

SPATIAL AND TEMPORAL PATTERNS OF MANGROVE AND MARSH FISH  
COMMUNITY STRUCTURE IN RELATION TO LOCAL AND REGIONAL HYDROLOGY

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## Introduction

Mangrove forests dominate the coastal landscape of south Florida. Landward of these mangroves, extensive brackish to freshwater marshes can be found. The fish communities of the freshwater Everglades have been extensively studied (Loftus & Eklund 1994) and their importance to higher trophic levels recognized (Ogden 1994). The paradigm of the importance of mangroves to coastal fisheries production rests on a limited number of studies conducted in mangrove estuaries and fringing mangrove habitats. Most researchers have captured fish in the larger open water bays which are surrounded by mangroves, rather than in the flooded forests themselves (e.g. Clark 1970, Odum & Heald 1972, Carter et al. 1973, Tabb et al. 1974, Yokel 1975, Colby et al. 1985, Browder et al. 1986). While these surveys provide information on the species composition and relative abundance of fishes in open water and tidal creek habitat, they say nothing of the direct use of vegetated intertidal habitats. Several authors have examined fish use of fringing red mangrove prop root habitat. Thayer et al. (1987) documented the fish fauna present in this habitat in Florida Bay. They found greater densities and biomass as well as consistent differences in species composition when compared to adjacent seagrass areas. Ley (1992) examined fish in mangrove prop root habitats in northeastern Florida Bay in relation to freshwater flow. Sheridan (1992) compared mangrove prop root, seagrass and open water habitats in Rookery Bay. He observed consistently lower fish diversity in prop root habitats compared with seagrass and open water areas of the bay.

Other mangrove forest types, such as basin and scrub forests (Odum et al. 1982) cover a greater area in south Florida than fringing forests. These basin and scrub forests are critical to the foraging and nesting ecology of wading bird populations (Ogden 1994). Tabb et al. (1974) is the single study which describes the fishes of scrub mangrove and marsh habitats. They found that young as well as non-breeding adults of as many as 14 species of important marine gamefish use the deeper waters of flooded marsh on a seasonal basis. Species diversity was highest during the low water/high salinity period of late winter and early spring when marine species are found in the headwaters of the North River in close association with freshwater bass, garfish and sunfish. They hypothesized that reproduction of killifish (Poecilia, Fundulus, Cyprinodon) and the mosquitofish, Gambusia is dependent on the extent of surface flooding. The fish communities of the extensive basin mangrove forests in southwest Florida are virtually unknown.

We hypothesize that fish utilization of the mangrove forests and adjacent brackish marshes is determined by local and regional patterns of hydrology (hydropattern and hydroperiod resulting from tidal inundation, rainfall, and sheetflow). Further, we hypothesize that two gradients in water sources, and thus salinity, structure these fish communities. The first gradient is a "local" scale pattern extending from the mangrove river

fringe to the interior marsh (Fig. 1). We feel that fringing mangrove forests are most closely linked, hydrologically, to tidal channels. These forests experience daily tidal inundation. Interior basin mangrove forests, however, appear to be driven by a combination of tidal action and rainfall (Twilley, 1985). Mangroves further inland near the marsh/mangrove ecotone may receive all their surface water via rainfall and sheetflow from adjacent, non-tidal marshes. The second gradient is a "regional" pattern along the large rivers of the southwest Florida coast. Mangrove forests located adjacent to the Gulf of Mexico are subject to strong daily tidal inundation whereas tidal flooding of upstream forests is reduced and may occur only seasonally (Fig. 1). During the summer and fall wet season, mangroves immediately downstream of the Everglades receive water via sheetflow and may be essentially freshwater systems. In the fall a regional rise in sealevel associated with the autumnal equinox and maximum freshwater flow may result in these forests experiencing a prolonged period of inundation (Tabb et al. 1974). During the dry season however, there is little sheetflow, regional sealevel is low and tidal action predominates. At this time upstream mangrove forests may experience hypersaline conditions. We propose to test these ideas along the Shark River, the largest mangrove dominated estuary draining the Everglades.

### Study Objectives

1. Measure the spatial and temporal patterns of inundation and flooding of the mangrove forest - brackish marsh habitats along both the local and regional gradients.
2. Quantify the spatial and temporal (seasonal and diel) patterns of fish community structure (species composition, biomass, size class distribution) within the intertidal vegetated habitats.
3. Quantify the diet of the principal species observed by habitat.
4. Define functional groups of fishes based on diet and habitat utilization purposes.
5. Use the functional groups and all other data to extend the Everglades Fish Model (Fleming et al. 1994) to the mangrove estuary.

### Study Site

The Shark River and its tributaries, approximately 30km long, drains Shark Slough, the central flow way of the Everglades (Fig. 2). The coastal forests in the vicinity of Ponce de Leon Bay are spatially extensive and tall, with individuals of red (Rhizophora mangle), black (Avicennia germinans), and white (Laguncularia racemosa) mangroves attaining heights of 25 m. Tree height declines as one moves upstream to Rookery Branch at the southern terminus of Shark Slough while the forest narrows to a river

fringe (Smith et al. 1994). Salinities in Shark River typically range from 34 - 38‰ in Ponce de Leon Bay to freshwater in its headwaters at Rookery Branch. Tidal range at the Gulf of Mexico is approximately 1.2 m and non-tidal at Rookery Branch. Highest annual water levels in Shark River occur in the fall coincident with the autumnal equinox and maximum sheetflow from the Everglades.

## Methods

*Hydrologic sampling:* Three transects will be established within the Shark River system: an upper reach station in Rookery Branch (S1, Fig. 2); a mid-river station downstream from Tarpon Bay (S4, Fig. 2); and a station near Ponce de Leon Bay (S3, Fig. 2). The South Florida Global Climate Change Program (SOFL-GCC) of the NBS has already established and currently maintains, surface, soil and groundwater monitoring stations, within the mangrove / marsh habitats, at these locations (Robblee et al. 1991). The National Park Service has built, but not yet instrumented, hydrological monitoring platforms in the river channels immediately adjacent to the SOFL-GCC stations. We propose to extend the hydrologic monitoring at S4 by adding a monitoring platform at the mangrove/marsh ecotone end of the transect (S5 in Fig. 2). This will provide a transect from the river edge to the interior marsh. Additionally we will instrument and maintain, for one year, the three NPS hydro platforms which are adjacent to the SOFL-GCC sites. Thus we will have accurate water level and conductivity data for river channels, adjacent mangroves and interior marsh sites. The data acquired from these monitoring platforms will be used to define both spatial and temporal hydrologic patterns along our study transects.

*Fish sampling:* Fish will be sampled using a variety of quantitative gears in four habitat types: creek, fringing mangrove prop root, basin forest, and fresh or brackish water marsh at each hydrology station. The need for gear development is anticipated because of the difficulty in sampling mangrove habitats. Initially throw traps (Robblee 1991), pop nets (Rozas & Odum 1987) and block nets (Thayer et al. 1987) will be used and modified as needed. Emphasis will be to use quantitative, comparable methods among the four habitats. Replicate samples will be collected in each habitat. All fish and invertebrates will be preserved, identified, sized, and weighed. All stomachs will be inspected for food and food items identified to lowest taxonomic level practical. Sampling will occur over several consecutive days each quarter and be timed to capture seasonal high and low water conditions. Initially day and night sampling will be conducted to evaluate if diel differences are present in the fish community.

*Modelling:* The field work described above will provide the basis for extending the Everglades Fish Model into the mangrove estuary. In the mangrove area, the fish communities will be modeled in the landscape divided into 500m x 500m spatial cells. A typical spatial cell might

contain a section of an estuary plus surrounding area that may be flooded to varying degrees on both diurnal and seasonal cycles. The water level pattern will be simulated on an appropriate degree of resolution (e.g., an hour or smaller). Other abiotic factors included in the model will be salinity and air and water temperatures. The biotic components of the model will consist of several functional groups (guilds of fish having similar ecological roles) of estuarine fish and food base for the fish. The food base in the estuary will be modeled using a general ecosystem model for subtropical coastal waters, consisting of between 15 and 20 compartments and calibrated to the mangrove estuary. Each functional group of fish will be divided into monthly age and corresponding size classes. Interactions between the functional groups of fish and both the lower and trophic level compartments and other functional groups of fish will be governed by nonlinear (density-dependent) differential equations. The tidal fluctuations occur within each day and are important to fish growth and population dynamics because some of the fish can move out into flooded land adjacent to estuaries and obtain an additional food input. Therefore, the movements and feeding of the fish will be modeled with temporal resolution of an hour or less.

#### **Integration with ongoing programs**

At present the NBS's SOFL-GCC program is conducting research in the Shark River system. In particular SOFL-GCC will be collecting an extensive amount of surface, soil and groundwater data (levels, conductivity and flows) in the southwest Florida mangrove zone. At present all SOFL-GCC platforms in the Shark River system are recording water level (all S stations in Fig. 2). Conductivity sensors will be installed by mid-June 1995. All data will be archived within the DBHYDRO database of Everglades National Park. A hydrological model of the mangrove coast will be developed based on these data as one component of SOFL-GCC. Dewitt Smith, manager of the ENP Marine Monitoring network is a Cooperating Co-Principal investigator on this proposal. SOFL-GCC has already established permanent mangrove forest vegetation monitoring plots at S3 and S4. Plots will be established at S1, S2 and along the S4-S5 transect in the near future. All SOFL-GCC data will be made available for use in the current project.

#### **Assistance to client bureaus**

This proposal directly addresses several key needs which have been identified by the Science Sub-Group of the Federal Task Force for Everglades Restoration: 1) we will provide much needed data on the hydrology of the Shark River which can be used to address issues relating to Florida Bay which lies downstream from Shark River, 2) the hydrological data will provide a valuable assessment of the impact of the Corps of Engineers Experimental Water Delivery project on the estuarine portions of Shark River, 3) we will provide the first comprehensive data on utilization of mangrove forests and brackish marshes (not creeks and open water) by

fish, 4) we will develop data for spatially explicit models of estuaries including salinity and fish, and, 5) we will expand the Across Trophic Level System Simulation (ATLSS) into the mangrove zone by providing data on mangrove fish and lower trophic levels. All of these items have been identified by participants in the Science Sub-Group (National Park Service, Fish & Wildlife Service, USGS and NOAA). In particular we will work closely with NPS staff to ensure that our hydrological monitoring is integrated with their programs and meets their needs.

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## Budget

### Personnel

|    |                                           |               |
|----|-------------------------------------------|---------------|
| 1) | 2 MSc graduate student assistantships     | \$30,000      |
| 2) | 1 GS-6 Hydro technician (NTE 1YR)         | 23,000        |
| 3) | University Overhead on MSc assistantships | <u>3,000</u>  |
|    | <b>Sub-total</b>                          | <b>56,000</b> |

### Equipment & Supplies

|    |                                                                                                           |               |
|----|-----------------------------------------------------------------------------------------------------------|---------------|
| 1) | Build & instrument 1 hydro station                                                                        | 12,500        |
| 2) | Fish sampling gear (36 pop-up traps,<br>9 flume weirs)                                                    | 5,000         |
| 3) | Expendable field supplies -(plastic bags,<br>buckets, safety gear, formalin, etc.)                        | 2,500         |
| 4) | Computer equipment & supplies                                                                             | 2,000         |
| 5) | Boat maintenance, gas & oil                                                                               | 2,000         |
| 6) | Helicopter time                                                                                           | 4,000         |
| 6) | Travel / perdiem (4 trips, 6 days/trip,<br>for 5 people, plus travel to 2 meetings<br>to present results) | <u>2,500</u>  |
|    | <b>Sub-total</b>                                                                                          | <b>30,500</b> |

|                    |                 |
|--------------------|-----------------|
| <b>GRAND TOTAL</b> | <b>\$86,500</b> |
|--------------------|-----------------|

## **Budget justification**

This project will require short periods of intensive field work followed by long periods of sample processing in the laboratory. Thus the major cost will be in the form of salaries. We are requesting two M.Sc. student assistantships. One will work under the direction of Mike Robblee and be responsible for overseeing collecting and processing of fish samples. The second will work with Don DeAngelis and be responsible for assisting in all aspects of field work and developing the ATLSS model for estuarine fish. The GS-6 Hydrological Technician will work under the direction of Thomas Smith. This individual will be responsible for building the station at S5, instrumenting the ENP stations, and maintaining all of the stations plus the hydro database.

Funds are also requested for building and instrumenting the station at S5. This is a remote location which can only be accessed by helicopter. Well drilling equipment, pipes, instruments, wood for the platform will all have to be sling-loaded by helicopter. All other sites can be reached by boat. Equipment to build semi-permanent (life of project) fish sampling stations is requested as are funds for expendable supplies and travel.

## Figure legends

- Fig. 1      Hypothesized hydrological relationships and forcings on the mangrove / marsh fish assemblages of the Shark River system.  
A) longitudinal gradient from tidal creek edge to interior marsh.  
B) upstream downstream gradient along an entire river.
- Fig. 2      Locations of the SOFL-GCC hydrological monitoring stations. S1 is at the upstream, freshwater edge / mangrove interface, S2 lies along the mid reaches of the river in a mangrove, brckish marsh zone, S3 is at the mouth of the Shark River in a stand of tall mangroves, S4 is in tall mangrove on the Harney River, the northern tributary of the Shark, S5 will be established in a brackish interior marsh some 400m south of S4.

Fig 1A

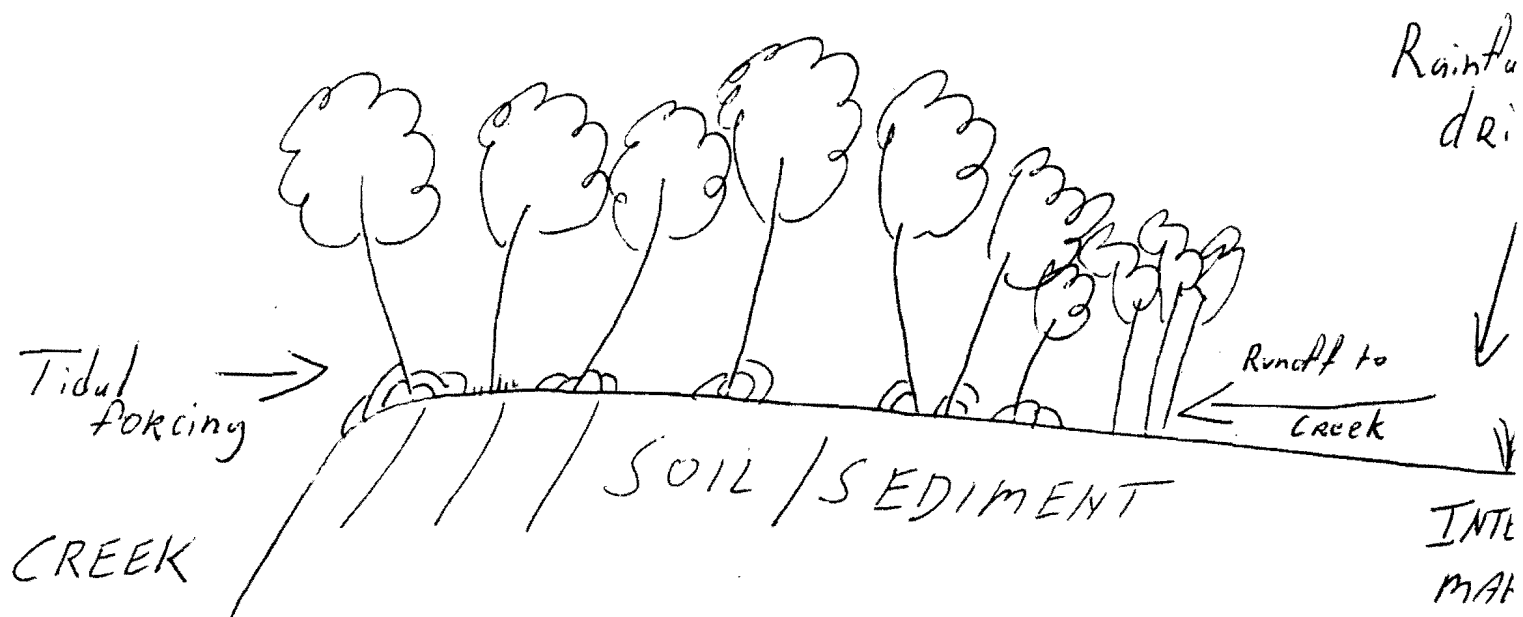


FIG 1B

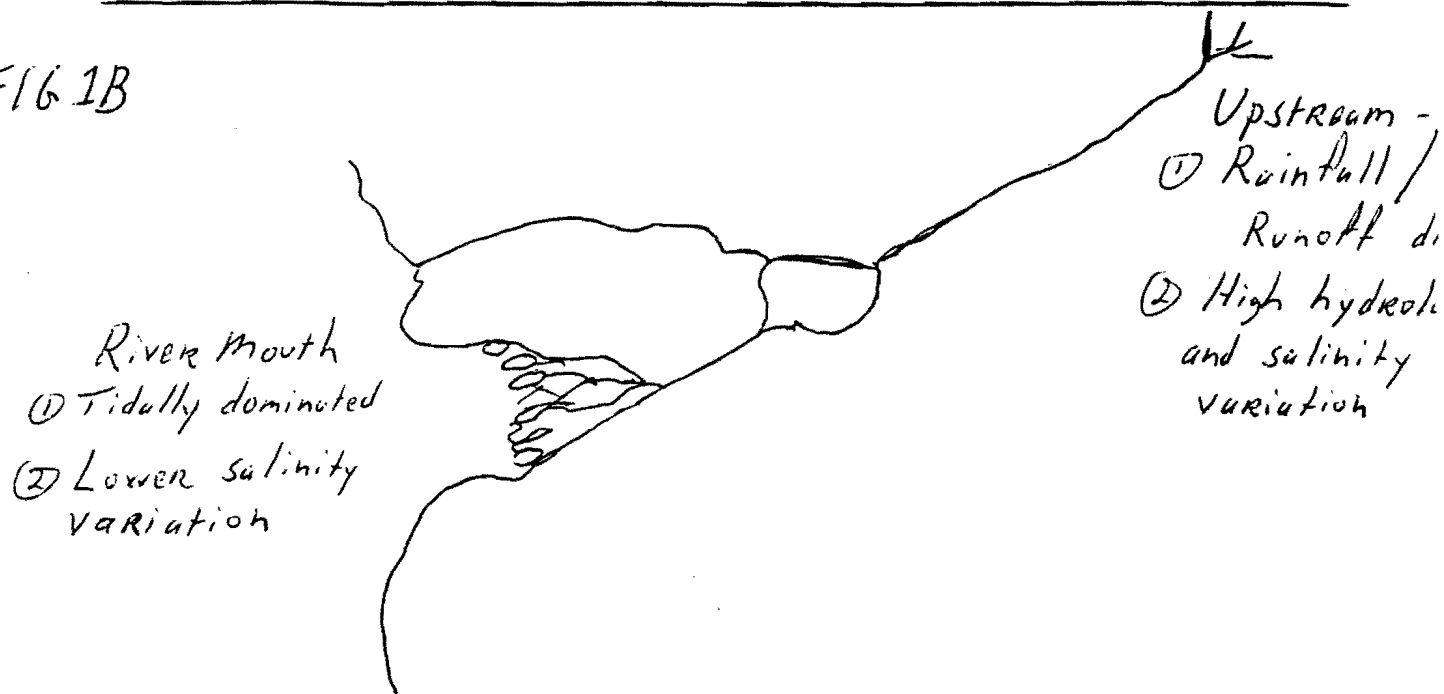


Fig. 2 - Kobblee, DeAngelis & Smith

