SOUTH FLORIDA RESEARCH CENTER

Report SFRC-86/07

The Early Life History of Spotted Seatrout, Red Drum, Gray Snapper, and Snook in Everglades National Park

Everglades National Park, South Florida Research Center, P.O. Box 279, Homestead, Florida 33030

The Early Life History of Spotted Seatrout, Red Drum, Gray Snapper, and Snook in Everglades National Park, Florida

Report SFRC-86/07

Edward S. Rutherford, Thomas W. Schmidt, and James T. Tilmant

National Park Service
South Florida Research Center
Everglades National Park
Homestead, Florida 33030

1986

Rutherford, Edward S., Thomas W. Schmidt, and James T. Tilmant. 1986. The Early Life History of Spotted Seatrout, Red Drum, Gray Snapper, and Snook in Everglades National Park, Florida. South Florida Research Center Report SFRC-86/07.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure		Page

LIST OF APPENDICES

ABSTRACT

We present results of recent studies on distribution, habitat, and relative abundance of larvae and juveniles of the four most popular gamefish species in Everglades National Park, (spotted seatrout, red drum, gray snapper, snook). National Park Service and National Marine Fisheries Service personnel sampled larvae from 1982 to 1985 in passes and creeks bordering the park and sampled juveniles from 1973 to 1976 and from 1982 to 1985 in mangrove creeks, channels, shorelines, banks, basins, and bays.

We collected larvae of spotted seatrout and red drum and juveniles of all four species. Spotted seatrout were found to spawn in park waters, predominantly in western Florida Bay. We caught spotted seatrout larvae in mesohaline and marine salinities during every month but January with peaks in June to September. Catches (larvae/100m^3) varied by station and year but approximated those taken 20 years ago. We collected juvenile spotted seatrout in euryhaline seagrass beds of mixed species composition (*Thalassia testudinum*, *Halodule wrightii*, and *Syringodium filiforme*). Juveniles were most abundant in western Florida Bay mixed species seagrass beds of 1,000-4,000 shoots/m^2, where the percent organic matter and density and biomass of *S. filiforme* were higher than in areas without spotted seatrout.

Red drum and gray snapper were found to spawn outside of park waters. Red drum entered the park from September to January as larvae and inhabited shallow brackish waters near mangrove shorelines and in creeks. Larval red drum catches were lower than those taken 20 years ago. Gray snapper entered park waters as post larvae and small juveniles, inhabiting euryhaline seagrass beds in banks, basins and channels, and mangrove prop roots. Juvenile gray snapper were most abundant in Florida Bay mixed seagrass beds 1,000-4,000 shoots/m^2 of higher densities and biomass of *Halodule wrightii* and *Syringodium filiforme* than other areas sampled. Adult spawning areas and habitat of young snook remain unknown as few young-of-year were collected. Juvenile snook 1-2 years old were present in euryhaline mangrove shorelines and creeks.

We estimated monthly mortality rates of juvenile spotted seatrout 16-144 mm S.L. (A=34.7%) and juvenile gray snapper 72-116 mm S.L. (A=39.5%) using catch curve analysis.

INTRODUCTION

Understanding the causes of recruitment variability in fish stocks is critical for sound management. Previous studies of the four most popular gamefish species in Everglades National Park (ENP) (red drum, spotted seatrout, snook, gray snapper) described the biology of adults (Croker 1960; Stewart 1961; Yokel 1966; Rutherford et al. 1982, 1983; Thue et al. 1983; Buker et al. in prep) and their response to fishing pressure and environmental factors (Higman 1967; Davis 1980). The biology of prerecruit stages of these species in park waters is poorly understood;

studies have been limited to relative abundance (Jannke 1971; Lindall et al. 1973; Collins and Finucane 1984) and distribution (Tabb, Dubrow, and Manning 1962; Tabb 1966; Yokel 1966; Roessler 1967; Clark 1971; Odum 1971; Lindall et al. 1973; Tabb, Drummond, and Kenny 1974; Schmidt 1979; Collins and Finucane 1984).

Considerable information has been gathered elsewhere in Florida on prerecruited gamefish food (Moody 1950; Springer and Woodburn 1960; Harrington and Harrington 1961; Fore and Schmidt 1973; Carr and Adams 1973; Alpern 1981) growth (Fore and Schmidt 1973; Gilmore et al. 1983; Peters and McMichael, in prep.) habitat and distribution (Moody 1950; Reid 1954; Springer and Woodburn 1960; Fore and Schmidt 1973; Gilmore et al. 1983; Peters and McMichael, in prep.) relative abundance (Alpern 1981; Leak 1983), and survival in relation to varying prey, salinity and temperature conditions (Taniguchi 1980).

In other Gulf areas, studies on spotted seatrout and red drum prerecruits have documented growth (Pearson 1929; Miles 1950; Simmons and Breuer 1962; Bass and Avault 1975; Lee et al. 1984), distribution (Pearson 1929; Miles 1950; Simmons and Breuer 1962; King 1971; Loman 1978), habitat preference (Pearson 1929; Miles 1950; Simmons 1962; Holt et al. 1983) and relative abundance (Sabins 1973; Holt et al. 1983; Herke et al. 1984a).

In this report we review literature and present results of recent studies on habitat, distribution and relative abundance of prerecruited spotted seatrout, red drum, snook and gray snapper in ENP as part of the 1983 NPS-USFWS research effort to determine the status of harvested finfish and shellfish stocks in ENP. Specific objectives of the larval and juvenile fish portion of the cooperative research program were:

1. Determine movement, distribution and relative abundance of larval and juvenile gamefish.
2. Determine habitats used by juvenile gamefish.
3. Estimate prerecruit mortality.
4. Determine relative strength of incoming year classes.

Description of Study Area

The mainland shoreline of Everglades National Park extends from the Florida Keys to Everglades City on Florida's west coast. It contains numerous bays, inlets, and rivers which lie at the terminus of the historically immense Everglades and Big Cypress swamp drainages. Tabb, Dubrow, and Manning (1962) described the animal and plant communities of park waters and identified distinct ecological zones. Their work provided the basis for delineating the six fishing areas used in Everglades National Park fishery investigations since 1960 (Higman 1966) and used as area designations in this study (Fig. 1). These areas differ in their topographical, hydrological and biological characteristics (Tabb, Dubrow, and Manning 1962).

METHODS

National Park Service Study

Larval Fish

Data on larval fish were provided by two past NPS studies involving plankton sampling. The first of these studies was specifically directed at larval gamefish. During that study, larvae were sampled monthly from November 1982 to December 1983 at two stations, Little Shark River and Cape Sable near the western edge of the park (Fig. 2). The Little Shark River station was chosen to sample larvae entering Whitewater Bay from offshore as Jannke (1971) reported finding red drum and spotted seatrout larvae there. The Cape Sable station was chosen to sample larvae presumably entering northwest Florida Bay from offshore. Previous studies (Stark 1964; Yokel 1966; Rutherford et al. 1983; Buker et al. in prep.) have shown that red drum and gray snapper spawn outside of park waters, while snook are believed to spawn in passes leading into lagoons and rivers (Marshall 1958). Exploratory samples were also taken inshore of these stations to determine larval movement. In addition to the larval gamefish study, plankton samples collected at night by a concurrent pink shrimp study in Florida and Coot Bays (Fig. 2) from March 1982 to August 1983 were analyzed for gamefish larvae (Appendix 1). These additional stations provided a wider distribution of sample sites (Fig. 2).

Plankton stations in Whitewater Bay and northeast Florida Bay were shallow ($<$ 2 m) and were characterized by variable currents and salinities. The Little Shark River station was deeper (2-4m) with intermediate salinities. Whale Harbor Channel in southeast Florida Bay was more similar to stations in west Florida Bay in having deep water (2-4m) and stable marine salinities (32-40%) (Fig. 3 A, B, Appendix II). All NPS samples were collected within 1 meter from the bottom.

Sampling at Little Shark River (Table 1) and previous work by Jannke (1971) showed that greatest catches of spotted seatrout larvae occurred at night on flood tide. Therefore, after January 1983, all tows were taken on an evening flood tide. Plankton samples with the 475 micron mesh net were collected during the new moon while 333 micron mesh samples were collected during the quarter moon.

Water quality measurements (salinity, temperature, D.O., pH), depth and current velocity were measured at each station before sampling. Six replicate tows were made at the monitoring sites with a 333 micron mesh net (63 cm diameter) on a bongo frame approximately 1 meter from the bottom. The number of replicates was calculated using the formula below (see statistics and sampling variability). Only one tow was taken at each exploratory station. Tows were taken at two knots into the current for six minutes and water volumes filtered were determined by a flowmeter mounted on the net. After each tow, nets were washed down and samples preserved in 10% buffered formalin. The same procedure was used to collect plankton for the pink shrimp project except that six replicate tows were taken at all stations and the 475 micron mesh nets (75 cm diameter) were towed by bridles.

All larval fish were counted and identified to the family level. Larvae of the four target gamefish species were identified, counted and measured (mm S.L.). The gamefish species were considered larvae at sizes of $<$8.0 mm for spotted seatrout, red drum, snook and 10 mm for gray snapper.

Relative differences among sites and seasonality of density were determined by Kruskal-Wallis tests for monitoring stations. Presence or absence of larvae was determined for the exploratory sites.

Juvenile Fish

1982-84: Exploratory sampling for juvenile gamefish in 1982-84 was conducted in shallow water areas ($<$ 2 m) in Whitewater Bay and Florida Bay in marshes, ponds, canals, small creeks, along mangrove shorelines and in grass flats from November 1982 to December 1984 (Fig. 4). Known juvenile snook habitat located northwest of the park near Marco Island was also sampled to determine time of entry into the bays. Samples were taken with either a 15.2 m seine (1.3 cm mesh in the wings and 0.3 cm mesh bag), 7.6 m seine, or rotenone. For each seine sample at least two replicate hauls were made. On one occasion explosives were used to sample mangrove creeks.

Exploratory sampling with the 15.2 m beach seine was concentrated from November 1982 to December 1984 in fishing areas 1 and 4 in spring, summer and fall (Fig. 4). Most samples (83%) were collected in 1983. Habitats sampled with this gear included banks and flats, shorelines, ponds, narrow creeks and canals. Most stations were covered by *Halodule wrightii*, *Thalassia testudinum*, and *Ruppia maritima*.

Seine (7.6 m) samples were made in fishing areas 1, 2, 4, and near Marco Island, in creeks, on flats, along shorelines and in ponds, with most (55%) samples taken in headwater creeks and ponds of areas 4 and near Marco Island. Rotenone samples were made in fishing areas 1, 4, and 5, in creeks, marsh, mud ponds, and canals. Most samples were taken in headwater creeks and ponds of area 4.

Samples of juvenile gamefish were also provided by the pink shrimp project from 1982 to 1984. Gear used in this study included a 475 micron mesh plankton net, benthic sled net, and roller frame trawl. Roller frame trawling was conducted from March 1982 to December 1984 in vegetated bays and basins at 4 sites (depth 1-2m): Johnson Key Basin and Blackwater Sound in Florida Bay, Midway Pass and Coot Bay in the Whitewater Bay area. The roller frame trawl had paired 1 meter nets, 1.27 cm bar mesh in the body and 0.95 cm bar mesh in the cod-end. At each station three paired replicates were taken at night at 2 kts for 10 minutes covering approximately 250 m^2.

Benthic sled-net samples were taken during the day along mangrove shorelines at six shallow water ($<$ 1 m) sites from October 1982 to December 1984: 2 sites in Coot Bay, 1 site in Whitewater Bay, 2 sites in west Florida Bay, and 1 site in central Florida Bay. Five replicate tows of a 0.5m wide, hand-pulled benthic sled-net with 2.5 mm mesh bag netting were taken at each station perpendicular to the shoreline, each tow covering 6 m^2.

1973-76: Unpublished data on juvenile spotted seatrout and gray snapper were collected by a National Park Service study of fish and macroinvertebrate biomass in Florida Bay May 1973-September 1976 (Schmidt 1979). In this study, monthly and quarterly samples were taken during the day at 27 stations using either a 4.2 m otter trawl (2.54 cm bar mesh in the body and a 0.64 cm mesh liner in the cod-end) or the same 15.2 m beach seine described above (Fig. 5). Trawls were made in bays, basins and channels 1-3 m deep. For each trawl sample two replicates were taken, each towed at 2 knots for 5 minutes covering approximately 480 m^2. Beach seine samples were made along shorelines, banks and flats at 15 sites ($<$ 1 m depth). Only one replicate was made at each site.

Most sampling effort was concentrated in the first year in western Florida Bay, with lesser effort in central Florida Bay the second year and in eastern Florida Bay the third year. Effort (number of sampling trips) was evenly divided between beach seine and otter trawl. Most trawl samples (77%) were taken in bays and basins with the rest in channels. The majority of bay-basin samples (58%) and channel samples (61%) were taken in fishing area 1. Most seine samples (84%) were collected on banks and flats with the remainder made along shorelines. Seventy three percent of the bank-flat seine hauls were made in area 1 while most (30%) shoreline samples were made in fishing area 3.

Samples in both NPS studies were immediately preserved in 10% buffered formalin. All fish and macroinvertebrates were counted and identified. The four gamefish species were weighed (0.1 g) and measured (mm S.L., F.L., or T.L.). For each sampling effort, the depth and benthic vegetation were noted and water quality measurements (salinity, temperature, DO, pH, and turbidity) were taken.

Statistics

Catches of spotted seatrout larvae were not normally distributed (Fig. 6). Log_{10} transformations of gamefish larval catches did not normalize these data, so nonparametric statistics (Kruskal-Wallis) were used to detect differences in gamefish larval catches among stations and seasons.

Differences in mean fish length were compared using analysis of variance (ANOVA). A Student Newman-Keuls test was used to detect specific differences. Multiple regression analysis was used to test for significant relationships between fish size, salinity, and temperature. Differences were considered significant at the a=.05 level.

Sample Size

The number of replicates (N) needed to estimate mean relative density of larvae within $\pm$ 20% at the 95% confidence level was determined by the formula below (Smith and Richardson 1977), assuming data are not normally distributed.

$$N = \frac{\frac{1}{M} + \frac{1}{K}}{D^2}$$

where $K = \frac{M^2}{S^2 - M}$

M = mean; S^2 = variance; D^2 = % difference or level of detection decided on by researcher.

This formula assumes a negative binomial distribution fits the untransformed data, which is true for most ichthyoplankton samples (Smith and Richardson 1977).

We used catches of all fish taxa (larvae and juveniles combined) caught in plankton nets to determine the number of replicates needed to estimate the mean density of fish larvae. Monthly catches of all fish taxa combined were variable (C.V. = 114%). Six replicate tows were adequate to estimate the mean density of all taxa combined within 20% most (67%) of the time.

Catches of spotted seatrout, the most abundant gamefish larvae collected by NPS personnel, were low (1983 Shark River mean = 3.82 $\pm$ 0.99 larvae/100 m^3) and highly variable (C. V. = 236%): sixty five percent of all samples had no spotted seatrout. Using the negative binomial sample size formula, the mean density of spotted seatrout could be estimated with $\pm$ 20% error with 6 replicate tows only in May, August and October; in other months the required number of tows generally exceed 20.

National Marine Fisheries Service Study: March 1984 - June 1985

Studies in Everglades National Park by National Marine Fisheries Service personnel provided additional information on gamefish larvae and juveniles. Results of ten sampling trips during March 1984-June 1985 were reported (Powell et al. 1987; Thayer et al. 1987).

Fish larvae were sampled at eight stations located near the park boundary and at 12 stations placed inshore of these stations (Fig. 7). At each station three replicate oblique tows and one neuston tow were made with a 333 micron mesh bongo net (60 cm) at approximately 2 knots. Samples were taken during the day at all stations and at night at some stations. Gamefish larvae were identified to species and measured, and all other larvae were identified to family.

Juvenile gamefish were sampled on nine sampling trips from March 1984 to June 1985 in S. Whitewater Bay, Coot Bay, and Florida Bay. Otter trawl samples were taken at two fixed stations and at 30 stratified randomly selected stations. Block net and rotenone were used to sample eight mangrove prop root habitats. The study area was divided into 5 strata and otter trawl samples randomly selected within each stratum for each trip. Strata included the South Whitewater Bay (4 samples) - Coot Bay (2 samples) stratum, Florida Bay channels (6 samples), and three basin-bank strata (6 samples each) in Florida Bay chosen by seagrass density, roughly corresponding to west, central and east Florida Bay.

At each otter trawl station one high speed (3-4 kts) bottom trawl and surface trawl were pulled between two boats for 2 minutes. Triplicate vegetation samples were taken for species composition, standing crop and shoot density midway along each trawl line. Distance trawled was marked by buoys and measured by optical range finder. All fish were identified, counted, and the total biomass and size range measured. The gamefish species were individually measured, weighed and their stomach content analyzed. Sediment characteristics (organic content, % silt-clay, depth) and water samples (temperature, salinity, turbidity) were also taken.

Estimates of monthly juvenile mortality rate were obtained from otter trawl catches collected by NMFS Beaufort Lab in ENP from May 1984 to June 1985 (Thayer et al. 1987). Juvenile spotted seatrout were divided into size classes using the growth rate developed by Peters (Florida DNR unpublished data) for Tampa Bay juvenile spotted seatrout: age (days)=12.472 + 1.836 (standard length (mm)) - 0.005 (standard length)^2, N=98, r^2=0.88. Lengths of juvenile gray snapper were divided into monthly age classes assuming an average monthly growth rate of 9 mm S.L. derived from scale-aged park gray snapper (Rutherford et al. 1983). It was assumed that fish were recruited to the gear at the size class with the highest frequency and stopped being vulnerable to the gear where the descending slope of the size frequency levelled off. Frequencies of fish were $\log_e$ transformed and the regression slope of frequency on age was the monthly instantaneous mortality rate.

RESULTS

Spotted Seatrout - Larvae

National Park Service Studies: 1982 - 1983

A total of 1,629 spotted seatrout larvae were collected from March 1982 to December 1983. Larvae were widely distributed throughout Whitewater Bay and Florida Bay, occurring in passes, tidal rivers and creeks, and open bays (Fig. 8). They were present nearly year round in 1983, but were most abundant in summer (July, September), followed by a secondary peak in spring (April-June) (Fig. 9, A & B). Summer catches were significantly higher (Kruskal-Wallis, $p < .05$) than spring catches at 2 of 4 stations (Table 2). Highest monthly catches of any station occurred in July 1983 (61 spotted seatrout/100 m^3) at Marker 5 - Middle Ground.

Spotted seatrout larvae were more abundant at monitoring stations in western Florida Bay than at sites in eastern Florida Bay or Whitewater Bay. Among the two monitoring stations sampled using 333 micron mesh net, larval catches were significantly higher ($p < .001$) at Cape Sable than at Little Shark River. Among stations sampled with 475 micron mesh net, spotted seatrout larvae were more abundant ($p < .05$) at Marker 5 than in Conchie Channel. Catches at other monitoring stations (Man-O-War Channel, Buttonwood Canal, Tarpon Creek, Whale Harbor) were too rare to compare monthly abundance.

Spotted seatrout were also caught at seven of eighteen exploratory stations in Whitewater Bay and Florida Bay. During July-September 1983, months of peak abundance, spotted seatrout larvae were ubiquitous, occurring at 82% of all stations sampled (exploratory and monitoring), compared to 30% in January-March 1983 (Fig. 10, A-D). In other months (March-July 1982, October 1982, October-December 1983) sampling effort for fish larvae was too low ($<$ 3 stations) to suggest distribution (Table 3).

Lengths of spotted seatrout larvae caught in plankton nets from 1982 to 1983 ranged from 1.3 - 8.0 mm S.L. ($\bar{x}$=3.2 + 0.1 mm, n=1540). Mean length of fish caught in 1983 in 333 micron mesh nets was greater ($p<.01$) than of fish caught in 475 micron mesh nets over all stations (Table 4). In western Florida Bay, however, there was no difference in mean size between fish caught at 333 stations (Cape Sable) and 475 stations (Marker 5).

Fish size varied among stations and months in 1983. Mean size of larvae increased with distance from tidal passes opening to the Gulf. At stations sampled with 333 micron mesh nets, fish were smaller in mean length at Cape Sable in W. Florida Bay than at Little Shark River or in Whitewater Bay (Joe River, Clearwater Pass, Cormorant Pass). At 475 micron net stations, mean length of spotted seatrout was smaller at Jewfish Creek in Eastern Florida Bay and Marker 5 Middle Ground in W. Florida Bay than at Conchie Channel (Table 4).

There was no increase in mean length of spotted seatrout by month for all 333 micron mesh stations combined. Spotted seatrout mean length was significantly ($p<.05$) smallest in March and again in August, probably reflecting the beginning and the peak of the spawning season. At the Little Shark River station, mean length was significantly ($p < .001$) smallest in August; in western Florida Bay mean length was smallest in March and July-September (Table 5). Among all 475 micron mesh stations combined mean length of spotted seatrout increased from 2.7 mm S.L. in April to 4.6 mm S.L. in August.

Spotted seatrout at the Coot Bay plankton stations were much larger than at any other station, ranging in length from 3.6-75.0 mm S.L. ($\bar{x}$=32.8 $\pm$ 1.8 mm S.L., N=103). All but two of these fish were juveniles. Most were caught in July, August and September in both 1982 and 1983 on flood tides into Coot Bay. The two larvae (3.6, 4.0 mm) were caught on a flood tide in Buttonwood Canal in March and May 1982 before the plug to Florida Bay was closed, suggesting these larvae may have been spawned in Florida Bay. It was impossible to define exact spawning sites from plankton data since eggs were not identified or counted and because no yolk sac larvae were present due to extrusion through the nets. The closest indications of spawning area were obtained by examining the frequency of preflexion larvae ($<$ 2.4 mm) by area.

Spawning activity indicated by presence of preflexion larvae appears to occur primarily in western Florida Bay with some activity in N.E. Florida Bay. Five hundred sixty six preflexion larvae were caught from 1982 to 1983; all but 6 of these were caught in 1983. Most (90.4%) of these larvae were caught in western Florida Bay, primarily from stations closest to the

Gulf (Marker 5, Cape Sable). Some (6.9%) small larvae were caught in eastern Florida Bay from the Jewfish Creek station while only 15 preflexion larvae came from the Shark River Station. No preflexion larvae were caught in Whitewater Bay (Table 6).

Presence of preflexion larvae by month in 1983 indicates spawning activity occurred from February to September and November to December, with the majority (78.9%) occurring in July-September. No preflexion larvae were collected in October (Table 6).

There was no significant relationship between fish size and salinity or temperature. Ranges of physical parameters in which spotted seatrout were caught are shown in Table 7.

National Marine Fisheries Study: March 1984 - June 1985

National Marine Fisheries Service collected a total of 580 spotted seatrout larvae from March 1984 to June 1985 (Powell et al. 1987). Larvae were collected on every trip during this period except November-December 1984 and were most abundant in spring (April-June) in both years. All spotted seatrout larvae were caught in western Florida Bay, Ponce de Leon Bay and Whitewater Bay stations (Fig. 11 A-D) while none came from south and southeast Florida Bay stations.

NMFS analyzed spawning distribution by examining the distribution of preflexion larvae. Most preflexion larvae were caught in Cormorant Pass in Whitewater Bay and northwest Florida Bay, with the rest in Ponce de Leon Bay and southwestern Florida Bay (Oxfoot and Blue Bank). All preflexion larvae were caught in intermediate-high salinity waters, while none were caught in brackish water.

NMFS compared diurnal catches of spotted seatrout larvae and reported no significant difference in catches of preflexion larvae, but slightly higher catches of larger larvae ($<$ 2.4 mm) at night. They concluded that step oblique bongo tows were not adequate to sample postflexion larvae due to the low number (N=7) collected day or night. Comparison of spotted seatrout catches by depth showed that more spotted seatrout were caught in step-oblique tows than in neuston tows.

Juvenile Spotted Seatrout

NPS Study: 1982 - 1984

A total of 248 spotted seatrout juveniles was collected from 1982 to 1984. These fish were caught by roller frame trawl, sled net, beach seine, and plankton net in a wide variety of shallow ($<$ 2 m) habitats in Whitewater and Florida Bays, including basins, bays, banks, flats, mangrove creeks and mangrove shorelines (Fig. 12, Tables 8 & 9). The only habitat sampled where juvenile spotted seatrout were not found was in the fresh headwater ponds and marshes of tidal rivers. Deepwater channels and passes were not sampled.

Juvenile spotted seatrout were caught from April to December with most (69%) caught from July to September during only 27% of the sampling trips (Table 10). Most of the catch (93%) was taken in the western Florida Bay - Flamingo area (Areas 1 and 2) and in the lower Whitewater Bay area (Area 4) where most effort (93%) was made (Table 11). An additional 101 juvenile spotted seatrout were caught by plankton net in the Coot Bay area in summer of 1982 and 1983.

More spotted seatrout (82%) were caught over <u>Halodule</u> and <u>Thalassia</u> beds than over other vegetation types or bare bottom (Table 12). Very few fish were caught in areas where dominant cover was marine algae.

Juveniles ranged in length from 17-403 mm S.L. ($\bar{x}$=51 ± 6 mm). Mean length was greatest in April, lowest in May-September and slowly increased from October to December (Fig. 13). There was no significant difference in mean length of fish collected in Whitewater Bay and Florida Bay. Small spotted seatrout, less than 40 mm S.L. (approximately 3 months old), were collected May-October and December. Although sample sizes of fish in April and May were low and the fish were collected by a variety of sampling gears, the general abundance and distribution of small juveniles in late spring - summer are consistent with those of spotted seatrout larvae and suggest bimodal recruitment concentrated in western Florida Bay, Whitewater Bay, and Coot Bay (Fig. 10 A-D).

Mean size of spotted seatrout differed significantly ($p < .001$) by habitat, being smaller in creeks, banks/flats, and shorelines than in basins/bays (Table 13). The difference in mean size was probably due to size selection of the different gears used (see below). All habitats successful for spotted seatrout contained small juveniles (< 40 mm S.L.).

Spotted seatrout occurred over a wide range of salinities (1-38%), temperatures (20-34 oC), and turbidities (0.9-38.0 NTU) but a narrow range of dissolved oxygen (7-9.6 ppm) and pH (6.8-8.6) (Table 14). There was no relation between size of fish and salinity or temperature. Although mean salinity of all spotted seatrout catches was 17.2%, the mid salinity range 12-24% was not adequately sampled.

Standard length-weight and standard length-total length relationships were calculated for juvenile spotted seatrout. A $\log_{10}$ transformation best fit the data (Table 15).

<u>Catches of juvenile spotted seatrout by individual gear types</u>:

Eighty-nine juvenile spotted seatrout were collected in 38% of all 15.2 m beach seine samples. The greatest proportion was taken in summer (July-September) from fishing areas 1 and 4 when the greatest sampling effort was made (Table 16, A & B). Juveniles were caught in most habitats sampled with this gear except creeks and shorelines in Florida Bay, mud ponds in the Whitewater Bay and Marco Island areas, and creeks in Shark River area. Fifty-eight percent of all juveniles caught by seine came from shoreline habitats of Coot and Whitewater Bays (Table 16 C).

Spotted seatrout were caught over a variety of seagrass types (all habitats combined) in proportion to the effort made (Table 16 D). Most (55%) successful catches came from *Thalassia* and *Halodule*-dominated beds where most effort (44%) was made. Fewer successful catches were taken from *Ruppia* beds. Among shoreline habitats, *Halodule* beds in Coot Bay produced by far the most juvenile spotted seatrout, whereas on banks most juvenile spotted seatrout were caught in *Thalassia* beds (Table 16 E).

Length of seine-caught spotted seatrout ranged from 20-121 mm S.L. ($\bar{x}$=48.6 $\pm$ 4.5 mm S.L.). Mean length of fish increased steadily from June to August, dropped in September and increased in November. There was no difference in mean length of fish among fishing areas 4 and 1.

One hundred one juvenile spotted seatrout were collected by the 475 micron mesh plankton net in 1982 and 1983. Although plankton samples were collected year round at numerous spots in Whitewater Bay and Florida Bay, these juveniles were taken on only 5 sample nights in the Coot Bay area in Tarpon Creek and Buttonwood Canal between July and September. Fish ranged in size from 17.0-75.0 mm S.L. ($\bar{x}$=32.5 $\pm$ 1.8 mm S.L.).

Roller frame trawl sampling for pink shrimp juveniles produced 39 spotted seatrout in 17% of the 104 samples collected from 1982 to 1984. Although most (53%) of the samples were taken in sparse *Halodule* basins of Whitewater Bay and Coot Bay, the majority (68%) of the thirty nine spotted seatrout collected came from dense *Thalassia* beds in western Florida Bay basins where 39% of the total effort was made. No juveniles were collected in 12 samples in east Florida Bay where marine algae was the dominant benthic vegetation. Thirty spotted seatrout (77%) were caught from April to October and 9 fish (23%) were caught in December. Fish ranged in length from 28-154 mm S.L. ($\bar{x}$=72.5 $\pm$ 12.1 mm S.L.). Mean lengths of fish caught in September and December were significantly ($p < .01$) greater than fish caught in July.

Four percent of 156 monthly sled net samples made from October 1981 to December 1984 captured a total of 15 spotted seatrout. All 15 individuals were caught in Coot Bay from May to August in sparse *Halodule* beds. Fish ranged in length from 19-48 mm S.L. ($\bar{x}$=32 $\pm$ 7.1 mm). No juvenile spotted seatrout were caught by 25' seine or rotenone.

NPS Study: 1973 - 1976

Schmidt collected 125 juvenile spotted seatrout 18-306 mm T.L. ($\bar{x}$=75.1 $\pm$ 11.7 mm T.L.) in three years of sampling. Seventy eight of these fish were caught in trawls. Only 11.5% of 192 trawls made produced spotted seatrout. Most trawled fish (85%) were caught in spring (April-June) and summer (Table 17 A). Most spotted seatrout (81%) were caught in basins and bays in fishing area 1 where most effort was made (Fig. 14) (Table 17 B). Among basins and bays in western Florida Bay, spotted seatrout were more common in *Syringodium*-dominated grassbeds than in *Thalassia*-dominated beds, even though most trawls (60%) were made in *Thalassia* grassbeds (Table 17 E).

Beach seine (15.2 m) collections produced a total of 47 juvenile spotted seatrout in 8% of 185 samples. Juveniles occurred more often in spring and summer, despite uniform sampling effort year round. All juveniles except one were collected in Halodule grassbeds of areas 1 and 3 (western Florida Bay), with 83% coming from a Halodule bed at the mouth of the Buttonwood Canal. Seining effort (50% of total) was unsuccessful in grassbeds of Thalassia and marine algae in western Florida Bay and in Halodule-dominated grassbeds sampled in eastern Florida Bay.

Mean length of spotted seatrout caught by otter trawl (90 mm ± 18.4) was greater than that caught by beach seine (56 ± 10.5 mm). Mean length of otter trawl catches was lowest in April-September and higher from October to March, although these differences were not significant due to low samples sizes. There was no difference in mean length of seine-caught spotted seatrout by month. Small spotted seatrout, <50 mm T.L. (40 mm S.L.), were collected in February, April-October, and December, indicating a protracted spawning season; most (64%) were caught in June and September. Small juveniles were caught in basins, channels, on banks and along shorelines. Ranges of environmental data for successful spotted seatrout collections by Schmidt (1979) are listed in Table 14.

Appendix III lists the 142 species caught with juvenile spotted seatrout in ENP in 1973-76 and 1982-84. The most common associated species were the pink shrimp *Penaeus duorarum* (69.2%), silver jenny *Eucinostomus gula* (56.4%), pinfish *Lagodon rhomboides* (48.1%), silver perch *Bairdiella chrysoura* (46.6%), rainwater killifish *Lucania parva* (39.1%), gulf pipefish *Syngnathus scovelli* (37.6%), and bay anchovy *Anchoa mitchilli* (33.1%). All common associated species (> 35% occurrence) were species associated with seagrass beds.

National Marine Fisheries Study: March 1984 - June 1985

A total of 158 juveniles was collected by NMFS sampling in Coot Bay, southeast Whitewater Bay and Florida Bay from March 1984 to June 1985 (Thayer et al. 1987). Spotted seatrout were collected on every sampling trip except March 1984 and January 1985. Fifty-two fish were caught in random samples among the five strata, 34 were caught in or adjacent to mangrove stations and an additional 72 were collected at regular stations near Bradley Key and Joe Kemp Key in western Florida Bay. Spotted seatrout juveniles were caught in every stratum but were most abundant in seagrass beds and channels in western Florida Bay (Fig. 15). Sixty percent (38) were collected in high density seagrass meadows of 1,000-4,000 shoots/m^2. Most fish (19) were caught in mixed seagrass beds of Thalassia, Halodule, and lush Syringodium. Multivariate analysis of variance (Manova) showed that successful spotted seatrout stations had significantly higher organic matter content, sediment thickness, and density and biomass of Syringodium than unsuccessful stations. Discriminant function analysis identified high Syringodium density and high percent organic matter as being most characteristic of spotted seatrout habitat. A discriminant function was developed for successful spotted seatrout stations and applied to all stations to see how well the criteria predicted spotted seatrout habitat. Sixty-one percent of successful spotted seatrout stations were correctly identified using environmental variables. Eighty-two percent of all unsuccessful spotted seatrout stations were correctly classified. Bradley Key and Joe Kemp Key, grass beds in western Florida Bay, provided especially good habitat for juvenile spotted seatrout. Twelve out of 13 stations there were identified by the discriminant analysis as spotted seatrout habitat and spotted seatrout were taken there on every trip.

Small juvenile spotted seatrout, ($<$ 25 mm S.L., 2-3 months old), were present May-November in concordance with abundance of larvae. The smallest spotted seatrout were caught in Whitewater Bay in June and in Florida Bay in June-July. Fish caught in channels were larger than those caught in seagrass beds, suggesting differential net avoidance or preference by small fish for seagrass beds. At the regular stations in western Florida Bay, spotted seatrout were smaller at Joe Kemp Key than at Bradley Key, possibly reflecting differential settlement patterns within a distance of less than 1 nautical mile.

Juvenile spotted seatrout were fully recruited to the otter trawl between 16-34 mm S.L. and were in most samples vulnerable to the gear through 144 mm S.L. (Fig. 16). The average monthly mortality rate calculated from this distribution for the period May 1984-March 1985 was 34.7%, which extrapolated over a year gives an annual rate of 99.38%.

Red Drum - Larvae

Only 21 red drum larvae were found in samples taken from March 1982 to December 1983. Red drum larvae were collected at four stations in Whitewater Bay and three stations in west Florida Bay from September to January; none were found in eastern Florida Bay (Fig. 17). Highest catches were taken in September and October, 1983 (Fig. 18). Samples in September 1983 indicated red drum larvae entered Whitewater Bay through Little Shark River and moved throughout the bay. Their abundance was too low and variable to warrant statistical analyses of catches among stations or months.

Red drum larvae ranged in length from 3.4-7.7 mm S.L. ($\bar{x}$=5.8 $\pm$ 0.5 mm S.L.). There was no significant difference in length of fish caught among stations or months.

Ranges of physical parameters when red drum were caught are listed in Table 18. No red drum larvae were reported in plankton samples collected by NMFS in Whitewater and Florida Bay from March 1984 to June 1985.

Juvenile Red Drum

Eighteen juvenile red drum (16-212 mm S.L.) were caught from December 1982 to August 1984. All sixteen fish smaller than 200 mm S.L. were caught by beach seine (n=13), explosives (n=2), and sled net (1) in low salinity areas of Whitewater Bay and near Marco Island from November to May (Fig. 17). Habitats in which they were found were shallow ($<$ 1.5 m), brackish, sparsely vegetated creeks and mangrove shorelines. The two larger fish ($>$200 mm S.L.) were taken by hook and line in a saline (32%) tidal mangrove creek in Cape Sable in June and August 1983.

Length of fish caught showed an increasing trend in size (mm) with month. The smallest red drum caught, 16 mm S.L., was taken by sled net in Coot Bay in December 1982, two months after the probable spawning peak in October. Fish caught in March-June 1983 were progressively larger in mean length from 81-207 mm S.L. Mean standard length dropped again in November-December 1983 to 22-36 mm as the fall 1983 recruits entered Whitewater Bay. Although sample sizes of these catches were low and sampling effort was not equal among areas, habitats or seasons, juveniles appeared to change habitat with size. The smallest red drum were caught in shallow grassbed areas of Whitewater Bay in late fall and winter. Juveniles were taken in mangrove creeks in spring and early summer. Environmental data for successful red drum catches are shown in Table 19.

No juvenile red drum were caught with roller frame trawl sampling in basin and bay habitats, nor were any juveniles caught during Schmidt's 1973-76 biomass study of Florida Bay in which channels, banks, and shorelines were sampled with otter trawl and seine. Subsequent randomized sampling by NMFS with otter trawl in 1984-85 failed to collect any red drum, however three small juvenile red drum (70-130 mm S.L.) were seined from the Buttonwood Canal boat ramp in March and May 1985.

Forty-seven species were collected, 1982-84, along with juvenile red drum (Appendix IV). Common associated species included the clown goby *Microgobius gulosus* (54.5%), bay anchovy (54.5%), rainwater killifish (45.5%), pink shrimp (36.4%), and spotted seatrout (36.4%).

Gray Snapper - Larvae

No gray snapper larvae were caught in NPS samples. Twenty-six snapper *spp.* larvae were caught by NMFS 1984-85, all from stations in southeast Florida Bay. Larvae $<$4.2 mm S.L. were caught at the Alligator Reef station while larger larvae were caught inshore of this station. Snapper larvae were caught June-August 1984 and September 1985, indicating a summer spawning period.

Juvenile Gray Snapper

NPS Studies: 1982-84, 1973-76

Only 18 gray snapper (40-332 mm F.L.) were collected from November 1982 to December 1984. Only three of these fish were below 100 mm F.L., the size at which they recruit into the sport fishery. The smallest juvenile (40 mm F.L.) was collected by roller frame trawl in November 1982 over *Thalassia* beds in western Florida Bay. All other fish were taken from April to November by seine on banks on western Florida Bay, along shorelines in Whitewater Bay and in a headwater canal near Marco Island, and by explosives in canals off Coot Bay. Physical parameters associated with these catches are shown in Table 20.

Additional information on juvenile gray snapper was provided by Schmidt's biomass study of Florida Bay 1973-76. He collected 142 fish 17-310 mm T.L. ($\bar{x}$=181 $\pm$ 5.1 mm) in channels, basins/bays, and along shorelines. Successful catches were fairly evenly distributed throughout the year, with slightly more fish being caught in summer (31%) and fall (28%) than in winter (21%) and spring (20%) (Table 17 A). The majority (91%) collected were caught by trawl, predominantly in western Florida Bay in Palm Key Basin and Sandy Key Basin (Fig. 19) where most sampling effort was made (Table 17 B). Numbers of gray snapper were higher in basin/bay habitats than in channels (Table 17 C). Comparison of trawl catches among basin/bay habitats in western Florida Bay showed that most successful catches (62%) came in *Syringodium*- dominated grassbeds even though most effort (60% of all trawl samples) was made in *Thalassia* beds (Table 17 E).

Seining for gray snapper was unproductive. Only 13 fish (17-310 mm T.L., n=10) were caught from 4% of all samples. All fish were collected in summer (n=10) and fall (n=3), mainly in areas 1 and 2. Most gray snapper (n=10) were caught over shallow *Thalassia* flats.

Mean lengths of gray snapper were smaller from November to February and June to August than from other months. Young of the year fish (< 100 mm T.L.) were caught in August, September, and November-January with the smallest individuals being caught in August. This is consistent with a reported spawning season of June-August (Starck 1964). Half of these small juveniles were caught in south Florida Bay (area 2), with the remainder spread over northeast and northwest Florida Bay (areas 1,3). Environmental data for successful gray snapper catches are listed in Table 20.

One hundred fifteen species were caught along with juvenile gray snapper in ENP in 1973-76 and 1982-84 (Appendix V). The most common associated species were silver jenny (84.4%), pinfish (81.1%), silver perch (56.7%), rainwater killifish (55.6%), white grunt *Haemulon plumieri* (54.4%), dusky pipefish *Sygnathus floridae* (55.6%). The common associated species (> 20% frequency occurrence) were species characteristic of seagrass beds in western Florida Bay (pinfish, silver jenny, silver perch) or seagrass beds near the Florida Keys (fringed filefish *Monacanthus ciliatus*, planehead filefish *M. hispidus*, emerald parrotfish *Nicholsima usta*) reflecting the dominant habitats in which gray snapper was found.

National Marine Fisheries Service Study: March 1984 - June 1985

Significant numbers (n=212) of juvenile gray snapper were also collected by recent NMFS studies in Whitewater and Florida Bay (Thayer et al. 1987). Juveniles were collected on every trip. Highest catches were taken in August and October 1984 and March and June 1985. Gray snapper were collected at all mangrove prop root stations and generally in channels near the Florida Keys and in banks/basins in western Florida Bay (Fig. 15). In Florida Bay gray snapper were caught in almost every channel sampled; 65% of all gray snapper collected in randomized samples were caught in channels. Seagrass densities at successful gray snapper stations were high (1,000-4,000 shoots/m^2). Seagrass beds in eastern Florida Bay channels contained *Thalassia* and *Halodule* while those in basin and bank stations in western Florida Bay contained *Thalassia* and *Syringodium* or *Syringodium* and *Halodule*. Successful gray snapper stations had significantly ($p < .05$) higher shoot densities and biomass of *Halodule* and *Syringodium* than unsuccessful gray snapper stations. Discriminant function analysis determined Halodule and Syringodium biomasses to be most characteristic of gray snapper habitat. Using these characteristics NMFS correctly predicted 68% of all successful gray snapper stations and 79% of all unsuccessful gray snapper stations. Grassbeds at Joe Kemp Key and Bradley Key in western Florida Bay were also good habitat for gray snapper. More gray snapper biomass was caught at Joe Kemp Key than at Bradley Key; smaller fish were collected at Bradley Key than at Joe Kemp Key. Small gray snapper ($<$ 36 mm S.L.) were collected in September, November, and January, suggesting a summer-fall spawning period.

Mortality rates were calculated for juvenile gray snapper caught by otter trawl in ENP in 1984-85 (Thayer et al. 1987). Gray snapper were recruited to the gear between 72-81 mm S.L. or approximately 9 months of age (Fig. 20). The monthly mortality rate, calculated from the regression slope of the descending limb (72-116 mm S.L.) of the age-frequency curve, was A=39.52%.

Snook - Larvae

No snook larvae were found in any of the NPS or NMFS plankton samples. Occurrence of snook in the plankton based upon spawning season is assumed to be May-November (Marshall 1958).

Juvenile Snook

Seventy-two juvenile snook 22-423 mm F.L. ($\bar{x}$=231 $\pm$ 43 mm) were caught from September 1983 to December 1984. Forty-eight juveniles 22-295 mm F.L. ($\bar{x}$=116 $\pm$ 40 mm) were caught by beach seine in shallow ($<$ 200 cm) headwater creeks, canals, and ponds north of Everglades National Park near Marco Island. Despite 16 trips to similar habitats in Whitewater Bay, no small snook were caught. Twenty four larger juveniles 269-423 mm F.L. ($\bar{x}$=335 $\pm$ 17 mm) were caught by hook and line and explosives in brackish rivers, mangrove creeks, and along mangrove shorelines in Whitewater Bay and Coot Bay. Sportfishermen also reported catching snook 305-405 mm F.L. (12-16 in) in Florida Bay during this time period (NPS unpublished data).

Juvenile snook appeared to utilize different habitats as they grew. Habitats in which young juveniles were caught were bare or sparsely vegetated with Ruppia maritima, Chara hornemanni, or freshwater plants (Nyas spp., Utricularia spp.). The smaller fish ($\bar{x}$=83 $\pm$ 70 mm F.L.: 22-295 mm) were collected in a headwater canal in August, September, and November. Assuming a reported growth rate of 1 mm/day (Fore and Schmidt 1973, Gilmore et al. 1983), small juveniles ($<$ 55 mm F.L.), were probably spawned June-September. Fish ranging in size 55-212 F.L. ($\bar{x}$=153 $\pm$ 38 mm) were caught in mud ponds from June to December. Fish ranging in size from 269-423 mm F.L. ($\bar{x}$=335 $\pm$ 17 mm) were taken in rivers, mangrove creeks, and along mangrove shorelines and were caught in January, April, and June-December. There was no correlation between fish length and salinity. Environmental data for successful catches of juvenile snook are shown in Table 21.

No juvenile snook were collected in Schmidt's 1973-76 study of Florida Bay. Three juvenile snook (370-390 mm S.L.) were taken by NMFS in 1984-85 in mangrove shorelines of lower Whitewater Bay and at Murray Key in Florida Bay.

Forty-seven species were collected along with juvenile snook from 1982 to 1984 (Appendix VI). The most common species were inland silverside *Menidia beryllina* (40.0%), rainwater killifish (33.3%), sailfin molly *Poecilia latipinna* (33.3%), and spotted seatrout (33.3%). Most of the common (> 20% frequency occurrence) associated species were euryhaline species associated with grassbeds (pinfish, spotted seatrout) or brackish mangrove creeks and marshes (inland silverside, clown goby, sailfin molly, mosquitofish, *Gambusia affinis*).

DISCUSSION

Spotted Seatrout

Spotted seatrout larvae and juveniles were found in most areas sampled in ENP, 1982-84, by NPS and NMFS personnel and were most abundant in western Florida Bay. The distribution of young spotted seatrout coincided with the distribution of adults. Harvest of adults is higher in western Florida Bay than in other park areas (Tilmant et al. 1986). Western Florida Bay has most of the characteristics listed by Tabb (1966) as favorable for abundance of spotted seatrout. It has extensive, lush (1,000-4,000 shoots/m^2) grassbed areas composed of *Thalassia testudinum*, *Halodule wrightii*, and *Syringodium filiforme*, areas of 3-6 m depth (i.e., channels) adjacent to grassflats to use as refuge from cold temperatures, and abundant food; NPS unpublished pink shrimp data show caridean and pink shrimp abundance in ENP is highest in western Florida Bay. NMFS found species diversity, biomass and density of seagrasses (mixed species) were highest in western Florida Bay (Thayer et al. 1987). However, other factors listed by Tabb (1966) as favorable for spotted seatrout abundance are missing from western Florida Bay. Large areas of brackish water and few predators and competitors are more characteristic of Whitewater Bay and northeast Florida Bay than of western Florida Bay. Although larval growth and survival (Taniguchi 1980) and juvenile metabolic rate (Wakeman and Wohlschlag 1977) are optimal in hyposaline (28 o/oo) waters, it may be more important to young-of-year spotted seatrout to optimize other environmental characteristics such as food and shelter than to optimize salinity.

Peak spawning of spotted seatrout, as represented by larval catches, varied by station and season in 1983. Comparison of larval catches at Little Shark River between 1966-67 and 1982-83 shows spotted seatrout were most abundant in May and June during 1966-67 and in June and August in 1983 (Fig. 21). Bimodal spawning in adult spotted seatrout has been documented previously in ENP (Stewart 1961; Rutherford et al. 1982) and in the Gulf (Hein and Shepard 1979a). Photoperiod (Hein and Shepard 1979a) and temperature have been suggested as initiating spawning in spotted seatrout (Tabb 1966; Jannke 1971; Hein and Shepard 1979a). Taniguchi (1980) found 100% survival of spotted seatrout eggs and larvae between 23.1-32.9 ^oC, with optimum temperature of 28.0 ^oC.

We recognize that using distributions of preflexion larvae will only give a rough estimate of spawning areas. Time from spawning to first feeding lasts approximately 3 days for spotted seatrout (Fable et al. 1978), thereby giving eggs and larvae ample time to disperse from the spawning site. Knowledge of currents outside Everglades National Park is sparse (Rehrer et al. 1967; Jannke 1971), further obscuring spawning locations.

Catches of larval spotted seatrout in ENP also fluctuated in annual abundance. Jannke (1971) found higher numbers of spotted seatrout larvae in 1966 than in 1967 at Little Shark River. Peak catches of larvae in 1983 were only slightly higher than in 1966 although a finer mesh net was used (333 micron as opposed to 475 micron) (Fig. 21). Variation in timing, duration, and location of larval catches could greatly affect predictions of year class strength.

Catches of spotted seatrout larvae in ENP were higher in 1983 than those reported by NMFS for estuarine coastal stations in 1971-72 (Collins and Finucane 1984). They used a larger mesh net (505 microns) and sampled in the day. Relative abundance of park spotted seatrout was also higher than that reported for Biscayne Bay, Florida, (Alpern 1981) using the same size mesh net. Other studies in the Gulf reported relative densities of larvae in the same range as our study (Sabins 1973; Daniels 1977).

Diurnal and tidal variation in spotted seatrout larval catches was studied in Louisiana by Sabins (1973). He caught more fish around a shallow bank during the day than at night and more on flood than on ebb tides. In both the NPS study and Jannke's study more spotted seatrout were caught at night on a flood tide. The difference may be due to sampling different habitats. Sabins sampled around an island adjacent to an inlet pass from the Gulf whereas park samples were taken directly in a pass. The larvae may settle out more during the day around shallow banks and then wait until night to ride currents into the bays. Net avoidance and protection from predators have been cited as reasons for higher nocturnal catches of ichthyoplankton (Thayer et al. 1983). NMFS personnel sampled in some of the same areas in 1984-85 as NPS personnel a year earlier and found no diurnal difference in catches of preflexion spotted seatrout, but greater nocturnal catches of larger larvae. Tidal stage was not recorded.

Variation in plankton catches with moon phase and depth was not studied by NPS. Jannke (1971) reported greatest catches of spotted seatrout and red drum larvae at Little Shark River near the bottom during the new and full moon. NMFS personnel reported higher catches of spotted seatrout larvae in step-oblique tows than in neuston tows 1984-1985.

The lack of correlation between spotted seatrout larval catches and current flow is surprising considering larvae are essentially planktonic and utilize currents to enter bays from offshore. Jannke (1971) found highest catches of spotted seatrout larvae at peak current speeds. It is possible that because we did not sample the whole tidal cycle we found no correlation.

There was no relationship between larval or juvenile spotted seatrout catches and other environmental variables (temperature, salinity) in earlier park studies (Roessler 1967; Jannke 1971). In a study of fishes entering Buttonwood Canal from Florida Bay, Roessler (1967) found season was the most important environmental factor influencing catches of fishes. He hypothesized that temperature and salinity may be more important factors at the spawning site than at his station in the Buttonwood Canal.

Spotted seatrout are known to spawn in channels, holes, and other deep-waters of inland bays (Pearson 1929; Tabb 1966; Mok and Gilmore 1983) and also offshore in the Gulf near passes and barrier islands (Jannke 1971; King 1971; Christmas and Waller 1973). Location of spawning is probably related to optimum salinities, current, and depth. Taniguchi (1980) predicted 100% survival of eggs and larvae in salinities between 18.6-37.5 $^{o}/oo$ with optimum survival at 28 $^{o}/oo$. In this study, preflexion larvae were caught in shallow areas of eastern Florida Bay and deeper areas of western Florida Bay and Shark River. Most were collected in western Florida Bay where salinities and temperatures are stable and water is deep relative to other park areas. Stewart (1961) found most ripe and running adult fish in this area. Rutherford et al. (1983) found most ripe adult fish in 1979 in Whitewater Bay although they made special effort to collect fish there. Salinities in Whitewater Bay were high as 1979 was a dry year. A 1971-72 NMFS ichthyoplankton study along S.W. Florida collected most spotted seatrout larvae between the 6 fathom isobath outside of the park's western boundary and passes leading to bays; very few larvae were collected in inshore bays or further offshore ($>$15 m isobath) in the Gulf (Houde et al. 1979; Collins and Finucane 1984).

Annual variability was apparent in distribution and relative abundance of juvenile spotted seatrout. Larger larvae and young juveniles were found inshore in 1983 in Coot Bay, lower Whitewater Bay and in western Florida Bay. National Marine Fisheries Service found most juveniles in 1984-85 in western Florida Bay but fewer in lower Whitewater Bay and Coot Bay. From the closing of the Buttonwood Canal in June 1982 to 1984, continuous low salinities (NPS unpublished hydrology data) in Coot Bay changed the dominant benthic vegetation from Thalassia and Halodule to Ruppia and Chara, possibly causing the decline in numbers of spotted seatrout caught there.

Tabb and Manning (1961) reported catching only four young-of-year spotted seatrout despite intensive sampling of Whitewater Bay, Coot Bay and Florida Bay with otter trawl and other gear from 1957 to 1960. They concluded that little or no spawning occurred in the park for at least that time period. Other collections of juvenile spotted seatrout in ENP were made by Roessler (1967) in Buttonwood Canal, Clark (1971) in Whitewater Bay and NMFS (1971-74) in the inland bays near Everglades City. They all collected young-of-year fish from April to December.

Spotted seatrout juveniles were found in almost all habitats sampled, however the majority were caught over seagrass beds dominated by Halodule, Thalassia, or Syringodium. Utilization of grassbeds by young-of-year spotted seatrout has been well-documented in Florida (Moody 1950; Reid 1954; Tabb 1961; Peters, Florida DNR pers. comm.) and in the Gulf (Pearson 1929; Miles 1949; Guest and Gunter 1958). Spotted seatrout juveniles were also found in mangrove creeks and canals in Whitewater and Coot Bay which were devoid of benthic vegetation. They were absent from marsh pond habitats in the headwaters of rivers and the mangrove prop-root habitat in both Whitewater and Florida Bays. In areas of limited benthic vegetation such as Louisiana estuaries, young spotted seatrout utilize the oyster bars and shallow shell banks for cover (Sabins 1973; Perret et al. 1980). Herke et al. (1984a) caught few young-of-year spotted seatrout in Louisiana coastal marshes relative to other species and postulated they used bays or nearshore Gulf waters.

Spotted Seatrout Mortality Rate

Estimated monthly mortality rates for young-of-year spotted seatrout, expanded over a year's time were higher than annual rates published for adult spotted seatrout (Tilmant et al. 1986; Tatum 1980) (Table 22). Monthly mortality values calculated for other juvenile fish species were 18.1-62.1% for 12-96 mm T.L. spot in Virginia (calculated using data from Weinstein and Walters 1981; Weinstein 1983) and 64-88% for 3-10 month old northern anchovy in California (Methot 1981). There are no published mortality estimates for larval spotted seatrout.

Our mortality estimates depend heavily on the accuracy for ENP spotted seatrout of the average monthly growth rate developed for young-of-year Tampa Bay spotted seatrout. More direct measurements of age and growth using otoliths and mark and recapture experiments would provide better estimates of mortality.

Gear Selectivity

Size range of small spotted seatrout larvae sampled by the 475 micron and 333 micron mesh nets was the same although the 475 micron mesh net collected more large spotted seatrout. It is unknown whether this was due to the different size ranges of the fish at those stations or to selectivity of the mesh sizes. The gears used to sample juvenile fishes were size selective. The otter trawl collected size ranges of spotted seatrout that overlapped those of the other gears. Although no gear sampled all size ranges or habitats well the two-boat otter trawl covered them better than other gears, in particular for basins/bays and channels. No efficiency tests were made by NPS for any fish species with any gear. NMFS personnel estimated 70% efficiency for the block net-rotenone method of sampling mangrove prop roots.

Red Drum

Results of this study and previous park studies of red drum larvae indicate a relatively short fall spawning period near the park's western boundary (Jannke 1971; Collins and Finucane 1984). Jannke reported catches of red drum larvae at Little Shark River in 1966 and 1967 from August to February with peaks in October (Fig. 22). Collins and Finucane (1984) reported larvae in offshore stations in August and November 1973. Other ichthyoplankton studies in the Gulf of Mexico indicate a fall spawning period (Sabins 1973; Holt et al. 1983; Peters and McMichael, in prep.).

Size of the smallest red drum larvae caught in this study or Jannke's study (>3.4 mm S.L.) was greater than sizes reported at hatching (1.8 mm S.L.) or first feeding (2.6 mm S.L.) (Holt et al. 1981; Lee et al. 1984), indicating that these larvae were probably spawned days before and carried by currents into the park. Most larvae caught by NMFS in 1971-72 occurred further offshore (26 m isobath) from Everglades City passes and were smaller (1.6-3.2 mm S.L.) (Collins and Finucane, 1984). Red drum are known to spawn offshore or near passes with larvae entering estuaries such as Whitewater Bay to spend their first four years of life (Pearson 1929; Miles 1950; Yokel 1966). Although some instances of estuarine spawning have been reported elsewhere (Murphy and Taylor, in prep.), few ripe and running adults have ever been taken in ENP waters (Buker et al. in prep).

Catches of red drum larvae appeared to be much higher at Little Shark River in 1966-67 than in 1982-83 (Fig. 22). The low catches in 1982-84 of red drum larvae during their peak season of abundance may reflect poor sampling effort. Only one station, Little Shark River was sampled during October when red drum are reportedly most abundant. NMFS sampled in September and November of 1984. Since red drum larvae enter the park over a short period of 2-3 months, we may have missed the peak by sampling monthly only at a few stations.

It is equally possible that there were reduced numbers of red drum larvae entering ENP in 1982-84. Fishing mortality on juvenile red drum in ENP and Florida's west coast is believed to be extremely high (Tilmant et al. 1986; Murphy and Taylor, in prep.). Murphy and Taylor (in prep.) report the age structure of Florida's estuarine and Gulf coast red drum population to be composed of young estuarine fish aged 1-4 and old fish aged 15-20, with few young adults. They suggest that intense fishing mortality experienced inshore by juvenile fish kills off most of the potential spawners before they can reproduce, leaving only a few old fish to supply eggs and larvae. If this scenario of low spawning stock is true, the potential is great for recruitment overfishing and a collapse of the fishery.

The few red drum juveniles collected in this study were taken shortly after larval catches at Little Shark River in the brackish, shallow grassbeds of Whitewater and Coot Bay. Later in the spring, they were found in mangrove creeks and rivers. Very few prior collections of red drum juveniles have been made in ENP. Tabb and Manning (1961) collected 5 juveniles, 70-120 mm T.L., in Coot Bay Pond in May 1959. Yokel (1966) collected 9 postlarvae (8-12 mm T.L.) from October to January in Little Sable Creek and Buttonwood Canal and one juvenile (37.5 mm T.L.) in January by seine near Chokoloskee, FL. Tabb (unpubl.) collected three juveniles (19-33 mm T.L.) with otter trawl at the Broad River mouth November 1966. Roessler (1967) caught 107 juveniles, 30-85 mm T.L., in Buttonwood Canal November 1963-May 1964. Odum (1971) caught 47 postlarvae moving up the North River in Whitewater Bay.

Most earlier studies of estuarine fishes in Everglades National Park used roller frame trawls or otter trawls (Tabb unpubl. data 1965-66; Clark 1971; Lindall et al. 1973; Schmidt, NPS unpubl. data 1979-80). Juvenile red drum are able to elude trawls by sliding under them or avoiding their path (Yokel 1966; McMichael, Florida DNR pers. comm.). Only Tabb and Manning

(1961), Odum (1971), and Tabb, Drummond and Kenney (1974) sampled the brackish backwater areas that small red drum apparently inhabit (Peters and McMichael, in prep.). We sampled few brackish ponds off Whitewater Bay during October 1982-January 1984 when small juvenile red drum would be most abundant.

Red drum juveniles may also utilize a different habitat altogether in the park. Most recruits (less than 400 mm F.L.) to the park red drum fishery are caught in Lake Ingraham on Cape Sable, a shallow hypersaline lake adjacent to the Gulf of Mexico (Buker et al. in prep.). Young-of-year red drum may enter the lake as larvae and grow up there or may migrate down the coast in late summer and fall, although all tagging studies of red drum indicate that they are essentially non-migratory (Beaumariage 1969; Osburn et al. 1982).

The failure to catch juvenile red drum in Florida Bay from 1982 to 1984 by any gear type does not necessarily reflect their relative abundance. Roessler (1967) caught 107 juveniles 30-85 mm T.L. in Buttonwood Canal, most of whom were moving from Florida Bay to Coot Bay. Peters and McMichael (in prep.) in Tampa Bay found red drum 9-29 mm S.L. along shorelines over soft mud or sandy bottom, with submerged vegetation and little current, and in shallow backwater areas of low salinity and muddy bottom. It is possible that juvenile red drum inhabit grassbeds in Florida Bay after settling out from the plankton and then move up into the brackish creeks and bays before they are large enough to be caught in seines (20 mm S.L.). We failed to find small red drum in limited sampling of creeks and bays off of Florida Bay.

In Tampa Bay, Peters and McMichael (in prep) collected red drum, 30-104 mm S.L., with seine in semi-exposed areas such as river mouths with mud or sand bottoms, little cover, and moderately low salinities and currents. Fish (> 105 mm S.L.) were found in exposed areas of embankments and rivers in mangrove-lined tidal creeks, and in boat basins throughout Tampa Bay in salinities of 12-25 o/oo (Peters and McMichael, in prep.). Pearson (1929), Springer and Woodburn (1960), and Holt et al. (1983) found juvenile red drum along shorelines and in seagrass beds of _Ruppia maritima_ or _Halodule wrightii_.

Most age and growth studies suggest that red drum enter the fishery (18 inches T.L. size limit) around their second spring as one year old fish (Pearson 1929; Bass and Avault 1975; Theiling and Loyocano 1974; Murphy and Taylor in prep.; Buker et al. in prep.). Recruitment is therefore fixed two falls earlier by adult fish outside of park waters.

Gray Snapper

Gray snapper apparently spawn outside of park waters and enter ENP as young juveniles. Starck (1964) reported spawning by adult gray snapper off Alligator Reef near Matecumbe Key, Fla. in June-September. Few ripe and running adult gray snapper have ever been reported in ENP, although mature adult fish with undeveloped gonads are abundant (Croker 1960; Rutherford et al. 1983). Only 26 snapper larvae were caught in recent ichthyoplankton samples 1982-85 in ENP, the youngest of which were caught near reefs outside the park. Before gray snapper larvae were described in 1980 by

Richards and Saksena (1980), Lutjanidae larvae were identified to the family level. Only eight Lutjanidae larvae were collected in park waters and nearshore in 1971-72 (Collins and Finucane 1984), while catches further offshore in the eastern Gulf of Mexico were much higher. Houde et al. (1979) collected 1,753 lutjanid larvae in 1971-74, most of which were Lutjanus sp.

Young juvenile gray snapper, 10-20 mm S.L., appear in grass beds in June-November (Starck 1964), after what is assumed to be a relatively short larval life of 25-40 days (Richards and Saksena 1980). The smallest juvenile gray snapper caught by NPS or NMFS personnel in ENP were collected in August, September, and November-January, suggesting a summer-fall spawning period. Tabb and Manning (1961) collected fish 20-35 mm T.L. in Whitewater Bay and in Florida Bay around Flamingo from September to February. Clark (1971) reported gray snapper recruits in Whitewater Bay in fall 1968 and 1969. Studies in other areas of Florida report catching small juvenile gray snapper from September to January in grassbeds (Reid 1954; Springer and Woodburn 1960).

Starck's (1964) observations of habitat use by juvenile gray snapper around the Florida Keys are applicable to recent NPS and NMFS studies. After inhabiting grassbeds and nearshore environments until 70-90 mm, they begin to congregate around snags, brush, on or near grass flats, near edges of channels and along mangrove shorelines at 90-210 mm S.L. or ages 1-3. Fish (170-210 mm S.L.) were collected in deeper water 10-20 ft of surrounding channels and bays. Fish over 200 mm S.L. were reported moving offshore to patch reefs, wrecks, and outer reefs (Starck 1964).

Schmidt (1979) reported higher catch rates of juveniles in basins than in channels, sampling mainly in western Florida Bay. Length ranges and mean lengths of fish were similar in both habitats with the smallest gray snapper in south Florida Bay shoreline grassbeds. NMFS randomly sampled throughout Florida Bay and the distribution they found is probably more representative. They caught gray snapper in channels in eastern Florida Bay and in basins and banks in western Florida Bay where fish biomass, species diversity and seagrass abundance and biomass were highest of areas sampled. Mangrove shoreline was significant habitat for gray snapper in Whitewater Bay and Florida Bay. Locations of the smallest gray snapper taken during their study were not specified. NPS collections of juvenile gray snapper in 1982-84 were probably low because they are not easily taken in gears used by the shrimp project, roller frame trawl and sled net, and were not common in the shallow flats or shorelines sampled by beach seine.

Gray snapper appeared to utilize Syringodium-dominant grassbeds more than Thalassia or Halodule-dominant beds during Schmidt's 1973-76 study. They were abundant in mixed seagrass beds (1,000-4,000 shoots/m^2) of Halodule and Syringodium grassbeds in Florida Bay in the 1984-85 NMFS study. Gray snapper juveniles were common in seagrass beds in western Florida Bay where juvenile spotted seatrout were often collected.

No juvenile gray snapper were collected in headwater ponds and only one was collected in a brackish water canal near Marco Island. Odum (1971) and Tabb et al. (1974) reported catching numerous juvenile gray snapper in the brackish rivers off Whitewater Bay. Tabb et al. (1974) stated that in Whitewater Bay, juvenile gray snapper utilize the "edge" habitat, that being river channel edges, mangrove prop roots and snags, and are not commonly trawled in open water grassbeds as are lane snapper Lutjanus synagris. Clark (1971), Lindall et al. (1973), and Schmidt (1979-80 NPS unpubl. data) all collected very few juvenile gray snapper by roller frame or otter trawl in Whitewater Bay. NPS creel surveys indicate that the size range of gray snapper caught in Whitewater Bay (68-445 mm F.L.) is greater than the range mentioned by Starck (1964) as inhabiting snags and mangrove roots. Otter trawl samples were successful for gray snapper in Florida Bay because of their abundance in basins and channels.

As with spotted seatrout, there was no relationship between catches of gray snapper and environmental parameters in 1973-76. Gray snapper can tolerate wide ranges in salinity (Starch 1964). Work by Reid (1954), Springer and Woodburn (1960), and Clark (1971) demonstrated that bottom cover explains most of the variability in fish distribution in Gulf coast estuaries while changes in abundance at a site are related more to seasonality than to any environmental factor measured (Reid 1954; Springer and Woodburn 1960; Roessler 1967; Clark 1971; Jannke 1971).

Monthly mortality rate of juvenile gray snapper was comparable to that calculated for juvenile spotted seatrout. Annual mortality of recruited gray snapper, A=72.2% (Tilmant et al. 1986), was not as high as juvenile gray snapper mortality extended over a year (A=99.8%).

Recruitment of gray snapper takes place in winter when fish spawned in the summer of the previous year enter the fishery (Croker 1960). Estimation of growth rates based upon monthly length-frequency distributions was not possible because mean lengths of fish caught did not vary greatly from month to month.

Snook

Small juvenile snook, $<$200 mm F.L., were caught during this study in headwater ponds and canals near Marco Island, northwest of the park. Previous studies in southwest Florida by Fore and Schmidt (1973) and in east central Florida by Gilmore et al. (1983) using seines and rotenone identified the habitat of small juvenile snook in brackish to fresh upland marshes and streams. Sampling in headwater areas of Whitewater Bay rivers with seine and rotenone during the period of their peak abundance (August-November), failed to produce young juveniles. Either few small juvenile snook were present or we missed them.

Since very few adult snook have been caught in the Whitewater Bay and Florida Bay areas in recent years (Tilmant et al. 1986), it is possible few larvae entered the estuary to grow up. No snook larvae were caught during 1982-84 by NPS or NMFS personnel, nor were any reported by NMFS in 1971-72 (Collins and Finucane 1984). Until recently, collections of snook larvae were rare anywhere in Florida (Gilmore et al. 1983; McMichael, Florida DNR pers. comm.).

Only 5 young-of-year snook were caught in earlier sampling efforts in marsh-creek habitats by Tabb and Manning (1961), Odum (1971), Tabb et al. (1974). These snook were caught in a roadside canal off Coot Bay Pond in May 1959 and were not measured.

In east central Florida, as snook grow to 172-345 mm F.L. (7-9 months) during March, they migrate out of the marshes into seagrass beds (Gilmore et al. 1983). Numerous juvenile snook, 270-420 mm F.L., were caught in ENP during 1983-84 along shorelines and in mangrove creeks and canals in both Whitewater Bay and Florida Bay. It is not known whether these fish moved into lower Whitewater Bay and Florida Bay from the upper west coast or were spawned here and overwintered.

By the time snook reach 457 mm F.L. (18 in), they are two-three years old and approximately half are mature (Marshall 1958; Thue et al. 1983). The new state regulations increased the minimum size limit to 584 mm T.L. or 3-4 years old, as well as closed off fishing during the spawning season, thereby insuring that snook will have a chance to spawn before being caught. Based on the results of the park's creel survey, snook recruitment may depend in part on higher than average rainfall, which by lowering salinities in more headwater creek and marshes would make available more habitat where snook spend their first seven months. After the 1982-83 period of heavy rainfall in south Florida, large numbers of juvenile snook, 300-400 mm F.L., were caught by fishermen in the park, suggesting lower salinities improved survival. Recruitment to the park fishery declined (Tilmant et al. 1986; Thue et al. 1983) during the dryer than average years of 1974-81 (NOAA climatological data).

Little is known about the age and growth of prerecruited snook. Fore and Schmidt (1973) and Gilmore et al. (1983) report juvenile snook reach an average length of 270 mm F.L. at 7-9 months in March, following their hatching date of June-August. Volpe (1959) used a back calculation formula without a correction factor and estimated one year old fish to be 160 mm F.L. Thue et al. (1983), using a formula with a correction factor reported mean length of one year old snook to be 375 mm F.L. Assuming snook start forming their first annulus during the spring (March-June) following spawning they will probably grow less than 375 mm F.L. Thue et al.'s (1983) sample of aged fish was biased towards older fish, making their estimates of size at earlier ages larger than the real mean.

Estimation of Year Class Strength

No quantitative estimate of year class strength based on samples of prerecruits was obtained for any of the target species. Habitat, relative abundance and distribution of park juvenile spotted seatrout and gray snapper were only recently quantified. Habitat and distribution of juvenile snook and red drum have not yet been established. Any estimate of year class strength based on juvenile prerecruits would require years of sampling prerecruits to correlate their relative abundance with creel survey recruitment estimates.

Estimation of recruitment using larval catches would not be desirable because of the effort and cost in sampling and the inherent variability in larval catches among tows at a location and among locations. Houde and Lovdal (1984) demonstrated fine-scale patchiness at the 10-1000 m scale for larval bay anchovy (Anchoa mitchilli) in Biscayne Bay, Florida. We found great variability relative to the mean in spotted seatrout catches. Estimation of year class strength is probably more feasible by sampling post-larvae or juveniles rather than by sampling larvae.

CONCLUSIONS

Spotted seatrout spawn in park waters in medium to high salinities, predominantly in western Florida Bay. Distribution of larvae and juveniles coincides with adult distribution; spotted seatrout are most abundant in areas of greatest seagrass density and biomass and prey (shrimp) density in Florida Bay. Spotted seatrout larvae were caught all year, but were most abundant in late spring or summer. Larval catches varied among years, but showed no significant declines from catches collected twenty years before.

Gray snapper spawn outside of park waters and probably enter the park as post-flexion larvae or early juveniles from June to January, with a peak in June-August. Problems in identification of snapper larvae remain. Catch of small juveniles indicates settlement in southeast and south Florida Bay grassbeds. Juvenile gray snapper utilize the mangrove prop root habitat in Whitewater Bay and Florida Bay and lush seagrass beds in channels and basins in Florida Bay.

Red drum spawn outside of park waters and enter Whitewater Bay and western Florida Bay in fall. The reduction in larval catches from previous years indicates either reduced relative abundance from 20 years before or inadequate sampling. Juvenile red drum appear to use shallow, brackish water areas in Whitewater Bay.

Snook spawning locations and habitats of small juveniles remain unknown in ENP. Small juveniles caught northwest of the park inhabit quiet brackish or fresh water ponds near tidal headwaters of rivers. Larger juvenile snook (> 300 mm F.L.) utilize mangrove shorelines and creeks in Whitewater Bay and Florida Bay. Strong recruitment in 1983-84 appeared related to abundant rainfall 1982-83.

NMFS was able to quantify juvenile spotted seatrout and gray snapper habitat using multivariate statistical methods. Both species are common in lush (1000-4000 shoots/m^2) mixed-species seagrass beds in western Florida Bay where densities of Halodule wrightii and Syringodium filiforme are higher than areas without these target species.

Estimation of annual recruitment will probably be most feasible by sampling juvenile and not larval stages because of great variability and high cost of sampling larvae.

ACKNOWLEDGEMENTS

We would like to acknowledge the following people for their contributions to this report. Edith Thue and Peggy Harrigan spent many hours collecting icthyoplankton and juvenile gamefish, and Peggy, along with David Buker and John Hampp, wrote programs for data storage. Park service data used in this report were also collected by John Hampp, John Holt, Kristin Larsen, Ilsa Patton, Dr. Edward Petuch, Ann Ramus, George Schmahl, Virginia Schmahl, Dr. Enid Sisskin, and Roger Stone. Annette Cordano patiently edited and entered the data. Steve Berkeley, Lise Dowd, Dane Herring, James Leak and associates sorted and identified the plankton samples. The Beaufort Lab, National Marine Fisheries Service, graciously provided length data from their collections for estimates of juvenile gamefish mortality. Kevin Peters and Bob McMichael of Florida D.N.R. reviewed this report. Barbara Blair and Claudette Doffermyre typed the manuscript.

LITERATURE CITED

Alpern, J. D. 1981. Relationships between larval fishes and their prey in Biscayne Bay, Florida. Master's Thesis. Univ. of Miami. Coral Gables, Florida.

Bass, R. J., and Avault, J. W., Jr. 1975. Food habits, length-weight relationship, condition factor, and growth of juvenile red drum, *Sciaenops ocellata*, in Louisiana. Trans. Am. Fish. Soc. 104:35-45.

Beaumariage, D. S. 1969. Returns from the 1965 Schlitz tagging program, including a cumulative analysis of previous results. Tech. Ser. No. 59. St. Petersburg, Florida: Florida Dept. Nat. Resources, Mar. Res. Lab.

Buker, D. G., Rutherford, E. S., and Thue, E. B. Age and growth of red drum *Sciaenops ocellatus* in Everglades National Park. Technical Report. Homestead, Florida: Everglades N.P., South Florida Research Center. In prep.

Carr, W. E. S., and Adams, C. A. 1973. Food habits of juvenile marine fishes occupying seagrass beds in the estuarine zone near Crystal River, Florida. Trans. Am. Fish. Soc. 102(3):511-540.

Christmas, J. Y., and Waller, R. S. 1973. Cooperative Gulf of Mexico estuarine inventory and study, Mississippi. Phase IV: Biology. Section 5. Estuarine vertebrates, Mississippi. Miss. Mar. Conserv. Comm.: 320-406.

Clark, S. H. 1971. Factors affecting the distribution of fishes in Whitewater Bay, Everglades National Park, Florida. Sea Grant Tech. Bull. No. 8. Miami, Florida: Univ. of Miami Sea Grant Program.

Collins, L. A., and Finucane, J. H. 1984. Icthyoplankton survey of the estuarine and inshore waters of the Florida Everglades, May 1971 to February 1972. NOAA Tech. Rept. NMFS 6. Washington D.C.: National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce.

Croker, R. A. 1960. A contribution to the life history of the gray (mangrove) snapper *Lutjanus griseus* (Linnaeus). Master's Thesis. Coral Gables, Florida: Univ. of Miami.

Daniels, K. L. 1977. Description, comparison and distribution of larvae of *Cynoscion nebulous* and *Cynoscion arenarius* from the northern Gulf of Mexico. Master's Thesis. Louisiana State Univ. Baton Rouge, Louisiana.

Davis, G. E. 1980. Changes in the Everglades National Park red drum and spotted seatrout fisheries 1958-1978: Fishing pressure, environmental stress, or natural cycles? Proc. Colloq. on the biology and management of red drum and seatrout. Spec. Rept. No. 5:81-87. Ocean Springs, Mississippi: Gulf States Mar. Fish. Comm.

Fable, W. A., Jr., Williams, T. D., and Arnold, C. R. 1978. Description of reared eggs and young larvae of the spotted seatrout Cynoscion nebulosus. U.S. Nat'l. Mar. Fish. Serv. Fish. Bull. 76:65-71.

Fore, P. L., and Schmidt, T. W. 1973. Biology of juvenile and adult snook, Centropumus undecimalis, in the Ten Thousand Islands, Florida. Chapter 16. In Ecosystems Analyses of the Big Cypress Swamp and Estuaries. EPA 904/9-74-002 N.P. Atlanta, Georgia: U.S. Environmental Protection Agency, Surveillance and Analysis Division.

Gilmore, R. G., Donohoe, C. J., and Cooke, D. W. 1983. Observations on the distribution and biology of east central Florida populations of the common snook Centropomus undecimalis (Bloch). Florida Sci. 46(3/4):313-336.

Guest, W. C., and Gunter, G. 1958. The seatrout or weakfishes (genus Cynoscion) of the Gulf of Mexico. Tech. Summary 1. Ocean Springs, Mississippi: Gulf States Mar. Fish. Comm.

Harrington, R. W. and Harrington, E. S. 1961. Food selection among fishes invading a high subtropical marsh: from onset of flooding through the progress of a mosquito brood. Ecol. 42:646-666.

Hein, S., and Shepard, J. 1979. Spawning of spotted seatrout in a Louisiana estuarine ecosystem. Proc. Ann. Conf. S.E. Assoc. Fish and Wildl. Agencies 33:451-465.

Herke, W. H., Rogers, B. D., and Knudsen, E. E. 1984a. Habits and habitats of young spotted seatrout in Louisiana marshes. Report 3. Baton Rouge, Louisiana: Louisiana State Univ. Agric. Center, School of Forestry, Wildlife and Fisheries.

Higman, J. B. 1966. Relationship between catch rates of sport fish and environmental conditions in Everglades National Park, Florida. Proc. 19th Ann. Ses. Gulf Caribb. Fish. Inst. 19:129-140.

Holt, J., Godbout, R., and Arnold, C. R. 1981. Effects of temperature and salinity on egg hatching and larval survival of red drum, Sciaenops ocellata. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 79(3):569-573.

Holt, S. A., Kitting, C. L., and Arnold, C. R. 1983. Distribution of young red drums among different sea-grass meadows. Trans. Am. Fish. Soc. 112:267-271.

Houde, E. D., Leak, J. C., Dowd, C. E., Berkeley, S. A., and Richards, W. J. 1979. Ichthyoplankton abundance and diversity in the eastern Gulf of Mexico. Report to Bur. Land Mgmt., Contract No. AA550-CT7-28. Miami, Florida: Univ. of Miami, Rosenstiel School of Marine and Atmospheric Sciences.

Houde, E. D., and Alpern Lovdal, J. D. 1985. Patterns of variability in ichthyoplankton occurrence and abundance in Biscayne Bay, Florida. Est. Coastal Shelf Sci. 20:79-103.

Jannke, T. E. 1971. Abundance of young sciaenid fishes in Everglades National Park, Florida in relation to season and other variables. Univ. Miami Sea Grant Tech. Bull. 11. Miami, Florida: Univ. of Miami Sea Grant Program.

King, B. D., III. 1971. Study of migratory patterns of fish and shellfish through a natural pass. Tech. Ser. 9. Rockport, Texas: Tex. Parks Wildl. Dept.

Leak, J. C. 1984. Growth and survival of bay anchovy, Anchoa mitchilli, larvae in north Biscayne Bay, Florida. PhD. Dissertation. Coral Gables, Florida: Univ. of Miami.

Lee, W. L., Holt, G. J., and Arnold, C. R. 1984. Growth of red drum larvae in the laboratory. Trans. Am. Fish. Soc. 113:243-246.

Lindall, W. N., Jr., Hall, J. R., Fable, W. A., Jr., and Collins, L. A. 1973. A survey of fishes and commercial invertebrates of the nearshore and estuarine zone between Cape Romano and Cape Sable, Florida. South Florida Environmental Project. Ecology Report No. DI-SFEP-74-44. St. Petersburg, Florida: National Marine Fisheries Service.

Loman, M. 1978. Other finfish. In Fisheries assessment and monitoring - Mississippi, p. 143-147. Complete Rep. P.L. 88-309, 2-215-R. Ocean Springs, Mississippi: Gulf Coast Research Lab.

Marshall, A. R. 1958. A survey of the snook fishery of Florida, with studies of the principal species, Centropomus undecimalis (Bloch). Florida St. Brd. Conserv. Tech. Ser. No. 22. Miami, Florida: Univ. of Miami, Rosenstiel School of Marine and Atmospheric Sciences.

Mercer, L. P. 1984. A biological and fisheries profile of red drum, Sciaenops ocellatus. Spec. Sci. Rept. 41. Morehead City, North Carolina: North Carolina Dept. Nat. Res. and Comm. Dev., Div. Mar. Fish.

Methot, R. D., Jr. 1983. Seasonal variation in survival of larval northern anchovy, Engraulis mordax estimated from the age distribution of juveniles. Fish. Bull. 81(4):741-750.

Miles, D. W. 1950. The life histories of spotted seatrout, Cynoscion nebulosus, and the redfish, Sciaenops ocellatus. Mar. Lab. Ann. Rept., 1949-1950. Rockport, Texas: Tex. Game Fish. Comm.

Mok, H. K., and Gilmore, R. G. 1983. Analysis of sound production in estuarine aggregations of Pogonias cromis, Bairdiella chrysoura, and Cynoscion nebulosus (Sciaenidae). Bull. Inst. Zool., Acad. Sin. (Taipei) 22(2):157-196.

Moody, W. D. 1950. A study of the natural history of spotted trout, Cynoscion nebulosus, in the Cedar Key, Florida area. Q. J. FL Acad. Sci. 12:147-171.

Murphy, M. D., and Taylor, R. G. Reproduction, growth and mortality of red drum Sciaenops ocellatus, in Florida. In prep.

Odum, W. E. 1971. Pathways of energy flow in a south Florida estuary. Sea Grant Tech. Bull. No. 7. Miami, Florida: Univ. of Miami Sea Grant Program.

Osburn, H. R., Matlock, G. C., and Green, A. W. 1982. Red drum (Sciaenops ocellatus) movement in Texas bays. Contrib. Mar. Sci. 25:85-97.

Pearson, J. C. 1929. Natural history and conservation of redfish and other commercial sciaenids on the Texas coast. Bull. U.S. Bur. Fish. 44:129-214.

Perret, W. S., Weaver, J. E., Williams, R. O., Johansen, P. L., McIlwain, T. D., Raulerson, R. C., and Tatum, W. M. 1980. Fishery profiles of red drum and spotted seatrout. No. 6. Ocean Springs, Mississippi: Gulf States Mar. Fish. Comm.

Peters, K. P., and R. H. McMichael, Jr. In Prep. Early life history of the red drum, Sciaenops ocellatus (Pisces: Sciaenidae) in Tampa Bay, Florida. Fla. Dept. Nat. Res., Bur. Mar. Res. St. Petersburg, Fl.

Powell, A. B., D. E. Hoss, W. F. Hettler, D. S. Peters, L. Simoneaux, and S. Wagner. Abundance and distribution of ichthyoplankton in Florida Bay and adjacent waters. National Park Service, South Florida Research Center, Technical Report SFRC-87/01.

Rehrer, R., Jones, A. C., and Roessler, M. A. 1967. Bottom water drift on the Tortugas grounds. Bull Mar. Sci. 17(3):562-575.

Reid, G. K., Jr. 1954. An ecological study of the Gulf of Mexico fishes, in the vicinity of Cedar Key, Florida. Bull. Mar. Sci. 4(1):1-94.

Richards, W. J., and Saksena, V. P. 1980. Description of larvae and early juveniles of laboratory-reared gray snapper, Lutjanus griseus (Linaeus) (Pisces, Lutjanidae). Bull. Mar. Sci. 30(2):515-521.

Roessler, M. 1967. Observations on the seasonal occurrence and life histories of fishes in Buttonwood Canal, Everglades National Park. PhD. Dissertation. Coral Gables, Florida: Univ. of Miami.

Rutherford, E. S., Thue, E. B., and Buker, D. G. 1982. Population characteristics, food habits and spawning activity of spotted seatrout, Cynoscion nebulosus, in Everglades National Park. Report T-668. Homestead, Florida: Everglades N.P., South Florida Research Center.

Rutherford, E. S., Thue, E. B., and Buker, D. G. 1983. Population structure, food habits and spawning activity of gray snapper Lutjanus griseus in Everglades National Park. SFRC-83/02. Homestead, Florida: Everglades N.P., South Florida Research Center.

Sabins, D. S. 1973. Diel studies of larval and juvenile fishes of the Caminada Pass area, Louisiana. Master's Thesis. Baton Rouge, Louisiana: Louisiana State Univ.

Schmidt, T. W. 1979. Ecological study of fishes and the water quality characteristics of Florida Bay, Everglades National Park, Florida. Project Report RSP-Ever N-36. Homestead, Florida: Everglades N.P., South Florida Research Center.

Simmons, E. G., and Breuer, J. P. 1962. A study of redfish, Sciaenops ocellata, and black drum, Pogonias cromis. Publ. Inst. Mar. Sci. Univ. Texas 8:184-211.

Smith, P. E., and S. L. Richardson. 1977. Standard techniques for pelagic fish egg and larval surveys. F.A.O. Fish. Tech. Paper 175, 100 p. F.A.O. Rome, Italy.

Springer, V. G., and Woodburn, K. D. 1960. An ecological study of the fishes of the Tampa Bay area. Prof. Pap. Ser. 1:1-104. St. Petersburg, Florida: Florida St. Board Conserv. Mar. Res. Lab.

Starck, W. A., II. 1964. A contribution to the biology of the gray snapper, Lutjanus griseus (Linnaeus), in the vicinity of lower Matecumbe Key, Florida. PhD. Dissertation. Coral Gables, Florida: Univ. of Miami.

Stewart, K. W. 1961. Contributions to the biology of the spotted seatrout (Cynoscion nebulosus) in the Everglades National Park, Florida. Master's Thesis. Coral Gables, Florida: Univ. of Miami.

Tabb, D. C. 1961. A contribution to the biology of the spotted seatrout, Cynoscion nebulosus (Cuvier), of east-central Florida. Tech. Ser. 35. Miami, Florida: Florida Board Conserv. Mar. Res. Lab., Rosenstiel School of Marine and Atmospheric Sciences.

Tabb, D. C. 1966. The estuary as a habitat for spotted seatrout, Cynoscion nebulosus. Am. Fish. Soc. Spec. Publ. 3:58-67.

Tabb, D. C., Drummond, B., and Kenny, N. 1974. Coastal marshes of southern Florida as habitat for fishes and effects of changes in water supply on these habitats. Final Rept. to U.S. Bur. Sport Fish. and Wildl. Branch of River Basins. Miami, Florida: Univ. of Miami, Rosenstiel School of Marine and Atmospheric Sciences.

Tabb, D. C., Dubrow, D. C., and Manning, R. B. 1962. The ecology of northern Florida Bay and adjacent estuaries. Tech. Ser. 39. Miami, Florida: Florida St. Board Conserv., Rosenstiel School of Marine and Atmospheric Sciences.

Tabb, D. C., and Manning, R. B. 1961. A checklist of the flora and fauna of northern Florida Bay and adjacent brackish waters of the Florida mainland collected during the period July, 1957 through September, 1960. Bull. Mar. Sci. Gulf Caribb. 11(4):552-649.

Taniguchi, A. K. 1980. Effects of salinity, temperature and food abundance upon survival of spotted seatrout eggs and larvae. Proc. Colloq. on the biology and management of red drum and seatrout. (Abstract). Ocean Springs, Mississippi: Gulf State Mar. Fish. Comm. Spec. Rep. No. 5:16

Tatum, W. M. 1980. Spotted seatrout (Cynoscion nebulosus) age and growth: data from annual fishing tournaments in coastal Alabama, 1964-1977. Proc. Colloq. on the biology and management of red drum and seatrout. Spec. Rep. No. 5:89-92. Ocean Springs, Mississippi: Gulf States Mar. Fish. Comm.

Thayer, G. W., D. R. Colby, M. A. Kjelson, and M. P. Weinstein. 1983. Estimates of larval fish abundance: diurnal variation and influences of sampling gear and towing speed. Trans. Am. Fish. Soc. 112:272-279.

Thayer, G. W., W. F. Hettler Jr., A. J. Chester, D. R. Colby, and P. T. McElhaney. 1987. Distribution and abundance of fish communities among selected estuarine and marine habitats in Everglades National Park. National Park Service, South Florida Research Center Technical Report SFRC-87/02.

Theiling, D. L., and Loyacano, H. A., Jr. 1976. Age and growth of red drum (Sciaenops ocellata) from a saltwater marsh impoundment in South Carolina. Trans. Am. Fish. Soc. 105(1):41-44.

Thue, E. B., Rutherford, E. S., and Buker, D. G. 1983. Age, growth and mortality of the common snook, Centropomus undecimalis, in Everglades National Park, Florida. Report T-683. Homestead, Florida: Everglades N.P., South Florida Research Center.

Tilmant, J. T., E. S. Rutherford, R. Dawson and E. B. Thue. 1986. An analysis of the recreational and commercial estuarine fishery harvest within Everglades National Park 1958-1985. Homestead, Florida: Everglades N.P., South Florida Research Center.

Volpe, A. V. 1959. Aspects of the biology of the common snook, Centropomus undecimalis (Bloch) of southwest Florida. Tech. Ser. 31. Miami, Florida: Florida St. Board Conserv., Rosenstiel School of Marine and Atmospheric Sciences.

Wakeman, J. M., and Wohlschlag, D. E. 1977. Salinity stress and swimming performance of spotted seatrout. Proc. Ann. Conf. S.E. Assoc. Fish. Wildl. Agencies 31:357-361.

Weinstein, M. P. 1983. Population dynamics of an estuarine-dependent fish, the spot (Leiostomus xanthurus), along a tidal creek-seagrass meadow coenocline. Can. J. Fish. Aquat. Sci. 40:1633-1638.

Weinstein, M. P., and Walters, M. F. 1981. Growth, survival and production in young-of-year populations of Leiostomus xanthurus Lacepede, residing in tidal creeks. Estuaries 4:185-197.

Yokel, B. J. 1966. A contribution to the biology and distribution of the red drum, Sciaenops ocellata. Master's Thesis. Coral Gables, Florida: Univ. of Miami.

Table 1. Diurnal catches of spotted seatrout and all larvae at Little Shark River, May 1983. Mean values are averages of 6 replicate tows with 333 micron mesh bongo net.

	Day		Night	
	Flood	Ebb	Flood	Ebb
Seatrout				
Mean catch / 100 m^3	0	0	3.0	0
1 s.d.			0.7	
All larvae				
Mean catch / 100 m^3	10.7	36.5	209.5	28.1
1 s.d.	2.3	10.2	101.3	7.1

Table 2. Results of Kruskal-Wallis tests of spotted seatrout larval catches (No./100m^3) by season at monitoring stations in Everglades National Park, 1983. Underlined seasons are not statistically different at a=.05 level.

	Seasons Compared	Significance
Little Shark River	$1<4<2<3$	$p < .001$
Cape Sable	$2<3$	$p < .02$
Marker 5		
Middle Ground	$2<3$	$p < .07$
Conchie Channel	$2<3$	$p < .70$

Table 3. Percent successful stations for spotted seatrout larvae by season in ENP, 1982-83.

	No. stations sampled	No. stations successful for spotted seatrout larvae	% successful for spotted seatrout larvae
1982			
Jan - Mar	2	1	50
Apr-Jun	2	1	50
Jul-Sep	5	0	0
Oct-Dec	21	3	14.3
1983			
Jan-Mar	10	3	30.0
Apr-Jun	13	8	61.5
Jul-Sep	11	9	81.8
Oct-Dec	3	2	66.7

Table 4. Mean size of spotted seatrout larvae (< 8.0 mm S.L.) caught in 333 micron and 475 micron mesh nets in Everglades National Park, 1982-1983. Mean values include 95% confidence intervals.

	Mean	Range	N	Months Caught
1982-83				
All stations				
Parkwide	3.2±0.1	1.3-8.0	1540	2-12
W. Florida Bay	2.7±0.1	1.4-6.1	1006	2-9,11-12
Whitewater Bay	4.5±0.1	2.0-8.0	442	3-10
E. Florida Bay	2.7±0.2	1.3-5.6	92	4,5,8,9,11
475 micron stations				
Parkwide	2.6±0.1	1.3-6.1	442	2-9,11
W. Florida Bay	2.6±0.1	1.4-6.1	348	2,4-8
Whitewater Bay	3.8±2.5	3.6-4.0	2	3-9
E. Florida Bay	2.7±0.2	1.3-5.6	92	4,5,8,9,11
333 micron stations				
Parkwide	3.4±0.1	1.4-8.0	1098	3-12
W. Florida Bay	2.7±0.1	1.4-5.3	658	3,5-9,11-12
Whitewater Bay	4.5±0.1	2.0-8.0	440	3-10
1983				
All stations				
Parkwide	3.2±0.1	1.3-8.0	1529	2-11
W. Florida Bay	2.7±0.1	1.4-6.1	1001	2-9,11
Whitewater Bay	4.5 0.1	2.0-8.0	440	3-10
E. Florida Bay	2.7±0.2	1.3-5.6	88	4,5,8
475 micron stations				
Parkwide	2.6±0.1	1.3-6.1	436	2,4-8
W. Florida Bay	2.6±0.1	1.4-6.1	348	2,4-8
Marker 5	2.6±0.2	1.4-6.1	319	2,4-8
Conchie Channel	3.1±0.7	1.9-4.9	29	4,6-8
E. Florida Bay	2.7±0.2	1.3-5.6	88	4,5,8
Jewfish Creek	2.6±0.3	1.6-5.4	86	4,5
333 micron stations				
Parkwide	3.4±0.1	1.4-8.0	1093	3-11
W. Florida Bay	2.7±0.1	1.4-5.3	653	3,5-9,11
Cape Sable	2.7±0.1	1.4-5.3	652	3,5-9
Whitewater Bay	4.5±0.1	2.0-8.0	440	3-10
Little Shark River	4.6±0.1	2.0-8.0	408	3-10
Cormorant Pass				
Clearwater Pass	5.5±0.1	3.3-7.9	32	4,6,8,9
Joe River				

Table 5. Mean size of spotted seatrout larvae (< 8.0 mm S.L.) caught by month at stations in Everglades National Park, 1983. Mean values have 95% confidence intervals.

	*333 micron			*475 micron	
	All Stations	Cape Sable	Little Shark River	All Stations	Marker 5
Feb.	....	....	....	2.0	....
March	2.6±0.1	2.5±0.2	5.2±18.4	....	....
April	4.8±0.2	....	4.9±0.5	2.8±0.4	3.5±3.4
May	3.8±0.1	3.4±0.4	4.2±0.3	2.7±0.2	3.6±1.4
June	4.6±0.2	3.3±0.2	5.6±0.2	2.8±0.2	2.8±0.1
July	4.0±0.3	2.3±0.8	4.5±0.7	2.5±0.1	2.4±0.1
Aug.	2.6±0.1	2.2±0.1	3.4±0.2	4.6±1.1	4.7±1.0
Sept.	3.2±0.1	2.7±0.1	3.8±0.1	....	....
Oct.	5.8±0.4	....	5.8±0.8	....	....
Nov.	3.1	....	....	....	....

* Mesh Size

Table 6. Number of spotted seatrout preflexion larvae (< 2.4 mm S.L.) caught in Everglades National Park, 1982-1983, all gears combined.

	Number	Percent
Station		
Shell Creek	1	0.2
Jewfish Creek	38	6.7
Man O War Channel	2	0.3
Marker 5	168	29.7
Cape Sable	328	58.0
Conchee Channel	9	1.6
Bradley-Murray Key	5	0.9
Little Shark River	15	2.6
Area		
W. Florida Bay	512	90.4
E. Florida Bay	39	6.9
Whitewater Bay	0	....
Shark River	15	2.7
Month		
Feb.	1	0.2
March	29	5.1
April	11	1.9
May	37	6.5
June	35	6.2
July	161	28.4
Aug.	158	27.9
Sept.	128	22.6
Nov.	1	0.2
Dec.	5	0.9
Totals:	N = 566	

Table 7. Environmental parameters of successful catches of spotted seatrout larvae (< 8.0 mm S.L.) in Everglades National Park, 1982-83. Mean values include 95% confidence intervals.

	Mean	Range	N
Salinity(ppt)	33.2±1.7	8-40.0	122
Temperature(°C)	29.7±0.3	20-30	122
D.O.(ppm)	6.9±0.1	4.8-9.1	64
pH	6.4±0.1	5.7-7.5	109
Turbidity(NTU)	5.8±0.1	1.9-16.0	70
Current speed(cm/sec)	34.9±1.0	0-131.0	119

Table 8. Total effort (number of samples) and number of juvenile gamefish collected by gear type in ENP, 1982-84. Plankton net catches of spotted seatrout are not included.

Gear	Spotted Seatrout		Red Drum		Gray Snapper		Snook		Number of Samples
	No.	% Total	No.	% Total	No.	% Total	No.	% Total	
Roller Frame	39	15.7	0	0	2	11.	0	0	104
Sled Net	15	6.0	1	5.6	0	0	0	0	156
15.2 m Seine	89	35.9	12	66.7	11	61.1	35	49.3	53
7.6 m Seine	0	0	0	0	0	0	12	16.9	11
3.7 m Seine	0	0	0	0	0	0	0	0	3
Rotenone	0	0	1	5.6	0	0	0	0	13
Hook & Line	2	1.0	2	11.1	0	0	23	32.4	11
Explosive	2	1.0	2	11.1	5	27.8	1	1.4	2
N =	147		18		18		71		353

Table 9. Total effort (number of samples all gears combined) and number of juvenile gamefish collected by habitat type in ENP, 1982-84. Plankton net catches of juvenile spotted seatrout are not included.

Gear	Spotted Seatrout		Red Drum		Gray Snapper		Snook		Number of Samples
	No.	% Total	No.	% Total	No.	% Total	No.	% Total	
Mangrove Creek	6	4.1	3	16.7	5	27.8	1	1.4	13
Bank/Flat	26	17.7	2	11.1	10	55.6	0	0	14
Basin/Bay	39	26.5	0	0	2	11.1	0	0	108
Shoreline	68	46.3	11	61.1	0	0	15	21.1	194
Marsh	0	0	0	0	0	0	0	0	1
Mud Pond	0	0	1	9.1	0	0	32	45.1	10
River	0	0	0	0	0	0	0	0	4
Canal	8	5.4	1	9.1	1	9.1	23	32.4	9
Total	147		18		18		71		353

Table 10. Total effort (number of samples all gears combined) and number of juvenile gamefish collected by month in ENP, 1982-84. Plankton net catches of juvenile spotted seatrout are not included.

Month	Spotted Seatrout		Red Drum		Gray Snapper		Snook		Number of Samples
	No.	% Total	No.	% Total	No.	% Total	No.	% Total	
January	0	0	0	0	0	0	0	0	21
February	0	0	0	0	0	0	0	0	19
March	0	0	1	5.6	0	0	0	0	28
April	3	2.0	2	11.1	5	27.8	1	1.4	24
May	3	2.0	1	5.6	0	0	0	0	24
June	12	8.2	2	11.1	9	50.0	2	2.8	37
July	28	19.1	0	0	0	0	0	0	34
August	20	13.6	1	5.6	3	16.7	16	22.5	34
September	53	36.1	0	0	0	0	26	36.6	29
October	9	6.1	0	0	0	0	1	1.4	25
November	8	5.4	1	5.6	1	5.6	10	14.1	34
December	11	7.5	10	55.6	0	0	15	21.1	44
Totals	147		18		18		71		353

Table 11. Total effort (number of samples, all gears combined) and number of juvenile gamefish collected by fishing area in ENP, 1982-84. Plankton catches of juvenile spotted seatrout are not included.

Fishing Areas	Spotted Seatrout		Red Drum		Gray Snapper		Snook		Number of Samples
	No.	% Total	No.	% Total	No.	% Total	No.	% Total	
N.Florida Bay (1)	28	19.2	0	0	3	16.7	0	0	46
S.Florida Bay (2)	25	16.4	0	0	1	5.6	0	0	96
Cape Sable (3)	2	1.4	3	11.1	8	44.4	0	0	7
Whitewater Bay (4)	84	57.5	14	77.8	5	27.8	16	22.5	186
Shark River (5)	0	0	0	0	0	0	0	0	4
Marco Island Area (7)	7	4.8	1	5.6	1	5.6	46	64.8	11
Unidentified	1	0.7	0	0	0	0	9	12.7	3
Totals	147		18		18		71		353

Table 12. Total effort (number of sampling trips, all gears combined) and number of juvenile gamefish collected in benthic vegetation types in ENP, 1982-84. Plankton net catches of juvenile spotted seatrout are not included.

Dominant Benthic Vegetation	Spotted Seatrout		Red Drum		Gray Snapper		Snook		Number of Samples
	No.	% Total	No.	% Total	No.	% Total	No.	% Total	
Bare	10	6.8	5	27.8	14	77.8	9	12.7	43
Thalassia	51	34.7	0	0	3	16.7	0	0	56
Halodule	70	47.6	1	5.6	0	0	0	0	173
Syringodium	2	1.4	0	0	1	5.6	0	0	3
Ruppia	9	6.1	8	44.4	0	0	5	7.0	20
Chara	3	2.0	2	11.1	0	0	28	39.4	9
Marine Algae	1	0.7	0	0	0	0	0	0	40
Nyas & *Utrichularia* *spp*.	1	0.7	2	11.1	0	0	29	40.9	12
Totals	147		18		18		71		353

Table 13. Mean length (mm S.L.) of juvenile spotted seatrout by habitat in ENP, 1982-84.*

Habitat Type	Mean ± 95% CI	Number of Fish
Creek	39.4 ± 9.7	106
Bank/flat	42.0 ± 11.7	24
Shorelines	51.5 ± 4.3	58
Canals	56.6 ± 56.1	8
Basin/bay	73.7 ± 12.2	31

* Mean lengths of fish in creek, bank/flat, and shoreline habitat were significantly smaller than mean length of fish in basin/bay habitat according to SNK range test.

Table 14. Environmental parameters for successful catches of juvenile spotted seatrout in ENP, 1982-84 and 1973-76. Mean values have 95% confidence intervals.

Parameter	Mean	Range	N
A. 1982-1984			
Salinity (ppt)	17.2±3.2	1.0-38.0	55
Temperature (°C)	28.6±0.9	20.0-34.0	55
pH	7.3±0.2	6.8-8.6	49
Dissolved oxygen (ppm)	8.0±0.3	7.0-9.6	14
Turbidity (NTU)	7.7±2.7	0.9-38.0	39
Depth (cm)	141±14	53-250	55
B. 1973-1976			
Salinity (ppt)	35.6±2.2	8.0-44.0	48
Temperature (°C)	28.0±1.2	14.3-32.5	48
pH	8.1±0.1	6.9-8.6	44
Dissolved oxygen (ppm)	7.7±0.5	4.4-10.2	40
Turbidity (NTU)	5.6±2.7	0.5-29.0	28
Depth (cm)	127±14.6	50.0-220.0	48

Table 15. Length-weight and standard length total length relationships for juvenile spotted seatrout in ENP, 1982-84.

Formula	r value	N
Log_{10} wt (grams) = -4.84037 + 3.0004 log_{10} length (mm S.L.).	0.9807	188
Total length (mm) = 3.1478 + 1.1875 (standard length mm).	0.9992	192
Standard length (mm) = -2.5629 + 0.8407 (total length mm).	0.9992	192

Table 16. Number of juvenile spotted seatrout collected with 15.2 m beach seine in ENP, 1982-84.

A. Number of Juvenile Spotted Seatrout Collected by Season

	Spring	Summer	Fall	Winter	Total
No. seatrout	8	73	8	0	89
No. samples	10	24	17	1	52
No. successful for seatrout	4	12	4	0	20
% successful	40.0	50.0	23.5	0	38.5

B. Number of Juvenile Spotted Seatrout Collected by Fishing Area

	1	2	3	4	5	Marco Island	Total
No. seatrout	23	2	2	55	0	7	89
No. samples	9	6	6	24	1	6	52
No. successful for seatrout	5	2	1	9	0	3	20
% successful	55.6	33.3	16.7	37.5	0	50.0	38.5

Table 16, continued. Number of juvenile spotted seatrout collected with 15.2 m beach seine in ENP, 1982-84.

C. Number of Juvenile Spotted Seatrout Collected by Habitat Type

	Creek	Bank/flat	Shoreline	Mud Pond	Canal	Total
No. seatrout	4	26	52	0	7	89
No. samples	4	13	26	3	6	52
No. samples successful for seatrout	1	7	9	0	3	20
% successful	25.0	53.9	34.6	0	50.0	38.5

D. Number of Juvenile Spotted Seatrout Collected by Benthic Vegetation Type

	Bare	*Thalassia*	*Halodule*	*Ruppia*	*Chara*	Marine Algae	*Nyas* & *Utrichularia*	Totals
No. seatrout	8	24	45	8	3	1	0	89
No. samples	6	12	11	12	6	3	3	52
No. successful	3	6	5	3	2	1	0	20
% successful	50.0	50.0	45.5	25.0	33.3	33.3	0	38.5

Table 16, continued. Number of juvenile spotted seatrout collected with 15.2 m beach seine in ENP, 1982-84.

E. Number of Juvenile Spotted Seatrout Collected by 15.2 m Beach Seine in Shoreline and Bank/flat Habitats by Vegetation Type.

	Thalassia	Halodule	Ruppia	Chara	Nyas Utrichularia	Bare	Total
Shorelines:							
No. seatrout	0	45	4	3	0		52
No. samples	2	9	9	5	1		26
No. successful for seatrout	0	5	2	2	0		9
% successful	0.0	55.6	22.2	40.0	0		34.6
Banks/Flats:							
No. seatrout	24	0				2	26
No. samples	9	2				2	13
No. successful for seatrout	6	0				1	7
% successful	66.7	0				50.0	53.9

Table 17. Catches of juvenile spotted seatrout and gray snapper by 15.2 m beach seine and otter trawl among seasons and fishing areas in Florida Bay, ENP, 1973-76.

A. Season

	Jan - Mar		Apr - Jun		Jul - Sep		Oct - Dec		Total	
	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl
No. samples	49	49	46	42	39	43	51	58	185	192
No. seatrout	1	8	23	37	17	28	6	5	47	78
No. snapper	0	30	0	28	10	34	3	37	13	129
% successful-										
seatrout	2.0	6.1	13.0	21.4	15.4	14.0	3.9	6.9	8.1	11.5
snapper	0	22.4	0	23.8	15.4	34.9	3.9	25.9	4.3	26.6

Table 17, continued. Catches of juvenile spotted seatrout and gray snapper by 15.2 m beach seine and otter trawl among seasons and fishing areas in Florida Bay, ENP, 1973-76.

B. Fishing Areas

	I		II		III		Total	
	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl
No. samples	121	116	28	45	36	31	185	192
No. seatrout	41	63	0	0	6	15	47	78
No. snapper	6	78	5	25	2	26	13	129
% successful-								
seatrout	9.9	16.4	0	0	8.3	9.7	8.1	11.5
snapper	3.3	23.3	7.1	24.4	5.6	41.9	4.3	26.6

C. Habitats

	Seine		Trawl		Totals	
	Banks/Flats	Shoreline	Channels	Basins	Seine	Trawl
No. samples	155	30	43	149	185	192
No. seatrout	41	6	6	72	47	78
No. snapper	12	1	20	109	13	129
% successful-						
seatrout	7.7	10.0	7.0	13.0	8.1	11.5
snapper	4.5	3.3	20.9	27.5	4.3	26.6

Table 17, continued. Catches of juvenile spotted seatrout and gray snapper by 15.2 m beach seine and otter trawl among habitats and benthic vegetation types in ENP, 1973-76.

D. Benthic Vegetation Type

	Thalassia		Halodule		Syringodium		Marine Algae		Totals	
	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl
No. samples	64	85	100	46	0	44	21	17	185	192
No. seatrout	1	5	46	10	0	63	0	0	47	78
No. snapper	10	42	3	19	0	66	0	2	13	129
% successful-										
seatrout	1.6	3.5	14.0	8.7	0.0	34.1	0.0	0.0	8.1	11.5
snapper	7.8	17.6	3.0	20.0	0	59.1	0	5.9	4.3	26.6

Table 17, continued.

E. Number of juvenile spotted seatrout and gray snapper collected in seagrass basins and banks in western Florida Bay by otter trawl and seine, ENP, 1973-75.

	Thalassia	Halodule	Syringodium	Marine Algae	Totals
Basins (Trawl):					
No. samples	50	12	21		83
No. seatrout	6	0	15		21
No. snapper	15	0	32		47
% successful-					
seatrout	6.0	0	23.8		0.1
snapper	10.0	0.0	61.9		21.7
Banks (Seine):					
No. samples	41	39		13	93
No. seatrout	1	14		0	15
No. snapper	5	1	0	0	6
% successful-					
seatrout	2.4	15.4		0.0	0.1
snapper	9.8	2.6	0.0	0.0	5.4

Table 18. Environmental parameters of successful catches of red drum larvae in Everglades N. P., 1982-83. Mean values include 95% confidence intervals.

	Mean	Range	N
Salinity (ppt)	25.0±7.0	8.0-35.0	10
Temperature (oC)	23.4±2.4	15.9-27.0	9

Table 19. Environmental parameters for successful catches of juvenile red drum in ENP, 1982-84. Mean values include 95% confidence intervals.

	Mean	Range	N
Salinity (ppt)	9.2±8.1	2.0-40.0	10
Temperature (oC)	24.7±2.5	19.0-30.0	10
pH	6.4±5.2	5.8-7.2	3
Dissolved oxygen (ppm)	8.1	....	1
Turbidity (NTU)	20.0	....	1
Depth (cm)	76.1±17	48-120	10

Table 20. Environmental parameters of successful catches of juvenile gray snapper in ENP, 1982-84 and 1973-76. Mean values have 95% confidence intervals.

	Mean	Range	N
A. 1982-1984			
Salinity (o/oo)	27.1±15.3	2.0-40.0	7
Temperature (oC)	27.8±2.6	24.0-31.0	7
pH	6.5±1.0	5.8-7.4	5
Dissolved oxygen (ppm)	9.2	7.6-10.7	2
Turbidity (NTU)	3.3	3.2-3.3	2
Depth (cm)	104±52	48-200	7
B. 1973-1976			
Salinity (o/oo)	38.8±1.1	25.8-66.6	82
Temperature (oC)	27.2±0.9	12.8-31.7	82
pH	8.0±0.1	6.6-8.8	73
Dissolved oxygen (ppm)	7.7±0.3	3.9-11.0	64
Turbidity (NTU)	3.6±1.3	0.5-26.0	48
Depth (cm)	150±10.5	40-300	82

Table 21. Environmental parameters for successful catches of juvenile snook, 1982-1984. Mean values include 95% confidence intervals.

	Mean	Range	N
Salinity (ppt)	8.9±7.2	0-36	10
Temperature (oC)	27.0±2.7	18-33	12
pH	6.0±2.5	5.8-6.3	3
Turbidity (NTU)	6.3	5.9-6.7	2
Depth (cm)	63±15	33-100	13

Table 22. Estimated total annual mortality rates (A) of spotted seatrout adults and juveniles in Florida and Louisiana.

	Adult		Juvenile
	Louisiana[1]	ENP[2]	ENP
Average	49.8%	47.3 ± 13.1%	99.4%
Range	36.2 - 58.1%	35.6 - 63.2%	---

1 From Tatum, W.M. 1980.
2 Tilmant et al. 1986.

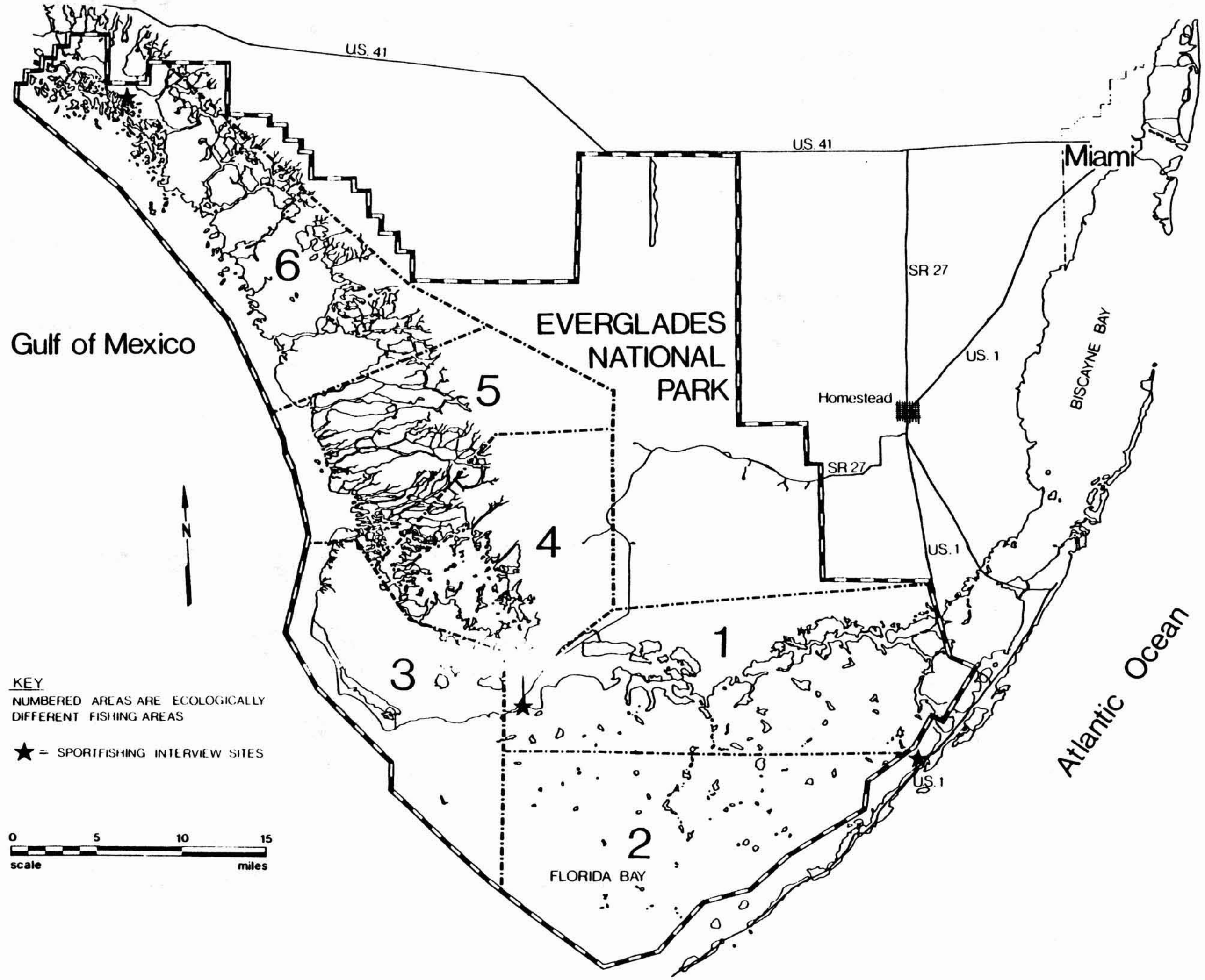


Figure 1. Fishing areas in Everglades National Park, Florida. Numbered areas are: (1) North Florida Bay (2) South Florida Bay (3) Cape Sable (4) Whitewater/Coot Bays (5) Shark River area (6) Ten Thousand Islands.

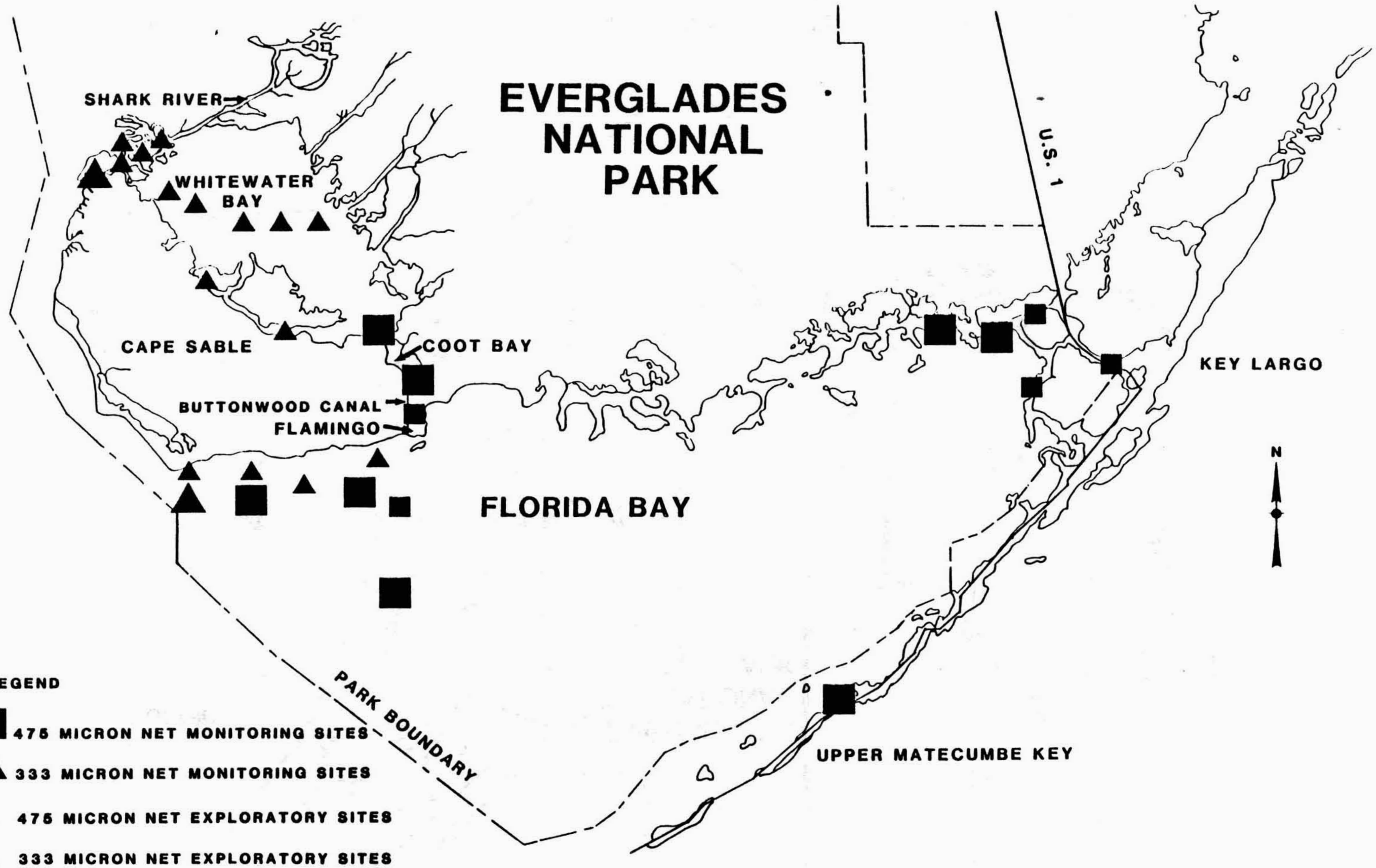
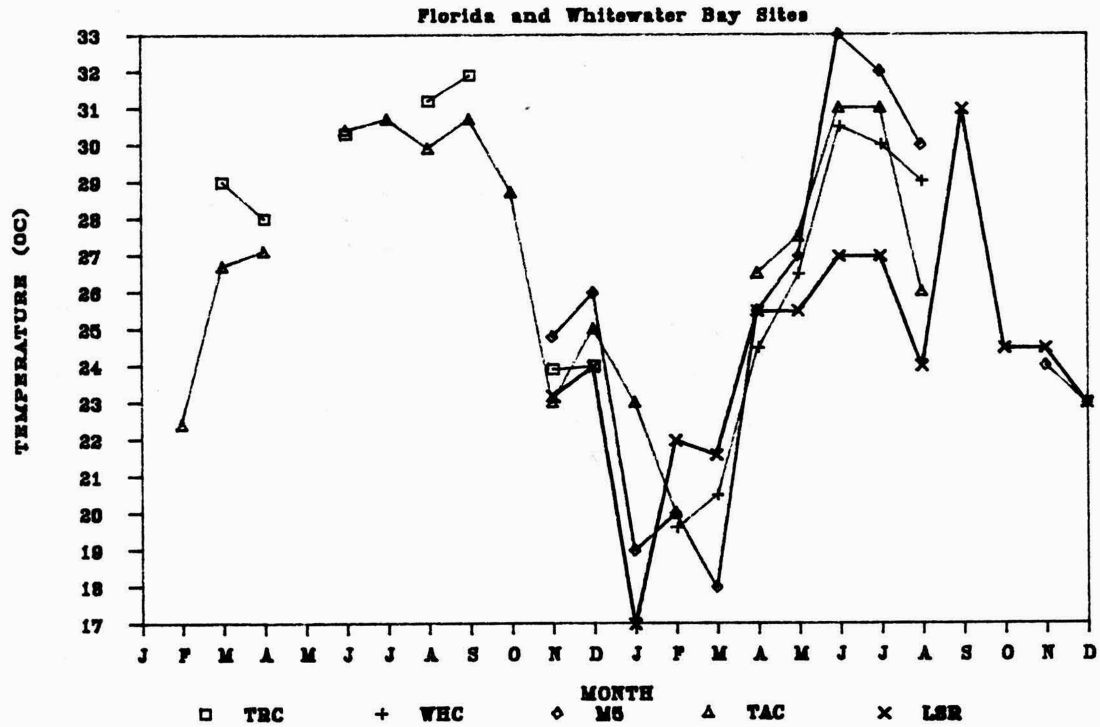


Figure 2. Plankton sampling stations in Everglades National Park, 1982-83. Stations collected by the NPS pink shrimp project (475 micron net) are indicated by squares; samples collected solely for gamefish larvae (333 micron net) are indicated by triangles.

A



B

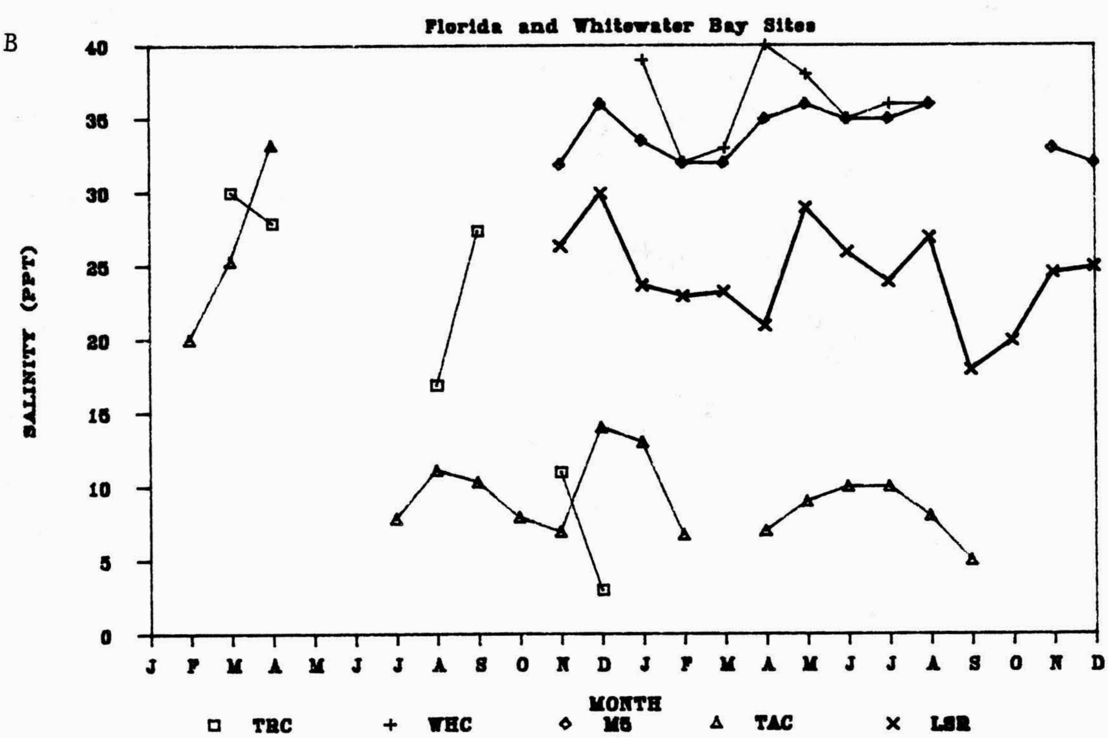


Figure 3. Temperature (A) and salinity (B) data at selected ichthyoplankton stations in Everglades National Park. Stations include: Trout Creek (TRC), Whale Harbor Channel (WHC), Marker 5 (M5), Tarpon Creek (TAC), and Little Shark River (LSR).

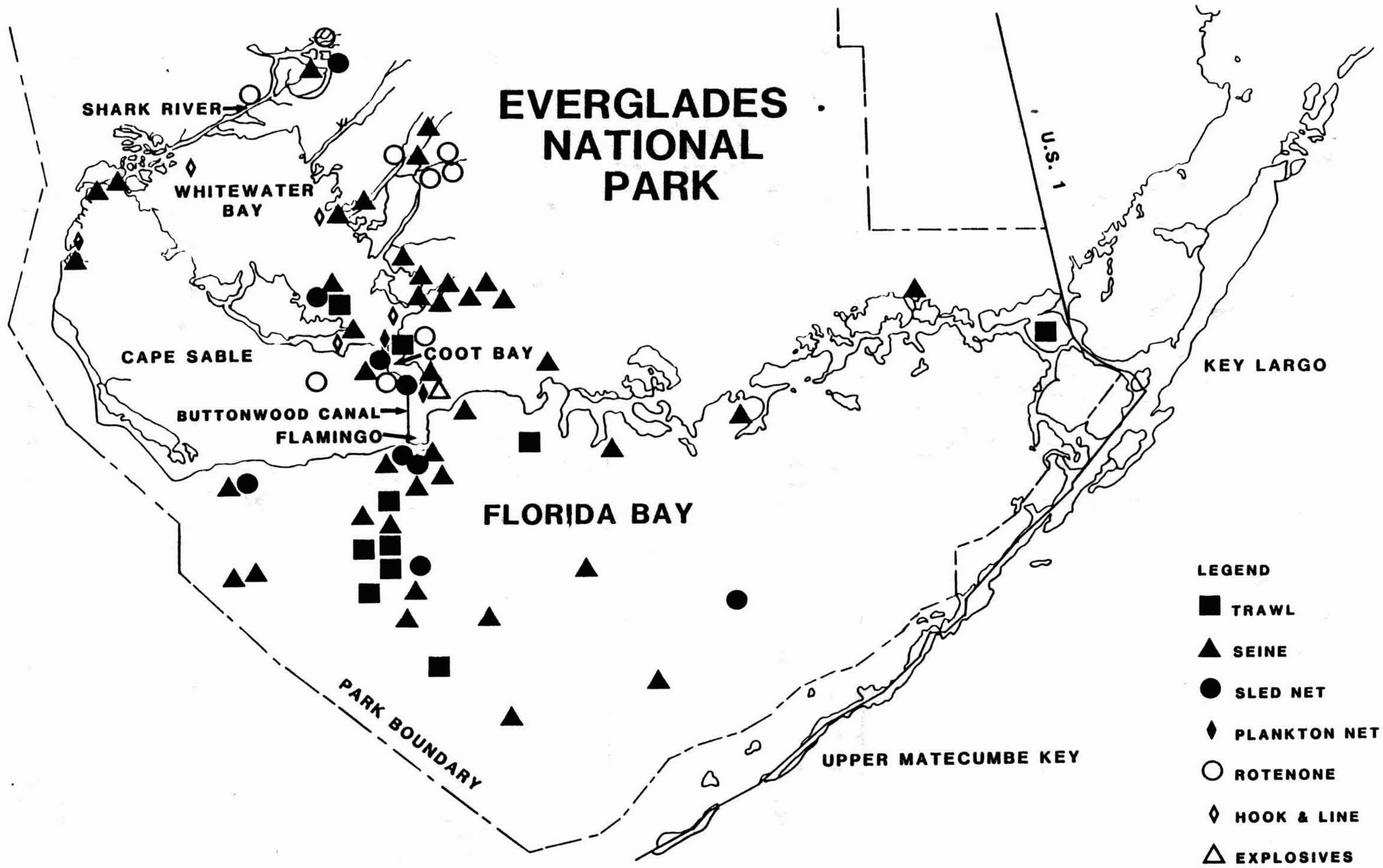


Figure 4. Juvenile gamefish sampling stations in ENP, 1982-84. Gears included were roller frame trawl, sled net, 15.2 m beach seine, 7.6 m beach seine, rotenone, and explosives.

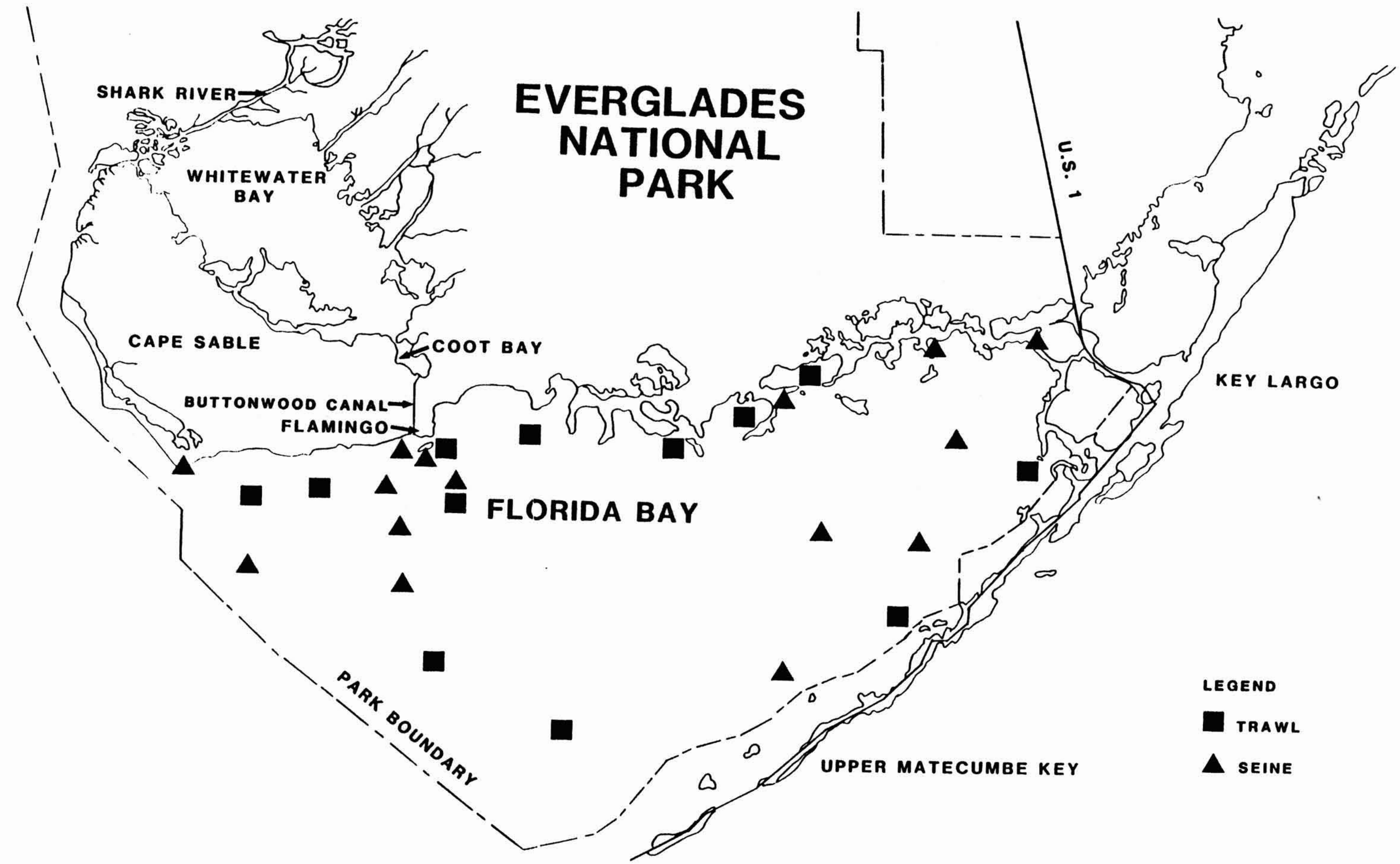


Figure 5. Sampling stations of NPS fish biomass study of Florida Bay (Schmidt 1979). Gears included otter trawl and 15.2 m beach seine.

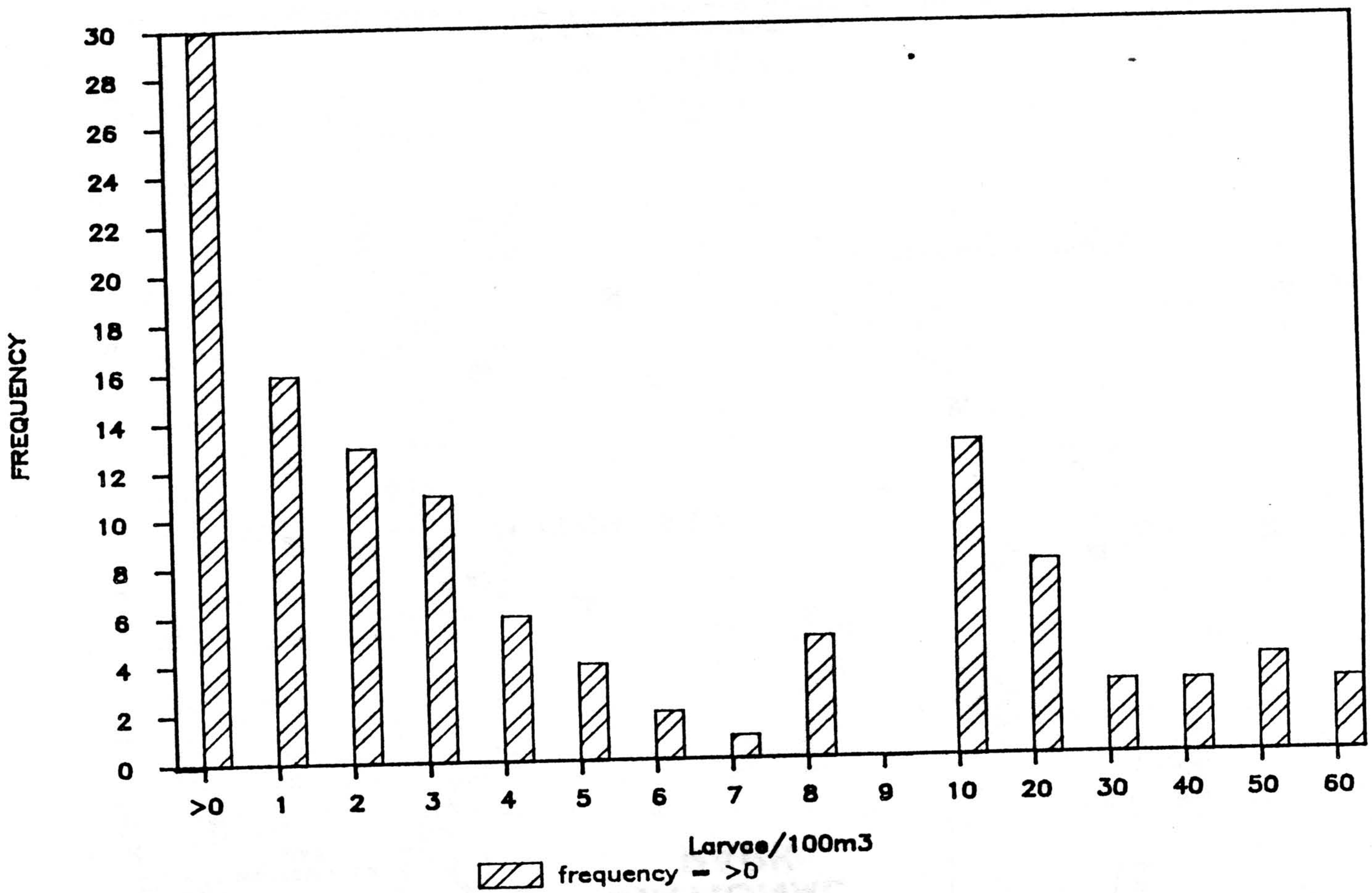


Figure 6. Catches of spotted seatrout larvae in ENP, 1982-83.

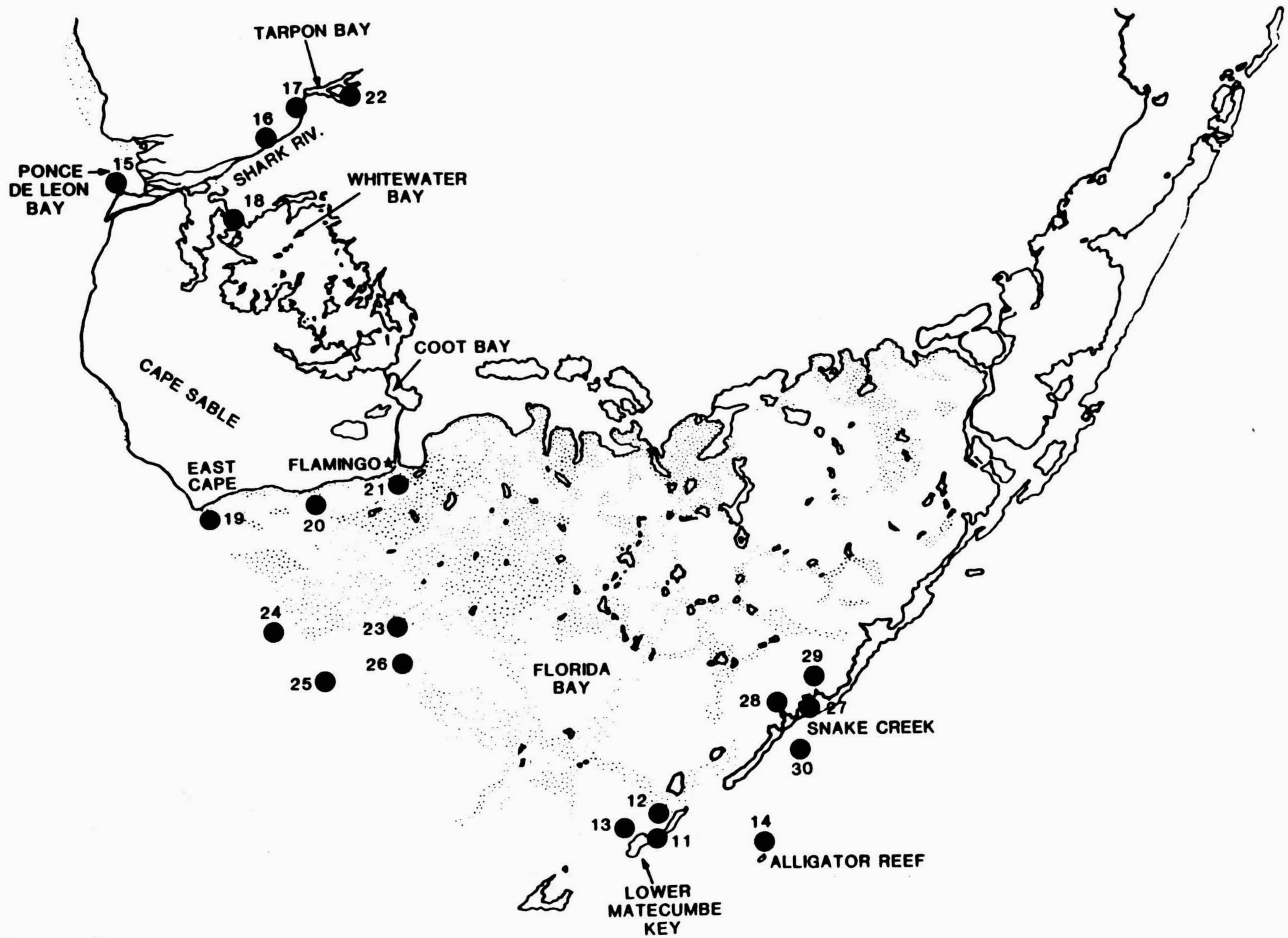


Figure 7. National Marine Fisheries Service ichthyoplankton sampling stations in ENP, 1984-85 (From Thayer and Hoss 1985).

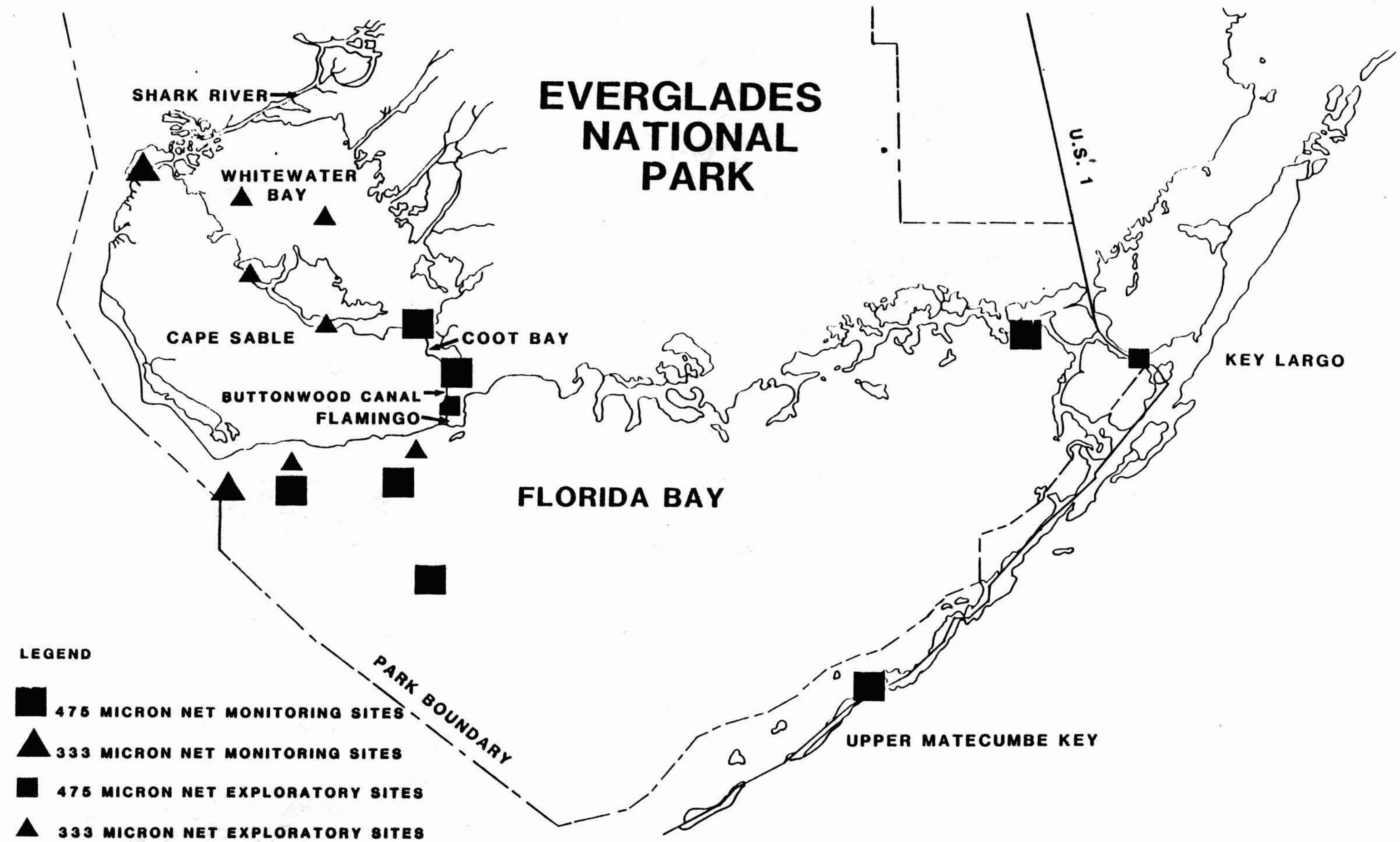


Figure 8. Distribution of spotted seatrout larvae by plankton net mesh size in ENP, 1982-83.

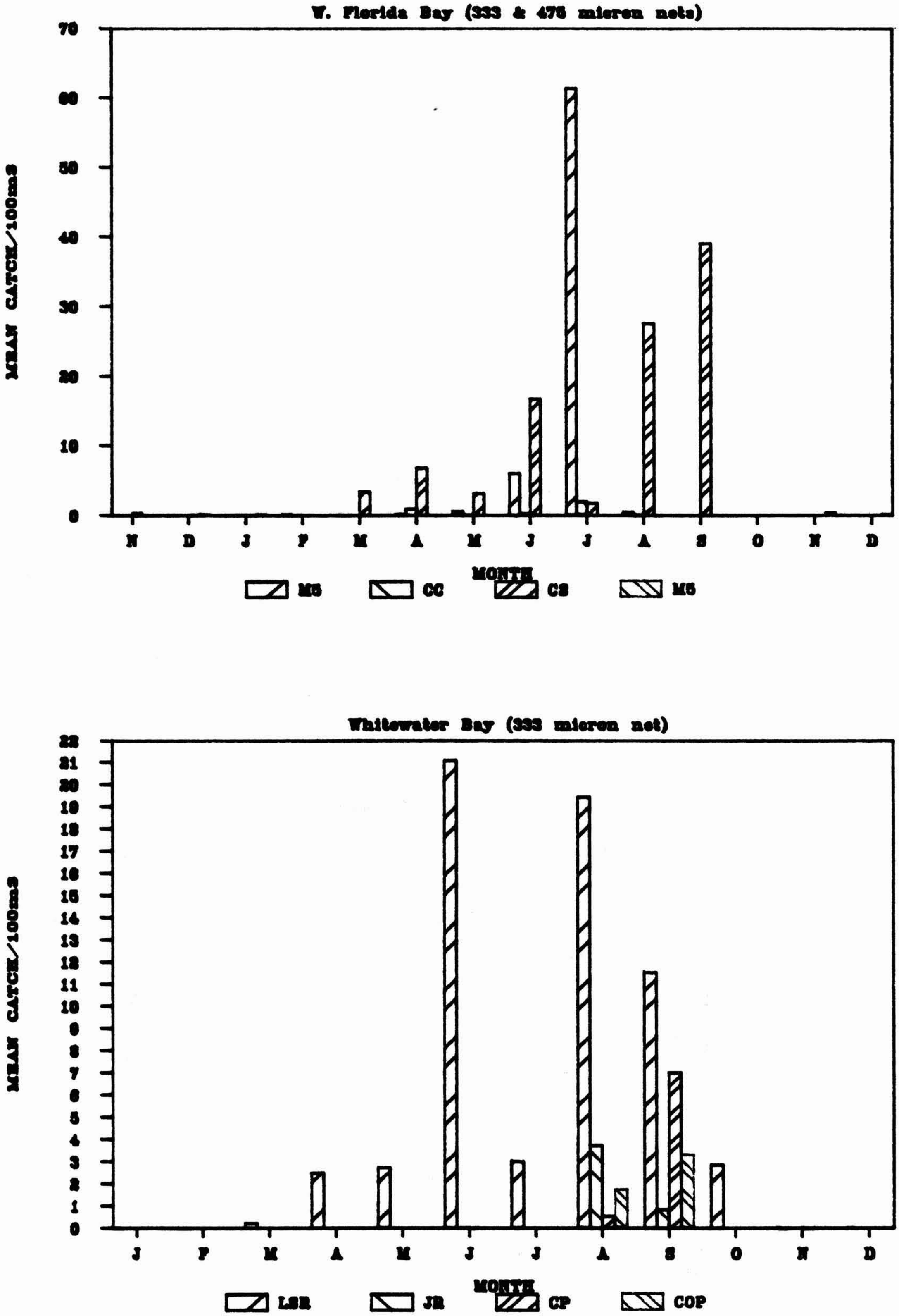


Figure 9. Mean catch/100 m^3 of spotted seatrout larvae at stations in (A) Western Florida Bay - Stations are Marker 5 (M5), Conchee Channel (CC), Cape Sable (CS); (B) Whitewater Bay, 1982-83 - Stations are Little Shark River (LSR), Joe River (JR), Clearwater Pass (CP), Cormorant Pass (COP).

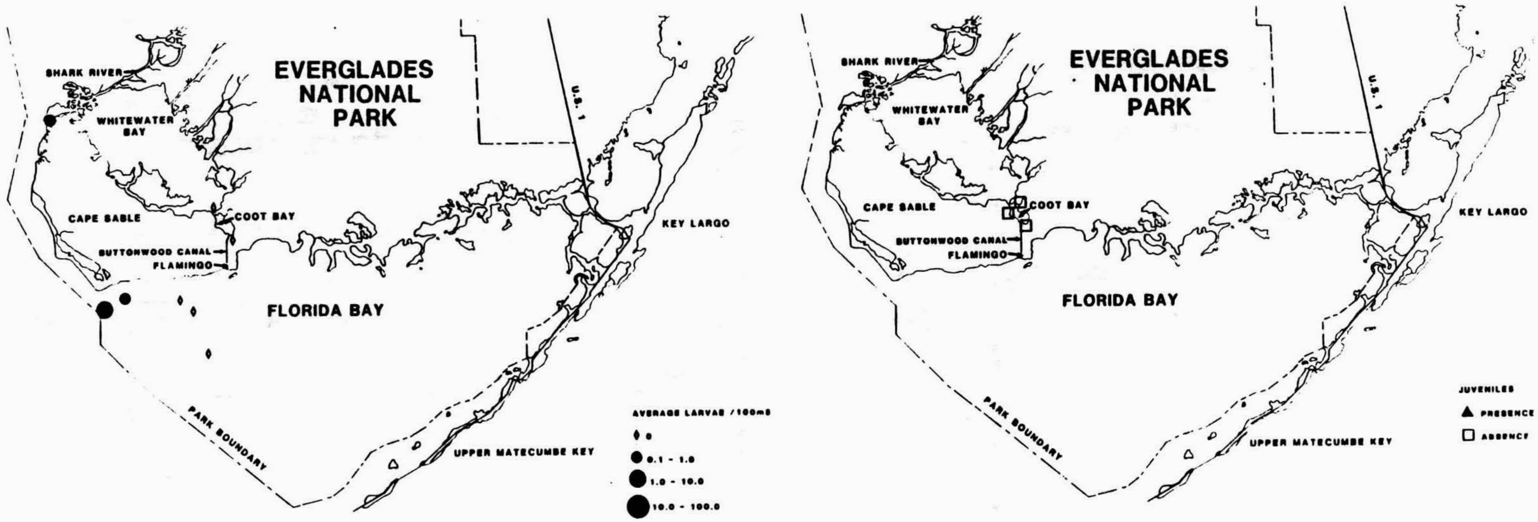


Figure 10a. Seasonal distribution of larval and juvenile spotted seatrout catches in ENP, 1983, winter (Jan-Mar).

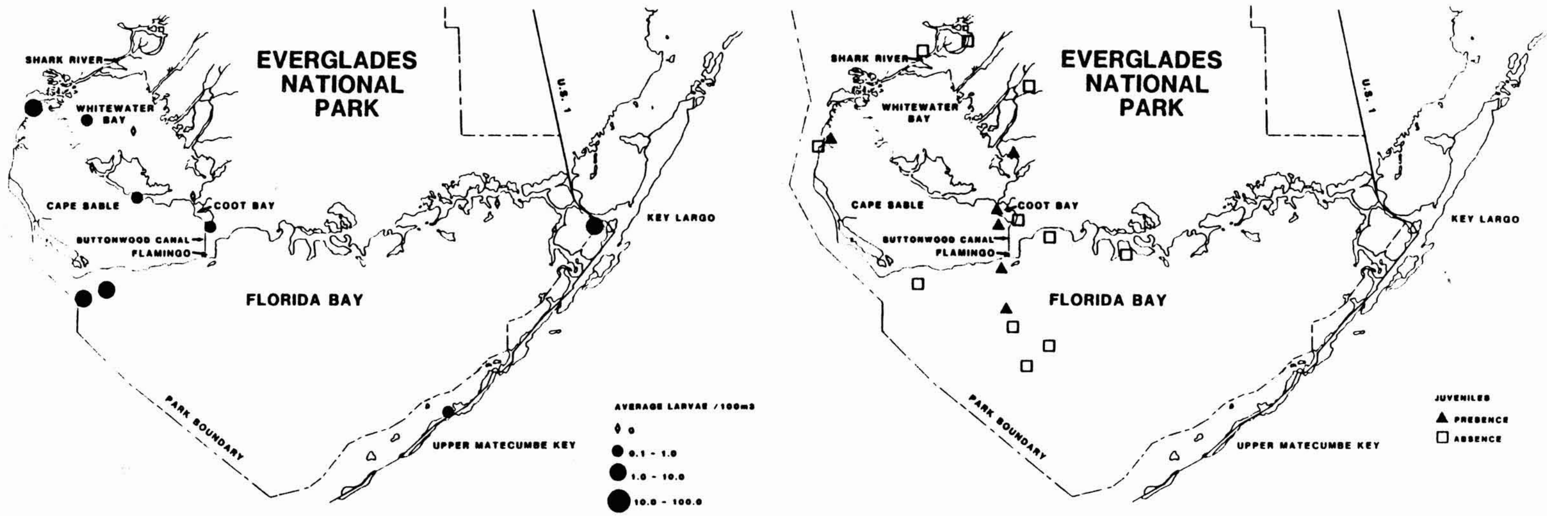


Figure 10b. Seasonal distribution of larval and juvenile spotted seatrout catches in ENP, 1983, spring (Apr-Jun).

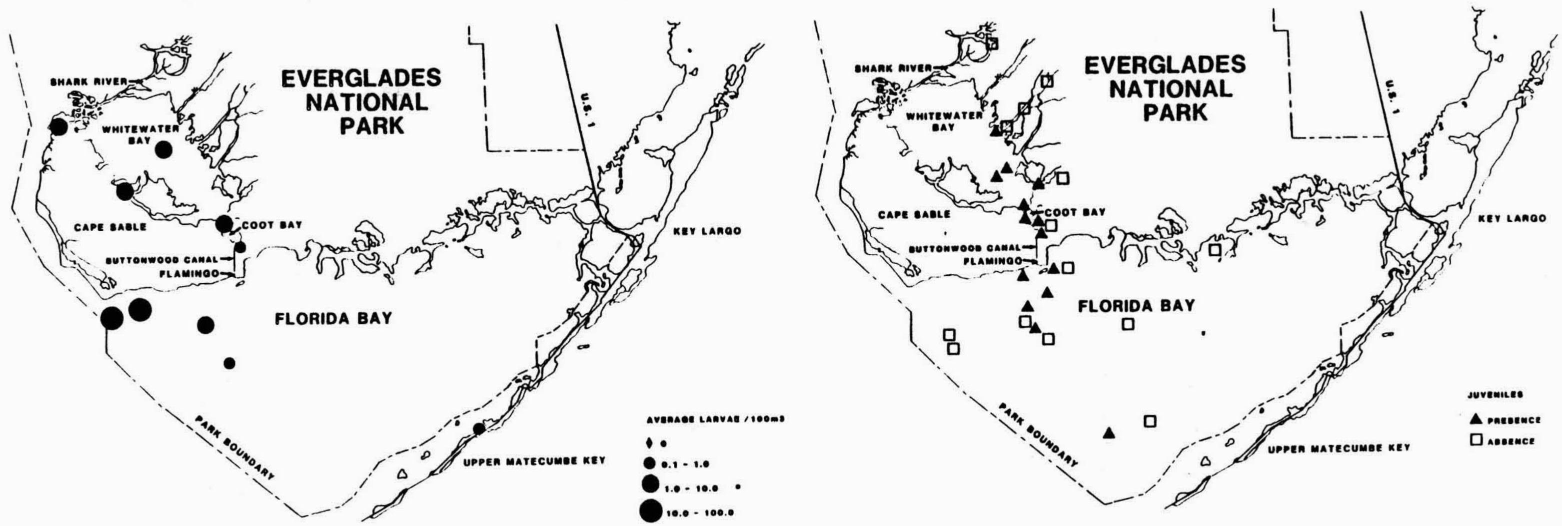


Figure 10c. Seasonal distribution of larval and juvenile spotted seatrout catches in ENP, 1983, summer (Jul-Sep).

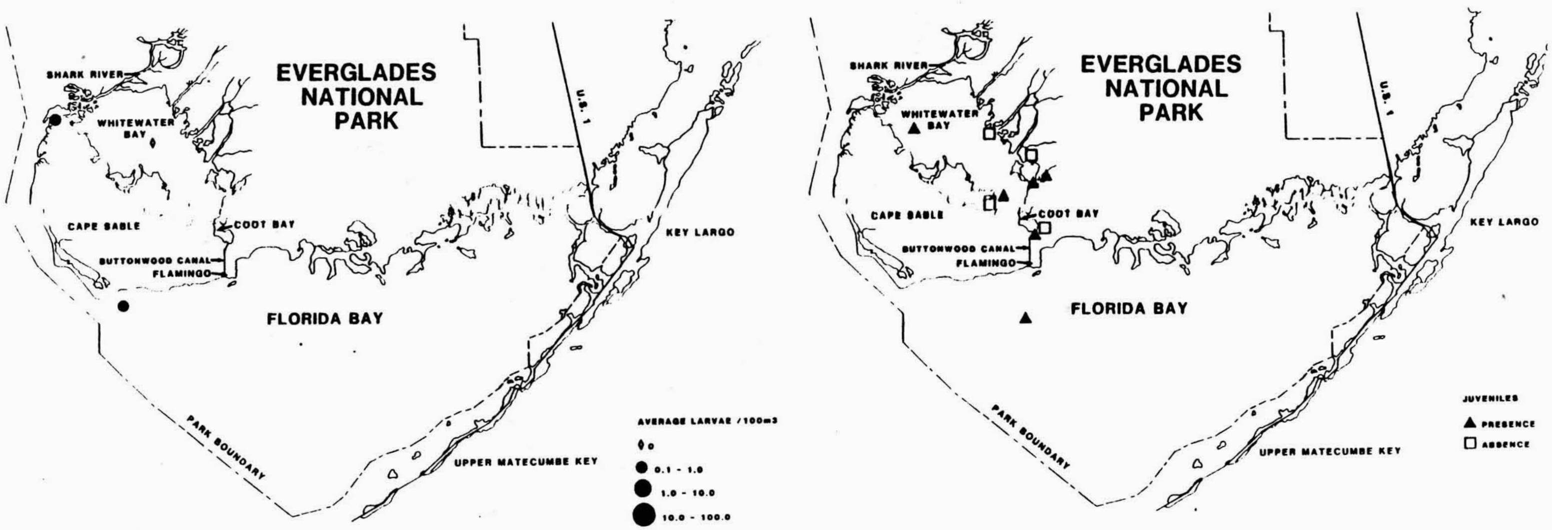


Figure 10d. Seasonal distribution of larval and juvenile spotted seatrout catches in ENP, 1983, fall (Oct-Dec).

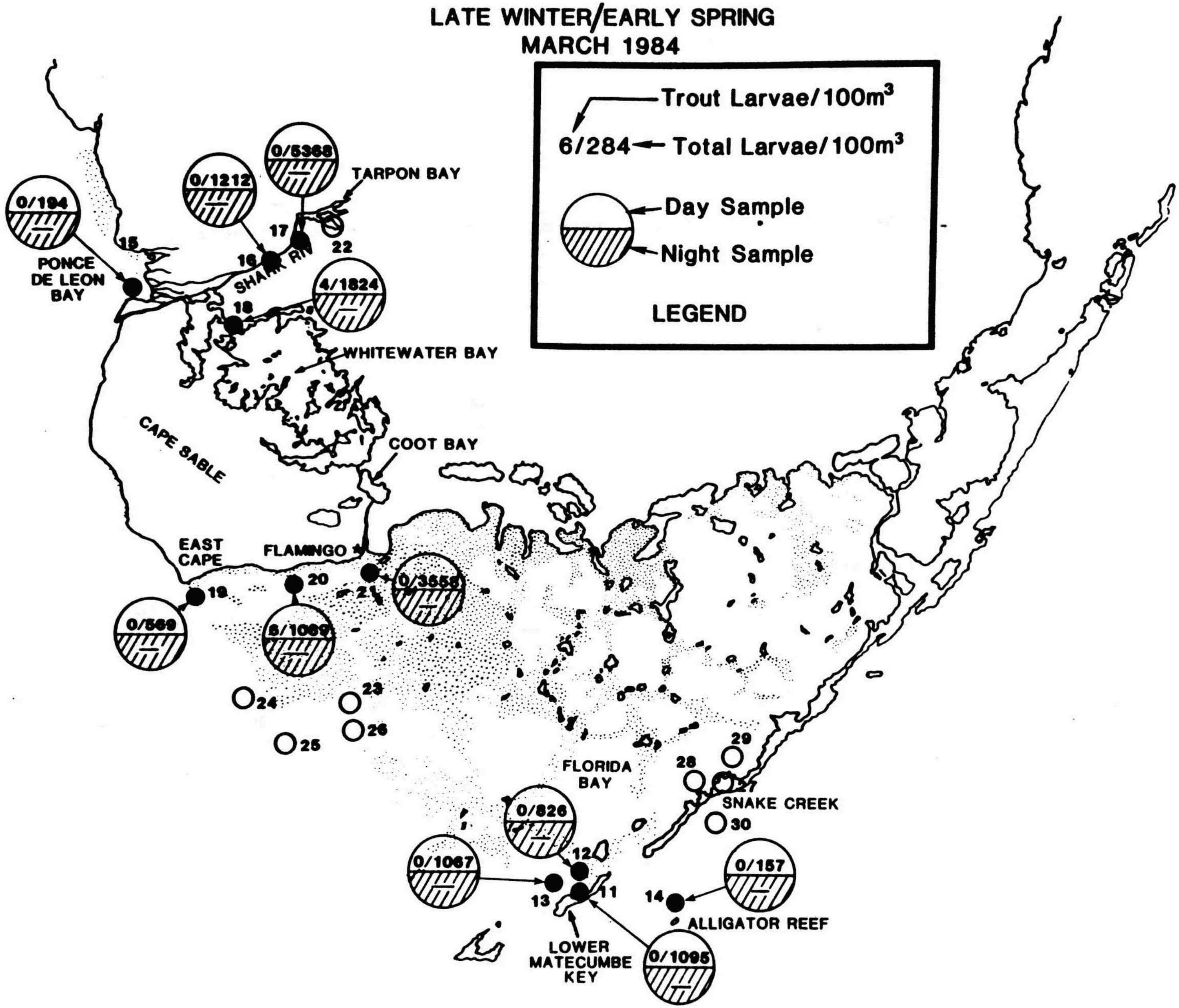


Figure 11a. The relative abundance of spotted seatrout and total fish larvae during late winter-early spring. Open circles indicate station not sampled (From Thayer and Hoss 1985).

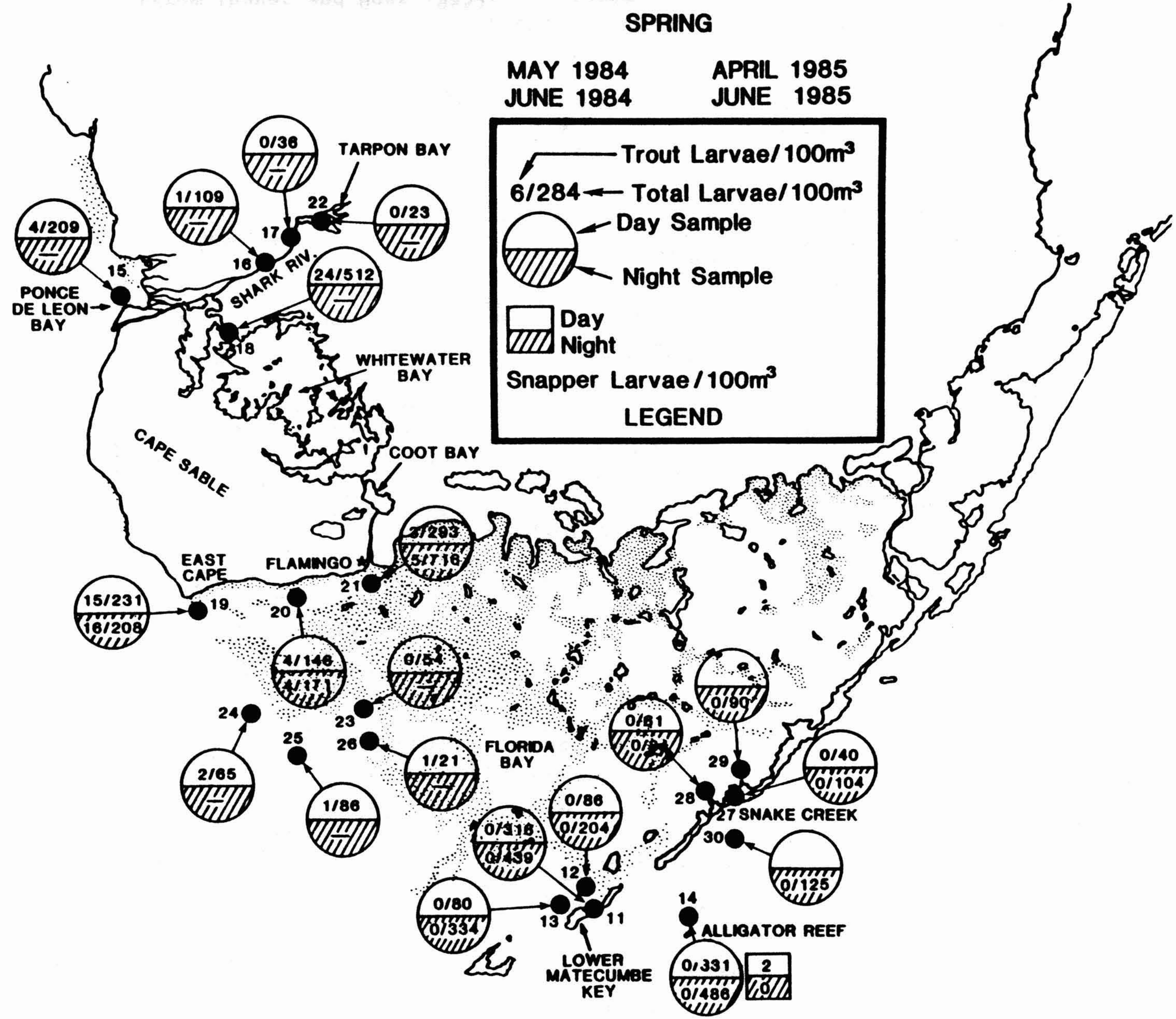


Figure 11b. The relative abundance of spotted seatrout and total fish larvae during spring (From Thayer and Hoss 1985).

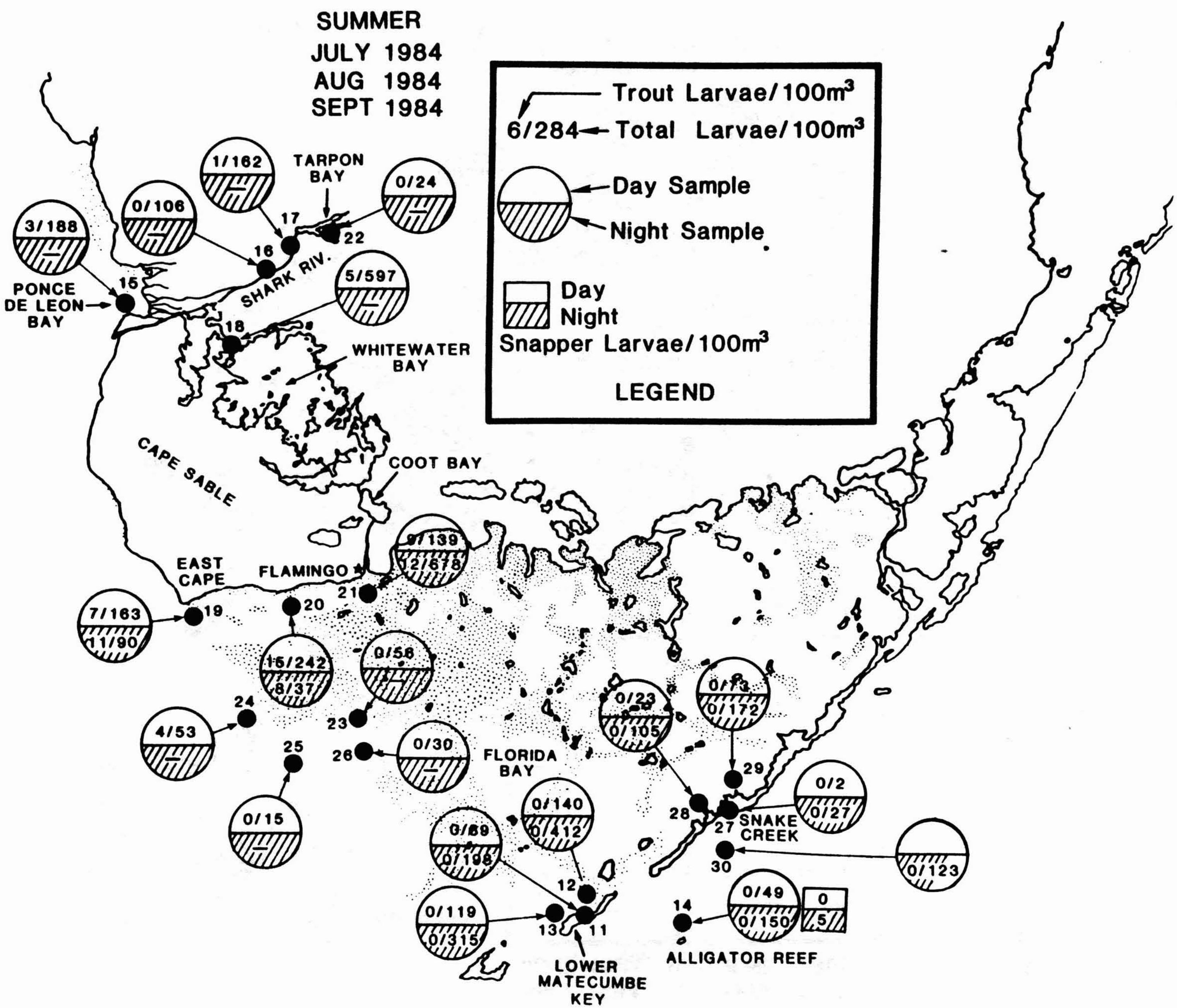


Figure 11c. The relative abundance of spotted seatrout and total fish larvae during summer (From Thayer and Hoss 1985).

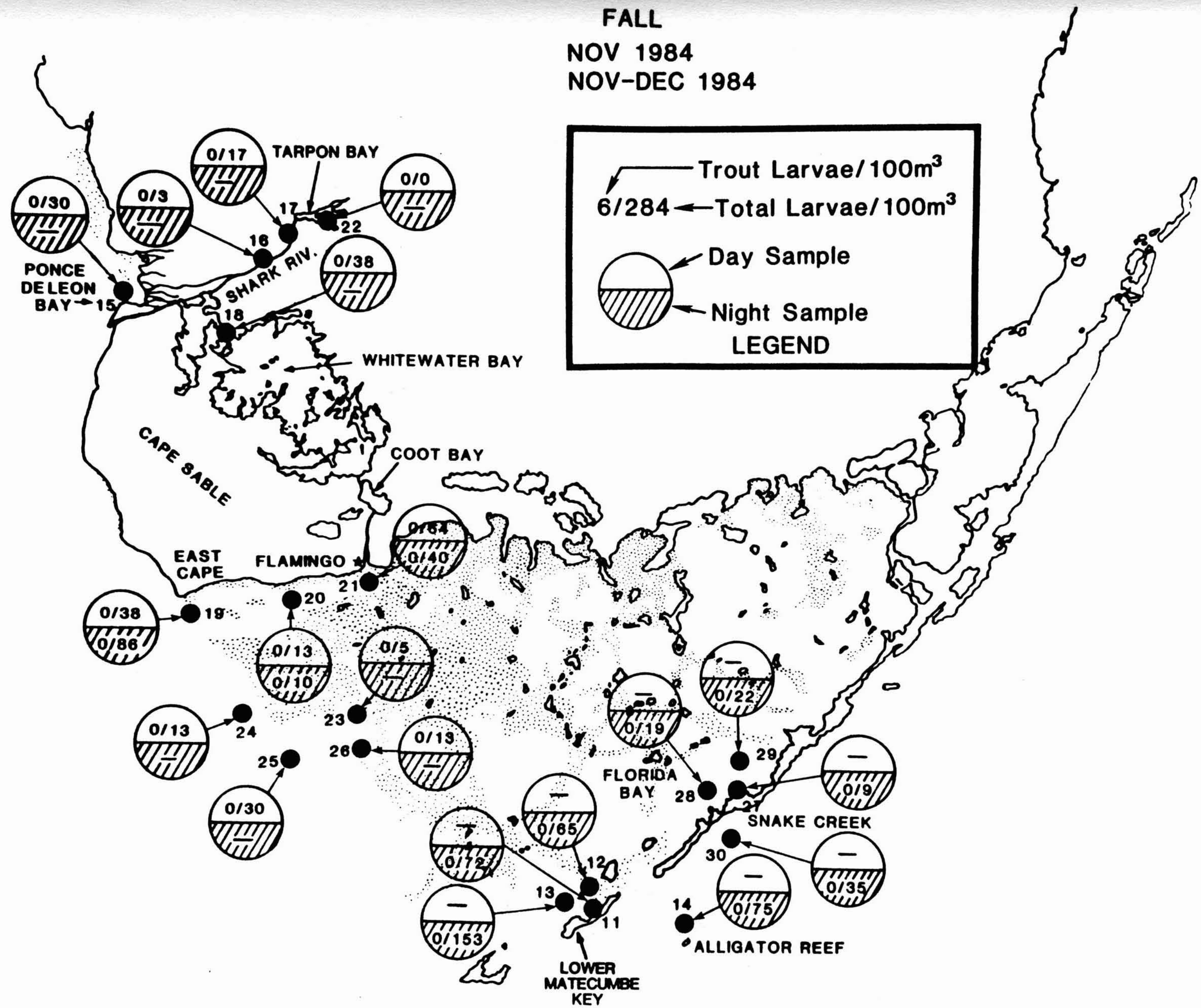


Figure 11d. The relative abundance of spotted seatrout and total fish larvae during fall (From Thayer and Hoss 1985).

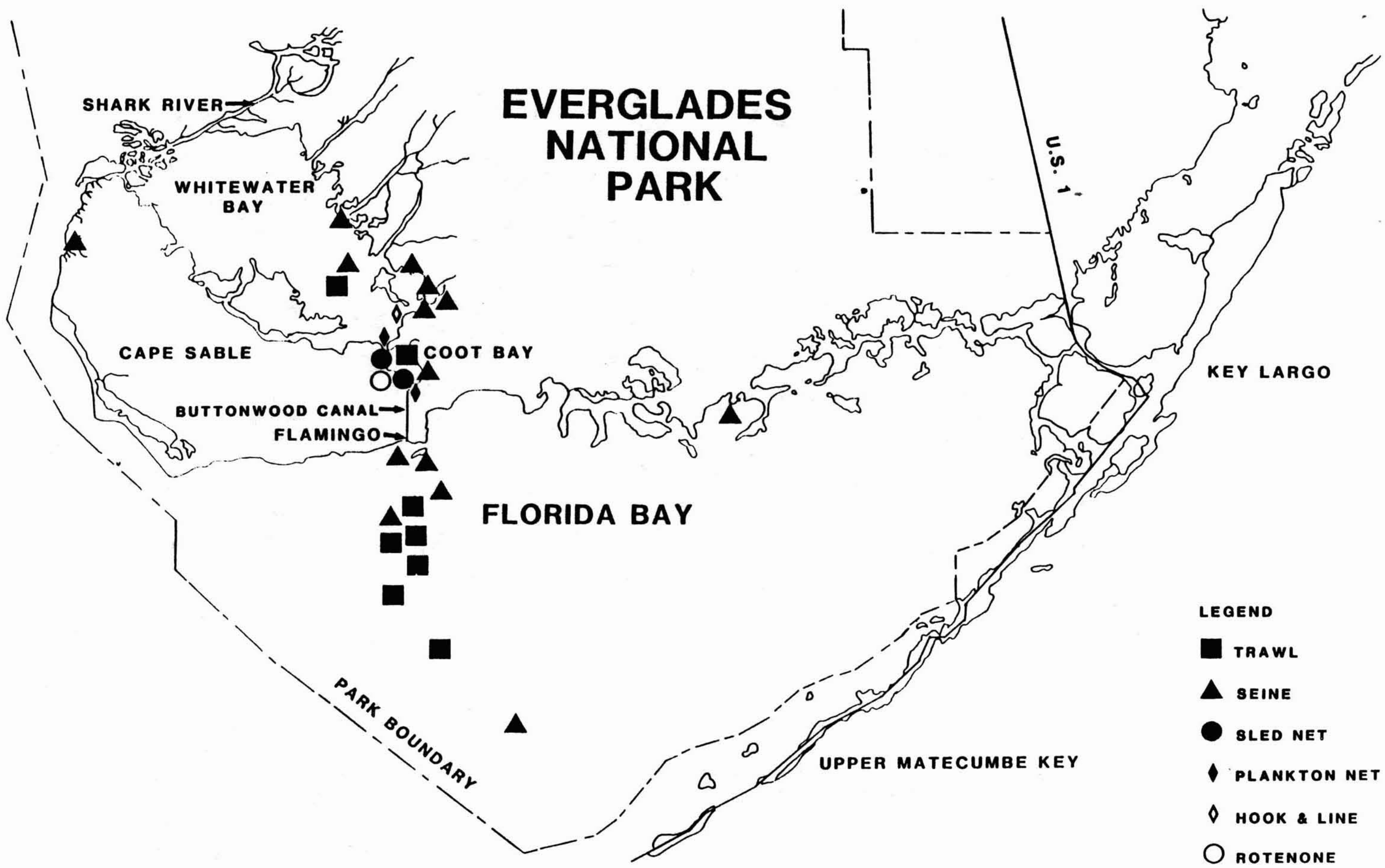


Figure 12. Distribution of juvenile spotted seatrout caught in ENP, 1982-84.

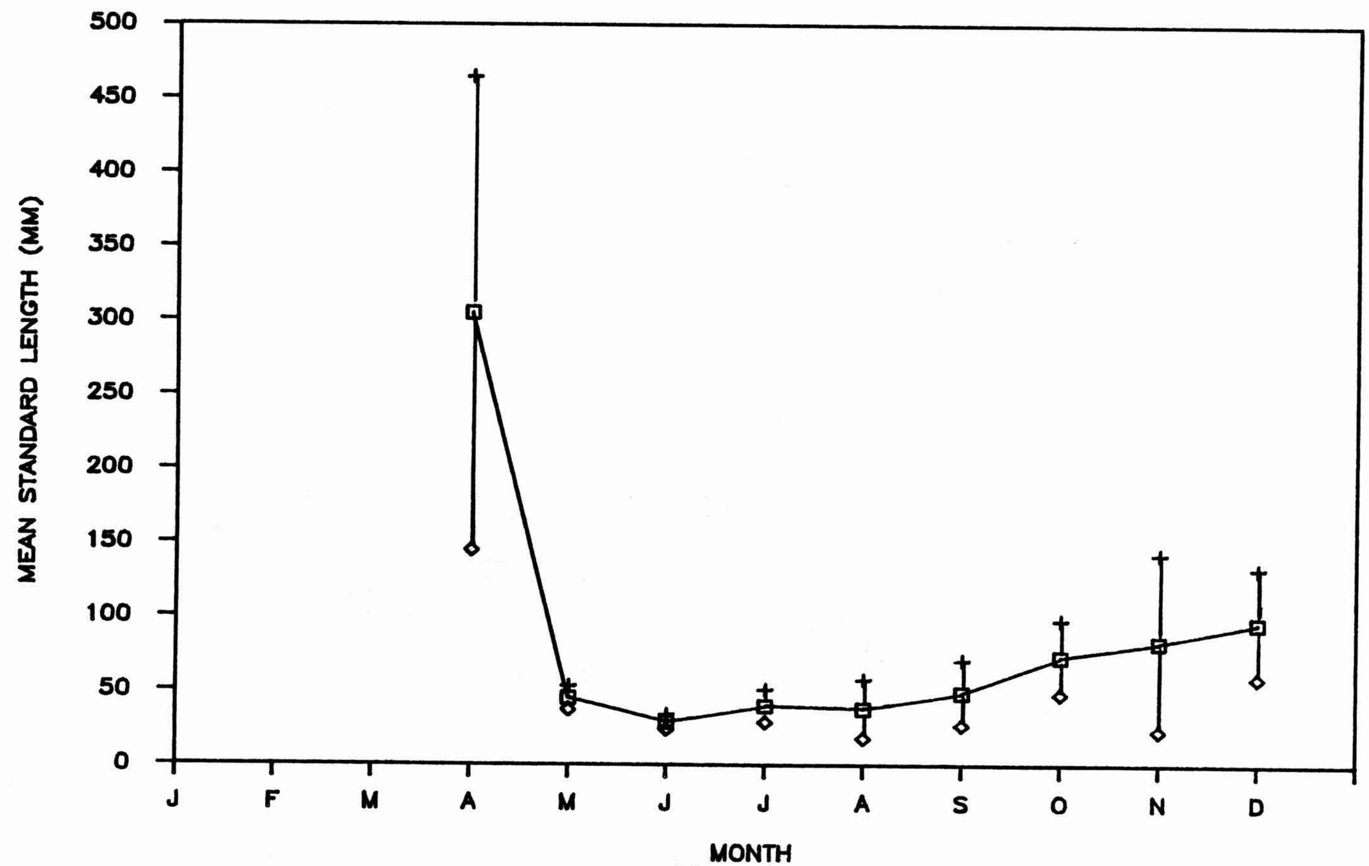


Figure 13. Mean standard length of spotted seatrout collected in ENP, 1982-84, all gears combined. Mean values include ± 1 standard deviation.

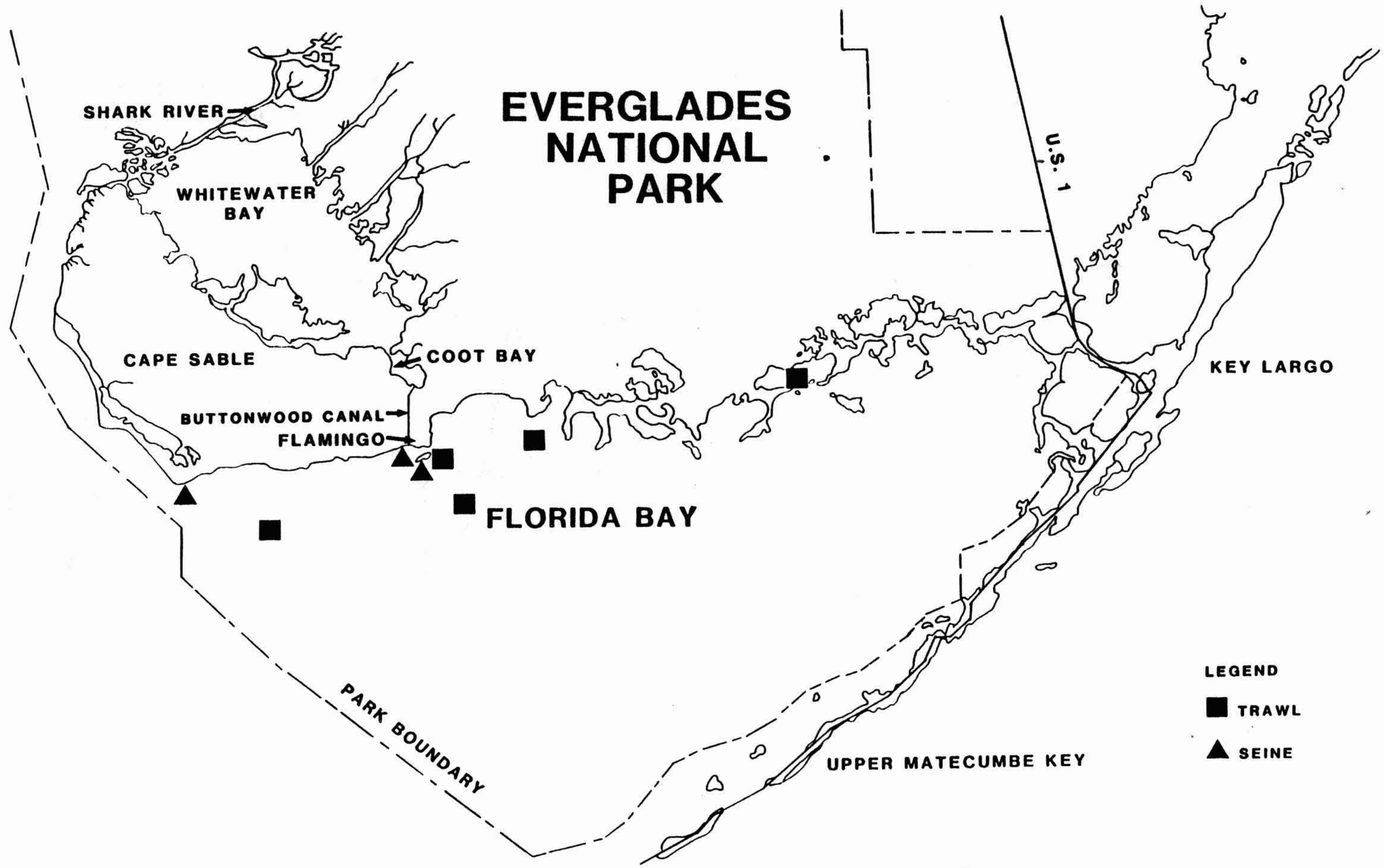


Figure 14. Distribution of juvenile spotted seatrout caught by otter trawl and beach seine in Florida Bay, ENP, 1973-76.

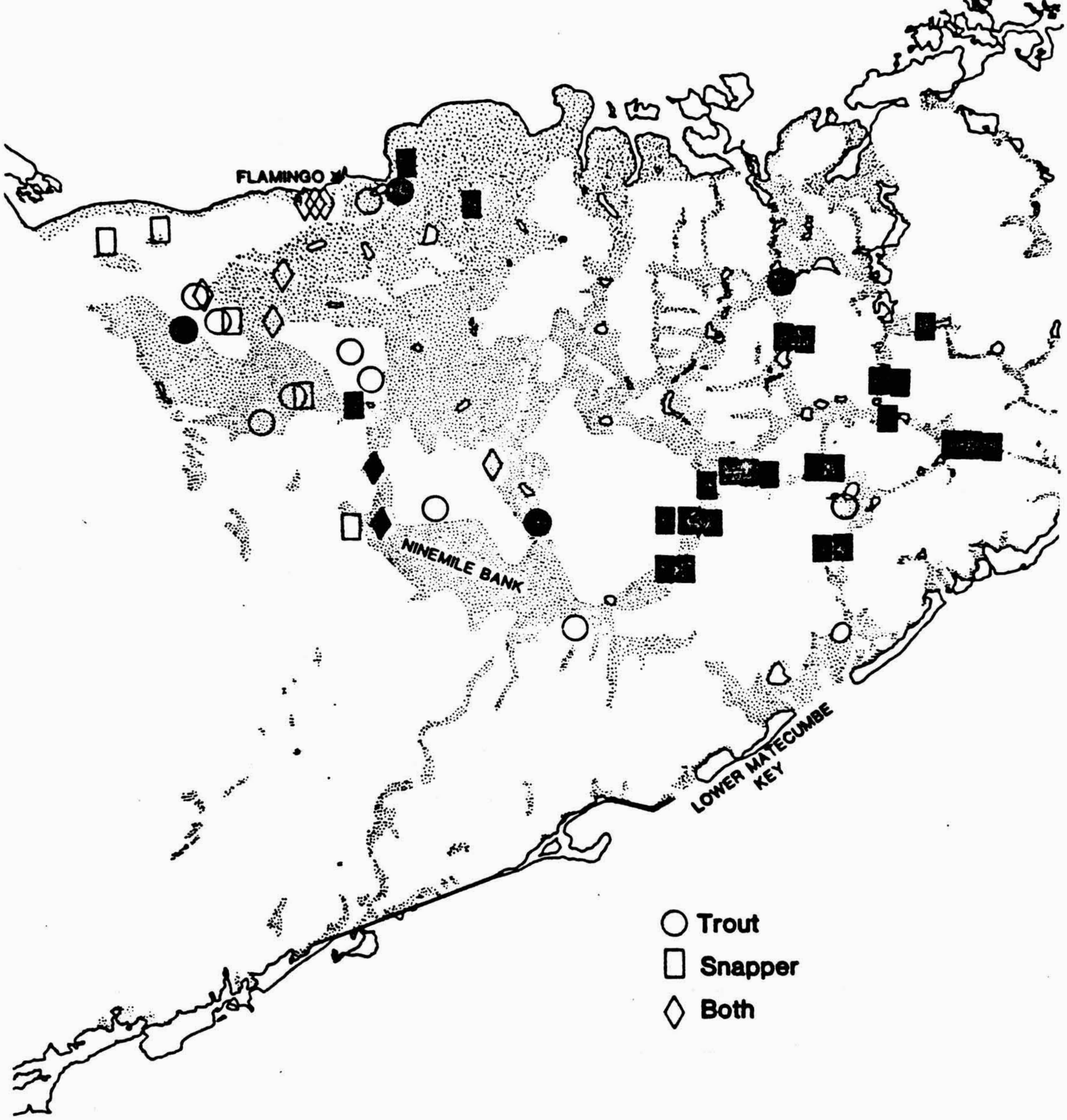


Figure 15. Distribution of juvenile spotted seatrout and juvenile gray snapper caught by otter trawl in Florida Bay, ENP, May 1984-June 1985. Darkened areas represent channel stations (From Thayer and Hoss 1985).

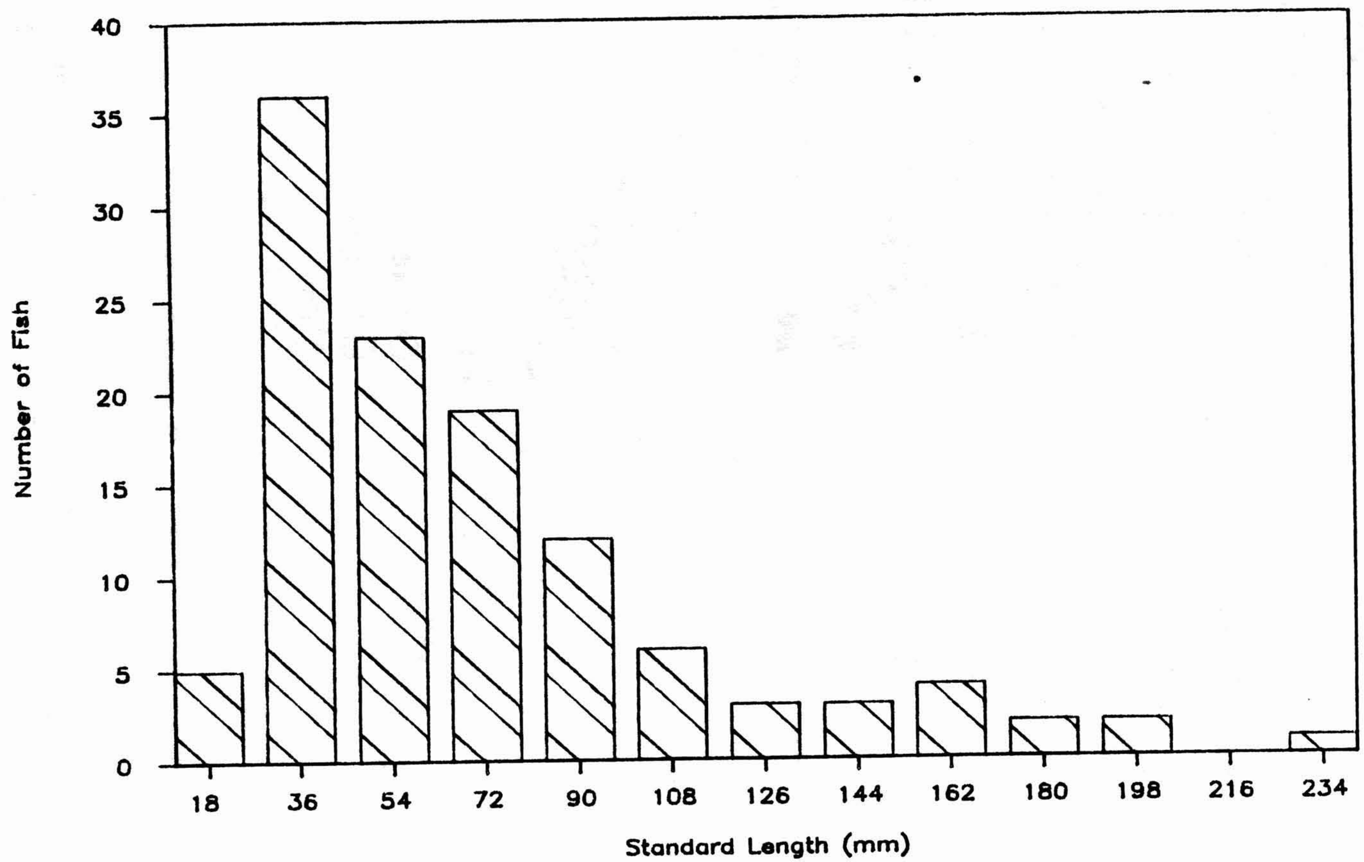


Figure 16. Length frequency of juvenile spotted seatrout caught by otter trawl in ENP, May 1984-March 1985. Data collected by Thayer and Hoss 1985.

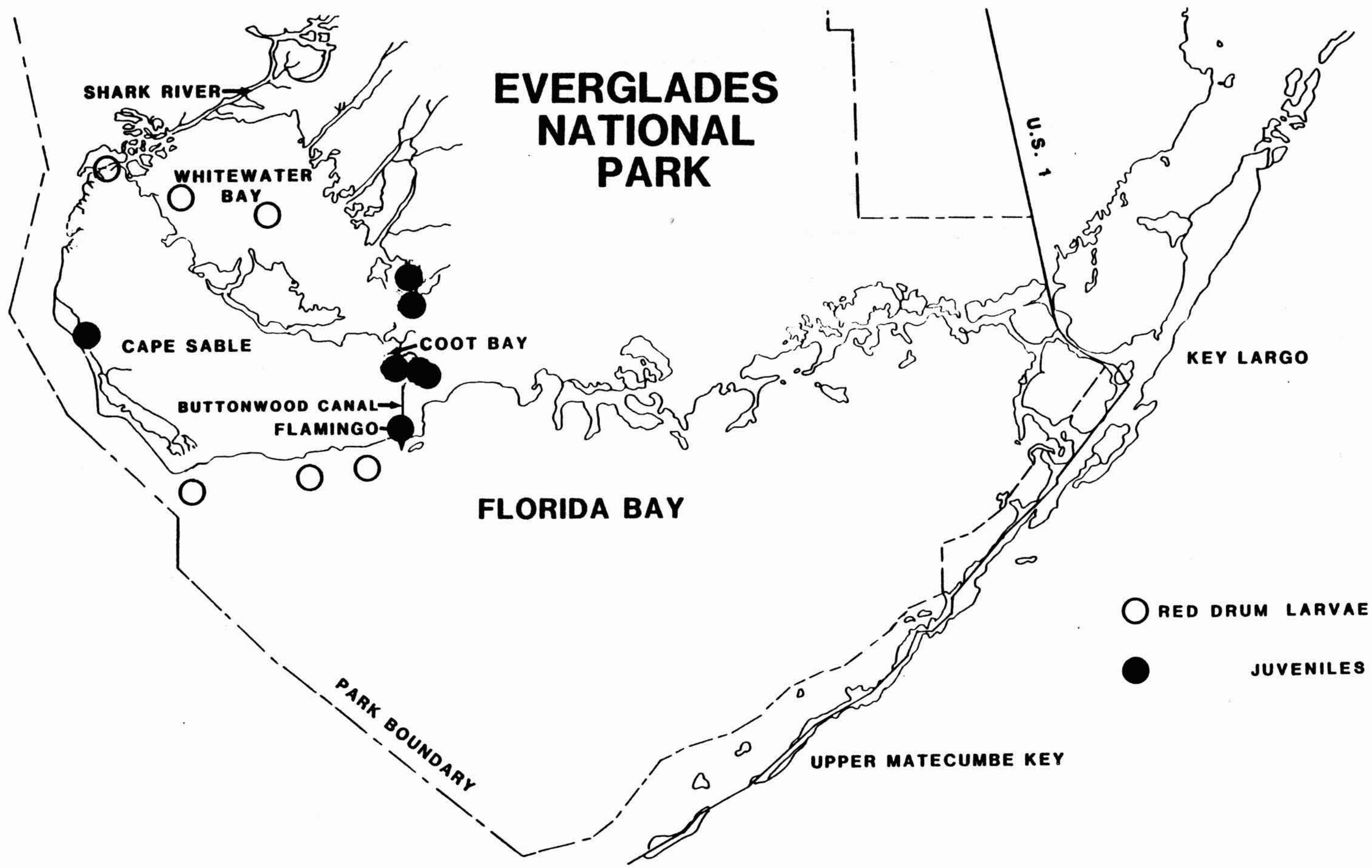


Figure 17. Distribution of successful red drum larval and juvenile catches in ENP, 1982-83.

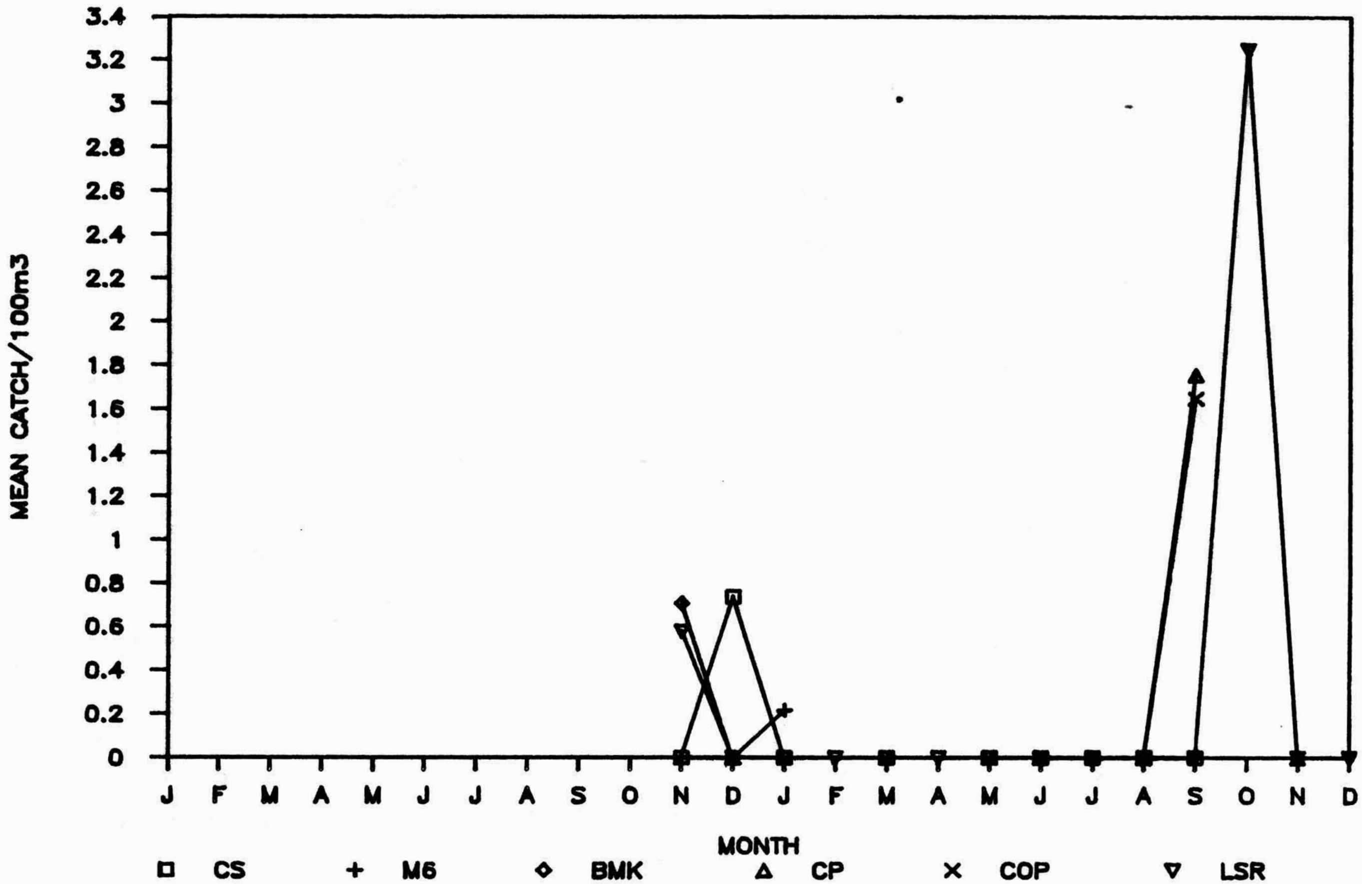


Figure 18. Mean catch/100 m^3 of red drum larvae by station in ENP, 1982-83. Stations include Cape Sable (CS), Bradley-Murray Key (BMK), Marker 6 (M6), Clearwater Pass (CP), Cormorant Pass (COP), and Little Shark River (LSR).

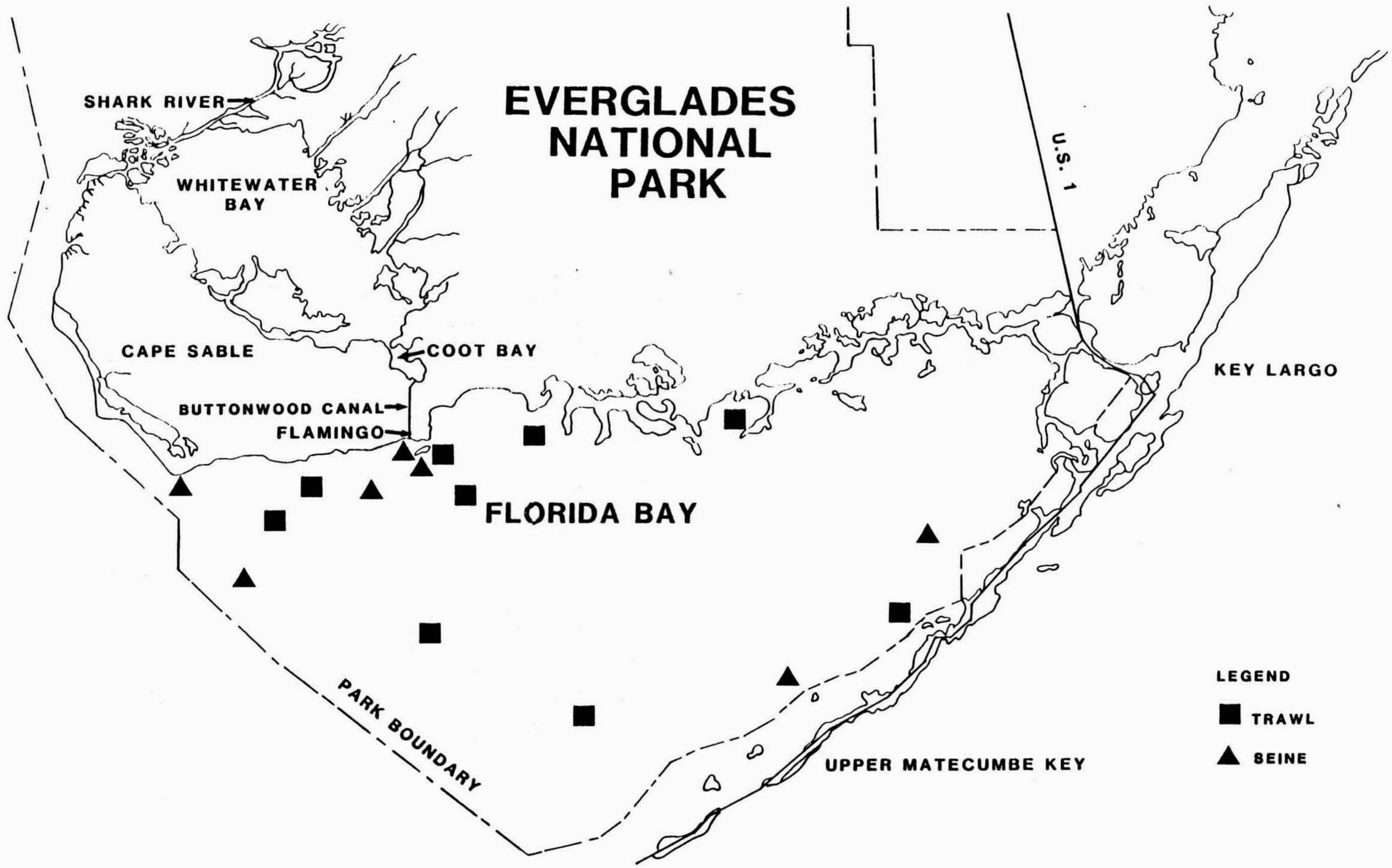


Figure 19. Distribution of juvenile gray snapper caught by otter trawl and beach seine in Florida Bay, ENP, 1973-76.

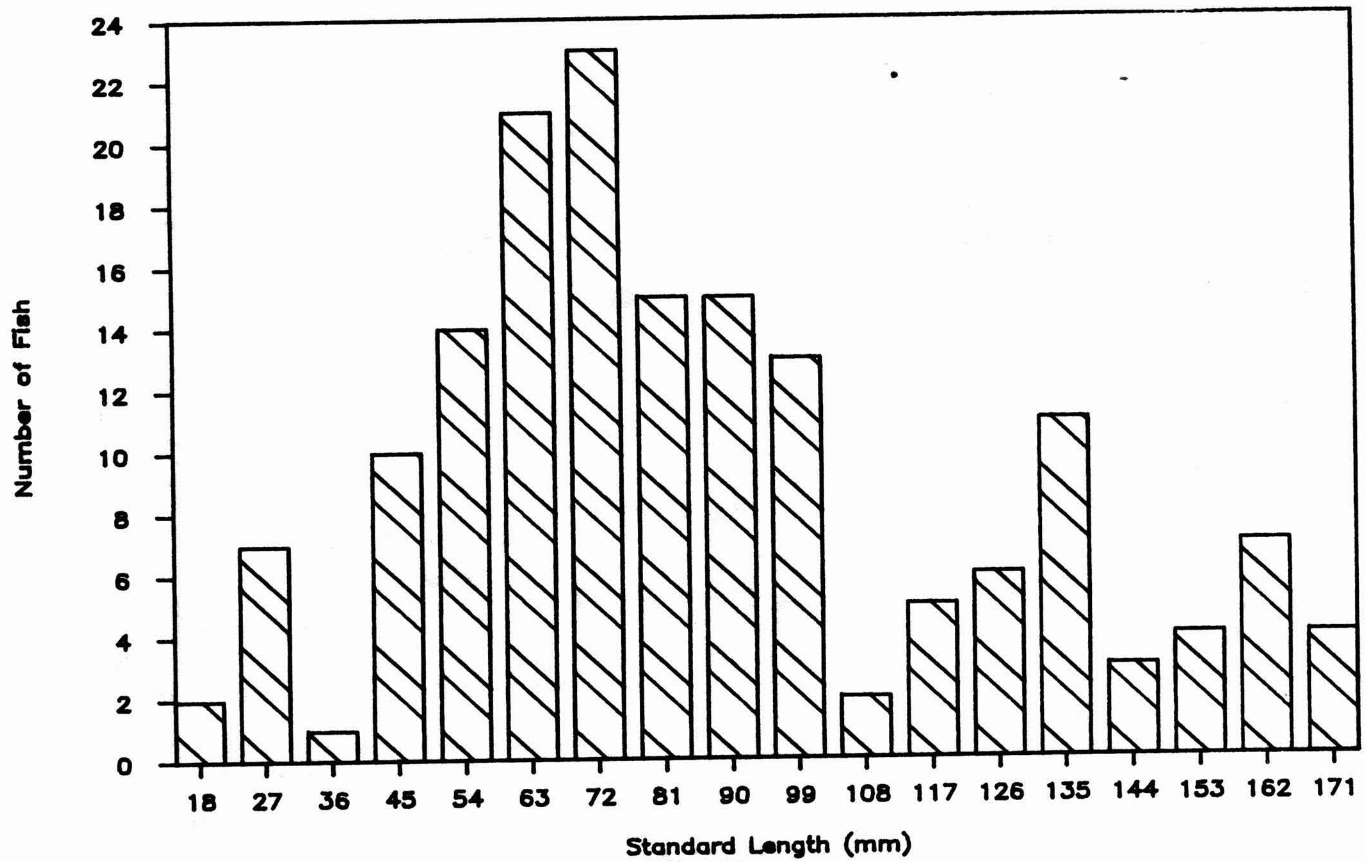


Figure 20. Length frequency of juvenile gray snapper caught by otter trawl in ENP, September 1984-June 1985.

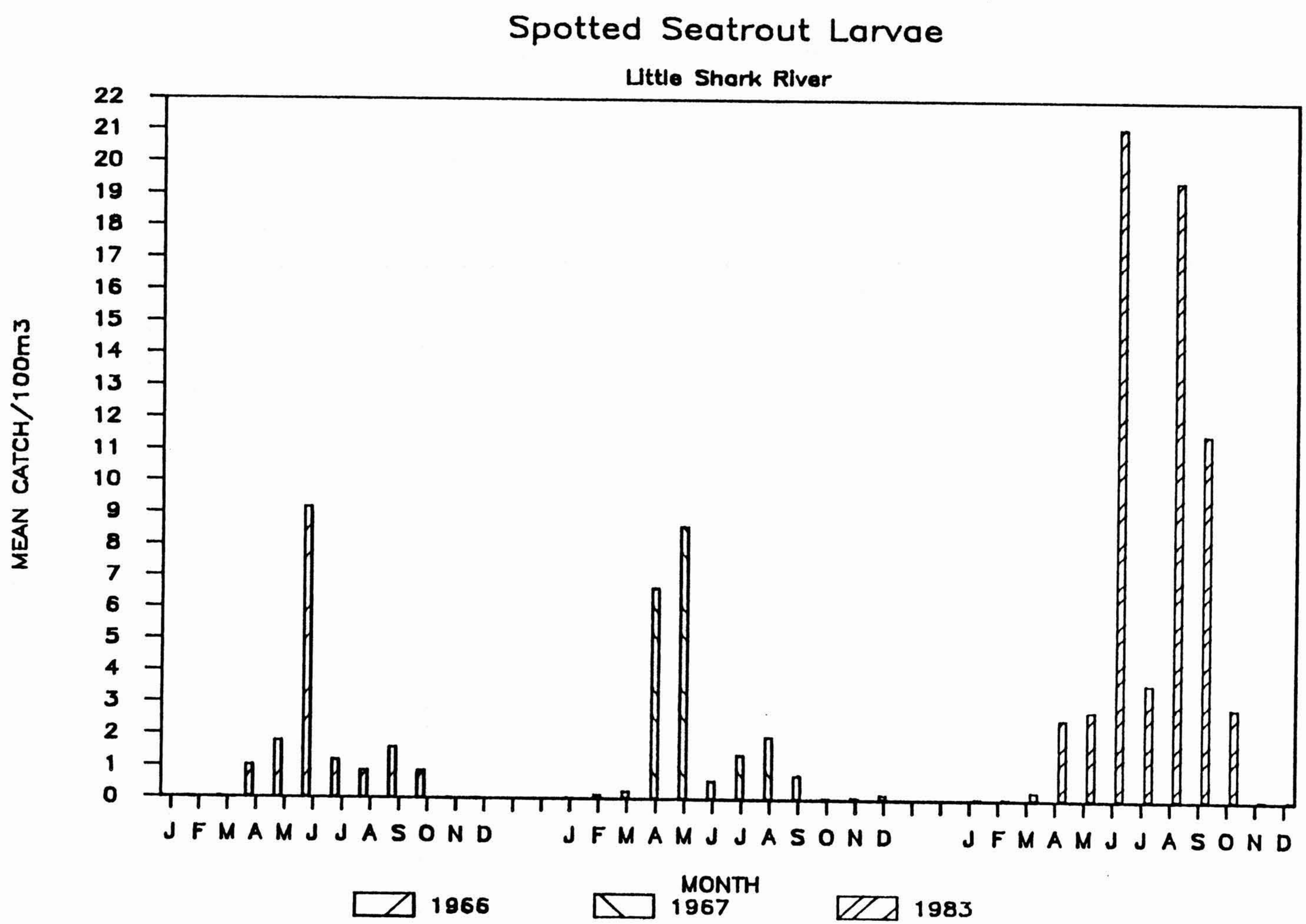


Figure 21. Mean catch/100 m^3 of spotted seatrout larvae at Little Shark River, 1966-67 and 1982-83.

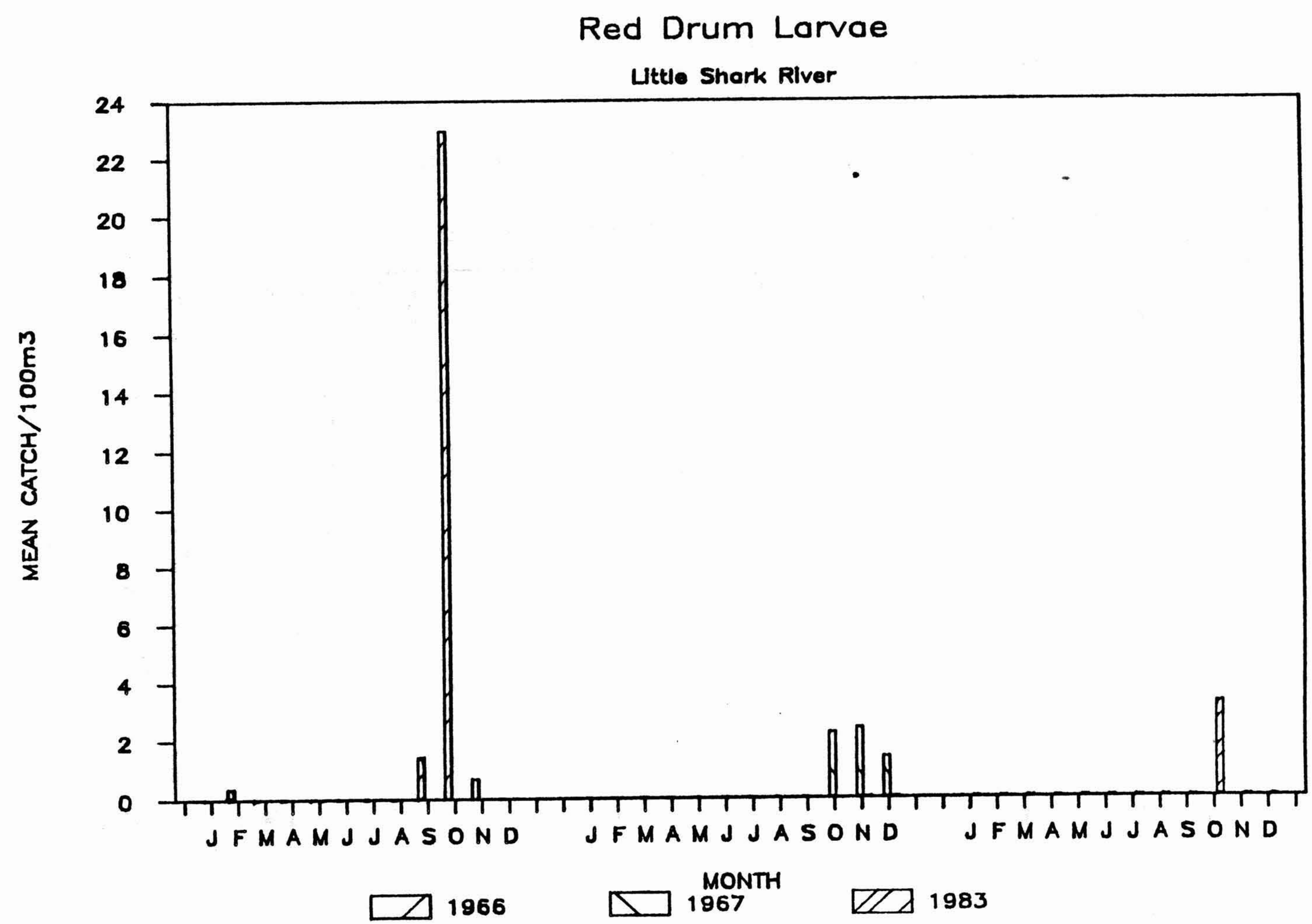


Figure 22. Mean catch/100 m^3 of red drum larvae at Little Shark River, 1966-67 and 1982-83.

Appendix I. Ichthyoplankton stations in Everglades National Park, 1982-1983. Stations sampled by a 333 micron mesh net are indicated (1) as monitoring sites or (2) as exploratory sites. Stations sampled by a 475 micron mesh net are indicated as (3) monitoring sites or (4) as exploratory sites.

AREA	CODED STATION NUMBER	LATITUDE d m s	LONGITUDE d m s	MESH SIZE SAMPLE FREQUENCY
Whitewater Bay				
Tarpon Creek	413	25 12 18	80 55 41	3
Buttonwood Canal	414	25 10 24	80 55 18	3
Joe River I	425	25 14 42	81 03 24	2
Joe River II	426	25 16 48	81 04 24	2
Clearwater Pass	427	25 17 36	80 59 30	2
W.of Clearwater Pass	428	25 17 18	81 01 06	2
E.of Clearwater Pass	429	25 18 00	80 58 42	2
Cormorant Pass	430	25 19 12	81 02 00	2
W.of Cormorant Pass	431	25 18 36	81 02 12	2
Shark River I	550	25 19 48	81 07 24	1
Shark River II	551	25 20 24	81 07 18	2
Shark River III	552	25 21 00	81 07 06	2
Shark River IV	553	25 21 12	81 07 12	2
Shark River V	554	25 22 06	81 07 24	2
West Florida Bay				
Cape Sable I	380	25 05 54	81 05 00	1
East Cape Canal	381	25 06 18	81 03 48	2
Marker 5-Middle Ground	351	25 05 42	81 01 48	3
Mouth western Conchie Ch.	382	25 06 18	80 59 06	2
Between Bradley, Murray Key	383	25 07 18	80 56 42	2
S.E. Conchie Channel	361	25 05 27	80 56 34	3
Man of War Channel	612	25 01 42	80 55 24	3
Clive Key Channel	159	25 04 36	80 55 54	4
East Florida Bay				
Trout Creek	131	25 12 53	80 32 00	3
Shell Creek	141	25 12 30	80 29 12	3
Jewfish Creek	543	25 11 00	80 23 24	4
Boggies	149	25 10 24	80 26 54	4
Long Sound Pass	140	25 13 24	80 27 24	4
Whale Harbor	283	24 56 36	80 36 49	3

Appendix II. Water quality characteristics of selected ichthyoplankton stations in ENP, 1982-1983.

	Eastern Florida Bay		Western Florida Bay		Whitewater Bay	
	Whale Harbor	Shell Creek	Marker 5	Cape Sable	Tarpon Creek	Little Shark River
Salinity (ppt)						
Mean	35.8±0.9	17.4±3.7	34.1±0.4	34.1±0.7	12.2±1.6	25.1±0.8
Range	29.0-40.0	3-30	31.9-36.0	29.0-37.0	5.0-37.9	18.0-30.0
N	54	28	59	46	91	87
Temperature (^{o}C)						
Mean	25.1±1.2	28.3±1.1	25.2±1.3	23.7±0.9	27.5±0.7	24.7±0.6
Range	19.6-30.5	23.9-31.9	16.0-33.0	16.3-28.0	21.7-31.0	17.0-31.0
N	48	34	59	46	93	87
Depth (cm)						
Mean	197.8±1.7	177.6±17.4	291.6±7.0	292±25.0	197.2±2.9	230.6±14.5
Range	180-280	45-200	195-300	210-420	150-210	120-360
N	54	34	59	46	92	87
Current Speed (cm/sec)						
Mean	54.7±8.7	104.6±3.7	26.4±2.3	33.4±5.6	43.6±10.9	47.1±4.7
Range	11-118	1-352	10.0-41.0	5-60.0	0-230	1-105
N	51	29	48	38	87	81
Dissolved Oxygen (ppm)						
Mean	8.2±0.4	7.2	7.8±0.1	7.4±0.1	7.8±0.2	6.4±0.5
Range	6.1-10.0	---	7.2-8.4	7.2-7.6	7.1-8.7	4.8-7.9
N	36	5	33	23	36	32
pH						
Mean	7.1±0.1	7.5±0.2	7.0±0.1	6.4±0.2	7.1±0.1	6.5±0.1
Range	6.4-8.0	6.5-8.2	6.6-7.4	6-7.4	6.5-8.2	5.7-7.4
N	48	34	46	32	90	55
Turbidity (NTU)						
Mean	3.7±0.9	2.9±0.3	7.5±1.2	7.5±3.6	11.6±2.8	3.9±0.6
Range	1.3-8.2	1.0-4.6	2.9-16.0	2-12.0	1.7-55.0	1.9-5.8
N	34	48	40	11	90	39

Appendix III. Associated fish and macrocrustacean species caught with juvenile spotted seatrout in ENP, 1973-76 and 1982-84.

Species	Common Name	Number times Caught with Target Species	Percentage time Caught with Target Species
Penaeus duorarum	pink shrimp	92	69.2
Periclimenes longicaudatus	glass shrimp	1	0.8
P. spp.	glass shrimp	5	3.8
Leander paulensis	shrimp	1	0.8
Leander spp.	shrimp	1	0.8
Palaemonetes intermedius	grass shrimp	2	1.5
P. pugio	grass shrimp	1	0.8
P. spp.	grass shrimp	4	3.0
Alphaeus heterochaelis	Big-clawed snapping shrimp	2	1.5
A. spp.	snapping shrimp	1	0.8
Thor floridanus	shrimp	3	2.3
Thor spp.	shrimp	1	0.8
Latreutes fucorum	shrimp	1	0.8
Hippolyte pleuracanthus	shoal-grass shrimp	19	14.3
H. spp.	shrimp	3	2.3
Tozeuma carolinense	arrow shrimp	16	12.0
T. spp.	shrimp	2	1.5
Libinia dubia	spider crab	6	4.5
L. emarginata	spider crab	7	5.3
L. spp.	spider crab	6	4.5
Neopanope texana	mud crab	2	1.5
Portunus gibbesii	swimming crab	1	0.8
Callinectes sapidus	blue crab	24	18.0
C. ornatus	ornate crab	4	3.0
Elops saurus	ladyfish	2	1.5
Ophichthidae	snake eels	5	3.8
Clupeidae spp.	herrings	7	5.3
Brevoortia patronus	Gulf menhaden	2	1.5
B. spp.	menhaden	1	0.8
Harengula jaguana	scaled sardine	17	12.8
Opisthonema oglinum	Atlantic thread herring	8	6.0
Engraulidae	anchovies	13	9.8
Anchoa hepsetus	striped anchovy	17	12.8
A. mitchilli	bay anchovy	44	33.1
A. spp.	anchovy	1	0.8
Synodus foetens	lizardfish	25	18.8
Clarius batrachus	walking catfish	1	0.8

Appendix III. Continued.

Species	Common Name	Number times Caught with Target Species	Percentage time Caught with Target Species
Arius felis	hardhead catfish	3	2.3
Bagre marinus	gulf topsail catfish	2	1.5
Opsanus beta	gulf toadfish	39	29.3
Chriodorus atherinoides	hardhead halfbeak	3	2.3
Hyporhamphus unifasciatus	halfbeak	2	1.5
Belonidae	needlefish	1	0.8
Strongylura marina	Atlantic needlefish	1	0.8
S. notata	redfin needlefish	6	4.5
S. timucu	timucu	5	3.8
Cyprinodontidae	killifishes	9	6.8
Cyprinodon variegatus	sheepshead minnow	4	3.0
Floridichthys carpio	goldspotted killifish	33	24.8
Fundulus confluentus	marsh killifish	2	1.5
F. grandis	gulf killifish	2	1.5
F. similis	longnose killifish	1	0.8
F. spp.	killifish	1	0.8
Lucania parva	rainwater killifish	53	39.9
Gambusia affinis	mosquitofish	4	3.0
Poecilia latipinna	sailfin molly	4	3.0
Atherinidae	silversides	9	6.8
Labidesthes sicculus	brook silverside	1	0.8
Membras martinica	rough silverside	7	5.3
Menidia beryllina	inland silverside	7	5.3
Sygnathidae	pipefishes	5	3.8
Hippocampus erectus	lined seahorse	6	4.5
H. zosterae	dwarf seahorse	23	17.3
H. spp.	seahorse	1	0.8
Micrognathus criniger	fringed pipefish	3	2.3
Sygnathus floridae	dusky pipefish	39	29.3
S. louisianae	chain pipefish	17	12.8
S. scovelli	gulf pipefish	50	37.6
Sygnathus spp.	pipefish	4	3.0
Centropomus undecimalis	snook	6	4.5
Hypoplectrus puella	barred hamlet	4	3.0
Mycteroperca bonaci	gag grouper	3	2.3
Centrarchidae	sunfishes	1	0.8
Lepomis spp.	sunfish	1	0.8
Carangidae	jacks	1	0.8

Appendix III. Continued.

Species	Common Name	Number times Caught with Target Species	Percentage time Caught with Target Species
Chloroscombus chrysurus	Atlantic bumper	1	0.8
Oligoplites saurus	leatherjacket	12	9.0
Selene vomer	lookdown	2	1.5
Trachinotus falcatus	permit	5	3.8
Lutjanidae	snappers	1	0.8
Lutjanus griseus	gray snapper	29	21.8
L. synagris	lane snapper	20	15.0
Gerreidae	mojarras	12	9.0
Diapterus auratus	Irish pompano	1	0.8
D. plumieri	striped mojarra	74	3.0
Eucinostomus argenteus	spotfin mojarra	30	22.6
E. gula	silver jenny	75	56.4
E. spp.	mojarra	9	6.8
Gerres cinereus	yellowfin mojarra	3	2.3
Haemulon parrai	sailor's choice	1	0.8
H. plumieri	white grunt	30	22.6
H. sciurus	blue striped grunt	5	3.8
Orthopristis chrysoptera	pigfish	39	29.3
Archosargus probatocephalus	sheepshead	20	15.0
Calamus arctifrons	grass porgy	12	9.0
Lagodon rhomboides	pinfish	64	48.1
Sciaenidae	drums	7	5.3
Bairdiella batabana	blue croaker	2	1.5
B. chrysoura	silver perch	62	46.6
Cynoscion arenarius	sand seatrout	2	1.5
Equetus punctatus	spotted drum	1	0.8
Leiostomus xanthurus	spot	2	1.5
Menticirrhus americanus	southern kingfish	1	0.8
Sciaenops ocellatus	red drum	5	3.8
Chaetodipterus faber	Atlantic spadefish	13	9.8
Lachnolaimus maximus	hogfish	1	0.8
Nicholsina usta	emerald parrotfish	9	6.8
Sparisoma rubripinne	redfin parrotfish	1	0.8
Mugil cephalus	striped mullet	7	5.3
M. trichodon	fantail mullet	7	5.3
Mugilidae	mullets	1	0.8
Sphyraena barracuda	great barracuda	8	6.0

Appendix III. Continued.

Species	Common Name	Number times Caught with Target Species	Percentage time Caught with Target Species
Blennidae	blennies	1	0.8
Chasmodes saburrae	Florida blenny	5	3.8
Callionymus pauciradiatus	spotted dragonet	2	1.5
Gobiidae	gobies	12	9.0
Gobiosoma bosci	masked goby	5	3.8
Gobiosoma robustum	code goby	13	9.8
Lophogobius cyprinoides	crested goby	2	1.5
Microgobius gulosus	clown goby	17	12.8
Triglidae	searobins	1	0.8
Prionotus scitulus	leopard searobin	4	3.0
P. tribulus	bighead searobin	1	0.8
Bothidae	flounders	1	0.8
Paralichthys albigutta	gulf flounder	1	0.8
P. lethostigma	southern flounder	2	1.5
Soleidae	soles	4	3.0
Achirus lineatus	lined sole	16	12.0
Trinectes maculatus	hogchoker	3	2.3
Symphurus plagiusa	blackcheek tonguefish	11	8.3
Monacanthus ciliatus	fringed filefish	21	15.8
M. hispidus	planehead filefish	21	15.8
Lactophrys quadricornis	scrawled cowfish	10	7.5
L. trigonus	trunkfish	2	1.5
Sphoeroides nephulus	southern puffer	17	12.8
S. spengleri	bandtail puffer	1	0.8
Chilomycterus antillarum	web burrfish	2	1.5
C. shoepfi	striped burrfish	28	21.1

Appendix IV. Associated fish and macroinvertebrates caught with juvenile red drum in ENP, 1982-84.

Species	Common Name	Number times Caught with Target Species	Percentage time Caught with Target Species
Penaeus duorarum	pink shrimp	4	36.4
Palaemonetes pugio	grass shrimp	1	9.1
Elops saurus	ladyfish	3	27.3
Anguilla rostrata	American eel	1	9.1
Brevoortia tyrannus	Atlantic menhaden	2	18.2
Opisthonema oglinum	Atlantic thread herring	1	9.1
Anchoa hepsetus	striped anchovy	1	9.1
A. mitchilli	bay anchovy	6	54.5
Arius felis	sea catfish	1	9.1
Bagre marinus	gafftopsail catfish	1	9.1
Opsanus beta	gulf toadfish	1	9.1
Strongylura timicu	timucu	1	9.1
Cyprinodon variegatus	sheepshead minnow	1	9.1
Floridichthys carpio	goldspotted killifish	3	27.3
Fundulus confluentus	marsh killifish	1	9.1
F. grandis	gulf killifish	1	9.1
Jordanella floridae	flagfish	1	9.1
Lucania parva	rainwater killifish	5	45.5
Gambusia affinis	mosquitofish	3	27.3
Poecilia latipinnia	sailfin molly	2	18.2
Labidesthes sicculus	brook silverside	1	9.1
Menidia beryllina	inland silverside	3	27.3
Syngnathus scovelli	gulf pipefish	1	9.1
S. spp.	pipefish	1	9.1
Centropomus undecimalis	snook	2	18.2
Lepomis macrochiris	bluegill	1	9.1
L. microlophus	redear sunfish	1	9.1
L. punctatus	spotted sunfish	3	27.3
L. spp.	sunfish	1	9.1
Oligoplites saurus	leatherjacket	1	9.1
Lutjanus griseus	gray snapper	2	18.2
Diapterus plumieri	striped mojarra	1	9.1
Eucinostomus argenteus	spotfin mojarra	2	18.2
E. gula	silver jenny	3	27.3
E. spp.	mojarras	3	27.3
Orthopristis chrysoptera	pigfish	1	9.1
Archosargus probatocephalus	sheepshead	2	18.2
Lagodon rhomboides	pinfish	1	9.1

Appendix IV. Continued.

Species	Common Name	Number times Caught with Target Species	Percentage time Caught with Target Species
Bairdiella chrysoura	silver perch	1	9.1
Cynoscion arenarius	sand seatrout	1	9.1
C. nebulosus	spotted seatrout	4	36.4
Mugil cephalus	striped mullet	2	18.2
Gobiidae	gobies	1	9.1
Gobiosoma robustum	code goby	2	18.2
Microgobius gulosus	clown goby	6	54.5
Achirus lineatus	lined sole	1	9.1
Trinectes maculatus	hogchoker	1	9.1

Appendix V. Associated fish and macrocrustacean species caught with juvenile gray snapper in ENP, 1973-76 and 1982-84.

Species	Common Name	Number times Caught with Target Species	Percentage time Caught with Target Species
Penaeus duorarum	pink shrimp	40	44.4
Periclemenes longicaudatus	glass shrimp	2	2.2
P. spp.	glass shrimp	4	4.4
L. paulensis	shrimp	2	2.2
Leander spp.	shrimp	1	1.1
Palaemonetes spp.	grass shrimp	2	2.2
H. pleuracanthus	shoal-grass shrimp	16	17.8
Hippolyte spp.	shrimp	1	1.1
Thor spp.	shrimp	1	1.1
Latreutes fucorum	shrimp	1	1.1
Tozeuma carolinense	arrow shrimp	23	25.6
Libinia dubia	spider crab	2	2.2
L. emarginata	spider crab	7	7.8
L. spp.	spider crab	5	5.6
Mithrax spp.	spider crab	1	1.1
Neopanope texana	mud crab	6	6.7
Portunus gibbesii	swimming crab	1	1.1
Callinectes sapidus	blue crab	16	17.8
C. ornatus	ornate crab	2	2.2
Panulirus argus	spiny lobster	8	8.9
Negaprion brevirostris	lemon shark	1	1.1
Elops saurus	ladyfish	2	2.2
Megalops atlanticus	tarpon	1	1.1
Brevoortia patronus	gulf menhaden	1	1.1
B. tyrannus	Atlantic menhaden	1	1.1
Harengula jaguana	scaled sardine	8	8.9
Opisthonema oglinum	Atlantic thread herring	4	4.4
Anchoa hepsetus	striped anchovy	5	5.6
A. mitchilli	bay anchovy	22	24.4
Anchoviella perfasciata	flat anchovy	1	1.1
Synodus foetens	inshore lizardfish	25	27.8
Arius felis	sea catfish	3	3.3
Bagre marinus	gafftopsail catfish	1	1.1
Opsanus beta	gulf toadfish	44	48.9
Ogcocephalus radiatus	polka-dot batfish	1	1.1
Chriodorus atherinoides	hardhead halfbeak	2	2.2
Hyporhamphus unifasciatus	halfbeak	1	1.1

Appendix V. Continued.

Species	Common Name	Number times Caught with Target Species	Percentage time Caught with Target Species
Strongylura notata	redfin needlefish	6	6.7
S. timucu	timucu	1	1.1
Floridichthys carpio	goldspotted killifish	23	25.6
Fundulus confluentus	marsh killifish	1	1.1
Lucania parva	rainwater killifish	51	56.7
Gambusia affinis	mosquitofish	1	1.1
Poecilia latipinnia	sailfin molly	2	2.2
Membras martinica	rough silversides	2	2.2
Menidia beryllina	inland silversides	1	1.1
Hippocampus erectus	lined seahorse	7	7.8
H. zosterae	dwarf seahorse	19	21.1
Hippocampus spp.	seahorses	1	1.1
Micrognathus criniger	fringed pipefish	4	4.4
Syngnathus floridae	dusky pipefish	50	55.6
S. louisianae	chain pipefish	9	10.0
S. scovelli	gulf pipefish	31	34.4
S. sp.	pipefishes	2	2.2
Centropomus undecimalis	snook	2	2.2
Diplectrum formosum	sand perch	5	5.6
Hypoplectrus puella	barred hamlet	7	7.8
Mycteroperca microlepis	gag	3	3.3
Echeneis naucrates	whitefin sharsucker	2	2.2
Oligoplites saurus	leatherjacket	4	4.4
Selene vomer	lookdown	1	1.1
Trachinotus falcatus	permit	1	1.1
Lutjanus apodus	schoolmaster	3	3.3
L. synagris	lane snapper	33	36.7
Diapterus plumieri	striped mojarra	2	2.2
Eucinostomus argenteus	spotfin mojarra	12	13.3
E. gula	silver jenny	76	84.4
Eucinostomus sp.	mojarra	2	2.2
Geres cinereus	yellowfin mojarra	3	3.3
Anisotremus virginicus	porkfish	1	1.1
Haemulon aurolineatum	tomtate	2	2.2
H. parrai	sailor's choice	4	4.4
H. plumieri	white grunt	49	54.4
H. sciurus	bluestriped grunt	12	13.3
Orthopristis chrysoptera	pigfish	37	41.1
Archosargus probatocephalus	sheepshead	14	15.6

Appendix V. Continued.

Species	Common Name	Number times Caught with Target Species	Percentage time Caught with Target Species
Archosargus rhomboidalis	sea bream	2	2.2
Calamus arctifrons	grass porgy	23	25.6
Lagodon rhomboides	pinfish	74	82.2
Bairdiella batabana	blue croaker	5	5.6
B. chrysoura	silver perch	51	56.7
Cynoscion arenarius	sand seatrout	1	1.1
C. nebulosus	spotted seatrout	29	32.2
Equetus punctatus	spotted drum	1	1.1
Menticirrhus littoralis	gulf kingfish	1	1.1
Sciaenops ocellatus	red drum	2	2.2
Chaetodipterus faber	spadefish	1	1.1
Lachnolaimus maximus	hogfish	2	2.2
Nicholsina usta	emerald parrotfish	19	21.1
Scarus taeniopterus	princess parrotfish	1	1.1
Sparisoma chrysopterum	redtail parrotfish	1	1.1
S. rubripinnie	redfin parrotfish	1	1.1
Mugil cephalus	striped mullet	4	4.4
M. trichodon	fantail mullet	2	2.2
Sphyraena barracuda	great barracuda	6	6.7
Paraclinus marmoratus	marbled blenny	4	4.4
Chasmodes saburrae	Florida blenny	4	4.4
Bathygobius soporator	frillfin goby	1	1.1
Gobiosoma robustum	code goby	4	4.4
Microgobius gulosus	clown goby	3	3.3
Paralichthys albigutta	gulf flounder	2	2.2
Achirus lineatus	lined sole	2	2.2
Symphurus plagiusa	blackcheek tonguefish	1	1.1
Aluteus schoepfi	scrawled filefish	1	1.1
Monocanthus ciliatus	fringed fielfish	34	37.8
M. hispidis	planehead filefish	36	40.0
Lactophrys quadricornis	scrawled cowfish	21	23.3
L. trigonus	trunkfish	4	4.4
Sphoeroides nephelus	southern puffer	15	16.7
S. spengleri	bandtail puffer	1	1.1
Chilomycterus schoepfi	striped burrfish	41	45.6

Appendix VI. Associated fish and macroinvertebrates caught with juvenile snook in ENP, 1982-84.

Species	Common Name	Number times Caught with Target Species	Percentage time Caught with Target Species
Penaeus duorarum	pink shrimp	2	13.3
Callinectes sapidus	blue crab	1	6.7
Elops saurus	ladyfish	1	6.7
Brevoortia patronus	gulf menhaden	1	6.7
B. tyrannus	Atlantic menhaden	1	6.7
Opisthonema oglinum	Atlantic thread herring	1	6.7
Anchoa mitchilli	bay anchovy	1	6.7
Synodus foetens	inshore lizardfish	1	6.7
Opsanus beta	gulf toadfish	2	13.3
Strongylura notata	redfin needlefish	1	6.7
Cyprinodon variegatus	sheepshead minnow	2	13.3
Floridichthys carpio	goldspotted killifish	2	13.3
Fundulus confluentus	marsh killifish	1	6.7
F. grandis	gulf killifish	2	13.3
F. spp.	killifish	2	13.3
Lucania parva	rainwater killifish	5	33.3
Gambusia affinis	mosquitofish	4	26.7
Poecilia latipinnia	sailfin molly	5	33.3
Atherinidae	silversides	1	6.7
Menidia beryllina	inland silversides	6	40.0
Oligoplites saurus	leatherjacket	1	6.7
Lutjanus griseus	gray snapper	2	13.3
Gereidae	mojarras	1	6.7
Diapterus plumieri	striped mojarra	3	20.0
Eucinostomus argenteus	spotfin mojarra	1	6.7
E. gula	silver jenny	2	13.3
E. melanopterus	flagfin mojarra	1	6.7
E. spp.	mojarras	4	26.7
Archosargus probatocephalus	sheepshead	3	20.0
Lagodon rhomboides	pinfish	3	20.0
Sciaenidae	drums	1	6.7
Cynoscion arenarius	sand seatrout	1	6.7
C. nebulosus	spotted seatrout	2	13.3
Leiostomus xanthurus	spot	2	13.3
Sciaenops ocellatus	red drum	2	13.3
Mugilidae	mullets	2	13.3
Mugil cephalus	striped mullet	1	6.7
Gobiidae	gobies	2	13.3
Gobionellus shufeldti	freshwater goby	1	6.7

Appendix VI. Continued.

Species	Common Name	Number times Caught with Target Species	Percentage time Caught with Target Species
Gobiosoma robustum	code goby	1	6.7
Lophogobius cyprinoides	crested goby	1	6.7
Microgobius gulosus	clown goby	3	20.0
Prionotus scitulus	leopard searobin	1	6.7
Bothidae	flounders	1	6.7
Achirus lineatus	lined sole	2	13.3
Chilomycterus schoepfi	striped burrfish	1	6.7