APPENDIX L

ESSENTIAL FISH HABITAT

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Pollock (*Pollachius virens*)
Excerpt from NEFMC EFH Amendment 1998

In its *Report to Congress: Status of the Fisheries of the United States* (September 1997), NMFS determined there is not enough information to determine if pollock is overfished or approaching an overfished condition. Essential Fish Habitat for pollock is described as those areas of the coastal and offshore waters (out to the offshore U.S. boundary of the exclusive economic zone) that are designated on Figures 7.1 - 7.4 and in the accompanying table and meet the following conditions:
Eggs: Pelagic waters of the Gulf of Maine and Georges Bank as depicted in Figure 7.1. Generally, the following conditions exist where pollock eggs are found: sea surface temperatures less than 17°C, water depths 30 and 270 meters, and salinities between 32 - 32.8‰. Pollock eggs are often observed from October through June with peaks from November to February.

Larvae: Pelagic waters of the Gulf of Maine and Georges Bank as depicted in Figure 7.2. Generally, the following conditions exist where pollock larvae are found: sea surface temperatures less than 17 °C and water depths between 10 and 250 meters. Pollock larvae are often observed from September to July with peaks from December to February.

Juveniles: Bottom habitats with aquatic vegetation or a substrate of sand, mud or rocks in the Gulf of Maine and Georges Bank as depicted in Figure 7.3. Generally, the following conditions exist where pollock juveniles are found: water temperatures below 18 °C, depths from 0 - 250 meters, and salinities between 29 - 32‰.

Adults: Bottom habitats in the Gulf of Maine and Georges Bank and hard bottom habitats (including artificial reefs) off southern New England and the middle Atlantic south to New Jersey as depicted in Figure 7.4. Generally, the following conditions exist where pollock adults are found: water temperatures below 14 °C, depths from 15 - 365 meters, and salinities between 31 - 34‰.

Spawning Adults: Bottom habitats with a substrate of hard, stony or rocky bottom in the Gulf of Maine and hard bottom habitats (including artificial reefs) off southern New England and the middle Atlantic south to New Jersey as depicted in Figure 7.4. Generally, the following conditions exist where pollock adults are found: water temperatures below 8 °C, depths from 15 - 365 meters, and salinities between 32 - 32.8‰. Pollock are most often observed spawning during the months September to April with peaks from December to February.

Winter flounder (*Pleuronectes americanus*)
Excerpt from NEFMC EFH Amendment 1998

In its *Report to Congress: Status of the Fisheries of the United States* (September 1997), NMFS determined the Gulf of Maine and Southern New England stocks of winter flounder are currently overfished. This determination is based on the fishing mortality rate. There is not enough information to determine if the Georges Bank stock is overfished or approaching an overfished condition. Essential Fish Habitat for winter flounder is described as those areas of the coastal and offshore waters (out to the offshore U.S. boundary of the exclusive economic zone) that are designated on Figures 15.1 - 15.4 and in the accompanying table and meet the following conditions:

Eggs: Bottom habitats with a substrate of sand, muddy sand, mud, and gravel on Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.1. Generally, the following conditions exist where winter flounder eggs are found: water temperatures less than 10 °C, salinities between 10 - 30‰, and water depths less than 5 meters. On Georges Bank, winter flounder eggs are generally found in water less than 8 °C and less than 90 meters deep. Winter flounder eggs are often observed from February to June with a peak in April on Georges Bank.

Larvae: Pelagic and bottom waters of Georges Bank, the inshore areas of the Gulf of Maine, southern New England, and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.2. Generally, the following conditions exist where winter flounder larvae are found: sea surface temperatures less than 15 °C, salinities between 4 - 30‰, and water depths less than 6 meters. On Georges Bank, winter flounder larvae are generally found in water less than 8 °C and less than 90 meters deep. Winter flounder larvae are often observed from March to July with peaks in April and May on Georges Bank.

Juveniles: *Young-of-the-Year*: Bottom habitats with a substrate of mud or fine grained sand on Georges Bank, the inshore areas of the Gulf of Maine, southern New England and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.3. Generally, the following conditions exist where winter flounder young-of-the-year are found: water temperatures below 28 °C, depths from 0.1 - 10 meters, and salinities between 5 - 33‰. *Age 1+ Juveniles*: Bottom habitats with a substrate of mud or fine grained sand on Georges Bank, the inshore areas of the Gulf of Maine, southern New England and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.3. Generally, the following conditions exist where juvenile winter flounder are found: water temperatures below 25 °C, depths from 1 - 50 meters, and salinities between 10 - 30‰.

Adults: Bottom habitats including estuaries with a substrate of mud, sand, and gravel on Georges Bank, the inshore areas of the Gulf of Maine, southern New England and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.4. Generally, the following conditions exist where winter flounder adults are found: water temperatures below 25 °C, depths from 1 - 100 meters, and salinities between 15 - 33‰.

Spawning Adults: Bottom habitats including estuaries with a substrate of sand, muddy sand, mud, and gravel on Georges Bank, the inshore areas of the Gulf of Maine, southern New England and the middle Atlantic south to the Delaware Bay as depicted in Figure 15.4. Generally, the following conditions exist where winter flounder adults are found: water temperatures below 15 °C, depths less than 6 meters, except on Georges Bank where they spawn as deep as 80 meters, and salinities between 5.5 - 36‰. Winter flounder are most often observed spawning during the months February - June.

Windowpane flounder (*Scophthalmus aquosus*)
Excerpt from NEFMC EFH Amendment 1998

In its *Report to Congress: Status of the Fisheries of the United States* (September 1997), NMFS determined windowpane flounder is currently overfished. This determination is based on an assessment of stock level. Essential Fish Habitat for windowpane flounder is described as those areas of the coastal and offshore waters (out to the offshore U.S. boundary of the exclusive economic zone) that are designated on Figures 14.1 - 14.4 and in the accompanying table and meet the following conditions:

Eggs: Surface waters around the perimeter of the Gulf of Maine, on Georges Bank, southern New England, and the middle Atlantic south to Cape Hatteras as depicted in Figure 14.1. Generally, the following conditions exist where windowpane flounder eggs are found: sea surface temperatures less than 20 °C and water depths less than 70 meters. Windowpane flounder eggs are often observed from February to November with peaks in May and October in the middle Atlantic and July - August on Georges Bank.

Larvae: Pelagic waters around the perimeter of the Gulf of Maine, on Georges Bank, southern New England, and the middle Atlantic south to Cape Hatteras as depicted in Figure 14.2. Generally, the following conditions exist where windowpane flounder larvae are found: sea surface temperatures less than 20 °C and water depths less than 70 meters. Windowpane flounder larvae are often observed from February to November with peaks in May and October in the middle Atlantic and July through August on Georges Bank.

Juveniles: Bottom habitats with a substrate of mud or fine-grained sand around the perimeter of the Gulf of Maine, on Georges Bank, southern New England and the middle Atlantic south to Cape Hatteras as depicted in Figure 14.3. Generally, the following conditions exist where windowpane flounder juveniles are found: water temperatures below 25 °C, depths from 1 - 100 meters, and salinities between 5.5 - 36‰.

Adults: Bottom habitats with a substrate of mud or fine-grained sand around the perimeter of the Gulf of Maine, on Georges Bank, southern New England and the middle Atlantic south to the Virginia-North Carolina border as depicted in Figure 14.4. Generally, the following conditions exist where windowpane flounder adults are found: water temperatures below 26.8 °C, depths from 1 - 75 meters, and salinities between 5.5 - 36‰.

Spawning Adults: Bottom habitats with a substrate of mud or fine-grained sand in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to the Virginia-North Carolina border as depicted in Figure 14.4. Generally, the following conditions exist where windowpane flounder adults are found: water temperatures below 21 °C, depths from 1 - 75 meters, and salinities between 5.5 - 36‰. Windowpane flounder are most often observed spawning during the months February - December with a peak in May in the middle Atlantic.

Bluefish (*Pomatomus saltatrix*)
Excerpt from NOAA Technical Memorandum NMFS-NE-144

EGGS: Eggs from the MAB are pelagic and spherical with a diameter of 0.95-1.00 mm. They have a smooth, transparent shell and a homogeneous yolk. The single oil globule is 0.26-0.29 mm in diameter and the perivitelline space is narrow (Fahay 1983). Incubation times depend on temperature. At 18.0-22.2oC, hatching occurs after 46- 48 h (Deuel et al. 1966). Eggs from the South Atlantic Bight (SAB) have not been described.

LARVAE AND PELAGIC-JUVENILES: Larvae are 2.0-2.4 mm long when they hatch; the eyes are unpigmented and the mouth parts are undeveloped. Characteristic pigment includes parallel lines of melanophores along the dorsal fin base, body midline, and anal fin base. Teeth are well developed at 4.3 mm and fin rays are complete at a size of about 13-14 mm (Fahay 1983). Larvae rarely occur deeper in the water column than 15 m; most are concentrated at a depth of about 4 m during the day, but they are about equally distributed between that depth and the surface at night (Kendall and Naplin 1981). The bluefish transforms from a larva to a "pelagic-juvenile" stage that is specially adapted for an oceanic, near-surface existence after completion of fin ray development (Figure 2). This specialized stage is characterized by a silvery, laterally compressed body, with dark blue counter-coloration on the dorsum. This transition occurs at an age of 18-25 d and at a size of 10- 12 mm SL (Hare and Cowen 1994). Scales begin to form at about 12 mm on the posterior part of the lateral line region, then proceed forward, until the head is completely scaled at about 37 mm (Silverman 1975). Swimming ability in many fish species dramatically improves during this transformation (e.g. Hunter 1981; Stobutzki and Bellwood 1994; Leis et al. 1996) and this improvement presumably applies to bluefish as well. It is during this stage that bluefish arrive at nursery areas in the central part of the MAB, after advection via the Gulf Stream from spawning areas in the SAB and after crossing the Slope Sea (Hare and Cowen 1996; Hare et al., in prep.) and the continental shelf (Cowen et al. 1993). This transport (active or passive) is crucial to the recruitment of these progeny to vital estuarine nursery areas, and therefore this life history stage might be considered a critical bottleneck.

JUVENILES (INCLUDING YOUNG-OFTHE- YEAR): Juveniles have a usual fish shape without unusual features. The caudal fin is forked and the body is somewhat laterally compressed, with a silvery, unpatterned color. The mouth is large and oblique and all fin spines are strong. Two distinct dorsal fins touch at their bases; the second dorsal fin is about the same length as the anal fin base (Able and Fahay 1998). The springspawned cohort is 60-76 d old with a mean size of 60 mm when they recruit to estuarine habitats in the MAB in late May to mid-June (McBride and Conover 1991; Cowen et al. 1993). The summer-spawned cohort either remains in coastal nursery areas (Kendall and Walford 1979; Able and Fahay 1998) or enters estuarine nurseries in mid- to late August when they are 33-47 d old with a mean length of 46 mm (McBride and Conover 1991). Juveniles of both cohorts depart MAB estuaries and coastal areas in October and migrate to waters south of Cape Hatteras, North Carolina. At this time, members of both cohorts range from 4 to 24 cm long (Able and Fahay 1998). During most years, the spring-spawned cohort dominates in the emigrating young-of-the-year.

ADULTS: Adult bluefish are blue-green above, silvery below, moderately stout-bodied, and armed with stout teeth along both jaws. The snout is pointed and the mouth is large and oblique. The caudal fin is large and forked. The fin ray formulae are first dorsal: 7-9 spines; second dorsal: 1 spine and 23-26 rays; anal: 2-3 spines and 25-28 rays. Vertebrae number 26. The maximum length is about 115 cm and maximum weights are 4.5-6.8 kg, although an occasional heavier fish has been taken. The maximum age is 12 years. The sex ratio is 1:1 for all age groups (Boreman 1982), although Lassiter (1962) reported a ratio of two females per male in North Carolina and Hamer (1959) found a ratio of three females to two males in New Jersey.

REPRODUCTION: A seminal study, based largely on the distribution of eggs and larvae, concluded that there were two discrete spawning events in western Atlantic bluefish. The first occurs during March-May near the edge of the continental shelf of the SAB. The second occurs between June and August in the MAB (Kendall and Walford 1979). Recent studies have re-examined this conclusion and refined our knowledge of a complex reproductive pattern, and support the concept of a single, migratory spawning stock (Hare and Cowen 1993; Smith et al. 1994). Sexual maturity and gonad ripening occur in early spring off Florida, early summer off North Carolina, and late summer off New York (Hare and Cowen 1993). In the New York Bight, gonadosomatic studies indicate that both sexes are ripe or ripening between June and September with a strong peak in July (Chiarella and Conover 1990). Larvae re-occur in the SAB in the fall (Collins and Stender 1987) and there are also indications that gonads reach a second peak in ripeness in fishes off Florida in September. Most bluefish are mature by age 2 (Deuel 1964). It is not known whether individuals spawn serially or what the contributions of individuals are to observed spawning patterns of the population. In South Africa, individuals may spawn repeatedly over a period of 5-6 months (Van der Elst 1976), but there is no comparable information for the U.S. population.

Summer Flounder (*Paralichthys dentatus*)
Excerpt from NOAA Technical Memorandum NMFS-NE-151

EGGS: Eggs of summer flounder are pelagic and buoyant. They are spherical with a transparent, rigid shell; yolk occupies about 95% of the egg volume. Mean diameter of mature unfertilized eggs is 0.98 mm. Eggs are most abundant between Cape Cod/Long Island and Cape Hatteras (Figures 14 and 15); the heaviest concentrations have been reported within 45 km of shore off New Jersey and New York during 1965-1966 (Smith 1973), and from New York to Massachusetts during 1980-1986 (Able et al. 1990). Able et al. (1990) discovered that the highest frequency of occurrence and greatest abundances of eggs in the northwest Atlantic occurs in October and November (Figure 15), although, due to limited sampling in December south of New England, December could be under represented. Festa (1974) also notes an October-November spawning period off New Jersey. Keller et al. (1999) found eggs (maximum density 19.5/100 m3) from February to June in Narragansett Bay during a December 1989 to November 1990 sampling period. In southern areas, eggs have been collected as late as January-May (Figure 14; Smith 1973; Able et al. 1990). The eggs have been collected mostly at depths of 30-70 m in the fall, as far down as 110 m in the winter, and from 10-30 m in the spring (Figure 16).

LARVAE: Planktonic larvae (2-13 mm) are often most abundant 19-83 km from shore at depths of around 10-70 m, and are found in the northern part of the Middle Atlantic Bight from September to February, and in the southern part from November to May, with peak abundances occurring in November (Smith 1973; Able et al. 1990; Figures 17, 18, 19). The smallest larvae (< 6 mm) were most abundant in the Mid-Atlantic Bight from October-December, while the largest larvae (³ 11 mm) were abundant November-May with peaks in November-December and March-May (Able et al. 1990). Off eastern Long Island and Georges Bank, the earliest spawning and subsequent larval development occurs as early as September (Able and Kaiser 1994). By October, the larvae are primarily found on the inner continental shelf between Chesapeake Bay and Georges Bank. During November and December they are evenly distributed over both the inner and outer portions of the shelf. By January and February the remaining larvae are primarily found on the middle and outer portions of the shelf. By April, the remaining larvae are concentrated off North Carolina (Able and Kaiser 1994).

From October to May larvae and postlarvae migrate inshore, entering coastal and estuarine nursery areas to complete transformation (Table 1; Merriman and Sclar 1952; Olney 1983; Olney and Boehlert 1988; Able et al. 1990; Szedlmayer et al. 1992). Larval to juvenile metamorphosis, which involves the migration of the right eye across the top of the head, occurs over the approximate range of 8-18 mm SL (Burke et al. 1991; Keefe and Able 1993; Able and Kaiser 1994; Figure 20). They then leave the water column and settle to the bottom where they begin to bury in the sediment and complete development to the juvenile stage, although they may not exhibit complete burial behavior until mid-late metamorphosis when eye migration is complete, often at sizes as large as 27 mm SL (Keefe and Able 1993, 1994). However, burying behavior of metamorphic summer flounder is also significantly affected by substrate type, water temperature, time of day, tide, salinity, and presence and types of predators and prey (Keefe and Able 1994). Keller et al. (1999) found larvae (maximum density 1.4/100 m3) from September to December in Narragansett Bay during a December 1989 to November 1990 sampling period. Able et al.

(1990) and Keefe and Able (1993) discovered that some transforming larvae (10-16 mm) entered New Jersey estuaries primarily during October- December, with continued ingress through April; Allen et al. (1978) collected larvae (12-15 mm) in February and April in Hereford Inlet near Cape May. Dovel (1981) recorded 9 larvae in the lower Hudson River estuary, New York in 1972. In North Carolina, the highest densities of larvae are found in Oregon Inlet in April, while farther south in Ocracoke Inlet, the highest densities occur in February (Hettler and Barker 1993). J.P. Monaghan, Jr. (North Carolina Dept. of Nat. Res. and Commer. Dev., Morehead City, NC, personal communication) mentions that for the years 1986-1988, peak immigration periods of larvae through Beaufort Inlet and into North Carolina estuaries were from late February through March. In the Cape Fear River Estuary, North Carolina, it has been reported that postlarvae first enter the marshes in March and April and are 9-16 mm SL during peak recruitment (Weinstein 1979; Weinstein et al. 1980b). Schwartz et al. (1979a, b) also notes that age 0 flounder appear in the Cape Fear River between March and May, depending on the year. Warlen and Burke (1990) found larvae (mean 13.1 mm SL) in the Newport River estuary just inside Beaufort Inlet from February-April, 1986, with peak abundance in early March. Powell and Robbins (1998) reported larval summer flounder adjacent to live-bottom habitats (rock outcroppings containing rich invertebrate communities and many species of tropical and subtropical fishes) in Onslow Bay (near Cape Lookout) in November (at stations of 17-22 m depth), February (28-30 m depth), and May (14-16 m and 17-22 m depth). Burke et al. (1998) conducted night-time sampling for transforming larvae and juveniles in Onslow Bay, Beaufort Inlet, and the Newport River estuary in February- March 1995. Although flounders were captured both in Onslow Bay and in the surf zone during the immigration period, densities were low and all were transforming larvae (7-15 mm SL). After the immigration period, flounders were absent, as juveniles were not caught. Within the Newport River estuary, flounders were locally very abundant as compared to within Onslow Bay and initial settlement was concentrated in the intertidal zone. During February most were transforming larvae, in March some were completely settled juveniles (11-21 mm SL). In South Carolina, Burns (1974) captured summer flounder larvae (14.9-17.5 mm) in New Bridge Creek, North Inlet estuary in February-March, while Bearden and Farmer (1972) recorded larvae and postlarvae in Port Royal Sound estuary from January-March. During 1986-1988, Wenner et al. (1990a) found that ingress of recently transformed larval and juvenile summer flounder (10-20 mm TL) into Charleston Harbor, South Carolina estuarine marsh creeks began in January and continued through April (Figure 21). Larvae and postlarvae were also found during this period in the Chainey Creek area (Wenner et al. 1986).

JUVENILES: As stated above, juveniles are distributed inshore (e.g., Figure 22) and in many estuaries throughout the range of the species during spring, summer, and fall (Table 1; Deubler 1958; Pearcy and Richards 1962; Poole 1966; Miller and Jorgenson 1969; Powell and Schwartz 1977; Fogarty 1981; Rountree and Able 1992a, b, 1997; Able and Kaiser 1994; Walsh et al. 1999). During the colder months in the north there is some movement to deeper waters offshore with the adults (Figure 3; Figure 23), although many juvenile summer flounder will remain inshore through the winter months while some juveniles in southern waters may generally overwinter in bays and sounds (Smith and Daiber 1977; Wilk et al. 1977; Able and Kaiser 1994). In estuaries north of Chesapeake Bay, some juveniles remain in their estuarine habitat for about 10 to 12 months before migrating offshore their second fall and winter; in North Carolina sounds, they often remain for 18 to 20 months (Powell and Schwartz 1977). The offshore juveniles return to the coast and bays in the spring and generally stay the entire summer. Fogarty (1981) examined the distribution patterns of prerecruit (£ 30.5 cm) summer flounder caught during the 1968-1979 spring surveys and found a striking absence of small fish in northern areas. Both spring and autumn bottom trawl survey data indicated that the concentration of young-of-year summer flounder was south of 39o latitude. The importance of the Chesapeake Bight to this species is demonstrated by the fact that almost all of the young-of-year caught during those spring surveys were from this area. In Mid-Atlantic estuaries, first year summer flounder can grow rapidly and attain lengths of up to at least 30.0 cm (Poole 1961; Almeida et al. 1992; Szedlmayer et al. 1992). Young-of-the-year summer flounder in New Jersey marsh creeks have average growth rates of 1.3-1.9 mm/d, and increase from about 16.0 cm TL at first appearance in late July to around 26.0 cm by September (Rountree and Able 1992b; Szedlmayer et al. 1992). First year fish from Pamlico Sound, North Carolina obtained mean lengths of 16.7 cm for males and 17.1 cm for females (Powell 1982). In Charleston Harbor and other South Carolina estuaries from 1986-1988, Wenner et al. (1990a) found transforming larvae were recruited into the estuarine creeks when 1-2 cm TL. Growth accelerated in May and June when they reached modal sizes of 8 and 14 cm TL, respectively. By September, modal size was 16 cm TL and reached from 23- 25 cm TL through October and November. Modal lengths of yearlings ranged from 23-25 cm in January through June and generally reached 28 cm by October. In Georgia, lab studies by Reichert and van der Veer (1991) found that juveniles from Duplin River of 28-46 mm SL had a maximum growth rate of about 1.3-1.4 mm/d at laboratory temperatures of 23.7-24.8°C. Juvenile summer flounder make use of several different estuarine habitats. Estuarine marsh creeks are important as nursery habitat, as has been shown in New Jersey (Rountree and Able 1992b, 1997; Szedlmayer et al. 1992; Szedlmayer and Able 1993), Delaware (Malloy and Targett 1991), Virginia (Wyanski 1990), North Carolina (Burke et al. 1991) and South Carolina (Bozeman and Dean 1980; McGovern and Wenner 1990; Wenner et al. 1990a, b). Other portions of the estuary that are used include seagrass beds, mud flats and open bay areas (Lascara 1981; Wyanski 1990; Szedlmayer et al. 1992; Walsh et al. 1999). Patterns of estuarine use by the juveniles can vary with latitude. In New Jersey, nursery habitat includes estuaries and marsh creeks from Sandy Hook to Delaware Bay (Allen et al. 1978; Rountree and Able 1992a, b, 1997; Szedlmayer et al. 1992; Szedlmayer and Able 1993; B.L. Freeman, New Jersey Dept. of Environ. Prot., Trenton, NJ, personal communication). The juveniles often make extensive use of creek mouths (Szedlmayer et al. 1992; Szedlmayer and Able 1993; Rountree and Able 1997). In the Hudson-Raritan estuary, New York and New Jersey, 1992-1997 surveys show the juveniles to be present in small numbers throughout the estuary in all seasons, with slightly higher numbers seen in the spring (Figure 24). In Great Bay, young-of-the-year stay for most of the summer, leaving as early as August and continuing until November-December (Able et al. 1990; Rountree and Able 1992a; Szedlmayer and Able 1992; Szedlmayer et al. 1992). As stated previously, Allen et al. (1978) collected both adult and juvenile summer flounder (200-400 mm) in Hereford Inlet near Cape May where they occurred in all of the major waterways, but were more abundant in the upper embayment from May to July and in the lower embayment from August to October. Most were caught on the channel slopes. Smith and Daiber (1977) report that in Delaware Bay, most summer flounder were collected May through September but a few juveniles have been caught in the deeper parts of the Bay in every winter month. The Delaware Bay Coastal Finfish Assessment Survey for 1996 found juveniles throughout their April to October sampling period (Michels 1997). In Maryland, J.F. Casey (Maryland Dept. of Nat. Res., Ocean City, MD, personal communication) indicated that although the coastal bays are excellent habitat for both adults and juveniles (Schwartz 1961), in areas of significant pollution, a lack of proper food sources precludes the presence of summer flounder. Other areas which lack sufficient water circulation also appear to have considerably reduced populations. Shore-side development and resultant runoff also appear to have reduced some local populations (Casey, personal communication). Since the 1970's, Maryland has been conducting trawl and seine surveys around Ocean City inlet. Casey (personal communication) reported sharp declines in young-of-the-year flounder in the coastal bay trawl samples. The majority of the summer flounder taken in this sampling were between 76 and 102 mm, with larger fish basically absent. Summer flounder were also sometimes found in Maryland's portion of the Chesapeake Bay with the majority of these fish in the 200- 300 mm range.

In Virginia, Musick (personal communication) states that the most important nursery areas for summer flounder appear to be in the lagoon system behind the barrier islands on the seaside of the Eastern Shore (Schwartz 1961), and the shoal water flat areas of higher salinity (> 18 ppt) in lower Chesapeake Bay. Young-of-the-year enter these nursery areas in early spring (March and April) and remain there until fall when water temperatures drop. Then these yearlings move into the deeper channel areas and down to the lower Bay and coastal areas. In most winters these age 1+ fish migrate out in the ocean but in warmer winters some may remain in deep water in lower Chesapeake Bay (Musick, personal communication). However, the Virginia Institute of Marine Science juvenile finfish survey for 1995 shows juvenile (as well as some adult) flounder occurring throughout most of the main stem of Chesapeake Bay and the major Virginia tributaries (Rappahannock, York, and James Rivers) over most of the year (Geer and Austin 1996; Figure 25; see also Wagner and Austin 1999). Lower numbers occurred from December-March (Figure 26). Wyanski (1990) found recruitment to occur from November to April on both sides of Virginia's Eastern Shore and from February to April on the western side of Chesapeake Bay. Peak recruitment occurred in November-December on the Eastern Shore, compared to March-April on the western side of the Bay. Wyanski (1990) and Norcross and Wyanski (1988) also found that young-of-the-year occur in a variety of habitats, including shallow, mud bottomed marsh creeks, shallow sand substrates (including seagrass beds), deep sand substrate, and deep fine-sand substrates. Tagged summer flounder have been recaptured from inshore areas to the northeast of their release sites in subsequent summers, leading to the hypothesis that their major nursery areas are the inshore waters of Virginia and North Carolina, and as they grow older and larger, they would return inshore to areas farther north and east of these nursery grounds (Poole 1966; Murawski 1970; Lux and Nichy 1981). However, tagging studies by Desfosse (1995) indicate that it is not the older and larger fish, but rather the smaller fish (length at tagging) which return to inshore areas north of Virginia. Summer flounder that were recaptured north of their release site in subsequent years were smaller (length at tagging) than those recaptured at their release sites, or to the south, in later years. Desfosse (1995) suggests that while Virginia waters do indeed form part of the nursery grounds for fish which move north in subsequent years, they are primarily a nursery area for fish which will return to these same waters as they grow older and larger. The estuarine waters of North Carolina, particularly those west and northwest of Cape Hatteras (Monaghan 1996) and in high salinity bays and tidal creeks of Core Sound (Noble and Monroe 1991), provide substantial habitat and serve as significant nursery areas for juvenile Mid-Atlantic Bight summer flounder. Powell and Schwartz (1977) found that juvenile summer flounder were most abundant in the relatively high salinities of the eastern and central parts of Pamlico Sound, all of Croatan Sound (Figure 13), and around inlets. Young-of-the-year disappeared from the catch during late summer, suggesting that the fish are leaving the estuaries at that time (Powell and Schwartz 1977). Upon leaving the estuaries, the juveniles enter the north-south, inshore-offshore migration of Mid-Atlantic Bight summer flounder (Monaghan 1996). Although North Carolina also provides habitat for summer flounder from the South Atlantic Bight, these fish do not exhibit the same inshore-offshore and north-south migration patterns as do Mid-Atlantic Bight fish (Monaghan 1996). Summer flounder > 30 cm are rarely found in the estuaries of North Carolina, although larger fish are found around inlets and along coastal beaches. Powell and Schwartz (1977) also noted that juvenile summer flounder were most abundant in areas with a predominantly sandy or sand/shell substrate, or where there was a transition from fine sand to silt and clay. Surveys by Hoffman (1991) in marsh creeks in Charleston Harbor, South Carolina showed that recently settled summer flounder were abundant over a wide variety of substrates including mud, sand, shell hash, and oyster bars.

ADULTS: Adult flounder normally inhabit shallow coastal and estuarine waters during the warmer months of the year and remain offshore during the colder months on the outer continental shelf at depths down to 150 m (Figure 4; Bigelow and Schroeder 1953; Grosslein and Azarovitz 1982). Some evidence suggests that older adults may remain offshore all year (Festa 1977). However, due to overfishing, most of the adults are £ 3 years of age and they return to the inner continental shelf and estuaries during the summer [Able and Kaiser 1994; Terceiro 1995; Northeast Fisheries Science Center 1997; in addition, Desfosse's (1995) study in Virginia waters notes that the majority of fish sampled from 1987-1989 were from 0-3 years of age, and over 90% of the summer flounder survey catch in Delaware Bay for 1996 was also less than age 3 (Michels 1997)]. The southern population may undertake less extensive offshore migrations (Fogarty et al. 1983). Tagging studies indicate that fish which spend their summer in a particular bay tend largely to return to the same bay in the subsequent year or to move to the north and east (Westman and Neville 1946; Hamer and Lux 1962; Poole 1962; Murawski 1970; Lux and Nichy 1981; Monaghan 1992; Desfosse 1995). For example, tagging studies indicate that the majority of summer flounder from inshore New Jersey return to inshore New Jersey the following year. This homing is also evident in summer flounder which return to New York waters, with some movement to waters off Connecticut, Rhode Island and Massachusetts (Poole 1962). Once inshore during the summer months, there appears to be very little movement of inshore fish to offshore waters (Westman and Neville 1946; Poole 1962; Desfosse 1995). Tagging studies conducted by Poole (1962) and Lux and Nichy (1981) on flounder released off Long Island and southern New England revealed that fish usually began seaward migrations in September or October. Their wintering grounds are located primarily between Norfolk and Veatch Canyons east of Virginia and Rhode Island, respectively, although they are known to migrate as far northeastward as Georges Bank. Fish that move as far north as the wintering grounds north of Hudson Canyon may become rather permanent residents of the northern segment of the Mid-Atlantic Bight (Lux and Nichy 1981). New York and New Jersey fish may move farther south in the winter months and generally may not move as far north in the summer as New England flounder (Poole 1962). The presence, distribution, and abundance of the adults nearshore and in the estuaries has been documented by both fishery dependent and independent data and each States' flounder experts (Table 1). For example, summer flounder in Massachusetts migrate inshore in early May and occur along the entire shoal area south of Cape Cod and Buzzards Bay, Vineyard Sound, Nantucket Sound, and the coastal waters around Martha's Vineyard (Figure 5; Howe et al. 1997). They also occur in the shoal waters in Cape Cod Bay (A.B. Howe, Massachusetts Div. of Mar. Fish., Sandwich, MA, personal communication). In some years summer flounder are found along the eastern side of Cape Cod and as far north as Provincetown by early May. The Massachusetts Division of Marine Fisheries considers the shoal waters of Cape Cod Bay and the region east and south of Cape Cod, including all estuaries, bays and harbors thereof, as critically important habitat (Howe, personal communication). Summer flounder begin moving offshore in late September and October and Howe (personal communication) believes that spawning occurs within territorial waters south of Cape Cod because occasional ripe and running fish have been taken there. Summer flounder are regularly taken in southern Massachusetts waters as late as December, presumably as fish are dispersing to offshore wintering grounds, which, in most years are well out on the continental shelf from approximately Veatch Canyon to Baltimore Canyon. T.R. Lynch (Rhode Island Dept. of Environ. Mgmt., Wickford, RI, personal communication) states that the coastal waters of Rhode Island, the immediate waters surrounding Block Island, and the waters of Little Narragansett Bay and all of Narragansett Bay are habitat for both adults and juveniles. Based on collections from the 1990-1996 Rhode Island Narragansett Bay survey, adults were distributed throughout the Bay and captured in all seasons except winter and most were caught in summer and autumn (Figure 6). The length frequencies show that similar sizes were captured in each season and lengths ranged from about 25-71 cm with most occurring from 30-50 cm (Figure 7). Abundance in relation to bottom depth shows a preference for depths greater than 12.2-15.2 m (40-50 ft) and that few were captured in depths less than 9.1 m (30 ft) (Figure 8). In Connecticut, E. Smith (Connecticut Dept. of Environ. Prot., Hartford, CT, personal communication) states that the flounder migrate to inshore waters in late April and early May, and are present in Long Island Sound throughout the April-November trawl survey period, and probably occur in limited numbers in winter as well (Figure 9 -- these figures include juveniles and adults, see Figure 10). August through October are often the months of highest relative abundance (Simpson et al. 1990a, b, 1991; Gottschall et al., in review). Although they occur on all bottom types, their abundance does vary by area and depth (Gottschall et al., in review). In April, abundance is similar at all depths, but from May through August abundance is highest in shallow water, especially in depths less than 9 m along the Connecticut shore from New Haven to Niantic Bay, and near Mattituck, New York (Figure 9; Gottschall et al., in review). In September, when abundance peaks, summer flounder are again distributed in all depths throughout the sound. After September, their abundance decreases, and the remaining fish are more common in deeper water. Abundance is highest in depths between 18- 27 m in October and depths > 27 m in November (Gottschall et al., in review). Abundance indices within the Sound are generally highest in the central Sound (Connecticut to Housatonic Rivers) and lowest west of the Housatonic River (Simpson et al. 1990a, b, 1991). Salinity range appears to be at least 15 ppt and greater. The trawl survey usually takes 400-700 fish in 320 tows per year. In 1989, only 47 fish were taken (D.G. Simpson, Connecticut Dept. of Environ. Prot., Waterford, CT, personal communication). From the Marine Angler Survey, about two-thirds of the sport flounder catch is from east of the Connecticut River, while the trawl survey catches indicate that the greater New Haven area is also important. In the Hudson-Raritan estuary, New York and New Jersey, summer flounder was the 13th most abundant species in the Wilk et al. (1977) survey and it occurred in 21% of all trawls and had a mean annual density in the Lower Bay complex of 1.2/15 min tow (see also reviews by Gaertner 1976 and Berg and Levinton 1985). The 1992-1997 Hudson-Raritan surveys show the adults to be present in moderate numbers throughout the estuary in all seasons except winter (Figure 11). In the fall, they tend to be found in greater numbers in the deeper waters of the Raritan Channel (Figure 11). In the spring, the greatest numbers occurred in Sandy Hook Bay. The greatest densities of summer flounder adults occurred in the summer, particularly in the deeper Raritan and Chapel Hill channels and Raritan and Sandy Hook Bays. This species was not reported in any trawls in the Arthur Kill-Hackensack River estuary. However, it has been collected in Newark Bay from April- October (Wilk et al. 1997; Figure 12). Great South Bay, on the south shore of Long Island, supports an important recreational fishery, particularly around Fire Island inlet (Neville et al. 1939; Schreiber 1973). Tagging studies by Murawski (1970) provided recaptured summer flounder from the entire New Jersey coastline. Summer flounder overwinter offshore of New Jersey in 30-183 m of water. Allen et al. (1978) collected both adult and juvenile summer flounder in Hereford Inlet near Cape May. They occurred in all of the major waterways, but were more abundant in the upper embayment from May to July and in the lower embayment from August to October. The majority were 200-400 mm and were caught on the slopes of the channels. In Barnegat Bay, an ichthyofauna survey by Vouglitois (1983) from 1976-1980 found a wide range of sizes of summer flounder, but in low numbers. This study was conducted along the western shoreline of the Bay, where muddy sediments predominate, and Vouglitois (1983) suggests that the scarcity of summer flounder is due to their apparent preference for sandy substrates. A hard sandy bottom does predominate in the eastern portion of the Bay and this is where most summer flounder have been caught. Delaware Bay is an important nursery and summering area for adults as well as a nursery area for juveniles (R. Smith, Delaware Dept. of Nat. Res. and Environ. Control, Dover, DE, personal communication). They are abundant in the lower and middle portions of the estuary, and rare in the upper estuary (Ichthyological Associates, Inc. 1980; Seagraves 1981; Weisberg et al. 1996; Michels 1997). Smith and Daiber (1977) caught adults from the shoreline to a maximum depth of 25 m, mostly from May through September, while R. Smith (personal communication) states that adults have been captured in Delaware Bay during all months of the year, but appear to be most common from April to November. The Delaware Bay Coastal Finfish Assessment Survey for 1996 found adults throughout the April to December sampling period, with the highest catch rate in April and greatest occurrences at mid-bay stations (Michels 1997). Delaware's coastal bays are also used by summer flounder as nursery and summering areas [e.g., Indian River and Rehobeth Bays (Michels 1997)]. In Virginia adult flounder use the Eastern Shore seaside lagoons and inlets and the lower Chesapeake Bay as summer feeding areas (Schwartz 1961; J.A. Musick, Virginia Inst. Mar. Sci., Gloucester Point, VA, personal communication). These fish usually concentrate in shallow warm water at the upper reaches of the channels and larger tidal creeks on the Eastern Shore in April, then move toward the inlets as spring and summer progress. They are most abundant in the ocean near inlets by July and August. Tagging studies by Desfosse (1995) revealed that fall migration begins out of Chesapeake Bay in October and is completed by December where most recaptures of fish were from the nearshore fishery from Cape Henry south to Cape Hatteras. The majority of tagged returns during January through March came from offshore from the Cigar north to Wilmington Canyon, and were concentrated east of Cape Henry from the Cigar to Norfolk Canyon. A second group came from inshore waters near Oregon Inlet, south to Cape Hatteras. Movement inshore started in March or perhaps as early as February, and continued from April till June. Virginia's artificial reefs also provide additional habitat for summer flounder (J. Travelstead, Virginia Mar. Res. Comm., Hampton, VA, personal communication; see also Lucy and Barr 1994). Reef materials include discarded vessels, automobile tires, and fabricated concrete structures. Both adults and juveniles occur in Pamlico Sound and adjacent estuaries (Figure 13), although it appears that juveniles are usually the more abundant, confirming the significant role of these estuaries as a nursery area for this species (Powell and Schwartz 1977). They occur in areas of intermediate or high salinities, often close to inlets, and prefer a sandy or sand/shell substrate (Powell and Schwartz 1977). Several surveys have shown that both adult and juvenile summer flounder occur in small numbers in the waters of South Carolina (e.g., Bearden and Farmer 1972; Hicks 1972; Wenner et al. 1981, 1986; Stender and Martore 1990; Wenner et al. 1990a, b). Artificial reefs also provide habitat for summer flounder off of South Carolina (Parker et al. 1979). Dahlberg (1972) surveyed the North and South Newport Rivers, Sapelo Sound, and the St. Catherines Sound estuarine complex in Georgia. Adult and juvenile summer flounder were most abundant in the lower reaches of the estuaries and were rarely trawled in the middle reaches.

Black Sea Bass (*Centropristis striata*)
Excerpt from NOAA Technical Memorandum NMFS-NE-143

EGGS: The northern population spawns buoyant, pelagic eggs on the continental shelf from spring through fall (Able and Fahay 1998; Reiss and McConaugha 1999). Spawning begins in the spring in the southern part of their range (North Carolina and Virginia) and progresses north into southern New England waters from summer through fall. In the Middle Atlantic Bight, the incubation period of the eggs is five days (approximately 120 hrs) at 15oC (Kendall 1972). Able and Fahay (1998) give an incubation period of 35-75 hrs depending on water temperature. Little else is known of this stage.

LARVAE: Larvae are 1.5-2.1 mm SL at hatching (Fahay 1983). The duration of the pelagic larval stage is unknown. Tucker (1989) reported that larval black sea bass can grow for two days before their yolk is exhausted and will die within three days thereafter if they can not acquire enough planktonic food. Cowen et al. (1993) classified black sea bass larvae in a New York Bight (bounded by Long Island and New Jersey coasts) mid-summer assemblage, which usually included cusk-eel (Ophidion sp.). Larvae settle and become demersal in coastal areas at 10-16 mm TL (Able and Fahay 1998). However, Kendall (1972) reported that settlement might be delayed until 25 mm TL. Allen et al. (1978) found 15-17 mm black sea bass larvae (transition to juveniles) in epibenthic sled collections off the oceanic side of the Cape May peninsula (New Jersey) in late July. Larval black sea bass were collected by plankton nets in the surf zone during June-July 1995-1996 off northern New Jersey (D. Clark, U.S. Army Corps Engineers, Vicksburg, MS, personal communication).

JUVENILES (< 19 CM TL): Most juvenile settlement does not occur in estuaries, but in coastal areas. Recently settled juveniles then find their way to estuarine nurseries. Adams (1993) reported a "major settlement" of juvenile black sea bass (< 3.0 cm) in August 1992 near an artificial reef about 15 km off the Virginia- North Carolina border. He did not observe a large settlement in 1991. The fish were observed by diving and occurred singly and in small groups near shelter on the artificial reef or in depressions containing shell fragments in the surrounding sand. The transport mechanism and fish behavior that move these early juveniles into estuaries are unknown (Able and Fahay 1998). Young-of-the-year (YOY) black sea bass enter Middle Atlantic Bight estuaries from July to September (Able et al. 1995b; Able and Hales 1997). This occurs earliest in the south. Kimmel (1973) collected 30-146 mm juveniles in Magothy Bay, Virginia as early as March; they occur later elsewhere in Chesapeake Bay (Chesapeake Bay Program 1996). Richards (1963a, b) did not find them in central Long Island Sound until September and October; this was confirmed by more recent surveys (1992-1997) of the Sound, (Gottschall et al., in review). Older juveniles return to estuaries in late spring and early summer, and may follow the migration routes of adults into coastal waters. Bean (1902) reported that juveniles were "very common" in Great South Bay (New York) and Great Egg Harbor Bay (New Jersey). Sherwood and Edwards (1902) noted that, at that time, black sea bass were decreasing in abundance in Vineyard Sound (Massachusetts). The seasonal recruitment of YOY black sea bass to estuaries is temporally and spatially variable. Juvenile black sea bass were collected in relatively high abundance (1.2-5.5 per tow) from trawls in Raritan Bay (New Jersey) during late summer 1997 (D. McMillan, NMFS, NEFSC, James J. Howard Marine Sciences Laboratory, Highlands, NJ, unpublished data), but they were rarely collected in surveys during the previous five years. Based on trap collections, juvenile black sea bass were a dominant species within and near shoreline pilings in New York Harbor in late summer 1993 (Able et al. 1995b). Black sea bass were rare in the Arthur Kill, a tributary to the Hudson-Raritan estuary (Howells and Brundage 1977) and in Raritan and Sandy Hook Bays (Breder 1922; Wilk et al. 1996). They were not collected in Newark Bay in the early 1990s (Wilk et al. 1997). Black sea bass are rare in Barnegat Bay (New Jersey) (Marcellus 1972; Vouglitois 1983; Tatham et al. 1984). However, Allen et al. (1978) reported that Hereford Estuary (New Jersey), about 60 km south, was an important black sea bass nursery area during several years of monitoring; they also reported significant fluctuations in annual abundance. Juvenile black sea bass grow relatively fast in estuaries during the summer. Schwartz (1961) found 30-37 mm TL juveniles in east shore bays of Virginia as early as April; they grew to 98-182 mm by November. Able and Fahay (1998) noted that YOY grow to 100 mm by the fall. Able and Hales (1997) reported mean growth rates of 0.45 mm/day from spring to fall, with a peak rate 0.74 mm/day in the summer, for age 0+ and 1+ juveniles in coastal southern New Jersey. In a previous study, age 1+ fish grew an average of 0.77 mm/day (Able et al. 1995a). In contrast, Allen et al. (1978) reported that postlarvae (early juveniles) that enter the Hereford Estuary in July at about 18 mm leave at > 40 mm TL in the fall; they also reported that 1 year old fish arrive in this estuary at about 60 mm and leave at about 100 mm TL. Kim (1987) found that juvenile growth in the laboratory was affected by food type, consumption rates, and fish size. Juvenile growth was increased 4-5 times on an enriched artificial diet. Laboratory studies indicated that temporary hypoxic conditions in estuaries in the summer could inhibit the growth of young-of-the-year fish (Hales and Able 1995). Growth of juveniles was clearly evident in otoliths and showed annulus formation in May or June (Dery and Mayo 1988).

ADULTS (³ 19 CM TL): Growth is sexually dimorphic in mature black sea bass; females grow faster but reach a lower maximum size (Lavenda 1949; Mercer 1978; Wilk et al. 1978). Shepherd and Idoine (1993) suggest that the species can have three sex-related growth rates: female, male, and transitional. Males grew faster than females off New York based on otolith annuli analyses of year 1 and older fish (Alexander 1981). Black sea bass from Massachusetts had growth rates almost double those reported for New York and Virginia, but different growth estimators were used (Dery and Mayo 1988; Kolek 1990; Caruso 1995). Fish from the Middle Atlantic Bight were larger at age and grew faster than fish from the South Atlantic Bight (Mercer 1978; Wenner et al. 1986). Growth is linear to about age 6, then slows; the Middle Atlantic Bight population is larger at age than the South Atlantic Bight population (Wenner et al. 1986). During warm months, black sea bass share the coastal habitat with several other species, including tautog (Tautoga onitis), spotted hake (Urophycis regia), red hake (U. chuss), conger eel (Conger oceanicus), ocean pout (Macrozoarces americanus), pinfish (Lagodon rhomboides), northern searobin (Prionotus carolinus), and transients such as gray triggerfish (Balistes capriscus) (Chee 1977; Musick and Mercer 1977; Eklund and Targett 1991). Inshore trawl surveys included butterfish (Peprilus triacanthus), smooth dogfish (Mustelus canis), round herring (Etrumeus teres), and windowpane (Scophthalmus aquosus) in the summer group containing black sea bass (Phoel 1985; Gabriel 1992; Brown et al. 1996). North of Maryland, cunner is a dominant member of the reef ichthyofauna. In estuaries, black sea bass co-occur on oyster shell plantings with summer flounder (Paralichthys dentatus), spot (Leiostomus xanthurus), oyster toadfish (Opsanus tau), and other species (Arve 1960).

REPRODUCTION: Like most of the Serranidae, the black sea bass is a protogynous hermaphrodite; most fish mature as females and change to males with additional growth (Lavenda 1949). In the Middle Atlantic Bight, individuals begin to mature at age 1 (8-17 cm TL) and 50% are mature at about 19 cm SL and 2-3 years of age (O'Brien et al. 1993). The majority of fish in this size group are females (Mercer 1978). The average size of transformation from female to male occurs at 23.9- 33.7 cm TL (Chesapeake Bay Program 1996). In the South Atlantic Bight, Cupka et al. (1973) reported that both sexes mature at smaller sizes (14-18 cm SL). Wenner et al. (1986) and Alexander (1981) found mature fish at about 10-11 cm (age 1+) off South Carolina and New York; a majority of fish were mature at about 19 cm TL and at an age of about 2-3 years. Alexander (1981) reported a decrease in the age and size of sex change since the 1940s with fewer mature males in the New York population; he associated this decrease with increasing fishing pressure. Mercer (1978) reported that 2-5 year old females release between 191,000 and 369,500 eggs. Based on collections of ripe fish and distributions of egg, black sea bass spawn primarily on the inner continental shelf between Chesapeake Bay and Montauk Pt., Long Island at depths of about 20-50 m (Breder 1932; Kendall 1972, 1977; Musick and Mercer 1977; Wilk et al. 1990; Eklund and Targett 1990; Berrien and Sibunka 1999). Spawning has been reported as far north as Buzzards Bay and Nantucket Sound, Massachusetts (Wilson 1891; Sherwood and Edwards 1902; Kolek 1990). Gravid females are not generally found in estuaries (Allen et al. 1978). Larvae have been collected in Cape Cod Bay, but these were probably stragglers swept from Buzzards Bay through the Cape Cod Canal and not the product of local spawning (MAFMC 1996). Spawning in the Middle Atlantic Bight population occurs from May to July (Kendall 1972, 1977; Musick and Mercer 1977; Feigenbaum et al. 1989; Wilk et al. 1990; Eklund and Targett 1990) during inshore migrations, but can extend to October-November (Fahay 1983; Berrien and Sibunka 1999). Larval distributions presented in Able et al. (1995a) suggest spawning occurs earliest off Virginia and North Carolina (in the vicinity of the wintering grounds) and progresses northerly and inshore as inner shelf waters warm. In Massachusetts coastal waters, spawning fish aggregate on sand bottoms broken by ledges; after spawning, the fish disperse to ledges and rocks in deeper water (Kolek 1990; MAFMC 1996). Kolek (1990) reported evidence from tagging studies of homing to spawning grounds. Some tagged adult black sea bass returned to the spawning grounds in northwestern Nantucket Sound where they were tagged. Kolek (1990) also reported this local spawning group spawned earlier and in shallower waters than generally reported by Kendall (1977). The complex social hierarchy of reef fishes, such as black sea bass, during spawning implies that the number of males may be an important factor limiting reproductive potential (Shepherd and Idoine 1993). They noted that theoretical studies suggest that, to the degree that nondominant males participate in spawning, the current relative abundance of males may not be limiting in the black sea bass population. Although nothing is known of the mating of this species, pairing is characteristic of the family (Breder and Rosen 1966).

Atlantic Mackerel (*Scomber scombrus*)
Excerpt from NOAA Technical Memorandum NMFS-NE-141

EGGS: The eggs of Atlantic mackerel are pelagic and spherical, ranging in size from 1.01-1.28 mm (avg. = 1.3 mm) in diameter, and have one oil globule ranging from 0.22-0.38 mm (avg. = 0.29 mm) in diameter (Berrien 1975). Sampling in the Gulf of St. Lawrence indicates that egg size decreased over time and in relation to ambient temperatures (Ware 1977).

LARVAE: Larvae average about 3.1-3.3 mm standard length (SL) at hatching and have a large yolk sac; the eyes are large and unpigmented (Sette 1943; Bigelow and Schroeder 1953; Colton and Marak 1969; Berrien 1975; Ware and Lambert 1985; Scott and Scott 1988). Hatching occurs at 90-120 h post-fertilization at an average temperature of 13.8°C (Berrien 1975). The 50% threshold for the onset of feeding is 3.8 mm (Ware and Lambert 1985). At about 4-6 mm the yolk sac is absorbed by which time there is a considerable change in body pigmentation and by 192 h, teeth are present (Berrien 1975). Larvae undergo major changes in body form and Sette (1943) describes a transition stage between the larval and post-larval stages (~ 9-10 mm) where fins are in various stages of development. This probably enhances successful prey capture as well as predator avoidance (Ware and Lambert 1985). To maintain rapid growth rates, with average digestive times of 1-2 h, Peterson and Ausubel (1984) concluded that the larvae must feed constantly.

JUVENILES: Post-larvae gradually transform from planktonic to swimming and schooling behavior at about 30-50 mm (Sette 1943). Fish reach a length of about 50 mm in approximately two months at which time they closely resemble adults and reach 20 cm in December after about one year of growth (Sette 1943; Bigelow and Schroeder 1953; Anderson and Paciorkowski 1980; Berrien 1982; Collette, in prep.). Kendall and Gordon (1981) show somewhat faster larval and juvenile growth rates based on daily growth increments from otoliths taken from fish collected in the Middle Atlantic Bight; i.e., approximately 70-80 mm in two months; however, these were not verified by comparison with fish of known age. Ware and Lambert (1985) found that in St. Georges Bay, Nova Scotia, at 15-17°C, growth rates of juveniles (> 15 mm) averaged 0.73 mm/d from birth to metamorphosis, similar to the estimates by Kendall and Gordon (1981). Using daily growth rings, D'Amours et al. (1990) estimated that young mackerel from the northern contingent would grow faster earlier in their first growing season which would be consistent with Sette's (1950) conclusions. However, Simard et al. (1992) calculated that growth curves of juvenile Atlantic mackerel, based on otolith samples from the northern and southern spawning groups were not significantly different at least up to 90 days in age.

ADULTS: By the end of their second year, Atlantic mackerel attain a size of about 26 cm and after five years about 33 cm (Anderson 1973; Isakov 1973; Stobo and Hunt 1974). Fish that are 6 years old can reach a length of 39-40 cm. Based on studies of Canadian mackerel, MacKay (1967) theorized that growth is population density dependent; i.e., that abundant year classes grow more slowly than less abundant year classes, although Moores et al. (1975) did not find this to be true for Newfoundland fish. Overholtz (1989) found the 1982 cohort to be one of the slowest growing on record; it is one of the largest recruiting year-classes recorded. Large differences in mackerel growth suggest that year-class size partially influences the initial pattern of growth during a cohort's first years (Overholtz et al. 1991b). Thus, early growth may be related to year-class size, while stock size may be more influential after the juveniles join the offshore adults (Overholtz et al. 1991b; Collette, in prep.). The adults are highly mobile and school. They are obligate swimmers due to the absence of a swim bladder and the necessity for ram gill ventilation to meet blood oxygenation demands (Roberts 1975). Nevertheless this species exhibits diurnal changes in activity, swimming faster during the day than at night (Olla et al. 1975, 1976). Under laboratory conditions, at temperatures ranging from 7.3- 15.8°C (within their preferred range), swimming speed of adults averaged 36 cm/s during the day and 29 cm/s at night (Olla et al. 1975, 1976). The fish continued to school both day and night although there were diurnal changes in cohesiveness of the group.

REPRODUCTION: There is some variation in estimates of size and age at maturity. Based on samples of Atlantic mackerel collected from 1987-1989 by the Northeast Fisheries Science Center (NEFSC) groundfish surveys, median length at maturity (L50) was 25.7 cm for females and 26.0 cm for males; median age (A50) was 1.9 years for both (O'Brien et al. 1993). By age 3, 99% of the females and 97% of the males were mature (O'Brien et al. 1993). Fish collected in Newfoundland waters from June-September 1970-1973 had higher values for L50 of 34 cm and 35 cm for females and males respectively (Moores et al. 1975). MacKay (1967) reported first spawning for mackerel occurred at age 2 and at lengths > 30 cm for fish collected in May-July 1965-1966 from the Gulf of St Lawrence and coastal Nova Scotia and Massachusetts. These differences in median maturity may be due to the slower growth of larger year classes that may delay spawning from one to three years (MacKay 1973; Overholtz 1989). Consequently, both year-class size and adult stock size may be important factors regulating growth in Atlantic mackerel (Overholtz 1989; Overholtz et al. 1991b).

Spawning occurs during spring and summer and progresses from south to north as the surface waters warm and fish migrate (Sette 1943). There are two spawning contingents; a southern group that spawns primarily in the Mid-Atlantic Bight and Gulf of Maine from mid-April to June and a northern contingent that spawns in the southern Gulf of St. Lawrence from the end of May to mid-August (Berrien 1982). The southern contingent begins the spring spawning migration by moving inshore between Delaware Bay and Cape Hatteras, usually between mid-March and mid-April depending to some extent on water temperature (Berrien 1982). The northern contingent begins to move inshore off southern New England usually in late May, mixing temporarily with part of the southern contingent before migrating eastward along the coast of Nova Scotia. Here other mackerel schools from offshore join the fish before moving into the Gulf of St. Lawrence to spawn (Berrien 1982). Small fish (< 30 cm) lag behind larger fish and spawn later (Berrien 1982).

Most of the spawning occurs in the shoreward half of continental shelf waters, although there is some spawning on the shelf edge and beyond (Berrien 1982; Collette, in prep.). Sette (1943) described the area bordered by southern New England and the Middle Atlantic states as the most important spawning grounds for mackerel. Current information indicates that the oceanic bight between Chesapeake Bay and southern New England is the most productive area. The Gulf of St. Lawrence is somewhat less so although the southern side is considered extremely productive for the northern contingent (MacKay 1973) while the Gulf of Maine and coast of outer Nova Scotia are the least (Sette 1950; Collette, in prep.). Some open bays; i.e., Cape Cod Bay and Massachusetts Bay, are sites of some importance with spawning fish abundant or common from May to July and August (Table 1). While according to Wheatland (1956), spawning occurs rarely in Gardiner's Bay and Long Island Sound, recent assessments of relative abundance of eggs and larvae in these areas show that both life stages are highly abundant and abundant in April and May (Table 2). Well-enclosed bays, especially those receiving considerable river inflow such as Chesapeake Bay and Delaware Bay show little evidence of spawning (Table 2).

Atlantic mackerel are serial, or batch spawners, with estimates of total fecundity ranging from 285,000 to 1.98 million eggs for southern contingent mackerel between 31 and 44 cm fork length (FL) (Morse 1980). Based on a very limited sample of northern contingent mackerel, fecundity estimates ranged from 211,000 to 397,000 eggs for 35 and 40 cm females respectively (MacKay 1973). Analysis of egg diameter frequencies indicate that five to seven egg batches are spawned by each female (Morse 1980).

Atlantic salmon (*Salmo salmar*)
Excerpt from NEFMC EFH Amendment 1998

In its Report to Congress: Status of the Fisheries of the United States (September 1997), NMFS determined Atlantic salmon is considered overfished, based upon an assessment of stock level. Essential fish habitat for Atlantic salmon is described as all waters currently or historically accessible to Atlantic salmon within the streams, rivers, lakes, ponds, wetlands, and other water bodies of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut identified as EFH in Figures 10.1 - 10.3 and in the accompanying table and that meet the following conditions:

Eggs: Bottom habitats with a gravel or cobble riffle (redd) above or below a pool of rivers as depicted in Figure 10.1. Generally, the following conditions exist in the egg pits (redds): water temperatures below 10° C, and clean, well-oxygenated fresh water. Atlantic salmon eggs are most frequently observed between October and April.

Larvae: Bottom habitats with a gravel or cobble riffle (redd) above or below a pool of rivers as depicted in Figure 10.1. Generally, the following conditions exist where Atlantic salmon larvae, or alevins/fry, are found: water temperatures below 10° C, and clean, well-oxygenated fresh water. Atlantic salmon alevins/fry are most frequently observed between March and June.

Juveniles: Bottom habitats of shallow gravel / cobble riffles interspersed with deeper riffles and pools in rivers and estuaries as depicted in Figure 10.2. Generally, the following conditions exist where Atlantic salmon parr are found: clean, well-oxygenated fresh water, water temperatures below 25° C, water depths between 10 cm and 61 cm, and water velocities between 30 and 92 cm per second. As they grow, parr transform into smolts. Atlantic salmon smolts require access downstream to make their way to the ocean. Upon entering the sea, "post-smolts" become pelagic and range from Long Island Sound north to the Labrador Sea.

Adults: For adult Atlantic salmon returning to spawn, habitats with resting and holding pools in rivers and estuaries as depicted in Figure 10.3. Returning Atlantic salmon require access to their natal streams and access to the spawning grounds. Generally, the following conditions exist where returning Atlantic salmon adults are found migrating to the spawning grounds: water temperatures below 22.8° C, and dissolved oxygen above 5 ppm. Oceanic adult Atlantic salmon are primarily pelagic and range from the waters of the continental shelf off southern New England north throughout the Gulf of Maine.

Spawning Adults: Bottom habitats with a gravel or cobble riffle (redd) above or below a pool of rivers as depicted in Figure 10.3. Generally, the following conditions exist where spawning Atlantic salmon adults are found: water temperatures below 10° C, water depths between 30 cm and 61 cm, water velocities around 61 cm per second, and clean, well-oxygenated fresh water. Spawning Atlantic salmon adults are most frequently observed during October and November.

Atlantic salmon EFH includes all aquatic habitats in the watersheds of the identified rivers, including all tributaries, to the extent that they are currently or were historically accessible for salmon migration. Atlantic salmon EFH excludes areas upstream of longstanding naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years.