Essential Fish Habitat (EFH) Assessment
Gloucester Harbor, Massachusetts
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Prepared for:
Massachusetts Office of Coastal Zone Management
251 Causeway Street, Suite 900
Boston, MA 02114-2119

Prepared by:
Maguire Group Inc.
225 Foxborough Boulevard
Foxborough, MA 02035
508-543-1700

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LIST OF ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations are used in this assessment**:**

10′ x 10′	Ten Minute by Ten Minute Quadrants
DMF	Massachusetts Department of Marine Fisheries
EFH	Essential Fish Habitat
FAH	Fluorescent Aromatic Hydrocarbons
FMC	Fisheries Management Council
FMP	Fisheries Management Plan
GHPC	Gloucester Harbor Planning Commission
MAFMC	Middle Atlantic Fisheries Management Council
MCZM	Massachusetts Office of Costal Zone Management
NEFMC	New England Fisheries Management Council
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PAH	Polyaromatic Hydrocarbon
pH	Per cent hydrogen ion concentration
PCA	Polychlorinated Alkane
PCB	Polychlorinated Biphenyl
SAV	Submerged Aquatic Vegetation
USACE	United States Army Corps of Engineers
YOY	Young of Year

1.0 INTRODUCTION

The Magnuson-Stevens Act of 1976 (Act) was passed in order to promote fish conservation and management. Under the Act, the National Marine Fisheries Service (NMFS) was granted legislative authority for fisheries regulation in the United States within a jurisdictional area located between three miles to 200 miles offshore, depending on geographical location. NMFS is an agency within the National Oceanic and Atmospheric Administration (NOAA) within the United States Department of Commerce (American Oceans, 2001). The NMFS was also granted legislative authority to establish eight regional fishery management councils that would be responsible for the proper management and harvest of fish and shellfish resources within these waters. Measures to ensure the proper management and harvest of fish and shellfish resources within these waters are outlined in Fisheries Management Plans prepared by the eight councils for their respective geographic regions. Gloucester Harbor, Massachusetts lies within the management jurisdiction of the New England Fisheries Management Council (NEFMC).

Recognizing that many marine fisheries are dependent on nearshore and estuarine environments for at least part of their life cycles, the Act was reauthorized, and changed extensively via amendments in 1996. The amendments, among other things, aimed to stress the importance of habitat protection to healthy fisheries. The authority of the NMFS and their councils was strengthened by the reauthorization in order to promote more effective habitat management and protection of marine fisheries. The marine environments important to marine fisheries are referred to as essential fish habitat (EFH) in the Act and are defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." To delineate EFH, coastal littoral and continental shelf waters are first mapped by the regional FMCs and superimposed with ten minute by ten minute (10′x10′) square coordinate grids. The survey data, gray literature, peer review literature, and reviews by academic and government fisheries experts were all used by the management councils to determine if these 10′x10′ grids support essential fish habitat for federally managed species. Both the NEFMC and the Mid-Atlantic Fisheries Management Council (MAFMC) have designated EFH in Gloucester waters.

1.1 PURPOSE

Gloucester Harbor lies within portions of two areas designated as EFH for the New England Groundfish Management Plans. The delineation of these EFH areas is depicted in Figure 1-1. The Massachusetts Office of Coastal Zone Management (MCZM) has prepared this EFH assessment for use in determining the potential impact of pending or future projects within Gloucester Harbor on the existing fisheries resources. The information provided in this harbor-wide EFH assessment is available as a reference resource for use by future applicants of proposed projects within the harbor. Information provided herein serves as an overview of the existing conditions and the potential impacts of various activities that may be proposed within the harbor.

It does not take the place of an individual EFH assessment for any specific proposed project as a stand-alone document. If used by others when preparing an EFH assessment within Gloucester Harbor, the information provided herein should be updated with temporally current conditions of the harbor and it should be augmented with project specific descriptions of the proposed action.

1.2 DESCRIPTION OF THE STUDY AREA

Gloucester Harbor is located on the north shore of the Massachusetts coast and borders the communities of Rockport to the east, and Manchester-By-The-Sea and Essex to the west (Figure 1-1). It is approximately 30 miles (48 kilometers) north of Boston and approximately 25 miles (40 kilometers) south of Portsmouth, NH. The harbor shoreline is characterized by intermittent smaller embayments separated by rocky headlands. Depths range from zero to 50 feet (0.0 to 15.2 meters). Figure 1-2 depicts the distribution of water depths throughout the harbor. The mean tidal range of Gloucester Harbor is 8.7 feet (2.65 meters) (NVAI, 1996). There are no major freshwater tributary streams to the harbor. However, the Annisquam River, a tidal stream fed by small fresh water tributaries is hydrologically connected to the western area of Gloucester Harbor.

The harbor mouth extends from Mussel Point, east to the Dogbar Breakwater at Eastern Point (Figure 1-3). Gloucester Harbor has various smaller coves and embayments between rocky headlands around its perimeter. Beginning from the mouth of the harbor on the western shore and proceeding in a clockwise direction, the following distinct regions of the harbor are delineated. Old House Cove lies between Mussel Point and Dolliver Neck. North of that location, Freshwater Cove lies between Dolliver Neck and the rocky headland of Stage Head. Continuing northeasterly, the Western Harbor embayment lies between Stage Head to the west and Fort Point to the east. At this location, the Annisquam River bisects the Western Harbor. Proceeding southeasterly from Fort Point, the mouth of Gloucester Inner Harbor lies between Fort Point and Rocky Neck. Southeast of Rocky Neck, Wonson’s Cove lies on the eastern side of Gloucester Harbor. Proceeding southerly to the Dog Bar Breakwater, lies the Southeast Harbor first, then the headlands of Black Bess Point, and finally Lighthouse Cove. Ten Pound Island, another major geographical feature of the harbor, lies within Gloucester Harbor just outside the mouth of the Inner Harbor. In addition, numerous submerged or partially submerged rocks, reefs and ledges lie within and around the perimeter of the harbor.

Smaller coves also lie within the Inner Harbor. Harbor Cove is located on the western side of the Inner Harbor. Harbor Cove accommodates numerous marinas and docking facilities for commercial fishing and recreational boats. Smith Cove is located on the southeastern side of the Inner Harbor. The Blynman Canal provides navigational access within the Annisquam River via the Western Harbor. At this location, the channel is authorized to a depth of 8 feet (2.4 meters). Authorized depth refers to the channel depth (mean low water) that is needed to accommodate the drafts of vessels that use the channel.

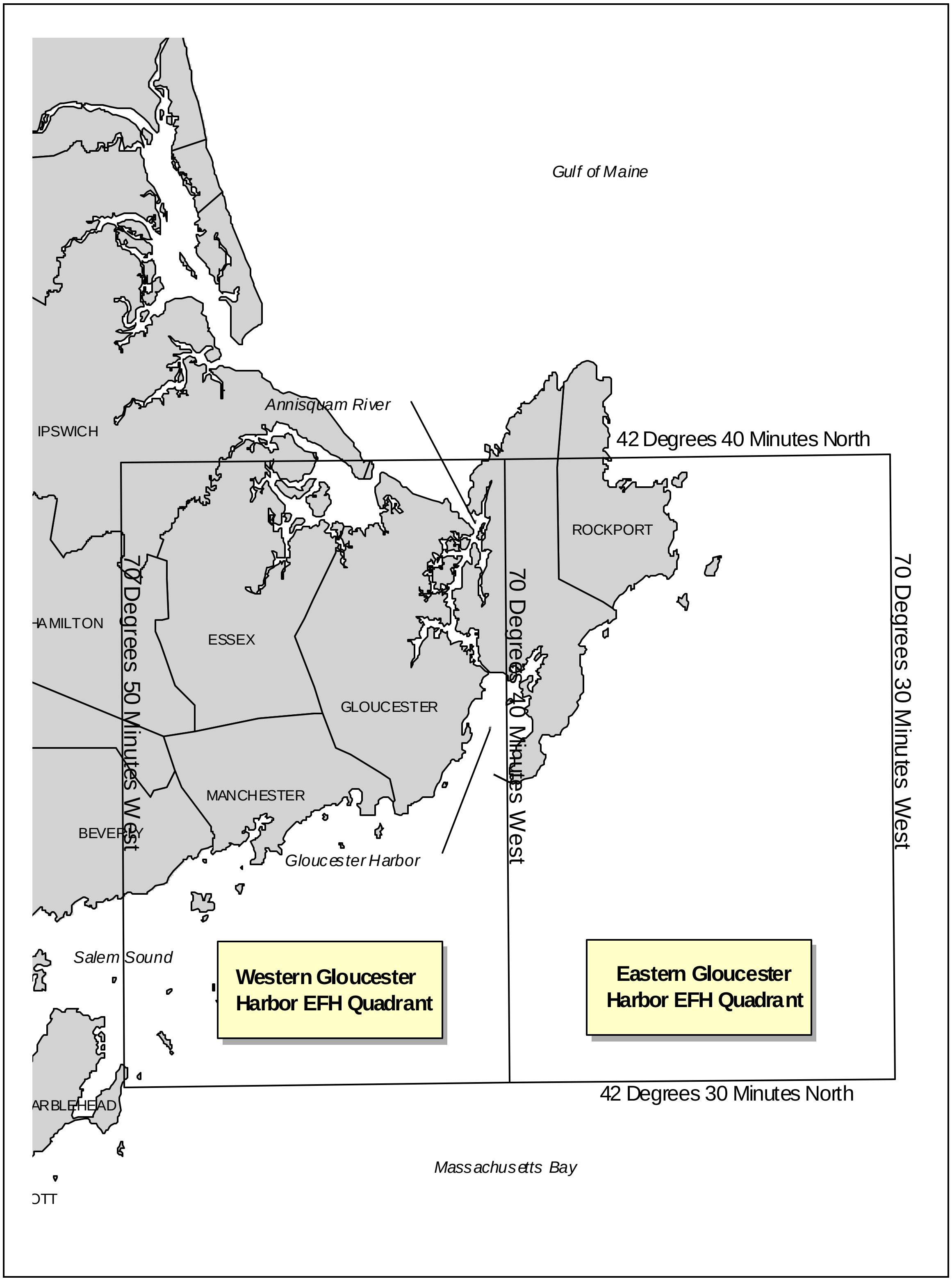

Figure 1-1. EFH Delineation Areas Inclusive of Gloucester Harbor

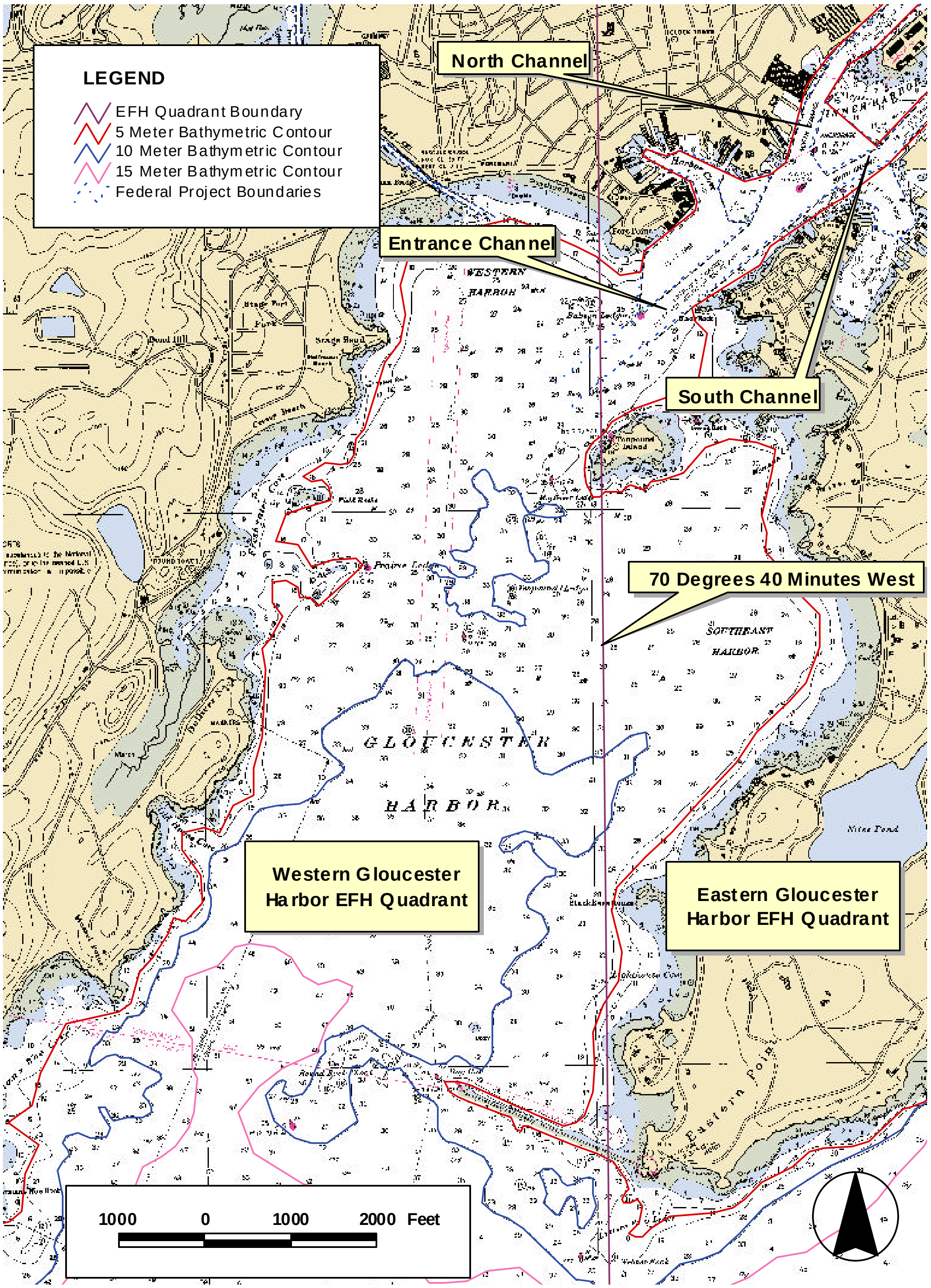

Figure 1-2. Bathymetry and Navigation Channels of Gloucester Harbor

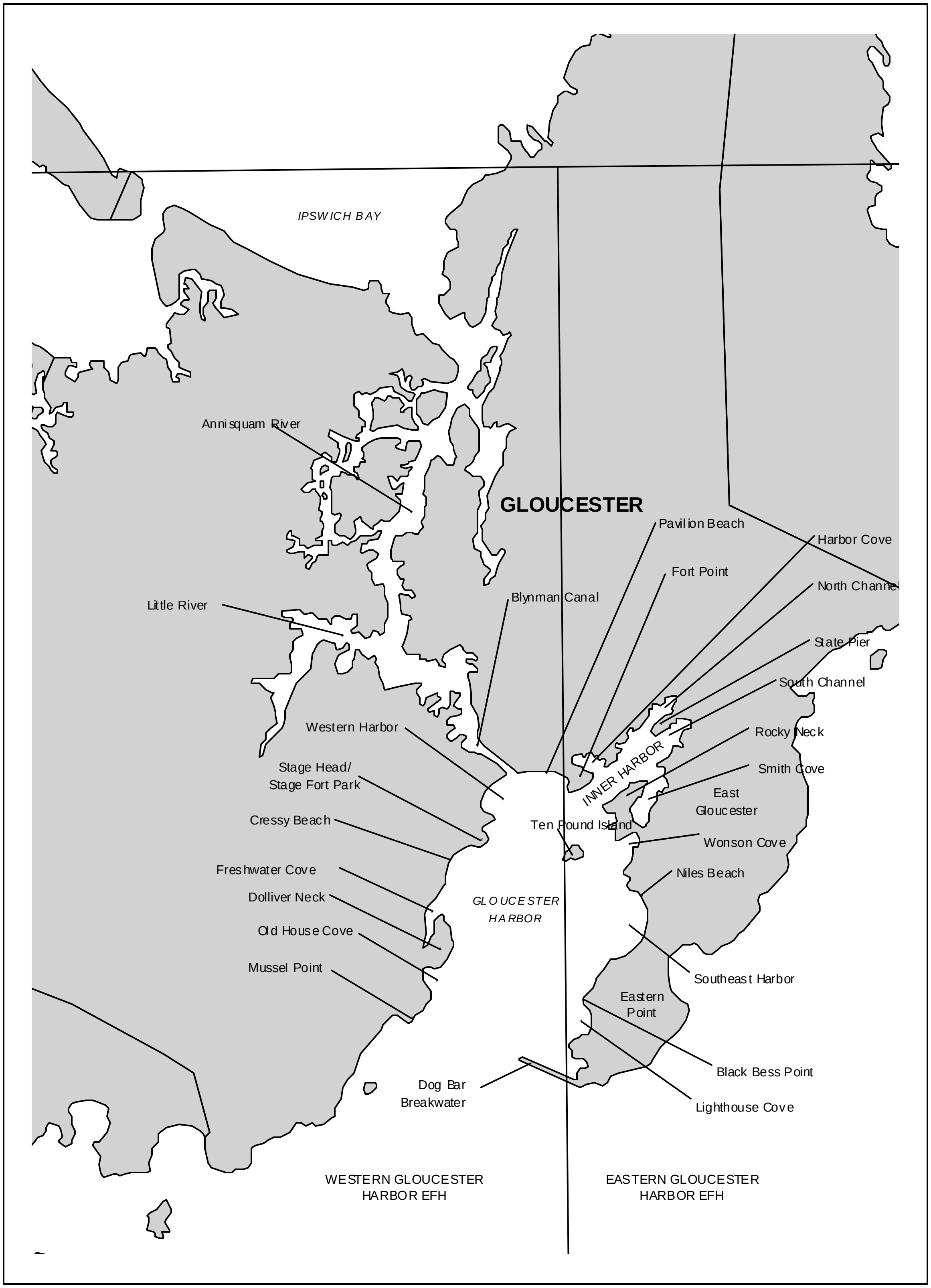

Figure 1-3. Gloucester Harbor Features Referenced in this Assessment

The United States Army Corps of Engineers (USACE) is responsible for maintaining channels at the authorized depth so long as economic justification can be established. Five channels provide access to and within the Inner Harbor (Figure 1-2). They are the Main Entrance Channel, the North Channel, the South Channel, Harbor Cove Channel, and Smith Cove Channel. The main federal navigation channel leading into the Inner Harbor (the Entrance Channel) is authorized to a depth of 20 feet (6.1 meters). It terminates at the Inner Harbor Anchorage Area, which has an authorized depth of 16 feet (4.9 meters). Here the channel forks into the North and South Channels relative to the State Fish Pier. North of the Main Entrance Channel lays Harbor Cove, its entrance channel, and anchorage areas. Harbor Cove Channel has an authorized depth of 18 feet (5.5 meters); the adjacent anchorage area 15 feet (4.6 meters). Both North and South Channel have an authorized depth of 20 feet (6.1 meters). Smith Cove Channel has an authorized depth of 16 feet (4.9 meters) (USACE, 1992). Figure 2 depicts the location of the navigation channels in the harbor. The harbor contains several marinas, a significant recreational fleet, harborside historical attractions, and various commercial fishing fleets and fish processing/cold storage facilities.

1.3 EFH DESIGNATION AREAS

All of Gloucester Harbor is designated as EFH. The harbor provides EFH for at least one life stage for 25 of the 30 managed species listed by the NEFMC. Data collected by NMFS for EFH areas is presented in tabular summaries, which correspond to ten-minute by ten-minute squares of latitude and longitude. An area of Gloucester Harbor is included in two of these 10′ x 10′ squares. One square includes the western half of Gloucester Harbor, Annisquam River, Ipswich Bay, and points west (e.g. eastern Salem Sound). The other square includes eastern Gloucester Harbor and points east (e.g. the eastern and southeastern shore of Cape Ann, Rockport Harbor). The tabular data summaries presented for each of these squares is presented in Tables 1-1 and 1-2.

Distribution of the managed species is a function of three major interdependent components: physical, chemical, and biological. Variation of any or all of these components may affect the distribution of the managed species within the harbor. This EFH Assessment was prepared based on the known specific habitat requirements for each life history stage of the listed managed species for the two EFH areas which include Gloucester Harbor and the Annisquam River, and knowledge of potential pending and future projects within the harbor that may impact these managed species.

Table 1-1. Summary of EFH Designation for Area Inclusive of Western Gloucester Harbor

10¢ x 10¢ Square Coordinates				
Boundary	**North**	**East**	**South**	**West**
Coordinate	42° 40.0’ N	70° 40.0’ W	42° 30.0’ N	70° 50.0’ W

Species	**Eggs**	**Larvae**	**Juveniles**	**Adults**
Atlantic cod *(Gadus morhua)*	X	X	X	X
haddock *(Melanogrammus aeglefinus)*	X	X	X	
pollock *(Pollachius virens)*	X	X	X	X
whiting *(Merluccius bilinearis)*	X	X	X	X
offshore hake *(Merluccius albidus)*				
red hake *(Urophycis chuss)*	X	X	X	X
white hake *(Urophycis tenuis)*	X	X	X	X
redfish *(Sebastes fasciatus)*	N/A	X	X	X
witch flounder *(Glyptocephalus cynoglossus)*				
winter flounder *(Pleuronectes americanus)*	X	X	X	X
yellowtail flounder *(Pleuronectes ferruginea)*	X	X	X	X
windowpane flounder *(Scopthalmus aquosus)*	X	X	X	X
American plaice *(Hippoglossoides platessoides)*	X	X	X	X
ocean pout *(Macrozoarces americanus)*	X	X	X	X
Atlantic halibut *(Hippoglossus hippoglossus)*	X	X	X	X
Atlantic sea scallop *(Placopecten magellanicus)*	X	X	X	X
Atlantic sea herring *(Clupea harengus)*		X	X	X
monkfish *(Lophius americanus)*				
bluefish *(Pomatomus saltatrix)*			X	X
long finned squid *(Loligo pealei)*	N/A	N/A	X	X
short finned squid *(Illex illecebrosus)*	N/A	N/A	X	X
Atlantic butterfish *(Peprilus triacanthus)*	X	X	X	X
Atlantic mackerel *(Scomber scombrus)*	X	X	X	X
summer flounder *(Paralicthys dentatus)*				X
scup *(Stenotomus chrysops)*	N/A	N/A	X	X
black sea bass *(Centropristus striata)*	N/A			X
surf clam *(Spisula solidissima)*	N/A	N/A	X	X
ocean quahog *(Arctica islandica)*	N/A	N/A		
spiny dogfish *(Squalus acanthias)*	N/A	N/A		
tilefish *(Lopholatilus chamaeleonticeps)*				

Square Description (i.e. habitat, landmarks, coastline markers): Waters within the square around western Cape Ann within the Atlantic Ocean within Massachusetts Bay surrounding: Manchester, MA., Manchester Bay, Bakers Island, Great Misery Island, Annisquam, MA., and Annisquam River, Essex Bay and Essex River, West Gloucester Harbor, western Gloucester, MA., Cross Island, southern Hog Island, and Kettle Island. Features also affected include: eastern Salem Sound, Manchester Harbor, Gales Pt., Beverly Farms, MA., Children’s I., Children’s I. Channel, Salem Channel, Newcomb Ledge, Halfway Rock, Cole Ridge, Middle Ground, Kettle Ledge, Burnham Rocks, Saturday Night Ledge, Great Egg Rock, Eagle Head, Town Head, Coolidge Pt., Magnolia, MA., Norma’s Woe Cove, and western Gloucester Harbor.

Key: X = Designated as EFH for this species and life stage.
N/A = not applicable to species.

Source: US Department of Commerce, National Oceanic and Atmospheric Administration (NOAA)

Table 1-2. Summary of EFH Designation for Area Inclusive of Eastern Gloucester Harbor

10¢ x 10¢ Square Coordinates				
Boundary	**North**	**East**	**South**	**West**
Coordinate	42° 40.0’ N	70° 30.0’ W	42° 30.0’ N	70° 40.0’ W

Species	**Eggs**	**Larvae**	**Juveniles**	**Adults**
Atlantic cod *(Gadus morhua)*	X	X	X	X
haddock *(Melanogrammus aeglefinus)*			X	
pollock *(Pollachius virens)*				
whiting *(Merluccius bilinearis)*	X	X	X	X
offshore hake *(Merluccius albidus)*				
red hake *(Urophycis chuss)*	X	X	X	X
white hake *(Urophycis tenuis)*	X	X	X	X
redfish *(Sebastes fasciatus)*	N/A	X	X	X
witch flounder *(Glyptocephalus cynoglossus)*		X	X	
winter flounder *(Pleuronectes americanus)*	X	X	X	X
yellowtail flounder *(Pleuronectes ferruginea)*		X	X	X
windowpane flounder *(Scopthalmus aquosus)*				
American plaice *(Hippoglossoides platessoides)*			X	X
ocean pout *(Macrozoarces americanus)*	X	X	X	X
Atlantic halibut *(Hippoglossus hippoglossus)*	X	X	X	X
Atlantic sea scallop *(Placopecten magellanicus)*	X	X	X	X
Atlantic sea herring *(Clupea harengus)*		X	X	X
monkfish *(Lophius americanus)*	X	X	X	X
bluefish *(Pomatomus saltatrix)*				
long finned squid *(Loligo pealei)*	N/A	N/A	X	X
short finned squid *(Illex illecebrosus)*	N/A	N/A	X	X
Atlantic butterfish *(Peprillus triacanthus)*	X	X	X	X
Atlantic mackerel *(Scomber scombrus)*	X	X	X	X
summer flounder *(Paralicthys dentatus)*				X
scup *(Stenotomus chrysops)*	N/A	N/A		
black sea bass *(Centropristus striata)*	N/A			X
surf clam *(Spisula solidissima)*	N/A	N/A	X	X
ocean quahog *(Artica islandica)*	N/A	N/A	X	X
spiny dogfish *(Squalus acanthias)*	N/A	N/A		
tilefish *(Lopholatilus chamaeleonticeps)*				

Square Description (i.e. habitat, landmarks, coastline markers): Waters within the square within the Atlantic Ocean surrounding: eastern Gloucester Harbor, eastern Gloucester, MA., Eastern Point, Salt Island., Salt Ledge, Milk Island, Thatcher Island, Emerson Point, Londoner, Avery Ledge, and Straitsmouth Island, and including within Sandy Bay, and around Rockport, MA.

Key: X = Designated as EFH for this species and life stage.
N/A = not applicable to species

Source: US Department of Commerce, National Oceanic and Atmospheric Administration (NOAA)

1.4 Existing Marine Fish Community of Gloucester Harbor

Gloucester Harbor is home to a number of fish species and other marine life. Fish species include both commercial and recreational species, bottom dwelling and free-swimming water column species and resident and migratory species. Ecologically, the harbor functions both as an ocean embayment and estuarine environment. Compared to classic estuaries, which receive large freshwater inputs, Gloucester Harbor does not have many freshwater tributaries entering the harbor. However, its numerous smaller coves and the tidal Annisquam River, provide spawning and nursery potential for a number of the harbor's fish.

The fish life of Gloucester Harbor has been characterized largely by two primary studies. Jerome (1969) conducted the first comprehensive study of the harbor's fish life for the Massachusetts Department of Marine Fisheries (DMF) from 1966-1967. The second study was conducted by Normandeau Associates, Inc. (NAI) in 1999. This recent effort was conducted as part of the Environmental Assessment for the Gloucester Harbor Dredged Material Management Plan, which was being prepared for the City of Gloucester by Massachusetts Coastal Zone Management (MACZM). Fish species identified within Gloucester Harbor during these studies are presented in Table 1-3.

1.4.1 Summary of Jerome et al., (1969) Surveys

Four shore stations and four off-shore stations were sampled by Jerome between 1966 and 1967. During shore sampling efforts, two 50-foot trawls were made with a 20 x 8 foot minnow seine with a 3/16th inch mesh size. Two sets were also conducted with a 60 by 4 foot haul seine with a 1/8th inch mesh size. For offshore sampling, a shrimp trawl was outfitted with a 30-foot sweep and a 25-foot headrope, and a seine stretch-mesh size of 1 inch in the cod end and 1½inch in the wings. A five-minute tow was conducted at each station. Catches were examined for finfish species composition, relative abundance, and size distribution.

Supplementary finfish data was also obtained employing other commercial seines and otter trawls. For near shore sampling efforts, a commercial dragger was employed, outfitted with a 120-foot haul seine with a mesh size of 1½inch in the wings and ¾inch in the bag. For offshore locations, a commercial dragger outfitted with an otter trawl having a sweep of 49 feet and a head rope of 38 feet was used to conduct twenty-minute tows at each station. Information concerning other species not captured during sampling was obtained from interviews with commercial and sport fisherman.

Near shore sampling

A total of 16 species were collected from all shore sampling stations collectively. Mummichog (*Fundulus heteroclitus*), Atlantic silverside (*Menidia menidia*) and winter flounder were the most abundant fish species collected from all shore sampling stations. They comprised 98.3% of the total finfish collected. Most of the species collected from shore locations were species tolerant of wide-ranging salinity (euryhaline species).

Examples included American sand lance (*Ammodytes hexapterus*), American smelt, Atlantic silverside, blueback herring (*Alosa aestivalis*), fourspine sticklebacks (*Apeltes quadracus*), mummichogs, ninespine sticklebacks (*Pungitius pungitius*), and winter flounder. In contrast, few truly marine fish (five species) were collected from near shore locations. The marine fish that were collected included Atlantic cod (Gadus morhua), Atlantic herring, Atlantic mackerel (*Scomber scombrus*), grubby (*Myoxocephalus aenaeus*) and lumpfish (*Cyclopterus lumpus*).

Offshore sampling

Twenty-eight species of fish were collected from seven offshore station locations. Winter flounder, yellowtail flounder, and Atlantic cod were the most abundant commercial species, while ocean pout, longhorn sculpin (*Myoxocephalus octodecimspinosus*) and fourspine sticklebacks were reported to be the most abundant "non-commercial" fish. Ten euryhaline species were collected from the offshore sampling locations including winter flounder, fourspine stickleback, blueback herring, American eels (*Anguilla rostrata*), Atlantic tomcod (*Microgadus tomcod*), Atlantic silversides, northern pipefish (*Syngnathus fuscus*) and mummichogs.

Annisquam River Saltmarsh Complex

Winter flounder was reported to be the most abundant fish species collected from estuarine waters of the Annisquam River Salt Marsh Complex. This was consistent with results reported by others within the same faunal regions (i.e., by Jerome, et al [1968] in the Parker River – Plum Island Sound estuarine system; and by Fiske et al., [1966] for the North River estuary). Atlantic silversides and mummichogs, important forage fish within the system, were also abundant.

Three of these stations in particular occurred in areas of overlap with the more recent sampling efforts conducted in the NAI study. They include one shore location (Niles Beach) and one off-shore location in the Southeast Harbor, and one off shore location within the center of the Outer Harbor between Dolliver Neck to the west and Black Bess Point to the east. For a comparison of fish community assemblages over time, the total species richness lists of these overlapping stations are presented in Table 1-3.

1.4.2 Summary of NAI Results

During the NAI study, seine and trawl sampling was conducted for fisheries in Gloucester Harbor from June 1998 through May 1999. Sampling methodology was consistent with the previous DMF study (Jerome et al., 1969). Fish sampling occurred twice per month at four nearshore locations and four deeper water locations within Gloucester Harbor.

1.4.2.1 Shore Surveys

Nearshore sampling locations consisted of a 50-foot seine with a 3/16 delta mesh, positioned parallel to shore in approximately 1 m of water and then directly hauled to shore covering a rectangular area. These seine sampling efforts resulted in large catches of a few species. On several sampling dates, no fish were caught. The most numerous fish captured by the seine was the Atlantic silverside, which accounted for 43% of the total catch at all seine-sampling locations. Winter flounder comprised 8%, while lumpfish blueback herring, and mummichog all comprised 6%. The shore seine sampling locations were Pavillion Beach, the northeast side of Ten Pound Island, near Halfmoon Beach and at Niles Beach.

Sampling revealed that the abundance of Atlantic silversides generally rose throughout the summer to a peak in abundance in September and October, primarily due to an increase in the capture of Young of Year (YOY) fish. The lowest numbers in the catch were observed from November through March and began to increase thereafter. Winter flounder, which ranked second in catch, was highest in September. Most of the captured comprised of YOY fish (less than 100 mm). Sampling events in January through April decreased to zero, due to the fish moving to deeper water. Lumpfish ranked third in overall catch and were primarily captured during one sampling event. Based on the captured fish length, most of the sample was comprised of YOY fish.

Blueback herring were recorded at the Ten Pound Island and Halfmoon Beach sample stations in June and July. Largely, the sample contained fish that were between 55 and 92 mm long, considered to be YOY. Mummichog were present in August, October and November, primarily at the Halfmoon Beach sampling station, at lengths less than 60 mm. Other fish observed in the sample catches were windowpane, Atlantic menhaden (*Brevoortia tyrannus*), northern pipefish, northern puffer (*Sphoeroides maculatus*) and grubby. Seine sampling revealed that fish species total abundance and diversity was generally greatest in the late summer and early fall months.

1.4.2.2 Offshore Surveys

Deeper water sampling was conducted with a 30-foot trawl made of 2-inch stretch mesh in the body and 1-inch stretch mesh in the cod end with a 1/4-inch liner. Each trawl was towed for approximately 400 m. When a 400 m tow length was not achieved, the length and catch was standardized by the following mathematical equation.

$$CPUE_{s,t} = (CATCH_{s,t}/TOW_t)\ 400$$

where,

$CPUE_{s,t}$ = Catch per unit effort for species S in Sample T
$CATCH_{s,t}$ = Catch of species S in sample T
TOW_t = Tow length in m of sample T

The trawl catches characterized the fish community of depths from 18 to 36 feet, within Gloucester Harbor. Trawl sampling locations were located in the Southeast Harbor at a depth of 30 to 36 feet (9 to 11 meters), in the outer Gloucester Harbor at a depth of 29-35 feet (8.8 to 10.7 meters), at the entrance to Blynman Canal at depths ranging from 18 to 25 feet (5.5 to 7.6 meters), and within the Inner Harbor near the entrance to the North Channel at depths between 25 and 28 feet (7.6 to 8.5 meters).

Catches were numerically dominated by winter flounder representing 27% of the CPUE, skates (*Rajaformes*), 20%, Atlantic cod 12%, and both red hake and rock gunnel (*Pholis gunnellus*) 7%. The skate species were grouped into one category due to the difficulty in field identification. Skates ranked first in biomass.

Monthly CPUE was relatively consistent from June through November, and then decreased during December through February as water temperatures decreased and the fish moved to deeper water (Figure 5-20). On average, monthly CPUE began to increase in March and reached the highest levels in April and May. Winter flounder and Atlantic cod contributed to the high CPUE in April and high catches of cod and skates resulted in the high CPUE in May. The fifth most abundant fish captured in Gloucester Harbor, rock gunnel, was observed in every month except August and January.

The DMF and NAI studies provide data, which is useful in characterizing the fish community of Gloucester Harbor. Fifteen species where captured in the DMF study, 23 species in the NAI study. These species represent a variety of feeding guilds and habitat requirements, which are apparently provided by the various features of Gloucester Harbor. However, limitations of the sampling method and sampling gear used during the studies prevent successful capture of every species known to occur within the harbor at any one time. For instance, faster, migratory, and pelagic species such as bluefish, tuna, billfishes, and swordfish; and fossorial fish such as eels, most likely could evade capture. Therefore, it is important to note that these studies actually under-represent the true species richness of Gloucester Harbor.

Table 1-3. Fishes collected from 1966-1967 and 1998-1999 surveys (Jerome et al. 1969; Normandeau 1999)

Common Name	***Scientific Name***	**1966-1967**	**1998-1999**
Atlantic cod	*Gadus morhua*	x	x
Atlantic silverside	*Menidia menidia*		x
Atlantic tomcod	*Microgadus tomcod*	x	
Atlantic wolffish	*Anarhichas lupus*	x	
Blueback herring	*Alosa aestivalis*		x
Butterfish	*Peprilus triancanthus*		x
Cunner	*Tautogolabrus adspersus*	x	x
Grubby	*Myxocephalus aenaeus*		x
Hake spp.	*Urophycis spp.*		x
Longhorn sculpin	*Myoxocephalus octodecemspinosus*	x	x
Lumpfish	*Cyclopterus lumpus*	x	x
Northern pipefish	*Syngnathus fuscus*		x
Ocean pout	*Macrozoarces americanus*	x	x
Pollock	*Pollachius virens*	x	x
Radiated shanny	*Ulvaria subbifurcata*		x
Rainbow smelt	*Osmerus mordax*	x	x
Red hake	*Urophycis chuss*		x
Rock gunnel	*Pholis gunnelus*		x
Sea raven	*Hemitripterus americanus*	x	x
Seasnail	*Liparis spp.*	x	x
Shorthorn sculpin	*Myoxocephalus scorpius*		x
Skates	*Raja spp.*	x	x
White hake	*Urophycis tenuis*		x
Windowpane	*Scophthalmus aquosus*	x	x
Winter flounder	*Pseudopleuronectes americanus*	x	x
Yellowtail flounder	*Limanda ferruginea*	x	

2.0 ESSENTIAL FISH HABITAT DESCRIPTIONS

Information on habitat requirements for the listed EFH species is provided in this section. This information was synthesized from various publications from NOAA, NMFS and the NEFMC. The information provided herein presents the special habitat requirements of the EFH species during the various stages of their life cycles. It should be noted that it is possible during dispersal, disturbance events, or as a result of other stimuli in the environment, for these listed EFH species to be found in habitats that deviate from those listed here. Therefore, the reader should note that potential seasonal and spatial variability of the conditions associated with these species are possible and should be expected.

In addition, the EFH quadrants that include the eastern and western portions of Gloucester Harbor also include offshore areas. The offshore areas typically reach greater depths than inside the harbor. Therefore, many species and their life stages listed in the EFH tables may not likely occur within Gloucester harbor. Where this applies to an EFH species or a species life stage, it is indicated below.

Information on commercial landings applicable to some of the following EFH species is provided as an indication of the commercial importance of that particular species. However, the commercial fish landed in Gloucester Harbor are not harvested from Gloucester Harbor, but rather from off-shore fishing grounds.

2.1 AMERICAN PLAICE (*Hippoglossoides platessoides*)

American plaice is a right-eye flounder (family *Pleuronectidae*) that ranges in North America from southern Labrador and Greenland, south to Rhode Island (Robins and Ray, 1986). This species is of great commercial value to the Gloucester Harbor commercial fishery. American plaice landings in Gloucester Harbor in 1999 were recorded at 998,000 pounds (452,693 kilograms). The Western Gloucester Harbor Quadrant is a designated EFH for American plaice eggs, larvae, juveniles, and adults, while the Eastern Gloucester Harbor Quadrant is a designated EFH for American plaice juveniles and adults (Refer to Tables 1-1 and 1-2).

Eggs

Viable eggs are found in bays or estuaries with greater than 25 parts per thousand ($^{o}/_{oo}$) salinity and temperatures below 54°F (12°C). Eggs can be observed all year, with peak densities occurring between April and May (NEFMC, 1998).

Larvae

Larvae are typically found in surface waters between 98 and 427 feet (30 and 130 meters) deep and at temperatures below 57°F (14°C). The larvae tolerate a wide range of salinities. They can be found between January and August, with peak densities occurring in April and May (NEFMC, 1998).

Juveniles
American plaice juveniles are found in bottom sediments ranging from fine–grained to sand or gravel substrates. Juveniles require water temperatures below 63°F (17°C). They prefer water depths between 148 and 492 feet (45 and 150 meters) but tolerate a wide range of salinities (NEFMC, 1998).

Adults
American plaice adults are also found in bottom sediments ranging from fine–grained to sand or gravel substrates. Adults prefer water temperatures below 63°F (17°C) and water depths between 148 and 574 feet (45 and 175 meters). They tolerate a wide range of salinities. Beginning in March, adults move shoreward to spawn in water depths of less than 295 feet (90 meters). Spawning continues through June (NEFMC, 1998).

2.2 ATLANTIC COD (*Gadus morhua*)

Atlantic cod is an economically important member of the family *Gadidae*. Atlantic cod landings in Gloucester Harbor in 1999 were recorded at 2,320,000 pounds (1,052,352 kilograms). This fish ranges in North America from southern Greenland and southeast Baffin Island, south to Cape Hatteras, North Carolina (winter) (Robins and Ray, 1986). Both Western and Eastern Gloucester Harbor Quadrants are designated EFH for eggs, larvae, juveniles, and adults of Atlantic cod.

Eggs
Viable eggs are reportedly found in harbor waters with a salinity range of greater than 32 to 33°/$_{00}$ and temperatures below 63°F (12°C). Eggs are observed beginning in the fall, with peak densities occurring in the following winter and spring (NEFMC, 1998).

Larvae
Cod larvae are typically pelagic. They can be found in nearshore waters at depths between 98 and 230 feet (30 and 70 meters) when sea surface temperatures are below 50°F (10°C) and salinity ranges from 32 to 33°/$_{00}$. Larvae are most often observed in the spring (NEFMC, 1998).

Juveniles
Atlantic cod juveniles are found in bottom habitats dominated by cobble or gravel substrates. Juveniles require water temperatures below 68°F (20°C), prefer water depths from 82 to 246 feet (25 to 75 meters) and salinity of 30 to 35°/$_{00}$ (NEFMC, 1998).

Adults
Atlantic cod adults are typically found in bottom habitats dominated by cobble, gravel or rock substrates (NEFMC, 1998). Adults prefer water temperatures below 50°F (10°C), depths from 33 to 492 feet (10 to 150 meters) and tolerate a wide range of salinities. Most cods are observed spawning during the fall, winter and early spring (NEFMC, 1998).

2.3 ATLANTIC HALIBUT (*Hippoglossus hippoglossus*)

Atlantic halibut is a right-eye flounder (family *Pleuronectidae*) that ranges in North America from southern Labrador to Chesapeake Bay (Robins and Ray, 1986). Both Western and Eastern Gloucester Harbor Quadrants are designated EFH for eggs, larvae, juveniles, and adults of Atlantic halibut.

Eggs

Eggs are usually found in pelagic waters with a maximum depth of 2,297 feet (700 meters). Salinities of less than 35°/$_{00}$ are required as are water temperatures between 39 and 45°F (4 and 7°C). Eggs can be observed between late fall and early spring, with peak densities occurring from November to December (NEFMC, 1998).

Larvae

Larvae are typically found in surface waters. A salinity range of 30 to 35°/$_{00}$ is the only requirement reported for this life stage of Atlantic halibut (NEFMC, 1998).

Juveniles

Atlantic halibut juveniles are found in bottom sediments ranging from fine–grained sediments, such as clay, to sand or gravel substrates. Juveniles inhabit waters from 66 to 197 feet (20 to 60 meters) in depth, with temperatures above 36°F (2°C) (NEFMC, 1998).

Adults

Adults are also found in bottom sediments ranging from fine–grained to sand or gravel substrates. Adults prefer water temperatures below 56°F (14^{o}C), water depths between 328 and 2,296 feet (100 and 700 meters) and salinities between 30 and 35°/$_{00}$. Between late fall and early spring, spawning adults seek out waters with temperatures below 45°F (7°C), depths of less than 2,296 feet (700 meters) and salinities less than 35°/$_{00}$. Peak spawning typically occurs in November and December (NEFMC, 1998).

2.4 ATLANTIC HERRING (*Clupea harengus*)

Atlantic herring is an economically important member of the family *Clupeidae*. This fish ranges in North America from Greenland and northern Labrador, south to North Carolina (Robins and Ray, 1986). Both Western and Eastern Gloucester Harbor Quadrants are designated EFH for larvae, juveniles, and adult Atlantic herring.

Larvae

Herring larvae are typically pelagic. Larvae prefer waters where sea surface temperatures are below 61°F (16^{o}C), water depths range from 164 and 295 feet (50 to 90 meters), and salinities of approximately 32°/$_{00}$. Larvae are typically observed from March to April with peak densities occurring from September through November (NEFMC, 1998).

Juveniles

Atlantic herring juveniles frequent open waters and bottom habitats with temperatures below 50^{o}F (10^{o}C). They prefer water depths from 49 to 443 feet (15 and 135 meters) and a salinity range of 26 to 32°/$_{00}$ (NEFMC, 1998).

Adults

Atlantic herring adults are also found in open waters and bottom habitats. They generally prefer water temperatures below 50°F (10^{o}C), inhabit water depths from 66 to 427 feet (20 to 130 meters) with salinities above 28°/$_{00}$. Atlantic herring adults use bottom habitats with a gravel, sand, cobble or shell fragment substrate for spawning. Patches of aquatic macrophytes are also used. Spawning typically occurs in water depth between 66 and 263 feet (20 and 80 meters) and in salinities ranging from 32 to 33°/$_{00}$. Spawning occurs from July through November in areas of well mixed water with tidal currents between 1.5 and 3.0 knots (NEFMC, 1998).

2.5 ATLANTIC MACKEREL (*Scomber scombrus*)

Atlantic mackerel (family *Scombridae*) ranges in North America from southern Labrador to Cape Hatteras (Robins and Ray, 1986). Both Western and Eastern Gloucester Harbor Quadrants are designated EFH for eggs, larvae, juveniles, and adults of Atlantic mackerel.

Eggs

Eggs of the Atlantic mackerel are found in both nearshore and off-shore waters. In nearshore waters they are typically found in mixing water salinity (between 0.5 and 25°/$_{00}$) to seawater salinity (greater than 25°/$_{00}$) and at depths between zero and 50 feet (zero and 15 meters). Eggs require temperatures between 41 and 73^{o}F (5 and 23°C) (NMFS, 2001).

Larvae

Larvae of the Atlantic mackerel are found in both nearshore and off-shore waters. In nearshore waters such as Gloucester Harbor they are typically found within mixing water salinity (between 0.5 and 25°/$_{00}$) to seawater salinity (greater than 25°/$_{00}$) range, at depths of 33 to 425 feet (10 to 130 meters) and at temperatures between 43 and 72^{o}F (6 and 22°C) (NMFS, 2001).

Juveniles

Atlantic mackerel juveniles are also found in both nearshore and off-shore waters. In nearshore waters such as Gloucester Harbor they are typically found in mixing water salinity (between 0.5 and 25°/$_{00}$) to seawater salinity (greater than 25°/$_{00}$) range, at depths ranging from zero (shore) to 1,050 feet (zero to 320 meters) and at temperatures between 39 and 72^{o}F (4°C and 22°C) (NMFS, 2001).

Adults

Adults are also found in both nearshore and off-shore waters. In nearshore waters such as Gloucester Harbor they are typically found in mixing water salinity (between 0.5 and

25°/$_{00}$) to seawater salinity (greater than 25°/$_{00}$) range, at depths ranging from shore between zero and 1,250 feet, (zero and 381 meters) and at temperatures between 39 and 61^{o}F (4°C and 16°C) (NMFS, 2001).

2.6 ATLANTIC SEA SCALLOP (*Placopecten magellanicus*)

Atlantic sea scallop (family *Pectinidae*) ranges in North America from Labrador to North Carolina (Gosner, 1978). Both Western and Eastern Gloucester Harbor Quadrants are designated EFH for eggs, larvae, juveniles, and adults of this species.

Eggs

Eggs of the Atlantic sea scallop are found in both nearshore and off-shore waters, but are usually taken commercially from off-shore waters. Eggs remain on the sea floor until they develop into free-swimming larvae. Eggs are reported from areas where water temperatures are generally below 63°F (17^{o}C). No specific salinity or depth range preferences are reported for this species. However, nearshore eggs are typically found in salinities greater than 25°/$_{00}$ (NEFMC, 1998).

Larvae

Larvae of the sea scallops are sessile. They are typically found attached to bottom habitats consisting of gravelly sand, shell fragments and pebbles; and also on various other sessile marine organisms such as red algae, hydroids, amphipods tubes, and bryozoans. Larvae are reported to prefer areas where the sea surface water temperatures are below 64°F (18^{o}C), and salinities are between 17 and 30°/$_{00}$ (NEFMC, 1998).

Juveniles

Juvenile Atlantic sea scallops are found in bottom habitats consisting of cobble, shells and silt substrates. They prefer water temperatures below 59°F (15^{o}C) and water depths between 59 and 361 feet (18 and 110 meters) deep (NEFMC, 1998).

Adults

Adult Atlantic sea scallops are found in bottom habitats consisting of cobble, shells and coarse to gravelly sand substrates. They prefer water temperatures below 70°F (21^{o}C), water depths between 59 and 361 feet (18 and 110 meters) deep, and salinities above 16.5°/$_{00}$ (NEFMC, 1998).

2.7 BLACK SEA BASS (*Centropristis striata*)

Black sea bass (family *Serranidae*) range in North America from Maine to northeastern Florida, and the eastern Gulf of Mexico (Robins and Ray, 1986). Both Western and Eastern Gloucester Harbor Quadrants are designated EFH for black sea bass adults. Adults are typically found within inshore waters of mixing water salinity (between 0.5 and 25°/$_{00}$) to seawater salinity (greater than 25°/$_{00}$) range. The adults prefer rock jetties and rocky bottom substrate areas, but may also be found in sand and shell fragment substrates. These fish enter nearshore waters in greatest abundance from May through October, and require a minimum temperature of 43^{o}F (6°C) (NMFS, 2001).

2.8 BLUEFISH (*Pomatomus saltatrix*)

Bluefish (family Pomatomidae) is an important commercial and sport fish that ranges from Nova Scotia south to Argentina (Robins and Ray, 1986). Western Gloucester Harbor is designated as an EFH for bluefish juveniles and adults.

Juveniles

Juvenile bluefish are normally found in estuaries or shallow water with temperatures between 59 and 86°F (15 and 30°C). Typical salinities of waters frequented by this species range from 23 to 33°/$_{00}$. Preferred substrates include sand, mud, silt, and clay.

Adults

Adult bluefish are most common in nearshore open water with temperatures ranging from 59 to 77°F (15 to 25°C) and with oceanic salinities.

2.9 HADDOCK (*Melanogrammus aeglefinus*)

In North America, haddock (Family *Gadidae*) range from northern Newfoundland south to Cape Hatteras, NC (Robins and Ray, 1986). Haddock is an important species to the Gloucester Harbor commercial fishery industry. Haddock landings in Gloucester Harbor in 1999 were recorded at 1,651,000 pounds (748,894 kilograms). The Western Gloucester Harbor Quadrant is designated EFH for eggs, larvae, and juvenile haddock, while the Eastern Gloucester Harbor Quadrant is designated as EFH for juvenile haddock.

Eggs

Eggs of this species are found in the greatest abundance in surface waters where temperatures are below 50°F (10^{o}C), at water depths between 164 and 295 feet (50 and 90 meters) and in salinity ranging from 34 to 36°/$_{00}$. Eggs occur between March to May with the greatest densities occurring in April (NEFMC, 1998).

Larvae

Larvae are found in surface waters where temperatures are below 57^{o}F (14^{o}C), water depths are between 98 and 295 feet (30 and 90 meters) and salinity ranges from 34 to 36°/$_{00}$ (NEFMC, 1998).

Juveniles

Juvenile haddock seek out areas of pebble gravel, with water temperatures below 52^{o}F (11^{o}C), depths of 115 to 328 feet (35 to 100 meters), and a salinity range from 31.5 to 34°/$_{00}$ (NEFMC, 1998).

2.10 SHORT-FINNED SQUID (*Illex illecebrosus*)

Both the Western and Eastern Gloucester Harbor Quadrants provide EFH for juvenile and adult short-finned squid (family *Ommastrephidae*). In northeastern North America, this species ranges from the Arctic Ocean south to Cape Cod. This species is of great economic importance since it is traditionally used as the preferred bait of the North Atlantic cod fisheries (Gosner, 1978). Juveniles (pre-recruits) are found in greatest abundance in open water ranging in depth from shore to 600 feet (182 meters) deep, and in temperatures from 36 to 73°F (2 to 23°C) (NMFS, 2001). Adults (recruits) have similar depth preferences but prefer a more narrow temperature range 39 to 66°F (4 to 19°C).

2.11 LONG-FINNED SQUID (*Loligo pealei*)

Both the western and eastern Gloucester Harbor quadrants provide EFH for juvenile and adult long-finned squid (family *Loliginidae*). In North America, this species ranges from southern Maine to the Caribbean, with greatest abundance from Cape Ann south to Cape Cod. This species is of great economic importance as a bait source and for consumption overseas in Italian fish markets (Gosner, 1978). Juveniles (pre-recruits) are found in greatest abundance in open water ranging in depth from shore to 700 feet (213 meters) deep, and in temperatures from 39 to 81°F (4 to 27°C) (NMFS, 2001). Adults (recruits) are found in greatest abundance in open water ranging in depth from shore to 1,000 feet (305 meters) deep, and prefer the same temperature range as juveniles.

2.12 MONKFISH (*Lophius americanus*)

Monkfish, also known as "Goosefish" (family *Lophiidae*), range in North America from Quebec to northeastern Florida (Robins and Ray, 1986). Monkfish is an important species to the Gloucester Harbor commercial fishery industry. Landings in Gloucester Harbor in 1999 were recorded at 2,220,000 pounds (1,006,992 kilograms). The Western Gloucester Harbor Quadrant is not designated as EFH for monkfish. However, the Eastern Gloucester Harbor Quadrant is designated EFH for eggs, larvae, juveniles, and adults of this species.

Eggs

Eggs of the monkfish are found in both nearshore and off-shore waters. In nearshore waters they are typically found within mixing water salinity (salinities greater than $0.5°/_{00}$, but less than $25°/_{00}$) to seawater salinity (greater than $25°/_{00}$) range and at depths between zero and 50 feet (zero and 15 meters). Eggs require temperatures between 41 and 73°F (5 and 23°C) (NMFS, 2001).

Larvae

Larvae of the monkfish are found in open waters at temperatures around 59°F (15°C) and at water depths between 82 and 3,281 feet (25 and 1,000 meters). Larvae reach greatest densities between March to September (NEFMC, 1998).

Juveniles

Juvenile monkfish prefer a variety of bottom habitats including those of a sand-shell fragment mix, algae covered rocks, hard sand, pebbly gravel, or mud. They prefer water temperatures below 55°F (13°C), depths of 82 to 656 feet (25 to 200 meters), and a salinity range of 30 to $37°/_{00}$.

Adults
Adults are also found in a variety of bottom habitats including those of a sand-shell fragment mix, algae covered rocks, hard sand, pebbly gravel, or mud. They prefer water temperatures below 55°F (13°C) and, like juveniles, prefer depths of 82 to 656 feet (25 to 200 meters) and a salinity range of 30 to 37°/$_{00}$ (NEFMC, 1998).

2.13 OCEAN POUT (*Macrozoarces americanus*)

This species, a member of the family *Zoarcidae*, ranges from Labrador to Delaware. Ocean pout has only recently been fished commercially. Both Western and Eastern Gloucester Harbor Quadrants are designated EFH for eggs, larvae, juveniles, and adults of this species.

Eggs
Eggs of ocean pout are found in bottom crevices, holes or nests in hard bottom habitats of both nearshore and off-shore waters. Parents or the female tends eggs where they are laid in waters with temperatures below 50°F (10°C), at depths of less than 164 feet (50 meters) and at salinity between 32 and 34°/$_{00}$ (NEFMC, 1998).

Larvae
Larvae of the ocean pout also inhabit hard bottom habitats, remaining close to nesting areas. Most are found in waters with temperatures below 50°F (10°C), at depths less than 50 meters (164 feet) and at salinities greater than 25°/$_{00}$ (NEFMC, 1998).

Juveniles
Juvenile ocean pout frequent smooth bottom habitats near rocks or algae. They prefer water temperatures below 57°F (14°C), depths less than 262 feet (80 meters), and salinities greater than 25°/$_{00}$.

Adults
Adults are found in a variety of bottom habitats. They prefer water temperatures below 59°F (15°C) and depths less than 361 feet (110 meters) and a salinity range of 32 to 34°/$_{00}$. Adults spawn in hard bottom substrates including artificial reefs and wrecks. Spawning occurs in late summer through early winter in water temperatures below 50°F (10°C), depths less than 164 feet (50 meters) and at a salinity range of 32 to 34°/$_{00}$. Peak spawning activity occurs in September and October.

2.14 POLLOCK (*Pollachius virens*)

Pollock, another important food and sport *Gadid* known to inhabit Gloucester waters, range from southwestern Greenland and northern Labrador, south to North Carolina (Robins and Ray, 1986). The Western Gloucester Harbor Quadrant is designated EFH for eggs, larvae, juvenile, and adults, while the Eastern Gloucester Harbor Quadrant has no EFH designation for any of the pollock life stages.

Eggs

Pollock eggs are generally found in open waters where surface temperatures are less than 63°F (17°C), at water depths between 98 to 886 feet (30 to 270 meters) and at salinities between 32 and 33$^{\circ}/_{00}$. Eggs occur between October and June with peak densities recorded from November to February (NEFMC, 1998).

Larvae

Larvae are also found in pelagic waters where temperatures are below 63°F (17°C). They prefer water depths of 33 to 820 feet (10 to 250 meters). They are typically found from September to July with peak densities occurring from December to February (NEFMC, 1998).

Juveniles

Juvenile pollock seek out bottom habitat with submerged aquatic vegetation or areas dominated by sand, mud, or rock substrates. They prefer water temperatures below 64°F (18°C), depths from zero to 820 feet (zero to 250 meters), and a salinity range of 29 to 32$^{\circ}/_{00}$ (NEFMC, 1998).

Adults

Adult pollock seek out hard bottom habitat or artificial reefs where water temperatures are below 57°F (14°C), depths range from 49 to 1,198 feet (15 to 365 meters), and salinities range from 31 to 34$^{\circ}/_{00}$. Adults spawn in hard stony or rocky substrate, including artificial reefs. Adults prefer the following conditions for spawning: water temperatures below 46°F (8°C), depths of 49 to 1,198 feet (15 to 365 meters), and a salinity range of 32 to 33$^{\circ}/_{00}$. Spawning typically occurs from September to April, with peaks occurring from December to February (NEFMC, 1998).

2.15 RED HAKE (*Urophycis chuss*)

Red hake, another commercially harvested *Gadid*, ranges in North America from southern Labrador to North Carolina (Robins and Ray, 1986). Both the Western and Eastern Gloucester Harbor Quadrants are designated EFH for eggs, larvae, juveniles, and adults of this species.

Eggs

Red hake eggs are generally found in open surface waters where sea surface temperatures are less than 50°F (10°C) and at salinities less than 25$^{\circ}/_{00}$. Hake eggs are generally found between May and November with greatest densities occurring in the months of June and July (NEFMC, 1998).

Larvae

Larvae are also found in pelagic waters. They prefer sea surface temperatures below 66°F (19°C), water depths less than 656 feet (200 meters), and a salinity of greater than 0.5$^{\circ}/_{00}$. They appear from May through December with peak densities recorded for the months of September and October (NEFMC, 1998).

Juveniles
Juvenile red hake seek out bottom habitat with shell fragment or live sea scallop bed substrates. Juveniles prefer water temperatures below 61°F (16^{o}C), water depths less than 328 feet (100 meters), and a salinity range from 31 to 33°/$_{00}$ (NEFMC, 1998).

Adults
Adult red hake seek out bottom habitats, especially depressions with a substrate of sand and mud in areas where water temperatures are below 54°F (12^{o}C). They prefer depths of 33 to 427 feet (10 to 130 meters) and salinities between 33 and 34°/$_{00}$. Adults spawn in the depressions of sand and mud when water temperatures are less than 50°F (10^{o}C), at depths of less than 328 feet (100 meters) and in areas where salinity falls to less than 25°/$_{00}$. Spawning typically occurs during the months from May to November, with peak spawning activity occurring in June and July (NEFMC, 1998).

2.16 REDFISH (*Sebastes spp.*)

Redfish is an economically important commercial finfish, often marketed under the name "ocean perch". They are members of the family *Scopaenidae*, a family that includes the more notorious scorpionfish. Within Gloucester Harbor, the genus *Sebastes* is most likely represented by two species, *Sebastes fasciatus*, the Acadian redfish, and *S. marinus*, or the golden redfish. The former ranges from the Gulf of Saint Lawrence to shelf waters of Nova Scotia, while the latter ranges from western Greenland and southeast Labrador to New Jersey (Robins and Ray, 1986). Both the western and eastern Gloucester Harbor quadrants are designated EFH for *S. fasciatus* larvae, juveniles, and adults. This species is ovoviviparous, meaning the eggs hatch within the mother and are born as larvae. Therefore, since there is no egg life stage for this species, Gloucester Harbor is not designated as EFH for Redfish eggs.

Larvae
Larvae are found in pelagic waters where sea surface temperatures are below 59^{o}F (15^{o}C), and water depths are between 164 and 886 feet (50 and 270 meters). Larvae are most often observed from March through October, with peak concentrations in August (NEFMC, 1998).

Juveniles
Juvenile redfish seek out bottom habitats with silt, mud or hard bottom substrates. Juveniles generally require water temperatures of below 55°F (13°C), depths from 82 to 1,312 feet (25 to 400 meters), and a salinity range from 31 to 34°/$_{00}$ (NEFMC, 1998).

Adults
Adult redfish are also found in bottom habitat with silt, mud or hard bottom substrates. They frequent areas where water temperatures are below 55°F (13°C), depths range from 164 to 1,148 feet (50 to 350 meters), and salinity ranges from 31 to 34°/$_{00}$. Adults spawn in similar conditions. Larvae emerge from females during the months of April through August (NEFMC, 1998).

2.17 SCUP (*Stenotomus chrysops*)

This species is a member of the family *Sparidae*. It is found from Nova Scotia, south to Florida (Robbins, et al., 1986). The Western Gloucester Harbor Quadrant is designated as EFH for juveniles and adults of this species. This species is not listed as an EFH species for the Eastern Gloucester Harbor Quadrant.

Juveniles

Juvenile scup are found in estuaries and bays with sand, mud, mussel, and eelgrass bed substrates types. They generally require water above 61°F (16ºC) and salinities greater than 15°/$_{00}$.

Adult

Adult scups are also found in estuaries with mixing to seawater salinity ranges and temperatures above 61°F (16ºC).

2.18 SUMMER FLOUNDER (*Paralicthys dentatus*)

Summer flounder is a left-eye flounder (family *Bothidae*) that ranges in North America from Maine and (rarely) Nova Scotia, south to northern Florida (Robins and Ray, 1986). Both the Western and Eastern Gloucester Harbor Quadrants are designated EFH for adults of this species.

Adults

Adults prefer bottom habitats of both inshore (warmer months) and offshore (colder months) waters to depths of 500 feet (150 m). They tolerate both the mixing water salinity (between 0.5 and 25°/$_{00}$) and seawater salinity (greater than 25°/$_{00}$) range. Stands of submerged aquatic vegetation, sea grasses, and macroalgae are recognized as Habitat of Particular Concern for this species by NMFS (2001).

2.19 SURF CLAM (*Spisula solidissima*)

The Surf Clam is a major commercial commodity; accounting for a majority of the clam crop in this country (Gosner, et al., 1978). Surf Clams are usually found from Nova Scotia south to South Carolina. Both the eastern and western Gloucester Harbor quadrants are designated as EFH for juveniles and adults of this species.

Juveniles

Juvenile surf clams are found in well sorted, medium and fine-grained sands and in waters with temperatures less than 77°F (25°C). They are typically found in water with a salinity of 28°/$_{00}$ or higher.

Adults

Adults are found in medium sized sands and prefer temperatures between 59 and 86°F (15 and 30 °C). Adults can survive in salinities as low as $12.5^{\circ}/_{00}$ but are more commonly found in salinities above $28^{\circ}/_{00}$.

2.20 WHITE HAKE (*Urophycis tenuis*)

White hake is a commercially important member of the family *Gadidae*. This species is fished both commercially and recreationally from Gloucester based fleets. White hake landings in Gloucester Harbor in 1999 were recorded at 1,204,000 pounds (546,134 kilograms). They range from southern Labrador to Nova Scotia and are normally found in arctic and cold-temperature shelf waters. Both Western and Eastern Gloucester Harbor Quadrants are designated as EFH for all four life stages of this species.

Eggs

Eggs of the white hake are usually found in surface waters between August and September. Little else is known about the habitat requirements that support development of white hake eggs (NEFMC, 1998).

Larvae

Larvae of white hake are generally found in water 33 to 820 feet (10 to 250 meters) deep with temperatures between 50 and 64°F (10 and 18°C). They are typically found from August to September.

Juveniles

Juvenile white hake are found in estuaries at depths between 16 and 738 feet (5 and 225 meters). Eelgrass and muddy to fine-grained, sandy sediment with temperatures below 66°F (19°C) are their recognized habitat.

Adults

Adult white hake are found in bottom habitats with a substrate of mud or fine-grained sediment. They inhabit water from 16 to 738 feet (5 to 325 meters) and temperatures below 57°F (14 °C).

2.21 WHITING (*Merluccius bilinearis*)

Whiting, also known as silver hake, is another commercially important member of the family *Gadidae*. They range from the Gulf of Saint Lawrence to South Carolina (Robins and Ray, 1986). Whiting landings in Gloucester Harbor in 1999 were recorded at 2,065,000 pounds (936,684 kilograms). Both the Western and Eastern Gloucester Harbor quadrants are designated EFH for eggs, larvae, juveniles, and adults of this species.

Eggs

Eggs of whiting are usually found in surface waters where temperatures are below 68°F (20°C), and at depths between 164 and 492 feet (50 and 150 meters). Eggs can be found all year, with peaks from June through October (NEFMC, 1998).

Larvae

Larvae of whiting are generally found in waters with temperatures below 68°F (20°C) and at water depths between 164 and 427 feet (50 and 130 meters). Larvae are found all year with peak densities recorded from July through September (NEFMC, 1998).

Juveniles

Juvenile whiting are found in bottom habitats with all substrate types. They prefer water temperatures below 70°F (21^{o}C), depths between 66 and 886 feet (20 and 270 meters) and salinities greater than 20°/$_{00}$ (NEFMC, 1998).

Adults

Adults are also found in bottom habitats with all substrate types. They prefer water temperatures below 72°F (22^{o}C) and depths between 98 and 1,066 feet (30 and 325 meters). Adults spawn in waters with temperatures below 55^{o}F (13^{o}C) and at depths between 98 and 1,066 feet (30 and 325 meters). The EFH for adults include areas with seawater salinity (greater than 25°/$_{00}$) (NEFMC, 1998).

2.22 WINDOWPANE FLOUNDER (*Scopthalmus aquosus*)

Windowpane flounder is a left-eye flounder (family *Bothidae*) that ranges in North America from the Gulf of Saint Lawrence, south to northern Florida (Robins and Ray, 1986). Windowpane flounder landings in Gloucester Harbor in 1999 were recorded at 2,000 pounds (907 kilograms). The Western Gloucester Harbor Quadrant is designated EFH for eggs, larvae, juveniles and adults of this species. The Eastern Gloucester Harbor Quadrant is not designated EFH for any of the windowpane life stages.

Eggs

Eggs of the windowpane flounder are found in surface waters with temperatures less than 68°F (20^{o}C), and at water depths less than 230 feet (70 meters). Eggs appear from February to November with peak densities occurring in July and August (NEFMC, 1998).

Larvae

Larvae inhabit pelagic waters where sea surface temperatures are less than 68°F (20°C) and water depths are less than 230 feet (70 meters). Larvae appear from February to November, with peak densities occurring in July and into August (NEFMC, 1998).

Juveniles

Juveniles inhabit benthic areas with mud or fine-grained sand substrates in areas where the water temperatures are below 77°F (25^{o}C), and at depths ranging from 3 to 328 feet (1 to 100 meters). They tolerate a wide range of salinity (between 5.5 and 36°/$_{00}$) (NEFMC, 1998).

Adults

Adults inhabit benthic areas with mud or fine-grained sand substrates where the water temperatures are below 80°F (27^{o}C), and at depths ranging from 3 to 246 feet (1 to 75 meters). Adults also tolerate a wide range of salinity (between 5.5 and 36°/$_{00}$). Spawning conditions are met when water temperatures are below 70°F (21^{o}C), water depths are between 3 and 246 feet (1 and 75 meters) and salinity is between 5.5 and 36°/$_{00}$. Spawning normally occurs from February to December (NEFMC, 1998).

2.23 WINTER FLOUNDER (*Pleuronectes americanus*)

Winter flounder is a right-eye flounder (family *Pleuronectidae*) that ranges in North America from Labrador, south to Georgia (Robins and Ray, 1986). Winter flounder landings in Gloucester Harbor in 1999 were recorded at 256,000 pounds (116,122 kilograms). Both the Western and Eastern Gloucester Harbor Quadrants are designated EFH for winter flounder eggs, larvae, juveniles, and adults.

Eggs

Winter flounder eggs are found in bottom habitats with sand, mud, and gravel where water temperatures are less than 50°F (10^{o}C), salinities range between 10 and 30°/$_{00}$ and water depths are less than 16 feet (5 meters).

Larvae

Larvae inhabit open water and benthic habitats in areas where sea surface water temperatures are less than 59°F (15°C), and salinities range from 4 to 30°/$_{00}$. In inshore waters such as Gloucester Harbor, they are typically found in waters less than 17 feet (6 meters) deep. Larvae are often observed from March to July with peaks in April and May.

Juveniles

Juvenile winter flounder are found in bottom habitats with a substrate of mud or fine grained sand. They are generally found in waters from 0.3 to 33 feet (0.1 to 10 meters) deep, water temperatures below 82°F (28°C), and salinities between 5 and 33°/$_{00}$.

Adults

Adults are also found in bottom habitats with sand, gravel, and mud substrates. The habitat is usually less than 17 feet (6 meters) deep and below 59°F (15°C), with salinities between 5.5 and 36°/$_{00}$.

2.24 WITCH FLOUNDER (*Glyptocephalus cynoglossus*)

Witch flounder is a right-eye flounder (family *Pleuronectidae*) that ranges in North America from the Gulf of Saint Lawrence and the Grand Banks, south to North Carolina (Robins and Ray, 1986). Witch flounder landings in Gloucester Harbor in 1999 were recorded at 590,000 pounds (267,624 kilograms). The Eastern Gloucester Harbor Quadrant is a designated EFH for witch flounder larvae and juveniles. The Western Gloucester Harbor Quadrant is not designated EFH for any of the witch flounder life stages.

Larvae
Witch flounder are generally found in surface waters up to 820 feet (250 meters) deep. They are usually found in high salinity water below 55°F (13°C). Larvae are most commonly found from March through November, with peaks in May through July.

Juveniles
Juvenile witch flounder are normally found in bottom habitats with a fine-grained substrate. They are usually found in water temperatures below 55°F (13°C) and at depths from 164 to 1,476 feet (50 to 450 meters), with salinities ranging from 34 to 36°/$_{00}$.

2.25 YELLOWTAIL FLOUNDER (*Pleuronectes ferruginea*)

Yellowtail flounder is a right-eye flounder (family *Pleuronectidae*) that ranges in North America from southern Labrador south to Chesapeake Bay (Robins and Ray, 1986). Yellowtail flounder landings in Gloucester Harbor in 1999 were recorded at 592,000 pounds (268,531 kilograms). The Western Gloucester Harbor Quadrant is a designated EFH for eggs, larvae, juveniles, and adults of this species. The Eastern Gloucester Harbor Quadrant is designated EFH for larvae, juveniles and adults.

Eggs
Yellowtail flounder eggs are usually found in surface water below 59°F (15°C). They are found in water from 98 to 295 feet (30 to 90 meters) deep with salinities ranging from 32 to 34°/$_{00}$. Eggs are most commonly seen from mid-March to July, with a peak from April to June.

Larvae
Yellowtail flounder larvae usually inhabit surface waters from 33 to 295 feet (10 to 90 meters) deep. They prefer waters below 63°F (17°C) and salinities from 32 to 34°/$_{00}$.

Juveniles
Juvenile yellowtail flounder are normally found in bottom habitats with a substrate of sand or sand and mud. Generally they inhabit waters from 66 to 164 feet (20 to 50 meters) deep, salinities from 32 to 34°/$_{00}$, and temperatures below 59°F (15°C).

Adults
Adult yellowtail flounder are generally found in bottom habitats from 66 to 164 feet (20 to 50 meters) deep, and temperatures below 59°F (15°C). The normal salinity range is from 32 to 34°/$_{00}$.

2.26 OCEAN QUAHOG (*Arctica islandica*)

Also known as the black clam, the ocean quahog ranges in North America from Newfoundland to Cape Cod in nearshore waters, and from Cape Cod, south to North Carolina in deeper waters (Gosner, 1978). Western Gloucester Harbor is not designated as EFH for this species. However, the Eastern Gloucester Harbor Quadrant is designated as EFH for juveniles and adults. Both juvenile and adult ocean quahogs prefer muddy sand bottom areas (Weiss, 1995). Ocean quahogs require sea water salinities and are typically found in marine waters from subtidal depth (approximately 30 feet) to depths of approximately 800 feet (240 meters) (NERO/NMFS, 2001).

3.0 DREDGING IMPACTS TO FISH AND EFH

Dredging, if not conducted properly with requisite environmental controls and adequate planning, may adversely affect fish and fish habitat. Dredging within a multi-use harbor such as Gloucester, is required to increase water depth for boats and ships associated with commercial and recreational fishing, commerce, recreational boating, tourism, for the placement of utilities (e.g., to Ten Pound Island) and to maintain channel flow capacity for floodwaters.

Adverse effects to fish and fish habitat include the following: destruction of benthic habitat, the impairment of water quality and the direct (i.e., toxicological) and indirect (i.e., habitat alteration) effects on the fish and their prey species. The extent of the effect depends on hydrologic processes, sediment texture and composition, chemical content of the sediment and pore water matrices, and the behavior or life stage of the receptor species.

3.1 IMPAIRMENT OF WATER QUALITY

Water quality impacts from dredging and dredge disposal include physical, chemical and biological impacts. Changes in water quality have concurrent impacts to the system which effect fish and EFH in various ways (Refer to Table 3-1).

3.1.1 Physical Impairment

Physical impairment of the water column occurs from changes in dissolved oxygen, changes in pH, changes in oxidation-reduction state, turbidity and resultant decrease in light penetration, and altered salinity. The degree of change or alteration of the water column's physical component depends on the physical parameters of the sediment being dredged. For instance: the pH of the sediment, the oxidation-reduction potential of the sediment, sediment size, organic matter content, and concentration of reactive iron and manganese.

3.1.2 Chemical Impairment

Chemical impairment of the water column produced by dredging and dredge disposal is caused by heavy metals, organochlorine compounds, polyaromatic hydrocarbons, total petroleum hydrocarbon, herbicides and pesticides, radionucleides, and other anthropogenic compounds or materials. These compounds are introduced into the harbor sediment via a variety of sources including but not limited to surfacewater runoff (non-point sources), municipal wastewater treatment effluent, industrial discharge, accidental and incidental oil and chemical spills, illegal discharges, etc. Depending on basin characteristics, and composition of the receiving matrix (i.e., sediment) concentrations of the chemicals can be greatest at the point of discharge or away (e.g., down stream) from the discharge. Exposure of fish to these chemicals in the water column or sediment matrices can cause various acute and chronic toxicological effects. Table 3-2 lists the various contaminant classes and their known toxicological effects on fish.

Table 3-1. Impact of Human-Induced Alterations to Various Ecological Attributes

Ecological Attribute	Impact of Human-Induced Alterations
1. Food (energy) source -type, amount, and particle size of organic material entering a tidal stream or tributary from the riparian zone vs. primary production in the stream -seasonal pattern of available energy -primary production of the basin	-decreased coarse particulate organic matter to estuary -increased fine particulate organic matter to estuary -increased algal production in basin -shifts in feeding guilds
2. Water Quality -temperature -turbidity -dissolved oxygen -nutrients (primarily nitrogen and phosphorus) -organic and inorganic chemicals, natural and synthetic -heavy metals and other toxic substances -pH -salinity	-expanded temperature extremes -increased turbidity -altered diurnal cycle of dissolved oxygen -increased nutrients (especially soluble nitrogen and phosphorus) -increased suspended solids -increased toxics -altered salinity
3. Habitat Structure -substrate type -water depth and current tidal velocity -spawning, nursery, and hiding places -diversity/complexity (pools, riffles, woody debris in tidal streams, submerged aquatic vegetation (SAV), shell beds, structures, reefs, wrecks, etc. in basin -basin size and shape	-decreased stability of substrate, banks and shoreline due to erosion and sedimentation -more uniform water depth -reduced habitat heterogeneity -decreased channel sinuosity of tidal or tributary streams -reduced habitat areas due to shortened channel, removed structures or debris -decreased instream cover and riparian vegetation
4. Flow Regime -water volume -temporal distribution of floods, low flows, tides	-altered flow extremes (both magnitude and frequency of high and low flows) -increased maximum flow velocity -decreased minimum flow velocity -reduced diversity of microhabitat velocities -fewer protected sites
5. Biotic Interactions -competition -predation -disease -parasitism -mutualism -introduction of non-native organisms	-increased frequency of diseased fish -altered primary and secondary production -altered trophic structure -altered decomposition rates and timing -disruption of seasonal rhythms -shifts in species composition and relative abundance -shifts in invertebrate functional groups e.g., filler feeders vs. suspension feeders -shifts in trophic guilds (increased omnivores and decreased piscivores) -increased frequency of fish hybridization -increased frequency of exotic species

Source: Adapted to marine systems from Karr (1991)

Table 3-2. Various Contaminant Classes and some of their Toxic Effects to Fish and Shellfish

Contaminant Class	Contaminant type	Reproductive effects	Behavioral Effects	Growth	Physiological	Cellular/ Molecular
Chlorinated compounds	Chlorine Polychlorinated Alkanes (or chlorinated paraffins) PCA's		F Inhibited spawning F Avoidance F Diminished or no startle response, loss of equilibrium (Cooley et al., 2001)	Develop dark coloration (Cooley et al., 2001)	F Reduction in filtration rate, foot activity index and byssus thread production in mussels (Rajagopal, et al., 1997) F Liver lesions F Inflammation (Cooley et al., 2001)	F Membrane disruption F Increase in Hepatic aryl hydrocarbon hydroxylase activity F Hepatocyte necrosis F Glycogen/lipid depletion (Cooley et al., 2001)
Petroelum products	Oil Gasoline Diesel	F Premature/delayed hatching in eggs F Alteration in reproductive schedules or behavior F Disruption of egg respiration F Reduced resistance to environmental stress which can contribute to reproductive failure. (Freedman, 1989)	F Alterations in: • Feeding • Migration • Reproduction • Swimming activity • Schooling behavior (Freedman, 1989) F Avoidance	F Fin erosion F Gill and epithelial hyperplasia F Enlarged liver F Reduced growth (Freedman, 1989) F Cartilage dysplasia F Abnormal branching and fusion of lamallea. (Spies, et al., 1996)	F Change in heart and respiration rates (Walker et al., 1998) F Impaired endocrine system F Suppression of immune system (Freedman, 1989) F Aneurysms F Histopathological lesions on the liver kidney and gills (Spies, et al., 1996)	F Cellular abnormalities F Blood changes F Membrane disruption (Freedman, 1989)
Pesticides/ Herbicides	Organophosphate	Estrogen disruption (Freedman, 1989)	Avoidance			F Depressed brain enzyme function (acetylcholinesterase) (Freedman, 1989) F Serine esterase inhibition in the brain, muscle, gill, liver and plasma. (Straus and Chambers, 1995)
	Organochlorine (e.g., endosulfan, DDT)	F Decreased fertility and fecundity. F Early oocyte loss. (O'connor, 2001)		F Alterations to the histoarchitecture of the heptopancreas and gills. F Thickening of basal laminae F Abnormal gill tips (Bhavan and Geraldine, 2000)	F Hemocytic infiltration of the interstitial sinuses, F Necrosis of the tubules of the heptopancreas F Accumulation of hemocytes in the hemocoelic space F Swelling and fusion of the lamellae, hyperplastic, necrotic and clavate-globule lamellae of the gills. (Bhavan and Geraldine, 2000)	F Depressed brain enzyme function (acetylcholinesterase) (Freedman, 1989) F Increased micronuclei frequency F Alterations in the absorption, storage and secretion of the heptopancreas F Alterations in respiration, osmotic and andionic regulations of the gills (O'connor, 2001)
	Carbamate	Males less likely to approach females		F Decreased hatching size F Abnormal spine development	F Decreased heart rate throughput embryonic development. F Tail lesions	
	Pyrethrins	F Reduces/inhibits male responses to female priming pheromone in Atlantic salmon. F Reduced number of fertilized eggs (Moore and Waring, 2001)			Impacts the pheromonal mediated endocrine system in mature male Atlantic salmon (Moore and Waring, 2001)	
Aromatics	In General	Inhibits ovarian development	F General behavioral responses impaired or impacted (Freedman, 1989) F Avoidance	Neoplasms in bivalve mollusks (Walker et al., 1998) and flatfishes (O'Connor, 2001)	F Suppression of immune system response (Freedman, 1989) F Skin lesions F Liver disorders (McMahon, 2001)	Damage to liver DNA (Freedman, 1989; O'Connor, 2001)

Table 3-2. Various Contaminant Classes and some of their Toxic Effects to Fish and Shellfish (*Continued)*

Contaminant Class	Contaminant type	Reproductive effects	Behavioral Effects	Growth	Physiological	Cellular/ Molecular
Metals	In General	Imposex in whelks and other *Nucella* spp. (Walker, 1998)		Delayed growth and development in larval and embryonic clams	F Elevated body – burden F Change in enzyme function due to change in enzyme configuration (Freedman, 1989)	F Antagonistic competition of other cation uptake (Walker, 1998) F DNA damage due to: • metal binding, • disruption of transcription; • inability to produce specific proteins (esp. enzymes) F Changes in heamoglobin concentrations and hematocrit values F Changes in red and white blood cell numbers F Changes in plasma and protein concentrations
	Chromium		Avoidance		F Aenemic conditions occur resulting in decreased oxygen utilization and hypoxia F Osmoregulation is influenced F Metabolism is decreased. (VanVuren and Nussey, 2001)	F Increases in mean corpuscular volume and delta-aminolevulinic dehydratase activity F Decreases in blood pH (VanVuren and Nussey, 2001)
	Copper					Changes in: • Ammonia levels • antibody titters • glucose concentrations • plasma salt levels • protein concentrations • haematocrit values • haemoglobin concentrations • white and red blood cell counts (VanVuren and Nussey, 2001)
	Mercury	Reduced gonadosomatic index and testicular atrophy (Friedman et al., 1996)		Reduction in fish length/weight (Friedman et al., 1996)	Impairs immune function (Friedman et al., 1996)	Suppresses plasma cortisol (Friedman et al., 1996)
	Manganese	High fish egg mortalities (VanVuren and Nussey, 2001)			Gill damage occurs resulting in: • internal hypoxia • reduced oxygen utilization • impaired osmoregulation • altered metabolic processes (VanVuren and Nussey, 2001)	F Changes in mean corpuscular volume F Increases in delta-aminolevulinic dehydrase and glucose-6-phosphates dehydrogenase activities F Decreases in plasma sodium and protein concentrations F Increase in plasma potassium, calcium,chlorides, glucose and lactate (VanVuren and Nussey, 2001)
	Lead				F Anemia F Lowering of blood sugar due to damage of the kidney tubules or depression of gluconeogenesis in the liver. (VanVuren and Nussey, 2001)	F Inhibition of heamoglobin synthesis and delta-aminolevulinic dehydrase activity. F Stimulation of alkaline phosphatase but inhibition of some enzymes involved in energy metabolism. F Disturbed ion balance, F Significant and persistant hypoglycaemia F Increases in blood lactate, mean corpuscular volume and cholesterol levels in circulating blood and tissues. (VanVuren and Nussey, 2001)

Table 3-2. Various Contaminant Classes and some of their Toxic Effects to Fish and Shellfish (*Continued)*

Contaminant Class	Contaminant type	Reproductive effects	Behavioral Effects	Growth	Physiological	Cellular/ Molecular
	Zinc	Egg production is reduced (VanVuren and Nussey, 2001)	F Increase in agnostic behavior by dormant individuals. (VanVuren and Nussey, 2001) F Three successive responses of fish to Zinc poisoning: • surfacing, • overturn and • immobilization of gill opercula	Gill damage	F Interference with the respiratory surface causing historical gill damage, impaired oxygen consumption. F Increased mucous production, coughing frequency, and ventilatory aberrations. F Reduced heart rate F Supression of immune response	F Fall in arterial-blood oxygen tension, F Decrease in blood pH (acidosis), F Reduction in oxygen available to tissues (hypoxia) F Changes in: • Blood lactate concentration • Leucocrit and cortisol levels • Delta-aminolevulic dehydrase activity • Liver and serum proteins • Blood glucose concentration • Ammonia levels
Contaminant Class	Contaminant type	Reproductive effects	Behavioral Effects	Growth	Physiological	Cellular/ Molecular
Surfactants	e.g. Nonyl-phenol	Decreased spermatogenesis (LeGac et al., 2001)	Inhibited gonadal development (LeGac et al., 2001)		Increase in blood plasma vitellogenin in juvenile or mature male trout (LeGac et al., 2001).	F Disrupts germ cell membrane receptivity to peptide Hormones (LeGac et al., 2001) F Endocrine disrupting effects on sex steroid production
	Polychlorinated Biphenyls (PCB's)	F Birth defects F Reduced spawning success (Holm et al., 1998)		Neoplasms (McMahon, 2001)	Fin erosion (McMahon, 2001)	F Increased micronuclei frequency (O'Connor, 2001) F Lipid accumulation in liver (Holm et al., 1998)
	Polyaromatic Hydrocarbons (PAH's)	High concentrations are acutely toxic to flatfish eggs		Hepatic neoplasms (O'Connor, 2001)		
	Fluorescent Aromatic Hydrocarbons (FAC's)	Disrupts vitellogenesis in female fish				Decreases levels of endogenous estradiol in female fish possibly resulting from depressed ovarian steroidogenesis. (O'Connor, 2001)
Sulfides				Discourages planktonic larval settlement of invertebrates	Various adverse effects to physiological functions (Teodora, 1992)	Adversely effects enzymes, oxygen transport proteins and cellular structure (Teodora, 1992)
Viruses				Neoplasms (Walker et al., 1998)		
Nutrients			F Lethargy, F Gulping of surficial air. F Inhibited consumption of phytoplankton; F Avoidance		F Hypoxia F Increased occurrence of BT algae	Increases in haematocrit as a result of swelling of red blood cells and/or fluid loss to the tissue with a subsequent decrease in plasma volume.

3.1.3 Biological Impairment

Microorganisms such as bacteria, viruses, and plankton cause biological impairment of water quality. Biological impairment can occur when introduction of dredge materials into the water column kills submerged aquatic vegetation and macroalgae (either through direct smothering or via impaired light penetration) leading to higher rates of bacterial decomposition and a resultant increase in bacterial oxygen demand. Disposal of materials contaminated by wastewater treatment effluent or failing sewer pipes, or failing individual subsurface sanitary disposal systems may introduce disease-causing organisms (i.e., bacteria and viruses) into the water column and into the biota proximal to the disposal site. Pathogens, alone (i.e., without accompanying sediment), are typically rapidly assimilated or neutralized by the estuarine system. Aside from potential serious human health impacts, they typically pose little impact to the biota of the system (Wilson, 1988).

3.2 DESTRUCTION OF BENTHIC HABITAT

Dredging and dredge disposal results in the destruction of benthic habitat either by direct removal of the benthic substrate by the dredging operation itself, or via disposal of dredged material onto the benthic habitat at the disposal site. Either operation may result in the change in substrate composition, either rendering the formerly suitable benthic substrate unsuitable for certain benthic organisms, or disrupting the ecological processes or interactions between benthic and water column communities.

3.2.1 Direct Removal of Benthic Substrate

Direct removal of suitable benthic substrate via dredging may impact EFH by removing prey species (e.g., benthic organisms) or food species (e.g., macroalgae), removal of suitable cover or settlement structure (shell beds, SAV) or by destruction of nursery and spawning areas. Re-colonization of the newly exposed substrate after dredging is a factor not only of site-specific basin characteristics (e. g. wave or tidal energy, bathymetry, etc.) but also of substrate requirements of the larvae of recolonizing species (Rhoads and Germano, 1982).

Removal of benthic sediment through dredging homogenizes the bottom substrate, reduces structural complexity and may release hydrogen sulfide; all factors that tend to discourage recruitment of benthic invertebrates, the food of many demersal fish. This impact is even of greater significance in areas where organisms with special microhabitat requirements that have been removed via dredging, formerly dominated the benthos. Even small structures or inconsistencies in the sea floor are exploited by larval species of benthic invertebrate and various demersal fish species.

Examples of these smaller structures include sand ripples; thalassinid crustacean mounds; sea cucumber fecal deposits; pits left by feeding elasmobranchs and crabs; submerged aquatic vegetation blades; urchin spines, kelp holdfasts and stipes; sponge, sea pen and bryozoan colonies; annelid worm, amphipod crustacean, vermetid gastropod, and cerianthid anemone tubes (Norse and Watling, 1999).

Regardless of the sizes of the structure, structural complexity provides smaller species with living space, increased food abundance, and refuge from predation. Certain species of demersal fish prefer one substrate to another for foraging or spawning. For instance, red hake are known to exploit the downcurrent side of sand wave crests catching prey items by surprise as they are carried by bottom currents over the sand wave (Norse and Watling, 1999). Redfish occupy areas around the base of boulders and rock reefs. As a general rule, both prey and fish species diversity increases with habitat complexity, therefore, the more structurally complex the marine habitat (e.g., coral reefs, boreal rocky intertidal zones) the greater the organism diversity.

Dredging along formerly sinuous channels of tidal wetlands to form navigation channels (such as within the Annisquam River) can risk concentrating flows within the channel itself, allowing for a more rapid runoff of floodwater or ebb of tide water. Changes in water levels, therefore, occur more rapidly, producing higher, high-water flows and lower, low-water flows (Mitsch and Gosselink, 1993). These concentrated flows also increase sedimentation rates by reducing sheet flow, and increasing water velocity. Anadromous fish incur the greatest impact. Plumes created by active dredging within riverine or tidal channels (such as the Annisquam River system) may reduce the magnitude of anadromous fish returns due to a blocking effect (Gibson, 1987).

3.2.2 Disposal of Material Onto Benthic Substrate

Disposal of the material directly onto the substrate may impact EFH by burying food sources, changing microhabitat requirements, destruction of nursery and spawning areas, and changing basin hydrology and bathymetry. In addition, the disposal of the material into the water column above the benthic substrate could impact the physical, chemical, and biological suitability of the water column within the EFH (refer to Section 3.1). The re-colonization of dredged material disposal areas follows successive steps ecologically similar to the re-vegetation and re-colonization succession trends of clearcut or burned terrestrial systems. The initial communities that form on dredged materials are typically characterized by opportunistic organisms with high reproductive rates. These organisms are eventually replaced by slower growing specialists with lower reproductive rates and narrower niche requirements. Eventually over time, the community on the re-colonized surface may return to pre-disturbance levels of diversity. Refer to Rhoads and Germano (1982), and Zajac and Whitlach (1989) for a characterization of re-colonizing benthic communities following disturbance.

3.3 DIRECT AND INDIRECT EFFECTS ON ORGANISMS

Dredging and dredged material disposal can cause adverse, direct (e.g., toxicity) and indirect (e.g., community impacts) effects to both fish species or other organisms in which fish communities are interdependent (i.e., their predator and prey species).

3.3.1 Direct Effects

Direct effects caused by disposal of the dredge materials include behavioral impairment (e.g., inhibition of migration patterns), destruction of eggs, destruction of nursery or spawning areas, physical impairment (e.g., turbidity induced clogged gills resulting in suffocation, or abrasion of sensitive epithelial tissue), or physiological impairment due to acute or chronic toxicity to contaminants within the dredge sediments (refer to Table 3-2).

3.3.2 Indirect Effects

Ecological impact of dredging, if implemented without the proper controls and planning, can affect various ecological attributes of the system, including energy flow, habitat structure, and biotic interactions.

3.3.2.1 Energy Flow

Food sources enter the system based on organic material input and via primary productivity by plankton, algae and saltmarsh or submerged aquatic vegetation. There are also seasonal patterns of energy that have developed as a result of climatic changes. Many organisms have evolved migration patterns, spawning activity, etc. to coincide or correspond with increased impulses of energy into the system. Disruption in these energy flow patterns could therefore disrupt these aspects of the organism's life cycle.

3.3.2.2 Habitat Structure

Habitat structural attributes vary with substrate type, water depth, current or tidal velocity, basin size and shape, and the diversity or complexity of substrate types such as the presence or absence of depressions, sediment wave ripples, woody debris, submerged aquatic vegetation, shell beds, structures, reefs, wrecks, etc.

3.3.2.3 Biotic Interactions

Indirect effects on fish and EFH are produced by dredging and dredge disposal through disruption of the symbiotic associations and ecological principles that govern the fish community (i.e., predator - prey relationships or other symbiotic relationships). Predator prey relationships can be locally disrupted by direct impact to the prey organism's population. Prey species are impacted by direct coverage of the organism during dredge disposal, impact to egg settlement rate (either through removal of suitable substrate or via release of hydrogen sulfide), destruction of prey species habitat, or otherwise impacting predator or prey species fecundity, survivorship and recruitment or colonization rates.

The degree or complexity of symbiotic interactions among fish species is not totally understood, therefore impacts to one species may have unknown or currently un-observed impacts to others. This concept is repeatedly demonstrated in coral reef fish, where the fish communities receive much attention. For instance, the pearlfish (*Carapus bermudensis*) was originally thought to be a commensal, living as a benign tenant within the digestive tract of its holothuroidean host, venturing out at night to feed. However further studied revealed that the pearlfish may, from time to time, feed on the tissue of its host's digestive tract (Guttman, 1983). Another example is that of the nine-lined goby which lives within the spines of many rock urchins for protection, and as such, was originally thought of as a commensal until it was discovered that this goby may occasionally feed off of the tube feet of its host (Goodwin, 1983).

Typically, animals that have been impacted by the various negative impacts to dredging and dredge disposal may now succumb to parasitism, disease, predation or intense competition. The loss of one species in an obligatory mutualistic relationship will result in the demise of the other. And finally, the interbasin transfer of sediment may aid in the spread of non-native species. These exotic species may add additional predation or competitive pressure on the native organisms, and may also introduce exotic diseases to which the native organisms have no natural resistance.

4.0 CUMULATIVE IMPACTS

Much of the land area surrounding Gloucester Harbor and its associated bays and inlets is surrounded by multi-use development. Land area within the watershed around the Western and Inner Harbors supports a variety of uses including industrial, commercial, institutional, residential, and open space. Most industrial and many commercial uses are centered around or support the maritime industry (GHPC, 1999).

Industrial development within the harbor supports fish processing, ice manufacturing, marine cargo and vessel services and other industries. Commercial development is related to fish harvesting, cold storage, seafood sales, and other various businesses, including marinas and parking areas. Residential land use dominates the harbor watershed around the southeastern and southwestern edges of the harbor.

The various fishing and non-fishing related land uses within the watershed might ultimately contribute to human-induced alterations to the various ecological attributes of the marine system. The impact of these human induced alterations are comparable to those presented in Table 3-1 in Section 3.0 – Dredging Impacts to Fish and EFH. A discussion of the various fishing and non-fishing activities and their effects on marine EFH and EFH designated species is provided below.

4.1 FISHING ACTIVITIES AND THEIR POTENTIAL EFFECTS ON MARINE EFH

The Magnuson-Stevens Act requires the NEFMC to minimize adverse effects on the EFH from fishing, to the extent practicable. Fishing activities may have an adverse impact to Gloucester EFH if the activities cause physical, chemical, or biological alterations to the EFH, cause the loss or injury to the prey species or their habitat, or alter predator-prey cycles or other biotic interactions. Impacts to EFH via fishing can occur on both a commercial and recreational level. Commercial impacts include over-harvesting, disruption of biotic interactions (e.g. predator-prey relationships), and gear impacts to benthic habitat. Recreation impacts involve disruption of benthic habitat via digging during over-exploitation of bait species. For instance, excessive exploitation of the bloodworm (*Glyceria dibranchiata*) in North America has been implicated with habitat destruction, disturbance impacts to wildlife, and demise of the species (Wilson, 1988).

4.1.1 Over-harvesting

Of the 25 species for which Gloucester Harbor is designated as EFH the NEFMC has identified fourteen species whose populations are either overexploited (i.e. formerly or currently harvested at unsustainable yields) or are currently approaching an over-exploited status (Table 4-1). For some species, emergency amendments to existing commercial (e.g. black sea bass) and recreational (e.g. summer flounder) harvest regulations appear necessary to protect further impact to extant populations from over-harvesting (DMF, 2001). The status of yet other species or stocks of other species is

Table 4-1. Status of Select Fisheries Involving Listed EFH Species

Species	NMFS Fishery Status
Atlantic cod *(Gadus morhua)*	Overfished
haddock *(Melanogrammus aeglefinus)*	Georges Bank stock is not even close to overfished. Not enough information for the Gulf of Maine
pollock *(Pollachius virens)*	Not enough information
whiting *(Merluccius bilinearis)*	Southern Georges Bank/Middle Atlantic stock is overfished Gulf of Maine/Northern Georges Bank is approaching overfished status
offshore hake *(Merluccius albidus)*	Currently undetermined
red hake *(Urophycis chuss)*	Overfished
white hake *(Urophycis tenuis)*	Approaching overfished
redfish *(Sebastes fasciatus)*	Neither currently overfished nor approaching an overfished condition
witch flounder *(Glyptocephalus cynoglossus)*	Overfished
winter flounder *(Pleuronectes americanus)*	Overfished
yellowtail flounder *(Pleuronectes ferruginea)*	Georges Bank and Southern New England stocks are not even close to overfished. Not enough information for Cape Cod or Middle Atlantic stocks
windowpane flounder *(Scopthalmus aquosus)*	Overfished
American plaice *(Hippoglossoides platessoides)*	Overfished
ocean pout *(Macrozoarces americanus)*	Not overfished
Atlantic halibut *(Hippoglossus hippoglossus)*	Overfished
Atlantic sea scallop *(Placopecten magellanicus)*	Overfished
Atlantic sea herring *(Clupea harengus)*	Not overfished
monkfish *(Lophius americanus)*	Overfished
bluefish *(Pomatomus saltatrix)*	Undetermined; commonly exhibits population fluctuations
long-finned squid *(Loligo pealei)*	Almost fully exploited
short-finned squid *(Illex illecebrosus)*	Almost fully exploited
Atlantic butterfish *(Peprillus triacanthus)*	Neither currently overfished nor approaching an overfished condition
Atlantic mackerel *(Scomber scombrus)*	Underexploited
summer flounder *(Paralicthys dentatus)*	Overfished
scup *(Stenotomus chrysops)*	Overfished
black sea bass *(Centropristus striata)*	Overexploited in Mid-Atlantic Bight stocks, no information for New England Stocks
surf clam *(Spisula solidissima)*	Neither currently overfished nor approaching an overfished condition
ocean quahog *(Artica islandica)*	Neither currently overfished nor approaching an overfished condition

Source: NMFS, EFH Source Documents

currently undetermined. Additional data, when it becomes available, may reveal still other species that may be currently overexploited.

Gloucester Harbor itself is not a major commercially harvested area for most of these species, especially those species with pelagic adult life stages. Rather, most are harvested in offshore regions proximal to Gloucester Harbor and Cape Ann, such as Georges Bank. Over harvesting of offshore areas may impact EFH of the Gloucester Harbor by removal of EFH designated species and their prey (refer to Section 4.1.2), or via the destruction of complex benthic habitats which would normally support these species, a portion of which might normally disperse into the harbor from off-shore areas.

4.1.2 Harvest or Impact to Prey Species

Over-harvesting of prey (i.e., lower trophic level) species may degrade the habitat value of EFH for higher trophic level fish by depleting the food sources of the higher trophic level fish. Pauly, et al. (1998) identified a worldwide trend in increasing harvest of lower trophic level fish. They suggest that continued harvest of lower trophic level fish species may lead to a collapse in the food webs which support higher trophic level fish (e.g. cod, halibut and pollock). The prey of each of the 25 EFH species listed for Gloucester Harbor and their various life stages are presented in Table 4-2.

Table 4-2. Essential Fish Habitat Species and their Respective Prey

Species	Life Stage	Prey	Source
Atlantic cod (*Gadus morhua*)	Larvae	Larval copepods	Fahay et al., 1999a
	Juvenile	Crustaceans and polychaetes	
	Adult	Redfish, herring, and haddock	
Haddock (*Melanogrammus aeglefinus*)	Larvae	Invertebrate eggs, copepods, and phytoplankton	Cargnelli et al., 1999h
	Juvenile	Benthic feeder on invertebrates, crustaceans, polychaetes, and fish	
	Adult	Echinoderms, polychates, crustaceans, and fish eggs	
Pollock (*Pollachius virens*)	Larvae	Size selective feeders. Mostly copepods	Cargnelli et al., 1999f
	Juvenile	Crustaceans, fish, and mollusks	
	Adult	Crustaceans, mollusks, and fish including Atlantic herring, pollock, redfish, and hake	
Whiting (*Merluccius bilinearis)*	< 20 cm	Crustaceans such as euphausiids and shrimp	Morse, et al., 1999
	> 20 cm	fish	
Red hake (*Urophycis chuss*)	Larvae	Copepods, microcrustaceans	Steimle et al., 1999d
	Juvenile	Mostly crustaceans such as *Crangon* sp. but also amphipods and polychaetes	
	Adult	Fish and Crustaceans	
White hake (*Urophycis tenuis*)	Juvenile	Polychaetes, small shrimp, and other crustaceans	Chang et al., 1999b

Species	Life Stage	Prey	Source
	Adult	Smaller fish including own species and crustaceans	
Redfish (*Sebastes fasciatus*)	Larvae	Small larvae eat copepod eggs, large larvae eat copepods and euphausiids.	Pikanowski et., al. 1999
	Juvenile	Copepods, euphausiids, mysids, and fish	
	Adult	Euphausiids, mysids, and fish	
Witch flounder (*Glyptocephalus cynoglossus*)	Juvenile	Polychaetes, echinoderms, crustaceans, mollusks, and coelenterates	Cargnelli et al., 1999g
	Adult	Polychaetes, echinoderms, crustaceans, mollusks, coelenterates	
Winter flounder (*Pleuronectes americanus*)	Larvae	Nauplii, invertebrate eggs, protozoans, polychaetes	Pereira et al., 1999
	Juvenile	Sand dollars, bivalve siphons, polychaetes, amphipods,	
	Adult	Amphipods, polychaetes, bivalves or siphons, capelin eggs, crustaceans	
Yellowtail flounder (*Pleuronectes ferruginea*)	Juvenile	Mostly polychaetes	Johnson et al., 1999b
	Adult	Crustaceans	
Windowpane flounder (*Scophthalmus aquosus*)	Larvae	Copepods and other zooplankton	Chang et al., 1999a
	Juvenile	Polychaetes and small crustaceans such as mysids	
	Adults	Polychaetes, mysids, decapods, shrimp, hake, and tomcod	
American plaice (*Hippoglossoides platessoides*)	Larvae	Plankton, diatoms, and copepods	Johnson et al., 1999a
	Juvenile	Small crustaceans, polychaetes, and cumaceans	
	Adults	Echinoderms such as sand dollars, sea urchins, and brittle stars	
Ocean pout (*Macrozoarces americanus*)	Larvae	Harpacticoid copepods	Steimle et al., 1999e
	Juveniles	Small benthic organisms such as amphipods and polychaetes	
	Adult	Benthic organisms, especially shelled, e.g., mollusks, crustaceans, echinoderms, sand dollars	
Atlantic halibut (*Hippoglossus hippoglossus*)	21 – 30 cm	Crustaceans such as decapods	Cargnelli et al., 1999b
	31 – 80 cm	Crustaceans, fish, and mollusks	
	81 – 134 cm	Squid, crab, silver hake, ocean pout,	
Atlantic sea scallop (*Placopecten magellanicus*)	Larvae	Filter feeders, primarily on phytoplankton, diatoms and, microscopic animals	Packer et al., 1999a
	Juvenile	Opportunistic feeders on suspended particles, primarily phytoplankton	

Species	Life Stage	Prey	Source
	Adult	Filter feeders on phytoplankton and other suspended organic particles from the water column	
Atlantic sea herring (*Clupea harengus*)	Larvae	Copepod eggs, nauplii, mollusk larvae	Reid et al., 1999
	Juvenile	Selective opportunistic feeders, mostly copepods	
	Adult	Euphausiid, chaetognaths, and copepods	
Monkfish (*Lophius americanus*)	Larvae	Zooplankton	Steimle et al., 1999c
	Juvenile	Small fish, shrimp, and squid	
	Adult	Mostly fish, crustaceans, mollusks, and occasionally seabirds	
Bluefish (*Pomatomus saltatrix*)	Larvae	Copepods	Fahay et al., 1999b
	Juvenile	Crustaceans, fish, and polychaetes	
	Adult	Sight feed on other fish	
Long finned squid (*Loligo pealei*)	Larvae	Copepods	Cargnelli et al., 1999c
	Juvenile	Euphausiids, arrow worms, shrimp, crabs	
	Adult	Silver hake, mackerel, herring, menhaden, bay anchovy, weakfish, silversides, crustaceans, squid	
Short finned squid (*Illex illecebrosus*)	Larvae	Yolk sack	Cargnelli et al., 1999a
	Recruit	Squid, crustaceans, juvenile Atlantic cod, mackerel, redfish, and sand lance	
Atlantic butterfish (*Peprillus triacanthus*)	Juvenile	Thaliaceans, squids, copepods, amphipods, decapods, coelenterates, polychaetes, small fish, and ctenophores	Cross et al., 1999
	Adult	Thaliaceans, squids, copepods, amphipods, decapods, coelenterates, polychaetes, small fish, and ctenophores	
Atlantic mackerel (*Scomber scombrus*)	Larvae	Other fish larvae such as yellowtail flounder	Studholme et al., 1999
	Juvenile	Small crustaceans, such as copepods, euphausiids, amphipods, mysid, shrimp, and decapod larvae	
	Adults	Similar to juvenile but with selection of larger fish such as, euphausiid, pandalid, and crangonid shrimp	
Summer flounder (*Paralicthys dentatus*)	Larvae	Polychaete tentacles, harpactacoid copepods, and clam siphons	Packer et al., 1999b
	Juvenile	Crustaceans, polychaetes, and invertebrate parts	
	Adult	Invertebrates, shrimp, weakfish, mysids, anchovies, squid, Atlantic silversides, herring, and hermit crabs	
Scup (*Stenotomus chrysops*)	Larvae	Yolk, zooplankton	Steimle et al., 1999b
	Juvenile	Small benthic invertebrates	
	Adult	Benthic and near bottom invertebrates and small fish	

Species	Life Stage	Prey	Source
Black sea bass (*Centropristus striata*)	Larvae	Use yolk reserves in a few days; feeding begins with zooplankton at 6mm	Steimle et al., 1999a
	Juvenile	Small epibenthic invertebrates such as crustaceans	
	Adult	Benthic, near-bottom invertebrates, and small fish	
Surf clam (*Spisula solidissima*)	Larvae	Larvae are planktotrophic	Cargnelli et al., 1999d
	Juvenile and adult	Planktivorous siphon feeders especially like diatoms and ciliates	
Ocean quahog (*Arctica islandica*)	Larvae	Phytoplankton	Cargnelli et al., 1999e
	Juvenile	Phytoplankton	
	Adult	Suspension feeders on phytoplankton.	

4.1.3 Gear Effects

The potential adverse effects that gear may cause on fish and EFH depend on the specifics of the fishery and the type of gear employed. For example, there are many different types or configurations of trawl gear including those that are deployed along the bottom or near the bottom, those that are used for mid-water and still others that use varying configurations of the net. Nets alone may vary in mesh size. Furthermore, the use of the gear may be restricted in certain areas such as shipping lanes, turning basins, mooring areas and so forth. Seasonal restrictions may also apply to certain gear used. The two most important impact categories caused by fishing include direct injury to fish and injury to fish habitat.

4.1.3.1 Injury to Fish

Gill nets are notorious for damaging fish either via compressing their gills leading to suffocation or via gill injury while struggling in the net (WADFW, 2001). For instance, recent experiments with salmonids in Washington state demonstrated that one out of five Coho and one out of ten Chinook salmon caught in tangle nets would be injured to the point where they could not reasonable be expected to survive if released.

Certain fish species individuals and their populations may be negatively impacted via commercial by-catch. As defined in the Magnuson-Stevens Act, (Sec. 104-297), the term "bycatch" means:

> *"...fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards. Such term does not include fish released alive under a recreational catch and release fishery management program."*

"Economic discards" refers to:

> *"Fish which are the target of a fishery, but which are not retained because they are of an undesirable size, sex, or quality, or for other economic reasons" (Sec. 104-297).*

The term "regulatory discards" means:

> *"Fish harvested in a fishery which fisherman are required by regulation to discard whenever caught, or are required by regulation to retain but not sell" (Sec 104-297).*

By-catch can result in the injury or removal of non-targeted fish species during commercial harvest operations of the targeted fish species. For instance, the use of gill nets near the bottom while fishing for flatfish may result in the capture of other demersal fish such as cod. Typically, injury to the bycatch occurs as external trauma via handling of the gear, or via internal trauma due to changes in pressure as gear is hauled up quickly from the bottom using mechanical means. Efforts are underway to improve commercial fishing gear to improve selectivity of target fish and reduce bycatch while maintaining utility of the gear (DMF, 2001).

4.1.3.2 Injury to Fish Habitat

The degree of impact caused by mobile fishing gear on the marine substrate is dependent upon the benthic composition. However, substrate types can be negatively impacted by gear that drags along the bottom substrate. Generally speaking, the more complex the bottom habitat, the more negative impact to the benthic habitat that could potentially be incurred.

Boulder and rock reef areas can be raked by bottom trawls that could potentially overturn boulders thereby killing the sessile invertebrates that have colonized the rock surfaces. These sessile creatures include sponges, cnidarians, bryozoans, echinoderms, etc. which are prey species for a number of EFH fish (refer to Table 4-2).

On smaller textured substrates such as cobbles, pebbles, sands, and mud, impacts incurred by use of bottom dragging trawls typically result in a loss of substrate complexity via a homogenization of substrate types (Eckelbarger, 2001). The homogenization of bottom substrates impacts EFH because it results in the reduction of the habitat's suitability to larval recruits of the exploited fish species or it discourages settlement of sessile invertebrate prey species. Recent studies have shown that any benthic structure has value in increasing survival time and total number of young cod when young are subjected to predation. Increasingly complex habitat helps survivorship of young cod (Lindholm, et al., 1999).

Trawls through soft bottom sediments such as mud can destroy invertebrate burrows, killing the inhabitants. This results in reducing bioturbation rates and thus sediment aeration producing areas that may have shallow to no aerobic surface layers. Disturbance of sediments with shallow to no aerobic surface layers can result in the release of hydrogen sulfide. Concentrations of dissolved hydrogen sulfide in the water column may discourage settlement of benthic invertebrate larvae. Norse and Watling (1999) attribute fishing with mobile fishing gear as the leading factor in disturbance to the seabed resulting in the reduction in complexity of benthic habitats and a concurrent decrease in the diversity of benthic environment. The magnitude of impact to the benthic marine habitat from bottom trawling worldwide, may surpass the scale of impact incurred on the terrestrial environment due to forest clear cutting worldwide.

The negative impact that gear may have on a fishery are greater if the gear disturbs or destroys special habitat areas known to take many years to form such as kelp beds, eelgrass beds, or coral reefs. Auster and Langton (1999) reviewed 90 gear impact studies and found that 88 of the 90 studies reviewed documented similar measurable impacts from mobile fishing gear. They found these studies to consistently cite reduced habitat complexity, changed community structure, and affected ecosystem processes as the major impacts from mobile fishing gear. Commercial fishing for lobster occurs both within and outside of Gloucester Harbor. Commercial fishing for groundfish and mollusk (employing a number of gear techniques such as trawling, purse seining, gill netting, pound netting, hook and line, traps, and hydraulic dredge) is excluded within Gloucester Harbor. Commercial fishing for pelagic species such as striped bass and bluefish occurs regularly within the harbor employing hook and line techniques. However, by comparison, commercial fishing for groundfish and pelagic species employing a variety of techniques occurs more extensively outside the harbor.

4.2 NON-FISHING ACTIVITIES AND THEIR POTENTIAL EFFECTS ON MARINE EFH

Non-fishing activities that may impact Gloucester Harbor EFH include those projects, actions or procedures that may:

- Alter sediment inputs to the estuary;
- Alter water flows, quantities, cycling, physical or chemical characteristics;
- Impact soil through compaction, or other changes in permeability;
- Alter riparian, or estuarine vegetation;
- Reduce or alter the stability of coastal landforms;
- Alter estuarine wetlands and wetlands along tributary waters;
- Alter predator species richness and abundance;
- Alter the amount or types of nutrients or prey;
- Alter estuarine or marine habitat (including water quality, vegetation, structure, or conveyances);
- Introduce or transfer exotic organisms and disease;
- Disturb nursery or spawning areas;
- Create a barrier or hazard to fish migration; and;
- Discharge pollutants, nutrients, or contaminants.

Any on-shore activity that disturbs or alters the watershed around the harbor (e.g. land clearing, urbanization, stream relocation, etc) has the potential to impact EFH directly (e.g. via pollutant or sediment inputs) or indirectly by altering watershed processes that affect tributary streams, salt marsh wetlands, shorelines and estuaries. This is typically the case as these alterations tend to be of such magnitude, scale, or duration as to surpass those produced by natural disturbances, or they exceed limits of the natural recovery processes in which the ichthyofauna have adapted.

The potential impact to the major components of the marine environment caused by human induced alterations in the landscape were presented in Table 3-1 (Section 3).

4.2.1 Wetland/Estuarine Alteration

Wetlands associated with the marine and estuarine environment are valuable habitat types relative to fish and EFH. These habitats are the transition areas between the upland and the open water communities. They provide a food rich environment for productive foraging, they are used as physiological transition zones between fresh and salt water environments. Wetlands offer refugia to juveniles and prey species from predators, and it is here where the transfer of energy from the upland to open water environments occurs.

Changes to the systems may occur through tideland conversion, exogenous material (i.e. material originating outside the system) input, runoff and sedimentation induced turbidity, physical disruption (e.g. noise, turbulence, obstructions), shading by structures and vessels, SAV control, water diversion, and the introduction of non-native species. Alteration of the watershed which results in changes to the pollutant quantities and concentrations, organic matter concentrations or physical parameters of the water column (i.e. temperature, dissolved oxygen, salinity, pH, light penetration) may also negatively impact the wetland/estuarine communities.

Alteration of the wetland and estuarine systems can cause a reduction or loss of juvenile or prey species rearing habitats, exposure of fish to pollutants, exposure of fish species to mammalian and avian predators, and alteration in the timing of life history stages or events. Wetlands associated with the marine environment including Gloucester Harbor include salt marshes, floodplains of tributary streams, and submerged aquatic vegetation beds (refer to Figure 4-1). These communities typically occur within estuarine environments and are productive interfaces between the upland and open water environments. Major salt marshes areas of the harbor occur within Freshwater Cove on the west side of the Main Harbor (within the Western Gloucester Harbor Quadrant) and along the Annisquam River north of the Western Harbor. The major SAV beds located within the harbor are found within the Southeast and Western harbors as well as off Black Bess Point and within Lighthouse Cove. The Western Harbor SAV beds are especially high value to fish habitat since they are located at the mouth of the Annisquam River. At this location, they provide strategic cover for juvenile diadromous fish. Diadromous fish are fish that partake in regular, periodic (typically seasonal), and obligatory movements between fresh and marine water habitats. These movements are

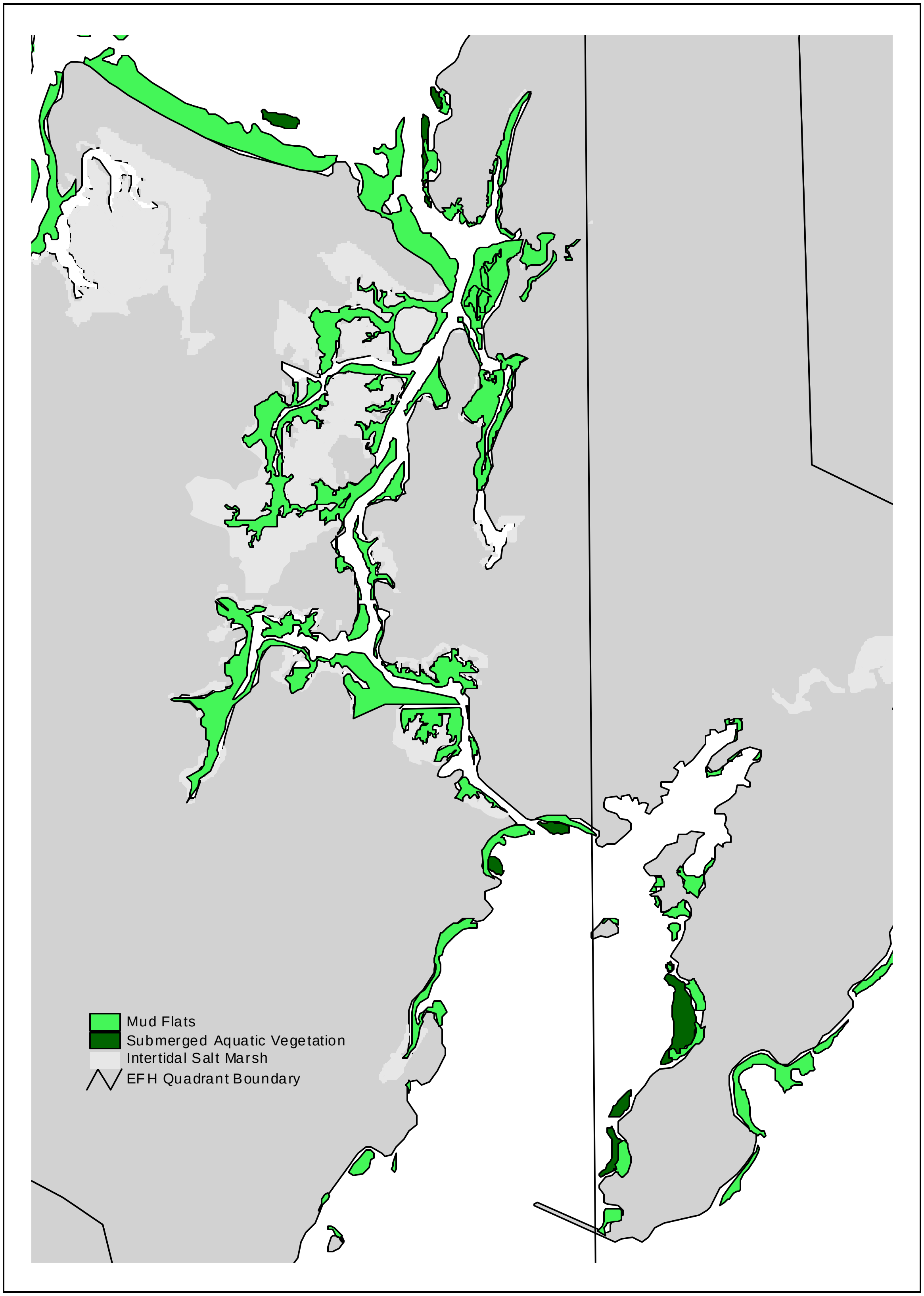

Figure 4-1. Marine Wetlands Associated with Gloucester Harbor

further classified into one of three categories: anadromy, catadromy, and amphidromy, defined below (Matthews, 1998):

- Anadromy: the periodic and obligatory migration of fish from marine waters into fresh water to spawn. An example in the Gloucester Harbor fish community would be the blueback herring.

- Catadromy: the periodic and obligatory migration of fish from fresh water into marine waters to spawn. An example in the Gloucester Harbor fish community would be the American eel.

- Amphidromy: the periodic movement of immature or juvenile fish between fresh and marine waters. An example in the Gloucester Harbor fish community would be the winter flounder.

Of the 24 and 23 fish species listed for the Western and Eastern Gloucester Harbor Quadrants respectively, four can be considered estuarine dependent. Estuarine dependent fish are those species of fish, which require estuarine habitats for some, if not all, of their life cycle. Day, et al., (1989) listed the summer flounder (*Paralicthys dentatus*), scup (*Stenotomus chrysops*) and the black sea bass (*Centropristus striata*) as estuarine dependent species, while Robins and Ray (1986) included the Atlantic herring (*Clupea harengus*). Typically, the primary estuarine habitats such as tidal creeks, salt marshes, and sea grass beds are used as nursery areas by many marine fish. These nursery areas are sought out by larval and juvenile life stages of the estuarine dependent fish, since not only do the estuaries tend to provide relative safety or protection from predators, but they also supply an abundant food source (through detrital food chains) with reduced competition at critical trophic levels (Day et. al., 1989). Typically, these species are adapted to survive in a dynamic environment subject to frequent environmental fluctuations. However, prolonged or permanent alterations of the physiochemical parameters of their environment (e.g. temperature, salinity, turbidity, dissolved oxygen) due to human-induced impact can be detrimental to the fish that reside in these estuarine habitats.

Three of the four estuarine dependent fish species are predominantly mid-Atlantic species (scup, black sea bass, and summer flounder) and as such tend to be at or near the northern limit of their range distribution in Gloucester Harbor. As commercially fished species, they are subject to range constrictions if overfished in the mid-Atlantic states (DMF, 2001). These periodic constrictions can result in the apparent absence or markedly low abundance of these species from many areas during certain years. Therefore, compared with larger, more extensive estuaries from within the midst of these species' ranges in the mid-Atlantic states (e.g. Chesapeake Bay, Delaware Bay, etc.), the limited area of the estuarine habitats located within Gloucester Harbor may not be as important on a regional basis to the recruitment of the Atlantic fishery stocks.

4.2.2 Agriculture

As a percentage of the total land area, there is a minimal amount of agricultural lands within the Gloucester Harbor watershed. None-the-less, activities associated with agriculture, such as vegetation removal, excessive or improper use of pesticides/herbicides and fertilizers can have significant impacts to marine and estuarine systems. Vegetation removal reduces the filtration of sediment and pollutants from surface water runoff. It promotes erosion, and allows water temperatures of estuarine tributary streams to increase in temperature. Excessive or improper use of pesticides, herbicides, and fertilizers impact water quality via toxicity to living organisms or by promoting eutrophication. Resultant impact to surface water down gradient of mis-managed agricultural land occurs in the form of turbid, low-oxygen, and potentially toxic waters. These impacted waters typically cannot support many fish species or their various life stages.

4.2.3 Aquaculture

Shellfish farming and depuration is an example of a common aquaculture activity in New England. Shellfish farming typically requires the dumping of shell spawn into appropriate waters. Harvesting requires raking and other disturbances to the benthic environment. These practices can cause the destruction of eelgrass beds; increased erosion of areas formerly stabilized by eelgrass; increased turbidity; loss of habitat complexity, juvenile refugia, or substrate; reduction in primary productivity; and increased wave energy resulting in juvenile displacement or strandings.

4.2.4 Construction/Urbanization

Construction and general urbanization activities include road-building, land-clearing for development, excavation for utilities, etc. These activities typically result in a greater impervious upland surface area due to development of areas that formerly contained natural vegetation as the predominant land coverage. Increased urbanization is directly proportional to an increase in interception of precipitation producing greater runoff of untreated stormwater. Urbanization typically reduces habitat complexity, alters tidal streams through channelization, decreases channel stability, and impairs water quality. It results in the increase of frequency and magnitude of flood events, and accelerated runoff rates result in lower stream flows during drier months by disrupting groundwater retention times. This typically impacts fish with extended freshwater larval or juvenile rearing stages of their life history. The net effect of urbanization is disruption of the hydrologic processes by increasing peak flows and decreasing low flows (CTDEP, 1995).

4.2.5 Oil and Hazardous/Regulated Material Handling, Processing, Transport, Disposal

Various exogenous chemicals have historically been or currently are transported by railroad, shipping, and roadways within the harbor and its watershed. These chemicals, when released through controlled loss, leakage, seepage, spills or deliberate disposal (either permitted or un-permitted), may enter the marine and estuarine ecosystems resulting in various acute and chronic toxicity responses to fish and their prey species. These substances and chemicals may be generated by various residential, commercial, industrial, municipal, institutional or military land uses. The various classes of chemicals are presented in the table below:

Table 4-3. Various Classes of Exogenous Materials, Typical Representative Contaminants and Likely Contaminant Sources

Contaminant Class	Typical Contaminants	Anthropogenic Contaminant Sources
Inorganic contaminants	Nutrients	Agricultural runoff, wastewater treatment plant discharges, excessive or improper fertilization
	Heavy metals	Atmospheric deposition, industrial discharge, wastewater discharges, leaching from treated wood used for in-water construction
Organic contaminants	Petroleum compounds	Road and pavement surface water runoff, leaking aboveground and underground storage tanks, bilge and ballast water pump-outs, roadway oiling, tanker transfers and commercial ship fillings, other releases (accidental spills)
	Volatile organic compounds	Industrial, commercial discharges, chemical spills
	Insecticides, herbicides, fungicides, other biocides	Residential lawns and gardens, agricultural areas, nurseries, golf-courses, wood treatment facilities and treated wood structures
	Polyaromatic hydrocarbons	Roadway oiling, atmospheric deposition from fossil fuel combustion
	PCBs	Industrial discharges, electrical transformers
Biological Wastes	Sewage and sewage treatment wastewater	Municipal wastewater treatment plants, sewer pipelines, failing subsurface disposal systems, disposal lagoons and cess pools, marine facility dumping
	Animal wastes	Animal lots, feed lots
Radionucleides	Low-level radioactive waste	Biomedical wastes, chemical spills

Table created from multiple reference sources

4.2.6 Introduction/Spread of Non-Native or Non-Endemic Species

The introduction of non-native plants and animals to surface waters occurs either deliberately (e.g., to enhance sport fishing or to control aquatic weeds) or without knowledge or intent through various water-related activities, such as bilge or ballast water pump-outs, dumping of live bait and associated seaweed packing, aquaculture escapes, and other inadvertent releases. Exotic species that have established themselves historically have done so to the detriment of native species. This detriment occurs as a result of competition, predation, inhibition of reproduction, environmental modification (e.g., alteration of food webs), introduction of new parasites and pathogens, hybridization, or a combination of these things.

4.2.7 Marina/Dock Construction

New marina and dock construction in Gloucester Harbor could potentially occur at new sites or as upgrades or expansions of existing sites. The need for new berthing and mooring areas was identified in the Gloucester Harbor Master Plan as a major avenue for expanding the recreational and tourism trade, and to provide safe haven or access to the harbor amenities to transient craft (GHPC, 1999).

Impacts from these activities are typically generated during dock or bulkhead construction, expansion, replacement or demolition. Impacts associated with these activities typically occur as construction/urbanization impacts discussed in Section 4.2.4 (i.e. removal of vegetation, turbidity and sedimentation, increased surface water runoff, etc.). However, the structures themselves introduce exogenous chemicals into the marine environment, the effects of which may not yet be totally understood, especially on a chronic toxicity level. Historically, wooden structures were treated with creosote or pentachlorophenol to prevent decomposition and decay by marine organisms. These structures have been implicated in the release of persistent polynuclear aromatic hydrocarbons into the aquatic environment. These substances have been phased out of production and have been replaced with chromated copper and copper-zinc arsenates, a class of compounds which may have their own toxicological concerns associated with their use due to potential release of toxic heavy metals over time, in fact, some studies suggest that copper-zinc arsenates may have higher acute toxicity than each of the individual metal's toxicities (Walker, 1990). Toxicological effects span the gambit of those outlined in Table 3-2 (Section 3.1.2).

4.2.8 Removal of in-water Structures

Removal of in-water structures such as, reefs, rock ledges, jetties, and even vertical bulkhead or seawalls could impact fish and EFH. This action is sometimes necessary to maintain safe navigation channels. The removal of navigational obstructions such as derelict pilings, dilapidated wharves, and shipwrecks was identified in the Gloucester Harbor Master Plan as a needed improvement in Gloucester Harbor. In addition, at least four locations have been identified by the Gloucester Department of Public Works as areas in need of seawall repair (GHPC, 1999).

The removal of long established structures, reefs, rock ledges, jetties, and bulkhead walls, could remove productive marine communities living within, on, or in association with the given structure. It acts to reduce habitat complexity, remove shelter, breeding, and feeding substrates. Typically, removal of these structures produces turbidity, may subject land areas to erosion, and may alter flows in embayments and tidal creeks. Removal of woody debris also removes a source of detrital nutrients for wood boring marine organisms. Norse and Watling (1999) cite various studies that have shown that the removal of structures and the reduction of habitat structural complexity has resulted in the favoring of sand-loving fish species and the loss of some commercially important species such as grouper and cod.

4.2.9 Road-building and Maintenance

The need for large-scale new road construction or reconstruction of existing roadways has not been identified as an immediate need for Gloucester. However, localized improvements to existing roadways have been identified and addressed in the Harbor Master Plan, should future economic opportunities, identified in the plan, be pursued. The potential need for replacement/improvements to the Blynman Canal drawbridge was also identified in the Harbor Master Plan as a potential long-term goal to handle increasing boat traffic on the Annisquam River (GHPC, 1999). Impacts to Fish and EFH from road building and maintenance are similar to those associated with urbanization/construction impacts (refer to Section 4.2.4). Typically, the major effects to wetland systems due to road building and maintenance projects are disruption/alteration of hydrologic regime, sediment loading and direct wetland removal (Mitsch and Gosselink, 1993).

4.2.10 Shipping Operations

Shipping operations are an integral part of the economic vitality of Gloucester Harbor. The harbor serves as homeports for fishing fleets and many recreational crafts. It is also a port of call for some commercial fishing boats and other commercial freighters. Shipping related activities that impact fish and EFH include oily bilge water/ballast water discharge, oil release from shipping accidents, ship wakes, and ship-induced wave energy. Release of oily wastewater into the water column can produce the same toxicological, behavioral, and developmental effects as outlined in Table 3-2 (Section 3.1.2).

Wave energy and wakes generated by shipping operations can produce erosion of beach sediment, displacement of juveniles and larval fishes and can cause juvenile strandings when waves over-wash rocks, jetties and beach areas.

4.2.11 Wastewater/Pollutant Discharge

Wastewater discharge to surface waters occurs via direct discharges (point sources) such as sewage treatment plants, power-generating facilities, and industrial effluents, or via non-discrete surface runoff (non-point sources), such as agricultural runoff, runoff from over-fertilized lawns and gardens, and runoff from parking lots and roadways. Other pollutant discharge can occur via atmospheric deposition, accidental release or spills, and via intentional discharge or disposal such as via pump-outs of oily bilge water or via the disposal of unsuitable dredge or fill materials.

Known sewage outfall locations (combined and otherwise) that occur in Gloucester are located in the upper reach of the Inner Harbor and in Harbor Cove. A sewer pipeline traverses the center of Gloucester Harbor from the proximity of the Blynman Canal to its outfall at a point just south of the Dogbar Breakwater, outside the Harbor.

Pollutant discharges can also occur from the seepage of contaminated groundwater into the harbor from landside contaminated sites. At least one known site that may have

contamination issues of concern in terms of impact to water quality is known to exist along the water's edge in Gloucester Harbor (GHPC, 1999).
Other future sources of wastewater discharge are possible. For instance, wastewater pretreatment has been identified as an economic constraint to potentially expanding the existing fish processing industry in Gloucester Harbor (GHPC, 1999).

Wastewater/Pollutant Discharges can impact fish and EFH via acute and chronic toxicity to various pollutants (Refer to Table 3-2, Section 3.1.2), via turbidity effects (discussed in Section 3) and via depletion or reduction of dissolved oxygen in the water column or benthic sediment. Historically, fish wastewater discharged to the tidal Thames River in London, UK resulted in the elimination of all fish, save the eel (*Anguilla anguilla*), from 1920 to 1960. Subsequent improvements and upgrades to the wastewater treatment systems resulted in the return of fish species diversity including the water quality-sensitive salmon (Moriarty, 1983).

4.2.12 Bank Stabilization

Bank stabilization activity includes bulkhead construction, stream or tidal channel armament or reinforcement. Construction of bulkheads typically results in creating an abrupt and unnatural interface between the surface water and upland habitats. Channel armament has traditionally occurred through the addition or deposition of concrete or riprap along the eroded channel walls. Both activities have the net impact of reducing habitat complexity. Channelization eliminates the formation of sloughs, and impairs the development of side channels, and floodplains, which are microhabitats utilized by larvae, juveniles and prey species. Juvenile habitat of fish species that prefer shallow inshore waters or undercut banks may be eliminated or reduced, rip-rap areas may create additional hiding places for ambush predators, and preserved wooden structures may be a source of toxicity to marine organisms (refer to Section 4.2.7).

4.2.13 Habitat Restoration

Habitat restoration projects usually occur as a result of wetland mitigation requirements in response to impacts from other projects such as new roadway or bridge construction. However habitat restoration sites typically fail to replicate the value of the originally impacted habitat for the following reasons (Hammer, 1992):

- Inaccurate assessment of physical processes governing the system;
- Inadequate knowledge of the habitat's community ecology;
- Inadequate assessment of the original cause of habitat degradation;
- Ineffective restoration efforts;
- The lack of pristine reference sites proximal to the restoration area;
- Failure to set appropriate monitoring or performance standards;
- Focus on benefit to a single species rather than the community; and
- Focus on mitigating losses rather than on preventing loss.

Inaccurate assessment of physical processes governing the system

Failure to understand the hydrology, diurnal, seasonal, or other physical aberrations in the system may prevent the restoration efforts from becoming successful. This is especially true for wetland restoration projects since wetlands are the product of hydrologic processes. In addition, many community assemblages are a product of disturbance events that originate from environmental aberrations or extremes (Levinton, 1982).

Inadequate knowledge of the habitat's community ecology

Some community assemblages are a product of biotic interactions such as competition, mutualism, parasitism, predation, and commensalism. In some communities, the degree of influence that biotic interactions have on community assemblages far surpasses those produced by environmental aberrations. For instance, the benthic invertebrate community of the seaward end of the boreal rocky intertidal zone is heavily influenced by biotic interactions as opposed to the extreme landward end of the rocky intertidal gradient which is governed by temperature extremes, solar radiation, desiccation, and ice scour.

Inadequate assessment of the original cause of habitat degradation

Failure to inadequately assess the original cause of habitat degradation can easily translate into habitat restoration failure, since the original cause has not been rectified. In many cases, the cause is not easily detected because the degradation may have occurred as a result of cumulative impacts. Cumulative impacts may be successive (additive in series) or synergistic (additive in concert). When cumulative impacts act upon an environment, the numerous confounding variables causing habitat degradation may be hard to identify, prioritize for abatement, or control.

Ineffective Restoration Efforts

Ineffective restoration efforts typically occur because it is very difficult to recreate a formerly long-existing and self-sustaining natural system. Typically restoration plans are ineffective because they are not designed around the physical processes that drive the systems being restored (such as hydrology or seasonal cycles). Other plans may fail to replicate the structural diversity or provide for microhabitats or special habitat requirements needed by organisms living within the system.

The Lack of Pristine Reference Sites Proximal to the Restoration Area

The lack of pristine reference sites proximal to the restoration area may result in the improper interpretation of monitoring performance criteria. Confounding variables may be negatively impacting the restoration area, causing failure. These variables may be a synergistic or cumulative effect of anthropogenic influences, or they may be due to abiotic interactions inherent in the natural community (e.g. disease cycles). It is also important to have a reference site proximal to the project site in order to remove geographical influences (e.g. climate) and clinal variation. Pristine habitats can incur anthropogenic impacts from far away sources due to winds, tides, currents, storms, or via transport by man. Therefore, there are very few areas, especially in the developed northeast, that offer pristine systems to use as references for the performance review of restoration efforts.

Failure to set appropriate monitoring or performance standards

Due to the complexity of factors that can influence and act upon the operation and functioning of any habitat system, one cannot expect to completely understand every component and each pathway for energy and nutrient flow. Therefore, readily identifiable indicators of system robustness and viability sometimes are not adequately assessed, and therefore appropriate adjustments to the restoration efforts sometimes cannot be made (Hammer, 1992).

Focus on benefit to a single species rather than that of the community

An all too common mistake in restoration efforts is to focus the benefit of the restored habitat on a single species rather than on the community in which the species lives. Without recreating a sustainable community for the target species the species may exhibit unregulated population growth enjoying initial success, but eventual demise due to the lack of population regulating mechanisms in the community. Predator prey relationships are a prime example of an inter-related, self-regulating, cyclic yet stable biotic interaction.

Focus on mitigating losses rather than on preventing loss

The best strategy for preventing the loss or degradation of natural ecosystems is first, avoidance of the impact, second minimization of the impact, and third, mitigation of the impact. Avoidance is not always possible due to the fact that humans are consumers and as such we exploit our natural resources. This exploitation can be based on need, greed, or as an indirect consequence of our activity in daily life. We may be limited by available infrastructure, cost, technology, etc while obtaining our resources to the point where all impacts cannot be avoided all of the time. When impact cannot be avoided, it should be minimized.

Minimization as a concept is not self-regulating due to the competitive nature of man. Resources, unless regulated by law and enforced, always run the risk of over-exploitation due to the "tragedy of the commons" where each individual tries to maximize personal benefits while minimizing personal cost. The tragedy is that all responsible for the impact know their actions collectively will lead to destruction of the resource, but no one will stop first while others are still willing to take. Many proponents of developments put forth their original development plans at a much larger scale than anticipated, knowing that regulators will require them to scale it back to "minimize" impact.

Once avoidance and minimization has failed to protect the resource or habitat, mitigation is required. Due to the reasons stated above, many development projects that are approved focus on minimizing the impacts rather than the initial steps of avoiding the impact. Since man cannot create what nature took millennia to do, mitigation is rarely adequate to replace what was lost.

4.3 SUMMATION OF CUMULATIVE IMPACTS

Multiple land uses exist within the Gloucester Harbor watershed. The economic vitality of the municipality and the surrounding region has been, currently is, and will continue to be dependent upon these land uses. Therefore, the harbor will continue to be subjected to a diverse array of projects or activities associated with the various uses within the watershed. These projects or activities have the potential to cumulatively impact the EFH of Gloucester Harbor. These activities include both fishing related (i.e. overharvesting, harvest or impact to prey species, gear effects) and non-fishing related (e.g. urbanization, oil/chemical handling, construction, shipping, wastewater pollutant discharge, etc.) activities. The cumulative impacts associated with these activities can impair water quality, destroy benthic habitat, and directly or indirectly effect organisms across multiple taxa within the marine community. When assessing cumulative impacts to EFH from any given activity, the anticipated changes to the food sources, water quality, habitat structure, flow regime, and biotic interactions of the harbor with respect to EFH should be considered.

5.0 CONCLUSIONS

Barring anthropogenic disturbances, the four main factors influencing fish habitat preference within a marine environment are temperature, salinity, depth and substrate. Although the EFH designation quadrants list 25 species for the 10' x 10' coordinates, variations in environmental factors typically prevent these species from being uniformly distributed throughout the quadrants areal coverage.

Therefore, to accurately assess impacts to the EFH listed species, applicants of proposed projects must determine, at a minimum, the temperature, salinity, depth and substrate of the marine environment within the areal extent of the project limits as well as within influence of the project limits (e.g. down current, or adjacent, etc.).

Table 5-1 is provided as a summary of Section 2.0 (Data gaps in Table 5-1 reflect areas where more research may be currently needed). It can be used as a screening tool to determine which species may likely occur within the thermal, salinity, and depth ranges of proposed project areas. For a complete project-specific EFH assessment, a detailed project description must be prepared and all direct and indirect or cumulative impacts to the EFH within the proposed project area must be considered. A copy of the EFH Assessment Worksheet is included in Appendix A for use by proponents of individual dredging projects.

Table 5-1. Summary of Temperature, Salinity, Depth and Substrate Requirements for Fish Species Listed within the Western and Eastern Gloucester Harbor EFH Quadrants.

Species	Life History Stages	Temperature (°C)	Salinity (ppt)	Depth (meters)	Substrate
American Plaice	Eggs	<14	>25		
	Larvae			30 – 130	
	Juveniles	6 – 8 spring	0.5 – 25	50 – 100	Fine-grained to sand or gravel
	Adults	4 – 6	> 25	54 – 90	Mud
Atlantic Cod	Eggs	4 – 8	26 – 36	< 100	None (water column)
	Larvae	< 10	32 - 33	30 – 75	None (water column)
	Juveniles	4 – 7	30 - 35	25 – 75	Cobble
	Adults	0 - 20		40 – 130	Coarse sediment
Atlantic Halibut	Eggs	4 – 7	< 35	0 – 700	Sand, gavel, clay
	Larvae		30 – 34	0 – 700	
	Juveniles	Prefer > 2		20 – 60	
	Adults	3 – 9	30.4 – 35.3	200 – 300	Sand, gravel, clay
Haddock	Juveniles	2 – 9	31 - 35	50 – 100	Pebble, gravel
Whiting	Eggs	5 – 20		10 –1250	None (water column)
	Larvae	5 – 16		50 –130	None (water column)

Species	Life History Stages	Temperature (°C)	Salinity (ppt)	Depth (meters)	Substrate
	Juveniles	<21	>20	20 – 270	Gravel to fine silt and clay
	Adults	<22	>25	5 – 400	Gravel to fine silt and clay
Red Hake	Eggs			Near surface	None (water column)
	Larvae	8 – 23		10 – 200	None (water column)
	Juveniles	2 - 22	24 – 32	5 – 100	Mud
	Adults	2 – 22	20 – 33	5 – 300	Mud
White Hake	Eggs	4 – 25		10 – 250	None (water column)
	Larvae	10– 18		10 – 150	None (water column)
	Juveniles	4 - 9		< 75	Mud and sand; eelgrass
	Adults	6 – 11	29.5 – 32.5	50 – 325 (spring)	Mud and sand
Redfish	Larvae	6 – 11		50 – 270	None (water column)
	Juveniles	5 - 10	32-34	50 – 200	Rock structure
	Adults	5 – 10	32-34	125 – 200	Sand, gravel
Witch Flounder	Larvae	4 – 12		10 – 210	None (water column)
	Juveniles	2 – 9	31 – 36	90 – 300	Muddy sand
	Adults	2 - 9	31 – 36	90 – 300	Muddy sand
Winter Flounder	Eggs	4 – 7	10 – 30	2 – 4	Varied, most commonly sand
	Larvae	3 - 15	18 – 22	10 – 70	Varied
	Juveniles	4 - 15	1 – 5		Highly variable
	Adults	4 - 12	< 22	0 – 9	Varies, but commonly soft enough for burying
Yellowtail Flounder	Larvae	6 – 10	32-34	10 – 90	
	Juveniles	4 – 8 spring	32-34	5 – 125	Sand; sand and mud
	Adults	8 – 14	32-34	20 – 50 spring	Sand to sandy-mud
Ocean Pout	Eggs	< 10	32 – 34	< 50	Rocky substrate
	Larvae	< 10	> 25	< 50	Rocky substrate
	Juveniles	3 – 14	23 – 30	< 100	Rocks and attached algae, shell fragments
	Adults	3 – 14	32 – 34	< 100	Varied; rocky substrate (spawning)
Atlantic Sea Scallop	Eggs	13 – 17			
	Larvae	12 – 18	16.9 – 30	0 – 10	Biofilm
	Juveniles	1.2 – 15		62 – 91	
	Adults	10 – 15	32 – 35	18 – 110	Gravel, shell, rock
Atlantic Sea Herring	Larvae	8 – 9 December	32	40 – 90	Gravel (preferred) also: sand, rocks, shell fragments, vegetation
	Juveniles	3 – 4	31 – 32.4	30 – 90	

Species	Life History Stages	Temperature (°C)	Salinity (ppt)	Depth (meters)	Substrate
	Adults	9 – 10	25 – 28	10 – 30	
Monkfish	Eggs	18		15 – 1000	
	Larvae	15		25 – 1000	
	Juveniles	< 13	29.9 – 36.7	25 – 200	Sand-shell mix, algae-covered rocks, hard sand, pebbly gravel or mud
	Adults	< 15	29.9 – 36.7	25 - 200	same
Long Finned Squid	Juveniles	10 – 15	31.5 – 34	10 - 15	None (water column)
	Adults	16 – 17	30	15 – 18	Over mud or sandy bottoms
Short Finned Squid	Juveniles	14.3 – 16.3	34 – 37	27 – 55	None (water column)
	Adults	10.2 – 12.9	30 – 36.5	185 – 366	Over various sediment types
Atlantic Butterfish	Eggs	11 – 17	30 – 34	< 200	
	Larvae	9 – 19		< 120	
	Juveniles	9 – 24	26 – 29	10 – 34	Sand and mud
	Adults	9 - 24	26 – 29	10 – 34	Sand and mud
Atlantic Mackerel	Eggs	7 – 9 April	25 – 27	10 – 30	None (water column)
	Larvae	8 – 10 May		70	None (water column)
	Juveniles	10	26.1 – 28.9	30 – 90 Spring	None (water column)
	Adults	14 Spring		10	None (water column)
Summer Flounder	Adults		0.5 – >25	0 – 500	Submerged aquatic vegetation
Black Sea Bass	Adults	9 – 12	25 – 30	10 – 20	Sand and shells
Surf Clam	Juveniles	< 25	< 28	8-66	Well sorted medium sand (avoids mud)
	Adults	> 15	< 28		Same
Ocean Quahog	Juveniles	1 – 6	32 – 34	45 – 75	Sand and mud
	Adults	6 - 16		25 – 61	Sand and mud
Pollock	Eggs	6-7	32-32.8	50-90	None (water column)
	Larvae	5-10		50-90	None (water column)
	Juveniles	8-12	29-32	25-75	Sand and mud
	Adults	6-8	33-34	75-175	Hard bottoms
Windowpane	Eggs	6-14		>70	None (water column)
	Larvae	3-14		>70	
	Juveniles	4-7	15-33	>75	Sand and mud
	Adults	4-8	21-31	>75	Sand and mud
Bluefish	Eggs	18-22	31	30-70	
	Larvae	18-26	30-32	30-70	
	Juveniles	10-34	23-33		
	Adults	14-16	32		None (water column)

Species	Life History Stages	Temperature (°C)	Salinity (ppt)	Depth (meters)	Substrate
Scup	Eggs	12-14	>15	<30	None (water column)
	Larvae	14-22	>15	<20	None (water column)
	Juveniles	16-22	>15	>38	Sand and mud
	Adults	7-25	>15	2-38	Structures

Source: NOAA, NMFS and NEFMC

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APPENDIX A

EFH ASSESSMENT WORKSHEET

NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGIONAL OFFICE

EFH ASSESSMENT WORKSHEET (05/14/01 v.)

Introduction:

The Magnuson-Stevens Fishery Conservation and Management Act mandates that federal agencies conduct an EFH consultation with NMFS regarding any of their actions authorized, funded, or undertaken that may adversely effect EFH. An adverse effect means any impact which reduces the quality and/or quantity of EFH. Adverse effects may include direct (e.g. contamination or physical disruption), indirect (e.g. loss of prey, or reduction in species' fecundity), site-specific or habitat-wide impacts including individual, cumulative, or synergistic consequences of actions.

This worksheet has been designed to assist Army Corps of Engineers (ACOE) project managers in determining whether an essential fish habitat (EFH) consultation is necessary, and developing the needed information should a consultation be required. This worksheet will lead you through a series of questions that will provide an initial screening to determine if an EFH consultation is necessary, and help you assemble the needed information for determining the extent of the consultation required. The information provided in this worksheet can then be used to develop the required EFH Assessment.

Instructions for Use:

An EFH Assessment must be submitted by the ACOE to NMFS as part of the EFH consultation. An EFH Assessment must include the following information:
1) A description of the proposed action;
2) An analysis of the effects of the action on EFH, the managed species and associated species; 3) The ACOE's view regarding the effects of the action on EFH.
In many cases, this worksheet can be used as an EFH Assessment. If the ACOE determines that the action will not cause substantial impacts to EFH, then this worksheet will suffice. If the action may cause substantial adverse effects on EFH, then a more thorough discussion of the action and its impacts in a separate EFH Assessment will be necessary.

The information contained at the NMFS Northeast Regional Office's website will assist you in completing this worksheet (http://www.nero.nmfs.gov/ro/doc/newefh.html). The EFH web site contains information regarding: the EFH consultation process; Guide to EFH Designations which provides a geographic species list; Guide to EFH Species which provides the legal description of EFH as well as important ecological information for each species and life stage; and other EFH reference documents including examples of EFH Assessments and EFH Consultations.

EFH ASSESSMENT WORKSHEET (05/14/01 v.)

PROJECT
NAME:____
DATE:_________

PROJECT NO.:____________________
LOCATION:____________________________________

PREPARER:____

Step 1. Generate the species list from the EFH website for the geographic area of interest. Use the species list as part of the initial screening process to determine if EFH occurs in the vicinity of the proposed action. Attach that list to the worksheet because it will be used in later steps. Make a preliminary determination on the need to conduct an EFH Consultation.

1. INITIAL CONSIDERATIONS		
EFH Designations	**Y**	**N**
Is action located in or adjacent to EFH?		
Is EFH designated for eggs?		
Is EFH designated for larvae?		
Is EFH designated for juveniles?		
Is EFH designated for adults?		
Is there Habitat Areas of Particular Concern (HAPC) at or near project site?		
Does action have the potential to adversely affect EFH for any life stages checked above to any degree? *If no, consultation is not required. If yes, consultation is required - complete remainder of worksheet.*		

Step 2. In order to assess impacts, it is critical to know the habitat characteristics of the site before the activity is undertaken. Use existing information, to the extent possible, in answering these questions. Please note that, there may be circumstances in which new information must be collected to appropriately characterize the site and assess impacts.

2. SITE CHARACTERISTICS

Site Characteristics	***Description***
Is the site intertidal/sub-tidal/ water column?	
What are the sediment characteristics?	
Is there HAPC at the site, if so what type, size, characteristics?	
Is there submerged aquatic vegetation (SAV) at or adjacent to project site? If so describe aerial extent.	
What is typical salinity and temperature regime/range?	
What is the normal frequency of site disturbance, both natural and man-made?	
What is the area of proposed impact (work footprint & far afield)?	

Step 3. This section is used to describe the anticipated impacts from the proposed action on the physical/chemical/biological environment at the project site and areas adjacent to the site that may be affected.

3. DESCRIPTION OF IMPACTS			
Impacts	***Y***	***N***	***Description***
Nature and duration of activity(s)			
Will benthic community be disturbed?			
Will SAV be impacted?			
Will sediments be altered and/or sedimentation rates change?			
Will turbidity increase?			
Will water depth change?			
Will contaminants be released into sediments or water column?			
Will tidal flow, currents or wave patterns be altered?			
Will ambient salinity or temperature regime change?			
Will water quality be altered?			

Step 4. This section is used to evaluate the consequences of the proposed action on the functions and values of EFH as well as the vulnerability of the EFH species and their life stages. Identify which species from the EFH

species list (generated in Step 1) will be adversely impacted from the action. Assessment of EFH impacts should be based upon the site characteristics identified in Step 2 and the nature of the impacts described within Step 3. The Guide to EFH Descriptions on the website should be used during this assessment to determine the ecological parameters/preferences associated with each species listed and the potential impact to those parameters.

4. EFH ASSESSMENT			
Functions and Values	***Y***	***N***	***Describe habitat type, species and life stages to be adversely impacted***
Will functions and values of EFH be impacted for:			
Spawning			
Nursery			
Forage			
Shelter			
Will impacts be temporary or permanent?			
Will compensatory mitigation be used?			

Step 5. This section provides the ACOE's determination on the degree of impact to EFH from the proposed action. The EFH determination also dictates the type of EFH consultation that will be required with NMFS.

5. DETERMINATION OF IMPACT		
	/	***ACOE's EFH Determination***
Overall degree of adverse effects on EFH (not including compensatory mitigation) will be: ***(check the appropriate statement)***		***There is no adverse effect on EFH*** ***EFH Consultation is not required***
		The adverse effect on EFH is not substantial. ***This is a request for an abbreviated EFH consultation. This worksheet is being submitted to NMFS to satisfy the EFH Assessment requirement.***
		The adverse effect on EFH is substantial. ***This is a request for an expanded EFH consultation. A detailed written EFH assessment will be submitted to NMFS expanding upon the impacts revealed in this worksheet.***