Chapter G3: Evaluation of I&E Data

EPA evaluated I&E impacts to aquatic organisms resulting from the CWIS of the Seabrook and Pilgrim facilities using the assessment methods outlined in Chapter A2 of Part A of this document. Section G3-1 of this chapter lists fish species that are impinged and entrained at Seabrook and Pilgrim and Section G3-2 presents life histories of the most abundant species in the facilities' I&E collections. Section G3-3 outlines Seabrook's I&E collection methods and Section G3-4 presents results of EPA's analysis of annual impingement and entrainment at Seabrook. Section G3-5 outlines Pilgrim's I&E collection methods and Section G3-6 presents annual impingement and entrainment results for Pilgrim. Section G3-7 summarizes and compares I&E results for the two facilities and Section G3-8 discusses some potential biases and uncertainties in I&E results.

Chapter Contents

G3-1 Aquatic Species Vulnerable to I&E at the Seabrook and Pilgrim Facilities G3-1
G3-2 Life Histories of Most Abundant Species in Seabrook and Pilgrim I&E Collections G3-3
G3-3 Seabrook's Methods for Estimating Impingement and Entrainment G3-13
G3-3.1 Seabrook Impingement and Entrainment Monitoring G3-13
G3-3.2 Seabrook Entrainment Monitoring G3-13
G3-4 Seabrook's Annual Impingement and Entrainment G3-14
G3-5 Pilgrim's Methods for Estimating Impingement and Entrainment G3-14
G3-5.1 Pilgrim Impingement and Entrainment Monitoring G3-14
G3-5.2 Pilgrim Entrainment Monitoring G3-14
G3-6 Pilgrim's Annual Impingement and Entrainment . . G3-14
G3-7 Summary and Comparison of I&E at Seabrook and Pilgrim G3-51
G3-8 Potential Biases and Uncertainties in I&E Estimates G3-51

G3-1 Aquatic Species Vulnerable to I&E at the Seabrook and Pilgrim Facilities

EPA evaluated aquatic species impinged and entrained by the Seabrook and Pilgrim facilities, including commercial, recreational, and forage species, based on information provided in facility I&E monitoring reports. Approximately 84 different species of fish have been identified in I&E collections at Seabrook since monitoring began in 1990, and at least 58 (69%) of these are valued commercially or recreationally (Normandeau Associates, 1991, 1993, 1994a, 1994b, 1995, 1996a, 1996b, 1997, 1999). At the Pilgrim facility, approximately 68 species have been identified in I&E collections since 1974, and 26 (38%) of these have commercial or recreational value (Boston Edison Company, 1991-1994, 1995a, 1995b, 1996-1999, Stone & Webster Engineering Corporation, 1977). Table G3-1 lists species identified in Seabrook and Pilgrim I&E collections. Species with impingement or entrainment losses above one percent of total impingement or entrainment losses respectively were evaluated. Species with similar life histories were evaluated together.

Table G3-1: Aquatic Species Vulnerable to I&E at the Seabrook and Pilgrim Facilities

Common Name	Scientific Name	Seabrook	Pilgrim	Commercial	Recreational	Forage
Alewife	*Alosa pseudoharengus*		✓		X	
Alligatorfish	*Aspidophoroides monopterygius*	✓				X
American eel	*Anguilla rostrata*	✓	✓	X	X	
American lobster	*Homarus americanus*	✓		X	X	
American plaice	*Hippoglossoides platessoides*	✓	✓	X		
American sand lance	*Ammodytes americanus*	✓	✓			X
American shad	*Alosa sapidissima*	✓		X	X	
Atlantic cod	*Gadus morhua*	✓	✓	X	X	
Atlantic herring	*Clupea harengus*	✓	✓	X		
Atlantic mackerel	*Scomber scombrus*	✓	✓	X	X	
Atlantic menhaden	*Brevoortia tyrannus*	✓	✓	X	X	
Atlantic moonfish	*Selene setapinnis*	✓	✓			X

Table G3-1: Aquatic Species Vulnerable to I&E at the Seabrook and Pilgrim Facilities (cont.)

Common Name	Scientific Name	Seabrook	Pilgrim	Commercial	Recreational	Forage
Atlantic seasnail	*Liparis atlanticus*	✓				X
Atlantic silverside	*Menidia menidia*	✓	✓			X
Atlantic tomcod	*Microgadus tomcod*	✓	✓		X	
Atlantic torpedo	*Torpedo nobiliana*					X
Bay anchovy	*Anchoa mitchilli*		✓			X
Black ruff	*Centrolophus niger*	✓	✓			X
Black sea bass	*Centropristis striata*	✓	✓	X	X	
Blackspotted stickleback	*Gasterosteus wheatlandi*		✓			X
Blue mussel	*Mytilus edulis*	✓	✓	X	X	
Blueback herring	*Alosa aestivalis*	✓	✓		X	
Bluefish	*Pomatomus saltator*	✓	✓	X	X	
Butterfish	*Peprilus triacanthus*	✓	✓	X	X	
Clearnose skate	*Raja eglanteria*	✓				X
Conger eel	*Conger oceanicus*	✓		X		
Cunner	*Tautogolabrus adspersus*		✓	X	X	
Flying gurnard	*Dactylopterus volitans*	✓	✓			X
Fourbeard rockling	*Enchelyopus cimbrius*	✓	✓			X
Fourspine stickleback	*Apeltes quadracus*	✓				X
Fourspot flounder	*Paralichthys oblongus*	✓	✓	X		
Goosefish	*Lophius americanus*	✓		X		
Grubby	*Myoxocephalus aenaeus*	✓	✓			X
Gulf snailfish	*Liparis coheni*	✓				X
Haddock	*Melanogrammus aeglefinus*	✓		X	X	
Hake species	Lotidae	✓	✓	X	X	
Herring species	Clupeidae			X	X	
Hogchoker	*Trinectes maculatus*	✓	✓			X
Killifish species	Fundulidae	✓			X	
Lefteye flounder	Bothidae	✓		X	X	
Little skate	*Leucoraja erinacea*	✓	✓	X		
Longhorn sculpin	*Myoxocephalus octodecemspinosus*	✓	✓	X		
Lumpfish	*Cyclopterus lumpus*	✓	✓			X
Moustache sculpin	*Triglops murrayi*	✓				X
Mummichog	*Fundulus heteroclitus heteroclitus*	✓	✓			X
Northern kingfish	*Menticirrhus saxatilis*	✓	✓		X	
Northern pipefish	*Syngnathus fuscus*	✓	✓			X
Northern puffer	*Sphoeroides maculatus*	✓	✓			X
Northern searobin	*Prionotus carolinus*	✓	✓			X
Ocean pout	*Zoarces americanus*			X		
Orange filefish	*Aluterus schoepfii*	✓	✓			X
Oyster toadfish	*Opsanus tau*					X
Pearlside	*Maurolicus muelleri*	✓	✓			X
Planehead filefish	*Stephanolepis hispidus*	✓	✓			X
Pollock	*Pollachius pollachius*	✓	✓	X	X	
Radiated shanny	*Ulvaria subbifurcata*	✓	✓			X
Rainbow smelt	*Osmerus mordax mordax*	✓	✓	X	X	
Red hake	*Urophycis chuss*	✓	✓	X		
Redfish (Red drum)	*Sciaenops ocellatus*	✓		X		
Righteye flounders	Pleuronectidae	✓		X	X	
Rock gunnel	*Pholis gunnellus*	✓	✓			X
Rough scad	*Trachurus lathami*					X
Round scad	*Decapterus punctatus*		✓			X
Sand lance species	*Ammodyte spp.*	✓	✓			X
Sand tiger	*Carcharias taurus*	✓				X

Table G3-1: Aquatic Species Vulnerable to I&E at the Seabrook and Pilgrim Facilities (cont.)

Common Name	Scientific Name	Seabrook	Pilgrim	Commercial	Recreational	Forage
Sculpin species	Cottidae	✓	✓	X		
Scup	*Stenotomus chrysops*	✓	✓	X	X	
Sea lamprey	*Petromyzon marinus*	✓				X
Sea raven	*Hemitripterus americanus*	✓				X
Searobin species	Triglidae	✓	✓		X	
Shorthorn sculpin	*Myoxocephalus scorpius*	✓	✓			X
Silver hake/Atlantic whiting	*Merluccius bilinearis*		✓	X	X	
Silver-rag	*Ariomma bondi*	✓	✓			X
Skate species	Rajidae			X		
Smallmouth flounder	*Etropus microstomus*		✓			X
Smooth dogfish	*Mustelus canis*	✓	✓			X
Smooth flounder	*Pleuronectes putnami*	✓				X
Snailfish species	Cyclopteridae	✓	✓			X
Spiny dogfish	*Squalus acanthias*		✓	X		
Spot	*Leiostomus xanthurus*		✓			X
Spotted hake	*Urophycis regia*	✓	✓			X
Striped anchovy	*Anchoa hepsetus*	✓				X
Striped bass	*Morone saxatilis*	✓	✓	X	X	
Striped cusk-eel	*Ophidion marginatum*		✓			X
Striped killifish	*Fundulus majalis*		✓			X
Striped searobin	*Prionotus evolans*	✓	✓			X
Summer flounder	*Paralichthys dentatus*	✓	✓	X	X	
Tautog	*Tautoga onitis*	✓	✓	X	X	
Threespine stickleback	*Gasterosteus aculeatus aculeatus*	✓	✓			X
White hake	*Urophycis tenuis*	✓	✓	X		
White perch	*Morone americana*	✓	✓	X	X	
Windowpane	*Scophthalmus aquosus*	✓	✓	X	X	
Winter flounder	*Pleuronectes americanus*	✓	✓	X	X	
Witch flounder	*Glyptocephalus cynoglossus*	✓		X		
Wolf-fish	*Anarhichas lupus*	✓			X	
Wrymouth	*Cryptacanthodes maculatus*	✓				X
Yellowtail flounder	*Limanda ferruginea*		✓	X	X	

Sources: Saila et al., 1997; Stone & Webster Engineering Corporation, 1977; Normandeau Associates 1991, 1993-1995, 1996a, 1996b, 1997; Boston Edison Company, 1991-1994, 1995a, 1995b, 1996-1999.

G3-2 Life Histories of Most Abundant Species in Seabrook and Pilgrim I&E Collections

Atlantic cod (*Gadus morhua*)

Atlantic cod is a member of the Gadidae family, which includes cods and haddocks. The species is found from Greenland south to Cape Hatteras, North Carolina (Fahay et al., 1999). Atlantic cod is an extremely important commercial and recreational fish in the United States and Canada. The northern cod stock declined by almost two orders of magnitude between 1962 and 1992. The collapse of the fishery was due to excessive pressure from fishing (Hutchings, 1996). The 1987 year class was the largest in the period from 1982 to 1998; however, recruitment remains poor and year classes through the 1990s were weak (NOAA, 2001c). Currently the United States and Canadian Atlantic cod fisheries are managed through techniques such as closures, minimum size limits, days-at-sea restrictions, and quotas.

In U.S. waters, cod are evaluated and managed as two stocks, (1) the Gulf of Maine, and (2) Georges Bank and south (NEFSC, 2000b). Commercial and recreational fishing occurs throughout the year, but most recreational fishing occurs in late summer in the lower Gulf of Maine. Both commercial and recreational fishing are managed under the New England

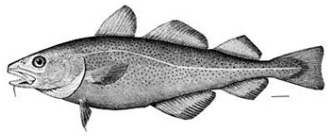
Fishery Management Council's Northeast Multispecies Management Plan. The goal of the plan is to reduce fishing mortality to levels which will allow stocks to rebuild.

Spawning begins in northern areas as early as February and ends in southern areas as late as December (Scott and Scott, 1988). Cod spawn repeatedly for up to 50 days once a year (Kjesbu, 1989). Annual fecundity increases with age and size (May, 1967), with large females producing between 3 to 9 million eggs (Fahay et al., 1999). Spawning occurs at various depths, from less than 110 m (360 ft) to more than 182 m (597 ft), depending on water temperature (Scott and Scott, 1988). Eggs are distributed throughout the water column, although their buoyancy tends to concentrate them in a cold intermediate layer if the water is stratified (Ouellet, 1997). Egg development in cooler waters (0 ˚C or 32 ˚F) usually extends for 40 days (Scott and Scott, 1988; Ouellet, 1997).

The pelagic larvae move to the bottom during the day and rise at night (Lough and Potter, 1993; Gotceitas et al., 1997). Age 0 and age 1 cod are both found in nearshore environments, preferably over sandy substrates (Fraser et al., 1996), and young cod often seek cover in eelgrass (*Zostera marina*) (Gotceitas et al., 1997). Juveniles 40 mm (0.16 in.) or larger are demersal by day, but will frequently rise up to 5 m (16 ft) off the bottom at night (Lough and Potter, 1993).

Atlantic cod eat a variety of foods throughout their lifetime (Scott and Scott, 1988). Fry eat copepods, amphipods, larvae, and small crustaceans; juveniles eat larger crustaceans; and adults over 50 cm (19 in.) eat fish, including smaller cod, as well as invertebrates. Age 0 cod primarily feed during the day, while age 1 cod generally feed at night (Grant and Brown, 1998).

Adult Atlantic cod live in diverse habitats ranging from inshore waters to the outer continental shelf, and from depths of 457 m (1,500 ft) to surface waters. They generally prefer cooler water temperatures ranging from -0.5 to 10 ˚C (31 to 50 ˚F; Scott and Scott, 1988). Off the New England coast, Atlantic cod migrate seasonally, moving into coastal waters in the fall and returning to deeper waters during spring (Fahay et al., 1999). Adults reach sexual maturity at ages 2 to 4 (NOAA, 2001c). Cod can reach a total length of 200 cm (78 in.), a maximum weight of 96 kg (212 lb), and a maximum age of 25 (Froese and Pauly, 2001).



ATLANTIC COD
(Gadus morhua)

Family: Gadidae (cods and haddocks).

Common names: Atlantic cod.

Similar species: Greenland cod (*G. ogac*), Pacific cod (*G. macrocephalus*).

Geographic range: Can be found from Greenland south to Cape Hatteras, North Carolina.[a]

Habitat: Diverse habitats ranging from inshore waters to the outer continental shelf, and from depths of 457 m (1,500 ft) to surface waters.[b]

Lifespan: Maximum reported age is 25 years.[c]

Fecundity: Large females may produce between 3 to 9 million eggs.[a]

Food source: Larvae and juveniles consume copepods, amphipods, larvae, and crustaceans. Adults feed on fish, including smaller cod, as well as invertebrates.[b] Age 0 cod feed during the day, Age 1 cod feed primarily at night.[d]

Prey for: Larger cod, squid, pollock, and seals.[c]

Life stage information:

Eggs: *pelagic*

- Distributed throughout the water column.[e]

Larvae: *pelagic*

- Move to the bottom during the day and rise at night.[f]
- Found in nearshore environments, preferably over sandy substrates or in eelgrass.[g,h]

Juveniles: *demersal*

- Larger juveniles are mainly demersal, but will rise up to 5 m (16 ft) off the bottom at night.[f]

***Adults*:**

- Adult Atlantic cod in the Gulf of Maine migrate northward in fall, traveling up to 500 km (310 miles) to overwinter off of eastern Canada.[i]
- Move into coastal waters in the fall, and return to deeper waters during spring.[a]

[a] Fahay et al., 1999.
[b] Scott and Scott, 1988.
[c] Froese and Pauly, 2001.
[d] Grant and Brown, 1998.
[e] Ouellet, 1997.
[f] Lough and Potter, 1993.
[g] Fraser et al., 1996.
[h] Gotceitas et al., 1997.
[i] Campana et al., 1999.
Fish graphic from NOAA, 2002e.

Atlantic herring (*Clupea harengus*)

Atlantic herring is a member of the Clupeidae family, which includes herring, sardines, and shads. It ranges from southwestern Greenland and Labrador to South Carolina (Scott and Scott, 1988). Herring fisheries developed in the late 1800's, concurrent with the development of canning technology. Herring were also used as bait for the lobster industry, which developed at about the same time. Annual landings were as high as 68 million kg (150 million lb) in the late 1800's (Atlantic States Marine Fisheries Commission, 2001a). Particularly aggressive foreign fisheries developed in the 1960's on Georges Bank, with landings peaking at 363 million kg (800 million lb) in 1968. This overfishing contributed to a crash of the Atlantic herring population. Current annual harvests are in the range of 36 to 45 million kg (80 to 100 million lb) (Atlantic States Marine Fisheries Commission, 2001a). Primary uses of Atlantic herring are as canned sardines, steaks, and bait for crab, lobster, and tuna fisheries (Atlantic States Marine Fisheries Commission, 2001a).

Atlantic herring along the northeastern Atlantic coast were previously managed as two stocks, the Gulf of Maine stock and the Georges Bank stock. However, herring from the two stocks are now considered together as a single coastal stock complex for current management purposes (NEFSC, 2000c). The offshore fishery collapsed in 1977, and subsequently the commercial fishery focused on the near shore waters of the Gulf of Maine. Stock biomass has increased substantially in recent years because of increased spawning and low fishing mortality. Recreational landings in recent years have been inconsequential.

Spawning occurs throughout the year, peaking in shallow waters in the spring and deeper waters in the fall (Scott and Scott, 1988). Spawning in waters of coastal Massachusetts takes place usually in October or November at depths ranging from 4 to 110 m (13 to 360 ft) (Kelly and Moring, 1986). Adults may travel long distances to return to spawning grounds, which consist of rock, gravel, or sandy substrates (Kelly and Morning, 1986). Fecundity increases with age and size, with females producing between 23,000 and 261,000 eggs (Messieh, 1976). Atlantic herring eggs are demersal, stick to the bottom in clumps or layers, and often cover the substrate (Atlantic States Marine Fisheries Commission, 2001a). Eggs are generally 1.0 to 1.4 mm (0.04 to 0.06 in.) in diameter and hatch after 10 to 30 days, depending on temperature. Larvae are 4 to 10 mm (less than 0.4 in.) in total length (Able and Fahay, 1998).

Larvae disperse to estuaries after hatching, and grow to approximately 30 mm (1.2 in.) long before transforming into juveniles (Able and Fahay, 1998). Transformation occurs after about 152 days at water temperatures of 7 to 12 ˚C (44 to 54 ˚F) (Doyle, 1977), but can last as long as 240 days for late-spawned (December) herring (Reid et al., 1999). Larvae hatched earlier in the season tend to grow faster than those hatched later (Jones, 1985). These juveniles, called “brit herring,” move in large inshore schools. Larger juveniles are referred to as “sardines” and are harvested commercially (Jury et al., 1994).

Adults are found in coastal and continental shelf waters at depths of up to 200 m (656 ft) and in water temperatures from 1 to 18 ˚C (34 to 64 ˚F; Atlantic States Marine Fisheries Commission, 2001a; Froese and Pauly, 2001). Feeding migrations may consist of hundreds of thousands of adults. Schools are composed of individuals of similar size classes, and tend to inhabit the upper water column. Most Atlantic herring migrate south in the fall from feeding grounds off Maine to southern New England (Kelly and Moring, 1986).

Food sources are primarily small planktonic copepods in the first year, and copepods thereafter. Atlantic herring switch to filter feeding if the density and size of food are appropriate (Froese and Pauly, 2001). Adult herring will also eat fish eggs, pteropods (small molluscs), and the larvae of mollusks and fish (Scott and Scott, 1988).

Growth rates of Atlantic herring are highly variable by stock, and herring typically reach maturity between the ages of 3 and 5 (Scott and Scott, 1988). Environmental factors such as temperature, food availability, and population size generally control growth. Atlantic herring reach 250 mm (10 in.) by the fourth year and may eventually reach 380 mm (15 in.) and 0.68 kg (1.5 lb) (Atlantic States Marine Fisheries Commission, 2001a). A Gulf of St. Lawrence study reported Atlantic herring of 12 years (Scott and Scott, 1988).

ATLANTIC HERRING
(Clupea harengus)

Family: Clupeidae (herrings).[a]

Common names: sea herring, sardine, herring.[b]

Similar species: Pacific herring (*C. pallasii*), alewives (*Alosa pseudoharengus*).[a]

Geographic range: Can be found from southwestern Greenland and Labrador to South Carolina.[a]

Habitat: Coastal and continental shelf waters at depths of up to 200 m (656 ft).[a]

Lifespan: Up to 12 years.[a]

Fecundity: Females produce between 23,000 and 261,000 eggs.[c]

Food source: Young of year primarily feed on small planktonic copepods; adults consume larger copepods, fish eggs, pteropods (small molluscs), and the larvae of mollusks and fish.[a]

Prey for: Almost all pelagic predators as well as many seabirds, marine mammals, and bottom dwellers (eggs only).[a]

Life stage information:

Eggs: *demersal*
- Stick to the bottom in clumps or layers, and often cover the substrate.[b]

Larvae: *pelagic*
- Larvae disperse to estuaries after hatching.[d]

Juveniles: *pelagic*
- Harvested commercially as "sardines."[e]

Adults:
- Form schools of hundreds of thousands of individuals of the same size class.[f]
- Most migrate south in the fall from feeding grounds off Maine to southern New England.[f]

[a] Scott and Scott, 1988.
[b] Atlantic States Marine Fisheries Commission, 2001a.
[c] Messieh, 1976.
[d] Able and Fahay, 1998.
[e] Jury et al., 1994.
[f] Kelly and Moring, 1986.
Fish graphic from Government of Newfoundland and Labrador, 2002.

Atlantic mackerel (*Scomber scrombrus*)

Atlantic mackerel is a member of the Scombridae family, which includes mackerels, tunas, and bonitos. Atlantic mackerel range from Labrador to Cape Lookout, North Carolina. The species tends to school in large groups in shelf areas with water temperatures of 9 to 12 ˚C (48 to 54 ˚F; Scott and Scott, 1988). Atlantic mackerel is fished both commercially and for sport. Fish caught in the United States and Canada peaked in 1973 at 400 million kg (400,000 metric tons) per year and declined to a low of 30 million kg (30,000 metric tons) in the late 1970's. Weak year classes occurred from 1975 through 1980 but stocks are currently very high (NEFSC, 2000a). Stock increases have resulted from low harvest rates combined with improved recruitment.

Winters are spent in deeper waters, but mackerel return to shore in springtime to spawn. There are two major spawning areas for Atlantic mackerel: between Cape Cod and Cape Hatteras, and in the Gulf of St. Lawrence (Scott and Scott, 1988). In the Gulf of St Lawrence, Atlantic mackerel spawn from June to mid-August, whereas in the northern regions of the Mid-Atlantic Bight they spawn from April to June (Ware and Lambert, 1985). In summer and fall, fish from the Mid-Atlantic Bight move into coastal areas along the Gulf of Maine, while the northern contingent remains in Canadian waters (Ware and Lambert, 1985).

Females are serial spawners, releasing five to seven successive batches of eggs each year (Morse, 1980b). Fecundity values for females in U.S. waters of the northwestern Atlantic range from approximately 156,000 to 1,640,000 eggs for females between 310 and 446 mm (12 to 19 in.) fork length (Griswold and Silverman, 1992). Eggs are pelagic and are released near the surface, where they concentrate in the upper 10 m (33 ft) of water (Scott and Scott, 1988). At hatching, larvae are about 3 mm (0.1 in.) long (Ware and Lambert, 1985). Larvae grow rapidly, reaching an average size of 200 mm (8 in.) by late fall (Scott and Scott, 1988).

Atlantic mackerel feed by both filter feeding and prey selection. Food sources include zooplankton, shrimp, crab larvae, small squid, fish eggs, and young fish such as capelin and herring. After spawning, adults generally migrate in schools to offshore feeding areas before returning to their overwintering sites (Scott and Scott, 1988).

Once juveniles join the offshore adults, they remain in schools. Adults are obligate swimmers owing to the absence of a swim bladder (Scott and Scott, 1988). Atlantic mackerel mature at about 2 years or 26 cm (10 in.) (NMFS, 1999b). They may live up to 17 years and attain length of up to 50 cm (20 in.) (Froese and Pauly, 2001).

ATLANTIC MACKEREL
(Scomber scombrus)

Family: Scombridae (mackerels, tunas, bonitos).[a]

Common names: Mackerel, tinker (half-grown mackerel).

Similar species:

Geographic range: Can be found from Labrador, Canada to Cape Lookout, North Carolina.[a]

Habitat: Open marine waters, mainly within the continental shelf.[b]

Lifespan: Maximum reported age is 17 years.[c]

Fecundity: Females produce approximately 156,000 to 1,640,000 eggs.[d]

Food source: Zooplankton, shrimp, crab larvae, small squid, fish eggs, and young capelin and herring.[a]

Prey for: Porbeagle sharks, dogfish, Atlantic cod, bluefin tuna, swordfish, porpoises, and harbor seals.[a]

Life stage information:

Eggs: *pelagic*
- Eggs are released near the surface.[a]

Larvae: *pelagic*
- Grow rapidly, reaching an average size of 200 mm (8 in.) by late fall.[a]

Juveniles:
- Join the offshore adults and remain in schools.[b]

Adults:
- School in large groups in shelf areas.[b]
- Are obligate swimmers owing to the absence of a swim bladder.[a]

[a] Scott and Scott, 1988.
[b] Studholme et al., 1999.
[c] Froese and Pauly, 2001.
[d] Griswold and Silverman, 1992.
Fish graphic from NOAA, 2001c.

Atlantic menhaden (*Brevoortia tyrannus*)

The Atlantic menhaden is a member of the Clupeidae (herring) family, and 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 adjacent to 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 piscivorous, recreationally important fish, as well as dolphins and birds (Hall, 1995).

The menhaden fishery is one of the most important and productive fisheries on the Atlantic coast, representing a multimillion-dollar enterprise worldwide (Hall, 1995). Menhaden are considered an “industrial fish” and are used in products such as paints, cosmetics, margarine (in Europe and Canada) and feed, as well as bait for other fisheries. The fishery in New England peaked in the 1950’s with 36 million kg (36,000 metric tons) landed. Landings in the 1960’s declined to their lowest level of approximately 2,700 kg (2.7 metric tons) because of overfishing. Since then, landings have varied, ranging from approximately 200,000 kg (200 metric tons) in 1989 to 1 million kg (1,000 metric tons) in 1998 (personal communication, National Marine Fisheries Service, Fisheries Statistics and Economics Division, Silver Spring, MD, March 19, 2001).

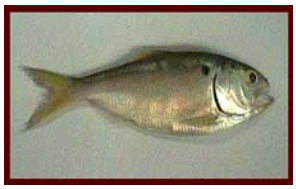
Atlantic menhaden spawn year round at sea and in larger bays. In waters from Maine to Massachusetts, spawning takes place from May to October (Scott and Scott, 1988). The majority of spawning occurs over the inner continental shelf, with lesser activity in bays and estuaries (Able and Fahay, 1998).

Females mature between ages 2 and 3, and release buoyant, planktonic eggs during spawning (Hall, 1995). Atlantic menhaden annual egg production ranges from approximately 40,000 to 700,000 eggs (Hall, 1995). Eggs are spherical and are 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. Those larvae that hatch at sea enter estuarine waters 1 to 2 months later (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 are 30 mm (0.1 in.) and 70 mg (0.0001 lb) and juveniles are 38 mm (0.15 in.) and approximately 470 mg (0.001 lb; Lewis et al., 1972). The juvenile growth rate 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 to the North Carolina capes, where they remain until March and early April. Few larvae can tolerate waters below 3 ˚C (37 ˚F), or waters that rapidly cool to 4.5 ˚C (40 ˚F). Adults and juveniles can tolerate a wide range of salinities from less than 1% up to 33-37% (Hall, 1995). Menhaden spawn in early spring and winter off North Carolina and in spring and late fall in the mid-Atlantic region (Wang and Kernehan, 1979). However, primary spawning grounds for Atlantic menhaden are offshore near Cape Cod (Jury et al., 1994).

Adult fish are usually 30-35 cm (12-14 in.) long and weigh 0.9 kg (2 lb). 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).[a]

Common names: Menhaden, moss bunker, fatback.[b]

Similar species: Gulf menhaden (*B. patronus*), yellowfin menhaden (*B. smithi*).

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

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

Lifespan: Approximately 7 to 8 years.[c]

Fecundity: Females produce between 40,000 to 700,000 eggs.[c]

Food source: Phytoplankton, zooplankton, annelid worms, detritus.[a]

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

Life stage information:

Eggs: *pelagic*
- Spawning takes place along the inner continental shelf, in open marine waters, with less activity in bay and estuaries.[d]
- Hatch after approximately 24 hours.[c]

Larvae: *pelagic*
- Hatch at sea, and enter estuarine waters 1 to 2 months later.[c]
- 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, primarily May to October from Main to Massachusetts.[a]

[a] Scott and Scott, 1988.
[b] Bigelow and Schroeder, 1953.
[c] Hall, 1995.
[d] Able and Fahay, 1998.
Fish graphic from U.S. EPA, 2002a.

Cunner (*Tautogolabrus adspersus*)

Cunner is a member of the Labridae family, which includes the tautog. Cunner is a dominant component of many temperate marine communities of the western Atlantic Ocean from Newfoundland to Chesapeake Bay (Bigelow and Schroeder, 1953). It is a territorial and sedentary species that occupies small, localized ranges within 10 km (6.2 miles) of shore. The species prefers complex habitats with natural or artificial structures such as bedrock outcrops, glacial boulders, pilings, shipwrecks, or breakwaters, and juveniles inhabit shallow waters (Lawton et al., 2000). Although large numbers of cunner were landed in the late 1800's and early 1900's, today they have little commercial or recreational value (Bigelow and Schroeder, 1953).

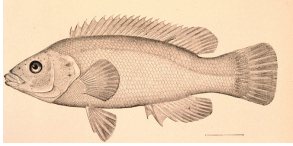
In Cape Cod Bay, cunner spawn close to shore from mid-March until mid-July (Lawton et al., 2000). In more northern areas the spawning season lasts from May to September. Spawning peaks in waters near Woods Hole, Massachusetts, during the first three weeks of June (Lawton et al., 2000). Males and females are able to spawn several times in a day, and more than once throughout the spawning season (Pottle and Green, 1979). Females produce approximately 5,000 to 600,000 eggs annually (Steimle and Shaheen, 1999). The number of eggs produced is related to fork length and fish weight; maximum egg production occurs between the ages of 7 and 9 years and is maintained until approximately 16 years of age (Steimle and Shaheen, 1999).

Cunner eggs are pelagic and range in size from 0.84 to 0.92 mm (0.033 to 0.036 in.) in diameter (Able and Fahay, 1998). Eggs hatch after several days in water temperatures of 12.8 to 18.3 ˚C (55 to 65 ˚F), and larvae are 2-3 mm (0.08 to 0.11 in.) long (Bigelow and Schroeder, 1953). The larval stage lasts 18-37 days (Lawton et al., 2000).

Cunner growth rates during the first year in waters near Nova Scotia range from 0.30 to 0.35 mm (0.01 in.) per day (Tupper and Boutilier, 1995). Larvae and juveniles collected in July in the Great Bay-Little Egg Harbor area, off the New Jersey shore, were 5.2-15.6 mm (0.2 to 0.6 in.) long (Able and Fahay, 1998). At age 1, cunner are about 4 to 8 cm (1.6 to 3.1 in.) long (Serchuk and Cole, 1974).

Adults do not migrate extensively, but they will travel short distances to escape extremes in water temperature (Bigelow and Schroeder, 1953). They move to protected areas in the fall and become inactive as water temperatures fall to 7-8 ˚C (45 to 46 ˚F). As temperatures decrease further, cunner become dormant (Olla et al., 1975). Some may overwinter in their summer habitat, but inshore areas that are susceptible to thermal currents are not suitable for the dormant period (Dew, 1976). When spring water temperatures reach 5 to 6 ˚C (41 to 43 ˚F), cunner move to seasonally transitory habitats such as mussel beds and seaweed (Olla et al., 1979). Cunner are active during the day and become inactive and seek cover at night (Olla et al., 1975). Cunner are omnivores that feed on mussels, small lobsters, and sea urchins in addition to plant material (State of Maine Division of Marine Resources, 2001b).

Dew (1976) found that cunner in the mid-Atlantic Bight mature at about age 1. Cunner sampled in Cape Cod Bay were up to 10 years old (Lawton et al., 2000), whereas data for other areas indicate a maximum age of 6 years (Froese and Pauly, 2001).



CUNNER(*Tautogolabrus adspersus*)

Family: Labridae (wrasses).

Common names: Perch, sea perch, blue perch, bergall, chogset, choggy.[a]

Similar species: Tautog (*Tautoga onitis*).

Geographic range: Prevalent from Newfoundland to Chesapeake Bay.[b]

Habitat: Natural or artificial structures within 10 km of shore.[c]

Lifespan: May live up to 10 years.[c]

Fecundity: Females produce approximately 5,000 to 600,000 eggs annually.[a]

Food source: Mussels, small lobsters, and sea urchins in addition to plant material.[d]

Prey for: Other shore fish such as sculpins, seabirds.[e]

Life stage information:

Eggs: *pelagic*

- Range in size from 0.84 to 0.92 mm (0.033 to 0.036 in.) in diameter.[f]

Larvae:

- 0.2-0.3 mm (.008 to 0.012 in.) in length.[b]

Juveniles:

- Can be found in high abundance in structurally complex habitats.[f]

Adults:

- Inactive as water temperatures fall**,** but they will travel short distances to escape extremes in temperature.[b]
- Become dormant in the winter.[g]

[a] Auster, 1989.
[b] Bigelow and Schroeder, 1953.
[c] Lawton et al., 2000.
[d] State of Maine Division of Marine Resources, 2001b.
[e] Scott and Scott, 1988.
[f] Able and Fahay, 1998.
[g] Olla et al., 1975.
Fish graphic from NOAA, 2002c.

Winter flounder (*Pleuronectes americanus*)

Winter flounder is a benthic flatfish of the family Pleuronectidae (righteye flounders), which is found in estuarine and continental shelf habitats. Its range extends from the southern edge of the Grand Banks south to Georgia (Buckley, 1989b). It is a bottom feeder, occupying sandy or muddy habitats and feeding on bottom-dwelling organisms such as shrimp, amphipods, crabs, urchins, and snails (Froese and Pauly, 2001).

Both commercial and recreational fisheries for winter flounder are important. U.S. commercial and recreational fisheries are managed under the New England Fishery Management Council's Multispecies Fishery Management Plan and the Atlantic States Marine Fisheries Commission's Fishery Management Plan for Inshore Stocks of Winter Flounder (NEFSC, 2000d). Three groups are recognized for management and assessment purposes: Gulf of Maine, Southern New England-Mid Atlantic, and Georges Bank. Management currently focuses on reducing fishing levels to reverse declining trends and rebuild stocks. The Gulf of Maine stock is currently considered overfished (NEFSC, 2000d). Although improvements in stock condition will depend on reduced harvest, the long-term potential catch (maximum sustainable yield) has not been determined.

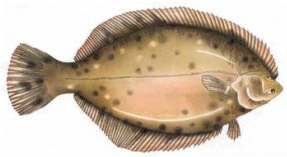
The winter flounder is a nonmigratory species. Tagging studies indicate that winter flounder north of Cape Cod remain in local inshore waters, while populations south of Cape Cod may disperse up to 3 miles offshore on a seasonal basis (Buckley, 1989b). Water temperature seems to be the most important determining factor of seasonal distribution. Winter flounder near Newfoundland may remain in shallow waters during the summer as long as temperatures do not exceed 15 ˚C (59 ˚F), while off of the coast of Rhode Island, winter flounder move to deeper, cooler waters in the summer (Buckley, 1989b).

Spawning occurs between January and May in New England, with peaks in the Massachusetts area in February and March (Bigelow and Schroeder, 1953). Spawning habitat is generally in shallow water over a sandy or muddy bottom (Scott and Scott, 1988). Adult fish tend to leave the shallow water in autumn to spawn at the head of estuaries in late winter. The majority of spawning takes place in a salinity range of 31 to 33 ppt and a water temperature range of 0 to 3 ˚C (32 to 37 ˚F). Females will usually produce between 500,000 and 1.5 million eggs annually, which sink to the bottom in clusters. The eggs are about 0.74 to 0.85 mm (approximately 0.03 in.) in diameter, and hatch in approximately 15 to 18 days (Bigelow and Schroeder, 1953).

Larvae are about 3.0 to 3.5 mm (0.1 in.) total length when they hatch out. They develop and metamorphose over 2 to 3 months, with growth rates controlled by water temperature (Bigelow and Schroeder, 1953). Larval growth appears to be optimal with a slow increase from spawning temperatures of 2 ˚C (36 ˚F) to approximately 10 ˚C (50 ˚F; Buckley, 1982). Larvae depend on light and vision to feed during the day and do not feed at night (Buckley, 1989b). Juveniles tend to remain in shallow spawning waters, and stay on the ocean bottom (Scott and Scott, 1988).

Fifty percent of females reach maturity at age 2 or 3 in the waters of Georges Bank, while they may not mature until age 5 in more northern areas such as near Newfoundland. Females are generally 22.5 to 31.5 cm (8 to 12.4 in.) long at maturity (Howell et al., 1992).

Winter flounder supports important commercial and recreational fisheries in the area, as it is the thickest and meatiest of the common New England flatfish (Bigelow and Schroeder, 1953). Annual commercial landings declined from 17.083 million kg (17,083 metric tons) in 1981 to 3.223 million kg (3,223 metric tons) in 1994 (personal communication, National Marine Fisheries Society, Fish Statistics and Economics Division, Silver Spring, MD, January 16, 2002.). Winter flounder is ecologically important as a prey species for larger estuarine and coastal fish such as striped bass (*Morone saxatilis*) and bluefish (*Pomatomus saltatrix*) (Buckley, 1989b).



WINTER FLOUNDER
(*Pleuronectes americanus*)

Family: Pleuronectidae (righteye flounders)

Common names: Blackback flounder, lemon sole, black flounder.[a]

Similar species: American plaice (*Hippoglossoides platessoides*), European plaice (*P. platessus*).

Geographic range: From the southern edge of the Grand Banks south to Georgia.[b]

Habitat: Bottom dweller. Found in coastal marine waters.[c]

Lifespan: May live up to 15 years.

Fecundity: Females produce between 500,000 and 1.5 million eggs annually.[a]

Food source: Bottom-dwelling organisms such as shrimp, amphipods, crabs, urchins and snails.[a]

Prey for: Striped bass, bluefish.[b]

Life stage information:

Eggs: *demersal*
- Approximately 0.74 to 0.85 mm (0.03 in.) in diameter.[a]
- Hatch in approximately 15 to 18 days.[a]

Larvae: *semi-pelagic*
- Approximately 3.0 to 3.5 mm (0.1 in.) total length when they hatch out.[a]

Juveniles: *demersal*
- Once winter flounder enter the juvenile stage, they remain benthic, preferring sandy bottomed substrates.[d]

Adults:
- Females mature at ages 2 and 3.[e]
- Migrate seasonally to offshore waters in the summer, and inshore waters in the winter.[b]

[a] Bigelow and Schroeder, 1953.
[b] Buckley, 1989b.
[c] Scott and Scott, 1988.
[d] Grimes et al., 1989.
[e] Howell et al., 1992.
Fish graphic from State of Maine Department of Marine Resources, 2001d.

G3-3 Seabrook's Methods for Estimating Impingement and Entrainment

G3-3.1 Seabrook Impingement and Entrainment Monitoring

Seabrook has sampled impinged organisms since 1990 (Normandeau Associates, 1990, 1991, 1993, 1994a, 1994b, 1995, 1996a, 1996b, 1997, 1999). Impinged fish are collected after being washed from the 9.525 mm mesh traveling screens within the circulating water pumphouse. Before 1998, screens were washed once per week, or more frequently during storm conditions, and collected fish were identified to species and counted (Normandeau Associates, 1999). Because of inadequate removal of small fish from screenwash debris, the facility believes that estimates from 1990 to 1994 are likely to be underestimated (Normandeau Associates, 1995). Prior to 1998, the number of fish impinged in unassessed screenwashes was estimated based on the volume of debris in the unassessed screenwash and the volume of debris in the assessed screenwash nearest in time to the collection date. The sum of assessed screenwashes and the calculated value for the unassessed screenwashes allowed calculation of an annual estimate of fish impinged (Normandeau Associates, 1997, 1999). In 1998 sampling procedures were adjusted so that traveling screens were washed at least twice each week and fish were counted in every screenwash. Since 1998, the annual impingement is the sum of the fish impinged from every screenwash (Normandeau Associates, 1999; R. Sher, Seabrook Station, personal communication, 2001).

G3-3.2 Seabrook Entrainment Monitoring

Seabrook has also conducted entrainment sampling since 1990 (Normandeau Associates, 1990, 1991, 1993, 1994b, 1995, 1996a, 1996b, 1997, 1999; Saila et al., 1997). Samples are collected with 0.505 mm mesh nets suspended in double-barrel

collection devices. Initially, three replicate samples were taken once during the day on each sampling date, but beginning in January 1998 the sampling design changed to include 24-hour sampling. Samples are taken four times each month, and in four diel periods (2400-0600, 0600-1200, 1200-1800, 1800-2400 hours). The weekly number of entrained organisms is estimated by calculating the arithmetic mean density in a sample for each sampling day and multiplying by the cooling water volume during the week the sample was taken. These weekly estimates are summed for a monthly estimate, and monthly estimates are summed to derive an annual estimate (Normandeau Associates, 1997). Slight variations in annual extrapolations methods can be found in Seabrook facility documents for previous years (Normandeau Associates, 1993, 1994a, 1995).

G3-4 Seabrook's Annual Impingement and Entrainment

EPA evaluated annual impingement and entrainment at Seabrook using the methods described in Chapter A5 of Part A of this document.[1] The species-specific life history values used by EPA for its analyses are presented in Appendix G1. Table G3-2 displays facility estimates of annual impingement (numbers of organisms) at the Seabrook facility, by species. Table G3-3 displays those numbers expressed as age 1 equivalents, Table G3-4 displays impingement of fishery species as yield lost to fisheries, and Table G3-5 displays impingement expressed as production foregone. Tables G3-6 through G3-9 display the same information for entrainment at Seabrook.

G3-5 Pilgrim's Methods for Estimating Impingement and Entrainment

G3-5.1 Pilgrim Impingement and Entrainment Monitoring

Impingement monitoring at Pilgrim has been conducted three times per week since 1974. Traveling screens are washed over a 24-hour period, once in the morning, once in the afternoon, and once at night. To estimate annual impingement numbers, Pilgrim divides the numbers of fish impinged during an impingement monitoring period by the numbers of hours of monitoring, and then the resulting impingement rate per hour is multiplied by 24 hours and by 365 days to obtain an annual number. After 1990, if all four intake screens were not washed, then the number of fish impinged was increased by a proportional factor (Boston Edison Company, 1991-1994, 1995a, 1995b, 1996-1999; Entergy Nuclear General Company, 2000).

G3-5.2 Pilgrim Entrainment Monitoring

Entrainment sampling at Pilgrim began in 1974 (Boston Edison Company, 1991-1994, 1995a, 1995b, 1996-1999; Entergy Nuclear General Company, 2000). Samples are taken in triplicate at low tide. In most years sampling was twice a month from October through February and weekly from March through September. However, this regime was modified in 1994. Sampling from October through February now involves taking single samples on three separate occasions during two alternate weeks each month. The standard mesh is 0.333 mm, except from late March through late May, when a 0.202 mm mesh is used. From March through September single samples are taken three times every week. All sampling is done with a 60 cm diameter plankton net fitted with a digital flow meter. This allows for calculation of arithmetic mean densities of larvae and eggs entrained. Annual numbers of entrainment were determined using the full load capacity of the plant (Entergy Nuclear Generating Company, 2001).

G3-6 Pilgrim's Annual Impingement and Entrainment

EPA evaluated annual impingement and entrainment at Pilgrim using the methods described in Chapter A5 of Part A of this document.[1] The species-specific life history values used by EPA for its analyses were the same as those used to evaluate Seabrook's losses and are presented in Appendix G1. Table G3-10 displays facility estimates of annual impingement (numbers of organisms) at the Pilgrim facility, by species. Table G3-11 displays those numbers expressed as age 1 equivalents, Table G3-12 displays impingement of fishery species as yield lost to fisheries, and Table G3-13 displays the Seabrook annual impingement expressed as production foregone. Tables G3-14 through G3-17 display the same information for entrainment at Pilgrim.

[1] In some cases the facility did not identify impinged or entrained organisms at the species level or life history data were not available for different species in the same family. In these cases, EPA grouped the losses together under a single species.

Table G3-2: Annual Impingement (numbers of organisms) at Seabrook, By Species, as Estimated by the Facility

Year	Alewife	American Lobster	American Plaice	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Moonfish	Atlantic Silverside	Atlantic Torpedo	Black Sea Bass	Blueback Herring
1990	0	4	0	3	18	44	4	0	0	0	0	0
1991	1	29	0	0	28	8	13	0	8	0	1	0
1992	0	8	0	28	26	22	3	0	67	0	0	0
1993	1	1	1	3	37	19	0	0	156	0	0	0
1994	0	31	0	1,215	59	514	0	0	5,348	0	0	13
1995	8	16	0	1,324	120	231	0	3	1,621	1	3	0
1996	1,753	31	0	823	491	577	1	0	1,119	5	0	111
1997	2,797	20	0	182	69	589	0	0	210	0	0	323
1998	14	4	0	708	39	583	0	1	834	0	3	7
Mean	508	16	0	476	99	287	2	0	1,040	1	1	50
Minimum	0	1	0	0	18	8	0	0	0	0	0	0
Maximum	2,797	31	1	1,324	491	589	13	3	5,348	5	3	323
SD	1,035	12	0	548	150	273	4	1	1,714	2	1	108
Total	4,574	144	1	4,286	887	2,587	21	4	9,363	6	7	454

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 07:56:36 MST 2002 Raw.losses. IMPINGEMENT; Plant:seabrook.90.98;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/raw.losses.imp.seabrook.90.98.csv

Table G3-2: Annual Impingement (numbers of organisms) at Seabrook, By Species, as Estimated by the Facility (cont.)

Year	Butterfish	Conger Eel	Cunner	Fourbeard Rockling	Goosefish	Grubby	Little Skate	Lumpfish	Northern Kingfish	Northern Pipefish	Northern Puffer	Ocean Pout	Oyster Toadfish	Planehead Filefish
1990	0	0	21	0	1	11	12	69	0	0	0	1	1	0
1991	0	1	2	1	0	26	105	96	1	6	0	2	0	0
1992	2	0	13	1	0	54	48	35	0	2	0	3	0	0
1993	0	0	13	0	0	67	35	131	0	83	0	0	0	0
1994	3	0	32	0	3	2,678	190	362	0	188	0	0	0	0
1995	14	0	342	6	13	2,415	157	355	0	579	0	6	0	15
1996	3	0	1,121	19	0	1,457	225	1,064	2	1,200	0	1	0	0
1997	223	0	233	0	0	430	177	413	0	243	5	0	0	0
1998	9	0	309	3	7	3,269	41	993	0	268	0	7	0	0
Mean	28	0	232	3	3	1,156	110	391	0	285	1	2	0	2
Minimum	0	0	2	0	0	11	12	35	0	0	0	0	0	0
Maximum	223	1	1,121	19	13	3,269	225	1,064	2	1,200	5	7	1	15
SD	73	0	361	6	5	1,322	79	388	1	390	2	3	0	5
Total	254	1	2,086	30	24	10,407	990	3,518	3	2,569	5	20	1	15

0=Sampled, but none collected.
Mon Feb 11 07:56:36 MST 2002 Raw.losses. IMPINGEMENT; Plant:seabrook.90.98;
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Table G3-2: Annual Impingement (numbers of organisms) at Seabrook, By Species, as Estimated by the Facility (cont.)

Year	Pollock	Radiated Shanny	Rainbow Smelt	Red Hake	Rock Gunnel	Rough Scad	Sand Tiger	Sculpin Spp.	Scup	Sea Lamprey	Seal	Searobin	Spiny Dogfish
1990	69	4	0	16	14	0	0	109	0	1	0	10	1
1991	124	1	12	55	11	3	0	143	1	5	0	12	2
1992	231	0	67	16	40	0	0	161	0	3	0	1	1
1993	32	0	80	5	25	0	0	170	0	6	0	1	0
1994	1,681	0	545	2,824	494	0	0	402	0	0	6	0	1
1995	899	92	213	2,269	1,298	0	0	446	14	0	6	0	0
1996	1,835	40	4,489	2,659	1,122	0	57	1,381	9	1	0	0	6
1997	379	2	365	601	459	0	0	434	0	6	0	11	0
1998	536	39	535	926	2,929	0	0	365	3	7	0	1	0
Mean	643	20	701	1,041	710	0	6	401	3	3	1	4	1
Minimum	32	0	0	5	11	0	0	109	0	0	0	0	0
Maximum	1,835	92	4,489	2,824	2,929	3	57	1,381	14	7	6	12	6
SD	688	32	1,436	1,207	964	1	19	392	5	3	3	5	2
Total	5,786	178	6,306	9,371	6,392	3	57	3,611	27	29	12	36	11

0=Sampled, but none collected.
Mon Feb 11 07:56:36 MST 2002 Raw.losses. IMPINGEMENT; Plant:seabrook.90.98;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/raw.losses.imp.seabrook.90.98.csv

Table G3-2: Annual Impingement (numbers of organisms) at Seabrook, By Species, as Estimated by the Facility (cont.)

Year	Striped Anchovy	Striped Bass	Striped Cusk Eel	Striped Killifish	Tautog	Threespine Stickleback	Unidentified	White Perch	Windowpane	Winter Flounder	Wolffish	Wrymouth
1990	1	0	0	0	3	0	4	1	54	21	0	5
1991	0	0	0	0	9	3	4	0	155	134	1	15
1992	0	0	0	0	9	3	5	0	97	209	0	16
1993	0	0	0	0	3	17	0	0	103	205	0	12
1994	0	0	0	4	0	67	6	0	985	1,512	0	55
1995	0	4	0	0	0	155	40	0	944	2,323	2	9
1996	0	1	0	47	34	320	88	4	1,168	3,239	13	206
1997	0	0	3	24	0	174	49	0	1,691	491	0	3
1998	0	0	0	0	3	798	0	1	776	1,156	1	21
Mean	0	1	0	8	7	171	22	1	664	1,032	2	38
Minimum	0	0	0	0	0	0	0	0	54	21	0	3
Maximum	1	4	3	47	34	798	88	4	1,691	3,239	13	206
SD	0	1	1	16	11	259	31	1	588	1,133	4	65
Total	1	5	3	75	61	1,537	196	6	5,973	9,290	17	342

0=Sampled, but none collected.
Mon Feb 11 07:56:36 MST 2002 Raw.losses. IMPINGEMENT; Plant:seabrook.90.98;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/raw.losses.imp.seabrook.90.98.csv

Table G3-3: Annual Impingement at Seabrook, by Species, Expressed as Age 1 Equivalents

Year	Alewife	American Plaice	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Atlantic Silverside	Blueback Herring	Butter-fish	Cunner	Fourbeard Rockling	Grubby	Little Skate	Lump-fish
1990	0	0	4	22	51	5	0	0	0	0	29	0	13	15	76
1991	1	0	0	34	9	16	0	14	0	0	3	1	32	135	105
1992	0	0	41	31	26	4	0	121	0	3	18	1	66	62	38
1993	1	1	4	44	22	0	0	281	0	0	18	0	82	45	143
1994	0	0	1,776	71	598	0	0	9,620	15	4	45	0	3,283	244	396
1995	11	0	1,936	144	269	0	9	2,916	0	19	476	7	2,961	201	389
1996	2,343	0	1,203	588	671	1	118	2,013	128	4	1,562	24	1,786	288	1,165
1997	3,738	0	266	83	685	0	0	378	371	299	325	0	527	227	452
1998	19	0	1,035	47	678	0	1	1,500	8	12	430	4	4,008	53	1,087
Mean	679	0	696	118	334	3	14	1,871	58	38	323	4	1,418	141	428
Minimum	0	0	0	22	9	0	0	0	0	0	3	0	13	15	38
Maximum	3,738	1	1,936	588	685	16	118	9,620	371	299	1,562	24	4,008	288	1,165
SD	1,383	0	801	180	318	5	39	3,084	125	98	503	8	1,620	102	425
Total	6,113	1	6,267	1,062	3,010	26	128	16,842	522	341	2,906	37	12,759	1,269	3,851

Note: Impingement losses expressed as age 1 equivalents are larger than raw losses (the actual number of organisms impinged). This is because the ages of impinged individuals are assumed to be distributed across the interval between the start of year 1 and the start of year 2, and then the losses are normalized back to the start of year 1 by accounting for mortality during this interval (for details, see description of S*j in Chapter A2, Equation 4 and Equation 5). This type of adjustment is applied to all raw loss records, but the effect is not readily apparent among entrainment losses because the majority of entrained fish are younger than age 1.
0=Sampled, but none collected.
Fri Feb 08 09:49:55 MST 2002 ;Results; I Plant: seabrook.90.98 ; Units: equivalent.sums Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/I.equivalent.sums.seabrook.90.98.csv

Table G3-3: Annual Impingement at Seabrook, by Species, Expressed as Age 1 Equivalents (cont.)

Year	Northern Pipefish	Pollock	Radiated Shanny	Rainbow Smelt	Red Hake	Rock Gunnel	Sculpin Spp.	Scup	Sea-robin	Striped Bass	Striped Killifish	Tautog	Threespine Stickleback	White Perch	Window-pane	Winter Flounder
1990	0	76	5	0	20	17	134	0	12	0	0	3	0	1	65	23
1991	8	136	1	16	70	13	175	1	15	0	0	10	4	0	186	147
1992	3	254	0	91	20	49	197	0	1	0	0	10	4	0	116	230
1993	113	35	0	108	6	30	208	0	1	0	0	3	24	0	124	226
1994	255	1,849	0	738	3,616	601	493	0	0	0	5	0	95	0	1,182	1,664
1995	786	989	112	288	2,905	1,579	547	16	0	6	0	0	220	0	1,133	2,557
1996	1,630	2,018	49	6,078	3,404	1,365	1,693	11	0	1	64	37	455	5	1,402	3,565
1997	330	417	2	494	769	558	532	0	14	0	33	0	247	0	2,030	540
1998	364	589	47	724	1,186	3,563	448	4	1	0	0	3	1,135	1	931	1,272
Mean	388	707	24	949	1,333	864	492	4	5	1	11	7	243	1	797	1,136
Minimum	0	35	0	0	6	13	134	0	0	0	0	0	0	0	65	23
Maximum	1,630	2,018	112	6,078	3,616	3,563	1,693	16	15	6	64	37	1,135	5	2,030	3,565
SD	529	757	39	1,945	1,546	1,173	480	6	7	2	23	12	368	2	706	1,247
Total	3,490	6,363	217	8,538	11,998	7,776	4,427	32	44	7	103	67	2,185	8	7,169	10,226

Note: Impingement losses expressed as age 1 equivalents are larger than raw losses (the actual number of organisms impinged). This is because the ages of impinged individuals are assumed to be distributed across the interval between the start of year 1 and the start of year 2, and then the losses are normalized back to the start of year 1 by accounting for mortality during this interval (for details, see description of S*j in Chapter A2, Equation 4 and Equation 5). This type of adjustment is applied to all raw loss records, but the effect is not readily apparent among entrainment losses because the majority of entrained fish are younger than age 1.
0=Sampled, but none collected.
Fri Feb 08 09:49:55 MST 2002 ;Results; I Plant: seabrook.90.98 ; Units: equivalent.sums Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/I.equivalent.sums.seabrook.90.98.csv

Table G3-4: Annual Impingement of Fishery Species at Seabrook Expressed as Yield Lost to Fisheries (in pounds)

Year	Alewife	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Atlantic Silverside	Blueback Herring	Butterfish	Cunner	Little Skate	Pollock
1990	0	7	7	1	0	0	0	0	0	3	111
1991	0	11	1	2	0	0	0	0	0	28	200
1992	0	10	4	1	0	0	0	0	0	13	373
1993	0	15	3	0	0	0	0	0	0	9	52
1994	0	23	83	0	0	4	0	0	0	50	2,713
1995	0	47	37	0	3	1	0	1	2	42	1,451
1996	12	192	93	0	41	1	1	0	7	60	2,962
1997	19	27	95	0	0	0	3	14	1	47	612
1998	0	15	94	0	0	1	0	1	2	11	865
Mean	3	39	46	0	5	1	0	2	1	29	1,038
Minimum	0	7	1	0	0	0	0	0	0	3	52
Maximum	19	192	95	2	41	4	3	14	7	60	2,962
SD	7	59	44	1	13	1	1	5	2	21	1,111
Total	31	348	417	4	44	7	4	16	13	262	9,340

0=Sampled, but none collected.
Fri Feb 08 09:50:05 MST 2002 ;Results; I Plant: seabrook.90.98 ; Units: yield Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/I.yield.seabrook.90.98.csv

Table G3-4: Annual Impingement of Fishery Species at Seabrook Expressed as Yield Lost to Fisheries (in pounds) (cont.)

Year	Rainbow Smelt	Red Hake	Scup	Searobin	Striped Bass	Tautog	Windowpane	Winter Flounder
1990	0	4	0	1	0	4	5	7
1991	0	13	0	1	0	11	14	46
1992	1	4	0	0	0	11	9	73
1993	1	1	0	0	0	4	9	71
1994	6	644	0	0	0	0	87	525
1995	2	518	3	0	8	0	84	806
1996	45	607	2	0	2	41	103	1,124
1997	4	137	0	1	0	0	150	170
1998	5	211	1	0	0	4	69	401
Mean	7	238	1	0	1	8	59	358
Minimum	0	1	0	0	0	0	5	7
Maximum	45	644	3	1	8	41	150	1,124
SD	15	275	1	0	3	13	52	393
Total	64	2,138	6	2	10	74	529	3,223

0=Sampled, but none collected.
Fri Feb 08 09:50:05 MST 2002 ;Results; I Plant: seabrook.90.98 ; Units: yield Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/I.yield.seabrook.90.98.csv

Table G3-5: Annual Impingement at Seabrook, By Species, Expressed as Production Foregone (in pounds)

Year	Alewife	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Atlantic Silverside	Blueback Herring	Butterfish	Cunner	Grubby	Little Skate	Lumpfish	Northern Pipefish
1990	0	0	2	4	0	0	0	0	0	0	1	1	2	0
1991	0	0	4	1	1	0	0	0	0	0	2	13	3	0
1992	0	0	4	2	0	0	0	0	0	0	4	6	1	0
1993	0	0	5	2	0	0	0	0	0	0	5	4	5	0
1994	0	9	8	47	0	0	3	1	0	0	200	23	13	0
1995	0	10	16	21	0	1	1	0	0	3	180	19	13	1
1996	73	6	67	52	0	19	1	6	0	9	109	28	38	2
1997	117	1	9	54	0	0	0	17	7	2	32	22	15	0
1998	1	5	5	53	0	0	1	0	0	2	244	5	35	0
Mean	21	4	13	26	0	2	1	3	1	2	86	14	14	0
Minimum	0	0	2	1	0	0	0	0	0	0	1	1	1	0
Maximum	117	10	67	54	1	19	3	17	7	9	244	28	38	2
SD	43	4	21	25	0	6	1	6	2	3	99	10	14	1
Total	191	33	121	235	2	20	6	24	8	16	776	122	124	4

0=Sampled, but none collected.
Fri Feb 08 09:50:00 MST 2002 ;Results; I Plant: seabrook.90.98 ; Units: annual.prod.forg Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/I.annual.prod.forg.seabrook.90.98.csv

Table G3-5: Annual Impingement at Seabrook, By Species, Expressed as Production Foregone (in pounds) (cont.)

Year	Pollock	Rainbow Smelt	Red Hake	Rock Gunnel	Sculpin Spp.	Scup	Searobin	Striped Bass	Tautog	Windowpane	Winter Flounder
1990	36	0	3	0	8	0	1	0	0	1	3
1991	64	0	10	0	11	0	1	0	1	3	18
1992	119	3	3	0	12	0	0	0	1	2	28
1993	17	3	1	0	13	0	0	0	0	2	27
1994	868	23	494	3	30	0	0	0	0	21	201
1995	464	9	397	7	33	2	0	2	0	20	309
1996	948	186	465	6	103	1	0	0	5	25	431
1997	196	15	105	3	32	0	1	0	0	36	65
1998	277	22	162	16	27	0	0	0	0	17	154
Mean	332	29	182	4	30	0	0	0	1	14	137
Minimum	17	0	1	0	8	0	0	0	0	1	3
Maximum	948	186	494	16	103	2	1	2	5	36	431
SD	355	60	211	5	29	1	0	1	1	13	151
Total	2,988	262	1,640	35	269	3	3	2	7	128	1,236

0=Sampled, but none collected.
Fri Feb 08 09:50:00 MST 2002 ;Results; I Plant: seabrook.90.98 ; Units: annual.prod.forg Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/I.annual.prod.forg.seabrook.90.98.csv

Table G3-6: Annual Entrainment (numbers of organisms) at Seabrook, By Species, as Estimated by the Facility

Year	Alligator-fish	American Eel	American Plaice	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Blue Mussel	Bluefish	Butterfish	Cunner
1990	0	0	3,000,000	0	3,200,000	700,000	519,000,000	100,000	3,991,300,000,000	0	0	42,700,000
1991	100,000	0	22,000,000	37,300,000	1,500,000	500,000	677,800,000	500,000	1,687,400,000,000	0	0	50,000
1992	200,000	0	53,100,000	18,100,000	3,000,000	4,900,000	456,300,000	1,400,000	121,900,000,000	0	0	0
1993	0	0	20,200,000	12,000,000	50,400,000	9,600,000	112,900,000	100,000	10,050,700,000,000	0	0	4,700,000
1994	200,000	0	400,000	8,300,000	500,000	100,000	0	0	NA	0	0	100,000
1995	300,000	0	22,700,000	9,500,000	6,900,000	11,200,000	74,500,000	200,000	13,231,000,000,000	0	300,000	4,400,000
1996	100,000	0	86,300,000	14,000,000	9,800,000	4,300,000	305,200,000	100,000	17,931,800,000,000	0	200,000	9,200,000
1997	100,000	0	22,600,000	10,100,000	3,800,000	2,100,000	23,500,000	200,000	1,744,500,000,000	100,000	0	239,700,000
1998	174,000	14,000	16,623,000	10,662,000	10,970,000	9,506,000	39,316,000	114,000	1,493,030,000,000	0	0	17,783,000
Mean	130,444	1,556	27,435,889	13,329,111	10,007,778	4,767,333	245,390,667	301,556	6,281,453,750,000	11,111	55,556	35,403,667
Minimum	0	0	400,000	0	500,000	100,000	0	0	121,900,000,000	0	0	0
Maximum	300,000	14,000	86,300,000	37,300,000	50,400,000	11,200,000	677,800,000	1,400,000	17,931,800,000,000	100,000	300,000	239,700,000
SD	98,193	4,667	26,684,083	10,214,826	15,568,118	4,345,642	252,134,888	435,111	6,612,079,486,100	33,333	113,039	77,814,636
Total	1,174,000	14,000	246,923,000	119,962,000	90,070,000	42,906,000	2,208,516,000	2,714,000	50,251,630,000,000	100,000	500,000	318,633,000

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 07:56:41 MST 2002 Raw.losses. ENTRAINMENT; Plant:seabrook.90.98;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/raw.losses.ent.seabrook.90.98.csv

Table G3-6: Annual Entrainment (numbers of organisms) at Seabrook, By Species, as Estimated by the Facility (cont.)

Year	Fourbeard Rockling	Goosefish	Grubby	Lumpfish	Northern Pipefish	Other	Pollock	Radiated Shanny	Rainbow Smelt	Red Hake	Redfish	Rock Gunnel	Sculpin Spp.
1990	159,600,000	100,000	0	12,400,000	0	0	203,550	4,800,000	200,000	61,200,000	0	0	0
1991	40,400,000	0	22,400,000	19,200,000	0	100,000	1,000,000	3,100,000	0	2,600,000	0	51,100,000	900,000
1992	51,500,000	0	18,900,000	33,500,000	0	300,000	465,964	1,100,000	100,000	100,000	400,000	45,300,000	1,600,000
1993	36,400,000	0	13,800,000	76,900,000	0	0	200,000	200,000	0	800,000	0	5,700,000	1,000,000
1994	1,900,000	0	4,900,000	3,600,000	0	2,000,000	100,000	0	0	1,000,000	50,000	11,000,000	2,600,000
1995	35,800,000	0	17,400,000	33,300,000	0	2,100,000	400,000	2,100,000	0	49,200,000	0	15,600,000	900,000
1996	81,400,000	300,000	18,600,000	65,100,000	100,000	0	400,000	2,000,000	100,000	286,800,000	0	33,800,000	2,600,000
1997	72,400,000	0	12,800,000	2,300,000	0	0	200,000	300,000	0	410,400,000	0	25,100,000	2,150,000
1998	47,193,000	886,000	17,315,000	40,466,000	0	0	2,974,000	1,702,000	228,000	26,267,000	0	16,872,000	2,960,000
Mean	58,510,333	142,889	14,012,778	31,862,889	11,111	500,000	660,390	1,700,222	69,778	93,151,889	50,000	22,719,111	1,634,444
Minimum	1,900,000	0	0	2,300,000	0	0	100,000	0	0	100,000	0	0	0
Maximum	159,600,000	886,000	22,400,000	76,900,000	100,000	2,100,000	2,974,000	4,800,000	228,000	410,400,000	400,000	51,100,000	2,960,000
SD	44,230,288	296,066	7,233,324	26,037,747	33,333	884,590	907,482	1,552,418	92,306	149,771,232	132,288	17,577,835	1,002,586
Total	526,593,000	1,286,000	126,115,000	286,766,000	100,000	4,500,000	5,943,514	15,302,000	628,000	838,367,000	450,000	204,472,000	14,710,000

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 07:56:41 MST 2002 Raw.losses. ENTRAINMENT; Plant:seabrook.90.98;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/raw.losses.ent.seabrook.90.98.csv

Table G3-6: Annual Entrainment (numbers of organisms) at Seabrook, By Species, as Estimated by the Facility (cont.)

Year	Searobin	Tautog	Unidentified	Windowpane	Winter Flounder	Wrymouth
1990	0	300,000	700,000	40,400,000	520,479,242	0
1991	0	200,000	4,100,000	19,950,000	800,030,734	100,000
1992	0	0	1,400,000	22,600,000	242,018,538	0
1993	0	0	6,300,000	29,200,000	62,666,462	0
1994	0	0	800,000	200,000	500,000	0
1995	0	0	36,800,000	19,400,000	60,200,044	0
1996	100,000	500,000	3,300,000	46,200,000	172,100,000	0
1997	0	100,000	4,400,000	34,200,000	199,800,000	0
1998	0	56,000	594,000	19,390,000	138,521,000	0
Mean	11,111	128,444	6,488,222	25,726,667	244,035,113	11,111
Minimum	0	0	594,000	200,000	500,000	0
Maximum	100,000	500,000	36,800,000	46,200,000	800,030,734	100,000
SD	33,333	174,876	11,541,012	13,662,276	257,347,153	33,333
Total	100,000	1,156,000	58,394,000	231,540,000	2,196,316,020	100,000

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 07:56:41 MST 2002 Raw.losses. ENTRAINMENT; Plant:seabrook.90.98;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/raw.losses.ent.seabrook.90.98.csv

Table G3-7: Annual Entrainment at Seabrook, By Species, Expressed as Age 1 Equivalents

Year	American Plaice	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Bluefish	Butterfish	Cunner	Fourbeard Rockling	Grubby	Lumpfish
1990	137	0	1,682	2,041	2,188	38	0	0	257,980	553,743	0	2,063
1991	628	1,112,394	3,509	1,458	3,061	21	0	0	302	46,849	402,989	3,195
1992	1,198	539,795	1,214	14,287	1,915	59	0	0	0	54,207	340,022	5,574
1993	533	357,875	1,134	27,991	474	4	0	0	28,396	60,164	248,270	11,358
1994	8	247,530	9	292	0	0	0	0	604	1,962	88,154	584
1995	1,995	283,318	5,463	32,656	313	8	0	178	26,583	76,991	313,036	4,633
1996	3,281	417,521	872	12,538	1,286	4	0	65	55,584	204,123	334,624	10,650
1997	1,816	301,211	1,693	6,123	117	8	5	0	1,237,732	304,634	230,279	337
1998	904	317,972	5,392	27,717	165	22	0	0	52,661	183,680	311,507	6,733
Mean	1,167	397,513	2,330	13,900	1,058	18	1	27	184,427	165,150	252,098	5,014
Minimum	8	0	9	292	0	0	0	0	0	1,962	0	337
Maximum	3,281	1,112,394	5,463	32,656	3,061	59	5	178	1,237,732	553,743	402,989	11,358
SD	1,045	304,636	1,987	12,671	1,105	19	2	60	403,080	174,661	130,132	4,015
Total	10,501	3,577,615	20,969	125,103	9,518	166	5	242	1,659,842	1,486,353	2,268,880	45,127

0=Sampled, but none collected.
Fri Feb 08 09:49:51 MST 2002 ;Results; E Plant: seabrook.90.98 ; Units: equivalent.sums Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/E.equivalent.sums.seabrook.90.98.csv

Table G3-7: Annual Entrainment at Seabrook, By Species, Expressed as Age 1 Equivalents (cont.)

Year	Northern Pipefish	Pollock	Radiated Shanny	Rainbow Smelt	Red Hake	Rock Gunnel	Sculpin Spp.	Searobin	Tautog	Windowpane	Winter Flounder
1990	0	7	409,203	26,168	219	0	0	0	35	19,939	71,318
1991	0	9	264,277	0	12	7,237,775	16,192	0	2	4,266	136,415
1992	0	6	93,776	13,084	0	6,416,266	28,785	0	0	4,958	56,990
1993	0	2	17,050	0	3	807,345	17,991	0	0	6,322	38,359
1994	0	1	0	0	5	1,558,034	46,775	0	0	331	8
1995	0	4	179,026	0	214	2,209,575	16,192	0	0	9,804	64,212
1996	7,034	4	170,501	486	1,159	4,787,413	46,775	2,044	26	15,340	197,222
1997	0	2	25,575	0	1,529	3,555,150	38,680	0	1	23,585	53,898
1998	0	29	145,097	29,832	117	2,389,740	53,252	0	0	8,306	83,990
Mean	782	7	144,945	7,730	362	3,217,922	29,405	227	7	10,317	78,046
Minimum	0	1	0	0	0	0	0	0	0	331	8
Maximum	7,034	29	409,203	29,832	1,529	7,237,775	53,252	2,044	35	23,585	197,222
SD	2,345	9	132,345	12,290	571	2,489,715	18,037	681	13	7,739	57,634
Total	7,034	64	1,304,505	69,571	3,258	28,961,298	264,641	2,044	64	92,851	702,411

0=Sampled, but none collected.
Fri Feb 08 09:49:51 MST 2002 ;Results; E Plant: seabrook.90.98 ; Units: equivalent.sums Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/E.equivalent.sums.seabrook.90.98.csv

Table G3-8: Annual Entrainment of Fishery Species at Seabrook Expressed as Yield Lost to Fisheries (in pounds)

Year	American Plaice	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Bluefish	Butter-fish	Cunner	Pollock	Rainbow Smelt	Red Hake	Sea-robin	Tautog	Window-pane	Winter Flounder
1990	16	551	283	303	13	0	0	1,163	10	196	39	0	39	1,470	22,481
1991	72	1,149	202	423	7	0	0	1	14	0	2	0	2	314	43,002
1992	137	398	1,980	265	20	0	0	0	9	98	0	0	0	366	17,965
1993	61	371	3,879	66	1	0	0	128	3	0	0	0	0	466	12,092
1994	1	3	40	0	0	0	0	3	1	0	1	0	0	24	2
1995	228	1,788	4,526	43	3	0	9	120	6	0	38	0	0	723	20,241
1996	376	285	1,738	178	1	0	3	251	6	4	207	102	29	1,131	62,170
1997	208	554	849	16	3	3	0	5,582	3	0	272	0	1	1,739	16,990
1998	104	1,765	3,842	23	8	0	0	237	43	223	21	0	1	612	26,476
Mean	134	763	1,927	146	6	0	1	832	10	58	65	11	8	761	24,602
Minimum	1	3	40	0	0	0	0	0	1	0	0	0	0	24	2
Maximum	376	1,788	4,526	423	20	3	9	5,582	43	223	272	102	39	1,739	62,170
SD	120	651	1,756	153	7	1	3	1,818	13	92	102	34	15	571	18,168
Total	1,202	6,864	17,339	1,316	57	3	12	7,486	93	521	581	102	71	6,845	221,419

0=Sampled, but none collected.
Fri Feb 08 09:50:03 MST 2002 ;Results; E Plant: seabrook.90.98 ; Units: yield Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/E.yield.seabrook.90.98.csv

Table G3-9: Annual Entrainment at Seabrook, By Species, Expressed as Production Foregone (in pounds)

Year	American Plaice	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Butterfish	Cunner	Fourbeard Rockling	Grubby	Lumpfish	Northern Pipefish
1990	53	0	318	827	3,789	0	0	4,552	13,170	0	9,946	0
1991	282	41,799	662	591	5,286	0	0	5	1,123	39,707	15,400	0
1992	595	20,283	230	5,788	3,318	0	0	0	1,300	33,503	26,869	0
1993	247	13,448	227	11,340	821	0	0	501	1,437	24,462	57,172	0
1994	2	9,301	2	118	0	0	0	11	47	8,686	2,840	0
1995	68	10,646	1,031	13,230	542	14	27	469	1,835	30,844	23,863	0
1996	357	15,689	167	5,080	2,227	7	10	981	4,862	32,971	51,645	268
1997	71	11,318	320	2,481	201	14	0	21,853	7,240	22,690	1,702	0
1998	62	11,948	1,019	11,229	286	36	0	932	4,367	30,693	32,456	0
Mean	193	14,937	442	5,632	1,830	8	4	3,256	3,931	24,840	24,655	30
Minimum	2	0	2	118	0	0	0	0	47	0	1,702	0
Maximum	595	41,799	1,031	13,230	5,286	36	27	21,853	13,170	39,707	57,172	268
SD	195	11,447	374	5,133	1,911	12	9	7,116	4,151	12,822	19,865	89
Total	1,736	134,433	3,974	50,684	16,470	71	37	29,304	35,380	223,557	221,893	268

0=Sampled, but none collected.
Fri Feb 08 09:49:58 MST 2002 ;Results; E Plant: seabrook.90.98 ; Units: annual.prod.forg Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/E.annual.prod.forg.seabrook.90.98.csv

Table G3-9: Annual Entrainment at Seabrook, By Species, Expressed as Production Foregone (in pounds) (cont.)

Year	Pollock	Radiated Shanny	Rainbow Smelt	Red Hake	Rock Gunnel	Sculpin Spp.	Searobin	Tautog	Windowpane	Winter Flounder
1990	3,231	1,356	3,325	3,041,125	0	0	0	10	1,214	50,876
1991	4,595	876	0	162,360	79,348	1,595	0	1	287	97,314
1992	2,885	311	1,662	6,245	70,342	2,836	0	0	332	40,657
1993	919	57	0	37,468	8,851	1,773	0	0	424	27,360
1994	459	0	0	62,446	17,081	4,609	0	0	19	385
1995	1,838	593	0	2,972,435	24,224	1,595	0	0	596	45,800
1996	1,838	565	90	16,086,117	52,485	4,609	279	8	970	1,302,172
1997	919	85	0	21,212,943	38,975	3,811	0	0	1,403	444,367
1998	14,229	481	3,790	1,623,287	26,199	5,247	0	0	512	566,875
Mean	3,435	480	985	5,022,714	35,278	2,897	31	2	640	286,201
Minimum	459	0	0	6,245	0	0	0	0	19	385
Maximum	14,229	1,356	3,790	21,212,943	79,348	5,247	279	10	1,403	1,302,172
SD	4,255	439	1,559	7,925,069	27,295	1,777	93	4	460	432,120
Total	30,914	4,324	8,867	45,204,425	317,506	26,076	279	19	5,756	2,575,807

0=Sampled, but none collected.
Fri Feb 08 09:49:58 MST 2002 ;Results; E Plant: seabrook.90.98 ; Units: annual.prod.forg Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/seabrook/tables.output.90.98.no.mussel/E.annual.prod.forg.seabrook.90.98.csv

Table G3-10: Annual Impingement (numbers of organisms) at Pilgrim, By Species, as Estimated by the Facility

Year	Alewife	American Eel	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Atlantic Moonfish	Atlantic Silverside	Bay Anchovy	Black Ruff	Black Sea Bass	Blue Mussel	Blueback Herring
1974	4,542	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1975	NA	NA	NA	NA	NA	NA	NA	NA	702	NA	NA	NA	NA	NA
1976	NA	NA	NA	NA	45,065	NA	NA	NA	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA	NA	NA	2,735	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	20,733	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981	NA	NA	NA	NA	NA	NA	NA	NA	83,346	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	NA	NA	1,696	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	1,114	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	185	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA	NA	3,278	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	3,760	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	586	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA	1,701	NA	NA	NA	NA	NA
1990	1,248	0	10	248	333	10	3,287	0	4,354	38	10	0	248	981
1991	419	0	52	315	41,419	0	1,975	0	4,806	52	0	35	629	542
1992	250	11	23	136	34	0	23	11	2,633	0	0	11	11	125
1993	676	0	0	390	130	0	52	0	9,365	0	0	0	0	325
1994	131	0	71	214	36	12	59	0	36,970	0	0	0	35	285
1995	26,972	0	0	288	144	0	1,052	14	15,857	0	0	58	0	1,254
1996	232	0	0	296	0	0	1,584	63	16,153	0	0	0	0	1,225
1997	289	0	0	58	19	0	1,078	0	5,814	19	0	0	39	347
1998	198	0	30	106	107	0	990	15	5,896	0	0	0	NA	122
1999	793	0	0	467	70	0	40,382	187	13,811	0	0	23	0	910
Mean	3,250	1	19	252	7,593	2	5,048	29	11,587	11	1	13	107	612
Minimum	131	0	0	58	0	0	23	0	185	0	0	0	0	122
Maximum	26,972	11	71	467	45,065	12	40,382	187	83,346	52	10	58	629	1,254
SD	7,969	3	25	128	16,703	5	12,456	59	19,184	19	3	20	211	442
Total	35,750	11	186	2,518	91,117	22	50,482	290	231,735	109	10	127	962	6,116

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 08:24:29 MST 2002 Raw.losses. IMPINGEMENT; Plant:pilgrim.74.99;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/raw.losses.imp.pilgrim.74.99.csv

Table G3-10: Annual Impingement (numbers of organisms) at Pilgrim, By Species, as Estimated by the Facility (cont.)

Year	Blue-fish	Butter-fish	Cunner	Flying Gurnard	Fourbeard Rockling	Grubby	Hog-choker	Little Skate	Lump-fish	Northern Kingfish	Northern Pipefish	Northern Puffer	Orange Filefish	Pearl-side	Planehead Filefish	Pollock	Radiated Shanny
1974	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1975	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1976	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	1,683	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	0	1,601	210	0	0	562	0	0	105	0	29	57	38	0	0	38	10
1991	0	52	402	0	0	804	17	140	87	17	52	262	0	0	0	70	35
1992	0	0	34	0	0	488	0	91	136	0	23	23	0	0	11	11	34
1993	0	13	104	0	0	663	0	130	468	0	117	13	0	26	0	78	52
1994	0	48	83	0	0	1,164	0	48	202	0	190	0	0	0	0	12	154
1995	0	29	288	14	0	649	0	43	144	0	130	29	0	0	0	43	72
1996	0	21	211	0	0	1,204	0	21	169	0	127	0	0	0	0	0	21
1997	0	1,040	39	0	0	443	0	58	173	0	39	96	0	0	0	0	0
1998	15	30	76	0	15	259	0	76	289	0	0	0	0	0	0	0	46
1999	0	140	117	0	0	933	0	0	210	0	163	0	0	0	0	47	23
Mean	2	297	295	1	2	717	2	61	198	2	87	48	4	3	1	30	45
Minimum	0	0	34	0	0	259	0	0	87	0	0	0	0	0	0	0	0
Maximum	15	1,601	1,683	14	15	1,204	17	140	468	17	190	262	38	26	11	78	154
SD	5	557	474	4	5	309	5	49	111	5	66	81	12	8	3	29	44
Total	15	2,974	3,247	14	15	7,169	17	607	1,983	17	870	480	38	26	11	299	447

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 08:24:29 MST 2002 Raw.losses. IMPINGEMENT; Plant:pilgrim.74.99;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/raw.losses.imp.pilgrim.74.99.csv

Table G3-10: Annual Impingement (numbers of organisms) at Pilgrim, By Species, as Estimated by the Facility (cont.)

Year	Rainbow Smelt	Red Hake	Rock Gunnel	Round Scad	Sculpin Spp.	Scup	Searobin	Silver Rag	Smooth Dogfish	Spiny Dogfish
1974	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1975	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1976	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	29,357	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	682	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	362	10	29	19	20	591	20	19	19	19
1991	717	157	105	0	17	315	122	0	17	17
1992	284	22	34	0	0	23	0	0	0	0
1993	9,560	221	117	0	13	13	65	0	0	13
1994	10,644	60	95	0	0	12	71	0	0	0
1995	2,335	114	72	0	0	0	72	0	0	0
1996	3,674	148	127	0	21	0	0	0	0	0
1997	1,579	250	0	0	0	0	58	0	0	0
1998	777	197	30	0	15	15	15	0	0	0
1999	1,446	606	23	0	23	0	140	0	0	0
Mean	5,118	178	63	2	11	97	56	2	4	5
Minimum	284	10	0	0	0	0	0	0	0	0
Maximum	29,357	606	127	19	23	591	140	19	19	19
SD	8,407	171	45	6	10	199	49	6	8	8
Total	61,417	1,785	632	19	109	969	563	19	36	49

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 08:24:29 MST 2002 Raw.losses. IMPINGEMENT; Plant:pilgrim.74.99;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/raw.losses.imp.pilgrim.74.99.csv

Table G3-10: Annual Impingement (numbers of organisms) at Pilgrim, By Species, as Estimated by the Facility (cont.)

Year	Spot	Striped Bass	Striped Cusk Eel	Killifish Striped	Tautog	Threespine Stickleback	Unidentified	White Perch	Windowpane	Winter Flounder
1974	NA	NA	NA	NA	NA	NA	514	NA	NA	NA
1975	NA	NA	NA	NA	NA	NA	957	NA	NA	NA
1976	NA	NA	NA	NA	NA	NA	13,396	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA	6,551	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	6,059	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	7,547	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	4,086	NA	NA	NA
1981	NA	NA	NA	NA	NA	NA	4,406	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	6,477	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	3,869	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	958	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	6,744	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	7,315	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	1,778	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	1,786	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	5,344	NA	NA	NA
1990	0	0	0	67	57	29	0	0	163	295
1991	0	0	0	139	315	35	0	52	227	1,171
1992	0	0	0	45	102	23	0	79	34	817
1993	13	0	13	39	299	78	0	0	143	1,184
1994	0	0	0	72	48	297	0	24	190	1,069
1995	0	0	0	58	72	159	0	14	158	1,326
1996	0	63	0	21	528	84	0	148	275	866
1997	0	0	0	0	154	39	0	39	96	770
1998	0	0	15	30	46	61	0	30	426	1,493
1999	0	0	0	187	210	23	0	163	653	1,400
Mean	1	6	3	66	183	83	2,992	55	236	1,039
Minimum	0	0	0	0	46	23	0	0	34	295
Maximum	13	63	15	187	528	297	13,396	163	653	1,493
SD	4	20	6	57	157	86	3,535	58	181	360
Total	13	63	28	658	1,831	828	77,787	549	2,365	10,391

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 08:24:29 MST 2002 Raw.losses. IMPINGEMENT; Plant:pilgrim.74.99;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/raw.losses.imp.pilgrim.74.99.csv

Table G3-11: Annual Impingement at Pilgrim, By Species, Expressed as Age 1 Equivalents

Year	Alewife	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Atlantic Silverside	Bay Anchovy	Blueback Herring	Bluefish	Butterfish	Cunner
1974	6,070	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1975	NA	NA	NA	NA	NA	NA	1,263	NA	NA	NA	NA	NA
1976	NA	NA	NA	52,439	NA	NA	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA	4,920	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	37,294	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,345
1981	NA	NA	NA	NA	NA	NA	149,922	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	3,051	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	2,004	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	333	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	5,896	NA	NA	NA	NA	NA
1986	NA	NA	NA	4,375	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	1,054	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	3,060	NA	NA	NA	NA	NA
1990	1,668	15	297	387	13	4,014	7,832	63	1,127	0	2,146	293
1991	560	76	377	48,196	0	2,412	8,645	87	623	0	70	560
1992	334	34	163	40	0	28	4,736	0	144	0	0	47
1993	903	0	467	151	0	64	16,846	0	373	0	17	145
1994	175	104	256	42	15	72	66,501	0	327	0	64	116
1995	36,045	0	345	168	0	1,285	28,523	0	1,441	0	39	401
1996	310	0	354	0	0	1,935	29,056	0	1,407	0	28	294
1997	386	0	69	22	0	1,317	10,458	32	399	0	1,394	54
1998	265	44	127	125	0	1,209	10,606	0	140	19	40	106
1999	1,060	0	559	81	0	49,318	24,843	0	1,045	0	188	163
Mean	4,343	27	301	8,836	3	6,165	20,842	18	703	2	399	411
Minimum	175	0	69	0	0	28	333	0	140	0	0	47
Maximum	36,045	104	559	52,439	15	49,318	149,922	87	1,441	19	2,146	2,345
SD	10,649	37	153	19,436	6	15,212	34,508	32	507	6	746	660
Total	47,775	272	3,015	106,027	28	61,653	416,842	182	7,027	19	3,987	4,524

Note: Impingement losses expressed as age 1 equivalents are larger than raw losses (the actual number of organisms impinged). This is because the ages of impinged individuals are assumed to be distributed across the interval between the start of year 1 and the start of year 2, and then the losses are normalized back to the start of year 1 by accounting for mortality during this interval (for details, see description of S*j in Chapter A2, Equation 4 and Equation 5). This type of adjustment is applied to all raw loss records, but the effect is not readily apparent among entrainment losses because the majority of entrained fish are younger than age 1.
NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:07 MST 2002 ;Results; I Plant: pilgrim.74.99 ; Units: equivalent.sums Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/I.equivalent.sums.pilgrim.74.99.csv

Table G3-11: Annual Impingement at Pilgrim, By Species, Expressed as Age 1 Equivalents (cont.)

Year	Fourbeard Rockling	Grubby	Hogchoker	Little Skate	Lumpfish	Northern Pipefish	Pollock	Radiated Shanny	Rainbow Smelt	Red Hake	Rock Gunnel	Sculpin Spp.	Scup
1974	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1975	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1976	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	39,747	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA	923	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	0	689	0	0	115	39	42	12	490	13	35	25	696
1991	0	986	19	180	95	71	77	43	971	201	128	21	371
1992	0	598	0	117	149	31	12	41	385	28	41	0	27
1993	0	813	0	167	512	159	86	63	12,943	283	142	16	15
1994	0	1,427	0	62	221	258	13	187	14,411	77	116	0	14
1995	0	796	0	55	158	177	47	88	3,161	146	88	0	0
1996	0	1,476	0	27	185	173	0	26	4,974	189	154	26	0
1997	0	543	0	74	189	53	0	0	2,138	320	0	0	0
1998	19	318	0	97	316	0	0	56	1,052	252	36	18	18
1999	0	1,144	0	0	230	221	52	28	1,958	776	28	28	0
Mean	2	879	2	78	217	118	33	54	6,929	229	77	13	114
Minimum	0	318	0	0	95	0	0	0	385	13	0	0	0
Maximum	19	1,476	19	180	512	258	86	187	39,747	776	154	28	696
SD	6	379	6	63	121	90	32	53	11,383	219	55	12	234
Total	19	8,789	19	778	2,171	1,182	329	544	83,153	2,285	769	134	1,140

Note: Impingement losses expressed as age 1 equivalents are larger than raw losses (the actual number of organisms impinged). This is because the ages of impinged individuals are assumed to be distributed across the interval between the start of year 1 and the start f year 2, and then the losses are normalized back to the start of year 1 by accounting for mortality during this interval (for details, see description of S*j in Chapter A2, Equation 4 and Equation 5). This type of adjustment is applied to all raw loss records, but the effect is not readily apparent among entrainment losses because the majority of entrained fish are younger than age 1.
NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:07 MST 2002 ;Results; I Plant: pilgrim.74.99 ; Units: equivalent.sums Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/I.equivalent.sums.pilgrim.74.99.csv

Table G3-11: Annual Impingement at Pilgrim, By Species, Expressed as Age 1 Equivalents (cont.)

Year	Searobin	Striped Bass	Striped Killifish	Tautog	Threespine Stickleback	White Perch	Windowpane	Winter Flounder
1974	NA	NA	NA	NA	NA	NA	NA	NA
1975	NA	NA	NA	NA	NA	NA	NA	NA
1976	NA	NA	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA
1981	NA	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA
1990	25	0	92	63	41	0	196	325
1991	150	0	190	346	50	69	272	1,289
1992	0	0	62	112	33	105	41	899
1993	80	0	53	328	111	0	172	1,303
1994	87	0	99	53	422	32	228	1,177
1995	89	0	79	79	226	19	190	1,460
1996	0	94	29	579	119	197	330	953
1997	71	0	0	169	55	52	115	848
1998	18	0	41	50	87	40	511	1,643
1999	172	0	256	230	33	217	784	1,541
Mean	69	9	90	201	118	73	284	1,144
Minimum	0	0	0	50	33	0	41	325
Maximum	172	94	256	579	422	217	784	1,643
SD	60	30	78	173	122	78	217	396
Total	693	94	901	2,009	1,177	732	2,839	11,438

Note: Impingement losses expressed as age 1 equivalents are larger than raw losses (the actual number of organisms impinged). This is because the ages of impinged individuals are assumed to be distributed across the interval between the start of year 1 and the start of year 2, and then the losses are normalized back to the start of year 1 by accounting for mortality during this interval (for details, see description of S*j in Chapter A2, Equation 4 and Equation 5). This type of adjustment is applied to all raw loss records, but the effect is not readily apparent among entrainment losses because the majority of entrained fish are younger than age 1.
NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:07 MST 2002 ;Results; I Plant: pilgrim.74.99 ; Units: equivalent.sums Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/I.equivalent.sums.pilgrim.74.99.csv

Table G3-12: Annual Impingement of Fishery Species at Pilgrim Expressed as Yield Lost to Fisheries (in pounds)

Year	Alewife	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Atlantic Silverside	Blueback Herring	Bluefish	Butterfish	Cunner
1974	31	NA	NA	NA	NA	NA	NA	NA	NA	NA
1975	NA	NA	NA	NA	NA	0	NA	NA	NA	NA
1976	NA	NA	7,268	NA	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	2	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	14	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	11
1981	NA	NA	NA	NA	NA	58	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	1	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	1	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	0	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	2	NA	NA	NA	NA
1986	NA	NA	606	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	0	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	1	NA	NA	NA	NA
1990	8	97	54	2	1,375	3	9	0	104	1
1991	3	123	6,680	0	826	3	5	0	3	3
1992	2	53	5	0	10	2	1	0	0	0
1993	5	153	21	0	22	7	3	0	1	1
1994	1	84	6	2	25	26	2	0	3	1
1995	182	113	23	0	440	11	11	0	2	2
1996	2	116	0	0	662	11	11	0	1	1
1997	2	23	3	0	451	4	3	0	67	0
1998	1	42	17	0	414	4	1	11	2	0
1999	5	183	11	0	16,888	10	8	0	9	1
Mean	22	99	1,225	0	2,111	8	5	1	19	2
Minimum	1	23	0	0	10	0	1	0	0	0
Maximum	182	183	7,268	2	16,888	58	11	11	104	11
SD	54	50	2,694	1	5,209	13	4	3	36	3
Total	241	987	14,695	4	21,112	162	53	11	193	20

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:21 MST 2002 ;Results; I Plant: pilgrim.74.99 ; Units: yield Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/I.yield.pilgrim.74.99.csv

Table G3-12: Annual Impingement of Fishery Species at Pilgrim Expressed as Yield Lost to Fisheries (in pounds) (cont.)

Year	Little Skate	Pollock	Rainbow Smelt	Red Hake	Scup	Searobin	Striped Bass	Tautog	Windowpane	Winter Flounder
1974	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1975	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1976	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	297	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	7	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	0	61	4	2	131	1	0	69	14	102
1991	37	113	7	36	70	7	0	384	20	406
1992	24	18	3	5	5	0	0	124	3	283
1993	34	126	97	50	3	4	0	364	13	411
1994	13	19	108	14	3	4	0	58	17	371
1995	11	69	24	26	0	4	0	88	14	460
1996	6	0	37	34	0	0	131	643	24	300
1997	15	0	16	57	0	4	0	188	8	267
1998	20	0	8	45	3	1	0	56	38	518
1999	0	76	15	138	0	9	0	256	58	486
Mean	16	48	52	41	21	3	13	223	21	361
Minimum	0	0	3	2	0	0	0	56	3	102
Maximum	37	126	297	138	131	9	131	643	58	518
SD	13	48	85	39	44	3	41	192	16	125
Total	161	483	622	407	215	34	131	2,230	209	3,605

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:21 MST 2002 ;Results; I Plant: pilgrim.74.99 ; Units: yield Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/I.yield.pilgrim.74.99.csv

Table G3-13: Annual Impingement at Pilgrim, By Species, Expressed as Production Foregone (in pounds)

Year	Alewife	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Atlantic Silverside	Blueback Herring	Blue-fish	Butter-fish	Cunner	Grubby	Little Skate	Lump-fish
1974	190	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1975	NA	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA
1976	NA	NA	NA	4,094	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA	2	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	13	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	13	NA	NA	NA
1981	NA	NA	NA	NA	NA	NA	52	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	2	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	342	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA
1990	52	0	34	30	1	628	3	52	0	50	2	42	0	4
1991	18	0	43	3,762	0	377	3	29	0	2	3	60	17	3
1992	10	0	19	3	0	4	2	7	0	0	0	36	11	5
1993	28	0	53	12	0	10	6	17	0	0	1	49	16	17
1994	5	1	29	3	1	11	23	15	0	2	1	87	6	7
1995	1,128	0	39	13	0	201	10	66	0	1	2	48	5	5
1996	10	0	41	0	0	303	10	64	0	1	2	90	3	6
1997	12	0	8	2	0	206	4	18	0	33	0	33	7	6
1998	8	0	15	10	0	189	4	6	2	1	1	19	9	10
1999	33	0	64	6	0	7,715	9	48	0	4	1	70	0	7
Mean	136	0	34	690	0	964	7	32	0	9	2	53	7	7
Minimum	5	0	8	0	0	4	0	6	0	0	0	19	0	3
Maximum	1,128	1	64	4,094	1	7,715	52	66	2	50	13	90	17	17
SD	333	0	17	1,517	1	2,380	12	23	1	17	4	23	6	4
Total	1,495	1	345	8,277	3	9,644	144	322	2	93	25	535	75	70

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:14 MST 2002 ;Results; I Plant: pilgrim.74.99 ; Units: annual.prod.forg Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/I.annual.prod.forg.pilgrim.74.99.csv

Table G3-13: Annual Impingement at Pilgrim, By Species, Expressed as Production Foregone (in pounds) (cont.)

Year	Pollock	Rainbow Smelt	Red Hake	Rock Gunnel	Sculpin Spp.	Scup	Searobin	Striped Bass	Striped Killifish	Tautog	White Perch	Windowpane	Winter Flounder
1974	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1975	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1976	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	1,219	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	28	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	20	15	2	0	1	67	2	0	1	8	0	3	39
1991	36	30	27	1	1	36	11	0	1	43	0	5	156
1992	6	12	4	0	0	3	0	0	0	14	0	1	109
1993	40	397	39	1	1	1	6	0	0	41	0	3	158
1994	6	442	10	1	0	1	7	0	1	7	0	4	142
1995	22	97	20	0	0	0	7	0	0	10	0	3	176
1996	0	153	26	1	2	0	0	27	0	72	1	6	115
1997	0	66	44	0	0	0	5	0	0	21	0	2	102
1998	0	32	34	0	1	2	1	0	0	6	0	9	199
1999	24	60	106	0	2	0	13	0	2	29	1	14	186
Mean	15	212	31	0	1	11	5	3	1	25	0	5	138
Minimum	0	12	2	0	0	0	0	0	0	6	0	1	39
Maximum	40	1,219	106	1	2	67	13	27	2	72	1	14	199
SD	15	349	30	0	1	23	4	8	0	21	0	4	48
Total	154	2,549	312	3	8	111	52	27	6	249	2	51	1,383

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:14 MST 2002 ;Results; I Plant: pilgrim.74.99 ; Units: annual.prod.forg Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/I.annual.prod.forg.pilgrim.74.99.csv

Table G3-14: Annual Entrainment (numbers of organisms) at Pilgrim, By Species, as Estimated by the Facility.

Year	Alewife	American Plaice	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Atlantic Silverside	Blue Mussel	Cunner
1974	957,330	NA	NA	NA	NA	NA	76,436,500	323,810	2,208,700,000,000	1,177,600,000
1975	0	NA	NA	NA	NA	NA	7,280,500	1,546,620	19,122,000,000,000	1,177,600,000
1976	12,976	NA	NA	NA	NA	NA	21,696,300	2,436,575	2,891,200,000,000	1,177,600,000
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	21,839,372	1,068,466	103,892,540	28,529,199	NA	NA	3,378,883,316
1981	NA	NA	NA	13,793,664	2,471,492	504,095,387	43,549,879	NA	NA	7,152,617,480
1982	NA	NA	NA	2,805,705	732,857	117,623,074	366,937,320	NA	NA	2,020,915,711
1983	NA	NA	NA	9,491,864	5,880,315	189,950,294	2,096,770	NA	NA	5,937,818,325
1984	NA	NA	NA	12,313,633	468,840	22,564,934	4,751,607	NA	NA	1,767,970,898
1985	NA	NA	NA	6,512,593	1,580,435	1,913,359,781	50,322,124	NA	NA	2,061,768,342
1986	NA	NA	NA	3,824,754	1,811,101	277,821,586	24,767,656	NA	NA	1,520,567,067
1987	NA	NA	NA	5,745,861	5,142,045	71,437,855	1,872,216	NA	NA	4,506,374,514
1988	NA	NA	NA	3,001,273	639,089	2,667,010,057	11,987,628	NA	NA	1,546,465,819
1989	NA	NA	NA	3,515,162	911,487	4,739,478,407	15,623,972	NA	NA	4,521,604,135
1990	NA	2,386,979	60,886,295	3,972,827	2,079,483	2,318,043,737	10,320,759	NA	NA	1,508,146,909
1991	NA	3,434,141	23,485,288	3,908,395	1,280,273	545,771,347	6,256,434	NA	NA	691,736,018
1992	NA	12,355,715	108,323,789	3,289,386	3,970,208	385,697,157	1,510,414	NA	NA	2,177,452,952
1993	NA	54,863,855	46,668,316	1,715,237	2,098,952	1,809,704,207	959,648,788	NA	NA	3,250,567,317
1994	NA	6,286,118	458,829,894	5,023,831	16,351,765	524,336,520	12,583,586	NA	NA	1,568,239,739
1995	NA	5,219,224	54,688,357	3,151,964	43,247,883	1,965,298,971	15,700,367	NA	NA	4,163,622,052
1996	NA	3,931,000	340,701,000	10,912,177	9,265,826	1,578,317,735	13,522,139	NA	NA	2,824,542,922
1997	NA	4,809,142	106,911,770	2,901,829	24,445,056	342,747,452	97,182,867	NA	NA	1,817,924,713
1998	NA	8,055,050	41,715,642	5,706,922	4,026,783	586,639,654	78,011,253	NA	NA	4,711,882,277
1999	NA	NA	NA	2,397,019	11,379,446	35,506,522	33,719,962	NA	NA	1,773,984,349
Mean	323,435	11,260,136	138,023,372	6,291,173	6,942,590	1,034,964,861	81,926,445	1,435,668	8,073,966,666,670	2,714,603,689
Minimum	0	2,386,979	23,485,288	1,715,237	468,840	22,564,934	1,510,414	323,810	2,208,700,000,000	691,736,018
Maximum	957,330	54,863,855	458,829,894	21,839,372	43,247,883	4,739,478,407	959,648,788	2,436,575	19,122,000,000,000	7,152,617,480
SD	549,007	16,618,143	153,899,234	5,039,143	10,525,822	1,222,538,368	205,740,114	1,060,743	9,573,961,142,770	1,704,407,272
Total	970,306	101,341,224	1,242,210,351	125,823,468	138,851,802	20,699,297,217	1,884,308,240	4,307,005	24,221,900,000,000	62,435,884,855

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 08:24:30 MST 2002 Raw.losses. ENTRAINMENT; Plant:pilgrim.74.99;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/raw.losses.ent.pilgrim.74.99.csv

Table G3-14: Annual Entrainment (numbers of organisms) at Pilgrim, By Species, as Estimated by the Facility (cont.)

Year	Fourbeard Rockling	Lumpfish	Pollock	Radiated Shanny	Rainbow Smelt	Red Hake	Rock Gunnel	Sculpin Spp.	Searobin	Tautog	Windowpane	Winter Flounder
1974	NA	NA	104,972,000	NA	30,105,000	NA	NA	NA	NA	NA	NA	225,000,000
1975	NA	NA	2,144,710	NA	145,400	NA	NA	NA	NA	NA	NA	52,280,000
1976	NA	NA	21,137,710	NA	87,242	NA	NA	NA	NA	NA	NA	33,725,000
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	28,726,407
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	29,856,493
1982	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	21,439,774
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	11,998,509
1984	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8,334,474
1985	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	11,508,028
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	15,221,824
1987	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3,526,013
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	19,243,313
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9,687,852
1990	161,001,461	7,829,710	NA	16,056,794	NA	NA	12,268,408	26,003,576	1,725,190	8,720,243	60,919,472	8,678,807
1991	141,180,985	7,257,673	NA	14,010,361	NA	NA	37,694,011	44,379,996	2,591,103	3,849,374	50,098,443	12,605,283
1992	126,361,457	2,222,841	NA	13,014,884	NA	NA	30,028,438	7,409,762	1,389,931	3,142,186	61,663,329	8,811,456
1993	60,326,651	9,340,124	NA	19,514,380	NA	NA	7,455,162	38,339,208	3,466,096	4,367,106	152,988,400	10,160,019
1994	60,933,441	10,595,602	NA	13,330,063	NA	23,254,273	62,079,785	34,041,077	1,080,077	1,321,569	73,781,569	20,701,312
1995	33,524,219	7,828,837	NA	16,190,247	NA	4,789,498	13,281,171	31,147,018	2,522,305	2,376,502	42,663,536	13,655,283
1996	29,396,000	4,305,000	NA	32,569,000	NA	14,447,000	33,497,000	50,775,000	1,213,000	5,319,000	99,739,000	18,648,291
1997	95,461,605	8,196,313	NA	12,958,397	NA	50,281,351	97,510,007	88,316,035	2,824,213	9,763,040	94,240,177	55,373,718
1998	140,083,704	830,815	NA	35,957,121	NA	62,604,501	15,175,912	47,161,167	918,471	28,756,809	115,833,081	86,846,061
1999	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,680,713
Mean	94,252,169	6,489,657	42,751,473	19,289,027	10,112,547	31,075,325	34,332,210	40,841,427	1,970,043	7,512,870	83,547,445	30,900,375
Minimum	29,396,000	830,815	2,144,710	12,958,397	87,242	4,789,498	7,455,162	7,409,762	918,471	1,321,569	42,663,536	3,526,013
Maximum	161,001,461	10,595,602	104,972,000	35,957,121	30,105,000	62,604,501	97,510,007	88,316,035	3,466,096	28,756,809	152,988,400	225,000,000
SD	49,932,536	3,299,177	54,714,979	8,782,788	17,313,996	24,451,867	29,178,718	22,049,094	903,184	8,439,294	35,562,535	46,599,404
Total	848,269,523	58,406,915	128,254,420	173,601,247	30,337,642	155,376,623	308,989,894	367,572,839	17,730,386	67,615,829	751,927,007	710,708,630

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 08:24:30 MST 2002 Raw.losses. ENTRAINMENT; Plant:pilgrim.74.99;
PATHNAME:P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/raw.losses.ent.pilgrim.74.99.csv

Table G3-15: Annual Entrainment at Pilgrim, By Species, Expressed as Age 1 Equivalents

Year	American Plaice	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Atlantic Silverside	Cunner	Fourbeard Rockling	Lumpfish	Pollock
1974	NA	NA	NA	NA	NA	28,754	1,416	724,630	NA	NA	1,201
1975	NA	NA	NA	NA	NA	2,383	3,578	724,630	NA	NA	70
1976	NA	NA	NA	NA	NA	5,842	10,265	724,630	NA	NA	206
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	3,758	3,115	1,459	5,305	NA	1,314,956	NA	NA	NA
1981	NA	NA	5,292	7,206	16,812	15,454	NA	4,660,735	NA	NA	NA
1982	NA	NA	567	2,137	925	16,201	NA	421,665	NA	NA	NA
1983	NA	NA	500	17,145	2,695	506	NA	1,313,416	NA	NA	NA
1984	NA	NA	1,583	1,367	98	202	NA	323,971	NA	NA	NA
1985	NA	NA	3,463	4,608	10,130	5,256	NA	603,370	NA	NA	NA
1986	NA	NA	2,474	5,281	3,844	2,292	NA	430,335	NA	NA	NA
1987	NA	NA	387	14,993	310	609	NA	1,046,996	NA	NA	NA
1988	NA	NA	644	1,863	11,351	1,430	NA	320,441	NA	NA	NA
1989	NA	NA	340	2,658	22,903	2,161	NA	1,116,427	NA	NA	NA
1990	47	1,815,806	3,707	6,063	9,942	1,546	NA	1,279,249	583,611	1,303	NA
1991	67	700,399	627	3,733	5,321	439	NA	222,102	714,005	1,208	NA
1992	242	3,230,530	1,149	11,576	1,990	444	NA	406,666	438,229	370	NA
1993	1,076	1,391,785	1,067	6,120	7,978	44,749	NA	672,052	211,060	1,554	NA
1994	123	13,683,639	4,511	47,678	2,358	1,336	NA	339,643	301,560	1,763	NA
1995	102	1,630,966	1,455	126,100	17,325	4,883	NA	1,022,608	119,501	1,303	NA
1996	77	10,160,693	5,696	27,017	9,882	3,514	NA	608,403	266,426	716	NA
1997	94	3,188,419	2,608	71,276	2,622	20,516	NA	909,960	393,940	1,364	NA
1998	158	1,244,082	1,809	11,741	5,062	14,609	NA	3,014,964	672,366	138	NA
1999	NA	NA	1,120	33,180	171	7,991	NA	648,654	NA	NA	NA
Mean	221	4,116,258	2,138	20,243	6,659	8,105	5,087	993,500	411,189	1,080	492
Minimum	47	700,399	340	1,367	98	202	1,416	222,102	119,501	138	70
Maximum	1,076	13,683,639	5,696	126,100	22,903	44,749	10,265	4,660,735	714,005	1,763	1,201
SD	326	4,589,722	1,708	30,691	6,520	11,010	4,613	988,573	208,799	549	617
Total	1,988	37,046,318	42,758	404,856	133,179	186,422	15,260	22,850,503	3,700,698	9,718	1,477

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:01 MST 2002 ;Results; E Plant: pilgrim.74.99 ; Units: equivalent.sums Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/E.equivalent.sums.pilgrim.74.99.csv

Table G3-15: Annual Entrainment at Pilgrim, By Species, Expressed as Age 1 Equivalents (cont.)

Year	Radiated Shanny	Rainbow Smelt	Red Hake	Rock Gunnel	Sculpin Spp.	Searobin	Tautog	Windowpane	Winter Flounder
1974	NA	3,938,972	NA	NA	NA	NA	NA	NA	731,769
1975	NA	19,024	NA	NA	NA	NA	NA	NA	170,030
1976	NA	11,415	NA	NA	NA	NA	NA	NA	109,684
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	126,854
1981	NA	NA	NA	NA	NA	NA	NA	NA	110,909
1982	NA	NA	NA	NA	NA	NA	NA	NA	182,727
1983	NA	NA	NA	NA	NA	NA	NA	NA	110,701
1984	NA	NA	NA	NA	NA	NA	NA	NA	128,815
1985	NA	NA	NA	NA	NA	NA	NA	NA	98,949
1986	NA	NA	NA	NA	NA	NA	NA	NA	75,135
1987	NA	NA	NA	NA	NA	NA	NA	NA	30,164
1988	NA	NA	NA	NA	NA	NA	NA	NA	207,002
1989	NA	NA	NA	NA	NA	NA	NA	NA	47,147
1990	1,368,852	NA	NA	1,737,690	467,819	3,238	1,016	12,584	72,462
1991	1,194,392	NA	NA	5,338,958	798,421	4,864	449	10,349	72,170
1992	1,109,527	NA	NA	4,253,211	133,306	2,609	366	12,737	73,003
1993	1,663,613	NA	NA	1,055,945	689,744	6,506	509	31,602	70,569
1994	1,136,396	NA	1,156	8,792,945	612,418	2,027	154	15,241	163,886
1995	1,380,229	NA	238	1,881,138	560,352	4,735	277	8,813	136,714
1996	2,776,528	NA	718	4,744,496	913,471	2,277	620	20,602	236,922
1997	1,104,711	NA	2,500	13,811,262	1,588,855	5,301	1,138	19,467	659,882
1998	3,065,367	NA	3,112	2,149,508	848,456	1,724	3,351	23,927	1,166,820
1999	NA	NA	NA	NA	NA	NA	NA	NA	37,806
Mean	1,644,402	1,323,137	1,545	4,862,795	734,760	3,698	875	17,258	209,571
Minimum	1,104,711	11,415	238	1,055,945	133,306	1,724	154	8,813	30,164
Maximum	3,065,367	3,938,972	3,112	13,811,262	1,588,855	6,506	3,351	31,602	1,166,820
SD	748,738	2,265,383	1,216	4,132,857	396,676	1,695	983	7,346	272,956
Total	14,799,615	3,969,411	7,724	43,765,153	6,612,841	33,282	7,879	155,321	4,820,123

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:01 MST 2002 ;Results; E Plant: pilgrim.74.99 ; Units: equivalent.sums Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/E.equivalent.sums.pilgrim.74.99.csv

Table G3-16: Annual Entrainment of Fishery Species at Pilgrim Expressed as Yield Lost to Fisheries (in pounds)

Year	Atlantic Cod	Atlantic Mackerel	Cunner	Atlantic Herring	Atlantic Menhaden	American Plaice	Pollock	Rainbow Smelt	Red Hake	Sea-robin	Atlantic Silverside	Tautog	Window-pane	Winter Flounder
1974	NA	NA	3,268	NA	9,846	NA	1,763	29,473	NA	NA	1	NA	NA	230,673
1975	NA	NA	3,268	NA	816	NA	103	142	NA	NA	1	NA	NA	53,598
1976	NA	NA	3,268	NA	2,001	NA	302	85	NA	NA	4	NA	NA	34,575
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	1,230	202	5,930	432	1,817	NA	NA	NA	NA	NA	NA	NA	NA	39,988
1981	1,732	2,325	21,020	999	5,292	NA	NA	NA	NA	NA	NA	NA	NA	34,962
1982	186	128	1,902	296	5,548	NA	NA	NA	NA	NA	NA	NA	NA	57,601
1983	164	373	5,923	2,376	173	NA	NA	NA	NA	NA	NA	NA	NA	34,896
1984	518	14	1,461	189	69	NA	NA	NA	NA	NA	NA	NA	NA	40,606
1985	1,134	1,401	2,721	639	1,800	NA	NA	NA	NA	NA	NA	NA	NA	31,191
1986	810	532	1,941	732	785	NA	NA	NA	NA	NA	NA	NA	NA	23,685
1987	127	43	4,722	2,078	209	NA	NA	NA	NA	NA	NA	NA	NA	9,509
1988	211	1,570	1,445	258	490	NA	NA	NA	NA	NA	NA	NA	NA	65,253
1989	111	3,167	5,035	368	740	NA	NA	NA	NA	NA	NA	NA	NA	14,862
1990	1,214	1,375	5,769	840	529	5	NA	NA	NA	161	NA	1,128	928	22,842
1991	205	736	1,002	517	150	8	NA	NA	NA	242	NA	498	763	22,750
1992	376	275	1,834	1,604	152	28	NA	NA	NA	130	NA	407	939	23,013
1993	349	1,103	3,031	848	15,323	123	NA	NA	NA	324	NA	565	2,330	22,245
1994	1,477	326	1,532	6,608	457	14	NA	NA	206	101	NA	171	1,124	51,661
1995	476	2,396	4,612	17,477	1,672	12	NA	NA	42	236	NA	307	650	43,096
1996	1,864	1,367	2,744	3,744	1,203	9	NA	NA	128	113	NA	688	1,519	74,684
1997	854	363	4,104	9,879	7,025	11	NA	NA	445	264	NA	1,263	1,435	208,013
1998	592	700	13,597	1,627	5,003	18	NA	NA	555	86	NA	3,721	1,764	367,814
1999	367	24	2,925	4,599	2,737	NA	NA	NA	NA	NA	NA	NA	NA	11,917
Mean	700	921	4,481	2,806	2,776	25	723	9,900	275	184	2	972	1,272	66,062
Minimum	111	14	1,002	189	69	5	103	85	42	86	1	171	650	9,509
Maximum	1,864	3,167	21,020	17,477	15,323	123	1,763	29,473	555	324	4	3,721	2,330	367,814
SD	559	902	4,458	4,254	3,770	37	906	16,950	217	84	2	1,092	542	86,043
Total	13,997	18,417	103,056	56,112	63,837	228	2,168	29,700	1,376	1,657	6	8,748	11,451	1,519,434

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:17 MST 2002 ;Results; E Plant: pilgrim.74.99 ; Units: yield Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/E.yield.pilgrim.74.99.csv

Table G3-17: Annual Entrainment at Pilgrim, By Species, Expressed as Production Foregone (in pounds)

Year	Alewife	American Plaice	American Sand Lance	Atlantic Cod	Atlantic Herring	Atlantic Mackerel	Atlantic Menhaden	Atlantic Silverside	Cunner	Fourbeard Rockling	Lumpfish	Pollock
1974	3,498	NA	NA	NA	NA	NA	8	0	382	NA	NA	146
1975	0	NA	NA	NA	NA	NA	1	425	382	NA	NA	4
1976	0	NA	NA	NA	NA	NA	4	5	382	NA	NA	28
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	6	1	24	7	NA	24,267	NA	NA	NA
1981	NA	NA	NA	3	3	56	5	NA	2,317	NA	NA	NA
1982	NA	NA	NA	1	1	32	118	NA	672	NA	NA	NA
1983	NA	NA	NA	2	8	44	0	NA	1,972	NA	NA	NA
1984	NA	NA	NA	3	1	7	2	NA	588	NA	NA	NA
1985	NA	NA	NA	2	2	557	14	NA	682	NA	NA	NA
1986	NA	NA	NA	1	2,139	66	7	NA	503	NA	NA	NA
1987	NA	NA	NA	1	7	21	0	NA	1,496	NA	NA	NA
1988	NA	NA	NA	1	1	795	3	NA	514	NA	NA	NA
1989	NA	NA	NA	1	1	1,394	4	NA	1,499	NA	NA	NA
1990	NA	1	68,231	700	2,456	17,208	2,506	NA	23,009	67	6,280	NA
1991	NA	2	26,318	119	1,512	143	714	NA	4,139	65	5,821	NA
1992	NA	6	121,391	217	4,690	113	719	NA	7,886	52	1,783	NA
1993	NA	25	680	202	2,479	537	72,767	NA	12,915	25	7,491	NA
1994	NA	3	514,178	851	19,316	4,073	2,167	NA	6,502	28	8,498	NA
1995	NA	2	797	275	51,088	528	7,909	NA	19,388	14	6,279	NA
1996	NA	2	4,964	1,076	13	450	5,693	NA	11,652	17	3,453	NA
1997	NA	2	1,558	492	28,877	95	33,242	NA	16,618	41	6,574	NA
1998	NA	4	46,748	342	4,757	158	23,675	NA	54,618	15,974	666	NA
1999	NA	NA	NA	212	13,442	10	12,947	NA	12,006	NA	NA	NA
Mean	1,166	5	87,207	225	6,540	1,316	7,066	143	8,886	1,809	5,205	59
Minimum	0	1	680	1	1	7	0	0	382	14	666	4
Maximum	3,498	25	514,178	1,076	51,088	17,208	72,767	425	54,618	15,974	8,498	146
SD	2,020	8	165,163	319	12,990	3,851	16,634	244	12,652	5,312	2,646	76
Total	3,498	46	784,865	4,507	130,797	26,311	162,512	430	204,389	16,284	46,846	178

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:10 MST 2002 ;Results; E Plant: pilgrim.74.99 ; Units: annual.prod.forg Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/E.annual.prod.forg.pilgrim.74.99.csv

Table G3-17: Annual Entrainment at Pilgrim, By Species, Expressed as Production Foregone (in pounds) (cont.)

Year	Radiated Shanny	Rainbow Smelt	Red Hake	Rock Gunnel	Sculpin Spp.	Searobin	Tautog	Windowpane	Winter Flounder
1974	NA	26,577	NA	NA	NA	NA	NA	NA	778
1975	NA	128	NA	NA	NA	NA	NA	NA	181
1976	NA	77	NA	NA	NA	NA	NA	NA	117
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	234
1981	NA	NA	NA	NA	NA	NA	NA	NA	259
1982	NA	NA	NA	NA	NA	NA	NA	NA	195
1983	NA	NA	NA	NA	NA	NA	NA	NA	106
1984	NA	NA	NA	NA	NA	NA	NA	NA	89
1985	NA	NA	NA	NA	NA	NA	NA	NA	97
1986	NA	NA	NA	NA	NA	NA	NA	NA	125
1987	NA	NA	NA	NA	NA	NA	NA	NA	27
1988	NA	NA	NA	NA	NA	NA	NA	NA	172
1989	NA	NA	NA	NA	NA	NA	NA	NA	85
1990	4,537	NA	NA	19,050	46,095	23,470	293	144,307	51,695
1991	3,959	NA	NA	58,532	78,670	35,250	129	118,674	51,519
1992	3,678	NA	NA	46,628	46	1	106	146,069	52,080
1993	5,514	NA	NA	11,576	67,962	47,153	147	362,402	50,364
1994	3,767	NA	2,152,223	96,398	210	14,693	44	174,775	116,938
1995	4,575	NA	443,276	20,623	192	34,314	80	101,062	97,529
1996	9,204	NA	1,337,095	52,014	90,006	1	179	236,264	169,001
1997	79	NA	4,653,626	6,818	544	38,421	328	223,238	470,681
1998	10,161	NA	5,794,155	23,565	83,600	12,495	967	274,388	832,257
1999	NA	NA	NA	NA	NA	NA	NA	NA	26,976
Mean	5,053	8,927	2,876,075	37,245	40,814	22,866	253	197,909	83,544
Minimum	79	77	443,276	6,818	46	1	44	101,062	27
Maximum	10,161	26,577	5,794,155	96,398	90,006	47,153	967	362,402	832,257
SD	3,031	15,285	2,263,063	28,804	40,359	17,090	284	84,241	192,674
Total	45,474	26,782	14,380,377	335,206	367,323	205,798	2,273	1,781,178	1,921,503

NA=Not sampled.
0=Sampled, but none collected.
Mon Feb 11 10:06:10 MST 2002 ;Results; E Plant: pilgrim.74.99 ; Units: annual.prod.forg Pathname: P:/Intake/Seabrook-Pilgrim/Science/scode/pilgrim/tables.output.74.99.no.mussel/E.annual.prod.forg.pilgrim.74.99.csv

G3-7 Summary and Comparison of I&E at Seabrook and Pilgrim

The data presented in Sections G3-4 and G3-6 indicate that the fish species most often impinged at both Seabrook and Pilgrim are fishery species. At Seabrook, the most frequently impinged fishery species are winter flounder, red hake and Atlantic silverside. At Pilgrim, the most abundant fishery species in impingement collections are Atlantic silverside, Atlantic herring, rainbow smelt, and Atlantic menhaden.

Entrainment rates at both facilities are several orders of magnitude higher than impingement rates. At Seabrook, the fish species most frequently entrained include the fishery species Atlantic mackerel, winter flounder, and red hake. At Pilgrim, the fishery species most frequently entrained include Atlantic mackerel and cunner. Entrainment losses of some forage fish are also high at both facilities, including fourbeard rockling, lumpfish, and rock gunnel at Seabrook, and American sand lance, fourbeard rockling, and lumpfish at Pilgrim.

The data presented in Sections G3-4 and G3-6 also indicate that I&E at Seabrook's offshore intake is substantially lower than I&E at Pilgrim's nearshore intake. EPA compared age 1 equivalent losses for years when both facilities were operating, including 1990-1993 and 1995-1998 (Seabrook was shut down during much of 1994 and so this year was not considered in the comparison). Total losses averaged over these years for the 32 species that are either impinged or entrained at both facilities indicate that impingement averages 68% less at Seabrook and entrainment averages 58% less.

G3-8 Potential Biases and Uncertainties in I&E Estimates

Pilgrim and Seabrook used different methods to estimate annual I&E, and therefore the I&E estimates of the two facilities may not be strictly comparable. In addition, Seabrook was shut down during parts of 1994 and 1997 (Normandeau Associates, 1999). Table G3-18 outlines the main factors that should be taken into account in comparing I&E losses at the two facilities.

Table G3-18: Differences in Methods Used by Pilgrim and Seabrook to Estimate Annual I&E and Potential Effects on EPA's Results

Estimation Parameters	Pilgrim	Seabrook	Effect on Comparison of Facility Losses
Mesh size for entrainment sampling	0.202 and 0.333 mm stage 1 and 2 larvae were adjusted for mesh extrusion	0.505 mm No adjustment	0
Flow used for density calculations	Design flow	Operational flow	Likely to overestimate the difference between the two facilities.
Entrainment sampling frequency	2-6 times per month	4 times per month	U
Impingement sampling frequency	8 hours 3 times per week	2 to 3 times per week	U
Adjustment for day/night sampling	Sampling day and night	No sampling at night and no adjustment	Likely to underestimate the difference between the two facilities.

U = Uncertain (could underestimate or overestimate the difference between the two facilities)..
0 = No effect.

The effect of various mesh sizes seems to have been adjusted properly at each facility, so differences in mesh sizes appear unimportant in comparing losses. At Pilgrim, mesh correction values were applied to both eggs and larvae to decrease the effect of different mesh sizes (0.202 and 0.333 mm) on I&E estimates. In contrast, Seabrook did not apply mesh correction values because a comparison of sampling efficiency with 0.505 mm and 0.333 mm mesh sizes in 1998 indicated that such a correction was unnecessary. Seabrook found that the flow through each mesh size and the total volume sampled for each mesh size were identical, and there were no significant differences in ichthyoplankton densities based on sampling with the different mesh sizes (Normandeau Associates, 1999).

Another potentially important difference in methods concerns the flow volume used to calculate entrainment density. Seabrook used the weekly cooling water volume measured during the week an entrainment sample was taken, whereas Pilgrim used the full-load flow. Pilgrim used this value even if the station was out of service and less than full capacity was being

circulated. Therefore, Pilgrim may have overestimated annual I&E losses, which would result in an overestimate of any differences in loss rates between the two facilities.
Time of day of sampling may also affect estimates of losses. At Pilgrim, entrainment sampling was conducted at least once a month at night, whereas prior to 1998 entrainment sampling at Seabrook took place only during the day. Different sets of organisms are susceptible to entrainment in the day and the night. Therefore, by sampling only during the day, Seabrook may have underestimated entrainment, resulting in an underestimate of differences in I&E rates at the two facilities.

Entrainment sampling frequencies differed between Seabrook and Pilgrim, but the effect of sampling frequency on I&E has never been studied. Therefore, the potential importance of various entrainment sampling frequencies on a comparison of losses between Seabrook and Pilgrim is unknown.

Methods used to estimate annual impingement numbers also differed between the two facilities. Once or twice a week, Seabrook collected all fish impinged on the traveling screens and summed the fish impinged in the individual screenwashes to obtain yearly estimates. In contrast, Pilgrim collected impinged fish over an 8 hour period three times per week and estimated hourly impingement rates by dividing the numbers of fish impinged during the monitoring period by the numbers of hours of monitoring. These rates were then multiplied by 24 hours and 365 days to obtain annual impingement numbers. The effect of these differences in collection methods is uncertain.