OFFSHORE FISHERIES AND RELATED HABITATS

Donald R. Ekberg¹ and Gene R. Huntsman²

In this discussion we shall first describe the environment and principal habitat types of the outer continental shelf of northeastern Florida and Georgia, secondly describe the principal groups of communities of open ocean fishes, then briefly relate the different groups of fishes to continental shelf habitats and, where pertinent, to nearshore wetlands, and finally describe the role of environment in moulding fish behavior.

I. ENVIRONMENT AND HABITATS

We will subdivide the description of the environment into two parts. First we will discuss, in general, the hydrology of the outer continental shelf. Second we will describe benthic habitats.

The oceanography of the region's outer continental shelf is both complex and variable, and its precise state at any particular time is presently unpredictable. For convenience we propose that three principal water masses occupy the continental shelf (Table I). The average position of those masses largely determine what fishes will occur at any given site. The interaction of these masses at their boundaries result in important oceanographic phenomena which ultimately affect fishery production.

The nearshore mass occurs from the shoreline to approximately the 25m isobath. This mass is greatly affected by continental weather and exhibits marked seasonal variation in properties, especially temperature. Further, drainage from rivers can drastically alter the salinity, clarity and nutrient content of the water and consequently its short term productivity. This variation is especially prevalent from Savannah to Jacksonville where major rivers discharge.

The outermost water mass is the Gulf Stream. While the Stream is highly variable in position, it has extremely constant properties. The Gulf Stream commonly exhibits meanders that migrate northeastward along the outer boundary of the continental shelf and the main axis of the stream may consequently lie

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### TABLE 1

**SIMPLIFIED OCEANOGRAPHY**

**OF GEORGIA – NORTHEAST FLORIDA SHELF**

<table>
<thead>
<tr>
<th>WATER MASS</th>
<th>LOCATION</th>
<th>PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEARSHORE</td>
<td>NEARLY CONSTANT SHORELINE -25M</td>
<td>HIGHLY VARIABLE, SEASONALLY COLD, VARIABLE SALINITY, CLARITY.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIDSHELF</td>
<td>25-M ISOBATH TO GULF STREAM</td>
<td>MODERATED SEASONAL VARIABILITY. BASICALLY WARM, CLEAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GREEN LATITUDINAL EFFECTS AS IMPORTANT AS SEASONAL ONES.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GULF STREAM</td>
<td>HIGHLY VARIABLE, MEANDERS</td>
<td>VERY CONSTANT, UNFORMLY WARM, CLEAR, HIGHLY SALINE, LOW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NUTRIENTS AND PLANKTON POPULATION.</td>
</tr>
</tbody>
</table>

**SPECIAL EVENTS:**

- **UPWELLING** - COMMON, ASSOCIATED WITH GULF STREAM MEANDERS. LONG AND SHORT TERM FISHERY EFFECTS.

- **COLD CORE RINGS** - UNCOMMON, SHORT TERM UNIMPORTANT FISHERY EFFECTS.
anywhere from 30 to 70 km offshore. Regardless of position the
Gulf Stream is characterized by water that is clear, warm, highly
saline and generally low in nutrients (Mathews and Pushuk, 1977).
Between the nearshore waters and the Gulf Stream lies the large
mid-shelf water mass which generally occupies the zone from the
30 m to the 200 m isobath. The mass is neither as constant as the
Gulf Stream nor as variable as the nearshore mass. The water is
generally warm (15–27°C), and while seasonal changes in tempera-
ture occur, they are buffered by the immense volume of water and
are not large. In general, the temperature of the mass reflects
latitude as much as season and the biota of the middle mass
becomes increasingly tropical from Savannah to Cape Canaveral.
Salinity varies little. The water is moderately nutrient rich,
usually green to blue green, with nutrients derived from continen-
tal and oceanic sources.

The interaction of the midshelf mass and the Gulf Stream
produces one of the most striking and important oceanographic
features of the region. Where the Gulf Stream meanders offshore,
that is when it loops to the eastward, cold bottom water from
beyond the continental shelf is forced up and onto the shelf
(Atkinson and Targett, 1983). This upwelling is a major source
of nutrients, especially nitrogen, for the midshelf watermass and
in the long run contributes to fisheries production. The short
run effects of upwelling on fisheries are very poorly understood.
It appears that upwelling modifies the distribution of pelagic
prey and sportfishes and that the incursion of cold water over
reef areas temporarily disrupts fishing success for reef fishes.
Upwelling occurs all along the U.S. South Atlantic coast but
seems to be particularly prevalent off St. Augustine and Daytona
(Atkinson and Targett, 1983). A less common, but very interest-
ing interaction of the midshelf water mass and Gulf Stream occurs
when a westerly meander of the Gulf Stream closes, or pinches
off, in its eastern side, and forms a circulating loop of warm
Gulf Stream water enclosing a core of cooler shelf water. These
cold core rings are known to track westerly across the continen-
tal shelf, sometimes to the shoreline, carrying the distinctive
Gulf Stream fauna and flora including sargassoo weed, Portugese
men-of-war and dolphin Coryphaena hippurus. The rings, unlike
upwelling, are relatively uncommon and their contribution to the
properties of the midshelf water mass are unimportant. Most
rings dissipate on the midshelf while a few rejoin the Gulf
Stream.

In summary, most of the Georgia–northeast Florida shelf is
overlaid by water that is, on the average, warm the year around.
However, the conditions prevailing at any particular place and
time are extremely unpredictable because of the complex and
dynamic interactions of the three water masses.

There are two principal types of the benthic habitats on the
outer Continental Shelf, unconsolidated sediments and reef areas
(Table II).
<table>
<thead>
<tr>
<th>TABLE II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BENTHIC COMMUNITIES</strong></td>
</tr>
<tr>
<td><strong>OF THE GEORGIA – NORTHEASTERN FLORIDA SHELF</strong></td>
</tr>
<tr>
<td><strong>SANDY PLAIN</strong></td>
</tr>
<tr>
<td><strong>REEFS</strong></td>
</tr>
<tr>
<td><strong>MAJOR REEF TYPES</strong></td>
</tr>
<tr>
<td><strong>SPONGE-CORAL SITES</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>ROCK RIDGES</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>SHELF-EDGE</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>OCULINA THICKETS</strong></td>
</tr>
</tbody>
</table>
Loose sediments, sand or occasionally mud, occupy most (70%) of the shelf area (Parker et al., 1983). Reefs which occupy approximately 30% of the outer shelf in this zone occur in several types. Approximately 22% of the shelf is occupied by low relief (<1m) rock outcrops and flat shelving rock which are overgrown macrobenthos. About 7% of the shelf area is high relief (>1m) rock ridges and ledges overgrown with macrobenthos (Parker et al., 1983). At and slightly beyond the shelf edge (approximately between the 100 and 1000m isobaths) rock outcrops of high relief are common. Sessile macrobenthos are present at these depths but in general are less richly developed than in shallower areas (Parker and Ross, in press).

Immediately to the south of the area of immediate interest to this discussion (between 27°N and 28°30'N) lie large, unique thickets of the coral Oculina varicosa at depths of 75 to 100m (Reed, 1980). O varicosa occurs as far north as Cape Hatteras, North Carolina, although usually only as single or scattered colonies, but some thickets may occur slightly north of Cape Canaveral.

II. OCEANIC FISHES

Fishes of the Georgia-northeast Florida shelf can be reasonably well assigned to five groups (Table III).

1. Nearshore and estuarine benthic species.
2. Open shelf sandy-plain dwellers.
3. Reef fishes.
4. Coastal pelagics.
5. Open-ocean pelagics.

We shall principally discuss the last three groups (Table IV). The nearshore species, primarily sciaenids and flatfishes, are excluded from our assignment, and the sandy plain dwellers, mostly triglids and synodontids rarely occur in sufficient concentrations to be of interest to man for food or sport (Wenner, 1983).

Oceanic pelagics include the billfishes, blue marlin, Makaira nigricans, white marlin Tetrapturus albidus, spearfishes, Tetrapturus spp., Atlantic sailfish Istiophorus platypterus, several tuna of the genus Thunnus, the skipjack tuna, Euthynnus pelamis, wahoo Acanthocybium solanderi, dolphin Coryphaena hippurus and several sharks. Coastal pelagics include such species as king, Spanish and cero mackerels Scomberomorus cavalla, S. maculatus and S. regalis, bluefish Pomatomus saltatrix, Atlantic bonito Sarda sarda, little tuna Euthynnus alletteratus, and menhaden Brevoortia spp.

The reef fishes are an extremely large and complex group including more than 300 species. Prominent to man's usage are snappers Lutjanus and Rhomboplites, groupers Epinephelus and Mycteroperca, porgies Pagrus and Calamus and grunts Haemulon. Reef fish species can be assigned to several communities related to depth and latitude, and ultimately to water temperature.
**TABLE III**

**MAJOR FISH COMMUNITIES OF GEORGIA - NORTHEAST FLORIDA SHELF**

<table>
<thead>
<tr>
<th>COMMUNITY</th>
<th>HABITATS</th>
<th>MAJOR COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEARSHORE-ESTUARINE</td>
<td>ESTUARIES, SURF ZONE NEAR SHELF TO 25m</td>
<td>SCIAENIDS-FLATFISHES</td>
</tr>
<tr>
<td>Sandy Plain Benthic</td>
<td>Sandy Plain of Midshelf 25 - 100m</td>
<td>Sea Robins and Lizardfishes</td>
</tr>
<tr>
<td>Coastal Pelagics</td>
<td>Nearshore to Midshelf</td>
<td>King and Spanish Mackerel, Little Tuna, Cobia, Bluefish, Menhaden</td>
</tr>
<tr>
<td>Reef Fishes</td>
<td>Hard Bottom and Sponge-Coral Areas Mid and Outer Shelf</td>
<td>Snappers, Groupers, Porgies, Grunts (Black Sea Bass at Inner Limit, Tilefish at Outer Limit)</td>
</tr>
<tr>
<td>Oceanic Pelagics</td>
<td>Gulf Stream and Outer Shelf Water Column</td>
<td>Blue and White Marlin, Spearfish, Sailfish, Tuna, Wahoo, Dolphin</td>
</tr>
<tr>
<td>COMMUNITY</td>
<td>RELATIONSHIPS</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>OCEAN PELAGICS</td>
<td>WEAK - INDIRECT TRANSFER FROM ESTUARIES OF SOME ENERGY AND NUTRIENTS THROUGH FOOD CHAIN AND WATER CURRENTS. NEARSHORE DEVELOPMENT WOULD HAVE LITTLE IMPACT.</td>
<td></td>
</tr>
<tr>
<td>REEF FISHES</td>
<td>MODERATELY WEAK - INDIRECT TRANSFER FROM ESTUARIES OF SOME ENERGY AND NUTRIENTS THROUGH FOOD CHAIN AND WATER CURRENTS. A FEW SPECIES MAY USE ESTUARIES AS NURSERY AREA... GAG, GREY SNAPPER, RED GROPER. NEARSHORE DEVELOPMENT MIGHT IMPACT THESE.</td>
<td></td>
</tr>
<tr>
<td>COASTAL PELAGICS</td>
<td>STRONG - FEEDING OF BOTH ADULTS AND JUVENILES IN ESTUARIES IS COMMON. SOME, LIKE MENHADEN, USE ESTUARIES AS NURSERY AREA. NEARSHORE DEVELOPMENT CAN HAVE MAJOR IMPACTS.</td>
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</tr>
</tbody>
</table>
(Grimes et al., 1982, Chester et al., 1984, Miller and Richards 1980). HeadBoat catches suggest an important faunal shift occurs in northeastern Florida. South of Jacksonville black sea bass Centropristis striata ceases to be important to catches, and at about St. Augustine the grey snapper Lutjanus griseus is at its northern limit of abundance. Red grouper are common at Daytona and occasionally north of there, while truly tropical species like yellowtail snapper Ocyurus chrysurus figure prominently in the catch from St. Augustine southward.

Tilefish Lopholatilus chamaeleonticeps are an important resource of Georgia and northeast Florida that does not fit precisely into any of our categories. Tilefish live in burrows in rough rocky terrain at the outer limits of the continental shelf (approx. 200m), and occur in relatively cold water (about 13°C). The distribution of tilefish overlaps the seaward range of deepwater groupers (Epinephelus nigritus, E. flavolimbatus and E. niveatus). Tilefish have life history characteristics like those of many reef fish, and are included with them for management purposes (South Atlantic Fishery Management Council, 1983).

III. FISH-HABITAT RELATIONSHIPS

Habitat usage and dependency of both the pelagic and reef groups are relatively easy to define. All life stages of oceanic pelagic species are found almost exclusively in the warm waters of the Gulf Stream and outer shelf. Eggs and larvae are pelagic, apparently drifting freely with ocean currents, and the adults feed and spawn without requirement for association with nearshore or estuarine conditions. We can hypothesize only indirect links between production of oceanic pelagic species and estuaries and wetlands. There is little doubt that at least some energy is transferred from the shore zone to oceanic pelagic fishes through interconnecting food chains. Similarly some nutrients must pass to the outer shelf from river mouths, as off the Savannah River. The importance of these contributions is unknown but circumstantial evidence suggests that the short run effects may be small. Indeed some of the most important fisheries for oceanic pelagic species occur where continental contributions to fishery production are small but where oceanic features such as upwelling are important.

Production of most reef species seems similarly independent of nearshore habitats. Again eggs and larvae of most important sport and commercial species are pelagic and develop totally in the open ocean. By and large, feeding and reproduction of adults takes place on reefs without migration to the shore zone. For the bulk of reef species it again appears that the only connection with nearshore habitats is the indirect transfer of nutrients and energy through food chains and water circulation. Good circumstantial evidence for the independence of reef production is the existence of thriving reef communities on oceanic banks far from land masses. On the other hand some reef production, unlike that of oceanic pelagics, can be tied to the benthic
production of a certain locality. Grass flats adjacent to reefs provide grazing for reef dwelling herbivores and carnivores in south Florida and elsewhere in the tropics. North of Cape Canaveral algal flats adjacent to reefs on the mid- and outer shelf may function like grass flats in supporting nominal reef production.

Finally a few reef species of the south Atlantic region may be dependent on estuarine areas to complete their life cycle. Prominent among these species is the gag grouper *Mycteroperca microlepis*, the most abundant grouper of the region. Juvenile gag grouper are found in estuaries during their first year of life from Cape Hatteras southward. Researchers have yet to collect juvenile gag grouper in the open ocean. Thus, there is strong circumstantial evidence that the gag grouper is estuarine dependent. Yet collecting of young fish in the open ocean is difficult and uncertain, and juveniles may occur there. Also juveniles of other reef species which are apparently not estuarine dependent also occasionally appear in estuaries. Thus, the appearance of juvenile gag grouper in estuaries might only reflect the great abundance and fecundity of the species and not a life history pattern. The exodus of juvenile gags from South Atlantic estuaries at the onset of cold weather may result in the production of the entire new year class of this large, valuable species or it may only result in the consignment of a group of misplaced juveniles to wandering and death in the cold winter water of the inner shelf. Among other reef species common in estuaries are juvenile black sea bass, a temperate reef fish important off Georgia and North Florida. The importance of these young fish is unknown. Young grey snapper are also moderately abundant in estuaries as far north as Pamlico Sound. The estuarine phase of the life history of this species may be critical. Finally, juvenile red grouper *Epinephelus morio*, a species which in the South Atlantic is only consequential from St. Augustine southward, are also moderately abundant in estuaries. The significance of that abundance is again unknown.

Although nearshore development is unlikely to have an immediate impact on reef fishes, these species are susceptible to mismanagement of their habitat. Ocean pollution and disruption of reefs through petroleum development have generated some concern, but these have not yet affected offshore reefs of Georgia and northeast Florida. Current regulations may prevent negative impacts.

The most immediate potential threat to live-bottom reefs is posed by roller trawls. The few semi-quantitative studies of the effects of roller trawls on sponge-coral habitats suggest that trawling can seriously disrupt the macrobenthos. Many believe that his disruption will heal slowly and that it will eventually result in reduced fishery yields. It is clear that the Oculina reefs could be devastated by trawling, but trawling in the known Oculina reef zone is proscribed by the coral management plan. The research necessary to answer questions about trawling effects
is expensive, and no quantitative research on the problem is currently funded.

We have left consideration of the coastal pelagic species till last because this group, of all discussed, is clearly the most dependent on nearshore habitats and thus clearly most susceptible to man's alterations of wetlands and estuaries. The coastal pelagics are opportunistic in their feeding and make use of a wide range of habitats. King mackerel, for instance, will prey on aggregations of baitfish in and at the mouths of estuaries, around midshelf reefs and in the Gulf Stream. Little tuna and cobia, *Rachycentron canadum*, are similarly wide ranging.

Spanish mackerel and especially bluefish are even more tightly bound to the shoreline and commonly occur and feed in estuaries (Kendall and Walford, 1979). Although spawning and transformation of larvae to juveniles apparently occurs in the open ocean, all other stages from juvenile through adult are linked closely to coastal wetland by a very short food chain. Among the prey species in the coastal pelagic community Atlantic menhaden and mullet (*Mugil* sp.) are the most valuable to man and are both tightly connected to estuaries and wetlands. Menhaden can possibly directly digest marsh-generated detritus (Lewis and Peters, 1985) and thus have the most direct link possible to coastal wetlands. Water quality in estuaries and production of coastal marshes figures largely in the maintenance of the menhaden and mullet resources. Because coastal pelagic species are so often found near the coast they are readily available to both commercial and recreational fishermen and their value is immense. Yet the same characteristics that make these species valuable to man make them easily vulnerable to his mismanagement of the coastal environment.

IV. ENVIRONMENTAL REQUIREMENTS

Now that we have shown the relationships of communities of fishes to their habitats, the next step could be to show the ecological factors that drive a single fish to a particular portion of his habitat. In order to sense its environment a fish must be sensitive to components of its environment. Table V gives some of these sensitivities. No single fish has been depicted here. The table has been assembled from a number of sources. Fish are extremely sensitive to a number of environmental variables. Chemicals may be sensed up to the parts per trillion range. This concentration level poses no survival danger to the fish nor to people who might eat the fish, but since fish do have the capability to sense chemicals at extremely low concentrations, they may also utilize this information for survival in their complex environment. A fine temperature sense and possibly even the ability to determine small magnetic fields, as has been demonstrated in the yellowfin tuna, may be utilized for migration. Diurnal and seasonal rhythms may be triggered by the amount and duration of light. It appears, therefore, that a very small perturbation of a fish's environment could attract or repel
TABLE V

FISH SENSORY SYSTEMS

<table>
<thead>
<tr>
<th>ENVIRONMENTAL VARIABLE</th>
<th>SENSITIVITY</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>0.04-0.10 UNITS</td>
<td>BULL (1940)</td>
</tr>
<tr>
<td>TEMPERATURE</td>
<td>0.05°C</td>
<td>BULL (1936)</td>
</tr>
<tr>
<td>PRESSURE</td>
<td>0.5-1.0 cm H₂O</td>
<td>DYKGRAAF (1942)</td>
</tr>
<tr>
<td>SALINITY</td>
<td>0.06%</td>
<td>BULL (1938)</td>
</tr>
<tr>
<td>POLLUTANTS</td>
<td>PPRILL. (10⁻¹²)</td>
<td>HASLER (1954)</td>
</tr>
<tr>
<td>NOISE</td>
<td>16-7,000 Hertz</td>
<td>BULL (1957)</td>
</tr>
<tr>
<td></td>
<td>50DB</td>
<td>POPPER (1970)</td>
</tr>
<tr>
<td>LIGHT</td>
<td>A FEW PHOTONS</td>
<td>LYTHGOE (1978)</td>
</tr>
<tr>
<td>ELECTRIC FIELDS</td>
<td>1mV/cm. (SHARKS &amp; SKATES)</td>
<td>SCHWASSMANN (1978)</td>
</tr>
<tr>
<td>MAGNETIC FIELDS</td>
<td>1-100 NANO TESLA (GAMMA)</td>
<td>WALKER, ET.AL. (1982)</td>
</tr>
<tr>
<td></td>
<td>(YELLOWFIN TUNA)</td>
<td></td>
</tr>
</tbody>
</table>
that fish from a given area. Since pH, salinity and oxygen concentration probably are not major factors in determining the behavior of an oceanic fish, one must consider food a major attractant for fish under normal circumstances. If such is the case, a study of predator-prey relationships should produce quantitative results answering a number of questions. Do fish hunt in a random fashion and then zero in on their prey using their sensors? What prey species are preferred? Will predators brave hostile environments to find prey? What is the correlation between predator and prey stocks? We can give partial answers to some of these questions now. Gut analysis gives us information about species preferred (Tables VII and VIII). Oceanic predators seldom venture into low salinity (estuaries) in search of prey. They generally wait for their prey to exit the estuaries and head for open sea. Can we then predict the catch of prey species based on the size of available prey stocks?

Table VI was developed to compare the two predators, king and Spanish mackerel, and their preys, menhaden and shrimp. Based on landings data from North Carolina, South Carolina, Georgia and Florida, no such relationship is apparent.

Oviatt (1977) collected menhaden, bluefish and striped bass landings data over a period of thirty years (Figure 1). Even at very low levels of menhaden, bluefish and striped bass had sufficient food to only maintain their population but to increase it somewhat. Although a positive correlation between prey and predator is intuitively expected, present information does not permit such a conclusion. Perhaps more detailed stock data (temporal and spatial) are needed. Perhaps other factors combine to limit stock sizes. Temperature and salinity data have been used (Barnett and Gillespie, 1973, 1975; Barrett and Ralph, 1976) to predict shrimp catch, but meager data are available about oceanic species. Fable and co-workers (1981) studies the relationship between a king mackerel catch and the average temperature of the preceding winters. This study revealed a positive correlation between catch and the temperature of the preceding winter.

Utilizing a tops down systems approach to connect primary and secondary production, Peters and Schaaf have shown that the fishery yield of fish from New York to Georgia requires 66% of the primary production of that area, which includes algae, vascular plants and submerged seagrasses. They concluded that algal production is insufficient to support this yield and must be augmented by vascular plants. Such is the case with menhaden who are known to ingest detritus directly and thus, since they are a major food source for coastal and oceanic pelagics, shorten the link between offshore fisheries and inshore habitats.

Another approach is relating fish to habitat is to develop a matrix of environmental requirements as shown in Tables VII and VIII.
<table>
<thead>
<tr>
<th>YEAR</th>
<th>MENHADEN</th>
<th>SHRIMP</th>
<th>KING MACKERAL</th>
<th>SPANISH MACKEREL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>8,285</td>
<td>26,615</td>
<td>4,132</td>
<td>5,989*</td>
</tr>
<tr>
<td>1982</td>
<td>10,358</td>
<td>25,580</td>
<td>6,045*</td>
<td>3,950</td>
</tr>
<tr>
<td>1981</td>
<td>15,456</td>
<td>16,514</td>
<td>5,739</td>
<td>4,227</td>
</tr>
<tr>
<td>1980</td>
<td>21,257*</td>
<td>32,996*</td>
<td>3,799</td>
<td>5,763</td>
</tr>
<tr>
<td>1979</td>
<td>5,036</td>
<td>32,295</td>
<td>3,824</td>
<td>4,901</td>
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</tbody>
</table>

*79-83 MAXIMUM
<table>
<thead>
<tr>
<th>Stage</th>
<th>Temperature</th>
<th>Salinity PPT</th>
<th>O2</th>
<th>Tissue</th>
<th>Metals</th>
<th>Organics PPM</th>
<th>Light</th>
<th>Food</th>
<th>Plankton</th>
<th>Benthic Structure</th>
<th>Parasites</th>
<th>Pathogens</th>
<th>Noise</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggs/Diapry</td>
<td>20$^\circ$ 22/ 10-28 W</td>
<td>6-34  5/ 25-36  3/</td>
<td>5-34</td>
<td>15-25 opt  3/</td>
<td></td>
<td>f(Lux)</td>
<td>&lt;25-500 Lux  3/</td>
<td>Tintinnids</td>
<td>0.5 Lux - moonlight  1/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Larvae &lt; 30mm</td>
<td>20$^\circ$ 22/ 15-25  3/</td>
<td>5-30</td>
<td>15-25 opt  3/</td>
<td>15-25</td>
<td>0.5 Lux - moonlight  1/</td>
<td></td>
<td>Copepods</td>
<td>0.5 Lux - moonlight  1/</td>
<td></td>
<td>Hake 25/</td>
<td>Cestodes</td>
<td>Trematodes  6/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prejuvenile 30-60mm</td>
<td>20.4$^\circ$ for 4 weeks at 15$^\circ$ 18/</td>
<td>0-1 for prey</td>
<td>3-34</td>
<td>0-1</td>
<td>3-10</td>
<td>0.5 Lux - moonlight  1/</td>
<td></td>
<td></td>
<td></td>
<td>Bluntnose 3/</td>
<td>Striped Bass 16/</td>
<td>Flowery 29/</td>
<td>0-468 V</td>
<td></td>
</tr>
<tr>
<td>Juvenile &gt; 60mm</td>
<td>5$^\circ$-36$^\circ$  3/</td>
<td>3-20</td>
<td>opt  3/</td>
<td></td>
<td></td>
<td></td>
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<td>Adult</td>
<td>25-20$^\circ$ 7/</td>
<td>10-13</td>
<td>22-27</td>
<td>Best for Jan. Recruitment in Grand Isle, LA.  11/</td>
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<td>PCB</td>
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</tbody>
</table>
REFERENCES FOR TABLE VII


29/ Poole, John C. 1964. Feeding habits of the summer flounder in Great South Bay, N.Y. Fish Game J. 11: 28-34.


<table>
<thead>
<tr>
<th>KING MACKEREL</th>
<th>TEMP °C</th>
<th>SALINITY x</th>
<th>O₂ ppm</th>
<th>TURB.</th>
<th>METALS</th>
<th>ORGANICS ppm</th>
<th>LIGHT</th>
<th>FOOD</th>
<th>SUBSTR.</th>
<th>BENTHIC STRUCTURE</th>
<th>PREDATORS</th>
<th>PARASITES/PATHOGENS</th>
<th>NOISE/ELECT.</th>
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<tr>
<td>S. Cavalla</td>
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<td>Eggs/Embryo</td>
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<tr>
<td>Larvae</td>
<td>25.85 to 34.47</td>
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<td>Juvenile</td>
<td>26.3 to 26.9 31.0 to 35.5</td>
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<tr>
<td>Adult</td>
<td>&gt;20 3/</td>
<td>&lt;36 3/ 0.02 - 18 ppm</td>
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<td>Cd, As</td>
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<td>clupeid fish (mainly thread herring, kelp, sardines, penaeid shrimp, squid, jacks, snapper, grunts)</td>
<td>Prefer bottom relief (holes, reefs, wrecks, &amp; rigs)</td>
<td>tursiophs, sharks, cephalopods, trematodes, nematodes</td>
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</tr>
</tbody>
</table>
REFERENCES FOR TABLE VIII


Rhode Island landings of menhaden, bluefish, and striped bass from 1945 to 1976. (Oviatt, 1977)
Environmental requirements for menhaden are given in Table VII. Even though these fish, which are the most numerous ones in U.S. waters, have been studied extensively, there are several gaps in our knowledge of environmental parameters. Furthermore, most of the information that we have has been gathered by observation of these coastal pelagics in their natural environments. Little data are at hand derived from experimental laboratory studies. We are beginning to understand the food and feeding requirements of these fish but environmental variables such as temperature, salinity, organics and metals need to be determined experimentally.

Table VII, a similar matrix for the king mackerel, demonstrates an even greater paucity of information.

In this review we have attempted to show the relationship of offshore fisheries to their various habitats. In particular, the strong link between coastal pelagics and wetland primary production. Furthermore, we have attempted to show that a system approach in which the requirements of the fish are utilized as the starting point, complements those studies showing the dependence of fish on primary production.

Assembling such information into a matrix such as that shown in Tables V and VI could be used to provide summarized information to decisionmakers and act as a framework for condensation of literature. We are currently inundated with "grey" as well as "white" literature. The decisionmaker who must act in a short period of time, such as those of us who respond to permit requests, have insufficient time to analyze all of the available data. The matrix could also serve as a focus for describing research needs.

In view of the lack of precise or accurate experimental data concerning the relationships of fish to their environments, it is suggested that experimental facilities be developed to determine these relationships. Such facilities would provide needed quantitative information and could be used to test research or fishing gear prior to starting elaborate and expensive field studies.
BIBLIOGRAPHY


GROWTH AND MANAGEMENT OF COASTAL WETLAND
AND WETLAND ADJACENT LANDS:
FISH HABITAT QUALITY AND THE DECISION-MAKING PROCESS

James W. Stoutmaire

The State of Florida is one of the fastest growing in the nation with some 75% of the state's population residing on or near the coast. If current trends continue, and every indication is that they will, by the year 2000 there will be a permanent coastal population of some 10 million people combined with a temporary and/or tourist population of three to four times as many. This tremendous growth in coastal regions has and will continue to put tremendous pressure on coastal resources. These pressures directly and indirectly have had and could continue to have tremendous impacts on coastal and interior wetlands.

Impacts on these wetlands can occur for a number of reasons including:

1. Filling of coastal wetlands areas for development as more suitable land becomes scarce and more expensive;
2. Draining of wetlands to provide flood protection or dry land for development or agriculture;
3. Interference with the natural flooding cycle of wetlands associated with flood control, water storage, or mosquito control;
4. Dredging or filling of isolated wetlands to provide lakes for development or more accessible land for agriculture or timber; and
5. Siltation and/or pollution of wetlands from non-point sources such as stormwater runoff or fertilizers and pesticides.

The list of potential sources of impacts on wetlands is virtually endless. The activities noted above and others have, in the past, resulted in the destruction of significant areas of wetlands as functioning habitat.

Recent research by the DNR Marine Laboratory in St. Petersburg has found that Charlotte Harbor, a relatively undisturbed area has, between 1945 and 1982, lost 29% of its seagrass and 51% of its salt marsh while gaining 10% in mangroves. The gain in mangroves appears to be partially due to colonization of mud flats and active management to discourage mangrove destruction. In contrast, Tampa Bay, a heavily developed area, has suffered a
much larger decline. On the east coast from 1952 to 1984, the Indian River suffered an 86% decline in mangrove areas due to destruction of mangroves or their withdrawal from the system due to mosquito impoundment dikes. Seagrasses have suffered a 36% decline during the same period. While these losses seem to be correlated with declining commercial and recreational fisheries, the relationship between decreased fish stocks and habitat loss is imperfectly understood. This is due in part to poor information on catches resulting from incomplete data collection techniques and in part to a general lack of information on habitat carrying capacity.

Florida has a number of growth and land management and regulatory programs which deal with wetlands and adjacent lands either directly or indirectly. These include:

1. DER permitting programs regulating water pollution and dredge and fill activities and the Coastal Management program;

2. DCA growth management programs such as DRI's and ACSC's;

3. DNR land management authority for leasing and land purchasing of Aquatic Preserves and coastal construction control;

4. Various regional programs conducted by Water Management Districts, Regional Planning Councils and Mosquito Impound Districts.

The Department of Environmental Regulation (DER) is the state's primary regulatory agency. The DER's permitting authorities with the most direct impact on fishery habitat are contained in Chapters 253 and 403, F.S. These statutes deal, respectively, with dredge and fill and water pollution. Until the recent enactment of the Warren S. Henderson Wetlands Protection Act of 1984, regulatory programs governed by these two statutes were poorly coordinated due to conflicting boundaries of jurisdiction and regulatory authority based on the distinction between sovereignty submerged lands, also called navigable waters, and waters of the state. Navigable waters were those available for commerce in their natural condition at the time Florida entered the union while waters of the state encompassed all other water bodies subject to certain exclusions such as areas owned entirely by one person and "lakes" which lack standing water and are dry each year. These distinctions led to numerous disputes over jurisdiction and limitations on regulatory authority since the two chapters provide differing performance standards. The Wetlands Protection Act dropped the distinction between navigable waters and waters of the state for the purposes of Chapters 253 and 403 and substituted waters of the state as defined in the statutes and supported by a detailed vegetation list and/or the presence of hydric soils combined with the 10 year flood line. In areas where waterbodies are temporarily dry, the DER's jurisdiction extends to the mean or ordinary high water line even if it is
landward of the vegetation line. It should be noted that these changes did not significantly impact on the linkage between DER's regulatory responsibility and DNR's land management responsibilities except to establish a time limitation on DNR's processing of a lease application. The DNR still holds title to sovereignty submerged lands and must grant permission to use those lands through a lease or sale before any activity may be conducted on the property. In addition, DER is still responsible for issuing permits to dredge or fill certain sovereignty lands which are no longer owned by the state but which have not been converted into uplands.

One of the major benefits of the Wetlands Protection Act was to consolidate the criteria used for permit review. In essence, water quality has become the primary consideration. However, other factors which are to be considered to determine the impact of permit issuance on the public interest include effects on fish, wildlife and habitat; health, safety, and welfare; the effect on navigation or flow of water; whether the project will cause erosion or shoaling; impacts on commercial and recreational fisheries; the duration of the project and its impacts; and impacts on archaeological and historic resources. The Act has also made it easier for DER to consider the cumulative impact of numerous small projects by allowing the agency to consider the impacts of past and future projects in the same area.

Finally the Act allows the DER to develop more stringent water quality protection standards in Outstanding Florida Waters, Aquatic Preserves, Areas of Critical State Concern, and certain areas with approved resource management plans and it grants clear authority to regulate peat mining.

The DER is responsible for two other programs that are of interest to the effective regulation and management of fishery habitat. These are the permitting of long term maintenance dredging projects as authorized under Chapter 403, F.S., and the Coastal Management Program under Chapter 380, Part 2, F.S.

The 1981 legislative session authorized DER to develop separate water quality standards for ports and to issue maintenance dredging permits for up to 25 years. In addition it established a funding source within the Department of Natural Resources to provide up to 50% of the cost of purchase of spoil disposal sites. This has provided an opportunity to implement more effective long term management strategies to deal with ongoing activities that have a significant impact on estuarine resources. The long term nature of the permits has allowed the development of more sophisticated permitting and monitoring standards than can be applied to the normal short term project. In addition, it is encouraging the ports to take a long range look at their requirements and potential environmental impacts. An indirect benefit of the project has been the refinement of analysis techniques to be used in evaluating water and more importantly sediment quality in estuarine areas. The DER, Office of Coastal Management, is currently investigating extending this concept to long term maintenance dredging associated with the Intracoastal Waterway.
The DER was charged by the 1978 legislature with developing a coastal management program under the terms of the Federal Coastal Zone Management Act. The legislature specified that this program had to work within existing authorities. The program was developed and received federal approval in September of 1981. The program is oriented around a number of issues of special focus, many of which are directly or indirectly related to management of fishery habitat. The two major components of the program that are of immediate interest to the management of fishery habitat are the grants program and the Interagency Management Committee. In brief, the grants program is based on allocating federal coastal management funds to a variety of coastal research projects including fishery habitat loss and carrying capacity, wetlands protection at the local level, improvements in mosquito impound management strategies, development of aquatic preserve management plans, etc. The Interagency Management Committee (IMC) was created in 1980 by resolution of the Governor and Cabinet. This group consists of the heads of 10 state agencies such as DER, DNR, DCA, HRS, OPB, GFWFC, etc. having significant management of policy responsibilities related to coastal resources. The IMC is responsible for resolving interagency conflicts as they relate to coastal resources, interpreting coastal policy directives such as the Governor's Executive Order on barrier islands, and developing legislative initiatives such as the Save Our Coasts legislation. The IMC is staffed by the DER/Office of Coastal Management supported by the Interagency Advisory Committee (IAC) consisting of staff from the respective agencies.

The Department of Community Affairs is the state land planning agency. Part of its activities as specified in Part I of the Chapter 380 F.S. are to conduct the state's Development of Regional Impact (DRI) and Area of Critical State Concern (ACSC) Programs. Neither of these two programs are primarily concerned with wetlands regulation, however, since they both are concerned with growth management they do impact on wetlands.

A DRI is defined as "any development which, because of its character, magnitude, or location, would have a substantial effect upon the health, safety, or welfare of citizens of more than one county; s. 380.06(1), F.S." While many of these developments are defined in DCA administrative rules, developments may be included in the DRI process if they meet this statutory definition. The DRI process is primarily implemented at the county and Regional Planning Council (RPC) level and will be discussed later. However, it is important to note that the act impowers various levels of government, including DCA, to seek injunctions to secure compliance with the act and DRI decisions. This includes determination that a development must complete the DRI process, the terms of a DRI decision, implementation of conditions of that decision and review of projects which have deviated from approved plans. While this process does provide an opportunity to ensure that adjacent land uses are compatible with wetlands, it must be noted that relatively few developments enter the DRI process. Discussions of refinements to the process by
the ELM's II committee indicate that rarely are as many as 10% of the projects in any given area subject to review for a variety of reasons.

The ACSC program provides a more direct opportunity for the state to influence local events. Geographic areas may be designated ACSC's based on an evaluation of impacts on environmental and natural resources of regional or statewide importance, archaeological or historical resources, or public facilities. Three areas have been designated ACSC's for reasons which include a concern with the management of wetlands and fishery habitat. These areas are Monroe County (Florida Keys), Big Cypress, and the Green Swamp. The Keys designation was the result of a concern over the inadequate regulation of development and its impact on the area. The Big Cypress designation was associated with creation of the Big Cypress National Preserve designed to protect a major portion of the upstream drainage basin for the Everglades. The Green Swamp designation was designed to protect a major recharge area for the Florida Aquifer.

Since this process results in more direct state control than the DRI process, designation is much more formal. Upon determination by DCA that an area should be considered for ACSC designation the Governor must appoint a Resource Planning and Management Committee (RPMC). This committee contains members of appropriate state agencies and all affected local and regional governments. This committee is charged with developing a program to correct the problems that led to the proposed designation. Should this voluntary plan be adopted by appropriate levels of government the process is brought to a halt at this point except for later reviews to assure implementation. This voluntary effort has been successful in the Charlotte Harbor and Suwannee River areas. Should the voluntary effort fail then DCA may recommend to the Governor and Cabinet sitting as the Administration Commission that the area be designated an ACSC, this designation is subject to review by the legislature and must include boundaries, the RPMC report, reasons for designation, principles for guiding development and an identification of public lands within the area. The affected governments must then adopt and enforce regulations which comply with the principles for guiding development or DCA acting through the Administration Commission will write the regulations. The DCA may then seek an injunction to secure compliance. An area may be removed from designation upon determination that appropriate governmental bodies are in compliance with the principles for guiding development.

The Department of Natural Resources is the state's primary land management agency. The department is charged with management, purchase and disposal of state lands under Chapter 253, F.S.; management of selected state lands under the Aquatic Preserve program under Chapter 258, F.S.; and regulation of coastal construction under Chapter 161, F.S.
The Governor and Cabinet sitting as the Trustees of the Internal Improvement Trust Fund hold ownership and management responsibility over public lands including many wetlands areas such as overflowed lands, sovereignty tidal lands, and waters of the state within 3 miles of the Atlantic coast and 10.35 miles of the Gulf coast. Proposals to sell or lease public land for private use must be evaluated to determine how the public interest is impacted. This includes evaluating impacts on wetlands and their productive capacity. In contrast to years past when the state disposed of millions of acres of wetlands to pay state bills or encourage various types of development, leasing of wetlands areas is severely restricted and is conducted in a public forum where all views are heard. The Trustees also conduct two major land buying programs; Conservation and Recreation Lands and Save Our Coasts; designed at least in part to purchase critical wetlands habitat areas.

Under Chapter 258, F.S., the DNR maintains some 36 aquatic preserves designed to provide additional management and protection for critical fresh and salt water habitat. State lands and private property, at the owners request, are selected for inclusion on the basis of their values as natural habitat with the goal being to maintain them in their natural or existing conditions or to restore them. Designation as an Aquatic Preserve is made by the Trustees subject to approval by the legislature. Once an area is designated additional protection is afforded by: 1) DER designation of the area as an Outstanding Florida Water; 2) a requirement that sale or lease of lands in the area must be in the public interest instead of merely not contrary to the public interest; and 3) further restrictions on dredge and fill and water discharge activities. To date DNR has developed and adopted specific management plans for preserves in Charlotte Harbor and Estero Bay and plans are being developed for several other preserves including four in the Indian River.

While not as directly impacting on wetlands and fishery habitat as other programs, the Coastal Construction Control Line and other programs under Chapter 161, F.S., administered by DNR under the direction of the Governor and Cabinet, indirectly provide some resource protection by regulating coastal structures. These programs provide some regulation of the type and design of structures which may be placed immediately adjacent to sandy coastal areas and govern beach nourishment programs. Obviously regulation of activities impacting on sand transport patterns and coastal erosion can impact on coastal wetlands areas.

Regional Planning Councils (RPC's) provide the main planning link between several adjacent counties and, in turn, the DCA. As such, the RPC's are responsible for reviewing all DRI applications from their areas. Generally speaking this is the single most important review since an RPC is most familiar with regional issues of concern. State input through DCA is usually directed toward controversial development and occasionally to broader statewide concerns. The affected RPC coordinates review of a project with the appropriate local and state agencies and pre-
pares an evaluation of a development with respect to its impact on
the environment and natural resources; economy; waste disposal
systems; transportation facilities; access to employment facili-
ties; etc. The final decision to grant or deny approval resides
with the directly affected local government which must consider
the extent to which the development complies with the state land
development plan, local land development regulations and the
report and recommendations of the RPC. Typically, approval
includes a number of conditions or modifications of the original
development plan designed to improve the development as related
to issues noted above.

Water Management Districts (WMD) were created under Chapter
373, F.S., to regulate the withdrawal, diversion, storage, and
consumption of water on a regional basis. These activities are
conducted under the general oversight of DER and the Governor and
Cabinet, sitting as the Land and Water Adjudicatory Commission.
In addition to regulatory powers the WMD's are allowed to levy
taxes to conduct their activities and to acquire property under
the Save Our Rivers program funded by documentary stamp taxes.
Until recently WMD's dealt primarily with injection of water into
underground formations, consumption of water for non-domestic
uses, water wells, and dams and other water control works. How-
ever, with the passage of the Warren S. Henderson Wetlands Pro-
tection Act of 1984 the WMD's took on significant new responsibili-
ties to regulate impacts on wetlands associated with agri-
cultural activities. The Act exempts "normal and necessary"
agriculture operations and agricultural water management systems
from regulation by DER and assigns them to the WMD's. Normal and
necessary activities include clearing, fencing, contouring,
plowing, planting, access roads, etc., while water management
systems refer to irrigation systems and farm ponds. Governor
Graham's instructions to the WMD's are that these activities and
systems are to be regulated to at least the same standards as
DER's regulation of other uses of wetlands. This is to include
consideration of fish and wildlife impacts; maintenance of state
water quality standards; protection of Aquatic Preserves, OPW's
and the Everglades; and consideration of the ecological value to
the wetlands impacted.

Under Chapter 388, F.S., mosquito control programs are the
responsibility of the Department of Health and Rehabilitative
Services (HRS) and various county programs. In years past these
efforts included extensive ditching and diking of coastal wet-
lands and wide use of oil and other chemicals. Today the use of
oil is severely restricted and the use of chemicals is limited by
an agreement between HRS and DER although DNR has recently ex-
pressed considerable concern about the use of certain agreed upon
chemicals. In addition, only those activities necessary to
actual maintain structures are exempt from DER's dredge and fill
permitting process. Obviously, the numerous mosquito impoundments
have an adverse impact on fishery habitat as these areas are
usually completely closed to normal water circulation patterns.
Several years ago Governor Graham appointed an interagency task
force to deal with mosquito control issues as related to fishery
habitat. This effort has been supported by research funded by
the DER/OCM and conducted by the Indian River Mosquito Control District, Institute of Food and Agricultural Science, and Harbor Branch Foundation designed to explore innovative impound management techniques. These efforts are just beginning to pay off in programs allowing for mosquito control while returning selected impounds to active tidal circulation.

In closing, this discussion has provided a brief and necessarily incomplete overview of Florida's regulatory and growth management programs as they relate to fishery habitat. I would like to stress that the regulatory and management programs discussed above are only as good as scientific information utilized to implement them. Unless the research community is willing to make an effort to communicate their findings, including implications for changes in regulatory and management programs, to the general public, politicians, and agency decision makers, no significant improvements can be made in the programs outlined in this discussion.