Chapter D2: Evaluation of Impingement and Entrainment in the Mid-Atlantic Region

Background: Mid-Atlantic Marine Fisheries

The Mid-Atlantic Fishery Management Council (MAFMC) manages fisheries in Federal waters off the Mid-Atlantic coast. States with voting representation on the MAFMC include New York, Pennsylvania, New Jersey, Delaware, Maryland, Virginia, and North Carolina. North Carolina is represented on both the MAFMC and the South Atlantic Fishery Management Council.

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The MAFMC has fishery management plans in place for Atlantic mackerel (*Scomber scombrus*), squid (*Loligo pealeii* and *Illex illecebrosus*), butterfish (*Peprilus triacanthus*), Atlantic surf clam (*Spisula solidissima*), ocean quahog (*Arctica islandica*), Atlantic bluefish (*Pomatomus saltatrix*), summer flounder (*Paralichthys dentatus*), scup (*Stenotomus chrysops*), black sea bass (*Centropristis striata*), and monkfish (*Lophius americanus*). Mid-Atlantic groundfish fisheries are primarily for summer flounder, scup, goosefish (*Lophius americanus*), and black seabass (NMFS, 1999b). Summer flounder is one of the most valuable groundfish species in the region, and is targeted by both recreational and commercial fishermen (NMFS, 1999b).

D2-1 Fishery Species Impinged and Entrained

Table D2-1 shows the status of stocks in the Mid-Atlantic region that are managed by the MAFMC, indicating in bold the stocks subject to impingement and entrainment (I&E). In this table, overfishing refers to the situation in which fishing mortality is above a management threshold, jeopardizing the long-term capacity of the stock to produce the potential maximum sustainable yield on a continuing basis. A stock is considered overfished when biomass falls below a given threshold. In some cases, heavy fishing in the past may have reduced a stock to low abundance, so that it is now considered overfished even though the stock is not currently subject to overfishing.

As indicated in Table D2-1, 6 of the 14 managed stocks are classified as overfished, including the stock of monkfish in the southern portion of the region, spiny dogfish, scup, black seabass, bluefish, and golden tilefish (*Lopholatilus chamaeleonticeps*). Other stocks are in the process of being rebuilt from levels below the maximum sustainable yield, including the northern stock of monkfish and summer flounder. The status of two other stocks, surfclam and squid (*Illex*), is unknown or undefined. As indicated in the table, some of the stocks requiring management are also subject to I&E.

Table D2-1: Summary of Stock Status for Harvested Species of the Mid-Atlantic Region Included in Federal Fishery Management Plans

Stock (species in bold are subject to I&E)	Overfishing? (fishing mortality above threshold)	Overfished? (biomass below threshold)	Approaching Overfished Condition?
Monkfish (north)	Yes	No-rebuilding	No
Monkfish (south)	Yes	Yes	N/A
Spiny dogfish	Yes	Yes	N/A
Summer flounder	Yes	No-rebuilding	No
Scup	Yes	Yes	N/A
Black seabass	Yes	Yes	N/A
Bluefish	No	Yes	N/A
Surfclam	No	Undefined	Unknown
Ocean quahog	No	No	No
Squid (*Illex*)	No	Unknown	Unknown
Squid (*Loligo*)	No	No	No
Atlantic mackerel	No	No	No
Butterfish	No	No	No
Golden tilefish	Yes	Yes	N/A

Source: Table 4 in NMFS, 2002a.

D2-2 I&E Species and Species Groups Evaluated

Table D2-2 provides a list of species in the Mid-Atlantic region that are subject to I&E and the species groups that were evaluated in EPA's analysis of regional I&E.

Table D2-2: Species Evaluated by EPA that are Subject to I&E in the Mid-Atlantic Region

Species Group	Species	Recreational	Commercial	Forage
Alewife	Alewife		X	
American shad	American shad		X	
Atlantic croaker	Atlantic croaker	X	X	
Atlantic menhaden	Atlantic menhaden		X	
Atlantic tomcod	Atlantic tomcod			X
Bay anchovy	Bay anchovy			X
Blue crab	Blue crab		X	
Blueback herring	Blueback herring			X
Hogchoker	Hogchoker			X
Other (commercial)	American butterfish		X	
	American eel		X	
	Brown bullhead		X	
	Channel catfish		X	
	Conger eel		X	
	Gizzard shad		X	
	Harvestfish		X	
	Silver hake		X	

Table D2-2: Species Evaluated by EPA that are Subject to I&E in the Mid-Atlantic Region

Species Group	Species	Recreational	Commercial	Forage
	White catfish		X	
	Yellow perch		X	
Other (forage)	Atlantic herring			X
	Atlantic needlefish			X
	Atlantic silverside			X
	Banded killifish			X
	Blackcheek tonguefish			X
	Bluegill			X
	Chain pickerel			X
	Fourspine stickleback			X
	Golden shiner			X
	Inland silverside			X
	Inshore lizardfish			X
	Lined seahorse			X
	Mississippi silvery minnow			X
	Mud minnow			X
	Mummichog			X
	Northern pipefish			X
	Northern stargazer			X
	Pumpkinseed			X
	River herring			X
	Sheepshead minnow			X
	Skilletfish			X
	Spottail shiner			X
	Spotted codling			X
	Striped anchovy			X
	Striped blenny			X
	Striped killifish			X
	Threespine stickleback			X
Other (recreational)	Black drum	X		
	Black sea bass	X		
	Bluefish	X		
	Northern puffer	X		
	Northern searobin	X		
	Orange filefish	X		
	Oyster toadfish	X		
	Sea lamprey	X		
	Spotted hake	X		
	Spotted seatrout	X		
Naked goby	Naked goby			X
Spot	Spot	X	X	
Striped bass	Striped bass	X	X	
Summer flounder	Summer flounder	X	X	
Weakfish	Weakfish	X	X	

Table D2-2: Species Evaluated by EPA that are Subject to I&E in the Mid-Atlantic Region

Species Group	Species	Recreational	Commercial	Forage
White perch	White perch	X	X	
Windowpane	Windowpane		X	
Winter flounder	Winter flounder	X	X	

Life histories of the species with the highest losses are summarized in the following section. The life history data used in EPA's analysis and associated data sources are provided in Appendix D1 of this report.

D2-3 Life Histories of Primary Species Impinged and Entrained in the Mid-Atlantic Region

Life history characteristics of the primary species impinged or entrained at the Salem facility are summarized in the following sections. The species described are those with the highest I&E rates at Salem (presented in sections D2-4 and D2-4).

Alewife (Alosa pseudoharengus)

Alewife is a member of the herring family, Clupeidae, and ranges along the Atlantic coast from Newfoundland to North Carolina (Scott and Crossman, 1998). Alewife tend to be more abundant in the mid-Atlantic and along the northeastern coast. They are anadromous, migrating inland from coastal waters in the spring to spawn. Adult alewife overwinter along the northern continental shelf, settling at the bottom in depths of 56 to 110 m (184 ft to 361 ft) (Able and Fahay, 1998). Adults feed on a wide variety of food items, while juveniles feed mainly on plankton (Waterfield, 1995).

Alewife has been introduced to a number of lakes to provide forage for sport fish (Jude et al., 1987b). Ecologically, alewife is an important prey item for many fish, and commercial landings of river herring along the Atlantic coast have ranged from a high of 33,974 metric tons (74.9 million pounds) in 1958 to a low of less than 2,268 metric tons (5 million pounds) in recent years (Atlantic States Marine Fisheries Commission, 2000b).

Spawning is temperature-driven, beginning in the spring as water temperatures reach 13 to 15 ˚C, and ending when they exceed 27 ˚C (Able and Fahay, 1998). Spawning takes place in the upper reaches of coastal rivers, in slow-flowing sections of slightly brackish or freshwater.

Females lay demersal eggs in shallow water less than 2 m (6.6 ft) deep (Wang and Kernehan, 1979). They may lay from 60,000 to 300,000 eggs at a time (Kocik, 2000). The demersal eggs are 0.8 to 1.27 mm (0.03 to 0.05 in) in diameter. Larvae hatch at a size of approximately 2.5 to 5.0 mm (0.1 to 0.2 in) total length (Able and Fahay, 1998). Larvae remain in the upstream spawning area for some time before drifting downstream to natal estuarine waters. Juveniles table a diurnal vertical migration in the water column, remaining near the bottom during the day and rising to the surface at night (Fay et al., 1983c). In the fall, juveniles move offshore to nursery areas (Able and Fahay, 1998).

Maturity is reached at an age of 3 to 4 years for males, and 4 to 5 years for females (Able and Fahay, 1998). The average size at maturity is 265 to 278 mm (10.4 to 10.9 in) for males and 284 to 308 mm (11.2 to 12.1 in) for females (Able and Fahay, 1998). Alewife can live up to 8 years, but the average age of the spawning population tends to be 4 to 5 years (Waterfield, 1995; PSEG, 1999).

ALEWIFE
(Alosa pseudoharengus)

Family: Clupeidae (herrings).

Common names: River herring, sawbelly, kyak, branch herring, freshwater herring, bigeye herring, gray herring, grayback, white herring.

Similar species: Blueback herring.

Geographic range: Along the western Atlantic coast from Newfoundland to North Carolina.[a]

Habitat: Wide-ranging, tolerates fresh to saline waters, travels in schools.

Lifespan: May live up to 8 years.[b,c]

Fecundity: Females may lay from 60,000 to 300,000 eggs at a time.[d]

Food source: Small fish, zooplankton, fish eggs, amphipods, mysids.[c]

Prey for: Striped bass, weakfish, rainbow trout.

Life stage information:

Eggs: *demersal*
- Found in waters less than 2 m (6.6 ft) deep.[d]
- Are 0.8 to 1.27 mm (0.03 to 0.05 in) in diameter.[f]

Larvae:
- Approximately 2.5 to 5.0 mm (0.1 to 0.2 in) at hatching.[f]
- Remain in upstream spawning area for some time before drifting downstream to natal estuarine waters.

Juveniles:
- Stay on the bottom during the day and rise to the surface at night.[g]
- Emigrate to ocean in summer and fall.[f]

Adults: *anadromous*
- Reach maturity at 3-4 years for males and 4-5 years for females.[f]
- Average size at maturity is 265-278 mm (10.4-10.9 in) for males and 284-308 mm (11.2-12.1 in) for females.[f]
- Overwinter along the northern continental shelf.[f]

Location:
- Range along the western Atlantic coast from Newfoundland to North Carolina.
- Some landlocked populations exist in the Great Lakes and smaller lakes.

[a] Scott and Crossman, 1998.
[b] PSEG, 1999.
[c] Waterfield, 1995.
[d] Kocik, 2000.
[e] Wang and Kernehan, 1979.
[f] Able and Fahay, 1998.
[g] Fay et al., 1983c.
Fish graphic courtesy of New York Sportfishing and Aquatic Resources Educational Program, 2001.

American shad (*Alosa sapidissima*)

American shad is a member of the herring family, Clupeidae. American shad ranges from the Gulf of St. Lawrence, Canada, south to Florida, and are most abundant from Connecticut to North Carolina (Able and Fahay, 1998). An anadromous species, American shad migrate inland to spawn in natal rivers. Suitable American shad spawning habitat has declined over the years because of degradation in water quality and the construction of dams blocking natal spawning grounds (Atlantic States Marine Fisheries Commission, 2000b). Though still commercially and recreationally an important species, the economic importance of American shad has declined in the last century with its decreased abundance (Wang and Kernehan, 1979).

Spawning generally takes place from mid-April through early June, when water temperatures reach 12 ˚C (Able and Fahay, 1998). The slightly demersal eggs may hatch in 12 to 15 days at 12 ˚C (54 ˚F) and in 6 to 8 days at 17 ˚C (63 ˚F) (Wang and Kernehan, 1979; Able and Fahay, 1998). Larvae hatch at 5 to 10 mm (0.2 to 0.4 in) , and are pelagic for 2 to 3 weeks. At 25 to 28 mm, shad become juveniles (Able and Fahay, 1998), and will remain in riverine habitats through the first summer, gradually dispersing downstream (Able and Fahay, 1998). Emigration from estuarine habitats to marine waters occurs in the fall, and is triggered by decreasing water temperatures. Young-of-year are approximately 75 to 125 mm (3.0 to 4.9 in) at this point (Able and Fahay, 1998).

At 1 year, juveniles reach approximately 120 mm (4.7 in). Males tend to mature at 3 to 5 years, while females mature at 4 to 6 years (Able and Fahay, 1998). Mortality rates vary according to spawning grounds. Over half of the American shad that spawn in the Hudson River survive spawning migration and return to spawn again the following year (Wang and Kernehan, 1979), compared to less than 5 percent in the Delaware River (Wang and Kernehan, 1979).

American shad have a potential lifespan of up to 11 years (Carlander, 1969), but generally do not live longer than 8 years (PSEG, 1999).

AMERICAN SHAD
(Alosa sapidissima)

Family: Clupeidae (herrings).

Common names: Shad, Atlantic shad, white shad.

Similar species: Atlantic herring, alewife, blueback herring, Atlantic menhaden.

Geographic range: Atlantic coast from the St. Lawrence River to Florida.[a] May migrate more than 12,000 miles during their average lifespan.

Habitat: Marine waters, returning to inland tributaries and streams to spawn.

Lifespan: Generally up to 8 years.[b]

Fecundity: Females can lay over 600,000 eggs, as several hovering males fertilize them.[c]

Food source: Primarily plankton feeders, while at sea they feed on plankton, small crustaceans, and small fishes.

Prey for: Sea lamprey, striped bass, bluefish.

Life stage information:

Eggs: *slightly demersal*

- Shad move far enough upstream for the eggs to drift downstream and hatch before reaching saltwater.
- The eggs mature rapidly and transform into young fish in 3 to 4 weeks.

Larvae: *pelagic*

- Larvae hatch out at 5 to 10 mm (0.2 to 0.4 in) and are pelagic for 2 to 3 weeks.[d]

Juveniles:

- The young-of-year remain in fresh to brackish water until early fall before entering the sea. Some juveniles do not enter the sea and instead overwinter in deep holes near the mouth of the bay.

Adults: *anadromous*

- American shad are anadromous and do not feed during their return migration.

Location:

- Inshore and offshore. Atlantic coast from the St. Lawrence River to Florida. Spends most of its life at sea in large schools. It only enters the freshwater river in which it was born to spawn.
- American shad may migrate more than 1,000 miles during their average lifespan of five years at sea. They enter the bay from January to June between the ages of 4 and 6 to spawn in the freshwater and low-salinity tributaries.

[a] Able and Fahay, 1998.
[b] PSEG, 1999.
[c] Walburg, 1960.
[d] Able and Fahay, 1998.
Fish graphic from State of Maine Department of Marine Resources, 2001a.

Atlantic croaker (*Micropogonias undulatus*)

The Atlantic croaker is a member of the drum family Sciaenidae. Its distribution ranges from Massachusetts to the Gulf of Mexico along the Atlantic coast, with the greatest abundance from Chesapeake Bay to Florida (Able and Fahay, 1998; Desfosse et al., 1999). Populations of Atlantic croaker fluctuated over the last century, showing high levels in the 1940's, then declining sharply in the 1950's and 1960's (Joseph, 1972). Numbers remained low until the mid-1970's and steadily increased since then (Wang and Kernehan, 1979). Commercial landings in Delaware were reported as low as 0.1 metric tons (220 lb) in 1988, increasing to 6.7 metric tons (14,770 lb) in 1999 (personal communication, National Marine Fisheries Service, Fisheries Statistics and Economics Division, Silver Spring, Maryland, March 26, 2001).

As a bottom-feeding fish, the Atlantic croaker feeds mainly on worms, crustaceans, and fish (Atlantic States Marine Fisheries Commission, 2000a). It can tolerate a wide range of salinities ranging from freshwater to 70 ppt (Able and Fahay, 1998). Spawning occurs offshore from September through December along the continental shelf between Delaware Bay and Cape Hatteras (Morse, 1980; Able and Fahay, 1998).

Female fecundity along the mid-Atlantic coast ranges from 100,800 to 1,742,000 eggs in females from 196 to 390 mm (7.7 to 15.4 in) in total length (Morse, 1980). Atlantic croaker larvae enter Delaware Bay in fall and spend the winter over the continental shelf. Young croaker use the estuary as a nursery area in late winter, spring, and summer. Larvae are most abundant in September-October and juveniles are most abundant in October-January. Young-of-year leave the offshore shelf waters for inshore estuaries beginning in October, at lengths of 8 to 20 mm (0.3 to 0.8 in) (Able and Fahay, 1998). Young-of-year are often found over soft mud bottoms at water temperatures between 9.5 and 23.2 ˚C (49.1 and 73.8 ˚F), and tend to overwinter in deeper areas of the same habitats (Cowan and Birdsong, 1995). By age 1, individuals in the Delaware Bay have reached lengths of 135 to 140 mm (Able and Fahay, 1998). In the fall, age 1 individuals leave their overwintering estuaries to migrate offshore and south for their second winter (Able and Fahay, 1998).

Maturity begins at lengths of 140 to 170 mm (5.5 to 6.7 in), as Atlantic croaker approach 2 years (White and Chittenden, 1977). Atlantic croaker is a relatively short-lived species, living to a maximum age of 2 to 4 years in the Mid-Atlantic Bight (White and Chittenden, 1977). Adults tend to be less than 200 mm (7.9 in) long south of Cape Hatteras (North Carolina), although they can reach more than 350 mm (13.8 in). Individuals north of Cape Hatteras are generally larger (White and Chittenden, 1977).

ATLANTIC CROAKER
(Micropogonias undulatus)

Family: Sciaenidae (drums).

Common names: Corvina, hardhead, king billy, roncadina, and grumbler.

Similar species: Red drum, weakfish, spotted seatrout, spot.

Geographic range: From Massachusetts to the Gulf of Mexico along the western Atlantic coast, with the greatest abundance from Chesapeake Bay to Florida.[a,b]

Habitat: Usually found over mud and sandy mud bottoms in coastal waters and estuaries.[b]

Lifespan: Croaker generally live for 2-4 years.[c]

Fecundity: Females may lay between 100,800 to 1.74 million eggs.[d]

Food source: Croaker are opportunistic bottom-feeders that consume a variety of invertebrates (mysid shrimp, copepods, marine worms) and occasionally fish.

Prey for: Striped bass, flounder, shark, spotted seatrout, other croaker, bluefish, and weakfish.

Life stage information:

Eggs: *weakly demersal*
- Develop offshore.

Larvae:
- Larvae are most abundant in September-October.[e]

Juveniles:
- Young-of-year migrate to inshore estuaries in the fall, and tend to overwinter in relatively deep areas with soft mud bottoms.
- Juvenile croaker leave estuaries in the fall to spend their second winter offshore.

Adults:
- Maturity begins at approximately 140-170 mm (5.5 to 6.7 in).[c]
- May reach over 350 mm (13.8 in).[c]

Location:
- New Jersey to the Gulf of Mexico and the Western Atlantic Coast. Most abundant between the Chesapeake Bay and Florida.
- Adult croaker generally spend the spring and summer in estuaries and move offshore and south along the Atlantic coast in the fall.
- Prefer muddy bottoms and depths less than 120 m.
- Euryhaline species — able to tolerate a wide range of salinities.

[a] Desfosse et al., 1999.
[b] Froese and Pauly, 2001.
[c] White and Chittenden, 1977.
[d] Morse, 1980.
[e] Able and Fahay, 1998.
Fish graphic from South Carolina Department of Natural Resources, 2001.

Atlantic menhaden (*Brevoortia tyrannus*)

The Atlantic menhaden, a member of the Clupeidae (herring) family, is a euryhaline species, occupying coastal and estuarine habitats. It is found along the Atlantic coast of North America, from Maine to northern Florida (Hall, 1995). Adults congregate in large schools in coastal areas; these schools are especially abundant in and near major estuaries and bays. They consume plankton, primarily diatoms and dinoflagellates, which they filter from the water through elaborate gill rakers. In turn, menhaden are consumed by almost all commercially and recreationally important piscivorous fish, as well as by dolphins and birds (Hall, 1995).

The menhaden fishery, one of the most important and productive fisheries on the Atlantic coast, is a multimillion-dollar enterprise (Hall, 1995). Menhaden are considered an "industrial fish" and are used to produce products such as paints, cosmetics, margarine (in Europe and Canada), and feed, as well as bait for other fisheries. Landings in New England declined to their lowest level of approximately 2.7 metric tons (5,952 lb) in the 1960s because of overfishing. Since then, landings have varied, ranging from approximately 240 metric tons (529,100 lb) in 1989 to 1,069 metric tons in 1998 (personal communication, National Marine Fisheries Service, Fisheries Statistics and Economics Division, Silver Spring, Maryland, March 19, 2001).

Atlantic menhaden spawn year round at sea and in larger bays (Scott and Scott, 1988). Spawning peaks during the southward fall migration and continues throughout the winter off the North Carolina coast. There is limited spawning during the northward migration and during summer months (Hall, 1995). The majority of spawning occurs over the inner continental shelf, with less activity in bays and estuaries (Able and Fahay, 1998).

Females mature just before age 3, and release buoyant, planktonic eggs during spawning (Hall, 1995). Atlantic menhaden annual egg production ranges from approximately 100,000 to 600,000 eggs for fish age 1 to age 5 (Dietrich, 1979). Eggs are spherical and between 1.3 to 1.9 mm (0.05 to 0.07 in) in diameter (Scott and Scott, 1988).

Larvae hatch after approximately 24 hours and remain in the plankton. Larvae hatched in offshore waters enter the Delaware Estuary 1 to 2 months later to mature (Hall, 1995). Juveniles then migrate south in the fall, joining adults off North Carolina in January (Hall, 1995). Water temperatures below 3 ˚C (37 ˚F) kill the larvae, and therefore larvae that fail to reach estuaries before the fall are more likely to die than those arriving in early spring (Able and Fahay, 1998). Larvae hatchout at 2.4 to 4.5 mm (0.09 to 0.18 in). The transition to the juvenile stage occurs between 30 and 38 mm (1.2 and 1.5 in) (Able and Fahay, 1998). The juvenile growth rate in some areas is estimated to be 1 mm (0.04 in) per day (Able and Fahay, 1998).

During the fall and early winter, most menhaden migrate south off of the North Carolina coast, where they remain until March and early April. They avoid waters below 3 ˚C, but can tolerate a wide range of salinities from less than 1 percent up to 33-37 percent (Hall, 1995). Sexual maturity begins at age 2, and all individuals are mature by age 3 (Scott and Scott, 1988).

Adult fish are commonly between 30 and 35 cm (11.8 and 13.8 in) in length. The maximum age of a menhaden is approximately 7 to 8 years (Hall, 1995), although individuals of 8-10 years have been recorded (Scott and Scott, 1988).

ATLANTIC MENHADEN
(*Brevoortia tyrannus*)

Family: Clupeidae (herrings).

Common names: menhaden, bunker, fatback, bugfish.

Similar species: Gulf menhaden, yellowfin menhaden.

Geographic range: From Maine to northern Florida along the Atlantic coast.[a]

Habitat: Open-sea, marine waters. Travels in schools.[b]

Lifespan:
- Approximately 7 to 8 years.[a]

Fecundity:
- Females may produce between 100,000 to 600,000 eggs.[c]

Food Source: Phytoplankton, zooplankton, annelid worms, detritus[b]

Prey for: Sharks, cod, pollock, hakes, bluefish, tuna, swordfish, seabirds, whales, porpoises.[b]

Life Stage Information

Eggs: *pelagic*
- Spawning takes place along the inner continental shelf, in open marine waters.[d]
- Eggs hatch after approximately 24 hours.

Larvae: *pelagic*
- Larvae hatch out at sea, and enter estuarine waters 1 to 2 months later.[a]
- Remain in estuaries through the summer, emigrating to ocean waters as juveniles in September or October.[d]

Adults
- Congregate in large schools in coastal areas.
- Spawn year round.[b]

[a] Hall, 1995.
[b] Scott and Scott, 1988.
[c] Dietrich, 1979.
[d] Able and Fahay, 1998.
Fish graphic from South Carolina Department of Natural Resources, 2001.

Atlantic silverside (*Menidia menidia*)

The Atlantic silverside is a member of the silverside family, Atherinidae. Its geographic range extends from coastal waters of New Brunswick to northern Florida (Fay et al., 1983c), but it is most abundant between Cape Cod and South Carolina (Able and Fahay, 1998). Atlantic silversides inhabit sandy seashores and the mouths of inlets (Froese and Pauly, 2001). Silversides are an important species of forage fish, eaten by valuable fishery species such as striped bass (*Morone saxatilis*), bluefish (*Pomatomus salatrix*), weakfish (*Cynoscion regalis*), and Atlantic mackerel (*Scomber scombrus*) (Fay et al., 1983c; McBride, 1995).

Atlantic silversides spawn in the upper intertidal zone during spring and summer. Spawning appears to be stimulated by new and full moons, in association with spring tides. On average, females produce 4,500 to 5,000 demersal eggs per spawning season, which may include four to five separate spawning bouts (Fay et al., 1983c). The eggs are 0.9 to 1.2 mm (0.04 to 0.05 in) in diameter. Larvae range in size from 5.5 to 15.0 mm (0.2 to 0.6 in) (Fay et al., 1983c). The sex of Atlantic silversides is determined during the larval stage, at approximately 32 to 46 days after hatching. Water temperatures between 11 and 19 ˚C (52 and 66 ˚F) produce significantly more females, whereas temperatures between 17 and 25 ˚C (63 and 77 ˚F) produce significantly more males (Fay et al., 1983c).

Juveniles occur in estuaries during the summer months, occupying intertidal creeks, marshes, and shore zones of bays and estuaries. Silversides typically migrate offshore in the winter (McBride, 1995). In studies of seasonal distribution in Massachusetts, all individuals left inshore waters during winter months (Able and Fahay, 1998).

The diet of juveniles and adults consists of copepods, mysids, amphipods, cladocerans, fish eggs, squid, worms, molluscs, insects, algae, and detritus (Fay et al., 1983c). Atlantic silversides feed in large schools, preferring gravel and sand bars, open beaches, tidal creeks, river mouths, and marshes (Fay et al., 1983c).

Silversides live for only 1 or 2 years, usually dying after completing their first spawning (Fay et al., 1983c). Adults can reach sizes of up to 15 cm (5.9 in) in total length (Froese and Pauly, 2001).

ATLANTIC SILVERSIDE
(*Menidia menidia*)

Family: Atherinidae (silversides).

Common names: Spearing, sperling, green smelt, sand smelt, white bait, capelin, shiner.[a]

Similar species: Inland silverside (*Menidia beryllina*).[a]

Geographic range: New Brunswick to northern Florida[a]

Habitat: Sandy seashores and the mouths of inlets.[b]

Lifespan: One or 2 years. Often die after their first spawning.[a]

Fecundity: Females produce an average of 4,500 to 5,000 eggs per spawning season.[a]

Food Source: Zooplankton, fish eggs, squid, worms, molluscs, insects, algae, and detritus.[a]

Prey for: Striped bass, bluefish, weakfish, and Atlantic mackerel.[a,c]

Life Stage Information

Eggs: *demersal*
- Found in shallow waters of estuarine intertidal zones.[a]
- Can be found adhering to submerged vegetation.[a]

Larvae:
- Range from 5.5 to 15.0 mm (0.2 to 0.6 in) in size.[a]
- Sex is determined during the larval stage by the temperature regime. Colder temperatures tend to produce more females, and warmer temperatures produce more males.[a]

Adults:
- Overwinter in offshore marine waters.[d]
- Can reach sizes of up to 15 cm (5.9 in) total length.[d]

[a] Fay et al., 1983c.
[b] Froese and Pauly, 2001.
[c] McBride, 1995.
[d] Able and Fahay, 1998.
Fish graphic from Government of Canada, 2001.

Bay anchovy *(Anchoa mitchilli)*

Bay anchovy is a member of the anchovy family, Engraulidae, and is one of the most abundant species in estuaries along the Atlantic and Gulf coasts of the United States (Vouglitois et al., 1987). In Delaware Bay, bay anchovy shares the status of most abundant species with the Atlantic silverside (de Sylva et al., 1962). Because of its widespread distribution and overall abundance, bay anchovy are an important component of the food chain for recreational and commercial fish, and as such have indirect economic importance (Morton, 1989).

Bay anchovy is commonly found in shallow tidal areas, feeding mainly on copepods and other zooplankton. It tends to appear in higher densities in vegetated areas such as eelgrass beds (Castro and Cowen, 1991).

The spawning period of bay anchovy is long, with records ranging from April to November (Vouglitois et al., 1987). In the Delaware Estuary, the spawning season usually occurs from early April through mid-June (Wang and Kernehan, 1979). Spawning within the Delaware Estuary primarily occurs in the western part of the C & D Canal, and in the Elk River (Wang and Kernehan, 1979) (see Figure B1-1), and has been correlated with areas of high zooplankton abundance (Dorsey et al., 1996). In Chesapeake Bay, a minimum of 50 spawning events per female was estimated, with spawning events occurring every 4 days in June and every 1.3 days in July. Spawning generally occurs nocturnally, and during peak spawning periods females may spawn nightly. Fecundity estimates for bay anchovy in mid-Chesapeake Bay were reported at 643 eggs in July 1986 and 731 eggs in July 1987 (Zastrow et al., 1991). The pelagic eggs are 0.8 to 1.3 mm (0.03 to 0.05 in) in diameter (Able and Fahay, 1998). Size of the eggs varies with increased water salinity.

Eggs hatch in approximately 24 hours at average summer temperatures (Monteleone, 1992). The yolk sac larvae are 1.8 to 2.0 mm (0.07 to 0.08 in) long, with nonfunctioning eyes and mouth parts (Able and Fahay, 1998). Mortality during these stages is high. In a study conducted in the Chesapeake Bay, 73 percent of the eggs died before hatching, and mortality for surviving larvae was 72 percent within the first 24 hours of hatching (Dorsey et al., 1996).

Growth estimates for larval bay anchovy have been estimated at 0.53 to 0.56 mm (0.021 to 0.022 in) per day in Great South Bay, New York (Castro and Cowen, 1991), and young-of-year growth rates averaged 0.47 mm (0.02 in) per day in Chesapeake Bay (Zastrow et al., 1991). Sexual maturity occurs at a length of 40 to 45 mm (1.6 to 1.8 in) in Chesapeake Bay (Zastrow et al., 1991). Individuals hatched early in the season may become sexually mature by their first summer (Morton, 1989).

Most young-of-year migrate out of the estuaries at the end of the summer in schools, and can be found in large numbers on the inner continental shelf in the fall (Vouglitois et al., 1987). The average size for adults is 75 mm (2.95 in) (Morton, 1989). Bay anchovy live for only 1 or 2 years (Zastrow et al., 1991).

Near the Salem station, bay anchovy eggs are present from May to November and are most abundant from May to August. Larvae are present from May to October, with greatest abundance from June to August. Juveniles are present throughout the year but are most abundant from July to October. Adults are also present year-round and are most abundant from April to November.

BAY ANCHOVY
(Anchoa mitchilli)

Family: Engraulidae (anchovies).

Common names: Anchovy.

Similar species: Atlantic silverside.

Geographic range: From Maine, south to the Gulf of Mexico.[a]

Habitat: Commonly found in shallow tidal areas with muddy bottoms and brackish waters; often appears in higher densities in vegetated areas such as eelgrass beds.[b]

Lifespan: 1-2 years.[c]

Fecundity: Females spawn a minimum of 50 times over the spawning season in the Chesapeake Bay. Fecundity per spawning event is about 700 eggs.[c]

Food source: Primarily feed on copepods and other zooplankton, as well as small fishes and gastropods.[b]

Prey for: Striped bass, weakfish, jellyfish.

Life stage information:

Eggs: *pelagic*
- Eggs are 0.8-1.3 mm (0.03 to 0.05 in) in diameter.[a]
- Eggs experience an average mortality of 73 percent.[d]

Larvae:
- Yolk-sac larvae are 1.8 to 2.0 mm (0.7 to 0.8 in) on hatching.[a]
- Daily mortality for yolk-sac larvae is as high as 88 percent.[b]
- Daily mortality for 3-15 day old larvae is approximately 28 percent.[b]

Juveniles:
- Young-of-year migrate out of estuaries at the end of summer, and can be found in large numbers on the inner continental shelf in fall.[e]

Adults:
- Adults reach sexual maturity at 40 to 45 mm (1.6 to 1.8 in) in Chesapeake Bay.[c]
- The average adult is 75 mm (2.95 in) long.[f]

Location:
- Ranges from Cape Cod, Massachusetts, south to the Gulf of Mexico. Spawns in the Delaware Estuary in the Elk River and C&D Canal.[g]
- Most commonly found in shallow tidal areas with muddy bottoms and brackish waters, but can be found in a wide range of habitats.
- Tolerates a wide range of salinities.

[a] Able and Fahay, 1998.
[b] Castro and Cowen, 1991.
[c] Zastrow et al., 1991.
[d] Dorsey et al., 1996.
[e] Vouglitois et al., 1987.
[f] Morton, 1989.
[g] Wang and Kernehan, 1979.
Fish graphic from NOAA, 2001a.

Blue crab (*Callinectes sapidus*)

The Atlantic blue crab can be found in Atlantic coastal waters from Long Island to the Gulf of Mexico. Blue crab supports the most economically important inshore commercial fishery in the mid-Atlantic (Epifanio, 1995); Chesapeake Bay provides over 50 percent of the commercial landings of Atlantic blue crab nationwide (Epifanio, 1995).

Females typically mate only once within their lifetime. Spawning in the Delaware Bay peaks from late July to early August. After an elaborate courtship ritual, females lay two to three broods of eggs, each containing over 1 million eggs. Mating occurs in areas of low salinity. The eggs hatch near high tide and the larvae are carried out to sea by the current (Epifanio,

1995). This stage of the lifecycle is called the zoeal stage. The zoea go through seven molts before entering the next stage, the megalops stage, and are carried back to estuarine waters (Epifanio, 1995). The zoea stages last approximately 35 days, and the megalops stage may vary from several days to a few weeks (Epifanio, 1995).

While in the zoeal stage along the continental shelf, larvae are vulnerable to predators, starvation, and transport to unsuitable habitats. Larvae are especially vulnerable to predators while molting. Dispersal of young Atlantic blue crabs is primarily controlled by wind patterns, and they do not necessarily return to their parent estuaries (Epifanio, 1995). In the Delaware Estuary, maturity is reached at approximately 18 months (Epifanio, 1995).

Atlantic blue crabs inhabit all regions of the Delaware Estuary. Males prefer areas of low salinity, while females prefer the mouth of the estuary. In the warmer months, crabs occupy shallower areas in depths of less than 4.0 m (13 ft). They can tolerate water temperatures exceeding 35 ˚C (95 ˚F), but do not fare as well in cold water (Epifanio, 1995). In winter months, adults burrow into the bottom of deep channels and remain inactive (Epifanio, 1995). Extremely cold weather has resulted in high mortality of overwintering crabs (Epifanio, 1995).

Atlantic blue crabs are omnivorous, foraging on molluscs, mysid shrimp, small crabs, worms, and plant material (Epifanio, 1995). Adults prey heavily on juvenile Atlantic blue crab (Epifanio, 1995).

Atlantic blue crab can live up to 3 years (Epifanio, 1995).

Impingeable sizes of blue crab are present throughout the year near Salem, but are most abundant from April to November.

ATLANTIC BLUE CRAB
(*Callinectes sapidus*)

Family: Portunidae (swimming crabs).

Common names: Blue crab.

Similar species: Lesser blue crab (*Callinectes similis*).

Lifespan: Up to 3 years. Maturity is reached at 18 months.[a]

Geographic range: Atlantic coast from Long Island to the Gulf of Mexico.[a]

Habitat: Inhabit all areas of the Delaware Estuary. In warmer weather they occupy shallow areas less than 4 m (13 ft) deep. They burrow into the bottom of deep channels and remain inactive in winter.[a]

Fecundity: Typically mate once in their lifetime. Mating occurs in low salinity areas. Females lay two to three broods of 1 million eggs each.[a]

Food Source: Atlantic blue crabs are omnivores, foraging on molluscs, mysids, shrimp, small crabs, worms, and plant material.[a]

Prey for: Juveniles are preyed upon by a variety of fish (eels, striped bass, weakfish) and are heavily preyed upon by adult blue crabs.[a]

Life Stage Information

Eggs:
- Hatch near high tide.[a]

Larvae:
- Carried out to sea by the current, where they remain for seven molts before returning to estuaries.[a]

***Adults*:**
- Males prefer lower salinity while females prefer the mouth of the bay.[a]

[a] Epifanio, 1995.
Graphic from U.S. FDA, 2001.

Blueback herring (*Alosa aestivalis*)

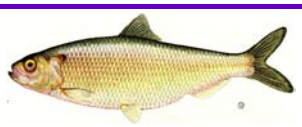
Blueback herring is a member of the herring family, Clupeidae. It is closely related to the alewife; together they are commonly referred to as river herring. The range of blueback herring extends from Nova Scotia south to northern Florida, though they are more abundant in the southern portion of their range (Scott and Scott, 1988). Within the Delaware Estuary, blueback herring tend to be more abundant in the upper region of the estuary than do the closely related alewife (Waterfield, 1995). Economically, blueback herring are an important bait species for the blue crab industry of the Delaware and Chesapeake bays. They are also a significant prey item for many estuarine fish species.

Adults spawn from spring to early summer in upstream brackish or freshwater areas of rivers and tributaries. Spawning occurs at night in fast currents over a hard substrate (Loesch and Lund, 1977). Spawning groups have been observed diving to the bottom and releasing the semi-adhesive eggs over the substrate, but many eggs are dislodged by the current and enter the water column. Loesch and Lund (1977) reported fecundity estimates of 45,800 to 349,700 eggs per female, and noted that fecundity was positively correlated with total fish length up to approximately 300 mm. After spawning, adults move downstream and return to the ocean.

Eggs float near the bottom for 2 to 4 days until hatching, depending on temperature. At hatching, larvae are 3.1 to 5.0 mm (0.12 to 0.20 in) (Jones et al., 1978). Larvae become juveniles at approximately 20 mm (0.79 in), or at 25 to 35 days (Able and Fahay, 1998). Juveniles are distributed high in the water column and avoid bottom depths (Able and Fahay, 1998). In the early juvenile stages, fish are swept downstream by the tide. Some juveniles will move upstream until late summer before migrating downstream in late summer to early fall. Juveniles are sensitive to sudden water temperature changes, and emigrate downstream in response to a decline in temperature (Able and Fahay, 1998). By late fall, most young-of-year emigrate to ocean waters to overwinter (Wang and Kernehan, 1979).

Male blueback herring mature at ages 3 to 4, and females mature at ages 4 to 5. Over half of the adults are repeat spawners, returning to natal spawning grounds every year (Scherer, 1972). Females tend to grow larger than males and dominate the older age groups. Blueback herring can live to 8 years (Froese and Pauly, 2001).

Near Salem, blueback herring juveniles are present from winter through late spring and again in fall.



BLUEBACK HERRING
(*Alosa aestivalis*)

Family: Clupeidae (herrings).

Common names: River herring, glut herring, summer herring, kyak, blackbelly.

Similar species: alewife, American shad, Atlantic menhaden.

Geographic range: From Nova Scotia south to northern Florida.[a]

Habitat: Euryhaline, marine. Adults form schools and overwinter near the bottom out from the coast.[b]

Lifespan: May live up to 8 years.[b]

Fecundity: Fecundity ranges from 45,800 to 349,700 eggs per female.[c] Over half of adults are repeat spawners and return to natal spawning grounds every year.[d]

Food source: Shrimp, zooplankton, finfish.

Prey for: Striped bass, weakfish, bluefish.

Life stage information:

Eggs: *pelagic*
- Eggs float near the bottom for 2-4 days.[e]

Larvae:
- Larvae are 3.1-5.0 mm at hatching.[e]
- The larval stage duration is 25-35 days.[f]

Juveniles:
- Blueback herring reach the juvenile stage at 20 mm (0.79 in), or at an age of 25-35 days.[f]
- Juveniles are distributed high in the water column and avoid bottom depths.
- Juveniles tend to move upstream until late summer before migrating downstream in late summer in response to a decline in temperature.

Adults:
- Males mature at ages 3-4, females at ages 4-5.
- Adults overwinter near the bottom and out from the coast, then return to shore in late spring to spawn.

Location:
- Range from Nova Scotia south to northern Florida.
- More common in upper region of Delaware estuary than the closely related alewife.

[a] Scott and Scott, 1988.
[b] Froese and Pauly, 2001.
[c] Loesch and Lund, 1977.
[d] Scherer, 1972.
[e] Jones et al., 1978.
[f] Able and Fahay, 1998.
Fish graphic courtesy of New York Sportfishing and Aquatic Resources Educational Program, 2001.

Spot (*Leiostomus xanthurus*)

Spot is a member of the drum family, Sciaenidae. Its range extends along the Atlantic coast from Massachusetts Bay to Campeche Bay, Mexico, and it is most abundant from Chesapeake Bay to South Carolina (Hildebrand and Schroeder, 1928; Mercer, 1987). Spot are occasionally harvested for food, but because of their small size, are typically used as bait and in pet food and fish meal (Hales and Van Den Avyle, 1989). Spot are often caught by anglers because they take the bait easily and are often found near piers and bridges (Hales and Van Den Avyle, 1989).

Ecologically they are an important species because of their high abundance and their status on the food chain as both predator and prey for many species. Because of their short lifespan, annual landings tend to consist of a single year class and fluctuate greatly from year to year, yet show no long-term trends (Atlantic States Marine Fisheries Commission, 2000c).

Spawning occurs in deeper waters along the continental shelf from late fall through early spring (Mercer, 1987). Females produce 30,000 to 60,000 eggs (Phillips et al., 1989), and eggs are 0.72-0.87 mm (0.028 to 0.034 in) in diameter (Able and Fahay, 1998). Larvae hatch out at 1.5 to 1.7 mm (0.06 to 0.07 in) in length and begin migrating to inshore estuaries, reaching the nursery estuarine waters in early to late spring. Young larvae show a preference for low salinity waters (Wang and Kernehan, 1979), and continue to migrate to the upper areas of estuaries to spend the summer. By the fall, young-of-year reach 10 to 11 cm (3.9 to 4.3 in) (Able and Fahay, 1998). First year growth rates for spot in Chesapeake Bay have been recorded from 10.5 mm (0.4 in) per month to 19.1 mm (0.8 in) per month (Hildebrand and Schroeder, 1928; McCambridge and Alden, 1984).

As water temperatures decrease in the fall, juveniles emigrate to the ocean in October and November. Larger individuals tend to leave the estuaries earliest. In the Chesapeake Bay, some young-of-year spot have remained in the estuaries throughout the first winter.

Spot are able to avoid heavy competition with Atlantic croaker by occupying different spatial and temporal niches. While Atlantic croaker spawn from October through February in the Delaware Estuary, spot spawn from December through March (Wang and Kernehan, 1979). They share a similar diet, consisting mostly of mysid shrimp, copepods, and marine worms, but spot feed more on burrowing worm species while Atlantic croaker show a preference for worms on the bottom surface (Chao and Musick, 1977).

Spot mature at 2 to 3 years (Atlantic States Marine Fisheries Commission, 2000c). The maximum recorded age for spot is 5 years (Mercer, 1987). The largest recorded spot was 35.6 cm (14.0 in) long, although most mature adults are 17.8 to 20.3 cm (7.0 to 8.0 in) (Atlantic States Marine Fisheries Commission, 2000c).

Spot may be particularly vulnerable to I&E in intake structures because of their slow swimming speeds and low endurance (Hales and Van Den Avyle, 1989). Young spot have significantly lower swimming speeds than most estuarine fishes and cannot maintain their orientation in currents exceeding 15 cm/s. Larger spot have increased swimming capabilities, but may also be vulnerable to I&E because they tend to drift with the currents (Hales and Van Den Avyle, 1989).

SPOT
(Leiostomus xanthurus)

Family: Sciaenidae (drums).

Common names: Spot croaker.

Similar species: Red drum, weakfish, spotted seatrout, Atlantic croaker.

Geographic range: Along the Atlantic coast from Massachusetts Bay to Campeche Bay, Mexico, and most abundant from Chesapeake Bay to South Carolina.[a,b]

Habitat: Often found near piers and bridges.[c] Occurs over sandy or muddy bottoms in coastal waters up to 60 m (197 ft) in depth.[d]

Lifespan: Up to 5 years.[b]

Fecundity: Females produce 30,000 to 60,000 eggs.[e]

Food source: Worms, mysid shrimp, copepods.[f]

Prey for: Striped bass, weakfish, bluefish, flounder, bonito, sandbar shark.

Life stage information:

Eggs: *pelagic*
- Eggs are 0.72-0.87 mm (0.028 to 0.034 in) in diameter.[f]

Larvae:
- Larvae are 1.5-1.7 mm (0.06 to 0.07 in) long at hatching.[e]
- Larvae migrate to inshore estuary waters, arriving in early to late spring.
- Young larvae prefer low salinity waters and are found in upper estuary waters.

Juveniles:
- As water temperature decreases in the fall, most young-of-year spot migrate out to the ocean.
- Larger individuals tend to leave the estuary earlier.

Adults:
- Spot mature at 2-3 years.[h]
- The largest recorded spot was 35.6 cm (14.0 in) long, although most mature adults are 17.8-20.3 cm (7.0 to 8.0 in).[h]

Location:
- Range along the western Atlantic coast from Massachusetts Bay to Campeche Bay, Mexico.
- Found over sandy or muddy bottoms in coastal waters to about 60 m depth.
- Found in nursery and feeding grounds in river estuaries in summer and fall.

[a] Hildebrand and Schroeder, 1928.
[b] Mercer, 1987.
[c] Hales and Van Den Avyle, 1989.
[d] Froese and Pauly, 2000.
[e] Phillips et al., 1989.
[f] Chao and Musick, 1977.
[g] Able and Fahay, 1998.
[h] Atlantic States Marine Fisheries Commission, 2000c.
Fish graphic from South Carolina Department of Natural Resources, 2001.

Striped bass (*Morone saxatilis*)

Striped bass is a member of the temperate bass family, Moronidae. Both migratory and nonmigratory populations span the Atlantic coast, from the St. Lawrence River, Canada, to the St. John's River in Florida (Scott and Scott, 1988). Striped bass has long been an important commercial and recreational species. The perceived decline in striped bass populations was the reason behind the creation of the Atlantic States Marine Fisheries Commission in 1942 (Miller, R.W., 1995). Spawning populations of striped bass were nearly eliminated from the Delaware River in the mid-1900's, because of poor water quality. Pollution in the lower portions of the Delaware River caused a decline in striped bass reproduction due to a decrease in dissolved oxygen for several years, but cleanup efforts in the 1980's and 1990's resulted in improved water quality and increased striped bass reproduction (Chittenden, 1971; Weisberg and Burton, 1993; Miller, R.W., 1995). A moratorium was declared on striped bass fishing in the State of Delaware from 1985 through 1989 (Miller, R.W., 1995). While populations of striped bass have rebounded, the fishery is still managed closely and tight restrictions on size limits and the length of the fishing season are kept to maintain the goals established under Amendment 5 of the Striped Bass Fishery Management Plan of 1995 (Atlantic States Marine Fisheries Commission, 2000g).

Striped bass are a popular catch among recreational anglers; however, consumption advisories are currently in place for striped bass from the Delaware River and Bay as a result of bioaccumulation of PCBs (PSEG, 1999). These advisories recommend limiting the consumption of striped bass to less than five 267 g (8-oz.) meals per year. A 1997 landings report estimated the yearly catch by recreational and commercial fisheries to be 4.094 million striped bass (Atlantic States Marine Fisheries Commission, 2000d). Angling efforts are typically centered on the C&D canal, from Port Penn to Augustine Beach, Delaware, and in the mouths of tributaries south of the canal (PSEG, 1999). In the Delaware Bay, there are currently no directed commercial fishing efforts for striped bass, although historically commercial harvesting of striped bass was an important resource (PSEG, 1999).

Striped bass are common along mid-Atlantic coastal waters. They are an anadromous fish that spend most of the year in saltwater but use the upper fresh and brackish water reaches of estuaries as spawning and nursery areas in spring and summer (Setzler et al., 1980). The principal spawning areas for striped bass along the Atlantic coast are the major tributaries of Chesapeake Bay, and the Delaware and Hudson rivers (NOAA, 2001c). The timing of spawning may be triggered by an increase in water temperature, and generally occurs from April to June (Fay et al., 1983c). Spawning behavior consists of a female surrounded by up to 50 males at or near the surface (Setzler et al., 1980). Eggs are broadcast loosely in the water and fertilized by the males. Females may release an estimated 14,000 to 40.5 million eggs, depending on the size of the female (Jackson and Tiller, 1952). A 23 kg (50 pound) female may produce approximately 5 million eggs (Mansueti and Hollis, 1963).

Striped bass eggs are semibuoyant, and require minimum water velocities to remain buoyant. Eggs that settle to the bottom may become smothered by sediment (Hill et al., 1989). The duration of larval development is influenced by water temperature; temperatures ranging from 24 to 15 $^{\circ}$C (75 to 59 $^{\circ}$F) correspond to larval durations of 23 to 68 days, respectively (Rogers et al., 1977). Saila and Lorda (1977) reported a 6 percent probability of survival for egg and yolk-sac stages of development, and a 4 percent probability of survival for the post yolk-sac stage.

At 30 mm (1.2 in), most striped bass enter the juvenile stage. Juveniles begin schooling in larger groups after age 2 (Bigelow and Schroeder, 1953). Migratory patterns of juveniles vary with locality (Setzler et al., 1980). In both the Delaware and the Hudson rivers, young-of-year migrate downstream from their spawning grounds to the tidal portions of the rivers to spend their first summer (Able and Fahay, 1998). In the Delaware River, young-of-year may spend 2 or more years within the estuary before joining the offshore migratory population (Miller, R.W., 1995). Similar trends were found in the Hudson River, where individuals were found to stay up to 3 years in estuaries before migrating offshore (Able and Fahay, 1998). Results of tagging studies reported by the Delaware Department of Natural Resources and Environmental Control (DDNREC, 2000) and Public Service Electric and Gas Company (PSEG, 1999) showed that striped bass tagged in the Delaware Estuary were recaptured from North Carolina to Maine. However, the majority of tagged fish were recovered between Maryland and Massachusetts.

Adult striped bass feed in intervals while schooling (Fay et al., 1983c). They primarily eat smaller fish species such as herring, silversides, and anchovies (Miller, R.W, 1995). Larvae feed primarily on copepods (Miller, R.W, 1995), and stomach contents of juveniles from the Delaware Estuary show mysid shrimp as a favored food item (Bason, 1971).

Adults may live up to 30 years (Atlantic States Marine Fisheries Commission, 2000d), and have been reported at sizes up to 200 cm (79 in) (Froese and Pauly, 2001).

STRIPED BASS
(Morone saxatilis)

Family: Moronidae (temperate basses).

Common names: Striper, rockfish, linesider, and sea bass.[g]

Similar species: White perch.

Geographic range: St. Lawrence River in Canada to the St. Johns River in Florida, and from the Suwannee River in western Florida to Lake Pontchartrain, Louisiana.[a]

Habitat: Juveniles prefer shallow rocky to sandy areas. Adults in inshore areas use a variety of substrates, including rock, boulder, gravel, sand, detritus, grass, moss, and mussel beds.[a]

Lifespan: Adults may reach 30 years.[b]

Fecundity: Females release 14,000 to 40.5 million eggs, depending on the size of the female.[c]

Food sources:
- Larvae feed primarily on mobile planktonic invertebrates (beetle larvae, copepodids *Daphnia* spp.).[a]
- Juveniles eat larger aquatic invertebrates and small fishes.[a]
- Adults are piscivorous. Clupeid fish are the dominant prey and adults prefer soft-rayed fishes.[a]

Prey for: Any sympatric piscivorous fish.[a]

Life stage information:

Eggs: *pelagic*
- Eggs and newly hatched larvae require sufficient turbulence to remain suspended in the water column; otherwise, they can settle to the bottom and be smothered.[d]

Larvae: *pelagic*
- Larvae range from 5 to 30 mm (0.2 to 1.2 in).[a]

Juveniles:
- Most striped bass enter the juvenile stage at 30 mm (1.2 in) total length.[d]
- Juveniles school in larger groups after 2 years of age.[d]
- Juveniles in the Delaware River generally remain in estuarine areas for 2 or more years before joining the offshore migratory population.[e]

***Adults*:** Anadromous
- Adults school offshore, but swim upstream to spawn.[f]
- May grow as large as 200 cm (79 in).[g]

Location:
- Estuaries are spawning grounds and nurseries and thus critically important to their life cycle.
- Mature striped bass are found in and around a variety of inshore habitats, including areas off sandy beaches and along rocky shorelines, in shallow water or deep trenches, and in rivers and the open bay.
- St. Lawrence River in Canada to the St. Johns River in Florida, and from the Suwannee River in western Florida to Lake Pontchartrain, Louisiana.
- Migratory behavior is more complex than that of most other anadromous fish. Seasonal movements depend on their age, sex, degree of maturity, and the river in which they were born.
- Mature striped bass move from the ocean into tidal freshwater to spawn in late winter and spring. Spawning generally occurs in April, May, and early June. Shortly after spawning, mature fish return to the coast. Most spend summer and early fall months in middle New England near-shore waters. In late fall and early winter they migrate south off the North Carolina and Virginia capes.

[a] Hill et al., 1989.
[b] Atlantic States Marine Fisheries Commission, 2000d.
[c] Jackson and Tiller, 1952.
[d] Bigelow and Schroeder, 1953.
[e] Miller, R.W, 1995.
[f] Setzler et al., 1980.
[g] Froese and Pauly, 2001.
Fish graphic from NOAA, 2001b.

Weakfish (*Cynoscion regalis*)

Weakfish is a member of the family Sciaenidae (drums), which is considered an important recreational and commercial resource along the Atlantic coast (Seagraves, 1995). Weakfish are found along the eastern seaboard, primarily from Massachusetts Bay to southern Florida (Seagraves, 1995). Adults travel in schools, following a seasonal migratory pattern from offshore wintering grounds in the spring to northern inland estuarine spawning grounds with warming of coastal waters in the spring (Seagraves, 1995). Weakfish spawn in the Delaware Estuary in spring and usually move north as far as Massachusetts for the summer (Shepherd and Grimes, 1984). These same fish over-winter as far south as Cape Hatteras, North Carolina. Weakfish favor shallow waters and sandy bottoms. They typically feed throughout the water column on fish, shrimp, and other small invertebrates (Seagraves, 1995).

Steady declines in weakfish landings since 1980 caused enough concern to prompt the Atlantic States Marine Fisheries Commission to develop a management plan for the species in 1985. In addition, the commission developed three amendments in an attempt to strengthen the management plan; the third amendment called for a 5-year restoration period to bring the weakfish population back to its historical age and size structure. Since 1993, annual landings have steadily increased (Atlantic States Marine Fisheries Commission, 2000f). Weakfish are very popular as a recreational fishing target in Delaware Bay and surrounding coastline. In a survey of Delaware anglers, weakfish was consistently one of the top three species targeted by anglers from 1982 to 1996 (PSEG, 1999). Recreational catches of weakfish in Delaware and New Jersey comprised greater than 70 percent the coastal recreational weakfish catch since 1995 (PSEG, 1999).

Spawning occurs shortly after the inshore migration, peaking from late April to June, with some geographic variation in timing. In the fall, an offshore and southerly migration of adults coincides with declining water temperatures (Atlantic States Marine Fisheries Commission, 2000f). Specific spawning time is correlated with the size of the individual; larger fish tend to spawn earlier (Shepherd and Grimes, 1984), often resulting in a bimodal distribution of size in larvae (Able and Fahay, 1998).

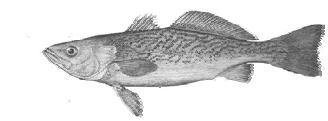
Fecundity of female weakfish varies with locality. A 50 cm (20 in) female weakfish from the New York Bight produced about 306,000 ova, while southern weakfish of the same size produced 2.05 million ova. Southern weakfish reproduce until approximately age 5, while northern weakfish can reproduce longer, meaning that lifetime fecundity would be similar (Shepherd and Grimes, 1984). Shepherd and Grimes (1984) found that females may not release all ova during spawning, and fertility may only be 60-75 percent of the estimated potential fecundity.

Weakfish eggs hatch approximately 50 hours after fertilization. The pelagic larvae hatch at 1.5 to 1.7 mm (0.6 to 0.7 in) in length, and move further upstream during the summer months. Though young-of-year are most abundant in estuarine waters, they have been found in coastal ocean waters and as far upstream as freshwater nurseries. Scales begin to form when larvae are approximately 14.3 mm (5.6 in) or 26 days old. Growth rates vary considerably depending on locality, salinity, and water temperature. Weakfish in the Delaware Bay tableed growth rates from 0.29 mm (0.1 in) per day at 20 ˚C (68 ˚F) to 1.49 mm (0.6 in) per day at 28 ˚C (82 ˚F) (Able and Fahay, 1998).

In the fall, weakfish less than 4 years of age tend to stay inshore and move southward to inner shelf waters, while older weakfish move southward to offshore areas until the spring (Seagraves, 1995).

As with most fish, size upon maturity for weakfish varies with locality. In northern weakfish, females mature at 25.4 cm (10 in), and males at 22.9 cm (9 in); in southern weakfish, both sexes mature at 17.8 cm (7 in). By age 2, all individuals are fully mature (Atlantic States Marine Fisheries Commission, 2000f). Weakfish may obtain a maximum size and age of approximately 80 cm (31.5 in) and 11 years in the northern part of their range (Shepherd and Grimes, 1983).

Weakfish larvae are most abundant near Salem from June to August (PSEG, 1999). Juveniles occur in summer and early fall. Eggs are present in some years, primarily in June and July.



WEAKFISH
(Cynoscion regalis)

Family: Sciaenidae (drums).

Common names: Gray/bastard/saltwater trout, silver seatrout, grey/bastard/common/silver weakfish, chickwick, gray/silver, silver seatrout.[a]

Similar species: Red drum, spot, spotted seatrout, Atlantic croaker.

Geographic Range: Along the Atlantic coast from Florida to Massachusetts, in shallow coastal and estuarine waters.[b] Estuaries provide feeding areas and spawning grounds for adult weakfish and are as important as nursery areas are for juveniles.[c]

Habitat: Occurs over sand and sandy mud bottoms in shallow coastal waters.[c]

Lifespan: Can live up to 11 years.[d]

Fecundity: Reach maturity at approximately 1 year. Fecundity for fish in the New York Bight is about 306,000. Females may not release all ova during spawning, meaning that fertility may be only 60-75 percent of total fecundity.[e]

Food source: Juveniles feed primarily on shrimp and other small invertebrates. Adults consume species such as butterfish, herrings, silversides, anchovies, young weakfish, Atlantic croaker, spot, scup, and killifishes.[f]

Prey for: Bluefish, striped bass, summer flounder, and larger weakfish.[f]

Life stage information:

Eggs:
- Hatch approximately 50 hours after fertilization.[c]

Larvae: *pelagic*
- Larvae are approximately 1.5-1.7 mm (0.6 to 0.7 in) long at hatching.[c]
- Larvae utilize tidal stream transport to move through the water column.[c]

Juveniles:
- Growth rates in the Delaware Bay range from 0.29 mm (0.1 in) per day at 20 ˚C (68 ˚F) to 1.49 mm (0.6 in) per day at 28 ˚C (82 ˚F).[c]
- Juveniles begin to migrate offshore and southward for overwintering in the fall.[c]

Adults:
- Travel in schools, and migrate seasonally from offshore wintering grounds to northern inland estuarine spawning grounds in the spring.[b]
- Adults can reach a maximum total length of 80 cm (31.5 in).[d]

Location:
- The young use the shore margins of the spawning area as nursery grounds.
- From spring through autumn, white perch are present on flats and in channels, retreating to deep channels in the winter.
- They move into waters with low salinity to freshwaters of large rivers in April through June.
- Located in estuaries and freshwater from Nova Scotia to South Carolina.
- Frequent areas with level bottoms of compact silt, mud, sand, or clay and show little preference for vegetation, structures, or other shelter.
- Able to live in salinities from zero to full strength seawater; they prefer waters < 18 percent salinity.

[a] Froese and Pauly, 2001.
[b] Seagraves, 1995.
[c] Able and Fahay, 1998.
[d] Shephard and Grimes, 1983.
[e] Shephard and Grimes, 1984.
[f] Seagraves, 1995.
Fish graphic from NOAA, 2001b.

White perch (*Morone americana*)

White perch is a member of the temperate bass family, Moronidae. Its geographic range extends from the upper St. Lawrence to South Carolina (Able and Fahay, 1998; Scott and Scott, 1988). Adults can be found in a wide range of habitats, but they prefer shallow water during warmer months (Stanley and Danie, 1983). In the winter months, adults can be found in deeper, saline waters (Beck, 1995). At the larval stage, white perch feed mainly on plankton. Adults feed on a variety of prey, including shrimp, fish, and crab. Their diet composition changes with seasonal and spatial food availability (Beck, 1995).

Unlike most other species, white perch has not suffered a drastic population decline in the past century. Because of their abundance, white perch are valuable for commercial fisheries and the recreational fishing industry. Their heartiness and abundance is due to their proliferation, early maturation, ability to utilize a large spawning and nursery ground, and tolerance of poor water quality (Beck, 1995).

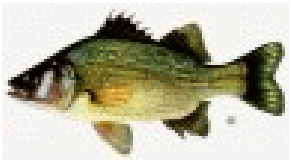
White perch are semi-anadromous, overwintering in deeper estuarine waters and migrating seasonally in the spring to spawn. Spawning occurs from April through early June in shallow waters of upstream brackish and freshwater tributaries. Fecundity estimates are higher for white perch than for other species of similar size, with estimates of 20,000 to 300,000 eggs per female (Stanley and Danie, 1983).

Depending on temperature, larvae hatch out between 2 to 6 days (Able and Fahay, 1998). Larvae are pelagic, remaining slightly below the surface of the water. They enter the juvenile stage in 6 weeks, at 20 to 30 mm (0.8 to 1.2 in) (Able and Fahay, 1998). Juveniles become increasingly demersal with size (Wang and Kernehan, 1979), and school in shallow, inshore waters through the summer. During the fall, juveniles tend to move offshore into more brackish, deeper waters to overwinter (Able and Fahay, 1998).

By age 1, white perch range from 72 to 93 mm (2.8 to 3.7 in). Rates of growth are positively correlated with water temperature during the first year (Able and Fahay, 1998). Most males and females reach maturity at age 2 to 3. Males were reported to mature at 72 mm (2.8 in) and females at 98 mm (3.9 in) (Stanley and Danie, 1983).

Average annual mortality rates for white perch in the Delaware River are 49 to 59 percent for males and 53 to 65 percent for females (Stanley and Danie, 1983). Mortality rates appear to be higher for females because females have higher growth rates and therefore reach a desirable harvest size earlier (Stanley and Danie, 1983). White perch up to 9 years of age have been caught in Delaware Bay (Wallace, 1971).

White perch larvae occur near Salem from April to July, with greatest abundance in April and May (PSEG, 1999). Juveniles occur from October to May. Adults are present throughout the year.



WHITE PERCH
(Morone americana)

Family: Moronidae, temperate bass.

Common names: White perch.[a]

Similar species: Striped bass.

Geographic range: Estuaries and freshwater from the upper St. Lawrence to South Carolina.[b,c]

Habitat: Occurs in fresh, brackish, and coastal waters, but prefers brackish, quieter waters.[a]

Lifespan: To 17 years (to 9 years in Delaware Bay).

Fecundity: Semi-anadromous spawners. Spawning occurs from April to early June in shallow waters of upstream brackish and freshwater tributaries. Females produce 20,000 to 300,000 eggs.[d]

Food source: White perch feed on zooplankton as larvae and juveniles. Adults primarily consume aquatic insects, but also crustaceans and fish, including their own young.[d]

Prey for: Striped bass, bluefish, weakfish, walleye.[a]

Life stage information:

Eggs: *demersal, semipelagic*
- Hatch out between 2 and 6 days.[b]

Larvae: *pelagic*
- Larvae float slightly below the surface of the water.[b]

Juveniles:
- White perch enter the juvenile stage in 6 weeks, at 20 to 30 mm (0.8 to 1.2 in).[b]
- School in shallow, inshore waters through the summer.[b]
- Move offshore to brackish, deeper waters to overwinter.[b]
- Growth rates are positively correlated with temperature during the first year.[b]

Adults:
- Reach maturity at 2 to 3 years of age, and lengths of 72 mm (2.8 in) for most males and 98 mm (3.9 in) for most females.[d]

[a] Froese and Pauly, 2001.
[b] Able and Fahay, 1998.
[c] Scott and Scott, 1988.
[d] Stanley and Danie, 1983.
Fish graphic courtesy of New York Sportfishing and Aquatic Resources Educational Program, 2001.

D2-4 I&E Data Evaluated

Table D2-3 lists Mid-Atlantic facilities in scope of the Phase II rule and the facility I&E data evaluated by EPA to estimate current I&E rates for the region. See Chapter A5 of Part A for a discussion of extrapolation methods.

Table D2-3: I&E Data Evaluated to Estimate Current I&E in the Mid-Atlantic Region

In Scope Facilities	I&E Data?	Years of Data
Astoria (NY)	No - extrapolated	
B L England (NJ)	No - extrapolated	
Baltimore Resco (MD)	No - extrapolated	
E F Barrett (NY)	No - extrapolated	
Bowline (NY)	No - extrapolated	
Brooklyn Navy Yard Cogeneration Partners, L.P. (NY)	No - extrapolated	
C P Crane (MD)	No - extrapolated	
Calvert Cliffs Nuclear (MD)	Yes	1975 - 1995
Chalk Point (MD)	Yes	1976, 1978, 1979
Chesapeake (VA)	No - extrapolated	
Chesterfield (VA)	No - extrapolated	
Danskammer (NY)	No - extrapolated	
Deepwater (NJ)	No - extrapolated	
Edge Moor (DE)	No - extrapolated	
Far Rockaway (NY)	No - extrapolated	
Glenwood (NY)	No - extrapolated	
Gould Street (MD)	No - extrapolated	
Grays Ferry Cogeneration Partnership (PA)	No - extrapolated	
Herbert A Wagner (MD)	No - extrapolated	
Hope Creek Nuclear (NJ)	No - extrapolated	
Hudson (NJ)	No - extrapolated	
Indian Point Nuclear (NY)	Yes	1981 - 1990
Indian Point 3 Nuclear (NY)	No - extrapolated	
Indian River (DE)	Yes	1975 - 1976
Kearny (NJ)	No - extrapolated	
Linden (NJ)	No - extrapolated	
Lovett (NY)	No - extrapolated	
Mercer (NJ)	No - extrapolated	
Morgantown (MD)	Yes	1976
Northport (NY)	No - extrapolated	
Oyster Creek Nuclear (NJ)	No - extrapolated	
Charles Poletti (NY)	No - extrapolated	
Possum Point (VA)	No - extrapolated	
Potomac River (VA)	No - extrapolated	
Ravenswood (NY)	No - extrapolated	
Riverside (MD)	No - extrapolated	
Roseton (NY)	No - extrapolated	
Salem Nuclear (NJ)	Yes	1978 - 1998
Sayreville (NJ)	No - extrapolated	

Table D2-3: I&E Data Evaluated to Estimate Current I&E in the Mid-Atlantic Region

In Scope Facilities	I&E Data?	Years of Data
Sewaren (NJ)	No - extrapolated	
Sparrows Point Div Bethlehem Steel Corp (MD)	No - extrapolated	
Surry Nuclear (VA)	No - extrapolated	
Westchester Resco Co., L.P. (NY)	No - extrapolated	
Yorktown (VA)	No - extrapolated	

D2-5 EPA's Estimate of Current I&E in the Mid-Atlantic Region Expressed as Age 1 Equivalents, Foregone Yield, and Production Foregone

Table D2-4 provides EPA's estimate of the annual age 1 equivalents, foregone fishery yield, and production foregone resulting from the impingement of aquatic species at facilities located in the Mid-Atlantic region. Table D2-5 displays this information for entrainment. Note that in these tables, "total yield" includes direct losses of harvested species and the yield of harvested species that is lost due to losses of forage species. As discussed in detail in Chapter A5 of Part A of the section 316(b) Phase II Regional Study Document, the conversion of forage to yield contributes only a very small fraction to total yield.

Table D2-4: Current Annual Impingement in the Mid-Atlantic Region Expressed as Age 1 Equivalents, Foregone Fishery Yield, and Production Foregone

Species	Age 1 Equivalents (#s)	Total Yield (lbs)	Production Foregone
Alewife	36,730	328	6,357
American shad	61	15	37
Atlantic croaker	1,548,681	315,292	222,691
Atlantic menhaden	167,155,354	32,499,546	21,439,964
Atlantic tomcod	7	0	1
Bay anchovy	37,370,733	0	50,156
Blue crab	12,883,412	93,769	888,043
Blueback herring	123,460	0	32,122
Hogchoker	1,215,841	0	549
Naked goby	19,768	0	4
Other (commercial)	2,921,928	568,102	374,777
Other (forage)	12,141,704	0	18,004
Other (recreational and commercial)	1,736,708	337,663	338,614
Other (recreational)	195,864	38,081	25,122
Spot	18,299,940	2,049,584	1,235,941
Striped bass	199,780	277,288	311,016
Summer flounder	126,268	177,517	7,984
Weakfish	827,030	650,200	537,233
White perch	23,360,666	10,280	1,472,639
Windowpane	657	61	30
Winter flounder	116,962	12,594	7,557

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Table D2-5: Current Annual Entrainment in the Mid-Atlantic Region Expressed as Age 1 Equivalents, Foregone Fishery Yield, and Production Foregone.

Species	Age 1 Equivalents (#s)	Total Yield (lb)	Production Foregone
Alewife	4,562	41	7,022
American shad	14,018	3,431	75,968
Atlantic croaker	41,156,879	8,379,019	15,509,049
Atlantic menhaden	6,411,986	1,246,665	356,167
Bay anchovy	937,050,082	0	4,579,187
Blue crab	219,544,794	1,597,900	14,179,364
Blueback herring	19,029	0	21,796
Hogchoker	6,779,081	0	17,520,451
Naked goby	102,950,816	0	1,845,772
Other (commercial)	30,744	5,977	70,610
Other (forage)	17,891,263	0	161,470
Other (recreational and commercial)	20,811,436	4,046,309	5,128,817
Spot	70,646,917	7,912,419	10,755,819
Striped bass	1,579,532	2,192,332	7,460,609
Weakfish	2,993,309	2,353,300	2,813,383
White perch	24,541,655	10,799	1,918,290
Winter flounder	431,307	46,442	1,530,530

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D2-6 Assumptions Used in Calculating Recreational and Commercial Losses

The lost yield estimates presented in Tables D2-4 and D2-5 are expressed as total pounds and include losses to both commercial and recreational catch. To estimate the economic value of these losses, total yield was partitioned between commercial and recreational fisheries based on the landings in each fishery. Table D2-6 presents the percentage impacts assumed for each species and the value per pound for commercially harvested species.

Age-1 equivalent fish that are spared from I&E are not necessarily old enough or large enough to be attractive to anglers. It may take one or more years for these fish to reach a harvestable age. For this reason, EPA discounts commercial and recreational benefits so that the cost and benefits estimates will be comparable. Tables D2-7 and D2-8 present the multiplicative discounting factors used in discounting benefits assuming a 3 percent real discount rate and a 7 percent real discount rate. For details on how these factors are developed, see Chapter A14.

Table D2-6: Percentage of Total Impacts Occurring to the Commercial and Recreational Fisheries and Commercial Value per Pound for Species Impinged and Entrained at Mid-Atlantic Facilities

Species Group	Percent Impact to Recreational Fishery[a,b]	Percent Impact to Commercial Fishery[a,b]	Commercial Value per Pound (2002$)[c]
Alewife	0.0%	100.0%	$0.11
American shad	0.0%	100.0%	$0.61
Atlantic croaker	66.4%	33.6%	$0.33
Atlantic herring	19.0%	81.0%	$0.08
Atlantic menhaden	0.0%	100.0%	$0.07
Blue crab	0.0%	100.0%	$0.76
Other (commercial)	0.0%	100.0%	$0.53
Other (recreational)	100.0%	0.0%	na
Other (recreational and commercial)	50.0%	50.0%	$0.53
Spot	52.4%	47.6%	$0.43
Striped bass	95.5%	4.5%	$1.69
Summer flounder	88.0%	12.0%	$1.55
Weakfish	77.2%	22.8%	$0.66
White perch	66.0%	34.0%	$0.60
Windowpane	0.0%	100.0%	$0.37
Winter flounder	63.0%	37.0%	$1.20
Other (forage)[d]	50.0%	50.0%	$0.39

[a] Based on landings from 1993 to 2001.
[b] Calculated using recreational landings data from NMFS (2003a, http://www.st.nmfs.gov/recreational/queries/catch/snapshot.html) and commercial landings data from NMFS (2003b, http://www.st.nmfs.gov/commercial/landings/annual_landings.html).
[c] Calculated using commercial landings data from NMFS (2003b).
[d] Assumed equally likely to be caught by recreational or commercial fishermen. Commercial value calculated as overall average for region based on data from NMFS (2003b).

Table D2-7: Factors Applied to Recreational Benefits to Implement Discounting in the Mid-Atlantic

Species Group	Discount Factors for Entrainment		Discount Factors for Impingement	
	3% Discount Rate	7% Discount Rate	3% Discount Rate	7% Discount Rate
Atlantic croaker	0.934	0.858	0.962	0.918
Other (recreational)	na	na	0.950	0.889
Other (recreational and commercial)	0.922	0.831	0.950	0.889
Spot	0.949	0.888	0.977	0.950
Striped bass	0.864	0.717	0.879	0.749
Summer flounder	na	na	0.941	0.874
Weakfish	0.950	0.890	0.979	0.953
White perch	0.900	0.786	0.904	0.796
Windowpane	0.884	0.759	na	na
Winter flounder	na	na	0.911	0.812
Other (forage)	0.919	0.829	0.919	0.829

Table D2-8: Factors Applied to Commercial Benefits to Implement Discounting in the Mid-Atlantic

Species Group	Discount Factors for Entrainment		Discount Factors for Impingement	
	3% Discount Rate	7% Discount Rate	3% Discount Rate	7% Discount Rate
Alewife	0.872	0.730	0.898	0.782
American shad	0.867	0.723	0.893	0.773
Atlantic croaker	0.899	0.788	0.926	0.843
Atlantic menhaden	0.930	0.847	0.958	0.906
Blue crab	0.949	0.888	0.978	0.950
Other (commercial)	0.913	0.813	0.940	0.870
Other (recreational and commercial)	0.913	0.813	0.940	0.870
Spot	0.921	0.831	0.949	0.889
Striped bass	0.841	0.675	0.848	0.692
Summer flounder	na	na	0.890	0.773
Weakfish	0.924	0.836	0.951	0.895
White perch	0.895	0.777	0.899	0.785
Windowpane	na	na	0.883	0.756
Winter flounder	0.859	0.711	0.885	0.761
Other (forage)	0.901	0.793	0.901	0.793