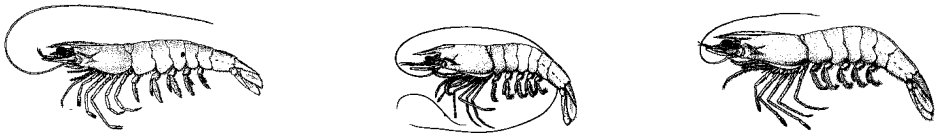
### 3.3.1 Penaeid and Deepwater Shrimp

In the southeastern United States, the shrimp industry is based on the white shrimp, *Penaeus setiferus*, the brown shrimp, *Penaeus aztecus*, the pink shrimp, *Penaeus duorarum* and the deeper water rock shrimp, *Sicyonia brevirostri. T*he royal red shrimp, *Pleoticus robustus* occurs in deeper water, and sustains a limited harvest.

#### 3.3.1.1 Description of the Penaied Shrimp Species and Distribution

With the exception of pink shrimp, which is also found off Bermuda, the three *Penaeus* species are restricted to the Atlantic Coast of the U.S. and the Gulf of Mexico. Other common names for the white shrimp (Figure 11) include gray shrimp, lake shrimp, green shrimp, green-tailed shrimp, blue tailed shrimp, rainbow shrimp, Daytona shrimp, common shrimp, and southern shrimp. The brown shrimp (Figure 11) is also known as brownie, green lake shrimp, red shrimp, redtail shrimp, golden shrimp, native shrimp, and also the summer shrimp in North Carolina. Other names for the pink shrimp (Figure 11) include spotted shrimp, hopper, pink spotted shrimp, brown spotted shrimp, grooved shrimp, green shrimp, pink night shrimp, red shrimp, skipper, and pushed shrimp.



Pink shrimp White shrimp Brown shrimp

Figure 11. Illustrations of white, brown and pink shrimp.

Juvenile and adult penaeids are omnivorous (eating both plants and animals) bottom feeders with most feeding activity occurring at night although daytime feeding may occur in turbid waters. Food items may consist of polychaetes, amphipods, nematodes, caridean shrimps, mysids, copepods, isopods, amphipods, ostracods, mollusks, foraminiferans, chironomid larvae, and various types of organic debris.

White shrimp appear to prefer muddy or peaty bottoms rich in organic matter and decaying vegetation when in inshore waters. Offshore they are most abundant on soft muddy bottoms. Brown shrimp appear to prefer a similar bottom type and as adults may also be found in areas where the bottom consists of mud, sand, and shell. Pink shrimp are found most commonly on hard sand and calcareous shell bottom. Both brown and pink shrimp generally bury in the substrate during daylight, being active at night. White shrimp do not bury with the regularity of pink or brown shrimp.

Shrimp are preyed on by a wide variety of species at virtually all stages in their life history. Predation on postlarvae has been observed by sheepshead minnows, water boatmen, and insect larvae. Grass shrimp, killifishes, and blue crabs prey on young penaeid shrimp, and a wide variety of finfish are known to prey heavily on juvenile and adult penaeid shrimp.

In Georgia and northern Florida, some white shrimp spawning may occur inshore, although most spawning occurs more than 1.2 miles from the coastline. Off Florida, spawning occasionally takes place inshore, at or near inlets, but most occurs offshore in depths of 6.1-24.4 m (20-80 ft). In South Carolina most spawning occurs within about four miles of the coast. Some shrimp with spermatophores attached have been found inside Charleston harbor (Whitaker, SCWMRD, pers. comm. 1991).

Spawning is correlated with bottom water temperatures and has been reported to occur at bottom temperatures of between 17° and 29° C although spawning generally occurs between 22° and 29° C. White shrimp begin spawning in April in Florida and Georgia and late April or May in South Carolina. Spawning may continue into September or October.

Brown shrimp spawn in relatively deep water. In the Gulf of Mexico, it was concluded that brown shrimp did not spawn in water less than 13.7 m (45 ft) and the greatest percentage of ripe females were at 45.7 m (150 ft). Spawning season for brown shrimp is uncertain, although there is an influx of postlarvae into the estuaries during February and March. Mature males and females have been found off South Carolina during October and November.

Pink shrimp apparently spawn between 3.7 and 15.8 m (12 and 52 ft). Off eastern Florida, peak spawning activity seems to occur during summer. In North Carolina, roe-bearing females are found as early as May, and by June, most pink shrimp are sexually mature.

All three species have eleven larval stages (5 nauplier, 3 protozoan, and 3 mysid) before developing into postlarvae. Duration of the larval period is dependent on temperature, food, and habitat. Records suggest larval periods of 10-12 days for white shrimp, 11-17 days for brown shrimp, and 15-25 days for pink shrimp. Brown shrimp postlarvae appear to overwinter in offshore bottom sediments (Whitaker, SCWMRD, pers. comm. 1991). Postlarval shrimp sizes range from approximately 2.9 to 12 mm (0.1-0.5 in) TL, with pink and white shrimp sizes overlapping and brown shrimp usually being larger.

The mechanism by which postlarvae are brought from distant spawning areas to inside estuaries is not well-known. Shoreward countercurrents north of Cape Canaveral have been suggested as the mechanism for transport of pink shrimp larvae from spawning areas to nursery areas along the northeast Florida coast. Movement of white shrimp postlarvae into the estuary is a result of nearshore tidal currents as white shrimp spawn relatively close to shore. There is some data on brown shrimp that suggest postlarvae may overwinter in offshore waters and migrate into estuaries the following spring. White and pink shrimp move into the estuary during late spring and early summer.

After entering the estuaries, postlarval shrimp occupy nursery areas which offer abundant food, suitable substrate, and shelter from predators. In the South Atlantic these areas are generally dominated by the marsh grass *Spartina alterniflora*.

White and pink shrimp enter the estuaries at about the same time, usually beginning in April and early May in the southern part of their range and in June and July in North Carolina sounds, where white shrimp are uncommon. Large white shrimp begin emigrating out of the estuary to the commercial fishing areas in August and continue through December. Smaller white and pink shrimp may remain in the estuary during winter and are termed overwintering stocks.

In the South Atlantic, juvenile and adult brown shrimp are rarely affected by severe winter weather because most have been captured by fishermen or predators, and others have moved offshore prior to the onset of cold weather.

Pink shrimp bury deeply in the substrate with the onset of cold weather and thus are protected to some extent from winter mortalities. However, pink shrimp can be adversely affected by low temperatures as evidenced by the mass mortalities in North Carolina during the winters of 1976-77 and 1977-78.

Pink and white shrimp that survive the winter grow rapidly in late winter and early spring before migrating to the ocean. The migrating white shrimp, called roe shrimp, make up the spring fishery and also produce the summer and fall crops of shrimp. When a majority of white shrimp do not survive the winter, the North Carolina and South Carolina fisheries are believed to

be dependent on a northward spring migration of white shrimp from more southerly areas to form the spawning stock. However, tagging data are inconclusive on the extent of this northward movement.

**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 white, brown and pink shrimp. Regional salinity and relative abundance maps for use in determining EFH for white, brown and pink shrimp, were prepared for the Council by NOAA SEA Division. Figures 12-17 present a representative sample of the distribution maps. The entire set of maps in color can be found at the SAFMC web site (www.safmc.noaa.gov) and are included in Appendix F. 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 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.

Rates of growth in penaeid shrimp are highly variable and depend on factors such as season, water temperature, shrimp density, salinity, size, and sex. Adolescent shrimp grow rapidly with estimates ranging from 1.0-2.3 mm per day for white shrimp, 0.5-2.5 mm per day for brown shrimp, and 0.25-1.7 mm per day for pink shrimp. Larger white shrimp may grow more than an inch per month.

Salinity is also a factor determining growth rate in white shrimp. High salinities appear to inhibit growth. Density also affects growth of white shrimp. During years of low densities, the average size is generally larger.

Temperature also affects brown shrimp growth rates, with rates as high as 3.3 mm per day recorded when the temperature exceeded 25° C but less than 1.0 mm per day when water temperature was below 20° C. Salinity also affects growth rates in brown shrimp. Salinities in excess of 10 ppt seems to enhance growth rate.

Pink shrimp in Florida Bay were found to grow 3.5 mm CL (carapace length) in winter and only 1.9 mm CL in spring. In North Carolina, maximum pink shrimp growth rates were recorded in summer.

**Distribution**

White shrimp range from Fire Island, New York to St. Lucie Inlet on the Atlantic Coast of Florida (Figure 18). Along the Atlantic Coast of the U.S., the white shrimp has centers of abundance in South Carolina, Georgia, and northeast Florida. White shrimp are generally concentrated in waters of 27 m (89 ft) or less, although occasionally found much deeper (up to 270 ft).

On the Atlantic Coast, brown shrimp occur from Martha's Vineyard, Massachusetts to the Florida Keys (Figure 19). While it may occur seasonally along the Mid-Atlantic states, breeding populations apparently do not range north of North Carolina. The species may occur in commercial quantities in waters as deep as 110 m (361 ft), but they are most abundant in water less than 55 m (180 ft).

Pink shrimp occur from southern Chesapeake Bay to the Florida Keys (Figure 20), and around the coast of the Gulf of Mexico to Yucatan south of Cabo Catoche. Maximum abundance is reached off southwestern Florida and the southeastern Golfo de Campeche. Along the Atlantic Coast of the U.S., pink shrimp occurs in sufficient abundance to be of major commercial significance only in North Carolina. Pink shrimp are most abundant in waters of 11-37 m (36-121 ft) although in some areas they may be abundant as deep as 65 m (213 ft). Pink shrimp are common in the estuaries and shallow marine waters surrounding southern Florida and into deep waters (approximately 100 meters) southeast of the Keys, and are the dominant species within the Dry Tortugas shrimping grounds and Florida Bay (Solamon, 1968). Adult pink shrimp congregate in deep water (> 6 fathoms) off the Dry Tortugas to spawn. Larvae can take two routes to the estuarine nursery areas where they spend most of their life cycle. One route is directly to the shallow-water estuaries of the 10,000 Island, Whitewater Bay, and Florida Bay. On the other route, larvae are swept southwesterly into the Florida Current by way of the Loop Current, and are carried northeasterly along the outer edge of the Florida Reef Tract or of east coast of Florida (Ingle et al., 1959).