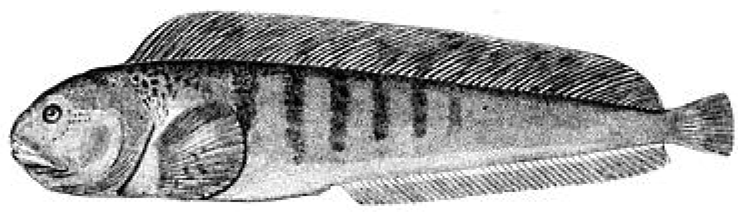
STATUS REVIEW OF ATLANTIC WOLFFISH
(Anarhichas lupus)



Prepared by the

Atlantic Wolffish Biological Review Team

for the

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ACFCMA	Atlantic Coastal Fisheries Cooperative Management Act
ACOE	Army Corps of Engineers
AFS	American Fisheries Society
ASMFC	Atlantic States Marine Fisheries Commission
BRD	incidental catch reduction device
BRT	Biological Review Team
C	degrees centigrade
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
cm	centimeters
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	catch-per-unit-of-effort
DFO	Department of Fisheries and Oceans (Canada)
DO	Dissolved Oxygen
DPS	Distinct Population Segment
EEZ	Economic Exclusive Zone
EFH	Essential Fish Habitat
ESA	Endangered Species Act
FMP	Fishery Management Plan
FPA	Federal Power Act
FR	Federal Register
GB	Georges Bank
GOM	Gulf of Maine
GIS	Geographic Information System
in	inches
IUCN	International Union for the Conservation of Nature and Natural Resources
kya	kilo year ago
km	kilometer
LNG	Liquefied Natural Gas
MADMF	Massachusetts Division of Marine Fisheries
MEDMR	Maine Department of Marine Resources
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSRA	Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006
mg/L	milligrams per liter (parts-per-million)
mm	millimeters
mt	metric ton
mtDNA	mitochondrial DNA
nDNA	nuclear DNA
NEFO	Northeast Fisheries Observer program
NEFMC	New England Fishery Management Council
NEFSC	Northeast Fisheries Science Center
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service

NOAA	National Oceanic and Atmospheric Administration
PECE	Policy for Evaluation of Conservation Efforts
pers.	Personal
pg/g	picograms-per-gram (parts-per-trillion)
ppm	parts-per-million
ppt	parts-per-thousand
PVA	Population Viability Analysis
rm	river mile
SARA	Species At Risk Act (Canada)
SFA	Sustainable Fisheries Act
SOC	Species of Concern
SPOIR	significant portion of its range
SSC	Scientific and Statistical Committees
TL	total length
TNC	The Nature Conservancy
µ	micro
USFWS	United States Fish and Wildlife Service
Yds	yards

1. EXECUTIVE SUMMARY

This status report provides a summary of the best available scientific and commercial information regarding Atlantic wolffish (*Anarhichas lupus*). NMFS currently considers this species to be a species of concern (SOC) as well as a candidate species. This status review was initiated to investigate the current status of the species in response to a petition received on October 1, 2008 from the Conservation Law Foundation, Dr. Erica Fuller and Dr. Les Watling, and upon NMFS determining that the petitioned action may be warranted. Following NMFS' positive 90-day finding, an Atlantic wolffish biological review team (BRT) was convened to review the status of the species concerned.

Atlantic wolffish are large demersal fish with life history characteristics unique even among Gulf of Maine (GOM) fishes (Rountree, 2002 in Collette and Klein-MacPhee). They are the largest members of the suborder Zoarcoidei (the blennylike fishes) and reach 1.8 meters (m) in the western Atlantic (Robins et al., 1986) and 2.5 m in other parts of its range (Nelson, 1994) with an average weight of 18-20 kilograms (kg). Respected by fishermen and scientists for their formidable teeth, Atlantic wolfish are also known for their unusually large egg size, prolonged incubation, male egg brooding behavior, internal fertilization, and the annual loss of their entire set of teeth (Rountree, 2002 in Collette and Klein-MacPhee). In the Gulf of Maine, individuals are believed to reach maturity by age five or six when they reach approximately 47 cm total length (Nelson and Ross, 1992; Templeman, 1986).

Atlantic wolffish can be found in northern latitudes of the eastern and western North Atlantic Ocean. In the north and eastern Atlantic, they range from eastern Greenland to Iceland, along northern Europe and the Scandinavian coast extending north and west to the Barents and White Seas and to the south in northern France and Ireland. In the northwest Atlantic, they are found from Davis Straits off of western Greenland, along Newfoundland and Labrador coasts to Grand Bank and continue southward through the Canadian Maritime Provinces to Cape Cod, USA.

Based on the best available scientific and commercial data, the BRT concluded that Atlantic wolffish observed in Western Atlantic Canada and the United States meet the requirements for being discrete and significant and combined to form one distinct population segment. The DPS consists of the following oceanic areas: 1) Canada's Scotian Shelf 2) southern Gulf of St. Lawrence, 3) northern Gulf of St. Lawrence, 4) southern Newfoundland and 5) United States. The BRT recognizes that additional population structuring could exist between the Western Atlantic Canada / United States DPS; however, genetic samples need to be collected from United States waters and analyzed in order to make that determination.

The Canadian Department of Fisheries and Oceans (DFO) summarizes the status of wolffish in the Gulf of Saint Lawrence, Scotian Shelf, and western and southern New Foundland in the science stock status report (DFO, 2000). According to this report (DFO, 2000), in western Canadian waters, Atlantic wolffish are distributed throughout the Northern Gulf of Saint Lawrence with the primary concentration along the western coast of Newfoundland. Both relative abundance and biomass in the summer research survey in Canada have increased in this area. In the Southern Gulf of Saint Lawrence, wolffish are distributed along the slope of the Laurentian channel. Relative abundance and mean weight per tow in this area increased until

1987, and have since declined. Additionally, the report indicated that wolffish are distributed throughout the Scotian Shelf, although relative abundance has declined in the mid-shelf, but increased in the northern shelf. Resource survey trends in parts of the Canadian portion of the DPS show improved recruitment at low biomass levels and stable or even increasing trends of abundance. Atlantic wolffish are captured incidentally throughout Canadian waters within most, if not all, gear types. Northern and spotted wolffish are threatened in Canada, and as such, a live release program was instituted in 2004 for these species. Atlantic wolffish are a species of Special Concern in Canada, and while this does not afford the species with any direct protection under the Species at Risk Act (SARA), it is possible that they benefit from the live release program for other species of wolffish.

In the United States, Atlantic wolffish are at low biomass, with various model estimates ranging between 475-998 mt of spawning stock biomass in 2007, according to findings presented at the NEFSC Data Poor Assessment Working Group (NEFSC, 2009). Current abundance levels are also low, ranging from 89,000 – 384,000 adult fish. Atlantic wolffish have been taken primarily in the United States as incidental catch in the otter trawl fishery. Although directed harvesting may occur, it is likely a small component of the fishery. Landings in the United States increased until peaking in 1983 at 1100 metric tons (mt) and then declined steadily until 2007, the latest complete year available, where landings were 63 mt.

In the United States, currently Atlantic wolffish are not directly managed, but Amendment 16 to the Northeast Multispecies Fishery Management Plan (FMP), as adopted by the NEFMC in June 2009, adds the Atlantic wolffish to the list of species managed under the FMP (NEFMC, 2009). As approved by the Council, Amendment 16 would prohibit the retention of wolffish in both the commercial and recreational fisheries, and require that any wolffish caught be released alive. If approved by NMFS, regulations implementing this prohibition would become effective in May 2010.

After compiling and evaluating the available data, the BRT has concluded that current demographic factors (abundance, population size/age structure, population growth rate/productivity, spatial structure/connectivity, and diversity) pose a low risk to the long term persistence of Atlantic wolffish. The BRT determined that the risks from anthropogenic stressors/natural limiting factors to the DPS were very low or low for most factors with moderate risk from commercial utilization and associated regulatory mechanisms.

While estimated population numbers from United States waters are low, the BRT concluded that they have not reached levels where the species is at risk of extinction now or in the foreseeable future. Given remaining uncertainties regarding the life history of Atlantic wolffish as well as the implementation of Amendment 16 and it’s effectiveness for Atlantic wolffish, NMFS has determined that it is appropriate to maintain Atlantic wolffish on the Species of Concern list.

2. INTRODUCTION AND BACKGROUND

2.1 Petition Background

This document provides a summary of the information gathered for an Endangered Species Act (ESA) status review for Atlantic wolffish (*Anarhichas lupus*), which will be referred to as Atlantic wolffish from this point forward. On October 1, 2008, NMFS received a petition from the Conservation Law Foundation, Dr. Erica Fuller and Dr. Les Watling (hereafter, the Petitioners), requesting that NMFS list the United States distinct population segment (DPS) of Atlantic wolffish, an Atlantic wolffish DPS consisting of one or more subpopulations in United States waters, or the entire species of Atlantic wolffish as endangered or threatened under the ESA and designate critical habitat for the species. The petition contains information on the species, including the taxonomy; historic and current distribution; physical and biological characteristics of its habitat and ecosystem relationships; population status and trends; and factors contributing to the species' decline. The Petitioners also included information regarding possible DPSs of Atlantic wolffish. The petition addresses the five factors identified in section 4(a)(1) of the ESA as they pertain to Atlantic wolffish: (1) current or threatened habitat destruction or modification or curtailment of habitat or range; (2) overutilization for commercial purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; and (5) other natural or man-made factors affecting the species' continued existence.

On January 5, 2009, NMFS determined that the petitioned action may be warranted and published a positive 90-day finding in the *Federal Register* (74 FR 249). Following NMFS' positive 90-day finding, NMFS convened an Atlantic wolffish biological review team (BRT) to review the status of the species concerned.

In order to conduct a comprehensive review, the BRT was asked by NMFS to assess the species' status and degree of threat to the species with regard to the factors provided in section 4 of the ESA without making a recommendation regarding listing. The BRT was provided a copy of the petition and all information submitted as part of the data request that was specified in the *Federal Register* Notice announcing the 90-day finding. In order to provide the BRT with all available information, NMFS organized a workshop during which Atlantic wolffish experts presented information on the life history, genetics, and habitats used by Atlantic wolffish. The BRT reviewed all this information during its consideration and analysis of potential threats to the species. This status review document is a summary of the information assembled by the BRT and incorporates the best scientific and commercial data available. In addition, the BRT summarized current conservation and research efforts that may yield protection, and drew scientific conclusions about the status of Atlantic wolffish throughout their range.

2.2 ESA Background

The purposes of the ESA are to provide a means to conserve the ecosystems upon which endangered species and threatened species depend, to provide a program for the conservation of endangered and threatened species, and to take appropriate steps to recover a species. The United States Fish and Wildlife Service (USFWS) and NMFS share responsibility for administering the ESA; NMFS is responsible for determining whether marine, estuarine or anadromous species, subspecies, or distinct population segments are threatened or endangered under the ESA. To be considered for listing under the ESA, a group of organisms must constitute a "species."

The ESA provides the following definitions:
*"the term **species** includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature."*

*"**endangered species**" is defined as "any species which is in danger of extinction throughout all or a significant portion of its range."*

"***threatened species***" *is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."*

Additional criteria regarding entities appropriate for listing under the ESA have been set forth. First, there is the ability to identify and list distinct populations segments (61 FR 4722) or evolutionarily significant units (56 FR 58612) when a population satisfies the criteria of being discrete and significant.

The process for determining whether a species (as defined above) should be listed is based upon the best available scientific and commercial information. The status is determined from an assessment of factors specified in section 4(a)(1) of the ESA including:

(A) The present or threatened destruction, modification, or curtailment of its habitat or range;
(B) Overutilization for commercial, recreational, scientific, or educational purposes;
(C) Disease or predation;
(D) Inadequacy of existing regulatory mechanisms;
(E) Other natural or manmade factors affecting the continued existence of the species.

The available information related to these five factors is described in depth below. Within this status review report (SRR), the BRT also summarizes any ongoing protective efforts to determine if they abate any risks to Atlantic wolffish. Finally, the BRT considers all of the available information and any protective efforts afforded to the species to determine the risk of Atlantic wolffish becoming extinct.

3. LIFE HISTORY AND BIOLOGY OF ATLANTIC WOLFFISH

3.1 Taxonomy

Common Name: Atlantic wolffish, striped wolffish, ocean catfish, ocean whitefish
Scientific Name: Anarhichas lupus

Class:	Actinopterygii (Ray finned fishes)
Subclass:	Osteichthyes
Order:	Perciformes
Suborder:	Zoarcoidei (the blennylike fishes)
Family:	Anarhichadidae
Genus:	Anarhichas
Species:	lupus

3.2 Species Description

Atlantic wolffish are large demersal fish with life history characteristics unique even among Gulf of Maine (GOM) fishes (Rountree, 2002 in Collette and Klein-MacPhee). Respected by fishermen and scientists for their formidable teeth, they are also known for their unusually large egg size, prolonged incubation, male egg brooding behavior, internal fertilization, and the annual loss of their entire set of teeth (Rountree, 2002 in Collette and Klein-MacPhee). The wolffish are the largest members of the suborder Zoarcoidei (the blennylike fishes) and reach 1.8 meters (m) in the western Atlantic (Robins et al. 1986) and 2.5 m in other parts of its range (Nelson, 1994) with an average weight of 18-20 kilograms (kg).

Among other things, Atlantic wolffish are distinguished by their teeth, coloring and fin arrangements. Wolffish dentition consists of large prominent top and bottom canine teeth that form tusks and a central band of molar teeth on the roof of their mouth as well as flattened grinding teeth caudally. This species has a robust elongate but laterally compressed body which varies in color (Rountree, 2002 in Collette and Klein-MacPhee). Atlantic wolffish pigmentation varies from slate blue to olive green and purplish brown, with varying numbers (10-15) of distinct dark transverse bars on the body (COSEWIC, Whitehead et al., 1986; Scott and Scott, 1988). Atlantic wolffish have a blunt snout with a rounded forehead. Fin arrangement includes a dorsal fin ray of uniform height with rounded corners extending from the nape to the caudal fin base, a short anal fin, a poorly developed caudal fin, and two large rounded pectoral fins. Other distinguishing features of Atlantic wolffish include the absence of pelvic fins, poorly developed scales over the entire body with none on the head, and the lack of a swim bladder (Gill, 1911; Rountree, 2002 in Collette and Klein-MacPhee).

Atlantic wolffish have a unique role in the ecosystem due in part to their highly specialized teeth, which enable them to crush their prey. In their most cranial aspect, the Atlantic wolffish have a row of six large conical canine tusks in the maxilla, and four similar teeth in the mandible. There are also clusters of five or six smaller canines behind them, randomly spaced and intervening between rows. The hard palate and the vomer are each armed with three plates of rounded, crushing teeth. Additionally the upper and lower jaws have a double row of about four pairs of large, rounded back molars united (but not fused) into a solid plate (Gill, 1911; Rountree, 2002 in Collette and Klein-MacPhee). The canine teeth are believed to grasp food, while the rounded teeth on the palate and vomer are used to crush hard skeletons and prey. The food may be completely crushed before it reaches the stomach, or, as other studies suggest, it may pass fairly intact into the small intestine; whole small crabs and intact sandollars have been found within the intestines of wolffish (Rountree, 2002 in Collette and Klein-MacPhee).

Atlantic wolffish teeth, worn down by the violent grinding and crushing action which occurs during feeding, are replaced annually (Rountree, 2002 in Collette and Klein-MacPhee). Both males and females experience a two to three month period in which the fish either fasts or eats softbodied animals while waiting for new teeth to become fully functional (Barsukov, 1959). Scientists have speculated that Atlantic wolffish may fast during this time of tooth replacement so as not to damage the developing teeth, and that the fasting time encompasses the spawning and brooding periods. However, there may be a great deal of individual variation in timing of tooth replacement in United States waters of the northwest Atlantic as evidenced by dive observations: "Nine adult and late juvenile Atlantic wolffish captured on Georges Bank (GB) in early December 1994 exhibited a wide range of tooth replacement stages from the presence of scattered old broken teeth, to the absence of all teeth, to the presence of new teeth in various stages of development, including scattered red teeth" (R. Rountree, pers. obs. reported in Collette and Klein-MacPhee).

3.3 General Life History

In the marine ecosystems that characterize the northwest Atlantic shelf, Atlantic wolffish are members of a demersal fish assemblage which occupies a wide range of ecological niches and may act as an apex predator in kelp forest ecosystems (Steneck et. al., 2004). In the north and eastern Atlantic they range from eastern Greenland to Iceland, along northern Europe and the Scandinavian coast extending north and west to the Barents and White Sea. In the northwest Atlantic wolffish are found from Davis Straits off of western Greenland, along Newfoundland and Labrador and continue southward through the Canadian Maritime Provinces to Cape Cod, United States. Atlantic wolffish are found infrequently from southern New England to New Jersey (Collete and Klein-MacPhee, 2002). The Northeast Fishery Science Center's (NEFSC) Bottom Trawl surveys have only encountered one fish southwest of Martha's Vineyard, Massachusetts since 1963.

Temperature ranges where Atlantic wolffish occur also deviate slightly with geographic region. Historically, in the GOM wolffish have been associated with temperatures ranging from 0 – 11.1°C (Collete and Klein-MacPhee, 2002). Bottom temperatures collected from NEFSC bottom trawl surveys where wolffish were encountered ranged from 0.0 – 10.0°C in spring and 0 – 14.3°C in fall. In Newfoundland wolffish thermal habitat ranged from -1.9 – 11.0 °C, Norway from -1.3 – 11.0 °C and in Iceland and Northern Europe -1.3 – 10.2 °C (Collete and Klein-MacPhee, 2002; Falk-Petersen and Hansen, 1991; Jonsson, 1982). Laboratory studies indicate wolffish can survive a wide span of temperatures ranging from -1.7 – 17.0°C and that feeding is negatively correlated with the higher temperature extremes (Hagen and Mann, 1992; King et al., 1989).

Although generally solitary, members of the species form male-female pairs in the spring, and, in some localities, may have limited migrations seasonally to shallower waters in order to spawn. Some of the more unusual characteristics of their life history include extremely large eggs, a prolonged incubation period during which the nests are guarded exclusively by the males, internal fertilization, and the annual loss of their entire set of teeth (Rountree, 2002 in Collette and Klein-MacPhee).

3.4 Longevity and Growth

In the GOM and GB regions, Atlantic wolffish may attain lengths of 1.5 m and weights of 18 kg (Goode, 1884; Idoine, 1998). NEFSC bottom trawl surveys have captured animals ranging in size from .03 – 1.37 m in spring and .04 – 1.2 m in fall and with a maximum weight of 11.77 kg. Mean length at age for Atlantic wolffish in the Gulf of Maine was determined to be 98 cm. at 22 years and at 4 cm at 0 years (Nelson and Ross, 1992). Fish over 100 cm were not sampled extensively in this study (10 fish from 100-118 cm.). Maximum ages in the Gulf of Maine are comparable to wolffish ages in other regions, such as 21 years in eastern Iceland and 23 years in Norway (Gunnarsson et. al., 2006; Falk-Petersen and Hansen, 1991). Age 0 fish grow quickly in Icelandic waters and may reach 10.5 cm in the first year (Jonsson, 1982). Gulf of Maine wolffish have faster growth rates than fish in Iceland but wolffish in the North Sea region grow the fastest (Nelson and Ross, 1992; Liao and Lucas, 2000).

In the Gulf of Maine, individuals are believed to reach maturity by age five or six when they reach approximately 47 cm total length (Nelson and Ross, 1992; Templeman, 1986). The length at fifty percent maturity (L_{50}) for females varies latitudinally which is likely due to the effects of temperature. Templeman (1986) showed that fish in northern Newfoundland mature at smaller sizes than faster growing southern fish in southern Newfoundland. L_{50} was reported as 51.4 cm in the northern area, 61.0 cm in the intermediate region and 68.2 cm in the south. In a study somewhat contradictory to Templeman 1986, Atlantic wolffish in east Iceland, where water temperatures are colder, had larger L_{50} values than fish in the relatively warmer waters of west Iceland (Gunnarsson et al., 2006). Authors indicate that maturity may be difficult to determine using visual methods in females because of the large egg size in this species. Second generation eggs are visible in young, immature fish when the fish reach the cortical alveolus stage but wolffish may not be able to spawn for several more years (Gunnarsson et. al., 2006; Templeman, 1986).

3.5 Reproduction and Development

In general, Atlantic wolffish are solitary in habit, except during mating season when bonded pairs form in spring/summer depending on geographic location (Collete and Klein-MacPhee, 2002; Keats et. al., 1985; Pavlov and Novikov, 1993). Spawning is believed to occur in September through October in the Gulf of Maine, but is likely dependent on temperature and possibly photoperiod (Collete and Klein-MacPhee, 2002; Pavlov and Moksness, 1994). Spawning is reported to occur from August – September in Nova Scotia, during autumn in Newfoundland, September – October in Iceland, July – October in Norway, and late summer – early autumn in the White Sea (Keats et al., 1985; Templeman, 1986; Jonsson, 1982; Falk-Petersen and Hansen, 1991; Pavlov and Novikov, 1993). In the Gulf of Maine, Nelson and Ross (1992) found evidence of a seasonal migration of adults (>47 cm) from shallow to deep in autumn and then deep to shallow in spring. Similar migrations occur in Iceland and the White Sea where wolffish migrate to colder temperatures before the spawning season (Pavlov and Novikov, 1993; Jonsson, 1982).

Atlantic wolffish have the lowest fecundity compared to their relatives, the spotted wolffish (Anarhichas minor) and the northern wolffish (Anarhichas denticulus). Some individuals may not spawn every year (Pavlov and Novikov, 1986; Falk-Petersen and Hansen, 1991; Pavlov and Moksness, 1996). Egg mass are typically 10-14 cm in diameter, but varies according to the size of the female (Johnson, 1982). Fecundity is related to fish size and body mass in this species and increases exponentially with length. Newfoundland mean fecundity estimates, combined from several Northwest Atlantic Fisheries Organization statistical areas, range from 2,440 eggs at 40 cm to 35,320 eggs at 120 cm (Templeman, 1986). In Norway, a female at 60 cm produces approximately 5,000 eggs while a female 80-90 cm will lay 12,000 eggs (Falk-Petersen and Hansen, 1991). Fecundity of wolffish in Iceland was measured between 400 and 16,000 eggs for fish at lengths of 25 and 83 cm respectively (Gunnarsson et. al., 2006). Mature eggs are large measuring 5.5 – 6.8 millimeters (mm) in diameter (Colette and Klein-MacPhee, 2002). Male Atlantic wolffish have small testes and produce small amounts of sperm peaking during late summer and autumn. These reproductive characteristics, combined with the morphological development of a papilla on the urogenital pore during spawning suggest internal fertilization (Pavlov and Novikov, 1993; Pavlov and Moksness, 1994, Johannessen et al., 1993). Males have been observed guarding egg clusters for several months but it is not certain if they continue until hatching (Keats et al., 1985; Collete and Klein-MacPhee, 2002). Hatching may take three to nine months depending on water temperature (Collete and Klein-MacPhee, 2002).

The sequence of Atlantic wolffish pre-spawning events suggests internal fertilization (Rountree, 2002 in Collette and Klein-MacPhee). One to two days prior to spawning, the female commences to rest motionless on the ocean floor during a side-laying phase. This side-laying phase is followed by a three to six hour labor phase. Copulation occurs at the end of the labor phase, after a 2-10 mm opening into the oviduct appears. Next, the female enters a resting phase lasting 8 to 15 hours during which eggs apparently become inseminated within the body cavity. At the end of the resting phase, the fertilized eggs are extruded during a brief extrusion phase lasting three to seven minutes. At this point the eggs become firmly attached to one another by mucus, the female curls up around the mass of eggs for 6 to10 hours, and then the mucus dissolves.

After the pre-spawning events, the eggs are hidden under rocks and boulders in nests, and guarded exclusively by an adult male from three to nine months (Rountree, 2002 in Collette and Klein-MacPhee). The length of time from spawning to hatching is variable, dependent upon temperature and external stimuli (Id.).

Studies in Europe and Canada provide what limited information is available regarding egg and larval development. The time necessary for proper egg development varies depending upon water temperature, with five to seven degrees Celsius optimal. Observations have also been made that the quality of wolffish eggs decline as water temperatures rise (N. Le Francois, pers. com., 2009). The upper limit for normal larval development in the northeast Atlantic is reported to be 9°C, with higher temperatures causing morphological anomalies (Pavlov and Moksness 1995). Prolarvae hatch between 17-20 mm in length and remain close to the bottom until the yolk sac is absorbed. The prolarval stage, which lasts three hours to six days, has a remnant yolk sac and an oil globule attached. Other features of this prolarval stage include large eyes, small teeth, completely differentiated fin folds, and pigment bands.

A short pelagic larval stage follows the prolarval stage, lasting 10-15 days, after which the fry (total length greater than 28 mm) move back to the bottom, absent the yolk sac, with a bigger body, and more developed teeth, coloring, and territorial behavior; however the total pelagic stage may last longer depending upon water temperature, and is spent near the area where the eggs were initially laid (Rountree, 2002 in Collette and Klein-MacPhee). Other reports indicate that juveniles are pelagic between 20 and 40 mm and settle back to the floor at more than 50 mm total length (Falk-Petersen and Hansen, 1990, 1991). These differences may reflect difference among local races.

The distribution of various life stages of Atlantic wolffish in the greater Gulf of Maine area suggests that Atlantic wolffish breed where they are found (Rountree, 2002 in Collette and Klein-MacPhee). Scientific reports indicate that both larval and juvenile stages are found in the channel between Browns Bank and Cape Sable, near Seal Island (Nova Scotia), on German Bank and off its slope, off Lurcher Schoal, off Machias (Maine), on Jeffreys Bank (off Penobscot Bay) and in Massachusetts Bay a few miles off Gloucester (Rountree, 2002 in Collette and Klein-MacPhee). Additionally, larvae have been collected in the northwest Atlantic from January to March (Collete and Klein-MacPhee, 2002), and scuba observations off the coast of Newfoundland reported recently hatched larval wolffish in October and November (Keats et al., 1986b).

3.6 Diet

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

3.7 Recruitment

Little information regarding Atlantic wolffish age-1 recruitment exists beyond a recent assessment in the Northeast Data Poor Stocks Working Group Report published by the NEFSC (Keith and Nitschke, 2009). The spring NEFSC survey shows a distinct mode ranging from 1-7 cm. As part of the report and assessment, this index was tuned to age-1 wolffish and had relatively low weight in the model. The recruitment index is variable and suffers from zero catch in many years and at times in groups of several years. The frequency of zero catch in the assessed United States regions appears to be increasing (Figure 3.7.1).

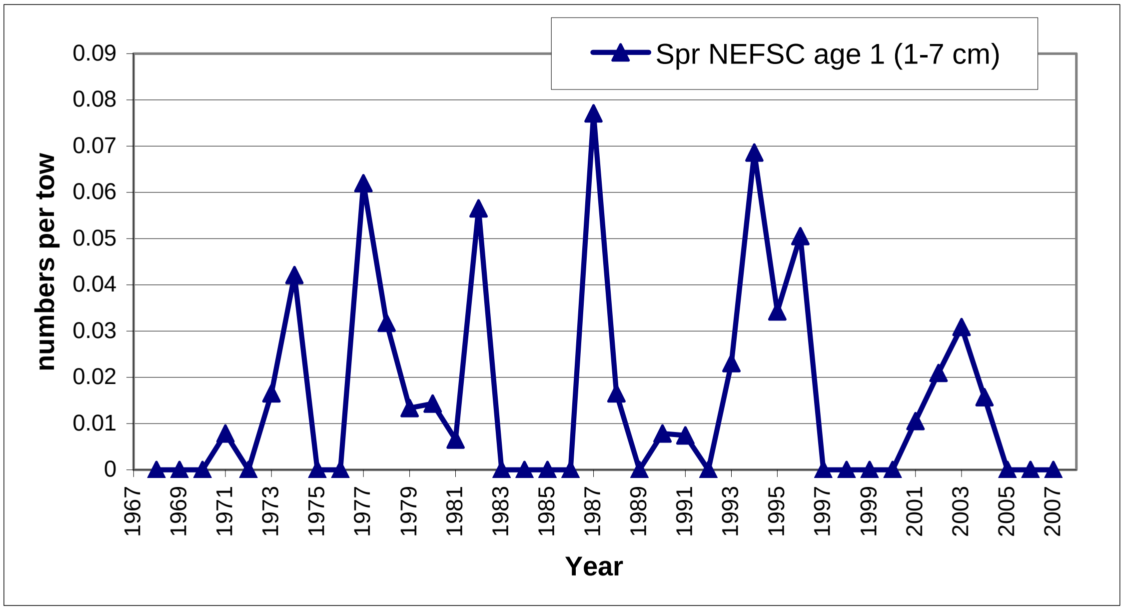


Figure 3.7.1. NEFSC spring age-1 stratified mean numbers per tow index. Lengths 1-7 cm were used as a proxy for age-1.

3.8 Natural Mortality

The best known source of natural mortality in Atlantic wolffish is predation by other fishes and by gray seals. As noted above, stomach contents analyses have been used to identify a large variety of fish-predators on juvenile wolffish, with spiny dogfish, sea raven and Atlantic cod being the dominant Atlantic wolffish predators in United States waters (Rountree, 2002 in Collette and Klein-MacPhee).

4. CONSIDERATION AS A DISTINCT POPULATION SEGMENT UNDER THE ESA

4.1. Distinct Population Segment Background

According to section 3 of the ESA, the term "species" includes "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife that interbreeds when mature." Congress included the term "distinct population segment" (DPS) in the 1978 amendments to the ESA. One of the purposes of establishing DPS is to conserve genetic diversity within a population. In February 1996, the USFWS and NMFS jointly published a policy to clarify their interpretation of the phrase "distinct population segment" for the purpose of listing, delisting, and reclassifying species (61 FR 4721). The policy identified the following three elements to be considered in determining whether to designate a DPS and to list the DPS as endangered or threatened under the ESA (61 FR 4721):

1. The discreteness of the population segment in relation to the remainder of the species or subspecies to which it belongs;
2. The significance of the population segment to the species or subspecies to which it belongs;
3. The conservation status of the population segment in relation to the ESA's standards for listing (i.e., Is the population segment, when treated as if it were a species, endangered or threatened?).

Determining if a population is discrete requires either one of the following conditions:

1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
2. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the ESA.

If a population is deemed discrete, then the population segment is evaluated on terms of significance which may include, but is not limited to, the following:

1. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon.
2. Evidence that loss of the discrete population segment would result in a significant gap in the range of the taxon.
3. Evidence that the DPS represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range; or
4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

If a population segment is deemed discrete and significant then it is a distinct population segment. The DPS should then be evaluated for endangered and threatened status based on the definitions of those terms described in section 3 of the ESA and a review of the factors enumerated in section 4(a)(1) of the ESA.

4.2 DPS Determination

4.2.1. Discreteness

Atlantic wolffish can be found in northern latitudes of the eastern and western North Atlantic Ocean. In the north and eastern Atlantic they range from eastern Greenland to Iceland, along northern Europe and the Scandinavian coast extending north and west to the Barents and White Sea's and to the south in northern France and Ireland. In the northwest Atlantic they are found from Davis Straits off of western Greenland, along Newfoundland and Labrador coasts to Grand Bank and continue southward through the Canadian Maritime Provinces to Cape Cod, USA.

With such a large range, Atlantic wolffish have been reported to spawn at different times of the year in different geographical regions. This may have contributed to the segmentation of Atlantic wolffish by contributing to regional reproductive isolation. Researchers have also speculated that reproductive isolation has played a role in the genetic structuring of other species such as capelin (Dodson et al., 2007) and bluemouth (Aboim et al., 2005) another demersal fish. Investigators have suggested that varying ocean depths and the large geographic distances spanned by ocean basins may represent hydrographic barriers for effective migrations of demersal species (McCusker et al. unpublished, Knutsen et al. unpublished and Shaw et al., 1999). Physical and behavioral barriers to dispersal, along with the hetereogeneity of spawning habitats and/or gyral retention of larvae may inhibit gene flow and drive population differentiation at both a large and local geographical scales (Imsland et al. 2008 and O'Leary et al., 2007).

In the Gulf of Maine, there is an indication of a seasonal migration. Adult wolffish may travel from shallow to deep waters in autumn and then deep to shallow waters in spring (Nelson and Ross, 1992). These migrations have been related to reproduction and are size dependent (Nelson and Ross, 1992). Tagging data has shown that wolffish migrations are usually short with occasionally longer ones (Jonsson, 1982; Templeman, 1984; Riget and Messtorff, 1988). Researchers reported the majority of recaptured wolffish only migrated 15 nautical miles (nm); however, a small percentage of tagged fish migrated distances in excess of 100 nm.

It has been suggested that currents in the Atlantic ocean form retention zones that may lead to population discontinuity (Rosques et al., 2002; Sinclair and Ilse, 1985) (Figure 4.2.1.1). Researchers suggest that the northwest and northeast-central Atlantic clades of capelin have been isolated by the Labrador Current, which has influenced the phylogeographic pattern of the species (Dodson et al ,2007). The North Atlantic current and the European continental shelf could also function as barriers for eastern populations in several marine species (Roques et al., 2002). Modeling of blue whiting larvae (*Micromesistus poutassou*) revealed that the retention of tracers was influenced by currents along the shelf edge in Europe and in the Rockall Trough (Bartsch and Coombs, 1997).

Isolation and recolonization driven by glacial events have also been suggested to influence genetic population differentiation (Nesbo et al., 2000 and O'Leary et al., 2007). Dodson et al. (2007) reported that the four genetic clades observed within capelin populations evolved through several glacial and climatic oscillations. Glaciation may also have strongly influenced other marine species in the North Atlantic/Mediterranean (Abiom et al., 2005). These events may have affected food chains in deep sea environments preventing pelagic larval dispersal (Aboim et al., 2005); hence, inhibiting geneflow.

Molecular tools have been utilized to differentiate species of wolffish (Johnstone et al. 2007; McCusker et al., 2008) and assess the population genetic structure of specific species of wolffish throughout their range (Imsland et al., 2008). McCusker and colleagues have recently researched genetic variation in Atlantic wolffish, *Anarhichas lupus*, across the North Atlantic using 14

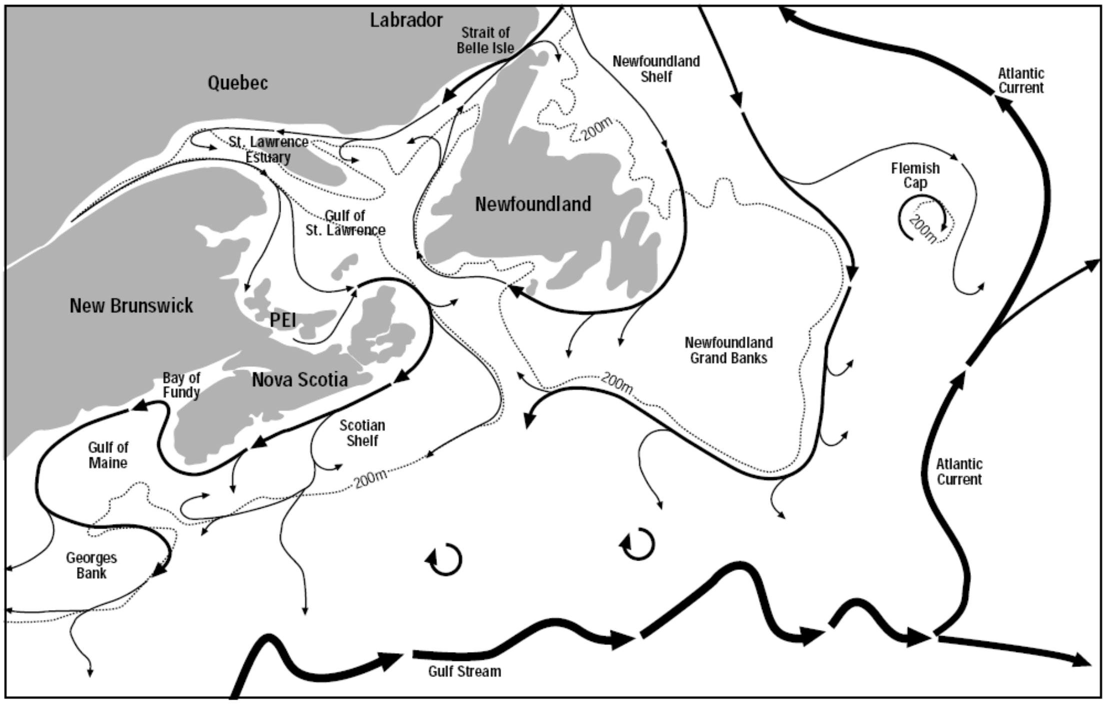


Figure T6.1.13: Major currents offshore Nova Scotia.

Figure 4.2.1.1. Schematic showing flow of major currents in the northwest Atlantic ocean (Nova Scotia Museum of Natural History, 1984).

microsatellite loci. Their results indicate that there are four genetically distinct populations of Atlantic wolffish. These four populations are referred to as: 1) North Atlantic, 2) Eastern Grand Banks, 3) Rockall Bank, and 4) Western Atlantic Canada. Comparable phylogeographical regions have been observed for a related species, Anarhicas minor, the spotted wolffish. Population genetic structure of this species revealed similar patterns between the western Atlantic, middle and eastern Atlantic, and Barents Sea populations (Imsland et al., 2008). Phylogeographical partitioning in these regions was also observed for Atlantic mackerel (Scomber scombrus) (Nesbo et al., 2000), deepwater red fish (Sebastes mentella) and the blackbelley rosefish (Helicolenus dactylopterus) (Aboim, 2005).

Atlantic wolffish is a species of Special Concern in Canada. Currently, the Canadians have a live release program for wolffish, which benefits Atlantic wolffish. The United States currently does not directly manage Atlantic wolffish. Although differences in management mechanisms exist between the United States and Canada, those currently in place in Canada are more protective and are not sufficiently different that it is necessary to employ the international boundary criterion in the DPS policy.

As noted, the available genetic information indicates that there are four Atlantic wolffish populations which are significantly different from one another. Fish from Western Atlantic Canada are genetically distinct from all other areas within Canada and in Europe (McCusker unpublished data). Atlantic wolffish from Western Atlantic Canada are the closest population to Atlantic wolffish residing in the United States. While genetic information is not available for

United States fish, because of the geographic proximity, lack of barriers, the ability to migrate hundreds of kilometers, and spatial overlap of United States fish with the Western Atlantic Canada population, it is probable that they are closely related. Although it is possible that United States samples are genetically distinct from western Atlantic Canadian samples, genetic samples need to be collected from United States waters and analyzed in order to make that determination. If the regions are different, it would be due to genetic drift related to small population size, rather than to historically significant isolation of this region from the rest of the range. Thus, based on the available genetic data and the other information presented above, the BRT concludes that the Atlantic wolffish from Western Atlantic Canada / United States are discrete from other Atlantic wolffish populations.

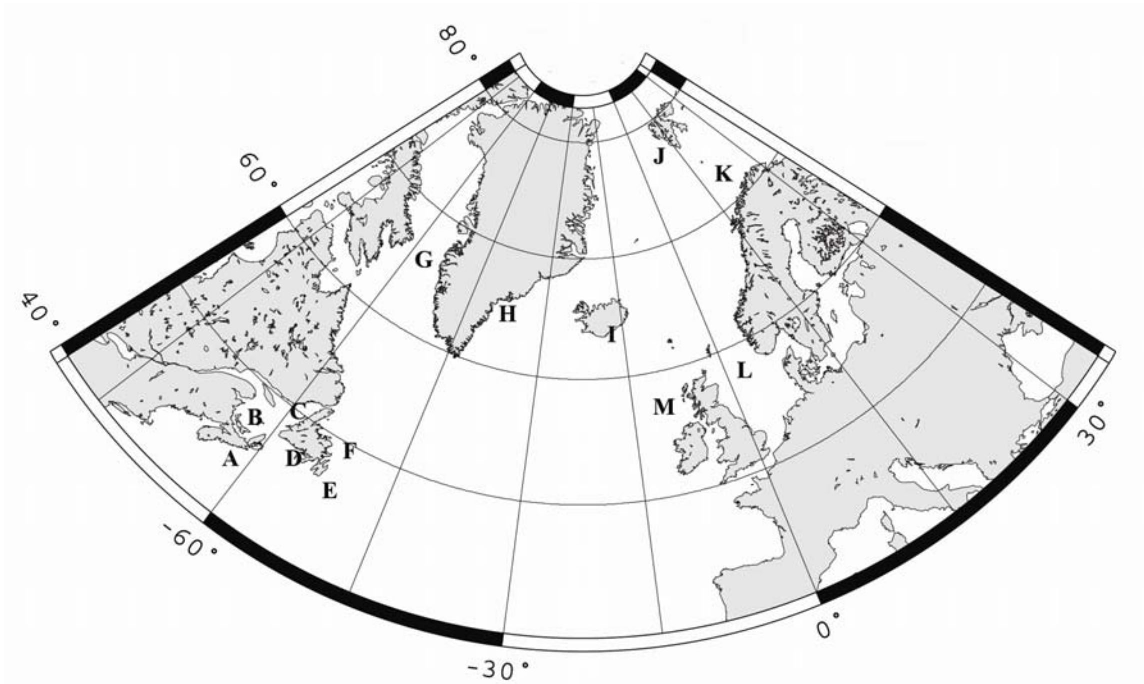
4.2.2 Significance

If a population is deemed discrete, then the population segment is evaluated in terms of significance. As noted earlier, McCusker and colleagues have assessed the genetic composition of Atlantic wolffish samples from Canada and Europe (Figure 4.2.2.1 and Figure 4.2.2.2) using 14 microsatellite loci and documented that there are four genetically distinct populations. Although some significant differences occurred within groups, the four main groups they identified were characterized by consistent significant differences from each of the other main groups ($p<0.003$) (Table 4.2.2.1.) An analysis of molecular variance (AMOVA) supported the presence of the four main groups (compared to two or three main groups) indicating that this configuration had the highest among group variation and lowest within-group variation (McCusker et. al unpublished data).

The mtDNA was also assessed to detect any genetic variation across the range of Atlantic wolffish in order to determine phylogeographic structure. Phylogeographic analyses supported the single refuge hypothesis during the last glaciation, with the most likely location of the refuge being in the eastern Atlantic. Therefore, post-glacial colonization of the range of wolffish most likely occurred from the eastern Atlantic to the western Atlantic. This resulted in the significant genetic differences observed between Atlantic wolffish populations.

Western Atlantic Canadian samples, in particular, were characterized by low diversity, possibly suggesting relatively recent (<20 kya) colonization of this part of the range (McCusker et. al unpublished data). Other studies performed on mtDNA have implicated Pleistocene glaciations as a major contributing factor on phylogeographic patterns within and among closely related species (Avise et al.,1998; Dodson et al., 2007).

The North Atlantic, Eastern Grand Banks, and White Sea populations constitute both northernmost and easternmost reproducing populations of Atlantic wolffish while fish from the United States represent the southernmost reproducing population. Genetic research detected greater genetic diversity in the North Atlantic and Eastern Atlantic populations when heterozygosity and allelic richness were plotted and compared to Western Atlantic Canada samples. Loss of any one of these populations would result in significant gaps in the range of this taxon and decreased genetic diversity; thus, all four genetically distinct populations are significant to the taxon as a whole.



A	Scotian Shelf
B	Southern Gulf St. Lawrence
C	Northern Gulf St. Lawrence
D	Southern Newfoundland
E	Southeast Grand Banks
F	Northeast Grand Banks
G	West Greenland
H	East Greenland
I	Iceland
J	Barents Sea (Spitsbergen)
K	Barents Sea (off Norway)
L	North Sea
M	Rockall Bank

Figure 4.2.2.1: Locations from which genetic samples were collected and analyzed

Table 4.2.2.2 Sample sizes and locations for microsatellite analysis.

	Location	NAFO/ ICES	Years	N
A	Scotian Shelf	4VWX	2002	75
		4VWX	2004	79
B	Southern Gulf of St. Lawrence	4TVn	2002, 2004	64
C	Northern Gulf of St. Lawrence	4RS	2004	63
D	Southern Newfoundland	3OP	2002, 2003	74
E	SE Grand Banks	3N	2001-2003	64
F	NE Grand Banks	3L	2001-2003	68
G	West Greenland	1ABCDE	2004	83
H	East Greenland	XIVb	2004	44
I	Iceland	Va	2002	96
		Va	2004	94
J	Spitsbergen	IIa2	2004	34
K	Barents Sea	IIa2	2004, 2005	111
L	North Sea	IVb	2002, 2004	66
M	Rockall Bank	VIb2	2005	34
		VIb2	2006	75
	Total			1,124

Table 4.2.2.1. F_{ST} values (Fstat) and p-values based on contingency tests (TFPGA) for Atlantic wolffish samples, using 14 loci (p-values<0.003 are significant even after correcting for number of sample sites and they are depicted in gray)

	Scotian Shelf-2002	Scotian Shelf-2004	Southern Gulf of St. Lawrence	Northern Gulf of St. Lawrence	South Newfoundland	SE Grand Banks	NE Grand Banks	West Greenland	East Greenland	Iceland-2002	Iceland-2004	Spitsbergen	Barents Sea	North Sea	Rockall-2005	Rockall-2006
Scotian Shelf-2002		0.0589	0.1066	0.0438	0.7387	0.0017	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Scotian Shelf- 2004	0.003		0.1682	0.0001	0.5374	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Southern Gulf of St. Lawrence	0.001	0.002		<.0001	0.4519	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Northern Gulf of St. Lawrence	0.004	0.006	0.010		0.0001	0.0009	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
South Newfoundland	-0.002	0.000	0.001	0.005		0.0026	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SE Grand Banks	0.003	0.009	0.011	0.007	0.004		0.1926	<.0001	<.0001	<.0001	<.0001	0.001	<.0001	<.0001	<.0001	<.0001
NE Grand Banks	0.007	0.010	0.018	0.008	0.007	0.000		0.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
West Greenland	0.022	0.024	0.031	0.016	0.022	0.009	0.006		0.4265	0.1305	0.1929	0.1656	0.0660	0.0012	<.0001	<.0001
East Greenland	0.019	0.025	0.032	0.019	0.021	0.010	0.007	0.000		0.7143	0.6933	0.4989	0.5500	0.4339	0.0002	<.0001
Iceland-2002	0.019	0.023	0.029	0.016	0.021	0.008	0.008	0.000	-0.001		0.9397	0.3340	0.1777	0.0030	<.0001	<.0001
Iceland- 2004	0.017	0.022	0.027	0.015	0.020	0.007	0.007	0.001	-0.001	-0.001		0.1455	0.2521	0.0509	0.0004	<.0001
Spitsbergen	0.020	0.026	0.031	0.014	0.020	0.008	0.009	0.000	-0.001	0.002	0.004		0.4544	0.3693	0.0030	<.0001
Barents Sea	0.020	0.024	0.030	0.015	0.021	0.009	0.008	0.001	0.000	0.002	0.001	-0.002		0.0311	<.0001	<.0001
North Sea	0.018	0.023	0.030	0.012	0.020	0.011	0.010	0.004	0.001	0.002	0.001	0.000	-0.001		<.0001	<.0001
Rockall-2005	0.026	0.031	0.035	0.025	0.028	0.016	0.019	0.005	0.005	0.007	0.004	0.005	0.007	0.007		0.6770
Rockall-2006	0.028	0.033	0.034	0.027	0.032	0.022	0.022	0.012	0.011	0.012	0.008	0.014	0.014	0.011	0.000	

Based on the available information, the BRT concluded that Atlantic wolffish observed in Western Atlantic Canada and the United States form one distinct population segment. The DPS consists of the following oceanic areas: 1) Canada's Scotian Shelf 2) southern Gulf of St. Lawrence, 3) northern Gulf of St. Lawrence, 4) southern Newfoundland and 5) United States. The BRT recognizes that additional population structuring could exist between the Western Atlantic Canada / United States DPS, but as mentioned previously, genetic samples need to be collected from United States waters and analyzed in order to make that determination. Future genetic research involving United States Atlantic wolffish samples may require the reassessment of this DPS.

5. HABITAT PREFERENCES FOR THE DPS

5.1 Habitat Background

Habitat-related information for the Western Atlantic Canada / United States DPS of Atlantic wolffish are summarized in this section in terms of the full range of depths and bottom temperatures, and substrate types, where different life stages of this species are known to occur, and where they are more commonly found. Tentative conclusions are reached concerning what habitat features constitute habitat preferences or requirements. Where information for the Western Atlantic Canada / United States DPS is lacking, or weak, additional information from other portions of this species' geographic range is included, notably for the Grand Banks and Labrador Shelf, in eastern Canada.

For benthic species such as wolffish, depth can serve as a proxy for habitat features such as temperature, salinity, energy level (disturbance caused by wave action or tidal currents), and, to a lesser extent, substrate type. Throughout their range, Atlantic wolffish are found from quite shallow water (<10 m) to maximum depths of 918 m on the Grand Banks (Kulka et al., 2004). Their presence in shallow, nearshore water has been confirmed by divers (e.g., Keats et al., 1985, observed them in 5-15 m of water in Newfoundland). Offshore, on the continental shelf and upper continental slope, they are collected in bottom trawls. On the Scotian Shelf, Scott (1982a, as reported in Kenchington, 2009) reported that 70% of the Atlantic wolffish caught in summer bottom trawl surveys came from 73-126 m, and the full depth range was 36-360 m. Nelson and Ross (1992) analyzed 1963-1989 NMFS bottom trawl survey data and showed that they are distributed throughout the Gulf of Maine in 22-274 m, with mean depths of occurrence of 100 m in the spring and 103 m in the fall. Seventy-five percent of them were caught in depths <120 m in the spring. There was a significant difference in the mean depths of occurrence of juvenile (<47 cm) and adult wolffish in the spring (91 m for adults and 116 m for juveniles), but not in the fall.[1]

5.2 Average Depth and Temperature Preferences

Atlantic wolffish are stenothermal, cold-water fish. Based on trawl survey data from the Grand Banks and the Labrador coast, Kulka et al. (2004) described them as "temperature-keepers," meaning that they maintain a similar temperature range by changing their depth distribution in response to seasonal changes in bottom water temperatures. They have been collected in bottom

[1] Neither of these analyses account for the distribution of sampling effort, i.e., the percentage of all survey tows made at different depths. If a higher proportion of tows are made in shallower water, for example, and the fish are uniformly distributed by depth, they will be more commonly caught in shallow water.

trawls at bottom temperatures below zero (-1.9°C in Newfoundland) and as high as 11°C, and are reported to be common between -0.4°C and 4°C in Newfoundland and 1-4°C on the Grand Banks (Rountree, 2002; Kulka et al., 2004). Scott (1982a, as reported in Kenchington 2009) reported that Atlantic wolffish were caught between 0 and 13°C on the Scotian Shelf and preferred a range of 3-6°C.

A more recent analysis of 1968-2008 NMFS spring and fall trawl survey data from United States waters in the GOM, southern New England, and GB (see Figure 6.3.7) was performed for juvenile and adult Atlantic wolffish. Depth and bottom temperature preferences for adult (≥65 cm) and juvenile (<65 cm) wolffish were determined using logistic regression on presence/ absence in the NEFSC survey. Overall, the proportion of total tows with wolffish is higher in the spring (adults=0.049, juveniles =0.046) than in the fall (adults=0.027, juveniles=0.037). A summary of the distribution of average depth and bottom temperatures of tows with wolffish is provided in Table 5.2.1. Juveniles appear to be slightly deeper than adults in the spring but have similar depth distribution as adults in the fall.

A logistic regression analysis of presence/absence was modeled as a second degree polynomial on either average depth or bottom temperature was conducted for all years pooled together. Years were pooled together because the number of tows with wolffish by size group in any given year is low.

Separate analyses were conducted for adult or juveniles and in the spring and fall surveys. In general, the proportion of tows with wolffish in both the spring and fall surveys has declined since the late 1980's (Figure 5.2.1). Interactions between year and either bottom temperature or depth are likely to exist, suggesting a more complex modeling approach than attempted here.

Determining depth and temperature preferences for wolffish were estimated for each season and size group by calculating the odds ratio of the proportion of positive wolffish tows for either variable (depth or temperature) compared with the highest fitted proportion (i.e., the value at the peak of the fitted curves in Figures 5.2.2-5.2.5).[2] Depths or temperatures with odds ratios between 0.5 and 1 were defined as preferred habitat. Tows at depths or temperatures with odds ratios less than 0.5 are less than ½ as likely to have wolffish compared with depth at the highest proportion.

Depth

The proportion of tows with adult wolffish increased rapidly, peaking at 0.069 at approximately 100 m in the spring survey (Figure 5.2.2). Compared with a tow at 100 meters, the odds ratio for obtaining a tow with adult wolffish declined below 0.5 at depths less than 27 m or greater than 173 m (Table 5.2.2).

Results were similar for juvenile wolffish, but the peak proportion of positive tows was 0.09 at approximately 127 m, slightly deeper than the adults (Figure 5.2.2). Compared with a tow at 127 meters, the odds ratio for obtaining a tow with juvenile wolffish declined below 0.5 at depths less than 70 m or greater than 184 m (Table 5.2.2).

[2] A positive wolffish tow is a tow that captures at least one Atlantic wolffish.

The proportion of tows with adult wolffish increased rapidly, peaking at 0.049 at 117 m in the fall survey (Figure 5.2.3). Compared with a tow at 117 m, the odds ratio for obtaining a tow with adult wolffish declined below 0.5 at depths less than 66 m or greater than 168 m (Table 5.2.2).

Results were similar for juvenile wolffish in the fall, but the peak proportion of positive tows was 0.081 at 115 m (Figure 5.2.3). Compared with a tow at 115 meters, the odds ratio for obtaining a tow with juvenile wolffish was less than 0.5 at depths less than 71 m or greater than 160 m (Table 5.2.2).

Table 5.2.1. Summary statistics for average depth and bottom temperature for tows with wolffish in the NEFSC spring and fall bottom trawl surveys (1968-2008).

Survey	Size group	minimum	25th quantile	median	mean	75th quantile	maximum	Number tows
		average depth in meters						
Spring	Adults (≥65 cm)	30.0	61.0	82.5	94.4	118.0	226.0	197
	Juveniles (<65 cm)	30.5	77.5	105.0	111.8	150.0	220.0	182
Fall	Adults (≥65 cm)	29.0	78.0	95.0	104.5	136.0	205.0	107
	Juveniles (<65 cm)	37.0	77.1	97.0	103.4	126.5	216.5	158
		bottom temperature C°						
Spring	Adults (≥65 cm)	2.0	3.9	4.5	4.6	5.3	7.3	159
	Juveniles (<65 cm)	2.2	4.0	4.6	4.8	5.3	8.6	156
Fall	Adults (≥65 cm)	4.5	6.4	7.3	7.7	9.0	11.1	98
	Juveniles (<65 cm)	4.5	6.3	7.4	7.6	8.5	14.8	132

Bottom Temperature

The fitted proportions had high uncertainty at low temperatures (Figure 5.2.4). The uncertainty is a function of few tows occurring at the low end of the temperature range. The proportion of spring tows with adult wolffish peaked at 0.091 at 2.8°C. The odds ratio for a obtaining a spring tow with adult wolffish declined below 0.5 at temperatures greater than 5.3°C compared with a tow at 2.8°C . Low temperatures with odds ratio less than 0.5 are not available for the observed temperatures.

Results were similar for juvenile wolffish in the spring, but the peak in proportion of positive tows was 0.08 at 2.4°C, slightly cooler than peak for the adults (Figure 5.2.4). The odds ratio for a spring tow with juvenile wolffish was less than 0.5 for temperatures greater than 6°C. As with the adult spring survey, temperatures with odds ratio less than 0.5 were not available at the low end of the temperature range.

The proportion of tows with adult wolffish peaked at 0.059 at 7.2°C in the fall survey (Figure 5.2.5). The odds ratio for obtaining a tow with adult wolffish was less than 0.5 at temperatures less than 4.8°C or greater than 9.7°C compared with a tow at 7.2°C.

Results were similar for juvenile wolffish, but the peak in proportion positive tows occurred at 0.08 at 6.9°C (Figure 5.2.5). The odds ratio for obtaining a tow with juvenile wolffish was less than 0.5 at temperatures lower than 3.7°C or greater than 9.6°C compared with a tow at 6.9°C.

<u>Summary for depth and temperature preferences</u>

Adult wolffish in United States waters were primarily associated with depths between 27 and 173 m in the spring (Table 5.2.2). Juveniles prefer a wider range of depths (70-184 m) in the spring. Depth preferences were similar for juveniles and adults in the fall. According to summer trawl survey data, Atlantic wolffish (juveniles and adults) on the Scotian Shelf prefer a depth range of 73-126 m (Scott 1982a). No data were available from the Gulf of St. Lawrence.

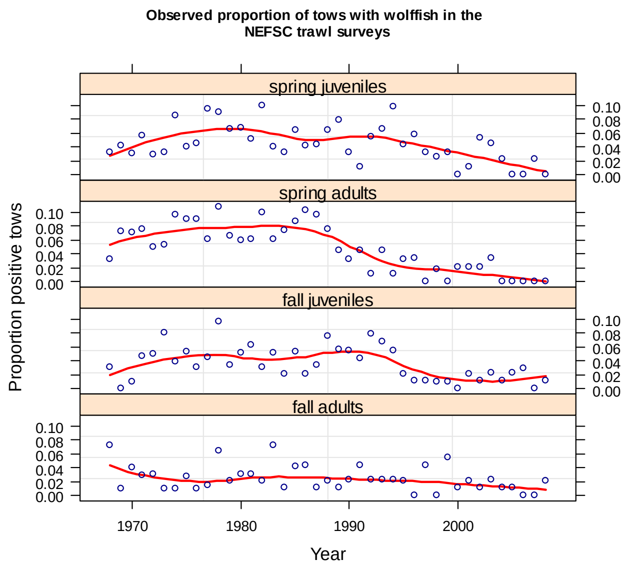
In the spring, wolffish in United States waters were primarily associated with bottom temperatures below 5.3°C (adults) and 6°C (juveniles) (Table 5.2.3). Temperature preferences were similar for adult (<9.7) and juveniles (<9.6) in the fall. Summer trawl survey data from the Scotian Shelf indicate that Atlantic wolffish prefer a bottom temperature range of 3-6°C (Scott 1982a). No data were available from the Gulf of St. Lawrence.

Table 5.2.2. Summary of depth at peak proportion tows with wolffish and depths that have odds ratios less than 0.5 compared with depth associated with peak proportion positive tows.

NEFSC survey		Shallow depths with odds ratio less than 0.5 Depth (m)	Depth (meters) at peak proportion Depth (proportion)	Deeper depths with odds ratio less than 0.5 Depth (m)
Spring	Adults (≥65 cm)	< 27	100 (0.07)	>173
Spring	Juveniles (<65 cm)	< 70	127 (0.09)	>184
Fall	Adults (≥65 cm)	<66	117 (0.049)	>168
Fall	Juveniles (<65 cm)	<71	115 (0.081)	>160

Table 5.2.3. Summary of bottom temperature at peak proportion tows with wolffish and bottom temperatures that have odds ratios less than 0.5 compared with bottom temperature associated with peak proportion of positive tows.

NEFSC survey		Temperatures with odds ratio less than 0.5 Temperature (C)	Temperature (C) at peak proportion Temperature (proportion)	Warmer temperatures with odds ratio less than 0.5 Temperature (C)
Spring	Adults (≥65 cm)	NA	2.8 (0.091)	> 5.3
Spring	Juveniles (<65 cm)	NA	2.4 (0.08)	> 6.0
Fall	Adults (≥65 cm)	<4.8	7.2 (0.059)	>9.7
Fall	Juveniles (<65 cm)	<3.7	6.9 (0.081)	>9.6



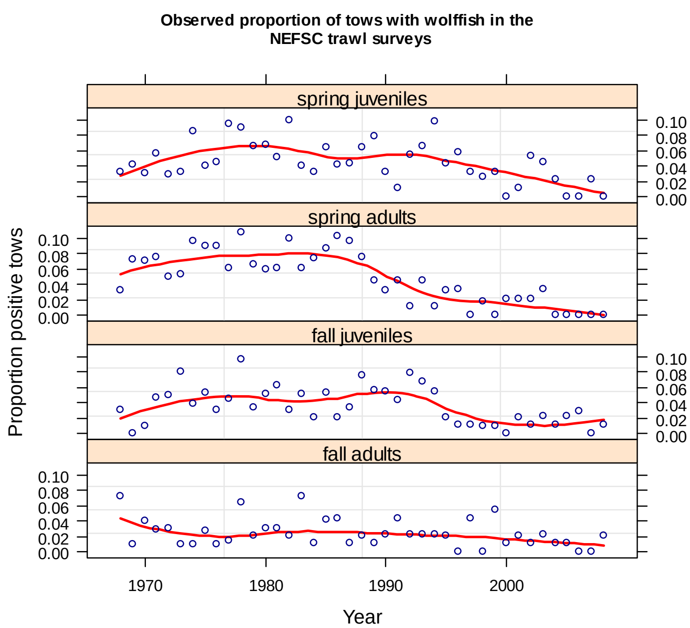
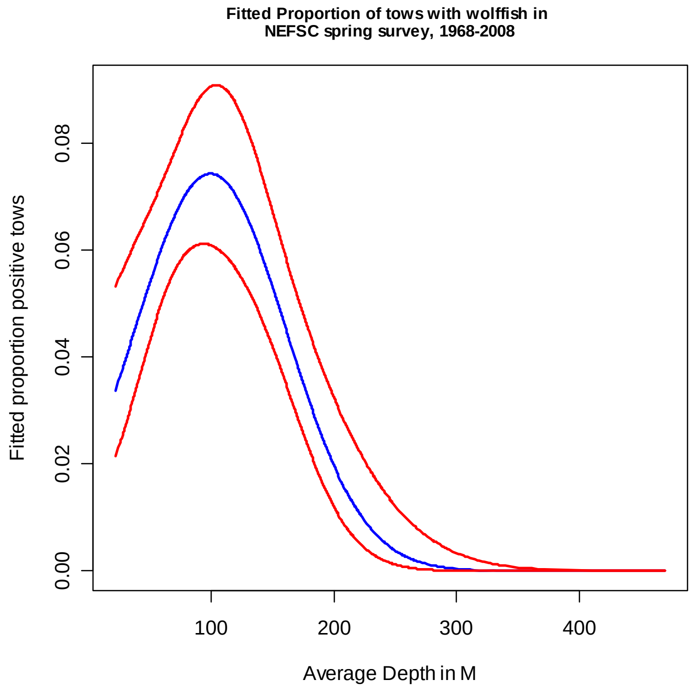


Figure 5.2.1. Trends in observed proportion of tows with wolffish in the NEFSC spring and fall survey. Red line is loess fit with span=0.5 and degree=1.



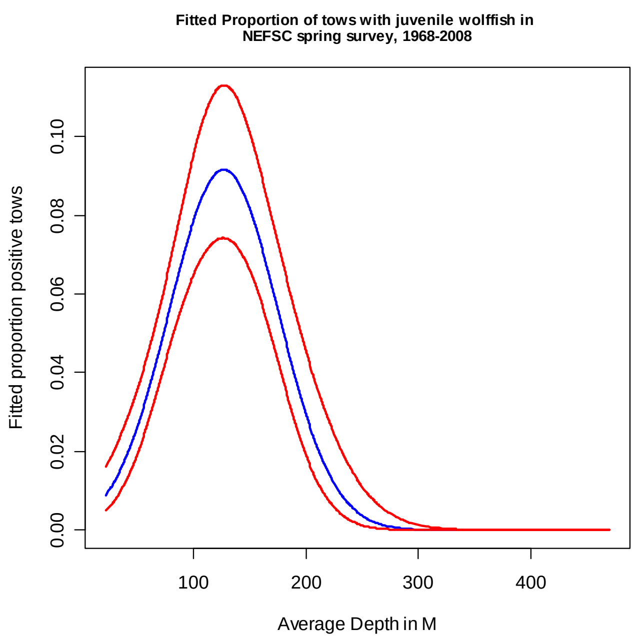
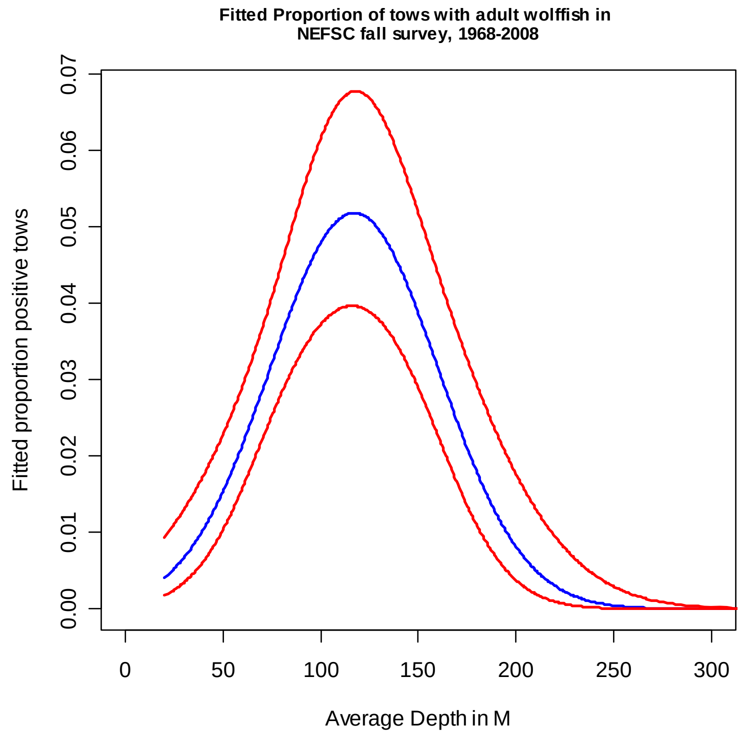


Figure 5.2.2. Fitted proportion of tows with wolffish in the NEFSC spring survey (1968-2008) against depth. Top panel: Adults (≥65 cm). Bottom panel: juveniles (<65 cm). Blue line is fitted proportion. Red lines are ± 1.96 standard errors.



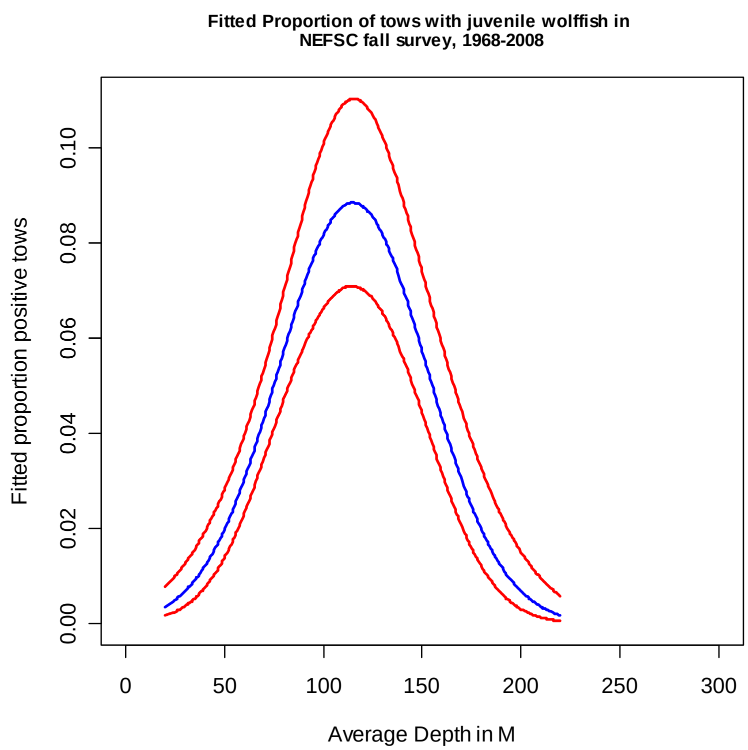
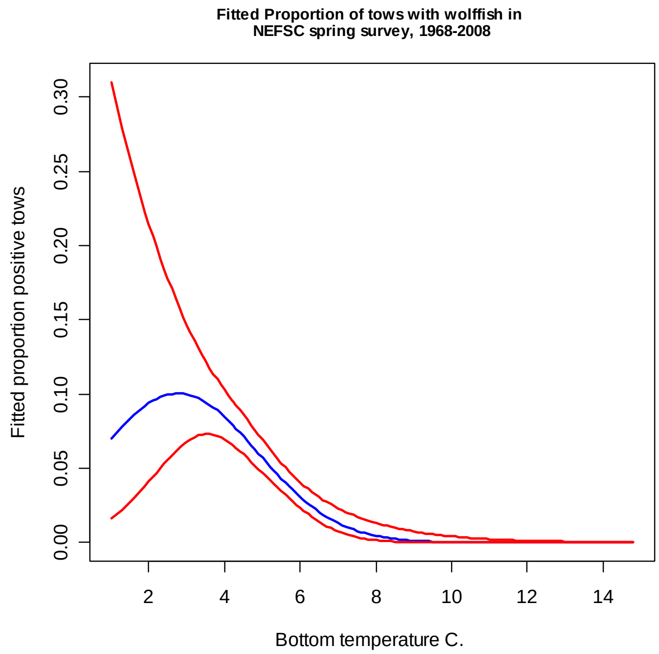


Figure 5.2.3. Fitted proportion of tows with wolffish in the NEFSC fall survey (1968-2008) against depth. Top panel: Adults (≥65 cm). Bottom panel: juveniles (<65 cm). Blue line is fitted proportion. Red lines are ± 1.96 standard errors.



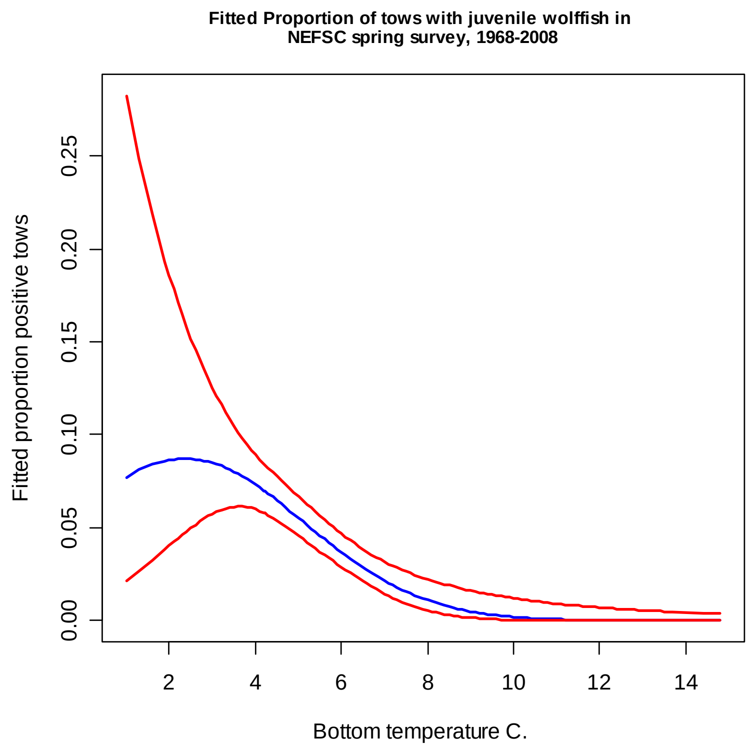


Figure 5.2.4. Fitted proportion of tows with wolffish in the NEFSC spring survey (1968-2008) against bottom temperature. Top panel: Adults (≥65 cm). Bottom panel: juveniles (<65 cm). Blue line is fitted proportion. Red lines are ± 1.96 standard errors.

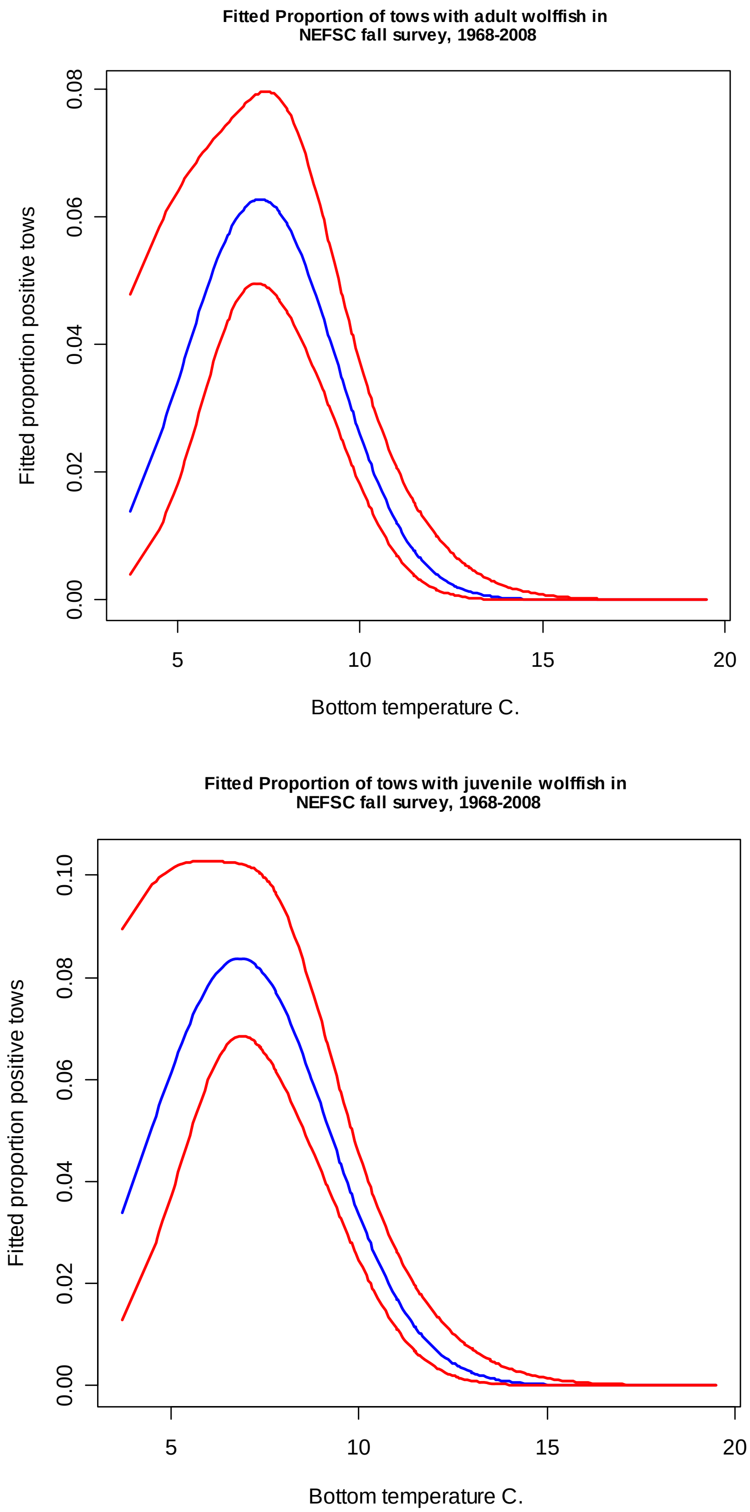


Figure 5.2.5. Fitted proportion of tows with wolffish in the NEFSC fall survey (1968-2008) against bottom temperature. Top panel: Adults (≥65 cm). Bottom panel: juveniles (<65 cm). Blue line is fitted proportion. Red lines are ± 1.96 standard errors.

5.3 Salinity

There is very little information available on salinity. Kulka et al. (2004) summarized observations made by divers at various shallow-water locations on the east and west coast of Newfoundland and reported that wolffish were not observed in reduced salinity, at estuarine locations. When observed, they were always deeper than major haloclines.

5.4 Substrate

The only direct observations of Atlantic wolffish in relation to bottom substrates and habitat features have been made in shallow marine environments by SCUBA divers and, in slightly deeper water, using submersibles and remotely-operated underwater vehicles (ROVs) equipped with video and still cameras. Indirect associations with bottom sediments have been inferred in deeper water from trawl survey and geological substrate data. The nearshore observations are particularly valuable since the adults are known to make use of structurally-complex bottom habitats with rocky crevices and boulder reefs for shelter during prolonged periods of time prior to spawning and while guarding demersal egg masses (see section on reproduction above).

Three underwater surveys using divers were conducted on Atlantic wolffish outside of the DPS range, one in the White Sea, in northern Europe (Pavlov and Novikov, 1993), and two in Newfoundland (Keats et al. 1985 and a series of dives reported on by Kulka et al. 2004). A fourth study was conducted in the Gulf of St. Lawrence by Larocque et al. (2008). In addition to substrate information, relevant observations relating to feeding and nesting behavior are also reported here.

In the White Sea, Atlantic wolffish were seen between 3 and 18 m in July and August 1989-1990 to "prefer complex bottom relief formed of rocks or large stones". They were "only rarely found in algal growths or over even-silted sand." Most (72%) of them were observed in shelters with "only a few fish occurring near to shelters or among stones outside the shelters." Shelters were located on slopes of 15-30 degrees in areas with good circulation and a "slightly silted bottom, usually a cavity between or under stones." Fish did not display territorial behavior, did not retain the same shelters and did not seem to protect them, often leaving one to occupy another. Large cod were often seen in the same shelter as wolffish. No spawning was observed, and no eggs were seen.

Keats et al. (1985) conducted monthly underwater surveys on the Avalon Peninsula, on the eastern (Atlantic) coast of Newfoundland, on many repeated occasions during 1979-1984. Fish were first observed between 5 and 15 m in March and April, "often in holes under large boulders…as well as in the open either swimming or resting on the bottom." Pairs inhabiting nesting holes were common by August, when first egg masses were seen. Paired individuals without egg masses and solitary individuals guarding egg masses were common by September. By early December, no egg masses and few adults were seen. All eight wolffish collected while guarding eggs were males. Eggs were not attached to the substrate. Male wolffish reduce feeding at or near spawning time and feed little or not at all while guarding eggs. Females reduce feeding during egg maturation, but resume feeding after spawning. Data collected by divers down to 30 m in various locations on the east and west coasts of Newfoundland during 1979-

2004 (Kulka et al. 2004) showed that Atlantic wolffish were never observed on soft bottoms composed of either mud or soft clay.

Larocque et al. (2008) presented the results of a survey of Atlantic wolffish habitat utilization in a shallow (0-30 m), rocky stretch of coastline of the Gaspe Peninsula (Les Méchins, Quebec), on the southern shore of the Gulf of St. Lawrence. A variety of habitat types were surveyed in the vicinity of a string of small islands and underwater reefs parallel to shore by divers using high-resolution maps of the seafloor that were created from multibeam sonar data. Indirect measurements of fish size and the height and width of shelter openings were made using laser beams set at equal, known distances to each other. Sixty-two Atlantic wolffish were encountered on two offshore reefs during 19 dives and 15 hours of observation.

During the day, when the diver surveys were conducted, wolffish were typically observed in shelters and not swimming around. Wolffish were observed at depths of 13-25 m (average 20 m), below the thermocline, and below near-surface waters that were subjected to strong surface currents, occasional low salinities, and strong waves. Most shelters were observed at the base of large rocks and boulders and located near the area where the rocky slope created by the offshore reefs ends. The base of the slope was described as a complex maze of rocks and boulders sitting on a gravel and bedrock bottom where there were a large number of overhangs, crevices, tunnels, and small grottos. Shelters typically had a small opening from which only the fish head was visible facing outwards. Sessile invertebrates such as sponges, anemones, and bryozoans often covered the entrance. Three wolffish with egg masses were observed - one egg mass was located outside the shelter and not protected. Based on their observations, Larocque et al. (2008) conclude that wolffish will occupy the same shelters for several weeks while others will be present for only hours or days and speculate that they could be using rocky habitats for reproduction while spending most of their lives in deeper waters on sandy or gravel substrates.

Auster and Lindholm (1995) analyzed data collected during submersible (July 1999) and ROV surveys (May-September 1993-2003) of deep boulder reefs (DBRs) in the Stellwagen Bank National Marine Sanctuary (SBNMS) at depths of 50-100 meters. Nineteen single and paired Atlantic wolffish were observed in 110 hours of observation. All used crevices under and between boulders on DBRs. Shell debris, from bivalves and crustaceans, was scattered at crevice entrances, evidence of "central place foraging activities." Wolffish were determined to be seasonal residents on DBRs. The authors reported that Atlantic wolffish have also been observed far from DBRs "so we assume that some individuals are either transient or move between reefs." Other species that are associated with DBRs in the Sanctuary are redfish (Sebastes spp.), cusk (Brosme brosme), Atlantic cod (Gadus morhua), and ocean pout (Zoarces americanus).

Analyses of trawl survey catches in relation to bottom substrates have not been nearly as conclusive, largely because habitat classification schemes and mapping techniques used in different areas are different. Kulka et al. (2004) analyzed trawl survey data from the Grand Banks/Labrador shelf for six selected years by relating catch rates (average numbers per tow) with five substrate types which were assigned to 0.1 degree squares based on acoustic roughness and hardness indices. They concluded that wolffish "appear to show little preference for any specific sediment" since the highest catch rates were associated with different sediment types in different years.

In an earlier analysis of the same trawl and substrate survey data, Simpson & Kulka (2003, as reported by Kenchington) showed that most wolffish were caught on "small rock" and "rock" bottom in spring and fall. The same number of fish was caught on "boulder/rock" or "hard bottom" in fall, but about half as many were caught in the spring. The results were not statistically significant. Kenchington pointed out that DFO surveys take larger wolffish (>55cm), but most of catch is older juveniles, so these results do not relate much to adults.

There are four analyses of substrate associations for Atlantic wolffish in various geographic portions of the DPS. On the Scotian shelf, Scott (1982a, as referenced by Kenchington) determined that Atlantic wolffish have an "index of preference" of 4, where habitat generalists score 5 and specialists score 1. They were found (in trawl survey tows) with "a frequency of occurrence >10% of that on any sediment type" on four out of five geological map units presented on surficial sediment charts of the shelf. The highest frequency was on "Sable Island Sand & Gravel" which coats the offshore banks and they were entirely missing from "LeHave Clay" that floors the deep basins. However, the frequency of occurrence on rocky slag gravels of the "Scotian Shelf Drift" was lower than that on sandy seabeds and no higher than that of the "Emerald Silt" which predominates on the flanks of the banks.

The Census of Marine Life analysis reported in the listing petition used World Wildlife Fund (WWF) "substrate layers" to calculate the percentage of positive tows made in each bottom type in NMFS and DFO fall and spring/summer surveys. Approximately 50% of all positive tows were made on gravel and till, 20% on sands and muddy sands, and 10% on clay and silt, with no significant change between seasons. Since only 25% of NMFS tows and 40% of DFO tows were made on gravel and till, these results indicate that Atlantic wolfish "prefer" gravel and till. There were no clear associations with the other three substrate types. No statistical test of significance was applied to these results.[3]

An analysis prepared by The Nature Conservancy (TNC) for the Biological Review Team (Alexander 2009) utilized interpolated maps of seafloor topography (depth and slope) and sediment type derived from the United States Geological Survey US Seabed database with trawl survey data from the Gulf of Maine region and related them to survey catches. The model indicated that 58% of Atlantic wolffish were caught over a sediment size greater than or equal to 0.44 mm (medium sand) and at depths greater than or equal to 70 m and less than 193 m, with 35% on high flats and 23% on steep slopes (2.5-8°C). Twenty percent were caught on the same sediment type at depths <70 m.

[3] Kenchington points out several problems with the CoML analysis. First, the sediment map has not been accepted for uses such as this by the scientific community. Second, the analysis appears to have included an extensive area of find sediments in southern New England (the "mud patch") that is generally outside the normal range of wolffish, which means that the frequency of occurrence on fine sediments will have been biased downwards. Third, without a statistical test of significance, no inferences about a "preference" for glacial till can be drawn. Fourth, glacial tills are not very common the GOM/GB region, so most of the tows in that area were actually made on various finer grades of "gravel." He concludes that wolffish are widespread across habitat types found in the GOM region, albeit with weak (ns) preferences for gravely areas and against sands, silts, and muds, and that these results are consistent with what Simpson and Kulka (1993) report for the Grand Banks.

Staff at the SBNMS displayed point trawl survey data inside and adjacent to the SBNMS analysis in relation to spatial coverages of bathymetry and sediment type (mud, sand, gravel and boulder reefs) derived from acoustic backscatter that showed an absence of wolffish from deep, muddy areas. Most of the fish were caught in the eastern portion of the Sanctuary or outside its eastern boundary, but data showing the location of the negative tows are needed to complete the analysis. Another factor complicating the use of a GIS display at such a high spatial resolution is that survey tows cover a linear distance of about three nautical miles, but only the starting points are shown.

Finally, in an analysis of trawl survey data within NMFS survey stratum 26 (which includes the SBNMS, see figure 6.3.7), Auster et al. (2001) showed that high catch rates of Atlantic wolffish were associated with high reflectance (rocky) bottom areas. In fact, Atlantic wolffish had the highest median reflectance value of all species examined, with a significant rank correlation coefficient at p=.052, described as a "weak, but significant correlation."

Summary

Substrate associations for adult Atlantic wolffish are well documented during the time of year that they utilize nearshore rocky habitats for reproduction. Based on the depth distribution information from the NEFSC trawl surveys in the Gulf of Maine region, the adults move into slightly shallower water in the spring (mean depth 82.5 m versus 105 m in the fall) where they have been observed with and without egg masses inhabiting shelters in deep boulder reefs in depths between 50 and 100 meters. Similar observations of adults inhabiting shelters in shallow (<30 m), rocky habitats prior to and after spawning have been made in the Gulf of St. Lawrence and Newfoundland. Few, if any, adult wolffish have been observed in other habitats in any of these surveys. There is clearly a strong preference for nearshore, rocky spawning habitat and for bottom temperatures <10°C. Rocky, nearshore habitats are plentiful in the Gulf of Maine and appear to provide critical spawning habitat for Atlantic wolffish.

It is important, however, to add that juvenile wolffish are found in a much wider variety of bottom habitats and that adults, once they have finished guarding the eggs and resume feeding, move into deeper water where they have been collected over a variety of bottom types (sand and gravel, but not mud). In fact, the collection of "aggregations" of Atlantic wolffish eggs in bottom trawls fishing in 130 meters of water on LeHave Bank (Scotian Shelf) in March 1966 (Powles, 1967; Templeman, 1986) indicates that spawning is not restricted to nearshore habitats, and may not be restricted to rocky habitats. Attempts to relate catches of Atlantic wolffish in bottom trawl surveys to substrate types are of limited value and somewhat contradictory,[4] but they do indicate that the juveniles do not have strong habitat preferences, and that adults are more widely distributed over a variety of bottom types once they leave their rocky spawning habitats.

[4] Bottom substrates are characterized using a variety of sampling techniques, ranging from acoustic surveys of large areas of the seafloor to point samples of finer sediments for grain size analysis. They are also classified using different categorization schemes and descriptive terminology. To add to the problem, there are a number of ways to spatially interpolate discrete sampling data to create substrate "polygons" in a GIS format, all of which are subject to problems that complicate the interpretation of the resulting "maps."

6. DISTRIBUTION AND ABUNDANCE

6.1 Worldwide Distribution and Status

Atlantic wolffish can be found in northern latitudes of the eastern and western North Atlantic Ocean. In the north and eastern Atlantic they range from eastern Greenland to Iceland, along northern Europe and the Scandinavian coast extending north and west to the Barents and White Seas and to the south in northern France and Ireland. In the northwest Atlantic they are found from Davis Straits off of western Greenland, along Newfoundland and Labrador coasts to Grand Bank and continue southward through the Canadian Maritime Provinces to Cape Cod, USA.

Northeast Atlantic

The distribution and status of Atlantic wolffish in the Northeast Atlantic was summarized by David Kulka at the Wolffish Biological Review Team meeting held March 24-25 in Boston, Ma. This summary was based on work completed by the ICES Working Group on Fish Ecology.

Barents Sea and White Sea

Wolffish are most densely distributed along the north coast of Norway and Russia. Biomass was low during the 1980's but has since fluctuated with an upward trend (Figure 6.1.1 and Figure 6.1.2 from ICES, 2006). Total area occupied has not changed since the 1970's and biomass has increased in the center of distribution with no increase in area occupied.

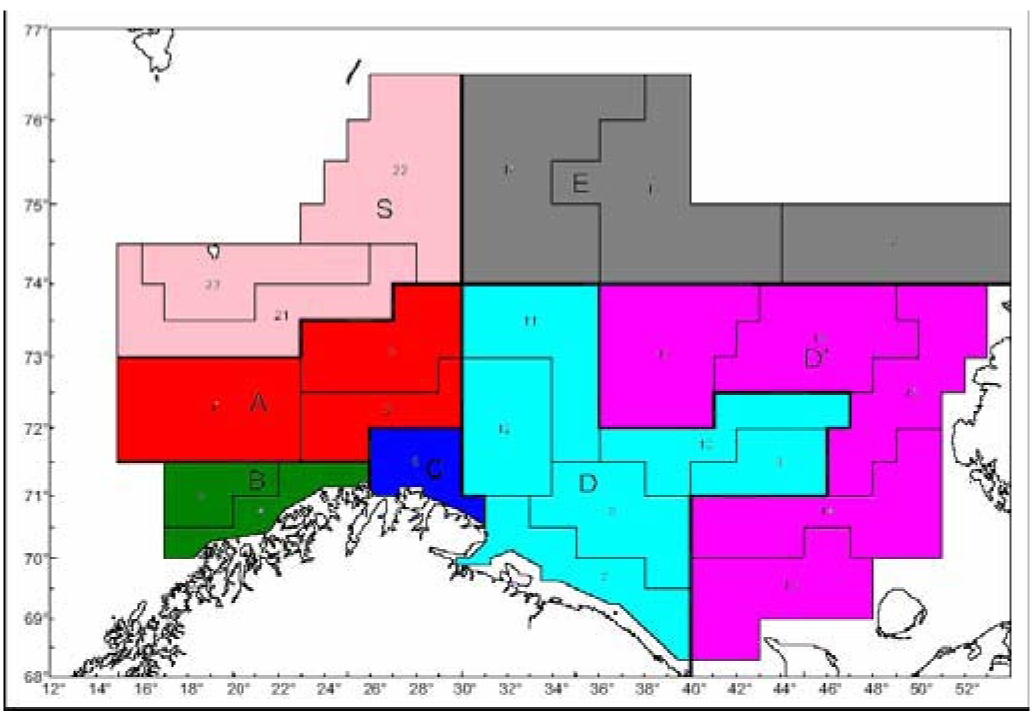


Figure 6.1.1 Norwegian trawl winter survey areas. Letters and colours correspond the bar segments in Figure 6.1.2. (from ICES, 2006).

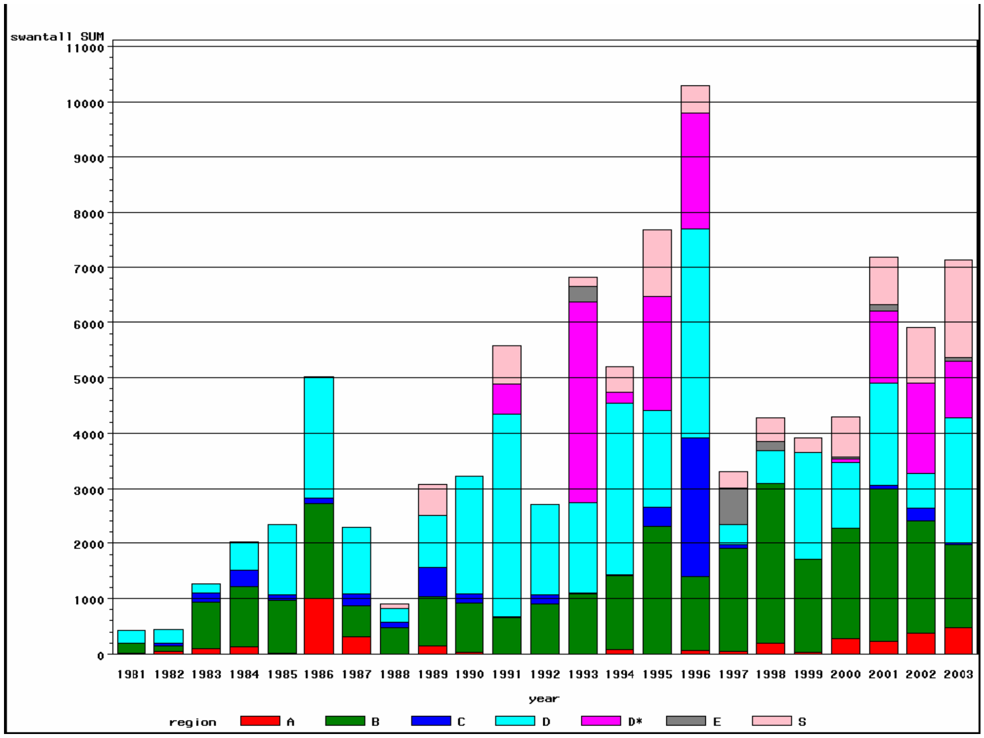
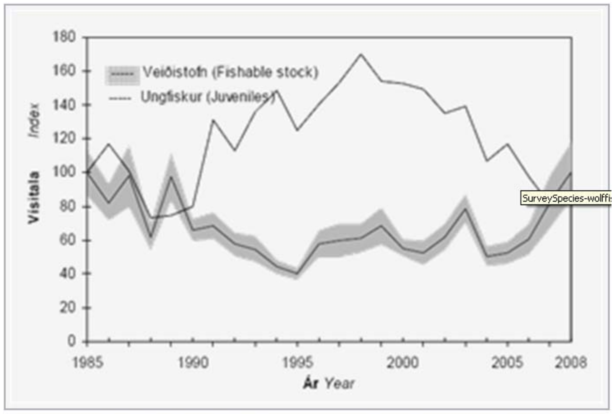


Figure 6.1.2 Number of Atlantic wolffish caught from IMR Barents Sea winter survey (thousands of fish). Letters and colors correspond to the map in Figure 6.1.1 (from ICES, 2006).

Survey indices are not available for this area so status remains unknown. Area occupied has decreased since the late 1980's concomitant with a 1 to 1.5 degree increase in water temperature in the North Sea. Atlantic wolffish are not found in the Irish Sea or Celtic Sea, but can be found in water greater than 200m along northern shelf.

Iceland
The following is taken from the 2008 status report from English summary of the State of Marine Stocks in Icelandic waters 2007/2008- Prospects for the Quota Year 2008/2009 (Figure 6.1.3)

> Atlantic wolffish are found all around Iceland, but is most common off Vestfirdir (West Fjords) peninsula in the west. It mostly occurs on mud or sand bottoms at depths between 40 and 200 m. …Landings of Atlantic wolffish (*Anarhichas lupus*) in 2007 were 16,200 t; similar to that of the year before. Fishable biomass and recruitment indices in the groundfish survey in March decreased considerably from 2003 to 2004. Since then, the recruitment indices have continued to decrease and are now similar to the low values of 1988–1990. The index of fishable biomass has increased since 2004 and is now similar to that of 1985. As in recent years, the MRI recommends a management strategy of F0.1 or 12 000 t in the quota year 2008/2009. In addition, the MRI recommends the continued closure of the major spawning area off west Iceland for fishing during the spawning and incubation season in autumn and winter to 200 m.



Atlantic catfish, stock index (biomass) and recruitment index (number of fish between 20 and 40 cm) in annual groundfish survey in March since 1985 (1985 = 100).

Source: The Marine Research institute

Figure 6.1.3 Trends in exploitable stock and recruitment survey indices for Atlantic wolffish in Icelandic waters.

Greenland

Wolffishes have been harvested by longliners operating both inshore and offshore and by pound net and gillnet fisheries in inshore areas only of West Greenland. Catches of all wolffish species combined are generally less than 1,000 tons for 2005-2007. The survey coverage is for NAFO subarea 1(Figure 6.1.4). Trends in wolffish abundance in the Greenland Shrimp survey were summarized by Nygaard and Sünksen (2008) (Figure 6.1.4):

Atlantic wolffish has in the past mainly been caught south of 68°00'N, but in 2003 and 2004 high abundances were found in 1BN (Table 10 and 11). In 2005 the highest abundance was however found in 1C and in 2006 in 1F. In 2004 the abundance and biomass was estimated to 4.4 million individuals and 600 tons. 2005 has the highest estimate in the time series for both abundance and biomass, but since then the abundance and biomass has decreased to 2.4 million individuals and 766 tons respectively. The abundance and biomass has from 1992-2001 varied through the time series without any significant trend with highest estimates in 1994 (4.8 million individuals and 644 tons) and lowest in 1992 (0.8 million individuals and 163 tons). In 2007 the length ranged between 4 and 90 cm (Fig. 9). The analysis of the length distribution reveals the dominance of small fish < 35cm. However, during 2004 - 2007 the proportion of larger fish has increased. Reference: Rasmus Nygaard and Kaj Sünksen. 2008. Biomass and Abundance of Demersal Fish Stocks off West Greenland Estimated from the Greenland Shrimp Survey, 1988-2007 (Nygaard and Sünksen, 2008).

NAFO's Scientific Council concluded that "The stock remains depleted despite a steady increase in recruitment since the early 1980s. The stock is dominated by small individuals."

A similar pattern of stable abundance and declining biomass was observed for the combined east and West Greenland surveys (Figure 6.1.5).

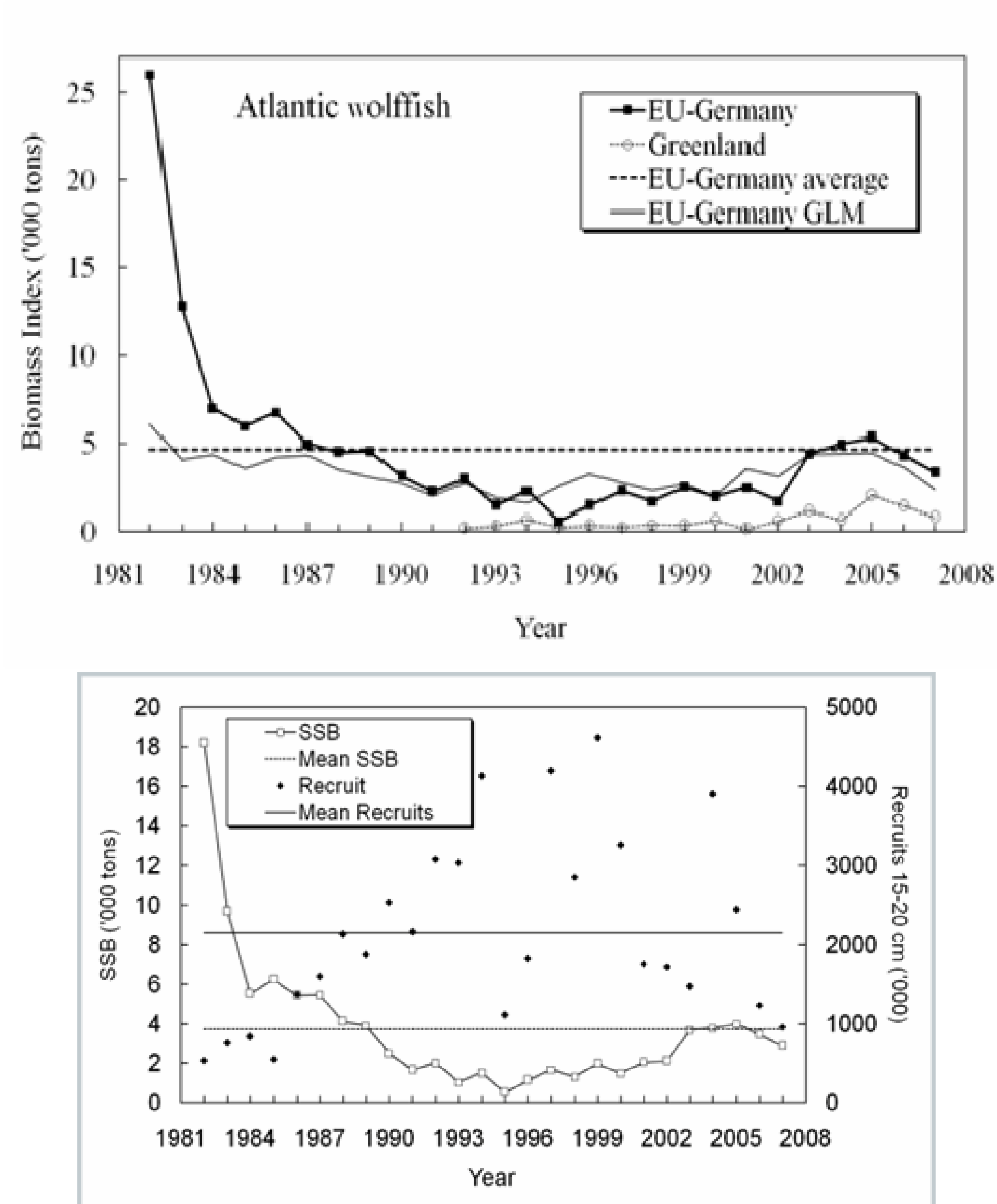


Figure 6.1.4. Top panel: Atlantic wolffish biomass index from the West Greenland (NAFO subarea 1) shrimp survey. Bottom panel: Indices of spawning stock biomass and recruitment for West Greenland. Source: Report of the NAFO Scientific Council Meeting 5-19, 2008.

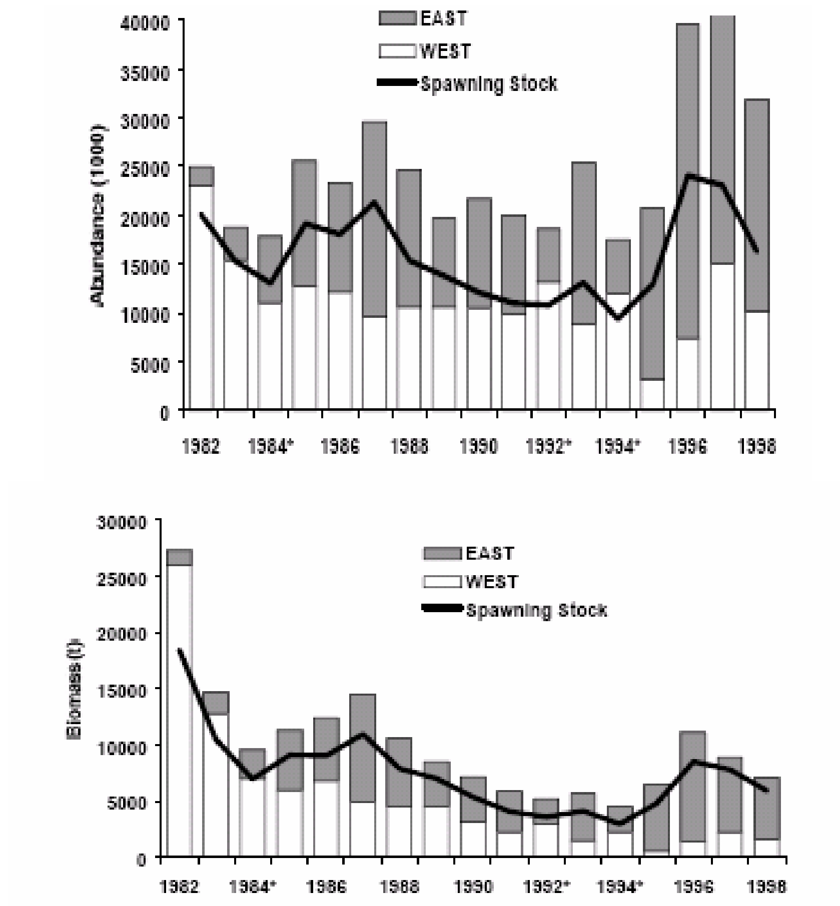


Figure 6.1.5. Combined East and West Greenland survey indices (Moller and Ratz, 1999)

6.2 Canadian Distribution and Abundance

Atlantic wolffish are widely distributed throughout Canadian waters. The distribution is continuous throughout eastern Canadian waters, extending into the adjacent NAFO Regulatory Area (Figure 6.2.1). Trawl surveys indices are reported by NAFO Division and cover both Canadian EEZ waters and international waters within the NAFO Regulatory Area. Larval wolffish were taken in plankton surveys of the Grand Banks in September and October. Simpson and Kulka (2002) reported that the Atlantic wolffish population declined 97% decline between the late ‘70s and early ‘90s in the northern part of its range (Labrador Shelf, NAFO Divisons 2J3K) and has been listed as a Species of Special Concern under the COSEWIC in 2001. The decline on the Grand Banks (NAFO Division 3LNO) was less than in the northern areas (NAFO Division 2J3K). Increases have been observed in most areas since the mid to late-90s. Note that the survey shifted from the Engel’s net to a Campelen shrimp trawl with higher catchability and different selectivity in 1996 (Figure 6.2.2.). Thus the two sets of indices are not comparable and need to be treated as discontinuous. Abundance remains low, but is increasing.

Casey examined a timeseries of Canadian DFO surveys from 1951 to 1995, standardized to vessel, diel changes, and relative catchability on the Southern Grand Bank and St. Pierre Bank (NAFO Divison 3P). Casey also accounted for changes in survey design (a fixed station design from 1955-1970, and a random stratified design thereafter. For St. Pierre Bank and Southern Grand Bank, Casey reported that “wolffish biomass had been increasing until the mid 1970’s when it peaked and subsequently declined on St. Pierre Bank, wolffish biomass increased until the mid 1970’s when it peaked and subsequently declined. Estimates of wolffish biomass on the southern Grand Bank however have been increasing steadily”. Recent trawl survey abundance indices have fluctuated without trend from 1996 to 2001 (Simpson and Kulka, 2002).

Gulf of Saint Lawrence, Scotian Shelf and Georges Bank

The remaining distribution information is related to the Western Atlantic Canada/U.S DPS. The status of wolffish in Gulf of Saint Lawrence (NAFO Division 4RST), Scotian Shelf (4VWX) and GB (5Y) was summarized from a DFO science stock status report (DFO, 2000). Atlantic wolffish are distributed throughout the Northern Gulf of Saint Lawrence (subarea 4RS) with the primary concentration along western coast of Newfoundland. Both relative abundance and biomass in the summer research survey have increased in this area. In the Southern Gulf of Saint Lawrence (4T), wolffish are distributed along the slope of the Laurentian channel. Relative abundance and mean weight per tow increased until 1987, and have since declined. Survey indices for the population remain low. Area occupied has increased in 4T during the 1980’s and the index remains high.

Wolffish are distributed throughout 4VWX, although relative abundance has declined in the mid-shelf, but increased in area 4V. Survey abundance has increased and remains high while survey biomass indices are near record lows. Increased relative abundance is based on small fish and mature survey biomass is near record lows. The area occupied (percent occurrence of wolffish in survey tows) declined during the 1980’s and has remained low during the 1990’s. The report only provided a series of USA and Canadian catches for the GOM (5Y) or GB (5Z).

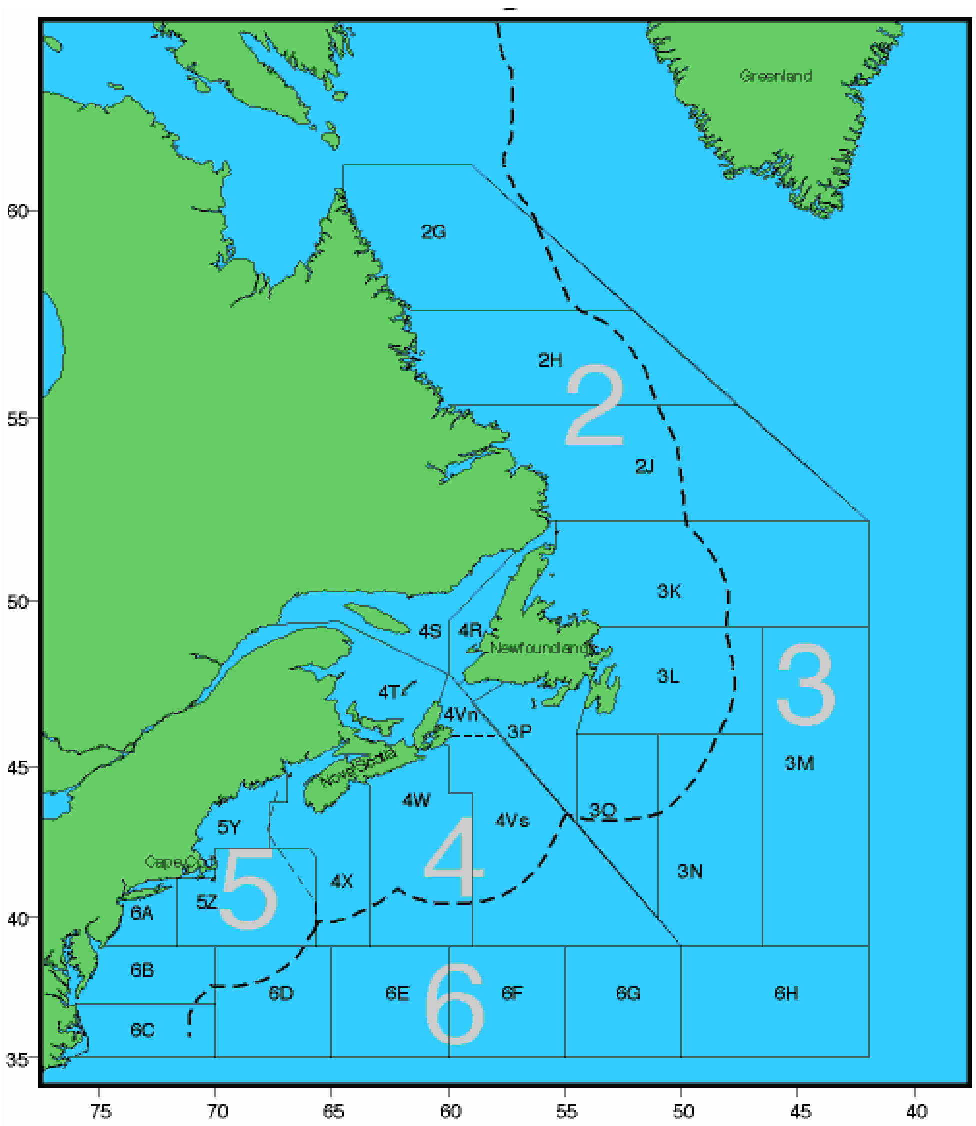


Figure 6.2.1 NAFO Fishing Boundaries (http://www.mar.dfo-mpo.gc.ca/communications/maritimes/back02e/B-MAR-02-07E.html)

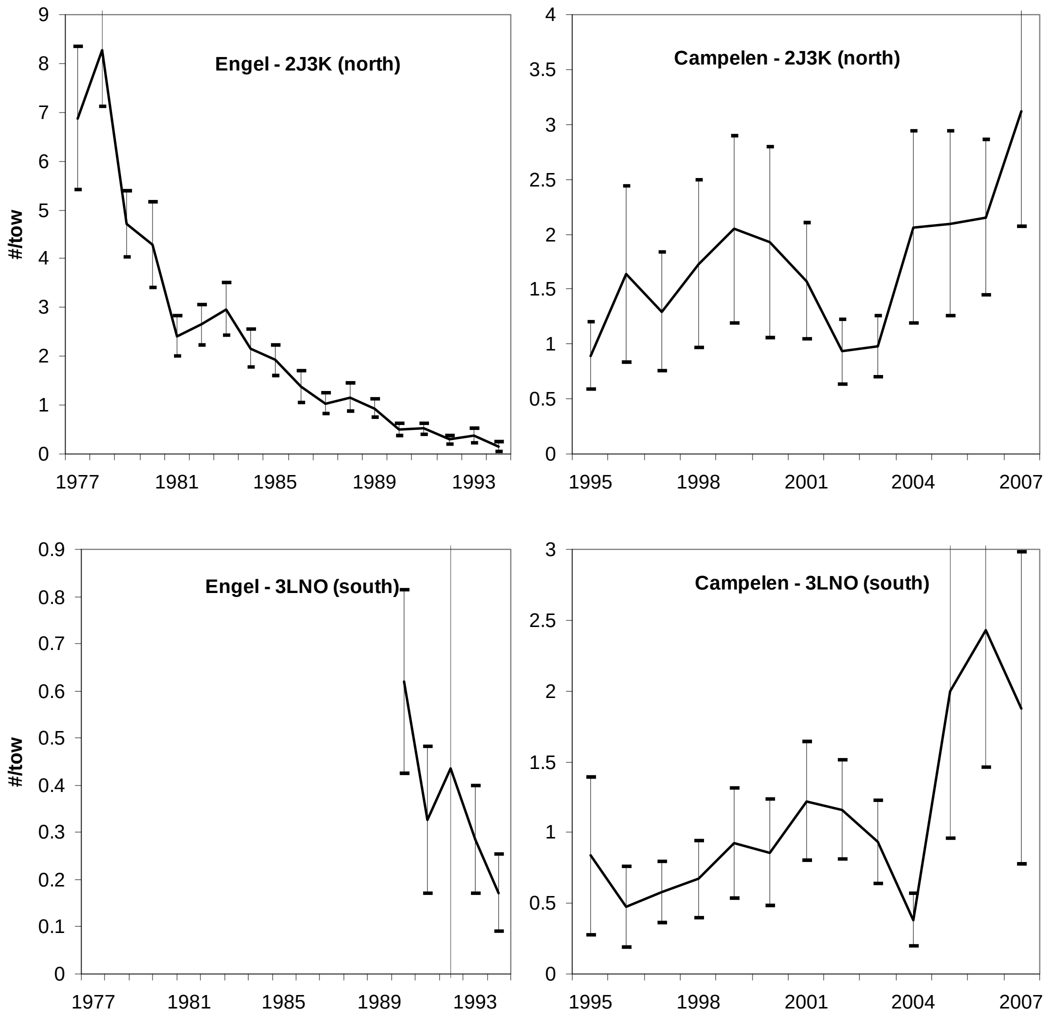


Figure 6.2.2. Survey indices for Atlantic wolffish in NAFO statistical areas 2J3K (north) and 3LNO (south). Note the surveys changed from Engel trawl to the Campelen trawl in 1995 so that the indices are not comparable across gears.

6.3 United States Distribution and Status

The general distribution of Atlantic wolffish in the United States is limited to GOM, Georges Bank (GB), and the Great South Channel (GSC). Rarely are they found south of New England. Wolffish are scattered throughout these regions but real concentrations appear in the Jeffreys Ledge, Cashes Ledge, Stellwagen Bank and Platts Bank portions of the GOM according to NEFSC, Massachusetts, Maine/New Hampshire and Cooperative Industry Based surveys (Figures 6.3.1). Fishery dependent data collected by Sea Sampling Observers and self reported Vessel Trip Reports from fishers show the distribution of Atlantic wolffish extends broadly along the slope waters of GB and throughout the central and southern reaches of the GOM (Figure 6.3.1).

Distributions of Atlantic wolffish by various individual surveys are shown in figures 6.3.2. The NEFSC has conducted winter, spring, summer shrimp, summer scallop, fall, and cooperative trawl and dredge surveys. Data used in these summaries are listed in table 6.3.1. Generally spring and fall NEFSC surveys cover the known range of habitat for wolffish in United States waters, however during the fall season wolffish behavior, such as nest guarding and teeth shedding, may make them less available to the survey gear. The summer shrimp survey area is limited to offshore GOM and the winter trawl survey and sea scallop surveys cover a portion of wolffish habitat on GB and in the GSC but does not extend to GOM. Winter and summer scallop surveys did not consistently sample all GB and GSC strata throughout time. The distributions of wolffish catches in the spring and fall NEFSC surveys are found primarily near Jeffreys Ledge, Stellwagen Bank and GSC areas (Figure 6.3.2 & 6.3.3). A time series of positive catches from spring and fall survey bottom trawl data (1968-2007) shows that Atlantic wolffish are currently captured less frequently across the range than in earlier time blocks (Figure 6.3.3). The distribution of positive tows from all years in the summer-shrimp surveys has occurred near Jeffreys Ledge, Platts Bank and Cashes Ledge areas (Figure 6.3.2). The winter and summer sea scallop surveys encountered Atlantic wolffish rarely: a single positive wolffish catch was recorded in the winter survey on the southern portion of GB while six positive tows were taken in the sea scallop sampling survey in the GSC region (Figure 6.3.2). NEFSC gear comparison and feeding habitat surveys also collected Atlantic wolffish. Wolffish catches in these surveys were distributed in Jeffreys Ledge, Stellwagen Bank, and GSC areas. Notably, positive wolffish catches were more frequently recorded on the southern portion of Georges Bank during the Coastal Ocean Program spring surveys than during other surveys (Figure 6.3.2).

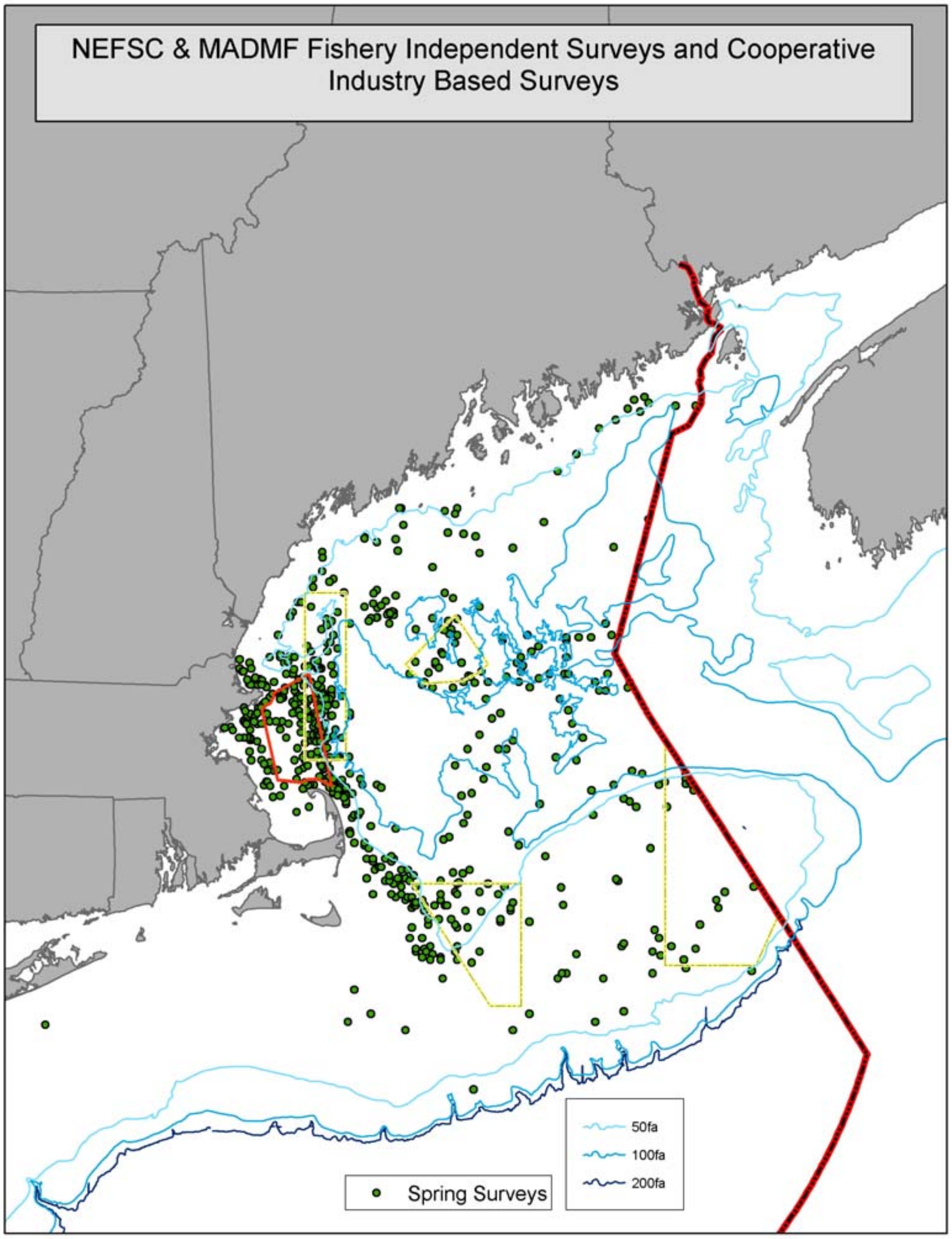


Figure 6.3.1. (continued)

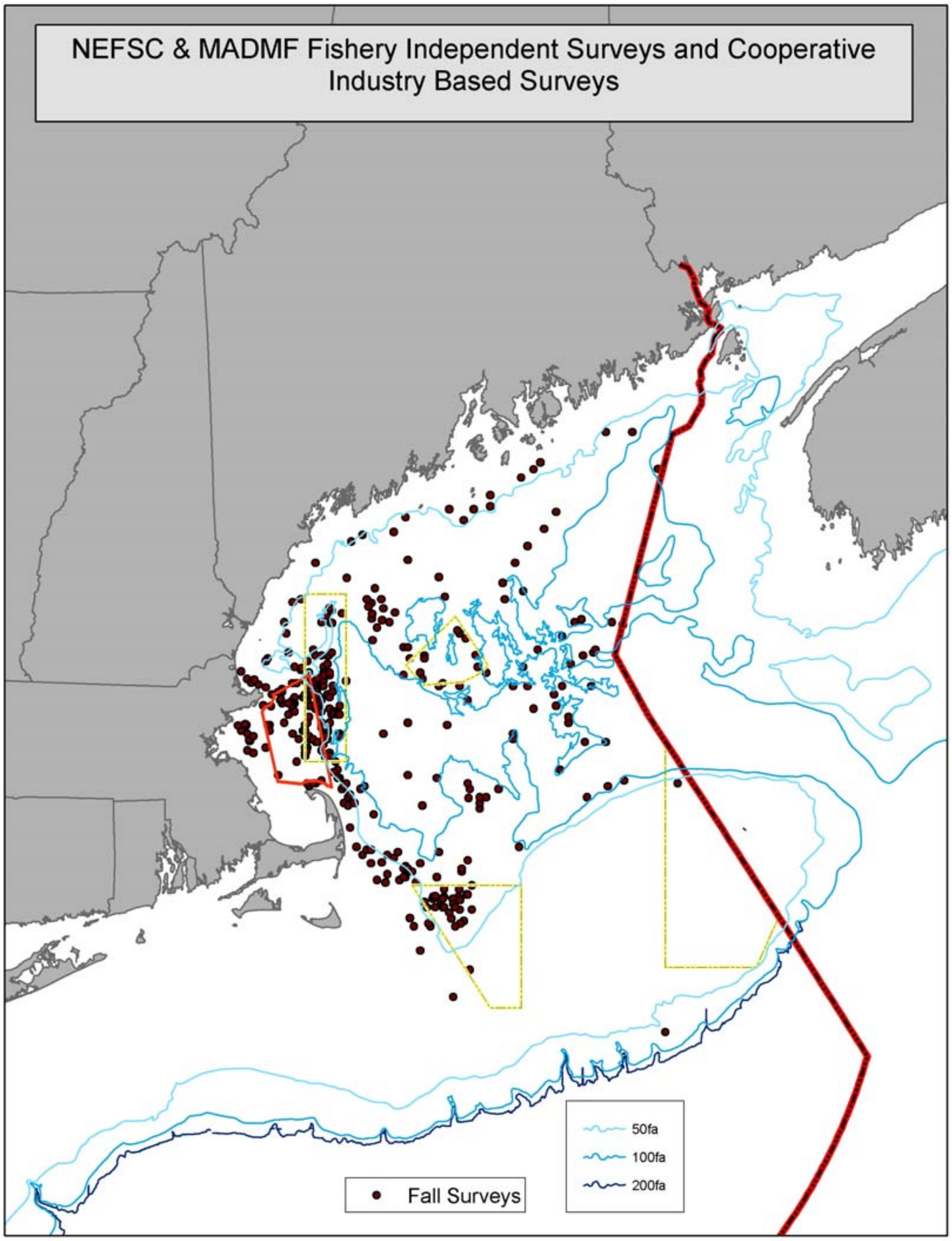
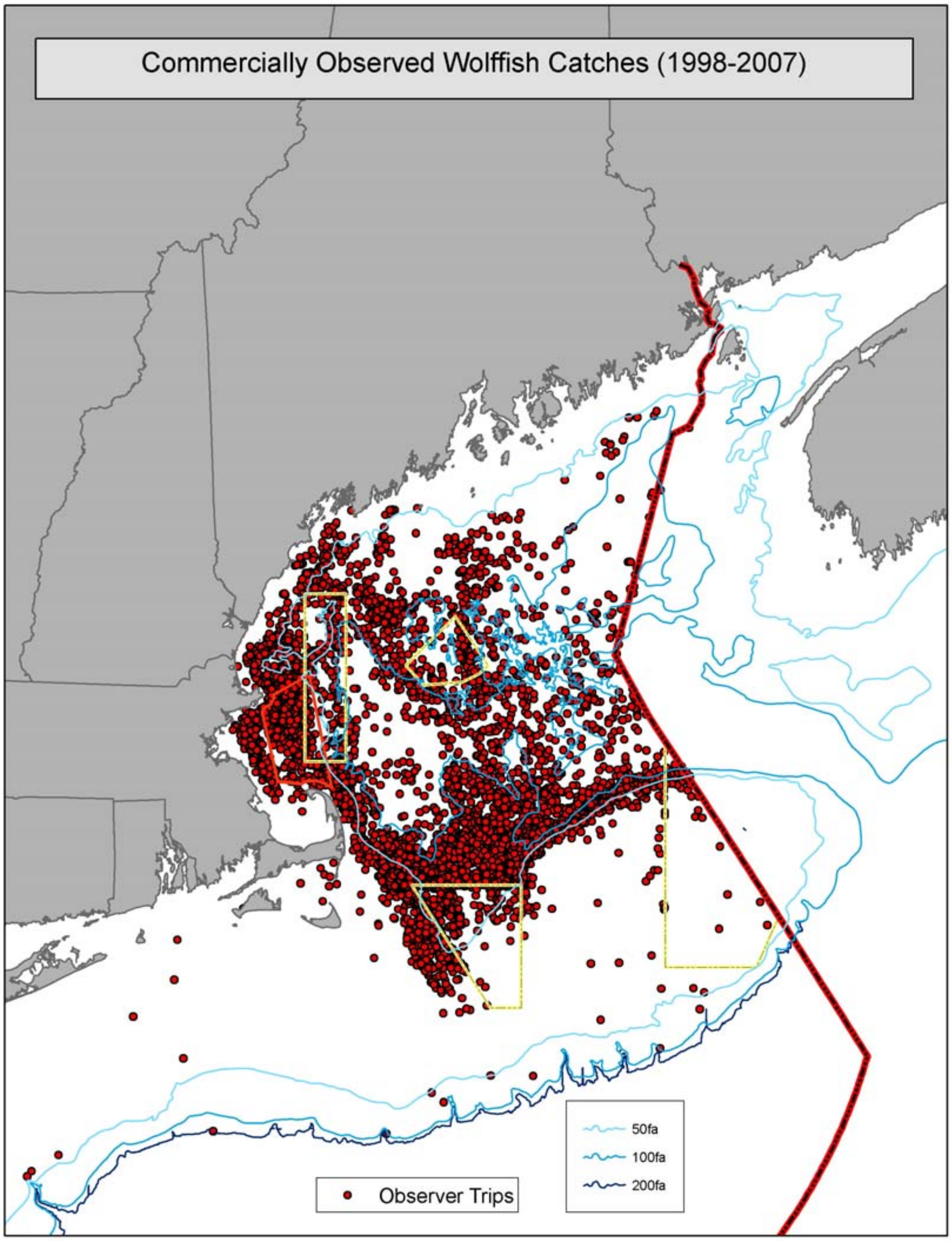


Figure 6.3.1. (continued)



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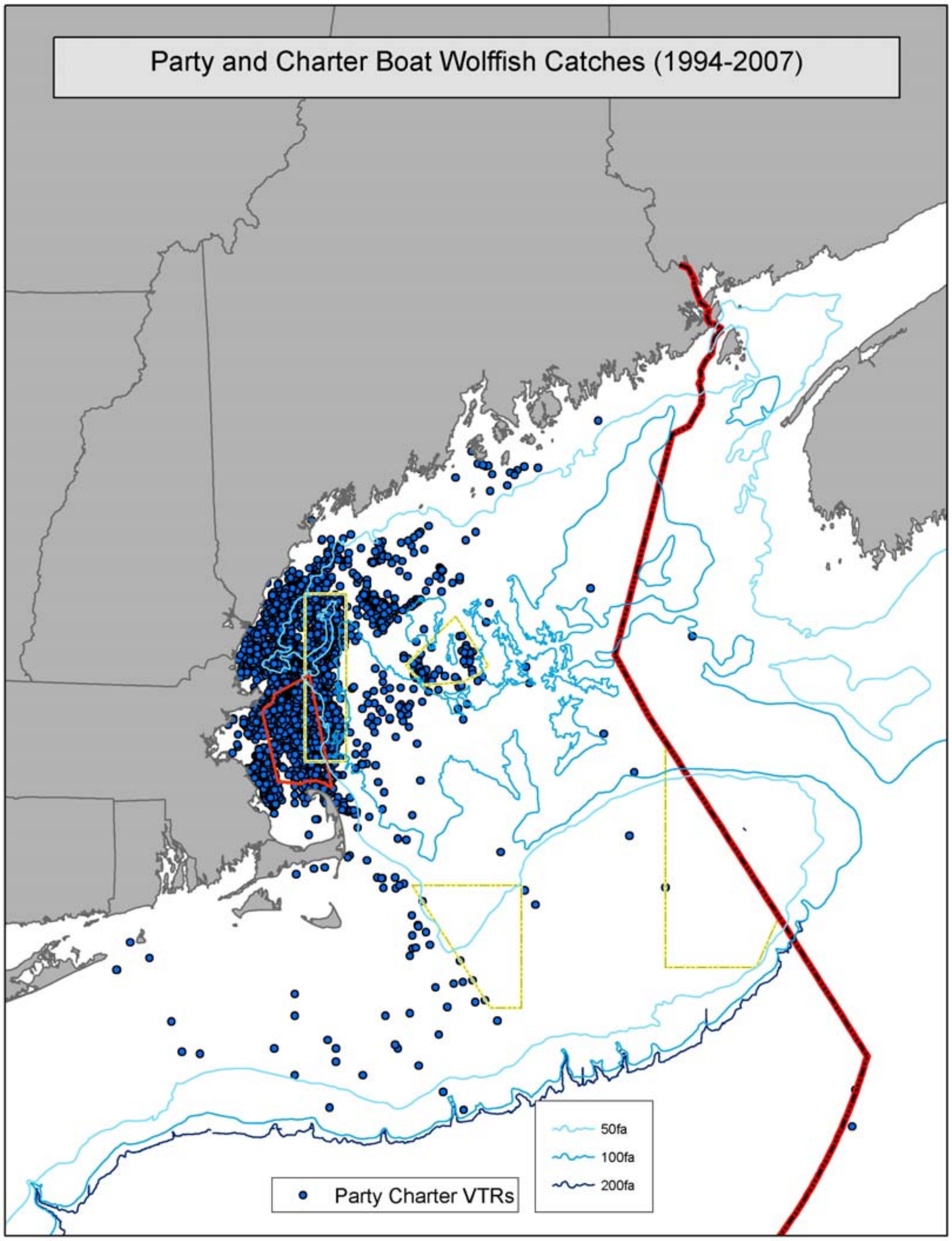
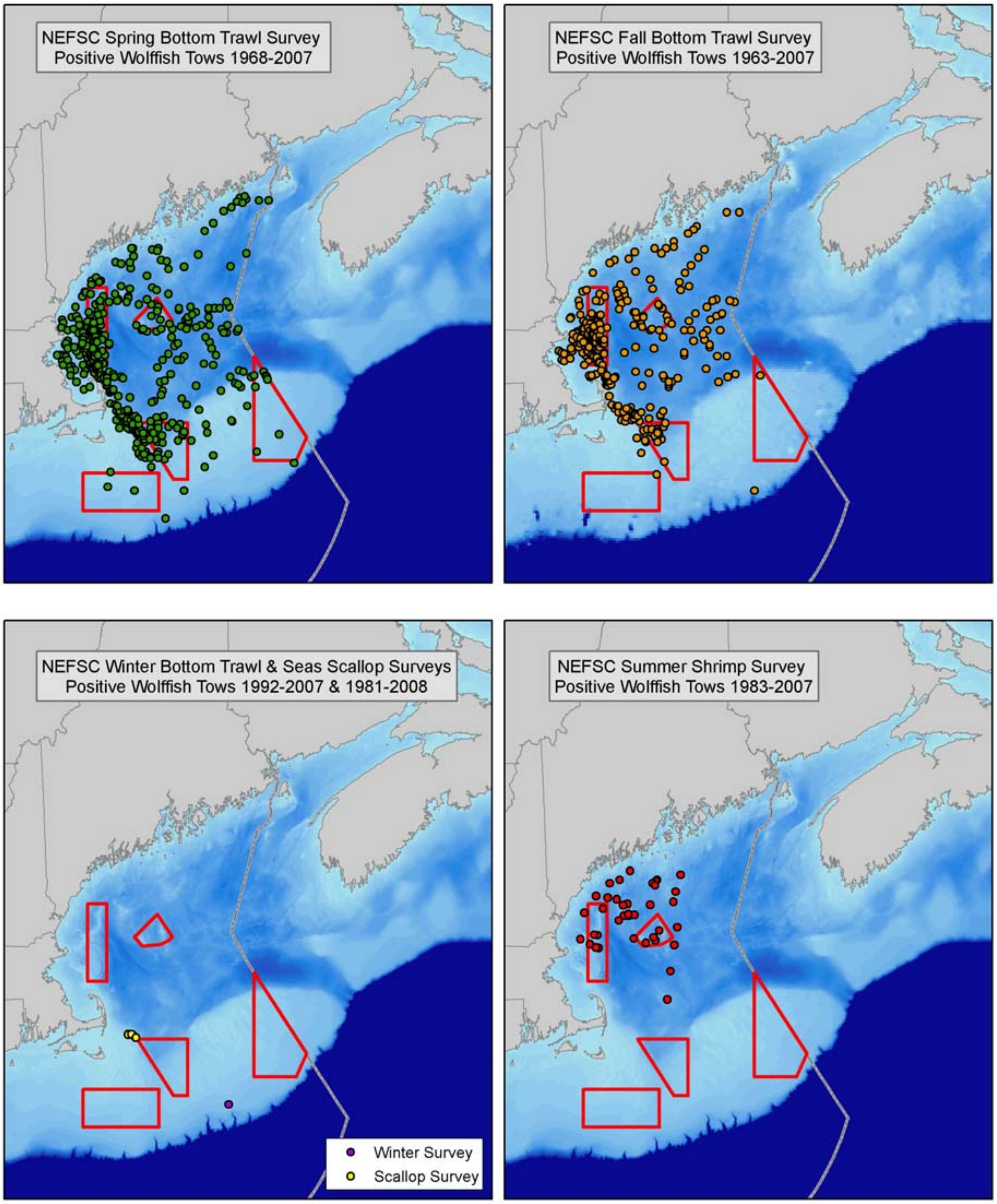


Figure 6.3.1. Overall distribution of Atlantic wolffish in United States waters based on fishery independent and fishery dependent data sources.

Table 6.3.1 Summary of Federal, State, and Cooperative data sources used in describing the distribution and status of Atlantic wolffish.

Survey	Years	Primary Gear
Winter BTS	1992-2007	Modified Yankee 36 flatfish net
Spring BTS	1968-2007	Yankee 36
Miscellaneous Surveys	1963-present	Yankee 36
Summer Shrimp	1982-2007	4 seam Shrimp Otter Trawl
Sea Scallop	1979-2007	8 ft Scallop Dredge
Fall BTS	1963-2007	Yankee 36
Cod IBS	2003-2007	2 seam High Rise w/ rockhopper
Cooperative Goosefish	2001&2004	Monkfish Net (+/- rockhopper)
MA DMF	1978-present	North Atlantic 2 seam Otter Trawl
ME DMR	2000-present	Modified 4 seam Shrimp Otter Trawl



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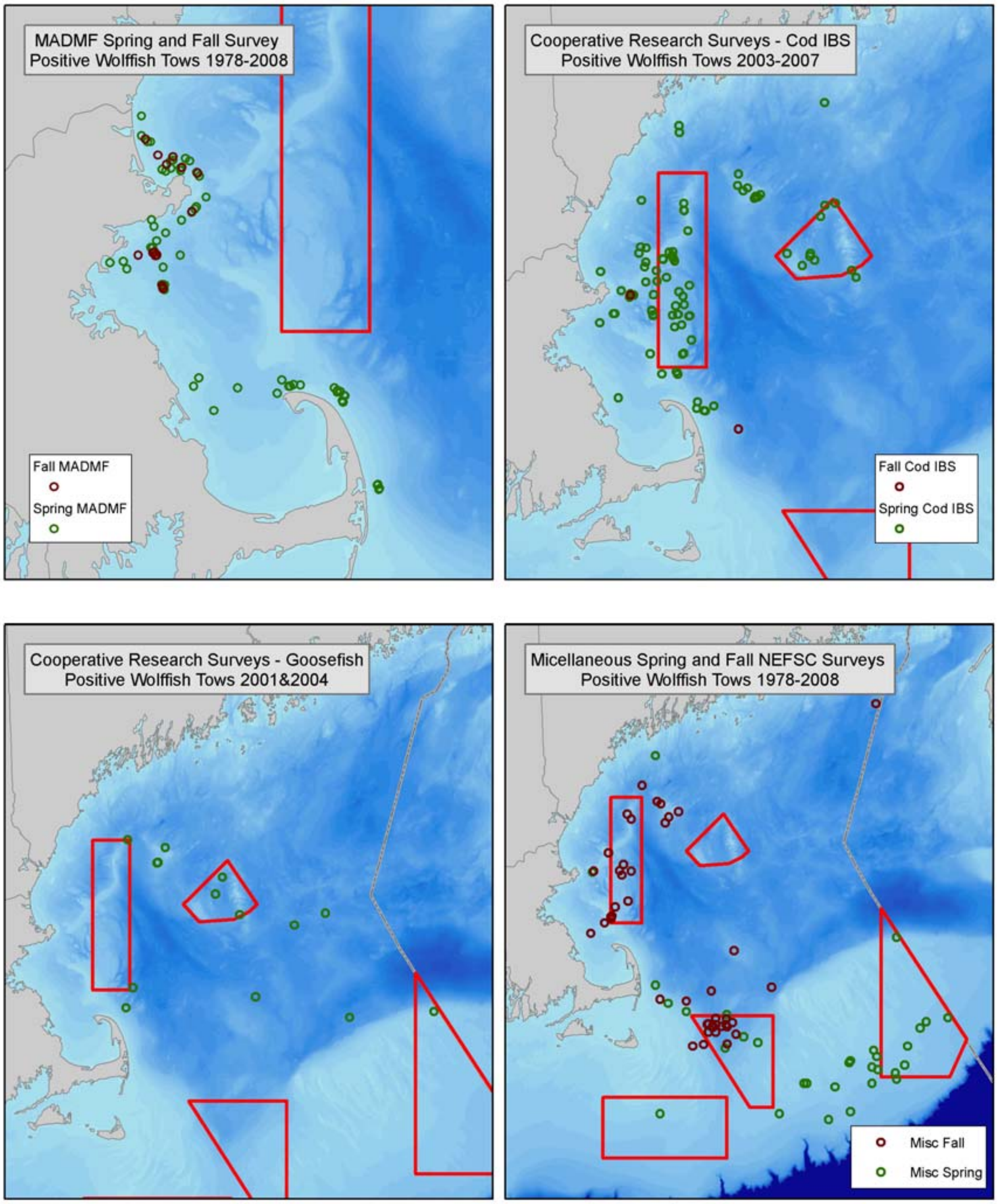
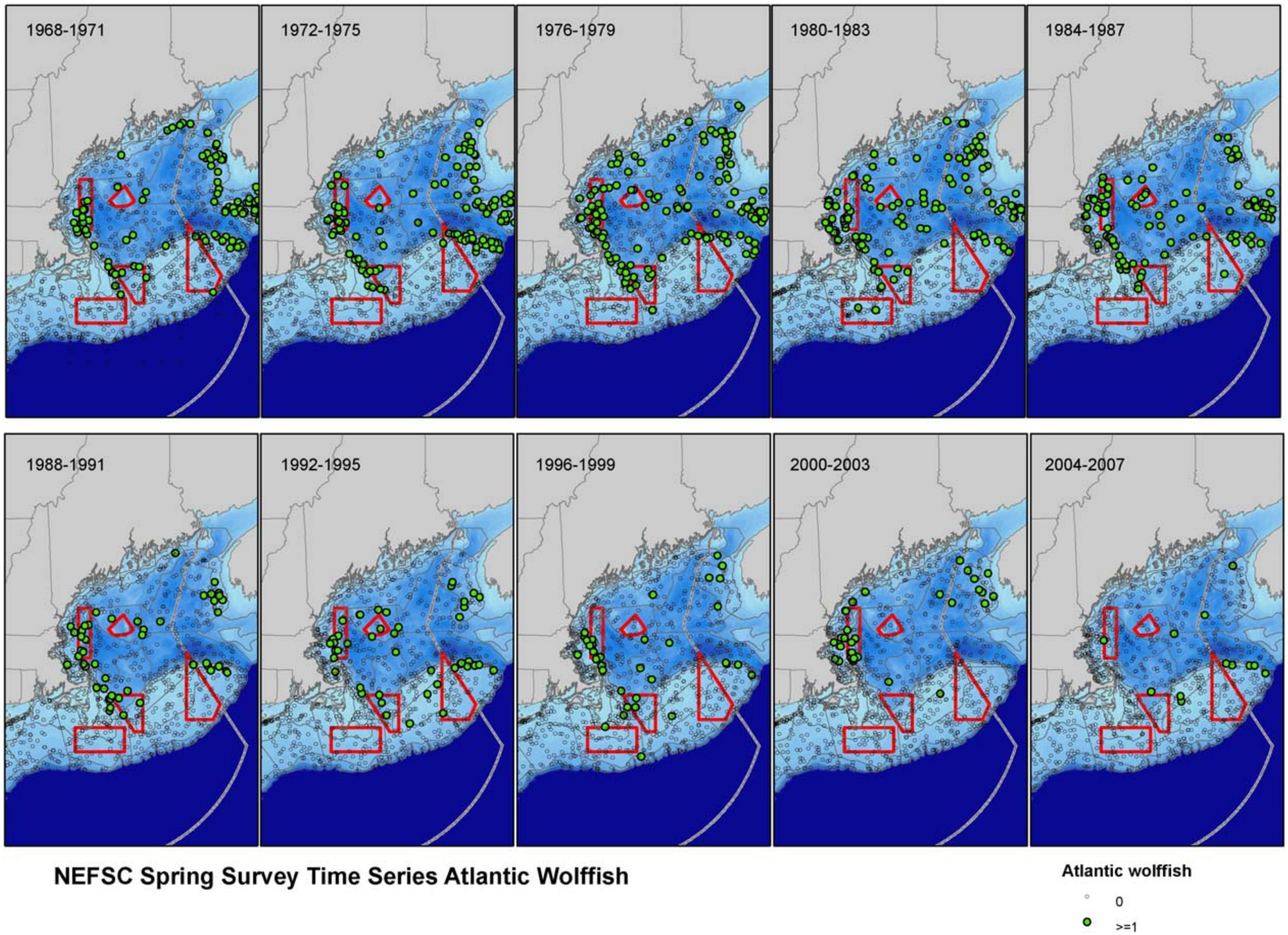


Figure 6.3.2. Positive catches of Atlantic wolffish from NEFSC spring, summer shrimp, fall, and winter trawl surveys, summer sea scallop survey, MADMF spring and fall surveys, Cod IBS, Cooperative Goosefish, and Miscellaneous NEFSC Gear and Food Habits surveys.



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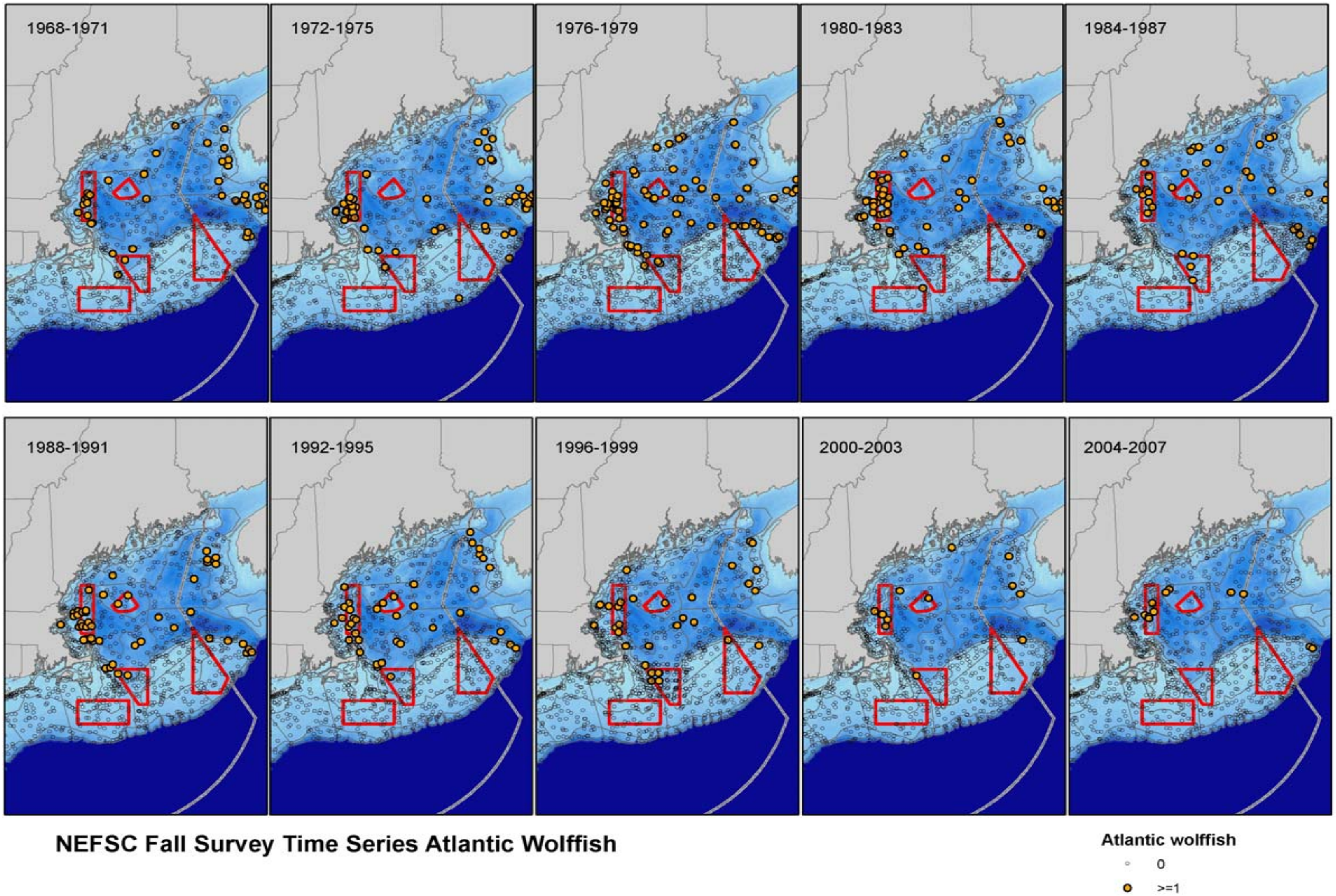


Figure 6.3.3. Positive and zero tows of Atlantic wolffish from NEFSC bottom trawls surveys in spring and fall, 1968-2007. United States and Canadian locations are displayed.

The Massachusetts Division of Marine Fisheries (MADMF) has captured Atlantic wolffish in both spring and fall surveys. MADMF has conducted a stratified random survey of inshore waters from 1978-2008 in May and September (King et al., 2007). The distribution of positive catches over all years is centered around Cape Ann and along outer Cape Cod (Figure 6.3.2). The geographic dispersion of positive tows has contracted since mid 1980's (Figure 6.3.4). Since 1998, all wolffish catches have been in the deeper strata (35, 36) located near Cape Ann (Table 6.3.2, Figure 6.3.4).

Table 6.3.2. Total number of wolffish observed by stratum and year for the MADMF spring and fall surveys.

1978 - 2008 MADMF Spring Survey.

	Region 3		Region 4				Region 5				
Year	**20**	**21**	**27**	**28**	**29**	**30**	**33**	**34**	**35**	**36**	**SUM**
1978	1	0	0	0	1	0	1	3	2	NA	8
1979	3	3	0	0	0	0	1	2	1	0	10
1980	2	2	0	0	0	0	1	1	8	1	15
1981	0	0	0	0	0	0	1	0	1	0	2
1982	0	1	0	0	0	0	1	0	4	1	7
1983	0	0	0	0	0	0	1	0	6	10	17
1984	0	3	1	0	0	0	1	1	1	0	7
1985	0	0	1	0	0	0	0	0	4	0	5
1986	0	1	0	0	0	0	0	2	0	0	3
1987	0	1	0	0	0	1	1	0	0	0	3
1988	1	1	0	0	0	1	0	0	0	0	3
1989	2	3	0	0	0	0	0	1	1	1	8
1990	0	0	0	0	0	0	0	0	1	0	1
1991	0	0	0	0	0	0	1	0	0	0	1
1992	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	1	0	0	1
1994	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	1	0	1
1996	0	0	0	0	0	0	0	0	2	0	2
1997	0	1	0	0	0	0	0	0	1	0	2
1998	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	1	0	1
2001	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	1	0	1
2004	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	1	1	2
2007	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	2	0	2
Sum	9	16	2	0	1	2	9	11	38	14	102
Mean	0.3	0.5	0.1	0.0	0.0	0.1	0.3	0.4	1.2	0.5	3.3
Str-wts	21	26	92	94	105	33	66	53	68	39	597

1978 - 2008 MADMF Fall Survey.

	Region 5				
Year	**33**	**34**	**35**	**36**	**SUM**
1978	0	0	0	0	0
1979	1	1	2	0	4
1980	0	0	3	0	3
1981	0	0	2	0	2
1982	0	1	1	0	2
1983	0	0	2	0	2
1984	0	0	0	0	0
1985	0	0	0	0	0
1986	0	0	0	0	0
1987	0	0	0	0	0
1988	0	0	0	0	0
1989	0	0	0	0	0
1990	0	0	0	0	0
1991	0	0	0	0	0
1992	0	0	1	0	1
1993	0	0	1	0	1
1994	0	0	1	0	1
1995	0	0	0	0	0
1996	0	0	0	0	0
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	0	0	0	0	0
2000	0	0	0	0	0
2001	0	0	0	0	0
2002	0	0	0	0	0
2003	0	0	1	0	1
2004	0	0	0	0	0
2005	0	0	0	0	0
2006	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	0	0	0
Sum	1	2	14	0	17
Mean	0.0	0.1	0.5	0.0	0.5
Str-wts	66	53	68	39	226

Total Number of Wolffish Observed by Stratum and Cruise. Select Strata.

NA indicates that no stations were completed in that year - stratum.

Str-wts represent the area of each stratum in square nautical miles.

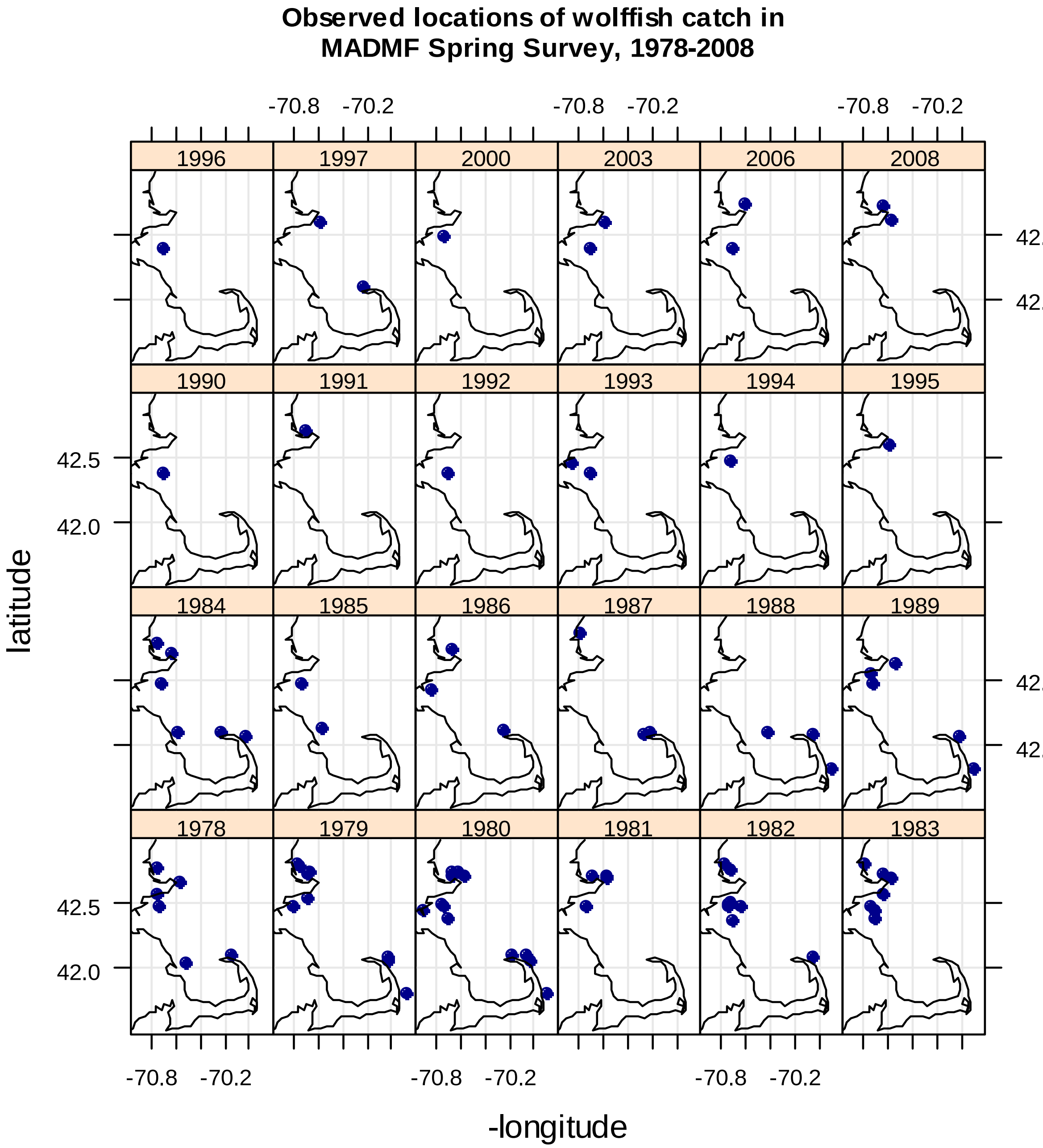


Figure 6.3.4. Location of tows with wolffish in the MADMF spring survey, 1978-2008.

Atlantic wolffish were observed in the Maine/New Hampshire trawl survey in both spring and fall seasons. The survey began in 2000 and is comprised of a combination of fixed and random stations across four depth strata and five regions covering approximately 9,800 km^2 of inshore habitat. Positive wolffish catches in the ME/NH survey are clustered in the southern half of the strata area (Figure 6.3.5). Other Maine surveys have encountered wolffish including the ARGO-ME Trawl Survey and the Maine Habitat Survey (Figure 6.3.5). The ARGO-ME trawl fixed transect survey ran from May 1992 through April of 1994. A total of 4 wolffish were caught in the three years of the survey (Figure 6.3.5). The Maine Department of Marine Resources conducted the ME Habitat Survey, (1996-1998), for three months in the spring and two in the fall in the area from the New Meadows River to Pemaquid Pt. This survey used a fixed station design. A total of nine wolffish were caught in this survey (Figure 6.3.5).

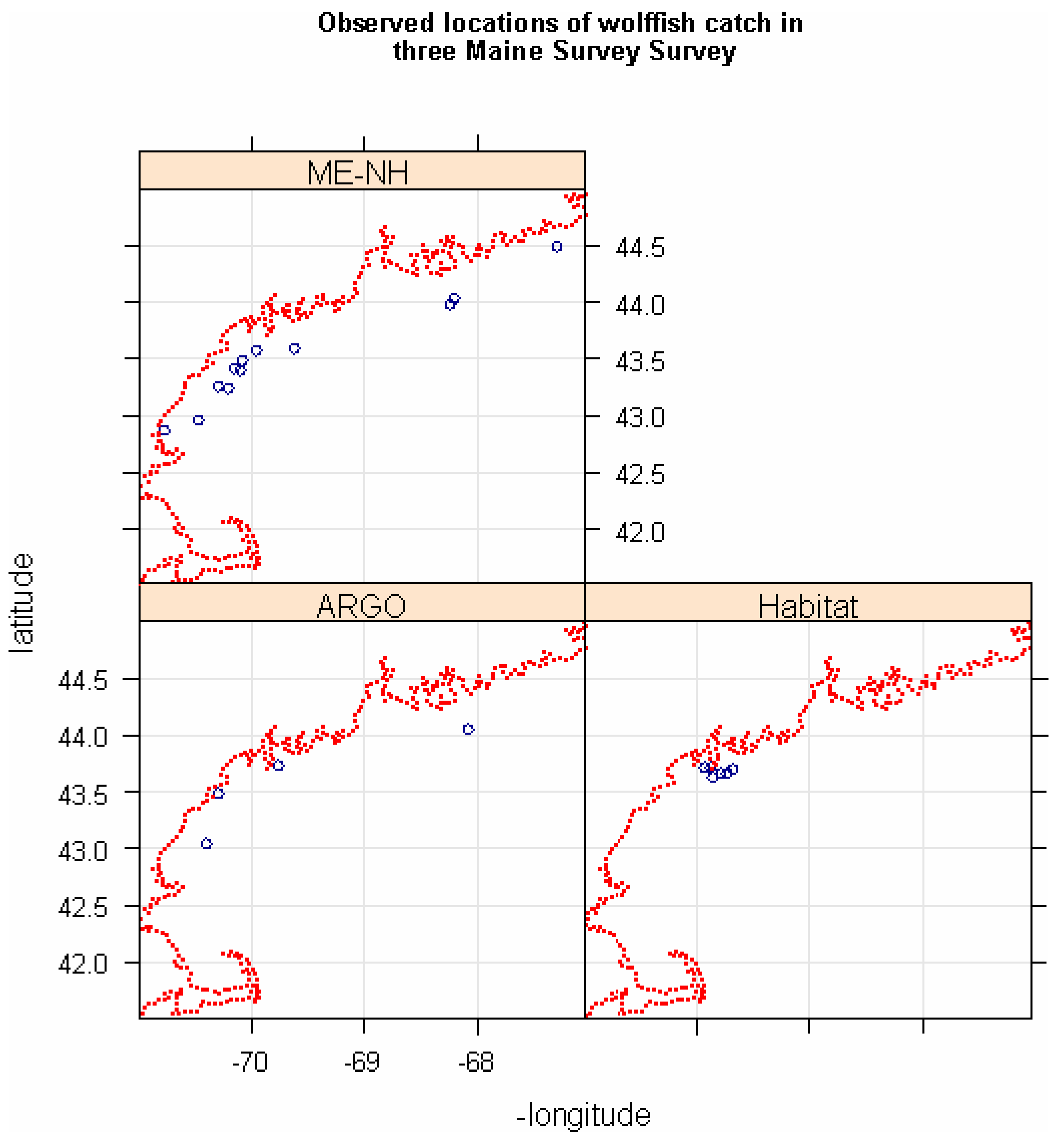


Figure 6.3.5. The geographic distribution of Atlantic wolffish from the Maine trawl surveys.

Industry-based surveys for Gulf of Maine cod (cod IBS) were conducted from 2003 to 2007 during 5 seasonal time periods. Station locations were based on a systematic grid and a stratified random grid design keying on industry hotspots (Hoffman et al, 2007). The cod IBS survey encountered Atlantic wolffish infrequently. Positive wolffish catches were concentrated on Jeffreys Ledge, Platts Bank, and inside the Western GOM Closed Area (Figure 6.3.2). Cooperative goosefish surveys were conducted in 2001 and 2004 (SAW 40). Atlantic wolffish were found rarely during these studies. The distribution of Atlantic wolffish from 14 positive sampling locations were scattered throughout the GOM (Figure 6.3.2).

NEFSC Data

In general Atlantic wolffish are caught infrequently during NEFSC bottom trawl surveys. In spring and fall wolffish are only encountered in 6.2% and 4.1% of all tows conducted in the United States portions of the GOM, GB and SNE regions, respectively (Table 6.3.3). A total of 870 wolffish have been collected during the 1968-2007 spring surveys and 800 in the 1963-2007 fall surveys. Frequency distributions of positive tows by year and season show the majority of wolffish encounters are of a single individual and the frequency of multiple wolffish catches has been reduced over time, most notably in the spring (Figure 6.3.6)

Table 6.3.3. Distribution of the count of Atlantic wolffish captured in NEFSC spring and fall survey tows from the Gulf of Maine, Georges Bank and Southern New England areas (1963-2007).

	NEFSC Spring Bottom Trawl			NEFSC Fall Bottom Trawl		
Count of Wolf / Tow	# of Tows	% Encounter Rate	Sum of Wolffish Caught	# of Tows	% Encounter Rate	Sum of Wolffish Caught
0	6268	93.78%		7323	95.91%	
1	242	3.62%	242	189	2.48%	183
2	93	1.39%	186	49	0.64%	96
3	30	0.45%	90	25	0.33%	75
4	16	0.24%	64	13	0.17%	52
5	5	0.07%	25	4	0.05%	15
6+	27	0.40%	263	32	0.42%	379
total tows	6684		∑ 870	7635		∑ 800
Positive wolffish tows	413			312		
Positive % encounter	6.18%			4.09%		

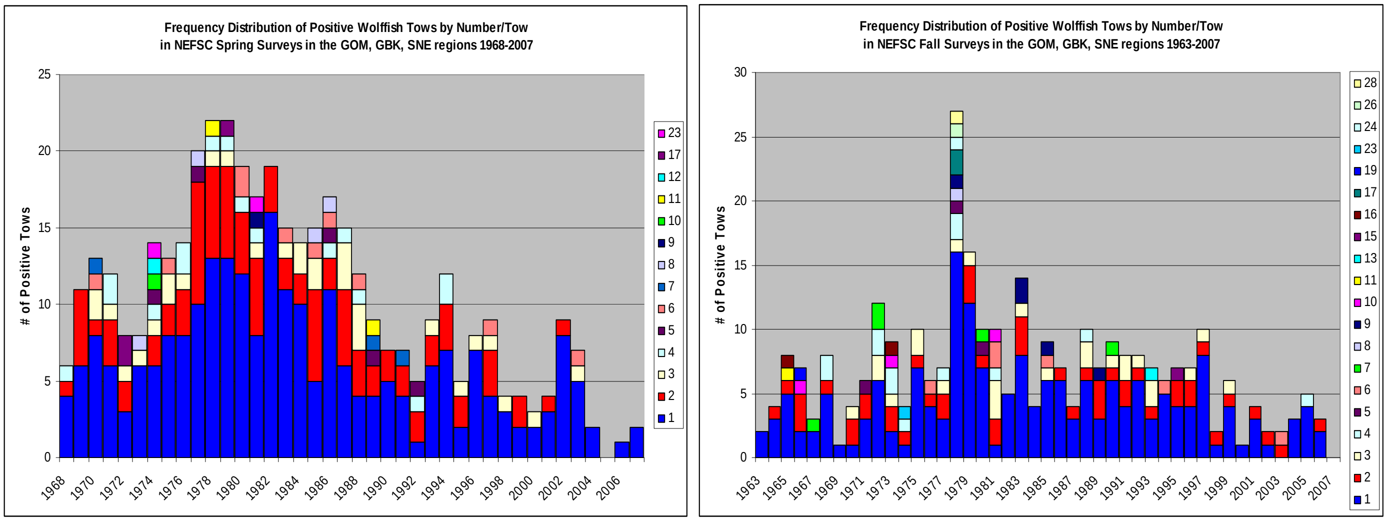


Figure 6.3.6. Frequency distributions of positive wolffish tows by number caught per tow for spring and fall NEFSC bottom trawl surveys.

Strata used in wolffish analyses were limited to offshore areas completely or almost completely within United States waters (Figure 6.3.7). Strata overlapping the United States / Canada border were excluded from this analysis. Due to the relatively sedentary nature of this fish it was believed to have not have affected the indices or overall trends in United States waters. Sampling effort per survey stratum in the Gulf of Maine has remained relatively consistent over most of the time series (Figure 6.3.8). The timing of the surveys in the Gulf of Maine has also been relatively consistent during the spring and fall. The spring bottom trawl survey typically began in late March, median week of year (woy) = 13, mean = 13.76, SD =1.70 and the fall began in early October, median woy = 41, mean = 40.74, SD=1.63. Inshore sampling did not commence until the mid 1970’s and was therefore not used. Higher sampling intensity did occur in portions of the 1970’s and 1980’s in select survey stratum but elevated abundance and biomass are not likely due to increased sampling effort (Figure 6.3.9).

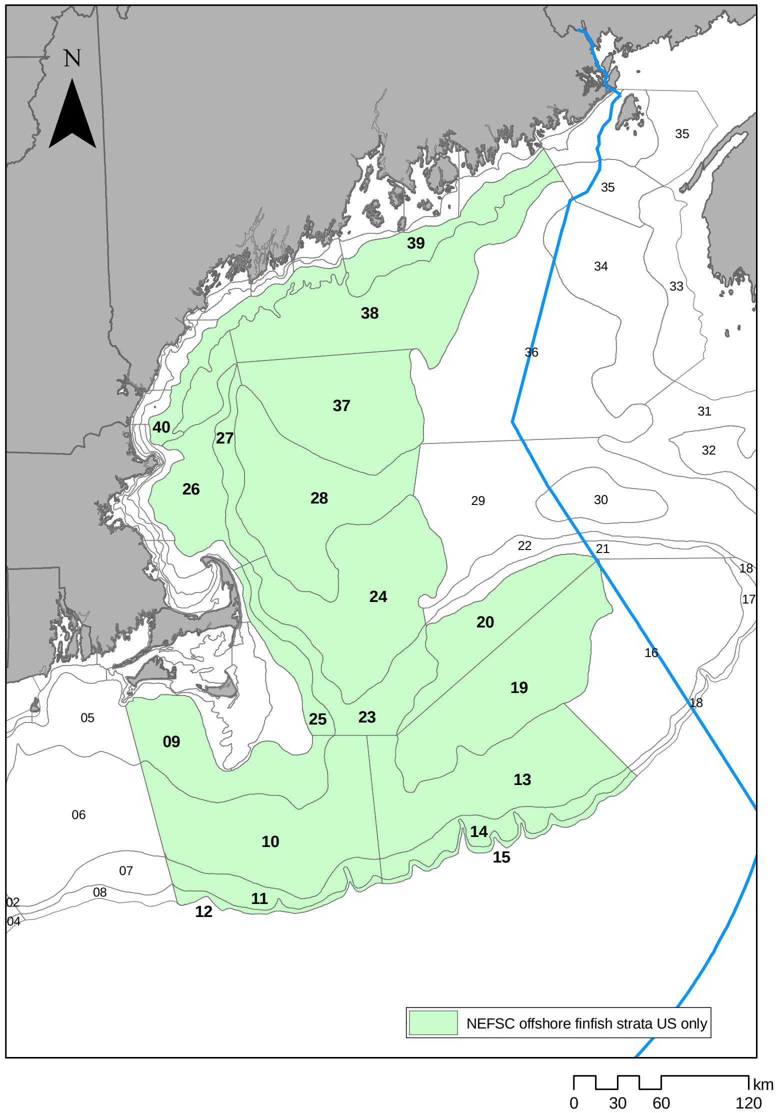


Figure 6.3.7. NEFSC survey strata used for United States portion of Atlantic wolffish biomass and abundance indices.

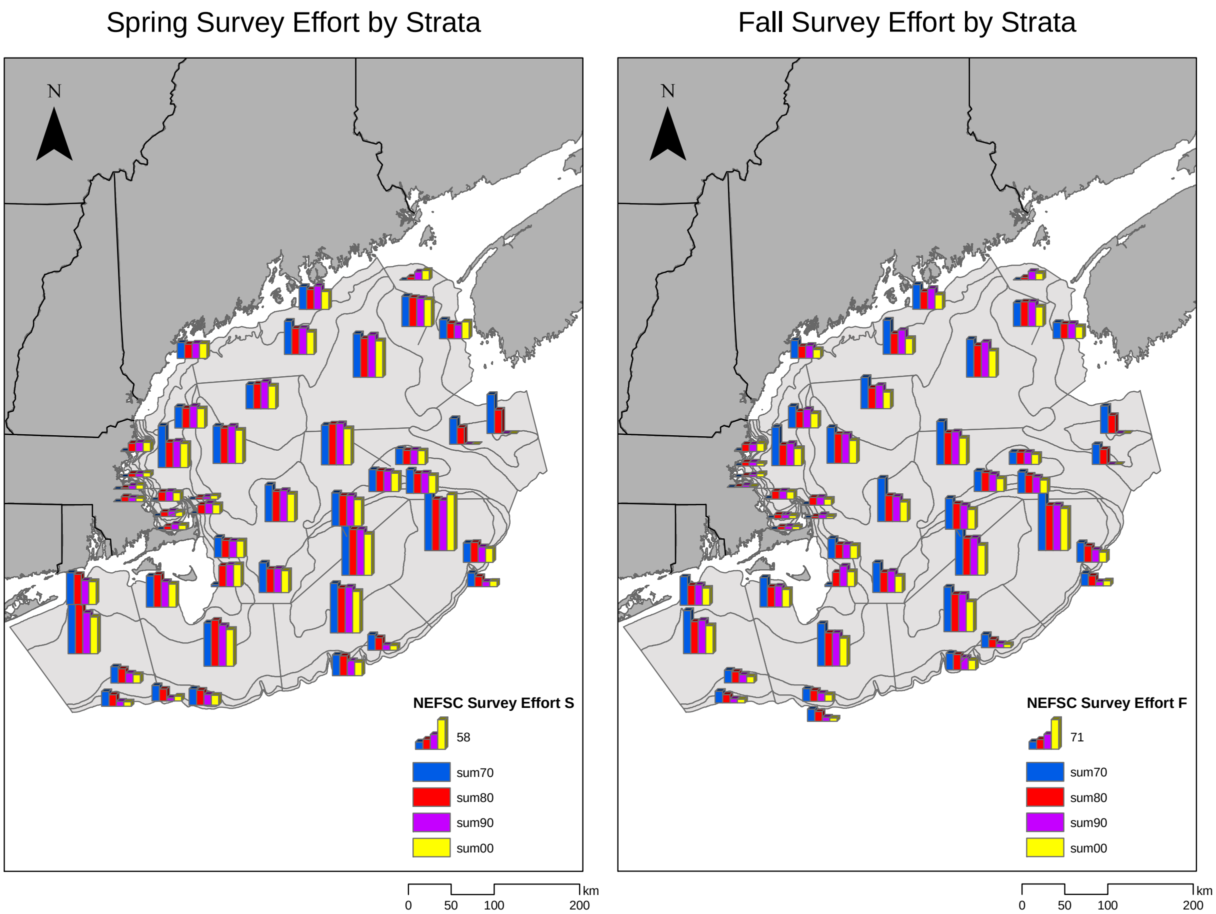


Figure 6.3.8. NEFSC spring and fall bottom trawl survey effort by decade per strata. Bars indicate number of stations per strata.

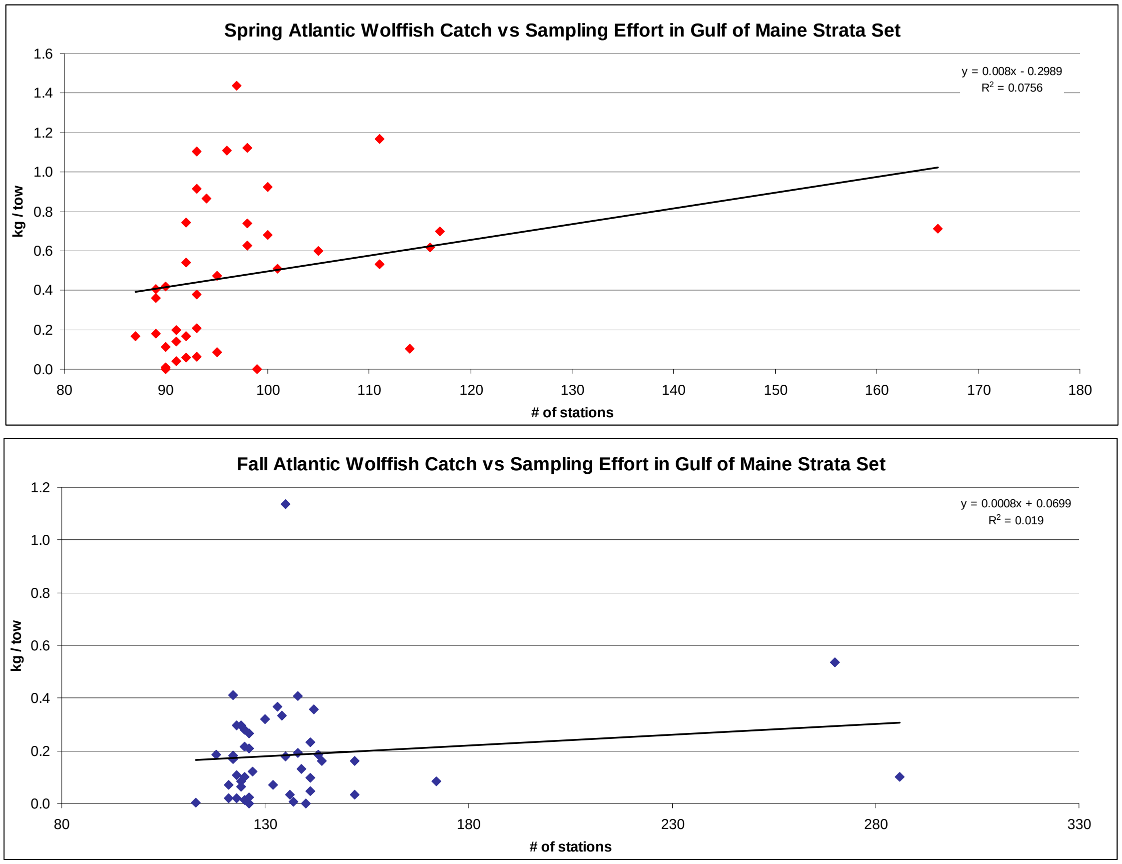
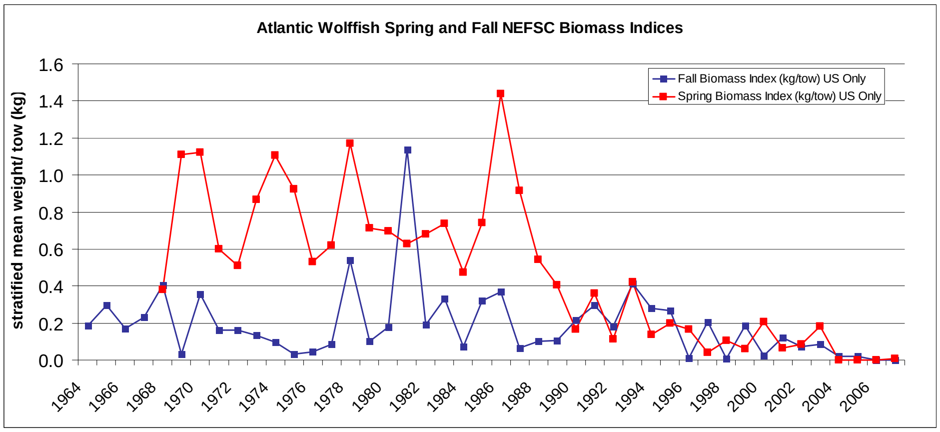


Figure 6.3.9. NEFSC sampling effort and biomass of Atlantic wolffish captured.

The NEFSC spring and fall bottom trawl survey indices show abundance and biomass of Atlantic wolffish has declined over the last two to three decades (Figure 6.3.10, Table 6.3.4). The spring survey typically encounters higher abundance and biomass than the fall. Survey differences may be attributed to wolffish being less available to the sampling gear while nest guarding and teeth shedding in the fall (Colette and Klein-MacPhee, 2002). Inter-annual variability among both surveys is high.



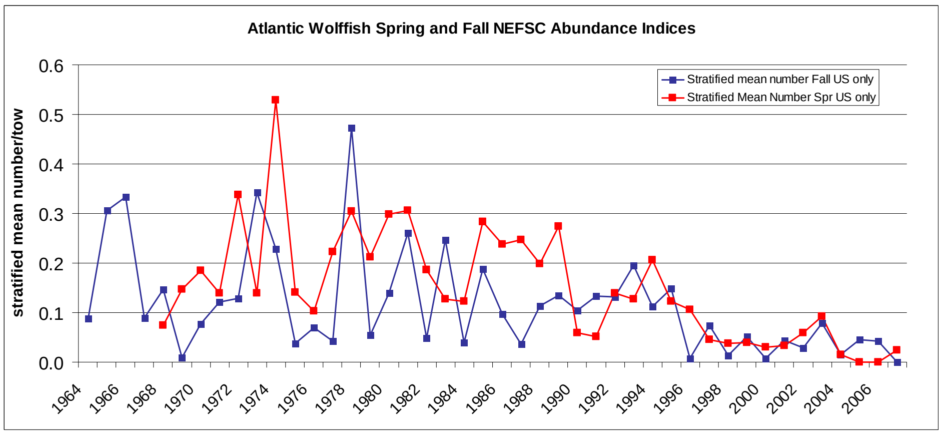
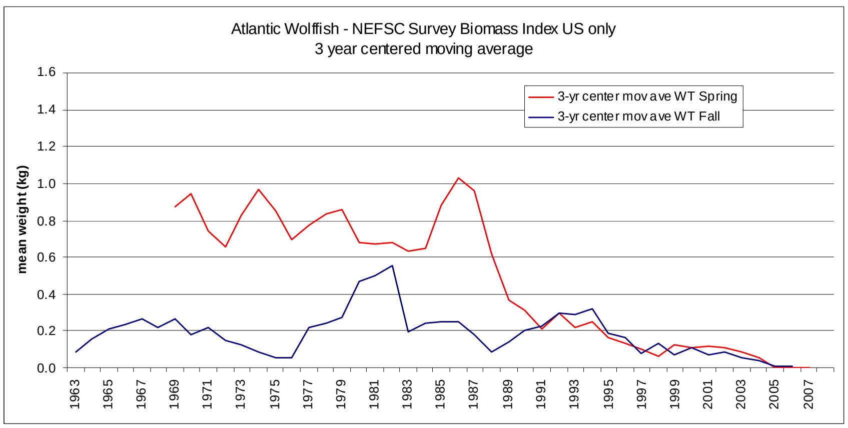


Figure 6.3.10. Spring and fall biomass and abundance indices for United States only survey strata, 1964-2007.

Table 6.3.4. Summary table of NEFSC survey indices.

YEAR	Spring Biomass Index (kg/tow) US Only	Fall Biomass Index (kg/tow) US Only	Spring Abundance Index US Only	Fall Abundance Index US Only
1963	--	0.003	--	0.03
1964	--	0.18	--	0.09
1965	--	0.30	--	0.31
1966	--	0.17	--	0.33
1967	--	0.23	--	0.09
1968	0.38	0.41	0.07	0.15
1969	1.11	0.03	0.15	0.01
1970	1.12	0.36	0.18	0.08
1971	0.60	0.16	0.14	0.12
1972	0.51	0.16	0.34	0.13
1973	0.87	0.13	0.14	0.34
1974	1.11	0.10	0.53	0.23
1975	0.92	0.03	0.14	0.04
1976	0.53	0.05	0.10	0.07
1977	0.62	0.08	0.22	0.04
1978	1.17	0.54	0.30	0.47
1979	0.71	0.10	0.21	0.05
1980	0.70	0.18	0.30	0.14
1981	0.63	1.14	0.31	0.26
1982	0.68	0.19	0.19	0.05
1983	0.74	0.33	0.13	0.25
1984	0.47	0.07	0.12	0.04
1985	0.74	0.32	0.28	0.19
1986	1.44	0.37	0.24	0.10
1987	0.91	0.06	0.25	0.04
1988	0.54	0.10	0.20	0.11
1989	0.40	0.11	0.27	0.14
1990	0.17	0.21	0.06	0.11
1991	0.36	0.30	0.05	0.13
1992	0.11	0.18	0.14	0.13
1993	0.42	0.41	0.13	0.19
1994	0.14	0.28	0.21	0.11
1995	0.20	0.27	0.12	0.15
1996	0.17	0.01	0.11	0.01
1997	0.04	0.21	0.05	0.07
1998	0.10	0.01	0.04	0.01
1999	0.06	0.19	0.04	0.05
2000	0.21	0.03	0.03	0.01
2001	0.06	0.12	0.03	0.04
2002	0.08	0.07	0.06	0.03
2003	0.18	0.08	0.09	0.08
2004	0.00003	0.02	0.02	0.01
2005	0.00	0.02	0.00	0.05
2006	0.00	0.002	0.00	0.04
2007	0.01	0.00	0.02	0.00
2008	--	--	--	--

The spring biomass index averaged 0.786 kg/tow and ranged between 0.38 and 1.44 kg/tow from 1968 to 1988. The resource has steadily declined since the mid to late 1980's the resource has steadily declined. The average spring biomass index for 1989-2007 was 0.143 kg/tow, only 18% of the 1968-1988 average, and ranged from 0.0 kg/tow to 0.42 kg/tow. The fall biomass index shows little trend over time and is relatively low over most of the time series (Figure 6.3.10). Since the mid 1990's wolffish biomass has fluctuated with a slightly declining trend. Abundance indices in both surveys show a decline in stratified mean number per tow since the mid 1990's (Table 6.3.4). Three year centered moving average plots of abundance and biomass removes the inter-annual variability within the indices and depicts an overall declining trend in the resource (Figure 6.3.11).



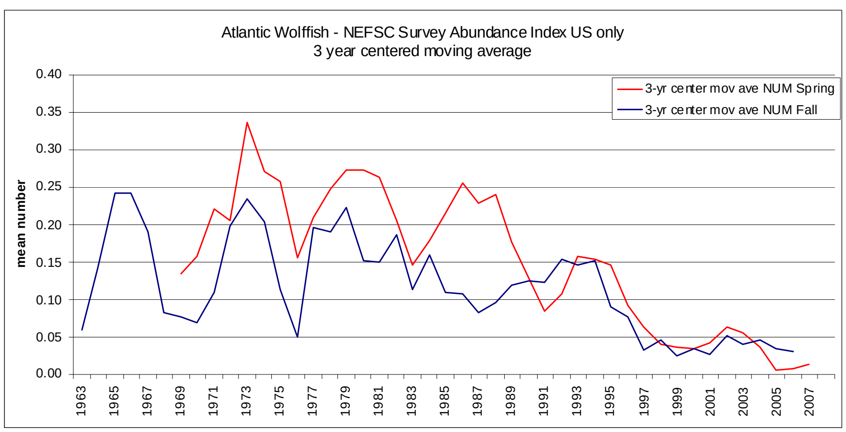
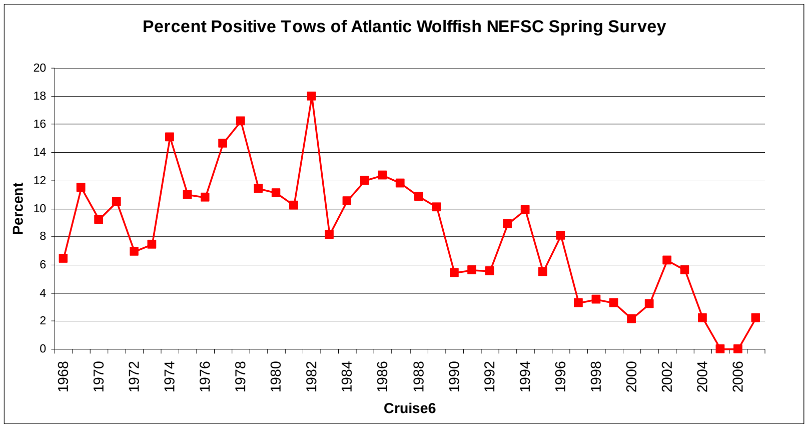


Figure 6.3.11. 3 year moving average for NEFSC spring and fall biomass and abundance indices.

Spring and fall percent positive Atlantic wolffish catch was plotted by year (Figure 6.3.12). This type of index for species rarely captured can be a good indicator of how frequently rare events occur over time. These indices indicate that the number of survey tows catching at least one wolffish has decreased with time in both the spring and fall. The spring index shows an almost continuous declining trend since the late 1970's/early 1980's, averaging around 12% and dropping to approximately 2%. The fall index appears relatively stable from the mid 1960's through the early 1990's, fluctuating around 6 %. It then declines quickly from 1993 to 1996 and becomes relatively stable again near 2 % until 2007 where it reaches zero.



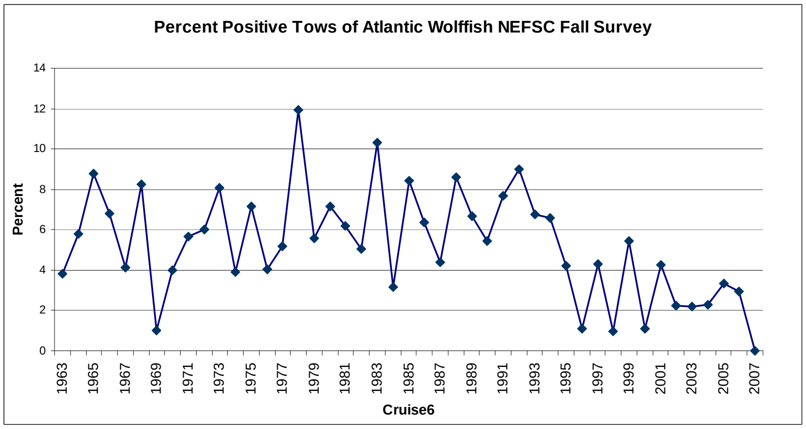


Figure 6.3.12. Percent positive Atlantic wolffish catches by year from NEFSC spring and fall bottom trawl surveys.

Atlantic wolffish are caught less frequently and in a more condensed area in recent years as compared to earlier decades during the NEFSC spring and fall bottom trawl surveys. Data were grouped by decade and survey catch in numbers were displayed using GIS (Figure 6.3.13). The spring survey shows high catch along Jeffreys Ledge, Stellwagen Bank National Marine Sanctuary and off outer Cape Cod through the Great South Channel during the 1970's and 1980's. Catches in the 1990's extend across a similar area but appear with less abundance and frequency. Highest catches during the 2000's are limited to Stellwagen Bank region. A similar pattern emerges from fall survey catches and the resource appears to be more concentrated within the Jeffreys Ledge and Stellwagen Bank regions. During the 1990's and 2000's catches are smaller and appear less frequently in the fall.

The Review Panel for the Northeast Data Poor Working Group 2008 concluded that there is a degree of uncertainty in which surveys may provide a reliable index of the Atlantic wolffish population (Miller et al, 2008). The main concerns about the survey index include the availability of fish to survey gears may not be proportionally related to abundance, wolffish may exhibit wide changes in distribution as they are at the southern extent of the range, and given concerns over availability and distribution, zero catches in resource surveys are difficult to interpret (Miller et al, 2008).

MADMF Surveys

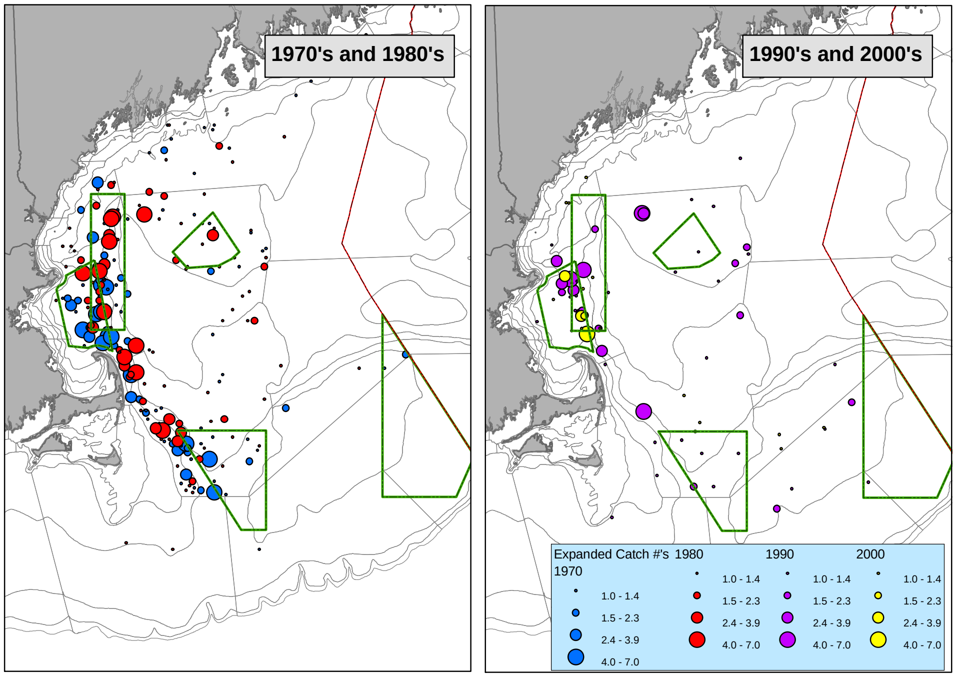
Catches of Atlantic wolffish occur infrequently in the MADMF trawl surveys. A total of 102 individual wolffish were captured in the spring survey (mean=3.3 per cruise, range=0-17). Catches in the spring are found in the deeper strata (20, 21, 27, 29, 30, 33-36) of regions 3, 4, and 5. The distribution of counts of wolffish captured per tow is shown in Table 6.3.5. Nearly 76% of the tows with wolffish had 1 individual and 92% had 2 individuals or less. The highest catch observation (10 wolffish) is based on expansion of a short tow containing 5 individuals. This tow was shortened because of approaching hard bottom and the net contained a large boulder, suggesting that this tow had been close to hard bottom.

Catches of wolffish in the fall survey occur less frequently than in the spring survey (Table 6.3.6): A total of 17 individuals in the fall survey (mean=0.6 per cruise, range=0-4) were captured from 1978-2008. Wolffish have only been caught in the deeper strata (33-36) of Region 5 (Massachusetts Bay and north) in the fall.

A time series of percentage of total tows containing wolffish is shown for the spring and fall surveys in Figure 6.3.14. For the spring series, the percent occurrence was based on tows in strata 20, 21, 27-30, 33-36. The average effort in this strata set was 33.6 tows per year (range: 24-40). The percent occurrence shows a fairly steady decline from 27% in 1983 to around 3% in 1990. Percent occurrence has fluctuated without trend from 0-6% since 1990. A similar analysis was conducted on the fall survey for strata 33-36. The average effort in this strata set was 12.8 tows per year (range: 7-16). Although present in just 9 of 31 fall surveys, wolffish presence/absence has been observed in non-random patterns over the fall timeseries. Wolffish were recorded in 1979-1983, again from 1992-1994 and the last wolffish observation on the fall survey was in 2003. Percent occurrence was higher in the 1979-1983 time period as the result of an additional 2-3 positive tows each survey. Wolffish have only been captured on four tows since 1983. No fall survey has observed more than a single fish at a single station since 1983.

The timeseries of relative abundance (stratified mean number per tow) for the spring and fall surveys are shown in Figure 6.3.15. The spring survey generally shows a steep decline during the early part of the timeseries with relative abundance fluctuating near record lows since 1990. The overall pattern of higher relative abundance in the early part of the series followed by lower abundance, and more years of zero catch, is also seen in the fall survey. The trends in relative abundance and percent occurrence in the spring survey is highly correlated (r=0.87). This is expected given that most of the catch in a tow consists of 1 or 2 wolffish.

Spring NEFSC Survey Catches by Decades - US Strata Only



Fall NEFSC Survey Catches by Decades - US Strata Only

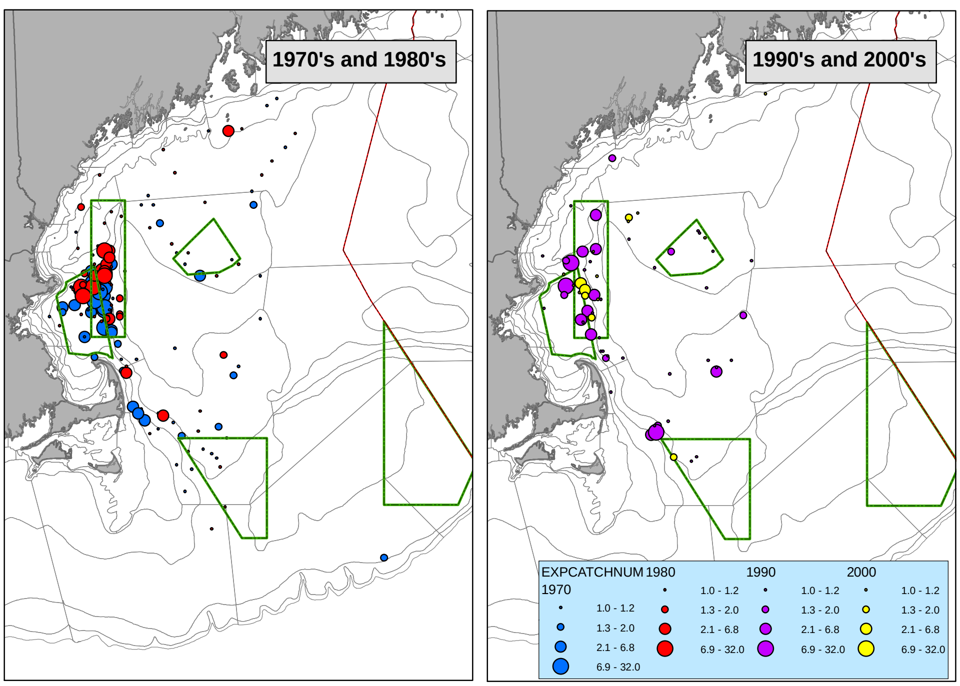


Figure 6.3.13. NEFSC spring and fall survey catches by decade.

Table 6.3.5. Distribution of the count of wolffish captured in MA DMF spring survey tows (1978-2008). *The observation with 10 wolffish is based on an expansion of a short tow (13 minutes) containing 5 individuals to standard duration (20 minutes).

Count of Wolffish / Tow	# tows	percent of all wolffish tows	% of total wolffish
1	53	76	52.0
2	11	16	21.6
3	3	4	9.0
4	2	3	8.0
10*	1	1	10.0

Table 6.3.6. Distribution of the count of wolffish capture in MA DMF fall survey tows (1978-2008).

Count in tows	# tows	percent of all tows	% of total wolffish
1	13	86.7	76.4
2	2	13.3	23.5

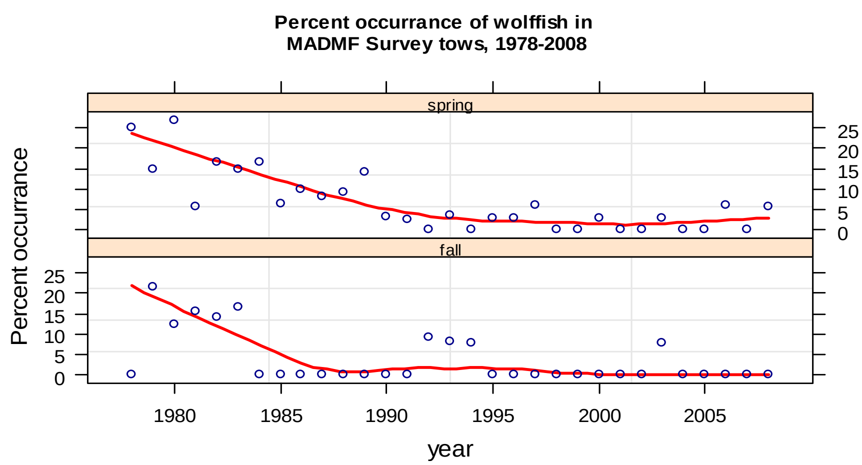


Figure 6.3.14. Timeseries of percent occurrence of wolffish captured in MA DMF survey tows. Red line is loess fit with span=0.5 and degree=1. Spring series for tows include strata 20, 21, 27, 29-30, 33-36. Fall series for tows in strata 33-36.

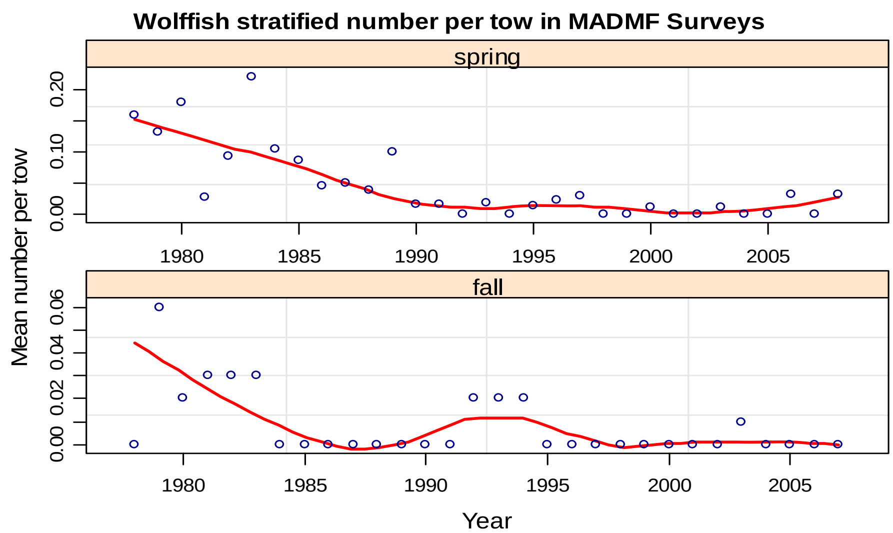


Figure 6.3.15. Trends in stratified mean number per tow for wolffish taken in the MA DMF spring and autumn bottom trawl surveys. Red line is loess fit with span=0.5 and degree=2. ME/NH Survey Data

Percent occurrence of wolffish in the ME/NH inshore trawl surveys for spring and fall seasons is shown in Table 6.3.7. There is an increasing trend in wolffish catches in the spring survey over the time-series and few catches in the fall. The ARGO-ME survey caught few wolffish with higher occurrence during July (Table 6.3.8). The Maine Habitat survey also caught few Atlantic wolffish with the greatest occurrence in June (Table 6.3.9).

Table 6.3.7. Number of tows and percent occurrence of wolffish in ME/NH Inshore Trawl Survey

	YEAR	NO. TOWS	% OCCURRENCE	NO. FISH
FALL	2000	78	0.0	0
	2001	75	0.0	0
	2002	81	0.0	0
	2003	78	0.0	0
	2004	87	1.1	1
	2005	54	0.0	0
	2006	85	2.4	2
	2007	87	0.0	0
	2008	79	0.0	0
SPRING	2001	111	0.0	0
	2002	94	0.0	0
	2003	101	0.0	0
	2004	103	0.0	0
	2005	104	1.8	2
	2006	109	1.8	3
	2007	108	0.9	2
	2008	112	3.6	4

Table 6.3.8. Number of tows and percent occurrence of wolffish in the ARGO-ME survey

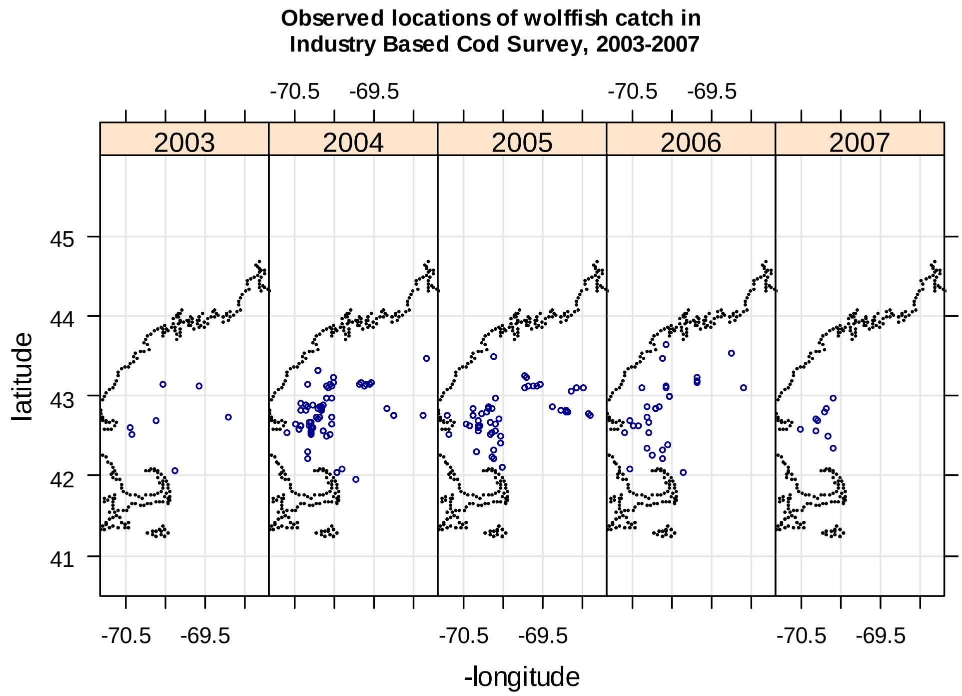
	Number of survey tows				Percent occurrance.		
MONTH	1992	1993	1994	Total	1992	1993	1994
01		41	12	53		0	0
02		7	12	19		0	8.3
03		69	12	81		0	0
04		23	12	35		0	0
05	69			69	0		
06	18			18	0		
07	24	12		36	4.2	8.3	
08		12		12		0	
09	60	12		72	1.6	0	
10	17	12		29	0	0	
12	10			10	0		
Total	198	188	48	434			

Table 6.3.9. Number of tows and percent occurrence of wolffish in the Habitat survey

Year	Month	Tows	Percent occurrance.	No. Fish
1996	October	33	0	0
	November	41	0	0
1997	March	25	0	0
	April	23	0	0
	May	48	0	0
	June	83	4.8	4
1998	March	10	0	0
	April	43	0	0
	May	52	0	0
	June	53	7.5	5
	September	36	0	0

<u>Cod Industry Based Survey Data</u>

Only total catch in weight for wolffish was recorded for completed tows in the cod IBS. Wolffish were caught in 6.8% (169 / 2476) of the cod IBS tows for all years combined. Generally, few individuals were caught in each tow as evidenced by the low catch weight. The median weight of wolffish catch was 5.1 kilograms (IQR: 2.9 to 8.0). The maximum and minimum weight caught was 0.1 and 77 kilograms, respectively. The catch in weight distribution of tows with wolffish by years is shown in Figure 6.3.16. Overall, the distribution of catch in weight seemed stable throughout the survey. Most wolffish were caught in the southwest portion of the Gulf of Maine (Figure 6.3.16).



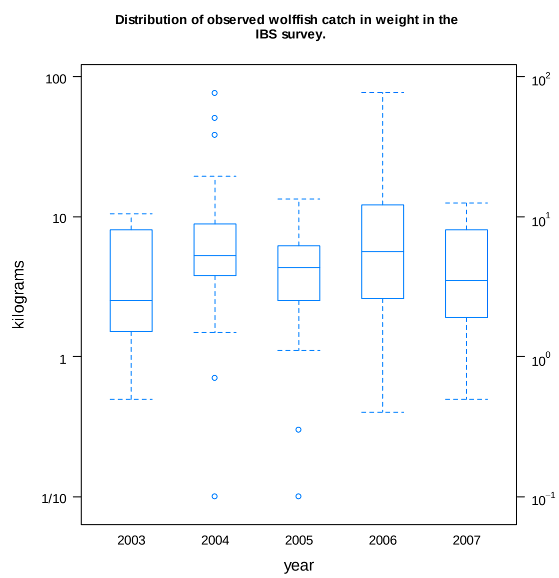


Figure 6.3.16. Top panel: locations of tows with wolffish catch in the cod IBS by year. Note that sampling in 2003 was confined to November-December and sampling in 2007 was confined to January-February and February-March. Bottom panel: boxplots of catch weight in tows by year. Note semi-logarithmic scale.

A summary of presence/absence of wolffish in the cod IBS tows are shown in Table 6.3.10. We examined the proportion of positive occurrence by survey period (Figure 6.3.17). Overall, proportion of positive occurrence was lowest in the January 1–February 12 and February 13-March 17 periods, and highest in April 20 –May 31. We modeled the proportion of positive occurrences as a function of a survey period using a logistic regression with period as a factor. Note that several small auxiliary cruises specially conducted for cod fish in the Massachusetts

Cod Conservation Zone during November-January were not included in the analysis. The overall model was highly significant ($P<0.001$). The log odds ratio estimates for March-April, April-May and November-December were significantly different from 0 (proportions compared to proportion in the January 1-February 12 reference period). The log odds ratio for February-March was not significantly different from 0. The predicted proportion by period, log odds ratio and odds ratios (compared with the January 1 -February 12 reference period) are shown in Table 6.3.11. Overall, the proportion occurrence increases through the spring and appears to be lowest in January-February period. Unfortunately, the survey was not conducted during the summer and early fall months. The probability of catching a wolffish in April 20-May 31 period is nearly 5 times higher than January 1-February 12 period.

Table 6.3.10. Summary of presence and absence of wolffish in tows of the cod IBS by cruise, year and period. Note that special cruises conducted for Massachusetts Division of Marine Fisheries Cod Conservation Zone not included.

Cruise	Year	Period	number of positive tows	number of negative tows	Number of total tows	Proportion positive
2350	2003	Nov 1 –Dec 31	7	114	121	0.058
2455	2004	Jan 1 –Feb 12	7	134	141	0.050
2456	2004	Feb13-Mar 17	5	144	149	0.034
2457	2004	Mar 18 –April 19	15	165	180	0.083
2458	2004	April 20 –May 31	33	144	177	0.186
2465	2004	Nov 1 –Dec 31	11	155	166	0.066
2561	2005	Jan 1 –Feb 12	4	155	159	0.025
2562	2005	Feb13-Mar 17	6	174	180	0.033
2563	2005	Mar 18 –April 19	15	162	177	0.085
2564	2005	April 20 –May 31	17	164	181	0.094
2565	2005	Nov 1 –Dec 31	10	154	164	0.061
2664	2006	April 20 –May 31	22	152	174	0.126
2665	2006	Nov 1 – Dec 31	8	155	163	0.049
2761	2007	Jan 1 –Feb 12	4	163	167	0.024
2762	2007	Feb13 - Mar 17	5	172	177	0.028
Total			169	2307	2476	0.068

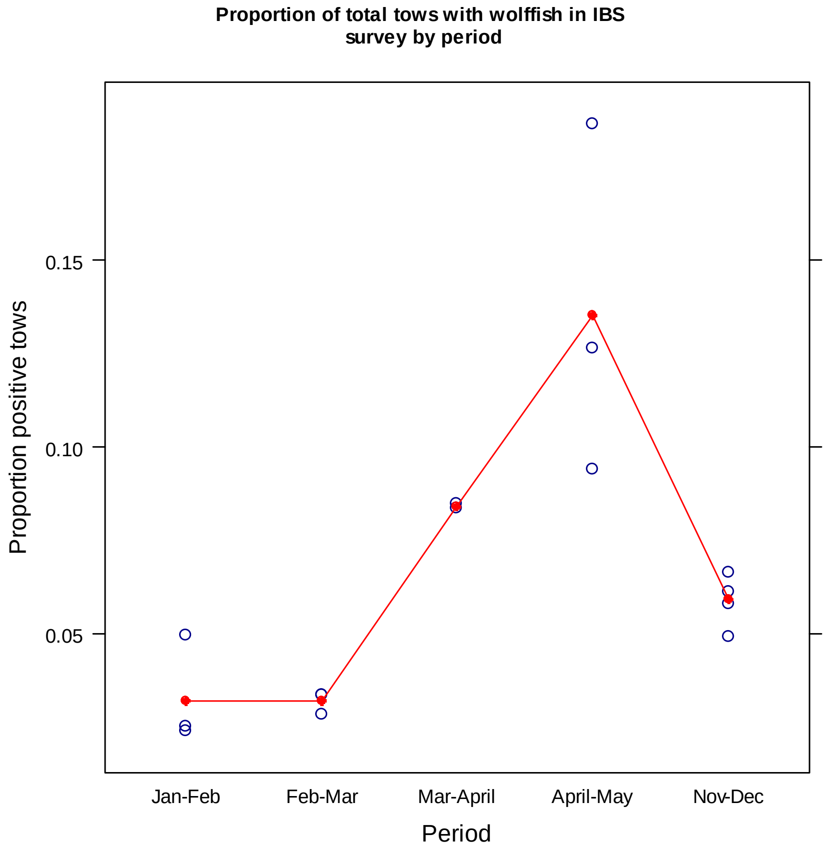


Figure 6.3.17. Observed proportion occurrence of wolffish in cod IBS tows by time period (blue dots). Red dots are fitted values from a GLM of proportion observed against time period.

Table 6.3.11. Predicted proportion of positive occurrences from the logistic regression of proportion occurrence on period. Odds ratio compare each period with the January-February period.

Period	Predicted proportion	Log odds ratio (probability)	Odds ratio compared to Jan-February
Jan -Feb	0.033		
Feb-Mar	0.033	-0.02 (P=0.96)	0.98
Mar-April	0.092	1.02 (P<0.01)	2.76
April-May	0.157	1.55 (P<0.001)	4.72
Nov-Dec	0.062	0.63 (P<0.05)	1.88

SMAST Study Fleet Data

The SMAST Study Fleet project collects catch information from a large mesh otter trawl fleet that targets groundfish and fishes primarily in the Georges Bank and Southern New England area. Data are self-reported using standardized methodology. The spatial-temporal distribution of the fleet shifts in response to distribution of groundfish species, market forces, and regulations. Several large groundfish regulatory actions have occurred during the study, including Amendment 13, Framework 42, and two interim actions. Wolffish are not targeted by the vessels in the Study Fleet, but occur as incidental catch in the groundfish fishery.

The Study Fleet project commenced in November of 2000 as a collaboration with industry for the collection of trawl catch and environmental data suitable for use by researchers and fishery managers. See Rountree et al. (2005) for details on the study and protocols. The project was initially established as a cooperative effort between the University and the Massachusetts Fisheries Recovery Commission. The project has continued through the Massachusetts Marine Fisheries Institute.

We used data collected from 2000-2004 and 2006-2008, but the number of hauls varies greatly by month and year (Table 6.3.12). The inconsistency in reported hauls by month across years makes interpretation of annual trends difficult because availability of wolffish to the otter trawl fleet varies seasonally. Additionally, the analyses are based haul level information, which are not independent, but occur as clusters within trips. Hauls within trips have spatial-temporal correlations relative to species composition, catch amounts and size composition. Only total weight per haul was recorded for wolffish.

Table 6.3.12. The number of reported hauls in SMAST Study Fleet by month and year.

	YEAR								
Month	2000	2001	2002	2003	2004	2006	2007	2008	Totals
January	0	353	0	358	209	0	299	0	1219
February	0	363	0	141	382	0	257	0	1143
March	0	763	0	374	195	0	208	22	1562
April	0	932	0	104	152	279	75	0	1542
May	0	583	0	0	43	179	0	0	805
June	0	339	0	131	183	685	0	42	1380
July	0	189	0	78	150	339	0	40	796
August	0	342	83	107	0	131	67	29	759
September	0	458	79	74	0	124	0	0	735
October	0	40	155	189	0	293	0	0	677
November	38	0	220	132	0	609	0	0	999
December	130	0	140	192	0	550	0	0	1012
Total	168	4362	677	1880	1314	3189	906	133	12629

The count of hauls with wolffish and the proportion of total hauls with wolffish by year and month is shown in Tables 6.3.13 and 6.3.14. Overall 498 hauls contained wolffish. The proportion of hauls with wolffish shows a strong seasonal pattern with low proportions in winter, early spring and late fall and higher proportions in late spring and summer. Overall, 4% of hauls (498 of 12,629) contain wolffish. This is similar to the overall rate (4.6% with 3,948 positive tows out of 85,917 total tows) for bottom trawl gear encountered in the NEFSC observer program for the period covering 1998-2008 (Van Atten, per com).

Table 6.3.13. The number of hauls with wolffish in the SMAST Study Fleet by month and year. Empty cells indicate no reported hauls for month-year combination.

	YEAR								
Month	2000	2001	2002	2003	2004	2006	2007	2008	totals
January		25		11	6		1		43
February		11		4	6		1		22
March		22		7	2		0	0	31
April		110		2	3	6	1		122
May		47			0	3	0		50
June		0		26	1	39	0	0	66
July		6		32	8	4	0	2	52
August		12	4	6		2	2	0	26
September		20	7	2		0	0		29
October		0	3	6		2	0		11
November	0		5	5		0	0		10
December	11		3	17		5	0		36
Total	11	253	22	118	26	61	5	2	498

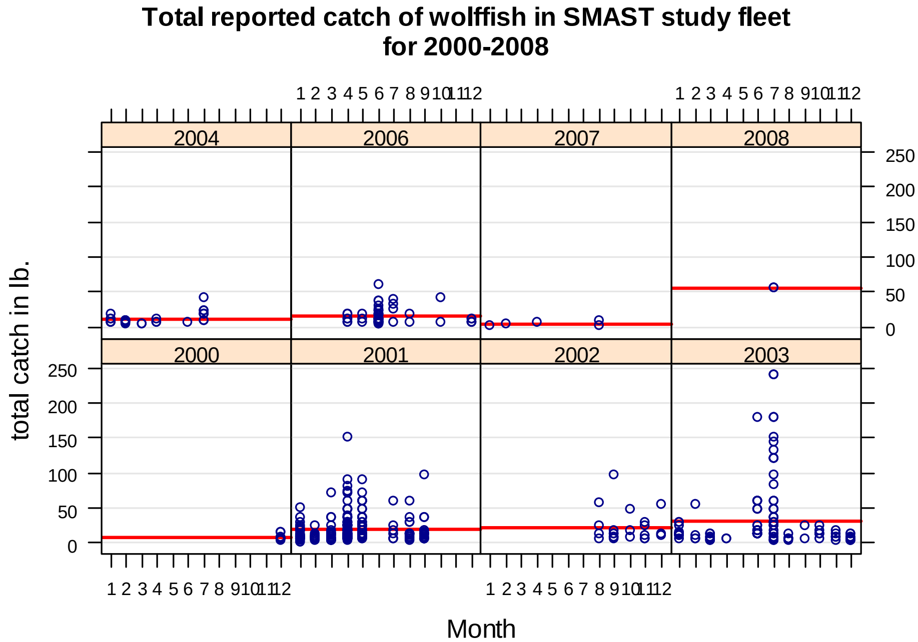
Table 6.3.14. Proportion of total hauls with wolffish from SMAST Study Fleet. Empty cells indicate no reported hauls for month-year combination.

	YEAR								
Month	2000	2001	2002	2003	2004	2006	2007	2008	totals
January		0.07		0.03	0.03		0.00		0.04
February		0.03		0.03	0.02		0.00		0.02
March		0.03		0.02	0.01		0.00	0.00	0.02
April		0.12		0.02	0.02	0.02	0.01		0.08
May		0.08			0.00	0.02			0.06
June		0.00		0.20	0.01	0.06		0.00	0.05
July		0.03		0.41	0.05	0.01		0.05	0.07
August		0.04	0.05	0.06		0.02	0.03	0.00	0.03
September		0.04	0.09	0.03		0.00			0.04
October		0.00	0.02	0.03		0.01			0.02
November	0.00		0.02	0.04		0.00			0.01
December	0.08		0.02	0.09		0.01			0.04
Total	0.07	0.06	0.03	0.06	0.02	0.02	0.01	0.02	0.04

Overall, the amount of wolffish caught per haul is relatively low with a median catch weight of 12 lbs (Table 5.3.15). This suggests that the number of wolffish per haul is low, mostly representing one to three animals. The distribution of weight in haul by month and year is shown in Figure 6.3.18. Again, slightly heavier catches occur in late spring and early summer than fall and winter. The same pattern is seen in the boxplots of catch weight by month (all years combined). Comparison from year to year is more difficult because of the low number of hauls in 2000, 2002, 2004, and 2007-2008 and the high variation in seasonal coverage (Table 6.3.12).

Table 6.3.15. Summary of the distribution of catch in weight (lb.) of wolffish in hauls for all years and month combined.

Year	Min.	1st Quantile	Median	Mean	3rd Quantile	95th Quantile	Maximum	Total count wolffish
2000	3.0	5.0	5.0	7.0	6.5	15.0	15.0	11
2001	2.0	7.2	12.0	19.5	24.0	60.0	150.0	253
2002	6.0	8.4	12.0	22.2	24.0	57.8	96.0	22
2003	2.4	6.0	12.0	32.4	30.0	144.9	240.0	118
2004	4.8	6.0	9.0	11.8	16.0	24.0	42.0	26
2006	3.6	6.0	12.0	14.8	18.0	37.2	60.0	61
2007	1.0	3.0	3.6	4.3	6.0	7.6	8.0	5
2008	55.2	55.2	55.2	55.2	55.2	55.2	55.2	2
All combined	1.0	6.0	12.0	21.43	24.0	60.0	240.0	498.0



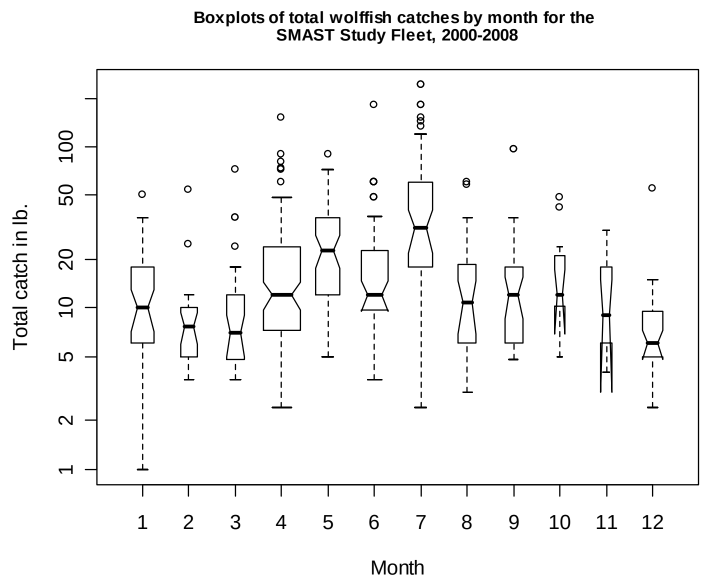


Figure 6.3.18. Top panel: distribution of wolffish catches in the SMAST Study Fleet by month and year. Redline is mean catch for year. Note that sampling by month is highly variable among years. Bottom panel: Boxplots of wolffish catches in SMAST Study Fleet by month (all years pooled). Box width is proportional to square root of the number of observations. Notches indicate approximate 95% confidence limits for differences between medians. Note y-scale is semi-logarithmic scale in bottom panel.

The location of all reported hauls and hauls with wolffish is shown in Figure 6.3.19. Despite the study fleet's limitation of characterizing the spatial-temporal patterns of the large mesh fleet, the data indicate that wolffish reside in the Georges Bank area and occur alongside eastern shore of Cape Cod, in the Great South Channel, along the edge of Close Area 1 and along the edge of Georges Bank. In years with large sample sizes that occur during late spring/ early summer, the geographic distribution appears contiguous across these areas at the temporal scale of the year. Few hauls with wolffish (5/ 906) were reported in 2007. Although most hauls in 2007 were in January-March, the percent occurrence appears lower during these months compared with other years.

In addition to SMAST Study Fleet data, fishery observers collect length samples at sea opportunistically providing information on commercial catch and the size structure of the population. Observer length data have been collected since 1989. Sample sizes from early in the time series are low but have exceeded 100 samples per year during 2003-2007 (Table 6.3.16). Median length has been variable over time but increased slightly during the 2003-2007 period indicating that larger fish are being harvested (Figure 6.3.20). Differences in length composition by commercial gear types were also plotted (Figure 6.3.21). Sample sizes are small in all gears except for otter trawl and gillnet, where size distributions and median values are similar (Table 6.3.17).

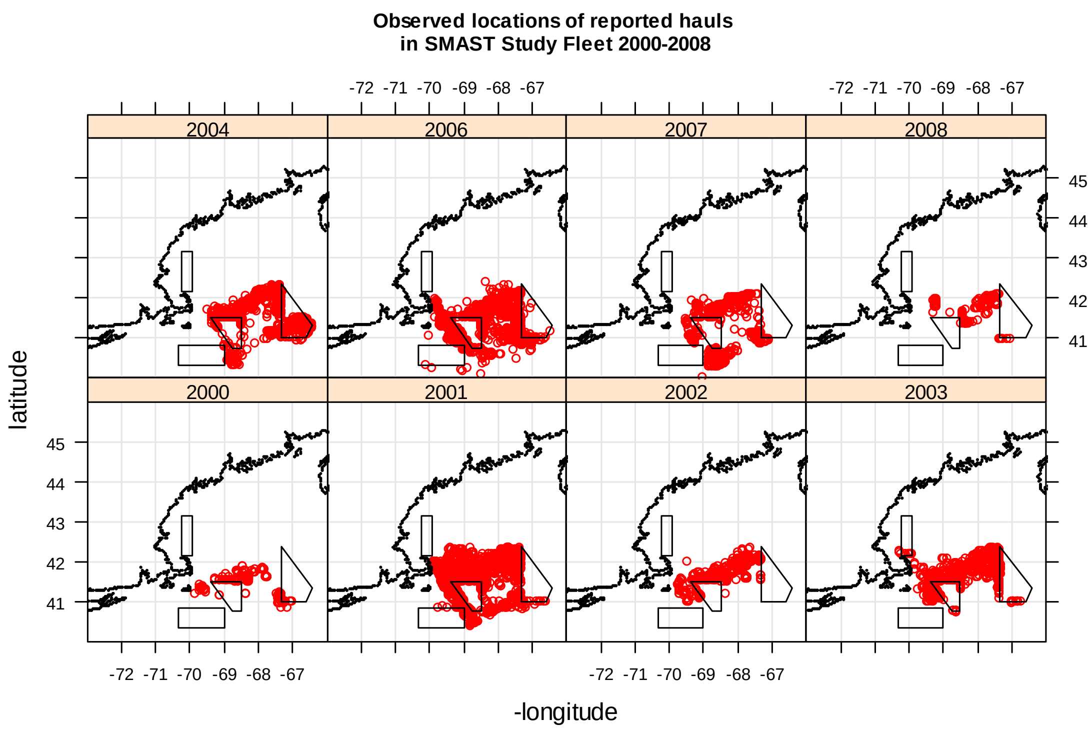


Figure 6.3.19 (continued)

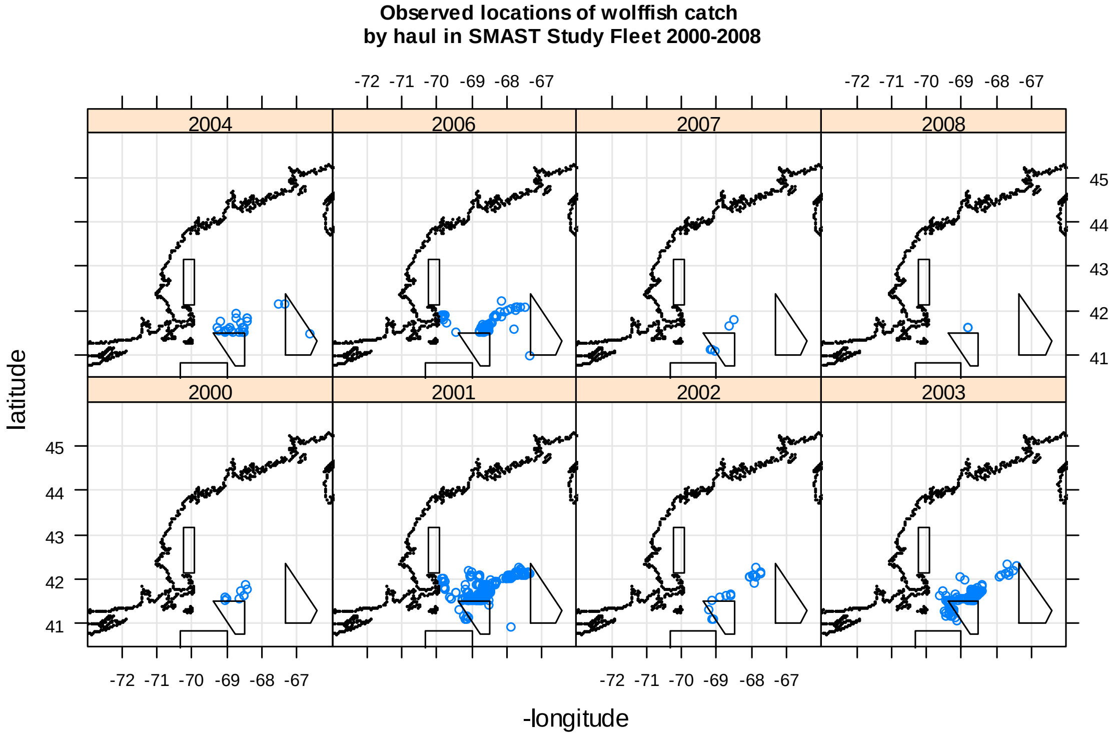


Figure 6.3.19. Top panel: Location of reported hauls in the SMAST Study Fleet. Bottom panel: location of hauls with wolffish in the SMAST Study Fleet.

Table 6.3.16. Summary Statistics of Commercial Observer Length Samples by Year, 1989-2007.

YEAR	Median Length (cm)	Mean Length (cm)	Std Dev.	Total N	Min-Max Range (cm)
1989	72	74.25	5.91	4	70 – 83
1991	77	81.89	13.25	9	70 – 114
1992	45.5	49.14	10.93	70	39 – 80
1993	61.5	64.58	11.01	24	49 – 86
1994	73	72.80	10.36	25	45 – 95
1995	62.5	62.00	18.08	20	21 – 102
1996	75	72.76	10.96	25	42 – 94
1997	81	78.38	12.52	13	47 – 92
1998	89	85.58	9.89	19	67 – 99
1999	83	82.14	11.28	7	65 – 94
2000	77	77.30	7.19	50	60 – 89
2001	76	75.69	10.86	74	52 – 96
2002	82	81.75	10.64	53	63 – 110
2003	77	73.78	13.41	186	31 – 113
2004	75	74.35	12.40	253	41 – 115
2005	81	80.23	11.38	264	29 – 107
2006	82	82.34	12.04	163	54 – 111
2007	83	81.59	12.48	129	44 – 105

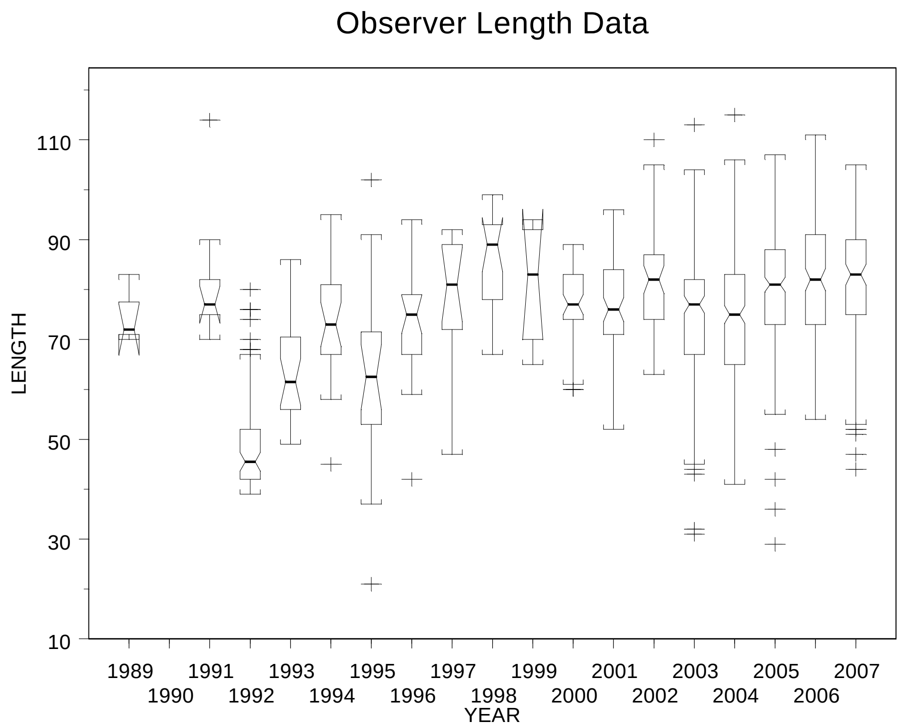


Figure 6.3.20. Fishery observer length distribution by year, 1989-2007.

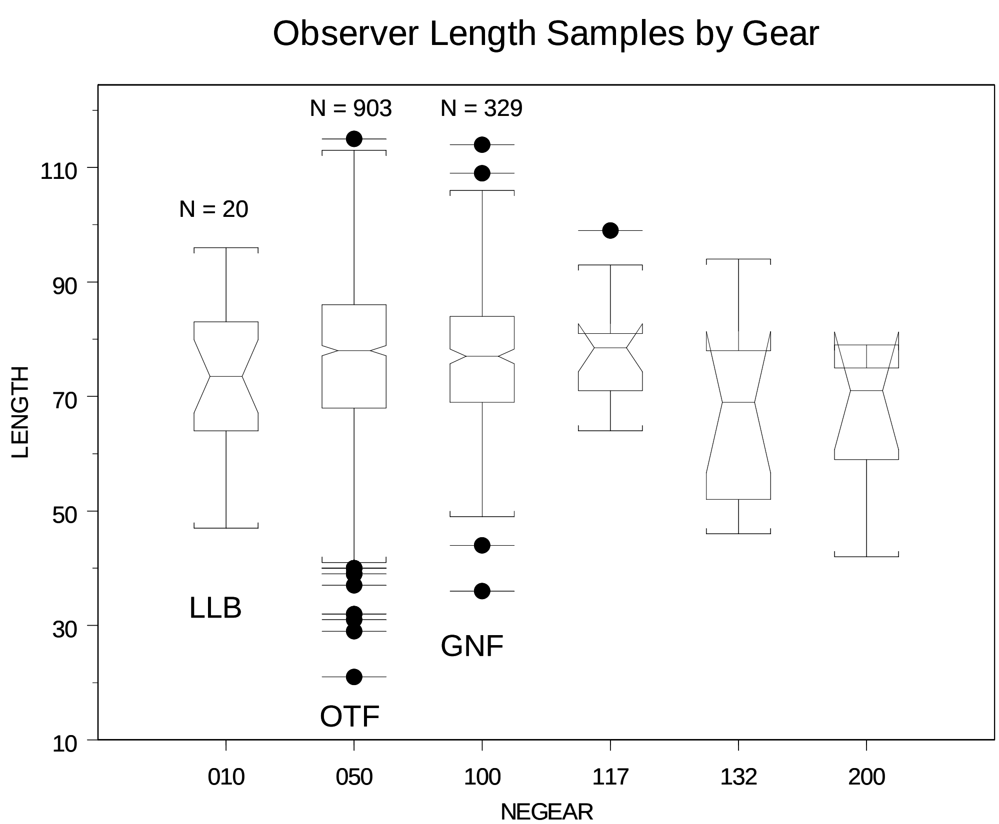


Figure 6.3.21. Fishery observer length distribution by major gear type: otter trawl and gillnet.

Table 6.3.17. Summary Statistics of Commercial Observer Length Samples by major gear type.

Gear Type	Gear Code	Median Length (cm)	Mean Length (cm)	Std Dev.	Total N	Min-Max Range (cm)
Longline Bottom	10	73.5	71.91	14.04	22	71-96
Otter Trawl Fish	50	78.0	76.21	14.75	1000	21-115
Gillnet Fixed	100	77.0	76.32	11.82	335	36-114
Gillnet Drift	117	78.5	77.71	9.90	14	64-99
Scallop Dredge	132	69.0	67.64	14.66	11	46-94
Offshore Lobster	200	71	66.17	13.83	6	42-79

Commercial lengths from port samples have been taken irregularly during the span of the commercial fishery. A large amount of samples were collected during 1982–1985 and samples have also been taken consistently since 2001. Commercial port sample length distributions were plotted by year (Figure 6.3.22). An increase in median length can be seen during the 2001 – 2007 time period. The median has increased from 75 cm in 2001 to 84 cm in 2007 (Table 6.3.18). These data suggest that median size in the commercial fishery may be increasing as the 95% confidence intervals from the 2001-2003 period do not overlap with the 2004-2007 period. Differences were then examined to see if the increase could be explained by changes in the major gear type since longlines, and gill nets have become a larger component of the fishery (Figure 6.3.23). Slight differences were observed in the size compositions of the various gears but this may be an artifact of low sample size of commercial gears other than otter trawls (Table 6.3.19). Commercial length samples were also plotted by statistical area to determine if any geographic trend in size could be seen (Figure 6.3.24). The primary fishery areas, 512-522, show similar length distributions. Areas 526 and 537 had anomalous length distributions but also had low sample sizes (Table 6.3.20).

Indices of catch per unit of effort (CPUE) were calculated from fishery observer trips and self reported Vessel Trip Reports (VTRs) in party and charter boat sectors for Atlantic wolffish. Observer CPUE was estimated for 1989-2007 in the longline, gillnet and otter trawl fisheries for United States statistical areas 512-515, 521-522, 525-526 and 537 (Table 6.3.21). CPUE was calculated based on the ratio: sum of kept wolffish per year / sum of days fished per year. Observer CPUE has declined in the three fishing sectors reviewed (Figure 6.3.25). Atlantic wolffish CPUE for the longline fishery is plotted on the second y-axis as it has an anomalous data point in 1993 and is significantly higher than the otter trawl and gillnet sectors.

Although observer based CPUE has declined, spatio-temporal plots of observed commercial hauls with wolffish catches from major fisheries indicate that the resource is widely dispersed and large catches are made by commercial gears (Figure 6.3.26). This data is highly subject to market forces, fishery management actions, and observer coverage.

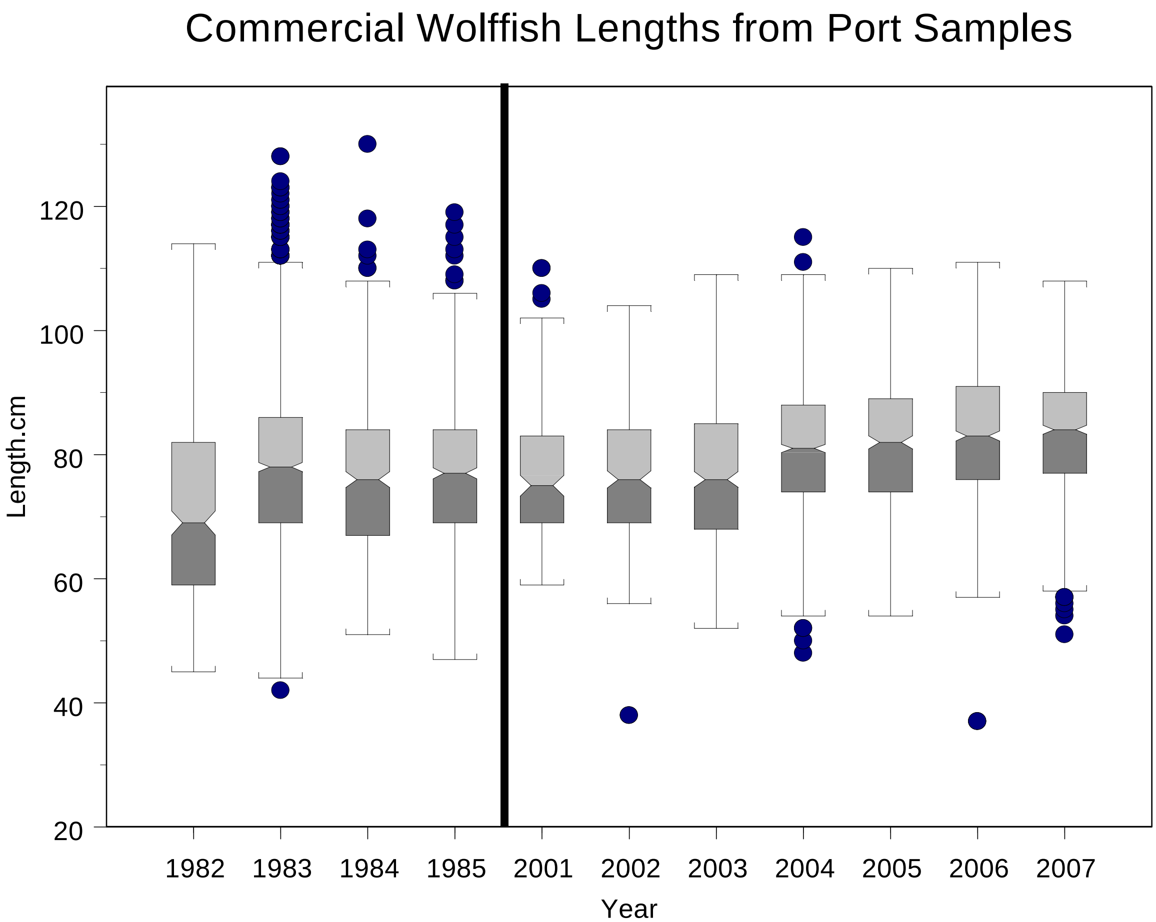


Figure 6.3.22. Atlantic wolffish commercial length distributions by year from port samples, 1982-1985 and 2001-2007.

Table 6.3.18. Commercial Port Sample Summary Statistics by Year, 1982-1985 and 2001-2007.

YEAR	Median Length (cm)	Mean Length (cm)	Std Dev.	Total N	Min-Max Range (cm)
1982	**69**	**71.71**	**15.35**	**354**	**45-114**
1983	**78**	**78.25**	**14.46**	**1349**	**42-128**
1984	**76**	**76.10**	**12.76**	**445**	**51-130**
1985	**77**	**76.98**	**11.86**	**729**	**47-119**
2001	**75**	**76.59**	**10.11**	**176**	**59-110**
2002	**76**	**76.34**	**10.30**	**297**	**38-104**
2003	**76**	**76.88**	**11.07**	**473**	**52-109**
2004	**81**	**80.83**	**10.72**	**1159**	**48-115**
2005	**82**	**81.40**	**9.95**	**500**	**54-110**
2006	**83**	**83.03**	**10.36**	**894**	**37-111**
2007	**84**	**83.55**	**10.01**	**800**	**51-108**

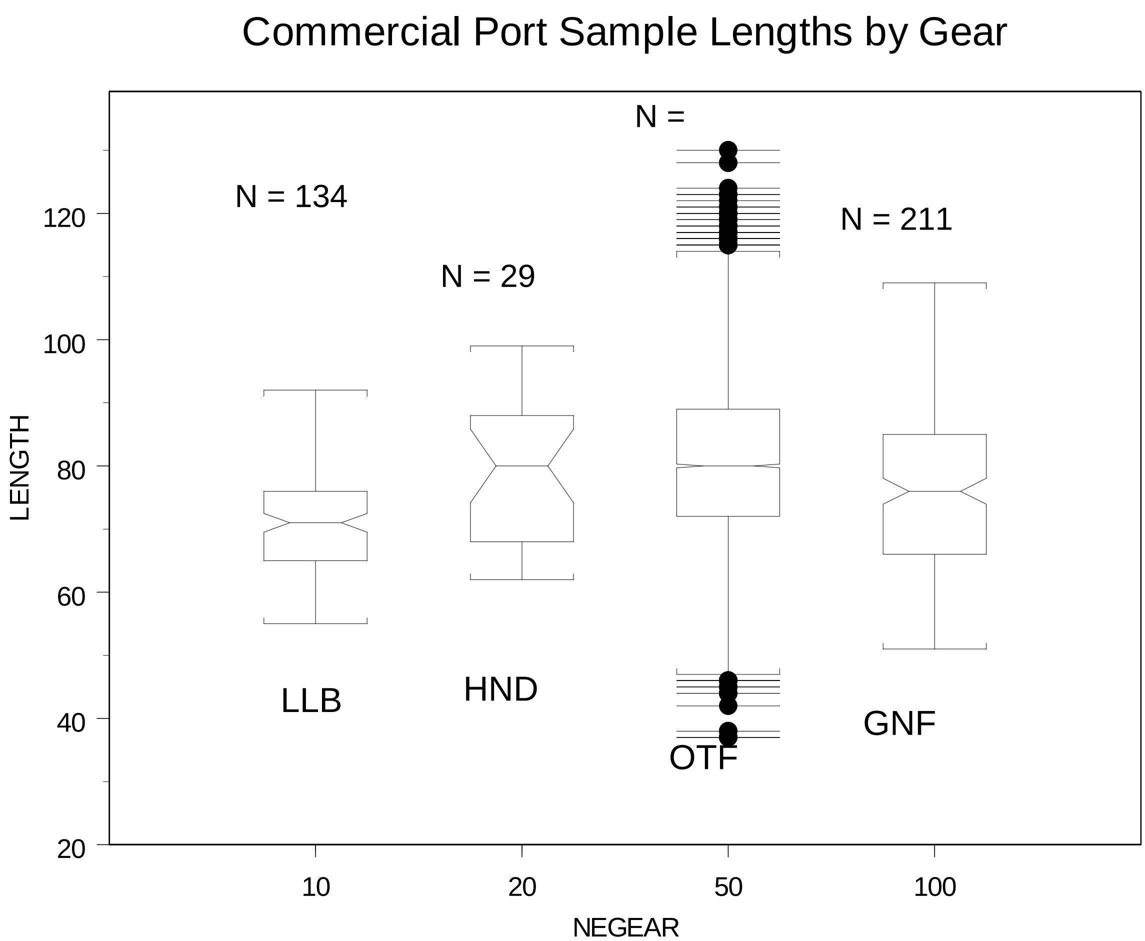


Figure 6.3.23. Commercial port sample length distributions by major gear type, all years combined (1982-1985 & 2001-2007).

Table 6.3.19. Commercial Port Samples Summary Statistics by Gear Type

Gear Type	Median Length (cm)	Mean Length (cm)	Std Dev.	Total N	Min-Max Range (cm)
Longline	**71**	**71.08**	**8.84**	**134**	**45-92**
Handline	**80**	**79.41**	**10.90**	**29**	**62-99**
Otter Trawl Fish	**80**	**80.04**	**12.63**	**7041**	**37-130**
Gill Net	**76**	**76.36**	**11.68**	**211**	**51-109**

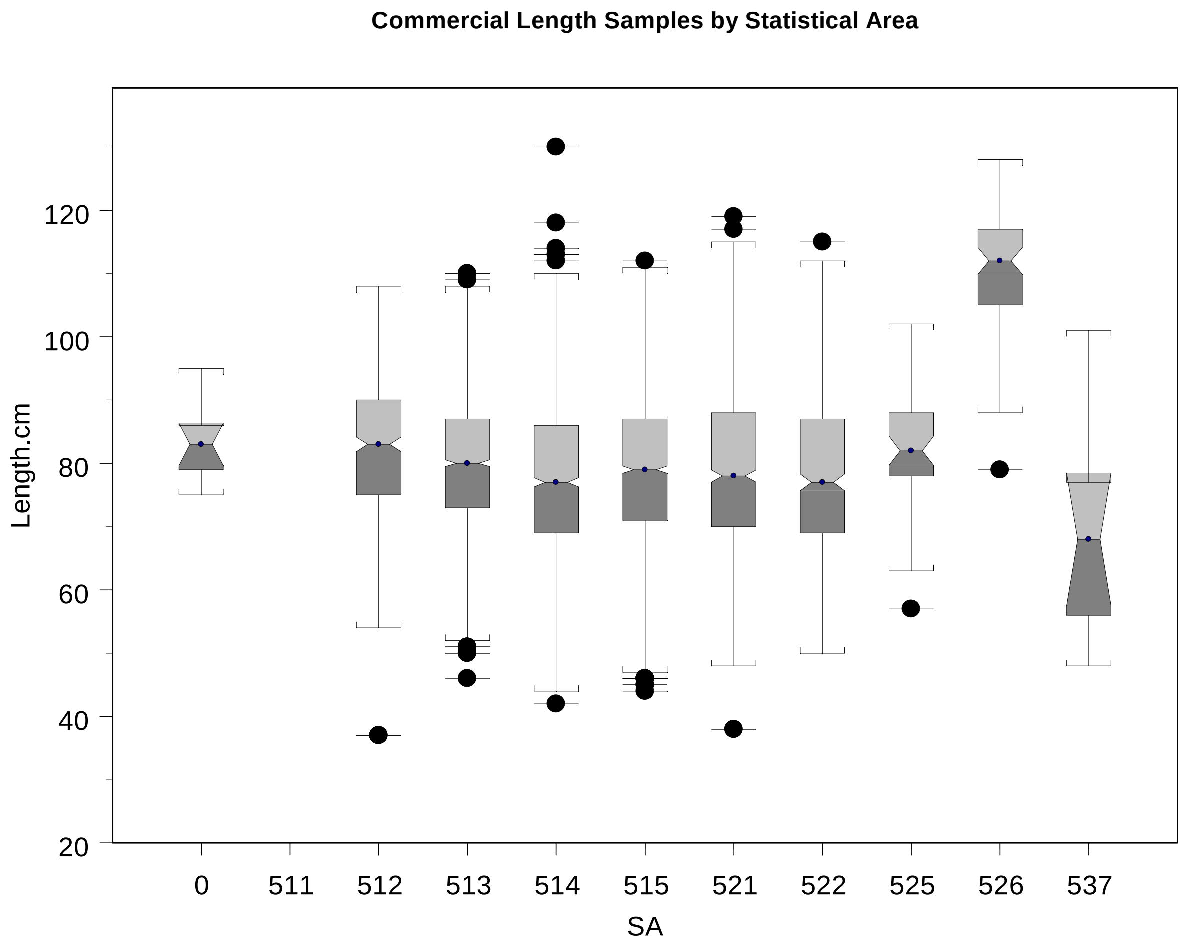


Figure 6.3.24. Commercial port sample length distributions by fishery statistical area in United States waters, all years combined (1982-1985 & 2001-2007).

Table 6.3.20. Commercial Port Samples Summary Statistics by Fishery Statistical Areas

Statistical Area	Median Length (cm)	Mean Length (cm)	Std Dev.	Total N	Min-Max Range (cm)
0	83	83.27	6.13	11	75 - 95
512	83	82.16	10.76	421	37 - 108
513	80	79.70	10.99	1745	46 - 110
514	77	77.69	12.04	1357	42 - 130
515	79	78.50	11.67	1956	44 - 112
521	78	79.19	12.53	894	38 - 119
522	77	77.88	12.39	478	50 - 115
525	82	82.70	9.30	47	57 - 102
526	112	110.72	9.67	79	79 - 128
537	68	68.00	15.43	10	48 - 101

The distribution of catch weight per haul by year and statistical area from observer data is shown in Figure 6.3.27. With the exception of statistical areas with few observations of wolffish (537, 525, 526), the distribution of catches is fairly stable across statistical areas and years. Median catch ranges from 10 to 14 lb per haul with an inter-quartile range spread from 11.3 to 13 lb. The 95th quantile also shows little variation among area and ranges from 40 to 57 lb. The median value of catch weight per haul is fairly steady from 1989-2008 (all areas combined), ranging from 10 to 15 lb. During this same period, the inter-quartile range, a measure of variability, does not have trend, but was more variable earlier in the timeseries. The 95th quantile also does not have a trend, but appears to have been more variable earlier in the timeseries. These data indicate that wolffish are generally caught in low numbers (1-3 animals in a haul) and that the distribution of catches is relatively stable over the time period. In a population undergoing severe depletion, we might expect the frequency of large tows to diminish over time, especially for a species that does not have a tendency to form large schools. Declines in the median catch or 75th quantile might be expected if larger animals are removed from the population. In the case of long-term recruitment failure, the median or 1st quantile might be expected to increase. No long-term trends are evident in these order statistics. Figure 6.3.28 indicates that catch rates over time have also been stable and without trend by gear types. Large catches are still available to commercial bottom trawls as indicated by outliers on the boxplots during recent years.

Table 6.3.21. Observer based CPUE (sum of kept wolffish per year / sum of days fished per year) for Atlantic wolffish by major fishing gear, 1989-2007.

YEAR	LLB	OTF	GNF
1989		19.51	5.79
1990		9.47	28.84
1991	52.25	19.64	14.72
1992	54.43	39.68	17.56
1993	262.50	43.05	21.25
1994		54.08	25.77
1995		19.57	62.17
1996		18.94	50.92
1997		30.09	17.75
1998		21.58	19.86
1999		20.47	14.52
2000		19.12	19.37
2001		24.45	18.70
2002	86.70	10.69	18.90
2003	29.60	12.91	32.67
2004	9.36	9.69	17.48
2005	18.98	5.45	19.87
2006	9.91	5.83	16.16
2007	8.20	5.72	8.03

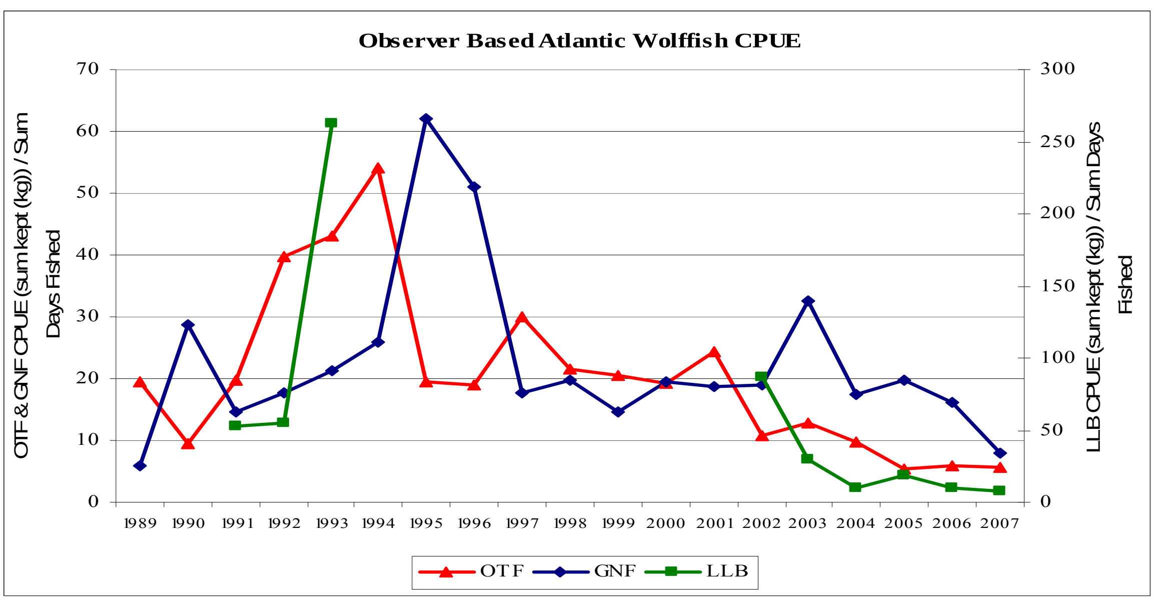


Figure 6.3.25. Catch per unit effort of Atlantic wolffish based on observer data in the otter trawl, gillnet and longline fisheries.

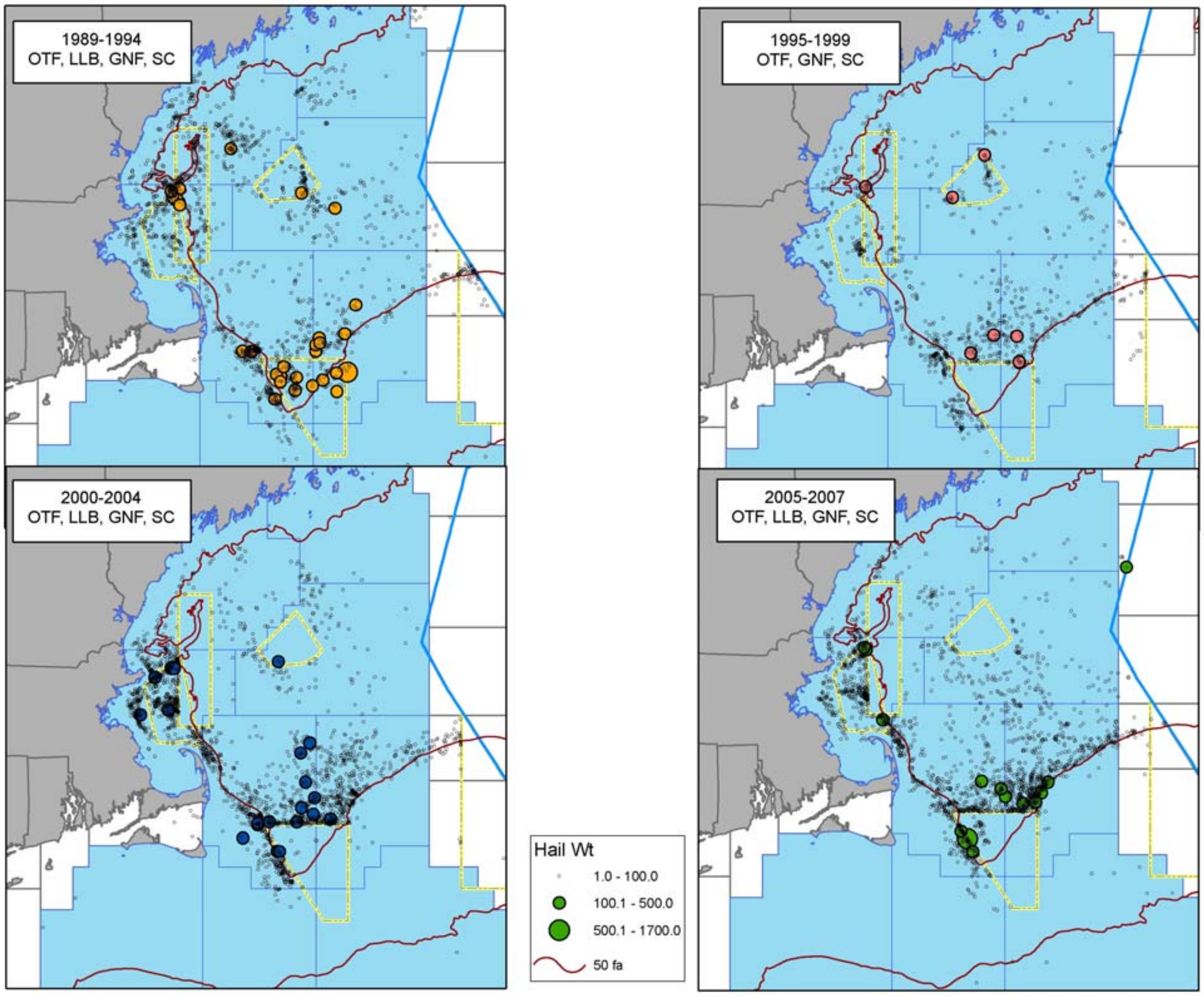


Figure 6.3.26. Locations of positive commercial wolffish catches by major gear type from Fishery Observers, 1998-2007.

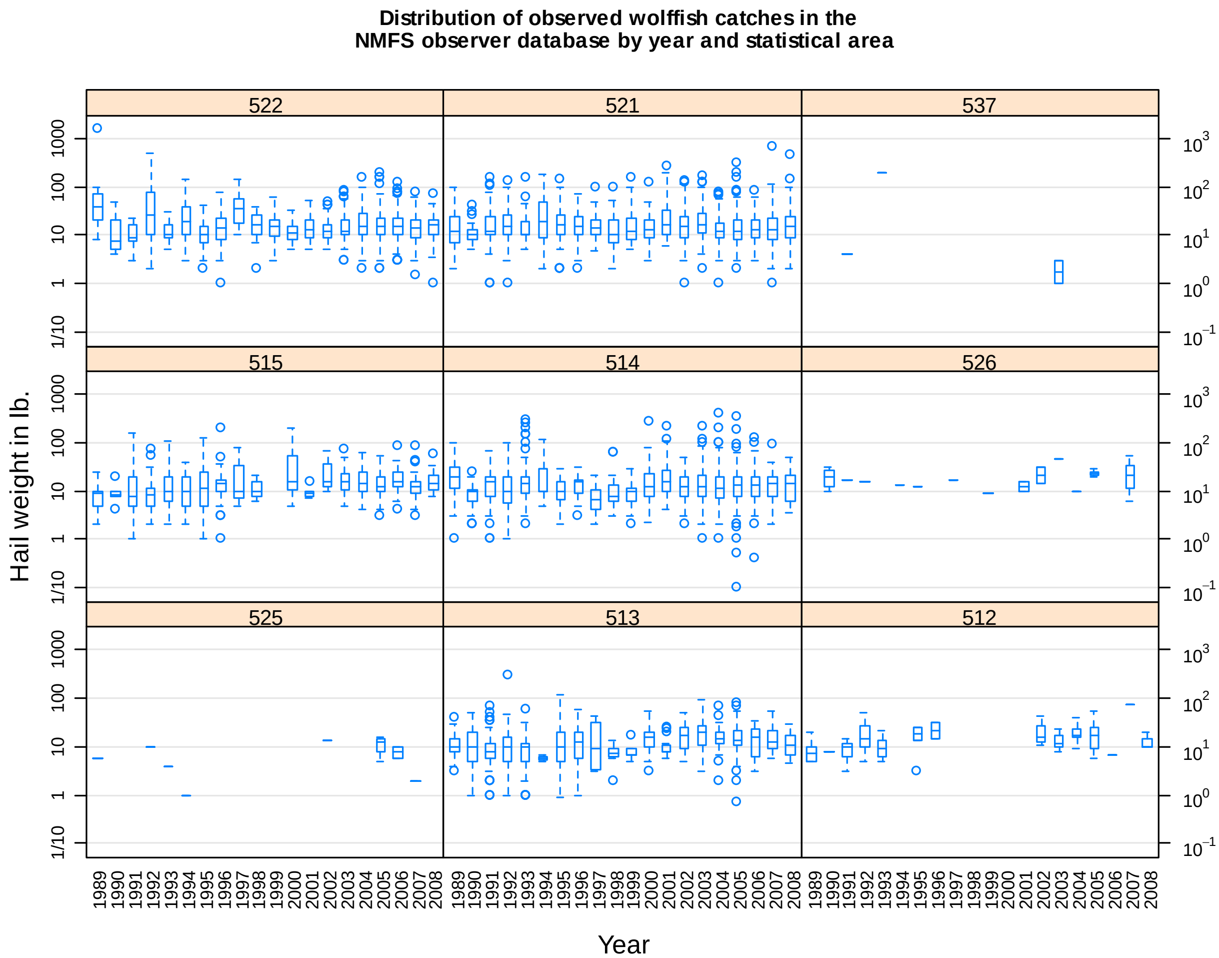


Figure 6.3.27. Boxplots of catch weight per haul by year and statistical area. Observations are for bottom trawl, sink gillnet and hookgear. Note y-scale is semi-logarithmic.

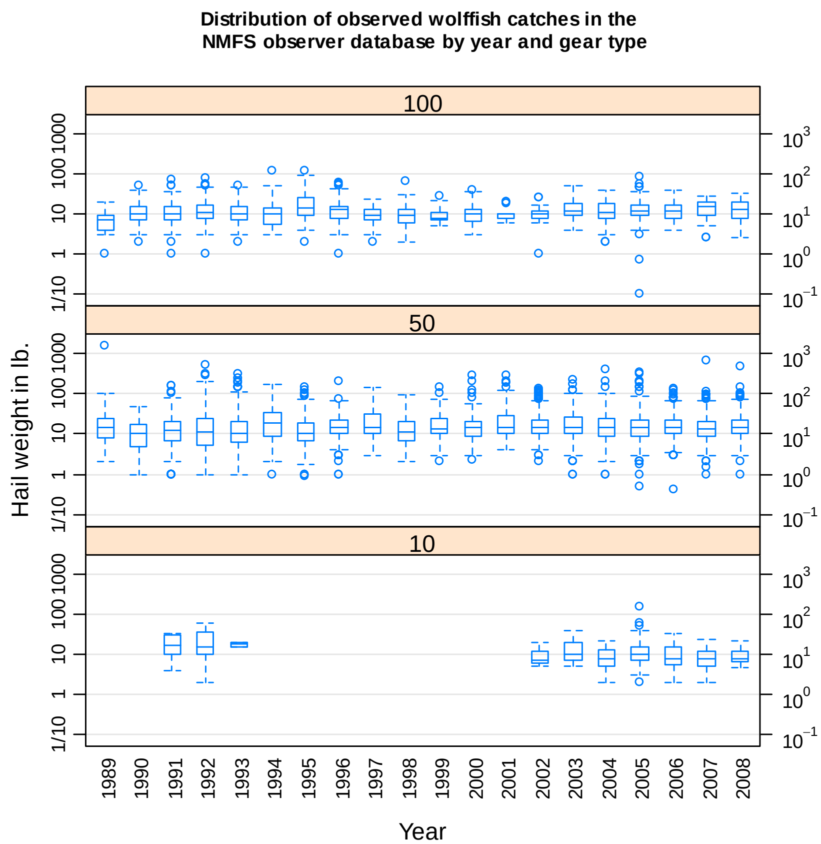


Figure 6.3.28. Distribution of catch weight per haul (lb) by gear type and year. Geartype 100=sink gillnets, 50=bottom trawls and 10 = hook gear. Note that y-scale is semi-logarithmic.

<u>VTR Party Charter</u>

Party and Charter boats with limited Northeast Multispecies permit have been required to file vessel trip reports since 1995. The vessel trip report includes date, location, and total counts by species for each trip, although records can have missing fields. In addition, a review of the data suggests that catch in pounds were mis-recorded in the count field. In this analysis we use the data in the count field, but caution that extremely high values may represent catch in pounds rather than number. As with other fisheries dependent data, the changes in the distribution of wolffish catches are influenced by regulations and market forces as well as changes in wolffish. In particular, changes in trip limits to Gulf of Maine cod and Gulf of Maine haddock can influence where vessels fish, and indirectly influence wolffish catch per unit effort and spatial-temporal distribution of wolffish catches.

A total of 14,908 trips caught wolffish. The total count of 54,515 wolffish were reported in 14,772 trips from 1995-2008. An additional 163 trips reported catching 3,612 lbs of wolffish. Approximately 97% of all wolffish catches occurred in statistical reporting areas 513 and 512 (Table 6.3.22). The number of wolffish captured in a trip (Table 6.3.23) is relatively low (50% of all trips landed 2 or less wolffish). The median catch per angler is 0.1 fish per angler. Wolffish comprise approximately 3% of the total catch of all species. These data suggest that wolffish are not a primary species target in the Party-Charter boat fleet. The MRFSS database indicates that only 0.02% of anglers in the Party-Charter boat mode for 2006-2007 listed wolffish as either the first or second primary species.

Table 6.3.22. Wolffish catch in number by statistical area and as percentage of total catch of all species in Party-Charter vessels on trips that caught wolffish.

Statistical Reporting Area	Count of wolffish	Statistical area catch as percent of total	Total count for all species	Wolffish catch as percentage of total catch
514	29,404	53.9	779,261	3.8
513	23,469	43.1	862,006	2.7
515	632	1.2	40,942	1.5
537	345	0.6	7,052	4.9
521	192	0.4	19,625	1.0
600's	168	0.3	9,022	1.9
510-512	135	0.2	3,830	3.5
538-561	57	0.1	54,628	0.1
526	56	0.1	9,916	0.6
522-525	32	0.1	54,572	0.1
other area	25	0.0	201	12.4
Total	54,515		1,841,055	3.1

Table 6.3.23. Summary statistics for counts of wolffish in party-charter boats for 1995-2008 combined.

Statistic	25^{th} quantile	median	mean	75th quantile	95^{th} quantile
Count of wolffish	1	2	3.7	4	13
Count of wolffish per angler	0.05	0.11	0.21	0.22	0.45

The location of Party-Charter boat trips that captured wolffish is shown in Figures 6.3.29-6.3.31. Figure 5.3.29 shows all locations of wolffish and Figure 5.3.30 shows locations within the Gulf of Maine. Figure 6.3.31 shows areas that caught more than 4 fish (75^{th} quantile) and more than 10 fish (92^{nd} quantiles). Overall, these graphs do not indicate a contraction in geographic dstribution of wolffish during the 1995-2008 period.

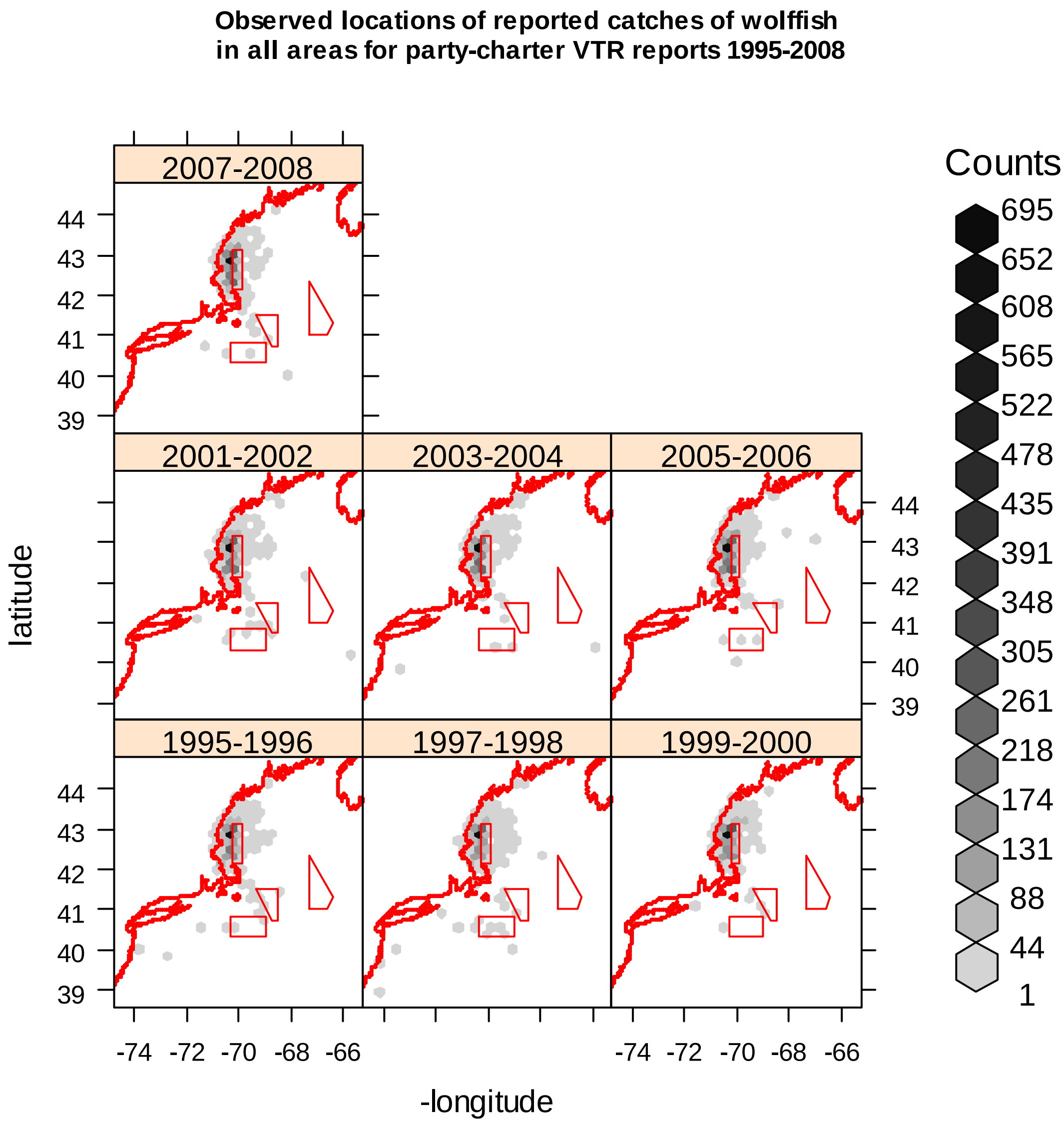


Figure 6.3.29. Density of locations of all party-charter boat trips catching wolffish for 1995-2008 in two year bins. Darker hexagons indicate higher density of trips.

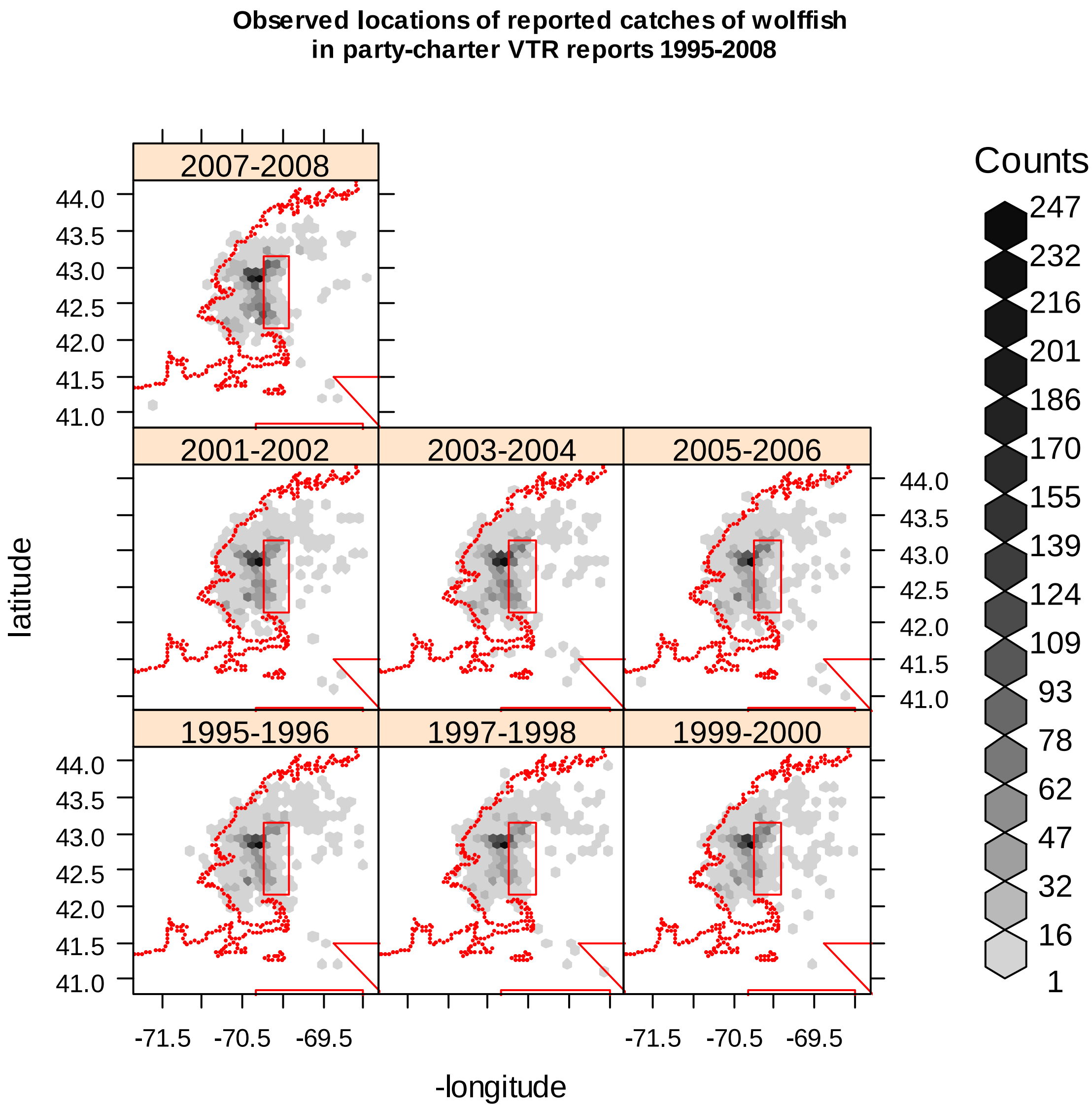


Figure 6.3.30. Locations of GOM party-charter boats trips with wolffish as reported in VTR for trips north of 41 degrees north latitude and west of 69 degrees longitude. Darker hexagons indicate higher number of trips.

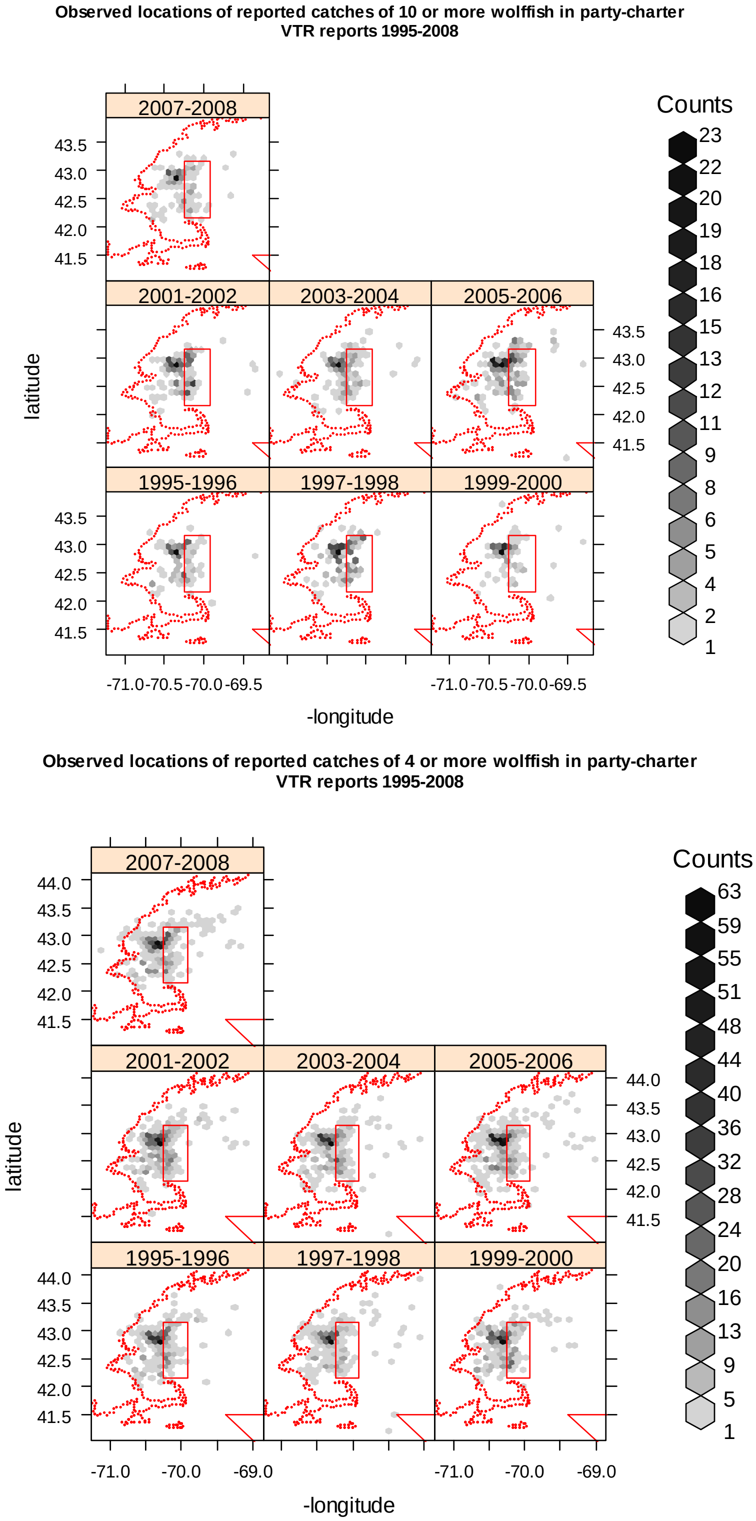


Figure 6.3.31. Locations of 75th and 92nd quantiles of wolffish catches in party charter vessels as reported in VTR. Color intensity of hexagons darken as density of location within hexagons increases. Top panel: locations of trips catching 10 or more wolffish. Bottom panel: location of trips catching 4 or more wolffish.

The percent occurrence of wolffish in party-charter boat was calculated using trips that caught wolffish and cod in statistical reporting area 513 and 514 with trips that caught cod, but not wolffish in the same areas (Figure 6.3.32). The percent occurrence is not standardized. These figures suggest that percent occurrence has declined since 1997 in both statistical reporting areas 513 and 514.

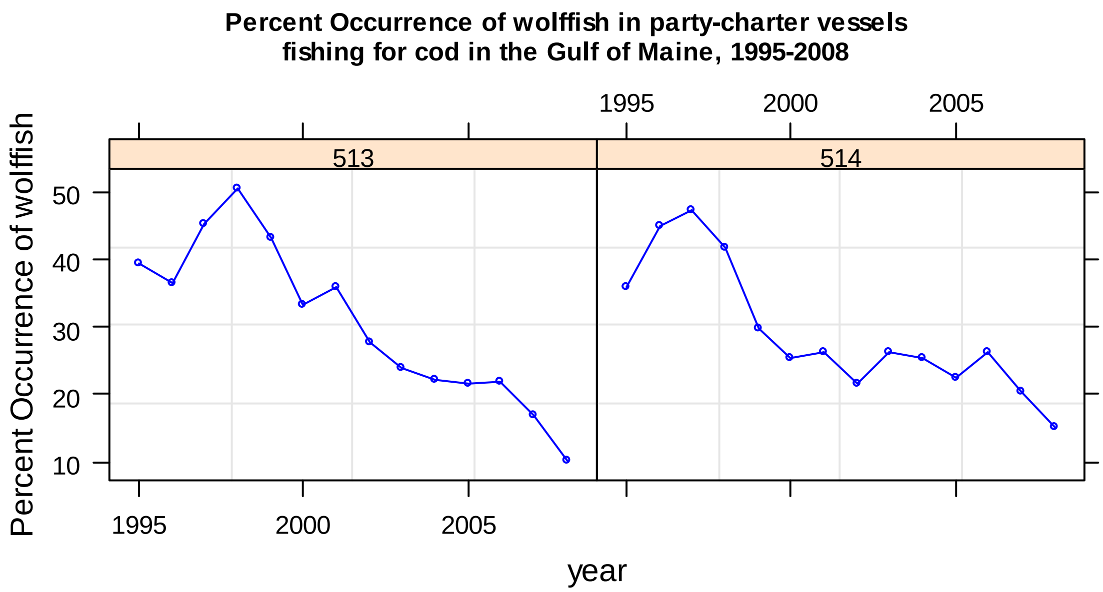


Figure 6.3.32. Percent occurrence of wolffish in party-charter boats landing cod in the statistical report areas 513 and 514 within the Gulf of Maine.

Boxplots of the distribution of wolffish catch per trip are shown in Figure 6.3.33. The downward shift in the distributions of the count of wolffish seems to have occurred between 1997 and 1998, and between 2006 and 2007.

Stock Assessment

A forward projecting stock assessment model, Statistical Catch At Length (SCALE), which tunes to size and age data from fishery independent resource trawl surveys, commercial catch, and commercial catch size distributions along with overall growth information, was developed to assess Atlantic wolffish in United States waters (NEFSC, 2008). This stock assessment model was accepted by the Data Poor Stocks Peer Review Panel in December 2008 as a basis for determining a range of biological reference points (BRPs) for Atlantic wolffish (Miller et al, 2008).

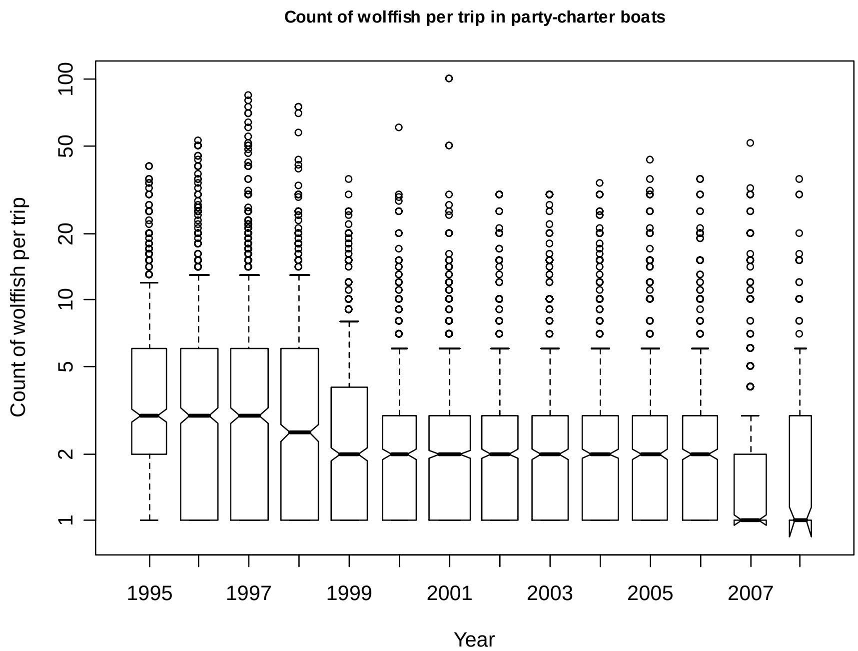


Figure 6.3.33. Boxplots of counts of wolffish per trip in party-charter boats for 1995-2008, all statistical areas combined. Non-overlap of notches indicates an approximately 95% difference in median. Boxplot width is proportional to square root of number of observations.

The wolffish assessment report was recently updated as an error in commercial landings was discovered following the assessment. The revised document and updated analysis resulted in the same status determinations for Atlantic wolffish as the original report, but the estimated population levels were approximately 45% higher in magnitude in the revised document. All estimates reported here are the updated values. The Review Panel has not commented on the revised report.

The SCALE model had difficulty estimating a logistic commercial fishery selectivity curve due to the sparseness of commercial data. Two different selectivity regimes were chosen to determine BRPs and their influence on stock status, using a fishing mortality rate at 40% ($F_{40\%}$) as a proxy for fishing mortality at maximum sustained yield (F_{MSY}). Run one had a relativity flat selectivity curve which was allowed to hit the L-50 bound of 90 cm (Figure 6.3.34). Run two was setup to hit the slope parameter bound of 0.15 which produces a steeper selectivity function with a lower, more realistic L-50 estimate (Figure 6.3.34).

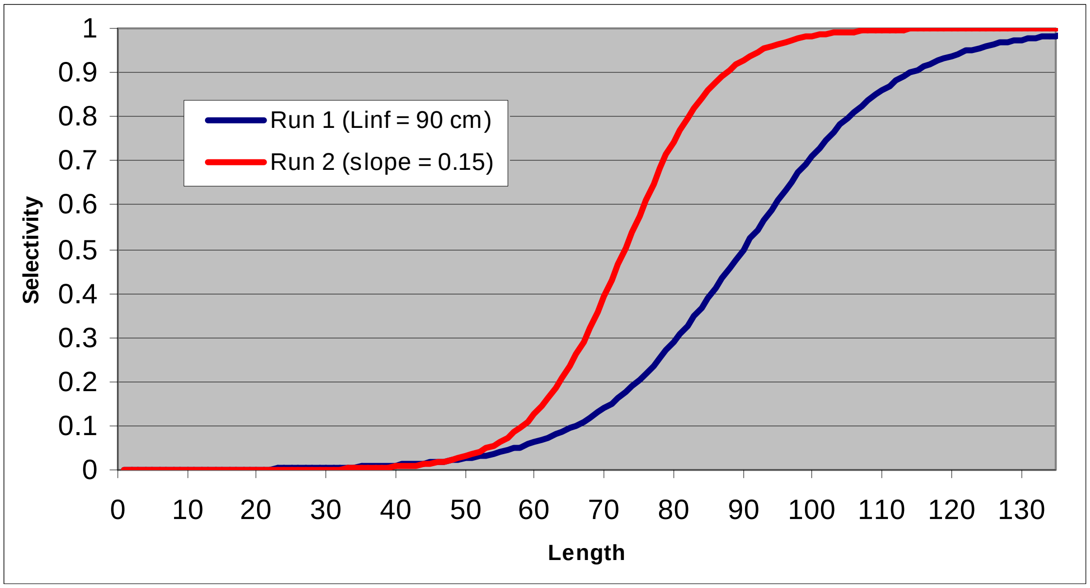


Figure 6.3.34. SCALE model commercial selectivity run 1 was allowed to hit the L-50 bound of 90 cm which estimates a relatively flat selectivity curve. SCALE run 2 hits the slope bound of 0.15 which estimated a lower L-50.

The maturation schedule of wolffish in United States waters is uncertain and this influences BRPs derived from the SCALE model. The sensitivity of these non-parametric BRPs was tested with a range of knife edge maturity cutoffs based on biological studies conducted in Iceland, Newfoundland and data from the Gulf of Maine (Table 6.3.24). Early Data-Poor Stocks Working Group meetings indicated that, given the wolffish life history traits of late maturation and low fecundity, $F_{50\%}$ may be an appropriate proxy for F_{MSY} and this was presented as a third option (Run 3) to the Panel (Table 6.3.24). Based on all SCALE model runs, the stock in 2007 is at a low biomass level, 26% to 45% of biomass at MSY (B_{MSY}), and is overfished, assuming a $B_{THRESHOLD}$ of ½ B_{MSY} (Figure 6.3.35). The Peer Review Panel concluded that $F_{40\%}$ is a reasonable F_{MSY} proxy and that its value is probably <0.35. The overfishing status is more uncertain as the ratio of F_{2007} to F_{MSY} falls in the range of 50% to 123% (Figure 6.3.35). MSY is likely in the range of 278-311 mt and SSB_{MSY} is likely in the range of 1,747-2,202 mt (Table 6.3.24). Estimated population numbers of 40+, 65+ and 75+cm Atlantic wolffish from the SCALE model in 2007 are shown in Table 6.3.25. They range from approximately 89,000 wolffish to 384,000 for SCALE Runs 1 & 2. Estimated total population numbers for all knife edge maturity sizes for wolffish has declined steadily over time (Figure 6.3.36).

Table 6.3.24. Estimated biological reference points based on F40 and F50 for three wolffish SCALE runs based on a range of knife edge maturity cutoffs (40, 65, and 75 cm).

SCALE run	1			2			3		
Selectivity	L50 = 90			slope = 0.15			slope = 0.15		
Length of maturity	40cm	65cm	75cm	40cm	65cm	75cm	40cm	65cm	75cm
F_{MSY} proxy	F40%	F40%	F40%	F40%	F40%	F40%	F50%	F50%	F50%
F_{MSY}	0.686	0.486	0.374	0.319	0.233	0.185	0.197	0.156	0.129
YPR	0.872	0.839	0.799	0.861	0.817	0.771	0.784	0.728	0.679
SSB per Recruit	6.098	5.432	4.846	6.098	5.430	4.838	7.627	6.796	6.050
Initial Recruits (000s)	355	355	355	361	361	361	361	361	361
MSY (mt)	310	298	284	311	295	278	283	264	245
SSB_{MSY} (mt)	2,167	1,931	1,722	2,202	1,961	1,747	2,754	2,448	2,184
SSB_{07} (mt)	890	656	475	998	753	562	998	753	562
F_{07}	0.413	0.413	0.413	0.158	0.158	0.158	0.158	0.158	0.158
SSB_{07}/SSB_{MSY}	41%	34%	28%	45%	38%	32%	36%	31%	26%
F_{07}/F_{MSY}	60%	85%	111%	50%	68%	86%	80%	102%	123%

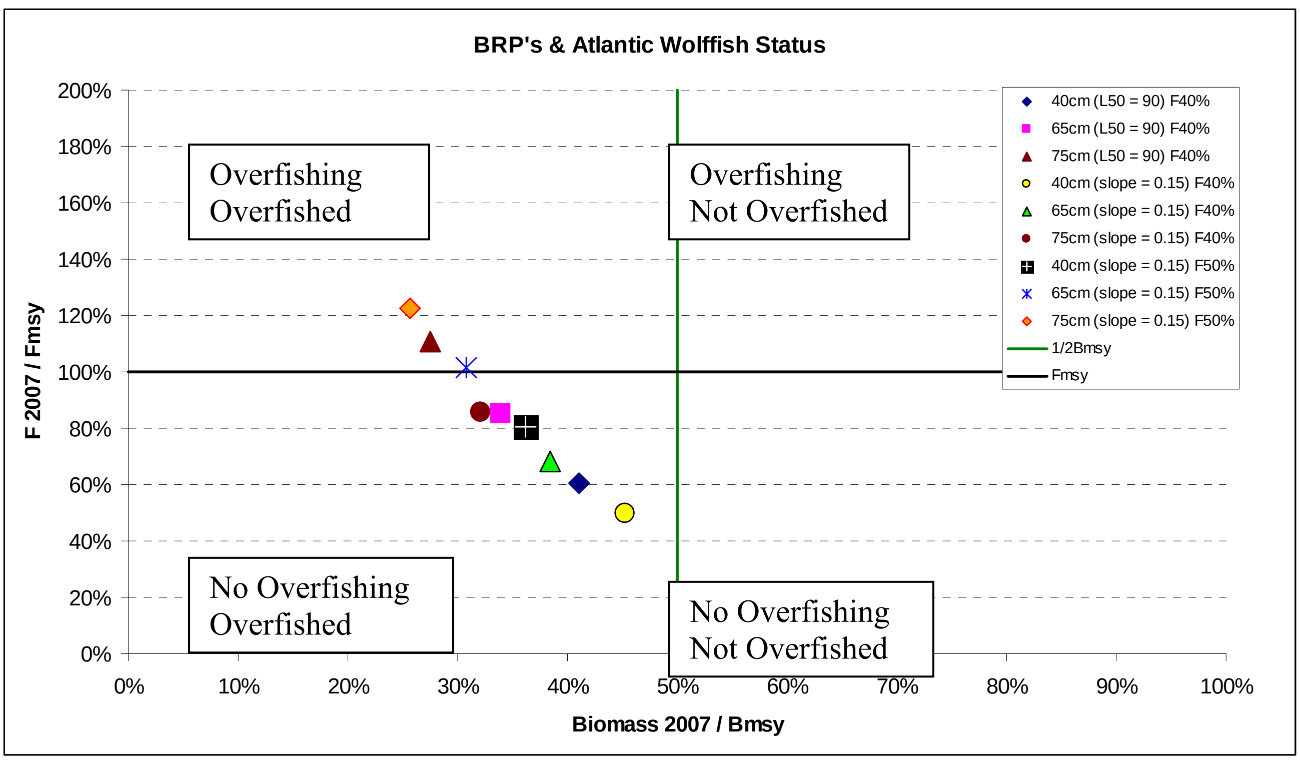


Figure 6.3.35. SCALE Biological Reference Points in reference to Overfished / Overfishing Status according to F_{MSY} and B_{MSY} Proxies.

Table 6.3.25. Estimated 2007 numbers of Atlantic wolffish by knife edge maturity cutoff from the SCALE model.

Maturity Cutoff	Run 1	Run 2
40+ cm	359,268	384,096
65+ cm	148,888	165,440
75+ cm	89,214	102,422

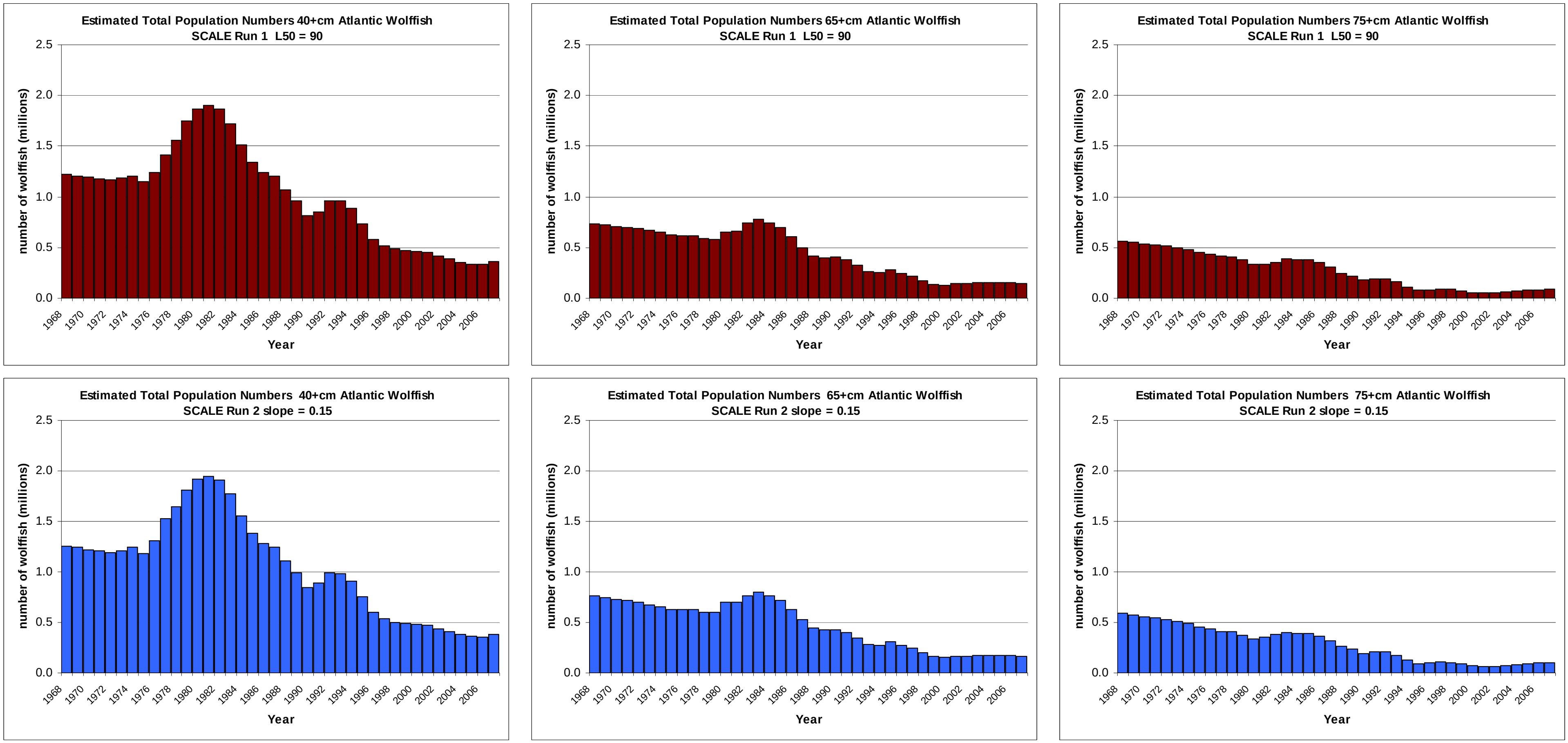


Figure 6.3.36. Estimated populations numbers of 40+, 65+ and 75+cm (SSB) Atlantic wolffish from SCALE model Runs 1&2.

6.4 Migration

Tagging studies on Atlantic wolffish from Newfoundland, Greenland and Iceland indicate that most individuals were recaptured within short distances of the original tagging sites (Templeman, 1984; Riget and Messtorff, 1988; Jonsson, 1982). However some significantly longer migrations were reported in Newfoundland that ranged from 210 – 530 nmi (Templeman, 1984). Long distance seasonal migrations from spawning grounds to feeding areas were observed in Iceland, surpassing 300-500 nautical miles, indicating that wolffish are capable of large scale movement (Jonsson, 1982).

6.5. Stock Status Summary

Atlantic wolffish abundance indices in the Barents and White Seas have fluctuated with an upward trend since reaching low levels in the 1980's. No apparent change has occurred in area occupied for this region. In the North Sea area occupied has decreased over time but estimates of relative abundance or biomass are unavailable. In Iceland the amount of fishable biomass has been increasing but recruitment is decreasing. In West Greenland the stock remains depleted even with an increase in recruitment in recent years. The majority of Atlantic wolffish in West Greenland consists of small individuals. In Canadian waters Atlantic wolffish are listed as a species of special concern and the overall population has declined and is at low biomass. In the Grand Banks, Gulf of Saint Lawrence and Scotian Shelf regions abundance remains low but appears to be increasing. Biomass estimates remain low as much of the abundance consists of smaller individuals. In the United States, the Atlantic wolffish stock is at relatively low biomass, with various model estimates ranging, between 475-998 mt of spawning stock biomass in 2007, according to findings presented at the NEFSC Data Poor Assessment Working Group. Current abundance levels are also low, ranging from 89,000 – 384,000 adult fish. Wolffish commercial catch has also declined over time and recreational landings have been relatively consistent. Catches are influenced by commercial regulations for other groundfish. In reference to B_{MSY} the stock appears to be overfished and overfishing may be occurring depending on the size at maturity cutoff used in the model for Gulf of Maine fish.

7. ESA LISTING FACTORS ANALYSIS

As stated previously, the ESA defines an "endangered" species as any species in danger of extinction throughout all or a significant portion of its range and a "threatened" species as any species likely to become endangered throughout all or a significant portion of its range within the foreseeable future. Section 4(b)(1)(a) of the ESA requires that determinations of whether a species is threatened or endangered be based solely on the best scientific and commercial data available and after taking into account those efforts, if any, being made to protect such species. A species may be determined to be endangered or threatened due to one or more of the following five factors described in Section 4(a)(1) of the ESA:

A. The present or threatened destruction, modification, or curtailment of habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. The inadequacy of existing regulatory mechanisms; and
E. Other natural or manmade factors affecting its continued existence.

In the following section, each of these five factors is examined for its historic, current, and/or potential impact on Atlantic wolffish status. It should be noted that current and potential threats, along with current distribution and abundance, determine present vulnerability to extinction. Information about historic threats is included to assist interpretation of historic population trends. The relationship between historic threats and population trends also provides insights that may help to project future population changes in response to current and potential threats.

7.1. The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

7.1.1 Fishing Activities

The adverse effects of commercial fishing activities on benthic marine habitats are well documented (ICES, 2000; NRC, 2002; DFO, 2006). Research on the direct effects of fishing on benthic marine habitats has shown that certain habitats are more vulnerable to modification by fishing, and that some gear types are more likely to modify benthic habitats than others. Indirect effects, such as how the selective removal of certain species by fishing, can modify the trophic dynamics of exploited marine ecosystems, are not considered here.

Direct effects that have the greatest impact are those that reduce the functional value of a habitat to provide ecological services such as shelter from predators or food. Areas of the seafloor that are most affected by fishing are those that are subjected to intense fishing activity, as measured by the frequency of bottom contact and the degree to which the physical or biological structure of the habitat is impacted. Reduction in habitat complexity is generally viewed as the most deleterious effect of fishing. This can take the form of the loss or dispersal of physical features such as boulder reefs, the loss of structure-forming organisms, the redistribution and mixing of surface sediments, the degradation of habitat and biogenic features, and the alteration of seafloor features such as sand waves and ripples, or burrows created by benthic organisms (ICES, 2000). Some impacts have longer-term effects than others and may even be permanent (e.g., the re-distribution of piled boulders), while others (smoothing of sand ripples) are temporary. For biological effects, recovery times depend on how quickly benthic organisms can re-colonize an affected area or, if damaged, how quickly they grow.

Fishing gears used in the Gulf of Maine region, on the Scotian Shelf, and in the Gulf of St. Lawrence that have the greatest potential to adversely impact benthic habitats utilized by Atlantic wolfish are bottom trawls and scallop dredges. The effects of trawls and dredges were evaluated in a recent report by the Committee on Ecosystem Effects of Fishing for the National Research Council's Ocean Studies Board (NRC, 2002). The Committee concluded that:

- Trawling and dredging reduce habitat complexity
- Repeated trawling and dredging result in discernable changes in benthic communities
- Bottom trawling reduces the productivity of benthic habitats
- Fauna that live in low natural disturbance regimes are generally more vulnerable to fishing gear disturbance

An additional source of information that relates specifically to the Northeast region is the report of a "Workshop on the Effects of Fishing Gear on Marine Habitats off the Northeastern United States" (NEFSC, 2002). A panel of fishing industry members and experts in the fields of benthic ecology, fishery ecology, geology, and fishing gear technology evaluated the effects, and the degree of impact, of bottom trawls, hydraulic clam dredges, scallop dredges, bottom gillnets, pots, and longlines on mud, sand, and gravel/rock bottom habitats. Trawls and scallop dredges were determined to have the greatest impact and impacts were determined to be greater in gravel/rock habitats with attached epifauna. Effects of trawls on major physical features in gravel and rocky bottom were described as permanent, and impacts to biological and physical structure were given recovery times of months to years. These conclusions are consistent with the conclusions reached by the NRC and ICES, and the results of a subsequent workshop that evaluated the habitat effects of ten gear types used in United States waters (Morgan and Chuenpagdee, 2003).

Auster (1998) developed a conceptual model based on observations of fishing gear impacts across gradients of habitat complexity and levels of fishing effort and concluded that, of the eight habitat types evaluated, piled boulder habitats utilized by Atlantic wolffish for reproduction (see Section 5) were the most vulnerable. Piled boulder habitat was also determined to respond more quickly than the other habitats to increasing levels of fishing effort, i.e., the loss of habitat complexity from very high values to relatively low values was predicted to be more severe. The same conclusions are reported in the NEFSC (2001) and NRC (2002) fishing effects evaluations.

Despite the high vulnerability of high relief, piled boulder habitats to damage from commercial fishing activities and the fact that any reduction in habitat complexity – caused by knocking over boulder piles – would be permanent, there is a very low probability that such damage would actually occur. Fishermen avoid rocky reefs and boulders because they cause serious damage to towed fishing gear resulting in lost fishing time and expensive repairs. Gears that are much more likely to be used in these habitats are lobster traps and hook and line gear used by recreational fishermen (e.g., party and charter boats), gears which have little or no adverse impacts on the structural complexity of rocky bottom habitats (NEFSC, 2002; Morgan and Chuenpagdee, 2003). Regulations which prohibit the use of bottom trawls with large rock-hopper ground gear in a large area in the western Gulf of Maine (see Section 7.4.2) further ensure that bottom trawls are not used in known high priority wolffish spawning habitat areas.

Mobile, bottom-tending fishing gear (trawls and dredges) does affect other continental shelf bottom habitats utilized by wolffish for other purposes besides reproduction. Atlantic wolffish have been caught in bottom trawl surveys over a variety of habitat types (see Section 5). Auster (1998) ranked pebble-cobble and dispersed boulders-cobble seafloor habitats as more vulnerable to fishing than shell or sand habitats, especially if they support the growth of shelter-forming epifauna like sponges, anemones, and tunicates. Reductions in seafloor complexity could potentially affect the ability of Atlantic wolffish – especially small juveniles – to find shelter from predators. Fishing could also change the composition of benthic communities that provide food for Atlantic wolffish, but the effect of selectively removing certain types of organisms or degrading the quality of their habitats would be ameliorated by the fact that wolffish feed on a wide variety of benthic organisms (see Section 3.6).

7.1.2 Non-fishing Activities

A number of non-fishing human activities that could possibly affect the continued existence of Atlantic wolffish are listed in Section 7.5. Some of them have the potential to destroy or modify habitats used by Atlantic wolffish. They are listed below according to their potential for affecting coastal boulder reef habitats in western Canada and the Gulf of Maine, or as more general threats to deeper and more varied continental shelf habitats. Some are listed in both categories. These potential impacts were identified based on information in Johnson et al. (2008).

Coastal shallow-water (<100 m) boulder reef habitats

Direct effects on physical structure (plowing or dredging of seafloor)
- Pipeline/cable installation
- Wind turbine installation

Direct effects on sediment quality (contamination, sedimentation)
- Disposal of dredge spoil
- Oil spills

Indirect impacts - increased bottom temperatures
- Climate change
- Heated effluent from power plants, industrial discharges

Indirect impacts - water quality
- Combined sewer overflows (CSOs)
- Land-based non-point source pollution, urban runoff

Deeper (>100 m) offshore habitats (variety of substrates)

- Pipeline/cable installation
- Disposal of dredge spoil
- Oil and gas exploration and production
- Mineral mining

The most serious threats to benthic marine wolffish habitats are those that could reduce the number or accessibility of nesting sites used by the adults during the spawning season. Any activity that would knock down piled boulders (e.g., installation of pipelines and cables) or increase the rate at which fine sediment in the water column settles into the crevices between boulders (e.g., disposal of dredge spoil) could reduce the amount of spawning habitat available for the fish. These impacts could occur in nearshore waters since adult wolffish are known to spawn in depths <30 meters within a mile or two from shore (see Section 5). Oil spills could cause the smothering of egg deposition sites, with the added potential for toxic effects on the eggs. Disruptions of egg laying and guarding behavior could also occur in localized situations where bottom water temperatures increase above 10°C during the warmer months of the year when the adults are reproducing in coastal waters. Localized effects on water column habitats used by pelagic eggs and larvae could be reduced if nearshore waters are warmed by effluents from power plants or from discharges from engine cooling operations at coastal liquefied natural gas facilities. In the long term, climate change could cause bottom water temperatures to increase, especially at the southern extreme of the range, in the Gulf of Maine. Most, if not all, of these potential threats to coastal boulder reef habitats can be avoided, or at least minimized, by the use of best management practices (Johnson et al., 2008), especially by avoiding sensitive, rocky-bottom habitats.

7.1.3 Summary and Evaluation

Coastal boulder reef spawning habitats utilized by Atlantic wolffish in western Canada and the Gulf of Maine are highly vulnerable to physical damage that would result from the use of mobile, bottom-tending fishing gear (bottom trawls and scallop dredges). However, these gears are not normally used in such environments because they are severely damaged or lost if they come in contact with piled boulders. Other sandy and hard bottom pebble-cobble habitats used by juvenile and adult wolffish are less vulnerable to modification from fishing, but are exposed to fishing gear effects over a wide expanse of the continental shelf. The general effects of bottom trawls and dredges include reduction in habitat complexity, changes in benthic community composition, and reduced benthic productivity, especially in deeper-water environments that are not disturbed by bottom currents and wave action. Fishing could reduce the survival of juvenile Atlantic wolffish by reducing the amount of shelter available for escaping predators, but if this is the case, the effect is probably negligible and is not expected to threaten the continued existence of the Western Canada – Gulf of Maine Atlantic wolffish DPS. In all cases, the potential adverse impacts of non-fishing human activities on boulder reef spawning habitat in coastal waters would be restricted to localized environments and are not expected to affect the continued existence of the DPS. Many of them could be avoided all together by siting project activities so that they avoid sensitive wolffish spawning habitats. Potential adverse impacts to offshore (depths >100 meters) benthic wolffish habitats from activities such as oil and gas exploration and production, mineral mining, dredge spoil disposal, and pipeline and cable installation would be localized and do not threaten the continued existence of the DPS.

7.2. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

7.2.1 History of effort in the Northeast multispecies fishery

In the United States portion of the DPS, Atlantic wolffish are primarily taken incidental to the federal multispecies fishery. This fishery is regulated by NMFS and NEFMC (see section 7.4). Many of the regulations implemented over the past 20 years have sharply reduced the amount of effort (Table 7.2.1.1) in the multispecies fishery and the amount of area available for fishing activity (Figure 7.2.1.1). The DAS allocated declined by almost 80% from 1996 to 2007. In addition to these effort reductions, gear regulations have also played an important role in the overall catch composition (e.g. mesh size) and the type of bottom that can be fished (e.g. ban of "street sweepers"). The reductions in effort and fishing areas, as well as gear limitations clearly play a role in the declining catches of wolffish in the multispecies fishery. Some fishers have said that because of their severely limited DAS they can no longer afford to fish harder bottom where they might (or used to) encounter wolffish, but will also likely damage their gear, thereby losing valuable fishing time.

Northeast Multispecies FMP
The Northeast Multispecies FMP was implemented 1986. It was the first plan in the world to set biological targets in terms of maximum spawning potential (%MSP). The plan greatly expanded the number of species included in the management unit. The plan also enlarged one of the haddock spawning closed areas, Area I, and established a large closed area off of southern New England to protect spawning yellowtail and to help reduce fishing mortality.

Amendment 2
In January 1989, the Council adopted Amendment 2 which established a seasonal large mesh area on Nantucket shoals to protect cod, applied mesh size regulations to the whole of mobile nets rather than only to the codend and excluded trawlers from Area II during the closure to improve enforcement of the closure.

Amendment 5
Amendment 5 (1994) proposed to rebuild the cod, haddock, and yellowtail stocks through a stepwise reduction in fishing mortality. Specifically, one of the objectives of Amendment 5 was to reduce fishing mortality through measures which included reductions in fishing time, a moratorium on new permits, an increased mesh size, modifications to existing closed areas, additional closed areas, control areas for juvenile fish, and possession limits on regulated species when possessing small mesh.
Amendment 7

The amendment (1996) accelerated the DAS effort reduction program established in Amendment 5, eliminated significant exemptions from the current effort control program, provided incentives to fish exclusively with mesh larger than the minimum required, broadened the area closures to protect juvenile and spawning fish, and increased the haddock possession limit to 1,000 pounds. It established a rebuilding program based primarily on days-at-sea (DAS) controls, area closures, and minimum mesh size.

Amendment 13 Development and Implementation
The main purpose of Amendment 13 (2004) was to end overfishing on groundfish stocks and to rebuild all of the groundfish stocks that were overfished. The Amendment addressed stock rebuilding issues, greatly reduced fishing effort and capacity in the multispecies fishery, included measures to minimize incidental catch, instituted improved reporting and recordkeeping requirements, and implemented additional measures to specifically address habitat protection.

Framework Adjustments
Framework 33 was implemented on June 1, 2000. This framework maintained some seasonal closures and implemented new ones, maintained or reduced trip limits, and mandated that party and charter vessels obtain a letter of authorization to fish in any of the GOM closed areas.

Framework 40A was created in order to mitigate economic and social impacts from the effort reductions imposed by Amendment 13. It was intended to provide additional opportunities for vessels in the fishery to target healthy stocks. The framework instituted the Category B (Regular) DAS Pilot Program, the Eastern United States / Canada Haddock SAP Pilot Program, and the Closed Area I Hook Gear Haddock Special Access Program, a program that allows longline vessels to fish in Closed Area I to target haddock.

Framework 42 introduced several measures to achieve rebuilding of fishing mortality targets. The Framework instituted a wide range of changes included the differential DAS system, where DAS are counted at the rate of 2:1 in certain areas in the Gulf of Maine (GOM) and Southern New England (SNE).

7.2.2. Directed Harvest

There is no evidence of a directed fishery for Atlantic wolffish throughout the Western Atlantic DPS. Atlantic wolffish are encountered during commercial and recreational fishing but are believed to not be a targeted species but still one of value to fishers. Exploratory fishing was conducted in Canada in the early 1990's but catch rates were unable to sustain a viable directed commercial fishery (Kulka et al., 2007).

Table 7.2.1.1: Number of permits and Days at Sea (DAS) allocated and used since 1996

	Number of Permitted Vessels that Called In	Total Number of Permitted Vessels	Total DAS allocated	DAS Allocated to Vessels that Called In	Total DAS Used
1996	990	1,705	236,218	140,612	51,968
1997	1,090	1,713	155,270	101,905	49,464
1998	1,062	1,636	156,989	106,415	52,935
1999	1,067	1,646	160,452	106,506	54,271
2000	1,082	1,649	160,720	109,757	61,290
2001	1,097	1,589	156,290	111,589	65,347
2002	992	1,402	71,218	61,763	41,707
2003	931	1,404	71,344	59,334	42,347
2004	773	1,484	44,492	40,317	30,096
2005	685	1,320	50,018	37,247	31,773
2006	625	1,284	50,820	34,106	31,794
2007	574	1,271	49,710	31,170	32,804

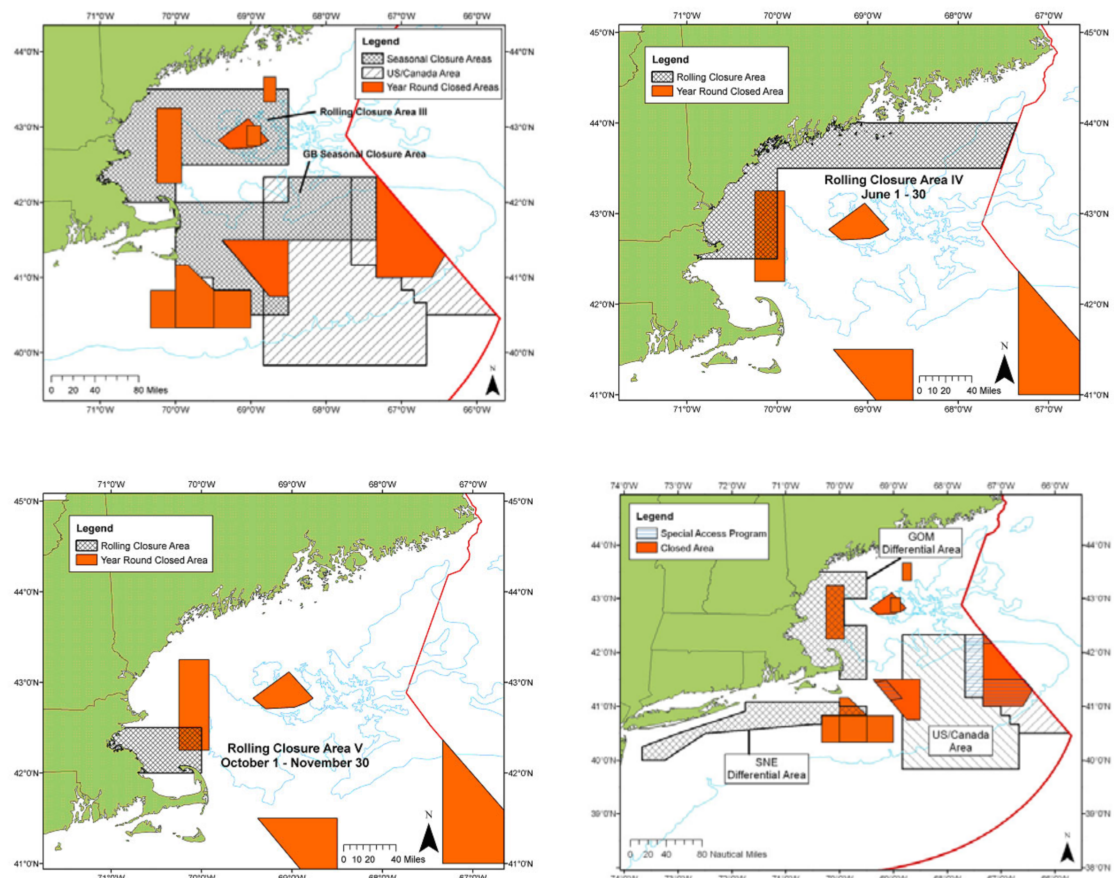


Figure 7.2.1.1 (continued)

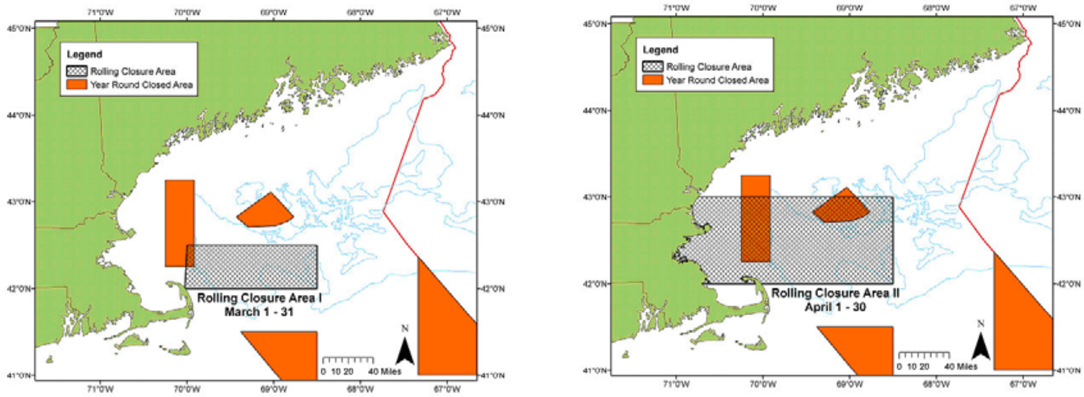


Figure 7.2.1.1 Year round closures, rolling closures and differential areas in the northeast multispecies fishery (Rolling closure III also shows the habitat closed areas)

7.2.3. Incidental catch

Atlantic wolffish are captured incidentally throughout Canadian waters by most, if not all, gear types. Currently threatened wolffish species, the northern and spotted wolffish, in Canada are required to be live released and have been since 2004. This program is likely beneficial to Atlantic wolffish as well. DFO commercial landings lump all wolffish species together, however northern wolffish is primarily discarded at sea and not landed and unlikely included in landings statistics. Commercial landings from the region south of the Grand Banks are composed primarily of Atlantic wolffish. This region encompasses a large part of the western Atlantic DPS, including the Gulf of St. Lawrence, Scotian Shelf, Bay of Fundy and the Gulf of Maine. The combined landings from these regions were approximately 1,000-1,500 mt in the 1960's, which increased to 2,000 mt from 1968-1979, then peaked in 1983 at approximately 4,000 mt, dropped steadily in the 1990's to approximately 1,000 mt and then averaged 625 mt in the early 2000's (Kulka et al., 2007). The incidental catches of wolffish in southern Newfoundland during the 1995-2002 period, (NAFO Area 3Ps), were approximately 114 mt (Kulka et al 2007) (Table 7.2.3.1). According to fishery observers Atlantic wolffish was the primary species recorded in this region.

In the United States, Atlantic wolffish have been taken primarily as incidental catch in the otter trawl fishery. Although directed harvesting may occur, it is likely a small component of the fishery. United States landings increased until peaking in 1983 at 1100 metric tons (mt) and then declined steadily until 2007, the latest complete year available, where landings were 63 mt (Figure 7.2.3.1 and Table 7.2.3.2).

Over all years, percent commercial landings of wolffish were dominated by otter trawl gear (90.8%), followed by fixed gillnets (4.3%) and bottom tending longlines (3.3%) (Table 7.2.3.3). However, otter trawls have decreased in importance over time as evidenced by increased reported landings of gillnets and longlines (Figure 7.2.3.2). Otter trawl gear accounted for a minimum of 74% to a maximum of 99% of the wolffish landings from 1964 to 2007 (Figure 7.2.3.2). Fixed gill nets and bottom tending longline fisheries account for the majority of remaining landings.

Table 7.2.3.1. Newfoundland and Labrador catch of wolffishes by NAFO Areas, 1995-2002 (from Kulka et al., 2007).

NAFO (Sub) Division	Landings kg Yearly Average	%	Value $ Yearly Average	%
3Ps	114,223	40	56,764	42
3Pn	52,312	18	23,429	17
4R	55,459	19	26,491	20
3N	34,849	12	15,927	12
3L	16,522	6	5,937	5
3K	11,835	4	5,499	4
3O	2,160	.7	1,280	1
2J	1,471	.5	644	.5
4S	182	.1	175	.1
4VN	77	.03	23	.02
2H	27	.01	13	.01
4VS	7	.002	3	.001
TOTAL	289,125		136,182	

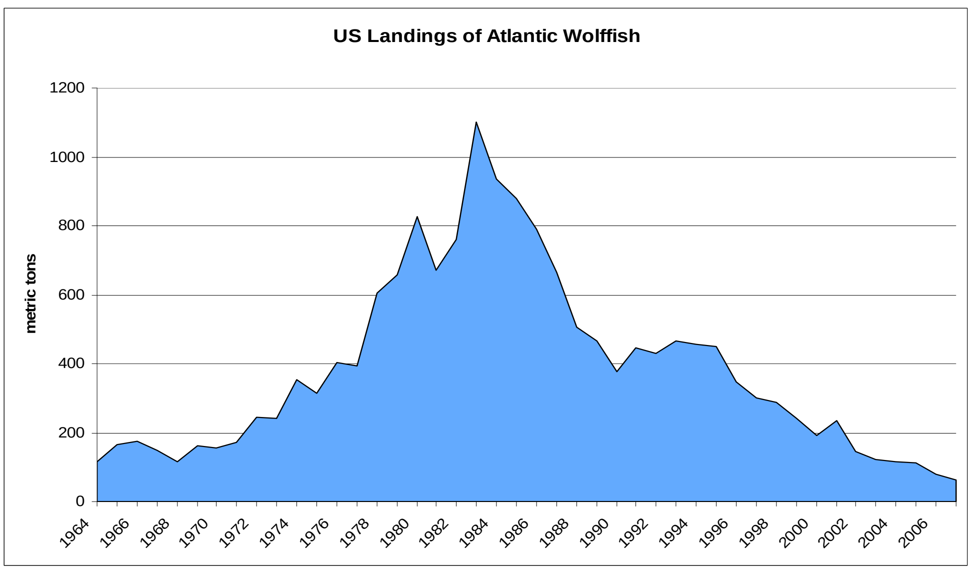


Figure 7.2.3.1. Time series of reported commercial landings from United States waters.

Table 7.2.3.2. Summary table of commercial landings (CFDBS), discards and recreational catch (MRFSS) of Atlantic wolffish, 1964-2007.

YEAR	MRFSS (mt)	CFDBS (mt) US Only	Discard OT LL GN (mt) US Only	Total Catch (mt) US Only	Total Catch (1000 mt) US Only
1963	--	--	--	--	--
1964	--	114.32	--	114.32	0.114
1965	--	166.51	--	166.51	0.167
1966	--	174.42	--	174.42	0.174
1967	--	149.58	--	149.58	0.150
1968	--	116.22	--	116.22	0.116
1969	--	163.28	--	163.28	0.163
1970	--	154.83	--	154.83	0.155
1971	--	172.80	--	172.80	0.173
1972	--	243.94	--	243.94	0.244
1973	--	242.63	--	242.63	0.243
1974	--	352.79	--	352.79	0.353
1975	--	313.12	--	313.12	0.313
1976	--	401.93	--	401.93	0.402
1977	--	393.76	--	393.76	0.394
1978	--	605.24	--	605.24	0.605
1979	--	656.49	--	656.49	0.656
1980	--	826.46	--	826.46	0.826
1981	0.81	671.61	--	672.42	0.672
1982	23.12	760.40	--	783.52	0.784
1983	11.90	1099.92	--	1111.83	1.112
1984	13.18	935.31	--	948.50	0.948
1985	15.95	879.96	--	895.91	0.896
1986	7.24	789.79	--	797.03	0.797
1987	37.71	665.13	--	702.83	0.703
1988	9.03	505.59	--	514.62	0.515
1989	20.49	466.84	26.98	514.31	0.514
1990	29.17	378.16	2.63	409.95	0.410
1991	16.86	446.56	1.95	465.37	0.465
1992	10.73	430.92	19.18	460.83	0.461
1993	20.11	467.22	13.38	500.71	0.501
1994	18.54	455.39	0.11	474.04	0.474
1995	20.45	449.81	5.77	476.02	0.476
1996	12.33	347.98	4.53	364.84	0.365
1997	20.21	301.77	7.82	329.79	0.330
1998	16.84	286.84	2.25	305.92	0.306
1999	8.54	242.75	0.35	251.64	0.252
2000	12.40	191.34	0.54	204.29	0.204
2001	16.67	236.00	6.47	259.14	0.259
2002	9.82	145.58	13.10	168.50	0.169
2003	24.23	123.05	3.82	151.11	0.151
2004	12.45	116.95	1.58	130.98	0.131
2005	10.73	114.04	1.31	126.08	0.126
2006	17.86	80.05	1.45	99.36	0.099
2007	12.87	63.32	0.84	77.03	0.077
2008	--	--	--	--	--

Table 7.2.3.3. Percent landings of Atlantic wolffish by major gear type for all years combined.

Percent Landings by Major Gear Type	
Gear Name	Grand Total
Offshore Lobster Pots	0.02%
Inshore Lobster Pots	0.03%
Longline- pelagic	0.05%
Handline	0.24%
Danish Seine	0.30%
Sea Scallop Dredge	0.40%
Shrimp Otter Trawl – bottom	0.51%
Longline – bottom	3.30%
Gill Net – fixed	4.33%
Fish Otter Trawl – bottom	90.83%
Grand Total	100.00%

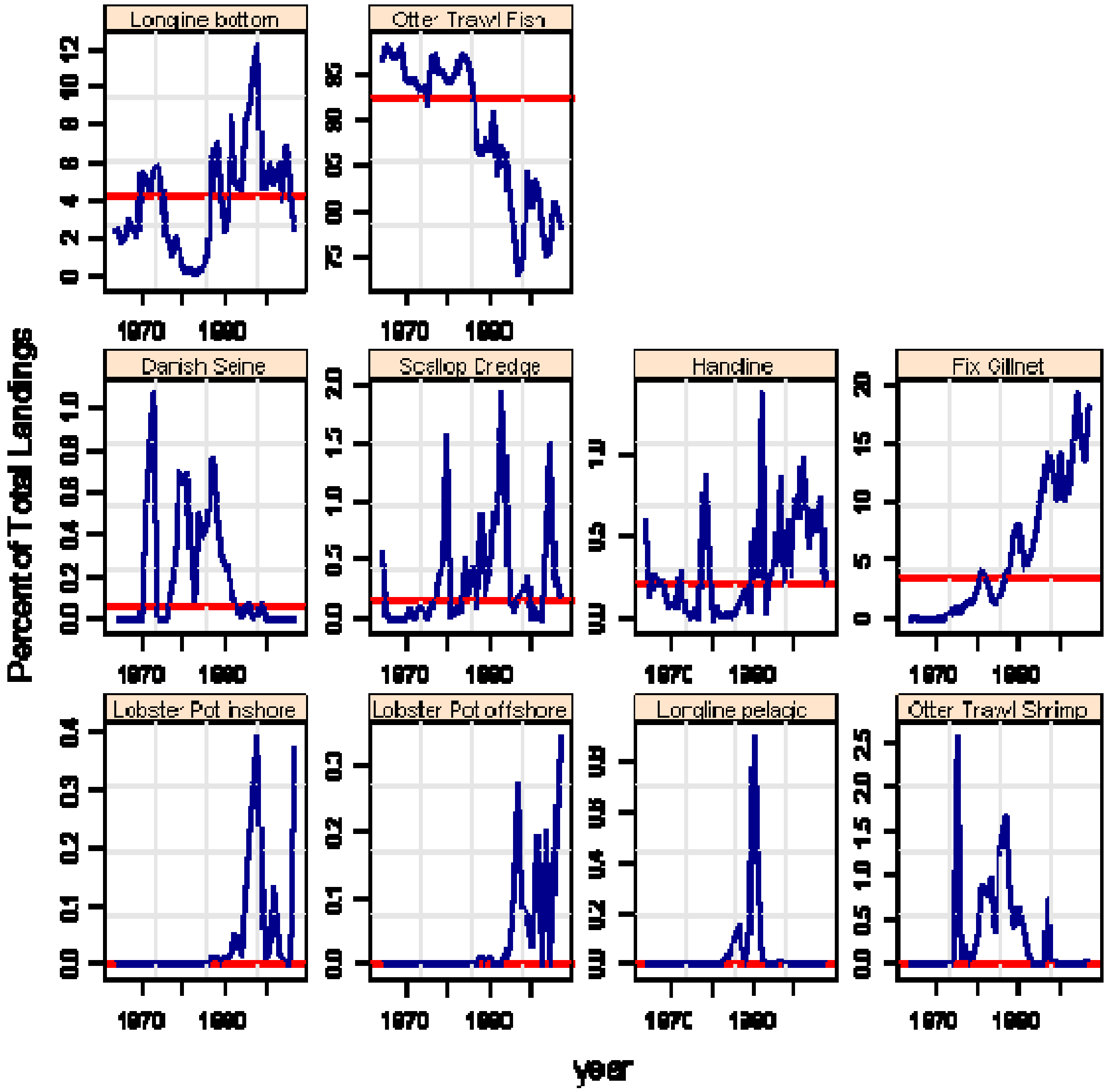


Figure 7.2.3.2. Commercial Landings of Atlantic wolffish by gear and year, 1964-2007. Note the Y axis is variable.

Table 7.2.3.4. Percent commercial landings of Atlantic wolffish by gear type over time from United States waters.

Gear Type	OT BOT FISH	FIXED GILL NET	LONGLINE BOTTOM	OT BOT SHRIMP	SS DREDGE	DANISH SEINE	HANDLIN E	LONGLINE PELAGIC	POT LOB IN	POT LOBOFF
1964	96.55%	0.00%	2.30%	0.00%	0.55%	0.00%	0.59%	0.00%	0.00%	0.00%
1965	97.80%	0.17%	1.84%	0.00%	0.05%	0.00%	0.14%	0.00%	0.00%	0.00%
1966	97.55%	0.08%	2.11%	0.00%	0.00%	0.00%	0.26%	0.00%	0.00%	0.00%
1967	96.78%	0.01%	3.00%	0.00%	0.00%	0.00%	0.21%	0.00%	0.00%	0.00%
1968	97.29%	0.01%	2.47%	0.00%	0.00%	0.00%	0.23%	0.00%	0.00%	0.00%
1969	97.80%	0.01%	2.12%	0.00%	0.00%	0.00%	0.07%	0.00%	0.00%	0.00%
1970	94.55%	0.04%	5.34%	0.00%	0.00%	0.00%	0.08%	0.00%	0.00%	0.00%
1971	94.11%	0.10%	5.12%	0.00%	0.06%	0.54%	0.07%	0.00%	0.00%	0.00%
1972	94.36%	0.06%	4.44%	0.00%	0.01%	0.84%	0.29%	0.00%	0.00%	0.00%
1973	92.99%	0.39%	5.40%	0.00%	0.08%	1.07%	0.06%	0.00%	0.00%	0.00%
1974	93.50%	0.69%	5.76%	0.00%	0.05%	0.00%	0.01%	0.00%	0.00%	0.00%
1975	91.81%	0.88%	4.69%	2.56%	0.02%	0.00%	0.03%	0.00%	0.00%	0.00%
1976	96.75%	0.72%	2.28%	0.08%	0.12%	0.00%	0.05%	0.00%	0.00%	0.00%
1977	97.11%	1.20%	1.14%	0.21%	0.16%	0.17%	0.01%	0.00%	0.00%	0.00%
1978	95.04%	1.36%	2.06%	0.00%	0.37%	0.30%	0.87%	0.00%	0.00%	0.00%
1979	95.17%	1.76%	1.46%	0.14%	0.43%	0.71%	0.32%	0.00%	0.00%	0.00%
1980	94.19%	2.69%	0.60%	0.33%	1.55%	0.65%	0.00%	0.00%	0.00%	0.00%
1981	94.00%	4.17%	0.15%	0.88%	0.04%	0.69%	0.06%	0.00%	0.00%	0.00%
1982	95.28%	3.23%	0.21%	0.82%	0.07%	0.36%	0.03%	0.00%	0.00%	0.00%
1983	96.96%	1.78%	0.09%	0.97%	0.08%	0.08%	0.03%	0.01%	0.00%	0.00%
1984	96.92%	1.40%	0.22%	0.38%	0.50%	0.49%	0.04%	0.04%	0.00%	0.00%
1985	96.08%	1.58%	0.39%	1.25%	0.20%	0.39%	0.01%	0.09%	0.00%	0.00%
1986	93.29%	2.54%	1.53%	1.46%	0.44%	0.48%	0.10%	0.15%	0.00%	0.00%
1987	87.09%	3.93%	6.28%	1.67%	0.10%	0.75%	0.13%	0.04%	0.01%	0.00%
1988	86.40%	4.27%	7.00%	0.80%	0.87%	0.48%	0.17%	0.00%	0.01%	0.01%
1989	87.68%	7.11%	4.06%	0.43%	0.21%	0.31%	0.06%	0.14%	0.00%	0.00%
1990	86.79%	8.11%	2.37%	0.63%	0.42%	0.24%	0.53%	0.89%	0.01%	0.01%
1991	90.54%	4.33%	3.02%	0.33%	0.89%	0.25%	0.28%	0.36%	0.01%	0.00%
1992	84.09%	5.06%	8.37%	0.10%	0.84%	0.14%	1.37%	0.01%	0.02%	0.00%
1993	87.04%	5.93%	4.94%	0.00%	1.92%	0.07%	0.05%	0.00%	0.05%	0.00%
1994	86.11%	7.75%	4.65%	0.01%	1.18%	0.02%	0.25%	0.00%	0.02%	0.01%
1995	81.09%	10.07%	8.14%	0.02%	0.13%	0.05%	0.36%	0.00%	0.12%	0.03%
1996	77.74%	12.00%	8.87%	0.02%	0.08%	0.07%	0.86%	0.01%	0.22%	0.12%
1997	73.20%	14.25%	10.84%	0.76%	0.16%	0.01%	0.22%	0.00%	0.30%	0.27%
1998	73.31%	13.32%	12.02%	0.04%	0.22%	0.01%	0.60%	0.00%	0.39%	0.09%
1999	84.06%	10.22%	4.79%	0.02%	0.35%	0.07%	0.28%	0.00%	0.14%	0.07%
2000	80.52%	14.01%	4.70%	0.00%	0.01%	0.00%	0.71%	0.00%	0.01%	0.03%
2001	83.11%	10.09%	5.87%	0.00%	0.07%	0.00%	0.63%	0.00%	0.03%	0.19%
2002	82.27%	11.56%	4.87%	0.00%	0.01%	0.00%	0.96%	0.00%	0.13%	0.19%
2003	78.33%	15.37%	5.84%	0.00%	0.00%	0.00%	0.44%	0.00%	0.02%	0.00%
2004	75.22%	19.24%	3.96%	0.01%	0.72%	0.00%	0.64%	0.00%	0.01%	0.20%
2005	75.78%	15.45%	6.74%	0.00%	1.48%	0.00%	0.55%	0.00%	0.00%	0.00%
2006	80.92%	13.53%	4.28%	0.01%	0.39%	0.00%	0.73%	0.00%	0.00%	0.14%
2007	78.35%	18.08%	2.45%	0.03%	0.16%	0.00%	0.21%	0.00%	0.37%	0.34%
Grand Total	90.83%	4.33%	3.30%	0.51%	0.40%	0.30%	0.24%	0.05%	0.03%	0.02%

Reported United States commercial wolffish landings come primarily from fishery statistical areas 513, 514, 515, 521 and 522 (Figure 7.2.3.3 & 7.2.3.4 and Table 7.2.3.5). Landings have fluctuated between statistical areas over time and spatial differences may be difficult to interpret due to management actions, such as permanent closures and rolling time closures, in the Gulf of Maine.

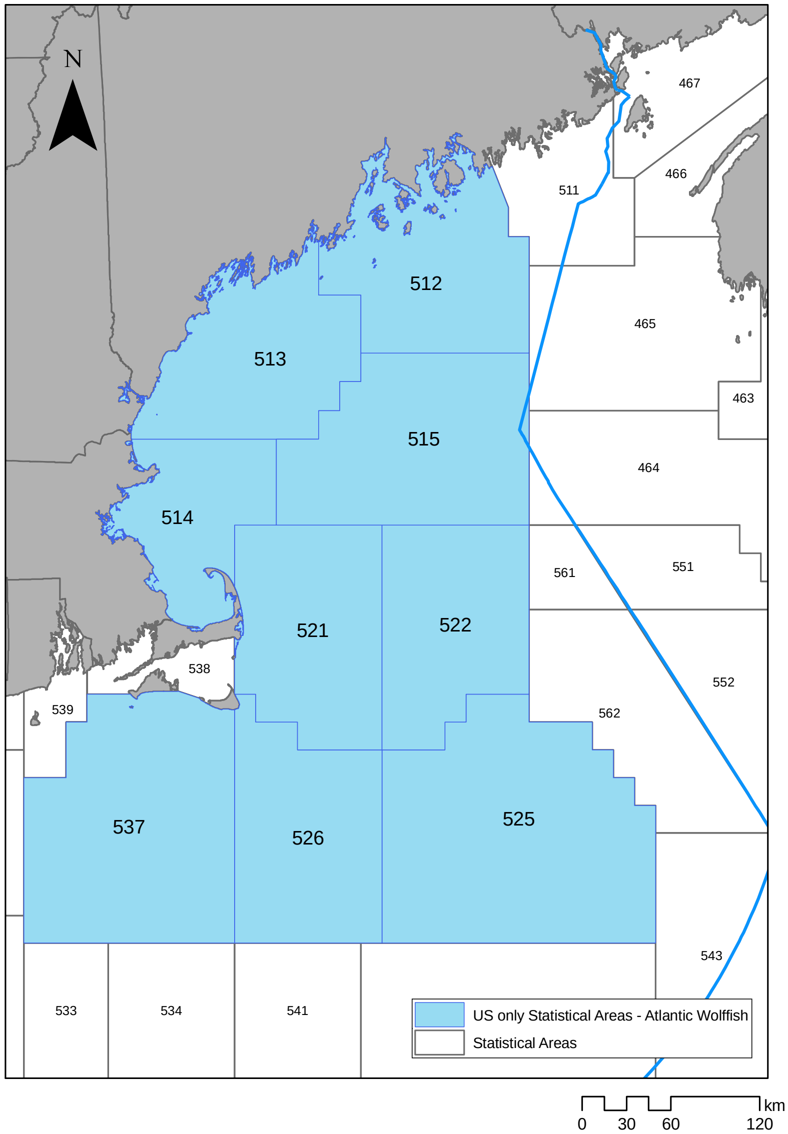


Figure 7.2.3.3. Fishery statistical areas used for Atlantic wolffish landings, catch and discard estimates.

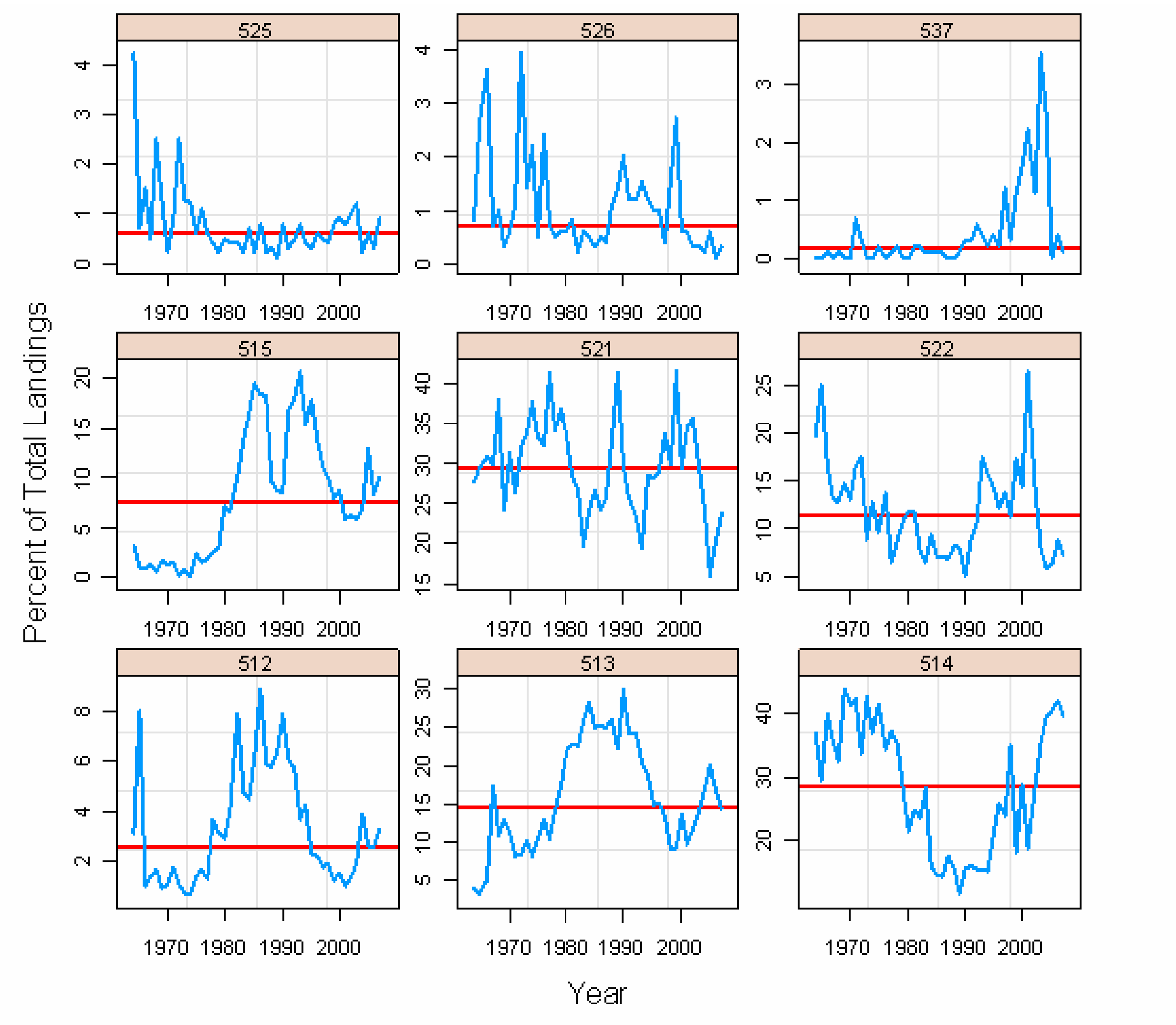


Figure 7.2.3.4. Reported commercial landings by fishery statistical area in the United States Note the Y axis scale is variable among panels.

Table 7.2.3.5. Percent United States Commercial Landings of Atlantic wolffish by Statistical Area and Year.

YEAR	512	513	514	515	521	522	525	526	537
1964	3.12	4.04	37.04	3.23	27.92	19.68	4.20	0.76	0.00
1965	8.06	3.35	29.81	0.92	29.43	25.04	0.72	2.64	0.04
1966	1.04	5.00	40.12	0.98	30.95	16.79	1.47	3.60	0.05
1967	1.45	17.26	35.79	1.27	29.84	13.21	0.49	0.70	0.00
1968	1.72	10.96	32.65	0.55	37.79	12.71	2.55	0.97	0.10
1969	0.86	12.90	43.91	1.74	24.19	14.83	1.31	0.26	0.01
1970	1.12	11.05	41.51	1.25	31.19	13.03	0.19	0.63	0.03
1971	1.85	8.22	42.60	1.63	26.38	16.63	0.85	1.11	0.73
1972	1.07	8.43	33.74	0.31	32.11	17.62	2.50	3.95	0.28
1973	0.74	10.16	42.75	0.80	33.97	8.85	1.32	1.41	0.00
1974	0.74	8.16	37.03	0.21	37.61	12.80	1.21	2.21	0.02
1975	1.36	10.36	41.55	2.50	33.34	9.56	0.60	0.50	0.23
1976	1.70	12.99	34.29	1.53	32.27	13.75	1.06	2.40	0.00
1977	1.34	10.35	37.32	2.02	41.23	6.41	0.58	0.69	0.06
1978	3.71	14.34	35.40	2.37	34.21	8.93	0.36	0.53	0.15
1979	3.10	17.30	28.31	3.09	36.66	10.77	0.16	0.61	0.00
1980	2.94	21.78	21.63	7.24	33.58	11.75	0.49	0.57	0.00
1981	3.99	22.82	24.83	6.61	28.63	11.73	0.39	0.80	0.21
1982	7.88	22.65	23.83	10.27	26.92	7.67	0.35	0.19	0.24
1983	4.65	25.89	28.51	13.92	19.84	6.35	0.22	0.57	0.06
1984	4.46	28.29	16.08	16.53	23.95	9.41	0.70	0.49	0.09
1985	6.17	25.18	14.83	19.47	26.63	7.09	0.21	0.35	0.05
1986	8.92	25.29	14.59	18.43	24.31	7.10	0.78	0.52	0.06
1987	5.90	25.25	17.55	18.22	25.56	6.91	0.18	0.42	0.01
1988	5.82	26.08	15.75	9.69	32.96	8.31	0.26	1.11	0.00
1989	6.39	22.29	11.78	8.76	41.19	8.01	0.10	1.37	0.13
1990	7.90	29.96	15.65	8.59	29.71	5.05	0.83	2.02	0.30
1991	6.08	24.30	16.41	16.68	25.59	9.10	0.33	1.22	0.29
1992	5.74	24.38	15.56	18.10	23.29	10.64	0.49	1.25	0.55
1993	3.73	20.35	15.56	20.61	19.51	17.49	0.83	1.49	0.42
1994	4.32	18.85	15.44	15.27	28.65	15.68	0.39	1.20	0.19
1995	2.26	14.92	20.65	17.80	28.26	14.39	0.29	1.04	0.39
1996	2.16	15.06	25.96	13.82	28.98	12.18	0.63	0.97	0.24
1997	1.82	13.48	24.10	11.09	33.59	13.72	0.54	0.43	1.23
1998	1.87	9.25	35.34	10.08	29.92	11.24	0.44	1.58	0.28
1999	1.18	9.34	18.35	7.91	41.27	17.39	0.83	2.66	1.06
2000	1.53	13.68	29.21	8.72	29.39	14.38	0.90	0.59	1.61
2001	0.96	9.84	18.99	5.81	34.47	26.30	0.83	0.60	2.21
2002	1.36	11.77	28.52	6.17	35.49	14.24	1.05	0.28	1.13
2003	1.91	14.05	35.62	5.81	29.78	7.93	1.18	0.25	3.47
2004	3.91	16.86	39.49	6.92	24.22	5.78	0.18	0.18	2.46
2005	2.58	20.06	40.80	12.93	16.14	6.22	0.61	0.64	0.03
2006	2.56	16.84	42.28	8.33	20.32	8.85	0.31	0.10	0.41
2007	3.29	14.39	39.78	10.08	23.84	7.30	0.85	0.34	0.12
Grand Total	4.11	19.26	24.64	10.28	29.20	10.70	0.59	0.94	0.27

Commercial fishery discards from the Northeast Fisheries Observer Program database were estimated for the period 1989-2007 from United States only statistical areas based on the Standardized Bycatch Reporting Methodology combined ratio estimation (Wigley et al., 2007). Discards appear to be a small component of the overall catch of Atlantic wolffish (Figures 7.2.3.6 & 7.2.3.7 and Table 7.2.3.2). Fisheries with little observer coverage and changes in discarding behavior could impact estimated totals. The maximum estimated discards in any one year are 26.98 mt, occurring in 1989 the first year of observer coverage (Table 7.2.3.2). Otter trawls account for 98.3% of the total discarded wolffish from all years. Discards appear to be increasing in the gillnet sector, which reported approximately 17% of the total wolffish discarded for 2007 (Table 7.2.3.6). Discards are assumed as part of the fishery mortality. Survival rates of discarded wolffish are unknown in United States waters but evidence from Canadian waters indicates that survivability may be high even after long tow times and after substantial exposure on deck (Grant et al., 2005).

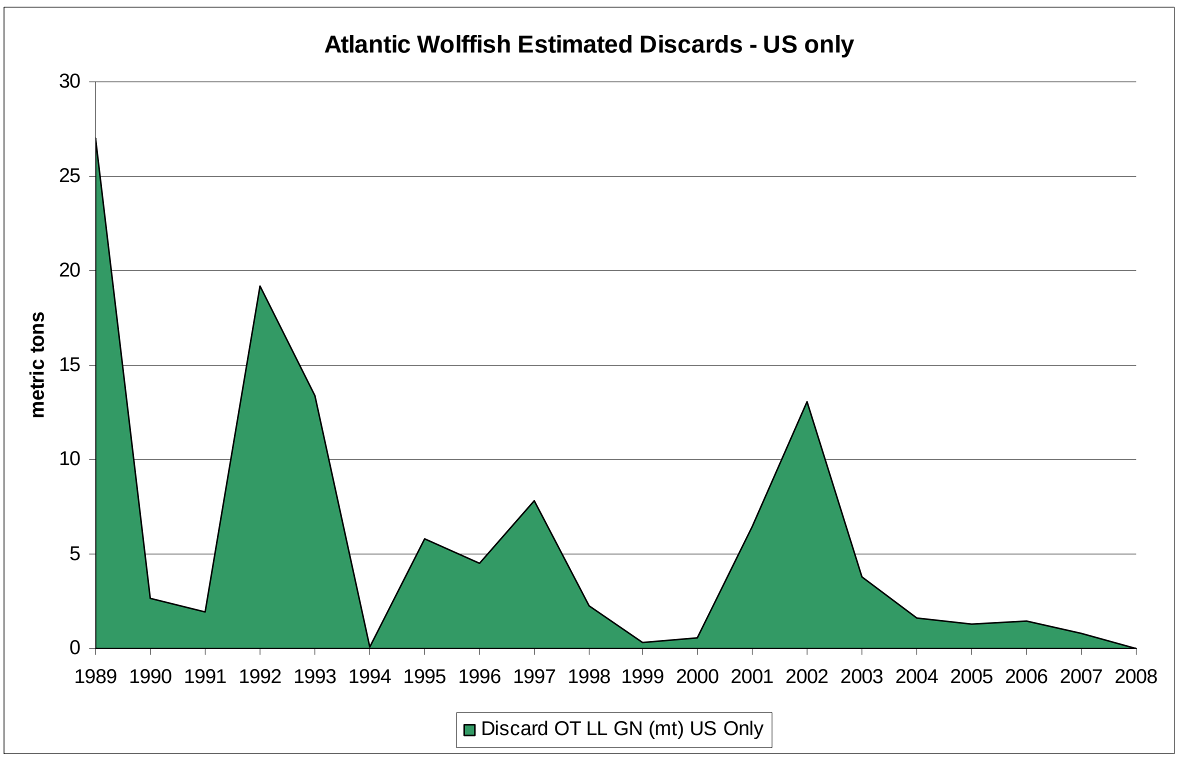


Figure 7.2.3.5. Estimated commercial discards based on Fishery Observer data, 1989-2007.

Table 7.2.3.6. Commercial Discard Estimates for Atlantic wolffish by major gear type in United States waters.

	Metric Tons				Percent		
YEAR	LL	OT	GN	Grand Total	LL	OT	GN
1989	0.00	26.98	0.00	26.98	0.00	100.00	0.00
1990	0.00	2.63	0.00	2.63	0.00	100.00	0.00
1991	0.00	1.95	0.00	1.95	0.00	100.00	0.00
1992	0.51	18.67	0.00	19.18	2.66	97.34	0.00
1993	0.00	13.38	0.00	13.38	0.00	100.00	0.00
1994	0.00	0.11	0.00	0.11	0.00	100.00	0.00
1995	0.00	5.77	0.00	5.77	0.00	100.00	0.00
1996	0.00	4.53	0.00	4.53	0.00	100.00	0.00
1997	0.00	7.11	0.71	7.82	0.00	90.91	9.09
1998	0.00	2.25	0.00	2.25	0.00	100.00	0.00
1999	0.00	0.35	0.00	0.35	0.00	100.00	0.00
2000	0.00	0.49	0.06	0.54	0.00	89.28	10.72
2001	0.00	6.47	0.00	6.47	0.00	100.00	0.00
2002	0.00	13.10	0.00	13.10	0.00	100.00	0.00
2003	0.00	3.67	0.15	3.82	0.00	96.01	3.99
2004	0.00	1.34	0.23	1.58	0.00	85.28	14.72
2005	0.00	1.22	0.09	1.31	0.00	93.37	6.63
2006	0.03	1.42	0.00	1.45	1.90	98.10	0.00
2007	0.01	0.69	0.14	0.84	0.65	82.16	17.19
Grand Total	0.54	112.13	1.39	114.06	0.48	98.31	1.21

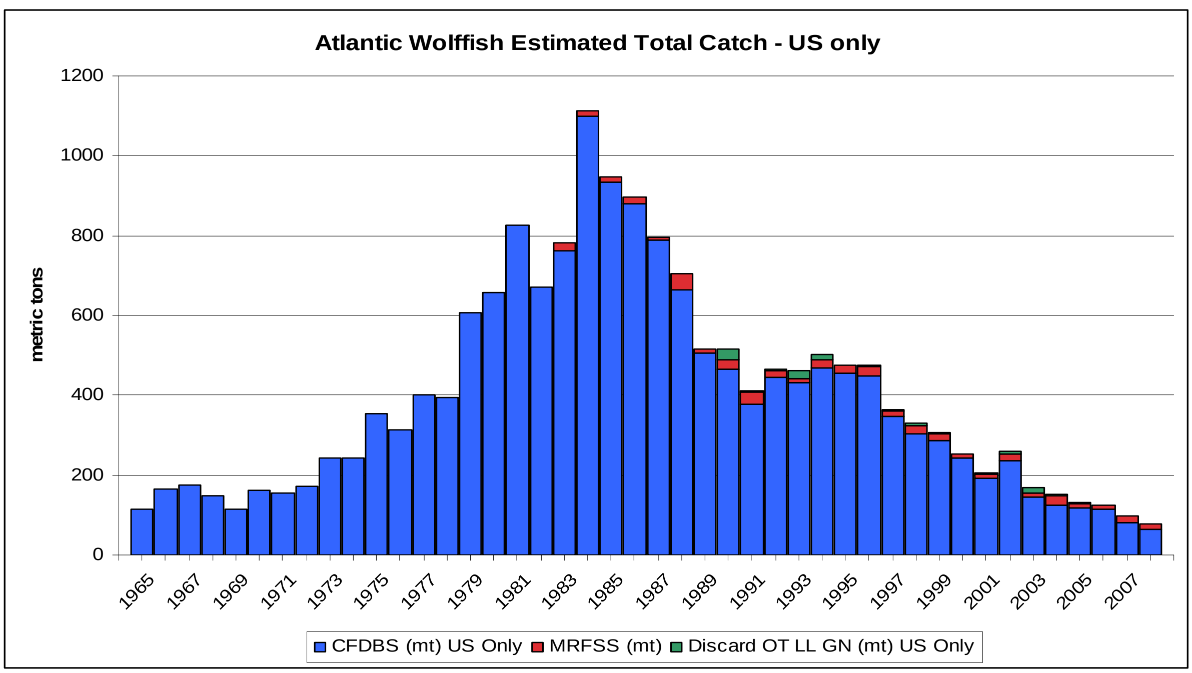


Figure 7.2.3.6. Total catch from reported commercial landings, estimated discards and recreational landings for United States only 1964-2007.

Maine Lobster Sea Sampling Program

The DMR lobster sea sampling program places trained observers onto commercial lobster boats. Catch and effort information is collected and biological data is recorded for each lobster caught. The data collected reflects what comes up in that lobsterman's trap for that day of the year. The program samples each lobster zone three times per month from May to November (Figure 7.2.3.7).

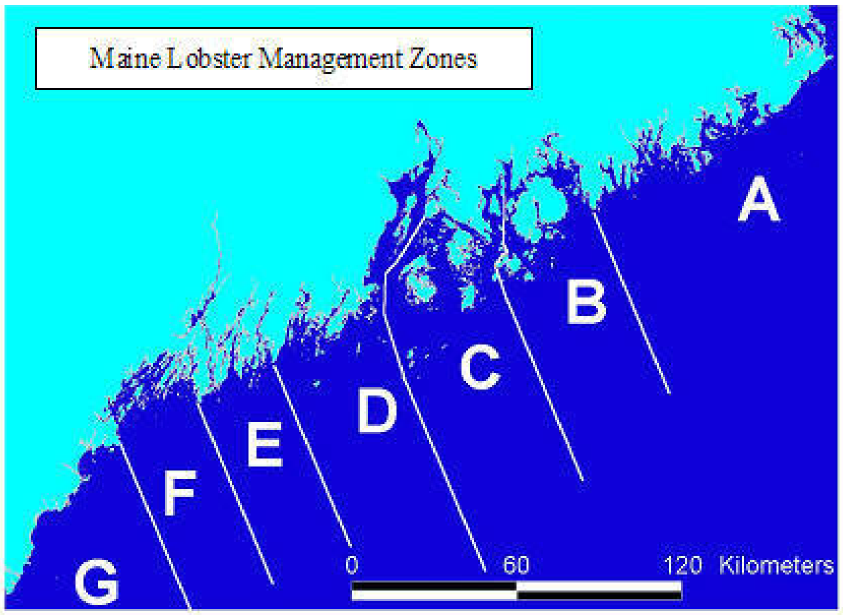


Figure 7.2.3.7 Maine lobster management zones.

Sea samplers schedule trips with a lobsterman who will be actively fishing the following day. A typical day of sea sampling begins between 4 and 7 a.m. and may end anywhere from 2 to 6 p.m. The sea sampler asks general trip information including soak time and string type. Throughout the trip, the sampler will ask to record geographical and depth information or will be equipped with his/her own GPS unit to record these data automatically. From the first trap to the last, the sampler measures each lobster, notes sex, cull status, v-notch condition (if present), egg development stage, and molt status. Samplers are asked to note any finfish incidental catch observed in the lobster pots if time permits (Figure 7.2.3.8). These incidental catch data have been recorded since 2002. Starting in 2006, it was noted in the database if incidental catch was observed or not.

Seven wolffish were observed in the lobster sea sampling program since 2002. All were caught between April and August, with the majority seen in June (Table 7.2.3.7). Table 7.2.3.8 summarizes the length and depth data. When these data are expanded using a ratio estimate of wolffish count to landed lobster count for statistical areas 511, 512 and 513 for the months of April-August, it accounts for a take of almost 19,000 (SD±1978) wolffish between 2002 and 2007.

Table 7.2.3.7: Atlantic wolffish observed in the ME lobster sea sampling program.

YEAR	APRIL	MAY	JUNE	JULY	AUGUST	TOTAL
2002	0	0	0	0	0	0
2003	0	0	0	0	0	0
2004	0	0	2	0	0	2
2005	0	0	0	0	0	0
2006	0	2	0	0	0	2
2007	0	0	2	0	1	3
2008	0	0	0	0	0	0
TOTAL	0	2	4	0	1	7

Table 7.2.3.8 Length and depth data for Atlantic wolffish caught in the ME lobster sea sampling program.

Length (cm)

Min	25th quartile	50th quartile	mean	75th quartile	max
35.6	40.6	53.3	57.3	69.9	91.4

Depth (m)

Min	25th quartile	50th quartile	mean	75th quartile	max
27.4	49.4	64.0	57.5	64.0	84.1

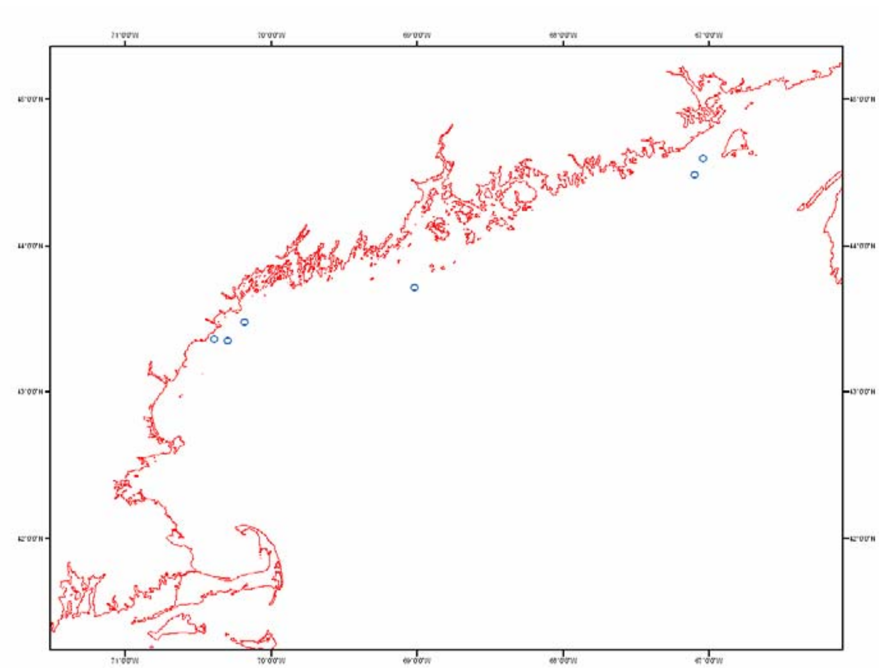


Figure7.2.3.8: Catch locations of Atlantic wolffish in the ME lobster sea sampling program.

7.2.4. Recreational Impacts

Recreational catch data was retrieved from the MRFSS database (Figure 7.2.4.1 and Table 7.2.4.1). Landings are reported in total number of fish and total weight per year. Landings include both A and B1 fish, these are fish permanently removed from the population. B2 fish are discarded live and are assumed to have survived. Adjusted landings were developed because average weight of an individual wolffish was highly variable. Average weight (kg) was calculated based on the reported numbers of landed fish (A + B1) divided by the reported landed weight (kg). A grand mean was calculated from average weights and used in the new adjusted landings values. Adjusted landing are less variable than the original reported values and are likely to describe the recreational portion of total catch. Recreational catches have become a greater portion of the total catch in recent years as commercial landings have steadily declined (Figure 7.2.3.7 and Table 7.2.3.2). Recreational catch makes up 16% of the total catch and is approximately 20% of the commercial landings in 2007 (Table 7.2.3.2).

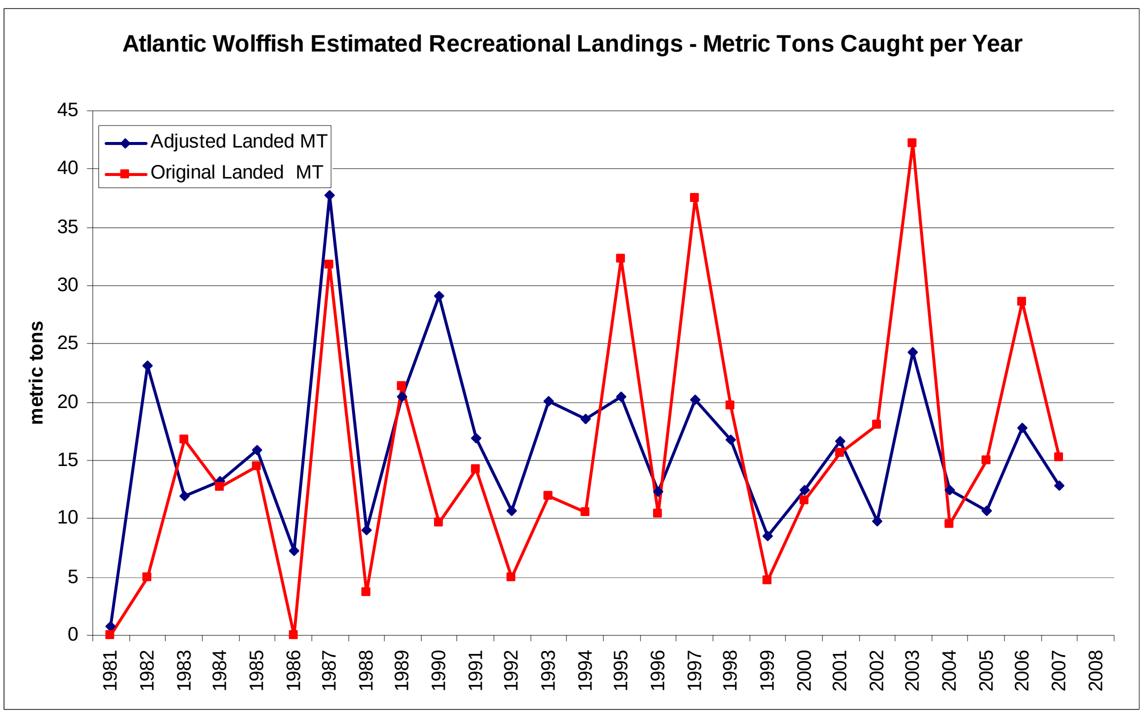


Figure 7.2.4.1. Reported and adjusted recreational landings by year from MRFSS database, 1981-2007.

Table 7.2.4.1 Atlantic wolffish recreational catch summary from MRFSS database, 1981-2007.

Year	Landed # (A + B1)	Discarded # (live) (B2)	Landed kg (A + B1)	Landed MT	Ave Wt kg	Adjusted Landed kg	Adj Landed MT
1981	334	0	unk	unk		806.38	0.81
1982	9,576	2,789	4,952	4.952	0.52	23,119.43	23.12
1983	4,930	88	16,776	16.776	3.40	11,902.54	11.90
1984	5,461	366	12,740	12.74	2.33	13,184.54	13.18
1985	6,607	0	14,428	14.428	2.18	15,951.34	15.95
1986	3,000	0	unk	unk		7,242.93	7.24
1987	15,618	691	31,733	31.733	2.03	37,706.68	37.71
1988	3,740	574	3,748	3.748	1.00	9,029.52	9.03
1989	8,486	6,956	21,415	21.415	2.52	20,487.83	20.49
1990	12,081	386	9,628	9.628	0.80	29,167.27	29.17
1991	6,984	7,180	14,250	14.25	2.04	16,861.54	16.86
1992	4,446	213	4,985	4.985	1.12	10,734.02	10.73
1993	8,329	1,544	11,969	11.969	1.44	20,108.78	20.11
1994	7,681	820	10,526	10.526	1.37	18,544.31	18.54
1995	8,470	2,027	32,287	32.287	3.81	20,449.20	20.45
1996	5,105	5,841	10,391	10.391	2.04	12,325.05	12.33
1997	8,369	833	37,474	37.474	4.48	20,205.35	20.21
1998	6,974	5,029	19,760	19.76	2.83	16,837.39	16.84
1999	3,538	2,389	4,741	4.741	1.34	8,541.83	8.54
2000	5,138	4,463	11,592	11.592	2.26	12,404.72	12.40
2001	6,905	4,841	15,628	15.628	2.26	16,670.81	16.67
2002	4,069	1,953	17,996	17.996	4.42	9,823.82	9.82
2003	10,035	1,204	42,207	42.207	4.21	24,227.59	24.23
2004	5,158	6,237	9,573	9.573	1.86	12,453.01	12.45
2005	4,445	481	14,955	14.955	3.36	10,731.60	10.73
2006	7,397	9,513	28,614	28.614	3.87	17,858.65	17.86
2007	5,329	8,678	15,253	15.253	2.86	12,865.85	12.87
2008							

Grand Mean Average Weight (kg) = **2.41**

7.2.5. Scientific and Educational Utilization

Overall, scientific collections or collections for educational purposes do not seem to be significantly affecting the status of Atlantic wolffish. The BRT found the following scientific or educational projects that directly target Atlantic wolffish:

The primary scientific utilization of Atlantic wolffish is related to its naturally occurring antifreeze proteins (AFPs). These AFPs are essential to the survival of many species of cold water marine fish. AFPs function by depressing the freezing point of the blood through the inhibition of ice crystal formation (Venugopal, 2006). Atlantic wolffish is one of the glycoprotein-producing fish along with Atlantic cod, Greenland cod, winter flounder, and sculpins.

Antifreeze protein studies were started out initially as a biological curiosity, and now have emerged as a valuable tool in food science, medicine, and biotechnology. AFPs can

be added to living tissues, foods, and other materials to depress the freezing point non-colligatively or to allow freeze/thaw without ice recrystalization. For applications such as food preservation, natural AFPs from fish blood may be a convenient source that is likely to meet consumer acceptance since the consumption of AFPs does not impart any toxicologically significant effect (Thenmozhi, 2006). Abundant AFPs could be generated as by-products of processing certain fish species for food, thereby enhancing the sustainability and profitability of fisheries and aquaculture industries.
Atlantic wolffish are also being studied as a source of antimicrobial polypeptides (APs) and digestive enzymes (DEs). APs are being explored as "natural antibiotics" for use in human healthcare and agriculture/aquaculture. They have the benefit of not inducing bacterial resistance like convential antibiotics. DEs are widely used in industry including detergents, food processing and leather production. Atlantic wolffish DEs are potentially benefical since they function at low temperatures and some are activated by salt, a useful trait in some food treatments like fermentation (Le Francois, 2004).
The development and application of AFPs, APs and DEs from Atlantic wolffish are still being explored in conjunction with aquaculture programs in Quebec. Outside of the DPS identified in this status review, these compounds are also being studied by aquaculture programs in Norway and Iceland.

During NEFSC trawl surveys, fish are collected from bottom trawls using a Yankee 36 otter trawl, a total weight of all individuals is recorded. Individual lengths and weights are taken, stomach contents are analyzed and age structures (otoliths) are taken at a 1:1cm basis. Other fishery independent surveys, such as the MADMF, ME and NH also collect and process wolffish. Occasionally Atlantic wolffish are taken for display purposes for the Woods Hole Science Aquarium and the New England Aquarium.

7.2.6. Summary and Evaluation

The long term persistence of Atlantic wolffish are not significantly affected by the overutilization for commercial, recreational, scientific, or educational purposes in the Western Atlantic Canada/US DPS. Because wolffish are widely dispersed across the DPS they are inevitably captured during recreational and commercial fishing activities. Slow growing, low fecund species are considered more vulnerable to the threats of extinction but Atlantic wolffish also employ valuable life history characteristics to improve productivity and survivability such as internal fertilization, large eggs and nest guarding (Musick, 1999; Keats et al., 1985; Pavlov and Novikov, 1993). Management action in Canada has likely benefited Atlantic wolffish, including effort controls in groundfish fisheries and listing under SARA as a Species of Concern (Kulka et al., 2007). Similarly, fishery management effort controls and permanent and seasonal area closures within the Gulf of Maine have reduced both fishing mortality over time and habitat disturbance in these areas. Proposed action by the NEFMC under the NE Multispecies FMP Amendment 16 will mandate no possession of Atlantic wolffish by 2010 and will likely succeed in further curbing fishing mortality and improving resource health. Although discard mortality rates are not specifically known in the Gulf of Maine, a study from the yellowtail fishery in Canadian waters indicates that discard survival rates may be high as 100% (Grant et al., 2005). While estimated population numbers from US waters are low they are not believed to have reached levels were recovery is not plausible. Resource survey trends in parts of the Canadian portion of the DPS show improved recruitment at low biomass levels and stable or even increasing trends of abundance. The threats to Atlantic wolffish from recreational fishing impose a low risk to wolffish in the DPS. While recreational landings of Atlantic wolffish have occurred and become more significant in terms of overall catch in the US, due to reduced commercial landings, they are still relatively low over the entire DPS. Stewardship programs for all three wolffish species in eastern Canada have likely reduced incidental catch mortality and are building support for conservation and recovery of the resource (Pers. Comm., K. Blanchard, 2009). Proposed action discussed previously by the NEFMC will prohibit possession Atlantic wolffish by recreational fishers as well. Atlantic wolffish are used in various scientific research projects and for educational purposes but these do not pose a significant risk to the long term persistence of this species as these numbers are low.

7.3. Predation and Disease

7.3.1. Predation

While there are limited data available on Atlantic wolffish predators, Rountree (2002 in Collette and Klein-MacPhee) indicated that Atlantic wolffish have been reported in the stomachs of Greenland sharks (Barsukov, 1959), Atlantic cod (Sæmundsson, 1949; Barsukov, 1959), haddock (Orlova et al., 1989) and gray seals (Pierce et al., 1990). Spotted wolffish are believed to prey upon Atlantic wolffish eggs (Jonsson, 1982 in Collette and Klein-MacPhee). The NEFSC reports that Atlantic wolffish have been documented in the stomachs of the following species: goosefish, sea raven, longhorn sculpin, winter skate, thorny skate, cod, spiny dogfish, pollock, haddock, and red hake (Pers. Comm. Jason Link, NEFSC, 2009; Link and Almeida, 2000). Information on Atlantic wolffish predation from the NEFSC's Fish Habitat Database (FHDBS), which is an ongoing study which began in 1973, is presented in Table 7.3.1.1 below (updated from Link and Almeida (2000). This information indicates that occurrences of wolffish are limited and the quantity of wolffish in stomach contents is low; thus, predation is not likely to be having a significant effect at the population level (Pers. Comm. Jason Link, NEFSC, 2009). As the table below indicates, the total number of wolffish found in the stomachs is 47 out of a total of 169,045 stomachs analyzed. According to the Petitioners (2008), the population status and abundance of many of these wolffish predators may have changed over time with some potentially increasing in abundance (e.g., dogfish and gray seals) and others decreasing (e.g., Atlantic cod). Other information indicates that Atlantic cod in the Gulf of Maine are increasing (GARM, 2008). As noted in the Commentary on the Petition to List Atlantic Wolffish under the Endangered Species Act (Kenchington, 2009), the increase in gray seals occurred only recently and thus, there is no apparent link between this increase and the decline observed in Atlantic wolffish. The BRT was not able to find information that demonstrates that there is or is not a link between gray seal population increases and Atlantic wolffish declines.

7.3.2. Disease

Rountree (2002 in Collette and Klein-MacPhee) reports that a sporozoan parasite has been documented to infect Atlantic wolffish muscle tissue resulting in a condition known as "hairy catfish." This condition may affect the marketability of the fish (Jonsson, 1982 in Collette and Klein-MacPhee). Rountree (2002, in Collette and Klein-MacPhee) also reports other studies which have indicated that parasites have been found in Atlantic wolffish and most often, these parasites are associated with benthic organisms (Zubchenko, 1980 in Collette and Klein-MacPhee). One parasitic fungoid microorganism (Mycelites ossifragus) has been found to burrow into wolffish teeth which may play a role in the destruction of their teeth (Barsukov, 1959 in Collette and Klein-MacPhee).

Table 7.3.1.1 FHDBS information for Atlantic wolffish (Link and Almeida, 2000).

	% Diet Composition of Wolffish, Avg estimator	95 % CI on Diet, avg	% Diet Composition of Wolffish, Unbiased estimator	95 % CI on Diet, unbiased	% Frequency of Occurrence	Frequency	Total Number of Predator Stomachs	Number of tows
Spiny Dogfish	0.0357	0.04563	0.0141	0.00021	0.0152	10	65825	8800
Winter skate	0.0609	0.12179	0.0238	0.0005	0.0058	1	17143	4154
Thorny skate	0.037	0.0373	0.0219	0.0001	0.1747	6	3435	1291
Atlantic cod	0.0408	0.04189	0.0433	0.00087	0.0356	7	19645	4055
Haddock	0.0076	0.01079	0.0024	0.0002	0.0211	2	9488	2085
Pollock	0.0655	0.10214	0.0764	0.00047	0.0515	3	5820	1798
Red Hake	0.0003	0.00058	0.0001	0.00203	0.0056	1	17841	4907
Longhorn sculpin	0.0121	0.0242	0.0041	0.00001	0.0082	1	12188	3069
Sea Raven	1.5692	1.15523	0.9538	0.00348	0.2007	15	7472	2564
Goosefish	0.0684	0.13671	0.1322	0.00208	0.0098	1	10188	4031

7.3.3. Summary and Evaluation

While data are limited, Atlantic wolffish do not currently appear to be significantly affected by disease or predation. Existing information indicates that there are some species that prey upon Atlantic wolffish, but they are limited in number, and the quantity of wolffish that appears in the stomachs of these predators is limited. There are some parasites found in Atlantic wolffish, but again, they are limited and do not appear to be having a significant impact on the species. Thus, neither disease nor predation are significantly affecting the long term persistence of Atlantic wolffish now, and we do not have evidence to suggest that this will change in the foreseeable future.

7.4 Existing Regulatory Authorities, Laws, and Policies

Within the distinct population segment discussed here, Atlantic wolffish are subject to several Federal (United States and Canadian), state and provincial, and interjurisdictional laws regulations, and agency activities. Following is a list of the most important laws and government policies affecting Atlantic wolffish and its habitat.

7.4.1 International Authorities

Canadian Authorities

Jurisdiction for wolffish fisheries in Canadian waters rests with the Department of Fisheries and Oceans Canada (DFO). The Atlantic wolffish was assessed as a "species of special concern" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2000. In 2004, the Atlantic wolffish was listed as a "species of special concern" under the Species at Risk Act (SARA). The Spotted and Northern wolffish were assessed as "threatened" by COSEWIC and listed as such under SARA (Kulka et al., 2007).

Under the SARA, listing as a species of special concern does not automatically provide additional protection for the Atlantic wolffish; however a management plan must be developed for this species. A combined management plan for all three species was developed and published in 2008 detailing the recovery strategy for these species. Following the listing as "threatened," DFO introduced a mandatory live release program for spotted and Northern wolffish in 2004. Atlantic wolffish caught incidentally in other fisheries may be retained and landed within a specified quota set annually. A public education program created following the listing of spotted and Northern wolffish encourages the live release of all wolffishes.

7.4.2 United States Interstate/Federal Authorities

Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et. seq.)

The MSA provides Regional Fishery Management Councils with authority to prepare Fishery Management Plans (FMP) for the conservation and management of fisheries in the United States Exclusive Economic Zone (EEZ), including the establishment of necessary habitat conservation measures.

The MSA was reauthorized and amended in 1996 by the Sustainable Fisheries Act (SFA) and again in 2007 by the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSRA). Among other modifications, the SFA added requirements that FMPs include provisions including standardized methods for reporting bycatch, describe and identify Essential Fish Habitat (EFH) for all managed species and minimize adverse impacts of fishing to the extent practicable, and measures to rebuild overfished stocks. The MSRA further modified the MSA by requiring Annual Catch Limits at a level such that overfishing does not occur and measures to ensure accountability

Atlantic wolffish is not currently managed under a FMP. However, several management measures approved by the New England Fishery Management Council (NEFMC) under the Northeast (NE) Multispecies FMP with the intention of protecting habitat or controlling effort in the groundfish fishery have provided some protection to wolffish populations throughout the GOM and GB. Several year-round closure areas have been implemented that prohibit commercial fishing with gear capable of catching groundfish, although recreational fishing is still permitted in these areas. The Western GOM Closed Area in particular, covers an area of historically high wolffish abundance. Amendment 13 to the NE Multispecies FMP established seven year-round habitat closures in the GOM/GB region that prohibit the use of mobile, bottom-tending fishing gear (NEFMC 2003). Most of the areas overlapped the existing groundfish closed areas, but some were in new areas (Figure 7.4.1) A series of rolling closures were created in the GOM in part to protect spawning groundfish aggregations, but which also provide protection to wolffish during limited times of the year. Within the GOM/GB Inshore Restricted Roller Gear Area, an inshore area of the western GOM that includes areas of historically higher wolffish abundance, any part of a trawl footrope, including discs, rollers, or rockhoppers may not exceed 12 inches in diameter. A separate action has prohibited the harvest of groundfish using brush-sweep, also known as “street sweeper,” trawl gear. These two provisions limit the ability of trawl gear to be used in rocky habitat areas considered preferred habitat for wolffish. The minimum mesh size of trawl and gillnet gear used in the GOM and GB has increased a number of times over the years, improving the probable escapement of wolffish. In addition, several rounds of reductions in days at sea have been implemented since 1994 with the intention of reducing effort in the groundfish fishery. A more detailed chronology of effort controls in the NE multispecies fishery is in section 7.2. All of these measures have provided indirect protection to wolffish populations.

Amendment 16 to the NE Multispecies FMP, as adopted by the NEFMC in June 2009, adds the Atlantic wolffish to the list of species managed under the FMP (NEFMC, 2009). As part of this inclusion, Amendment 16 identifies EFH for the species. Following inclusion in the FMP, the amendment must establish management measures to address the determination that the Atlantic wolffish stock is “overfished.” As approved, by NEFMC, Amendment 16 would prohibit the retention of wolffish in both the commercial and recreational fisheries, and require that any wolffish caught is released alive. If approved by the NMFS, regulations implementing this prohibition would become effective in May 2010.

<u>Lacy Act (16 U.S.C. 3371-3378)</u>

The Lacy Act makes it a Federal crime to import, export, or engage in interstate transport of any fish or wildlife taken illegally. By providing for Federal criminal prosecution of state, Federal, or foreign fish and wildlife laws, the Lacy Act would strengthen protections if adopted under other authority.

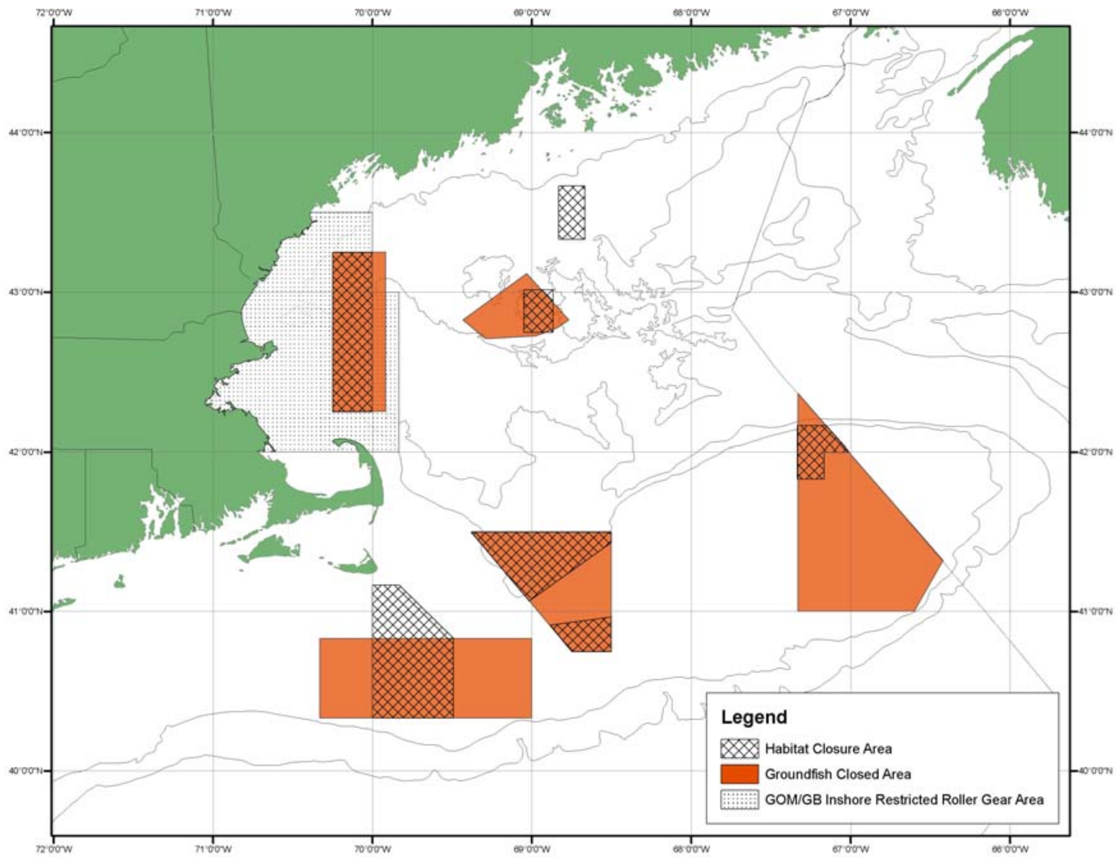


Figure 7.4.1 Selected areas protected under the NE Multispecies FMP.

National Environmental Policy Act (NEPA) (42 U.S.C. 4321-4347)

NEPA requires an environmental review process of all Federal actions. This includes preparation of an environmental impact statement for major Federal actions that may affect the quality of the human environment. Less rigorous environmental assessments are reviewed for most other actions, while some actions are categorically excluded from formal review. These reviews provide an opportunity for the agency and the public to comment on projects that may impact fish and wildlife habitat.

Coastal Zone Management Act (CZMA) (16 U.S.C. 1451-1464)

The CZMA was enacted to establish the national policy on the resources of the coastal zone. Comprehensive planning programs, to be carried out on the state level, were established to enhance, protect, and utilize coastal resources. Federal activities must comply with individual state programs. Habitat may be protected by state planning and regulating of development within the coastal zone.

Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA)

The MSPRSA protects fish habitat through establishment and maintenance of marine sanctuaries. Created under the MPRSA in 1992, the Gerry E. Studds Stellwagen Bank National Marine Sanctuary currently prohibits sand and gravel mining, and provides some protection for historical shipwrecks within the sanctuary boundary. However, the sanctuary designation does not regulate fishing or provide any other protections for wolffish at this time.

7.4.3 State Authorities

No states currently regulate the harvest of Atlantic Wolffish. It is possible that some states will adopt complimentary management measures to those adopted under Amendment 16 to the NE Multispecies FMP to provide consistent management between state and Federal waters.

7.4.4 Summary and Evaluation

Current regulatory mechanisms provide both direct and indirect protections to Atlantic wolfish within the DPS. Within Canadian waters landings are controlled under an annual quota and fishermen are encouraged to release Atlantic wolffish as part of the live-release program for spotted and Northern wolffish, in place since 2004. Within the United States EEZ the wolffish has benefited from management measures designed to protect depleted groundfish stocks. The recent stock assessment for wolffish in United States waters determined that the stock was overfished but could not determine if overfishing was currently occurring (NE DPSWG, 2009). Under current conditions, the commercial exploitation of Atlantic wolffish could pose a moderate risk to the perpetuation of this species within the DPS. The recreational harvest of wolffish is approximately 20 percent of the commercial catch and would pose a low risk to the species. If Amendment 16 to the NE Multispecies FMP is approved as adopted by the NEFMC, a live-release program for both commercial and recreational fisheries would be implemented in United States waters in May 2010. Grant et al. (2005) found very high survival rates of Atlantic wolffish caught in the Canadian yellowtail flounder trawl fishery. The lack of swim bladder and general hardiness of the species suggest that survival would also be high for other gear types. Therefore, if Amendment 16 is approved and implemented, the risk to Atlantic wolffish from both commercial and recreational fishing would become quite low.

7.5. Other Natural or Manmade Factors Affecting its Continued Existence

7.5.1. Climate Change

Based on current global climate models for greenhouse gas emission scenarios, the Intergovernmental Panel on Climate Change (IPCC, 2007) recently concluded that:

1. By 2100 average global surface air temperatures will increase by 1.8°C (lower-emissions scenario) to 4.0°C (higher-emissions scenario) above 2000 levels. The most drastic warming will occur in northern latitudes in the winter.
2. Sea level rose 12-22 cm in the 20th century and may rise another 18-38 cm (lower-emissions scenario) and as high as 26-59 cm (higher-emissions scenario) by 2099. However, these projections were based upon contributions from increased ice flow from Greenland and Antarctica at rates observed for the 1993-2003 period. If this contribution were to grow linearly with global average temperature change, the upper ranges for sea level rise would increase by an additional 10-20 cm.
3. Global precipitation is likely to increase, with more precipitation and more intense storms in the mid to high latitudes in the northern hemisphere.
4. Increasing atmospheric carbon dioxide concentrations may acidify the oceans, reducing pH levels by 0.14 and 0.35 units by 2100, adding to the present decrease of 0.1 units since preindustrial times.

According to Johnson et al. (2008), the primary impacts of global climate change that may threaten riverine, estuarine, and marine fishery resources include:

1. Increasing rates of sea-level rise and intensity and frequency of coastal storms and hurricanes will increase threats to shorelines, wetlands, and coastal ecosystems;
2. Marine and estuarine productivity will change in response to reductions in ocean pH and alterations in the timing and amount of freshwater, nutrients, and sediment delivery;
3. High water temperatures and changes in freshwater delivery will alter estuarine stratification, residence time, and eutrophication.

Increased ocean temperatures are expected to cause pole-ward shifts in the ranges of many marine organisms, including commercial species, and these shifts may have secondary effects on their predators and prey.

Sea surface temperatures of the northeastern US coast have increased more than 0.6°C in the past 100 years, and are projected to increase by another 3.8-4.4°C under the high-emissions scenario and by 2.2-2.8°C under the lower-emissions scenario over the next 100 years (Frumhoff et al., 2007). The IPCC Working Group II Report (IPCC, 2007b) concluded there is "high confidence" that observed changes in marine and freshwater biological systems are associated with rising water temperatures, including: (1) shifts in ranges and changes in algal, plankton, and fish abundance in high-latitude oceans; (2) increased algal and zooplankton abundance in high-latitude and high-altitude lakes; and (3) range changes and earlier migrations of fish in rivers.

Mountain (2002) predicted a northward shift in the distributional patterns of many species of fish because of increasing water temperatures in the Mid-Atlantic region as a result of climate change. Nearly thirty years of standardized catch data on the northeast continental shelf revealed significant surface and bottom water temperature anomalies that resulted in changes to the distribution of 26 out of 30 fish species examined (Mountain and Murawski, 1992). Increased water temperatures were correlated with fish moving northward or shallower to cooler water (Mountain and Murawski, 1992). Based on the projected sea surface temperature increases under the higher-emission scenarios, Frumhoff et al. (2007) predicted bottom temperatures by the year 2100 on Georges Bank would approach the 30ºC threshold of thermally-suitable habitat and practical limit of Atlantic cod distribution. The 26ºC threshold for the growth and survival of young cod would be exceeded by the end of the century under both emission scenarios on Georges Bank (Frumhoff et al. 2007). Bottom temperatures in the eastern Scotian Shelf dropped during the 1980s with a dip in the long-term mean achieved in 1985 and a new minimum sustained in the early 1990s (Choi et al., 2004).

According to the German Advisory Council on Global Change (2006), anthropogenic climate changes initially affect phytoplankton communities and consequently, impact primary production. According to Sarmiento et al., 2004 (cited in German Advisory Council on Global Change, 2006), the quality of the information that can be used in climate, ocean, and ecosystem models is insufficient to allow for definitive conclusions regarding future impacts on primary production. However, some regional models are capable of identifying the connections between changes in ocean currents and resulting perturbations in primary production (Brander, 2005 cited in German Advisory Council on Global Change, 2006). Changes in primary productivity will result in alterations in secondary production by zooplankton, which are a significant food source for some fish populations (German Advisory Council on Global Change, 2006). According to Schubert et al. (2006), changes in zooplankton assemblages as a result of human induced climate changes have already been recognized. Current rates of ocean primary production are estimated to have declined by about 6.7% in the North Atlantic based on remote sensing data, relative to the early 1980s (Gregg et al. 2003).

There is also evidence to suggest that within the next several decades, high latitude calcifying organisms (such as pteropods and cold water corals) may be negatively affected as changes in seawater chemistry occur (Orr et al., 2005). Increasing atmospheric carbon dioxide concentrations are reducing ocean pH and carbonate ion concentrations resulting in lower calcium carbonate saturation (Orr et al., 2005). According to Orr et al. (2005), organisms with exoskeletons comprised of calcium carbonate may be unable to maintain their shells due to this low saturation of calcium carbonate. While this is a significant issue, evidence suggests that these changes may occur in polar regions not occupied by the Western Atlantic Canada/United States DPS. Thus, impacts to this DPS are not expected.

Potential impacts of global warming on commercial marine species in eastern Canada were evaluated in a recent project conducted at McGill University.[5] Conclusions for Atlantic wolffish indicated that this species ranked as "one of the most sensitive fish species to global warming examined in this study, largely due to its lack of mobility, hence dispersal, in the egg and recently hatched stages." The report cites the period immediately before and after hatching of the eggs as the most critical stage, based on

[5] Climate Change and Thermal Sensitivity of Canadian Atlantic Commercial Marine Species, Climate Change Impacts and Adaptation Program, Project A515 [http://www.geog.mcgill.ca/climatechange/index.htm].

research from eastern Atlantic that the upper thermal limit for successful hatching is 7-8°C (Pavlov and Moksness, 1994). Affects of global warming on spawning and egg survival were dismissed because of the ability of the adults to shift their distribution to remain in suitable bottom temperatures, and because suitable spawning habitats are available in the northern part of their range. Results from all global warming models and scenarios were generally similar and predicted a potential loss of habitat only in waters south of Cape Cod. Since this is not an area within the distribution of the Western Atlantic Canada / United States DPS where wolffish are common, global warming would have no no impact to the distribution of spawning adult wolffish or to egg survival.

The report goes on to state that the planktonic late larval/early juvenile stage "may be the most vulnerable where surface water temperatures exceed 9-11°C." In eastern Canada, the critical time period when the larvae could be in the upper water column would be from February to March or April. Since near surface waters are very cold at this time of year, the report concludes that there should be "no detrimental effects in shelf waters of Labrador, Newfoundland, or Nova Scotia." Furthermore, "in most models the Gulf of St. Lawrence surface waters warm appreciably, but should approach critical thresholds of 9-11°C."

The report leaves open the possibility that surface waters from the Gulf of Maine southward could warm to the point where larval survival or development are affected. For this to occur, wolffish larvae would have to be exposed to temperatures of 9-11°C during the very short period of time (10-15 days, see Section 3.5) when they are fully planktonic. Information on spawning and egg hatching times for Atlantic wolffish in the Gulf of Maine are scanty (Section 3.5), but it indicates that spawning probably occurs in August-September. If so, and given egg incubation times of 3-9 months (depending on temperature), eggs could hatch as early as November-December or as late as May-June. Larvae hatching in November would currently be exposed to a near surface water temperatures of about 10°C, which drop to 6-7°C in December (Figures 7.5.1.1 and 7.5.1.2). Under the least severe model scenario, predicted increases of 2.2-2.8°C in surface water temperatures along the northeastern United States coast over the next 100 years (Frumhoff et al., 2007) would cause surface waters in the Gulf of Maine to exceed 10°C in November. The same would be true in December under the most severe model predictions (3.8-4.4°C increase). However, since Atlantic wolffish eggs in the Gulf of Maine probably hatch over several months in the winter, beginning in November, and because it is difficult to predict what the effect of reduced larval survival in November-December would have on recruitment of juvenile fish to the DPS, it is unlikely that global warming will affect the continued persistence of the DPS, certainly not during the next 20 years.

7.5.2. Competition and Prey Availability

Green sea urchin and wolffish predator/prey relationship

Other species observed in a survey of wolffish habitat in the Gulf of Saint Lawrence (Larocque et al., 2008), along with wolffish near or in shelters included arctic shanny (Stichaeus punctatus), redfish (Sebastes spp.), ocean pout (Zoarces americanus),

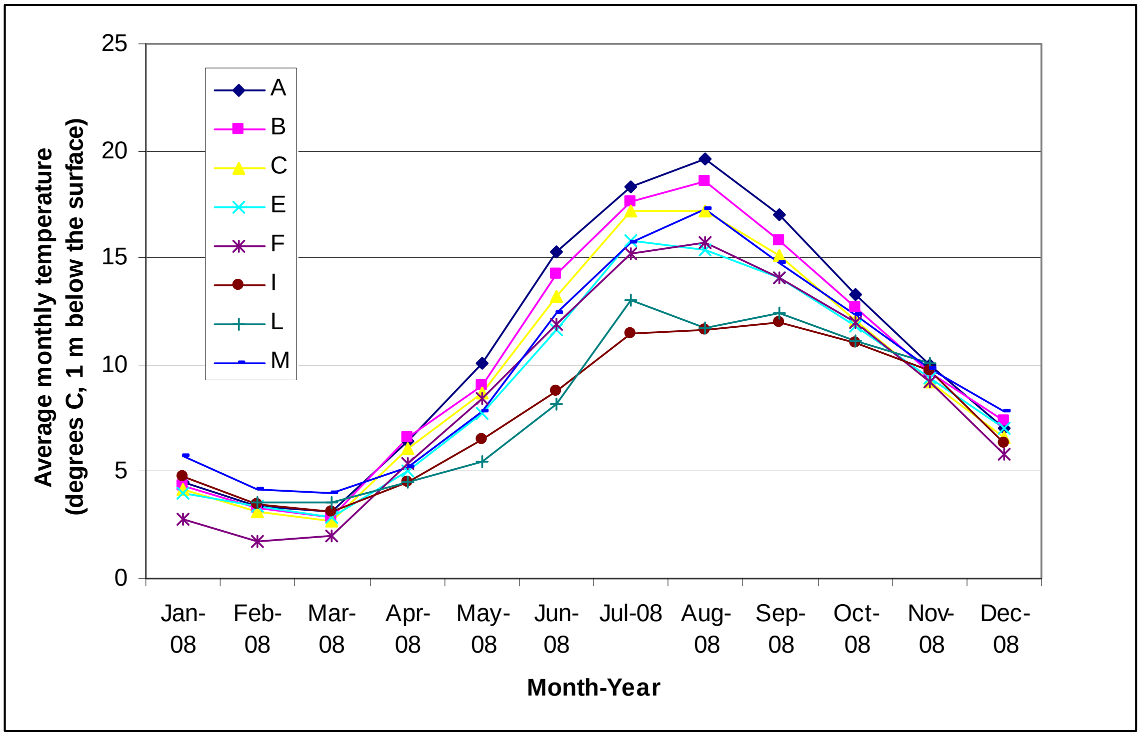


Figure 7.5.1.1. Average monthly water temperatures 1 meter below the surface at eight locations (GOMOOS buoys) in the Gulf of Maine in 2008.

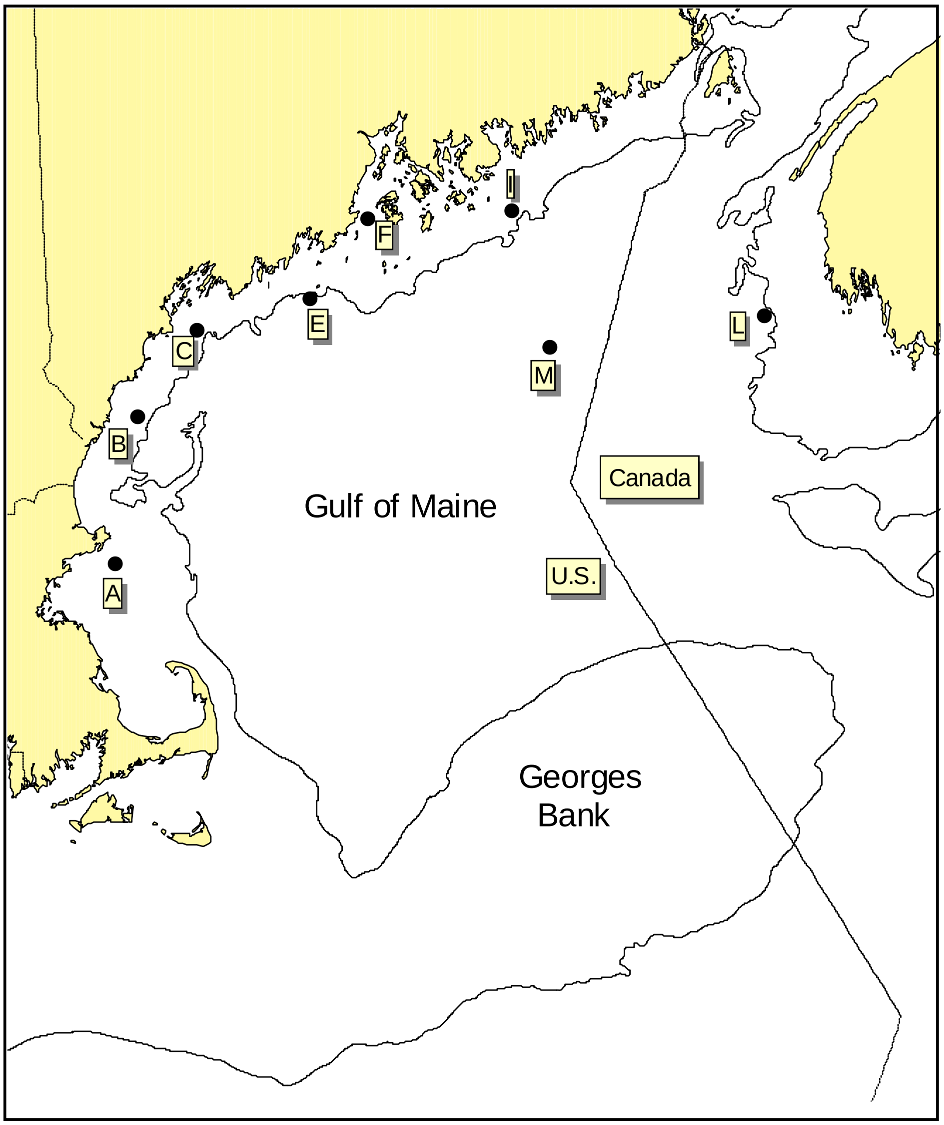


Figure 7.5.1.2. Location of Gulf of Maine Ocean Observing System (GOMOOS) buoys used to show surface water temperatures. Depth contour is 50 fathoms (approximately 100 meters).

Greenland cod (*Gadus ogac*), and Atlantic cod (*Gadus morhua*). Ocean pout has a reproduction pattern similar to Atlantic wolffish (coastal migration and egg guarding) and could be a competitor for shelters at the Les Méchins study site. However, ocean pout were seldom seen in shelters that would be considered adequate for wolffish.

Atlantic wolffish are described as typical benthophages (Albikovskaya, 1983). However, in several studies they exhibit a preference for green sea urchins when inhabiting inshore areas in the Gulf of Maine and the Maritime provinces of Canada. Keats et al. (1986) reported that the wolffish diet in Nova Scotia was dominated by urchins and wolffish can influence the abundance and behavior of urchins. This was later supported by Hagen and Mann (1992) who hypothesized that urchin "outbreaks" may be triggered by reductions in predator pressure. They cited wolffish as one of the primary predators of the green sea urchin especially at high densities. Credible evidence supports the existence of a classic predator/prey response between wolffish and green sea urchins within certain portions of its range (Bernstein et al., 1981; Hagen and Mann, 1992; Keats et al., 1886).

In the Gulf of Maine and the Maritimes, green sea urchins were found at relatively low abundances prior to 1960. After 1960, a mosaic of kelp beds and urchin barrens began appearing (Steneck et al., 2004) and eventually dominated the near-shore habitat by the 1970s. The urchin population peaked in the 1980s followed by an intense fishery in the Gulf of Maine and a disease outbreak in Nova Scotia which lead to a collapse of the stocks. By the mid-1990s kelp beds again dominated the near-shore ecosystems, but in the Gulf of Maine the urchin population continues to decline (Taylor, 2004; Margaret Hunter, pers. com.). Coincidentally, catches of Atlantic wolffish in the United States were highest between 1979 and 1987. It is important to note that during this time period there were few regulatory influences on incidental catch in the multispecies fishery. Because of this, catch is perhaps a better proxy for abundance prior to 1989 when Amendment 2 was implemented.

7.5.3. Aquaculture and Enhancement

Within the defined DPS, work to develop a commercial aquaculture industry around spotted and Atlantic wolffish is on going. This research is being lead by Nathalie Le Francois, formerly of the University of Quebec and currently at the Montreal Biodome. The spotted and Atlantic wolffish were identified as high potential species for aquaculture in Quebec due to their resistance to cold and disease, their ability to be reared in high densities and their tolerance to low oxygen and salinity (Le Francois, 2004). Atlantic wolffish hatch fully developed and are immediately able to utilize commercial feed. They also have a very high growth rate making them an efficient aquaculture species. Wolffish cultivation is similar to that of Atlantic salmon making the technology transfer easy (Le Francois, 2004). There is potentially a strong market in North America for their white, firm filets as demonstrated in Norway where wolffish are being commercially reared. There are no Atlantic wolffish aquaculture programs in United States at this time.

Atlantic wolffish is currently listed as species of concern in Canada. While this may potentially complicate the continuation of aquaculture research and development, it also may provide an opportunity for aquaculture to contribute to stock enhancement or preservation of gametes (Le Francois, 2004). At present, Canada has no immediate plans to augment the wild population with progeny from captive broodstock.

7.5.4. Summary and Evaluation

Climate change models predict that bottom water temperatures could increase enough during the next 100 years to cause the loss of spawning habitat south of Cape Cod, but not in the Gulf of Maine where the species is more common. Sea surface waters could warm to the point that the survival of pelagic larvae in November and December is reduced, but this would not pose a threat to the continued persistence of the DPS. The decline in wolffish abundance in recent years can not be attributed to a reduction in the numbers of sea urchins in the Gulf of Maine since other prey species are readily available, or to competition from other species of fish. Aquaculture research in Canada does not pose a threat to the DPS since there are no immediate plans to harvest wild brood stock. In fact, research is underway in Canada to enhance wild populations of Atlantic wolffish. In summary, none of the other natural or manmade factors described above threaten the long-term persistence of the Western Atlantic Canada / United States DPS of Atlantic wolffish.

8. PUBLIC INFORMATION SESSIONS WITH FISHERS

As stated previously, the NEFSC trawl survey data is one source of information on the distribution of Atlantic wolffish. However, given the nature of the trawl gear, which does not sample in extreme rocky areas, there might be areas where wolffish are currently found that are not being sampled in the survey. Some members of the fishing industry may be encountering this species in rocky areas and other key habitats which currently may not be sampled through the trawl survey. Thus, the BRT sought input from the fishing industry to get a more complete estimate of abundance for this species to aid in assessing its status. A total of three information sessions were held in New Bedford and Gloucester, Massachusetts and Portland, Maine. Members of the fishing industry were invited to attend and provide information on their experiences with wolffish and address 14 specific questions that were developed by the BRT.

The following is a summary of the information that was provided by the participants at these sessions:

At all three information sessions, the majority of attendees were commercial groundfish fishers who primarily use trawl gear. While they are capable of fishing in some areas that the NEFSC trawl survey does not generally sample, they too do not fish in boulder habitat due to the potential for damaging their gear. In Gloucester, two gillnetters and one lobster fisher also attended.

When asked what their general impressions of the abundance and distribution of wolffish are and whether or not abundance has changed over time, fishers in New Bedford indicated that they have never caught significant numbers of wolffish as it has always been relatively rare in the areas they fish. They agreed that they have not seen a change in abundance in the 30 to 45 years that they have been fishing. In Gloucester and Portland, the fishers indicated that the number of wolffish they have caught recently has been reduced due to regulatory effects such as closed areas and reduced days at sea. All of the fishers indicated that when they did catch wolffish in the past or still do catch them, they are primarily over hard, rocky bottom on the edges of Georges Bank, Fippenies, Cashes Ledge, Eastern Middle Bank fingers and near Jefferies Ledge. One fisherman indicated that he has also occasionally caught wolffish over muddy bottom. They also indicated that at times, they catch a single wolffish and at other times, they catch multiple wolffish in a single tow or net. The fishers also indicated that the recreational boats and party/charter boats tend to catch significant numbers of Atlantic wolffish.

All of the fishers indicated that wolffish are caught as incidental catch and that in general, there are no directed fisheries for them. The market is typically low for wolffish so they are often discarded or kept for personal use. However, several fishers indicated that they will sell them. The market price varied from 30 to 40 cents in Portland to up to $1 in New Bedford. Fishers in Gloucester indicated that the price is often higher in the summer as the fish is more popular then, but the quality of the meat is not as good at that time as it is at other times of the year. The Gloucester fishers also indicated that the market for wolffish is currently stronger than it has been in the past.

Fishers in New Bedford said that they do catch a few wolffish while targeting yellowtail flounder while fishers in Gloucester stated that all gear types catch them but with the closures and other regulatory measures, the predominant catch is currently by recreational fishers. A gill net fisherman indicated that due to the mesh sizes that are used, they rarely catch wolffish as they are often able to squirm through the net. One fisher in Portland indicated that gill nets that are tied down are capable of catching wolffish in the spring, but they are rarely taken in stand up nets.

The New Bedford fishers indicated that they have not seen any seasonal variation in catch while the Gloucester and Portland fishers indicated that they tend to catch more in the spring and early summer (April through June/early July). Fishers at all three sessions indicated that the wolffish that they do catch are generally 2 ½ to 3 feet in length, and indicated that the mesh size of the nets that they use is too large to catch smaller fish.

The fishers all agreed that wolffish are a hardy species and that they can remain on deck for some time and still be returned to the water alive. One fisherman stated that their nickname "catfish" is derived from the fact that they have 9 lives. They referenced the live release program for wolffish in Canada and cited this as a potential example of the low post release mortality rates experienced by this species. They all indicated that if required, they would not have any reservations about releasing the fish alive and that because they eat crabs, shellfish, and urchins, they do not typically compete with their target species for resources. In Gloucester, the lobster fisherman indicated that he throws the wolffish that are caught in his traps back and does not use them as bait as wolffish eat lobsters and even cut up, the lobsters are afraid of them. In Portland, the fishers said that the lobster fishers there do use wolffish that are caught in their traps for bait at times, and if they don't, they most likely kill them as they want to prevent the wolffish from preying on their target species.

In order to determine if the fishers have encountered fish with abnormalities that may be associated with potential disease, they were asked if they have caught fish with missing fins, other evidence of potential disease, noticeable presence of parasites, and other abnormalities. The fishers indicated that they have not observed any wolffish with these conditions. They were also asked if they have ever caught wolffish without teeth. This question was designed to test the hypothesis that wolffish hide in rocky dens after they have lost their teeth and thus, are not susceptible to catch in most types of fishing gear. Most of the fishers indicated that they have never seen wolffish without teeth; however, one fisherman in Portland indicated that he has caught a number of wolffish without teeth on the Grand Banks over sandy bottom. They stated that they have seen wolffish with evidence of some predation attempts as they have encountered them with their tails bitten off.

The primary message that all of the commercial fishers shared was that the reduction in the landings for Atlantic wolffish that has been observed recently is an artifact of the regulatory measures that have been implemented to manage other groundfish species and not indicative of a decrease in abundance. They indicated that if they were able to fish in the closed areas, they would be able to capture significant numbers of Atlantic wolffish as these areas contain suitable habitat for the species.

9. QUALITATIVE THREATS ASSESSMENT

Qualitative threats assessments are performed to help summarize the status of the species, and do not represent a decision by the BRT on whether the species should be proposed for listing as endangered or threatened under the ESA. There are no standard methods or protocols employed to estimate the risk to the long term persistence of species. Instead, the method used is dependent on the availability of data for the species in question. Information such as geographic range, population numbers, population trends, and expert opinion can be utilized in a purely qualitative methodology (reviewed in Regan et al., 2005), or through the use of ranking or scoring systems, in semi-quantitative analysis. Models relying on stochasticity and variances in genetics, birth-death demography, ecology and interactions among mechanisms can be employed in a highly quantitative methodology, such as Population Viability Analysis (PVA) (Boyce, 1992; Ludwig, 1999). Because wolffish is a data poor species, information was not available to the BRT to perform a quantitative threats assessment. Consequently, the BRT adopted a qualitative ranking system that is adapted from similar types of qualitative analyses used on the West Coast (e.g., Pacific salmon, Pacific herring, Pacific hake, rockfish, etc.) and for other species assessed in the Northeast Region (e.g., Atlantic and shortnose sturgeon).

9.1. Demographic Risks

In the qualitative threats assessment, the BRT identified the following five demographic variables which individually and collectively are considered to be strong indicators of potential risk to the long term persistence of the species: abundance, population age/size structure, population growth rate/productivity, spatial structure/connectivity, and genetic diversity. The BRT discussed what is known about each of these criteria and also any uncertainties associated with each criterion. Following this discussion, the BRT ranked each criterion for its effect on the long term persistence of wolffish. The following rankings and the associated definitions were used:

> Very low risk = highly unlikely that this criterion alone or in combination with other criteria contributes significantly to risk to the persistence of the species
>
> Low risk = unlikely that this criterion contributes significantly to risk to the persistence of the species by itself, but some concern that it may in combination with other factors
>
> Moderate risk = this criterion contributes significantly to risk to the long term persistence of the species, but does not in itself constitute a risk to the persistence of the species in the near future
>
> High risk = this criterion contributes significantly to risk to the long term persistence of the species and is likely to contribute to the short term risk to the persistence of the species in the foreseeable future
>
> Very high risk = this criterion by itself indicates a danger to the persistence of the species in the near future

As depicted in Table 9.1.1, the BRT ranked all of the criteria low, meaning that it is unlikely that the particular criterion contributes significantly to risk of the persistence of the species by itself, but there is some concern that it may in combination with other factors. The following is a summary of the discussion regarding the available information for each criterion as well as any associated uncertainties and the final ranking.

For the abundance criterion, the BRT noted that commercial fishing effort is not likely to increase significantly in the foreseeable future and that if Amendment 16 is implemented as proposed (e.g., includes the ban on possession of wolffish), that commercial fishing will have less of an effect on abundance in the near future. There are indications that wolffish may be increasing in some areas in Canada, which is a positive sign in relation to abundance of the DPS. Also, the data from Canada indicate an increase in the number of small wolffish which suggests that the DPS is capable of producing recruits even at low biomass. As such, the risk from low abundance is believed to be minimal.

The BRT discussed population size/age structure for the DPS. They noted that there has been a period of low recruitment for the past two to three years, and it is not known if this will persist. The NEFSC trawl survey data indicate that the size structure of the DPS has been consistent over time and that large fish are still being caught in the survey. The data indicate that the size structure of the DPS has not changed significantly over time and thus, the risk from changes to this criterion was determined by the BRT to be low.

During the discussion regarding the population growth rate/productivity criterion, the BRT noted that a large decline in Atlantic wolffish occurred from the mid 1980's through mid 1990's. However, since then, the population biomass appears to have stabilized at the lowest levels of the time series. Atlantic wolffish are a K selected species (e.g., a species which invests more in producing fewer offspring which have a relatively high probability of surviving to adulthood). Consequently, while they do not produce a large number of offspring, the survival of the early life stages may be higher than other species. Additionally, there is evidence from Canada that good year class production can be achieved even at low biomass as mentioned above. The BRT determined the risk of changes in population growth rate/productivity to be low for the DPS.

The BRT determined that populations do not appear to be spatially segregated, and there are no apparent barriers between wolffish within the DPS to prevent mixing. The larval pelagic stage most likely increases potential for connectivity within the DPS. Also, while it appears that most wolffish do not migrate long distances, limited tagging data are available which have indicated that they are capable of long distance migrations. Thus, the risk from impacts to spatial structure/connectivity to the DPS is low.

Atlantic wolffish is a widely dispersed species. Of the areas throughout the range of the taxon from which genetic samples have been taken and analyzed, there are four genetically discrete populations. There were no significant genetic differences observed between areas within Western Atlantic Canada, leading to the conclusion that they are capable of mixing and that there are no barriers within this range which may lead to significant genetic diversity. Genetic information is lacking for fish from the United States; however, given there are no significant barriers to mixing between the United States and the Western Atlantic Canada population and that fish have been observed along the border between Canada and the United States, it is probable they are genetically similar. Given the broad range of the DPS and the lack of barriers to mixing within it, the risk from decreased genetic diversity is low.

Table 9.1.1 Qualitative threats assessment of the five demographic variables.

Demographic criteria	**Risk Category**				
	very low	low	moderate	high	very high
abundance		x			
population size/age structure		x			
population growth rate/productivitiy		x			
spatial structure/connectivity		x			
diversity		x			

9.2. Threats Analysis

The BRT identified the anthropogenic stressors and natural limiting factors that are associated with any of the five ESA factors (discussed in more detail in section 7 of this report) and evaluated each stressor/factor in terms of its effect to the long term persistence of the species. The same ranking system and associated definitions as discussed above in the demographic risk analysis were used to rank each stressor/factor (e.g., from very low to very high).

Two anthropogenic stressors were associated with Factor A (i.e., present or threatened destruction, modification, or curtailment of its habitat or range) – loss or degradation of habitat from fishing related activities and from other anthropogenic activities (e.g., dredging, aggregate extraction, offshore energy development, etc.). The available information indicates that for most of the year, wolffish are habitat generalists occurring over many different bottom types; however, for part of the year, they have an affinity for boulder reefs which provide shelter for them and their young. Consequently, impacts to this habitat could be significant. Most of the commercial fishermen with bottom tending gear avoid boulder reef habitats in order to prevent damage to their gear. It is possible that fishing gear could be developed that is capable of fishing in boulder reef areas which could lead to impacts to this habitat. However, the likelihood of this is uncertain. Because fishing effort is currently low in the boulder reef areas, it is unlikely that significant destruction to these habitats from fishing gear is occurring. Currently, there are several areas that are closed to bottom tending gear, and these closures may result in some habitat protection for the DPS. It is not known if these areas will continue to be closed in the future. If Amendment 16 to the Multi-species FMP is implemented as proposed, it will include Essential Fish Habitat (EFH) designations which will also provide protection to important habitats for the DPS. It is also possible that other anthropogenic activities such as dredging, aggregate extraction, and offshore energy development could impact have localized impacts to these boulder reef habitats. Given the wide range of the DPS, if there are impacts to habitat from fishing gear or other anthropogenic activities, they are likely to be localized and not affect a significant portion of the DPS. Thus, the BRT considered the risk to the DPS associated with these two anthropogenic factors to be low.

The BRT evaluated the risk to the DPS from overutilization for commercial and recreational purposes (Factor B). The BRT agreed that the available information for recreational harvest may not be an accurate reflection of the catch; however, the reported recreational catch does represent 20% of the reported commercial catch. Recreational fishermen also have the ability to fish in the boulder reef areas that commercial fishermen do not typically fish in and may encounter wolffish more frequently in these areas.

After a period of high fishing mortality rates, reported commercial utilization rates for wolffish have declined in response to regulatory measures implemented for other groundfish stocks. The BRT expects that the commercial fishing rate associated with groundfish fisheries will continue to decline, but given the potential for changes in management measures in the future, this is uncertain. If Amendment 16 is approved as proposed (e.g., includes a ban on possession for commercial and recreational catch), then this would most likely reduce wolffish mortality from both commercial and recreational fishing. This ban on possession would lead to a live release program for both commercial fishermen participating in the multi-species groundfish fishery and recreational fishermen. The success of a live release program is unknown but given expected high post release survival rates for wolffish, they are expected to be good. There has been a mandatory live release program for Northern and Spotted wolffish in Canada since 2004 and many fishers are applying this practice to Atlantic wolffish. Because Atlantic wolffish are listed as a species of special concern in Canada (and not listed as threatened or endangered under SARA), it is uncertain if the live release program for Atlantic wolffish will continue into the future. Limited data are available regarding the amount of wolffish taken in lobster gear, but incidental catch has been reported and thus, this could represent a source of incidental catch that has not been addressed. The BRT evaluated the risk to the DPS from both commercial and recreational overutilization (Factor B). The BRT determined that the risk from recreational fisheries is low. The BRT also determined that currently, there is a moderate risk to the DPS from commercial fisheries. However, if the ban on possession in Amendment 16 is implemented and effective, then overutilization from commercial fisheries represents a low risk to the DPS.

The BRT evaluated the risk to the DPS from disease and predation (Factor C). According the NEFSC, there are some predators of Atlantic wolffish but they are limited, and the quantity of wolffish that has been observed in these predators' stomachs is small. There is uncertainty regarding potential changes in predator population abundances, and it is possible that increases in various predators could lead to higher predation rates; thereby, having a more significant impact to the DPS. The likelihood of this happening, however, is unknown. Thus, the BRT ranked the threat from predation as low. There are limited data available on diseases that affect wolffish, but there is nothing to suggest that any particular disease is impacting the DPS at this time. As such, the BRT ranked the threat from disease as very low risk.

Currently, there are no direct regulatory mechanisms for wolffish in the United States; however, there are regulations for other species (e.g., groundfish) which provide indirect benefits through mechanisms such as reduced fishing effort and closed areas. The lack of direct regulatory mechanisms for the DPS is likely to change in the foreseeable future. As stated previously, if Amendment 16 is approved as proposed (e.g., includes a ban on possession for commercial and recreational catch), then this would directly reduce wolffish mortality. Thus, in evaluating the risk posed by the inadequacy of existing regulatory mechanisms (Factor D), the BRT determined that there is a moderate risk at this time; however, if Amendment 16 is implemented and effective, that would reduce it to a low risk. As indicated above, there is a mandatory live release program for Northern and Spotted wolffish in Canada that began in 2004. This program provides some protection to Atlantic wolfish fish from the DPS. However, since Atlantic wolffish are a species of special concern, it is not known if this program will continue into the future. Consequently, the BRT ranked the risk from the inadequacy of existing regulatory mechanisms outside of the United States as low.

Finally, the BRT considered all other natural or manmade factors that may affect the DPS (Factor E), which included competition/prey availability, climate change impacts, ocean acidification, and aquaculture/enhancement. When evaluating the risk posed by competition, the BRT noted that there may be some competition for shelters during reproduction; however, adult wolffish have been observed with other species. Therefore, this most likely is not a significant impact to the species. Also, wolffish consume a wide variety of prey. Thus, while declines in green urchin populations, a significant prey species for wolffish, this may pose a localized risk to the DPS. It is not, however, significant throughout the entire DPS.

Wolffish have specific thermal tolerances (e.g., they do not prefer temperatures above 10°C) so it is possible that rising water temperatures associated with climate change could impact the DPS. However, it is not known whether bottom temperatures in the area occupied by the DPS will increase and how this might affect the range of the species (e.g., potential for range contraction). If a spawning cue is related to temperature, changes in ocean temperatures could impact the DPS, but this is also not known. The BRT, therefore, concluded that effects from climate change are highly uncertain and there is not much known upon which to base decisions. The impacts from potential ocean acidification are also unknown, but impacts to the DPS are not expected within the foreseeable future. Currently, there are no aquaculture operations for wolffish in the United States, but there are limited aquaculture activities for wolffish in Canada. The Canadian researchers are experimenting with hybridization with spotted wolffish; however, hybridization between these two species occurs in the wild, and therefore, impacts of hybridization on the DPS are not known. The BRT ranked the threat to the DPS from these other natural and manmade factors as very low. There are potential enhancement activities proposed by Canadian researchers in Canada using wolffish from the Canadian portion of the DPS. Again, the impacts of potential enhancement on the DPS are not known, but could raise the risk from very low to low.

Table 9.2.1 Qualitative threats assessment of anthropogenic stressors and natural limiting factors.

Anthropogenic stressors and natural limiting factors	**Risk Category**				
	very low	low	moderate	high	very high
loss or degradation of habitat - fishing activities		x			
loss or degradation of habitat - other anthropogenic activities such as dredging, aggregate extraction		x			
overutilization - recreational		x			
overutilization - commercial			x		
predation		x			
disease	x				
regulatory mechanisms - U.S.			x		
regulatory mechanisms - Canada		x			
competition/prey availability	x				
climate change	x				
ocean acidification	x				
aquaculture/enhancement	x				

10. CONCLUSION

The Western Atlantic Canada / United States DPS meets both the discreteness and the significance criteria under the DPS Policy. Therefore, the Western Atlantic Canada / United States DPS (as defined in Section 4 of this Status Review) should constitute a "species" under the ESA. While the BRT makes no specific recommendation to the Services regarding the conservation status (i.e., threatened, not threatened or endangered) of the Western Atlantic Canada / United States, the species has declined from historic levels. The BRT has concluded that current demographic factors (abundance, population size/age structure, population growth rate/productivity, spatial structure/connectivity, and diversity) pose a low risk to the long term persistence of Atlantic wolffish. The BRT future determined that the risks from anthropogenic stressors/natural limiting factors to the DPS were very low or low for most factors and moderate risk from commercial utilization and associated regulatory mechanisms (Tables 9.11 and 9.2.1).

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