3.3.1.2 Description of the Deepwater Shrimp Species and Distribution

Rock Shrimp

Rock shrimp (Figure 21) are very different in appearance from the three species of *Penaeus*. Rock shrimp can be easily separated from *Penaeus* species by their thick, rigid, stony exoskeleton. The affected environment, including a description of the shrimp fisheries in the south Atlantic region, is presented in detail in the original shrimp plan (SAFMC 1993) and the profile of the shrimp fishery in the south Atlantic (SAFMC 1981). A description of Council concerns and recommendations on protecting shrimp habitat is also included in the original FMP.

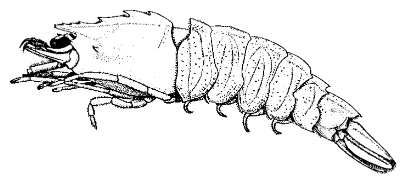

Figure 21. Rock shrimp *Sicyonia brevirostris*.

Biological Characteristics

Rock shrimp are dioecious (separate sexes). Female rock shrimp attain sexual maturity at about 17 mm carapace length (CL), and all males are mature by 24 mm CL. Seasonal temperature initiates maturation. Rock shrimp have ovaries that extend from the anterior end of the cephalothorax to the posterior end of the abdomen. Rock shrimp, as with most shrimp species, are highly fecund. Fecundity most probably, as with penaeids, increases with size. In rock shrimp, copulation is believed to take place between hard shelled individuals. During copulation the male anchors the spermatophore to the female's thelycum by the petasma and other structures and a glutinous material. Fertilization is believed to take place as ova and spermatozoa are simultaneously expulsed from the female. Spawning season for rock shrimp is variable with peak spawning beginning between November and January and lasting 3 months. Individual females may spawn three or more times in one season. Peak spawning activity seems to occur monthly and coincides with the full moon (Kennedy et al. 1977). Five ovarian stages, one more than found in penaeid shrimp, have been identified for rock shrimp (Kennedy et al. 1977): 1) Undeveloped; 2) Developing; 3) Nearly Ripe; 4) Ripe; and 5) Advanced Ripe.

Larval and Postlarval Phases

Kennedy et al. (1977) found rock shrimp larvae to be present year round with no trend relative to depth, temperature, salinity, and length or moon phase. The development from egg to postlarvae takes approximately one month. Subsequently the development from postlarvae to the smallest mode of recruits takes two to three months. The major transport mechanism affecting planktonic larval rock shrimp is the shelf current systems near Cape Canaveral, Florida (Bumpus 1973). These currents keep larvae on the Florida Shelf and may transport them inshore in spring.

Growth Patterns, Mortality, and Recruitment

Rates of growth in rock shrimp are variable and depend on factors such as season, water temperature, shrimp density, size, and sex. Rock shrimp grow about a count a month. Growth is 2 - 3 mm CL per month in juveniles and 0.5 - 0.6 mm CL per month in adults (Kennedy et al. 1977).

Density is thought to also affect growth of rock shrimp. In 1993, the industry indicated that rock shrimp were abundant but never grew significantly over 36/40 count which was the predominant size class harvested during July and August of that year. During years of low densities, the average size appears to be generally larger.

Since rock shrimp live between 20 and 22 months, natural mortality rates are very high, and with fishing, virtually the entire year class will be dead at the end of the season. The intense fishing effort which exists in today's fishery, harvests exclusively the incoming year class. Three year classes were present in sampling conducted between 1973 and 1974 by Kennedy et al. (1977). Fishing mortality in combination with high natural mortality and possibly poor environmental conditions, may be high enough to prevent any significant escapement of adults to constitute a harvestable segment of the population. The better than average rock shrimp production in the 1994 season possibly resulted from better environmental conditions more conducive to rock shrimp reproduction and spawning.

Ecological Relationships
Food, Substrate, and Predation

Along the Florida Atlantic coast, the predominant substrate inside of 200 m depth is fine to medium sand with small patches of silt and clay (Milliman 1972). Juvenile and adult rock shrimp are bottom feeders. Stomach contents analyses indicated that rock shrimp primarily feed on small bivalve mollusks and decapod crustaceans (Cobb et al. 1973). Based on stomach contents of rock shrimp analyzed, Kennedy et al. (1977) found the relative abundance of particular crustaceans and mollusks corresponding to their availability in the surrounding benthic habitat.

Distribution

Recruitment to the area offshore of Cape Canaveral occurs between April and August with two or more influxes of recruits entering within one season (Kennedy et al. 1977).

Keiser (1976) described the distribution of rock shrimp in coastal waters of the southeastern United States. Whitaker (1982) presented a summary of information on rock shrimp off South Carolina. The only comprehensive research to date on rock shrimp off the east coast of Florida was by Kennedy et al. (1977). The following section incorporates some of the more significant findings presented by Kennedy et al. (1977) regarding the biology of rock shrimp on the east coast of Florida.

Rock shrimp (*Sicyonia brevirostris*) are found in the Gulf of Mexico, Cuba, the Bahamas, and the Atlantic Coast of the U.S. up to Virginia (SAFMC 1993) (Figure 22). The center of abundance and the concentrated commercial fishery for rock shrimp in the south Atlantic region occurs off northeast Florida south to Jupiter Inlet (Figure 23). Although rock shrimp are also found off North Carolina, South Carolina, and Georgia and are occasionally landed in these states, no sustainable commercially harvestable quantities of rock shrimp comparable to the fishery prosecuted in the EEZ off Florida are being exploited.

Rock shrimp live mainly on sand bottom from a few meters to 183 m (600 ft), occasionally deeper (SAFMC 1993). The largest concentrations are found between 25 and 65 m (82 and 213 ft).

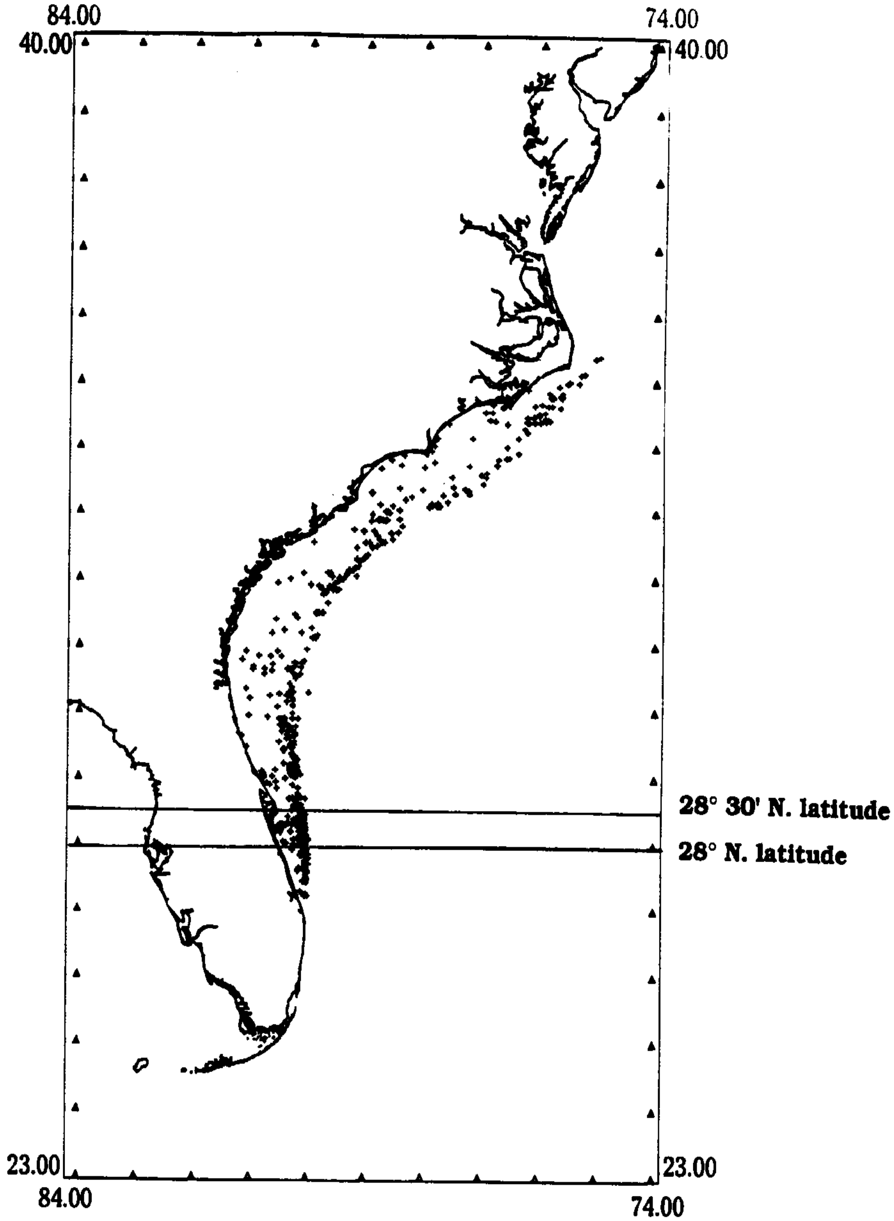

Figure 22. Rock shrimp distribution in the south Atlantic region as indicated from historical research efforts (1956-1991) using finfish and shrimp trawls (Source: NMFS 1994).

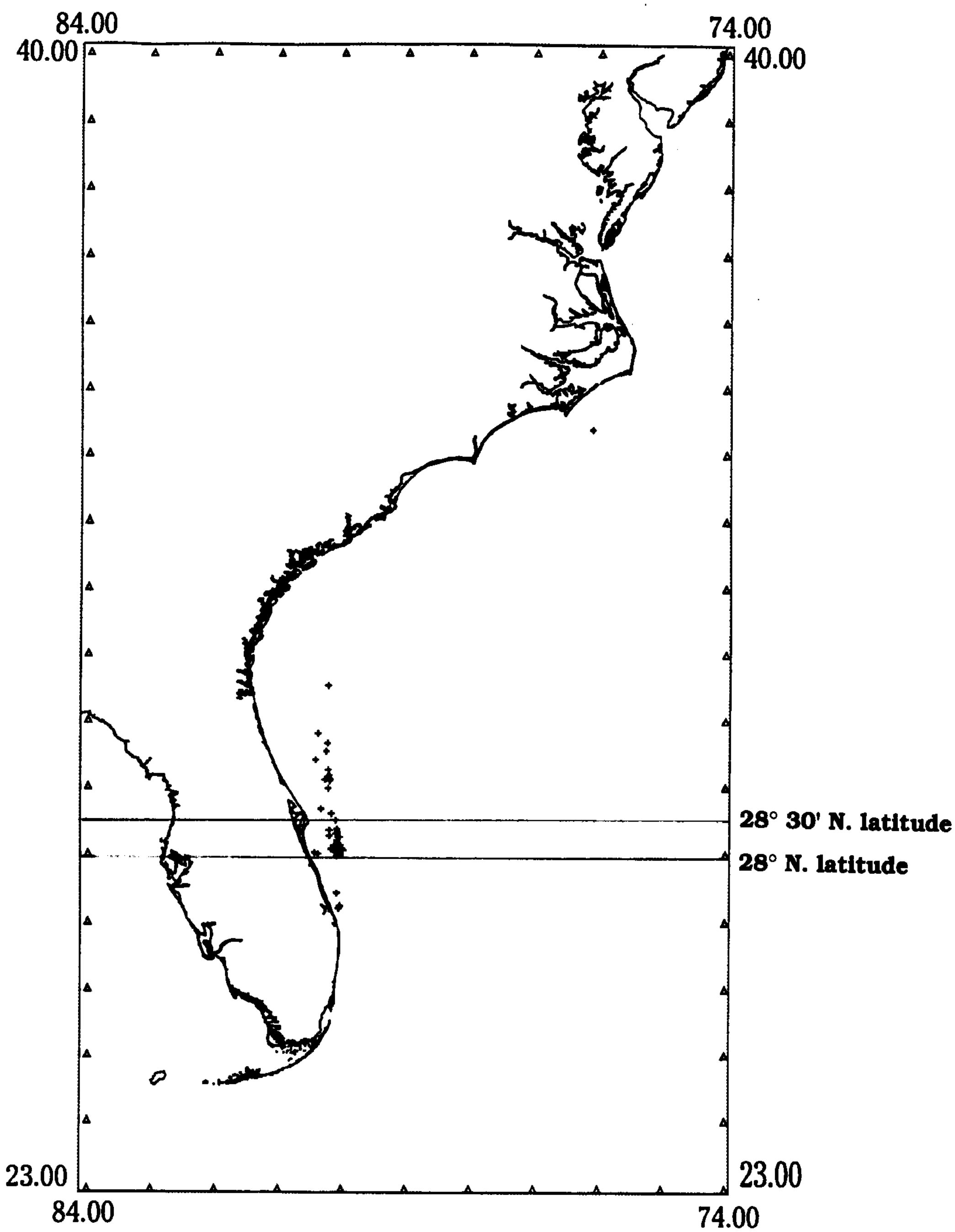

Figure 23. Harvestable rock shrimp distribution in the south Atlantic region as indicated from historic research efforts (1956-1991) using finfish and shrimp trawls (Source: NMFS 1994).

Royal Red Shrimp

Royal red shrimp are found throughout the Gulf of Mexico and South Atlantic area from Cape Cod to French Guiana. In the South Atlantic they are found in large concentrations primarily off northeast Florida. They inhabit the upper regions of the continental slope from 180 m (590 ft) to about 730 m (2,395 ft), but concentrations are usually found at depths of between 250 m (820 ft) and 475 m (1,558 ft) over blue/black mud, sand, muddy sand, or white calcareous mud.

3.3.1.3 Essential Fish Habitat and Environmental Requirements for Penaeid Shrimp

For peneaid shrimp, Essential Fish Habitat includes inshore estuarine nursery areas, offshore marine habitats used for spawning and growth to maturity, and all interconnecting water bodies as described in the Habitat Plan. Inshore nursery areas include tidal freshwater (palustrine), estuarine, and marine emergent wetlands (e.g., intertidal marshes); tidal palustrine forested areas; mangroves; tidal freshwater, estuarine, and marine submerged aquatic vegetation (e.g., seagrass); and subtidal and intertidal non-vegetated flats. This applies from North Carolina through the Florida Keys.

The three commercially important penaeid shrimp of the southeastern United States occupy similar habitats with the greatest differences being in optimal substrate and salinity. Apparently all three species can tolerate a wide range of habitat conditions; however, there appear to be optimal conditions which result in the highest growth rates and greatest survival.

Shrimp have a life cycle which requires a variety of habitats. The habitats can basically be divided into offshore and inshore. The high salinity, oceanic waters serve as habitat for large mature shrimp which will spawn offshore. Brown and pink shrimp apparently move to relatively deep continental shelf water and white shrimp appear to remain nearshore in shallower water (SAFMC 1981).

The relative abundance of the three shrimp species in the South Atlantic may be related to offshore bottom sediment composition. Kennedy and Barber suggest that spawning pink shrimp may be most abundant off Cape Canaveral and Cape Lookout because that species has an affinity for hard, coarse, and particularly calcareous bottom sediments which occur in those areas. They also note that the nearshore soft sediments correlate well with white and brown shrimp distribution from northern Florida to Pamlico Sound, North Carolina.

Offshore water also serves as habitat for larval and postlarval shrimp. These shrimp are planktonic and feed on zooplankton in the water column. There is some evidence that postlarval brown shrimp may overwinter in nearshore bottom sediments (Temple and Fischer, 1967). Aldrich et al. (1968) demonstrated that brown shrimp postlarvae buried in laboratory experiments when water temperature was reduced to 12˚-16.5˚C (54˚-62˚F). For their experiments, they used substrate material taken from Galveston Bay which was 75 percent clay, 22 percent silt and 3 percent sand.

The inshore phase of the life cycle is perhaps the most critical because most of the rapid growth occurs here. This critical habitat is dominated on the Atlantic coast by smooth cordgrass (*Spartina alterniflora*) and *Juncus* (in North Carolina's Pamlico Sound) which produce most of the primary production. Schelske and Odum (1961) stated that up to 10 tons of *Spartina* plant tissues are produced per acre per year. Turner (1977) found a direct relationship between commercial landings to absolute area and type of estuarine-intertidal vegetation. He suggested that the "...measurements of intertidal areas are relative indices of the amount of "edge" in an area and thus indirect measurement of the habitat."

Shrimp enter the inshore habitat as postlarvae and maintain a benthic existence. The areas where juveniles appear most abundant have a mud-silt substrate and intermediate salinities. Gunter et al. (1964) found that juvenile white shrimp were most abundant in waters of salinities less than 10 ppt in Alabama and Texas bays. Truesdale (1970) presented somewhat contradictory information. He concluded that salinity, per se, had no effect on postlarval distribution and abundance in Trinity Bay, Texas except during periods of high river discharge. Zein-Eldin and Aldrich (1965) and Zein-Eldin and Griffith (1970) found that salinity, per se, did not affect the growth of postlarval shrimp.

Apparently white shrimp have a greater tolerance to low salinity than brown shrimp. Gunter (1961) attributes the predominance of white shrimp in Louisiana to the lower estuarine salinities. Conversely, brown shrimp dominate in the waters around the much drier Texas. Gunter points out that the connection between rainfall and Texas white shrimp production was dramatically illustrated in 1957 when a long drought was broken and landings jumped from 2,229,000 pounds in 1957 to 7,370,000 pounds in 1958. Parker (1970) reported brown shrimp in areas where bottom salinity ranged from 0.9 to 36.5 ppt. Gaidry and White (1973) reported that commercial catches of brown shrimp were poor in those years when salinities where less than 15 ppt at the time postlarvae were present in the estuaries. They also stated that years of low commercial landings of brown shrimp were associated with prolonged estuarine temperatures of less than 20˚ C (68˚F) at the time of postlarval immigration into the estuary. Laboratory studies with juvenile and adult brown and white shrimp indicate that white shrimp are better adapted to tolerate low salinity, whereas, brown shrimp are better adapted to higher salinities (McFarland and Lee, 1963). Gunter et al. (1964), found that juvenile white shrimp were more abundant in areas with waters of salinities less than 10 ppt while brown shrimp juveniles were more abundant in salinities between 10.0 and 19.9 ppt.

Juvenile shrimp appear to be most abundant at the *Spartina* grass-water interface. This “estuarine edge” is the most productive zone in many estuaries. Because there is a minimum of wind generated turbulence and stabilization of sediments, rich bands are found that along the edges of marshes (Odum, 1970). Furthermore, Odum (1970) found the percentages of organic detritus in sediments along the shore in the Everglades estuary are several times greater than a few meters offshore. Mock (1967) examined two estuarine habitats, one natural and one altered by bulk-heading. He found a 0.6 m (2 ft) band of rich organic material along the natural shore and very little organic material along the bulkheaded shore. White shrimp were 12.5 times and brown shrimp 2.5 times more numerous in the natural area as in the altered area. Loesch (1965) found that juvenile white shrimp in Mobile Bay were most abundant nearshore in water less than 0.6 m (2 ft) deep containing large amounts of organic detritus. Brown shrimp were congregated in water 0.6 to 0.9 m (2-3 ft) deep where there was attached vegetation.

As shrimp increase in size, they begin migrating toward high salinity, oceanic waters. Parker (1970) observed that size of brown shrimp at the time of emigration is apparently related to density of individuals but smaller individuals tended to concentrate in shallow peripheral zones. St. Amant et al. (1966) observed that as juveniles increased in size they move into deeper, larger bays, through the lower bays and to offshore waters. Lindner and Anderson (1956) stated that shrimp size increased from inside to outside waters. The largest shrimp were in the outside waters where salinity values were highest.

Water temperature directly or indirectly influences white shrimp spawning, growth, habitat selection, osmoregulation, movement, migration, and mortality (Muncy 1984). Spring water temperature increases trigger spawning, and rapid water temperature declines in fall portend the end of spawning (Lindner and Anderson 1956). Growth is fastest in summer and slow or negligible in winter. Water temperatures below 20°C inhibit growth of juvenile shrimp (Etzold and Christmas 1977) and growth is virtually nil at 16°C (St. Amant and Lindner 1966). Growth rates increase rapidly as temperatures increase above 20°C. Increased water temperatures affects molting rate (Perez-Farfante 1969). Good correlation between heating-degree-days and catch/effort ratio for penaeid shrimp was similar to correlations of yield-per-hectare versus latitude (Turner 1977). Temperature and food supply limited the growth of white shrimp postlarvae more than did salinity differences between 2 and 35 ppt (Zein-Eldin 1964).

Severe winters in 1939-40, 1966, 1976-77, and 1977-78 caused mass mortality and reduced catches in the South Atlantic white shrimp fishery (McKenzie 1981; Shipman 1983a; Whitaker 1983a). The Georgia Department of Natural Resources (1983) reported a 34% drop in white shrimp landings in 1981 and a 99% drop in 1981 spring catch of roe shrimp after the unusually cold 1980-81 winter. White shrimp are more tolerant of high temperatures and less tolerant of low temperatures than either brown or pink shrimp (Etzold and Christmas 1977). Among postlarvae, brown shrimp were more resistant than white shrimp to higher temperatures.

White shrimp mortality was reported at water temperatures of 8°C and lower (Joyce 1965). Mortality of white shrimp is total at 3°C or lower, regardless of salinity. White shrimp survival at low temperatures depends on ambient temperature, the rate of temperature decline, the duration of low temperatures and salinity (Joyce 1965). The impact of low water temperature and low salinity on white shrimp was discussed by Music (1979) and Shipman (1983a). Adult white shrimp (>90mm long) may be more susceptible than juveniles to cold temperatures (Whitaker 1983a). Wiesepape (1975) found the 24-h LC_{50} (temperature causing 50% mortality in 24 h) to be 36° and 37°C for white shrimp acclimated at 29° and 34°C, respectively. Postlarvae and 30-mm long juveniles have similar but higher resistance times than 50-mm juveniles.

Adult white shrimp spawn offshore where salinities are at least 27 ppt. The larvae move shoreward and become second-stage postlarvae as they enter estuaries on flood tides. Juvenile white shrimp moved 160 km upstream into water of less than 1.0-ppt salinity waters in the St. Johns River, Florida (Joyce 1965). Juvenile white shrimp have even been recovered from Lake Monroe Power Station filter screens located 270 km from the mouth of the St. Johns River -- especially when low rainfall and low river stages caused reverse tidal flow (Edwin Joyce pers. comm., February 1984). The high calcium ion concentrations in the St. Johns River may explain the relative ease with which marine species enter and remain in low salinity waters (Joyce 1965). The lowest salinity in which white shrimp were recorded in the northern Gulf of Mexico was 0.42 ppt (Perez-Farfante 1969). Although field studies indicate that juvenile white shrimp prefer low salinities, laboratory studies have revealed that white shrimp appear to tolerate a wide range of salinities; they have been successfully reared at salinities of 18 to 34 ppt (Perez-Farfante 1969). McKenzie (1981) cited several studies in which fast growth was reported for white shrimp at salinities of 7 to 15 ppt.

White shrimp in Georgia move toward higher salinity waters as sexual development progresses, and most spawn offshore in the sea (Harris 1974).

Temperature-salinity tolerance ranges for white shrimp vary at different life stages, but the interactions are more pronounced at the extremes of tolerance. For example, Couch (1978) reported that broken-back syndrome (dorsal separation of the third and fourth pleural plates on abdominal) appears after sudden drops in salinity (from 15 ppt to 3 ppt) in cold water (8°C). The critical thermal maxima for white shrimp are influenced largely by acclimation temperatures, and to a lesser extent by salinity and size of test animal (Laney 1973). Freshwater inflow may affect coastal water temperatures, which in turn affect the growth rates (White and Boudreaux 1977) and migration of white shrimp (Shipman 1983b). Spring spawning of white shrimp coincides with a rapid rise in bottom water temperatures in high salinity offshore waters (McKenzie 1981).

White shrimp prefer shallow, muddy-bottom substrate. Landings of shrimp along the Louisiana coast were highest in areas where substrates were highly organic (Barrett and Gillespie 1973; Gaidry 1974). A relative higher linear correlation ($R^2 = 0.69$) between intertidal land area and average annual shrimp catch along Louisiana's inshore regions was reported by Turner (1977). The relation between inshore catches and hectares of vegetated estuarine habitat in the northeastern Gulf of Mexico (Tampa Bay, Florida, to Mobile Bay and Perdido Bay, Alabama) also showed a strong correlation ($R^2 = 0.64$). A direct relationship between commercial shrimp landings and intertidal vegetated areas and degrees latitude was reported by Turner (1977). The annual landings (kg/ha) in 1955-64 were 19.7 in North Carolina, 7.9 in South Carolina, 13 in Georgia, and 22.4 in east Florida. White shrimp undoubtedly composed most of the landings except in North Carolina. Southward fall migration probably account for the high landings from Florida waters. The area of nearshore soft sediments correlate well with white and brown shrimp distribution from Pamlico Sound, North Carolina to northern Florida (McKenzie 1981).

Temporal and spatial shifts by brown, white, and pink shrimp help reduce direct interspecific competition especially for certain substrates (Lassuy 1983). White shrimp burrow less deeply into muddy substrates and are more active in daylight than are brown or pink shrimp. Staggered seasonal recruitment of brown and white shrimp into the south Atlantic estuaries would reduce competition (Baisden 1983).

3.3.1.4 Essential Fish Habitat and Environmental Requirements for Rock Shrimp

For rock shrimp, essential fish habitat consists of offshore terrigenous and biogenic sand bottom habitats from 18 to 182 meters in depth with highest concentrations occurring between 34 and 55 meters. This applies for all areas from North Carolina through the Florida Keys. Essential fish habitat includes the shelf current systems near Cape Canaveral, Florida which provide major transport mechanisms affecting planktonic larval rock shrimp. These currents keep larvae on the Florida Shelf and may transport them inshore in spring. In addition the Gulf Stream is an essential fish habitat because it provides a mechanism to disperse rock shrimp larvae.

A description of shrimp habitat and recommendations to protect habitat were contained in the shrimp management plan (SAFMC 1993). The bottom habitat on which rock shrimp thrive is thought to be limited. Kennedy et al. (1977) determined that the deepwater limit of rock shrimp was most likely due to the decrease of suitable bottom habitat rather than to other physical parameters including salinity and temperature. Cobb et al. (1973) found the inshore distribution of rock shrimp to be associated with terrigenous and biogenic sand substrates and only sporadically on mud. Rock shrimp also utilize hard bottom and coral or more specifically *Oculina* coral habitat areas. This was confirmed with research trawls capturing large amounts of rock shrimp in and around the Oculina Bank HAPC prior to its designation.

Other than Kennedy et al. (1977), no characterization of habitat essential to rock shrimp or bycatch in the rock shrimp fishery has been conducted. A list of species associated with the benthic habitat inhabited by rock shrimp was compiled from research trawling efforts (1955-1991) that captured harvestable levels of rock shrimp. In addition, Kennedy et al. (1977), during research efforts sampling the major distribution area of rock shrimp off the east coast of Florida, compiled a list of crustacean and molluscan taxa associated with rock shrimp benthic habitat.

3.3.1.5 Essential Fish Habitat and Environmental Requirements for Royal Red Shrimp

Essential fish habitat for royal red shrimp include the upper regions of the continental slope from 180 meters (590 feet) to about 730 meters (2,395 feet), with concentrations found at depths of between 250 meters (820 feet) and 475 meters (1,558 feet) over blue/black mud, sand, muddy sand, or white calcareous mud. In addition the Gulf Stream is an essential fish habitat because it provides a mechanism to disperse royal red shrimp larvae.

3.3.1.6 Essential Fish Habitat-Habitat Areas of Particular Concern for Shrimp

Penaeid Shrimp

Areas which meet the criteria for essential fish habitat-habitat areas of particular concern (EFH-HAPCs) for penaeid shrimp include all coastal inlets, all state-designated nursery habitats of particular importance to shrimp (for example, in North Carolina this would include all Primary Nursery Areas and all Secondary Nursery Areas), and state-identified overwintering areas.

Estuarine tidal creeks and salt marshes that serve as nursery grounds are perhaps the most important habitats occupied by penaeid shrimp. The major factor controlling shrimp growth and production is the availability of nursery habitat. Remaining wetland habitat must be protected if present production levels are to be maintained. In addition, impacted habitats must be restored if future production is to be increased. Other areas of specific concern are the barrier islands since these land masses are vital to the maintenance of estuarine conditions needed by shrimp during their juvenile stage. Passes between barrier islands into estuaries also are important since the slow mixing of sea water and fresh water are also of prime importance to estuarine productivity.

In North Carolina, essential fish habitat-habitat areas of particular concern include estuarine shoreline habitats since juveniles congregate here. Seagrass beds, prevalent in the sounds and bays of North Carolina and Florida, are particularly critical areas. Core Sound and eastern Pamlico Sound, based on a preliminary aerial survey funded through the Albemarle-Pamlico Estuarine Study, have approximately 200,000 acres of seagrass beds making North Carolina second only to Florida in abundance of this type of habitat (Department of Commerce 1988b). In subtropical and tropical regions shrimp and spiny lobster postlarvae recruit into grass beds from distant offshore spawning grounds (Fonseca et al. 1992).

South Carolina and Georgia lack seagrass beds. Here, the nursery habitat of shrimp is the high marsh areas with shell hash and mud bottoms. In addition, there is seasonal movement out of the marsh into deep holes and creek channels adjoining the marsh system during winter. Therefore, the area of particular concern for early growth and development encompasses the entire estuarine system from the lower salinity portions of the river systems through the inlet mouths.

Rock Shrimp

No essential fish habitat-habitat areas of particular concern have been identified for rock shrimp however, deep water habitat (e.g. the rock shrimp closed area/proposed expanded Oculina Bank HAPC) may serve as nursery habitat and protect the stock by providing a refuge for rock shrimp.

3.3.2 Red Drum
3.3.2.1 Description of the Species and Distribution

Red drum (Figure 24) occur in a variety of habitats distributed from Massachusetts to Key West, Florida on the Atlantic coast (Simmons and Breuer 1962). Red drum historically have been found as far north as Massachusetts with concentrations great enough to support a moderate commercial fishery in New Jersey in the early 1930s. Commercial red drum landings have generally declined along the mid-Atlantic coast with none being reported north of the Chesapeake Bay since 1950 (Yokel 1980). The distribution of red drum along the Atlantic coast in recent years, as indicated from recreational and commercial landings, extends from the Chesapeake Bay area through Florida.

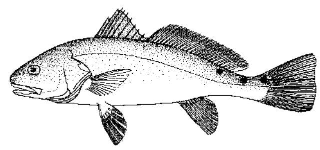

Figure 24.   Red Drum, *Sciaenops ocellatus*.

Eggs, Larvae and Juveniles

Red drum spawn in the ocean along beaches and in the vicinity of inlets and passes and possibly in high salinity estuaries. Red drum spawn at night and produce planktonic, spherical eggs between 0.86 mm and 0.98 mm in diameter (Johnson et al. 1977). Eggs are clear with a single, gold-colored oil droplet. Environmental requirements for optimum incubation were determined in the laboratory as a salinity of 25-35 ppt below which the eggs would sink and above which the eggs would clump together. In addition, optimum spawning occurred at temperatures of 22˚-30˚C (Holt et al. 1983). Red drum eggs and larvae are carried through tidal and current movement into estuarine systems. Increased spawning activity is associated with new and full moon periods during the spawning season.

Juvenile red drum have a pronounced seasonal pattern of distribution in Chesapeake Bay and North Carolina moving into deeper areas of estuaries or the ocean in the fall and winter (Yokel 1980). Juveniles have been collected throughout Chesapeake Bay from September to November and through December in North Carolina (Hildebrand and Schroeder 1928; Mansueti 1960). In North Carolina, juvenile one and two year old red drum occur year round in estuaries, both in mainland bays and rivers, and along the grass flats behind barrier islands (Ross et al., 1987). A portion of these cohorts migrate into the ocean after their first year and occur along beaches during the late fall through early spring. Peak recruitment of young fish generally occurs September through November in North Carolina estuaries.

Adults

After maturation, adult red drum spend less time in the estuaries and more time in the ocean (Yokel 1966).   They migrate seasonally along the coast, inshore and/or north in spring and offshore and/or south in fall. Chesapeake Bay red drum are taken through October and are most abundant during spring and fall. Large schools of adult red drum were identified during aerial surveys conducted as part of the Atlantic Marine Gamefish Research Program. The annual survey encompassed 12 monthly flights over the continental shelf from Cape Cod, Massachusetts to Miami, Florida to measure sea surface temperature and record sightings of all fish and other surface life. Large schools of adult red drum were identified offshore south of Hatteras, North Carolina in April. Additional sightings of red drum offshore were noted to occur north of Hatteras in May and June. Large numbers of red drum are occasionally gigged in North Carolina sounds in the winter.

Annually, the best catches of large red drum occur around the eastern shore of Virginia and in the lower Chesapeake Bay in May-June and September-October. Largest catches of adult red drum along the Outer Banks are made from late March through May and from October through November (Ross and Stevens 1989). Large schools of red drum have been observed in Pamlico Sound, North Carolina during the summer (Mercer 1984). In winter, red drum have been caught in the trawl fishery and in trawl surveys at depths of 10 to 40 m. Red drum have been reported off South Carolina in 13-26 m of water in the winter and early spring.

In addition, large red drum were captured by shark gillnet fishermen in the EEZ offshore of Folly Beach, South Carolina in May 1989. Recreational fishermen in South Carolina have identified large schools of adult red drum nearshore feeding along bars during rising tides at night. In Georgia, red drum older than four years are generally found along beaches and in offshore waters. Recent sonic tagging studies conducted by Georgia Department of Natural Resources have resulted in field verification of red drum surface schools offshore in the EEZ (Music and Pafford 1984).

Movement Patterns

Adult red drum migrate seasonally along the Atlantic coast (Yokel 1966). Reports from fishermen and menhaden spotter pilots indicate that red drum typically arrive at Cape Hatteras, North Carolina between March and April, some entering Pamlico Sound and others proceeding up the coast. Red drum are expected about a week later at Oregon Inlet and three weeks to a month later in Virginia, some entering Chesapeake Bay. Apparently in times of high abundance and proper environmental conditions, red drum averaging 13-14 kg (33-36 lb) were present along the New Jersey coast from May to October (Welsh and Breder 1923). Red drum leave Virginia in most years by October and fall fishing along the North Carolina coast starts in September and usually ends in November (Yokel 1966).

After their first or second year some red drum move along the barrier island beaches during fall and spend winter in deep holes or sloughs, while others winter in the estuary. As they get older, they spend spring, early summer and fall along the beaches and winter offshore. As spring approaches, these adult fish move from offshore wintering grounds towards the beaches with concentrations showing up around Ocracoke, Hatteras and Oregon Inlets, North Carolina. They occur along beaches near inlets for one to two months and move inside Pamlico Sound in summer. In August they school up around inlets to spawn and remain there and along the beaches through November, then move offshore again.

Red drum also exhibit a north/south movement pattern as follows: A large body of fish moves inshore and north along the beaches in the spring up to the Chesapeake Bay and Virginia barrier islands. Also a large number of fish, generally 5-25 lb, spend their summer around shoals off Cape Hatteras, Cape Lookout and the four inlets north of Cape Lookout.

One consistent pattern that can be drawn from Atlantic coast red drum tagging studies is that red drum tend to stay in the same general estuarine system from post larval stages through their third or fourth year of life. They then move out of the estuarine system into the spawning stock associated with nearshore and offshore areas. Some large fish move into bays, sounds and harbor systems, even after maturity, and are susceptible to capture. The majority of tagging conducted along the Atlantic coast has been directed toward smaller red drum, less than four years old. Large red drum are being tagged through efforts of recreational fishermen participating in sport fish tagging programs conducted by state fishery agencies. Returns of large fish (>32 in TL) have been very low and and many of these returns have occurred at the same general time. Thus movement of these fish can be cited as the minimum distance traveled, not accounting for possible migration and return to spawning grounds (such as specific inlet mouths or bar systems associated with these high energy areas).

Ecological Relationships - Food

A dietary analysis of red drum (5-300 mm SL) stomach contents was conducted by Daniel (1988) Prey varied with fish size. Copepods were predominant prey by volume for fish 5-15 mm SL, representing 27% of the total volume. Mysids comprised 34% of the total volume of prey for fish 16-30 mm. The highest level of fish consumption occurred in juvenile red drum in the 76 and 100 mm size class (72% by volume) found in 70% of the individual samples. Fish were also a major component of juvenile red drum in both the 100-125 mm SL (51% by volume) and the 125-150 mm SL (60% by volume) size classes. A shift in composition of prey species was observed for red drum 200-300 mm SL. The predominant species observed in this size class included decapods (mainly mud crabs and fiddler crabs) accounting for 96% by volume and 95% of the (83) individuals analyzed. Music and Pafford (1984) analyzed the stomach contents of red drum which ranged from 101 mm to 1,100 mm collected in Glynn County Georgia from January 1979 through June 1982. Red drum 300-600 mm in length were found to have 17% fish, 72% arthropods and 11% plant material, with fiddler crabs (16%) and white shrimp (11%) being the predominant food item by occurrence. Red drum 601-1,100 mm in length were found to have 36% fish, 59% arthropods and 5% plant material, with fiddler crabs (14%) and mud crabs (11%) being the predominant food item by occurrence.

3.3.2.2 Essential Fish Habitat and Environmental Requirements

For red drum, essential fish habitat includes all the following habitats to a depth of 50 meters offshore: tidal freshwater; estuarine emergent vegetated wetlands (flooded saltmarshes, brackish marsh, and tidal creeks); estuarine scrub/shrub (mangrove fringe); submerged rooted vascular plants (sea grasses); oyster reefs and shell banks; unconsolidated bottom (soft sediments); ocean high salinity surf zones; and artificial reefs. The area covered includes Virginia through the Florida Keys.

Red drum are distributed along the Atlantic coast, in the ocean and estuarine areas in relation to their stage of maturity. Juvenile red drum utilize the shallow backwaters of estuaries as nursery areas and remain there until they move to deeper water portions of the estuary associated with river mouths, oyster bars and front beaches. Estuarine wetlands are especially important to larval red drum. The types of estuarine systems vary along the Atlantic and subsequently, the preferred juvenile habitat also varies with distribution. Young red drum are found in quiet, shallow, protected waters with grassy or slightly muddy bottoms. Shallow bay bottoms or oyster reef substrates are preferred by subadult and adult red drum. Red drum utilize the oceanic system which is the area of the Atlantic ocean from the beachfront seaward. Large red drum are thought to migrate along the Atlantic coast and are subjected to man's alterations of the natural system. Nearshore and offshore bar and bank areas such as Gaskins and Joiner Banks in South Carolina have been identified as areas where concentrations of red drum could be located. Nearshore artificial reefs along the Atlantic are also known to attract red drum as they make their spring and fall migrations. In the fall and spring red drum concentrate around inlets, shoals, capes, and from the surfzone to several miles offshore, moving among these areas.

The distribution of red drum between estuarine habitat and oceanic waters is dependant mainly on stage of development and temporal and environmental factors. Red drum are euryhaline. Adult and subadult red drum are most often found in diluted/concentrated seawater of 20 to 40 ppt and rarely above 50 ppt, while juveniles range into the freshest parts of estuaries. Eggs and newly hatched larvae require salinities above 25 ppt. Spawning occurs in or near passes of inlets (e.g. "Grillage" at the mouth of Charleston Harbor) with larvae being transported into the upper estuarine areas of low salinity. As larvae develop into juveniles and sub-adults, they utilize progressively higher salinity estuarine and beachfront surf zones. Red drum move out of estuarine areas as adults and occupy the high salinity surf zone nearshore and offshore coastal waters. In North Carolina and Virginia, large adults move into estuaries during summer months.

Red drum are eurythermal, occuring over a temperature range of 2˚-33˚C, although they usually move into deeper water at extremes. Larger juveniles and adults are more susceptible to the effects of winter cold waves than small fish. High red drum mortality during freezes occurs and has the ability to decimate large portions of juvenile year classes. Thermal optimum is dependant on salinity, a characteristic of euryhaline fish.

Spatial and Temporal Distribution and Relative Abundance in Estuarine Habitat

NOAA's Estuarine Living Marine Resource Program (ELMR), through a joint effort of National Ocean Service and NMFS, conducts regional compilations of information on the use of estuarine habitat by select marine fish and invertebrates. A report prepared through the ELMR program (NOAA 1991b) and revised information (NOAA 1998), provided the Council during the Habitat Plan development process, present known spatial and temporal distribution and relative abundance of fish and invertebrates using southeast estuarine habitats. Twenty southeast estuaries selected from the National Estuarine Inventory (NOAA 1985) are included in the analysis which resulted from a review of published and unpublished literature and personal consultations. The resultant information emphasizes the importance and essential nature of estuarine habitat to all life stages of red drum.

Regional salinity and relative abundance maps for use in determining EFH for red drum were prepared for the Council by NOAA SEA Division (Appendix F). Figures 25-28 present a representative sample of the distibution maps for juvenile red drum. The remainder of the coverages and additional information on species and habitat distribution are available over the Internet on the Council web page under the habitat homepage (www.safmc.noaa.gov). These maps portray salinity and species relative abundances for estuaries and coastal embayments on state and/or regional maps. Depending on data availability, maps were produced at various scales: 1:24K, 1:80K, and 1:250K. For species relative abundances, these maps were be developed only for juveniles of estuarine species (Nelson et al. 1991) showing the highest juvenile relative abundance in any salinity zone by season for each estuary. These maps will eventually be provided to the Council as ArcView shape files with associated data for inclusion into the Councils GIS system.