Dona and Robert's Bay Second Annual Watershed and Estuary Analysis 2004

Submitted to:
Sarasota County
Comprehensive Watershed Management Team

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Executive Summary

This document reports the status of ongoing data collection efforts undertaken to gain a better understanding of the Dona and Roberts Bay ecosystem and its response to watershed alterations. The watersheds that drain to Dona and Roberts Bay have undergone significant hydraulic alterations that have changed the quantity and timing of freshwater flows to the estuary. The Cow Pen Slough (CPS), Blackburn canal, and the Intracoastal Waterway are some examples of these hydraulic alterations.

Biology

Seagrasses were monitored quarterly using the Braun Blanquet method during 2004. Seagrass coverage in transect areas is sparse and subject to seasonal variation. *Halodule wrightii,* (a pioneer species with the highest tolerance to environmental fluctuations) is the only species observed in transect locations. Aerial seagrass mapping efforts conducted by the Southwest Florida Water Management District (SWFWMD) in 2003 indicated a 22% increase in overall seagrass coverage for the Dona and Roberts Bay area and an overall increase of 12% for Sarasota County since the 2001 SWFWMD mapping effort.

Oyster monitoring in 2004 indicated an increase in both the number of live individuals and the ratio of live to dead oysters at all monitoring sites since the 2003 monitoring. Curry Creek continues to have the least live and percent live oyster coverage and Lyon's Bay the most stable population. A mollusk survey, conducted by Mote Marine Laboratory during 2004, found that mollusk distribution in Shakket and Curry Creek is indicative of an altered system. The study also indicated that oyster populations historically extended further upstream in Curry Creek than present distributions.

Salinity

Salinity data from various monitoring programs were consolidated and analyzed for response to freshwater inputs. Salinity is highly variable especially in the wet season. In the latter part of the wet season, salinity remains at low levels for a duration sufficient to affect overall health and reproductive success of oysters, a keystone environmental indicator species.

Hydrology

Available hydrologic data continues to be collected and analyzed in order to discern present, historic, and target water budgets for the estuary. Data for 2004 indicates that the excess freshwater discharge to the estuary from the CPS watershed in 2004 was 61,626 acre-feet or 55.01 million gallons per day (mgd). Blackburn Canal delivered approximately 22,323 acre-feet or 19.93 (mgd) of water from the Myakka River to Curry Creek and Robert's Bay.

Natural Systems

A GIS analysis was used to compare land use distribution in the contributing watersheds for the DARB system. The analysis found that 59% of the land use classifications consisted of altered terrain such as developed areas, agriculture, and storm-water systems, while 41% consisted of wetlands or undeveloped uplands. In comparison, the Deer Prairie Slough watershed contained 4% altered terrain (primarily agriculture) and 96% undeveloped uplands and wetlands. Three large parcels were purchased by Sarasota County in 2004. Due to their strategic location in the watershed, these acquisitions provide opportunities for water management and restoration. Various natural system restoration efforts in the Dona and Robert's Bay watershed commenced in 2004. A tidal creek and tidal marsh restoration was completed on the Curry Creek Preserve which was acquired by the voter approved Environmentally Sensitive Lands Protection Program. Two Sarasota County Public Works mitigation projects will commence in 2005 in the Dona and Robert's Bay watershed. One project is on Curry Creek and one on Fox and Shakkett Creek.

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Section I
Introduction and Background

This document serves as the second report addressing the ongoing data collection efforts to evaluate the status and trends, explore interrelationships, discuss restoration success and possibilities in the areas of biological indicators, salinity, and hydrology as related to Dona and Robert's Bays.

Project Background

Sarasota County Government's (SCG's) local economy depends on tourism and an influx of resident retirees (Daltry, Presentation to Sarasota County, 2004). Our natural habitats and coastal resources attract many people to our area. As our population increases so does the potential for impacts to natural resources that have attracted people to the area. Properly managing our natural resources requires a more thorough understanding of the cause and effect relationship of anthropogenic landscape alterations to our ecosystems. The Sarasota County Center for Watershed Management has drafted the Comprehensive Watershed Management Plan (CWMP) focusing on managing SCG's water resources around four interconnected areas: Water Quality, Flood Protection, Water Supply, and Natural Systems. The programs and projects discussed in this report address the CWMP's Natural Systems goal: "*To enhance, protect and conserve the hydrologic and ecologic functions of natural systems including estuaries, freshwater, and groundwater systems.*" The majority of efforts described in this report are in support of Tasks 3 and 4 of the Dona Bay Watershed Management Plan drafted by SCG in October 2004. Task 3 is the development of a water budget for the Dona Bay Watershed. Task 4 deals with the development of Environmental Indicators for Dona and Robert's Bay.

Improvements in technology and communication enable scientists, planners, and policy makers to share and analyze larger environmental data sets with increasing speed and accuracy. The following watershed analysis collects, consolidates, and examines data from a variety of sources. The report focuses on various environmental indicators in the areas of biology and salinity. The report also examines watershed hydrology. This integrated approach provides a sense of existing conditions, as well as an opportunity to guide and monitor the success of the SCG's restoration and management efforts for the Dona and Robert's Bay (DARB) watershed.

DARB Watershed Description

The DARB watershed has a contributing area of 62,376 acres and is one of the five major watersheds in Sarasota County (Figure 1). The predominant land use type in the upper watershed is pasture and low density residential; the tidally influenced portions of the DARB watershed consist primarily of medium to high density residential. The DARB watershed is comprised of several drainage basins. The Cow Pen Slough, Shakket Creek, Coastal Venice, Curry Creek, Lyons Bay, and Hatchet Creek basins all discharge freshwater to the DARB. The largest is the Cow Pen Slough basin.

Much of the Cow Pen Slough drainage basin drained east via Cow Pen Slough (CPS) toward the Myakka River and a much smaller area historically drained toward Dona Bay.

The Natural Resource Conservation Service (NRCS), formerly known as the Soil Conservation Service (SCS), excavated the CPS Canal in order to efficiently drain the land for agriculture. The canal was partially completed in the early 1970s (Lincer, 1975). During the construction, concerns of fresh water impacts to Dona Bay were raised and the project was subsequently halted. The completed portion now extends from the tidal headwaters of Shakket Creek north to the eastern portion of the Bee Ridge landfill. The canal increased the size of the DARB watershed from approximately 5 square miles to 75 square miles. The canal has two control structures. One is located south of S.R. 72 (upper weir), and the second is located at the tidal freshwater interface west of King's Gate Mobile Home Park (lower weir). The lower weir discharges directly into the upstream end of Shakket Creek. Both structures are gated and are opened by SCG staff in early June each year in anticipation of the rainy season. The gates are closed in November to conserve water during the dry months. This schedule has been established by agricultural interests and has been maintained regardless of rainfall or estuarine habitat needs.

In addition to the CPS Canal, other alterations have resulted in a substantial increase in freshwater input to the DARB system. The Blackburn Canal was dug to connect the Myakka River to Curry Creek, increasing freshwater inputs from the Myakka River to Robert's Bay (Deleuw, Cather & Brill, 1959). Hatchett Creek has been deepened and extended several miles inland. Additionally, a tidal flow dye study conducted in 2003 by SCG staff supports the results of a previous study from the 1970s. The study indicated that during certain flow conditions and at certain times during the year, Alligator Creek and Woodmere Creek watersheds may also drain toward Venice inlet via the Intracoastal Waterway (ICW), rather than Lemon Bay as was the case historically and is still widely accepted. Other alterations affecting DARB basin hydrology and ecology include dredging for navigation, coastal wetland filling, dredging of finger canals, shoreline hardening (seawalls) and the construction of the ICW.

Monitoring Program Description

Current trends in data show that estuaries in southwest Florida have been adversely impacted by alterations to the quantity and timing of freshwater inflows. The DARB system may be an extreme example of this scenario. In 1975, Mote Marine Laboratory submitted a report, "The Ecological Status of Dona and Robert's Bays," to the Sarasota Board of County Commissioners. The report documented freshwater impacts to the DARB system predominantly from increased freshwater flows and sediment deposition. The data gathering effort for the 1975 report was instrumental in the NRCS's decision to abandon the CPS work plan. Aside from that report, there are limited historical biological, water quality, and hydrological data for the DARB area. New data are being collected in DARB to provide a better understanding of the water budget and to guide management of the watershed.

Biology

This report addresses SCG monitoring of seagrass and oyster habitat as biological indicators of estuarine health for the DARB system. Research has shown that seagrass beds provide important habitat for a variety of estuarine and marine fauna. Oysters are another widely accepted biological indicator. Oyster beds provide important shelter, habitat, and foraging areas and also help prevent erosion by stabilizing shorelines. Oysters and seagrasses are susceptible to changes in salinity and sediment loads. Little background data exist for these two habitats in the DARB system. The results from the SCG monitoring program will be used as baseline data for analysis of future trends. Other biological monitoring projects supporting the program are also addressed.

Salinity and Hydrology

Many variables affect the status of our natural systems. In integrated systems, it is difficult to look solely at estuarine biological indicator status and infer any conclusions or make informed water management decisions. The biology of an estuary is driven by the water quality and hydrology of the system. Therefore, this report will also examine available water quality and hydrologic data. Available data from 2003 and 2004 will be compared and evaluated for any evident correlation to observed responses in the status of biological indicators. Hydrological data for this report is collected at SCG's Automated Rainfall Monitoring Stations (ARMS). Sites are located strategically throughout the county and provide stage and precipitation data via a radio telemetry network. Site locations are shown in Figure 1.

Natural Habitat

The productive component (the biology) of an estuary is driven by its water budget. A water budget in turn is driven by the physical characteristics of the surrounding watershed and its effects on the dynamics of surface water flow through the landscape. Preserving Natural habitat in the landscape is one strategy that will help maintain a natural flow regime across the landscape. Maintaining or restoring natural flow regime is vital in SCG's efforts to improve the ecological values and functions of the DARB estuary. Environmentally sensitive land acquisition provides an opportunity to preserve, enhance, or restore natural systems. A summary of SCG's acquisition, preservation, and restoration efforts in the DARB watershed is found in Section V of this report.

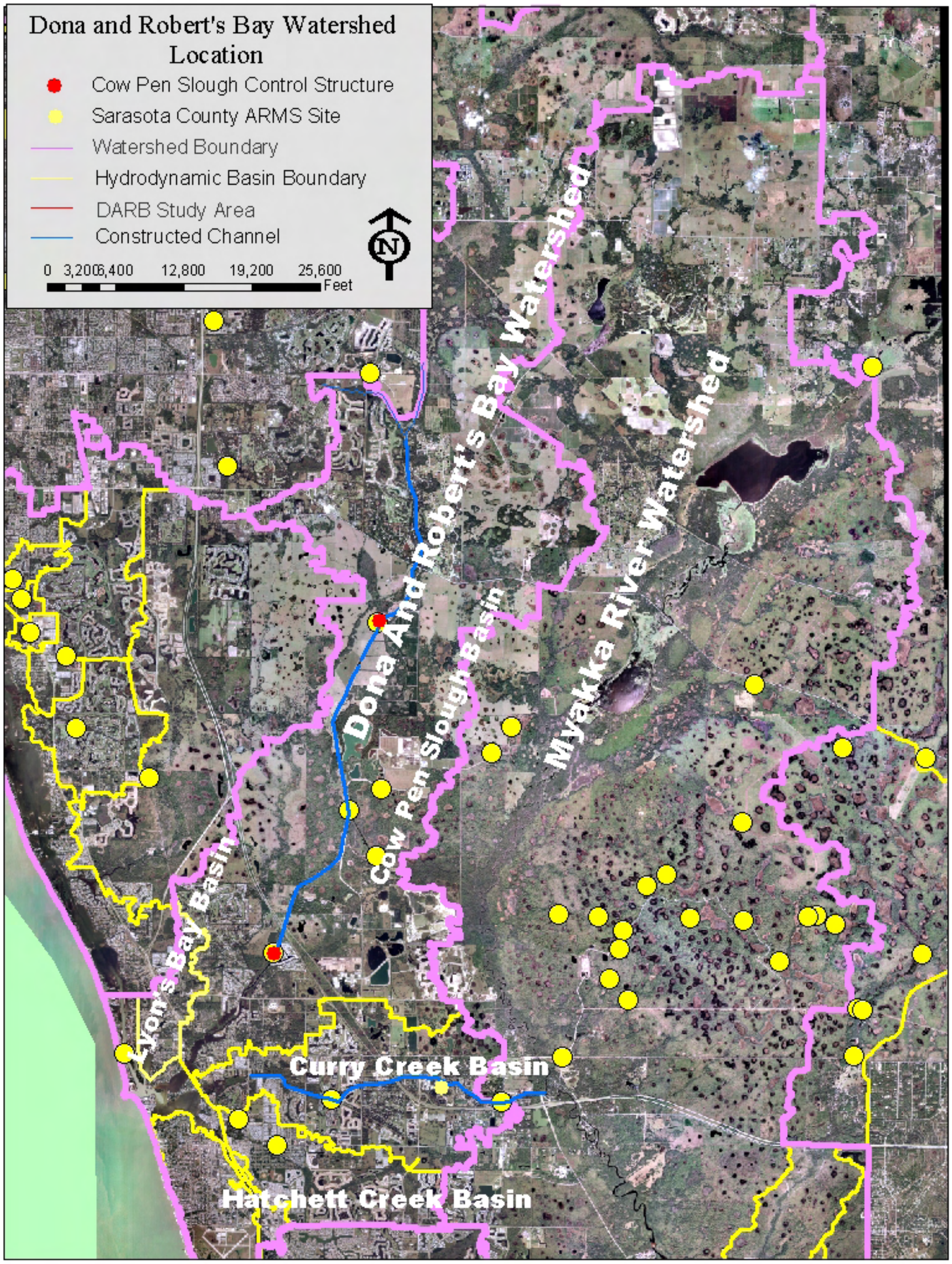


Figure 1. Dona and Robert’s Bay Watershed location map and SCG ARMS sites...

SECTION II
BIOLOGY

DARB Seagrass

Seagrass as an Environmental Indicator

A wealth of scientific studies exists on the biology and ecology of seagrass. The intensive monitoring and data collection efforts that have occurred since the 1960's have improved our understanding of seagrass ecology. Improving technology has enhanced the quality, accuracy, and speed of data collection and analysis. Current technology has enhanced our understanding of the vital role that seagrass plays in the estuarine and marine environment. Improved monitoring techniques such as satellite imagery, high-resolution aerial photography, spectral analyses, and GIS allow us to document long-term trends in seagrass coverage.

The role of seagrass functions and values on the estuarine ecosystem has been thoroughly documented. Various types of commercially important estuarine and marine fauna depend on seagrass habitat for all or part of their life cycle. Many of our local sport-fish species use seagrass beds as nursery habitat and also forage in the grass beds during their adult stage. Fly-fishing on seagrass flats has become a popular tourist activity as evidenced by the many specialized fishing guides in our area. A study conducted in 1991 showed that tourists spent $2 billion fishing Florida waters during that year (Steadman and Hanson, 1998). Commercial and sport-fish species are not the only beneficiaries of healthy seagrass habitats. Throughout the food chain, a wide variety of fauna, big and small, rely on healthy seagrass habitat. Seagrass provides an essential food source for the West Indian Manatee, an endangered species. Seagrass has also been shown to improve water quality by increasing available oxygen and cycling nutrients in the water column. Further, seagrass improves water quality by slowing water flow and allowing suspended sediments to settle out of the water column. Healthy grass beds help slow erosion by stabilizing soils and buffering wave action.

Although seagrass is tolerant to environmental fluctuations, studies have indicated that seagrass responds to both natural and anthropogenic changes in water quality. The Southwest Florida Water Management District (SWFWMD) has attributed increases in seagrass acreage in Sarasota Bay to improved wastewater treatment (Tomasko et al.,. 2002). Work conducted by the South Florida Water Management District (SFWMD) in the southern Indian River Lagoon indicates that seagrass health can be directly correlated to water quality (Crean et al.., 2003). Scientific observation has indicated that seagrass coverage in our area increases in drought years and recedes during abnormally wet years. Seagrass beds provide many fundamental ecological functions and values and respond to hydrologic change. Therefore, scientists worldwide, and environmental regulation agencies such as the United States Environmental Protection Agency (EPA) and Florida's water management districts promote the monitoring of seagrass as an indicator of environmental health.

Methods

SCG relies on data collected by SWFWMD to monitor trends in seagrass acreage. The SWFWMD conducts aerial seagrass bed mapping throughout the District's coastal counties every other year. Aerial mapping began in 1986 and is taken in late fall at the end of the growing season. A photographic interpolation is conducted, seagrass polygons are scrutinized for change, and any change is incorporated into the original polygons. Seagrass polygons are categorized as patchy or continuous. When the GIS work is finalized, data are available to download from the Water Management District's website. It takes approximately one year of data entry and analyses before results are released to the public. The last aerial photographs were taken in late 2003. The data from the 2003 event was released in February 2005.

In May 2003, SCG established three seagrass transects (LYB1, DB1, and RB1) in the DARB study area to monitor composition and health (Figure 2). Transect locations were selected in areas that were identified by the SWFWMD as containing consistently seagrass. A field reconnaissance confirmed sparse seagrass coverage in these locations. Transects started at the shallow end of the bed and terminated at the deep edge of the bed. A GPS position was taken as well as a compass bearing from a fixed location marked either by a piling or flagging tape on mangrove islands. Using a 200 m tape and a 1m x 1m quadrat, seagrass was analyzed every 10 m for bed lengths less than 50 m. For bed lengths over 50m, data were collected from the beginning, middle and edges of beds. For beds longer than 150 meters, data were collected at 50 m intervals. Transects were analyzed for abundance with the Braun Blanquet method. This method is the used by the Florida Department of Environmental Protection to monitor seagrass beds annually in Charlotte Harbor, Lemon Bay, and Sarasota Bay at the end of the wet season. The Braun Blanquet method classifies coverage into categories based on percentages (i.e., r = solitary, + = few, and category 1 = <5% cover). For data analyses and presentation purposes a numerical value of 0.5 is assigned to the "+" category and a value of 0.1 is assigned to the "r" category. Species composition, depth, shoot density, sediment type, and epiphyte density are also recorded. Physical water quality parameters were taken at each station as well as photosynthetically available radiance or PAR. In 2004, transects were monitored quarterly to investigate seasonal variation.

Results

Aerial mapping of seagrass by the SWFWMD in late 2003, (Figure 2), indicated an increase in seagrass acreage for both the DARB estuary and Sarasota County since the 2001 mapping event (Figure 3). DARB seagrass acreage increased from 84 to 102 acres. This constitutes a 22% increase in DARB seagrass. Seagrass acreage for Sarasota County increased 12% from 5435 acres to 6092 acres since the 2001 mapping event. Transect data and field observations however, indicated sparse coverage of seagrass in the DARB area in October 2003.

Quantitative monitoring of seagrass transects occurred in January, April, July and October of 2004. Monitoring during 2003 took place in October. The quarterly monitoring results showed seasonal variation at all stations. No seagrass was found at the

Figure 2. SCG Transect locations and 2003 SWFWMD seagrass bed delineation

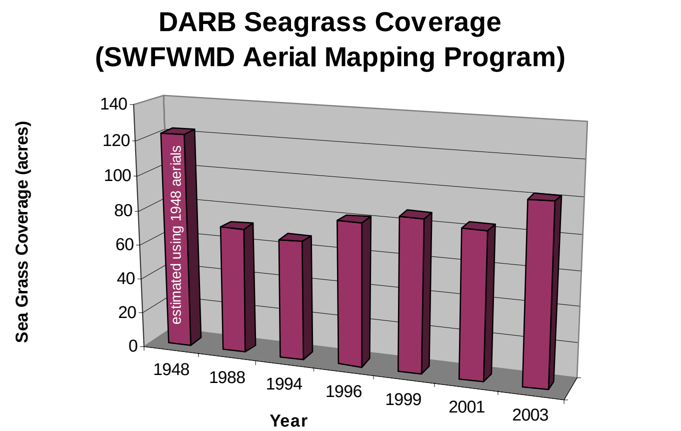


Figure 3. DARB seagrass acreage history from SWFWMD mapping data.

Robert's Bay transect during the January 2004 event nor the Lyon's Bay transect during the October 2004 event. Table 1 presents the results for abundance values, mean blade length, bed length and PAR. Figures 4, 5, and 6 illustrate the trend for those respective parameters. Results indicate continuing sparse coverage of seagrass in areas consistently mapped as grass beds by the SWFWMD. Visual observations throughout the project area verified sparse coverage with observed seagrass shoots being new and emergent or coated with algae during most events. *Halodule wrightii* was the only species observed at transect locations. Of the species of seagrass that occur in our area, *Halodule wrightii* is the species most tolerant to fluctuating environmental conditions. Scientists consider it to be a pioneer species.

	Mean Braun Blanquet Abundance			Mean Blade Length (cm)			Bed Length (m)			PAR (% at deep edge)		
Date	LYB1	DB1	RB1	LYB1	DB1	RB1	LYB1	DB1	RB1	LYB1	DB1	RB1
10/3/2003	0.5	1	0.75	4.3	5.27	3.3	8	39	44	NO	METER	
1/12/2004	0.8	0.4		6.29	6.07		40	20		68.92	Too Shallow	47.2
4/7/2004	0.4	0.4	0.67	11.3	6.7	7.67	30	25	76	61	91.9	31.45
7/16/2004	1	2.13	2.67	10.48	7.85	17.27	37	30	63	25.68	85.95	21.42
10/6/2004		1	0.1		4.9	3.6	0	30	40	25.78	Too Shallow	16.52

Table 1. Seagrass abundance, mean blade length, and bed length.

Transect data using the Braun Blanquet method indicated that overall, seagrass at all three transects fell below abundance category 1 meaning that generally, seagrass abundance at all stations fell below 5% cover. The July 2004 monitoring event was an exception. July abundance values ranged from category 1 (below 5%) in Lyons Bay to category 2 (5%-25%) in Dona and Roberts Bay. Mean blade lengths were also generally less than 8cm throughout the study area except in July 2004. Mean blade length averaged across all transects approached 12 cm in July. The lowest recorded bed lengths, 8 m and 0 m (no seagrass observed) occurred at the Lyon's Bay transect during October 2003 and October 2004, respectively.

Plants produce their metabolic energy through the conversion of sunlight in a process called photosynthesis. Water quality has an effect on light penetration in the water column. SCG uses a LICOR meter with a flat sensor to determine the percentage of surface light available for seagrass photosynthesis at the deep edge of the seagrass bed.

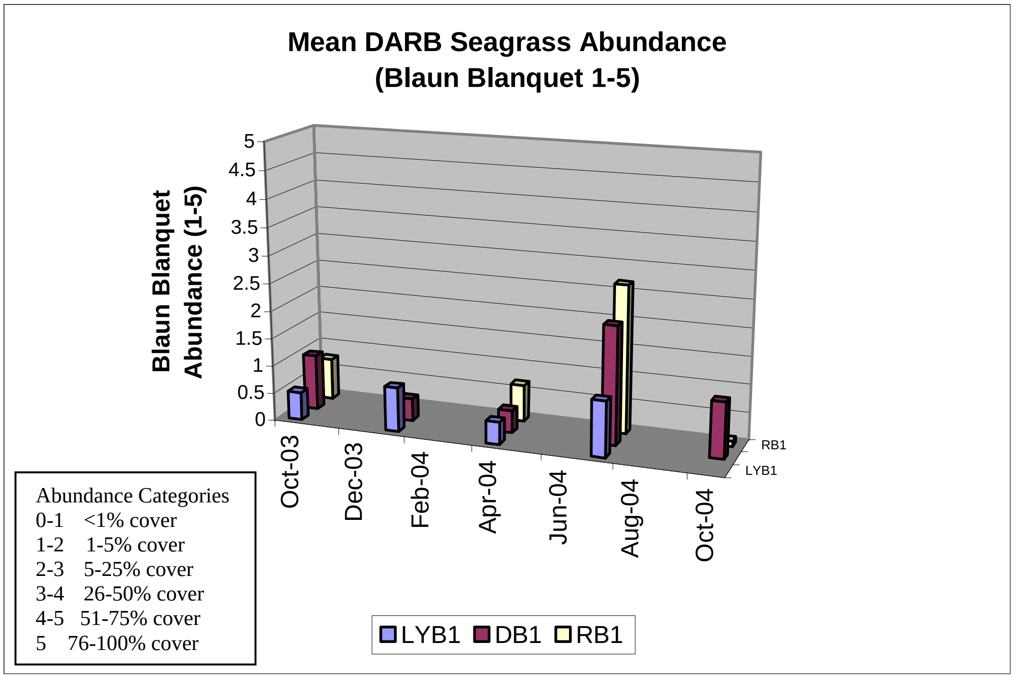


Figure 4. Blaun Blanquet abundance trends

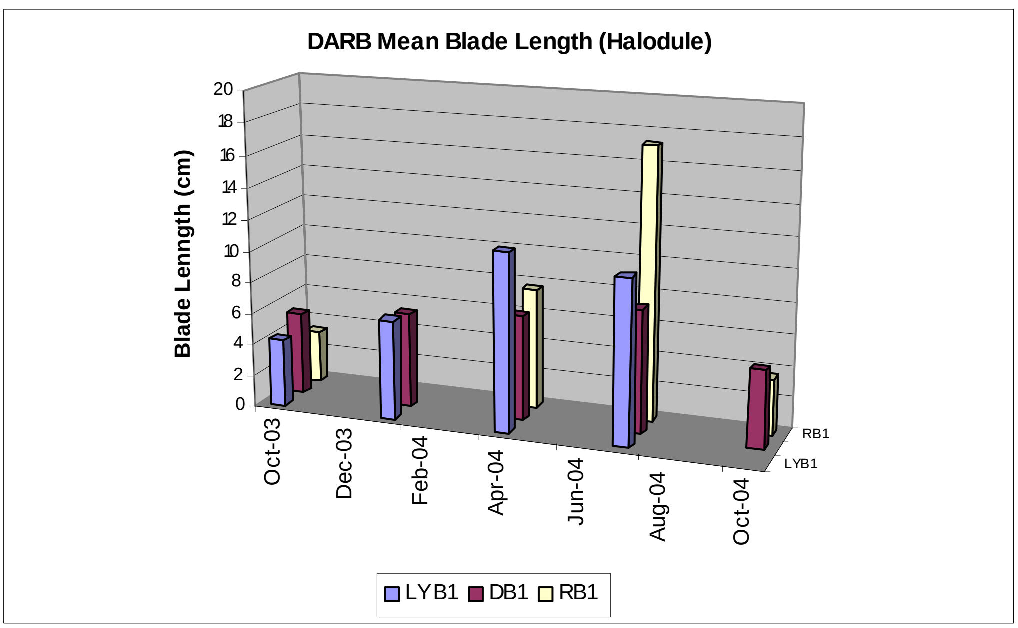


Figure 5. Mean blade length.

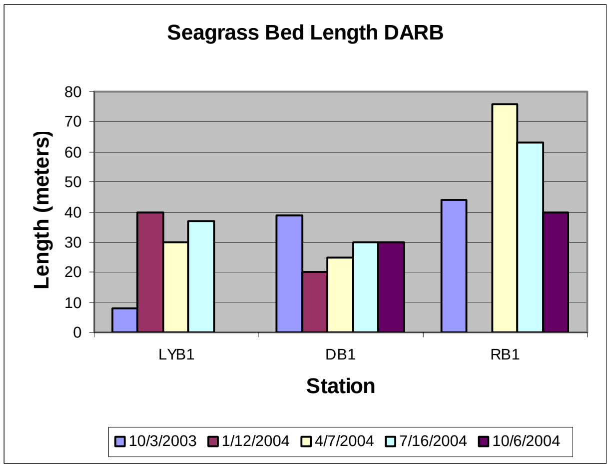


Figure 6. Seagrass Bed Length Trends

Discussion

Seagrass in DARB is sparse compared to other areas with continuous beds. Quantitative results indicate that generally seagrass coverage at DARB transects is less than 5% SCG conducted visual field surveys to ascertain the locations of other grass beds. DARB seagrass appear to be most abundant near the ICW between Albee Road Bridge and the Venice Inlet between river kilometers 1.0 and 1.7. The densest areas are northwest of the mouth of Lyon's Bay. Two species of seagrass, *Halodule wrightii* and *Thalassia testudinum*, were observed growing in this area. Due to the variability of factors affecting seagrass development, it is hard to ascertain exactly why conditions are not favorable in the DARB area. Historical and anecdotal evidence indicate that the area once supported a larger population of seagrass before the construction of the ICW, CPS, and Blackburn Canal. The scarcity and low coverage of seagrass in the DARB transects tends to amplify variability. Seagrass remains an important indicator for the system. SCG staff is investigating different monitoring protocols for environmental indicators in order to establish a monitoring program that provides the most cost effective and informative data for resource managers.

DARB Oyster Beds

Oysters as an Environmental Indicator

Like seagrass, oysters also fill an important environmental niche. They provide many of the same ecosystem functions as seagrass. Oyster beds provide habitat for many of the same types of marine fauna. They also provide habitat for species that are adapted to oyster beds such as oyster drills, conch, mud crab, other bivalves, and specialized fish. An individual oyster can filter between 4 and 40 liters of water per day, (Volety et al, 2003) providing a valuable water quality function. Water clarity and PAR have been observed increasing immediately downstream of oyster beds. Recent work conducted by Volety shows that oyster bed health is affected by water quality, and in particular salinity.

Oysters have specific environmental requirements and are susceptible to fluctuations in the environment. For example, salinity is a primary factor that affects oyster status. Optimal salinity range for oysters is 15 ppt - 25 ppt (Kennedy et al., 1996). Salinities below 10 ppt affect their reproductive success. Salinity below 3 ppt is lethal to most juvenile oysters (spat). If salinity remains below 2 ppt for more than a month most adult oysters perish. The growth rate of oysters slows above 30 ppt and they are more susceptible to predators, parasites, and disease in areas with higher salinities. Oysters also provide shoreline stabilization. Due to their wide variety of ecosystem functions and values, oysters are considered a keystone species, or a species that is the foundation on which an entire community is based.

Oysters have a history of being a popular food commodity. Oyster meat is in great demand and an industry has grown around oyster harvesting and cultivation. With some coastal economies depending on oysters, scientific research and study on this species has garnered a great deal of support. As with seagrass, there exists a wealth of scientific literature on this species.

Oysters grow near the mouths of most of the tidal creeks in Sarasota County. Due to their immobility, importance as a habitat, responsiveness to environmental change, and water quality enhancement capabilities, oysters are an important indicator of estuarine health. SCG has developed a target of 70% live oysters on oyster reefs. Healthy oyster beds occurring in areas that are not heavily impacted range between 65% and 85% live. Oyster studies further south in areas such as the Caloosahatchee River and Fakahatchee Bay, have healthy oyster populations ranging from 600 to 1400 live oysters per square meter. Studies indicate that healthy oyster beds in the southern Gulf Coast region typically support 500-1000 or more oysters per square meter.

Methods

To gage the health of oyster beds, an initial effort to locate and map oyster beds in the DARB project area was undertaken in early 2003. Oyster beds were delineated in the field using a Trimble Geoexplorer 3. The GPS data were loaded onto ortho-rectified color aerials. This method allowed correlation with pixel signatures on the aerial photos enabling further delineations. Most oyster bed habitat in the DARB project area was then delineated using the color aerial photography from 2001. At least thirty percent of the oyster beds in the area were field verified. 1948 aerials were used to estimate the historic extent of oyster beds. Due to the quality of the 1948 photos, only the areas east of U.S. 41 were analyzed for historic extent. In 2004, SCG contracted Mote Marine Laboratory to evaluate historic extent of oyster beds upstream of U.S. 41 on Curry and Shakket Creeks.

Six permanent oyster-sampling sites were selected, one site in each of the three bay segments (Dona-DB1, Lyons-LYB1 and Robert's Bay RB1), two in Shakket Creek (SC1 and SC2), and one in Curry Creek (CC1). In the spring and fall, oysters at each station were collected from three randomly placed quarter meter square PVC quadrats. The collected oysters were placed in five gallon buckets for counting on the boat, where the number of live oysters, dead oysters, and spat were recorded. The five longest live oysters were also recorded. Oysters were considered dead if both shells of the bivalve were still conjoined yet contained no tissue. Physical water quality parameters are also recorded at each sampling station. The data was analyzed using a one-way ANOVA analysis as well as three different analyses of variance (Levene's, Brown-Forsythe's, Scheffe's). The statistical analysis was run on the percent of live oysters as well as the number of actual live oysters. 2003 and 2004 data were compared using a two-way ANOVA analyses and the same three tests for variance. Delineated oyster bed locations and sampling stations for the study area are presented in Figure 7. Additionally, Figure 7 illustrates the river kilometer system (RKS) that was established on a GIS layer as a data reference tool. The RKS starts at 0.0 kilometer at Venice Inlet and extends upstream through all of the tributaries to a predetermined point.

Results

Both percentage of live oysters and number of live oysters increased in 2004 at all sites except the Lyon's Bay site, where numbers remained consistent with the 2003 data. Statistical analyses and field sheets of the quantitative data collected in 2004 can be found in Appendix A. Analyses indicated that the sampling site in Lyon's Bay (LB1) had the largest number of percent live and the most stable numbers of live oyster. Statistical analyses also showed that Lyon's Bay was significantly different to all other sites for both percentage and number of live oysters (except RB1 which was similar in percent live only).

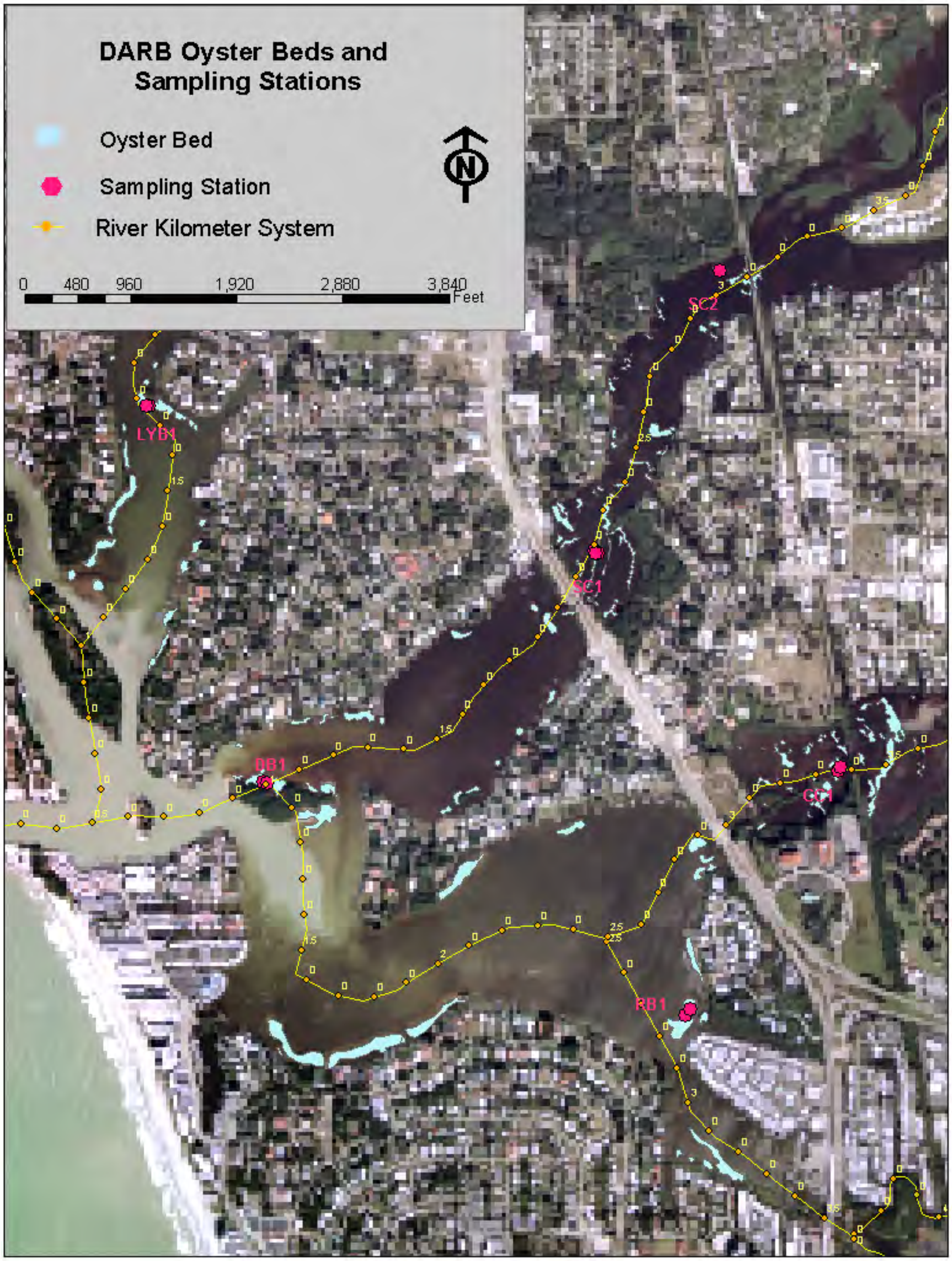
Both number and percentage of live oysters were also significantly different from all other sites at Curry Creek. No live oysters were observed at the Curry Creek site during the 2003 event. The Curry Creek site increased in live oysters and percentage live during 2004. Curry Creek remains the site with the lowest percentage of live and number of live oysters.

Oysters in Dona Bay and Shakket Creek increased in both percentage live and total live oysters during 2004 (Figure 8 a & b).

Statistical analyses indicated oysters in the Shakket Creek and Dona Bay segments of the DARB study area were the most similar to one another in number of live and percent live oysters. Visual observations indicated that the most robust oyster habitat remains in Shakket Creek between U.S. 41 and the railroad trestle.

The Robert's Bay station, located in close proximity to the ICW and the historic mouth of Hatchett Creek, remained fairly consistent in percentage of live oysters and experienced an increase in actual number of live oysters. Visual observations at the RB1 site indicated an increase of oyster spat recruitment on available substrate. The Robert's Bay site differed from the other sites. Here, oysters tend to grow in scattered clumps or balls on suitable substrate rather than a reef structure. The Levene's test of variance and post hoc test indicated that there was no significant difference in percent of live oysters when comparing the Robert's Bay site with the healthiest site in Lyon's Bay. However, when examining the amount of live oysters only, the qualitative statistics indicate that the Robert's Bay site was more similar to all other sites except the Lyon's Bay site. Figures 9 and 10 are graphic representations of the ranges of percentage live oysters estimated for the study area from data collected for 2003 and 2004, respectively. The figures are for graphic representation only and are not meant to imply that the whole area is covered with oysters.

Figure 7. Oyster bed locations and sampling stations



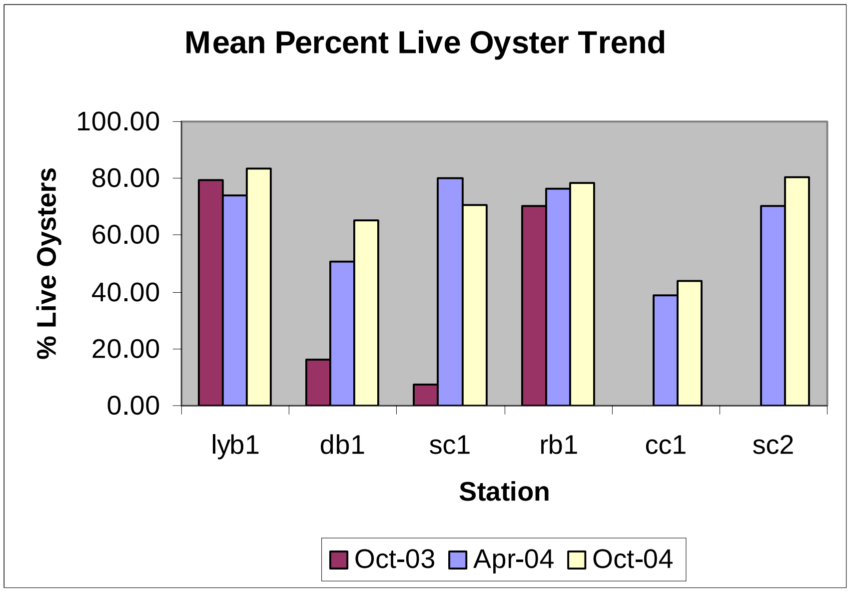


Figure 8a. Mean percent live oyster trend.

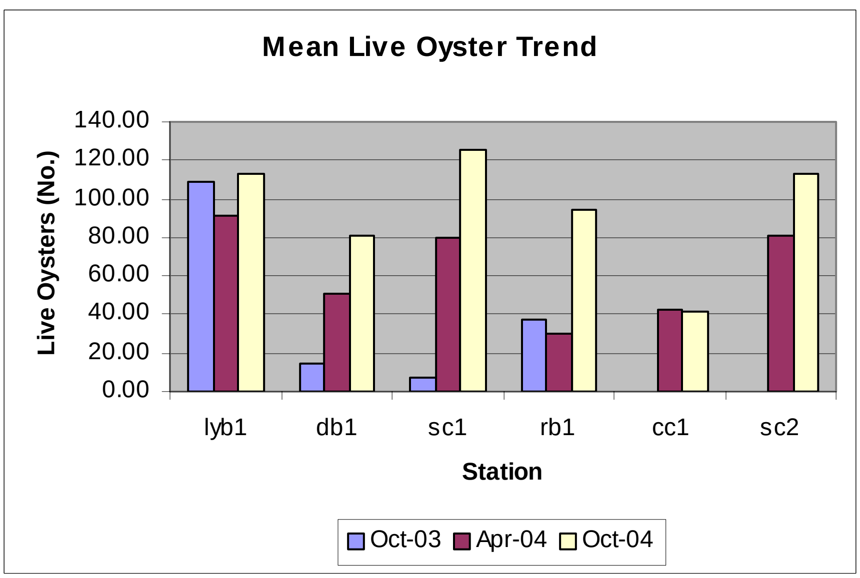


Figure 8b. Mean live oyster values.

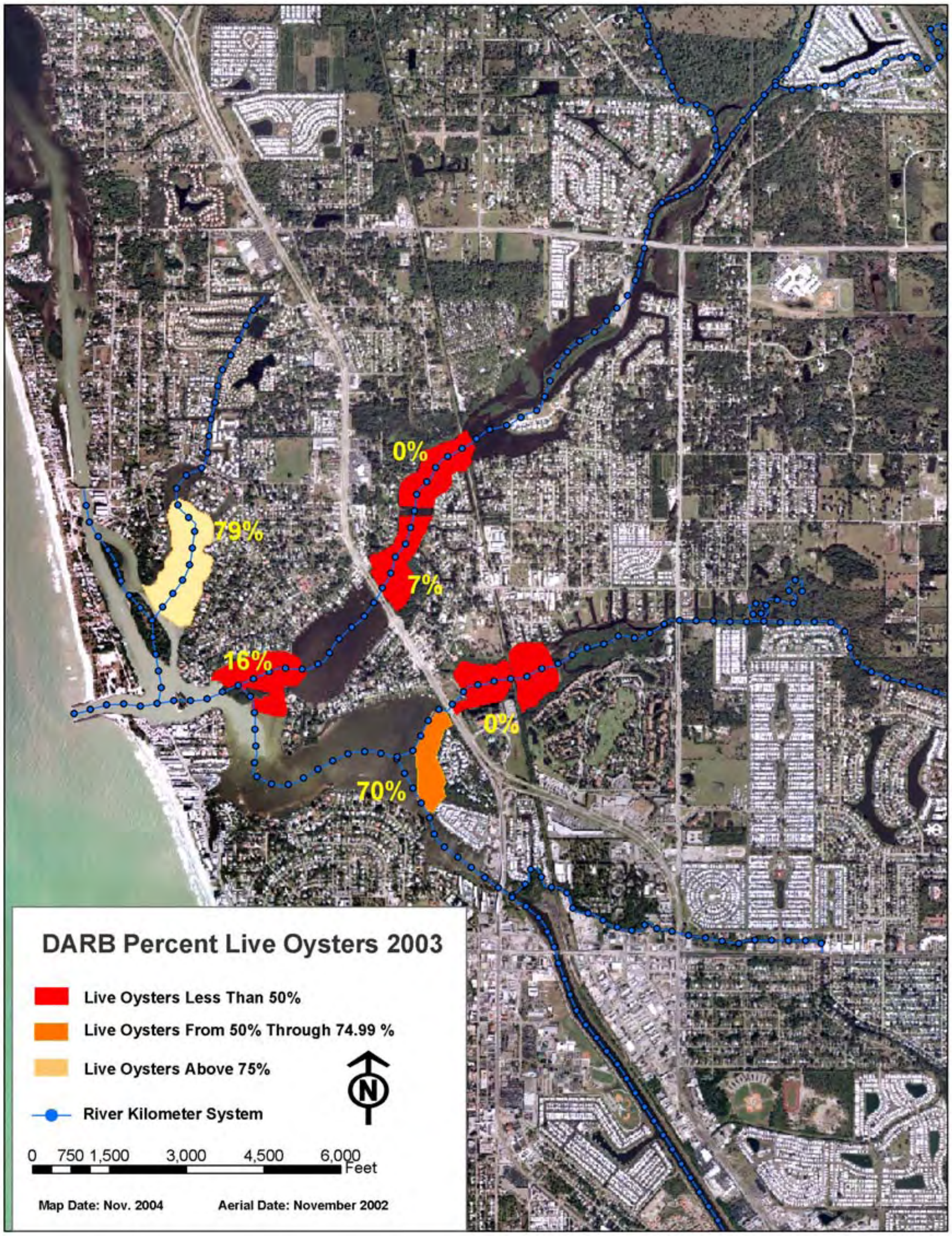


Figure 9. 2003 DARB percent live oysters

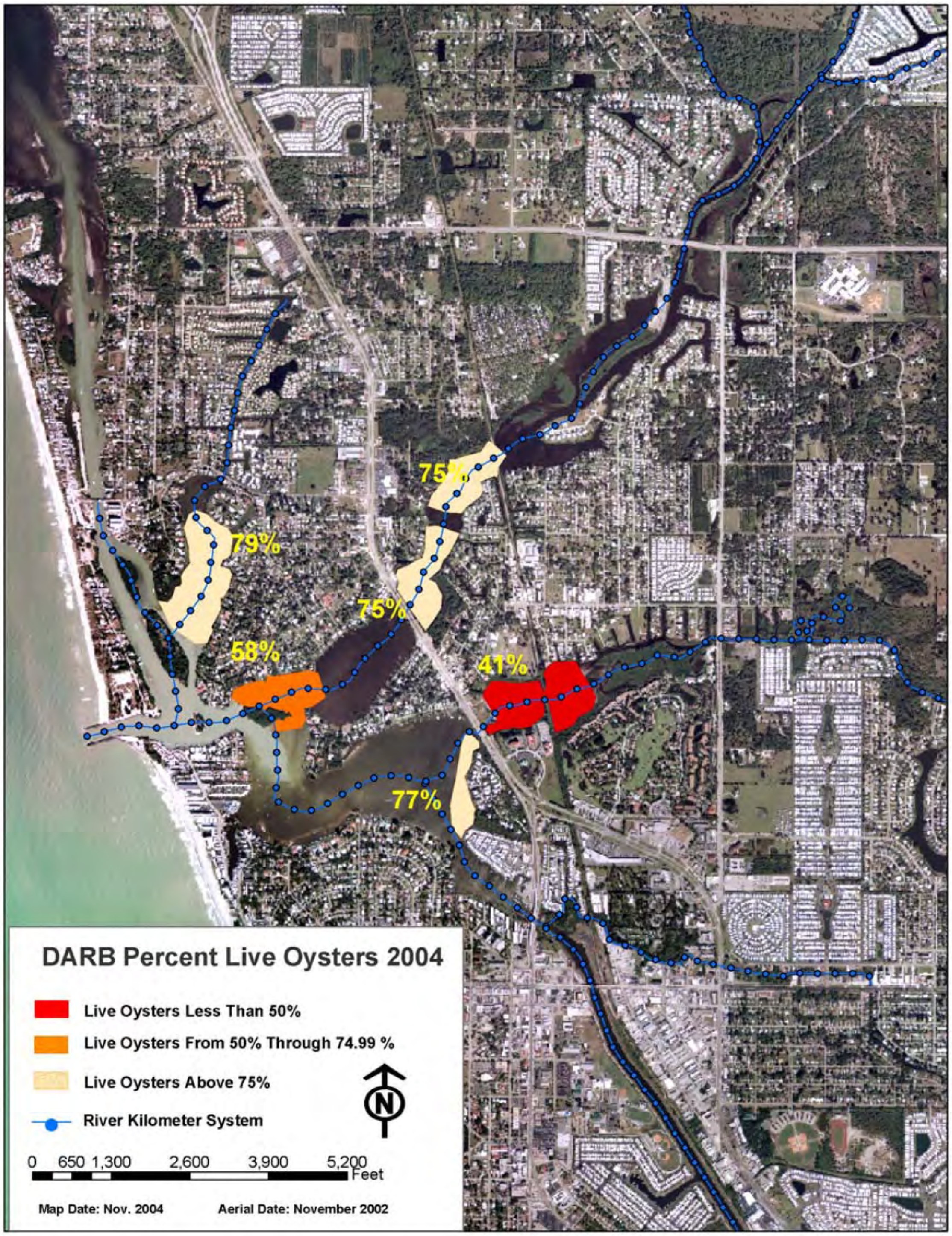


Figure 10. 2004 DARB percent live oysters

Spat recruitment at all sites was higher in 2004 than 2003. In 2003 an average of one spat per square quarter meter was observed, compared to an average of twelve in 2004. Oysters in our area are capable of setting spat throughout the year but winter sets are minimal. Spring is the peak season of spat production and recruitment in southwest Florida. Oysters continue to reproduce throughout the wet season with another peak of activity in the fall. Overall, live oyster numbers in DARB were less than in the healthier sites in the Caloosahatchee River and Fakahatchee Bay. These areas located south of Sarasota County have higher oyster counts per square meter than the DARB area (Volety, 2003).

Discussion

The percent of live oysters in the DARB area appear to exhibit high annual and seasonal variability. A qualitative survey conducted in September 1982 by SCG found no live oysters in Curry Creek, Shakket Creek, or Dona Bay. Yet in February 1983, live oysters were found throughout the Dona and Robert's Bays area (Sauers, 1983). A more recent study of an oyster relocation project in Shakket Creek showed the number of live oysters increased overall during a three year monitoring project, yet the second year of monitoring in October showed a large decrease in live oysters at all stations (Ed Barber and Associates, 2003). The 2004 monitoring of oysters showed a substantial increase in oyster populations at all stations except Lyon's Bay. The highest increases of 75 and 41 percent occurred at the upstream stations in Shakket and Curry Creeks respectively, where no live oysters were found in 2003.

Example of shoreline oyster colony in Shakket Creek

An oyster mortality observed in the DARB area during the 2003 wet season was attributed to an abnormally wet, rainy season. The Caloosahatchee estuary system also experienced a similar, yet not as severe, mortality in upstream stations in 2003. In 2004, the DARB watershed received considerably less rainfall than in 2003 (see Hydrology Section). The number of live and percent live oysters has increased throughout most of the DARB stations since 2003. This increase correlates, and is most likely, attributed to rain and runoff driven salinity regimes that are discussed further in the hydrology section.

Other Biological Monitoring Efforts

In addition to the oyster and seagrass monitoring efforts, other studies are being conducted to add to our understanding of the DARB estuary. In 2004 SCG contracted Mote Marine Laboratory to conduct a mollusk survey, a historical oyster distribution analysis and a benthic macro-invertebrate survey in DARB and the Myakka River.

The Mote mollusk study indicated that mollusk distribution data was different in DARB than all sites previously studied for the SWFWMD Minimum Flow Level's program and other similar efforts. This difference is attributed to the high proportion of marine species collected in the lower reaches of DARB. Waters west (downstream) of U.S. 41 were dominated by marine species. East of U.S. 41, the oyster is the dominant species. The prevalence of both live and dead oyster beds in both Shakket and Curry Creeks indicate this species has the potential to play a major role in the ecology of the DARB system. Sampling indicated a higher density of oysters in Curry Creek than Shakket Creek. The higher observed density was the consequence of collected dead material. An additional effort was undertaken to map the historic oyster extend in Curry and Shakket Creeks. Dredging activities have heavily impacted the upstream reaches of Shakket Creek. This study did not indicate that oysters once colonized areas of Shakket Creek that no longer support lives oysters. Efforts on Curry Creek did indicate some buried reefs upstream of modern reefs. The Mote report suggested that future management and monitoring might be improved by dwelling solely on oysters and their growth, recruitment, disease, predation and mortality. (Estevez, 2005)

As part of the SWFWMD's minimum flows and levels study, the District has contracted the University of South Florida's College of Marine Science and FWCC's Fisheries-Independent Monitoring Program to conduct a study entitled *"Fish and invertebrate responses to Freshwater inflow into the Dona and Robert's Bay Estuary."* Data collection for this project began in June 2004 and should extend through June of 2005. The draft report is scheduled for release in August of 2005. SWFWMD provided water quality data associated with this study to SCG for the water quality section of this report. In addition, Sarasota County contracted Sauers Environmental Services Inc. to investigate environmental indicators and monitoring methodology applicable to meeting SCG watershed management goals and objectives.

SECTION III
Water Quality

Programs and Background

Many variables affect the health and status of estuaries. One of the most important is the mix of fresh and salt water. Many different water quality parameters can affect the health of estuarine dependent organisms. Salinity is probably the most important parameter that affects oyster health and distribution. Parameters that affect water clarity, such as turbidity, color, total suspended solids, and chlorophyll, affect the ability of seagrass to assimilate sunlight. Most fauna depend on dissolved oxygen for cellular respiration. Fauna tend to move away from water with low dissolved oxygen (DO) concentrations. It is impossible to make any assumptions about the status of an estuary without an understanding of salinity fluctuation and ranges. Historically, there have been few data collected for the DARB study area. From late 2002 to present, various programs to study the area have been initiated to gain a better understanding of water quality status and fluctuations.

As part of the county's MS-4 permit under the NPDES program, SCG has contracted Mote Marine Laboratory to collect monthly random grab samples throughout the coastal waters of Sarasota County. No grab sampling stations were previously located in the DARB, thus five additional stations were added (DR1-DR5) in 2003. Although many parameters are collected as part of this program, this report focuses primarily on salinity. Also as part of the NPDES permit, SCG purchased water quality data loggers to supplement the NPDES data collection. The meters are deployed for up to five days. Quality assurance spot readings are taken at the deployment sites during deployment, mid deployment, and retrieval and GPS readings are taken for each deployment site. Additional physical water quality parameter data are collected in conjunction with biological monitoring efforts. Data from all the above-mentioned programs have been consolidated and analyzed and are discussed below.

Salinity

Identifying the current salinity regime is crucial to understanding the current biological distribution of the estuary. As salinity regimes change, biological distribution will follow. Biological health is impaired in systems with sporadic, irregular, and highly variable salinity regimes. With adequate understanding of the current water budget, it is easier to identify appropriate salinity and hydrology regimes for the system. Comparing the current and historic (pre-alteration or more natural) water budget is essential for restoration or enhancement goals. Once the relationships to discharge and salinity are identified SCG can establish target salinity regimes for certain estuarine areas or bay segments and use salinity measurements as another strategic measure of success.

Methods

The salinity regime of 2004 was analyzed by creating a database from grab samples from various monitoring programs and a database of data from data logger deployments. Figure 11 shows data collection locations by program. The following data sets were entered into the "grab sample" database: Mote monthly grab samples supporting the

NPDES program; SWFWMD twice monthly grab samples supporting the MFL study; monthly grab samples from both USF and FMRI for the study on fish and macro-invertebrate distribution; spot readings from SCG oyster and seagrass monitoring; and, quality assurance grab samples for SCG meter deployments. All data have associated GIS coordinates. Data were corresponded to both the RKS and bay segments. Bay segments were created to split the DARB study area into segments with geographic or bathymetric boundaries that may affect water flow. For instance, U.S. 41 is a segment boundary between both DBA and SCA bay segments and RBB and CCA bay segments because natural flows are constricted at these points. Data sets were then divided into bay segment files. These files were averaged separately for mean, maximum, and minimum, top and bottom salinity readings for both the dry and wet season. It is important to note that although the official wet season runs from June through October, rainfall is variable and often not intense enough to drive salinity regimes until mid-June and often July. For example, in 2003 there was an intense rain event the last week of June and the CPS gates were opened in early June. In 2004, rains were not very heavy until July. It is also important in evaluating oyster response to approximate the duration of low salinity values during the wet season. For this reason, only July through October 2004 readings are used to average wet season salinity regimes. A separate database was created for SCG meter deployments. These data sets were looked at separately because the grab samples are more of a snapshot. Enough spot readings were taken to glimpse a variety of conditions and derive average values and ranges. SCG meter deployments provide a more narrow time period perspective, but can more accurately illustrate the relationship between rain event and tide driven salinity fluctuations.

The USGS has four fixed stations in the DARB study area. These stations record stage, temperature and conductivity every 15 minutes. Although many gaps exist in the data, enough data were collected to show more accurate salinity levels and ranges for periods where data exist. These locations are also illustrated on Figure 10. Although data collection was more intense during 2004, a comparison between 2004 and 2003 is attempted.

Results

Results indicated that, as expected, the DARB estuary has a more variable salinity regime in the wet season than in the dry season. Upstream bay segments had lower mean salinities than segments closer to the Gulf. All stations showed broader ranges in the wet season. Available data from the Lyon’s Bay segment demonstrated that it had the smallest range of fluctuation in both the dry and wet season. It also had a higher average than the other stations. Curry Creek showed the most radical salinity swing, from a dry season average of 30.19 ppt to a wet season average of 2.69 ppt. Both these bay segments had smaller data sets. Wet season meter deployments in Curry Creek, however, showed salinity values below 1 ppt for a period of five days. In 2003 meter, deployments in Curry Creek showed a salinity drop below 1ppt for a period of at least 9 days. Table 2 shows salinity ranges from grab samples at the top of the water column.

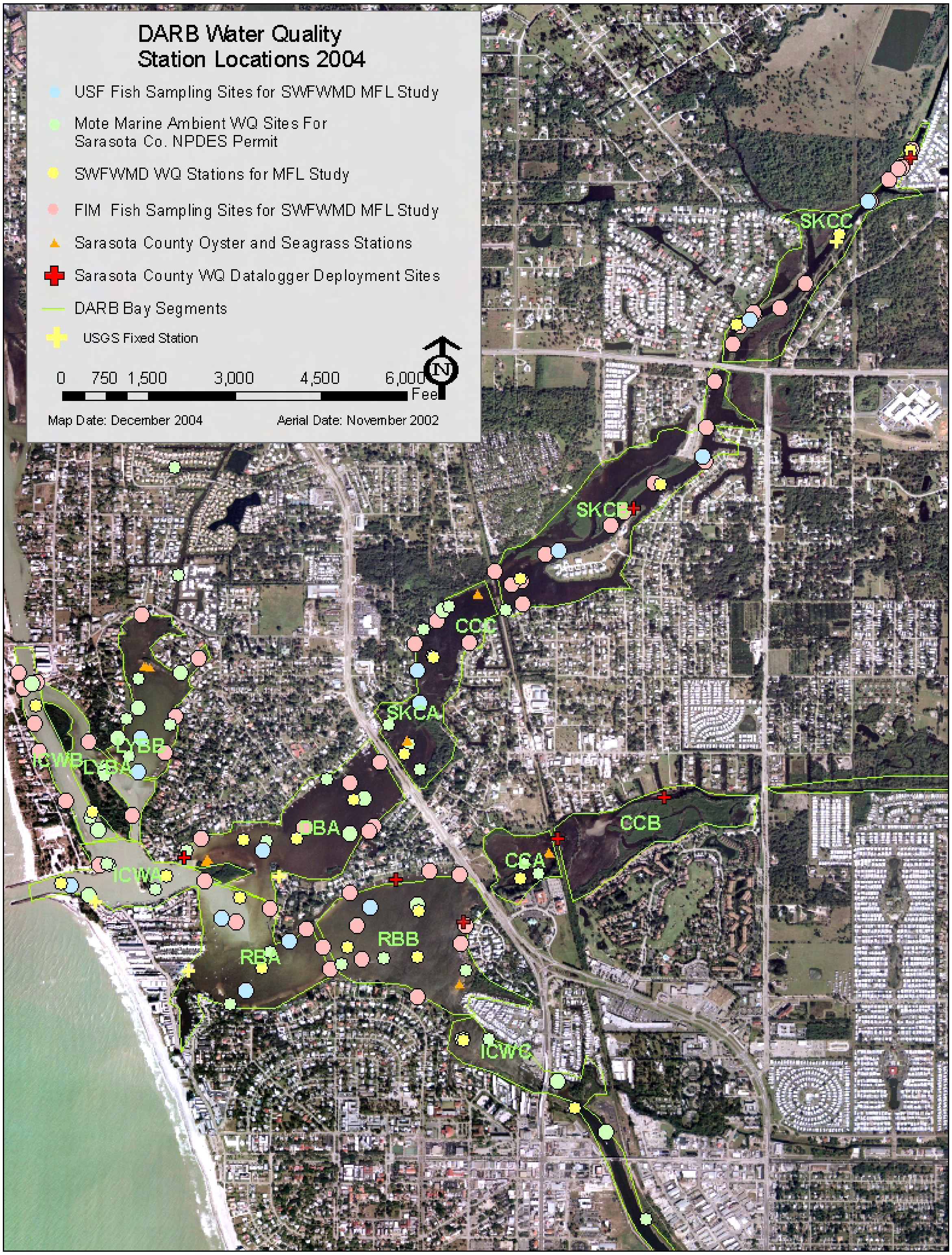


Figure 11. Water quality sampling sites and bay segments.

Figures 12 through 15 are graphical representations of salinity ranges per bay segment for the top and bottom of the water column in both the 2004 wet and dry seasons.

DARB 2004 Top of Water Column Salinity									
		Dry Season 2004				Wet Season 2004			
Bay Segment ID	RKS Range	Min	Max	Average	STDEV	Min	Max	Average	STDEV
ICWA	0.3-1	27.93	35.69	32.85	2.25	2.92	36.10	27.86	7.80
ICWB	2.6-8.2	26.53	34.45	31.89	2.07	22.50	34.16	30.56	3.90
ICWC	0.8-1.74	30.94	35.83	33.93	1.40	23.76	34.58	31.53	3.06
LYBA	0.85-1.7	34.30	36.10	35.49	0.83	No Data	No Data	33.4	No Data
LYBB	1.15-2.35	30.60	35.30	33.50	1.18	22.02	35.45	31.4	4.97
DBA	0.9-1.9	21.81	34.78	31.74	3.28	0.57	36.58	21.8	10.10
SCA	2.1-2.6	18.57	34.12	28.51	4.46	0.18	34.70	14.73	11.10
SCB	2.8-4.74	5.45	32.95	23.11	6.56	0.10	24.78	6.78	7.66
SCC	4.95-6.33	0.68	31.48	18.36	8.39	0.09	21.19	4.62	5.64
RBA	0.72-1.7	26.42	36.20	33.01	2.14	5.97	34.29	27.10	8.06
RBB	2.0-3.7	25.25	34.61	32.41	2.44	4.79	36.25	25.1	7.87
CCA	2.6-3.3	23.69	33.62	30.19	3.67	0.14	8.75	2.69	3.89
CCB	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
CCC	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data

Table 2. DARB 2004 Surface salinity

Data collected by the USGS painted an informative picture due to the time span and amount of data collected. Enough data were available for wet season 2003 and 2004 and the 2003-2004 dry season. Table 3 provides USGS station information as well as ranges of complete data sets. Figures 16 through 18 graphically illustrate salinity fluctuations at the upstream Shakket Creek and southwest Dona Bay USGS stations. Mean, maximum, and minimum salinity readings as well as length of consecutive days where salinities remained below 10 ppt can be found in Table 4 for Shakket Creek and Dona Bay. Additionally, average USGS salinity range values are represented by appropriately shaded triangles on Figures 12 through 15.

USGS I.D.	Site Location	Latitude	Longitude	Installation Date	Parameters	Data Date Ranges
2299732	Venice Harbor at Venice Yacht Club at Venice, Fl	27° 06' 32"	82° 27' 40"	4/20/04	Stage Conductivity	SPCond. TOP ONLY 5/1/04-5/10/04, 5/21/04-6/10/04, 6/21/04-6/30/04
2299735	Venice Inlet at Crow's Nest Marina at Venice, Fl	27° 06' 44",	82° 27' 56"	4/22/04	Stage Conductivity	SPCond. TOP ONLY 4/22/04-5/24/04 SPCond Top & Bottom 5/24/04-9/30/04
2299727	Shakket Creek near Nokomis, Fl	27° 08' 37.2"	82° 25' 48.6"	5/1/03	Stage Conductivity	SPCond Top & Bottom 6/12/03-9/30/04
2299733	Donna Bay at Nokomis, Fl	27° 06' 48.3"	82° 27' 24.3"	5/2/03	Stage Conductivity	SPCond Top & Bottom 7/6/03-7/10/03, 7/1703-9/19/03, 10/20/03-2/15/04, 3/9/04-9/6/04 Top only 9/6/04-9/15/04

Table 3. USGS DARB fixed station information

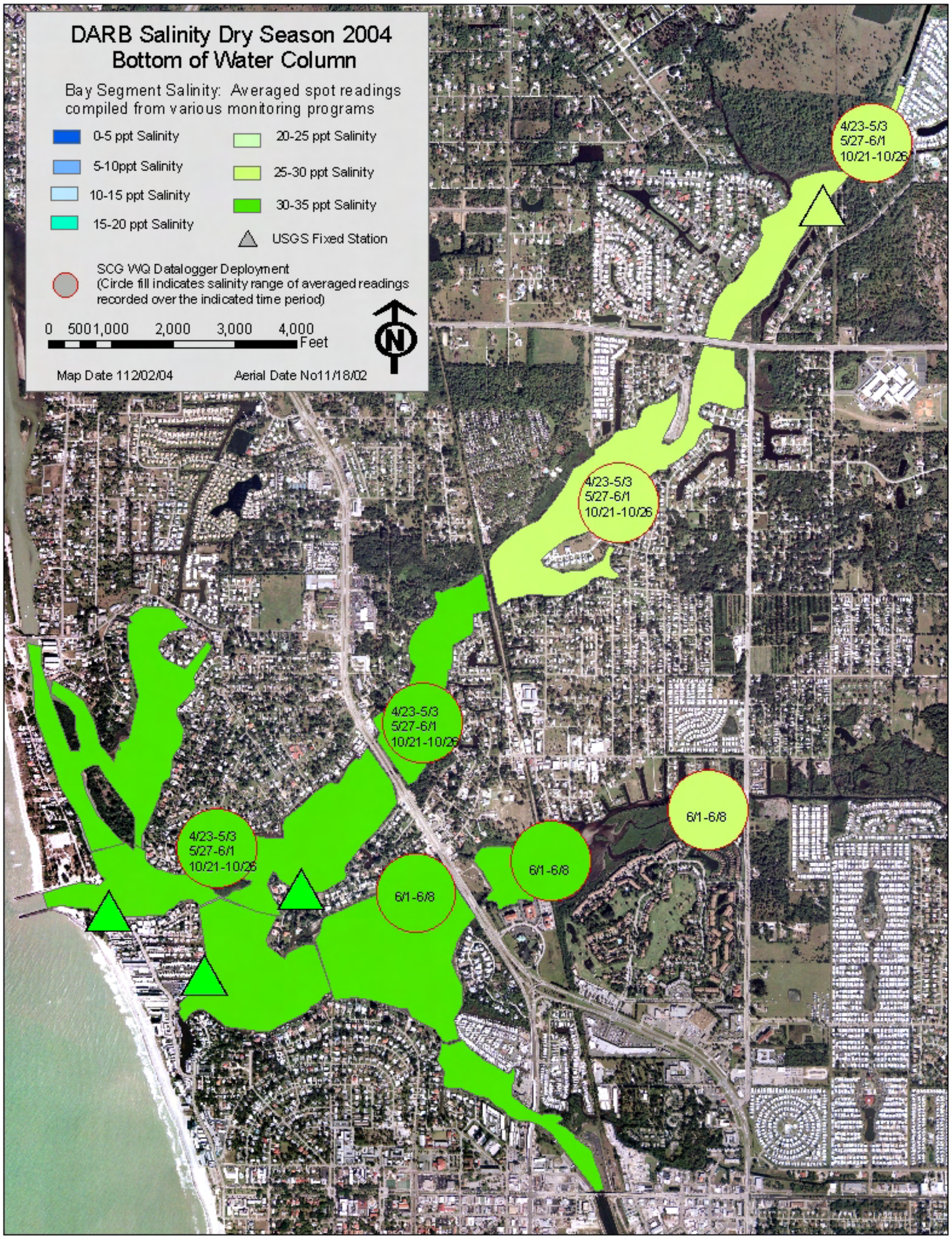


Figure 12. DARB dry season salinity ranges by bay segment for bottom of the water column.

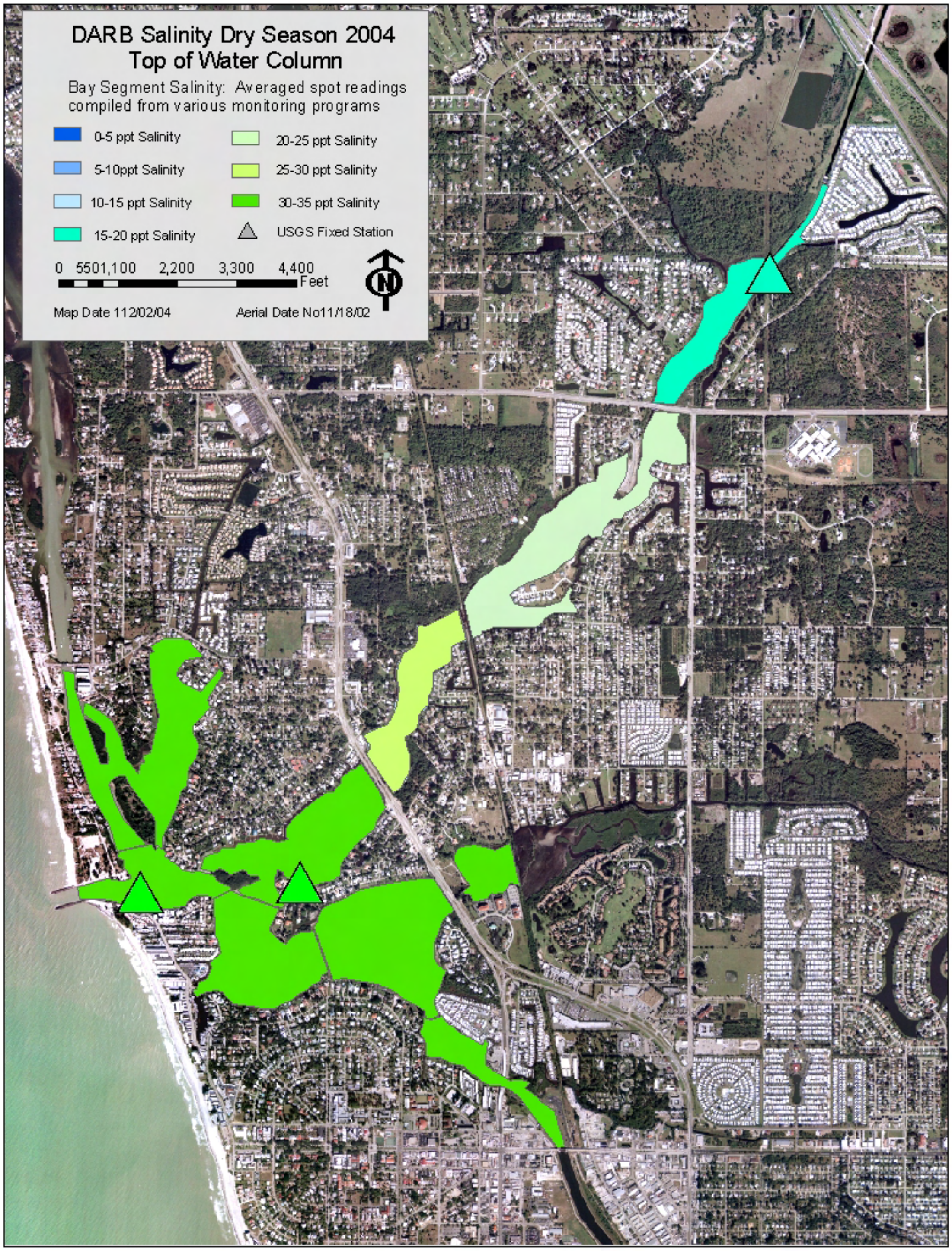


Figure 13. DARB dry season salinity ranges by bay segment for top of the water column.

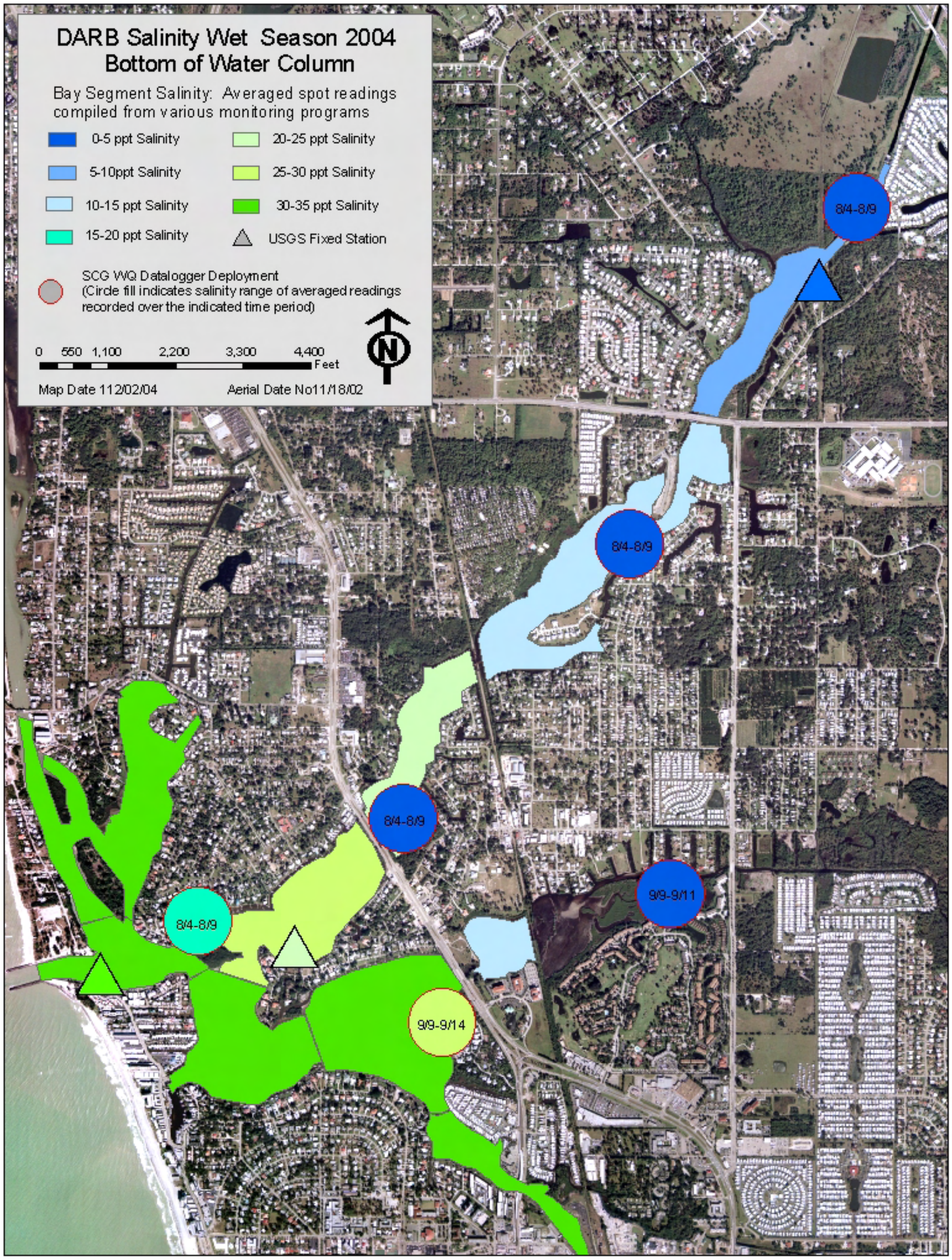


Figure 14. DARB wet season salinity ranges by bay segment for bottom of the water column.

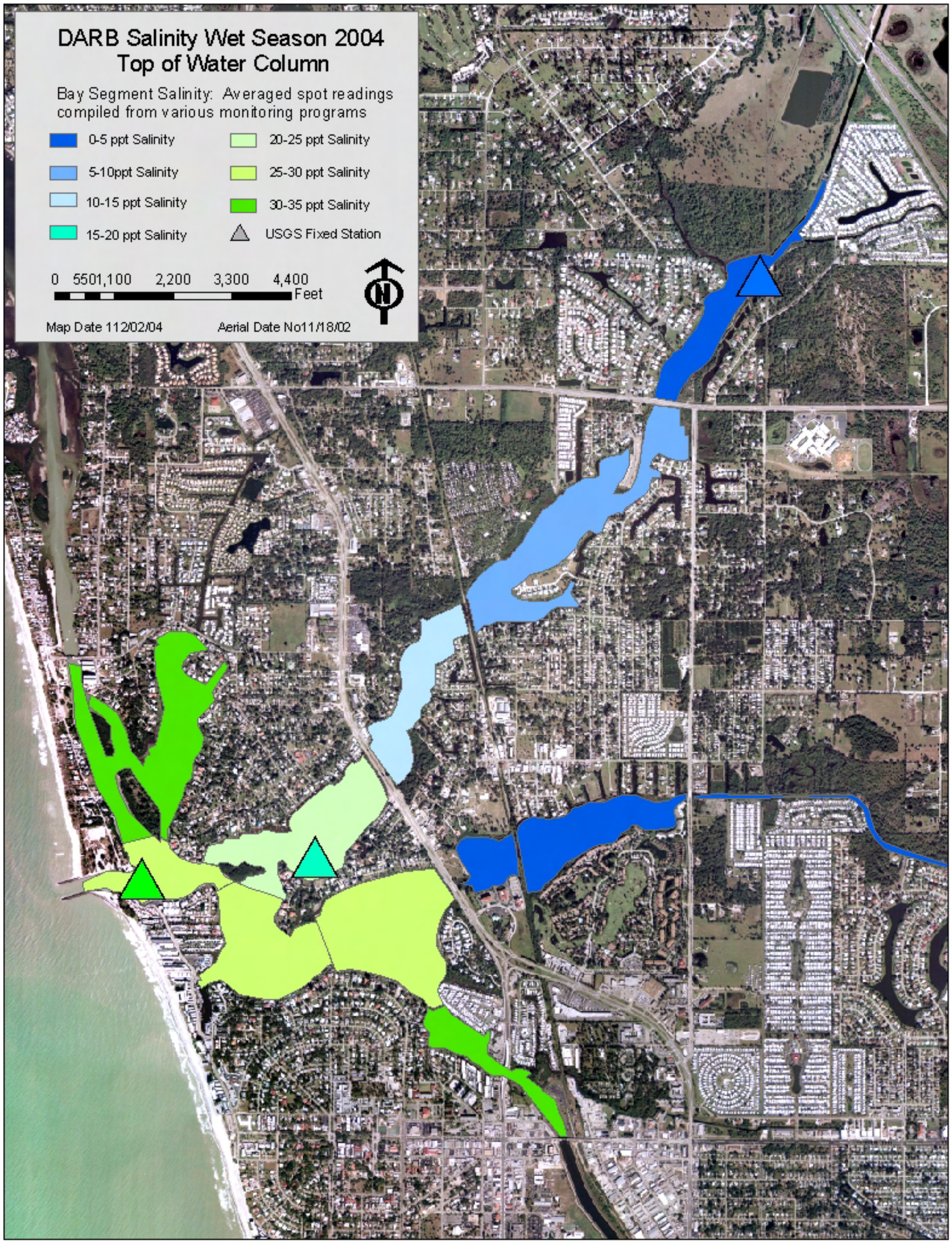


Figure 15. DARB wet season salinity ranges by bay segment for top of the water column.

	Shakket Creek USGSID 2299727 RKS 5.7 Bay Segment SCC	Dona Bay USGSID 2299733 RKS 1.3 Bay Segment DBA
Wet Season 2003 (Data Date Range)	6/12/03 - 10/31/03	7/6/03 - 9/19/03
Top Of Water Column		
Mean Salinity (ppt)	2.45	6.47
Minimum Salinity (ppt)	0.01	0.11
Maximum Salinity (ppt)	31.14	38.39
Maximum Number of Consecutive Days With Salinity <10 ppt (Date Range)	122 Days 6/17/03 - 10/17/03	21 Days 8/9/03 - 8/30/03
Bottom Of Water Column		
Mean Salinity (ppt)	5.29	12.38
Minimum Salinity (ppt)	0.07	0.13
Maximum Salinity (ppt)	33.82	39.78
Maximum Number of Consecutive Days With Salinity <10 ppt (Date Range)	97 Days 6/17/03 - 09/22/03	8 Days 8/9/03 - 8/17/03
Dry Season 2003 / 2004 (Data Date Range)	11/01/03 - 6/30/04	10/20/03 - 2/15/04
Top Of Water Column		
Mean Salinity (ppt)	17.95	34.90
Minimum Salinity (ppt)	0.12	4.13
Maximum Salinity (ppt)	38.39	43.36
Maximum Number of Consecutive Days With Salinity <10 ppt (Date Range)	12 Days 12/15/03 - 12/27/03	1 Day 12/17/03 - 12/18/03
Bottom Of Water Column		
Mean Salinity (ppt)	25.25	35.23
Minimum Salinity (ppt)	0.12	5.65
Maximum Salinity (ppt)	39.13	42.88
Maximum Number of Consecutive Days With Salinity <10 ppt (Date Range)	6 Days 12/16/03 - 12/22/03	No full days where salinity remained below 10 ppt
Wet Season 2004 (Data Date Range)	7/1/04 - 10/31/04	7/1/04 - 9/6/04
Top Of Water Column		
Mean Salinity (ppt)	2.63	19.77
Minimum Salinity (ppt)	0.07	0.45
Maximum Salinity (ppt)	27.98	42.98
Maximum Number of Consecutive Days With Salinity <10 ppt (Date Range)	66 Days 7/19/04 - 09/23/04	7 Days 8/03/04 - 8/10/04
Bottom Of Water Column		
Mean Salinity (ppt)	4.37	21.06
Minimum Salinity (ppt)	0.07	0.65
Maximum Salinity (ppt)	28.59	43.74
Maximum Number of Consecutive Days With Salinity <10 ppt (Date Range)	62 Days 7/20/04 - 9/21/04	7 Days 8/03/04 - 8/10/04

Table 4. USGS data analysis.

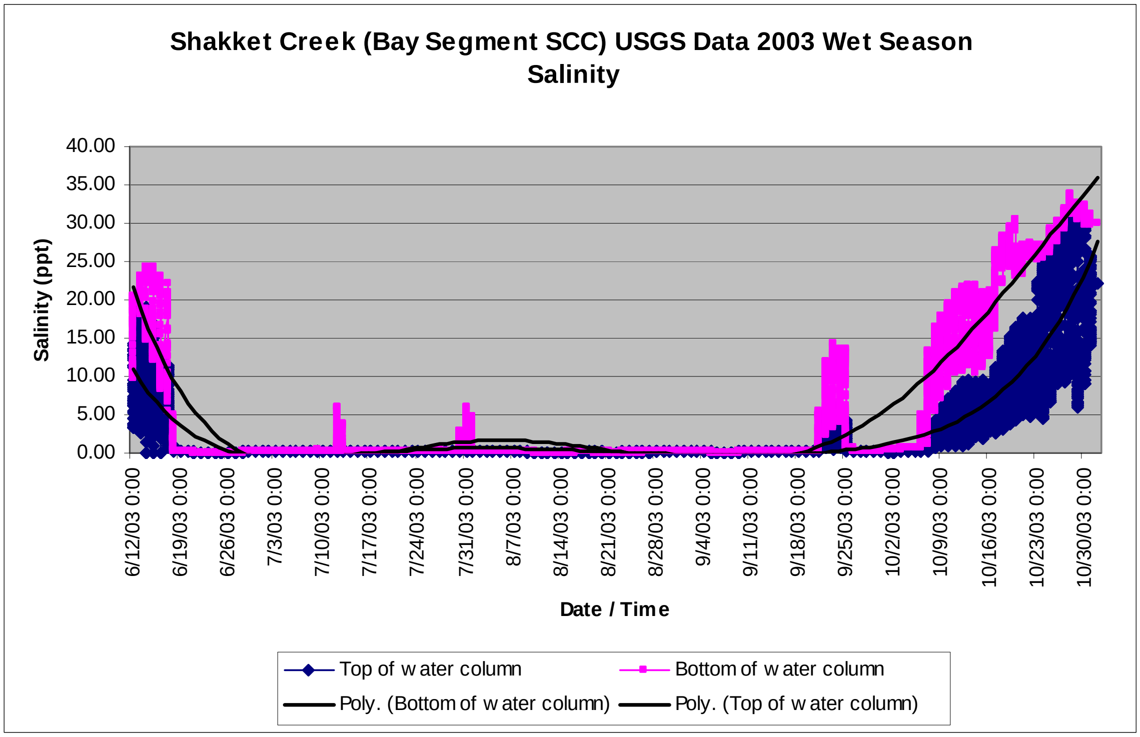


Figure 16a. 2003 wet season salinity for the Shakket Creek USGS station.

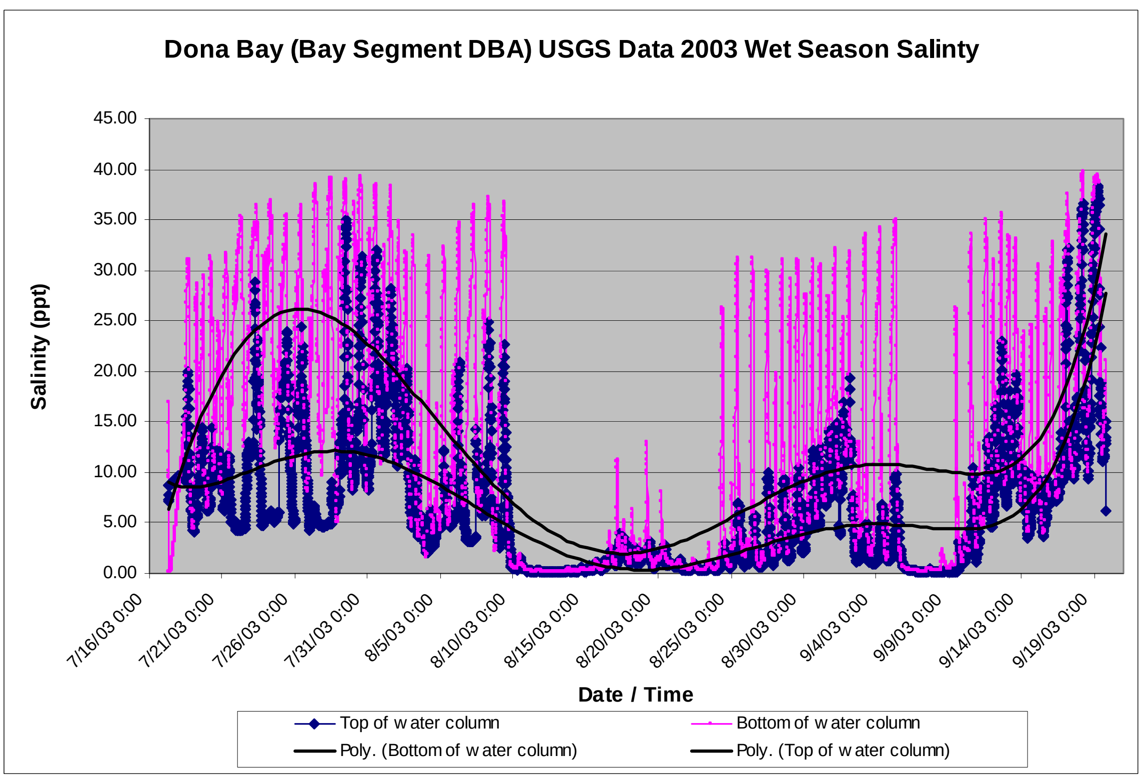


Figure 16b. 2003 wet season salinity the Dona Bay USGS station.

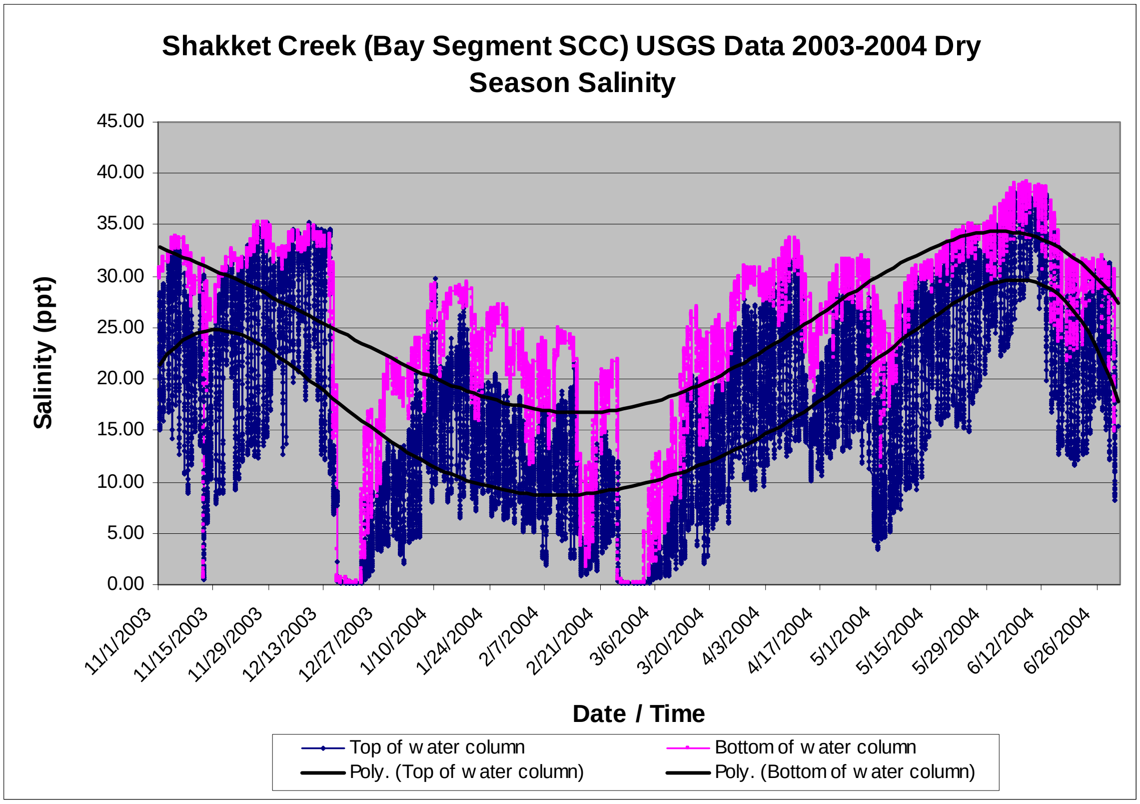


Figure 17a. 2003-2004 dry season salinity for the Shakket Creek USGS station.

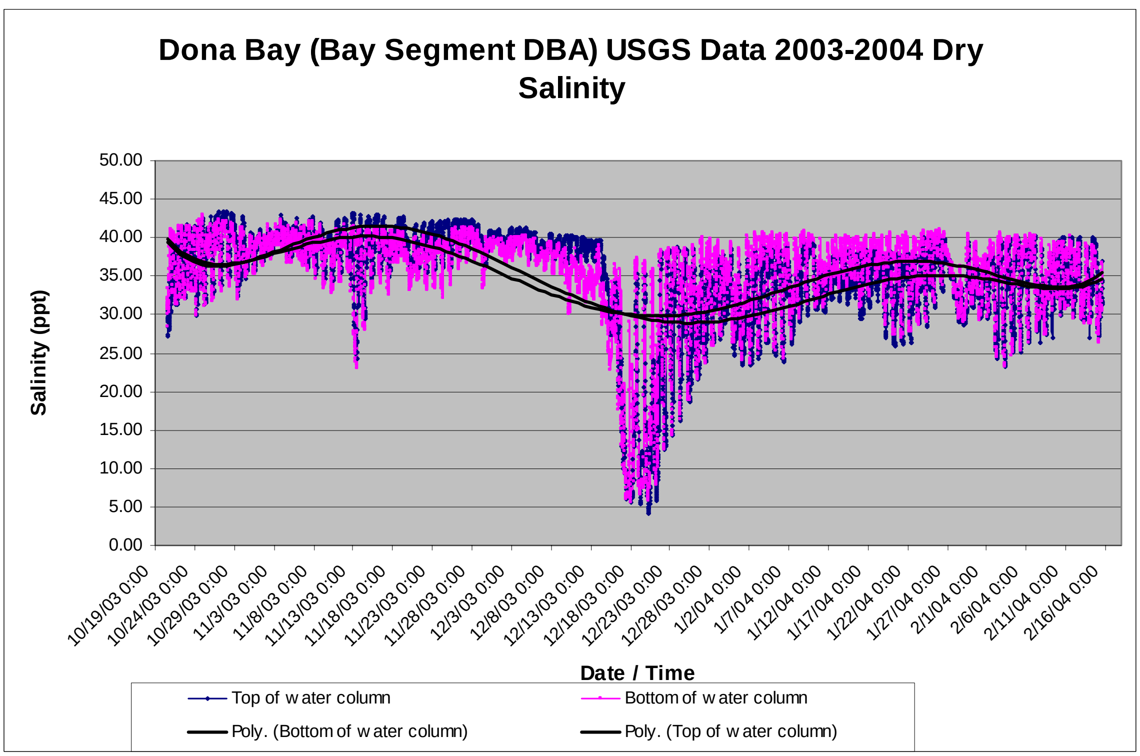


Figure 17b. 2003-2004 dry season salinity for the Dona Bay USGS station.

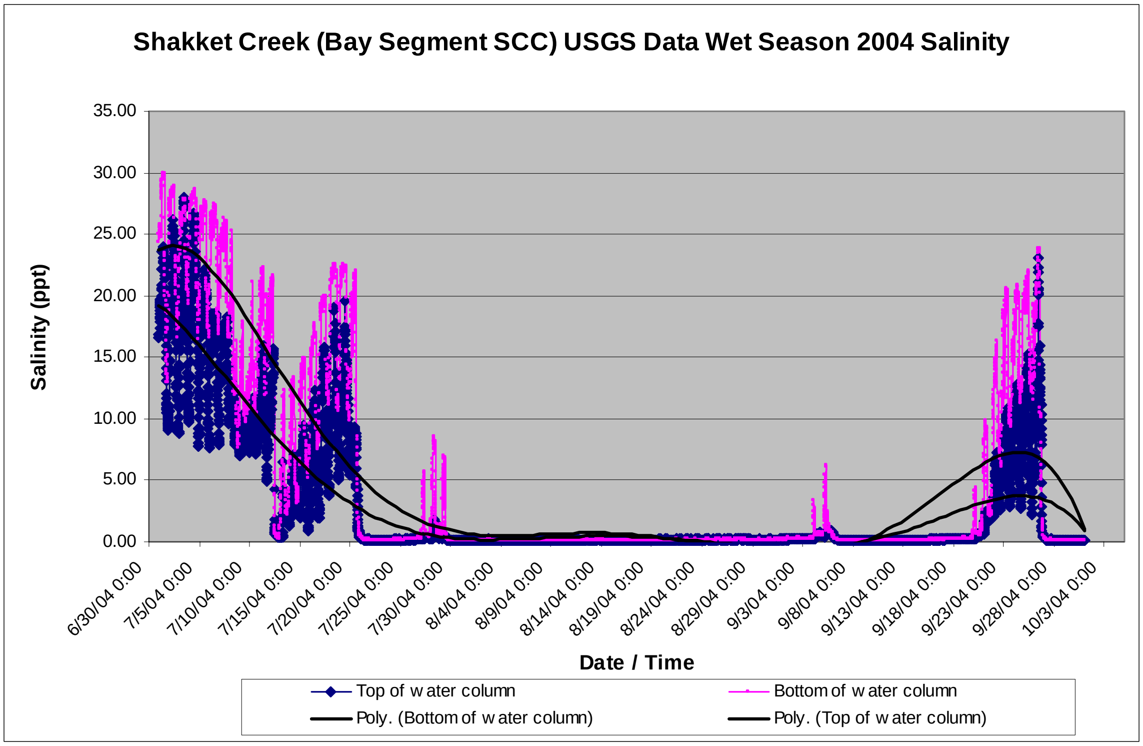


Figure 18a. 2004 wet season salinity for the Shakket Creek USGS station.

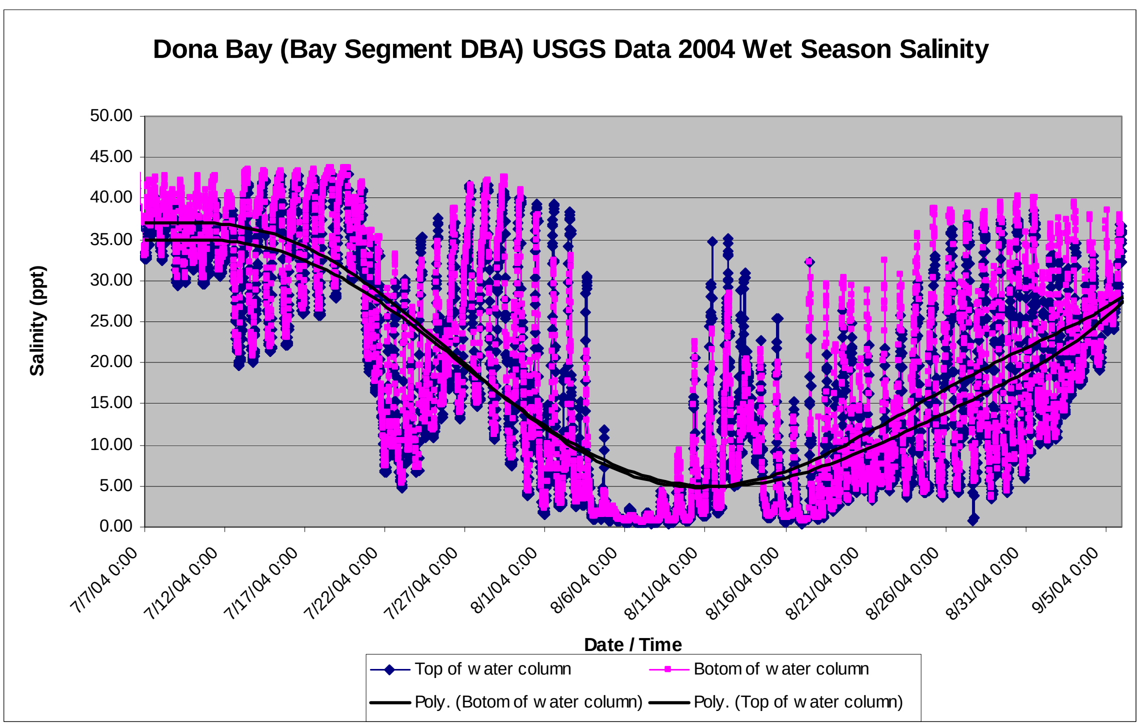


Figure 18b. 2004 wet season salinity for the Dona Bay USGS station.

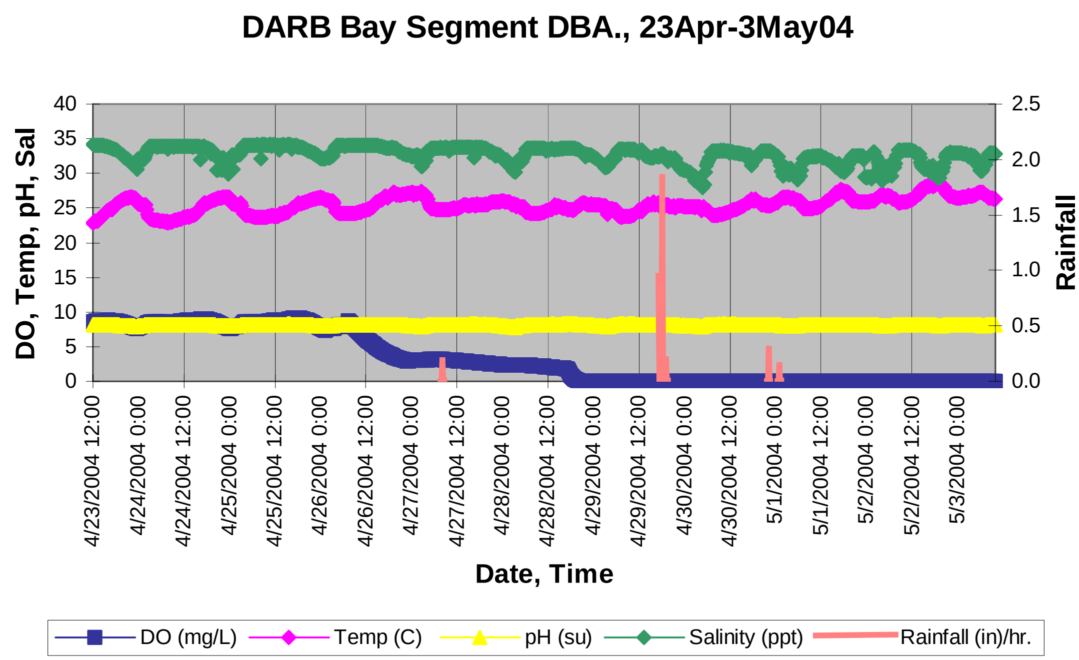
Dissolved Oxygen

The data from the consolidated monitoring programs used in the salinity analysis, except for the Mote MS-4 monitoring, contain only the physical parameters of DO, salinity, temperature, and pH. DO ranges and average values from spot readings in 2004 are summarized by bay segment in Table 5.

SCG deployed water quality meters in Shakket Creek, Dona Bay, Curry Creek, and Robert's Bay during the dry season and wet season of 2004. Data was logged every 15 minutes and the meters are deployed for up to five days at the bottom of the water column. Figures 12 and 14 show circles at data logger deployment locations shaded with the appropriate average salinity range color and deployment date. Figures 19 through 24 show all recorded physical parameters and their response to rainfall events for one dry season and one wet season deployment.

DARB 2004 Dissolved Oxygen (mg/L)									
		Dry Season 2004				Wet Season 2004			
Bay Segment ID	**RKS Range**	**Min**	**Max**	**Average**	**STDEV**	**Min**	**Max**	**Average**	**STDEV**
ICWA	0.3-1	5.71	11.85	7.82	1.27	2.09	8.61	5.70	1.48
ICWB	2.6-8.2	5.14	10.82	6.94	1.10	3.70	6.47	5.16	0.79
ICWC	0.8-1.74	5.60	10.84	7.60	1.29	2.51	8.61	6.63	1.23
LYBA	0.85-1.7	7.00	7.90	7.51	0.28	No Data	No Data	No Data	No Data
LYBB	1.15-2.35	3.53	8.56	6.71	1.18	4.40	9.52	6.81	1.68
DBA	0.9-1.9	2.93	9.72	6.75	1.18	0.16	8.02	5.23	1.23
SCA	2.1-2.6	0.80	10.65	6.49	1.53	0.45	6.40	4.62	1.32
SCB	2.8-4.74	3.26	9.96	5.92	1.27	2.57	7.22	5.27	1.26
SCC	4.95-6.33	0.68	8.74	4.73	1.79	0.73	8.92	5.67	1.81
RBA	0.72-1.7	5.00	10.79	7.15	1.12	3.09	7.05	5.59	1.00
RBB	2.0-3.7	2.58	11.13	6.97	1.48	2.63	7.65	5.27	1.19
CCA	2.6-3.3	5.19	9.76	6.64	1.24	2.38	5.80	3.86	1.20
CCB	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
CCC	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data

Table 5. DARB 2004 dissolved oxygen (mg/L)



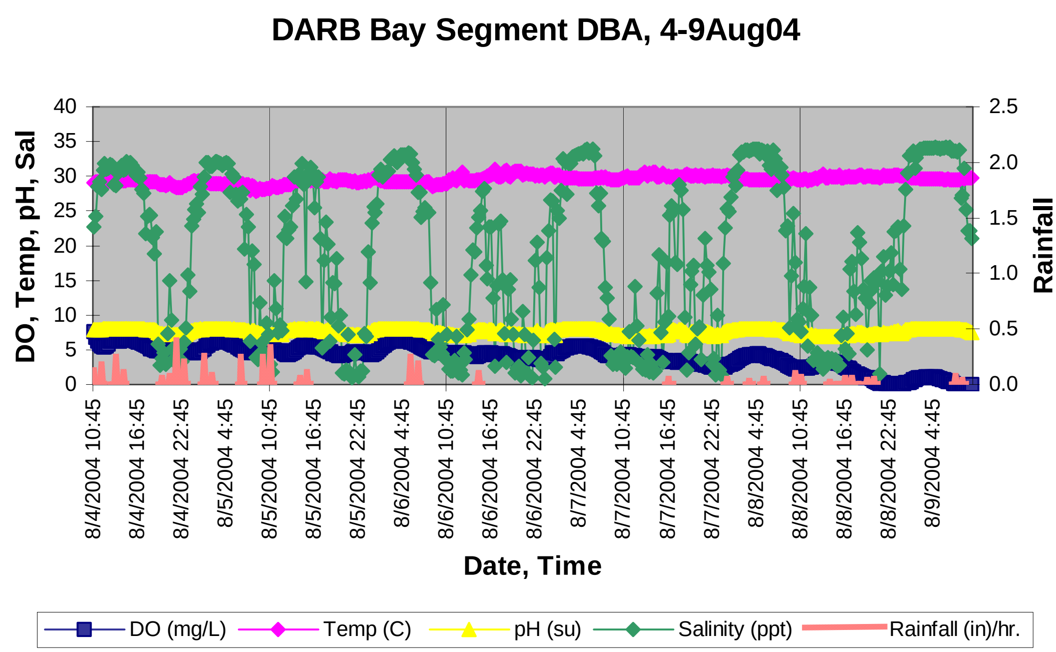
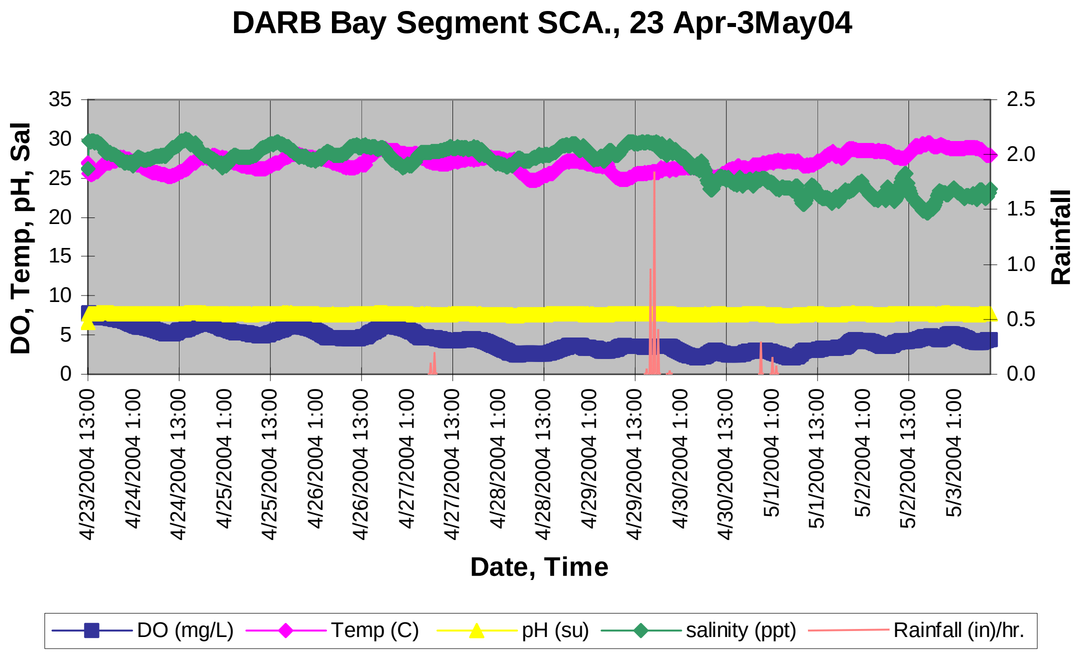


Figure 19. Meter deployment data for April and August 2004 in bay segment DBA



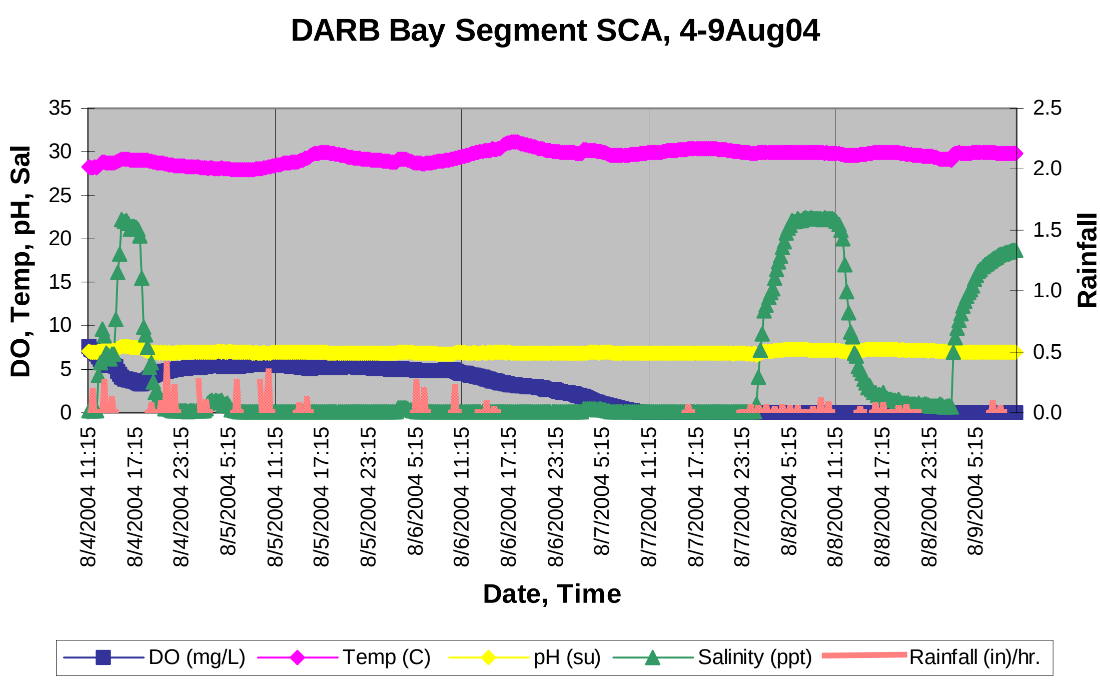
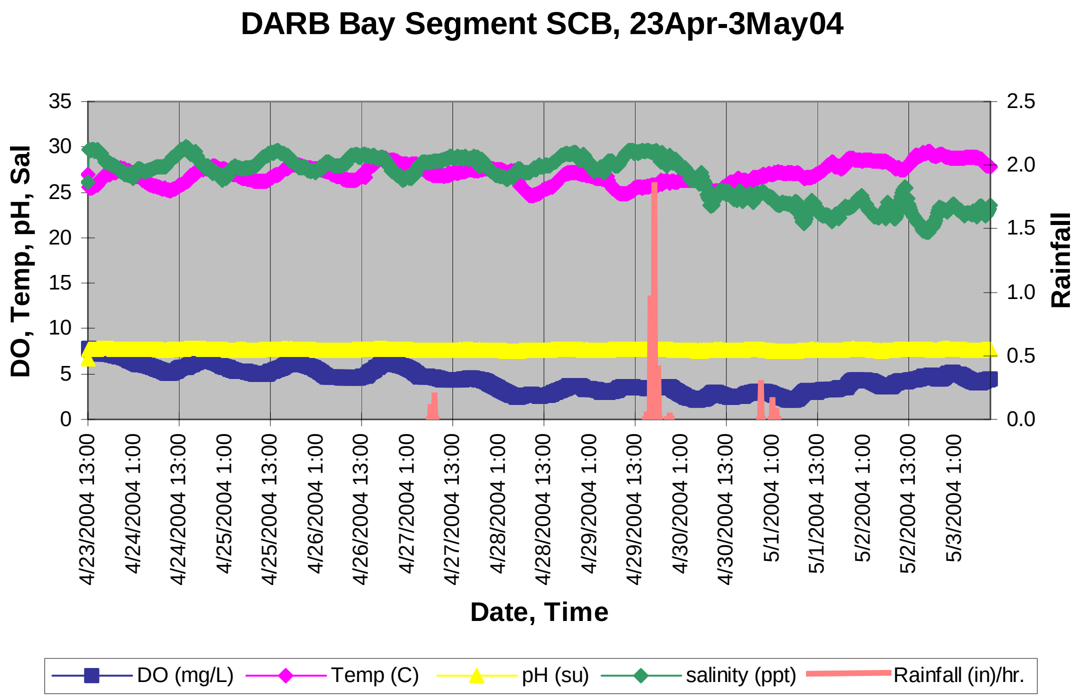


Figure 20. Meter deployment data for April and August 2004 in bay segment SCA



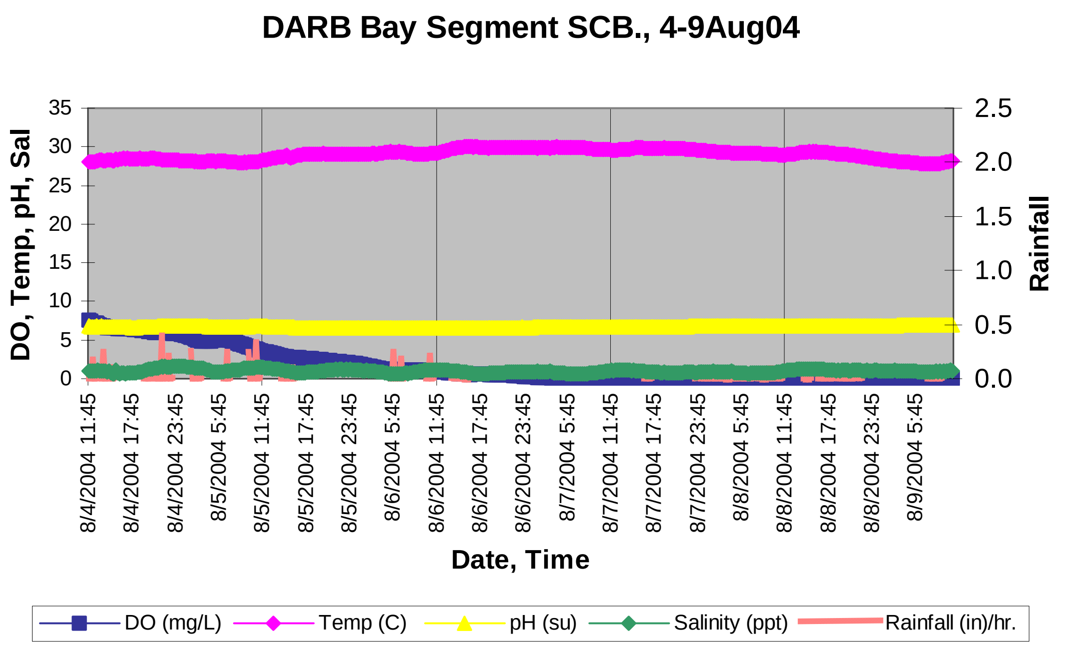
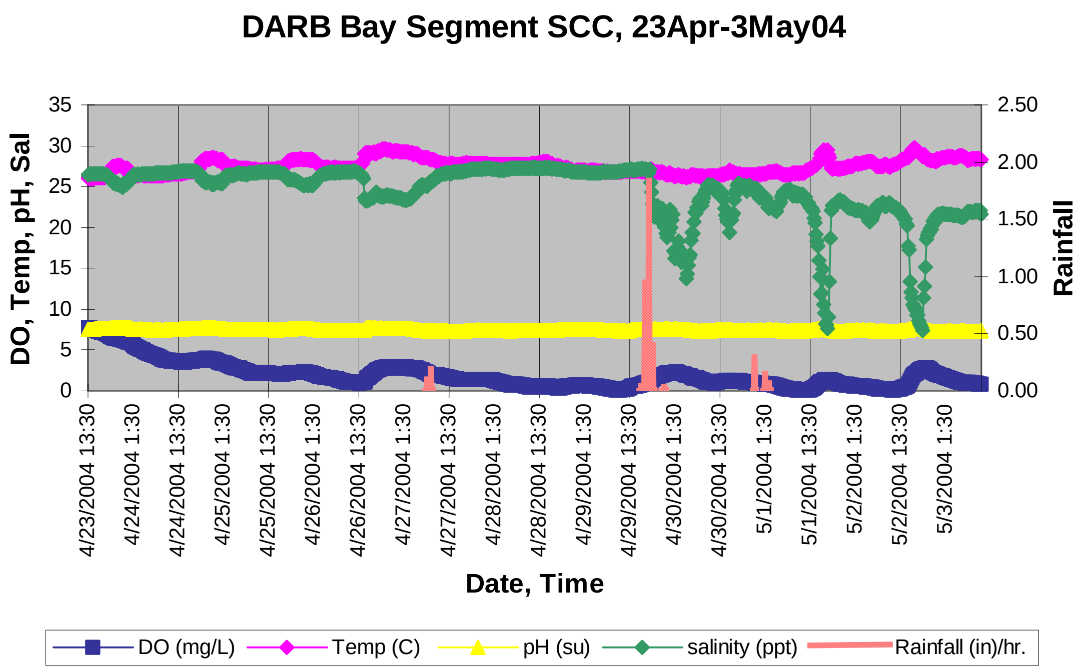


Figure 21. Meter deployment data for April and August 2004 in bay segment SCB



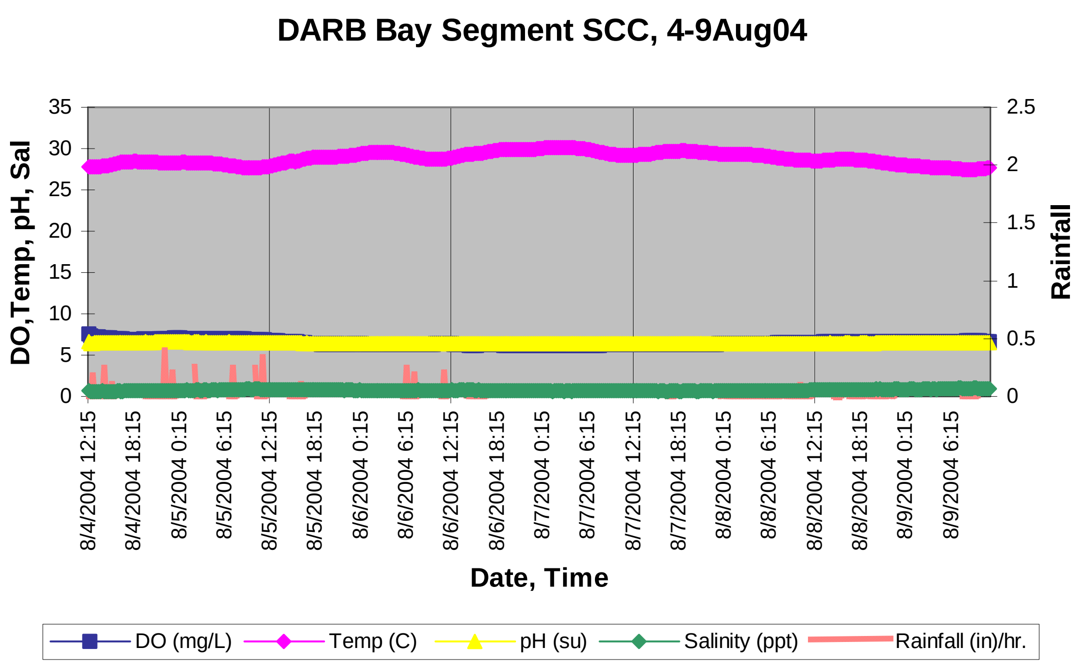
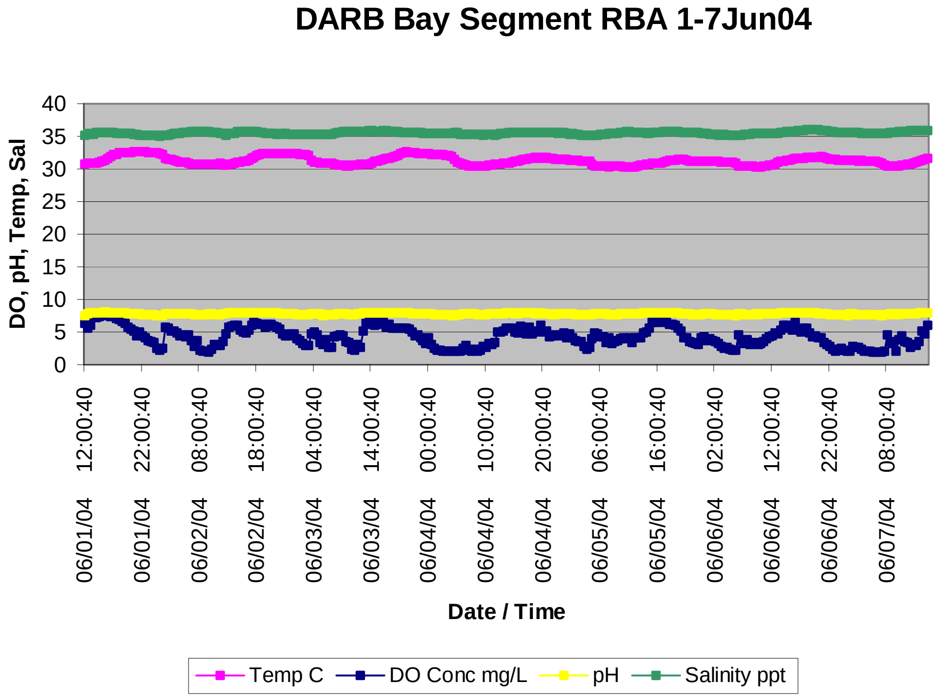


Figure 22. Meter deployment data for April and August 2004 in bay segment SCC



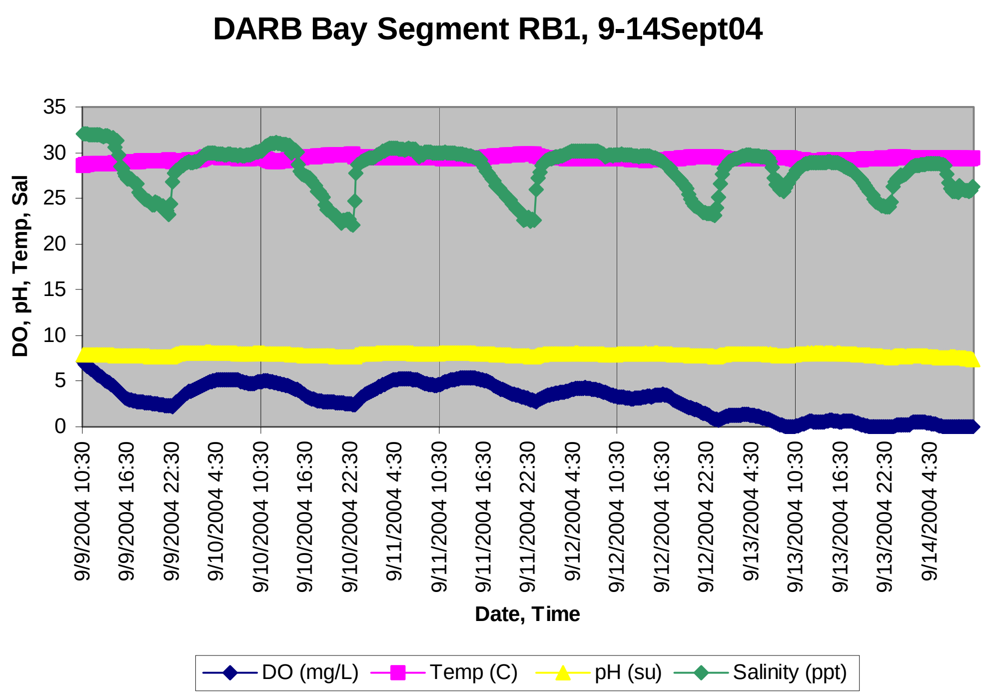
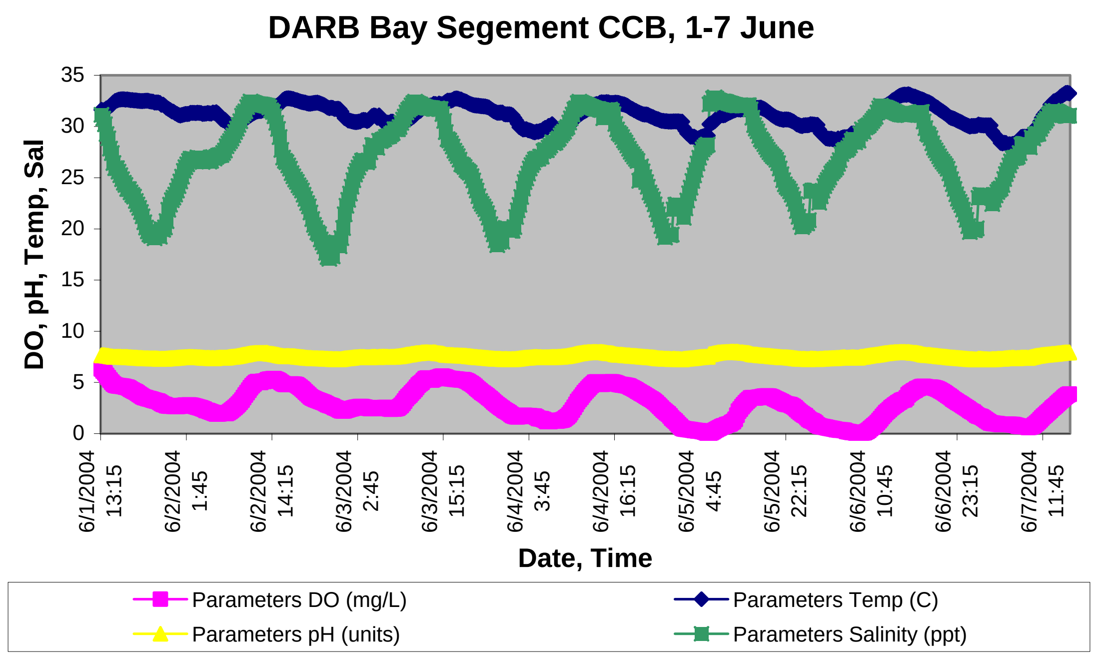


Figure 23. Meter deployment data for June and September 2004 in bay segment RBA



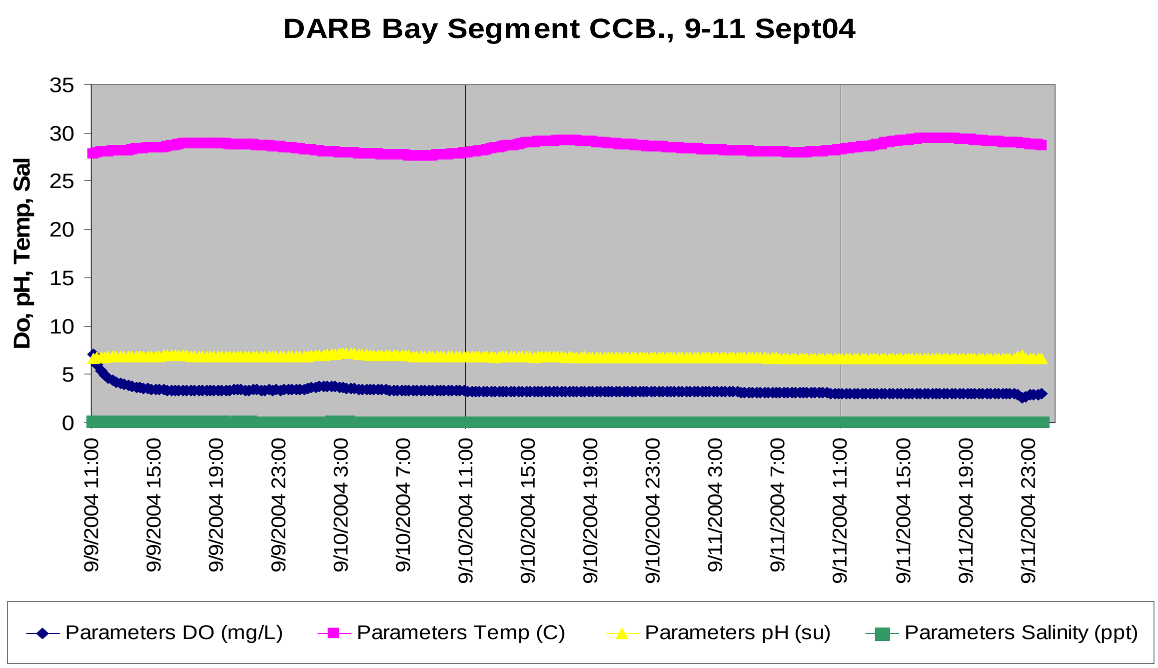


Figure 24. Meter deployment data for June and September 2004 in bay segment CCB

Discussion

Salinity is a parameter that clearly responds to rainfall and runoff inputs in the DARB watershed. Range of salinity fluctuation increased in most areas during the wet season. Lyon's Bay was an exception. When comparing wet and dry season salinity values, Lyon's Bay had the lowest difference in average values. Curry Creek had the greatest observed change in salinity regime. Spot reading averages did not capture the lowest salinity readings experienced during the wet season. Meter deployments showed salinity, in response to rainfall and tide, actually had lower average ranges in bay segments during wet season deployment than the averaged spot readings. USGS data indicated that salinity did not exceed 10 ppt in Shakket Creek at river kilometer 1.7 for 122 consecutive days during the 2003 wet season and 66 consecutive days during the 2004 wet season. The USGS data for the Dona Bay station at river kilometer 1.3 indicated that salinity remained below 10 ppt for 21 consecutive days in 2003 and 7 consecutive days in 2004 during the wet season. Salinity remained below 5 ppt for the majority of the time periods mentioned above. USGS data indicates that salinity values in this location most likely remained below 10 ppt for the entire 2003 wet season.

DO data from spot readings indicated lower average DO values in the wet season, the lowest of which was in Curry Creek. The Curry Creek average for the entire wet season was below the 4 mg/L FDEP stipulated minimum DO threshold for estuaries. Through future data gathering efforts and rating curves from CPS and Blackburn Canal, SCG will be able to predict salinity regimes based on flow measurements. The more thorough knowledge of the water budget enables SCG to set discharge targets as well as salinity targets in bay segments to aid in both restoration planning and measuring success.

Section IV
Hydrology

Basin Hydrology

Water quality and particularly salinity are established factors that affect the health, distribution, and behavior of estuarine organisms. A watershed's hydrology has a profound effect on water quality, particularly salinity regimes. The largest freshwater inputs to the DARB project area are CPS and the Curry Creek / Blackburn Canals. These two altered conveyance systems have increased the amount and duration of freshwater inputs to the DARB system. To illustrate the change in hydrology, Figure 25 displays the 1847 watercourses and current watercourses overlaid on a county aerial. A thorough understanding of basin hydrology is necessary to understand the biological distribution and response to a fluctuating salinity regime. Lack of groundwater-fed rivers and streams, as well as little topographic relief in our area, points to a rainfall and runoff driven hydrology for the DARB system.

SCG measures rainfall and stage (in 15 or 60 minute increments depending on the site) throughout the county as part of a radio telemetry network. All DARB basin rainfall and stage data discussed in this section are collected from telemetry sites located in the DARB. Myakka River watershed rainfall data were retrieved from the SWFWMD CWM database available on the SWFWMD website. The county has hired VHB and John Coffin with Hydrologic Data Inc. to develop stage discharge rating curves at specific SCG ARMS sites. ARMS site locations are displayed on Figure 1 in the introduction section of this report. SCG has contracted Biological Research Associates (BRA) with Kimley-Horn and Associates Inc. (KHA) to prepare monthly and annual water budgets using available hydrologic data for the Dona Bay portion of the DARB estuary. USGS stage and discharge data from fixed recording stations on the Myakka River and Blackburn Canal were used to determine runoff volumes for the Blackburn Canal (Roberts Bay portion of the DARB watershed).

DARB Rainfall

To calculate DARB watershed rainfall the following ARMS stations were used: the upper and lower CPS stations, three stations at the central county landfill, and the Bee Ridge landfill station. Average rainfall amounts used for the DARB rainfall analyses were calculated using a ten-year average of ARMS sites on the CMR reserve. The SWFWMD CWM database rainfall data was used for the Myakka basin rainfall analysis.

In the wet season, the majority of water discharged through the Blackburn Canal to Curry Creek comes from the Myakka River basin. It is important to look at Myakka River basin rainfall to understand Curry Creek hydrology. Rainfall measurements have shown that precipitation varies across the county. Natural areas to the east generally experience heavier rainfall in the wet season than more developed coastal areas. A comparison of

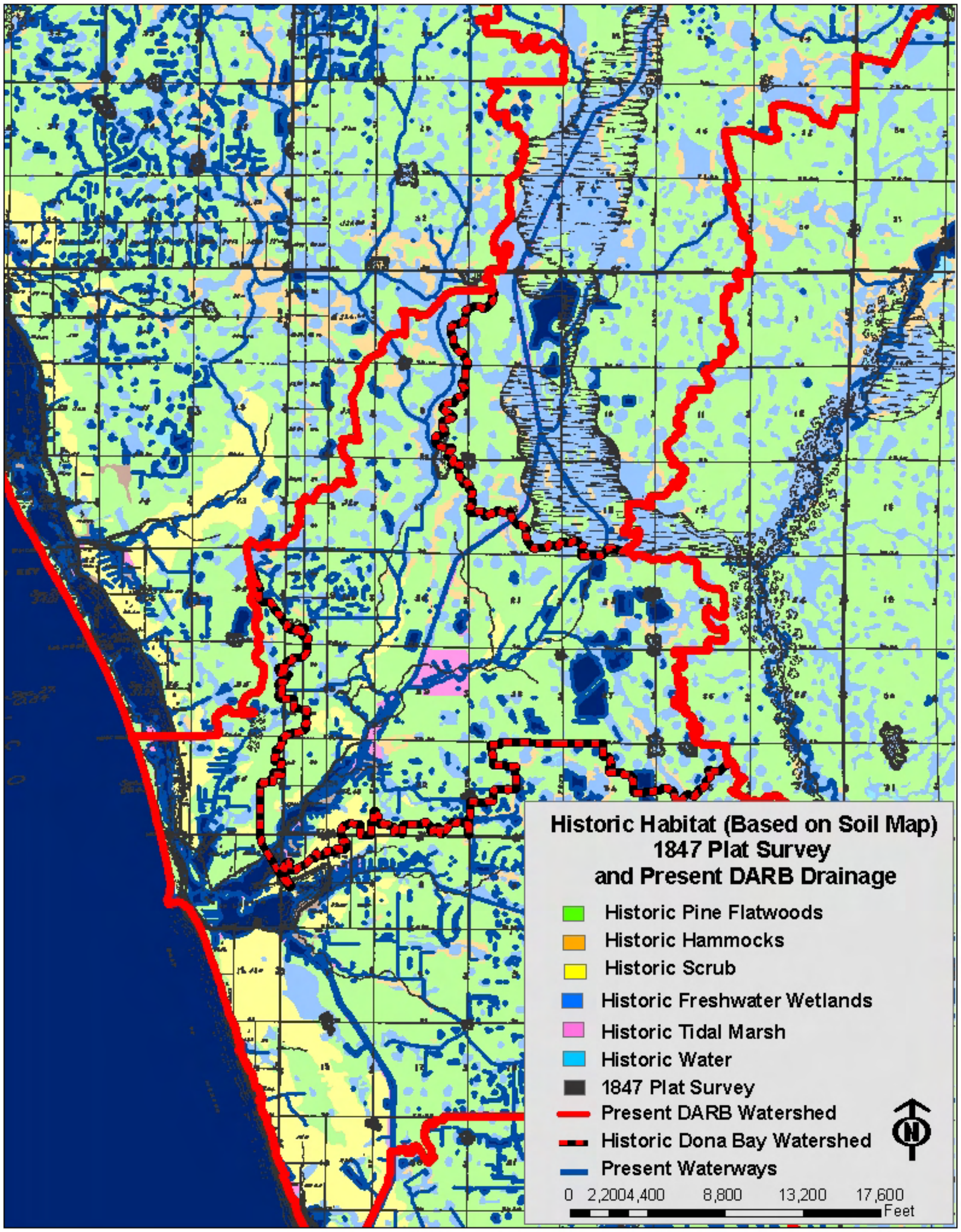
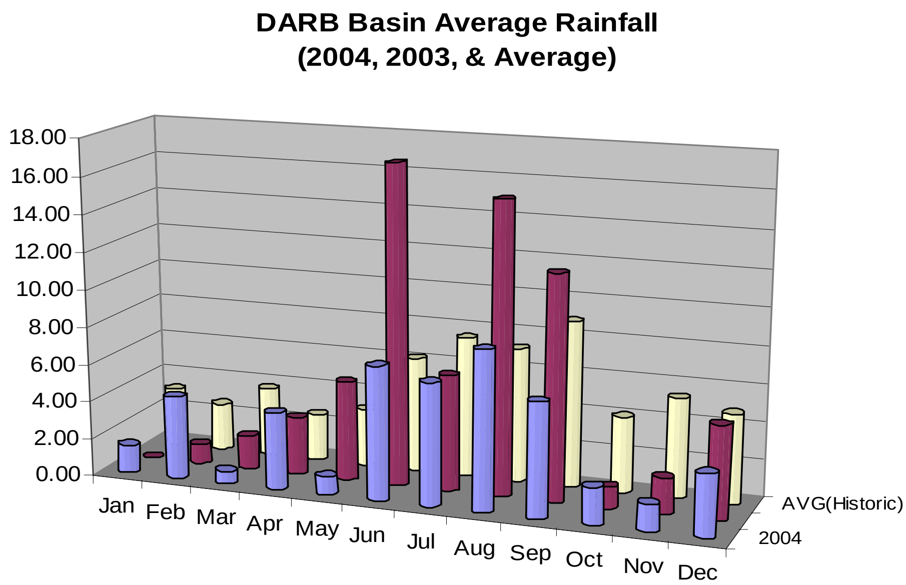
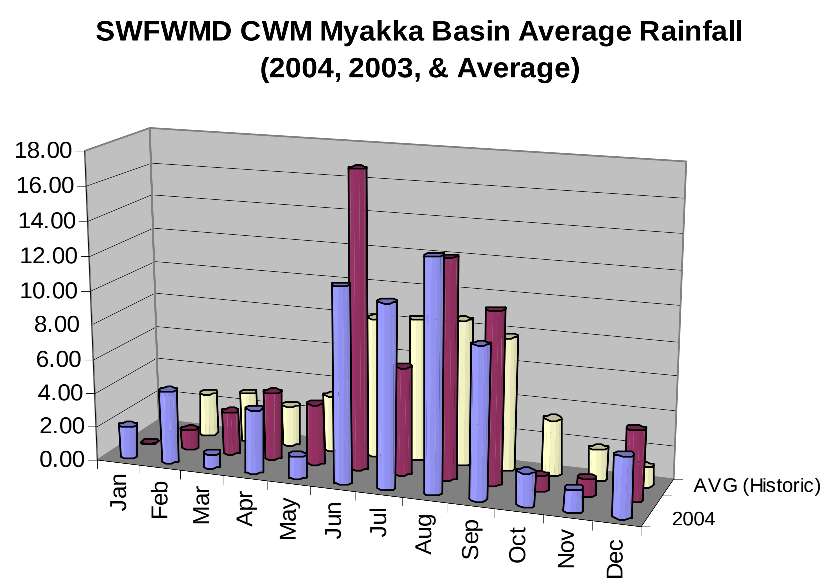


Figure 25. DARB 1847 survey, historic soil habitat, and watershed alterations.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	1.52	4.46	0.67	4.14	1.01	7.16	6.55	8.52	6.11	2.00	1.43	3.32
2003	0.02	1.06	1.82	3.12	5.33	17.03	6.22	15.54	12.01	1.15	1.94	4.99
AVG(Historic)	3.16	2.56	3.71	2.52	3.08	6.18	7.54	7.20	8.89	4.06	5.35	4.77

Figure 26a. 2003 and 2004 DARB watershed rainfall (calculated from SCG ARMS data).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	1.87	4.29	0.83	3.72	1.31	11.31	10.62	13.37	8.74	1.90	1.28	3.48
2003	0.06	1.14	2.54	3.98	3.56	17.28	6.28	12.73	9.99	0.88	1.02	4.11
AVG (Historic)	2.25	2.62	2.90	2.42	3.30	8.18	8.38	8.54	7.80	3.29	1.85	1.16

Figure 26b. 2003 and 2004 Myakka River watershed rainfall (calculated.from SWFWMD CWM data)

Myakka basin and DARB basin rainfall show that this was not the case in 2003. Figures 26a and 26b display the 2003 and 2004 rainfall comparisons for both the DARB and Myakka River watersheds. A rainfall analysis shows that, in 2003, DARB received 70.23 inches of rain compared to 63.57 inches in the Myakka basin. In contrast, the DARB basin recorded 46.89 inches of rainfall compared to 62.72 inches in the Myakka River basin during 2004. DARB basin rainfall was approximately 9 inches higher than average in 2003 and 9 inches lower than average in 2004. Myakka River basin rainfall was 11 inches above average in 2003 and approximately 10 inches above the SWFWMD CWM basin average in 2004.

Excess Discharge to DARB from Cow Pen Slough

As stated previously, the CPS canal has diverted the entire CPS contributing watershed from the Myakka River basin to Dona Bay. Historically, the CPS may have overflowed to Dona Bay during extreme flood events. Prior to the canal construction, watershed runoff would have either been stored on the land in freshwater marshes and sloughs or have slowly flowed toward the Myakka River. Theoretically, all water discharged over the CPS lower weir is excess runoff that historically would not have drained to Dona Bay.

Cow Pen Slough discharge ratings, based on stage and weir structure, have been studied and refined over the past two years. As previously stated, SCG contracted BRA Inc. with Kimley Horn and Associates Inc. to prepare monthly and annual water budgets using available hydrologic data for the Dona Bay portion of the DARB estuary. Gaps in ARMS stage and subsequent discharge ratings were reconciled by KHA. Small data gaps during no flow or constant flow conditions were directly filled when the value at both the beginning and end of the gap were equal. A regression equation was used to interpolate values for gaps during a change in flow. For larger gaps KHA ran model simulations to reconcile stage and discharge values (Suau, 2005).

The total volume of fresh water discharged across the lower weir in 2003 was calculated at approximately 74,641 acre-feet which equates to 26.67 inches of annual runoff or 69.95 million gallons per day. The 2004 discharge over the lower weir was 54,126 acre-feet or 19.34 inches of annual runoff which can be represented by 55.01 million gallons per day. Figures 27a and 27b graphically represent the discharge for the upper weir for 2003 and 2004 and lower weir for 2003 and 2004, respectively.

The estimated historical Dona Bay watershed areas for Shakket Creek, Fox Creek, and Salt Creek identified in Figure 25 total 10,064 acres. This area would have generated runoff volumes of 21,060 acre-feet for 2003 and 16,560 acre-feet for 2004, corresponding to average flows of 18.90 (mgd) and 14.78 (mgd) respectively. Table 6 summarizes the estimated historical and existing volumes of runoff to Dona Bay for 2003 and 2004. The existing volume estimates include the historical plus the excess volumes previously presented. (Suau, 2005)

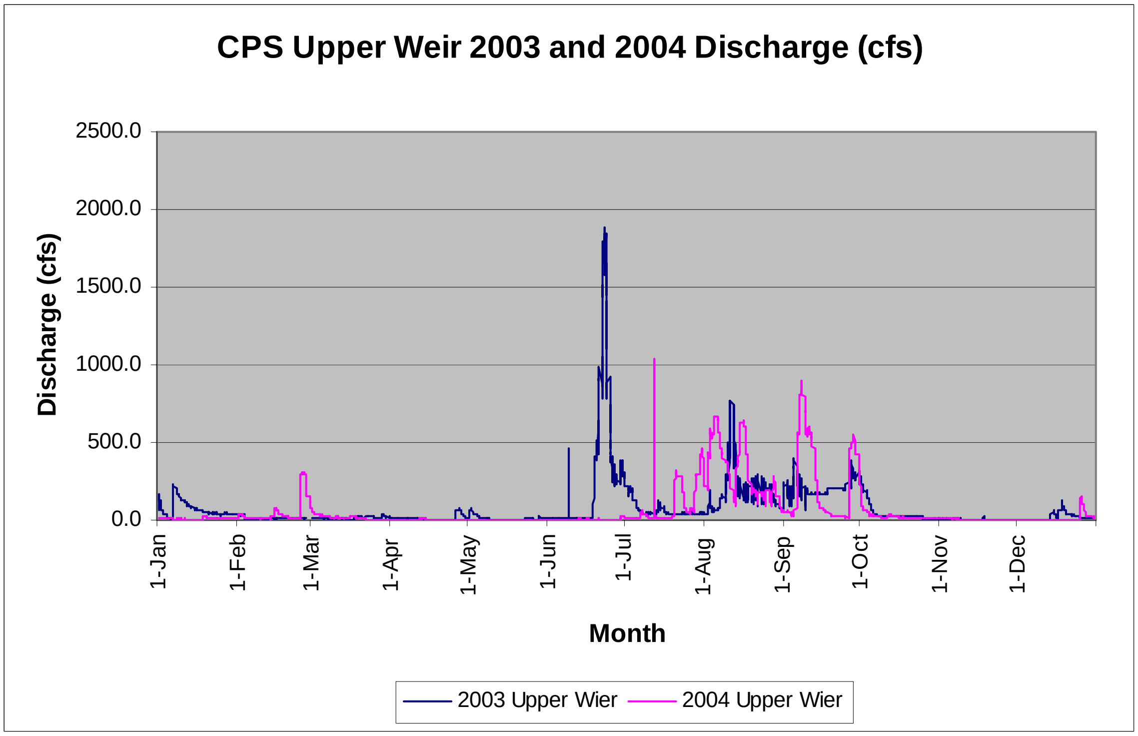


Figure 27a. CPS upper weir discharge for 2003 and 2004.

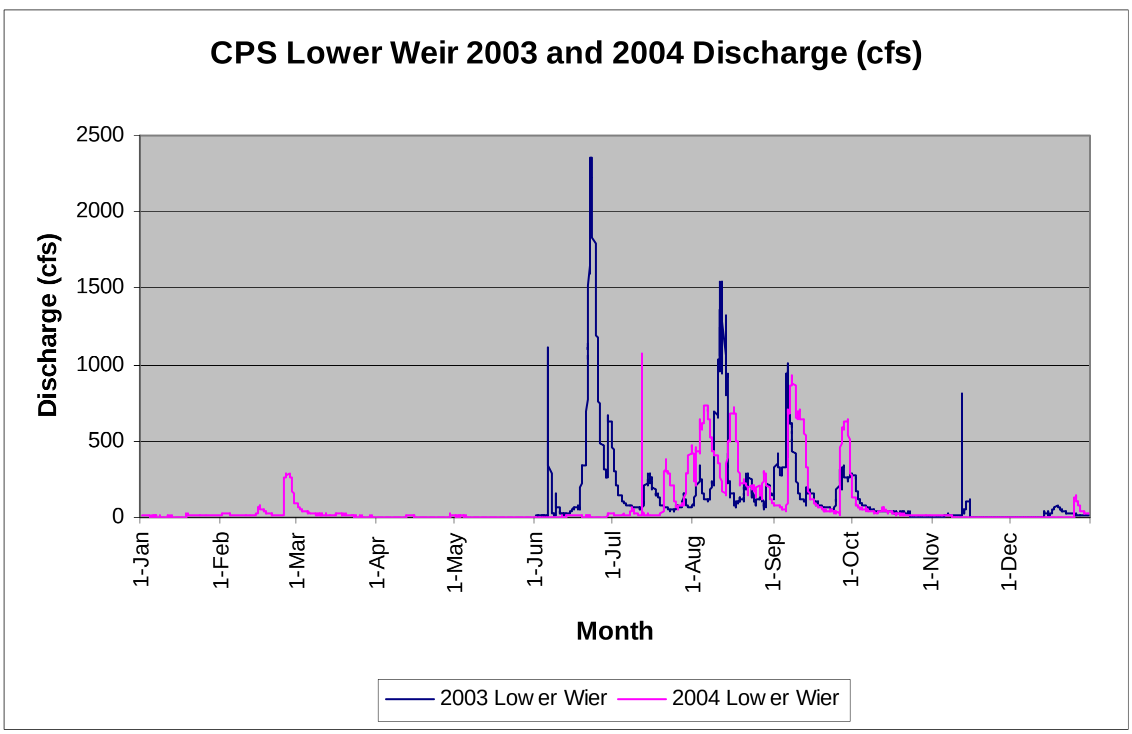


Figure 27b. CPS lower weir discharge for 2003 and 2004.

DONA BAY WATERSHED				
RUNOFF VOLUME COMPARISON				
	CURRENT		HISTORICAL	
YEAR	ac-ft	(mgd)	ac-ft	(mgd)
2003	99430	88.75	21060	18.80
2004	78186	69.79	16560	14.78

Table 6 (Suau, 2005)

Excess Discharge to DARB from Blackburn Canal

Studies conducted on the Myakka River estimate that discharges to Blackburn Canal are between five to ten percent of the flow on the Myakka River (DeLeuw et al., 1992 and Suau, 2005). For the purpose of estimating flow, the USGS gage No. 02298830, located on the Myakka River near Sarasota, was used for volume estimations. Figure 28 graphically illustrates the estimated discharge for Blackburn Canal for both 2003 and 2004. The discharge values were calculated at seven percent of the discharge calculated at the Myakka River USGS station. The total estimated volume of fresh water discharged into Blackburn Canal from the Myakka River in 2003 was approximately 31,708 acre-feet compared to 20,286 acre-feet in 2004.

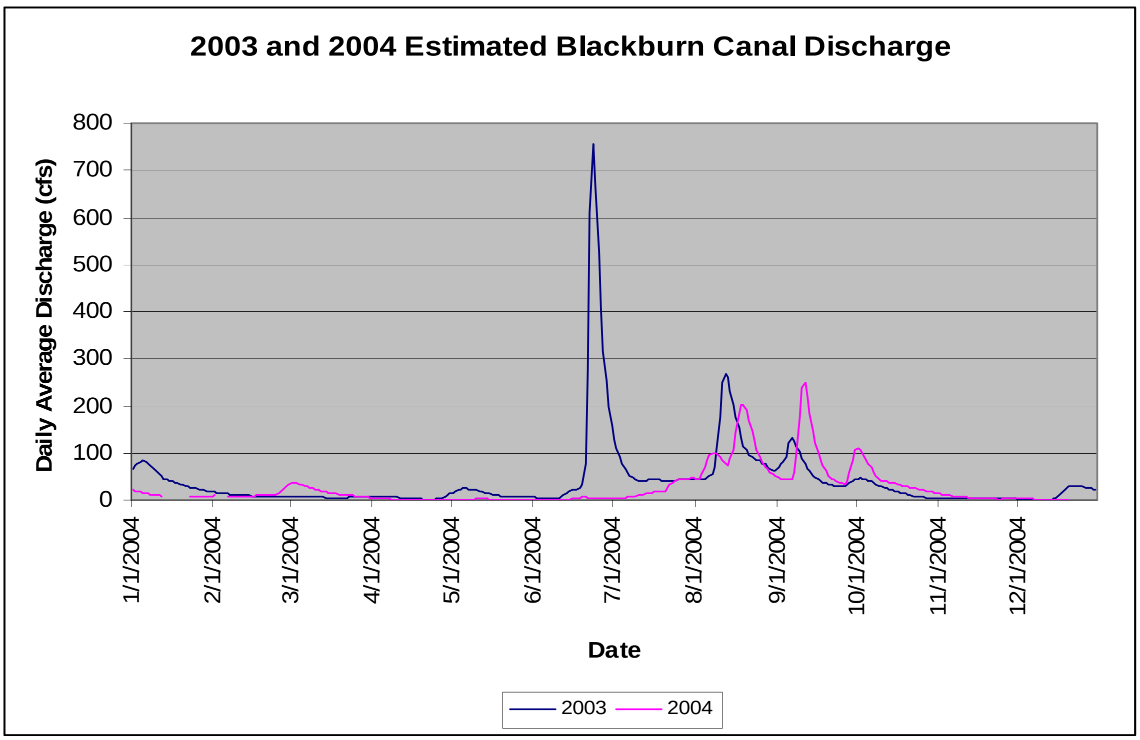


Figure 28. Estimated Blackburn Canal discharge volumes for 2003 and 2004.

Blackburn Canal was cut below sea level and tides in DARB and the Myakka River/Blackburn Canal confluence are out of phase from one another. This has made calculating a discharge rating curve challenging. Figure 29 displays available SCG ARMS measured stage values for 2003 and 2004 on Blackburn Canal at Jackson Road. Jackson Road is the approximate location of the historical drainage basin division between Curry Creek and the Myakka River. Therefore, any westerly flows through this location could be considered excess flow to the DARB watershed. The USGS installed a monitoring station in October

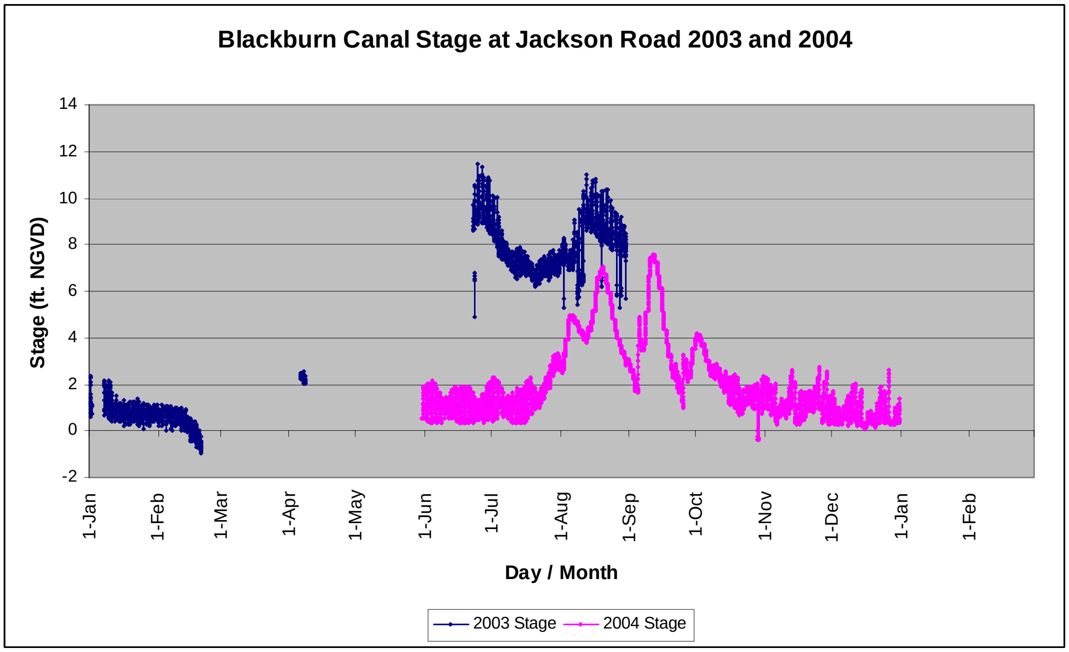


Figure 29. Blackburn Canal ARMS stage data for 2003 and 2004

2004 at Blackburn Canal and Jackson Road and began collecting stage and discharge data. Future data evaluation efforts will use measured discharge at this point, allowing for valid reconciliation of discharges diverted from the Myakka River by Blackburn Canal.

Discussion

USGS gage No. 02298830, located on the Myakka River near Sarasota has been recording water levels since 1936. The gage recorded a peak discharge rate of 11,100 cubic feet per second (cfs) in June 2003, which was the highest reading on record. The previous highest peak discharge reading was 8,680 cfs recorded on 6/29/92 (Kane, 2004). The 2003 wet season also experienced more precipitation and freshwater runoff to the Robert's Bay estuary than in 2004.

Data collection efforts are beginning to suggest that the tidally driven salt wedge does not penetrate much further upstream of the U.S. 41 Curry Creek bridge during the latter part of the wet season. Two separate meter deployments, one in August 2003 and one in August 2004, showed little to no salinity in the estuarine portions of Curry Creek. Even though estuarine biota is adapted to fluctuations in the environment, these natural fluctuations are usually not as extreme as the observed long-term salinity drops in Curry Creek.

The estuarine portion of Curry Creek between Albee Farm Road and U.S.41, as in the case with Shakket Creek and CPS, has been impacted by alteration-induced increase in runoff volumes. An additional problem at Curry Creek is the bottleneck at the U.S. 41 outlet to Robert's Bay. Historically, the Shakett Creek and Curry Creek estuaries widened at the mouth. Shakket and Curry Creeks are now constricted at their historic mouth. All the additional freshwater volumes from Blackburn Canal have to leave at the extreme southwest corner of Curry Creek. Flows need to change direction and slow in order to continue to Robert’s Bay. This causes an impoundment of freshwater east of U.S. 41 during higher flows. Although the problem also exists at the Shakket Creek/Dona Bay interface, it is not as pronounced because Shakket Creek has two outlets.

Section V
Natural Systems

Importance of Our Natural Lands to the Estuary

Watershed characteristics drive hydrologic input and water quality. Organisms respond to changes in water quality and the local hydrology of the watershed. For example, a developed watershed with a high impervious area that directly discharges to an estuary has higher pollutant and sediment loads, both inorganic and organic, than an undeveloped watershed. Figure 30 illustrates how undeveloped SCG watersheds, such as Deer Prairie Creek and the Myakka River, have a lower percent of impervious surface than more developed watersheds such as the Island of Venice and Whitaker Creek. Figure 30 represents percent impervious acreage and percent altered land use classifications for some Sarasota County subbasins.

“Biological health is impossible unless human presence is very low and the natural vegetation and soil systems are well preserved near streams and throughout water sheds.” (Horner et al., 2004) Storm-driven pulses of runoff often inundate a system with fresh water and nutrients which, in turn, feed algae blooms that deplete the water column of available oxygen resulting in anoxic conditions. Fish kills are documented in these scenarios. Fish kills are highly visible, but the effects on macro-invertebrates and the smaller organisms at the bottom of the food chain often go unnoticed.

Natural systems that have not been ditched or drained tend to hold more water on the land where it is filtered through natural processes. Water remains on the surface longer and drains slower toward the estuary. More water is taken up in natural systems through the evapotranspiration of plants than released as runoff. The converse is true in developed systems. This is easily observed by comparing wet season hydrographs from natural systems like the Myakka River to hydrographs from developed areas such as Whitaker Bayou. The Myakka tends to have an elongated hydroperiod with a long recession time that lasts throughout the wet season (Suau, 2004). Whitaker Bayou will stage up quickly then recedes quickly after storm events.

Natural processes allow for less freshwater pulsing and a decrease in discharge volume. The smaller volume of water that is ultimately discharged to the estuary tends to be less polluted with sediments and nutrients. Environmental regulation agencies are aware of this and stipulate natural habitat buffers along wetlands, streams and other watercourses. Lee County has put forth considerable effort in preserving bay coastline. SCG has implemented the voter approved Environmentally Sensitive Land Protection Program (ESLPP) and has purchased 14,841 acres of natural habitat to date and, through partnerships and donations, has protected an additional 1,513 acres. The majority of the habitat preserved under this program is in the Myakka River corridor. Many of the other parcels are strategically situated around watercourses throughout the County such as Red Bug Slough, Curry Creek Preserve, and the parcels that make up the Deer Prairie Creek and Lemon Bay Preserves.

The health of our estuaries, bays, and other watercourses and their associated biota depend not only on good water quality and appropriate water budgets but also on the preservation and proper management of the natural habitats in the watershed. Any effort to balance and accommodate the needs of a growing population, and still provide for the beneficial use of our natural and cultural resources, must involve careful coordination between stakeholders.

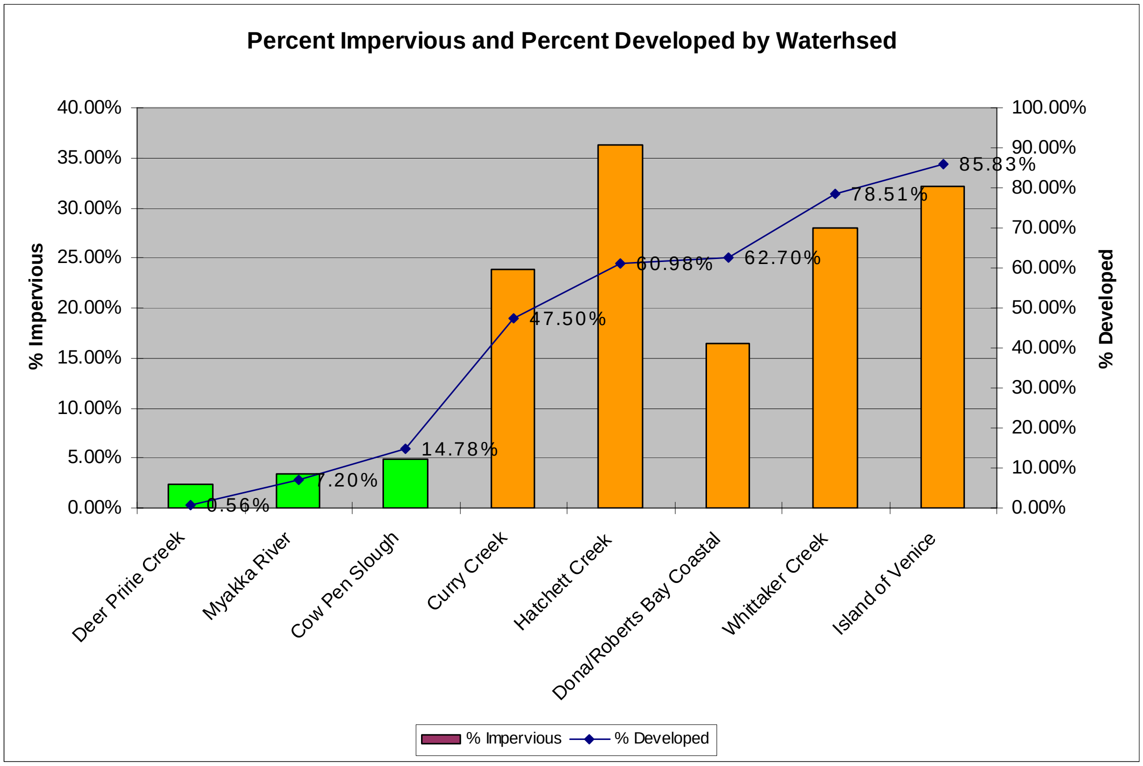


Figure 30. Percent impervious and percent altered land use classifications.

Future growth and land use planning should be tailored in a fashion that either facilitates restoration or protects existing natural ecosystem function. In other words, future development should attempt to mimic natural system processes.

DARB Watershed Land Use Composition

The following five watersheds drain to the DARB estuary system: Cow Pen Slough, Coastal Venice, Curry Creek, Hatchett Creek, and Dona and Robert's Bay. Two other watersheds, Myakka River and Alligator Creek, also discharge a portion of runoff to the DARB basins during certain flow regimes. Data from a GIS analysis conducted by SCG Stormwater was used to determine the land use classifications of the five major contributing watersheds. The SWFWMD 1999 GIS Landuse layer was used for this effort. Forty-five different land use classifications were analyzed and grouped into the following five categories: wetlands, naturally vegetated uplands, open water (stormwater management systems), agriculture, and developed. The analysis results show that the DARB contributing watersheds are comprised of approx. 41% natural area (wetlands and naturally vegetated uplands) and approx. 59% altered (open water, agriculture, and developed) land use classifications. This contrasts with Sarasota County's relatively undeveloped watersheds. The Deer Prairie Slough (DPS) watershed for example is comprised of approximately 96% natural lands and 4% altered lands. The Myakka River watershed is comprised of approximately 75% natural lands and 25% altered lands. Figure 31a illustrates the proportion of land use categories that contribute to the DARB watershed from each subbasin. Figure 31b is an example of one of the most developed watersheds in our area, Whitaker Creek. Figures 32a and 32b illustrates the proportions of land use categories for the DPS and Myakka River watersheds, respectively.

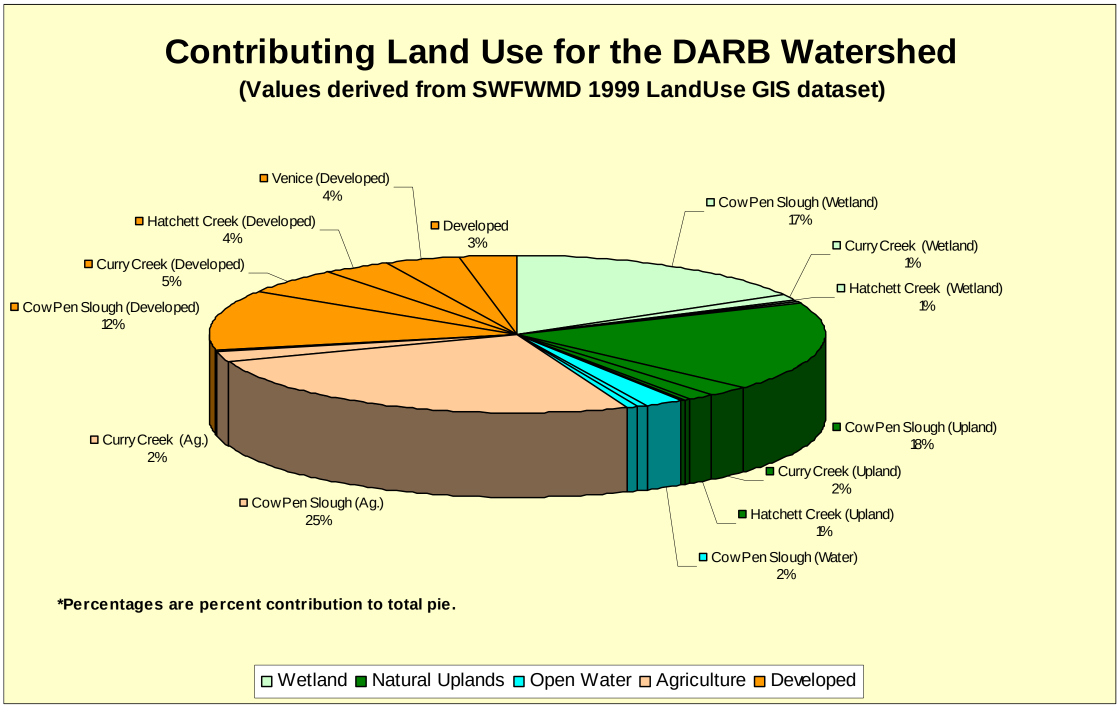


Figure 31a. DARB land use composition.

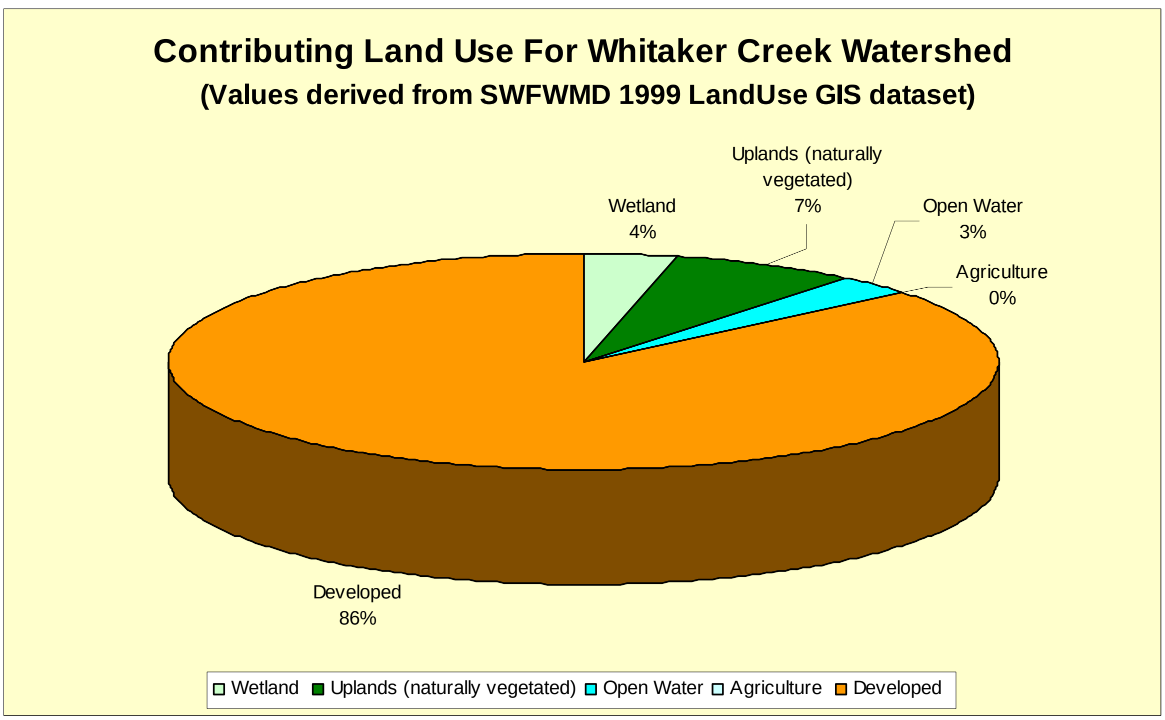


Figure 31b. Whitaker Creek land use composition.

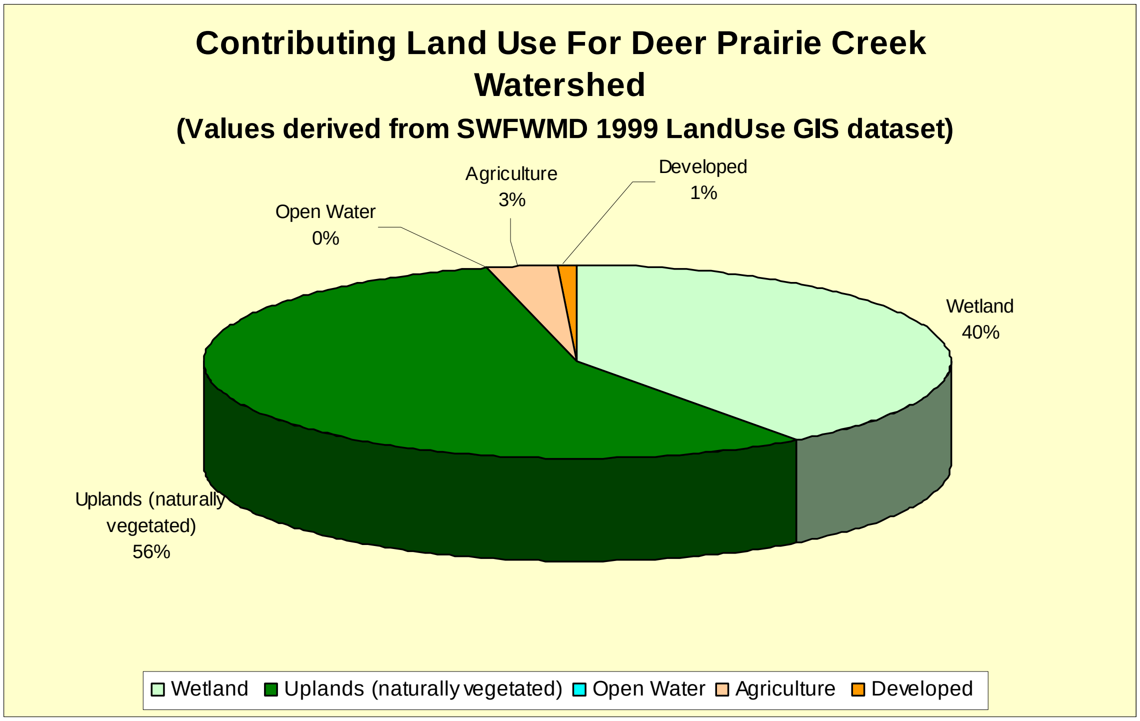


Figure 32a. Deer Prairie Slough watershed land use composition.

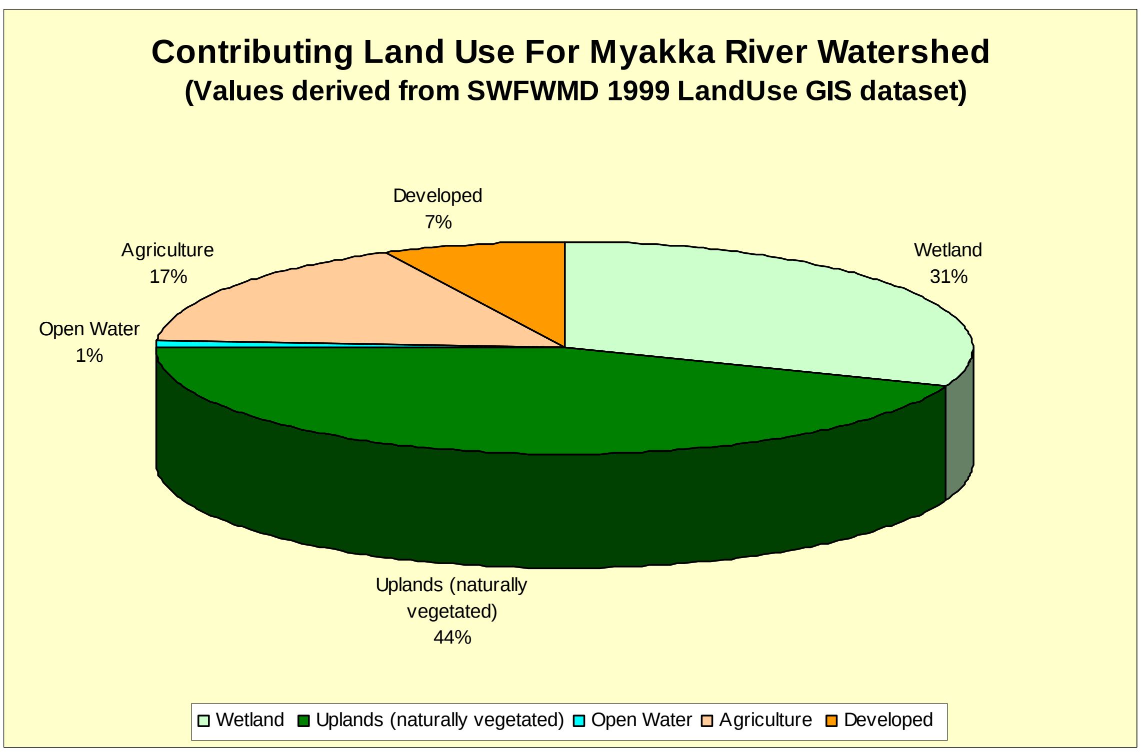


Figure 32b. Myakka River watershed land use composition.

Habitat Acquisition

SCG Natural Resources directs both the ESLPP and Land Management Program. The ESLPP has preserved 88.8 acres of land in the DARB watershed to date. In 2004, SCG purchased three properties strategic for water resource management located in the CPS Basin (Figure 33).

<u>Albritton Parcel</u>

SCG Solid Waste purchased 1,000 acres of the the Albritton parcel, located north of the Pinelands Reserve and the successful 350-acre Old CPS wetland restoration project. This site lies mainly in what was once a large herbaceous marsh in the broadest portion of CPS prior to channelization. It is strategically located in the old flow way of the slough. After the canal was dug, the site was converted to agriculture and is now a citrus grove. The site was purchased mainly as a source for landfill cover for the Central County Solid Waste Disposal Complex. The fill excavation will be planned to facilitate the meeting of environmental needs, such as water attenuation, natural filtration, wetland habitat restoration and a future water supply source. These activities are expected to enhance the status of the DARB system by reducing the large wet season freshwater discharge to the estuary.

<u>Venice Minerals</u>

SCG Stormwater and the ESLPP purchased the Venice Minerals property. This property lies just south and east of the ESLPP Rocky Ford property. The site is adjacent to the southeastern flow way of the old CPS, where it once used to sheet-flow east toward the Myakka River. The majority of the site is a shell and sand mining operation that will result in a reservoir when mining activities are complete. The eastern portion of the site, purchased by the ESLPP, contains 146 acres of natural area that falls within the Myakka River watershed. The purchase of this area also affords enhancement opportunities for DARB. Re-establishing some of the natural hydrology to the historic CPS can reduce the volume and intensity of freshwater flows to the estuary.

<u>Fox Creek</u>

The Fox Creek Regional Mitigation Project is a 140-acre parcel located in the DARB watershed on the east side of the lower CPS control structure. The site was purchased in early 2004 by Sarasota County Public Works as a regional mitigation area to offset unavoidable wetland and upland impacts from future County infrastructure projects. The site borders both a freshwater portion of CPS and an estuarine portion of Shakket Creek. Several mitigation activities are proposed and include the following: freshwater wetland creation (forested and herbaceous); freshwater wetland enhancement (forested); estuarine wetland creation; scrub creation/enhancement; mesic hammock (stream bank) restoration/enhancement; and, upland enhancement and preservation. These activities will aid DARB enhancement and restoration efforts by providing habitat, freshwater attenuation, and natural water quality treatment.

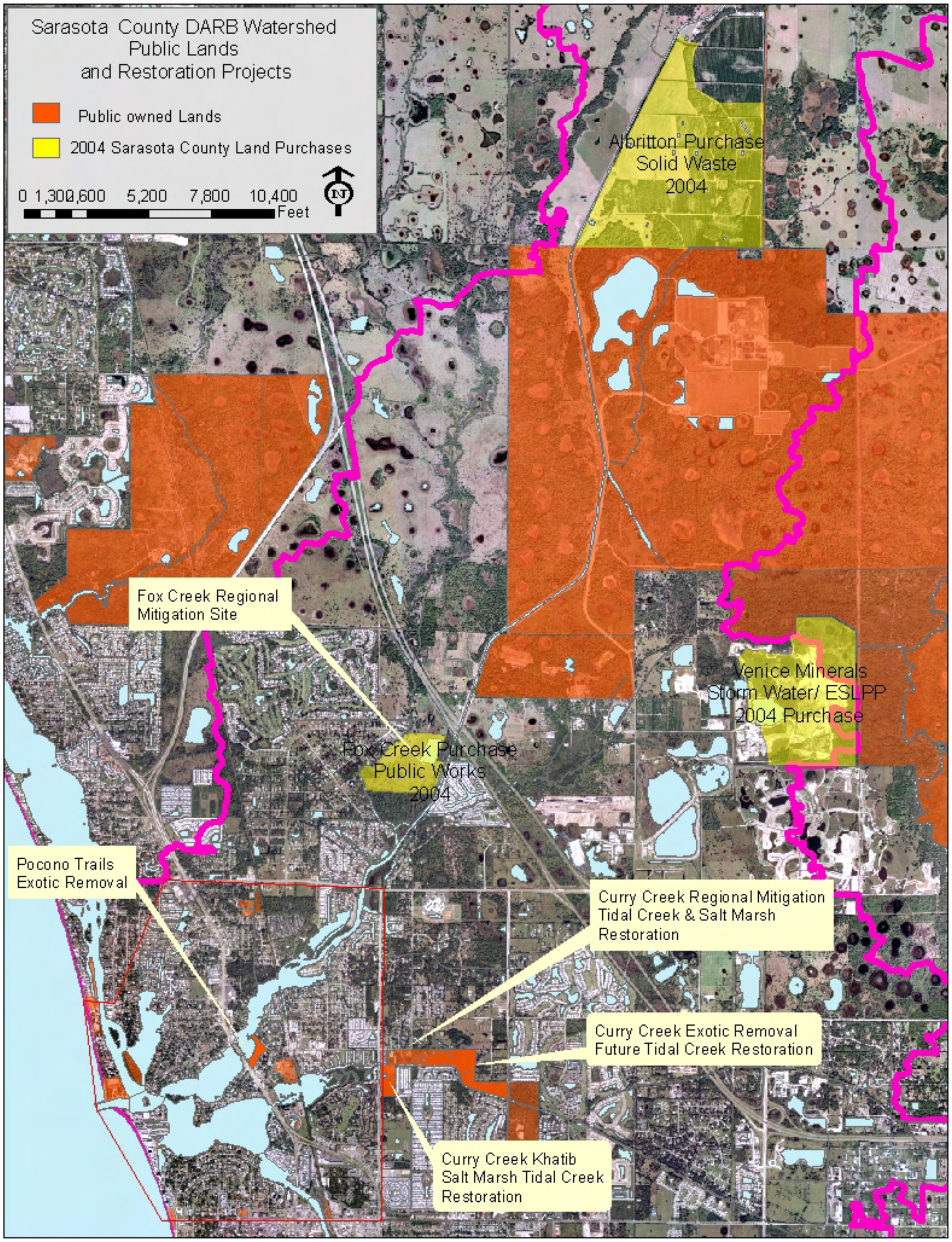


Figure 33. DARB land acquisition, public lands, and restoration projects.

DARB Restoration and Enhancement

The Curry Creek Preserve is located in the historic headwater area of Curry Creek. It contains the historic tidal meanders that after the Blackburn Canal construction, now dead-end into side-cast spoil that separates the historic creek from the Canal. The preserve is made up of three separate parcels purchased by the ESLPP and a parcel purchased by SCG Public Works. Two restoration projects began in the Preserve in 2004. On the Khatib Parcel, the only portion on the south side of the creek, SCG Natural Resources restored an area that was once meandering creek and salt marsh habitat. Figure 26a, b, & c show aerial photos of the preserve after the initial mulching event in 2001 and post-restoration, June and December 2004. The project restored 0.25 kilometers of meandering tidal creek and approximately 1.5 acres of high tidal marsh habitat.

Public Works began a project on their portion of the preserve in 2004. This project will yield mitigation credits as part of the regional mitigation program. The regional mitigation project will involve the restoration or enhancement of 1.37 acres of mangroves, 0.15 acres of mixed hammock, 4.16 acres of salt marsh, 1.58 acres of tidal creek, and 4.53 acres of uplands. Other potential projects could restore salt marsh systems by reconnecting historic wetlands that are separated from the Blackburn Canal by spoil berms.

Land Management

The acquired environmentally sensitive lands need appropriate land management and, often, restoration to retain ecological functions and values that are disappearing as our county continues to develop. In December 2004, the SCG BCC approved the comprehensive Land Management Master Plan. "The intent of the LMM PLAN is to provide focus and direction for proactive, rather than reactive, land management activities at the community and landscape levels throughout the County." (Perry, 2004) The plan provides guidelines to those managing natural areas for conservation or preservation in Sarasota County.

Most of our natural habitats are fire dependent as well as water dependent. Natural Resources implemented the ecological prescribed burning program. This program conducts prescribed ecological burns on our natural lands. 2,422 acres of natural habitat were treated with ecological burning in 2004. Since the inception of the program, there have been no catastrophic wild fires and thousands of acres of habitat have been enhanced through the process of prescribed natural fire.

Land managers are restoring natural habitat functions and values by removing exotic vegetation. Pocono Trails, located on the southern shoreline of Shakket Creek where it joins Dona Bay, and Curry Creek are two examples of projects where dense thickets of Brazilian pepper have been removed. The Pocono Trails shoreline has been enhanced and native mangroves are recruiting the area.

Maintaining, restoring, and enhancing the ecological integrity of DARB would be incomplete without the measures that SCG Natural Resources have taken through implementation of a proactive acquisition and land management program. Natural system hydrologic restoration projects provide habitat for estuarine biota and help alleviate some of the stress caused by increased hydrologic inputs.

Figure 26a. Pre-restoration, 2001

Figure 26b. Post-restoration June 2004

Figure 26c. Post-restoration December 2004

Figure 26. Curry Creek Khatib parcel restoration site

Section VI

Bringing It All Together

Discussion

Evaluating the status of estuarine environmental indicators requires a broad comprehensive approach. Mere data collection is not useful without taking the whole system into consideration. Estuarine organism status depends on the estuarine environment as a whole. A considerable number of variables contribute to the estuarine environment. This investigation has focused on major ones, such as salinity and hydrology. The 2003 and 2004 monitoring effort evaluated oysters and seagrass for number of live organisms and relative abundance. Available hydrologic and water quality data were compiled and evaluated. Water budgets for 2003 and 2004 were derived for CPS. Many variables have not been examined including physical anthropogenic disturbances such as boat wake energy and the destruction of natural shoreline. Oysters were not tested for disease or parasites. The algae coating DARB seagrass has not been evaluated.

Oyster populations are responding to dynamic hydrologic regimes. 2003 was an above average wet season and an oyster die-off was documented. 2004 experienced rainfall 15 inches below average and 20 inches less than 2003 totals for the CPS portion of the DARB watershed. It is evident that the decrease in the intensity and volume of freshwater discharges during the 2004 wet season has resulted in a positive effect on the percent and number of live oysters in the DARB study area. An increase in oyster population was observed. Documented hydrologic differences between Curry Creek and Shakket Creek also point to oyster response to runoff. The oysters in Shakket Creek had a larger percentage increase in live individuals than Curry Creek. Shakket Creek experienced a 68% to 75% increase in percentage of live oysters. Curry Creek experienced a 41% increase in percent live oysters since 2003. Salinity data indicates that Curry Creek maintained lower salinity concentrations than Shakket Creek during both 2003 and 2004 wet seasons.

The February release of SWFWMD 2003 mapped seagrass acreage indicated a 22% increase in seagrass coverage for the DARB area since the 2001-mapping event. Contrasting with the SWFWMD 2003 mapping efforts, both 2003 and 2004 SCG seagrass transect monitoring efforts yielded very little seagrass coverage. Areas where seagrass was observed growing in thicker beds may need to be evaluated for differences in salinity regimes and water quality parameters. SCG staff is investigating different monitoring protocols for environmental indicators in order to establish a monitoring program that provides the most cost effective and informative data for resource managers.

SCG has hired a team of consultants to draft the Dona Bay Watershed Management Plan. The plan has the following objectives:

1. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
2. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
3. Protect existing and future property owners from flood damage.
4. Protect existing water quality.
5. Develop potential alternative surface water supply options that are consistent with, and support, other plan objectives.

The consolidation of data from various monitoring programs provides a more informed and holistic look at the ecology of the system. Through continued and increased data collection and cooperation with the various stakeholders, SCG will enhance the understanding of our local natural systems. Smart growth planning and informed stewardship can help SCG shape future development in a manner that reduces the human footprint and allows for a symbiotic relationship between our growing human population and the environment.

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Appendix A.

Oyster Field Sheets
Oyster Statistical Analysis

Oyster Sampling

Date: 4/6&7/2004 Samplers Michael Jones and Joe Jacobson and Jeff Banner

Location: DARB study area

Est. Tide High rising Weather Clear to slightly overcast

Date Time	Bed No. I.D.	Quadrat (1,2)	Live No.	Dead No.	Spat No.	Longest 5 Live (cm)	GPS pt. (y,n)	DO (mg/L)	pH	Sp. Cond (uS/cm)	Temp. ©	Salinity (ppt)	Depth (cm)	River Kilo#
4/6/2004	lyb1	1	90	22	13		n	6.83			20.55	33.91		1.8
4/6/2004	lyb1	2	90	40	19		n							
4/6/2004	lyb1	3	95	37	19	7,8,8,8.5,9	n							
4/6/2004	db1	1	52	44	7	5,5,6,6,6	n	7.9	7.42		20.55	34.26		1
4/6/2004	db1	2	49	51	23	3.5,4,5,6,6	n							
4/6/2004	db1	3	51	53	13	5,5,6,7,7	n							
4/7/2004	sc1	1	32	10	2	3,4,4,5,5	n	6.47	7.97	49856	21.61	32.18	25	2.1
4/7/2004	sc1	2	107	32	19	3,3,3,4,5	n							
4/7/2004	sc1	3	100	15	3	3,4,4,4,6	n							
4/7/2004	rb1	1	47	24	4	5.5,6.5,6,7,8	n	7.76	7.93	52000	22.98	34.29	20	2.8
4/7/2004	rb1	2	20	7	5	3,3,3,5,6	n							
4/7/2004	rb1	3	23	3	6	4.5,5,5.5,5,6	n							
4/7/2004	cc1	1	40	105	1	2,2.5,3,3,3.5	n	7.37	7.53	51094	23.26	33.58	20	3.35
4/7/2004	cc1	2	46	85	0	4,4,5,5,6	n							
4/7/2004	cc1	3	42	36	1	4,4,4,4,2.5	n							
4/7/2004	sc2	1	76	36	1	3,4,4,5,5	n	6.33	7.89	49000	22.09	32.05	25	3
4/7/2004	sc2	2	61	29	0	3,3,4,4,5	n							
4/7/2004	sc2	3	107	36	0	3,4,4,4,5	n							

Comments:

Oyster Sampling

Date: 10/05 and 10/06 2004 Samplers Michael Jones and Joe Jacobson and Jeff Banner

Location: DARB study area

Est. Tide High rising Weather Clear to slightly overcast

Date Time	Bed No. I.D.	Quadrat (1,2)	Live No.	Dead No.	Spat No.	Longest 5 Live (cm)	GPS pt. (y,n)	DO (mg/L)	pH	Sp. Cond (uS/cm)	Temp. ©	Salinity (ppt)	Depth (cm)	River Kilo#
10/5/2004	lyb1	1	100	18	20	7,7.5,5,5,4	y	4.92	7.56		29.25	28.72		1.8
10/5/2004	lyb1	2	124	26	27	4,7,8,5.5,4	y							
10/5/2004	lyb1	3	114	24	46	8,8,6,6,5	y							
10/5/2004	db1	1	92	56	7	5,5,5,4,4	y	7.14	7.55		31.84	13.19		1
10/5/2004	db1	2	90	20	5	5,4,6,6,5	y							
10/5/2004	db1	3	61	58	40	4,4,3,4,4	y							
10/6/2004	sc1	1	177	24	11	6,6,5.5,6,6	y	4.72	7.45		29.48	10.32		2.1
10/6/2004	sc1	2	31	55	5	4,4,5,3,4	y							
10/6/2004	sc1	3	169	23	8	6,7,6,7,8	y							
10/6/2004	rb1	1	78	9	0	7,7,7,6,6	y	7.65	7.74		30.89	21.39		2.8
10/6/2004	rb1	2	59	34	3	6,6,6,5,6	y							
10/6/2004	rb1	3	146	31	24	5,6,6,6,6	y							
10/6/2004	cc1	1	7	33	2	6,5,5,6,4	y	5.8	7.04		30.22	0.27		3.35
10/6/2004	cc1	2	63	72	1	4,6,5,5.5,7	y							
10/6/2004	cc1	3	53	26	0	4.5,7,7,5,6	y							
10/6/2004	sc2	1	138	42	10	5,5,6,5,5	y	5.6	7.22		30.05	5.2		3
10/6/2004	sc2	2	121	30	9	6.5,5.5,5,5.5,6.5	y							
10/6/2004	sc2	3	80	15	5	4,5,5.5,5,5	y							

Comments:

[4/14/2004 12:20 "/LiveOysters" (2453109)]

One-Way ANOVA

Summary Statistics

Dataset	N	Mean	SD	SE
LiveOysters_CC1	3	42.66667	3.05505	1.76383
LiveOysters_DB1	3	50.66667	1.52753	0.88192
LiveOysters_LYB1	3	91.66667	2.88675	1.66667
LiveOysters_RB1	3	30	14.79865	8.544
LiveOysters_SC1	3	79.66667	41.42865	23.91884
LiveOysters_SC2	3	81.33333	23.45918	13.54417

Null Hypothesis: The means of all selected datasets are equal
Alternative Hypothesis: The means of one or more selected datasets are different

ANOVA

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	9268.66667	1853.73333	4.43890	0.01604
Error	12	5011.33333	417.611111		

At the 0.05 level,
the population means are significantly different.

Levene's Test for Equal Variance

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	3000527.53	600105.506	3.27649	0.04275
Error	12	2197859.93	183154.994		

At the 0.05 level,
the population variations are significantly different.

Brown-Forsythe's Test for Equal Variance

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	1388.66667	277.733333	0.91376	0.50413
Error	12	3647.33333	303.944444		

At the 0.05 level,
the population variations are not significantly different.

Means Comparison using Bonferroni Test

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
LiveOysters_CC1	42.66667				
LiveOysters_DB1	50.66667	-8	-68.88365	52.88365	No
LiveOysters_LYB1	91.66667	-49	-109.88365	11.88365	No
LiveOysters_RB1	30	12.66667	-48.21699	73.55032	No
LiveOysters_SC1	79.66667	-37	-97.88365	23.88365	No
LiveOysters_SC2	81.33333	-38.66667	-99.55032	22.21699	No
LiveOysters_DB1	50.66667				
LiveOysters_LYB1	91.66667	-41	-101.88365	19.88365	No
LiveOysters_RB1	30	20.66667	-40.21699	81.55032	No
LiveOysters_SC1	79.66667	-29	-89.88365	31.88365	No
LiveOysters_SC2	81.33333	-30.66667	-91.55032	30.21699	No
LiveOysters_LYB1	91.66667				
LiveOysters_RB1	30	61.66667	0.78301	122.55032	Yes
LiveOysters_SC1	79.66667	12	-48.88365	72.88365	No
LiveOysters_SC2	81.33333	10.33333	-50.55032	71.21699	No
LiveOysters_RB1	30				
LiveOysters_SC1	79.66667	-49.66667	-110.55032	11.21699	No
LiveOysters_SC2	81.33333	-51.33333	-112.21699	9.55032	No
LiveOysters_SC1	79.66667				
LiveOysters_SC2	81.33333	-1.66667	-62.55032	59.21699	No

Means Comparison using Scheffe' Test

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
LiveOysters_CC1	42.66667				
LiveOysters_DB1	50.66667	-8	-73.75328	57.75328	No
LiveOysters_LYB1	91.66667	-49	-114.75328	16.75328	No

LiveOysters_RB1	30	12.66667	-53.08661	78.41995	No
LiveOysters_SC1	79.66667	-37	-102.75328	28.75328	No
LiveOysters_SC2	81.33333	-38.66667	-104.41995	27.08661	No
LiveOysters_DB1	50.66667				
LiveOysters_LYB1	91.66667	-41	-106.75328	24.75328	No
LiveOysters_RB1	30	20.66667	-45.08661	86.41995	No
LiveOysters_SC1	79.66667	-29	-94.75328	36.75328	No
LiveOysters_SC2	81.33333	-30.66667	-96.41995	35.08661	No
LiveOysters_LYB1	91.66667				
LiveOysters_RB1	30	61.66667	-4.08661	127.41995	No
LiveOysters_SC1	79.66667	12	-53.75328	77.75328	No
LiveOysters_SC2	81.33333	10.33333	-55.41995	76.08661	No
LiveOysters_RB1	30				
LiveOysters_SC1	79.66667	-49.66667	-115.41995	16.08661	No
LiveOysters_SC2	81.33333	-51.33333	-117.08661	14.41995	No
LiveOysters_SC1	79.66667				
LiveOysters_SC2	81.33333	-1.66667	-67.41995	64.08661	No

Means Comparison using Tukey Test

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
LiveOysters_CC1	42.66667				
LiveOysters_DB1	50.66667	-8	-64.04541	48.04541	No
LiveOysters_LYB1	91.66667	-49	-105.04541	7.04541	No
LiveOysters_RB1	30	12.66667	-43.37875	68.71208	No
LiveOysters_SC1	79.66667	-37	-93.04541	19.04541	No
LiveOysters_SC2	81.33333	-38.66667	-94.71208	17.37875	No
LiveOysters_DB1	50.66667				
LiveOysters_LYB1	91.66667	-41	-97.04541	15.04541	No
LiveOysters_RB1	30	20.66667	-35.37875	76.71208	No
LiveOysters_SC1	79.66667	-29	-85.04541	27.04541	No
LiveOysters_SC2	81.33333	-30.66667	-86.71208	25.37875	No

LiveOysters_LYB1	91.66667				
LiveOysters_RB1	30	61.66667	5.62125	117.71208	Yes
LiveOysters_SC1	79.66667	12	-44.04541	68.04541	No
LiveOysters_SC2	81.33333	10.33333	-45.71208	66.37875	No

LiveOysters_RB1	30				
LiveOysters_SC1	79.66667	-49.66667	-105.71208	6.37875	No
LiveOysters_SC2	81.33333	-51.33333	-107.37875	4.71208	No

LiveOysters_SC1	79.66667				
LiveOysters_SC2	81.33333	-1.66667	-57.71208	54.37875	No

[4/14/2004 12:20 "/LiveOysters" (2453109)]

One-Way ANOVA

Summary Statistics

Dataset	N	Mean	SD	SE
Percentliveoy_CC1	3	38.84895	13.52242	7.80717
Percentliveoy_DB1	3	50.73504	2.97194	1.71585
Percentliveoy_LYB1	3	73.85254	5.79723	3.34703
Percentliveoy_RB1	3	76.24427	11.28972	6.51812
Percentliveoy_SC1	3	80.04181	6.00127	3.46483
Percentliveoy_SC2	3	70.15337	4.0461	2.33602

Null Hypothesis: The means of all selected datasets are equal
Alternative Hypothesis: The means of one or more selected datasets are different

ANOVA

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	4034.93273	806.986546	11.95123	0.00025
Error	12	810.279716	67.5233097		

At the 0.05 level,
the population means are significantly different.

Levene's Test for Equal Variance

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	33463.8918	6692.77835	2.29667	0.11050
Error	12	34969.5353	2914.12794		

At the 0.05 level,
the population variations are not significantly different.

Brown-Forsythe's Test for Equal Variance

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	121.125355	24.2250711	0.67756	0.64877
Error	12	429.038469	35.7532058		

At the 0.05 level,
the population variations are not significantly different.

Means Comparison using Bonferroni Test

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
Percentliveoy_CC1	38.84895				
Percentliveoy_DB1	50.73504	-11.88609	-36.36779	12.59561	No
Percentliveoy_LYB1	73.85254	-35.00358	-59.48528	-10.52188	Yes
Percentliveoy_RB1	76.24427	-37.39531	-61.87701	-12.91361	Yes
Percentliveoy_SC1	80.04181	-41.19285	-65.67455	-16.71115	Yes
Percentliveoy_SC2	70.15337	-31.30441	-55.78611	-6.82271	Yes
Percentliveoy_DB1	50.73504				
Percentliveoy_LYB1	73.85254	-23.11749	-47.59919	1.3642	No
Percentliveoy_RB1	76.24427	-25.50922	-49.99092	-1.02752	Yes
Percentliveoy_SC1	80.04181	-29.30676	-53.78846	-4.82506	Yes
Percentliveoy_SC2	70.15337	-19.41832	-43.90002	5.06338	No
Percentliveoy_LYB1	73.85254				
Percentliveoy_RB1	76.24427	-2.39173	-26.87343	22.08997	No
Percentliveoy_SC1	80.04181	-6.18927	-30.67097	18.29243	No
Percentliveoy_SC2	70.15337	3.69917	-20.78253	28.18087	No

Percentliveoy_RB1	76.24427				
Percentliveoy_SC1	80.04181	-3.79754	-28.27924	20.68416	No
Percentliveoy_SC2	70.15337	6.0909	-18.3908	30.5726	No

Percentliveoy_SC1	80.04181				
Percentliveoy_SC2	70.15337	9.88844	-14.59326	34.37014	No

Means Comparison using Scheffe' Test

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
Percentliveoy_CC1	38.84895				
Percentliveoy_DB1	50.73504	-11.88609	-38.32589	14.55372	No
Percentliveoy_LYB1	73.85254	-35.00358	-61.44339	-8.56378	Yes
Percentliveoy_RB1	76.24427	-37.39531	-63.83512	-10.9555	Yes
Percentliveoy_SC1	80.04181	-41.19285	-67.63266	-14.75304	Yes
Percentliveoy_SC2	70.15337	-31.30441	-57.74422	-4.8646	Yes

Percentliveoy_DB1	50.73504				
Percentliveoy_LYB1	73.85254	-23.11749	-49.5573	3.32231	No
Percentliveoy_RB1	76.24427	-25.50922	-51.94903	0.93058	No
Percentliveoy_SC1	80.04181	-29.30676	-55.74657	-2.86696	Yes
Percentliveoy_SC2	70.15337	-19.41832	-45.85813	7.02148	No

Percentliveoy_LYB1	73.85254				
Percentliveoy_RB1	76.24427	-2.39173	-28.83153	24.04808	No
Percentliveoy_SC1	80.04181	-6.18927	-32.62907	20.25054	No
Percentliveoy_SC2	70.15337	3.69917	-22.74063	30.13898	No

Percentliveoy_RB1	76.24427				
Percentliveoy_SC1	80.04181	-3.79754	-30.23735	22.64227	No
Percentliveoy_SC2	70.15337	6.0909	-20.34891	32.53071	No

Percentliveoy_SC1	80.04181				
Percentliveoy_SC2	70.15337	9.88844	-16.55137	36.32825	No

Means Comparison using Tukey Test

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
Percentliveoy_CC1	38.84895				
Percentliveoy_DB1	50.73504	-11.88609	-34.4223	10.65012	No
Percentliveoy_LYB1	73.85254	-35.00358	-57.53979	-12.46737	Yes
Percentliveoy_RB1	76.24427	-37.39531	-59.93152	-14.8591	Yes
Percentliveoy_SC1	80.04181	-41.19285	-63.72906	-18.65664	Yes
Percentliveoy_SC2	70.15337	-31.30441	-53.84062	-8.7682	Yes
Percentliveoy_DB1	50.73504				
Percentliveoy_LYB1	73.85254	-23.11749	-45.6537	-0.58128	Yes
Percentliveoy_RB1	76.24427	-25.50922	-48.04543	-2.97301	Yes
Percentliveoy_SC1	80.04181	-29.30676	-51.84297	-6.77055	Yes
Percentliveoy_SC2	70.15337	-19.41832	-41.95453	3.11789	No
Percentliveoy_LYB1	73.85254				
Percentliveoy_RB1	76.24427	-2.39173	-24.92794	20.14448	No
Percentliveoy_SC1	80.04181	-6.18927	-28.72548	16.34694	No
Percentliveoy_SC2	70.15337	3.69917	-18.83704	26.23538	No
Percentliveoy_RB1	76.24427				
Percentliveoy_SC1	80.04181	-3.79754	-26.33375	18.73867	No
Percentliveoy_SC2	70.15337	6.0909	-16.44531	28.62711	No
Percentliveoy_SC1	80.04181				
Percentliveoy_SC2	70.15337	9.88844	-12.64777	32.42465	No

[11/15/2004 12:45 "/LiveOysters" (2453324)]

One-Way ANOVA

Summary Statistics

Dataset	N	Mean	SD	SE
percentLiveOy_CC1	3	43.75176	24.92248	14.389
percentLiveOy_DB1	3	65.08028	15.48643	8.94109
percentLiveOy_LYB1	3	83.34038	1.21745	0.70289
percentLiveOy_RB1	3	78.5273	13.54807	7.82198
percentLiveOy_SC1	3	70.70902	30.01862	17.33126
percentLiveOy_SC2	3	80.33655	3.77607	2.18011

Null Hypothesis: The means of all selected datasets are equal
Alternative Hypothesis: The means of one or more selected datasets are different

ANOVA

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	3212.08072	642.416145	1.96521	0.15666
Error	12	3922.73580	326.894650		

At the 0.05 level,
the population means are not significantly different.

Levene's Test for Equal Variance

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	864091.372	172818.274	2.41286	0.09810
Error	12	859486.135	71623.8446		

At the 0.05 level,
the population variations are not significantly different.

Brown-Forsythe's Test for Equal Variance

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	713.258713	142.651743	0.64864	0.66813
Error	12	2639.08658	219.923882		

At the 0.05 level,
the population variations are not significantly different.

Means Comparison using Bonferroni Test

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
percentLiveOy_CC1	43.75176				
percentLiveOy_DB1	65.08028	-21.32852	-75.195	32.53795	No
percentLiveOy_LYB1	83.34038	-39.58862	-93.4551	14.27786	No
percentLiveOy_RB1	78.5273	-34.77554	-88.64202	19.09093	No
percentLiveOy_SC1	70.70902	-26.95726	-80.82374	26.90922	No
percentLiveOy_SC2	80.33655	-36.58479	-90.45127	17.28169	No
percentLiveOy_DB1	65.08028				
percentLiveOy_LYB1	83.34038	-18.26009	-72.12657	35.60639	No
percentLiveOy_RB1	78.5273	-13.44702	-67.3135	40.41946	No
percentLiveOy_SC1	70.70902	-5.62873	-59.49521	48.23775	No
percentLiveOy_SC2	80.33655	-15.25627	-69.12274	38.61021	No
percentLiveOy_LYB1	83.34038				
percentLiveOy_RB1	78.5273	4.81307	-49.05341	58.67955	No
percentLiveOy_SC1	70.70902	12.63136	-41.23512	66.49784	No
percentLiveOy_SC2	80.33655	3.00383	-50.86265	56.87031	No
percentLiveOy_RB1	78.5273				
percentLiveOy_SC1	70.70902	7.81829	-46.04819	61.68477	No
percentLiveOy_SC2	80.33655	-1.80924	-55.67572	52.05723	No
percentLiveOy_SC1	70.70902				
percentLiveOy_SC2	80.33655	-9.62753	-63.49401	44.23895	No

Means Comparison using Scheffe' Test

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
percentLiveOy_CC1	43.75176				
percentLiveOy_DB1	65.08028	-21.32852	-79.50338	36.84633	No
percentLiveOy_LYB1	83.34038	-39.58862	-97.76347	18.58624	No

percentLiveOy_RB1	78.5273	-34.77554	-92.9504	23.39931	No
percentLiveOy_SC1	70.70902	-26.95726	-85.13211	31.2176	No
percentLiveOy_SC2	80.33655	-36.58479	-94.75964	21.59006	No

percentLiveOy_DB1	65.08028				
percentLiveOy_LYB1	83.34038	-18.26009	-76.43495	39.91476	No
percentLiveOy_RB1	78.5273	-13.44702	-71.62187	44.72783	No
percentLiveOy_SC1	70.70902	-5.62873	-63.80359	52.54612	No
percentLiveOy_SC2	80.33655	-15.25627	-73.43112	42.91859	No

percentLiveOy_LYB1	83.34038				
percentLiveOy_RB1	78.5273	4.81307	-53.36178	62.98793	No
percentLiveOy_SC1	70.70902	12.63136	-45.54349	70.80621	No
percentLiveOy_SC2	80.33655	3.00383	-55.17103	61.17868	No

percentLiveOy_RB1	78.5273				
percentLiveOy_SC1	70.70902	7.81829	-50.35657	65.99314	No
percentLiveOy_SC2	80.33655	-1.80924	-59.9841	56.36561	No

percentLiveOy_SC1	70.70902				
percentLiveOy_SC2	80.33655	-9.62753	-67.80239	48.54732	No

Means Comparison using Tukey Test

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
percentLiveOy_CC1	43.75176				
percentLiveOy_DB1	65.08028	-21.32852	-70.9144	28.25735	No
percentLiveOy_LYB1	83.34038	-39.58862	-89.17449	9.99725	No
percentLiveOy_RB1	78.5273	-34.77554	-84.36142	14.81033	No
percentLiveOy_SC1	70.70902	-26.95726	-76.54313	22.62861	No
percentLiveOy_SC2	80.33655	-36.58479	-86.17066	13.00108	No

percentLiveOy_DB1	65.08028				
percentLiveOy_LYB1	83.34038	-18.26009	-67.84596	31.32578	No
percentLiveOy_RB1	78.5273	-13.44702	-63.03289	36.13885	No
percentLiveOy_SC1	70.70902	-5.62873	-55.2146	43.95714	No
percentLiveOy_SC2	80.33655	-15.25627	-64.84214	34.32961	No

percentLiveOy_LYB1	83.34038				
percentLiveOy_RB1	78.5273	4.81307	-44.7728	54.39894	No
percentLiveOy_SC1	70.70902	12.63136	-36.95451	62.21723	No
percentLiveOy_SC2	80.33655	3.00383	-46.58204	52.5897	No
percentLiveOy_RB1	78.5273				
percentLiveOy_SC1	70.70902	7.81829	-41.76758	57.40416	No
percentLiveOy_SC2	80.33655	-1.80924	-51.39512	47.77663	No
percentLiveOy_SC1	70.70902				
percentLiveOy_SC2	80.33655	-9.62753	-59.2134	39.95834	No

[12/20/2004 14:51 "/LiveOysters" (2453359)]

One-Way ANOVA

Summary Statistics

Dataset	N	Mean	SD	SE
LiveOysters_CC1	3	41	29.86637	17.24336
LiveOysters_DB1	3	81	17.34935	10.01665
LiveOysters_LYB1	3	112.66667	12.05543	6.9602
LiveOysters_RB1	3	94.33333	45.74203	26.40917
LiveOysters_SC1	3	125.66667	82.08126	47.38964
LiveOysters_SC2	3	113	29.8161	17.21434

Null Hypothesis: The means of all selected datasets are equal
Alternative Hypothesis: The means of one or more selected datasets are different

ANOVA

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	14064.2778	2812.85556	1.52638	0.25353
Error	12	22114.0000	1842.83333		

At the 0.05 level,
the population means are not significantly different.

Levene's Test for Equal Variance

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	41454691.8	8290938.36	2.89965	0.06072
Error	12	34311484.7	2859290.39		

At the 0.05 level,
the population variations are not significantly different.

Brown-Forsythe's Test for Equal Variance

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
Model	5	3329.33333	665.866667	0.46693	0.79379
Error	12	17112.6667	1426.05556		

At the 0.05 level,
the population variations are not significantly different.

Means Comparison using Bonferroni Test

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
LiveOysters_CC1	41				
LiveOysters_DB1	81	-40	-167.89622	87.89622	No
LiveOysters_LYB1	112.66667	-71.66667	-199.56289	56.22955	No
LiveOysters_RB1	94.33333	-53.33333	-181.22955	74.56289	No
LiveOysters_SC1	125.66667	-84.66667	-212.56289	43.22955	No
LiveOysters_SC2	113	-72	-199.89622	55.89622	No
LiveOysters_DB1	81				
LiveOysters_LYB1	112.66667	-31.66667	-159.56289	96.22955	No
LiveOysters_RB1	94.33333	-13.33333	-141.22955	114.56289	No
LiveOysters_SC1	125.66667	-44.66667	-172.56289	83.22955	No
LiveOysters_SC2	113	-32	-159.89622	95.89622	No
LiveOysters_LYB1	112.66667				
LiveOysters_RB1	94.33333	18.33333	-109.56289	146.22955	No
LiveOysters_SC1	125.66667	-13	-140.89622	114.89622	No
LiveOysters_SC2	113	-0.33333	-128.22955	127.56289	No

LiveOysters_RB1	94.33333				
LiveOysters_SC1	125.66667	-31.33333	-159.22955	96.56289	No
LiveOysters_SC2	113	-18.66667	-146.56289	109.22955	No

LiveOysters_SC1	125.66667				
LiveOysters_SC2	113	12.66667	-115.22955	140.56289	No

Means Comparison using Scheffe' Test

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
LiveOysters_CC1	41				
LiveOysters_DB1	81	-40	-178.12568	98.12568	No
LiveOysters_LYB1	112.66667	-71.66667	-209.79234	66.45901	No
LiveOysters_RB1	94.33333	-53.33333	-191.45901	84.79234	No
LiveOysters_SC1	125.66667	-84.66667	-222.79234	53.45901	No
LiveOysters_SC2	113	-72	-210.12568	66.12568	No

LiveOysters_DB1	81				
LiveOysters_LYB1	112.66667	-31.66667	-169.79234	106.45901	No
LiveOysters_RB1	94.33333	-13.33333	-151.45901	124.79234	No
LiveOysters_SC1	125.66667	-44.66667	-182.79234	93.45901	No
LiveOysters_SC2	113	-32	-170.12568	106.12568	No

LiveOysters_LYB1	112.66667				
LiveOysters_RB1	94.33333	18.33333	-119.79234	156.45901	No
LiveOysters_SC1	125.66667	-13	-151.12568	125.12568	No
LiveOysters_SC2	113	-0.33333	-138.45901	137.79234	No

LiveOysters_RB1	94.33333				
LiveOysters_SC1	125.66667	-31.33333	-169.45901	106.79234	No
LiveOysters_SC2	113	-18.66667	-156.79234	119.45901	No

LiveOysters_SC1	125.66667				
LiveOysters_SC2	113	12.66667	-125.45901	150.79234	No

Means Comparison using Tukey Test

[12/14/2004 12:32 "/Data1" (2453353)]

Two-Way ANOVA

Selected Data

Dataset	Variable Type
Data1_PercentLive	Dependent Variable
Data1_Station	Factor A Classification Variable
Data1_Year	Factor B Classification Variable

ANOVA

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
A	5	15647.4485	3129.48969	26.96511	0.00000
B	1	5668.74809	5668.74809	48.84452	0.00000
A * B	5	7604.54932	1520.90986	13.10485	0.00000
Error	24	2785.36793	116.056997		

Factor A: Means Comparison using Bonferroni Test

Level	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
CC1	13.94973				
DB1	28.8684	-14.91866	-35.18508	5.34775	No
LYB	72.20159	-58.25185	-78.51827	-37.98544	Yes
RB1	66.05477	-52.10504	-72.37145	-31.83862	Yes
SKC1	36.63432	-22.68458	-42.951	-2.41816	Yes
SKC2	30.53506	-16.58533	-36.85175	3.68109	No
DB1	28.8684				
LYB	72.20159	-43.33319	-63.59961	-23.06677	Yes
RB1	66.05477	-37.18637	-57.45279	-16.91995	Yes
SKC1	36.63432	-7.76592	-28.03234	12.5005	No
SKC2	30.53506	-1.66667	-21.93308	18.59975	No
LYB	72.20159				
RB1	66.05477	6.14682	-14.1196	26.41324	No
SKC1	36.63432	35.56727	15.30085	55.83369	Yes
SKC2	30.53506	41.66652	21.4001	61.93294	Yes

RB1	66.05477				
SKC1	36.63432	29.42045	9.15404	49.68687	Yes
SKC2	30.53506	35.5197	15.25329	55.78612	Yes
SKC1	36.63432				
SKC2	30.53506	6.09925	-14.16717	26.36567	No

Factor A: Means Comparison using Scheffe' Test

Level	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
CC1	13.94973				
DB1	28.8684	-14.91866	-37.43329	7.59596	No
LYB	72.20159	-58.25185	-80.76648	-35.73722	Yes
RB1	66.05477	-52.10504	-74.61966	-29.59041	Yes
SKC1	36.63432	-22.68458	-45.19921	-0.16995	Yes
SKC2	30.53506	-16.58533	-39.09996	5.9293	No
DB1	28.8684				
LYB	72.20159	-43.33319	-65.84782	-20.81856	Yes
RB1	66.05477	-37.18637	-59.701	-14.67174	Yes
SKC1	36.63432	-7.76592	-30.28055	14.74871	No
SKC2	30.53506	-1.66667	-24.1813	20.84796	No
LYB	72.20159				
RB1	66.05477	6.14682	-16.36781	28.66145	No
SKC1	36.63432	35.56727	13.05264	58.0819	Yes
SKC2	30.53506	41.66652	19.15189	64.18115	Yes
RB1	66.05477				
SKC1	36.63432	29.42045	6.90582	51.93508	Yes
SKC2	30.53506	35.5197	13.00508	58.03433	Yes
SKC1	36.63432				
SKC2	30.53506	6.09925	-16.41538	28.61388	No

Factor A: Means Comparison using Tukey Test

Level	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
CC1	13.94973				
DB1	28.8684	-14.91866	-34.14981	4.31248	No
LYB	72.20159	-58.25185	-77.483	-39.02071	Yes
RB1	66.05477	-52.10504	-71.33618	-32.87389	Yes
SKC1	36.63432	-22.68458	-41.91573	-3.45344	Yes
SKC2	30.53506	-16.58533	-35.81648	2.64581	No
DB1	28.8684				
LYB	72.20159	-43.33319	-62.56433	-24.10204	Yes
RB1	66.05477	-37.18637	-56.41752	-17.95523	Yes
SKC1	36.63432	-7.76592	-26.99706	11.46523	No
SKC2	30.53506	-1.66667	-20.89781	17.56448	No
LYB	72.20159				
RB1	66.05477	6.14682	-13.08433	25.37796	No
SKC1	36.63432	35.56727	16.33613	54.79842	Yes
SKC2	30.53506	41.66652	22.43538	60.89767	Yes
RB1	66.05477				
SKC1	36.63432	29.42045	10.18931	48.6516	Yes
SKC2	30.53506	35.5197	16.28856	54.75085	Yes
SKC1	36.63432				
SKC2	30.53506	6.09925	-13.13189	25.3304	No

Factor B: Means Comparison using Bonferroni Test

Level	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
1	28.82546				
2	53.92249	-25.09703	-32.50847	-17.68559	Yes

Factor B: Means Comparison using Scheffe' Test

Level	Mean	Difference	Simultaneous		Significant

		between	Confidence Intervals		at 0.05
1	28.82546	Means	Lower Limit	Upper Limit	Level
2	53.92249	-25.09703	-32.50848	-17.68558	Yes

Factor B: Means Comparison using Tukey Test

Level	Mean	Difference	Simultaneous		Significant
		between	Confidence Intervals		at 0.05
1	28.82546	Means	Lower Limit	Upper Limit	Level
2	53.92249	-25.09703	-32.50851	-17.68555	Yes

[12/14/2004 12:42 "/Data1" (2453353)]

Two-Way ANOVA

Selected Data

Dataset	Variable Type
Data1_No.Live	Dependent Variable
Data1_Station	Factor A Classification Variable
Data1_Year	Factor B Classification Variable

ANOVA

Source	DoF	Sum of Squares	Mean Square	F Value	P Value
A	5	24062.3681	4812.47361	10.55753	0.00002
B	1	23028.0625	23028.0625	50.51860	0.00000
A * B	5	12442.9792	2488.59583	5.45944	0.00171
Error	24	10940.0000	455.833333		

Factor A: Means Comparison using Bonferroni Test

Level	Mean	Difference	Simultaneous		Significant
		between	Confidence Intervals		at 0.05
CC1	20.91667	Means	Lower Limit	Upper Limit	Level
DB1	40.08333	-19.16667	-59.33135	20.99802	No
LYB	105.75	-84.83333	-124.99802	-44.66865	Yes
RB1	49.91667	-29	-69.16468	11.16468	No
SKC1	54.83333	-33.91667	-74.08135	6.24802	No
SKC2	48.58333	-27.66667	-67.83135	12.49802	No

DB1	40.08333				
LYB	105.75	-65.66667	-105.83135	-25.50198	Yes
RB1	49.91667	-9.83333	-49.99802	30.33135	No
SKC1	54.83333	-14.75	-54.91468	25.41468	No
SKC2	48.58333	-8.5	-48.66468	31.66468	No
LYB	105.75				
RB1	49.91667	55.83333	15.66865	95.99802	Yes
SKC1	54.83333	50.91667	10.75198	91.08135	Yes
SKC2	48.58333	57.16667	17.00198	97.33135	Yes
RB1	49.91667				
SKC1	54.83333	-4.91667	-45.08135	35.24802	No
SKC2	48.58333	1.33333	-38.83135	41.49802	No
SKC1	54.83333				
SKC2	48.58333	6.25	-33.91468	46.41468	No

Factor A: Means Comparison using Scheffe' Test

Level	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
CC1	20.91667				
DB1	40.08333	-19.16667	-63.78693	25.4536	No
LYB	105.75	-84.83333	-129.4536	-40.21307	Yes
RB1	49.91667	-29	-73.62027	15.62027	No
SKC1	54.83333	-33.91667	-78.53693	10.7036	No
SKC2	48.58333	-27.66667	-72.28693	16.9536	No
DB1	40.08333				
LYB	105.75	-65.66667	-110.28693	-21.0464	Yes
RB1	49.91667	-9.83333	-54.4536	34.78693	No
SKC1	54.83333	-14.75	-59.37027	29.87027	No
SKC2	48.58333	-8.5	-53.12027	36.12027	No
LYB	105.75				
RB1	49.91667	55.83333	11.21307	100.4536	Yes

SKC1	54.83333	50.91667	6.2964	95.53693	Yes
SKC2	48.58333	57.16667	12.5464	101.78693	Yes
RB1	49.91667				
SKC1	54.83333	-4.91667	-49.53693	39.7036	No
SKC2	48.58333	1.33333	-43.28693	45.9536	No
SKC1	54.83333				
SKC2	48.58333	6.25	-38.37027	50.87027	No

Factor A: Means Comparison using Tukey Test

Level	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
CC1	20.91667				
DB1	40.08333	-19.16667	-57.27961	18.94628	No
LYB	105.75	-84.83333	-122.94628	-46.72039	Yes
RB1	49.91667	-29	-67.11295	9.11295	No
SKC1	54.83333	-33.91667	-72.02961	4.19628	No
SKC2	48.58333	-27.66667	-65.77961	10.44628	No
DB1	40.08333				
LYB	105.75	-65.66667	-103.77961	-27.55372	Yes
RB1	49.91667	-9.83333	-47.94628	28.27961	No
SKC1	54.83333	-14.75	-52.86295	23.36295	No
SKC2	48.58333	-8.5	-46.61295	29.61295	No
LYB	105.75				
RB1	49.91667	55.83333	17.72039	93.94628	Yes
SKC1	54.83333	50.91667	12.80372	89.02961	Yes
SKC2	48.58333	57.16667	19.05372	95.27961	Yes
RB1	49.91667				
SKC1	54.83333	-4.91667	-43.02961	33.19628	No
SKC2	48.58333	1.33333	-36.77961	39.44628	No
SKC1	54.83333				

SKC2	48.58333	6.25	-31.86295	44.36295	No

Factor B: Means Comparison using Bonferroni Test

Level	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
1	28.05556				
2	78.63889	-50.58333	-65.27159	-35.89508	Yes

Factor B: Means Comparison using Scheffe' Test

Level	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
1	28.05556				
2	78.63889	-50.58333	-65.2716	-35.89507	Yes

Factor B: Means Comparison using Tukey Test

Level	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
1	28.05556				
2	78.63889	-50.58333	-65.27166	-35.895	Yes

Dataset	Mean	Difference between Means	Simultaneous Confidence Intervals Lower Limit	Upper Limit	Significant at 0.05 Level
LiveOysters_CC1	41				
LiveOysters_DB1	81	-40	-157.73269	77.73269	No
LiveOysters_LYB1	112.66667	-71.66667	-189.39936	46.06603	No
LiveOysters_RB1	94.33333	-53.33333	-171.06603	64.39936	No
LiveOysters_SC1	125.66667	-84.66667	-202.39936	33.06603	No
LiveOysters_SC2	113	-72	-189.73269	45.73269	No
LiveOysters_DB1	81				
LiveOysters_LYB1	112.66667	-31.66667	-149.39936	86.06603	No
LiveOysters_RB1	94.33333	-13.33333	-131.06603	104.39936	No
LiveOysters_SC1	125.66667	-44.66667	-162.39936	73.06603	No
LiveOysters_SC2	113	-32	-149.73269	85.73269	No
LiveOysters_LYB1	112.66667				
LiveOysters_RB1	94.33333	18.33333	-99.39936	136.06603	No
LiveOysters_SC1	125.66667	-13	-130.73269	104.73269	No
LiveOysters_SC2	113	-0.33333	-118.06603	117.39936	No
LiveOysters_RB1	94.33333				
LiveOysters_SC1	125.66667	-31.33333	-149.06603	86.39936	No
LiveOysters_SC2	113	-18.66667	-136.39936	99.06603	No
LiveOysters_SC1	125.66667				
LiveOysters_SC2	113	12.66667	-105.06603	130.39936	No