



THIRD BIENNIAL MOSQUITO LAGOON CONFERENCE

US DEPARTMENT OF THE INTERIOR

**Fish and Wildlife Service
Merritt Island National Wildlife Refuge
and
National Park Service
Canaveral National Seashore**

**August 6th and 7th, 2002
Emma Parrish Theater
301 Julia Street
Titusville, FL**

INTRODUCTION

The Mosquito Lagoon Workshop was first initiated in 1998 by the Canaveral National Seashore (Seashore) and the Merritt Island National Wildlife Refuge (Refuge) to provide biologists conducting research in Mosquito Lagoon and other portions of the Seashore, Refuge, and Kennedy Space Center a workshop to interact and explore opportunities for cooperative investigations. A primary objective of the workshop was to develop a forum by which researchers could exchange up-to-date information and data on ongoing studies. This forum ultimately helps the biologists and managers at the Seashore and Refuge to better understand this complex system, preserving and protecting the outstanding natural resources for future generations of Americans to enjoy. The conference is held every other year, with participation by more than 20 federal, state, and local agencies and educational institutions.

The workshop began as a one-day event and has now expanded to a 2-day conference with 41 papers being presented in 2002. The wide variety of topics includes historical landscape changes, weather patterns, tides, sea turtles, seagrasses, oysters, fish, horseshoe crabs, migratory waterfowl, shorebirds, wading birds, dolphins, lizards, drift algae, water quality, groundwater, sea level rise, some upland habitats, exotic species, and wetland restoration. Although the main focus has been on estuarine and wetland subjects, the Conference seeks an ecosystem approach to include studies of abiotic factors (e.g., weather, nutrients, and water quality) and non-biological issues of public use or other social-economic investigations that would link directly to natural resource management important to our study area. Paper presentations and abstract submissions for aquatic and terrestrial systems (upland habitats and species) are appropriate.

For the 2002 Biennial Mosquito Lagoon Conference, special acknowledgment and appreciation are extended to Ms. Laurilee Thompson of the Dixie Crossroads Restaurant for sponsoring the facilities at Emma Parrish Theater. Additional appreciation goes to all the individuals who volunteered their time to attend and present information to us and the individuals who assisted in organizing this year's event. We hope you enjoy this year's program and we are already looking forward to the 2004 Mosquito Lagoon Conference!

THE MOSQUITO AND INDIAN RIVER LAGOONS: A PICTORIAL HISTORY OF HUMAN SETTLEMENT AND ACTIVITIES

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While scientists and resource managers readily acknowledge the importance of an area's ecological history in interpreting current conditions and setting management objectives, the background of human impacts and socio-economic trends involved in moving the system to its current status often receive less consideration. In the present day, northern Merritt Island is the result of ~10,000 years of human influence on the natural forces shaping the coastal system.

As part of the evaluation for scrub jay upland habitat restoration, MINWR biologists initiated a project to locate photographs depicting Refuge habitat and development milestones prior to the 1940's. From 1943 onward, there are aerial photographs of the Refuge that demonstrate changes in vegetation and human development. Few applicable photos of the earlier period were found, however, what did emerge was an interesting documentation of human settlement and the early patterns of agrarian and hunting utilization of the area. Individuals, libraries, and historical societies were sources of photographs that illustrated early 20th century human activity in coastal Brevard and Volusia Counties.

These photos, along with an accompanying narrative account of settlement of northern Merritt Island and brief ecological history, will provide both perspective and human interest to researchers and managers working in this important area.

COASTAL CHANGE ALONG THE MERRITT ISLAND - CAPE CANAVERAL BARRIER ISLAND COMPLEX

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The Coastal Monitoring and Analysis Project was initiated in 2002 to assess coastal change on the Merritt Island-Cape Canaveral Barrier Island Complex. Point shoreline data derived from 1870s navigation charts were obtained from Florida Department of Environmental Protection (FDEP). On-screen digitizing over rectified aerial photography of shoreline and duneline was performed for 1969, 1994, 1999, and 2000. Shoreline difference analysis was performed for all years since the 1870s at a measurement interval of 300m and again for all

years since 1969 at a measurement interval of 10m for all of Kennedy Space Center (KSC), Merritt Island National Wildlife Refuge (MINWR), Canaveral National Seashore (CNS), and Cape Canaveral Air Force Station (CCAFS). Duneline change analysis was performed for all years since 1969 northward of the KSC-CCAFS boundary at a measurement interval of 10m. Shoreline accretion and recession in the False Cape - 'True' Cape region of hundreds of meters occurred since the 1870s. Dune accretion is greatest in the False Cape area. Significant dune recession occurred near the shuttle pads during the 1999 storm season.

HISTORICAL CHANGES IN INTERTIDAL OYSTER (*CRASSOSTREA VIRGINICA*) REEFS IN THE CANAVERAL NATIONAL SEASHORE POTENTIALLY RELATED TO BOATING ACTIVITIES

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Previous research in the late 1990s had shown that some intertidal oyster (*Crassostrea virginica*) reefs in that portion of the Mosquito Lagoon within the Canaveral National Seashore, Florida had dead margins consisting of mounded up, disarticulated shells. It was hypothesized that boating activities were the cause of the damage because all the reefs were adjacent to major navigation channels. We characterized the history of the appearance of dead margins (and other reef changes) using aerial photographs taken between 1943 and 2000. Imagery analyzed included prints (black & white, color, or color infrared) from 1943, 1951, 1963, 1975, 1988, and 1995, and digital imagery from 2000 (USGS 1:12,000 digital ortho-quarterquads), at scales from 1:6,000 to 1:24,000. Prints were scanned at a resolution sufficient to yield 1-m pixels. After scanning, each set of images was referenced to the year 2000 imagery using ArcView and ArcInfo GIS software. All reefs found to have dead margins based on 1995 and 2000 aerials were visited in November 2001 and March 2002 to confirm the presence and extent of dead areas. This provided a ground-truthing for the "signature" (a highly reflective, light-colored area adjacent to darker-colored live reef) to be used to detect the appearance of dead margins in the historical aerials, and the signature for live reef (a lighter central area surrounded by a dark margin). The earliest appearance of dead margins was in the 1951 aerials on reefs adjacent to the intracoastal waterway (ICW), a major navigation channel. The appearance of dead margins occurred later in areas away from the ICW. The total number and areal extent of dead margins increased with time in all areas. Our current estimate is that between 10 and 20% of the reefs in the Seashore have been damaged. The most dramatic changes have occurred in reefs along the ICW, some apparently migrating away from the channel as much as 50 m and with empty shells mounded up a meter above the high water line. This historical analysis provides strong (although only correlative) evidence that boating activity has had dramatically detrimental

effects on some oyster reefs in the Park. Ongoing studies are aimed at further testing this hypothesis and elucidating the actual mechanisms involved.

APPROPRIATENESS OF POTENTIAL AND HISTORICAL SEAGRASS RESTORATION TARGETS FOR MOSQUITO LAGOON

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Throughout the Indian River Lagoon system, two types of seagrass restoration and protection targets have been set. The first target is based on the potential depth to which seagrass can grow – calculated from several “healthy” sites throughout the Lagoon system. This target depth is 1.7 m. The second target is based on historical distribution – wherever seagrass has occurred there in the past. Although the southern two-thirds of Mosquito Lagoon are relatively unimpacted and pristine, the area is a paradox in two aspects: (1) the average deep edge of seagrass beds is shallow – only 0.9 m, and (2) total suspended solids (TSS) values are quite high and variable (mean = 20–17 mg/L). TSS is the principal “optical pollutant” inhibiting light penetration, thus limiting the depth distribution of seagrass. In southern Mosquito Lagoon, the high TSS values could be due to internally resuspended material, and the potential target of 1.7 m (26,953 acres) may be unattainable. Questions remain – why such shallow seagrass, why such high and variable TSS, and can conditions be improved? Because seagrass distribution has been relatively stable over the past decades, historical targets (20,958 acres) are presently considered more appropriate. In 1999, there were 15,756 acres of seagrass in Mosquito Lagoon.

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CAN MOSQUITO LAGOON BE USED AS A MODEL TO SET SEAGRASS LIGHT TARGETS FOR THE INDIAN RIVER LAGOON SYSTEM?

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The basis for developing a light requirement includes the assumption that light limits the depth of seagrass growth and the deep edge of seagrass is thus growing at the minimum light required. Therefore, the minimum light requirement for seagrass in the Indian River Lagoon (IRL) is defined as the amount of light reaching the deep edge of the seagrass beds. This light

requirement is calculated as the %PAR (photosynthetically active radiation) equaling the percentage of the subsurface irradiance reaching the deep edge of seagrass.

The seagrass deep edge in Mosquito Lagoon (ML) averages 0.87 m – almost 20 cm shallower than the average of the entire Indian River Lagoon and 40 cm shallower than the Northern Banana River (NBR). The light requirement of 37% at ML’s deep edge is 5% higher than the rest of the IRL and 7% higher than NBR.

A preliminary depth target of 1.7 m was established, based on several “healthy” sites throughout the IRL system. A seagrass depth index (SDI) was developed to determine the percentage the deep edge of the seagrass was to the target depth of 1.7 m. Since the deep edge of the seagrass is so shallow in ML, the SDI is 51% – only half of the target depth. In contrast, the IRL and NBR are 62 and 75% of the 1.7 m target.

	Depth at the edge of the seagrass bed	%PAR at edge of bed	Seagrass Depth Index
Mosquito Lagoon	0.87 m	37%	51%
Northern Banana River	1.27 m	24%	75%
Indian River Lagoon System	1.06 m	32%	62%

It is unfortunate that the pristine seagrass beds in ML are unable to be the “model” seagrass beds for restoration in the remaining IRL system. But maybe the higher light requirement reflects the contribution of other factors, besides just light, as being involved in limiting the maximum depth of seagrass growth in Mosquito Lagoon.

DEVELOPMENT OF HORSESHOE CRAB EMBRYOS AND LARVAE IN A HYPERSALINE ENVIRONMENT

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The horseshoe crab, *Limulus polyphemus*, generally inhabits estuarine systems with salinities ranging from 5–34. Previous studies indicate that the optimal temperature and salinity for embryonic and larval development is 25–30 °C and 20–30, respectively, however salinities above 40 have not been examined. Studies of the *L. polyphemus* population in the Indian River Lagoon (IRL), Florida, indicate that larval development and survival may be impacted by high temperatures (<45 °C) and salinities (55), especially in Mosquito Lagoon. Development time, survival, and length of the molt cycle were determined for artificially fertilized eggs raised at five salinity (30–60) and temperature (25–40 °C) combinations. The osmotic concentration of the perivitelline fluid of the eggs and egg volume was determined after exposure to salinities ranging from 5–90. *Limulus polyphemus* embryos and larvae successfully developed, hatched

and molted at salinities up to 60. Embryonic development and hatching failed at temperatures ≥ 35 °C. Larvae survived in salinities ranging from 5 to 90, with mortality only in the extreme salinities of 5, 80 and 90. The perivitelline fluid of the eggs osmoconformed at salinities ranging from 5–90. Egg volume increased in hyposmotic solutions and decreased in hyperosmotic solutions. The results of this study indicate that *Limulus polyphemus* embryos and larvae are able to survive and develop in high salinity environments. Temperature, more than salinity, is the limiting factor of larval *L. polyphemus* distribution. *Limulus polyphemus* larvae are able to tolerate wide and rapid fluctuations in salinity. In the Indian River Lagoon, the hypersaline conditions experienced during the spawning season do not account for the low number of larvae observed, however, the high temperatures experienced in the shallow waters where the horseshoe crabs nest may contribute to the low density of larvae.

THE DISTRIBUTION OF *RIVULUS MARMORATUS* AT THE NORTHERN EXTREME OF ITS RANGE: AN 'OUTLIER' POPULATION IN MOSQUITO LAGOON?

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The distribution of the Neotropical killifish *Rivulus marmoratus* has been fairly well defined from coastal southern Brazil to central Florida. This range roughly coincides with that of the red mangrove (*Rhizophora mangle*), with which the fish appears closely affiliated. On the east coast of Florida, where the fish has been most intensively studied, no collections were made in the Indian River Lagoon (IRL) north of Melbourne until 1995, when another population was identified from Mosquito Lagoon. This population, which appears to be very small and is found in 'atypical' habitat for the species, is separated from other known populations by over 100 km. Several possibilities exist: this population is an 'outlier' and has been present but undetected until now; it represents a recent range shift northward along the IRL that has not been detected in other collections; it was introduced via inlet input (Ponce Inlet) or human activity. Further field and/or genetic studies may provide some insight, but more field collections should be made in Mosquito Lagoon

STUDIES ON THE BIOLOGY OF THE BOTTLENOSE DOLPHIN, *TURSIOPS TRUNCATUS*, IN MOSQUITO LAGOON AND THE NORTHERN INDIAN RIVER LAGOON

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Prior to 1973 there were no organized studies of bottlenose dolphins in either the Indian River Lagoon (IRL) or Mosquito Lagoon (ML). In 1973 SeaWorld, in cooperation with the University of Miami and others, began an organized cetacean carcass salvage program in the lagoons and along the adjacent ocean beaches. This program is continued today by the Hubbs-SeaWorld Research Institute (HSWRI). In 1978, under a contract from the National Marine Fisheries Service, HSWRI, in cooperation with SeaWorld and the University of Miami, began a three year program to assess the home ranges of bottlenose dolphins inhabiting the IRL. Over 100 dolphins were captured, sampled, freeze-branded and released. With the exception of dolphin 56, none of the marked dolphins have been found dead or alive outside of the lagoon system. A number of them have been found dead in the lagoons during stranding operations and others have been resighted during dolphin biology field studies. For example, dolphin V2 was resighted in May 2002 just south of the Titusville bridge. It had been nearly 20 years since the last official resighting of this animal. This continues to confirm that at least some dolphins are life-long residents of the lagoons.

More recently several University of Central graduate students have conducted MS thesis work on aspects of dolphin biology in the lagoon. These studies included age estimation and growth, dolphin/blue crab fishery interactions and the effects of boating activity on dolphin behavior. Continuing, long-term studies in ML and the northern IRL include intensive carcass salvage, dolphin habitat use and dolphin photo-ID. The HSWRI carcass salvage program was key to the discovery and study of an 'unusual dolphin mortality event' in the IRL in 2001. These studies have been funded jointly by HSWRI, SeaWorld, Discovery Cove and the University of Central Florida.

At the present time no one knows how many bottlenose dolphins inhabit the lagoons. Estimates from 20 years ago range from 200-300 to just under 1000. And to make it more interesting, some of the previous studies have suggested a doubling or tripling of the estimated population in the summer months. HSWRI is currently conducting regular aerial surveys to provide a long overdue quantitative estimate of the bottlenose dolphin in the lagoons. This study is funded jointly by Protect Wild Dolphin funds and HSWRI.

Long-term studies on the biology of bottlenose dolphins in the Mosquito and Indian River lagoons are key not only to the documentation of basic dolphin biology but also to the documentation of trends or patterns in mortality and habitat use as human use of the lagoons changes.

RESULTS FROM THE FIRST DERELICT CRAB TRAP CLEAN-UP IN MERRITT ISLAND NATIONAL WILDLIFE REFUGE

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Currently, blue crab (*Callinectes sapidus*) is one of the largest commercial and recreational fisheries in the state of Florida (Steel and Perry 1990). The invention of the wire crab trap in the 1950's resulted in a dramatic increase in the number of traps and fisherman. Although the invention of the crab trap improved fishing efficiency, it amplified problems associated with the fishery. Of particular issue are the effects of abandoned, derelict, or lost crab traps on the species itself, on other marine and terrestrial species, and the surrounding habitat. In Florida, annual estimates of trap disposal and overall trap loss due to theft or inadvertent loss is between 30-50% (GSMFC 2001). Derelict traps cause injury and even death to numerous Florida wildlife including several species of fish, sea turtles, diamondback terrapins, river otters, racoons, and the endangered Florida manatee. Merritt Island National Wildlife Refuge (MINWR) authorizes year-round recreational and commercial harvest of blue crabs and is home to all of the above impacted species. On June 5-6, 2001, the USFWS organized a derelict crab trap clean-up at MINWR to determine the extent of derelict traps in this managed area. The clean-up focused on the Mosquito Lagoon and its associated tributaries. A total of fifty derelict traps were recovered in approximately nine hours. The highest concentration of traps were found at the south end of Eddy Creek and the area just south of Bafoon Beach by the boat ramp. Of the traps collected, 30 were considered complete or in workable condition; the remaining 20 were incomplete, or non-workable. The majority of traps were found fully submerged, however, several were retrieved from shallow depths, while two traps were recovered from land. Sixty-nine floats were recovered, of which fifty-seven were attached to their line, and twelve had no line. Due to inclement weather and logistics an additional 61 floats were recorded, but not recovered. Future clean-ups should occur on a regular basis to reduce impacts to resident fish and wildlife and assess accumulation rates in the area.

TIDAL DATUMS, GEODETIC DATUMS, AND SEA LEVEL RISE

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Vertical datums define what is zero height. At any location on the Earth there could be several datums that could be used, and when dealing with vertical data, the datum should be specified. The datum could be arbitrary, 'That nail in the tree is 10.00 m.', based on nearby water level measurements, 'The nail in the tree is 4.56 m above mean sea level', or based on a mathematical representation of the Earth's gravitational field, 'The nail in the tree is 2.86 m NAVD88'. This presentation will hopefully reduce common confusion between these datums. Tidal datums are local, calculated from water level measurements over a tidal epoch. A tidal

epoch is 19 years and is the time required for all of the common tidal constituents to have moved completely through their cycle. Some of the more commonly used tidal datums are mean sea level (MSL), mean lower low water (MLLW), and mean higher high water (MHHW). Geodetic datums are based on a mathematical representation of the Earth's surface defined by the gravitational potential. A geodetic datum is required to compare vertical information from different locations. There is an older geodetic datum called National Geodetic Vertical Datum of 1929 (NGVD29). It has been replaced by the North America Vertical Datum of 1988 (NAVD88). The conversion between NGVD29 and NAVD88 can be calculated for a particular latitude/ longitude with the VERTCON software developed by the U.S. Army Corps of Engineers. A web version of VERTCON is available at http://www.ngs.noaa.gov/cgi-bin/VERTCON/vert_con.prl. Many times there is confusion between geodetic and tidal datums, usually between MSL and NGVD29. Part of the problem is that they are relatively close to each other. For example, at Ponce Inlet the difference between the two is approximately 0.193 m.

Tidal datums are inappropriate for near tideless estuaries, like most of Mosquito and Indian River Lagoons. By using the definition of a tidal datum a number could be calculated, but it isn't correct to apply where there isn't a tide, though many times surveys inappropriately use tidal datums. The National Oceanographic Service correctly does not publish tidal datums for stations internal to the Mosquito or Indian River Lagoons, though many surveys have been made based on MLLW. Sea level rise is a function of several factors; Post Glacial Rebound (PGR) and other vertical crustal movements, temperature driven changes in water density, circulation patterns, wind and meteorology, changes in storage (man-made reservoirs, glaciers,...etc.), and anthropomorphic changes to the environment. With a water level record from Key West dating to 1846, it was found that sea level rise for Florida has been constant at approximately 1.9 mm/year. This corresponds with data collected by the St. Johns River Water Management District which indicates an average sea level rise of approximately 2.7 to 3.8 mm/year.

SPATIAL RAINFALL ANALYSIS AT JOHN F. KENNEDY SPACE CENTER AND CAPE CANAVERAL AIR STATION, FL. (1989-2000)

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This paper presents a spatial-temporal analysis of ten years of rainfall data collected at Kennedy Space Center, FL from 1989 through 2000. The data are from 16 Tropical Rainfall Measuring Mission (TRMM) ground validation sites, the National Acid Deposition Program (NADP) site (FL99), the Shuttle Landing Facility (SLF) site, and the City of Titusville site. Analysis showed that the 1980's were drier than the 1990's. The period from 1984 through 1988, 1996, and 1997 was dropped from the scope of this paper because only the NADP data were available. The year 1992 was the most "normal" of the period from 1989 through 2000, with the least deviations from the 10-year mean on a monthly basis. A temporal analysis on the years 1989, 1991, 1992, and 1998 to showed that there were differences from year to year due to the types of storms which occurred (i.e., convective or frontal). A spatial analysis using a composite

year (1989-1995 & 1998-2000) using Arcview Spatial Analyst tool showed a distinct North to South and East to West driest to wettest pattern. The year 1993 was excluded since it was an extreme drought year and 1994 and 1995 were excluded because of the “storm of the Century” and two hurricanes (i.e. extreme events). Spatial patterns for the years 1989, 1991, 1992, and 1998 were discussed individually and in comparison with the composite year analysis previously mentioned. The spatial differences (driest to wettest) were as follows: 1989: 53.39 cm, 1991: 75.52 cm, 1992: 42.90 cm, and 1998: 54.16 cm. It is evident that the use of a single station (i.e., SLF or NADP) to represent the climate of all of KSC, or any similar size area or major city is not sufficient.

GROUNDWATER/SURFACE WATER INTERACTION COMPARISON BETWEEN MOSQUITO LAGOON AND CENTRAL AND SOUTHERN INDIAN RIVER LAGOON AREAS

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Because the Mosquito and Indian River Lagoons are two of Florida's most important natural resources, it is essential that the hydrology of these lagoons be understood and that the pollutant pathways into the surface water be identified. This presentation reviews the findings of a 1997 study for the National Park Service on groundwater flow characteristics of the Mosquito Lagoon, and recaps two site specific studies on OSDS (septic tank) nutrient loading to the lagoon from that study. Briefly, in that study, groundwater seepage to the Mosquito Lagoon was found to be high, ranging from 1580 to more than 3000 mL/m²/hr for the various transects, averaging 1251 mL/m²/hr. Also, one OSDS site was found to be polluting the lagoon and one was not. Factors influencing the groundwater quantity and quality (particularly N and P) inputs to the lagoon will be reviewed and the potential OSDS impacts discussed. GW/SW interaction data presently being collected for the southern portion of the Indian River Lagoon will be compared with Mosquito Lagoon data, and reasons for seepage/recharge differences will be identified. Finally, results from a site specific Summer 2002 study of OSDS nutrient and bacterial loading to Crane Creek, a tributary of the Indian River Lagoon in Melbourne, will be reported. Factors, such as soil type, water table elevations etc. influencing the OSDS results from the Crane Creek and NPS studies will be identified and the potential management implications of such site specific data to situations occurring in the Mosquito Lagoon will be discussed.

LONG-TERM TRENDS IN WATER QUALITY IN MOSQUITO LAGOON

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Surface water quality has been sampled in the southern portion of Mosquito Lagoon just west of Eddy Creek ramp, in the vicinity of Canaveral National Seashore. Sampling started in 1984 and is done on a quarterly basis. Grab samples are tested for a multitude of analytes that include metals (arsenic, lead, nickel, silver, aluminum, boron, barium, beryllium, cadmium, chromium, copper, iron, mercury, manganese, molybdenum, nickel, lead, calcium, potassium, magnesium, antimony, silicon, zinc, and titanium); nutrients (nitrate, nitrite, total kjeldhal nitrogen, ionized ammonia, total phosphorus, and orthophosphate); as well as salinity, pH, sulfates, total dissolved and suspended solids, dissolved oxygen, biochemical oxygen demand, total organic carbon, chemical oxygen demand and oil and grease.

Analyses of the data over the past years show that the water quality is very good when compared to the Indian River Lagoon system. Because tides in the lower portion of Mosquito Lagoon are wind driven, no clear temporal cycles are seen, however, some wet and dry season trends can be discerned. Because of high detection limits used by the analytical laboratory, some species of metals may appear elevated, when in fact they are not. The southern portion of Mosquito Lagoon can be considered high quality body of water. This is very important to the overall quality of the IRL system since this area provides an excellent habitat for its abundant sea grass beds and fish.

HOGS MONITORING AND MANAGEMENT MERRITT ISLAND NWR - PRELIMINARY RESULTS

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European settlers introduced hogs into Florida and Merritt Island. These introductions began with the early Spanish settlers and continued with other farmers and settlers. Hogs at the refuge have a potential to create damage to vegetation, invertebrate and other wildlife species. In addition there are road accidents involving wild hogs on refuge grounds. Hogs populations have an exponential gross curve. All these factors combined, create the necessity for management program for the hog population on the refuge grounds.

The purpose of this short study was to examine the current management program, try to estimate its influence on the hog population and propose recommendation for the future. In

order to estimate removal methods efficiency I enlisted the assistance of the trapper how work on KSC, and, using his traps we have trapped and tagged hogs. Traps were baited with corn seeds 2 nights prior to 1st setting and then re-baited and reexamined every 2 days. Hogs were tagged with cattle ear tags with individual numbers, and released after tagging. For each hog I recorded sex, age, and weight. From this data I calculated sex ratio and age structure.

Two other data sets examined were: 1) KSC security accidents reports for the years 1995-7, 2001-2002. 2) Road kills reporting by Dynamac personal for the years 1992-95. Each report / accident was located and digitized on Geographical information system (GIS). Reports were analyzed to determine yearly, monthly, and time of day differences in road accidents and kills.

From the 6/7/02 to the 23/7/02 there 173 trappings of 89 individual hogs. Of those hogs, 35 were males (40%) and 53 were females (60%). Age structure showed that about 75% percent were less then 1 year old.

Analysis of accidents reports showed that most accidents were at night and early mornings. More accidents happened in late fall, winter and early spring then in summer. A large number of accidents happened near citrus groves, and on the other hand there were no accidents were there were deep and wide canals along the roads. These finding can serve as the base for recommendations to improve management practices in the refuge.

Acknowledgments:

I wish to thank: Dr. Ross Hinkle from Dynamac Corp. and the Kennedy Space Center for accepting me on the PBI program. I thank Marc Epstein and the rest of the staff on MINWR for all their assistance, John Tanner for his willingness to participate in the study and the time and effort he invested in the success of the study.

MOSQUITO LAGOON GREEN TURTLES (*CHELONIA MYDAS*): POTENTIAL INGESTION OF TOXIC DINOFLAGELLATES BASED ON FEEDING ECOLOGY

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The diet of *Chelonia mydas* (green turtles) were analyzed from the intestinal tracts of 60 individuals that died after an initial cold stun in December of 1989. The intestinal tracts had been frozen preserved in 1989 and were analyzed during the summer of 2001. Results of the diet analyses showed that in 1989 the *C. mydas* population in Mosquito Lagoon primarily foraged on seagrass. Recently, biologists have queried the potential role of biotoxins consumed in the diet of green turtles. Epiphytic growth of organisms on seagrass and macroalgae are common in the lagoon. I processed samples of macroalgae and seagrass seasonally to extract and quantify the amount of epiphytic dinoflagellates with a focus on the toxic species of *Prorocentrum*. Implications of diet and water quality changes on the health and immune status of green turtles will be discussed.

RELATIVE ABUNDANCE AND DISTRIBUTION OF MARINE TURTLES INHABITING MOSQUITO LAGOON: SUMMARY OF 2001 SURVEYS

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This presentation summarizes progress during 2001 for the juvenile sea turtle netting project. Objectives of this project are: 1) Compare current marine turtle species composition, size class and distribution to baseline data collected in 1976-1979, 2) Evaluate current seasonal distribution and occurrence of sea turtles (catch per-unit-effort, CPUE) in this system, and 3) Provide updated statistical summaries of CPUE to determine regional "importance value" of this lagoon relative to other juvenile habitats on the Florida East Coast.

Sampling occurred over nine days with one set per day and an overall netting effort of 53.8 hours of net soak time (24.1 net kilometer hours). In 2001, 17 green turtles (*Chelonia mydas*) and three loggerheads, (*caretta*) were captured. The 2001 capture rate was our highest annual rate with 0.82 turtles per km net hour. The cumulative rate for all years is now 0.50 turtles per km net hour. This appears to be the lowest rate of capture in the Indian River Lagoon sites currently being studied (L. Ehrhart and M. Bresette, pers. comm.).

All turtles were juveniles, with the exception of three *C. caretta* that were probably all adults with greatest carapace lengths (GCL (sl)) ranging from 79.6 to 98.8 cm. (Standard carapace lengths ranged from 78.4 to 97.3 cm). Turtles averaged slightly smaller than the cumulative averages for the project to date. Carapace lengths (SL) for greens ranged from 37.9 - 66.8 cm in 2001 with an average of 48.9 cm. For the 7-year period, the mean and std for standard carapace length for *Chelonia* is 50.0 +/- 10.3 cm (range = 31.5 - 83.4). Table 3 shows the statistical summaries for morphometrics for *Chelonia* this year. All turtles with papillomas were greens and ranged in carapace length (SL, notch to notch) from 38.6 to 56.4 cm. Eleven greens (64%) had papilloma tumors present. We encountered one recapture in August, a loggerhead (SCL of 93.6 cm in 1997 and 97.3 cm in 2001). *Limulus polyphemus* (horseshoe crabs) are still conspicuously absent from the nets.

Acknowledgments

Additional field observers included: K. Adkins, J. Stiner, S. Trout, G. Ehrlinger. All field activities and funding were supported by the NASA Kennedy Space Center Ecological Program - Dynamac, Life Sciences Support Contract No. NAS10-12180. Sincere appreciation to Dr. Bill Knott and Burt Summerfield/ NASA for continuous support.

CHANGES IN LOGGERHEAD DEMOGRAPHY AFTER 25 YEARS OF NESTING ON THE EAST COAST OF FLORIDA

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Population demographic studies of nesting loggerheads at Canaveral National Seashore, Kennedy Space Center and Cape Canaveral Air Force Station beaches began in the late 1970s by Ehrhart. Since 1979, however, data have not been systematically collected on nesting individuals, until the present study that aims to document the status and demographic changes in this rookery that stretches 40 km along the east Coast of Central Florida.

Morphometric data were collected from the year 2001 nesters and their size classes were compared to those of the late 1970s to see how and if, they changed. Data were collected for carapace morphometrics, and individuals were also biopsied for genetic analysis, and tagged with external flipper tags and PITs. On a subsample of nests we also collected data on clutch size, egg weight, min/max diameter and hatching success.

Statistically significant differences were found in carapace length and width both over-curvature and straight-line, in the year 2001 individuals (smaller). Mean clutch sizes were not statistically significantly different amongst the 4 years. Minimum egg diameter was collected in the 1970s and differences were found between 1977 and all others. Average incubation time and percentage hatching success appear lower in 2001. However, these comparisons must be carefully scrutinized because 1976-78 clutches were often incubated in protected hatcheries.

Six turtles were recaptured twice and one on three occasions. Although the 2001 sample size is relatively small, average internesting intervals were slightly longer than those observed in the 1970s. Two noteworthy observations included 1) One turtle previously tagged in Florida Bay was observed nesting here; 2) Two nesting loggerhead turtles were afflicted with the fibropapilloma virus.

Although these trends are based on one nesting season, and further sampling is required before solid conclusions can be made, the results can provide valuable information for regulatory agencies to assess trends in population stocks and viability of sea turtles nesting in Florida.

**CONSUMPTION AND MIGRATION OF FISH BIOMASS FROM A RECONNECTED
SALTMARSH IMPOUNDMENT IN THE NORTHERN INDIAN RIVER LAGOON,
FLORIDA**

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Salt marshes are among the most productive ecosystems in the world, and although they are thought to enhance the productivity of open estuarine waters, the mechanism by which energy transfer occurs has been debated for decades. One possible mechanism is the transfer of saltmarsh production to estuarine waters by vagile fishes and invertebrates. Saltmarsh impoundments in the Indian River Lagoon, Florida that have been reconnected to the estuary by culverts provide unique opportunities for studying marsh systems with respect to aquatic communities. The boundaries between salt marshes and the estuary are clearly defined by a system of dikes that confine fishes into a known area, and the exchange of aquatic organisms are restricted to culverts where they may be easily sampled. A multi-gear approach was used to estimate standing stock, immigration/emigration, and predation monthly. Changes in saltmarsh fish abundance, and exchange with the estuary reflected the seasonal pattern of marsh flooding in the northern Indian River Lagoon system. During a six-month period of marsh flooding, saltmarsh fishes had continuous access to marsh food resources. Piscivorous fishes regularly entered the marsh via creeks and ditches to prey upon marsh fishes, and piscivorous birds aggregated following major fish migrations to the marsh surface or to deep habitats. As water levels receded in winter, saltmarsh fishes concentrated into deep habitats and migration to the estuary ensued. The monthly estimates of fish standing stock, net fish migration, and predation were used to develop a biomass budget to estimate the annual production of fishes and the relative yield to predatory fish, birds, and direct migration to the estuary. Annual production of saltmarsh fishes was estimated to be 17.7 g m^{-2} salt marsh, which falls within the range of previously reported values for estuarine fish communities. The relative yields were 21% to piscivorous fishes, 14% to piscivorous birds, and 32% to export. Annual export of fish biomass was $5.2 \text{ g fish m}^{-2}$ salt marsh representing about 2% of saltmarsh primary production. Saltmarsh fishes convert marsh production to high quality vagile biomass and move this production to the estuary providing an efficient link between salt marshes and estuarine predators.

IMPLICATIONS OF RECENT FISH RESEARCH TO MANAGEMENT AND RESTORATION OF SALTMARSH IMPOUNDMENTS IN THE NORTHERN INDIAN RIVER LAGOON, FLORIDA

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Recent research at Merritt Island National Wildlife Refuge (MINWR), Florida has found that saltmarsh impoundments reconnected by culverts to the Indian River Lagoon provide habitat to estuarine sport fishes, and also export substantial quantities of fish biomass to adjacent estuarine waters. Closing water control structures and managing water levels appears to benefit avian wildlife by increasing prey abundance and access to prey, but at the expense of saltmarsh baitfish export and nursery functions to estuarine predators. Where mosquito control and wildlife management are not a priority, resource managers at MINWR are increasing saltmarsh access to estuarine fishes by restoring selected impoundments (opening water control structures or completely removing dikes). Comparison among habitats in an open impoundment that would be affected by restoration efforts (i.e. estuary shoreline, perimeter ditches, and shallow creeks) showed that fish use varied among habitats. Fish abundance and community structure along the estuary shoreline (although fringed with marsh vegetation) were not analogous to marsh creeks and ditches. Perimeter ditches provided deep-water habitat for large estuarine predators, and shallow creeks served as an alternative habitat for resident fishes when the marsh surface was dry. Regardless of restoration strategy (complete removal of dikes or opening of a sufficient number of culverts), baitfish export from seasonally flooded marshes at MINWR would be restored. Restoration of nursery function is probably dependent upon marsh morphology (amount of creeks and embayments reconnected to the estuary relative to loss of perimeter ditch), and marsh location with respect to estuarine spawning sites and larval dispersal patterns.

WATER RESOURCES MANAGEMENT PLAN FOR CANAVERAL NATIONAL SEASHORE

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Superintendent Robert Newkirk approved the new, 244-page, Canaveral National Seashore (CANA) Water Resources Management Plan (WRMP) in December 2001. The primary purpose of this plan is to provide information on potential threats to CANA water resources and guidance on actions that can assist with the prevention or mitigation of water resources degradation. The document is divided into two sections. The first section provides background information on demography, land ownership and land use, climate, physiography, hydrology, water quality, sediments, anthropogenic influences, flora and fauna, and relevant legislation and statutes. The second part of the document identifies and includes project statements for the most pressing CANA water resource issues, based on an interagency scoping meeting. These include: 1) completing an aquatic species inventory, 2) determining if oysters, clams and blue crabs are being harvested at sustainable levels and if harvesting alters aquatic biodiversity, 3) completing a water quality assessment and long-term monitoring scheme, 4) better understanding how mosquito impoundment reconnection and restoration changes aquatic biodiversity, 5) determining primary use areas of the endangered West Indian manatee, 6) determining the status of boat propeller scarring on seagrass beds, 7) determining if critical finfish spawning and nursery areas require additional protection, and 8) developing a spill contingency plan and protocols for regulating waste management. Copies of the entire WRMP are available on-line as a .pdf file or through a searchable database at: <http://biology.ucf.edu/fellershouse/wrmp.html>

SHELL MOVEMENT AND JUVENILE SURVIVAL OF THE OYSTER *CRASSOSTREA VIRGINICA* ON INTERTIDAL REEFS ADJACENT TO WATERS WITH INTENSE BOATING ACTIVITY IN MOSQUITO LAGOON

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Resulting from anthropogenic influences or natural disturbance events, some reefs of the eastern oyster *Crassostrea virginica* in central Florida have been declining in size in recent years. Additionally, dead margins (i.e. mounds of tightly packed, disarticulated shells extending above the high tide line) are commonly found adjacent to boating channels. To determine the impact of water motion on shell dispersal and juvenile survival, experiments were run on eight reefs in Mosquito Lagoon, the northernmost region of the Indian River Lagoon system. Four reefs had large dead margins, while the other four monitored reefs had no dead margins. To measure shell movement, 25 pre-weighed, loose, oyster shells were deployed within 0.25m² quadrats on the exposed, middle and protected regions of each reef and dispersal of shells was assessed weekly for four weeks during Winter 2001-02, Spring 2002 and Summer 2002. Boating activity adjacent to all reefs was also recorded during the trials. There was a positive correlation between shell dispersal on the exposed regions of reefs and the mean number of boats per hour that passed by the study reefs. Shells that weighed less than 50 grams and those which exceeded

100 grams moved less than intermediate weight shells, and the protected sides of the reefs experienced the least amount of shell movement. In a separate experiment to determine the impact of shell movement on juvenile oyster survival, 1-cm diameter clay mimics were attached to 20 loose shells at the exposed, middle and protected regions of all reefs. After four weeks, clay damage was recorded and used as a proxy to estimate damage to juvenile *C. virginica* at this vulnerable stage in its life-history. Mimics were recorded as intact, nicked, severely damaged or missing. Damage was greatest on exposed sides of reefs in areas with intense boating activity.

RECRUITMENT OF THE OYSTER *CRASSOSTREA VIRGINICA* ON INTERTIDAL REEFS IN AREAS WITH INTENSE BOATING ACTIVITY IN THE MOSQUITO LAGOON, FLORIDA

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Productivity, diversity and survival of estuaries are threatened by explosive coastal population growth and associated recreational activities. One major area of recreational growth has been the number of people motoring in small pleasure crafts at high rates of speed. In counties bordering Mosquito Lagoon, there were 51,000 registered boaters in 1998. Numbers have increased 10% annually since 1986 and continue to grow. In areas of Mosquito Lagoon with intense boating activity, intertidal reefs of *Crassostrea virginica* with dead margins commonly occur. The dead margins consist of mounds of disarticulated shells. The cause(s) of the reef die-offs is unclear. However, the disarticulated shells may be reducing reef sustainability if these surfaces are unavailable for oyster recruitment. Recruitment trials were run on eight reefs (4 impacted, 4 non-impacted) in three eight-week trials in Summer 2001, Winter 2001-2002, and Spring 2002. New recruit survival, sediment loads, temperature and relative water motion were monitored at all sites. In the Summer 2001 trial, no significant differences in terms of recruitment between sites were identified. Impacted reefs showed greater water motion on the seaward side adjacent to heavily traveled boat channels. In Winter 2001-02, there were significantly fewer recruits than the summer. Impacted reefs also experienced greater water motion on exposed regions. Seasonal effects were recorded for relative water motion and recruitment. Data of this type is needed to identify causes of reef declines, habitat-specific management protocols and appropriate restoration techniques.

NO-TAKE ESTUARINE RESERVES AT MERRITT ISLAND NATIONAL WILDLIFE REFUGE PROVIDE MULTISPECIES BENEFITS FOR RECREATIONAL FISHING

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I empirically examine impacts of no-fishing, estuarine reserves at Merritt Island National Wildlife Refuge (MINWR), Cape Canaveral, Florida on an economically important, recreational fishery over four decades. MINWR reserves are the oldest, and until 1999, the largest no-take reserves in North America. Using International Gamefish Foundation world records as data, I tested hypotheses predicting a higher concentration of world records near reserves than elsewhere in Florida and an increased proportion of world records after reserves were established. Results support both predictions for resident estuarine gamefishes. A total of 62% of all Florida world records for black drum (*Pogonias cromis*), 54% for red drum (*Sciaenops ocellatus*), and 50% for spotted seatrout (*Cynoscion nebulosus*) occurred within 100 km of the Cape (~13% of the Florida coast). The proportion of world records increased significantly near reserves for all three species after closing areas to fishing. Although Common snook (*Centropomus undecimalis*) world records did not increase near MINWR, a juvenile population became established at MINWR after fishing was stopped. Results suggest that more world records occurred near no-fishing zones than would have occurred if all areas were open under the same set of fishing regulations. Data are not consistent with other possible factors offered to explain the concentration of world records, including population growth, the Florida net ban, state wide regulations on size and bag limits, increased popularity of catch and release fishing, fishing promotions, and other Florida gear and seasonal restrictions. A secondary concentration of world records for these species occurred in Everglades National Park, another area with a high level of resource protection including the elimination of commercial fishing and the establishment of size and bag limits a decade before the rest of Florida. These records primarily followed the introduction of new IGFA line classes, but were not sustained, and were replaced by larger records from the Cape. Results show multispecies benefits of no-take reserves for recreational fishing and support predictions that no-take marine reserves can support sustainable fishing when used in conjunction with other fishery conservation measures.

MARINE PROTECTED AREA FISHERY MANAGEMENT: THE KENNEDY SPACE CENTER MODEL

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Studies of fish population dynamics, migration, spawning and habitat utilization within the protected waters of the Kennedy Space Center (KSC), Merritt Island National Wildlife

Refuge (MINWR) have effectively demonstrated the value of resource management through limited site access. Historical studies conducted by the U.S. Fish and Wildlife Service, National Park Service Canaveral National Seashore (CNS), U.S. Geological Survey, National Marine Fisheries Service, Florida Fish and Wildlife Conservation Commission University of Central Florida, Florida Institute of Technology and Dynamac Corporation have examined life histories of the principal fishery species within the Cape Canaveral area. These species include the sciaenids, red drum, *Sciaenops ocellata*, black drum, *Pogonias cromis*, spotted seatrout, *Cynoscion nebulosus*, weakfish, *C. regalis*, silver perch, *Bairdiella chrysoura*, and spot, *Leiostomus xanthurus* as well as the snook, *Centropomus undecimalis* (Centropomidae). Although other species have also been examined in detailed studies the above species are emphasized in regional and local management scenarios as they have high economic value in recreational and commercial fisheries. Marine protected area (MPA) management programs have received considerable national and international interest as an effective tool in enhancing fishery recovery as well as protecting vital fish habitats. One of the most vital fishery habitats of concern are fish spawning sites. Effective spawning and reproduction is necessary to allow fish population recovery and growth. A series of management scenarios are presented that have already allowed fishery production to be enhanced, thus giving KSC and the MINWR international attention, as well as potential future management scenarios for other MINWR/CNS sites that are presently unprotected.

A 1991 CREEL AND AERIAL SURVEY OF THE MOSQUITO LAGOON: THE QUONDAM STUDY

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From 1987-1991 a creel/exit ramp survey and aerial survey of the Mosquito Lagoon area was conducted. However, the data base for the first few years was lost in transit and data from the 1990-1991 portion was never analyzed but kept in storage at the Merritt Island National Wildlife Refuge. In the past year, interest has been renewed in the resource utilization of Mosquito Lagoon and the original data was analyzed as part of a new study to characterize the resource use of Mosquito lagoon. Data from the 1990-1991 study will be used as a baseline in comparison of the current study. The methodology for the aerial survey component of the 1990-1991 study is comparable to the current study. Even though both studies cover the same total area, the 1990-1991 is on a coarser spatial scale with Mosquito Lagoon divided into three areas,

compared to ten smaller units in the present study. However, by combining areas and using total boat count numbers, data from the two studies can be compared. For the creel or exit ramp surveys, the questions from the 1990-1991 study were incorporated in the questionnaire design of the present study. By using the information from this study as a baseline, information from the current study will give managers and researchers insight to the changes in the resource utilization of the Mosquito lagoon area over the past 11 years.

**RESOURCE USE CHARACTERIZATION STUDY OF MOSQUITO LAGOON WITHIN
THE BOUNDARIES OF THE MERRITT ISLAND NATIONAL WILDLIFE REFUGE:
PART 1- PRELIMINARY RESULTS FROM THE AERIAL SURVEYS**

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The waters of Mosquito Lagoon, within the boundaries of the Merritt Island National Wildlife Refuge and Kennedy Space Center, is one of the largest remaining undeveloped regions of Florida's estuarine habitat. As a natural resource this is very important to local managers. Except for a small baseline study conducted from 1988-1991, very little is known about the number of users and type of user groups within Mosquito Lagoon. In an effort to quantify the resource utilization of the area a study was implemented in January of 2002. One of the objectives of the study is to quantify use patterns by using aerial surveys. The study area covers the portions of Mosquito Lagoon that are located within the boundaries and jurisdiction of Merritt Island National Wildlife Refuge and Kennedy Space Center. Geographically this includes waters of Mosquito Lagoon starting at the southern terminus and proceeding north to the Georges Bar area.

Bi-weekly aerial surveys using a fixed-wing aircraft have been flown since January 2002. The survey flights are grouped into weekends and weekdays and from each group the flight date and time is randomly chosen. These fixed transects are flown at a constant speed and altitude to allow for repeatability of the area surveyed. Data collected includes watercraft type, location, number of occupants and activity. To date over 3,400 boats have been observed during 43 surveys. Results indicate that Saturday is the highest use day and the early and late weekdays are the lowest. Also the areas around Georges Bar and Haulover Canal consistently had the highest boat count per survey.

**RESOURCE USE CHARACTERIZATION STUDY OF MOSQUITO LAGOON WITHIN
THE BOUNDARIES OF THE MERRITT ISLAND NATIONAL WILDLIFE REFUGE:
PART 2- PRELIMINARY RESULTS FROM THE EXIT RAMP CREEL SURVEYS**

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**TRENDS IN WADING BIRD FORAGING HABITAT USE ON THE MERRITT ISLAND
NATIONAL WILDLIFE REFUGE: 1987-2002**

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This presentation summarizes results of fifteen years (1987-2002) of monthly aerial surveys of wading bird use of foraging habitats within impoundments on the Kennedy Space Center/Merritt Island National Wildlife Refuge (KSC/MINWR). Thirteen impoundments were surveyed continuously since the beginning of the effort; additional impoundments were added since. During this study, some impoundments at KSC/MINWR were used much more heavily by

wading birds than were others. Analysis of habitat within these impoundments suggests that the ratio of open water to vegetated habitats explains some of the variability in wading bird use between impoundments. Preliminary analysis suggests that an increase in interspersed open water and vegetated habitats is preferred by wading birds for foraging habitat. More detailed investigation of the mechanism responsible for wading bird preferential use of some impoundments is needed. Over all impoundments, wading birds used open water habitat more often than would be expected based on availability if they used all habitats equally. Conversely, wading birds were observed in vegetated habitats less often than expected based on availability if they used all habitats equally. Many wading bird species increased their use of vegetated habitat in Fall and Winter when impoundments at KSC/MINWR are flooded. These shifts may represent important elements in overall foraging strategies of these species. Because there are many factors that determine wading bird habitat preference and use, managers should not assume that a simple increase in open water habitat at KSC/MINWR would benefit wading birds. During this study, there were some indications that certain species of wading bird showed a slight decline in numbers during at least some seasons. Species that warrant additional monitoring include White Ibis, Snowy Egret, Glossy Ibis, Tricolored Heron, Little Blue Heron, and Wood Stork. The mean number of wading birds per survey in the focal impoundments was greatest during the Pre-nesting and Nesting seasons, declined during Post-nesting season, and was lowest during Winter. Post-nesting and Winter are characterized by high water levels within impoundments at KSC/MINWR. During these times, shallow habitat along the IRL shoreline provided additional alternative habitats for wading birds. Numbers of nesting attempts by wading birds at KSC/MINWR was steady during most of the study period, but have declined precipitously since 2000. White Ibis accounted for over half of all wading bird nests counted during the study. The mean number of nests per colony decreased during the study period, and the number of individual colonies increased. A similar pattern has been reported for wading bird nesting colonies throughout Florida between 1976 and 1989. Combined with the overall decline in numbers statewide these trends are alarming and continued and increased monitoring of wading bird nesting colonies on KSC/MINWR is warranted. Evidence for decline in the numbers of nesting Snowy Egret, Glossy Ibis, Little Blue Heron, and Wood Stork on KSC/MINWR warrant special concern for these species.

EFFECTS OF GROUP SIZE AND PREY DENSITY ON FORAGING RATES OF WADING BIRDS IN IMPOUNDED SALT MARSH HABITAT

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Wading birds often forage in large mixed-species aggregations. Proposed explanations include social facilitation, clumping at prey concentrations, and predator avoidance. We examined the relationships between wading bird group size, foraging rate, and prey density.

Groups of foraging wading birds were observed in impounded wetlands in Florida in 1998 and 2001. Foraging rates of Great Egrets, Snowy Egrets and Tricolored Herons were measured using direct observation (n=268) and video recordings (n=100). Prey density was measured at group foraging sites and related unused sites using 1 m² throw-traps (n=63). The dispersion of wading birds and their prey was also investigated. Results indicate that foraging rate is influenced by group size for Great Egrets and Snowy Egrets but not for Tricolored Herons. Prey density was not significantly different between locations used by different sized groups (F=2.66, df=51, p=0.058), but individuals foraged at sites with lower prey density than did groups (t=2.727, df=51, p=0.005). Prey density was not significantly different between used and random sites (t=1.207, df=52, p=0.233). Rates of aggression in aggregations were low (26 of 256 focal individuals during 851.7 minutes of observation). Implications for the social facilitation hypothesis of mixed-species foraging aggregations in wading birds will be explored.

**DIEL FORAGING AND SITE FIDELITY OF LESSER SCAUP ON THE MOST
SIGNIFICANT WINTERING GROUNDS ALONG THE ATLANTIC FLYWAY; THE
INDIAN RIVER LAGOON SYSTEM**

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Continental populations of Lesser Scaup (*Aythya affinis*) have been steadily declining since the mid 1980's, considerably below population goals of the North American Waterfowl Management Plan. Hence, there is a need to better understand the underlying causes of declines and formulate strategies to curb them. The "spring condition hypothesis" is one of the leading explanations used to account for current trends. It states that reproductive success is declining as result of females arriving on the breeding grounds in inferior condition when compared to historical data. Therefore, the ability of scaup to progressively improve their body condition on their northbound migration might be influenced by body condition at the time of departure from wintering grounds. Foraging and wintering site movement patterns may be important in elucidating the functional role of the Indian and Banana Rivers; the single most important wintering grounds along the Atlantic Flyway. We documented diel foraging and site fidelity patterns of wintering Lesser Scaup during the 2002 winter. No significant difference between mid and late winter periods was noted in diurnal foraging for both male and female scaup. Nocturnal data also showed no seasonal effect on female foraging patterns. However, male scaup increased nocturnal foraging significantly in late winter by ~ 514 %. Our overall diel findings are similar to other wintering time activity budget studies at more northern locales, signifying that there is likely no thermal or longitudinal gradient in partitioning of wintering

behavior. Telemetry research established that mean distance traveled between diurnal and nocturnal sites was ~ 2.79 km. Apparent high fidelity to sites may be indicative of high quality habitat (at least in relation to adjacent available habitats). Extensive movement between diurnal and nocturnal sites has been shown to be the result of searching for optimal forage conditions. Additionally, little documented use of the comparable adjacent Mosquito Lagoon remains inexplicable. Based on these preliminary findings we suggest that wintering scaup in Florida are not endeavoring to increase nutrient reserves prior to migration, signifying that wintering grounds may be important for basic winter maintenance, but may not be correlated to the Spring Condition Hypothesis.

SEASONAL NUMBERS OF SHOREBIRDS AND WATERFOWL IN IMPOUNDMENTS MANAGED UNDER HYDROLOGICAL REGIMES AT MERRITT ISLAND NWR

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Between 1999 and 2002, local volunteers and refuge staff conducted avian surveys in 12 impoundments every 10 days, in accordance with the International Shorebird Survey protocols, except all birds were recorded. Preliminary analysis shows a defined seasonal “pulse” of bird use, reflecting migratory patterns of species groups. Overall, bird numbers begin increasing in September, peaking in January, and start to gradually decline through May. Among all bird groups and study sites, species richness (SR) was 127. Shorebirds dominated the use (58%), followed by wading birds (21%), waterfowl (9%), diving birds (9%), landbirds (3%), and others. Dunlin (*Calidris alpina*) and yellowlegs (*Tringa spp.*) comprised greater than 62% of the shorebird use (SR=33). Wading birds use was highest in winter, however, May and September showed smaller peaks, which may be linked to breeding and post fledgling use. White ibis (*Plegadis chihi*; 26%), snowy egret (*Egretta thula*; 23%), tricolor heron (*E. tricolor*; 16%), and great egret (*Casmerodius albus*; 12%) were the primary species recorded. Generally, waterfowl are the primary group fall to winter and shorebirds most abundant winter to spring. As expected, migratory waterfowl showed a distinct seasonal use from September through April, with a peak in December and January. Among 17 species recorded, blue-winged teal (*Anas discors*; 28%), northern pintail (*A. acuta*; 24%), American widgeon (*A. americana*; 11%), and lesser scaup (*Aythya affinis*; 11%) were the primary species of use. Although landbirds (e.g., Passeriformes and others) only represented 3% of the recorded use, species richness was 39 and probably reflected habitats associated with dike and transitional communities.

Total number of shorebirds and waterfowl were used to compare seasonal numbers (adjusted by open area) between impoundments under an open (T-10-H and C) and RIM regime (T-10-D and E). Thirty-four species of shorebirds and 17 of species of waterfowl were recorded.

Seasonal numbers did not differ between hydrological treatments. As expected, numbers of both groups were highest during fall (waterfowl) and spring (shorebirds), patterns correlated with patterns of water depth. Prey biomass was significantly higher in open than in RIM impoundments. RIM impoundments may serve for other functions (e.g., resting). These findings, and those of selected species, will be discussed in the context of broader.

The refuge manages a complex of wetlands including restored natural systems and marsh impoundments under a diverse management regime. The results show that the refuge is fulfilling the primary purpose for which it was established, meeting National Refuge System goals, and is consistent with local and regional goals. We are working with others to accomplish these goals, adapting new concepts, and meeting the challenge of national mandates.

ECOLOGICAL AND EVOLUTIONARY RESEARCH ON INTRODUCED LIZARDS USING DREDGE-SPOIL ISLANDS IN MOSQUITO LAGOON AS EXPERIMENTAL UNITS

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In new lands, invaders often undergo rapid non-genetic change (phenotypic plasticity) and long-term genetic (evolutionary) divergence in response to novel conditions. I study the distribution, spread, ecological impacts, and morphology of the Cuban brown anole (*Anolis sagrei*), an arboreal, insectivorous lizard introduced to Florida in the 1940s. In 1994, I was given permission to release 18 brown anoles from a single source (Pahokee Campground on Lake Okeechobee) onto each of two ecologically distinct dredge-spoil islands in Mosquito Lagoon (one mostly forested, one non-forested, both previously lacking lizards). These introductions were permitted because brown anoles were abundant on the mainland and barrier island surrounding Mosquito Lagoon and had reached nearby dredge-spoil islands, so the introductions extended their range only a few hundred meters. This served as the pilot study for experiments testing for negative effects of brown anoles on the native green anole (*Anolis carolinensis*).

The population on the small, non-forested island expanded most rapidly and within three years reached a density of ca. 12,000 lizards/ha and a biomass of ca. 43.3 kg/ha, among the highest values recorded for any terrestrial vertebrate. Lizard body size increased on the forested island, but decreased on the non-forested island, explained by differences in physical conditions, resources, density-dependent effects, and predation levels. The two islands differ in vegetation parameters that influence the behavior and limb morphology of arboreal lizards (e.g., the diameter of the perches available), and vegetation on both islands is vastly different from the source habitat. This presented the opportunity to further study the influence of habitat on morphology, and the role that rapid morphological changes might play in the success of this

species as an invader. I returned to the source site and the two islands in September 2001 and collected 60 lizards from each site and conducted detailed morphometric analyses using x-ray technology. Measurements of long bones revealed significant differences in limb lengths that were directly related to the diameter of available perches at each site.

Phenotypic plasticity, a measurable morphological trait, may increase the survival chances of invaders in new lands, and set up the conditions under which further evolutionary divergence may take place. In fact, brown anoles are larger on islands and mainlands where they were introduced than on their native islands of Cuba and the Bahamas. Habitat influences the morphology of invaders that possess the ability to rapidly adjust to local conditions, which results in spatial and temporal heterogeneity in the outcome of their interactions with native species, and presents exotic species managers with “moving targets.”

RESTORATION OF IMPACTED SALT MARSHES IN CANAVERAL NATIONAL SEASHORE

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The United States Fish and Wildlife Service (USFWS), St. Johns River Water Management District (SJRWMD), and East Volusia Mosquito Control District (EVMCD) entered into a cooperative agreement to restore six impounded salt marshes in the Volusia County portion of the Canaveral National Seashore / Merritt Island National Wildlife Refuge (MINWR) with the support of the National Park Service. The six “V” impoundments are on the barrier island in the extreme southern Volusia County and are the northern-most impoundments managed as part of MINWR. They were constructed in 1969 and encompass over 800 acres of wetland (including enclosed water and some adjacent upland). These impoundments have only limited connection to the estuary via culverts. The three main objectives were to: (1) to restore the shorelines of 4 impounded salt marshes totaling 229 acres and over 5 miles of shoreline, (2) to reconnect via culverts the remaining 2 impounded salt marshes totaling over 600 acres, and (3) to accomplish effective mosquito control through Open Marsh Water Management (OMWM) utilizing rotary ditching to greatly reduce the need for pesticides. Upon completion of the project, a total of approximately 5.25 miles of shoreline will be restored. This activity will restore over 40 acres of spoil dike and borrow ditch to marsh elevation.

ECOLOGY OF DRIFT ALGAE IN MOSQUITO LAGOON

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Although drift algae can be the dominant taxa in shallow-water estuaries, very little is known about its ecology and physiology. To better understand the biology of drift algae in Mosquito Lagoon, we asked three questions: 1) What is the composition and rate of accumulation of drift macrophytes throughout the water column? 2) Is there a difference in photosynthetic performance in drift versus attached algal species? 3) Do growth rates differ for drift versus attached algae? Since November 2001, we have been conducting field experiments to address these questions at the University of Central Florida Field Station in Canaveral National Seashore.

1) Composition of drift was characterized by deployment of nets (1 x 3 m; 2 mm mesh) at two distances from shore (6 and 21 m). On each date, collections were made at ten-minute intervals for one hour. Drift was separated by species, and wet weights recorded. *Codium decorticaum* (Chlorophyta: Codiaceae) composed 15% of the drift during the sampling period. Additional species during this time included: *Halodule wrightii*, *Spyridia filamentosa*, *Chondria* sp., *Hypnea musciformis*, and *Gracilaria tikvahiae*. Accumulation was not significantly different between near shore and offshore; 37g/hr and 41.2g/hr, respectively (P-value = 0.24).

2) To date, we have examined photosynthetic performance and growth in *Codium decorticaum*. Changes in biomass and short-term physiology by electron transport rate (ETR) for *C. decorticaum* were used as indications of acclimation from an attached to drift state. Three treatments (n=10) of drift, attached to oyster shells, and manipulated drift (removed from oyster shells at start of trial) were deployed for 50 days in the field. A Diving-PAM Fluorometer (Walz: Germany) was used to obtain rapid light response curves *in situ* at the start and end of the trial. Temperature, salinity, and light levels were also recorded during the trial. From preliminary analysis of the rapid light response curves, it does not appear that there is a difference in photosynthetic performance between drift and attached algae. There also appears to be no detectable changes 50 days after an attached individual enters the drift in *C. decorticaum*.

3) There was no significant difference between drift and attached *C. decorticaum* growth rates (P-value = 0.15). Experiments will continue for the next year with *G. tikvahiae* and *H. musciformis* to better understanding of the ecology and physiology of these important drift organisms in Mosquito Lagoon.

THE WETLANDS INITIATIVE AT MINWR: COLLABORATIVE RESEARCH TO IMPROVE MANAGEMENT

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Most of the historic Indian River Lagoon (IRL, Florida) wetlands were impounded for mosquito control and isolated from the estuary since the late 1950s and 1960s. Most of these impounded estuarine wetlands are located within the Merritt Island National Wildlife Refuge (MINWR) and Kennedy Space Center. Previous research has demonstrated the benefits of reconnecting wetlands to the estuary for fisheries and emergent wetland vegetation. The USFWS, local mosquito control districts, and SJRWMD have reconnected many of these impounded wetlands. Reconnection by culverts, however, is recognized as only the first step in restoring the ecosystem functions of these impounded wetlands. Appropriate management is critical.

In order to optimize the benefits of reconnection and provide appropriate management, the MINWR staff has been facilitating a broad research effort (now called the Wetlands Initiative at MINWR) to directly compare the effects of various restoration and management strategies on a comprehensive list of wetland functions, flora, and fauna. The USFWS, SJRWMD, and many other organizations have been successful at gathering experts and funding to conduct this 3-5 year study. The Initiative has 18 participating agencies and researchers with major support provided by EPA, USFWS, USGS, NASA, Florida DEP, and SJRWMD.

THE WETLANDS INITIATIVE AT MINWR: USING A MASS BALANCE APPROACH TO DETERMINE THE EXCHANGE VOLUME BETWEEN A MANAGED SALT MARSH AND THE IRL

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A mass balance approach was developed to determine exchange volume between several impoundments and the Indian River Lagoon (IRL). Using GIS software, a Triangulated Irrregular Network (TIN) was developed for impoundments T-10-C, D, E, H, and restored area T-10-K. The TIN is a surface representation of topography. Using the TIN, the volume is determined for each hourly water surface elevation provided by a sensor in each impoundment. Hourly rainfall and evaporation values have also been estimated. The bi-directional exchange volume is the amount of water that passes through culverts between an impounded salt marsh and the IRL, and is a function of the change in volume within the managed salt marsh, rainfall, and evaporation.

**EPA WETLANDS INITIATIVE: COMPARISON OF WATER QUALITY IN THE
DIFFERENT WATER MANAGEMENT REGIMES OF IMPOUNDED MARSHES AT
MERRITT ISLAND NATIONAL WILDLIFE REFUGE AND THE ADJACENT INDIAN
RIVER LAGOON**

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The goal of the IRL Wetlands Initiative is to determine if re-establishment of the hydrologic connection between impounded marshes in the Indian River Lagoon can restore the ecological function of the impoundments to a state similar to that of "native" marshes and what impact continued hydrologic management will have on the restoration process. The effect of the management regimes; rotational impoundment management, wildlife/aquatic management, open marsh management and restored areas on water quality in the impoundments and in the adjacent lagoon were examined at the Merritt Island National Wildlife Refuge. Biweekly water samples were collected from the impoundment and the adjacent lagoon at two sites in each management regime. Sixteen water quality parameters; ammonium, chlorophyll, color, conductivity, dissolved oxygen, dissolved organic carbon, nitrate + nitrite ((NO₃+NO₂)-N), nitrite-N (NO₂-N), nitrate-nitrite (NO₃-N), pH, phosphate, precipitated organic carbon, salinity, temperature, total suspended solids and turbidity were measured at each sampling date. Total microbial density was monitored monthly using Acridine Orange Direct Counts (AODC). Chlorophyll "a" and pheophytin "a" ratios were determined for each hydrologic regime. Our results indicate that there is a seasonal trend in nitrogen levels both inside and outside the impoundments. Dissolved inorganic nitrogen levels are higher in the summer than in the winter. Conductivity, color, dissolved oxygen, salinity, temperature and chlorophyll showed seasonal trends both inside and outside the impoundments. The data reveal no differences between the total bacterial counts by AODC in the impoundments or the restored marsh versus those of the lagoon. However, an exception was noted during the winter of 2000-2001 when bacteria in the adjacent lagoon were higher than in the T10J impoundment. We believe this result is due to resuspension of sediments and bacteria into the water column due to wind forcing. These preliminary results indicate no evidence of an impoundment or water management effect on water quality characteristics within the impoundment or in the adjacent lagoon.

COMPARISON OF RECENT WETLAND SEDIMENTATION AND SURFACE ELEVATION DYNAMICS IN MOSQUITO IMPOUNDMENTS UNDER DIFFERENT WATER MANAGEMENT REGIMES AT MERRITT ISLAND NATIONAL WILDLIFE REFUGE

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One objective of the Wetland Initiative is to determine recent rates of change in marsh elevation and the contribution of organic matter accumulation and mineral sediment deposition to maintenance of marsh elevation for the purpose of evaluating the influence of the various management regimes on sediment accretionary dynamics of these marsh habitats. This objective is being addressed by several integrated tasks. Our task is to measure sediment elevation directly in conjunction with sediment deposition rates to determine the separate influence of surface (e.g., deposition and erosion) and subsurface (e.g., root growth and decomposition, compaction, water storage) processes on sediment elevation dynamics. These data sets will be integrated with studies by other investigators measuring plant growth, soil organic matter, and historical rates of sediment accretion in order to accomplish the objective.

We simultaneously measured sediment elevation with a surface elevation table (SET) and vertical accretion from artificial marker horizons in a native (i.e., never impounded) and restored (formerly impounded) marsh, as well as in six impoundments, two each with the following hydrologic regimes: open exchange (OPEN), rotational impoundment management (RIM), and wildlife aquatic management (WAM). Where possible, we measured elevation and accretion in vegetated and unvegetated areas within an impoundment. In all, 39 sampling stations were established. All measurements were made from small platforms to minimize disturbance of the substrate during sampling. The first year data presented here were collected from two samplings approximately 12 months apart. Additional samplings are planned to facilitate the evaluation of seasonal and annual trends for the 3-year project. Although the present data analyses must be considered preliminary, some interesting patterns are emerging from the data after one year. There were no significant differences in sediment elevation, vertical accretion, or shallow subsidence (vertical accretion minus elevation change) among native marsh, restored marsh, and the three impoundment-management regimes. However, there were significant differences in vertical accretion among management regimes. Sediment accretion in WAM was greater than in OPEN. It was also marginally significantly greater than elevation change in WAM, suggesting that the lack of elevation gain was more likely caused by a subsurface process such as compaction than by the surface process of erosion. In addition, the elevation response differed significantly between vegetated and unvegetated surfaces within the management regimes. Vegetated surfaces gained significantly more elevation than unvegetated surfaces (RIM and WAM) and experienced significantly less shallow subsidence (WAM). The loss of marker horizons from many unvegetated surfaces suggests, however, that for some of these areas both erosion and compaction influenced sediment elevation.

SALT MARSH ICHTHYOFAUNAL COMMUNITY STRUCTURE UNDER THREE DIFFERING WATER MANAGEMENT STRATEGIES

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Impounded salt marshes within Merritt Island National Wildlife Refuge are managed to address many specific goals including mosquito control, promotion of emergent or submergent vegetation and wildlife accessibility. The majority of impounded marshes are currently managed under three different hydrological protocols (open, rotational impoundment management, wildlife aquatic management) that differ in their degree of connection to adjacent lagoonal habitats and likely impose consequences on the local ichthyofauna. The purpose of this study is to compare overall fish community structure between management types and with a nearby, restored marsh over a 36-month period. Ongoing monthly collections in seven impoundments, beginning January 2001, utilizing cast nets, culvert traps and throw traps have yielded 35 fish species to date. Results show that many transient fish species (e.g. ladyfish, *Elops saurus*, striped mullet, *Mugil cephalus*, spot, *Leiostomus xanthurus*) are present under all three management schemes and can recruit here as small juveniles despite the microtidal nature of the region and the great distance (30 km) to nearest ocean inlet. Overall species counts are similar (25 open, 26 RIM, 23 WAM) but have decreased steadily in WAM impoundments, likely due to more extreme environmental conditions resulting from restrictive hydrological exchange. Mean body size has also increased in several species from WAM collections as natural life history migrations are interrupted.

FORECASTING THE PROBABILITY OF WETLAND RESTORATION SUCCESS USING HISTORICAL SEDIMENT ACCUMULATION RATES: MERRITT ISLAND NATIONAL WILDLIFE REFUGE

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Analysis of historical landscape change along the western margin of the Merritt Island National Wildlife Refuge (MINWR) suggest much of the wetland habitat has converted to open water over the past half century. This alteration appears to be a consequence of surface-water management undertaken using a network of impoundments hydraulically connected by culverts, flap-gates, and weir structures.

In 1998 the Environmental Protection Agency (EPA) authorized and funded an extensive research program designed to quantify the effects of surface-water management on the ecosystem function and habitat value of wetlands in the MINWR. Of particular interest were the probabilities

of success should a managed wetland be targeted for “restoration”. This project was designed to quantify historical wetland sedimentation rates using cesium activity profiles (DeLaune and others, 1978).

Two impoundments were selected for analysis. Impoundment D was chosen as representative of an impacted marsh as it has been subject to intense surface-water management for more than a half century. Impoundment K was selected as a natural marsh because impoundment structures were removed almost immediately (~10 years) after their construction. This impoundment has been subject to minimal surface water management and a natural hydroperiod for nearly four decades. In each impoundment, two cesium-coring stations were established at two distinct sites. In impoundment D, the sites were selected to acquire data representative of an open and marginal marsh. In impoundment K, both sites were selected as representative of open marsh.

The data acquired during this project suggest marsh surface elevations in Impoundment D have been markedly altered by surface-water management. Spatial patterns of sediment texture and composition, when used in conjunction with cesium data, suggest the barren marsh substrate in the open areas of Impoundment D are subject to erosion, while sediment deposition occurs along the impoundment margins and embayments. This process of sediment redistribution appears to be induced by wind-driven circulation associated with elevated water levels designed to maintain optimal waterfowl feeding habitat. Impoundment D substrate elevations in open areas appear to have been deflated to nearly 25 cm *below* sea level (i.e., NGVD). Hence, attempts to restore wetland habitat by simply re-establishing a natural hydroperiod by removal of the perimeter dike or installation of culverts may prove unsuccessful.

In contrast, Impoundment K sediment accumulation is relatively high and reflects the presence of dense high-marsh vegetation at elevations approximating sea level (-5 cm NGVD). This implies restoration of impounded wetland habitat in the MINWR may be possible wherein the substrate elevation is near sea level. These conditions are conducive to floral recruitment and the subsequent natural succession of wetland species.

ORGANIC MATTER DYNAMICS IN BLACK POINT IMPOUNDMENTS: CONTRIBUTIONS TO SEDIMENT SURFACE ACCRETION

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Organic matter accumulation and plant root decomposition were measured in seven Black Point impoundments using litter bag techniques in conjunction with measurements of sediment surface elevation change to determine the relative contribution biological processes to sediment surface elevation change. Time constants for decomposition and especially organic matter accumulation are long, thus basing conclusions on data from less than three years of observations must be viewed with caution. Nonetheless, the results for both processes from year one bags suggest that changes in the marsh surface elevation are largely the result of biological processes occurring in on the surface or in the root zone (0-20 cm below the sediment surface). Generally, impoundment regions where emergent vegetative cover has been stable over the period of measurement show a balance between decomposition and organic matter accumulation (net change in organic matter is not different from zero) or an increase in organic matter content (net change in organic matter is > zero). Rates of decomposition are similar in vegetated and unvegetated areas, but there is a net loss of organic matter from unvegetated area probably as a result of little organic matter production. Thus, impoundment water management practices that discourage vigorous emergent plant growth are likely to lower the sediment surface with respect to sea-level.

POSTER PAPERS:

A TEN YEAR OVERVIEW OF THE PHYSICAL WATER PARAMETERS IN THE NORTHERN BANANA RIVER 1991-2000

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In 1991 the Dynamac corp. acquired Hydrolab data sonde III's and deployed them in the Northern end of the Banana river within the boundaries of the Kennedy Space Center. The Northern Banana River is an ideal location to provide data from within a relatively undisturbed portion of the river in general. The Hydrolab Data-sonde III's are programmable, downloadable water measurement tool that can be put into the environment to take continuous measurements of physical water parameters at set intervals. Hydrolab data sonde III's documented temperature, P.H., Salinity, and Dissolved Oxygen with the sensors located 35cm above the river bottom. Hydrolabs took bi-hourly readings and were typically left in the field for two weeks before retrieval, cleanup, calibration and redeployment. Over 30,000 readings were taken throughout the ten-year time span. These measurements were averaged weekly to look for long term trends. Long term data analysis shows very predictable temperature patterns for the entire study with higher temperatures in the summer months with a high of 34.06C on July 27, 1993 and a low for the entire study of 8.45 on

February 09, 1995. Salinity increased in the mid winter months and decreased in the spring . Highest reading for salinity 33.8ppt occurred on December 01, 1993 while the lowest reading of 12.6 ppt was on March 14, 1995. Large amounts of rainfall in 1995 decreased salinities to a ten year low. Dissolved Oxygen (D.O.) readings were highest in the winter months and lowest in the summer. Highest D.O. of 18.72mg/l was recorded on February 9, 1995, with multiple readings of >1mg/l were taken during the summer months. Only 9,929 P.H. readings were taken due malfunctions. The PH on a seasonal basis remained between 6.22 and 9.36.

**EGRESS OF ADULT SPORT FISH FROM AN ESTUARINE FISH
REPLENISHMENT ZONE WITHIN MERRITT ISLAND NATIONAL WILDLIFE
REFUGE, FLORIDA**

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A mark-recapture study was conducted within Merritt Island National Wildlife Refuge in the waters surrounding Kennedy Space Center, Florida (where public access has been restricted since 1962) to document egress of adult sport fish from a potential estuarine fish replenishment zone. A total of 3,358 sport fish were tagged within the restricted areas. The species tagged were red drum *Sciaenops ocellatus* (n = 1,366), spotted seatrout *Cynoscion nebulosus* (n = 927), black drum *Pogonias cromis* (n = 760), and common snook *Centropomis undecimalis* (n = 305). Results showed that adult sport fish moved from the restricted areas within Merritt Island National Wildlife Refuge to surrounding areas open to fishing. The recapture rate based on angler responses outside of the restricted areas were 3.1, 0.7, 2.6, and 16.1 percent for red drum, spotted seatrout, black drum, and common snook, respectively. In general, red drum, spotted seatrout, and black drum were recaptured in waters adjacent to the restricted areas. Common snook, however, migrated from the restricted areas south to inlets. Mark-recaptures for red drum, spotted seatrout, and black drum, together with a previous study that found greater abundance and size of sport fish in the restricted areas than in adjacent areas open to fishing, substantiate the fish replenishment zone function of the restricted areas. The restricted areas within Merritt Island National Wildlife Refuge protect fish populations and large adult sport fish egress to surrounding waters open to fishing.
