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The Gulf of Maine supports a wide variety of fish and shellfish species; approximately 100 species of fish and invertebrates have been identified throughout the Gulf of Maine-Georges Bank area. The large variety of species in this region is due to the geographic and thermal transition zone at Cape Cod that separates the Gulf of Maine from the Mid-Atlantic region. The Gulf of Maine supports mainly boreal, cold temperate, non-migratory species while the Mid-Atlantic is composed largely of warm-water, migratory species.

Among the pelagic (open water) species found in the Gulf of Maine are herring, mackerel, sharks, swordfish, bluefish, bluefin tuna, capelin, and menhaden. Most of these species exhibit clear seasonal migratory movements in response to changes in water temperature. Demersal species (those that live at or near the bottom) in the gulf include cod, haddock, hake, pollock, whiting, cusk, and several species of flatfish, such as halibut and flounder. Seasonal movements among several demersal species are generally confined to shifts within the gulf, though some, such as pollock, are migratory (USDOC 1993d).

The seasonal distribution and migration of fish and invertebrate species can be grouped into classifications of abundant species which demonstrate particular movement patterns (Table 7). These groupings are based on their seasonal movements within the 60-fathom (110 meter) contour (USDOC 1993d; Azarovitz and Groslein 1987).

System boundaries for many fish species may be provided by the circulation patterns of the Gulf of Maine. Massachusetts Bay, located at the southwestern end of the coastal circulation pattern, acts as a "catch basin" for a variety of species.

Spawning areas for several fish species occur within the general southwestern Gulf of Maine area, including many species important to commercial fisheries, such as pollack, Atlantic cod, herring and squid (US DOC 1993d). NOAA reported that spawning for the Atlantic

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herring occurs in the Gulf of Maine during late August through October, and that Jeffrey's Ledge is an important spawning ground (USDOC 1989b). One of the major spawning grounds for Atlantic Cod is Massachusetts Bay, west of Stellwagen Bank (Campbell 1987). Spawning of the Atlantic cod occurs from December through April. The only known spawning stock of pollock in the northwest Atlantic uses Massachusetts Bay as its primary spawning ground (Campbell 1987). The spawning period for this species occurs in Massachusetts Bay October through March (Pett and McKay, 1990).

Strong evidence exists that Stellwagen Bank provides spawning habitat for the American sand lance (Ammodytes americanus), a ubiquitous fish in the Stellwagen Bank area (USDOC 1993d). Schools of 500-10,000+ are found over Stellwagen Bank (Meyer et al. 1979). The sand lance forms an important link in the trophic chain between the zooplankton upon which they prey and their predators: cod, haddock, silver hake, yellowtail flounder, striped bass, bluefish, and several species of whale (Meyer et al. 1979, Pett and McKay, 1990), such as humpback and fin whales (Sherman, et. al. 1981; Sherman, et. al. 1984; Richards, 1965). Other species known to spawn in the Gulf of Maine area include Fourbeard rockling (April through June), and Witch flounder (March through June) (USDOI 1984, Pett and McKay, 1990).

Table 7: Seasonal distribution of certain abundant fish and invertebrate species on Georges Bank, based on bottom trawl surveys (based on table 30.3, Azarovitz and Grosslein 1987).

Considerable information has been collected on commercially important in the region, but only a few studies have treated the fauna as a whole (Azarovitz and Grosslein 1987). A historical review of the fishes of Massachusetts Bay is provided by Collette and Hartel (1988). Table 8 presents a summary of the results of that study.

A number of surveys have been done which show higher than average concentrations of certain species in the general area of Stellwagen Bank (Pett and McKay, 1990). While surveying the northwest Atlantic, Bowman et al. (1987) found the greatest concentrations of juvenile Atlantic cod on Stellwagen Bank and the Great South Channel during autumn. The greatest concentrations of haddock in the northwest Atlantic were found to occur on Georges Bank and Stellwagen Bank (USDOI 1984), although haddock is widely distributed throughout the Gulf of Maine. Campbell (1987) and Lux and Kelly (1978) found haddock in high concentrations over Stellwagen Bank from February through September. Lux and Kelly (1978) found concentrations of redfish on the outer grounds east of Stellwagen Bank. Concentrations of spiny dogfish on Stellwagen appear to be higher than the immediate, surrounding areas of Massachusetts Bay, Cape Cod Bay, and the area east of Stellwagen Bank.

Information on the invertebrates of Stellwagen Bank is found in a comprehensive review of the invertebrates of the north Atlantic region by TRIGOM (1974). Hubbard et al. (1988) and Gilbert (1975) sampled invertebrate populations found in Stellwagen Basin, and specifically, invertebrate populations found at or near the Massachusetts Bay Disposal Site.

Pelagic invertebrates found over Stellwagen Bank include coelenterates (jellyfish) and molluscs (squid). Species of coelenterates found in the Gulf of Maine include Lucernaria sp., Haliclystus sp., and Cyanea sp. (Payne and Selzer 1986, TRIGOM 1974). Squid found on Stellwagen Bank include the short-fin squid, Illex illecebrosus, and the long-fin squid, Loligo pealei (Pett and McKay 1990). Other pelagic invertebrates found in this area are the American lobster, the Northern, or Pink shrimp, the Surf clam, the Ocean Quahog, and the Sea Scallop. Both the short-fin and long-fin squid migrate into Massachusetts Bay waters from summer to early autumn (Hubbard et al. 1988; Pett and McKay, 1990).

Commercial Fishery Resources

Many of the fish species in the Gulf of Maine area have been an important commercial resource for the New England region (Table 9).

Data on fishery resources is collected both from research vessel sampling programs which provide "fishery-independent information" and directly from the commercial and recreational fisheries in what is known as "fishery-dependent information" (Clark 1981).

The Northeast Fisheries Science Center (NEFSC) of the National Marine Fisheries Service

(NMFS) conducts research vessel surveys of northeast fishery resources. The objective of the surveys is to provide realistic estimates of the trends in populations over time. The data also provides a general quantitative picture of the distribution and seasonal movements of the fish.

Landings data (fishery-dependent information) has been collected by NMFS Among the surveys conducted by NMFS are the spring and autumn bottom trawl surveys begun in 1963 and 1968 respectively; these represent the longest running continuous time series of research vessel sampling in the world. The one-half hour trawls are made at sites randomly selected prior to each survey. The objective of each tow is to catch a representative sample of the various species and relative numbers in a particular area. The species in the catch are counted, weighed, and measured, findings made on age distribution, sex, feeding, and disease-related conditions and the information entered into a cumulative trawl survey data set.

Table 9: Commercially important fish species.

Landings data (fishery-dependent information) has been collected by NMFS port agents through interviews with a statistically significant number of fishermen at the dock (NMFS ceased conducting these port interviews in 1994). This information, on what fish have been caught, how much, and where the fish were caught are compiled in NMFS's commercial fisheries "weigh-out" data base. The data is collected for squares of 10-minutes of longitude and latitude which encompass approximately 770 square nautical miles. Consequently, the "area fished" information is not very precise. Further, for purposes of determining the amount of fish caught in the Stellwagen Bank and sanctuary area, the squares do not correspond well with either the physical feature of the bank or the shape and orientation of the sanctuary boundary. The reliability of the data is also affected by changes from year to year in the amount of interview data collected (Kellogg 1990). Another factor is that the information in the weigh-out data base is from boats greater than five tons and a large number of the boats taking fish in the area of Stellwagen Bank are smaller.

According to NOAA, a number of these commercially important species are overexploited (USDOC 1989). These include: the Atlantic cod stock in the Gulf of Maine, pollock, haddock, redfish, witch flounder, American plaice, and yellowtail flounder stocks. In addition, NOAA considers that spawning biomass is below maintenance level for cod, pollack, haddock, and yellowtail flounder. Two species are labeled by NOAA as "underexploited". These are the current stocks of the silver hake, and stocks of red hake (USDOC 1989) (Pett and McKay, 1990; USDOC 1993d).

Descriptions of the Species

American Sand Lance

American sand lance is an eel-like fish which grows to, on average, 25cm in length. They prey primarily on copepods, but also eat fish eggs and larvae. In turn, they are important in the diet of bluefish, cod, pollock, spiny dogfish, silver hake, and whales. The sand lance rely on sandy bottoms for habitat and are therefore found in somewhat patchy distributions. They do not migrate and their geographic distributions do not vary significantly seasonally (Azarovitz and Grosslein, in Backus and Bourne (eds.), 1987).

Sculpins

Sculpins are not an important commercial species; they are used by fishermen only for lobster bait. However, they are important to the ecology of their habitat as result of their feeding behavior: they eat almost any bottom-dweller they encounter, including most invertebrates, fish eggs, and juvenile fish of many important species. They are demersal fish, found on all bottom types (Avarovitz and Grosslein, in Backus and Bourne (eds.), 1987). They are often partially buried in bottom sediments. Sculpins are also an important forage species for carnivorous fish and concentrate in the Great South Channel during fall (USDOI 1984e).

Flounders

Three flounder species are considered to be of commercial importance in New England

fisheries: Winter flounder, Witch flounder, and Yellowtail flounder. Winter flounder are also known as "blackback", and are sought after for sport fishing as well as commercial fishing. This fish ranges from Labrador to Georgia, and can grow to 62cm in length and obtain the age of 12 years (Brown, 1987). They are sedentary fish, preferring soft muddy or sandy bottoms. In winter, coastal populations move into very shallow or estuarine waters to spawn. The Winter flounder feeds during the day, and primarily eats small invertebrates (Azarovitz and Grosslein, 1987).

Witch flounder are most common along the continental shelf of Georges Bank in waters 300-450m deep. They are demersal, preferring fine, soft ground between rocky patches (USDOI 1984e; Avarovitz and Grosslein, 1987). This fish is also known as "gray sole", and feeds primarily on small invertebrates, rarely eating fish (Avarovitz and Grosslein, 1987).

Yellowtail flounder can reach 65cm in length, however, most individuals caught currently are less than 50cm long. They are found, as adults, distributed widely in waters 10 to 100m deep, on sandy or sandy-mud bottoms; they avoid soft mud or hard, rocky bottom types (Avarovitz and Grosslein, 1987; Pett and McKay, 1990). Juveniles prefer rough bottoms, which offer more protection (Avarovitz and Grosslein, 1987). Yellowtail flounder can reach a maximum age of about 14 years (Brown, 1987). Lux and Kelly (1978) reported 897 yellowtail flounder from the Stellwagen Bank area (Lux and Kelly, 1978; Pett and McKay, 1990). Heavy fishing has strongly affected the spawning populations of the Yellowtail flounder (Azarovitz and Grosslein, 1987).

Spiny dogfish

Spiny dogfish are voracious predators of almost any species smaller than themselves, and have, therefore, a significant impact on mackerel, herring, scup, cod, silver hake, and haddock populations. Spiny dogfish are themselves generally 1m in length, and have no significant natural enemies (Avarovitz and Grosslein, 1987; Brown, 1987). They are abundant in the Gulf of Maine area where they remain year-round, avoiding warm shallows. Spiny dogfish can live for 30-40 years (Avarovitz and Grosslein, 1987; Brown, 1987), but have a low reproductive potential; females do not reach maturity until age 14, and generally do not exceed 4-6 pups for each two-year gestation period (Avarovitz and Grosslein, 1987).

Atlantic Herring

Atlantic Herring are pelagic fish found widely distributed throughout the Gulf of Maine (Avarovitz and Grosslein, 1987; Pett and McKay, 1990). Herring are migratory, but maintain individual populations in certain areas (Avarovitz and Grosslein, 1987). They range from polar ice in Greenland to Cape Hatteras; can grow to 44cm and live to the age of 18 years (Brown, 1987). This fish feeds on copepods, euphausiids, mollusk larvae, and fish eggs, mainly in the upper water column (Avarovitz and Grosslein, 1987; Pett and McKay, 1990). They are in turn preyed upon by many fish as well as seabirds, porpoises and whales. The herring population of Georges Bank was decimated by intense fishing activity in the 1960's and 1970's, collapsing altogether in 1977. As a result of the tendency to maintain discreet populations, there has been no appreciable increase in herring abundance on Georges Bank since its demise (Avarovitz and Grosslein, 1987).

Atlantic Cod

The Atlantic Cod is a demersal to midwater fish, ranging from surf to 366m (Pett and McKay, 1990). Cod can grow to 90kg, however, currently they do not get much bigger than 7 or 8kg. Cod can reach the age of 22 years (Brown, 1987). They prefer rocky or pebbly bottoms. This fish forages for clams, crabs, shrimp, worms, squid, and many fishes; larger cod may eat skates, flatfish, and even sculpin and searobins. Cod are a cool-water fish, and regional abundance shifts seasonally (Avarovitz and Grosslein, 1987). This fish spawns mainly during the winter in the Gulf of Main region (Brown, 1987). Lux and Kelly (1978) found cod on Stellwagen Bank in their study, with n=1465 (Pett and McKay, 1990; Lux and Kelly, 1978).

Haddock

Haddock are bottom-feeders, foraging for crabs, worms, clams, and sometimes fishes (Avarovitz and Grosslein, 1987). Haddock are found on sand and gravel bottoms, in waters

varying in depth from 45-135m (Pett and McKay, 1990). This fish prefers cool waters, and migrates northeastward from most locations in the summer and fall. Haddock can reach the age of 18 years and obtain 122cm in length (Brown, 1987). Haddock have always been a highly prized commercial species; small haddock may be more familiar as "scrod". In the 1970's the Georges Bank haddock fishery collapsed completely and has currently not completely recovered (Avarovitz and Grosslein, 1987). Lux and Kelly found 4071 haddock on Stellwagen Bank when sampling in 1978 (Pett and McKay, 1990; Lux and Kelly, 1978).

Pollock

Pollock are generally found in large, fast-swimming schools, frequenting almost all depths and feeding on large zooplankton and fish. They are generally 4-7 kg in weight, but have been known to exceed 30kg. Pollock prefer cool water and rough bottoms; they are often found near wrecks. This fish migrates seasonally to follow the cooler waters (Avarovitz and Grosslein, 1987).

Hake

Three species of hake are commercially important in New England regional fisheries: White hake, Red hake, and Silver hake. Red Hake are generally 50cm in length and 2kg in weight (Avarovitz and Grosslein, 1987), but can reach a maximum of 75cm in length (Brown, 1987). Red hake have a life span of approximately 12 years (Brown, 1987). They migrate seasonally according to water temperature as well as part of their spawning pattern. Red hake can be found from the Gulf of St. Lawrence to North Carolina (Brown, 1987). Juveniles live in empty scallop shells, which is thought to be an instinctive protective measure. This fish is good to eat when fresh, but does not keep well; this limits its usefulness as a directed commercial fishery. Red Hake are often confused with White hake, especially as juveniles. Both species occur throughout the same range, although White hake are found distributed in general farther to the north.

Silver hake are also known as "whiting" and prefer warmer waters than do most of the other member of the Cod family, and ranges from the Newfoundland Banks to South Carolina (Avarovitz and Grosslein, 1987; Brown, 1987). This fish is a voracious feeder which ranges throughout the water column, preying primarily upon fish and squid (Avarovitz and Grosslein, 1987). This fish was fished extensively in the 1960's and 1970's by Soviet and East bloc fleets, and is an important commercial fishery resource for the New England region (Avarovitz and Grosslein, 1987). Silver hake reach a maximum length of 66cm; females of the species can live to 12 years of age whereas the males only live for about 6 years. Silver hake spawns principally in July and August in the Gulf of Maine area (Brown, 1987).

Butterfish

Butterfish are schooling pelagic fish which migrate seasonally within the range from Georges Bank to Cape Hatteras. They are an important ecological link in the food web; Butterfish eat jellyfish, copepods, and sometimes other small fish, and are themselves preyed upon heavily by squid, bluefish, and others. Commercially, they are fished for use in fish meal and as bait, and to a minor extent as a foodfish. Most butterfish spawn in inshore waters (Avarovitz and Grosslein, 1987).

American Plaice

American Plaice are bottom-living fish with a small midwater foraging range (Avarovitz and Grosslein, 1987). They prefer sand-mud bottoms and are most concentrated in the Gulf of Maine from 150-250m depth (USDOI 1984e; Pett and McKay, 1990). They are not migratory and regional populations are can be physiologically distinguished from one another. American plaice forage for a variety of invertebrates and very rarely eat fish. Juvenile plaice are food for many species but adults are preyed upon only by halibut, dogfish, and other large predators. This fish prefers cold waters (Avarovitz and Grosslein, 1987). Lux and Kelly (1978) reported 2073 American plaice in the Stellwagen Bank area, and greater concentrations in Massachusetts Bay (Pett and McKay, 1990).

Bluefish

Bluefish are a favorite of sport and commercial fishermen alike, but the recreational catch

exceeds the commercial catch. This is largely because Bluefish have replaced striped bass, stocks of which are currently very low, as the main recreational fishery of the Middle Atlantic. This fish is a voracious, fast-swimming predator which feeds throughout the water column on fishes only slightly smaller than itself. Bluefish have a wide range of distribution, but generally prefer warmer waters and migrate seasonally to follow water temperature (Avarovitz and Grosslein, 1987). They are fast-growing and can live for 14 years; this fish reaches a maximum length of 114cm (Brown, 1987).

Scup

Scup are an important commercial and recreational fishery south of Georges Bank to Cape Hatteras. Scup are bottom-feeders and forage for small invertebrates. This fish moves to inshore waters in late spring and summer, where they spawn (Avarovitz and Grosslein, 1987).

Redfish

Redfish, also known as "ocean perch", are found generally in deep waters, where they remain on the bottom during the day. They feed at night near the surface. Redfish grow extremely slowly, and it often takes ten years for an individual to reach a length of 20cm. This, coupled with the fact that they are easily taken by trawlers during the day when on the bottom, makes them especially vulnerable to overfishing (Avarovitz and Grosslein, 1987).

Cusk

Cusk is a member of the Cod family that prefers hard, rocky bottoms and is found in deep, cold waters. This fish is solitary-living. They are not extremely abundant throughout the Gulf of Maine area, and though harvested commercially, this limits their usefulness for a directed fishery (Avarovitz and Grosslein, 1987).

Squid

There are two squid species found in the Stellwagen Bank region: Shortfin squid and Longfin squid. Shortfin squid are distributed throughout the Northwest Atlantic from Greenland to Florida. They are a fast-growing species with a lifespan of little more than two years. Shortfin squid grow to maximum of 50cm mantle length, and feed primarily on small crustaceans and some pelagic fishes such as herring or mackerel. They have been known to feed on their young. This fish is in turn an important prey species for many fish and mammals. They are most abundant in shelf waters in the fall, and overwinter from the edge of the continental shelf out to an unknown extent (Avarovitz and Grosslein, 1987).

Longfin squid is also a shelf species, moving inshore from the shelf edge during spring and summer, where they spawn. Like the Shortfin squid, Longfin eat small crustaceans, fish, and often their own young, and play an important role in the diets of many fish and marine mammals. They have been shown to account for up to 30% of the bluefish diet (Avarovitz and Grosslein, 1987).

Atlantic Mackerel

The Atlantic mackerel is a pelagic fish of commercial importance which moves inshore in the Gulf of Maine region during spring (USDOI 1984e; Pett and McKay, 1990). This fish ranges from Labrador to North Carolina. Mackerel can reach the age of 18-20 years and a maximum length of 56cm. In spring and early summer mackerel spawn in the Gulf of Maine region (Brown, 1987).

Bluefin Tuna

The Atlantic bluefin tuna is an important recreational and commercial fish in the Stellwagen Bank area (Jarvis 1990, Terkla 1990). The Atlantic bluefin is a pelagic fish which is present in the Gulf of Maine from June to October (USDOI 1984e; Pett and McKay, 1990).

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Page last modified by the Stellwagen Web team on July 23, 2004

Revised July 23, 2004 by NOSWebAdmins@noaa.gov
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