.5	-0.4	6.7	83.2	-7.0	3.9	48.6	-9.4	22.4	330.5	-2.8	0.2	241.8	0.0	975.8	20771.3	-36.5
WHP	1.1	0	-10.5	1.5	27.1	-0.4	5.6	77.4	-7.2	3.3	46.5	-9.5	31.1	437.2	-2.0	0.2	244.2	0.0	495.0	10835.8	-60.3
WHP	1.1	0	-6.9	1.3	23.7	-0.4	7.4	87.2	-6.9	3.4	46.6	-9.5	24.0	349.1	-2.6	0.2	289.2	0.0	906.0	19308.0	-39.6
WHP	1.1	0	-9.1	0.6	14.6	-0.4	8.7	94.8	-6.6	3.0	45.4	-9.6	19.3	292.0	-3.0	0.0	68.0	0.0	299.6	6694.9	-70.7
WHP	1.1	0	-11.5	0.8	17.5	-0.4	1.7	55.2	-7.9	2.9	45.2	-9.7	18.6	283.8	-3.1	0.1	165.2	0.0	259.5	5979.7	-73.0
WHP	1.1	0	-10.6	1.5	26.6	-0.4	5.6	77.5	-7.2	3.3	46.4	-9.6	30.5	429.5	-2.1	0.2	245.1	0.0	490.8	10774.3	-60.6
WHP	1.1	0	-6.9	1.3	23.6	-0.4	7.5	87.6	-6.9	3.4	46.7	-9.5	23.9	348.7	-2.6	0.2	292.8	0.0	912.9	19466.6	-39.3
WHP	1.1	0	-9.1	0.6	14.7	-0.4	8.8	95.1	-6.6	3.0	45.5	-9.6	19.4	293.8	-3.0	0.0	68.5	0.0	302.5	6750.1	-70.5
WHP	1.1	0	-11.5	0.8	17.6	-0.4	1.7	55.4	-7.9	3.0	45.3	-9.6	18.7	285.3	-3.1	0.1	166.0	0.0	261.7	6022.0	-72.9
WHP	1.1	0	-10.6	1.5	26.7	-0.4	5.7	77.6	-7.2	3.3	46.5	-9.5	30.7	431.4	-2.1	0.2	245.8	0.0	494.3	10846.1	-60.5
WHP	1.1	0	-6.9	1.3	23.7	-0.4	7.5	87.7	-6.9	3.4	46.8	-9.5	24.0	350.2	-2.6	0.2	293.5	0.0	918.3	19577.0	-39.0
WHP	1.1	30	-10.7	1.5	26.6	-0.4	5.1	74.7	-7.3	3.7	47.8	-9.4	29.3	414.5	-2.2	0.1	214.3	0.0	518.6	11347.0	-59.4
WHP	1.1	30	-8.4	1.1	21.2	-0.4	5.3	75.4	-7.3	4.8	51.5	-9.1	17.4	269.7	-3.2	0.1	171.1	0.0	1070.1	22909.9	-33.0
WHP	1.1	30	-9.1	0.6	14.7	-0.4	8.8	95.0	-6.6	2.9	45.1	-9.7	19.4	293.8	-3.0	0.0	68.9	0.0	296.1	6618.5	-70.9
WHP	1.1	30	-10.9	0.9	19.1	-0.4	2.7	60.8	-7.7	2.2	42.7	-9.9	23.1	338.4	-2.7	0.1	228.3	0.0	246.6	5672.5	-73.2

Appendix Table A-3

Site	Salt Trmt	Lag	Farfante-penaeus lower	Cynoscion	Cynoscion upper	Cynoscion lower	Sfloridae	Sfloridae upper	Sfloridae lower	Atherino-morus	Atherino-morus upper	Atherinomorus lower	S.scovelli	S.scovelli upper	S.scovelli lower	Opsanus	Opsanus upper	Opsanus lower	all forage	all forage upper	all forage lower
WHP	1.1	30	-10.8	1.5	26.1	-0.4	5.2	74.7	-7.3	3.7	47.6	-9.4	28.6	406.7	-2.3	0.1	215.1	0.0	512.9	11254.0	-59.8
WHP	1.1	30	-8.5	1.1	21.1	-0.4	5.3	75.7	-7.3	4.8	51.5	-9.1	17.4	268.9	-3.2	0.1	173.1	0.0	1075.7	23037.8	-32.8
WHP	1.1	30	-9.1	0.6	14.7	-0.4	8.8	95.3	-6.6	2.9	45.2	-9.7	19.5	295.1	-3.0	0.0	69.4	0.0	298.3	6661.1	-70.7
WHP	1.1	30	-10.9	0.9	19.1	-0.4	2.7	60.9	-7.7	2.2	42.8	-9.9	23.2	339.6	-2.7	0.1	229.3	0.0	248.2	5702.5	-73.1
WHP	1.1	30	-10.8	1.5	26.1	-0.4	5.2	74.9	-7.3	3.7	47.7	-9.4	28.7	407.9	-2.2	0.1	215.6	0.0	515.6	11310.1	-59.6
WHP	1.1	30	-8.5	1.1	21.1	-0.4	5.3	75.8	-7.3	4.8	51.6	-9.1	17.4	269.7	-3.2	0.1	173.5	0.0	1080.9	23145.5	-32.5
WHP	1.3	0	-12.0	1.1	21.7	-0.4	2.9	62.2	-7.7	4.8	51.7	-9.1	18.5	283.6	-3.1	0.1	117.8	0.0	553.1	12287.1	-59.0
WHP	1.3	0	-9.3	1.0	19.4	-0.4	4.8	72.8	-7.4	4.7	51.2	-9.1	14.9	238.4	-3.4	0.1	155.4	0.0	1016.8	21906.6	-36.2
WHP	1.3	0	-10.8	0.4	12.0	-0.4	6.2	80.8	-7.1	4.2	49.6	-9.3	11.9	201.7	-3.6	0.0	38.8	0.0	313.5	7243.5	-71.5
WHP	1.3	0	-12.8	0.5	13.5	-0.4	-0.4	43.7	-8.3	4.5	50.6	-9.2	9.7	175.7	-3.8	0.0	78.2	0.0	286.2	6680.6	-72.7
WHP	1.3	0	-12.3	1.0	20.1	-0.4	2.8	61.7	-7.7	4.7	51.1	-9.1	16.8	261.6	-3.2	0.1	116.0	0.0	522.9	11735.0	-60.8
WHP	1.3	0	-9.6	0.9	18.7	-0.4	4.8	72.9	-7.3	4.7	51.1	-9.1	14.2	230.3	-3.4	0.1	156.5	0.0	1004.0	21690.6	-37.0
WHP	1.3	0	-10.7	0.4	12.3	-0.4	6.5	82.1	-7.1	4.5	50.3	-9.2	12.5	209.3	-3.6	0.0	39.9	0.0	332.8	7622.0	-70.4
WHP	1.3	0	-12.7	0.6	14.0	-0.4	-0.3	44.4	-8.3	4.8	51.5	-9.1	10.4	183.4	-3.7	0.0	80.0	0.0	306.9	7082.3	-71.5
WHP	1.3	0	-12.2	1.1	20.9	-0.4	3.0	62.7	-7.7	5.0	52.2	-9.0	17.9	275.5	-3.1	0.1	118.5	0.0	564.9	12585.1	-58.6
WHP	1.3	0	-9.3	1.0	19.6	-0.4	5.0	74.1	-7.3	5.0	52.1	-9.0	15.3	243.7	-3.3	0.1	160.3	0.0	1085.1	23349.3	-32.9
WHP	1.3	30	-12.1	1.1	21.2	-0.4	2.4	59.7	-7.8	5.3	53.4	-9.0	17.1	265.8	-3.2	0.1	101.3	0.0	589.1	13078.7	-57.4
WHP	1.3	30	-10.5	0.8	17.1	-0.4	2.7	61.0	-7.7	6.6	57.5	-8.6	9.7	175.8	-3.8	0.0	83.8	0.0	1272.6	27524.6	-25.1
WHP	1.3	30	-10.8	0.4	12.1	-0.4	6.3	81.3	-7.1	4.2	49.3	-9.3	12.1	204.4	-3.6	0.0	39.8	0.0	309.9	7159.6	-71.6
WHP	1.3	30	-12.4	0.6	14.9	-0.4	0.6	49.2	-8.1	3.6	47.3	-9.5	13.1	216.2	-3.5	0.1	114.7	0.0	261.0	6109.2	-73.6
WHP	1.3	30	-12.4	1.0	19.6	-0.4	2.3	59.2	-7.8	5.2	52.7	-9.0	15.4	245.3	-3.3	0.1	99.9	0.0	556.7	12475.6	-59.3
WHP	1.3	30	-10.8	0.7	16.5	-0.4	2.7	61.2	-7.7	6.5	57.3	-8.6	9.3	170.0	-3.8	0.0	84.5	0.0	1259.5	27288.5	-25.9
WHP	1.3	30	-10.7	0.4	12.3	-0.4	6.5	82.5	-7.0	4.3	49.9	-9.2	12.7	211.3	-3.6	0.0	40.9	0.0	327.1	7497.2	-70.7
WHP	1.3	30	-12.3	0.7	15.3	-0.4	0.7	49.9	-8.1	3.8	48.2	-9.4	13.8	225.0	-3.5	0.1	117.2	0.0	278.3	6440.6	-72.6
WHP	1.3	30	-12.3	1.0	20.3	-0.4	2.5	60.1	-7.8	5.5	53.8	-8.9	16.4	257.1	-3.3	0.1	101.9	0.0	597.0	13294.6	-57.2
WHP	1.3	30	-10.6	0.8	17.1	-0.4	2.9	62.1	-7.7	6.8	58.3	-8.5	10.0	178.8	-3.8	0.1	86.4	0.0	1349.4	29154.7	-21.4
WHP	10	0	-11.7	1.2	22.5	-0.4	3.4	65.1	-7.6	4.5	50.5	-9.2	20.5	307.8	-2.9	0.1	136.6	0.0	536.2	11895.8	-59.6
WHP	10	0	-9.2	1.0	19.6	-0.4	4.9	73.1	-7.3	4.7	51.3	-9.1	15.2	241.9	-3.4	0.1	157.5	0.0	1025.2	22075.5	-35.7
WHP	10	0	-10.9	0.4	12.0	-0.4	6.1	80.4	-7.1	4.3	49.9	-9.2	11.8	200.7	-3.6	0.0	38.0	0.0	317.1	7324.5	-71.4
WHP	10	0	-12.6	0.6	14.2	-0.4	0.1	46.4	-8.2	4.0	48.8	-9.3	11.4	195.5	-3.7	0.1	95.3	0.0	270.4	6340.1	-73.4
WHP	10	0	-12.1	1.1	20.9	-0.4	3.3	64.5	-7.6	4.3	50.0	-9.2	18.6	284.6	-3.1	0.1	134.4	0.0	506.5	11358.3	-61.4
WHP	10	0	-9.5	0.9	19.0	-0.4	4.9	73.4	-7.3	4.7	51.2	-9.1	14.6	234.7	-3.4	0.1	158.8	0.0	1016.6	21946.0	-36.4
WHP	10	0	-10.7	0.4	12.3	-0.4	6.4	81.5	-7.1	4.5	50.6	-9.2	12.4	208.0	-3.6	0.0	39.0	0.0	335.8	7691.7	-70.3
WHP	10	0	-12.5	0.6	14.7	-0.4	0.2	47.2	-8.2	4.3	49.7	-9.3	12.0	203.7	-3.6	0.1	97.4	0.0	288.7	6692.2	-72.3
WHP	10	0	-12.0	1.1	21.7	-0.4	3.5	65.5	-7.6	4.6	51.0	-9.2	19.8	298.7	-3.0	0.1	137.1	0.0	543.9	12112.6	-59.4
WHP	10	0	-9.2	1.0	19.8	-0.4	5.1	74.4	-7.3	5.0	52.1	-9.0	15.6	247.1	-3.3	0.1	162.3	0.0	1090.2	23452.0	-32.6
WHP	10	30	-11.9	1.2	22.2	-0.4	3.0	63.0	-7.7	4.9	51.8	-9.1	19.3	293.3	-3.0	0.1	121.6	0.0	563.2	12485.7	-58.4
WHP	10	30	-10.2	0.8	17.8	-0.4	3.2	63.9	-7.6	6.1	56.1	-8.7	11.0	191.6	-3.7	0.1	97.8	0.0	1218.3	26311.7	-27.4
WHP	10	30	-10.8	0.4	12.0	-0.4	6.2	80.8	-7.1	4.3	49.7	-9.3	12.0	202.8	-3.6	0.0	38.7	0.0	314.4	7262.1	-71.4
WHP	10	30	-12.2	0.7	15.3	-0.4	0.9	50.8	-8.1	3.3	46.4	-9.6	14.2	229.6	-3.4	0.1	128.0	0.0	253.4	5946.1	-73.9
WHP	10	30	-12.2	1.1	20.6	-0.4	3.0	62.5	-7.7	4.7	51.2	-9.1	17.5	271.3	-3.2	0.1	119.8	0.0	532.0	11912.6	-60.3
WHP	10	30	-10.5	0.8	17.2	-0.4	3.2	64.1	-7.6	6.1	56.0	-8.7	10.6	186.0	-3.7	0.1	98.8	0.0	1209.6	26169.5	-28.0
WHP	10	30	-10.7	0.4	12.3	-0.4	6.4	81.9	-7.1	4.4	50.3	-9.2	12.5	209.4	-3.6	0.0	39.7	0.0	331.0	7587.9	-70.5
WHP	10	30	-12.1	0.7	15.8	-0.4	1.0	51.6	-8.0	3.5	47.1	-9.5	14.9	238.3	-3.4	0.1	130.6	0.0	268.8	6241.1	-73.0
WHP	10	30	-12.1	1.1	21.3	-0.4	3.1	63.3	-7.7	5.0	52.1	-9.1	18.5	283.2	-3.1	0.1	122.0	0.0	567.1	12622.9	-58.5
WHP	10	30	-10.2	0.8	17.8	-0.4	3.4	65.0	-7.6	6.4	56.8	-8.6	11.3	194.6	-3.7	0.1	100.8	0.0	1286.7	27766.2	-24.1
WHP	20	0	-13.0	0.8	17.2	-0.4	0.3	47.9	-8.2	6.5	57.5	-8.6	9.8	176.9	-3.8	0.0	51.7	0.0	624.3	14073.8	-56.8
WHP	20	0	-11.3	0.6	15.1	-0.4	1.5	54.7	-7.9	6.9	58.8	-8.5	6.8	140.4	-4.0	0.0	60.5	0.0	1252.8	27293.8	-26.8
WHP	20	0	-12.4	0.2	9.1	-0.4	2.6	60.8	-7.8	6.5	57.4	-8.6	4.8	115.8	-4.2	0.0	14.9	0.0	373.9	8823.5	-70.1
WHP	20	0	-13.5	0.3	10.8	-0.4	-2.1	34.2	-8.6	6.1	56.2	-8.7	4.5	111.9	-4.2	0.0	37.5	0.0	325.2	7648.5	-71.4
WHP	20	0	-13.3	0.7	15.5	-0.4	0.3	47.7	-8.2	6.2	56.5	-8.7	8.3	158.6	-3.9	0.0	51.8	0.0	582.3	13277.8	-59.1
WHP	20	0	-11.7	0.6	14.0	-0.4	1.5	54.4	-8.0	6.6	57.8	-8.6	5.9	129.6	-4.1	0.0	60.7	0.0	1178.3	25786.6	-30.7
WHP	20	0	-12.5	0.2	9.0	-0.4	2.7	61.2	-7.7	6.5	57.5	-8.6	4.8	115.1	-4.2	0.0	15.1	0.0	376.8	8889.4	-70.0
WHP	20	0	-13.6	0.3	10.7	-0.4	-2.1	34.6	-8.6	6.3	56.8	-8.7	4.5	112.7	-4.2	0.0	37.9	0.0	336.9	7887.0	-70.8

Appendix Table A-3

Site	Salt Trmt	Lag	Farfante-penaeus lower	Cynoscion	Cynoscion upper	Cynoscion lower	Sfloridae	Sfloridae upper	Sfloridae lower	Atherino-morus	Atherino-morus upper	Atherinomorus lower	S.scovelli	S.scovelli upper	S.scovelli lower	Opsanus	Opsanus upper	Opsanus lower	all forage	all forage upper	all forage lower
WHP	20	0	-13.3	0.7	15.6	-0.4	0.3	48.2	-8.2	6.5	57.3	-8.6	8.5	161.1	-3.9	0.0	52.2	0.0	607.3	13805.8	-57.9
WHP	20	0	-11.7	0.6	14.3	-0.4	1.6	55.1	-7.9	6.9	58.6	-8.5	6.3	133.6	-4.1	0.0	61.7	0.0	1240.5	27089.5	-27.6
WHP	20	30	-13.1	0.8	16.9	-0.4	0.0	46.5	-8.2	6.9	59.0	-8.5	9.0	168.0	-3.9	0.0	46.4	0.0	660.3	14885.7	-55.2
WHP	20	30	-12.0	0.5	13.6	-0.4	0.2	47.6	-8.2	8.5	64.2	-8.0	4.4	110.6	-4.2	0.0	37.9	0.0	1505.1	32910.3	-15.6
WHP	20	30	-12.4	0.2	9.1	-0.4	2.6	61.0	-7.8	6.4	57.0	-8.6	4.9	116.4	-4.2	0.0	15.1	0.0	366.6	8666.2	-70.4
WHP	20	30	-13.3	0.4	11.5	-0.4	-1.5	37.7	-8.5	5.4	53.5	-9.0	6.0	130.7	-4.1	0.0	50.3	0.0	299.4	7059.2	-72.5
WHP	20	30	-13.4	0.6	15.2	-0.4	0.0	46.1	-8.2	6.6	57.9	-8.6	7.6	149.9	-4.0	0.0	46.1	0.0	610.3	13918.3	-57.9
WHP	20	30	-12.3	0.5	12.7	-0.4	0.2	47.4	-8.2	8.2	63.1	-8.1	3.7	102.1	-4.3	0.0	38.0	0.0	1414.9	31047.6	-20.1
WHP	20	30	-12.5	0.2	9.1	-0.4	2.7	61.4	-7.7	6.4	57.2	-8.6	4.9	116.3	-4.2	0.0	15.4	0.0	371.5	8772.0	-70.2
WHP	20	30	-13.3	0.4	11.5	-0.4	-1.4	38.1	-8.5	5.6	54.3	-8.9	6.2	132.4	-4.1	0.0	50.8	0.0	313.3	7342.3	-71.8
WHP	20	30	-13.3	0.7	15.4	-0.4	0.1	46.6	-8.2	6.9	58.7	-8.5	7.8	153.5	-4.0	0.0	46.7	0.0	642.8	14599.4	-56.3
WHP	20	30	-12.2	0.5	13.0	-0.4	0.3	48.1	-8.2	8.5	64.1	-8.0	4.0	106.2	-4.3	0.0	38.8	0.0	1506.3	32974.9	-15.7
RL	0.9	0	-7.2	2.0	33.9	-0.3	10.6	105.3	-6.3	-0.4	34.2	-10.6	69.9	911.3	1.1	0.5	742.5	0.0	462.4	10098.4	-58.0
RL	0.9	0	-3.2	1.7	29.8	-0.3	9.8	100.5	-6.5	0.0	35.4	-10.5	51.0	680.4	-0.4	0.4	605.0	0.0	906.3	19268.9	-35.8
RL	0.9	0	-6.7	0.8	17.7	-0.4	10.8	106.1	-6.3	0.3	36.4	-10.4	38.5	526.5	-1.4	0.1	120.8	0.0	341.3	7340.3	-66.0
RL	0.9	0	-8.6	1.1	21.2	-0.4	5.6	77.1	-7.2	0.3	36.5	-10.4	41.3	560.9	-1.2	0.3	470.7	0.0	261.6	5907.0	-70.3
RL	0.9	0	-7.0	2.1	34.6	-0.3	10.6	105.4	-6.3	-0.3	34.4	-10.6	71.6	932.4	1.3	0.5	740.3	0.0	472.9	10262.4	-57.2
RL	0.9	0	-3.0	1.8	30.1	-0.3	9.7	100.2	-6.5	0.1	35.5	-10.5	51.6	687.5	-0.4	0.4	599.5	0.0	913.8	19388.0	-35.3
RL	0.9	0	-6.7	0.8	17.7	-0.4	10.7	105.8	-6.3	0.3	36.5	-10.4	38.5	526.6	-1.4	0.1	119.6	0.0	341.3	7335.9	-66.0
RL	0.9	0	-8.6	1.1	21.2	-0.4	5.6	77.0	-7.2	0.4	36.5	-10.4	41.4	561.8	-1.2	0.3	467.7	0.0	261.9	5906.0	-70.3
RL	0.9	0	-6.9	2.1	34.7	-0.3	10.6	105.3	-6.3	-0.3	34.5	-10.6	71.9	935.4	1.3	0.5	738.0	0.0	474.0	10273.5	-57.1
RL	0.9	0	-3.0	1.8	30.1	-0.3	9.7	100.1	-6.5	0.1	35.6	-10.5	51.7	688.1	-0.4	0.4	597.1	0.0	913.7	19378.3	-35.3
RL	0.9	30	-7.3	1.9	32.7	-0.3	10.7	105.6	-6.3	0.2	35.9	-10.5	65.7	860.3	0.8	0.5	707.5	0.0	464.8	10136.2	-58.1
RL	0.9	30	-3.0	1.7	28.7	-0.3	10.2	102.7	-6.4	0.6	37.2	-10.4	48.6	650.3	-0.6	0.4	608.9	0.0	907.2	19245.3	-35.8
RL	0.9	30	-6.9	0.9	18.0	-0.4	10.5	104.4	-6.3	0.0	35.2	-10.5	39.5	539.7	-1.4	0.1	119.7	0.0	341.6	7376.8	-66.0
RL	0.9	30	-8.4	1.1	21.7	-0.4	5.8	78.4	-7.2	0.1	35.6	-10.5	43.4	586.6	-1.0	0.3	506.9	0.0	260.8	5892.9	-70.2
RL	0.9	30	-7.0	2.0	33.3	-0.3	10.7	105.7	-6.3	0.2	36.1	-10.5	67.1	877.5	0.9	0.4	705.3	0.0	473.8	10275.2	-57.5
RL	0.9	30	-2.8	1.7	29.0	-0.3	10.1	102.5	-6.4	0.6	37.3	-10.4	49.0	656.2	-0.6	0.4	603.9	0.0	913.6	19345.2	-35.4
RL	0.9	30	-6.8	0.9	18.0	-0.4	10.4	104.1	-6.4	0.0	35.2	-10.5	39.5	539.8	-1.4	0.1	118.7	0.0	341.5	7372.7	-66.0
RL	0.9	30	-8.4	1.1	21.7	-0.4	5.8	78.3	-7.2	0.1	35.6	-10.5	43.5	587.4	-1.0	0.3	504.0	0.0	261.0	5890.6	-70.1
RL	0.9	30	-7.0	2.0	33.4	-0.3	10.7	105.6	-6.3	0.2	36.1	-10.5	67.3	879.9	0.9	0.4	703.4	0.0	474.6	10283.1	-57.4
RL	0.9	30	-2.8	1.7	29.0	-0.3	10.1	102.4	-6.4	0.6	37.3	-10.4	49.1	656.7	-0.6	0.4	601.8	0.0	913.4	19334.7	-35.4
RL	1	0	-7.6	1.8	31.2	-0.3	10.4	104.3	-6.3	0.4	36.6	-10.4	61.1	802.9	0.4	0.4	667.3	0.0	453.7	9941.7	-59.1
RL	1	0	-3.2	1.6	27.8	-0.3	10.3	103.3	-6.4	0.8	37.9	-10.3	46.3	622.2	-0.8	0.4	605.4	0.0	891.9	18950.5	-36.8
RL	1	0	-6.8	0.7	16.5	-0.4	11.3	109.0	-6.2	1.1	38.9	-10.2	34.6	479.6	-1.8	0.1	120.6	0.0	333.7	7178.7	-66.6
RL	1	0	-9.6	0.9	19.1	-0.4	4.4	70.7	-7.4	1.0	38.7	-10.2	33.0	459.3	-1.9	0.2	345.0	0.0	258.9	5910.5	-71.3
RL	1	0	-7.6	1.8	31.2	-0.3	10.4	104.3	-6.3	0.4	36.6	-10.4	61.1	802.9	0.4	0.4	667.3	0.0	453.7	9941.8	-59.1
RL	1	0	-3.2	1.6	27.8	-0.3	10.3	103.3	-6.4	0.8	37.9	-10.3	46.3	622.3	-0.8	0.4	605.4	0.0	891.9	18950.7	-36.8
RL	1	0	-6.8	0.7	16.5	-0.4	11.3	109.0	-6.2	1.1	38.9	-10.2	34.6	479.7	-1.8	0.1	120.6	0.0	333.7	7178.7	-66.6
RL	1	0	-9.6	0.9	19.1	-0.4	4.4	70.7	-7.4	1.0	38.7	-10.2	33.0	459.3	-1.9	0.2	345.0	0.0	258.9	5910.6	-71.3
RL	1	0	-7.6	1.8	31.2	-0.3	10.4	104.3	-6.3	0.4	36.6	-10.4	61.1	803.0	0.4	0.4	667.3	0.0	453.7	9942.1	-59.1
RL	1	0	-3.2	1.6	27.8	-0.3	10.3	103.3	-6.4	0.8	37.9	-10.3	46.3	622.3	-0.8	0.4	605.4	0.0	891.9	18951.2	-36.8
RL	1	30	-8.0	1.7	29.9	-0.3	9.9	101.3	-6.4	0.9	38.3	-10.3	55.6	736.0	0.0	0.4	581.8	0.0	460.8	10095.0	-59.2
RL	1	30	-3.3	1.5	26.6	-0.4	10.4	103.9	-6.4	1.3	39.8	-10.1	43.1	584.0	-1.1	0.4	579.6	0.0	902.1	19142.8	-36.6
RL	1	30	-6.9	0.8	16.8	-0.4	11.1	108.1	-6.2	0.7	37.6	-10.3	36.0	495.8	-1.7	0.1	122.8	0.0	332.1	7161.4	-66.7
RL	1	30	-9.3	1.0	19.7	-0.4	4.9	73.1	-7.3	0.8	37.9	-10.3	35.4	488.6	-1.7	0.2	387.2	0.0	257.5	5869.0	-71.1
RL	1	30	-8.0	1.7	29.8	-0.3	9.9	101.2	-6.4	0.9	38.2	-10.3	55.4	732.9	-0.1	0.4	581.4	0.0	458.7	10059.0	-59.4
RL	1	30	-3.3	1.5	26.6	-0.4	10.4	103.8	-6.4	1.3	39.8	-10.1	43.0	582.6	-1.1	0.4	579.8	0.0	899.7	19101.5	-36.7
RL	1	30	-6.9	0.8	16.8	-0.4	11.1	108.2	-6.2	0.7	37.6	-10.3	35.9	495.6	-1.7	0.1	122.9	0.0	331.9	7159.9	-66.7
RL	1	30	-9.3	1.0	19.6	-0.4	4.9	73.1	-7.3	0.8	37.9	-10.3	35.4	488.5	-1.7	0.2	387.5	0.0	257.4	5868.8	-71.2
RL	1	30	-8.0	1.7	29.7	-0.3	9.9	101.2	-6.4	0.9	38.2	-10.3	55.3	732.6	-0.1	0.4	581.6	0.0	458.5	10057.2	-59.4
RL	1	30	-3.3	1.5	26.6	-0.4	10.4	103.9	-6.4	1.3	39.8	-10.1	43.0	582.5	-1.1	0.4	580.1	0.0	899.8	19102.8	-36.7
RL	1.1	0	-8.4	1.6	28.5	-0.3	9.5	98.7	-6.5	1.0	38.6	-10.2	51.3	683.0	-0.4	0.3	533.7	0.0	449.9	9916.7	-60.2
RL	1.1	0	-3.7	1.4	25.7	-0.4	10.3	103.3	-6.4	1.4	40.2	-10.1	40.9	556.1	-1.3	0.4	563.4	0.0	884.8	18828.1	-37.8

Appendix Table A-3

Site	Salt Trmt	Lag	Farfante-penaeus lower	Cynoscion	Cynoscion upper	Cynoscion lower	Sfloridae	Sfloridae upper	Sfloridae lower	Atherino-morus	Atherino-morus upper	Atherinomorus lower	S.scovelli	S.scovelli upper	S.scovelli lower	Opsanus	Opsanus upper	Opsanus lower	all forage	all forage upper	all forage lower
RL	1.1	0	-7.3	0.7	15.2	-0.4	11.1	108.2	-6.2	1.7	41.1	-10.0	30.1	424.4	-2.1	0.1	110.2	0.0	326.1	7083.8	-67.6
RL	1.1	0	-10.6	0.8	17.0	-0.4	3.2	63.6	-7.6	1.7	40.8	-10.0	25.6	368.7	-2.5	0.2	242.1	0.0	259.3	5999.1	-72.2
RL	1.1	0	-8.7	1.6	27.7	-0.3	9.4	98.3	-6.5	0.9	38.2	-10.3	49.5	661.2	-0.5	0.3	531.1	0.0	434.8	9659.0	-61.2
RL	1.1	0	-4.0	1.4	25.2	-0.4	10.2	103.1	-6.4	1.4	39.9	-10.1	39.9	544.2	-1.3	0.4	563.7	0.0	865.7	18479.3	-38.9
RL	1.1	0	-7.3	0.7	15.1	-0.4	11.2	108.3	-6.2	1.7	41.1	-10.0	30.0	422.8	-2.1	0.1	110.9	0.0	324.9	7066.7	-67.7
RL	1.1	0	-10.6	0.8	16.9	-0.4	3.2	63.7	-7.6	1.6	40.8	-10.0	25.5	367.5	-2.5	0.2	243.2	0.0	258.7	5995.2	-72.2
RL	1.1	0	-8.8	1.6	27.6	-0.3	9.4	98.3	-6.5	0.9	38.2	-10.3	49.3	658.4	-0.6	0.3	531.7	0.0	433.6	9644.6	-61.3
RL	1.1	0	-4.1	1.4	25.2	-0.4	10.2	103.2	-6.4	1.4	39.9	-10.1	39.8	543.4	-1.3	0.4	564.9	0.0	865.7	18487.6	-39.0
RL	1.1	30	-9.0	1.5	27.0	-0.4	8.5	93.3	-6.7	1.5	40.4	-10.1	45.4	610.5	-0.9	0.3	431.5	0.0	464.1	10245.4	-60.2
RL	1.1	30	-4.2	1.3	24.4	-0.4	9.8	100.8	-6.5	2.0	42.1	-9.9	36.9	507.8	-1.6	0.3	497.8	0.0	908.5	19341.0	-37.2
RL	1.1	30	-7.2	0.7	15.5	-0.4	11.3	108.9	-6.2	1.3	39.7	-10.1	31.6	443.0	-2.0	0.1	117.3	0.0	320.7	6967.6	-67.7
RL	1.1	30	-10.4	0.8	17.5	-0.4	3.6	66.1	-7.6	1.4	39.9	-10.1	27.7	395.0	-2.3	0.2	276.4	0.0	255.7	5907.8	-72.1
RL	1.1	30	-9.3	1.5	26.1	-0.4	8.4	92.7	-6.7	1.4	39.9	-10.1	43.4	586.4	-1.0	0.3	428.6	0.0	444.8	9907.6	-61.4
RL	1.1	30	-4.6	1.3	23.8	-0.4	9.8	100.5	-6.5	1.9	41.7	-10.0	35.8	493.6	-1.7	0.3	497.3	0.0	882.3	18856.1	-38.7
RL	1.1	30	-7.3	0.7	15.4	-0.4	11.3	109.1	-6.2	1.3	39.6	-10.2	31.4	440.3	-2.0	0.1	118.0	0.0	318.6	6937.1	-67.8
RL	1.1	30	-10.4	0.8	17.5	-0.4	3.6	66.2	-7.6	1.4	39.8	-10.1	27.6	393.1	-2.3	0.2	277.7	0.0	254.7	5896.6	-72.2
RL	1.1	30	-9.4	1.4	25.9	-0.4	8.4	92.7	-6.7	1.3	39.8	-10.1	43.1	582.8	-1.1	0.3	429.0	0.0	442.8	9879.6	-61.6
RL	1.1	30	-4.7	1.3	23.8	-0.4	9.8	100.6	-6.5	1.9	41.7	-10.0	35.7	492.2	-1.7	0.3	498.4	0.0	881.3	18846.2	-38.8
RL	1.3	0	-10.1	1.3	24.0	-0.4	6.7	83.3	-7.0	2.2	42.7	-9.9	35.2	486.2	-1.7	0.2	293.0	0.0	478.9	10670.2	-60.6
RL	1.3	0	-6.0	1.1	21.7	-0.4	8.5	93.1	-6.7	2.6	43.9	-9.8	29.2	412.5	-2.2	0.2	375.1	0.0	909.6	19524.0	-38.5
RL	1.3	0	-9.2	0.5	12.5	-0.4	8.9	95.4	-6.6	2.8	44.6	-9.7	20.1	302.0	-2.9	0.0	69.6	0.0	312.0	7076.3	-70.0
RL	1.3	0	-12.1	0.5	13.4	-0.4	0.9	50.8	-8.1	2.9	45.3	-9.7	14.5	234.2	-3.4	0.1	117.3	0.0	269.6	6389.5	-72.9
RL	1.3	0	-10.8	1.1	21.6	-0.4	6.3	81.3	-7.1	1.7	41.1	-10.0	30.5	428.8	-2.1	0.2	283.2	0.0	416.3	9518.7	-64.4
RL	1.3	0	-7.1	1.0	19.8	-0.4	8.1	91.2	-6.8	2.1	42.4	-9.9	25.7	369.7	-2.5	0.2	364.8	0.0	802.5	17447.6	-44.6
RL	1.3	0	-9.6	0.4	11.9	-0.4	8.7	94.5	-6.7	2.5	43.8	-9.8	18.8	286.1	-3.1	0.0	69.1	0.0	291.7	6714.6	-71.3
RL	1.3	0	-12.3	0.5	12.8	-0.4	0.8	50.3	-8.1	2.7	44.6	-9.7	13.6	223.1	-3.5	0.1	116.4	0.0	255.1	6131.7	-73.8
RL	1.3	0	-11.1	1.1	20.6	-0.4	6.2	80.4	-7.1	1.5	40.5	-10.1	28.7	406.1	-2.2	0.2	278.5	0.0	392.0	9074.6	-65.9
RL	1.3	0	-7.6	0.9	18.9	-0.4	7.9	90.3	-6.8	1.9	41.8	-10.0	24.2	351.8	-2.6	0.2	359.6	0.0	758.0	16588.4	-47.1
RL	1.3	30	-10.6	1.2	22.7	-0.4	5.6	77.4	-7.2	2.9	45.0	-9.7	30.3	427.0	-2.1	0.1	224.4	0.0	513.1	11449.5	-59.5
RL	1.3	30	-6.9	1.0	20.4	-0.4	7.3	86.8	-6.9	3.2	46.0	-9.6	25.1	362.4	-2.5	0.2	291.2	0.0	975.3	20979.7	-36.1
RL	1.3	30	-8.9	0.5	12.9	-0.4	9.6	99.4	-6.5	2.3	43.1	-9.8	22.0	324.9	-2.8	0.0	81.3	0.0	300.5	6784.9	-70.2
RL	1.3	30	-11.9	0.6	13.8	-0.4	1.3	53.1	-8.0	2.6	43.9	-9.8	16.0	252.1	-3.3	0.1	136.5	0.0	259.0	6148.0	-73.3
RL	1.3	30	-11.3	1.0	20.3	-0.4	5.3	75.4	-7.3	2.4	43.2	-9.8	26.0	374.0	-2.5	0.1	216.5	0.0	442.7	10131.5	-63.6
RL	1.3	30	-8.0	0.9	18.5	-0.4	7.0	84.9	-7.0	2.7	44.4	-9.7	21.8	322.9	-2.8	0.2	282.7	0.0	854.2	18605.1	-42.8
RL	1.3	30	-9.3	0.4	12.2	-0.4	9.4	98.4	-6.5	2.1	42.2	-9.9	20.5	306.5	-2.9	0.0	80.6	0.0	279.4	6414.6	-71.6
RL	1.3	30	-12.1	0.5	13.2	-0.4	1.2	52.6	-8.0	2.3	43.2	-9.8	15.0	239.1	-3.4	0.1	135.2	0.0	243.7	5876.1	-74.3
RL	1.3	30	-11.5	1.0	19.3	-0.4	5.1	74.4	-7.3	2.1	42.5	-9.9	24.3	352.6	-2.6	0.1	212.6	0.0	414.7	9609.9	-65.3
RL	1.3	30	-8.4	0.8	17.7	-0.4	6.8	84.0	-7.0	2.5	43.7	-9.8	20.5	306.0	-2.9	0.2	278.2	0.0	802.7	17597.1	-45.6
RL	10	0	-10.2	1.3	23.9	-0.4	6.6	82.9	-7.0	2.2	42.8	-9.9	34.7	480.1	-1.8	0.2	287.7	0.0	478.4	10671.6	-60.7
RL	10	0	-6.5	1.1	21.0	-0.4	7.9	90.0	-6.8	2.8	44.8	-9.7	27.0	386.0	-2.4	0.2	332.7	0.0	932.9	20057.3	-37.8
RL	10	0	-9.5	0.4	12.1	-0.4	8.4	92.6	-6.7	2.9	45.2	-9.7	18.6	283.7	-3.1	0.0	63.0	0.0	311.8	7125.7	-70.3
RL	10	0	-12.0	0.5	13.6	-0.4	1.2	52.8	-8.0	2.5	43.8	-9.8	15.7	248.1	-3.3	0.1	135.1	0.0	253.9	6067.2	-73.7
RL	10	0	-10.9	1.1	21.2	-0.4	6.2	80.6	-7.1	1.7	41.0	-10.0	29.6	417.4	-2.2	0.2	276.5	0.0	408.6	9385.2	-64.9
RL	10	0	-7.7	0.9	18.9	-0.4	7.5	87.9	-6.9	2.3	43.1	-9.8	23.3	341.3	-2.7	0.2	321.9	0.0	809.1	17642.7	-44.7
RL	10	0	-9.9	0.4	11.4	-0.4	8.2	91.6	-6.8	2.6	44.2	-9.7	17.2	266.3	-3.2	0.0	62.3	0.0	288.0	6696.7	-71.8
RL	10	0	-12.2	0.5	13.0	-0.4	1.1	52.2	-8.0	2.3	43.0	-9.9	14.6	234.4	-3.4	0.1	133.6	0.0	237.5	5776.2	-74.7
RL	10	0	-11.2	1.0	20.1	-0.4	6.0	79.5	-7.1	1.5	40.2	-10.1	27.5	391.6	-2.3	0.2	270.9	0.0	380.2	8863.5	-66.6
RL	10	0	-8.2	0.9	18.0	-0.4	7.3	86.8	-6.9	2.1	42.3	-9.9	21.7	321.6	-2.8	0.2	316.1	0.0	754.7	16582.9	-47.8
RL	10	30	-10.6	1.2	22.8	-0.4	5.8	78.3	-7.2	2.8	44.6	-9.7	30.9	434.2	-2.1	0.1	234.3	0.0	503.9	11257.7	-59.9
RL	10	30	-7.2	1.0	20.0	-0.4	7.0	85.2	-7.0	3.3	46.5	-9.5	24.0	349.1	-2.6	0.2	273.2	0.0	985.7	21229.9	-35.9
RL	10	30	-9.3	0.4	12.3	-0.4	8.9	95.7	-6.6	2.6	44.0	-9.8	20.0	300.3	-3.0	0.0	71.3	0.0	301.9	6877.7	-70.6
RL	10	30	-11.8	0.6	14.0	-0.4	1.6	54.6	-7.9	2.2	42.8	-9.9	16.9	262.6	-3.2	0.1	151.8	0.0	246.8	5901.0	-73.9
RL	10	30	-11.3	1.0	20.2	-0.4	5.4	76.0	-7.2	2.2	42.6	-9.9	26.1	375.4	-2.5	0.1	224.9	0.0	427.7	9833.4	-64.4
RL	10	30	-8.3	0.9	18.0	-0.4	6.7	83.1	-7.0	2.8	44.7	-9.7	20.5	307.1	-2.9	0.2	263.9	0.0	849.8	18554.7	-43.3

Appendix Table A-3

Site	Salt Trmt	Lag	Farfantepenaeus lower	Cynoscion	Cynoscion upper	Cynoscion lower	Sfloridae	Sfloridae upper	Sfloridae lower	Atherinomorus	Atherinomorus upper	Atherinomorus lower	S.scovelli	S.scovelli upper	S.scovelli lower	Opsanus	Opsanus upper	Opsanus lower	all forage	all forage upper	all forage lower
RL	10	30	-9.7	0.4	11.7	-0.4	8.7	94.6	-6.7	2.3	43.0	-9.8	18.4	281.0	-3.1	0.0	70.4	0.0	277.6	6445.0	-72.1
RL	10	30	-12.1	0.5	13.3	-0.4	1.4	54.0	-8.0	2.0	42.0	-9.9	15.6	247.1	-3.3	0.1	149.8	0.0	229.6	5599.2	-75.0
RL	10	30	-11.6	0.9	19.1	-0.4	5.2	74.9	-7.3	1.9	41.7	-10.0	24.1	350.9	-2.6	0.1	220.0	0.0	396.3	9247.9	-66.3
RL	10	30	-8.8	0.8	17.1	-0.4	6.5	82.0	-7.1	2.5	43.8	-9.8	19.0	288.4	-3.0	0.2	258.8	0.0	789.4	17367.7	-46.6
RL	20	0	-11.4	1.1	20.9	-0.4	3.3	64.8	-7.6	4.9	52.1	-9.1	22.2	328.7	-2.8	0.1	116.8	0.0	671.0	14896.9	-52.7
RL	20	0	-8.7	0.9	18.3	-0.4	4.4	70.8	-7.4	5.7	54.4	-8.9	16.9	263.8	-3.2	0.1	135.8	0.0	1368.2	29482.8	-18.8
RL	20	0	-10.9	0.3	10.6	-0.4	4.8	73.1	-7.4	5.9	55.2	-8.8	11.4	196.1	-3.7	0.0	25.8	0.0	440.4	10069.9	-65.4
RL	20	0	-12.7	0.4	12.3	-0.4	-0.9	41.0	-8.4	5.5	53.9	-8.9	9.6	175.6	-3.8	0.0	55.6	0.0	378.6	8712.4	-67.8
RL	20	0	-11.6	1.0	20.0	-0.4	3.3	64.5	-7.6	4.8	51.4	-9.1	21.0	314.3	-2.9	0.1	116.9	0.0	643.4	14374.1	-54.2
RL	20	0	-9.0	0.8	17.7	-0.4	4.4	70.5	-7.4	5.5	53.9	-8.9	16.2	254.4	-3.3	0.1	135.7	0.0	1320.2	28521.7	-21.4
RL	20	0	-11.0	0.3	10.5	-0.4	4.8	73.1	-7.4	5.8	54.9	-8.8	11.2	193.8	-3.7	0.0	26.0	0.0	435.4	9977.1	-65.7
RL	20	0	-12.7	0.4	12.1	-0.4	-0.9	41.0	-8.4	5.4	53.8	-8.9	9.5	173.9	-3.8	0.0	55.9	0.0	375.9	8663.7	-67.9
RL	20	0	-11.7	1.0	19.8	-0.4	3.3	64.5	-7.6	4.7	51.3	-9.1	20.7	310.9	-2.9	0.1	117.1	0.0	638.2	14279.8	-54.5
RL	20	0	-9.1	0.8	17.6	-0.4	4.4	70.5	-7.4	5.5	53.8	-8.9	16.0	252.5	-3.3	0.1	136.0	0.0	1313.2	28386.6	-21.7
RL	20	30	-11.7	1.0	19.9	-0.4	2.6	60.9	-7.8	5.5	54.0	-8.9	19.4	295.5	-3.0	0.1	94.8	0.0	709.6	15812.3	-51.3
RL	20	30	-9.1	0.8	17.7	-0.4	3.7	67.0	-7.6	6.3	56.6	-8.7	15.1	241.4	-3.4	0.1	111.9	0.0	1477.7	31892.3	-14.0
RL	20	30	-10.6	0.3	11.0	-0.4	5.3	75.9	-7.3	5.6	54.1	-8.9	12.6	211.4	-3.6	0.0	29.3	0.0	430.7	9806.8	-65.6
RL	20	30	-12.5	0.5	12.6	-0.4	-0.7	42.6	-8.3	5.1	52.8	-9.0	10.6	186.8	-3.7	0.0	62.8	0.0	367.2	8446.5	-68.2
RL	20	30	-11.8	1.0	19.4	-0.4	2.6	60.8	-7.8	5.4	53.5	-8.9	18.7	286.7	-3.1	0.1	95.3	0.0	691.6	15471.0	-52.3
RL	20	30	-9.3	0.8	17.3	-0.4	3.7	66.9	-7.6	6.2	56.2	-8.7	14.6	235.3	-3.4	0.1	112.2	0.0	1443.6	31208.2	-15.8
RL	20	30	-10.6	0.3	10.9	-0.4	5.3	75.9	-7.3	5.5	54.0	-8.9	12.5	209.9	-3.6	0.0	29.4	0.0	427.8	9754.8	-65.7
RL	20	30	-12.6	0.5	12.5	-0.4	-0.6	42.6	-8.3	5.1	52.7	-9.0	10.5	185.6	-3.7	0.0	63.1	0.0	365.7	8419.5	-68.3
RL	20	30	-11.9	0.9	19.2	-0.4	2.6	60.9	-7.8	5.3	53.4	-9.0	18.6	284.7	-3.1	0.1	95.5	0.0	688.4	15413.3	-52.5
RL	20	30	-9.4	0.8	17.2	-0.4	3.7	67.0	-7.6	6.2	56.1	-8.7	14.5	234.2	-3.4	0.1	112.5	0.0	1440.1	31142.7	-16.0

Appendix Table A-4. Predictions for northeast scenarios for trawl/seine with 95% confidence intervals.

Site	Salt Trmt	Lag	Year	Month	Dayofyr	Salinity	Temper-ature	Depth	BB.Tt	BB.Hw	BB.Sf	Gear	Habitat	Anchoa	Anchoa upper	Anchoa lower	Floridichthys	Floridichthys upper	Floridichthys lower	Anarch-opterus	Anarch-opterus upper	Anarch-opterus lower	Lutjanus	Lutjanus upper	Lutjanus lower	Hippo-campus
TR	0.9	0	1	7	196	7.3124	31.885	0.8	2.2	1.8	0.0	trawl	bas	18	577	0	159	5341	3	7	71	0	0	8	0	14
TR	0.9	0	1	10	288	2.5849	27.704	0.8	2.0	1.6	0.0	trawl	bas	36	1136	1	173	5851	3	6	58	0	0	8	0	9
TR	0.9	0	3	1	15	6.9428	22.35	0.8	1.8	1.3	0.0	trawl	bas	25	794	0	68	2321	0	5	52	0	0	7	0	8
TR	0.9	0	3	5	135	20.324	29.281	0.8	2.0	1.5	0.0	trawl	bas	9	275	0	41	1398	-1	6	62	0	0	9	0	12
TR	0.9	0	3	7	196	7.3124	31.885	0.8	2.2	1.8	0.0	trawl	bas	18	583	0	158	5332	3	7	72	0	0	8	0	15
TR	0.9	0	3	10	288	2.5849	27.704	0.8	2.0	1.7	0.0	trawl	bas	37	1145	1	173	5847	3	6	58	0	0	8	0	9
TR	0.9	0	5	1	15	6.9428	22.35	0.8	1.8	1.4	0.0	trawl	bas	25	797	0	68	2321	0	5	52	0	0	7	0	8
TR	0.9	0	5	5	135	20.324	29.281	0.8	2.0	1.5	0.0	trawl	bas	9	277	0	41	1398	-1	6	62	0	0	9	0	12
TR	0.9	0	5	7	196	7.3124	31.885	0.8	2.2	1.9	0.0	trawl	bas	19	586	0	158	5328	3	7	72	0	0	8	0	15
TR	0.9	0	5	10	288	2.5849	27.704	0.8	2.0	1.7	0.0	trawl	bas	37	1149	1	173	5846	3	6	58	0	0	8	0	9
TR	0.9	30	1	7	196	13.561	31.885	0.8	2.2	1.8	0.0	trawl	bas	13	397	0	117	3920	2	7	68	0	0	10	0	16
TR	0.9	30	1	10	288	5.8475	27.704	0.8	2.0	1.7	0.0	trawl	bas	30	933	0	148	4971	3	5	56	0	0	9	0	10
TR	0.9	30	3	1	15	5.865	22.35	0.8	1.8	1.3	0.0	trawl	bas	27	848	0	72	2451	0	5	52	0	0	7	0	7
TR	0.9	30	3	5	135	13.602	29.281	0.8	2.0	1.6	0.0	trawl	bas	13	420	0	57	1943	0	6	65	0	0	8	0	10
TR	0.9	30	3	7	196	13.561	31.885	0.8	2.2	1.9	0.0	trawl	bas	13	402	0	116	3913	2	7	68	0	0	10	0	16
TR	0.9	30	3	10	288	5.8475	27.704	0.8	2.0	1.7	0.0	trawl	bas	30	940	0	148	4968	3	5	56	0	0	9	0	10
TR	0.9	30	5	1	15	5.865	22.35	0.8	1.8	1.3	0.0	trawl	bas	27	852	0	72	2451	0	5	52	0	0	7	0	7
TR	0.9	30	5	5	135	13.602	29.281	0.8	2.0	1.6	0.0	trawl	bas	13	422	0	57	1942	0	6	65	0	0	8	0	10
TR	0.9	30	5	7	196	13.561	31.885	0.8	2.2	1.9	0.0	trawl	bas	13	404	0	116	3909	2	7	69	0	0	10	0	16
TR	0.9	30	5	10	288	5.8475	27.704	0.8	2.0	1.7	0.0	trawl	bas	30	944	1	148	4966	2	5	56	0	0	9	0	10
TR	1	0	1	7	196	8.1249	31.885	0.8	2.2	1.8	0.0	trawl	bas	17	545	0	153	5139	3	7	71	0	0	8	0	15
TR	1	0	1	10	288	2.8721	27.704	0.8	2.0	1.6	0.0	trawl	bas	35	1109	1	171	5773	3	6	57	0	0	8	0	9
TR	1	0	3	1	15	7.7143	22.35	0.8	1.8	1.3	0.0	trawl	bas	24	751	0	65	2235	0	5	52	0	0	7	0	8
TR	1	0	3	5	135	22.582	29.281	0.8	2.1	1.5	0.0	trawl	bas	7	237	0	36	1257	-1	6	61	0	0	10	0	12
TR	1	0	3	7	196	8.1249	31.885	0.8	2.2	1.8	0.0	trawl	bas	17	545	0	153	5139	3	7	71	0	0	8	0	15
TR	1	0	3	10	288	2.8721	27.704	0.8	2.0	1.6	0.0	trawl	bas	35	1109	1	171	5773	3	6	57	0	0	8	0	9
TR	1	0	5	1	15	7.7143	22.35	0.8	1.8	1.3	0.0	trawl	bas	24	751	0	65	2235	0	5	52	0	0	7	0	8
TR	1	0	5	5	135	22.582	29.281	0.8	2.1	1.5	0.0	trawl	bas	7	237	0	36	1257	-1	6	61	0	0	10	0	12
TR	1	0	5	7	196	8.1249	31.885	0.8	2.2	1.8	0.0	trawl	bas	17	545	0	153	5139	3	7	71	0	0	8	0	15
TR	1	0	5	10	288	2.8721	27.704	0.8	2.0	1.6	0.0	trawl	bas	35	1109	1	171	5772	3	6	57	0	0	8	0	9
TR	1	30	1	7	196	15.068	31.885	0.8	2.2	1.8	0.0	trawl	bas	11	359	0	108	3648	1	7	67	0	0	10	0	17
TR	1	30	1	10	288	6.4973	27.704	0.8	2.1	1.6	0.0	trawl	bas	29	890	0	143	4818	2	5	56	0	0	9	0	10
TR	1	30	3	1	15	6.5166	22.35	0.8	1.8	1.3	0.0	trawl	bas	26	807	0	69	2374	0	5	52	0	0	7	0	7
TR	1	30	3	5	135	15.114	29.281	0.8	2.0	1.5	0.0	trawl	bas	12	378	0	53	1806	0	6	64	0	0	8	0	11
TR	1	30	3	7	196	15.068	31.885	0.8	2.2	1.8	0.0	trawl	bas	11	359	0	109	3649	1	7	67	0	0	10	0	17
TR	1	30	3	10	288	6.4973	27.704	0.8	2.1	1.6	0.0	trawl	bas	28	889	0	143	4819	2	5	56	0	0	9	0	10
TR	1	30	5	1	15	6.5166	22.35	0.8	1.8	1.3	0.0	trawl	bas	26	806	0	69	2374	0	5	52	0	0	7	0	7
TR	1	30	5	5	135	15.114	29.281	0.8	2.0	1.5	0.0	trawl	bas	12	378	0	53	1806	0	6	64	0	0	8	0	11
TR	1	30	5	7	196	15.068	31.885	0.8	2.2	1.8	0.0	trawl	bas	11	358	0	109	3649	1	7	67	0	0	10	0	17
TR	1	30	5	10	288	6.4973	27.704	0.8	2.1	1.6	0.0	trawl	bas	28	889	0	143	4819	2	5	56	0	0	9	0	10
TR	1.1	0	1	7	196	8.9374	31.885	0.8	2.3	1.7	0.0	trawl	bas	16	513	0	147	4946	2	7	70	0	0	8	0	15
TR	1.1	0	1	10	288	3.1594	27.704	0.8	2.1	1.6	0.0	trawl	bas	35	1082	1	169	5696	3	6	57	0	0	8	0	9
TR	1.1	0	3	1	15	8.4857	22.35	0.8	1.9	1.3	0.0	trawl	bas	23	709	0	63	2153	0	5	51	0	0	7	0	8
TR	1.1	0	3	5	135	24.84	29.281	0.8	2.1	1.4	0.0	trawl	bas	6	205	0	33	1141	-1	6	59	0	0	10	0	13
TR	1.1	0	3	7	196	8.9374	31.885	0.8	2.3	1.7	0.0	trawl	bas	16	508	0	147	4957	3	7	70	0	0	8	0	15
TR	1.1	0	3	10	288	3.1594	27.704	0.8	2.1	1.6	0.0	trawl	bas	34	1072	1	169	5702	3	6	57	0	0	8	0	9
TR	1.1	0	5	1	15	8.4857	22.35	0.8	1.9	1.3	0.0	trawl	bas	23	706	0	63	2153	0	5	51	0	0	7	0	8
TR	1.1	0	5	5	135	24.84	29.281	0.8	2.1	1.4	0.0	trawl	bas	6	204	0	33	1142	-1	6	59	0	0	10	0	13
TR	1.1	0	5	7	196	8.9374	31.885	0.8	2.3	1.7	0.0	trawl	bas	16	505	0	148	4962	3	7	70	0	0	8	0	15
TR	1.1	0	5	10	288	3.1594	27.704	0.8	2.1	1.6	0.0	trawl	bas	34	1068	1	169	5705	3	6	57	0	0	8	0	9
TR	1.1	30	1	7	196	16.574	31.885	0.8	2.3	1.7	0.0	trawl	bas	10	324	0	101	3395	1	7	67	0	0	10	0	17
TR	1.1	30	1	10	288	7.147	27.704	0.8	2.1	1.6	0.0	trawl	bas	27	849	0	139	4671	2	5	56	0	0	9	0	10
TR	1.1	30	3	1	15	7.1683	22.35	0.8	1.9	1.3	0.0	trawl	bas	24	766	0	67	2301	0	5	52	0	0	7	0	8
TR	1.1	30	3	5	135	16.625	29.281	0.8	2.0	1.5	0.0	trawl	bas	11	339	0	49	1681	0	6	63	0	0	8	0	11
TR	1.1	30	3	7	196	16.574	31.885	0.8	2.3	1.7	0.0	trawl	bas	10	320	0	101	3405	1	7	66	0	0	10	0	17

Appendix Table A-4. Predictions for northeast scenarios for trawl/seine with 95% confidence intervals.

Site	Salt Trmt	Lag	Year	Month	Dayofyr	Salinity	Temper-ature	Depth	BB.Tt	BB.Hw	BB.Sf	Gear	Habitat	Anchoa	Anchoa upper	Anchoa lower	Floridichthys	Floridichthys upper	Floridichthys lower	Anarch-opterus	Anarch-opterus upper	Anarch-opterus lower	Lutjanus	Lutjanus upper	Lutjanus lower	Hippo-campus
TR	1.1	30	3	10	288	7.147	27.704	0.8	2.1	1.6	0.0	trawl	bas	27	839	0	139	4677	2	5	56	0	0	9	0	10
TR	1.1	30	5	1	15	7.1683	22.35	0.8	1.9	1.2	0.0	trawl	bas	24	761	0	67	2301	0	5	52	0	0	7	0	8
TR	1.1	30	5	5	135	16.625	29.281	0.8	2.0	1.4	0.0	trawl	bas	11	337	0	49	1682	0	6	63	0	0	8	0	11
TR	1.1	30	5	7	196	16.574	31.885	0.8	2.3	1.7	0.0	trawl	bas	10	317	0	101	3410	1	7	66	0	0	10	0	17
TR	1.1	30	5	10	288	7.147	27.704	0.8	2.1	1.5	0.0	trawl	bas	27	834	0	139	4680	2	5	55	0	0	9	0	10
TR	1.3	0	1	7	196	10.562	31.885	0.8	2.3	1.6	0.0	trawl	bas	14	456	0	136	4584	2	7	69	0	0	9	0	15
TR	1.3	0	1	10	288	3.7338	27.704	0.8	2.1	1.5	0.0	trawl	bas	33	1025	1	165	5551	3	6	57	0	0	8	0	9
TR	1.3	0	3	1	15	10.029	22.35	0.8	1.9	1.2	0.0	trawl	bas	20	630	0	58	2000	0	5	51	0	0	7	0	8
TR	1.3	0	3	5	135	29.356	29.281	0.8	2.1	1.3	0.0	trawl	bas	5	158	0	29	1008	-1	5	56	0	1	11	0	13
TR	1.3	0	3	7	196	10.562	31.885	0.8	2.3	1.5	0.0	trawl	bas	14	438	0	138	4622	2	7	68	0	0	9	0	15
TR	1.3	0	3	10	288	3.7338	27.704	0.8	2.1	1.4	0.0	trawl	bas	32	992	1	166	5579	3	5	56	0	0	8	0	9
TR	1.3	0	5	1	15	10.029	22.35	0.8	1.9	1.1	0.0	trawl	bas	20	618	0	59	2004	0	5	51	0	0	7	0	8
TR	1.3	0	5	5	135	29.356	29.281	0.8	2.1	1.2	0.0	trawl	bas	5	156	0	29	1012	-1	5	55	0	1	11	0	13
TR	1.3	0	5	7	196	10.562	31.885	0.8	2.3	1.4	0.0	trawl	bas	14	430	0	138	4642	2	7	68	0	0	8	0	15
TR	1.3	0	5	10	288	3.7338	27.704	0.8	2.1	1.3	0.0	trawl	bas	31	976	1	166	5595	3	5	56	0	0	8	0	9
TR	1.3	30	1	7	196	19.588	31.885	0.8	2.3	1.6	0.0	trawl	bas	8	265	0	87	2944	1	6	65	0	1	11	0	18
TR	1.3	30	1	10	288	8.4464	27.704	0.8	2.1	1.5	0.0	trawl	bas	25	768	0	131	4394	2	5	55	0	0	9	0	10
TR	1.3	30	3	1	15	8.4716	22.35	0.8	1.9	1.2	0.0	trawl	bas	22	688	0	63	2163	0	5	51	0	0	7	0	8
TR	1.3	30	3	5	135	19.648	29.281	0.8	2.1	1.3	0.0	trawl	bas	8	272	0	42	1460	-1	6	61	0	0	9	0	11
TR	1.3	30	3	7	196	19.588	31.885	0.8	2.3	1.4	0.0	trawl	bas	8	252	0	88	2974	1	6	64	0	1	11	0	18
TR	1.3	30	3	10	288	8.4464	27.704	0.8	2.1	1.4	0.0	trawl	bas	24	739	0	132	4421	2	5	55	0	0	9	0	10
TR	1.3	30	5	1	15	8.4716	22.35	0.8	1.9	1.1	0.0	trawl	bas	21	673	0	63	2169	0	5	51	0	0	7	0	8
TR	1.3	30	5	5	135	19.648	29.281	0.8	2.1	1.2	0.0	trawl	bas	8	265	0	43	1466	-1	6	61	0	0	9	0	11
TR	1.3	30	5	7	196	19.588	31.885	0.8	2.3	1.3	0.0	trawl	bas	8	246	0	89	2990	1	6	64	0	1	10	0	18
TR	1.3	30	5	10	288	8.4464	27.704	0.8	2.2	1.3	0.0	trawl	bas	23	724	0	132	4439	2	5	54	0	0	9	0	10
TR	10	0	1	7	196	18.125	31.885	0.8	2.3	1.4	0.0	trawl	bas	9	276	0	95	3194	1	6	65	0	0	10	0	17
TR	10	0	1	10	288	12.872	27.704	0.8	2.1	1.3	0.0	trawl	bas	18	556	0	106	3570	1	5	53	0	0	10	0	11
TR	10	0	3	1	15	17.714	22.35	0.8	2.0	0.8	0.0	trawl	bas	11	362	0	40	1394	-1	4	47	0	0	8	0	9
TR	10	0	3	5	135	32.582	29.281	0.8	2.2	0.8	0.0	trawl	bas	4	129	0	29	1033	-1	5	50	0	1	10	0	12
TR	10	0	3	7	196	18.125	31.885	0.8	2.4	0.8	0.0	trawl	bas	8	244	0	98	3292	1	6	62	0	0	9	0	17
TR	10	0	3	10	288	12.872	27.704	0.8	2.2	0.8	0.0	trawl	bas	16	498	0	109	3661	1	5	51	0	0	9	0	11
TR	10	0	5	1	15	17.714	22.35	0.8	2.0	0.5	0.0	trawl	bas	11	340	0	41	1414	-1	4	46	0	0	8	0	9
TR	10	0	5	5	135	32.582	29.281	0.8	2.2	0.5	0.0	trawl	bas	4	121	0	30	1048	-1	5	49	0	0	10	0	12
TR	10	0	5	7	196	18.125	31.885	0.8	2.4	0.5	0.0	trawl	bas	7	229	0	100	3349	1	6	61	0	0	9	0	16
TR	10	0	5	10	288	12.872	27.704	0.8	2.2	0.5	0.0	trawl	bas	15	470	0	111	3718	1	5	50	0	0	9	0	10
TR	10	30	1	7	196	25.068	31.885	0.8	2.3	1.5	0.0	trawl	bas	6	184	0	68	2308	0	6	62	0	1	12	0	20
TR	10	30	1	10	288	16.497	27.704	0.8	2.1	1.3	0.0	trawl	bas	14	445	0	89	2993	1	5	51	0	1	11	0	12
TR	10	30	3	1	15	16.517	22.35	0.8	2.0	0.8	0.0	trawl	bas	12	387	0	43	1480	-1	4	47	0	0	8	0	9
TR	10	30	3	5	135	25.114	29.281	0.8	2.1	0.8	0.0	trawl	bas	5	176	0	33	1163	-1	6	57	0	0	9	0	12
TR	10	30	3	7	196	25.068	31.885	0.8	2.4	0.8	0.0	trawl	bas	5	161	0	71	2383	0	6	59	0	1	11	0	19
TR	10	30	3	10	288	16.497	27.704	0.8	2.2	0.7	0.0	trawl	bas	13	397	0	91	3071	1	5	50	0	0	10	0	11
TR	10	30	5	1	15	16.517	22.35	0.8	2.0	0.4	0.0	trawl	bas	11	363	0	44	1502	-1	4	47	0	0	8	0	9
TR	10	30	5	5	135	25.114	29.281	0.8	2.2	0.4	0.0	trawl	bas	5	165	0	34	1182	-1	5	56	0	0	9	0	12
TR	10	30	5	7	196	25.068	31.885	0.8	2.4	0.5	0.0	trawl	bas	4	151	0	72	2425	0	6	58	0	1	10	0	18
TR	10	30	5	10	288	16.497	27.704	0.8	2.2	0.4	0.0	trawl	bas	12	375	0	93	3119	1	5	49	0	0	10	0	11
TR	20	0	1	7	196	28.125	31.885	0.8	2.3	1.2	0.0	trawl	bas	4	149	0	63	2121	0	6	58	0	1	12	0	20
TR	20	0	1	10	288	22.872	27.704	0.8	2.2	1.0	0.0	trawl	bas	9	286	0	66	2230	0	5	48	0	1	12	0	13
TR	20	0	3	1	15	27.714	22.35	0.8	2.0	0.4	0.0	trawl	bas	6	190	0	26	922	-1	4	42	0	0	10	0	11
TR	20	0	3	5	135	42.582	29.281	0.8	2.2	0.3	0.0	trawl	bas	3	111	0	49	1678	0	3	33	-1	0	10	0	9
TR	20	0	3	7	196	28.125	31.885	0.8	2.4	0.3	0.0	trawl	bas	4	127	0	65	2213	0	5	56	0	1	11	0	19
TR	20	0	3	10	288	22.872	27.704	0.8	2.2	0.3	0.0	trawl	bas	8	250	0	68	2308	0	4	46	0	1	11	0	13
TR	20	0	5	1	15	27.714	22.35	0.8	2.0	0.1	0.0	trawl	bas	5	181	0	26	935	-1	4	42	0	0	10	0	11
TR	20	0	5	5	135	42.582	29.281	0.8	2.2	0.1	0.0	trawl	bas	3	106	0	50	1699	0	3	33	-1	0	9	0	9
TR	20	0	5	7	196	28.125	31.885	0.8	2.4	0.1	0.0	trawl	bas	3	121	0	66	2241	0	5	55	0	1	11	0	19
TR	20	0	5	10	288	22.872	27.704	0.8	2.2	0.1	0.0	trawl	bas	7	241	0	69	2331	0	4	46	0	1	11	0	12

Appendix Table A-4. Predictions for northeast scenarios for trawl/seine with 95% confidence intervals.

Site	Salt Trmt	Lag	Year	Month	Dayofyr	Salinity	Temper-ature	Depth	BB.Tt	BB.Hw	BB.Sf	Gear	Habitat	Anchoa	Anchoa upper	Anchoa lower	Floridichthys	Floridichthys upper	Floridichthys lower	Anarch-opterus	Anarch-opterus upper	Anarch-opterus lower	Lutjanus	Lutjanus upper	Lutjanus lower	Hippo-campus
TR	20	30	1	7	196	35.068	31.885	0.8	2.3	1.2	0.0	trawl	bas	4	122	0	66	2220	0	5	49	0	1	13	0	19
TR	20	30	1	10	288	26.497	27.704	0.8	2.2	1.0	0.0	trawl	bas	7	234	0	57	1926	0	4	47	0	1	13	0	14
TR	20	30	3	1	15	26.517	22.35	0.8	2.0	0.4	0.0	trawl	bas	6	202	0	27	956	-1	4	43	0	0	10	0	11
TR	20	30	3	5	135	35.114	29.281	0.8	2.2	0.3	0.0	trawl	bas	3	114	0	33	1131	-1	4	45	0	0	10	0	12
TR	20	30	3	7	196	35.068	31.885	0.8	2.4	0.3	0.0	trawl	bas	3	103	0	69	2318	0	4	47	0	1	12	0	18
TR	20	30	3	10	288	26.497	27.704	0.8	2.2	0.3	0.0	trawl	bas	6	204	0	59	1994	0	4	45	0	1	12	0	13
TR	20	30	5	1	15	26.517	22.35	0.8	2.0	0.1	0.0	trawl	bas	6	191	0	27	969	-1	4	42	0	0	9	0	11
TR	20	30	5	5	135	35.114	29.281	0.8	2.2	0.1	0.0	trawl	bas	3	109	0	33	1146	-1	4	45	0	0	10	0	11
TR	20	30	5	7	196	35.068	31.885	0.8	2.4	0.1	0.0	trawl	bas	3	99	0	69	2347	0	4	46	0	1	11	0	17
TR	20	30	5	10	288	26.497	27.704	0.8	2.2	0.1	0.0	trawl	bas	6	197	0	59	2014	0	4	44	0	1	12	0	13
TC	0.9	0	1	7	196	10.276	31.059	0.8	2.1	1.1	0.0	trawl	bas	14	429	0	117	3947	2	6	64	0	0	8	0	14
TC	0.9	0	1	10	288	3.7509	26.941	0.8	2.0	1.1	0.0	trawl	bas	31	974	1	142	4795	2	5	54	0	0	8	0	8
TC	0.9	0	3	1	15	12.64	21.542	0.8	1.8	0.9	0.0	trawl	bas	18	558	0	45	1554	-1	5	48	0	0	7	0	8
TC	0.9	0	3	5	135	24.629	28.484	0.8	1.9	0.9	0.0	trawl	bas	6	197	0	28	987	-1	5	56	0	0	9	0	12
TC	0.9	0	3	7	196	10.276	31.059	0.8	2.1	1.2	0.0	trawl	bas	14	434	0	117	3933	2	6	65	0	0	8	0	14
TC	0.9	0	3	10	288	3.7509	26.941	0.8	2.0	1.2	0.0	trawl	bas	32	987	1	142	4782	2	5	54	0	0	8	0	9
TC	0.9	0	5	1	15	12.64	21.542	0.8	1.8	1.0	0.0	trawl	bas	18	564	0	45	1551	-1	5	48	0	0	7	0	8
TC	0.9	0	5	5	135	24.629	28.484	0.8	1.9	1.0	0.0	trawl	bas	6	199	0	28	986	-1	5	56	0	0	9	0	12
TC	0.9	0	5	7	196	10.276	31.059	0.8	2.1	1.2	0.0	trawl	bas	14	440	0	117	3923	2	6	65	0	0	8	0	14
TC	0.9	0	5	10	288	3.7509	26.941	0.8	2.0	1.2	0.0	trawl	bas	32	998	1	142	4772	2	5	54	0	0	8	0	9
TC	0.9	30	1	7	196	18.386	31.059	0.8	2.1	1.1	0.0	trawl	bas	8	261	0	79	2650	0	6	61	0	0	9	0	16
TC	0.9	30	1	10	288	7.0545	26.941	0.8	2.0	1.1	0.0	trawl	bas	25	791	0	121	4069	2	5	52	0	0	8	0	9
TC	0.9	30	3	1	15	10.225	21.542	0.8	1.8	0.9	0.0	trawl	bas	20	637	0	51	1757	0	5	48	0	0	7	0	7
TC	0.9	30	3	5	135	21.16	28.484	0.8	1.9	0.9	0.0	trawl	bas	7	240	0	33	1161	-1	6	57	0	0	8	0	11
TC	0.9	30	3	7	196	18.386	31.059	0.8	2.1	1.1	0.0	trawl	bas	8	261	0	79	2652	0	6	61	0	0	9	0	16
TC	0.9	30	3	10	288	7.0545	26.941	0.8	2.0	1.1	0.0	trawl	bas	25	789	0	121	4071	2	5	52	0	0	8	0	9
TC	0.9	30	5	1	15	10.225	21.542	0.8	1.8	0.9	0.0	trawl	bas	20	636	0	51	1757	0	5	48	0	0	7	0	7
TC	0.9	30	5	5	135	21.16	28.484	0.8	1.9	0.9	0.0	trawl	bas	7	240	0	33	1162	-1	6	57	0	0	8	0	11
TC	0.9	30	5	7	196	18.386	31.059	0.8	2.1	1.1	0.0	trawl	bas	8	260	0	79	2653	0	6	61	0	0	9	0	16
TC	0.9	30	5	10	288	7.0545	26.941	0.8	2.0	1.1	0.0	trawl	bas	25	788	0	121	4073	2	5	52	0	0	8	0	9
TC	1	0	1	7	196	11.418	31.059	0.8	2.1	1.1	0.0	trawl	bas	12	396	0	111	3738	1	6	64	0	0	8	0	14
TC	1	0	1	10	288	4.1676	26.941	0.8	2.0	1.0	0.0	trawl	bas	30	937	0	140	4710	2	5	53	0	0	8	0	9
TC	1	0	3	1	15	14.044	21.542	0.8	1.8	0.8	0.0	trawl	bas	16	501	0	42	1457	-1	4	47	0	0	7	0	8
TC	1	0	3	5	135	27.365	28.484	0.8	1.9	0.8	0.0	trawl	bas	5	166	0	26	902	-1	5	54	0	0	10	0	12
TC	1	0	3	7	196	11.418	31.059	0.8	2.1	1.0	0.0	trawl	bas	12	391	0	112	3749	1	6	64	0	0	8	0	14
TC	1	0	3	10	288	4.1676	26.941	0.8	2.0	1.0	0.0	trawl	bas	30	927	0	140	4722	2	5	53	0	0	8	0	8
TC	1	0	5	1	15	14.044	21.542	0.8	1.8	0.8	0.0	trawl	bas	16	497	0	42	1459	-1	4	47	0	0	7	0	8
TC	1	0	5	5	135	27.365	28.484	0.8	1.9	0.8	0.0	trawl	bas	5	165	0	26	904	-1	5	53	0	0	9	0	12
TC	1	0	5	7	196	11.418	31.059	0.8	2.1	0.9	0.0	trawl	bas	12	387	0	112	3758	1	6	63	0	0	8	0	14
TC	1	0	5	10	288	4.1676	26.941	0.8	2.0	0.9	0.0	trawl	bas	29	918	0	140	4732	2	5	53	0	0	8	0	8
TC	1	30	1	7	196	20.428	31.059	0.8	2.1	1.0	0.0	trawl	bas	7	229	0	71	2404	0	6	60	0	0	10	0	17
TC	1	30	1	10	288	7.8383	26.941	0.8	2.0	1.0	0.0	trawl	bas	24	744	0	117	3926	2	5	52	0	0	8	0	9
TC	1	30	3	1	15	11.362	21.542	0.8	1.8	0.8	0.0	trawl	bas	19	582	0	49	1669	0	5	48	0	0	7	0	8
TC	1	30	3	5	135	23.511	28.484	0.8	1.9	0.8	0.0	trawl	bas	6	204	0	30	1045	-1	5	56	0	0	9	0	11
TC	1	30	3	7	196	20.428	31.059	0.8	2.1	0.9	0.0	trawl	bas	7	222	0	72	2421	0	6	59	0	0	10	0	17
TC	1	30	3	10	288	7.8383	26.941	0.8	2.0	0.9	0.0	trawl	bas	23	725	0	117	3951	2	5	52	0	0	8	0	9
TC	1	30	5	1	15	11.362	21.542	0.8	1.8	0.7	0.0	trawl	bas	18	571	0	49	1676	0	4	48	0	0	7	0	8
TC	1	30	5	5	135	23.511	28.484	0.8	1.9	0.7	0.0	trawl	bas	6	200	0	30	1050	-1	5	55	0	0	9	0	11
TC	1	30	5	7	196	20.428	31.059	0.8	2.1	0.8	0.0	trawl	bas	7	218	0	72	2434	0	6	59	0	0	10	0	17
TC	1	30	5	10	288	7.8383	26.941	0.8	2.0	0.8	0.0	trawl	bas	23	710	0	118	3972	2	5	51	0	0	8	0	9
TC	1.1	0	1	7	196	12.56	31.059	0.8	2.1	1.0	0.0	trawl	bas	12	366	0	105	3541	1	6	63	0	0	8	0	15
TC	1.1	0	1	10	288	4.5844	26.941	0.8	2.0	1.0	0.0	trawl	bas	29	903	0	137	4626	2	5	53	0	0	8	0	9
TC	1.1	0	3	1	15	15.449	21.542	0.8	1.8	0.7	0.0	trawl	bas	14	452	0	40	1366	-1	4	46	0	0	8	0	8
TC	1.1	0	3	5	135	30.102	28.484	0.8	1.9	0.7	0.0	trawl	bas	4	144	0	24	862	-1	5	51	0	0	10	0	12
TC	1.1	0	3	7	196	12.56	31.059	0.8	2.1	0.8	0.0	trawl	bas	11	354	0	106	3571	1	6	62	0	0	8	0	14

Appendix Table A-4. Predictions for northeast scenarios for trawl/seine with 95% confidence intervals.

Site	Salt Trmt	Lag	Year	Month	Dayofyr	Salinity	Temper-ature	Depth	BB.Tt	BB.Hw	BB.Sf	Gear	Habitat	Anchoa	Anchoa upper	Anchoa lower	Floridichthys	Floridichthys upper	Floridichthys lower	Anarch-opterus	Anarch-opterus upper	Anarch-opterus lower	Lutjanus	Lutjanus upper	Lutjanus lower	Hippo-campus
TC	1.1	0	3	10	288	4.5844	26.941	0.8	2.0	0.8	0.0	trawl	bas	28	874	0	138	4662	2	5	52	0	0	7	0	8
TC	1.1	0	5	1	15	15.449	21.542	0.8	1.8	0.6	0.0	trawl	bas	14	441	0	40	1373	-1	4	46	0	0	7	0	8
TC	1.1	0	5	5	135	30.102	28.484	0.8	1.9	0.6	0.0	trawl	bas	4	141	0	24	866	-1	5	51	0	0	10	0	12
TC	1.1	0	5	7	196	12.56	31.059	0.8	2.1	0.7	0.0	trawl	bas	11	345	0	107	3594	1	6	62	0	0	8	0	14
TC	1.1	0	5	10	288	4.5844	26.941	0.8	2.0	0.7	0.0	trawl	bas	27	853	0	139	4691	2	5	52	0	0	7	0	8
TC	1.1	30	1	7	196	22.471	31.059	0.8	2.1	1.0	0.0	trawl	bas	6	201	0	65	2184	0	6	59	0	1	10	0	17
TC	1.1	30	1	10	288	8.6221	26.941	0.8	2.0	1.0	0.0	trawl	bas	22	701	0	113	3788	1	5	51	0	0	8	0	9
TC	1.1	30	3	1	15	12.498	21.542	0.8	1.8	0.7	0.0	trawl	bas	17	533	0	46	1585	-1	4	47	0	0	7	0	8
TC	1.1	30	3	5	135	25.862	28.484	0.8	1.9	0.7	0.0	trawl	bas	5	175	0	27	955	-1	5	54	0	0	9	0	12
TC	1.1	30	3	7	196	22.471	31.059	0.8	2.1	0.7	0.0	trawl	bas	6	191	0	65	2211	0	6	58	0	0	10	0	17
TC	1.1	30	3	10	288	8.6221	26.941	0.8	2.0	0.7	0.0	trawl	bas	21	670	0	114	3831	2	5	51	0	0	8	0	9
TC	1.1	30	5	1	15	12.498	21.542	0.8	1.8	0.5	0.0	trawl	bas	16	517	0	46	1597	-1	4	47	0	0	7	0	8
TC	1.1	30	5	5	135	25.862	28.484	0.8	1.9	0.5	0.0	trawl	bas	5	170	0	27	962	-1	5	54	0	0	9	0	11
TC	1.1	30	5	7	196	22.471	31.059	0.8	2.1	0.6	0.0	trawl	bas	6	185	0	66	2230	0	6	57	0	0	10	0	17
TC	1.1	30	5	10	288	8.6221	26.941	0.8	2.0	0.6	0.0	trawl	bas	21	648	0	115	3864	2	5	50	0	0	8	0	9
TC	1.3	0	1	7	196	14.844	31.059	0.8	2.1	0.9	0.0	trawl	bas	10	314	0	94	3176	1	6	62	0	0	8	0	15
TC	1.3	0	1	10	288	5.4179	26.941	0.8	2.0	0.9	0.0	trawl	bas	27	841	0	132	4459	2	5	52	0	0	8	0	9
TC	1.3	0	3	1	15	18.257	21.542	0.8	1.8	0.6	0.0	trawl	bas	12	370	0	35	1199	-1	4	45	0	0	8	0	9
TC	1.3	0	3	5	135	35.575	28.484	0.8	1.9	0.5	0.0	trawl	bas	4	123	0	27	958	-1	4	43	0	0	10	0	11
TC	1.3	0	3	7	196	14.844	31.059	0.8	2.1	0.6	0.0	trawl	bas	9	295	0	96	3228	1	6	61	0	0	8	0	15
TC	1.3	0	3	10	288	5.4179	26.941	0.8	2.0	0.6	0.0	trawl	bas	25	794	0	134	4527	2	5	51	0	0	7	0	8
TC	1.3	0	5	1	15	18.257	21.542	0.8	1.8	0.4	0.0	trawl	bas	11	356	0	35	1211	-1	4	45	0	0	8	0	9
TC	1.3	0	5	5	135	35.575	28.484	0.8	1.9	0.3	0.0	trawl	bas	3	119	0	28	967	-1	4	43	0	0	10	0	11
TC	1.3	0	5	7	196	14.844	31.059	0.8	2.1	0.4	0.0	trawl	bas	9	284	0	97	3262	1	6	60	0	0	8	0	15
TC	1.3	0	5	10	288	5.4179	26.941	0.8	2.0	0.4	0.0	trawl	bas	24	765	0	136	4572	2	5	51	0	0	7	0	8
TC	1.3	30	1	7	196	26.557	31.059	0.8	2.1	0.9	0.0	trawl	bas	5	158	0	54	1853	0	6	56	0	1	11	0	18
TC	1.3	30	1	10	288	10.19	26.941	0.8	2.0	0.9	0.0	trawl	bas	20	625	0	105	3523	1	5	51	0	0	9	0	10
TC	1.3	30	3	1	15	14.77	21.542	0.8	1.8	0.5	0.0	trawl	bas	14	453	0	41	1427	-1	4	46	0	0	7	0	8
TC	1.3	30	3	5	135	30.564	28.484	0.8	1.9	0.5	0.0	trawl	bas	4	137	0	25	869	-1	5	50	0	0	10	0	12
TC	1.3	30	3	7	196	26.557	31.059	0.8	2.1	0.5	0.0	trawl	bas	4	147	0	56	1889	0	5	55	0	1	11	0	18
TC	1.3	30	3	10	288	10.19	26.941	0.8	2.0	0.5	0.0	trawl	bas	19	584	0	107	3585	1	5	50	0	0	8	0	9
TC	1.3	30	5	1	15	14.77	21.542	0.8	1.8	0.3	0.0	trawl	bas	14	435	0	42	1443	-1	4	45	0	0	7	0	8
TC	1.3	30	5	5	135	30.564	28.484	0.8	1.9	0.3	0.0	trawl	bas	4	132	0	25	878	-1	5	49	0	0	9	0	12
TC	1.3	30	5	7	196	26.557	31.059	0.8	2.1	0.3	0.0	trawl	bas	4	141	0	56	1910	0	5	54	0	1	10	0	18
TC	1.3	30	5	10	288	10.19	26.941	0.8	2.0	0.3	0.0	trawl	bas	18	562	0	108	3623	1	5	49	0	0	8	0	9
TC	10	0	1	7	196	21.418	31.059	0.8	2.1	0.9	0.0	trawl	bas	6	208	0	68	2311	0	6	59	0	0	10	0	17
TC	10	0	1	10	288	14.168	26.941	0.8	2.0	0.8	0.0	trawl	bas	15	483	0	86	2910	1	5	49	0	0	9	0	10
TC	10	0	3	1	15	24.044	21.542	0.8	1.8	0.4	0.0	trawl	bas	8	253	0	26	919	-1	4	43	0	0	9	0	10
TC	10	0	3	5	135	37.365	28.484	0.8	1.9	0.3	0.0	trawl	bas	3	118	0	30	1053	-1	4	40	0	0	10	0	10
TC	10	0	3	7	196	21.418	31.059	0.8	2.1	0.4	0.0	trawl	bas	6	190	0	70	2369	0	6	57	0	0	9	0	16
TC	10	0	3	10	288	14.168	26.941	0.8	2.0	0.3	0.0	trawl	bas	14	446	0	88	2975	1	5	48	0	0	9	0	10
TC	10	0	5	1	15	24.044	21.542	0.8	1.8	0.2	0.0	trawl	bas	8	243	0	26	929	-1	4	42	0	0	9	0	10
TC	10	0	5	5	135	37.365	28.484	0.8	1.9	0.1	0.0	trawl	bas	3	114	0	30	1064	-1	4	39	0	0	9	0	10
TC	10	0	5	7	196	21.418	31.059	0.8	2.1	0.2	0.0	trawl	bas	6	183	0	71	2395	0	6	56	0	0	9	0	16
TC	10	0	5	10	288	14.168	26.941	0.8	2.0	0.1	0.0	trawl	bas	14	431	0	89	3004	1	4	47	0	0	9	0	10
TC	10	30	1	7	196	30.428	31.059	0.8	2.1	0.9	0.0	trawl	bas	4	131	0	50	1721	0	5	53	0	1	12	0	19
TC	10	30	1	10	288	17.838	26.941	0.8	2.0	0.7	0.0	trawl	bas	12	385	0	72	2434	0	5	48	0	0	10	0	11
TC	10	30	3	1	15	21.362	21.542	0.8	1.8	0.4	0.0	trawl	bas	9	295	0	30	1042	-1	4	44	0	0	8	0	9
TC	10	30	3	5	135	33.511	28.484	0.8	1.9	0.3	0.0	trawl	bas	4	123	0	26	903	-1	4	46	0	0	10	0	11
TC	10	30	3	7	196	30.428	31.059	0.8	2.1	0.3	0.0	trawl	bas	3	120	0	52	1766	0	5	51	0	1	11	0	18
TC	10	30	3	10	288	17.838	26.941	0.8	2.0	0.3	0.0	trawl	bas	11	355	0	74	2490	0	4	46	0	0	10	0	11
TC	10	30	5	1	15	21.362	21.542	0.8	1.8	0.1	0.0	trawl	bas	9	284	0	30	1053	-1	4	43	0	0	8	0	9
TC	10	30	5	5	135	33.511	28.484	0.8	1.9	0.1	0.0	trawl	bas	3	119	0	26	912	-1	4	45	0	0	9	0	11
TC	10	30	5	7	196	30.428	31.059	0.8	2.1	0.1	0.0	trawl	bas	3	115	0	52	1784	0	5	51	0	1	11	0	18
TC	10	30	5	10	288	17.838	26.941	0.8	2.0	0.1	0.0	trawl	bas	11	343	0	74	2513	0	4	46	0	0	9	0	11

Appendix Table A-4. Predictions for northeast scenarios for trawl/seine with 95% confidence intervals.

Site	Salt Trmt	Lag	Year	Month	Dayofyr	Salinity	Temper-ature	Depth	BB.Tt	BB.Hw	BB.Sf	Gear	Habitat	Anchoa	Anchoa upper	Anchoa lower	Floridichthys	Floridichthys upper	Floridichthys lower	Anarch-opterus	Anarch-opterus upper	Anarch-opterus lower	Lutjanus	Lutjanus upper	Lutjanus lower	Hippo-campus
TC	20	0	1	7	196	31.418	31.059	0.8	2.1	0.7	0.0	trawl	bas	4	124	0	51	1732	0	5	51	0	1	12	0	18
TC	20	0	1	10	288	24.168	26.941	0.8	2.0	0.6	0.0	trawl	bas	8	257	0	53	1816	0	4	45	0	1	12	0	13
TC	20	0	3	1	15	34.044	21.542	0.8	1.8	0.2	0.0	trawl	bas	5	164	0	23	815	-1	3	35	-1	0	10	0	10
TC	20	0	3	5	135	47.365	28.484	0.8	1.9	0.2	0.0	trawl	bas	3	113	0	55	1868	0	2	26	-1	0	9	0	7
TC	20	0	3	7	196	31.418	31.059	0.8	2.1	0.2	0.0	trawl	bas	3	112	0	52	1781	0	5	50	0	1	11	0	18
TC	20	0	3	10	288	24.168	26.941	0.8	2.0	0.1	0.0	trawl	bas	7	237	0	55	1858	0	4	44	0	1	11	0	12
TC	20	0	5	1	15	34.044	21.542	0.8	1.8	0.0	0.0	trawl	bas	5	160	0	23	822	-1	3	35	-1	0	10	0	10
TC	20	0	5	5	135	47.365	28.484	0.8	1.9	0.0	0.0	trawl	bas	3	110	0	55	1880	0	2	26	-1	0	9	0	6
TC	20	0	5	7	196	31.418	31.059	0.8	2.1	0.0	0.0	trawl	bas	3	110	0	53	1792	0	5	49	0	1	11	0	18
TC	20	0	5	10	288	24.168	26.941	0.8	2.0	0.0	0.0	trawl	bas	7	233	0	55	1868	0	4	44	0	1	11	0	12
TC	20	30	1	7	196	40.428	31.059	0.8	2.1	0.7	0.0	trawl	bas	3	112	0	73	2468	0	3	37	-1	1	12	0	15
TC	20	30	1	10	288	27.838	26.941	0.8	2.0	0.6	0.0	trawl	bas	6	211	0	47	1600	-1	4	43	0	1	12	0	13
TC	20	30	3	1	15	31.362	21.542	0.8	1.8	0.2	0.0	trawl	bas	5	175	0	22	779	-1	3	38	0	0	10	0	10
TC	20	30	3	5	135	43.511	28.484	0.8	1.9	0.2	0.0	trawl	bas	3	113	0	44	1500	-1	3	30	-1	0	9	0	8
TC	20	30	3	7	196	40.428	31.059	0.8	2.1	0.2	0.0	trawl	bas	3	101	0	75	2538	0	3	36	-1	1	11	0	14
TC	20	30	3	10	288	27.838	26.941	0.8	2.0	0.1	0.0	trawl	bas	6	195	0	48	1637	0	4	42	0	1	12	0	13
TC	20	30	5	1	15	31.362	21.542	0.8	1.8	0.0	0.0	trawl	bas	5	170	0	22	785	-1	3	38	-1	0	10	0	10
TC	20	30	5	5	135	43.511	28.484	0.8	1.9	0.0	0.0	trawl	bas	3	111	0	44	1509	-1	3	30	-1	0	9	0	8
TC	20	30	5	7	196	40.428	31.059	0.8	2.1	0.0	0.0	trawl	bas	3	99	0	76	2553	0	3	36	-1	1	10	0	14
TC	20	30	5	10	288	27.838	26.941	0.8	2.0	0.0	0.0	trawl	bas	6	192	0	48	1645	0	4	42	0	1	12	0	13

Appendix Table A-4.

Site	Salt Trmt	Lag	Hippo-campus upper	Hippo-campus lower	Lucania	Lucania upper	Lucania lower	M. gulosus	M. gulosus upper	M. gulosus lower	M. microlepis	M. microlepis upper	M. microlepis lower	Eucino-stomus	Eucino-stomus upper	Eucino-stomus lower	Opisthonema	Opisthonema upper	Opisthonema lower	Lagodon	Lagodon upper	Lagodon lower
TR	0.9	0	136	-2	64	4363	0	38	188	2	0	10	0	207	5249	-28	0.0000	0.0004	0.0000	21	294	-7
TR	0.9	0	97	-3	73	4988	0	46	221	4	0	10	0	574	13158	-11	0.0000	0.0005	0.0000	24	321	-7
TR	0.9	0	86	-3	40	2780	0	28	147	-1	0	8	0	148	3990	-31	0.0000	0.0003	0.0000	13	220	-8
TR	0.9	0	116	-3	27	1869	-1	12	82	-5	0	8	0	68	2248	-35	0.0000	0.0003	0.0000	27	352	-6
TR	0.9	0	137	-2	63	4346	0	38	188	2	0	10	0	211	5328	-28	0.0000	0.0004	0.0000	21	296	-7
TR	0.9	0	97	-3	72	4966	0	46	222	4	0	10	0	580	13267	-11	0.0000	0.0005	0.0000	24	322	-7
TR	0.9	0	86	-3	40	2772	0	28	147	-1	0	8	0	149	4004	-31	0.0000	0.0003	0.0000	13	220	-8
TR	0.9	0	116	-3	27	1865	-1	12	82	-5	0	8	0	68	2259	-35	0.0000	0.0003	0.0000	27	352	-6
TR	0.9	0	137	-2	63	4336	0	38	189	2	0	10	0	212	5360	-28	0.0000	0.0004	0.0000	21	297	-7
TR	0.9	0	97	-3	72	4955	0	46	222	4	0	10	0	582	13312	-11	0.0000	0.0005	0.0000	24	322	-7
TR	0.9	30	149	-2	55	3734	0	25	132	-2	0	9	0	204	5171	-29	0.0000	0.0003	0.0000	22	303	-7
TR	0.9	30	102	-3	67	4604	0	37	184	1	0	9	0	572	13069	-11	0.0000	0.0004	0.0000	24	326	-7
TR	0.9	30	84	-3	41	2848	0	30	156	0	0	8	0	148	3987	-31	0.0000	0.0003	0.0000	13	218	-8
TR	0.9	30	105	-3	32	2176	-1	22	122	-2	0	9	0	72	2336	-35	0.0000	0.0004	0.0000	26	343	-6
TR	0.9	30	149	-2	54	3715	0	25	133	-2	0	9	0	208	5247	-28	0.0000	0.0003	0.0000	22	305	-7
TR	0.9	30	102	-3	67	4582	0	37	185	1	0	9	0	578	13179	-11	0.0000	0.0004	0.0000	24	327	-7
TR	0.9	30	84	-3	41	2839	0	30	156	0	0	8	0	149	4002	-31	0.0000	0.0003	0.0000	13	218	-8
TR	0.9	30	105	-3	31	2170	-1	22	122	-2	0	9	0	72	2348	-35	0.0000	0.0004	0.0000	26	343	-6
TR	0.9	30	149	-2	54	3705	0	25	133	-2	0	9	0	210	5282	-28	0.0000	0.0003	0.0000	22	306	-7
TR	0.9	30	102	-3	67	4570	0	37	185	1	0	9	0	580	13229	-11	0.0000	0.0004	0.0000	24	327	-6
TR	1	0	138	-2	63	4288	0	36	179	1	0	10	0	203	5161	-29	0.0000	0.0004	0.0000	21	293	-7
TR	1	0	97	-3	72	4967	0	45	218	3	0	10	0	569	13041	-12	0.0000	0.0005	0.0000	24	320	-7
TR	1	0	87	-3	40	2739	0	26	140	-1	0	7	0	146	3940	-31	0.0000	0.0003	0.0000	13	220	-8
TR	1	0	120	-3	26	1780	-1	10	71	-5	0	7	0	65	2184	-35	0.0000	0.0003	0.0000	27	352	-6
TR	1	0	138	-2	63	4288	0	36	179	1	0	10	0	203	5161	-29	0.0000	0.0004	0.0000	21	293	-7
TR	1	0	97	-3	72	4967	0	45	218	3	0	10	0	569	13040	-12	0.0000	0.0005	0.0000	24	320	-7
TR	1	0	87	-3	40	2740	0	26	140	-1	0	7	0	146	3940	-31	0.0000	0.0003	0.0000	13	220	-8
TR	1	0	120	-3	26	1780	-1	10	71	-5	0	7	0	65	2183	-35	0.0000	0.0003	0.0000	27	352	-6
TR	1	0	138	-2	63	4288	0	36	179	1	0	10	0	203	5161	-29	0.0000	0.0004	0.0000	21	293	-7
TR	1	0	97	-3	72	4968	0	45	218	3	0	10	0	569	13044	-12	0.0000	0.0005	0.0000	24	320	-7
TR	1	30	152	-2	53	3608	0	22	121	-2	0	9	0	199	5058	-29	0.0000	0.0003	0.0000	22	303	-7
TR	1	30	102	-3	66	4545	0	35	178	1	0	9	0	566	12919	-12	0.0000	0.0004	0.0000	24	326	-7
TR	1	30	85	-3	41	2817	0	29	150	-1	0	8	0	145	3931	-31	0.0000	0.0003	0.0000	13	218	-8
TR	1	30	107	-3	31	2111	-1	19	111	-3	0	9	0	69	2283	-35	0.0000	0.0003	0.0000	26	343	-6
TR	1	30	152	-2	53	3609	0	22	121	-2	0	9	0	199	5045	-29	0.0000	0.0003	0.0000	22	302	-7
TR	1	30	102	-3	66	4547	0	35	178	1	0	9	0	565	12902	-12	0.0000	0.0004	0.0000	24	326	-7
TR	1	30	85	-3	41	2818	0	29	150	-1	0	8	0	145	3930	-31	0.0000	0.0003	0.0000	13	218	-8
TR	1	30	107	-3	31	2111	-1	19	111	-3	0	9	0	69	2281	-35	0.0000	0.0003	0.0000	26	343	-6
TR	1	30	152	-2	53	3609	0	22	121	-2	0	9	0	199	5042	-29	0.0000	0.0003	0.0000	22	302	-7
TR	1	30	102	-3	66	4548	0	35	178	1	0	9	0	565	12901	-12	0.0000	0.0004	0.0000	24	326	-7
TR	1.1	0	139	-2	62	4214	0	34	171	1	0	10	0	199	5069	-29	0.0000	0.0004	0.0000	21	292	-7
TR	1.1	0	98	-3	72	4948	0	44	214	3	0	10	0	563	12900	-12	0.0000	0.0005	0.0000	23	319	-7
TR	1.1	0	88	-3	39	2701	0	25	134	-2	0	7	0	143	3881	-31	0.0000	0.0003	0.0000	13	219	-8
TR	1.1	0	123	-3	25	1698	-1	8	63	-6	0	7	0	62	2122	-35	0.0000	0.0003	0.0000	27	353	-6
TR	1.1	0	139	-2	62	4230	0	34	171	1	0	10	0	195	4978	-29	0.0000	0.0004	0.0000	21	290	-7
TR	1.1	0	97	-3	72	4969	0	44	213	3	0	10	0	556	12759	-12	0.0000	0.0005	0.0000	23	318	-7
TR	1.1	0	88	-3	39	2708	0	25	134	-2	0	7	0	143	3862	-31	0.0000	0.0003	0.0000	13	219	-8
TR	1.1	0	123	-3	25	1702	-1	8	63	-6	0	7	0	61	2107	-35	0.0000	0.0003	0.0000	27	352	-6
TR	1.1	0	139	-2	62	4238	0	34	171	1	0	10	0	193	4940	-29	0.0000	0.0004	0.0000	21	289	-7
TR	1.1	0	97	-3	73	4981	0	44	213	3	0	10	0	554	12701	-12	0.0000	0.0005	0.0000	23	317	-7
TR	1.1	30	155	-2	51	3488	0	19	111	-3	0	9	0	194	4942	-29	0.0000	0.0003	0.0000	22	302	-7
TR	1.1	30	103	-3	66	4488	0	34	171	1	0	9	0	558	12745	-12	0.0000	0.0004	0.0000	24	325	-7
TR	1.1	30	86	-3	40	2787	0	27	145	-1	0	8	0	143	3867	-31	0.0000	0.0003	0.0000	13	217	-8
TR	1.1	30	110	-3	30	2047	-1	17	102	-3	0	8	0	66	2218	-35	0.0000	0.0003	0.0000	26	342	-6
TR	1.1	30	155	-2	51	3504	0	19	111	-3	0	9	0	189	4827	-29	0.0000	0.0003	0.0000	22	299	-7

Appendix Table A-4.

Site	Salt Trmt	Lag	Hippo-campus upper	Hippo-campus lower	Lucania	Lucania upper	Lucania lower	M. gulosus	M. gulosus upper	M. gulosus lower	M. microlepis	M. microlepis upper	M. microlepis lower	Eucino-stomus	Eucino-stomus upper	Eucino-stomus lower	Opisthonema	Opisthonema upper	Opisthonema lower	Lagodon	Lagodon upper	Lagodon lower
TR	1.1	30	103	-3	66	4513	0	34	171	1	0	9	0	550	12565	-12	0.0000	0.0004	0.0000	24	323	-7
TR	1.1	30	86	-3	40	2797	0	27	144	-1	0	8	0	141	3841	-32	0.0000	0.0003	0.0000	13	217	-8
TR	1.1	30	110	-3	30	2053	-1	17	101	-3	0	8	0	65	2197	-35	0.0000	0.0003	0.0000	26	341	-6
TR	1.1	30	154	-2	52	3513	0	19	110	-3	0	9	0	186	4778	-29	0.0000	0.0003	0.0000	22	298	-7
TR	1.1	30	103	-3	66	4526	0	34	170	1	0	9	0	546	12485	-13	0.0000	0.0004	0.0000	24	323	-7
TR	1.3	0	142	-2	60	4068	0	30	156	0	0	10	0	190	4867	-29	0.0000	0.0004	0.0000	21	290	-7
TR	1.3	0	98	-3	72	4912	0	42	206	3	0	10	0	546	12529	-13	0.0000	0.0005	0.0000	23	316	-7
TR	1.3	0	89	-3	38	2626	0	22	122	-2	0	7	0	136	3728	-32	0.0000	0.0002	0.0000	13	218	-8
TR	1.3	0	126	-2	23	1569	-1	5	50	-6	0	7	0	58	2035	-35	0.0000	0.0003	0.0000	28	358	-6
TR	1.3	0	141	-2	60	4107	0	30	155	0	0	10	0	175	4556	-30	0.0000	0.0004	0.0000	20	281	-7
TR	1.3	0	98	-3	73	4972	0	42	205	3	0	10	0	520	11971	-14	0.0000	0.0005	0.0000	23	311	-7
TR	1.3	0	89	-3	38	2646	0	22	122	-2	0	7	0	132	3636	-32	0.0000	0.0002	0.0000	13	216	-8
TR	1.3	0	126	-2	23	1577	-1	5	50	-6	0	7	0	55	1975	-36	0.0000	0.0003	0.0000	27	353	-6
TR	1.3	0	140	-2	60	4126	0	30	154	0	0	10	0	168	4402	-30	0.0000	0.0004	0.0000	19	277	-7
TR	1.3	0	97	-3	73	5001	0	42	205	3	0	10	0	506	11668	-15	0.0000	0.0005	0.0000	22	307	-7
TR	1.3	30	161	-2	48	3258	0	15	93	-4	0	8	0	183	4705	-29	0.0000	0.0003	0.0000	22	301	-7
TR	1.3	30	105	-3	64	4378	0	31	158	0	0	9	0	538	12306	-13	0.0000	0.0004	0.0000	24	323	-7
TR	1.3	30	87	-3	40	2728	0	25	134	-2	0	8	0	135	3698	-32	0.0000	0.0003	0.0000	13	215	-8
TR	1.3	30	114	-3	28	1925	-1	13	84	-4	0	8	0	59	2057	-35	0.0000	0.0003	0.0000	26	337	-6
TR	1.3	30	160	-2	48	3295	0	15	92	-4	0	9	0	167	4348	-30	0.0000	0.0003	0.0000	21	290	-7
TR	1.3	30	104	-3	65	4440	0	31	157	0	0	9	0	507	11642	-14	0.0000	0.0004	0.0000	23	315	-7
TR	1.3	30	87	-3	40	2751	0	25	133	-2	0	8	0	130	3583	-32	0.0000	0.0003	0.0000	13	212	-8
TR	1.3	30	113	-3	28	1938	-1	13	84	-4	0	8	0	55	1978	-36	0.0000	0.0003	0.0000	25	331	-6
TR	1.3	30	159	-2	49	3313	0	15	92	-4	0	9	0	158	4164	-31	0.0000	0.0003	0.0000	20	285	-7
TR	1.3	30	104	-3	66	4469	0	30	157	0	0	9	0	489	11259	-15	0.0000	0.0004	0.0000	23	311	-7
TR	10	0	156	-2	50	3400	0	17	100	-3	0	9	0	167	4362	-30	0.0000	0.0003	0.0000	21	288	-7
TR	10	0	111	-3	58	3978	0	22	122	-2	0	8	0	481	11038	-16	0.0000	0.0004	0.0000	23	316	-7
TR	10	0	98	-3	32	2208	-1	11	77	-5	0	7	0	107	3087	-33	0.0000	0.0002	0.0000	12	209	-8
TR	10	0	121	-3	22	1512	-1	3	45	-7	0	6	0	44	1740	-36	0.0000	0.0003	0.0000	26	342	-6
TR	10	0	152	-2	50	3431	0	16	98	-4	0	9	0	122	3404	-32	0.0000	0.0003	0.0000	17	256	-7
TR	10	0	108	-3	59	4026	0	22	120	-2	0	9	0	383	8953	-20	0.0000	0.0004	0.0000	20	286	-7
TR	10	0	97	-3	32	2213	-1	11	76	-5	0	7	0	90	2712	-34	0.0000	0.0002	0.0000	11	197	-8
TR	10	0	119	-3	22	1512	-1	3	44	-7	0	7	0	34	1533	-36	0.0000	0.0003	0.0000	24	322	-6
TR	10	0	149	-2	50	3425	0	16	97	-4	0	10	0	101	2959	-33	0.0000	0.0004	0.0000	16	239	-7
TR	10	0	106	-3	59	4021	0	21	119	-2	0	9	0	333	7884	-22	0.0000	0.0004	0.0000	19	269	-7
TR	10	30	172	-2	42	2882	0	9	67	-5	0	8	0	164	4295	-30	0.0000	0.0003	0.0000	22	298	-7
TR	10	30	116	-3	54	3641	0	16	99	-4	0	8	0	470	10795	-16	0.0000	0.0004	0.0000	24	319	-7
TR	10	30	96	-3	33	2272	0	12	83	-5	0	7	0	106	3066	-33	0.0000	0.0002	0.0000	12	207	-8
TR	10	30	120	-3	25	1713	-1	7	60	-6	0	8	0	39	1625	-36	0.0000	0.0003	0.0000	23	313	-7
TR	10	30	167	-2	43	2910	0	8	66	-6	0	8	0	118	3308	-33	0.0000	0.0003	0.0000	18	264	-7
TR	10	30	114	-3	54	3684	0	16	97	-4	0	8	0	371	8688	-21	0.0000	0.0004	0.0000	21	288	-7
TR	10	30	95	-3	33	2276	0	12	82	-5	0	7	0	88	2684	-34	0.0000	0.0002	0.0000	11	194	-8
TR	10	30	118	-3	25	1712	-1	7	60	-6	0	8	0	29	1419	-37	0.0000	0.0003	0.0000	21	293	-7
TR	10	30	164	-2	43	2904	0	8	65	-6	0	8	0	97	2864	-34	0.0000	0.0003	0.0000	16	246	-7
TR	10	30	112	-3	54	3679	0	16	96	-4	0	9	0	322	7645	-23	0.0000	0.0004	0.0000	19	271	-7
TR	20	0	174	-2	40	2718	0	6	57	-6	0	7	0	145	3892	-31	0.0000	0.0003	0.0000	21	291	-7
TR	20	0	126	-2	46	3140	0	9	67	-5	0	7	0	404	9377	-19	0.0000	0.0003	0.0000	23	310	-7
TR	20	0	109	-3	25	1751	-1	3	42	-7	0	6	0	83	2582	-34	0.0000	0.0002	0.0000	12	205	-8
TR	20	0	94	-3	21	1452	-1	4	47	-7	0	5	0	58	2043	-35	0.0000	0.0003	0.0000	33	409	-6
TR	20	0	167	-2	40	2713	0	6	56	-6	0	8	0	91	2736	-34	0.0000	0.0003	0.0000	16	245	-7
TR	20	0	122	-3	46	3138	0	8	66	-6	0	8	0	294	7051	-24	0.0000	0.0004	0.0000	19	270	-7
TR	20	0	108	-3	25	1747	-1	3	42	-7	0	6	0	70	2296	-35	0.0000	0.0002	0.0000	11	193	-8
TR	20	0	93	-3	21	1449	-1	4	47	-7	0	5	0	49	1847	-36	0.0000	0.0003	0.0000	31	389	-6
TR	20	0	165	-2	40	2706	0	6	55	-6	0	8	0	78	2471	-34	0.0000	0.0003	0.0000	15	233	-7
TR	20	0	121	-3	46	3132	0	8	65	-6	0	8	0	268	6487	-25	0.0000	0.0004	0.0000	18	259	-7

Appendix Table A-4.

Site	Salt Trmt	Lag	Hippo-campus upper	Hippo-campus lower	Lucania	Lucania upper	Lucania lower	M. gulosus	M. gulosus upper	M. gulosus lower	M. microlepis	M. microlepis upper	M. microlepis lower	Eucino-stomus	Eucino-stomus upper	Eucino-stomus lower	Opisthonema	Opisthonema upper	Opisthonema lower	Lagodon	Lagodon upper	Lagodon lower
TR	20	30	165	-2	36	2495	0	4	49	-7	0	6	0	170	4418	-30	0.0000	0.0003	0.0000	25	328	-6
TR	20	30	131	-2	42	2897	0	6	55	-6	0	7	0	402	9340	-19	0.0000	0.0003	0.0000	24	317	-7
TR	20	30	108	-3	26	1792	-1	3	45	-7	0	6	0	83	2562	-34	0.0000	0.0002	0.0000	12	202	-8
TR	20	30	114	-3	21	1476	-1	3	43	-7	0	6	0	36	1566	-36	0.0000	0.0003	0.0000	25	333	-6
TR	20	30	159	-2	36	2492	0	4	47	-7	0	7	0	108	3094	-33	0.0000	0.0003	0.0000	19	276	-7
TR	20	30	127	-2	42	2895	0	5	54	-6	0	7	0	293	7028	-24	0.0000	0.0003	0.0000	19	276	-7
TR	20	30	107	-3	26	1788	-1	3	45	-7	0	6	0	69	2281	-35	0.0000	0.0002	0.0000	11	191	-8
TR	20	30	113	-3	21	1472	-1	3	43	-7	0	6	0	28	1410	-37	0.0000	0.0003	0.0000	24	316	-7
TR	20	30	157	-2	36	2485	0	4	47	-7	0	7	0	94	2796	-34	0.0000	0.0003	0.0000	18	263	-7
TR	20	30	126	-2	42	2890	0	5	53	-6	0	7	0	267	6475	-26	0.0000	0.0004	0.0000	18	265	-7
TC	0.9	0	132	-2	47	3224	0	30	154	0	0	11	0	138	3756	-32	0.0000	0.0004	0.0000	16	246	-7
TC	0.9	0	93	-3	58	3971	0	41	201	2	0	10	0	437	10168	-18	0.0000	0.0005	0.0000	19	277	-7
TC	0.9	0	89	-3	28	1946	-1	18	104	-3	0	7	0	109	3141	-33	0.0000	0.0003	0.0000	11	194	-8
TC	0.9	0	115	-3	19	1342	-1	7	62	-6	0	8	0	41	1682	-36	0.0000	0.0003	0.0000	22	303	-7
TC	0.9	0	133	-2	47	3225	0	30	154	0	0	11	0	143	3866	-31	0.0000	0.0004	0.0000	17	250	-7
TC	0.9	0	93	-3	58	3965	0	41	201	2	0	10	0	449	10430	-17	0.0000	0.0005	0.0000	20	280	-7
TC	0.9	0	89	-3	28	1942	-1	18	104	-3	0	7	0	112	3196	-33	0.0000	0.0003	0.0000	11	196	-8
TC	0.9	0	115	-3	19	1339	-1	7	62	-6	0	8	0	43	1713	-36	0.0000	0.0003	0.0000	22	306	-7
TC	0.9	0	133	-2	47	3219	0	30	154	0	0	10	0	147	3954	-31	0.0000	0.0004	0.0000	17	252	-7
TC	0.9	0	93	-3	58	3957	0	41	202	2	0	10	0	458	10638	-17	0.0000	0.0005	0.0000	20	283	-7
TC	0.9	30	149	-2	39	2655	0	16	96	-4	0	9	0	133	3636	-32	0.0000	0.0004	0.0000	17	255	-7
TC	0.9	30	97	-3	54	3681	0	33	167	0	0	10	0	431	10013	-18	0.0000	0.0005	0.0000	20	281	-7
TC	0.9	30	85	-3	30	2063	-1	21	119	-2	0	8	0	106	3077	-33	0.0000	0.0003	0.0000	10	189	-8
TC	0.9	30	109	-3	21	1447	-1	11	75	-5	0	8	0	40	1663	-36	0.0000	0.0004	0.0000	21	295	-7
TC	0.9	30	148	-2	39	2654	0	16	96	-4	0	9	0	132	3615	-32	0.0000	0.0004	0.0000	17	254	-7
TC	0.9	30	97	-3	54	3681	0	33	167	0	0	10	0	429	9964	-18	0.0000	0.0005	0.0000	20	280	-7
TC	0.9	30	85	-3	30	2063	-1	21	119	-2	0	8	0	106	3069	-33	0.0000	0.0003	0.0000	10	189	-8
TC	0.9	30	109	-3	21	1446	-1	11	75	-5	0	8	0	40	1658	-36	0.0000	0.0004	0.0000	21	294	-7
TC	0.9	30	148	-2	39	2654	0	16	96	-4	0	9	0	132	3603	-32	0.0000	0.0004	0.0000	17	254	-7
TC	0.9	30	97	-3	54	3681	0	33	167	0	0	10	0	427	9936	-18	0.0000	0.0005	0.0000	20	280	-7
TC	1	0	134	-2	46	3140	0	27	144	-1	0	10	0	134	3669	-32	0.0000	0.0004	0.0000	16	245	-7
TC	1	0	93	-3	57	3934	0	40	196	2	0	10	0	424	9900	-18	0.0000	0.0005	0.0000	19	274	-7
TC	1	0	90	-3	27	1883	-1	16	95	-4	0	7	0	103	2992	-33	0.0000	0.0003	0.0000	11	191	-8
TC	1	0	117	-3	18	1269	-1	5	53	-6	0	7	0	38	1603	-36	0.0000	0.0003	0.0000	22	302	-7
TC	1	0	134	-2	46	3141	0	27	143	-1	0	10	0	130	3578	-32	0.0000	0.0004	0.0000	16	242	-7
TC	1	0	93	-3	57	3936	0	40	196	2	0	10	0	414	9674	-19	0.0000	0.0005	0.0000	19	271	-7
TC	1	0	90	-3	27	1884	-1	16	95	-4	0	7	0	100	2943	-33	0.0000	0.0003	0.0000	10	190	-8
TC	1	0	117	-3	18	1269	-1	5	53	-6	0	7	0	36	1577	-36	0.0000	0.0003	0.0000	22	300	-7
TC	1	0	133	-2	46	3141	0	27	143	-1	0	11	0	127	3509	-32	0.0000	0.0004	0.0000	16	240	-7
TC	1	0	93	-3	57	3937	0	40	195	2	0	10	0	406	9500	-19	0.0000	0.0005	0.0000	18	269	-7
TC	1	30	153	-2	37	2530	0	13	85	-4	0	9	0	129	3537	-32	0.0000	0.0004	0.0000	17	255	-7
TC	1	30	98	-3	53	3613	0	31	159	0	0	10	0	417	9713	-19	0.0000	0.0005	0.0000	19	278	-7
TC	1	30	86	-3	29	2008	-1	19	111	-3	0	8	0	100	2932	-33	0.0000	0.0003	0.0000	10	186	-8
TC	1	30	112	-3	20	1370	-1	8	65	-6	0	8	0	36	1565	-36	0.0000	0.0004	0.0000	21	291	-7
TC	1	30	152	-2	37	2528	0	13	85	-4	0	9	0	119	3332	-32	0.0000	0.0004	0.0000	16	248	-7
TC	1	30	98	-3	53	3614	0	31	159	0	0	10	0	393	9193	-20	0.0000	0.0005	0.0000	19	271	-7
TC	1	30	86	-3	29	2009	-1	19	111	-3	0	8	0	94	2821	-34	0.0000	0.0003	0.0000	10	183	-8
TC	1	30	112	-3	20	1370	-1	8	65	-6	0	8	0	33	1504	-37	0.0000	0.0004	0.0000	20	285	-7
TC	1	30	151	-2	37	2527	0	13	85	-4	0	9	0	112	3183	-33	0.0000	0.0004	0.0000	16	242	-7
TC	1	30	97	-3	53	3614	0	31	158	0	0	10	0	374	8799	-21	0.0000	0.0005	0.0000	18	265	-7
TC	1.1	0	136	-2	45	3056	0	25	134	-1	0	10	0	131	3589	-32	0.0000	0.0004	0.0000	16	245	-7
TC	1.1	0	93	-3	57	3896	0	39	191	2	0	10	0	413	9650	-19	0.0000	0.0005	0.0000	19	271	-7
TC	1.1	0	92	-3	26	1819	-1	14	88	-4	0	7	0	96	2857	-34	0.0000	0.0003	0.0000	10	189	-8
TC	1.1	0	117	-3	17	1210	-1	4	47	-7	0	7	0	36	1563	-36	0.0000	0.0003	0.0000	22	305	-7
TC	1.1	0	135	-2	45	3053	0	25	134	-2	0	10	0	119	3338	-33	0.0000	0.0004	0.0000	15	236	-7

Appendix Table A-4.

Site	Salt Trmt	Lag	Hippo-campus upper	Hippo-campus lower	Lucania	Lucania upper	Lucania lower	M. gulosus	M. gulosus upper	M. gulosus lower	M. microlepis	M. microlepis upper	M. microlepis lower	Eucino-stomus	Eucino-stomus upper	Eucino-stomus lower	Opisthonema	Opisthonema upper	Opisthonema lower	Lagodon	Lagodon upper	Lagodon lower
TC	1.1	0	93	-3	57	3896	0	39	190	2	0	11	0	384	9023	-20	0.0000	0.0005	0.0000	18	263	-7
TC	1.1	0	91	-3	26	1820	-1	14	87	-4	0	7	0	90	2722	-34	0.0000	0.0003	0.0000	10	184	-8
TC	1.1	0	117	-3	17	1209	-1	4	47	-7	0	7	0	32	1492	-37	0.0000	0.0003	0.0000	22	298	-7
TC	1.1	0	134	-2	45	3050	0	25	133	-2	0	11	0	110	3158	-33	0.0000	0.0004	0.0000	15	230	-7
TC	1.1	0	92	-3	57	3894	0	38	190	2	0	11	0	362	8558	-21	0.0000	0.0005	0.0000	17	256	-7
TC	1.1	30	157	-2	35	2410	0	11	75	-5	0	8	0	125	3450	-32	0.0000	0.0003	0.0000	17	255	-7
TC	1.1	30	99	-3	52	3544	0	29	152	0	0	10	0	405	9439	-19	0.0000	0.0005	0.0000	19	275	-7
TC	1.1	30	87	-3	28	1951	-1	18	104	-3	0	8	0	94	2805	-34	0.0000	0.0003	0.0000	10	184	-8
TC	1.1	30	115	-3	19	1300	-1	6	57	-6	0	8	0	32	1491	-37	0.0000	0.0003	0.0000	21	288	-7
TC	1.1	30	155	-2	35	2405	0	11	75	-5	0	9	0	109	3109	-33	0.0000	0.0004	0.0000	16	242	-7
TC	1.1	30	98	-3	52	3542	0	29	151	-1	0	10	0	364	8570	-21	0.0000	0.0005	0.0000	18	263	-7
TC	1.1	30	87	-3	28	1950	-1	18	103	-3	0	8	0	85	2626	-34	0.0000	0.0003	0.0000	9	178	-8
TC	1.1	30	114	-3	19	1299	-1	6	57	-6	0	8	0	28	1395	-37	0.0000	0.0004	0.0000	20	279	-7
TC	1.1	30	154	-2	35	2400	0	11	75	-5	0	9	0	98	2886	-33	0.0000	0.0004	0.0000	15	234	-7
TC	1.1	30	97	-3	52	3536	0	29	150	-1	0	10	0	336	7980	-22	0.0000	0.0005	0.0000	17	254	-7
TC	1.3	0	140	-2	42	2893	0	21	118	-2	0	10	0	125	3455	-32	0.0000	0.0004	0.0000	16	244	-7
TC	1.3	0	94	-3	56	3819	0	37	182	1	0	10	0	394	9241	-20	0.0000	0.0005	0.0000	18	267	-7
TC	1.3	0	95	-3	24	1697	-1	10	74	-5	0	7	0	87	2648	-34	0.0000	0.0002	0.0000	10	185	-8
TC	1.3	0	109	-3	16	1145	-1	3	43	-7	0	6	0	40	1644	-36	0.0000	0.0003	0.0000	25	328	-6
TC	1.3	0	138	-2	42	2881	0	21	117	-3	0	10	0	103	3007	-33	0.0000	0.0004	0.0000	14	227	-8
TC	1.3	0	93	-3	56	3808	0	36	180	1	0	11	0	342	8132	-22	0.0000	0.0005	0.0000	17	251	-7
TC	1.3	0	94	-3	24	1694	-1	10	73	-5	0	7	0	77	2435	-35	0.0000	0.0002	0.0000	9	178	-8
TC	1.3	0	108	-3	16	1142	-1	3	43	-7	0	6	0	34	1522	-37	0.0000	0.0003	0.0000	24	316	-7
TC	1.3	0	136	-2	42	2872	0	21	116	-3	0	10	0	92	2753	-34	0.0000	0.0004	0.0000	13	218	-8
TC	1.3	0	92	-3	55	3798	0	36	180	1	0	11	0	312	7485	-24	0.0000	0.0005	0.0000	16	241	-7
TC	1.3	30	164	-2	32	2200	-1	7	60	-6	0	8	0	120	3345	-32	0.0000	0.0003	0.0000	18	258	-7
TC	1.3	30	101	-3	50	3410	0	26	139	-1	0	9	0	385	9002	-20	0.0000	0.0005	0.0000	19	272	-7
TC	1.3	30	90	-3	27	1842	-1	14	91	-4	0	7	0	85	2617	-34	0.0000	0.0003	0.0000	9	180	-8
TC	1.3	30	116	-3	17	1193	-1	4	46	-7	0	7	0	30	1439	-37	0.0000	0.0003	0.0000	21	294	-7
TC	1.3	30	161	-2	32	2188	-1	7	59	-6	0	8	0	96	2845	-34	0.0000	0.0003	0.0000	16	238	-7
TC	1.3	30	99	-3	50	3397	0	26	137	-1	0	10	0	327	7766	-23	0.0000	0.0005	0.0000	17	253	-7
TC	1.3	30	89	-3	27	1837	-1	14	90	-4	0	8	0	74	2391	-35	0.0000	0.0003	0.0000	9	172	-8
TC	1.3	30	115	-3	17	1189	-1	4	46	-7	0	7	0	24	1319	-37	0.0000	0.0003	0.0000	20	282	-7
TC	1.3	30	159	-2	32	2180	-1	7	59	-6	0	8	0	84	2591	-34	0.0000	0.0004	0.0000	14	228	-7
TC	1.3	30	98	-3	50	3386	0	26	137	-1	0	10	0	296	7120	-24	0.0000	0.0005	0.0000	16	242	-7
TC	10	0	153	-2	36	2468	0	12	80	-5	0	9	0	116	3273	-33	0.0000	0.0004	0.0000	16	247	-7
TC	10	0	106	-3	45	3086	0	19	110	-3	0	9	0	364	8531	-21	0.0000	0.0004	0.0000	19	271	-7
TC	10	0	102	-3	21	1476	-1	5	52	-6	0	6	0	75	2404	-35	0.0000	0.0002	0.0000	10	183	-8
TC	10	0	104	-3	16	1129	-1	3	44	-7	0	6	0	38	1607	-36	0.0000	0.0004	0.0000	25	330	-6
TC	10	0	150	-2	36	2442	0	12	79	-5	0	9	0	87	2657	-34	0.0000	0.0004	0.0000	14	223	-8
TC	10	0	104	-3	45	3063	0	19	109	-3	0	9	0	296	7104	-24	0.0000	0.0005	0.0000	16	247	-7
TC	10	0	101	-3	21	1470	-1	5	51	-6	0	7	0	65	2189	-35	0.0000	0.0002	0.0000	9	175	-8
TC	10	0	103	-3	16	1125	-1	3	43	-7	0	6	0	32	1482	-37	0.0000	0.0004	0.0000	24	317	-7
TC	10	0	148	-2	36	2432	0	12	79	-5	0	9	0	77	2432	-34	0.0000	0.0004	0.0000	13	213	-8
TC	10	0	103	-3	45	3053	0	19	108	-3	0	9	0	271	6564	-25	0.0000	0.0005	0.0000	15	238	-7
TC	10	30	165	-2	30	2052	-1	5	51	-6	0	7	0	120	3350	-32	0.0000	0.0003	0.0000	18	266	-7
TC	10	30	112	-3	41	2827	0	14	89	-4	0	8	0	355	8339	-21	0.0000	0.0004	0.0000	19	274	-7
TC	10	30	98	-3	23	1569	-1	7	61	-6	0	7	0	75	2393	-35	0.0000	0.0002	0.0000	9	179	-8
TC	10	30	112	-3	16	1148	-1	3	43	-7	0	6	0	29	1416	-37	0.0000	0.0003	0.0000	22	299	-7
TC	10	30	161	-2	30	2029	-1	5	50	-6	0	8	0	89	2696	-34	0.0000	0.0003	0.0000	16	239	-7
TC	10	30	109	-3	41	2805	0	14	88	-4	0	9	0	288	6923	-25	0.0000	0.0004	0.0000	17	250	-7
TC	10	30	97	-3	22	1563	-1	7	60	-6	0	7	0	65	2183	-35	0.0000	0.0002	0.0000	9	171	-8
TC	10	30	111	-3	16	1144	-1	3	43	-7	0	7	0	23	1304	-37	0.0000	0.0004	0.0000	21	287	-7
TC	10	30	160	-2	29	2022	-1	5	50	-6	0	8	0	79	2472	-34	0.0000	0.0003	0.0000	15	229	-7
TC	10	30	108	-3	41	2796	0	14	87	-4	0	9	0	265	6422	-26	0.0000	0.0004	0.0000	16	241	-7

Appendix Table A-4.

Site	Salt Trmt	Lag	Hippo-campus upper	Hippo-campus lower	Lucania	Lucania upper	Lucania lower	M. gulosus	M. gulosus upper	M. gulosus lower	M. microlepis	M. microlepis upper	M. microlepis lower	Eucino-stomus	Eucino-stomus upper	Eucino-stomus lower	Opisthonema	Opisthonema upper	Opisthonema lower	Lagodon	Lagodon upper	Lagodon lower
TC	20	0	164	-2	29	2020	-1	4	49	-6	0	7	0	113	3198	-33	0.0000	0.0003	0.0000	18	262	-7
TC	20	0	121	-3	35	2425	0	7	61	-6	0	7	0	323	7657	-23	0.0000	0.0004	0.0000	19	273	-7
TC	20	0	102	-3	18	1250	-1	1	35	-7	0	5	0	78	2472	-34	0.0000	0.0002	0.0000	12	201	-8
TC	20	0	78	-3	16	1108	-1	4	50	-6	0	4	0	64	2171	-35	0.0000	0.0004	0.0000	34	423	-5
TC	20	0	159	-2	29	1991	-1	4	49	-7	0	8	0	82	2534	-34	0.0000	0.0003	0.0000	15	233	-7
TC	20	0	119	-3	35	2402	0	7	60	-6	0	8	0	261	6338	-26	0.0000	0.0004	0.0000	17	249	-7
TC	20	0	101	-3	18	1247	-1	1	35	-7	0	5	0	71	2312	-35	0.0000	0.0002	0.0000	11	194	-8
TC	20	0	78	-3	16	1106	-1	4	49	-6	0	4	0	59	2060	-35	0.0000	0.0004	0.0000	33	412	-6
TC	20	0	158	-2	29	1986	-1	4	48	-7	0	8	0	75	2404	-35	0.0000	0.0004	0.0000	14	227	-7
TC	20	0	118	-3	35	2397	0	7	60	-6	0	8	0	248	6069	-26	0.0000	0.0004	0.0000	16	243	-7
TC	20	30	136	-2	28	1927	-1	5	50	-6	0	5	0	160	4190	-31	0.0000	0.0003	0.0000	25	326	-6
TC	20	30	126	-2	33	2247	0	5	50	-6	0	7	0	323	7658	-23	0.0000	0.0004	0.0000	20	280	-7
TC	20	30	105	-3	18	1283	-1	1	37	-7	0	5	0	71	2317	-35	0.0000	0.0002	0.0000	10	190	-8
TC	20	30	87	-3	16	1112	-1	4	47	-7	0	5	0	50	1874	-36	0.0000	0.0004	0.0000	30	378	-6
TC	20	30	133	-2	28	1899	-1	4	49	-7	0	6	0	119	3321	-33	0.0000	0.0004	0.0000	21	291	-7
TC	20	30	123	-3	32	2225	0	4	50	-6	0	7	0	262	6356	-26	0.0000	0.0004	0.0000	17	255	-7
TC	20	30	104	-3	18	1279	-1	1	36	-7	0	6	0	64	2173	-35	0.0000	0.0002	0.0000	10	184	-8
TC	20	30	86	-3	16	1109	-1	4	47	-7	0	5	0	46	1778	-36	0.0000	0.0004	0.0000	29	369	-6
TC	20	30	132	-2	28	1895	-1	4	49	-7	0	6	0	111	3160	-33	0.0000	0.0004	0.0000	20	284	-7
TC	20	30	122	-3	32	2221	0	4	49	-6	0	7	0	250	6105	-26	0.0000	0.0004	0.0000	17	250	-7

Appendix Table A-4.

Site	Salt Trmt	Lag	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Cynoscion	Cynoscion upper	Cynoscion lower	S. floridae	S. floridae upper	S. floridae lower	Atherino-morus	Atherino-morus upper	Atherino-morus lower	S. scovelli	S. scovelli upper	S. scovelli lower	Opsanus	Opsanus upper	Opsanus lower	all forage	all forage upper	all forage lower
TR	0.9	0	26	348	-10	2	27	0	17	140	-5	-2	30	-11	99	1284	3	2	2774	0	682	20812	-46
TR	0.9	0	39	466	-9	1	23	0	14	126	-6	-2	30	-11	64	848	1	1	1672	0	1069	28983	-29
TR	0.9	0	27	354	-10	0	13	0	18	146	-5	-1	33	-11	46	625	-1	0	404	0	434	11946	-60
TR	0.9	0	32	402	-10	1	15	0	16	137	-5	2	41	-10	56	741	0	2	3010	0	318	10724	-66
TR	0.9	0	27	354	-10	2	27	0	17	140	-5	-1	31	-11	101	1299	4	2	2780	0	688	20900	-46
TR	0.9	0	40	470	-9	1	23	0	14	126	-6	-2	30	-11	64	854	1	1	1671	0	1075	29084	-28
TR	0.9	0	27	356	-10	0	13	0	18	146	-5	-1	33	-11	46	627	-1	0	403	0	435	11959	-60
TR	0.9	0	33	404	-10	1	15	0	16	137	-5	2	41	-10	56	744	0	2	3009	0	319	10737	-66
TR	0.9	0	27	356	-10	2	27	0	17	140	-5	-1	31	-11	101	1306	4	2	2781	0	690	20932	-46
TR	0.9	0	40	472	-9	1	23	0	14	126	-6	-2	30	-11	65	856	1	1	1669	0	1078	29125	-28
TR	0.9	30	33	404	-10	1	24	0	20	157	-5	0	36	-10	89	1151	3	2	3191	0	613	18821	-50
TR	0.9	30	44	503	-8	1	22	0	16	134	-5	-1	33	-11	60	801	0	1	1800	0	1025	27524	-31
TR	0.9	30	26	345	-10	0	13	0	17	143	-5	-1	32	-11	47	636	-1	0	393	0	441	12188	-60
TR	0.9	30	27	351	-10	1	17	0	13	121	-6	0	35	-11	64	849	1	2	2566	0	353	11428	-64
TR	0.9	30	33	410	-10	1	25	0	20	157	-5	0	37	-10	90	1165	3	2	3196	0	618	18904	-50
TR	0.9	30	44	508	-8	1	22	0	16	134	-5	-1	33	-11	61	807	0	1	1797	0	1031	27624	-31
TR	0.9	30	26	346	-10	0	13	0	17	143	-5	-1	32	-11	47	638	-1	0	392	0	442	12202	-60
TR	0.9	30	27	353	-10	1	17	0	13	121	-6	0	35	-11	65	852	1	2	2564	0	354	11442	-63
TR	0.9	30	34	413	-9	1	25	0	20	158	-5	0	37	-10	91	1172	3	2	3197	0	620	18940	-50
TR	0.9	30	44	510	-8	1	22	0	16	134	-5	-1	33	-11	61	809	0	1	1796	0	1034	27669	-31
TR	1	0	26	350	-10	1	26	0	17	142	-5	-1	31	-11	97	1251	3	2	2817	0	666	20419	-47
TR	1	0	39	465	-9	1	23	0	14	127	-6	-2	30	-11	63	838	1	1	1683	0	1059	28736	-29
TR	1	0	27	357	-10	0	13	0	18	148	-5	0	34	-11	45	612	-1	0	412	0	426	11719	-61
TR	1	0	34	414	-9	1	14	0	17	143	-5	2	43	-10	52	700	0	2	3164	0	306	10513	-67
TR	1	0	26	350	-10	1	26	0	17	142	-5	-1	31	-11	97	1251	3	2	2817	0	666	20418	-47
TR	1	0	39	465	-9	1	23	0	14	127	-6	-2	30	-11	63	838	1	1	1683	0	1059	28735	-29
TR	1	0	27	357	-10	0	13	0	18	148	-5	0	34	-11	45	612	-1	0	412	0	426	11720	-61
TR	1	0	34	414	-9	1	14	0	17	143	-5	2	43	-10	52	699	0	2	3163	0	305	10512	-67
TR	1	0	26	350	-10	1	26	0	17	142	-5	-1	31	-11	97	1251	3	2	2817	0	666	20419	-47
TR	1	0	39	465	-9	1	23	0	14	127	-6	-2	30	-11	63	838	1	1	1683	0	1059	28739	-29
TR	1	30	33	412	-9	1	23	0	21	161	-5	1	38	-10	85	1106	2	2	3291	0	592	18328	-51
TR	1	30	44	506	-8	1	21	0	16	136	-5	-1	33	-11	59	786	0	1	1825	0	1009	27126	-32
TR	1	30	26	346	-10	0	13	0	17	144	-5	-1	33	-11	46	623	-1	0	399	0	433	11973	-60
TR	1	30	27	357	-10	1	16	0	14	124	-6	0	36	-11	62	814	0	2	2656	0	341	11187	-64
TR	1	30	33	411	-10	1	23	0	21	161	-5	1	38	-10	85	1103	2	2	3289	0	591	18310	-51
TR	1	30	44	505	-8	1	21	0	16	136	-5	-1	33	-11	59	785	0	1	1825	0	1009	27109	-32
TR	1	30	26	345	-10	0	13	0	17	144	-5	-1	33	-11	46	622	-1	0	399	0	433	11972	-60
TR	1	30	27	357	-10	1	16	0	14	124	-6	0	36	-11	62	813	0	2	2656	0	340	11184	-64
TR	1	30	33	410	-10	1	23	0	21	161	-5	1	38	-10	85	1103	2	2	3288	0	591	18307	-51
TR	1	30	44	505	-8	1	21	0	16	136	-5	-1	33	-11	59	785	0	1	1826	0	1008	27108	-32
TR	1.1	0	26	351	-10	1	26	0	17	143	-5	-1	32	-11	94	1218	3	2	2860	0	650	20032	-48
TR	1.1	0	39	463	-9	1	22	0	14	127	-6	-2	30	-11	62	827	0	1	1693	0	1047	28465	-30
TR	1.1	0	27	359	-10	0	12	0	18	150	-5	0	35	-11	44	598	-1	0	419	0	417	11489	-61
TR	1.1	0	35	423	-9	1	13	0	18	148	-5	3	46	-10	49	657	-1	2	3290	0	294	10313	-67
TR	1.1	0	26	345	-10	1	26	0	17	143	-5	-1	31	-11	93	1200	3	2	2850	0	644	19924	-49
TR	1.1	0	38	458	-9	1	22	0	14	127	-6	-2	30	-11	62	820	0	1	1693	0	1040	28327	-30
TR	1.1	0	27	357	-10	0	12	0	18	150	-5	0	34	-11	44	595	-1	0	420	0	415	11470	-62
TR	1.1	0	35	420	-9	1	13	0	18	148	-5	3	46	-10	49	653	-1	2	3288	0	293	10291	-68
TR	1.1	0	25	342	-10	1	25	0	17	143	-5	-1	31	-11	92	1193	3	2	2847	0	641	19882	-49
TR	1.1	0	38	456	-9	1	22	0	14	127	-6	-2	30	-11	61	816	0	1	1694	0	1036	28273	-31
TR	1.1	30	34	419	-9	1	23	0	21	165	-4	1	39	-10	82	1061	2	2	3393	0	573	17864	-53
TR	1.1	30	44	507	-8	1	21	0	16	137	-5	-1	34	-11	58	770	0	1	1851	0	993	26711	-33
TR	1.1	30	26	346	-10	0	12	0	18	146	-5	-1	33	-11	45	608	-1	0	406	0	424	11753	-61
TR	1.1	30	28	361	-10	1	15	0	15	127	-6	0	37	-10	59	777	0	2	2746	0	328	10945	-65
TR	1.1	30	33	409	-10	1	22	0	21	165	-4	1	39	-10	80	1041	2	2	3379	0	564	17721	-53

Appendix Table A-4.

Site	Salt Trmt	Lag	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Cynoscion	Cynoscion upper	Cynoscion lower	S. floridae	S. floridae upper	S. floridae lower	Atherino-morus	Atherino-morus upper	Atherino-morus lower	S. scovelli	S. scovelli upper	S. scovelli lower	Opsanus	Opsanus upper	Opsanus lower	all forage	all forage upper	all forage lower
TR	1.1	30	43	500	-8	1	21	0	16	137	-5	-1	34	-11	57	761	0	1	1851	0	983	26533	-34
TR	1.1	30	26	343	-10	0	12	0	18	146	-5	-1	33	-11	44	605	-1	0	407	0	422	11727	-61
TR	1.1	30	27	358	-10	1	15	0	14	127	-6	0	37	-10	58	772	0	2	2745	0	326	10917	-65
TR	1.1	30	33	405	-10	1	22	0	21	165	-4	1	39	-10	79	1032	2	2	3373	0	561	17663	-53
TR	1.1	30	43	496	-8	1	21	0	16	137	-5	-1	33	-11	57	757	0	1	1851	0	978	26458	-34
TR	1.3	0	27	352	-10	1	25	0	18	147	-5	-1	33	-11	89	1150	3	2	2943	0	619	19267	-50
TR	1.3	0	38	457	-9	1	22	0	15	128	-6	-2	30	-11	60	801	0	1	1711	0	1019	27832	-32
TR	1.3	0	27	359	-10	0	12	0	19	154	-5	0	36	-11	41	565	-1	0	434	0	397	11002	-63
TR	1.3	0	35	420	-9	0	12	0	19	154	-5	4	50	-9	41	564	-1	2	3291	0	274	9818	-69
TR	1.3	0	24	331	-11	1	23	0	18	145	-5	-1	32	-11	84	1092	2	2	2902	0	596	18880	-52
TR	1.3	0	36	437	-9	1	21	0	14	127	-6	-2	30	-11	58	772	0	1	1703	0	988	27263	-33
TR	1.3	0	26	350	-10	0	11	0	19	153	-5	0	35	-11	40	554	-1	0	435	0	391	10899	-63
TR	1.3	0	33	408	-10	0	11	0	19	153	-5	4	50	-9	40	551	-1	2	3275	0	268	9719	-69
TR	1.3	0	23	320	-11	1	23	0	18	145	-5	-1	32	-11	82	1063	2	2	2880	0	585	18688	-52
TR	1.3	0	35	426	-9	1	21	0	14	127	-6	-2	30	-11	57	757	0	1	1698	0	971	26952	-34
TR	1.3	30	36	432	-9	1	21	0	23	174	-4	2	42	-10	75	974	2	2	3607	0	536	17018	-55
TR	1.3	30	44	507	-8	1	20	0	17	140	-5	0	35	-11	55	733	0	1	1899	0	956	25804	-35
TR	1.3	30	26	342	-10	0	12	0	18	149	-5	0	34	-11	42	576	-1	0	418	0	404	11276	-62
TR	1.3	30	28	364	-10	1	14	0	16	134	-5	1	39	-10	52	700	0	2	2920	0	301	10458	-67
TR	1.3	30	32	401	-10	1	20	0	22	172	-4	2	41	-10	70	915	1	2	3547	0	510	16549	-56
TR	1.3	30	41	480	-9	1	19	0	17	139	-5	0	34	-11	52	702	0	1	1888	0	918	25119	-37
TR	1.3	30	24	332	-11	0	12	0	18	148	-5	-1	34	-11	41	562	-1	0	418	0	396	11146	-63
TR	1.3	30	27	350	-10	1	14	0	16	133	-5	1	39	-10	51	679	0	2	2902	0	294	10332	-68
TR	1.3	30	31	385	-10	1	19	0	22	171	-4	2	41	-10	68	885	1	2	3512	0	496	16303	-57
TR	1.3	30	39	464	-9	1	19	0	16	138	-5	-1	34	-11	51	683	0	1	1879	0	897	24717	-38
TR	10	0	31	388	-10	1	20	0	22	167	-4	1	39	-10	72	940	1	2	3421	0	520	16797	-56
TR	10	0	45	513	-8	1	17	0	19	150	-5	1	38	-10	47	629	-1	1	2063	0	847	23134	-41
TR	10	0	29	369	-10	0	9	0	23	173	-4	2	42	-10	31	434	-2	0	503	0	320	8987	-68
TR	10	0	26	344	-10	0	10	0	18	148	-5	5	51	-9	31	437	-2	2	2843	0	234	8771	-72
TR	10	0	22	311	-11	1	17	0	20	160	-5	0	37	-10	59	778	0	2	3205	0	448	15429	-61
TR	10	0	35	425	-9	1	15	0	18	145	-5	0	36	-11	39	535	-1	1	1963	0	728	20804	-48
TR	10	0	24	329	-11	0	8	0	22	169	-4	1	40	-10	28	394	-2	0	488	0	291	8499	-70
TR	10	0	22	308	-11	0	9	0	18	145	-5	4	49	-9	28	398	-2	2	2749	0	213	8375	-74
TR	10	0	18	275	-11	1	16	0	20	156	-5	0	35	-11	52	700	0	2	3081	0	414	14754	-63
TR	10	0	30	380	-10	1	14	0	17	142	-5	0	35	-11	35	486	-2	1	1895	0	666	19572	-52
TR	10	30	38	452	-9	1	18	0	26	189	-4	4	47	-9	63	828	1	3	3968	0	478	15743	-58
TR	10	30	50	552	-8	1	16	0	20	160	-5	2	42	-10	43	584	-1	1	2235	0	810	22026	-43
TR	10	30	27	356	-10	0	9	0	22	169	-4	1	40	-10	31	440	-2	0	488	0	322	9115	-68
TR	10	30	25	335	-10	0	11	0	17	142	-5	2	43	-10	39	534	-1	2	3108	0	243	9374	-71
TR	10	30	28	358	-10	1	15	0	24	181	-4	3	44	-10	51	678	0	2	3704	0	404	14274	-63
TR	10	30	38	454	-9	1	14	0	19	155	-5	1	39	-10	36	494	-2	1	2122	0	688	19647	-50
TR	10	30	23	317	-11	0	9	0	21	165	-4	1	39	-10	28	398	-2	0	472	0	293	8619	-70
TR	10	30	21	298	-11	0	10	0	17	139	-5	2	41	-10	35	483	-2	2	2998	0	222	8950	-73
TR	10	30	23	316	-11	1	14	0	23	176	-4	2	43	-10	45	608	-1	2	3556	0	369	13566	-65
TR	10	30	33	407	-10	0	13	0	19	151	-5	1	38	-10	32	449	-2	1	2048	0	627	18431	-54
TR	20	0	35	428	-9	1	16	0	26	193	-4	4	50	-9	53	712	0	3	3924	0	436	14752	-61
TR	20	0	52	573	-7	1	13	0	23	177	-4	4	48	-9	34	474	-2	2	2515	0	698	19356	-49
TR	20	0	31	390	-10	0	7	0	27	198	-3	5	52	-9	21	315	-3	0	575	0	260	7344	-71
TR	20	0	11	210	-12	0	7	0	13	117	-6	7	58	-9	16	250	-3	1	1205	0	230	7670	-75
TR	20	0	23	315	-11	0	13	0	24	181	-4	3	45	-10	40	546	-1	2	3557	0	347	12942	-67
TR	20	0	38	447	-9	0	11	0	22	168	-4	3	44	-10	27	382	-2	1	2328	0	560	16606	-57
TR	20	0	27	353	-10	0	6	0	26	194	-3	4	50	-9	19	289	-3	0	557	0	238	6957	-73
TR	20	0	9	192	-12	0	7	0	12	115	-6	6	57	-9	14	231	-3	1	1172	0	214	7393	-76
TR	20	0	20	288	-11	0	12	0	24	178	-4	3	44	-10	37	506	-2	2	3456	0	326	12505	-68
TR	20	0	34	416	-9	0	11	0	21	166	-4	2	43	-10	25	358	-3	1	2274	0	526	15926	-59

Appendix Table A-4.

Site	Salt Trmt	Lag	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Cynoscion	Cynoscion upper	Cynoscion lower	S. floridae	S. floridae upper	S. floridae lower	Atherino-morus	Atherino-morus upper	Atherino-morus lower	S. scovelli	S. scovelli upper	S. scovelli lower	Opsanus	Opsanus upper	Opsanus lower	all forage	all forage upper	all forage lower
TR	20	30	32	401	-10	1	14	0	25	188	-4	7	57	-9	42	570	-1	2	3034	0	443	14072	-61
TR	20	30	56	610	-7	0	13	0	25	187	-4	5	52	-9	31	440	-2	2	2655	0	684	18870	-49
TR	20	30	30	384	-10	0	7	0	27	196	-3	4	50	-9	22	323	-3	0	572	0	261	7407	-71
TR	20	30	19	280	-11	0	8	0	17	139	-5	5	51	-9	24	350	-3	1	2322	0	208	7938	-75
TR	20	30	20	293	-11	0	11	0	23	176	-4	5	52	-9	31	435	-2	2	2747	0	349	12218	-68
TR	20	30	41	476	-9	0	10	0	24	178	-4	4	49	-9	24	354	-3	2	2458	0	546	16118	-57
TR	20	30	26	347	-10	0	7	0	26	192	-4	4	49	-9	20	296	-3	0	554	0	239	7025	-73
TR	20	30	16	256	-11	0	8	0	16	137	-5	4	50	-9	22	323	-3	1	2256	0	193	7648	-76
TR	20	30	17	269	-11	0	11	0	23	173	-4	5	51	-9	28	403	-2	2	2669	0	328	11783	-69
TR	20	30	37	444	-9	0	10	0	23	176	-4	4	48	-9	23	333	-3	2	2402	0	513	15447	-59
TC	0.9	0	17	269	-11	1	21	0	16	137	-5	-1	31	-11	64	841	1	1	2117	0	490	15355	-58
TC	0.9	0	28	365	-10	1	19	0	13	121	-6	-2	29	-11	45	617	-1	1	1308	0	838	22981	-41
TC	0.9	0	23	323	-11	0	10	0	19	152	-5	1	38	-10	32	446	-2	0	360	0	324	8938	-67
TC	0.9	0	25	333	-10	0	11	0	16	138	-5	3	44	-10	36	493	-2	2	2383	0	230	8120	-72
TC	0.9	0	18	276	-11	1	21	0	16	138	-5	-1	31	-11	65	859	1	1	2134	0	498	15507	-57
TC	0.9	0	29	374	-10	1	19	0	13	122	-6	-2	29	-11	46	629	-1	1	1315	0	853	23269	-40
TC	0.9	0	24	328	-11	0	10	0	19	152	-5	1	38	-10	32	452	-2	0	360	0	328	9008	-67
TC	0.9	0	25	339	-10	0	12	0	17	138	-5	3	44	-10	36	500	-2	2	2390	0	233	8171	-72
TC	0.9	0	19	282	-11	1	22	0	16	138	-5	-1	31	-11	66	874	1	1	2144	0	504	15619	-57
TC	0.9	0	30	381	-10	1	20	0	13	122	-6	-2	30	-11	47	638	-1	1	1319	0	865	23494	-39
TC	0.9	30	23	323	-11	1	18	0	20	159	-5	1	38	-10	54	722	0	2	2550	0	425	13555	-61
TC	0.9	30	31	391	-10	1	18	0	15	129	-6	-1	32	-11	42	578	-1	1	1412	0	796	21698	-43
TC	0.9	30	21	298	-11	0	10	0	18	144	-5	0	35	-11	33	456	-2	0	338	0	330	9238	-67
TC	0.9	30	21	305	-11	0	12	0	15	129	-6	1	40	-10	38	519	-2	1	2195	0	235	8224	-72
TC	0.9	30	23	321	-11	1	18	0	20	159	-5	1	38	-10	54	719	0	2	2546	0	423	13523	-62
TC	0.9	30	31	390	-10	1	18	0	15	129	-6	-1	32	-11	42	576	-1	1	1410	0	793	21642	-44
TC	0.9	30	20	297	-11	0	10	0	17	144	-5	0	35	-11	32	455	-2	0	338	0	329	9227	-67
TC	0.9	30	21	304	-11	0	12	0	15	129	-6	1	40	-10	38	518	-2	1	2193	0	235	8215	-72
TC	0.9	30	23	320	-11	1	18	0	20	159	-5	1	38	-10	54	717	0	2	2544	0	422	13506	-62
TC	0.9	30	31	389	-10	1	18	0	15	129	-6	-1	32	-11	42	575	-1	1	1409	0	792	21611	-44
TC	1	0	18	271	-11	1	20	0	17	139	-5	-1	32	-11	61	811	0	1	2164	0	474	14954	-59
TC	1	0	28	361	-10	1	19	0	13	121	-6	-2	29	-11	44	600	-1	1	1312	0	818	22529	-42
TC	1	0	23	321	-11	0	10	0	19	155	-5	1	39	-10	30	421	-2	0	368	0	307	8545	-68
TC	1	0	25	332	-10	0	10	0	17	142	-5	3	46	-10	32	447	-2	2	2415	0	216	7829	-73
TC	1	0	17	265	-11	1	20	0	17	139	-5	-1	31	-11	60	796	0	1	2150	0	468	14831	-59
TC	1	0	27	353	-10	1	18	0	13	121	-6	-2	29	-11	43	590	-1	1	1305	0	806	22277	-43
TC	1	0	23	316	-11	0	10	0	19	154	-5	1	39	-10	29	416	-2	0	367	0	304	8483	-68
TC	1	0	24	327	-11	0	10	0	17	142	-5	3	46	-10	31	442	-2	2	2406	0	213	7782	-73
TC	1	0	16	261	-11	1	20	0	16	138	-5	-1	31	-11	59	785	0	1	2139	0	462	14735	-59
TC	1	0	26	348	-10	1	18	0	13	121	-6	-2	29	-11	43	582	-1	1	1299	0	796	22083	-43
TC	1	30	25	332	-10	1	17	0	21	165	-4	1	40	-10	51	685	0	2	2662	0	407	13132	-62
TC	1	30	31	389	-10	1	17	0	15	130	-6	-1	32	-11	41	558	-1	1	1427	0	772	21123	-45
TC	1	30	20	294	-11	0	10	0	18	146	-5	0	36	-10	31	432	-2	0	343	0	314	8862	-68
TC	1	30	22	307	-11	0	11	0	16	134	-5	2	42	-10	34	478	-2	1	2283	0	220	7936	-73
TC	1	30	23	315	-11	1	17	0	21	163	-4	1	40	-10	49	655	-1	2	2619	0	392	12834	-63
TC	1	30	29	371	-10	1	17	0	15	129	-6	-1	32	-11	39	535	-1	1	1408	0	743	20539	-47
TC	1	30	19	284	-11	0	10	0	18	146	-5	0	36	-11	30	420	-2	0	340	0	305	8718	-68
TC	1	30	20	296	-11	0	11	0	16	133	-5	2	41	-10	33	464	-2	1	2261	0	214	7823	-73
TC	1	30	21	303	-11	1	16	0	21	162	-5	1	39	-10	47	633	-1	2	2586	0	380	12616	-64
TC	1	30	27	357	-10	1	16	0	15	128	-6	-1	32	-11	37	518	-2	1	1392	0	720	20094	-48
TC	1.1	0	18	274	-11	1	20	0	17	142	-5	-1	32	-11	59	784	0	1	2211	0	459	14579	-60
TC	1.1	0	27	356	-10	1	18	0	13	122	-6	-2	29	-11	43	585	-1	1	1317	0	800	22100	-43
TC	1.1	0	23	320	-11	0	9	0	20	158	-5	1	40	-10	28	398	-2	0	376	0	292	8183	-69
TC	1.1	0	24	323	-11	0	10	0	17	144	-5	4	49	-9	28	402	-2	1	2329	0	206	7523	-74
TC	1.1	0	16	257	-11	1	19	0	17	140	-5	-1	32	-11	56	742	0	1	2168	0	441	14228	-61

Appendix Table A-4.

Site	Salt Trmt	Lag	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Cynoscion	Cynoscion upper	Cynoscion lower	S. floridae	S. floridae upper	S. floridae lower	Atherino-morus	Atherino-morus upper	Atherino-morus lower	S. scovelli	S. scovelli upper	S. scovelli lower	Opsanus	Opsanus upper	Opsanus lower	all forage	all forage upper	all forage lower
TC	1.1	0	25	336	-10	1	17	0	13	120	-6	-2	29	-11	40	556	-1	1	1294	0	764	21396	-45
TC	1.1	0	22	307	-11	0	9	0	20	157	-5	1	40	-10	27	383	-2	0	372	0	282	8007	-70
TC	1.1	0	22	310	-11	0	9	0	17	142	-5	4	48	-9	27	388	-2	1	2301	0	198	7389	-74
TC	1.1	0	15	245	-12	1	18	0	17	139	-5	-1	31	-11	53	712	0	1	2135	0	427	13974	-62
TC	1.1	0	23	321	-11	1	17	0	13	119	-6	-2	28	-11	39	534	-1	1	1276	0	738	20871	-47
TC	1.1	30	26	342	-10	1	16	0	22	171	-4	2	42	-10	49	651	-1	2	2777	0	392	12767	-63
TC	1.1	30	31	387	-10	1	17	0	15	132	-6	-1	33	-11	39	539	-1	1	1443	0	750	20586	-46
TC	1.1	30	20	292	-11	0	9	0	18	149	-5	0	37	-10	29	411	-2	0	348	0	299	8520	-69
TC	1.1	30	22	307	-11	0	10	0	16	138	-5	3	44	-10	31	440	-2	2	2340	0	208	7686	-74
TC	1.1	30	22	313	-11	1	15	0	22	168	-4	2	41	-10	45	602	-1	2	2698	0	366	12260	-65
TC	1.1	30	27	356	-10	1	16	0	15	129	-6	-1	32	-11	36	501	-2	1	1406	0	700	19602	-49
TC	1.1	30	18	275	-11	0	9	0	18	147	-5	0	36	-10	27	391	-2	0	343	0	286	8284	-70
TC	1.1	30	20	290	-11	0	10	0	16	136	-5	2	43	-10	30	419	-2	1	2300	0	198	7501	-74
TC	1.1	30	20	293	-11	1	15	0	21	166	-4	2	40	-10	42	570	-1	2	2642	0	349	11924	-66
TC	1.1	30	25	334	-10	1	15	0	15	128	-6	-1	31	-11	34	475	-2	1	1379	0	666	18928	-51
TC	1.3	0	19	281	-11	1	18	0	18	147	-5	0	34	-11	55	735	0	1	2312	0	433	13912	-61
TC	1.3	0	26	350	-10	1	17	0	14	123	-6	-2	30	-11	41	559	-1	1	1328	0	768	21351	-45
TC	1.3	0	23	322	-11	0	8	0	21	165	-4	2	42	-10	25	360	-3	0	395	0	269	7578	-71
TC	1.3	0	18	277	-11	0	8	0	16	135	-5	5	53	-9	21	313	-3	1	1741	0	196	6884	-75
TC	1.3	0	15	249	-12	1	17	0	17	144	-5	-1	33	-11	49	663	-1	1	2222	0	399	13266	-63
TC	1.3	0	22	314	-11	1	16	0	13	120	-6	-2	29	-11	37	507	-2	1	1282	0	705	20093	-49
TC	1.3	0	21	300	-11	0	8	0	21	162	-5	2	41	-10	23	338	-3	0	386	0	252	7293	-72
TC	1.3	0	16	259	-11	0	8	0	16	133	-5	5	52	-9	20	296	-3	1	1704	0	184	6675	-76
TC	1.3	0	13	231	-12	1	16	0	17	142	-5	-1	32	-11	46	620	-1	1	2167	0	380	12895	-65
TC	1.3	0	20	292	-11	1	15	0	13	118	-6	-2	28	-11	34	477	-2	1	1252	0	668	19354	-51
TC	1.3	30	28	360	-10	1	15	0	24	181	-4	3	47	-10	43	587	-1	2	2937	0	369	12193	-65
TC	1.3	30	31	387	-10	1	16	0	16	135	-5	0	34	-11	37	508	-2	1	1479	0	712	19663	-48
TC	1.3	30	20	292	-11	0	9	0	19	153	-5	1	38	-10	26	376	-2	0	361	0	277	7951	-70
TC	1.3	30	21	300	-11	0	9	0	17	141	-5	4	48	-9	26	371	-2	1	2238	0	192	7219	-75
TC	1.3	30	22	313	-11	1	14	0	23	176	-4	3	45	-10	38	520	-1	2	2803	0	331	11427	-67
TC	1.3	30	25	340	-10	1	15	0	15	131	-6	-1	33	-11	32	454	-2	1	1418	0	641	18248	-52
TC	1.3	30	17	270	-11	0	8	0	19	151	-5	1	37	-10	24	352	-3	0	352	0	260	7650	-71
TC	1.3	30	18	278	-11	0	9	0	17	139	-5	3	47	-9	24	348	-3	1	2185	0	180	6985	-76
TC	1.3	30	20	289	-11	0	13	0	23	173	-4	3	44	-10	35	485	-2	2	2729	0	311	11029	-69
TC	1.3	30	23	316	-11	1	14	0	15	129	-6	-1	32	-11	30	426	-2	1	1383	0	604	17502	-55
TC	10	0	23	318	-11	1	16	0	21	166	-4	2	41	-10	47	636	-1	2	2669	0	383	12623	-64
TC	10	0	33	409	-10	1	14	0	17	144	-5	1	38	-10	33	458	-2	1	1599	0	659	18189	-51
TC	10	0	26	343	-10	0	7	0	24	181	-4	4	48	-9	20	304	-3	0	440	0	238	6721	-72
TC	10	0	14	243	-12	0	8	0	15	128	-6	6	54	-9	18	273	-3	1	1463	0	187	6553	-76
TC	10	0	17	266	-11	1	14	0	20	160	-5	1	38	-10	40	545	-1	2	2509	0	336	11680	-67
TC	10	0	27	350	-10	0	13	0	17	139	-5	0	36	-11	28	399	-2	1	1516	0	575	16530	-56
TC	10	0	23	317	-11	0	7	0	24	178	-4	4	47	-9	19	284	-3	0	428	0	222	6428	-74
TC	10	0	13	226	-12	0	7	0	14	126	-6	5	53	-9	16	257	-3	1	1429	0	175	6347	-77
TC	10	0	15	247	-12	1	13	0	20	157	-5	1	38	-10	37	511	-2	2	2446	0	318	11330	-68
TC	10	0	24	327	-11	0	12	0	16	137	-5	0	35	-11	26	376	-2	1	1481	0	544	15900	-58
TC	10	30	28	359	-10	1	14	0	25	186	-4	5	51	-9	38	521	-1	2	2830	0	356	11718	-66
TC	10	30	37	440	-9	1	13	0	19	154	-5	2	41	-10	30	425	-2	1	1737	0	628	17296	-53
TC	10	30	23	320	-11	0	7	0	22	172	-4	3	45	-10	21	317	-3	0	414	0	242	6927	-72
TC	10	30	18	272	-11	0	8	0	16	137	-5	4	50	-9	21	319	-3	1	1939	0	181	6780	-76
TC	10	30	21	299	-11	0	12	0	24	178	-4	4	48	-9	32	443	-2	2	2654	0	307	10717	-69
TC	10	30	30	376	-10	0	12	0	18	149	-5	1	39	-10	26	369	-3	1	1645	0	545	15635	-58
TC	10	30	21	296	-11	0	7	0	22	169	-4	3	44	-10	20	296	-3	0	403	0	226	6641	-74
TC	10	30	16	253	-12	0	8	0	16	135	-5	4	49	-9	20	300	-3	1	1894	0	170	6570	-77
TC	10	30	18	278	-11	0	11	0	23	176	-4	3	47	-9	29	415	-2	2	2588	0	289	10368	-70
TC	10	30	27	352	-10	0	11	0	18	147	-5	1	39	-10	24	349	-3	1	1610	0	515	15044	-59

Appendix Table A-4.

Site	Salt Trmt	Lag	Farfante-penaeus	Farfante-penaeus upper	Farfante-penaeus lower	Cynoscion	Cynoscion upper	Cynoscion lower	S. floridae	S. floridae upper	S. floridae lower	Atherino-morus	Atherino-morus upper	Atherino-morus lower	S. scovelli	S. scovelli upper	S. scovelli lower	Opsanus	Opsanus upper	Opsanus lower	all forage	all forage upper	all forage lower
TC	20	0	25	339	-10	0	13	0	25	184	-4	5	51	-9	35	483	-2	2	2702	0	341	11338	-67
TC	20	0	41	479	-9	0	12	0	22	171	-4	4	48	-9	25	360	-3	1	1964	0	565	15660	-56
TC	20	0	24	327	-11	0	6	0	25	186	-4	7	59	-8	13	218	-4	0	370	0	222	6196	-74
TC	20	0	4	151	-13	0	6	0	9	99	-7	8	62	-8	9	163	-4	0	575	0	217	6843	-77
TC	20	0	18	279	-11	0	11	0	23	176	-4	4	48	-9	29	406	-2	2	2519	0	291	10317	-70
TC	20	0	33	408	-9	0	10	0	21	165	-4	3	46	-10	21	312	-3	1	1856	0	486	14077	-61
TC	20	0	22	309	-11	0	5	0	25	184	-4	7	58	-9	12	207	-4	0	363	0	210	5987	-75
TC	20	0	3	145	-13	0	6	0	9	98	-7	8	62	-8	8	157	-4	0	566	0	209	6705	-77
TC	20	0	17	266	-11	0	11	0	23	174	-4	4	48	-9	27	390	-2	2	2480	0	281	10115	-71
TC	20	0	32	393	-10	0	10	0	21	164	-4	3	45	-10	20	302	-3	1	1833	0	470	13752	-62
TC	20	30	16	259	-11	0	11	0	20	157	-5	7	60	-8	23	332	-3	1	1396	0	383	11417	-67
TC	20	30	44	502	-8	0	11	0	24	179	-4	5	52	-9	22	330	-3	1	2028	0	555	15285	-56
TC	20	30	25	340	-10	0	6	0	26	190	-4	6	56	-9	15	239	-3	0	420	0	218	6132	-74
TC	20	30	7	177	-12	0	6	0	11	109	-6	7	59	-8	11	195	-4	1	816	0	196	6458	-77
TC	20	30	11	212	-12	0	9	0	19	150	-5	6	57	-9	18	279	-3	1	1301	0	327	10336	-70
TC	20	30	36	429	-9	0	10	0	23	173	-4	4	50	-9	19	287	-3	1	1918	0	477	13718	-61
TC	20	30	23	322	-11	0	6	0	25	188	-4	6	55	-9	14	228	-3	0	412	0	207	5939	-75
TC	20	30	6	169	-13	0	6	0	11	108	-6	7	58	-9	11	187	-4	1	804	0	189	6327	-78
TC	20	30	10	203	-12	0	9	0	18	149	-5	6	56	-9	17	269	-3	1	1283	0	316	10137	-71
TC	20	30	34	415	-9	0	9	0	23	172	-4	4	49	-9	18	278	-3	1	1895	0	462	13415	-62