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OMNIBUS ESSENTIAL FISH HABITAT AMENDMENT 2 FINAL ENVIRONMENTAL IMPACT STATEMENT

Appendix B: EFH supplementary tables, prey species information, and spawning information

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Tables

Abbreviations Used in Supplementary Habitat Tables

BOF = Bay of Fundy
Nfld = Newfoundland
CB = Chesapeake Bay
CT = Connecticut
DB or DBay = Delaware Bay
GB = Georges Bank
GOM = Gulf of Maine
LIS = Long Island Sound
MA = Massachusetts
ME= Maine
NC = North Carolina
NJ = New Jersey
RB = Raritan Bay
SS = Scotian Shelf
YOY = young-of-the-year juvenile

Introduction

To summarize the life history information necessary to understand the relationship of each species and life history stage to, or its dependence on, various habitats, using text, tables, and figures, as appropriate, the Council developed EFH designation text (text descriptions) for each species and life stage. The final text descriptions are provided in the body of the EIS. This appendix supplements those text descriptions with EFH supplemental tables, prey descriptions, and peak spawning descriptions. This information is organized by species in section 2.0.

Supplementary tables

As part of the process of developing the text descriptions, the Council created supplemental tables that include all the relevant habitat-related information that was compiled for each species and life stage. The tables summarize all available information on environmental and habitat variables that control or limit the distribution and abundance of each species and life stage, with some additional information on ecological factors limiting reproduction, growth, and survival. Sources of information are listed under each table: some of the information was derived from analyses of NMFS and state trawl survey data done as part of the EFH designation process for this amendment and some was provided in various state survey reports. Much of the information was available in the NMFS EFH Source Document series and in a number of recent revisions and update memos, and in Colette and Klein-MacPhee's Fishes of the Gulf of Maine (2002). Minimum and maximum depths used in the preferred EFH text descriptions are shown as bold, underlined values.

Prey species

Information on primary prey consumed by each species and life stage was also included in the text descriptions, and is detailed below. The EFH Final Rule (50 CFR 600) requires that Fishery Management Plans (FMPs) established or amended under the Sustainable Fisheries Act of 1996 defines essential fish habitat (EFH) as:

> "Those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: ''Waters'' include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; ''substrate'' includes sediment, hard bottom, structures underlying the waters, and associated biological communities; ''necessary'' means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and ''spawning, breeding, feeding, or growth to maturity'' covers a species' full life cycle."

Further, the Rule requires that these FMPs *"list the major prey species for the species in the fishery management unit and discuss the location of prey species' habitat."* According to the Rule:

> "Loss of prey may be an adverse effect on EFH and managed species because the presence of prey makes waters and substrate function as feeding habitat, and the definition of EFH includes waters and substrate necessary to fish for feeding. Therefore, actions that reduce the availability of a major prey species, either through direct harm or capture, or through adverse impacts to the prey species' habitat that are known to cause a reduction in the population of the prey species, may be considered adverse effects on EFH if such actions reduce the quality of EFH. … Adverse effects on prey species and their habitats may result from fishing and non-fishing activities."

National Marine Fisheries Service has offered the Councils the following draft guidance (April 2006) on implementing the Prey Species Requirement of the EFH Final Rule as follows:

> The definition of EFH in the regulatory guidelines acknowledge that prey, as part of "associated biological communities", may be considered a component of EFH for a species and/or lifestage (50 CFR 600.10). However, including prey in EFH identifications and descriptions has considerable implications for the overall scope of EFH when those prey are considered during the EFH consultation process. It is important that prey do not become a vehicle for overly expansive interpretations of EFH descriptions. To avoid this pitfall, the following suggestions should be considered when including prey in an EFH description:
>
> 1. Prey species alone should not be described as EFH. Instead, prey should be included in EFH descriptions as a component of EFH (along with others components such as depth, temperature, sediment type).
>
> 2. If the FMP identifies prey as a component of EFH, the FMP should specify those prey species and how their presence "makes the waters and substrate function as feeding habitat" (50 CFR 600.815(a)(7)).
>
> 3. While prey may be considered a component of EFH, prey habitat should not be identified as EFH in FMPs unless it is also EFH for a managed species. Identifying prey habitat as EFH could be viewed as over-extending the scope of EFH which should consist of habitat necessary for the managed species (50 CFR Preamble). However prey species habitat should be discussed in the FMP (52 CFR 600.815 (a)(7)).

Accordingly, the New England Fishery Management Council has developed a description of the major prey types for each managed species under its jurisdiction. In addition, benthic invertebrate prey types and their vulnerability to fishing gear impacts are summarized in the Swept Area Seabed Impact approach appendix to this amendment.

The sources of information used to describe the primary prey for a managed species include the EFH species source documents (1^{st} and 2^{nd} editions) and the new EFH species update memos and references therein, plus a few published sources that were not included in the source documents or update memos. The major data source used for the prey information in these source documents is the NEFSC bottom trawl survey food habits database from 1963 to the present (see Link and Almeida [2000] for methods). This database has been used in many food habits studies and publications over the years, and these studies and publications often covered different years or subsets of the database. Generally, the results agree; it is often the details at a certain prey taxonomic level that may differ. The section of the prey tables that cover the continental shelf are largely based upon these various studies or publications, and because the use of these studies and publications often varied from one EFH species source document or update memo to another, this is reflected in the prey tables for each species. Generally, major prey phyla are defined as those prey items exceeding, depending on the study, the 5% threshold for one or several of the following measures in the stomachs of a managed species: percent frequency of occurrence, percent numerical abundance, percent stomach volume, and precent prey weight. It should be noted that prey species, families, etc. mentioned in the text or tables, depending on the study from which they came, are sometimes just examples of the primary prey within a phyla; thus, the tables, for example, should not be taken as an exhaustive list of prey items. See Table 55, Table 56, and Table 57 at the end of this document for a summary of these data.

Peak spawning periods

Finally, peak spawning periods were identified for each species. The sources of information used to describe the spawning periods for a managed species include the EFH species source documents (1st and 2nd editions) and the new EFH species update memos and references therein, and a few published sources that were not included in the source documents or update memos. Also presented, where applicable, are egg distribution and abundance information from the Northeast Fisheries Science Center (NEFSC) Marine Monitoring Assessment and Prediction (MARMAP) ichthyoplankton surveys (1978-1987) and the Georges Bank U.S. Global Ocean Ecosystems Dynamics (GLOBEC) ichthyoplankton surveys (1995-1999). See Table 58 at the end of this document for a summary of these data.

Habitat, prey, and spawning information by species

The organization of these sections is by fishery management plan, then by species, and mirrors Volume 2 of the FEIS, which contains the EFH designations.

Acadian redfish

Supplementary table

Table 1 – Summary of habitat information for redfish

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Larvae	Pelagic, in water column	Present 40- >2000 on and off shelf, common 80-260	Present 2.5-13.5 on shelf, common 3.5-9.5	No information
Juveniles	Pelagic habitats during settlement Benthic habitats with a wide variety of sediment types, primarily mud YOY on boulder reefs; also associated with cerianthid anemone patches when larger (also adults)	Present 15-85 inshore, common **50**-85 (MA) and 60-150 (ME) Present 30-400, common 100-**200**, on shelf Shoal water to **592** m, most common 128-366	Present 1.5-12.6 inshore, common 1.5-10.5 (MA) and 3.1-9 (ME) Present 1.5-19.5 on shelf, common 3.5-9.5	Present 30.6-34 inshore Present 30.5-36.5 on shelf, common 32.5-34.5
Adults	Benthic habitats with a wide variety of sediment types, primarily mud Most abundant over silt, mud, or hard bottom, rare over sand Boulders, deep-water corals, other epifauna	Present 35-99 inshore Present 20-500,, common **140-300**, on shelf Present 400-**600** off-shelf Shoal water to 592, most common 128-366	Present 1.9-11 inshore, common 3.5-8.5 (MA) Present 0.5-21.5 on shelf, common 4.5-9.5 on shelf Prefer 3-7, can tolerate 0-13	Present 31.7-33.6 inshore Present 31.5-35.5 on shelf, common 32.5-34.5

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: Redfish bear live young (no egg stage). Also, the information in this table refers primarily to the Acadian redfish (*Sebastes fasciatus*) – which is more common in U.S. waters of the GOM and on GB, but deep-water redfish (*Sebastes mentella*) are also caught in trawl surveys and are not distinguished from Acadian redfish in the database.

Sources of information:

- **Larvae**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore trawl survey data in areas mapped as EFH (MA and ME); depth and temperature ranges ("common") based on MA trawl survey data in NEFSC (2004a) and (for juveniles) ME/NH trawl survey data provided by Maine Dept. Marine Resources.
- **Juveniles and Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore trawl survey data in areas mapped as EFH (MA and ME); depth and temperature ranges ("common") based on MA trawl survey data in NEFSC (2004a) and (for juveniles) ME/NH trawl survey data provided by Maine Dept. Marine Resources. Continental shelf and slope: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004a); sediment types based on information in NEFSC (2004a). Off-shelf depth information (size not specified) was taken from NEFSC (2004a) and Moore et al. (2003).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of redfish (*Sebastes* spp.) comes from the EFH Update Memo (NEFSC 2004a, and references therein).

Redfish larvae feed on copepods, euphausiids, and fish and invertebrate eggs. Redfish feed on the pelagic calanoid-euphausiid assemblage throughout ontogeny and prey size is proportional to fish size. Small larvae eat larval copepods and eggs. Larger larvae and fry eat copepods and euphausiids.

The most frequently observed food items from the 1973-2001 NEFSC food habits database for both juvenile and adult redfish up to 50 cm, were crustaceans, mostly euphausiids, decapods, and larvaceans (subphylum Urochordata). Bowman et al. (2000), using the NEFSC food habits database from 1977-1980, also noted the dominance of crustaceans in the diet of all size classes of redfish and in all geographic locations sampled (Georges Bank, Gulf of Maine, and Scotian Shelf). Juveniles < 21 cm fed primarily on copepods (*Calanus* sp.) and the euphausiid, *Meganyctiphanes norvegica*. Large juveniles/adults 21-40 cm consumed mostly copepods (*Calanus* sp.), the euphausiid, *Meganyctiphanes norvegica*, and decapods (the latter for fish 36-40 cm). Adults 41-45 cm fed primarily on amphipods (*Parathemisto* sp.) and the euphausiid, *Meganyctiphanes norvegica*. Silver hake was the only fish prey of note, being a significant prey item of adults 31-35 cm in the Gulf of Maine. The proportion of fish in the diet is positively correlated with body size and depth. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult redfish include: euphausiids, (28%), crustacean shrimp (19%), pandalid shrimp (18%), silver hake (10%), other fish (8%), and decapod shrimp (6%).

Table 2 – Major prey items of redfish

Life Stage	*Major prey*	*Location*
Larvae	**Larval and adult copepods, euphausiids, fish and invertebrate eggs**	U.S. northeast continental shelf
Juveniles, very small adults, ≤ 25 cm	**Crustaceans**: copepods (*Calanus* sp.), euphausiids (*Meganyctiphanes norvegica*), decapods; **Larvaceans (subphylum Urochordata)**	U.S. northeast continental shelf

Life Stage	***Major prey***	***Location***
Adults, > 25 cm	**Crustaceans**: copepods (*Calanus* sp.), amphipods (*Parathemisto* sp.), euphausiids (*Meganyctiphanes norvegica*), decapods (pandalid shrimp, other shrimp); **Larvaceans (subphylum Urochordata); Fish**: silver hake, other fish	U.S. northeast continental shelf

Peak spawning

Information on the spawning periods of redfish (*Sebastes* spp.) comes from the EFH Update Memo (NEFSC 2004a, and references therein).

Nothing is known about redfish breeding behavior, but eggs are fertilized internally and develop into larvae within the oviduct and are released near the end of the yolk sac phase (Klein-MacPhee and Collette 2002a). Copulation probably occurs from October to January, but fertilization is delayed until February to April (Ni and Templeman 1985; Klein-MacPhee and Collette 2002a). **Larvae are released throughout the range of the adults**, perhaps in mid-water, from April to August; the release of larvae lasts for 3-4 months with a peak in late May to early June (Steele 1957; Kelly and Wolf 1959; Kelly et al. 1972; Kenchington 1984; Klein-MacPhee and Collette 2002a).

MARMAP surveys (1977-1987) collected larvae on the continental slope **south and east of Georges Bank** and throughout the **Gulf of Maine** from March through October. Only a few larvae were collected in March on the **slope southeast of Georges Bank**. These larvae are possibly a mix of *S. fasciatus* and *S. mentella*. [Kenchington (1984) reviewed evidence that larvae collected along the continental slope on the Scotian Shelf in early spring are *S. mentella*.] In April, larvae were more abundant on the slope and the first larvae appeared in the **Gulf of Maine** and in the **Northeast Channel**. In May, larvae were more dispersed on the slope and in the **Gulf of Maine**. In June and July, larvae were randomly distributed throughout the **Gulf of Maine** and in the **Great South Channel**. Larval abundance peaked in August, and by September, larvae were scarce and were found only in the **Gulf of Maine**. Only a few larvae were collected in October.

American plaice

Supplementary table

Table 3 – Summary of habitat information for American plaice

Life Stage	**Habitat**	**Depth (m)***	**Temperature (ºC)****	**Salinity (ppt)****
Eggs	Pelagic, in water column	Present 20-240 on shelf, common 40-140	Present 1.5-8.5 on shelf, common 2.5-7.5 Highest growth and survival rates 2-6	No information
Larvae	Pelagic, in water column	Present 20-220 on shelf, common 40-120	Present 3.5-13.5 on shelf, common 4.5-8.5	No information
Juveniles	See adults	Present 7-85 inshore, common **40**-85 (MA) and 60-140 (ME)	Present 1-16 inshore, common 2.5-10.5 (MA) and 2.1-9 (ME)	Present 28-34 inshore

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
		Present to 500 on shelf, common 50-**180**	Present 0.5-16.5 on shelf, common 2.5-10.5	Present 30.5-35.5, on shelf, common 31.5-34.5
Adults	Prefer soft bottom substrate (mud and sand), avoid rocky or hard bottoms (GOM) Most abundant on sand and gravel (SS) Lab study: Prefer fine, gravelly sand over coarser gravel In shallow water, frequently collected over sandy bottom bordering bedrock (Nfld)	Present 8-85 inshore, common **40**-85 (MA) and 80-160 (ME) Common 70-**300** on shelf Present to >500 on and off shelf Normally occur 25-180, abundant 54-90 (GOM) Spawn <90	Present 1-14 inshore, common 2.5-10.5 (MA) and 2.1-8 (ME) Present 0.5-17.5 on shelf, common 2.5-9.5 Optimum spawning 3-6 Develop 1.7-7.7, but tolerate -1.5 Upper limit 10-13	Present 28-34 inshore Present 30.5-35.5 on shelf, common 31.5-34.5

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs**: Shelf depth and temperature ranges derived from MARMAP and GLOBEC data in Johnson (2004); additional temperature data from Johnson (2004).
- **Larvae**: Shelf depth and temperature ranges derived from MARMAP and GLOBEC data Johnson (2004).
- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from analysis of MA trawl survey data in Johnson (2004) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Johnson (2004).
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from analysis of MA trawl survey data in Johnson (2004) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. Continental shelf: substrate information summarized in Johnson (2004); depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Johnson (2004). Other information from Johnson (2004) and from Klein-MacPhee (2002b).

Prey species

The main source of information on the prey consumed by the larval, juvenile and adult stages of American plaice (*Hippoglossoides platessoides*) comes from the EFH Source Document (Johnson 2004 and references therein). Larvae feed on plankton, diatoms, and copepods found in the upper water layers. Prior to settling, juveniles feed on small crustaceans, polychaetes, and cumaceans. According to the NEFSC food habits database, dominant (exceeds 5% weight threshold in fish stomachs) prey of smaller juveniles (< 20 cm) was ophiuroids and polychaetes (Fig. 2 in source document); Bowman and Michaels (1984) reported that polychaetes [including Nephtyidae (Bowman et al. 2000)] were especially important prey of plaice < 20 cm. Another important prey item of juveniles 21-25 cm appears to be nematodes (Bowman et al. 2000). Larger juveniles and smaller adults (20-40 cm) feed on echinoderms, especially ophiuroids (*Ophiura sarsi*) but also echinoids, crustaceans (decapods such as the sand shrimp *Crangon septemspinosa*, and euphausiids), and bivalves (Fig. 2 in source document, and Bowman et al. 2000). Previous studies suggest there are ontogenetic shifts in diet, with American plaice consuming fewer polychaetes as their body size increased. Smaller, mostly juvenile (< 16-30 cm) individuals fed predominately on polychaetes, crustaceans, and small brittle stars, while adults > 30 cm fed primarily on bivalve mollusks, brittle stars and other echinoderms, decapods, and fish.

Adult plaice are opportunistic feeders, flexible in their dietary habits, and will take whatever is most abundant or accessible. The stomach contents of plaice from the Gulf of Maine, Georges Bank, and southern New England are generally similar although the specific prey consumed can vary geographically. Dominant prey of adults 41-70 cm includes echinoderms (ophiuroids, such as *O. sarsi*; asteroids; and echinoids such as the sand dollar, *Echinarachnius parma*) and bivalves (including *Chlamys islandica* and *Cyclocardia borealis*) (Fig. 2 in source document, and Bowman et al. 2000).

In Sheepscot Bay, Maine, polychaetes, mysid shrimp, amphipods, sand shrimp (*Crangon septemspinosa*), and Atlantic herring are important prey; mysids generally decrease in importance with increasing fish size while polychaetes appear to increase.

Table 4 – Major prey items of American plaice

Life Stage	*Major prey*	*Location*
Larvae	**Diatoms, copepods,** other plankton	U.S. northeast continental shelf
Early juveniles (pre-settlement)	**Polychaetes; Crustaceans**: cumaceans	U.S. northeast continental shelf
Small juveniles (< 20 cm)	**Polychaetes**: *Nephtyidae*; **Echinoderms:** ophiuroids	U.S. northeast continental shelf
Large juveniles, small adults (20-40 cm)	**Nematodes** (*juveniles* 21-25 cm); **Crustaceans:** decapods (sand shrimp *Crangon septemspinosa*), euphausiids; **Mollusks:** bivalves; **Echinoderms**: ophiuroids (*Ophiura sarsi*), echinoids	U.S. northeast continental shelf
Larger adults (41-70 cm)	**Mollusks:** bivalves (*Chlamys islandica*, *Cyclocardia borealis*); **Echinoderms**: ophiuroids (*O. sarsi*), asteroids, echinoids, (sand dollar, *Echinarachnius parma*)	U.S. northeast continental shelf
	Polychaetes; Crustaceans: amphipods, mysid shrimp, sand shrimp (*Crangon septemspinosa*); **Fish:** Atlantic herring	Sheepscot Bay, ME

Spawning

Information on the spawning periods of American plaice (*Hippoglossoides platessoides*) comes from the EFH Source Document (Johnson 2004 and references therein).

In the northern part of its range (Canada), plaice spawn in the summer (Hebert and Wearing-Wilde 2002). In the southern part of its range in the **Gulf of Maine**, the spawning season extends from March through the middle of June, with peak spawning activity in April and May (Bigelow and Schroeder 1953; Colton et al. 1979; Smith et al. 1975). Nursery areas are found in coastal waters of the **Gulf of Maine** (Bigelow and Schroeder 1953).

The NEFSC MARMAP ichthyoplankton surveys (1978-1987) captured eggs throughout the year. During February and March, eggs were collected on **Stellwagen Bank**, **off Cape Ann, on Jeffreys Ledge, along coastal Maine, and on Georges Bank**. During April and May, the highest egg concentrations occurred along the **eastern edge of Georges Bank and along the coastal areas off eastern Massachusetts, the Gulf of Maine, southwest Nova Scotia, and Browns Bank**. From June through December, eggs were collected almost exclusively along the **coastal areas in the Gulf of Maine**; some eggs were collected on **Georges Bank** and the Scotian Shelf.

GLOBEC ichthyoplankton surveys on **Georges Bank** during 1995-1999 show that American plaice eggs were generally restricted to locations within depth zones ≥ 56 m. They were most abundant at greater depths on **Georges Bank** (56-110 m); **along the Great South Channel, the central and eastern part of the southern flank and the northern part of the Northeast Channel** where depths are > 185 m. Very few eggs were captured during January. Catches increased tenfold by February along the eastern part of the **Northeast Peak** reaching *peak* numbers by March. The occurrence of eggs extended eastward along the **southern flank of Georges Bank** and into the **eastern section of Georges Basin**. By April, the high concentrations shifted toward the **western part of the southern flank**. In May and June catches of eggs declined dramatically, with centers of abundance still along the **southern flank of Georges Bank**.

Atlantic cod

Supplementary table

Table 5 – Summary of habitat information for Atlantic Cod

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Pelagic, in water column	Present 20-140 on shelf, common 20-140 Present 500-1000 off-shelf	Collected -2 to 20 inshore Present 1.5-15.5 on shelf, common 3.5-13.5 Lab studies: 5-8.3 optimum for hatching, high mortalities at 0; 2-8.5 optimum for incubation; upper limit for development 12; highest survival at hatching 2-10	Most collected 32-33 (GB, Nantucket Shoals) Lab studies: highest survival at hatching 28-36; high mortality 10-12.5

Life Stage	***Habitat***	***Depth (m)****	***Temperature (ºC)*****	***Salinity (ppt)*****
Larvae	Pelagic, in water column	Present to 350 on shelf, common 20-120 Present 500-1000 off-shelf Abundant on southern flank GB in 50-100	Present 1.5-15.5 on shelf, common 3.5-12.5 Lab study: growth increased from 4 to 10	Most collected 32-33 (GB, NS)
Juveniles	YOY more abundant in or near seagrass and macroalgae beds, (L&S 06, Keats 87,G&B 98) also on sand; highest growth in seagrass (T&B 95), highest survival in cobble and rock reef habitats (T&B 1995) YOY on sand, gravelly sand, and pebble-gravel substrate (GB) Lough YOY prefer cobble and hide in vegetation when predator present, larger ones return to fine grains when predator absent (field and lab studies – Borg, Linehan, Gotceitas, Fraser, Lind 95) Decreased YOY mortality in high density sponge habitat vs. flat sand (lab study – Lind 99) Age 1 juvs on gravel in low relief, older juvs mostly on coarse substrate, high relief (Nfld) source? Larger juveniles much more abundant on gravel than sand or mud (SW GOM - Grabowski) Age 2 and 3 juveniles prefer boulder and kelp habitats (Cote 04)	Present 4-85, common 6-55 (MA) and 10-50 (ME) Present to 400 on shelf, common **30-120** YOY most abundant <27 in spring, 27-55 in fall; age 1+ most abundant 18-55 spring and 37-55 fall (MA) YOY 1-10 (inshore ME)	Present 1.5-19, common 5.5-12.5 (MA) Present 0.5-17.5 on shelf, common 2.5-11.5 Growth optimal near 10 YOY common 7-12 (inshore ME)	Present 28-34 (ME) Present 30.5-35.5 on shelf, common 32.5-33.5
Adults	Lab studies (?): prefer coarse sediments to mud (Scott 82) Associated with gravel and deep boulder reefs (SW GOM – L&A 03/05, Lind 07))	Present 5-85, common 20-75 (MA) and 80-180 (ME) Present to 500, on and off shelf, common **30-160**	Present 1.3-14.2, common 3.5-12.5 (MA) and 3.1-8 (ME) Present 0.5-19.5 on and off shelf, common 2.5-11.5	Present 31.2-34 (ME) Present 29.5-35.5 on shelf, common 32.5-33.5

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
	Mostly on rocky, pebbly, gravelly, or sandy substrates, also on clay with shell fragments (B&S) Typically found along rocky slopes and ledges in seaweeds (SS) Scott 82)	Most abundant 10-150 Spawn near bottom, usually <73 (GB, GOM); also spawn in nearshore areas	Can occur from near 0 to 20, usually <10 except in fall Spawn -1 to 12, optimum 5-7 (GB,GOM)	Lab study: first mortalities at 2.7 Average 32 at spawning

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs**: Shelf depth and temperature ranges derived from MARMAP and GLOBEC data in Lough (2004), all other information also from Lough (2004).
- **Larvae**: Shelf depth and temperature ranges derived from MARMAP and GLOBEC data in Lough (2004), all other information also from Lough (2004).
- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from analysis of MA trawl survey data in Lough (2004) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. Inshore substrate information derived from a variety of sources, including Cote et al. (2004), Keats et al. (1987), Grant and Brown (1998), Lazzari and Stone (2006), Borg et al. (1997), Linehan et al. (2001), Tupper and Boutilier (1995), Gotceitas et al. (1995,1997), Lindholm et al. (1999), and Fraser et al. (1996). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Lough (2005); substrate information in Lough (2005) and Klein-MacPhee (2002b). Other information from Lough (2005) and M. Lazzari (Maine DMR, pers. comm.).
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from analysis of MA trawl survey data in Lough (2004) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. Continental shelf: substrate information in Lough (2004) and Klein-MacPhee (2002b); depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Lough (2004). Other information from Lough (2004) and from Klein-MacPhee (2002b).

Prey species

The main source of information on the prey consumed by the larval, juvenile and adult stages of Atlantic cod (*Gadus morhua*) comes from the EFH Source Document (Lough 2004 and references therein), Klein-MacPhee (2002b), and Link and Garrison (2002). Larvae feed on copepods, changing from the naupliar and copepodite stages at smaller sizes (4-18 mm SL) to adult copopods at larger (> 18 mm) sizes. Common copepod prey on Georges Bank include *Pseudocalanus*, *Calanus*, and *Oithona*. Late pelagic juveniles on Georges Bank feed on calanoid copepods, mysid shrimp (*Neomysis americana*), harpacticoid copepods (*Tisbe* sp.) and hermit crab larvae. After settling to the bottom, age 0 juveniles (< 10 cm TL) feed on benthic prey, predominantly mysids. There is a rapid transition from pelagic to benthic prey at a size of 60-100 mm SL.

Older juvenile cod (10-35 cm TL) feed primarily on crustaceans, including amphipods, and to a lesser extent on pandalid shrimp, euphausiids, and the sand shrimp, *Crangon septemspinosa*. Small adult cod (35-50 cm TL) feed on crustaceans (including crabs, amphipods and pandalid shrimp), and fish (sand lance and silver hake). Medium-sized (50-90 cm TL) adults feed primarily on fish (herrings, silver hake, sand lance), and crabs (including *Cancer* sp.). Larger (90-120+ cm TL) adult cod feed on herring, other fish (including gadids, silver hake, other hakes, bluefish, mackerels, toadfish, redfish, and flatfish), *Cancer* crabs, and squid.

Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the NEFSC food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult cod include:
Atlantic herring (9%), herring (7%), silver hake (8%), other fish (16%), crangonid shrimp (8%), and decapod crabs (6%).

Table 6 – Major prey items of Atlantic cod

Life Stage	***Major Prey***	***Location***
Larvae (< 20-50 mm SL)		Georges Bank
Small (4-18 mm)	**Nauplii and Copepodite Stages of Copepods:** *Pseudocalanus* sp., *Calanus* sp., *Oithona* sp.	
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Large (> 18 mm)	**Adult Copepods:** *Pseudocalanus* sp., *Calanus* sp., *Centropages* sp., *Paracalanus* sp.	
Juveniles (< 35 cm TL)		U.S. northeast continental shelf
Pelagic YOY (<10 cm TL)	**Crustaceans:** copepods and mysid shrimp (*Tisbe* sp., *Neomysis americana*)	
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Benthic YOY (<10 cm TL)	**Crustaceans:** mysid shrimp	
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Juveniles (10-35 cm TL)	**Crustaceans**: amphipods, decapods (pandalid shrimp, *Crangon septemspinosa*), euphausiids	
Adults (>35 cm TL)		U.S. northeast continental shelf
Small adults (35 - 50 cm TL)	**Crustaceans**: amphipods, decapods (crabs, pandalid shrimp) **Fish**: sand lance, silver hake	
------	--------	
Medium-sized adults (50-90 cm TL)	**Crustaceans:** *Cancer* sp. **Fish**: herrings, silver hake, sand lance	
------	--------	
Large adults (90-120+ cm TL)	**Crustaceans**: *Cancer* sp. **Mollusks**: squids	

Life Stage	*Major Prey*	*Location*
	Fish: herrings, gadids, silver hake, other hakes, bluefish, mackerels, redfish, toadfish, flatfish.	

Peak spawning

Information on the spawning periods of Atlantic cod (*Gadus morhua*) comes from the EFH Source Document (Lough 2004 and references therein).

On **Georges Bank**, an analysis of the MARMAP ichthyoplankton data set indicates that 60% of spawning occurs between February 23 and April 6, based on the abundance of Stage III eggs, back-calculated to spawning date. Ninety percent occurs between mid-November and mid-May, with a median date of mid-March (Colton et al. 1979; Page et al. 1998). Spawning begins along the **southern flank of Georges Bank** and progresses toward the north and west. It ends latest in the year on the **eastern side of the bank**. Historically, cod have spawned on both **eastern and western Georges Bank**. During the MARMAP period (1978-1987), spawning could either be split between **eastern and western Georges Bank**, **or occur predominantly on one side or the other** (Lough et al. 2002). Composite egg distributions indicate that the *most intense* spawning activity occurs on the **Northeast Peak of Georges Bank** (Page et al. 1998). Data from the more recent U.S. GLOBEC Georges Bank surveys (1995-1999) also indicated peak spawning occurs during the February-March period and mostly on the **Northeast Peak** (Mountain et al. 2003).

The results of the present compilation of egg distributions indicate that *most* spawning occurs not only on the **Northeast Peak of Georges Bank**, but also around the **perimeter of the Gulf of Maine, and over the inner half of the continental shelf off southern New England**. It occurs year-round, with a peak in winter and spring. Peak spawning is related to environmental conditions. It is delayed until spring when winters are severe and peaks in winter when they are mild (Smith et al. 1979; Smith et al. 1981). Spawning peaks in April on Browns Bank (Hurley and Campana 1989). Within the **Gulf of Maine**, cod generally spawn throughout the winter and early spring in most locations, but the period of peak spawning varies depending on location (Schroeder 1930). In general, spawning occurs later in the year in the more northerly regions. Within **Massachusetts Bay**, Fish (1928) reported peak spawning activity during January and February. Bigelow and Welsh (1924) noted that **north of Cape Ann, Massachusetts**, most spawning occurred between February and April and further north, between **Cape Elizabeth and Mt. Desert Island, Maine**, the peak spawning period was between March and May. Reproduction also occurs in **nearshore areas, such as Beverly-Salem Harbor, MA**, where eggs are found November through July (with a peak in April).

Atlantic halibut

Supplementary table

Table 7 – Summary of habitat information for Atlantic halibut

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Pelagic, in water column	No information	Lab study: optimum 5-7	No information

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
		(Assume same as juveniles and adults)	(Assume same as juveniles and adults)	(Assume same as larvae)
Larvae	Pelagic, in water column	No information (Assume same as juveniles and adults)	No information (Assume same as juveniles and adults)	Prefer 30-35
Juveniles	Juvenile nursery grounds on shelf with sandy bottoms See adults	Present 20-400 on shelf, common **60-140** (juvs and adults) Most common 20-60 (Canada) Occur as deep as 700 off-shelf (juvs/adults)	Present 1.5-14.5 on shelf, common 2.5-12.5 (juvs/adults) Survive sub-zero, but prefer >2	Present 31.5-35.5 on shelf, common 31.5-34.5 (juvs/adults)
Adults	Usually on sand, gravel or clay, not on soft mud or rock (GOM)	Range 37-1000, depth limit uncertain Spawn as deep as 700 Believed to spawn on continental slope and on offshore banks at depths of at least 183 Found mainly on banks (SS) and head of Bay of Fundy 165-229	Found -0.5 to 13.6, avoid <2.5; most caught 3-9, average 5-6 Spawn 4-7	Found 30.4-35.3 (SS) Spawn at 35 or less

* *Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs and Larvae**: All information fromNEFSC (2004a).
- **Juveniles**: Depth and temperature ranges based on NEFSC trawl survey data in NEFSC (2004a); all other information also from NEFSC (2004a).
- **Adults**: All information summarized in NEFSC (2004a).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of Atlantic halibut (*Hippoglossus hippoglossus*) comes from the EFH Update Memo (NEFSC 2004b, and references therein). Given the benthic occurrence of the eggs and larval development, no eggs were collected during the MARMAP (Marine Monitoring Assessment and Prediction) ichthyoplankton surveys and larvae were only collected at 2 out of 1,672 stations. Thus, we have no information on the food habits of the larvae. Larval exogeneous feeding occurs 28-35 days after hatching when the yolk sac has been completely absorbed at a size of roughly 11-13 mm (SL).

The range of lengths of Atlantic halibut collected in the NEFSC bottom trawl survey is 20-120 cm (TL), with most sizes less than 80-90 cm (TL). Since the length at maturity is 103 cm for females and 82 cm for males, most of the NEFSC food habits database is based upon juveniles and immature adults, and the limited information on the prey preferences of the juvenile/immature adult stages are combined in the prey table. Based on Fig. 3 in update memo, which is based on the NEFSC food habits database from 1973-2001, dominant (exceeds 5% weight threshold in fish stomachs) prey are fish (gadids, clupeids, eelpouts), squids, and decapod crustaceans. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the fish stomachs include: longhorn sculpin (18%); other fish (10%); cod (8%); *Cancer* crabs (8%); pandalids (8%); silver hake (7%); and *Illex* squid (5%).

The diet of Atlantic halibut changes with increasing size. Fish up to 30 cm feed almost exclusively on invertebrates, mainly annelids and crustaceans (crabs, shrimps); those 30-80 cm in length feed on both invertebrates (mainly crustaceans, some mollusks) and fish; and those greater than 80 cm in length feed almost exclusively on fish (Kohler 1967). However, Bowman et al. (2000) found that fish less than 31 cm had diets composed of mostly unidentified fishes (76.6%), as well as crustaceans (23.4%, mostly *Crangon septemspinosa*) (Table 2 in update memo). The most important prey of larger halibut during that same study were squid (*Illex*), crustaceans (pandalid shrimp, *Cancer* crabs), and fish including rock eel, silver hake, northern sand lance, ocean pout, and longhorn sculpin (Bowman et al. 2000; Table 2 in update memo). With the exception of the Scotian Shelf, fish were the major prey item in all regions sampled (Bowman et al. 2000; Table 3 in update memo). In an earlier study, Maurer and Bowman (1975) reported that 91% (by weight) of the stomach contents of juvenile and adult halibut were fish, of which greater than 50% were longhorn sculpin and its eggs, but also included cod and other gadids. Nickerson (1978) reported that the fish prey of halibut included cod, cusk, haddock, ocean perch, sculpins, silver hake, herring, capelin, skates, flounder, and mackerel.

Table **8** – Major prey items of Atlantic halibut

Life Stage	***Major Prey***
Juveniles and adults	**Crustaceans**: decapods (*Cancer* crabs, pandalid shrimp, *Crangon septemspinosa*); **Squid**: *Illex*; **Fish**: gadids (e.g., cod), clupeids, eelpouts (ocean pout), longhorn sculpin, silver hake, rock eel, northern sand lance

Peak spawning

Information on the spawning periods of Atlantic halibut (*Hippoglossus hippoglossus*) comes from the EFH Update Memo (NEFSC 2004b, and references therein).

Spawning in the western Atlantic is believed to occur on the **slopes of the continental shelf and on the offshore banks** (McCracken 1958; Nickerson 1978; Neilson et al. 1993), at depths of at least 183 m (Scott and Scott 1988), over rough or rocky bottom (Collins 1887). Spawning occurs during late winter and early spring (McCracken 1958; Scott and Scott 1988; Miller et al.

1991; Methven et al. 1992; Trumble et al. 1993), with peak spawning having been reported during November to December (Neilson et al. 1993). Kohler (1964) reported that spawning occurred during winter to early spring on the **Scotian Shelf**, during February to April in the **Gulf of St. Lawrence**, and during winter to late spring off **Newfoundland** (Kohler 1964). DFO Canada (2003) reports that halibut in the **Gulf of St. Lawrence** appear to spawn from January to May. In northern Norway, spawning has been reported during December to March, with peak spawning from late January to early February (Haug 1990). However, historical descriptions of spawning have reported ripe halibut as late as August (Goode 1884).

Atlantic wolffish

Supplementary table

Table 9 – Summary of habitat information for Atlantic wolffish

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Large eggs on bottom (not attached) in masses 10-14 cm in diameter in rocky coastal habitats Eggs also collected in bottom trawls on Scotian shelf (130 m, substrate unknown, but probably not rocky)	In shallow (<30) and deep (100-130) water	5-7 optimum development	No information
Larvae	Benthic for first 3 hrs – 6 days Pelagic 10-15 days		9 maximum for normal development (NE Atlantic)	No information
Juveniles	Little known about distribution or habitat use after settlement	Present 30-220, mostly **70-184** in SW GOM and GSC A few 10-50 throughout Gulf of Maine, esp near Jeffreys Ledge Juveniles >30 cm not in shallow water (Newfoundland)	Present 2.2-14.8, mostly 4-8.5 in SW GOM and GSC	No information
Adults	Found on a variety of sand and gravel substrates, not in mud Spawn in rocky habitats, e.g., boulder reefs (see eggs)	Present 30-226, mostly 27-**173** in SW GOM and GSC Occur <10 to approx 1000 throughout range Spawn 5-15 in Newfoundland, 50-100 in SW GOM	Present 2-11.1, mostly 3.9-9 in SW GOM and GSC Found 0-11 in GOM Found 0-13, prefer 3-6, on SS	No information

	Spawn 13-25 in Gulf of StL, avoiding shallow water with highly variable temperature, salinity, and turbidity	

**   Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: Observations of eggs and adult wolffish in shelters in shallow water, rocky habitats were made by SCUBA divers in Newfoundland and the Gulf of St. Lawrence, and using remotely-operated underwater vehicles and submersibles in the southwestern Gulf of Maine. Maximum depths reported for spawning adults are limited by survey depths and do not represent maximum depth of spawning.

Sources of information:

All information obtained from Rountree (2002) and Atlantic Wolffish Biological Review Team 2009, Status Review of Atlantic wolfish (*Anarhichas lupus*). Depth and bottom temperature ranges were based on an analysis of fall and spring NMFS trawl survey data.

Prey species

Atlantic wolffish feed almost exclusively on hard-shelled benthic invertebrates such as mollusks, crustaceans and echinoderms (Rountree 2002). Wolffish stomach contents include sea urchins, whelks, cockles, sea clams, brittle stars, crabs, scallops and other shellfish in addition to an occasional redfish (Rountree 2002; Templeman 1985). As an apex predator in the kelp forest ecosystem (Steneck et al. 2004), the Atlantic wolffish is believed to be a key player in the regulation of the density and spatial distribution of lower trophic level organisms such as green sea urchins, crabs, and giant scallops (O'Dea and Haedrich 2002). Although young Atlantic wolffish eat primarily echinoderms, mature wolffish eat mollusks and crustaceans as well as echinoderms. Travel between shelters and feeding grounds occurs during feeding periods as evidenced by crushed shells and debris observed in the vicinity of occupied shelters (Rountree, 2002; Pavlov and Novikov, 1993). Fasting does occur for several months, coincident with teeth replacement, spawning and nest guarding (Rountree 2002).

Habitat associations and spawning

Rocky, nearshore habitats are plentiful in the Gulf of Maine and appear to provide critical spawning habitat for Atlantic wolffish. Auster and Lindholm (2005) analyzed data collected during submersible (July 1999) and ROV surveys (May-September 1993-2003) of deep boulder reefs in the Stellwagen Bank National Marine Sanctuary at depths of 50-100 meters. Nineteen single and paired Atlantic wolffish were observed in 110 hours of observation. All used crevices under and between boulders on deep boulder reefs. Shell debris from bivalves and crustaceans was scattered at crevice entrances, evidence of "central place foraging activities."

Based on the depth distribution information from the NEFSC trawl surveys in the Gulf of Maine region, the adults move into slightly shallower water in the spring where they have been observed with and without egg masses inhabiting shelters in deep boulder reefs in depths between 50 and 100 meters. Once they have finished guarding the eggs and resume feeding, adults move into deeper water where they have been collected over a variety of bottom types (sand and gravel, but not mud). Juvenile wolffish are found in a much wider variety of bottom habitats.

Similar associations with nearshore rocky spawning habitats have been observed in the Gulf of St. Lawrence and Newfoundland. However, the collection of "aggregations" of Atlantic wolffish eggs in bottom trawls fishing in 130 meters of water on LeHave Bank (Scotian Shelf) in March 1966 (Powles 1967; Templeman 1986) indicates that spawning is not restricted to nearshore habitats, and may not be restricted to rocky habitats.

In summary, attempts to relate catches of Atlantic wolffish in bottom trawl surveys to substrate types are of limited value and somewhat contradictory, but the data indicate that the juveniles do not have strong habitat preferences, and that adults are more widely distributed over a variety of bottom types once they leave their rocky spawning grounds.

Haddock

Supplementary table

Table 10 – Summary of habitat information for haddock

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Pelagic, in water column	Present 1-1000 on and off shelf, common 40-200	Present 0.5-12.5 on and off shelf, common 3.5-7.5 Lab study: highest survival 4-10	Found 34-36
Larvae	Pelagic, in water column	Present to 350 on shelf, common 40-160 Assume 1000 max (same as eggs)	Common 3.5-11.5 on shelf	Assume same as eggs
Juveniles	Pelagic habitats during settlement Pebble gravel bottom	Present 7-84 inshore, common 30-85 (MA) and **<u>20</u>**-100)ME) Present 20-400 on shelf, common 40-**<u>140</u>**	Present 3-14.5 inshore, common 4.5-10.5 (MA) and at max 10 (ME) Present 0.5-15.5 on shelf, common 4.5-12.5	Present 31-34 inshore Present 30.5-35.5 on shelf, common 31.5-35.5, 32 optimal
Adults	Prefer gravel, pebbles, clay, broken shells, and smooth, hard sand, esp between rocky patches Not common on rocks, ledges, kelp or soft mud	Present 30-83 inshore, common 80-130 (ME) Present 20-400 on shelf, common **<u>50-160</u>**	Present 3.2-11.5 inshore, common 2.1-9 (ME) Present 0.5-15.5 on shelf, common 3.5-10.5	Present 31-34 inshore Present 31.5-35.5 on shelf, common 32.5-33.5 Spawn 31.5-34

Life Stage	Habitat	Depth (m)*	Temperature (ºC)**	Salinity (ppt)**
			Spawn 2-7, optimum 4-6	

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs**: Depth and temperature ranges derived from MARMAP and GLOBEC data in Brodziak (2005), other information from Brodziak (2005).
- **Larvae**: Depth and temperature ranges derived from MARMAP and GLOBEC data in Brodziak (2005).
- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on MA and ME inshore trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from MA trawl survey data in Brodziak (2005). Continental shelf: sediment types based on information in Brodziak (2005) and Klein-MacPhee (2002b); depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Brodziak (2005). Other information from Brodziak (2005) and Mark Lazzari (Maine DMR, pers. comm.).
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on MA and ME inshore trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from MA trawl survey data in (Brodziak 2005). Continental shelf: sediment types based on information in Brodziak (2005) and Klein-MacPhee (2002b); depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Brodziak (2005). Other information from Brodziak (2005) and Klein-MacPhee (2002b).

Prey species

The main source of information on the prey consumed by haddock (*Melanogrammus aeglefinus*) comes from the EFH Source Document (Brodziak 2005 and references therein). Haddock diet changes with life history stage. Pelagic larvae and small juvenile haddock feed on phytoplankton, copepods, and invertebrate eggs in the upper part of the water column. Juvenile haddock eat small crustaceans, primarily copepods and euphausiids, as well as polychaetes and small fishes. During the transition from pelagic to demersal habitat, juvenile diet changes to primarily benthic prey. Planktonic prey, such as copepods and pteropods decrease in importance after juveniles become demersal, while ophiuroids and polychaetes increase in importance. When juveniles reach 8 cm in length, they feed primarily on echinoderms, small decapods, and other benthic prey. Benthic juveniles above 30 cm and adults feed primarily on crustaceans, polychaetes, mollusks, echinoderms, and some fish. Regional variation in haddock food habits also exists. Echinoderms are more common prey items in the Gulf of Maine than on Georges Bank. In contrast, polychaetes are more common prey on Georges Bank than in the Gulf of Maine.

Food habits data collected during NEFSC bottom trawl surveys reveal that the species composition of haddock prey varies by haddock size class. Unidentified fish, amphipods, and euphausiids were the most common prey items by weight for small haddock less than 20 cm in length. The diet of haddock between 20 and 50 cm in length was more varied and included amphipods, ophiuroids, polychaetes, decapods, *Ammodytes* sp. (sand lance), and bivalves. Ophiuroids, amphipods, polychaetes, cnidarians, scombrids (mackerel), and *Ammodytes* sp. were the most common prey items of large haddock with lengths between 50-80 cm. Extra-large haddock over 80 cm in length fed primarily upon clupeids (herring), ophiuroids, amphipods, scombrids, and euphausiids. Overall, the NEFSC food habits data show that haddock diet includes more ophiuroids and becomes more varied as fish increase in size. It also shows that amphipods are an important prey item for all demersal life history stages and that fish are an important component of the diet of very large haddock. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult haddock include: ophiuroids (22%), gammarid amphipods (14%), polychaetes (9%) and fish eggs (8%).

Table 11 – Major prey items of haddock

Life Stage	*Major prey*	*Location*
Larvae, small juveniles	**Phytoplankton, copepods, invertebrate eggs**	U.S. northeast continental shelf
Small juveniles	**Polychaetes; Crustaceans**: copepods, euphausiids, amphipods, decapods; **Echinoderms**: ophiuroids; **Fish**	U.S. northeast continental shelf
Large juveniles, small adults	**Polychaetes; Crustaceans**: amphipods, euphausiids, decapods; **Mollusks**: bivalves; **Echinoderms**: ophiuroids; **Fish**: *Ammodytes* sp. (sand lance)	U.S. northeast continental shelf
Large adults	**Cnidarians; Crustaceans**: amphipods, euphausiids; **Echinoderms**: ophiuroids; **Fish**: *Ammodytes* sp. (sand lance), scombrids (mackerel), clupeids (herring)	U.S. northeast continental shelf

Peak spawning

Information on the spawning periods of haddock (*Melanogrammus aeglefinus*) comes from the EFH Source Document (Brodziak 2005 and references therein). **Georges Bank** is the principal haddock spawning area in the northeast U.S. continental shelf ecosystem. Haddock spawning is concentrated on the **Northeast Peak** of Georges Bank. The western edge of Georges Bank also supports a smaller spawning concentration (Walford 1938).

Although the vast majority of reproductive output originates from **Georges Bank**, some limited spawning activity occurs on **Nantucket Shoals** (Smith and Morse 1985) and along the **South Channel** (Colton and Temple 1961). In the **Gulf of Maine**, **Jeffreys Ledge** and **Stellwagen Bank** are the two primary spawning sites (Colton 1972). In addition, Ames (1997) also reported numerous small, isolated spawning areas in **inshore Gulf of Maine waters**. Based on interviews with retired commercial fishers from Maine and New Hampshire, Ames (1997) identified 100 haddock spawning sites, covering roughly 500 square miles, from **Ipswich Bay to Grand Manan Channel.**

The timing of haddock spawning activity varies among areas. In general, spawning occurs later in more northerly regions (Page and Frank 1989). There is also inter-annual variation in the onset and peak of spawning activity. On **Georges Bank**, spawning occurs from January to June

(Smith and Morse 1985), usually *peak*ing from February to early-April (Smith and Morse 1985; Lough and Bolz 1989; Page and Frank 1989; Brander and Hurley 1992) but the timing can vary by a month or more depending upon water temperature (Marak and Livingstone 1970; Page and Frank 1989). In the **Gulf of Maine**, spawning occurs from early February to May, usually peaking in February to April (Bigelow and Schroeder 1953). Overall, cooler water temperatures tend to delay haddock spawning and may contract the duration of spawning activity (Marak and Livingstone 1970; Page and Frank 1989).

During 1978-1987, MARMAP ichthyoplankton surveys caught haddock eggs from **New Jersey to southwest Nova Scotia**. The highest densities were found on **Georges Bank** and Browns Bank, which are important haddock spawning areas (Colton and Temple 1961; Laurence and Rogers 1976; Brander and Hurley 1992). Eggs were collected from January through August. The highest concentrations occurred in April, followed by March and May. This pattern is consistent with the timing of peak spawning from March to May (Bigelow and Schroeder 1953; Page and Frank 1989; Brander and Hurley 1992). In particular, the highest mean densities of eggs occurred in April (77.3 eggs/10 m^2) and March (21.1 eggs/10 m^2). By July and August, mean densities had decreased substantially (< 0.1 eggs/10 m^2).

Data from the more recent U.S. GLOBEC Georges Bank surveys (February-July, 1995; January-June, 1996-1999) showed the highest concentration of eggs to be on the eastern, Canadian side of **Georges Bank**, with peaks occurring during February-March and into April.

Ocean pout

Supplementary table

Table 12 – Summary of habitat information for ocean pout

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Benthic habitats in sheltered nests, sometimes in rocky crevices	No information (Assume same as spawning adults)	No information (Assume same as spawning adults)	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Variety of substrates, including shells, rocks, algae, soft sediments, sand, and gravel	Present 7-82 inshore, common 20-65 (MA) Present to 300 on shelf, common 30-**<u>120</u>** Found along the shore at low tide (BOF) Few YOY 0-10 (ME)	Present 1.3-20.2 inshore, common 2.5-10.5 (MA) Present 1.5-18.5 on shelf, common 2.5-11.5	Present 31.8-33.1 inshore Present 30.5-36.5 on shelf, common 31.5-33.5

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Adults	Also see juveniles Spawn on rocky bottom in sheltered areas (e.g., crevices in boulder reefs) Prefer sand and gravel on shelf, also with shells Sandy mud, muddy sand, “broken” and “hard” bottom, pebbles and gravel in GOM, not found on soft mud in deep basins	Present 5-86 inshore, common 25-80 (MA) Present to 400 on shelf, common **20-140** Occur 27-363 on SS and in Bay of Fundy, (juvs and adults) Spawn <50 or <100 in GOM	Present 1.3-18 inshore, common 3.5-10.5 (MA) Present 0.5-17.5 on shelf, common 1.5-11.5 Prefer 6-9, can tolerate 0-16 Spawn 10 or less	Present 3.3-33 inshore Present 29.5-36.5 on shelf, common 31.5-33.5 Prefer 32-34, but enter rivers in deeper, more saline water

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: This species has no larval stage - ocean pout hatch as juveniles

Sources of information:

- **Eggs**: All information from Steimle et al. (1999).
- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges (“common”) from MA inshore trawl survey data in NEFSC (2004b). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004b); sediment types derived from information in Steimle et al. (1999) and NEFSC (2004b). Additional information from Steimle et al. (1999) and NEFSC (2004b), Klein-MacPhee and Collette (2002b), and M. Lazzari (Maine DMR, pers. comm.).
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges (“common”) from MA inshore trawl survey data in NEFSC (2004b). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004b); sediment types derived from information in Steimle et al. (1999) and NEFSC (2004b). Additional information from Steimle et al. (1999) and NEFSC (2004b) and Klein-MacPhee and Colette (2002b), and Auster and Lindholm (2005).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of ocean pout (*Macrozoarces americanus*) comes from the EFH Update Memo and EFH Source Document (Steimle et al. 1999, NEFSC 2004b, and references therein). Crustaceans and echinoderms are the major prey items for almost all sizes of ocean pout. Bowman et al. (2000) showed that ocean pout 1-10 cm in length fed exclusively on the amphipod *Parathemisto* sp. Ocean pout 11-20 cm ate mostly polychaetes, followed by crustaceans, while those 21-30 cm fed on ophiuroids and crustaceans in equal proportions, followed by polychaetes. Echinoderms (ophiuroids and sand dollars) were the major prey items in the diet for larger ocean pout. In terms of the geographic areas sampled in the Bowman et al. (2000) study, crustaceans were the major prey items in New England and on the Scotian Shelf, while echinoderms dominated on Georges Bank, in the Gulf of Maine, and inshore north of Cape Hatteras. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult ocean pout include: echinoids (44%); asteroids (20%); and C*ancer* crabs (9%).

Sand dollars (*Echinarachnius parma*) are a primary prey in waters of coastal Maine, Georges Bank, southern New England, Block Island Sound, and Middle Atlantic Bight; brittlestars and mollusks are also eaten. In the northern Gulf of Maine, ocean pout switch from crustaceans during the spring to mollusks and polychaetes during the summer and fall; off southern Maine, ocean pout primarily ate bivalve mollusks. Jonah crabs (*Cancer borealis*) constituted 76% of ocean pout diet (by total prey weight) off Nantucket shoals, while sand dollars and amphipods were dominant prey on Georges Bank. Juveniles on the sandy, mid- to outer-continental shelf (approximately 35-95 m) of the New York Bight fed primarily on gammarid amphipods and polychaetes. This is consistent with data in the NEFSC food habits database Many benthic species preyed upon by ocean pout are commercially valuable, including sea urchins, scallops, juvenile American lobsters, and crabs. Fish are eaten rarely, although demersal sculpin eggs are consumed when encountered.

Table 13 – Major prey items of ocean pout

Life Stage	***Major prey***	***Location***
Juveniles, very small adults 1-30 cm	**Polychaetes**: Aphroditidae, Cirratulidae **; Crustaceans**: amphipods (*Parathemisto* sp., *Leptocheirus pinguis*, *Unciola irrorata*); **Mollusks**: Pectinidae; **Echinoderms**: ophiuroids (*Ophiopholis aculeata*)	U.S. northeast continental shelf, coastal, inshore
Adults	**Crustaceans**: amphipods (*Leptocheirus pinguis*, *Unciola irrorata*), decapods (*Cancer borealis, Hyas coarctatus*); **Mollusks**: *Cerastoderma pinnulatum*, *Placopectin magellanicus;* **Echinoderms**: ophiuroids (*Ophiura sarsi*), echinoids (*Echinarachnius parma*)	U.S. northeast continental shelf, coastal, inshore

Peak spawning

Information on the spawning periods of ocean pout (*Macrozoarces americanus*) comes from the EFH Source Document (Steimle et al. 1999 and references therein). Spawning occurs in the late summer through early winter (*peak* in September-October) with earlier peaks (August-October) in the south (Wilk and Morse 1979). Spawning occurs on hard bottom, sheltered areas (Bigelow and Schroeder 1953), including artificial reefs and shipwrecks, at depths of < 50 m and temperatures of 10°C or less (Clark and Livingstone 1982). These spawning/nesting habitats **include the saline parts of New England estuaries** (Jury et al. 1994).

Pollock

Supplementary table

Table 14 – Summary of habitat information for pollock

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Pelagic, in water column	Present to 280 on shelf, common 40-120 Usually found 50-250	Present 2.5-13.5 on shelf, common 2.5-13.5 Optimum development 3.3-8.9	No information
Larvae	Pelagic, in water column	Present to 280 on shelf, common 20-160 Normally from shore to 200, reported as deep as 1550	Present 1.5-17.5 on shelf, common 3.5-11.5 Larvae strong and active 3.3-8.9	No information
Juveniles	Pelagic habitats Wide variety of substrates, including sand, mud, and rocky bottom with eelgrass and macroalgae	Present 4-83 inshore, common at min 6, max 70 (MA) Present 10-400 on shelf, common 40-**<u>180</u>** YOY and age 1 utilize inshore subtidal and intertidal zones; common 0-10 in ME estuaries and bays Age 2+ move offshore to 130-150	Present 1.6-17 inshore, common at min 5, max 12 (MA) Present 0.5-17.5 on shelf, common 2.5-11.5 Found 0-16	Present 28-33.7 inshore (ME) Present 31.5-35.5 on shelf, common 31.5-34.5 Prefer 31.5
Adults	Pelagic habitats Little preference for bottom type Spawn over hard, stony or rocky bottom	Present to 400 on shelf, common **<u>80-300</u>** Range 35-365, most <137, prefer 100-125 Found further offshore than juveniles	Present 1.5-16.5 on shelf, common 4.5-9.5 on shelf Found 0-14, tend to avoid >11 and <3 Spawning begins <8, peaks 4.5-6 (MA Bay)	Common 32.5-35.5 on shelf Found 31-34 (SS) Spawn 32-32.8 (MA Bay)

**   Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs**: Shelf depth and temperature ranges derived from MARMAP data in Cargnelli et al. (1999a); other information from Cargnelli et al. (1999a) and NEFSC (2004d).

- **Larvae**: Shelf depth and temperature ranges derived from MARMAP data data in Cargnelli et al. (1999a); other information from Cargnelli et al. (1999a) and NEFSC (2004d).
- **Juveniles**: Inshore: depth, temperature, and salinity ranges (present and "common") based on MA and ME inshore trawl survey data in areas mapped as EFH in Cargnelli et al. (1999a) and NEFSC (2004d). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004d); sediment types based on information in Cargnelli et al. (1999a) and NEFSC (2004d). Other information also obtained from Cargnelli et al. (1999a) and NEFSC (2004d).
- **Adults**: Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004d); sediment types based on information in Cargnelli et al. (1999a) and NEFSC (2004d). Other information also obtained from Cargnelli et al. (1999a) and NEFSC (2004d).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of pollock (*Pollachius virens*) comes from the EFH Source Document and update memo (Cargnelli et al. 1999, NEFSC 2004d, and references therein). The primary prey of small larvae (4-18 mm) is larval copepods while larger larvae (> 18 mm) feed primarily on adult copepods. The primary prey of juvenile pollock is crustaceans. Euphausiids, in particular *Meganyctiphanes norvegica*, are the most important crustacean prey of juveniles. Fish and mollusks make up a smaller proportion of the juvenile diet; however, in some cases fish may play a more important role in the diet. For example, one study showed that the diet of subtidal juveniles in the Gulf of Maine was dominated by fish, especially young Atlantic herring (*Clupea harengus*). The diet of adults is comprised of, in order of decreasing importance, euphausiids, fish and mollusks. *M. norvegica* is the single most important prey item and Atlantic herring is the most important fish species. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult pollock include: silver hake (19%); krill (14%); decapod shrimp (10%); sand lance (9%); crustacean shrimp (8%); and Atlantic herring (7%).

Bowman and Michaels (1984) found that the diet preferences of adults vary with size: crustaceans were the most important prey item among smaller adults (41-65 cm), fish were most important among medium size adults (66-95 cm), and mollusks (the squid *Loligo*) were the most important prey among the largest adults (> 95 cm). Bowman et al. (2000) summarized stomach contents, primarily from the NEFSC bottom trawl surveys from 1977-1980 by length. For fish < 31 cm, the main prey choices were chaetognatha and crustaceans; of the latter, the major identifiable crustacean was *Meganyctiphanes norvegica*. Crustacea often remain a major prey choice for larger pollock, but fish, particularly *Ammodytes*, become important for fish > 61 cm. Cephalopods are also important prey items for fish between 61-70 cm.

Table 15 – Major prey items of pollock

Life Stage	*Major prey*	*Location*
Larvae	**Larval and adult copepods**	U.S. northeast continental shelf

Life Stage	***Major prey***	***Location***
Juveniles, very small adults 1-40 cm	**Chaetognaths**: *Sagitta elegans;* **Crustaceans**: amphipods (*Ericthonius rubricornis*), euphausiids (*Meganyctiphanes norvegica*); **Mollusks**: squids	U.S. northeast continental shelf
Adults	**Nematodes; Crustaceans**: amphipods, euphausiids (*Meganyctiphanes norvegica*), decapods (*Crangon septemspinosa, Dichelopandalus leptocerus, Pandalus borealis*); **Mollusks**: squids (*Loligo* sp., *Illex* sp.); **Fish**: sand lance, Myctophidae, silver hake, Anarhichadidae, Atlantic herring	U.S. northeast continental shelf

Peak spawning

Information on the spawning periods of pollock (*Pollachius virens*) comes from the EFH Source Document and update memo (Cargnelli et al. 1999, NEFSC 2004d, and references therein).

The principal pollock spawning sites in the northwest Atlantic are in the **western Gulf of Maine, Great South Channel, Georges Bank**, and on the Scotian Shelf. In the **Gulf of Maine**, spawning is concentrated in **Massachusetts Bay, Stellwagen Bank, and from Cape Ann to the Isle of Shoals** (Steele 1963; Hardy 1978; Collette and Klein-MacPhee 2002). Spawning is believed to occur throughout the Scotian Shelf; Emerald, LaHave, and Browns banks are the principal sites (Mayo et al. 1989).

Spawning takes place from September to April. Spawning time is more variable in northern sites than in southern sites. In the **Gulf of Maine** spawning occurs from November to February (Steele 1963; Colton and Marak 1969), *peaking* in December (Collette and Klein-MacPhee 2002). On the Scotian Shelf, spawning occurs from September to April (Markle and Frost 1985; Clay et al. 1989) and *peak*s from December to February (Clay et al. 1989).

The 1978-1987 MARMAP offshore ichthyoplankton surveys collected eggs during October to June from off **Delaware Bay to southwest Nova Scotia**. *Highest monthly mean egg densities* occurred in November (24.4 eggs/10 m^2), December (36.8 eggs/10 m^2), January (86.1 eggs/10 m^2) and February (19.6 eggs/10 m^2) in **Massachusetts Bay, Georges Bank, and Browns Bank**. Egg densities were considerably lower in months prior to and after this period (≤ 1.40 eggs/m^2). This concurs with reports that *peak* spawning occurs during November to February (Hardy 1978; Fahay 1983; Clay et al. 1989).

White hake

Supplementary table

Table 16 – Summary of habitat information for white hake

Life Stage	***Habitat***	***Depth (m)****	***Temperature (ºC)*****	***Salinity (ppt)*****
Eggs	Pelagic, in water column	No information (see spawning adults)	No information	No information
Larvae	Pelagic, in water column	Small larvae on slope in MAB, cross shelf-slope front	No information	No information

Life Stage	***Habitat***	***Depth (m)****	***Temperature (ºC)****	***Salinity (ppt)****
		Also see juveniles		
Juveniles	Oceanic pelagic habitats before settlement Benthic habitats in estuaries and on shelf Prefer fine grained, muddy substrates YOY in eel grass in coastal ME, but no evidence that eelgrass, other vegetation, or structured bottom habitats are essential	Present 5-99 inshore, common 20-80 (MA) and 50-190 (ME) Present to 500 on and off shelf, common 30-**<u>300</u>** Small pelagic juvs near edge of shelf in MAB, larger juvs (>60 mm) near the coast YOY utilize very shallow inshore waters and estuaries (0-10 coastal ME); larger juvs occur >50	Present 1.3-20.7 inshore, common 2.5-12.5 (MA) Present 0.5-18.5 on shelf, common 3.5-13.5 Occur 2-15, prefer 4-10	Present 13.4-34 inshore Present 29.5-35.5 on shelf, common 32.5-34.5
Adults	Prefer fine grained, muddy substrates absent on gravel and sand on SS	Present 25-84 inshore, common **<u>25</u>**-80 (ME) Present 10- >500 on and off shelf, common 100-**<u>400</u>** On slope to **<u>900</u>** Spawn on slope	Present 1.9-13.1 inshore, common 4.5-13.5 (MA) and 5.1-12 (ME) Present 1.5-21.5 on shelf, common 5.5-10.5 on shelf	Present 32-34 inshore Present 28.5-36.5 on shelf, common 33.5-35.5

**   Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

<u>Note</u>: White hake eggs and larvae were not differentiated from eggs and larvae of red, spotted, and longfin hake in the MARMAP survey

Sources of information:

- **Juveniles**: <u>Inshore</u>: depth, temperature, and salinity ranges (presence only) based on MA and ME inshore trawl survey data from areas mapped as EFH; depth and temperature ranges ("common") derived from MA trawl survey data in NEFSC (2004e) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. <u>Continental shelf</u>: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004e); sediment data and other information in Chang et al. (1999b). Additional information from Chang et al. (1999b), NEFSC (2004e), M. Lazzari (Maine DMR, pers. comm.), and Able and Fahay (2010).
- **Adults**: <u>Inshore</u>: depth, temperature, and salinity ranges (presence only) based on MA and ME inshore trawl survey data from areas mapped as EFH; depth and temperature ranges ("common") derived from MA trawl survey data in NEFSC (2004e) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. <u>Continental shelf and slope</u>: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in

NEFSC (2004e); sediment data and other information in Chang et al. (1999b); off-shelf depth data from Moore et al. (2003).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of white hake (*Urophycis tenuis*) comes from the EFH Source Document and update memo (Cargnelli et al. 1999, NEFSC 2004e, and references therein).

Using the NEFSC food habits database from 1977-1980, Bowman et al. (2000) showed that the primary prey of juveniles < 21 cm were polychaetes and crustaceans. Crustacean prey included calanoid copepods, amphipods (*Anonyx sarsi*), and decapods (*Crangon septemspinosa*). Large juveniles/smaller adults 21-50 cm fed mostly on crustaceans, squids, and fish. Crustacean prey included decapods (*Crangon septemspinosa*; the pandalid shrimp *Dichelopandalus leptocerus* and *Pandalus borealis*), and euphausiids (*Meganyctiphanes norvegica*). Squids included *Loligo pealeii*. Fish prey included gadids, silver hake, and white hake (most likely juveniles). Adults > 50 cm also fed primarily on crustaceans, squid, and fish. Crustacean prey included euphausiids (*Meganyctiphanes norvegica)* and decapods (pandalid shrimp *Dichelopandalus leptocerus*). Squids included *Illex* sp. Fish prey included gadids, red hake, and silver hake. Regionally, fish dominated the diet in all locations sampled.

Using NEFSC diet data from 1973-1997, Garrison and Link (2000) observed an increasing amount of piscivory in white hake with increasing size. Euphausiids (12.8% of diet), crangonid shrimp (15.7%), pandalid shrimp (14.2%), and unclassified shrimp (19.9%) account for the majority of juvenile (< 20 cm) white hake diets. Larger juvenile/smaller adult white hake 20-50 cm had a large proportion of shrimp taxa in their diets, but unclassified fishes (25.5%) and silver hake (16.2%) were also important components. Large adults > 50 cm fed almost exclusively on fish taxa, with silver hake (21.7%), clupeids (7.1%), Atlantic herring (6.5%), argentines (6.6%), and unclassified fishes (33.5%) as major prey. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult white hake include: other fish (32%), silver hake (22%), Atlantic herring (7%), and other herrings (6%).

Table 17 – Major prey items of white hake

Life Stage	***Major prey***	***Location***
Juveniles, < 20-21 cm	**Polychaetes; Crustaceans**: calanoid copepods, amphipods (*Anonyx sarsi*), decapods (*Crangon septemspinosa*, pandalid shrimp), euphausiids	U.S. northeast continental shelf
Larger juveniles/ smaller adults, 20-21 to 50 cm	**Crustaceans**: decapods (*Crangon septemspinosa*; the pandalid shrimp *Dichelopandalus leptocerus* and *Pandalus borealis*), euphausiids (*Meganyctiphanes norvegica*); **Mollusks**: squids (*Loligo pealeii*); **Fish**: gadids, silver hake, white hake (most likely juveniles)	U.S. northeast continental shelf
Larger adults, > 50 cm[1]	**Fish**: silver hake, clupeids, Atlantic herring, argentines	U.S. northeast continental shelf

[1]Based on Garrison and Link (2000) only.

Peak spawning

Information on the spawning periods of white hake (*Urophycis tenuis*) comes from the EFH Source Document and update memo (Cargnelli et al. 1999, NESFC 2004e, and references therein). The northern stock of white hake spawns in late summer (August-September) in the southern Gulf of St. Lawrence and on the Scotian Shelf (Markle et al. 1982). The timing and extent of spawning in the **Georges Bank-Middle Atlantic Bight** stock has not been clearly determined. Based on the distribution and abundance of pelagic juveniles, as well as circulation patterns throughout the region, Fahay and Able (1989) suggested that the southern stock spawns in early spring (April-May) in **deep waters along the continental slope,** *primarily* off **southern Georges Bank and the Middle Atlantic Bight** (Lang et al. 1996). The spawning contribution of the **Gulf of Maine** population is negligible (Fahay and Able 1989).

Windowpane flounder

Supplementary table

Table 18 – Summary of habitat information for windowpane flounder

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Pelagic, in water column	Present to 200 on shelf, common to 80	Present 2.5-24.5 on shelf, common 4.5-20.5	Found 18.2-30
Larvae	Pelagic, in water column	Present to 200 on shelf, common to 80	Present -0.5 to 25.5 on shelf, common 8.5-19.5	No information
Juveniles	Lab study: YOY prefer sand over mud	Present 3-82 inshore, common 8-24 (RBay), 6-18 (CBay), 15-55 (MA), and 20-100 (ME)	Present 0.1-30 inshore, common 13.5-23.5 (RB), 14-26 (CBay), and 7-19 (MA)	Present 1-36 inshore, common 14.5-24.5 (RB), 24-32 (CBay)
	Otherwise, same as adults	Present to 300 on shelf, common to **<u>60</u>**	Present 0.5-28.5 on shelf, common 2.5-20.5	Present 26.5-35.5 on shelf, common 30.5-33.5
Adults	Primarily sand (SNE, MAB) Also mud (LIS,GOM)	Present 4-82 inshore, common 10-24 (RBay), 10-26 (CBay), 5-35 (MA), and 50-130 (ME)	Present 0.1-25, common 6.5-20.5 (RB), 4-18 (CBay), 3-15 (DBay), 9-18 (MA), and 4.1-13 (ME)	Present 1-36 inshore, common 26.5-31.5 (RB), 22-32 (CBay), and 23-30 (DBay)
		Present to 400 on shelf, common to **<u>70</u>**	Present 0.5-25.5 on shelf, common 4.5-19.5 Tolerate 0-27 Spawn 6-21, mostly 8.5-13.5	Present 23.5-35.5 on shelf, common 30.5-33.5

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs**: Shelf depth and temperature ranges derived from MARMAP data in Chang et al. (1999c); salinity data from Klein-MacPhee (2002c).

- **Larvae**: Shelf depth and temperature ranges derived from MARMAP data in Chang et al. (1999c).
- **Juveniles**: Inshore: depth, salinity, and temperature ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth, temperature, and salinity ranges ("common") derived from MA trawl survey data in NEFSC (2006a), Raritan Bay trawl survey data in Chang et al. (1999c), ME/NH trawl survey data provided by Maine Dept. Marine Resources, and Chesapeake Bay trawl survey data in Geer (2002). YOY substrate information from Neuman and Able (1998). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2006a). Additional information obtained from Chang et al. (1999c).
- **Adults**: Inshore: depth, salinity, and temperature ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth, temperature, and salinity ranges ("common") derived from MA trawl survey data in NEFSC (2006a), Raritan Bay trawl survey data in Chang et al. (1999c), ME/NH trawl survey data provided by Maine Dept. Marine Resources, and Chesapeake Bay trawl survey data in Geer (2002). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2006a); substrate information from Bigelow and Schroeder (1953), Able and Fahay (2010) and Gottschall et al. (2002). Additional information obtained from Chang et al. (1999c).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of windowpane (*Scophthalmus aquosus*) comes from the EFH Source Document and update memo (Chang et al. 1999, NEFSC 2006a, and references therein). The 1973-1990 NEFSC food habits database indicates windowpane feed on small crustaceans (e.g., mysid shrimp and decapod shrimp) and various fish larvae including hakes and tomcod, as well as their own species (Langton and Bowman 1981). Fish become more important in the diet of larger windowpane.

Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult windowpane include: mysids (18%), crangonidae (14%), gammarid amphipods (11%), sand lance (7%), other fish (6%), and pandalid shrimp (6%).

Bowman et al. (2000) summarized the diet composition of windowpane, based on the NEFSC bottom trawl surveys from 1977-1980 by both length and geographic area. Crustaceans, including amphipods, mysids (*Mysidopsis bigelowi* and *Neomysis americana*), and decapods (decapod larvae) were the dominant prey for juveniles up to 20 cm. Other important prey for windowpane 16-20 cm were polychaetes and fish. Large juveniles/adults $\geq$ 21 cm also fed primarily on crustaceans, including amphipods (*Gammarus annulatus*), mysids (*Neomysis americana*), and decapods (*Crangon septemspinosa*). Fish, including silver hake, sand lance, cusk, were also important prey items for that size class, especially for adults $\geq$ 36 cm, where they were the dominant prey items. Of the geographic areas sampled, decapod crustaceans made up 100% of the diet of windowpane found inshore south of Cape Hatteras. Fish, particularly sand lance, were the dominant prey items for fish in the Mid-Atlantic and on Georges Bank. Crustaceans dominated in southern New England and inshore north of Cape Hatteras.

A similar dietary analysis by Link et al. (2002) focused on flatfish of the northwest Atlantic taken during the NEFSC bottom trawl surveys from 1973-1998 for all seasons. In this study, the major portion of the windowpane diet was composed of shrimps (mysids, *Crangon septemspinosa*, pandalids) and benthic invertebrates. Fish were an important but secondary component of the diet. The study also noted that there was no significant change in the diet in the 25 years covered by the study.

Table 19 – Major prey items of windowpane flounder

Life Stage	***Major prey***	***Location***
Juveniles, ≤ 20 cm	**Crustaceans**: amphipods, mysids (*Mysidopsis bigelowi*, *Neomysis americana*), decapods (decapod larvae)	U.S. northeast continental shelf
Larger juveniles/adults, > 20 cm	**Crustaceans**: amphipods (*Gammarus annulatus*), mysids (*Neomysis americana*), decapods (*Crangon septemspinosa*, pandalid shrimp); **Fish**: silver hake, sand lance, cusk	U.S. northeast continental shelf
Juveniles, adults	**Crustaceans**: mysids	Johns Bay, Maine (Hacunda 1981)
Juveniles, adults	**Crustaceans**: decapods (*Crangon septemspinosa*), mysid shrimp (*Neomysis americana*); **Fish**: bay anchovy, goby, naked goby	New Haven Harbor, CT (Carlson 1991)
Juveniles, adults	**Crustaceans**: mysid shrimp (*Neomysis americana*); **Mollusks**: squid; **Fish**	Block Island Sound, RI (Smith 1950)
Juveniles, adults	**Chaetognaths; Crustaceans**: decapods (*Crangon septemspinosa*), mysid shrimp (*Neomysis americana*); **Fish**: larval sand lance and silver hake	Long Island/Block Island Sounds (Moore (1947)
Juveniles, adults	**Crustaceans**: decapods (*Crangon septemspinosa*), mysid shrimp (*Neomysis americana*)	Long Island Sound (Richards 1963)
Juveniles, adults	**Crustaceans**: decapods (*Crangon septemspinosa*), mysid shrimp (*Neomysis americana*); **Fish**: eggs, larvae	Eastern Long Island Sound (Hickey 1975)
YOY to adult	**Crustaceans**: amphipods (*Gammarus lawrencianus*), decapods (*Crangon septemspinosa*), mysid shrimp (*Neomysis americana*);	Hudson-Raritan estuary (Steimle et al. 2000)
YOY to adult	**Crustaceans**: mysid shrimp (*Neomysis americana*)	New Jersey coast (Warkentine and Rachlin 1988)
YOY to adult	**Crustaceans**: decapods (*Crangon septemspinosa*), mysid shrimp (*Neomysis americana*); **Fish**: sand lance	Little Egg Harbor, NJ (Festa 1979)
YOY to adult	**Crustaceans**: amphipods, decapods (*Crangon septemspinosa*, crab larvae), mysid shrimp	Hereford Inlet, NJ (Allen et al. 1978)
YOY to adult	**Crustaceans**: copepods, decapods (*Crangon septemspinosa*), mysid shrimp (*Neomysis americana*)	Delaware Bay (de Sylva et al. 1962)
YOY to adult	**Crustaceans**: decapods (*Crangon septemspinosa*), mysid shrimp (*Neomysis americana*); **Fish**: bay anchovy	Mouth of Chesapeake Bay (Kimmel 1973)

Peak spawning

Information on the spawning periods of windowpane (*Scophthalmus aquosus*) comes from the EFH Source Document and update memo (Chang et al. 1999, NEFSC 2006a, and references therein). Gonadal development indices (Wilk et al. 1990) and egg and larval distributions

(Colton and St. Onge 1974; Smith et al. 1975; Colton et al. 1979; Morse et al. 1987) indicate that spawning occurs throughout most of the year. Spawning begins in February or March in **inner shelf** waters, peaks in the **Middle Atlantic Bight** in May, and extends onto **Georges Bank** during the summer (Able and Fahay 1998). Spawning also occurs in the **southern portion of the Middle Atlantic Bight** in the autumn (Smith et al. 1975). There is a split spawning season in the **central Middle Atlantic Bight** with peaks in the spring and autumn (Morse and Able 1995; Able and Fahay 1998). Evidence for a split spawning season is available for **Virginia and North Carolina** (Smith et al. 1975), for **Long Island Sound**, **New York** (Wheatland 1956), and for **Great South Bay, New York** (Dugay et al. 1989; Monteleone 1992). Gonad development indicated that split spawning off **New Jersey and New York** peaks in May and in September (Wilk et al. 1990). However, neither Perlmutter (1939) nor Smith et al. (1975) found evidence for a split spawning season in **Long Island Sound** or in oceanic waters north of **Virginia**. Colton and St. Onge (1974) collected larvae on **Georges Ban**k from July to November but found no indication of a split spawning season.

Some spawning may occur in the **high salinity portions of estuaries in the Middle Atlantic Bight**, including **Great South Bay, New York** (Monteleone 1992), **Sandy Hook Bay, New Jersey** (Croker 1965), inside **Hereford Inlet, New Jersey** (Allen et al. 1978), and in the **coastal habitats of the Carolinas** (Wenner and Sedberry 1989).

Windowpane eggs have been collected in several studies (Colton and St. Onge 1974; Smith et al. 1975; Colton et al. 1979; Morse et al. 1987; Berrien and Sibunka 1999). During the MARMAP ichthyoplankton surveys, eggs were collected at 16% of the stations sampled; primarily at depths < 40 m between **Georges Bank** and **Cape Hatteras**. Eggs densities were generally low in the **Gulf of Maine**. Eggs were collected in nearshore shelf waters in the **Middle Atlantic Bight** from February to November. Egg densities peaked in May and October. Eggs were present on **Georges Bank** from April through October and density peaked during July-August.

Winter flounder

Supplementary table

Table 20 – Summary of habitat information for winter flounder

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Eggs adhesive, attached to mud, sand, muddy sand, gravel, and submerged aquatic vegetation Sand seems to be preferred substrate south of Cape Cod Most suitable habitats where eggs are not dispersed by currents, etc. or buried by sediment	Collected 0.3-18 inshore but more common <5 (LIS, NY harbor) Spawning in GOM and on GB in deeper water (see adults)	Collected 1-10 Lab studies:maximum survival at hatching 0-10, best hatching success 4-5, 15 lethal	Collected 10-32 Lab studies: maximum survival 10-30, optimum development, survival at 3C=15-35, >3C=15-25
Larvae	Initially planktonic, but in lower water column as they get older	Present to 180 on shelf, common to 80	Most abundant 2-15 inshore, found 1-19.5 (NJ)	Found 4-30 inshore, higher on GB (assume max is 33)

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
			Present 2.5-12.5 on shelf, common 2.5-12.5	Present 0-22 in Ches Bay, common 6-15
Juveniles	YOY found inshore on a variety of muddy and sandy substrates, with and without eelgrass and macroalgae In marsh creeks (NJ) Prefer muddy sediments with debris (shell, wood, leaves) to sandy sediments (CT estuaries) YOY more abundant in eelgrass (inshore GOM) or next to eelgrass (MAB) Renentl-metamorphosed juveniles more likely to settle in areas of low current velocity and fine sediments; older juveniles less dependent on structure and sediment type (MAB) Inshore nursery grounds close to spawning areas (MAB) Lab: small YOY prefer fine sediments for burial; slightly larger ones prefer coarser sand	Present to 86 inshore, common 7-24(RB), 15-50 (MA), and at min 7 (DBay) Present to 300 on shelf, common 10-**<u>60</u>** YOY collected 0.5-12 inshore, age 1+ to 27 <10 (GOM) Intertidal (BOF) YOY mostly <1 m to escape predators, move into deeper water in fall (NJ)	Present 0-32 inshore, common 7.5-24.5 (RB) and 3.5-15.5 (MA), 1-14 (DB) Present 0.5-22.5 on shelf, common 2.5-16.5 Lab study: YOY select 8-27, modal preference 18.5 Maximum growth in field 16-18 Minimum lethal -1.5 to 1, max 30 (YOY, Mystic R)	Present 3-40 inshore, common 23.5-33.5 (RB) and min 9 (DB) Present 28.5-34.5 on shelf, common 31.5-33.5 Collected 19-21 (YOY 23-33) Optimum growth for YOY <24 (NJ) Lab study: older juvs avoid salinities <10 (YOY <5)
Adults	Inshore on muddy sand, offshore on hard bottom (GOM) More abundant on sand and gravel than on sand and mixed substrates (SS) Spawn in estuaries and coastal waters in SW GOM Ripe and running adults caught in 20-30 m on granule-oebble bottom (Jeffreys Ledge, SW GOM) Also see eggs	Present 2-86 inshore, common 7-24 (RB), 15-60 (MA), and at min 8 (DBay) Present to >500 on and off shelf, common 10-**<u>70</u>** Spawn as deep as 72 on GB and as shallow as 2-6 inshore Intertidal (BOF)	Present 0-24 inshore, common 5.5-12.5 (RB), 1-13 (DB), 5.5-15.5 (MA) Present 0.5-23.5 on shelf, common 1.5-12.5 Prefer 13.5 (lab), 12-15 (field) Major egg production <3.3 in New England	Present 8-36 inshore, common 23.5-33.5 (RB), and min 9 (DB) Found 15-34.5, common 31.5-33.5 on shelf

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
		Most spawning in coastal or offshore waters, not in estuaries (SW GOM)		

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs**: Pereira et al. (1999), NEFSC (2004f), and Wilber et al. (2013).
- **Larvae**: Temperature and depth ranges for continental shelf derived from MARMAP survey data in Pereira et al. (1999); other information also from Pereira et al. (1999).
- **Juveniles**: <u>Inshore</u>: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on MA and Raritan Bay trawl survey data in Pereira et al. (1999) and NEFSC (2004f), ME/NH trawl survey data provided by Maine Dept. Marine Resources, and Delaware Bay trawl survey data in Morse (2000). Use of depths <10 m and eelgrass by YOY juveniles in GOM reported by Lazzari & Stone (1996) and Lazzari (2008). All other substrate information summarized in Pereira et al. (1999) and NEFSC (2004f). <u>Continental shelf</u>: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004f). Substrate and other information (inshore and continental shelf) obtained from Pereira et al. (1999), NEFSC (2004f), Bigelow and Schroeder (1953), and Able and Fahay (1998).
- **Adults**: <u>Inshore</u>: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on MA and Raritan Bay trawl survey data in Pereira et al. (1999) and NEFSC (2004f), ME/H trawl survey data provided by Maine Dept. Marine Resources, and Delaware Bay trawl survey data in Morse (2000). <u>Continental shelf</u>: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004f). Substrate and other information (inshore and continental shelf) obtained from Pereira et al. (1999), Pereira (2004), Bigelow and Schroeder (1953). Information on spawning depths and locations in the SW GOM obtained from DeCelles and Cadrin (2010) and Fairchild et al. (2013).

<u>Prey species</u>

The main source of information on the prey consumed by the juvenile and adult stages of winter flounder (*Pseudopleuronectes americanus*) comes from the EFH Source Document and EFH Update Memo (Pereira et al. 1999; NEFSC 2004f, and references therein).

Pearcy (1962) investigated the food habits of winter flounder larvae from hatching through metamorphosis in the Mystic River, CT estuary. A large percentage of the stomach contents were unidentifiable but nauplii, harpacticoids, calanoids, polychaetes, invertebrate eggs, and phytoplankton were all present. Food item preference changed with larval size: smaller larvae (3-6 mm) ate more invertebrate eggs and nauplii while larger larvae (6-8 mm) preferred polychaetes and copepods. Plant material was found in larval stomachs but usually with other food items and was probably incidentally ingested (Pearcy 1962). Copepods and harpacticoids were important foods for metamorphosing and recently metamorphosed winter flounder. Amphipods and polychaetes gradually become more important for both YOY and yearling flounder (Pearcy 1962).

Winter flounder have been described as omnivorous or opportunistic feeders, consuming a wide variety of prey. Polychaetes and crustaceans (mostly amphipods; e.g., gammarids) generally make up the bulk of the diet (Link et al. 2002). The major prey items in the diet of juvenile/small adult winter flounder ($\leq$ 30 cm), based on the NEFSC food habits database from 1973-1990, are amphipods (*Ericthonius* sp., *Unciola irrorata, Leptocheirus pinguis, Ampelisca agassizi*, *Byblis serrata*, *Aeginina longicornis*) and polychaetes (Ampharetidae, Sabellidae, Maldanidae, *Trichobranchus glacialis*, *Lumbrineris fragilis*, *Nereis* sp.), as well as hydroids. Adults $\geq$ 31 cm feed mostly on amphipods (*Pontogeneia inermis*, *Unciola irrorata*, *Leptocheirus pinguis*, *Aeginina longicornis*), cnidarians (anthozoans, hydroids, sea anemones), polychaetes, and mollusks (bivalves). Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult winter flounder include: polychaetes (39%), anemones/corals (16%), and gammarid amphipods (6%).

In the Navesink River and Sandy Hook Bay (NJ) estuary, ontogenetic shifts in dietary preferences suggest that winter flounder should be divided into three size classes (15-49 mm, 5.0-29.9 cm, and ≥ 30.0 cm) based on a cluster analysis of the winter flounder diet's (Stehlik and Meise 2000). The smallest group fed on spionid polychaetes and copepods, which were scarce in the diets of the two larger size groups. The intermediate size group fed on other polychaetes, amphipods, and bivalve siphons but increased consumption of sand shrimp (*Crangon septemspinosa*) in the summer and fall. The largest size group fed extensively on a bivalve (*Mya arenaria*) and glycerid polychaetes.

Winter flounder may modify their diet based on availability of prey, and degradation or improvement of environmental conditions causing shifts in benthic invertebrate populations may also cause shifts in prey selection such as eating the pollution-tolerant annelid *Capitella* or eating the pollution-sensitive amphipod, *Unciola irrorata,* once environmental conditions have improved. In addition, winter flounder are one of only a handful of species that consume planktonic hydroids (Avent et al. 2001). Twenty-eight percent of the winter flounder populations on Georges Bank eat planktonic hydroids, *Clytia gracilis*, but they compose only about 4.1% of the diet by weight. Hydroid consumption was not related to fish size and they were found in the stomachs of fish measuring approximately 100-400 mm in length (Avent et al. 2001). For inshore diet studies, see table, below.

Table 21 – Major prey items of winter flounder

Life Stage	***Major prey***	***Location***
Juveniles, small adults, $\leq$ 30 cm	**Cnidarians**: hydroids	U.S. northeast continental shelf

Life Stage	***Major prey***	***Location***
	Polychaetes: Ampharetidae, Sabellidae, Maldanidae, *Trichobranchus glacialis*, *Lumbrineris fragilis*, *Nereis* sp. **Crustaceans**: amphipods (*Ericthonius* sp., *Unciola irrorata*, *Leptocheirus pinguis*, *Ampelisca agassizi*, *Byblis serrata, Aeginina longicornis*)	
Adults, ≥ 31 cm	**Cnidarians**: anthozoans, hydroids, sea anemones **Polychaetes** **Crustaceans**: amphipods (*Pontogeneia inermis*, *Unciola irrorata*, *Leptocheirus pinguis*, *Aeginina longicornis*) **Mollusks**: bivalves	U.S. northeast continental shelf
Juveniles	**Crustaceans**: ostracods, copepods, amphipods, isopods, "shrimp"	Woods Hole harbor, MA (Linton 1921)
Juveniles, adults	**Polychaetes**: *Nereis* sp., *Glycera* sp., *Capitella* sp. **Crustaceans**: amphipods (*Ampelisca* sp.), decapods (*Pagurus* sp., *Crangon septemspinosa*) **Mollusks**: bivalves (*Macoma* sp., *Solemya* sp., *Mya* siphons)	Woods Hole harbor, MA (Lux et al. 1996)
Ages 1+	**Polychaetes; Crustaceans**: amphipods; **Mollusks**: bivalves (*Nucula proxima, Tellina agilis, Yoldia* sp.)	Buzzards Bay, MA (Frame 1974)
Ages 1+	**Cnidarians**: *Obelia* sp. ;**Crustaceans**: amphipods (*Unciola irrorata*, *Leptocheirus pinguis*)	Block Island Sound, RI (Smith 1950)
Juveniles, adults	**Cnidarians**: *Ceriantheopsis americanus* (tube anemone); **Polychaetes**: *Nephtys incisa, Pherusa affinis, Nereis* sp.	Narragansett Bay, RI (Bharadwaj 1988)
Juveniles	**Polychaetes**: *Nereis* sp., spionids; **Crustaceans**: amphipods (*Ampelisca* sp., *Lembos* sp.), isopods (*Edotea* sp.), tanaids (*Leptochelia* sp.)	Rhode Island coast (Mulkana 1966)
Juveniles	**Nematodes; Polychaetes; Crustaceans**: amphipods	Charles Pond, RI (Worobec 1984)
Larvae, metamporhosing, YOY, yearling	**Invertebrate eggs, nauplii** -- smaller larvae (3-6 mm): **Polychaetes, copepods --** larger larvae (6-8 mm): **Copepods, harpacticoids** -- metamorphosing and recently metamorphosed **Amphipods, polychaetes** -- YOY, yearling	Mystic River, CT estuary (Pearcy 1962)
Juveniles, adults	**Cnidarians**: hydroids; **Polychaetes**: *Streblospio* sp.; **Crustaceans**: amphipods (*Ampelisca abdita*), decapods (*Crangon septemspinosa*), mysid shrimp	New Haven Harbor, CT (Carlson 1991)
Juveniles	**Crustaceans**: amphipods *(Ampelisca abdita*)	Jamaica Bay, NY (Franz and Tanacredi 1992)
Juveniles	**Cnidarians**: hydroids; **Nemerteans; Polychaetes**: *Ampharete* sp., *Nereis succinea*, *Nephtys incise*, *Melinna cristata;* **Crustaceans**: amphipods (*Leptocheirus pinguis*), decapods (mysid shrimp *Neomysis americana*)	Long Island Sound (Richards 1963)

Life Stage	***Major prey***	***Location***
Juveniles	**Nematodes; Polychaetes; Crustaceans**: ostracods, copepods, amphipods, isopods	Southern Long Island, NY (Tressler and Bere 1938)
Juveniles, adults	**Polychaetes**: sabellids, terebelllids; **Crustaceans**: amphipods; **Mollusks**: bivalves (clam siphons)	Southern Long Island, NY (Kurtz 1975)
Juveniles	**Polychaetes**: *Asabellides oculata;* **Crustaceans**: amphipods (*Gammarus* sp.)	Raritan Bay, NY (Conover et al. 1985)
Juveniles, small adults, < 30 cm; adults, ≥ 30 cm	Juveniles, small adults; **Cnidarians**: hydroids; **Polychaetes**: *Glycera* sp.; **Crustaceans**: amphipods (*Ampelisca vadorum*, *Unciola* sp.), decapods (mysid shrimp *Neomysis americana*); **Mollusks**: bivalves (northern quahog siphons, Atlantic surfclam siphons, *Ensis directus*); Adults **Mollusks**: bivalves (northern quahog siphons, other bivalves) Other prey that may be important in the diet: **Nemerteans; Polychaetes**: *Asabellides oculata;* **Crustaceans**: amphipods (*Gammarus lawrencianus*, *Ampelisca abdita*, *Corophium* sp.), decapods (juvenile rock crab *Cancer irroratus*, *Crangon septemspinosa*); **Mollusks**: bivalves (blue mussel spat/juveniles)	Hudson-Raritan estuary (Steimle et al. 2000)
Juveniles, adults	**Polychaetes**: spionids, glycerids; **Crustaceans**: copepods (the calanoid *Eurytemora affinis*), amphipods (ampeliscid), decapods (*Crangon septemspinosa*), mysid shrimp; **Mollusks**: bivalves (*Mya* siphons)	Navesink River, Sandy Hook Bay (NJ) estuary (Stehlik and Meise 2000)
Juveniles, adults	**Nemerteans; Polychaetes; Crustaceans**: amphipods (*Ampelisca* sp.), decapods (*Palaemonetes* sp.); **Mollusks**: bivalves (clam siphons)	Little Egg Harbor, NJ (Festa 1979)
Juveniles, adults	**Polychaetes; Crustaceans**: amphipods, isopods, decapods (*Crangon septemspinosa*); **Mollusks**: bivalves	Hereford Inlet, NJ (Allen et al. 1978)
Juveniles, adults	**Cnidarians**: hydroids; **Polychaetes**: *Nereis succinea;* **Crustaceans**: decapods (*Crangon septemspinosa*); **Mollusks**: bivalves (clam siphons); **Fish**: sand lance	Manasquan River, NJ (Scarlett and Giust 1989)
Juveniles, adults	**Cnidarians**: hydroids; **Polychaetes**: *Nereis* sp., *Glycera* sp.; **Crustaceans**: isopods (*Cyathura* sp.); **Mollusks**: bivalves (clam siphons)	Central NJ estuaries (Scarlett 1986, 1988)
Juveniles	**Polychaetes; Crustaceans**: isopods (*Edotea* sp.)	Delaware Bay (de Sylva 1962)
	Polychaetes	Rehobeth Bay, DE (Timmons 1995)

Life Stage	***Major prey***	***Location***
Juveniles	**Polychaetes**: *Scolecolepides viridis, Nereis succinea;* **Crustaceans**: amphipods (*Corophium lacustra*); **Mollusks**: bivalves (*Macoma* sp.)	Chesapeake Bay (Homer and Boynton 1978)

Peak spawning

Information on the spawning periods of winter flounder (*Pseudopleuronectes americanus*) comes from the EFH Source Document and update memo (Pereira et al. 1999; NEFSC 2004f, and references therein), and from more recent studies done in the southwestern Gulf of Maine and the New York harbor area.

With the exception of the **Georges Bank** population, adult winter flounder migrate inshore in the fall and early winter and spawn in late winter and early spring. Bigelow and Schroeder (1953) reported that *peak* spawning occurs during February and March in **Massachusetts Bay and south of Cape Cod** and somewhat later along the **coast of Maine** continuing into May. Most of the ripe and running female winter flounder examined by Fairchild et al. (2013) in 2009 in **Ipswich Bay, Massachusetts**, were collected between late March and early May, with peak spawning between April 12 and May 9. In a ten-year study in the **New York harbor** area, Wilber et al.(2013) reported that spawning began as early as early January in some years and as late as March in other years. Spawning occurs earlier (November to April) in the **southern part of the range** (Klein-MacPhee 2002). Winter flounder eggs are generally collected from very shallow waters (less than about 5 m).

Data from recent U.S. GLOBEC Georges Bank surveys (February-July, 1995; January-June, 1996-1999) showed **Georges Bank** eggs occurred during March-June, with the highest numbers in March and May on the central and northern sections on the Bank. Winter flounder eggs have also been collected in standard plankton tows utilizing bongo nets by the NEFSC MARMAP survey. In some cases this was probably due to the nets accidentally hitting the bottom, but this explanation is not sufficient to explain the large numbers of eggs collected on **Georges Bank and Nantucket Shoals**, especially during April. The large numbers of eggs collected on **Georges Bank** are probably due to the unique hydrodynamic conditions found there. The water mass on **central Georges Bank** is characterized by lack of stratification at any time of year due to good vertical mixing (Backus and Bourne 1987). These same forces probably lift demersal eggs up into the water column and make them available to sampling by bongo net.

Pereira et al. (1999) and NEFSC (2004f) discuss **inshore locations** where winter flounder eggs have been found.

Witch flounder

Supplementary table

Table 22 – Summary of habitat information for witch flounder

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Pelagic, in water column	Present to 1500 on and off shelf, common to 160	Present 3.5-17.5 on and off shelf, common 4.5-12.5	No information
Larvae	Pelagic, in water column	Present to 1500 on and off shelf, common 40-100	Present 3.5-20.5 on shelf, common 5.5-13.5 Maximum survival 15	No information
Juveniles	See adults	Present 5-99 inshore, common **<u>50</u>**-85 (MA) and 80-170 (ME) Present 20-**<u>1500</u>** on and off shelf, common 80-**<u>400</u>**	Present 1.5-12.6 inshore, common 3.5-10.5 (MA) and 3.1-9 (ME) Present 0.5-19.5 on shelf, common 3.5-11.5	Present 31.2-34 inshore Present 30.5-36.5 on shelf, common 32.5-34.5
Adults	Mud, clay, silt, muddy sand substrates, rarely on other bottom types; common on smooth ground between rocky patches (GOM) Small-scale associations with depressions in mud	Present 6-99 inshore, common **<u>35</u>**-85 (MA) and 100-200 (ME) Present 20-**1500** on and off shelf, common 100-**<u>400</u>** Found 20-1569, most 90-330 in U.S. waters (also juveniles)	Present 0.2-16.3 inshore, common 3.5-10.5 (MA) and 4.1-8 (ME) Present 0.5-21.5 on shelf, common 3.5-10.5 Found 0-15, most 2-9 (also juveniles) Spawn 0-10	Present 32.1-34 inshore Present 30.5-36.5 on shelf, common 32.5-35.5 Found 31-36 (also juveniles)

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs**: Shelf depth and temperature ranges derived from MARMAP data in Cargnelli et al. (1999b).
- **Larvae**: Shelf depth and temperature ranges derived from MARMAP data in Cargnelli et al. (1999b); additional information also from Cargnelli et al. (1999b).
- **Juveniles**: <u>Inshore</u>: depth, temperature, and salinity ranges (presence only) based on inshore trawl surveys in areas mapped as EFH; depth and temperature ranges ("common") from MA inshore trawl survey data in NEFSC (2006b) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. <u>Continental shelf and slope</u>: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2006b); additional depth information for slope from Moore et al. (2003).
- **Adults**: : <u>Inshore</u>: depth, temperature, and salinity ranges (presence only) based on inshore trawl surveys in areas mapped as EFH; depth and temperature ranges

("common") from MA inshore trawl survey data in NEFSC (2006b) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. Continental shelf and slope: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2006b); additional depth information for slope from Cargnelli et al. (1999b), NEFSC (2006b), and Moore et al. (2003); sediment types and other information from Cargnelli et al. (1999b), NEFSC (2006b) and Auster et al. (1991).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of witch flounder (*Glyptocephalus cynoglossus*) comes from the EFH Source Document and update memo (Cargnelli et al. 1999, NEFSC 2006b, and references therein). The main food items in the witch flounder diet are polychaetes and crustaceans, although mollusks and echinoderms are also important. Overall, polychaetes were by far the most important food item, accounting for greater than 70% of the diet. However, there is a distinct ontogenetic shift in diet, with polychaetes increasing in importance and crustaceans decreasing in importance with age. By sexual maturity, polychaetes dominate the diet considerably, while crustaceans are far less important.

The 1973-1990 NEFSC food habits data for witch flounder verify that polychaetes are the most important food source of witch flounder. During 1973-1980, small (5-30 cm) witch flounder fed primarily on polychaetes (37%) and crustaceans (27%). Polychaetes remained the most important food source among larger (> 30 cm) individuals; however, crustaceans declined in importance, replaced in the diet by mollusks and echinoderms. The 1981-1990 data also show that polychaetes dominate the witch flounder diet. Again, an ontogenetic shift in diet is evident, although this shift contrasts with that described above: crustaceans increase in importance while polychaetes decrease in importance in larger fish.

Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the only prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult witch flounder was polychaetes (71%).

Bowman and Michaels (1984) reported that the major food items of smaller juveniles (< 20 cm) were crustaceans (74% of the diet), while polychaetes accounted for only 19%. However, larger juveniles (21-30 cm) fed primarily on polychaetes (45-65%) followed by crustaceans (15-37%). Mollusks and echinoderms were consumed in smaller quantities (0-5%) (Bowman and Michaels 1984). Adults 31-60 cm fed primarily on polychaetes (60-66%) and echinoderms (6-18%), with crustaceans, mollusks, and coelenterates accounting for a smaller part of the diet. Adults > 60 cm fed almost exclusively on polychaetes (98%) (Bowman and Michaels 1984). There is little variation in diet with geographic area. An exception is southern New England, where squid can be almost as important a food source as polychaetes.

Using the NEFSC food habits database from 1977-1980, Bowman et al. (2000) showed that in all areas sampled, polychaetes made up at least 75% of the stomach contents by weight. The primary prey of juveniles < 30 cm were polychaetes (Lumbrineridae, including *Lumbrineris fragilis*; Sternaspidae), followed by ascidians and crustaceans (amphipods). Polychaetes also dominated the diets of all the adult size classes; family/species included Lumbrineridae, including *Lumbrineris fragilis* and *Ninoe brevipes*; *Nephtys* sp.; *Glycera dibranchiata*, Goniadidae, including *Goniada* sp. and *Ophioglycera gigantea*; Terebellidae; and Capitellidae. Other important prey included bivalves (*Yoldia* sp.) for adults 36-40 cm, and echinoderms (sea cucumbers) for fish 56-60 cm.

Table 23 – Major prey items of witch flounder

Life Stage	*Major prey*	*Location*
Juveniles, < 30 cm	**Polychaetes**: (Lumbrineridae, including *Lumbrineris fragilis*; Sternaspidae); **Crustaceans**: amphipods	U.S. northeast continental shelf
Adults, ≥ 30 cm	**Polychaetes**: (Lumbrineridae, including *Lumbrineris fragilis* and *Ninoe brevipes*; *Nephtys* sp.; *Glycera dibranchiata*, Goniadidae, including *Goniada* sp. and *Ophioglycera gigantea*; Terebellidae; and Capitellidae)	U.S. northeast continental shelf

Peak spawning

Information on the spawning periods of witch flounder (*Glyptocephalus cynoglossus*) comes from the EFH Source Document and update memo (Cargnelli et al. 1999, NEFSC 2006b) and references therein).

Witch flounder spawn from March to November, with peak spawning occurring in summer. The general trend is for spawning to occur progressively later from south to north (Martin and Drewry 1978; Brander and Hurley 1992). In the **Gulf of Maine-Georges Bank** region, spawning occurs from April to November, and peaks from May to August (Bigelow and Schroeder 1953; Evseenko and Nevinsky 1975; Burnett et al. 1992; O'Brien et al. 1993). The **western and northern areas of the Gulf of Maine** tend to be the most active spawning sites (Burnett et al. 1992). In the **Middle Atlantic Bight**, spawning occurs from April to August, *peaking* in May or June (Smith et al. 1975; Martin and Drewry 1978), and the most important spawning grounds are off **Long Island** (Smith et al. 1975).

The MARMAP offshore ichthyoplankton surveys found eggs earlier in the **Middle Atlantic Bight** than in **New England**, where eggs were not found until May. This agrees with studies suggesting that spawning occurs later to the north (Martin and Drewry 1978; Brander and Hurley 1992). The highest egg densities appear to be in the **Gulf of Maine and Massachusetts Bay** in May and June. High densities of eggs occurred in May (monthly mean 5.7 eggs/10 m^2) in **Massachusetts Bay, along the south flank of Georges Bank and throughout the Middle Atlantic Bight**. The highest abundances occurred in June (monthly mean 8.0 eggs/10 m^2) off **New England**, particularly in the **Gulf of Maine and Georges Bank**. This concurs with reports that spawning peaks in May and June (Smith et al. 1975; Martin and Drewry 1978; Neilson et al. 1988).

Yellowtail flounder

Supplementary table

Table 24 – Summary of habitat information for yellowtail flounder

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Pelagic, in water column	Present 0-400 on shelf, common 20-100 Present 500-1000 off-shelf	Present 1.5-15.5 on shelf, common 3.5-10.5	No information
Larvae	Pelagic, in water column	Present 0-260 on shelf, common 20-120 Present 1000-1500 off-shelf	Present 4.5-17.5 on shelf, common 6.5-12.5 on shelf	No information
Juveniles	YOY settle mid-shelf on sand (NY Bight) Also see adults	Present 4-85, common 20-50 (MA) and **<u>20</u>**-110 (ME) Present to 400 on shelf, common 30-**<u>80</u>** YOY: prefer 56-87 on shelf	Present 1.3-18, common 2.5-13.5 (MA) Present 0.5-18.5 on shelf, common 2.5-12.5	Present 28-33 inshore Present 30.5- 35.5 on shelf, common 32.5-33.5
Adults	Occur on any sandy bottom or mixture of sand and mud, but avoid rocks, stony ground, and soft mud (GOM) Prefer sand and gravel over sand and mixed sediments (Nfld, Labrador) More abundant on sand and shell hash, gravely sand, and rock-sand sediment types; rarely found on mud or muddy sand substrates (Grand Banks)	Present 4-85, common **<u>25</u>**-65 (MA) and 30-110 (ME) Present to 400 on shelf, common 30-**<u>90</u>** Common 9-64 off Cape Cod	Present 1.3-17, common 4.5-12.5 (MA) and 2.1-11 (ME) Present 0.5-19.5 on shelf, common 2.5-14.5 Lab study: tolerate -1 to 18, max survival 8-14 Spawn 5-12	Present 28-35 inshore Present 30.5-36.5 on shelf, common 32.5-33.5 Lab study: maximum survival 32-38

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs and Larvae**: Shelf depth and temperature ranges, and off-shelf depths, derived from MARMAP and GLOBEC data in Johnson et al. (1999) and NEFSC (2006c).

- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore trawl surveys in areas mapped as EFH; depth and temperature ranges ("common") from MA inshore trawl survey data in NEFSC (2006c) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2006c). YOY information from Steves et al. (1998) and Sullivan et al. (2006). Other information from Johnson et al. (1999).
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore trawl surveys in areas mapped as EFH; depth and temperature ranges ("common") from MA inshore trawl survey data in NEFSC (2006c). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2006c); substrate and other information from Bigelow and Schroeder (1953), Simpson and Walsh (2004), and Bowering and Brodie (1991). Other information from Johnson et al. (1999).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of yellowtail flounder (*Limanda ferruginea*) comes from theEFH Source Document and update memo (Johnson et al. 1999, NEFSC 2006c, and references therein). The 1973-2001 NEFSC food habits database for yellowtail flounder shows that polychaetes comprised approximately 35% of the adult yellowtail diet. This was closely followed by amphipods (29%). Unidentified well-digested prey accounted for > 20% of the total diet, other items occurring in lower volumes include bivalves, cnidarians, decapods, and mysids. Other studies mention echinoderms (sand dollars, *Echinarachius parma*) as well. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult yellowtail flounder include: polychaetes (38%), gammarid amphipods (19%), and other amphipods (6%).

Bowman et al. (2000) summarized the diet composition of yellowtail flounder, based on the NEFSC bottom trawl surveys from 1977-1980 by both length and geographic area. Juveniles 6-25 cm ate primarily polychaetes and crustaceans. Polychaete prey included *Ampharete arctica*, *Ophelia* sp. and Sigalionidae. Crustacean prey included amphipods (*Unicola irrorata*, Oedicerotidae) and decapods (*Crangon septemspinosa*). Large juveniles/small adults 26-30 also preyed primarily on polychaetes (*Spiophanes bombyx*, Nephtyidae) and crustaceans (amphipods, including *Unicola irrorata* and *Dulichia* sp.; the decapod *Crangon septemspinosa*); nemertians (phylum Rhynchocoela) were also significant in the diet. Adults $\geq$ 31 cm consumed primarily polychaetes and crustaceans, as well as tube anemones. Polychaete prey including mostly *Spiophanes bombyx*, but also *Drilonereis* sp. Crustacean prey was mostly amphipods, including *Leptocheirus pinguis*, *Ericthonius rubricornis*, and gammarids, including *Gammarus annulatus*. Of the geographic areas sampled, polychaetes were the most selected prey type on Georges Bank, followed by crustaceans. In southern New England and inshore north of Cape Hatteras, the most selected prey choice was crustaceans, followed by polychaetes. The decapod *Crangon septemspinosa* was only eaten in significant quantities inshore north of Cape Hatteras, while tube anemones were only important in southern New England.

A similar dietary analysis by Link et al. (2002) focused on flatfish of the northwest Atlantic taken during the NEFSC bottom trawl surveys from 1973-1998 for all seasons. In this study, juvenile and adult yellowtail flounder consumed primarily polychaetes, gammarid and other amphipods, and other benthic invertebrates. Unclassified amphipods and unidentified digested prey comprised 10% of the total diet. There were no significant ontogenetic shifts in diet across the 25-year time series.

Table 25 – Major prey items of yellowtail flounder

Life Stage	*Major prey*	*Location*
Juveniles, 6-25 cm	**Polychaetes**: *Ampharete arctica*, *Ophelia* sp., Sigalionidae **Crustaceans**: amphipods (*Unicola irrorata,* gammarids, Oedicerotidae), decapods (*Crangon septemspinosa*)	U.S. northeast continental shelf
Large juveniles/small adults, 26-30 cm	**Nemerteans; Polychaetes**: *Spiophanes bombyx*, Nephtyidae; **Crustaceans**: amphipods (*Unicola irrorata, Dulichia* sp., gammarids), decapods (*Crangon septemspinosa*)	U.S. northeast continental shelf
Adults, $\geq$ 31 cm	**Cnidarians**: tube anemones (Ceriantharia); **Polychaetes**: *Spiophanes bombyx*, *Drilonereis* sp.; **Crustaceans**: amphipods (*Leptocheirus pinguis*, *Ericthonius rubricornis*, *Gammarus annulatus*, gammarids)	U.S. northeast continental shelf

Peak spawning

Information on the spawning periods of yellowtail flounder (*Limanda ferruginea*) comes from the EFH Source Document and update memo (Johnson et al. 1999, NEFSC 2006c, and references therein).

Spawning generally occurs from March through August at temperatures of 5-12^{o}C (Fahay 1983). Collections from the MARMAP ichthyoplankton surveys (1977-1987) showed little or no spawning activity during February. By March and April, eggs appeared on the continental shelf off **New Jersey and Long Island, on Georges Bank, northwest of Cape Cod**, and on Browns Bank. The distribution and abundance of eggs expanded in **southern New England** in May. On **Georges Bank**, the distribution and abundance of eggs expanded in June and declined thereafter; spawning ended in August. Eggs were found in the **Gulf of Maine** from April to September. The densest egg concentrations occurred on the northeast and southwest part of **Georges Bank, west from Nantucket Shoals to New Jersey, northwest of Cape Cod along western Gulf of Maine**, and off southwest Nova Scotia. Peak abundances were from April to June.

During the **Georges Bank** GLOBEC ichthyoplankton surveys (1995-1999), yellowtail eggs were found in all months sampled (excluding January). They were most abundant at depths > 60 m, especially along the **Northeast Peak**, all regions of the **Southern Flank**, as well as the **Great South Channel**. Egg concentrations peaked in April and by May eggs extended into the **Southern Flank and central Georges Bank**. Fewer eggs were captured in June and even less in July.

Silver hake

Supplementary table

Table 26 – Summary of habitat information for silver hake

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Pelagic, in water column	Common 40-200 on shelf Present to 1500 on and off shelf	Collected 14.8-21.4 (NBay) and 13-22 (MAB) Present 4.5-26.5 on and off shelf, common 5.5-23.5	No information
Larvae	Pelagic, in water column	Present to 1500 on and off shelf Common 40-140 on shelf	Collected 12-22.4 (NBay) Present 4.5-26.5 on and off shelf, common 9.5-17.5	No information
Juveniles	Pelagic habitats (at night), benthic habitats during the day Found mostly on flat sand, also sand wave crests, shells and depressions created by benthic organisms (MAB/SNE) YOY more abundant on silt-sand with amphipod tubes (NYB/MAB) Juvs/adults most abundant on mud and mud-sand (LIS)	Present 5-99 inshore, common **<u>40</u>**-80 (MA), **<u>10</u>**-25 (RBay), 12-26 (CBay), 11-22 (DBay), and 60-170 (ME) Present to >500 on and off shelf, common **<u>40-400</u>** YOY most abundant 55 (MAB)	Present 0.2-22 inshore, common 1.5-11.5 (MA), 4.5-21.5 (RBay), 7-13 (CBay), 5-16 (DBay), and 2.1-10 (ME) Present 0.5-22.5 on and off shelf, common 4.5-18.5	Present 13.4-36 inshore, common 26.5-33.5 (RB) and 26-33 (DB) Present 19.5-36.5 on and off shelf, common 32.5-34.5
Adults	Pelagic habitats (at night), benthic habitats during the day Sandy or pebbly bottom or on mud, but seldom over rocks (GOM) Found mostly on flat sand, also sand wave crests, shells and depressions created by benthic organisms (MAB/SNE)	Present 6-99 inshore, common **<u>35</u>**-80 (MA) 70-170 (ME), and at min 10 (DBay) Present to >500 on and off shelf, common 70-**<u>400</u>** Prefer 40-200 (GB), 60-100 (MAB) Limited inshore spawning	Present 1.3-18 inshore, common 4.5-11.5 (MA) and at max 16 (DBay) Present 1.5-21.5 on and off shelf, common 5.5-13.5	Present 24-36 inshore, common 26.5-33.5 (RB) and 24-30 (DB) Present 31.5-36.5 on and off shelf, common 33.5-34.5

**   Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs and Larvae**: Shelf and slope depth and temperature ranges derived from MARMAP data in Lock and Packer (2004), other information obtained from Lock and Packer (2004).
- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, salinity, and temperature ranges ("common") from analysis of MA, Raritan Bay, Delaware Bay, and Chesapeake Bay trawl survey data in Lock and Packer (2004) and Morse (2000), and ME/NH trawl survey data provided by Maine Dept. Marine Resources. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Lock and Packer (2004); sediment types and other information also from Lock and Packer (2004).
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, salinity, and temperature ranges ("common") from analysis of MA, Raritan Bay, and Delaware Bay trawl survey data in Lock and Packer (2004) and Morse (2000) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Lock and Packer (2004); sediment types and other information also from Klein-MacPhee (2002) and Lock and Packer (2004).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of silver hake (*Merluccius bilinearis*) comes from the EFH Source Document (Lock and Packer 2004, and references therein). Variations in diet in diet of silver hake are dependent upon size, sex, season, migration, spawning, and age with size having the most influence on diet. Silver hake larvae feed on planktonic organisms such as copepod larvae and younger copepodites. The diet of young silver hake consists of euphausiids, shrimp, amphipods, and decapods. All silver hake are ravenous piscivores that feed on smaller hake and other schooling fishes such as young herring, mackerel, menhaden, alewives, sand lance**,** or silversides, as well as crustaceans and squids.

The 1973-2001 NEFSC food habits database for silver hake generally confirms previous studies. Several other studies, such as Garrison and Link (2000) and Tsou and Collie (2001a, b) use the same database, although the years differ. Garrison and Link (2000) found that small (< 20 cm) silver hake consumed large amounts of euphausiids, pandalids, and other shrimp species. The diet of medium sized (20-50 cm) silver hake consisted of fishes, squids, and shrimp taxa. The diet of large (> 50 cm) silver hake consisted of over 50% fish, including Atlantic herring, clupeids, Atlantic mackerel, and other scombrids. A higher proportion of cephalopods, sand lance, and amphipods are present in the diets of silver hake that occupy southern habitats (Southern Atlantic Bight, Mid- Atlantic Bight, Southern New England). Silver hake of northern regions (Gulf of Maine, Georges Bank, Scotian Shelf) prey more heavily on pelagic fishes, euphausiids, and pandalid shrimps. For example, euphausiids make up 25% of the diet for silver hake of the Gulf of Maine and 7.2% for the Middle Atlantic Bight. Atlantic herring comprise

0.2% of the Middle Atlantic Bight diet and 12.9% of the Georges Bank diet. Squids (*Loligo* sp. and cephalopods), sand lance, and butterfish accounted for 5-10% of silver hake diets in the Middle Atlantic Bight and Southern New England compared to less than 1% in the Gulf of Maine and Southwestern Nova Scotian Shelf regions. Other studies confirm that silver hake is a major piscivore on Georges Bank, with an ontogenetic shift in diet towards increased piscivory.

Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult silver hake include: other fish (16%), Atlantic herring (9%), crangonids (8%), silver hake (8%), clupeids (7%), and decapod crabs (6%).

Bowman (1984) studied samples collected from eight NEFSC Marine Resources Monitoring, Assessment, and Prediction (MARMAP) bottom trawl surveys conducted by NMFS between March 1973 and November 1976. These surveys were concentrated in the Middle Atlantic, Southern New England, and Georges Bank. It was found that 80% of the diet by weight was fish, 10.2% crustaceans, and 9.2% squid. Euphausiids consisted mainly of *Meganyctiphanes norvegica* and *Euphausia*. Decapod groups included Crangonidae (*Crangon septemspinosa* and *Sclerocrangon boreas*), Pandalidae (*Dichelopandalus leptocerus* and *Pandulus borealis*), and Pasiphaedae (*Pasiphaea multidentata*), as well as other unidentifiable decapods, which were mostly shrimp. Amphipods present in the stomachs of silver hake were mainly from the Ampeliscidae (*Ampelisca agaxxize, A. spinipes, A. vadorum*, and *Byblis serrata*), Oedicerotidae (*Manoculodes edwardsi* and *M. intermedius*), and Hyperiidea families. Other crustacean groups included the Mysidacea, Cumacea, and Copepoda. Additional stomach contents that were identified include cephalopods (*Loligo pealei* and *Rossia*), Polychaeta, and miscellaneous organisms such as Echinodermata, and Chaetognatha. The study also found that silver hake measuring less than 20 cm fork length (FL) ate mostly crustaceans, while those that were greater than 20 cm FL ate mostly fish and squid. Silver hake 3-5 cm FL contained the largest percentage of smaller crustacean forms, such as amphipods and copepods. Fish 6-20 cm FL ate decapods, euphausiids, and mysids.

Bowman (1984) found cephalopods to be another important prey group of silver hake. Fish in Southern New England ate the largest quantities of squid, 13.7% by weight. Squid comprised 6.7% of the silver hake diet of Georges Bank and 4.3% of the diet for Middle Atlantic. The percentage of euphausiids and squid in the diet tends to increase at deeper bottom depths, while the percent weight of fish in the diet shows a corresponding decrease. The trend is that fish sampled at deeper depths will have less food on average in their stomachs. Availability of prey is probably one of the most important factors in determining what type and how much food silver hake eat.

Cannibalism is common among silver hake. Conspecific juveniles contribute more than 10% to the adult diet and more than 20% to the total diet.Cannibalism can account for more than 50% of predation rates on Georges Bank, and was observed to be especially important to silver hake in the spring. Cannibalism is most common in adult silver hake, although it can occur at the early juvenile stage.

Migration results in seasonal and yearly variations in silver hake diet. The diet changes from fish in the spring and autumn to fish, crustaceans, and mollusks during the summer. Small fish 26-55 mm consume more food in October and November, while larger fish 86-115 mm experience increased food consumption by January. Tsou and Collie (2001a) used the NMFS food-habits database to identify trophic relationships for silver hake on Georges Bank for years 1978-1992. It was discovered that more fish were consumed in the autumn with herring being the major prey item during that season.

In terms of sex differences, male diets have the largest percentage of crustaceans, while female diets have the largest percentage of fish and squid. Crustaceans constitute 48% of the total weight of all prey in the diet of male silver hake. Fish consumption is half that of crustaceans and consists of mainly myctophids and other silver hake. Crustaceans rank highest in frequency of occurrence in the diet of female silver hake; however, weight contribution is less for males. Fish prey represent 53% of the female silver hake diet. Females generally consume twice the amount by weight of fish prey as males. The noted differences between the sexes in prey selection are associated with size. Because females are larger, hence faster, they are able to consume larger, highly mobile prey such as fish and squid. Males on the other hand tend to be smaller at age and therefore concentrate much of their feeding activity on crustaceans, which are abundant and easily obtained. After the age of 5, females constitute over 70% of the silver hake population, so it is expected that the diet of older silver hake will consist of larger prey.

Diet also differs between the northern and southern stocks. The northern stock primarily consumes euphausiids, Atlantic herring, silver hake, and other fish, while the southern stock consumes crangonid shrimp, squids, cephalopods, and sand lance. *Illex* sp. and *Loligo* sp. of squid are found in the diet of silver hake that live in southern habitats (Garrison and Link 2000).

For inshore diet studies, see Table 27, below.

Table 27 – Major prey items of silver hake

Life Stage	***Major prey***	***Location***
Larvae	**Copepod larvae and younger copepodites**	U.S. northeast continental shelf
Juveniles, ≤ 22 cm	**Crustaceans**: copepods, amphipods (Ampeliscidae, including *Ampelisca agaxxize, A. spinipes, A. vadorum*, *Byblis serrata*; Oedicerotidae, including *Manoculodes edwardsi*, *M. intermedius*; Hyperiidea), cumaceans, decapods (Crangonidae, including *Crangon septemspinosa*, *Sclerocrangon boreas*; pandalid shrimp, including *Dichelopandalus leptocerus*, *Pandulus borealis*; Pasiphaedae, including *Pasiphaea multidentata*), euphausiids (*Meganyctiphanes norvegica*, *Euphausia*), mysids	U.S. northeast continental shelf
Larger juveniles/adults, ≥ 20 cm	**Crustaceans**: copepods, amphipods (Ampeliscidae, including *Ampelisca agaxxize, A. spinipes, A. vadorum*, *Byblis serrata*; Oedicerotidae, including *Manoculodes edwardsi*, *M. intermedius*; Hyperiidea), cumaceans, decapods (Crangonidae, including *Crangon septemspinosa*, *Sclerocrangon boreas*; pandalid shrimp, including *Dichelopandalus leptocerus*, *Pandulus borealis*; Pasiphaedae, including *Pasiphaea multidentata*; crabs), euphausiids (*Meganyctiphanes norvegica*, *Euphausia*), mysids; **Mollusks**: squids (*Loligo*	U.S. northeast continental shelf

Life Stage	***Major prey***	***Location***
	sp., *Rossia*); **Fish**: Atlantic herring, other clupeids, Atlantic mackerel, other scombrids, sand lance, butterfish, silversides, silver hake	
	Crustaceans: copepods, amphipods (*Leptocheirus pinguis*), decapods (*Crangon septemspinosa*), mysid shrimp (*Neomysis americana*); **Mollusks**: squid; **Fish**: bay anchovy, sand lance, juvenile silver hake	Block Island Sound, RI (Smith 1950)
	Polychaetes: (*Glycera* sp.); **Crustaceans**: amphipods (*Ampelisca* sp.**,** *Leptocheirus pinguis*), decapods (*Crangon septemspinosa*), mysids (*Neomysis americana*, *Heteromysis Formosa*)	Long Island Sound (Richards 1963)
Mostly juveniles	**Crustaceans**: amphipods (*Gammarus lawrencianus*, *Ampelisca abdita*), decapods (*Crangon septemspinosa*), mysid shrimp (*Neomysis americana*); **Fish**: juvenile silver hake, Atlantic menhaden, anchovies	Hudson-Raritan estuary (Steimle et al. 2000)
Adults	**Crustaceans**: amphipods, decapods (*Crangon septemspinosa*), mysid shrimp; **Fish**: juvenile silver hake, blueback herring, silversides	New Jersey surf zone (Schaefer 1960)

Peak spawning

Information on the spawning periods of silver hake (*Merluccius bilinearis*) comes from the EFH Source Document (Lock and Packer 2004, and references therein).

Silver hake eggs and larvae have been collected in all months on the continental shelf in U.S. waters, although the onset of spawning varies regionally (Bigelow and Schroeder 1953; Marak and Colton 1961; Sauskan and Serebryakov 1968; Fahay 1974; Morse et al. 1987; Waldron 1988; Berrien and Sibunka 1999). The primary spawning grounds most likely coincide with concentrations of ripe adults and newly spawned eggs. These grounds occur **between Cape Cod, Massachusetts, and Montauk Point, New York** (Fahay 1974), on the **southern and southeastern slope of Georges Bank** (Sauskan 1964) and the **area north of Cape cod to Cape Ann**, Massachusetts (Bigelow and Schroeder 1953).

Spawning begins in January along the **shelf and slope in the Middle Atlantic Bight**. During May, spawning proceeds north and east to **Georges Bank**. By June spawning spreads into the **Gulf of Maine** and continues to be centered on **Georges Bank** through summer. In October, spawning is centered in **southern New England** and by December is observed again along the shelf and slope in the **Middle Atlantic Bight**. Peak spawning occurs May to June in the southern stock and July to August in the northern stock (Brodziak 2001). Over the U.S. continental shelf, significant numbers of eggs are produced beginning in May. Numbers increase through August and decline rapidly during September and October (Berrien and Sibunka 1999).

Silver hake eggs were found throughout the area surveyed during the NEFSC MARMAP ichthyoplankton surveys. They were most abundant in the deeper parts of **Georges Bank** (> 60 m) and the shelf off **southern New England**. Eggs were captured in all months of the year. From January to March, eggs occurred in small numbers in the deep waters of the **Middle Atlantic Bight**. By April, the occurrence of eggs extended eastward along the **southern edge of Georges Bank** and the total number of eggs increased slightly. During May and June the catches of eggs extended into the shelf and into nearshore waters of the **Middle Atlantic Bight and southern New England areas**. Some eggs were captured in the **western part of the Gulf**

of Maine. By July and August the center of abundance had shifted east onto **Georges Bank with southern New England and the Gulf of Maine** continuing to show some catches of eggs. In September and October the occurrences of eggs began to decline with centers of abundance still on **Georges Bank** and extending into **southern New England**. Few eggs were captured in November or December, but those that were occurred in deeper waters of the **Middle Atlantic Bight**.

Red hake

Supplementary table

Table 28 – Summary of habitat information for red hake

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Pelagic, in water column	No information	No information	No information
Larvae	Pelagic, in water column	Present to 1500 on shelf, common 20-120 Found 10-200 Most abundant 40-120 (MAB)	Present 7.5-23.5 on shelf, common 11.5-20.5 8-23, most 11-19 (MAB, Aug-Sept)	No information
Juveniles	Pelagic habitats during settlement Benthic habitats with mud and sand substrates YOY in depressions on open seabed and associated with eel grass and macroalgae Shelter is critical for older juveniles (e.g., shells, biogenic structure, bottom depressions, inside live scallops)	Present 4-99 inshore, common 26-65 (MA), 30-140 (ME), 10-24 (RB), min 7 (DB), min 13 (CB) Present to 500 on shelf, common 0-**80** YOY <10 (ME)	Present 0.4-25 inshore, common 2.5-11.5 (MA), 4.1-10 (ME), min 4.5, max 21.5 (RB), 4.5-12.5 (DB), 4-14 (CB) Present 1.5-22.5 on shelf, common 4.5-17.5	Present 1-36 inshore, common 26.5-33.5 (RB), 6.5-30.5 (DB), 22-32 (CB) Present 28.5-36.5 on shelf, common 31.5-33.5
Adults	Most common on soft sediments (mud and sand) or shell beds, much less common on gravel or hard bottoms	Present 6-99 inshore, common **20**-75 (MA) and 80-190 (ME) Present to 500 on shelf, common 50-300 Present 400-**750** off-shelf	Present 1.3-19.7 inshore, common 4.5-10.5 (MA) and 2.1-9 (ME) Present 1.5-21.5 on shelf, common 3.5-13.5 Spawn 5-10	Present 23-34.5 inshore Present 30.5-36.5 on shelf, common 32.5-34.5

* *Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: Red hake eggs were not differentiated from eggs of spotted and white hake in MARMAP survey.

Sources of information:

- **Larvae**: Depth and temperature ranges for shelf derived from MARMAP survey data and other information in NEFSC (2004g).
- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on MA and Raritan Bay trawl survey data in NEFSC (2004g), ME/NH trawl survey data provided by Maine Dept. Marine Resources, Delaware Bay trawl survey data in Morse (2000), and Chesapeake Bay trawl survey data in Geer (2002). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004g); sediment types derived from information in NEFSC (2004g). Other information on depth (for YOY juveniles) provided by M. Lazzari (Maine DMR, pers. comm.).
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth and temperature ranges ("common") based on MA trawl survey data in NEFSC (2004g) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004g); sediment types derived from information in NEFSC (2004g). Other information taken from NEFSC (2004g) and Haedrich and Merrett (1988).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of red hake (*Urophycis chuss*) comes from the EFH Update Memo (NEFSC 2004g, and references therein). Larvae prey mainly on copepods and other micro-crustaceans. Juvenile red hake commonly prey on small benthic and pelagic crustaceans, including larval and small decapod shrimp and crabs, mysids, euphausiids, and amphipods. Based on the NEFSC food habits database (1973-2001), the primary prey items of juvenile hake ($\leq$ 20 cm) were amphipods, decapods, euphausiids, and polychaetes. Larger juveniles/small adult hake (21-40 cm) consumed mostly decapods and gadids, with each making up approximately 23% of the diet. Other major prey included amphipods, euphausiids, squids, and other fish. Bowman et al. (2000), using the NEFSC food habits database from 1977-1980, showed that the principal prey items of juveniles (< 26 cm) were polychaetes, amphipods (*Pontogeneia inermis*, *Leptocheirus pinguis*), decapods (*Crangon septemspinosa*, pagurid crabs, *Dichelopandalus leptocerus*), euphausiids (*Meganyctiphanes norvegica*), and fish (silver hake, searobins). Garrison and Link (2000) conducted a multivariate analysis on NEFSC diet data from over 12,000 red hake. The amount of fish consumed increased as the fish size increased. The diet of juvenile red hake < 20 cm consisted mainly of decapod shrimp (Crangonidae, Pandalidae), euphausiids, gammarid and other amphipods, and polychaetes. Larger juvenile/adult hake 20-50 cm consumed fish, decapod shrimp (Pandalidae), and euphausiids. In the Middle Atlantic Bight, amphipods, small decapods (e.g., the shrimp *Crangon septemspinosa*), and polychaetes are important prey of juveniles, but dominant prey can change seasonally and include copepods and chaetognaths.

The NEFSC food habits database from 1973-2001 shows that adult red hake > 40 cm fed primarily on fish (gadids, clupeids, and unidentified), followed by decapods and euphausiids. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult red hake include: other fish (15%), pandalid shrimp (11%), euphausiids (11%), crustacean shrimp (9%), and silver hake (7%). Bowman et al. (2000), using the NEFSC food habits database from 1977-1980, showed that the principal prey items of adults were amphipods (*Leptocheirus pinguis*), euphausiids (*Meganyctiphanes norvegica*), decapods (*Dichelopandalus leptocerus*; the crab *Cancer irroratus* for hake > 35 cm, the shrimp *Pandalus borealis* for hake > 45 cm), mollusks (bivalves, squids), and fish (sand lance, silver hake). In the Garrison and Link (2000) study mentioned previously, fish such as clupeids and silver hake, decapod shrimp (Pandalidae), and euphausiids were important prey for large hake > 50 cm.

Bowman et al. (2000), using the NEFSC food habits database from 1977-1980, also enumerated diets from six principal offshore areas (offshore of Cape Hatteras, Middle Atlantic, Southern New England, Georges Bank, Gulf of Maine, and Scotian Shelf) and two inshore areas (inshore north of Cape Hatteras and inshore south of Cape Hatteras). Combined percentages of crustaceans, fish, and mollusks made up 70-80% of the total food composition for the Gulf of Maine, Scotian Shelf, and Georges Bank regions. In the Southern New England, Middle Atlantic, and inshore north of Cape Hatteras regions, diet composition was evenly divided among the three categories of mollusks, crustacean, and fish. Crustaceans and fish were also heavily consumed in Middle Atlantic and inshore areas. Garrison and Link (2000) showed that fish prey were generally more important in northern habitats. Euphausiids and pandalid shrimps typically accounted for > 10% of the diets on Georges Bank, the Gulf of Maine, and the southwest Scotian Shelf., and generally were < 5% of the diets in the Mid-Atlantic Bight and southern New England. Decapod larvae (8.5%), crangonid shrimp (9.1%), and C*ancer* crabs (8.7%) were important prey in the Mid-Atlantic Bight, while they accounted for < 1% of diets in the Gulf of Maine and southwest Scotian Shelf.

Garrison and Link (2000) also observed annual and seasonal trends in the diet of red hake. Euphausiid shrimp made up 30% from 1976-1980, but declined to 2% in 1996-1997, while the occurrence of pandalid shrimp increased from 4-8% in the 1970s to 12-15% in the 1990s. During the spring, euphausiids were the dominant prey, while pandalids were consumed primarily during summer (33%). In winter months, cephalopods (28%) and *Cancer* crabs (11%) were the dominant prey. Red hake preyed upon silver hake particularly during the winter months (13.5%); predation on silver hake decreased by spring and summer and they contributed to only a small part of the diet by autumn (3%).

For the inshore areas north of Cape Hatteras, Bowman et al. (2000) noted that crustaceans (decapods such as *Dichelopandalus leptocerus*, *Crangon septemspinosa*) and fish (silver hake, Atlantic mackerel) were heavily preyed upon. Other major prey included polychaetes. For a list of other inshore diet studies of red hake, see the table, below.

Table 29 – Major prey items of red hake

Life Stage	*Major prey*	*Location*
Larvae	**Copepods and other micro-crustaceans**	U.S. northeast continental shelf
Juveniles, < 26 cm	**Polychaetes; Crustaceans**: amphipods (*Pontogeneia inermis*, *Leptocheirus pinguis*), decapods (*Crangon septemspinosa*, pagurid crabs, *Dichelopandalus leptocerus*, other pandalid shrimp), euphausiids (*Meganyctiphanes norvegica*); **Fish**: silver hake, searobins	U.S. northeast continental shelf
Larger juveniles/smaller adults, 20-50 cm	**Crustaceans**: amphipods, decapods (Pandalid shrimp), euphausiids; **Mollusks**: squids; **Fish**: gadids	U.S. northeast continental shelf
Adults, ≥ 26 cm	**Polychaetes; Crustaceans**: amphipods (*Leptocheirus pinguis*), decapods (*Dichelopandalus leptocerus*, *Pandalus borealis*, *Cancer irroratus*), euphausiids (*Meganyctiphanes norvegica*); **Mollusks**: bivalves, squids; **Fish**: gadids, clupeids, silver hake, sand lance	U.S. northeast continental shelf
	Polychaetes: (*Glycera* sp.)' **Crustaceans**: amphipods (*Ampelisca* sp.**,** *Leptocheirus pinguis*), decapods (*Crangon septemspinosa*), mysids (*Neomysis americana*, *Heteromysis Formosa*)	Long Island Sound (Richards 1963)
Mostly juveniles	Crustaceans**: amphipods (*Gammarus lawrencianus*), decapods (*Crangon septemspinosa*), mysid shrimp (*Neomysis americana*)**	Hudson-Raritan estuary (Steimle et al. 2000)
Juveniles	**Crustaceans**: calanoid copepods, amphipods (*Unciola* sp., *L. pinguis*, *Monoculodes* sp., and *Ericthonius* sp.), decapods (*Crangon septemspinosa*), mysids	Coastal New Jersey (Luczkovich and Olla 1983)
Mostly juveniles	**Nematodes; Crustaceans**: copepods, amphipods, isopods, decapods (*Crangon septemspinosa*), mysids (*Neomysis americana*); **Fish**	Central New Jersey (Rachlin and Warkentine 1988)

Peak spawning

Information on the spawning periods of red hake (*Urophycis chuss*) comes from the EFH Update Memo (NEFSC 2004g, and references therein).

Major spawning areas occur on the **southwestern part of Georges Bank** and on the **continental shelf off southern New England and eastern Long Island**; however, a nearly ripe female was collected during April in **Chesapeake Bay** (Hildebrand and Schroeder 1928). Spawning adults and eggs are also common in the **marine parts of most coastal bays between Narragansett Bay, Rhode Island, and Massachusetts Bay**, but rarely in coastal areas to the south or north (Jury et al. 1994; Stone et al. 1994). Based on condition of the gonads from red hake collected in the **New York Bight**, spawning occurs at temperatures between 5-10°C from April through November (Wilk et al. 1990). Approximate spawning seasons for red hake are March through October for **Middle Atlantic Bight and Southern New England** and May through September for **Georges Bank and Gulf of Maine** (Link and Burnett 2001). In the **Gulf of Maine**, spawning may not begin until June with a peak during July to August (Dery 1988; Scott and Scott 1988). In the **New York Bight and on Georges Bank**, spawning red hake are most abundant in May to June (Collette and Klein-MacPhee 2002). Eklund (1988) reported a peak in their gonadosomatic index (GSI) during May to July and the presence of ripe eggs in June to July off **Delaware**. Hatching occurs in 3-7 days during May and September (Able and Fahay 1998).

Offshore hake

Supplementary table

Table 30 – Summary of habitat information for offshore hake

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Pelagic, in water column	Rare <70, common 100-1500, on continental shelf and slope	Present 4.5-20.5, common 7.5-19.5, on continental shelf and slope	No information
Larvae	Pelagic, in water column	Present 20-1500, common 60-1500, on continental shelf and slope	Present 4.5-19.5, common 4.5-18.5, on continental shelf and slope	No information
Juveniles	Pelagic habitats at night, benthic habitats during the day	Rare <100, common **<u>160</u>**-500, on continental shelf Found as deep as **<u>750</u>** on slope	Present 2.5-16.5, common 7.5-12.5, on continental shelf and slope	Present 31.5-36.5, common 34.5-36.5, on continental shelf and slope
Adults	Pelagic habitats at night, benthic habitats during the day	Rare <70, common **<u>200</u>**-500, on continental shelf Found as deep as **<u>750</u>** on slope Spawn 330-550 on edge of shelf	Present 3.5-16.5, common 6.5-12.5, on continental shelf and slope	Present 31.5-36.5, common 34.5-36.5, on continental shelf and slope

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs**: Shelf and off-shelf depth and temperature ranges derived from MARMAP data in NEFSC (2004h).
- **Larvae**: Shelf and off-shelf depth and temperature ranges derived from MARMAP data in NEFSC (2004h).
- **Juveniles**: Depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004h); other information from Haedrich and Merrett (1988).
- **Adults**: Depth, temperature, and salinity ranges derived from NEFSC trawl survey data in NEFSC (2004h); other information from Haedrich and Merrett (1988).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of offshore hake (*Merluccius albidus*) comes from the EFH Source Document and update memo (Chang et al. 1999, NEFSC 2004h, and references therein). Offshore hake feed on pelagic invertebrates, e.g. euphausiids and other shrimps, and pelagic fish, including conspecifics.

Data from the NEFSC food habits database (1973-2001) show that offshore hake fed mostly on fish (gadids, hakes, and other fish), squids, and euphausiids. Analysis of samples from the same dataset from 1973-1997 by Garrison and Link (2000) showed decapod shrimp to be the primary prey of small (< 20 cm) juvenile *M. albidus*. Larger juveniles/small adults (20-50 cm) fed primarily on euphausiids and unclassified fish. Large-sized offshore hake (> 50 cm) were primarily piscivorous, feeding heavily on silver hake, its congener. Euphausiid prey have been identified as *Meganyctiphanes* sp. and *Thysanoessa raschi*; decapod prey includes pandalid shrimp, *Pandalus* sp. and *Dichelopandalus* sp., and pelagic shrimp, *Pasiphaea* sp. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult offshore hake include: silver hake (26%), other fish (20%), *Illex* squid (14%), and cephalopods (9%).

Table 31 – Major prey items of offshore hake

Life Stage	***Major prey***	***Location***
Small juveniles, < 20 cm	**Crustaceans**: decapod shrimp (pandalid shrimp, *Pandalus* sp. and *Dichelopandalus* sp.; pelagic shrimp, *Pasiphaea* sp.)	U.S. northeast continental shelf, slope
Larger juveniles/small adults, 20-50 cm	**Crustaceans**: euphausiids (*Meganyctiphanes* sp., *Thysanoessa raschi*); **Mollusks**: squid (*Illex* sp.); **Fish**: gadids, hakes (especially silver hake)	U.S. northeast continental shelf, slope
Large adults, > 50 cm	**Crustaceans**: euphausiids (*Meganyctiphanes* sp., *Thysanoessa raschi*); **Mollusks**: squid (*Illex* sp.); **Fish**: gadids, hakes (especially silver hake)	U.S. northeast continental shelf, slope

<u>Peak spawning</u>

Information on the spawning periods of offshore hake (*Merluccius albidus*) comes from the EFH Source Document and update memo (Chang et al. 1999, NEFSC 2004h, and references therein).

There is little information available on the reproductive biology of offshore hake. Spawning appears to occur over a protracted period or even continually throughout the year from the **Scotian Shelf through the Middle Atlantic Bight**. For example, in New England, Cohen et al. (1990) indicates that spawning occurs from April to July at depths ranging from 330-550 m. Eggs and larvae have also been collected off of **Massachusetts** from April through July (Marak 1967). Smith et al. (1980) reported that eggs and larvae were also present from April through June **south of New England** and in February and March **south of Long Island, NY**. Colton et al. (1979) indicated that while there was some uncertainty in the timing of offshore hake spawning in the **Mid-Atlantic Bight**, it appears to extend from June through September. This is supported by results from the **New York Bight** where Wilk et al. (1990) showed that while mean gonadosomatic indices (GSI) were highest in June and July, females in various stages of gonadal development were collected from spring through late fall.

Offshore hake eggs were collected as part of the NEFSC MARMAP ichthyoplankton surveys from 1978-1987. They were most abundant along the continental shelf from **eastern Georges Bank to the Middle Atlantic Bight just south of Delaware Bay and infrequently off Cape**

Hatteras. Egg densities exceeded 10 per 10 m^2 during the first four years of the survey, but declined to less than 5 per 10 m^2 during the final five years, with the exception of 1984 (Berrien and Sibunka 1999). Eggs were collected in every month of the year, although the catch varied seasonally.

In January and February, eggs were sparsely distributed with small numbers collected from off **Georges Bank to Delaware Bay and Cape Hatteras**. From March through June, eggs were collected in larger numbers as density increased along the outer margin of the continental shelf with abundance highest from **east of Georges Bank to off the Hudson Canyon**, although small numbers were collected from **south of Delaware Bay to as far north as the Northeast Channel**. From July through September, the numbers of eggs dropped sharply and were irregularly distributed from southeast of **Georges Bank to Delaware Bay**. Abundance rose again in October with a distribution similar to that in April, ranging from the **Northeast Channel to the Mid-Atlantic Bight off the Hudson Canyon**. Abundance decreased again during November and December with a distribution generally similar to that in January and February.

Monkfish

Supplementary table

Table 32 – Summary of habitat information for monkfish

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Pelagic, in upper water column, in large mucoidal egg “veils”	18-40 (NJ) Collected within 1 meter of shore See larvae	Most at 10-20 Upper limit for normal development 17-18	No information
Larvae	Pelagic, in water column	Found in surf zone and near-shore habitats (NJ) Present to 1500 on and off shelf, common to 160 on shelf	Present 6.5-20.5 on shelf, common 8.5-17.5 on shelf	No information
Juveniles	Pelagic habitats during settlement Also see adults	Present 8-100 inshore, common 30-85 (MA) and **20**-150 (ME) Present to **1000** on and off shelf (YOY at 900), common **50-400** on shelf Common 91-182 (GOM)	Present 1.5-13 inshore, common 3.5-10.5 (MA) and 2.1-10 (ME) Present 1.5-24.5 on shelf, common 4.5-13.5	Present 31-33.6 inshore Present 29.5-36.5 on shelf, common 30.5-36.5
Adults	Found on hard sand, pebbly bottoms, gravel and broken shells, and soft mud	Present 8-84 inshore, common **20**-65 (MA)	Present 1.9-16.5 inshore, common 5.5-11.5 (MA) Present 0.5-21.5 on shelf, common 4.5-14.5	Present 30-34 inshore

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
	Prefer clay and mud over sand and gravel (SS)	Present to **1000** on and off shelf, common **50-400** on shelf		Present 29.5-36.5, common 33.5-35.5 on shelf

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs**: Depth information from NEFSC (2006d) and Caruso (2002); temperature data from NEFSC (2006d).
- **Larvae**: Shelf depth and temperature ranges derived from MARMAP survey data in NEFSC (2006d); other information from NEFSC (2006d).
- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from MA trawl survey data in NEFSC (2006d) and ME/NH trawl survey data provided by Maine Dept. Marine Resources. Continental shelf and slope: depth, temperature, and shelf salinity ranges derived from NEFSC trawl survey data in NEFSC (2006d); substrate types and other depth information from NEFSC (2006d) and Moore et al. (2003).
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; inshore depth and temperature ranges ("common") from MA trawl survey data in NEFSC (2006d). Continental shelf and slope: depth, temperature, and shelf salinity ranges from NEFSC trawl survey data in NEFSC (2006d); substrate types and other depth information derived from NEFSC (2006d) and Moore et al. (2003).

Prey species

The main source of information on the prey consumed by the juvenile and adult stages of monkfish (goosefish) (*Lophius americanus*) comes from the EFH Update Memo (NEFSC 2006d, and references therein). Monkfish are opportunistic feeders; prey found in their stomachs include a variety of benthic and pelagic species. Diets can vary regionally and seasonally, depending on what is available as prey. Larger monkfish eat larger prey and often have empty stomachs. Monkfish eat spiny dogfish, *Squalus acanthias*, skates, *Raja* spp., eels, sand lance, Atlantic herring, Atlantic menhaden, *Brevoortia tyrannus*, smelt, *Osmerus mordax*, mackerel, *Scomber* spp., weakfish, *Cynoscion regalis*, cunner, tautog, *Tautoga onitis*, black sea bass, *Centropristis striata*, butterfish, pufferfish, sculpins, sea raven, *Hemitripterus americanus*, searobins, *Prionotus* spp., silver hake, *Merluccius bilinearis*, Atlantic tomcod, *Microgadus tomcod*, cod, *Gadus morhua*, haddock, *Melanogrammus aeglefinus*, hake, *Urophycis* spp., witch and other flounders, squid, large crustaceans, and other benthic invertebrates. They even have been known to prey on sea birds and diving ducks.

Larvae feed on zooplankton, including copepods, crustacean larvae, and chaetognaths. Pelagic YOY juveniles consume chaetognaths, hyyperiid amphipods, calanoid copepods, and ostracods. Small benthic juveniles (5-20 cm TL) start eating fish, such as sand lance (*Ammodytes* spp.), soon after they settle to the bottom, but invertebrates, especially crustaceans such as red (bristle-beaked) shrimp (*Dichelopandalus leptocerus*) and squid, can make up a large part of their diet. The consumption of invertebrates decreases among larger juveniles (20-40 cm TL) and monkfish > 40 cm TL (larger juveniles and adults) eat comparatively few invertebrates.

The 1973-2001 NEFSC food habits database showed that monkfish consumed primarily fish, as well as squids, and the type of prey consumed varied with the size of the monkfish. Gadids are always a dominant component, but small to medium size monkfish also consume relatively large amounts of clupeids and squid. Flatfish and scombrids also contribute significantly to the diets of larger monkfish. Bowman et al. (2000), using the same NEFSC food habits database, but only for the years 1977-1980, also found the same general trends in changing prey consumption with size, with the addition of skates being important in the diet of larger monkfish. Regionally, Bowman et al. (2000) showed that fish dominated the diet in the Mid-Atlantic, southern New England, Gulf of Maine, and on the Scotian Shelf, while squids, particularly *Illex*, dominated at inshore North of Cape Hatteras. Fish (including, and especially, skates) and squids co-dominated on Georges Bank. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult monkfish include: other fish (32%); silver hake (6%) and Atlantic herring (5%).

Cannibalism (non-kin, inter-cohort) may be important and perhaps explains the apparent high mortality of smaller males although the reported occurrence of cannibalism is low. In 2001, only nine incidences of cannibalism were detected among 2,160 stomachs examined (0.42%) by the NEFSC. All of the cannibals were females 63-105 cm TL, and the size of the prey was 45-49 cm.

Table 33 – Major prey items of monkfish

Life Stage	***Major prey***	***Location***
Larvae	**Zooplankton**: copepods, crustacean larvae, chaetognaths.	U.S. northeast continental shelf
YOY juveniles	**Zooplankton**: chaetognaths, hyperiid amphipods, calanoid copepods, ostracods.	U.S. northeast continental shelf
Juveniles 1-40 cm	**Mollusks**: squids; **Fish**: sand lance, silver hake, fourbeard rockling, witch flounder	U.S. northeast continental shelf
Large juveniles, small adults 41-50 cm	**Mollusks**: squids (*Illex* sp.); **Fish**: silver hake, flounders	U.S. northeast continental shelf
Adults > 50 cm	**Mollusks**: squids (*Illex* and *Loligo* sp.); **Fish**: e.g., spiny dogfish, skates, eels, sand lance, Atlantic herring, Atlantic menhaden, smelt, mackerel, weakfish, cunner, tautog, black sea bass, butterfish, pufferfish, sculpins, sea raven, searobins, silver hake, other hakes, Atlantic tomcod, cod, haddock, witch flounder, other flounders.	U.S. northeast continental shelf

Peak spawning

Information on the spawning periods of monkfish (goosefish) (*Lophius americanus*) comes from the EFH Update Memo (NEFSC 2006d, and references therein).

Spawning occurs from spring through early fall with a peak in May-June (Wood 1982; Armstrong et al. 1992) although pelagic individuals (larvae and juveniles) have been reported for all months of the year except December, suggesting that spawning occurs at some level for most months of the year **within the species' geographic range**. Regionally, goosefish has been reported to spawn in the early spring off the **Carolinas**, in May-July off **New Jersey**, in May-June in the **Gulf of Maine**, and into September in Canadian waters (Scott and Scott 1988; Hartley 1995). Peak gonadosomatic indices (GSI) occurred in March-June for males and in May-June for females (Armstrong et al. 1992). Spawning locations are not well known but are thought to be on inshore shoals to offshore (Connolly 1920; Wood 1982; Scott and Scott 1988).

Eggs were only occasionally caught (N = 28) in the NEFSC MARMAP ichthyoplankton surveys from the Gulf of Maine to North Carolina. Eggs were not collected in **Sandy Hook Bay** by Croker (1965) and were only rarely found in **Long Island Sound** by Merriman and Sclar (1952) and Wheatland (1956). Egg veils were reported from late May through late July in waters (18-40 m depth) off **Barnegat Light, New Jersey** (R.C. Chambers, NMFS/NEFSC/James J. Howard Marine Sciences Laboratory, unpublished data). Eggs have been reported in open coastal bays and sounds in low numbers (Smith 1898; Herman 1963; Caruso 2002).

Smooth skate

Supplementary table

Table 34 – Summary of habitat information for smooth skate

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Found mostly on soft mud in deeper areas, but also on sand, broken shells, gravel, and pebbles on offshore banks in GOM	Present 12-99 inshore Present 30-500 on shelf, common **<u>100-400</u>** Found 31-874, most abundant 110-457, min 46 on offshore banks (GOM) Occurs 46-956 NC to Grand Banks	Present 3.2-10 inshore Present 1.5-16.5 on shelf, common 4.5-9.5 Found 2-10 southern Nova Scotia to GB	Present 32.1-33.3 inshore Present 31.5-35.5, common 32.5-35.5
Adults	See juveniles	Present 30-400 on shelf, common **<u>100-400</u>**	Present 2.5-21.5 on shelf, common 3.5-9.5	Present 31.5-35.5 on shelf, common 32.5-35.5

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
		Also, see juveniles		

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) derived from ME trawl survey data in areas mapped as EFH. Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types and other information obtained from Packer et al. (2003a). Presence on continental slope based on NEFSC deep-water trawl survey data and information in Moore et al. (2003).
- **Adults**: Depth, temperature, and salinity ranges for continental shelf derived from NEFSC trawl survey data in Packer et al. (2003a). Presence on continental slope based on NEFSC deep-water trawl survey data and information in Moore et al. (2003).

Note: Information on off-shelf depth distribution in Moore et al. (2003) is not specific to juveniles or adults, nor is substrate information in the EFH Source Document.

Prey species

The main source of information on the prey consumed by smooth skate (*Malacoraja senta*) comes from the EFH Source Document (Packer et al. 2003a and references therein). Generally, the diet of smooth skate is limited to epifaunal crustaceans. Decapod shrimps and euphausiids are the primary food items although amphipods and mysids are also important. Larger smooth skate also feed on small fish.

McEachran (1973) studied skates collected from Nova Scotia to Cape Hatteras during 1967-1970; the following diet description is from him and McEachran et al. (1976).

On Georges Bank, *Pagurus pubescens*, *Dichelopandalus leptocerus*, *Crangon septemspinosa*, and *Eualus pusiolus* were the major decapods eaten, while on the Nova Scotian shelf, *P. pubescens*, *Pandulus* spp., and *C. septemspinosa* were the most numerious decapod prey consumed. *Meganyctiphanes norvegica* was the only euphausiid eaten, and was eaten more frequently during the winter than during the autumn. *Monoculodes* sp. was the major amphipod eaten on Georges Bank and *Dulichia* (= *Dyopedos*) *monacantha* and *Pontogeneia inermis* were the most frequently eaten amphipods eaten in the Gulf of Maine and on the Nova Scotian shelf. The mysids *Erythrops erythrophthalma* and *Neomysis americana* were also consumed in large numbers.

As smooth skate grow, the diet shifts from amphipods and mysids to decapods, and euphausiids appear to be directly correlated to the size of the skate (McEachran et al. 1976). Using NEFSC data from Georges Bank and the Gulf of Maine from 1977-1980, Bowman et al. (2000) reported that that in terms of percent weight, the major decapods consumed by skate 36-51 cm TL included *Pandalus borealis* and *D. leptocerus*. Skate 51-55 cm TL consumed pagurid crabs. *M. norvegica* was eaten by skate 56-60 cm TL, but also by skate < 31 cm TL.

The 1981-1990 NEFSC food habits database for smooth skate generally confirms the McEachran (1973) and McEachran et al. (1976) studies, even though the sample sizes are often quite small. Decapods and crustaceans are the major components of the skates' diet, particularly for skates > 21 or 31 cm TL. Several fish species are minor, but important components of the diet of skates > 31 cm TL. Amphipods, which are a major part of the diet of skates 11-20 cm TL, rapidly decrease in occurrence for larger skates. However, there doesn't seem to be a remarkable increase in the occurrence of decapods or euphausiids with increasing skate size. It is interesting to note though the rather high (54%) occurrence of euphausiids in the stomachs of skates 21-30 cm TL, this may mirror the previously mentioned presence of *M. norvegica* in skate < 31 cm TL as reported by Bowman et al. (2000).

The following is a description of the diet from the NEFSC food habits database broken down by smooth skate size class.

For smooth skate 11-20 cm TL, 39% of the diet consisted of identifiable amphipods. Identifiable euphausiids made up 23% of the diet, while pagurid crabs and pandalid shrimp, both decapods, together made up 15% of diet. Identifiable mysids and isopods each made up only 8% of the diet. For skate 21-30 cm TL, 54% of the diet consisted of identifiable euphausiids, and 23% of the diet identifiable amphipods.

The percent occurrence of identifiable amphipods in the diet of smooth skate 31-40 cm TL dropped to 17% and identifiable euphausiids dropped to 29% of the diet. Identifiable decapods made up 21% of the diet; they included pagurid crabs, pandalid shrimp, and *C. septemspinosa*. Identifiable fish made up 13% of the diet, among which were a yellowtail flounder and a hake. Minor prey items included polychaetes (4%) and stomatopods (4%).

The percent occurrence of identifiable euphausiids in the diet of skate 41-50 cm TL increased to 38%, while identifiable amphipods continued to decrease, down to 7%. Identifiable decapods, including pandalid shrimp and *C. septemspinosa*, made up 21% of the diet. Identifiable fish increased to 17% of the diet, species included silver hake and witch flounder.

The percent occurrence of identifiable euphausiids in the diet of 51-60 cm TL skate decreased to 32%, while identifiable amphipods dropped down to 2%. Identifiable decapods, including pagurid crabs, pandalid shrimp, and *C. septemspinosa*, increased to 29%. Identifiable fish, including silver hake and sand lance, made up 13% of the diet.

Finally, for smooth skate 61-70 cm TL, identifiable euphausiids made up 38% of the diet, identifiable pandalid shrimp 25% of the diet, identifiable fish 13%, and identifiable polychaetes 13%. However, only 7 skate stomachs were examined, making any conclusions about diet preference for this size class suspect.

Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult smooth skate include: pandalid shrimp

(27%), euphausiids (14%), crustacean shrimp (13%), silver hake (5%), other fish (5%), and decapod crabs (5%).

Table 35 – Major prey items of smooth skate

Life Stage	*Major prey*	*Location*
Juveniles, ≤ 50 cm[1]	**Crustaceans**: amphipods (gammarid), isopods, mysids, euphausiids, decapods (*C. septemspinosa*, pagurid crabs, pandalid shrimp); **Fish**: yellowtail flounder, silver hake, witch flounder	U.S. northeast continental shelf
Large juveniles, adults > 50 cm[1]	**Polychaetes**: [for skate 61-70 cm, but small sample size makes this suspect] ;**Crustaceans**: euphausiids, decapods (*C. septemspinosa*, pagurid crabs, pandalid shrimp) ; **Fish**: silver hake, sand lance	U.S. northeast continental shelf

[1]From NEFSC food habits database in Packer et al. *(2003) and Figure 2 therein, and J. Link (pers. comm.). For a list of other major prey species from other studies, see text.*

Peak spawning

Smooth skate (*Malacoraja senta*) appears to spawn year round. Females with fully formed egg capsules are found both in summer and winter (McEachran 2002). Sulikowski et al. (2007) examined the reproductive condition of male and female skates in the **Gulf of Maine.** Their data indicate that at least in the Gulf of Maine, the species is reproductively active year round. See Packer et al. 2003 and references therein for additional information.

Thorny skate

Supplementary table

Table 36 – Summary of EFH information for thorny skate

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Benthic habitats associated primarily with mud, also mud and sand, sand, and mud and sand mixed with *gravel* Found on wide variety of bottom types from sand, gravel, broken shell, pebbles, to soft mud	Present 11.5-84 inshore, common **35**-75 (MA) and at min 71 (ME) Present 10-500 and >500 on and off shelf, common 70-**400** Also see adults	Present 2.5-13.4 inshore, common 2.5-10.5 (MA) and 2.1-10 (ME) Present 0.5-25.5 on shelf, common 0.5-10.5	Present 31.7-34 inshore (ME) Present 30.5-36.5, common 32.5-34.5
Adults	Benthic habitats associated primarily with mud, also mud and sand Also see juveniles	Present 30-500 on shelf, common **80-300** Found 18-183 on shelf, as deep as 786-**896** off NY, to 699 off SNE, 300-1200 off VA	Present 1.5-14.5 on shelf, common 3.5-8.5	Present 31.5-35.5 on shelf, common 32.5-34.5

* *Depth to bottom*

*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Note: As used in the analysis of sediment associations, the term "gravel" refers to all grain sizes above a diameter of 2 mm, i.e., any sediment coarser than sand, and therefore includes pebbles, cobbles, and even boulders

Sources of information:

- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on ME and MA trawl survey data from areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on MA trawl survey data in EFH Source Document. Continental shelf and slope: depth, temperature, and salinity ranges derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data plus information in EFH Source Document (Packer et al 2003b).
- **Adults**: Depth, temperature, and salinity ranges for continental shelf and slope derived from NEFSC trawl survey data; sediment types derived from GIS overlap analysis of NEFSC trawl survey and USGS USSeabed sediment data plus information in EFH Source Document; other information also from EFH Source Doc (Packer et al 2003b).

Note: Information on maximum depths and substrates in EFH Source Document is not specific to life stage. Adults of this species are not caught in inshore trawl surveys.

Prey species

The main source of information on the prey consumed by thorny skate (*Amblyraja radiata*) comes from the EFH Source Document (Packer et al. 2003b and references therein). Prey of thorny skate in the western North Atlantic includes hydrozoans, aschelminths, gastropods, bivalves, squids, octopus, polychaetes, pycnogonids, copepods, stomatopods (larvae), cumaceans, isopods, amphipods, mysids, euphausids, shrimps, hermit crabs, crabs, holothuroideans, and fishes. The feeding habits of thorny skate are size-dependent, but it is also an opportunistic feeder on the most abundant and available prey species in an area.

McEachran (1973) studied skates collected from Nova Scotia to Cape Hatteras during 1967-1970; the following diet descriptions are from him and McEachran et al. (1976). Polychaetes and decapods were the major prey items eaten, followed by amphipods and euphausids. Fishes and mysids contributed little to the diet. *Nephtys* spp. and *Glycera* spp. were the most frequently eaten polychaetes on Georges Bank while *Nephtys* spp., *Eunice pennata*, and *Aphrodite hastata* were the most abundant polychaetes eaten in the Gulf of Maine and on the Nova Scotian shelf. *Orchomonella minuta* and *Leptocheirus pinguis* were the most numerous amphipod prey in the Mid-Atlantic Bight, while *L. pinguis*, ampeliscids, and *Orchomonella* sp. were the most frequently eaten amphipods on Georges Bank. *Pontogeneia inermis* and *Tmetonyx* sp. were the most abundant amphipods eaten in the Gulf of Maine, while on the Nova Scotian shelf ampeliscids and *L. pinguis* were the most frequently eaten amphipods. On Georges Bank, *Hyas* sp., *Eualus pusiolus*, *Dichelopandalus leptocerus*, and *Crangon septemspinosa* were the most frequently eaten decapods. *Pandalus* spp., *Pagurus pubescens*, *Axius serratus*, and *Pasiphaea* sp. were the dominant species eaten in the Gulf of Maine. *Hyas* sp., *P. pubescens*, *E. pusiolus*, *A.*

serratus were the major decapod prey eaten on the Nova Scotian shelf. *Meganctiphanes norvegica* was the only euphausid in the diet. The mysids eaten were *Neomysis americana* and *Erythrops erythrophthalma*. The most commonly eaten fishes were sand lance, longhorn sculpin, and Atlantic hagfish.

McEachran (1973) and McEachran et al. (1976) found that the diet of thorny skate was size dependent. Fish $\leq$ 40 cm TL fed mostly on amphipods while fish > 40 cm TL fed mostly on polychaetes and decapods. Mysids decreased in the diet while fishes increased with increase in size of the skate. Fishes were a major component of the diet of skates > 70 cm TL. Consumption of euphausids was independent of skate size (McEachran 1973; McEachran et al. 1976).

The 1973-1990 NEFSC food habits database for thorny skate generally confirms the previous studies. Overall, crustaceans declined in importance with increasing skate size. Amphipods, which included species such as *Psammonyx nobilis* and *L. pinguis,* decreased with increasing skate size, while the percent occurrence of decapods, which included *C. septemspinosa*, *Cancer* and pagurid crabs, and pandalid shrimp, generally did not change with skate size. The percent occurrence of polychaetes, which included those from the Nephtyidae and Aphroditidae families, increased with increasing skate size until the skate were about 60 cm TL. Fish became noticeable in the diet of the larger skates, around > 50-60 cm TL, but were never a major component of the diet (at least as measured here in terms of percent occurrence).

The following is a detailed description of the diet from the NEFSC food habits database broken down by thorny skate size class.

For thorny skate 11-20 cm TL, 61-78% of the diet consisted of crustaceans, with 24-48% of the diet consisting of identifiable amphipods. The most abundant amphipod species included *Ericthonius rubricornis*, *Psammonyx nobilis*, *Monoculodes edwardsi*, and several unidentifiable gammarid amphipods. Identifiable decapods (11% of the diet during the 1973-1980 study period) included *C. septemspinosa* and *Cancer* and *Pagurus* crabs. Euphausids (*M. norvegica*), mysids (*E. erythrophthalma*), and cumaceans were also eaten. Identifiable polychaetes (15-34% of the diet) included those from the Nephtyidae and Aphroditidae families.

For skate 21-30 cm TL, 56-66% of the diet consisted of crustaceans, with 23-34% of the diet consisting of identifiable amphipods. Major amphipod species included *L. pinguis*, *Melita dentata*, and *Hippomedon serratus*. Identifiable decapods (5-10% of the diet) again included *C. septemspinosa* and *Cancer* and pagurid crabs. *Cirolana* (= *Politolana*?) *polita* was one of the identifiable isopods. Identifiable polychaetes made up 18-39% of the diet and included those from the Aphroditidae and Terebellidae families.

The percentage of crustaceans in the diet of thorny skate 31-40 cm TL dropped to 44-52%. Some of the more numerous identifiable amphipods (10-26% of the diet) included *P. nobilis*, *L. pinguis*, and *Byblis serrata*. *C. septemspinosa*, pagurid crabs, and *E. pusiolus* were the major identifiable decapod prey (8-15% of the diet). Identifiable polychaete prey (38-48% of the diet) included members of the families Aphroditidae, Nephtyidae, Lumbrineridae, as well as the species *Sternaspis scutata*.

The percent occurrence of crustaceans in the diet of thorny skate 41-50 cm TL was between 42-59%. Identifiable decapods (5-11% of the diet) included *C. septemspinosa*, pandalid shrimp, and *E. pusiolus*. Identifiable amphipods, which decreased to 8-17% of the diet, included *L. pinguis*, while identifiable euphausids (10% of the diet during the 1981-1990 study period) included *M. norvegica*. Identifiable polychaetes made up 35-50% of the diet; major families included the Aphroditidae and Nephtyidae.

The percent occurrence of crustaceans in the diet for skate 51-60 cm TL declined to 37-41%. Identifiable decapods (13-15% of the diet) included *E. pusiolus*, pandalid shrimp, pagurid crabs, and *D. leptocerus*. *M. norvegica* was a dominant euphausid (7% of the diet during the 1981-1990 study period). Among the polychaetes, which were 40-48% of the diet, were found members of the Nephtyidae (e.g., *N. discors*) and Aphroditidae (e.g., *A. hastata*) families, as well as *E. pennata*. The percent occurrence of identifiable fish in the diet increased to 5-11%.

The percent occurrence of crustaceans dropped to 34-40% for skate 61-70 cm TL. Among the identifiable decapods (13-23% of the diet) were pagurid crabs, pandalid shrimp, *Hyas* sp., *D. leptocerus*, and *C. septemspinosa*. Identifiable polychaetes (36-49% of the diet) again included members of the Nephtyidae and Aphroditidae families. The percent occurrence of identifiable fish in the diet increased to 10-14%.

For skate 71-80 cm TL, crustaceans made up 25-42% of the diet. Major identifiable decapods (16-18% of the diet) again included pagurid crabs, pandalid shrimp, *Hyas* sp., and *D. leptocerus*. Identifiable polychaetes made up 38-47% of the diet and included members of the Aphroditidae, Nephtyidae, Nereidae, Sabellidae, and Opheliidae families. The percent occurrence of identifiable fish in the diet increased to 13-17% and included sand lance, wrymouth, and silver hake.

Finally, the percent occurrence of crustaceans in the diet for skate 81-90 cm TL declined to 34-35%. Identifiable decapods (12-16% of the diet) included pandalid shrimp, *Hyas* sp., *Cancer* crabs, and *D. leptocerus*. *M. norvegica* was a dominant euphausid. Identifiable polychaetes comprised 31-35% of the diet, most of which were in the Nephtyidae, Aphroditidae, and Nereidae families. Identifiable fish, which made up 10-22% of the diet, included hagfish, wrymouth, and herring.

Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult thorny skate include: polychaetes (21%), other fish (13%), Atlantic herring (7%), wrymouth (6%), and decapod crabs (5%).

Using NEFSC data from 1977-1980, Bowman et al. (2000) found that in terms of percent weight, crustaceans and polychaetes were dominant in the diet of skate < 31-60 cm TL, while fish, including herring, sand lance, and wrymouth were dominant in the diet of skate 61-90 cm TL. Squid and herring dominated the diet of skate > 90 cm TL.

Table 37 – Major prey items of thorny skate

Life Stage	*Major prey*	*Location*
Juveniles, < 81 cm[1]	**Polychaetes**: Nephtyidae (e.g., *N. discors*), Aphroditidae (e.g., *A. hastata*), Terebellidae, Lumbrineridae, Nereidae, Sabellidae, and Opheliidae, *Sternaspis scutata*, *Eunice pennata;* **Crustaceans**: amphipods (*Ericthonius rubricornis*, *Psammonyx nobilis*, *Monoculodes edwardsi*, *Leptocheirus pinguis*, *Melita dentata*, *Hippomedon serratus*, *Byblis* serrata, unidentifiable gammarids), cumaceans, isopods (*Cirolana* [= *Politolana*?] *polita*), decapods (*Crangon septemspinosa*, pagurid crabs, *Cancer* crabs, spider crabs *Hyas* sp., *Eualus pusiolus*, pandalid shrimp including *Dichelopandalus leptocerus*), euphausiids (*Meganctiphanes norvegica*), mysids (*Erythrops erythrophthalma*); **Mollusks; Fish**: sand lance, wrymouth, silver hake	U.S. northeast continental shelf
Very large juveniles, adults, ≥ 81 cm[1]	**Polychaetes**: Nephtyidae, Aphroditidae, Nereidae; **Crustaceans**: decapods (*Cancer* crabs, spider crabs *Hyas* sp., pandalid shrimp including *Dichelopandalus leptocerus*), euphausiids (*Meganctiphanes norvegica*); **Mollusks; Fish**: hagfish, wrymouth, Atlantic herring.	U.S. northeast continental shelf

[1]*From NEFSC food habits database in Packer* et al. *(2003) and Figure 3 therein, and J. Link (pers. comm.). For a list of other major prey species from other studies, see text.*

Peak spawning

Information on the spawning periods of thorny skate (*Amblyraja radiata*) comes from the EFH Source Document (Packer et al. 2003b and references therein). Females with fully formed egg capsules are captured over the entire year (Templeman 1982a), although the percentage of mature females with capsules is higher during the summer (McEachran 2002). A study by Sulikowski et al. (2005) in the **Gulf of Maine off New Hampshire** indicates that thorny skate have a reproductive cycle that is continuous throughout the year. Bigelow and Schroeder (1953a) reported that females with ripe eggs have been taken in Nova Scotian waters or in the **Gulf of Maine** in April, June, July, and September.

Barndoor skate

Supplementary table

Table 38 – Summary of habitat information for barndoor skate

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	See adults	Present 20-400 on shelf, common **50-160** Assumed present on slope to **750** (see adults)	Present 2.5-18.5 on shelf, common 2.5-11.5	Present 31.5-36.5 on shelf, common 32.5-34.5
Adults	Found on mud as well as sand and gravel	Present 20-400 on shelf, common **40-400**	Present 3.5-16.5 on shelf, common 4.5-16.5	Present 31.5-36.5 on shelf, common 32.5-34.5

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
		Range from shoreline to about **750**, most abundant <150		Observed in mouth of CBay where salinity is 21-24 and in "brackish" water in Delaware R

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- Juveniles and adults: Depth, temperature, and salinity ranges based on NEFSC trawl survey data in Packer et al. (2003c); sediment types from Packer et al. (2003c).

Prey species

The main source of information on the prey consumed by barndoor skate (*Dipturus laevis*) comes from the EFH Source Document (Packer et al. 2003c and references therein). Food of the barndoor skate consists of benthic invertebrates and fishes. Prey includes polychaetes, gastropods, bivalve mollusks, squids, crustaceans, hydroids, and fishes. Smaller individuals apparently subsist mainly on benthic invertebrates, such as polychaetes, copepods, amphipods, isopods, the shrimp *Crangon septemspinosa*, and euphausiids, while larger skate eat larger and more active prey such as razor clams (*Ensis directus*), large gastropods, squids, crabs (*Cancer* spp. and spider crabs), lobsters and fishes. Fish prey includes spiny dogfish, alewife, Atlantic herring, menhaden, hakes, sculpins, cunner, tautog, sand lance, butterfish, and various flounders.

Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult barndoor skate include: *Cancer* crabs (23%); decapod crabs (18%); other fish (10%); Atlantic herring (9%); pandalid shrimp (8%); and silver hake (7%).

Table 39 – Major prey items of barndoor skate

Life Stage	*Major Prey*	*Location*
Juveniles and Adults	Smaller individuals **Polychaetes; Crustaceans**: copepods, amphipods, isopods, the sand shrimp *Crangon septemspinosa*, euphausiids Larger individuals **Crustaceans**: decapods (*Cancer* spp., spider crabs, lobsters); **Mollusks**: razor clams (*Ensis directus*), large gastropods, squids; **Fish**: Atlantic herring, hakes (esp. silver), spiny dogfish, alewife, menhaden, sculpins, cunner, tautog, sand lance, butterfish, various flounders	U.S. northeast continental shelf

Peak spawning

Information on the spawning periods of barndoor skate (*Dipturus laevis*) comes from the EFH Source Document (Packer et al. 2003c and references therein).

Females containing fully formed egg capsules have been taken in December and January (Vladykov 1936; Bigelow and Schroeder 1953), although it is not known if egg capsule production and deposition is restricted to the winter (McEachran 2002).

Little skate

Supplementary table

Table 40 – Summary of habitat information for little skate

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Sandy benthic habitats	<27 (GOM)	Embryos begin growing >7-8	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	See adults	Present 4-80 inshore, common 15-30 (MA), at min 8 (RB)	Present 0-24 inshore, common 7.5-18.5 (MA), 3.5-18.5 (RB)	Present 15-36 inshore, common 22.5-32.5 (RB)
		Present to 400 on shelf, common 10-**80**	Present 0.5-24.5 on shelf, common 2.5-17.5	Present 25.5-36.5 on shelf, common 29.5-33.5
Adults	Generally on sandy or gravelly bottoms, but also on mud (GOM)	Present 4-78 inshore, common 16-30 (MA), 7-19 (j/a DB)	Present 2.2-21.6 inshore, common 6.5-16.5 (MA), 7.5-22.5 (j/a DB)	Present 13.4-35 inshore, common 24.5-34.5 (j/a DB)
	Biogenic depressions and flat sand (SNE)	Present to 400 on shelf, common 20-**100**	Present 1.5-21.5 on shelf, common 2.5-15.5	Present 28.5-36.5 on shelf, common 32.5-33.5
	Sand and sand-mud (LIS)	Generally found <111, occ >183, 15-46 (SNE), as deep as 329 on GB, 384 off NJ	Generally found 1-21, most 2-15	

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Eggs**: Packer et al. (2003d)
- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on Raritan Bay and MA trawl survey data in Packer et al. (2003d). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Packer et al. (2003d).
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on Delaware Bay and MA trawl survey data in Packer et al. (2003c). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Packer et al. (2003d); sediment types from Packer et al. (2003d).

Prey species

The main source of information on the prey consumed by little skate (*Leucoraja erinacea*) comes from the EFH Source Document (Packer et al. 2003d and references therein). Generally, invertebrates such as decapod crustaceans (e.g.; crabs and sand shrimp, *Crangon septemspinosa*) and amphipods are the most important prey items, followed by polychaetes. Isopods, bivalves, and fishes are of minor importance. The fishes that are eaten included sand lance, alewives, herring, cunners, silversides, tomcod, and silver hake. Hydroids, copepods, ascidians and squid are also ingested.

McEachran (1973) studied skates collected from Nova Scotia to Cape Hatteras during 1967-1970; the following diet descriptions are from him and McEachran et al. (1976).

Crangon septemspinosa, *Pagurus acadianus*, *Cancer irroratus*, and *Dichelopandalus leptocerus* were the most frequently eaten decapods in the Mid-Atlantic Bight and on Georges Bank. *C. septemspinosa* was the most numerous decapod in the stomachs while *P. acadianus* and *C. irroratus* accounted for most of the stomach volume. In the Gulf of Maine and on the Nova Scotian shelf *Pagurus pubescens*, *C. septemspinosa*, *Hyas* sp., and *Eualus pusiolus* were the most frequently eaten decapods.

The most frequently consumed amphipods in the Mid-Atlantic Bight and on Georges Bank were *Monoculoides* sp., *Unciola* sp., *Leptocheirus pinguis*, ampeliscids, haustoriids, and *Dulichia* (= *Dyopedos*) *monacantha*. *L. pinguis* predominated in the Mid-Atlantic Bight and *Monoculodes* sp. and *Unciola* predominated in little skate from Georges Bank. Haustoriid amphipods were abundant only in the little skate from Georges Bank and contributed significantly to the stomach contents only during the autumn survey. *Pleustes panoplus*, *L. pinguis*, *Hippomedon serratus*, *Monoculodes* sp., and *Unciola* sp. were the most frequently eaten amphipods in the Gulf of Maine and on the Nova Scotian shelf.

Eunice pennata and *Nereis* spp. were the most numerous polychaetes, with *E. pennata* abundant only on the Nova Scotian shelf and *Nereis* spp. numerous only in the Mid-Atlantic Bight. Other major polychaetes consumed in the Mid-Atlantic Bight and on Georges Bank were *Nepthys* spp., *Lumbrineris fragilis*, *Aphrodite hastata*, maldanids, (mostly *Clymenella torquata*), *Glycera* spp., and *Pherusa affinis*. *A. hastata* contributed most to the stomach volume. The polychaetes *Ophelia denticulata*, *Nothria conchylega*, and *Pectinaria* sp. predominated in stomachs from the Gulf of Maine and the Nova Scotian shelf.

McEachran (1973) and McEachran et al. (1976) showed that the diet of little skate is size-dependent. Skate < 41 cm TL consumed considerably fewer decapods and more amphipods than those that were ≥ 41 cm TL. Most decapods eaten by skates ≤ 30 cm TL were *C. septemspinosa*. Haustoriid amphipods were almost never found in skates > 30 cm TL. Cumaceans and copepods were also limited to the smaller skates. All sizes fed on fishes, but the frequency of occurrence increased with the size of the skate. Polychaetes were eaten by all sizes.

The 1973-1990 NEFSC food habits database for little skate generally confirms the McEachran (1973) and McEachran et al. (1976) studies. Crustaceans dominated the diet overall, but declined in importance with increasing skate size while the percent occurrence of polychaetes increased with increasing skate size. Amphipods occurred more frequently than decapods until the skates were > 41 cm TL. *C. septemspinosa* was the major decapod prey for all sizes of skate. The following is a description of the diet from the NEFSC food habits database broken down by little skate size class.

For juvenile little skate 1-10 cm TL, 97% of the diet consisted of crustaceans, with 42% of the diet consisting of identifiable amphipods. The most abundant amphipod species included *B. serrata*, *U. irrorata*, *Monoculodes intermedius*, *Synchelidium* sp., as well as several unidentifiable Gammaridea. Identifiable cumaceans made up 27% of the diet, notable species included *Cyclaspis varians* and *Diastylis* spp. Identifiable decapods made up only 8% of the diet, all of which were either *C. septemspinosa* or classified as unidentifiable Crangonidae.

For juveniles 11-20 cm TL, 90% of the diet consisted of crustaceans, and at least half of the diet consisted of identifiable amphipods. Major amphipod species included *B. serrata*, *U. irrorata*, *L. pinguis*, *Ericthonius rubricornis*, and several unidentifiable gammarids, ampeliscids, oedicerotids, and caprellids. Identifiable decapods made up 18-20% of the diet, most of which were *C. septemspinosa*; other important decapods included pagurid and *Cancer* crabs.

The percentage of crustaceans in the diet of juvenile little skate 21-30 cm TL dropped to 83%, although almost half of the diet still consisted of identifiable amphipods. The major amphipod prey species were similar to the 11-20 cm TL size class, with the addition of *M. edwardsi*. Identifiable decapods again made up 18-20% of the diet, the majority of which were again *C. septemspinosa* along with *Cancer* and pagurid crabs. Identifiable polychaetes made up only 10-11% of the diet, most of which were terebellids.

The percent occurrence of crustaceans in the diet of juveniles 31-40 cm TL dropped further, down to 73-78%, with identifiable amphipods making up only 32-36% of the overall diet. The usual amphipods were dominant; in order of abundance they were *U. irrorata*, *L. pinguis*, unidentifiable gammarids, *B. serrata*, unidentifiable ampeliscids, *M. edwardsi*, and unidentifiable caprellids, haustoriids, and oedicerotids. Identifiable decapods made up 25-28% of the diet; *C. septemspinosa* was again the dominant decapod prey, followed by *Cancer* and pagurid crabs, and *Dichelopandalus leptocerus*. Identifiable polychaetes made up only 14-15% of the diet; the majority were terebellids and maldanids.

The percent occurrence of crustaceans in the diet continued to decline for juvenile/small adult little skate 41-50 cm TL: down to 66-71%, with identifiable amphipods making up only 22-28% of the diet, while identifiable decapods made up 29-32%. The usual amphipods were dominant, especially *L. pinguis* and *U. irrorata*, followed by the others previously mentioned. *C. septemspinosa* continued to be the dominant decapod prey, followed by *Cancer* and pagurid crabs. Identifiable polychaetes made up 17-18% of the diet, with the dominant family being the Terebellidae. Other abundant families included the Nephtyidae, Maldanidae, Aphroditidae, and the Flabelligeridae.

Finally, the percent occurrence of crustaceans in the diet declined to 64-69% for adult skate 51-60 cm TL, with identifiable amphipods making up only 19-22% of the diet, while identifiable decapods 29-34%. *L. pinguis* was the dominant amphipod; *C. septemspinosa*, *Cancer*, and pagurid crabs were the dominant decapods. Identifiable polychaetes made up 19-20% of the diet, with the dominant family being the Terebellidae.

Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult little skate include: gammarid amphipods (15%), decapod crabs and shrimps (12%), *Cancer* crabs (11%), polychaetes (11%), *C. septemspinosa* (7%), and bivalves (6%).

Other authors also show similar size-dependent trends in the diet of little skate. Bowman and Michaels (1984) and Bowman et al. (1987) reported that while crustaceans were the dominant prey of all sizes of little skate, juvenile skate < 35 cm TL preyed mostly on amphipods (including *Unciola*) and those > 35 cm TL ate large quantities of decapods (including *C. septemspinosa*). Polychaetes, mollusks, and fish were found primarily in little skate > 20 cm TL. Again, using NEFSC data from 1977-1980, Bowman et al. (2000) also found that in terms of percent weight, crustaceans were important for all size classes of skate. Juvenile skate < 15-30 cm TL fed mostly on amphipods, including *L. pinguis*, *Unciola* spp, *Gammarus annulatus*, and Oedicerotidae. Juvenile and small adult skate 36 to > 51 cm TL fed mostly on decapods, including *C. irroratus*, *C. borealis*, *P. acadianus*, and *C. septemspinosa* [although, as in the McEachran (1973) and McEachran et al. (1976) studies, *C. septemspinosa* was eaten mostly by juvenile skates ≤ 30 cm TL]. On Georges Bank, Nelson (1993) discovered that colonial amphipods and small epibenthic decapods dominated the diets of juvenile little skate < 39 cm TL at both of his study sites, but species composition was site and size dependent. At one site, *Ericthonius fasciatus* and *U. inermis* comprised the largest portions of the diet of juvenile skates < 39 cm TL. As skate length increased, *E. fasciatus* declined while *U. inermis* became increasingly important in the diets. For skates > 40 cm TL, the epibenthic decapods *C. septemspinosa* and young-of-the-year *C. irroratus* and the isopod *C. polita* were large components of the diet. The polychaete *Glycera dibranchiata* and young-of-the-year hakes (eaten mostly in summer) also increased in the diet. At a second site, the dominant prey items for juvenile skate < 39 cm TL was *C. septemspinosa*, followed by (except for juvenile skates 10-19 cm TL) the amphipod *Protohaustorius wigleyi*. Other notable amphipods were *Monoculodes edwardsi*, *Rhepoxynius hudsoni*, *Pontogeneia inermis*, and *Aeginina longicornis; C. polita* and *C. irroratus* were the most important epibenthic arthropods. For skates > 40 cm TL, *M. edwardsi*, *C. septemspinosa*, *C. polita*, and *P. inermis* were dominant; the cnidarian *Cerianthus* spp. dominated in terms of weight.

Information and citations for the inshore studies can be found in the Little Skate EFH Source Document (Packer et al. 2003d). In Sheepscot Bay, Maine, little skate ate a variety of prey, but seemed to focus most on crustaceans and Atlantic herring. *C. septemspinosa*, the jonah crab *Cancer borealis*, the amphipods *L. pinguis* and *U. inermis*, and several other varieties of crustaceans were important in the diet, followed by polycheates such as *Nephtys* spp. In Johns Bay, Maine, little skate fed primarily on the decapod crustaceans *C. septemspinosa* and *C. irroratus*, followed by the amphipods *L. pinguis*, *Unciola* spp. and *Monoculodes* spp. Polychaetes were the next major prey group. In Block Island Sound, *L. pinguis* was most abundant in the diet, followed by *C. irroratus, C. septemspinosa*, *Upogebia affinis* (a mud shrimp), *Glycera dibranchiata*, *Byblis serrata* (an amphipod), *Unciola irrorata*, *Nephtys incisa*, and *E. directus*. Decapods made up 76% of the diet by weight in New Haven Harbor. *C.*

septemspinosa and *C. irroratus* were the most important prey items, followed by mantis shrimp, *Squilla empusa*. Fish were the next major group, but only made up 10% of the diet by weight and only 4% by number. In the Hudson-Raritan estuary, he most frequently found prey, overall, was *Crangon septemspinosa* at a frequency of occurrence of 82.8%. This prey was followed by juvenile or small Atlantic rock crabs at a frequency of occurrence of 49.5%, then by the mysid shrimp, *Neomysis americana*), at a frequency of occurrence of 16.3%, and finally the lady crab, *Ovalipes ocellatus*, at a frequency of occurrence of 10.9% (Steimle et al. 2000). In Delaware Bay, *C. septemspinosa* made up > 70% of the diet, followed by *E. directus* and *Euceramus praelongus* (a burrowing crab).

In Sheepscot Bay, a study by Packer and Langton (unpublished manuscript) again indicated that the percentage of crustacean prey in the diet decreased as the skate size increased. This was due to decreases in amphipods, cumaceans, and *C. septemspinosa*. Polychaetes (including *Nephtys* spp.) were a small but important part of the diet for juvenile skate > 20 cm TL. Atlantic herring occurred only in the stomachs of fish > 40 cm TL, but were only prominent in terms of percent weight. In Long Island Sound, Richards (1963) found that amphipods and *C. septemspinosa* were more important to smaller skates. Tyler (1972) also noted that smaller skates (≤ 44 cm TL) ate mysids and amphipods and larger skate consumed decapods, euphausids, and polychaetes.

In the inshore diet studies mentioned above, the skates generally depended more on a few major prey species than skates from the McEachran (1973) and McEachran et al. (1976) studies. This may be attributable to the benthic faunal composition in these inshore areas; these areas have a less diverse fauna than the wide region sampled as part of the McEachran (1973) and McEachran et al. (1976) studies. But it is clear that the food habits of little skate are fairly generalized, and it is an opportunistic predator.

Table 41 – Major prey items of little skate

Life Stage	*Major prey*	*Location*
Juveniles, ≤ 40 cm[1]	**Polychaetes**: terebellids, maldanids; **Crustaceans**: amphipods (*B. serrata*, *U. irrorata*, *Monoculodes intermedius*, *Synchelidium* sp., *L. pinguis*, *Ericthonius rubricornis*, *M. edwardsi*, unidentifiable gammarids, ampeliscids, haustoriids, oedicerotids, caprellids), cumaceans (*Cyclaspis varians*, *Diastylis* spp.), decapods (*C. septemspinosa*, pagurid and *Cancer* crabs, *Dichelopandalus leptocerus*), isopods; **Mollusks; Fish**	U.S. northeast continental shelf
Large juveniles, very small adults, 41- 50 cm[1]	**Polychaetes**: Terebellidae, Nephtyidae, Maldanidae, Aphroditidae, Flabelligeridae; **Crustaceans**: amphipods (*L. pinguis*, *U. irrorata*, etc.), decapods (*C. septemspinosa*, *Cancer* and pagurid crabs), isopods; **Mollusks; Fish**	U.S. northeast continental shelf
Adults, 51-60 cm[1]	**Polychaetes**: Terebellidae; **Crustaceans**: amphipods (*L. pinguis*), decapods (*C. septemspinosa*, *Cancer* and pagurid crabs), isopods; **Fish**	U.S. northeast continental shelf
	Polychaetes: e.g., *Nephtys* spp.; **Crustaceans**: amphipods (*L. pinguis*, *U. inermis*), decapods (*C. septemspinosa*, *Cancer borealis*); **Fish**: Atlantic herring	Sheepscot Bay, Maine
	Polychaetes: e.g., *Nephtys* spp.; **Crustaceans**: amphipods (*L. pinguis*, *U. inermis*, *Monoculodes* spp.), decapods (*C. septemspinosa*, *Cancer irroratus*)	Johns Bay, Maine

Life Stage	***Major prey***	***Location***
	Polychaetes: *Glycera dibranchiata*, *Nephtys incisa* **Crustaceans**: amphipods (*L. pinguis*, *Byblis serrata*, *Unciola irrorata*), decapods (*C. septemspinosa*, *Cancer irroratus*, the mud shrimp *Upogebia affinis*); **Mollusks**: *Ensis directus*	Block Island Sound, RI
	Crustaceans: decapods (*C. septemspinosa*, *Cancer irroratus*, mantis shrimp *Squilla empusa*); **Fish**	New Haven Harbor
Mostly adults	**Crustaceans**: decapods (*C. septemspinosa*, *Cancer irroratus,* the lady crab, *Ovalipes ocellatus*), the mysid shrimp *Neomysis americana*	Hudson-Raritan estuary
	Crustaceans: decapods (*C. septemspinosa*, the burrowing crab *Euceramus praelongus*); **Mollusks**: *Ensis directus*	Delaware Bay

[1]*From NEFSC food habits database in Packer* et al. *(2003) and Figure 3 therein, and J. Link (pers. comm.). For a list of other major prey species from other studies, see text.*

Peak spawning

Information on the spawning periods of little skate (*Leucoraja erinacea*) comes from the EFH Source Document (Packer et al. 2003d and references therein). Egg cases are found partially to fully developed in mature females year-round but several authors report that they are most frequently encountered from late October-January and from June-July (Fitz and Daiber 1963; Richards et al. 1963; Scott and Scott 1988); Bigelow and Schroeder (1953) also mention that eggs are taken off **southern New England** mostly from July to September.

In **Block Island Sound**, Johnson (1979) also reported pregnant little skate were present during all months of the year, but the seasonal percentages of pregnant females varied. Periods of relatively high pregnancy-frequency were October-December and April-May, while low periods occurred in August-September and February-March. Peaks in egg production were in November and May when 34% and 44% of the females examined were pregnant, respectively. The lowest levels of production came in September and March when approximately 1% of the females were pregnant.

Johnson (1979) found the mean number of mature and maturing eggs per fish increased significantly prior to and during the spawning peaks, reaching maxima in October and May. The average number of mature and maturing eggs decreased significantly between what appears to be two spawning seasons with minima in August and January. The greatest ovarian production occurred in the spring. In **Delaware Bay**, Fitz and Daiber (1963) also showed that the greatest ovarian production occurred in the spring, while the size and number of eggs was at a minimum in February and March.

Johnson (1979) reported that ovarian weight also increased significantly during two spawning seasons. Comparison of the female gonad weight expressed as a percentage of total body weight demonstrated two seasonal *peaks* with maxima occurring in October and May; these seasonal peaks represented and increase in ovarian production. After the height of spawning, the female gonad weight dropped off significantly, reaching a minima in January and August.

Rate of egg laying in Johnson’s (1979) study varied from 0.20-0.67 eggs/d, with an average rate of 0.39 eggs/d. Johnson (1979) suggests that an average female little skate which spawns twice annually (once during fall and spring) produces approximately 30 eggs/yr. Bigelow and Schroeder (1953) observed that eggs in aquaria were laid at intervals of from five days to several weeks, and were partially buried in sand.

Gestation is at least six months or more. Aquarium studies mentioned by Bigelow and Schroeder (1953) showed that eggs laid in May-July hatched between the end of November and beginning of January, about 5-6 months. Richards et al. (1963) also determined that eggs spawned in the late spring and early summer required five to six months to hatch. Since the water temperature of the aquarium in which the eggs were kept was slightly above that of the natural environment, it is possible that the incubation time was underestimated. Perkins (1965) in a study conducted at **Boothbay Harbor, Maine**, found under aquarium conditions where the water temperature closely approximated that of the inshore waters, eggs deposited in November and December hatched after twelve months of incubation. Johnson (1979) performed flow-through seawater system studies using ambient temperatures resembling those of the **inshore waters of Block Island Sound** at 20 m. The incubation period ranged from 112-366 d and was dependent on month of deposition. Eggs deposited in September 1975 hatched after an average of 360 d. Incubation time decreased progressively from September, and eggs deposited in July 1977 developed and hatched in an average of 122 d. The rate of embryonic growth appeared to be directly related to temperature. In Perkins (1965) study, incubation of eggs deposited in November and December showed the first embryonic activity in March when the water temperature had risen to 7°C.

Winter skate

Supplementary table

Table 42 - Summary of habitat information for winter skate

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	See adults	Present 4-81 inshore, common 5-25 (MA) Present to 400 on shelf, common 10-**90** Also see adults	Present 0.1-21.8 inshore, common 8.5-16.5 (MA) and 3.5-13.5 (RB) Present 0.5-21.5 on shelf, common 2.5-17.5 Also see adults	Present 15-36 inshore, common at min 15.5 (RB) Present 28.5-35.5 on shelf, common 31.5-33.5
Adults	Sandy and gravelly bottoms, also on mud in Penobscot Bay (GOM) Most abundant on sand (j/a LIS)	Present 5-65 inshore, common 5-45 (MA), 7-19 (j/a DB) Present to 400 on shelf, common 20-**80** Most abundant 46-64 (GOM), found 15-46 (SNE)	Present 2.4-19.4 inshore, common 7.5-15.5 (MA), min 4.5 max 17.5 (j/a DB) Present 0.5-20.5 on shelf, common 2.5-16.5 Found 2-15 (southern NS to Cape Hatteras),	Present 27.2-36 inshore, common 20.5-34.5 (j/a DB) Present 29.5-36.5 on shelf, common 31.5-33.5

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
		and 33-113 (MAB), rare <2-7	20 in summer to 1-2 in winter (coastal MA), 10-12 (MAB in winter)	

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data for areas mapped as EFH; depth, temperature, and salinity ranges (“common”) based on Raritan Bay and MA trawl survey data in Packer et al. (2003e). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Packer et al. (2003e).
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data for areas mapped as EFH; depth, temperature, and salinity ranges (“common”) based on Raritan Bay, Delaware Bay, and MA trawl survey data in Packer et al. (2003e). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Packer et al. (2003e); substrate information and all other information from Packer et al. (2003e).

Note: Delaware Bay data were applied to juveniles and adults – winter skates caught during survey were not distinguished by life stage.

Prey species

The main source of information on the prey consumed by winter skate (*Leucoraja ocellata*) comes from the EFH Source Document (Packer et al. 2003e and references therein). Generally, polychaetes and amphipods are the most important prey items in terms of numbers or occurrence, followed by decapods, isopods, bivalves, and fishes. Hydroids are also ingested. In terms of weight, amphipods, decapods and fish can be most important; fish are especially prevalent in the larger winter skate. Bigelow and Schroeder (1953) reported rock crabs and squid as favorite prey, other items included polychaetes, amphipods, shrimps, and razor clams. The fishes that were eaten included smaller skates, eels, alewives, blueback herring, menhaden, smelt, sand lance, chub mackerel, butterfish, cunners, sculpins, silver hake, and tomcod.

McEachran (1973) studied skates collected from Nova Scotia to Cape Hatteras during 1967-1970; the following diet descriptions are from him and McEachran et al. (1976). *Nephtys* spp., *Nereis* spp., *Lumbrineris fragilis*, *Ophelia denticulata*, and maldanids (mostly *Clymenella torquata*) were the most abundant polychaetes in the Mid-Atlantic Bight and Georges Bank stomachs. *Nephtys* spp., *Pectinaria* sp., *O. denticulata*, and *Aphrodite hastata* were the most frequently consumed prey in the Gulf of Maine and on the Nova Scotian shelf. Haustoriids, *Leptocheirus pinguis*, *Monoculodes* sp., *Hippomedon serratus*, ampeliscids, *Paraphoxus* sp., and *Tmetonyx* sp. were the most frequently eaten amphipods over the survey area. *Crangon septemspinosa* was the most abundant decapod in the diet. *Cancer irroratus*, *Dichelopandalus leptocerus*, *Pagurus acadianus*, and *Hyas* sp. were consistently eaten but in small numbers.

Among the minor prey items included *Cirolana* (= *Politolana*?) *polita*, which was the dominant isopod. Other isopods eaten included *Chiridotea tuftsi* and *Edotea triloba*, but they contributed little to the overall diet. The only identifiable bivalves eaten were *Solemya* sp. and *Ensis directus*. The most frequently eaten fish was sand lance, while yellowtail flounder and longhorn sculpin were occasionally eaten. Winter skate from Georges Bank had the most diverse diet and those from the Mid-Atlantic Bight the least diverse diet. There was no significant change in the diet with increase in skate size; however, the numbers of polychaetes gradually increased and amphipods gradually decreased with increasing skate size. The number of fish and bivalves also increased with predator size and the two taxa were a major part of the diet of skate > 79 cm TL. The ingestion of decapods was independent of skate size.

The 1973-1990 NEFSC food habits database for winter skate generally confirms the McEachran (1973) and McEachran et al. (1976) studies. Crustaceans made up > 50% of the diet for skate < 61 cm TL, while fish dominated the diet of skate > 91 cm TL. Overall crustaceans declined in importance with increasing skate size (includes both amphipods and decapods) while the percent occurrence of polychaetes increased with increasing skate size until the skate were about 81 cm TL. Amphipods occurred more frequently than decapods until the skates were > 71 cm TL. Among the most frequently occurring prey species for almost all sizes of skate included the decapods *C. septemspinosa* and *Cancer* and pagurid crabs, the isopod *Cirolana* (= *Politolana*?) *polita*, and sand lance. The following is a detailed description of the diet from the NEFSC food habits database broken down by winter skate size class.

For winter skate 21-30 cm TL, 74-84% of the diet consisted of crustaceans, with 38-43% of the diet consisting of identifiable amphipods. The most abundant amphipod species included *Unciola irrorata*, *Byblis serrata*, and *H. serratus*. Identifiable decapods made up 23-25% of the diet, most of which were species such as *C. septemspinosa* and *C. irroratus*. Identifiable polychaete species (9-13% of the diet) included *Ampharete arctica*. Identifiable isopod species (9% of the diet) included *Cirolana* (= *Politolana*?) *polita*. Nematodes, bivalves, and fish were included in the “other prey phyla” category (3-17% of the diet).

For skate 31-40 cm TL, 72-76% of the diet consisted of crustaceans, with 37-39% of the diet consisting of identifiable amphipods. Major amphipod species included *B. serrata*, *U. irrorata*, *H. serratus*, and several unidentified haustoriids. Identifiable decapods made up 17-23% of the diet, most of which were *C. septemspinosa* and *C. irroratus*. Identifiable polychaetes (12-17% of the diet) included *Scalibregma inflatum*, *L. fragilis*, and unidentified maldanids. Identifiable isopods (5-8% of the diet) included *Cirolana* (= *Politolana*?) *polita*. Miscellaneous items (6-9% of the diet) included nematodes and bivalves. Among the identifiable fish present in the diet (3-4%) were sand lance, yellowtail flounder, and hakes.

The percentage of crustaceans in the diet of winter skate 41-50 cm TL dropped to 62-69%, although identifiable amphipods still made up the major portion (33-35%) followed by decapods (14-22%). Identifiable polychaetes made up 19-23% of the diet; other prey species (including mollusca), 6-9% of the diet; identifiable isopods, 7% of the diet; and identifiable fish, 3-8% of the diet. All the major prey species (except for the lack of the polychaete *S. inflatum*) were similar to the 31-40 cm TL size class, with the additions of several more *Unciola* species, *L. pinguis* (an amphipod), unidentified pagurid crabs, and nephtyid polychaetes.

The percent occurrence of crustaceans in the diet of winter skate 51-60 cm TL dropped further, down to 53-54%, with identifiable amphipods making up only 26-32% of the overall diet. Some of the dominant identifiable amphipods included *Psammonyx nobilis*, unidentified oedicerotids, *H. serratus*, and unidentified haustoriids. Identifiable decapods made up only 9-12% of the diet; *C. septemspinosa* was again the dominant decapod prey, followed by *C. irroratus* and pagurid crabs. *Cirolana* (= *Politolana*?) *polita* was again one of the major identifiable isopods, which all together made up 7-12% of the diet. The percent occurrence of identifiable polychaetes continued to increase in the diet, up to 26-29%; several of the more numerous species present were in the genera *Nephtys* and *Nereis*. Identifiable fish also increased in the diet, up to 6-13%, with sand lance the dominant species. Other prey phyla, including bivalves and nematodes, accounted for 9-11% of the diet.

The percent occurrence of crustaceans in the diet continued to decline for winter skate 61-70 cm TL: down to 38-44%, with identifiable amphipods making up only 13-20% of the diet, while identifiable decapods made up 11-12%. Major amphipod species included *M. edwardsi*, *U. irrorata*, *H. serratus*, and unidentified haustoriids and oedicerotids. *C. septemspinosa* continued to be the dominant decapod prey, followed by *Cancer* and pagurid crabs. Identifiable isopods again made up 7-12% of the diet; *Cirolana* (= *Politolana*?) *polita* continued to be one of the major prey species. The percent occurrence of identifiable polychaetes in the diet increased, up to 28-32%; species in the genera *Nephtys* and *Nereis* were again dominant. The percent occurrence of identifiable fish in the diet continued to increase also, up to 11-24%, most of which were sand lance. Nine percent of the diet consisted of identifiable mollusks, with bivalves being dominant.

While the percent occurrence of crustaceans dropped to 29-36% for winter skate 71-80 cm TL, the percent occurrence of identifiable decapods was greater than the percent occurrence of amphipods: 11-13% versus 7-12%. The former were dominated by *C. septemspinosa*, *Cancer* and pagurid crabs, and *D. leptocerus*, while several haustoriid species and *U. irrorata* were some of the major amphipod prey. Identifiable isopods made up 8-9% of the diet, the dominant species continued to be *Cirolana* (= *Politolana*?) *polita*. Identifiable polychaetes (25-35% of the diet) included *L. fragilis* and several *Nephtys* and *Nereis* species. The percent occurrence of identifiable fish in the diet varied widely between the two sampling periods, from 16-36%, although sand lance was still the dominant species. Identifiable mollusks made up 9-10% of the diet, most of which were bivalves.

Fish as prey items became increasingly important for winter skate 81-90 cm TL. They made up 29-42% of the overall diet. As usual sand lance were the dominant fish prey, other species ingested included other skate, longhorn sculpin, and silver hake. Crustaceans in the diet declined to 19-30%. The major identifiable decapod species (8-11% of the diet) continued to be *C. septemspinosa* and *Cancer* and pagurid crabs as well as pandalid shrimp and *Ovalipes ocellatus*. The major identifiable amphipod species (3-8% of the total diet) were several haustoriid species. *Cirolana* (= *Politolana*?) *polita* was once again the dominant identifiable isopod (all isopods together made up 5-7% of the diet). Several *Nephtys* species were the major identifiable polychaetes ingested, all polychaetes together made up 22-28% of the diet. Bivalves, particularly of the familiy Solenidae, were the dominant identifiable molluscan prey ingested, with all mollusks together accounting for 7-17% of the diet.

Identifiable fish made up >50% of the diet of winter skate 91-100 cm TL. Sand lance was the overwhelming dominant, some of the minor fish prey included silver hake, herring, and butterfish. Crustaceans were down to 12-23% of the diet. Identifiable decapods made up 5-10% of the diet, *C. septemspinosa*, *Cancer* and pagurid crabs, *D. leptocerus*, and pandalid shrimp were some of the major decapods ingested. Identifiable amphipods made up only 4-5% of the total diet, with few conspicuous species. Identifiable polychaetes accounted for 10-13% of the diet, with the genus *Nephtys* the most notable. "Other prey phyla" and identifiable mollusks together accounted for 10-12% of the diet, bivalves and nematodes dominated this category.

Finally, identifiable fish made up > 60% of the diet of 101-110 cm TL winter skate from the 1981-1990 NEFSC trawl surveys. Most were sand lance. Mollusks were 14% of the diet, polychaetes were 13% of the diet, and crustaceans were down to 11% of the diet.

Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult winter skate include: sand lance (17%), bivalve mollusks (13%), polychaetes (12%), other fish (8%), and gammarid amphipods (7%).

Using NEFSC data from 1977-1980, Bowman et al. (2000) found that in terms of percent weight, crustaceans were dominant in the diet of skate < 31-50 cm TL, while fish, mostly sand lance, were dominant in the diet of skate 51-110 cm TL. For skate < 31 cm TL, amphipods dominated, especially *L. pinguis*. For skate 31-50 cm TL, decapods dominated, especially *C. septemspinosa* and *C. irroratus*. On Georges Bank Tsou and Collie (2001a), using NEFSC dietary data from 1989-1990, also showed that fish, especially sand lance, were most important for winter skate > 50 cm TL. Other noted fish prey included sliver hake, mackerel, and herring (see also Tsou and Collie 2001b).

Table 43 – Major prey items of winter skate

Life Stage	***Major prey***	***Location***
Juveniles, < 81 cm[1]	**Nematodes; Polychaetes**: *Ampharete arctica*, Nephtyidae, *Scalibregma inflatum*, *Lumbrineris fragilis*, unidentified maldanids, Nereidae; **Crustaceans**: amphipods (*Unciola irrorata* and spp., *Psammonyx nobilis*, *Monoculodes edwardsi*, *Leptocheirus pinguis*, *Hippomedon serratus*, *Byblis* serrata, unidentified haustoriids, unidentified oedicerotids, unidentified gammarids), isopods (*Cirolana* [= *Politolana*?] *polita*), decapods (*Crangon septemspinosa*, pagurid crabs, *Cancer irroratus* crabs, the pandalid shrimp *Dichelopandalus leptocerus*); **Mollusks**: bivalves; **Fish**: sand lance	U.S. northeast continental shelf
Very large juveniles, adults, ≥ 81 cm[1]	**Nematodes; Polychaetes**: Nephtyidae; **Crustaceans**: amphipods (unidentified haustoriids, unidentified gammarids), isopods (*Cirolana* [= *Politolana*?] *polita*), decapods (*Crangon septemspinosa*, pagurid crabs, *Cancer* crabs, the lady crab *Ovalipes ocellatus*, pandalid shrimp including *Dichelopandalus leptocerus*); **Mollusks**: bivalves (Solenidae); **Fish**: sand lance, other skate, longhorn sculpin, silver hake, herring, butterfish	U.S. northeast continental shelf

Very large juveniles, adults, ≥ 81 cm[1]	**Polychaetes**: *Nephtys incisa*, *Nereis* sp., *Lumbrineris* sp.; **Crustaceans**: amphipods (*Leptocheirus pinguis*, *Monoculodes edwardsi*), decapods (*Crangon septemspinosa*, *Cancer irroratus;* **Mollusks**: *Ensis directus*	Block Island Sound, RI (Smith 1950)
Juveniles	**Crustaceans**: decapods (*Crangon septemspinosa*, *Cancer irroratus*, the lady crab *Ovalipes ocellatus;* **Fish**: sand lance, longhorn sculpin, Atlantic herring, winter flounder	Hudson-Raritan estuary (Steimle et al. 2000)

[1]From NEFSC food habits database in Packer et al. *(2003) and Figure 3 therein, and J. Link (pers. comm.). For a list of other major prey species from other studies, see text.*

Peak spawning

Information on the spawning periods of winter skate (*Leucoraja ocellata*) comes from the EFH Source Document (Packer et al. 2003e, and references therein).

Bigelow and Schroeder (1953) report egg deposition to occur during summer and fall off Nova Scotia and, quoting Scattergood, probably in the **Gulf of Maine** as well. They also state that egg deposition continues into December and January off **southern New England**.

A recent study by Sulikowski et al. (2004) in the **Gulf of Maine off New Hampshire** indicates that several morphological parameters and steroid hormones have been shown to peak in female winter skates during the summer, and egg-case production is highest in the fall. However, the presence of reproductively capable females during most months of the year and spermatocysts within the male testis year round implies that reproduction could occur at other times of the year. Thus, the Sulikowski et al. (2004) study, combined with the criteria described by Wourms (1977) and Hamlett and Koob (1999), collectively support the conclusion that winter skate display a partially defined reproductive cycle with a single peak (Sulikowski et al. 2004).

Rosette skate

Supplementary table

Table 44 – Summary of habitat information for rosette skate

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Sand and mud bottoms	Present 10-500 on shelf, common **80-400** Found 33-530, most common 74-274	Present 4.5-25.5 on shelf, common 8.5-17.5 Found 5.3-15	Present 30.5-36.5 on shelf, common 34.5-36.5
Adults	Assume same as juveniles	Not caught in trawl surveys, see juveniles	Not caught in trawl surveys, see juveniles	Not caught in trawl surveys, see juveniles

**   Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Juveniles**: All information from Packer et al. (2003f).

Prey species

The main source of information on the prey consumed by rosette skate (*Leucoraja garmani virginica*) comes from the EFH Source Document (Packer et al. 2003f and references therein). The major prey items of juvenile and adult rosette skate are crustaceans, followed by polychaetes. Crustacean prey includes copepods, amphipods, cumaceans, and decapods such as the shrimp *Crangon septemspinosa* and *Cancer* and galatheoid crabs. Other prey include cephalopods such as squids and octopods, and small fishes. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult rosette hake include: decapod crabs (15%), polychaetes (14%), *Cancer* crabs (10%), other crabs (7%), and gammarid amphipods (6%).

Table 45 – Major prey items of rosette skate

Life Stage	*Major prey*	*Location*
Juveniles and adutls	**Polychaetes; Crustaceans**: gammarid amphipods, decapods (*Cancer* crabs, other crabs)	U.S. northeast continental shelf

Peak spawning

Information on the spawning periods of rosette skate (*Leucoraja garmani virginica*) comes from the EFH Source Document (Packer et al. 2003f and references therein). North of Cape Hatteras the egg capsules are found in mature females year-round but are most frequent during the summer (McEachran 1970).

Clearnose skate

Supplementary table

Table 46 – Summary of habitat information for clearnose skate

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	No information	No information	No information	No information
Larvae	Not applicable	Not applicable	Not applicable	Not applicable
Juveniles	Found on soft bottoms, but also on rocky or gravelly bottoms	Present 2.7-76 inshore, common min 5 (RB) Present to 300 on shelf, common to **<u>30</u>**	Present 2.8-27.2 inshore, common 14.5-22.5 (RB) Present 3.5-27.5 on shelf, common 9.5-25.5 Juvs/adults common 11.5-22.5 (DB),10-24 (CB)	Present 19-35 inshore, common 19.5-31.5 (RB) Present 25.5-36.5 on shelf, common 30.5-36.5
Adults	Found on soft bottoms, but also on rocky or gravelly bottoms	Present 4-76 inshore, common min 5 (RB)	Present 4-25.4 inshore, common 14.5-22.5 (RB),	Present 19.6-35 inshore, common 19.5-31.5 (RB),

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
		Present to 300 on shelf, common to **40**	11.5-22.5 (j/a DB), 10-24 (j/a CB) Present 3.5-25.5 on shelf, Common 7.5-24.5 Found 9-30, mostly 9-20 in north, 19-30 NC	21.5-34.5 (j/a DB), 22-32 (j/a CB) Present 25.5-36.5 on shelf, common 30.5-36.5

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on Raritan Bay trawl survey data in Packer et al. (2003g). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Packer et al. (2003b); substrate types in Packer et al. (2003g).
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl survey data in areas mapped as EFH; depth, temperature, and salinity ranges ("common") based on Raritan Bay, Delaware Bay, and Chesapeake Bay trawl survey data in Packer et al. (2003g). Continental shelf: depth, temperature, and salinity ranges derived from NEFSC trawl survey data in Packer et al. (2003g); substrate types in Packer et al. (2003g).

Note: Delaware Bay and Chesapeake Bay temperature and salinity data were applied to juveniles and adults – clearnose skates caught during these two surveys were not distinguished by life stage. Also, the substrate information in the EFH Source Document is common to both life stages.

Prey species

The main source of information on the prey consumed by clearnose skate (*Raja eglanteria*) comes from the EFH Source Document (Packer et al. 2003g and references therein). Clearnose skate appear to feed mostly on crustaceans and fish. Crustacean prey include amphipods, mysid shrimps (e.g. *Neomysis americana*), the shrimp *Crangon septemspinosa*, mantis shrimps, crabs including *Cancer*, mud, hermit, and spider crabs, and *Ovalipes ocellatus* (lady crab). Fish prey include soles, weakfish, butterfish, and scup. Other prey include polychaetes and mollusks (bivalves, e.g. *Ensis directus*; squids). Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult clearnose skate include: other fish (20%); decapod crabs (16%); *Cancer* or rock crabs (16%); *Loligo* squids (14%); and tonguefish or *Symphurus* sp.(6%).

In the Hudson-Raritan estuary, crustaceans (*Crangon septemspinosa*, juvenile or small Atlantic rock crabs, *Ovalipes ocellatus*), fish (conger eel, juvenile winter flounder, juvenile windowpane), and mollusks (*Ensis directus*) were most frequently found in the stomachs (Steimle et al. 2000). In Delaware Bay, crustaceans (*Crangon septemspinosa*, mud crabs, *Neomysis americana*) dominated the diet (Fitz and Daiber 1963). Kimmel (1973) examined juveniles (< 44 cm TL) from the mouth of Chesapeake Bay and found crustaceans (*Crangon septemspinosa*; mud shrimp, *Upogebia affinis*) and mollusks (*Ensis directus*) dominated the diet. This is consistent with the prey that Hildebrand and Schroeder (1928) noted in the few clearnose skate that they examined from inside Chesapeake Bay. In North Carolina, fish prey included striped anchovy, croaker, spot, and blackcheek tonguefish (Schwartz 1960).

Table 47 – Major prey items of clearnose skate

Life Stage	*Major Prey*	*Location*
Juveniles and Adults	**Crustaceans**: amphipods, mysid shrimps (*Neomysis americana*), the shrimp *Crangon septemspinosa*, mantis shrimps, crabs including *Cancer*, mud, hermit, and spider crabs, lady crab (*Ovalipes ocellatus*); **Mollusks**: squids (*Loligo*); **Fish**: soles, weakfish, butterfish, scup, tonguefish	U.S. northeast continental shelf
Juveniles	**Crustaceans**: *Crangon septemspinosa*, mud shrimp (*Upogebia affinis*); M**ollusks**: razor clams (*Ensis directus*)	Mouth of Chesapeake Bay
Juveniles and Adults	**Crustaceans**: *Crangon septemspinosa*, juvenile or small Atlantic rock crabs, *Ovalipes ocellatus*, mud crabs, *Neomysis Americana;* **Mollusks**: razor clams (*Ensis directus*); **Fish**: conger eel, juvenile winter flounder, juvenile windowpane, striped anchovy, croaker, spot, and blackcheek tonguefish.	Hudson-Raritan estuary, Delaware Bay, North Carolina

Peak spawning

Information on the spawning periods of clearnose skate (*Raja eglanteria*) comes from the EFH Source Document (Packer et al. 2003g and references therein). The patterns of estradiol concentrations and follicle dynamics indicate the presence of a well-defined annual reproductive cycle, in which mating and egg deposition take place from December to mid May (Rasmussen et al. 1999). **North of Cape Hatteras** the egg cases are deposited in the spring and summer; in **Delaware Bay**, Fitz and Daiber (1963) reported spawning to occur only in the spring. Off the central west coast of Florida, egg deposition occurs from December through mid-May (Luer and Gilbert 1985).

Atlantic sea scallop

Supplementary table

Table 48 – Summary of Habitat Information for Atlantic Sea Scallop

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Benthic habitats	No information	No information	No information
Larvae	Pelagic and benthic habitats Spat survival enhanced on sedentary branching plants or animals, or any hard surface (e.g., shells, small pebbles);	No information	Lab study: viable 12-18 (mass mortalities >18)	Lab study: viable as low as 10.5, 16.9-30 preferred

Life Stage	***Habitat***	***Depth (m)****	***Temperature (ºC)*****	***Salinity (ppt)*****
	do not survive on shifting sand			
Juveniles	Attach to shells and bottom debris, including gravel and small rocks, most abundant on gravel Older juveniles on same substrates as adults Currents stronger than 10 cm/s retard feeding and growth	Common 40-120 on shelf (not including GOM), present 20-160 Typically **18-110**, but also found as shallow as 2 inshore (GOM) (also adults) Most abundant 62-91 (GB) Found primarily 45-75 in south, less common 25-45 (too warm) Not common >110, but occur as deep as 170-180 in GOM	Present 0.5-20.5, common 5.5-10.5, on shelf (in summer) Lab studies: maximum survival 1.2-15 or <18 Growth faster in warmer, shallower water (eastern GB)	Lab study: maximum survival >25
Adults	Found on firm sand, gravel, shells, and rock, most abundant on gravel Strong tidal currents (> 25 cm/s) inhibit feeding	Same as juveniles Common or abundant in coastal GOM bays and estuaries (ELMR) (juveniles and adults) Found from low tide level to ~100	Optimal growth 10-15, >21 lethal Spawn 6.5-16 Otherwise, same as juveniles	Prefer full strength seawater, <16.5 lethal

** Depth to bottom*
*** Bottom water temperatures and salinities for benthic life stages and water column temperatures and salinities for pelagic life stages*

Sources of information:

- **Larvae**: All information obtained from Hart and Chute (2004).
- **Juveniles**: Shelf depth and temperature ranges derived from NEFSC summer scallop dredge survey data (all sizes); temperature range (“common”) in GOM based on ME/NH trawl survey data provided by Maine Dept. Marine Resources; substrate and salinity information and additional information on depths and temperatures from Hart et al. (2004).
- **Adults**: All information from Hart and Chute (2004).

Note: Eggs are slightly heavier than seawater and probably remain on the sea floor as they develop into free-swimming larvae which settle to bottom (as “spat”) before metamorphosing into juveniles. Juveniles and adults inhabit similar habitats, so information on depth and bottom temperatures in the table is common to both life stages. The NEFSC scallop dredge survey does not include the Gulf of Maine and is only done in summer.

Prey species

The main source of information on the prey consumed by the larval, juvenile, and adult stages of the Atlantic sea scallop (*Placopecten magellanicus*) comes from the EFH Source Document (Hart and Chute 2004 and references therein). The Atlantic sea scallop is a pelagic filter feeder in the larval stage and benthic suspension feeders as juveniles/adults. Their diet primarily consists of phytoplankton and microzooplankton (such as ciliated protozoa), but particles of detritus can also be ingested, especially during periods of low phytoplankton concentrations. Dissolved organic matter (absorbed through the tissues) has been suggested as an additional minor source of nutrition, particularly for scallop larvae. Palp-pedal feeding (using the ciliated end of the foot to bring organic matter from biofilms to the labial palps) as well as DOM absorption may also be used by post-settlement scallops, during the time that feeding structures on the gill develop. It is presumed that DOM is a minor nutritional source despite its high concentration, since much of it is found as refractory organic carbon.

Atlantic sea scallops in coastal areas and embayments digest detritus from seaweeds and sea grasses and may be exposed periodically to significant amounts of resuspended inorganic material, while offshore scallops consume primarily phytoplankton and resuspended organic matter. Phytoplankton appears necessary to meet scallop energetic demands, although seaweed detritus may be an important food supplement in nearshore environments. One study showed that a scallop population in shallow water (20 m) fed equally on pelagic and benthic food species, while a deep water population (180 m) fed primarily on benthic species. In both populations, seasonal variations in food items occurred and coincided with bloom periods of individual algal species. The gut contents generally reflected the available organisms in the surrounding habitat, indicating that sea scallops are opportunistic filter feeders which take advantage of both benthic and pelagic food. A total of 27 species of algae, ranging in size from 10-350 μm were identified, plus a number of miscellaneous items including pollen grains, ciliates, zooplankton tests, detrital material, and bacteria.

Table 49 – Major prey items of Atlantic sea scallop

Life Stage	*Major Prey*	*Location*
Pre-settlement (larvae: trochophore and veliger stages)	**Phytoplankton ;Microzooplankton; Detritus**	U.S. northeast continental shelf
Post-settlement (spat, juveniles, adults)	**Phytoplankton; Microzooplankton; Detritus**	U.S. northeast continental shelf
Post-settlement (spat, juveniles, adults)	**Phytoplankton; Seaweed, seagrass detritus; Resuspended inorganic material**	Nearshore, bays and embayments

Peak spawning

Information on the spawning periods of the Atlantic sea scallop (*Placopecten magellanicus*) comes from the EFH Source Document (Hart and Chute 2004 and references therein).

Shumway et al. (1988) summarized the gametogenic cycle of sea scallops from **Maine**. Spawning takes place in September/October and the animals enter a reproductively quiescent or rest period. Barber et al. (1988) found that spawning and reabsorption of mature ova was evident in September and to a greater extent in October, after which the animals underwent a period of recovery (December/January).

Spawning generally occurs synchronously when males extrude sperm and the females release eggs en masse into the water, but it may occur over a more protracted period of time depending on environmental conditions. It has been suggested that year-class strength may correlate with the degree of spawning synchrony, rather than fecundity per se (Langton et al. 1987).

A major annual spawning period occurs during late summer to fall (August to October) (Parsons et al. 1992) although spring or early summer spawning can also occur, especially in the **Mid-Atlantic** (Barber et al. 1988; DuPaul et al. 1989; Schmitzer et al. 1991; Davidson et al. 1993; Almeida et al. 1994; Dibacco et al. 1995). The timing of spawning can vary with latitude, starting in summer in southern areas and in fall in the northern areas. MacKenzie et al. (1978) reported that **off the coast of North Carolina and Virginia**, spawning generally occurred as early as July and that further north on the **Mid-Atlantic shelf** spawning occurred in August. However, there are exceptions to this pattern. MacDonald and Thompson (1988) report that scallops off of **New Jersey** spawned up to two months later than scallops from Newfoundland (September-November versus late August-early September). They found no clearly identifiable latitudinal trends in the timing of spawning. A biannual spawning cycle on the **Mid-Atlantic shelf** has been reported south of the **Hudson Canyon**, with spawning occurring both in the spring and fall (DuPaul et al. 1989; Schmitzer et al. 1991; Davidson et al. 1993). Kirkley and DuPaul (1991) found that spring spawning in the **Mid-Atlantic** is the more predictable and dominant spawning event, while fall spawning is minor, temporally irregular, and sometimes does not occur. Schmitzer et al. (1991) also reported that the spring spawning was of longer duration and the scallops showed greater fecundity than in the fall.

North of the Hudson Canyon there is generally a single annual spawning event starting in late summer or early fall. However, there are some reports of biannual spawning (spring and fall) in the **Gulf of Maine** and **Georges Bank**, with the fall spawning being dominant (Barber et al. 1988; Almeida et al. 1994, DiBacco et al. 1995). On **Georges Bank** fall spawning generally occurs in late September or early October (Posgay and Norman 1958; MacKenzie et al. 1978; McGarvey et al. 1992; DiBacco et al. 1995). In **Cape Cod Bay**, spawning occurs in late September and early October (Posgay 1950). In the **Gulf of Maine** spawning occurs in August and September (Drew 1906; Welch 1950; Baird 1953; Culliney 1974; Robinson et al. 1981; Barber et al. 1988). In the Bay of Fundy the spawning period extends from late July to November (Stevenson 1936; Dickie 1955; Beninger 1987; MacDonald and Thompson 1988; Dadswell and Parsons 1992).

Scallops beds generally spawn synchronously in a short time, going from completely ripe to completely spent in less than a week (Posgay and Norman 1958; Posgay 1976). “Dribble spawning” over an extended time period has been reported in scallops from Newfoundland coastal waters (Naidu 1970) and possibly in the **Gulf of Maine** (Langton et al. 1987) and in **New Jersey** in June and July (MacDonald and Thompson 1988). A rapid temperature change, the presence in the water of gametes from other scallops, agitation, or tides may trigger scallop spawning (Parsons et al. 1992a).

Atlantic herring

Supplementary table

Table 50 – Summary of habitat information for Atlantic herring

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	Benthic habitats with boulders, coarse sand, cobble/pebble, gravel, and/or macroalgae Not on mud or fine sand Strong bottom currents enhance survival	5-90 inshore and on shelf	Bottom temperatures over egg beds 7-15 Normal development 1-22	Spawn 32-33 in GOM/GB
Larvae	Pelagic, in water column, some over-winter in estuaries	Present to 1500 on and off shelf, common 40-220 Inshore: minimum 20	Present -0.5 to 14.5 on and off shelf, common 1.5-12.5 Lab study: tolerate -1.8 to 24	Lab study: survived 2.5-52.5 for 7 days (assume max=35)
Juveniles	Pelagic, in estuarine and oceanic habitats	Present 4-99 inshore, common 10-65 (MA), 9-17 (RBay), 9-21 (DBay), 4-16 (CBay) and 10-50 (ME) Present to 400 on shelf, common 20-**<u>300</u>** on shelf YOY caught in beach seines	Present 0-28 inshore, common 3.5-14.5 (MA), 13.5-21.5 (RBay), 5-13 (DBay), 10-22 (CBay) and 6.1-13 (ME) Common 2.5-10.5 on shelf Can survive -1.1 Lab study: prefer 8-12	Present 5-36.5 inshore, common 20.5-31.5 (RBay), 11-26 (DBay), 18-28 (CBay) Common 30.5-34.5 on shelf YOY can tolerate salinities as low as 5 for a short time; older juveniles avoid brackish water Lab study: prefer 28-32
Adults	Pelagic, in water column; spawn on bottom	Present 4-84 inshore, common 30-85 (MA), 7-16 (RBay), 10-21 (DBay) and 8-150 (ME) Present to 400 on shelf, common 10-**<u>300</u>** Spawn 5-90 (see eggs)	Present 0-20 inshore, common 1.5-10.5 (MA), 1.5-9.5 (RBay), 0-11 (DBay) and 2.1-7 (ME) Common 2.5-10.5 on shelf Prefer 5-9 during spawning season (GB)	Present 16-36, common 18.5-33.5 (RBay), 11-29 (DBay) Common 29.5-35.5 on shelf Rarely found in low salinities; lower limit 28 Spawn 32-33

** Depth to bottom*

*** Bottom water temperatures and salinities for eggs and water column temperatures and salinities for larvae, juveniles, and adults*

Note: Information based on bottom trawl survey data cited in this table were not used to map EFH for this species, since it is a pelagic species.

Sources of information:

- **Eggs**: All information on eggs obtained from Stevenson and Scott (2005).
- **Larvae**: Shelf depth and temperature ranges derived from MARMAP data in Stevenson and Scott (2005); other information from Stevenson and Scott (2005) and Lazzari and Stevenson (1992).
- **Juveniles**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl surveys in areas mapped as EFH; depth, temperature, and salinity ranges ("common") from analysis of MA, Chesapeake Bay, and Raritan Bay trawl survey data in Stevenson and Scott (2005), ME/NH trawl survey data provided by Maine Dept. Marine Resources, and Delaware Bay trawl survey data in Morse (2000). Continental shelf: depth and temperature ranges derived from NEFSC bottom trawl survey data in Stevenson and Scott (2005). All other information from Stevenson and Scott (2005) and from reports on seine surveys conducted in NH, RI, MD, and VA.
- **Adults**: Inshore: depth, temperature, and salinity ranges (presence only) based on inshore seine and trawl surveys in areas mapped as EFH; depth, temperature, and salinity ranges ("common") from analysis of MA and Raritan Bay trawl survey data in Stevenson and Scott (2005), ME/NH trawl survey data provided by Maine Dept. Marine Resources, and Delaware Bay trawl survey data in Morse (2000). Continental shelf: depth and temperature ranges derived from NEFSC bottom trawl survey data in Stevenson and Scott (2005). All other information from Stevenson and Scott (2005) and Munroe (2002).

Prey species

The main source of information on the prey consumed all life stages of Atlantic herring (*Clupea harengus*) comes from the EFH Source Document (Stevenson and Scott 2005 and references therein). Atlantic herring prey upon a variety of planktivorous organisms. All life stages of herring are opportunistic feeders, and will take advantage of whatever prey of the appropriate size is available. As they grow and the size of their jaws increases, they consume larger organisms. Their diet therefore varies with season, their age and size, and location.

Newly-hatched larvae (7-20 mm) in coastal waters of central Maine feed primarily on the small, early developmental stages of copepods; during the winter, larger larvae (21-30 mm) feed on the adult stages of small copepods as well. During the spring, when a wider variety of planktonic organisms are available and the larvae are larger, their diet includes organisms such as barnacle larvae, crustacean eggs, copepods, and free-swimming ciliate protozoans (tintinnids). Three copepod species preyed upon by larval herring on Georges Bank are *Pseudocalanus* sp., *Paracalanus parvus*, and *Centropages typicus*.

Juveniles feed on up to 15 different groups of zooplankton; the most common are copepods, decapod larvae, barnacle larvae, cladocerans, and molluscan larvae. Adults have a diet dominated by euphausiids, chaetognaths, and copepods. The most important prey items of adults herring collected on Georges Bank were chaetognaths (*Sagitta elegans*, 43% by weight), euphausiids (*Meganyctiphanes norvegica*, 23%; *Thysanoessa inermis*, 6.1%), pteropods (*Limacina retroversa*, 6.2%), and copepods (3%). The copepod *Calanus finmarchicus* is a common prey item. In addition, adults also consume fish eggs and larvae, including larval herring, sand lance, and silversides.

Food habits data collected during NEFSC bottom trawl surveys reveal that the most abundant identifiable prey items (percent by weight) for Atlantic herring include amphipods, copepods, and euphausiids. Jason Link (NOAA/NMFS/NEFSC, Woods Hole Laboratory, personal communication) has updated the food habits database from 1973-2005 and reports that the prey exceeding the 5% by weight threshold in the stomachs of juvenile and adult Atlantic herring include: euphausiids (18%), copepods (16%), and gammarid amphipods (7%).

Table 51 – Major prey items of Atlantic herring

Life Stage	*Major Prey*	*Location*
Larvae		Central Gulf of Maine, Georges Bank
Newly hatched (7-20 mm)	**Copepods**: small, early developmental stages	
--------------	------------	
Large (21-30 mm)	**Copepods**: adult stages of small copepods (e.g.; are *Pseudocalanus* sp., *Paracalanus parvus*, and *Centropages typicus* are *Pseudocalanus* sp., *Paracalanus parvus*, and *Centropages typicus*)	
-------------	------------	
Larger (> 30 mm)	**Barnacle larvae, crustacean eggs, copepods, free-swimming ciliate protozoans (tintinnids)**	
Juveniles (< 25 cm TL)	**Zooplankton: copepods, decapod larvae, barnacle larvae, cladocerans, molluscan larvae.**	U.S. northeast continental shelf
Adults ($\geq$ 25 cm TL)	**Chaetognaths**: *Sagitta elegans;* **Crustaceans**: euphausiids (*Meganyctiphanes norvegica*, *Thysanoessa inermis*), amphipods, copepods; **Mollusks**: pteropods (*Limacina retroversa*)	U.S. northeast continental shelf; Georges Bank

Peak spawning

Information on the spawning periods of Atlantic herring (*Clupea harengus*) comes from the EFH Source Document (Stevenson and Scott 2005 and references therein).

In the northwest Atlantic, herring spawn from **Labrador to Nantucket Shoals**. Spawning occurs in the spring, summer, and fall in more northern latitudes, but summer and fall spawning predominates in the **Gulf of Maine-Georges Bank region** (Haegele and Schweigert 1985).

In U.S. waters of the **Gulf of Maine**, herring eggs have been observed along the **eastern Maine coast**, at several **other locations along the Maine coast** (e.g., outer Penobscot Bay and near Boothbay), on Jeffreys Ledge and Stellwagen Bank, and on **eastern Georges Bank**. **Nantucket Shoals** is known to be an important spawning ground based on the concentrations of recently-hatched larvae that were repeatedly collected there during the 1970s and 1980s (Grimm 1983; Smith and Morse 1993). High concentrations of recently-hatched larvae have also been collected in the vicinity of **Cultivator Shoals on western Georges Bank**, in the vicinity of **Stellwagen Bank and Jeffreys Ledge**, and on the **outer continental shelf in southern New England** (Grimm 1983; Smith and Morse 1993). High densities of recently-hatched larvae have also been observed in **Saco Bay and Casco Bay on the southern Maine coast** (Graham et al. 1972b, et al. 1973).

The spawning season in the **Gulf of Maine-Georges Bank** region begins in July and lasts until December. Spawning begins earlier in the northern areas of the **Gulf**. Off southwestern Nova Scotia, spawning occurs from July to November and peaks in September-October (Boyar 1968; Das 1968, 1972) Spawning in **eastern Maine coastal waters** during 1983-1988 extended from late July through early October, with peak spawning in late August (Stevenson 1989), but more recent egg bed surveys (1997-2002) in the same area indicated that spawning did not start until late August and lasted until October 21 (Neal and Brehme 2001; Neal 2003). Based on larval surveys, Graham et al. (1972b) concluded that spawning peaks in mid-September to mid-October in **eastern Maine** and in October in **western Maine**. Boyar et al. (1973) reported that spawning on **Jeffreys Ledge** in 1972 started in early September and peaked during the first three weeks of October. On **Georges Bank**, spawning occurs from late August to December (Boyar 1968; Berenbeim and Sigajev 1978; Lough et al. 1980) with a peak in September-October (Boyar 1968; Pankratov and Sigajev 1973; Grimm 1983). On **Nantucket Shoals**, spawning peaks from October to early November, 1-2 weeks later than on **Georges Bank** (Lough et al. 1980; Grimm 1983). Larval surveys conducted during 1971-1975 indicated that spawning on **Georges Bank** started on the **Northeast Peak** of the Bank in September and extended southwest to **Nantucket Shoals** in October, declined in November and was absent in December (Grimm 1983).

Deep-sea red crab

Supplementary table

Table 52 - Summary of habitat information for deep-sea red crab

Life Stage	*Habitat*	*Depth (m)**	*Temperature (ºC)***	*Salinity (ppt)***
Eggs	See adults	See adults	See adults	See adults
Larvae	Pelagic, in surface waters	Most abundant <40 (NS,GOM,GB)	Most abundant 6-19.5 (NS,GOM,GB) Survive as high as 25	Most abundant 29-33 (NS,GOM,GB)
Juveniles	Benthic habitats on continental shelf and slope, including canyons and seamounts, on flat, smooth, silt-clay sediments, in biogenic	Occur as shallow as 40 in GOM (also adults?) Settle mid-slope (~1000), then move up-slope	Most abundant 4-9 on slope Growth fastest 9-15	

	depressions and burrows in clay outcrops, and in crevices near boulders	Most abundant 320-1280 on slope (GB-MD) Obs 230-1646 on slope, caught as deep as 1463 *** Obs at 2000 on seamounts****	
Adults	See juveniles	Present 229-1280 on slope (GB-MD) Most abundant 320-914 on slope (GB-MD) Move up and down slope Spawn 320-640 on slope	Caught 3.1 to at least 12.7 on slope (juvs and adults) Most abundant 5-8 on slope Upper limit 10-12 Thermal stress >10

*   *Depth to bottom*
*** Bottom water temperatures, salinities, and dissolved oxygen concentrations for benthic life stages and surface water temperatures and salinities for pelagic life stages*
**** Assumed to be juveniles given depth distribution by size reported by Wigley* et al. *(1975)*
***** From ROV surveys of Bear and Retriever seamounts reported by Peter Auster and by Moore* et al. *(2004), no information on sizes*

Note: EFH for red crab eggs is the same as for adults because the eggs remain attached to the females until they hatch.

Prey species

The main source of information on the prey consumed by red deepsea crab [*Chaceon (Geryon) quidquedens*] comes from the EFH Source Document (Steimle et al. 2001 and references therein). No information is known on the natural diets of red crab larvae, but it is probably zooplanktivorous, as they were found to thrive on rotifers, brine shrimp, and chopped mollusk meats in laboratory cultures.

Red crabs are opportunistic feeders. Post-larval, benthic red crabs eat a wide variety of infaunal and epifaunal benthic invertebrates (e.g. bivalves) that they find in the silty sediment or pick off the seabed surface. Smaller red crabs eat sponges, hydroids, mollusks (gastropods and scaphopods), small polychaetes and crustaceans, and possibly tunicates. Larger crabs eat similar small benthic fauna and larger prey, such as demersal and mid-water fish (*Nezumia* and myctophids), squid, and the relatively large, epibenthic, quill worm (*Hyalinoecia artifex*).They can also scavenge deadfalls (e.g., trawl discards) of fish and squid, as they are readily caught in traps with these as bait and eat them when held in aquaria.

Table 53 – Major prey items of deep-sea red crab

Life Stage	***Major Prey***	***Location***
Larvae (4 zoeal and 1 megalopa stages)	**Zooplankton**	U.S. northeast continental shelf/slope
Juveniles and Adults	<u>Smaller</u> **Sponges; Hydroids; Polychaetes; Mollusks**: gastropods, scaphopods <u>Larger</u> **Sponges; Hydroids; Annelids**: polychaetes, quill worm (*Hyalinoecia artifex*); **Mollusks**: gastropods, scaphopods, squids; **Fish**: *Nezumia*, myctophids	U.S. northeast continental shelf/slope

<u>Peak spawning</u>

Information on the spawning periods of red deepsea crab [*Chaceon (Geryon) quidquedens*] comes from the EFH Source Document (Steimle et al. 2002 and references therein). Erdman et al. (1991) suggested that the egg brooding period may be about nine months, at least for the Gulf of Mexico population, and larvae are hatched in the early spring there. There is no evidence of any restricted seasonality in spawning activity in any geographic region of the population, although a mid-winter peak is suggested as larval releases are reported to extend from January to June (Wigley et al. 1975; Haefner 1977; Lux et al. 1982; Erdman et al. 1991; Biesiot and Perry 1995). Laboratory studies also found hatching to occur from April to June (Perkins 1973). Gerrior (1981), however, suggested that red crab egg hatching occurred later, between July and October, based on the ratio of egg-bearing to non-egg-bearing crabs.

Atlantic salmon

Supplementary table

Table 54 - Summary of habitat information for Atlantic salmon

Life Stage	*Habitat*	*Substrate (grain size diameter in mm)*	*Water Depth*	*Temperature (ºC)*	*Salinity (ppt)*	*Dissolved Oxygen (mg/l)*	*Water Velocity (cm/sec)*	*pH*	*Primary Prey*
Eggs	10-25 cm deep in intra-gravel riffle and run habitats in shallow, gravel/rocky stream beds, in nests (redds)	<100, mostly 2-64	17-76 cm (mean 38 cm)	6-7 optimum for incubation, occur 0-16; increased mortality 8-12	Fresh water	7 optimal under normal temperatures, <3 lethal	Intra-gravel velocities of 53 optimal, 15-20 minimal	Hatching may be impeded <5.5 and prevented <4	NA
Larvae (alevins)	Intra-gravel riffle and run habitats in shallow, gravel/rocky stream beds	<100, mostly 2-64 (presumed same as eggs)	17-76 cm (mean 38 cm)	0-16 (presumed same as eggs)	Fresh water	7 optimal under normal temperatures, <3 lethal, 3-6 may retard development	Intra-gravel velocities of 53 optimal, 15-20 minimal	No info	NA
Juveniles (fry)	Riffle and run habitats in shallow streams with gravel/rocky substrate	15-64 (fry do not emerge if grain size is 6-15)	No info	No info	Fresh water	No info	Maximum 15-19, washouts of emerging fry may occur 10-25; larger fry (up to 4 cm TL) withstand >50	No info	Plankton and small invertebrates
Juveniles (parr)	Riffle and run habitats, in shallow, gravel/rocky stream beds, as well as pools and vegetated areas of lower velocity	NA	<7 cm TL, 10-15 cm; 30-60 optimal for larger parr	Maximum 22-25 in absence of nighttime cooling; fastest growth at 15-19; 25-28 lethal; minimum required for feeding 7	Fresh water	Select highest available, normally occur >5	Prefer 30-92, fastest growth at 30, highest densities at 50-65	5-7	Variety of aquatic invertebrates (e.g., insect larvae and nymphs, aquatic annelids, and mollusks) and terrestrial invertebrates (e.g., insects) that fall into the water

Life Stage	*Habitat*	*Substrate (grain size diameter in mm)*	*Water Depth*	*Temperature (ºC)*	*Salinity (ppt)*	*Dissolved Oxygen (mg/l)*	*Water Velocity (cm/sec)*	*pH*	*Primary Prey*
Juveniles (smolts)	Variety of riverine, lacustrine, and estuarine habitats	NA	NA	Downstream migration ceases >10	<25	No info	No info	No info	Same as parr?
Juveniles (post-smolts)	Coastal and open ocean pelagic marine habitats	NA	NA	Enter sea in spring (April-May) when SST is 4-10	>25	NA	NA	NA	Insects and marine invertebrates, later larval and juvenile fish (e.g., Atlantic herring, sand lance), pelagic amphipods, and euphausiids
Spawning adults	Spawn in shallow, fresh water streams, but also utilize riverine, lacustrine, estuarine, and coastal marine habitats during upstream migration	Spawn <100, mostly 2-64	Spawn in 17-76 cm (mean 38 cm)	Enter rivers in spring (April-May) when SST is 4-10 >23 curtails upstream migration in summer Spawn 4.4-14 in fall	Full range from marine to fresh water	<5 curtails upstream migration	No info	No info	N/A
Non-spawning adults	Variety of riverine, lacustrine, and estuarine habitats, and pelagic marine habitats	NA	NA	Most frequently observed in oceanic waters with SST 4-10	Full range from fresh water to marine	No info	NA	No info	Variety of fish (e.g., herring, alewives, smelt, capelin, haddock, mummichogs, sculpins, sand lance, mackerel, and flatfishes) and aquatic insects

Peak spawning

Information on the spawning periods of Atlantic salmon (*Salmo salar*) comes from the EFH Source Document (Maltz et al., in draft, and references therein).

Spawning in freshwater occurs in late October through November. U.S. Atlantic salmon populations are typically spring run with the majority of fish entering rivers in June through August. Therefore, depending upon their date of return, these fish may spend 1-6 months in the river prior to spawning. Incubation time may be 4-7 months in **Maine rivers** (DeCola 1970).

Summary tables

Table 55 – Summary of pelagic prey consumed by managed species

Prey group	Pelagic genera or species	American plaice	Atlantic cod	Atlantic halibut	Atlantic herring	Atlantic sea	Barndoor skate	Clearnose skate	Deep-sea red	Haddock	Little skate	Monkfish	Ocean Pout	Offshore hake	Pollock	Redfish	Red hake	Rosette skate	Silver hake	Smooth skate	Thorny skate	White hake	Witch flounder	Windowpane	Winter flounder	Winter skate	Yellowtail	Count
Plankton	**Plankton, total**	x	x		x	x	x		x	x		x			x	x	x		x			x		x	x			**15**
	Phytoplankton					x				x									x									**3**
	Microzooplankton					x																						**1**
	Zooplankton								x			x																**2**
	Copepods	x	x		x		x			x		x			x	x	x		x			x		x	x			**13**
	Diatoms	x																										**1**
	Decapod larvae				x							x												x				**3**
	crustacean eggs				x																				x			**2**
Chaetognaths	**Chaetognaths, total**				x							x			x									x				**4**
	Sagitta elegans				x										x													**2**
Mollusks	**Mollusks, total***	x	x	x	x		x	x	x	x	x	x	x	x	x		x		x		x	x		x	x	x		**20**
	pteropods				x																							**1**
	cephalopods (squids)		x	x			x	x	x			x		x	x		x		x			x		x				**12**
	Illex			x								x		x	x													**4**
	Loligo							x				x			x				x			x						**5**
	Rossia																		x									**1**
Fish	**Fish, total***	x	x	x			x	x	x	x	x	x		x	x	x	x		x	x	x	x		x	x	x		**20**
	Atlantic herring	x									x	x			x				x		x					x		**7**
	Herring		x				x			x																x		**4**
	Blueback herring																		x									**1**
	Alewife						x																					**1**
	Bay anchovy																		x					x				**2**
	Striped anchovy							x																				**1**
	Menhaden						x					x							x									**3**
	Clupeids			x						x							x		x			x						**5**
	Bluefish		x																									**1**

Prey group	Pelagic genera or species	American plaice	Atlantic cod	Atlantic halibut	Atlantic herring	Atlantic sea	Barndoor skate	Clearnose skate	Deep-sea red	Haddock	Little skate	Monkfish	Ocean Pout	Offshore hake	Pollock	Redfish	Red hake	Rosette skate	Silver hake	Smooth skate	Thorny skate	White hake	Witch flounder	Windowpane	Winter flounder	Winter skate	Yellowtail	Count
	Mackerels		x							x		x							x									4
	Butterfish						x	x				x							x							x		5
	Myctophids								x						x													2
	Silversides																		x									1
	Argentines																					x						1
*** totals include benthic and pelagic species**																												

Table 56 – Summary of benthic invertebrate prey consumed by managed species

Prey group	Subgroups (order or family)	Genera or species	American plaice	Atlantic cod	Atlantic halibut	Atlantic herring	Atlantic sea	Barndoor skate	Clearnose skate	Deep-sea red	Haddock	Little skate	Monkfish	Ocean Pout	Offshore hake	Pollock	Redfish	Red hake	Rosette skate	Silver hake	Smooth skate	Thorny skate	White hake	Witch flounder	Windowpane	Winter flounder	Winter skate	Yellowtail	Count
Sponges										x																			1
Urochordates																	x												1
Nemerteans																										x		x	2
Cnidarians	**Cnidarians, all**									x	x															x		x	4
		Hydroids								x																x			2
		Anthozoans																								x		x	2
Nematodes			x													x		x								x	x		5
Polychaetes	**Polychaetes, all**		x					x		x	x	x		x				x	x	x	x	x	x	x		x	x	x	16
	Oenonidae	**Oenonids, all**																										x	1
		Drilonereis sp.																										x	1
	Sigalionidae	**Sigalionids, all**																											0
	Opheliidae	**Opheliids, all**																										x	1
		Ophelia sp.																										x	1

Prey group	Subgroups (order or family)	Genera or species	American plaice	Atlantic cod	Atlantic halibut	Atlantic herring	Atlantic sea	Barndoor skate	Clearnose skate	Deep-sea red	Haddock	Little skate	Monkfish	Ocean Pout	Offshore hake	Pollock	Redfish	Red hake	Rosette skate	Silver hake	Smooth skate	Thorny skate	White hake	Witch flounder	Windowpane	Winter flounder	Winter skate	Yellowtail	Count
	Scalibregmatidae	**Scalibrematids, all**																									x		**1**
		Scalibregma inflatum																									x		**1**
	Spionidae	**Spionids, all**																								x		x	**2**
		Streblospio sp.																								x			**1**
		Marenzelleria viridis																								x			**1**
		Spiophanes bombyx																										x	**1**
	Capitellidae	**Capitellids,all**																						x		x			**2**
		Capitella sp.																								x			**1**
	Cirratulidae	**Cirratulids, all**												x															**1**
	Nephtyidae	**Nephytids, all**	x									x										x		x		x	x	x	**7**
		Nephtys spp.										x												x					**2**
		Nephtys incisa										x														x	x		**3**
		Nephtys discors																				x							**1**
	Terebellids	**Terebellids, all**										x										x		x					**3**
	Maldanids	**Maldanids, all**										x														x	x		**3**
	Aphroditidae	**Aphroditids, all**										x										x							**2**
		Aphrodite hastata																				x							**1**
	Flabelligeridae	**Flabelligerids, all**										x														x			**2**
		Pherusa affinis																								x			**1**
	Glyceridae	**Glycerids, all**										x						x		x				x		x			**5**
		Glycera dibranchiata										x												x					**2**
		Glycera sp.																x		x						x			**3**
	Lumbrineridae	**Lumbrinerids, all**																				x		x		x	x		**4**
		Lumbrineris fragilis																						x		x	x		**3**
		Lumbrineris sp.																									x		**1**
		Ninoe brevipes																						x					**1**
	Nereidae	**Nereids, all**																				x				x	x		**3**
		Nereis sp.																								x	x		**2**
		Nereis succinea																								x			**1**

Prey group	Subgroups (order or family)	Genera or species	American plaice	Atlantic cod	Atlantic halibut	Atlantic herring	Atlantic sea	Barndoor skate	Clearnose skate	Deep-sea red	Haddock	Little skate	Monkfish	Ocean Pout	Offshore hake	Pollock	Redfish	Red hake	Rosette skate	Silver hake	Smooth skate	Thorny skate	White hake	Witch flounder	Windowpane	Winter flounder	Winter skate	Yellowtail	Count
	Sabellidae	**Sabellids, all**																				x				x			**2**
	Ophelidae	**Ophelids, all**																				x							**1**
	Sternaspidae	**Sternaspids, all**																				x		x					**2**
		Sternaspis scutata																				x							**1**
	Eunicidae	**Eunicids, all**																				x							**1**
		Eunice pennata																				x							**1**
	Goniadidae	**Goniadids, all**																						x					**1**
		Goniada sp.																						x					**1**
		Ophioglycera gigantea																						x					**1**
	Ampharetidae	**Ampharetids, all**																								x	x	x	**3**
		Ampharete arctica																									x	x	**2**
		Ampharete sp.																								x			**1**
	Ampharetidae	*Melinna cristata*																								x			**1**
		Asabellides oculata																								x			**1**
	Trichobranchidae	*Trichobranchids, all*																								x			**1**
		Trichobranchus glacialis																								x			**1**
Crustaceans	**Crustaceans, all**		x	x	x	x		x	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**23**
	Amphipods, all		x	x		x		x	x		x	x		x		x	x	x		x	x	x	x	x	x	x	x	x	**20**
	Aoridae (gammarid)	**Aoridae, all**										x		x				x		x		x				x		x	**7**
		Unciola irrorata										x		x												x	x	x	**5**
		Unciola inermis										x																	**1**
		Unciola sp.																x								x	x		**3**
		Lembos sp.																								x			**1**
		Leptocheirus pinguis										x		x				x		x		x				x	x	x	**8**
		Chyroceridae, all										x				x		x				x				x			**5**

Prey group	**Subgroups (order or family)**	**Genera or species**	**American plaice**	**Atlantic cod**	**Atlantic halibut**	**Atlantic herring**	**Atlantic sea**	**Barndoor skate**	**Clearnose skate**	**Deep-sea red**	**Haddock**	**Little skate**	**Monkfish**	**Ocean Pout**	**Offshore hake**	**Pollock**	**Redfish**	**Red hake**	**Rosette skate**	**Silver hake**	**Smooth skate**	**Thorny skate**	**White hake**	**Witch flounder**	**Windowpane**	**Winter flounder**	**Winter skate**	**Yellowtail**	**Count**
	Ischyroceridae (gammarid)	*Ericthonius rubricornis*										x				x						x						x	**4**
		Ericthonius sp.																x								x			**2**
	Ampeliscids (gammarid)	**Ampeliscids, all**										x						x		x		x				x	x		**6**
		Byblis serrata										x								x		x				x	x		**5**
		Ampelisca sp.																x		x						x			**3**
		Ampelisca agassizi																		x						x			**2**
		Ampelisca spinipes																		x									**1**
		Ampelisca vadorum																		x						x			**2**
		Ampelisca abdita																		x						x			**2**
	Haustoriids (gammarid)	**Haustoriids, all**										x															x		**2**
	Oedicerotids (gammmarid)	**Oedicerotids, all**										x						x		x		x					x	x	**6**
		Monoculodes intermedius										x								x									**2**
		Monoculodes spp.										x						x											**2**
		Monoculodes edwardsi										x								x		x					x		**4**
		Synchelidium sp.										x																	**1**
	Eusiridae (gammarid)	**Eusiridids, all**																x								x			**2**
		Pontogeneia inermis																x								x			**2**
	lysianassidae (gammarid)	**lysianassids, all**																				x					x		**2**
		Psammonyx nobilis																				x					x		**2**
		Hippomedon serratus																				x					x		**2**
	Melitidae (gammarid)	**Melitids, all**																				x							**1**
		Melita dentata																				x							**1**
	Uristidae (gammarid)	**Uristids, all**																					x						**1**
		Anonyx sarsi																					x						**1**
	Corophiidae	**Corophids, all**																								x			**1**
		Corophium sp.																								x			**1**

Prey group	Subgroups (order or family)	Genera or species	American plaice	Atlantic cod	Atlantic halibut	Atlantic herring	Atlantic sea	Barndoor skate	Clearnose skate	Deep-sea red	Haddock	Little skate	Monkfish	Ocean Pout	Offshore hake	Pollock	Redfish	Red hake	Rosette skate	Silver hake	Smooth skate	Thorny skate	White hake	Witch flounder	Windowpane	Winter flounder	Winter skate	Yellowtail	Count
		Corophium lacustre																											**0**
	Podoceridae (gammarid)	**Podocerids, all**																										x	**1**
		Dulichia sp.																										x	**1**
	Gammeridae (gammarid)	**Gammarids, all**																x		x					x	x		x	**5**
		Gammarus lawrencianus																x		x					x	x			**4**
		Gammarus annulatus																							x			x	**2**
		Gammarus sp.																								x			**1**
	Other gammarids	Unidentified gammarids										x							x		x	x					x	x	**6**
	Caprellids	**Caprellids, all**										x														x			**2**
		Aeginina longicornis																								x			**1**
	Hyperiids	**Hyperiids, all**												x			x			x									**3**
		Parathemisto sp.												x			x												**2**
	Cumaceans	**Cumaceans, all**	x									x								x		x							**4**
	Isopods	**Isopods, all**						x				x						x			x	x				x	x		**7**
		Cirolana [= *Politolana?] polita*																				x					x		**2**
	Decapods, all		x	x	x			x	x		x	x		x	x	x	x	x	x	x	x	x	x		x	x	x	x	**21**
	Other decapods	*Eualus pusiolus*																				x							**1**
		mud shrimp (*Upogebia affinis*)							x			x																	**2**
		Pasiphaea sp.													x					x									**2**
		Crangon septemspinosa	x	x	x			x	x			x				x		x		x	x		x		x	x	x	x	**15**
		Sclerocrangon boreas																		x									**1**
		Palaemonetes sp.																								x			**1**
		Mantis shrimps							x			x																	**2**

Prey group	Subgroups (order or family)	Genera or species	American plaice	Atlantic cod	Atlantic halibut	Atlantic herring	Atlantic sea	Barndoor skate	Clearnose skate	Deep-sea red	Haddock	Little skate	Monkfish	Ocean Pout	Offshore hake	Pollock	Redfish	Red hake	Rosette skate	Silver hake	Smooth skate	Thorny skate	White hake	Witch flounder	Windowpane	Winter flounder	Winter skate	Yellowtail	Count
	Pandalid shrimp	**Pandalid shrimp, all**		x	x							x			x	x	x	x		x	x	x	x		x		x		13
		Dichelopandalus leptocerus										x			x	x		x		x		x	x				x		8
		Pandalus borealis														x				x			x						3
	Crabs	**Crabs, all**		x	x			x	x			x		x				x	x	x	x	x				x	x		13
		Cancer spp.		x	x			x	x			x		x				x	x			x				x	x		11
		mud crabs							x																				1
		spider crabs/*Hyas*						x	x					x								x							4
		hermit/pagurid							x			x						x			x	x				x	x		7
		lady crab (*Ovalipes ocellatus*)							x			x															x		3
		Lobster						x																					1
	Euphausids	**Euphausiids, all**	x	x		x		x			x				x	x	x	x		x	x	x	x						13
		Meganyctiphanes norvegica				x									x	x	x	x		x		x	x						8
		Thysanoessa inermis				x																							1
		Thysanoessa raschi													x														1
	Mysid shrimp	mysid shrimp, all	x	x					x			x						x		x	x	x			x	x			10
		Neomysis americana		x					x			x						x		x					x	x			7
		Heteromysis formosa																x		x									2
		Erythrops erythrophthalma																				x							1
		Mysidopsis bigelowi																							x				1
Mollusks	**Mollusks, all**		x	x	x	x		x	x	x	x	x	x	x	x	x		x		x		x	x		x	x	x		20

Prey group	Subgroups (order or family)	Genera or species	American plaice	Atlantic cod	Atlantic halibut	Atlantic herring	Atlantic sea	Barndoor skate	Clearnose skate	Deep-sea red	Haddock	Little skate	Monkfish	Ocean Pout	Offshore hake	Pollock	Redfish	Red hake	Rosette skate	Silver hake	Smooth skate	Thorny skate	White hake	Witch flounder	Windowpane	Winter flounder	Winter skate	Yellowtail	Count
	Bivalves	**Bivalves, all**	x					x	x		x	x		x				x								x	x		**9**
		razor clam *(Ensis directus)*						x	x			x														x	x		**5**
		Chlamys islandica	x																										**1**
		Cyclodardia borealis	x																										**1**
		Pectinidae												x															**1**
		Cerastoderma pinnulatum												x															**1**
		clam siphons																								x			**1**
		blue mussels																								x			**1**
		Macoma sp.																								x			**1**
		Solemya sp.																								x			**1**
		Nuculla proxima																								x			**1**
		Tellina agilis																								x			**1**
		Yoldia sp.																								x			**1**
		Solenidae																									x		**1**
	Gastropods	*gastropods*						x		x																			**2**
	Scaphalopods	*scaphalopods*								x																			**1**
Echinoderms	**Echinoderms, all**		x								x			x															**3**
	Ophiuroids	**Ophiuroids, all**	x								x			x															**3**
		Ophiura sarsi	x											x															**2**
		Ophiopholis aculeata												x															**1**
	Echinoids	**Echinoids, all**	x											x															**2**
		Echinarachnius parma	x											x															**2**
	Asteroids	**Asteroids, all**	x																										**1**

Table 57 – Summary of benthic fish prey consumed by managed species

Benthic fish species	American plaice	Atlantic cod	Atlantic halibut	Atlantic herring	Atlantic sea	Barndoor skate	Clearnose skate	Deep-sea red	Haddock	Little skate	Monkfish	Ocean Pout	Offshore hake	Pollock	Redfish	Red hake	Rosette skate	Silver hake	Smooth skate	Thorny skate	White hake	Witch flounder	Windowpane	Winter flounder	Winter skate	Yellowtail	Count
Silver hake		x	x			x					x		x	x	x	x		x	x	x	x		x		x		**14**
White hake																					x						**1**
Other hakes		x				x					x		x														**4**
Cod			x								x																**2**
Haddock											x																**1**
Tomcod											x																**1**
Other gadids		x	x										x			x					x						**5**
Fourbeard rockling											x																**1**
Redfish		x																									**1**
Toadfish		x																									**1**
Windowpane							x																				**1**
Winter flounder							x																		x		**2**
Witch flounder											x								x								**2**
Yellowtail flounder																			x								**1**
Flatfish/flounder		x				x	x				x																**4**
Eelpouts/Ocean pout			x																								**1**
Longhorn sculpin			x																						x		**2**
Sculpins						x					x																**2**
Rock eel			x																								**1**
Sand lance		x	x			x			x		x			x		x		x	x	x			x	x	x		**13**
Cunner						x					x																**2**
Tautog						x					x																**2**

Benthic fish species	**American plaice**	**Atlantic cod**	**Atlantic halibut**	**Atlantic herring**	**Atlantic sea**	**Barndoor skate**	**Clearnose skate**	**Deep-sea red**	**Haddock**	**Little skate**	**Monkfish**	**Ocean Pout**	**Offshore hake**	**Pollock**	**Redfish**	**Red hake**	**Rosette skate**	**Silver hake**	**Smooth skate**	**Thorny skate**	**White hake**	**Witch flounder**	**Windowpane**	**Winter flounder**	**Winter skate**	**Yellowtail**	**Count**
Weakfish							**x**				**x**																**2**
Scup							**x**																				**1**
Tonguefish							**x**																				**1**
Conger eel							**x**																				**1**
Croaker							**x**																				**1**
Spot							**x**																				**1**
Nezumia/grenadier								**x**																			**1**
Cusk																							**x**				**1**
Gobies																							**x**				**1**
Black sea bass											**x**																**1**
Sea raven											**x**																**1**
Searobins											**x**					**x**											**2**
Wolffish														**x**													**1**
Wrymouth																				**x**							**1**
Spiny dogfish						**x**					**x**																**2**
Hagfish																				**x**							**1**
Skates											**x**														**x**		**2**

Table 58 – Peak spawning periods.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Notes
American plaice			M	P	P	M							GLOBEC: Georges Bank peak egg abundance also in March.
Atlantic cod, GB	M	P	P	P	M						M	M	GLOBEC: peak February-March, mostly on Northeast Peak.
Atlantic cod, GOM	P	P	P	P	P	M					M	M	Peak spawning period varies depending on location; spawning occurs later in year in more northerly regions.
Atlantic halibut (Can.)	M	M	M	M	M						P	P	Spawning on slopes of continental shelf and offshore banks.
Atlantic herring, GB							M	P	P	P	M		Includes Nantucket Shoals.
Atlantic herring, GOM								M	P	P	P	M	Coastal areas, includes Jeffreys Ledge.
Atlantic salmon										M	M		Spawn in freshwater; no peak periods given.
Haddock, GB	M	P	P	P	M	M							Concentrated on Northeast Peak.
Haddock, GOM		P	P	P	M								Two primary spawning sites are Jeffreys Ledge, Stellwagen Bank.
Monkfish			M	M	P	P	M	M	M				
Ocean pout								P	P	P	M	M	Earlier peak spawning (August-October) in the south.
Offshore hake		M	M	M	M	M	M	M	M	M			No peak periods given; spawning occurs over a protracted period or continually throughout the year.
Pollock	P	P	M	M					M	M	P	P	Spawning time more variable in north than in south.
Redfish				M	P	P	P	P					Eggs fertilized internally, larvae released. MARMAP: peak August.
Red hake, GOM					M	M	P	P	M				
Red hake, GB					P	P	M	M	M				
Red hake, MAB/SNE			M	M	M	M	M	M	M	M			No peak periods given.
Red hake, NYB					P	P	M	M	M	M	M		
Silver hake					P	P	P	P	M	M			Peak May-June in southern stock, July-August in northern stock.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Notes
White hake, southern stock				M	M								Deep waters along continental slope, primarily off southern Georges Bank and Mid-Atlantic Bight. No peak periods given.
Windowpane, GB				M	M	M	P	P	M	M			MARMAP.
Windowpane, MAB		M	M	M	P	M	M	M	P	P	M		Split spawning season. MARMAP data included.
Winter flounder	M	P	P	P	P						M	M	Spawning occurs earlier in southern part of range. Peak: February, March in Mass. Bay and south of Cape Cod and somewhat later along coast of Maine continuing into May. GB peak (MARMAP/GLOBEC egg collections): March-May.
Witch flounder, GB/GOM				M	P	P	P	P	M	M	M		Spawning occurs progressively later from south to north.
Witch flounder, MAB			M	M	P	P	M	M					Spawning occurs progressively later from south to north.
Yellowtail flounder			M	P	P	P	M	M					

M: Major spawning months
P: Peak spawning months
Information obtained from EFH Source Documents and Update Memos.
Table does not include Atlantic sea scallops, barndoor skate, clearnose skate, deep-sea red crab, little skate, rosette skate, smooth skate, thorny skate, winter skate.

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