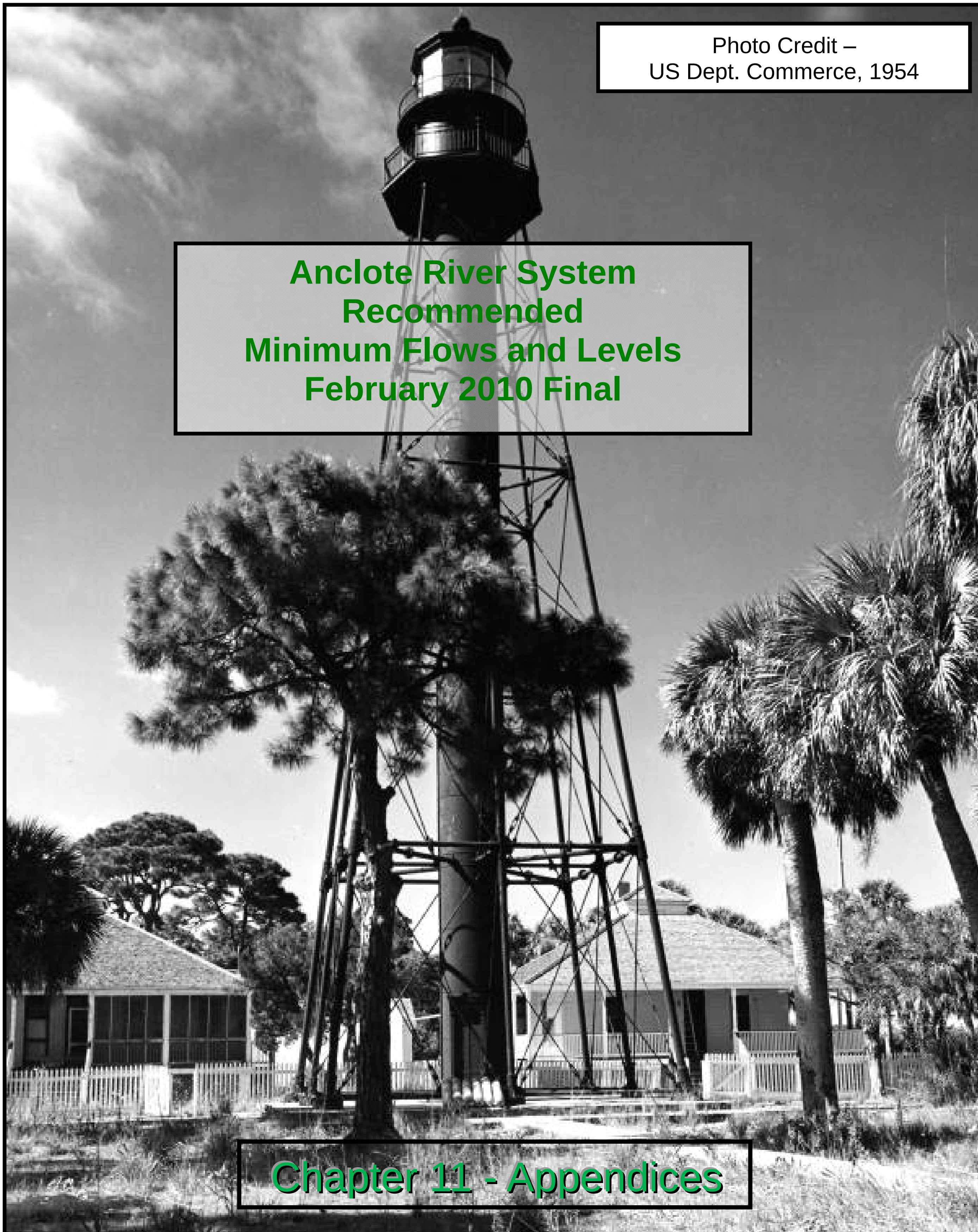
Photo Credit –
US Dept. Commerce, 1954

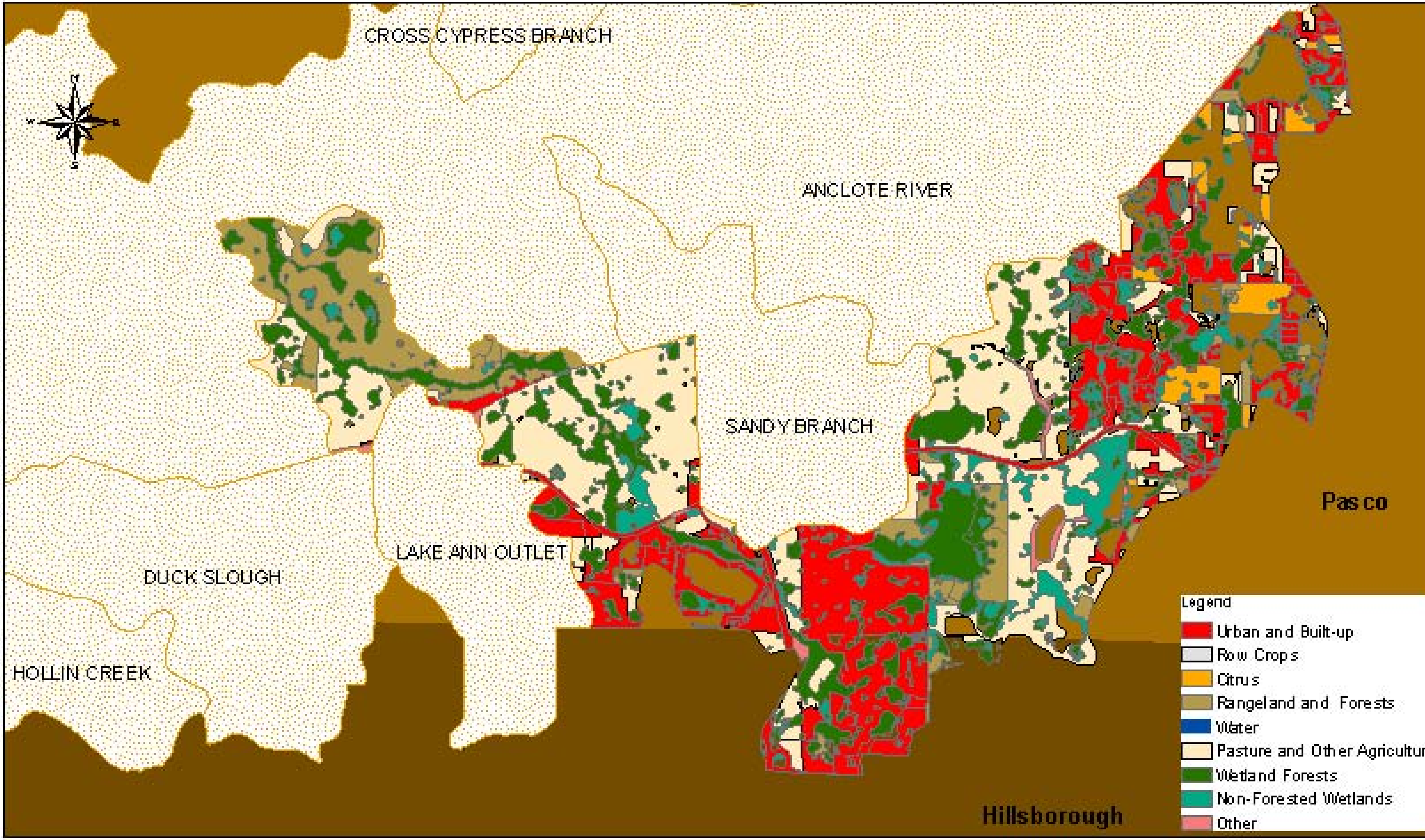
Anclote River System Recommended Minimum Flows and Levels February 2010 Final



Chapter 11 - Appendices

Prepared by: Southwest Florida Water Management District
Pursuant to 373.042 F.S.

Chapter 11 Appendices – Bound and Numbered Separately



2004 Land Use/Cover Map for the South Branch Sub-basin, Anclote River Watershed

Appendix Page 1

0 0.2 0.4 0.8 1.2 1.6 Miles

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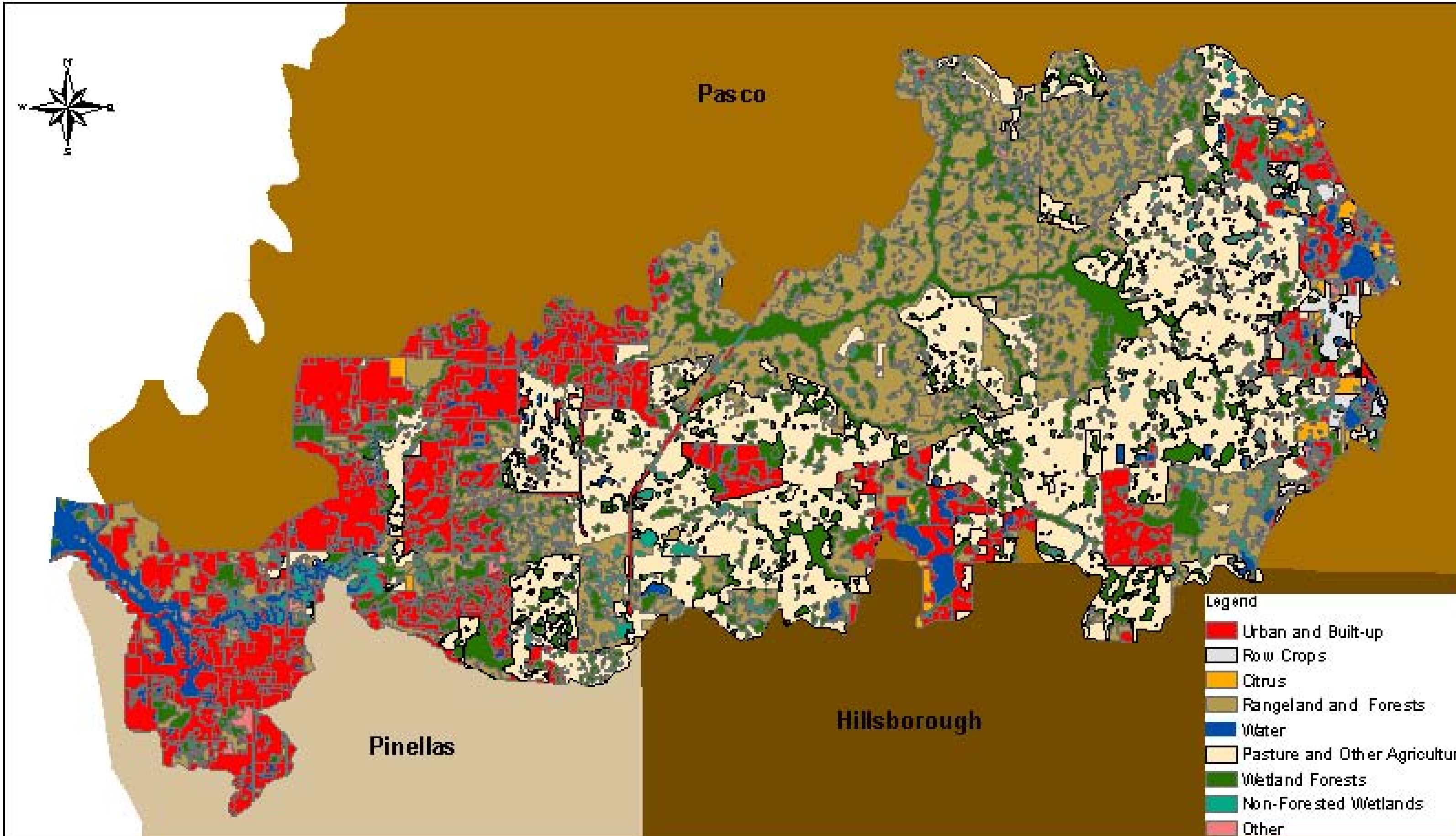

1990 Land Use/Cover Map for the Anclote River Watershed

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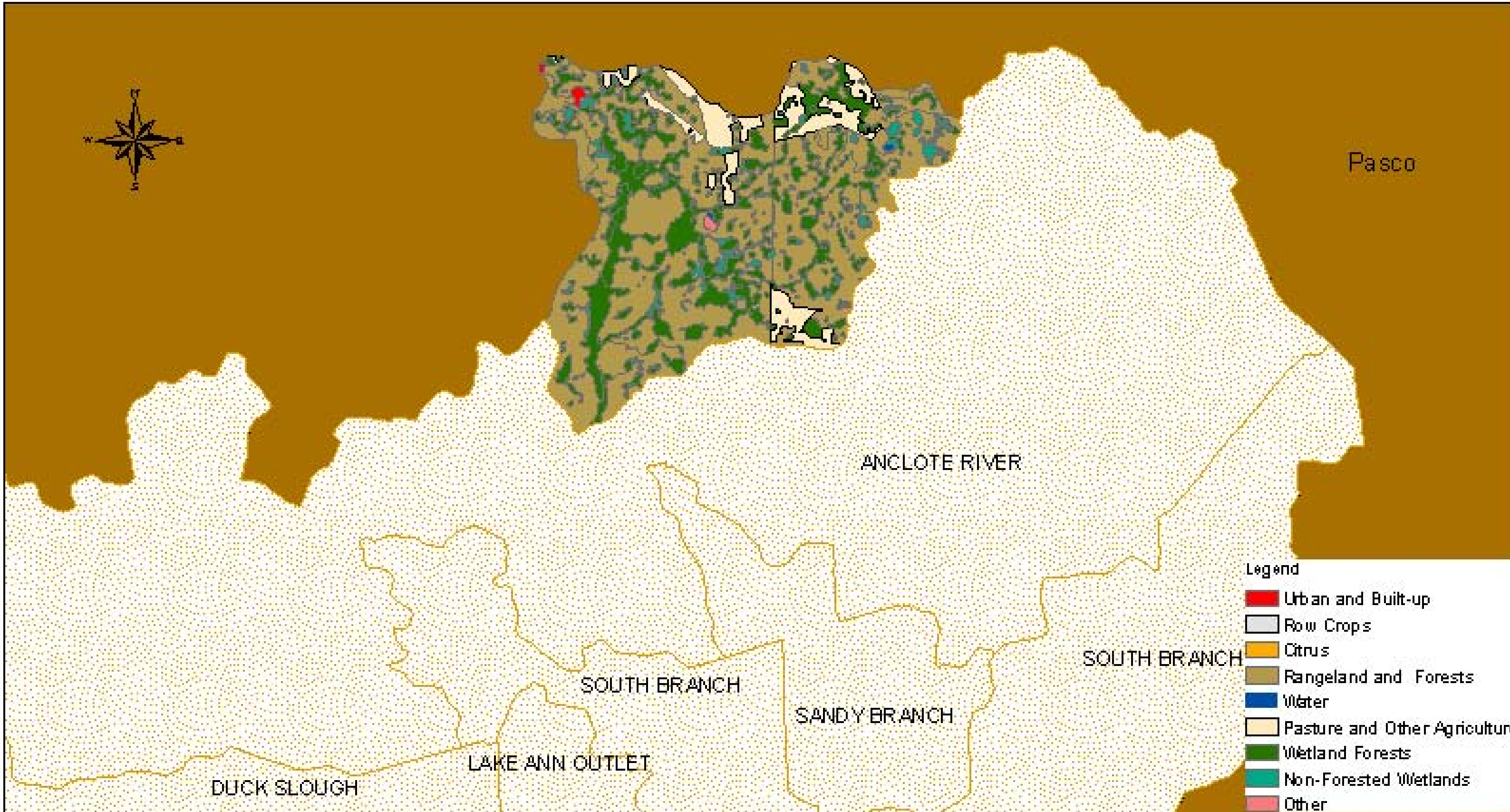

1990 Land Use/Cover Map for the Cross Cypress Branch Sub-basin, Anclote River Watershed

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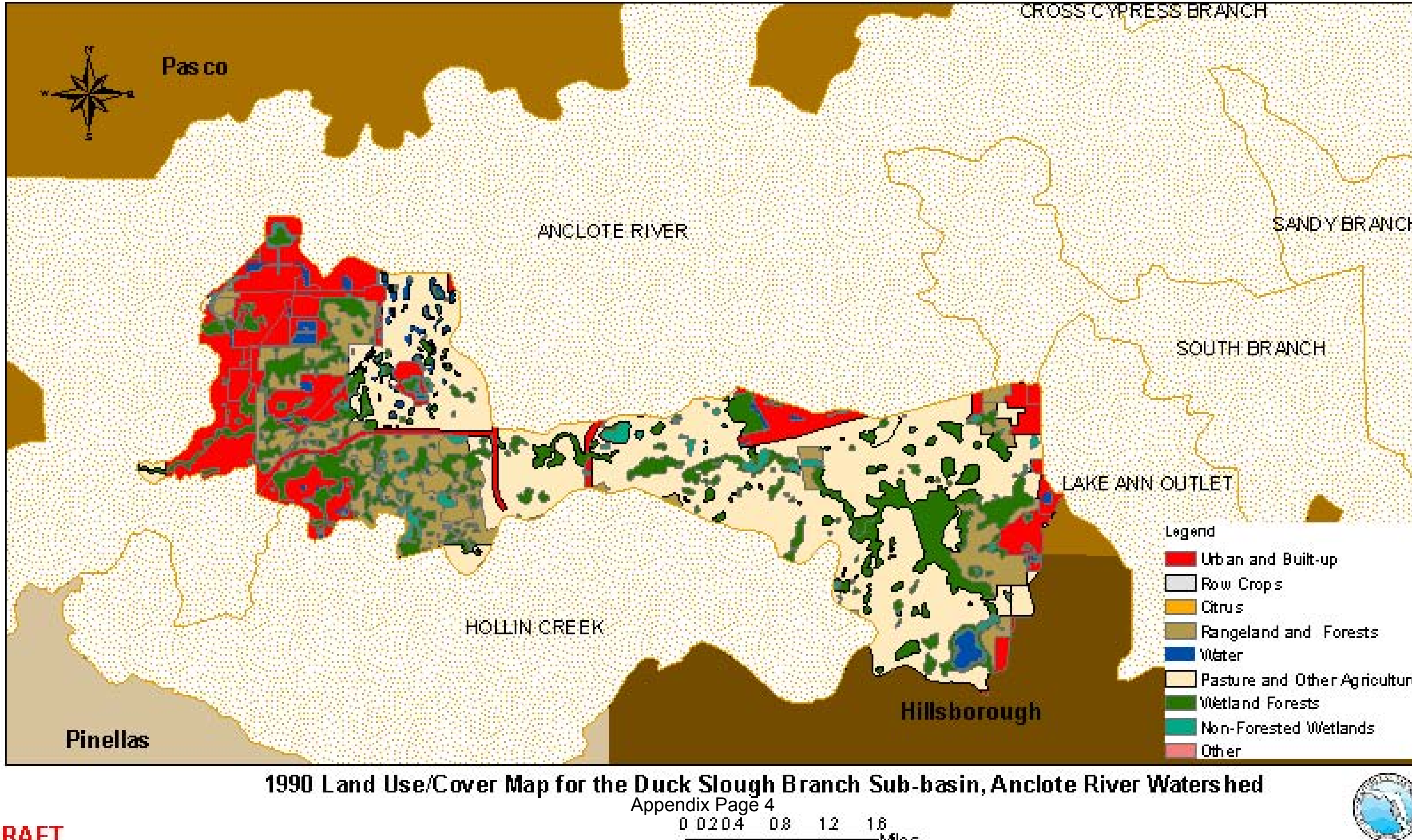

1990 Land Use/Cover Map for the Duck Slough Branch Sub-basin, Anclote River Watershed

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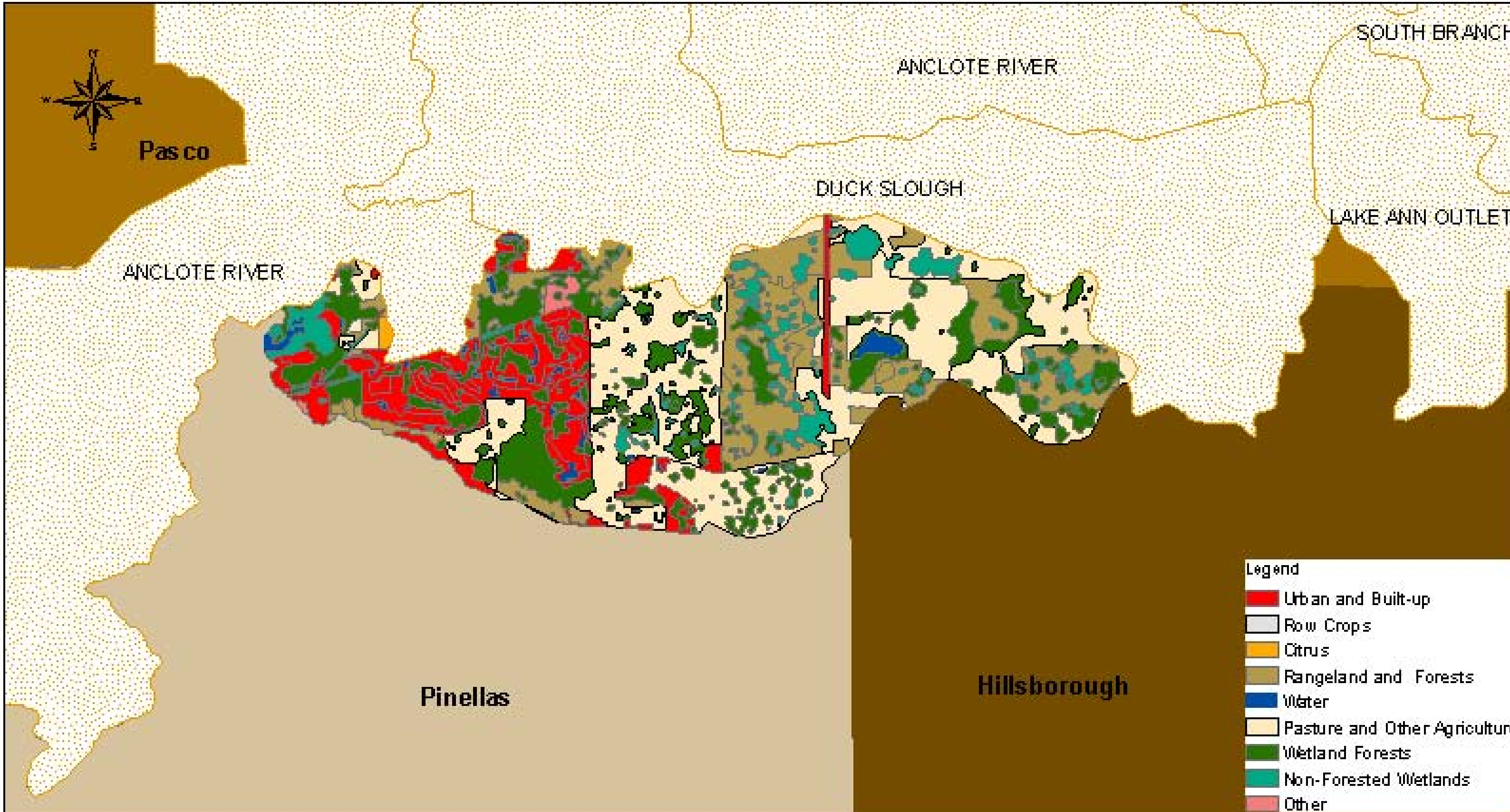

1990 Land Use/Cover Map for the Hollin Creek Sub-basin, Anclote River Watershed

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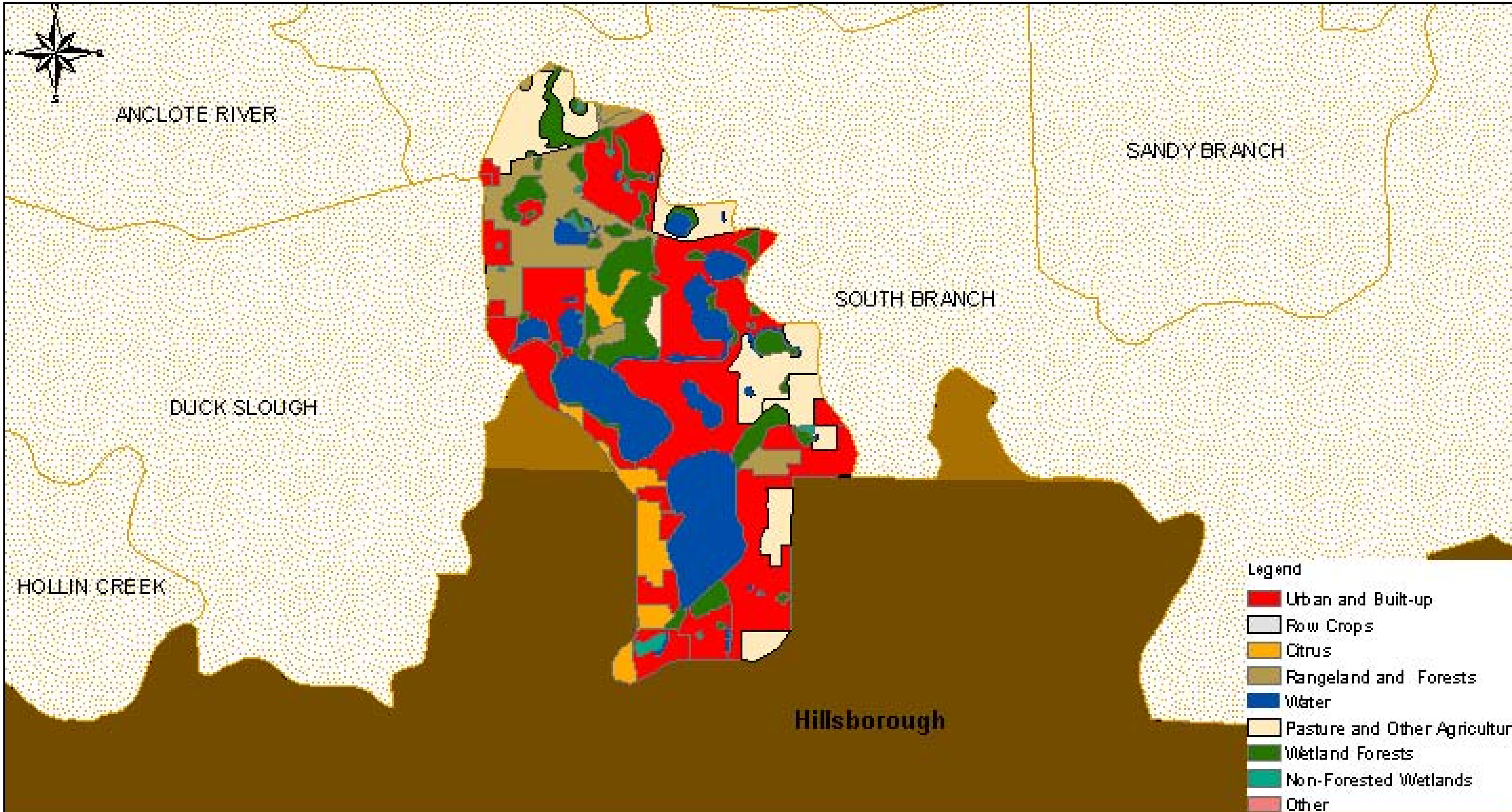

1990 Land Use/Cover Map for the Lake Ann Outlet Sub-basin, Anclote River Watershed

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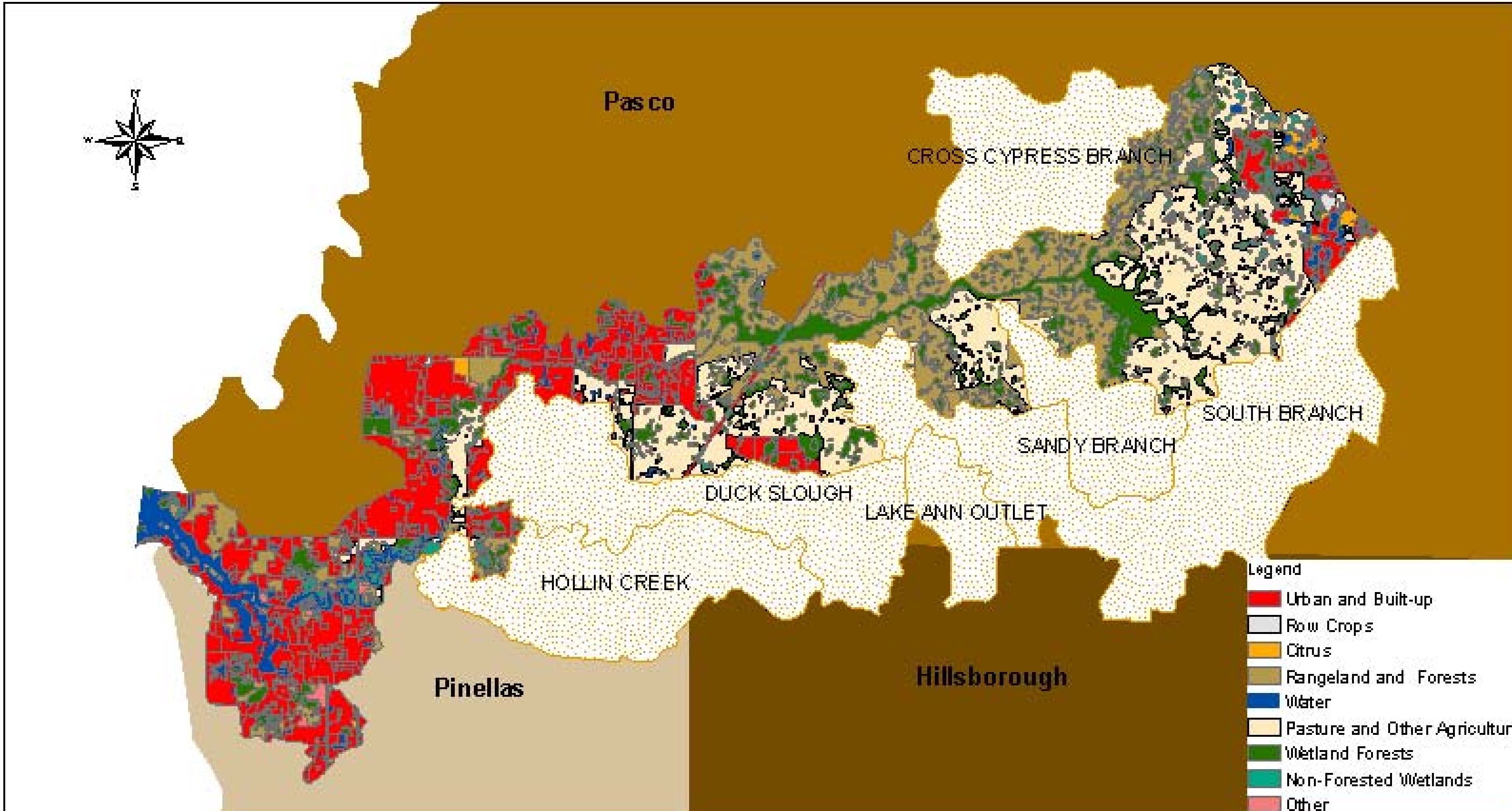

1990 Land Use/Cover Map for the Anclote Mainstem Sub-basin, Anclote River Watershed

0 0.375 0.75 1.5 2.25 3 Miles

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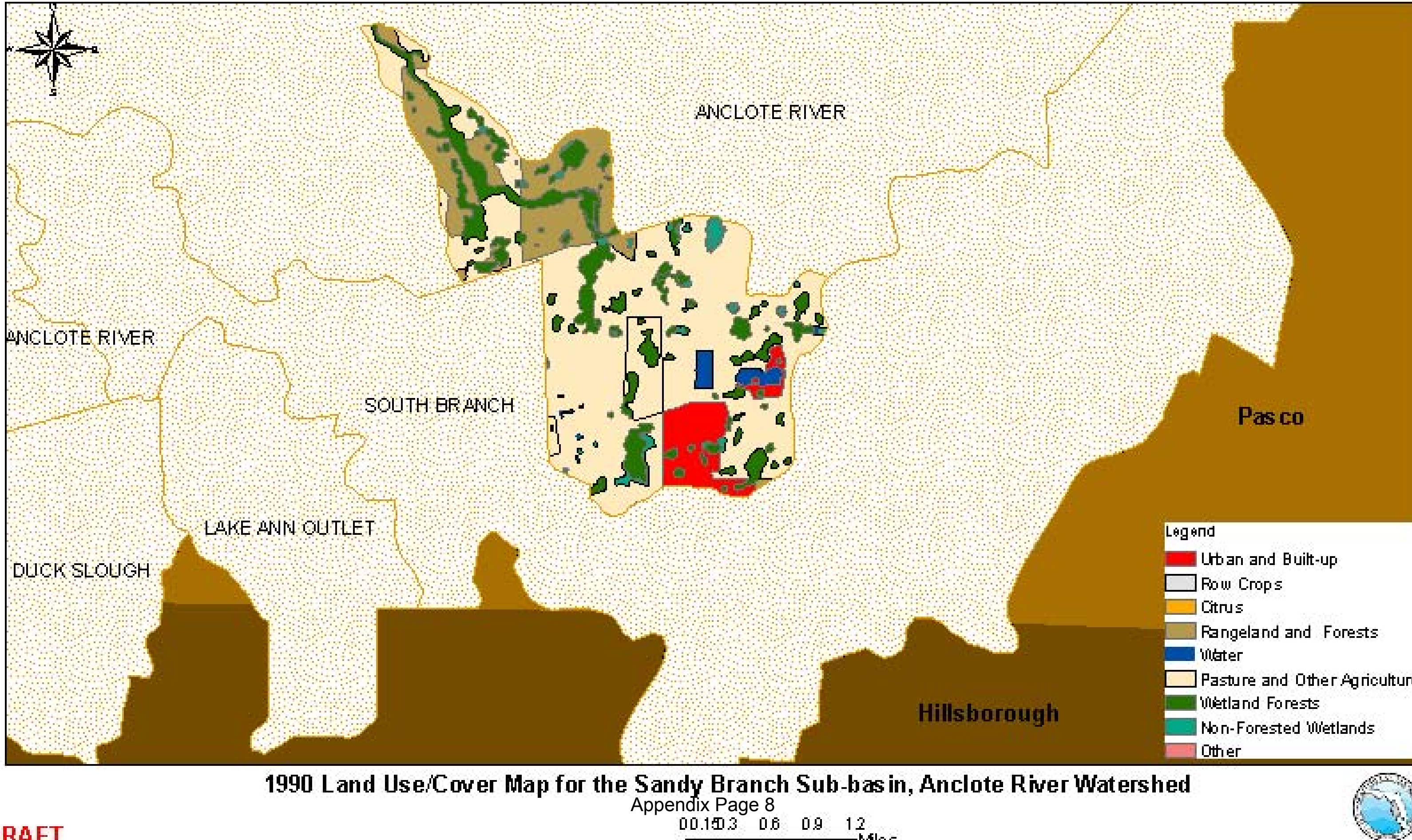

1990 Land Use/Cover Map for the Sandy Branch Sub-basin, Anclote River Watershed

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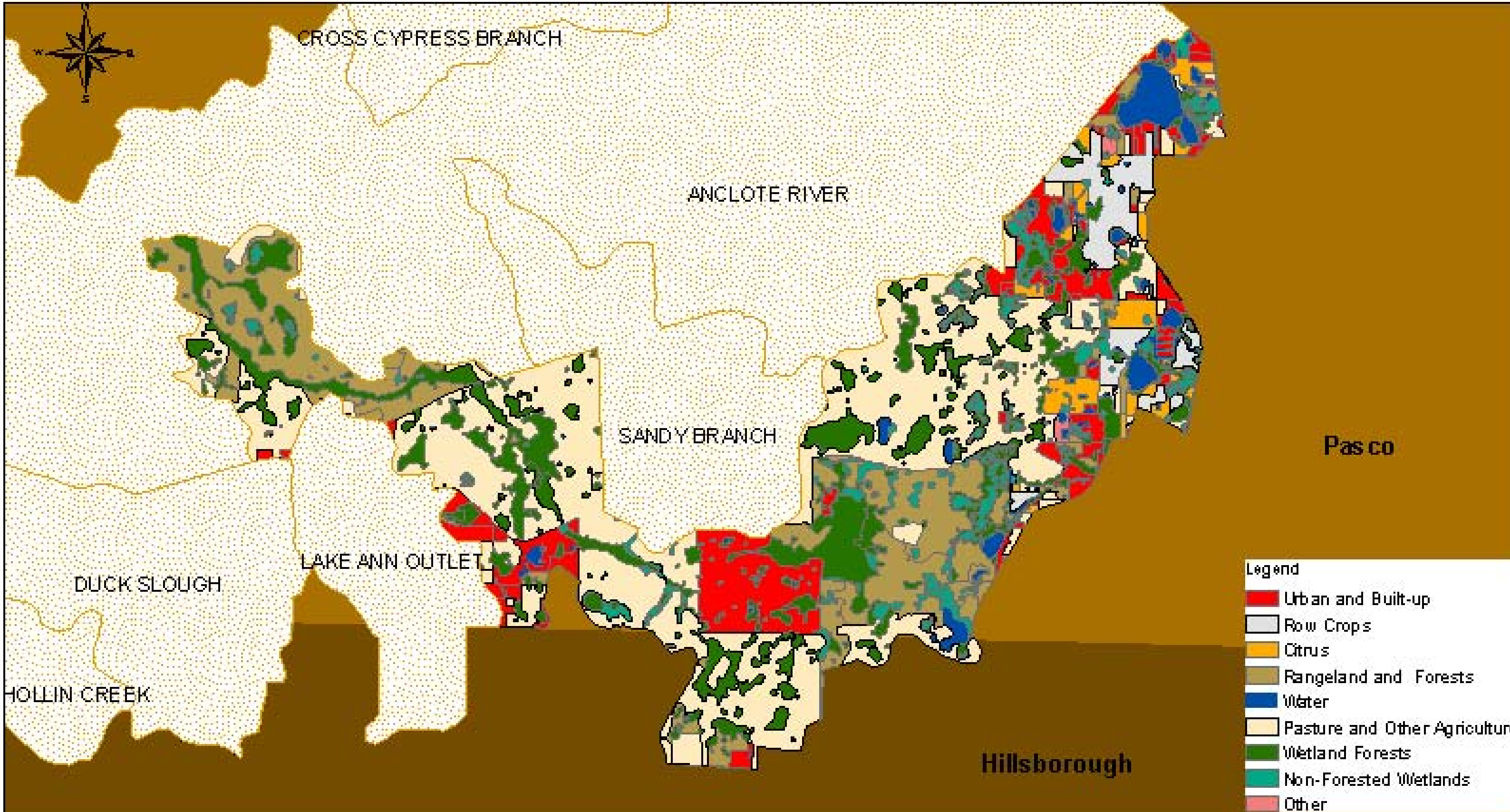

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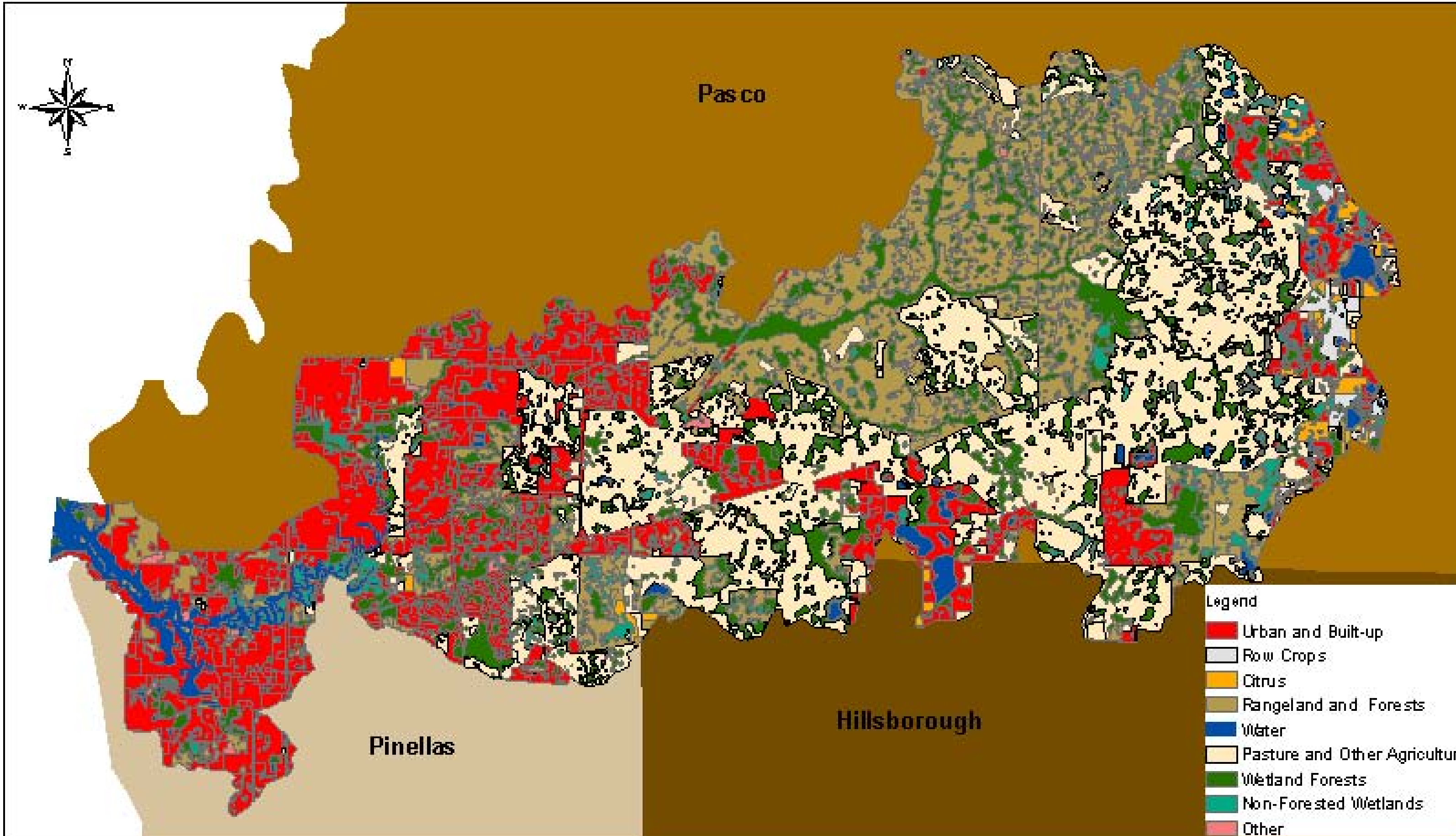

1995 Land Use/Cover Map for the Anclote River Watershed

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Miles

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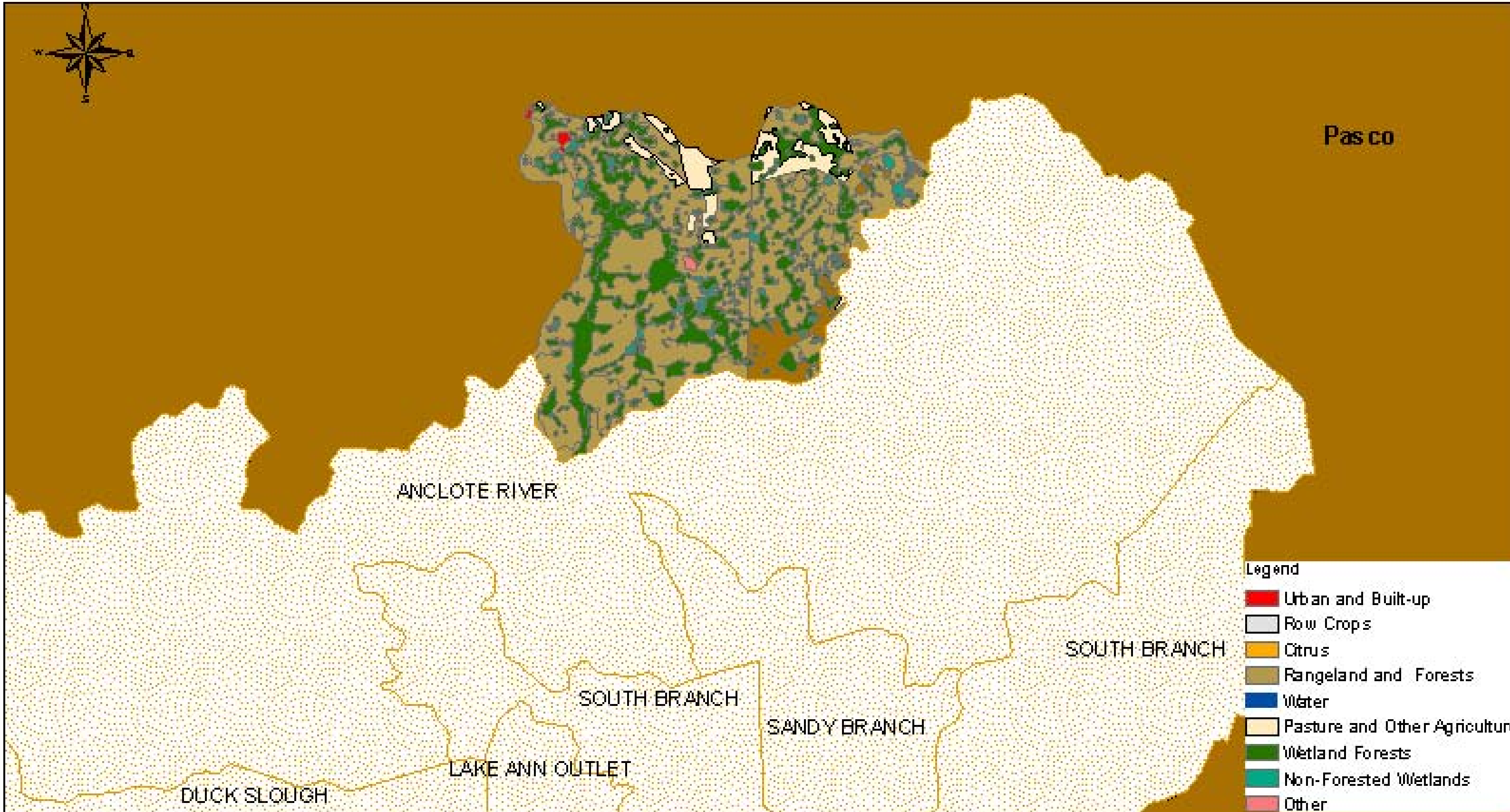

1995 Land Use/Cover Map for the Cross Cypress Branch Sub-basin, Anclote River Watershed

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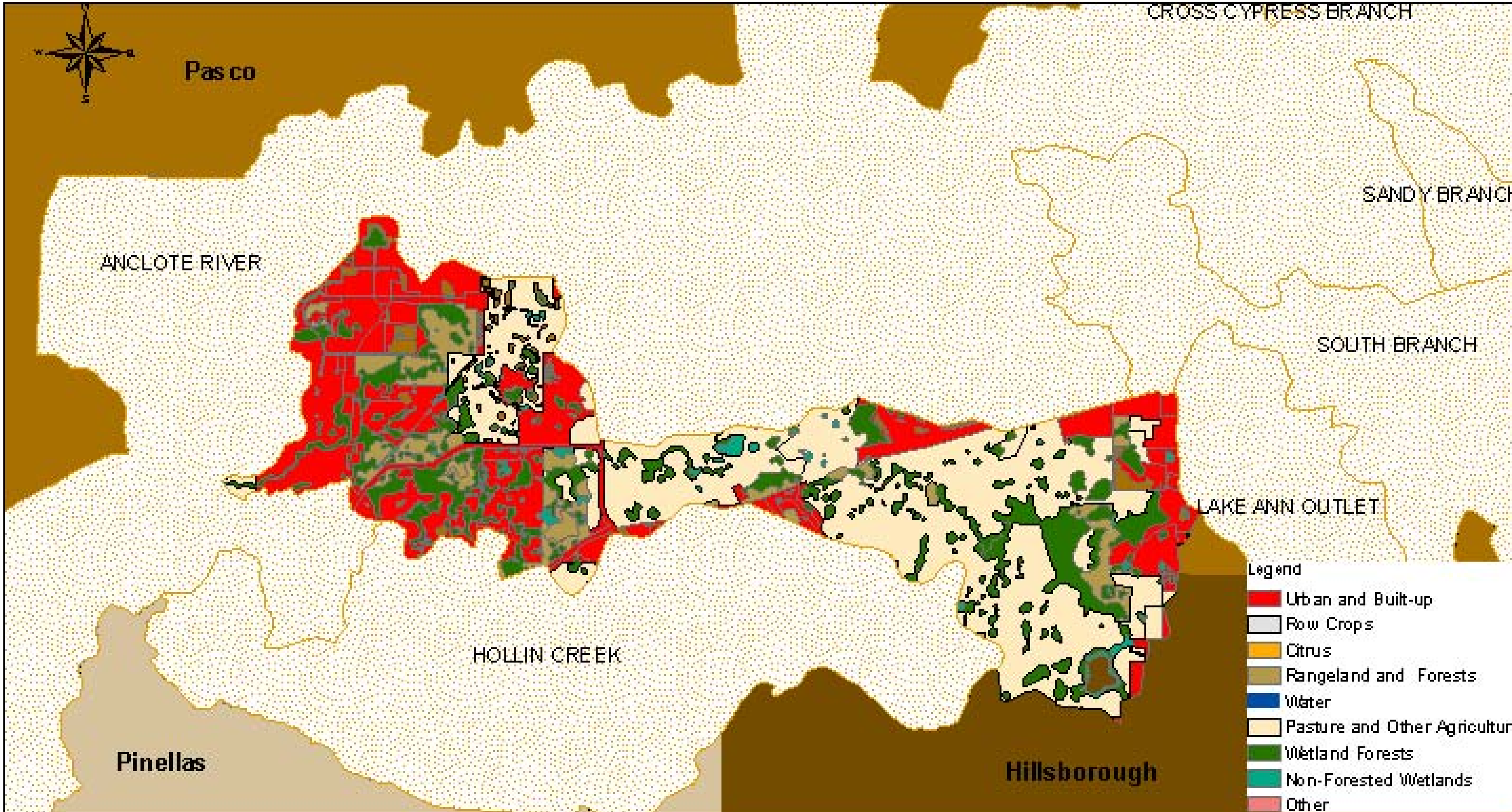

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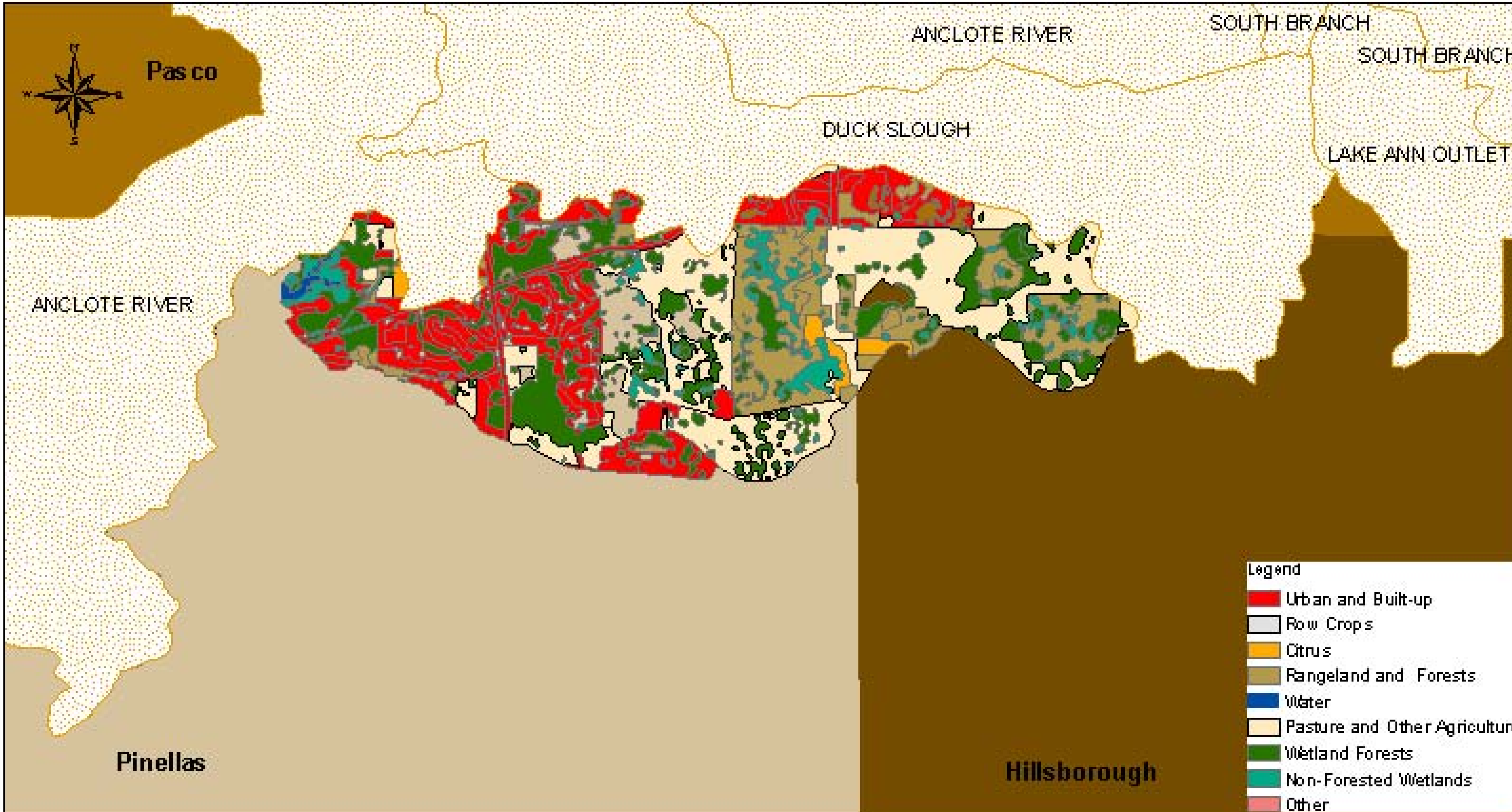
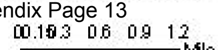


1995 Land Use/Cover Map for the Hollin Creek Sub-basin, Anclote River Watershed



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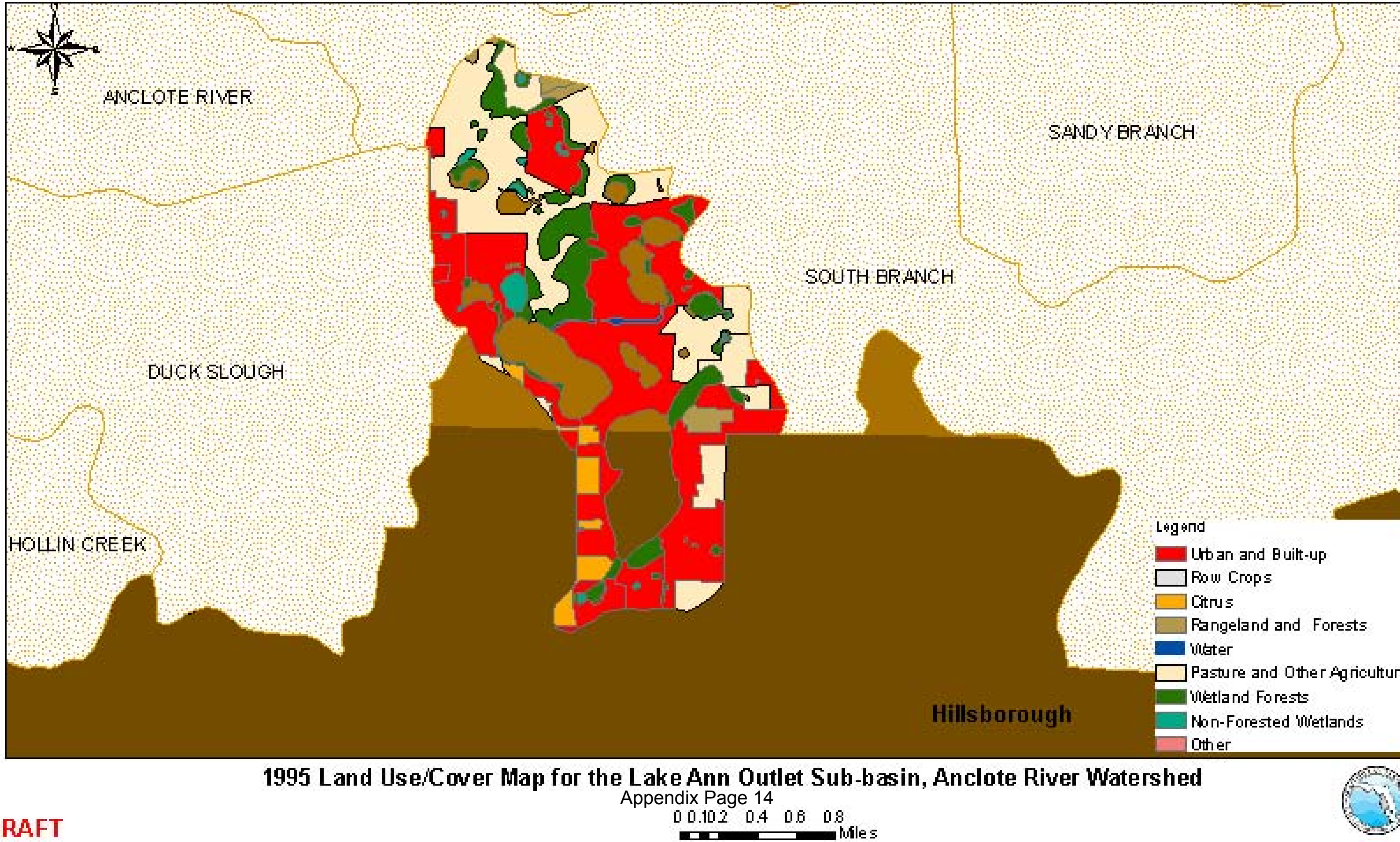

1995 Land Use/Cover Map for the Lake Ann Outlet Sub-basin, Anclote River Watershed

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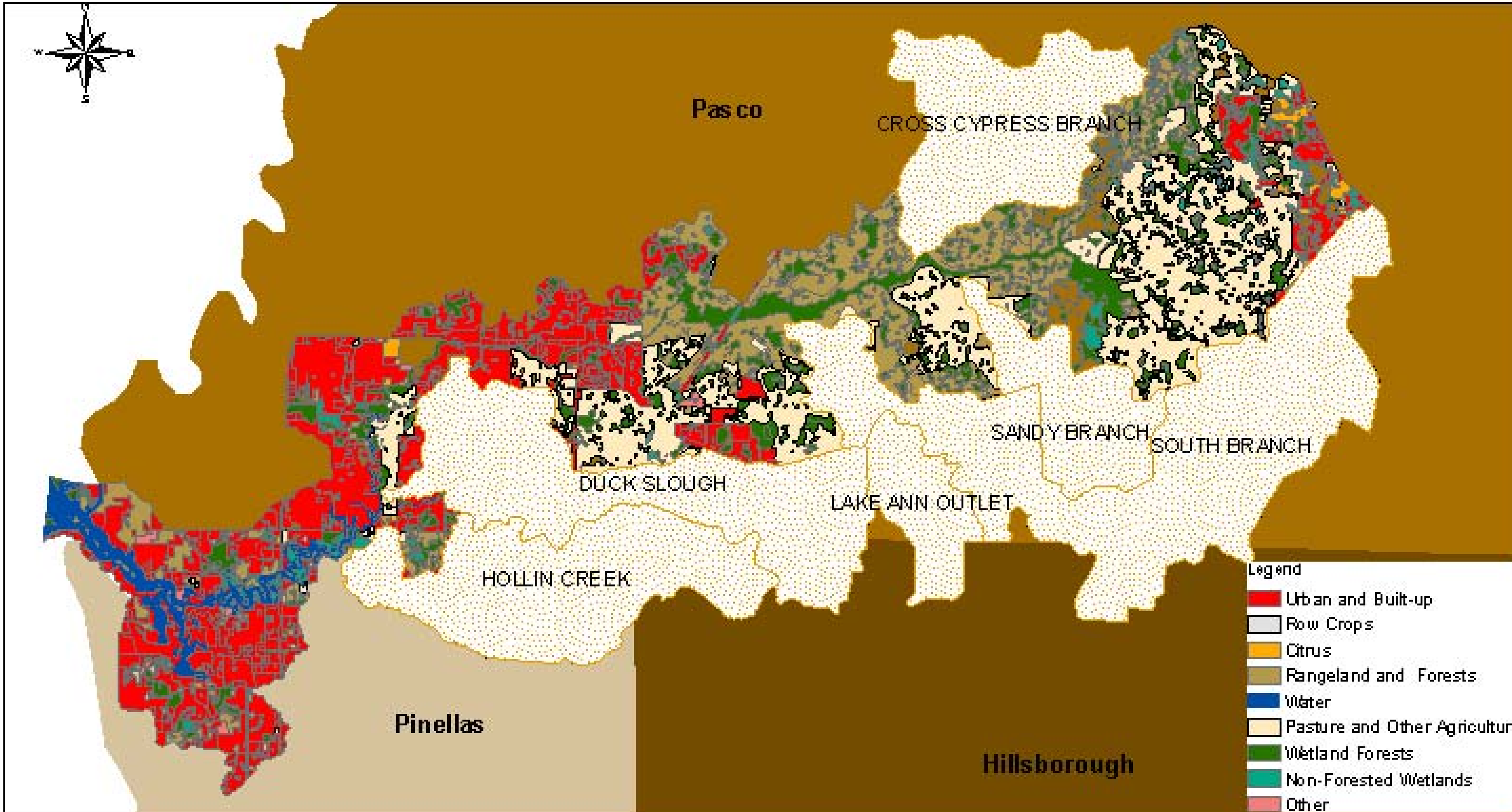

1995 Land Use/Cover Map for the Mainstem Sub-basin, Anclote River Watershed

0 0.35 0.7 1.4 2.1 2.8 Miles

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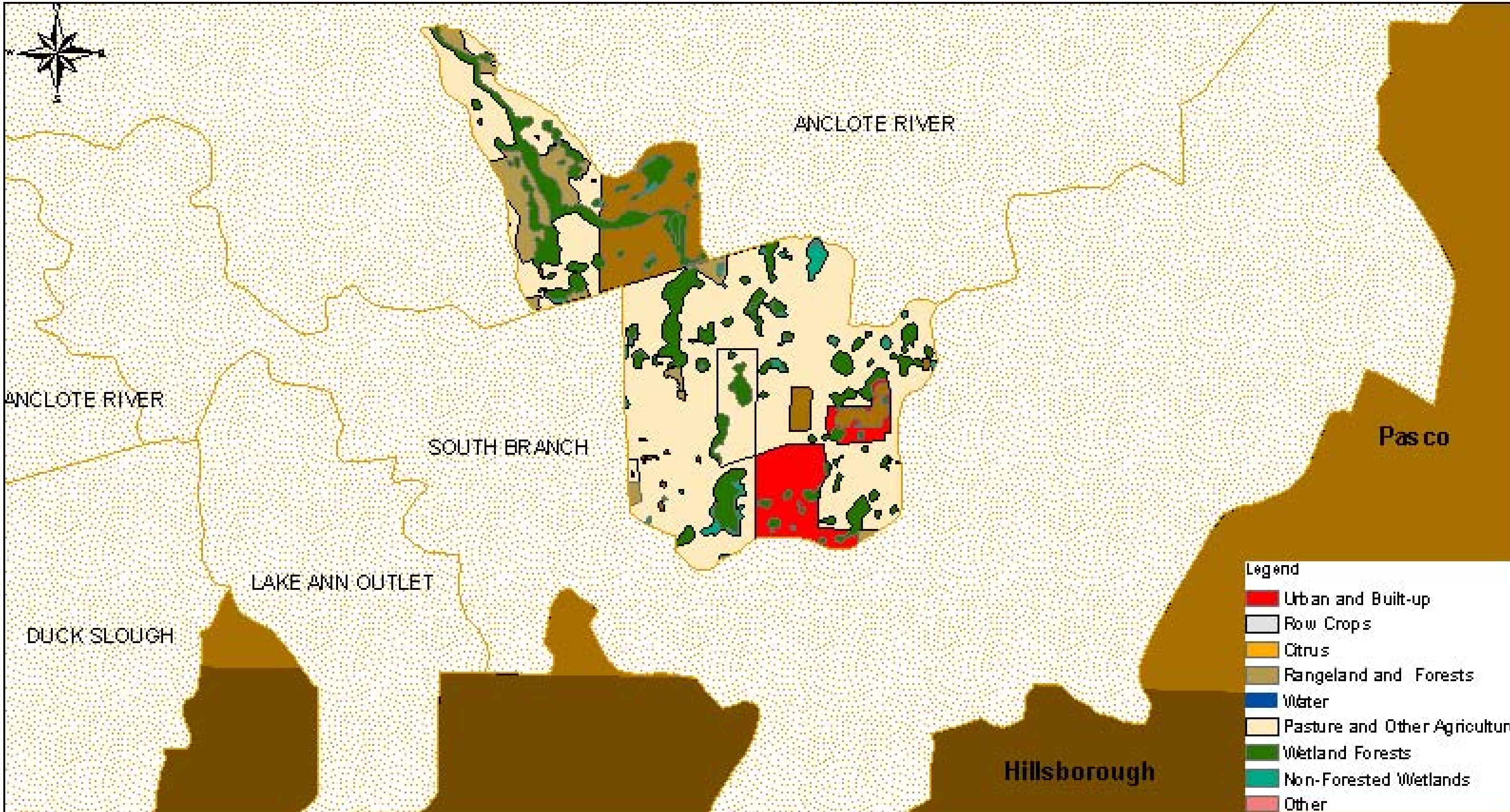
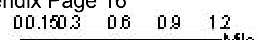


1995 Land Use/Cover Map for the Sandy Branch Sub-basin, Anclote River Watershed



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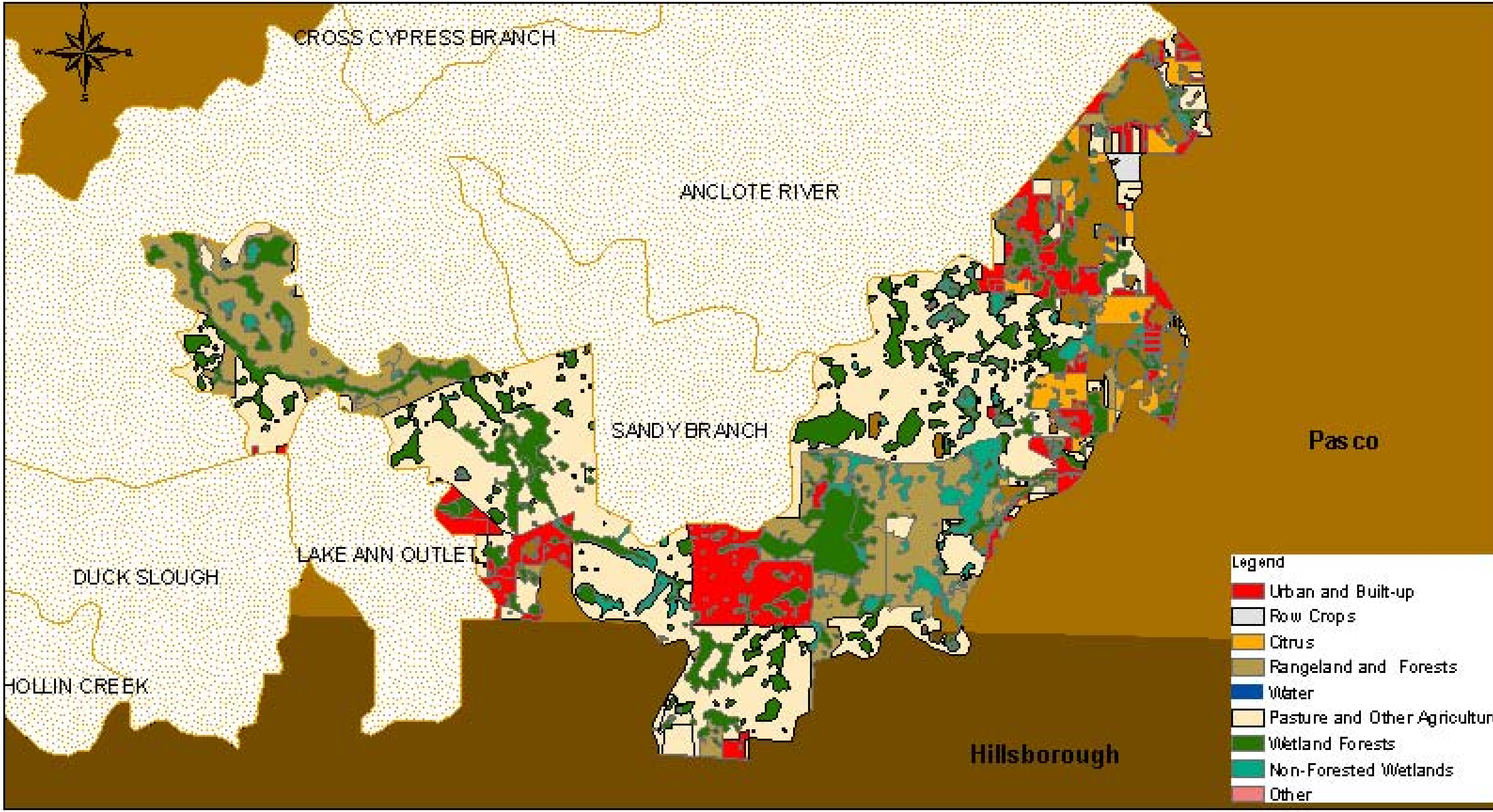

1995 Land Use/Cover Map for the South Branch Sub-basin, Anclote River Watershed

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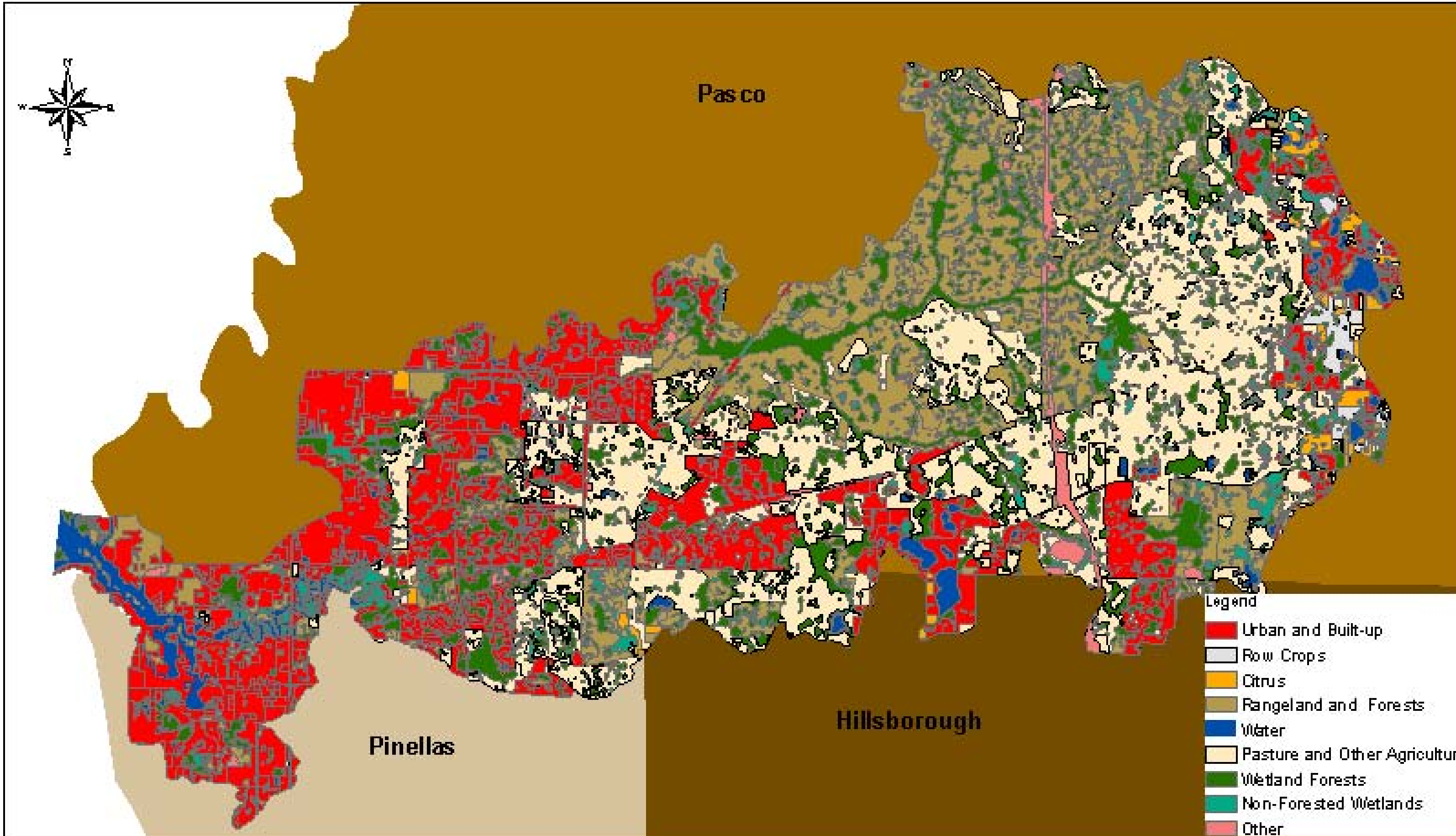

1999 Land Use/Cover Map for the Anclote River Watershed

0 0.45 0.9 1.8 2.7 3.6
Miles

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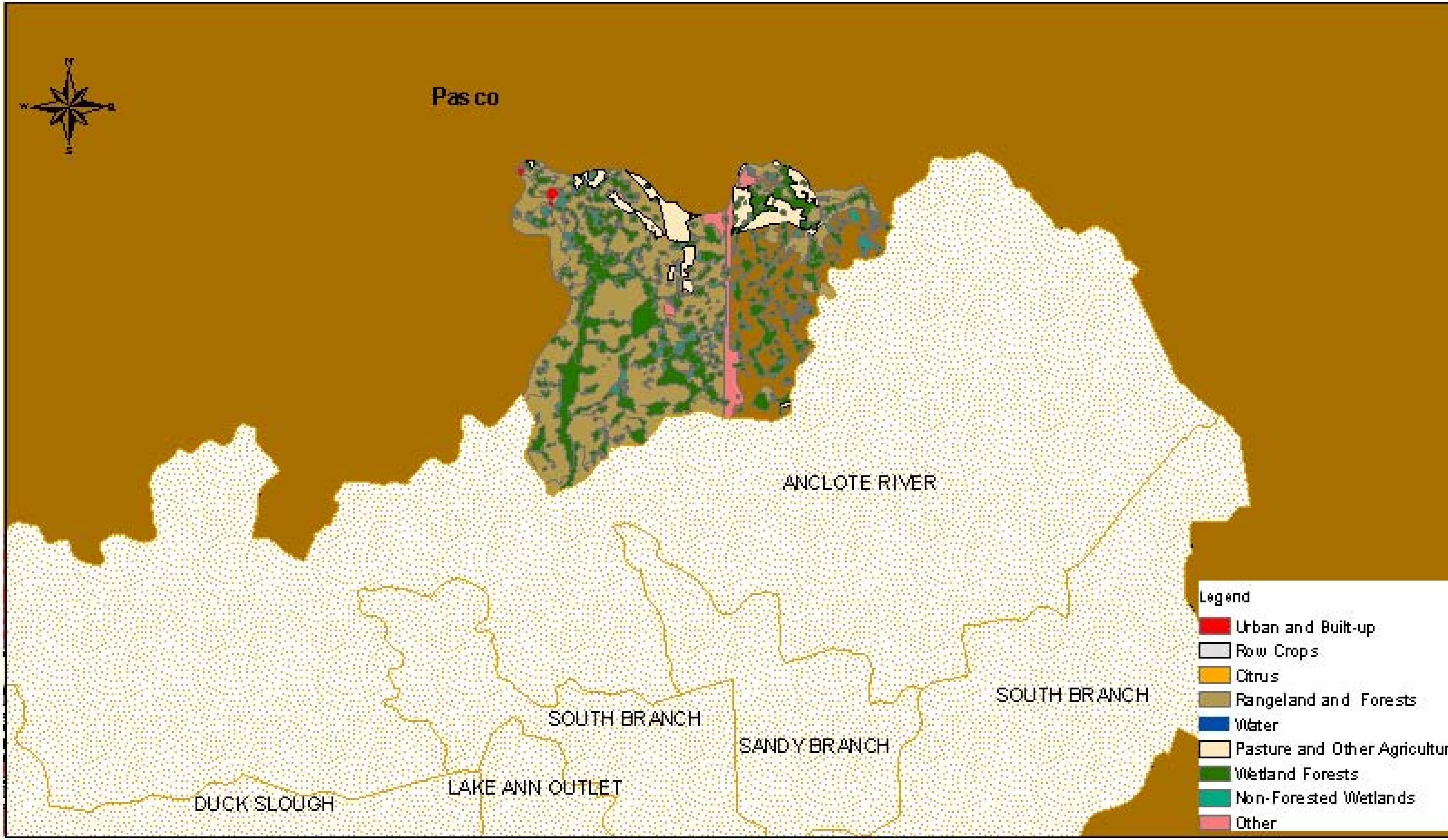

2004 Land Use/Cover Map for the Cross Cypress Branch Sub-basin, Anclote River Watershed

0 0.35 0.7 1.4 2.1 2.8 Miles

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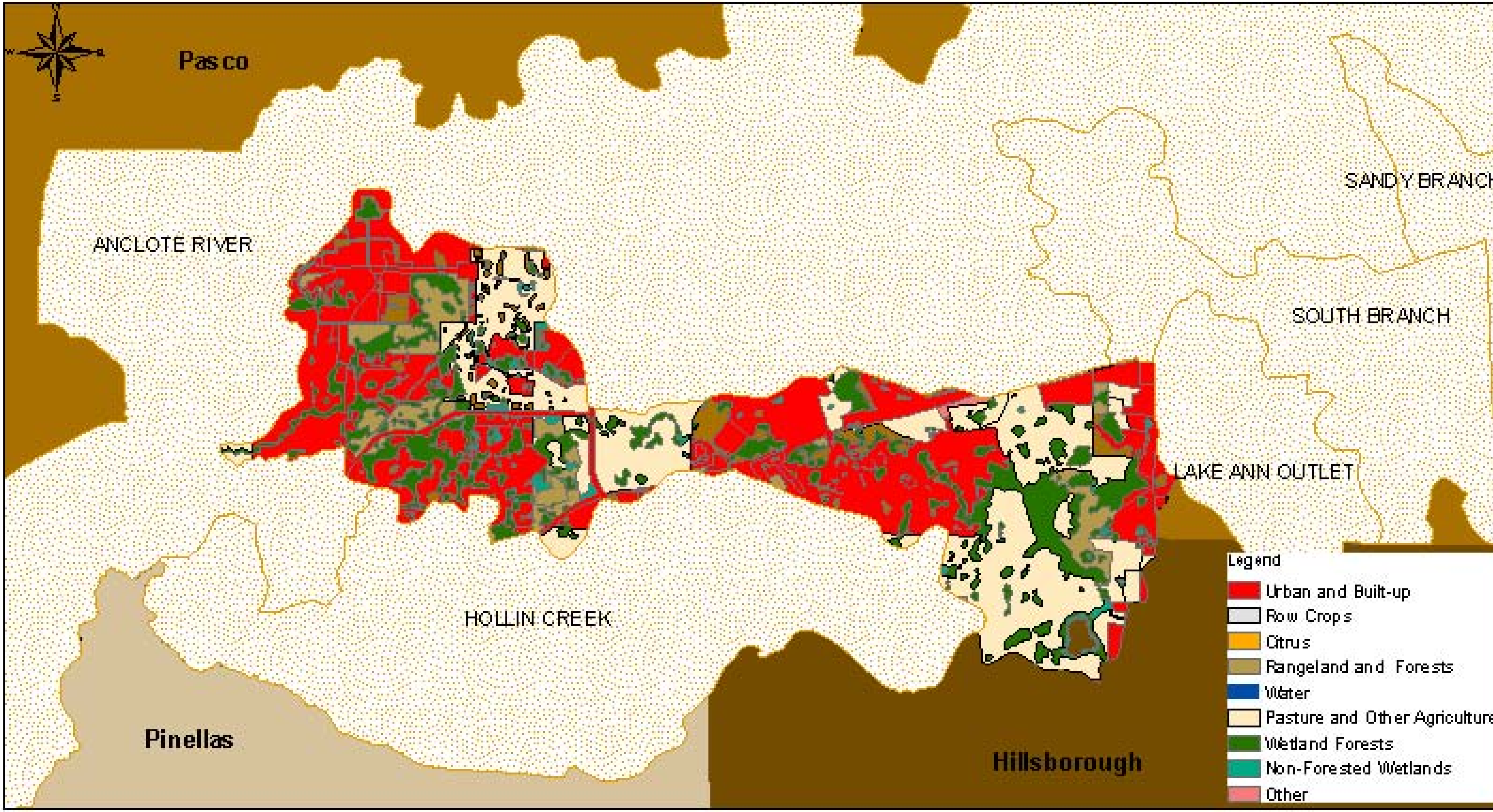

1999 Land Use/Cover Map for the Duck Slough Sub-basin, Anclote River Watershed

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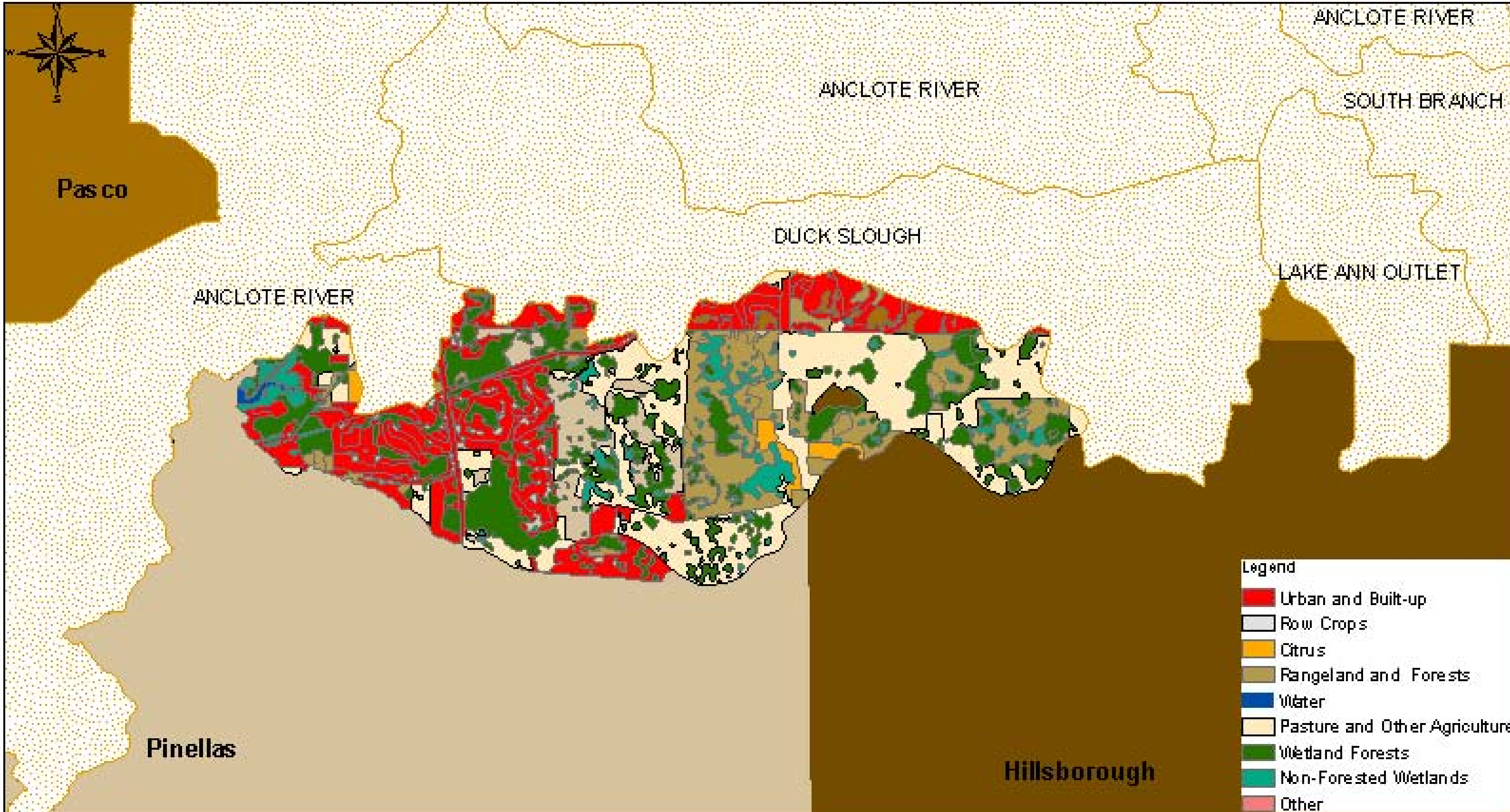

1999 Land Use/Cover Map for the Hollin Creek Sub-basin, Anclote River Watershed

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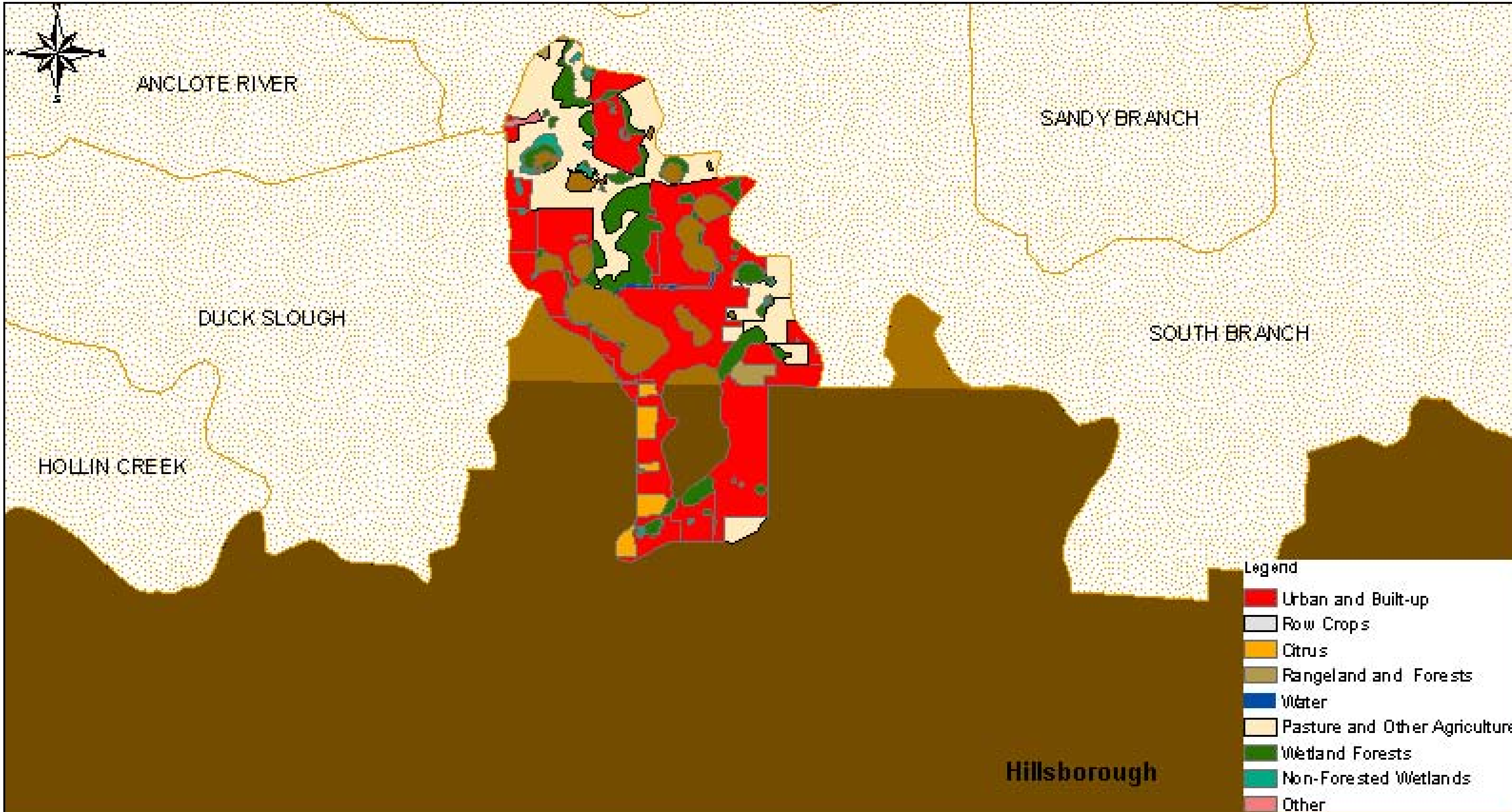

1999 Land Use/Cover Map for the Lake Ann Outlet Sub-basin, Anclote River Watershed

0 0.150.3 0.6 0.9 1.2
Miles

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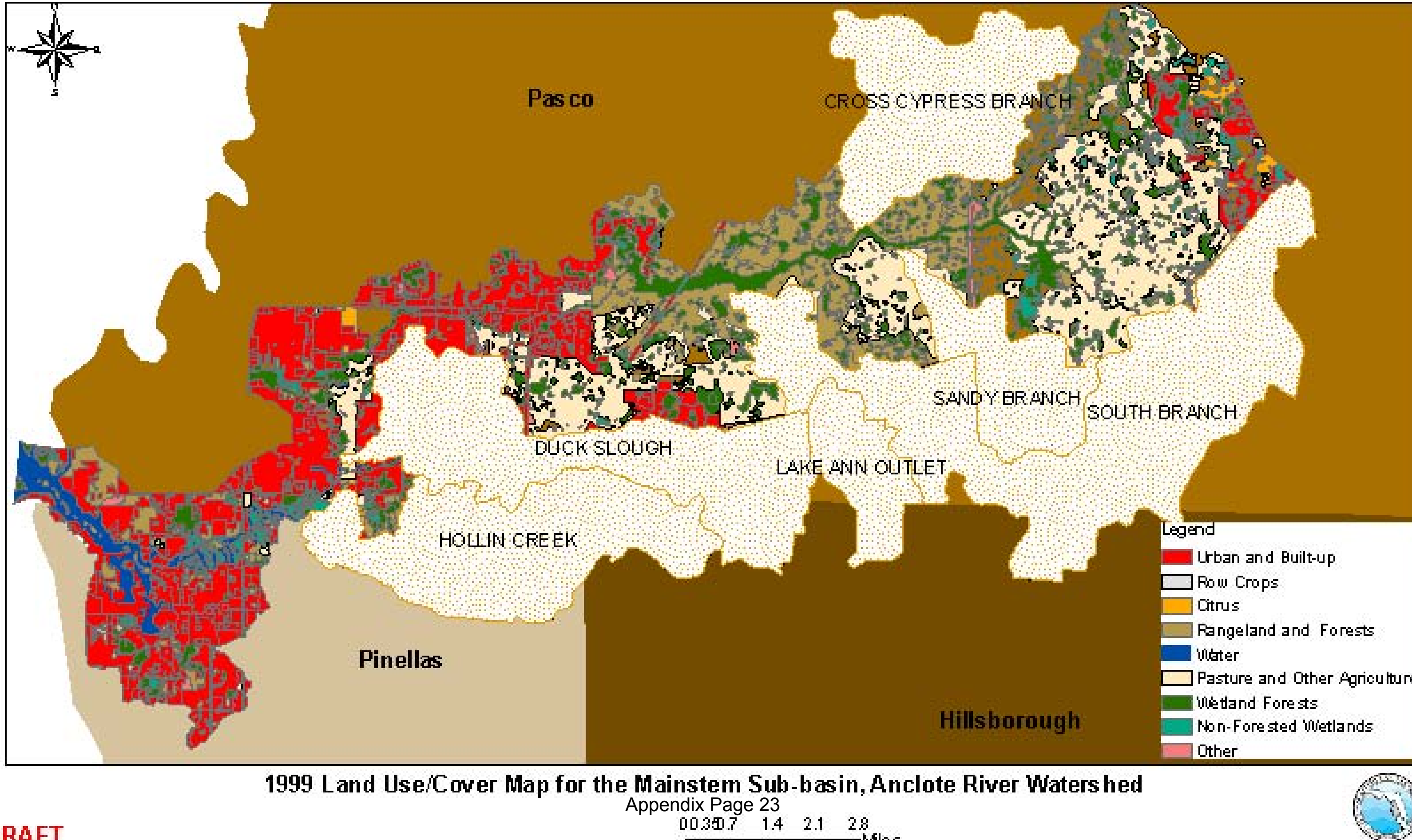

1999 Land Use/Cover Map for the Mainstem Sub-basin, Anclote River Watershed

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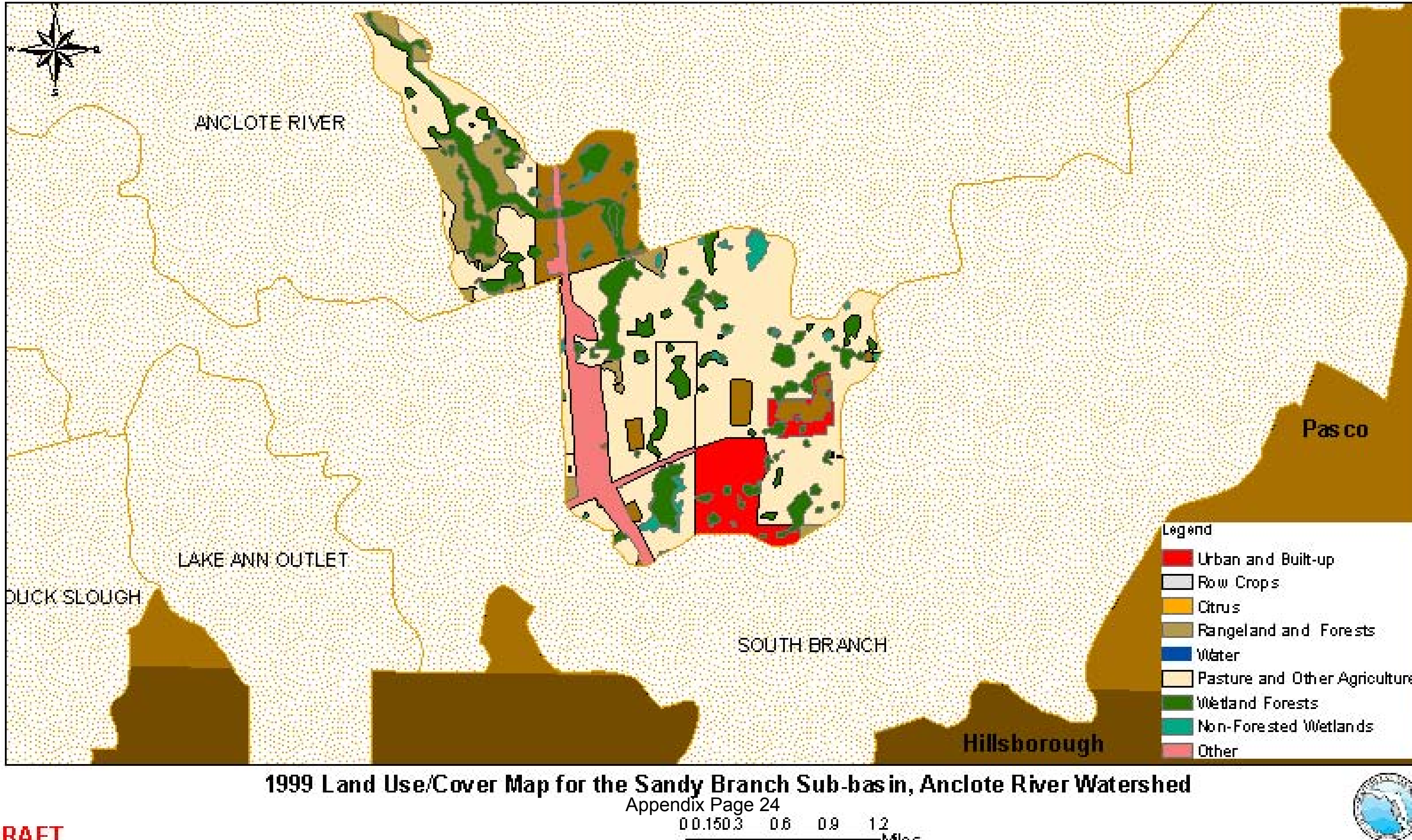

1999 Land Use/Cover Map for the Sandy Branch Sub-basin, Anclote River Watershed

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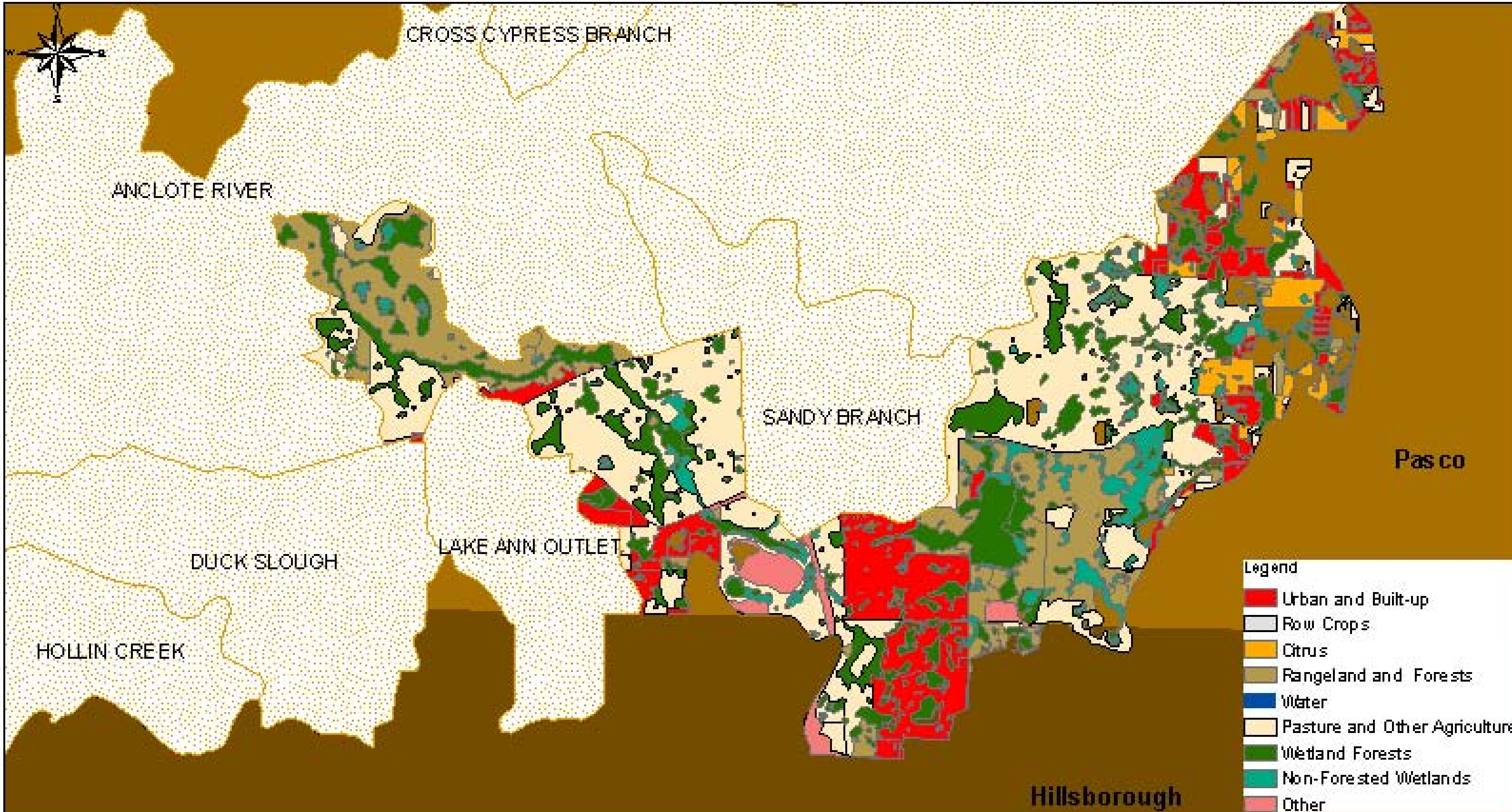

1999 Land Use/Cover Map for the South Branch Sub-basin, Anclote River Watershed

0 0.2 0.4 0.8 1.2 1.6 Miles

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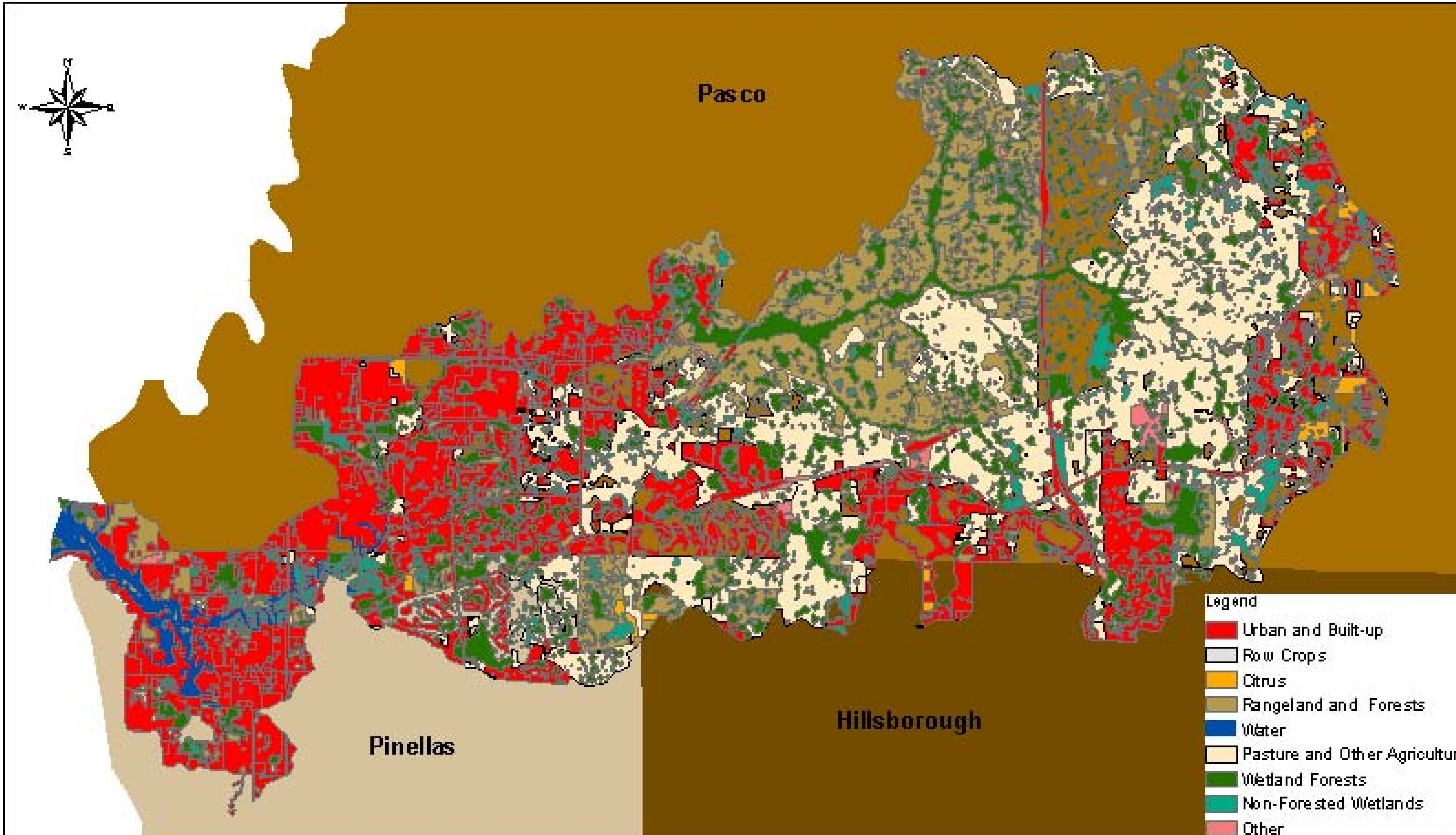

2004 Land Use/Cover Map for the Anclote River Watershed

0 0.45 0.9 1.8 2.7 3.6 Miles

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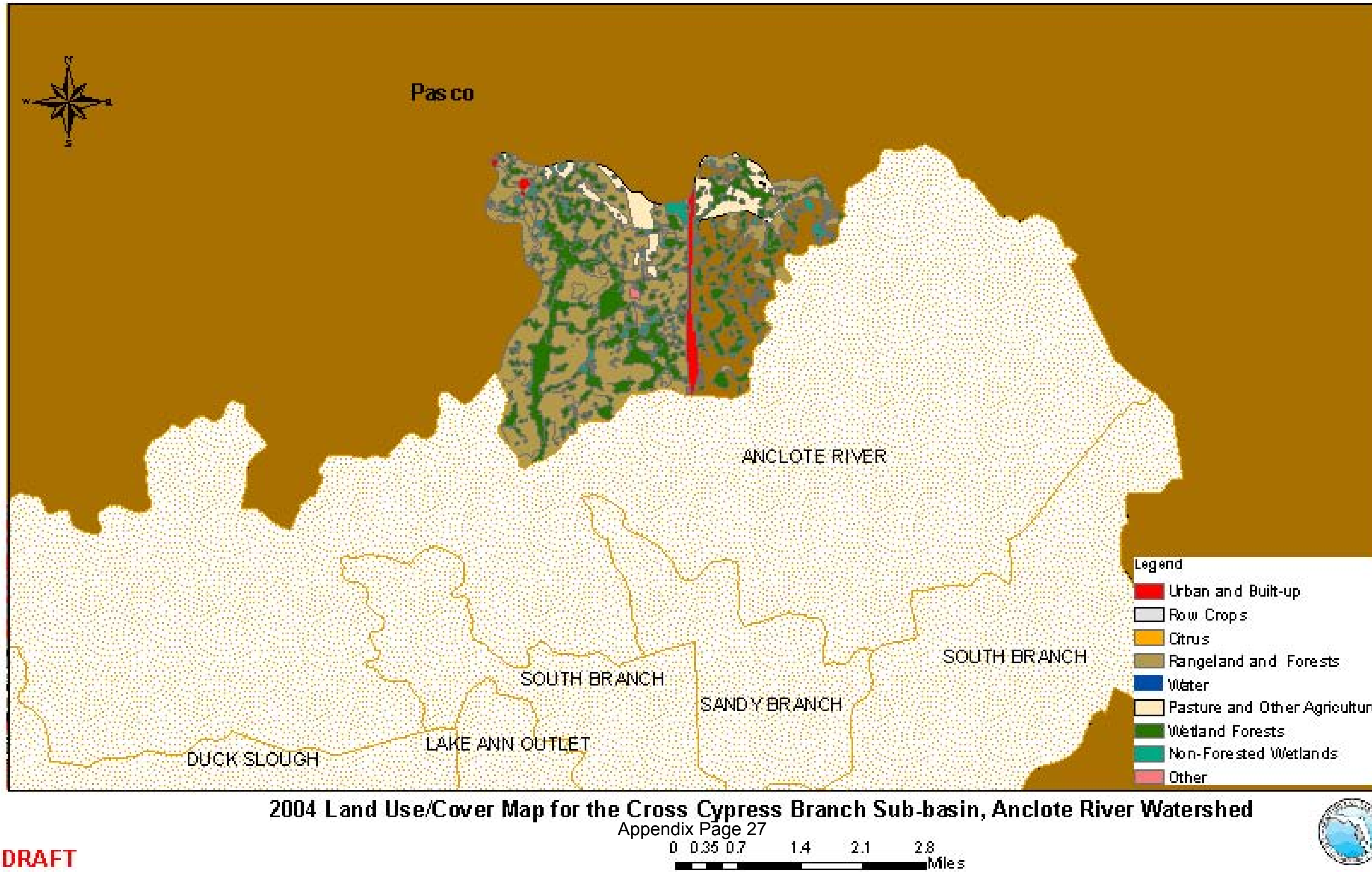

2004 Land Use/Cover Map for the Cross Cypress Branch Sub-basin, Anclote River Watershed

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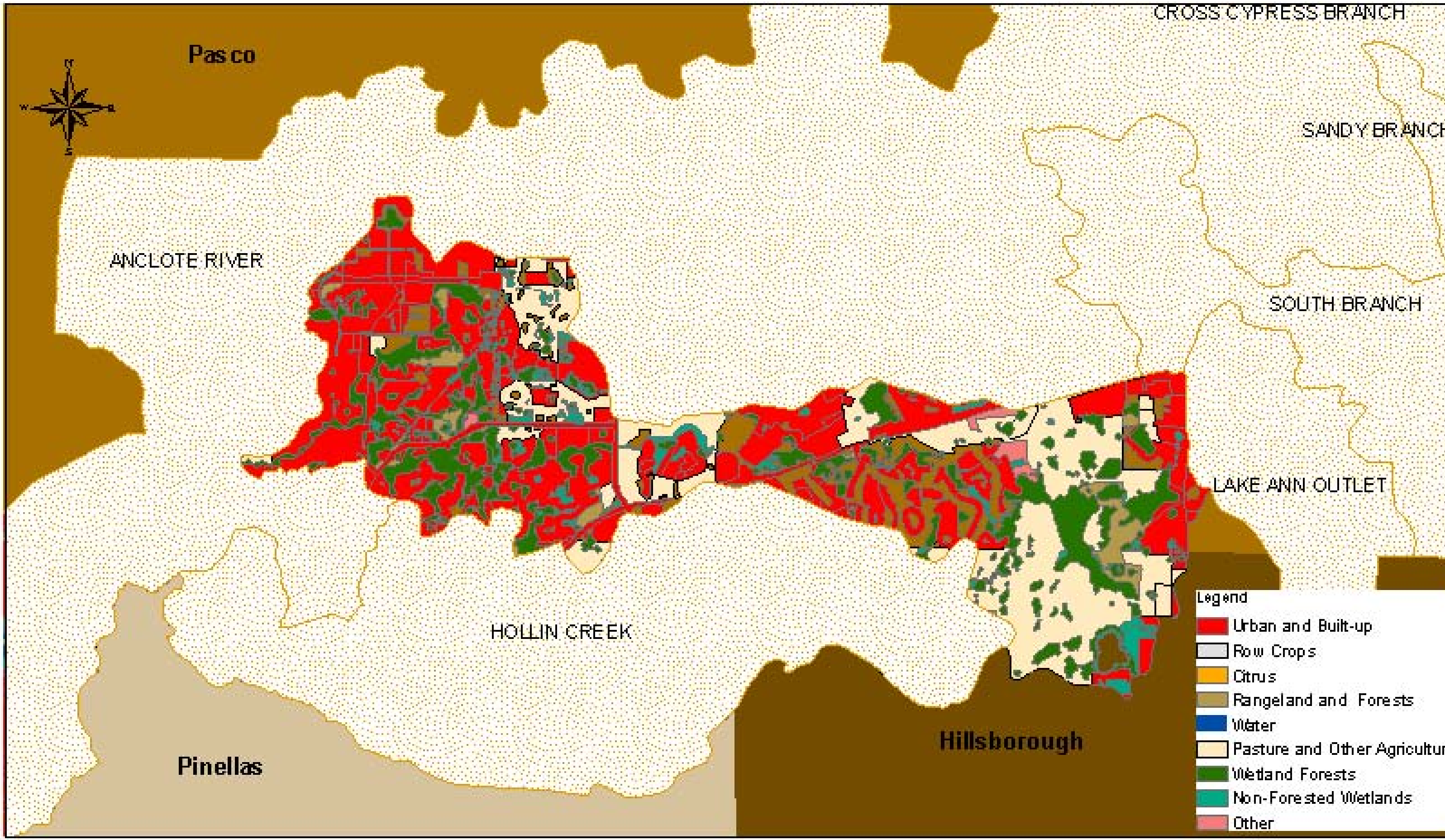

2004 Land Use/Cover Map for the Duck Slough Sub-basin, Anclote River Watershed

0 0.25 0.5 1 1.5 2 Miles

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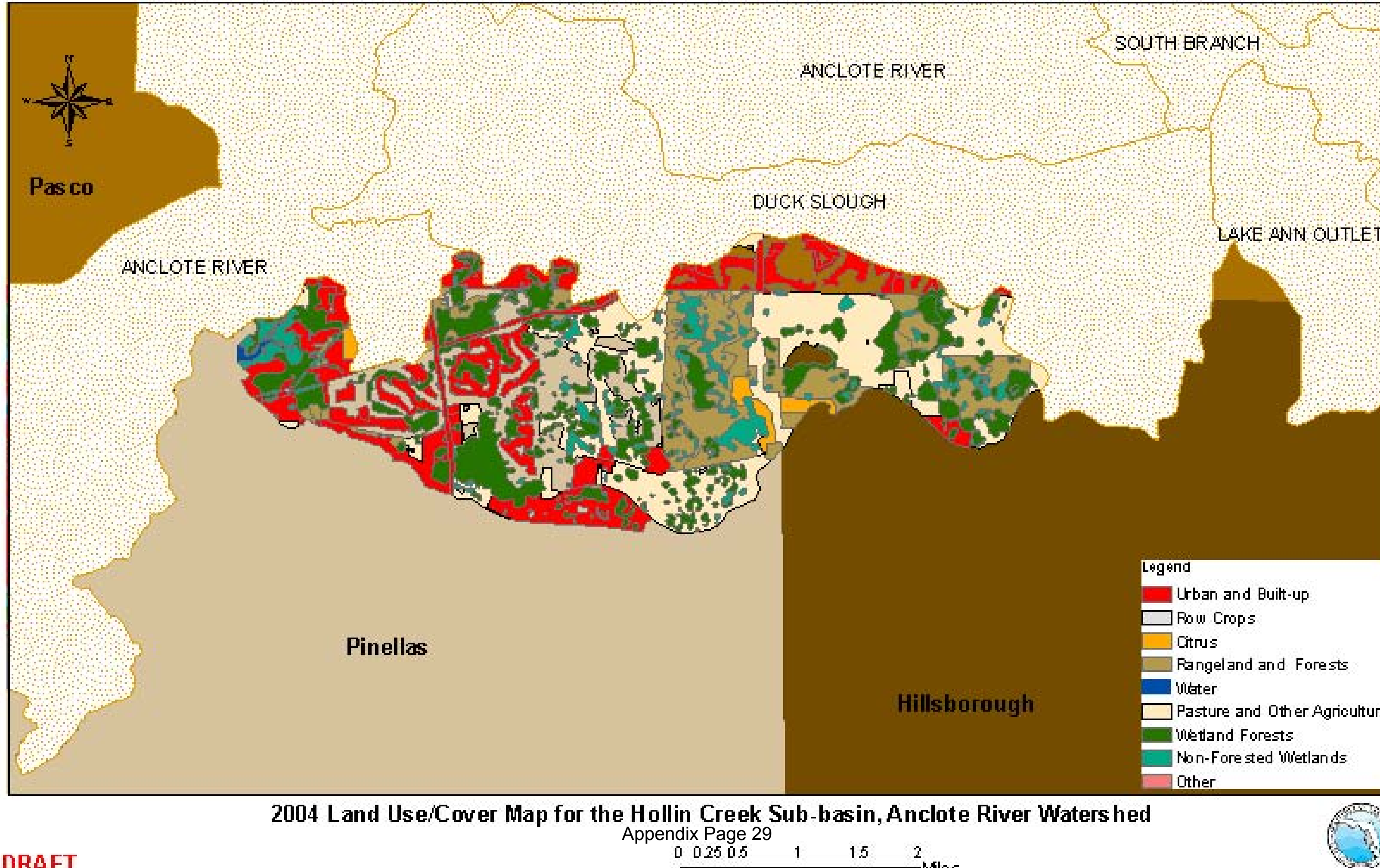

2004 Land Use/Cover Map for the Hollin Creek Sub-basin, Anclote River Watershed

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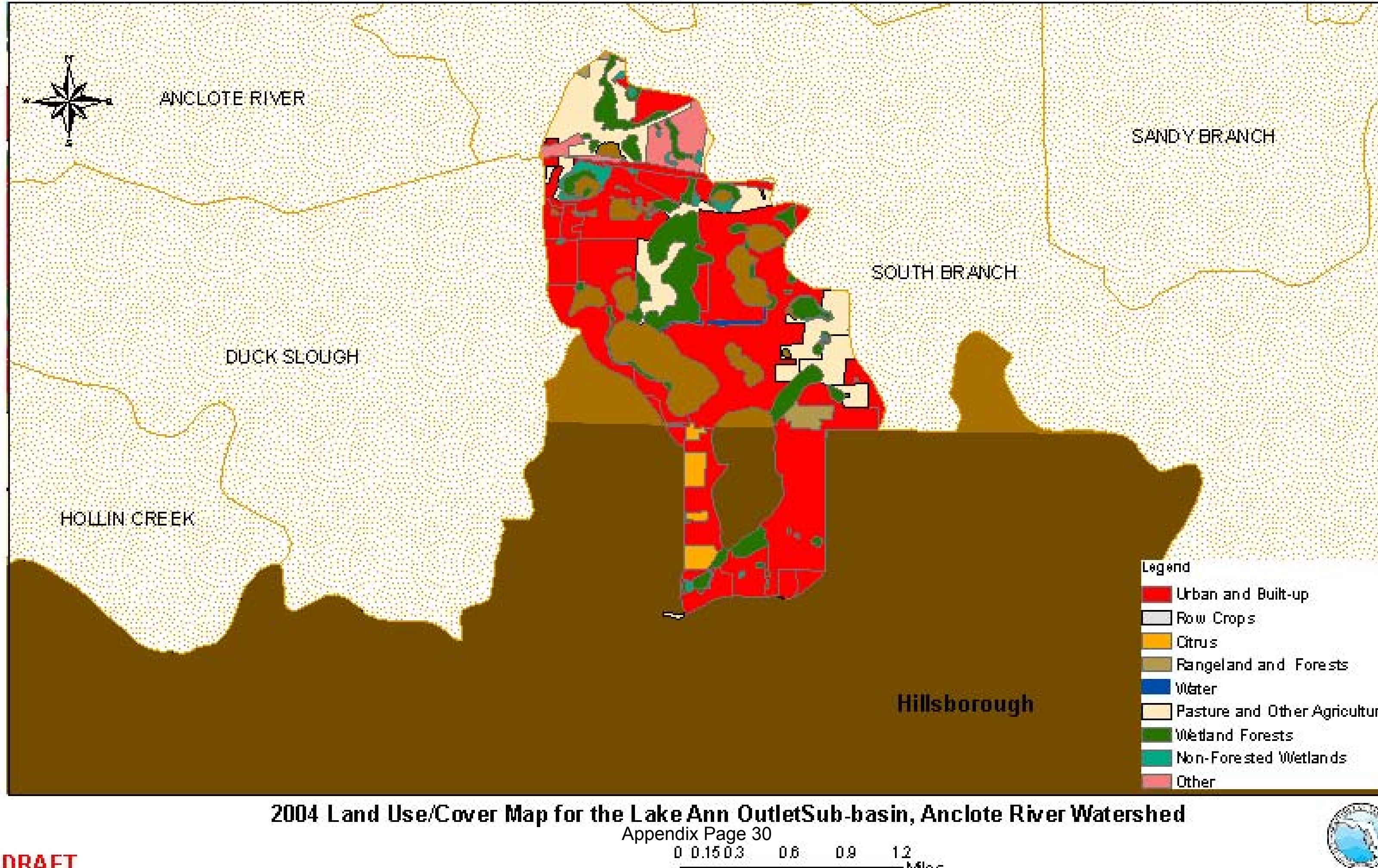

2004 Land Use/Cover Map for the Lake Ann OutletSub-basin, Anclote River Watershed

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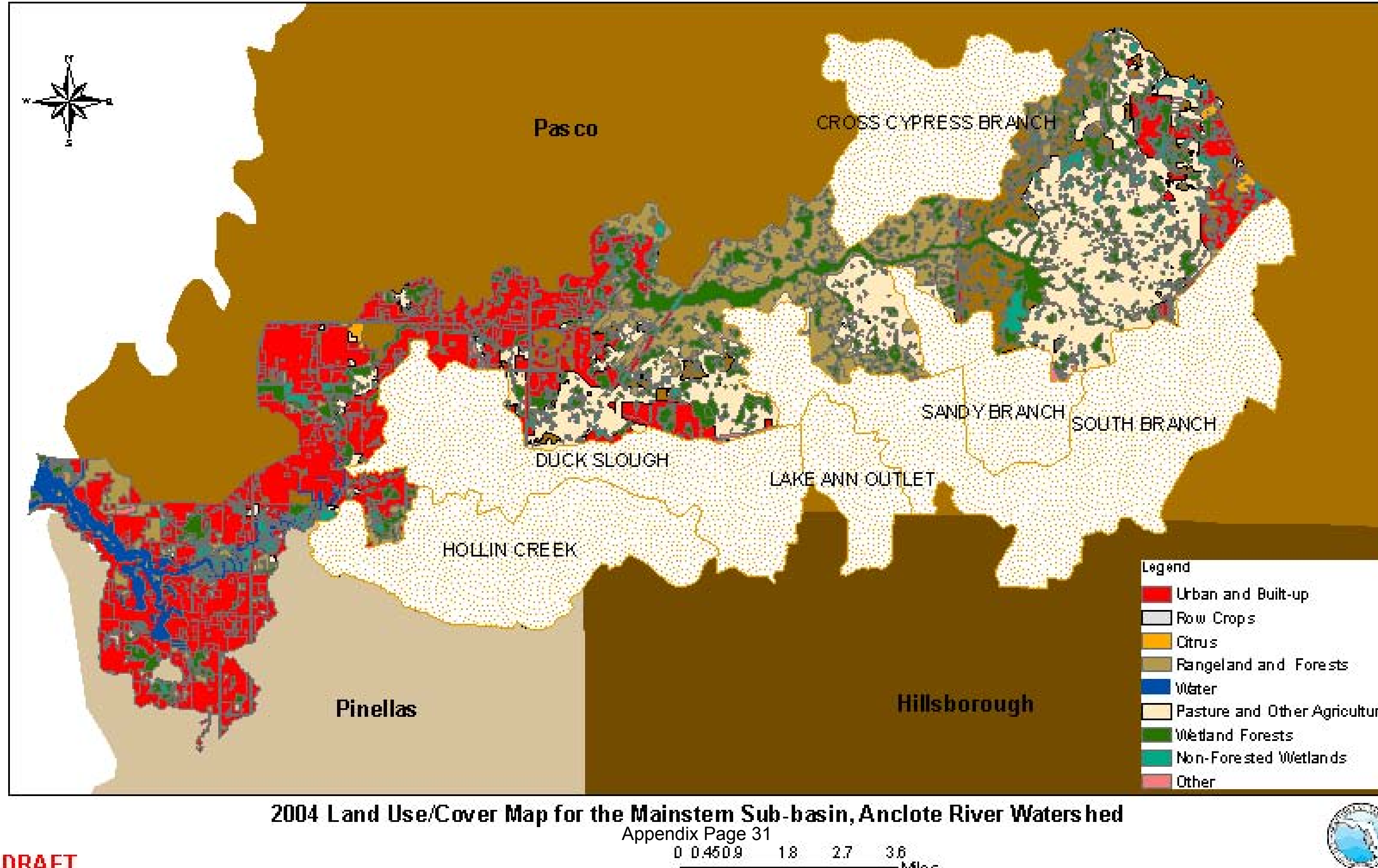

2004 Land Use/Cover Map for the Mainstem Sub-basin, Anclote River Watershed

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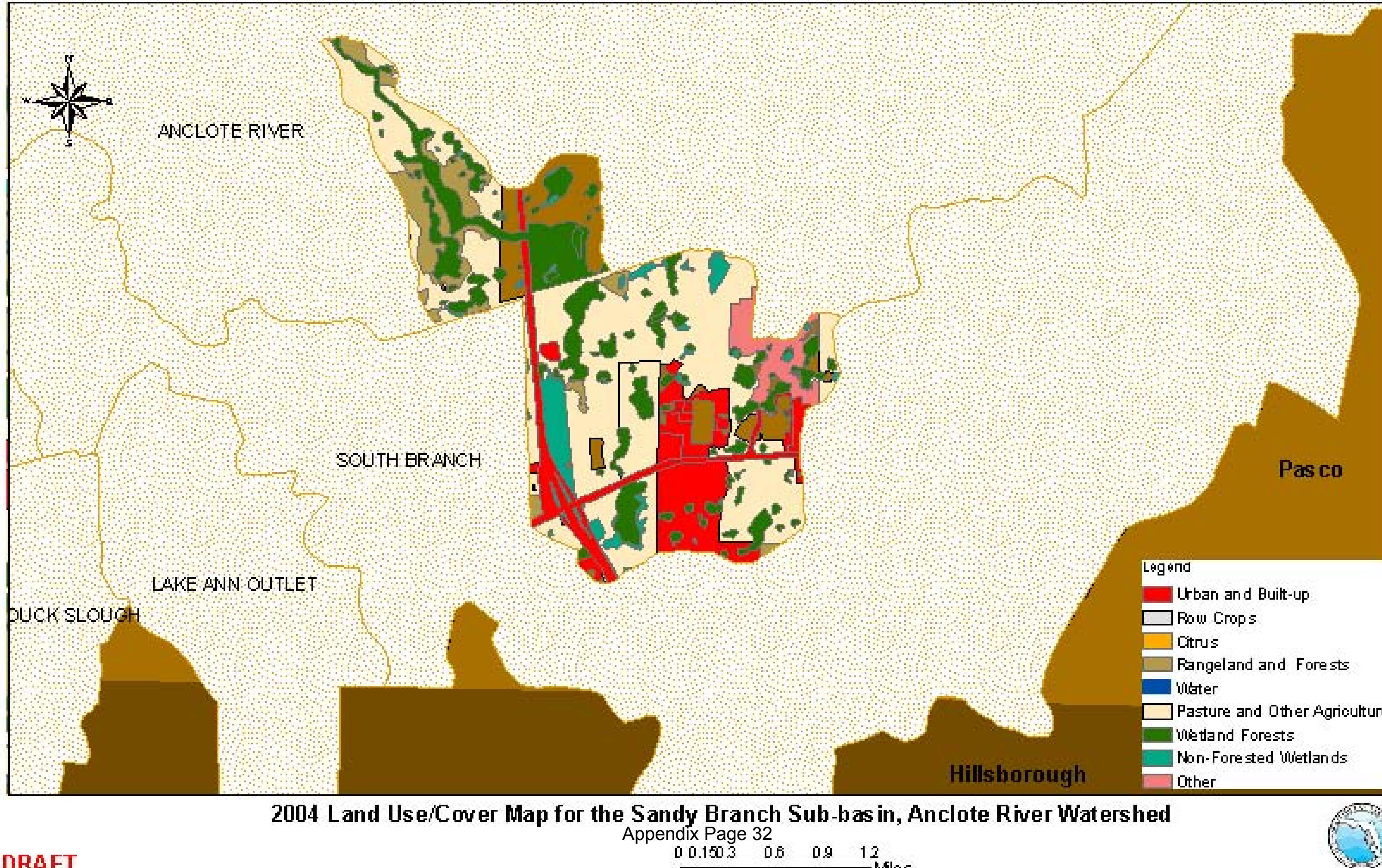

2004 Land Use/Cover Map for the Sandy Branch Sub-basin, Anclote River Watershed

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Technical Memorandum

June 9, 2009

TO: Mike Heyl, Senior Environmental Scientist, Ecological Evaluation Section
Marty Kelly, Ph. D., Manager, Ecological Evaluation Section

THROUGH: Mark Barcelo, P.E., Manager, Hydrologic Evaluation Section

FROM: Ron Basso, P.G., Senior Professional Geologist, Hydrologic Evaluation Section

Subject: Predicted groundwater withdrawal impacts to the Anclote River based on numerical model results

1.0 Introduction

The Anclote River is located in southwest Pasco County and contains a drainage basin area of 75 square miles upstream of the Elfers gage (Figure 1). Mean annual discharge for the Anclote River near Elfers gage averaged 64.7 cubic feet per second (cfs) or 42 million gallons per day (mgd) from 1947 through 2006.

Prior to establishment of a Minimum Flow (MF), an evaluation of hydrologic changes in the vicinity of the river is necessary to determine if the water body has been significantly impacted by existing groundwater withdrawals. The establishment of the MF for the Anclote River is not part of this report. This memorandum describes the hydrogeologic setting near the river and provides the results of several numerical model simulations of predicted stream flow change due to existing groundwater withdrawals.

2.0 Hydrogeologic Conditions

The hydrogeologic framework of the area includes a surficial sand aquifer system; a discontinuous, intermediate clay confining unit and the thick carbonate Upper Floridan aquifer (UFA). In general, the surficial aquifer system is in good hydraulic connection with the underlying UFA because the clay confining unit is generally thin, discontinuous, and breeched by numerous karst features. The surficial sand aquifer is generally a few tens of feet thick and overlies the limestone of the UFA that averages nearly 1,000 feet thick in the area (Miller, 1986). In between these two aquifers is the Hawthorn Group clay that varies between a few feet to as much as 25 feet thick. Because the clay unit is breached by buried karst features and has previously been exposed to erosional processes, preferential pathways locally connect the overlying surficial aquifer to the UFA resulting in moderate-to-high leakage to the UFA (SWFWMD, 1996). Thus the UFA is defined as a leaky artesian aquifer system.

The UFA is the principal aquifer in the watershed area and is the major source of water for municipal water use. Tampa Bay Water, a regional utility service for portions of Hillsborough, Pasco, and Pinellas Counties, has five major wellfields within or adjacent to the Anclote River watershed (Figure 1). In the mid-1990s, these wellfields withdrew a total of 65 to 70 mgd of groundwater from the UFA.

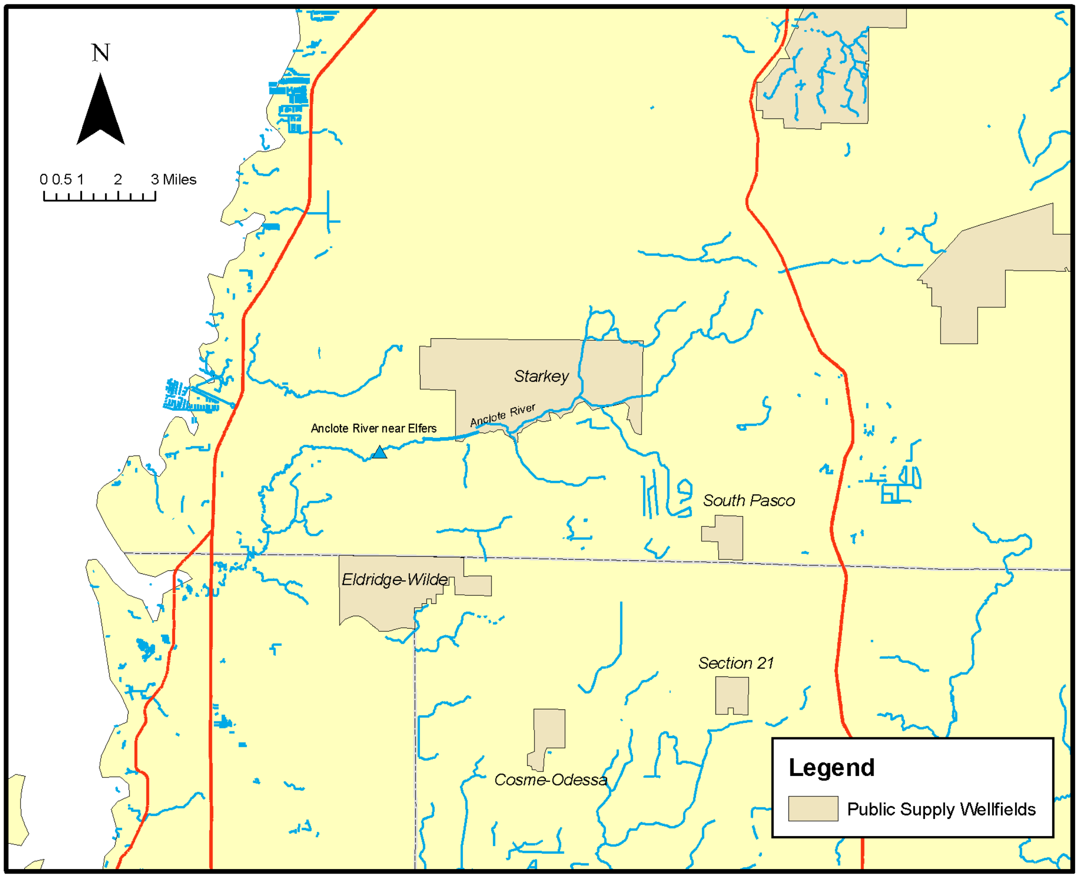

Figure 1. Location of Anclote River.

3.0 Numerical Model Results

A number of regional groundwater flow models have included the Anclote River area. Ryder (1982) simulated the entire extent of the Southwest Florida Water Management District. In 1993, the District completed the Northern Tampa Bay groundwater flow model that covered a 2,000 square mile area of Hillsborough, Pinellas, Pasco, and Hernando Counties (SWFWMD, 1993). In 2002, the USGS simulated the entire Florida peninsula in their Mega Model of regional groundwater flow (Sepulveda, 2002). The most recent and advanced simulation of southwest Pasco County and the surrounding area is the Integrated Northern Tampa Bay model. The construction and calibration of this model was part of a cooperative effort between the SWFWMD and Tampa Bay Water, a regional water utility that operates 11 major wellfields in the area. The Integrated Northern Tampa Bay Model covers a 4,000 square-mile area of the Northern Tampa Bay region (Figure 2).

An integrated model represents the most advanced simulation tool available to the scientific community in water resources investigations. It combines the traditional ground-water flow model with a surface water model and contains an interprocessor code that links both systems. One of the many advantages of an integrated model is that it simulates the entire hydrologic system. It represents the "state-of-art" tool in assessing changes due to rainfall, drainage alterations, and withdrawals.

The model code used to run the INTB simulation is called the Integrated Hydrologic Model (IHM) which combines the HSPF surface water code and the MODFLOW ground-water code using interprocessor software. During the INTB development phase, several new enhancements were made to move the code toward a more physically-based simulation. The most important of these enhancements was the partitioning of the surface into seven major land use segments: urban, irrigated land, grass/pasture, forested, open water, wetlands, and mining/other. For each land segment, parameters were applied in the HSPF model consistent with the land cover, depth-to-water table, and slope. Recharge and ET potential were then passed to each underlying MODFLOW grid cell based on an area weighted-average of land segment processes above it. Other new software improvements included a new ET algorithm/hierarchy plus allowing the model code to transiently vary specific yield and vadose zone storages.

The INTB model contains 172 subbasin delineations in HSPF (Figure 3). There is also an extensive data input time series of 15-minute rainfall from 300 stations for the period 1989-1998, a well pumping database that is independent of integration time step (1-7 days), a methodology to incorporate irrigation flux into the model simulation, construction of an approximate 150,000 river cell package that allows simulation of hydrography from major rivers to small isolated wetlands, and GIS-based definition of land cover/topography. An empirical estimation of ET was also developed to constrain model derived ET based on land use and depth-to-water table relationships.

The MODFLOW gridded domain of the INTB contains 207 rows by 183 columns of variable spacing ranging from 0.25 to one mile. The groundwater portion is comprised of three layers: a surficial aquifer (layer 1), an intermediate confining unit or aquifer (layer 2), and the Upper Floridan aquifer (layer 3). The model simulates leakage between layers in a quasi-3D manner through a leakance coefficient term.

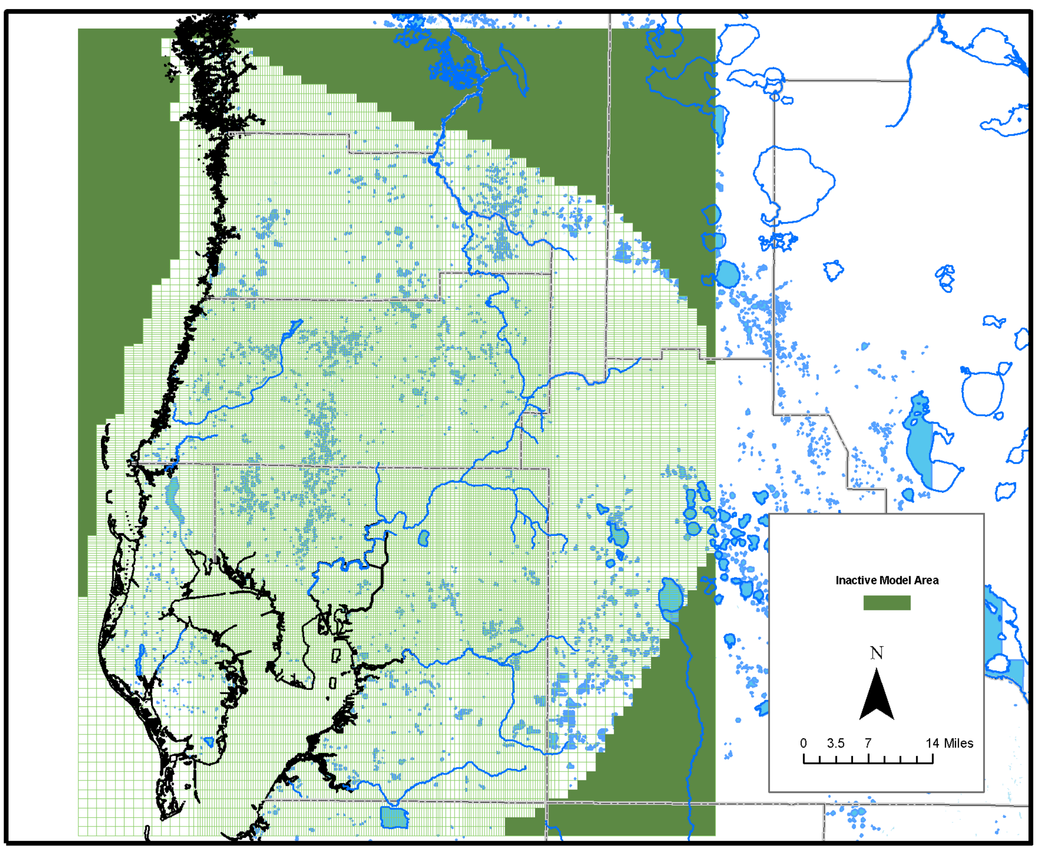

Figure 2. Groundwater grid used in the INTB model.

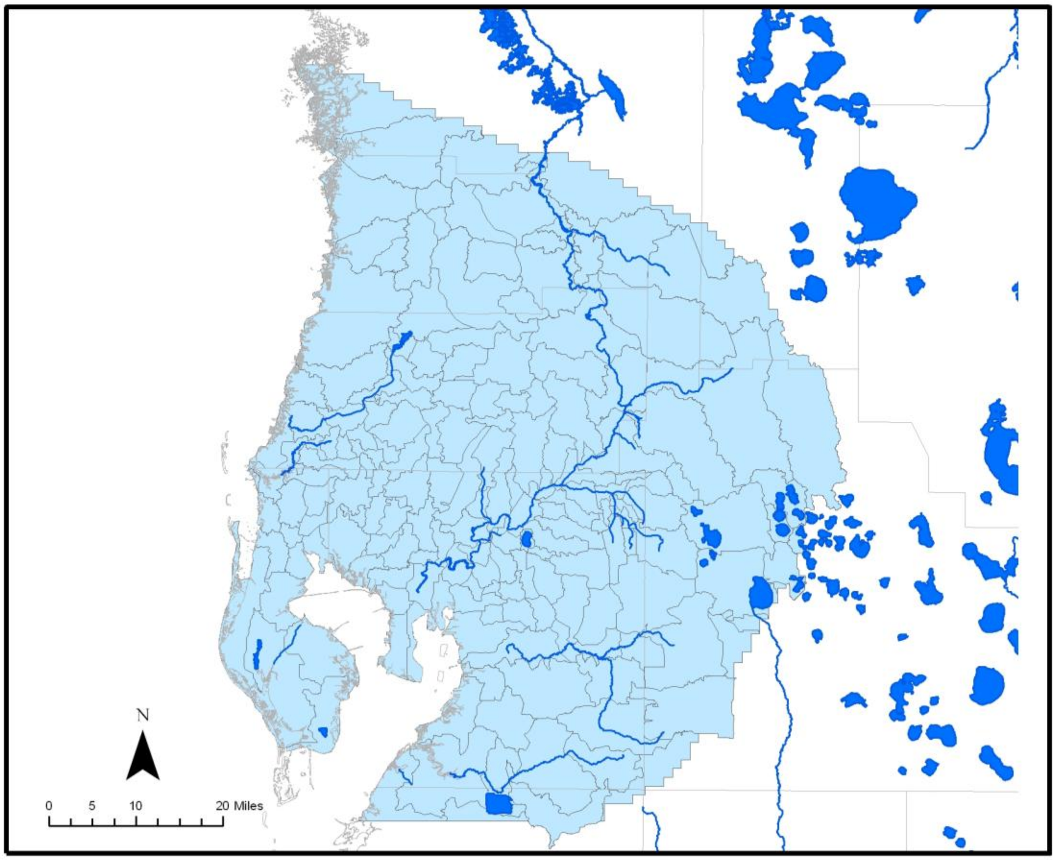

Figure 3. HSPF subbasins in the INTB model.

The INTB model is a regional simulation and has been calibrated to meet global metrics. The model is calibrated using a daily integration step for a transient 10-year period from 1989-1998. Model-wide mean error for all wells in both the surficial (SAS) and Upper Floridan aquifers is less than 0.2 feet. Mean absolute error was less than two feet for both the SAS and UFA. Total stream flow and spring flow mean error averaged for the model domain is each less than 10 percent.

3.1 INTB Model Scenarios

Six different groundwater withdrawal scenarios were run with the INTB model. The first scenario consisted of simulating the impacts from groundwater withdrawn within the Central West-Central Florida Groundwater Basin. The area of withdrawals totaled 197 mgd (average 1989-1998 conditions) and is shown in Figure 4. The simulated stream flow hydrograph of the Anclote River at the Elfers gage showing both current conditions and zero withdrawals within the CWCFGWB is illustrated in Figure 5. The predicted mean and median stream flow decline for the Anclote River is 17.8 cfs and 8.7 cfs, respectively due to 197 mgd of groundwater extraction in the CWCFGWB.

To estimate the impact of the five major wellfields and also develop a timeline of predicted flow declines to the Anclote River due to groundwater withdrawals – all five wellfields within or near the Anclote River basin were modeled in addition to the Eldridge-Wilde, Starkey, and South Pasco wellfields which were each modeled separately. The final scenario consisted of simulating the potential impact to the Anclote River from a combination of groundwater withdrawals from Cross Bar and Cypress Creek wellfields located in central Pasco County. Table 1 summaries the mean and median flow declines as predicted by the INTB model for each scenario. Figures 6-17 depict the predicted drawdown in the surficial and Upper Floridan aquifers for each of the six scenarios.

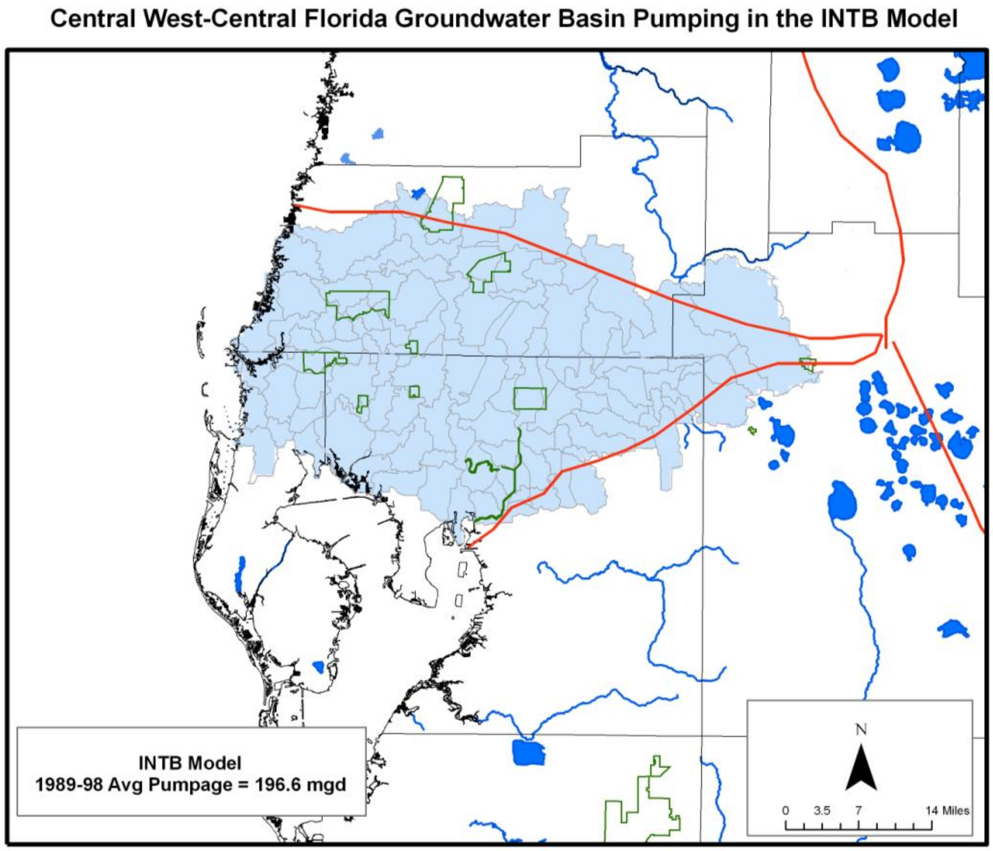

Figure 4. INTB scenario 1 where impacts to the hydrologic system were simulated due to groundwater withdrawals of 197 mgd (1989-1998 average) in the shaded area.

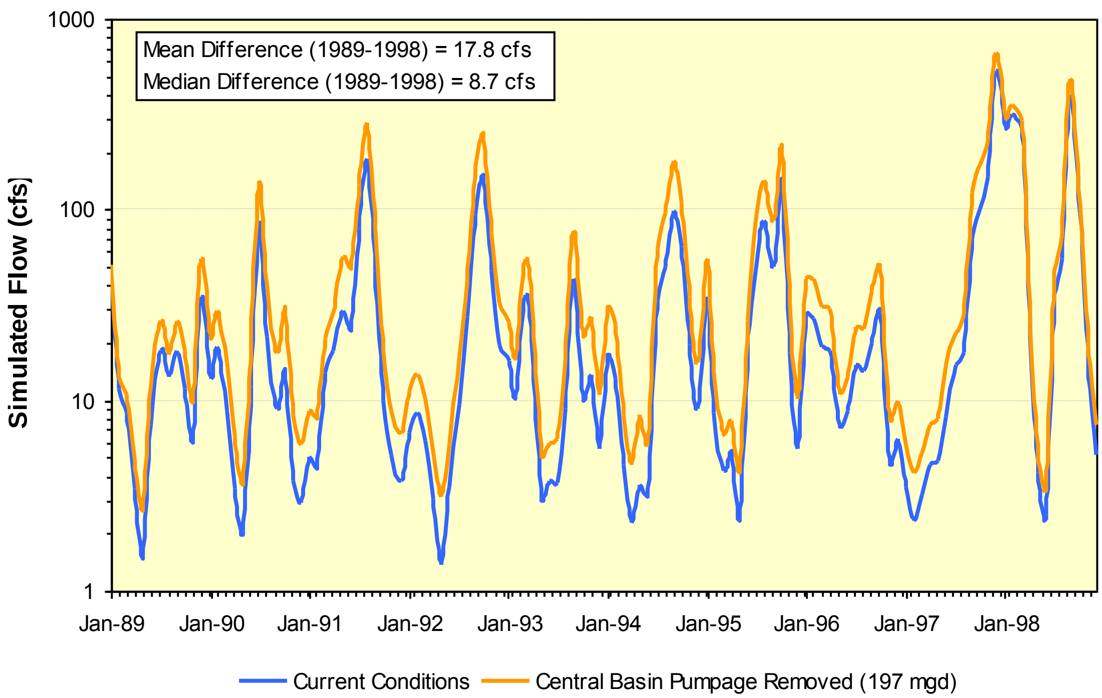

Figure 5. Simulated monthly stream flow change to the Anclote River near Elfers due to 197 mgd of groundwater withdrawn within the Central West-Central Florida Groundwater Basin.

Table 1. Description and results of changes to Anclote River stream flow from six different INTB model scenarios.

Model Scenario No.	Groundwater Extraction (mgd)*	Description	Mean Stream Flow Reduction (cfs) Anclote River near Elfers	Median Stream Flow Reduction (cfs) Anclote River near Elfers
1	196.6	Central West-central Florida Groundwater Basin	17.8	8.7
2	67.1	Starkey, Eldridge-Wilde, S. Pasco, Cosme-Odessa, and Section 21 Wellfields	14.4	6.8
3	51.8	Cypress Creek and Cross Bar Wellfields	0.4	0.3
4	25.5	Eldridge-Wilde Wellfield	3	1.7
5	13.1	South Pasco Wellfield	4.8	1.8
6	12.3	Starkey Wellfield	4.6	2.4

* = 1989-1998 Average Quantities

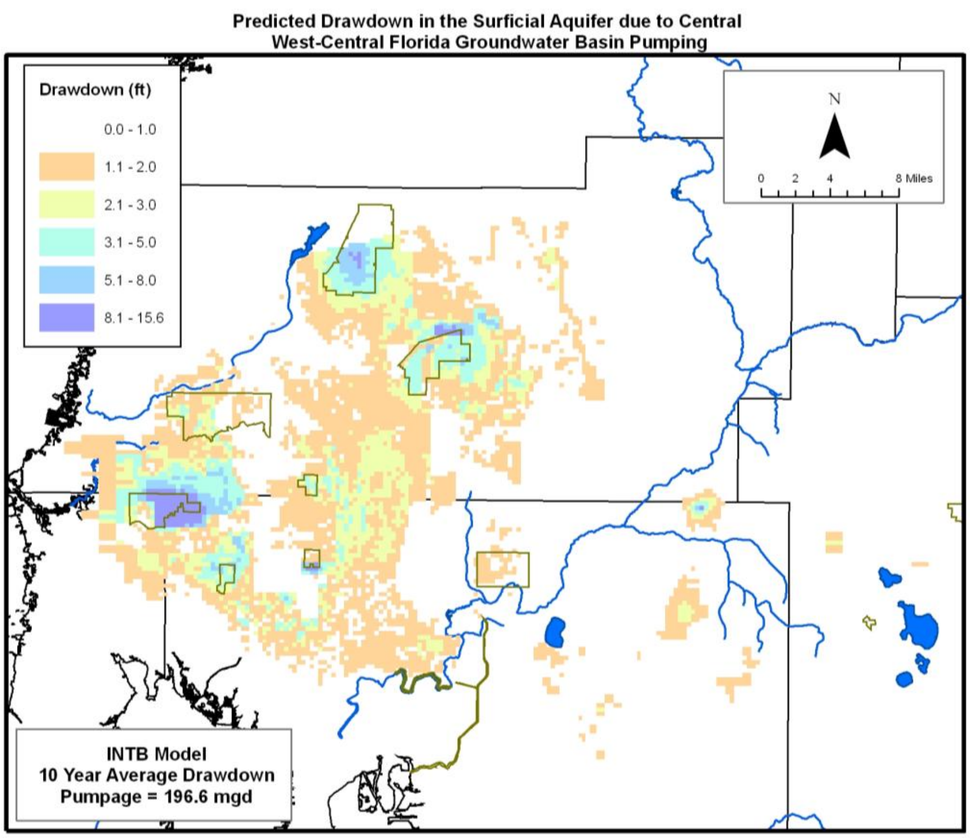

Figure 6. Predicted decline in the Surficial Aquifer due to197 mgd of groundwater withdrawals within the Central West-Central Florida Groundwater Basin.

Predicted Drawdown in the Upper Floridan Aquifer due to Central West-Central Florida Groundwater Basin Pumping

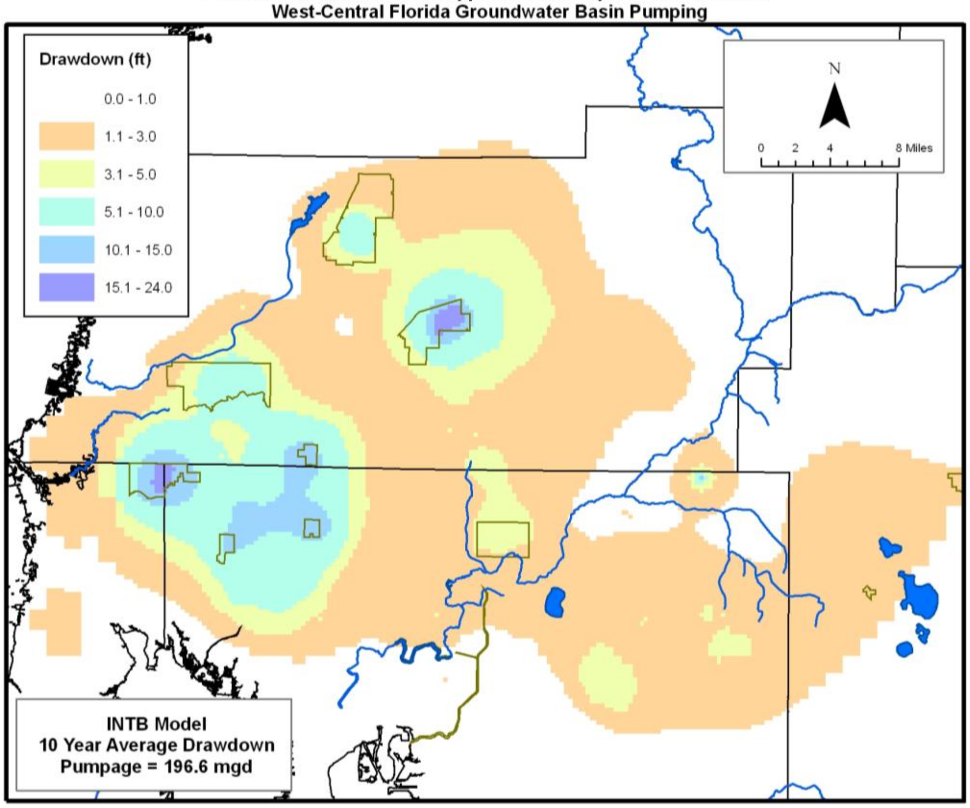

Figure 7. Predicted decline in the Upper Floridan Aquifer due to 197 mgd of groundwater withdrawals within the Central West-Central Florida Groundwater Basin.

Predicted Drawdown in the Surficial Aquifer due to Tri-County Wellfields (except NW Hillsborough)

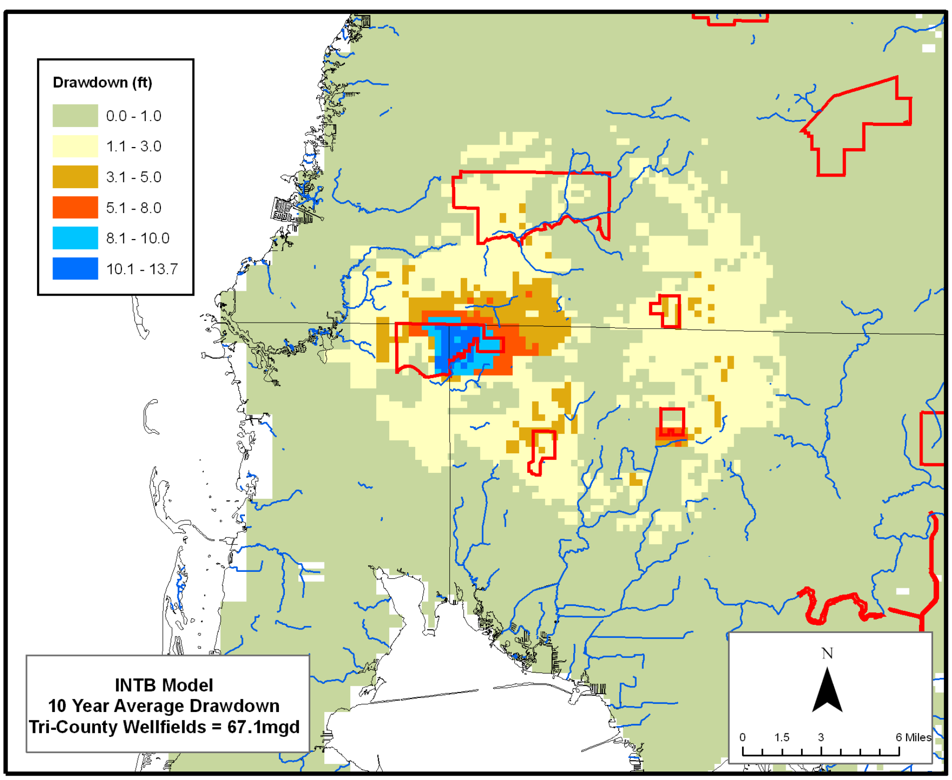

Figure 8. Predicted decline in the Surficial Aquifer due to 67.1 mgd of groundwater withdrawals from five wellfields (Eldridge-Wilde, Starkey, Section 21, South Pasco, and Cosme-Odessa).

Predicted Drawdown in the Upper Flordan Aquifer due to Tri-County Wellfields (except NW Hillsborugh)

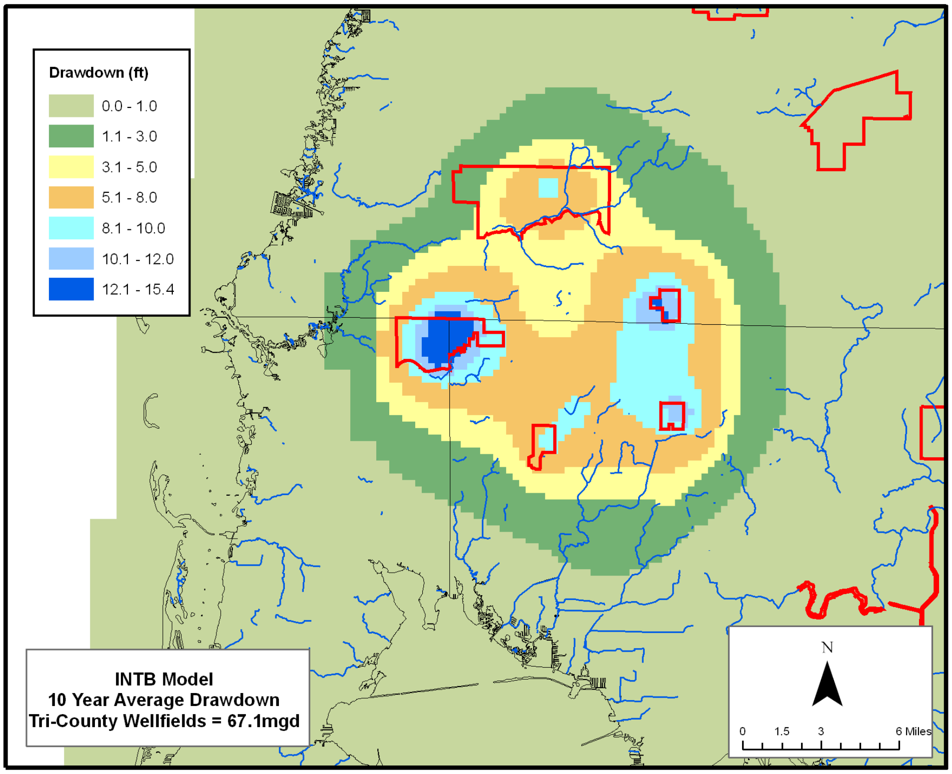

Figure 9. Predicted decline in the Upper Floridan Aquifer due to 67.1 mgd of groundwater withdrawals from five wellfields (Eldridge-Wilde, Starkey, Section 21, South Pasco, and Cosme-Odessa).

Predicted Drawdown in the SAS due to Cypress Creek & Cross Bar Wellfields

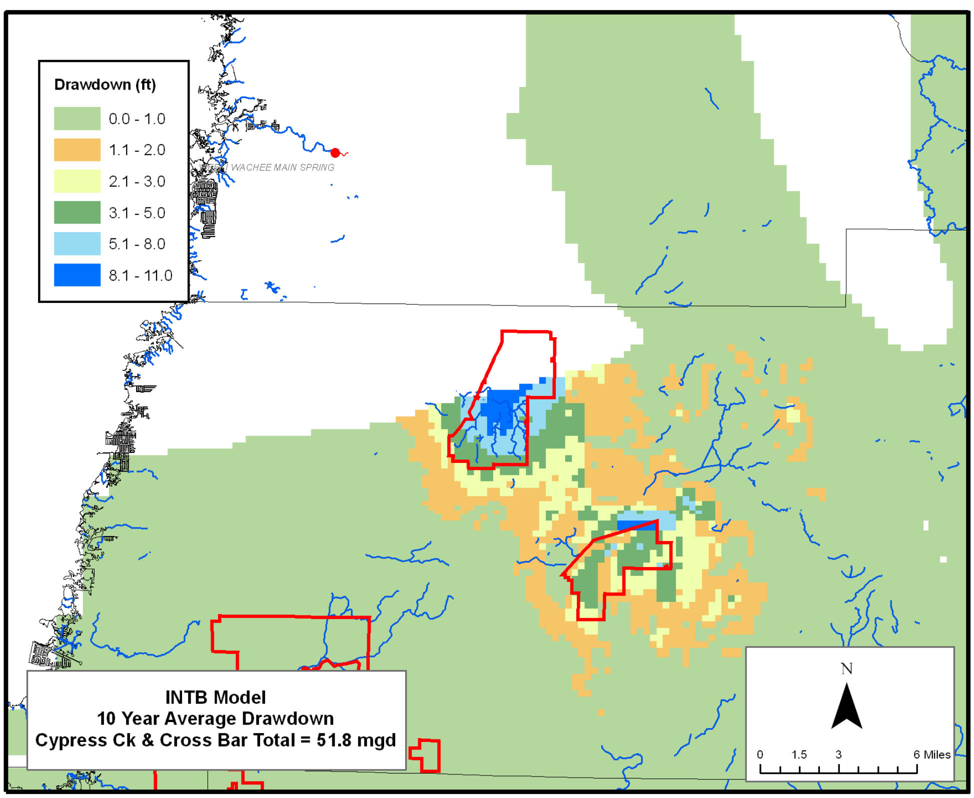

Figure 10. Predicted decline in the Surficial Aquifer due to 51.8 mgd of groundwater withdrawals from the Cross Bar and Cypress Creek wellfields.

Predicted Drawdown in the UFA due to Cypress Creek & Cross Bar Wellfields

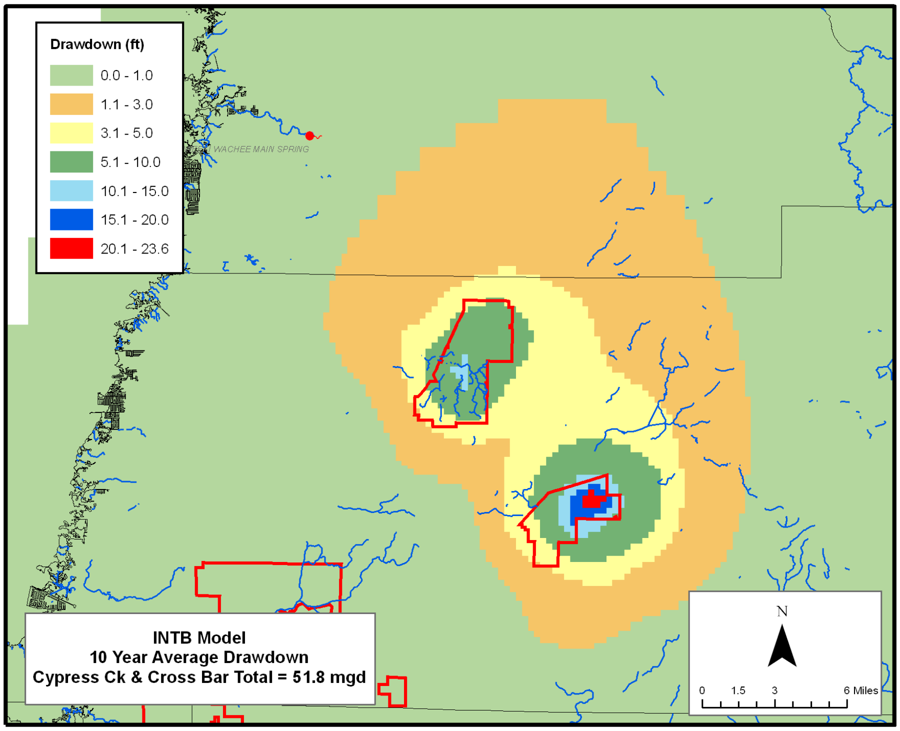

Figure 11. Predicted decline in the Upper Floridan Aquifer due to 51.8 mgd of groundwater withdrawals from the Cross Bar and Cypress Creek wellfields.

Predicted Drawdown in the Surficial Aquifer due to Eldridge-Wilde Wellfield

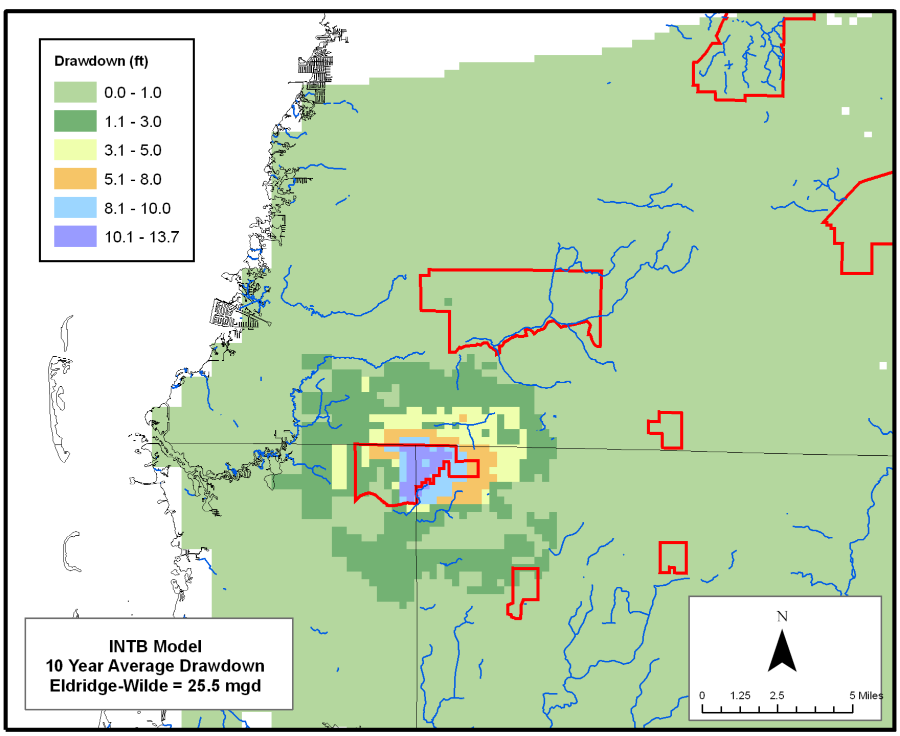

Figure 12. Predicted decline in the Surficial Aquifer due to 25.5 mgd of groundwater withdrawals from Eldridge-Wilde wellfield.

Predicted Drawdown in the Upper Floridan aquifer due to Eldridge-Wilde Wellfield

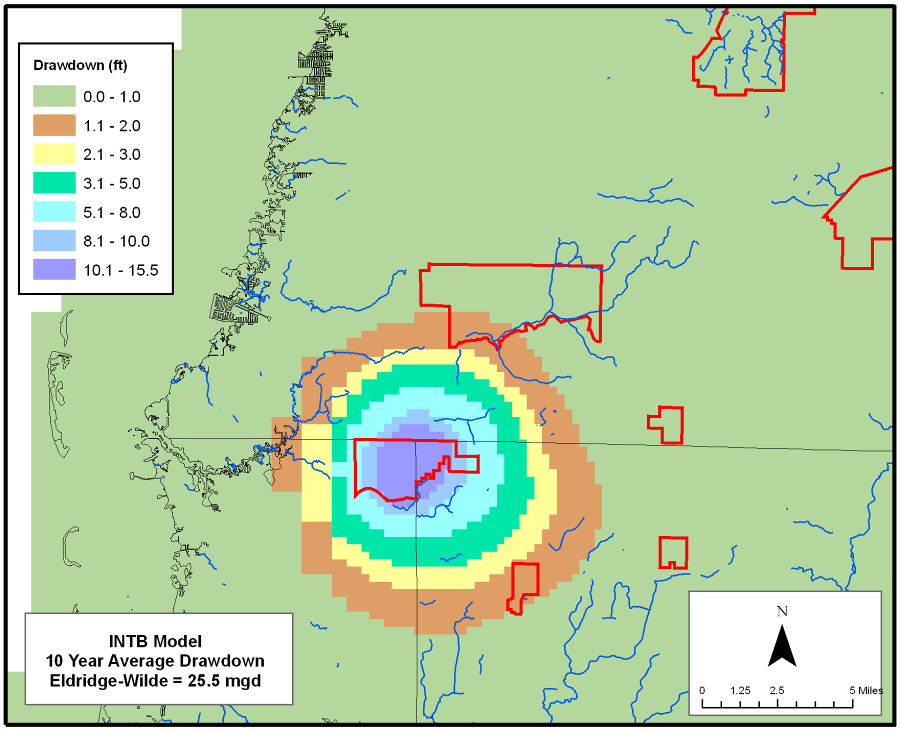

Figure 13. Predicted decline in the Upper Floridan Aquifer due to 25.5 mgd of groundwater withdrawals from Eldridge-Wilde wellfield.

Predicted Drawdown in the SAS due to South Pasco Wellfield

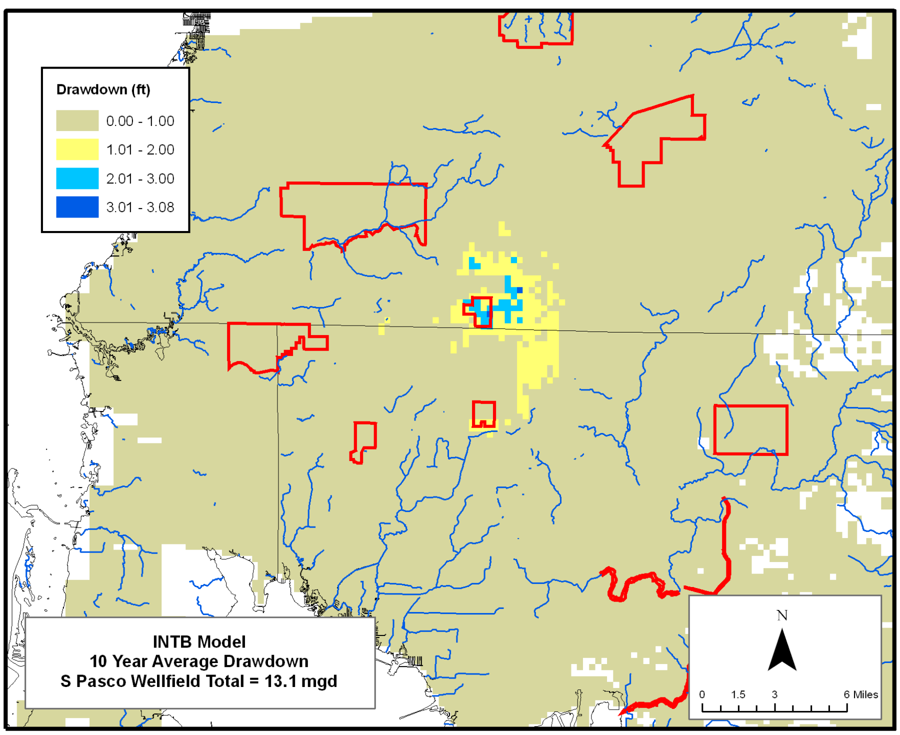

Figure 14. Predicted decline in the Surficial Aquifer due to 13.1 mgd of groundwater withdrawals from South Pasco wellfield.

Predicted Drawdown in the UFA due to South Pasco Wellfield

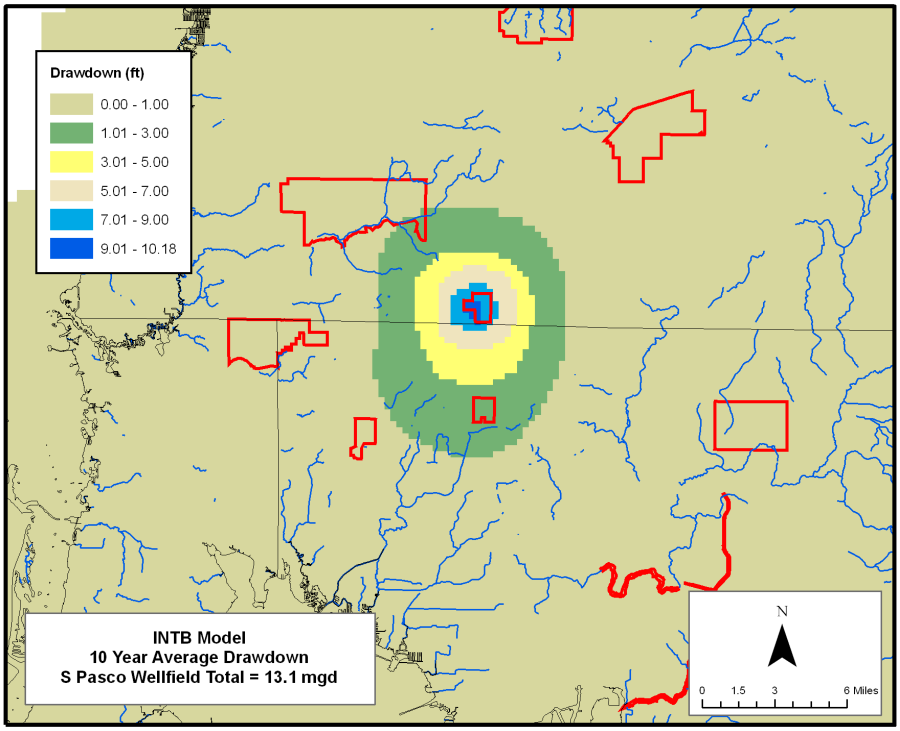

Figure 15. Predicted decline in the Upper Floridan Aquifer due to 13.1 mgd of groundwater withdrawals from South Pasco wellfield.

Predicted Drawdown in the Surficial Aquifer due to Starkey Wellfield

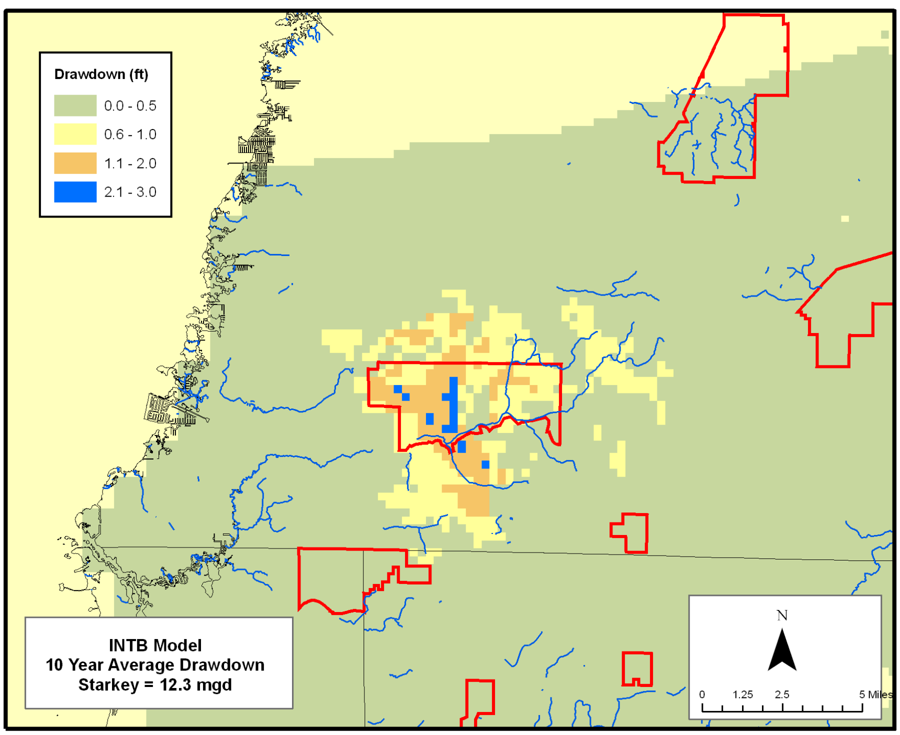

Figure 16. Predicted decline in the Surficial Aquifer due to 12.3 mgd of groundwater withdrawals from Starkey wellfield.

Predicted Drawdown in the UFA due to Starkey Wellfield

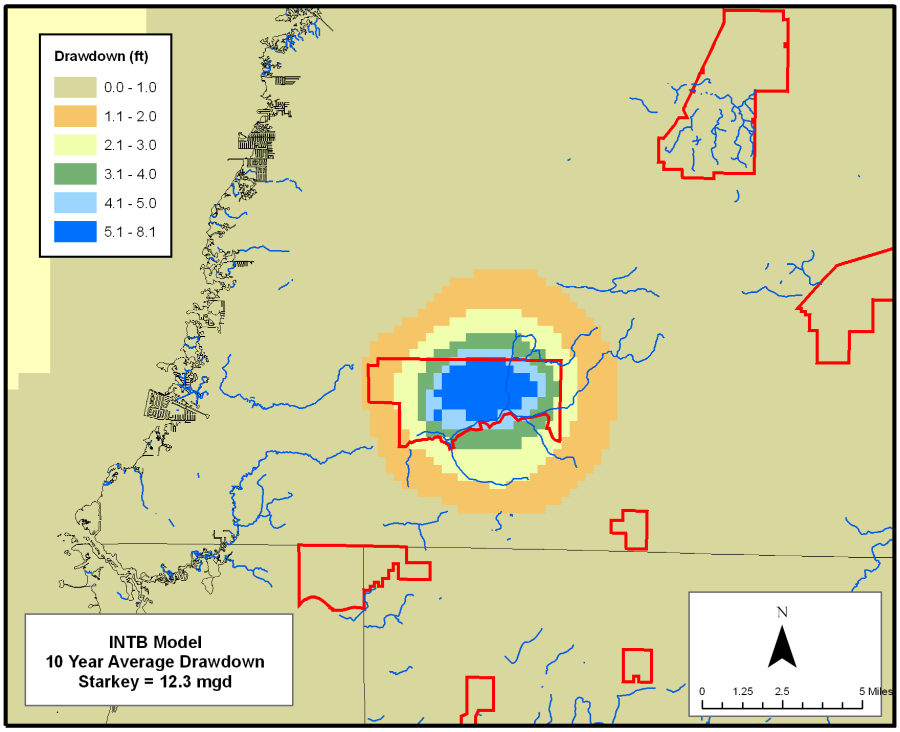

Figure 17. Predicted decline in the Upper Floridan Aquifer due to 12.3 mgd of groundwater withdrawals from Starkey wellfield.

4.0 Estimation of groundwater impacts to Anclote River Flow from 1955 to Present Conditions

The earliest groundwater withdrawals for public supply began as early as the 1930s at Cosme-Odessa wellfield. However, stream flow measurements did not originate from the Elfers gage on the Anclote River until 1946. After Cosme-Odessa, the Eldridge–Wilde wellfield began pumping in 1956. Thereafter, Section 21, South Pasco, and the Starkey wellfield initiated withdrawals in 1963, 1973, and 1976, respectively. All five wellfields extracted a combined average of between 65 and 70 mgd during the 1990s. Figure 18 displays the groundwater withdrawal history of the five wellfields within or near the Anclote River Basin.

To estimate the approximate impact to the Anclote River through time due to groundwater extraction, a ratio of stream flow decline of the Anclote River at the Elfers gage per one mgd groundwater withdrawal quantity was calculated for each of the five wellfields based on the scenario runs (Table 2). In addition to these five wellfields, a little more than three cfs of impact to the Anclote River is predicted from the model from all other users.

The projected decline in Anclote River stream flow through time was developed by multiplying the mean and median flow declines per mgd listed in Table 2 by the actual wellfield extraction through time. The flow decline was estimated beginning in 1955 for five year periods through current 2008 withdrawal conditions. Due to implementation of the partnership plan, TBW's groundwater withdrawals declined significantly in 2003 when an offstream reservoir was brought on-line.

The total projected stream flow decline from other users was simply incrementally apportioned through time from 1955 to the full impact in 1995 since water use history of these withdrawals is poorly understood. After 1995, other user's impact was held steady except for slight downward adjustments due to decreased withdrawals from Cypress Creek and Cross Bar wellfields during 2005 and 2008. The chronological history of projected impacts to Anclote River stream flow is shown in Figure 18 and summarized in Table 3.

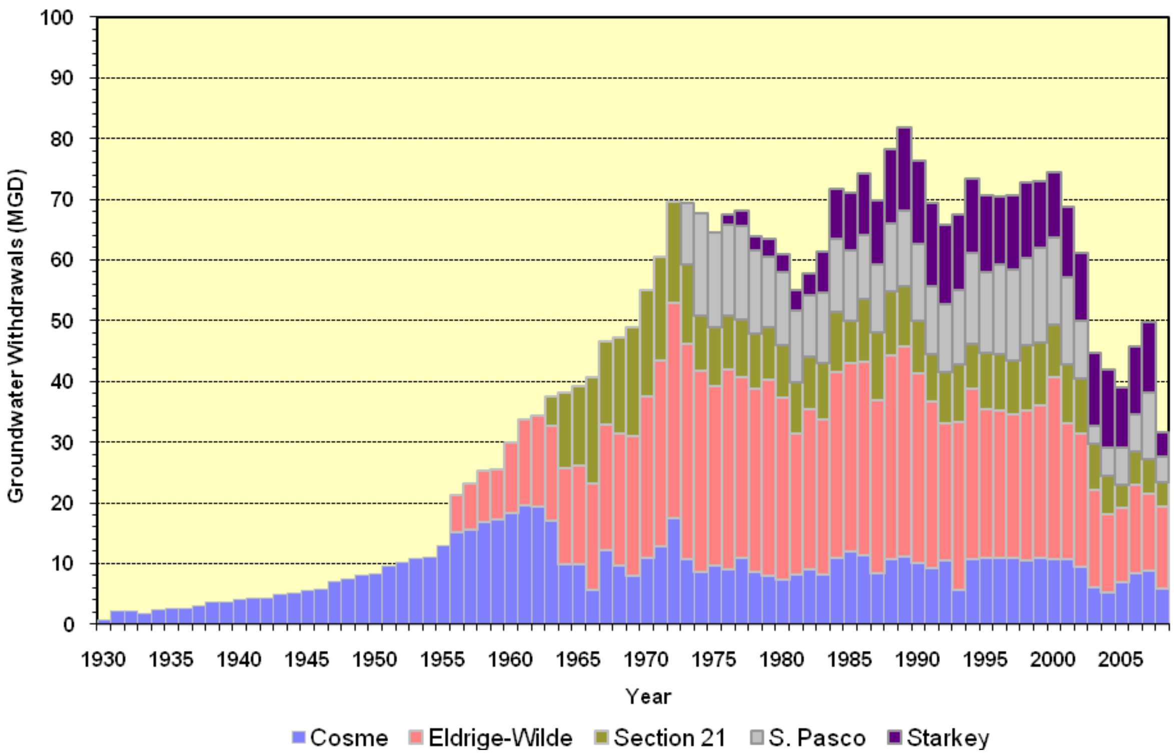

Figure 18. Groundwater withdrawal history from five wellfields within or near the Anclote River Basin.

Table 2. Ratio of Anclote River decline per one mgd of groundwater extraction from the five wellfields.

Wellfield	Groundwater Extraction (mgd)*	Mean Stream Flow Reduction (cfs) Anclote River near Elfers	Mean Stream Flow Reduction (cfs) Per MGD of Groundwater Withdrawn	Median Stream Flow Reduction (cfs) Anclote River near Elfers	Median Stream Flow Reduction (cfs) Per MGD of Groundwater Withdrawn
Eldridge-Wilde	25.5	3	0.11	1.7	0.07
South Pasco	13.1	4.8	0.37	1.8	0.14
Starkey	12.3	4.6	0.37	2.4	0.20
Cosme-Odessa	8.1	1	0.12	0.45	0.06
Section 21	8.1	1	0.12	0.45	0.06

* = 1989-1998 Average Quantities

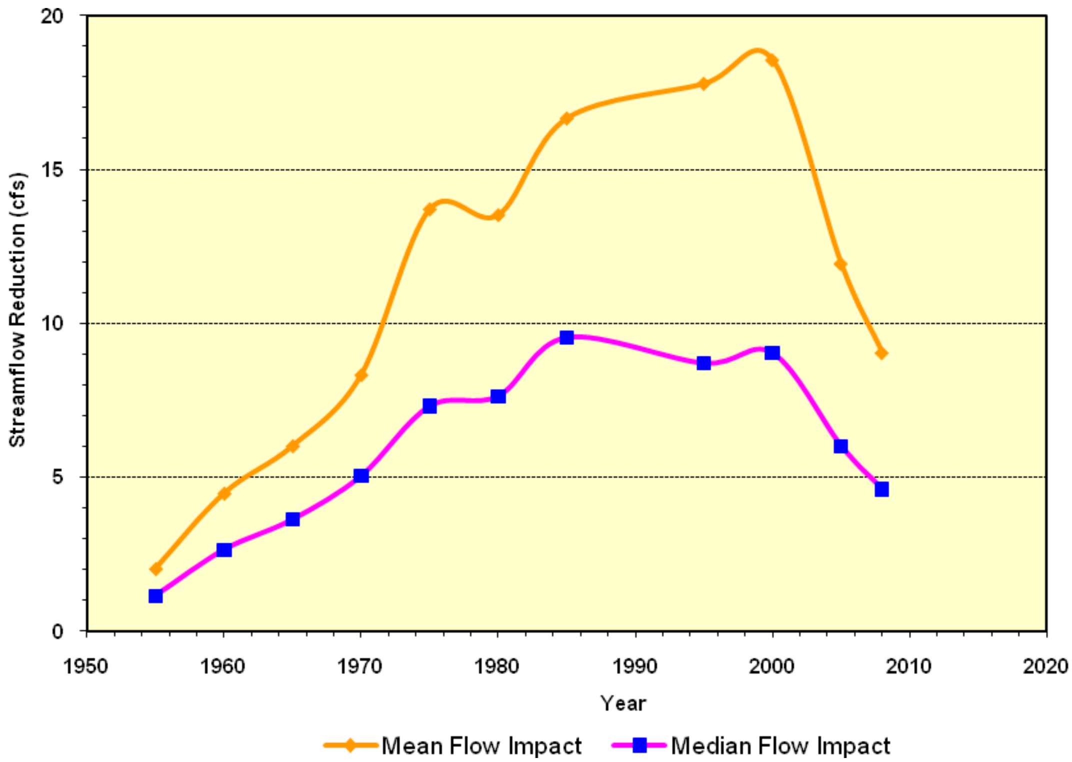

Figure 19. Projected decline through time in Anclote River stream flow due to groundwater withdrawals in the region.

Table 3. Projected decline in mean and median Anclote River stream flow through time due to groundwater withdrawals

Year	Groundwater Withdrawn (mgd)	Wellfields	Mean Flow Wellfield Impact (cfs)	Median Flow Wellfield Impact (cfs)	Other Groundwater Use Mean Impact (cfs)	Other Groundwater Use Median Impact (cfs)	Total Impact Mean Flow (cfs)	Total Impact Median Flow (cfs)
1955	13	Cosme-Odessa	1.6	0.7	0.4	0.2	2.0	0.2
1960	30	Cosme-Odessa, Eldridge-Wilde	3.6	1.8	0.8	0.5	4.5	2.3
1965	39.3	Cosme-Odessa, Eldridge-Wilde, Sec 21	4.8	2.4	1.3	0.7	6.0	3.1
1970	55.1	Cosme-Odessa, Eldridge-Wilde, Sec 21	6.6	3.4	1.7	1.0	8.3	4.3
1975	64.6	Cosme-Odessa, Eldridge-Wilde, Sec 21, S. Pasco	11.6	5.2	2.1	1.2	13.7	6.4
1980	60.9	Cosme-Odessa, Eldridge-Wilde, Sec 21, S. Pasco, Starkey	11.0	5.1	2.5	1.4	13.5	6.5
1985	76.4	Cosme-Odessa, Eldridge-Wilde, Sec 21, S. Pasco, Starkey	13.7	6.6	2.9	1.7	16.7	8.3
1995	67.1	Cosme-Odessa, Eldridge-Wilde, Sec 21, S. Pasco, Starkey	14.4	6.8	3.4	1.9	17.8	8.7
2000	74.4	Cosme-Odessa, Eldridge-Wilde, Sec 21, S. Pasco, Starkey	15.2	7.1	3.4	1.9	18.6	9.0
2005	39.1	Cosme-Odessa, Eldridge-Wilde, Sec 21, S. Pasco, Starkey	8.7	4.2	3.2*	1.8*	11.9	6.0
2008	31.6	Cosme-Odessa, Eldridge-Wilde, Sec 21, S. Pasco, Starkey	5.8	2.8	3.2*	1.8*	9.0	4.6

* Accounts for reductions in Cypress Creek and Cross Bar wellfields.

<u>References</u>

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Ryder, P., 1982, Digital Model of Predevelopment Flow in the Tertiary limestone (Floridan) Aquifer System in West-Central Florida, U.S. Geological Survey Water-Resources Investigations Report 81-54.

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Southwest Florida Water Management District, 1996, Northern Tampa Bay Water Resource Assessment Project, Surface-Water/Ground-Water Interrelationships.

August 25, 2008
(Revised 12/22/2009)

To: Marty Kelly, Ph.D. Director, Minimum Flows and Levels Program

From: Mike Heyl, Chief Environmental Scientist. Ecologic Evaluation Section

Subject: Adjustments to Flow Record for Groundwater Impacts

1.0 Introduction

The headwaters of the Anclote River are in an area of substantial groundwater withdrawals from the upper Floridan aquifer. During 1995-2005, 67.1 mgd was withdrawn from in this area. The impact of these withdrawals on Anclote stream flow at Elfers was estimated by Basso (2007) for five-year increments. Intervening years were interpolated and are presented in Figure 1 and Table 1. In order to re-create a natural, unimpacted record of flow for the MFL evaluation, it is necessary to distribute the annual impacts to daily impacts. Several approaches were investigated and are described in this technical memorandum.

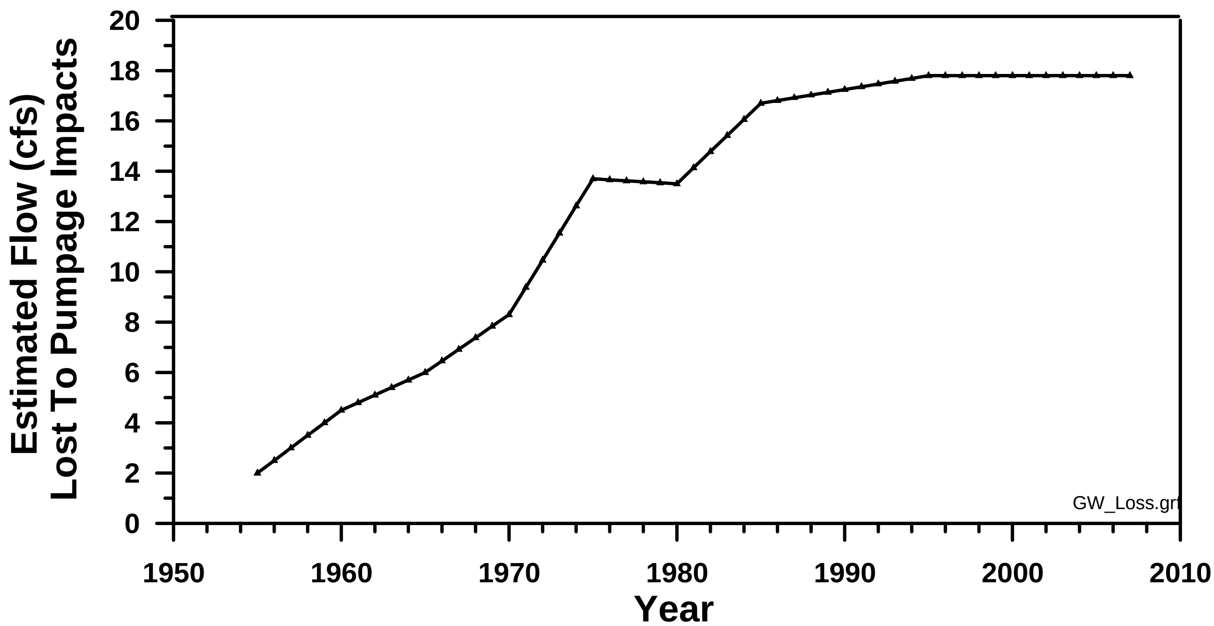


Figure 1. Estimate annual average impact of groundwater pumpage on Anclote stream flow.

Table 1. Estimated annual average groundwater withdrawal influences to Anclote River flow at Eflers.

Year	Adjust (cfs)	Year	Adjust (cfs)	Year	Adjust (cfs)
1955	2.00	1973	11.54	1991	17.36
1956	2.50	1974	12.62	1992	17.47
1957	3.00	1975	13.70	1993	17.58
1958	3.50	1976	13.66	1994	17.69
1959	4.00	1977	13.62	1995	17.80
1960	4.50	1978	13.58	1996	17.80
1961	4.80	1979	13.54	1997	17.80
1962	5.10	1980	13.50	1998	17.80
1963	5.40	1981	14.14	1999	17.80
1964	5.70	1982	14.78	2000	17.80
1965	6.00	1983	15.42	2001	17.80
1966	6.46	1984	16.06	2002	17.80
1967	6.92	1985	16.70	2003	17.80
1968	7.38	1986	16.81	2004	17.80
1969	7.84	1987	16.92	2005	17.80
1970	8.30	1988	17.03	2006	17.80
1971	9.38	1989	17.14	2007	17.80
1972	10.46	1990	17.25		

2.0 Technical Approaches

2.1 Distribution of impacts according to pumpage rates.

Anclote flows have been measured by the USGS at Elfer's (USGS 02310000) continuously since June 1946. While groundwater pumpage began in 1932, interpolating from Basso (2007) the estimated groundwater impact in 1957 was a modest 3 cfs and the period 1947 -1957 (inclusive) was used to represent flows minimally impacted by groundwater withdrawals. The average flow from January 1 1947 through December 31, 1957 was 71 cfs (median = 16.0 cfs). For contrast, the average flow for the period 1995-2005 (inclusive) was 68 cfs, but the median was down to 8 cfs. Figure 2 compares the day of year (DOY) mean and median for these two periods.

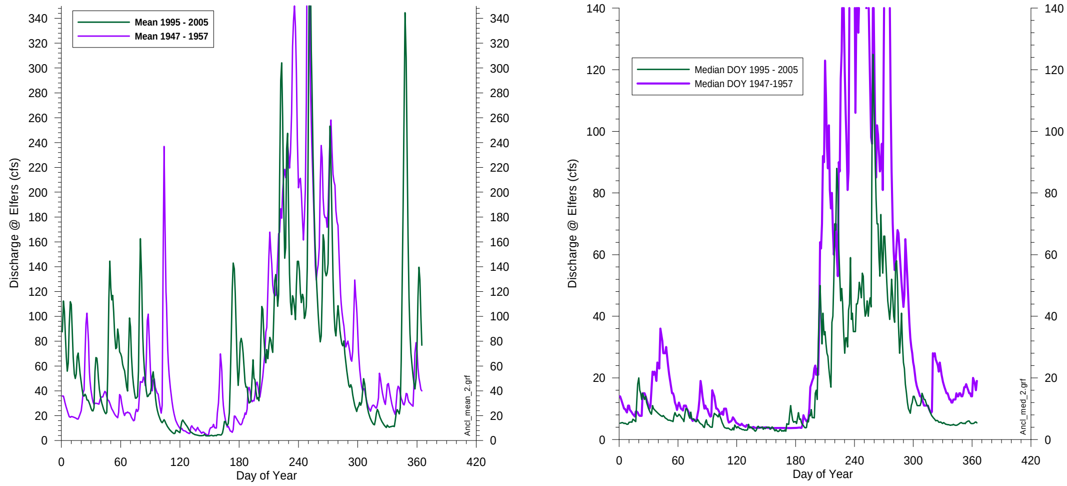


Figure 2. Day of Year Flows (mean and median) [1] for 1947-57 and 1995 – 2005.

The initial approach to distribute the impacts utilized monthly pump factors derived from records of pumpage in the well fields from 1955 - 1998. For a given year, each monthly withdrawal was divided by the annual average pumpage for that year to derive a ratio of monthly annual average pumpage. These monthly ratios were then summarized to mean and median values and daily values interpolated. The procedure is illustrated in Table 2 for mean pumpage factors.

Table 2. Protocol for determining monthly adjustments from observed pumpage.

	Observed Monthly Total Pumpage / Annual Total Pumpage								Daily Interpolation	
	1955	1956	1957		1997	1998	Average Monthly ==>		0.917	31-Jan
Jan Total / Annual Total	0.975	0.944	0.837		1.022	0.860	0.917		0.916	1-Feb
Feb Total / Annual Total	0.940	0.957	0.839		0.980	1.061	0.892		0.915	2-Feb
Mar Total / Annual Total	1.164	1.188	0.883		1.080	0.900	1.030		0.914	3-Feb
Apr Total / Annual Total	1.063	1.086	0.830		0.956	1.031	1.094		0.914	4-Feb
May Total / Annual Total	1.196	1.162	0.817		1.020	1.098	1.165		0.913	5-Feb
Jun Total / Annual Total	1.086	1.009	1.045	Extended ====>	1.017	1.053	1.043		0.912	6-Feb
Jul Total / Annual Total	0.869	0.917	0.990		0.971	0.971	0.981		0.911	7-Feb
Aug Total / Annual Total	0.852	0.944	1.028		1.079	0.948	0.947		Extended ====>	
Sep Total / Annual Total	0.856	0.824	1.040		1.048	0.943	0.934			
Oct Total / Annual Total	0.967	0.878	1.174		0.967	1.015	1.032		0.893	27-Feb
Nov Total / Annual Total	0.983	1.028	1.290		1.007	1.088	0.998		0.893	28-Feb
Dec Total / Annual Total	1.049	1.063	1.227		0.854	1.032	0.968		0.892	29-Feb

[1] Median display truncates 26 values above 140 cfs.

2.2 Distribution of impacts according to stream flow.

A distribution of the withdrawal impacts based on observed daily flow was completed as a comparison to the distribution derived from pumpage. The annual pumpage impact was distributed according to the long-term day of year fraction of annual flows as illustrated in Table 3. The average day of year (DOY) value was calculated for years 1955 through 2005. Each of the DOY averages were then divided by the daily average flow for the period to arrive at the fraction of flow (relative to long-term daily average) that occurs at each calendar day as illustrated below in Table 3.

Table 3. Protocol for establishing DOY adjustment factors from stream flow.

	Observed Flow (cfs)							
	1955	**1956**	**1957**		2004	2005	**Average DOY ==>**	**Average DOY Fraction**
1-Jan	14	6.6	3.6	**Extended ====>**	5.8	13	43.38	= 43.4 / **63.3**
2-Jan	13	6.3	2.9		5.6	13	48.18	= 48.2 / **63.3**
3-Jan	12	6.1	2.7		5.5	12	49.04	0.77
4-Jan	11	5.8	2.6		5.4	11	47.53	0.75
5-Jan	10	5.6	2.5		5.2	11	43.64	0.69
6-Jan	9.9	5.4	2.7		5.3	11	39.38	0.62
				Extended ====>				
30-Dec	7.6	3.6	62		17	11	47.66	0.75
31-Dec	7.1	3.6	53		15	9.9	42.99	0.68
						Average Daily Flow 1/1/1955 - 12/31/05	**63.29**	

Using January 6, 2004 as an example, the annual 17.8 cfs pumpage impact (See Table 1) was distributed according to the DOY fraction. Thus, a groundwater adjustment of 11.0 cfs (e.g. 0.62 * 17.8 cfs) was applied to the observed January 6, 2004 flow of 5.3 cfs resulting in an adjusted baseline flow of 16.3 cfs.

2.3 Comparison of adjustment factors.

Groundwater impacts were distributed using the factors derived from both flow and pumpage records. The results are compared with median and mean DOY observed values for 1955-2005 in Figure 3. The mean results appear reasonable, but the median values adjusted with pump factors appears to be inflated and implies dry season flows on the order of 20 cfs. Such values have rarely been observed (between 1955-2005 less than 19 percent of the Block 1 observed flows are > 20 cfs), and even during the relatively un-impacted 1947-1957 period as illustrated in Figure 4 only 17% of the observations were greater than 20 cfs. Given the better dry season fit exhibited, the observed flow record was adjusted using the DOY factors derived from the flow pattern instead of the factors derived from pumpage history. Figure 5 provides a comparison of the corrected and uncorrected flows for 10/1/1955 through 9/30/2007 while Figure 6 illustrates the difference (observed – corrected) in flow for the same period.

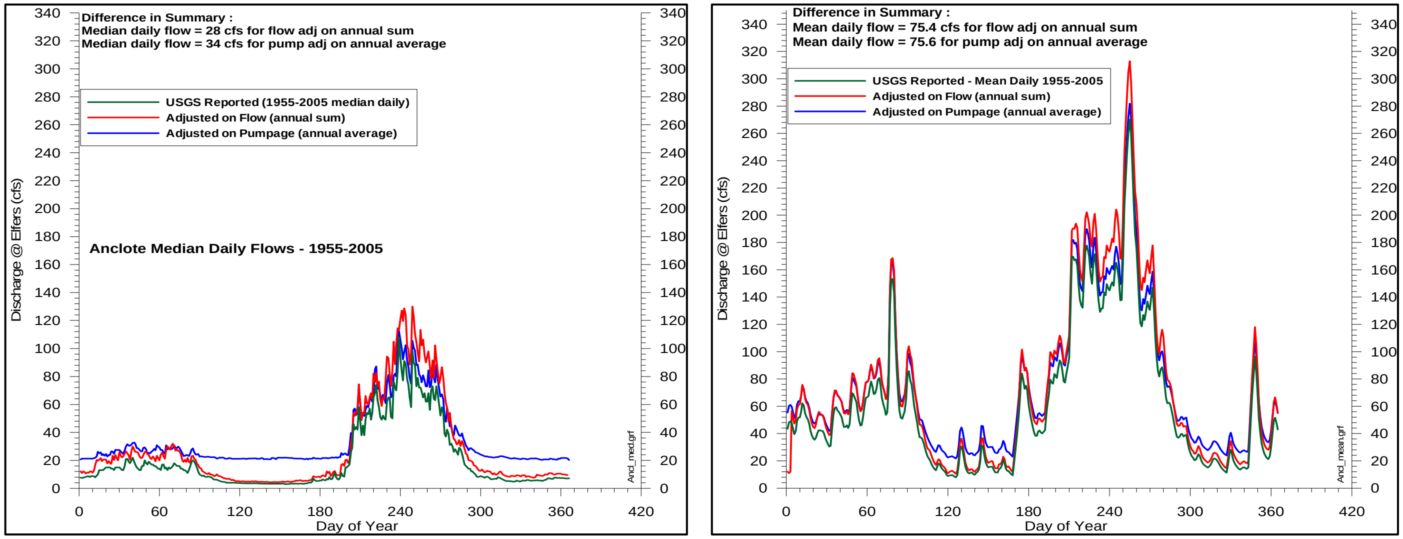


Figure 3. Comparison of 1955-2005 flows adjusted for groundwater withdrawals using factors derived from pumpage and from seasonal flow patterns.

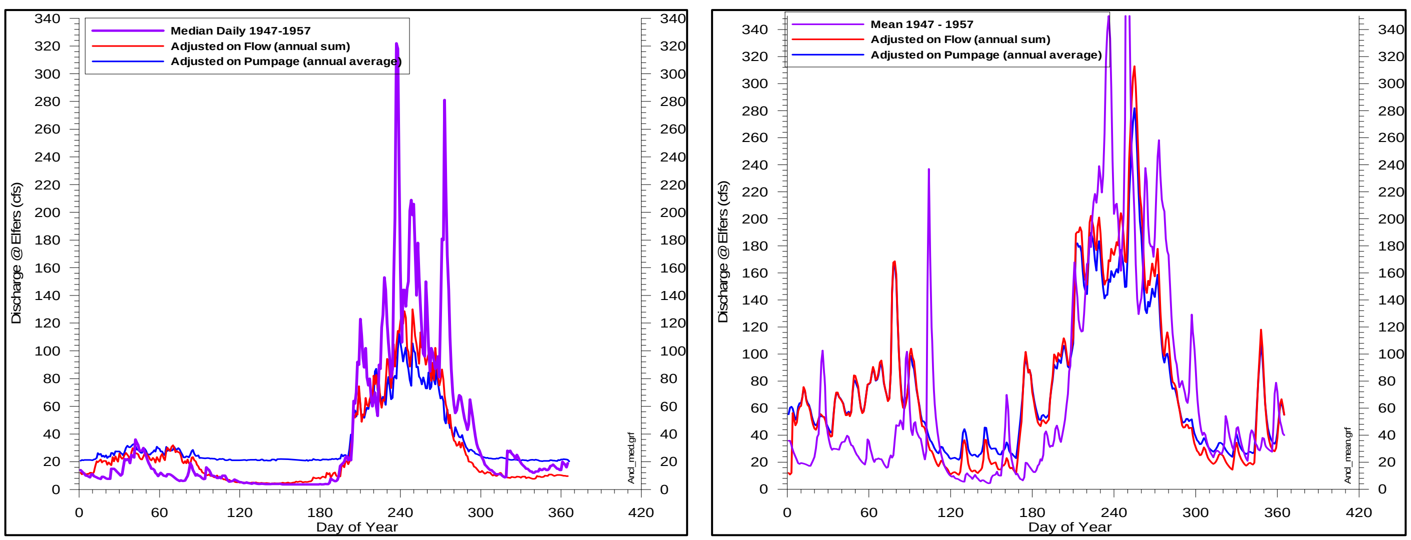


Figure 4. Comparison of 1947 – 1957 flows adjusted for groundwater withdrawals using factors derived from pumpage and from seasonal flow patterns.

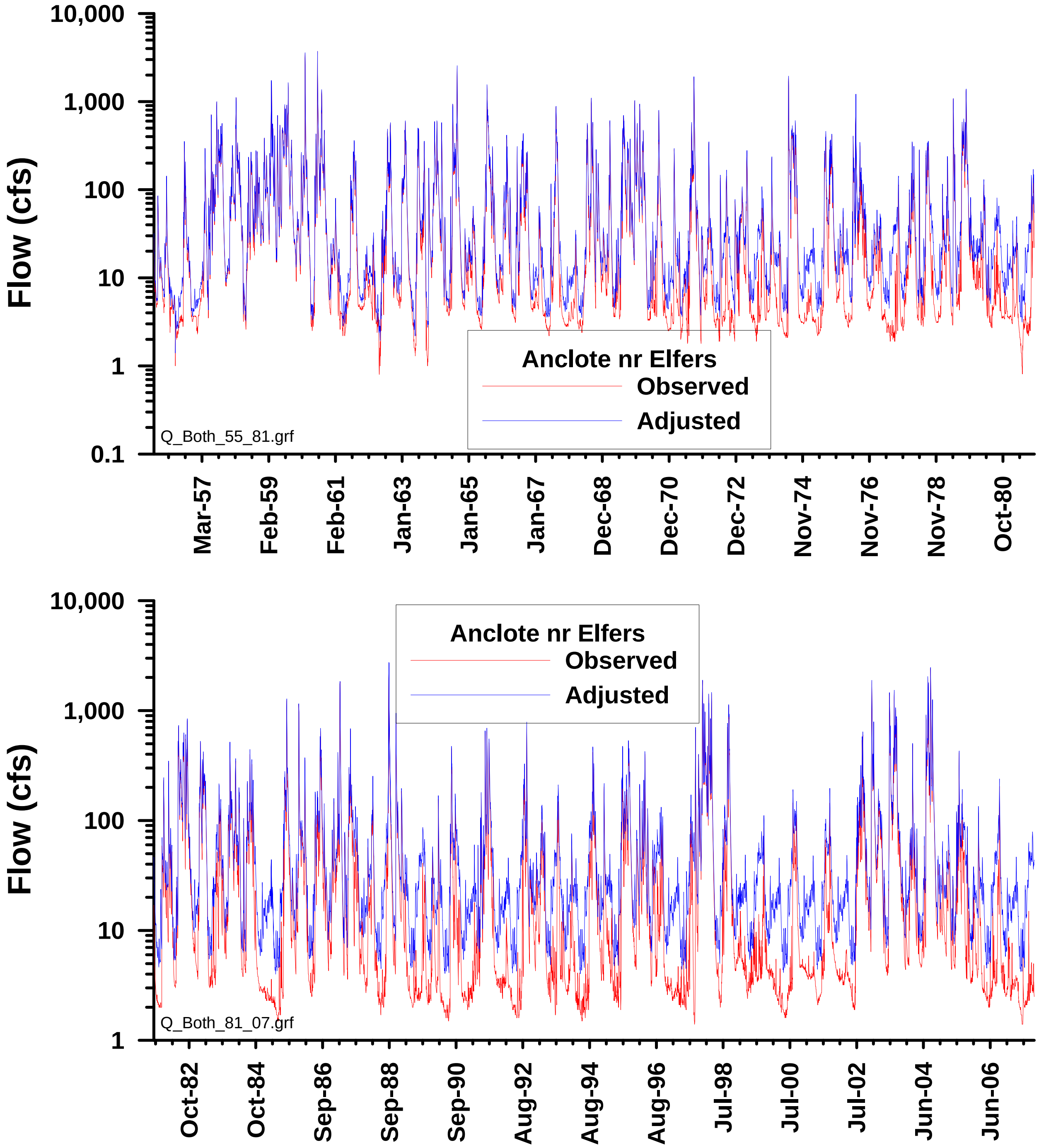
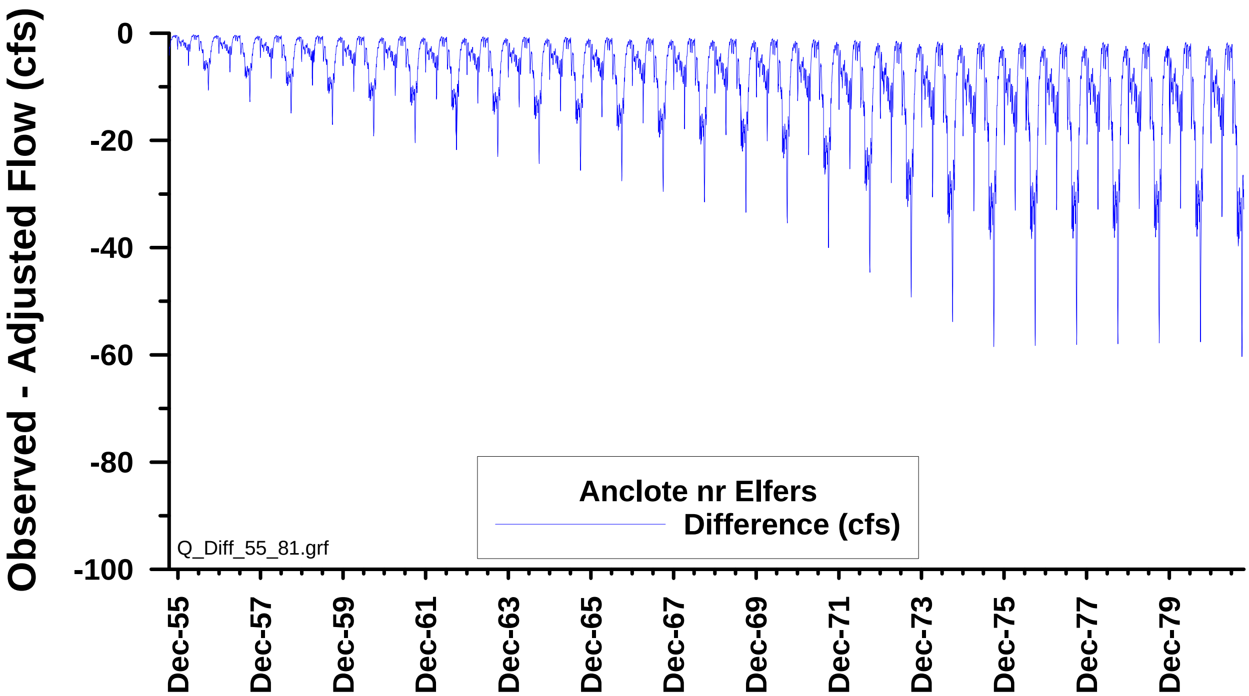


Figure 5. Comparison of observed and adjusted flows at Anclote nr. Elfers (USGS 02310000) 1955 – 2007.



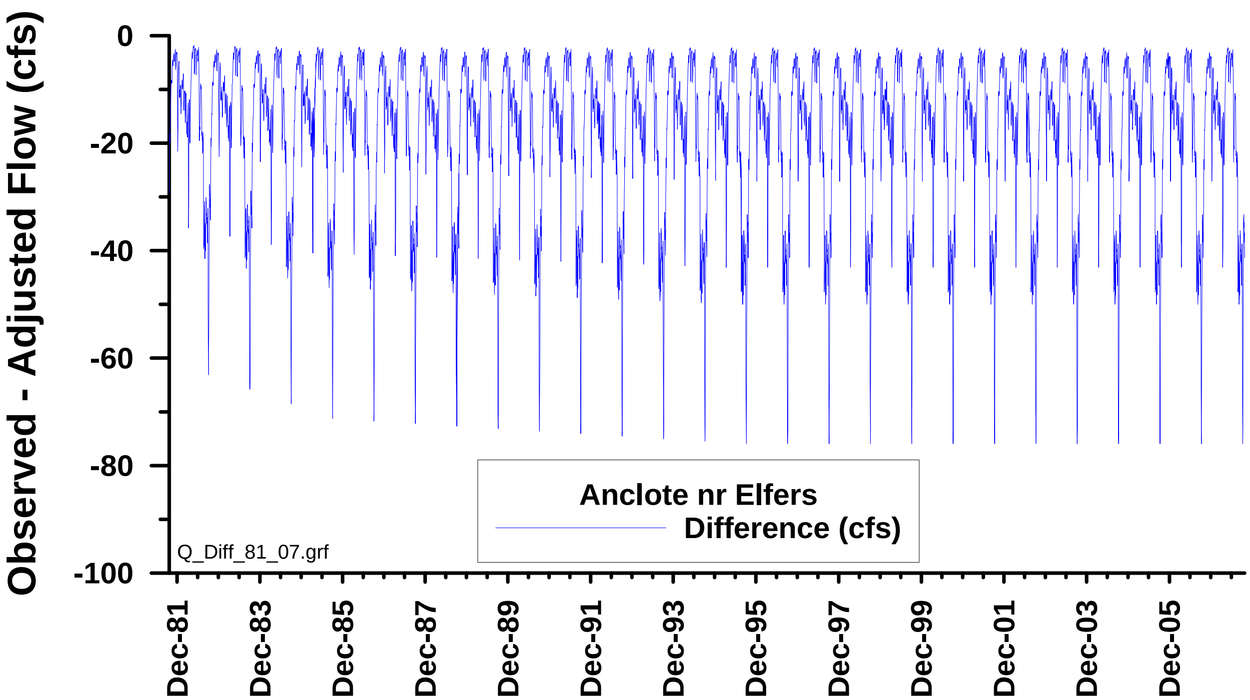


Figure 6. Estimated difference (cfs) between observed and adjusted flows at Anclote nr Elfers using flow adjusted protocol described previously

Water Quality Moinitoring Sites					
Agency / Station Type	**Station Identifier**	**Latitude (decimal degrees N)**	**Longitude (decimal degrees W)**	**Distance From Mouth [km]**	**Period of Record**
USGS Stream Gaging Station	Anclote River near Elfers	28.21389	82.66667	25.67	10/1962 - 9/1999
USGS Stream Gaging Station	Anclote River at Perrine Road near Elfers	28.19389	82.71861	16.07	10/1982 - 10/2006
USGS Stream Gaging Station	Anclote River at US Alternate 19	28.15750	82.75667	5.46	10/2003 - 10/2006
USGS Stream Gaging Station	Anclote River at Hickory Point at Anclote	28.17139	82.78500	5.46	2/2004 - 10/2006
SWFWMD Synoptic Survey	C	28.20691	82.70826	19.74	4/1985
SWFWMD Synoptic Survey	B	28.20586	82.70886	19.49	4/1985
SWFWMD Synoptic Survey	A	28.20557	82.70981	19.29	4/1985
SWFWMD Synoptic Survey	2	28.20538	82.71072	19.16	3/1985
SWFWMD Synoptic Survey	3	28.20448	82.71110	18.95	3/1985 - 4/1985
SWFWMD Synoptic Survey	4	28.20440	82.71350	18.69	1/1985 - 5/1985; 8/2004 - 8/2006
SWFWMD Synoptic Survey	5	28.20236	82.71401	18.32	6/1984 - 5/1986
SWFWMD Synoptic Survey	6	28.19853	82.71411	17.76	6/1984 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	7	28.19993	82.71685	17.33	5/1984 - 5/1986
SWFWMD Synoptic Survey	8	28.19701	82.71963	16.63	5/1984 - 5/1986
SWFWMD Synoptic Survey	9	28.19465	82.71862	16.15	5/1984 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	10	28.19099	82.71743	15.46	9/1984 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	11	28.18840	82.71803	15.02	9/1984 - 5/1986
SWFWMD Synoptic Survey	12	28.18487	82.71633	14.54	3/1985 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	13	28.18308	82.71757	14.08	10/1985
SWFWMD Synoptic Survey	14	28.18122	82.71543	13.64	3/1985 - 5/1986
SWFWMD Synoptic Survey	15	28.17653	82.71719	13.04	2/1984 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	16	28.17229	82.72184	11.98	2/1984 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	17	28.17083	82.72484	11.15	2/1984 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	18	28.16769	82.72557	10.77	8/1984 - 12/1985
SWFWMD Synoptic Survey	19	28.16861	82.72980	10.30	3/1984 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	21	28.16566	82.73497	9.92	8/2004 - 8/2006
SWFWMD Synoptic Survey	23	28.16394	82.73994	8.84	8/1985 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	24	28.15945	82.74396	7.97	8/1985 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	25	28.15897	82.74844	7.01	8/1985 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	26	28.15928	82.74780	6.94	8/1985
SWFWMD Synoptic Survey	27	28.15775	82.75639	5.47	8/1985 - 5/1986; 8/2004 - 8/2006
SWFWMD Synoptic Survey	28	28.15644	82.76738	4.33	8/2004 - 8/2006
SWFWMD Synoptic Survey	29	28.16056	82.77454	3.31	8/2004 - 8/2006
SWFWMD Synoptic Survey	30	28.16728	82.78285	2.19	8/2004 - 8/2006
SWFWMD Synoptic Survey	31	28.17398	82.78937	1.19	8/2004 - 8/2006
SWFWMD Ambient Water Quality	21FLSWFD_FLO0096	28.21417	82.42333	25.67	6/1995 - 9/1997
Pinellas County Ambient Water Quality	21FLPDEM_03 Jan	28.17429	82.72238	12.20	1/2003 - 12/2006
Pinellas County Ambient Water Quality	21FLPDEM_01 Jan	28.15768	82.75675	5.40	1/2003 - 12/2006
FDEP Ambient Water Quality	21FLGW_FLO0096	28.21417	82.66611	25.67	11/1997 - 9/1998
FDEP Ambient Water Quality	21FLA_24040007	28.21436	82.66633	25.67	3/1993 - 7/1995
FDEP Ambient Water Quality	21FLA_24040071	28.21472	82.66583	25.67	3/1997
FDEP Ambient Water Quality	21FLA_24040072	28.21167	82.67333	24.70	3/1997
FDEP Ambient Water Quality	21FLA_24040073	28.21611	82.69306	22.40	3/1997
FDEP Ambient Water Quality	21FLA_24040008	28.17608	82.78964	1.00	3/1993 - 7/1995

ANALYSIS OF BENTHIC COMMUNITY STRUCTURE AND ITS RELATIONSHIP TO FRESHWATER INFLOWS IN THE ANCLOTE RIVER

Purchase Order # 05PC0001660

Prepared for:
Southwest Florida Water Management District

Prepared by:
Stephen A. Grabe and Anthony Janicki
Janicki Environmental, Inc.

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ANALYSIS OF BENTHIC COMMUNITY STRUCTURE AND ITS RELATIONSHIP TO FRESHWATER INFLOWS IN THE ANCLOTE RIVER

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1.0 INTRODUCTION

The Southwest Florida Water Management District (District) is one of five water management districts charged with protecting and managing the State of Florida's water resources. One of the District's legislatively mandated responsibilities is to establish minimum flows and levels for surface water bodies including freshwater streams and the freshwater inflow to estuarine waters.

The objectives of this project are to quantify relationships between physical parameters, especially salinity, and the responses of benthic macroinvertebrates in the Anclote River.

1.1 Minimum Flows and Levels

Minimum flows and levels (MFLs) are the *"… flow below which significant harm occurs to the water resources or ecology of the area"* (SWFWMD, 2001). Specifically, minimum flows are defined in Florida Statutes (372.042) as "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area". MFLs may vary both seasonally and spatially within a river.

The general approach to developing an MFL for an estuarine water body is to establish defensible *quantitative* relationships between key ecological components of the system in question (*e.g.*, freshwater inflow and salinity) and a resource of concern (*e.g.,* benthic macroinvertebrates). The rationale for this approach is that the inflow regime and the resultant salinity distributions affect the structure and function of biological communities.

1.2 Benthic Macroinvertebrates

Benthic (bottom-dwelling) organisms are small but important invertebrates that include organisms such as aquatic insects, worms, snails, clams, and shrimp. The benthos live in or on the substrates of rivers, estuaries, etc. Benthic organisms are generally sessile, although some species may undergo migrations into the water column (*e.g.*, amphipod crustaceans) or produce planktonic larvae (e.g., polychaete worms). As a group, however, they are relatively sedentary and are considered to be effective integrators of a variety of environmental factors, including salinity (Boesch and Rosenberg, 1981; U.S.E.P.A., 1999). Unlike the more vagile nekton, most benthic invertebrates lack the mobility to escape large or rapid fluctuations in environmental conditions.

Benthic organisms occupy a variety of niches with respect to energy transfer. The benthos process organic material as detritivores, suspension feeders, and deposit feeders, forming an essential link in the transfer of energy to secondary consumers including other benthic organisms, finfish, and avifauna. Tubiculous and fossorial benthic organisms may fulfill an important role in reworking sediments. In this role as bioturbators, they may bring suspended sediments into contact with the water column thereby translocating nutrients and pollutants and oxygenating sediments.

1.3 Relationships Between Flow and Benthic Macroinvertebrates

With respect to supporting MFL development, the benthos is an important biotic resource that is responsive to changes in flow regimes. Flow is an influential component of riverine and estuarine systems. Changes in flow can potentially affect many ecological and environmental variables.

Flow affects the volume and velocity of the river, which directly affects benthos (Figure 1-1). Under extremely high flows, benthic organisms may be physically washed out of the system. Some aquatic insects take advantage of flowing water by undergoing "drift". Aquatic drift can reduce overcrowding and facilitate feeding. Additionally, flow affects salinity, dissolved oxygen, sediments, and nutrients, which also affect the abundance and distribution of the benthos (Figure 1-1).

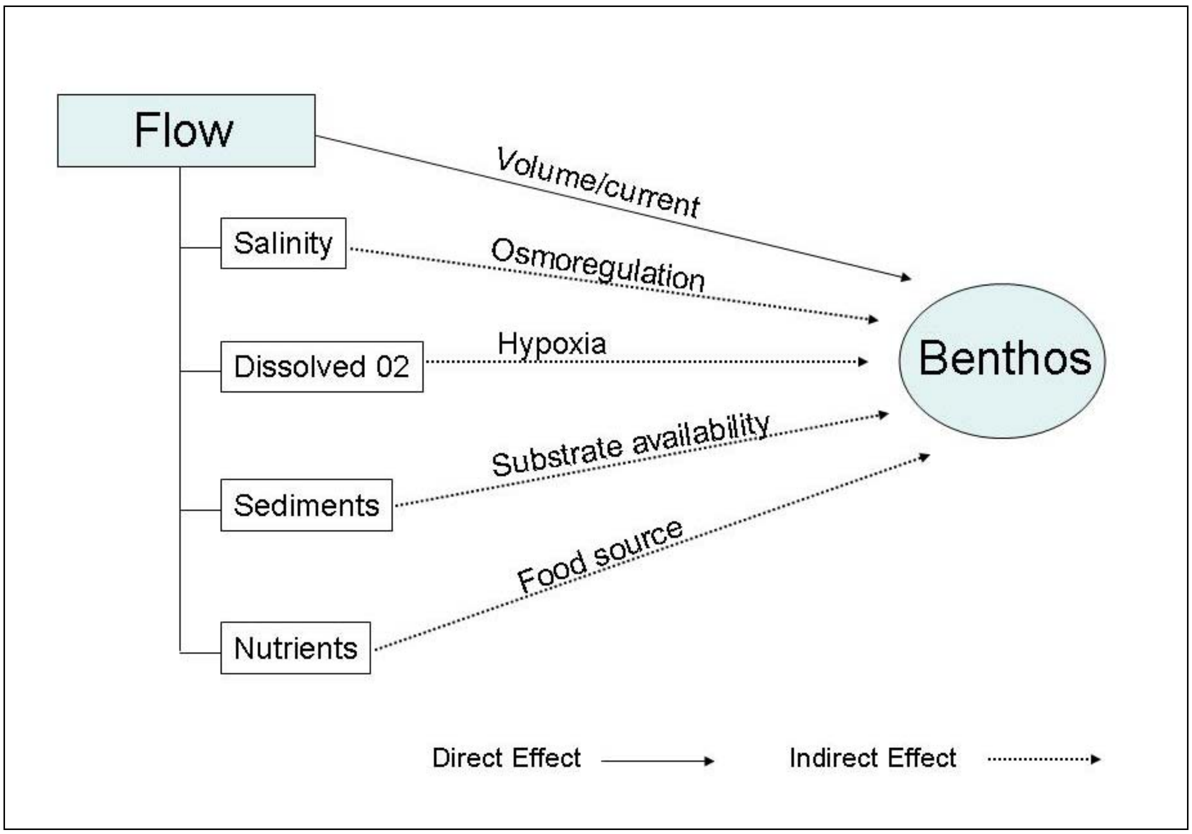

Figure 1-1. Conceptual diagram showing the direct (solid line) and indirect (dashed line) effects of flow on benthos.

Salinity is a critical physical factor affecting the biota of tidal rivers. Salinity is largely influenced by the amount of freshwater inflow entering an estuary, and it is typically negatively correlated with flow. Salinity can affect the distribution and abundance of individual species, and the overall composition of the benthic community. During high flow periods, salinity at a particular location is expected to be lower and may provide new habitat for the more motile species that are intolerant of elevated salinities. During low flow periods, saline waters may penetrate further upstream, facilitating habitat expansion for estuarine species. Generally, the salinity gradient will shift upstream and downstream based on flow conditions.

Benthic organisms are limited in their distribution within a tidal river by the physiological challenges and stresses associated with variable salinity environments. Osmotic limitations restrict the ability of many freshwater species from using habitats in downstream portions that are tidally influenced. Marine species also face osmotic problems, which restrict access to upstream freshwater habitats. True estuarine species typically tolerate a wide-range of salinities, although they may have discrete "preferences" for optimal reproduction and growth.

Changes in the timing and amount of freshwater inflow may alter the salinity regime such that shifts in dominant species occur. The physical environment may become less favorable for some species and more favorable for others. That is, the "preferred" salinity regime may now occur at a different time, in a different location, or occupy a smaller area of the system than currently. For example, the displacement of a particular salinity regime could move it to a reach of the river where the sedimentary factors are unfavorable (*cf.* "static" *vs.* "dynamic" habitats of Browder and Moore, 1981). Since sediment type is also a key abiotic factor affecting the structure of benthic communities, community structure could be altered. Changes in freshwater inflow then may have profound effects in terms of energy flow within the system as well as the physical reworking of the sediments.

Freshwater flow affects both concentrations and loadings of other water quality constituents (Boynton and Kemp, 2000; Gillanders and Kingsford, 2002). Dissolved constituents such as ions, dissolved nutrients, and metals may be diluted at higher flows and concentrated at lower flows (FDER, 1985; Grabe, 1989). The magnitude and timing of freshwater inflows affects the amount of nutrients and organic matter that enters a waterway. Thus, increased productivity may occur some time after a period of increased flows (Kalke and Montagna, 1989; Bate *et al.*, 2002). Sediment loads downstream are also increased during high flows (e.g, the Mississippi River delta). Loadings of contaminants, including metals and organic compounds that bind to smaller particles (Seidemann, 1991) are often associated with increased sediment loads. Additionally, increased sedimentation may suffocate sediment dwelling organisms.

Freshwater inflow will also affect stream current velocities. Current velocity affects substrate composition by influencing the available parent material as well as organic inputs. The main components of substrate composition are grain-size, the interstitial spaces between the grains, and the presence or absence of organic detritus. Larger grained sediments drop out from the current first, and are deposited furthest upstream. Finer grained sediments are carried further downstream, with the finest sediments being carried the furthest. Organic inputs may be of various sizes, ranging from fallen trees to small organic fragments. The interstices, or the small spaces between larger grained substrate material, form micro-habitats that are used by particular benthic organisms; the interstitial spaces also provide an area for the finer grained organic matter to collect.

Flow can also affect dissolved oxygen concentrations by modifying residence times and by physically altering stratification conditions. Increased residence times can be associated with decreased dissolved oxygen.

Residence time affects the ability of phytoplankton to take up nutrients, as well as the ability for secondary producers to consume phytoplankton, and this extends to other consumers as well. Higher flows are associated with increased nutrient loading. Lower flows permit a longer residence time for chlorophyll and nutrients. During high flow conditions, flushing is more rapid and residence time in the river is reduced (Peterson and Festa, 1984; Jassby *et al*., 1995; Flannery *et al*., 2002).

1.4 Quantitative Responses of Benthic Macroinvertebrates to Changes in Freshwater Inflow

Janicki Environmental, Inc. (2007) developed a suite of quantitative tools capable of supporting the development of MFLs for the District. The expected quantitative responses of the benthos to changes in freshwater inflow were defined. These quantitative responses are expected to integrate all of the direct influences of flow changes and the indirect influences of flow changes (e.g., salinity changes, dissolved oxygen concentration changes). Quantitative responses were derived in an unbiased manner from a large (>2,000 samples) database extending over two decades from 12 southwest Florida tidal rivers.

The species that make up estuarine benthic communities exist in a continual state of change, but the basic structure of the community may be observed to have a relatively predictable response signal above the often high degree of natural variability.

The spatial and temporal distributions (presence/absence response patterns) of various organisms within a tidal river can be limited by the physiological challenges and stresses associated with variable flow environments. True estuarine species are typically euryhaline and have adaptations that allow them to live within a wide range of salinity conditions.

Species abundances are also affected by the stresses caused by altered flows. Such changes may affect the success of individual animals within a species, consequently affecting the overall abundance of that species. For example, while the distribution of a given species may be determined by salinity, species able to tolerate saline conditions may still be affected by salinity-related stressors. Species typically have an optimal salinity that is somewhere within the range of salinity that they may be able to inhabit. The salinity in which the early life stages of certain species develop, may impact their growth and survival rates. It will also affect the availability of prey and where adults of the species congregate and forage.

Community structure, which integrates species presence and abundance, is also dependent upon the salinity regime. Responses in the benthic community are expected to be the composite result of the affects of salinity on all the individual species within the community, as described previously. Community responses include derived metrics such as taxa richness and diversity and their responses to changes in freshwater inflow.

1.5 Study Area

The Anclote River (Figure 1-2) originates near Land O' Lakes and enters the Gulf of Mexico at Tarpon Springs in Pasco County. Fernandez (1990) estimated the river's watershed to be 290 km^2. The Anclote River is tidal approximately 23 kilometers upstream of the mouth of river (Fernandez, 1990) (*n.b.* River Mile 0 in Fernandez (1990) = RKM 1.6 in this report). The Anclote River is widest (914 m) upstream of U.S. Highway 19 (RKM 8.4), in a large area of salt marsh. The channel is indistinct and the river becomes extensively braided from RKM 5.3 to RKM 12 (Figure 1-2). The intake canal for Progress Energy's Anclote River Plant is located at RKM 1.

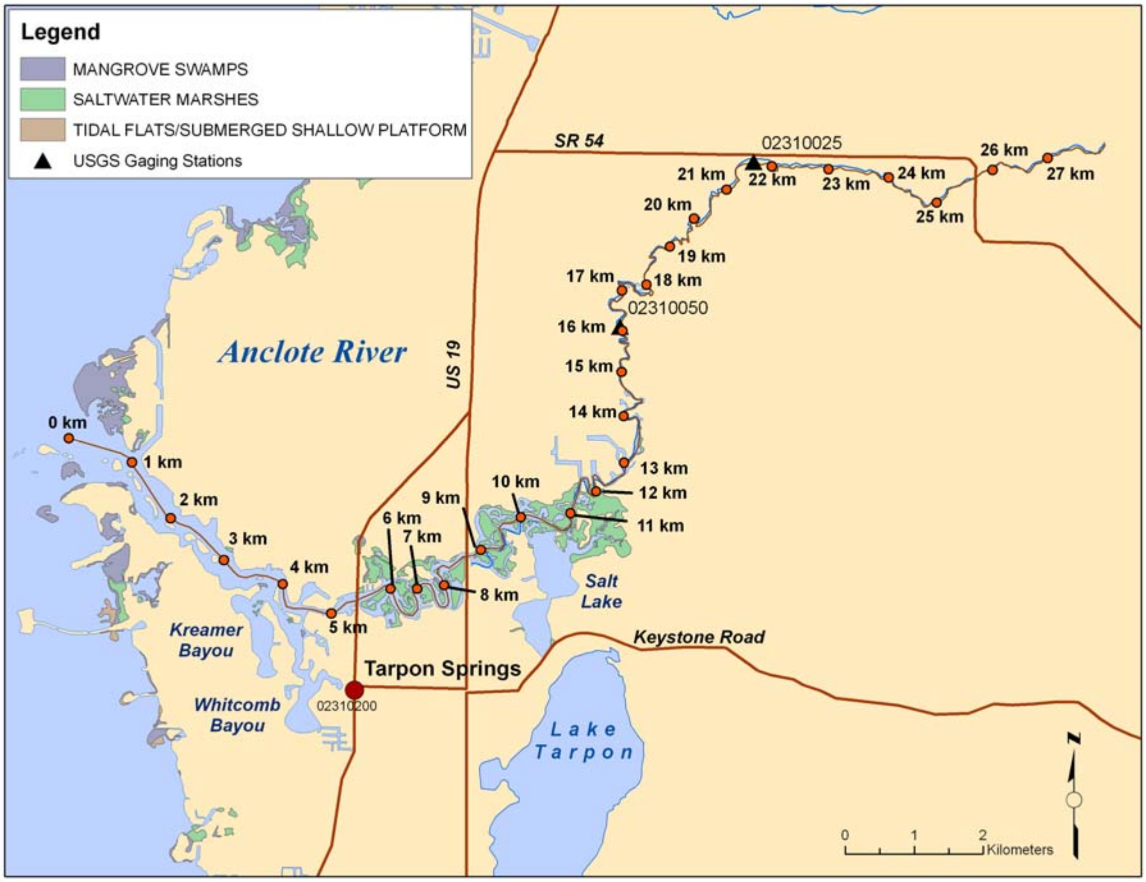

Figure 1-2. The Anclote River study area.

Average monthly flows at Elfers (USGS gage 02310025; drainage basin = 188 km^2), Florida (1946 to 2004) have ranged from 15 (May) to 181 cfs (September). Fernandez (1990) estimated that the 5 ppt isohaline was upstream of RKM 12.6 at least 60% of the time.

Beds of submerged aquatic vegetation are found offshore of the mouth upstream to approximately RKM 2, near the abandoned Stauffer's site (William Fonferek, ACOE, personal communication). The longitudinal distribution of emergent vegetation showed that halophytes (e.g., *Rhizopora mangle*) were found as far upstream as RKM 11 (U.S. Fish and Wildlife Service, 1988) after which freshwater vegetation begins to become established and halophytes are phased out. Field observations by Jeff Winter (PBS&J) and Stephen Grabe (Janicki Environmental, Inc.) during May 2005 (Figure 1-3) generally confirmed this relationship. *Avicinnia germinans* was absent upstream of RKM 9.5, *Distichlis spicata* by RKM 10, and *Rhizopora mangle* by RKM 11. Freshwater species began to appear at RKM 12 (e.g., *Typha* and *Cladium jamaicense*), corresponding to the long-term average location of the 0.44 ppt isohaline (Fernandez, 1990). The distribution of *Juncus roemerianus* overlapped those of both halophytic and halophobic species (Figure 1-3).

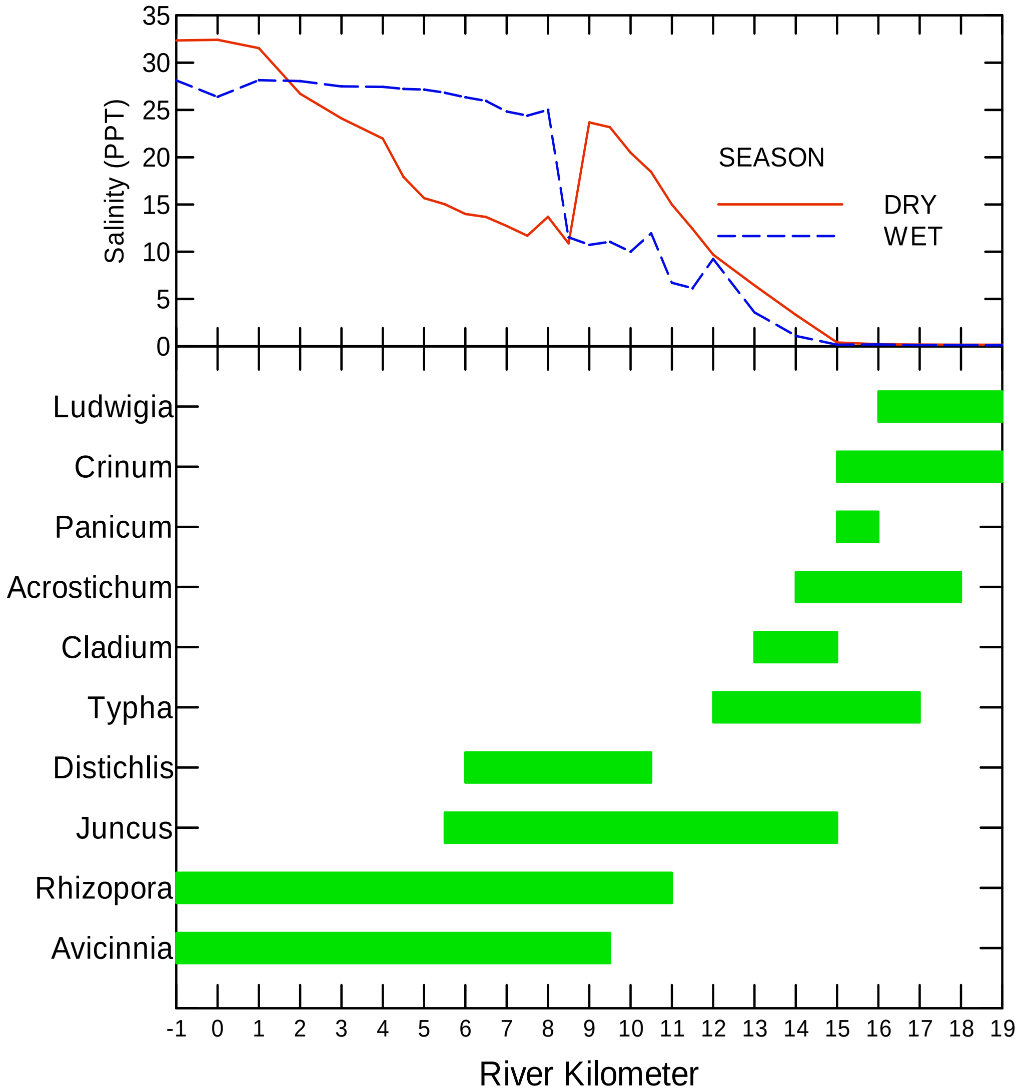

Figure 1-3. **Longitudinal distribution of emergent vegetation *vs.* river kilometer and salinity in the Anclote River, 2005 (Jeff Winter and Stephen Grabe, field observations, May 2005).**

The only known historical survey of benthic macroinvertebrates of the Anclote River estuary was that done for the District during 1974 by Geraghty and Miller (1976). Quarterly surveys were made at four locations (from approximately RKM 3 to 19). Peracarid crustaceans, especially amphipods, were among the dominants on most dates and at most locations (Table 1-1). Polychaetes were among the dominants at the most upstream station during the driest months. Insect larvae (*Chaoborus* sp.) were reported as a dominant as far downstream as RKM 12.5 at the end of the wet season.

Table 1-1. Anclote River benthos (1974): ranked abundant taxa by month and station (Geraghty & Miller 1976).

Month	Approximately RKM 3-shallow (near Stauffers)	Approximately RKM 3-channel (near Stauffers)	Approximately RKM 12.5	Approximately RKM 19
June	*Apseudes sp.* *Monocorophium acherusicum* Amphipoda *Onuphis sp.* *Ampelisca holmesi*	*Apseudes sp.* *Ampelisca holmesi* *Metharpinia floridana* Amphipod	*Ampelisca holmesi* *Pseudoleptocuma minor* Amphipoda *Monocorophium acherusicum*	Amphipoda *Apocorophium sp.* *Laeonereis culveri*
August	*Ampelisca holmesi* Amphipoda *Glycinde sp*	Syllidae	No dominants	*Cyathura polita*
October	*Streblospio sp.* *Amphicteis gunneri* *Capitella capitata* *Pseudoleptocuma minor* *Ampelisca holmesi*	*Typosyllis hyalina* *Phyllodoce arenae*	*Chaoborus sp.*	No dominants
December	*Ampelisca holmesi* *Pseudoleptocuma minor* Tubificidae Amphipoda *Apocorophium sp.*	Tubificidae *Aricidea sp.*	*Streblospio sp.* *Monocorophium acherusicum*	*Polydora sp.* Tubificidae *Chironomus sp.*

2.0 METHODS

2.1 Study Design

The District funded a survey in 2005 of the distribution of benthic macroinvertebrates in the Anclote River and how these distributions related to salinity (Janicki Environmental, Inc., 2005). The benthic community was surveyed twice during 2005, first a "dry season" survey took place in May and then a "wet season" survey took place in September.
The approach was to divide the river into three strata (Figure 2-1):

- Lower Stratum: RKM –1 to RKM 4 (adjoining Sting Ray Cove to the Alternate 19 Bridge) in 1 RKM intervals. Five samples were collected each season.
- Middle Stratum: RKM 4 to RKM 12 (above Alternate 19 Bridge to upstream of Belcher Hole, (opposite Melaleuca Drive, Holiday) in 0.5 RKM intervals. Fifteen samples were collected each season.
- Upper Stratum: RKM 12 to RKM 19 (upstream of Belcher Hole), in 1 RKM intervals. Eight samples were collected each season.

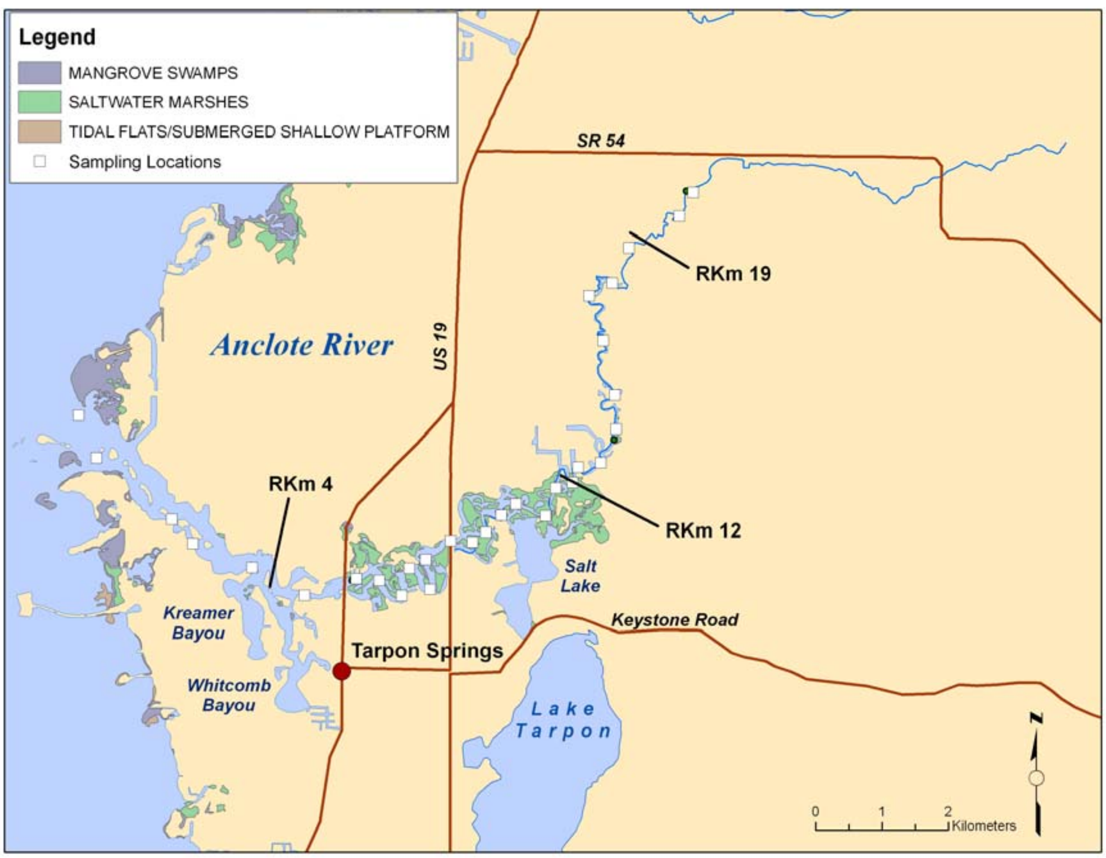

Figure 2-1. Map depicting 2005 sampling locations for benthos in the Anclote River.

Sample locations along each transect was selected using unbiased methods within the boxes formed by these transects because:

- There is a dearth of information on the spatial distribution of benthos within the Anclote River, although there are data (Geraghty and Miller 1976) that show near-shore densities were much higher than mid-channel densities near RKM 3 in 1974.
- The downstream reach of the river is channelized and the river between the Alternate 19 and U.S. 19 bridges exhibit more braiding are is quite shallow in some areas.

2.2 Field Methods

Benthos were collected with a 7.62 cm diameter hand core sampler (area = 45.6 cm^2). A second core sample was collected and aliquots were removed for sediment grain size and organic content analyses. These samples were labeled and stored on ice until transferred to Mote Marine Laboratory for processing.

All macroinvertebrate samples were processed in a similar manner. Each sample was bagged with an internal label and magnesium sulfate solution was added to relax the organisms. Samples were sieved (0.5 mm mesh) to remove finer-grained particles of sediment and meiofauna and fixed in a 10% solution of buffered formalin and Rose Bengal stain.

2.3 Laboratory Methods

Macroinvertebrate samples were transferred from the fixative to a preservative (a solution of 50% to 70% isopropanol or ethanol) after at least 48 hours. All organisms were sorted from the samples, to at least 90% recovery, under a dissecting microscope. Macroinvertebrates were identified to the lowest practical identification level—typically genus or species. If an animal was a member of one of the "minor" taxonomic groups, such as the Nemertea, identifications might only be to that higher taxonomic level.

Sediment samples were analyzed for grain-size composition, skewness, kurtosis, percentage of organic matter (as loss on ignition; Dean, 1974). Grain-size distribution was measured by a laser diffraction instrument (Coulter LS-200) by Mote Marine Laboratory.

2.4 Data Analysis Approach

Three generic approaches to analyzing the benthic data were used:

- Several univariate metrics that describe the distribution, abundance, and composition of the benthos were calculated.
- Regression (linear and logistic) techniques were used to examine associations between these univariate metrics and several variables that define the habitats in which the benthos were found.
- Multivariate analyses were used to explore how the benthic community was organized, spatially and temporally.

2.4.1 Univariate Metrics

Three univariate metrics for calculated for the Anclote River benthos:

- Dominant taxa were identified by season and stratum. Dominance was calculated as the geometric mean of the frequency of occurrence (a measure of the distribution in the river) and relative abundance (a measure of a taxon's contribution to the river's standing crop).
- Species (taxa) richness is the number of distinct species (taxa) identifiable in a sample. Species or taxa richness is the simplest representation of "diversity".
- Total benthic abundance (as numbers of individuals/m^2) is an indicator of the standing crop of the benthic community. Extremely high or extremely low standing crop can be indicative of a perturbed environment.

2.4.2 Regression Analyses

The relationships between taxa richness and total abundance and a suite of environmental variables were evaluated using stepwise multiple linear regression. The environmental variables considered included:

- water temperature, salinity and dissolved oxygen measured at the time of collection,
- sample depth,
- sediment grain size characteristics, % silt+clay, and % organic matter, and
- flow variables (cumulative flows over the 7, 14, 28, 56, and 112 days preceding the collection of the benthic samples). Montagna and Kalke (1992) used this approach to examine the effects of flow on the benthos of Texas estuaries.

The *p* value for a variable to be retained was 0.05.

The relationships between species richness and abundance with salinity also were evaluated using a polynomial regression approach. The resultant relationships and equations can be used to predict expected responses of the benthos to a "best fit" combination of abiotic variables as well as salinity alone.

Janicki Environmental, Inc. (2007) employed univariate logistic regression (Huisman *et al.*, 1993, Peeters and Gardiniers, 1998, Ysebaert *et al.*, 2002) to estimate the probability of occurrence as a function of salinity for selected taxa from 12 Gulf Coast tidal rivers. The "optimum" or "preferred" salinity for each taxon was that with the highest probability of occurrence. An "optimal habitat range" was then calculated as the salinity $\pm$75% of the optimum (Peeters and Gardiniers, 1998). The taxa selected were based on dominance ranking.

2.4.3 Multivariate Community Metrics

A set of benthic metrics were identified to quantify the effects of salinity and other variables on multivariate benthic community structure. These were selected based on benthic analyses and analytical tools developed by Janicki Environmental, Inc. (2007).

Total abundance (as the number of individuals/m^2) was 4th root transformed for all multivariate community analyses. The 4th root transformation in multivariate analyses permits a greater number of taxa to influence the results (Clarke and Warwick, 2001). The use of untransformed data yields results strongly influenced by the most abundant taxa. Cao *et al*. (1998) argue that "rare" taxa may be more sensitive to environmental perturbation than common species. Therefore, an analytical approach that is more responsive to the "community" rather than to only a few, numerically abundant taxa was desirable. Thorne *et al*. (1999) have also demonstrated that the 4th root transformation is preferred in multivariate community analyses because it represents a "good compromise between untransformed and binary data". Therefore, the 4th root transformation was employed in the multivariate analyses.

The benthic macroinvertebrate data were stratified *a priori* into groups by river stratum and season. Multivariate statistical routines in the PRIMER software package (Clarke and Warwick, 2001) used in this study included:

- non-metric multidimensional scaling (MDS) - MDS was used to graphically represent the resemblance of the benthic assemblages within the defined group (e.g., stratum by season). MDS is an ordination technique in which rank similarities of a large number of variables are expressed as a two-dimensional map).
- "Similarity Percentage" (SIMPER) - SIMPER objectively identified those taxa that explained relatively large proportions of the similarity within a group (*e.g.,* lower stratum in the dry season).
- "Analysis of Similarities" (ANOSIM) - ANOSIM tests the statistical significance of the pair-wise comparisons of the a priori defined groups.

3.0 RESULTS

This section presents a characterization of the abiotic nature of the Anclote River a description of the spatial and temporal character of the benthic macroinvertebrate community, and the relationships between the benthic community structure and several abiotic variables.

3.1 Abiotic Characteristics

This section describes the salinity, sediment characteristics, and other physicochemical and flow conditions measured during the two survey periods.

3.1.1 Streamflow

The sampling program was designed to capture any seasonal differences in the benthic community due to variation on river flow. However, the flows at the USGS Elfers Gauge (02310000) on the collection dates were somewhat higher in the "dry season" than occurred in the "wet season" (Table 3-1). Antecedent streamflows for the 7- and 14-day periods preceding benthic sample collections were similar during both the dry and wet seasons (Table 3-1). From 28 days through 112 days the wet season flows were higher than dry season flows. Flows during the 2005 wet season survey were five to ten times that of the 60-year median; dry season flows were approximately half the 60-year median.

Table 3-1. Mean antecedent inflows (cfs) to the Anclote River (USGS Elfers Gauge 02310000) for the dates of sample collection for 7, 14, 28, 56, and 112 days preceding benthic sample collections, by dry and wet season survey periods, 2005.

Days Preceding Sample Collection	Dry Season (cfs)	Wet Season (cfs)
0	46	14
7	328	243
14	588	576
28	698	1,350
56	1,000	2,715
112	1,682	6,164

3.1.2 Hydrographic and Sediment Characteristics

Mean values for the measured abiotic variables are shown in Table 3-2. Variables are summarized by season and by stratum within season. Benthic samples were collected at water depths ranging between 0.1 and 5.0 meters, with a median depth of 1.1 meters (Table 3-2). The deepest sample location was the dry season collection at RKM 11.0 (Belcher Hole).

Mean salinities were generally similar between seasons within each stratum (Table 3-2). The mean salinities declined by between 9 and 17 ppt between strata in each season. Wet and dry season salinities generally varied by >10 ppt at RKMs 5-10 and <1 ppt upstream of RKM 14. DO was somewhat lower during the dry season.

Sediments from the lower stratum were generally very-fine sand-sized sediments (mean ϕ= 3-4) (Table 3-2). The percentage of silt+clay and organic matter in the sediments were was also generally higher in this portion of the river. The coarsest sediments were found between RKM 5.5 and 7.5 and at RKM 18.

Table 3-2. Summary of mean (range) bottom water abiotic variables and sediment characteristics coincident with benthic sample collections in the Anclote River, by season and stratum, 2005.

Variable	Dry Season			Wet Season		
	Lower Stratum	Middle Stratum	Upper Stratum	Lower Stratum	Middle Stratum	Upper Stratum
Temperature (ºC)	27.0 (25.3-28.9)	28.4 (27.0-30.8)	27.3 (25.1-29.1)	29.1 (28.4-30.0)	29.7 (29.3-30.2)	27.3 (25.3-29.6)
Salinity (ppt)	26.7 (17.9-32.4)	15.3 (10.9-23.7)	2.6 (0.2-9.7)	27.6 (26.4-28.2)	18.8 (6.1-27.2)	1.8 (0.1-9.2)
DO (mg/L)	3.5 (1.8-4.8)	3.8 (3.0-4.8)	3 (2.5-3.8)	5.4 (4.1-6.6)	5.3 (2.7-6.5)	3.1 (2.4-4.0)
Silt + Clay (%)	26.7 (0.5-39.2)	7.1 (0.8-17.7)	6.8 (1.9-15.1)	29.1 (22.8-36.3)	10.7 (0.5-51.2)	6 (2.5-14.3)
Sediment Grain Size (Mean ϕ)	3.2 (2.1-3.9)	2.5 (1.3-3.4)	2.5 (1.4-3.2)	3.4 (3.0-3.8)	2.6 (1.2-4.3)	2.5 (2.0-3.1)
Sediment Organic Content (%)	2.6 (0.2-3.7)	0.7 (0.2-1.7)	0.7 (0.2-1.4)	3.9	2.1 (0.2-20.9)	0.6 (0.2-1.3)
Depth (m)	0.7 (0.1-1.5)	1.3 (0.2-5.0)	1.4 (0.5-2.2)	1.7 (0.7-3.5)	1.5 (0.5-3.5)	1.7 (1.0-2.4)

3.2 Biota

Species characteristic of the Anclote River are identified and compared by season and location within the river. The relationships between benthic community structure and several abiotic variables, including salinity, are presented.

3.2.1 Spatial and Seasonal Characteristics of the Dominant Organisms

Examination of the dominant organisms within a community aids in the understanding of how environmental variation can affect the nature and integrity of that community. The data from this study show distinct spatial and seasonal differences in the dominant benthic organisms.

Overall, the benthos of the Anclote River is a diverse assemblage of taxa comprised of taxa similar to those of other unimpounded tidal rivers in the District, such as the Little Manatee River (Janicki Environmental, 2007). In these two rivers, for example, crustaceans comprise a significant portion of the benthic community as opposed to the predominance of polychaete worms in the impounded rivers, such as the Lower Hillsborough River and Tampa Bypass Canal.

Spatially, polychaete worms, *Caecum* spp. (Gastropoda), the isopod *Xenanthura brevitelson*, and the amphipod *Ampelisca abdita* were typical dominants in the lower stratum of the Anclote River during this study (Table 3-3). Their dominance declined upriver. The amphipods *Grandidierella bonnieroides* and two *Apocorophium* species were dominants in the middle stratum (Table 3-3). *Apocorophium lacustre* dominance declined and that of the gastropod *Pyrgophorus platyrachus* increased in the upper stratum (Table 3-3).

Seasonally, within the lower stratum, *Aricidea taylori, Laeonereis culveri*, and *Xenanthura* were more dominant during the dry season and *Caecum* spp. were more dominant during the wet season (Table 3-3). Amphipods were dominant in the middle stratum during both seasons although there was a species shift. Wet season dominants included *Grandidierella* and *Apocorophium louisianum* whereas *Apocorophium lacustre* and *Cerapus* sp. A were dry season dominants (Table 3-3). *Pyrgophorus* was highly dominant in the wet season whereas *Grandidierella* and *Apocorophium louisianum* were dominant in the dry season.

Other notable trends included:

- the upstream shift in high dominance scores from the wet season (middle stratum) to the dry season (upper stratum) by both *Grandidierella* and *Apocorophium louisianum*;
- the higher dominance scores during the dry season than during the wet season of eight of the 10 ranked dominant polychaetes in the lower stratum; and
- the six-fold increase in *Pyrgophorus* dominance from the dry season to the wet season in the upper stratum.

3.2.2 Spatial and Seasonal Characteristics of Benthic Community of the Anclote River

Numbers of taxa varied seasonally and longitudinally within the Anclote River (Figure 3-1). Dry season values were higher than wet season values throughout most of the river. In the dry season, the numbers of taxa were generally higher below RKM 5.5 and between RKM 16 and 17 (Figure 3-1). Numbers of taxa peaked at RKM 3 during the wet season survey.

Table 3-3. Dominance scores for the dominant macroinvertebrate taxa identified from infaunal samples collected in the Anclote River, by stratum and season, 2005.						
Taxa	**Lower Stratum**		**Middle Stratum**		**Upper Stratum**	
	Wet Season	**Dry Season**	**Wet Season**	**Dry Season**	**Wet Season**	**Dry Season**
ANNELIDA						
Aricidea taylori	0	25	0	1	0	2
Capitella capitata	0	15	0	7	0	0
Heteromastus filiformis	4	16	6	2	0	0
Hobsonia florida	0	5	2	3	4	14
Kingbergonuphis simoni	7	7	0	0	0	0
Laeonereis culveri	0	26	5	4	0	5
Leitoscoloplos robustus	0	6	1	10	0	0
Mediomastus sp.	2	13	10	5	4	0
Prionospio heterobranchiata	0	13	0	2	0	0
Streblospio gynobranchiata	0	0	7	3	0	2
Typanosyllis prolifera	11	4	0	0	0	0
Tubificidae	0	0	0	0	23	18
MOLLUSCA						
Caecum nitidum	14	0	0	0	0	0
Caecum pulchellum	14	0	1	8	0	0
Pisidium sp.	0	0	0	0	0	10
Pyrgophorus platyrachus	0	0	2	0	60	9
CUMACEA						
Cyclaspis cf. varians	0	7	1	8	0	0
ISOPODA						
Cyathura polita	6	9	17	13	0	0
Edotia montosa	2	0	1	5	0	18
Xenanthura brevitelson	12	22	3	16	0	0
AMPHIPODA						
Americorophium ellisi	0	0	8	16	0	0
Ampelisca abdita	20	15	1	2	0	0
Apocorophium lacustre	13	0	6	32	0	0
Apocorophium louisianum	6	0	40	11	15	38
Cerapus sp. A	12	3	15	32	0	0
Grandidierella bonnieroides	18	13	52	29	14	50
INSECTA						
Ablabesmyia sp.	0	0	0	0	0	7
Ablabesmyia rhamphe	0	0	0	0		6

Table 3-3. Dominance scores for the dominant macroinvertebrate taxa identified from infaunal samples collected in the Anclote River, by stratum and season, 2005.						
Taxa	**Lower Stratum**		**Middle Stratum**		**Upper Stratum**	
	Wet Season	**Dry Season**	**Wet Season**	**Dry Season**	**Wet Season**	**Dry Season**
Dubiraphia sp.	0	0	0	0	4	5
Polypedilum scalaneum	0	0	0	0	0	13

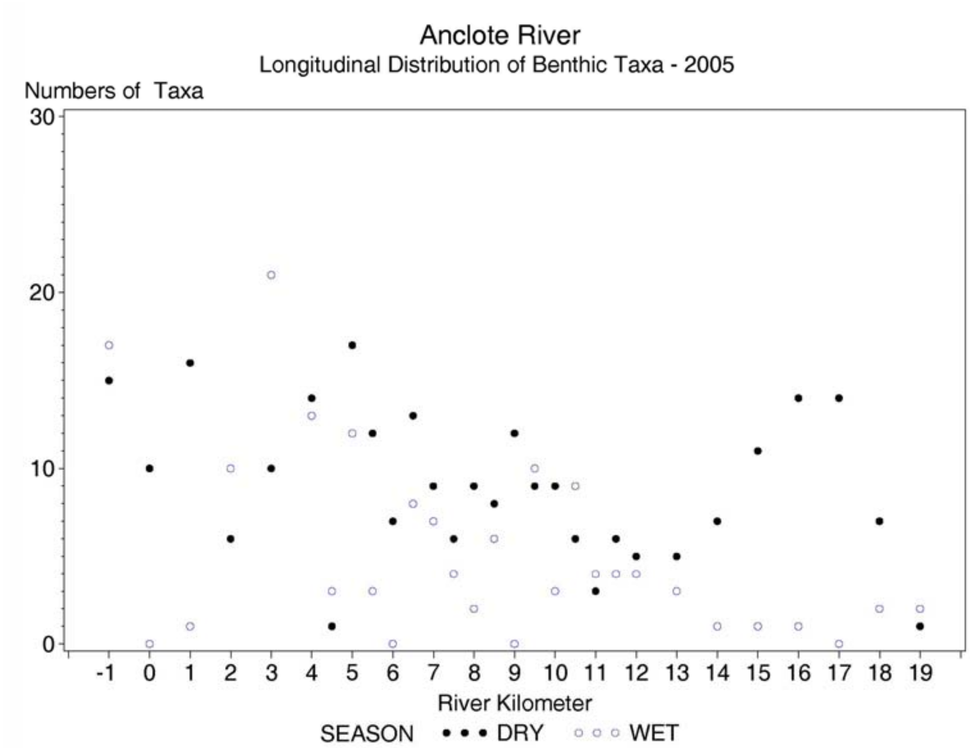

Figure 3-1. Longitudinal distribution of the numbers of benthic taxa in the Anclote River during the dry and wet season surveys of 2005.

The overall density of benthic macroinvertebrates did not show any consistent longitudinal pattern during either season (Figure 3-2). During the wet season, however, four samples were devoid of live animals. Dry season densities were higher than those of the wet season throughout most of the river (Figure 3-2).

3.2.3 Relationships Among Univariate Community Metrics and Habitat Variables

Two univariate metrics of community structure were calculated: numbers of taxa (taxa richness) and total benthic abundance.

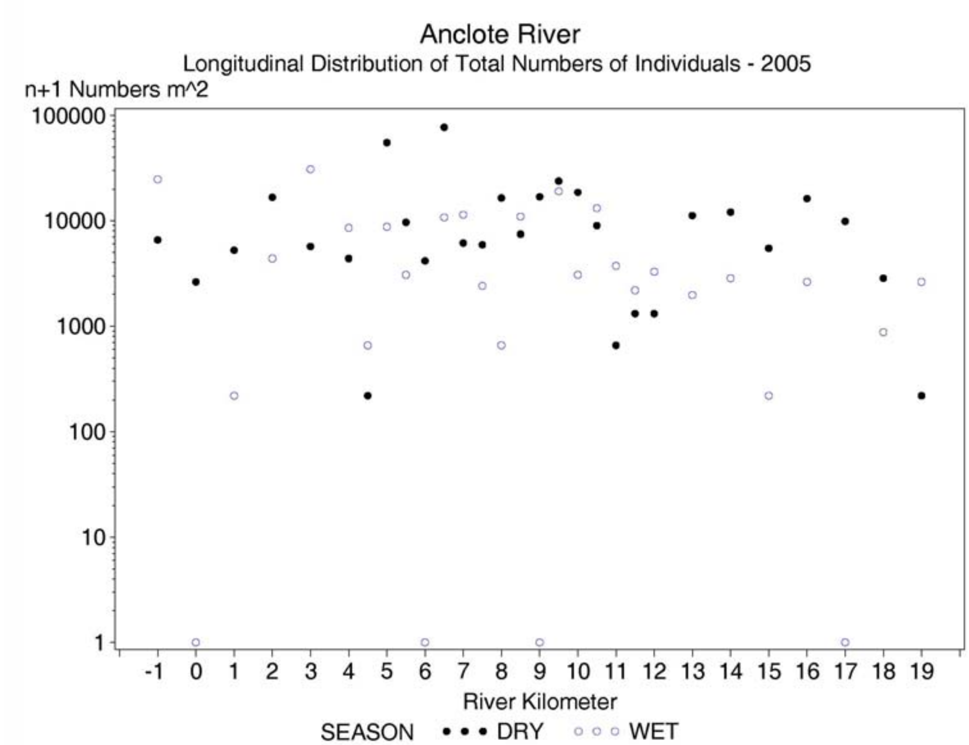

Figure 3-2. Longitudinal distribution of total benthic abundance in the Anclote River during the dry and wet season surveys of 2005.

Stepwise multiple regression analyses (Table 3-4) showed that:

- overall, variation in the habitat variables explained very little of the observed variation in either the numbers of taxa or the total abundance of organisms;
- none of the variables had a significant relationship with total abundance of organisms in the wet season;
- depth was the only variable to have a significant (negative) effect on numbers of taxa in the dry season;
- numbers of taxa increased as salinity increased in the wet season; and
- total benthic abundance increased with both temperature and decreased with depth in the dry season.

To further examine the relationships between salinity and both the numbers of taxa and total abundance of organisms, several nonlinear regression techniques were applied. These analyses (Table 3-5) showed that:

- overall, variation in salinity explained very little of the observed variation in either the numbers of taxa or the total abundance of organisms;
- numbers of taxa generally increased with salinity in the dry season; and
- total benthic abundance showed little or no relationship to salinity in either season.

Table 3-4. Results of stepwise multiple regression analyses that examine the relationship between the numbers of taxa and the total benthic abundance and several bottom water and sediment abiotic variables in the Anclote River.		
Numbers of Taxa (Log n + 1)	**Equation**	**R^2**
Wet Season	Y = 0.31 + 1.688*Log(Salinity)	0.16
Dry Season	Y = 1.12 – 0.57*Log(Depth)	0.13
Total Abundance of Organisms (Log Individuals + 1/m^2)	**Equation**	**R^2**
Dry Season	Y = 8.38 - 0.21*Log(Depth) + 8.77*Log(Temperature)	0.32

Table 3-5. Results of polynomial regression analyses that examine the relationship between log (n + 1) numbers of taxa and total benthic abundance and salinity in the Anclote River, 2005.		
Numbers of Taxa (Log n + 1)	**Equation**	**R^2**
Wet Season	Y = 0.338 + 1.688*Salinity -0.1645*$Salinity^2$ + 0.004*$Salinity^3$	0.32
Dry Season	Y = 9.1 -0.387*Salinity + 0.025*$Salinity^2$ – 0.00028*$Salinity^3$	0.15
Total Abundance of Organisms (Log Individuals + 1/m^2)	**Equation**	**R^2**
Wet Season	Y = 2.49 + 0.29*Salinity -0.103*$Salinity^2$ + 0.0006*$Salinity^3$	0.05
Dry Season	Y = 3.62 -0.008*Salinity + 0.002*$Salinity^2$ – 0.00006*$Salinity^3$	0.04

3.2.4 Multivariate Community Structure

Spatial and seasonal differences in the structure of the Anclote River benthic community were examined. MDS and several complementary analyses were used to achieve this objective. Additionally, the association between community structure and various abiotic variables measured in conjunction with the collection of the benthic samples was also examined.

An MDS plot is an effective graphical tool to identify samples that aggregated in multidimensional space. The greater the distance between points (samples) on the MDS plot, the greater the difference between the samples. Samples with more similar benthic community structures, therefore, will be found more closely aggregated in the MDS plot.

The MDS plot generated from the Anclote River benthic data showed that some degree of discrimination between the dry and wet season samples (Figure 3-3). Within the dry season, samples were generally segregated by stratum. Conversely, the wet season samples collected from the middle and upper strata were the most tightly clustered of any group, indicating they were more similar than other groups of samples. The benthic samples collected from the lower stratum were more widely dispersed than those from the other strata.

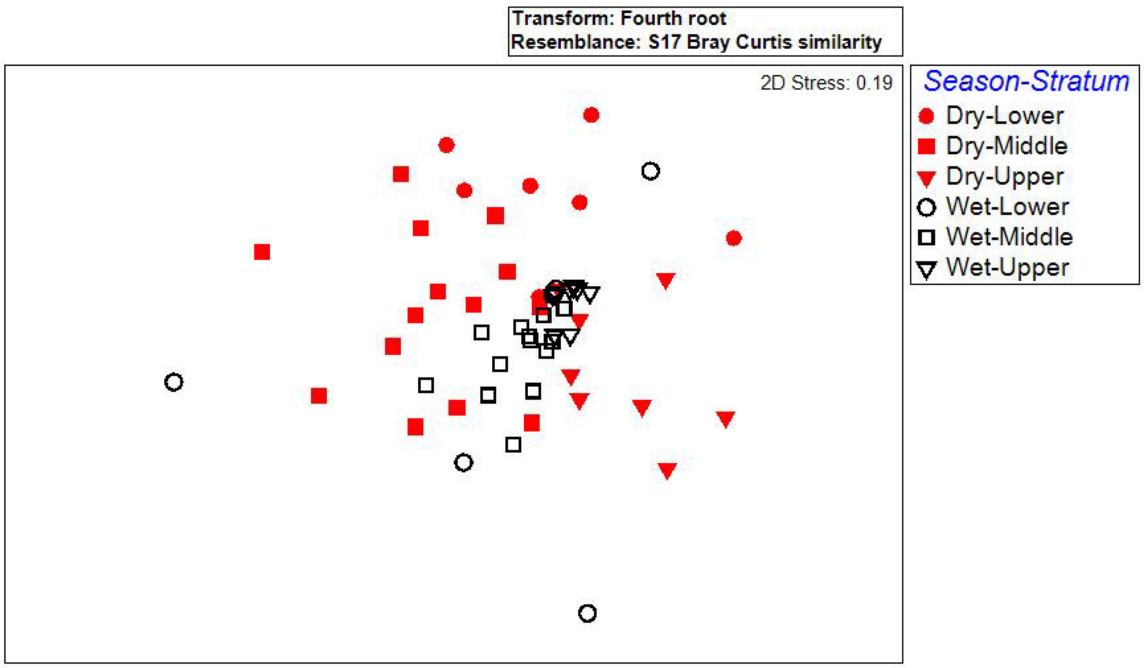

Figure 3-3. MDS plot of the resemblance of benthic stations in the Anclote River 2005, by season and stratum.

An ANOSIM test was used to examine the significance of the seasonal and spatial differences in benthic community structure displayed in the MDS plot. The ANOSIM results show that the spatial differences (*i.e.*, the differences between strata) were generally more significant during the dry season than in the wet season (Tables 3-6 and 3-7). The seasonal differences in benthic community structure were more significant in the middle and upper strata than in the lower stratum.

SIMPER analysis was used to identify those dominant taxa that contributed most to the differences in the benthic community structure between strata within each season and between seasons within each stratum (Tables 3-6 and 3-7). The taxa that contributed most significantly to the differences between seasons and strata included:

- *Grandidierella bonnieroides,*
- *Cerapus sp. A,*
- *Apocorophium louisianum,* and
- *Pyrgophorus platyrachis.*

There was evidence of a downstream movement of *Grandidierella* and *Apocorophium louisianum* from the dry season to the wet season. *Pyrgophorus* was present at relatively high densities in the upper stratum during the wet season and virtually absent during the dry season.

Grandidierella was the most abundant species in the middle and upper strata during the wet season, followed by *Apocorophium louisianum*. *Ampelisca abdita* and *Xenathura brevitelson* were the most abundant organisms in the lower stratum during the wet season. Five polychaetes were relatively abundant in the lower stratum during the dry season. Several peracarid crustaceans (*Grandidierella, Cyathura polita*, and *Cerapus* sp. A) were abundant in the middle stratum during the dry season and less abundant both upstream and downstream.

The association between various abiotic variables and univariate community metrics was examined in Section 3.2.4. Here the association between abiotic variable and multivariate community structure is explored. Note that this is an exploratory analysis and should be not be interpreted as being "significant" or causative.

A BIO-ENV test showed that location in the river (RKM) was the single variable with the highest rank correlation to the Bray-Curtis similarity of the benthic community (Table 3-8). Water temperature and mean ϕ also had relatively high correlations with benthic community structure. Salinity was not found in any of the "best fit" combinations of up to five variables (Table 3-8).

3.2.5 Relationships Among Salinity and the Probability of Occurrence of Selected Taxa

The effect of salinity on benthic community structure also depends upon how the distributions of individual taxa vary with changes in salinity. Logistic regression has been used to quantify the relationship between salinity and the probability of occurrence of estuarine biota (Huisman et al., 1993; Peeters and Gardiniers, 1998; Ysebaert et al., 2002). Janicki Environmental (2007) employed univariate logistic regression to estimate the probability of occurrence as a function of salinity for selected taxa from 12 Southwest Florida tidal rivers. The "optimum" or "preferred" salinity was that with the highest probability of occurrence for that taxon. A "preferred habitat range" was calculated as the salinity range coincident with the 25^{th} and 75^{th} percent probability of occurrence (Peeters and Gardiniers, 1998).

Table 3.6. Dominant organisms that contribute to between-strata differences in each season. Probability of significance in parentheses.

Species	Between Strata Differences					
	Dry Season			Wet Season		
	Lower-Middle (0.01)	Middle-Upper (0.01)	Lower-Upper (0.001)	Lower-Middle (0.01)	Middle-Upper (NS)	Lower-Upper (0.05)
Grandidierella bonnieroides	■	■	■	■		■
Apocorophium louisianum		■	■	■		■
Cerapus sp. A	■	■		■		
Apocorophium lacustre	■	■		■		■
Xenanthura brevitelson	■	■	■	■		■
Cyathura polita	■	■		■		
Americorophium ellisi	■	■				
Laeonereis culveri	■		■			
Mediomastus sp.	■		■	■		
Pyrgophorus platyrachis			■			■
Caecum pulchellum				■		■
Ampelisca abdita	■		■	■		■
Edotia montosa		■	■			
Leitoscoloplos robustus	■	■				
Heteromastus filiformis	■		■			
Hobsonia florida		■	■			
Capitella capitata complex	■		■			
Tubificidae			■			■
Cyclaspis cf. varians	■	■				
Aricidea taylori	■		■			

Table 3.7. Dominant organisms that contribute to between-season differences in each stratum. Probability of significance in parentheses.

Species	Between Season Differences		
	Lower Stratum (0.05)	Middle Stratum (0.001)	Upper Stratum (0.01)
Grandidierella bonnieroides			
Apocorophium louisianum			
Cerapus sp. A			
Apocorophium lacustre			
Xenanthura brevitelson			
Cyathura polita			
Americorophium ellisi			
Laeonereis culveri			
Mediomastus sp.			
Pyrgophorus platyrachis			
Caecum pulchellum			
Ampelisca abdita			
Edotia montosa			
Leitoscoloplos robustus			
Heteromastus filiformis			
Hobsonia florida			
Capitella capitata complex			
Tubificidae			
Cyclaspis cf. varians			
Aricidea taylori			

Table 3-8. Association (Spearman rank correlations, ρ) between benthic community structure in the Anclote River, 2005 and selected abiotic variables.						
Number of variables	**ρ**	**RKM**	**Temperature**	**Mean ϕ**	**Depth**	**Dissolved Oxygen**
1	0.35					
2	0.35					
3	0.35					
4	0.33					
5	0.31					

Figure 3-4 presents a summary of the salinity preference data derived from the univariate logistic regressions for series of selected benthic taxa. These taxa include several dominant taxa from the Anclote River, including representatives of taxonomic groups (e.g., amphipods such as *Grandidierella bonnieroides* and *Ampelisca abdita*) that have been identified as being preferred prey items by Peebles (2005). Appendix A presents the results of the logistic regression analyses.

Polypedilum scalaenum larvae were collected in the Anclote River only during the dry season survey and in the upper stratum (Figure 3-7), where measured salinities ranged from 0.2 to 9.7 ppt (Table 3-2). This group of insect larvae is relatively tolerant of salinities up to 11 ppt (Figure 3-4). *Apocorophium louisianum* abundance decreased upstream in both seasons. Highest densities occurred in the lower stratum where salinities exceeded 18 ppt. This pattern differs from that expected based upon the logistic regression analysis (Figure 3-5).

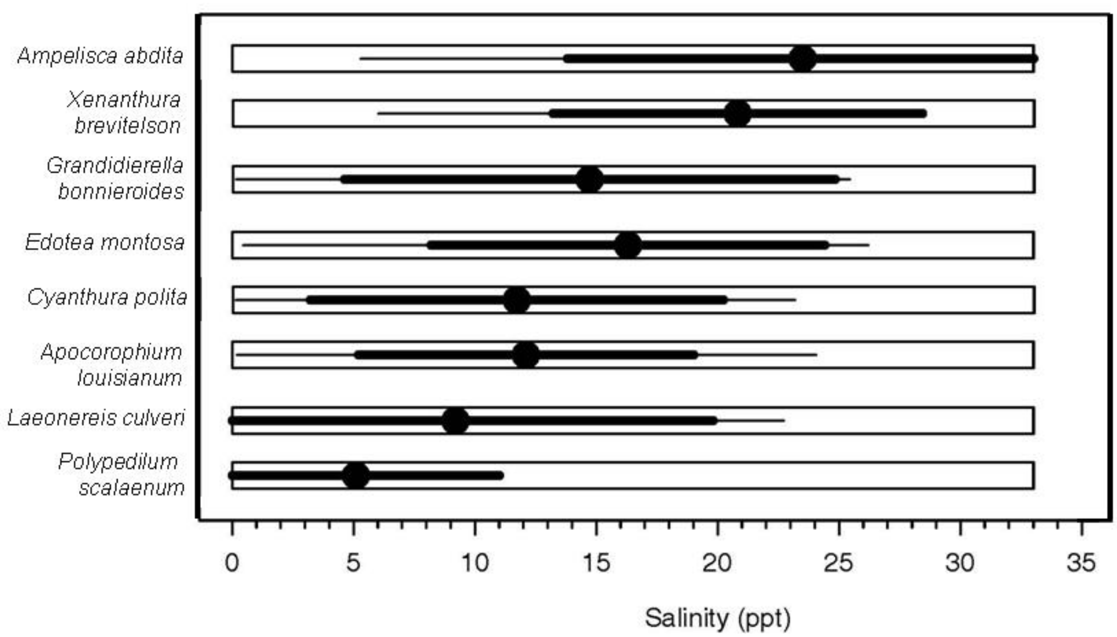

Figure 3-4. **Summary of salinity optimum (circle), optimal habitat range (solid bar), 10th to 90th percentile probability of occurrence (thin line), and model domain (open bar) of salinity for eight selected benthic taxa derived from Janicki Environmental (2007).**

Five of these species had the high end of their optimum habitat range in the polyhaline salinity range (18-29 ppt) (Janicki Environmental, Inc., 2007) (Figure 3-4). *Laeonereis culveri* was only abundant during the dry season in the lower stratum (Figure 3-5). *Cyathura polita* was abundant in both the upper and lower strata, particularly in the dry season survey (Figure 3-5). *Grandidierella bonnieroides* abundance decreased upstream during the dry season (Figure 3-5). *Edotia montosa* and *Xenanthura brevitelson* were each most abundant during the dry season in the upper stratum (Figure 3-5). There was some evidence that populations of both of these isopods shift downstream during the wet season and move upstream in the dry season.

The high end of the optimum habitat range for *Ampelisca abdita* was within the euhaline salinity ranges (>29 ppt) (Janicki Environmental, Inc., 2007) (Figure 3-4). *Ampelisca abdita* was rarely collected above the lowest stratum in either season (Figure 3-5).

With respect to setting an MFL, several of these species may be provide more information than others. *Edotia montosa* and *Xenanthura brevitelson* showed evidence of moving upstream during the dry season, when antecedent flows are typically lower than during the wet season, and downstream during the wet season. *Laeonereis culveri* showed some evidence of only being able to establish populations in the Anclote River during the dry season.

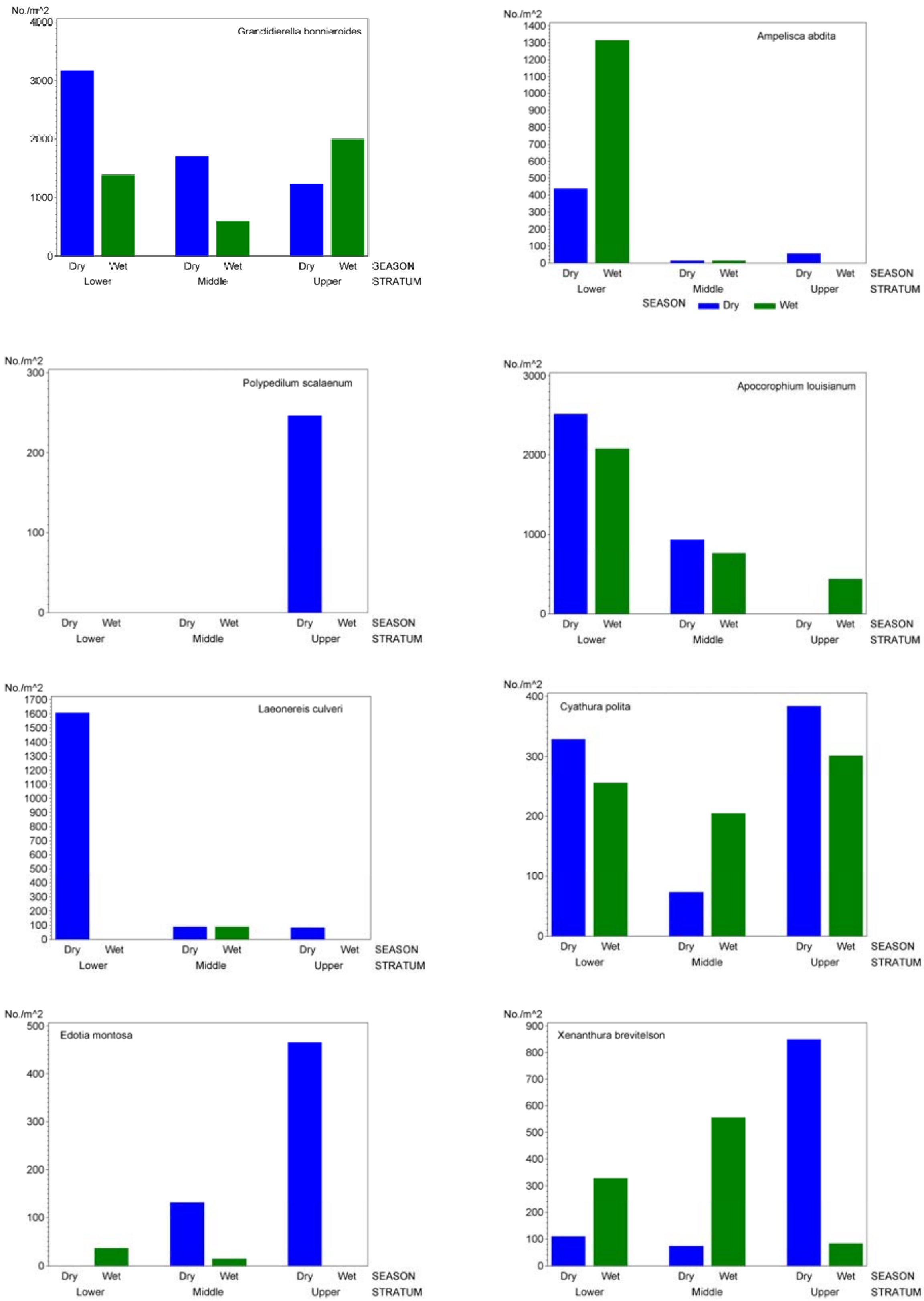

Figure 3-5. Mean abundance of selected dominants, by season and stratum.

4.0 CONCLUSIONS

The following conclusions can be drawn from the analysis of the benthic macroinvertebrate data:

- The benthic macroinvertebrates in the Anclote River were exposed to a wide range of salinities during both the dry (range=32 ppt) and wet (range=28 ppt) season surveys. The greatest (>10 ppt) seasonal range occurred at RKMs 5-10 and the smallest range (<1 ppt) occurred upstream of RKM 14.
- The Anclote River benthos was dominated by a number of crustacean taxa similar to that of the unimpounded Little Manatee River, but different from the Lower Hillsborough River and Tampa Bypass Canal where annelid worms are often dominant.
- In the dry season the dominant taxa include *Grandidierella bonnieroides, Apocorophium lacustre,* and *Cerapus sp. A*.
- In the wet season the dominant taxa include *Apocorophium louisianum* and *Pyrgophorus platyrachis*.
- Numbers of taxa varied longitudinally within the Anclote River during both seasons. Dry season values were higher than wet season values at most locations in the river. Numbers of taxa peaked at RKM 3 during the wet season survey. Numbers of taxa generally declined upstream of RKM 3, with few taxa reported upstream of RKM 14.
- The total abundance of benthic macroinvertebrates did not show any consistent upstream-downstream trend during either season.
- Statistically significant relationships between the number of taxa and a number of habitat variables were found. For example, salinity and depth had significant relationships with the number of taxa in the wet and dry seasons, respectively. However, each explained less than 33% of the variance in the number of taxa and, therefore, application of these relationships to develop an MFL should only be done considering this low predictive power.
- Similar results were found for the total abundance of organisms. In the dry season total abundance was positively related to temperature and negatively related to depth. Again, only a small fraction of the variance was explained by either variable. In the wet season, no significant relationships were found between total abundance and any of the habitat variables examined.
- Multivariate community structure, based upon samples stratified by season and river stratum (lower, middle, and upper), differed for most comparisons of these groups. The wet season samples collected from the middle and upper strata were more similar than other groups of samples. These groups were similar because of the high densities of *Grandidierella bonnieroides*.
- Location in the river (RKM) was the single abiotic variable with the highest rank correlation coefficient to multivariate community structure. Secondary factors included temperature and mean sediment grain size. Salinity measured at the time of collection was *not* among the key variables associated with community structure.
- Fourteen taxa common in the Anclote River were found to have significant relationships between salinity and their probability of occurrence, based upon a regional analysis of these relationships.
- The benthic community as a whole showed significant changes seasonally and spatially. The benthic community in the lower stratum generally differed from that

found in the upper strata. The multivariate analyses, in conjunction with plots showing seasonal and spatial abundances suggested that several species exhibited upstream-downstream shifts in abundance. Such shifts in the populations of selected species may be more useful than other techniques in evaluating the benthic response to an altered flow regime.

5.0 APPLICATION OF QUANTITATIVE DATA ANALYSES TO MFL DETERMINATION

The analyses reported above were performed to describe the seasonal and spatial nature of the benthic macroinvertebrate community in the Manatee and Braden rivers. The analyses were also performed with the objective of identifying defensible, quantifiable relationships between benthic community integrity and freshwater flows or some surrogate of flow such as salinity. While statistically significant relationships between the number of taxa and the total abundance of organisms and several habitat variables were found, the underlying equations had little predictive power. Therefore, other variables or combinations of variables have greater influence on the variability in the number of taxa and total abundance than salinity. Application of these relationships to develop an MFL should only be done considering this low predictive power.

The distribution of the bivalve *Corbicula fluminea*—and perhaps *Polymesoda caroliniana*, may be useful in evaluating a biotic response to an altered salinity flow regime. *Corbicula* will likely find available habitat reduced if freshwater inflow is reduced. Subtidal populations of *Polymesoda,* perhaps more than intertidal populations, may expand their distribution upstream under reduced flows.

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APPENDIX A

Logistic Regression: Regression Coefficients and Statistics for Selected Taxa Based on Data from 12 Southwest Florida Tidal Rivers (Source: Janicki Environmental, Inc., 2007)

Logistic regression was used by Janicki Environmental, Inc. (2007) to model relationships between salinity and the probability of occurrence for selected benthic species from 12 southwest Florida tidal rivers. Several species were characteristic of the Anclote River in 2005 and the summary statistics are tabulated below. Samples were coded as presence/absence for each species of interest. Using the Logit function:

$$g_{(y)} = \log\left[\frac{p_{(y)}}{1-p_{(y)}}\right] = \beta_0 + \beta_1 x + \beta_2 x^2$$

where:

x = salinity
p(y) = probability of a species being present, as a function of x
g(y) = transformation of the odds of species occurrence
β_0, β_1, and β_2 regression coefficients

Estimates of the log odds of occurrence based on linear regression coefficients for salinity were developed. The log odds can be equated to a probability of occurrence as follows:

$$P_{(y)} = \frac{1}{1+\exp(-\alpha-\beta_1 X_1-\beta_2 X_2 ....-\beta_k X_k)}$$

Taxon	Variable	DF	Parameter Estimate	S.E.	Wald X^2	Pr $>X^2$
Ampelisca abdita	Intercept	1	-3.0596	0.16	382.4	0.000
	salinity	1	0.1871	0.02	64.7	0.000
	salinity^2	1	-0.0036	0.00	21.9	0.000
Apocorophium louisianum	Intercept	1	-3.1130	0.17	317.6	0.000
	salinity	1	0.1362	0.04	11.1	0.001
	salinity^2	1	-0.0061	0.00	12.8	0.000
Edotea montosa	Intercept	1	-2.5859	0.13	373.8	0.000
	salinity	1	0.1872	0.02	56.6	0.000
	salinity^2	1	-0.0058	0.00	39.9	0.000
Grandidierella bonnieroides	Intercept	1	-1.3713	0.09	249.3	0.000
	salinity	1	0.1140	0.02	36.8	0.000
	salinity^2	1	-0.0038	0.00	28.2	0.000
Laeonereis culveri	Intercept	1	-0.6309	0.08	68.3	0.000
	salinity	1	0.0646	0.02	11.3	0.001
	salinity^2	1	-0.0037	0.00	23.6	0.000
Polypedium scalaenum Group	Intercept	1	-1.2298	0.09	183.4	0.000
	salinity	1	0.0757	0.04	3.7	0.053
	salinity^2	1	-0.0095	0.00	17.7	0.000
Xenanthura brevitelson	Intercept	1	-4.2657	0.28	235.2	0.000
	salinity	1	0.2640	0.04	43.2	0.000
	salinity^2	1	-0.0065	0.00	24.4	0.000
Cyathura polita	Intercept	1	-1.5114	0.09	281.7	0.000
	salinity	1	0.1012	0.02	23.8	0.000
	salinity^2	1	-0.0041	0.01	25.1	0.000

FRESHWATER INFLOW EFFECTS ON FISHES AND INVERTEBRATES IN THE ANCLOTE RIVER ESTUARY

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SUMMARY

Quantitative ecological criteria are needed to establish minimum flows and levels for rivers and streams within the Southwest Florida Water Management District (SWFWMD), as well as for the more general purpose of improving overall management of aquatic ecosystems. As part of the approach to obtaining these criteria, the impacts of managed freshwater inflows on downstream estuaries are being assessed. A 12-month study of freshwater inflow effects on habitat use by estuarine organisms in the Anclote River estuary was undertaken from October 2004 to September 2005.

The general objective of the present data analysis was to identify patterns of estuarine habitat use and organism abundance under variable freshwater inflow conditions and to evaluate responses. Systematic monitoring was performed to develop a predictive capability for evaluating potential impacts of proposed freshwater withdrawals and, in the process, to contribute to baseline data. The predictive aspect involves development of regressions that describe variation in organism distribution and abundance as a function of natural variation in inflows. These regressions can be applied to any proposed alterations of freshwater inflows that fall within the range of natural variation documented during the data collection period.

For sampling purposes, the tidal Anclote River and nearby Gulf of Mexico were divided into six zones from which plankton net, seine net and trawl samples were taken on a monthly basis. Salinity, water temperature, dissolved oxygen and pH measurements were taken in association with each net deployment. Daily freshwater inflow estimates for the Anclote estuary were derived from gauged streamflow records. A large body of descriptive habitat-use information was generated and is presented in accompanying appendices.

Larval gobies and anchovies dominated the plankton net's larval fish catch. Gobies of the genera *Gobiosoma* and *Microgobius* were dominant in comparable proportions, and the anchovies were strongly dominated by the bay anchovy (*Anchoa mitchilli*). Other abundant larval fishes included silversides (*Menidia* spp.) and skilletfish (*Gobiesox strumosus*). Juvenile spot (*Leiostomus xanthurus*) were abundant relative to

other tidal rivers in west-central Florida. Spot spawn far offshore and move landward during the late larval and early juvenile stages. One possibility is that the proximity of the Anclote survey area to the open Gulf of Mexico resulted in high juvenile recruitment of spot into the area. The plankton-net invertebrate catch was dominated by gammaridean amphipods, larval crabs (decapod zoeae), larval shrimps (decapod mysis) and by river-plume taxa such as the copepods *Acartia tonsa* and *Labidocera aestiva*, the chaetognaths *Sagitta* spp., the planktonic shrimp *Lucifer faxoni*, and the ostracod *Parasterope pollex*. The strong representation of river-plume taxa occurred because two stations were located in the open gulf near the river mouth (i.e., they were in the river plume). The amphipods were most abundant in the brackish marshes and in the channel downstream of the marshes, as is commonly observed in other estuaries.

Seine fish collections were dominated by spot (*Leiostomus xanuthurus*), pinfish (*Lagodon rhomboides*), bay anchovy (*Anchoa mitchilli*), and eucinostomus mojarras (*Eucinostomus* spp.). These taxa comprised over 84% of total seine catch of fishes. Fish collections from deeper, trawled areas were dominated by pinfish, spot, bay anchovy, and eucinostomus mojarras. These taxa comprised over 86% of total trawl catch of fishes. Invertebrates collected by seines were dominated by daggerblade grass shrimp (*Palaemonetes pugio*) and brackish grass shrimp (*P. intermedius*)—these two species formed nearly 94% of the invertebrate seine catch; invertebrate trawl catches primarily consisted of arrow shrimp (*Tozeuma carolinense*), brackish grass shrimp, pink shrimp (*Farfantepenaeus duorarum*), and longtail grass shrimp (*Periclimenes longicaudatus*), which together comprised nearly 98% of total trawl catch of invertebrates.

Use of the area as spawning habitat was indicated by the presence of fish eggs or newly hatched larvae. The eggs of unidentified herrings (clupeids), the bay anchovy (*Anchoa mitchilli*), the striped anchovy (*A. hepsetus*), silversides (*Menidia* spp.) and unidentified sciaenid fishes were collected from the survey area. Sciaenid eggs were by far the most abundant egg type, followed by eggs of the bay anchovy – both types were most abundant in the Gulf of Mexico and in the lower part of the tidal river. If it is assumed that the relative abundances of different species of early-stage sciaenid larvae reflect relative spawning intensity, then the kingfishes (*Menticirrhus* spp.) are the sciaenids that are most likely to have spawned in this area. Larval distributions suggest that blennies, the lined sole (*Achirus lineatus*) and the hogchoker (*Trinectes maculatus*) spawned near the river mouth, whereas skilletfish (*Gobiesox strumosus*) and gobies (primarily *Microgobius* spp. and *Gobiosoma* spp., but also *Bathygobius soporator*) may have spawned within the interior of the tidal river. The repeated collection of very small juveniles of live-bearing Gulf pipefish (*Syngnathus scovelli*) within the interior of the tidal river suggests that this species is also reproducing within the local area.

Estuary-dependent taxa are spawned at seaward locations and migrate into tidal rivers during the late larval or early juvenile stage, whereas estuary-resident taxa are present within tidal rivers throughout their life cycles. The number of estuary-dependent taxa using the study area as a nursery is somewhat greater than resident taxa: overall, six of the ten most abundant taxa in deeper habitats and seven of the ten most abundant taxa in nearshore habitats can be considered estuary-dependent. There are considerable differences in abundance: estuary-dependents constituted nearly 86% of the total abundance of the top ten most abundant taxa in seined areas, and over 83% of total abundance of top ten taxa in trawled areas. These dependents were mostly offshore spawners and included taxa of commercial importance (i.e., pink shrimp) and taxa of ecological importance due to high abundance (i.e., spot, pinfish, eucinostomus mojarras, tidewater mojarra, and silver jenny). The juvenile nursery habitats for selected species were characterized from seine and trawl data in terms of preference for shallower or deeper areas, zone of the study area, type of shoreline, and salinity.

Based on plankton-net data, alteration of flows would appear to have the lowest potential for impacting many taxa during the period from December through March, which is the period when the fewest estuarine taxa were present. The highest potential to impact many species would appear to be from June through October. Some species were present throughout the year, whereas others had more seasonal spawning and recruitment patterns.

Based on seine or trawl collections, there were few clear seasonal patterns of taxon richness in the Anclote River estuarine system, undoubtedly due to the relatively short duration of sampling and the unusual hydrological conditions encountered. Monthly taxon richness in seined areas was quite variable—the longest single period of relatively high richness was from October–December; in deeper (trawled) habitats, the September–February period had greatest taxon richness. Overall abundances and abundances of newly recruiting nekton taxa indicate extensive use of the study area during all months, however. Thus, we tentatively conclude that the period from October to February appears to have the greatest potential for negative effects of anthropogenic change to the tidal river inflow, at least in terms of impacting the most species. There is no time of the year when inflow reduction would not have the potential to affect economically or ecologically important taxa, however.

Ten (26%) of the 38 plankton-net taxa evaluated for distribution responses to freshwater inflow exhibited significant responses. Nine of these were negative responses, wherein animals moved downstream as inflows increased. Downstream movement is the typical inflow response seen in tidal rivers on Florida's west coast. Overall, the time lags associated with these responses were highly variable, with many occurring within a seasonal time frame.

The relatively short time series (12 months) did not produce a wide variety of flow conditions over which to assess organism distribution responses. Just over one-half (51%) of the 35 pseudo-species/gear combinations (hereafter simply referred to as 'pseudo-species') evaluated for distributional responses to freshwater inflow exhibited significant response for at least one lagged flow period. The best-fitting models were widely dispersed among inflow lag periods. Responses to inflow within each life-history category were largely associated with different lag periods: short (0–14 days) for residents, medium (21–91 days) to long (98–364 days) for estuarine spawners, and long (98–364 days) for offshore spawners. The majority of the best models that included long lag periods involved offshore spawners. Nearly 90 percent of the significant responses were negative (i.e., animals moved upstream with decreasing freshwater inflow). The pseudo-species' centers of abundance may have shifted downstream during periods of higher inflow because individuals were seeking areas with more suitable salinities, although some physical displacement during periods of extremely high flows cannot be discounted for smaller individuals.

Sixteen (42%) of the 38 plankton-net taxa evaluated for abundance relationships with freshwater inflow exhibited significant responses. All of these were positive responses (i.e., increased abundance with increased inflow). Although it is unusual for all of the responses to be positive, there are two conditions that would favor this condition. Negative responses are usually caused by elevated flows washing river-plume taxa away from the river mouth and out of the survey area. In the present case, however, (1) the study area did not experience strongly elevated inflows during the survey, and (2) there were stations in the receiving body of water (the Gulf of Mexico) that could intercept washed-out organisms. In fact, several river-plume species had positive responses, including the ostracod *Sarsiella zostericola*, the copepod *Labidocera aestiva*, postlarvae of the shrimp *Hippolyte* spp., the chaetognaths *Sagitta* spp. and bay anchovy adults, *Anchoa mitchilli*. Organisms that typically congregate within the interiors of tidal rivers also had positive responses, including estuarine mysids (*Americamysis almyra* adults, *Americamysis* juveniles, *Bowmaniella dissimilis*), gammaridean amphipods, bay anchovy juveniles and polychaetes. In general, it could be concluded that these positive results were observed – despite the short duration of the study - because there was substantial variation in inflow and because the survey area was geographically scaled to the spatial range of freshwater influence on distribution. Only two of the positive responders, dipteran pupae and chironomid larvae, belong to groups that are primarily freshwater groups.

None of the time lags in the plankton-net distribution responses was short enough to be considered a catchability response (i.e., organisms fleeing the effects of sudden floods and thereby becoming more vulnerable to collection). A few lags were seasonal in nature, but most occurred over time frames that would be expected from true population responses.

As noted for distribution responses to freshwater inflow, the relatively short time series of sampling did not give a wide variety of flows over which to assess abundance responses; results should therefore be interpreted with caution. Among the 38 pseudo-species considered in these analyses, abundances of 60.5% were significantly related to average inflow. The greatest proportion of variance in abundance was explained by linear models for 10 pseudo-species and by quadratic models for 13 pseudo-species. Of the 10 linear models, three were negative relationships, indicating increasing abundance with decreasing inflow, and seven were positive relationships, indicating increasing abundance with increasing inflow. Almost half (46.1%) of quadratic models suggested greatest abundance at intermediate inflows ('intermediate-maximum'). Of the remaining quadratic models, three suggested least abundance at intermediate inflow ('intermediate-minimum'), two suggested greatest abundance at higher flow levels, and one indicated greatest abundance at the lower levels of inflow. The percentage of significant abundance responses to inflow ranged from 56% of tested pseudo-species in estuarine spawners to 65% in offshore spawners. Offshore and estuarine spawners tended to exhibit intermediate-maximum or positive responses to inflow, whereas tidal-river residents also showed intermediate-minimum responses to inflow. The majority of the best-fitting regression models incorporated longer lags for all life history categories, but this trend was most pronounced for estuarine and offshore spawners. An increase in abundance with increased flow may suggest beneficial aspects of increased nutrient input, for example, or perhaps better detection of the tidal-river nursery area. Intermediate-minimum relationships, where abundance is greatest at either low or high flows and least at intermediate flows, are difficult to explain in ecological terms. Intermediate-maximum relationships, which are opposite in nature to intermediate-minimum relationships, perhaps indicate differing forces operating at opposite ends of the inflow spectrum. At low flows, opportunities for either chemical detection of tidal nursery habitats or selective tidal-stream transport may be reduced, and at high flows, physical displacement may occur, or perhaps undesirable properties of fresher water (e.g., low pH) become more prominent.

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1.0 INTRODUCTION

Rivers export nutrients, detritus, and other productivity promoting materials to the estuary and sea. Freshwater inflows also strongly influence the stratification and circulation of coastal waters, which in itself may have profound effects on coastal ecosystems (Mann and Lazier 1996). Estuary-related fisheries constitute a very large portion of the total weight of the U.S. fisheries yield (66% of finfish and shellfish harvest, Day et al. 1989; 82% of finfish harvest, Imperial et al. 1992). The contribution of estuary-related fisheries is consistently high among U.S. states that border the Gulf of Mexico, where the estimates typically exceed 80% of the total weight of the catch (Day et al. 1989). Examples from around the world indicate that these high fisheries productivities are not guaranteed, however. In many locations, large amounts of fresh water have been diverted from estuaries to generate hydroelectric power or to provide water for agricultural and municipal use. Mann and Lazier (1996) reviewed cases where freshwater diversions were followed by the collapse of downstream fisheries in San Francisco Bay, the Nile River delta, James Bay, Canada, and at several inland seas in the former U.S.S.R. Sinha et al. (1996) documented a reversal of this trend where an increase in fisheries landings followed an increase in freshwater delivery to the coast.

Fishery yields around the world are often positively correlated with freshwater discharge at the coast (Drinkwater 1986). These correlations are often strongest when they are lagged by the age of the harvested animal. In south Florida, Browder (1985) correlated 14 years of pink shrimp landings with lagged water levels in the Everglades. Associations between river discharge and fisheries harvests have also been identified for various locations in the northern and western Gulf of Mexico (Day et al. 1989, Grimes 2001). Surprisingly, discharge-harvest correlations sometimes extend to non-estuarine species. Sutcliffe (1972, 1973) reported lagged correlations between discharge of the St. Lawrence River and the harvest of non-estuarine species such as American lobster and haddock. In recognition of the potential complexities behind these correlations, Drinkwater (1986) advised that the effect of freshwater inflows be considered on a species-by-species basis.

Freshwater influence on coastal ecosystems extends beyond its immediate effects on fisheries. Because of the intricate nature of many food web interactions, changes in the abundance of even a single species may be propagated along numerous pathways, some anticipated and some not, eventually causing potentially large changes in the abundance of birds, marine mammals and other groups of special concern (Christensen 1998, Okey and Pauly 1999). Mann and Lazier (1996) concluded “one lesson is clear: a major change in the circulation pattern of an estuary brought about by damming the freshwater flows, a tidal dam, or other engineering projects may well have far reaching effects on the primary and secondary productivity of the system.”

This project was conducted to support the establishment of minimum flows for the Anclote River estuarine system by the Southwest Florida Water Management District (SWFWMD). Minimum flows are defined in Florida Statutes (373.042) as the “limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.” In the process of establishing minimum flows for an estuarine system, the SWFWMD evaluates the effects of the freshwater inflows on ecological resources and processes in the receiving estuary. The findings of this project will be used by the SWFWMD to evaluate the fish nursery function of the Anclote River estuary in relation to freshwater inflows. It is not the purpose of this project to determine the level of effect that constitutes significant harm, as that determination will be made by the Governing Board of the SWFWMD.

1.1 Objectives

This project uses plankton-net, seine, and trawl surveys to document the abundance and distribution of fishes and invertebrates that use the tidal Anclote River as habitat. There were several objectives for this project. One was to produce a descriptive database that could serve as a baseline for comparison with future ecological change. These baseline data also provide seasonality records that identify the times of year when the risk of adverse impacts would be greatest for specific organisms.

Another principal objective was to develop regressions to model the responses of estuarine organisms to variations in freshwater inflows. The resulting models would then be available for evaluating proposed minimum flows or the potential impacts of proposed freshwater management plans. These models were developed for both estuarine fishes and the invertebrate prey groups that sustain young fishes while they occupy estuarine nursery habitats.

2.0 METHODS

2.1 Study Area

The Anclote River watershed occupies parts of Pasco, Pinellas and Hillsborough counties in west central Florida. Watershed area above the Elfers gauge is 186 km^2 (73 mi^2). River length is approximately 55 km, with estuarine waters occupying the lower 16 km (Fig. 2.1.1). At Tarpon Springs, near the river's mouth at the Gulf of Mexico, the semi-diurnal tide has a range of <1.9 m. Bottom substrates in the tidal river are dominated by mud, sand, shell and limestone.

Mangrove shorelines (black mangrove, *Avicennia germinans*, and red mangrove, *Rhizophora mangle*) are primarily limited to the Gulf of Mexico shore and the lower 3 km of river. Patches of submerged aquatic vegetation are common in the Gulf of Mexico and near the river mouth. Between 5.4 and 10 km upstream, there are >2 km^2 of brackish marsh, dominated by black rush (*Juncus roemarianus*). Isolated areas of higher elevation upstream of 10 km are vegetated by coastal-hammock trees and shrubs.

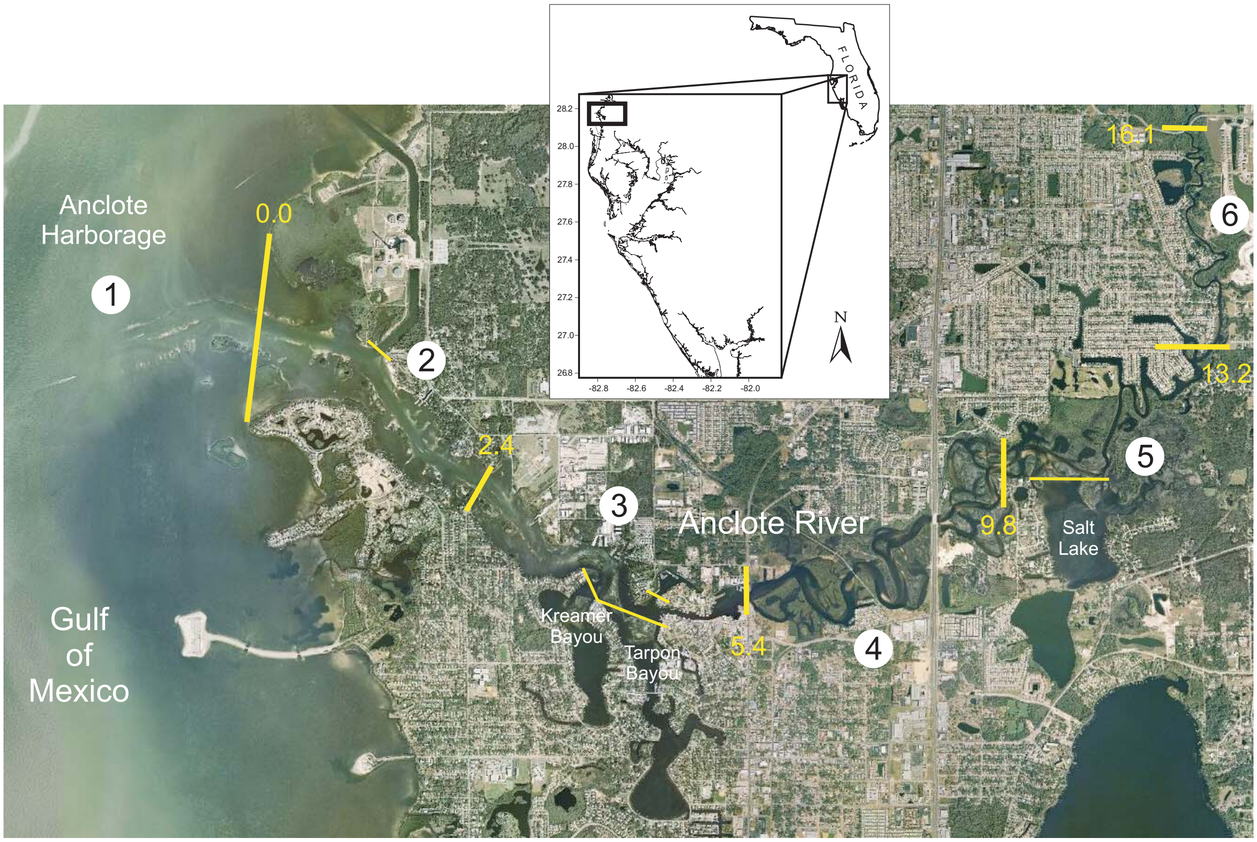


Fig. 2.1.1. Map of survey area, including sampling zones (circled numbers) and zone boundaries (yellow lines).

2.2 Survey Design

Three gear types were implemented to monitor organism distributions: a plankton net deployed during nighttime flood tides and a bag seine and otter trawl deployed during the day under variable tide stages. The plankton net surveys were conducted by the University of South Florida College of Marine Science, and the seine and trawl surveys were conducted by the Fisheries-Independent Monitoring (FIM) program of the Fish and Wildlife Research Institute (Florida Fish and Wildlife Conservation Commission).

The small organisms collected at night by the plankton net represent a combination of the zooplankton and hyperbenthos communities. The term *zooplankton* includes all weakly swimming animals that suspend in the water column during one or more life stages. The distribution of such animals is largely subject to the motion of the waters in which they live. The term *hyperbenthos* applies to animals that are associated with the bottom but tend to suspend above it, rising higher into the water column at night or during certain times of year (vertical migrators). The permanent hyperbenthos of estuaries (non-transient hyperbenthos) tends to be dominated by peracarid crustaceans, especially mysids and amphipods (Mees et al. 1993). Many types of hyperbenthos are capable of actively positioning themselves at different places along the estuarine gradient by selectively occupying opposing tidal flows.

The faunal mixture that forms in the nighttime water column includes the planktonic eggs and larvae of fishes (ichthyoplankton). One of the most common reasons for using plankton nets to survey estuarine waters is to study ichthyoplankton. Although fish eggs and larvae are the intended focus of such studies, invertebrate plankton and hyperbenthos almost always dominate the samples numerically. The invertebrate catch largely consists of organisms that serve as important food for juvenile estuary-dependent and estuary-resident fishes. In an effort to characterize the invertebrate catch more completely, all water-column animals collected by the plankton net were enumerated at a practical taxonomic level.

Seines and trawls were used to survey larger organisms that typically evade plankton nets. Generally speaking, the data from seine hauls document habitat use by shallow-water organisms whereas the data from trawls document habitat use in deeper areas. The dominant catch for both gear types is juvenile fishes, although the adults of smaller species are also commonly caught. The seines and trawls also regularly collect a few of the larger macroinvertebrate species from tidal rivers, notably juvenile and adult blue crabs (*Callinectes sapidus*) and juvenile pink shrimp (*Farfantepenaeus duorarum*).

Monthly sampling in the Anclote River and Gulf of Mexico began in October 2004 and ended in September 2005. The study area was divided into six collection zones (Fig. 2.1.1, Table 2.2.1). Two plankton-net tows, two seine hauls and two trawl deployments were made each month in each zone. The locations for seine and trawl deployment were randomly selected within each zone during each survey, whereas the plankton-net collections were made at fixed stations. The longitudinal position of each station was measured as the distance from the mouth of the tidal river, following the geometric centerline of the channel. Seines in the Gulf zone were set along the shoreline, including island shorelines.

Table 2.2.1. Distribution of sampling effort within the tidal Anclote River (October 2004–September 2005). Zone position is measured relative to the river mouth.

River km	Plankton	Seine	Trawl
-1.8–0.0 (Gulf)	24	24	12
0.0–2.4	24	24	12
2.4–5.4	24	24	12
5.4-9.8	24	24	12
9.8-13.2	24	24	12
13.2-16.1	24	24	12
Totals	144	144	72

2.3 Plankton Net Specifications and Deployment

The plankton gear consisted of a 0.5-m-mouth-diameter 500-µm-mesh conical (3:1) plankton net equipped with a 3-pt nylon bridle, a calibrated flow meter (General Oceanics model 2030R or SeaGear model MF315), a 1-liter plastic cod-end jar, and a 9-kg (20-lb.) weight. The net was deployed between low slack and high slack tide, with sampling beginning within two hours after sunset and typically ending less than four hours later. Tow duration was 5 min, with tow time being divided equally among bottom, mid-water and surface depths. The fishing depth of the weighted net was controlled by adjusting the length of the tow line while using tachometer readings to maintain a constant line angle. The tow line was attached to a winch located on the gunnel near the transom. Placement of the winch in this location caused asymmetry in the steering of the boat, which caused propeller turbulence to be directed away from the towed net. Tow speed was approximately 1.3 m s^{-1}, resulting in a tow length of >400 m over water and a typical filtration of 70-80 m^3. Upon retrieval of the net, the flowmeter reading was recorded, and the contents of the net were rinsed into the cod-end jar using an electric wash-down pump and hose with an adjustable nozzle. The samples were preserved in 6-10% formalin in ambient saline.

The net was cleaned between surveys using an enzyme solution that dissolves organic deposits. Salinity, temperature, pH and dissolved oxygen were measured at one-meter intervals from surface to bottom after each plankton-net deployment.

2.4 Seine and Trawl Specifications and Deployment

The gear used in all seine collections was a 21.3-m center-bag seine with 3.2-mm mesh and leads spaced every 150 mm. To deploy the seine in riverine environments (i.e., shorelines with water depth ≤1.8 m in the study area), the boat dropped off a member of the seine crew near the shoreline with one end of the seine, and the boat then payed out the net in a semicircle until the boat reached a second drop-off point near the shoreline. The lead line was retrieved simultaneously from both ends, with effort made to keep the lead line in contact with the bottom. This process forced the catch into the bag portion of the seine. Area sampled by each boat-deployed seine collection was approximately 68 m^2.

The 6.1-m otter trawl had 38-mm stretched mesh, a 3.2-mm mesh liner, and a tickler chain. It was towed in deeper areas (≥ 1.8 m, < 7.6 m) for five minutes in a straight line; when a suitably deep site could not be found and depths were between 1.0 and 1.8 m, the trawl was towed in an arc. Tow speed averaged 0.6 m s^{-1}, resulting in a typical tow length of about 180 m. Trawl width averaged 4 m, giving an approximate area sampled by a typical tow of 720 m^2. Salinity, temperature, pH, and dissolved oxygen were measured at the surface and at 1-m intervals to the bottom in association with each gear deployment.

2.5 Plankton Sample Processing

All aquatic taxa collected by the plankton net were identified and counted, except for invertebrate eggs and organisms that were attached to debris (sessile stages of barnacles, bryozoans, sponges, tunicates and sessile coelenterates). During sorting, the data were entered directly into an electronic database via programmable keyboards that interfaced with a macro-driven spreadsheet. Photomicrographs of representative specimens were compiled into a reference atlas that was used for quality-control purposes.

Most organisms collected by the plankton net fell within the size range of 0.5-50 mm. This size range spans three orders of magnitude, and includes mesozooplankton (0.2-20 mm) macrozooplankton/micronekton (>20 mm) and analogous sizes of hyperbenthos. To prevent larger objects from visually obscuring smaller ones during sample processing, all samples were separated into two size fractions using stacked sieves with mesh openings of 4 mm and 250 µm. The >4 mm fraction primarily consisted of juvenile and adult fishes, large macroinvertebrates and large particulate organic matter. In most cases, the fishes and macroinvertebrates in the >4 mm fraction could be identified and enumerated without the aid of microscopes.

A microscope magnification of 7-12X was used to enumerate organisms in the >250 µm fraction, with zoom magnifications as high as 90X being available for identifying individual specimens. The >250 µm fraction was usually sorted in two stages. In the first sorting stage, the entire sample was processed as 10-15 ml aliquots that were scanned in succession using a gridded petri dish. Only relatively uncommon taxa (n<50) were enumerated during this first stage. After the entire sample had been processed in this manner, the collective volume of the aliquots was recorded within a graduated mixing cylinder, the sample was inverted repeatedly, and then a single 30-60 ml aliquot was poured. The aliquot volume typically represented about 12-50% of the entire sample volume. The second sorting stage consisted of enumerating the relatively abundant taxa within this single aliquot. The second sorting stage was not required for all samples. The second stage was, however, sometimes extended to less abundant taxa (*n*<50) that were exceptionally small or were otherwise difficult to enumerate.

2.5.1 Staging Conventions.

All fishes were classified according to developmental stage (Fig. 2.5.1.1), where

> **preflexion** larval stage = the period between hatching and notochord flexion; the tip of the straight notochord is the most distal osteological feature.
>
> **flexion** larval stage = the period during notochord flexion; the upturned notochord or urostyle is the most distal osteological feature.
>
> **postflexion** larval stage = the period between completion of flexion and the juvenile stage; the hypural bones are the most distal osteological feature.
>
> **metamorphic** stage (clupeid fishes) = the stage after postflexion stage during which body depth increases to adult proportions (ends at juvenile stage).
>
> **juvenile** stage = the period beginning with attainment of meristic characters and body shape comparable to adult fish and ending with sexual maturity.

Decapod larvae were classified as zoea, megalopa or mysis stages. These terms are used as terms of convenience and should not be interpreted as technical definitions. Planktonic larvae belonging to Anomura and Brachyura (crabs) were called zoea. Individuals from these groups displaying the planktonic to benthic transitional morphologies were classified as megalopae. All other decapod larvae (shrimps) were classified as mysis stages until the uropods differentiated into exopods and endopods (5 total elements in the telsonic fan), after which they were classified as postlarvae until they reached the juvenile stage. The juvenile stage was characterized by resemblance to small (immature) adults. Under this system, the juvenile shrimp stage (e.g., for *Palaemonetes*) is equivalent to the postlarval designation used by some authors.

In many fish species, the juvenile stage is difficult to distinguish from other stages. At its lower limit, the juvenile stage may lack a clear developmental juncture that distinguishes it from the postflexion or metamorphic stage. Likewise, at its upper limit, more than one length at maturity may be reported for a single species or the reported length at maturity may differ between males and females. To avoid inconsistency in the staging process, length-based staging conventions were applied to the more common taxa. These staging conventions agree with stage designations used by the U.S. Fish and Wildlife Service (e.g., Jones et al. 1978). The list in Table 2.5.1.1 is comprehensive, representing the conventions that have been required to date by various surveys. Some of the species or stages in the list were not encountered during the surveys covered by this report.

Table 2.5.1.1. Length-based staging conventions used to define developmental stage limits. Fish lengths are standard length (SL) and shrimp length is total length.

Postflexion-juvenile transition (mm):

Lucania parva	10
Menidia spp.	10
Eucinostomus spp.	10
Lagodon rhomboides	10
Bairdiella chrysoura	10
Cynoscion arenarius	10
Cynoscion nebulosus	10
Sciaenops ocellatus	10
Menticirrhus spp.	10
Leiostomus xanthurus	15
Orthopristis chrysoptera	15
Achirus lineatus	5
Trinectes maculatus	5
Gobiesox strumosus	5
Eugerres plumieri	10
Prionotus spp.	10
Symphurus plagiusa	10
Anchoa mitchilli	15
Sphoeroides spp.	10
Chilomycterus schoepfii	10
Lepomis spp.	10
Micropterus salmoides	10
Membras martinica	10
Chloroscombrus chrysurus	10
Hemicaranx amblyrhynchus	10
Micropogonias undulatus	15
Chaetodipterus faber	5

Juvenile-adult transition (mm):

Anchoa mitchilli	30
Lucania parva	15
Gambusia holbrooki	15
Heterandria formosa	10
Menidia spp.	35
Eucinostomus spp.	50
Gobiosoma bosc	20
Gobiosoma robustum	20
Microgobius gulosus	20
Microgobius thalassinus	20
Gobiesox strumosus	35
Trinectes maculatus	35
Palaemonetes pugio	20
Membras martinica	50
Syngnathus spp.	80
Poecilia latipinna	30
Anchoa hepsetus	75

Metamorph-juvenile transition (mm):

Brevoortia spp.	30
Dorosoma petenense	30

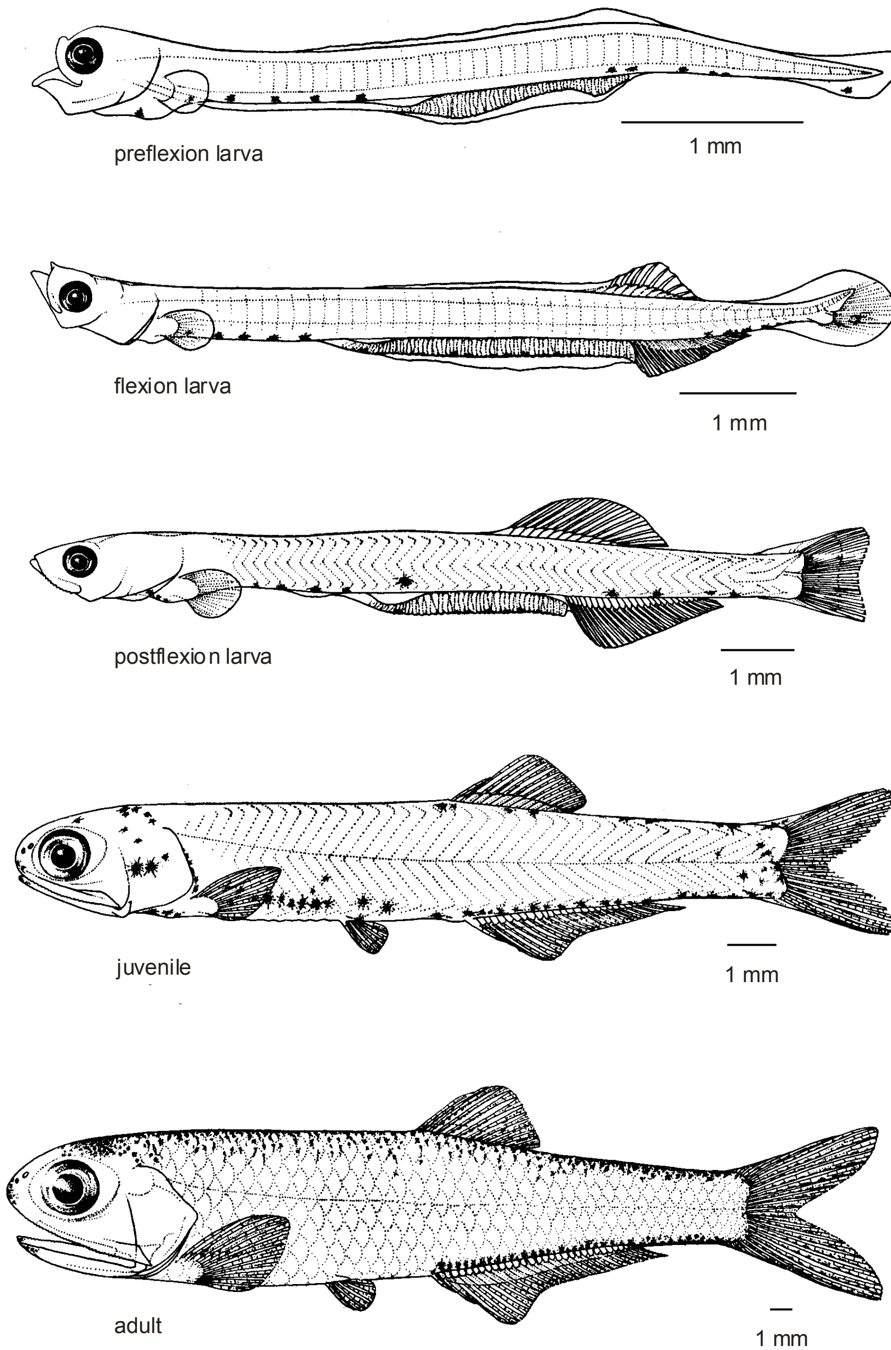


Fig. 2.5.1.1. Fish-stage designations, using the bay anchovy as an example. Specimens measured 4.6, 7.0, 10.5, 16, and 33 mm standard length.

2.6 Seine and Trawl Sample Processing

Fish and selected crustaceans collected in seine and trawl samples were removed from the net into a bucket and processed onboard. Animals were identified to lowest practical taxonomic category, generally species. Representative samples (three individuals of each species from each gear on each sampling trip) were brought back to the FWC/FWRI laboratory to confirm field identification. Species for which field identification was uncertain were also brought back to the laboratory. A maximum of 10 measurements (mm) were made per taxon, unless distinct cohorts were identifiable, in which case a maximum of 10 measurements were taken from each cohort; for certain economically valuable fish species, twenty individuals were measured. Standard length (SL) was used for fish, post-orbital head length (POHL) for pink shrimp, and carapace width (CW) for crabs. Animals that were not measured were identified and counted. When large numbers of individuals (>> 1,000) were captured, the total number was estimated by fractional expansion of sub-sampled portions of the total catch split with a modified Motoda box splitter (Winner and McMichael, 1997). Animals not chosen for further laboratory examination were returned to the river.

Due to frequent hybridization and/or extreme difficulty in the identification of smaller individuals, members of several abundant species complexes were not identified to species. We did not separate menhaden, *Brevoortia*, species. *Brevoortia patronus* and *B. smithi* frequently hybridize, and juveniles of the hybrids and the parent species are difficult to identify (Dahlberg, 1970). *Brevoortia smithi* and hybrids may be the most abundant forms on the Gulf coast of the Florida peninsula, especially in tidal rivers (Dahlberg, 1970), and we treated them as one functional group. The two abundant silverside species (genus *Menidia*) tend to hybridize, form all-female clones, and occur in great abundance that renders identification to species impractical due to the nature of the diagnostic characters (Duggins et al., 1986; Echelle and Echelle, 1997; Chernoff, personal communication). Species-level identification of mojarras (genus *Eucinostomus*) was limited to individuals ≥ 40 mm SL due to great difficulty in separating *E. gula* and *E. harengulus* below this size (Matheson, personal observation). The term “eucinostomus mojarras” is used for these small specimens. Species-level identification of gobies of the genus *Gobiosoma* (i.e., *G. robustum* and *G. bosc*) used in analyses were limited to individuals ≥ 20 mm SL for the same reason; these are hereafter referred to as “gobiosoma gobies”. Similarly, needlefishes (*Strongylura* spp.) other than *S. notata* were only identified to species at lengths ≥ 100 mm SL.

2.7 Data Analysis

2.7.1 Freshwater Inflow (*F*).

Inflow rates to the study area include data from one gauged streamflow site, USGS site 02310000 (Anclote River near Elfers). All flow rates were expressed as average daily flows in cubic feet per second (cfs).

2.7.2 Organism-Weighted Salinity (S_U).

The central salinity tendency for catch-per-unit-effort (CPUE) was calculated as

$$S_U = \frac{\sum(S \cdot U)}{\sum U}$$

where U is CPUE (No. m^{-3} for plankton data and No. 100 m^{-2} for seine and trawl data) and S is water-column average salinity during deployment.

2.7.3 Center of CPUE (km_U).

The central geographic tendency for CPUE was calculated as

$$km_U = \frac{\sum(km \cdot U)}{\sum U}$$

where *km* is distance from the river mouth.

2.7.4 Organism Number (N) and Relative Abundance ($\overline{N}$).

Using plankton-net data, the total number of organisms in the Anclote study area was estimated by summing the products of mean organism density ($\overline{U}$, as No. m^{-3}) and tide-corrected water volume (V) from the six collection zones as

$$N = \sum (\overline{U} \cdot V)$$

Volumes corresponding to NGVD were contoured (Surfer 7, Golden Software, kriging method, linear semivariogram model) using bathymetric transects provided by SWFWMD, and these volumes were then adjusted to the actual water level at the time of collection using data from the water-level recorder at Alt. US Hwy 19 (USGS gauge 02310175). The following water bodies were not included in the area and volume calculations: Kreamer Bayou inside a line extending from Ferguson Pt. to Chesapeake Pt., Tarpon Bayou inside a line extending from Chesapeake Pt. to a point of land west-southwest of the Sponge Docks (28° 9.34' N, 82° 45.07' W), the embayment on the north shore near Anclote Road, Salt Lake starting at its northern shoreline, the power plant canal, residential canals, and all adjoining creeks and embayments that are not part of the conveying channel. The latter group does not exclude channels that are part of the divided channel system; these were included.

Within the tidal river, zone-specific volume increased in a nonlinear manner in the downstream direction. The volume of Zone 1, which was in open water and therefore had an ecologically arbitrary seaward boundary, was extrapolated from a regression of trends in estimated zone volume within the river (average estimated zone volume = $[1463 - 222.7 \times \text{zone number}]^2$, $n=5$, $r^2=0.98$, $p=0.001$). Extrapolation of this relationship to zone number 1, followed by division by an average depth of 0.98 meter NGVD (from USGS topo maps), resulted in an area for Zone 1 equivalent to 1.5 km^2. The two plankton stations in Zone 1 were 0.8 km apart, with the seaward-most station being 1.8 km offshore of the river mouth. Zone 1 was therefore represented by a 1 km wide rectangle centered longitudinally on the navigational channel from the river mouth to a distance 2.3 km offshore.

For seine and trawl data, relative abundance (mean number per 100 m^2 sampled area) in the Gulf and Anclote River zones was calculated for each month as

$$\overline{N} = 100 \times \frac{N_{total}}{A_{total}}$$

where N_{total} = total number of animals captured in that month and A_{total} is the total area sampled in that month. $\overline{N}$ is also occasionally referred to as CPUE in some instances.

2.7.5 Inflow Response Regressions.

Regressions were run for km_U on F, N on F, and $\overline{N}$ on F. N, $\overline{N}$, km_U (seine/trawl data only) and F were Ln-transformed prior to regression to improve normality. To avoid censoring zero values in seine and trawl regressions, a constant of 1 was added to $\overline{N}$ and F, and an additional constant, 1.79, was added to all km_U values (all gears) to adjust for negative values when taxa were centered below the mouth of the river.

Regressions using plankton-net data were limited to taxa that were encountered during a minimum of 10 of the monthly surveys. The fits of the following regression models were compared to determine if an alternative model produced consistently better fit than the linear model (Y = a + b**F*):

Square root-Y: Y = (a + b**F*)^2
Exponential: Y = exp(a + b**F*)
Reciprocal-Y: Y = 1/(a + b**F*)
Square root-*F*: Y = a + b*sqrt(*F*)
Reciprocal-*F*: Y = a + b/*F*
Double reciprocal: Y = 1/(a + b/*F*)
Logarithmic-*F*: Y = a + b*ln(*F*)
Multiplicative: Y = a**F*^b
S-curve: Y = exp(a + b/*F*)

where Y is km_U or N. In these regressions, F was represented by same-day inflow and by mean inflows extending as far back as 120 days prior to the sampling date. The combination of consecutive dates that produced the maximum regression fit was used to model the N and km_U responses to F for each taxon. This approach provided an indication of the temporal responsiveness of the various taxa to inflow variations. An organism was considered to be responsive if the regression slope was significantly different from zero at $p<0.05$.

Seine and trawl regressions were limited to taxa that were reasonably abundant (total abundance>100 in seines, >50 in trawls) and frequently collected (present in at least 3% of collections for each gear). Monthly length-frequency plots (Appendix C) were examined in order to assign appropriate size classes ('pseudo-species') and recruitment windows for each of these taxa. For distribution regressions (km_U), all months were considered when a pseudo-species was collected in at least one sample from that month. For abundance regressions ($\overline{N}$), all samples collected within a determined recruitment period from monthly length-frequency plots (Appendix C) were considered. Mean flows from the date of sampling, as well as continuously lagged weekly averages from the day of sampling to 365 d before sampling (i.e., average flow of sampling day and preceding 6 days, average flow of sampling day and preceding 13 days, etc.), were considered and linear and quadratic regressions were evaluated.

2.7.6 Data Limitations and Gear Biases.

All nets used to sample aquatic organisms are size selective. Small organisms pass through the meshes and large organisms evade the gear altogether. Intermediate-sized organisms are either fully retained or partially retained. When retention is partial, abundance becomes relative. However, temporal or spatial comparisons can still be made because, for a given deployment method and size of organism, the selection process can usually be assumed to have constant characteristics over space and time. The 500-µm plankton gear retains a wide range of organism sizes completely, yet it should be kept in mind that many estimates of organism density and total number are relative rather than absolute. Organism measurements from Little Manatee River and Tampa Bay plankton samples (Peebles 1996) indicate that the following taxa will be collected selectively by 500-µm mesh: marine-derived cyclopoid copepods, some cladocerans, some ostracods, harpacticoid copepods, cirriped nauplii and cypris larvae, the larvacean *Oikopleura dioica*, some decapod zoeae, and some adult calanoid copepods. Taxa that are more completely retained include: cumaceans, chaetognaths, insect larvae, fish eggs, most fish larvae and postlarvae, some juvenile fishes, gammaridean amphipods, decapod mysis larvae, most decapod megalopae, mysids, isopods, and the juveniles and adults of most shrimps. This partitioning represents a very general guide to the relative selectivities of commonly caught organisms.

The plankton nets were deployed during nighttime flood tides because larval fishes and invertebrates are generally more abundant in the water column at night (Colton et al. 1961, Temple and Fisher 1965, Williams and Bynum 1972, Wilkins and Lewis 1971, Fore and Baxter 1972, Hobson and Chess 1976, Alldredge and King 1985, Peebles 1987, Haney 1988, Lyczkowski-Shultz and Steen 1991, Olmi 1994) and during specific tide stages (Wilkins and Lewis 1971, King 1971, Peebles 1987, Olmi 1994, Morgan 1995a, 1995b). Organisms that selectively occupy the water column during flood tides tend to move upstream, and organisms that occupy the water column during all tidal stages tend to have little net horizontal movement other than that caused by net estuarine outflow (Cronin 1982, McCleave and Kleckner 1982, Olmi 1994). The plankton catch was therefore biased toward organisms that were either invading the tidal rivers or were attempting to maintain position within the tidal rivers. This bias would tend to exclude the youngest larvae of some estuarine crabs, which are released at high tide to facilitate export downstream with the ebb tide (Morgan 1995a). However, as the young crabs undergo their return migrations at later larval stages, they become most available for collection during nighttime flood tides (Olmi 1994, Morgan 1995b).

Seines and trawls tend to primarily collect small fish, either adults of small-bodied species or juveniles of larger taxa. Trawls tend to capture larger fish than seines (Nelson and Leffler, 2001), and whether this is due to gear characteristics or preferred use of channel habitat by larger fish is uncertain. Sampling efficiency inevitably varies by species and size class (Rozas and Minello, 1997), but we assume reasonable consistency between samples collected with a given gear type. We acknowledge that movement of various taxa (e.g. killifishes, Fundulidae and Cyprinodontidae) into emergent vegetation at high water levels occurs (Rozas and Minello, 1997) and could complicate interpretation of some results.

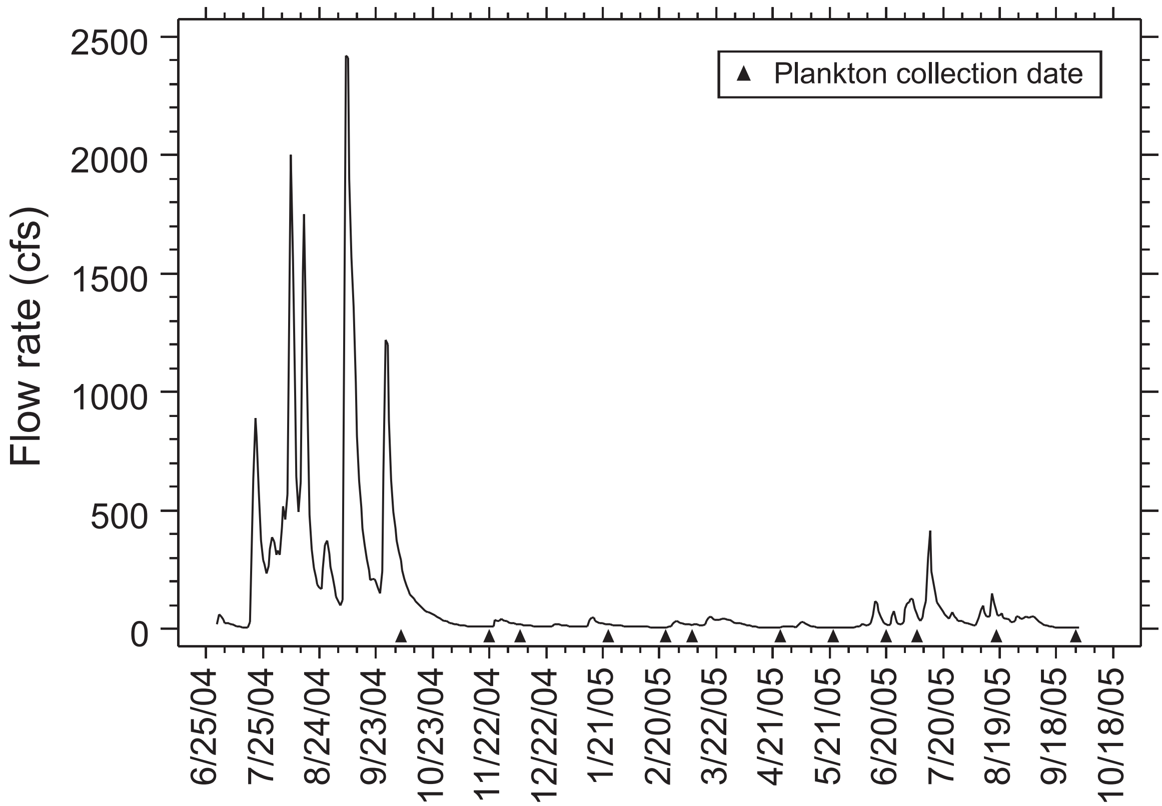
3.0 RESULTS AND DISCUSSION

3.1 Streamflow Status During Survey Years

During the one-year survey period (October 2004 through September 2005), flows averaged 40 cfs (Fig. 3.1.1). However, there was a large disparity in the strengths of the two summer rainy seasons that influenced the biological databases. During the period of July through September, 2004, gauged streamflow averaged 505 cfs, whereas the average for the same period in 2005 was 57 cfs, a full order of magnitude lower. This provided a good comparison of biological responses during an otherwise abbreviated survey duration.

3.2 Physico-chemical Conditions

Summary statistics from the electronic meter data collected during plankton sampling are presented in Table 3.2.1. Temperatures underwent seasonal variation within a typical range (Fig. 3.2.1). The two summer peaks in freshwater inflow (Fig. 3.1.1) reduced average salinities, with the reduction in October 2004 being much stronger than the reduction in September 2005. The lowest pH was also observed in October 2004, in agreement with inflow's effect of increasing overall respiration rates within the estuary. Hypoxia was not a chronic problem in the Anclote River. The lowest dissolved oxygen (DO) levels were observed during the rainy season of 2005 in reaches upstream of km 5 (Table 3.2.1). Hypoxia may have also occurred during the rainy season of 2004, as DO levels were still somewhat reduced during October, 2004. DO only occasionally reached strong supersaturation levels, which suggests that microalgal blooms sometimes occur, but not as commonly as in tidal rivers such as the Alafia and Hillsborough Rivers (Peebles 2005, MacDonald et al. 2005).



Plankton collection dates:	Seine and trawl collection dates:
10-06-2004	10-18-2004, 10-19-2004
11-22-2004	11-09-2004, 11-10-2004
12-08-2004	12-09-2004
1-24-2005	1-19-2005, 1-20-2004
2-23-2005	2-15-2005
3-09-2005	3-15-2005
4-25-2005	4-05-2005
5-23-2005	5-10-2005
6-20-2005	6-07-2005
7-06-2005	7-14-2005
8-17-2005	8-18-2005
9-28-2005	9-14-2005

Fig. 3.1.1. Anclote River gauged streamflow and collection dates.

Table 3.2.1. Electronic meter summary statistics during plankton net deployment. Mean depth is mean depth at deployment. Sample sizes (n) reflect the combination of survey frequency (12 monthly surveys) and depth of measurement. Measurements were made at surface, bottom and at one-meter intervals between surface and bottom.

Location (km from mouth)	Mean Depth (m)	Salinity (psu)					Water Temperature (°C)					Dissolved Oxygen (mg/l)					pH				
		n	mean	std. dev.	min.	max.	n	mean	std. dev.	min.	max.	n	mean	std. dev.	min.	max.	n	mean	std. dev.	min.	max.
-1.8	3.1	53	28.6	3.3	20.9	33.0	53	24.2	6.7	10.9	32.6	53	8.4	1.4	5.8	12.7	53	8.0	0.3	7.3	8.4
-1.0	3.5	58	28.1	3.5	20.9	32.6	58	25.1	6.6	11.1	32.6	58	8.1	1.2	6.4	12.5	58	8.2	0.2	7.7	8.4
0.3	3.3	57	26.8	3.6	17.9	32.2	57	24.3	6.4	12.0	32.6	57	7.8	1.4	4.1	11.4	57	8.1	0.2	7.5	8.4
1.7	3.2	55	25.2	4.0	7.6	32.1	55	25.9	6.2	12.5	32.8	55	6.9	1.5	4.8	9.8	55	8.1	0.1	7.8	8.3
2.9	3.0	52	23.0	4.6	5.5	29.2	52	25.0	6.4	12.4	33.2	52	6.4	1.3	4.5	9.5	52	8.0	0.1	7.6	8.3
4.5	3.9	64	20.5	5.8	2.4	27.6	64	25.1	6.4	11.7	33.0	64	5.7	1.5	3.4	9.8	64	7.9	0.2	7.4	8.2
6.0	2.2	43	16.6	6.9	1.9	23.6	43	24.5	6.5	11.9	31.8	43	5.6	1.5	2.8	8.7	43	7.7	0.2	7.3	8.2
8.9	1.2	30	12.7	6.6	0.4	19.3	30	24.6	5.7	13.0	30.8	30	5.3	1.5	2.7	8.1	30	7.6	0.3	7.1	8.1
10.1	1.2	31	10.2	6.4	0.2	17.8	31	24.1	5.3	13.1	29.9	31	5.2	1.5	2.5	8.3	31	7.5	0.3	6.8	8.1
12.3	1.5	32	8.1	6.8	0.1	21.2	32	24.6	4.6	13.7	29.9	32	4.6	1.8	0.1	7.1	32	7.4	0.3	6.6	8.1
13.3	1.2	31	3.6	3.2	0.1	8.4	31	23.3	4.9	13.9	28.9	31	4.9	1.1	2.7	6.7	31	7.3	0.4	6.5	8.0
15.1	2.1	42	1.4	1.6	0.1	5.7	42	22.4	4.7	14.0	28.7	42	5.1	1.1	2.8	7.0	42	7.3	0.4	6.4	8.2

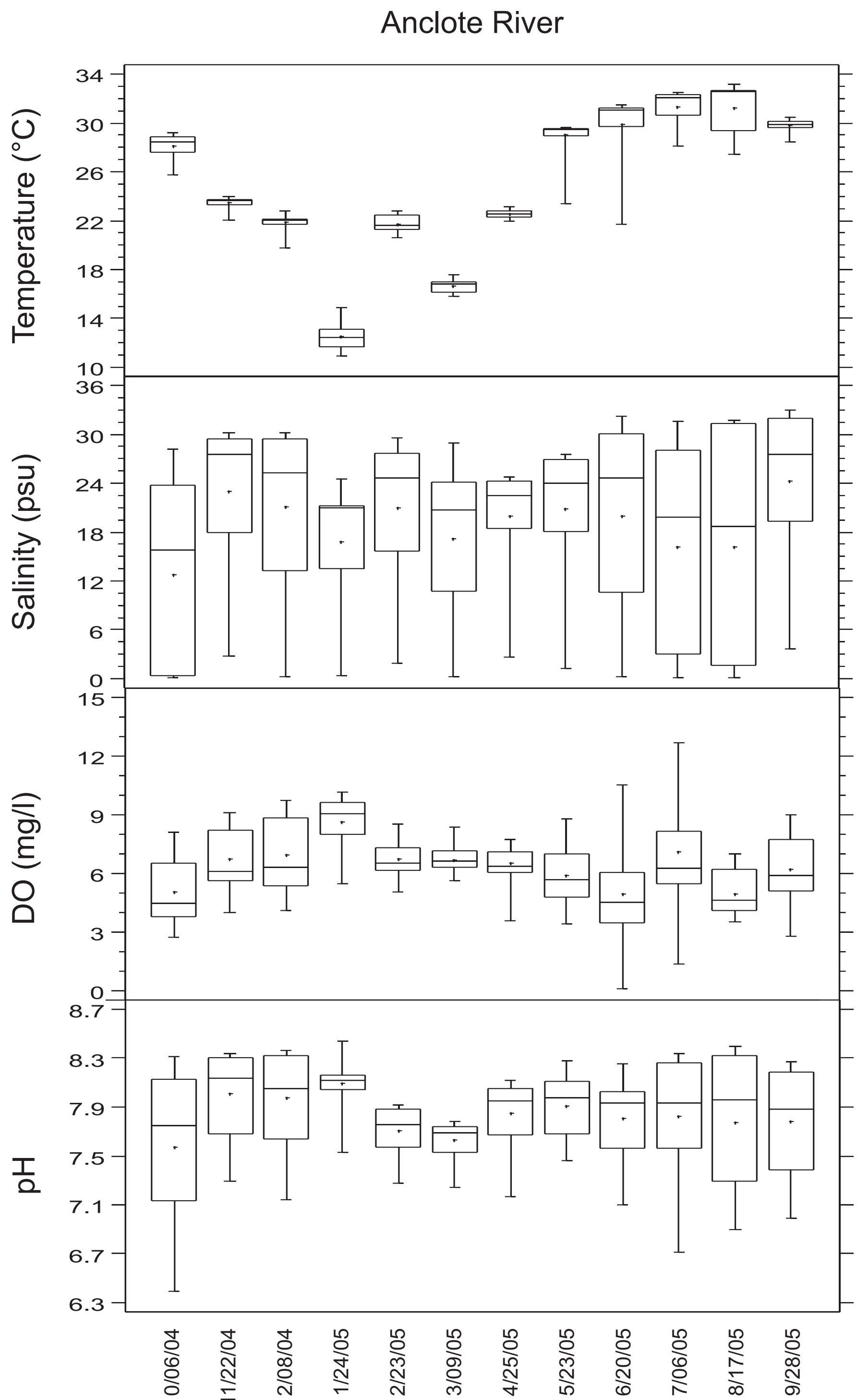


Fig. 3.2.1. Electronic meter data associated with the plankton-net surveys of the tidal Anclote River, where the cross identifies the mean, the horizontal line identifies the median, the box delimits the interquartile range, and the whiskers delimit the total range.

3.3 Catch Composition

3.3.1 Fishes.

3.3.1.1 **Plankton net.** Larval gobies and anchovies dominated the larval fish catch (Table A1). Gobies of the genera *Gobiosoma* and *Microgobius* were dominant in comparable proportions, and the anchovies were dominated by the bay anchovy (*Anchoa mitchilli*). Other abundant larval fishes included silversides (*Menidia* spp.) and skilletfish (*Gobiesox strumosus*). *Menidia* can be exceptionally abundant within estuaries, but can also complete their life cycle within fresh water. Juvenile spot (*Leiostomus xanthurus*) were abundant relative to other tidal rivers in west-central Florida. Spot spawn far offshore and move landward during the late larval and early juvenile stages. Perhaps the proximity of the Anclote survey area to the Gulf of Mexico resulted in high juvenile recruitment of spot into the area.

3.3.1.2 **Seine.** The seine catch (Table B1) was dominated by spot (*Leiostomus xanthurus*), pinfish (*Lagodon rhomboides*), bay anchovy (*Anchoa mitchilli*), and eucinostomus mojarras (*Eucinostomus* spp.). These taxa comprised over 84% of total seine catch of fishes.

3.3.1.3 **Trawl.** The trawl catch (Table B2) was dominated by pinfish, spot, bay anchovy, and eucinostomus mojarras. These taxa comprised over 86% of total trawl catch of fishes.

3.3.2. Invertebrates.

3.3.2.1. **Plankton net.** The plankton-net invertebrate catch (Table A1) was dominated by gammaridean amphipods, larval crabs (decapod zoeae), larval shrimps (decapod mysis) and by river-plume taxa such as the copepods *Acartia tonsa* and *Labidocera aestiva*, the chaetognaths *Sagitta* spp., the planktonic shrimp *Lucifer faxoni*, and the ostracod *Parasterope pollex*. The strong representation of river-plume taxa occurred because two stations were located in the open gulf near the river mouth (i.e., they were in the river plume, Table A3). The amphipods were most abundant in the brackish marshes and in the channel downstream of the marshes, as is commonly observed in other estuaries. The mysid *Americamysis almyra* is often a numerical dominant in estuaries supplied by surface runoff, but was not as strongly dominant in the tidal Anclote River.

3.3.2.2 **Seine.** The seine catch (Table B1) was dominated by daggerblade grass shrimp (*Palaemonetes pugio*) and brackish grass shrimp (*P. intermedius*), which together comprised nearly 94% of the invertebrate catch.

3.3.2.3 **Trawl.** The trawl catch (Table B2) was dominated by arrow shrimp (*Tozeuma carolinense*), brackish grass shrimp, pink shrimp (*Farfantepenaeus duorarum*), and longtail grass shrimp (*Periclimenes longicaudatus*). These taxa comprised nearly 98% of total trawl catch of invertebrates.

3.4 Use of Area as Spawning Habitat

The eggs of unidentified herrings (clupeids), the bay anchovy (*Anchoa mitchilli*), the striped anchovy (*A. hepsetus*), silversides (*Menidia* spp.) and unidentified sciaenid fishes were collected from the survey area (Table A1). Sciaenid eggs were by far the most abundant egg type, followed by eggs of the bay anchovy – both types were most abundant in the Gulf of Mexico and in the lower part of the tidal river (Table A3). If it is assumed that the relative abundances of different species of early-stage sciaenid larvae reflect relative spawning intensity, then the kingfishes (*Menticirrhus* spp.) are the sciaenids that are most likely to have spawned in this area (Tables A3 and 3.4.1). The data in Tables A3 and 3.4.1 also suggest that blennies, the lined sole (*Achirus lineatus*) and the hogchoker (*Trinectes maculatus*) spawned near the river mouth, whereas skilletfish (*Gobiesox strumosus*) and gobies (primarily *Microgobius* spp. and *Gobiosoma* spp., but also *Bathygobius soporator*) may have spawned within the interior of the tidal river. The repeated collection of very small juveniles of live-bearing Gulf pipefish (*Syngnathus scovelli*) within the interior of the tidal river suggests that this species is also reproducing within the local area. A review of trends in spawning habitat among coastal fishes is presented by Peebles and Flannery (1992).

Table 3.4.1. Relative abundance of larval stages for non-freshwater fishes with a collection frequency >10 for the larval-stage aggregate, where *Pre* = preflexion (youngest larval stage), *Flex* = flexion stage (intermediate larval stage) and *Post* = postflexion (oldest larval stage). **X** identifies the most abundant stage and x indicates that the stage was present.

Taxon	**Common Name**	**Pre**	**Flex**	**Post**
Anchoa spp.	anchovies	**X**	x	x
Gobiesox strumosus	skilletfish	**X**	x	
Menidia spp.	silversides	**X**	x	x
Menticirrhus spp.	kingfishes	**X**	x	x
blenniids	blennies	**X**		x
gobiids	gobies	**X**	x	x
Achirus lineatus	lined sole	**X**	x	x
Trinectes maculatus	hogchoker	**X**	x	x
Brevoortia spp.	menhaden		x	**X**
Elops saurus	ladyfish			**X**

3.5 Use of Area as Nursery Habitat

The number of estuary-dependent taxa using the study area as a nursery is somewhat greater than resident taxa: overall, six of the ten most abundant taxa in deeper habitats and seven of the ten most abundant taxa in nearshore habitats can be considered estuary-dependent. There are considerable differences in abundance: estuary-dependents constituted nearly 86% of the total abundance of the top ten most abundant taxa in seined areas, and over 83% of total abundance of top ten taxa in trawled areas. These dependents were mostly offshore spawners and included taxa of commercial importance (i.e., pink shrimp) and taxa of ecological importance due to high abundance (i.e., spot, pinfish, eucinostomus mojarras, tidewater mojarra, and silver jenny).

3.6 Seasonality

3.6.1. Plankton Net.

The number of taxa collected during an individual survey is not a true measure of species richness because many taxa could not be identified to species level. Nevertheless, this index produces a clear seasonal pattern. Specifically, more taxa tend to be collected during the warmer months than during winter (Fig. 3.6.1.1).

Species diversity tends to be highest near the mouths of tidal rivers due to an increased presence of marine-derived species and at the upstream end due to the presence of freshwater species. This creates a low-diversity zone in the middle reaches of tidal rivers (Merriner et al. 1976). Changes in streamflow can shift this pattern downstream or upstream.

For a given species of fish, the length of the spawning season tends to become shorter at the more northerly locations within a species' geographic range, but the time of year when spawning takes place is otherwise consistent for a given species. Among species with long or year-round spawning seasons, local conditions have been observed to have a strong influence on egg production within the spawning season (Peebles 2002). Local influences include seasonally anomalous water temperature, seasonal variation in the abundance of prey, and seasonal variation in retention or transport of eggs and larvae after spawning. The latter processes (prey availability and retention and transport) are influenced by freshwater inflows at the coast.

Alteration of flows would appear to have the lowest potential for impacting many taxa during the period from December through March, which is the period when the fewest estuarine taxa were present. The highest potential to impact many species would appear to be from June through October. Some species were present throughout the year (bay anchovy, Fig. 3.6.1.2), whereas others had more seasonal spawning and recruitment patterns (menhaden and kingfish, Fig. 3.6.1.2).

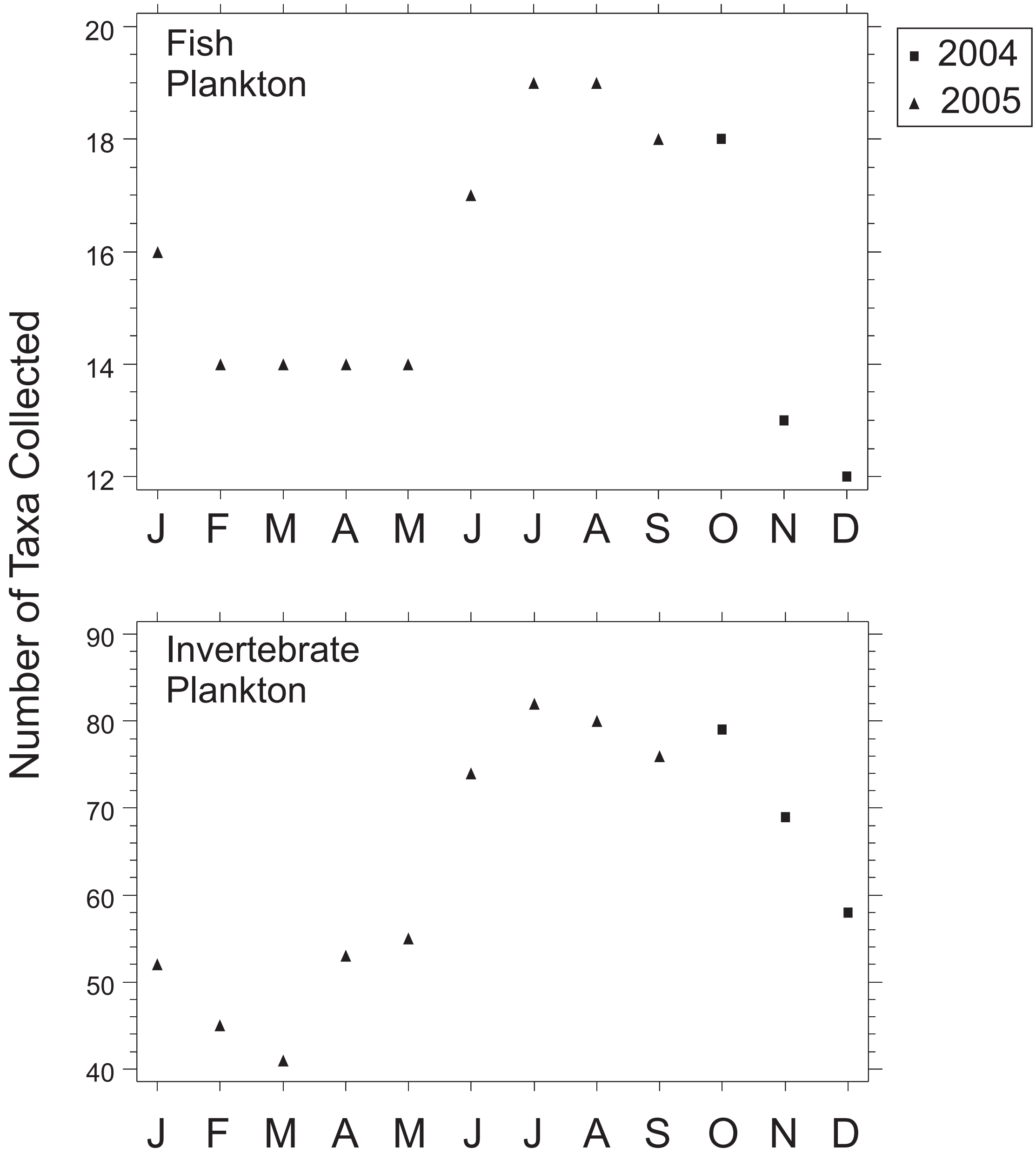


Fig. 3.6.1.1. Number of taxa collected per month by plankton net.

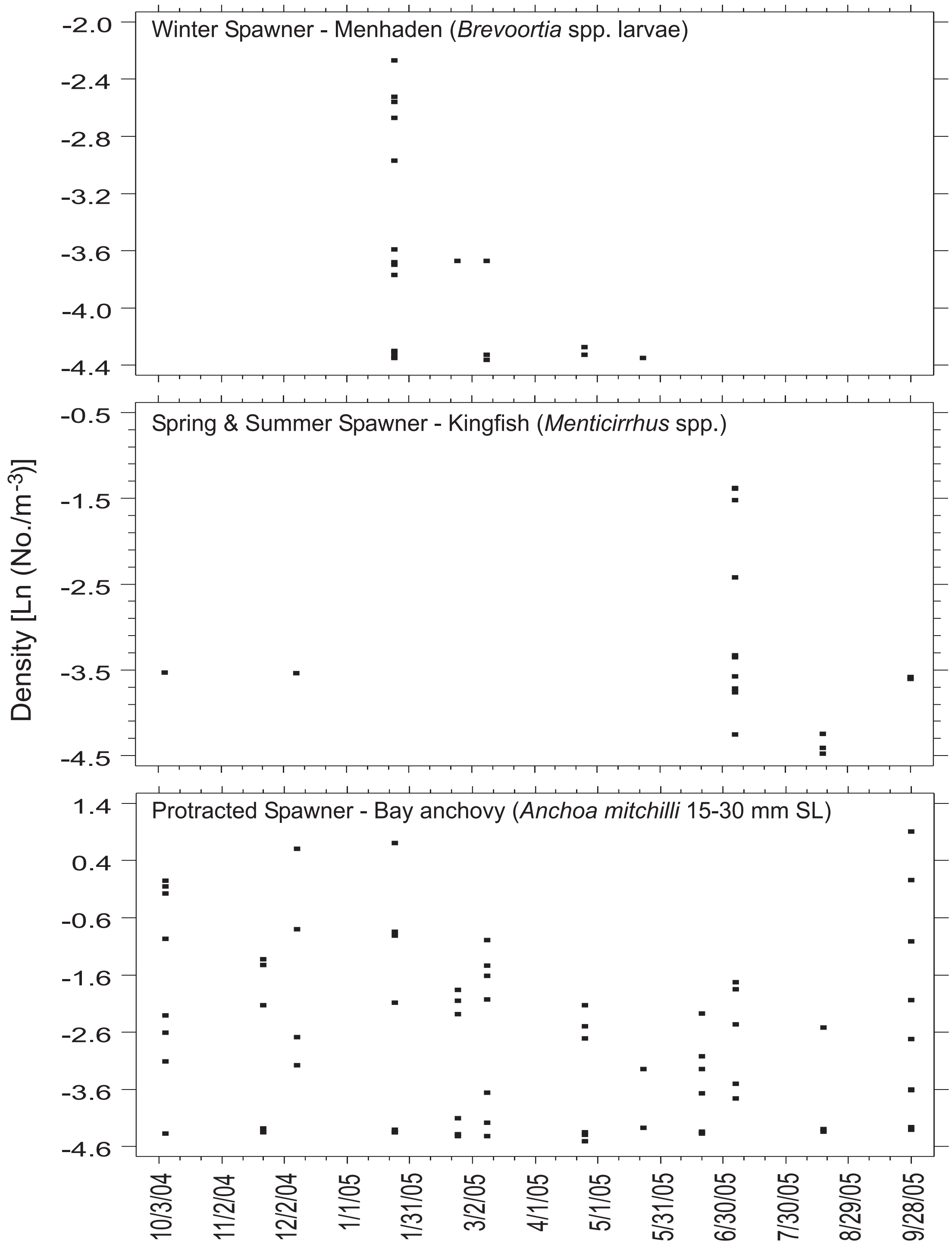


Fig. 3.6.1.2. Examples of species-specific seasonality from plankton-net data.

3.6.2. Seine and Trawl.

Few clear seasonal patterns of taxon richness were evident in the Anclote River estuarine system (Fig. 3.6.2.1), which may be attributed to both the relatively short duration of sampling and the unusual hydrological conditions encountered during the study. Monthly taxon richness in seined areas was quite variable—the longest single period of relatively high richness was from October–December; in deeper (trawled) habitats, the September–February period had greatest taxon richness. Overall abundances and abundances of new recruits of nekton taxa indicate extensive use of the study area during all months (see Appendix C), but temporal resource partitioning among species is evident (i.e., there is a seasonal succession of species that may allow estuaries to annually support a greater abundance of animals than if all species were present simultaneously). Twenty-seven taxa were deemed abundant enough to determine seasonality in either the deeper, trawled habitats or in shallow, seined habitats (i.e., total catch of at least 100 individuals in seined habitats or 50 individuals in trawled habitats and occurrence in ≥3% of samples). If the top months with maximum abundance for each of these taxa are considered (Fig. 3.6.2.2), then peaks for residents occurred throughout the year. Estuarine spawners had peak periods of abundance from fall to spring. Offshore spawners had peaks in abundance that tended to be concentrated from late summer/early fall to spring. Among new recruits (i.e., the smallest two or three 5-mm size classes captured by our gears), peak recruitment periods varied among life-history categories (Fig. 3.6.2.3): of the 16 taxa for which these trends could be judged, offshore spawners tended to recruit in winter, while residents tended to recruit in late summer and fall; there were relatively few data that could be assessed for estuarine spawners.

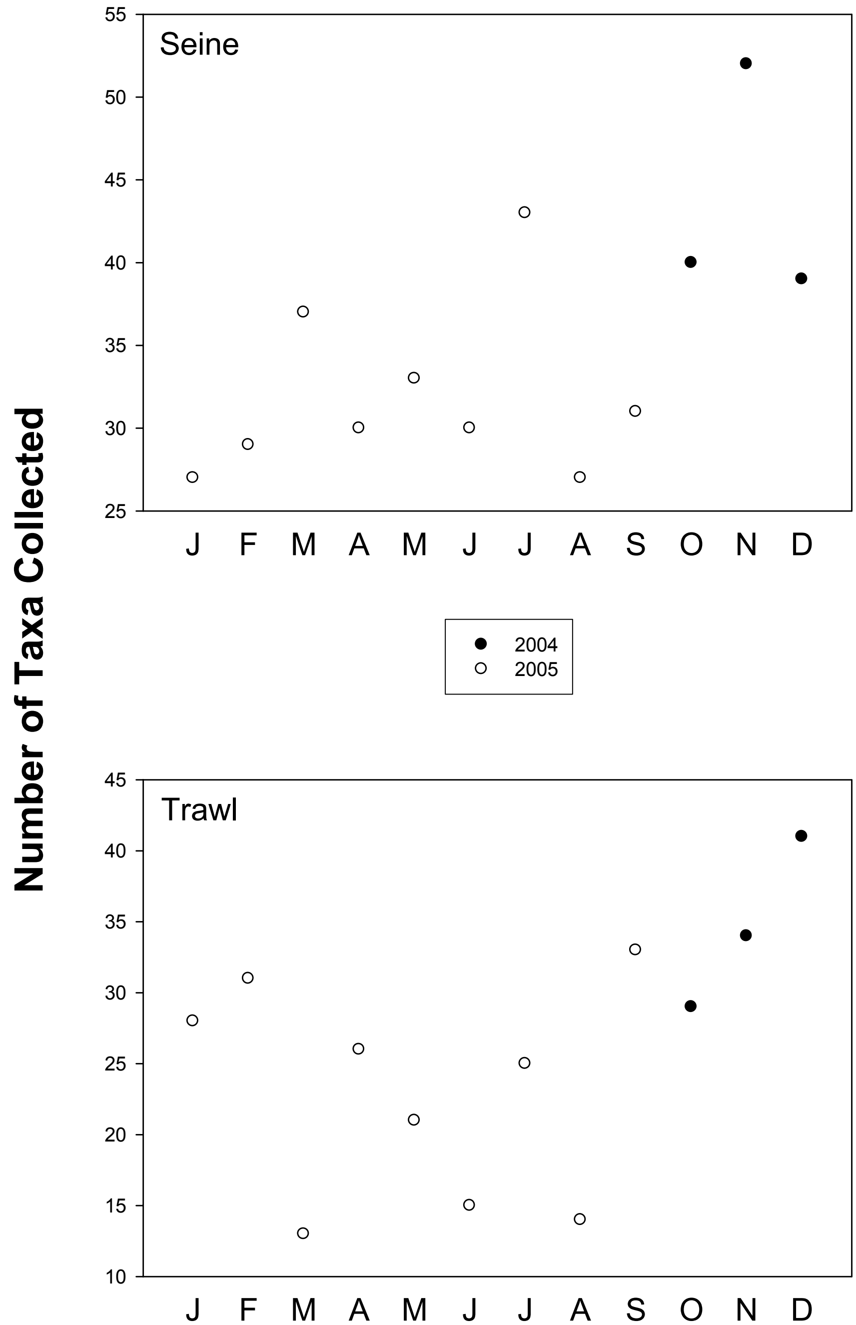


Fig. 3.6.2.1 Number of taxa collected per month by seine and trawl.

	January	February	March	April	May	June	July	August	September	October	November	December
Offshore Spawners												
F. duorarum							S			ST	ST	T
C. sapidus	S		ST	T	T					S		T
E. gula								T	T	S	S	ST
E. harengulus	T					ST	T	S	S			
O. chrysoptera						S	S			T	T	T
L. rhomboides	T	ST	S	S		T						T
L. xanthurus	ST	ST	S		T							
M. cephalus		S	S	S	S							
Total Peaks	**5**	**5**	**5**	**3**	**3**	**4**	**3**	**2**	**2**	**5**	**4**	**6**
Estuarine Spawners												
P. longicaudatus		T		T								
T. carolinense		T		T								
A. mitchilli	T	T		S	S							ST
S. notata						S	S	S				
F. carpio	S	S					S					
S. nephelus			S		ST					S	T	T
Total Peaks	**2**	**4**	**1**	**3**	**3**	**1**	**2**	**1**	**0**	**1**	**1**	**3**
Tidal River Residents												
P. intermedius	ST	S	S	T								
P. pugio	S		S	S								
N. petersoni		S	S									
L. parva	S		S				S					
L. goodei				S			S					S
G. holbrooki		S		S							S	
P. latipinna				S	S							
Menidia spp.			S			S					S	
L. sicculus									S	S	S	
L. macrochirus									S	S	S	
M. gulosus							ST	ST	ST		S	S
Total Peaks	**4**	**3**	**5**	**5**	**1**	**1**	**4**	**2**	**4**	**2**	**5**	**2**

Fig. 3.6.2.2. Top months of relative abundance for all individuals collected in seines (S) and trawls (T).

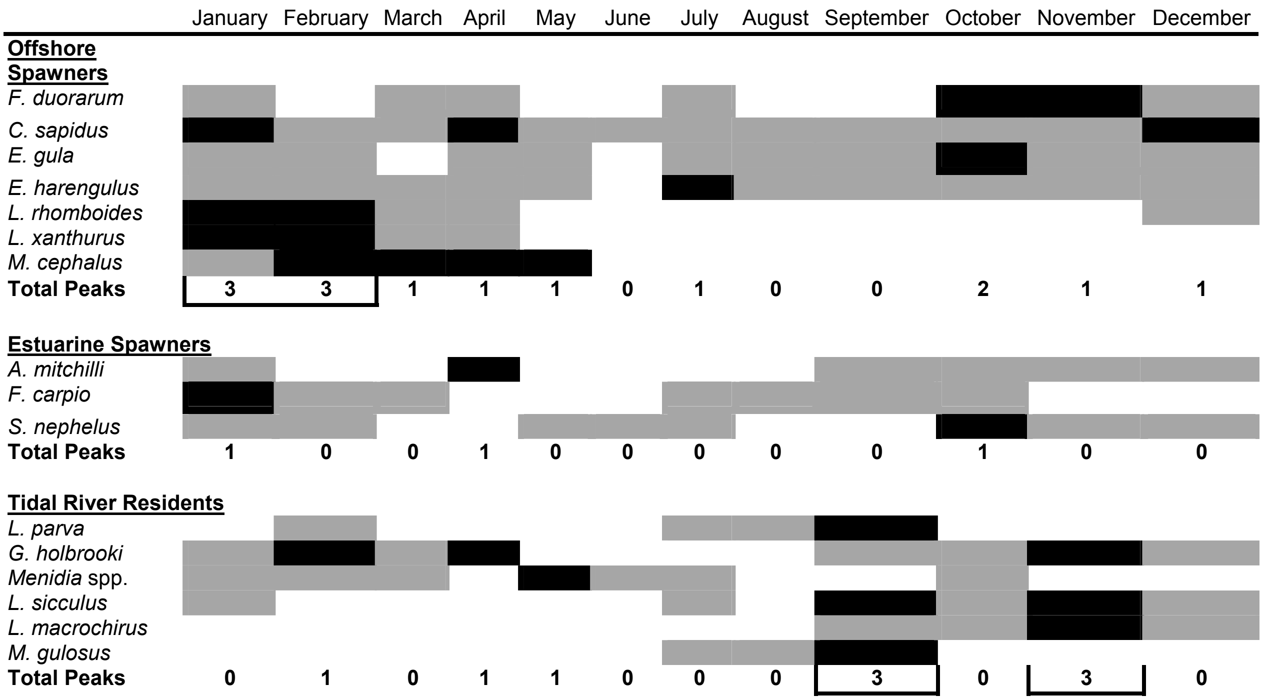


Fig. 3.6.2.3. Months of occurrence (■) and peak abundance (■) for new recruits collected by seine and trawl.

3.7 Distribution (km_u) Responses to Freshwater Inflow

3.7.1 Plankton Net.

Ten (26%) of the 38 plankton-net taxa evaluated for distribution responses to freshwater inflow exhibited significant responses. Nine of these were negative responses, wherein animals moved downstream as inflows increased (Table 3.7.1.1). Downstream movement is the typical inflow response seen in tidal rivers on Florida's west coast. The exception was upstream movement by the copepod *Pseudodiaptomus coronatus*. This relationship had the second lowest fit of the significant relationships and may be spurious. This common species is regarded as being bottom-oriented, which may have made it prone to upstream displacement if freshwater inflow created two-layered circulation in the tidal river (i.e., bottom water moving upstream to replace surface water moving downstream). Overall, time lags for the responses were highly variable, with many occurring within a seasonal time frame.

Table 3.7.1.1. Plankton-net organism distribution (km_U) responses to mean freshwater inflow (Ln *F*), ranked by linear regression slope. Other regression statistics are sample size (*n*), intercept (*Int.*), slope probability (*P*) and fit (adjusted r^2, as %). *D* is the number of daily inflow values used to calculate mean freshwater inflow. None of the time series data appeared to be serially correlated (Durbin-Watson statistic, p>0.05 for all taxa).

Description	***Common Name***	***n***	***Int.***	***Slope***	***P***	***r^2***	***D***
Pseudodiaptomus coronatus	copepod	12	-6.098	2.494	0.0422	35	120
Labidocera aestiva	copepods	12	0.929	-0.346	0.0470	34	120
chaetognaths, sagittid	arrow worms	10	0.859	-0.402	0.0197	43	1
gastropods, opisthobranch	sea slugs	12	5.295	-0.977	0.0065	54	70
Edotea triloba	isopod	12	12.722	-1.233	0.0086	51	61
Anchoa mitchilli juveniles	bay anchovy	11	16.540	-1.684	0.0001	79	7
Americamysis almyra	opossum shrimp, mysid	12	17.034	-1.774	0.0006	70	33
ostracods, podocopid	ostracods, seed shrimps	12	18.472	-2.511	0.0302	39	106
gobiid preflexion larvae	gobies	12	16.838	-2.668	0.0048	65	117
unidentified Americamysis juveniles	opossum shrimps, mysids	12	20.430	-3.050	0.0000	89	31

3.7.2 Seine and Trawl.

The relatively short time series (12 months) did not produce a wide variety of flow conditions over which to assess organism distribution responses. Just over one-half (51%) of the 35 pseudo-species/gear combinations (hereafter simply referred to as 'pseudo-species') evaluated for distributional responses to freshwater inflow exhibited significant response for at least one lagged flow period. For the purposes of this discussion, we refer only to the best models for each of the 18 pseudo-species (i.e., statistically significant [$\alpha<0.05$] models with normally distributed residuals that explain the greatest proportion of the variance [highest r^2 value] for each pseudo-species) (Table 3.7.2.1). Best models are plotted in Appendix G.

The best models were widely dispersed among inflow lag periods (Fig. 3.7.2.1). Inflow lag periods are characterized as either short (0-14 days), medium (21-91 days), or long (98-364 days). Responses to inflow within each life-history category were largely associated with different lag periods: primarily short for residents, medium to long for estuarine spawners, and most commonly long for offshore spawners.

Nearly 90 percent of the significant responses were negative (i.e., animals moved upstream with decreasing freshwater inflow). The strongest negative responses (high adjusted r^2 values) were found in offshore or estuarine spawners (Table 3.7.2.1); this is mostly because these species tended to have fewer regression points to fit (because of relatively short periods of non-zero abundance) and also because there were 13 pseudo-species from these life-history categories and only five tidal-river residents. The pseudo-species' centers of abundance may have shifted downstream during periods of higher inflow because individuals were seeking areas with preferred salinities, although some physical displacement during periods of extremely high flows cannot be discounted for smaller individuals.

Table 3.7.2.1. Best-fit seine and trawl-based pseudo-species distributional response ($\ln(km_U)$) to continuously lagged mean freshwater inflow ($\ln(\text{inflow}+1)$) for the Anclote River estuary. Degrees of freedom (*df*), intercept, slope, probability that the slope is significant (*P*), and fit (Adj-r^2) are provided. The number of days in the continuously-lagged mean inflow is represented by *D*. An "x" in *DW* indicates that the Durbin-Watson statistic was significant ($p<0.05$), a possible indication that serial correlation was present.

Species	***Common name***	***Gear***	***Size***	***Period***	***df***	***Intercept***	***Linear coef.***	***Linear P***	***Adj-r^2***	***DW***	***D***
Callinectes sapidus	Blue crab	seines	<=40	Jan. to Dec.	10	3.0625	-0.2024	0.007	53.39	x	175
Callinectes sapidus	Blue crab	trawls	<=40	Jan. to Dec.	7	3.4489	-0.3119	0.0345	49.47		210
Anchoa mitchilli	Bay anchovy	seines	>=36	Jan. to Dec.	7	0.4259	0.3464	0.0207	55.8		231
Anchoa mitchilli	Bay anchovy	trawls	<=25	Jan. to Dec.	5	3.2308	-0.1549	0.0017	88.29		21
Anchoa mitchilli	Bay anchovy	trawls	26 to 35	Jan. to Dec.	4	3.5286	-0.2338	0.0035	90.54		56
Anchoa mitchilli	Bay anchovy	trawls	>=36	Jan. to Dec.	4	3.6844	-0.3095	0.0007	95.68		42
Lucania parva	Rainwater killifish	seines	All sizes	Jan. to Dec.	7	0.4297	0.3075	0.0199	56.25		1
Floridichthys carpio	Goldspotted killifish	seines	<=30	Jan. to Dec.	6	2.6546	-0.2925	0.0465	51.03		350
Poecilia latipinna	Sailfin molly	seines	All sizes	Jan. to Dec.	6	4.0718	-0.5157	0.0032	78.93		1
Labidesthes sicculus	Brook silverside	seines	All sizes	Jan. to Dec.	9	2.9717	-0.0239	0.0281	43.14		133
Lepomis macrochirus	Bluegill	seines	>=36	Jan. to Dec.	7	3.0245	-0.056	0.0378	48.27		7
Eucinostomus harengulus	Tidewater mojarra	seines	>=40	Jan. to Dec.	10	2.6634	-0.0909	0.0428	34.99		7
Lagodon rhomboides	Pinfish	seines	<=35	Jan. to Dec.	6	3.4185	-0.5518	0.0195	62.53	x	1
Lagodon rhomboides	Pinfish	seines	>=71	Jan. to Dec.	8	1.0585	0.1525	0.0001	86.81	x	70
Lagodon rhomboids	Pinfish	trawls	<=35	Jan. to Dec.	5	3.1391	-0.4951	0.0044	82.82		28
Lagodon rhomboids	Pinfish	trawls	>=71	Jan. to Dec.	8	1.6162	-0.211	0.0487	40.27		161
Mugil cephalus	Striped mullet	seines	<=50	Jan. to Dec.	4	19.1442	-3.2328	0.0468	66.87		357
Microgobius gulosus	Clown goby	seines	All sizes	Jan. to Dec.	10	2.9578	-0.0932	0.0476	33.76	x	1

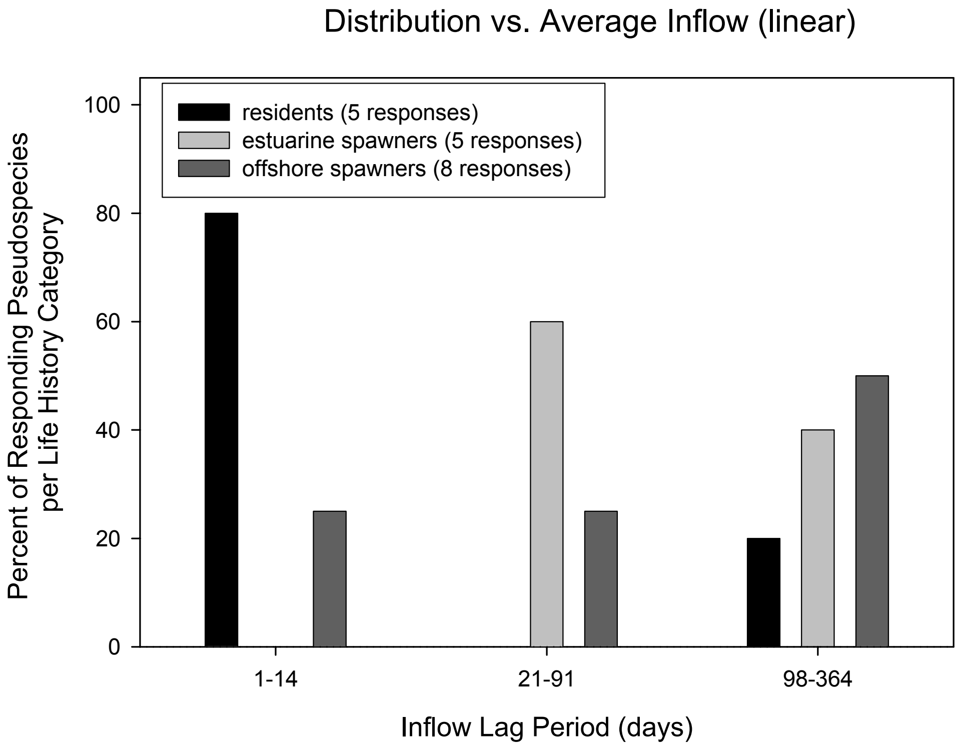


Fig. 3.7.2.1. Summary of linear regression results assessing distribution (km_U) in relation to inflow and lag period.

3.8 Abundance (N, $\bar{N}$) Responses to Freshwater Inflow

3.8.1 Plankton Net.

Sixteen (42%) of the 38 plankton-net taxa evaluated for abundance relationships with freshwater inflow exhibited significant responses (Table 3.8.1.1). All of these were positive responses. Although it is unusual for all of the responses to be positive, there are two conditions that would favor this condition. Negative responses are usually caused by elevated flows washing river-plume taxa away from the river mouth and out of the survey area. In the present case, however, (1) the study area did not experience strongly elevated inflows during the survey, and (2) there were stations in the receiving body of water (the Gulf of Mexico) that could intercept washed-out taxa. In fact, several river-plume species had positive responses, including the ostracod *Sarsiella zostericola*, the copepod *Labidocera aestiva*, postlarvae of the shrimp *Hippolyte* spp., the chaetognaths *Sagitta* spp. and bay anchovy adults, *Anchoa mitchilli*. Organisms that typically congregate within the interiors of tidal rivers also had positive responses, including estuarine mysids (*Americamysis almyra* adults, *Americamysis* juveniles, *Bowmaniella dissimilis*), gammaridean amphipods, bay anchovy juveniles and polychaetes. In general, it could be concluded that these positive results were observed – despite the short duration of the study - because there was substantial variation in inflow and because the survey area was geographically scaled to the spatial range of freshwater influence on distribution (stations were also positioned in the receiving body). Only two of the positive responders, dipteran pupae and chironomid larvae, belong to groups that are primarily freshwater groups.

None of the time lags was short enough to be considered a catchability response (i.e., organisms fleeing the effects of sudden floods and thereby becoming more vulnerable to collection). A few lags were seasonal in nature, but most occurred over time frames that would be expected from true population responses.

Table 3.8.1.1. Plankton-net organism abundance responses to mean freshwater inflow (Ln *F*), ranked by linear regression slope. Other regression statistics are sample size (*n*), intercept (*Int.*), slope probability (*P*) and fit (adjusted r^2, as %). *DW* identifies where serial correlation is possible (x indicates $p<0.05$ for Durbin-Watson statistic). *D* is the number of daily inflow values used to calculate mean freshwater inflow.

Description	***Common Name***	***n***	***Int.***	***Slope***	***P***	***r2***	***DW***	***D***
Sarsiella zostericola	ostracod, seed shrimp	10	5.387	1.723	0.0464	41		31
Americamysis almyra	opossum shrimp, mysid	12	6.512	1.695	0.0010	68		23
dipterans, pupae	flies, mosquitoes	11	4.005	1.218	0.0061	59	x	48
Labidocera aestiva	copepod	12	10.353	1.112	0.0223	42		23
Hippolyte zostericola postlarvae	zostera shrimp	12	10.258	1.048	0.0062	54	x	94
unidentified Americamysis juveniles	opossum shrimps, mysids	12	8.654	0.981	0.0321	38	x	25
branchiurans, Argulus spp.	fish lice	11	7.084	0.933	0.0024	66	x	120
amphipods, gammaridean	amphipods	12	13.942	0.902	0.0004	73		93
Anchoa mitchilli juveniles	bay anchovy	12	7.502	0.826	0.0386	36		120
decapod megalopae	post-zoea crab larvae	10	11.217	0.790	0.0128	56		39
Bowmaniella dissimilis	opossum shrimp, mysid	12	11.164	0.756	0.0070	53		38
amphipods, caprellid	skeleton shrimps	11	9.166	0.737	0.0034	63		94
dipterans, chironomid larvae	midges	12	6.691	0.666	0.0035	59		75
Anchoa mitchilli adults	bay anchovy	11	7.454	0.635	0.0232	45		22
chaetognaths, Sagitta spp.	arrow worms	12	13.114	0.578	0.0196	44		120
polychaetes	sand worms, tube worms	12	11.313	0.539	0.0008	69		93

3.8.2 Seine and Trawl.

As noted for distribution responses to freshwater inflow, the relatively short time series of sampling did not give a wide variety of flows over which to assess abundance responses; results should therefore be interpreted with caution. Among the 38 pseudo-species considered in these analyses, abundances of 60.5% were significantly related to average inflow (Table 3.8.2.1). The greatest proportion of variance in abundance was explained by linear models for 10 pseudo-species and by quadratic models for 13 pseudo-species. Of the 10 linear models, three were negative relationships, indicating increasing abundance with decreasing inflow, and seven were positive relationships, indicating increasing abundance with increasing inflow. Almost half (46.1%) of quadratic models suggested greatest abundance at intermediate inflows ('intermediate-maximum'). Of the remaining quadratic models, three suggested least abundance at intermediate inflow ('intermediate-minimum'), two suggested greatest abundance at higher flow levels, and one indicated greatest abundance at the lower levels of inflow. The percentage of significant abundance responses to inflow ranged from 56% of tested pseudo-species in estuarine spawners to 65% in offshore spawners. Offshore and estuarine spawners tended to exhibit intermediate-maximum or positive responses to inflow, whereas tidal-river residents also showed intermediate-minimum responses to inflow (Fig. 3.8.2.1). All best models are plotted in Appendix I.

The majority of the best-fitting regression models incorporated longer lags for all life history categories, but this trend was most pronounced for estuarine and offshore spawners (Fig. 3.8.2.2). Best models incorporated lagged inflows ranging from 14 to 287 days for residents, 161 to 245 days for estuarine spawners, and 21 to 357 days for offshore spawners.

Potentially spurious regression results (e.g., Figs. I1, I11, and I17) are unlikely to be biologically meaningful and should be interpreted cautiously. The nine strongest abundance-inflow relationships—those where inflow explained a sizeable portion of variance (r^2>~50%) in at least six data points—mostly involved offshore-spawning species but also included some tidal-river residents. Relationships of abundance to flow in these nine pseudo-species were positive (Figs. I2, I14, I15, and I21), intermediate-minimum (Figs. I8 and I18), or intermediate-maximum (Figs. I3, I10, and I20). An increase in abundance with increased flow may suggest beneficial aspects of increased nutrient input, for example, or perhaps better detection of the tidal-river nursery area. Intermediate-minimum relationships, where abundance is greatest at either low or high flows and least at intermediate flows, are difficult to explain in ecological terms. Intermediate-maximum relationships, which are opposite in nature to intermediate-minimum relationships, perhaps indicate differing forces operating at opposite ends of the inflow spectrum. At low flows, opportunities for either chemical detection of tidal nursery habitats or selective tidal-stream transport may be reduced, and at high flows, physical displacement may occur, or perhaps undesirable properties of fresher water (e.g., low pH) become more prominent.

Table 3.8.2.1. Best-fit seine and trawl-based pseudo-species abundance ($\bar{N}$) response to continuously-lagged mean freshwater inflow (ln(cpue) vs. ln(inflow)) for the Anclote River estuary. The type of response is either quadratic (Q) or linear (L). Degrees of freedom (*df*), intercept, slope (*Linear coef.*), probability that the slope is significant (*Linear P*), quadratic coefficient (*Quad. coef.*), probability that the quadratic coefficient is significant (*Quad. P*), and fit (r^2) are provided. The number of days in the continuously-lagged mean inflow is represented by *D*. An "x" in *DW* indicates that the Durbin-Watson statistic was significant (p<0.05), a possible indication that serial correlation was present.

Species	***Common name***	***Gear***	***Size***	***Period***	***Response***	***df***	***Intercept***	***Linear coef.***	***Linear P***	***Quad. Coef.***	***Quad. P***	***Adj-r^2***	***DW***	***D***
Palaemonetes intermedius	Brackish grass shrimp	seines	All sizes	Dec. to Apr.	L	3	1255.1488	-237.06	0.0477	.	.	77.81		273
Palaemonetes pugio	Daggerblade grass shrimp	seines	All sizes	Nov. to May	L	5	-4.0586	2.5999	0.0038	.	.	83.78	x	14
Callinectes sapidus	Blue crab	trawls	<=40	Oct. to May	Q	5	-172.7243	68.192	0.0184	-6.708	0.0185	73.4		259
Anchoa mitchilli	Bay anchovy	seines	26 to 35	Jan. to Dec.	Q	9	-38.9353	19.2345	0.0426	-2.182	0.0449	39.21		231
Anchoa mitchilli	Bay anchovy	seines	>=36	Jan. to Dec.	Q	9	-55.6959	27.2449	0.025	-3.122	0.0247	44.65		245
Anchoa mitchilli	Bay anchovy	trawls	<=25	Jan. to Dec.	L	10	-0.5936	0.1926	0.021	.	.	42.8	x	168
Anchoa mitchilli	Bay anchovy	trawls	>=36	Jan. to Dec.	L	10	-0.7878	0.2504	0.0049	.	.	56.4		161
Lucania parva	Rainwater killifish	seines	All sizes	Jan. to Sep.	Q	6	24.3348	-11.26	0.0093	1.2846	0.0093	70.29		252
Poecilia latipinna	Sailfin molly	seines	All sizes	Jan. to Dec.	Q	9	-17.55	8.7991	0.0335	-1.013	0.0333	41.18		231
Labidesthes	Brook	seines	All	Sep.	Q	7	-5.6869	3.19	0.0087	-0.328	0.0157	78.14		42

Table 3.8.2.1, Page 2 of 2

Species	Common name	Gear	Size	Period	Response	df	Intercept	Linear coef.	Linear P	Quad. Coef.	Quad. P	Adj-r^2	DW	D
sicculus	silverside		sizes	to Jun.										
Lepomis macrochirus	Bluegill	seines	<=35	Sep. to Jan.	Q	2	168.8059	-80.554	0.006	9.2276	0.0059	98.96		287
Eucinostomus gula	Silver jenny	seines	>=40	Jan. to Dec.	L	10	0.2573	0.549	0.0074	.	.	52.79		105
Eucinostomus harengulus	Tidewater mojarra	seines	>=40	Jan. to Dec.	L	10	4.387	-0.3909	0.0407	.	.	35.57		231
Orthopristis chrysoptera	Pigfish	trawls	All sizes	Jan. to Dec.	Q	9	1.0147	-0.5205	0.0093	0.0661	0.0047	80.11		126
Lagodon rhomboides	Pinfish	seines	<=35	Jan. to Jul.	L	5	-5.3375	1.9969	0.0002	.	.	94.54		238
Lagodon rhomboides	Pinfish	seines	36 to 70	Jan. to Dec.	Q	9	17.4419	-6.5555	0.0041	0.6598	0.0076	78.32		126
Lagodon rhomboides	Pinfish	trawls	<=35	Jan. to Jul.	L	5	-221.648	44.0493	0.0097	.	.	76.78		357
Lagodon rhomboides	Pinfish	trawls	36 to 70	Jan. to Dec.	Q	9	15.9777	-7.7155	0.0056	0.907	0.005	62.07	x	217
Leiostomus xanthurus	Spot	seines	<=30	Jan. to Apr.	L	2	-10.7586	3.2392	0.0007	.	.	99.87		189
Leiostomus xanthurus	Spot	seines	>=31	Feb. to Jul.	Q	3	-7.5057	8.0698	0.004	-1.277	0.0033	97.07		21
Leiostomus xanthurus	Spot	trawls	>=31	Feb. to Jul.	Q	3	7.194	-4.4229	0.023	0.6798	0.0136	98.5		161
Microgobius gulosus	Clown goby	seines	All sizes	Jul. to Dec.	L	4	3.0382	-0.4612	0.0471	.	.	66.77		35
Sphoeroides nephelus	Southern puffer	trawls	<=60	Oct. to Jul.	Q	7	-3.2803	1.6067	0.006	-0.181	0.0063	68.8		252

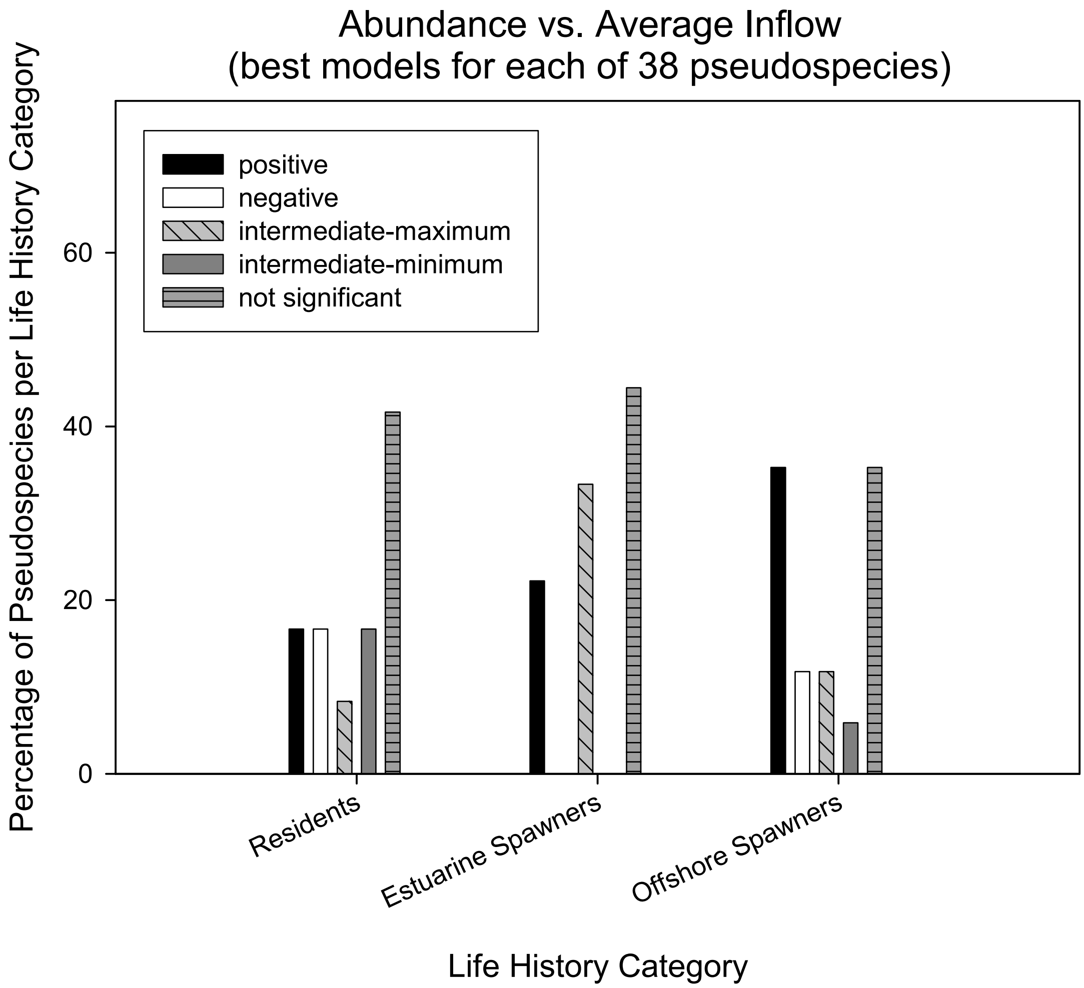


Fig. 3.8.2.1. Summary of regression results assessing abundance ($\bar{N}$) in relation to inflow. Positive and negative indicate increase and decrease in abundance with increasing inflow, respectively, while intermediate indicates maximum or minimum abundance at intermediate inflows.

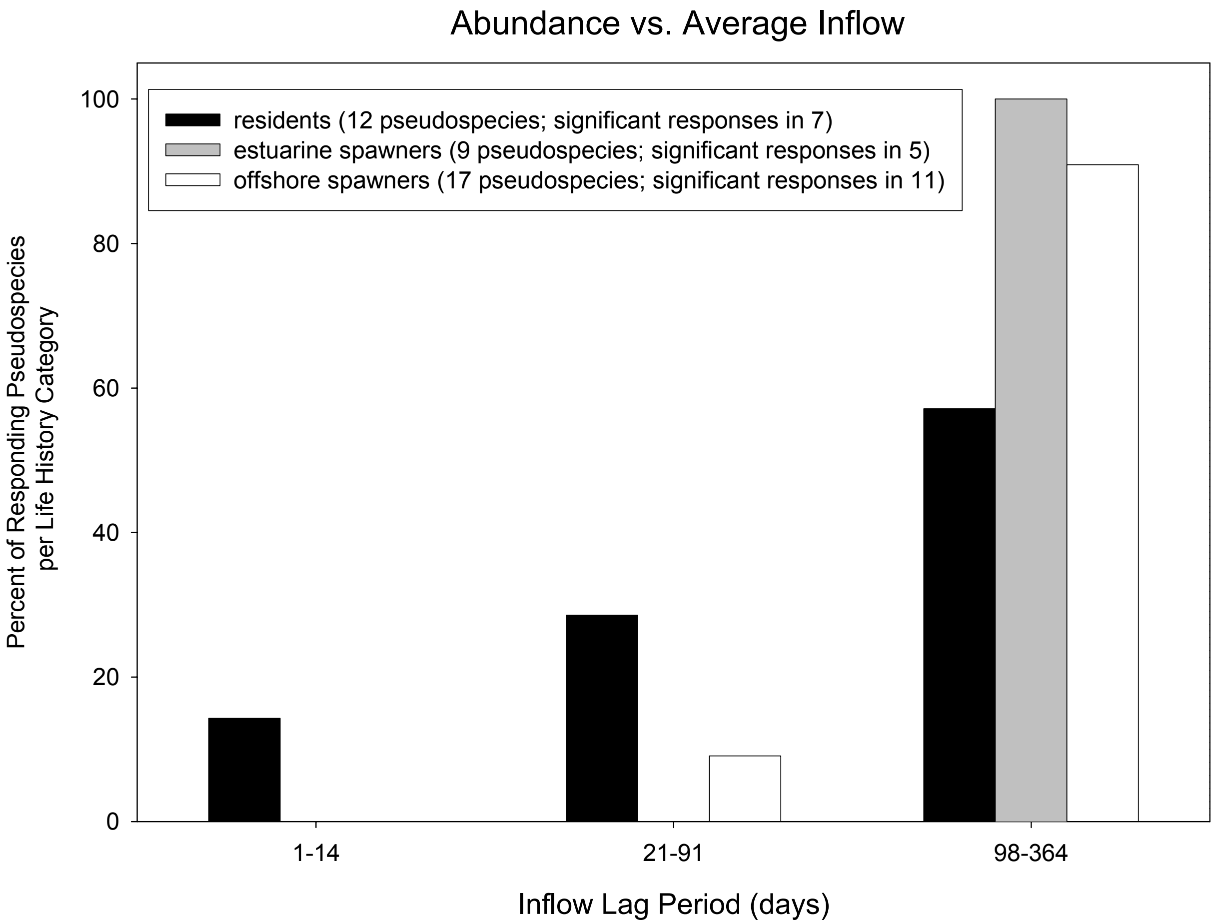


Fig. 3.8.2.2. Summary of regression results assessing abundance ($\bar{N}$) in relation to inflow and lag period.

4.0 CONCLUSIONS

4.1 Descriptive Observations

1.) **Dominant Catch.** Larval gobies and anchovies dominated the planktonic (larval) fish catch. Gobies of the genera *Gobiosoma* and *Microgobius* were dominant in comparable proportions, and the anchovies were dominated by the bay anchovy (*Anchoa mitchilli*). Other abundant larval fishes included silversides (*Menidia* spp.) and skilletfish (*Gobiesox strumosus*). Juvenile spot (*Leiostomus xanthurus*) were abundant in the plankton-net catch relative to other tidal rivers in west-central Florida. Seine fish collections were dominated by spot (*Leiostomus xanuthurus*), pinfish (*Lagodon rhomboides*), bay anchovy (*Anchoa mitchilli*), and eucinostomus mojarras (*Eucinostomus* spp.). Fish collections from deeper, trawled areas were also dominated by pinfish, spot, bay anchovy, and eucinostomus mojarras.

The plankton-net invertebrate catch was dominated by gammaridean amphipods, larval crabs, larval shrimps and by river-plume taxa such as the copepods *Acartia tonsa* and *Labidocera aestiva*, the chaetognaths *Sagitta* spp., the planktonic shrimp *Lucifer faxoni*, and the ostracod *Parasterope pollex*. The strong representation of river-plume taxa occurred because two stations were located in the river plume. Invertebrates collected by seines were dominated by daggerblade grass shrimp (*Palaemonetes pugio*) and brackish grass shrimp (*P. intermedius*); invertebrate trawl catches primarily consisted of arrow shrimp (*Tozeuma carolinense*), brackish grass shrimp, pink shrimp (*Farfantepenaeus duorarum*), and longtail grass shrimp (*Periclimenes longicaudatus*).

2.) **Use of Area as Spawning Habitat.** The eggs of unidentified herrings (clupeids), the bay anchovy (*Anchoa mitchilli*), the striped anchovy (*A. hepsetus*), silversides (*Menidia* spp.) and unidentified sciaenid fishes were collected from the survey area (Table A1). Sciaenid eggs were by far the most abundant egg type, followed by eggs of the bay anchovy – both types were most abundant in the Gulf of Mexico and in the lower part of the tidal river. If it is assumed that the relative abundances of different species of early-stage sciaenid larvae reflect relative spawning intensity, then the kingfishes (*Menticirrhus* spp.) are the sciaenids that are most likely to have spawned in this area. Blennies, the lined sole (*Achirus lineatus*) and the hogchoker (*Trinectes maculatus*) spawned near the river mouth, whereas skilletfish (*Gobiesox strumosus*) and gobies (primarily *Microgobius* spp. and *Gobiosoma* spp., but also *Bathygobius soporator*) may have spawned within the interior of the tidal river. The repeated collection of very small juveniles of live-bearing Gulf pipefish (*Syngnathus scovelli*) within the interior of the tidal river suggests that this species is also reproducing within the local area.

3.) **Use of Area as Nursery Habitat.** The number of estuary-dependent taxa using the study area as a nursery is somewhat greater than resident taxa: overall, six of the ten most abundant taxa in deeper habitats and seven of the ten most abundant taxa in nearshore habitats can be considered estuary-dependent. There are considerable differences in abundance: estuary-dependents constituted nearly 86% of the total abundance of the top ten most abundant taxa in seined areas, and over 83% of total abundance of top ten taxa in trawled areas. These dependents were mostly offshore spawners and included taxa of commercial importance (i.e., pink shrimp) and taxa of ecological importance due to high abundance (i.e., spot, pinfish, eucinostomus mojarras, tidewater mojarra, and silver jenny). The juvenile nursery habitats for selected species were characterized from seine and trawl data in terms of preference for shallower or deeper areas, zone of the study area, type of shoreline, and salinity (Appendices D and E). Distribution of fishes within the Anclote River Estuary as determined from this study compares very well with distributions noted in the same estuary by Szedlmayer (1991). The studies differ in that Szedlmayer (1991) observed dominance of the nearshore fish assemblages by residents (primarily silversides, which constituted nearly 80% of total catch), whereas we noted greater abundance of transient, estuary-dependent species.

4.) **Plankton Catch Seasonality.** Alteration of flows would appear to have the lowest potential for impacting many taxa during the period from December through March, which is the period when the fewest estuarine taxa were present. The highest potential to impact many species would appear to be from June through October. Some species were present throughout the year, whereas others had more seasonal spawning and recruitment patterns.

5.) **Seine and Trawl Catch Seasonality.** Based on seine or trawl collections, there were few clear seasonal patterns of taxon richness in the Anclote River estuarine system, undoubtedly due to the relatively short duration of sampling and the unusual hydrological conditions encountered. Monthly taxon richness in seined areas was quite variable—the longest single period of relatively high richness was from October–December; in deeper (trawled) habitats, the September–February period had greatest taxon richness. Overall abundances and abundances of newly recruiting nekton taxa indicate extensive use of the study area during all months, however. Thus, we tentatively conclude that the period from October to February appears to have the greatest potential for negative effects of anthropogenic change to the tidal river inflow, at least in terms of impacting the most species. There is no time of the year when inflow reduction would not have the potential to affect economically or ecologically important taxa, however.

4.2 Responses to Freshwater Inflow

1.) **Plankton Catch Distribution Responses.** Ten (26%) of the 38 plankton-net taxa evaluated for distribution responses to freshwater inflow exhibited significant responses. Nine of these were negative responses, wherein animals moved downstream as inflows increased. Downstream movement is the typical inflow response seen in tidal rivers on Florida's west coast. Overall, time lags for the responses were highly variable, with many occurring within a seasonal time frame.

2.) **Seine and Trawl Catch Distribution Responses.** The relatively short time series (12 months) did not produce a wide variety of flow conditions over which to assess organism distribution responses. Just over one-half (51%) of the

35 pseudo-species/gear combinations (hereafter simply referred to as 'pseudo-species') evaluated for distributional responses to freshwater inflow exhibited significant response for at least one lagged flow period. The best-fitting models were widely dispersed among inflow lag periods. Responses to inflow within each life-history category were largely associated with different lag periods: short (0–14 days) for residents, medium (21–91 days) to long (98–364 days) for estuarine spawners, and long (98–364 days) for offshore spawners. The great majority of the best models that included long lag periods involved offshore spawners. Ninety-four percent of the significant responses were negative (i.e., animals moved upstream with decreasing freshwater inflow). The pseudo-species' centers of abundance may have shifted downstream during periods of higher inflow because individuals were seeking areas with more suitable salinities, although some physical displacement during periods of extremely high flows cannot be discounted for smaller individuals.

3.) **Plankton Catch Abundance Responses.** Sixteen (42%) of the 38 plankton-net taxa evaluated for abundance relationships with freshwater inflow exhibited significant responses. All of these were positive responses. Several river-plume species had positive responses, including the ostracod *Sarsiella zostericola*, the copepod *Labidocera aestiva*, postlarvae of the shrimp *Hippolyte* spp., the chaetognaths *Sagitta* spp. and bay anchovy adults, *Anchoa mitchilli*. Organisms that typically congregate within the interiors of tidal rivers also had positive responses, including estuarine mysids (*Americamysis almyra* adults, *Americamysis* juveniles, *Bowmaniella dissimilis*), gammaridean amphipods, bay anchovy juveniles and polychaetes. Only two of the positive responders, dipteran pupae and chironomid larvae, belong to groups that are primarily freshwater groups. None of the time lags was short enough to be considered a catchability response (i.e., organisms fleeing the effects of sudden floods and thereby becoming more vulnerable to collection). A few lags were seasonal in nature, but most occurred over time frames that would be expected from true population responses.

4.) **Seine and Trawl Catch Abundance Responses.** As noted for distribution responses to freshwater inflow, the relatively short time series of sampling did not give a wide variety of flows over which to assess abundance responses; results should therefore be interpreted with caution. Offshore and estuarine spawners tended to exhibit intermediate-maximum or positive responses to inflow, whereas tidal-river residents also showed intermediate-minimum responses to inflow. The majority of the best-fitting regression models incorporated longer lags for all life history categories, but this trend was most pronounced for estuarine and offshore spawners. An increase in abundance with increased flow may suggest beneficial aspects of increased nutrient input, for example, or perhaps better detection of the tidal-river nursery area. Intermediate-minimum relationships, where abundance is greatest at either low or high flows and least at intermediate flows, are difficult to explain in ecological terms. Intermediate-maximum relationships, which are opposite in nature to intermediate-minimum relationships, perhaps indicate differing forces operating at opposite ends of the inflow spectrum. At low flows, opportunities for either chemical detection of tidal nursery habitats or selective tidal-stream transport may be reduced, and at high flows, physical displacement may occur, or perhaps undesirable properties of fresher water (e.g., low pH) become more prominent.

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Appendix A:

Plankton data summary tables

Table A1, page 1 of 5.

Plankton-net catch statistics (October 2004 through September 2005, n=144 samples)

Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	*Kmu* (km)	*Su* (psu)	Mean CPUE (No./10^3 m^3)	Max CPUE (No./10^3 m^3)
foraminiferans	foraminiferans	42	13	0.4	29.1	4.21	232.77
Liriope tetraphylla	hydromedusa	11	4	2.7	27.2	1.21	88.39
Clytia sp.	hydromedusa	462	19	11.2	12.3	39.80	2435.29
medusa sp. a	hydromedusa	166	6	7.7	7.3	15.73	1453.15
medusa sp. c	hydromedusa	17	5	1.5	27.9	1.87	88.39
medusa sp. d	hydromedusa	16	3	4.1	17.9	1.69	116.63
medusa sp. e	hydromedusa	43	7	7.1	14.0	4.00	240.32
medusa, Bougainvillia sp.	hydromedusa	12	7	0.7	27.0	1.03	71.35
medusa, Obelia sp.	hydromedusa	5	3	-0.8	32.2	0.47	28.61
Mnemiopsis mccradyi	comb jelly, ctenophore	79	5	9.5	16.8	7.06	421.96
Beroe ovata	sea walnut, ctenophore	1	1	4.5	21.2	0.09	12.84
turbellarians	flatworms	8	5	2.3	23.2	0.77	27.70
nemerteans	ribbon worms	2	2	14.2	2.1	0.18	13.72
nematodes	roundworms, threadworms	114	28	2.4	24.6	10.87	197.58
polychaetes	sand worms, tube worms	2,541	115	8.3	12.4	243.99	13701.21
oligochaetes	freshwater worms	65	16	12.1	3.9	5.50	328.89
hirudinoideans	leeches	5	4	10.1	4.1	0.47	29.97
Simocephalus vetulus	water flea	1,363	17	14.2	0.3	119.32	9473.81
Grimaldina brazzai	water flea	1	1	12.3	0.1	0.08	12.18
Ilyocryptus sp.	water flea	157	6	13.1	0.1	13.74	1177.01
Sida crystallina	water flea	5	5	11.2	4.6	0.44	13.02
Latona setifera	water flea	9	2	15.1	0.1	0.82	106.37
Penilia avirostris	water flea	30	6	1.7	25.8	2.82	153.65
Latonopsis fasciculata	water flea	46	5	13.4	0.2	4.12	399.75
Euryalona occidentalis	water flea	8	2	14.6	0.1	0.70	74.30
Leydigia sp.	water flea	2	2	12.8	0.2	0.18	14.10
Evadne tergestina	water flea	16	3	-0.1	28.3	1.46	125.71
decapod zoeae	crab larvae	129,227	135	3.3	22.4	11748.57	84175.05
decapod mysis	shrimp larvae	33,773	132	8.7	10.7	3132.71	64863.87
decapod megalopae	post-zoea crab larvae	2,944	82	0.7	24.5	280.98	5005.17
shrimps, unidentified postlarvae	shrimps	16	4	-0.4	29.6	1.72	139.33
penaeid postlarvae	penaeid shrimps	3	1	-1.0	29.0	0.25	35.68
penaeid metamorphs	penaeid shrimps	75	18	0.3	25.0	8.45	436.69
Farfantepenaeus duorarum juveniles	pink shrimp	17	10	1.6	21.5	1.73	63.17
Lucifer faxoni mysis	shrimp	78	8	-0.3	29.5	8.64	487.98
Lucifer faxoni juveniles and adults	shrimp	7,921	62	1.1	22.9	728.90	24712.61
Palaemon floridanus adults	Florida grass shrimp	1	1	-1.8	22.4	0.09	12.67
Palaemonetes spp. postlarvae	grass shrimp	201	41	2.5	23.4	19.24	231.34
Palaemonetes pugio juveniles	daggerblade grass shrimp	31	18	9.8	11.5	2.85	132.29
Palaemonetes pugio adults	daggerblade grass shrimp	5	4	6.5	18.9	0.44	26.69
Palaemonetes vulgaris adults	grass shrimp	1	1	-1.0	29.8	0.10	15.07
Periclimenes longicaudatus juveniles	longtail grass shrimp	27	11	0.3	27.9	2.79	94.45
alphaeid postlarvae	snapping shrimps	217	26	0.2	25.8	22.73	769.41
alphaeid juveniles	snapping shrimps	3	3	3.3	18.2	0.28	14.18
Alpheus viridari juveniles	snapping shrimp	1	1	-1.8	24.8	0.08	11.07
Hippolyte zostericola postlarvae	zostera shrimp	5,038	66	-0.4	28.6	501.53	8900.17
Hippolyte zostericola juveniles	zostera shrimp	143	29	1.0	26.9	14.68	795.51
Hippolyte zostericola adults	zostera shrimp	9	4	1.9	24.0	0.84	53.04
Thor sp. juveniles	shrimp	1	1	1.7	20.0	0.10	14.85
Latreutes parvulus postlarvae	sargassum shrimp	2	1	-1.8	24.8	0.15	22.14
Tozeuma carolinense postlarvae	arrow shrimp	7	2	-1.2	26.0	0.69	73.82
Tozeuma carolinense juveniles	arrow shrimp	253	14	-1.2	32.1	25.73	2255.52
Tozeuma carolinense adults	arrow shrimp	85	6	-1.2	30.0	10.76	935.77
processid postlarvae	night shrimps	147	18	-0.5	30.8	13.98	534.96
Ambidexter symmetricus postlarvae	shrimp	122	12	0.2	23.9	12.76	400.93
Ambidexter symmetricus juveniles	shrimp	26	9	0.1	28.6	2.60	133.63
Callianassa spp. juveniles	ghost shrimps	1	1	8.9	0.4	0.09	12.90
Upogebia spp. postlarvae	mud shrimps	21	7	-0.5	26.0	2.01	118.12
Upogebia spp. juveniles	mud shrimps	26	11	4.8	18.1	2.38	65.65
paguroid megalops larvae	hermit crabs	36	4	-0.6	28.8	3.67	191.53
paguroid juveniles	hermit crabs	828	24	-1.1	30.6	72.65	3289.10

Table A1, page 2 of 5.

Plankton-net catch statistics (October 2004 through September 2005, n=144 samples)

Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	*Kmu* (km)	*Su* (psu)	Mean CPUE (No./10^3 m^3)	Max CPUE (No./10^3 m^3)
Callinectes sapidus juveniles	blue crab	146	29	4.7	17.4	14.16	468.55
Callinectes sapidus adults	blue crab	1	1	0.3	26.9	0.10	13.68
Portunus sp. juveniles	swimming crab	9	5	1.5	22.6	0.95	59.40
Pinnixa sp. a juveniles	pea crab	4	1	1.7	20.0	0.41	59.40
Pinnixa sayana juveniles	pea crab	2	2	-1.0	28.8	0.18	14.30
unidentified Americamysis juveniles	opossum shrimps, mysids	3,384	82	8.8	8.6	313.24	8649.70
Americamysis almyra	opossum shrimp, mysid	8,024	88	8.8	8.4	738.69	23200.90
Americamysis bahia	opossum shrimp, mysid	1	1	1.7	21.5	0.08	11.63
Americamysis stucki	opossum shrimp, mysid	220	15	0.4	26.4	21.93	826.81
Bowmaniella dissimilis	opossum shrimp, mysid	7,303	114	7.4	12.6	677.67	14156.79
Mysidopsis mortenseni	opossum shrimp, mysid	2	1	1.7	26.6	0.17	24.22
Taphromysis bowmani	opossum shrimp, mysid	403	48	10.2	10.3	36.68	1047.62
cumaceans	cumaceans	6,421	107	4.1	23.3	591.81	14862.52
Sinelobus stanfordi	tanaid	36	18	10.8	7.4	3.20	64.48
Apseudes sp.	tanaid	28	10	3.5	23.7	2.72	103.93
Hargeria rapax	tanaid	325	50	4.1	21.2	30.07	429.02
Cyathura polita	isopod	27	13	6.2	12.8	2.57	84.87
Xenanthura brevitelson	isopod	29	13	4.2	20.1	2.67	73.44
Munna reynoldsi	isopod	655	22	14.8	0.7	64.17	7442.85
Anopsilana jonesi	isopod	2	2	7.9	4.2	0.18	13.79
cymothoid sp. a (Lironeca) juveniles	isopod	94	44	4.5	19.7	8.50	113.41
Cassidinidea ovalis	isopod	27	17	6.6	17.5	2.46	65.65
Harrieta faxoni	isopod	202	29	0.9	29.4	19.22	696.66
Sphaeroma quadridentata	isopod	20	9	2.8	21.5	1.92	89.08
Sphaeroma terebrans	isopod	228	30	12.7	4.3	20.74	705.06
Sphaeroma walkeri	isopod	1	1	4.5	21.7	0.09	12.33
Edotea triloba	isopod	2,719	82	7.3	7.3	233.83	17139.52
Erichsonella attenuata	isopod	104	28	2.6	26.3	9.72	375.03
Erichsonella filiforme	isopod	1	1	-1.0	24.6	0.08	11.80
amphipods, gammaridean	amphipods	235,817	143	5.4	17.5	22386.56	552672.94
amphipods, caprellid	skeleton shrimps	295	53	1.0	27.1	28.87	393.53
cirriped nauplius stage	barnacles	76	13	-0.4	26.7	8.61	583.15
branchiurans, Argulus spp.	fish lice	136	39	0.5	25.6	13.85	316.57
Alteutha sp.	copepod	1	1	6.0	23.6	0.10	13.81
unidentified harpacticoids	copepods	272	42	0.7	27.5	26.81	506.30
siphonostomatids	parasitic copepods	198	31	0.4	29.1	18.76	528.08
Monstrilla sp.	copepod	5	3	0.0	30.7	0.50	30.33
Macrocyclops albidus	copepods	29	13	13.6	1.0	2.58	75.94
Mesocyclops edax	copepod	40	14	13.3	1.4	3.58	111.46
Oithona spp.	copepods	32	5	-1.2	25.3	3.29	236.23
Orthocyclops modestus	copepod	12	9	13.3	1.0	1.05	25.44
Saphirella spp.	copepods	36	16	10.7	6.2	3.33	104.91
paracalanids	copepods	21	4	-0.4	25.5	1.94	135.84
Acartia tonsa	copepod	27,575	96	-0.6	28.4	2630.40	40528.43
Calanopia americana	copepod	854	28	0.9	29.2	83.83	2358.40
Centropages hamatus	copepod	17	8	-0.2	22.4	1.47	62.95
Centropages velificatus	copepod	93	18	0.9	27.8	9.07	214.06
Diaptomus spp.	copepods	2	2	11.1	2.4	0.20	14.99
Eucalanus sp.	copepod	3	2	1.8	25.7	0.27	28.02
Eurytemora affinis	copepod	8	6	14.3	1.5	0.72	38.20
Labidocera aestiva	copepod	6,070	78	-0.1	25.8	567.39	16639.60
Osphranticum labronectum	copepod	2	1	12.3	5.4	0.17	24.74
Pseudodiaptomus coronatus	copepod	153	38	3.4	20.6	14.68	920.65
Temora turbinata	copepod	88	18	-0.2	27.2	8.45	293.33
myodocopod sp. a	ostracod, seed shrimp	22	7	-1.0	26.9	2.25	118.12
Euconchoecia chierchiae	ostracod, seed shrimp	1	1	1.7	25.2	0.09	13.26
Sarsiella zostericola	ostracod, seed shrimp	155	31	1.5	28.6	14.44	495.58
Parasterope pollex	ostracod, seed shrimp	2,689	62	1.0	26.9	246.81	6055.12
ostracods, podocopid	ostracods, seed shrimps	97	34	7.8	14.1	8.83	173.50
collembolas, podurid	springtails	3	3	12.6	1.8	0.27	13.02
ephemeropteran larvae	mayflies	67	12	13.7	0.7	6.10	172.85

Table A1, page 3 of 5.

Plankton-net catch statistics (October 2004 through September 2005, n=144 samples)

Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	*Kmu* (km)	*Su* (psu)	Mean CPUE (No./10^3 m^3)	Max CPUE (No./10^3 m^3)
odonates, anisopteran larvae	dragonflies	1	1	15.1	0.1	0.09	12.38
odonates, zygopteran larvae	damselflies	9	4	12.0	2.5	0.82	49.48
hemipterans, corixid adults	water boatmen	1	1	13.3	0.1	0.09	12.66
hemipterans, gerrid adults	water striders	2	1	15.1	0.2	0.20	28.90
coleopterans, curculionid adults	beetles	1	1	15.1	0.3	0.10	14.10
coleopterans, elmid larvae	riffle beetles	2	1	15.1	3.0	0.18	26.45
coleopterans, elmid adults	riffle beetles	6	2	11.2	0.2	0.53	49.83
coleopterans, gyrinid larvae	whirligig beetles	2	1	15.1	0.1	0.18	25.44
coleopterans, dytiscid adults	predaceous diving beetles	1	1	6.0	22.0	0.10	14.38
dipterans, pupae	flies, mosquitoes	393	32	13.6	1.2	35.27	804.96
dipterans, ceratopogonid larvae	biting midges	4	3	13.3	2.7	0.35	24.74
dipteran, Chaoborus punctipennis larvae	phantom midge	105	18	11.1	3.3	9.16	298.96
dipterans, chironomid larvae	midges	425	43	13.4	3.2	38.49	1005.08
dipterans, sciomyzid larvae	marsh flies	1	1	15.1	3.0	0.09	13.22
trichopteran larvae	caddisflies	22	8	14.2	0.2	1.99	72.26
pycnogonids	sea spiders	534	16	3.0	28.6	50.41	3308.33
Limulus polyphemus larvae	horsehoe crab	116	17	4.7	25.0	11.38	576.74
acari	water mites	36	12	12.5	3.3	3.24	193.52
gastropods, prosobranch	snails	1,066	80	3.8	21.3	103.59	3599.00
gastropods, opisthobranch	sea slugs	120	39	2.2	23.5	11.08	311.46
pelecypods	clams, mussels, oysters	881	67	6.0	17.8	84.01	3918.66
ophiopluteus larvae	brittlestars	12	2	-1.6	29.5	1.07	109.23
ophiuroidean juveniles	brittlestars	10	5	-0.9	30.1	1.00	53.72
brachiopod, Glottidia pyramidata larvae	lamp shell	18	6	-0.2	27.1	1.77	59.40
chaetognaths, sagittid	arrow worms	9,752	95	-0.0	27.3	922.84	18088.49
ascidiacean larvae	tunicate larvae	2	2	-1.8	32.4	0.18	14.46
appendicularian, Oikopleura dioica	larvacean	9,055	33	-0.7	30.0	890.56	36804.95
Branchiostoma floridae	lancelet	2	1	0.3	29.2	0.21	29.70
Elops saurus postflexion larvae	ladyfish	28	15	6.0	17.0	2.51	79.11
Elops saurus juveniles	ladyfish	1	1	10.1	11.0	0.10	13.85
Myrophis punctatus postflexion larvae	speckled worm eel	21	2	-1.1	21.9	1.70	219.56
Myrophis punctatus metamorphs	speckled worm eel	2	2	-1.4	22.2	0.17	12.67
Myrophis punctatus juveniles	speckled worm eel	8	4	4.3	21.0	0.70	51.37
clupeid eggs	herrings	14	4	-1.6	28.0	1.23	74.80
clupeid preflexion larvae	herrings	20	3	-1.6	29.7	1.82	192.92
Brevoortia spp. flexion larvae	menhaden	2	1	-1.0	21.9	0.16	23.11
Brevoortia spp. postflexion larvae	menhaden	42	13	9.0	12.5	3.74	103.48
Brevoortia spp. metamorphs	menhaden	8	7	6.9	14.0	0.72	25.18
Harengula jaguana postflexion larvae	scaled sardine	96	5	2.4	19.2	8.22	547.24
Harengula jaguana metamorphs	scaled sardine	1	1	2.9	17.6	0.09	12.73
Opisthonema oglinum juveniles	Atlantic thread herring	1	1	1.7	20.0	0.10	14.85
Anchoa spp. preflexion larvae	anchovies	133	25	1.1	24.0	12.16	356.77
Anchoa spp. flexion larvae	anchovies	103	15	1.4	22.3	9.32	244.33
Anchoa spp. juveniles	anchovies	1	1	4.5	14.1	0.10	14.09
Anchoa hepsetus eggs	striped anchovy	1	1	0.3	24.3	0.08	11.74
Anchoa mitchilli eggs	bay anchovy	465	13	0.4	27.5	41.03	4864.68
Anchoa mitchilli postflexion larvae	bay anchovy	92	27	4.0	16.0	8.62	190.35
Anchoa mitchilli juveniles	bay anchovy	1,246	68	11.0	7.0	113.03	2470.17
Anchoa mitchilli adults	bay anchovy	101	39	6.8	12.3	9.12	149.86
Notemigonus crysoleucas flexion larvae	golden shiner	1	1	10.1	1.4	0.09	13.35
Synodus foetens juveniles	inshore lizardfish	3	3	1.1	21.1	0.26	14.64
Gobiesox strumosus preflexion larvae	skilletfish	138	39	7.1	18.9	12.41	231.78
Gobiesox strumosus flexion larvae	skilletfish	15	6	8.9	18.4	1.37	91.91
Lucania parva postflexion larvae	rainwater killifish	1	1	10.1	0.9	0.10	14.99
Lucania parva adults	rainwater killifish	1	1	2.9	17.6	0.09	12.73
Gambusia holbrooki juveniles	eastern mosquitofish	2	1	13.3	0.1	0.18	25.31
Heterandria formosa juveniles	least killifish	1	1	15.1	0.1	0.09	12.72
Menidia spp. eggs	silversides	1	1	-1.0	32.6	0.09	13.54
Menidia spp. preflexion larvae	silversides	149	39	10.0	11.3	12.90	320.41
Menidia spp. flexion larvae	silversides	8	5	6.5	15.2	0.71	26.70
Menidia spp. postflexion larvae	silversides	1	1	4.5	26.3	0.09	13.51

Table A1, page 4 of 5.

Plankton-net catch statistics (October 2004 through September 2005, n=144 samples)

Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	*Kmu* (km)	*Su* (psu)	Mean CPUE (No./10^3 m^3)	Max CPUE (No./10^3 m^3)
Menidia spp. juveniles	silversides	6	5	14.5	1.5	0.55	26.59
Menidia spp. adults	silversides	1	1	15.1	4.0	0.10	13.72
Membras martinica preflexion larvae	rough silverside	7	5	3.0	24.4	0.54	24.70
fish eggs, percomorph	sciaenid eggs (primarily)	19,995	46	0.8	26.8	1854.32	47274.78
Hippocampus erectus juveniles	lined seahorse	1	1	-1.0	29.8	0.10	15.07
Hippocampus erectus adults	lined seahorse	1	1	-1.8	25.3	0.12	16.66
Hippocampus zosterae juveniles	dwarf seahorse	1	1	-1.8	25.3	0.12	16.66
Syngnathus floridae juveniles	dusky pipefish	7	6	2.7	23.4	0.66	28.92
Syngnathus floridae adults	dusky pipefish	1	1	-1.8	33.0	0.10	14.46
Syngnathus louisianae juveniles	chain pipefish	3	1	-1.8	30.1	0.43	62.38
Syngnathus scovelli juveniles	gulf pipefish	15	8	2.9	22.5	1.49	73.44
Prionotus spp. preflexion larvae	searobins	1	1	-1.0	32.6	0.09	13.54
Prionotus tribulus juveniles	bighead searobin	2	2	6.5	17.5	0.19	13.54
Lepomis spp. flexion larvae	sunfishes	1	1	15.1	0.1	0.09	13.30
Oligoplites saurus preflexion larvae	leatherjack	3	2	0.5	25.0	0.25	23.27
Oligoplites saurus flexion larvae	leatherjack	1	1	1.7	21.5	0.08	11.63
Oligoplites saurus postflexion larvae	leatherjack	1	1	1.7	27.0	0.10	14.29
Oligoplites saurus juveniles	leatherjack	1	1	8.9	10.6	0.09	12.95
gerreid preflexion larvae	mojjaras	2	1	4.5	20.0	0.20	29.38
Eucinostomus spp. postflexion larvae	mojarras	29	9	4.6	22.0	2.82	144.19
Eucinostomus spp. juveniles	mojarras	43	8	5.1	10.7	4.17	164.29
Orthopristis chrysoptera flexion larvae	pigfish	1	1	4.5	19.8	0.09	13.19
Orthopristis chrysoptera postflexion larvae	pigfish	1	1	-1.8	27.0	0.09	12.47
Orthopristis chrysoptera juveniles	pigfish	3	1	-1.0	21.9	0.24	34.67
Archosargus probatocephalus postflexion larva	sheepshead	2	1	-1.8	27.0	0.17	24.93
Lagodon rhomboides postflexion larvae	pinfish	14	5	1.5	26.7	1.39	92.88
Lagodon rhomboides juveniles	pinfish	102	18	3.0	21.0	9.10	323.57
Bairdiella chrysoura flexion larvae	silver perch	1	1	1.7	21.5	0.08	11.63
Cynoscion arenarius preflexion larvae	sand seatrout	3	2	-0.1	28.1	0.25	24.70
Cynoscion nebulosus preflexion larvae	spotted seatrout	1	1	-1.8	33.0	0.10	14.46
Cynoscion nebulosus juveniles	spotted seatrout	1	1	10.1	1.4	0.09	13.35
Leiostomus xanthurus postflexion larvae	spot	3	3	5.4	16.1	0.27	13.19
Leiostomus xanthurus juveniles	spot	241	13	6.7	15.3	21.57	843.48
Menticirrhus spp. preflexion larvae	kingfishes	72	9	-0.1	28.0	6.46	251.42
Menticirrhus spp. flexion larvae	kingfishes	11	6	0.6	25.5	0.95	35.68
Menticirrhus spp. postflexion larvae	kingfishes	5	3	4.3	11.3	0.47	29.28
Sciaenops ocellatus flexion larvae	red drum	2	1	4.5	14.0	0.20	28.29
Sciaenops ocellatus postflexion larvae	red drum	4	3	3.8	12.5	0.36	25.27
Mugil cephalus juveniles	striped mullet	4	4	7.9	12.6	0.34	12.93
Mugil curema juveniles	white mullet	2	1	6.0	23.6	0.19	27.62
blenniid preflexion larvae	blennies	82	29	0.9	25.7	7.24	165.23
Hypsoblennius spp. postflexion larvae	blennies	1	1	-1.0	32.2	0.10	14.30
gobiid preflexion larvae	gobies	1,249	79	7.3	14.1	113.03	1083.96
gobiid flexion larvae	gobies	382	52	4.1	21.8	34.97	503.85
gobiid postflexion larvae	gobies	6	2	2.1	18.7	0.62	59.40
Bathygobius soporator preflexion larvae	frillfin goby	7	6	4.1	23.8	0.63	25.20
Bathygobius soporator flexion larvae	frillfin goby	1	1	2.9	23.6	0.09	12.60
Gobionellus spp. postflexion larvae	gobies	2	2	3.7	21.4	0.18	13.54
Gobionellus oceanicus juveniles	highfin goby	1	1	6.0	5.2	0.09	12.64
Gobiosoma spp. postflexion larvae	gobies	361	44	2.8	21.2	32.91	773.01
Gobiosoma bosc juveniles	naked goby	2	1	4.5	14.1	0.20	28.18
Gobiosoma robustum juveniles	code goby	2	2	4.5	13.0	0.20	14.18
Microgobius spp. flexion larvae	gobies	352	42	6.9	17.0	32.44	652.99
Microgobius spp. postflexion larvae	gobies	222	28	7.1	12.4	20.55	493.12
Microgobius spp. juveniles	gobies	20	1	4.5	20.0	2.04	293.76
Microgobius gulosus juveniles	clown goby	21	9	10.3	5.9	1.88	91.13
Paralichthys spp. juveniles	flounders	15	5	0.9	21.4	1.30	64.67
Achirus lineatus preflexion larvae	lined sole	70	12	-0.5	28.3	6.06	321.10
Achirus lineatus flexion larvae	lined sole	8	6	0.3	27.4	0.73	28.23
Achirus lineatus postflexion larvae	lined sole	4	3	0.9	27.0	0.35	24.22
Trinectes maculatus preflexion larvae	hogchoker	28	7	-0.2	26.8	2.52	107.03

Plankton-net catch statistics (October 2004 through September 2005, n=144 samples)

Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	*Kmu* (km)	*Su* (psu)	Mean CPUE (No./10^3 m^3)	Max CPUE (No./10^3 m^3)
Trinectes maculatus flexion larvae	hogchoker	5	3	1.0	24.7	0.52	35.81
Trinectes maculatus postflexion larvae	hogchoker	15	7	4.9	13.7	1.42	99.26
Trinectes maculatus juveniles	hogchoker	14	7	11.8	7.2	1.34	82.34
Stephanolepis hispidus juveniles	planehead filefish	3	3	-0.6	30.2	0.36	20.79
Chilomycterus schoepfii juveniles	striped burrfish	1	1	6.0	20.0	0.09	13.68
unidentified preflexion larvae	fish	2	1	-1.0	32.6	0.19	27.08

Table A2. Page 1 of 6.

Anclote River plankton net catch by month (October 2004 to September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (12)	Feb (12)	Mar (12)	Apr (12)	May (12)	Jun (12)	Jul (12)	Aug (12)	Sep (12)	Oct (12)	Nov (12)	Dec (12)
foraminiferans	foraminiferans		4	1			4		23	5		3	2
Liriope tetraphylla	hydromedusa											11	
Clytia sp.	hydromedusa	4		1	13				1	418	3	22	
medusa sp. a	hydromedusa				2				156	5		3	
medusa sp. c	hydromedusa										2	15	
medusa sp. d	hydromedusa									6	10		
medusa sp. e	hydromedusa							5	21	17			
medusa, Bougainvillia sp.	hydromedusa							8	1	3			
medusa, Obelia sp.	hydromedusa						2		1	2			
Mnemiopsis mccradyi	comb jelly, ctenophore						2			77			
Beroe ovata	sea walnut, ctenophore	1											
turbellarians	flatworms	3				4			1				
nemerteans	ribbon worms									1	1		
nematodes	roundworms, threadworms	4	33	17	2	4	9		8	17		9	11
polychaetes	sand worms, tube worms	45	132	68	111	58	90	295	91	124	149	131	1247
oligochaetes	freshwater worms		11	3			1	3	15	2	29	1	
hirudinoideans	leeches	1						3	1				
Simocephalus vetulus	water flea	1		5			10	842	356		146		3
Grimaldina brazzai	water flea										1		
Ilyocryptus sp.	water flea							1	26		130		
Sida crystallina	water flea			1				2	1		1		
Latona setifera	water flea							1	8				
Penilia avirostris	water flea						2	20				8	
Latonopsis fasciculata	water flea								41		5		
Euryalona occidentalis	water flea							8					
Leydigia sp.	water flea										1		1
Evadne tergestina	water flea					1		15					
decapod zoeae	crab larvae	188	6319	22432	16225	11616	12724	16230	6080	29973	4288	2854	298
decapod mysis	shrimp larvae	161	241	291	2202	4479	14623	9187	292	1043	1062	137	55
decapod megalopae	post-zoea crab larvae	37			399	134	257	523	251	32	1029	239	43
shrimps, unidentified postlarvae	shrimps											4	12
penaeid postlarvae	penaeid shrimps							3					
penaeid metamorphs	penaeid shrimps	6				1	3			2	28	25	10
Farfantepenaeus duorarum juveniles	pink shrimp							3			9	5	
Lucifer faxoni mysis	shrimp							5				73	
Lucifer faxoni juveniles and adults	shrimp	28	12	3	1	31	142	6575	1	31	450	385	262
Palaemon floridanus adults	Florida grass shrimp	1											
Palaemonetes spp. postlarvae	grass shrimp	4		1		6	45	27	31	53	28	6	
Palaemonetes pugio juveniles	daggerblade grass shrimp	2						1		5	5	16	2
Palaemonetes pugio adults	daggerblade grass shrimp	1				2			1			1	
Palaemonetes vulgaris adults	grass shrimp											1	
Periclimenes longicaudatus juveniles	longtail grass shrimp	4				3						11	9
alphaeid postlarvae	snapping shrimps				2		11	64	3	15	66	53	3
alphaeid juveniles	snapping shrimps							1	1		1		
Alpheus viridari juveniles	snapping shrimp				1								
Hippolyte zostericola postlarvae	zostera shrimp	9	11	108	46	114	395	934	436	459	706	556	1264
Hippolyte zostericola juveniles	zostera shrimp	20		12	8	10	14	6	1	9		58	5
Hippolyte zostericola adults	zostera shrimp				2	4	2		1				

Table A2. Page 2 of 6.

Anclote River plankton net catch by month (October 2004 to September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (12)	Feb (12)	Mar (12)	Apr (12)	May (12)	Jun (12)	Jul (12)	Aug (12)	Sep (12)	Oct (12)	Nov (12)	Dec (12)
Thor sp. juveniles	shrimp										1		
Latreutes parvulus postlarvae	sargassum shrimp				2								
Tozeuma carolinense postlarvae	arrow shrimp							2			5		
Tozeuma carolinense juveniles	arrow shrimp						11			210		23	9
Tozeuma carolinense adults	arrow shrimp									4		81	
processid postlarvae	night shrimps					2	16	36	13	80			
Ambidexter symmetricus postlarvae	shrimp				2			1			85	17	17
Ambidexter symmetricus juveniles	shrimp					3	2	6		13		2	
Callianassa spp. juveniles	ghost shrimps										1		
Upogebia spp. postlarvae	mud shrimps							8		1	11	1	
Upogebia spp. juveniles	mud shrimps				1		1	3	3	9	9		
paguroid megalops larvae	hermit crabs					14							22
paguroid juveniles	hermit crabs				15	8	123	314	292	76			
Callinectes sapidus juveniles	blue crab	30	1			1	3			6	75	16	14
Callinectes sapidus adults	blue crab					1							
Portunus sp. juveniles	swimming crab										5	4	
Pinnixa sp. a juveniles	pea crab										4		
Pinnixa sayana juveniles	pea crab				1		1						
unidentified Americamysis juveniles	opossum shrimps, mysids	484	15	55	219	80	207	1225	596	228	54	46	175
Americamysis almyra	opossum shrimp, mysid	338	11	31	241	69	2232	2884	350	146	1333	36	353
Americamysis bahia	opossum shrimp, mysid							1					
Americamysis stucki	opossum shrimp, mysid						3		5	105	107		
Bowmaniella dissimilis	opossum shrimp, mysid	146	102	123	690	149	380	601	1939	1593	906	281	393
Mysidopsis mortenseni	opossum shrimp, mysid						2						
Taphromysis bowmani	opossum shrimp, mysid	41	2	5	5	9	132	70	73	66			
cumaceans	cumaceans	113	264	196	1198	256	324	394	416	3023	122	79	36
Sinelobus stanfordi	tanaid	1	4	1			4	6	12	2		5	1
Apseudes sp.	tanaid						3	4	3	18			
Hargeria rapax	tanaid	2	8	3	55	48	21	50	3	55	13	11	56
Cyathura polita	isopod					1	7	5	6	2	6		
Xenanthura brevitelson	isopod		1		5	6	10	3	2	2			
Munna reynoldsi	isopod		1	7	1	5	516	85	20	3	1	3	13
Anopsilana jonesi	isopod								1		1		
cymothoid sp. a (Lironeca) juveniles	isopod	2		5	22	13	25	9		6	4	2	6
Cassidinidea ovalis	isopod		1		1		5		3	10	4	1	2
Harrieta faxoni	isopod				1	5	10	26	24	130		4	2
Sphaeroma quadridentata	isopod		1		2	5	2	7				3	
Sphaeroma terebrans	isopod				7	11	62	122	7	9	8	2	
Sphaeroma walkeri	isopod				1								
Edotea triloba	isopod	5	3	5	37	64	185	2094	25	217	24	13	47
Erichsonella attenuata	isopod	1	3		3	4	6	8	7	64	5		3
Erichsonella filiforme	isopod				1								
amphipods, gammaridean	amphipods	1174	1094	2158	14220	10201	10707	33955	5963	29514	69965	18193	38673
amphipods, caprellid	skeleton shrimps	4	12	10	24	18	69	14	8	40		49	47
cirriped nauplius stage	barnacles						4			1	42	26	3
branchiurans, Argulus spp.	fish lice	13	11	5	4		1	3	3	6	41	39	10
Alteutha sp.	copepod											1	
unidentified harpacticoids	copepods	11	87	11		14	4	1	4	16	5	62	57

Table A2. Page 3 of 6.

Anclote River plankton net catch by month (October 2004 to September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (12)	Feb (12)	Mar (12)	Apr (12)	May (12)	Jun (12)	Jul (12)	Aug (12)	Sep (12)	Oct (12)	Nov (12)	Dec (12)
siphonostomatids	parasitic copepods					14	18	37	6	123			
Monstrilla sp.	copepod						1			2			2
Macrocyclops albidus	copepods	2		1	2			8	7		9		
Mesocyclops edax	copepod	1					2	12	9	1	13		2
Oithona spp.	copepods							3		2	27		
Orthocyclops modestus	copepod							4	2		6		
Saphirella spp.	copepods	1			2			18	5	2	1	4	3
paracalanids	copepods	2	11								8		
Acartia tonsa	copepod	1380	5678	1633	9	2255	2090	3720	196	4635	2331	2124	1524
Calanopia americana	copepod					1	16	6	301	501	2	22	5
Centropages hamatus	copepod	10	2	4							1		
Centropages velificatus	copepod					3	4	40				34	12
Diaptomus spp.	copepods			1				1					
Eucalanus sp.	copepod	1										2	
Eurytemora affinis	copepod	1	1	3					1		1	1	
Labidocera aestiva	copepod	42	59	97	7	103	506	3018	26	247	1724	168	73
Osphranticum labronectum	copepod							2					
Pseudodiaptomus coronatus	copepod	1	5	5	9	10	3	7	3	26	72	10	2
Temora turbinata	copepod					18	3	45		2	12	8	
myodocopod sp. a	ostracod, seed shrimp				1					7	14		
Euconchoecia chierchiae	ostracod, seed shrimp					1							
Sarsiella zostericola	ostracod, seed shrimp		1	1	11	5	13	12	15	90		2	5
Parasterope pollex	ostracod, seed shrimp	6	62	9	68	138	937	798	220	414	20	9	8
ostracods, podocopid	ostracods, seed shrimps	3	15	2	2	1	17	8	13	22	4	3	7
collembolas, podurid	springtails	1							2				
ephemeropteran larvae	mayflies						12	9	27		19		
odonates, anisopteran larvae	dragonflies							1					
odonates, zygopteran larvae	damselflies							6	3				
hemipterans, corixid adults	water boatmen										1		
hemipterans, gerrid adults	water striders						2						
coleopterans, curculionid adults	beetles												1
coleopterans, elmid larvae	riffle beetles											2	
coleopterans, elmid adults	riffle beetles								2		4		
coleopterans, gyrinid larvae	whirligig beetles										2		
coleopterans, dytiscid adults	predaceous diving beetles												1
dipterans, pupae	flies, mosquitoes	2	5		6	19	33	116	113	10	78	9	2
dipterans, ceratopogonid larvae	biting midges							4					
dipteran, Chaoborus punctipennis larvae	phantom midge					1		33	11	1	56		3
dipterans, chironomid larvae	midges	5	7	16	15	12	24	97	44	10	57	92	46
dipterans, sciomyzid larvae	marsh flies											1	
trichopteran larvae	caddisflies					1	5	5	2		9		
pycnogonids	sea spiders				3		10	2		519			
Limulus polyphemus larvae	horsehoe crab		3						1	6		93	13
acari	water mites	1	4				2	25	3			1	
gastropods, prosobranch	snails	58	30	4	4	17	96	45	622	122	8	32	28
gastropods, opisthobranch	sea slugs	40	3	2	27	9	4	7	4	4	11	2	7
pelecypods	clams, mussels, oysters	55	5	3	11	41	148	38	212	52	2	14	300
ophiopluteus larvae	brittlestars								9		3		

Table A2. Page 4 of 6.

Anclote River plankton net catch by month (October 2004 to September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (12)	Feb (12)	Mar (12)	Apr (12)	May (12)	Jun (12)	Jul (12)	Aug (12)	Sep (12)	Oct (12)	Nov (12)	Dec (12)
ophiuroidean juveniles	brittlestars		2		1		2	2	3				
brachiopod, Glottidia pyramidata larvae	lamp shell				1		10				7		
chaetognaths, sagittid	arrow worms	1150	253	552	677	142	318	2289	286	1428	769	1234	654
ascidiacean larvae	tunicate larvae								1	1			
appendicularian, Oikopleura dioica	larvacean		64			4	5720	5	2	1257	1088	651	264
Branchiostoma floridae	lancelet									2			
Elops saurus postflexion larvae	ladyfish	4	1	22									1
Elops saurus juveniles	ladyfish												1
Myrophis punctatus postflexion larvae	speckled worm eel	21											
Myrophic punctatus metamorphs	speckled worm eel	2											
Myrophis punctatus juveniles	speckled worm eel	7	1										
clupeid eggs	herrings		7	7									
clupeid preflexion larvae	herrings		2					15			3		
Brevoortia spp. flexion larvae	menhaden	2											
Brevoortia spp. postflexion larvae	menhaden	36	2	2	2								
Brevoortia spp. metamorphs	menhaden	5		2		1							
Harengula jaguana postflexion larvae	scaled sardine							96					
Harengula jaguana metamorphs	scaled sardine							1					
Opisthonema oglinum juveniles	Atlantic thread herring										1		
Anchoa spp. preflexion larvae	anchovies					5	2	68	23	6	29		
Anchoa spp. flexion larvae	anchovies					2	2	74	2		23		
Anchoa spp. juveniles	anchovies								1				
Anchoa hepsetus eggs	striped anchovy				1								
Anchoa mitchilli eggs	bay anchovy		458	1	6								
Anchoa mitchilli postflexion larvae	bay anchovy						9	32	7	1	37	2	4
Anchoa mitchilli juveniles	bay anchovy	231	34	76	24	4	18	37	8	319	257	50	188
Anchoa mitchilli adults	bay anchovy	3	3	3	15	7	13	36	5	1	14	1	
Notemigonus crysoleucas flexion larvae	golden shiner								1				
Synodus foetens juveniles	inshore lizardfish				2						1		
Gobiesox strumosus preflexion larvae	skilletfish	20	24	7	5	4	3	14		22		35	4
Gobiesox strumosus flexion larvae	skilletfish		1			1				10		2	1
Lucania parva postflexion larvae	rainwater killifish							1					
Lucania parva adults	rainwater killifish							1					
Gambusia holbrooki juveniles	eastern mosquitofish										2		
Heterandria formosa juveniles	least killifish										1		
Menidia spp. eggs	silversides									1			
Menidia spp. preflexion larvae	silversides	1	33	21	44	8	7	18	7	5		4	1
Menidia spp. flexion larvae	silversides			3			1		2	2			
Menidia spp. postflexion larvae	silversides									1			
Menidia spp. juveniles	silversides					1	2		2	1			
Menidia spp. adults	silversides									1			
Membras martinica preflexion larvae	rough silverside	1	6										
fish eggs, percomorph	sciaenid eggs (primarily)		307	74	1	4515	9786	4632	19	656	5		
Hippocampus erectus juveniles	lined seahorse											1	
Hippocampus erectus adults	lined seahorse										1		
Hippocampus zosterae juveniles	dwarf seahorse										1		
Syngnathus floridae juveniles	dusky pipefish	2			1				1	2		1	
Syngnathus floridae adults	dusky pipefish									1			

Table A2. Page 5 of 6.

Anclote River plankton net catch by month (October 2004 to September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (12)	Feb (12)	Mar (12)	Apr (12)	May (12)	Jun (12)	Jul (12)	Aug (12)	Sep (12)	Oct (12)	Nov (12)	Dec (12)
Syngnathus louisianae juveniles	chain pipefish											3	
Syngnathus scovelli juveniles	gulf pipefish	2				1	6						6
Prionotus spp. preflexion larvae	searobins									1			
Prionotus tribulus juveniles	bighead searobin	2											
Lepomis spp. flexion larvae	sunfishes								1				
Oligoplites saurus preflexion larvae	leatherjack							2	1				
Oligoplites saurus flexion larvae	leatherjack							1					
Oligoplites saurus postflexion larvae	leatherjack								1				
Oligoplites saurus juveniles	leatherjack						1						
gerreid preflexion larvae	mojjaras						2						
Eucinostomus spp. postflexion larvae	mojarras					2					6	20	1
Eucinostomus spp. juveniles	mojarras										38	4	1
Orthopristis chrysoptera flexion larvae	pigfish			1									
Orthopristis chrysoptera postflexion larvae	pigfish			1									
Orthopristis chrysoptera juveniles	pigfish	3											
Archosargus probatocephalus postflexion larva	sheepshead			2									
Lagodon rhomboides postflexion larvae	pinfish			2								5	7
Lagodon rhomboides juveniles	pinfish	79	9	7								7	
Bairdiella chrysoura flexion larvae	silver perch							1					
Cynoscion arenarius preflexion larvae	sand seatrout		3										
Cynoscion nebulosus preflexion larvae	spotted seatrout									1			
Cynoscion nebulosus juveniles	spotted seatrout								1				
Leiostomus xanthurus postflexion larvae	spot			3									
Leiostomus xanthurus juveniles	spot	240		1									
Menticirrhus spp. preflexion larvae	kingfishes							65	1	4			2
Menticirrhus spp. flexion larvae	kingfishes							9	2				
Menticirrhus spp. postflexion larvae	kingfishes							3			2		
Sciaenops ocellatus flexion larvae	red drum										2		
Sciaenops ocellatus postflexion larvae	red drum										4		
Mugil cephalus juveniles	striped mullet	1		2	1								
Mugil curema juveniles	white mullet											2	
blenniid preflexion larvae	blennies		10	5	28	5	8	10	4	7			5
Hypsoblennius spp. postflexion larvae	blennies						1						
gobiid preflexion larvae	gobies		1	4	136	239	126	261	219	245	16		2
gobiid flexion larvae	gobies		2	1	61	58	59	84	25	86	4	2	
gobiid postflexion larvae	gobies										6		
Bathygobius soporator preflexion larvae	frillfin goby				1		3			3			
Bathygobius soporator flexion larvae	frillfin goby						1						
Gobionellus spp. postflexion larvae	gobies	2											
Gobionellus oceanicus juveniles	highfin goby										1		
Gobiosoma spp. postflexion larvae	gobies				1	7	76	212	25	26	1	12	1
Gobiosoma bosc juveniles	naked goby								2				
Gobiosoma robustum juveniles	code goby							1	1				
Microgobius spp. flexion larvae	gobies		3		49	41	75	24	61	98	1		
Microgobius spp. postflexion larvae	gobies				2	5	14	62	82	57			
Microgobius spp. juveniles	gobies						20						
Microgobius gulosus juveniles	clown goby							3	12	6			
Paralichthys spp. juveniles	flounders	15											

Table A2. Page 6 of 6.

Anclote River plankton net catch by month (October 2004 to September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (12)	Feb (12)	Mar (12)	Apr (12)	May (12)	Jun (12)	Jul (12)	Aug (12)	Sep (12)	Oct (12)	Nov (12)	Dec (12)
Achirus lineatus preflexion larvae	lined sole							59	4	7			
Achirus lineatus flexion larvae	lined sole						3	4		1			
Achirus lineatus postflexion larvae	lined sole						3	1					
Trinectes maculatus preflexion larvae	hogchoker					2		19	2	5			
Trinectes maculatus flexion larvae	hogchoker							2	3				
Trinectes maculatus postflexion larvae	hogchoker						1	10	1	2	1		
Trinectes maculatus juveniles	hogchoker									6	2	1	5
Stephanolepis hispidus juveniles	planehead filefish						1					2	
Chilomycterus schoepfii juveniles	striped burrfish					1							
unidentified preflexion larvae	fish									2			

Table A3, page 1 of 6. Location specific plankton-net catch.

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

		Location (km from mouth)											
Description	Common Name	-1.8	-1.0	0.3	1.7	2.9	4.5	6.0	8.9	10.1	12.3	13.3	15.1
foraminiferans	foraminiferans	11.20	23.41	7.21	2.89	6.11	0.00	1.18	0.75	1.21	0.00	0.00	1.16
Liriope tetraphylla	hydromedusa	0.00	0.00	2.86	8.04	2.55	0.00	0.00	2.34	0.00	0.00	0.00	0.00
Clytia sp.	hydromedusa	5.03	9.21	24.30	2.18	8.59	0.00	22.77	14.32	17.87	223.74	174.33	18.71
medusa sp. a	hydromedusa	2.01	0.00	0.00	0.00	3.82	8.97	59.01	132.10	0.00	0.00	0.00	0.00
medusa sp. c	hydromedusa	3.03	0.00	5.72	8.04	5.09	2.62	0.00	0.00	0.00	0.00	0.00	0.00
medusa sp. d	hydromedusa	10.60	4.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.49
medusa sp. e	hydromedusa	2.34	3.24	0.00	0.00	2.45	1.28	15.27	5.97	21.85	0.00	0.00	0.00
medusa, Bougainvillia sp.	hydromedusa	2.42	6.49	0.00	1.06	2.37	0.00	0.00	0.00	1.19	0.00	0.00	0.00
medusa, Obelia sp.	hydromedusa	0.00	5.06	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mnemiopsis mccradyi	comb jelly, ctenophore	0.00	0.00	0.00	0.00	0.00	0.00	25.45	26.23	2.37	38.36	0.00	0.00
Beroe ovata	sea walnut, ctenophore	0.00	0.00	0.00	0.00	0.00	1.17	0.00	0.00	0.00	0.00	0.00	0.00
turbellarians	flatworms	2.34	1.63	0.00	0.00	4.98	0.00	0.00	0.00	0.00	0.00	1.13	0.00
nemerteans	ribbon worms	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.15	1.25
nematodes	roundworms, threadworms	21.42	30.05	24.67	18.07	2.55	9.73	6.06	20.28	4.98	1.18	3.29	0.00
polychaetes	sand worms, tube worms	369.10	377.60	311.56	142.74	104.93	24.98	38.47	4.77	25.97	105.50	226.30	1462.12
oligochaetes	freshwater worms	0.00	0.00	0.00	0.00	0.00	2.46	2.20	9.05	3.27	31.08	7.09	16.81
hirudinoideans	leeches	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.22	2.72	1.18	0.00	0.00
Simocephalus vetulus	water flea	6.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.22	169.85	426.98	941.35
Grimaldina brazzai	water flea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.00	0.00
Ilyocryptus sp.	water flea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.99	135.14	5.78
Sida crystallina	water flea	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	1.18	2.32	1.13
Latona setifera	water flea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.80
Penilia avirostris	water flea	0.00	11.83	13.97	0.00	7.64	0.00	0.00	0.00	0.00	0.00	3.52	0.00
Latonopsis fasciculata	water flea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.00	6.72	36.34	9.67
Euryalona occidentalis	water flea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.35	6.75
Leydigia sp.	water flea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00	0.00	1.28
Evadne tergestina	water flea	0.00	6.49	12.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
decapod zoeae	crab larvae	21150.88	25910.20	20931.76	12934.56	14056.29	15179.36	10896.11	9223.82	9237.04	5976.58	4894.10	3408.70
decapod mysis	shrimp larvae	592.69	676.31	636.05	594.64	865.11	2458.18	6889.21	7087.35	11092.57	6250.28	3379.42	488.24
decapod megalopae	post-zoea crab larvae	799.11	1043.29	319.68	472.55	629.86	283.17	44.39	19.07	52.54	11.23	3.37	0.00
shrimps, unidentified postlarvae	shrimps	12.67	0.00	4.14	3.21	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
penaeid postlarvae	penaeid shrimps	0.00	3.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
penaeid metamorphs	penaeid shrimps	51.60	13.48	2.70	10.80	15.53	14.24	2.30	0.00	0.00	0.00	0.00	0.00
Farfantepenaeus duorarum juveniles	pink shrimp	5.67	0.00	5.74	2.70	2.43	2.57	3.51	0.00	0.00	0.00	0.00	0.00
Lucifer faxoni mysis	shrimp	18.90	40.23	46.90	3.21	1.27	2.62	0.00	0.00	0.00	0.00	0.00	0.00
Lucifer faxoni juveniles and adults	shrimp	1270.33	2746.80	1050.22	1172.54	986.31	2300.36	6.06	7.03	0.00	2.25	0.00	0.00
Palaemon floridanus adults	Florida grass shrimp	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Palaemonetes spp. postlarvae	grass shrimp	40.68	35.76	11.97	59.48	30.72	25.90	7.35	21.34	16.50	2.19	0.00	0.00
Palaemonetes pugio juveniles	daggerblade grass shrimp	0.00	0.00	5.39	0.00	0.00	5.00	1.15	1.17	1.13	5.59	14.22	3.65
Palaemonetes pugio adults	daggerblade grass shrimp	0.00	1.05	1.03	0.00	0.00	0.00	0.00	2.43	0.00	0.00	1.20	0.00
Palaemonetes vulgaris adults	grass shrimp	0.00	1.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Periclimenes longicaudatus juveniles	longtail grass shrimp	9.60	2.42	15.01	5.63	1.26	2.62	0.00	0.00	0.00	0.00	0.00	0.00
alphaeid postlarvae	snapping shrimps	96.95	67.38	50.56	33.05	15.11	30.98	0.00	2.39	1.19	0.00	0.00	0.00
alphaeid juveniles	snapping shrimps	0.00	0.00	1.03	0.00	0.00	2.57	0.00	0.00	0.00	0.00	0.00	0.00
Alpheus viridari juveniles	snapping shrimp	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hippolyte zostericola postlarvae	zostera shrimp	2437.95	1520.61	1341.79	694.95	394.71	160.34	12.72	2.39	0.00	0.00	0.00	0.00
Hippolyte zostericola juveniles	zostera shrimp	21.90	21.12	31.55	102.35	4.70	10.59	0.00	0.00	0.00	0.00	0.00	0.00

Table A3, page 2 of 6. Location specific plankton-net catch.

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

		Location (km from mouth)											
Description	Common Name	-1.8	-1.0	0.3	1.7	2.9	4.5	6.0	8.9	10.1	12.3	13.3	15.1
Hippolyte zostericola adults	zostera shrimp	0.00	2.15	0.00	6.12	0.00	2.67	0.00	0.00	0.00	0.00	0.00	0.00
Thor sp. juveniles	shrimp	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Latreutes parvulus postlarvae	sargassum shrimp	2.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tozeuma carolinense postlarvae	arrow shrimp	2.34	6.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tozeuma carolinense juveniles	arrow shrimp	242.66	47.61	15.93	25.77	1.27	1.23	0.00	2.34	0.00	0.00	0.00	0.00
Tozeuma carolinense adults	arrow shrimp	90.33	30.14	11.45	6.43	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
processid postlarvae	night shrimps	75.54	42.39	30.90	28.14	2.44	1.23	0.00	2.39	0.00	0.00	0.00	0.00
Ambidexter symmetricus postlarvae	shrimp	39.10	43.13	27.77	37.54	9.14	10.29	0.00	0.00	0.00	0.00	0.00	0.00
Ambidexter symmetricus juveniles	shrimp	6.41	3.24	18.42	4.74	0.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00
Callianassa spp. juveniles	ghost shrimps	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17	0.00	0.00	0.00	0.00
Upogebia spp. postlarvae	mud shrimps	8.88	13.98	1.15	0.00	1.27	0.00	0.00	0.00	0.00	1.10	0.00	0.00
Upogebia spp. juveniles	mud shrimps	1.01	5.71	0.00	6.70	1.15	0.00	5.05	5.97	4.53	1.11	0.00	0.00
paguroid megalops larvae	hermit crabs	16.89	6.89	24.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
paguroid juveniles	hermit crabs	509.70	290.31	96.95	48.02	2.22	3.81	0.00	0.00	0.00	0.00	0.00	0.00
Callinectes sapidus juveniles	blue crab	6.69	3.80	1.14	10.63	49.98	66.19	14.75	17.68	7.22	0.00	6.06	1.28
Callinectes sapidus adults	blue crab	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Portunus sp. juveniles	swimming crab	1.89	2.74	0.00	5.40	1.27	0.00	0.00	0.00	1.13	0.00	0.00	0.00
Pinnixa sp. a juveniles	pea crab	0.00	0.00	0.00	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pinnixa sayana juveniles	pea crab	0.00	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified Americamysis juveniles	opossum shrimps, mysids	20.16	15.31	19.93	42.10	110.92	935.19	597.89	245.62	932.26	357.39	378.71	445.13
Americamysis almyra	opossum shrimp, mysid	4.41	15.36	3.42	45.64	152.98	1710.94	2302.57	399.02	1850.65	2248.83	380.62	555.74
Americamysis bahia	opossum shrimp, mysid	0.00	0.00	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Americamysis stucki	opossum shrimp, mysid	43.02	113.39	19.19	74.18	1.22	23.33	12.72	0.00	0.00	0.00	0.00	0.00
Bowmaniella dissimilis	opossum shrimp, mysid	284.49	279.06	132.11	170.12	155.28	1737.34	846.88	1351.76	3395.83	151.31	345.73	21.37
Mysidopsis mortenseni	opossum shrimp, mysid	0.00	0.00	0.00	2.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Taphromysis bowmani	opossum shrimp, mysid	1.15	2.10	6.61	29.44	26.14	38.32	5.87	17.07	89.90	145.70	38.24	79.63
cumaceans	cumaceans	901.69	889.19	558.88	711.44	439.11	730.52	1193.57	1665.12	634.63	10.25	10.41	2.46
Sinelobus stanfordi	tanaid	0.00	0.00	0.00	0.00	0.00	2.67	7.33	2.73	1.21	14.88	10.47	2.63
Apseudes sp.	tanaid	0.00	1.30	9.45	5.07	2.44	13.94	0.00	0.00	0.00	2.25	0.00	1.13
Hargeria rapax	tanaid	14.99	8.23	25.78	99.03	80.24	18.21	63.59	67.09	16.53	0.00	0.00	0.00
Cyathura polita	isopod	0.00	0.00	0.00	0.00	9.43	10.22	1.17	3.65	8.03	0.00	1.17	0.00
Xenanthura brevitelson	isopod	0.00	0.00	0.00	5.72	8.46	10.04	9.47	1.23	0.00	0.00	0.00	0.00
Munna reynoldsi	isopod	2.34	0.00	0.00	0.00	0.00	0.00	0.00	6.71	7.63	20.18	61.12	742.10
Anopsilana jonesi	isopod	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.00	1.13	0.00	0.00	0.00
cymothoid sp. a (Lironeca) juveniles	isopod	3.35	6.98	6.86	8.84	35.59	11.30	15.69	5.97	6.50	6.65	2.34	1.25
Cassidinidea ovalis	isopod	1.10	1.63	0.00	2.20	0.00	3.80	8.36	9.17	4.86	0.00	1.10	0.00
Harrieta faxoni	isopod	22.25	54.93	40.51	91.23	26.54	13.79	1.17	1.21	0.00	0.00	0.00	0.00
Sphaeroma quadridentata	isopod	3.78	1.07	2.57	4.82	9.36	0.00	1.18	0.00	0.00	0.00	0.00	2.40
Sphaeroma terebrans	isopod	0.00	0.00	0.00	1.09	0.00	3.80	2.51	8.79	40.28	96.20	32.80	85.99
Sphaeroma walkeri	isopod	0.00	0.00	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00
Edotea triloba	isopod	5.45	12.75	6.38	36.03	61.58	139.19	1618.60	640.97	250.17	224.21	60.81	4.92
Erichsonella attenuata	isopod	1.10	5.22	11.27	39.37	46.94	8.59	12.53	2.27	0.00	0.00	0.00	0.00
Erichsonella filiforme	isopod	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
amphipods, gammaridean	amphipods	1260.25	2220.15	3671.53	71893.80	44768.18	46692.92	46314.76	23652.99	20628.55	17047.42	11194.51	3715.42
amphipods, caprellid	skeleton shrimps	51.76	50.89	95.77	75.88	58.87	42.36	2.34	0.00	0.00	0.00	0.00	0.00
cirriped nauplius stage	barnacles	60.58	10.75	9.30	24.70	6.24	0.00	0.00	0.00	0.00	1.10	0.00	0.00
branchiurans, Argulus spp.	fish lice	50.70	37.27	27.98	27.21	18.55	11.65	5.00	0.75	1.09	0.00	1.17	0.00

Table A3, page 3 of 6. Location specific plankton-net catch.

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

		Location (km from mouth)											
Description	Common Name	-1.8	-1.0	0.3	1.7	2.9	4.5	6.0	8.9	10.1	12.3	13.3	15.1
Alteutha sp.	copepod	0.00	0.00	0.00	0.00	0.00	0.00	1.26	0.00	0.00	0.00	0.00	0.00
unidentified harpacticoids	copepods	101.89	57.54	68.50	35.10	39.77	23.34	16.51	5.90	1.21	0.00	1.17	0.00
siphonostomatids	parasitic copepods	67.78	75.15	25.19	38.19	10.81	10.34	9.74	7.14	1.28	0.00	0.00	0.00
Monstrilla sp.	copepod	0.00	4.06	0.00	2.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Macrocyclops albidus	copepods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	7.97	12.77	11.97
Mesocyclops edax	copepod	0.00	0.00	0.00	0.00	0.00	2.67	0.00	0.00	3.48	7.83	9.29	23.61
Oithona spp.	copepods	13.63	27.18	2.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orthocyclops modestus	copepod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	4.54	3.47	4.65
Saphirella spp.	copepods	0.00	0.00	0.00	0.00	0.00	0.00	2.56	11.47	13.20	2.37	13.97	0.00
paracalanids	copepods	1.15	23.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.18	0.00	0.00
Acartia tonsa	copepod	11169.89	12045.23	7587.56	2289.88	831.02	261.06	84.11	110.51	44.66	5.60	2.27	2.50
Calanopia americana	copepod	243.66	167.97	66.63	406.60	124.39	57.32	19.09	5.97	4.75	1.10	0.00	0.00
Centropages hamatus	copepod	3.42	7.71	5.72	1.18	0.00	0.00	1.15	0.00	0.00	0.00	0.00	0.00
Centropages velificatus	copepod	18.07	19.46	34.93	15.53	13.65	15.75	1.31	0.00	0.00	0.00	0.00	0.00
Diaptomus spp.	copepods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36	1.20	0.00	0.00
Eucalanus sp.	copepod	0.00	1.05	0.00	0.00	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eurytemora affinis	copepod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00	1.17	7.14
Labidocera aestiva	copepod	1474.61	3329.84	836.19	931.23	452.15	311.79	68.67	13.03	10.11	0.00	0.00	0.00
Osphranticum labronectum	copepod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.00	0.00
Pseudodiaptomus coronatus	copepod	14.70	6.37	7.86	90.38	10.96	13.94	8.53	27.39	8.52	2.25	0.00	1.25
Temora turbinata	copepod	35.70	23.22	35.46	2.12	7.64	6.43	0.00	0.00	0.00	0.00	0.00	0.00
myodocopod sp. a	ostracod, seed shrimp	12.83	13.20	1.15	1.09	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euconchoecia chierchiae	ostracod, seed shrimp	0.00	0.00	0.00	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sarsiella zostericola	ostracod, seed shrimp	27.61	25.19	17.75	42.01	53.34	17.08	5.03	0.00	0.00	1.10	0.00	0.00
Parasterope pollex	ostracod, seed shrimp	180.51	475.08	1167.97	733.80	481.01	160.39	22.65	7.13	2.37	0.00	0.00	0.00
ostracods, podocopid	ostracods, seed shrimps	23.47	6.69	9.18	0.00	4.68	0.00	0.00	8.87	3.64	17.20	16.89	25.01
collembolas, podurid	springtails	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.36	1.17	0.00
ephemeropteran larvae	mayflies	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	1.13	9.01	32.72	35.70
odonates, anisopteran larvae	dragonflies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13
odonates, zygopteran larvae	damselflies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.72	5.68	2.34	0.00
hemipterans, corixid adults	water boatmen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00
hemipterans, gerrid adults	water striders	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63
coleopterans, curculionid adults	beetles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28
coleopterans, elmid larvae	riffle beetles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40
coleopterans, elmid adults	riffle beetles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.53	0.00	2.34	0.00
coleopterans, gyrinid larvae	whirligig beetles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.31
coleopterans, dytiscid adults	predaceous diving beetles	0.00	0.00	0.00	0.00	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.00
dipterans, pupae	flies, mosquitoes	0.00	0.00	0.00	0.00	0.00	0.00	14.40	6.98	15.52	82.54	103.74	238.49
dipterans, ceratopogonid larvae	biting midges	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	1.17	1.13
dipteran, Chaoborus punctipennis larvae	phantom midge	0.00	9.73	0.00	0.00	0.00	0.00	0.00	8.09	28.54	27.03	27.94	18.61
dipterans, chironomid larvae	midges	2.34	0.00	0.00	0.00	2.66	1.23	1.12	17.47	11.22	148.99	90.82	228.04
dipterans, sciomyzid larvae	marsh flies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20
trichopteran larvae	caddisflies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.32	8.16	14.55
pycnogonids	sea spiders	2.01	3.53	9.45	208.13	303.06	81.57	34.35	14.32	2.37	1.10	0.00	0.00
Limulus polyphemus larvae	horsehoe crab	0.00	0.00	0.00	15.99	29.57	54.80	31.44	16.10	0.00	1.13	0.00	0.00
acari	water mites	1.18	0.00	2.35	0.00	0.00	0.00	0.00	1.17	2.58	0.00	20.06	15.04
gastropods, prosobranch	snails	220.72	421.05	98.99	94.65	66.88	30.30	12.64	5.77	86.25	58.65	145.14	115.08

Table A3, page 4 of 6. Location specific plankton-net catch.

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

		Location (km from mouth)											
Description	Common Name	-1.8	-1.0	0.3	1.7	2.9	4.5	6.0	8.9	10.1	12.3	13.3	15.1
gastropods, opisthobranch	sea slugs	11.50	21.57	16.24	24.20	34.84	20.06	11.79	2.34	2.55	0.00	0.00	0.00
pelecypods	clams, mussels, oysters	138.55	195.95	176.09	49.00	60.50	15.72	18.27	9.25	12.11	19.40	13.63	391.36
ophiopluteus larvae	brittlestars	9.93	4.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ophiuroidean juveniles	brittlestars	3.34	7.13	2.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachiopod, Glottidia pyramidata larvae	lamp shell	3.42	9.23	5.13	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognaths, sagittid	arrow worms	3722.56	3390.01	1749.59	1617.18	930.27	321.55	274.41	41.12	20.30	9.12	0.00	4.72
ascidiacean larvae	tunicate larvae	2.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
appendicularian, Oikopleura dioica	larvacean	3914.28	2745.49	4803.81	120.86	72.55	1.23	0.00	0.00	0.00	0.00	0.00	0.00
Branchiostoma floridae	lancelet	0.00	0.00	2.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elops saurus postflexion larvae	ladyfish	0.00	1.16	1.09	6.71	2.21	7.19	2.52	2.55	3.50	3.57	2.33	0.00
Elops saurus juveniles	ladyfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26	0.00	0.00	0.00
Myrophis punctatus postflexion larvae	speckled worm eel	2.30	19.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Myrophis punctatus metamorphs	speckled worm eel	1.15	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Myrophis punctatus juveniles	speckled worm eel	0.00	2.17	0.00	0.00	0.00	4.67	0.00	2.34	0.00	0.00	0.00	0.00
clupeid eggs	herrings	12.68	3.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
clupeid preflexion larvae	herrings	17.54	6.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brevoortia spp. flexion larvae	menhaden	0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brevoortia spp. postflexion larvae	menhaden	0.00	6.30	0.00	0.00	1.23	4.67	1.21	7.02	8.57	11.72	2.25	6.02
Brevoortia spp. metamorphs	menhaden	0.00	0.00	2.29	1.18	1.23	0.00	0.00	1.17	0.00	1.20	1.17	1.16
Harengula jaguana postflexion larvae	scaled sardine	1.17	3.24	0.00	44.42	49.75	9.02	0.00	0.00	0.00	0.00	0.00	0.00
Harengula jaguana metamorphs	scaled sardine	0.00	0.00	0.00	0.00	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Opisthonema oglinum juveniles	Atlantic thread herring	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anchoa spp. preflexion larvae	anchovies	16.88	47.26	13.73	31.32	33.52	12.91	1.25	0.00	1.28	0.00	0.00	1.11
Anchoa spp. flexion larvae	anchovies	17.14	16.22	10.04	39.62	32.87	3.87	0.00	0.00	0.00	0.00	0.00	2.25
Anchoa spp. juveniles	anchovies	0.00	0.00	0.00	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00
Anchoa hepsetus eggs	striped anchovy	0.00	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anchoa mitchilli eggs	bay anchovy	4.53	30.30	443.31	51.13	3.24	3.39	0.00	0.00	1.27	0.00	0.00	0.00
Anchoa mitchilli postflexion larvae	bay anchovy	7.16	1.63	5.99	17.28	33.51	20.59	7.13	8.32	6.48	2.28	2.43	0.00
Anchoa mitchilli juveniles	bay anchovy	0.00	9.17	2.24	10.57	55.43	125.63	146.49	91.02	58.31	511.66	97.93	371.23
Anchoa mitchilli adults	bay anchovy	0.00	4.92	2.14	12.65	20.21	9.02	20.48	3.30	22.16	11.48	10.72	2.25
Notemigonus crysoleucas flexion larvae	golden shiner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.21	0.00	0.00	0.00
Synodus foetens juveniles	inshore lizardfish	1.01	0.00	0.00	1.09	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gobiesox strumosus preflexion larvae	skilletfish	14.03	1.07	2.14	12.03	5.93	15.75	17.39	34.12	35.48	13.83	10.64	0.00
Gobiesox strumosus flexion larvae	skilletfish	0.00	0.00	0.00	0.00	1.26	0.00	0.00	10.70	5.91	0.00	0.00	0.00
Lucania parva postflexion larvae	rainwater killifish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36	0.00	0.00	0.00
Lucania parva adults	rainwater killifish	0.00	0.00	0.00	0.00	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gambusia holbrooki juveniles	eastern mosquitofish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.30	0.00
Heterandria formosa juveniles	least killifish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.16
Menidia spp. eggs	silversides	0.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Menidia spp. preflexion larvae	silversides	0.00	2.32	0.00	2.53	5.65	10.54	14.48	26.50	39.56	12.52	44.28	10.55
Menidia spp. flexion larvae	silversides	1.13	0.00	0.00	0.00	2.21	0.00	0.00	3.56	2.43	0.00	0.00	0.00
Menidia spp. postflexion larvae	silversides	0.00	0.00	0.00	0.00	0.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00
Menidia spp. juveniles	silversides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.36	4.84
Menidia spp. adults	silversides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25
Membras martinica preflexion larvae	rough silverside	0.00	2.25	0.00	1.04	1.12	1.17	0.00	1.50	0.00	0.00	0.00	0.00
fish eggs, percomorph	sciaenid eggs (primarily)	3857.30	5751.79	5186.49	4535.01	241.05	4161.36	410.36	104.09	27.31	0.00	0.00	0.00
Hippocampus erectus juveniles	lined seahorse	0.00	1.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A3, page 5 of 6. Location specific plankton-net catch.

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

		Location (km from mouth)											
Description	Common Name	-1.8	-1.0	0.3	1.7	2.9	4.5	6.0	8.9	10.1	12.3	13.3	15.1
Hippocampus erectus adults	lined seahorse	1.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hippocampus zosterae juveniles	dwarf seahorse	1.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Syngnathus floridae juveniles	dusky pipefish	2.63	1.07	0.00	0.00	1.27	0.00	2.47	1.17	0.00	0.00	0.00	0.00
Syngnathus floridae adults	dusky pipefish	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Syngnathus louisianae juveniles	chain pipefish	5.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Syngnathus scovelli juveniles	gulf pipefish	5.37	0.00	1.14	0.00	2.40	9.32	0.00	0.00	0.00	0.00	1.23	0.00
Prionotus spp. preflexion larvae	searobins	0.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prionotus tribulus juveniles	bighead searobin	0.00	0.00	0.00	0.00	1.23	0.00	0.00	0.00	1.22	0.00	0.00	0.00
Lepomis spp. flexion larvae	sunfishes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.21
Oligoplites saurus preflexion larvae	leatherjack	1.10	0.00	0.00	2.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oligoplites saurus flexion larvae	leatherjack	0.00	0.00	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oligoplites saurus postflexion larvae	leatherjack	0.00	0.00	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oligoplites saurus juveniles	leatherjack	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.18	0.00	0.00	0.00	0.00
gerreid preflexion larvae	mojjaras	0.00	0.00	0.00	0.00	0.00	2.67	0.00	0.00	0.00	0.00	0.00	0.00
Eucinostomus spp. postflexion larvae	mojarras	2.34	0.00	0.00	0.00	9.15	15.68	5.02	2.34	1.26	1.15	0.00	0.00
Eucinostomus spp. juveniles	mojarras	7.56	1.34	0.00	0.00	10.65	5.14	14.94	3.52	10.19	0.00	1.23	0.00
Orthopristis chrysoptera flexion larvae	pigfish	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00
Orthopristis chrysoptera postflexion larvae	pigfish	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orthopristis chrysoptera juveniles	pigfish	0.00	3.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Archosargus probatocephalus postflexion larva	sheepshead	2.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lagodon rhomboides postflexion larvae	pinfish	10.71	0.00	0.00	0.00	1.34	0.00	3.77	2.34	0.00	0.00	0.00	0.00
Lagodon rhomboides juveniles	pinfish	22.33	29.42	2.35	6.57	6.24	18.71	2.43	19.15	10.83	0.00	1.16	0.00
Bairdiella chrysoura flexion larvae	silver perch	0.00	0.00	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cynoscion arenarius preflexion larvae	sand seatrout	0.00	2.25	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cynoscion nebulosus preflexion larvae	spotted seatrout	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cynoscion nebulosus juveniles	spotted seatrout	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.21	0.00	0.00	0.00
Leiostomus xanthurus postflexion larvae	spot	1.13	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	1.16	0.00
Leiostomus xanthurus juveniles	spot	17.28	21.01	43.49	11.76	7.39	4.67	12.14	32.98	76.68	28.22	18.01	8.78
Menticirrhus spp. preflexion larvae	kingfishes	19.88	25.17	22.86	5.95	8.10	2.64	0.00	0.00	0.00	0.00	0.00	0.00
Menticirrhus spp. flexion larvae	kingfishes	1.10	3.24	3.57	3.17	0.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00
Menticirrhus spp. postflexion larvae	kingfishes	0.00	0.00	0.00	0.00	2.66	1.29	2.20	0.00	0.00	0.00	0.00	0.00
Sciaenops ocellatus flexion larvae	red drum	0.00	0.00	0.00	0.00	0.00	2.57	0.00	0.00	0.00	0.00	0.00	0.00
Sciaenops ocellatus postflexion larvae	red drum	0.00	0.00	1.15	0.00	1.33	0.00	2.30	0.00	0.00	0.00	0.00	0.00
Mugil cephalus juveniles	striped mullet	0.00	0.00	1.07	0.00	1.11	0.00	0.00	0.00	0.00	1.18	0.00	1.16
Mugil curema juveniles	white mullet	0.00	0.00	0.00	0.00	0.00	0.00	2.51	0.00	0.00	0.00	0.00	0.00
blenniid preflexion larvae	blennies	17.78	20.01	17.93	10.23	10.71	14.67	3.49	0.00	0.00	0.00	0.00	0.00
Hypsoblennius spp. postflexion larvae	blennies	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
gobiid preflexion larvae	gobies	52.64	77.19	49.73	53.02	162.11	97.83	208.76	200.36	267.57	77.69	105.40	127.42
gobiid flexion larvae	gobies	38.90	52.96	41.74	21.51	71.03	50.65	82.31	24.97	58.27	1.06	7.26	7.18
gobiid postflexion larvae	gobies	0.00	0.00	0.00	5.40	2.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bathygobius soporator preflexion larvae	frillfin goby	0.00	1.30	0.00	0.00	3.51	2.35	0.00	0.00	0.00	0.00	1.10	0.00
Bathygobius soporator flexion larvae	frillfin goby	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gobionellus spp. postflexion larvae	gobies	0.00	0.00	0.00	0.00	1.23	1.17	0.00	0.00	0.00	0.00	0.00	0.00
Gobionellus oceanicus juveniles	highfin goby	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	0.00	0.00
Gobiosoma spp. postflexion larvae	gobies	78.99	79.38	42.13	32.85	25.13	62.02	18.12	31.74	58.20	2.26	0.00	0.00
Gobiosoma bosc juveniles	naked goby	0.00	0.00	0.00	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.00
Gobiosoma robustum juveniles	code goby	0.00	0.00	0.00	0.00	0.00	2.57	0.00	0.00	0.00	0.00	0.00	0.00

Table A3, page 6 of 6. Location specific plankton-net catch.

Data are presented as mean number per 1,000 cubic meters.

Organisms are listed in phylogenetic order.

		Location (km from mouth)											
Description	Common Name	-1.8	-1.0	0.3	1.7	2.9	4.5	6.0	8.9	10.1	12.3	13.3	15.1
Microgobius spp. flexion larvae	gobies	0.00	0.00	1.07	18.51	58.62	81.08	69.96	73.85	108.01	5.42	3.52	4.64
Microgobius spp. postflexion larvae	gobies	0.00	0.00	0.00	9.76	24.49	78.04	25.18	37.59	79.14	8.92	2.19	3.64
Microgobius spp. juveniles	gobies	0.00	0.00	0.00	0.00	0.00	26.71	0.00	0.00	0.00	0.00	0.00	0.00
Microgobius gulosus juveniles	clown goby	0.00	0.00	0.00	0.00	0.00	0.00	3.46	4.63	6.04	9.38	1.10	0.00
Paralichthys spp. juveniles	flounders	1.15	4.20	3.43	5.88	0.00	2.34	0.00	0.00	0.00	0.00	0.00	0.00
Achirus lineatus preflexion larvae	lined sole	28.01	31.65	2.54	10.18	4.75	0.00	2.20	0.00	0.00	0.00	0.00	0.00
Achirus lineatus flexion larvae	lined sole	3.65	0.00	2.57	1.06	2.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Achirus lineatus postflexion larvae	lined sole	0.00	1.30	0.00	3.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trinectes maculatus preflexion larvae	hogchoker	12.35	11.36	0.00	0.00	9.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trinectes maculatus flexion larvae	hogchoker	0.00	3.26	0.00	0.00	3.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trinectes maculatus postflexion larvae	hogchoker	0.00	0.00	0.00	0.00	3.54	11.48	1.15	1.05	1.34	0.00	0.00	0.00
Trinectes maculatus juveniles	hogchoker	0.00	0.00	0.00	0.00	2.60	0.00	2.46	0.00	0.00	1.13	0.00	11.33
Stephanolepis hispidus juveniles	planehead filefish	3.10	0.00	0.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chilomycterus schoepfii juveniles	striped burrfish	0.00	0.00	0.00	0.00	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.00
unidentified preflexion larvae	fish	0.00	2.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix B:

Seine and trawl summary tables

Seine catch statistics (October 2004 through September 2005, n=144).

Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	km_U (km)	S_U (psu)	Mean CPUE (No./100m^2)	Max CPUE (No./100m^2)
Farfantepenaeus duorarum	Pink shrimp	80	23	4.405	18.1	0.82	26.47
Palaemonetes intermedius	Brackish grass shrimp	1268	27	2.551	21.9	12.95	727.94
Palaemonetes paludosus	Riverine grass shrimp	3	1	2.49	24.1	0.03	4.41
Palaemonetes pugio	Daggerblade grass shrimp	4101	32	13.41	4.35	41.88	1702.94
Palaemon floridanus	Florida grass shrimp	2	1	0.06	27.9	0.02	2.94
Alpheus spp.	Snapping shrimp	1	1	3.32	24.2	0.01	1.47
Tozeuma carolinense	Arrow shrimp	2	1	-0.77	25	0.02	2.94
Ambidexter symmetricus	Night shrimp	1	1	0.8	22.6	0.01	1.47
Callinectes sapidus	Blue crab	266	62	5.18	18.3	2.72	66.18
Rhinoptera bonasus	Cownose ray	1	1	1.09	31.1	0.01	1.47
Amia calva	Bowfin	4	3	15.74	0.96	0.04	2.94
Elops saurus	Ladyfish	2	1	10.39	0.3	0.02	2.94
Brevoortia spp.	Menhadens	40	3	5.449	16.5	0.41	55.88
Harengula jaguana	Scaled sardine	1	1	2.68	21.8	0.01	1.47
Anchoa hepsetus	Striped anchovy	16	1	1.73	24.5	0.16	23.53
Anchoa mitchilli	Bay anchovy	5919	19	5.058	18.6	60.45	5748.53
Synodus foetens	Inshore lizardfish	34	26	5.178	21.6	0.35	4.41
Notropis petersoni	Coastal shiner	836	5	15.72	0.78	8.54	732.35
Loricariidae spp.	Suckermouth catfish	1	1	13.22	0.1	0.01	1.47
Opsanus beta	Gulf toadfish	1	1	10.39	0.3	0.01	1.47
Hyporhamphus unifasciatus	Silverstripe halfbeak	1	1	-0.96	32.5	0.01	1.47
Hyporhamphus meeki	False silverstripe halfbeak	1	1	-1.68	32.6	0.01	1.47
Strongylura spp.	Needlefishes	3	2	1.833	26.8	0.03	2.94
Strongylura marina	Atlantic needlefish	1	1	4.55	27.4	0.01	1.47
Strongylura notata	Redfin needlefish	198	30	2.474	23.8	2.02	30.88
Strongylura timucu	Timucu	11	8	2.637	23.3	0.11	4.41
Cyprinodon variegatus	Sheepshead minnow	54	8	1.072	26.5	0.55	29.41
Fundulus confluentus	Marsh killifish	4	4	11.77	7.95	0.04	1.47
Fundulus similis	Striped killifish	10	4	3.631	22.2	0.10	8.82
Fundulus grandis	Gulf killifish	65	15	4.124	16.9	0.66	29.41
Lucania parva	Rainwater killifish	87	19	2.419	19.9	0.89	26.47
Lucania goodei	Bluefin killifish	294	6	15.98	0.32	3.00	354.41
Floridichthys carpio	Goldspotted killifish	1044	34	1.204	24.1	10.66	332.35
Gambusia holbrooki	Eastern mosquitofish	777	12	15.71	1.04	7.94	486.76
Poecilia latipinna	Sailfin molly	143	12	11.94	9.13	1.46	101.47
Menidia spp.	Silversides	3422	75	7.925	15.8	34.95	439.71
Labidesthes sicculus	Brook silverside	210	16	14.95	1.96	2.14	77.94
Syngnathus floridae	Dusky pipefish	1	1	8.02	22.3	0.01	1.47
Syngnathus louisianae	Chain pipefish	5	3	3.96	16.9	0.05	4.41
Syngnathus scovelli	Gulf pipefish	40	17	3.931	19.1	0.41	26.47
Prionotus tribulus	Bighead searobin	6	4	4.038	19.9	0.06	2.94
Centropomus undecimalis	Common snook	5	4	5.586	17.9	0.05	2.94
Lepomis spp.	Sunfishes	7	2	15.37	0.19	0.07	5.88
Lepomis auritus	Redbreast sunfish	2	1	16.09	0.3	0.02	2.94
Lepomis gulosus	Warmouth	2	1	16.09	0.3	0.02	2.94
Lepomis macrochirus	Bluegill	154	13	14.81	1.39	1.57	75.00
Lepomis marginatus	Dollar sunfish	18	4	15.38	0.36	0.18	13.24
Lepomis microlophus	Redear sunfish	11	2	15.78	0.25	0.11	13.24
Lepomis punctatus	Spotted sunfish	2	1	16.09	0.3	0.02	2.94
Micropterus salmoides	Largemouth bass	15	9	14.18	2.02	0.15	4.41
Etheostoma fusiforme	Swamp darter	3	2	15.19	1.02	0.03	2.94
Caranx hippos	Crevalle jack	1	1	13.69	5.75	0.01	1.47

Seine catch statistics (October 2004 through September 2005, n=144).

Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	km_U (km)	S_U (psu)	Mean CPUE (No./100m^2)	Max CPUE (No./100m^2)
Caranx latus	Horse-eye jack	1	1	10.09	10.8	0.01	1.47
Oligoplites saurus	Leatherjack	27	15	3.515	23.5	0.28	7.35
Trachinotus falcatus	Permit	7	4	3.317	22.2	0.07	5.88
Lutjanus griseus	Gray snapper	4	2	4.243	11.9	0.04	4.41
Eucinostomus spp.	Eucinostomus mojarras	4458	85	8.484	12.9	45.53	416.18
Eucinostomus gula	Silver jenny	1453	62	3.012	23.3	14.84	185.29
Eucinostomus harengulus	Tidewater mojarra	1453	82	8.01	16.8	14.84	173.53
Eugerres plumieri	Striped mojarra	23	8	12.77	4.94	0.23	11.76
Haemulon plumieri	White grunt	1	1	-1.69	31.7	0.01	1.47
Orthopristis chrysoptera	Pigfish	40	6	3.34	27.2	0.41	38.24
Lagodon rhomboides	Pinfish	11463	116	4.431	21.6	117.06	2979.41
Archosargus probatocephalus	Sheepshead	8	6	8.528	12.6	0.08	2.94
Diplodus holbrooki	Spottail pinfish	18	7	-1.16	30.4	0.18	8.82
Cynoscion nebulosus	Spotted seatrout	12	5	4.818	14.2	0.12	8.82
Bairdiella chrysoura	Silver perch	316	1	2.14	17	3.23	464.71
Leiostomus xanthurus	Spot	26259	76	5.641	17.6	268.17	6458.82
Menticirrhus saxatilis	Northern kingfish	1	1	1.7	24.5	0.01	1.47
Sciaenops ocellatus	Red drum	10	7	7.346	14.6	0.10	4.41
Cichlasoma spp.	Cichlasoma cichlids	13	1	11.45	8.8	0.13	19.12
Tilapia spp.	Tilapias	2	2	13.57	0.53	0.02	1.47
Tilapia melanotheron	Blackchin tilapia	1	1	13.69	5.75	0.01	1.47
Mugil cephalus	Striped mullet	1747	30	14.11	3.87	17.84	920.59
Mugil curema	White mullet	6	3	6.09	13.6	0.06	4.41
Mugil gyrans	Whirligig mullet	42	9	3.201	22	0.43	35.29
Sphyraena borealis	Northern sennet	6	1	4.02	30.8	0.06	8.82
Sphyraena barracuda	Great barracuda	1	1	3.07	18.4	0.01	1.47
Astroscopus y-graecum	Southern stargazer	1	1	2.35	25.5	0.01	1.47
Ctenogobius boleosoma	Darter goby	2	1	2.77	31.7	0.02	2.94
Ctenogobius smaragdus	Emerald goby	1	1	1.84	27.1	0.01	1.47
Gobiosoma spp.	Gobiosoma gobies	18	10	11.8	4.06	0.18	11.76
Gobiosoma bosc	Naked goby	42	18	11.59	7.6	0.43	11.76
Gobiosoma robustum	Code goby	2	2	2.89	17.6	0.02	1.47
Gobiosoma longipala	Twoscale goby	1	1	-0.08	28.3	0.01	1.47
Microgobius gulosus	Clown goby	137	32	12.2	4.67	1.40	61.76
Paralichthys albigutta	Gulf flounder	9	7	3.254	23.1	0.09	2.94
Trinectes maculatus	Hogchoker	92	23	13.84	3.73	0.94	14.71
Achirus lineatus	Lined sole	12	10	5.314	17.6	0.12	4.41
Stephanolepis hispidus	Planehead filefish	4	2	7.308	8.83	0.04	4.41
Sphoeroides nephelus	Southern puffer	91	29	2.376	23.2	0.93	19.12
	Unidentified species	1	1	5.34	21.1	0.01	1.47

Trawl catch statistics (October 2004 through September 2005, n=72).

Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	km_U (km)	S_U (psu)	Mean CPUE (No./100m^2)	Max CPUE (No./100m^2)
Farfantepenaeus duorarum	Pink shrimp	210	19	3.406	22.1	0.40	11.60
Palaemonetes intermedius	Brackish grass shrimp	379	7	0.468	29	0.88	59.87
Palaemonetes pugio	Daggerblade grass shrimp	8	2	15.02	0.43	0.02	1.08
Periclimenes longicaudatus	Longtail grass shrimp	107	3	-1.37	29	0.20	8.36
Palaemon floridanus	Florida grass shrimp	4	2	-1.47	28.1	0.01	0.40
Alpheus spp.	Snapping shrimp	1	1	0.37	29.2	0.00	0.17
Hippolyte zostericola	Zostera shrimp	15	4	-1.3	28.9	0.03	0.94
Lysmata wurdemanni	Peppermint shrimp	1	1	-1.24	28.9	0.00	0.13
Lysmata rathbunae	Rathbun cleaner shrimp	1	1	-1.57	29	0.00	0.13
Tozeuma carolinense	Arrow shrimp	872	6	-1.5	29	1.64	102.27
Thor dobkini	Squat grass shrimp	6	1	-1.57	29	0.01	0.81
Callinectes sapidus	Blue crab	107	37	3.805	22.5	0.21	1.72
Callinectes ornatus	Shelligs	1	1	5.13	4.4	0.00	0.15
Dasyatis sabina	Atlantic stingray	7	7	5.157	21.5	0.01	0.17
Dasyatis say	Bluntnose stingray	2	2	2.457	23	0.00	0.15
Lepisosteus osseus	Longnose gar	4	3	10.91	9.4	0.01	0.27
Amia calva	Bowfin	1	1	14.87	0.3	0.00	0.15
Elops saurus	Ladyfish	1	1	15.11	0.5	0.00	0.27
Anchoa mitchilli	Bay anchovy	888	13	12.68	5.93	2.13	75.33
Synodus foetens	Inshore lizardfish	36	22	4.855	21.6	0.07	0.75
Ariopsis felis	Hardhead catfish	8	3	3.841	17.6	0.02	0.54
Opsanus beta	Gulf toadfish	15	5	-1.28	27.1	0.04	2.02
Gobiesox strumosus	Skilletfish	1	1	5.02	22.6	0.00	0.13
Ogcocephalus radiatus	Polka-dot batfish	1	1	-1.44	30.6	0.00	0.13
Urophycis floridana	Southern hake	3	2	-0.45	27.6	0.01	0.27
Lucania parva	Rainwater killifish	119	4	-1.25	26.6	0.36	25.18
Menidia spp.	Silversides	1	1	-1.04	26.2	0.00	0.13
Labidesthes sicculus	Brook silverside	1	1	13.54	3.13	0.00	0.15
Syngnathus floridae	Dusky pipefish	41	9	-0.88	27.9	0.08	1.89
Syngnathus louisianae	Chain pipefish	6	3	3.317	24.5	0.01	0.40
Syngnathus scovelli	Gulf pipefish	14	8	1.587	27.9	0.03	0.67
Hippocampus erectus	Lined seahorse	1	1	1.09	27.5	0.00	0.13
Scorpaena brasiliensis	Barbfish	8	3	-1.36	28.3	0.02	0.54
Prionotus scitulus	Leopard searobin	14	8	1.525	27	0.03	0.49
Prionotus tribulus	Bighead searobin	13	7	7.654	19.1	0.03	0.75
Serranidae spp.	Sea basses	1	1	-1.54	25.3	0.00	0.15
Centropristis striata	Black sea bass	22	5	-1.39	28	0.05	1.21
Diplectrum formosum	Sand perch	3	1	-1.29	28	0.01	0.51
Lepomis macrochirus	Bluegill	14	4	14.85	0.54	0.03	1.35
Lepomis marginatus	Dollar sunfish	1	1	14.87	0.3	0.00	0.15
Micropterus salmoides	Largemouth bass	7	2	14.82	0.39	0.01	0.60
Lutjanus griseus	Gray snapper	9	8	0.059	24	0.02	0.30
Lutjanus synagris	Lane snapper	8	4	1.175	25.6	0.01	0.40
Ocyurus chrysurus	Yellowtail snapper	7	1	0.37	29.2	0.02	1.18
Eucinostomus spp.	Eucinostomus mojarras	849	28	8.651	12.3	1.69	51.42
Eucinostomus gula	Silver jenny	172	14	0.096	28.5	0.34	11.54
Eucinostomus harengulus	Tidewater mojarra	33	6	12.5	4.09	0.07	3.75
Diapterus plumieri	Striped mojarra	3	1	14.87	0.3	0.01	0.45
Haemulon plumieri	White grunt	33	6	-1.3	27.4	0.07	2.16
Orthopristis chrysoptera	Pigfish	50	7	-0.95	27.4	0.10	2.70
Lagodon rhomboides	Pinfish	2788	28	0.492	26.1	5.79	84.70
Archosargus probatocephalus	Sheepshead	48	13	4.078	21.3	0.09	2.02

Table B2, page 2 of 2.

Trawl catch statistics (October 2004 through September 2005, n=72).

Organisms are listed in phylogenetic order.

Taxon	Common Name	Number Collected	Collection Frequency	km_U (km)	S_U (psu)	Mean CPUE (No./100m^2)	Max CPUE (No./100m^2)
Diplodus holbrooki	Spottail pinfish	16	3	-1.38	26.2	0.04	1.80
Calamus arctifrons	Grass porgy	2	1	2.31	24.1	0.00	0.27
Cynoscion nebulosus	Spotted seatrout	16	6	3.372	18.1	0.03	0.94
Bairdiella chrysoura	Silver perch	28	7	-1.12	26	0.06	2.25
Leiostomus xanthurus	Spot	2354	14	6.821	16.6	5.08	142.26
Menticirrhus americanus	Southern kingfish	13	4	4.978	20.3	0.03	0.81
Menticirrhus saxatilis	Northern kingfish	1	1	6.4	23.9	0.00	0.13
Pogonias cromis	Black drum	2	2	4.62	12.2	0.00	0.13
Sciaenops ocellatus	Red drum	9	2	10.14	6.15	0.02	0.94
Chaetodipterus faber	Atlantic spadefish	2	2	1.265	24.2	0.00	0.13
Sphyraena barracuda	Great barracuda	1	1	-1.54	25.3	0.00	0.15
Lachnolaimus maximus	Hogfish	3	1	-1.54	25.3	0.01	0.45
Nicholsina usta	Emerald parrotfish	10	5	-1.02	28.4	0.02	0.54
Paraclinus fasciatus	Banded blenny	1	1	-1.29	26.5	0.00	0.22
Gobiosoma spp.	Gobiosoma gobies	5	3	0.647	24.9	0.01	0.67
Gobiosoma bosc	Naked goby	2	1	14.76	0.5	0.00	0.30
Gobiosoma robustum	Code goby	13	3	-0.49	27.6	0.03	1.35
Microgobius gulosus	Clown goby	35	13	11.92	7.03	0.07	1.95
Paralichthys albigutta	Gulf flounder	28	17	1.801	27	0.06	0.51
Ancylopsetta quadrocellata	Ocellated flounder	1	1	-0.09	28.6	0.00	0.13
Trinectes maculatus	Hogchoker	29	8	10.83	7.32	0.06	2.25
Achirus lineatus	Lined sole	6	5	1.104	26.4	0.01	0.25
Symphurus plagiusa	Blackcheek tonguefish	23	8	2.318	22.5	0.04	0.67
Monacanthidae spp.	Filefishes	7	1	-1.54	25.3	0.01	1.05
Aluterus schoepfii	Orange filefish	1	1	-0.94	32.4	0.00	0.15
Monacanthus ciliatus	Fringed filefish	8	3	-1.44	26.1	0.02	0.75
Stephanolepis hispidus	Planehead filefish	33	4	-0.68	27.2	0.06	2.02
Acanthostracion quadricornis	Scrawled cowfish	5	4	-1.12	27.7	0.01	0.30
Sphoeroides nephelus	Southern puffer	80	21	2.4	24.6	0.15	1.21
Chilomycterus schoepfii	Striped burrfish	30	13	-0.21	28.3	0.06	1.08

Table B3. Page 1 of 4.

Seine catch by month (October 2004 through September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (12)	Feb (12)	Mar (12)	Apr (12)	May (12)	Jun (12)	Jul (12)	Aug (12)	Sep (12)	Oct (12)	Nov (12)	Dec (12)
Farfantepenaeus duorarum	Pink shrimp	7	0	5	2	1	0	12	0	0	39	8	6
Palaemonetes intermedius	Brackish grass shrimp	1031	90	85	9	4	0	11	0	0	0	11	27
Palaemonetes paludosus	Riverine grass shrimp	0	0	0	0	3	0	0	0	0	0	0	0
Palaemonetes pugio	Daggerblade grass shrimp	650	47	741	1627	138	0	0	0	0	2	256	640
Palaemon floridanus	Florida grass shrimp	0	0	0	0	0	0	0	0	0	0	0	2
Alpheus spp.	Snapping shrimp	0	0	1	0	0	0	0	0	0	0	0	0
Tozeuma carolinense	Arrow shrimp	0	0	0	0	0	0	0	0	2	0	0	0
Ambidexter symmetricus	Night shrimp	1	0	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	Blue crab	79	21	38	32	17	8	5	4	1	47	6	8
Rhinoptera bonasus	Cownose ray	0	0	0	0	0	1	0	0	0	0	0	0
Amia calva	Bowfin	0	0	1	0	0	1	0	0	0	0	2	0
Elops saurus	Ladyfish	0	0	0	0	0	0	2	0	0	0	0	0
Brevoortia spp.	Menhadens	0	1	0	38	1	0	0	0	0	0	0	0
Harengula jaguana	Scaled sardine	1	0	0	0	0	0	0	0	0	0	0	0
Anchoa hepsetus	Striped anchovy	0	0	0	0	16	0	0	0	0	0	0	0
Anchoa mitchilli	Bay anchovy	35	1	6	3909	1775	0	50	10	1	43	2	87
Synodus foetens	Inshore lizardfish	0	4	1	2	4	4	2	2	3	4	5	3
Notropis petersoni	Coastal shiner	1	498	326	0	0	0	0	0	0	0	11	0
Loricariidae spp.	Suckermouth catfish	0	0	0	0	0	0	0	1	0	0	0	0
Opsanus beta	Gulf toadfish	0	0	0	0	0	0	1	0	0	0	0	0
Hyporhamphus unifasciatus	Silverstripe halfbeak	0	0	0	0	0	1	0	0	0	0	0	0
Hyporhamphus meeki	False silverstripe halfbeak	0	0	0	0	0	1	0	0	0	0	0	0
Strongylura spp.	Needlefishes	0	0	0	0	2	1	0	0	0	0	0	0
Strongylura marina	Atlantic needlefish	0	0	0	0	0	0	0	1	0	0	0	0
Strongylura notata	Redfin needlefish	0	0	0	0	2	25	70	69	10	3	3	16
Strongylura timucu	Timucu	0	0	0	0	0	0	0	0	6	1	3	1
Cyprinodon variegatus	Sheepshead minnow	3	9	7	24	0	0	6	0	0	0	0	5
Fundulus confluentus	Marsh killifish	2	0	1	1	0	0	0	0	0	0	0	0
Fundulus similis	Striped killifish	0	0	0	0	0	0	0	0	0	1	6	3
Fundulus grandis	Gulf killifish	29	0	6	1	1	0	19	0	1	0	3	5

Table B3. Page 2 of 4.

Seine catch by month (October 2004 through September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (12)	Feb (12)	Mar (12)	Apr (12)	May (12)	Jun (12)	Jul (12)	Aug (12)	Sep (12)	Oct (12)	Nov (12)	Dec (12)
Lucania parva	Rainwater killifish	22	3	14	6	0	1	28	8	4	0	0	1
Lucania goodei	Bluefin killifish	0	9	0	32	0	0	10	1	0	0	241	1
Floridichthys carpio	Goldspotted killifish	277	201	8	96	0	0	288	6	28	76	15	49
Gambusia holbrooki	Eastern mosquitofish	3	331	3	226	0	1	1	0	48	1	162	1
Poecilia latipinna	Sailfin molly	1	1	1	70	17	0	0	0	35	0	17	1
Menidia spp.	Silversides	299	270	353	160	247	752	199	29	285	126	540	162
Labidesthes sicculus	Brook silverside	4	15	1	14	2	7	3	0	37	22	90	15
Syngnathus floridae	Dusky pipefish	0	0	0	0	0	0	0	0	0	0	0	1
Syngnathus louisianae	Chain pipefish	0	0	0	0	0	0	0	0	0	3	1	1
Syngnathus scovelli	Gulf pipefish	0	1	3	1	2	7	21	0	0	1	1	3
Prionotus tribulus	Bighead searobin	0	0	0	0	0	0	0	0	0	3	3	0
Centropomus undecimalis	Common snook	0	0	0	0	0	1	0	1	2	1	0	0
Lepomis spp.	Sunfishes	0	0	0	0	0	0	0	0	0	3	4	0
Lepomis auritus	Redbreast sunfish	0	0	0	0	0	0	0	0	0	0	2	0
Lepomis gulosus	Warmouth	0	0	0	0	0	0	0	0	0	0	2	0
Lepomis macrochirus	Bluegill	0	0	16	1	13	4	0	4	18	27	62	9
Lepomis marginatus	Dollar sunfish	0	0	4	0	0	0	0	0	0	4	9	1
Lepomis microlophus	Redear sunfish	0	0	0	0	0	0	0	0	0	2	9	0
Lepomis punctatus	Spotted sunfish	0	0	0	0	0	0	0	0	0	0	2	0
Micropterus salmoides	Largemouth bass	0	1	0	0	0	1	1	5	4	3	0	0
Etheostoma fusiforme	Swamp darter	0	0	0	0	0	0	0	0	0	0	2	1
Caranx hippos	Crevalle jack	0	0	0	0	0	0	0	0	1	0	0	0
Caranx latus	Horse-eye jack	0	0	0	0	0	0	0	0	0	0	1	0
Oligoplites saurus	Leatherjack	0	0	0	0	0	0	7	9	10	0	1	0
Trachinotus falcatus	Permit	0	0	0	0	0	0	0	0	2	1	4	0
Lutjanus griseus	Gray snapper	0	0	0	0	0	0	1	0	0	3	0	0
Eucinostomus spp.	Eucinostomus mojarras	355	641	365	355	72	1	638	8	22	379	817	805
Eucinostomus gula	Silver jenny	101	51	3	121	56	56	17	110	185	223	313	217
Eucinostomus harengulus	Tidewater mojarra	17	36	64	139	104	213	110	182	212	79	146	151
Eugerres plumieri	Striped mojarra	4	0	0	0	0	0	0	0	4	11	1	3

Table B3. Page 3 of 4.

Seine catch by month (October 2004 through September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (12)	Feb (12)	Mar (12)	Apr (12)	May (12)	Jun (12)	Jul (12)	Aug (12)	Sep (12)	Oct (12)	Nov (12)	Dec (12)
Haemulon plumieri	White grunt	0	0	0	0	0	0	1	0	0	0	0	0
Orthopristis chrysoptera	Pigfish	0	0	0	0	1	28	10	1	0	0	0	0
Lagodon rhomboides	Pinfish	909	2945	4551	1169	609	407	567	37	66	59	42	102
Archosargus probatocephalus	Sheepshead	0	0	0	0	0	1	2	3	0	0	0	2
Diplodus holbrooki	Spottail pinfish	0	0	0	0	0	8	5	0	3	1	1	0
Cynoscion nebulosus	Spotted seatrout	0	0	0	0	0	0	5	0	0	6	1	0
Bairdiella chrysoura	Silver perch	0	0	0	0	0	0	316	0	0	0	0	0
Leiostomus xanthurus	Spot	15045	5973	2907	990	996	250	87	2	4	0	5	0
Menticirrhus saxatilis	Northern kingfish	0	0	0	0	1	0	0	0	0	0	0	0
Sciaenops ocellatus	Red drum	2	0	0	0	1	0	0	0	2	0	4	1
Cichlasoma spp.	Cichlasoma cichlids	0	0	0	0	0	0	0	0	0	0	13	0
Tilapia spp.	Tilapias	0	0	0	0	1	0	0	1	0	0	0	0
Tilapia melanotheron	Blackchin tilapia	0	0	0	0	0	0	0	0	1	0	0	0
Mugil cephalus	Striped mullet	60	315	293	345	649	73	4	0	0	0	6	2
Mugil curema	White mullet	0	0	0	0	1	0	3	0	0	0	2	0
Mugil gyrans	Whirligig mullet	0	0	2	0	0	0	2	0	0	3	35	0
Sphyraena borealis	Northern sennet	0	0	0	0	0	6	0	0	0	0	0	0
Sphyraena barracuda	Great barracuda	0	0	0	0	0	0	0	0	0	1	0	0
Astroscopus y-graecum	Southern stargazer	0	0	1	0	0	0	0	0	0	0	0	0
Ctenogobius boleosoma	Darter goby	0	0	0	0	0	2	0	0	0	0	0	0
Ctenogobius smaragdus	Emerald goby	0	0	0	1	0	0	0	0	0	0	0	0
Gobiosoma spp.	Gobiosoma gobies	0	0	1	0	0	0	1	10	0	2	3	1
Gobiosoma bosc	Naked goby	0	6	6	4	0	0	3	6	0	1	1	15
Gobiosoma robustum	Code goby	0	0	0	0	0	0	1	0	0	1	0	0
Gobiosoma longipala	Twoscale goby	0	0	1	0	0	0	0	0	0	0	0	0
Microgobius gulosus	Clown goby	2	7	3	7	1	2	11	20	11	7	11	55
Paralichthys albigutta	Gulf flounder	0	2	2	0	2	0	1	1	0	0	1	0
Trinectes maculatus	Hogchoker	0	7	3	3	20	7	1	7	7	13	7	17
Achirus lineatus	Lined sole	0	0	0	0	2	0	2	0	1	4	1	2
Stephanolepis hispidus	Planehead filefish	0	0	0	0	0	0	1	0	0	3	0	0

Table B3. Page 4 of 4.

Seine catch by month (October 2004 through September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (12)	Feb (12)	Mar (12)	Apr (12)	May (12)	Jun (12)	Jul (12)	Aug (12)	Sep (12)	Oct (12)	Nov (12)	Dec (12)
Sphoeroides nephelus	Southern puffer	4	5	12	1	28	5	4	0	0	19	4	9
	Unidentified species	0	1	0	0	0	0	0	0	0	0	0	0

Table B4. Page 1 of 3.

Trawl catch by month (October 2004 through September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (6)	Feb (6)	Mar (6)	Apr (6)	May (6)	Jun (6)	Jul (6)	Aug (6)	Sep (6)	Oct (6)	Nov (6)	Dec (6)
Farfantepenaeus duorarum	Pink shrimp	15	8	0	5	2	0	16	0	5	30	87	42
Palaemonetes intermedius	Brackish grass shrimp	10	0	0	356	2	0	0	1	7	0	0	3
Palaemonetes pugio	Daggerblade grass shrimp	4	0	0	4	0	0	0	0	0	0	0	0
Periclimenes longicaudatus	Longtail grass shrimp	0	40	0	5	0	0	0	0	0	0	0	62
Palaemon floridanus	Florida grass shrimp	0	3	0	0	0	0	0	0	1	0	0	0
Alpheus spp.	Snapping shrimp	0	0	0	1	0	0	0	0	0	0	0	0
Hippolyte zostericola	Zostera shrimp	0	7	0	5	0	0	0	0	2	0	0	1
Lysmata wurdemanni	Peppermint shrimp	0	0	0	0	0	0	0	0	0	0	0	1
Lysmata rathbunae	Rathbun cleaner shrimp	0	1	0	0	0	0	0	0	0	0	0	0
Tozeuma carolinense	Arrow shrimp	0	758	0	25	0	0	0	0	2	0	0	87
Thor dobkini	Squat grass shrimp	0	6	0	0	0	0	0	0	0	0	0	0
Callinectes sapidus	Blue crab	9	12	5	13	13	5	7	6	6	8	7	16
Callinectes ornatus	Shelligs	0	0	0	0	0	0	1	0	0	0	0	0
Dasyatis sabina	Atlantic stingray	0	3	1	0	1	0	0	0	0	0	1	1
Dasyatis say	Bluntnose stingray	1	0	0	0	1	0	0	0	0	0	0	0
Lepisosteus osseus	Longnose gar	2	1	1	0	0	0	0	0	0	0	0	0
Amia calva	Bowfin	1	0	0	0	0	0	0	0	0	0	0	0
Elops saurus	Ladyfish	0	0	0	1	0	0	0	0	0	0	0	0
Anchoa mitchilli	Bay anchovy	161	335	0	1	5	0	1	0	9	125	2	249
Synodus foetens	Inshore lizardfish	5	6	0	1	4	0	1	2	2	5	4	6
Ariopsis felis	Hardhead catfish	0	0	0	0	0	0	2	2	0	4	0	0
Opsanus beta	Gulf toadfish	0	0	0	0	0	2	0	0	9	1	2	1
Gobiesox strumosus	Skilletfish	0	0	0	0	0	0	0	0	0	0	1	0
Ogcocephalus radiatus	Polka-dot batfish	0	0	1	0	0	0	0	0	0	0	0	0
Urophycis floridana	Southern hake	0	3	0	0	0	0	0	0	0	0	0	0
Lucania parva	Rainwater killifish	0	0	0	2	0	3	0	0	114	0	0	0
Menidia spp.	Silversides	0	0	0	0	1	0	0	0	0	0	0	0
Labidesthes sicculus	Brook silverside	0	0	0	0	0	0	0	0	0	0	0	1
Syngnathus floridae	Dusky pipefish	7	7	0	2	0	2	0	0	0	0	2	21
Syngnathus louisianae	Chain pipefish	0	0	0	0	0	0	0	0	0	0	1	5
Syngnathus scovelli	Gulf pipefish	0	1	1	3	1	1	1	0	1	0	0	5
Hippocampus erectus	Lined seahorse	0	0	0	0	0	0	0	0	0	0	0	1

Table B4. Page 2 of 3.

Trawl catch by month (October 2004 through September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (6)	Feb (6)	Mar (6)	Apr (6)	May (6)	Jun (6)	Jul (6)	Aug (6)	Sep (6)	Oct (6)	Nov (6)	Dec (6)
Scorpaena brasiliensis	Barbfish	0	0	0	2	0	0	0	0	0	0	2	4
Prionotus scitulus	Leopard searobin	1	3	5	0	0	0	3	0	0	1	0	1
Prionotus tribulus	Bighead searobin	1	9	1	0	0	0	0	0	0	0	0	2
Serranidae spp.	Sea basses	0	0	0	0	0	0	0	0	0	0	1	0
Centropristis striata	Black sea bass	0	9	0	0	0	0	0	2	3	0	4	4
Diplectrum formosum	Sand perch	0	0	0	0	0	0	0	0	0	3	0	0
Lepomis macrochirus	Bluegill	9	0	0	0	0	0	1	0	1	3	0	0
Lepomis marginatus	Dollar sunfish	1	0	0	0	0	0	0	0	0	0	0	0
Micropterus salmoides	Largemouth bass	4	0	0	0	3	0	0	0	0	0	0	0
Lutjanus griseus	Gray snapper	2	0	0	0	0	1	1	0	2	0	2	1
Lutjanus synagris	Lane snapper	0	0	0	0	0	0	0	0	0	2	1	5
Ocyurus chrysurus	Yellowtail snapper	0	0	0	7	0	0	0	0	0	0	0	0
Eucinostomus spp.	Eucinostomus mojarras	36	1	0	0	0	9	44	4	1	6	222	526
Eucinostomus gula	Silver jenny	3	0	0	5	0	0	2	78	15	9	6	54
Eucinostomus harengulus	Tidewater mojarra	27	0	0	0	0	0	2	2	1	0	1	0
Diapterus plumieri	Striped mojarra	3	0	0	0	0	0	0	0	0	0	0	0
Haemulon plumieri	White grunt	10	1	0	0	0	2	0	0	3	1	0	16
Orthopristis chrysoptera	Pigfish	0	3	0	0	4	6	0	0	0	7	18	12
Lagodon rhomboides	Pinfish	707	884	7	250	9	309	2	20	55	28	196	321
Archosargus probatocephalus	Sheepshead	15	4	0	0	4	0	2	1	16	1	2	3
Diplodus holbrooki	Spottail pinfish	0	0	0	0	0	0	0	0	8	0	7	1
Calamus arctifrons	Grass porgy	0	0	0	0	2	0	0	0	0	0	0	0
Cynoscion nebulosus	Spotted seatrout	0	0	0	1	0	0	5	0	9	1	0	0
Bairdiella chrysoura	Silver perch	0	3	0	0	0	1	1	0	0	1	15	7
Leiostomus xanthurus	Spot	659	1675	3	5	12	0	0	0	0	0	0	0
Menticirrhus americanus	Southern kingfish	0	0	0	0	0	0	2	0	4	1	6	0
Menticirrhus saxatilis	Northern kingfish	0	0	0	0	1	0	0	0	0	0	0	0
Pogonias cromis	Black drum	0	0	0	0	0	0	1	0	0	1	0	0
Sciaenops ocellatus	Red drum	0	0	0	0	0	0	0	0	0	7	2	0
Chaetodipterus faber	Atlantic spadefish	0	0	0	0	0	0	0	0	1	1	0	0
Sphyraena barracuda	Great barracuda	0	0	0	0	0	0	0	0	0	0	1	0
Lachnolaimus maximus	Hogfish	0	0	0	0	0	0	0	0	0	0	3	0

Table B4. Page 3 of 3.

Trawl catch by month (October 2004 through September 2005).

Number of monthly samples is indicated in parentheses.

Taxon	Common Name	Jan (6)	Feb (6)	Mar (6)	Apr (6)	May (6)	Jun (6)	Jul (6)	Aug (6)	Sep (6)	Oct (6)	Nov (6)	Dec (6)
Nicholsina usta	Emerald parrotfish	0	1	1	2	0	0	0	0	0	0	2	4
Paraclinus fasciatus	Banded blenny	0	0	0	0	0	0	0	0	1	0	0	0
Gobiosoma spp.	Gobiosoma gobies	0	0	0	1	0	0	0	0	4	0	0	0
Gobiosoma bosc	Naked goby	0	0	0	0	2	0	0	0	0	0	0	0
Gobiosoma robustum	Code goby	0	0	0	6	0	0	0	0	6	0	0	1
Microgobius gulosus	Clown goby	0	0	0	0	1	0	6	3	20	2	2	1
Paralichthys albigutta	Gulf flounder	1	3	6	3	2	1	1	3	3	3	0	2
Ancylopsetta quadrocellata	Ocellated flounder	0	0	0	0	0	0	1	0	0	0	0	0
Trinectes maculatus	Hogchoker	1	0	0	0	0	0	16	0	3	8	0	1
Achirus lineatus	Lined sole	0	0	0	0	0	0	0	0	1	2	0	3
Symphurus plagiusa	Blackcheek tonguefish	0	0	0	0	0	0	2	0	1	10	6	4
Monacanthidae spp.	Filefishes	0	0	0	0	0	0	0	0	0	0	7	0
Aluterus schoepfii	Orange filefish	0	0	0	0	0	1	0	0	0	0	0	0
Monacanthus ciliatus	Fringed filefish	5	2	0	0	0	0	0	0	0	0	0	1
Stephanolepis hispidus	Planehead filefish	0	0	0	0	0	0	0	0	0	0	11	22
Acanthostracion quadricornis	Scrawled cowfish	0	1	2	0	0	0	0	0	0	0	2	0
Sphoeroides nephelus	Southern puffer	7	8	8	3	18	7	2	0	0	7	9	11
Chilomycterus schoepfii	Striped burrfish	0	4	0	2	1	4	0	1	1	1	2	14

Table B5, page 1 of 2. Location-specific seine catch.

Data are presented as mean number per $100m^2$.

Organisms are listed in phylogenetic order.

Taxon	Common Name	Location (km from mouth) -1.8-0.0	0.0-2.4	2.4-5.4	5.4-9.8	9.8-13.2	13.2-16.1
Farfantepenaeus duorarum	Pink shrimp	0.368	1.042	1.838	1.287	0.368	0.000
Palaemonetes intermedius	Brackish grass shrimp	7.966	4.779	63.664	1.287	0.000	0.000
Palaemonetes paludosus	Riverine grass shrimp	0.000	0.000	0.184	0.000	0.000	0.000
Palaemonetes pugio	Daggerblade grass shrimp	0.000	0.061	0.000	0.674	118.260	132.292
Palaemon floridanus	Florida grass shrimp	0.000	0.123	0.000	0.000	0.000	0.000
Alpheus spp.	Snapping shrimp	0.000	0.000	0.061	0.000	0.000	0.000
Tozeuma carolinense	Arrow shrimp	0.123	0.000	0.000	0.000	0.000	0.000
Ambidexter symmetricus	Night shrimp	0.000	0.061	0.000	0.000	0.000	0.000
Callinectes sapidus	Blue crab	0.551	5.821	4.228	1.287	3.309	1.103
Rhinoptera bonasus	Cownose ray	0.000	0.061	0.000	0.000	0.000	0.000
Amia calva	Bowfin	0.000	0.000	0.000	0.000	0.000	0.245
Elops saurus	Ladyfish	0.000	0.000	0.000	0.000	0.123	0.000
Brevoortia spp.	Menhadens	0.000	0.061	2.328	0.000	0.000	0.061
Harengula jaguana	Scaled sardine	0.000	0.000	0.061	0.000	0.000	0.000
Anchoa hepsetus	Striped anchovy	0.000	0.980	0.000	0.000	0.000	0.000
Anchoa mitchilli	Bay anchovy	0.000	66.176	242.463	45.772	5.760	2.512
Synodus foetens	Inshore lizardfish	0.245	0.184	0.797	0.551	0.306	0.000
Notropis petersoni	Coastal shiner	0.000	0.000	0.000	0.000	0.000	51.225
Loricariidae spp.	Suckermouth catfish	0.000	0.000	0.000	0.000	0.000	0.061
Opsanus beta	Gulf toadfish	0.000	0.000	0.000	0.000	0.061	0.000
Hyporhamphus unifasciatus	Silverstripe halfbeak	0.061	0.000	0.000	0.000	0.000	0.000
Hyporhamphus meeki	False silverstripe halfbeak	0.061	0.000	0.000	0.000	0.000	0.000
Strongylura spp.	Needlefishes	0.000	0.184	0.000	0.000	0.000	0.000
Strongylura marina	Atlantic needlefish	0.000	0.000	0.061	0.000	0.000	0.000
Strongylura notata	Redfin needlefish	4.105	2.145	3.431	2.206	0.245	0.000
Strongylura timucu	Timucu	0.061	0.368	0.184	0.061	0.000	0.000
Cyprinodon variegatus	Sheepshead minnow	2.206	0.797	0.000	0.061	0.245	0.000
Fundulus confluentus	Marsh killifish	0.000	0.000	0.000	0.000	0.184	0.061
Fundulus similis	Striped killifish	0.000	0.123	0.490	0.000	0.000	0.000
Fundulus grandis	Gulf killifish	1.225	0.797	0.551	0.429	0.919	0.061
Lucania parva	Rainwater killifish	2.512	1.838	0.123	0.000	0.858	0.000
Lucania goodei	Bluefin killifish	0.000	0.000	0.000	0.000	0.061	17.953
Floridichthys carpio	Goldspotted killifish	24.510	21.140	18.260	0.061	0.000	0.000
Gambusia holbrooki	Eastern mosquitofish	0.000	0.000	0.000	0.000	0.061	47.549
Poecilia latipinna	Sailfin molly	0.000	0.061	0.000	0.061	6.066	2.574
Menidia spp.	Silversides	0.858	39.767	22.488	59.130	51.961	35.478
Labidesthes sicculus	Brook silverside	0.000	0.000	0.000	0.000	0.000	12.868
Syngnathus floridae	Dusky pipefish	0.000	0.000	0.000	0.061	0.000	0.000
Syngnathus louisianae	Chain pipefish	0.061	0.000	0.184	0.000	0.061	0.000
Syngnathus scovelli	Gulf pipefish	0.123	1.409	0.368	0.123	0.429	0.000
Prionotus tribulus	Bighead searobin	0.000	0.000	0.306	0.061	0.000	0.000
Centropomus undecimalis	Common snook	0.123	0.000	0.000	0.061	0.123	0.000
Lepomis spp.	Sunfishes	0.000	0.000	0.000	0.000	0.000	0.429
Lepomis auritus	Redbreast sunfish	0.000	0.000	0.000	0.000	0.000	0.123
Lepomis gulosus	Warmouth	0.000	0.000	0.000	0.000	0.000	0.123
Lepomis macrochirus	Bluegill	0.000	0.000	0.000	0.061	0.306	9.069
Lepomis marginatus	Dollar sunfish	0.000	0.000	0.000	0.000	0.000	1.103
Lepomis microlophus	Redear sunfish	0.000	0.000	0.000	0.000	0.000	0.674
Lepomis punctatus	Spotted sunfish	0.000	0.000	0.000	0.000	0.000	0.123
Micropterus salmoides	Largemouth bass	0.000	0.000	0.000	0.000	0.184	0.735
Etheostoma fusiforme	Swamp darter	0.000	0.000	0.000	0.000	0.000	0.184
Caranx hippos	Crevalle jack	0.000	0.000	0.000	0.000	0.000	0.061
Caranx latus	Horse-eye jack	0.000	0.000	0.000	0.000	0.061	0.000
Oligoplites saurus	Leatherjack	0.061	0.735	0.490	0.245	0.123	0.000
Trachinotus falcatus	Permit	0.000	0.306	0.061	0.061	0.000	0.000
Lutjanus griseus	Gray snapper	0.061	0.000	0.000	0.184	0.000	0.000
Eucinostomus spp.	Eucinostomus mojarras	16.789	25.735	46.385	24.755	103.983	55.515
Eucinostomus gula	Silver jenny	6.740	26.532	49.755	5.944	0.061	0.000
Eucinostomus harengulus	Tidewater mojarra	0.000	7.047	25.000	22.120	22.733	12.132

Table B5, page 2 of 2. Location-specific seine catch.

Data are presented as mean number per $100m^2$.

Organisms are listed in phylogenetic order.

Taxon	Common Name	Location (km from mouth) -1.8-0.0	0.0-2.4	2.4-5.4	5.4-9.8	9.8-13.2	13.2-16.1
Eugerres plumieri	Striped mojarra	0.000	0.000	0.000	0.184	0.490	0.735
Haemulon plumieri	White grunt	0.061	0.000	0.000	0.000	0.000	0.000
Orthopristis chrysoptera	Pigfish	0.000	0.797	1.654	0.000	0.000	0.000
Lagodon rhomboides	Pinfish	89.093	80.699	367.279	73.407	89.461	2.451
Archosargus probatocephalus	Sheepshead	0.000	0.061	0.000	0.245	0.184	0.000
Diplodus holbrooki	Spottail pinfish	1.103	0.000	0.000	0.000	0.000	0.000
Cynoscion nebulosus	Spotted seatrout	0.000	0.123	0.368	0.184	0.061	0.000
Bairdiella chrysoura	Silver perch	0.000	19.363	0.000	0.000	0.000	0.000
Leiostomus xanthurus	Spot	173.591	415.931	295.956	112.316	541.238	69.975
Menticirrhus saxatilis	Northern kingfish	0.000	0.061	0.000	0.000	0.000	0.000
Sciaenops ocellatus	Red drum	0.184	0.000	0.000	0.000	0.368	0.061
Cichlasoma spp.	Cichlasoma cichlids	0.000	0.000	0.000	0.000	0.797	0.000
Tilapia spp.	Tilapias	0.000	0.000	0.000	0.000	0.061	0.061
Tilapia melanotheron	Blackchin tilapia	0.000	0.000	0.000	0.000	0.000	0.061
Mugil cephalus	Striped mullet	0.797	0.061	4.718	0.490	16.912	84.069
Mugil curema	White mullet	0.000	0.061	0.000	0.306	0.000	0.000
Mugil gyrans	Whirligig mullet	0.306	0.368	1.593	0.184	0.123	0.000
Sphyraena borealis	Northern sennet	0.000	0.000	0.368	0.000	0.000	0.000
Sphyraena barracuda	Great barracuda	0.000	0.000	0.061	0.000	0.000	0.000
Astroscopus y-graecum	Southern stargazer	0.000	0.061	0.000	0.000	0.000	0.000
Ctenogobius boleosoma	Darter goby	0.000	0.000	0.123	0.000	0.000	0.000
Ctenogobius smaragdus	Emerald goby	0.000	0.061	0.000	0.000	0.000	0.000
Gobiosoma spp.	Gobiosoma gobies	0.000	0.000	0.123	0.123	0.123	0.735
Gobiosoma bosc	Naked goby	0.000	0.061	0.245	0.306	0.858	1.103
Gobiosoma robustum	Code goby	0.000	0.000	0.123	0.000	0.000	0.000
Gobiosoma longipala	Twoscale goby	0.061	0.000	0.000	0.000	0.000	0.000
Microgobius gulosus	Clown goby	0.000	0.123	0.245	0.368	4.841	2.819
Paralichthys albigutta	Gulf flounder	0.000	0.245	0.184	0.123	0.000	0.000
Trinectes maculatus	Hogchoker	0.000	0.000	0.000	0.123	1.348	4.167
Achirus lineatus	Lined sole	0.000	0.061	0.368	0.245	0.061	0.000
Stephanolepis hispidus	Planehead filefish	0.000	0.061	0.000	0.184	0.000	0.000
Sphoeroides nephelus	Southern puffer	0.490	3.064	1.532	0.306	0.184	0.000
	Unidentified species	0.000	0.000	0.061	0.000	0.000	0.000

Table B6, page 1 of 2. Location-specific trawl catch.

Data are presented as mean number per $100m^2$.

Organisms are listed in phylogenetic order.

Taxon	Common Name	Location (km from mouth) -1.8-0.0	0.0-2.4	2.4-5.4	5.4-9.8	9.8-13.2	13.2-16.1
Farfantepenaeus duorarum	Pink shrimp	0.166	0.390	1.835	0.027	0.000	0.000
Palaemonetes intermedius	Brackish grass shrimp	0.012	5.124	0.137	0.000	0.000	0.000
Palaemonetes pugio	Daggerblade grass shrimp	0.000	0.000	0.000	0.000	0.000	0.140
Periclimenes longicaudatus	Longtail grass shrimp	1.209	0.000	0.000	0.000	0.000	0.000
Palaemon floridanus	Florida grass shrimp	0.052	0.000	0.000	0.000	0.000	0.000
Alpheus spp.	Snapping shrimp	0.000	0.014	0.000	0.000	0.000	0.000
Hippolyte zostericola	Zostera shrimp	0.179	0.011	0.000	0.000	0.000	0.000
Lysmata wurdemanni	Peppermint shrimp	0.011	0.000	0.000	0.000	0.000	0.000
Lysmata rathbunae	Rathbun cleaner shrimp	0.011	0.000	0.000	0.000	0.000	0.000
Tozeuma carolinense	Arrow shrimp	9.730	0.112	0.000	0.000	0.000	0.000
Thor dobkini	Squat grass shrimp	0.067	0.000	0.000	0.000	0.000	0.000
Callinectes sapidus	Blue crab	0.120	0.263	0.627	0.180	0.045	0.042
Callinectes ornatus	Shelligs	0.000	0.000	0.012	0.000	0.000	0.000
Dasyatis sabina	Atlantic stingray	0.011	0.014	0.023	0.022	0.012	0.000
Dasyatis say	Bluntnose stingray	0.000	0.011	0.012	0.000	0.000	0.000
Lepisosteus osseus	Longnose gar	0.000	0.000	0.000	0.012	0.034	0.000
Amia calva	Bowfin	0.000	0.000	0.000	0.000	0.000	0.012
Elops saurus	Ladyfish	0.000	0.000	0.000	0.000	0.000	0.022
Anchoa mitchilli	Bay anchovy	0.000	0.090	1.046	0.195	1.990	9.485
Synodus foetens	Inshore lizardfish	0.037	0.079	0.108	0.184	0.011	0.000
Ariopsis felis	Hardhead catfish	0.000	0.045	0.025	0.025	0.000	0.000
Opsanus beta	Gulf toadfish	0.244	0.000	0.000	0.000	0.000	0.000
Gobiesox strumosus	Skilletfish	0.000	0.000	0.011	0.000	0.000	0.000
Ogcocephalus radiatus	Polka-dot batfish	0.011	0.000	0.000	0.000	0.000	0.000
Urophycis floridana	Southern hake	0.022	0.014	0.000	0.000	0.000	0.000
Lucania parva	Rainwater killifish	2.161	0.022	0.000	0.000	0.000	0.000
Menidia spp.	Silversides	0.011	0.000	0.000	0.000	0.000	0.000
Labidesthes sicculus	Brook silverside	0.000	0.000	0.000	0.000	0.000	0.012
Syngnathus floridae	Dusky pipefish	0.386	0.082	0.010	0.000	0.000	0.000
Syngnathus louisianae	Chain pipefish	0.000	0.034	0.020	0.000	0.011	0.000
Syngnathus scovelli	Gulf pipefish	0.000	0.135	0.023	0.010	0.000	0.000
Hippocampus erectus	Lined seahorse	0.000	0.011	0.000	0.000	0.000	0.000
Scorpaena brasiliensis	Barbfish	0.095	0.000	0.000	0.000	0.000	0.000
Prionotus scitulus	Leopard searobin	0.048	0.039	0.076	0.000	0.000	0.000
Prionotus tribulus	Bighead searobin	0.000	0.014	0.020	0.073	0.049	0.000
Serranidae spp.	Sea basses	0.012	0.000	0.000	0.000	0.000	0.000
Centropristis striata	Black sea bass	0.277	0.000	0.000	0.000	0.000	0.000
Diplectrum formosum	Sand perch	0.042	0.000	0.000	0.000	0.000	0.000
Lepomis macrochirus	Bluegill	0.000	0.000	0.000	0.000	0.000	0.171
Lepomis marginatus	Dollar sunfish	0.000	0.000	0.000	0.000	0.000	0.012
Micropterus salmoides	Largemouth bass	0.000	0.000	0.000	0.000	0.000	0.087
Lutjanus griseus	Gray snapper	0.080	0.024	0.012	0.000	0.000	0.000
Lutjanus synagris	Lane snapper	0.034	0.022	0.034	0.000	0.000	0.000
Ocyurus chrysurus	Yellowtail snapper	0.000	0.098	0.000	0.000	0.000	0.000
Eucinostomus spp.	Eucinostomus mojarras	0.978	1.430	1.726	0.055	1.066	4.868
Eucinostomus gula	Silver jenny	1.187	0.800	0.070	0.000	0.000	0.000
Eucinostomus harengulus	Tidewater mojarra	0.025	0.011	0.036	0.000	0.022	0.312
Diapterus plumieri	Striped mojarra	0.000	0.000	0.000	0.000	0.000	0.037
Haemulon plumieri	White grunt	0.411	0.000	0.000	0.000	0.000	0.000
Orthopristis chrysoptera	Pigfish	0.533	0.079	0.000	0.000	0.000	0.000
Lagodon rhomboides	Pinfish	20.049	4.253	10.137	0.056	0.175	0.069
Archosargus probatocephalus	Sheepshead	0.000	0.376	0.060	0.044	0.081	0.000
Diplodus holbrooki	Spottail pinfish	0.249	0.000	0.000	0.000	0.000	0.000
Calamus arctifrons	Grass porgy	0.000	0.022	0.000	0.000	0.000	0.000
Cynoscion nebulosus	Spotted seatrout	0.019	0.093	0.074	0.000	0.011	0.000
Bairdiella chrysoura	Silver perch	0.315	0.011	0.012	0.000	0.000	0.000
Leiostomus xanthurus	Spot	0.000	6.282	12.028	0.161	8.253	3.746
Menticirrhus americanus	Southern kingfish	0.000	0.000	0.154	0.000	0.000	0.000
Menticirrhus saxatilis	Northern kingfish	0.000	0.000	0.000	0.011	0.000	0.000

Table B6, page 2 of 2. Location-specific trawl catch.

Data are presented as mean number per $100m^2$.

Organisms are listed in phylogenetic order.

Taxon	Common Name	Location (km from mouth) -1.8-0.0	0.0-2.4	2.4-5.4	5.4-9.8	9.8-13.2	13.2-16.1
Pogonias cromis	Black drum	0.000	0.011	0.000	0.011	0.000	0.000
Sciaenops ocellatus	Red drum	0.000	0.000	0.000	0.000	0.101	0.000
Chaetodipterus faber	Atlantic spadefish	0.000	0.022	0.000	0.000	0.000	0.000
Sphyraena barracuda	Great barracuda	0.012	0.000	0.000	0.000	0.000	0.000
Lachnolaimus maximus	Hogfish	0.037	0.000	0.000	0.000	0.000	0.000
Nicholsina usta	Emerald parrotfish	0.106	0.000	0.010	0.000	0.000	0.000
Paraclinus fasciatus	Banded blenny	0.019	0.000	0.000	0.000	0.000	0.000
Gobiosoma spp.	Gobiosoma gobies	0.069	0.000	0.000	0.000	0.011	0.000
Gobiosoma bosc	Naked goby	0.000	0.000	0.000	0.000	0.000	0.025
Gobiosoma robustum	Code goby	0.112	0.096	0.000	0.000	0.000	0.000
Microgobius gulosus	Clown goby	0.014	0.020	0.023	0.022	0.115	0.221
Paralichthys albigutta	Gulf flounder	0.038	0.146	0.151	0.000	0.000	0.000
Ancylopsetta quadrocellata	Ocellated flounder	0.011	0.000	0.000	0.000	0.000	0.000
Trinectes maculatus	Hogchoker	0.070	0.000	0.021	0.000	0.012	0.260
Achirus lineatus	Lined sole	0.014	0.034	0.020	0.000	0.000	0.000
Symphurus plagiusa	Blackcheek tonguefish	0.056	0.043	0.168	0.000	0.000	0.000
Monacanthidae spp.	Filefishes	0.087	0.000	0.000	0.000	0.000	0.000
Aluterus schoepfii	Orange filefish	0.012	0.000	0.000	0.000	0.000	0.000
Monacanthus ciliatus	Fringed filefish	0.096	0.000	0.000	0.000	0.000	0.000
Stephanolepis hispidus	Planehead filefish	0.294	0.079	0.011	0.000	0.000	0.000
Acanthostracion quadricornis	Scrawled cowfish	0.047	0.011	0.000	0.000	0.000	0.000
Sphoeroides nephelus	Southern puffer	0.139	0.258	0.520	0.000	0.011	0.000
Chilomycterus schoepfii	Striped burrfish	0.207	0.141	0.012	0.000	0.000	0.000

Appendix C:

Length-frequency plots for selected taxa

Farfantepenaeus duorarum (Pink shrimp)

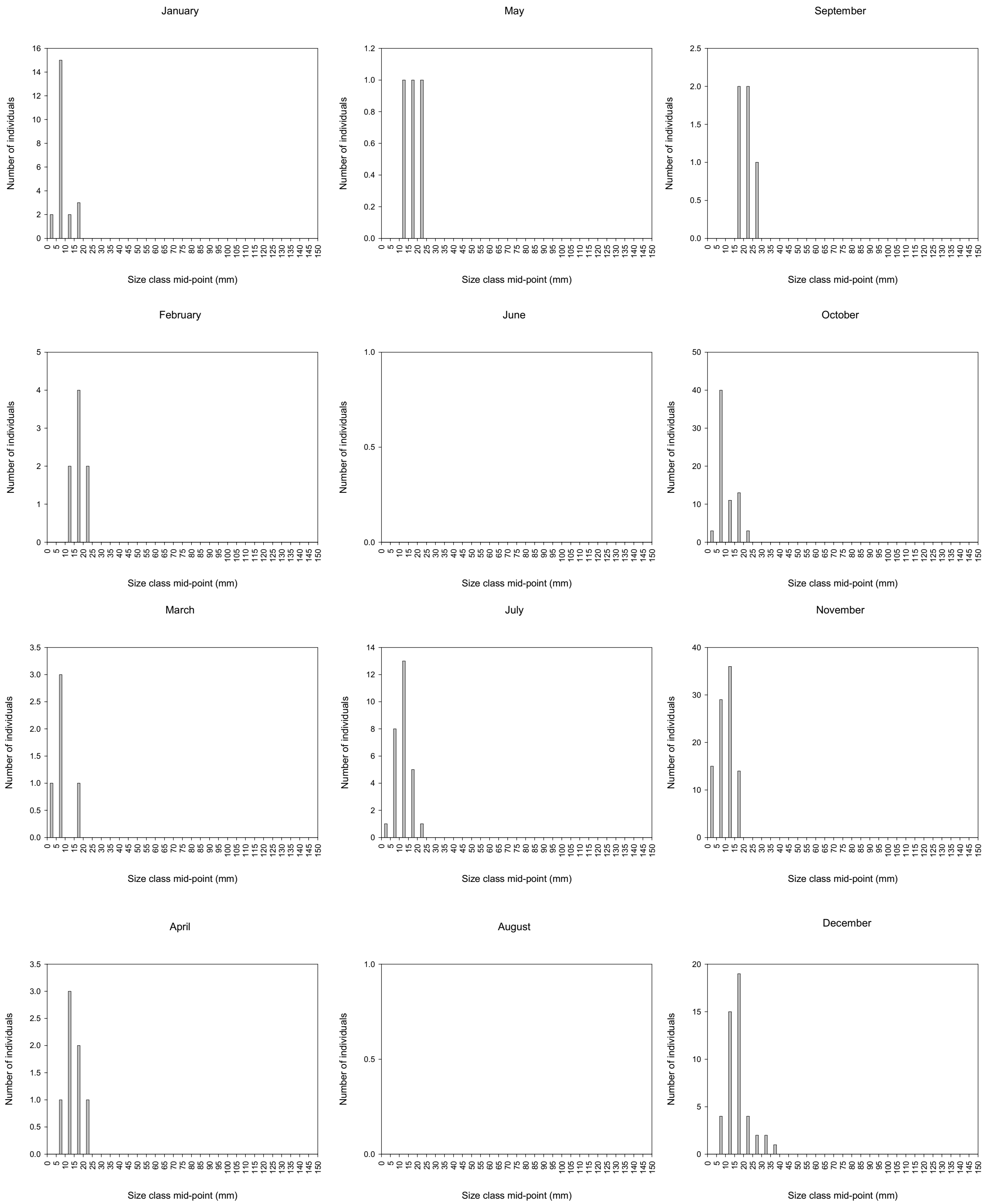


Fig. C1. Monthly length frequencies of Pink shrimp collected in seines and trawls.

Callinectes sapidus **(Blue crab)**

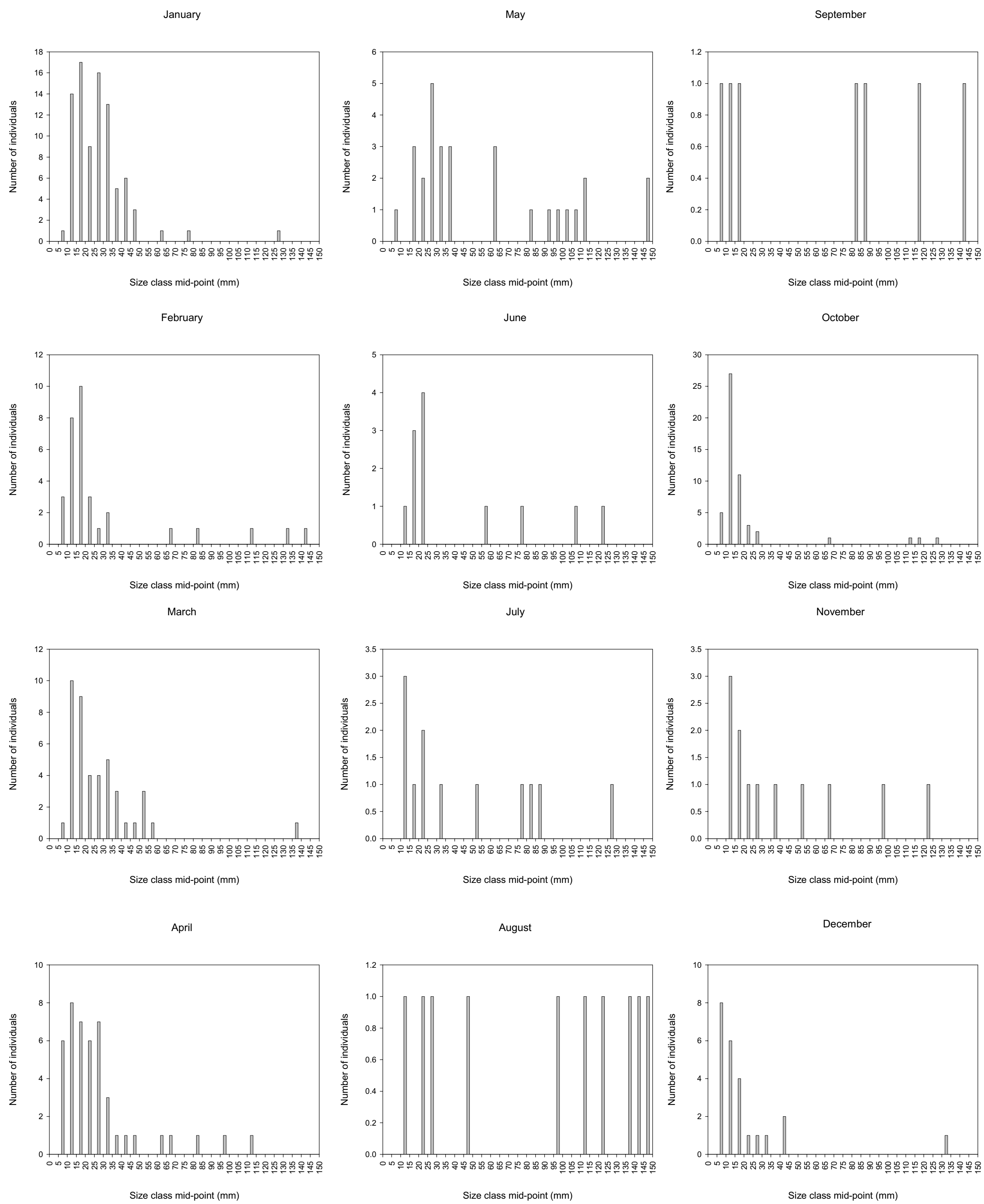


Fig. C2. Monthly length frequencies of Blue crab collected in seines and trawls.

Anchoa mitchilli (Bay anchovy)

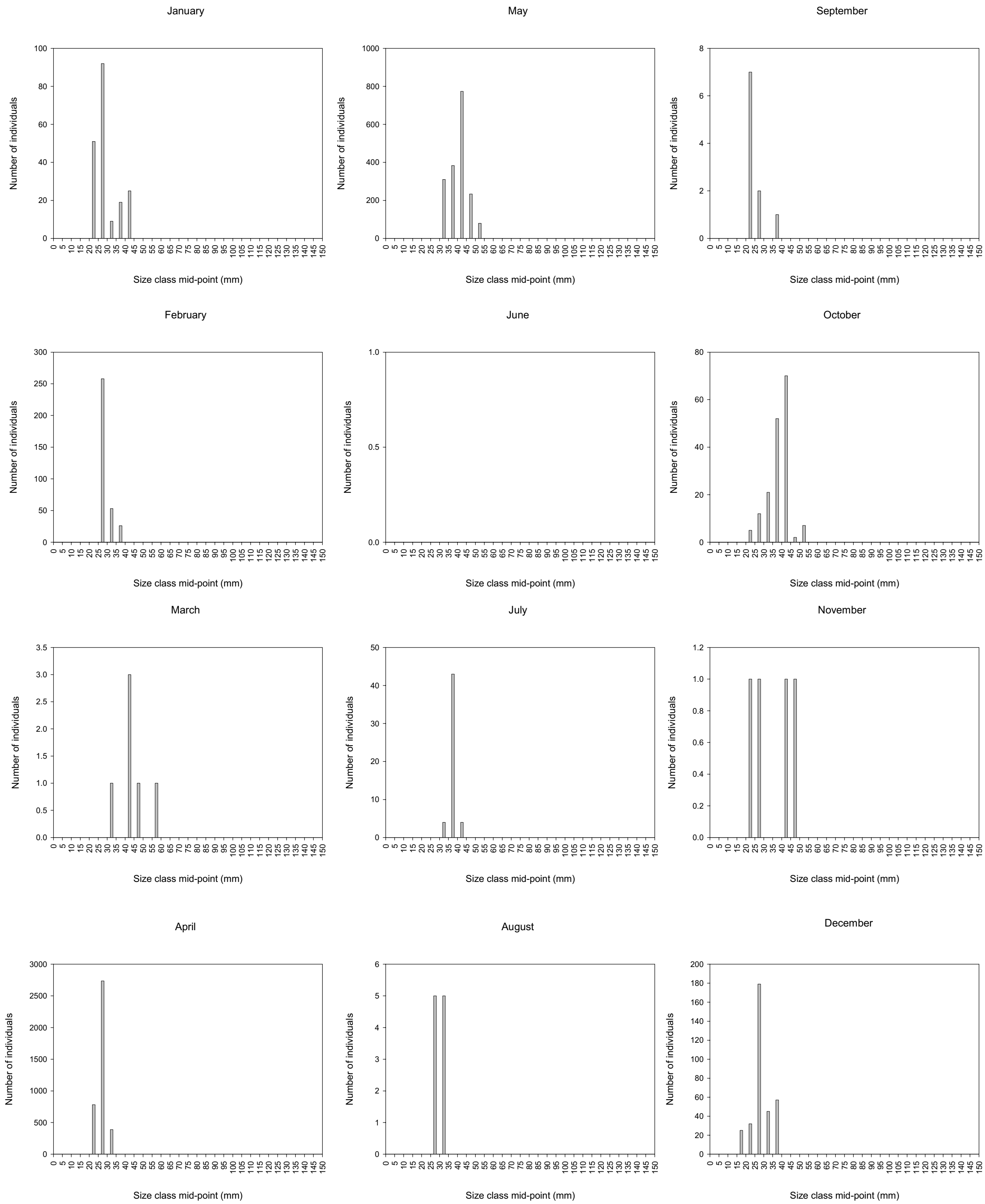


Fig. C3. Monthly length frequencies of Bay anchovy collected in seines and trawls.

Notropis petersoni (Coastal shiner)

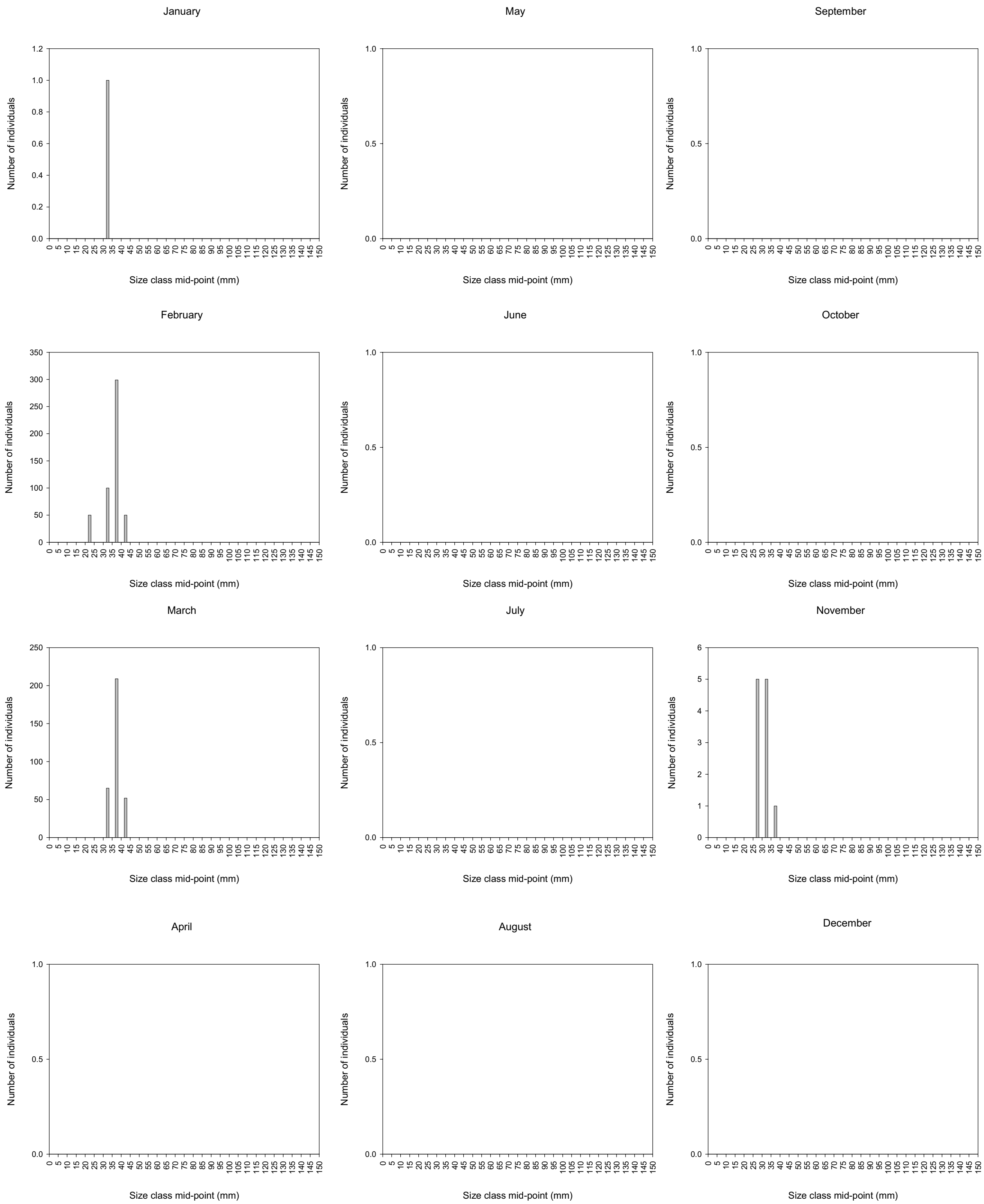


Fig. C4. Monthly length frequencies of Coastal shiner collected in seines and trawls.

Strongylura notata (Redfin needlefish)

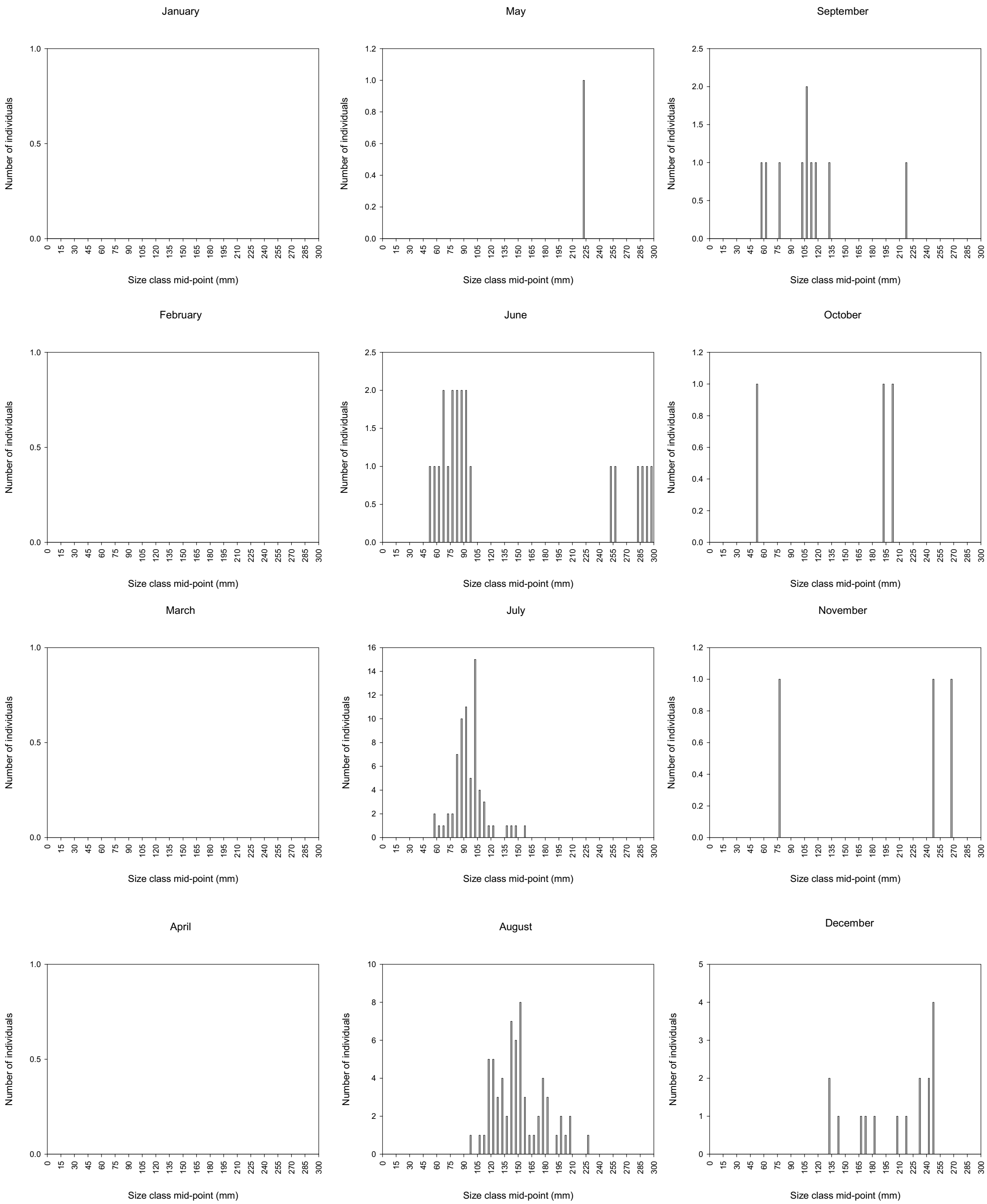


Fig. C5. Monthly length frequencies of Redfin needlefish collected in seines and trawls.

Lucania parva (Rainwater killifish)

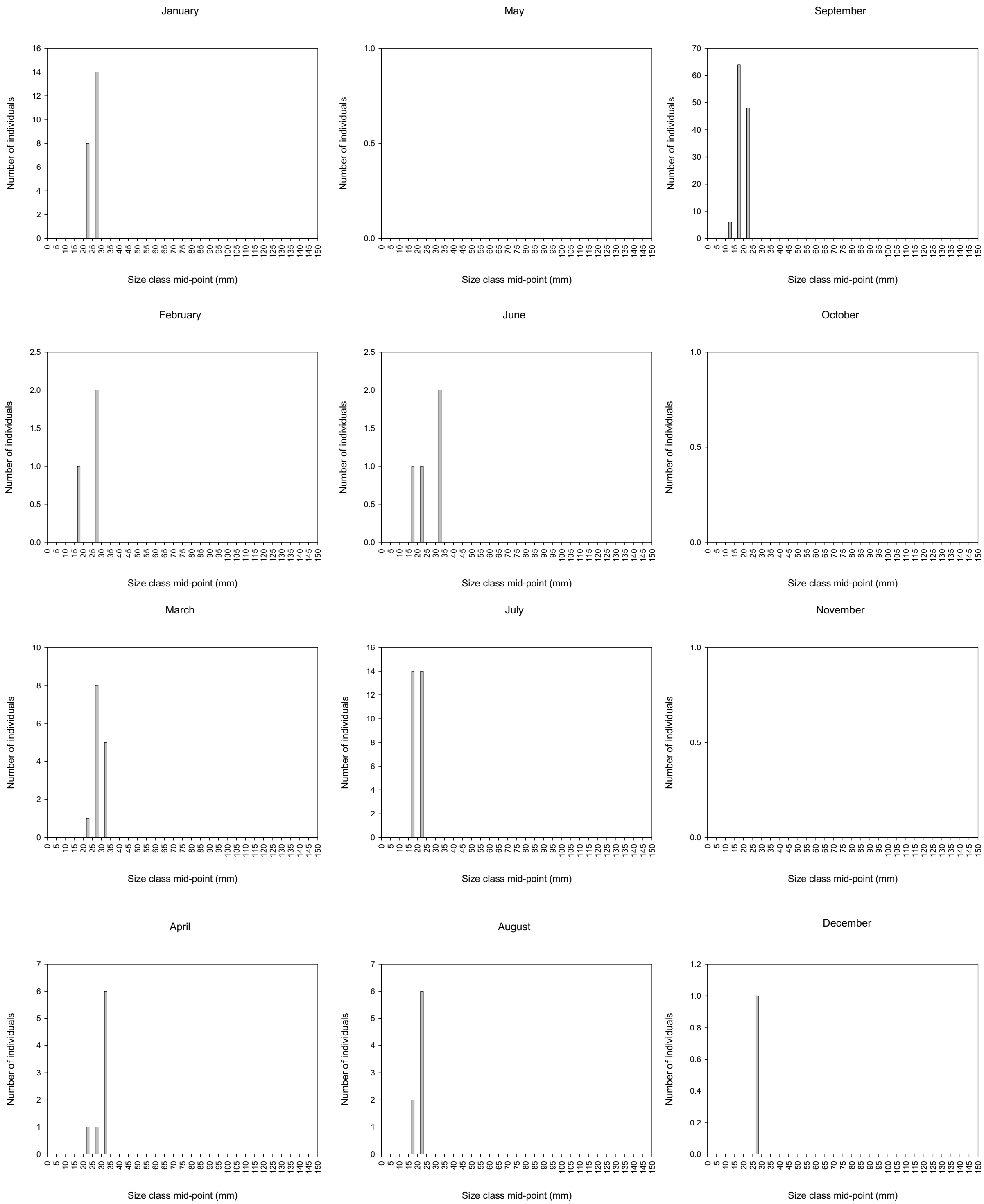


Fig. C6. Monthly length frequencies of Rainwater killifish collected in seines and trawls.

Lucania goodei (Bluefin killifish)

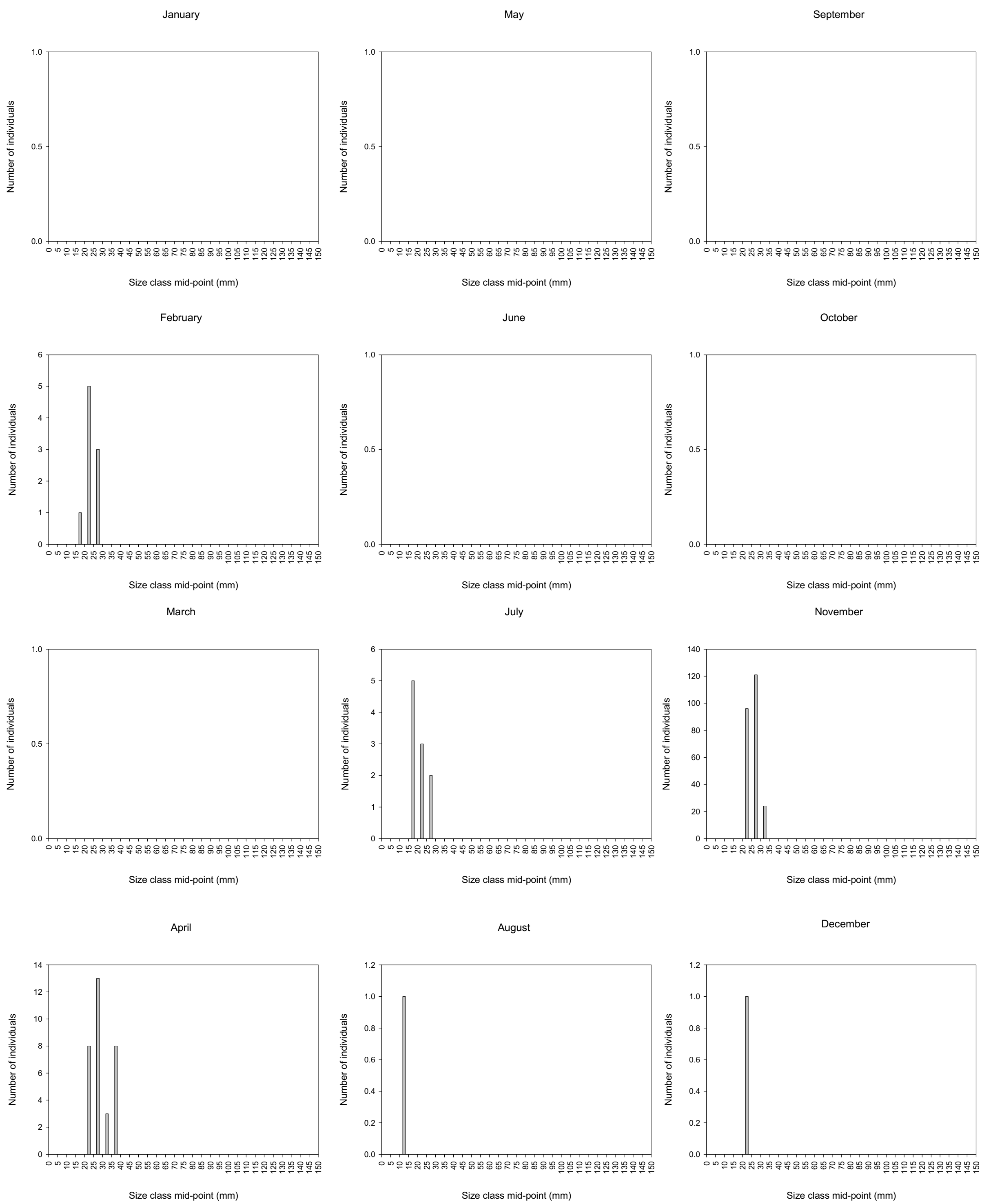


Fig. C7. Monthly length frequencies of Bluefin killifish collected in seines and trawls.

Floridichthys carpio (Goldspotted killifish)

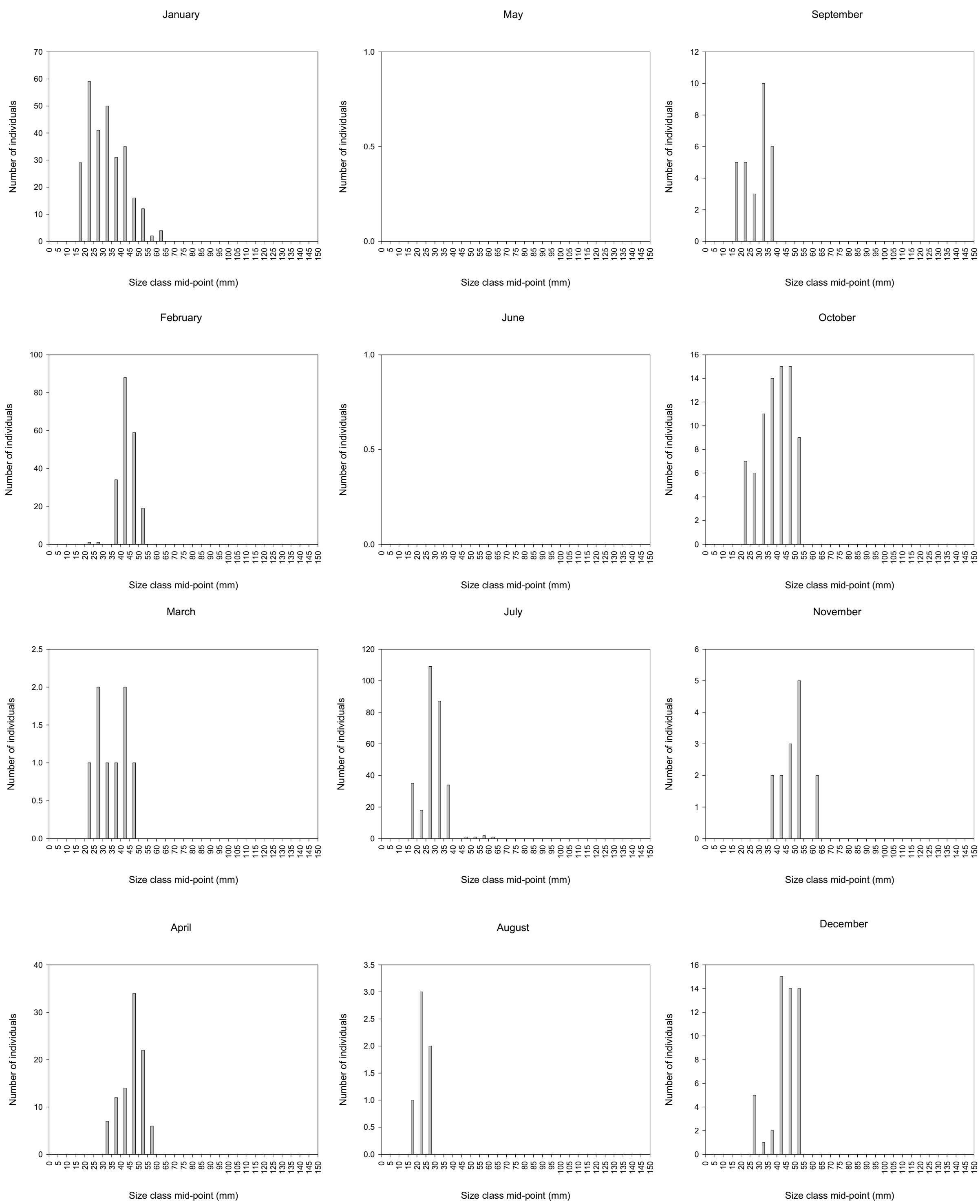


Fig. C8. Monthly length frequencies of Goldspotted killifish collected in seines and trawls.

Gambusia holbrooki (Eastern mosquitofish)

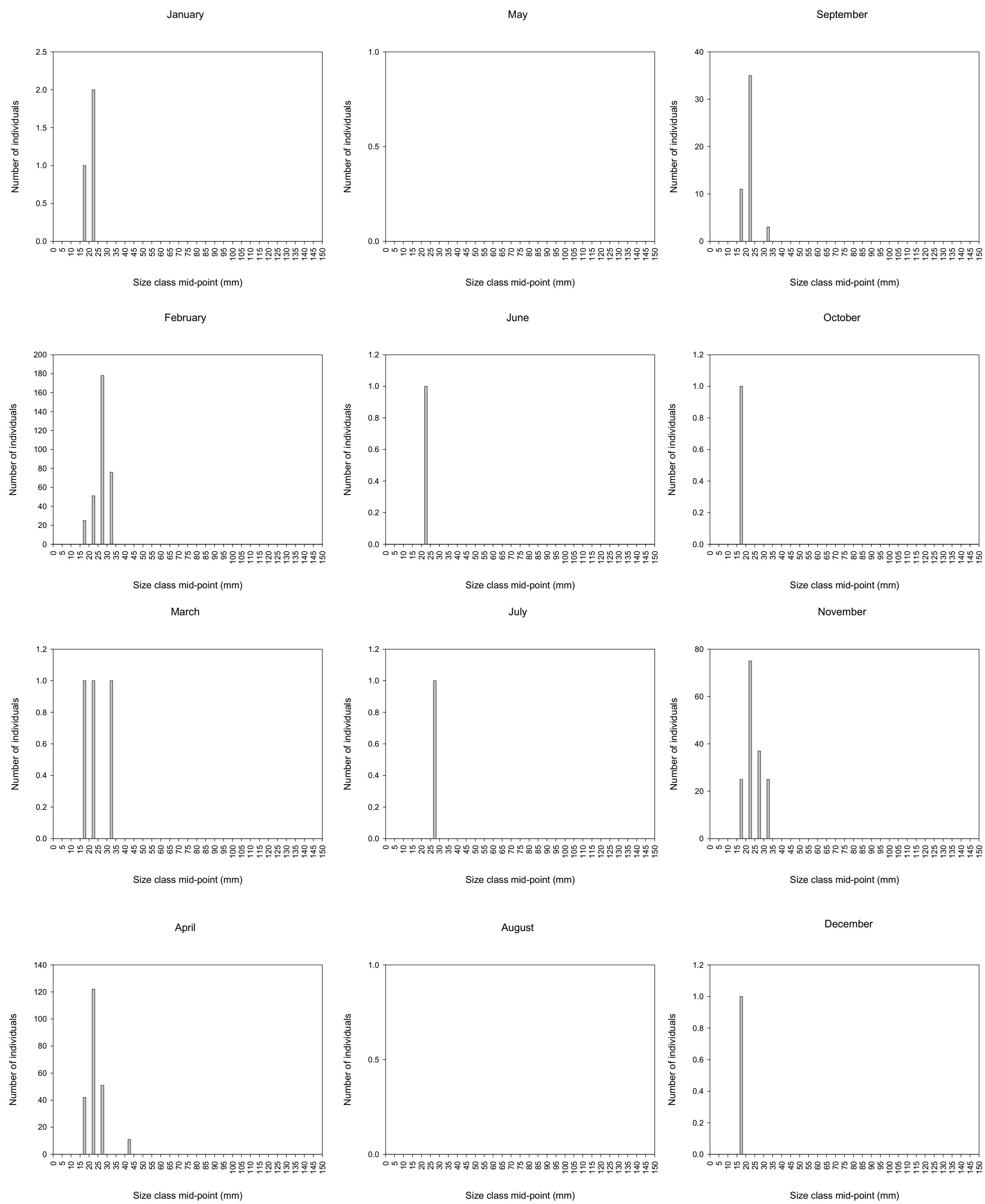


Fig. C9. Monthly length frequencies of Eastern mosquitofish collected in seines and trawls.

Poecilia latipinna (Sailfin molly)

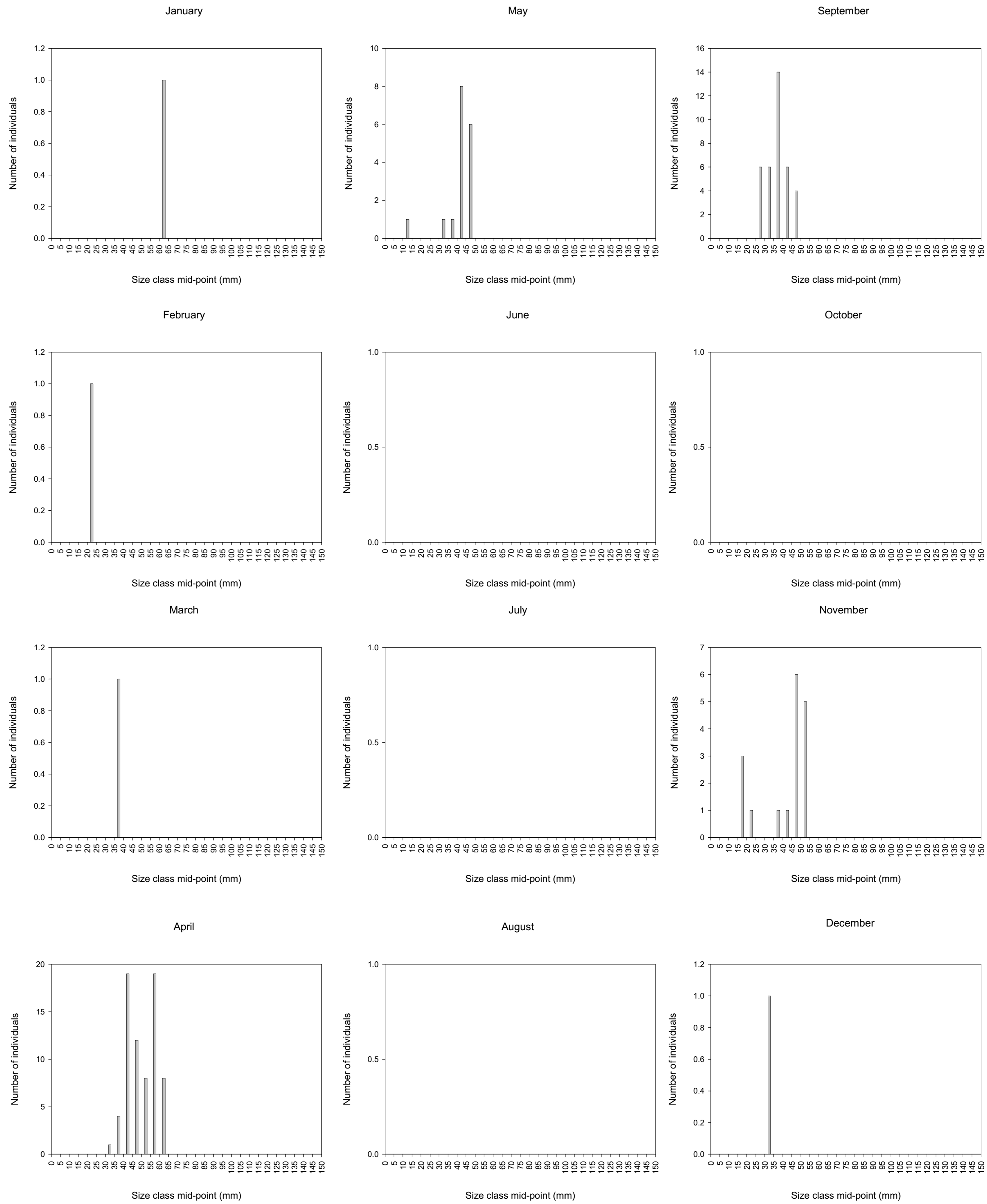


Fig. C10. Monthly length frequencies of Sailfin molly collected in seines and trawls.

Menidia spp. (Silversides)

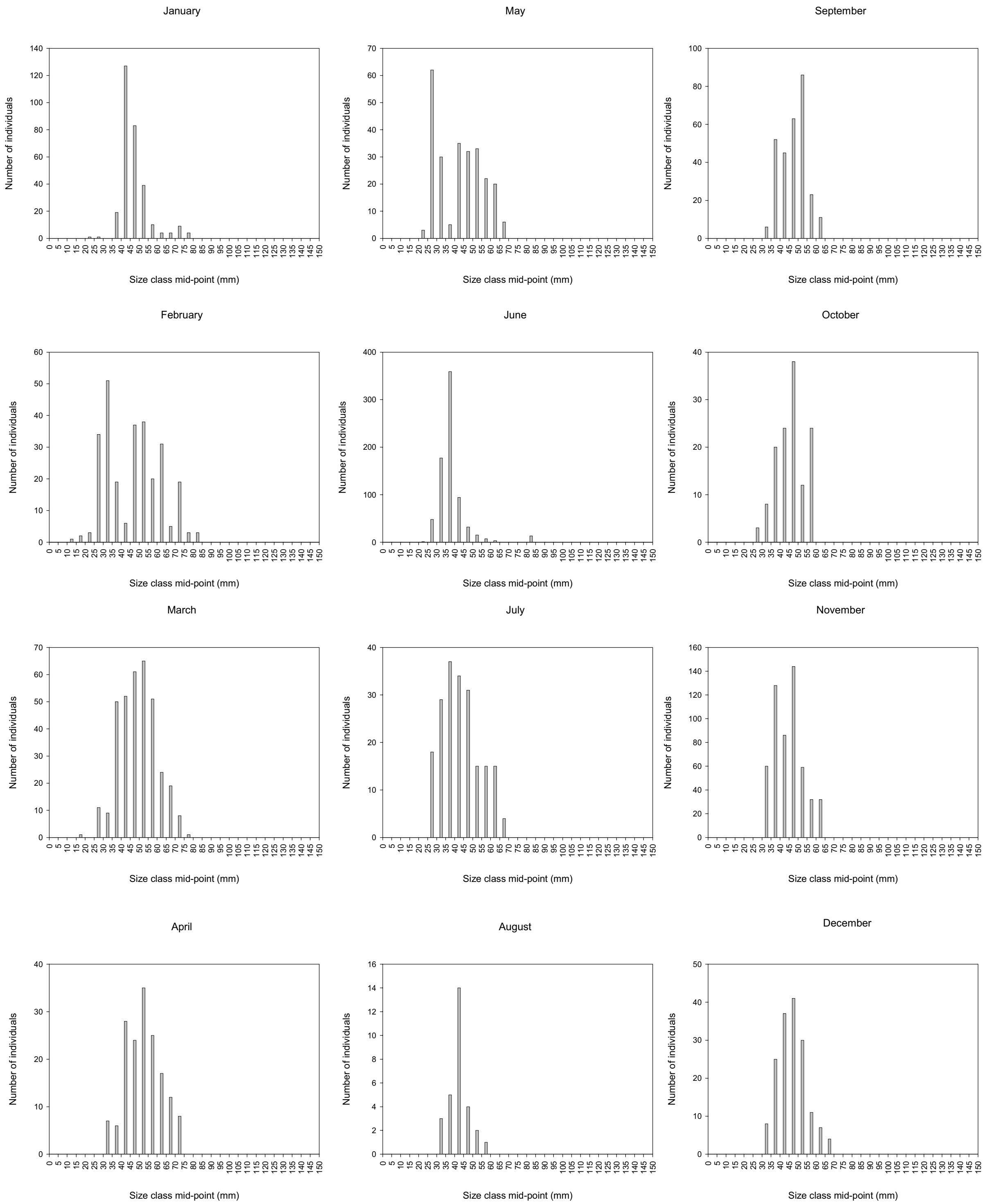


Fig. C11. Monthly length frequencies of Silversides collected in seines and trawls.

Labidesthes sicculus (Brook silverside)

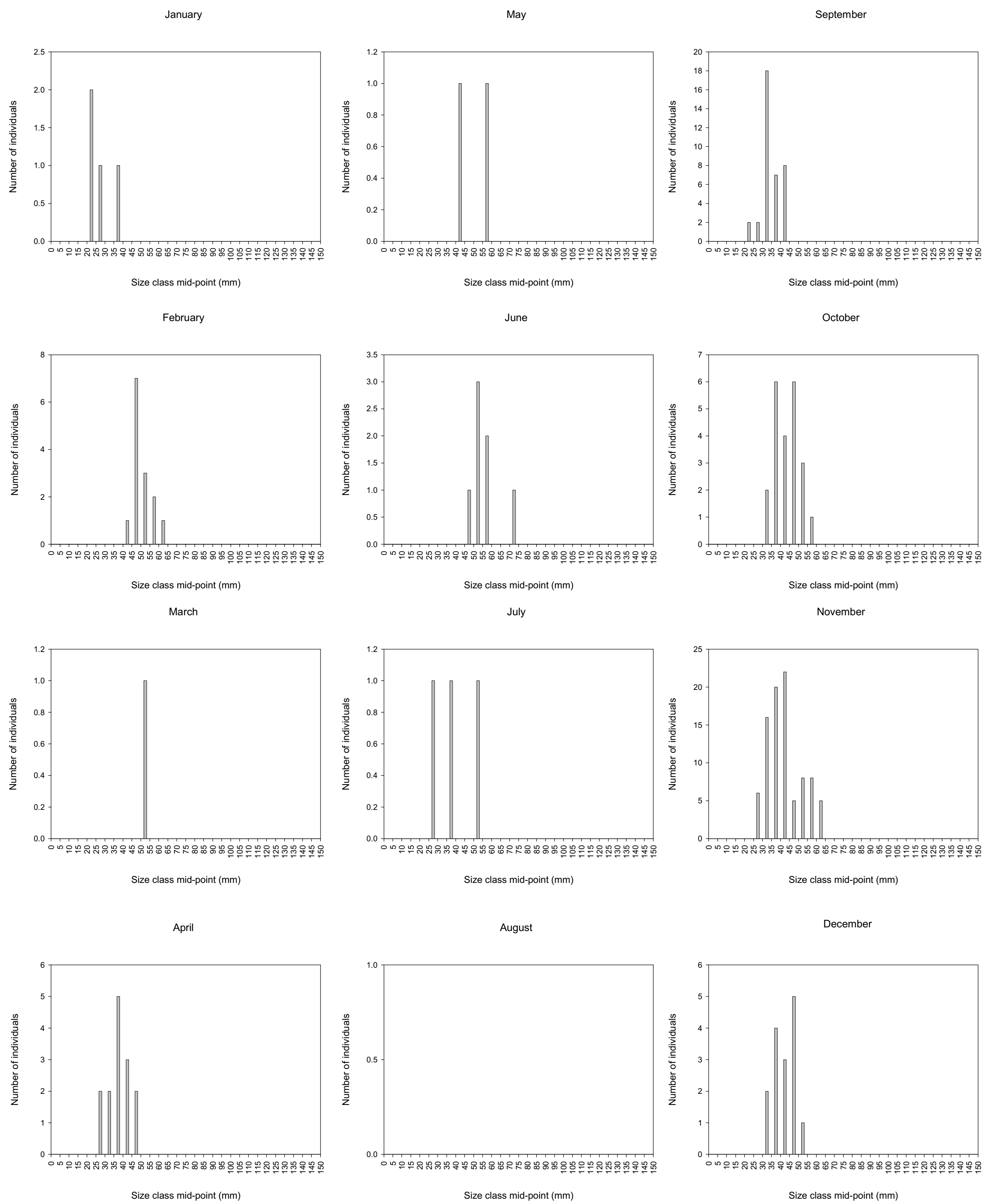


Fig. C12. Monthly length frequencies of Brook silverside collected in seines and trawls.

Lepomis macrochirus (Bluegill)

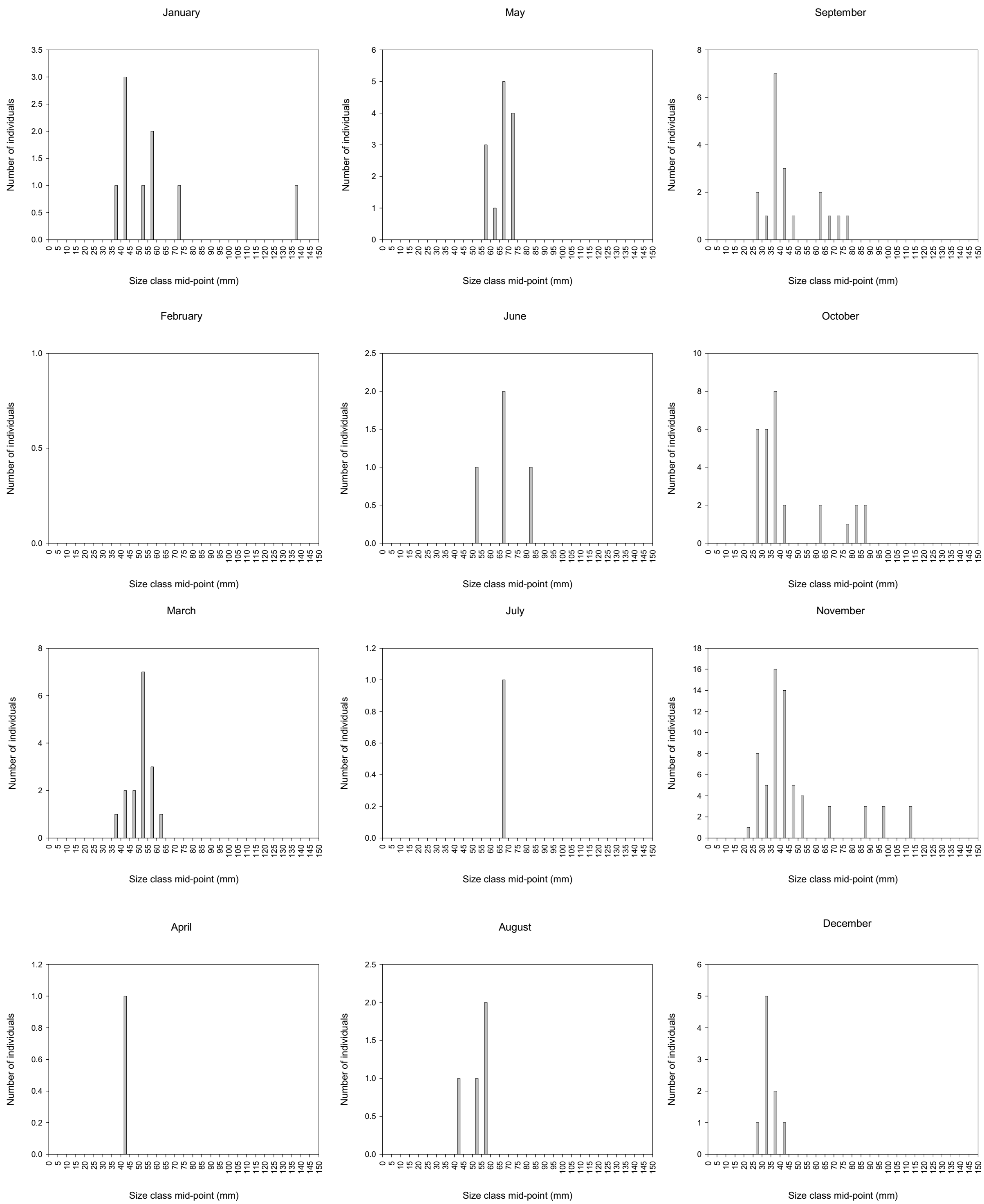


Fig. C13. Monthly length frequencies of Bluegill collected in seines and trawls.

Eucinostomus spp. (Eucinostomus mojarras)

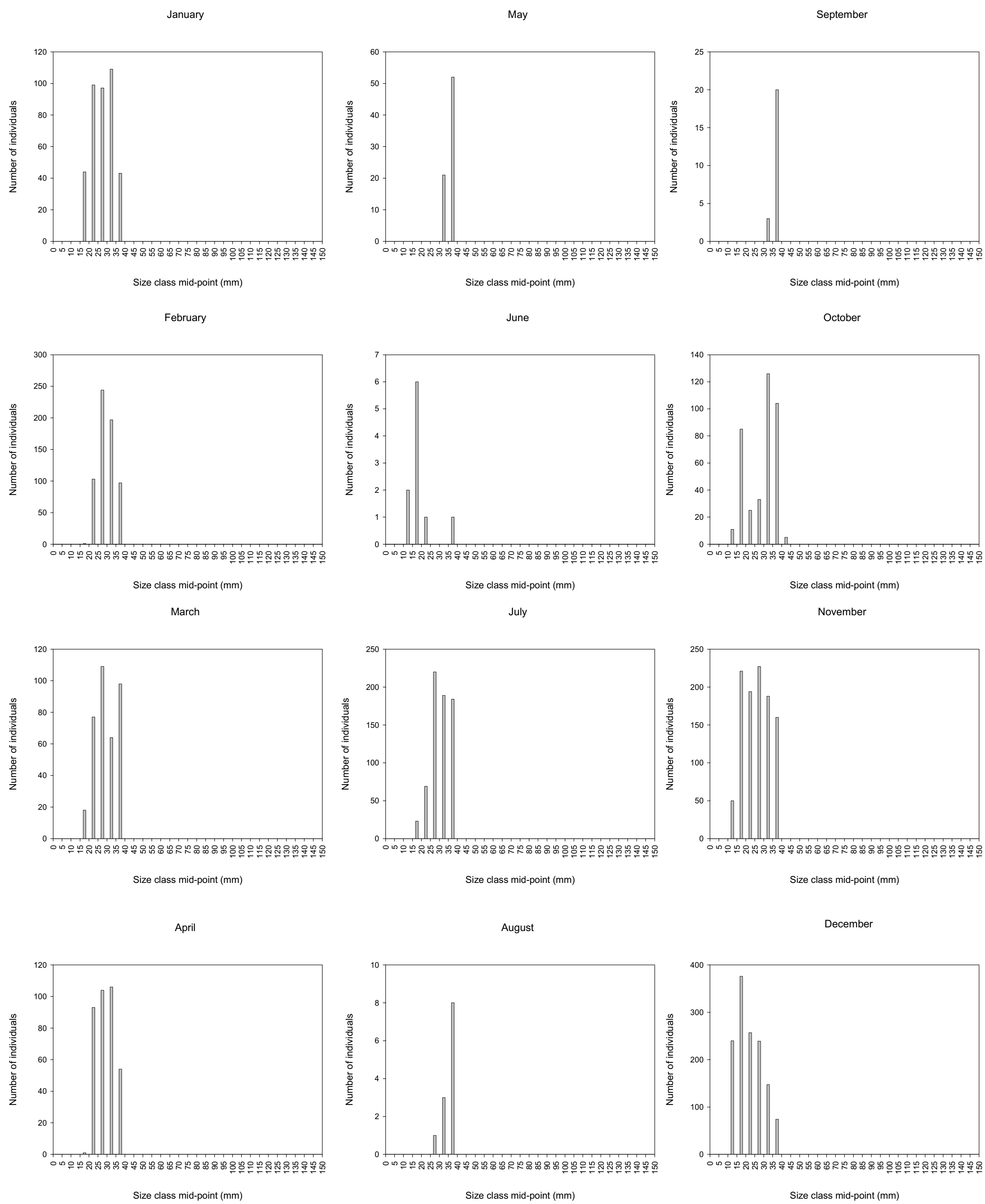


Fig. C14. Monthly length frequencies of Eucinostomus mojarras collected in seines and trawls.

Eucinostomus gula (Silver jenny)

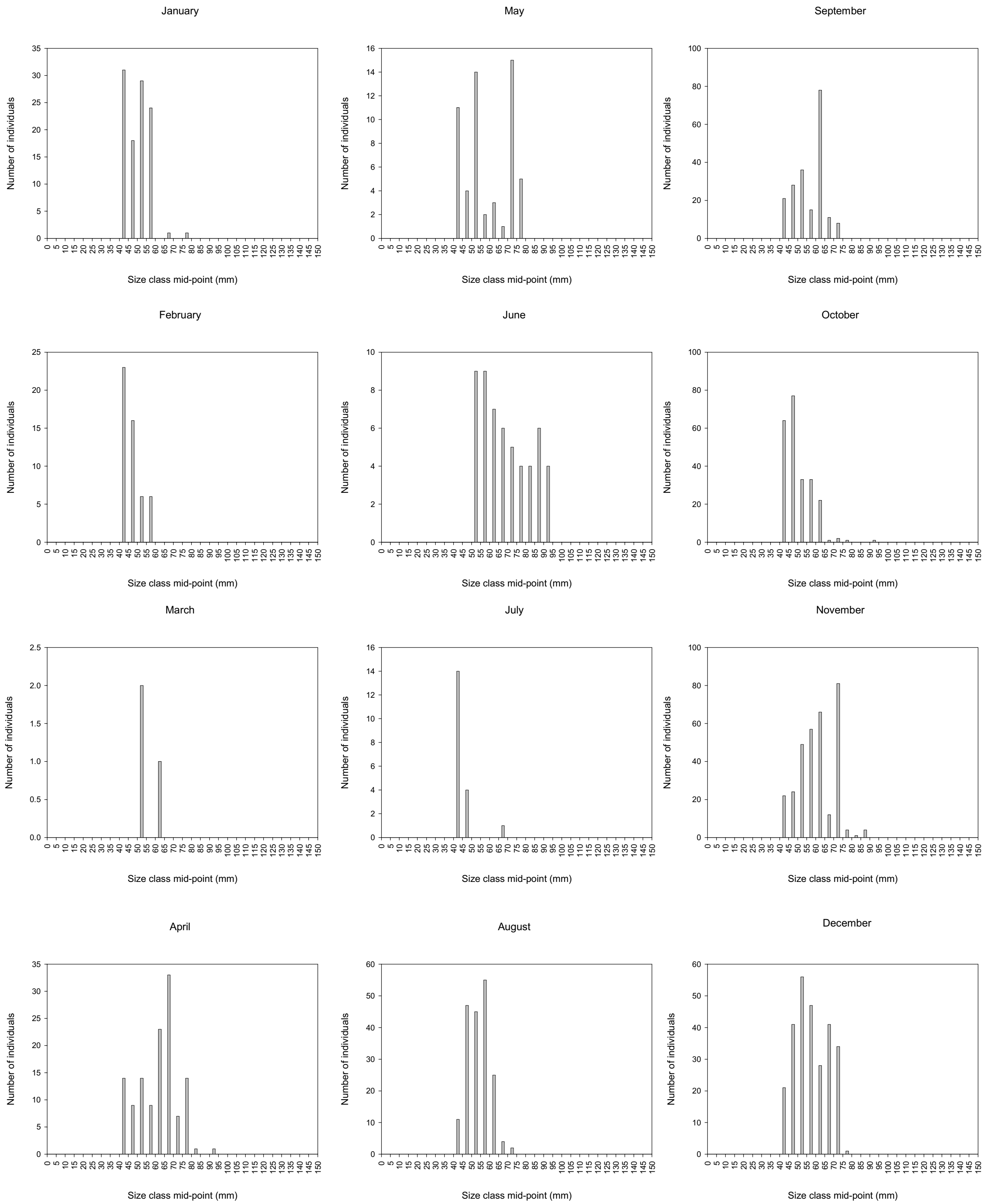


Fig. C15. Monthly length frequencies of Silver jenny collected in seines and trawls.

Eucinostomus harengulus (Tidewater mojarra)

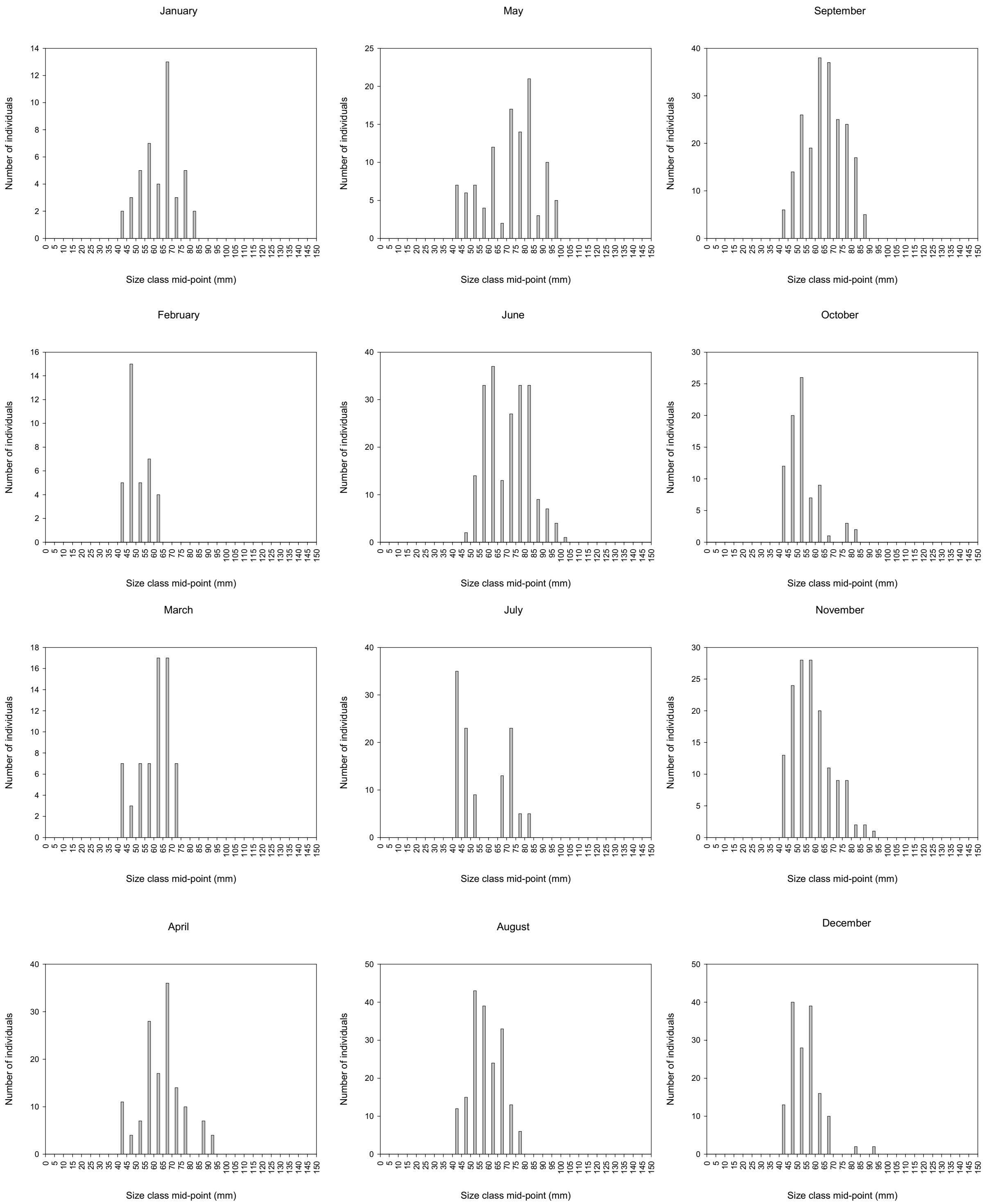


Fig. C16. Monthly length frequencies of Tidewater mojarra collected in seines and trawls.

Orthopristis chrysoptera (Pigfish)

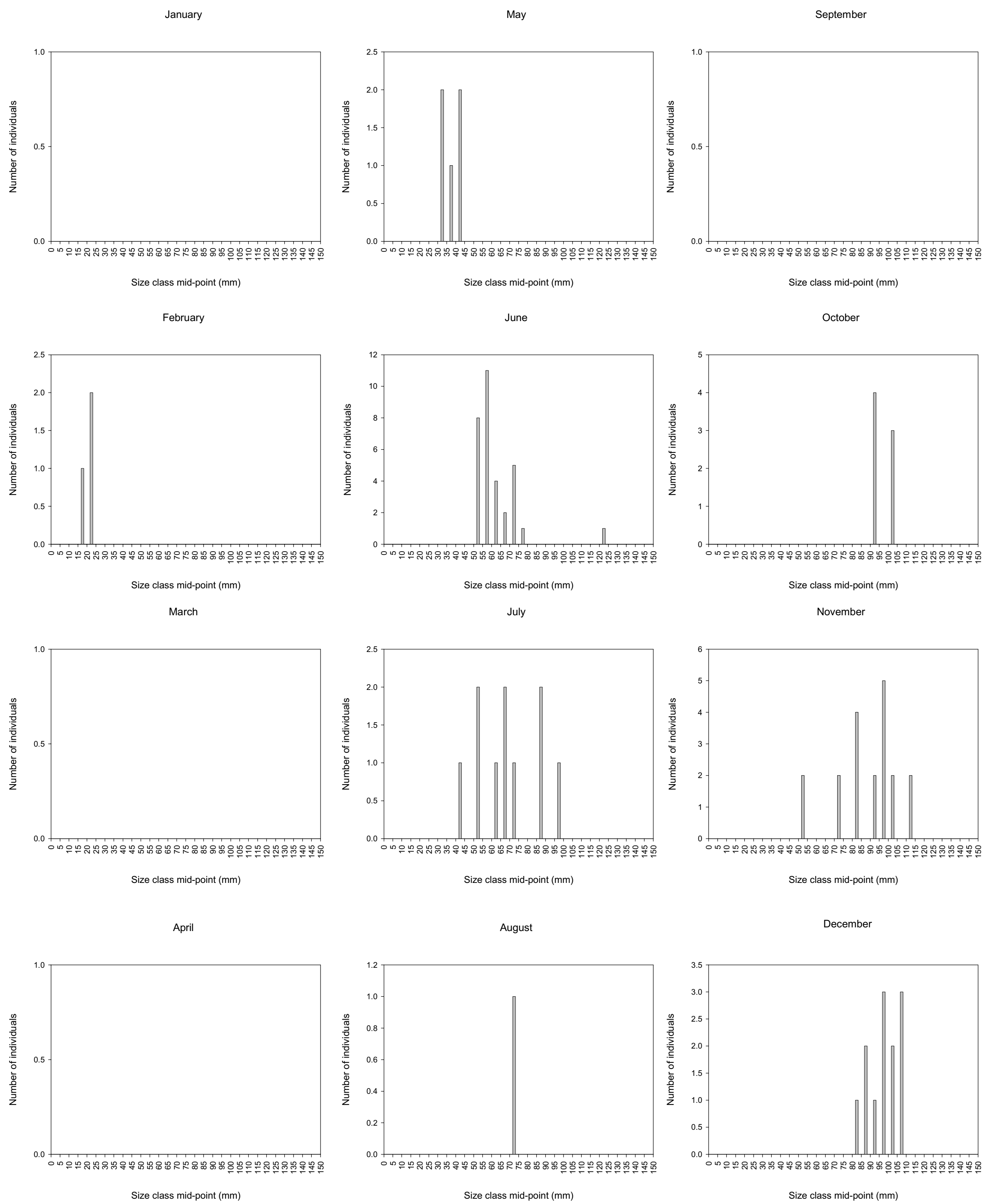


Fig. C17. Monthly length frequencies of Pigfish collected in seines and trawls.

Lagodon rhomboides (Pinfish)

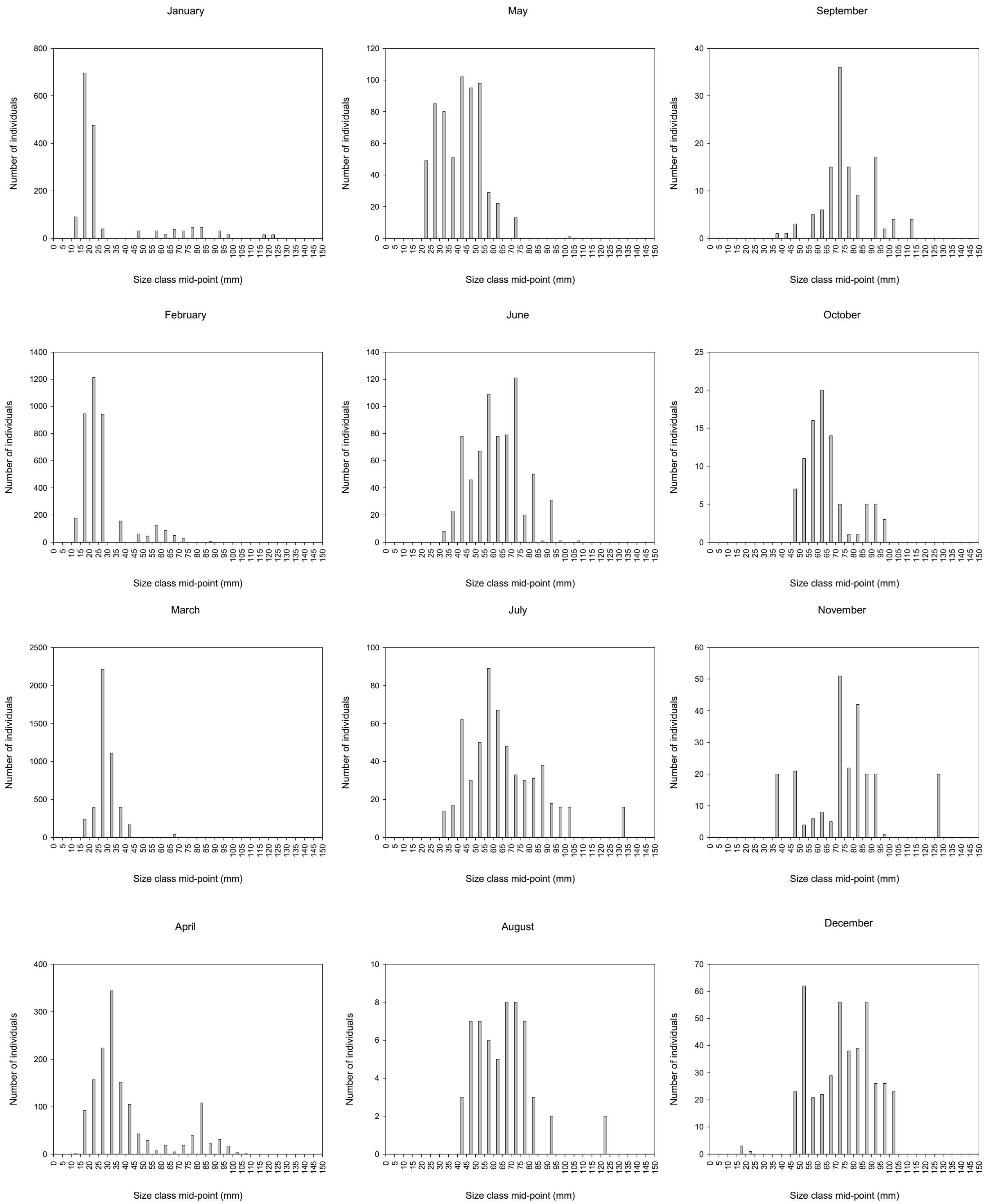


Fig. C18. Monthly length frequencies of Pinfish collected in seines and trawls.

Leiostomus xanthurus (Spot)

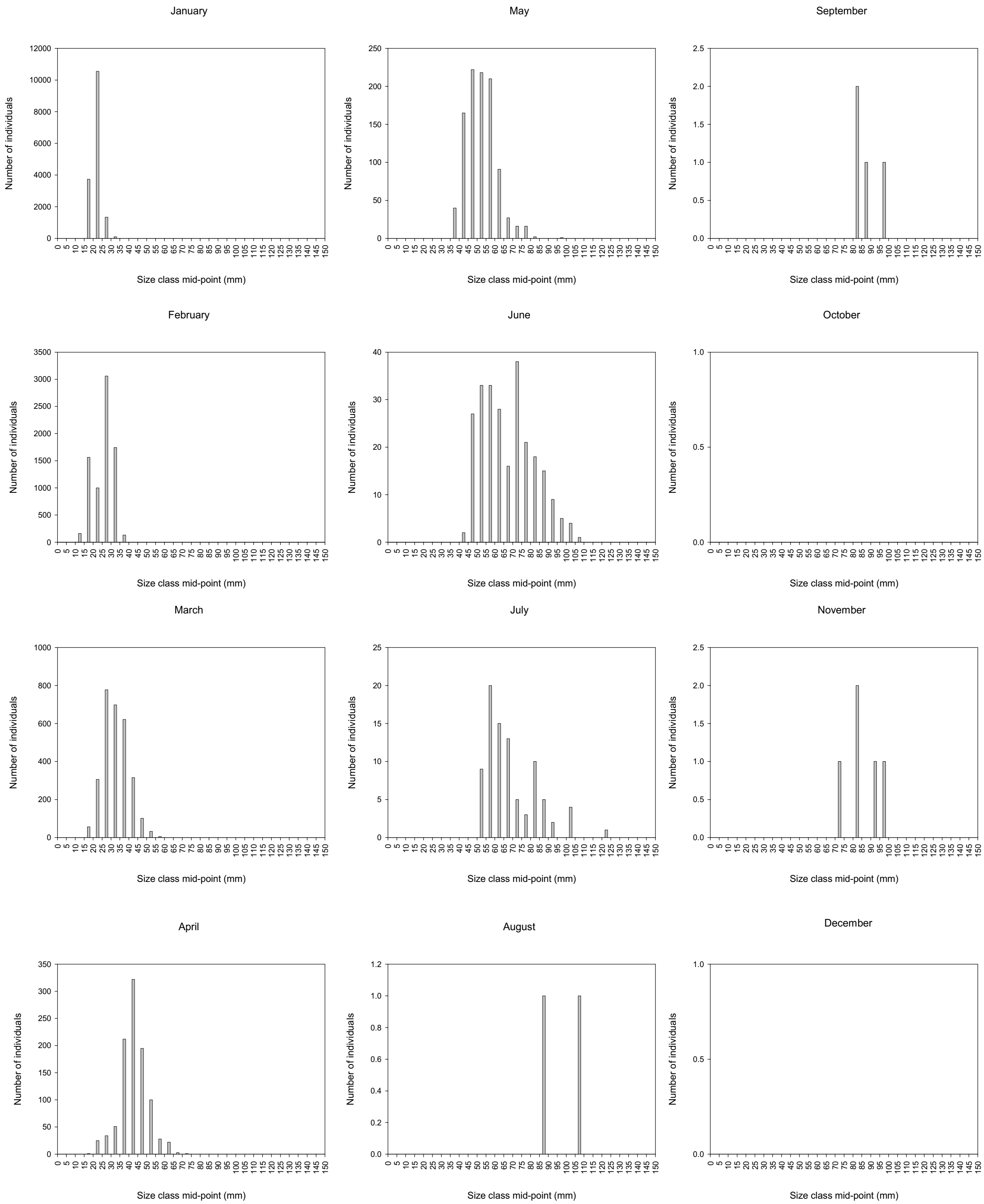


Fig. C19. Monthly length frequencies of Spot collected in seines and trawls.

Mugil cephalus **(Striped mullet)**

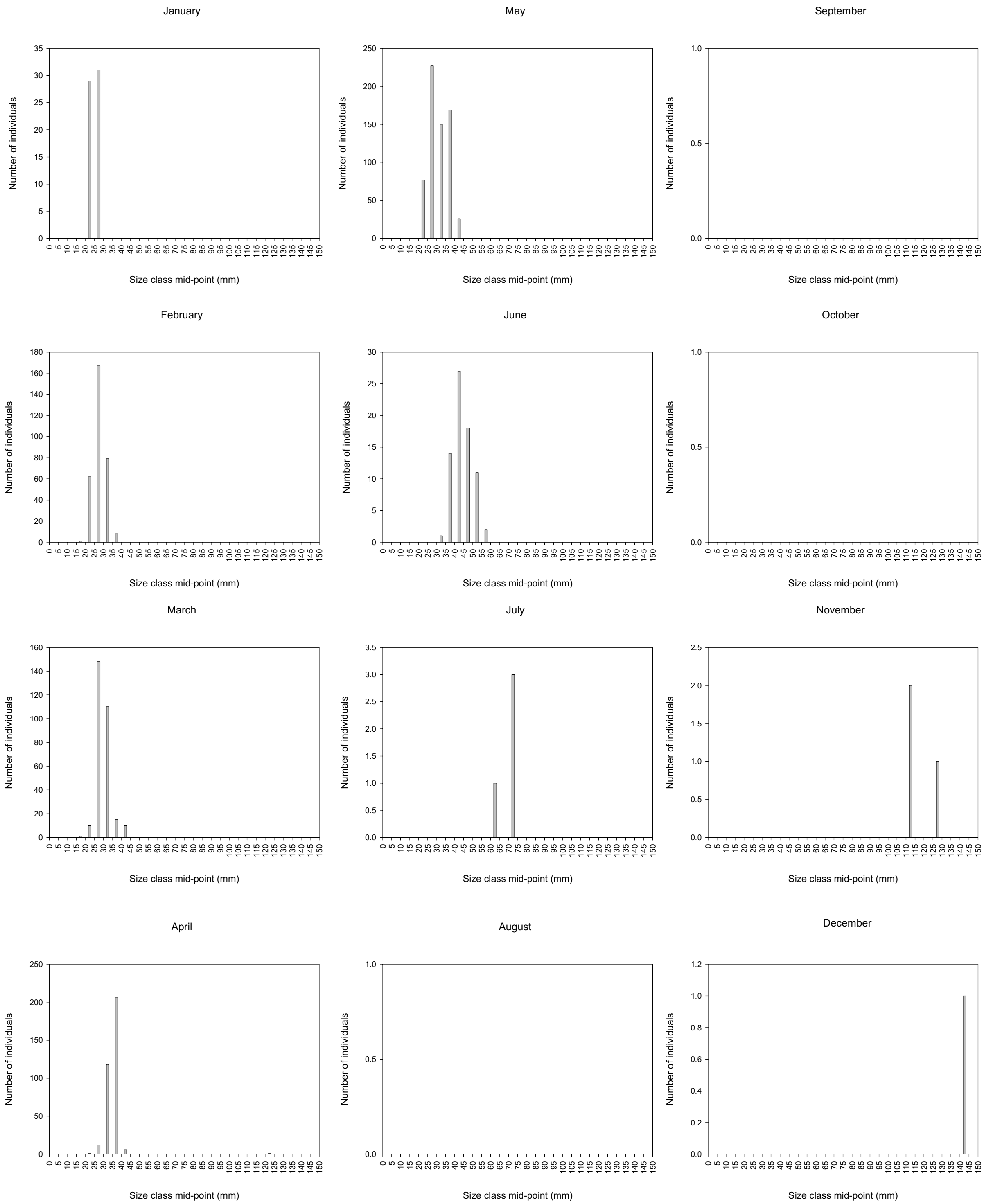


Fig. C20. Monthly length frequencies of Striped mullet collected in seines and trawls.

***Microgobius gulosus* (Clown goby)**

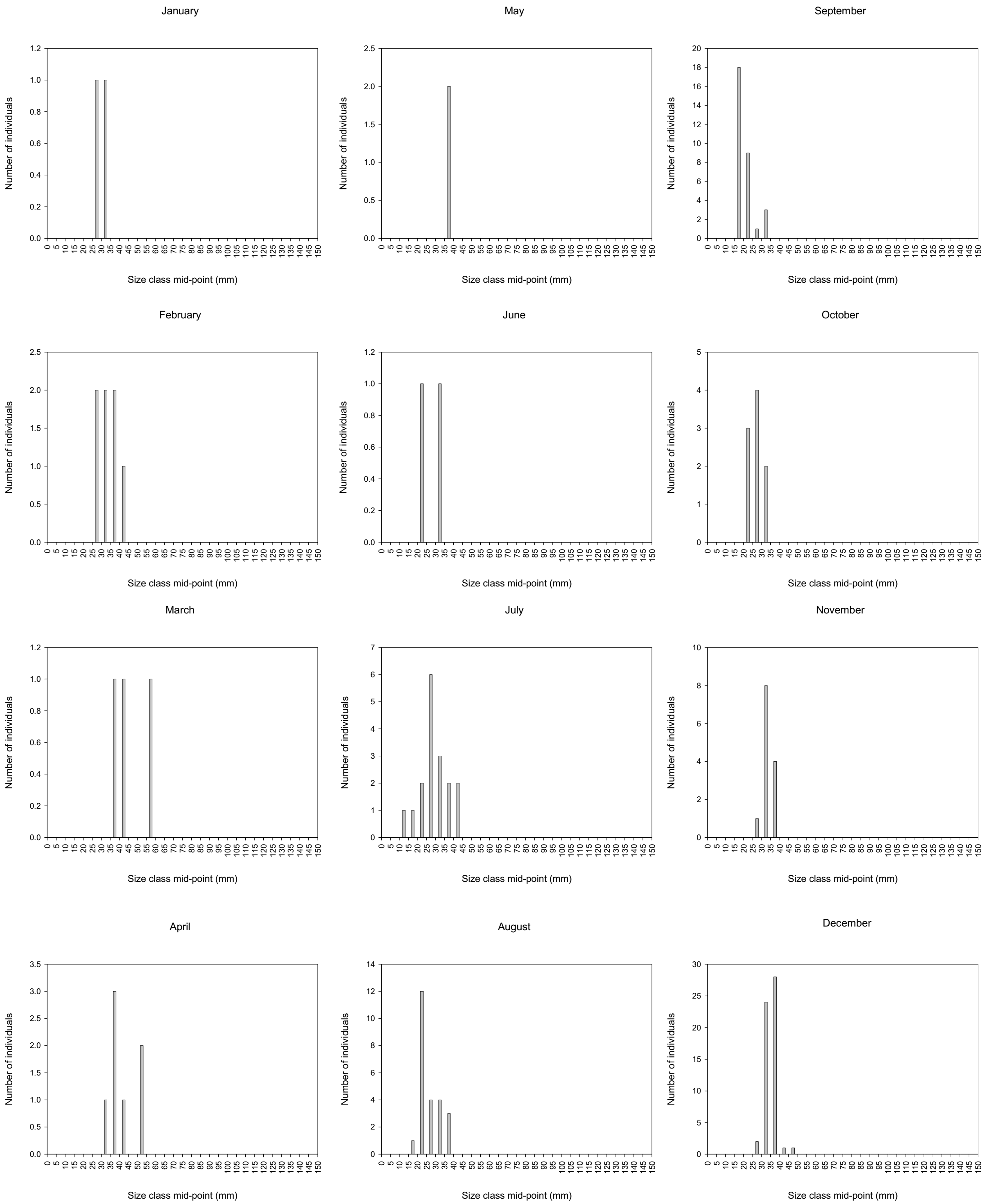


Fig. C21. Monthly length frequencies of Clown goby collected in seines and trawls.

Sphoeroides nephelus (Southern puffer)

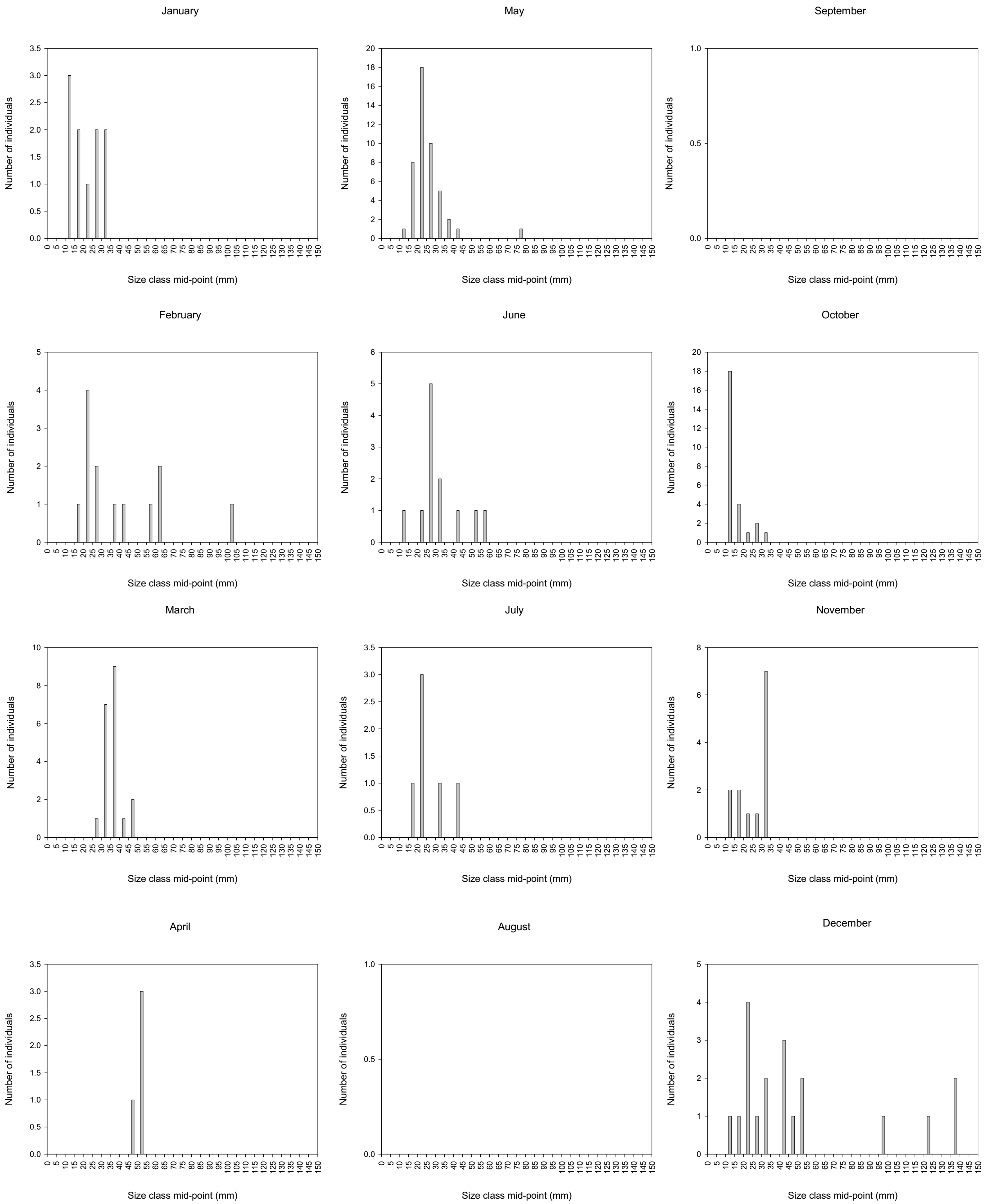


Fig. C22. Monthly length frequencies of Southern puffer collected in seines and trawls.

Appendix D:

Seine catch overview plots

Note: The Modified Venice salinity classification used in the plots is as follows: limnetic (0-0.49), oligohaline (0.5-4.99), low mesohaline (5-11.99), high mesohaline (12-17.99), polyhaline (18-29.99) and euhaline (>=30 psu).

Palaemonetes intermedius (Brackish grass shrimp), Seines

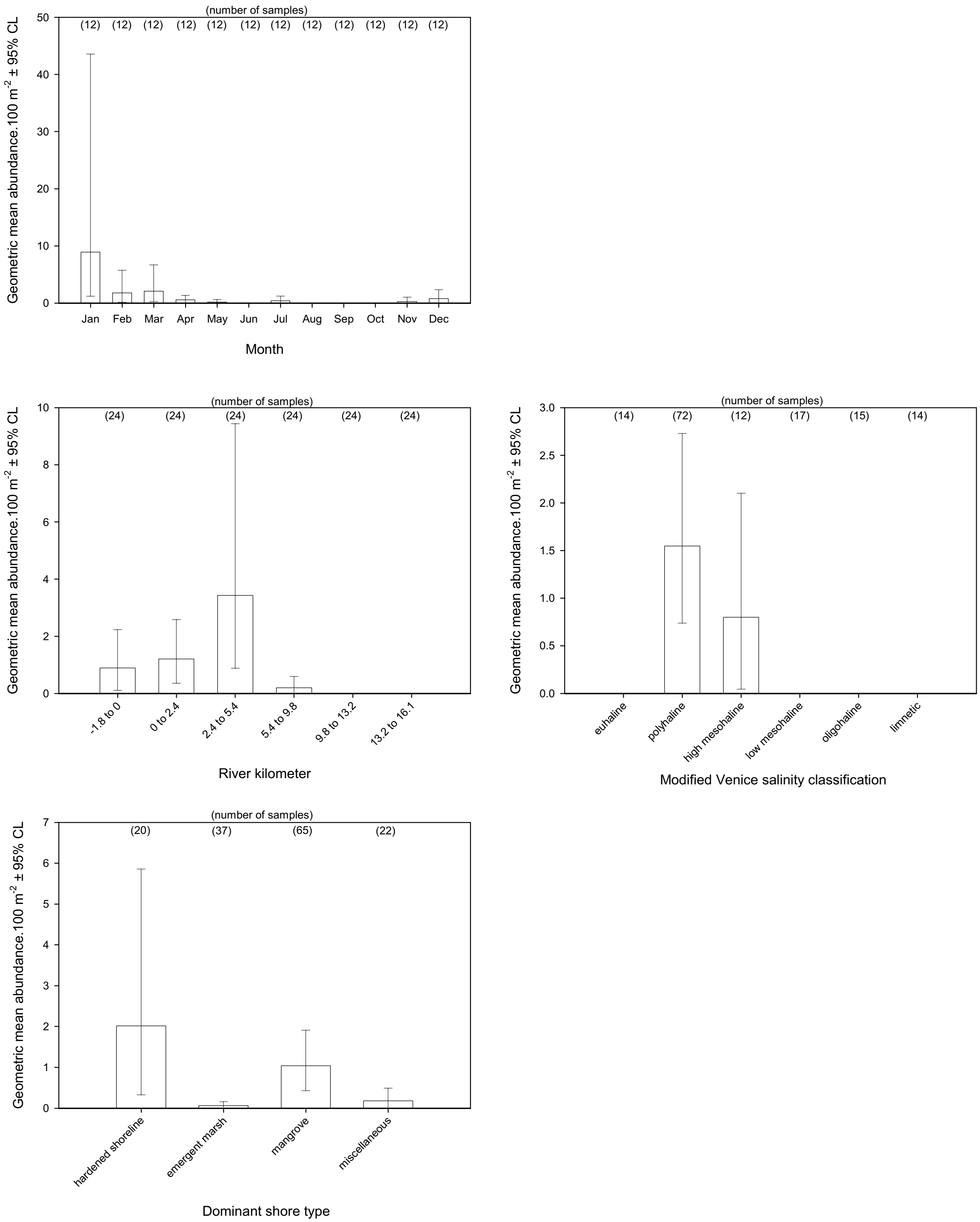


Fig. D1. Relative abundance of Brackish grass shrimp in shoreline (seined) habitats.

Palaemonetes pugio (Daggerblade grass shrimp), Seines

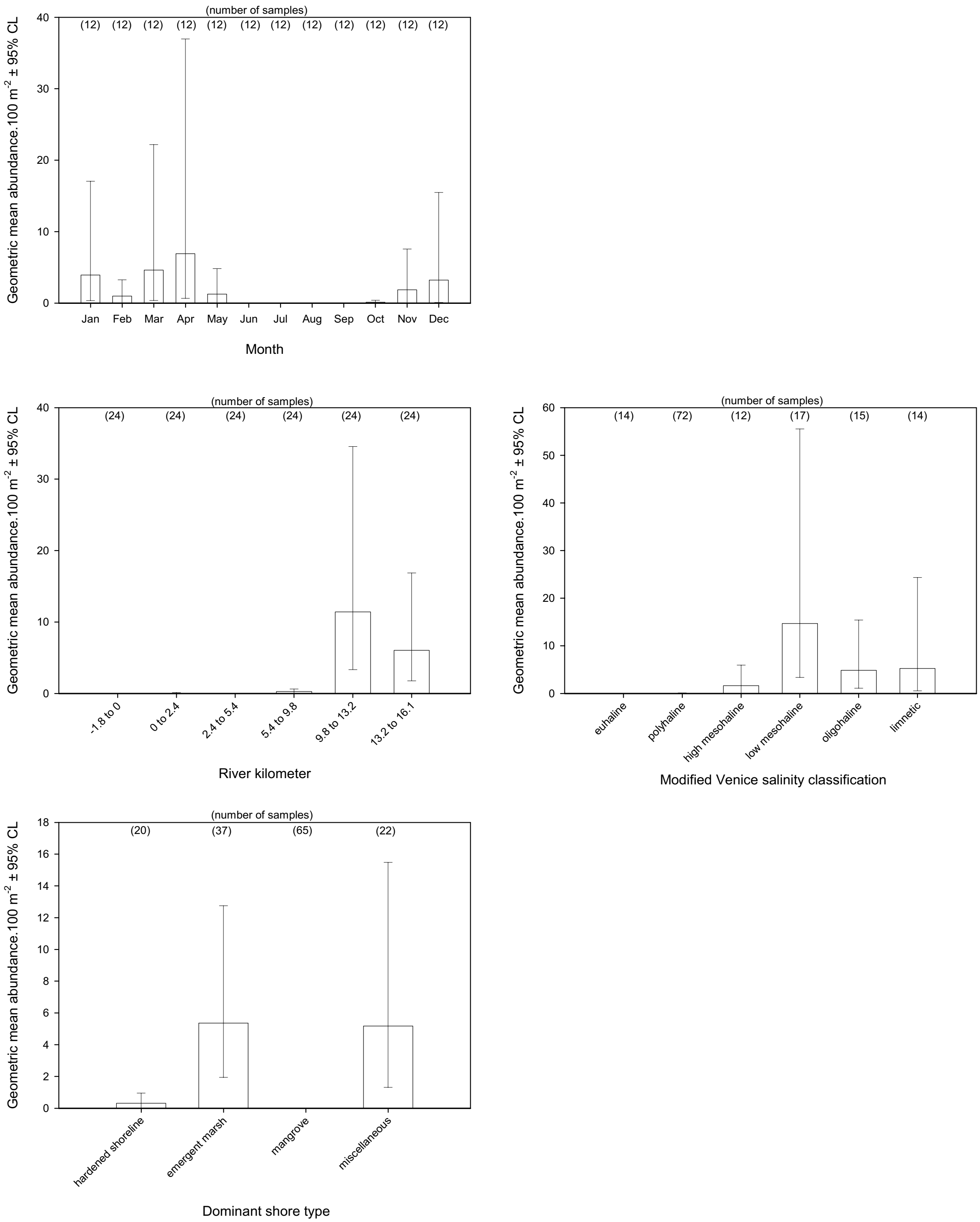


Fig. D2. Relative abundance of Daggerblade grass shrimp in shoreline (seined) habitats.

Callinectes sapidus (Blue crab), Seines

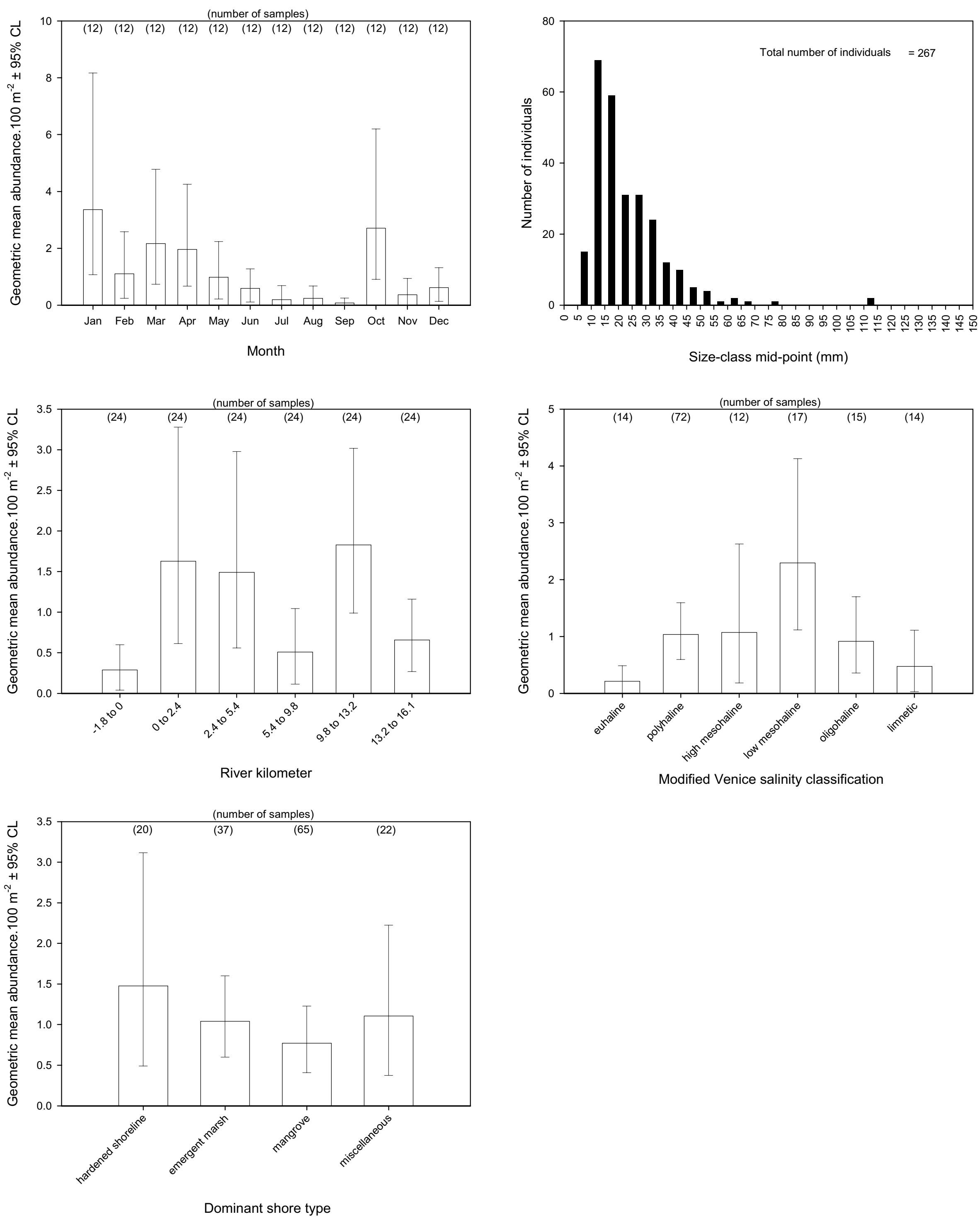


Fig. D3. Relative abundance of Blue crab in shoreline (seined) habitats.

Anchoa mitchilli (Bay anchovy), Seines

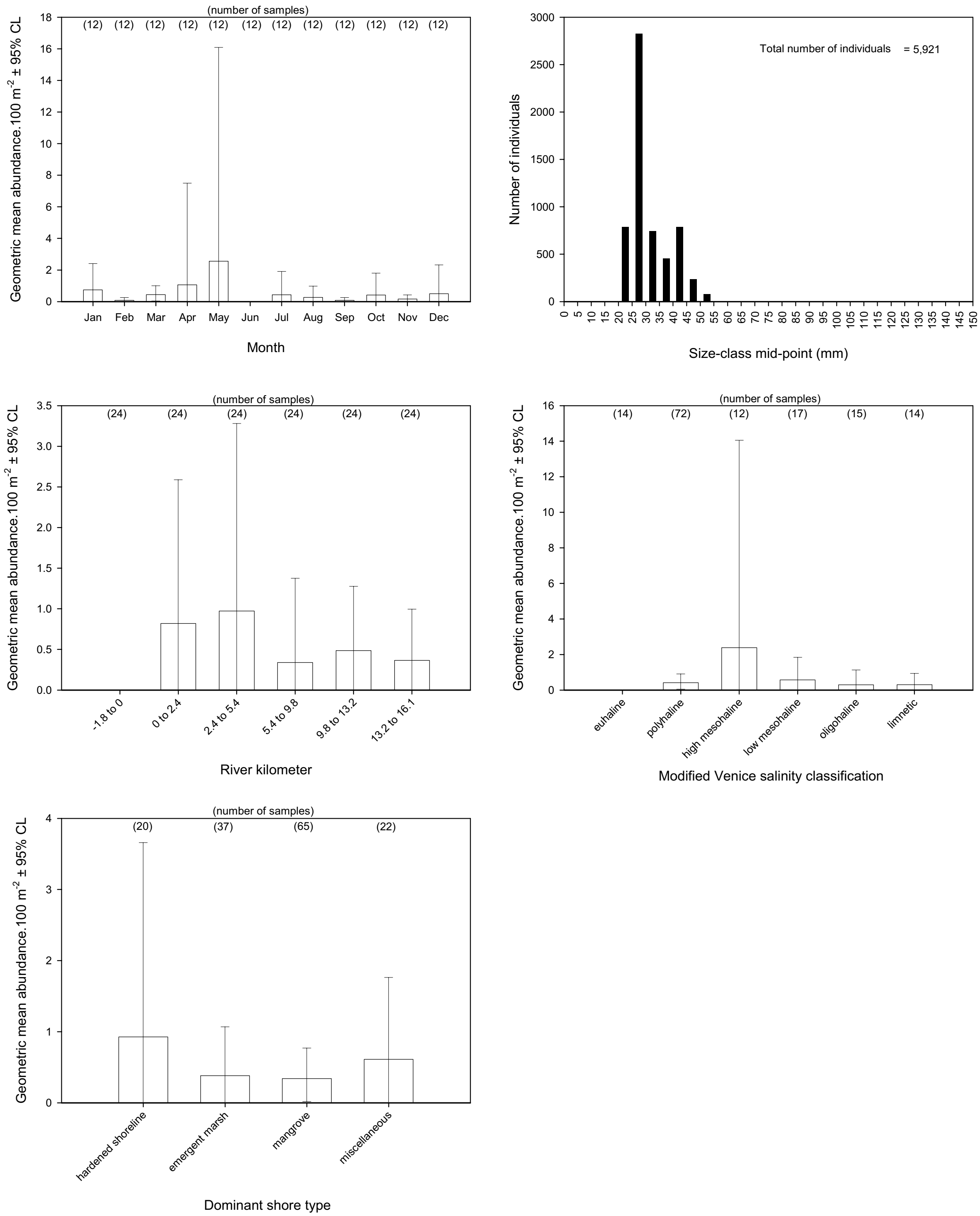


Fig. D4. Relative abundance of Bay anchovy in shoreline (seined) habitats.

Notropis petersoni (Coastal shiner), Seines

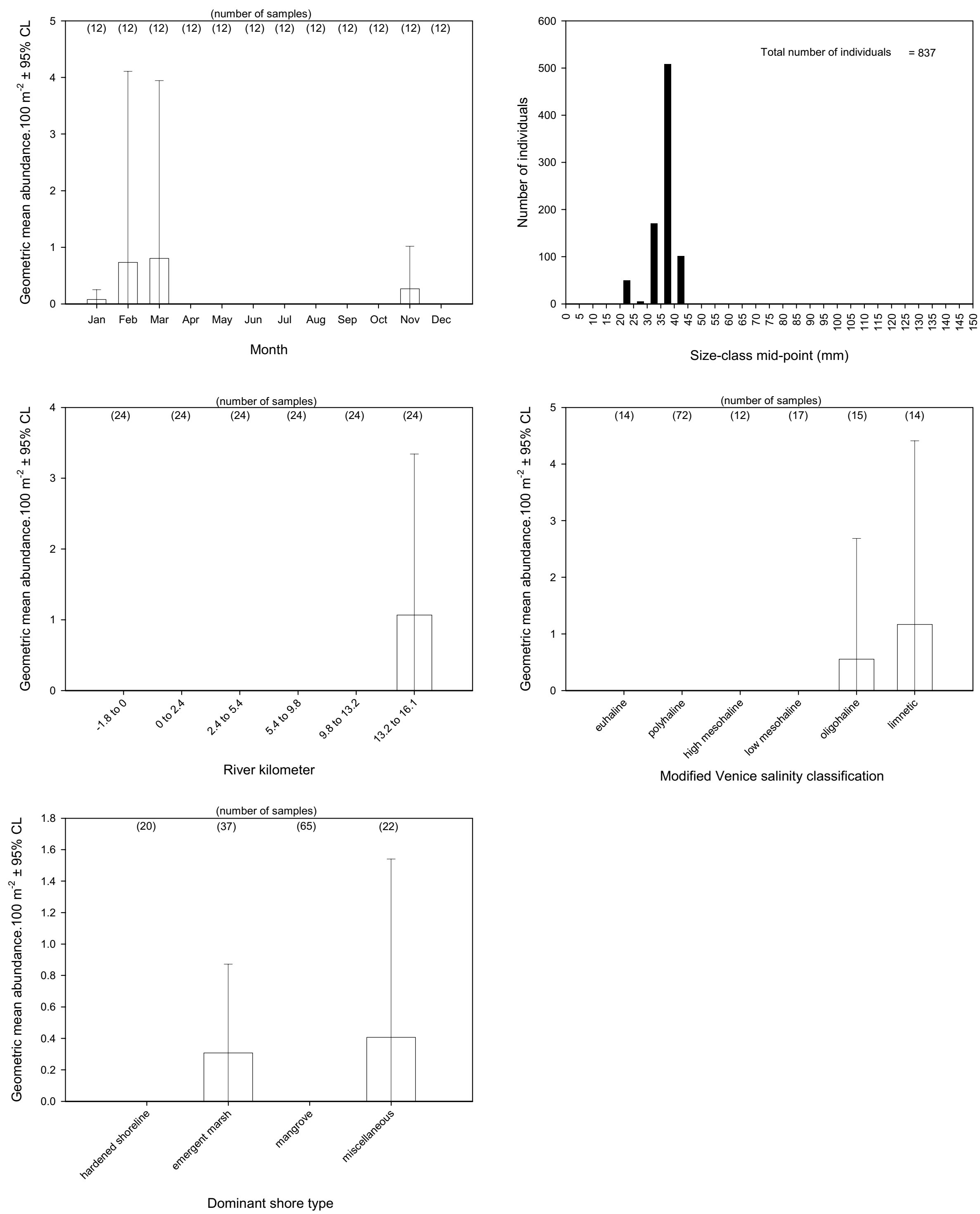


Fig. D5. Relative abundance of Coastal shiner in shoreline (seined) habitats.

Strongylura notata (Redfin needlefish), Seines

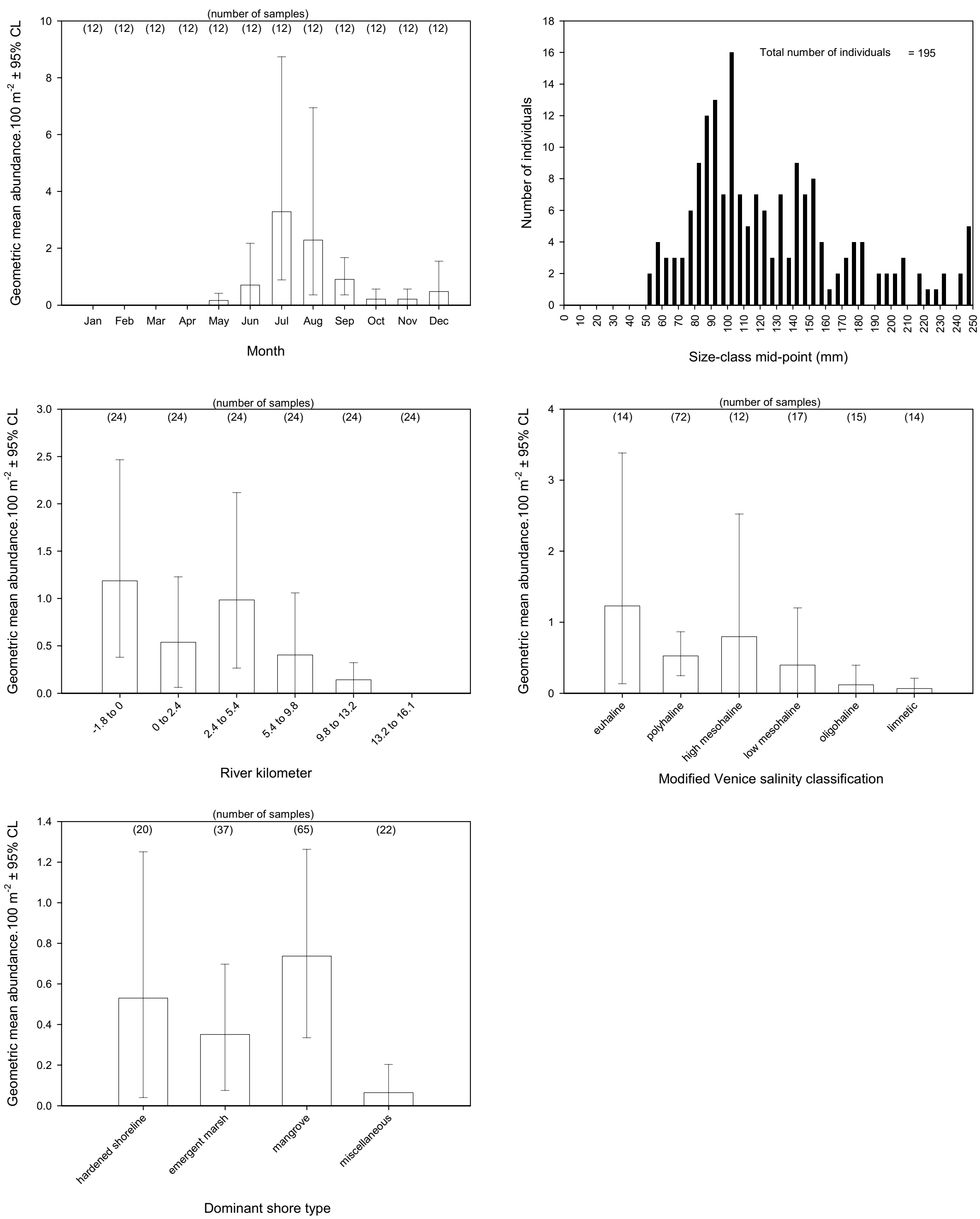


Fig. D6. Relative abundance of Redfin needlefish in shoreline (seined) habitats.

Lucania goodei (Bluefin killifish), Seines

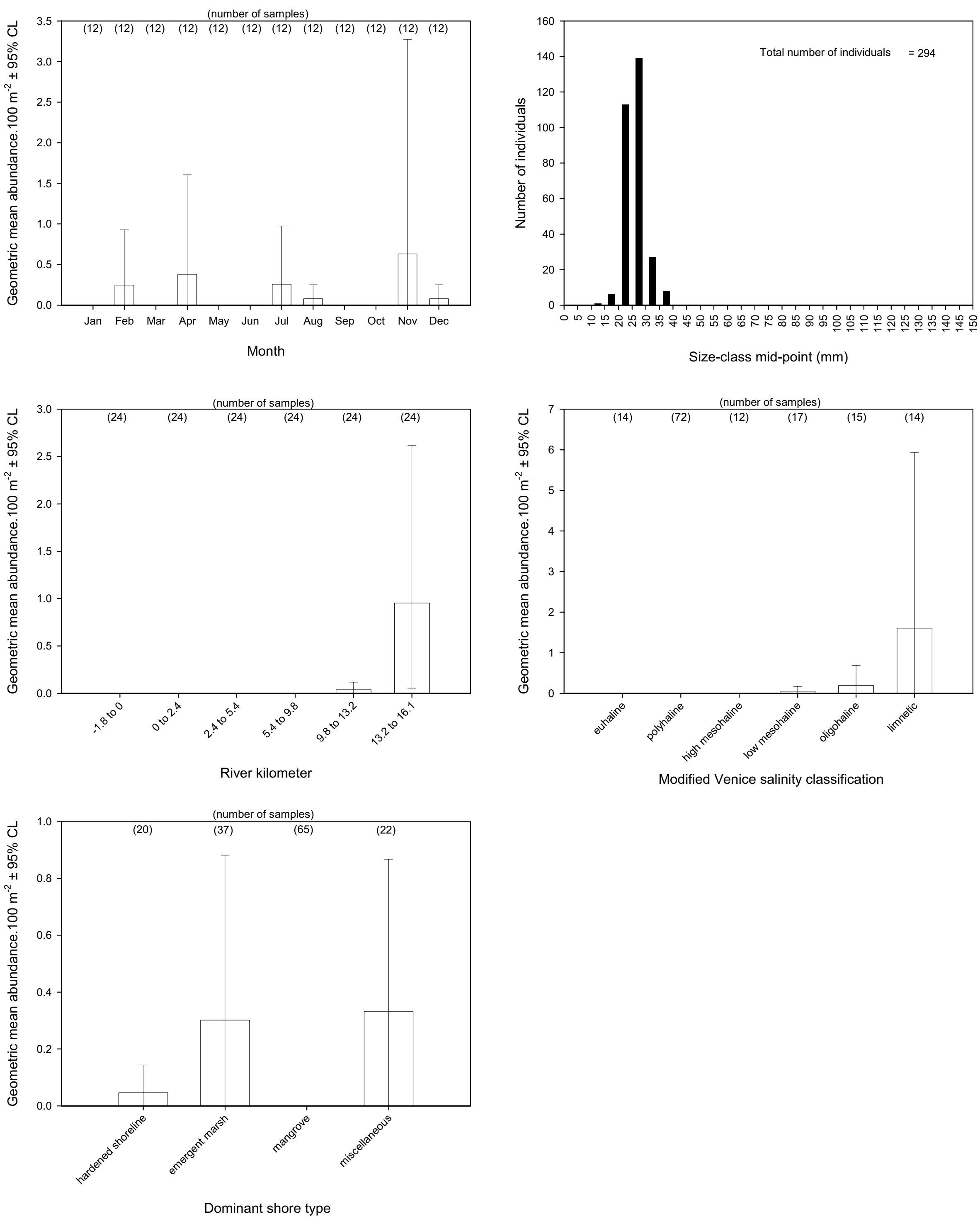


Fig. D7. Relative abundance of Bluefin killifish in shoreline (seined) habitats.

Floridichthys carpio (Goldspotted killifish), Seines

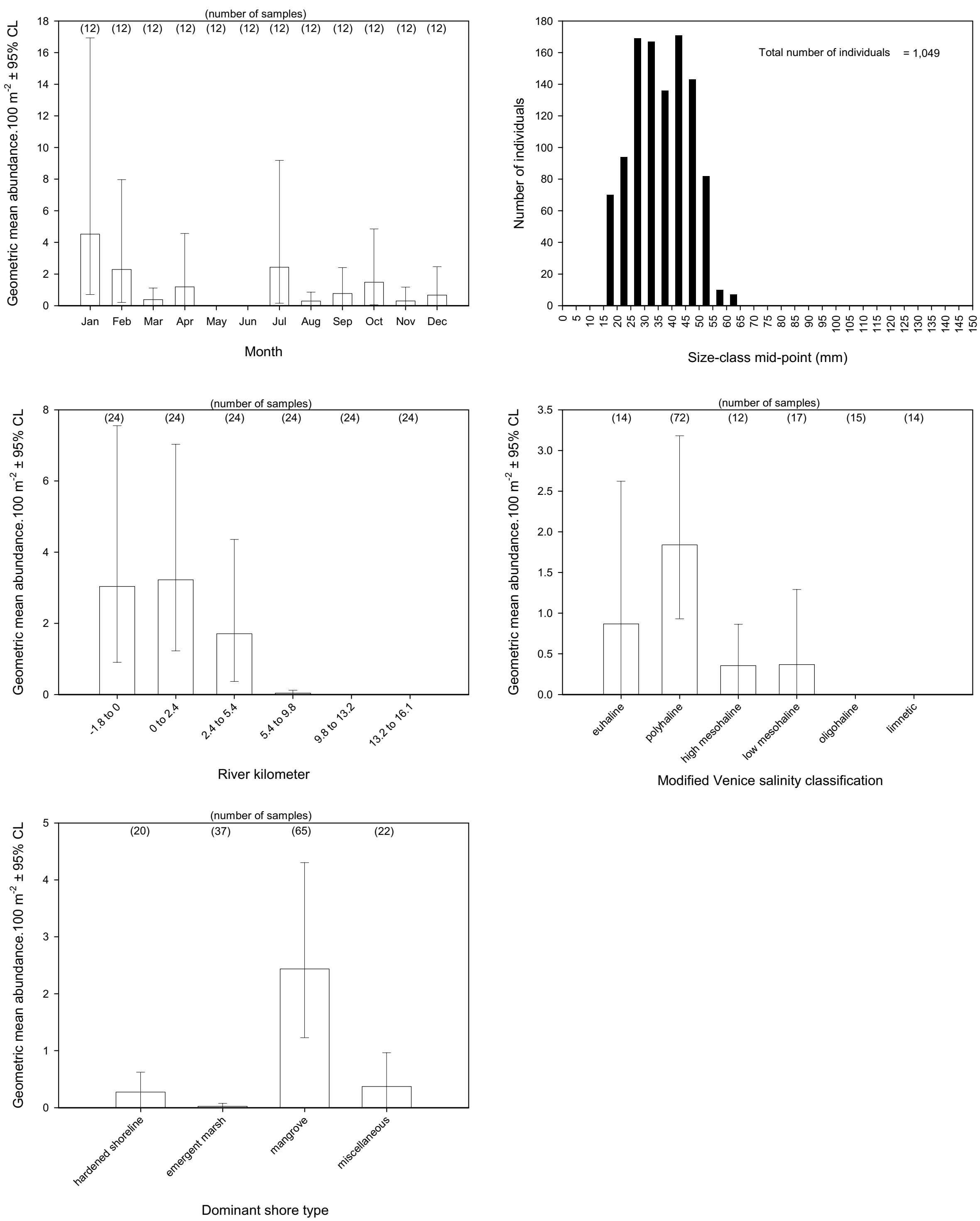


Fig. D8. Relative abundance of Goldspotted killifish in shoreline (seined) habitats.

Gambusia holbrooki (Eastern mosquitofish), Seines

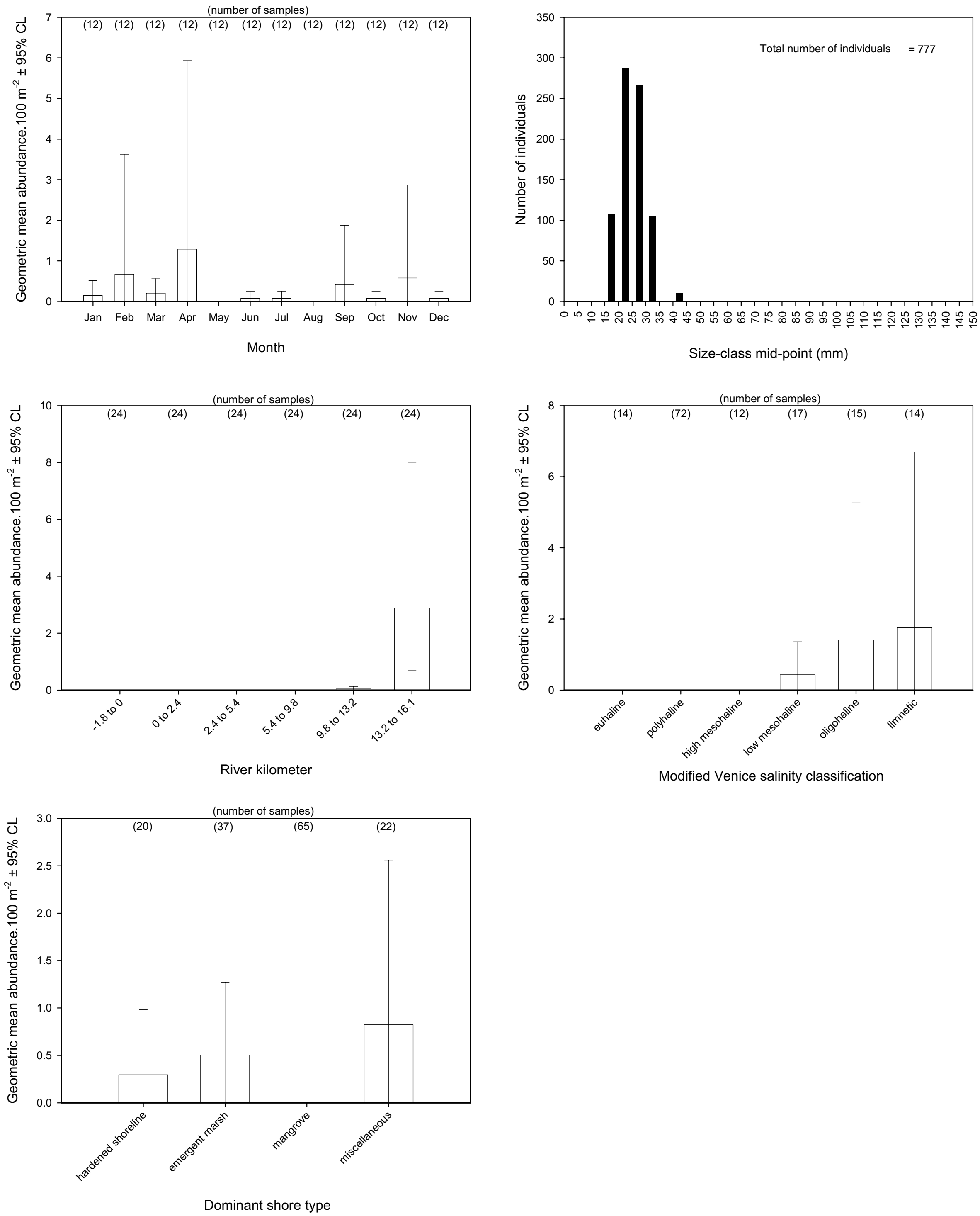


Fig. D9. Relative abundance of Eastern mosquitofish in shoreline (seined) habitats.

Poecilia latipinna (Sailfin molly), Seines

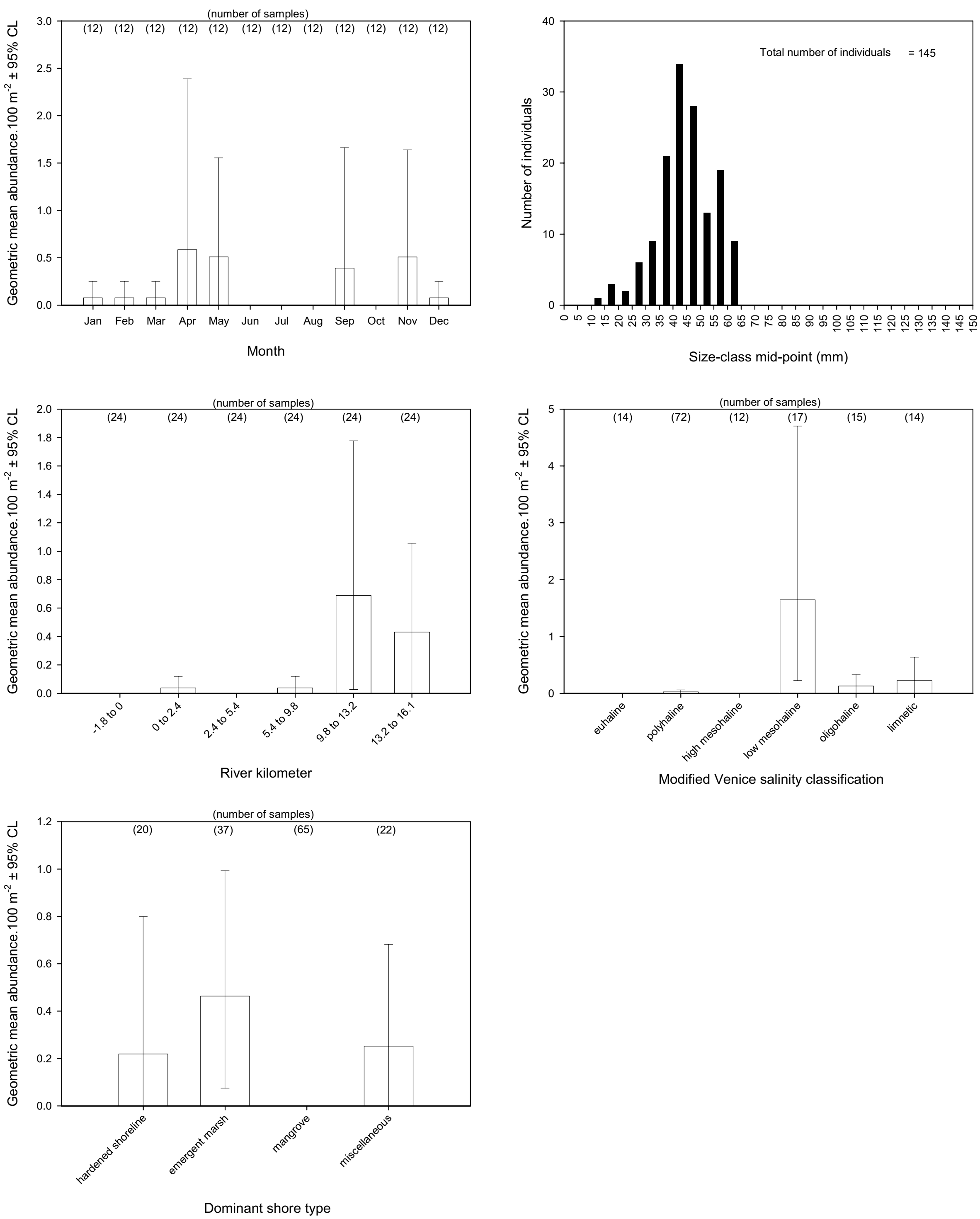


Fig. D10. Relative abundance of Sailfin molly in shoreline (seined) habitats.

Menidia spp. (Silversides), Seines

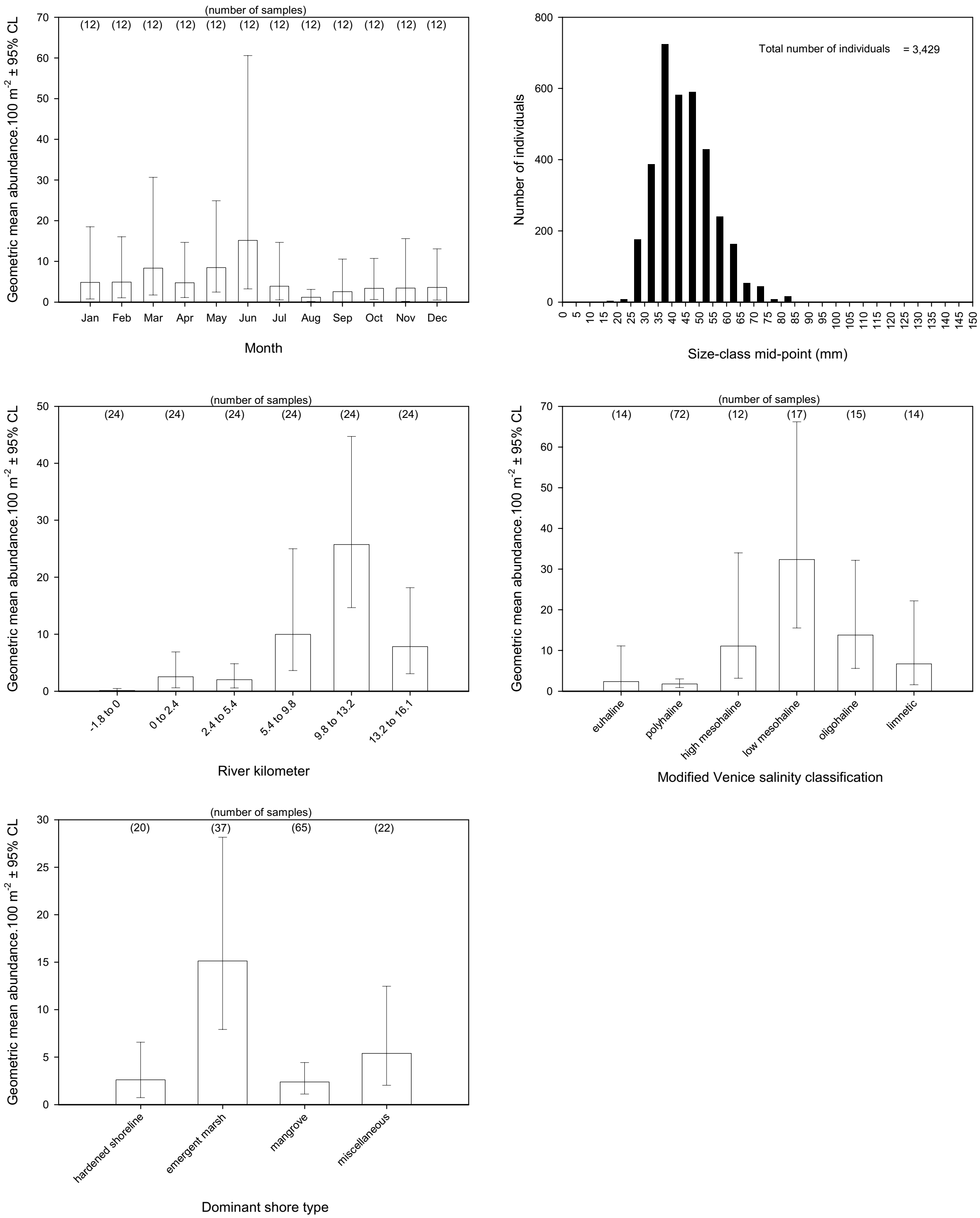


Fig. D11. Relative abundance of Silversides in shoreline (seined) habitats.

Labidesthes sicculus (Brook silverside), Seines

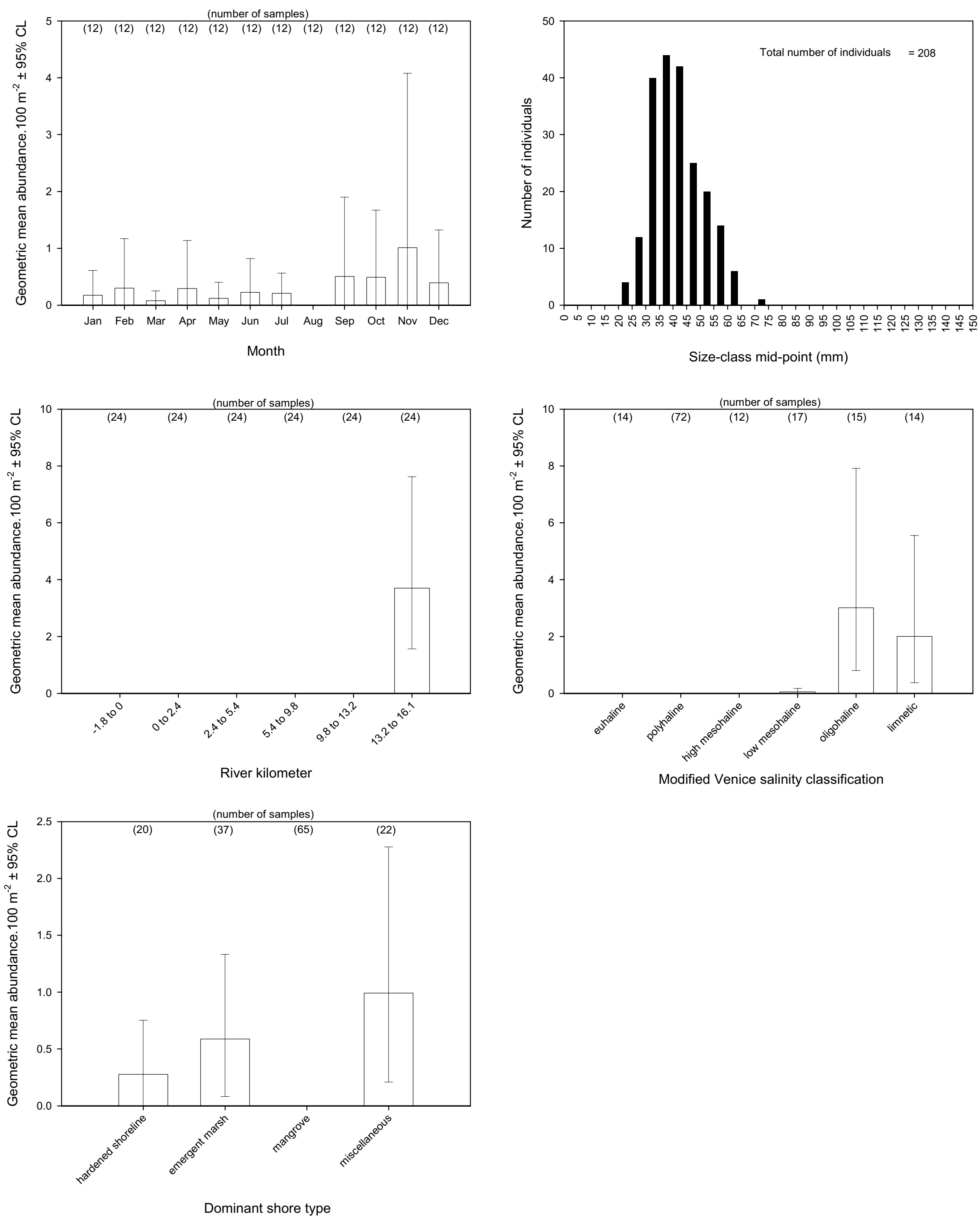


Fig. D12. Relative abundance of Brook silverside in shoreline (seined) habitats.

Lepomis macrochirus (Bluegill), Seines

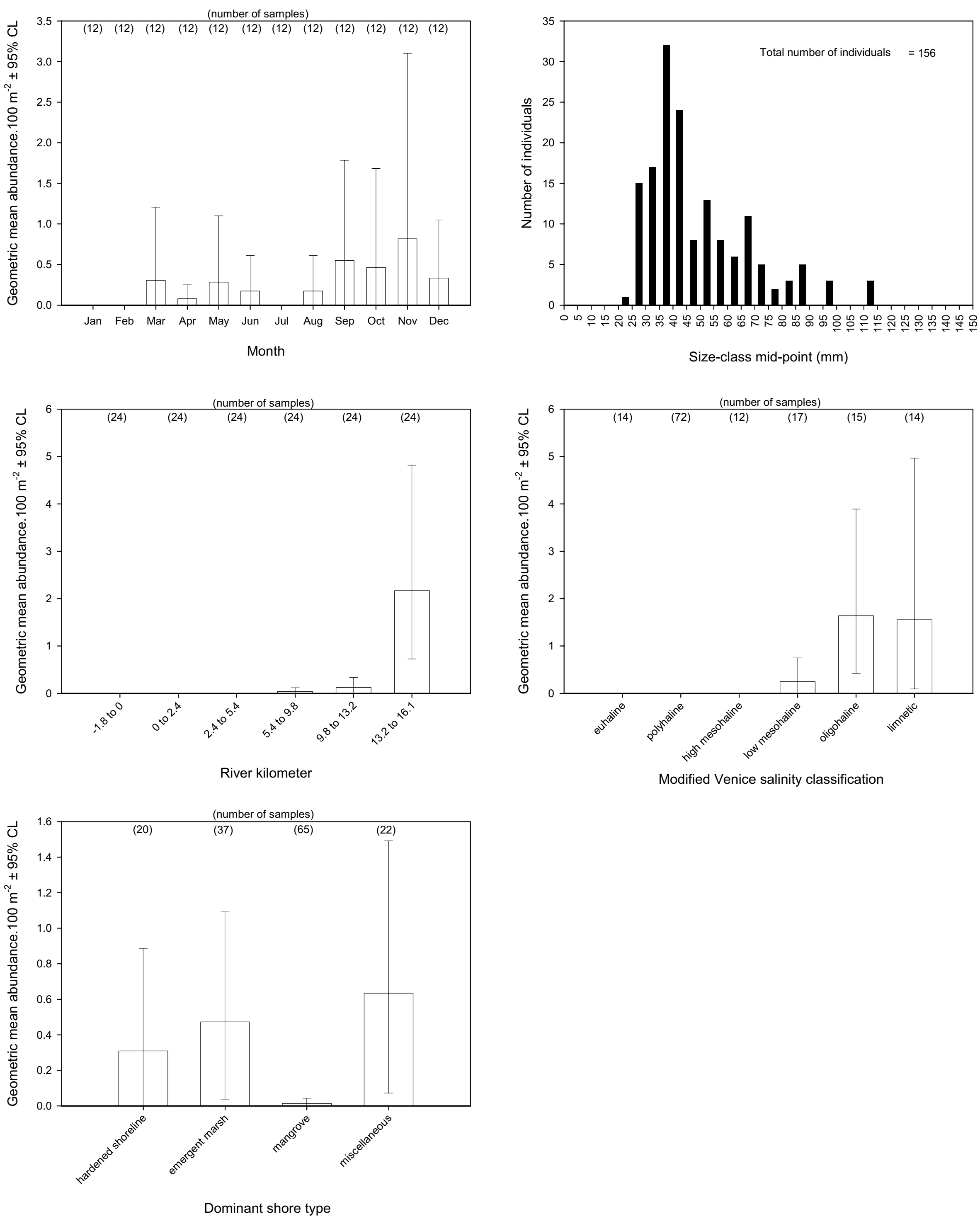


Fig. D13. Relative abundance of Bluegill in shoreline (seined) habitats.

Eucinostomus spp. (Eucinostomus mojarras), Seines

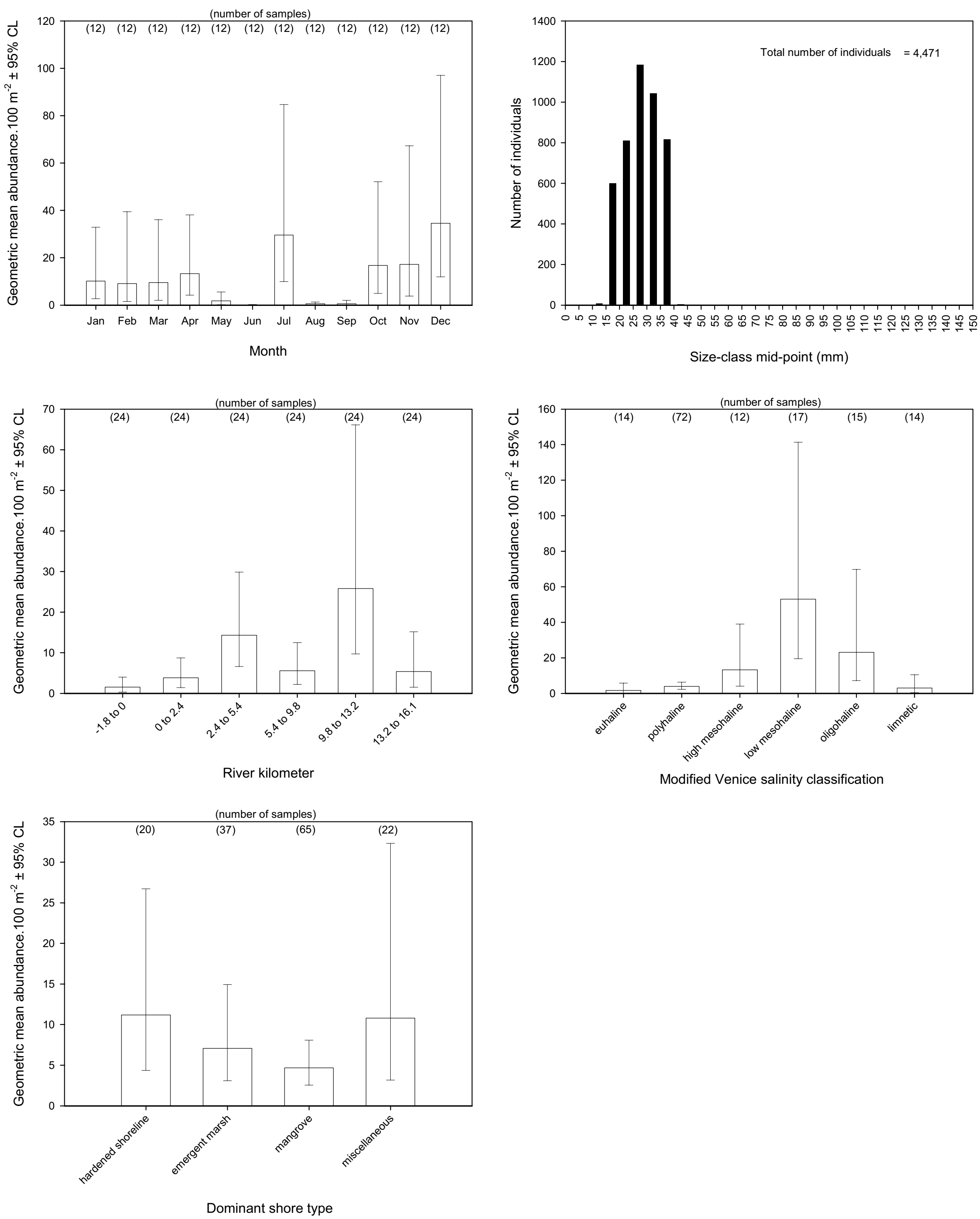


Fig. D14. Relative abundance of Eucinostomus mojarras in shoreline (seined) habitats.

Eucinostomus gula (Silver jenny), Seines

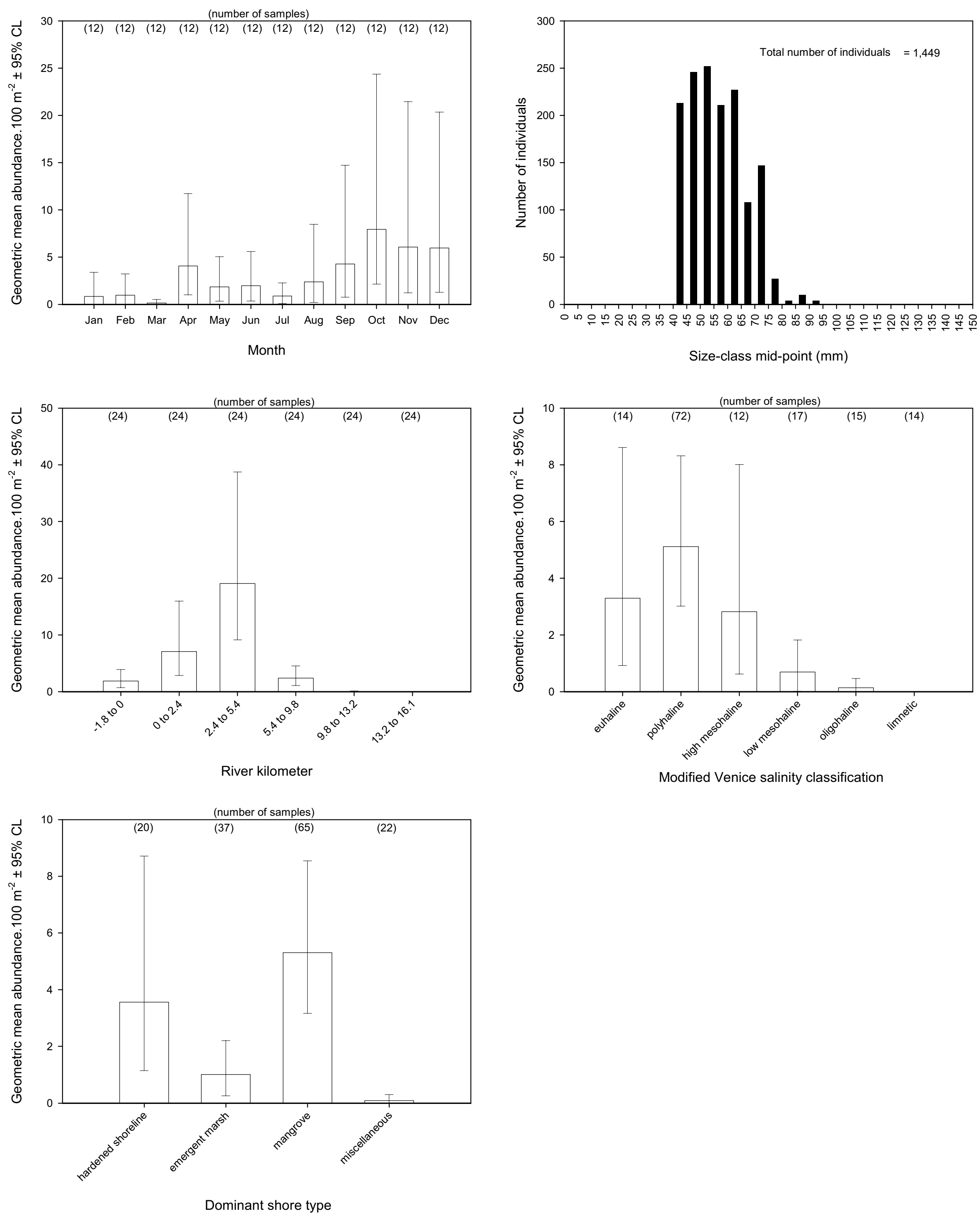


Fig. D15. Relative abundance of Silver jenny in shoreline (seined) habitats.

Eucinostomus harengulus (Tidewater mojarra), Seines

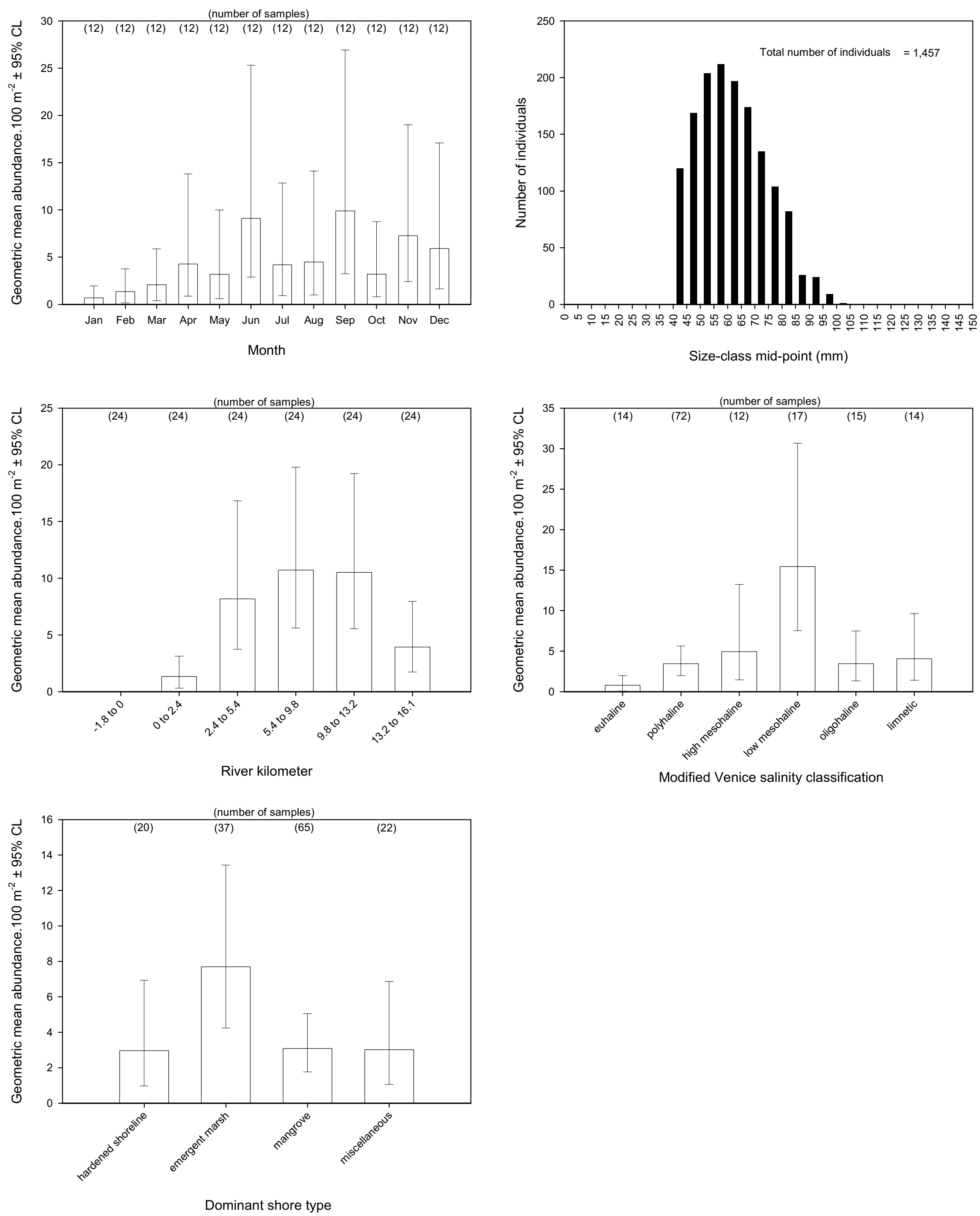


Fig. D16. Relative abundance of Tidewater mojarra in shoreline (seined) habitats.

Lagodon rhomboides (Pinfish), Seines

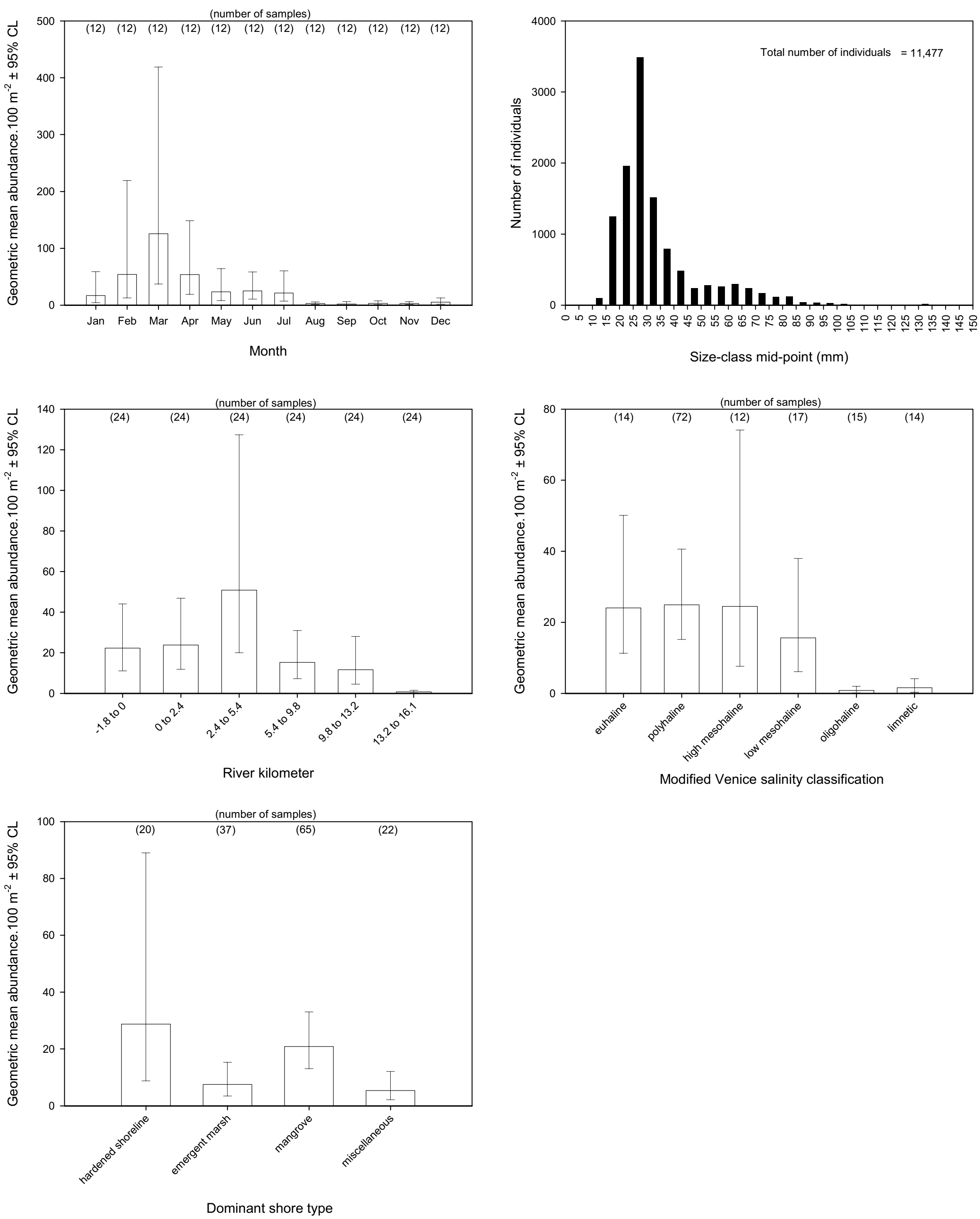


Fig. D17. Relative abundance of Pinfish in shoreline (seined) habitats.

Leiostomus xanthurus (Spot), Seines

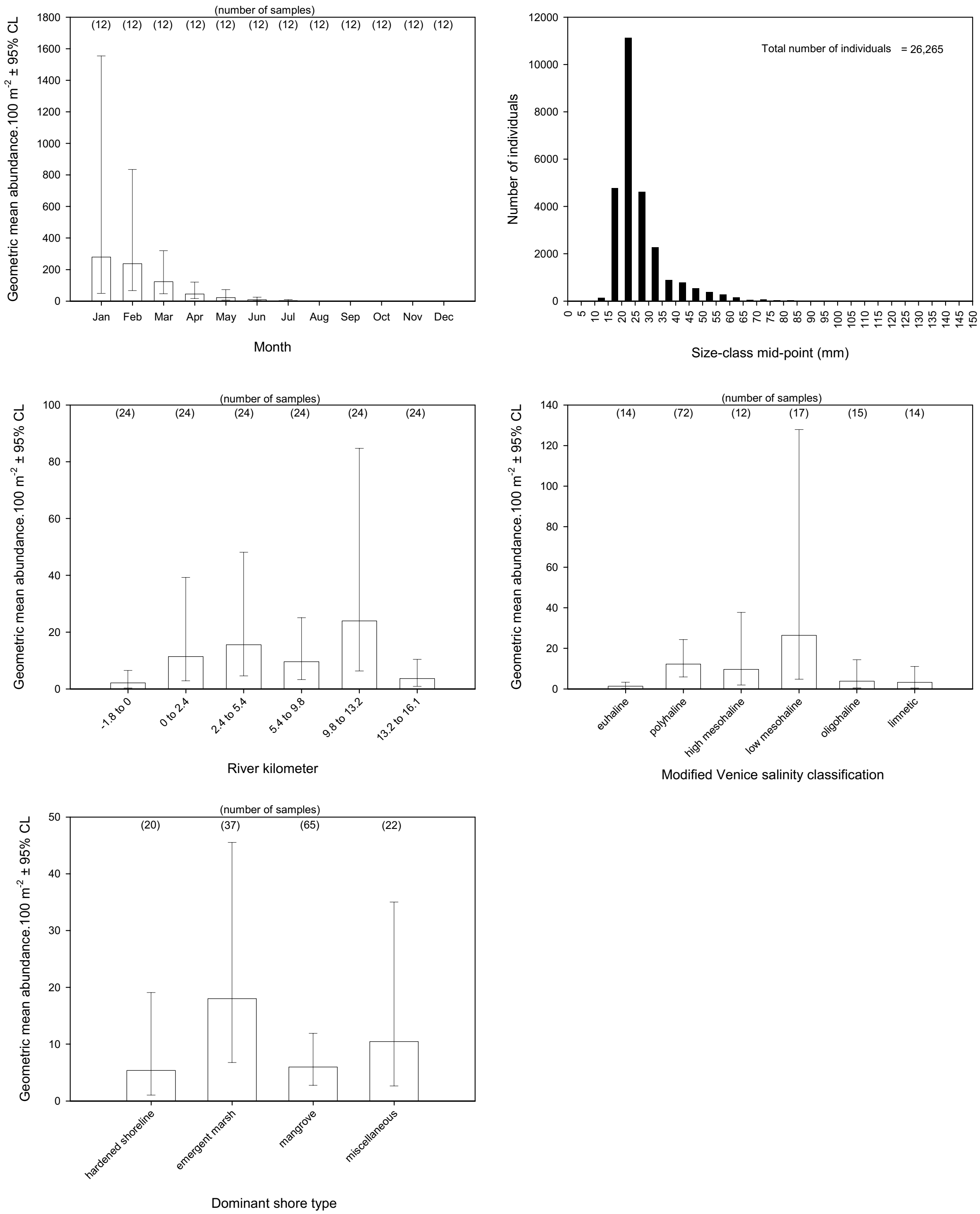


Fig. D18. Relative abundance of Spot in shoreline (seined) habitats.

Mugil cephalus (Striped mullet), Seines

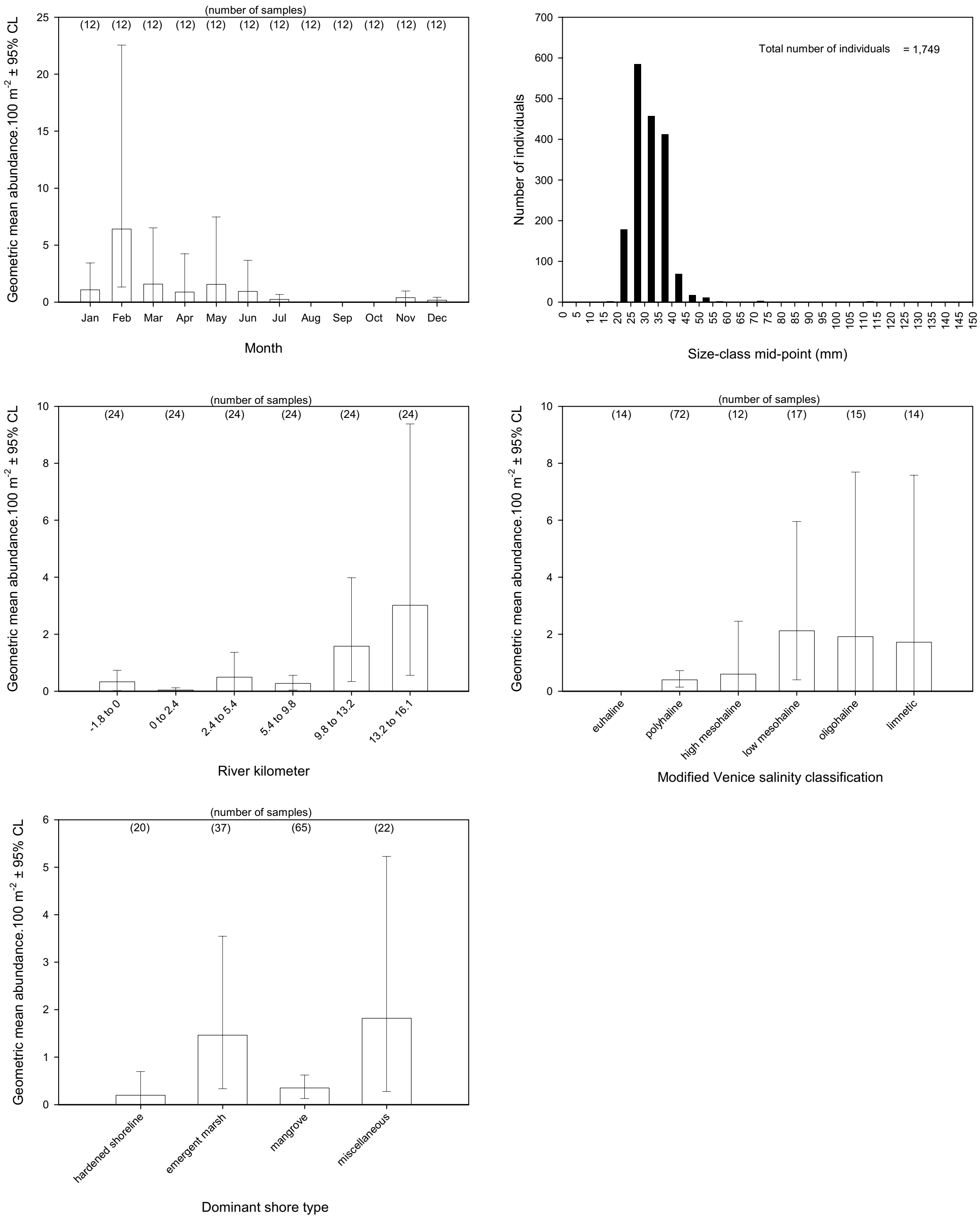


Fig. D19. Relative abundance of Striped mullet in shoreline (seined) habitats.

Microgobius gulosus (Clown goby), Seines

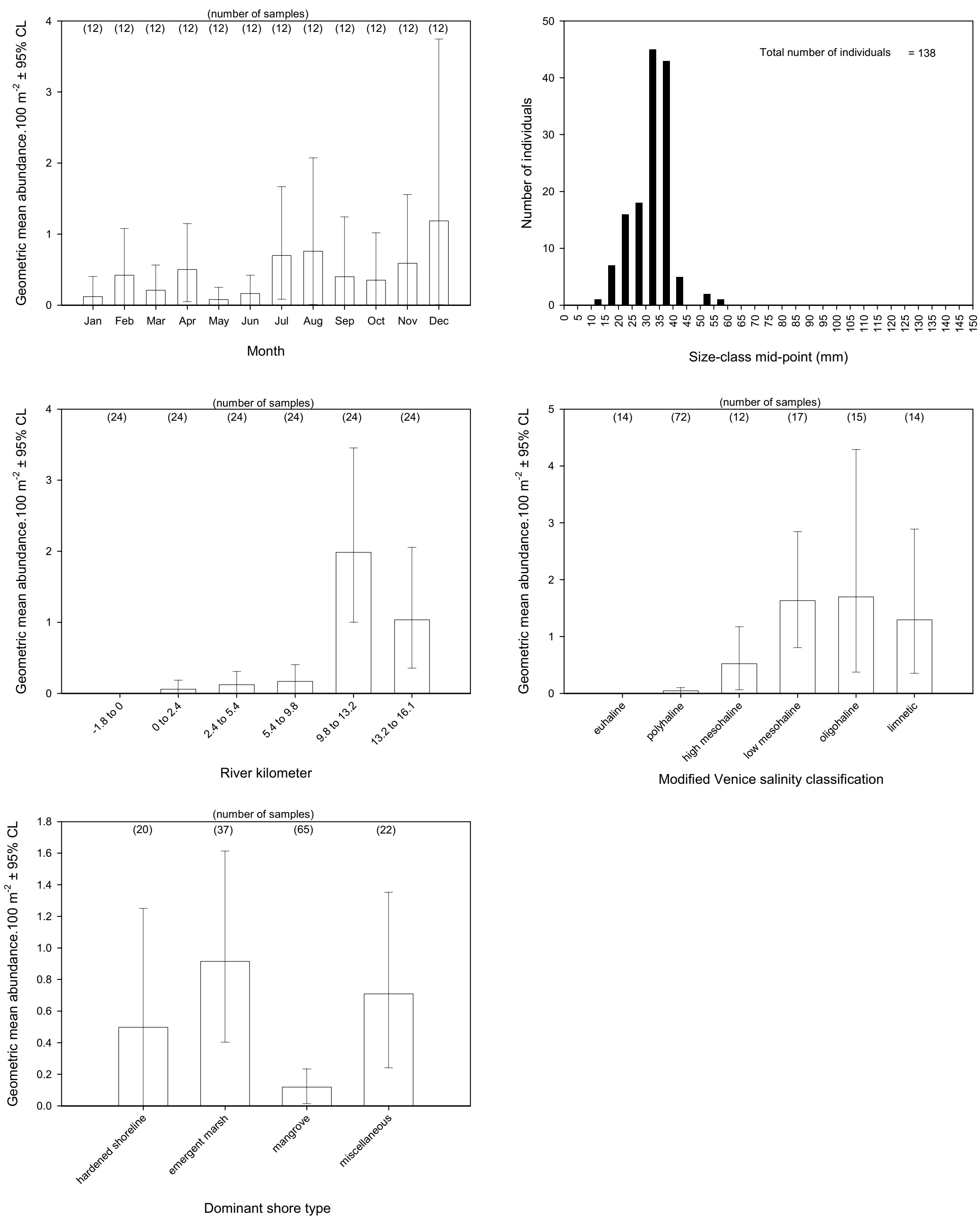


Fig. D20. Relative abundance of Clown goby in shoreline (seined) habitats.

Appendix E:

Trawl catch overview plots

Farfantepenaeus duorarum (Pink shrimp), Trawls

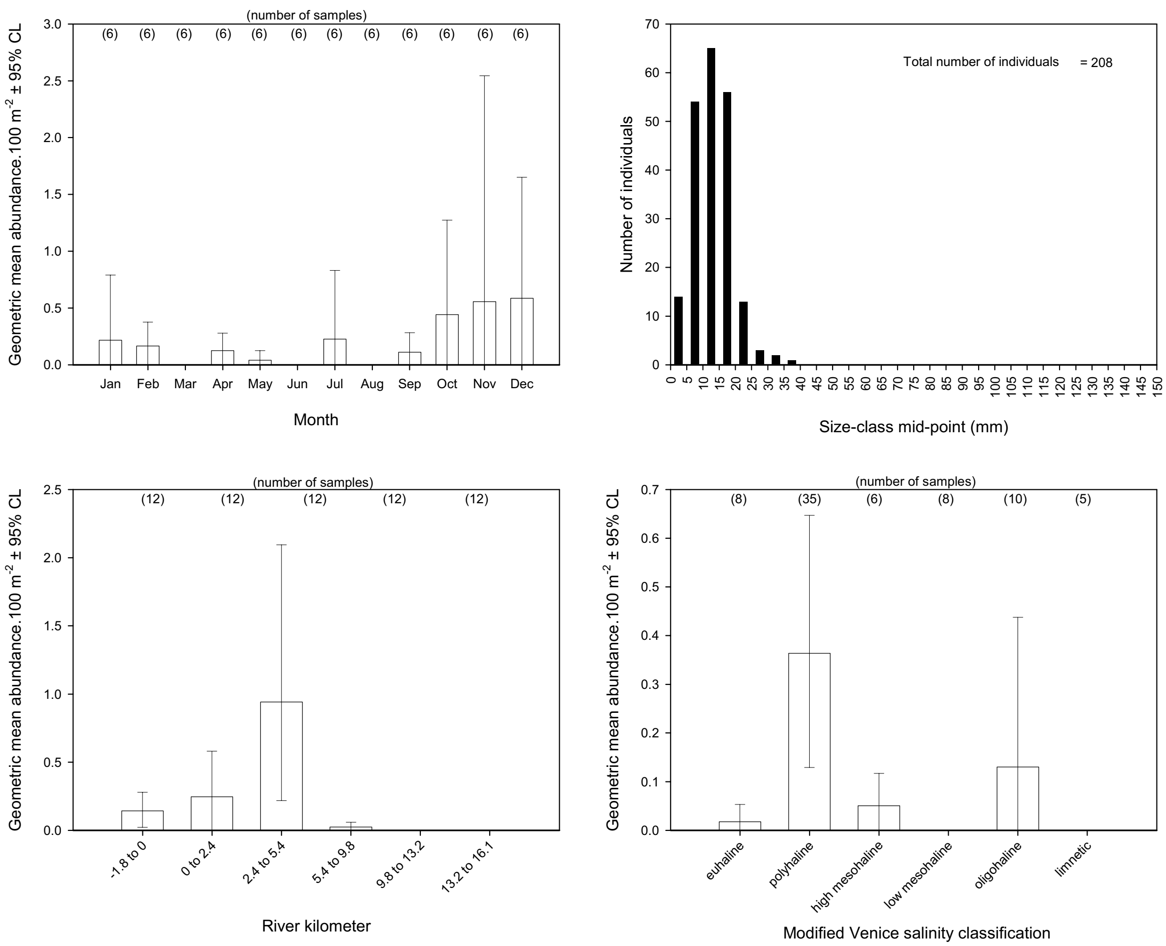


Fig. E1. Relative abundance of Pink shrimp in deeper (trawled) habitats.

Palaemonetes intermedius (Brackish grass shrimp), Trawls

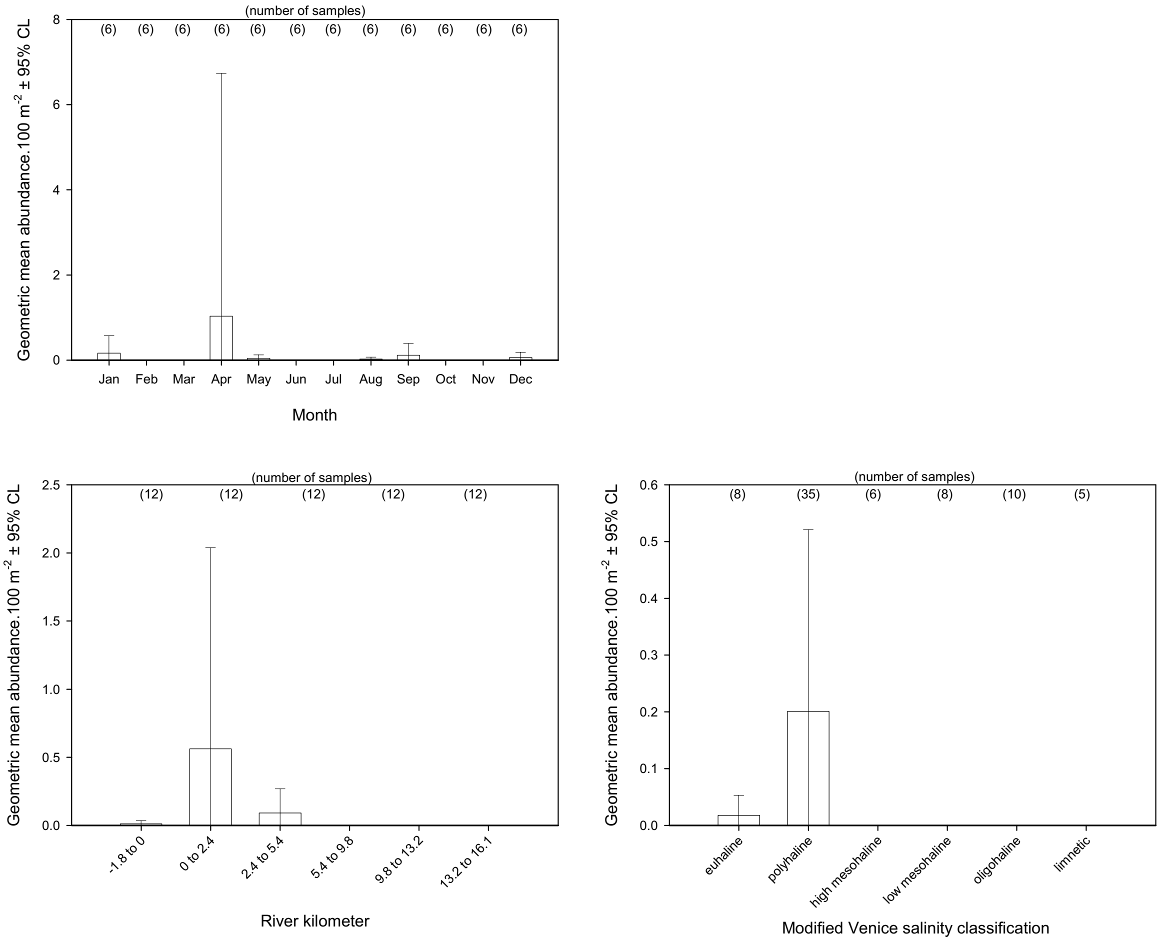


Fig. E2. Relative abundance of Brackish grass shrimp in deeper (trawled) habitats.

Periclimenes longicaudatus (Longtail grass shrimp), Trawls

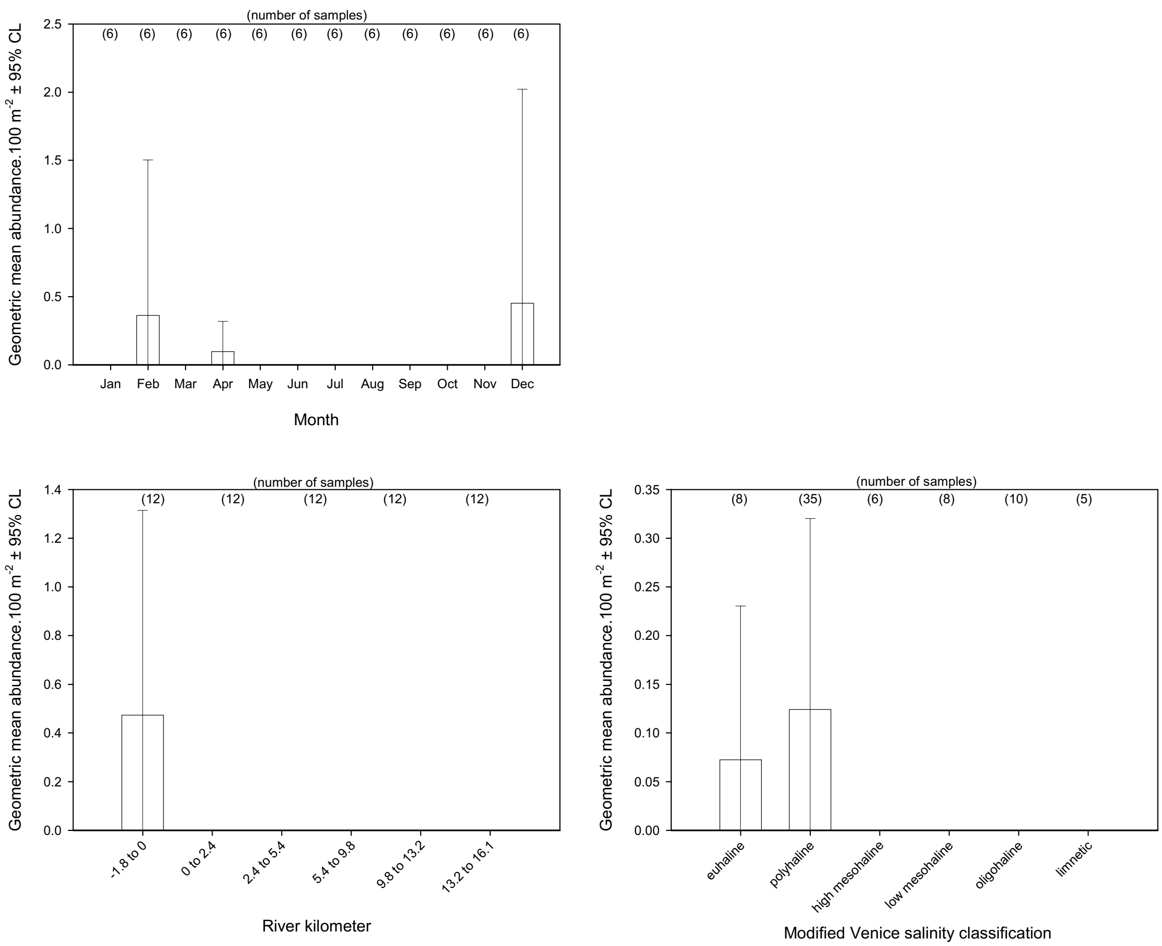


Fig. E3. Relative abundance of Longtail grass shrimp in deeper (trawled) habitats.

Tozeuma carolinense (Arrow shrimp), Trawls

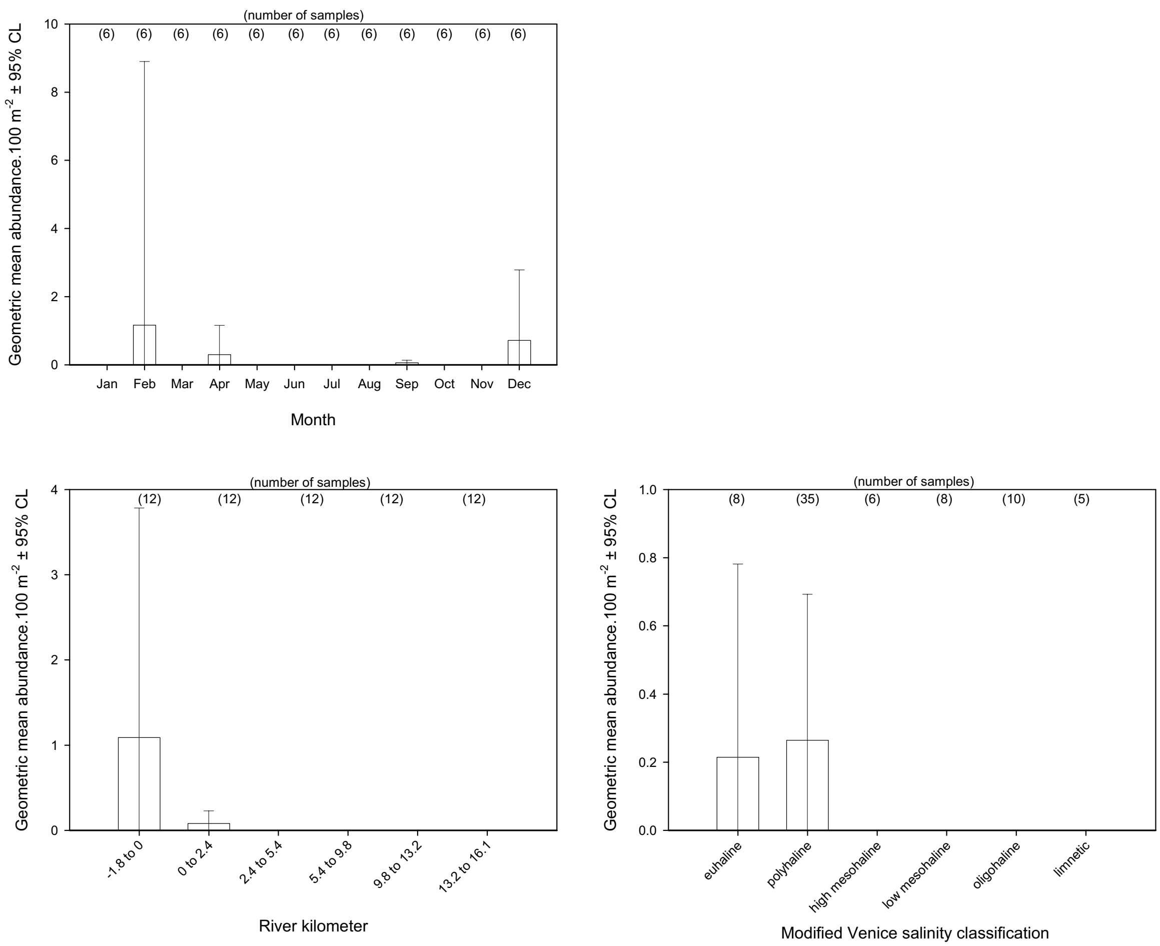


Fig. E4. Relative abundance of Arrow shrimp in deeper (trawled) habitats.

Callinectes sapidus **(Blue crab), Trawls**

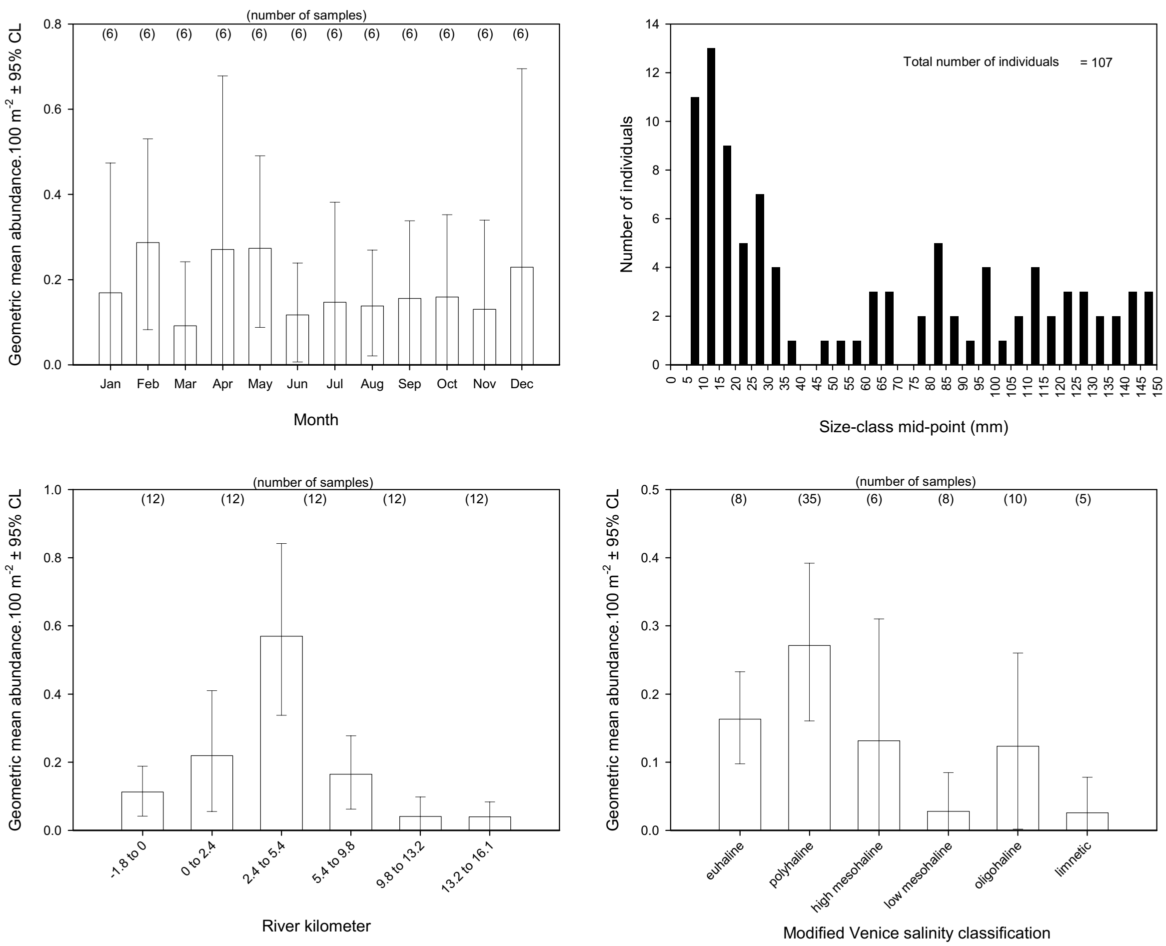


Fig. E5. Relative abundance of Blue crab in deeper (trawled) habitats.

Anchoa mitchilli (Bay anchovy), Trawls

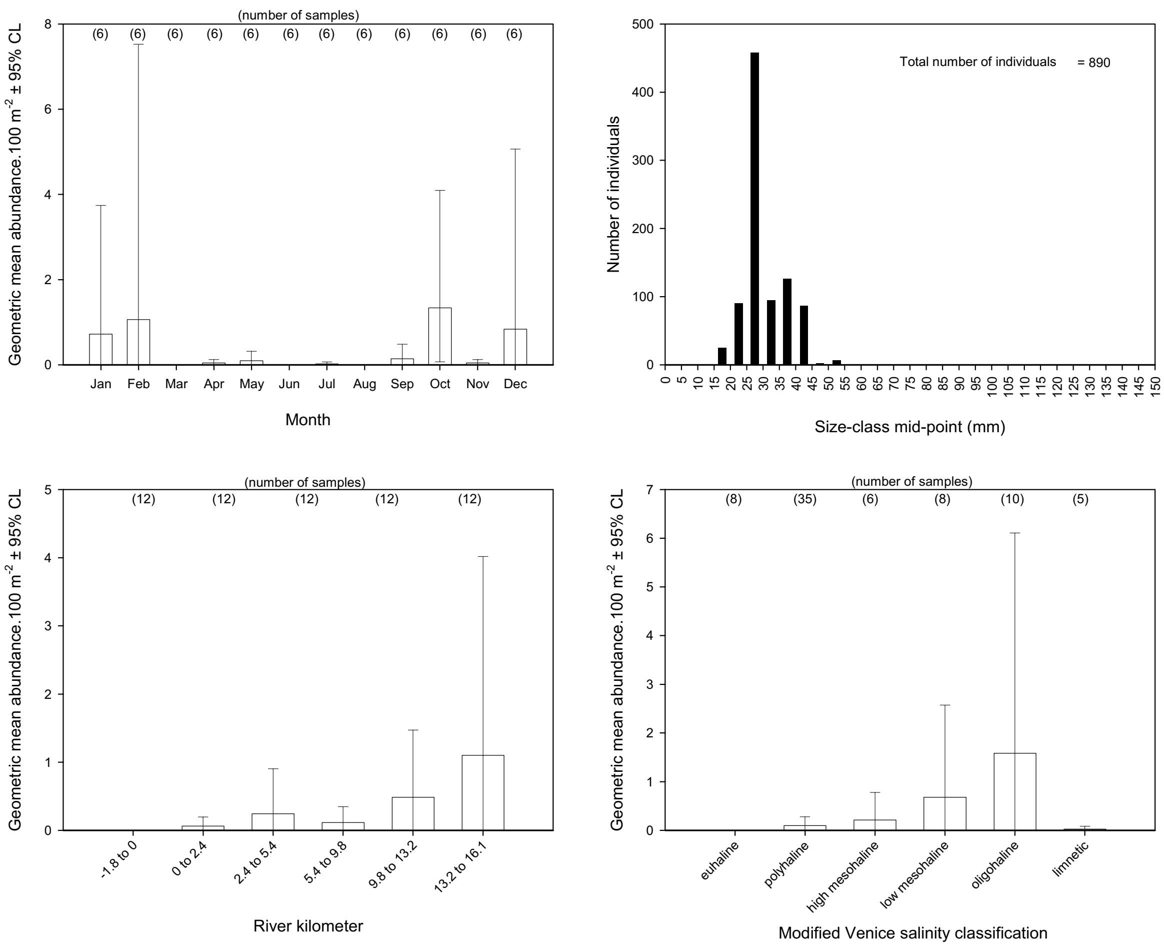


Fig. E6. Relative abundance of Bay anchovy in deeper (trawled) habitats.

Lucania parva (Rainwater killifish), Trawls

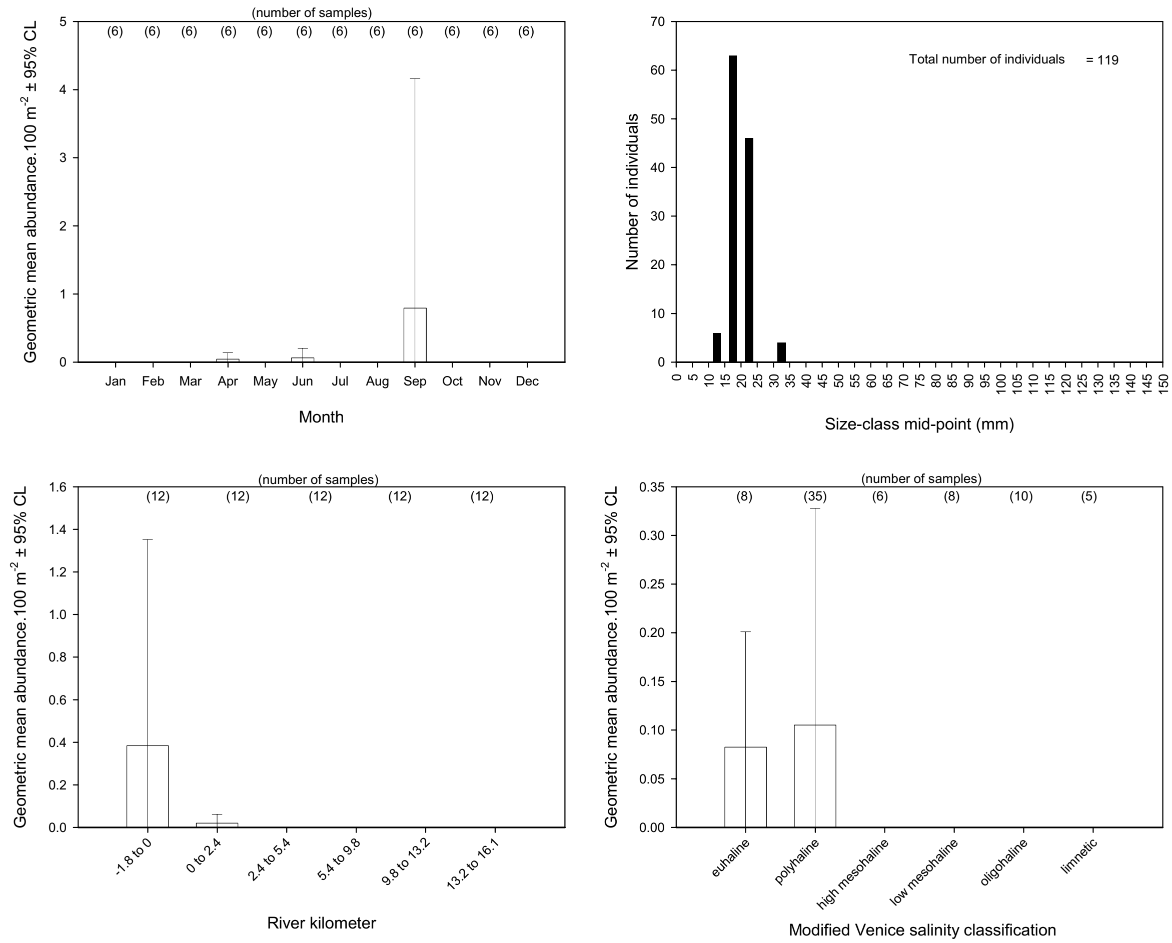


Fig. E7. Relative abundance of Rainwater killifish in deeper (trawled) habitats.

Eucinostomus spp. (Eucinostomus mojarras), Trawls

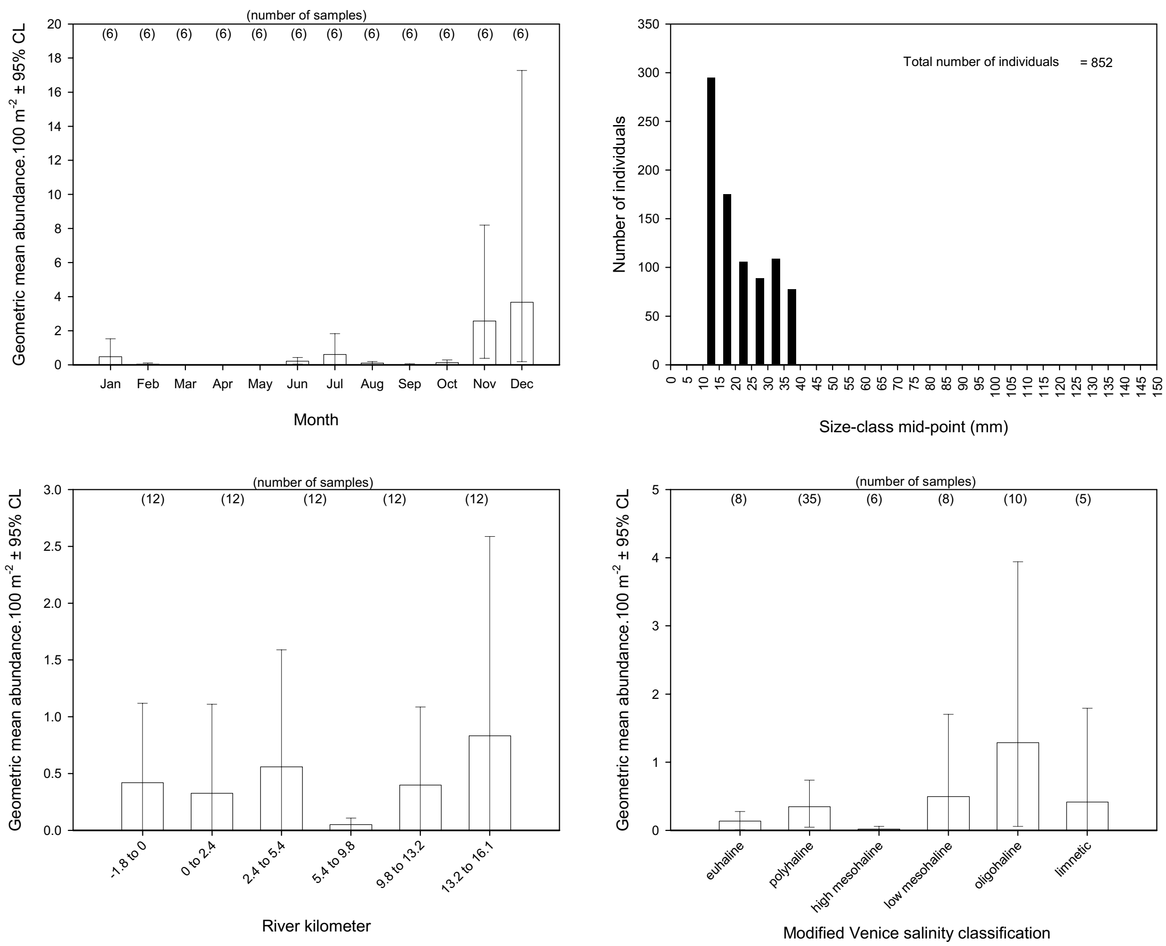


Fig. E8. Relative abundance of Eucinostomus mojarras in deeper (trawled) habitats.

Eucinostomus gula (Silver jenny), Trawls

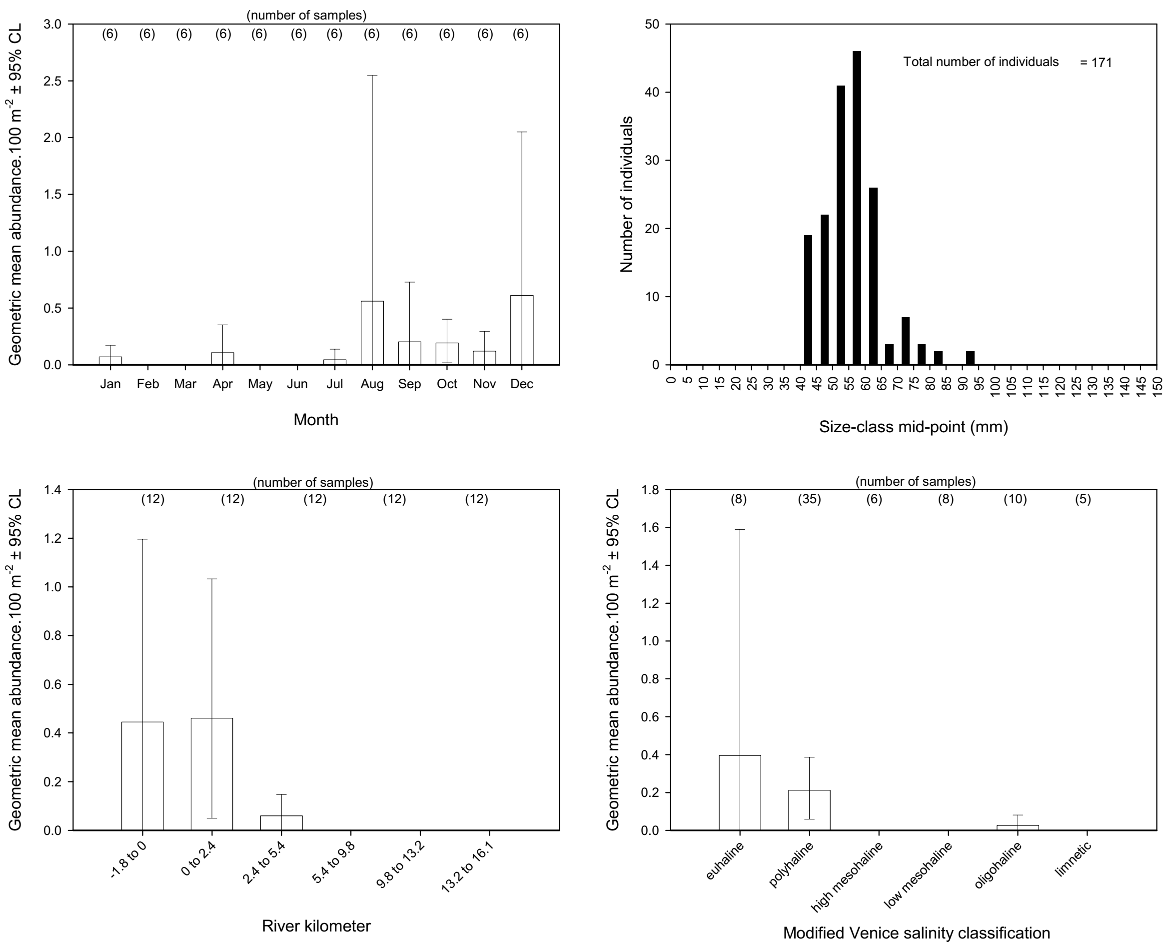


Fig. E9. Relative abundance of Silver jenny in deeper (trawled) habitats.

Orthopristis chrysoptera (Pigfish), Trawls

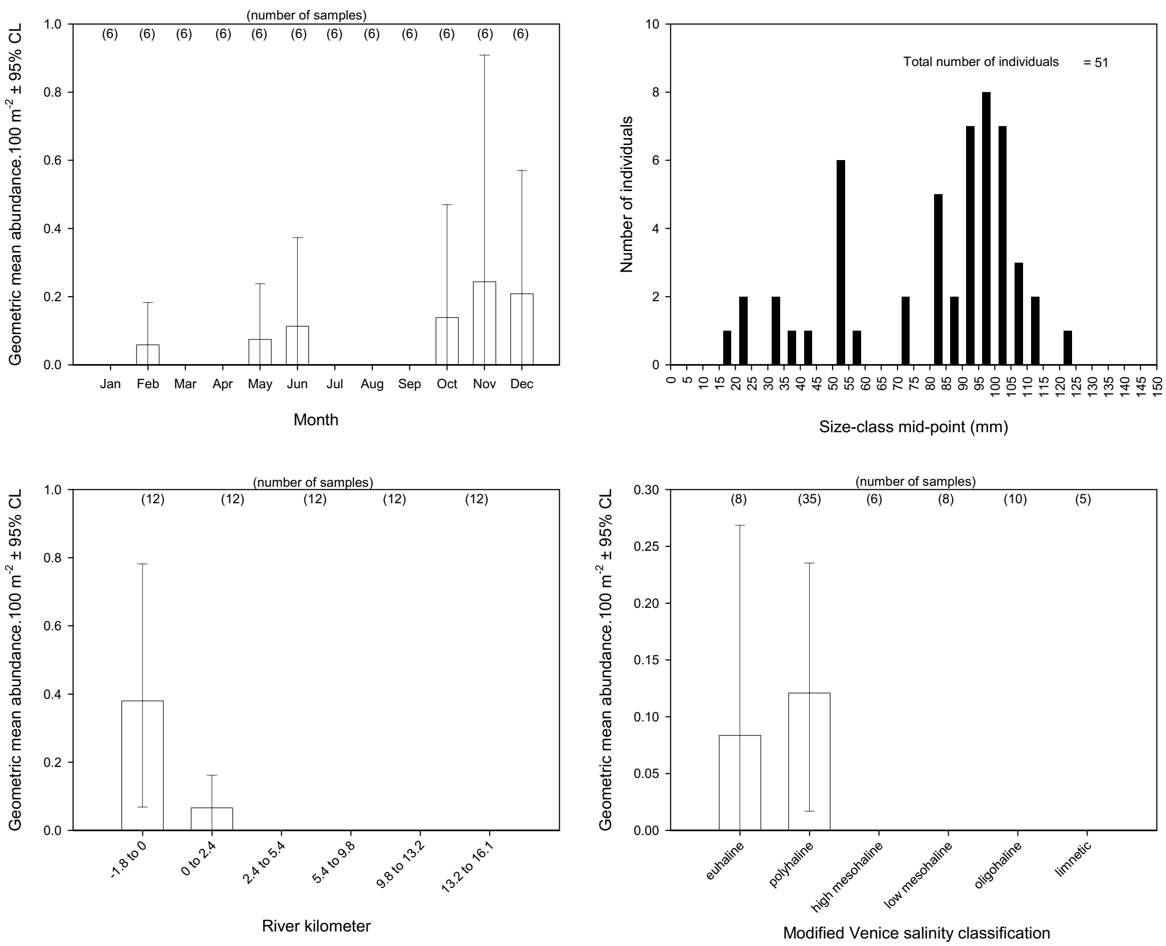


Fig. E10. Relative abundance of Pigfish in deeper (trawled) habitats.

Lagodon rhomboides (Pinfish), Trawls

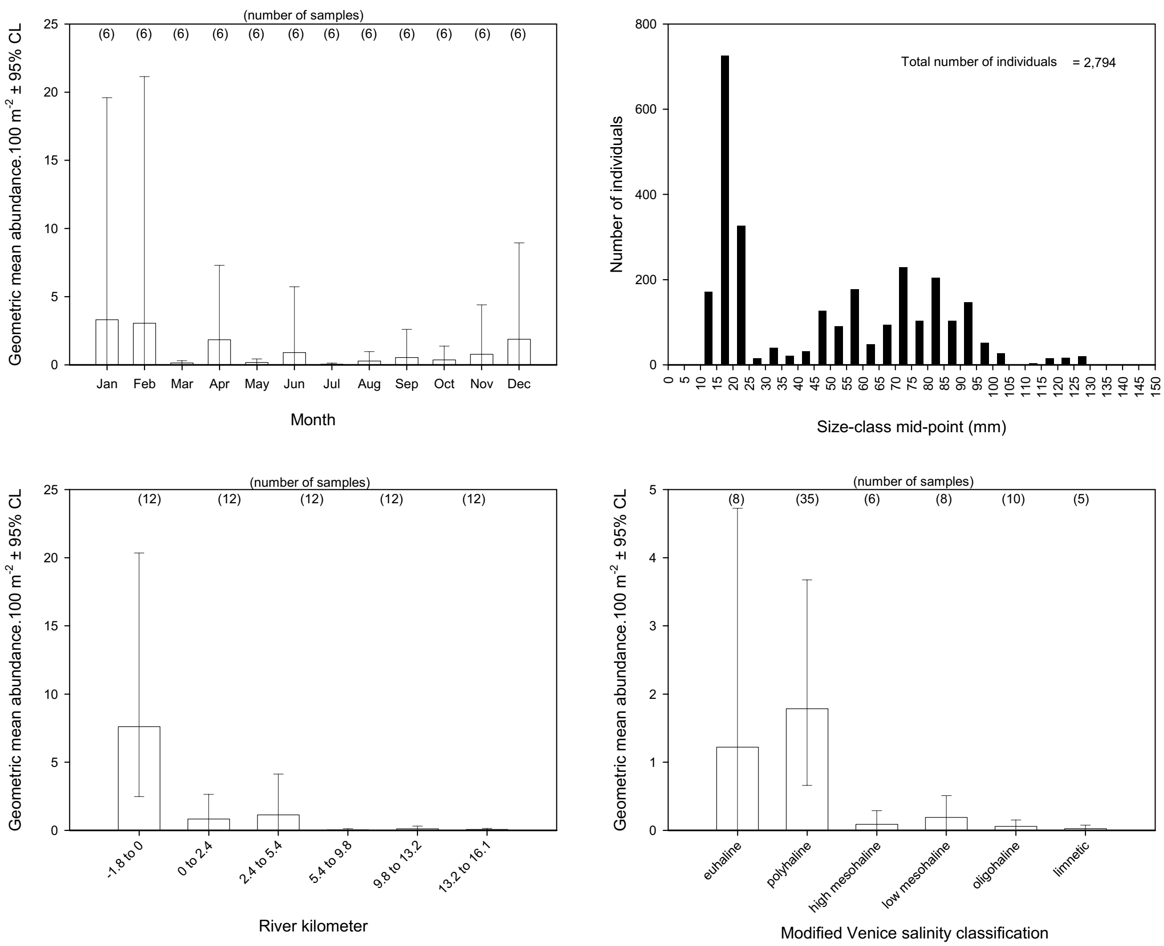


Fig. E11. Relative abundance of Pinfish in deeper (trawled) habitats.

Leiostomus xanthurus (Spot), Trawls

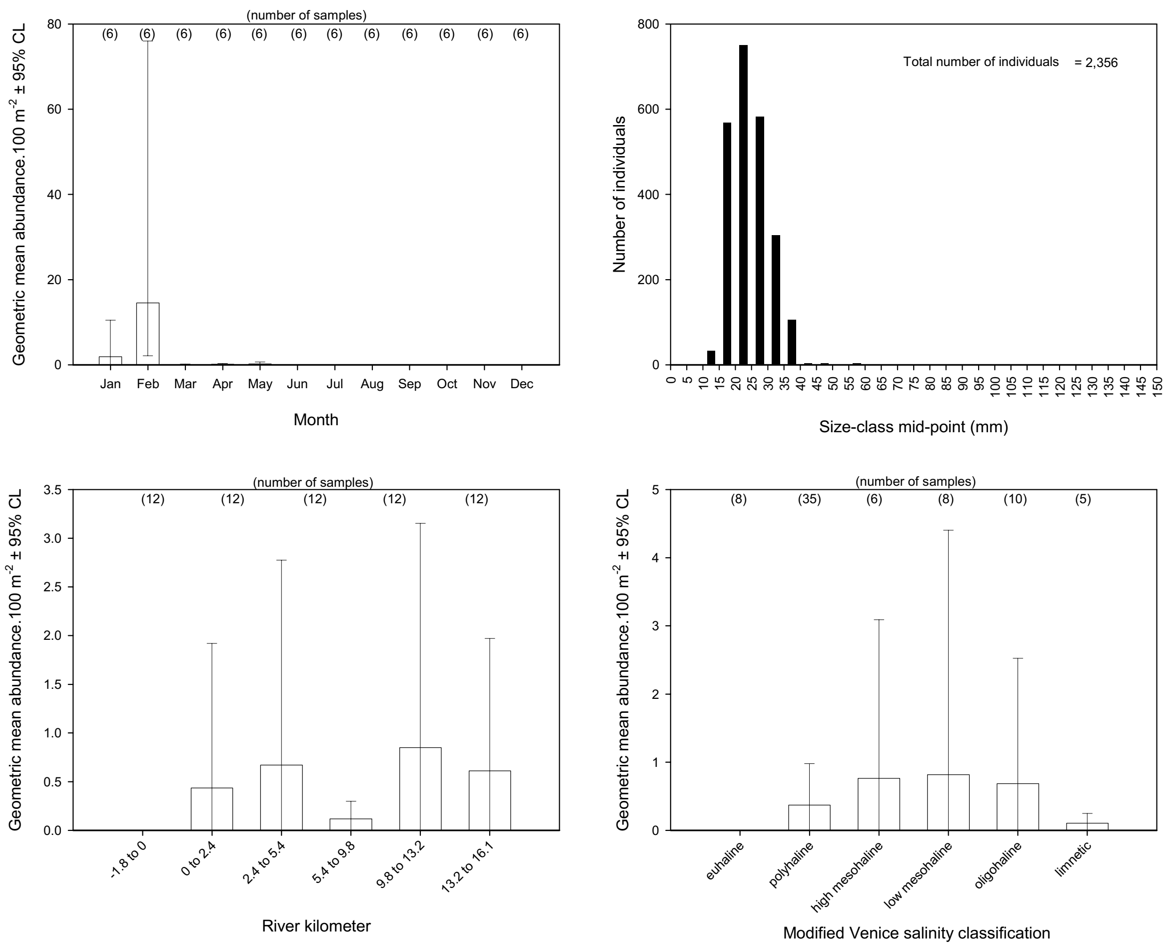


Fig. E12. Relative abundance of Spot in deeper (trawled) habitats.

Sphoeroides nephelus (Southern puffer), Trawls

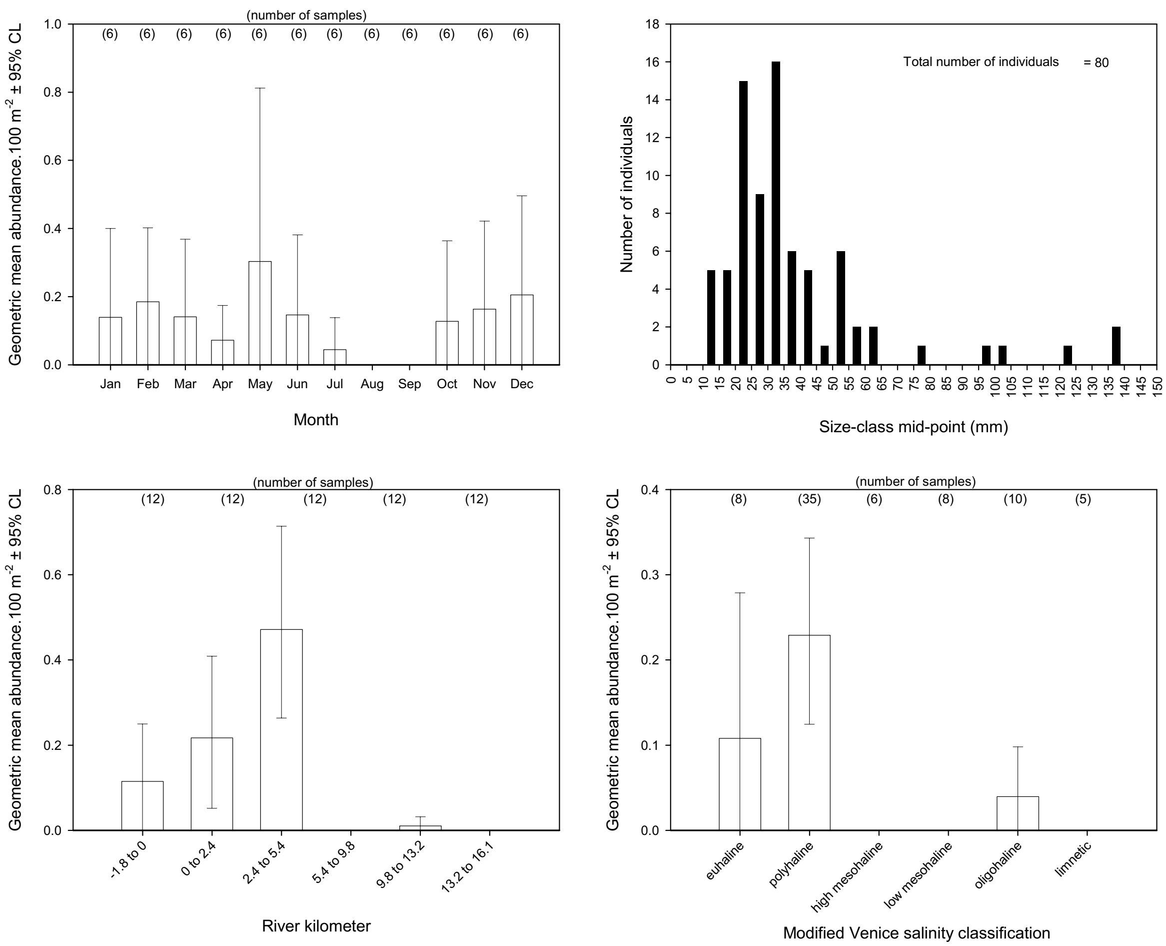
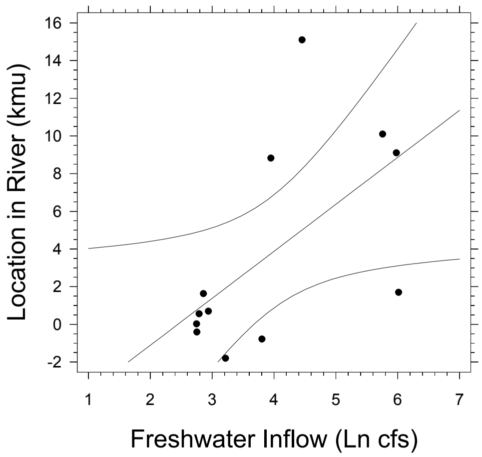


Fig. E13. Relative abundance of Southern puffer in deeper (trawled) habitats.

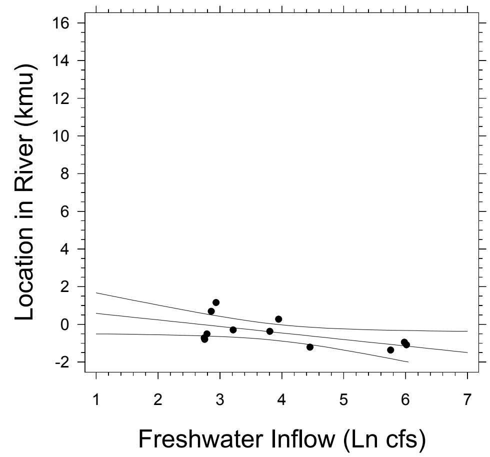
Appendix F:

Plots of the plankton-net distribution responses in Table 3.7.1.1
with 95% confidence limits for predicted means

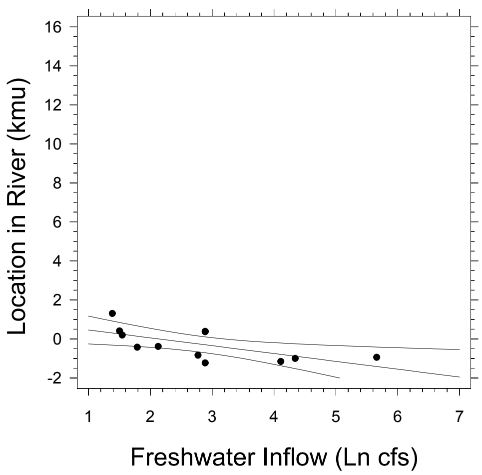
Pseudodiaptomus coronatus



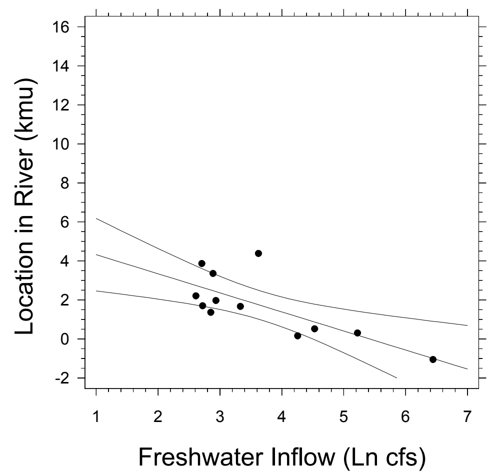
Labidocera aestiva



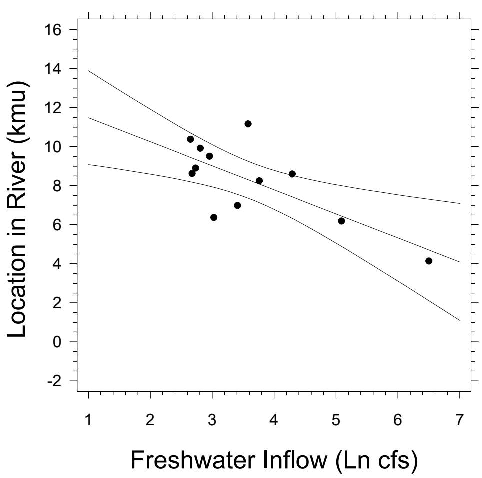
chaetognaths, sagittid



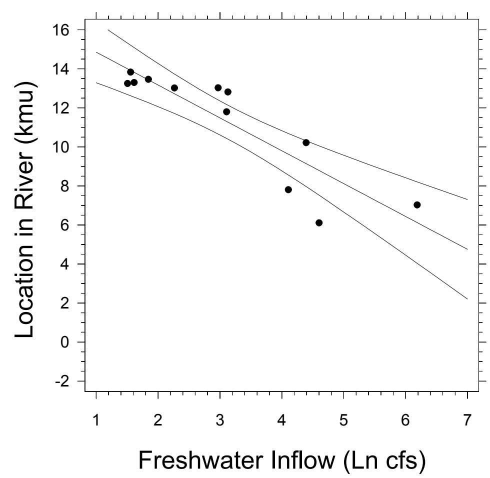
gastropods, opisthobranch

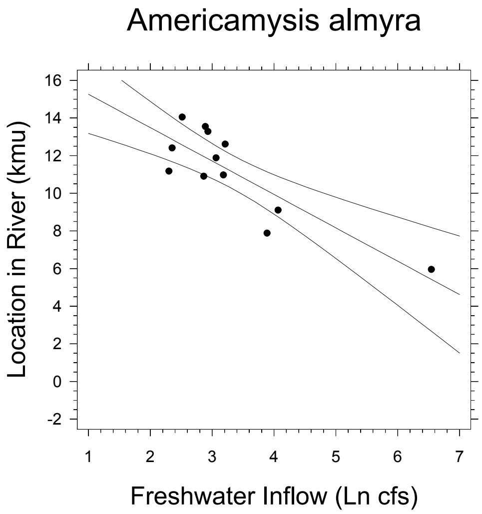


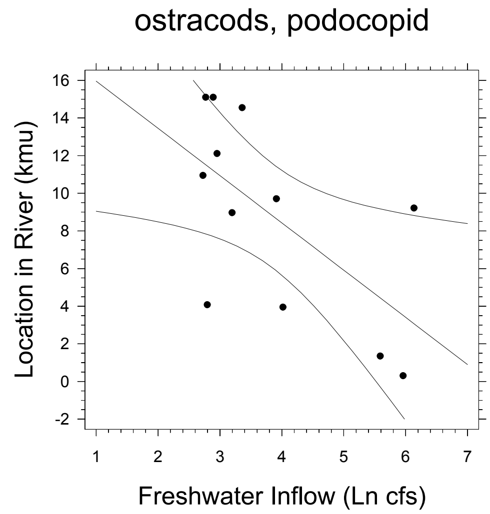
Edotea triloba

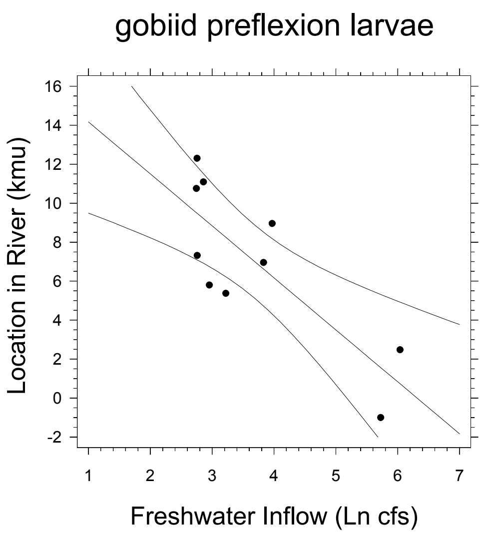


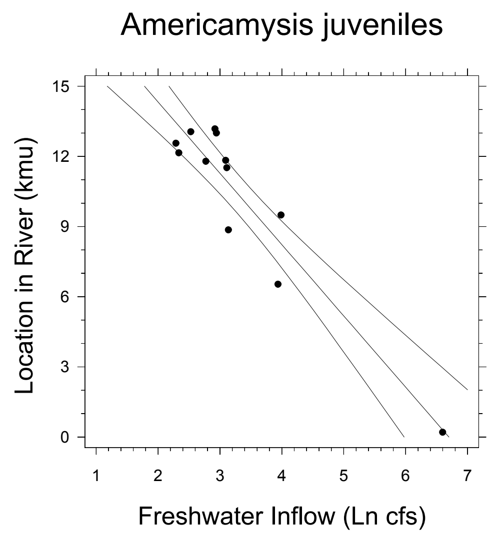
Anchoa mitchilli juveniles




Americamysis almyra
Location in River (kmu)
Freshwater Inflow (Ln cfs)
16
14
12
10
8
6
4
2
0
-2
1
2
3
4
5
6
7


ostracods, podocopid
Location in River (kmu)
Freshwater Inflow (Ln cfs)
16
14
12
10
8
6
4
2
0
-2
1
2
3
4
5
6
7


gobiid preflexion larvae
Location in River (kmu)
Freshwater Inflow (Ln cfs)
16
14
12
10
8
6
4
2
0
-2
1
2
3
4
5
6
7


Americamysis juveniles
Location in River (kmu)
Freshwater Inflow (Ln cfs)
15
12
9
6
3
0
1
2
3
4
5
6
7

Appendix G:

Plots of the seine and trawl distribution responses in Table 3.7.2.1

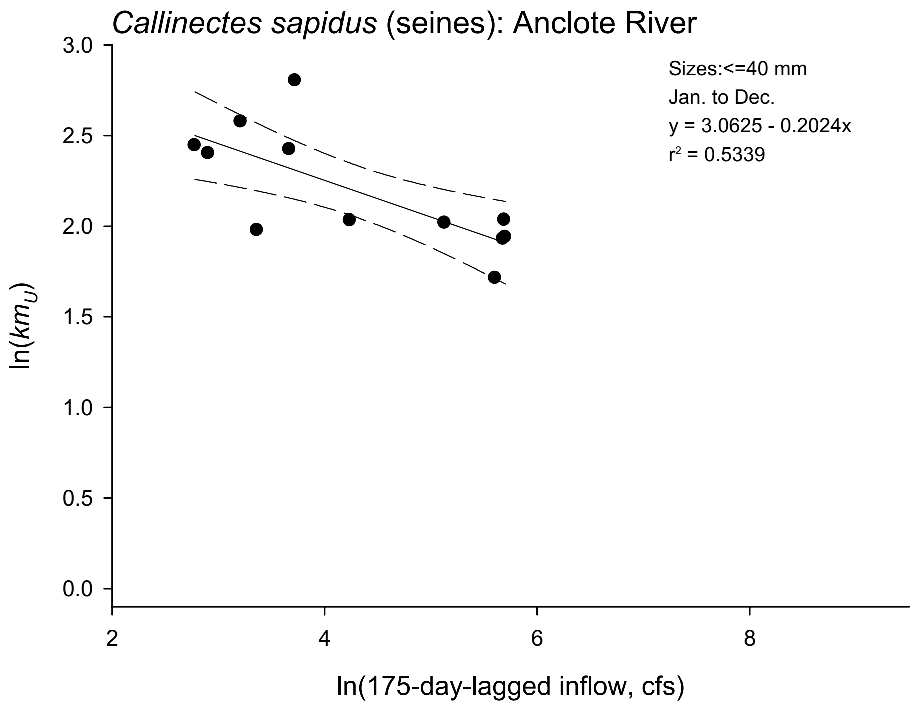


Fig. G1. Distribution response of Blue crab (<=40 mm) in the Anclote River estuary to 175-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

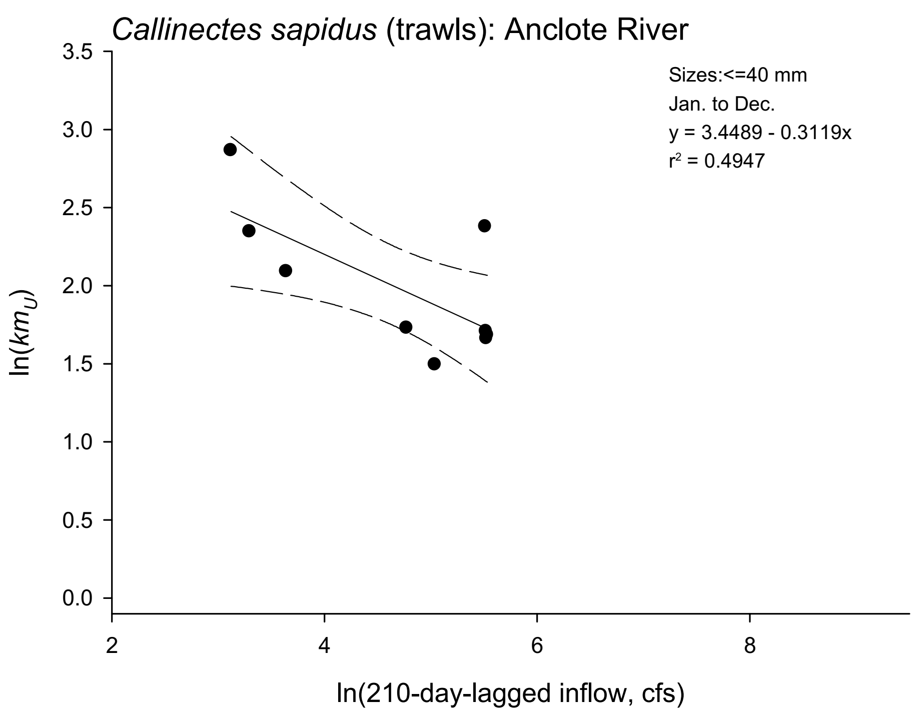


Fig. G2. Distribution response of Blue crab (<=40 mm) in the Anclote River estuary to 210-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

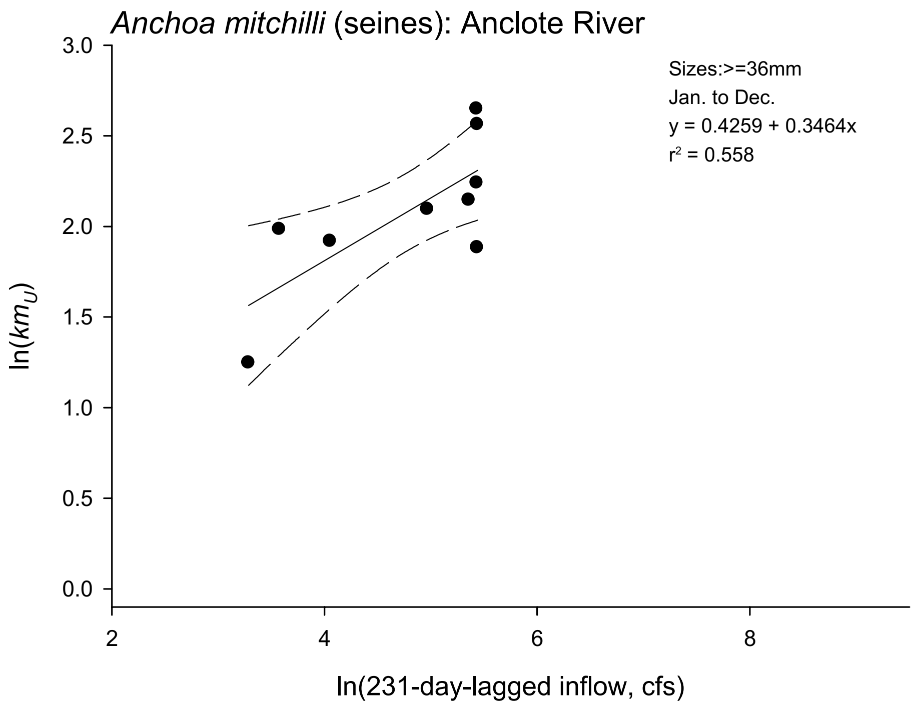


Fig. G3. Distribution response of Bay anchovy (>=36 mm) in the Anclote River estuary to 231-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

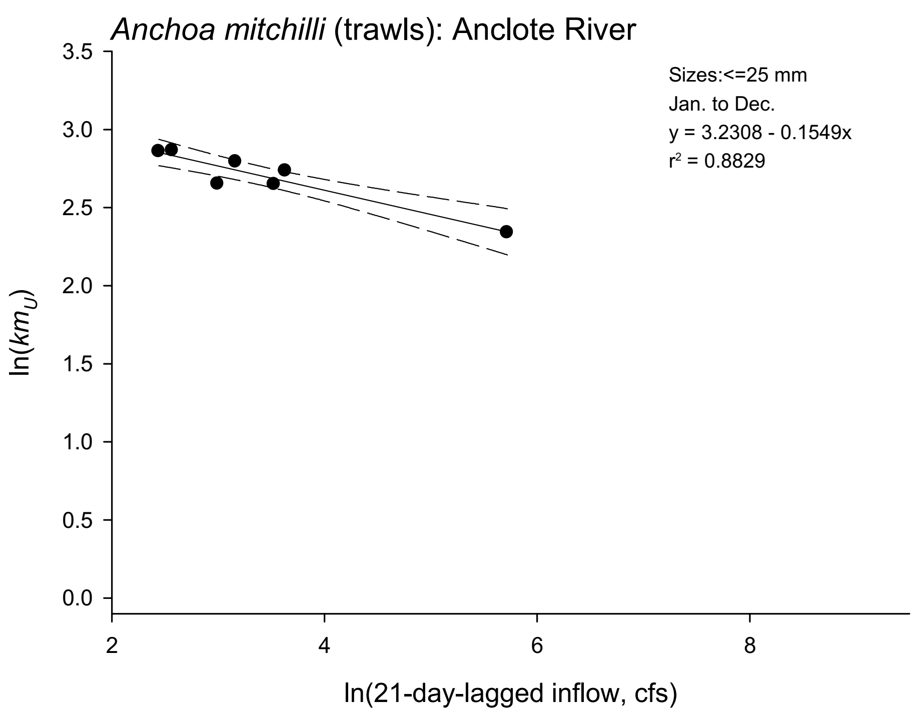


Fig. G4. Distribution response of Bay anchovy (<=25 mm) in the Anclote River estuary to 21-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

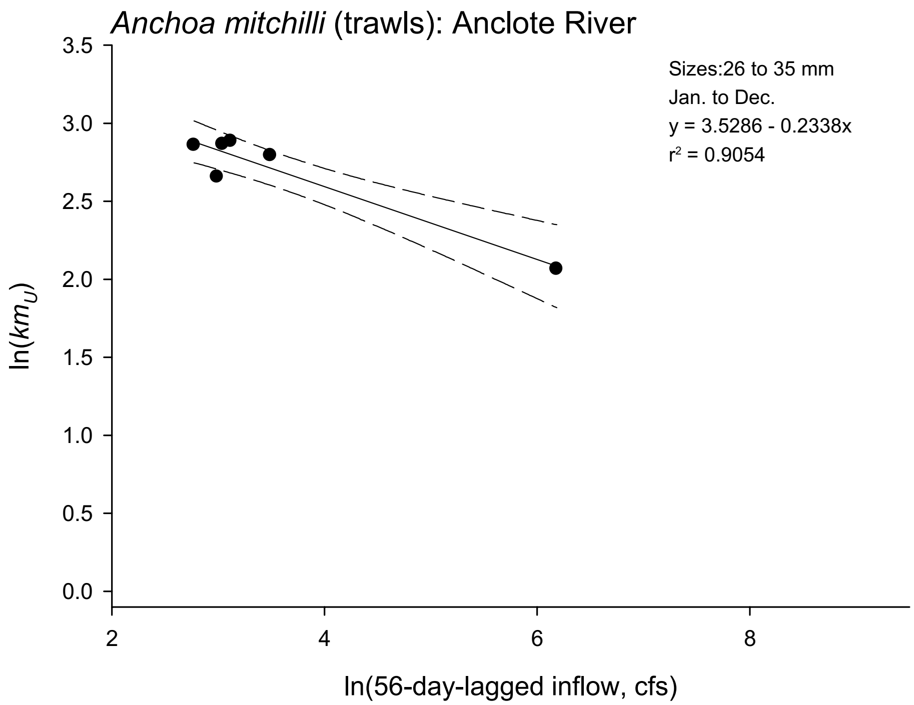


Fig. G5. Distribution response of Bay anchovy (26 to 35 mm) in the Anclote River estuary to 56-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

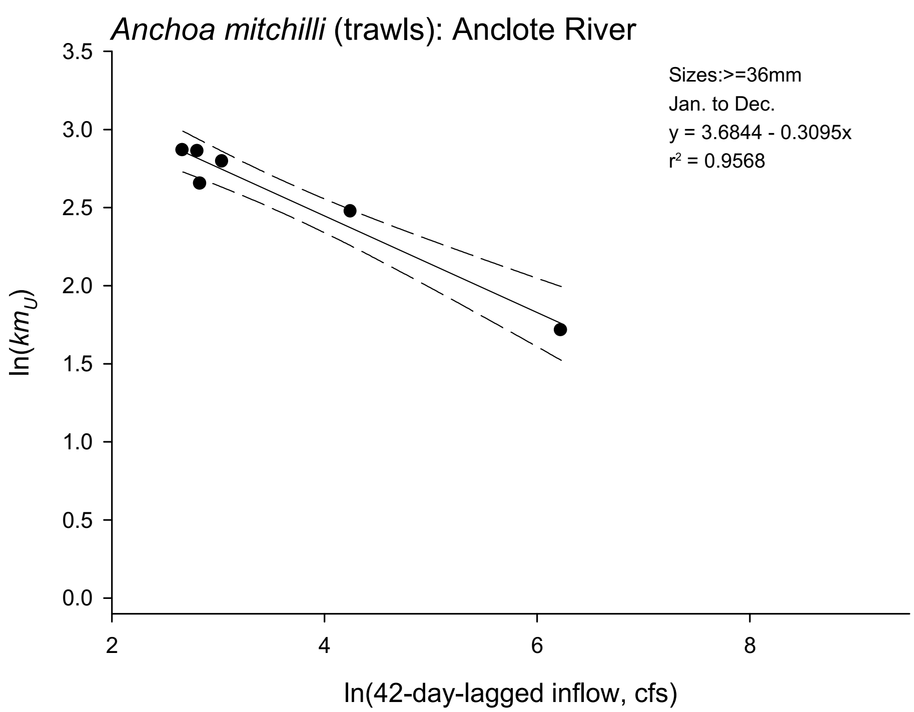


Fig. G6. Distribution response of Bay anchovy (>=36 mm) in the Anclote River estuary to 42-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

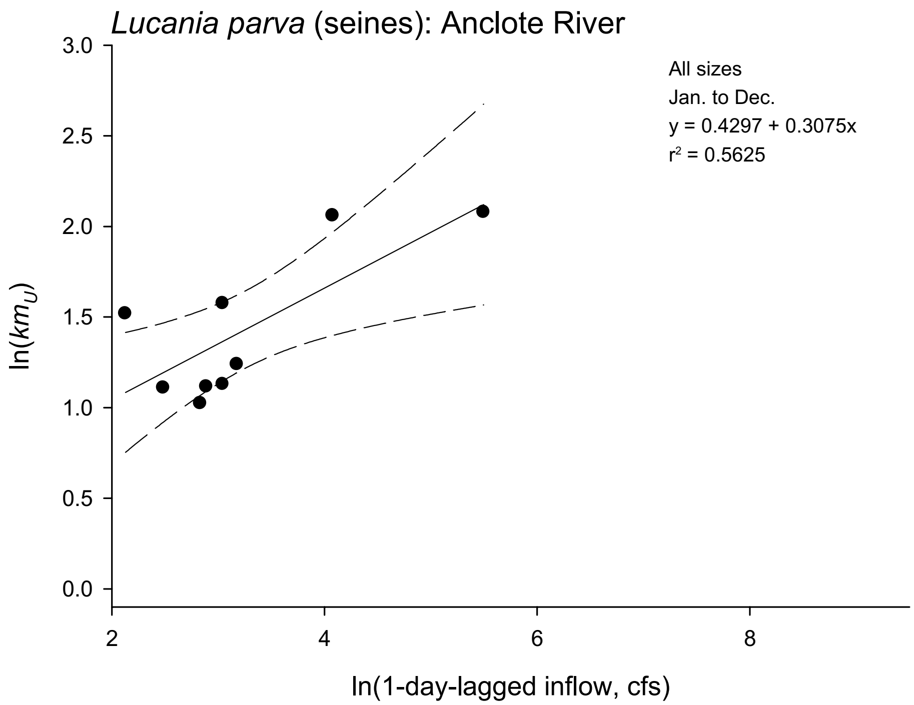


Fig. G7. Distribution response of Rainwater killifish (All sizes) in the Anclote River estuary to 1-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

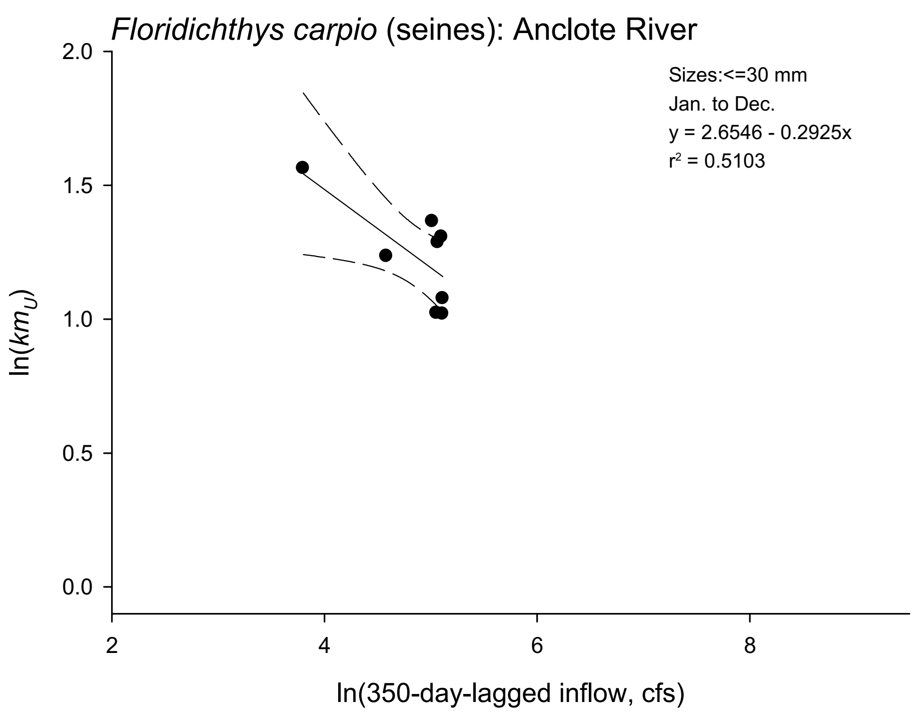


Fig. G8. Distribution response of Goldspotted killifish (<=30 mm) in the Anclote River estuary to 350-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

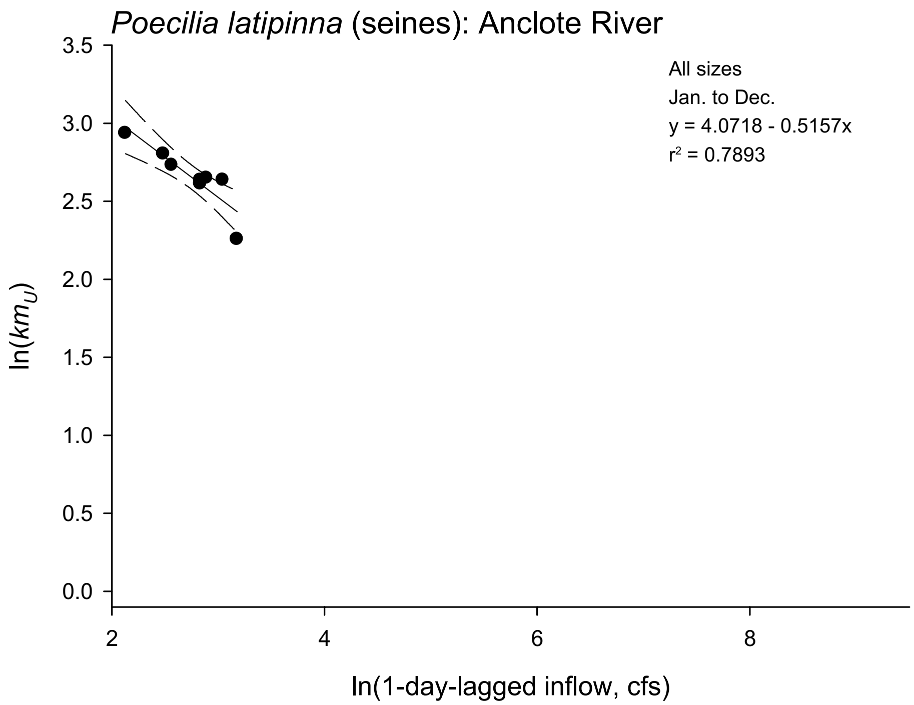


Fig. G9. Distribution response of Sailfin molly (All sizes) in the Anclote River estuary to 1-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

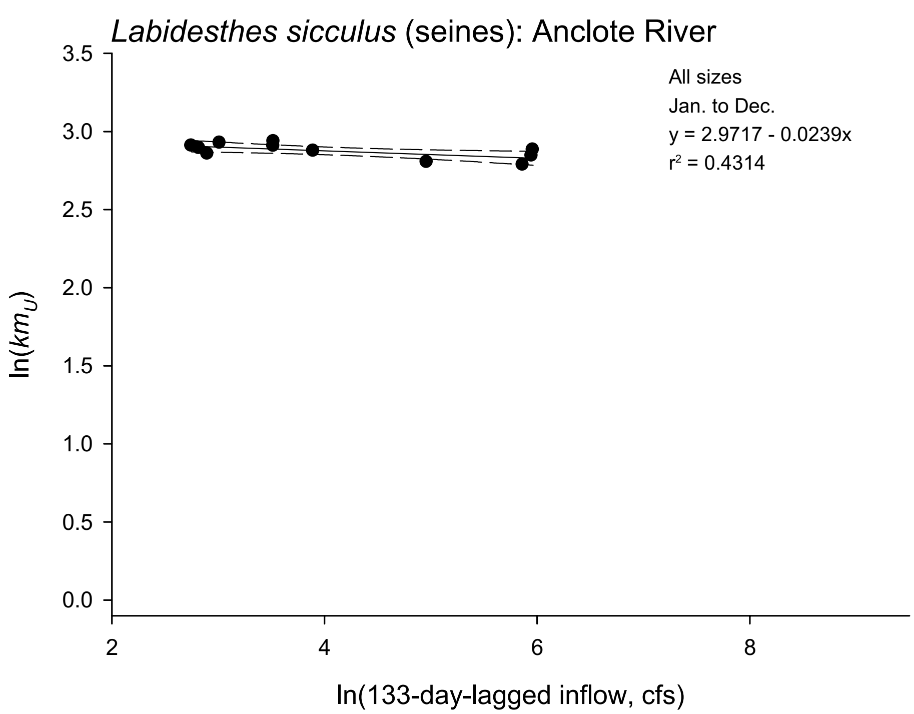


Fig. G10. Distribution response of Brook silverside (All sizes) in the Anclote River estuary to 133-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

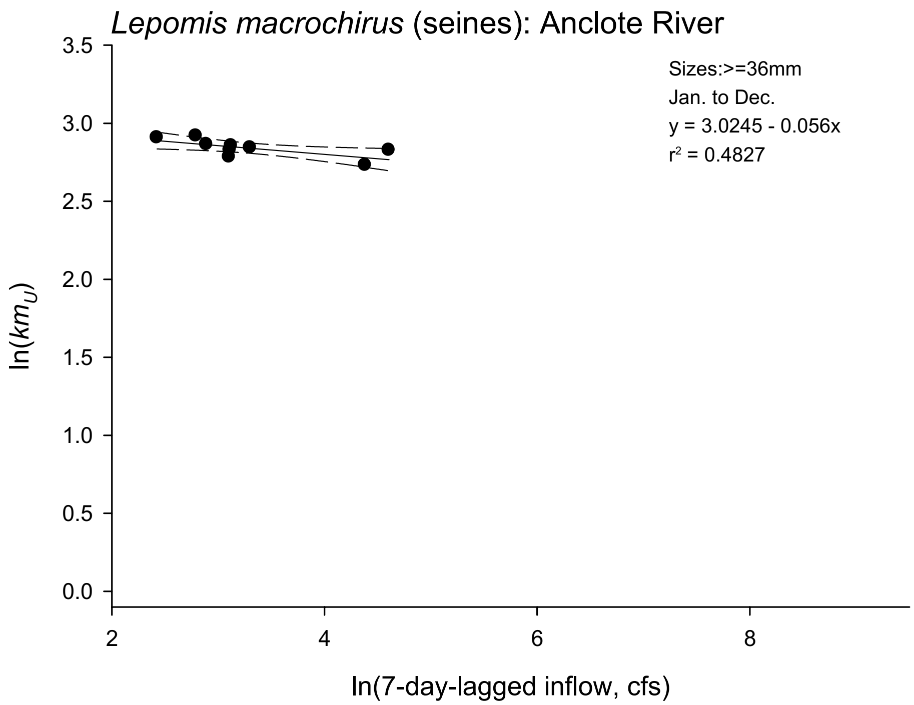


Fig. G11. Distribution response of Bluegill (>=36 mm) in the Anclote River estuary to 7-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

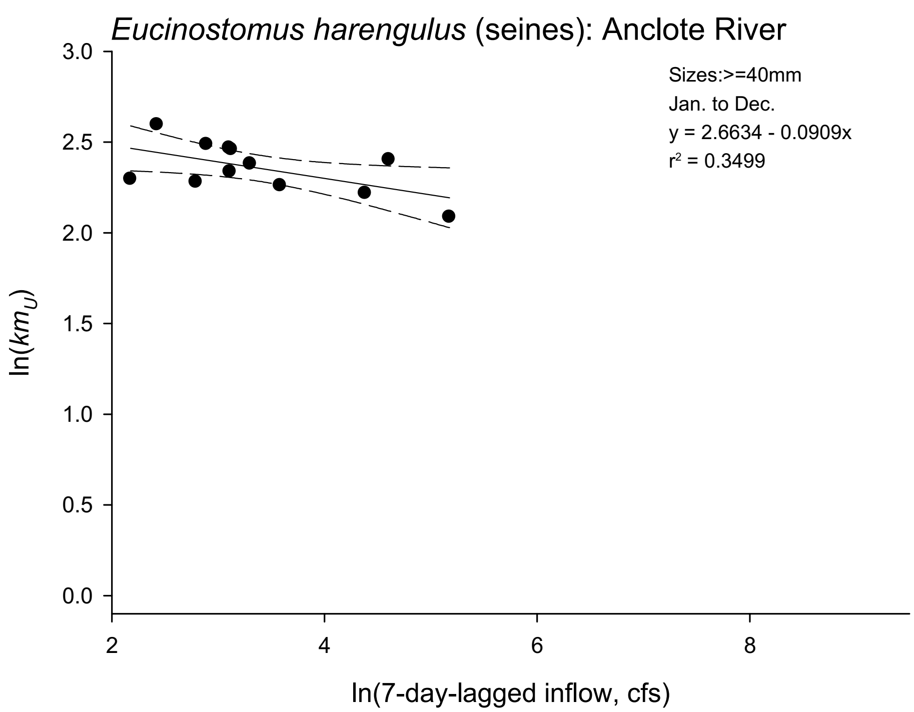


Fig. G12. Distribution response of Tidewater mojarra (>=40 mm) in the Anclote River estuary to 7-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

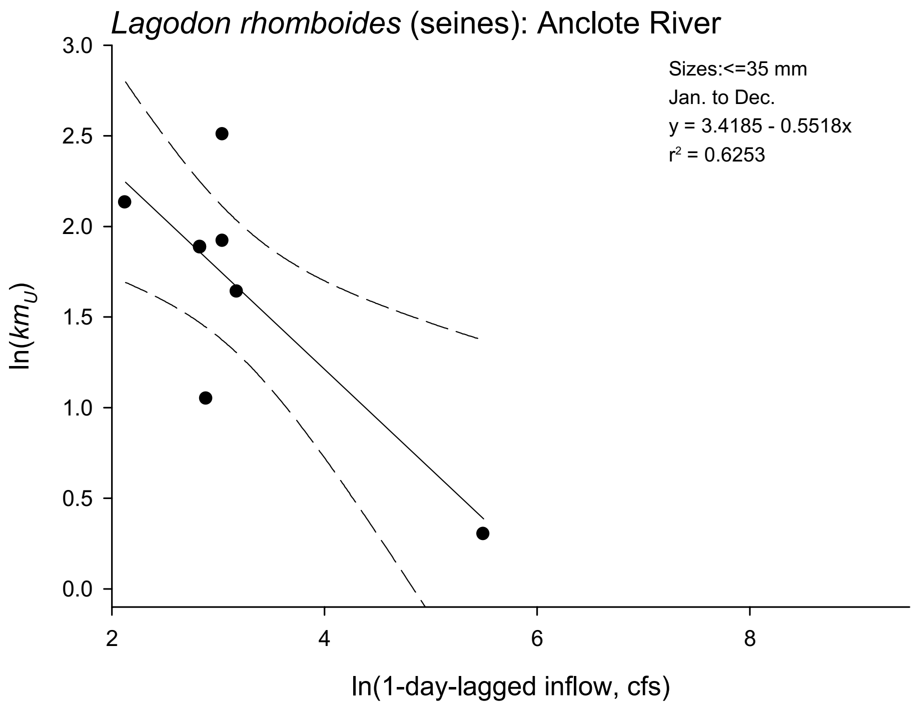


Fig. G13. Distribution response of Pinfish (<=35 mm) in the Anclote River estuary to 1-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

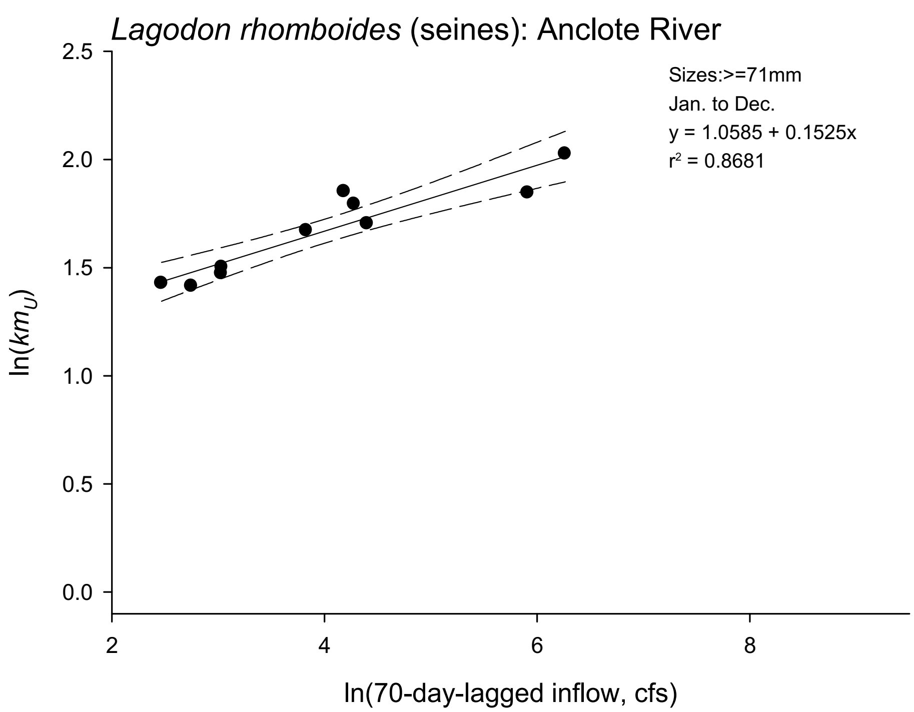


Fig. G14. Distribution response of Pinfish (>=71 mm) in the Anclote River estuary to 70-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

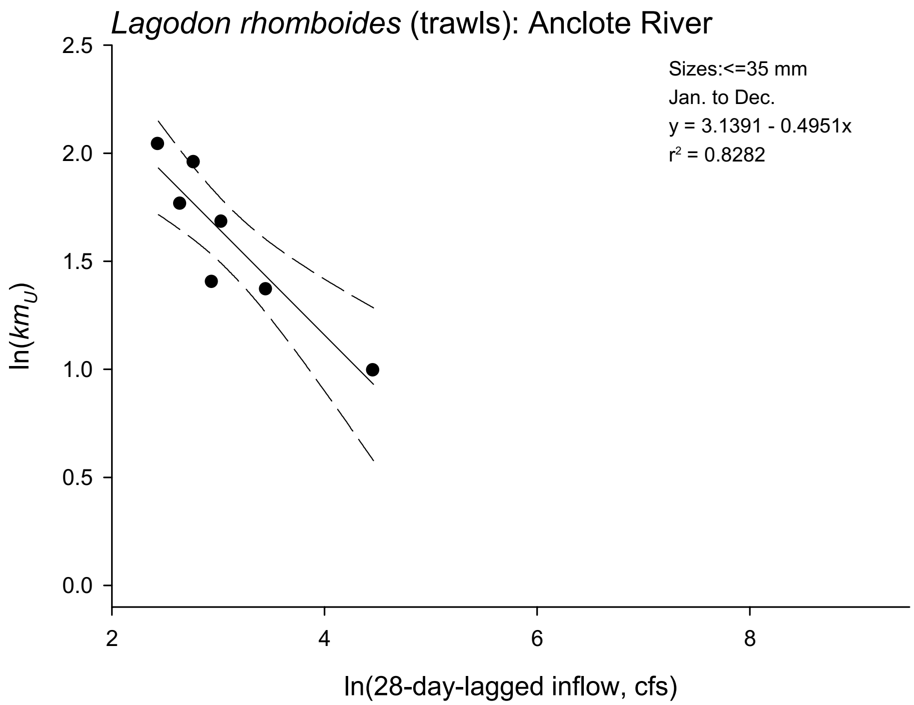


Fig. G15. Distribution response of Pinfish (<=35 mm) in the Anclote River estuary to 28-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

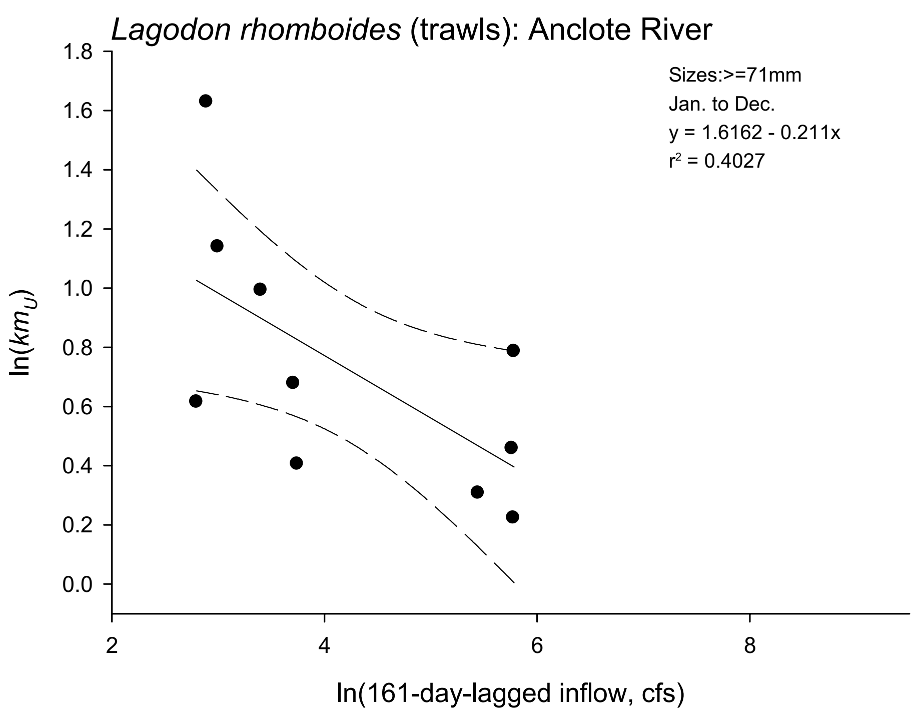


Fig. G16. Distribution response of Pinfish (>=71 mm) in the Anclote River estuary to 161-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

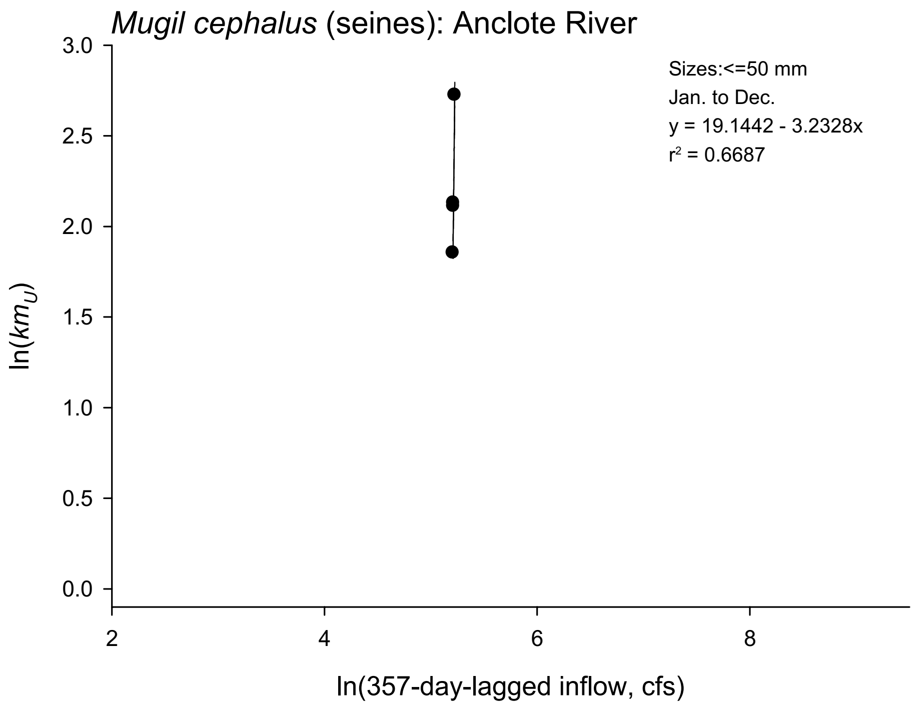


Fig. G17. Distribution response of Striped mullet (<=50 mm) in the Anclote River estuary to 357-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

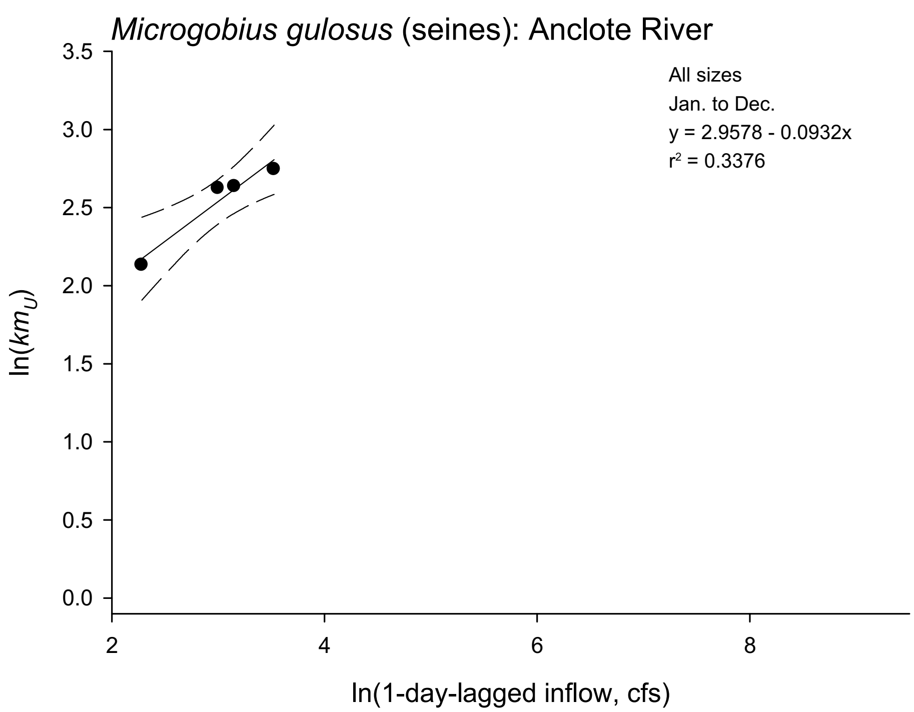
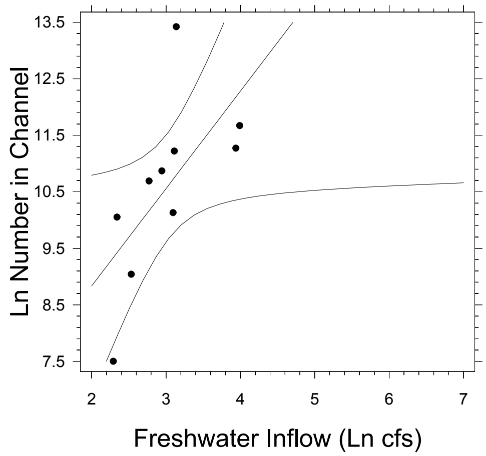


Fig. G18. Distribution response of Clown goby (All sizes) in the Anclote River estuary to 1-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

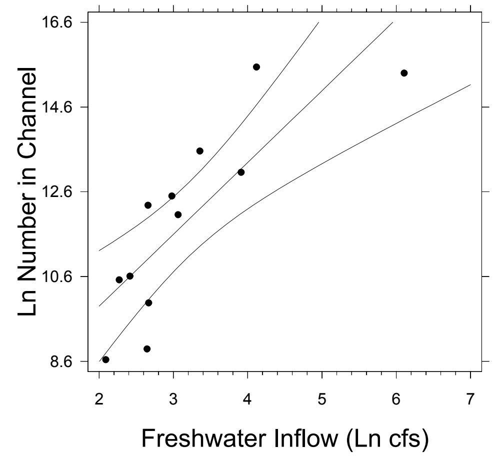
Appendix H:

Plots of the plankton-net abundance responses in Table 3.8.1.1
with 95% confidence limits for predicted means

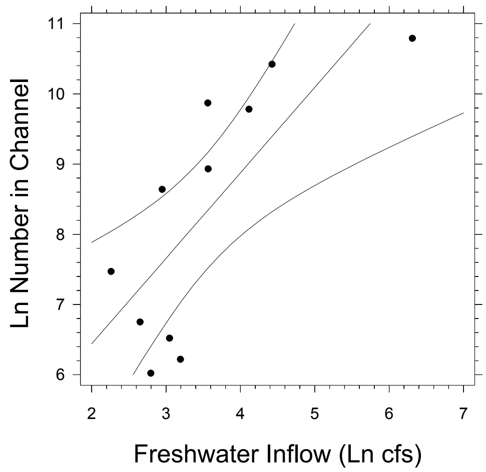
Sarsiella zostericola



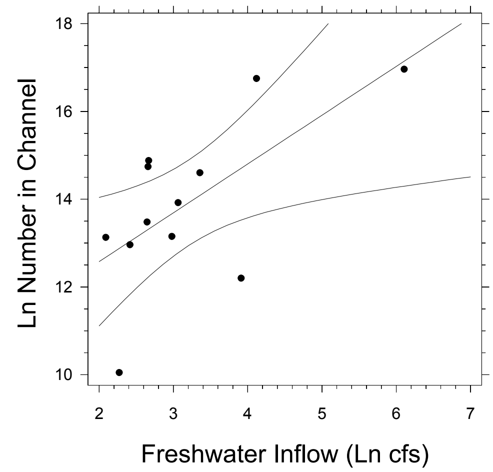
Americamysis almyra



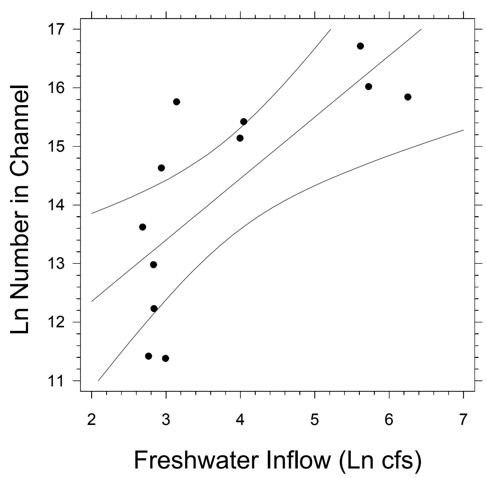
dipterans, pupae



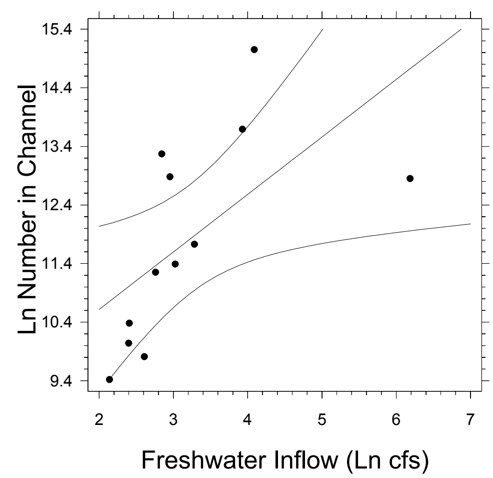
Labidocera aestiva



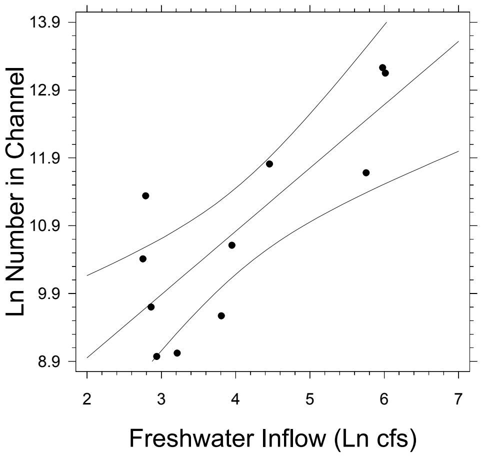
Hippolyte zostericola postlarvae



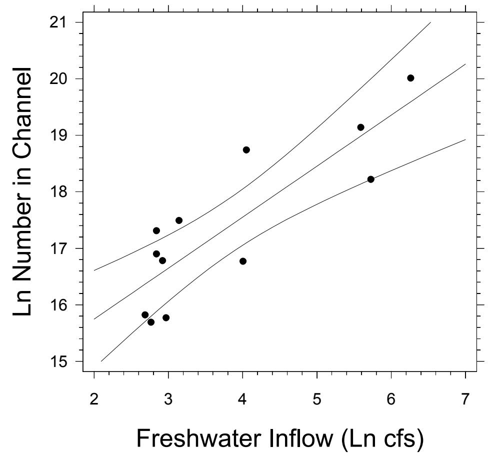
Americamysis juveniles



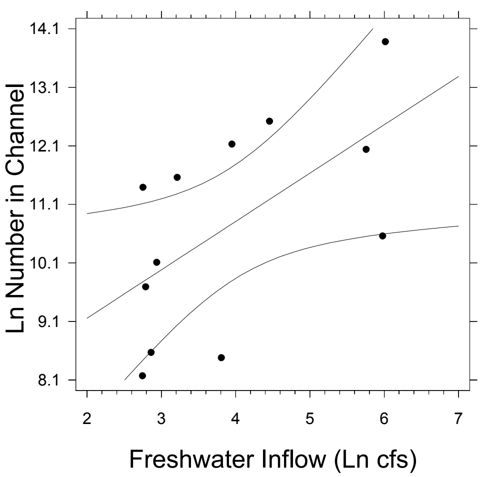
branchiurans, Argulus spp.



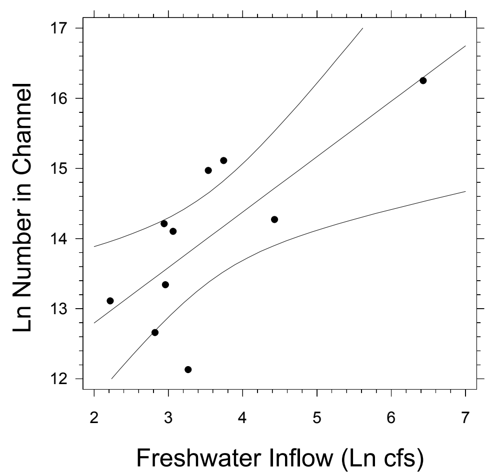
amphipods, gammaridean



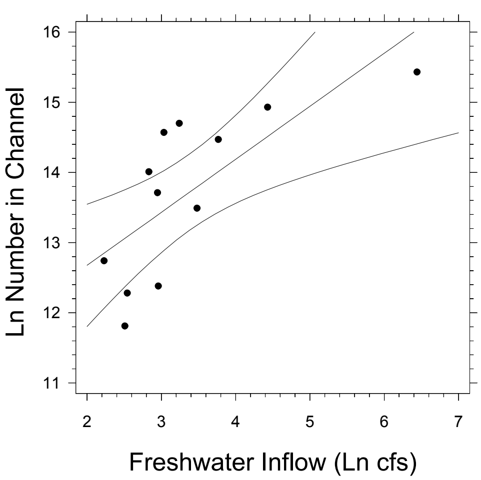
Anchoa mitchilli juveniles



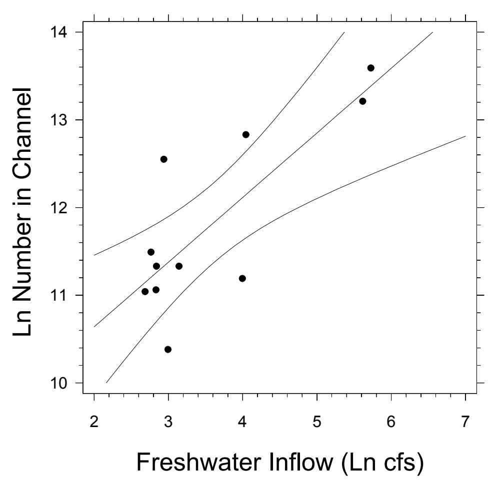
decapod megalopae

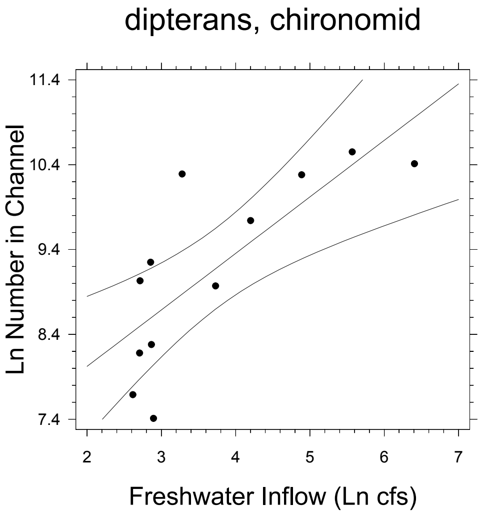


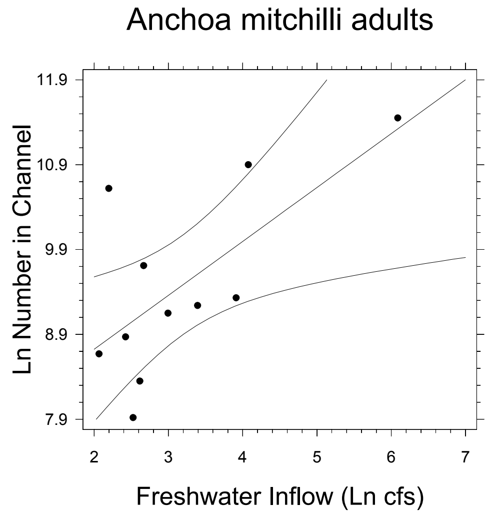
Bowmaniella dissimilis

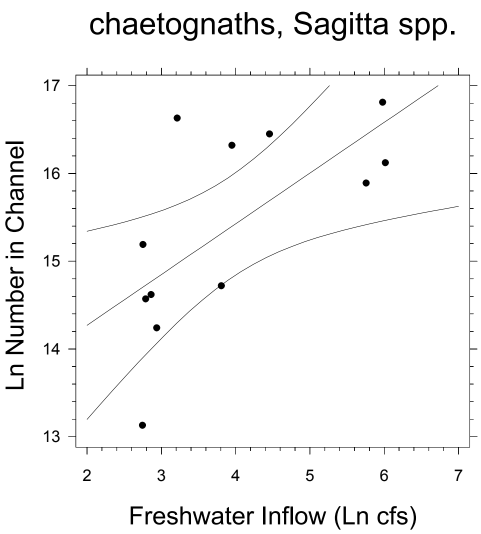


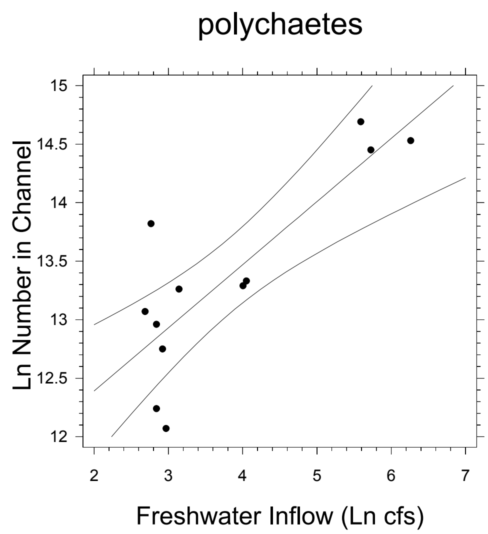
amphipods, caprellid




dipterans, chironomid
Ln Number in Channel
11.4
10.4
9.4
8.4
7.4
2
3
4
5
6
7
Freshwater Inflow (Ln cfs)


Anchoa mitchilli adults
Ln Number in Channel
11.9
10.9
9.9
8.9
7.9
2
3
4
5
6
7
Freshwater Inflow (Ln cfs)


chaetognaths, Sagitta spp.
Ln Number in Channel
17
16
15
14
13
2
3
4
5
6
7
Freshwater Inflow (Ln cfs)


polychaetes
Ln Number in Channel
15
14.5
14
13.5
13
12.5
12
2
3
4
5
6
7
Freshwater Inflow (Ln cfs)

Appendix I:

Plots of the seine and trawl abundance responses in Table 3.8.2.1

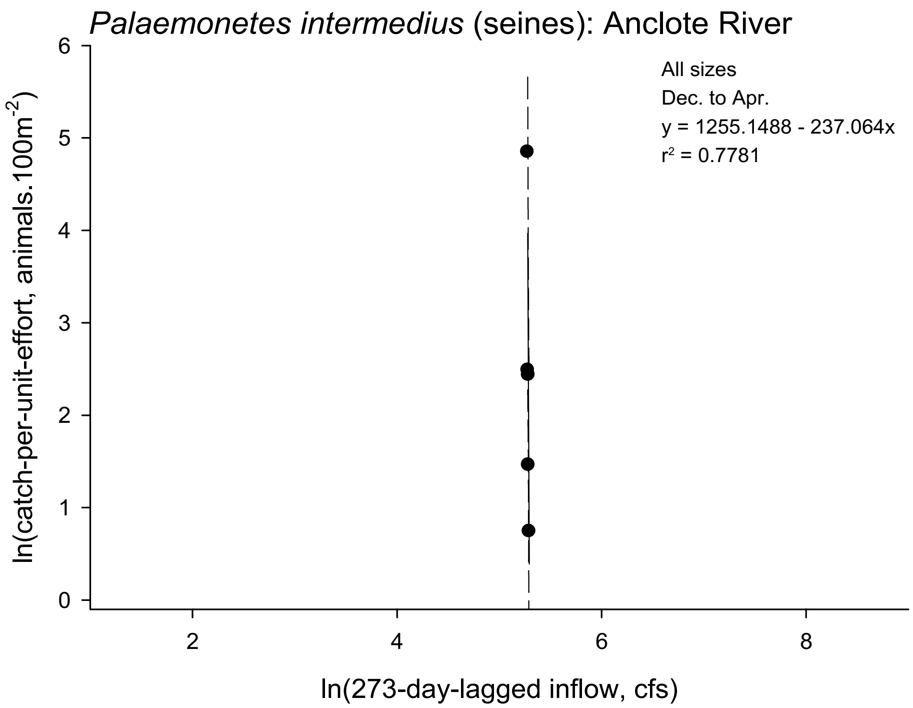


Fig. I1. Abundance response of Brackish grass shrimp (All sizes) in the Anclote River estuary to 273-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

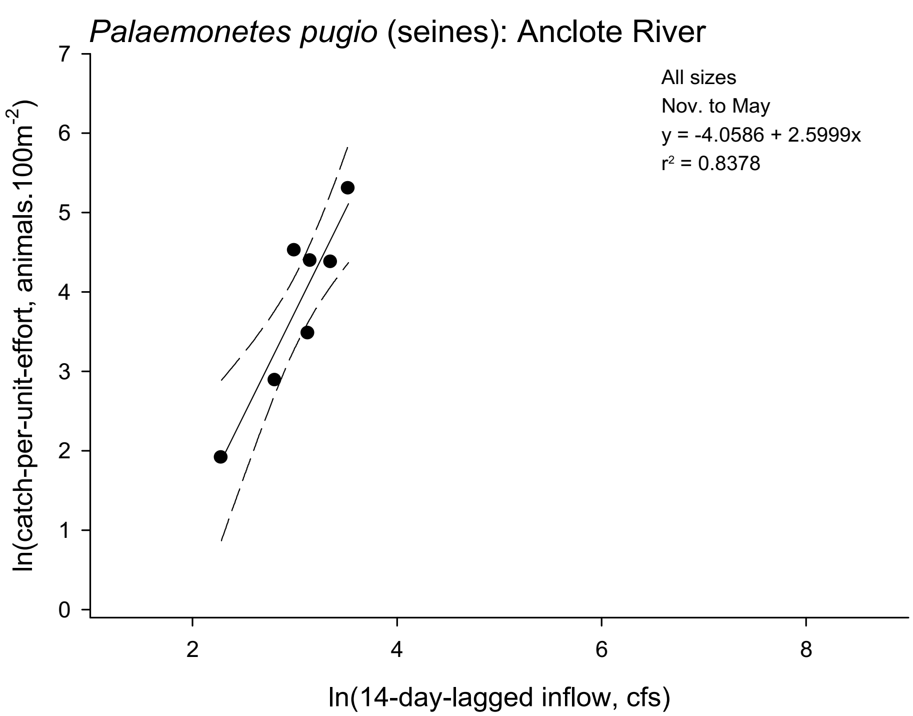


Fig. I2. Abundance response of Daggerblade grass shrimp (All sizes) in the Anclote River estuary to 14-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

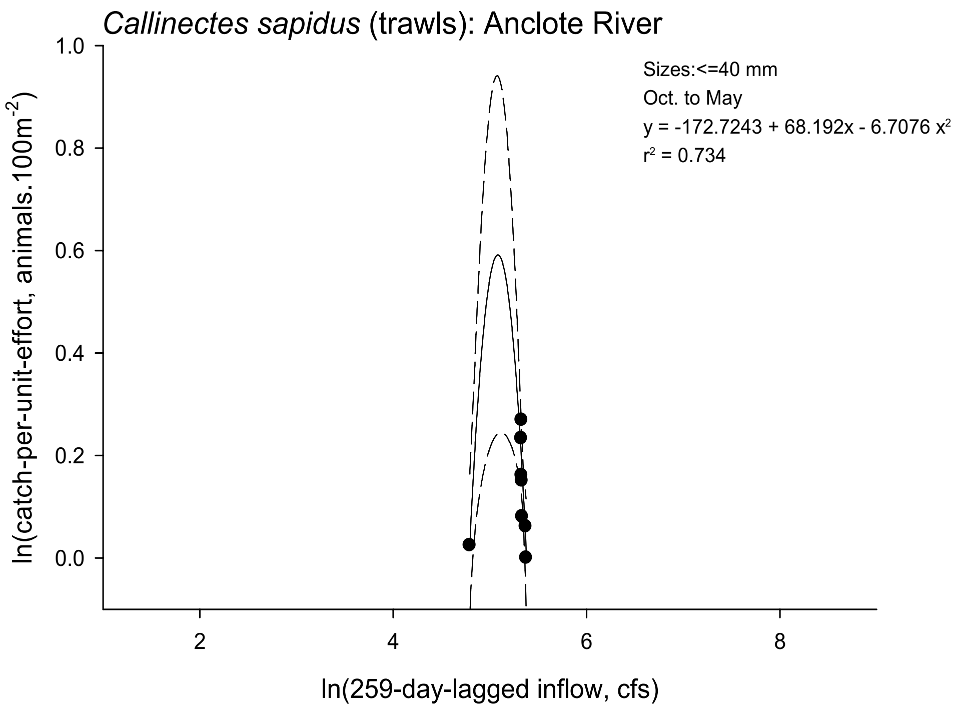


Fig. I3. Abundance response of Blue crab (<=40 mm) in the Anclote River estuary to 259-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

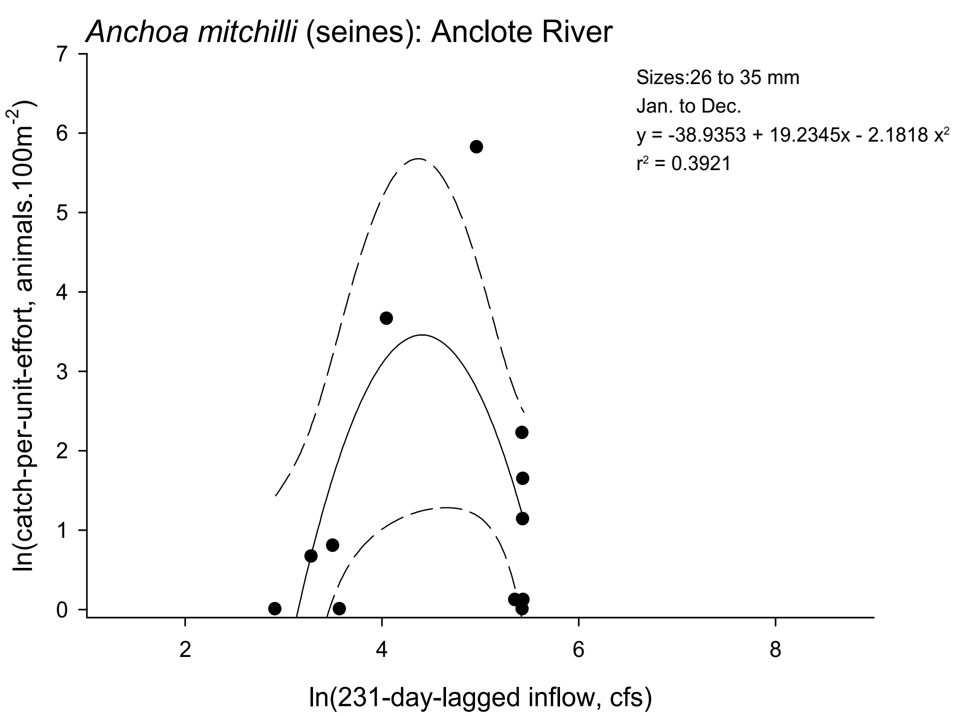


Fig. I4. Abundance response of Bay anchovy (26 to 35 mm) in the Anclote River estuary to 231-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

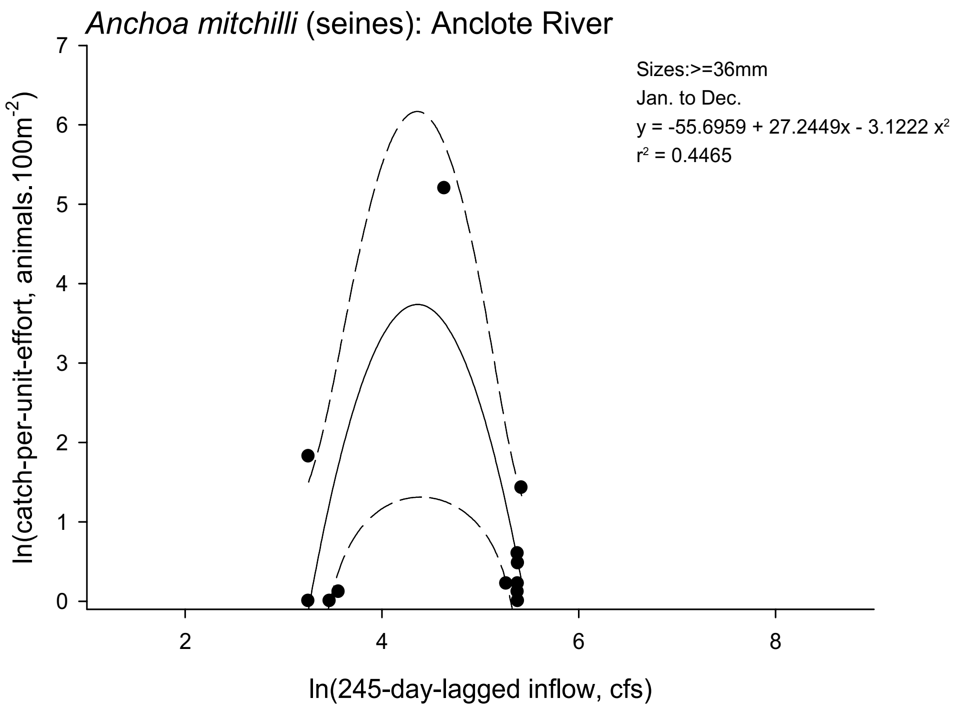


Fig. I5. Abundance response of Bay anchovy (>=36 mm) in the Anclote River estuary to 245-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

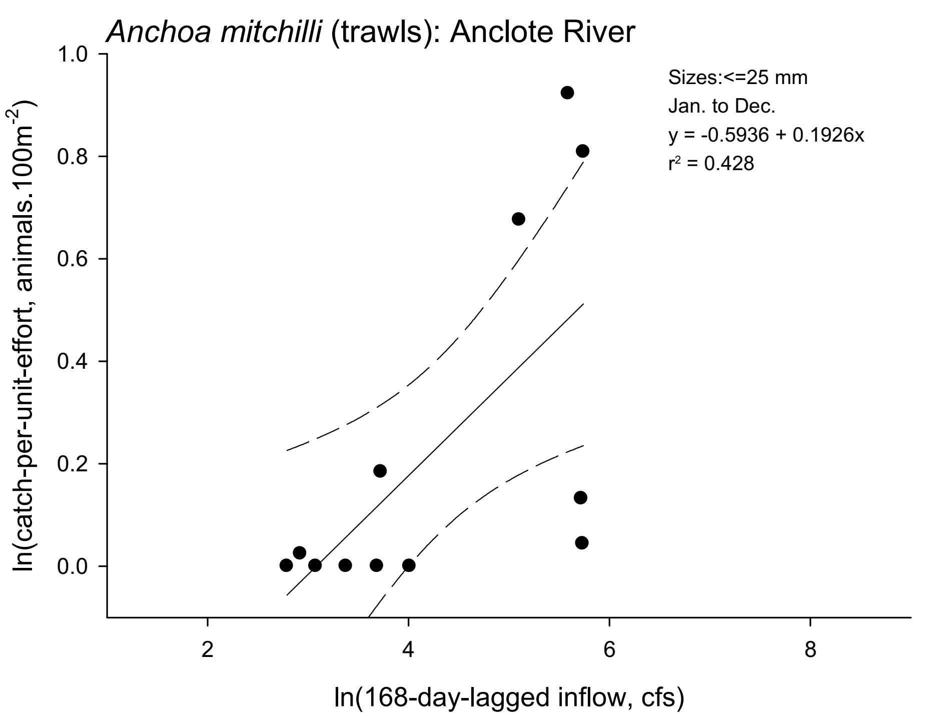


Fig. I6. Abundance response of Bay anchovy (<=25 mm) in the Anclote River estuary to 168-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

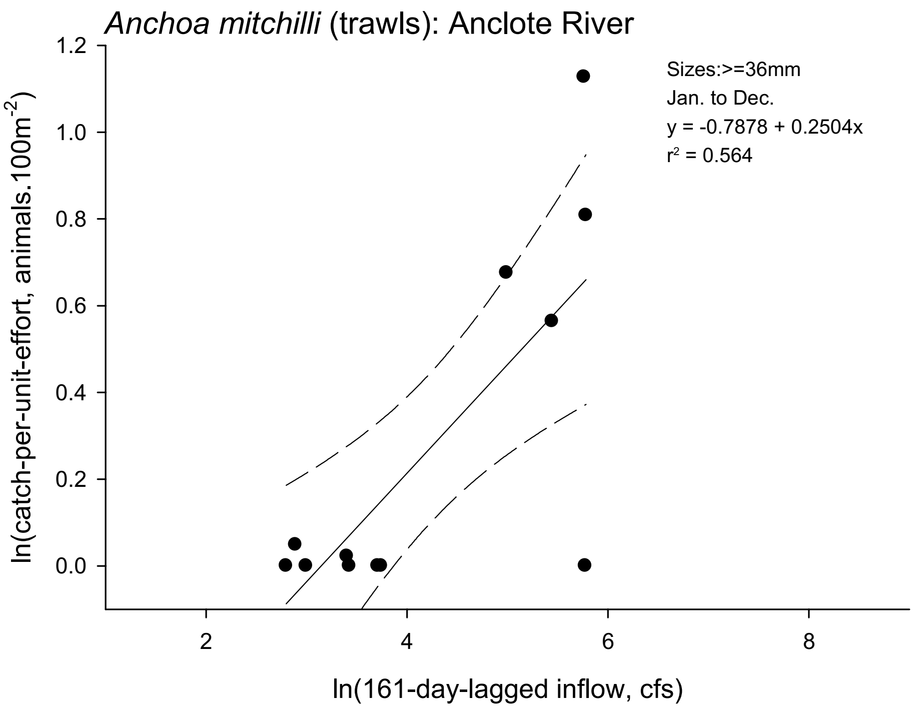


Fig. I7. Abundance response of Bay anchovy (>=36 mm) in the Anclote River estuary to 161-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

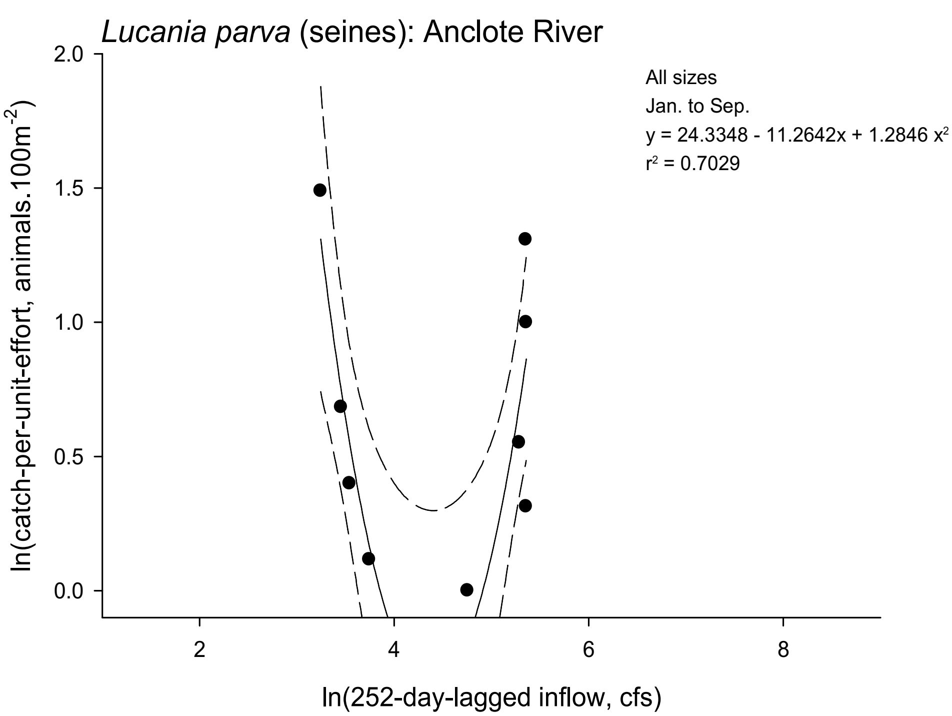


Fig. I8. Abundance response of Rainwater killifish (All sizes) in the Anclote River estuary to 252-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

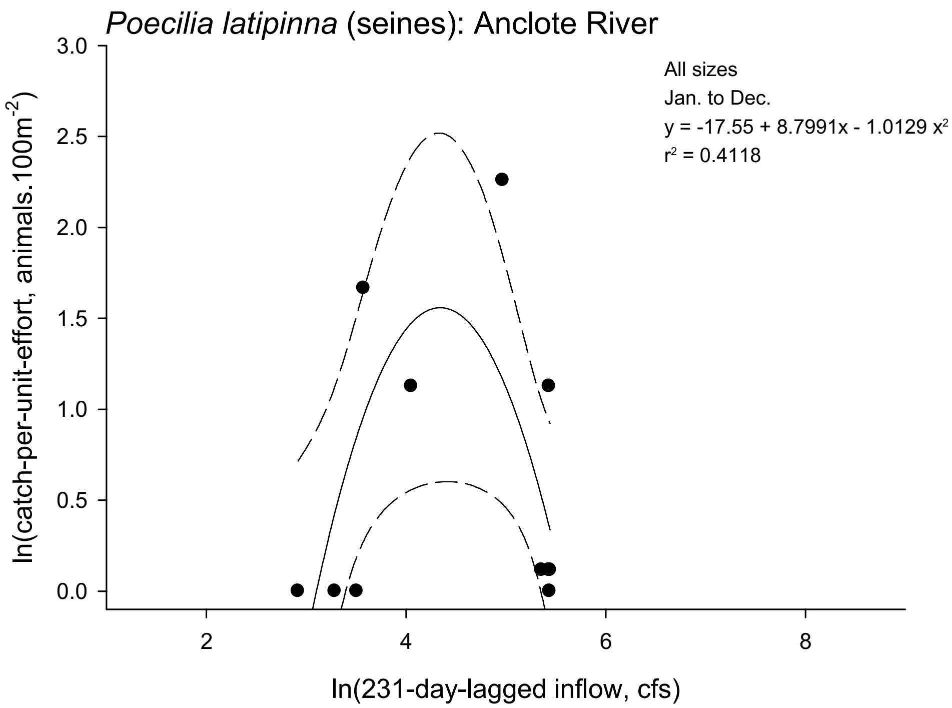


Fig. I9. Abundance response of Sailfin molly (All sizes) in the Anclote River estuary to 231-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

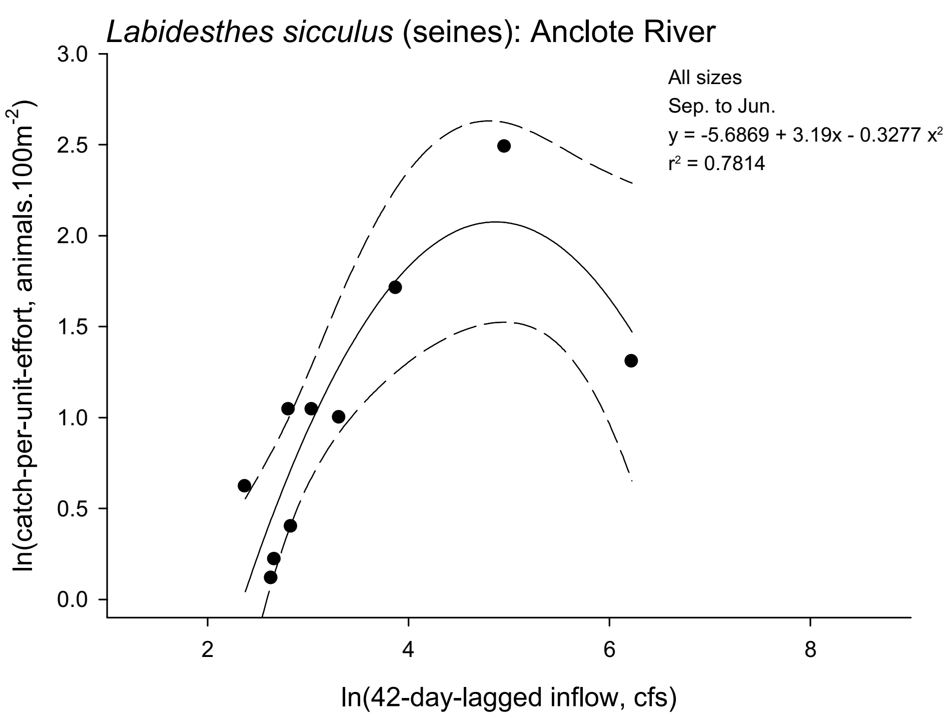


Fig. I10. Abundance response of Brook silverside (All sizes) in the Anclote River estuary to 42-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

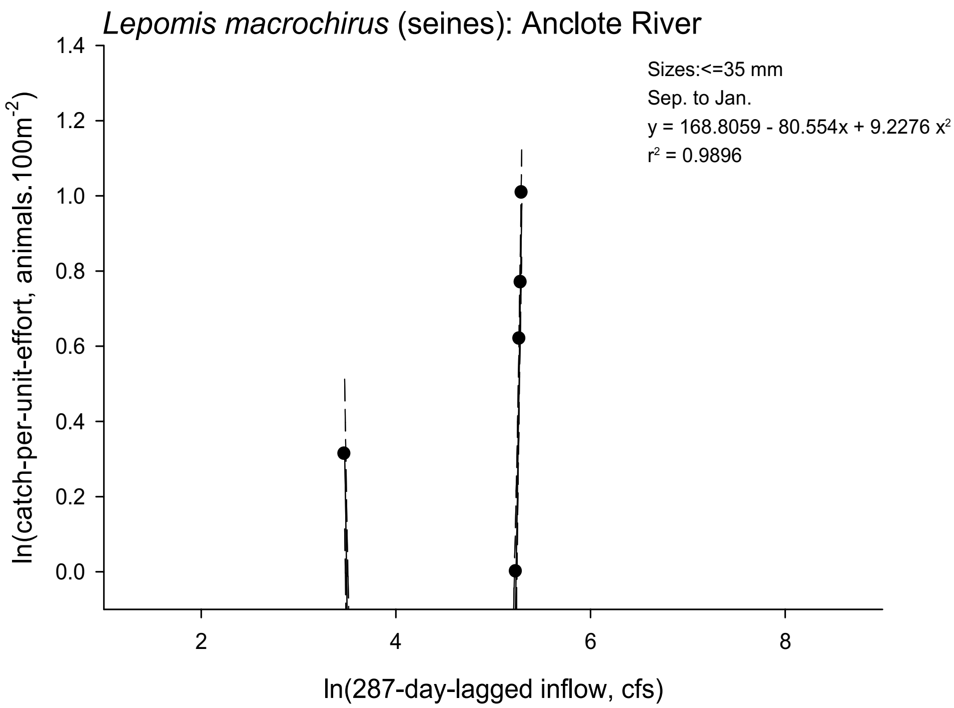


Fig. I11. Abundance response of Bluegill (<=35 mm) in the Anclote River estuary to 287-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

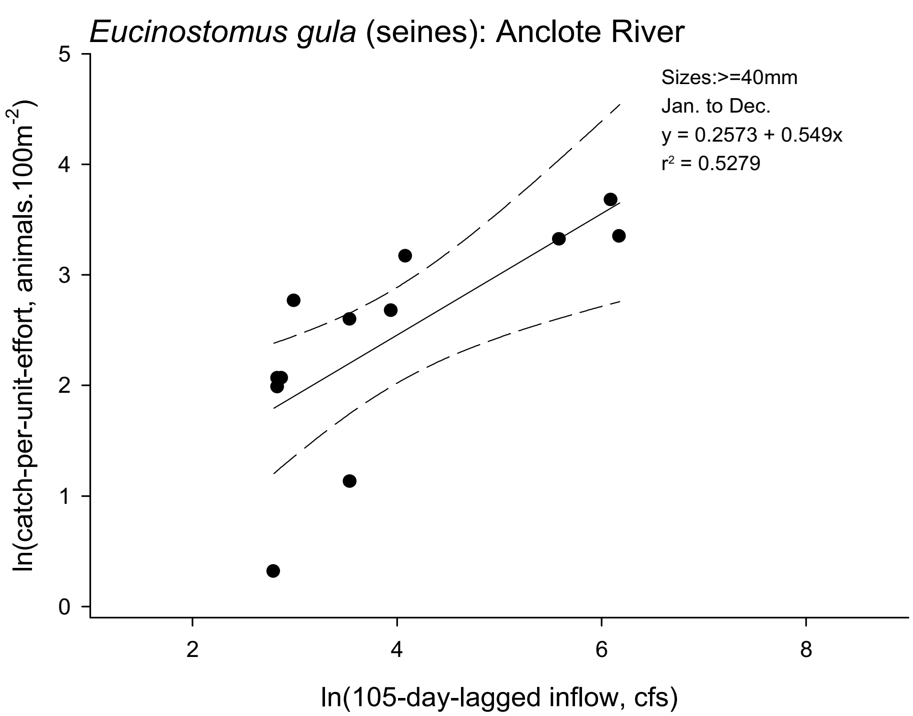


Fig. I12. Abundance response of Silver jenny (>= 40mm) in the Anclote River estuary to 105-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

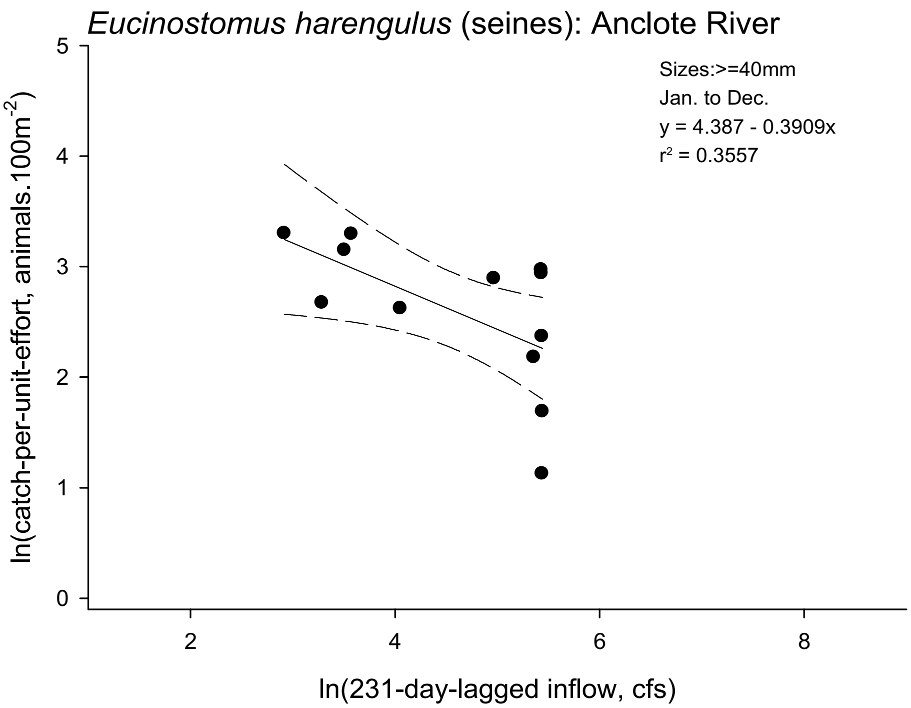


Fig. I13. Abundance response of Tidewater mojarra (>=40 mm) in the Anclote River estuary to 231-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

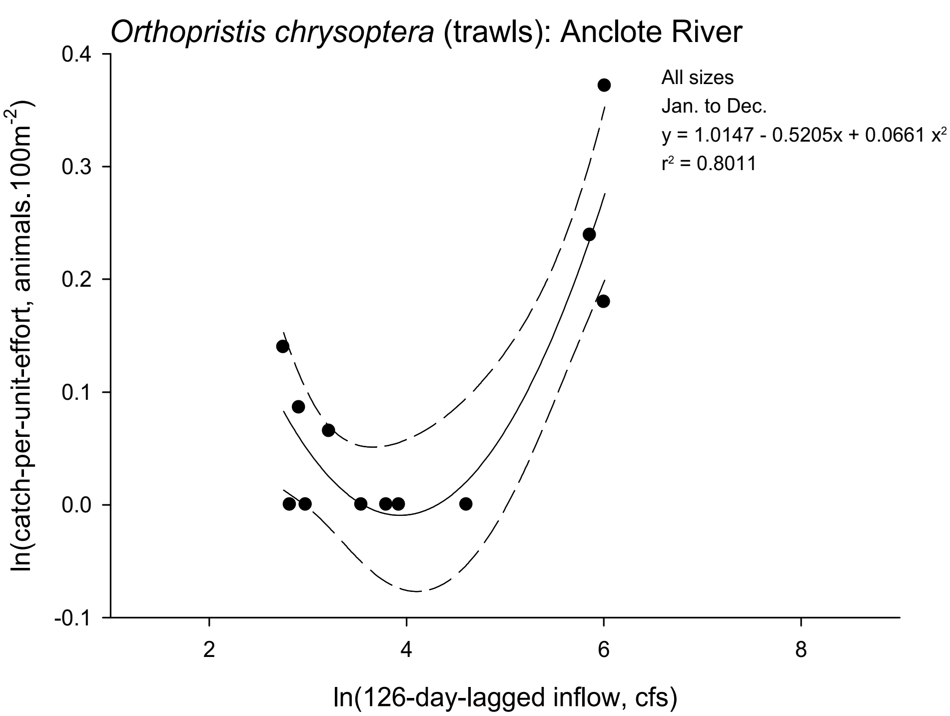


Fig. I14. Abundance response of Pigfish (All sizes) in the Anclote River estuary to 126-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

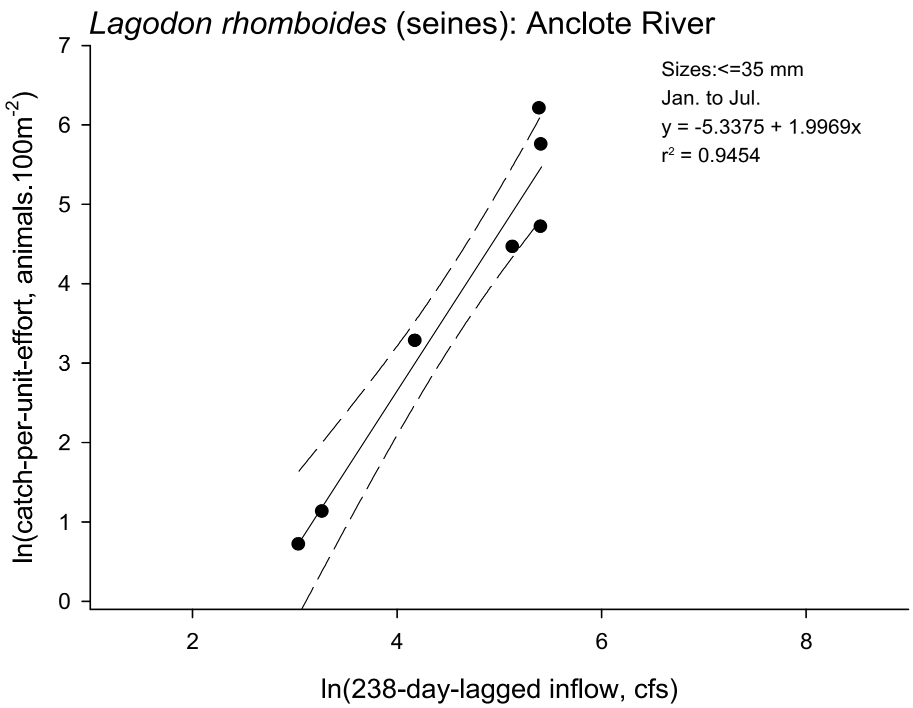


Fig. I15. Abundance response of Pinfish (<=35 mm) in the Anclote River estuary to 238-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

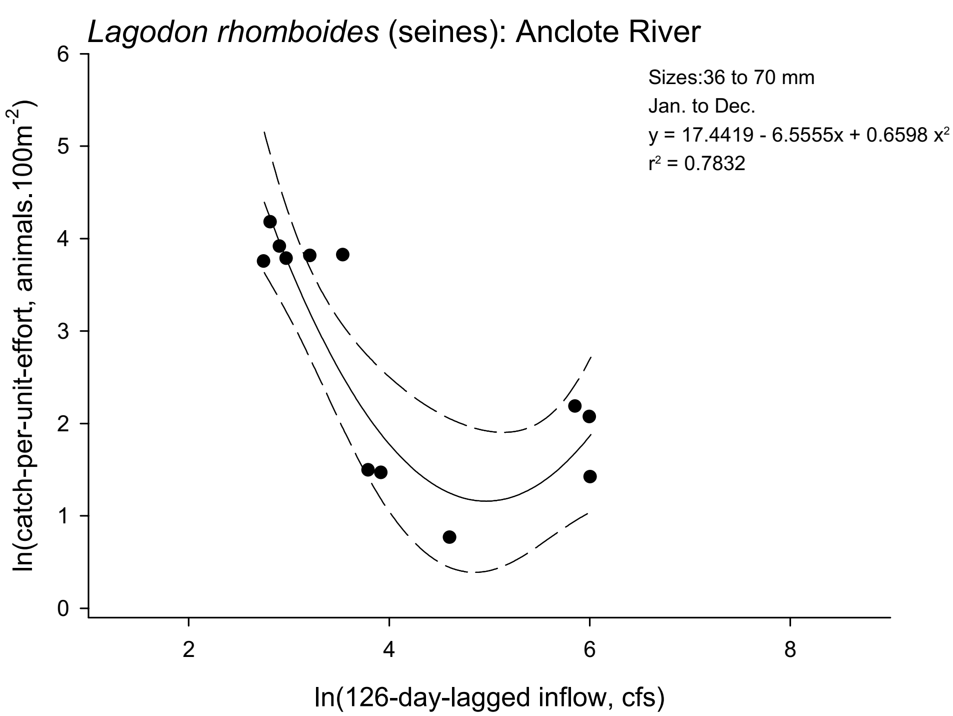


Fig. I16. Abundance response of Pinfish (36 to 70 mm) in the Anclote River estuary to 126-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

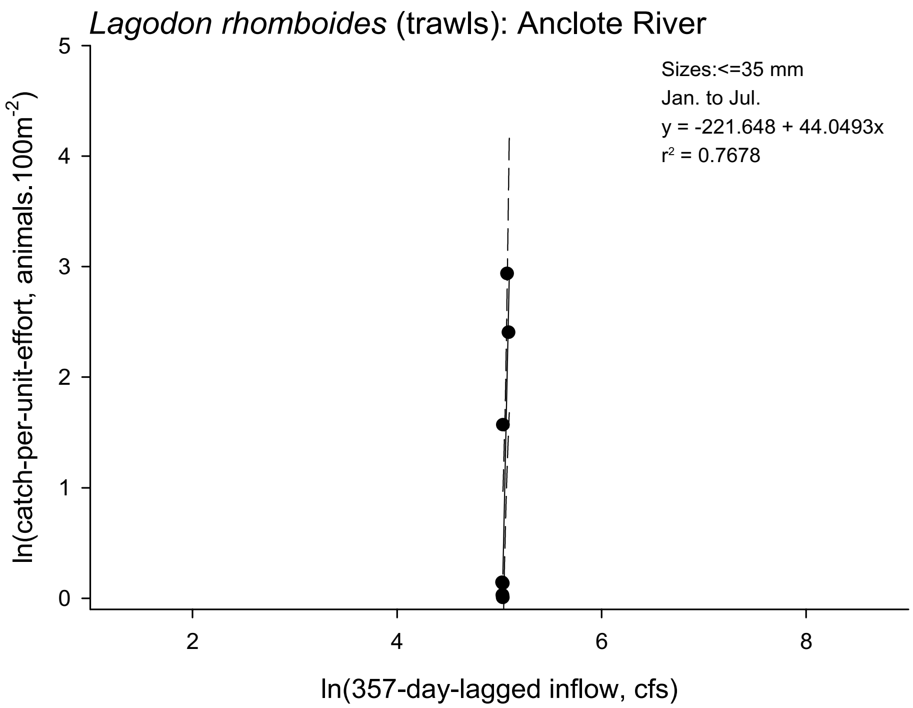


Fig. I17. Abundance response of Pinfish (<=35 mm) in the Anclote River estuary to 357-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

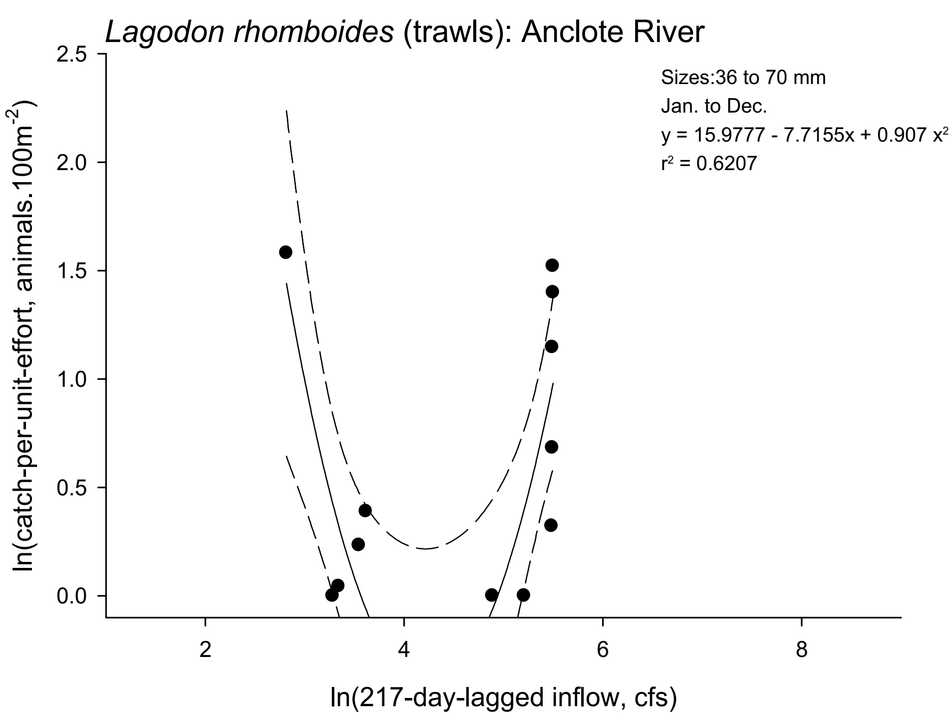


Fig. I18. Abundance response of Pinfish (36 to 70 mm) in the Anclote River estuary to 217-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

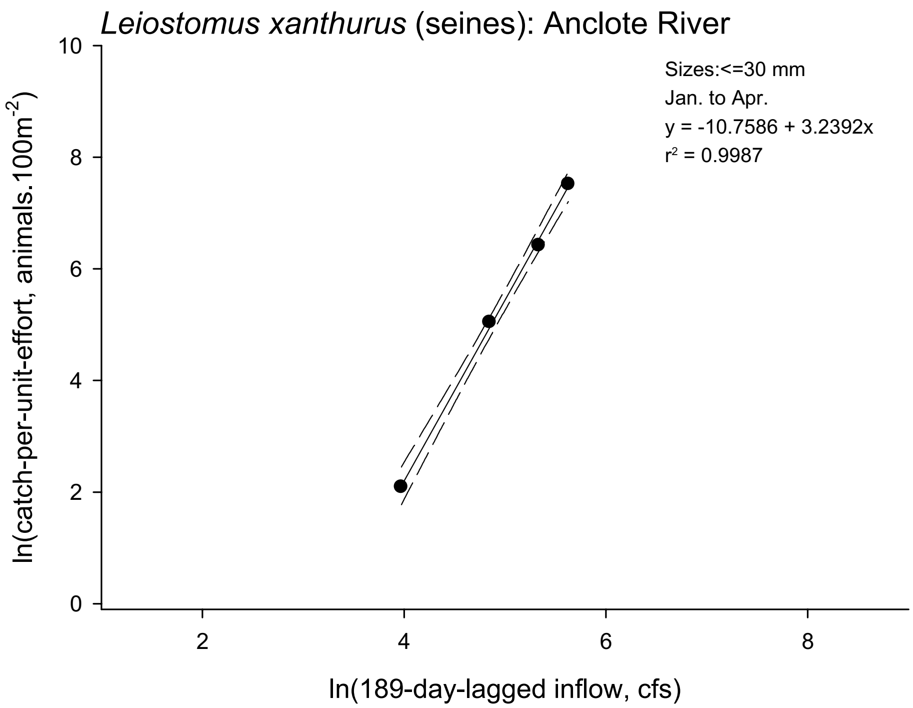


Fig. I19. Abundance response of Spot (<=30 mm) in the Anclote River estuary to 189-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

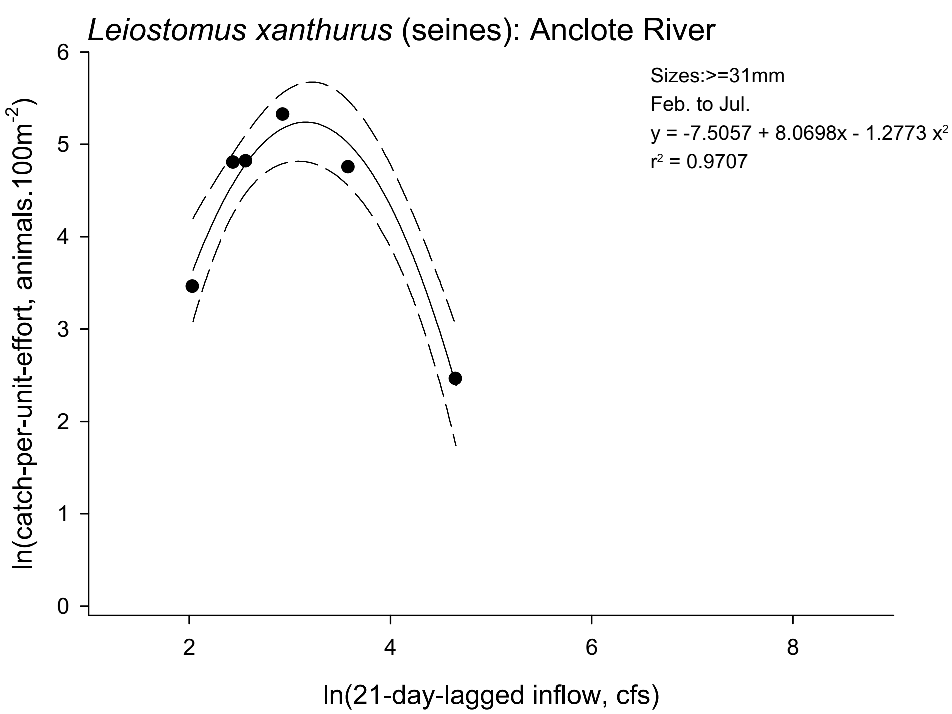


Fig. I20. Abundance response of Spot (>=31 mm) in the Anclote River estuary to 21-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

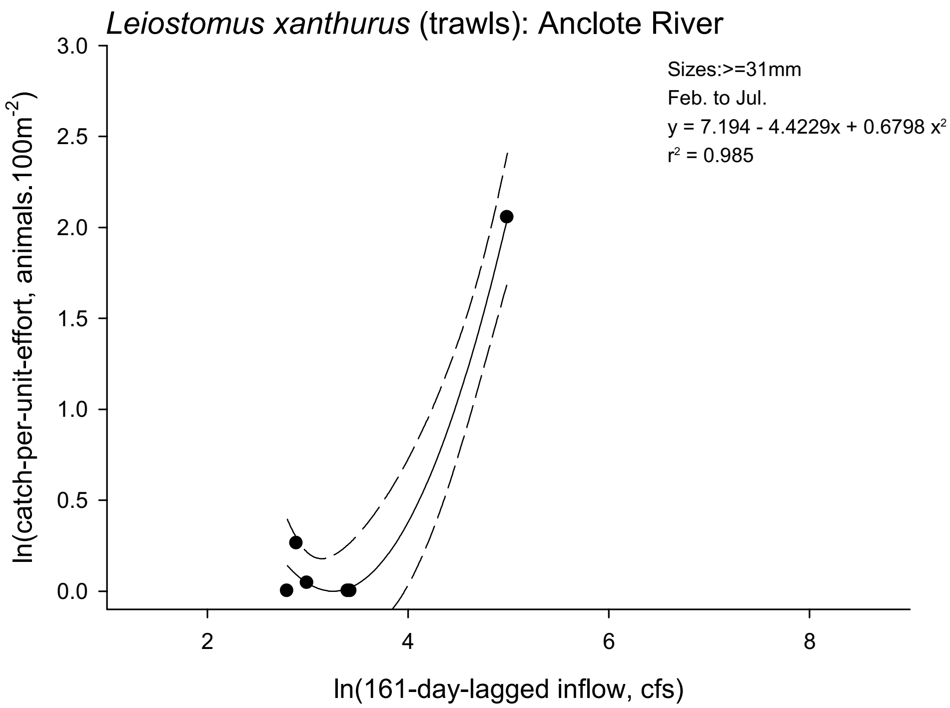


Fig. I21. Abundance response of Spot (>=31 mm) in the Anclote River estuary to 161-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

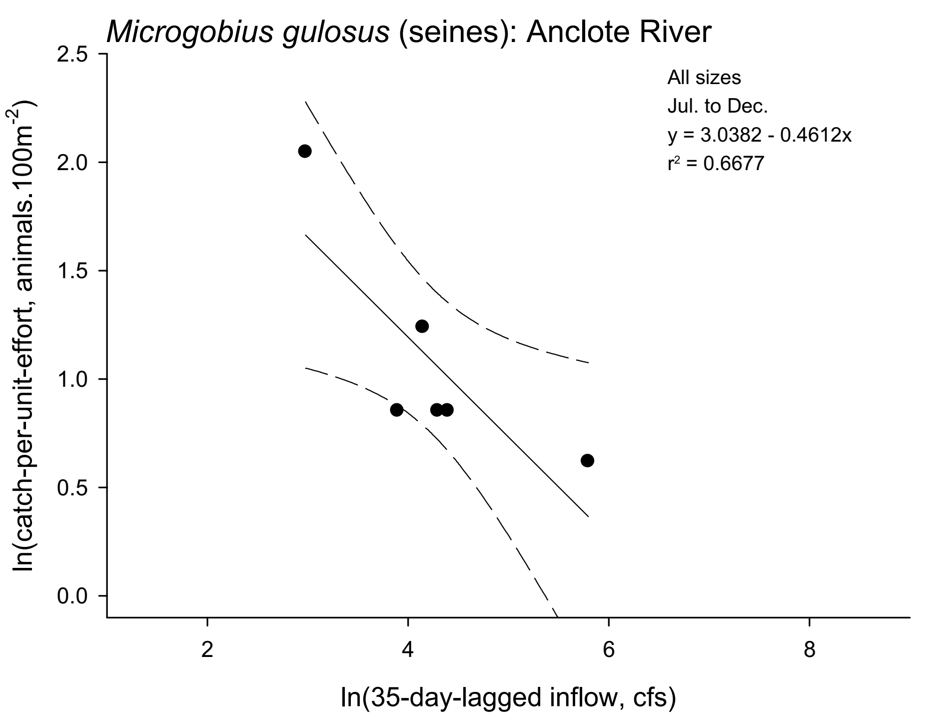


Fig. I22. Abundance response of Clown goby (All sizes) in the Anclote River estuary to 35-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

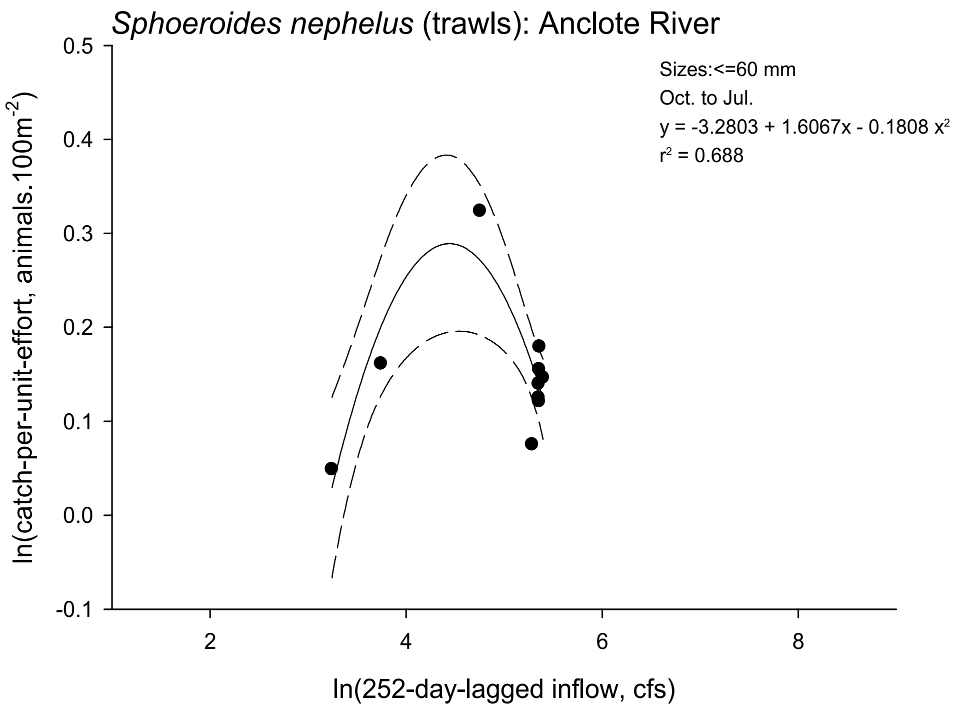


Fig. I23. Abundance response of Southern puffer (<=60 mm) in the Anclote River estuary to 252-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

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Fifty years of advancing the science of the sea.

April 18, 2006

Mr. Michael G. Heyl
Southwest Florida Water Management District
7601 U.S. Highway 301
Tampa, Fl. 33637-6759

Re: District Purchase Order 05PC0001646-1: Anclote River Mollusk and Vegetation Survey

Dear Mr. Heyl:

This two-part report describes studies conducted by Drs. Ernest Estevez and Brad Robbins on mollusks and shoreline type within the Anclote River. This study is part of the Southwest Florida Water Management District's program to describe west-central Florida tidal rivers for the purpose of establishing regulatory minimum flows in each.

The project called for live and dead mollusks to be assessed using rapid survey techniques comparable to those previously used by Mote Marine Laboratory in studies of the Peace, Myakka, Weeki Wachee and Alafia Rivers, Shell Creek, and McKay, Dona, and Roberts Bays. A "windshield" survey of the Anclote River' shorelines coupled with an assessment of aerial photographs and landuse maps was used to delineate the River's shoreline by type.

Please accept the enclosed materials as a final letter report of findings for the cited effort.

We appreciate the opportunity to have conducted this interesting study, and hope the District finds it useful in its work.

Sincerely,

Ernest D. Estevez, Ph.D.
Director
Center for Coastal Ecology

Bradley D. Robbins
Manager
Landscape Ecology Program

Part One: Mollusk Survey

Rapid-survey methods were employed from December 12, 2005 to February 10, 2006, to census the macro-mollusk communities of the Anclote River, Florida. The Anclote River was sampled from its mouth to river kilometer (RK) 3.0 on one kilometer intervals; then on half kilometer intervals to RK 12.0, and then at RK 13, 14, and 15. A District RK map was used to locate stations and all sampled sites corresponded to sites defined by the Scope of Work, except that RK 11.5 was moved to RK 11.3 to avoid local human disturbances. Because RK 16 was not sampled as per the Purchase Order, a replacement effort was made at RK –1.0.

Because the primary objective of the study was to identify down-stream patterns in species dispersion, samples were collected across each transect at representative sites, and data were pooled for the entire transect. In single-channel reaches, subtidal samples were collected close by opposite banks and at evenly spaced intervals across the channel. In reaches with marsh islands and multiple channels, subtidal effort was distributed so as to sample in each channel or basin.

Collection of intertidal samples was biased by two criteria. First, accreting banks were preferred over eroding ones, meaning in practice that the insides of bends were preferred over outsides, and that samples were collected more from point-bars, marsh islands, and shoals than from steeply inclined banks. Second, a preference was made for the bank judged to be least altered by human activity. Sea walls and filled areas were avoided where possible.

Subtidal samples (< MLW) were collected by a petite ponar grab rather than pipe cores because larger mollusks are often missed or lost by the cores. Ponar grabs offer a larger sampling surface area (0.0232 square meters) than pipe cores (0.00456 square meters). A sample was comprised of one ponar grab at a given location. Five such subtidal samples were taken in different environments along each half-kilometer transect, giving a per-transect sampling surface area of 0.116 square meters. Contents of each sample were concentrated over a 3.0 millimeter sieve and processed in the field. Unknowns were bagged and returned to the Laboratory for identification.

Intertidal samples (> MLW) usually were collected by spade although ponar grabs were used in areas where the substratum was unfit for wading. Intertidal effort was the same as subtidal effort except that hand collections of particular species were added to intertidal samples so as to record the presence of rare or cryptic species. The gastropods *Neritina* and *Littoraria*, for example, are often found in low numbers, near the tops of black needlerush shoots. Oysters and mussels likewise grow cryptically behind mangrove roots or within crevices of fallen wood.

Where safe to do so, subtidal areas were also visually reconnoitered by wading or snorkeling and intertidal areas were walked in search of rare occurrences.

Specimens were sorted as live or dead and identified in the field or Laboratory. For each species in each sample, both live and dead median size was determined by arranging specimens from smallest to largest and measuring the median specimen to the nearest millimeter. Gastropods were measured from the apex to opposite end; bivalves were measured from front end to hind end. For data analysis, a mean value of median sizes was computed for each species. The percentage of juveniles (<10 mm) if any was recorded by species where identification was possible, for live and dead lots at each transect. Condition was scored for each whole live animal or single dead valve as percent covered by mechanical erosion, shell dissolution, or other loss or damage.

Findings

An Excel spreadsheet of all species at all stations is provided in Attachment 1. This Report contains graphs depicting data for individual species that were numerous enough to warrant description, an Exhibit section for other species, and graphs depicting summary community data and the spatial arrangement of species as a function of river kilometer for both rivers.

A total of 38 taxa were collected. Species richness was high, even in comparison to other tidal streams in southwest Florida that have been studied by the same method. Species richness values for other systems are 11 in Shell Creek, 15 in the Weeki Wachee River, 20 in the Alafia River, 24 in the Myakka, and 34 in both the Peace and Dona/Roberts Bay systems.

The mollusk fauna of the Anclote River is similar to that of other studied streams, in terms of their species composition in low-salinity reaches. The lower Anclote, on the other hand, supports a number of species not found in other recently-studied rivers. The additional species reflect the proximity of the river to Anclote Anchorage, where conditions are favorable for a productive and diverse molluscan fauna. The lower Anclote River is most similar to the Dona/Roberts Bays area in this regard, where the Gulf of Mexico is also immediately adjacent.

In terms of species abundance, the jackknife clam, *Tagelus plebeius*, was most common. *Tagelus* is an excellent indicator of the tidal river community. Only one mussel species, *Geukensia demissa*, was common but two other intertidal species, *Polymesoda caroliniana* and *Littoraria irrorata*, also were abundant. As shown in the following list, oysters were common in comparison to other species but this rank is an artifact of their high numbers in reefs.

Rank Order Abundance of Mollusk Species in the Anclote River.

Species	Total	Percent	Cumulative Percent
Crassostrea virginica	276	28.78	28.78
Molgulidae	142	14.81	43.59
Tagelus plebeius	112	11.68	55.27
Geukensia demissa	71	7.40	62.67
Polymesoda caroliniana	62	6.47	69.13
Mulinia lateralis	36	3.75	72.89
Chione cancellata	31	3.23	76.12
Littoraria irrorata	31	3.23	79.35
Laevicardium mortoni	28	2.92	82.27
Tellina tampaensis	28	2.92	85.19
Ischadium recurvum	27	2.82	88.01
Carditamera floridana	19	1.98	89.99
Nassarius vibex	15	1.56	91.55
Anomalocardia auberiana	10	1.04	92.60
Anomia simplex	8	0.83	93.43
Crepidula plana	8	0.83	94.26
Anodontia alba	7	0.73	94.99
Argopecten gibbus	5	0.52	95.52
Bulla striata	5	0.52	96.04
Lucinisca nassula	4	0.42	96.45
Melongena corona	4	0.42	96.87
Prunum apicinum	4	0.42	97.29
Cerithium muscarum	3	0.31	97.60
Conus jaspidus stearnsi	3	0.31	97.91
Polinices duplicatus	3	0.31	98.23
Brachiodontes exustus	2	0.21	98.44
Ensis minor	2	0.21	98.64
Rangia cuneata	2	0.21	98.85
Amygdalum papyrium	1	0.10	98.96
Arene tricarinata	1	0.10	99.06
Atrina rigida	1	0.10	99.17
Corbicula maniliensis	1	0.10	99.27
Laevicardium laevigatum	1	0.10	99.37
Lima pellucida	1	0.10	99.48
Mactra fragilis	1	0.10	99.58
Melampus coffeus	1	0.10	99.69
Mytilopsis leucophaeata	1	0.10	99.79
Trachycardium egmontianum	1	0.10	99.90
Turbo castanea	1	0.10	100.00

The Anclote River fauna is comprised of many species that were represented by dead-only material, even when Anclote Anchorage fauna are discounted. Despite extra effort to identify and censor relict or fossil material, a few of the dead-only reports may represent contamination of the modern fauna. The Anclote River west of U.S. Highway Alternate 19 has been dredged extensively, exposing and spoiling much old material as subtidal and intertidal fill, and as eroding spoil islands.

Compared to other southwest Florida rivers studied by similar methods, Anclote River mollusk collections tended to produce small specimens that occurred in low densities and over shorter reaches of the river. Considering these tendencies along with high species richness, Anclote River fauna may be shaped by constant but low levels of successful recruitment, followed by slow growth or high mortality prior maturation. Reasons for small mollusk sizes, densities, and ranges are not evident from the collected data.

Low densities make interpretation of individual species data difficult when so few stations were occupied. The introduced, naturalized and invasive species *Corbicula maniliensis* was found as dead material at RK 11.3, but may not occur in the river's upstream reaches owing to steep channel banks and unsuitable sediment conditions at depth.

The subtidal clam *Rangia cuneata* was also found at only one station (RK 15.0) but is probably a stable element of the fauna because it was collected as both live and dead material and as very large specimens. One live *Rangia* measured 76 mm and is the largest live *Rangia* specimen collected to date in mollusk surveys in southwest Florida. Mussel species that tend to occupy broad river reaches elsewhere occur at one or two stations in the Anclote River, and except for one species discussed below, mussels are not a dominant element of the Anclote's molluscan fauna.

Tagelus was present as live and dead material. Their shells are fragile so it is reasonable to assume that the material was recent. Highest densities were from RK 4.0-6.5 and largest live and dead shells were upstream of RK 5.0 (Figure 1). *Geukensia demissa* was the only mussel to occur in high density or occupy a substantial reach of the river. This mostly intertidal species was most abundant downstream but largest, upstream within its 11 kilometer reach (Figure 2). Another intertidal species, *Polymesoda caroliniana*, was common in the upper half of the tidal river and, like Tagelus, was most abundant downstream but largest, upstream within its reach (Figure 3).

Oyster was encountered at 13 stations between the river mouth and RK 9.0, but their range and abundance is imperfectly described by sampling on half or whole kilometer intervals. In general, small and mostly dead oyster reefs occur at and near the river mouth and lower few kilometers, but large live reefs are most conspicuous from RK 4.0 to RK 7.0. Reefs then become smaller and more widely spaced upstream to near RK 9.0. Intertidal oysters were more common than subtidal ones and, like the other intertidal species, were most abundant downstream but largest, upstream within its reach (Figure 4).

One species collected in very high number was not a mollusk but is reported here because its presence corresponded with a paucity of mollusks, and like many clams, it is also a filter-feeder. A soft tunicate in the Family Molgulidae represented about 15 percent of the total specimen count. It was primarily subtidal, only found alive, and very abundant in off-channel areas between RK 3.0 and 5.0 (Figure 5).

Distribution patterns for the combined fauna are interesting. Attached graphs depict the dispersion of species in relation to river position, using various attributes. Sorts of species occurrence by upstream or downstream appearances (Figures 6, 7) show strong changes, characteristic of rapid rates of community structure evolution. The marine community of Anclote Anchorage is distinctive. Once within the river the lower river fauna shifts near RK 4.0 and then diminishes with upstream distance. Above RK 8.0 a riverine, low salinity community prevails.

A downstream "sag" appears in species richness near RK 2.0 (Figures 8,9), and is evident in faunal densities in the RK 1.0-3.0 reach (Figures 10,11). This depression in diversity and density is not regarded to be a property of the natural mollusk community but rather the effect of severe habitat limitations imposed by extensive dredging and spoiling, and the effects of a high energy environment created by boat wakes. On balance, sharp declines in abundance from RK 4.0 to 5.0, and sharp declines in diversity from RK 5.0 to 6.0, are considered to be the result of naturally occurring changes in community structure.

Remarks

The Anclote River presents a diverse fauna relative to other tidal systems studied by similar methods. The present survey depicts a fauna comprised of many small and often dead specimens of many species, most of which occur in relatively short river reaches. Species replacement rates are high as a function of river location (Figure 12). An authentic tidal river fauna occurs in the Anclote River, primarily from RK 7.5 to RK 11.3. It is bracketed by a downstream estuarine and an upstream oligohaline fauna. An apparent "sag" in downstream richenss and density is considered to be the consequence of habitat constraints. The constraining effects of tunicate competition, heavy algal accumulations at some stations, and poor sediments probably account for some of the patterns observed in Anclote mollusk fauna, especially in off-channel and back-bay areas. Dynamic means, ranges, and extremes of salinity along the tidal river may also contribute to the observed results though no salinity data were collected in the present effort.

Notes

Two stations with positions not specified by the Anclote River kilometer map are:

RK	Location	Latitude	Longitude
-1.0	Anclote Anchorage	28.17786	82.81018
11.3	Anclote River	28.17216	82.72421

Exhibits

Graphs of mollusk species data for species with low occurrences.

Attachment

1. Excel file, "Ancloteclamdata"– species occurrences, density, size, juveniles, and condition.

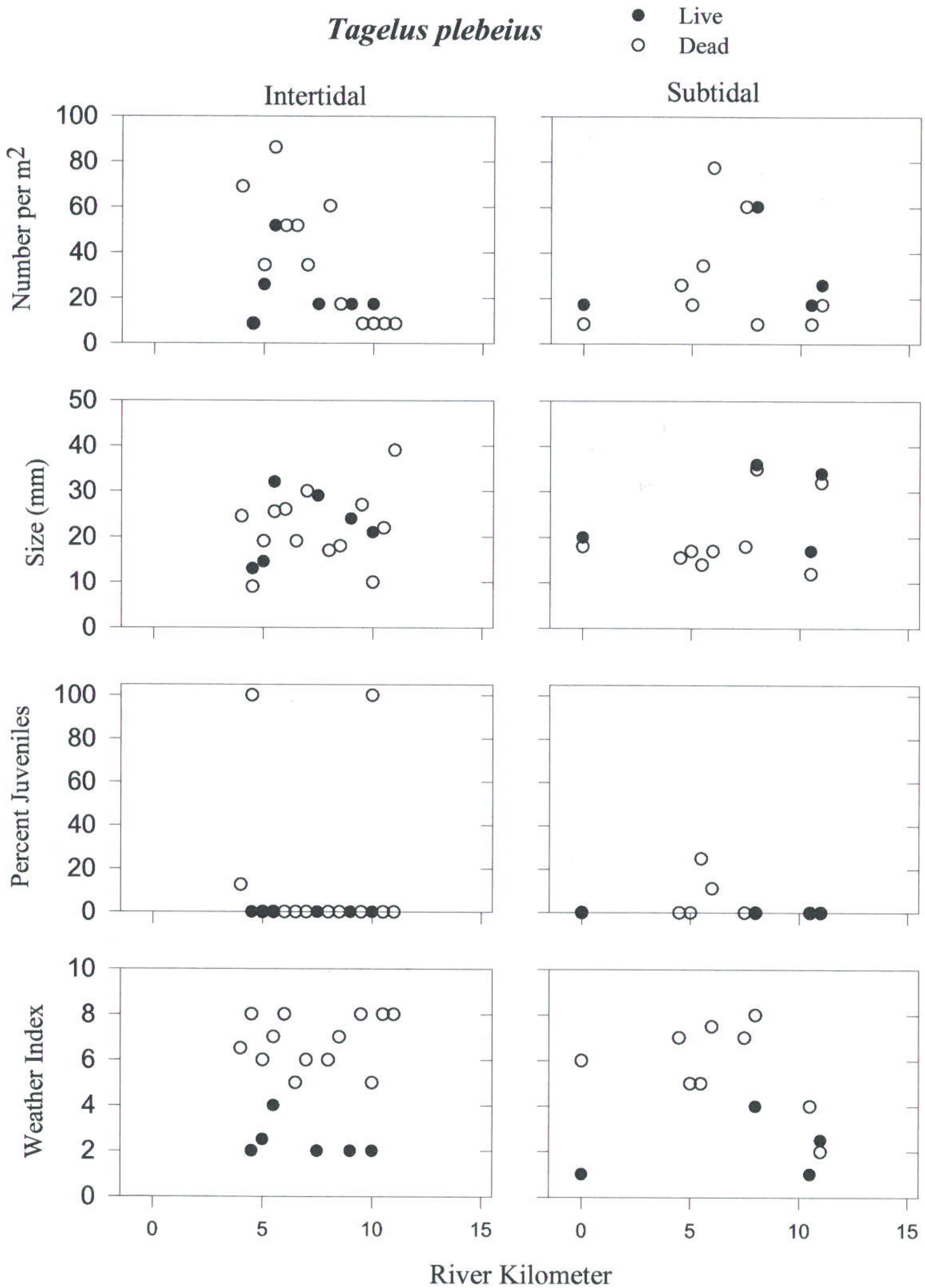


Figure 1: Habitat, density and condition data for *Tagelus plebius*.

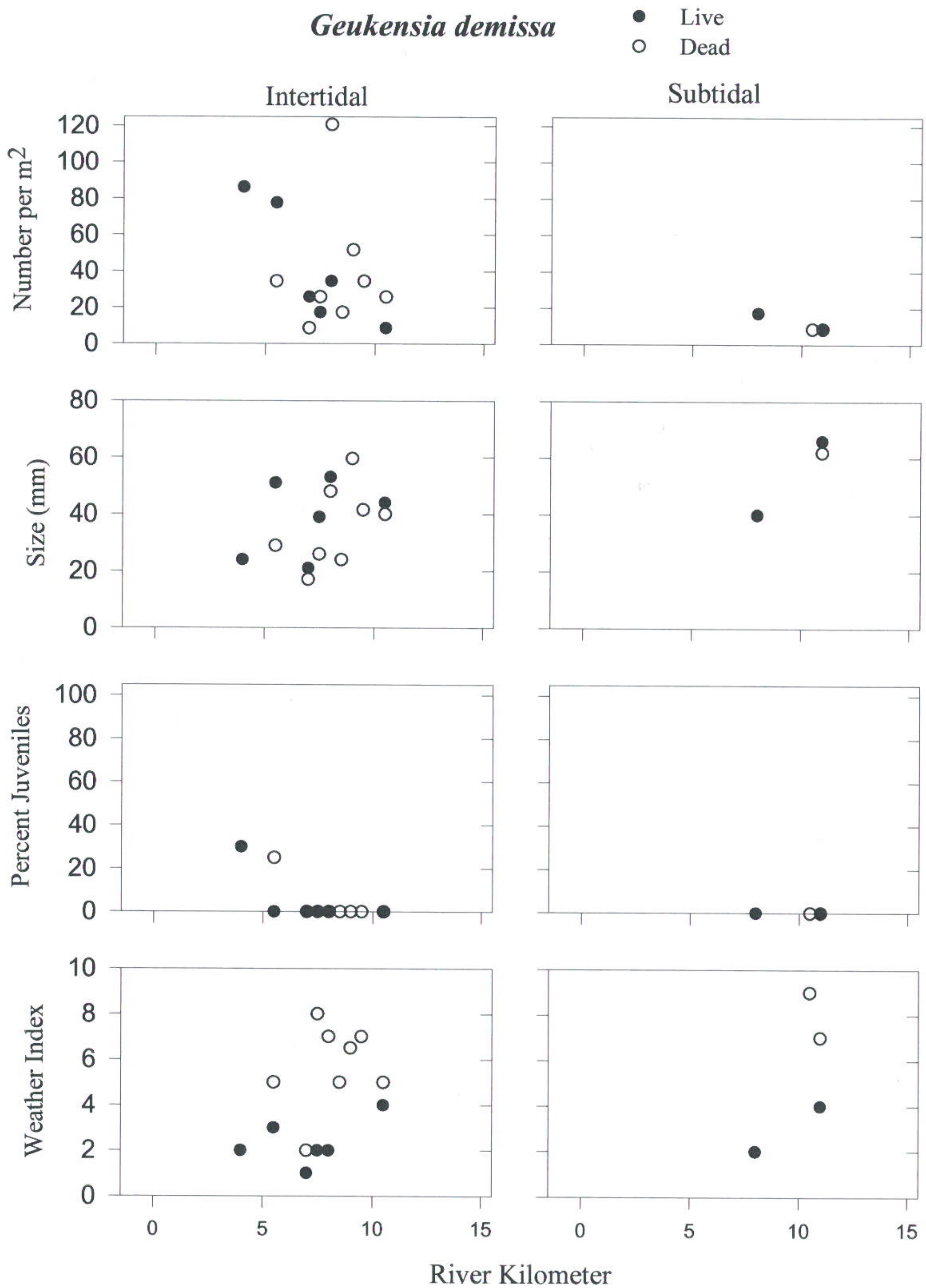


Figure 2: Habitat, density and condition data for *Geukensia demissa*.

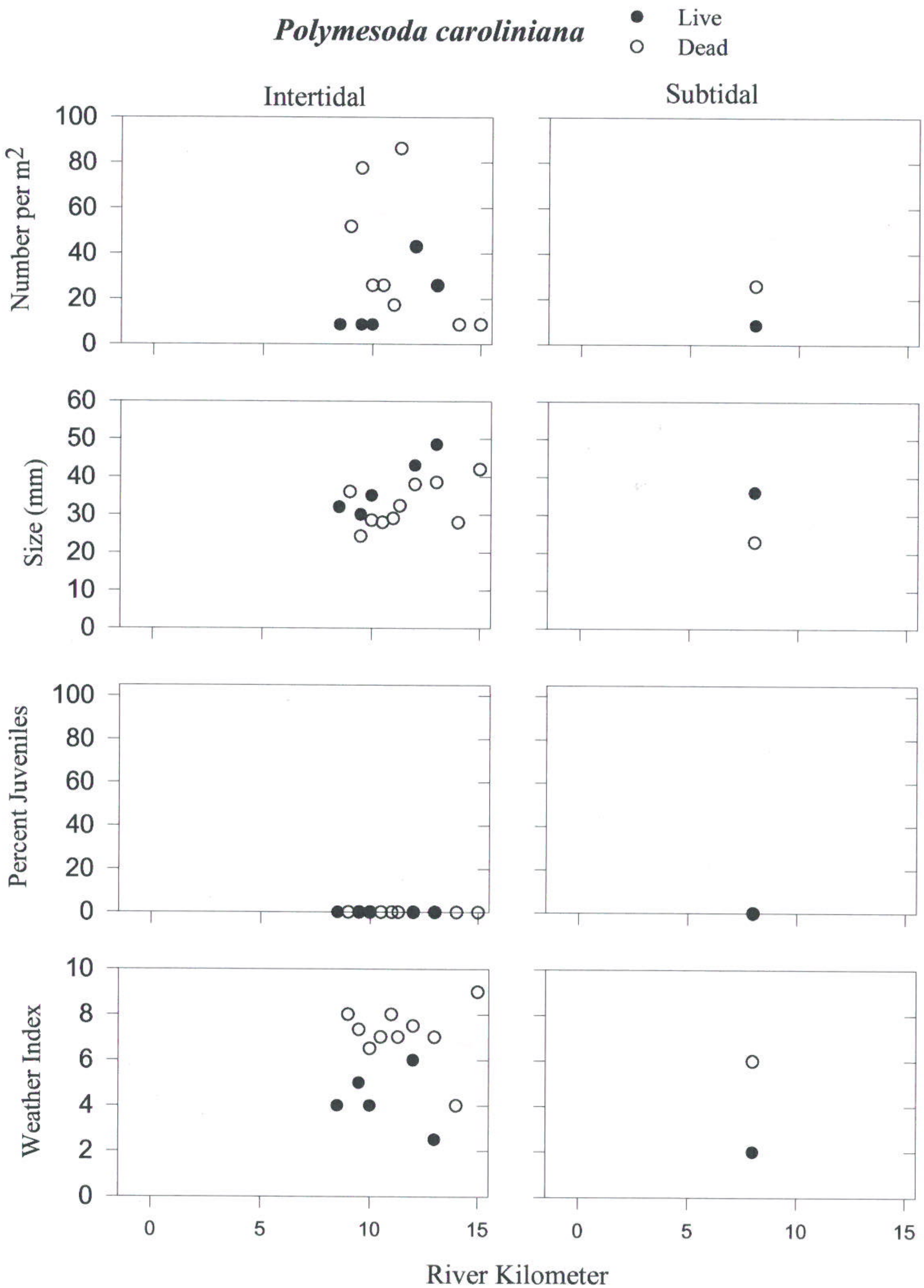


Figure 3: Habitat, density and condition data for *Polymesoda caroliniana*.

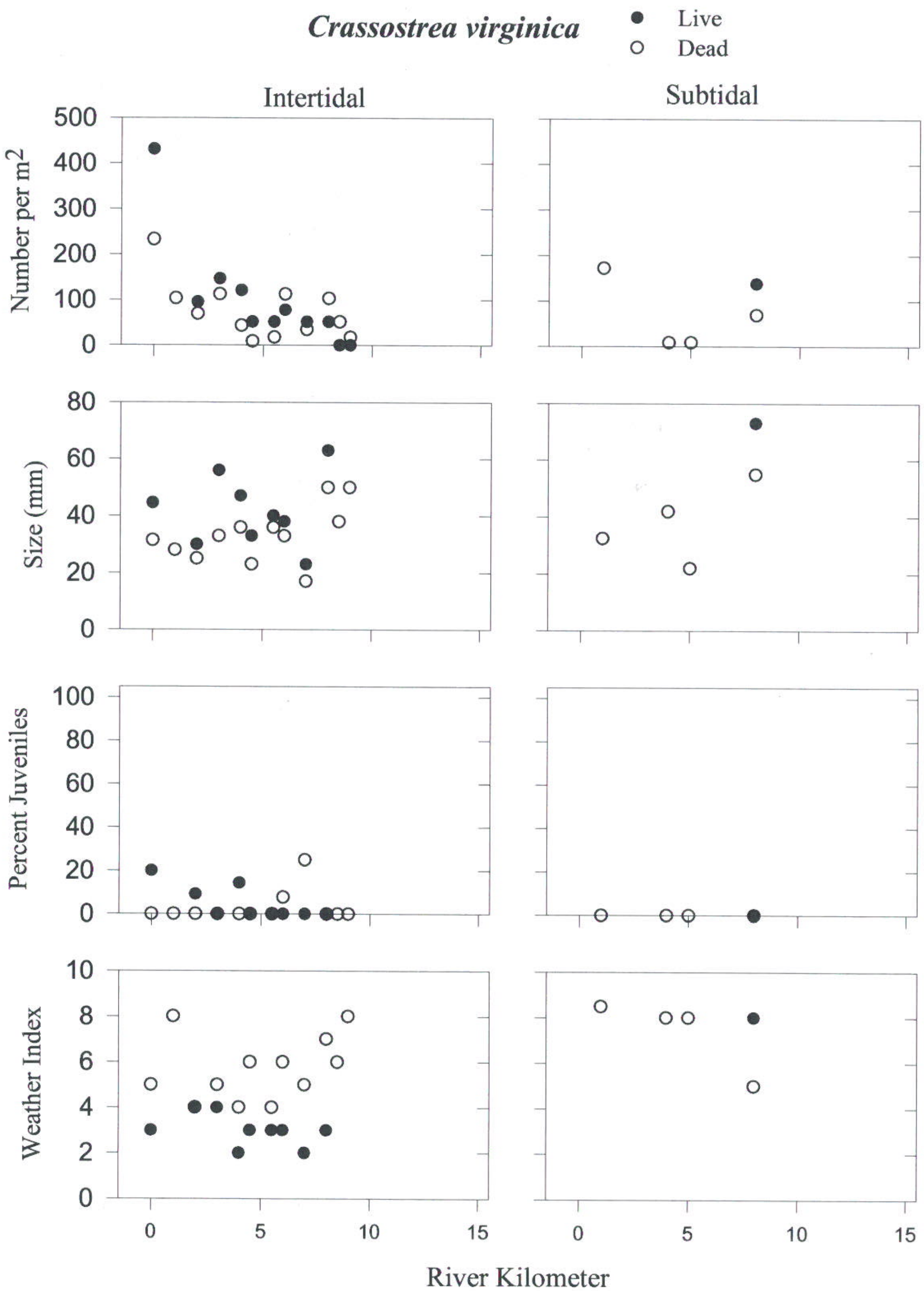


Figure 4: Habitat, density and condition data for *Crassostrea virginica*.

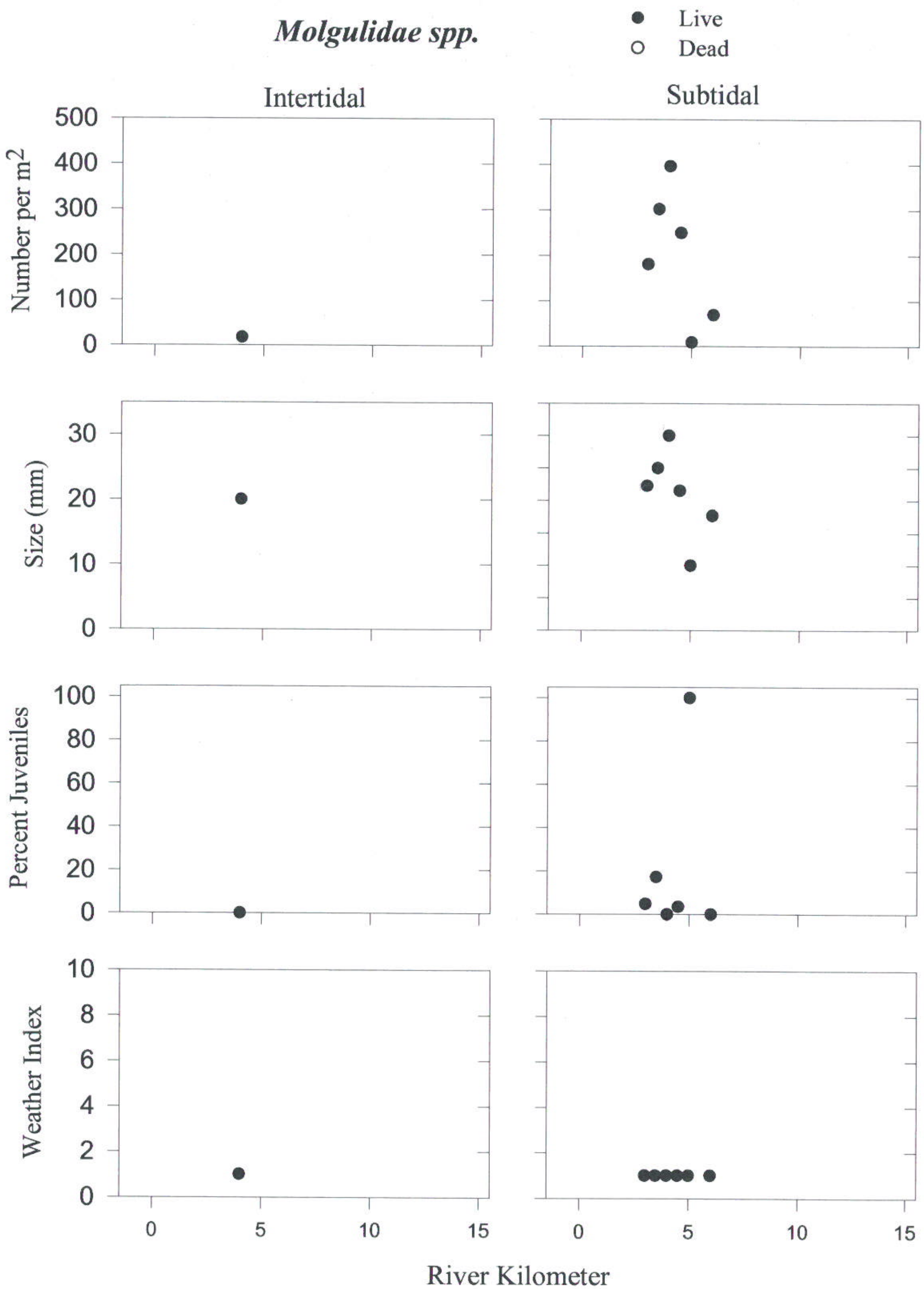


Figure 5: Habitat, density and condition data for Molgulidae sp.

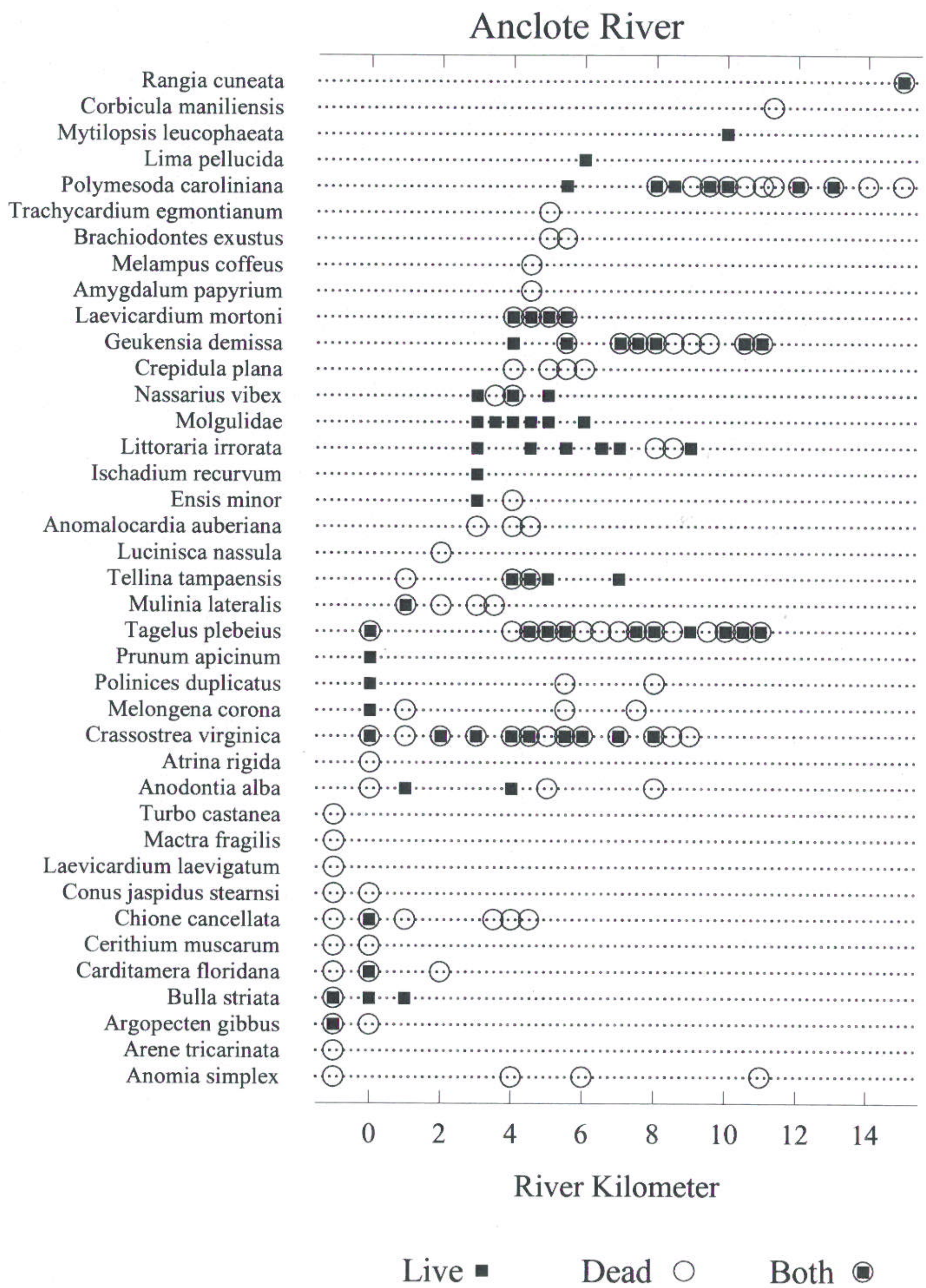


Figure 6: Upstream sort of species occurrences for live and dead material by river kilometer.

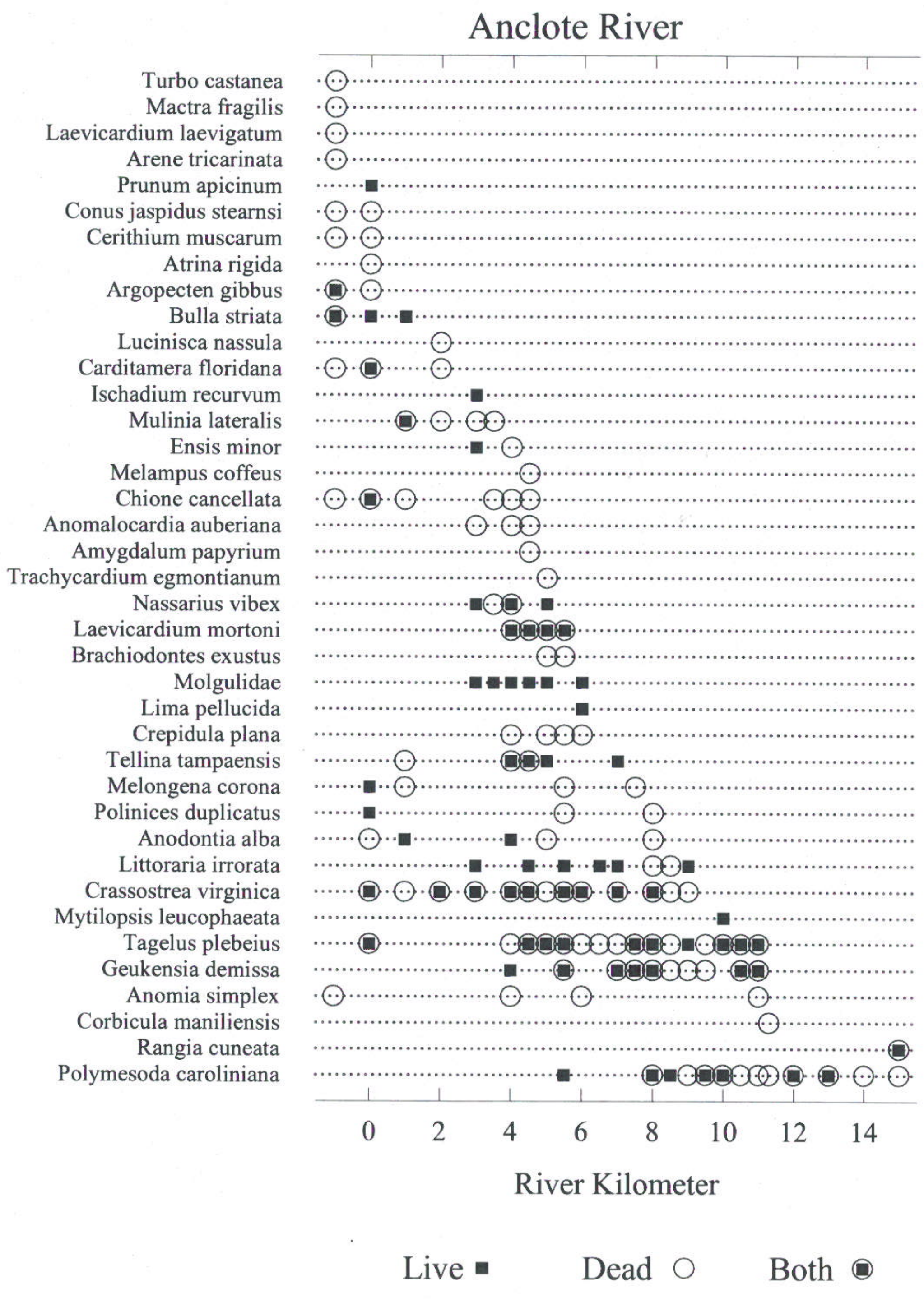


Figure 7: Downstream sort of species occurrences for live and dead material by river kilometer.

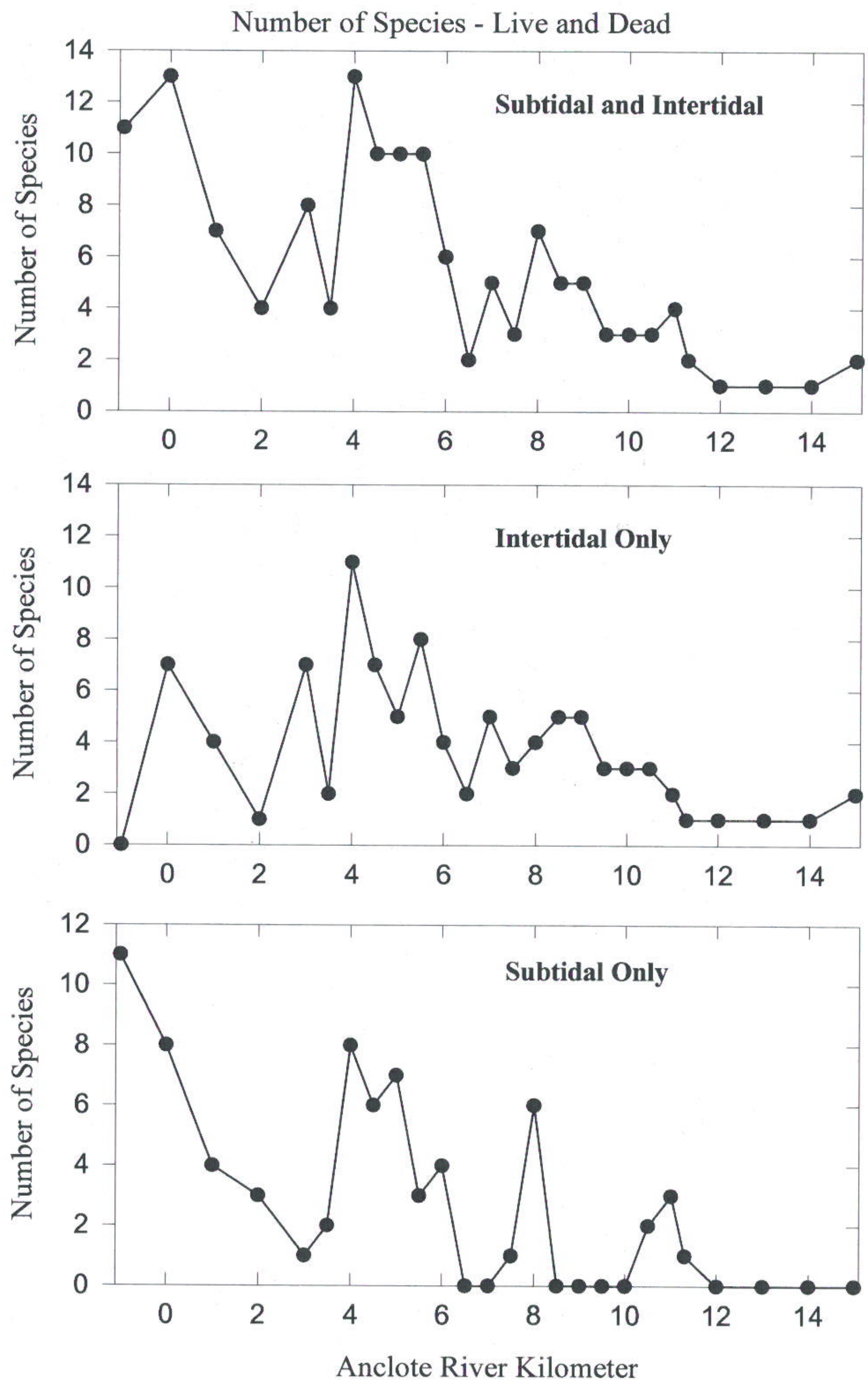


Figure 8: Species richness by river kilometer for live and dead material combined.

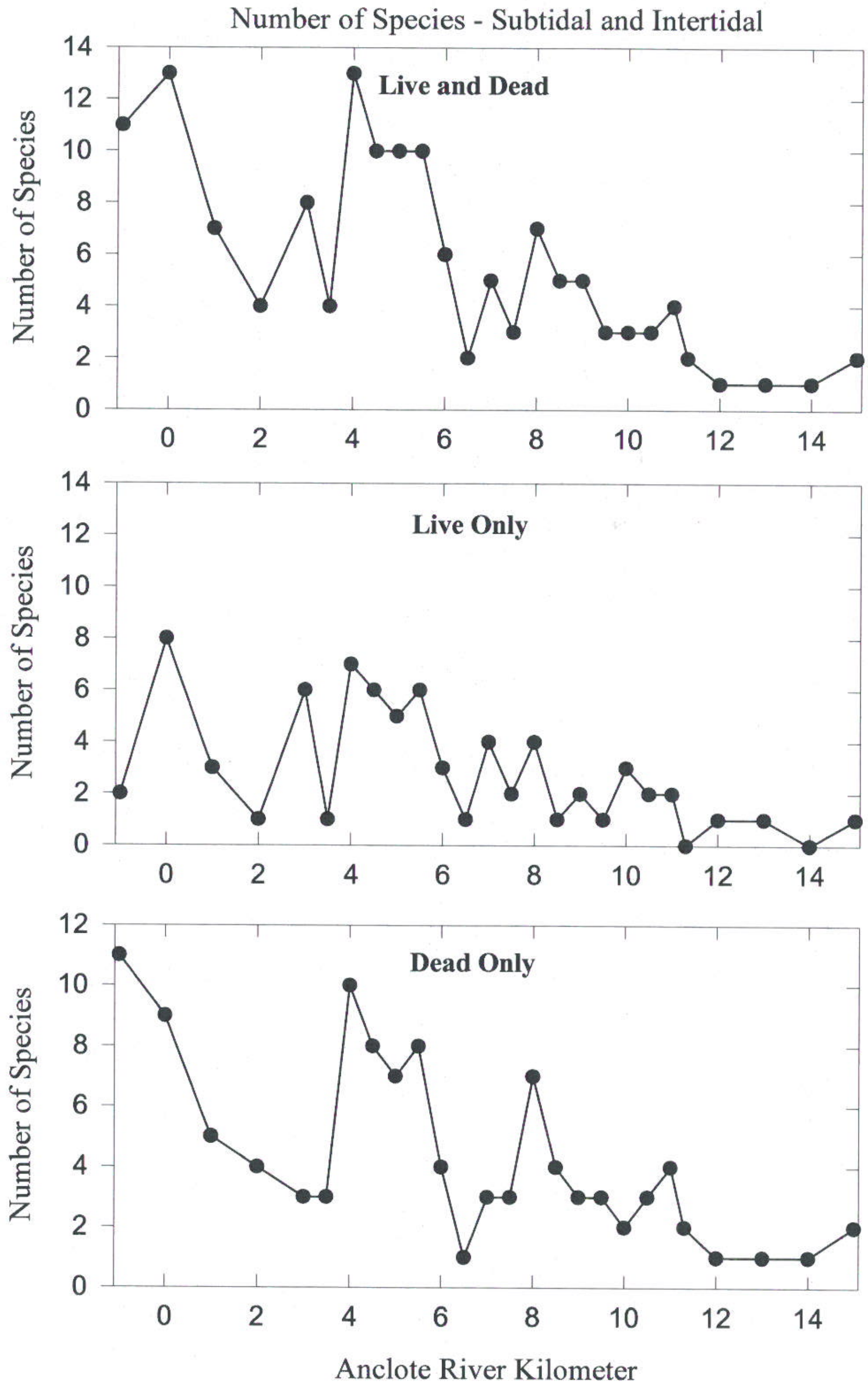


Figure 9: Species richness by river kilometer for intertidal and subtidal material combined.

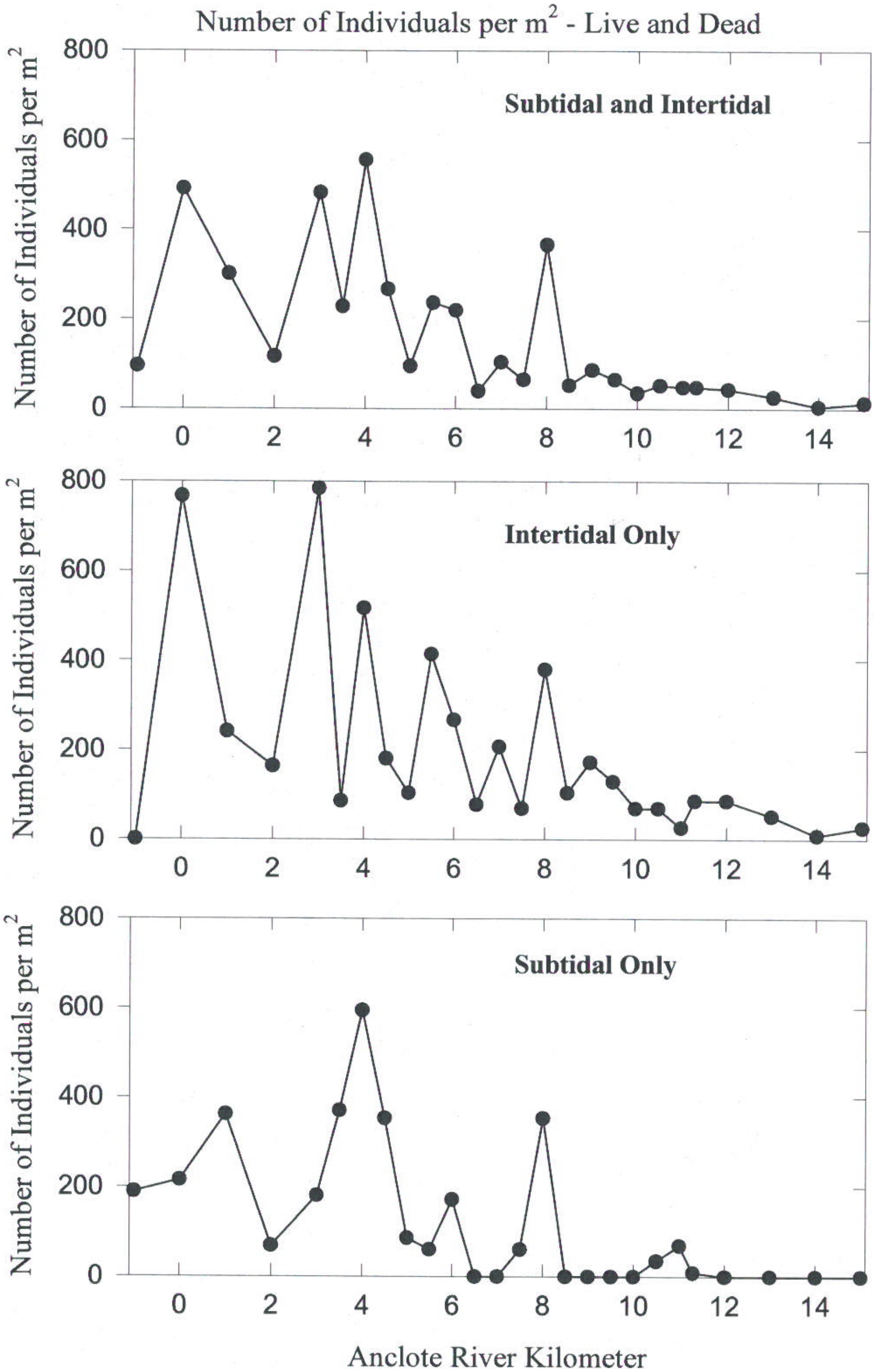


Figure 10: Faunal density by river kilometer for live and dead material combined.

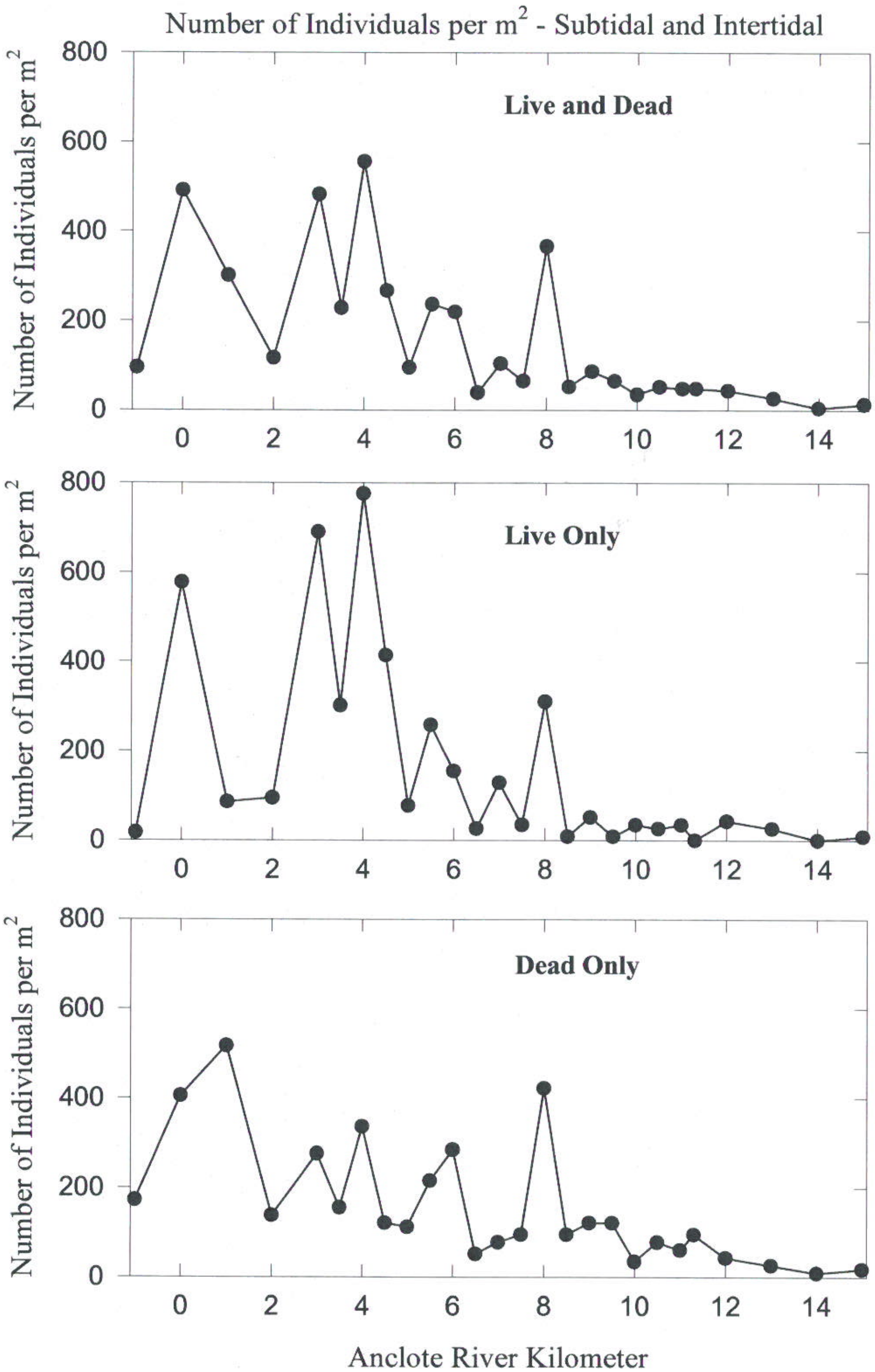


Figure 11: Faunal density by river kilometer for intertidal and subtidal material combined.

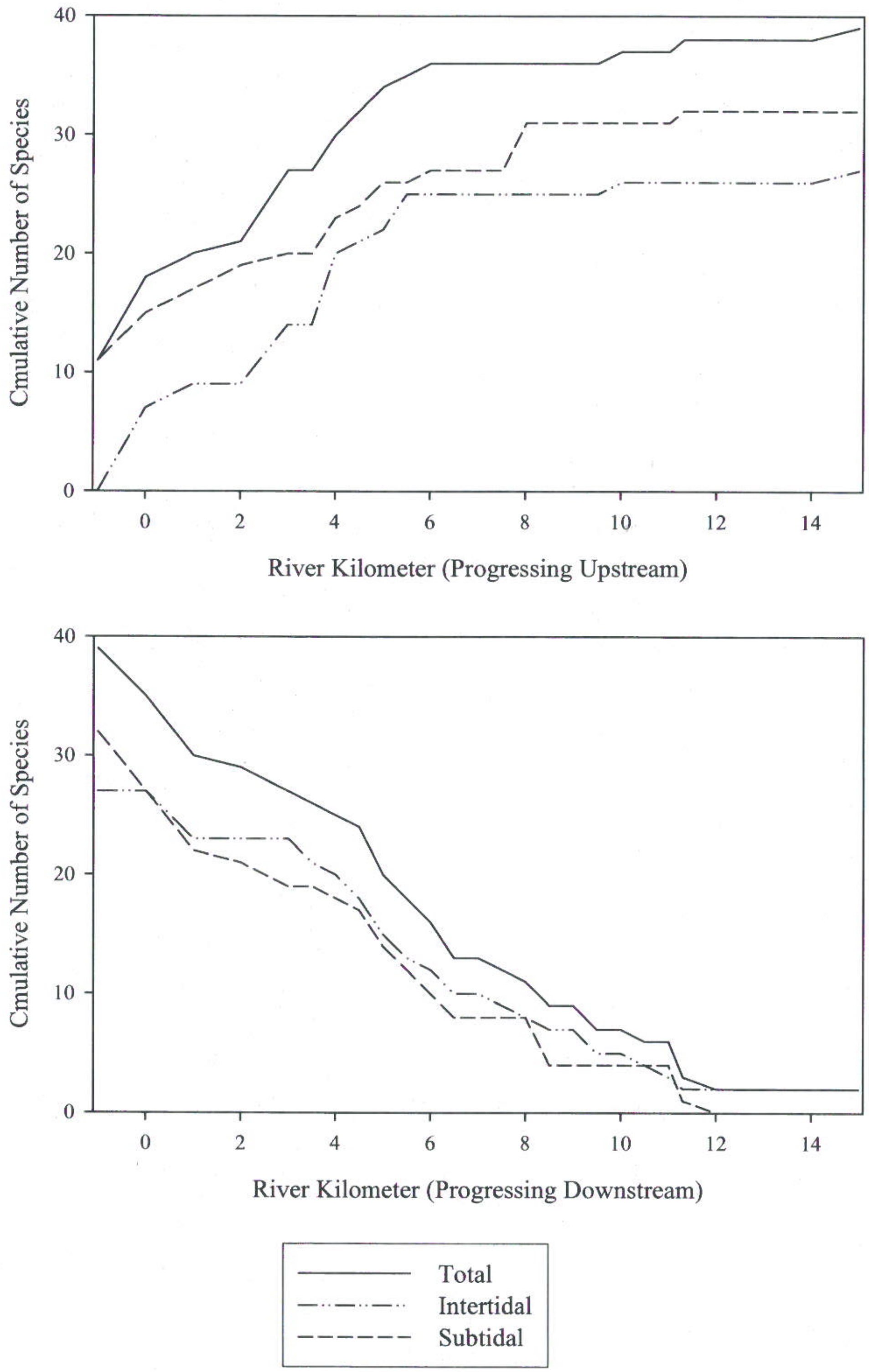
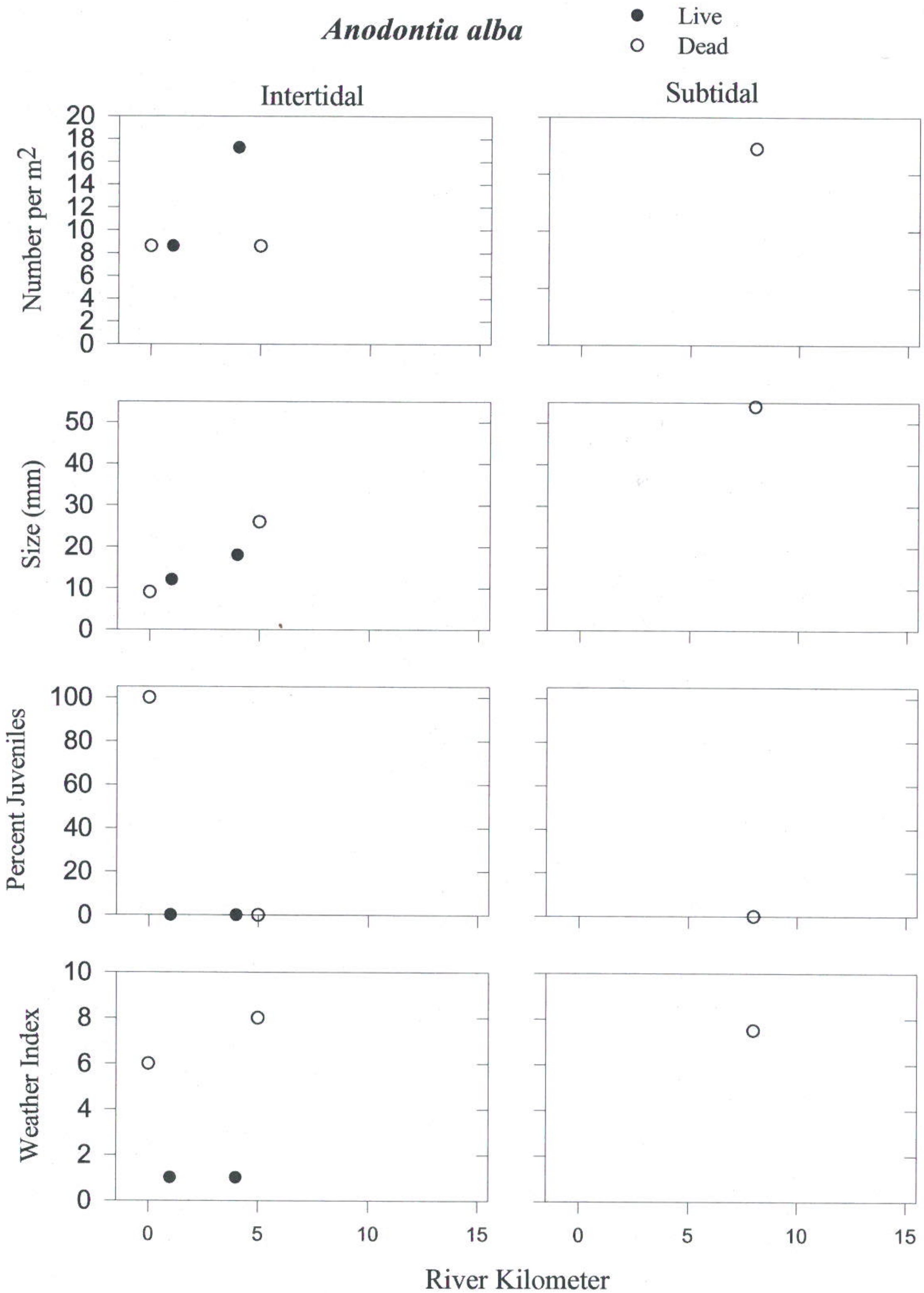
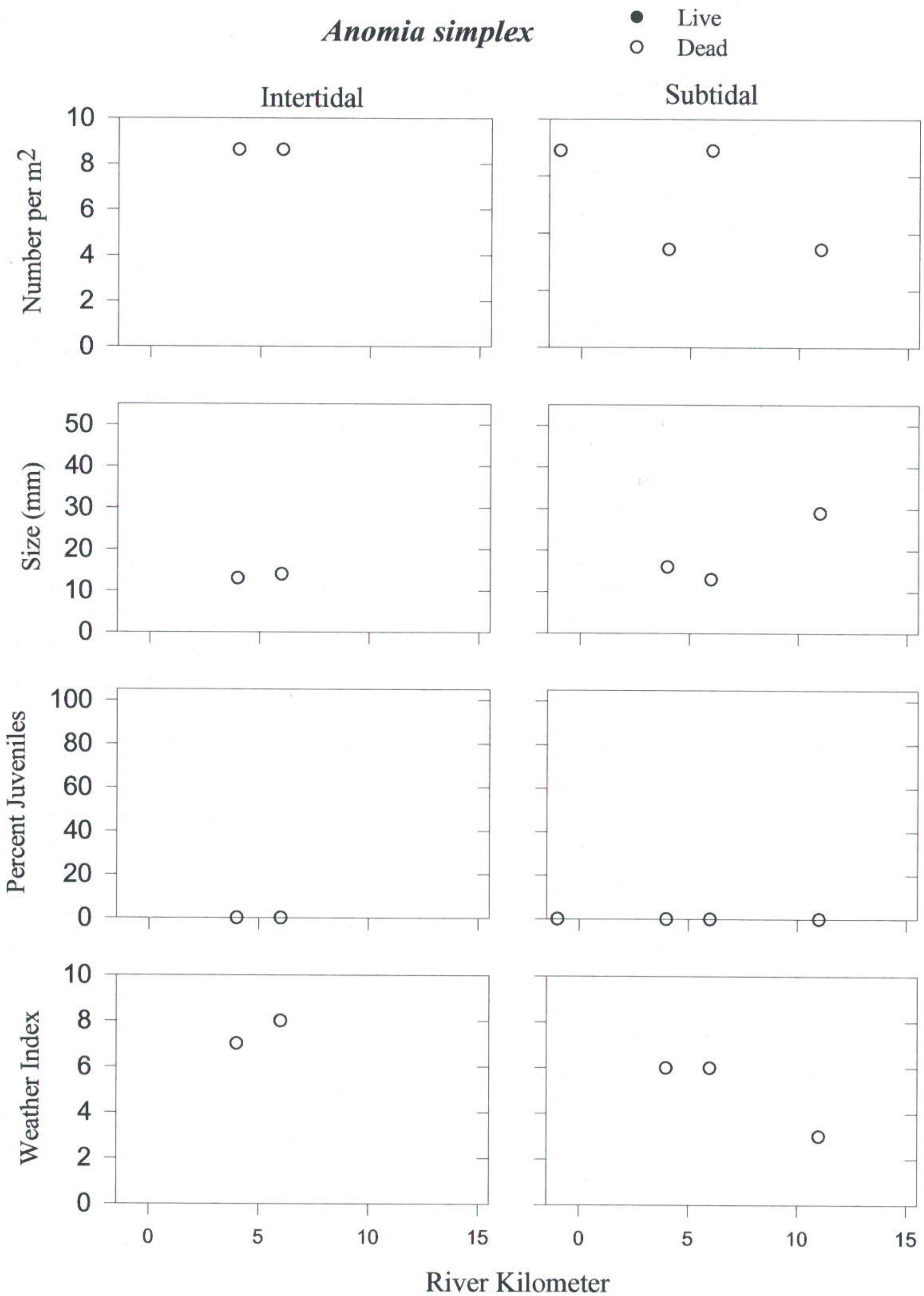
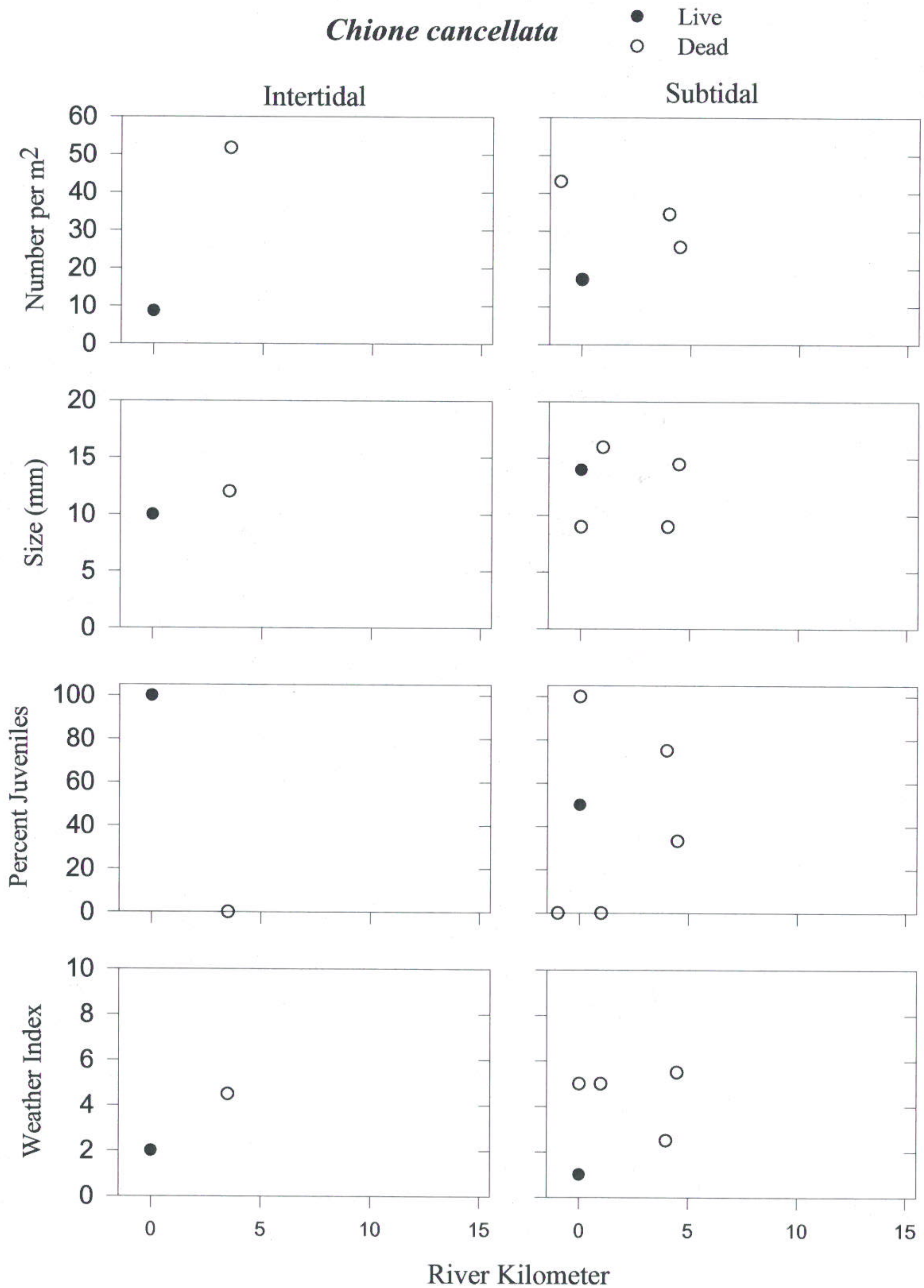


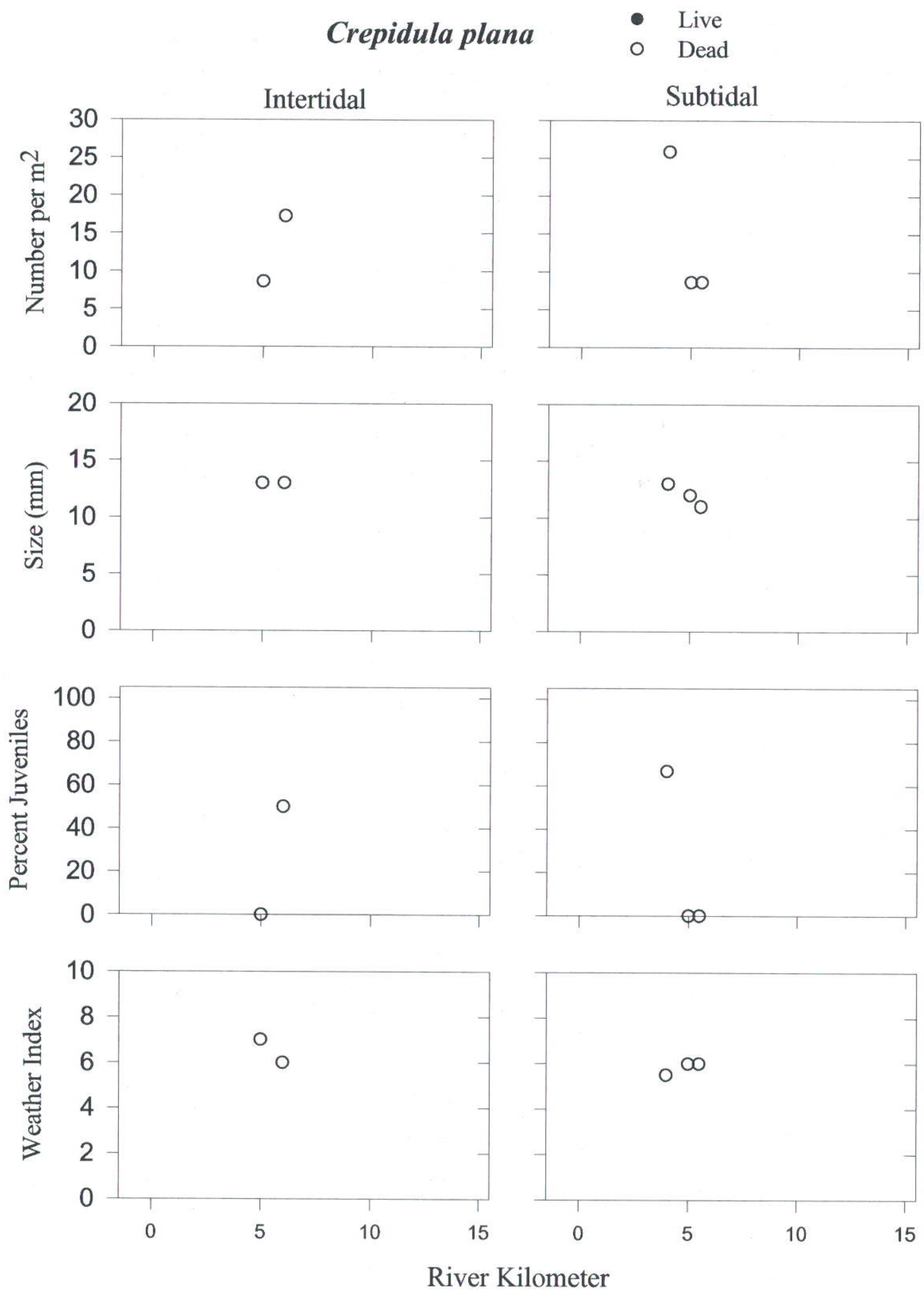
Figure 12: Cumulative species richness by river kilometer.

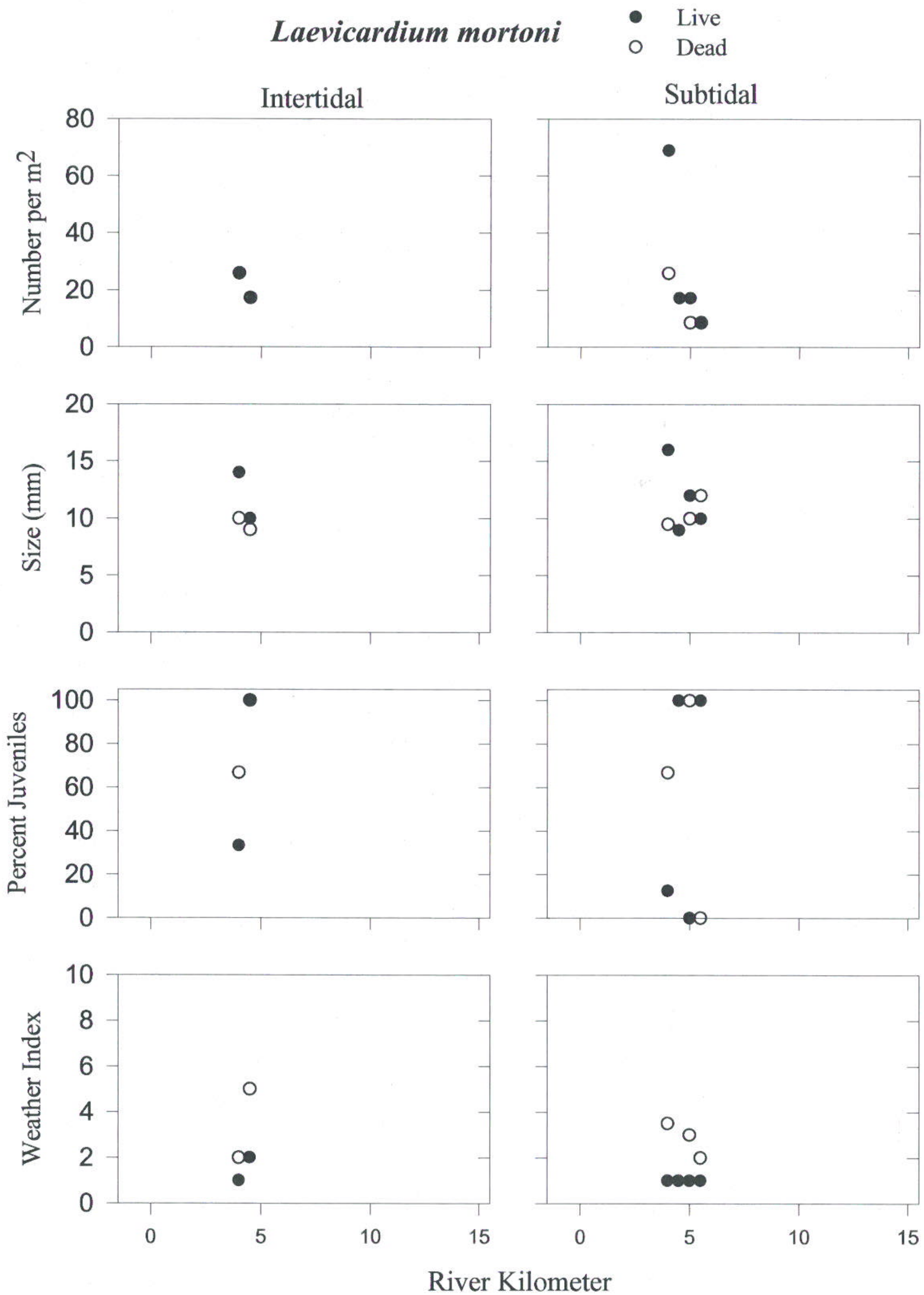
Exhibits

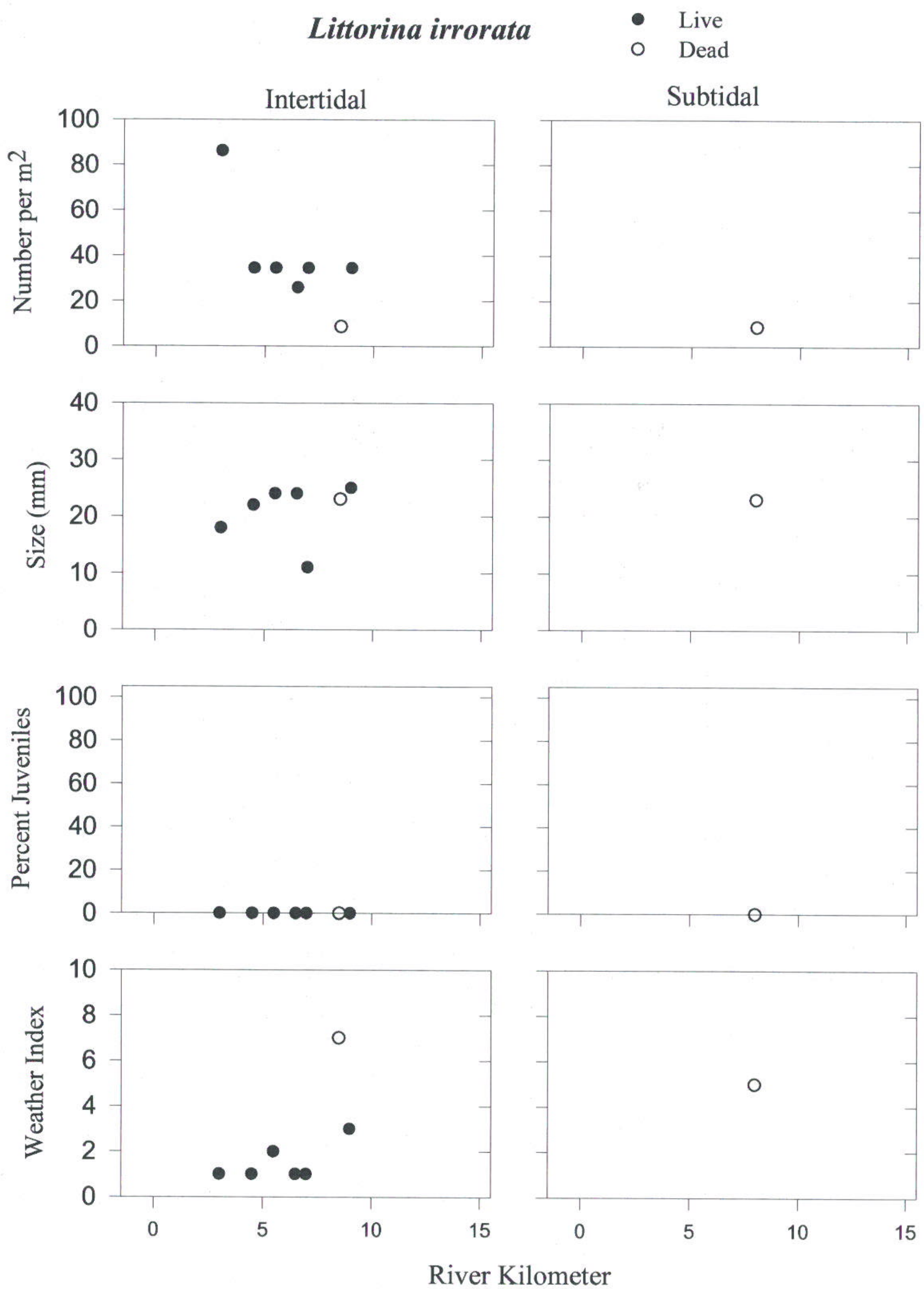

Anodontia alba
Live
Dead
Intertidal
Subtidal
Number per m2
Size (mm)
Percent Juveniles
Weather Index
River Kilometer
0
5
10
15


Anomia simplex
Live
Dead
Intertidal
Subtidal
Number per m2
Size (mm)
Percent Juveniles
Weather Index
River Kilometer
0
5
10
15

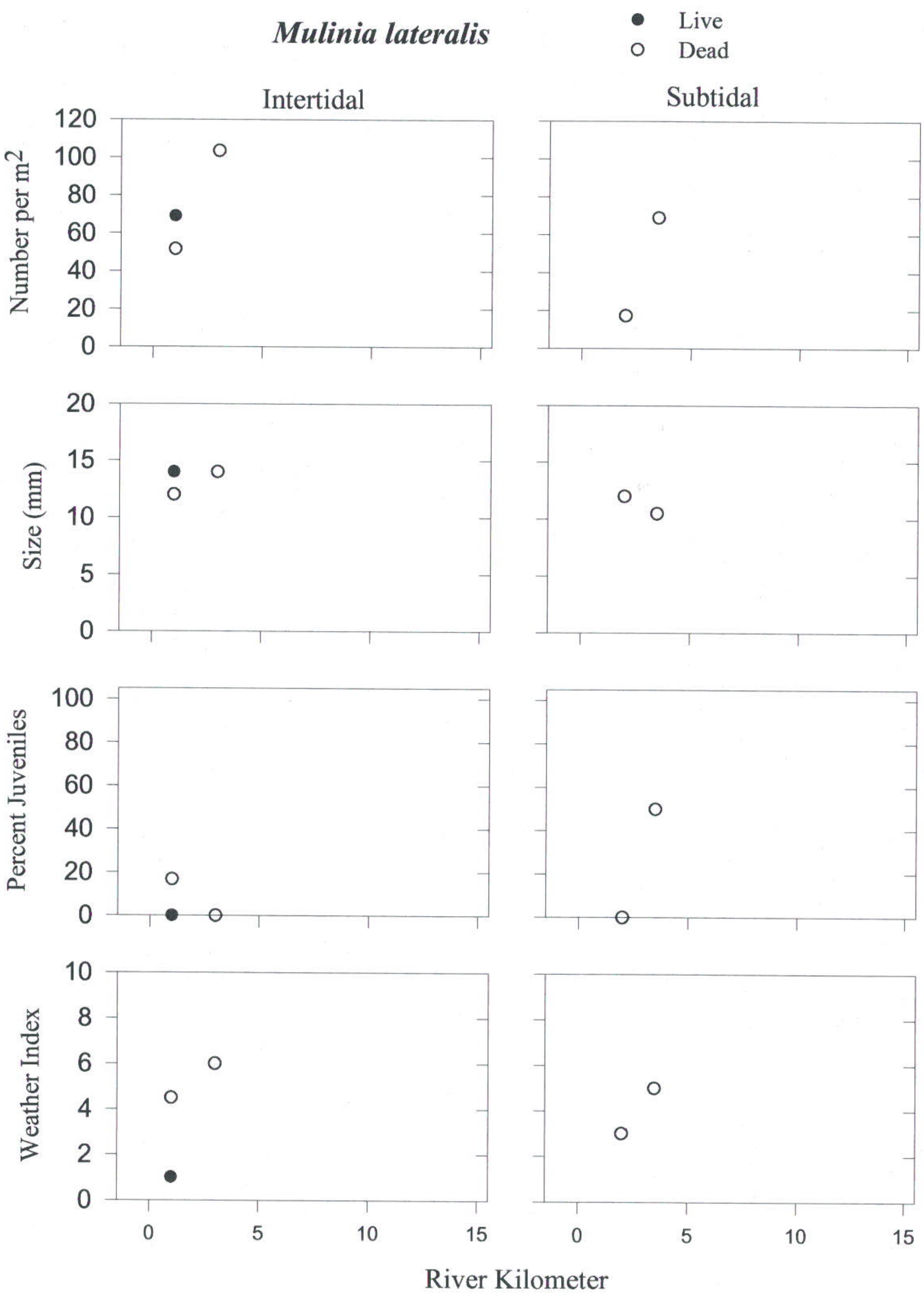

Chione cancellata
Live
Dead
Intertidal
Subtidal
Number per m2
Size (mm)
Percent Juveniles
Weather Index
River Kilometer
0
5
10
15

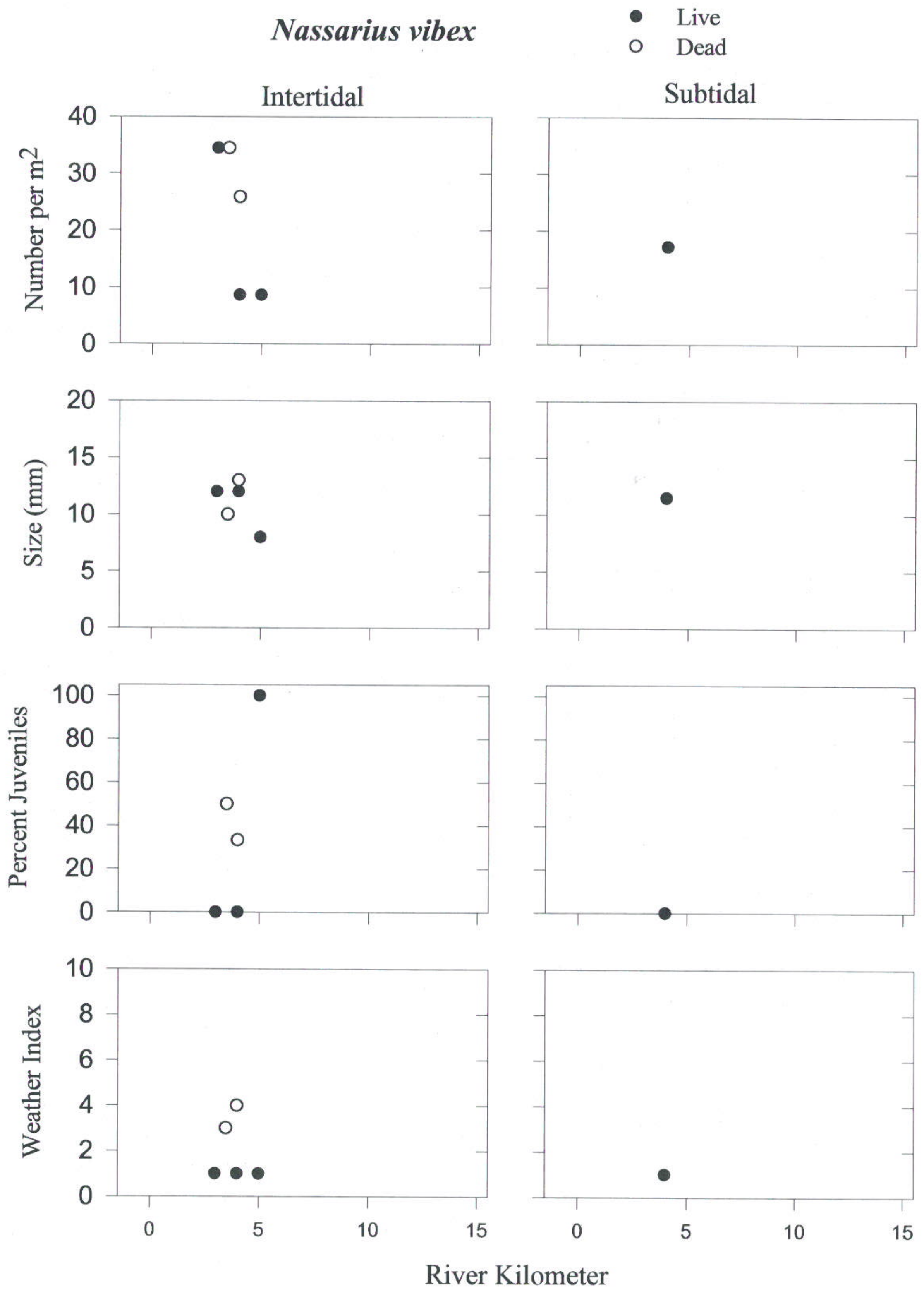

Crepidula plana
Live
Dead
Intertidal
Subtidal
Number per m2
30
25
20
15
10
5
0
Size (mm)
20
15
10
5
0
Percent Juveniles
100
80
60
40
20
0
Weather Index
10
8
6
4
2
0
0
5
10
15
0
5
10
15
River Kilometer


Laevicardium mortoni
Live
Dead
Intertidal
Subtidal
Number per m2
Size (mm)
Percent Juveniles
Weather Index
River Kilometer
0
5
10
15
20
40
60
80
100

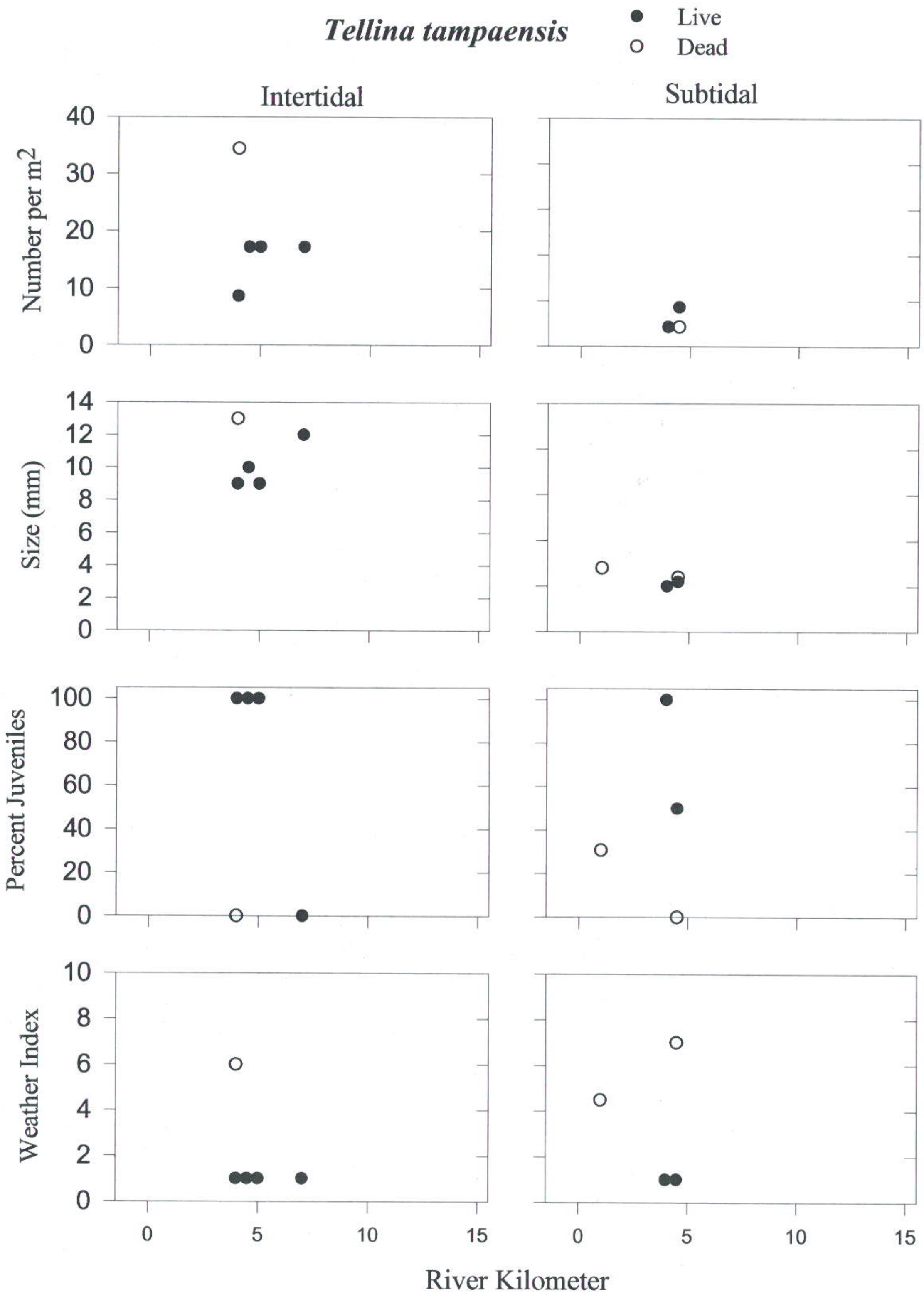


Littorina irrorata
Live
Dead
Intertidal
Subtidal
Number per m2
Size (mm)
Percent Juveniles
Weather Index
River Kilometer
0
5
10
15


Mulinia lateralis
Live
Dead
Intertidal
Subtidal
Number per m2
120
100
80
60
40
20
0
Size (mm)
20
15
10
5
0
Percent Juveniles
100
80
60
40
20
0
Weather Index
10
8
6
4
2
0
0
5
10
15
0
5
10
15
River Kilometer



Nassarius vibex
Live
Dead
Intertidal
Subtidal
Number per m2
Size (mm)
Percent Juveniles
Weather Index
River Kilometer
0
5
10
15


Tellina tampaensis
Live
Dead
Intertidal
Subtidal
Number per m2
Size (mm)
Percent Juveniles
Weather Index
River Kilometer
0
5
10
15

Part Two: Shoreline Mapping

A "windshield" survey of the Anclote River to identify changes/breaks in shoreline type was conducted during January 2006. The survey was conducted from a small boat. All shorelines associated with the main channel (Figure 1) of the river including island and bayou shorelines were included in the survey. Changes/breaks in shoreline type were spatially registered using a WAAS-enabled GPS and photographed digitally. Logistic constraints (e.g. sawyers and logjams) associated with the river's narrow physiognomy upstream of RK18 restricted the survey to areas below RK20.

Field data were used to create a GIS shapefile depicting the river's shoreline with segments defined by type (e.g. mangrove) using the appropriate FLUCCS code (Tables 1 – 4). Segment definitions were developed to represent a minimum of 90% of the visible shoreline as seen from the survey boat – for example, medium density residential areas with single story units (1211) with a narrow fringe of mangrove trees are defined as 1211 not as mangrove swamp (612).

Each shoreline segment was classified at FLUCCS Levels 1 through 4 as depicted in Figures 2 through 5 with classifications based on a compilation of the survey data and data (e.g. shoreline position) extracted from the District's 2004 (1:24000) natural color aerial photographs. After completing this exercise, the river was split into additional segments defined by river kilometer and shoreline position (North or South) (Figure 6) using data provided by the District (Figure 7). This shapefile was used to categorize each shoreline segment by river kilometer and shoreline position (Figure 8). Note that river kilometer polygons are not of equal size because of the sinuosity of the river. This caveat is also true for the amount of shoreline contained in the smaller shoreline position polygons created (Figure 9). Differences in the proportion of shoreline by river kilometer and shoreline position are illustrated in Figure 10.

FLUCCS Level 1 (Wetlands) is the dominant shoreline classification category with the Urban and Built-Up (FLUCCS 1; Table 1) being secondary. A comparison of these categories across river kilometers is illustrated in Figure 11. More specific wetland categories (FLUCCS Level 2; Table 2) show large-scale breaks in shoreline by category (Figure 12). This pattern does not change when examining the shoreline segments at the more specific FLUCCS Level 3 or 4 classifications (e.g. Figure 13). Less generalized Urban and Built-Up categories (FLUCCS Level 2) shows that the largest concentration of high density urbanization can be found at RK5 and 6 (Figure 14), indicative of Tarpon Springs and its wharves with high-density housing extending from RK1 to RK15 (Figure 14).

The most specific category used to classify the river's shoreline segments was FLUCCS Level 4 (Table 4). From a remote sensing perspective this is considered a fairly high level of resolution (1:6000); however, mapping at this level of resolution resulted in some areas of interest not being identified in the shoreline shapefile because of their small size. For example, just above RK16 is a freshwater marsh fringe (Figure 15) that is < 1 m wide and no more than 15 m in length. Although this is identifiable from a boat, it does meet the criteria of representing a minimum of 90% of the visible shoreline as seen from the survey boat thus it is not represented in the shoreline shapefile. Other freshwater wetlands are illustrated in Figures 16 through 18. Saltwater wetlands including both forested and non-forested are illustrated in Figures 19 through 23. Examples of armored shores at varying urban classifications are illustrated in Figures 24 through 28. Finally, Figure 29 is an example of FLUCCS code 8147 defined by this study as a bridge.

In addition to this letter report, the project's deliverables include 1) an Excel file containing shoreline segment length, segment endpoint coordinates, FLUCCS code, river kilometer, and other ancillary information; 2) an Arc shapefile depicting shoreline classifications at each FLUCCS level; 3) the 1999 FLUCCS classification shapefile; 4) the 2004 (1:24000) natural color aerial photographs; and 5) digital images of shoreline designations.

Table 1: Level 1 FLUCCS descriptions.

Level 1	Attribute
1	Urban and Built-Up
2	Agriculture
3	Rangeland
6	Wetlands
7	Barren Land
8	Transportation, Communications and Utilities

Table 2: Level 2 FLUCCS descriptions.

Level 2	Attribute
11	Residential, Low Density
12	Residential, Medium Density
13	Residential, High Density
14	Commercial and Services
15	Industrial
18	Recreational
19	Open Land
21	Cropland and Pastureland
32	Shrub and Brushland
61	Wetland Hardwood Forests
63	Wetland Forested Mixed
64	Vegetated Non-Forested Wetlands
71	Beaches Other Than Swimming
74	Disturbed Land
81	Transportation
83	Utilities

Table 3: Level 3 FLUCCS descriptions.

Level 3	Attribute
111	Fixed Single Family Units
113	Mixed Units
121	Fixed Single Family Units
131	Fixed Single Family Units
133	Multiple Dwelling Units
145	Tourist Services
150	Industrial
155	Other Light Industrial
159	Industrial Under Construction
181	Swimming Beach
182	Golf Course
186	Community Recreational Facilities
191	Undeveloped Land within Urban Areas
193	Urban Land in transition without positive indicators of intended activity
194	Other Open Land
211	Improved Pasture
322	Coastal Scrub
612	Mangrove Swamps
630	Wetland Forested Mixed
642	Saltwater Marshes
710	Beaches Other Than Swimming Beaches
743	Spoil Areas
744	Fill Areas
814	Roads and Highways
815	Port Facilities
831	Electric Power Facilities

Table 4: Level 4 FLUCCS descriptions.

Level 3	Attribute
1111	Single Story Units
1112	Two of More Story Units
1130	Mixed Units
1211	Single Story Units
1311	Single Story Units
1330	Multiple Dwelling Units
1335	Townhouse Units
1450	Tourist Services
1500	Industrial
1550	Other Light Industrial
1590	Industrial Under Construction
1810	Swimming Beach
1820	Golf Course
1860	Community Recreational Facilities
1910	Undeveloped Land within Urban Areas
1930	Urban Land in transition without positive indicators of intended activity
1940	Other Open Land
2110	Improved Pasture
3220	Coastal Scrub
6120	Mangrove Swamps
6300	Wetland Forested Mixed
6422	Needlerush
7100	Beaches Other Than Swimming Beaches
7430	Spoil Areas
7440	Fill Areas
8147	Bridges
8150	Port Facilities
8152	Piers
8310	Electric Power Facilities

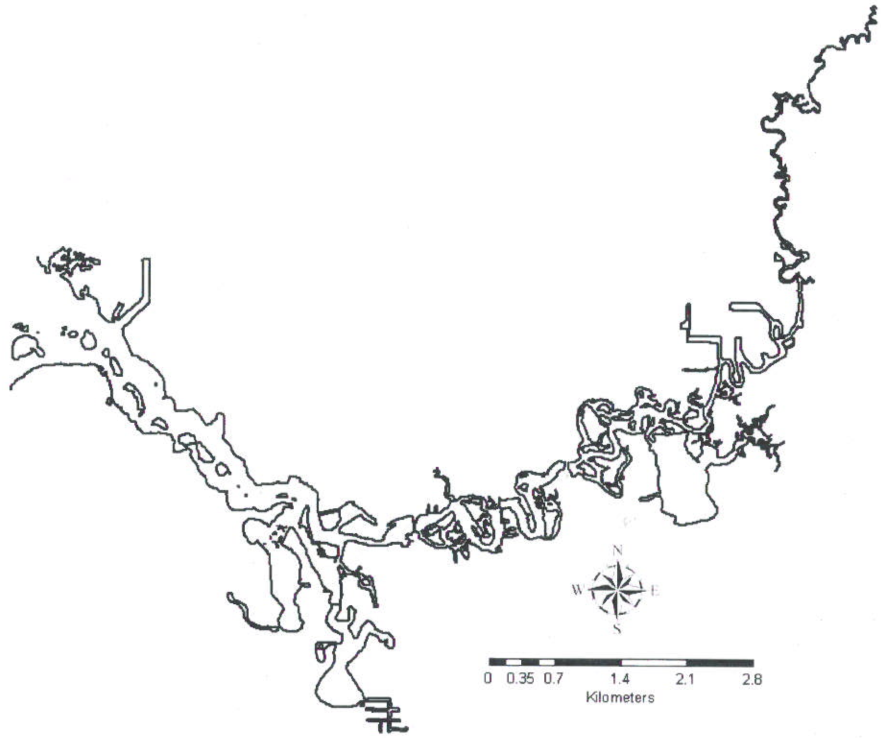


Figure 1: Shoreline depiction delineated from the District's 2004 natural color aerial photographs (1:24000).

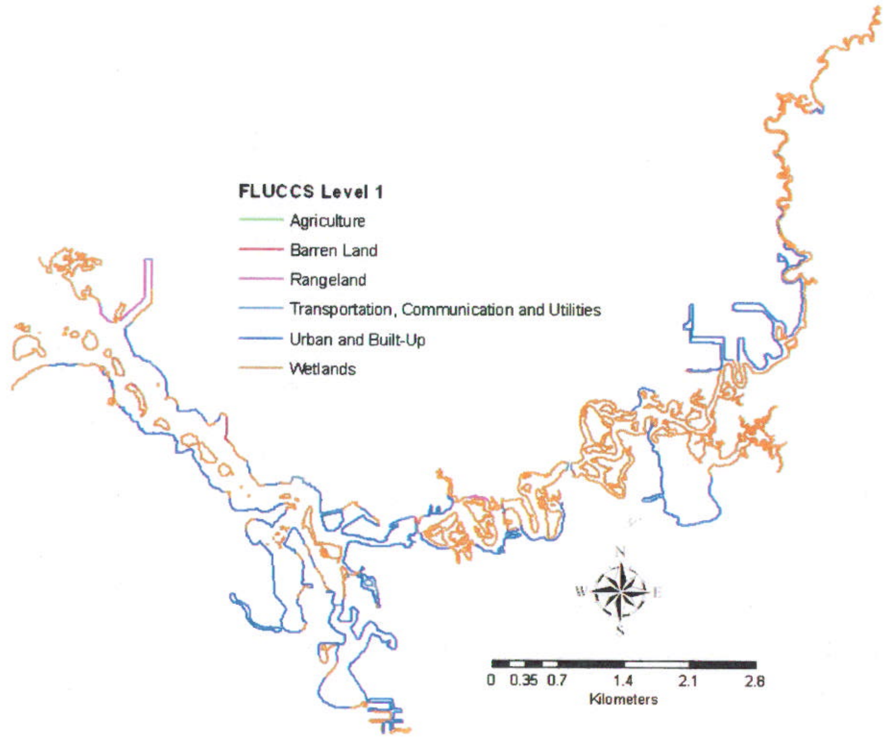


Figure 2: A depiction of the Anclote River's shoreline with shoreline segments defined at FLUCCS Level 1.

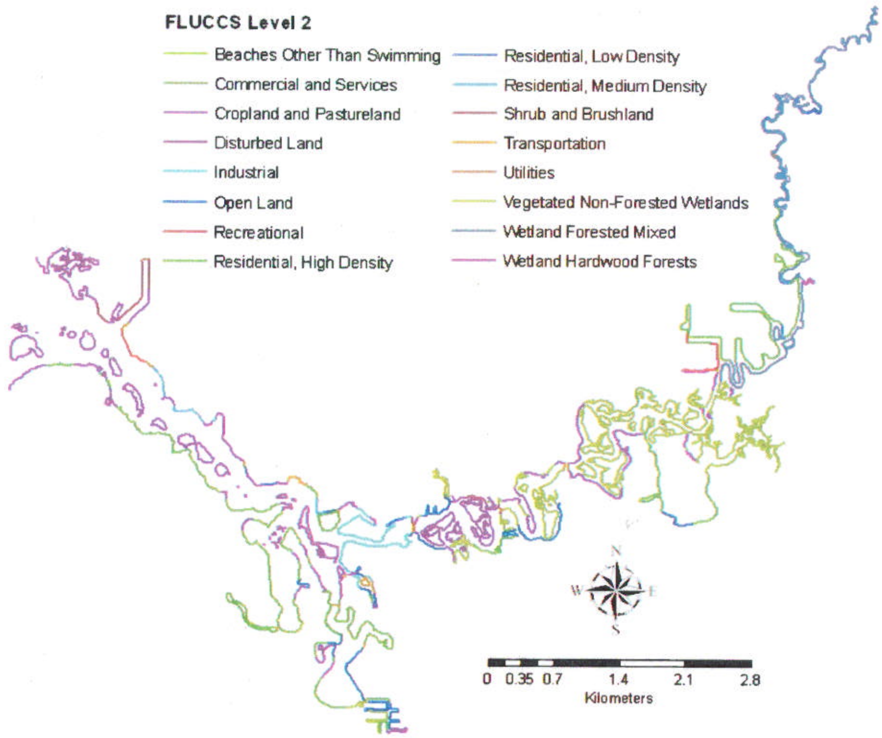


Figure 3: A depiction of the Anclote River's shoreline with shoreline segments defined at FLUCCS Level 2.

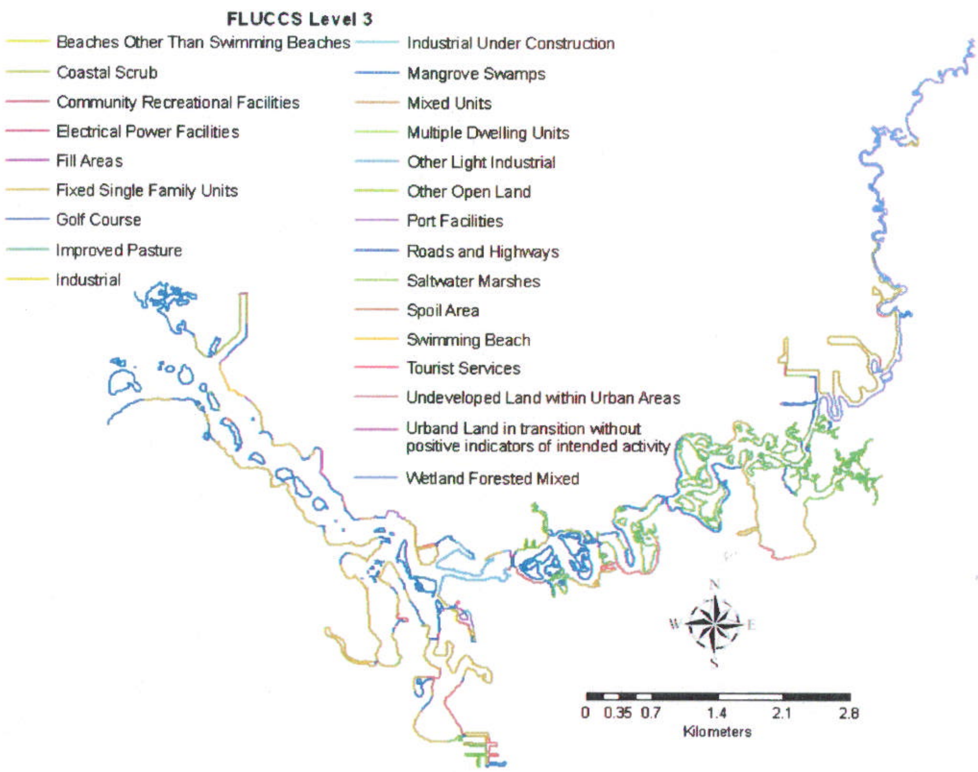


Figure 4: A depiction of the Anclote River's shoreline with shoreline segments defined at FLUCCS Level 3.

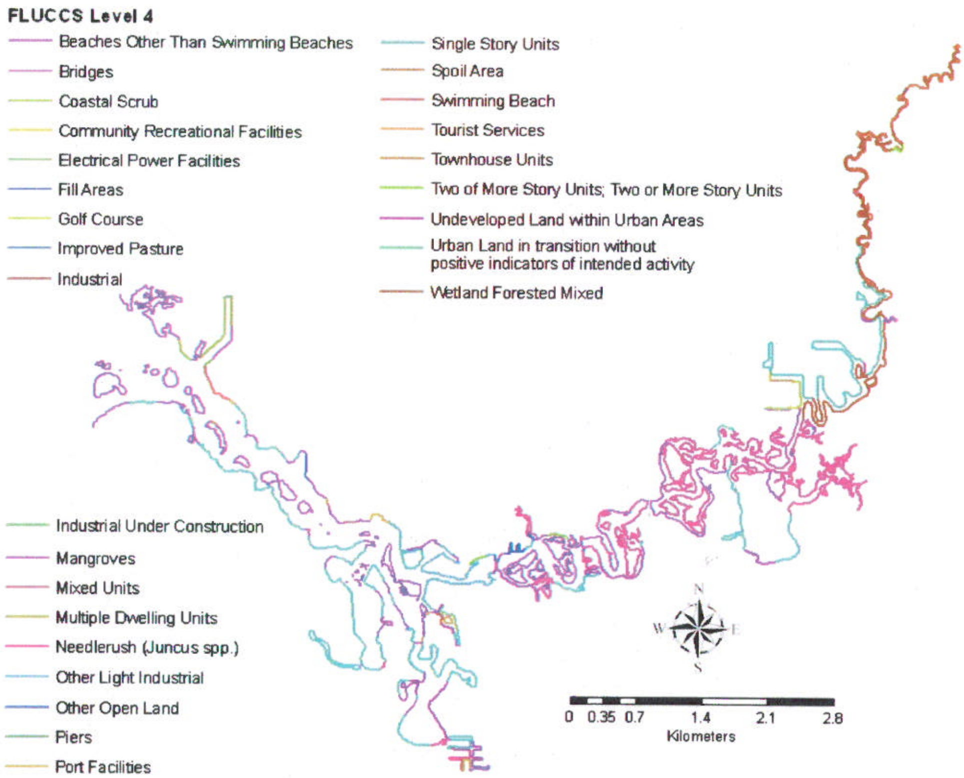


Figure 5: A depiction of the Anclote River's shoreline with shoreline segments defined at FLUCCS Level 4.

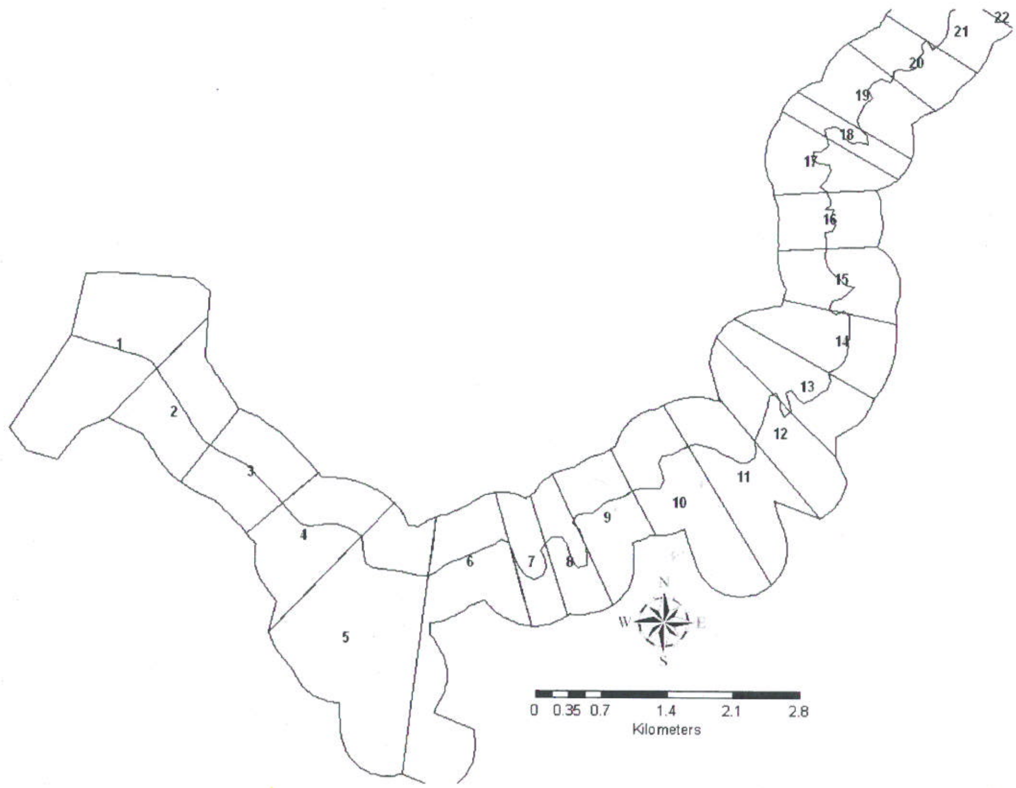


Figure 6: Anclote River divisions based on river kilometer and shoreline.

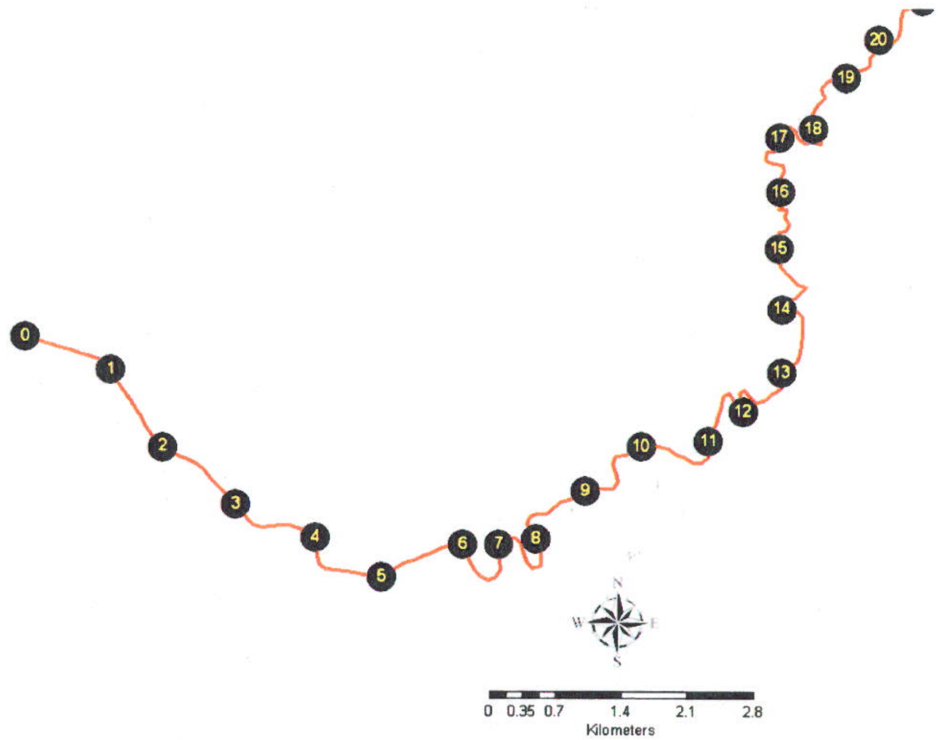


Figure 7: A representation of two shapefiles (centerline and river km) and their associated data provided by the District.

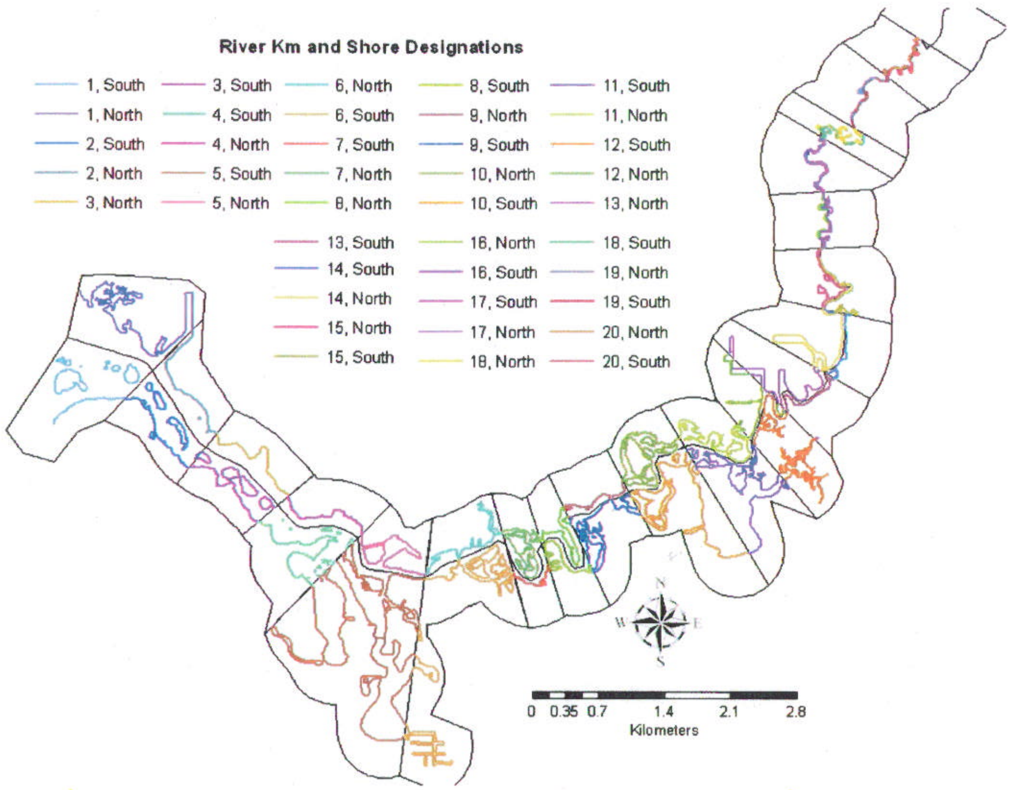


Figure 8: Anclote River shoreline segments clipped with the shapefile depicted in Figure 6.

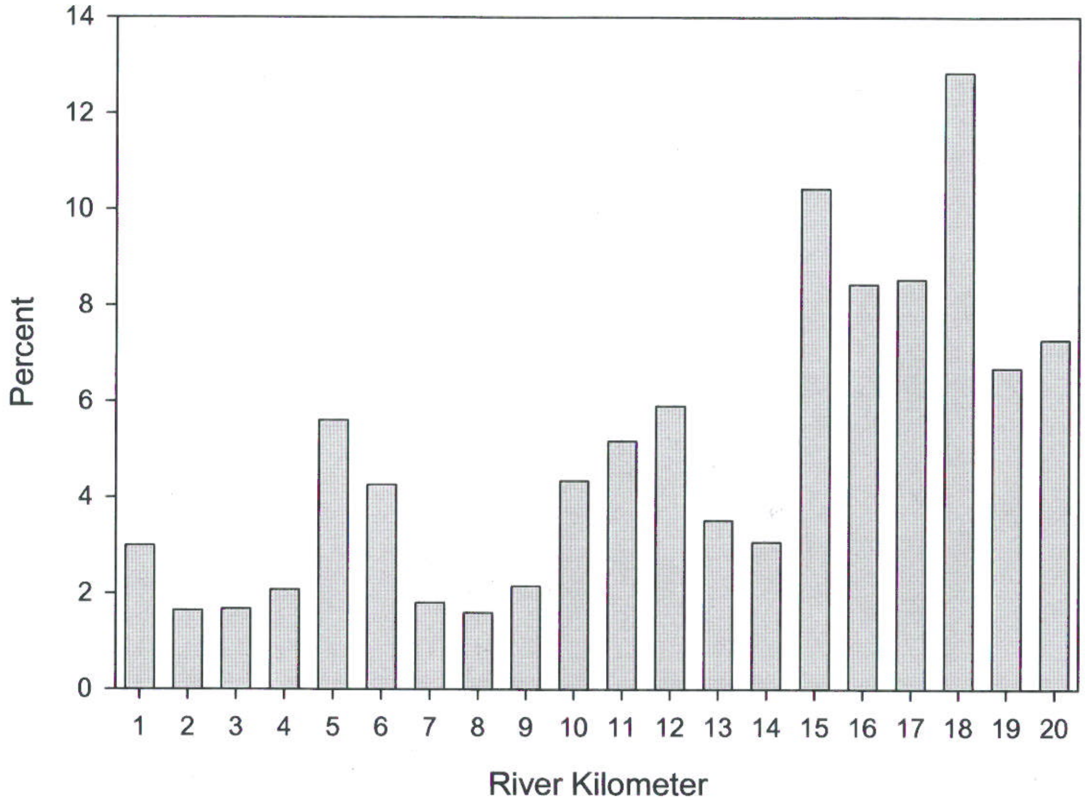


Figure 9: Distribution of shoreline length by river kilometer.

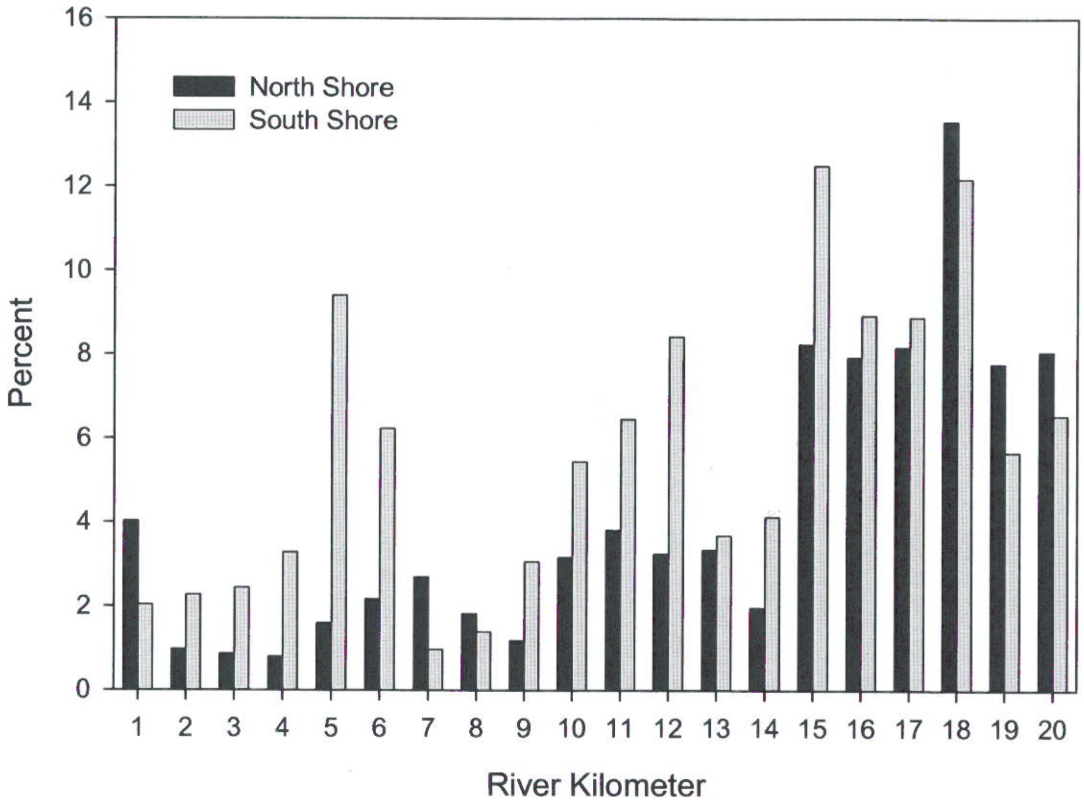


Figure 10: Distribution of shoreline length by river kilometer and shore designation.

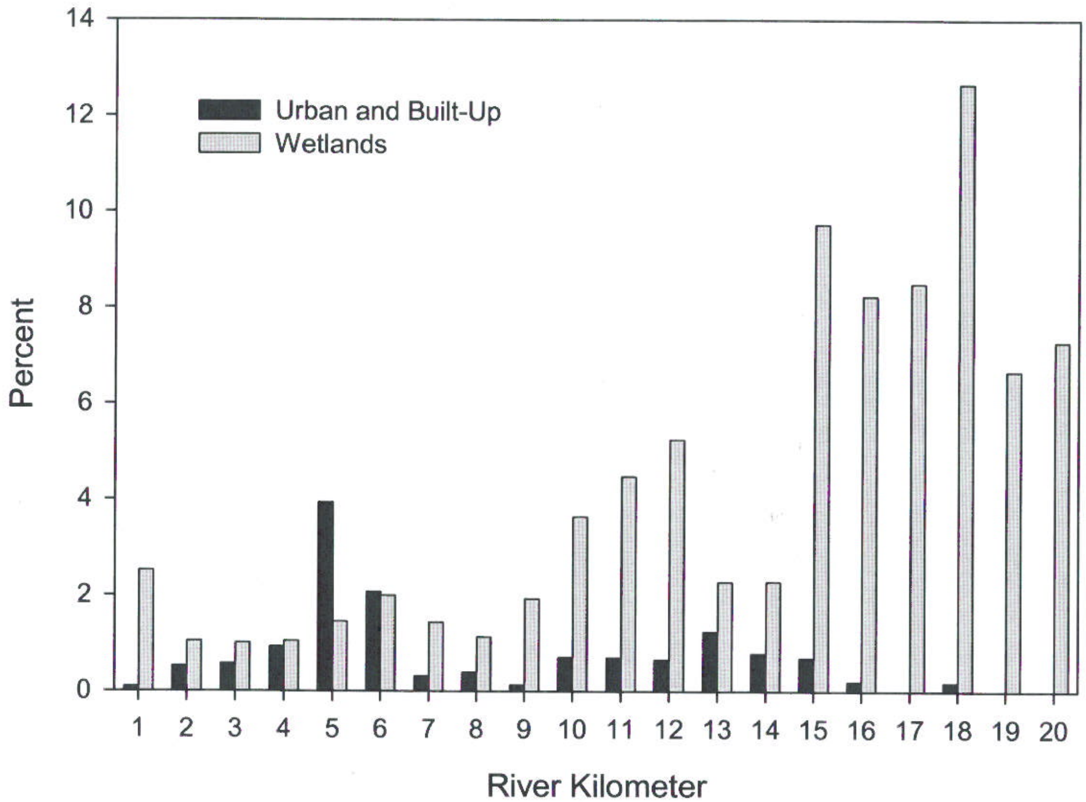


Figure 11: Distribution of major shoreline types (FLUCCS Level 1).

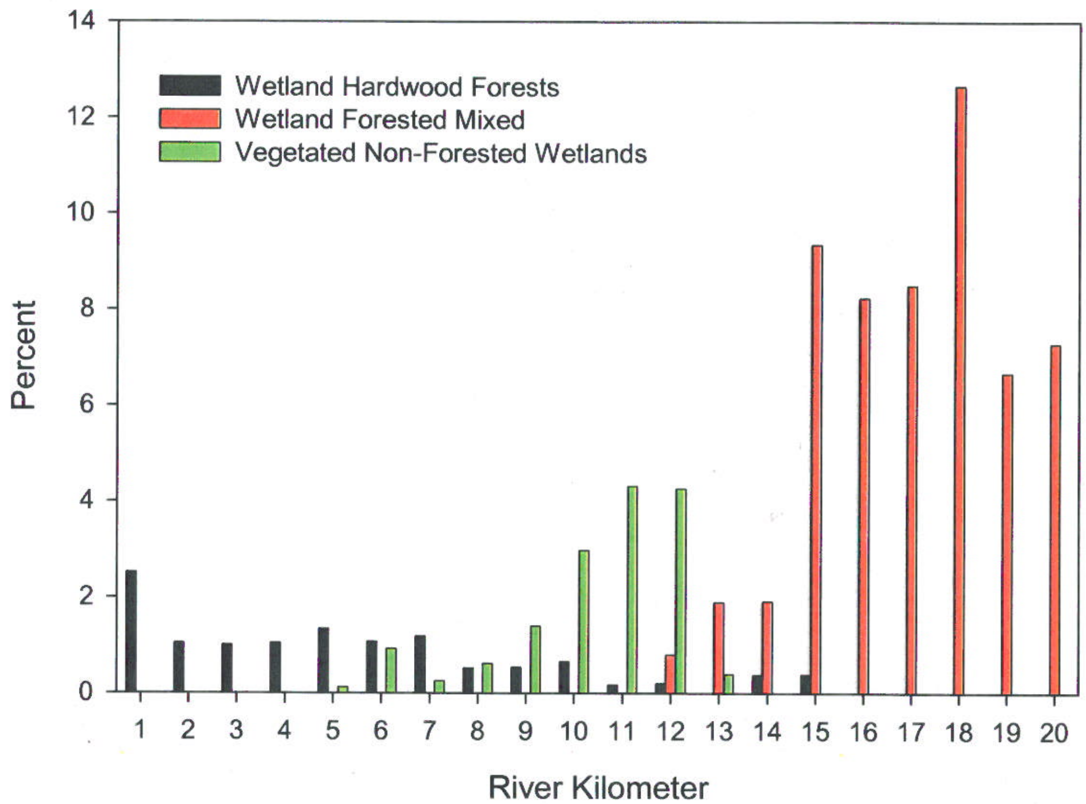


Figure 12: Distribution of wetlands by type (FLUCCS Level 2).

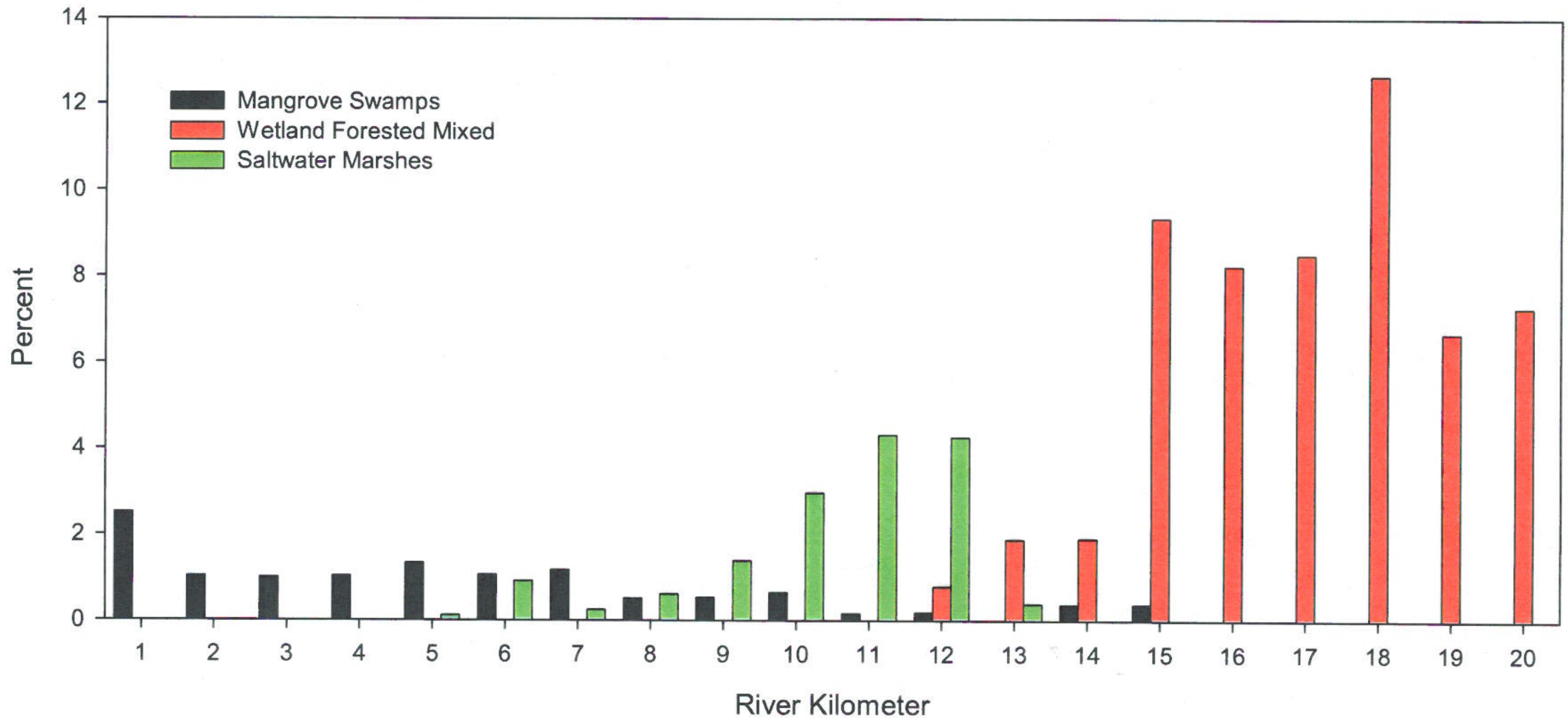


Figure 13: Distribution of wetlands (FLUCCS Level 3) by river kilometer.

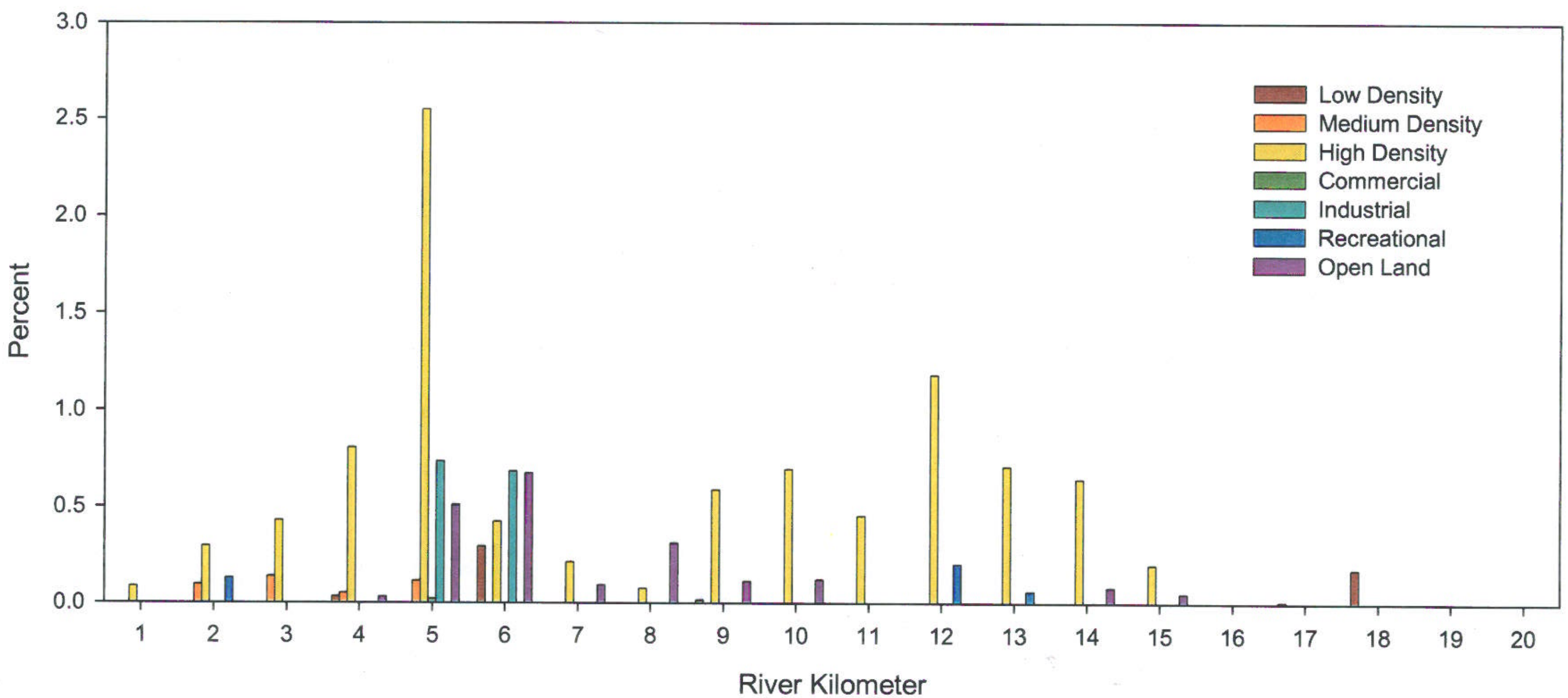


Figure 14: Distribution of urban areas (FLUCCS Level 2) by river kilometer.

Figure 15: An example of a small freshwater marsh fringe fronting a stand of mixed hardwoods and palms at RK16.

Figure 16: An example of the natural shorelines and narrow waterway with its inherent sawyers and logjams above river km 18.

Figure 17: An example of giant leather ferns growing along a natural shoreline. This freshwater wetland, located between RK17 and RK18, is too small to be delineated in Level 4 shapefile.

Figure 18: A typical unarmored shoreline classified as FLUCCS Level 4, Wetland Forested Mixed.

Figure 19: Saltwater marsh with a single mangrove sapling at about RK12.

Figure 20: A Brazilian pepper growing along the southern bank of the river above RK13.

Figure 21: A natural shoreline bordering a single-family dwelling (FLUCCS code 1111).

Figure 22: An example of a slightly modified mangrove dominated shoreline. Note the debris or rubble used to armor the shoreline.

Figure 23: A saltwater marsh fringe (*Juncus* spp.) with mangrove seedlings at RK11.

Figure 24: Golf course located on the northern bank at RK12 with rubble used to armor the shoreline.

Figure 25: An example of new construction with rubble used to armor the shoreline at RK15.

Figure 26: An armored shoreline with docks and a small stand of *Typha* spp. at RK17.

Figure 27: Two examples of concrete walls used to armor the shoreline.

Figure 28: An example of an older shoreline armoring strategy.

Figure 29: An example of FLUCCS code 8147 at RK16 defined by this study (Table 4).

A MULTIVARIATE STATISTICAL ANALYSIS OF RELATIONSHIPS BETWEEN FRESHWATER INFLOWS AND MOLLUSK DISTIBUTIONS IN TIDAL RIVERS IN SOUTHWEST FLORIDA

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Final report submitted to:

Southwest Florida Water Management District
2379 Broad St.
Brooksville, Florida 34604-6899

December 2006

A MULTIVARIATE STATISTICAL ANALYSIS OF RELATIONSHIPS BETWEEN FRESHWATER INFLOWS AND MOLLUSK DISTIBUTIONS IN TIDAL RIVERS IN SOUTHWEST FLORIDA

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A MULTIVARIATE STATISTICAL ANALYSIS OF RELATIONSHIPS BETWEEN FRESHWATER INFLOWS AND MOLLUSK DISTIBUTIONS IN TIDAL RIVERS IN SOUTHWEST FLORIDA

Abstract

The estuaries and rivers of the western coast of Florida, bordering the Gulf of Mexico, has been under intense study for some time with a goal to identify relationships between inflows, salinity, and natural resources. The mollusks have been show to be especially sensitive to salinity in many past studies, in many parts of the world. Several recent studied supported by the Southwest Florida Water Management District have focused on mollusk distributions for six tidal rivers: Peace River, Alafia River, Myakka River, Weeki Wachee River, Shell Creek, and the Shakett Creek Dona/Roberts Bay system. The purpose of the current project is to perform an inter-river, multivariate analysis that examines relationships between freshwater inflows, physicochemical variables that are affected by freshwater inflows (e.g. salinity, dissolved oxygen), and the distribution of mollusk populations in tidal rivers of southwest Florida.

The design of all studies consists of mollusks being sampled along transects within each river system. The transects run lengthwise originating at the mouth of each river, heading upstream. To enable all of the rivers to be compared simultaneously, the measure of distance along each transect was standardized by grouping all stations along each transect into two-kilometer (2-km) segments. Community structure of mollusk species was analyzed using non-metric multi-dimensional scaling (MDS). Relationships between mollusk communities and environmental factors were identified by using a mulitvariate procedure that matches biotic (i.e., mollusc community structure) with environmental (i.e., sediments, temperature, dissolved oxygen, salinity and, pH) variables. Analyses were constrained to variables that were common to all data sets.

In this limited analysis of southwest Florida mollusk communities, it is concluded that mollusk species are controlled more by water quality rather than the sediment they live in or on. The most important variable correlated with mollusk communities is salinity, which is a proxy for freshwater inflow. It is almost impossible to directly link community changes in response to inflow changes, because not replicates over time were carried out in the rivers sampled. Although total mollusk abundance was not a good indicator of inflow effects, certain indicator species have been identified however, that characterize salinity ranges in southwest Florida rivers. *Corbicula fluminea*, *Rangia cuneata*, and *Neritina usnea* were the only common species that occurred at salinities below 1 psu. Although, *C. fluminea* was the best indicator of freshwater habitat, because densities were highest below 2 psu, it is an introduced bivalve species. *Rangia cuneata*, a bivalve, has been noted as an indicator of a fresh- to brackish-water with an estimated tolerance of up to 20 psu in other studies as well. *Neritina usnea* is a gastropod and is also common in fresh- to brackish-water salinities. These salinity ranges may be useful in predicting mollusk community reactions to alterations in salinity that result from actual or simulated changes in freshwater inflow.

Introduction

The Southwest Florida Water Management District (the District) has completed individual studies of mollusk distributions for six tidal rivers in southwest Florida located between the Springs Coast, and Charlotte Harbor, and includes Tampa Bay (Figure 1). A consistent methodology was used in these studies and the District has the complete data files for these projects: Peace River, Alafia River, Myakka River, Weeki Wachee River, Shell Creek, and the Shakett Creek Dona/Roberts Bay system (Table 1). The District also has extensive data for freshwater inflows and physicochemical variables (e.g. salinity, dissolved oxygen, pH) in these systems that cover the period of mollusk data collection. As yet, however, there has not been an effort that combines data from these tidal rivers to describe and quantify factors that affect mollusk distributions in tidal rivers in the region.

The purpose of the current project is to perform an inter-river, multivariate analysis that examines relationships between freshwater inflows and the distribution of mollusk populations in tidal rivers of southwest Florida. Relationships between mollusk distributions and physicochemical variables that are affected by freshwater inflows (e.g. salinity, dissolved oxygen) will also be evaluated. The overall purpose of the project will be to better define the physical and chemical requirements of mollusk species that inhabit tidal river systems in southwest Florida.

Understanding the relationship between salinity and other environmental parameters that relate to mollusk distributions is important to evaluate the freshwater flow requirements needed to protect the natural resources in these tidal river systems. The approach used in this project was to collect the data from the six tidal river systems in one place, organize the data into compatible file formats, and analyze the combined data sets.

Table 1. Reports on the mollusks of tidal rivers of southwest Florida.

River System	Report
Peace River	Mote Marine Laboratory. 2002. Benthic Macroinvertebrate and Mollusk indicators. Mote Marine Laboratory Technical Report 744, Sarasota, Fl.
Alafia River	Mote Marine Laboratory. 2003. An Investigation of Relationships between Freshwater Inflows and Benthic Macroinvertebrates in the Alafia River Estuary. Mote Marine Laboratory Technical Report 912, Sarasota, Fl.
Shell Creek	Estevez, E.D. 2004. Molluscan Bio-indicators of the Tidal Shell Creek, Florida. Mote Marine Laboratory Technical Report 971, Sarasota, Fl.
Myakka River Dona/Roberts Bay	Estevez, E.D. 2004. Molluscan Bio-indicators of the Tidal Myakka River and Inshore Waters of Venice, Florida. Mote Marine Laboratory Technical Report 990, Sarasota, Fl.
Weeki Wachee River	Estevez, E.D. 2005. Letter Report for mollusk surveys of the Weeki Wachee and Mud River. Letter Report submitted by Mote Marine Laboratory to the Southwest Florida Water Management District. Brooksville, Fl.

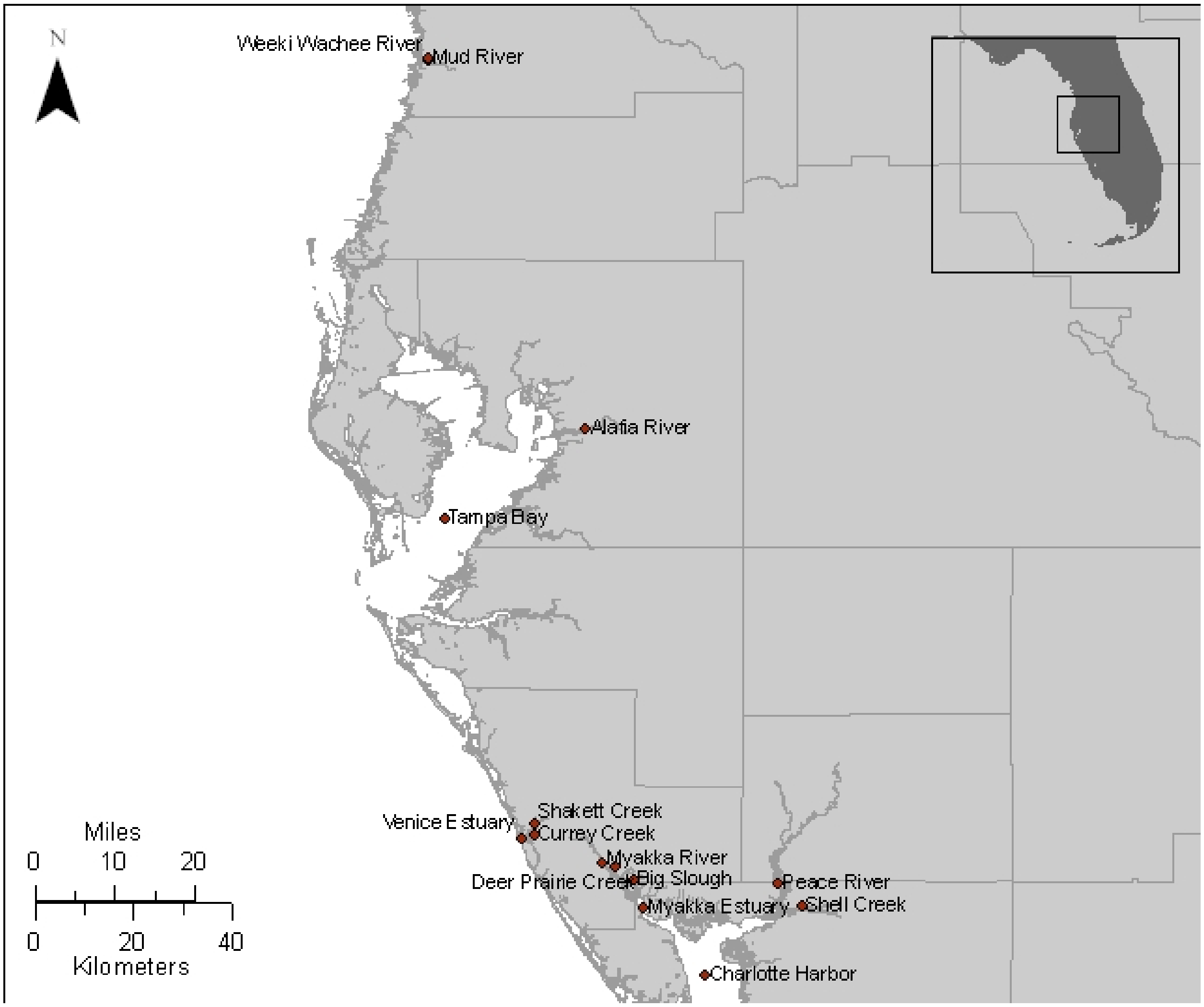

Figure 1. Map of the west coast of Florida showing the study sites.

Methods

Study Area

Data on mollusks that were extracted from the reports listed in Table 1, which were provided by the Mote Marine Laboratory (MML) (MML 2002, 2003, 2004; Estevez 2004a, 2004b). The data set was quite complex, and had to be concatenated, merged, and formatted prior to multivariate analysis.

The first step in data base creation was to determine the relationship between site designations in the data set and if there were any differences in the actual sampling designs in the different rivers and if there were aggregation relationships among the rivers (Table 2).

Table 2. Location of site names in the mollusk data set within river systems, and sampling year.

Estuary	River System	Site (or creek)	Year	Photo Map Figure
Tampa Bay	Alafia	Alafia	2001	3
Charlotte Harbor	Myakka	Big Slough	2004	
Charlotte Harbor	Myakka	Blackburn	2004	4
Charlotte Harbor	Myakka	Deer Prairie	2004	4
Charlotte Harbor	Myakka	Myakka	2004	4
Charlotte Harbor	Peace	Peace	1999	5
Charlotte Harbor	Peace	Peace	2000	5
Charlotte Harbor	Peace	Shell	2004	6
Venice	Dona/Roberts Bay	Currey	2004	7
Venice	Dona/Roberts Bay	Shakett	2004	7
Weeki Wachee	Weeki Wachee	Mud River	2005	8
Weeki Wachee	Weeki Wachee	Weeki Wachee	2005	8

The study sites are all located on the west coast of Florida (Figure 1). They group into four areas: Weeki Wachee River estuary, Alafia River in Tampa Bay, Curry River and Shakett River located in the Dona/Roberts Bay estuary, and Charlotte Harbor estuary. Most of the sites were in the Charlotte Harbor estuary (Figure 2).

The Alafia River is about 80 km long, and the watershed area is about 1062 km^2. All mollusk samples were collected from the main channel of the river (Figure 3).

The Myakka River (Figure 4) has three areas where mollusks have been sampled. Big Slough is near the 14 km marker, Deer Prairie Creek is near the 19 km marker, and Blackburn Canal is near the 32 km marker.

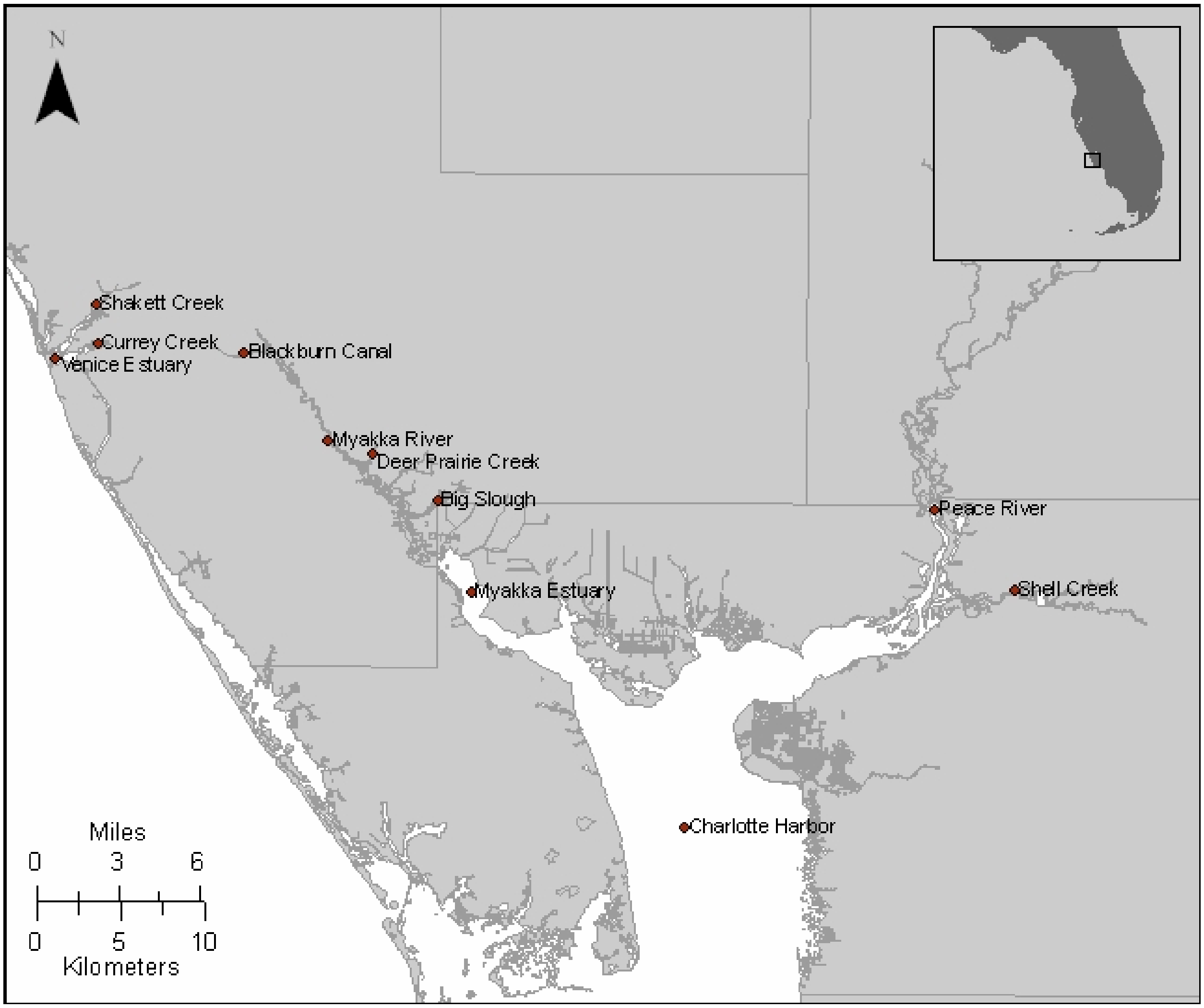

Figure 2. Map of Charlotte Harbor estuary showing locations of rivers and creeks connected to it.

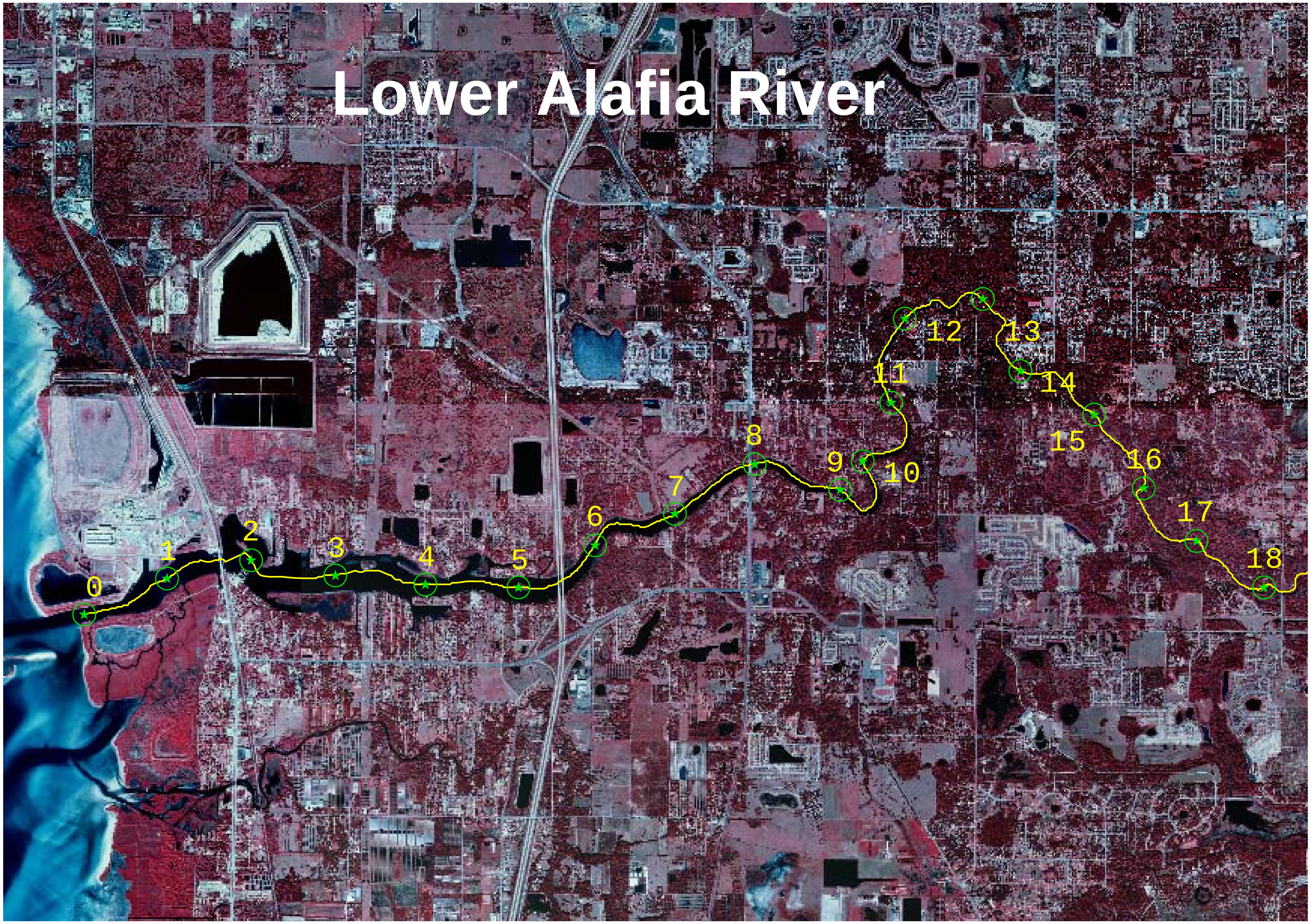

Figure 3. Alafia River photomap with centerline and distances.

Figure 4. Myakka River photomap with centerline and distance markers in kilometers.

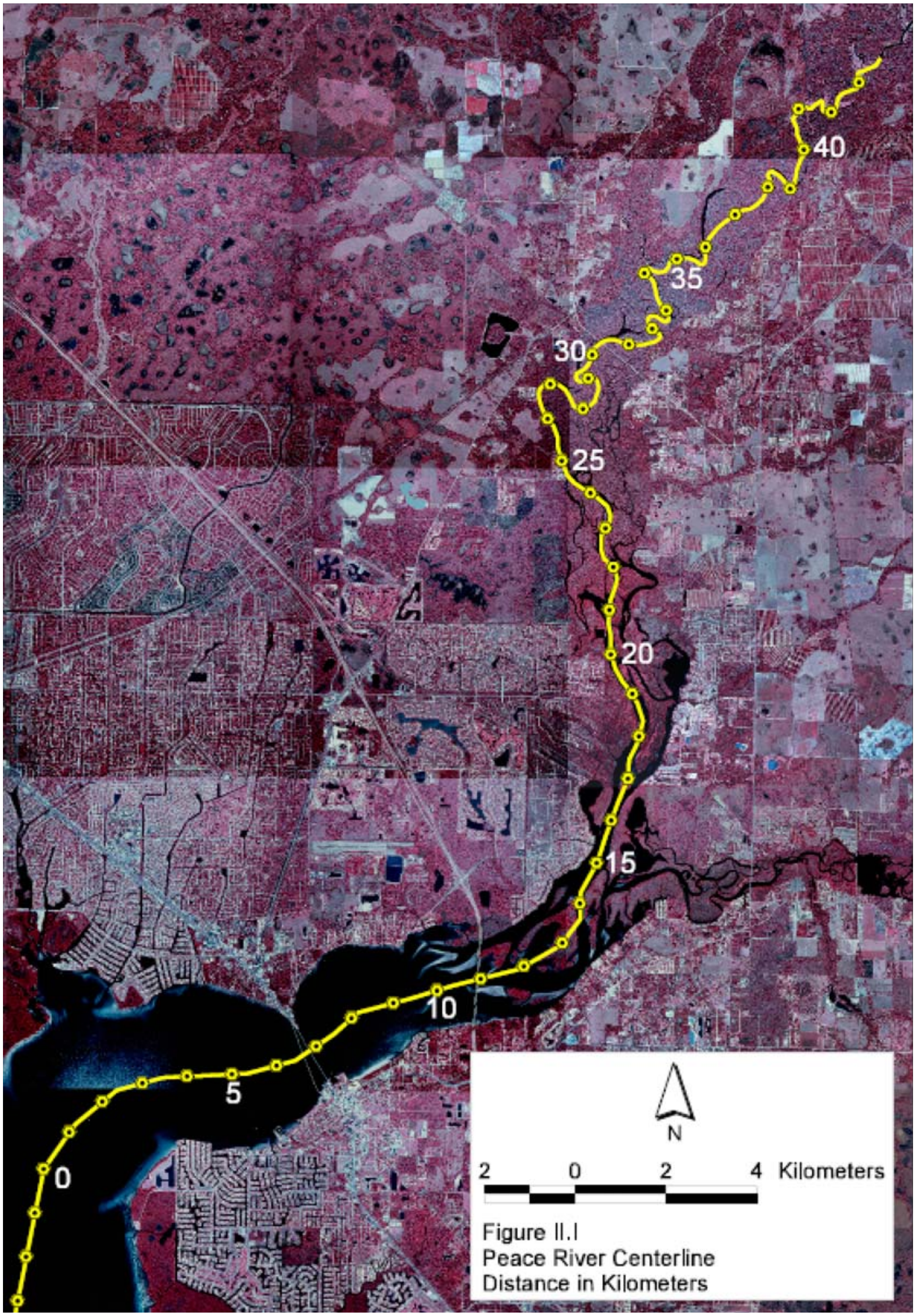

Figure 5. Peace River photomap with centerline distances in kilometers.

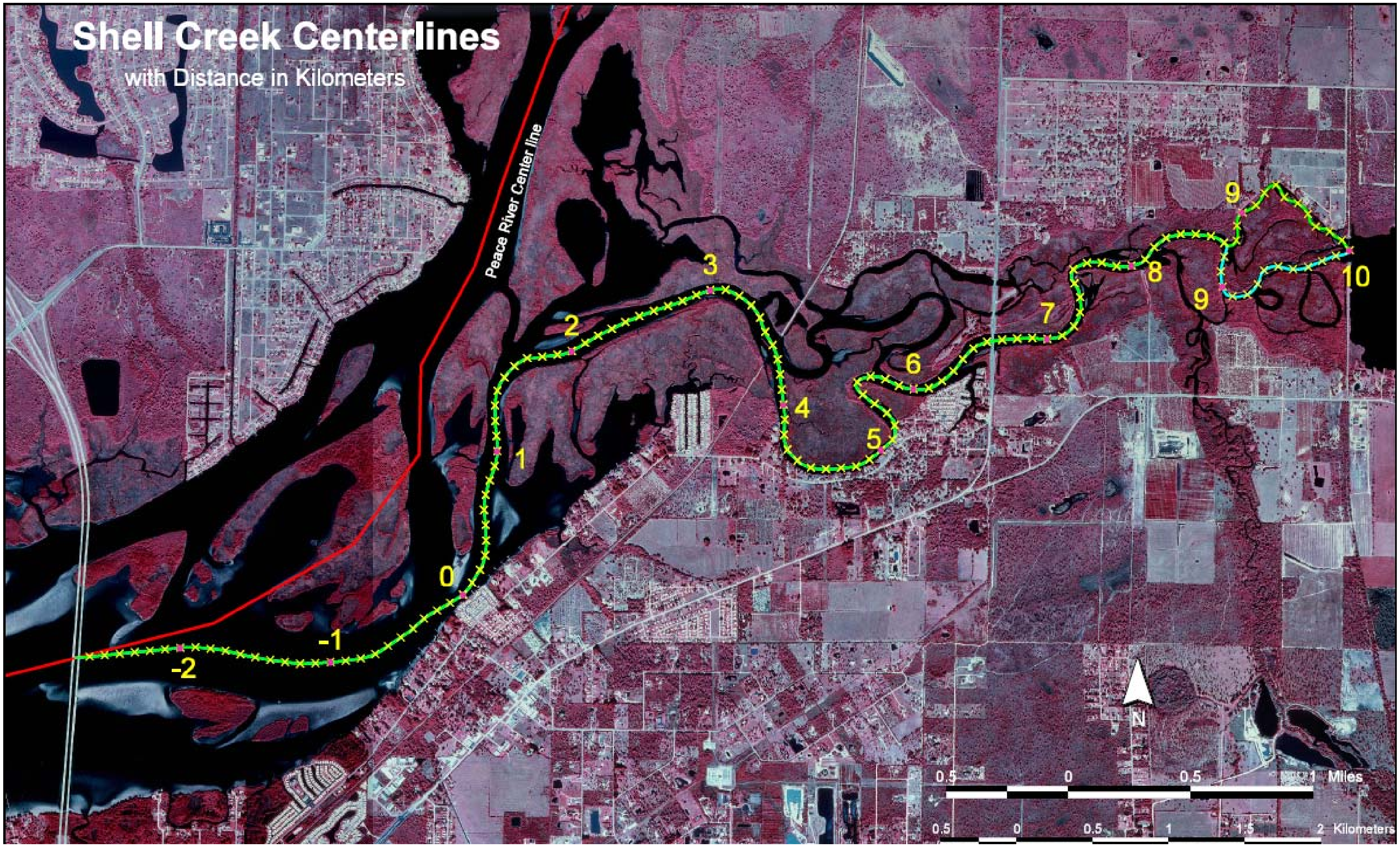

Figure 6. Shell Creek photomap showing centerline km markers.

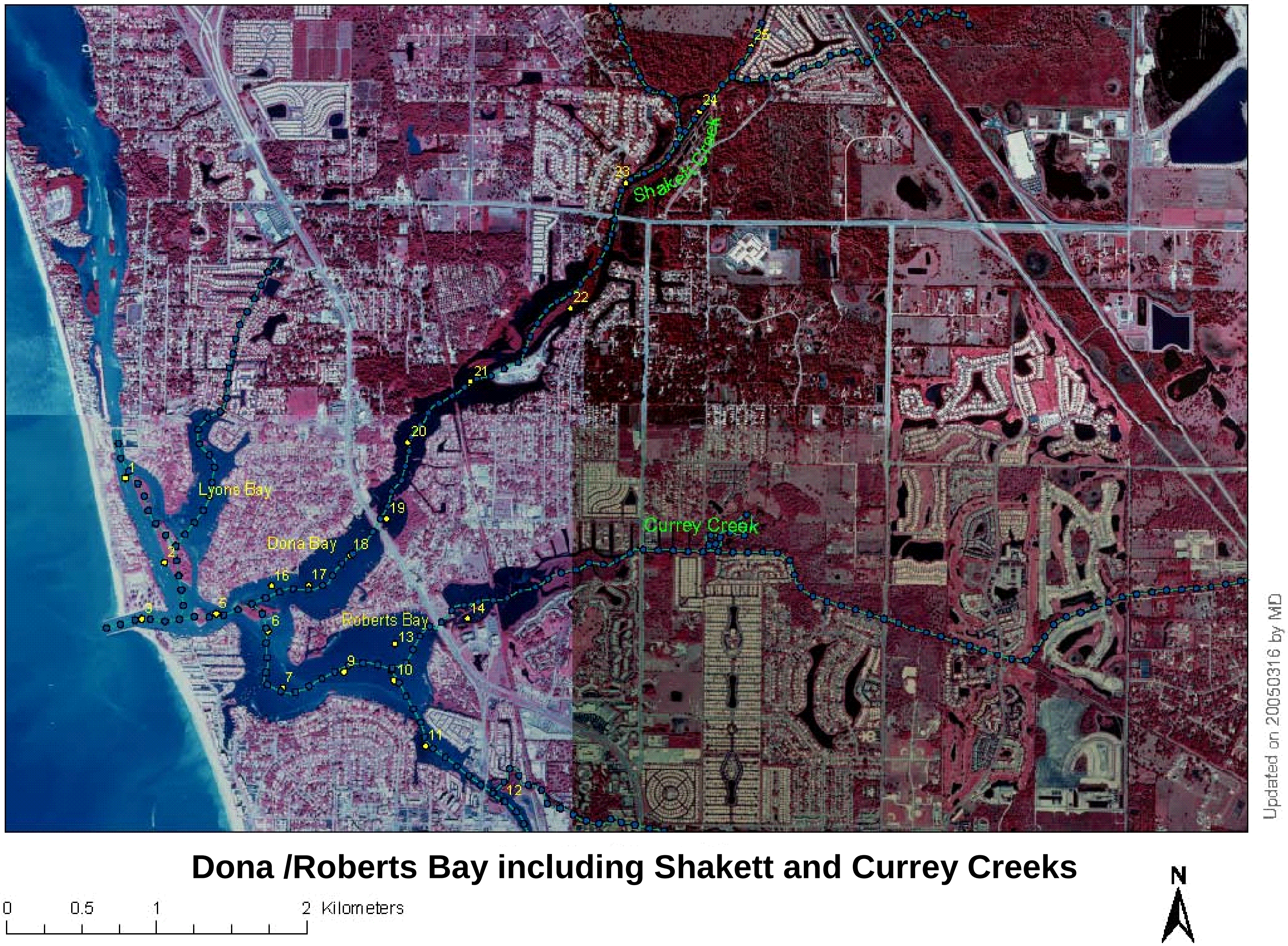

Figure 7. Dona/Roberts Bay photomap showing centerline km markers in Shakett and Currey Creeks .

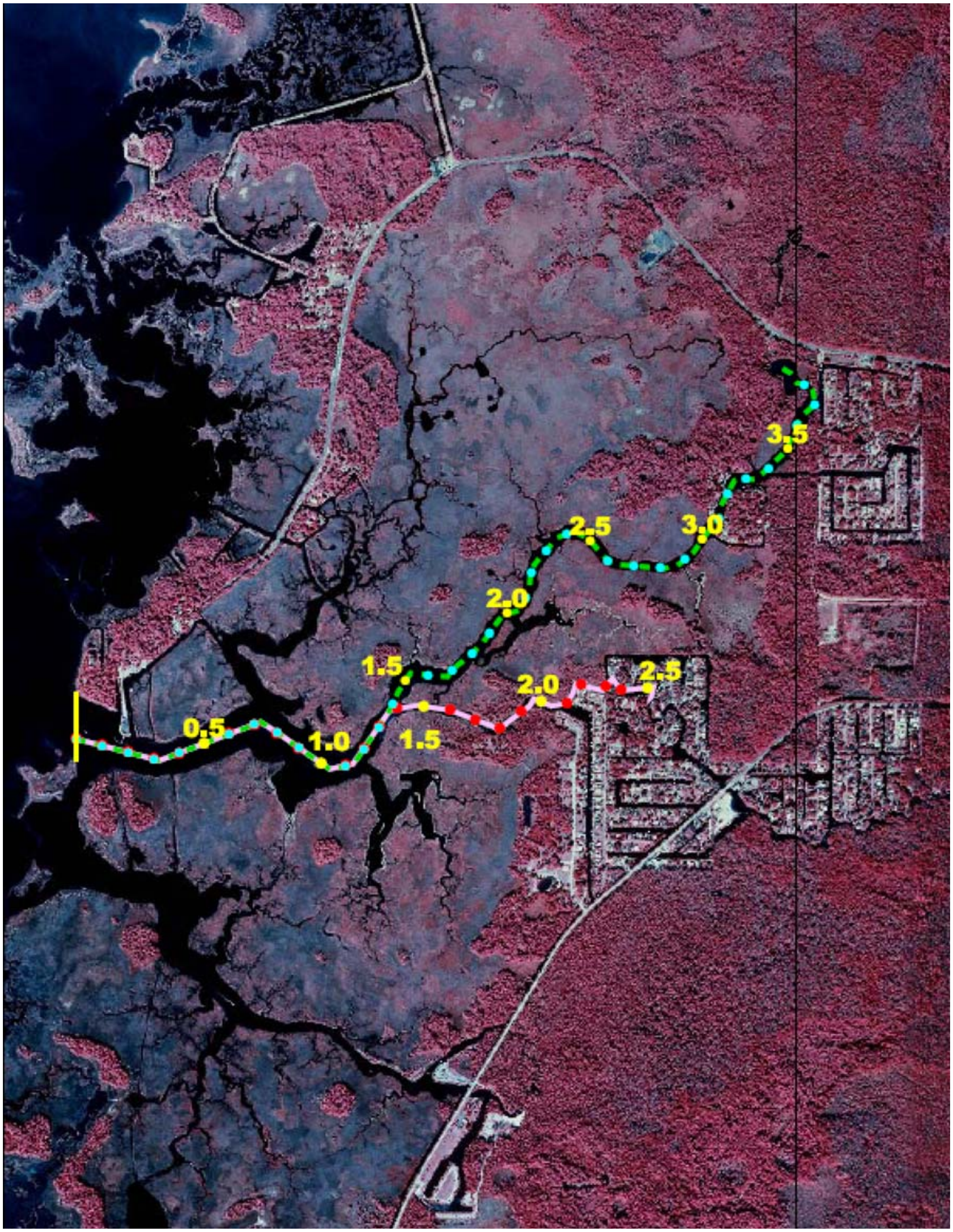

Figure 8. The Weeki Wachee River system showing centerline km markers, and the center line for the Mud River Tributary to the north.

The Peace River (Figure 5) includes Shell Creek near the 15 km marker. The Peace River ecosystem has been sampled three times. Twice in the Peace River itself, and once just in Shell Creek (Figure 6).

Shakett and Currey Creeks are located in the Dona/Roberts Bay complex in the region designated as the Venice Estuary (Figure 7). Shakett Creek ends in Dona Bay and Currey Creek ends in Roberts Bay.

The Weeki Wachee River is a small, spring-fed system in which the penetration of brackish water is generally less than 2.5 km upstream from the river mouth (Figure 8). Mud river, which is also spring-fed, joins the Weeki Wachee about 1.4 km upstream of the river mouth. While the upsream reaches of the Weeki Wachee are fresh, the Mud River receives flow from brackish springs and salinity in the Mud River increases upstream toward the river head.

Mollusca Data

The sampling design employed by Mote Marine Laboratory (MML) consists of mollusks being sampled along transects within each river system (MML 2002, 2003, 2004; Estevez 2004a, 2004b). The transects run lengthwise originating at the mouth of each river, heading upstream, hence distance and station names increase with marine influence having the lowest numbers and freshwater influence having the highest numbers (Figures 3 - 8). The content of the original data sets varied with each river system, however they all contained the distance along the river transect where samples were taken and the mollusc species found. These distances represented the stations within the river site, and a total of 180 such stations were sampled across all sites. At each sampling location, mollusks were sampled systematically across the river channel perpendicular to the river centerline so that samples were collected from mid-channel, shallow subtidal, and intertidal areas.

For each sampling event, the variables reported included the size of the sampling device, the number of juvenile mollusks, the number of live mollusks, the number of dead mollusks, size of shells and whether the samples were taken from the subtidal or intertidal area of the river system. For all statistical analyses in the current study, mollusk counts from the subtidal and intertidal zones of each station were combined. Several sampling devices were used, but all the data reported on here is from one sized 0.464 m^2. The raw counts were converted to abundance of individuals per square meter (i.e., n/m^2) for all analyses, e.g., species richness, frequency or occurrence, and multivariate analyses.

For the current study, analysis was focused on the data relating to live mollusks. Without shell dating and knowledge of shell transport information after death, it is very difficult to correlate the presence of empty shells of dead mollusks with freshwater inflow and other physiographic information. However, the dead shells do provide information on historical communities, so are listed in this report.

Samples from multiple years of sampling were found only from the Peace River (Table 2). For the purpose of the current study, the sampling stations at Peace River were averaged over the two years they were sampled (1999 and 2000).

To enable all of the rivers to be compared simultaneously, the measure of distance along each transect (Figs. 3 - 8) had to be reduced and standardized. To do this, the distance of each sampling station from each transect was aggregated into two-kilometer (2-km) segment bins. This was performed by rounding the actual distance from the mouth of the river (in kilometers) to increments of two. Each segment was numbered as the midpoint of the actual distance, thus a segment labeled 2 km would encompass stations found at 1.0 km to 2.9 km of a transect. Overall, 67 new stations, or 2-km segments, were created for analysis (Table 3). While this approach was necessary to ensure comparability over the spatial extent of river systems, it created an unbalanced sampling design, because more than one sampling station occurred within many new 2-km segments. Thus, species abundance were averaged for each new 2-km segment prior to analysis to ensure a balanced sampling design.

The scientific names of all the species were verified and made to be consistent across all data sets. In addition, the full taxonomic description was verified. The convention for species names and taxonomy used in the current study is based on the Species 2000 website, http://www.sp2000.org/. The Species 2000 lists are prepared with cooperation with the Integrated Taxonomic Information System (ITIS). The specific source was the Annual Check List 2006.

Hill's number one (N1) diversity index was used to report species diversity (Hill, 1973). Hill's N1 is the exponential form ($e^{H'}$) of the Shannon-Weaver diversity index H'. N1 was used because it has units of numbers of species, and is easier to interpret than most other diversity indices (Ludwig and Reynolds, 1988).

A second measure of diversity, taxonomic distinctness (Δ^*) was calculated. Taxonomic distinctness addresses the problems associated with measures of species richness and other diversity indices because it is based not just on species abundances, but also the taxonomic distance through classification of every pair of individuals (Warwick and Clark 1995). For example, a sample with two clams is very different from a sample with one clam and one snail, even though both have a richness measure of 2. The Δ^* statistic was calcuated using Primer software (Clarke and Warwick, 2001).

Table 3. Aggregation of Mote Marine Laboratory (MML) sampling data for the current analyses. For each river-site, the MML stations were placed in 2-km bins where all stations within the 2-km bin were treated as replicates and averaged.

River	Site	2-km Bin Name	Number of MML Stations
Alafia	Alafia	0	2
Alafia	Alafia	2	3
Alafia	Alafia	4	4
Alafia	Alafia	6	4
Alafia	Alafia	8	4
Alafia	Alafia	10	4
Alafia	Alafia	12	3
Alafia	Alafia	16	1
Alafia	Alafia	18	1
Dona/Roberts	Currey	2	3
Dona/Roberts	Currey	4	2
Dona/Roberts	Shakett	0	1
Dona/Roberts	Shakett	2	4
Dona/Roberts	Shakett	4	4
Dona/Roberts	Shakett	6	3
Myakka	BigSlough	2	2
Myakka	Blackburn	0	1
Myakka	DeerPrairie	2	2
Myakka	DeerPrairie	4	1
Myakka	Myakka	-0	2
Myakka	Myakka	2	2
Myakka	Myakka	4	2
Myakka	Myakka	6	2
Myakka	Myakka	8	2
Myakka	Myakka	10	2
Myakka	Myakka	12	2
Myakka	Myakka	14	3
Myakka	Myakka	16	1
Myakka	Myakka	18	2
Myakka	Myakka	20	3
Myakka	Myakka	22	2
Myakka	Myakka	24	1
Myakka	Myakka	26	3
Myakka	Myakka	28	2
Myakka	Myakka	30	2
Myakka	Myakka	32	2
Myakka	Myakka	36	2
Myakka	Myakka	38	3
Myakka	Myakka	40	1
Peace	Peace	0	1
Peace	Peace	2	1

River	Site	2-km Bin Name	Number of MML Stations
Peace	Peace	4	1
Peace	Peace	6	1
Peace	Peace	8	4
Peace	Peace	10	4
Peace	Peace	12	4
Peace	Peace	14	4
Peace	Peace	16	5
Peace	Peace	18	5
Peace	Peace	20	4
Peace	Peace	22	5
Peace	Peace	24	4
Peace	Peace	26	5
Peace	Peace	28	4
Peace	Peace	30	4
Peace	Peace	32	4
Peace	Peace	34	3
Peace	Peace	36	1
Shell	Shell	0	2
Shell	Shell	2	4
Shell	Shell	4	4
Shell	Shell	6	3
Shell	Shell	8	4
WeekiWachee	MudRiver	2	2
WeekiWachee	MudRiver	4	1
WeekiWachee	WeekiWachee	0	2
WeekiWachee	WeekiWachee	2	4
Total Number of segment bins and stations		67	180

Multivariate Analyses

Community structure of mollusk species was analyzed by non-metric multi-dimensional scaling (MDS). MDS is a statistical tool that can be used to compare many variables (multivariate data) from different stations at once rather than a single variable (univariate data). In the current study, MDS was used to compare abundances of individuals of each species for each river-site-segment combination. Thus, the data was organized into a matrix where each row was a station, i.e., a river-site-segment combination (Table 3) and each column was a species abundance variable. The distance between river-site-segment combinations in the MDS plot can be related to community similarities or differences between rivers, sites, and segments. All multivariate statistical analysis was performed using Primer software (Clarke and Warwick, 2001).

Analysis is a multi-step procedure. First, data is transformed using the natural logarithm plus 1 (i.e., ln+1). Then, the data matrix of species and river-site-segment combinations, is converted to a Bray-Curtis similarity matrix for each station. Differences and similarities among communities were highlighted based on cluster analysis calculated from the similarity matrix. The MDS scores for each river-segment combination is calculated from the similarity matrix, and then plotted in 2-dimensional space. Overlying the MDS plot with a cluster of samples with the same similarity score allows visualization of station similarities. Often a subset of variables, i.e., a subset of species in the present case, can explain much of the spatial pattern in an MDS plot. The BVSTEP procedure in the Primer software package finds the smallest subset of species that explains the same overall pattern as the whole data set.

Physicochemical Variables

Physicochemical data for each tidal river system were provided by the Southwest Florida Water Management District. Profiles of temperature, dissolved oxygen, salinity and pH were taken along all transects. Profiles were measured at different dates at various distances along the transects of each river. Multiple samples were taken along the transects within a 2 - 13 year period. The length of period and actual years sampled varied with each river (Table 4). As with the mollusc data, the distance along each transect was converted into two kilometer segments. The four water quality parameters measured (temperature, dissolved oxygen, salinity and pH) were all averaged by transect segment and river. Water chemistry samples were taken in all of the rivers, however parameters measured in the rivers were inconsistent between rivers. This inconsistency meant that no single variable was measured in all of the rivers. For this reason, use of the water chemistry data in this current study was limited.

Principle Components Analysis (PCA), a parametric multivariate method, was used to determine differences between river-segment combinations. As with MDS, the distance between river-segment combinations in the PCA plot can be related to actual similarities or differences in water quality between river-segment combinations.

Table 4. Period when water quality profiles were taken in each river system.

River System	Site (or creek)	Start of Period	End of Period
Alafia	Alafia	Jan 1999	Dec 2003
Myakka	Myakka	Feb 1998	Mar 2005
Peace	Peace	Aug 1996	Dec 2004
Shell	Shell	Feb 1991	Dec 2004
Venice	Curry	Aug 2003	May 2005
Venice	Shakett	Aug 2003	May 2005
Weeki Wachee	Mud River	July 2003	May 2005
Weeki Wachee	Weeki Wachee	July 2003	May 2005

Sediment

Samples along each transect were also analyzed by MML for sediment characteristics. The parameters available were sediment grain size distributions (median, mean, % sand, %silt, % clay, skewness, kurtosis), sediment moisture, and the proportion of organic material present in the sediment.

Relating Mollusks and Environmental Factors

Relationships between mollusk communities and environmental factors were investigated using the Biota-Environment (BIO-ENV) procedure. The BIO-ENV procedure is a multivariate method that matches biotic (i.e., mollusc community structure) with environmental variables (Clarke and Warwick 2001). This is carried out by calculating weighted Spearman rank correlations (ρ_w) between sample ordinations from all of the environmental variables and an ordination of biotic variables (Clarke and Ainsworth, 1993). Correlations are then compared to determine the best match. The BIO-ENV procedure uses different numbers of abiotic sample variables in calculating correlations to investigate the different levels of environmental complexity. For this study, the mollusk species abundance MDS ordination was compared with all physicochemical and sediment variables. Any river-segment combination that did not have all sediment, physiochemical (temperature, dissolved oxygen, salinity and pH) variables as well as any mollusc data were omitted from this analysis because multivariate analysis can only be performed when all variables are present. The significance of relationships were tested using RELATE, a non-parametric form of the mantel test. The BIO-ENV and RELATE procedures were calculated with Primer software (Clarke and Warwick 2001).

Salinity was used as a proxy for distance from a freshwater source because salinity increases as distance from the freshwater source increases. Salinity was directly compared with individual species abundances, total mollusk abundances and mollusk diversity.

The relationship between macrofauna characteristics and salinity were examined with a non-linear model, which was used successfully in Texas estuaries (Montagna et al., 2002). The assumption behind the model is that there is an optimal range for salinity and values decline prior to and after meeting this maximum value. That is, the relationship resembles a bell-shaped curve. The shape of this curve can be predicted with a three-parameter, log normal model:

$$Y = a \times \exp(-0.5 \times (\ln(X / c) / b)^2)$$

The model was used to characterize the nonlinear relationship between a biological characteristic (Y) and salinity (X) and inflow (X). The three parameters characterize different attributes of the curve, where *a* is the maximum value, *b* is the skewness or rate of change of the response as a function of salinity, and *c* the location of the peak response value on the salinity axis. The model was fit to data using the Regression Wizard in SigmaPlot, which uses the Marquardt-Levenberg algorithm to find coefficients (parameters) of the independent variables that give the best fit between the equation and the data (Systat, 2006).

Results

<u>Physical Environments</u>

With the exception of Mud River, salinity decreases with distance from the river or creek mouth in all the river systems (Figure 9). The transect in each river was a different length and covered different salinity ranges, thus a km segment number in one river did not correspond to a similar salinity range in another system (Figure 10). The transects of the Alafia, Myakka and Peace Rivers were at least 20 km long and had mean salinity ranges between 20 and 25 psu. Although the Shakett and Weeki Wachee River transects covered less than 8 km, they also covered a mean salinity range of at least 15 psu. The transects in Currey and Shakett Creeks and Mud River did not extend to freshwater, as did the transects on the other river systems. A salinity barrier on Shakett Creek truncates this river and structurally isolates a freshwater zone under most flow conditions. As described earlier, the Mud River is an unusual system that is fed by brackish springs and salinity increases toward the river head. Only two transect segments were sampled in each of Currey Creek and the Mud River.

Principal Components (PC) analysis was used to compare the physical environments among the river systems. Only six of the eight river/creek systems could be analyzed because of a lack of sufficient data for two of the river systems (Mud River and Currey Creek). The PC analysis reduces the four environmental variables of salinity, temperature, pH, and dissolved oxygen (DO) to just two axes or PCs. The first (PC1) and second (PC2) principal components of the physicochemical data explain 47.9 % and 25.3 % of the variation within the data set respectively (total 73.1 %; Figure 11a). PC1 is dominated by by salinity differences and PC2 is dominated by temperature and dissolved oxygen. This means that PC1 represents changes over distance along the transects or between rivers, and PC2 represents temporal change, e.g., seasonal changes, in water properties with higher temperatures and lower DO in summer compared to winter.

The PC analysis demonstrates the differences between the different water bodies (Figure 11b). The Weeki Wachee, Shakett, Myakka are all distinct water bodies. The differences are primarily a result of separation along the PC2 axis. Whereas the Shakett and Myakka had similar temperature and DO conditions, they were distinct from the Weeki Wachee in this regard. However, separation along PC1 indicates the Shakett and Myakka had distinct salinity regimes, but different from the Weeki Wachee system. The Peace, Alfia, and Shell rivers were very similar to one another with respect to their physical characteristics.

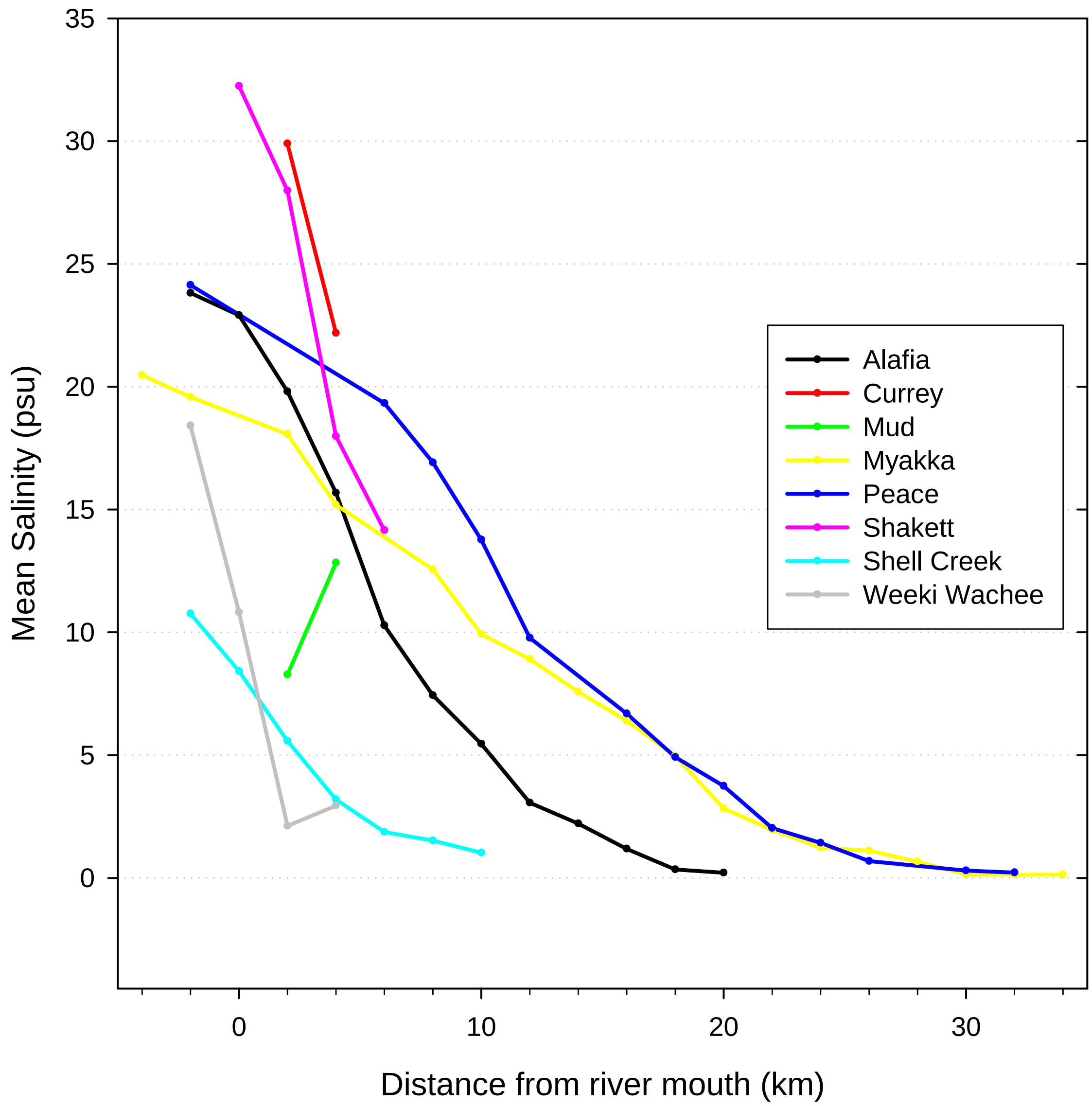

Figure 9. Mean salinity along transects at each creek /site system

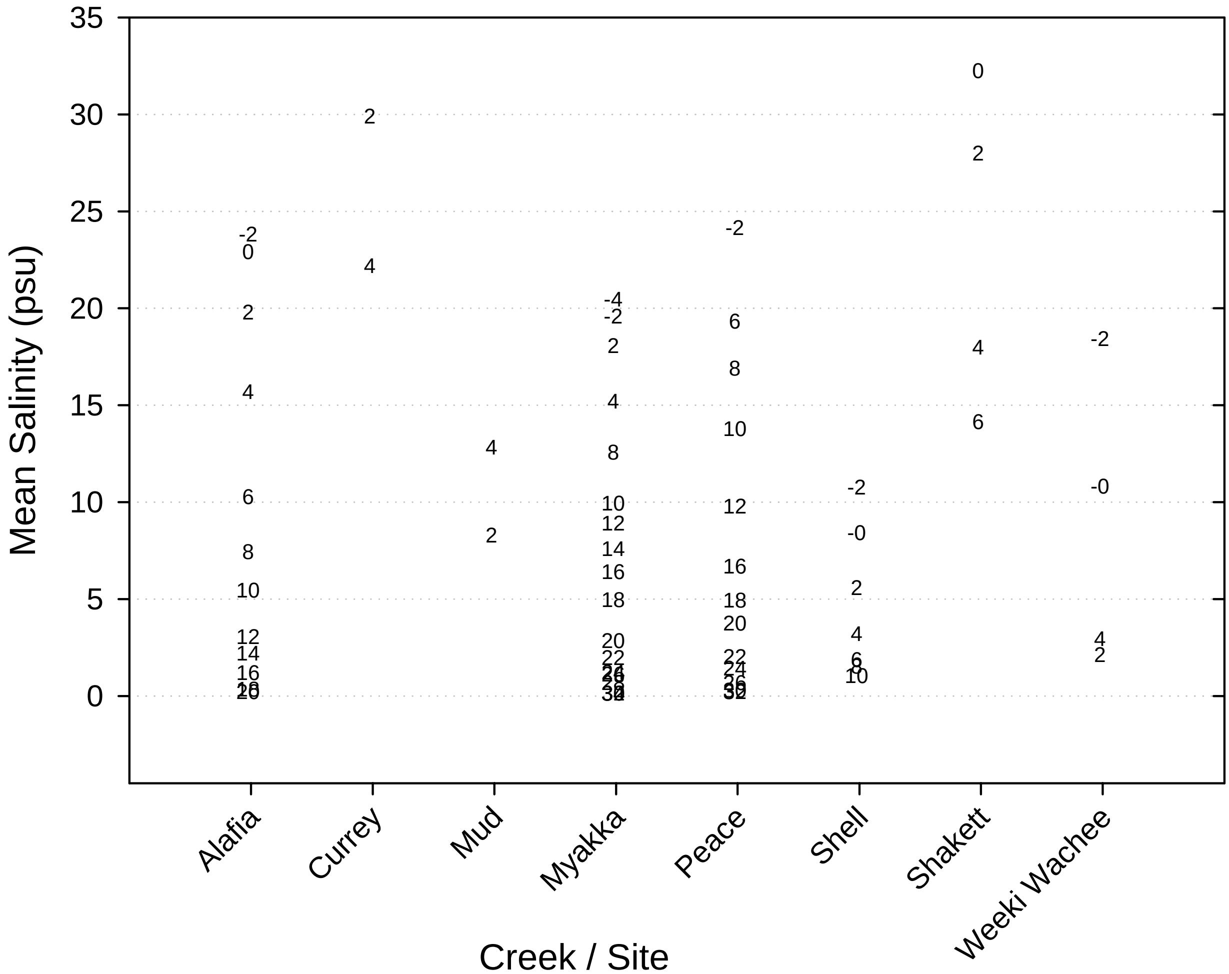

Figure 10. Salinity for each transect segment for each creek / site. The number value represents the distance in 2-km segments upstream from the mouth of the river.

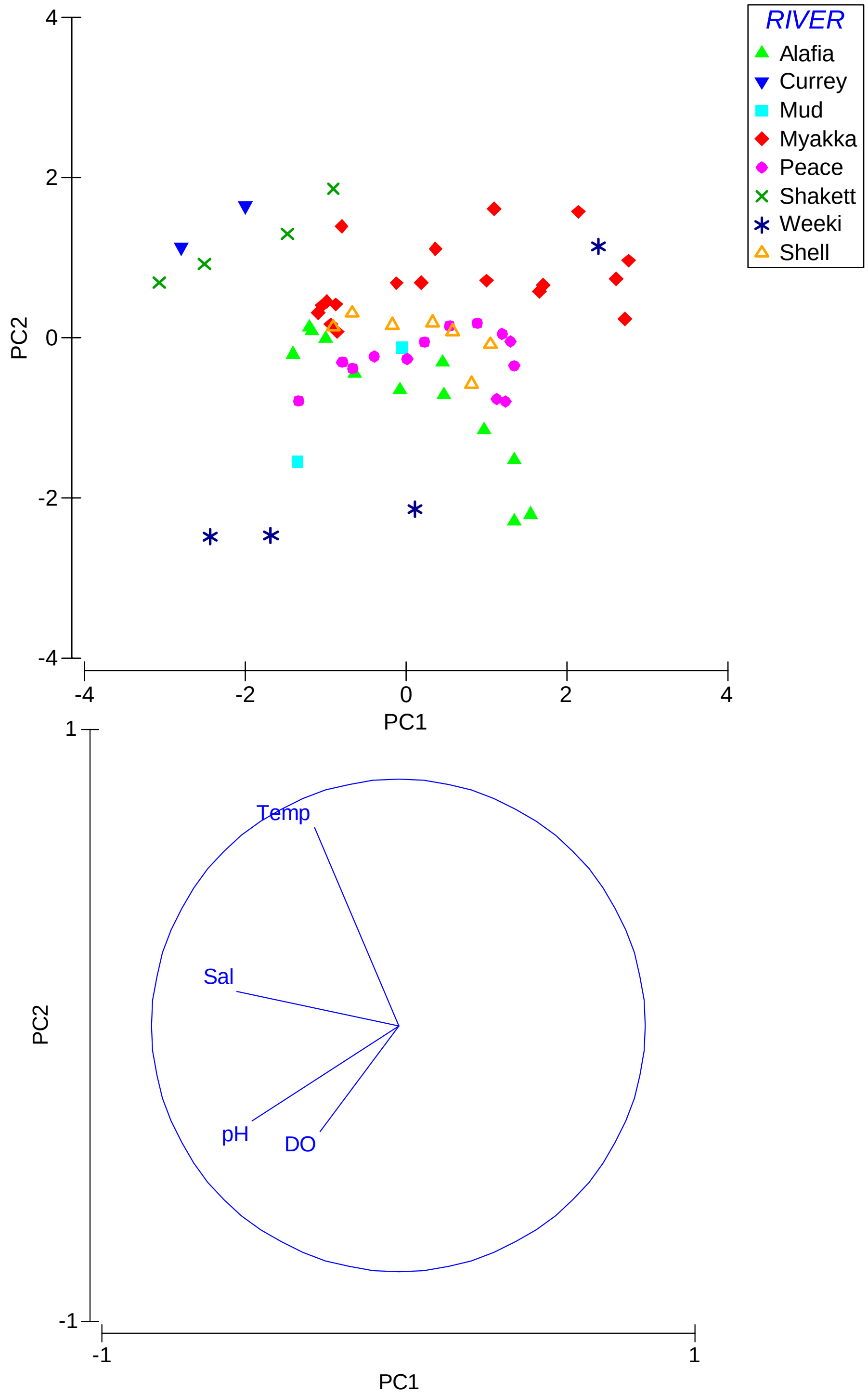

Figure 11. Principal Components Analysis of water quality in southwest Florida rivers. A. Principal Component variable loadings (bottom). B. Transect segment-river station scores (top).

Taphonomy

Examining the fossil shells or death-assemblages, i.e., taphonomy, is a good technique to understand the derivation of extant benthic communities. A total of 58 dead species were found, two of which were Brachiopoda and not Mollusca (Table 5). The total taxonomic list is presented for completeness only. However, 23 more species were found among dead shells than live shells. The total abundance was similar with an average of 95 m^{-2} dead shells compared to an average of 82 m^{-2} live shells. The proportion of dead shells to live shells was similar overall because a paired-difference test was not significantly different ($p = 0.7822$). The dead shells are interesting because more species exist in this region than were found live. This does not mean that species have gone extinct or are now longer found in the environment. Shells are transported after death, and the age of the shells are unknown, therefore the remainder of this current report focuses on the living fauna.

Mollusca Community Structure

A total of 35 species were found in all the live specimens from all of the rivers sampled (Table 5). Two species, *Glotttidia pyramidata* and an unidentified species, were actually brachipods, and not mollusks. So, there were actually only 33 species of Mollusca. Of these, 25 species were bivalves and eight species were gastropods. Two families of bivalves, Tellinidae and Mytilidae, were represented by four species each, and there were three species of Veneridae. Otherwise, all families were represented by only one or two species.

The dominant species was the Asian Clam, *Corbicula fluminea*, which is an exotic species that was introduced to Florida waters (Table 6). The large number of *Corbicula* was largely due to very high densities of this species in the tidal freshwater reaches of the Peace River. A total of 1,036 individuals were found among all samples, and the average abundance was 33 individuals m^{-2} were found among the 27 different river-segment samples. This represented 40% of total average abundance. The next four most dominant species were *Polymesoda caroliniana* (11 %), *Rangia cuneata* (8 %), *Tagelus plebius* (6 %), and *Amygdalum papyrium* (5%). These top five most abundant mollusks were bivalves and comprised 70 % of all species found. The dominant gastropod, *Neritina usnea*, was the sixth ranked species in dominance (4% of total average abundance). The second most dominant species, *P. Caroliniana*, was found most often, 35 times in the river-segment samples

Dominance patterns were different in different rivers (Table 7). For example, *C. flumninea* was dominant only in the Peace and Myakka rivers. In contrast, *P. carolinian* was dominant in Shell Creek and Big Slough, the second dominant in Deer Praire, Myakkaand Weeki Wachee. *Rangia cuneata* was dominant in Deer Praire and was the only organism found in Blackburn. *Tagelus plebeius* was co-dominant in Weeki Wachee, and dominant in Mud and Currey creeks. *Geukensia granosissima* was dominant in the Alafia River, and *Crassostrea virginica* was co-dominant in Weeki Wachee and dominant in Shakett Creek. However, the distribution of *C. virginica* in the Weeki Wachee River was largely limited to individuals located near the river mouth.

Similarity in mollusk communities among the river-segment sites was generally low (Figure 12). The Bray-Curtis similarity matrix is most easily visualized in the multidimensional scaling (MDS) plot (Figure 13). All of the river-segment combinations are found in associations of groups of no more than 15 % similarity. At the 15% similarity level there are three groups, two smaller groups with low station numbers (i.e., more mare conditions), and there is one large group. At the 25% similarity level, the large group splits into 4 smaller groups. Although the pattern of river-segment groupings is based on 35 species, it is being driven by just seven species: *Corbicula fluminea*, *Crassostrea virginica*, *Littoraria irrorata*, *Neritina usnea*, *Polymesoda caroliniana*, *Rangia cuneata*, and *Tagelus plebeius* (BVSTEP, rho > 0.95, r = 0.96). These species drive the trend that downstream segments close to marine sources (with low 2-k segment numbers) tend to group to the left and higher segment numbers groups the right.

The four groups at the 25% level within the large central group at the 15% similarity level(Figure 13), can be explained based on the distribution of three species (Figure 14). From left to right, the station groups are dominated by *Crassostrea virginica*, *Littoraria irrorata*, and *Corbicula fluminea*. The is a small cluster of seven river-segment combinations from downstream reaches of the Peace, Shakett and Weeki Wachee systems, which were dominated by high densities of *Crassostrea virginica*. The largest cluster of river-segment combinations and nearly wholly bounded by the 25 % similarity level in the center, is a group of mid to lower segments, and included segments from all rivers and this cluster is dominated by high densities of *Polymesoda caroliniana*. Other species that were common in this large group of stations were *Littoraria irrorata* and *Tagelus plebeius*. Finnally, in the right hand corner of the large center group is a cluster of freshwater stations in the Myakka and Peace rivers that all have very high densities of *Corbicula fluminea*. *Neritina usnea* and *Rangia cuneata* were alos dominant in this cluster.

Three stations were distinct from all the three clusters described above. The Blackburn-0 km station segment had only a few mollusks, the Peace-6 km station was dominated by just one specie, the clam *Macoma constricta*. The Shakett-0 km station had high densities of *Tagelus plebeius*.

The 16 km segment of the transect in the Alafia River was 100 % different from all of the other stations. This station had only one mollusk, an unidentified Planorbidae, which was not found elsewhere. The station was so different from all others, it is not included in the MDS plot in Figure 13).

Table 5. Taxonomic list of all live and dead species found. Abundance of all dead and live individuals found per m^2 averaged over all samples (i.e., river-site-segment combinations). Abbreviations: PH = Phylum, CL = Class, OR = Order, and FA = Family.

PH	**CL**	**OR**	**FA**	**Species**	**Dead**	**Live**
Brachiopoda						
				Brachiopoda (unidentified)	0	0.008
	Lingulida					
		Lingulidata				
			Lingulidae			
				Glottidia pyramidata	0.016	0.064
Mollusca						
				Mollusca (unidentified)	0.016	0.023
	Gastropoda					
		Pulmonata				
			Ellobium			
				Melampus sp.	0.055	0
		Basommatophora				
			Planorbidae			
				Planorbidae (unidentified)	0.208	0.032
		Neotaeniogloassa				
			Littorinidae			
				Littoraria irrorata	0.469	1.811
			Epitoniidae			
				Epitonium rupicola	0.031	0
			Calyptraeidae			
				Crepidula fornicata	0.318	0
			Naticidae			
				Polinices duplicatus	0.133	0.048
			Cerithiidae			
				Cerithium atratum	0.495	0
			Triphoridae			
				Triphora melanura	0.031	0
		Cephalaspidea				
			Bullidae			
				Bulla striata	0.073	0
			Haminoeidae			
				Haminoea succinea	0.851	1.062
		Neogastropoda				
			Conidae			
				Conus sp.	0.010	0
			Nassariidae			
				Nassarius vibex	2.944	1.395
			Melongenidae			
				Melongena corona	0.247	0.153

PH	CL	OR	FA	Species	Dead	Live
			Muricidae			
				Eupleura sp.	0.021	0
				Urosalpinx tampaensis	0.042	0
		Neritopsina				
			Neritidae			
				Neritina usnea	5.990	3.028
	Bivalvia					
				Bivalvia (unidentified)	0.062	0.317
		Myoida				
			Pholadidae			
				Cyrtopleura sp.	0	0.008
		Veneroida				
			Cardiidae			
				Laevicardium mortoni	0.497	0.131
			Corbiculidae			
				Corbicula fluminea	23.306	33.107
				Polymesoda caroliniana	13.281	9.052
			Dreissenidae			
				Mytilopsis leucophaeata	6.093	0.796
			Lasaeidae			
				Mysella planulata	0.492	0.137
			Lucinidae			
				Anodontia alba	0.062	0
				Lucina pectinata	0.203	0.011
			Mactridae			
				Mulinia lateralis	0.923	1.734
				Rangia cuneata	11.418	6.619
				Spisula solidissima similis	0.031	0
			Pharidae			
				Ensis minor	0.031	0
			Pisidiidae			
				Musculium partumeium	0.031	0.011
				Pisidium sp.	0.008	0
			Semelidae			
				Abra aequalis	0.008	0
			Solecurtidae			
				Tagelus plebeius	5.604	4.553
			Solenidae			
				Solen viridis	0.016	0

PH	CL	OR	FA	Species	Dead	Live
			Tellinidae			
				Macoma constricta	0.515	2.662
				Macoma tenta	0.102	0.056
				Tellina versicolor	0.325	2.741
				Tellina sp.	1.265	0.139
			Veneridae			
				Anomalocardia auberiana	1.369	0.075
				Chione cancellata	2.051	0.348
				Cyclinella tenuis	0.161	0.059
				Macrocallista nimbosa	0.016	0
				Mercenaria campechiensis	0.130	0
				Veneridae (unidentified)	0.016	0
		Arcoida				
			Arcidae			
				Anadara transversa	0.122	0.064
			Noetiidae			
				Noetia ponderosa	0.016	0
		Mytiloida				
			Mytilidae			
				Amygdalum papyrium	0.261	4.268
				Brachidontes modiolus	0	0.127
				Geukensia granosissima	1.201	2.793
				Ischadium recurvum	1.861	1.780
		Ostreoida				
			Ostreidae			
				Crassostrea virginica	9.923	2.626
				Ostrea frons	0.445	0
			Pectinidae			
				Argopecten irradians	0.224	0
			Anomiidae			
				Anomia simplex	0.916	0
		Pterioida				
			Pinnidae			
				Atrina serrata	0.010	0
Total					**94.945**	**81.837**

Table 6. Species dominance based on average abundance. Total number of live individuals found and the frequency of number of times found among all unaggregated samples, average abundance among the 67 samples (i.e., river, site, 2-km segment combinations), and percent composition of the total community abundance.

Species	**Total**	**Frequency**	**Abundance ($n\ m^{-2}$)**	**Percent (%)**
Corbicula fluminea	1,036	27	33.107	40.454
Polymesoda caroliniana	344	35	9.052	11.061
Rangia cuneata	225	28	6.619	8.088
Tagelus plebeius	180	28	4.553	5.563
Amygdalum papyrium	150	11	4.268	5.215
Neritina usnea	109	26	3.028	3.700
Geukensia granosissima	173	9	2.793	3.413
Tellina versicolor	96	8	2.741	3.349
Macoma constricta	85	5	2.662	3.253
Crassostrea virginica	137	17	2.626	3.208
Littoraria irrorata	94	19	1.811	2.213
Ischadium recurvum	92	15	1.780	2.176
Mulinia lateralis	130	13	1.734	2.119
Nassarius vibex	47	11	1.395	1.705
Haminoea succinea	33	3	1.062	1.297
Mytilopsis leucophaeata	40	5	0.796	0.973
Chione cancellata	11	3	0.348	0.426
Bivalvia (unidentified)	20	4	0.317	0.387
Melongena corona	8	5	0.153	0.187
Tellina sp.	10	4	0.139	0.170
Mysella planulata	17	1	0.137	0.167
Laevicardium mortoni	6	3	0.131	0.161
Brachidontes modiolus	17	4	0.127	0.155
Anomalocardia auberiana	7	3	0.075	0.092
Anadara transversa	3	2	0.064	0.079
Glottidia pyramidata	4	1	0.064	0.079
Cyclinella tenuis	3	3	0.059	0.072
Macoma tenta	5	2	0.056	0.069
Polinices duplicatus	2	2	0.048	0.059
Planorbidae (unidentified)	1	1	0.032	0.039
Mollusca (unidentified)	3	2	0.023	0.028
Lucina pectinata	1	1	0.011	0.013
Musculium partumeium	1	1	0.011	0.013
Brachiopoda	1	1	0.008	0.010
Cyrtopleura sp.	1	1	0.008	0.010

Table 7. Dominance of all species as a percentage of all the average number of individuals found in each site (river or creek) sampled.

	River or Creek										
Species	**Alafia**	**Big Slough**	**Blackburn**	**Currey**	**Deer Prairie**	**Mud**	**Myakka**	**Peace**	**Shakett**	**Shell**	**Weeki**
Corbicula fluminea	1.23	0	0	0	4.65	0	42.12	53.32	0	0.26	1.25
Polymesoda caroliniana	19.07	40	0	1.9	44.19	21.74	17.23	3.51	2.13	46.59	21.25
Rangia cuneata	0	24	100	0	51.16	0	8.86	5.79	0	30.90	0
Tagelus plebeius	3.69	28	0	34.18	0	30.43	9.54	1.36	24.63	19.31	23.75
Crassostrea virginica	21.88	0	0	5.7	0	26.09	0	1.06	27.59	0	25
Geukensia granosissima	29.44	0	0	0	0	0	6.22	0.22	0	0	0
Amygdalum papyrium	1.23	0	0	0	0	0	0	8.28	0	0	0
Neritina usnea	5.89	8	0	0	0	0	0.45	4.95	1.31	0.77	0
Ischadium recurvum	0	0	0	1.9	0	0	0.45	2.52	16.26	1.02	15.0
Littoraria irrorata	4.53	0	0	1.27	0	8.69	7.92	0.47	2.46	0.51	8.75
Macoma constricta	0	0	0	0	0	13.04	0	5.16	0	0	0
Chione cancellata	0	0	0	27.85	0	0	0	0	6.9	0	0
Tellina versicolor	0	0	0	0	0	0	0	5.42	0	0	0
Mulinia lateralis	1.71	0	0	3.8	0	0	2.49	2.44	0	0.13	0
Nassarius vibex	0	0	0	3.8	0	0	0.11	2.63	0.99	0	0
Mytilopsis leucophaeata	3.56	0	0	0	0	0	3.85	0	0	0.51	0
Haminoea succinea	0	0	0	0	0	0	0	2.1	0	0	0
Laevicardium mortoni	0	0	0	10.76	0	0	0	0	2.46	0	0
Tellina sp.	0	0	0	1.27	0	0	0	0	6.9	0	2.5
Bivalvia (unidentified)	4.35	0	0	0	0	0	0	0.1	0	0	0
Anomalocardia auberiana	0	0	0	1.27	0	0	0	0	3.94	0	0
Anadara transversa	0	0	0	3.8	0	0	0	0.06	0	0	0
Melongena corona	0	0	0	0	0	0	0	0.27	0	0	2.5
Mysella planulata	2.24	0	0	0	0	0	0	0	0	0	0
Cyclinella tenuis	0	0	0	1.27	0	0	0.11	0	1.97	0	0
Macoma tenta	0.66	0	0	0	0	0	0	0	0.99	0	0
Brachidontes modiolus	0	0	0	0	0	0	0	0.25	0	0	0
Lucina pectinata	0	0	0	1.27	0	0	0	0	0	0	0
Mollusca (unidentified)	0	0	0	0	0	0	0	0.01	0.99	0	0
Planorbidae (unidentified)	0.53	0	0	0	0	0	0	0	0	0	0
Glottidia pyramidata	0	0	0	0	0	0	0.45	0	0	0	0
Polinices duplicatus	0	0	0	0	0	0	0.11	0.06	0	0	0
Cyrtopleura sp.	0	0	0	0	0	0	0	0	0.49	0	0
Musculium partumeium	0	0	0	0	0	0	0.08	0	0	0	0
Brachiopoda	0	0	0	0	0	0	0	0.02	0	0	0

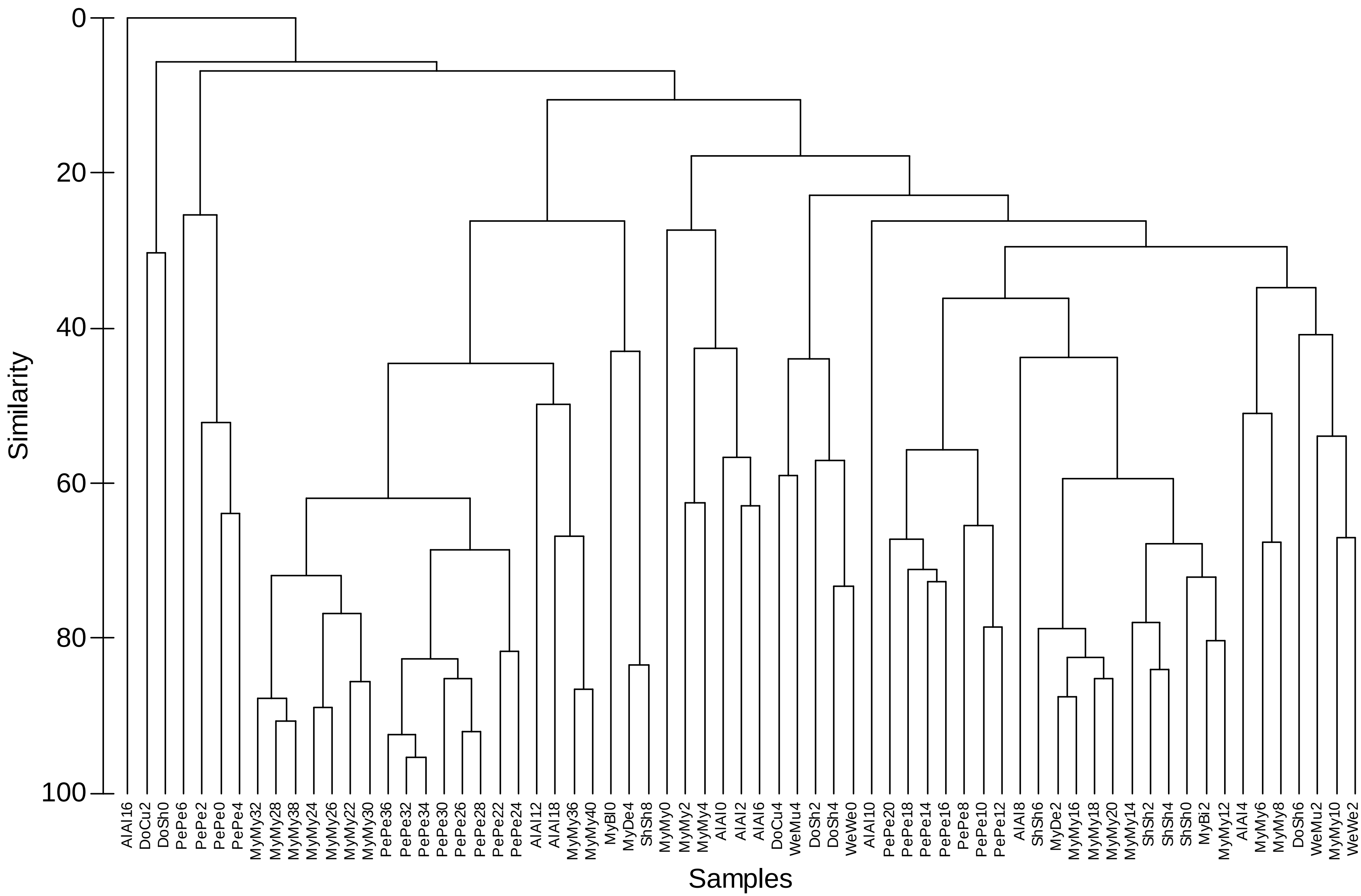

Figure 12. Bray-Curtis similarity indices for each station (i.e., river, site, 2-km segment combination).

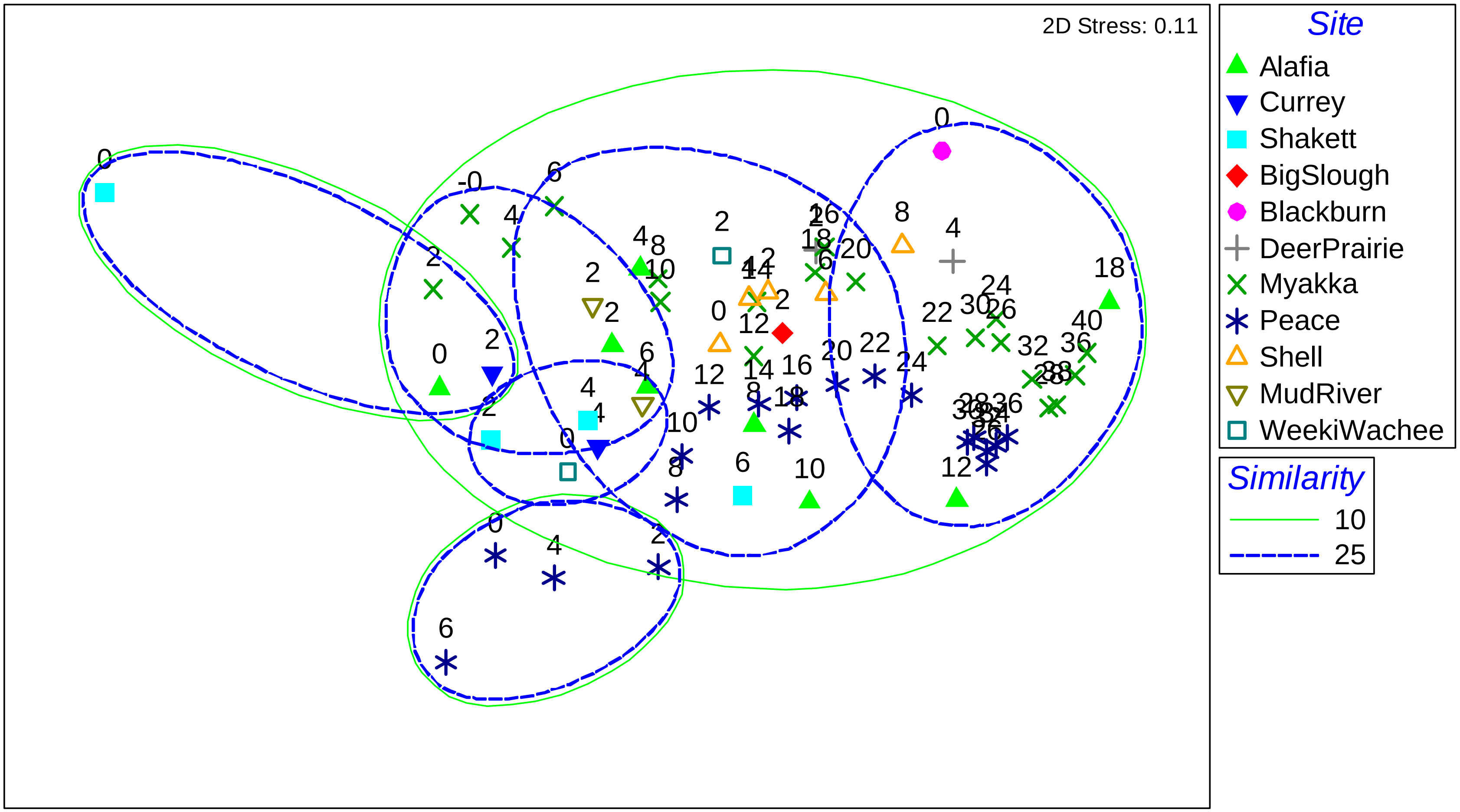

Figure 13. Relationships between mollusk communities from multi-dimensional scaling (MDS) analysis. Symbols represent the river or creek site with shape and color, and the km segment number is listed above the river symbol. Segment 16 from the Alafia River is outside the range of this plot.

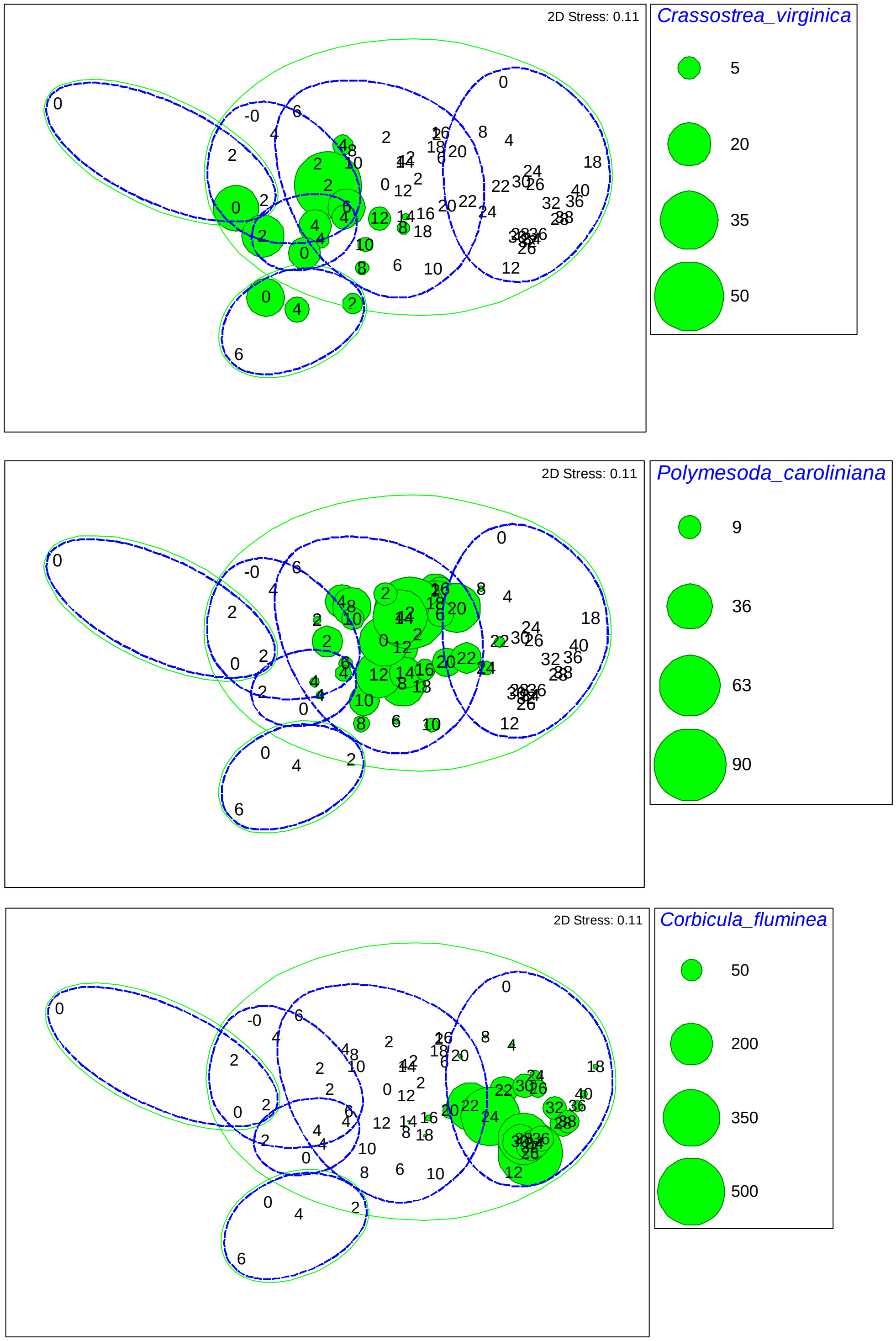

Figure 14. Abundance of three species (as bubbles) driving similarities among samples in the MDS plot in Figure 13.

Mollusca Diversity

Diversity characteristics were calculated for each river-site-segment combination. Hill's diversity index, N1, typically increased or was high in segments from 0 km to 2 km, then decreased to 10 km, then increased again, peaking in the 20 km to 24 km range, and decreased again toward the freshwater source (Figure 15). However, N1 is influenced by sample size, so it is best to compare metrics that do not have these problems, such as the taxonomic distinctness index, Δ* (Figure 16). The trend for Δ* is different, with a large range in the 0 km to 14 km range, and then an abrupt decreasing trend from 14 km to 40 km. The two rivers with the longest segments, Myakka and Peace, look different for N1, but similar for Δ*. Shell Creek is interesting because it has the highest Δ* diversity, but the second to lowest N1 diversity compared to other rivers in the 0 km to 10 km range. Overall, the trend for N1 is a double peak at 2 km and 22 km, whereas the overall trend for Δ* is one single peak around 12 km.

Univariate measures of diversity are difficult to compare among the rivers and river-sites because there was an uneven sampling effort of segments among these locations and there is a strong change of changing diversity along the salinity gradient (Figures 15 - 16). . However, most sites were sampled from the 0 km to 8 km range, so this portion of each transect can be averaged to compare sites (Table 8). An one-way, block analysis of variance was calculated to test for differences between sites. All measures were different among sites. Total abundance (N) was different at the p = 0.0087 level. Species richness (S) was barely significant for site differences (p =0.0470). The number of dominant species (N1) was different among sites (p = 0.0130), and so was taxonomic distinctness (Δ*) different among sites (p = 0.0015). Hill's diversity index, N1, ranges from 1.2 dominant species in the Peace River to 5.5 in Big Slough. Most other sites have N1 values of 3 - 4. Taxonomic distinctness index, Δ*, ranges from 33 at Shakett Creek to 78 at Shell Creek. The Δ* is only 40 for Big Slough, even though it has the highest number of species (11) and dominant species (5.5). Shell, Weeki Wachee, Alafia, and Currey are the most diverse sites.

Table 8. Diversity characteristics by river or creek site averaged over segments 0 km - 8 km. A. Aggregated by sites, i.e., rivers or creeks within river systems. B. Aggregated by river systems. Abbreviations: S = species richness, i.e., number of species, N = abundance of individuals m^{-2}, N1 = Hill's diversity index of number of dominant species, Δ* = taxonomic distinctness, -std = standard deviation.

Site	Segments	S	S-std	N	N-std	N1	N1-std	Δ*	Δ*-std
Alafia	5	5.4	1.7	74.8	43.6	3.4	1.1	59.1	3.6
Big Slough	1	11.0		48.1		5.5		39.7	
Blackburn	1	5.0		8.6		4.5		50.3	
Currey	2	4.0	2.8	74.9	0.7	2.0	1.3	58.6	30.2
Deer Prairie	2	6.0	5.7	27.8	27.1	3.7	2.7	35.0	32.4
Mud	2	4.0	0.0	12.4	6.9	3.7	0.1	53.0	8.8
Myakka	5	3.8	3.1	22.4	16.1	2.7	1.7	37.5	24.6
Peace	5	1.6	0.5	56.3	26.4	1.2	0.3	17.9	16.3
Shakett	4	3.5	0.6	86.8	64.7	2.3	0.7	33.2	4.9
Shell	5	2.4	0.5	225.8	162.0	1.3	0.2	78.3	2.6
Weeki Wachee	2	4.5	0.7	21.6	10.7	3.1	0.9	62.4	7.4

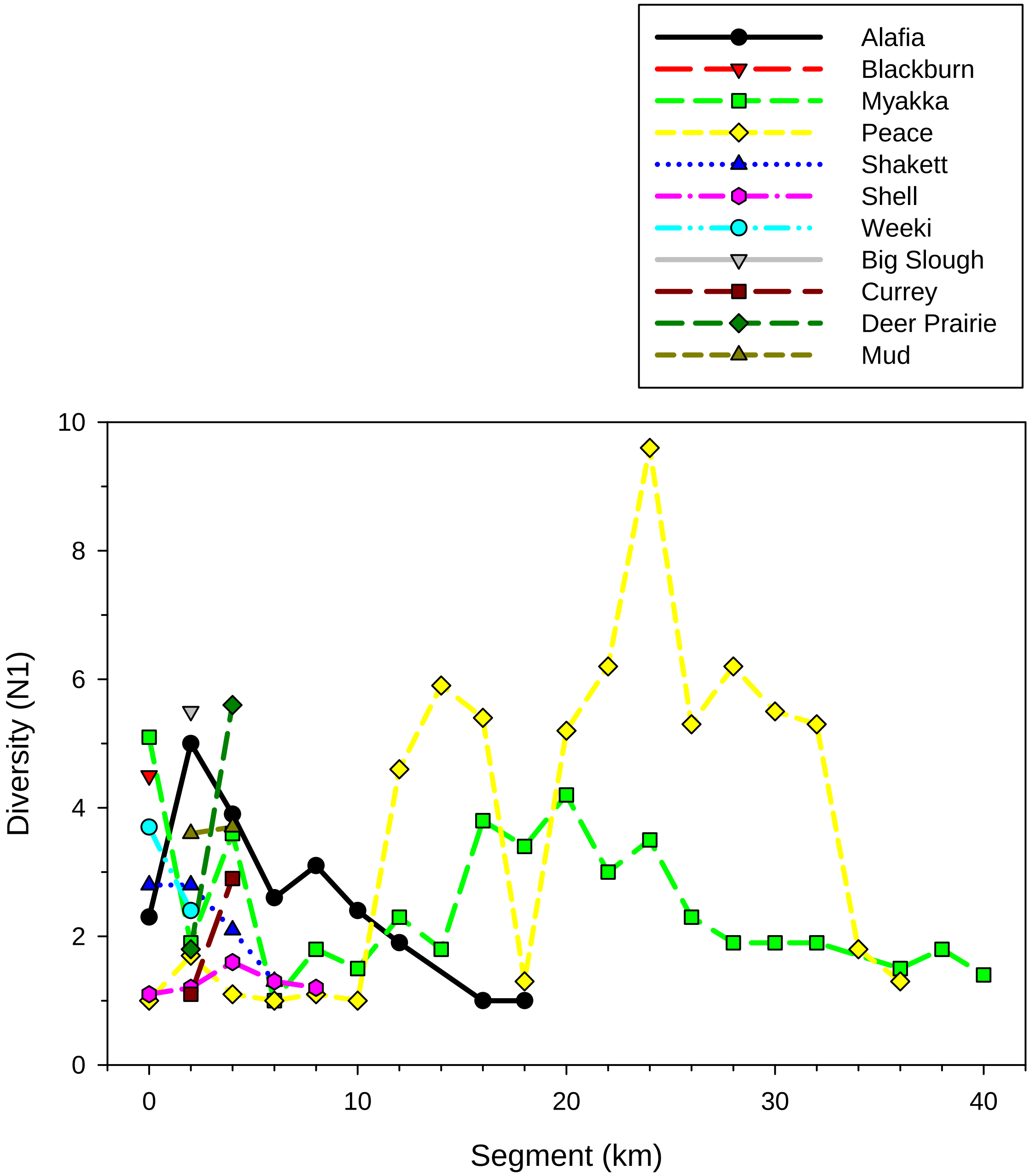

Figure 15. Diversity calculated as Hill's N1, the number of dominant species in segment site combinations.

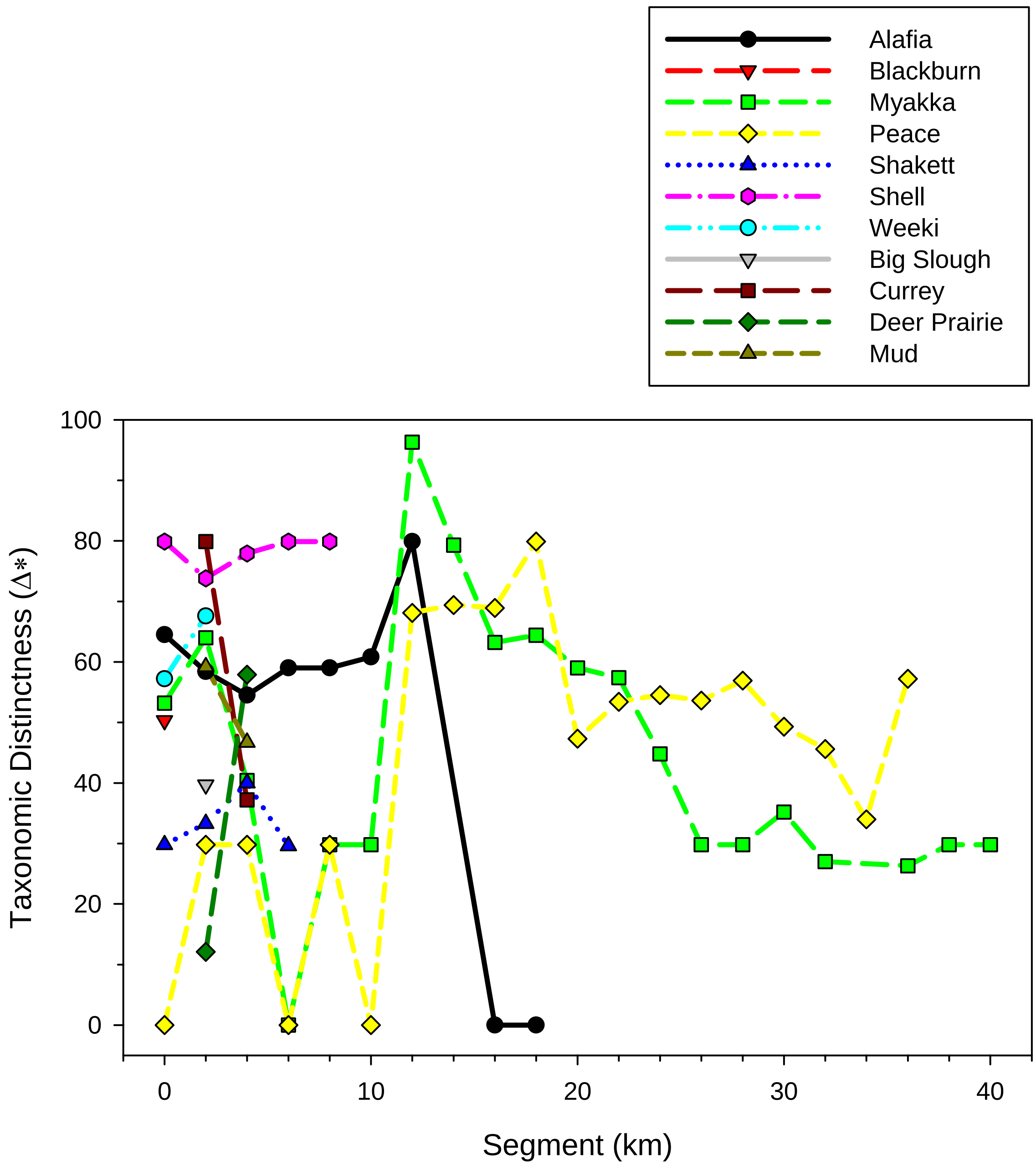

Figure 16. Diversity calculated as taxonomic distinctness (Δ*), the taxonomic distance through phylogenetic classification of every pair of individuals.

Mollusk-Environment Relationships

There are at least two approaches to relating mollusks to the environment, but in all cases salinity is used as the surrogate for inflow. One approach is to relate (by univariate or multivariate models) salinity with abundance, diversity, or community structure. The second approach is to examine the relationship between abundance and salinity to identify those species or species groups that might have optimal, or highest abundance, within specific salinity ranges.

For the first approach, a multivariate analysis (the BIO-ENV procedure) was used to identify the combinations of environmental variables that could predict mollusk abundance. Out of 62 transect-segments sampled for water quality and 67 transect-segments sampled for molluscs, there were only 45 common transect-segments that could be analyzed using BIO-ENV because of missing data in the other 17. Salinity, temperature, and pH were the environmental variables that correlated the highest with the mollusk community distributions ($\rho_w = 0.612$; Table 9). The RELATE procedure was used to determine that this correlation was significant ($p < 0.001$). The single variable that correlated the highest with mollusk communities was salinity ($\rho_w = 0.576$). In fact, salinity was the only variable that fit the community distributions in all the tests. The water quality variables had higher correlations with the mollusk communities than any single, or combination of, sediment characteristics. Of the sediment variables, median and mean grain size fit best, but all sediment variables always were selected after Salinity, temperature, and pH. It is therefore obvious that overlying water properties, especially salinity values, have more control on the mollusk communities than the sediment characteristics.

Table 9. Top ten correlations between mollusk species abundance (i.e., the resemblance matrix used for the similarity (Figure 12) and multi-dimensional scaling plot (Figure 13)) and normalized environmental data from Biota-Environment (BIOENV) analysis.

No. of Variables	Correlation (ρ_w)	Variables Selected
3	0.619	Salinity, Temperature, pH
2	0.608	Salinity, pH
4	0.594	Salinity, Temperature, pH, Median grain size
4	0.579	Salinity, Temperature, pH, Mean grain size
1	0.566	Salinity
2	0.559	Salinity, Temperature
4	0.555	Salinity, Temperature, pH, Kurtosis grain size
4	0.554	Salinity, Temperature, pH, %Clay
4	0.552	Salinity, Temperature, pH, %Solids
4	0.552	Salinity, Temperature, pH, %Silt

In the second approach, total mollusk abundance did not correlate with salinity among all river sites (Figure 17b). The highest abundances occurred at low salinities, but this is attributed to the large population of *Corbicula fluminea* that occurred in the Peace River at low salinities. Mollusk diversity increased with salinity, particularly as salinity increased from 0 to 2 psu, but the correlation was weak (Figure 17a). Hill's N1 values were consistently close to one where mean salinity was close to one, however, as salinity and overall N1 increased, so too did the range of N1 values.

Two rivers, the Myakka and Peace, were sampled in long transects (Figure 9). Examining distributions along salinity gradients in these two rivers alone would remove bias to differences in systems (Figures 16, 18 and 19). In both rivers there was a strong relationship between diversity and abundance with salinity where the abundance and diversity increased with increasing salinity, then peaked, and then declined. This curve is similar to a 3-parameter log normal distribution, which was found to fit total macrofauna abundance in a Texas estuary (Montagna et al., 2002), so the data was fit to that non-linear model. The relationship between salinity and diversity was stronger in the Peace River than the Myakka River based on the probability level (P) and goodness of fit parameter (R^2) (Table 10).

The ten dominant species were examined for correlations with salinity (Table 11). *Corbicula fluminea* was only found where mean salinities were lower than 7 psu, but was most common where mean salinities were less than or equal to 2 psu (Figure 20a), but the fitted maximum salinity value (parameter c in Table 10) was 0.6 psu. *C. fluminea* was also only found in abundances higher than 10 m^{-2} in the Myakka and Peace Rivers. *Polymesoda caroliniana* was found in all river systems but occurred where salinities were between 1 and 20 psu (Figure 20b) and peaked at salinity values of 5 psu (Table 10). Both *P. caroliniana* and *C. fluminea* are in the same family (Corbiculidae). *Rangia cuneata* and *Tagelua plebius* were found in low to moderate salinities and had calculated salinity peaks at 4 and 7 psu respectively (Figure 21). , *Crassostrea virginica* and *Geukensia granosissima* were generally found at higher salinities (Figure 22) and had calculated salinity peaks at 24 and 10 psu respectivley. *Mulinia lateralis* and *Neritina usnea* had different distributions (Figure 23). *Mulinia* ranged from 5 tp 15 ppt, and the model calculated a peak at 14 psu. According to the model, *N. usnea* abundance did not change with salinity (P = 0.43). *Littoriaria irrorata* and *Ischadium recurvum* were found over a wide range of salinities (Figure 24), and peak salinities were calculated as 14 and 12 psu respectively. Two other species not figured, *Amygdalum papyrium* and *Tellina versicolor* were all found in less than 9 segments so therefore a reasonable salinity range could not be estimated.

Table 10. Parameters from nonlinear regression to predict mollusk characteristics from salinity. These parameters are represented on lines in Figures 16, 18 - 24. Probability (P) that model fits the data, per cent of variance explained by data (R^2), parameters for maximum biological value (*a*), rate of change (*b*), and maximum salinity value (*c*), and standard deviation for parameters in parentheses. N1 = Hill's diversity index, and n = abundance (individuals per m^2), all species are n m^{-2}.

Variable	**P**	**R^2**	**a**	**b**	**c**
Myakka N1	0.1658	0.26	3.11 (0.36)	2.45 (0.65)	2.15 (0.86)
Myakka n	0.0682	0.36	54.9 (7.9)	2.63 (0.84)	0.59 (0.41)
Peace N1	0.0098	0.64	7.29 (1.02)	1.61 (0.31)	0.99 (0.28)
Peace n	0.0013	0.77	218 (24.8)	1.44 (0.20)	1.05 (0.20)
C. fluminea	0.0001	0.31	178 (43.2)	0.78 (0.19)	0.63 (0.18)
P. caroliniana	0.0001	0.32	28.8 (5.1)	0.66 (0.13)	4.89 (0.63)
R. cuneata	0.0001	0.38	27.3 (4.8)	0.49 (0.08)	3.69 (0.31)
T. plebius	0.0003	0.28	15.4 (3.0)	0.48 (0.12)	7.30 (0.90)
G. granosissima	0.0001	0.77	156 (11.9)	0.006 (3e-7)	10.3 (3e-6)
C. virginica	0.0001	0.33	19.3 (4.2)	0.18 (0.04)	22.4 (1.0)
M. lateralis	0.0001	0.37	324 (53.3)	0.006 (3e-7)	13.6 (8e-6)
N. usnea	0.4320	0.03	4.92 (1.71)	2.96 (2.77)	0.45 (1.33)
L. irrorata	0.0001	0.33	6.43 (1.28)	0.31 (0.07)	13.8 (0.98)
I. recurvum	0.0169	0.16	5.68 (1.81)	0.31 (0.11)	12.3 (1.3)

Table 11. Salinity Range of twelve most abundant species

Species	**Salinity Range (psu)**	**Transect segments with sp. present**
Corbicula fluminea	< 7 (most ≤ 2)	20
Polymesoda caroliniana	1 to 20	32
Rangia cuneata	< 16 (most ≤ 10)	23
Tagelus plebeius	> 2	25
Geukensia granosissima	10 to 24	5
Amygdalum papyrium	2 to 20	8 (7 in Peace R.)
Crassostrea virginica	> 7	13
Mulinia lateralis	> 2	10
Neritina usnea	< 18	20
Tellina versicolor	2 to 18	7 (all in Peace R.)
Littoraria irrorata	> 2	17
Ischadium recurvum	> 6	11

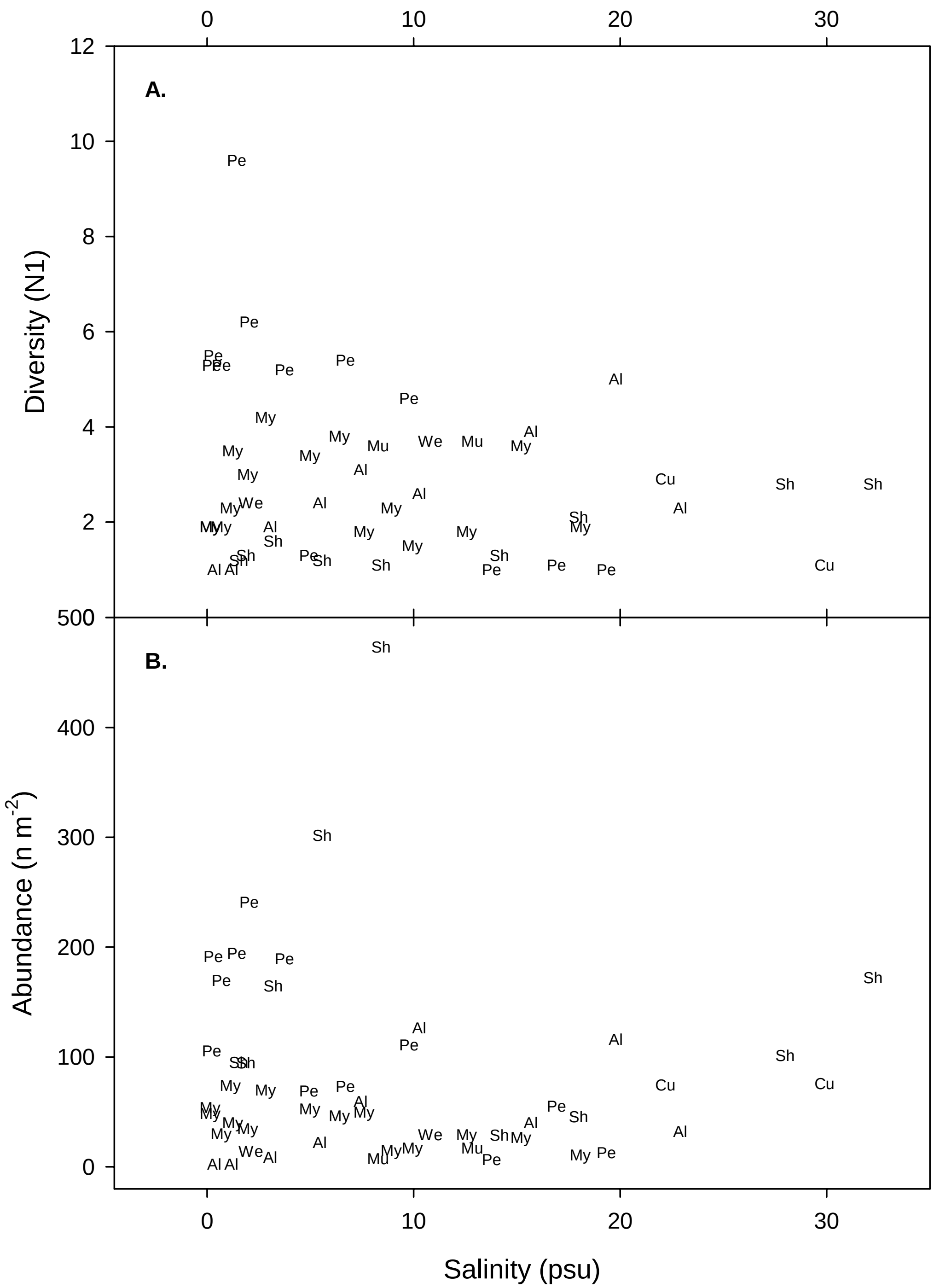

Figure 17. Relationship between salinity and total mollusks at all sites. A. Hill's N1 diversity index (top). B. Abundance (bottom). Key to abbreviations: Al = Alafia River, Bi = Big Slough, Bl = Blackburn Creek, Cu = Currey Creek, De = Deer Praire Creek, My = Myakka River, Pe = Peace River, Sh = Shakett Creek, She = Shell Creek, We = Weeki Wachee River.

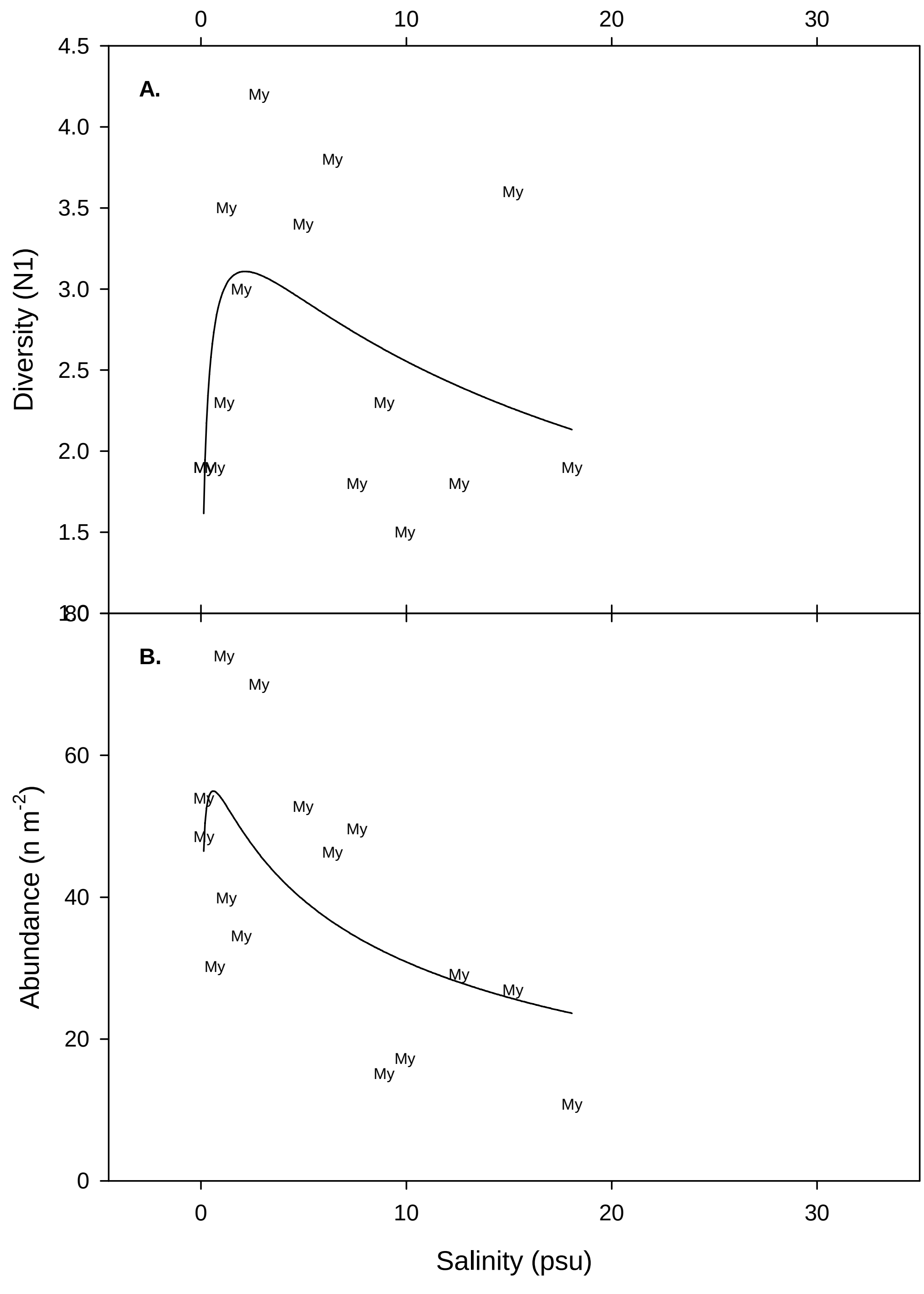

Figure 18. Relationship between salinity and total mollusks at Myakka (My) River sites. A. Hill's N1 diversity index (top). Line is fit with the log normal, 3-parameter model.

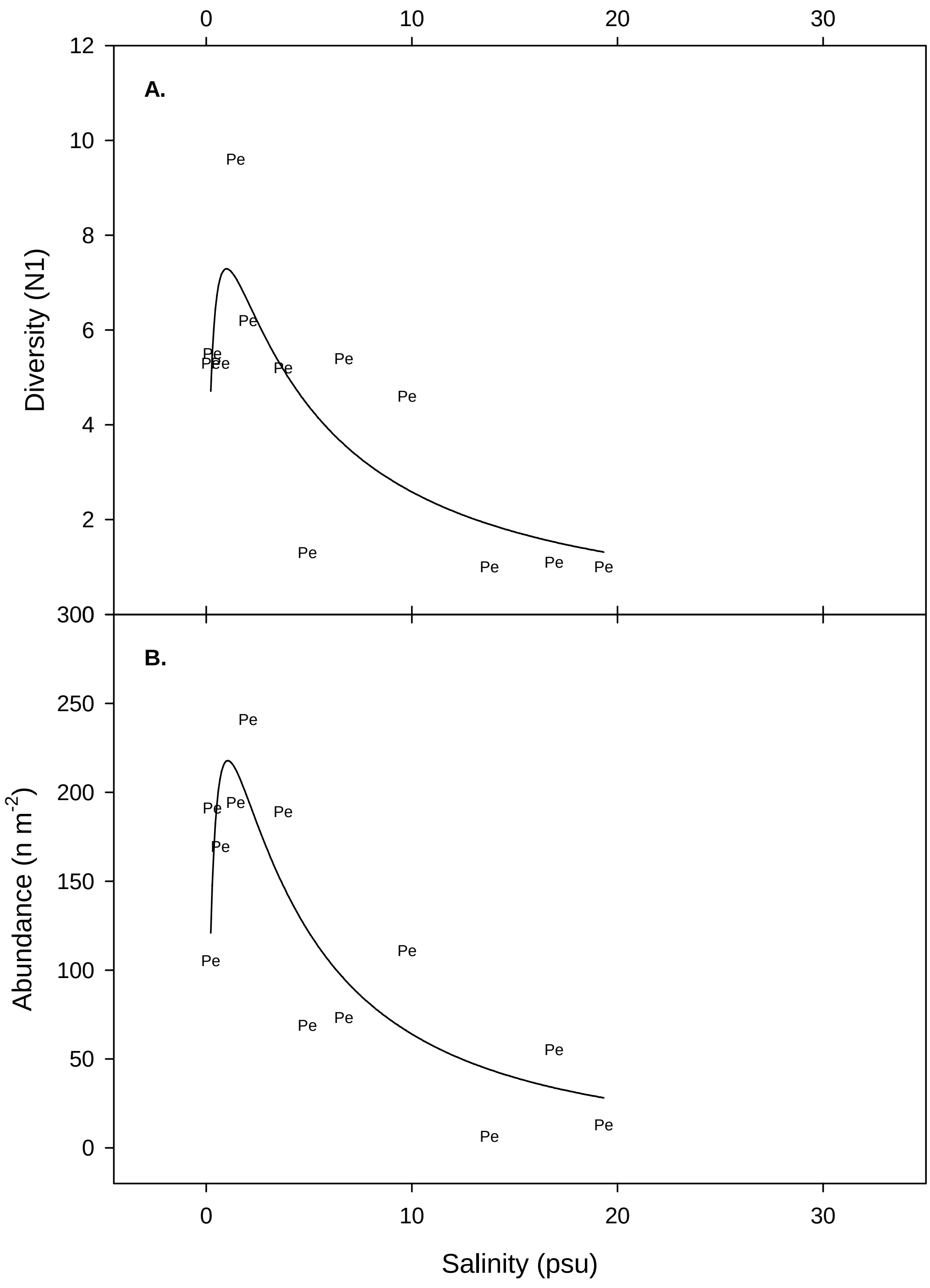

Figure 19. Relationship between salinity and total mollusks at Peace (Pe) River sites. A. Hill's N1 diversity index (top). Line is fit with the log normal, 3-parameter model.

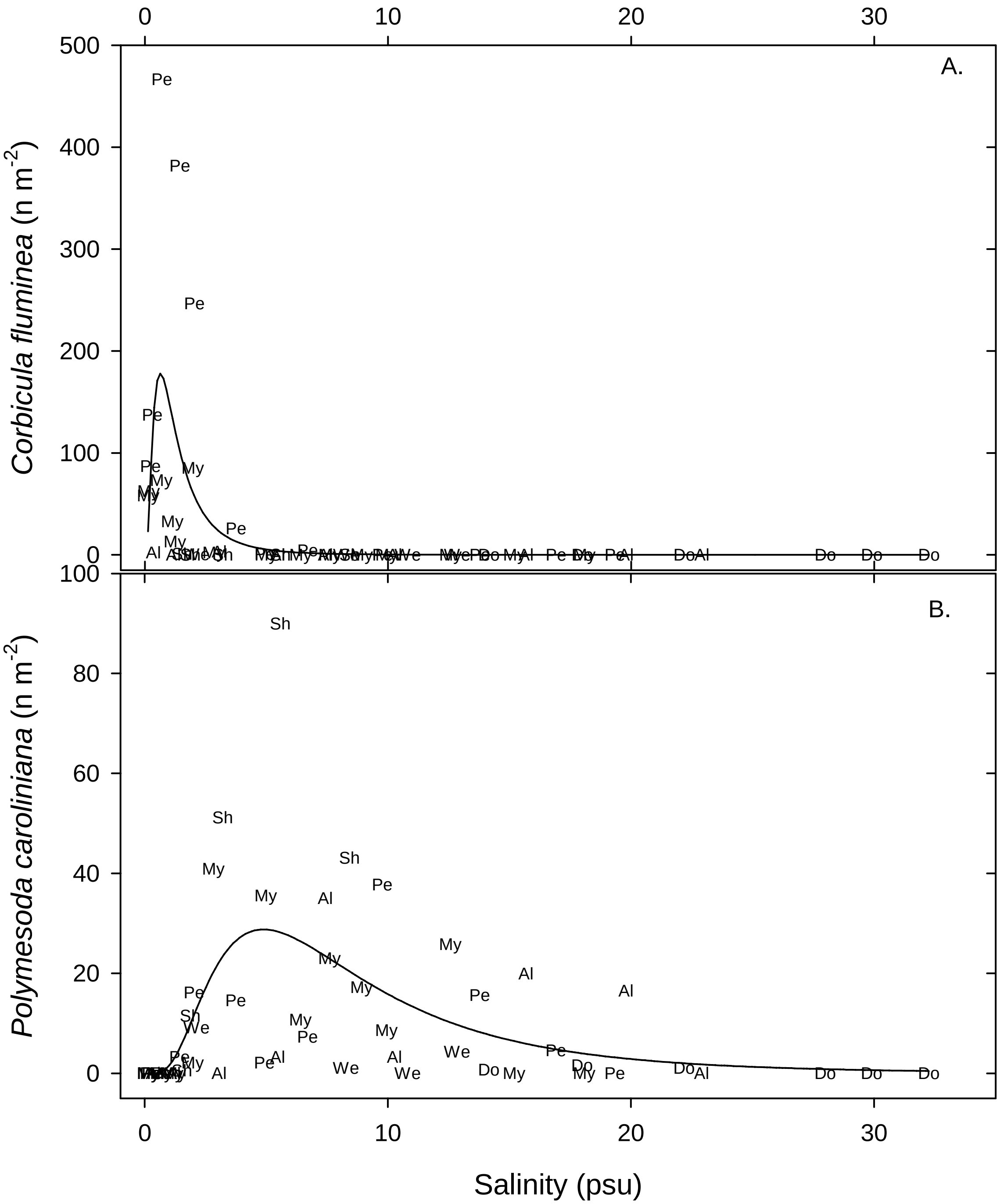

Figure 20. Relationship between salinity and species abundance. A. *Corbicula fluminea*, and B. *Polymesoda caroliniana*. Key: Al = Alafia River, Cu = Currey Creek, Do = Dona/Roberts Bay, My = Myakka River, Pe = Peace River, Sh = Shakett Creek, She = Shell Creek, We = Weeki Wachee River.

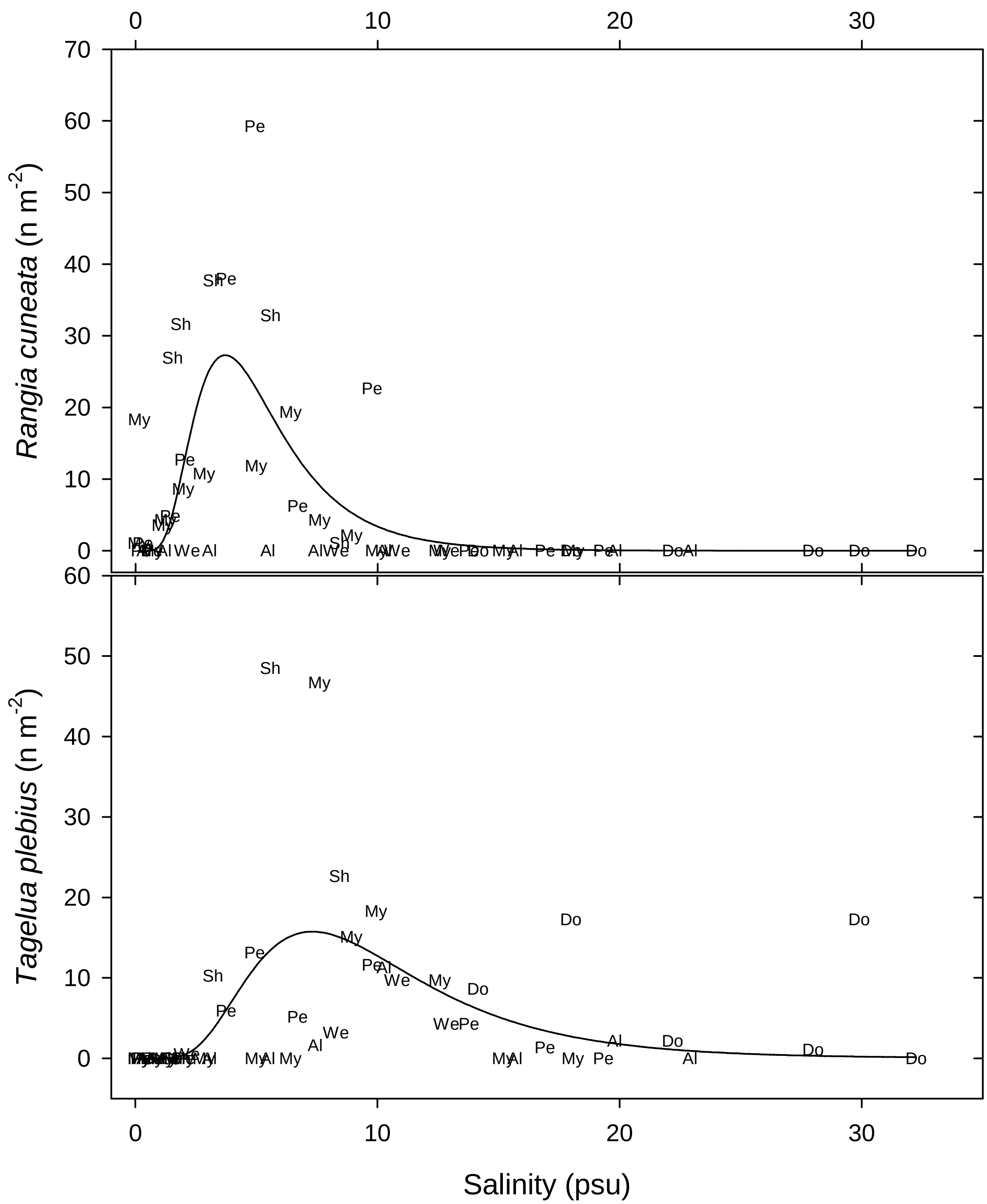

Figure 21. Relationship between salinity and species abundance. A. *Rangia cuneata*, and B. *Tagelus plebius*. Key: Al = Alafia River, Cu = Currey Creek, Do = Dona/Roberts Bay, My = Myakka River, Pe = Peace River, Sh = Shakett Creek, She = Shell Creek, We = Weeki Wachee River.

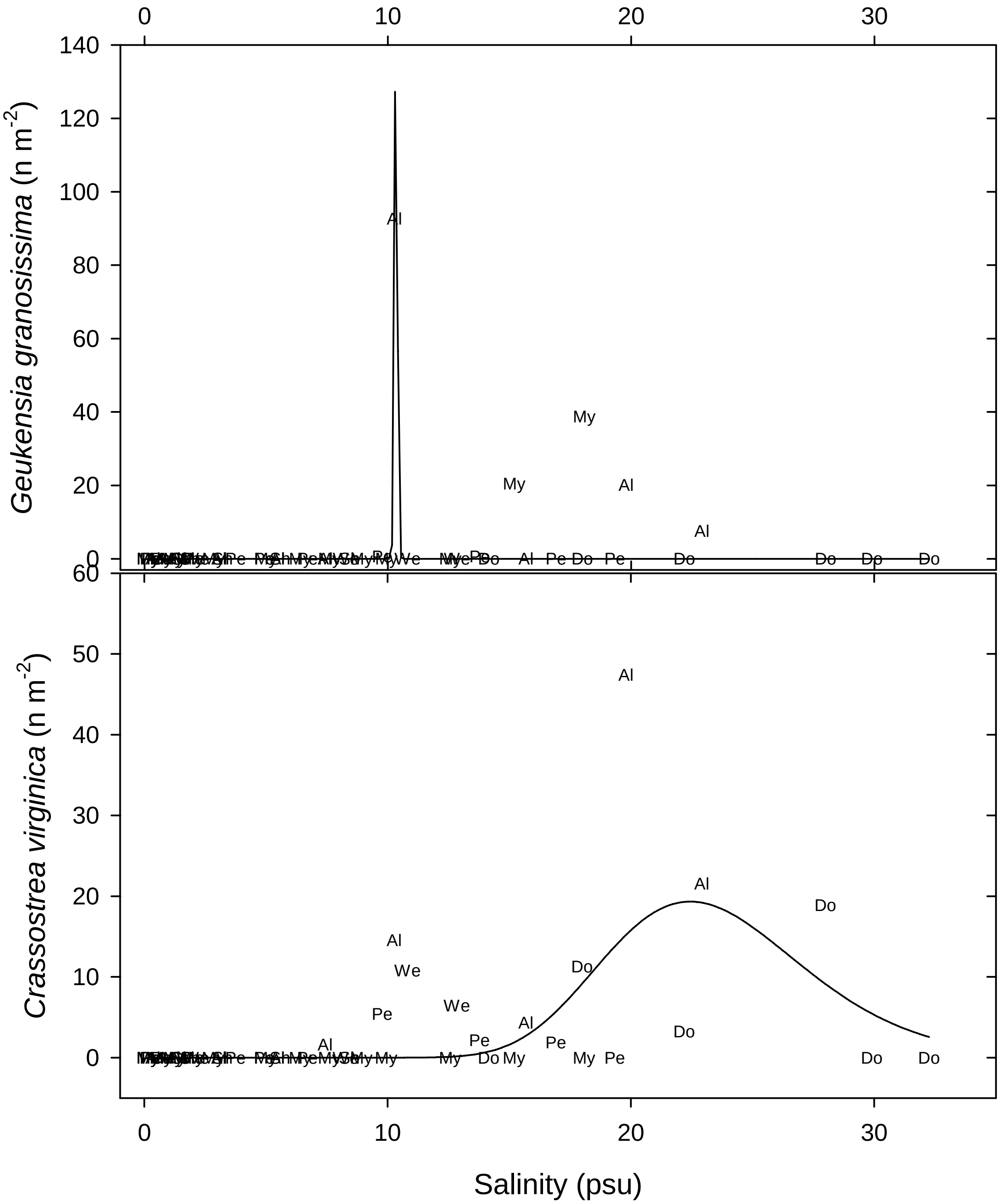

Figure 22. Relationship between salinity and species abundance. A. *Geukensia granosissima*, and B. *Crassostrea virginica*. Key: Al = Alafia River, Cu = Currey Creek, Do = Dona/Roberts Bay, My = Myakka River, Pe = Peace River, Sh = Shakett Creek, She = Shell Creek, We = Weeki Wachee River.

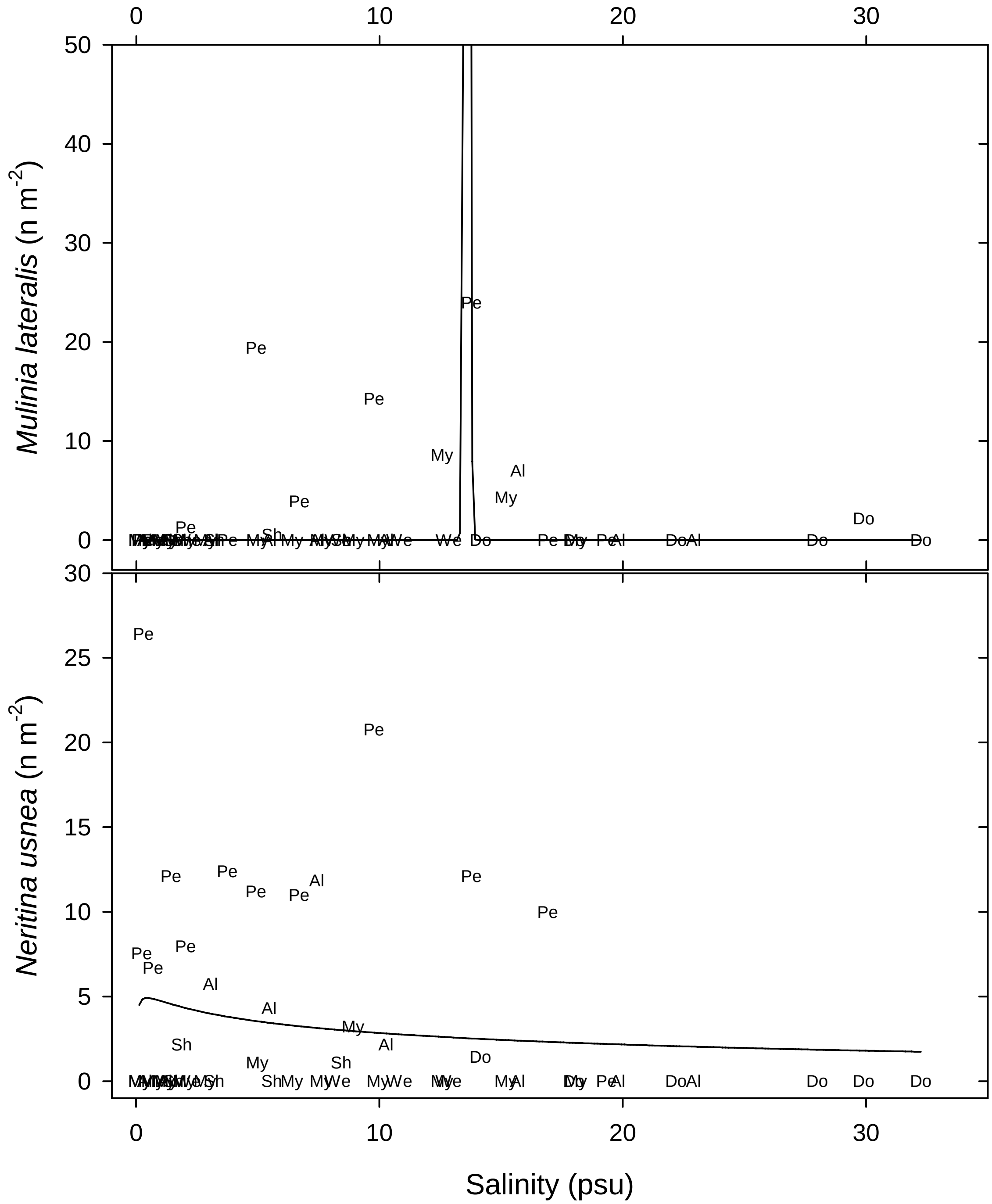

Figure 23. Relationship between salinity and species abundance. A. *Mulinea lateralis*, and B. *Neritina usnea*. Key: Al = Alafia River, Cu = Currey Creek, Dona/Roberts Bay, My = Myakka River, Pe = Peace River, Sh = Shakett Creek, She = Shell Creek, We = Weeki Wachee River.

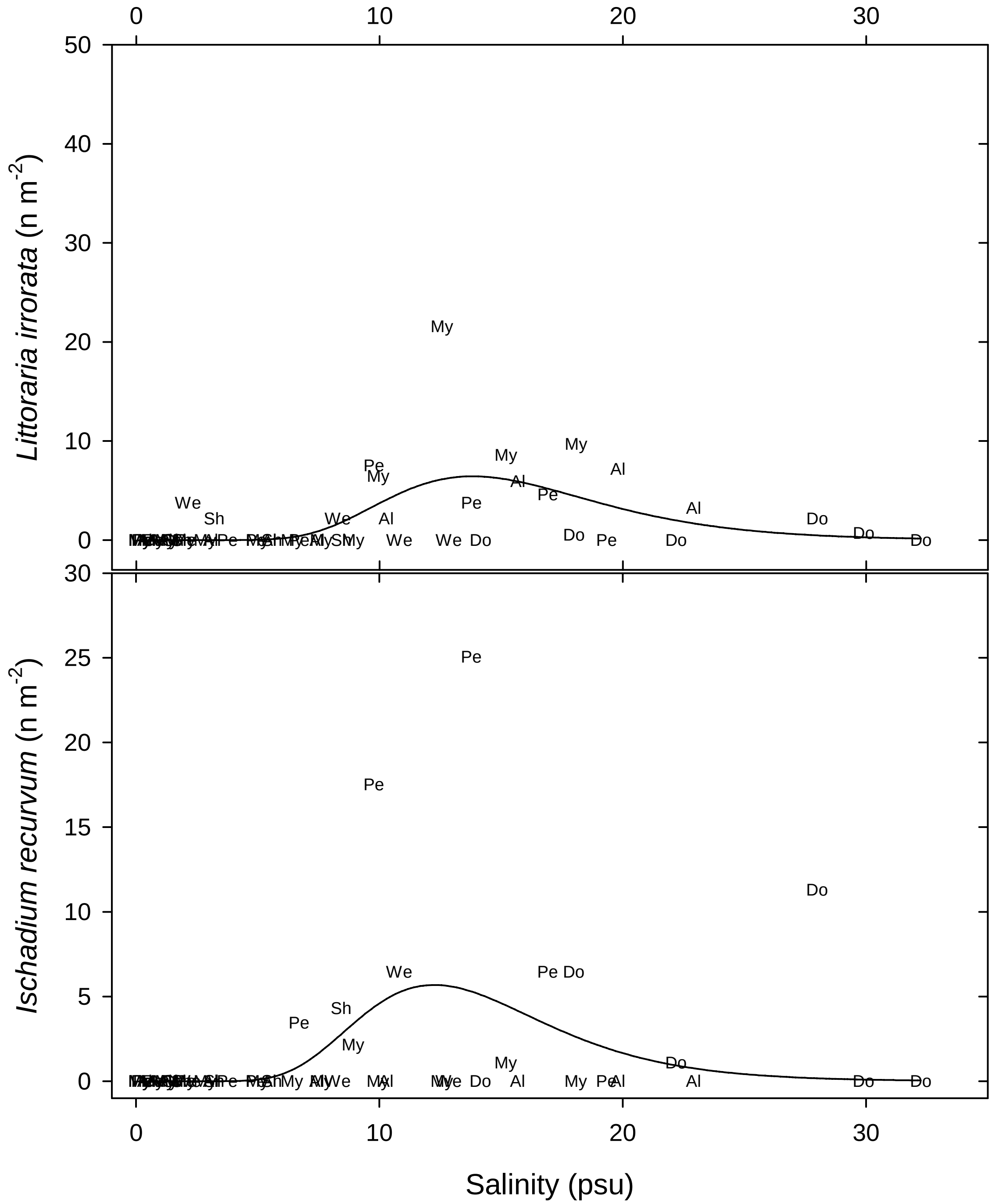

Figure 24. Relationship between salinity and species abundance. A. *Littoraria* irrorata, and B. *Ischadium recurvum*. Key: Al = Alafia River, Cu = Currey Creek, Dona/Roberts Bay, My = Myakka River, Pe = Peace River, Sh = Shakett Creek, She = Shell Creek, We = Weeki Wachee River.

Discussion

The overall purpose of this project was to better define the physical and chemical requirements of mollusk species that inhabit tidal river systems in southwest Florida. To meet this purpose, an inter-river analysis was performed to examine relationships between freshwater inflows and the distribution of mollusk populations. Although the available data of mollusk species abundances and water quality were useful, the data was from independent investigations without regard to some larger, regional scale design and analysis. Thus, the data did not fit well into a sampling design that could be used toward the purpose of this report. The most important factor that inhibited a more comprehensive interpretation was that the mollusk samples were not taken in the same year (Table 2) and not always the same season. Two exceptions to this lack of synoptic sampling were the Myakka and Dona/Roberts Bay systems. The lack of synoptic sampling is important because the physical environment of an estuary is quite variable and strongly reacts to the different atmospheric events over short-term (e.g., storms) and long-term (e.g., seasonal or yearly weather cycles) temporal scales. Mollusks, as indicators of environmental change, are affected by these physical changes in an estuary. Therefore, by taking samples at different times, especially different years, the ability to compare the mollusk communities between estuarine rivers is impaired. In a stable estuarine river system, replicates could help to mitigate this problem, however, apart from the Peace River, there were no replicates reported. The water quality variables were also sampled over different time periods depending on the river sampled. This is not as great a problem as with the mollusk samples because many replicates were taken, which allows estimating the average conditions in a system. Caution has to be used when interpreting the current analysis because a poor assumption, that mollusk communities do not change over time, had to be made to allow the comparisons of rivers at a regional scale.

There was little similarity in the mollusk communities among all the rivers as most stations shared 25% or less species in common (Figures 12 and 13). Although sampling occurred over different years, there were community similarities at similar transect segments along each river. There were upstream clusters, downstream clusters, and larger clusters of intermediate range transects. The segments with the most similar mollusk communities occurred in the most upstream segments of the Peace, Myakka and Alafia Rivers. These segments had the most stable and lowest mean salinities (Figures 9 and 10), likely resulting from the minimal tidal influence in these areas. Further downstream, decreased and more variable freshwater influences, allows different species and communities to persist compared to stable upstream waters. Other factors such as tides, waves, currents, and inshore geomorphology create diversity both within and between estuarine river systems. This increase in physical diversity between rivers results in the higher differences in mollusk communities between rivers downstream than upstream.

The highest correlations between mollusk communities and any combination of physical variables (sediment or water quality), were dominated by water quality variables, especially salinity (Table 9). From this, it can be concluded that salinity differences is more important than sediment differences in regulating mollusk community habitats in southwest Florida. This conclusion by the way, is a conclusion that is robust, because it is independent of the problem of a lack of synoptic samples. The combinations with the highest correlations almost always included salinity, temperature and pH. The best single physical indicator of mollusk communities was salinity (Table 9). Because salinity is a direct indicator for freshwater inflow, this means that freshwater inflow is the most important factor controlling mollusk communities. It also means that to assess the effects of freshwater inflow on mollusk communities in southwest Florida, confounding factors, e.g., sediment type, water temperature, are less important than the effects of freshwater inflow.

Species ranges were estimated by comparing mean salinity values for each transect-segment with abundances of mollusk species in those same segments (Figures 20 to 24, Table 11). *Corbicula fluminea*, *Rangia cuneata*, and *Neritina usnea* were the only common species that occurred at salinities below 1 psu. However *C. fluminea* was the best indicator of freshwater habitat, because densities were highest below 2 psu. *C. fluminea* is an introduced bivalve species can survive salinities up to 13 psu (Morton and Tong, 1985) however mostly occur in freshwater (Aguirre and Poss, 1999). *R. cuneata* has been noted as an indicator of a fresh- to brackish-water with an estimated tolerance of up to 20 psu (Swingle and Bland, 1974; Montagna and Kalke, 1995). *N. usnea* is a gastropod also common in fresh- to brackish-water salinities. *Polymesoda caroliniana* is a native brackish water bivalve (Gainey and Greenberg, 1977) also from the Corbiculidae family. In this current study, *P. caroliniana* was present at salinities between 1 and 20 psu. *P. caroliniana* is a good indicator because it is present in all creeks/sites. *T. plebius, Crassostrea virginica, Mulinea lateralis, Littoriaria irrorata*, and *Ischadium recurvum* are also good indicators for bracksish to seawater salinities. Total mollusk abundance and aggregated mollusk species diversity do not make good indicators for freshwater inflow across all rivers (Figure 17), but is useful within rivers (Figures 16, 18 and 19). In addition, there is evidence of seriation in the mollusk communities as evidence of the trend of transect numbers increasing from left to right in the MDS analysis (Figure 14).

In this limited analysis of southwest Florida mollusk communities, it is concluded that mollusk species are controlled more by water quality rather than the sediment they live in or on. The most important variable correlated with mollusk communities is salinity, which is a proxy for freshwater inflow. It is almost impossible to directly link community changes in response to inflow changes, because not replicates over time were carried out in the rivers sampled. Certain indicator species have been identified however, that characterize salinity ranges in southwest Florida rivers. These salinity ranges may be useful in predicting mollusk community reactions to alterations in salinity that result from actual or simulated changes in freshwater inflow.

Taking all samples in the same month as well as taking replicate samples over time would greatly improve the ability to accurately determine the relationships of mollusk communities relative to those in other rivers. Synchronization of sampling and sample replication would also improve the ability to accurately correlate between mollusk communities and freshwater inflows. The use of transect-segments in this study design is still appropriate however.

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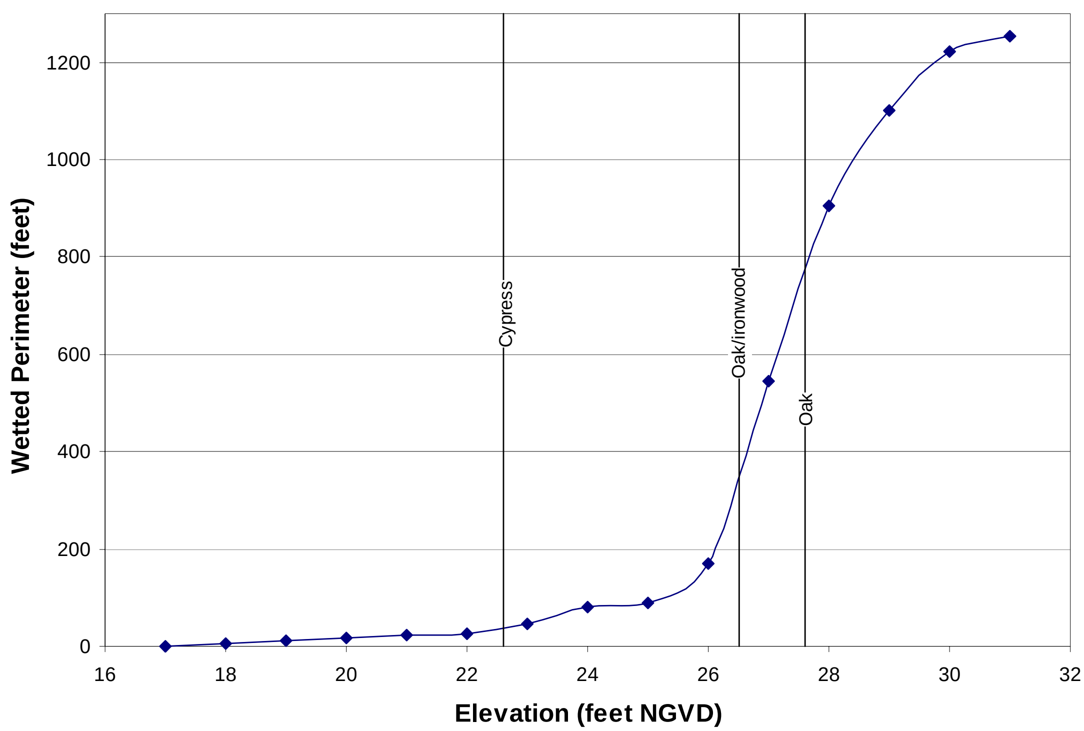
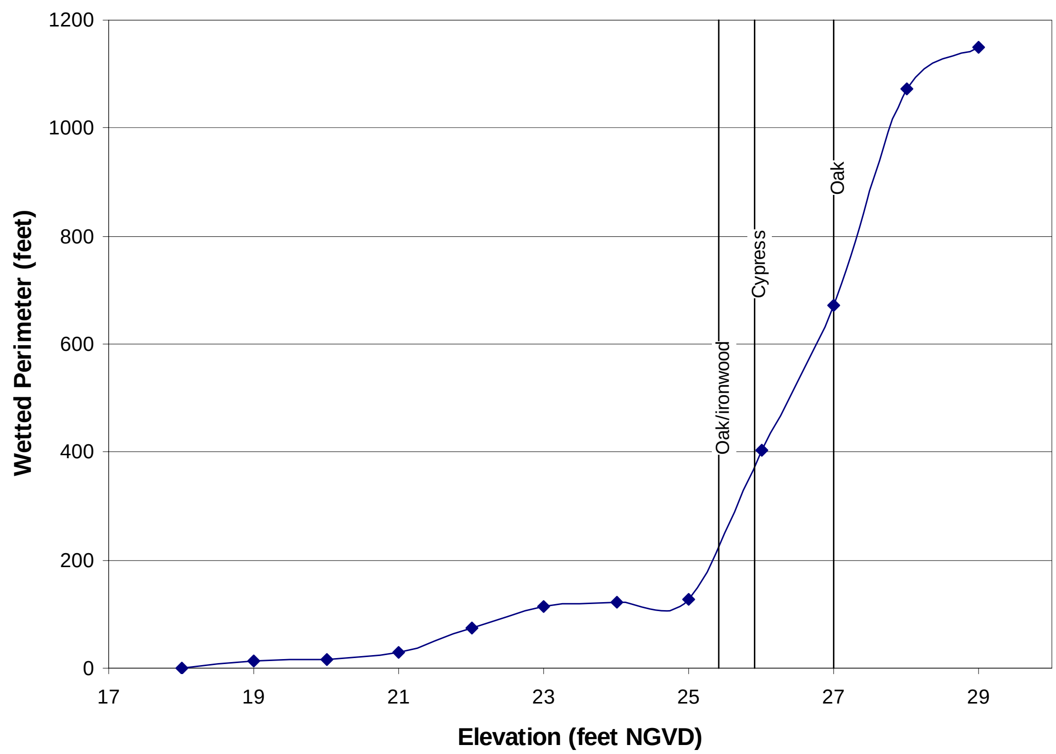
Appendix 11-9
Wetted Perimeter Graphs
for the Anclote River Study Corridor

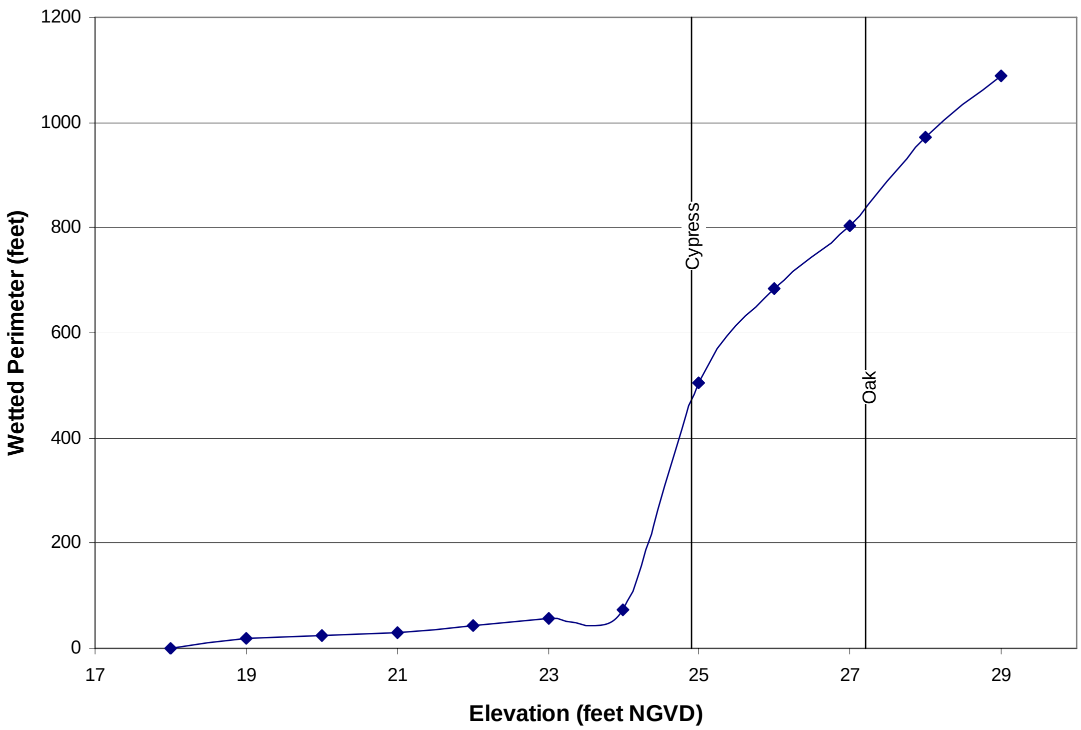
Anclote River Wetted Perimeter: Transect 1



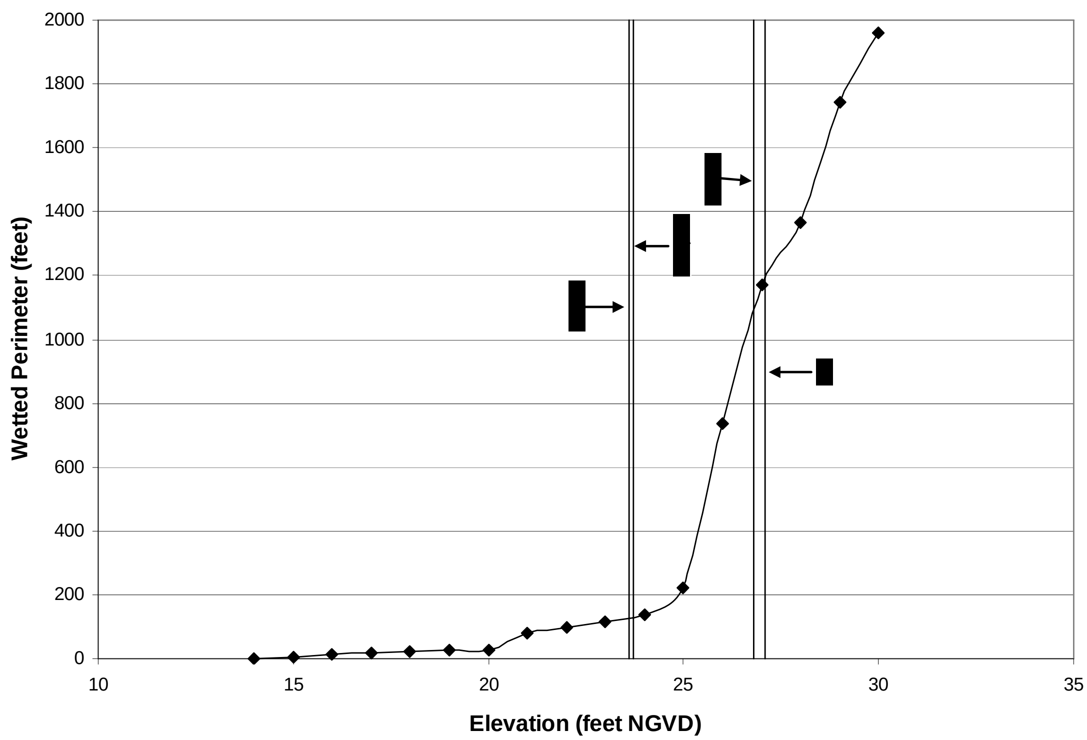
Anclote River Wetted Perimeter: Transect 2



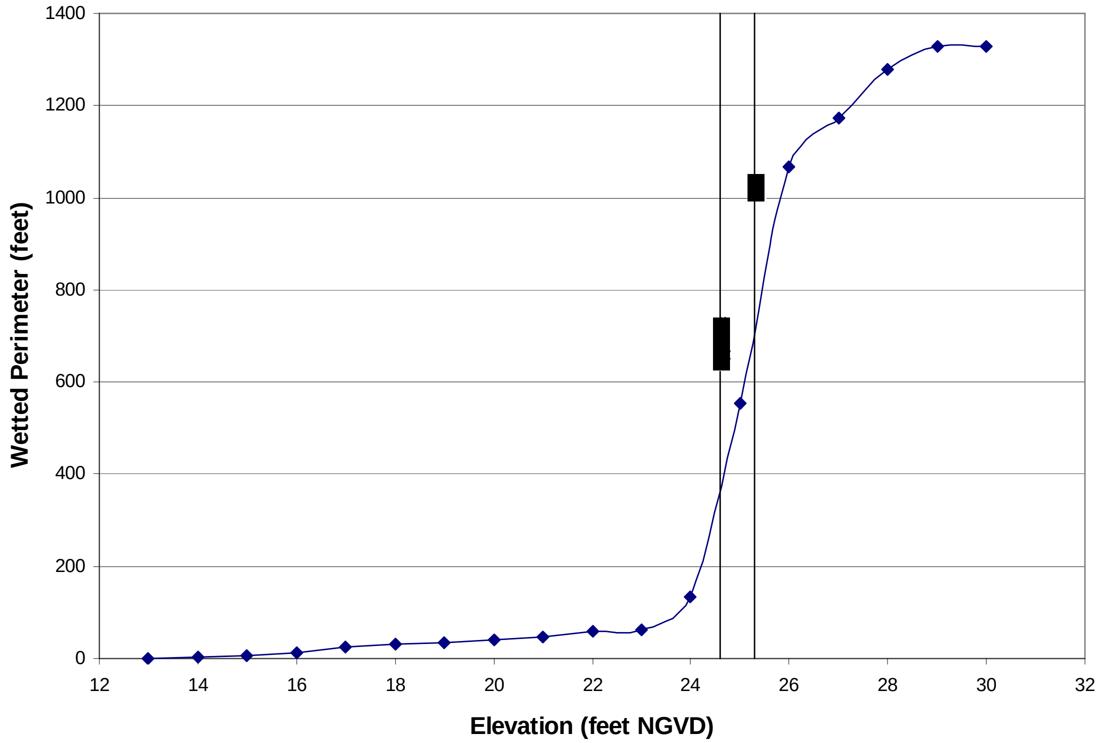
Anclote River Wetted Perimeter: Transect 4



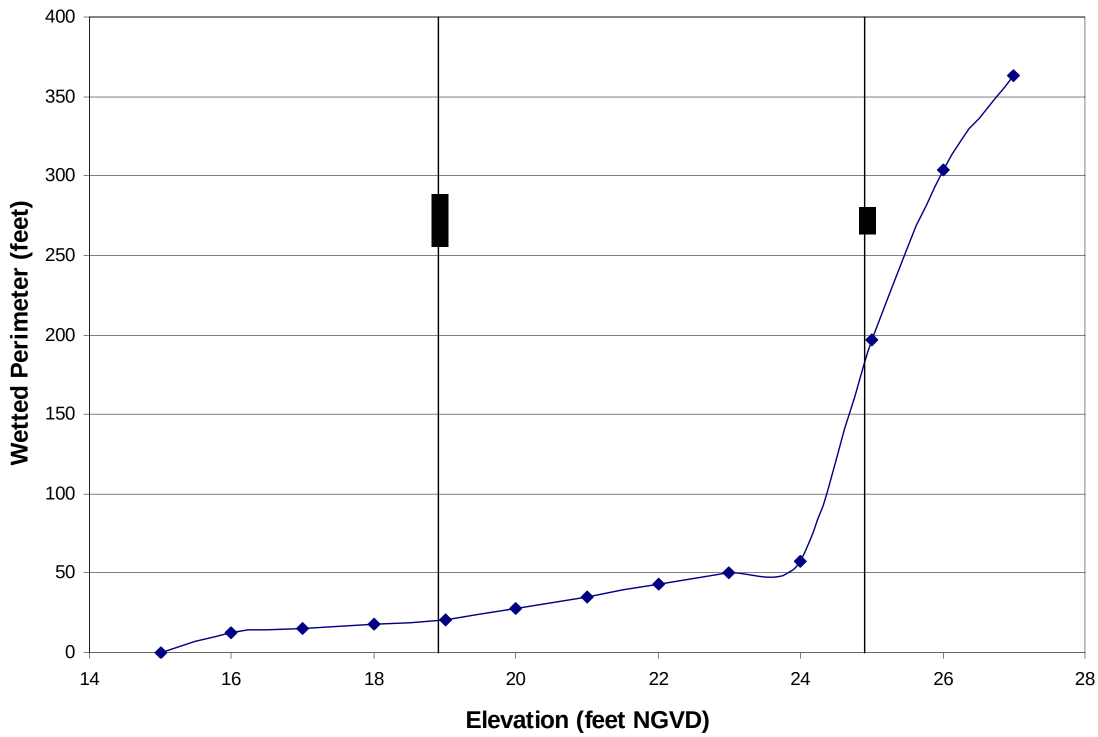
Anclote River Wetted Perimeter: Transect 6



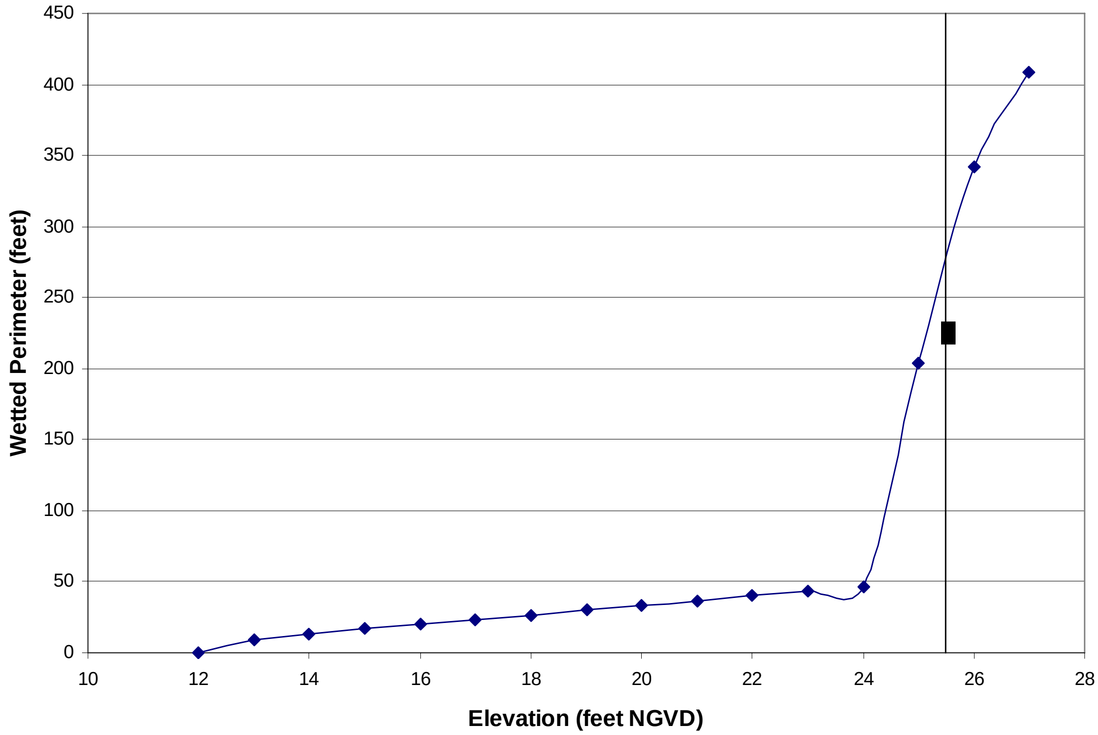
Anclote River Wetted Perimeter: Transect 7



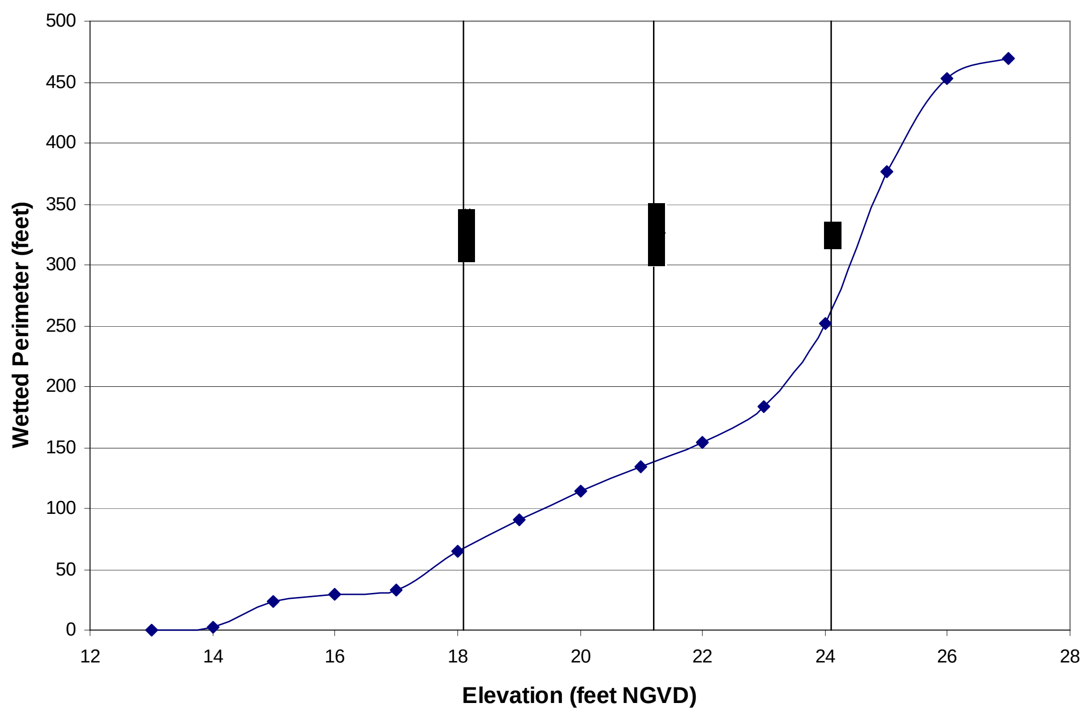
Anclote River Wetted Perimeter: Transect 8



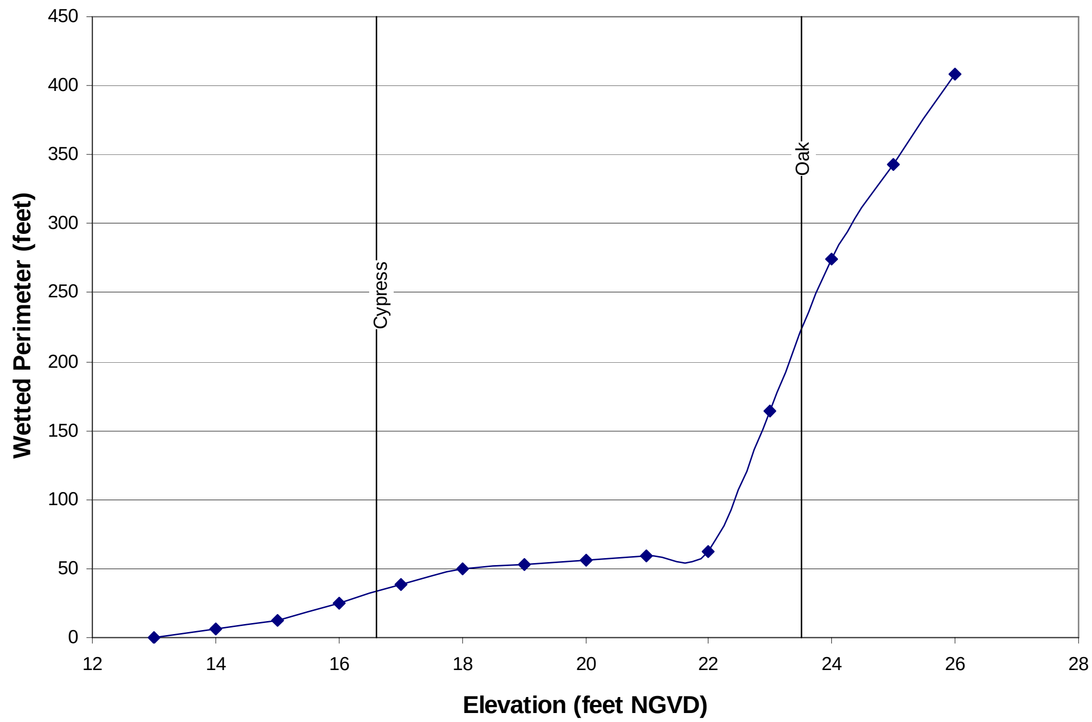
Anclote River Wetted Perimeter: Transect 10



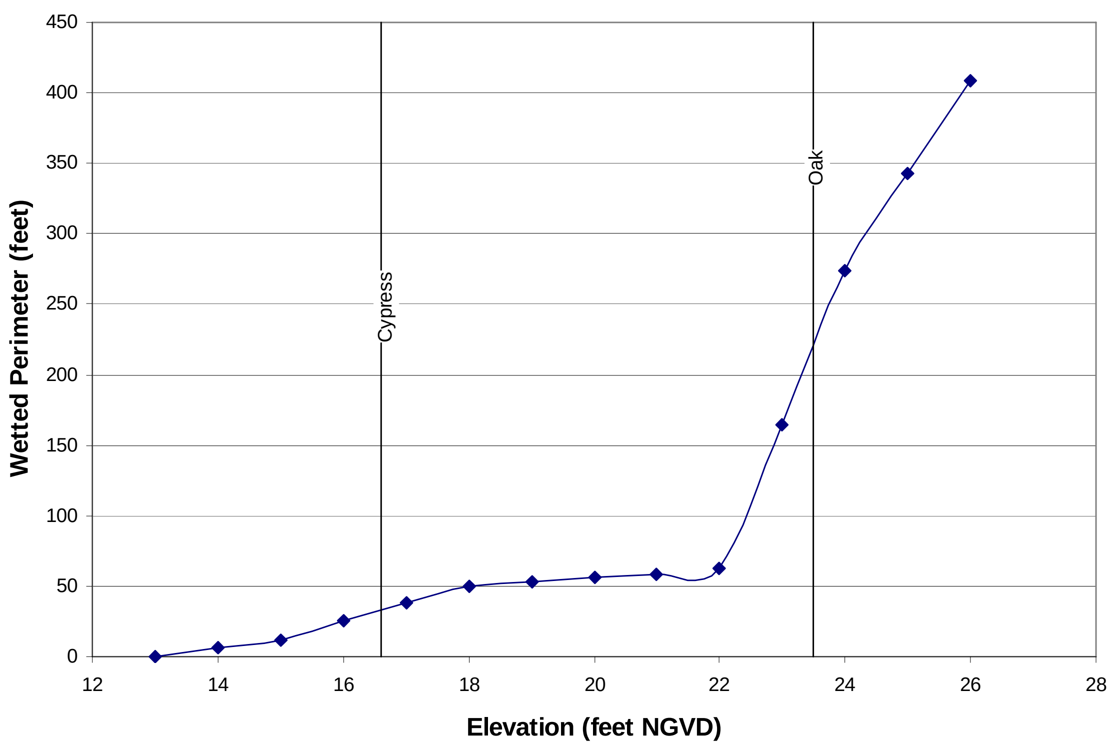
Anclote River Wetted Perimeter: Transect 13

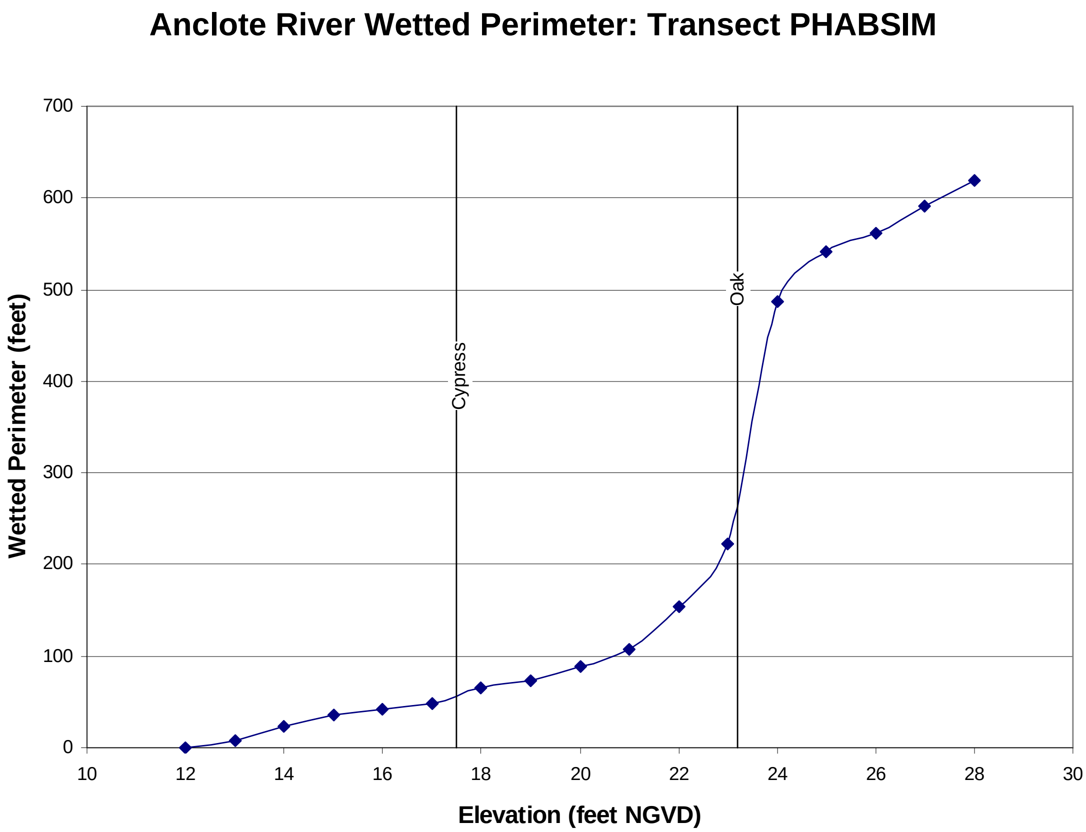


Anclote River Wetted Perimeter: Transect 15



Anclote River Wetted Perimeter: Transect 21

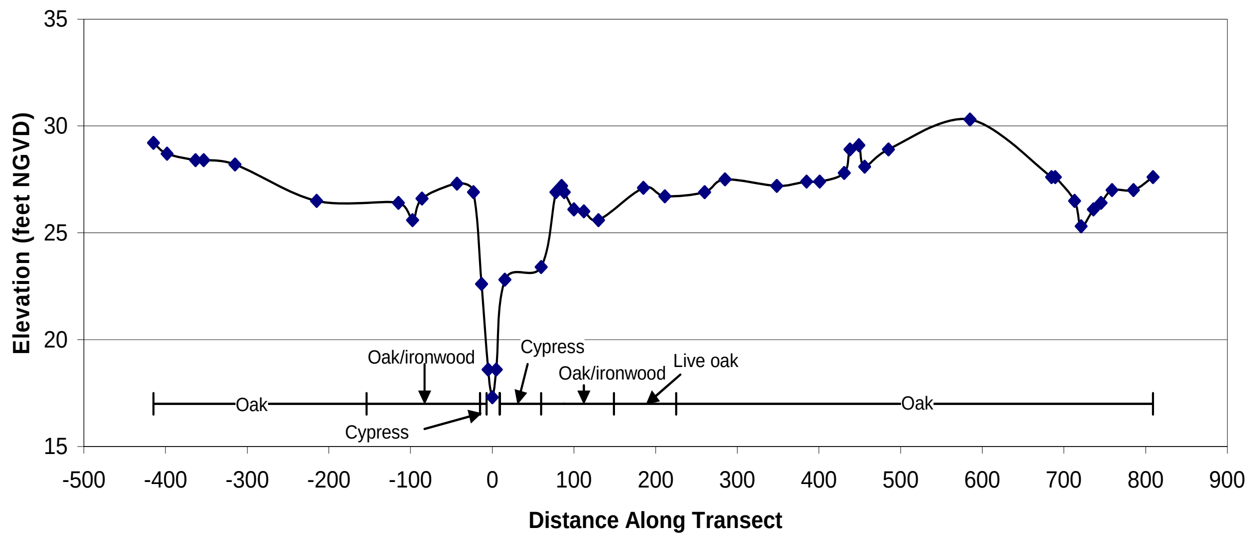




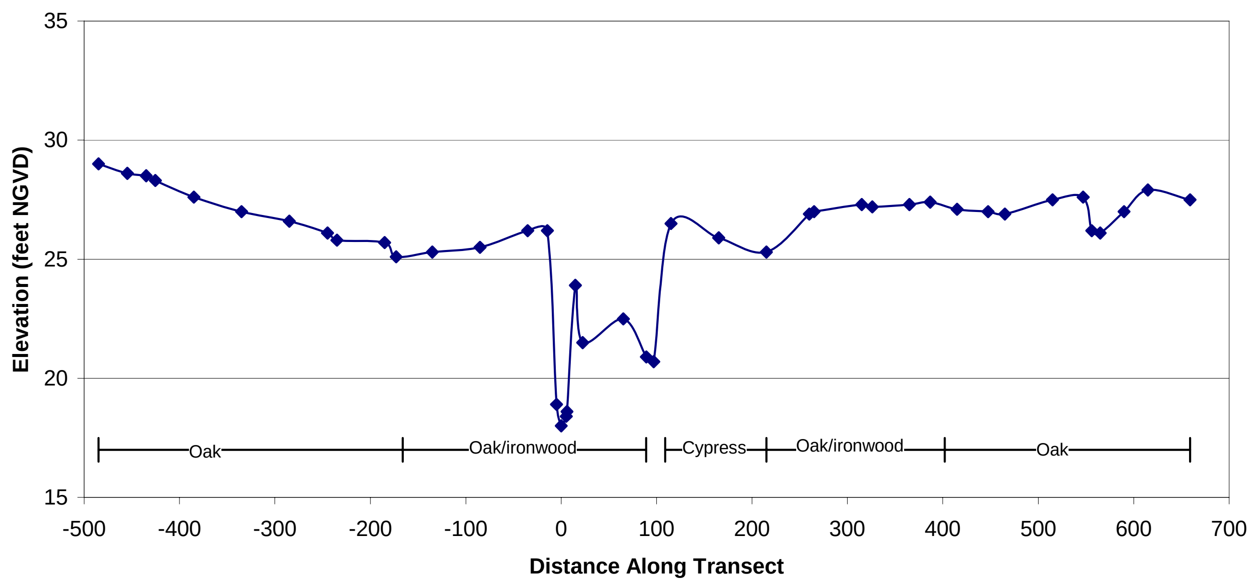
Anclote River Wetted Perimeter: Transect PHABSIM
Wetted Perimeter (feet)
0
100
200
300
400
500
600
700
Cypress
Oak
10
12
14
16
18
20
22
24
26
28
30
Elevation (feet NGVD)

Appendix 11-10
Elevation and Vegetation Profiles
for the Anclote River Study Corridor

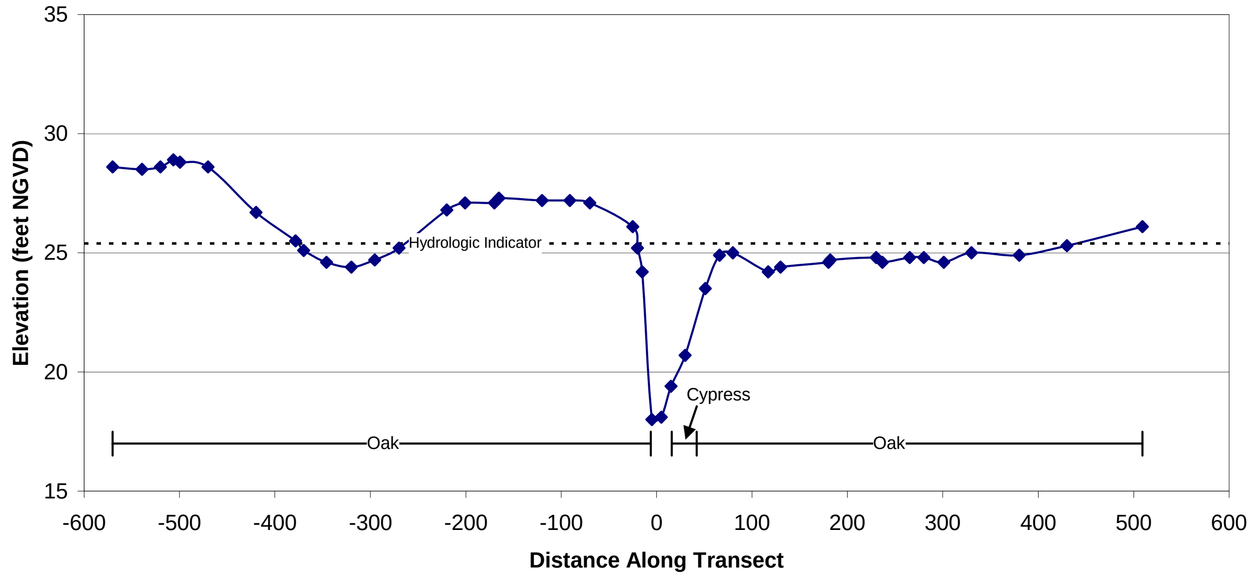
Anclote River Transect 1



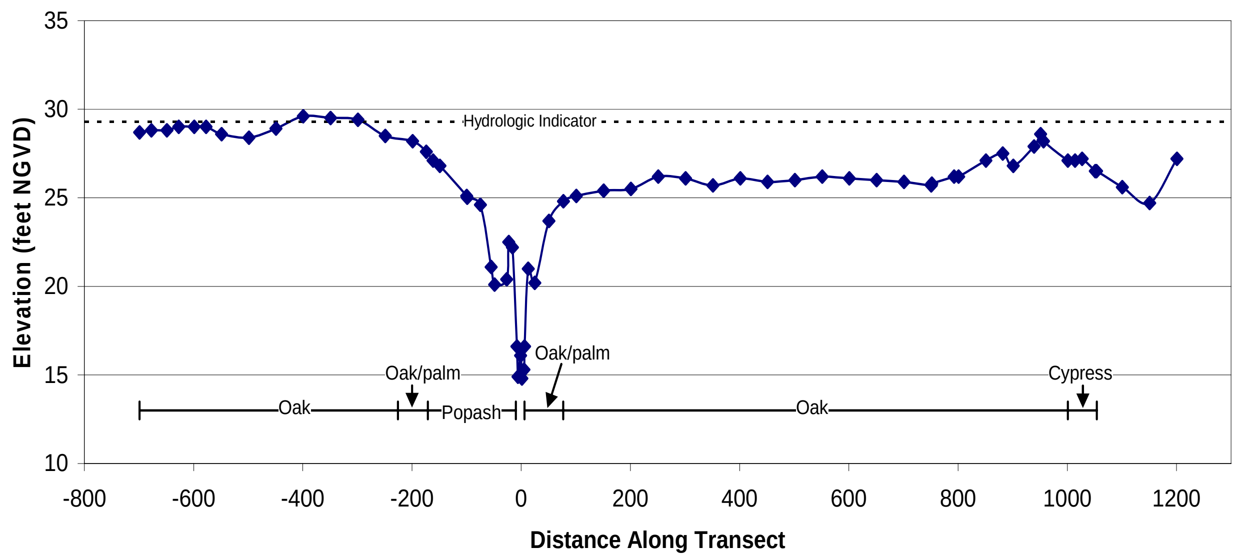
Anclote River Transect 2



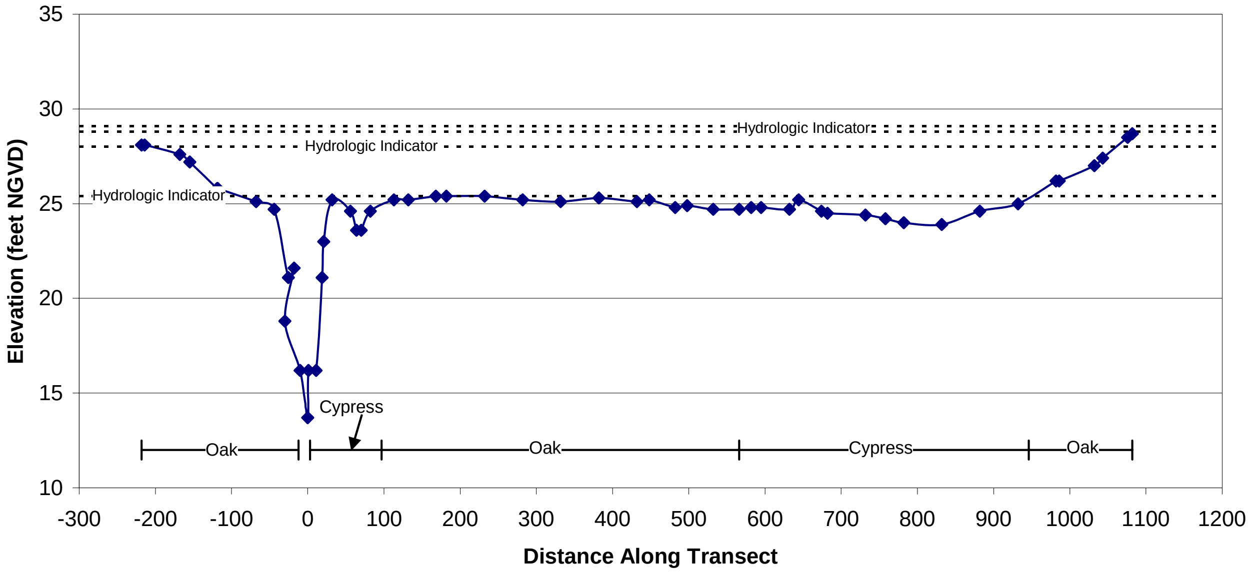
Anclote River Transect 4



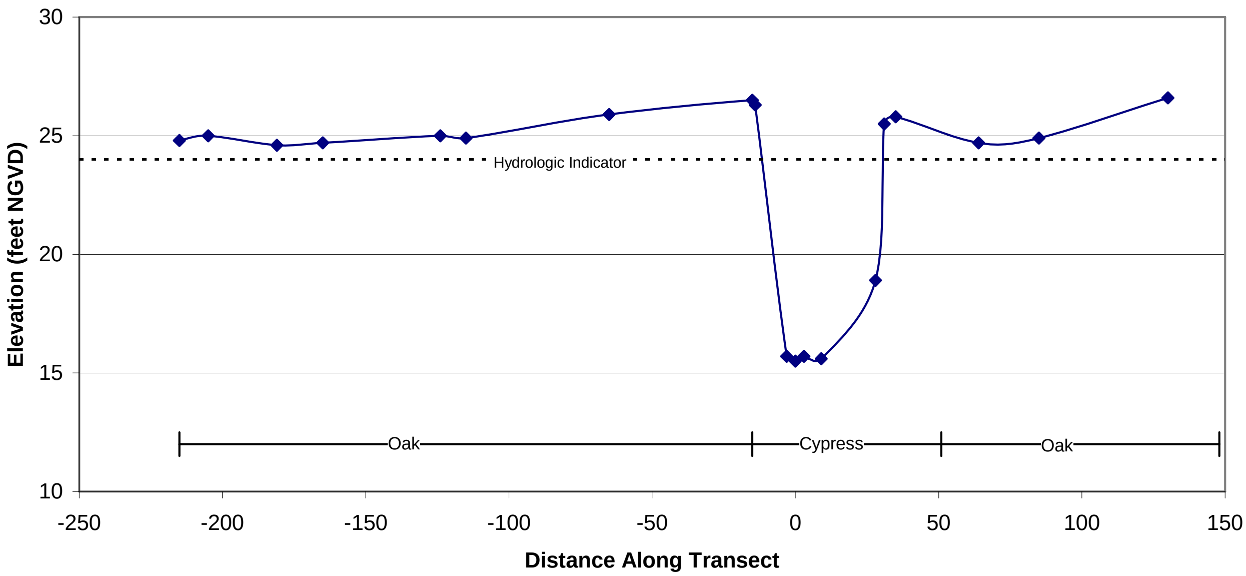
Anclote River Transect 6



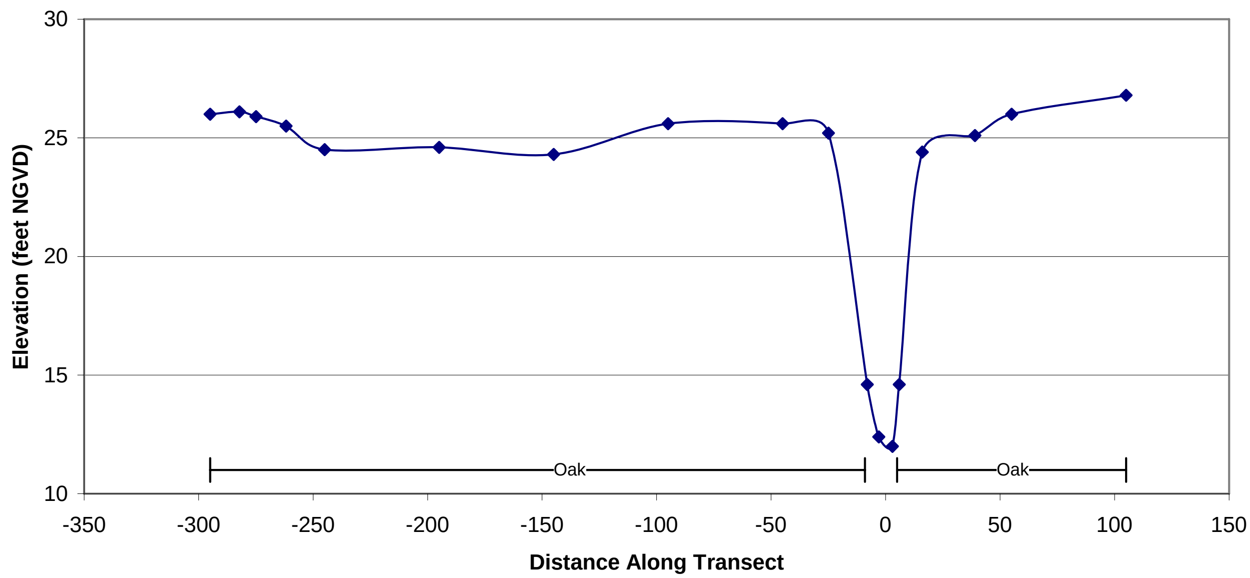
Anclote River Transect 7



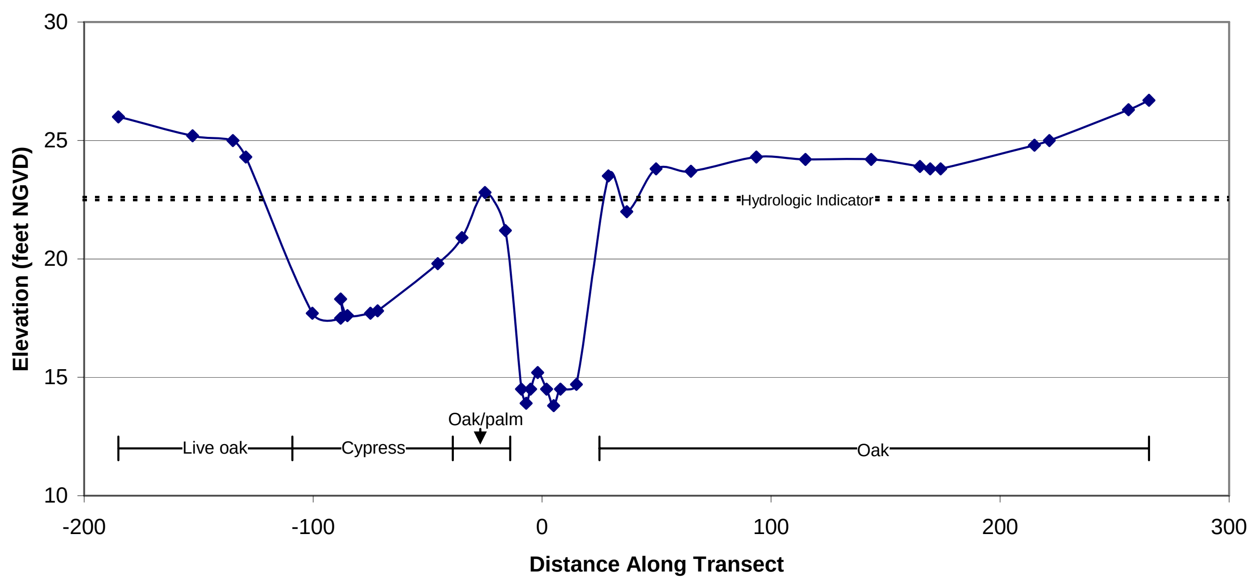
Anclote River Transect 8



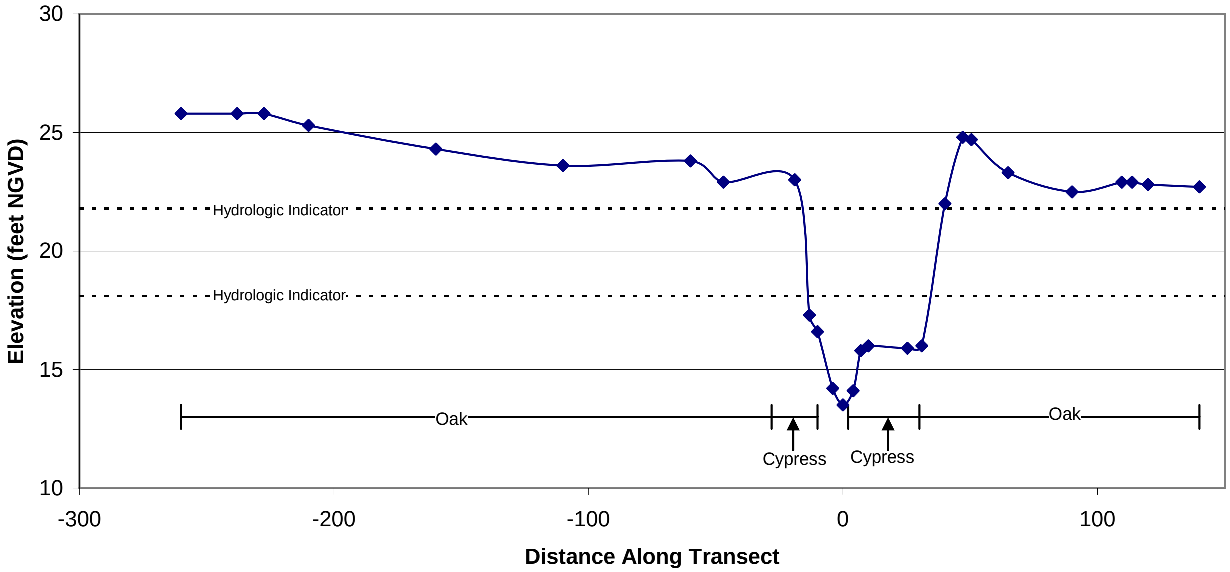
Anclote River Transect 10



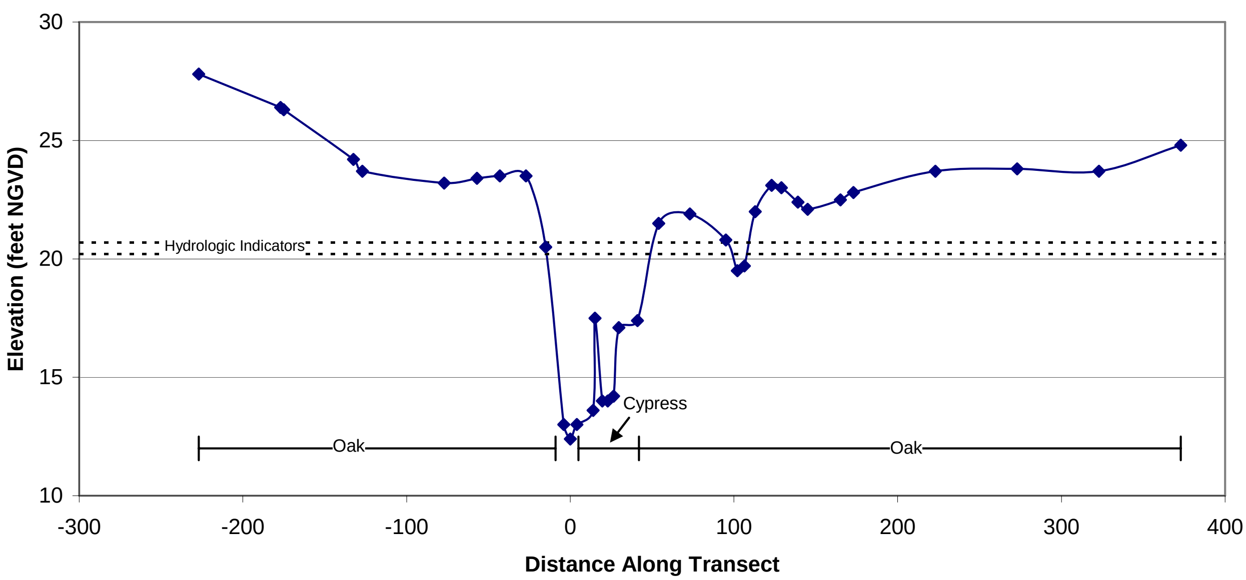
Anclote River Transect 13



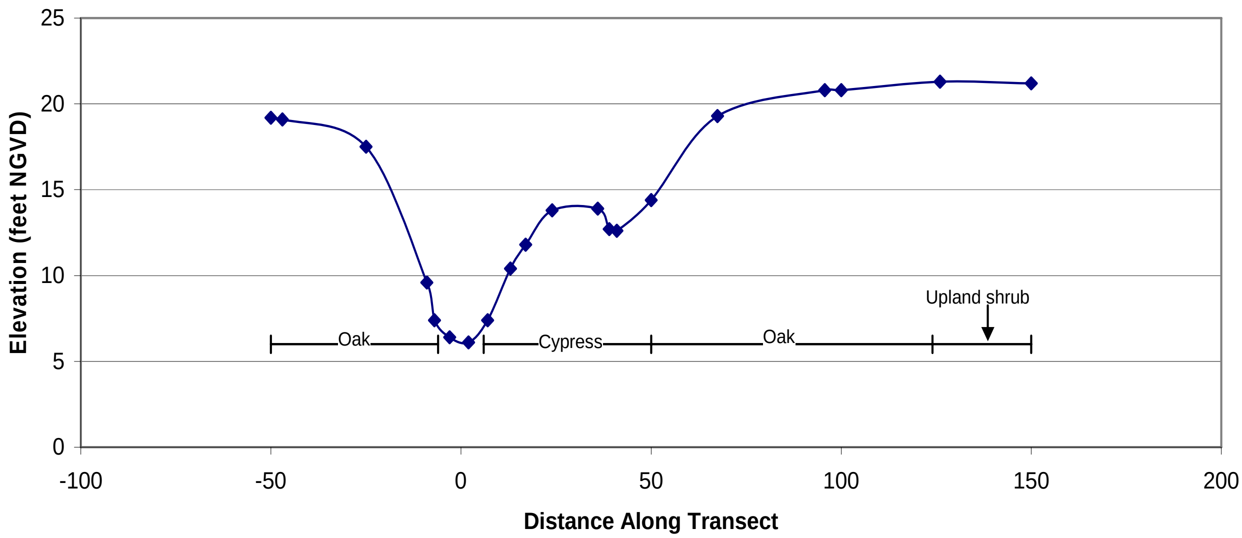
Anclote River Transect 15



Anclote River Transect 21



Anclote River Transect PHABSIM



IFIM/PHABSIM PROTOCOL

Anclote River

Started with IFG4 deck/file containing all transects and all calibration sets. These were entered from downstream to upstream with a dummy transect.

Three sets of transects were created:

- Abandoned Gauge site at 0.5571 cfs, 10.748 cfs, and 77.173 cfs (total simulated range: 0.2228 cfs – 154.34 cfs)
- Waterfall site at 1.403 cfs, 12.094 cfs, and 66.395 cfs (total simulated range: 0.5612 cfs – 132.79 cfs)
- Elfers site at 4.005 cfs, 15.608 cfs, and 68.313 cfs (total simulated range: 1.6002 cfs – 136.62 cfs)

The simulated flow ranges encompass all low flows during both wet and dry AMO periods (lowest flow = 3.7006 cfs, at a 50% reduction) but does not encompass a few of the highest flows (highest flow = 758.04 cfs at existing conditions). An appropriate regression (usually first- or second-order polynomial) was used during time-series analysis to create WUA values for the very high flows. Since these high flow values occur less than 5% of the time, they are unlikely to affect the overall estimate of MFL's at a 15% habitat loss.

The following codes were entered on the N/S lines:

CODE	DESCRIPTION
0	**Delimiter**
1	No cover and silt **or** terrestrial vegetation
2	No cover and sand
3	No cover and gravel
4	No cover and cobble
5	No cover and small boulder
6	No cover and boulder, angled bedrock, or woody debris
7	No cover and mud or flat bedrock
8	Overhead vegetation and terrestrial vegetation
9	Overhead vegetation and gravel
10	Overhead vegetation and cobble
11	Overhead vegetation and small boulder, boulder, angled bedrock, or woody debris
12	Instream cover and cobble
13	Instream cover and small boulder, boulder, angled bedrock, or woody debris

14	Proximal instream cover and cobble
15	Proximal instream cover and small boulder, boulder, angled bedrock, or woody debris
16	Instream cover or proximal instream cover and gravel
17	Overhead vegetation or instream cover or proximal instream cover and silt or sand
18	Aquatic Vegetation – macrophytes
100	**Delimiter**

The IFG4 predicted WSL's were placed in a (hand-made) table to be compared with observed WSL's for the given discharges on the CAL lines. The predicted WSL's were all within 0.2 ft of the observed values [accepted surveying error for the "tourch" technique] and IFG4 was considered to be an adequate predictor.

A second discharge is added to each CAL line (see A.51 from the PHABSIM user's manual). This second discharge is the calculated flow for that transect using the velocities measured. This is used as a secondary adjustment factor when predicting velocities and roughness coefficients.

The IFG4 input decks/files were then converted to several IFG4 input decks/files, each with a single velocity set, corresponding to measured calibration sets. The simulated discharges overlap but encompass the measured discharge for that calibration set.

	ABANA. in4	ANBANB.in4	ANBANC.in4
Simulated Discharge Range	0.2 – 13 cfs	9.5 – 95 cfs	75 – 155 cfs

	WATFA. in4	WATFB.in4	WATFC.in4
Simulated Discharge Range	0.5 – 13 cfs	9.5 – 90 cfs	70 – 155 cfs

	ELFA. in4	ELFB.in4	ELFC.in4
Simulated Discharge Range	1.6 – 9 cfs	7 – 110 cfs	90 – 140 cfs

For each *.IN4 model, an IFG4 run was made. VAF (Velocity Adjustment Factor) values are checked. The slope of the VAF values must be positive. The VAF value at the discharge for which the velocity set is given should be between 0.85 and 1.15. Ideally, such a tight fit allows expansion of the simulation beyond .4 x the lowest discharge and 2 x the highest discharge.

- Where VAF slope was a problem for a particular transect, WSL's are adjusted up or down [usually lowering WSL increases VAF value and increasing WSL decreases VAF value for given discharge] (based upon the range of WSL's [right bank, center, and left bank] measured in the field).

In all cases, VAF values were found to be acceptable, since all slopes were positive; although, some sites performed better than others; the Elfers site having the tightest predictive reliability and the Waterfall site having the least reliability.

	ABANA. in4	ANBANB.in4	ANBANC.in4
VAF Range			
• Tr 1	0.955 – 1.231	0.947 – 0.962	0.893 – 0.957
• Tr 2	0.268 – 7.747	0.798 – 2.661	0.955 – 1.017
• Tr 3	0.065 – 0.312	1.627 – 1.678	0.959 – 0.975

	WATFA. in4	WATFB.in4	WATFC.in4
VAF Range			
• Tr 1	0.537 – 0.879	.283 - .734	0.964 – 0.987
• Tr 2	0.309 – 4.079	1.224 – 4.296	0.748 – 0.977
• Tr 3	0.502 – 4.521	2.923 – 6.083	1.08 – 1.237

	ELFA. in4	ELFB.in4	ELFC.in4
VAF Range			
• Tr 1	1.046 – 1.128	0.878 – 1.056	1.01 – 1.046
• Tr 2	0.711 – 1.281	0.724 – 1.274	1.02 – 1.025
• Tr 3	0.906 – 1.093	0.856 – 1.263	1.047 – 1.136

[Note: the table of VAF values is presented after adjustment of Manning's "n" values for some data points}

After each *.IN4 file/model was calibrated to produce the best VAF's possible, the roughness values ("n") **calculated by IFG4** for each transect was checked. Those with values greater than 0.2 are chosen for adjustment. For each transect with some "n" values greater than 0.2, the mean value for "n" is calculated. Those "n" values above the median value are replaced with the mean value on the NS lines of the *.IN4 deck/file. This approach tries to adjust the worst problems without making drastic changes in WSL predictions and it is transect-specific [as compared to creating an NMAX line]. Professional judgment was also used, in some cases, to adjust other "n" values, where appropriate.

After "n" adjustments, IFG4 was run, again, with the adjusted roughness values and particular attention was placed on the predictions of velocities at the highest discharges. Each IFG4 output was checked for velocity "hot spots" at the high discharge simulations. Where predicted velocities exceeded 4.5 fps in a single cell **and** adjacent cells had low velocities, higher "n" values for that vertical/cell were added to the NS lines in the *.IN4 deck/file. This inserted "n" value was usually derived from the "n" values predicted by IFG4 for adjacent cells. When several contiguous cells had velocities that ranged from 3 to 6 fps (especially at high discharges), they were considered to be acceptable (i.e., **not** hot spots).

HABTAV was run with the appropriate HSI models for the "A", "B", "C", etc., models and the ZHAQF output files were examined. These contained habitat (WUA) versus discharge relationships for overlapping discharge ranges.

The overlapping ZHAQF values were combined on a spreadsheet (XCEL or SigmaPlot) into a single habitat versus discharge relationship. Weighted averages were used to combine the overlapping WUA values (these were different since different VAF values to adjust predicted velocities were not the same for comparable discharges in different runs). When an abrupt "jump" in the relationship occured, a plot of WUA/Q values is created and a curve smoothing routine (usually a third or fourth-order polynomial regression in SigmaPlot) was used for those values.

The WAU / Discharge results were prepared for the final report of WUA and Discharge and were the values used for time-series analysis.

Time-Series Analysis

Two sets of simulations were assessed, using Wet AMO Years (1955 – 1969 plus 1995 – 2006) and Dry AMO Years (1970 – 1994).

The TSLIB (time-series library) from the USGS Mid-Continent Research Laboratories was used to conduct the analysis.

Monthly discharge files were created for existing conditions, 10% monthly flow reductions, 20% monthly flow reductions, 30% monthly flow reductions, and 40% monthly flow reductions. For each set of discharge conditions, a monthly time-series was created as the amount of habitat (WUA) available for each discharge for each month. HAQ files (habitat availability) were created for the high discharge events by linear (first-order regression) or curvilinear (second-order polynomial regression) fits. Duration analysis was then accomplished through the percentage of time that the average and median habitat values were met or exceeded for each month over the period of record. Comparisons to existing conditions were made to evaluate the amount of habitat gain or loss under conditions of reduced flow.

During this analysis, habitat suitability curves for both “catalog” (USGS Blue Books of habitat suitability) and locally derived HIS’s were compared. Although the catalog and locally derived curves were quite similar, there was sufficient difference in at least one category of local preference (usually in substrate/cover preference, more often than not) that the predicted amount of available habitat was an order of magnitude less for Florida curves as opposed to catalog curves. This result supports conclusions by Gore and Nestler (1988) and Gore et al. (2001) who have indicated that habitat-specific derivations of suitability curves are the most appropriate application for this type of analysis.

Since predictions of less initial habitat availability are predicted in the PHABSIM runs for Florida curves, losses in smaller amounts of habitat result in larger incremental gains or losses in habitat. [For example if the catalog curves predict 2350 square feet of habitat under existing conditions (per 1000 linear feet of river) and the time series predicts a loss of 50 square feet of habitat, this results in a 3% habitat loss; however, if Florida curves for the same species predict only 235 square feet of habitat under existing conditions and the time series predicts only a loss of 20 square feet of habitat, the result is a 9% loss]. It should not be surprising, then, that some habitat gain / loss analyses are dramatically different using locally derived habitat information where a much lower initial habitat availability is predicted.

References:

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Gore, J.A., J.B. Layzer, and J. Mead. 2001. Macroinvertebrate instream flow studies after 20 years: a role in stream and river restoration. *Regulated Rivers* 17: 527-542.

Appendix 11-2. Protocol For Assessing Minimum Expected Long-Term Flow Statistics

The following procedure was used to develop the long-term reference flows described in Table 8-11.

Step 1. Apply freshwater MFL criteria to baseline (observed flow at USGS 02310000 – corrected for groundwater impacts) flow record. Tabulate flow remaining after MFL withdrawals

Step 2. Using remaining flow record from step 1, calculate the average flow for annual (calendar year) and seasonal (Blocks 1, 2, and 3) periods for years 1955 through 2006. (See Table 1.)

Step 3. Calculate 5 and 10 year moving averages for each period

Step 4. Locate minimum for each moving average period. (See Table 2.)

Step 5. Repeat steps 1 through 4 for median values.

Table 1 – Anclote baseline flow at USGS 02310000 after application of freshwater MFL

YEAR	ANN_MEDIAN	ANN_MEAN	B1_MEDIAN	B1_MEAN	B2_MEDIAN	B2_MEAN	B3_MEDIAN	B3_MEAN
1955	10.6	28.7	4.0	4.9	11.5	16.2	49.5	83.4
1956	7.0	18.0	4.7	4.6	7.3	12.4	20.1	45.8
1957	30.0	95.9	50.0	72.8	11.7	23.4	236.7	275.9
1958	58.4	92.8	22.2	44.1	79.2	125.1	51.2	82.6
1959	113.1	205.7	77.9	149.8	84.2	148.7	307.3	391.9
1960	44.5	178.6	13.5	47.2	35.4	132.9	206.7	431.4
1961	10.1	30.7	5.4	7.4	9.8	13.3	72.9	95.1
1962	12.0	40.3	4.5	9.8	11.3	12.0	96.3	136.3
1963	25.5	65.5	7.3	33.0	28.5	71.3	41.1	91.8
1964	34.3	123.1	9.4	14.4	34.7	88.2	203.2	326.2
1965	15.2	76.8	5.8	18.9	14.0	19.7	161.1	266.1
1966	28.0	58.9	10.6	21.9	19.4	43.6	95.1	135.0
1967	10.9	42.4	5.3	11.0	9.7	12.4	57.1	143.0
1968	13.4	65.1	6.2	47.2	12.0	29.8	62.3	161.3
1969	30.6	94.2	8.8	13.0	30.6	81.4	187.1	217.4
1970	17.8	74.5	9.3	11.0	52.2	99.8	36.4	96.7
1971	13.3	71.3	8.7	9.4	13.1	24.3	136.6	243.6
1972	14.3	25.0	6.2	14.6	14.4	27.0	24.6	33.2
1973	17.9	29.7	9.5	12.1	23.0	37.7	28.6	33.6
1974	14.4	92.2	6.3	114.0	12.5	14.9	239.9	229.0
1975	15.0	53.0	6.7	15.8	14.2	19.9	166.4	167.0
1976	19.3	51.6	37.9	93.2	14.3	16.3	58.7	76.9
1977	16.8	20.2	7.1	8.9	17.7	19.2	30.7	35.8
1978	20.6	52.1	9.7	29.8	19.4	41.0	54.7	101.8
1979	27.8	111.1	15.4	78.1	24.5	36.3	259.0	308.0
1980	16.5	21.6	12.0	15.4	15.4	20.3	32.7	31.8
1981	12.9	20.3	6.3	8.6	12.0	14.4	33.0	46.8
1982	37.1	106.2	14.0	104.8	28.1	40.3	191.6	246.8
1983	29.0	67.6	12.7	23.8	40.3	95.0	51.7	61.8
1984	44.1	62.2	15.1	38.9	40.0	55.8	80.6	103.7
1985	15.5	50.7	6.8	9.6	14.8	16.6	98.6	171.5
1986	37.5	72.8	9.0	21.2	37.0	66.7	89.9	147.0
1987	42.7	85.6	28.5	59.8	32.8	92.9	70.0	100.8
1988	25.5	92.7	9.4	10.4	28.9	62.5	68.3	254.4
1989	19.5	24.1	7.5	10.0	20.1	25.4	37.0	38.1
1990	16.3	32.4	6.9	35.3	14.1	18.6	49.9	58.1
1991	17.8	54.5	26.0	53.6	13.3	14.6	87.7	139.5
1992	18.0	38.8	7.2	9.7	17.3	20.2	63.4	112.6
1993	21.8	30.6	11.4	15.3	20.0	27.9	39.8	54.4
1994	19.5	36.2	7.0	9.8	18.7	22.7	72.7	96.2
1995	22.6	59.3	7.9	12.2	22.3	39.0	131.0	158.0
1996	34.4	42.5	22.9	29.7	25.7	46.0	43.5	50.5
1997	20.1	78.9	8.1	10.6	19.1	118.8	51.2	75.9
1998	41.9	147.7	12.0	13.8	97.7	194.4	81.6	208.5
1999	16.8	21.1	9.1	11.8	16.0	16.3	39.7	42.4
2000	14.9	25.0	7.3	9.9	14.2	14.9	63.2	64.3
2001	15.5	23.5	7.8	10.8	14.6	15.3	50.4	55.7
2002	21.6	84.5	7.7	22.2	18.4	86.4	129.8	154.4
2003	60.4	148.1	17.5	144.3	40.2	65.8	221.8	326.0
2004	31.0	160.7	12.2	26.4	29.1	44.6	365.2	566.1
2005	24.8	38.0	17.9	43.8	20.7	23.7	60.4	61.3
2006	16.3	23.9	7.7	10.5	15.0	19.2	41.2	49.8

Table 2. Five and ten-year moving average of mean period flows with minimum identified. (Equivalent for median period flows not shown for clarity)

YEAR	ANN_MEAN	B1_MEAN	B2_MEAN	B3_MEAN		ANN_MN5yr	B1_MN5yr	B2_MN5yr	B3_MN5yr		ANN_MN10yr	B1_MN10yr	B2_MN10yr	B3_MN10yr
1955	28.68	4.86	16.19	83.44										
1956	18.01	4.60	12.38	45.85										
1957	95.86	72.83	23.37	275.88										
1958	92.80	44.14	125.10	82.63										
1959	205.67	149.83	148.73	391.92		88.20	55.25	65.15	175.94					
1960	178.57	47.16	132.91	431.40		118.18	63.71	88.50	245.53					
1961	30.72	7.42	13.30	95.08		120.72	64.28	88.68	255.38					
1962	40.33	9.78	12.02	136.27		109.62	51.67	86.41	227.46					
1963	65.48	33.04	71.29	91.80		104.15	49.45	75.65	229.29					
1964	123.13	14.44	88.23	326.21		87.65	22.37	63.55	216.15		87.93	38.81	64.35	196.05
1965	76.84	18.86	19.70	266.06		67.30	16.71	40.91	183.08		92.74	40.21	64.70	214.31
1966	58.91	21.94	43.63	135.01		72.94	19.61	46.97	191.07		96.83	41.94	67.83	223.23
1967	42.43	11.04	12.37	143.04		73.36	19.86	47.04	192.42		91.49	35.76	66.73	209.94
1968	65.12	47.22	29.75	161.27		73.29	22.70	38.74	206.32		88.72	36.07	57.19	217.81
1969	94.18	13.05	81.44	217.40		67.49	22.42	37.38	184.55		77.57	22.39	50.46	200.35
1970	74.50	11.03	99.77	96.71		67.03	20.86	53.39	150.68		67.16	18.78	47.15	166.88
1971	71.26	9.41	24.31	243.62		69.50	18.35	49.53	172.41		71.22	18.98	48.25	181.74
1972	25.02	14.58	27.01	33.20		66.01	19.06	52.46	150.44		69.69	19.46	49.75	171.43
1973	29.65	12.10	37.71	33.56		58.92	12.03	54.05	124.90		66.10	17.37	46.39	165.61
1974	92.21	114.02	14.94	229.01		58.53	32.23	40.75	127.22		63.01	27.33	39.06	155.89
1975	53.00	15.76	19.89	166.96		54.23	33.18	24.77	141.27		60.63	27.02	39.08	145.98
1976	51.62	93.21	16.33	76.93		50.30	49.93	23.18	107.93		59.90	34.14	36.35	140.17
1977	20.20	8.91	19.18	35.78		49.34	48.80	21.61	108.45		57.68	33.93	37.03	129.44
1978	52.08	29.80	41.05	101.79		53.82	52.34	22.28	122.10		56.37	32.19	38.16	123.50
1979	111.13	78.14	36.25	308.01		57.61	45.16	26.54	137.89		58.07	38.70	33.64	132.56
1980	21.64	15.45	20.32	31.81		51.33	45.10	26.63	110.86		52.78	39.14	25.70	126.07
1981	20.34	8.57	14.42	46.77		45.08	28.17	26.24	104.83		**47.69**	39.05	**24.71**	106.38
1982	106.22	104.80	40.28	246.77		62.28	47.35	30.46	147.03		55.81	48.08	26.04	127.74
1983	67.55	23.79	95.00	61.77		65.38	46.15	41.25	139.02		59.60	49.24	31.77	130.56
1984	62.24	38.91	55.76	103.69		55.60	38.30	45.16	98.16		56.60	41.73	35.85	118.03
1985	50.74	9.58	16.64	171.46		61.42	37.13	44.42	126.09		56.38	41.11	35.52	118.48
1986	72.81	21.24	66.66	147.04		71.91	39.66	54.87	146.15		58.50	33.92	40.56	125.49
1987	85.59	59.76	92.93	100.84		67.79	30.66	65.40	116.96		65.03	39.00	47.93	131.99
1988	92.72	10.45	62.53	254.41		72.82	27.99	58.90	155.49		69.10	37.07	50.08	147.26
1989	24.10	10.04	25.38	38.13		65.19	22.21	52.83	142.38		60.40	30.26	48.99	120.27
1990	32.40	35.28	18.56	58.13		61.53	27.35	53.21	119.71		61.47	32.24	48.82	122.90
1991	54.47	53.59	14.57	139.52		57.86	33.82	42.79	118.21		64.88	36.74	48.83	132.18
1992	38.76	9.69	20.21	112.57		48.49	23.81	28.25	120.55		58.14	27.23	46.82	118.76
1993	30.57	15.30	27.88	54.37		**36.06**	24.78	21.32	**80.55**		54.44	26.38	40.11	118.02
1994	36.24	9.79	22.69	96.20		38.49	24.73	**20.78**	92.16		51.84	23.47	36.81	117.27
1995	59.28	12.16	39.00	157.96		43.86	20.11	24.87	112.13		52.69	23.73	39.04	115.92
1996	42.53	29.67	45.99	50.48		41.47	15.32	31.16	94.32		49.67	24.57	36.97	106.26
1997	78.86	10.64	118.78	75.86		49.50	15.51	50.87	86.97		48.99	19.66	39.56	103.76
1998	147.72	13.76	194.44	208.52		72.93	15.20	84.18	117.80		54.49	19.99	52.75	99.17
1999	21.13	11.81	16.29	42.40		69.90	15.61	82.90	107.04		54.20	20.17	51.84	99.60
2000	24.99	9.92	14.90	64.27		63.05	15.16	78.08	88.31		53.45	17.63	51.48	100.22
2001	23.48	10.83	15.33	55.68		59.24	**11.39**	71.95	89.35		50.36	**13.36**	51.55	**91.83**
2002	84.48	22.18	86.43	154.40		60.36	13.70	65.48	105.05		54.93	14.61	58.17	96.01
2003	148.09	144.30	65.77	325.96		60.43	39.81	39.74	128.54		66.68	27.51	61.96	123.17
2004	160.70	26.41	44.60	566.14		88.35	42.73	45.41	233.29		79.13	29.17	64.15	170.17
2005	37.99	43.79	23.67	61.25		90.95	49.50	47.16	232.69		77.00	32.33	62.62	160.50
2006	23.95	10.55	19.20	49.82		91.04	49.45	47.93	231.51		75.14	30.42	59.94	160.43
2007	20.59	9.79	17.39	40.48		78.27	46.97	34.13	208.73		69.31	30.33	49.80	156.89