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ISOP Monitoring Results: 2000-2001

An Analysis of Hydrologic Parameters within the mangrove zone of northeastern Florida Bay and Their Impacts on Resident Fishes, and Roseate Spoonbills

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ABSTRACT

In November 1999, the U.S. Army Corps of Engineers terminated the Experimental Program of Water Deliveries (EPWD) to Everglades National Park and adopted the Interim Structural and Operational Plan (ISOP) as an emergency measure designed to protect the Cape Sable Seaside Sparrow while still providing adequate water supplies to the Park. The impact of implementing the ISOP on the hydrology, hydrography and ecology of the mangrove wetlands of northeastern Florida Bay was examined for the hydrologic year 2000-01. An evaluation of 23 years of rainfall data indicated that 1991-92 was spatially, temporally and quantitatively similar to 2000-01. In 2000-01 water management operations were dictated by the ISOP, while in 1991-92 operations were dictated by Test 5 of the EPWD. Comparison of these two years allows for a statistical comparison of the two operational plans.

Hydrology, hydrography, fish community structure, fish abundance, and Roseate Spoonbill nesting patterns were examined in this effort. Based on the statistical analyses performed, we fail to reject the null hypothesis (that 1991-92 and 2000-01 did not differ in physical and biological independent variables i.e., salinity, water level, fish abundance and community structure, spoonbill nesting number and success) and conclude that there was no difference between the ISOP and Test 5 under a rainfall regime similar to 2000-01.

That the ISOP and Test 5 resulted in virtually identical environmental and ecological conditions in the coastal wetlands is a reason for concern. Test 5 was the operational plan when Florida Bay went through it's well-publicized "ecological collapse" in the late 1980's and early 1990's. In the intervening years between Test 5 and the ISOP the overall health of Florida Bay has widely been perceived to have improved. The ISOP may reverse the observed positive trends. A solution would be to

expedite implementation of the C-111 and Modified Water Deliveries Projects, and acceleration of the Southern Everglades CERP projects . We believe this would end the current impasse and allow for enough operational flexibility that sparrow protection and Florida Bay restoration would not be at odds.

I. INTRODUCTION

Implementation of Test Iteration 7 of the Experimental Program of Water Deliveries (EPWD) to Everglades National Park (ENP) began October 1, 1995 (USACOE 1995). The Environmental Assessment (EA) for Test 7 spelled out the design and terms of the test iteration. The EA specified that an integral part of the test was the establishment of a monitoring program to assess ecological responses during the period of Test 7. Four criteria were used to rate various potential monitoring projects (USACOE 1995). Primary among the criteria was the potential sensitivity of the monitoring protocol to hydrological change. The other three criteria were; 1. the existence of baseline data so that evaluations could be made, 2. relevance to ecological modeling efforts (specifically the ATLSS modeling effort) and 3. significance to Section 7 of the Endangered Species Act. Based on these four criteria, the Audubon of Florida's Estuarine Research Project (ERP) was rated as essential to the Test 7 monitoring program (USACOE 1995) and was subsequently contracted by the U.S. Army Corp of Engineers (USACOE) and ENP. Under the auspices of the Test 7 monitoring program, the charge to the ERP was to evaluate the relative impact of Test 7 on the fishes of the mangrove transition zone between the fresh water environs of the Taylor Slough/C-111 basins and Florida Bay.

In November 1999, the USACOE terminated the EPWD to ENP because of potential negative impacts that Test 7 was projected to have on populations of the federally endangered Cape Sable Seaside Sparrow (CSSS). In lieu of Test 7, the USACOE adopted the Interim Structural and Operational Plan (ISOP) as an emergency measure designed to protect the CSSS while still providing adequate water supplies to ENP (USACOE 2000). Although this emergency plan superseded Test 7 operations, the USACOE and ENP continued to contract with the ERP to monitor the impact of ISOP implementation on the coastal wetland ecosystem of Florida Bay. This document reports the findings of this on-going monitoring effort for the 2000-2001 hydrologic year (June 1, 2000 – May 30, 2001).

II. BACKGROUND INFORMATION

The ecotone between the freshwater Everglades and the marine environment of northeastern Florida Bay is a relatively narrow (=5km) band of coastal mangrove forest. Receiving influences from both freshwater and marine systems, this mangrove ecotone has the capacity to reflect ambient conditions in both major ecosystems and, is therefore, an ideal habitat for evaluating anthropogenic impacts on the larger hydroscape. The primary goal of the ERP is to investigate the impact of upstream water management practices in the Taylor Slough and C-111 basins on the downstream mangrove ecosystem. To this end, the ERP has established four field locations within the mangrove ecotone at which physical and biological parameters are sampled using scientific methodologies. Salinity and water level data are the principal parameters used to evaluate the physical environment while aspects of the resident demersal fish community are used to evaluate within ecosystem function. This fish community is the primary prey base for myriad predators (e.g. piscivorous birds, fishes, reptiles and amphibians). Roseate Spoonbills are a conspicuous bird species that depend on this prey source in order to nest successfully in nearby northeastern Florida Bay (Lorenz et al. 2002). Therefore, Roseate Spoonbill nesting parameters are also monitored as part of the ERP so as to evaluate the linkages between biotic function with the mangrove ecotone and the surrounding hydroscape.

Importance of mangrove fishes. The community of small fishes that thrive in the mangrove areas north of Florida Bay are a vital food source for a variety of important animal species. In addition, these prey base fishes are excellent indicators of ecosystem health because they have naturally high rates of reproduction and mortality (their life span can be as short as 3 months). Consequently, the community will quickly show quantifiable changes in response to changes in habitat quality. These fishes are also useful as indicators because their small size limits movement. As a result, they spend their entire life cycle within the mangrove habitat and are termed resident mangrove fishes. In contrast, many of the larger fish species, birds and reptiles that are used as indicators of ecosystem health are wide ranging. This allows them to move to more favorable secondary habitats when conditions deteriorate in their primary habitat. These mangrove transients may not accurately reflect short term perturbations in the mangrove system. Since the resident fish community cannot leave the system when adverse conditions arise they better reflect changes in mangrove hydrology.

Description of fish sampling sites The eastern most fish sampling site was located outside of ENP on Biscayne Bay near the western end of Card Sound Bridge on Barnes Sound (BS: 25° 17.65N by 80° 24.57'W). This site was impounded by roadbeds and received no freshwater sheet flow from the Everglades, therefore, all freshwater input to BS was from local rainfall or groundwater seepage. As a result, water management operational changes have only minimal impacts on the hydrology of this site, i.e., this location is considered the control site when examining the impacts of water management.

The other three sampling sites were located just north of Florida Bay in the Taylor Slough/C-111 drainage area of ENP (Figure 1). These sites were located north of Little Madeira Bay on Taylor River (TR: 25° 13.20'N by 80° 39.00'W), north of the eastern end of Joe Bay (JB: 25° 15.00'N by 80° 31.92'W), and on a tributary west of Highway Creek (HC: 25° 15.25'N by 80° 27.28'W) near US Highway 1. General areas for site locations were selected based on the potential to show differences in the prey base community due to the influence of natural fresh water Everglades sheet flow. Specific sampling sites were selected based on close proximity (within 1 km) to ENP hydrological monitoring stations so that the data collected by these stations could be used to interpret the results of fish collections.

Historically, the amount of fresh water these sites received from the Everglades presumably decreased from west (TR) to east (HC) based on site proximity to Taylor Slough. However, the natural sheet flow pattern of the Everglades has been largely disrupted by canalization. Since about 1983, the amount of fresh water received at TR, JB and HC has primarily been determined by water management operations (Johnson and Fennema 1989). Fresh water sheet flow now reaches northeastern Florida Bay via both Taylor Slough and the C-111 canal. Water from the C-111 exits the canal across the now degraded southern levee on the lower (east to west) reach of the canal ultimately resulting in sheet flow into northeastern Florida Bay (Lorenz 2000). Between 1983 and 1990, about 90% of water arriving at Florida Bay was delivered via the C-111 canal (Johnson and Fennema 1989, Ley et al. 1995). Because the eastern end of the canal was at a lower elevation than the central or western regions, most of this water exited the canal near US-1. This resulted in the majority of fresh water being delivered to the Highway Creek (the HC site) region of Florida Bay with decreasing amounts of fresh water being delivered to the bay at more western locations. Starting in about 1990, a series of operational changes were made concerning the C-111 canal so that a more equitable distribution of water was delivered across the northeastern coast of Florida Bay (Ley et al. 1995). These changes resulted in a variety of hydrological regimes at the three Florida Bay mangrove sampling sites since 1990 (Lorenz 2000).

All sites were located in similar dwarf mangrove habitat and each was characterized by a deep central creek surrounded by shallow flats that became seasonally exposed. Vegetation consisted of widely spaced (0.5-5.0 m between plants) dwarf red mangrove (<u>Rhizophora</u> <u>mangle</u>) trees (0.5-2.0 m tall) with varying amounts of vegetation between trees. Growth of <u>Eleocharis</u> sp., <u>Utricularia</u> sp. and <u>Chara</u> sp. was seasonal. The substrate for all sites was flocculent, unconsolidated, carbonate marl (Browder et al. 1994).

<u>Hydrologic cycles.</u> The mangrove ecotone of northeastern Florida Bay does not experience a lunar or diurnal tide (Holmquist et al. 1989). The annual cycle of water depth change in the mangrove swamp is controlled by three factors that cycle seasonally: sea level, wind, and rainfall (Figures 4A, 5A, & 6A provide examples of the annual water level cycle at three sites for two years). Starting approximately in June, water levels climb throughout the summer months and peak in late September or early October. Water levels typically decline through October and November culminating in dry season conditions from January through April or May. Salinity follows a similar but inverted pattern to water level (Figures 4B, 5B, & 6B also provide examples of the annual salinity cycle at three sites for two years). Salt concentrations are typically highest in late May or early June and rapidly decline with the onset of the wet season in June. With the exception of relatively brief pulses in salinity in the early wet season (usually only occurs in dry years), salinity remains low throughout the wet season and is typically at or near freshwater conditions from September through December. Salinity begins to pulse upward in December and typically a steady and sustained climb begins in January or February which continues through to the beginning of the wet season. Although still apparent, the cycles in water level and salinity at the BS site (Figure 7) are dampened due to lack of freshwater input caused by the impoundments of US-1 and Card Sound Road. Because the natural break point in the annual hydro-cycle is the initiation of the wet season, all analyses focus on the hydrologic year (June to May). These stereotypic cycles are affected by a high degree of spatial, inter-annual and intra-annual variation of physical conditions in the mangrove zone.

Results from previous fish collections. Several studies of fishes in southern Florida freshwater wetlands have demonstrated that seasonal fluctuations in water level have a dramatic effect on the fish community (Higer and Kolipinski 1967; Kushlan 1980, Duever et al. 1986, Loftus and Kushlan 1987, Loftus and Eklund 1994, DeAngelis et al. 1997, Lorenz 2000). The paradigm postulated by these studies was that during high water periods, fishes utilize expansive ephemeral wetlands as foraging grounds and refugia from predation (Kushlan 1980, DeAngelis et al. 1997, Lorenz 2000). This exploitation of periodically flooded areas results in exponential increases in fish abundance (Loftus and Eklund 1994, DeAngelis et al. 1997). During the dry season, wetland surfaces become dry and fishes either become stranded or are forced into deeper areas (Kushlan 1978, Kushlan 1980, Loftus and Kushlan 1987, Loftus and Eklund 1994, DeAngelis et al 1997, Lorenz 2000). This "concentration effect" exposes the wetland fishes to high rates of mortality due to strandings, adverse physical conditions (e.g. low dissolved oxygen and high temperatures) and heavy predation from a variety of piscine and avian predators (Hunt 1952, Kushlan 1978, Master 1989, Master 1992, DeAngelis et al., 1997, Lorenz 2000).

According to this paradigm, length of hydroperiod is a major abiotic factor in determining Everglades fish abundance and community structure (Kushlan 1976a, Kushlan 1980, Loftus and Kushlan 1987, Loftus and Eklund 1994, Lorenz 1999, Lorenz 2000). In the freshwater Everglades, Kushlan (1976b) indicated that prey fish start to become concentrated in pond habitats at about 10-20 cm depth relative to the depth at which the surrounding wetland became dry. Lorenz (2000) performed a more rigorous analysis of the depth/fish concentration relationship at the four mangrove sites and found that fish begin to be forced from the wetland surface and become concentrated in the deeper creek habitat at about 12.5 cm relative to the deepest part of the flats (i.e., that immediately adjacent to the creek). Based on these findings, hydroperiod in the coastal wetlands was defined as the continuous time period that water levels exceeded 12.5 cm relative depth.

Fish collections made between June 1991 and May 1999 were analyzed in conjunction with hydrologic data (Lorenz 1999, Lorenz 2000). Analyses focused on the impact of fluctuating salinity, water level and temperature on the fish community in order to better understand the impact that flow manipulation has had on the ecotone. Regression analysis indicated that fish density was significantly related to both short term and long term changes in water level. Analysis of variance of density between sites supported the regression, indicating that longer hydroperiod sites had higher densities than sites with shorter hydroperiods. Changes in biomass were primarily related to long term salinity conditions and secondarily to long term changes in water level. Analysis of variance of biomass between sites indicated that sites with longer freshwater periods had higher biomass than sites with shorter freshwater periods. Detrended Correspondence Analysis (DCA) of community biomass supported the hypothesis that salinity was a primary determinant of community structure. (These relationships are reflected in Figures 4-7 where mean density estimated from fish sample collections is presented with water level [Top Panels: A] and estimated mean biomass is presented with salinity [Bottom Panels: B]).

These results indicated that anthropogenic changes in water delivery could have negatively impacted the ecotonal prey base. The implication is that decreased freshwater flow to Florida Bay may have eroded the ecosystems trophic structure from the bottom up. This situation is potentially reversible: changes in the quantity of fresh water and the timing of deliveries to the mangrove zone via Taylor Slough and the C-111 canal could create longer hydroperiods in the mangrove zone. Longer hydroperiods would also reduce salt water intrusion into the area, and may help re-create the higher secondary productivity that was once associated with the Everglades/Florida Bay interface.

Results from Roseate Spoonbill studies. Surveys of Florida Bay's Roseate Spoonbill nesting population conducted since 1950, indicate that spoonbills relocate nesting effort and experience reduced nesting success in response to anthropogenic perturbations to their foraging grounds (Lorenz et al. 2002). Birds nesting in northeastern Florida Bay primarily forage in the coastal wetlands from western Taylor Slough to Turkey Point. Starting in the mid-1980s the number of nests in the northeastern basin began a steady decline. In 1999, less than 22% of Florida Bay's spoonbills nested in these colonies, down from the approximately 60% that nested between 1967 and 1982. Nesting success in the northeastern colonies had decreased from an average of 1.4 chicks per nest between 1966 and 1982 to an average of less than 0.7 after 1984. Concurrent with this decline in the northeastern colonies, the percentage of nests in the three colonies of the northwestern region of the bay increased from less than 20% prior to 1984 to 53% in 1999. Likewise the number of nests found in the six colonies from the central region increased from only a few nests per year to more than 10% of the total nests. The average success of these colonies from 1984 to 1999 was 1.2 chicks per nest. The decline in nesting effort and nesting success in the northeastern bay and the shift to nesting in other regions indicates a degradation of the foraging grounds in the coastal wetlands associated with Taylor Slough and the C-111 basin (Lorenz et al. 2002). As mentioned above, analyses of the prey-base fish community in these wetlands indicated that water management practices since the mid-1980s have adversely impacted the abundance and availability of prey species for spoonbills. These results indicate that Roseate Spoonbills respond in a predictable manner to impacts caused by changes in water management and are, therefore, a good indicator species for the overall health of the Florida Bay estuary. Changes in water management designed to restore more historic hydrologic regimes should improve conditions for spoonbills by making prey both more abundant and more available. Therefore, water management activities can be evaluated based on spoonbill responses.

Expected impact of the ISOP. Beginning in the early 1980's, water management practices resulted in lower water in the Taylor Slough drainage during the wet season and higher water during the dry season (Johnson and Fennema 1989). This alteration in the natural hydrologic cycle has disrupted this annual cycle of growth and concentration in the prey base fish community (Lorenz 2000). A stated goal of Everglades restoration is to re-establish seasonal extremes in water level to historic conditions (Ogden et al. 1999). Therefore, a desirable outcome of any water management protocol would be higher water levels during the wet season and lower water levels during the dry season while the opposite would be considered undesirable.

The EPWD was expressly designed to accomplish this goal. As stated in the Corps of Engineers' Environmental Assessment, Test 7 of the EPWD was designed "to restore and maintain the natural abundance, diversity and ecological integrity of ENP, including Florida Bay, by attempting to restore the hydrology of park lands to a situation that resembles the pre-drainage condition" (USACOE 1995). Unfortunately, previous results from the ERP indicate that this goal was not realized (Lorenz et al. 2000).

Although, the primary goal of the ISOP was to protect CSSS populations, the USACOE maintained that ISOP operations will be beneficial to ecosystems in the Taylor Slough watershed because of increased freshwater flow to the slough (USACOE 2000). Since the EPWD failed to restore natural hydrologic flows to Florida Bay (Lorenz et al. 2000), it is possible that the ISOP would improve conditions in the coastal wetlands compared to conditions during the Experimental program. The goal of this report is to evaluate the impact of the ISOP by comparing conditions following implementation of the ISOP to previous conditions under the Experimental Program.

Hydroperiod and salinity at mangrove sites are affected by both rainfall and water management. The strategy used in this report to evaluate the ISOP is to identify a year similar in rainfall pattern to the reporting year (June 2000-May 2001). Once a comparable rainfall year has been identified, comparisons of mangrove hydrology and aspects of the fish community and Roseate Spoonbill nesting patterns can be made between the two years to see what effects, if any, the ISOP had on the coastal wetland ecosystem.

Statistical notes. Critical regions for all Analyses of Variance (ANOVA) were set at the traditional $p<0.05$. Multiple means separations were performed for each significant ANOVA. Unless otherwise indicated, the critical region for *post hoc* tests was set at $p<0.01$ thus reducing the likelihood of increased Type I errors caused by multiple *post hoc* tests (Sokal and Rohlf 1980). The post hoc test used was Tukey HSD test for unequal sample sizes (Statsoft 1995).

III. RAINFALL COMPARISONS BETWEEN YEARS

Methods. The National Oceanic and Atmospheric Administration operates rain collection gages at 25 locations across southern Florida (Table 1) and publishes the data in annual summaries for the state. Analysis of Variance was used to analyze twenty-three annual hydrologic cycles (June 1978 - May 2001) of mean annual rainfall data from the 25 stations (i.e., one datum per year per location) in an effort to identify years with similar annual rainfall quantities to 2000-01

Although the total quantity of rainfall across south Florida is critical to understanding hydropatterns in the southern Everglades, the timing of rainfall is more important when making comparisons between years. Correspondence Analysis (CA) (ter Braak 1995) was performed on mean monthly rainfall for each of the 25 locations (i.e., one datum per month per location) in an effort to analyze intra-annual rainfall patterns from years that ANOVA identified as having similar rainfall quantity to 2000-01. Once the CA identified a year of similar spatial rainfall patterns, ANOVA was used to evaluate any temporal differences between the subject years.

Results and Discussion. Results of the ANOVA of annual rainfall indicated that there was a significant year effect ($F_{22,512}=14.34$, $p<0.01$). The results of *post hoc* analysis of the least squares means (Figure 2) indicated that 7 out of 22 years were not significantly different ($p<0.05$) from 2000-01 in total rainfall across southern Florida (Figure 2). The results also indicate that 2000-01 was a dry year overall.

To determine similarities in temporal rainfall patterns among these 8 years (2000-01 and seven similar years), CA was performed on the mean monthly rainfall from all 25 collection locations. The primary and secondary axes accounted for 34.6% and 23.1% of the temporal variability in rainfall across southern Florida, respectively. In essence, the CA ordination technique condenses a distribution of data into a single point on a two dimensional graph. When plotted, points that are relatively close to each other represent distributions with similar patterns. Figure 3A indicates that out of the seven years with similar total rainfall, 1991-92 had the closest monthly rainfall distribution to 2000-01. (In Figure 3A, 1985-86 appears closer than 1991-92 to 2000-01, however, Axis 1 accounts for more variability and 1991-92 is much closer to 2000-01 on Axis 1. Therefore 1991-92 is more similar to 2000-01 than is 1985-86. This was confirmed by calculating a distance adjusted for axis weight: 1985-86 was 9.4 units from 2000-01 while 1991-92 was only 8.4 units distant).

The results of correspondence analyses are somewhat subjective in that similarities and differences are relative to the distributions included in the analyses. Figure 3A indicates that 2000-01 was more similar to 1991-92 than to any other of the 7 years used in the analysis, however, it does not actually indicate how similar the two years were in actual spatial and temporal rainfall patterns. Direct comparisons between years can be made through a two-way ANOVA of year and month across the 25 sampling sites. The results indicate a significant interaction ($F_{11,540}$=8.97, $p<0.01$), i.e., the two years were significantly different in aspects of the temporal-spatial rainfall pattern. The results of the *post hoc* tests (Figure 3B) indicated that the two years were, overall, very similar in temporal rainfall pattern, with only two months (June and May) having significantly different amounts of rainfall between the two years.

The combined results of the Analyses of Variance (Figure 2, Figure 3B) and the Correspondence Analyses (Figure 3A) indicate that 2000-01 and 1991-92 were very similar in rainfall intensity on both temporal and spatial scales. In 1991-92, water management operations were dictated by the Test 5 of the EPWD protocol while 2000-01 operations were determined by the ISOP. The similarity in rainfall between the two years allows for a direct comparison between the impacts of the two operational plans on the physical and biological components of the coastal wetland ecosystem. The main assumption of this design is that, in the absence of changes in water management practices, years with similar rainfall patterns should result in similar salinity and water level patterns in the mangrove zone. Therefore, any observed differences in salinity and water level between 1991-92 and 2000-01 would be the result of changes in water management practices, i.e., the switch from EPWD to the ISOP.

Changes in the fish community could also be attributed to differences in water management since fish abundance and community structure have been linked to salinity and water level (Lorenz 1999, Lorenz 2000). Likewise, spoonbill nesting patterns can also be attributed to altered hydrologic regimes (Lorenz et al. 2001). Therefore, based on the above analysis of rainfall patterns, the null hypothesis for the remainder of this report is that 1991-92 and 2000-01 did not differ in physical and biological independent variables (i.e., salinity, water level, fish abundance and community structure, spoonbill nesting number and success). In this comparison, BS (the only site outside ENP) can be considered a control site since it was not impacted by either operational plan (due to the fact that the US-1 roadbed blocks sheet flow to BS from the upstream sources that would be impacted by the plans). Should the null hypothesis be rejected, a reasonable conclusion might be to attribute any differences in physical or biological parameters between the two years at the experimental sites to the differences between the two operational plans.

However, the main assumption (that all observed changes would be caused by water management) may not be fully accurate. For example, wind speed and direction have been shown to be causal agents in determining mangrove water levels, especially during the dry season (Baratta and Fennema 1994, Holmquist et al. 1989, Lorenz 2000). Although such events would be relatively short lived and the impact negligible when comparisons are made over a full year, the combined impact of non-management related impacts can not be fully discounted. These and other alternative explanations for observed differences in mangrove zone parameters will discussed in more detail below.

IV. WATER LEVEL AND SALINITY IN THE COASTAL WETLANDS

Methods. Beginning in November 2000, hydrostations created by Remote Data Inc. were established at the sampling sites. These hydrostations use Hydrolab sensors to continuously monitor water level and salinity. Daily averages were used directly in statistical analyses. Any missing data was supplemented with ancillary data as described in subsequent paragraphs. Prior to November 2000, water level and salinity data were collected as follows.

Water levels were continuously monitored at each site using a Telog brand 2108 potentiometric recorder with a float and pulley design. Accuracy of the equipment was checked by comparing the current measurement of the recorder against a nearby staff gauge each time the system was downloaded. Gaps in the water record were supplemented with regression adjusted data from the nearby ENP hydrostation. Regression models between the Telog data and ENP hydrostations at TR, JB, HC and BS explained 98%, 88%, 86%, and 95% of the variability, respectively. All regression equations were significant ($p<0.01$) and a review of residuals indicated that none of the assumptions for regression analysis were violated. Water level was analyzed using a 2-way ANOVA to determine the difference between 1991-92 and 2000-01 for both months and sites. There was no water level recording devise established at BS prior to February 1992. The lack of data for most of the subject year precluded using any data from BS in the analysis of water levels.

Salinity was measured at the site on the day of fish collections using an optical refractometer. These data were strongly correlated to the data recorded by the nearby ENP hydrostations, however there were differences between the two methods. Therefore, the continuous records from the ENP hydrostations were refined to better reflect conditions at the sites through the application of regression models. The hydrostation at TR was located immediately adjacent to the site and was found to be strongly correlated with the refractometer data ($r^2=0.96$). Breakpoint regression was used to convert hydrostation data at JB and HC because the relationship between the refractometer and hydrostation changed between the wet and dry seasons. The breakpoint and regression equations were derived using the computer program 'Statistica' (Statsoft 1995). The conversion models generated by this method explained 92% and 84% of the variability between the refractometer and hydrostation data sets for HC and JB respectively. All regression equations were significant ($p<0.01$).

Unlike water level, BS salinity data was available for most of the 1991-92 cycle year and, was therefore, included in the salinity analyses. Salinity at BS was found to fluctuate diurnally with tidal exchange. As a result, the correlation between the single refractometer reading collected on the day of fish collection and the average daily salinity generated by the hydrostation were not as clear as at the other sites ($r^2=0.54$). However, based on close spatial proximity, conditions recorded at the hydrostation were assumed to accurately reflect conditions at the site. The strong relationship between mean daily water level recorded at the station and the site ($r^2=.95$) lends strong support to this assumption. Therefore, the salinity regression was used as a predictor of on site salinity. Although the low precision of this model may result in slight miscalculations in the estimation of on site salinity on a daily level, the impact this has on the long term trends are likely to be insignificant. Salinity was analyzed using a 2-way ANOVA to determine the difference between 1991-92 and 2000-01 for both months and sites.

Results. Average daily water level and salinity for each site and each subject year are presented in Figures 4-7. The ANOVA of water level revealed significant two-way interactions between Month and Year ($F_{11,2070}$=44.18, $p<0.01$). The *post hoc* test indicated that there were significant differences in water levels between the two years for June and for most of the dry season (December-April; Figure 8A). There was no interaction between Sites and Years ($F_{2,2088}$=2.2, p=0.12), however there was a site effect ($F_{2,2088}$=20.3, $p>0.01$) with TR having significantly higher water level than either JB or HC (Figure 8B).

The ANOVA of salinity revealed significant two-way interactions between Month and Year ($F_{11,2854}$=5.01, $p<0.01$) and between Site and Year ($F_{3,2870}$=48.7, $p<0.01$). Means separations of the Month and Year interaction (Figure 9A) indicated that salinity was significantly different between the two years for only four of the twelve months (September, October, January, and May). The general trend indicated by the post hoc tests was that salinity was consistently higher in 1991-92 compared to 2000-01 (Figure 9A). Looking at annual means by site (Figure 9B) HC and BS were significantly more saline in 1991-92, while there was no appreciable difference between years at TR or JB.

Discussion. In general, water levels in the mangrove wetlands were no different between the two years during the wet season (Figure 4A), however, there were marked differences during the dry season. Initially, dry season water levels were lower during 1991-92 (December) however, record drought conditions in January and February 2001 (SFWMD Surface Water Reports) resulted in unprecedented low water within the coastal wetlands. In mid-to-late March 2001, 2 separate rainfall events brought some drought relief (SFWMD Surface Water Reports). Although March rainfall was not significantly different between years (Figure 3B), operations under the ISOP in 2000-01 may have exacerbated the impact of March rainfall by shunting water toward the coastal areas in order to avoid flooding CSSS habitat. The end result was that, on average, water levels at the sites increased by almost 10 cm (Figure 8A). The impact of this event was particularly apparent at JB (Figure 5A). As discussed below, this event had dire consequences for nestling Roseate Spoonbills.

In April, the drought returned (SFWMD Surface Water Reports) and water levels were again significantly lower than in 1991-92. Although 2000-01 dry season water level was lower overall (a desirable circumstance), this was likely due to the record low rainfall which occurred and was not caused by differences in water management practices between the two years. To the contrary, the reversal in water depth caused by ISOP operations in March had major deleterious affects on prey availability and spoonbill nesting success (see below). Under the conditions experienced in 2000-01 and 1991-92, it appears that the ISOP was even a less of a success than the EPWD at accomplishing the desired hydropatterns.

Overall, salinity was lower throughout 2000-01 compared to 1991-92 (Figure 9A), however, comparisons of salinity differences at the control site (BS) with the impacted sites (TR, JB and HC) indicates that interim changes in water management practices are unlikely to explain the observed difference. Because the impact of water management practices at BS are minimal, the significantly higher salinity at BS in 1991-92 (Figure 9B) can not be attributed to differences between the EPWD and the ISOP. A more likely explanation is that antecedent conditions prior to 1991-92 resulted in higher initial salinity which persisted longer through this relatively dry year (Figure 7B). That TR and JB had almost identical mean salinity (Figure 9B) and very similar annual salinity patterns (Figures 4 and 5) further indicate little difference between the Test 5 of the EPWD and the ISOP in influencing coastal wetland salinity.

In contrast, HC was significantly higher in 1991-92, possibly indicating a positive response to the ISOP. However, this seems unlikely based on interim management activities. In 1991-92, most of the water delivered to the SDCS was inadvertently shunted toward HC (Van lent et al 1993, Ley et al. 1995, Lorenz et al. 2000, Lorenz 2000). Between 1992 and 1996, major structural changes were made to the SDCS (e.g. shunting a greater percentage of the water toward Taylor Slough and away from the C-111, dredging the western gaps in the C-111, degrading the birm on the southern edge of the C-111) so that less water would flow toward the Highway Creek area (Ley et al. 1995, Lorenz 2000). These activities were moderately successful (Ley et al. 1995) indicating that less, not more, fresh water should arrive at HC under the ISOP. Again, a more likely explanation for the higher salinity in 1991-92 is that antecedent conditions promoted higher salinity. 1991-92 followed a prolonged four year drought that resulted in unusually high salinity in northeastern and central Florida Bay (Fourqurean and Robblee 1999). This higher salinity in the open bay would result in the transition between fresh water and marine conditions remaining closer to the coastal wetlands during the early wet season. This close proximity of the marine environment likely explains the observed salinity increase at HC earlier in 1991-92 compared to 2000-01 and the mean annual difference between the two years.

The results indicate that the ISOP has had very little positive impact on the hydrology and hydrography of the coastal wetlands. Furthermore, it appears that ISOP operations are very similar to Test 5 of the EPWD in reference to delivering water to Taylor Slough and Florida Bay. Given that Test 6 and Test 7 were designed to rectify problems with Tests 1-5, (USACOE 1995), it appears that the ISOP is a step backward in achieving the desired goal of restored historic flows to Florida Bay.

V. IMPACT ON MANGROVE FISHES

Methods A $9m^2$ drop net method was developed for this study and has been demonstrated to be an effective and unbiased sampling method (Lorenz et al. 1997). Nets were set up, left over night and deployed the following day within 2 hrs after sunrise. Each net surrounded an individual dwarf mangrove tree, thereby sampling both prop root habitat and the open area between trees. Fish were cleared from the net using the fish toxicant rotenone. After about 24 hrs, any fish missed in the initial collection were found floating on the surface and added to the sample. Net clearing efficiencies ranged from 78% to 90% for the most common fish species and averaged 86% for all marked and recaptured fish (Lorenz et al. 1997). All fish collected were taxonomically identified, weighed and measured. Weights for specimens collected during the second day collection were calculated from length-weight regressions generated from first day collection fishes.

Three nets were collected in each microhabitat (creek and flats) at each site, for a total of six nets per sample. The relatively small variance within microhabitat versus the substantial variance between microhabitat (i.e., creeks generally had more fish than flats) indicated that this type of stratification was necessary (Snedacor and Cochran 1967). Sample collections were scheduled for June, September, and monthly from November through April. Complete samples were collected for all four sites in 2000-01 but only HC and JB had a full complement of months for 1991-92. The first collection was made at TR in December 1991 and at BS in March 1992. The partial collection from TR was used in all analyses but the very limited collection from BS (two months) precluded this sites use in any analyses.

Larger transient fishes bias estimates of resident fish biomass toward relatively higher numbers. In order to focus on only resident fish community, larger transient fishes had to be removed from the data set. Resident fishes were defined as those that utilized the entire dwarf mangrove habitat. The largest fishes in collections from the flats nets were about 6.5 cm. Fish larger than 6.5 cm were regularly collected in the creek nets indicating that fish larger than 6.5 cm did not reside in the flats microhabitat. Using this criterion, all fish larger than 6.5 cm were removed from the data prior to statistical analyses.

Annual community composition at each site was analyzed through use of Correspondence Analysis (CA) of eight of the most common species. Species were selected for inclusion in the CA if they made up more than 1% of the total catch in both years and was represented in at least 3 of the 4 sites (Tables 2 and 3). Results of CA are traditionally presented as a bi-plot with both sampling sites and species identified. For purposes of this report, the CA bi-plot also identified species by their salinity preference category. These categories were based on Lorenz (2000) who used ten years of fish collections at six sites in the southern Everglades to calculate the median salinity in which each species was captured. Each species was then assigned a salinity category based on the median collection salinity according to the Venice System of Estuarine Classification (Bulger et al. 1993). Categories used were as follows: species found in a median salinity of between 0-1 ppt salinity were classified as freshwater species. Oligohaline, mesohaline, and polyhaline categories were represented by fish with a median salinity of 1-5 ppt, 5-18 ppt and 18-30 ppt respectively. Classifying species according to salinity preferences on the CA biplot greatly improved interpretation of the results.

A stratified mean biomass and number of fish per m^2 for each site were calculated using the method of Snedacor and Cochran (1967). Calculation of a stratified estimate required that the weight of each strata (in this case the wetted area of the creeks and the flats respectively) be known. A complicating factor was that the wetted areas for each of these strata changed through time due to seasonal and climatic water level fluctuations. In order to estimate wetted area of the strata at any given water depth, remote sensing techniques were employed. High altitude false color images (1:1800 scale) depicting 1 km^2 of wetland centered on each sampling site were acquired from ENP. Using the Idrisi GIS package (Eastman, 1995), each image was separated into several discrete color bands representing small incremental changes (on the order of 5 cm) in wetland surface elevation. Each site was then physically surveyed to determine the depth range of each color relative to the continuous water level recorder. When the GIS data were combined with the water level record, the wetted area for each strata could be estimated and used to calculate the weighted mean for each sample collected. Therefore each 6 net sample resulted in a single estimate for biomass and density thus avoiding pseudoreplication (Heffner et al. 1996). Spatial and temporal differences in stratified density and biomass per unit area were examined with ANOVA between sites, months, and years.

Results. *Community structure*. The percent of catch by site for all species collected is presented for 1991-92 in Tables 2 and for 2000-01 in Tables 3. Total percent for all sites combined, total number of species and individuals collected, and total sampling effort are also provided in these tables. At the population level, both years were represented by the same common species (i.e., species that made up >5% of the total catch) with the exception of G. holbrooki which made more than 20% of the catch in 2000-01 but less than 1% of the catch in 1991-92. A possible reason for the lack of G. holbrooki (although admittedly unsubstantiated) is the abundance of the exotic cichlid, C. urophthalmus, in 1991-92 (18% compared to 8% in 2000-01). This relatively large bodied fish is an opportunistic feeder and may have exerted such high predation pressure on the smaller species that it was under-represented. F. confluentus was also not as common in 1991-92 as it was in 2000-01.

The primary and secondary axis of the CA explained for 62% and 20% of the variability in community structure between sites and years (Figure 10). An examination of the species scores on the biplot indicated that Axis 1 defined differences in salinity preferences of the species such that species with low salinity preferences had higher scores. Axis 2 was not as clearly defined but when combined with Axis 1, there seems to be a general gradient of increasing species salinity preference from the upper right to the lower left of the biplot. An examination of the individual site/years indicates that the sites were sparsely spread (i.e., there were no clusters indicating that none of site/years were similar to one another) indicating that each site and year had a distinctive community structure. The site/years follow the same general trend as the species salinity preferences: years with the lowest salinity mean (Figure 9B) are toward the upper right, while site/years with higher salinity means (Figure 9B) are to the lower left of the biplot. The biplot further indicates that BS00-01 and HC91-92 were dominated by species with high salinity preferences while both years at TR were dominated by low salinity species. Both years at JB and HC00-01 tended to be intermediate.

Numerical analyses. Figures 4-7 provide the stratified mean density and biomass calculated for each sample collection, the date of collection and the hydrologic and hydrographic conditions under which each sample was collected. By number, the catch per unit effort was almost identical between years: 2000-01 averaged 4.2 fish/m^2 and 1991-92 averaged 4.3 fish/m^2 (Tables 2 and 3). This close similarity in catch was confirmed by the Analyses of Variance. There was no significant interaction between Years and Months for either density ($F_{7,28}$=0.46, p=0.86; Figure 11A) or biomass ($F_{7,28}$=0.25, p=0.97; Figure 12A). Furthermore, there was no interaction between Site and Year for biomass ($F_{2,38}$=1.8, p=0.18; Figure 12B). There was a significant interaction between Site and Year for density ($F_{2,38}$=3.9, $p<0.05$), however, the post hoc test indicated that none of the sites had significant differences between years ($p>0.01$, Figure 11B). There were significant differences in density by site with TR having higher density then either JB or HC (Figure 11B). Cumulatively, these results indicate a high degree of similarity between the two subject years.

Discussion. *Water Level impacts on the fish community.* Previous findings indicate that higher water levels and longer annual hydroperiods promote higher overall prey fish abundance (Lorenz 1999). Significant differences between sites for water level and density support this prior finding. TR had significantly higher water level than either JB or HC (Figure 8B) and also had significantly higher densities of fish (Figure 11B). Based on this conclusion, it is not surprising that there were no significant differences between subject years for either of the analyses for density. Although there were significant depth differences between the years for the dry season months (Figure 8A), two of the five months were higher in 2000-01, with the other 3 being higher in 1991-92. i.e., there was relative balance between years overall. As presented in the previous section, the two years were very similar in their water level cycles on both temporal and spatial scales. This similarity in hydropattern likely led to similar conditions for fish productivity. The end result was that there was no difference between the years in mean monthly fish density or mean fish density by site (Figure 11).

Salinity impacts on the fish community. Previous findings indicated that prolonged periods of low salinity (<8 ppt) result in higher fish biomass (Lorenz 1999). Further studies indicated that a shift in community structure occurred concurrent with the increase in biomass in low salinity environments (Lorenz 2000). The overall conclusion being that, in these coastal wetlands, lower salinity promotes a fish community that has greater biomass than higher salinity communities. The results presented here agree with these previous findings. The CA clearly indicates that the salinity regime for each site/year is reflected in the community structure (i.e., site/years with high salinity were dominated by species with a higher salinity preference). Furthermore, Figures 9B (mean salinity by site) and Figure 12B are almost mirror images indicating that sites with lower salinity had higher fish biomass. Only two sites (BS and HC) showed significant differences in mean salinity between years (Figure 9B). Unfortunately, the limited fish data collected at BS in 1991-92 precludes any inter-annual comparison at this site. The differences in biomass at HC were not significant (Figure 12B) possibly indicating that the salinity differences between the 2 years was not ecologically relevant.

The month and year comparisons of salinity indicated 4 months with significant differences between years, with 1991-92 having higher salinity in all 4 (Figure 9A). These differences would be expected to be reflected in the monthly means for biomass. However, the differences between these months are largely attributable to differences at BS (Figure 7). As demonstrated in the previous section, each of the three sites affected by water management (TR, JB, HC), had salinity regimes that were remarkably similar between the two years. This parity between years is reflected in close overlap of monthly biomass (Figure 12A).

To summarize, the hydrographic and hydrologic similarities between years presented previously (Section III) created an environment such that resident fish production rates were, in all likelihood, very close between years. This being the case, our estimates of standing stock were not temporally or spatially discernable between years. In conclusion, under the rainfall conditions detailed above (Section II), water management operation under the ISOP resulted in almost identical hydrologic conditions and prey base fish abundance as Test 5 of the EPWD.

VI. ROSEATE SPOONBILL NESTING PATTERNS

Methods. Thirty-two of Florida Bay's keys have been used by Roseate Spoonbill's as nesting colonies (Lorenz et al. 2002). These colonies have been divided into five distinct nesting sub-regions based on each colony's primary foraging location (Lorenz et al. 2002). Colonies in the Northeastern (NE) sub-region feed in coastal wetlands described in the previous sections (Bjork and Powell 1994). Consequently, these colonies can be considered the 'experimental' or 'impacted' group when evaluating the effects of water management practices. Following completion of the SDCS, spoonbill nesting declined in the NE sub-region and increased in the Northwestern (NW) sub-region. Birds from the NW sub-region forage in the wetlands on Cape Sable (Bjork and Powell 1994); an area largely free from direct influence of water management practices. For our purposes, the NW sub-region acts as the 'control' group when examining water management impacts.

Prey availability is defined as the mean number or biomass of fish collected in the strata with the highest abundance (as opposed to the stratified means presented in Section

V which estimate a per m^2 mean across the entire potential wetted area). In other words, prey availability is a measure of the prey concentration effect caused by the drawing down of wetland surface water. Prey availability data for 2000-01 and 1991-92 was estimated for the NE colonies from fish collections made at the four northeastern coastal sites (TR, JB, HC, and BS; Figures 4-7). In addition, fish samples were also collected at a site on Cape Sable adjacent to Bear Lake (BL; Figure 1) using identical methodology to the northeastern sites. This location is a popular feeding area for spoonbills nesting in the NW sub-region (Bjork and Powell 1994), so BL fish and hydrologic data will be used to evaluate prey availability for these colonies.

During the 2000-01 nesting cycle (November-May), complete nest counts were performed at Tern Key and Sandy Key, representing the NE and NW sub-regions, respectively (Table 4). Nest counts were performed by entering the active colony and thoroughly searching for nests. Nesting success was estimated for 4 of the sub-regions through mark and re-visit surveys of the largest colony within the sub-region (Table 4). These surveys entail marking approximately 50 nests shortly after full clutches had been laid and re-visiting the nests on an approximate 2 week cycle to monitor chick development. Nesting success data for the NE and NW sub-regions for 1991-92 were derived from Bjork and Powell (1994).

Results and Discussion. *Northeastern Sub-region: Tern Key*. Spoonbill nesting surveys were conducted at Tern Key on Nov. 9, 25, Dec. 15, Jan. 4, 29, Feb. 14, Mar. 1, 14 and 26. As has been the norm for the last several decades, there were two distinct nestings at Tern Key. For the first nesting, we estimated the first egg was laid on Dec. 8, the mean lay date was Dec. 11 and the last clutch started Dec. 19 (Table 4). The estimated mean hatch date was Jan. 1 and the mean fledge date was Feb. 11. As has been the trend in recent years, the first nesting effort was alarmingly small: only 65 nests compared to almost 200 nests ten years ago and over 500 nests twenty-five years ago (Lorenz et al. 2002). This nesting resulted in mixed success with an average of 0.77 chicks per attempt. The standard definition of successful nesting (≥1 chick/nest attempt) suggests a failed nesting. However, almost half of the nests succeeded in fledging young with an average of 1.76 chicks/nest (Table 4). These results indicate that about half of the nesting parents were successful in finding food in sufficient quantities to fledge young.

Hatching at Tern Key was moderately well timed with fish availability. Based on a mean hatch date of January 1, the critical 21d post-hatching period overlapped with relatively high available biomass (Figure 13A) but available fish density was just beginning to increase during this period (Figure 13B). A possible explanation for this difference between biomass and number is that water levels at most of the sampling sites was above the 12.5 cm concentration threshold at the beginning of the month but dropped below later in January (Figures 4-6, 8). As water level recedes, larger fishes become threatened with stranding before the smaller fishes, and, therefore, retreat to the deep water habitats earlier. This may explain why the available biomass increased before density (Figure 13). Since spoonbills tend to exploit fish smaller than 3cm (Hancock et al. 1962), the concentrations of fishes that occurred in January 2001 may have been larger than ideal for the needs of the chicks. This relative scarcity of ideal sized prey may explain the loss of more than 50% of the nests at Tern Key in January (Table 4). By February, water levels were well below 12.5cm (Figures 4-8) and available density and biomass peaked for the year (Figure 13). These ideal foraging conditions likely explain the high degree of nest success experienced in February: our surveys indicated that all nests that were still active at the end of January successfully fledged chicks in February (Table 4).

In contrast to 2000-01, spoonbills nesting on Tern Key were highly successful in 1991-92 (Table 4). Nesting began in December and hatching was favorably timed with high availability of prey biomass (Figure 13). High available biomass persisted through the nesting cycle (Figure 13) culminating with a 1.5 chick per nest attempt success rating (double that of 2000-01). The only downside was that 40% of the nests failed over the critical 21d post-hatching period. Similar to 2000-01, perhaps this was also attributable to the persistent low available density through the nesting period. The small size of newly hatched chicks (e.g. <5d post-hatching) may prohibit them from consuming all but the smallest fish. Since most of the available biomass was in the form of relatively few (i.e., large) fish (Figure 13), there may have been high chick mortality in the first few days post-hatching thereby explaining the high degree of abandonment in the first 21d.

Once the chicks were large enough to consume larger fish, finding suitable prey items was no longer a problem, thereby explaining the high production rate for the surviving (active) nests (Table 4).

Although there is no information regarding a second nesting attempt at Tern Key in 1991-92, it is instructive to examine the second nesting in 2000-01. As in the previous few years, the second nesting was much larger than the first (105 nests). We estimated the mean lay date as Feb. 16 and the mean hatch date as March 9. These chicks had the misfortune of hatching during a period of high rainfall (Figure 2), high water level (Figures 4-8) and low prey fish availability (Figure 13).. Flooding in urban and agricultural areas prompted water managers to shunt much of the unwanted water to the coastal areas possibly explaining the unseasonably high water levels at our fish sampling sites. As water levels increased, fish dispersed over a much wider area, thereby lowering availability. The predictable consequence for spoonbills was that the second nesting failed. On March 26, only 40% of the nests were still active. Although the success ratio was relatively high (0.8 chicks/attempt), the chicks were still relatively young (mean age 11d) and in poor condition. Most were emaciated, lethargic and many appeared dead until the nest was touched. The vast majority of the unmarked nests were observed to be empty and many dead chicks were found within the colony. Only 2 adults were observed indicating recent abandonment (at this age, one of the parents typically stays with the young at all times so there should have been as many adult spoonbills as active nests). It was unlikely that any of the remaining chicks survived more than a day or two (Table 4). A large mixed species heronry was active, and no more spoonbill surveys were performed so as to minimize disturbance. However, the Key was visited on two subsequent occasions and observations were made from outside the colony. No fledglings or adults were observed as would have been expected had any of the chicks survived. We believe that the second nesting was a complete failure (probably <0.1 chick per attempt, if any). This event once again demonstrates how anthropogenically induced pulses in water depth can have lethal consequences.

Northwestern Sub-Region: Sandy Key. Nesting surveys were conducted at Sandy Key on Dec. 8, 22, Jan. 9, 23, and Mar. 26. We estimate that eggs were first laid on Nov. 23, the mean egg laying date was Dec. 10, and mean hatch date was Dec. 31 (Table 4).

On Jan. 9, the colony appeared healthy but had collapsed by Jan. 23. As many as 75 dead chicks were found floating along the shoreline; certainly, many more had already decomposed or were eaten by scavengers. Out of 130 initial nests, only 10 living chicks were observed.

We concluded that the combination of drought conditions and inclement weather probably caused the colony's collapse. Unprecedented low water levels at BL (Figure 14) resulted in unexpectedly low prey fish abundance at the BL sampling site (Figure 15). In some instances, available prey were as much as two orders of magnitude lower compared to the nesting periods of previous years (Figure 15). A possible explanation for the depauperate prey base may be that shorter hydroperiods on the ephemeral wetlands south of Bear Lake resulted in lower fish production (Figure 14). Furthermore, unusually low water levels during the dry season caused the shallows surrounding Bear Lake to become completely dry (an unprecedented event in the 10 years of data collection), thereby forcing the prey into Bear Lake proper (Figure 14). The lake itself is about 1m deep precluding wading bird foraging. Nesting spoonbills dependant on this normally reliable food source would have found it difficult to meet the high energetic demands of their chicks. Furthermore, the strong winds and cool whether that occurred throughout January (personal observations) would have made it physically difficult for adults to make the foraging flight from Sandy Key to Cape Sable. A final survey performed on Mar. 10 confirmed the extremely low success rate (only 10 juvenile birds) and that no second nesting occurred (only 10 adults).

In contrast, 1991-92 experienced above average water levels and longer hydroperiod during the wet season (Figure 14). The draw down was steady and remained below 12.5 cm for the entire nesting period (Figure 14, Table 4). Furthermore, the draw down was not so severe as to completely dry the foraging ground as was the case in 2000-01 (Figure 14). Prey availability was extremely high (Figure 15) during the post-hatching period. Presumably, these conditions made it possible for adult spoonbills to find enough food with relative ease. The outcome was that spoonbills had one of their best nesting cycles in the history of nesting at Sandy Key (Lorenz et al. 2002): 85% of the nests succeeded with 2.4 chicks per successful nest (Table 4).

Because Sandy Key was the ‘control’ site in reference to water management impacts, failure in 2000-01 indicates that the failure of the first nesting at Tern Key in 2000-01 was possibly not a result of water management but rather other environmental conditions. That both Tern and Sandy Keys were successful under almost identical conditions in 1991-92 (as per previous sections) is further evidence that the 2000-01 failure was not anthropogenic in origin. A likely culprit was the continuous cold and windy weather experienced throughout January of 2001.

A possible reason for prey being available in 2000-01 at the northeast and not at northwestern foraging sites may be due to open hydrologic connection between Florida Bay and the northeastern foraging grounds. There is a well developed coastal ridge at the northwestern foraging grounds which blocks any direct hydrological connection between the wetlands of Cape Sable and the marine environment. In the northeast, the wetlands grade into Florida Bay and are heavily influenced by the marine environment. This marine influence likely ameliorated the effect of the drought on the wetlands through high marine water levels and wind driven tides. As a result, hydroperiods were longer resulting in greater fish abundance. Furthermore, the draw downs were more protracted thereby explaining the temporal and spatial staggering of peak fish availability.

VII. SYNTHESIS, SUMMARY AND CONCLUSIONS

The goal of this report was to evaluate possible impacts of ISOP implementation on the coastal wetland ecosystem. The combined results of the temporal and spatial analyses of annual rainfall patterns strongly indicated that 1991-92 was very similar to the subject year (2000-01). Since the ISOP was implemented in 2000-01 but not in 1991-92, differences in biotic and abiotic characteristics of the coastal wetlands between the two years were used to evaluate the effect of operating the water management system under the ISOP. Hydrology, hydrography, fish community structure, fish abundance, and Roseate Spoonbill nesting patterns were examined in this effort. The null hypothesis was that 1991-92 and 2000-01 did not differ in physical and biological independent variables (i.e., salinity, water level, fish abundance and community structure, spoonbill nesting number and success).

The results from analyses of water level and salinity within the coastal wetlands indicated very few differences between 2000-01 and 1991-92, i.e., the ISOP had very little positive impact on the hydrology and hydrography of the coastal wetlands. Furthermore, it appears that ISOP operations are remarkably similar to Test 5 of the EPWD in reference to delivering water to Taylor Slough and Florida Bay. Given that Test 6 and Test 7 were designed to rectify problems with Tests 1-5, (USACOE 1995), it appears that the ISOP may actually mimic conditions that inhibit the desired goal of restored historic flows to Florida Bay.

The hydrographic and hydrologic similarities between subject years created an environment such that resident fish production rates were, in all likelihood, very close between years. This being the case, our estimates of standing stock were not temporally or spatially discernable between 2000-01 and 1991-92. Under the rainfall conditions detailed in Section 2 of this report, the ISOP resulted in almost identical prey base fish abundance as Test 5 of the EPWD.

Although the first nesting of spoonbills in northeastern Florida Bay failed in 2000-01, our data suggests that this was not a result of ISOP operations. The 'control' colony (Sandy Key) also failed in 2000-01 indicating that the failure of the spoonbill nesting during January for all of northern Florida Bay was the result of natural environmental conditions. That both Tern and Sandy Keys were successful under almost identical conditions in 1991-92 (as per previous sections) is further evidence that the 2000-01 failure was not anthropogenic in origin. A likely culprit was the continuous cold and windy weather experienced throughout January of 2001.

The only possible discernable effect of the ISOP that differed from Test 5 of the EPWD was a negative impact on the second spoonbill nesting at Tern Key. Rainfall events in March resulted in unseasonable increases in water depth on the coastal wetland foraging grounds. This situation may have been exacerbated by flood control activities in urban and agricultural areas. Although flow through the SDCS was held to a minimum by water managers, unwanted water was shunted to the coastal areas. When chicks hatched in March 2001, they were faced with the adverse combination high water level on the foraging grounds and low prey fish availability. The second nesting was a complete failure (probably <0.1 chick per attempt, if any). This event once again demonstrates how even short lived pulses in water depth can have lethal consequences.

This report attempted to evaluate the impact of the ISOP on the coastal wetland ecosystem of northeastern Florida Bay compared to the EPWD. Based on the statistical analyses performed, we fail to reject the null hypothesis and conclude that there was no difference between the two operational plans under the rainfall regime detailed in Section III. Although the ISOP was designed to provide favorable conditions to the CSSS, it was also hoped that downstream impacts would be minimal, or possibly even beneficial to the coastal wetlands. Based on our findings, this pretense should be dismissed. For all practical purposes, the ISOP appears to mimic conditions associated with Test 5 of the EPWD; causing negative hydrologic conditions in Taylor Slough and Florida Bay similar to those observed with Test 5. In the ten years after Test 5, water managers have made great structural and operational improvements in the freshwater delivery system for Florida Bay (Ley et al. 1995, Lorenz 2000). And, although there was still much room for improvement (Lorenz et al. 2000), the overall health of the bay seemed to improve (Lorenz-Personal Observation). The ISOP may reverse the observed positive trends.

That the ISOP and Test 5 resulted in virtually identical environmental and ecological conditions in the coastal wetlands is a reason for concern. Test 5 was the operational plan when Florida Bay went through it's well-publicized "ecological collapse" in the late 1980's and early 1990's(Fourqurean and Robblee 1999). In partial response to the ecological collapse of Florida Bay state and federal government approved the Central Everglades Restoration Plan at a cost of $8 billion, the most costly public works project ever planned. The ISOP appears to be a step backwards.

Recognizing that the loss of biodiversity is the most serious ecological problem facing our planet and that there is no innate value of a species, each is priceless, we do not propose that the Cape Sable Seaside Sparrow be sacrificed for the sake of the greater Everglades and Florida Bay. However, implementation of the C-111 and Modified Water Deliveries Projects, and acceleration of the Southern Everglades CERP projects (including linking Mod Water and complementary CERP projects instead of sequencing them), would end the current impasse and allow for enough operational flexibility that sparrow protection and Florida Bay restoration would not be at odds.

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Table 1. NOAA rainfall gage locations

Everglades Division	**Lower East Coast Division**
Belle Glade	Coral Springs
Canal Point	Ft Lauderdale
Clewiston	Hialeah
Devils Garden	Homestead
Everglades	Loxahatchee
Flamingo	Miami Beach
Fort Myers	Miami Airport
Immokalee	Perrine
La Belle	Pompano Beach
Moore Haven	Royal Palm
Naples	Stuart
Oasis	West Palm Beach
Punta Gorda	
Tamiami	

Table 2 Phylogenetic list of all species sampled and the percent of catch at each site for 2000-01. Percent catch for all sites combined, total fish collected per site, number of species collected, number of dates and total nets sampled are also included. All fish collected are represented, however, only fish less than 6.5 cm were used in subsequent analyses. Species used in the community analysis (DCA) are marked with an asterisk (*).

ORDER Family Genus species	Common Name	TR	JB	HC	BS	All Sites
ELOPIFORMES						
Elopidae	Tarpons					
Leptocephalus larvae	Larval Elopidae	0.04		0.20	0.99	0.14
SILURIFORMES						
Ictaluridae	Freshwater catfish					
Ictalurus sp.	Yellow Bullhead	0.04				0.02
BATRACHOIDIFORMES						
Batrachoididae	Toadfishes					
Opsanus beta (juv)	Gulf Toadfish		0.05	0.20	0.50	0.09
ATHERINIFORMES						
Atherinidae	Silversides					
Menidia sp	Inland Silverside	2.45	0.59	0.39	0.50	1.45
Belonidae	Needlefishes					
Strongylura notata (juv)	Redfin Needlefish		0.05			0.02
Cyprinodontidae	Killifishes					
Adinia xenica	Diamond Killifish			6.89	4.46	1.10
Cyprinodon variegatus*	Sheepshead Minnow	2.97	24.60	32.28	14.52	13.92
Floridichthys carpio*	Goldspotted Killifish			3.54	21.62	2.63
Fundulus chrysotus	Golden Topminnow	2.64	0.32			1.36
F. confluentus*	Marsh Killifish	7.13	3.61	14.17	2.64	6.13
F. grandis (<6.5cm)	Gulf Killifish	0.04	7.93	4.92	9.41	4.06
F. grandis (>6.5cm)	Gulf Killifish		0.86	1.77	7.59	1.25
F. grandis (Total)*	Gulf Killifish	0.04	8.79	6.69	17.00	5.32
F. similis (<6.5cm)	Longnose Killifish					0
F. similis (>6.5cm)	Longnose Killifish				0.33	0.04
F. similis (Total)	Longnose Killifish				0.33	0.04
Jordanella floridae	Florida Flagfish	0.45	4.69			1.75
Lucania goodei	Bluefinned Killifish	1.04	1.89	1.18		1.22
Lucania parva*	Rainwater Killifish	10.33	16.72	13.78	21.29	13.90
Poeciliidae	Livebearers					
Belonesox belizanus	Pike Killifish	0.07	0.05	0.20		0.07
Gambusia holbrooki	Mosquitofish	36.85	10.14	0.79	0.33	20.95
Heterandria formosa	Least Killifish	2.86	0.05			1.38
Poecilia latipinna*	Sailfin Molly	12.11	13.32	8.27	6.60	11.57
PERCIFORMES						
Gerreidae	Mojarras					
Eucinostomus sp. (<6.5cm)	Mojarra sp.	0.37			0.99	0.28
Eucinostomus sp. (<6.5cm)	Mojarra sp.				0.50	0.05
Eucinostomus sp. (Total)	Mojarra sp.	0.37			1.49	0.34
Gobiidae	Gobies					
Gobiosoma bosc	Naked Goby		0.27	0.39		0.12
Lophogobius cyprinoides	Crested Goby	2.82				1.34
Microgobius gulosus*	Clown Goby	2.19	0.27	0.20	7.76	1.98
Centrarchidae	Sunfishes					
Elassoma evergladei	Pygmy sunfish	0.07				0.04
Lepomis sp.	Sunfish sp.	1.56	9.76			3.94
L. macrochirus	Bluegill Sunfish			0.20		0.02
Cichlidae	Cichlids	10.81	4.15	10.04		7.40

C. urophthalmus (<6.5cm)	Mayan Cichlid					
C. urophthalmus (>6.5cm)	Mayan Cichlid	1.52	0.54	0.59		0.95
C. urophthalmus (Total)*	Mayan Cichlid	12.33	4.69	10.63		8.36
Tilapia mariae	Spotted Tilapia	1.63				0.78
PLEURONECTIFORMES						
Soleidae	Soles					
Trinectes maculatus	Hogchoker		0.11			0.04
Totals		2692	1854	508	606	5660
Number Of Species		25	23	21	19	36
Number Of Nets Sampled		38	37	32	44	151
Number Of Dates Sampled		8	8	7	8	31

Table 3 Phylogenetic list of all species sampled and the percent of catch at each site for 1991-92. Percent catch for all sites combined, total fish collected per site, number of species collected, number of dates and total nets sampled are also included. All fish collected are represented, however, only fish less than 6.5 cm were used in subsequent analyses. Species used in the community analysis (DCA) are marked with an asterisk (*).

ORDER Family Genus species	Common Name	TR	JB	HC	BS	All Sites
ELOPIFORMES						
Elopidae	Tarpons					
Leptocephalus larvae	Larval Elopidae					0
SILURIFORMES						
Ictaluridae	Freshwater catfish					
Ictalurus sp.	Catfish sp					0
BATRACHOIDIFORMES						
Batrachoididae	Toadfishes					
Opsanus beta (juv)	Gulf Toadfish		0.06		0.76	0.08
ATHERINIFORMES						
Atherinidae	Silversides					
Menidia sp	Inland Silverside	1.12	3.83	0.08	14.89	2.87
Belonidae	Needlefishes					
Strongylura notata (juv)	Redfin Needlefish					0
Cyprinodontidae	Killifishes					
Adinia xenica	Diamond Killifish		0.38	0.32	0.38	0.30
Cyprinodon variegatus*	Sheepshead Minnow	2.39	21.83	40.88	11.45	24.31
Floridichthys carpio*	Goldspotted Killifish	1.28	1.66	10.10	10.69	5.10
Fundulus chrysotus	Golden Topminnow					0
F. confluentus*	Marsh Killifish		2.68	2.92	0.38	2.15
F. grandis (<6.5cm)	Gulf Killifish	0.16	1.21	8.45	0.76	3.46
F. grandis (>6.5cm)	Gulf Killifish	0.32	2.87	5.13	5.34	3.38
F. grandis (Total)*	Gulf Killifish	0.48	4.08	13.58	6.11	6.85
F. similis (<6.5cm)	Longnose Killifish		1.02	0.32		0.54
F. similis (>6.5cm)	Longnose Killifish		0.19	0.16		0.13
F. similis (Total)	Longnose Killifish		1.21	0.47		0.67
Jordanella floridae	Florida Flagfish					0
Lucania goodei	Bluefinned Killifish					0
Lucania parva*	Rainwater Killifish	26.48	29.61	14.92	12.98	22.91
Poeciliidae	Livebearers					
Belonesox belizanus	Pike Killifish	0.16	0.32	0.08		0.19
Gambusia holbrooki	Mosquitofish		1.60	0.16		0.73
Heterandria formosa	Least Killifish					0
Poecilia latipinna*	Sailfin Molly	9.41	8.10	9.23	35.50	10.64
PERCIFORMES						
Gerreidae	Mojarras					
Eucinostomus sp. (<6.5cm)	Mojarra sp.				0.38	0.03
Eucinostomus sp. (<6.5cm)	Mojarra sp.					0
Eucinostomus sp. (Total)	Mojarra sp.				0.38	0.03
Gobiidae	Gobies					
Gobiosoma bosc	Naked Goby					0
Lophogobius cyprinoides	Crested Goby	9.73				1.64
Microgobius gulosus*	Clown Goby	8.77	1.91	0.32	6.49	2.85
Centrarchidae	Sunfishes					
Elassoma evergladei	Pygmy sunfish					0
Lepomis sp.	Sunfish sp.	2.39	0.83			0.75
L. macrochirus	Bluegill Sunfish					0
Cichlidae	Cichlids	35.89	20.29	6.55		16.81

C. urophthalmus (<6.5cm)	Mayan Cichlid					
C. urophthalmus (>6.5cm)	Mayan Cichlid	1.75	1.53	0.39		1.07
C. urophthalmus (Total)*	Mayan Cichlid	37.64	21.83	6.95		17.89
Tilapia mariae	Spotted Tilapia	0.16				0.03
PLEURONECTIFORMES						
Soleidae	Soles					
Trinectes maculatus	Hogchoker		0.06			0.03
Totals		627	1567	1267	262	3723
Number Of Species		16	22	19	14	26
Number Of Nets Sampled		17	35	33	12	97
Number Of Dates Sampled		4	8	8	2	22

Table 4. Summary of Roseate Spoonbill colony surveys performed in 2000-01 and in 1991-92. Table provides estimates of critical developmental dates, dates of nest surveys, estimated nest production, total nests for each colony and predicted reproductive outcome.

Region	Colony Year	Date	Estimated Mean Age of Chicks	% attempts active	Chicks/active nest	Chicks/Attempt	Predicted Outcome
Northeastern Region	**Tern Key**	11-Dec-01	Mean first egg				
	2000-01	1-Jan-01	Mean Hatch Date	100	2.82 (eggs)	65 nests	
	1st Nesting	4-Jan-01	4d	92	2.60	2.40	
		29-Jan-01	29d	46	1.76	0.77	**Failure**
		14-Feb-01	45d			**0.77**	**(Mixed)**
	Tern Key	23-Nov-91	Mean first egg				
	1991-92*	15-Dec-91	Mean Hatch date	100	3.7 (eggs)	172 nests	
		29-Dec-91	14d	81	2.70	2.20	
		5-Jan-92	21d	61	2.40	**1.50**	**Success**
	Tern Key	16-Feb-01	Mean first egg				
	2000-01	9-Mar-01	Mean Hatch Date	100	2.9 (eggs)	105 nests	
	2nd Nesting	14-Mar-01	4d	100	2.90	2.90	
		26-Mar-01	16d	40	2.00	0.80	
		28-Mar-01**	18d			**<0.1**	**Failure**
Northwestern Region	**Sandy Key**	10-Dec-00	Mean first egg				
	2000-01	31-Dec-00	Mean Hatch Date	100	2.85 (eggs)	130 nests	
		9-Jan-01	10d	81	1.86	1.51	
		22-Jan-01	23d	9	1.00	0.09	
		3-Mar-01	63d			**0.07**	**Failure**
	Sandy Key	4-Dec-91	Mean first egg				
	1991-92*	25-Dec-91	Mean Hatch Date	100	3.3 (eggs)	232 nests	
		8-Jan-92	14 d	97	2.60	2.50	
		15-Jan-92	21d	85	2.40	**2.00**	**Success**

*Dates and data estimated from Bjork and Powell 1994. ** Estimated date based on colony observation on 26-Mar-01.

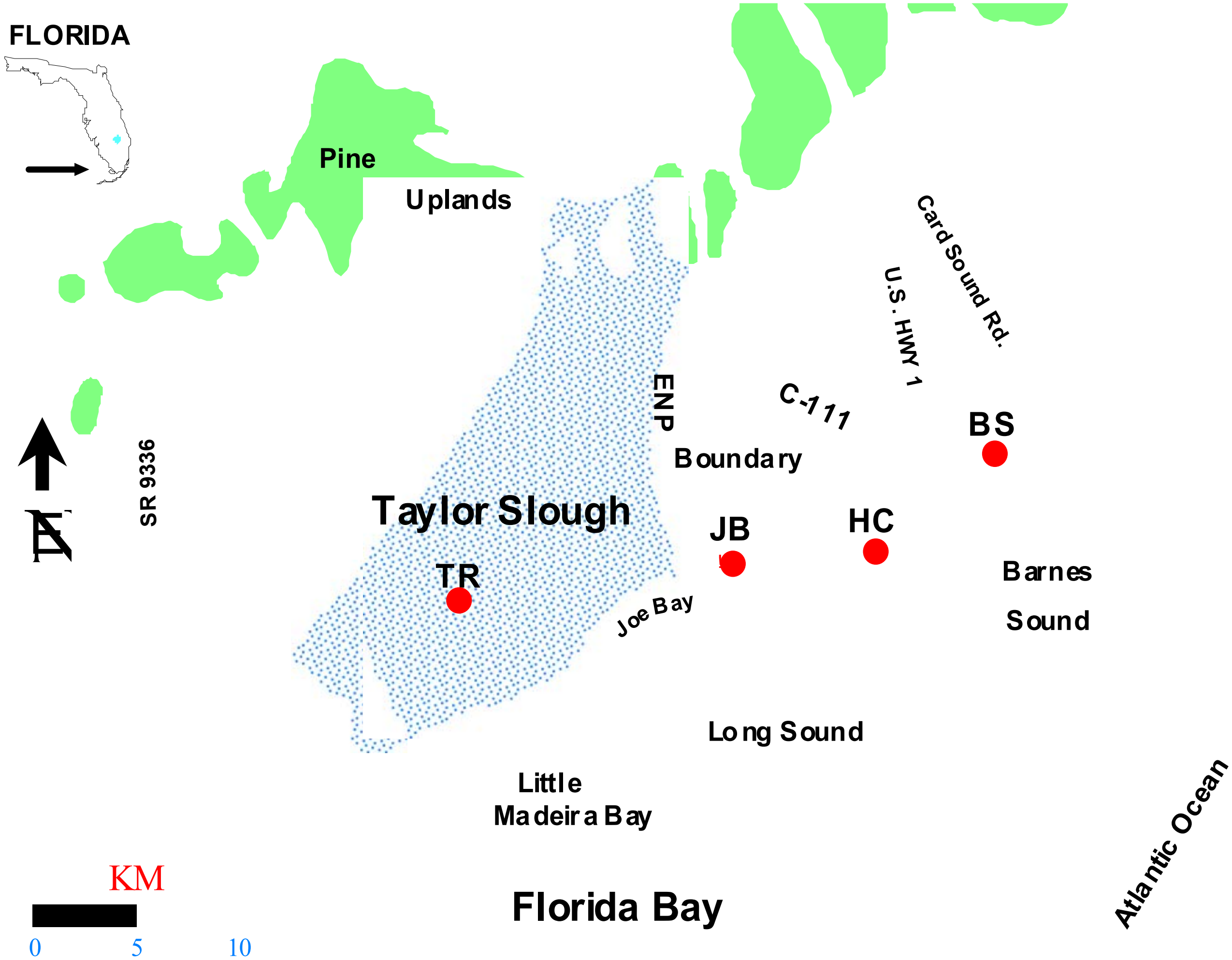


Figure 1. Map of southern Florida indicating the four mangrove zone collection sites, Taylor Slough, C-111 canal, U.S. Highway 1, and Card Sound Road.

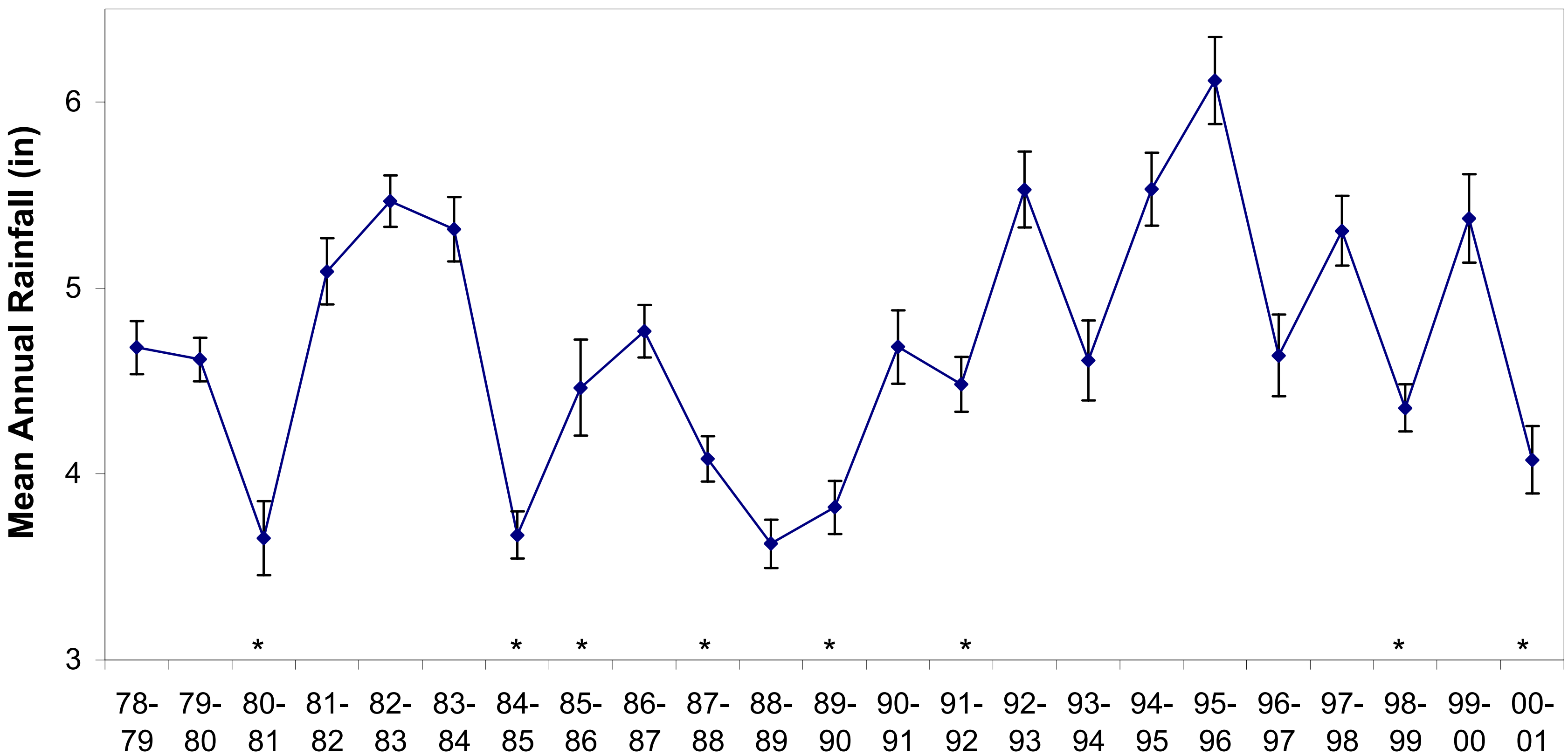


Figure 2. Mean (±SE) annual rainfall for southern Florida based on data collections from 26 NOAA rainfall stations. Years marked with an asterisk (*) are not significantly different ($p<0.05$) from 2000-01.

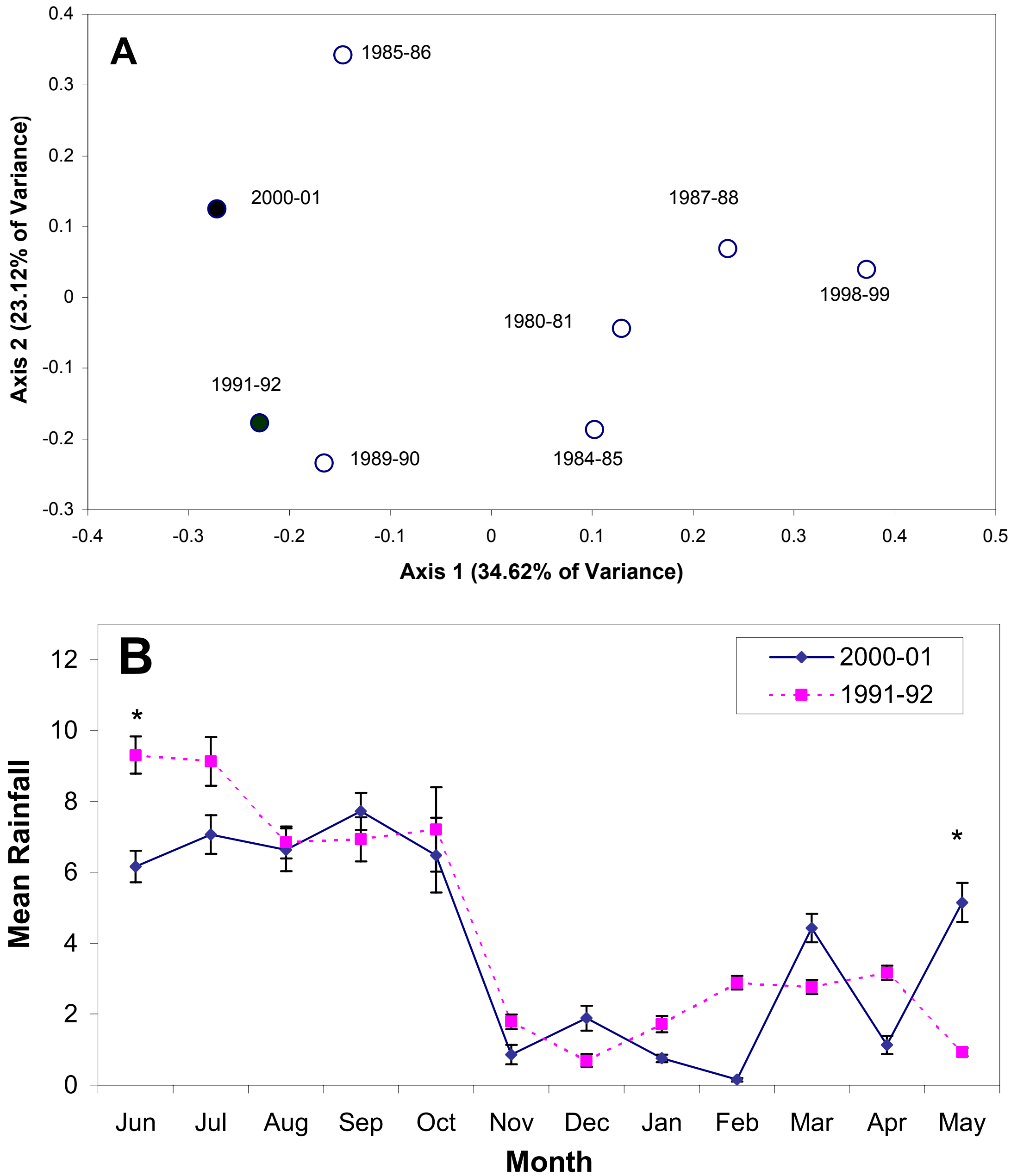


Figure 3. Analysis of rainfall from 26 NOAA collection sites. A. Plot of ordination scores from correspondence analysis of monthly spatial variation for 2000-01 and seven years with similar annual mean rainfall to 2000-01. B. Monthly mean rainfall (± standard error) for 2000-01 and 1991-92 (the most similar rainfall year to 2000-01 as indicated by Figure 3A). An asterisk (*) indicates significant ($p<0.01$) differences between years.

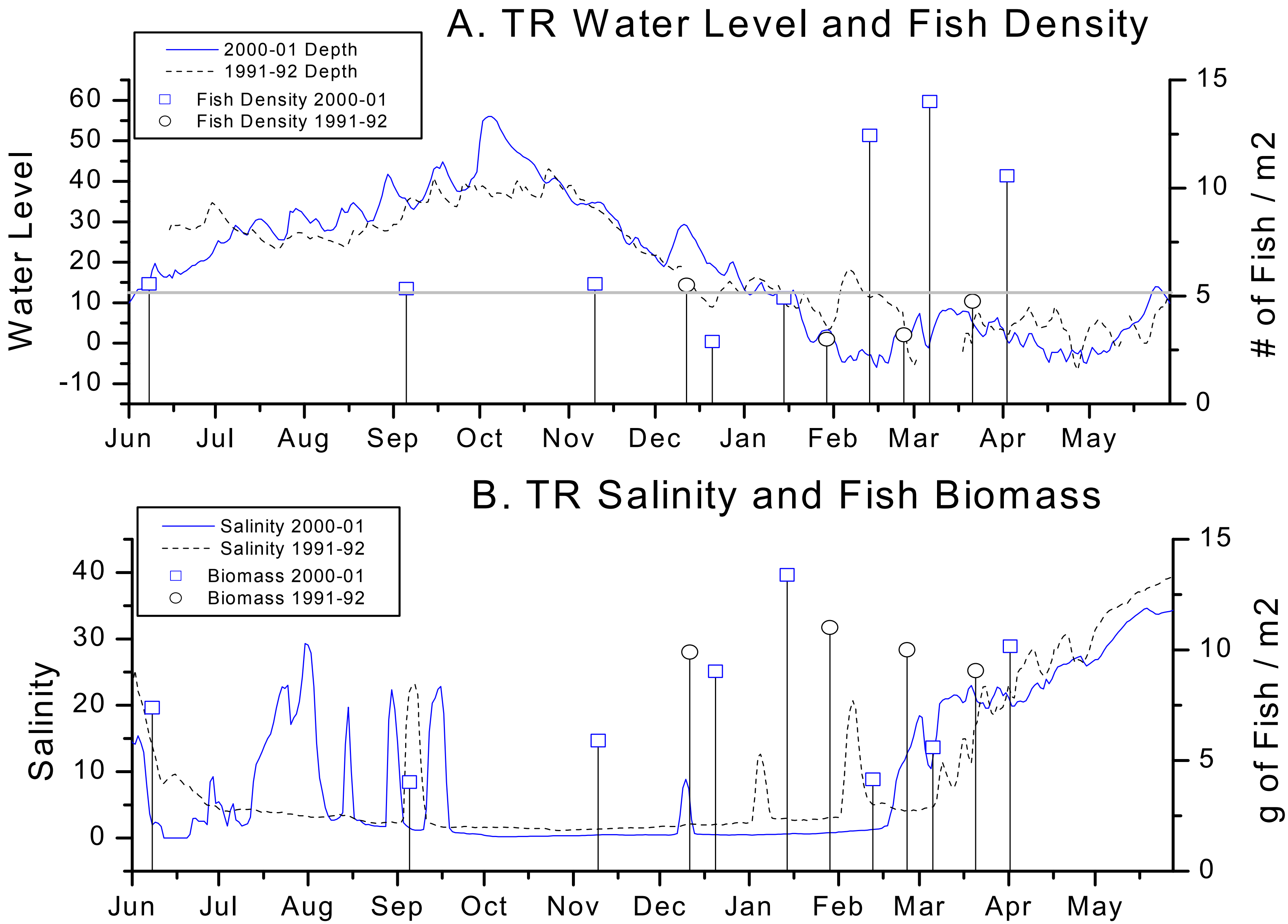


Figure 4 TR water level, salinity, fish density and biomass for 2000-01 and 1991-92. A. Between year comparison of annual water level cycle (left axis) and estimated fish density for each date of sample collection (right axis). Line at 12.5 cm indicates when wetland surface begins to dry. B. Between year comparison of annual salinity cycle and estimated mean biomass of fish for each date of sample collection.

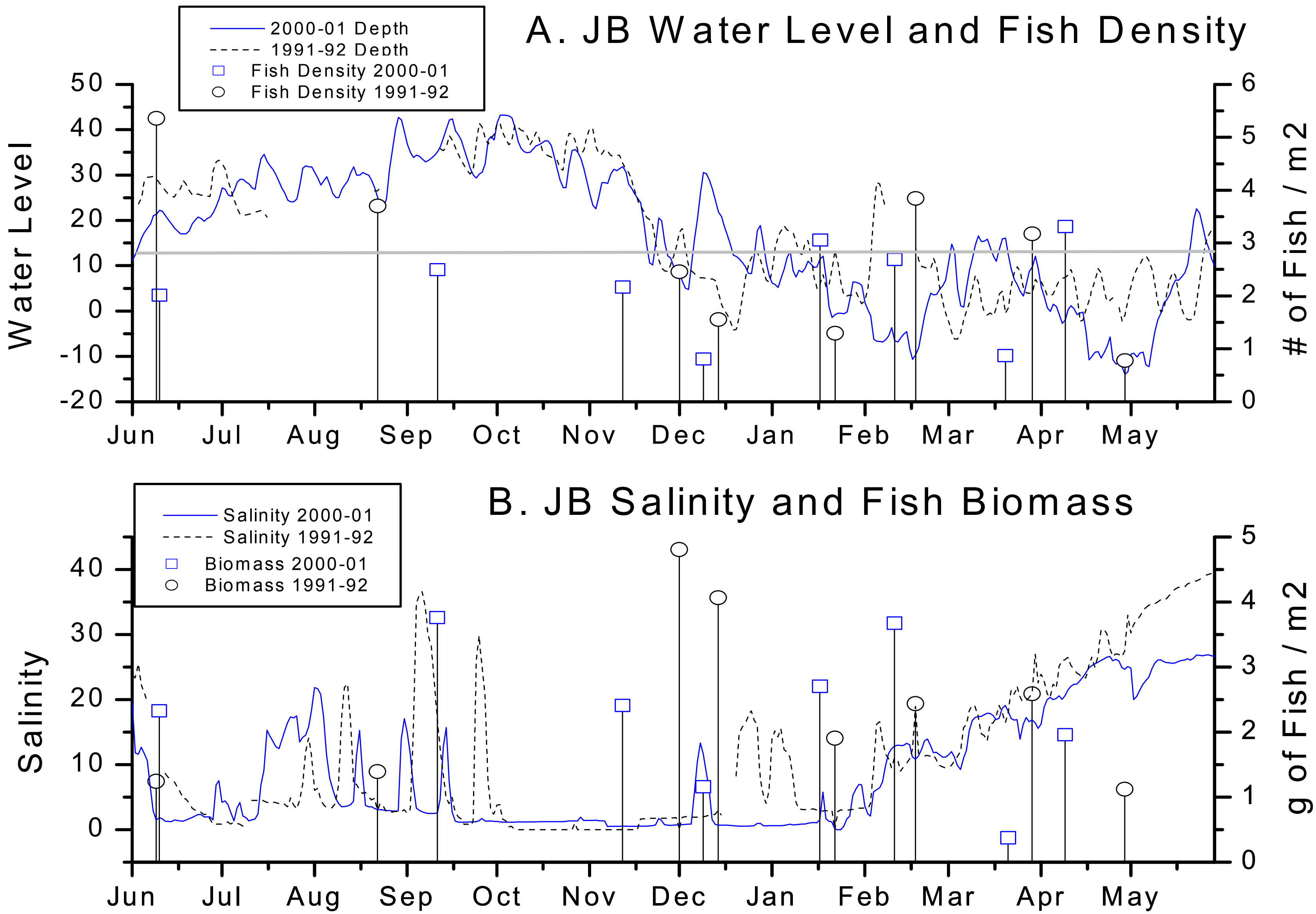


Figure 5 JB water level, salinity, fish density and biomass for 2000-01 and 1991-92. A. Between year comparison of annual water level cycle (left axis) and estimated fish density for each date of sample collection (right axis). Line at 12.5 cm indicates when wetland surface begins to dry. B. Between year comparison of annula salinity cycle and estimated mean biomass of fish for each date of sample collection.

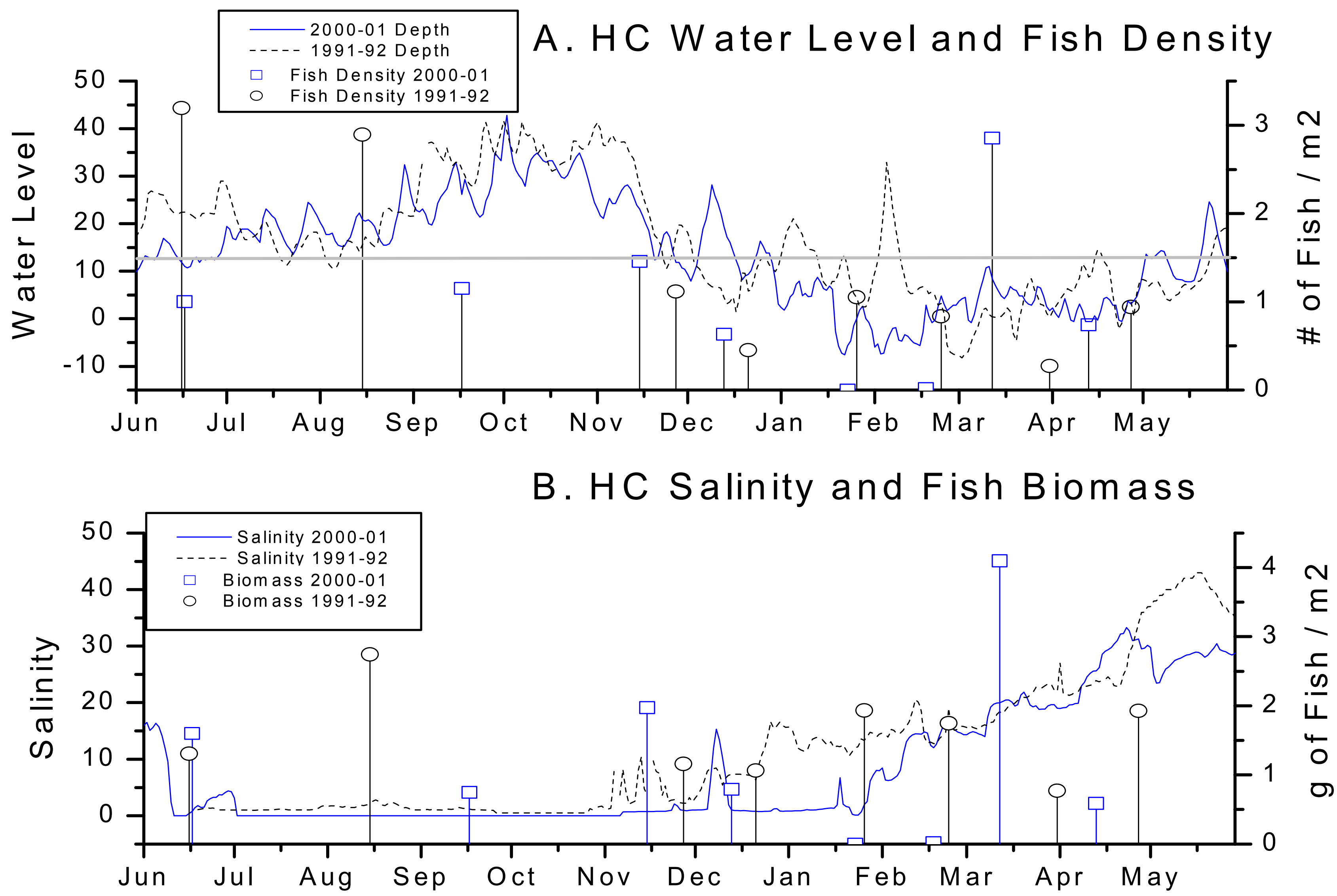


Figure 6 HC water level, salinity, fish density and biomass for 2000-01 and 1991-92. A. Between year comparison of annual water level cycle (left axis) and estimated fish density for each date of sample collection (right axis). Line at 12.5 cm indicates when wetland surface begins to dry. B. Between year comparison of annual salinity cycle and estimated mean biomass of fish for each date of sample collection.

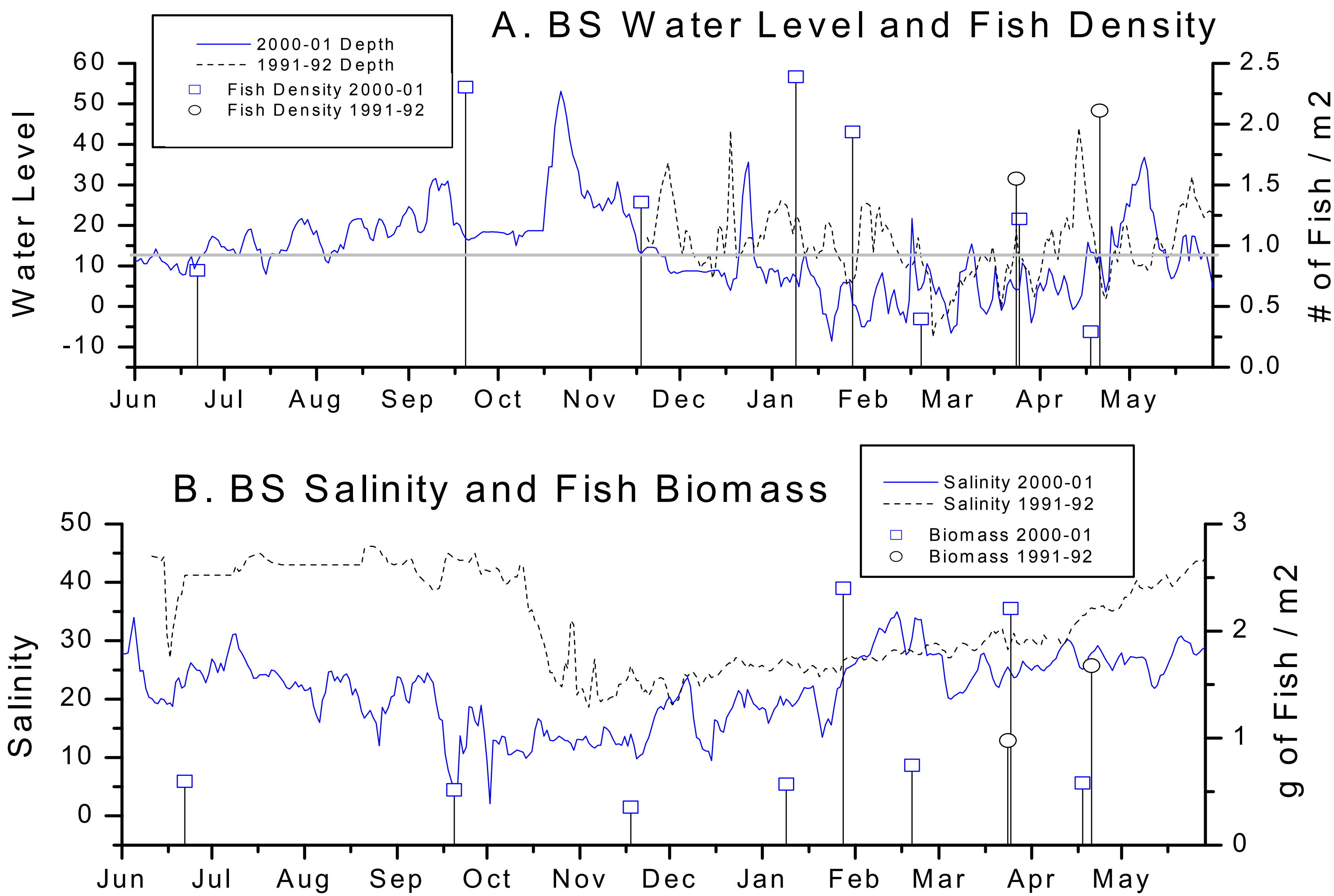


Figure 7 BS water level, salinity, fish density and biomass for 2000-01 and 1991-92. A. Between year comparison of annual water level cycle (left axis) and estimated fish density for each date of sample collection (right axis). Line at 12.5 cm indicates when wetland surface begins to dry. B. Between year comparison of annual salinity cycle and estimated mean biomass of fish for each date of sample collection.

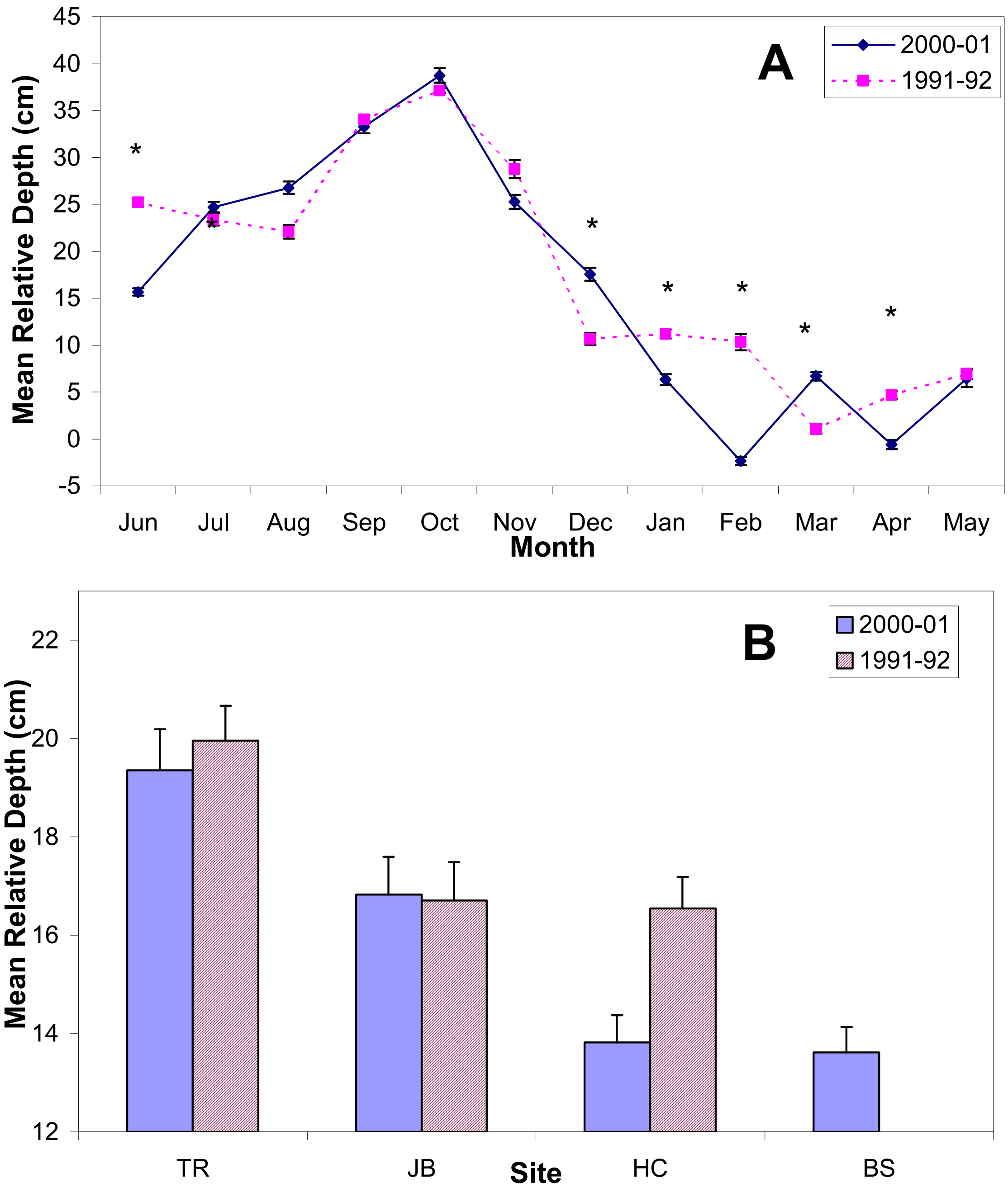


Figure 8. Comparison of mangrove zone mean relative depth (cm) between 2000-01 and 1991-92. A. Mean (±SE) monthly depth of four sites. B. Mean (±SE) annual depth at four mangrove sites. Asterisk (*) indicates significant (p<0.01) differences between years.

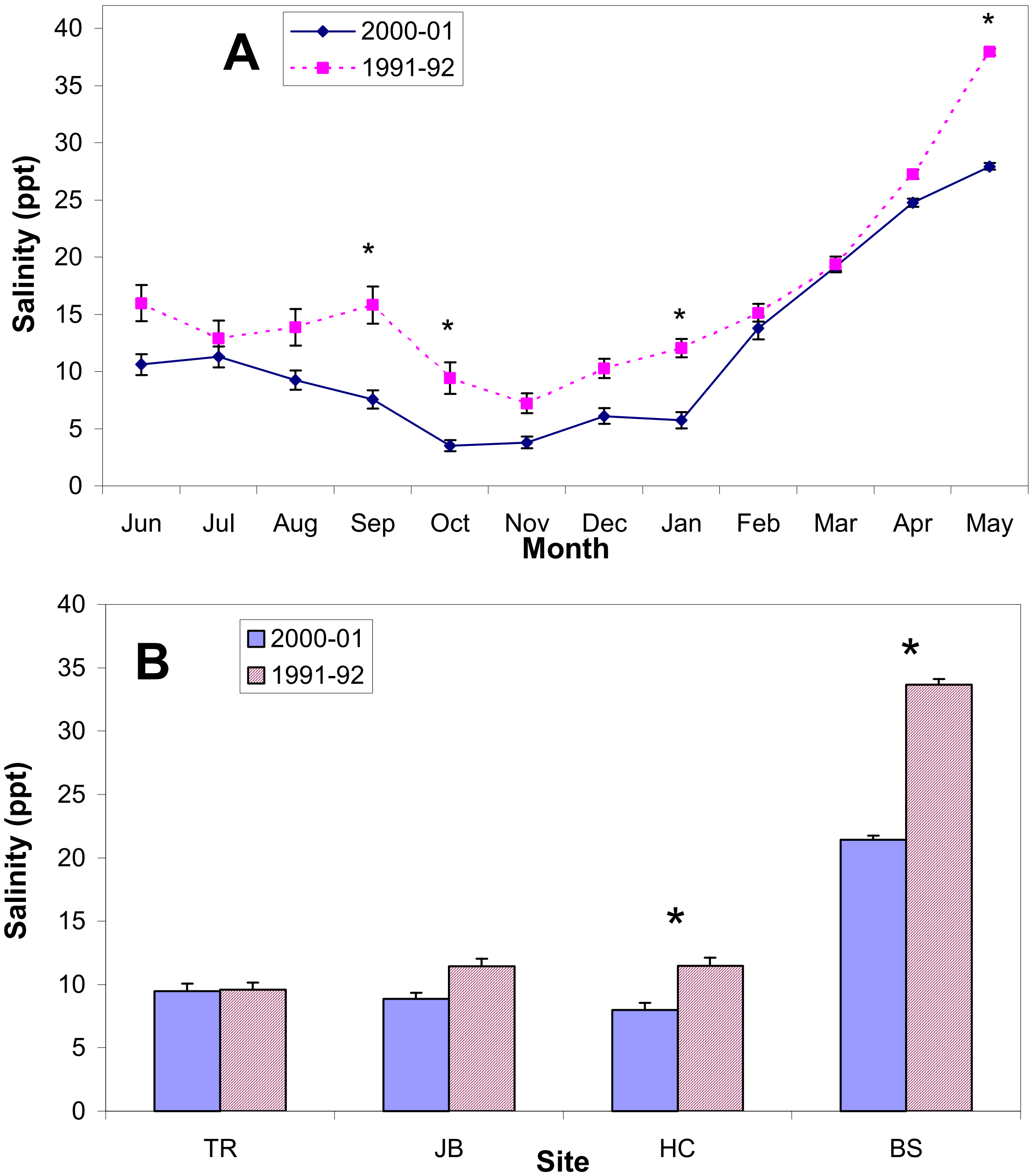


Figure 9. Comparison of mangrove zone salinity (in parts per thousand) between 2000-01 and 1991-92 A. Mean (+SE) monthly salinity of four sites. B. Mean (+SE) annual salinity at four mangrove sites. Asterisk (*) indicates significant (p<0.01) differences between years.

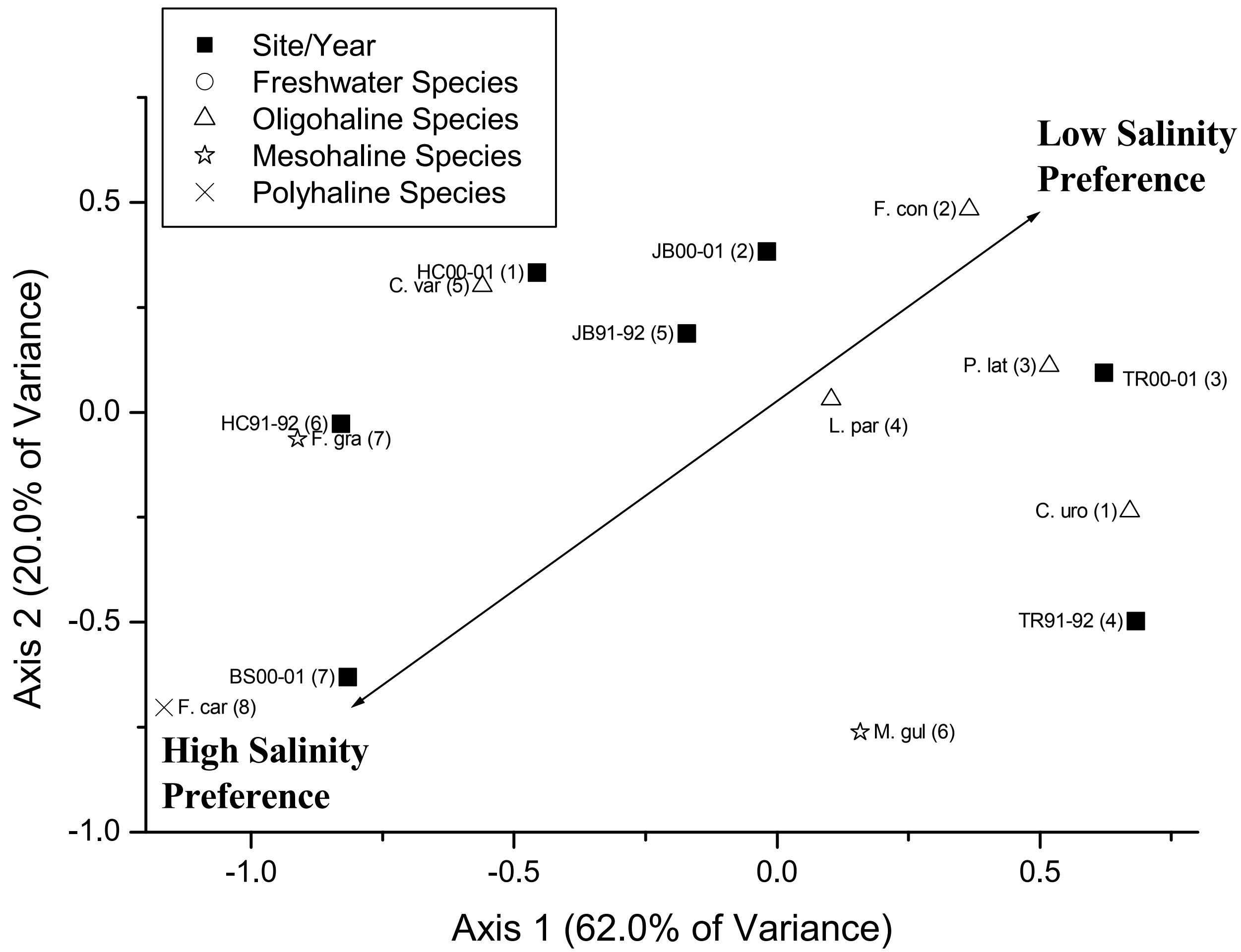


Figure 10. Biplot of ordination scores from correspondance analysis of community structure. Species are identified by the first let of the genus and the first 3 letters of the species. Species are also subdivided by salinity preferences based on Lorenz (2000). Numbers in parathesis indicate salinity preference ranking for species (from Lorenz 2000) or mean salinity ranking for sites (from Figure 9B) with the lowest number having the lowest salinity preference.

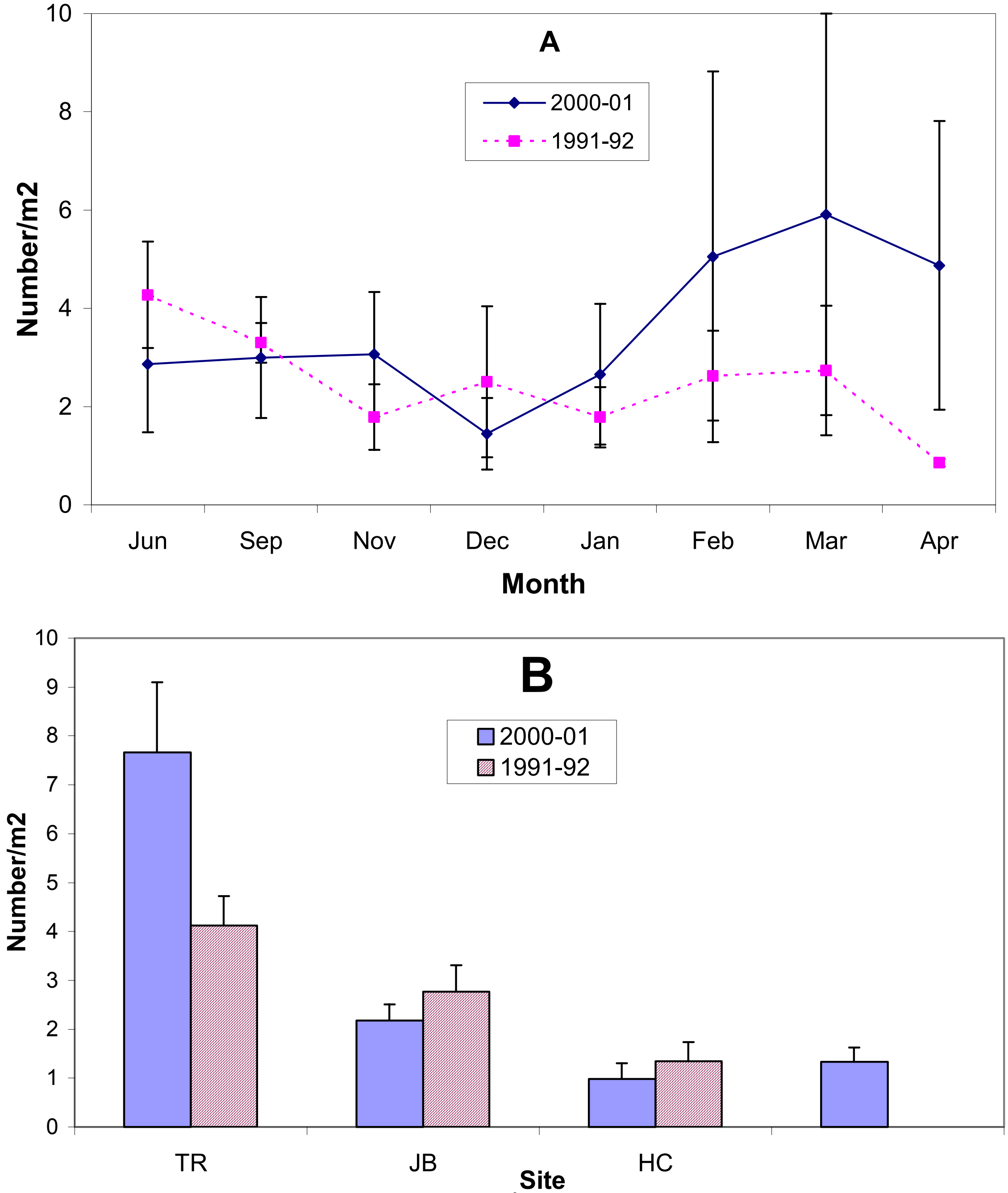


Figure 11. Mean (±SE) stratified density per m^2 (± standard error) for the 2000-01 and 1991-92 collection years. A. Number of fish by month. B. Number of fish by site. There were no significant differences between years for either interaction tested.

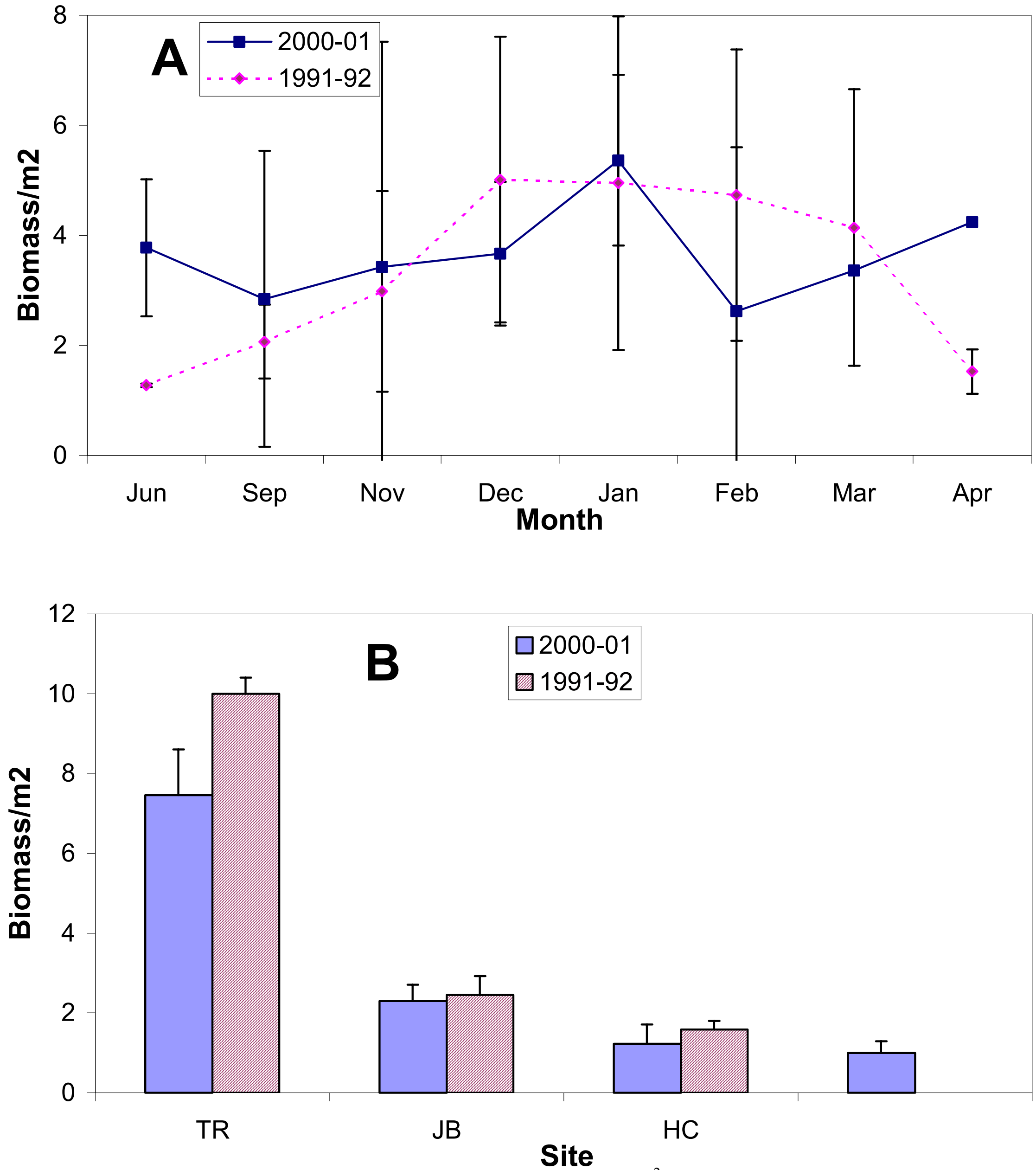
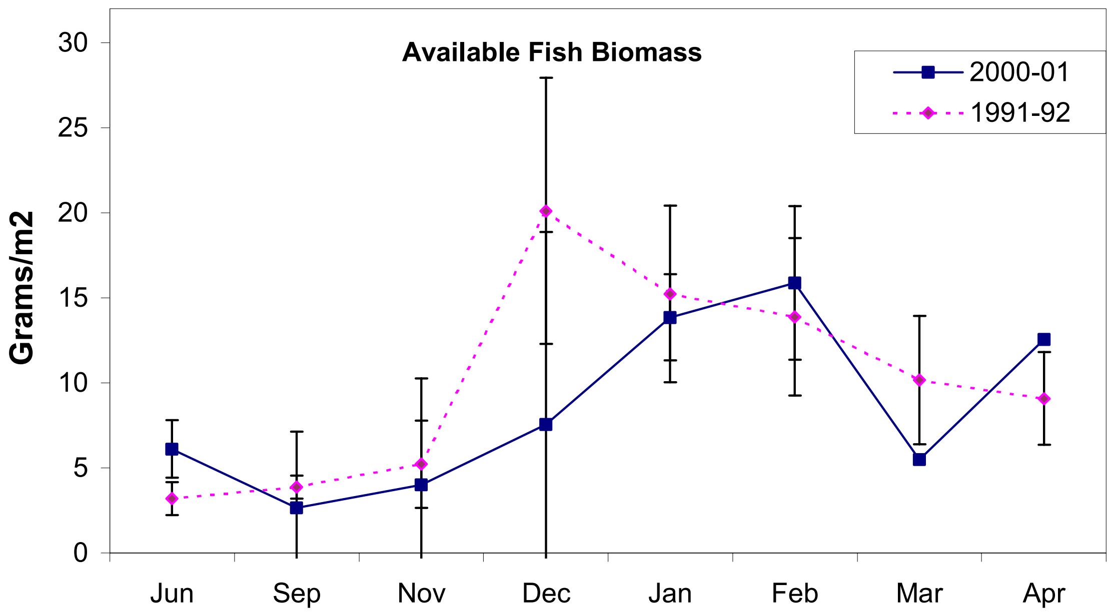


Figure 12. Mean (±SE) stratified biomass (g) per m^2 (± standard error) for the 2000-01 and 1991-92 collection years. A. Biomass by month. B. Biomass by site. There were no significant difference between years for either interaction tested.



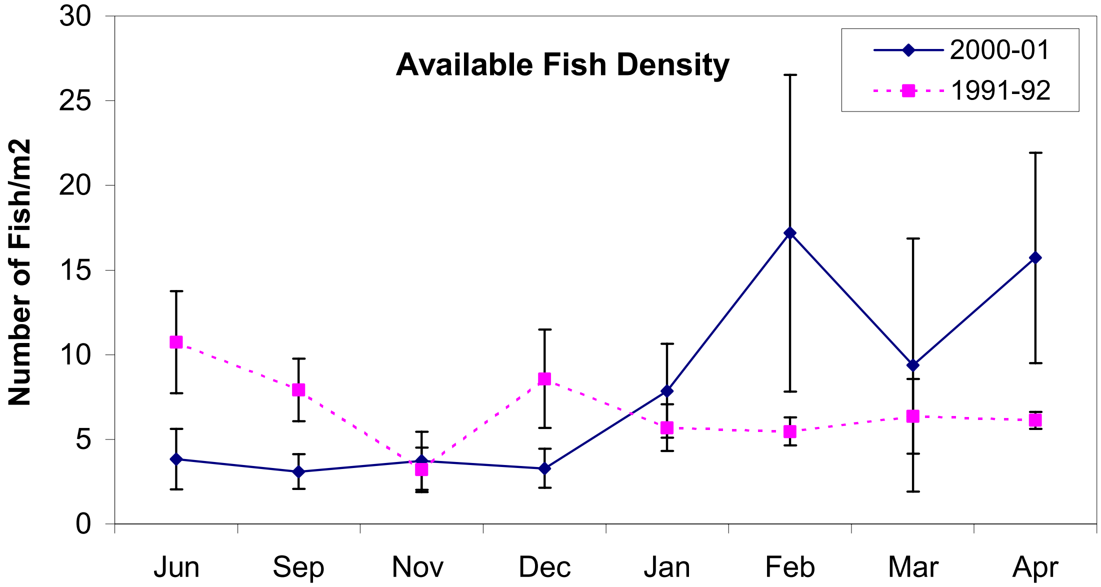


Figure 13. Mean (+SE) monthly prey availability (i.e., mean abundance from the sub-habitat with the highest abundance) from four fish sampling sites in the coastal wetlands for 2000-01 and 1991-92. A. Mean prey biomass. B. Mean prey density. There were no significant differences between years.

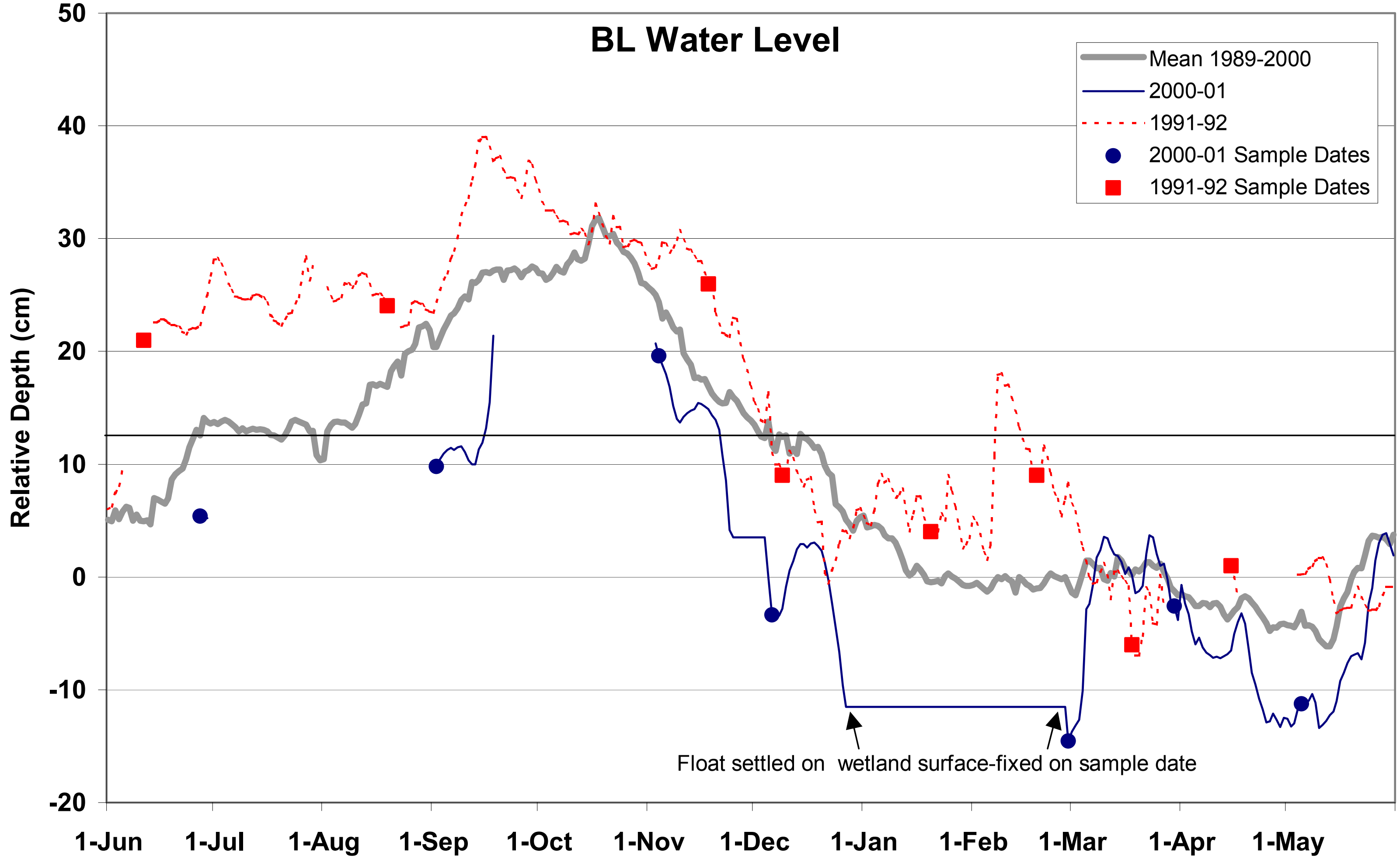


Figure 14. Annual water level cycle at BL. Mean for 12 year period of record, and daily averages for 2000-01 and 1991-92 are presented. Dates of fish collection are also indicated. Horizontal line at 12.5 cm indicates depth at which fish begin to concentrate in deeper water. Between Dec. 27 2000 and Feb. 27 2001 the float settled on the substrate. On Feb.28, the float well was excavated so as to allow water level readings below -11.5. This indicates water level was at or below -11.5 for this period.

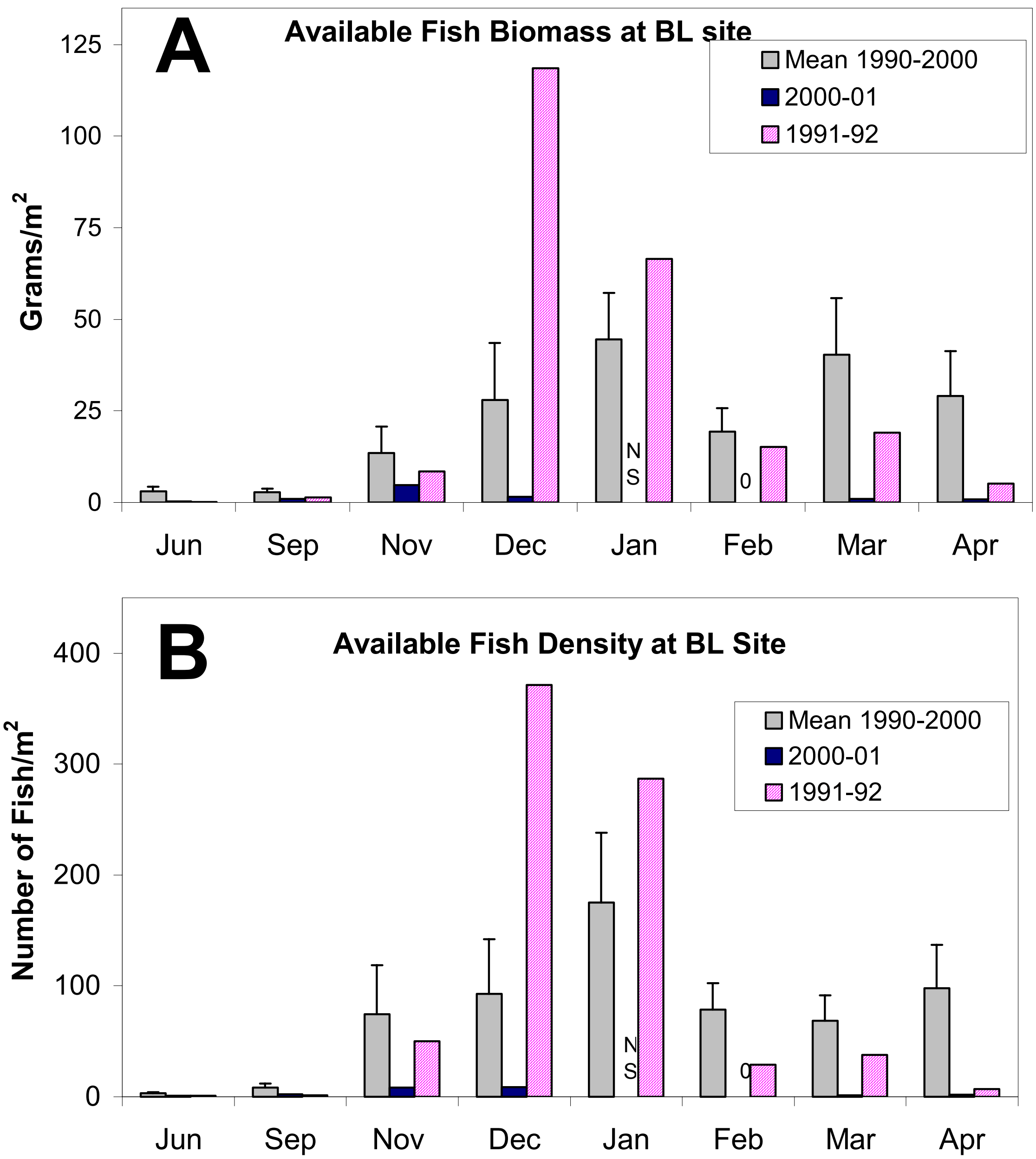


Figure 15. Monthly prey availability at BL. Mean and std. Error (error bars) are provided for the period of record (1990-2000) for comparisons to the subject years (1991-92 and 2000-01). A. Available biomass. B. Mean available density. No sample was collected in Jan 2001 (ns). In Feb 2001, there were no fish collected (0).

ADDENDUM 1: STATUS REPORT: JULY 1, 2001 - SEPTEMBER 30, 2001

Monitoring the Effects of Changes in the Taylor Slough Water Delivery Patterns on Aquatic Plants, Fish and Roseate Spoonbills In the Mainland Coastal Wetlands of Northeastern Florida Bay

NAS Estuarine and Marine Research Group
Primary Investigator: Jerome J. Lorenz

The following progress report details the activities of the National Audubon Society's Florida Bay Estuarine Fish Project from July 1, 2001 through September 30, 2001. This report is supplemental to the annual report (June 1, 2000 – May 31, 2001) which is the final of three deliverables of the Cooperative Agreement (No. 1443 CA 5280-01-014) between Everglades National Park and the National Audubon Society. The requirements and procedures detailed in this report are based on the methods defined in the Scope of Work (Attachment A of Cooperative Agreement) and as specified in the document "Monitoring Resident Fishes and ATLSS - Related Studies in the Mangrove Zone North of Florida Bay." Attached is an invoice for work performed during the report period.

Objective 1: Monitor estuarine fish abundance and diversity at NAS sampling sites in northeastern Florida Bay.

As proposed in the Cooperative Agreement, fish collections continued at all four sites in the mangrove coastal wetlands of northeastern Florida Bay. In addition to the four sampling sites in northeastern Florida Bay, additional samples were collected at a site south of Bear Lake (BL site) on Cape Sable. A single sample was collected in September. In addition to sample collections, our activities centered on processing and organizing previously collected samples and writing the annual report for the period June 1, 2000 – May 31, 2001 (main text of this report). Hydrological monitoring has proceeded as planned. Data from ENP and SFWMD will be used in tandem with NAS data to develop a comprehensive hydrologic data set used to analyze Year 3 of the ISOP.

At each site, we continue to sample three nets in deeper, open-water areas (this in addition to the 6 nets we were contracted to collect). First established during the 1997-1998 hydrologic year, these nets were constructed to surround areas with submerged aquatic macrophytes but no prop root habitat so as to acquire a better understanding of prey base fish utilization of submerged macrophyte communities. As part of Objective 3, aquatic plant surveys were used to quantify the abundance and type of vegetation within these nets. Over the course of the annual hydrologic cycle, we expect the plant community structure within the nets to change in conjunction with salinity fluctuations and, subsequently, we expect fish utilization of the area within the nets to change in conjunction with changes in the plant community.

Objective 2: Monitor nesting parameters of Roseate Spoonbills at the Tern Key and Sandy Key nesting colonies.

Spoonbills completed their nesting cycle by March 2001, therefore no data was collected during this report period. We expect the spoonbill activity to begin again in October and actively prepared to begin our monitoring as part of this report period. Also during this report period we developed an account of the 2000-01 nesting cycle for the South Florida Annual Wading Bird Report published by the South Florida Water Management District. A copy of the Wading Bird Report is included with this report. This account not only includes data collected under this contract at Tern and Sandy Keys, but also include surveys performed by volunteer at other colonies within ENP. Our volunteer team collected nesting success data at Middle Butternut and East Bob Allen. Nest counts were also performed on all colonies within the northwestern, northeastern and central colonies. Unfortunately, we did not have enough manpower to survey the numerous colonies in the southeastern and southwestern regions of the bay.

Objective 3: Monitor community structure and abundance of submerged aquatic macrophytes in the creek systems associated with the four NAS fish sampling sites in the mainland coastal wetlands.

Benthic macrophyte surveys were conducted in September as presented in the Cooperative Agreement. Each survey used the point intercept percent cover method to quantify the macrophyte community at six locations along a complete upstream to downstream transect from the four fish sampling sites. The following physical parameters were collected at each transect station during these vegetation surveys: salinity, water depth, secchi, and temperature.

Objective 4: Establish and maintain hydrostations to monitor water level, temperature and salinity at the NAS mangrove fish and plant sampling sites.

Water level and temperature continued to be continuously monitored at the five NAS location using Telog and Onset datalogers, respectively. Over the past year, hydrostation developed by Remote Data Inc. have been installed at all five fish sampling sites. These data recorders have proved very reliable and have performed very well under these harsh conditions. These hydrostations use Hydrolab Datasonde sensors to collect conductivity, salinity, water level, temperature, and dissolved oxygen. In addition to the parameters listed above, the JB station also collects rainfall and pH and the BS station collects rainfall. Parameters are sampled hourly and stored on a Cambell CR-10 data recorder. Each station is equipped with a cell phone and the data is transmitted to the Science Center on a daily basis.

Other progress: Publication Updates

The manuscript 'Nesting patterns of Roseate Spoonbills in Florida Bay 1935-1999: implications of landscape scale anthropogenic impacts' was published in the book "The Everglades, Florida Bay and the Coral Reefs of the Florida Keys: An Ecosystem Sourcebook.". A reprint is included with the report

Galley prints for the manuscript entitled "Size-structure of gray snapper (*Lutjanus griseus*) within a mangrove 'no-take' sanctuary" by Craig H. Faunce, Jerome J. Lorenz, and Joseph E. Serafy have been received from the Bulletin of Marine Science and were returned without changes. We anticipate a publication date in 2002. A copy of the galley print is included with this report

The manuscript entitled "Age, growth, and mortality of the Mayan cichlid from the southern Everglades" has been published in *Fishery Bulletin* and a reprint is included. This publications concludes our work on Mayan Cichlids.

A manuscript entitled “Changes in the Demersal Fish Community in Response to Altered Salinity Patterns in an Estuarine Coastal Wetland: Implications for Everglades and Florida Bay Restoration Efforts.” Was submitted for publication in the Marine Ecology Progress Series.

We are currently preparing a manuscript based on our visual fish census data within the deep water mangrove prop root habitat of the ENP crocodile sanctuary. This manuscript will examine the structure of the fish assemblages in relation to environmental parameters. Reprints of all publications will be forwarded to your office upon their receipt.

ADDENDUM 2: REPORT ON ACTIVITIES AND COLLECTIONS FROM PERMIT #2000116

Principal Investigator: Jerry Lorenz, National Audubon Society, 115 Indian Mound Trail, Tavernier, Florida 33070.

Introduction

This report summarizes the activities and results of the sampling program operated by the National Audubon Society's Tavernier Science Center in 2000-2001 and therefore satisfies, in part, the requirements for permit renewal. A thorough analysis of the data collections are presented in the main text of this report. Out goal in this addendum is to present a detailed account of all the resources collected and removed from Everglades National Park under Permit # 2000116.

Methods

Fish Collections:

Fish were collected using nine 9m^2 drop nets at five locations of the southeastern Everglades following Lorenz et al. (1997). Sites were located within the mangrove ecotone at Bear Lake (BL), Taylor River (TR), Joe Bay (JB), Highway Creek (HC) and Barnes Sound (BS). The location of these sites in relation to Taylor Slough and South Florida is given in Figure 1. Samples were standardized to fall on certain months of the year Samples were collected in September, November and December 2000 and January, February, March, April , June, September and November 2001.. These months were chosen based upon when water level was changing, since water level was found to be one of the most influential environmental factors affecting fish distribution (Lorenz 1999). Actual dates of individual samples at each site are given in Table 1.

Hydrology

Beginning in November 2000, hydrostations created by Remote Data Inc. were established at the sampling sites. These hydrostations use Hydrolab sensors to continuously monitor water level, salinity, temperature, and dissolved oxygen. Prior to November 2000, water level and salinity data were collected as follows.

Water levels were continuously monitored at each site using a Telog brand 2108 potentiometric recorder with a float and pulley design. Accuracy of the equipment was checked by comparing the current measurement of the recorder against a nearby staff gauge each time the system was downloaded. Salinity and temperature were measured at the site on the day of fish collections using an optical refractometer and thermometer.

Submerged Aquatic Vegetation:

Visual surveys of submerged aquatic plants were performed at Taylor River, Joe Bay and Highway Creek according to the protocol described in the Cooperative Agreement. Surveys were performed in December 2000, March, April, June, July, September, October and December 2001 following Lorenz (1997). Six locations were monitored along a transect from the fish collection site downstream to Florida Bay proper. In addition we collected the salinity, depth, and temperature of the water during plant monitoring.

Roseate Spoonbill monitoring.

Spoonbill nest counts were conducted at 16 of the 32 colonies in Florida Bay. Counts were made on multiple dates between November 2000 and April 2001. Nesting success surveys were conducted at 4 colonies representing the northwestern (Sandy Key), northeastern (Tern Key), southeastern (Middle Butternut Key), and central (East Bob Allen Key) sub-regions of Florida Bay. Nesting surveys were conducted at Sandy Key on Dec. 8, 22, Jan. 9, 23, and Mar. 26; at Tern Key on Nov. 9, 25, Dec. 15, Jan. 4, 29, Feb. 14, Mar. 1, 14 and 26; at Middle Butternut Key on Dec. 15, Jan. 4 and 29; and at East Bob Allen Key on Dec. 15, Jan. 4, 11, Feb. 17 and 23. Methods were as presented in the spoonbill section in the South Florida Wading Bird Report accompanying this report.

Results and Discussion

Fish Collections:

A thorough analysis and discussion of the fish collections are presented in the main text of this report. Our goal in this addendum is to present a detailed account of all the fish removed from Everglades National Park under Permit # 2000116. Table 1 indicates the dates that collections were made at the 5 sites. Tables 2-6 present the species and number of all the fish specimens removed from ENP during the permit period. These specimen's are stored at the Tavernier Science Center. They are kept in freezer (accompanied by a gas generator in case of prolonged power failure) so as to allow their use in chemical (e.g. stable isotope, toxicants) analysis in the future. This has proven to be a highly effective and useful storage method over the last decade. Details of the individual fish (e.g. length and weight) are part of the database which will be forwarded to Mr. Darrill Tidwell at the SFNRC for incorporation into the ENP scientific data base.

Hydrology

Hydrology data was continuously collected for the permit period. A detailed analysis and discussion of this data is presented in the main text of this report. The daily averages for each site will be forwarded to Mr. Darrill Tidwell at the SFNRC for incorporation into the ENP scientific data base.

Submerged Aquatic Vegetation:

Voucher specimens of SAV were collected, however, these have not been inventoried at this time. Voucher specimens consisted of pinching a stem of each species found at each site. Similar to the fish specimens, the plant collections are stored at the Tavernier Science Center in a freezer so as to allow their use in chemical (e.g. stable isotope, toxicants) analysis in the future. Details of the SAV visual surveys (% cover by species for each quadrat at each sample location) are part of the database which will be forwarded to Mr. Darrill Tidwell at the SFNRC for incorporation into the ENP scientific data base.

Roseate Spoonbill monitoring

No specimens were collected as part of this effort. Details of our surveys are presented in the main text of this report, however, a more detailed account of our activities is presented in the spoonbill section of the South Florida Wading Bird Report accompanying this report.

Proposed upcoming work (for permit renewal)

We propose to continue our sampling efforts using identical gear within previously sampled sites as outlined in cooperative agreement # CA 5280-5-9018. The personnel conducting the research are Jerry Lorenz, Craig Faunce, David Green, Pete Frezza, Joe Wolkowski, and Linda Lorenz.

Literature Cited

Lorenz, J.J. 1997. The effects of hydrology on resident fishes of the Everglades mangrove zone. Final Report to the South Florida Research Center, Everglades National Park, Homestead. 193 pgs.

Lorenz, J.J., C.C. McIvor, G.V.N. Powell, and P.C. Frederick. 1997. A drop net and removable walkway used to quantitatively sample fishes over wetland surfaces in the dwarf mangroves of the southern Everglades. Wetlands 17:346-359.

Lorenz JJ (2000) Impacts of water management on Roseate Spoonbills and their piscine prey in the coastal wetlands of Florida Bay. Ph.D. Dissertation, University of Miami, Coral Gables FL

Lorenz JJ, Ogden JC, Bjork RD, Powell GVN (2002) Nesting patterns of Roseate Spoonbills in Florida Bay 1935-1999: implications of landscape scale anthropogenic impacts. In: Porter JW, Porter KG (eds) The Everglades, Florida Bay and coral reefs of the Florida Keys, an ecosystem sourcebook. CRC Press, Boca Raton, FL p 555-598

Table 1. Dates of fish collection at each of the five sampling sites.

			Site		
Sample	Bear Lake	Taylor River	Joe Bay	Highway Creek	Barnes Sound
September-00	2-Sep	6-Sep	13-Sep	19-Sep	22-Sep
November-00	4-Nov	11-Nov	14-Nov	17-Nov	20-Nov
December-00	6-Dec	22-Dec	11-Dec	15-Dec	11-Jan
January-01	-	16-Jan	19-Jan	-	30-Jan
February-01	-	15-Feb	13-Feb	20-Feb	22-Feb
March-01	30-Mar	8-Mar	22-Mar	14-Mar	27-Mar
April-01	8-May	4-Apr	11-Apr	15-Apr	20-Apr
June-01	27-Jun	7-Jun	12-Jun	16-Jun	20-Jun
September-01	28-Aug	8-Sep	11-Sep	19-Sep	25-Sep
November-01	1-Nov	28-Nov	20-Nov	15-Nov	11-Nov

Table 2. Species and number of fish collected at Bear Lake (BL) in 2000-2001

Common Name	Species	Sep-00	Nov-00	Dec-00	Feb-01	Mar-01	Apr-01	Jun-01	Sep-01	Nov-01	TOTAL
Eastern Mosquitofish	*Gambusia holbrooki*	0	38	137		1	24	0	0	5	205
Sailfin Molly	*Poecilia latipinna*	0	125	47		20	7	3	0	0	202
Sheepshead Minnow	*Cyprinodon variegatus*	34	47	1		0	6	0	0	0	88
Clown Goby	*Microgobius gulosus*	4	1	3		0	0	0	3	0	11
Mojarras	*Gerreidae spp.*	11	0	0		0	0	0	0	0	11
Marsh Killifish	*Fundulus confluentus*	0	0	1		0	2	0	0	0	3
Rainwater Killifish	*Lucania parva*	0	0	0		0	0	1	0	0	1
Hogchoker	*Trinectes maculatus*	0	0	0		1	0	0	0	0	1
Florida Flagfish	*Jordanella floridae*	0	0	1		0	0	0	0	0	1
Naked Goby	*Gobiosoma bosc*	0	0	0		0	1	0	0	0	1
TOTAL	10 Species	49	211	190	0	22	40	4	3	5	524

Table 3. Species and number of fish collected at Taylor River (TR) in 2000-2001

Common Name	*Species*	Sep-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	Jun-01	Sep-01	Nov-01	TOTAL
Eastern Mosquitofish	*Gambusia holbrooki*	0	0	1	1	480	294	211	1	1	0	989
Sailfin Molly	*Poecilia latipinna*	32	47	25	66	20	25	62	13	1	12	303
Rainwater Killifish	*Lucania parva*	85	104	1	6	1	1	30	11	33	23	295
Mayan Cichlid	*Cichlasoma urophthalmus*	31	24	89	85	0	6	17	0	4	4	260
Marsh Killifish	*Fundulus confluentus*	0	0	0	0	51	56	81	0	0	0	188
Clown Goby	*Microgobius gulosus*	6	4	1	0	2	1	2	59	61	14	150
Sheepshead Minnow	*Cyprinodon variegatus*	21	10	0	4	3	0	34	9	49	4	134
Crested Goby	*Lophogobius cyprinoides*	35	11	3	9	6	1	1	1	23	9	99
Least Killifish	*Heterandria formosa*	0	0	0	0	67	6	4	0	0	0	77
Golden Topminnow	*Fundulus chrysotus*	0	0	0	2	58	11	0	0	0	0	71
Silversides	*Menidia peninsulae*	40	0	0	0	0	0	4	1	0	0	45
Sunfishes	*Lepomis spp.*	0	0	10	25	7	0	0	0	0	0	42
Spotted Tilapia	*Tilapia mariae*	0	21	8	0	0	0	0	0	0	0	29
Bluefin Killifish	*Lucania goodei*	0	6	1	3	4	1	13	0	0	0	28
Mojarras	*Gerreidae spp.*	10	0	0	0	0	0	0	2	1	0	13
Florida Flagfish	*Jordanella floridae*	0	0	0	0	1	6	5	0	0	0	12
Pigmy Sunfish	*Elassoma evergladei*	0	0	0	0	2	0	0	0	0	0	2
Leptocephalus larvae	*Leptocephalus larvae*	1	0	0	0	0	0	0	0	0	0	1
Bullhead Catfishes	*Ameiurus spp.*	0	0	0	1	0	0	0	0	0	0	1
Pike Killifish	*Belonesox belizanus*	0	1	0	0	0	0	0	0	0	0	1
Code Goby	*Gobiosoma robustum*	0	0	0	0	0	0	0	1	0	0	1
Gulf Killifish	*Fundulus grandis*	0	0	0	0	0	0	1	0	0	0	1
TOTAL	*22 Species*	261	228	139	202	702	408	465	98	173	66	2742

Table 4. Species and number of fish collected at Joe Bay (JB) in 2000-2001

Common Name	Species	Sep-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	Jun-01	Sep-01	Nov-01	TOTAL
Sheepshead Minnow	*Cyprinodon variegatus*	8	3	0	14	173	1	234	33	55	39	560
Rainwater Killifish	*Lucania parva*	23	37	5	33	68	12	97	38	40	53	406
Sailfin Molly	*Poecilia latipinna*	3	7	0	34	134	4	40	8	0	0	230
Eastern Mosquitofish	*Gambusia holbrooki*	0	4	6	22	46	1	109	0	0	2	190
Sunfishes	*Lepomis spp.*	0	10	11	44	116	0	0	0	0	1	182
Gulf Killifish	*Fundulus grandis*	0	0	0	0	157	0	6	14	2	2	181
Mayan Cichlid	*Cichlasoma urophthalmus*	23	45	12	0	1	0	0	0	0	7	88
Florida Flagfish	*Jordanella floridae*	0	0	0	3	84	0	0	0	0	0	87
Marsh Killifish	*Fundulus confluentus*	0	1	1	16	16	4	27	6	0	2	73
Bluefin Killifish	*Lucania goodei*	0	0	0	23	12	0	0	0	0	0	35
Silversides	*Menidia peninsulae*	0	0	0	1	0	0	10	0	0	0	11
Goldspotted Killifish	*Floridichthys carpio*	0	0	0	0	0	0	0	0	4	2	6
Golden Topminnow	*Fundulus chrysotus*	0	1	0	0	5	0	0	0	0	0	6
Naked Goby	*Gobiosoma bosc*	0	0	0	0	0	5	0	0	1	0	6
Clown Goby	*Microgobius gulosus*	0	0	0	0	0	0	0	0	1	1	2
Hogchoker	*Trinectes maculatus*	1	0	1	0	0	0	0	0	0	0	2
Redfin Needlefish	*Strongylura notata*	1	0	0	0	0	0	0	0	0	0	1
Gulf Toadfish	*Opsanus beta*	0	0	0	0	1	0	0	0	0	0	1
Least Killifish	*Heterandria formosa*	0	0	0	0	1	0	0	0	0	0	1
Mojarras	*Gerreidae spp.*	0	0	0	0	0	0	0	0	0	1	1
TOTAL	23 Species	59	108	36	190	814	27	523	99	103	110	2069

Table 5. Species and number of fish collected at Highway Creek (HC) in 2000-2001

Common Name	Species	Sep-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	Jun-01	Sep-01	Nov-01	TOTAL
Sheepshead Minnow	*Cyprinodon variegatus*	0	37	7		0	36	63	534	35	11	723
Gulf Killifish	*Fundulus grandis*	0	0	1		0	32	0	110	1	0	144
Marsh Killifish	*Fundulus confluentus*	0	1	0		1	0	65	31	2	0	100
Sailfin Molly	*Poecilia latipinna*	0	0	1		1	17	7	72	1	0	99
Diamond Killifish	*Adinia xenica*	0	0	0		0	3	32	48	0	1	84
Rainwater Killifish	*Lucania parva*	21	17	12		0	1	0	20	7	4	82
Goldspotted Killifish	*Floridichthys carpio*	18	0	0		0	0	0	0	20	20	58
Mayan Cichlid	*Cichlasoma urophthalmus*	13	27	5		0	0	0	0	2	2	49
Eastern Mosquitofish	*Gambusia holbrooki*	0	2	0		0	2	0	4	0	0	8
Bluefin Killifish	*Lucania goodei*	0	0	6		0	0	0	0	0	0	6
Clown Goby	*Microgobius gulosus*	1	0	0		0	0	0	0	1	3	5
Naked Goby	*Gobiosoma bosc*	0	0	0		0	2	0	2	0	0	4
Silversides	*Menidia peninsulae*	0	0	0		0	0	1	0	0	0	1
Leptocephalus larvae	*Leptocephalus larvae*	1	0	0		0	0	0	0	0	0	1
Pike Killifish	*Belonesox belizanus*	0	1	0		0	0	0	0	0	0	1
Gulf Toadfish	*Opsanus beta*	0	1	0		0	0	0	0	0	0	1
Sunfishes	*Lepomis spp.*	0	0	0		0	0	0	0	1	0	1
TOTALS	17 Species	54	86	32	0	2	93	168	821	70	41	1367

Table 6. Species and number of fish collected at Barnes Sound (BS) in 2000-2001

Common Name	Species	Sep-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	Jun-01	Sep-01	Nov-01	TOTAL
Sheepshead Minnow	*Cyprinodon variegatus*	0	8	0	38	13	17	0	137	2	3	218
Goldspotted Killifish	*Floridichthys carpio*	34	0	25	30	8	6	28	37	9	2	179
Rainwater Killifish	*Lucania parva*	45	19	40	14	2	1	2	2	12	6	143
Gulf Killifish	*Fundulus grandis*	0	0	4	44	10	45	0	4	0	0	107
Clown Goby	*Microgobius gulosus*	6	12	22	6	0	0	0	0	9	13	68
Sailfin Molly	*Poecilia latipinna*	3	0	3	13	12	1	1	3	1	0	37
Diamond Killifish	*Adinia xenica*	0	0	0	27	0	0	0	0	0	0	27
Marsh Killifish	*Fundulus confluentus*	0	0	0	16	0	0	0	1	0	0	17
Mojarras	*Gerreidae spp.*	3	4	0	0	0	0	0	3	3	1	14
Leptocephalus larvae	*Leptocephalus larvae*	6	0	0	0	0	0	0	0	0	0	6
Silversides	*Menidia peninsulae*	0	1	2	0	0	0	0	0	0	0	3
Eastern Mosquitofish	*Gambusia holbrooki*	1	0	0	1	0	0	0	0	0	0	2
Longnose Killifish	*Fundulus similis*	0	0	0	0	0	2	0	0	0	0	2
Gulf Toadfish	*Opsanus beta*	0	0	0	0	0	0	0	1	0	0	1
TOTALS	14 species	98	44	96	189	45	72	31	188	36	25	824