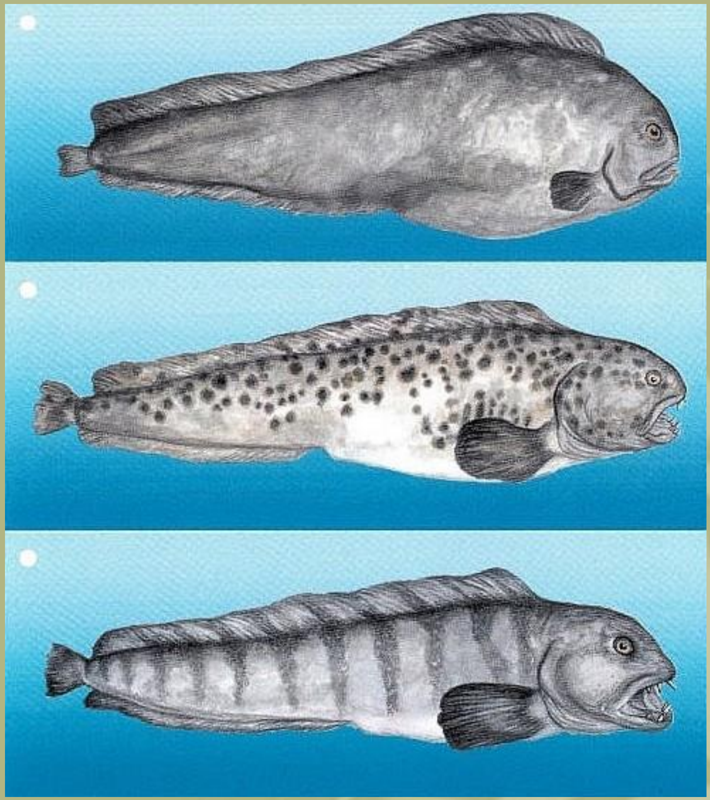
Species at Risk Act
Recovery Strategy Series

Recovery Strategy for Northern Wolffish (*Anarhichas denticulatus*) and Spotted Wolffish (*Anarhichas minor*), and Management Plan for Atlantic Wolffish (*Anarhichas lupus*) in Canada

Northern Wolffish, Spotted Wolffish, Atlantic Wolffish



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For copies of the recovery strategy, or for additional information on species at risk, including Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk Public Registry.

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Declaration

The original version of the *Recovery Strategy for Northern Wolffish (Anarhichas denticulatus) and Spotted Wolffish (Anarhichas minor), and Management Plan for Atlantic Wolffish (Anarhichas lupus) in Canada* was prepared in cooperation with jurisdictions responsible for the species. Fisheries and Oceans Canada has amended the original document to include updates since 2008 as required under the *Species at Risk Act*. Consultations on the amendment of this document were held in 2015. For further details please see appendix A.

Success in the recovery and management of these species depends on the commitment and cooperation of many different constituencies that continue to be involved in implementing the directions set out in this strategy, and will not be achieved by Fisheries and Oceans Canada or any other jurisdiction alone. In the spirit of the Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans invites all Canadians to join Fisheries and Oceans Canada in supporting and implementing this strategy for the benefit of Northern Wolffish, Spotted Wolffish, Atlantic Wolffish, and Canadian society as a whole. Fisheries and Oceans Canada will continue to support implementation of this strategy, relative to available resources and varying species at risk conservation priorities. A report on the implementation of the 2008 recovery strategy and the progress towards meeting its objectives was published in 2013. The Minister will continue to report on progress until the recovery objectives have been achieved or the species' recovery is no longer feasible.

This strategy will be complemented by an action plan which will provide details on specific recovery measures to be taken to support conservation of the species. The Minister will take steps to ensure that, to the extent possible, Canadians directly affected by these measures will be consulted.

Responsible jurisdictions

The responsible jurisdiction for Northern, Spotted and Atlantic Wolffish in Atlantic Canadian waters is Fisheries and Oceans Canada.

Acknowledgments

This amended recovery strategy and management plan would not have been possible without the contribution of DFO staff from the Newfoundland and Labrador, Maritimes, Gulf, Quebec, Central and Arctic and National Capital Regions as well as Dena Wiseman.

Strategic environmental assessment statement

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans and program proposals to support environmentally-sound decision making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the Federal Sustainable Development Strategy's (FSDS) goals and targets.

Recovery and management planning are intended to benefit species at risk and biodiversity in general. However, it is recognized that recovery strategies and management plans may also inadvertently lead to environmental effects beyond the intended benefits. The planning process, based on national guidelines, directly incorporates consideration of all environmental effects, with particular focus on possible impacts on non-target species or habitats. The results of the SEA are incorporated directly in recovery strategies and management plans themselves, but are also summarized below.

This recovery strategy and management plan will clearly benefit the environment by promoting the conservation and recovery of Northern, Spotted and Atlantic Wolffish in Canadian waters. The potential for the strategy to inadvertently lead to adverse effects on other species was considered; however, because the recovery objectives recommend additional research on the species and education and outreach initiatives, the SEA concluded that this strategy will positively impact the environment and will not result in any significant adverse effects.

Executive summary

Four species of wolffish (family Anarhichadidae) inhabit Canadian waters: Northern Wolffish *(Anarhichas denticulatus)*, Spotted Wolffish *(Anarhichas minor*) and Atlantic Wolffish (*Anarhichas lupus*) in both the Atlantic and Arctic Oceans, and Bering Wolffish *(Anarhichas orientalis)* in the Arctic Ocean only. In May 2001, Northern and Spotted Wolffish were assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Threatened due to declines in their abundance and biomass (COSEWIC 2001a,b). A third species, Atlantic Wolffish, was assessed by COSEWIC as Special Concern (COSEWIC 2000). All three wolffish species were included in Schedule 1 of the *Species at Risk Act* (SARA) at the time of the Act's proclamation in June 2003. The status of all three wolffish species was reassessed by COSEWIC in 2012. Although there are some signs of population recovery, COSEWIC recommended that all designations remain unchanged (COSEWIC 2012a,b,c). Therefore, under SARA, the status for Northern and Spotted Wolffish remained as Threatened and the status for Atlantic Wolffish remained as Special Concern.

Northern and Spotted Wolffish are the focus of this document; however, this document also serves as a management plan for Atlantic Wolffish. This is because the distributions of the three species overlap throughout much of their range. Although Atlantic Wolffish is designated as Special Concern, it also underwent a decline as great as that observed for the two Threatened species over the northern part of its range (Northeast Newfoundland and Labrador Shelf). The two Threatened species are primarily distributed on the Grand Banks and areas to the north. Atlantic Wolffish has a wider distribution in the Gulf of St. Lawrence, Scotian Shelf, Bay of Fundy and Georges Bank, whereas the other two species are rare. While all three species have undergone substantial declines during the 1980s and 1990s, the proximal cause(s) remain uncertain.

This document was originally published in 2008 and was developed by a multi-sector, multi-regional Recovery Team with representation from the fishing industry, academia, the Government of Newfoundland and Labrador, and the Government of Canada. Government representation included expert scientists, fisheries managers and economists who assisted in formulating a framework for the conservation and recovery of these wolffish species.

The 2008 version of this recovery strategy and management plan represents a collaborative and consultative effort by the recovery team to present knowledge available at that time and to recommend recovery solutions.

The 2008 recovery strategy and management plan identifies the lack of information that exists in regard to population dynamics of wolffish, their ecology, abundance, distribution, habitat utilization, behaviour and interaction with their environment. It points out the immediate need for additional research to enhance formulation of recovery approaches. The document discusses the threats and issues believed to be affecting wolffish conservation and recovery, and presents recommendations to mitigate them. It also promotes stewardship among stakeholders as a means to facilitate and promote recovery.

The goal of this amended recovery strategy and management plan is to increase the population levels and distribution of Northern, Spotted, and Atlantic Wolffish in eastern

Canadian waters such that the long-term viability of these species is achieved. This will be accomplished via the objectives and strategies outlined below.

Five primary objectives have been identified to achieve this goal:

- enhance understanding of the biology and life history of wolffish species
- identify, conserve, and/or protect wolffish habitat required for viable population sizes and densities
- reduce the potential for wolffish population declines by minimizing human impacts
- promote wolffish population growth and recovery
- develop communications and education programs to promote the conservation and recovery of wolffish populations

Each objective is designed to achieve the goals of the recovery strategy and management plan.

Recommended actions to achieve these objectives are:

- study life history
- study population structure within eastern Canadian waters
- identify recovery biological reference points
- study ecosystem interactions
- further identify habitat, including critical habitat, as information becomes available
- define measures to conserve and/or protect wolffish habitat
- identify and mitigate impacts of human activity
- increase resource user knowledge and raise public awareness of wolffish species through education and communication
- promote stewardship initiatives
- consult and cooperate with harvesters, processors, scientists, regulators, enforcement, observers, dockside monitors, governments, Indigenous groups and other ocean users
- monitor wolffish spatial and temporal abundance patterns
- monitor spatial and temporal patterns of natural and human induced mortality

Adherence to the recommendations put forth in this document, including the mitigation of known threats, provides the best chance of conserving and restoring the three wolffish species to a state in which they are no longer considered at risk. However, it is recognized that the implementation of recovery activities are constrained by available resources and that non-human elements (environmental influences) have played a role in the decline of the species, and that often these effects cannot be controlled or effectively mitigated. There is also a need for adaptive management and modification or revision of this recovery strategy and management plan as new information becomes available.

This document was amended in 2020. The most significant portion of this amendment is the identification of critical habitat for Northern and Spotted Wolffish. The recovery section of this document has also been revised to include current information. Other parts of this document have been updated as required.

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Part A: species information and evaluation of current status

1. Introduction

Wolffish (Family Anarhichadidae), also referred to as “catfish” by the fishing industry, inhabit a wide range of northern latitudes in the Atlantic and Pacific Oceans (Scott and Scott 1988). Four species of the genus *Anarhichas* commonly inhabit Canadian waters: Northern or Broadhead Wolffish (*Anarhichas denticulatus*), Spotted Wolffish (*Anarhichas minor*) and Atlantic Wolffish (*Anarhichas lupus*) in the Atlantic and Arctic Oceans (Barsukov 1959; Templeman 1985, 1986b), and Bering Wolffish (*Anarhichas orientalis*) in the Arctic Ocean (Houston and McAllister 1990). The first three species are also distributed in the northeastern Atlantic (Barsukov 1959; Baranenkova et al. 1960) including southeast and southwest of Greenland, (Möller and Rätz 1999; Stransky 2001), the latter contiguous with Canadian waters. The west Greenland components (Atlantic and Spotted Wolffish) underwent a decline similar in magnitude and timing to the decline in Canadian waters, while the east Greenland component did not (Möller and Rätz 1999). Reported catches off west Greenland have not exceeded 100 tonnes in recent years. All three species extend into U.S. waters, but there they are uncommon (Atlantic Wolffish) or rare (Spotted and Northern Wolffish).

Kulka and DeBlois (1996) described the distribution of the three species off eastern Newfoundland as quite extensive, inhabiting most of the Labrador and northeast Newfoundland Shelves (less so in recent years) to the southern Grand Banks and Flemish Cap (appendix C: figure 1). The northern limit of all three species occurs in the Davis Strait. Research surveys on the Scotian Shelf and in the Gulf of St. Lawrence regularly catch both Northern and Spotted Wolffish, but at much lower rates than from the Grand Banks to the Labrador Shelf region. This would indicate that the former regions represent the southern fringe of distribution for these two wolffish species. Atlantic Wolffish differed from the other two species in that they are densely concentrated on the shallow part of the southern Grand Banks (Kulka and DeBlois 1996). Atlantic Wolffish is also common in the deeper parts of the Gulf of St. Lawrence, on the Scotian Shelf, in the Bay of Fundy (McRuer et al. 2000) and Gulf of Maine/Georges Bank (Nelson and Ross 1992).

Wolffish have been exploited in a directed fishery off Greenland (Smidt 1981; Möller and Rätz 1999), but within Canadian waters they have only ever comprised bycatch. Kulka (1986) reported on bycatch levels of the three species in Canadian waters. It was noted that annually during the 1980s, about 1,000 tonnes of the three species (combined) were caught in many fisheries directed for other species. About half of the Spotted and Atlantic Wolffish caught was landed and all of Northern Wolffish were reported as discarded. Information on distribution presented by Kulka and DeBlois (1996) and Simpson and Kulka (2002) indicate a potential for overlap of fisheries with the distribution of wolffish species outside 200 miles on the Grand Banks and the Flemish Cap.

With the decline in the traditional groundfish (demersal species) resources in the waters around Newfoundland and Labrador, in the early 1990s, interest in the exploitation of alternate species increased. Spotted and Atlantic Wolffish had been considered in the mid-1990s as potential candidates for new directed fisheries. However, experimental fishing did not identify areas where catch rates were sufficiently high to warrant directed commercial exploitation. This finding was consistent with studies that indicate wolffish do not form dense concentrations (Templeman 1986a; Kulka and DeBlois 1996; Simpson and Kulka 2002).

Kulka and DeBlois (1996) and Simpson and Kulka (2002) noted a significant decline in research trawl survey indices (numbers and weights) of the three species starting in the late 1970s and early 1980s. While all three species have undergone a substantial decline during the 1980s to 1990s, the proximal cause remains uncertain. These declines in abundance were concurrent with a widespread reduction in abundance of many groundfish species from the Grand Banks to the northern Labrador Shelf.

In 2001, Northern and Spotted Wolffish were assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Threatened and Atlantic Wolffish was assessed as Special Concern (COSEWIC 2000; COSEWIC 2001a,b). All three wolffish species where included in Schedule 1 of the *Species at Risk Act* (SARA) at the time of the Act's ratification in June 2003. The status of all three wolffish species was reassessed by COSEWIC in 2012. Although there were some signs of population recovery, COSEWIC recommended that all designations remain unchanged (COSEWIC 2012a,b,c). Therefore, under SARA, the status for Northern and Spotted Wolffish remained as Threatened and the status for Atlantic Wolffish remained as Special Concern. These species are not protected under analogous provincial or territorial legislation.

This document serves as an amendment to the 2008 version of the *Recovery Strategy for Northern Wolffish (Anarhichas denticulatus) and Spotted Wolffish (Anarhichas minor), and Management Plan for Atlantic Wolffish (Anarhichas lupus) in Canada*. Based on knowledge accumulated to date, the recovery of wolffish species as stated in the 2008 version of this recovery strategy and management plan is still considered feasible.

Further information can be found in the 2008 version of this recovery strategy which is available on the Species at Risk Public Registry.

1.1 Species information and evaluation of current status

Species information: Northern Wolffish

Common name:	Northern Wolffish, Broadhead Wolffish, Bullheaded Wolffish, Catfish
Scientific name:	*Anarhichas denticulatus*
Status:	Threatened (SARA Schedule 1)
Reason for designation:	This species underwent strong declines in both abundance and in range size during the 1980s. For the next decade there was little change, but since about 2002 there have been small increases in both range size and abundance. These have been in parallel with recovery measures, including mandatory release of individuals taken as bycatch. While these recent increases are encouraging, the species is still at very low levels compared with the beginning of research surveys in the 1970s. Although there has been a general decrease in the level of fishing over its range, its recovery may still be limited by bycatch in fisheries

	in the deep waters in which it occurs (COSEWIC 2012a).
Canadian occurrence:	Arctic Ocean, North Atlantic Ocean
status history:	Designated Threatened in May 2001. Status re-examined and confirmed in November 2012.

Species information: Spotted Wolffish

Common name:	Spotted Wolffish, Leopardfish, Catfish
Scientific name:	*Anarhichas minor*
Status:	Threatened (SARA Schedule 1)
Reason for designation:	This species underwent strong declines from the late 1970s until the mid-1990s, but since then there has been some recovery over most of its Canadian range. This is indicated by both increases in abundance and area of occupancy. These increases parallel a reduction in bottom fisheries that had a high incidental catch of this species, as well as introduction of recovery measures including mandatory release. While these recent increases are encouraging, the species is still at low levels compared with the beginning of the research surveys (COSEWIC 2012b).
Canadian occurrence:	Arctic Ocean, North Atlantic Ocean
Status history:	Designated Threatened in May 2001. Status re-examined and confirmed in November 2012.

Species information: Atlantic Wolffish

Common name:	Atlantic Wolffish, Striped Wolffish, Catfish
Scientific name:	*Anarhichas lupus*
Status:	Special Concern (SARA Schedule 1)
Reason for designation:	This species underwent steep declines in both abundance and area of occupancy over much of its range from the 1980s until the mid-1990s, including its historical stronghold in waters east and north of Newfoundland. Since then it has been increasing in abundance and area of occupancy. While these recent increases are encouraging, the species remains at low abundance compared to the early 1980s. Population increases have probably been aided by reduced commercial fisheries, which take wolffish as bycatch. There have been continuing declines in abundance on the Scotian Shelf and in the Southern Gulf of St. Lawrence, where historically there were fewer individuals than areas to the east and north (COSEWIC 2012c).
Canadian occurrence:	Arctic Ocean, North Atlantic Ocean
Status history:	Designated Special Concern in November 2000. Status re-examined and confirmed in November 2012.

Table 1 below compares the distribution, migration, temperature, depth and bottom type for the three species of wolffish. Further information can be found in the 2008 version of the recovery strategy and management plan which is available on the Species at Risk Public Registry.

Table 1. Comparison of essential life history attributes of Northern, Spotted and Atlantic Wolffish. References cited below as superscript are found, similarly superscripted, in literature cited (page 52).

Essential life history attributes	Northern Wolffish	Spotted Wolffish	Atlantic Wolffish
Distribution	1980 to 1984 : largest concentrations on NE Newfoundland & Labrador Shelves & Banks, also commonly found on SE & SW slopes of the Grand Banks & along Laurentian Channel. Uncommon in the Gulf of St. Lawrence & rare on the Scotian Shelf. 1995 to 2003 : area occupied & density at low levels in Newfoundland & Labrador Shelves.[1, 2] 2004 to 2012 : increase in density and area occupied, in most areas surveyed in Newfoundland and Labrador (NL) waters.[3, 4]	1980 to 1984 : concentrated on the NE Newfoundland & Labrador Shelves & Banks, south on SE & SW slopes of the Grand Banks. Also found in the Gulf of St. Lawrence & Scotian Shelf. 1995 to 2003 : area occupied & density at low levels on Newfoundland & Labrador Shelves.[1, 2] 2004 to 2012 : increase in density and area occupied, in most areas surveyed in NL waters.[3, 4]	1980 to 1984 : similar to Northern Wolffish with an additional concentration on the Southern Grand Banks, in the Gulf of St Lawrence & on the Scotian Shelf & Georges Bank. 1995 to 2003 : area occupied & density at low levels in northern part of survey range, distribution on the Southern Grand Banks, Scotian Shelf & Gulf of St Lawrence relatively constant.[1, 2] 2004 to 2012 : increase in density and area occupied, in most areas surveyed in NL waters.[3, 4]
Migration	Limited migrations noted from tagging.[5]	Limited migrations noted from tagging.[5]	Short migrations, with some longer migrations noted from tagging,[5] observed moving inshore to spawn,[6] and pelagic young may be dispersed by tides.[7]
Temperature	NL : more common at 2 to 5°C.[8] NE Atlantic : range of -1.0 to 6°C, more common at 1 to 2°C.[9]	NL : more common at 1.5 to 5°C.[8] NE Atlantic : range of -1 to 7.3°C, more common at 0 to 2°C.[9]	NL : more common at -1.5 to 4.0°C.[8] NE Atlantic : range of -1.3 to10.2°C, more common in 1 to 4°C.[9]
Depth	NL : greater range of depth than other sp., 38 to 1,504 m, mainly at >500 m to 1,000 m. NE Atlantic : down to 840 m, best catch rates at 70 to 300 m.[9]	NL : rarely in shallow areas, 56 to 1,046 m, mainly at 200 to 750 m.[8] NE Atlantic : down to 600 m, best catch rates at 200 to 530 m.[9]	NL : nearshore to 918 m, mainly in 150 to 350 m.[8] NE Atlantic : down to 500 m, best catch rates at <100 m.[9]

Essential life history attributes	Northern Wolffish	Spotted Wolffish	Atlantic Wolffish
Bottom type	Rocky bottom (at least) during spawning.[10] Found over all bottom types observed but highest concentrations over sand & shell hash during the fall survey, coarse sand in spring.	Stony bottom (at least) during spawning.[10] Found over all bottom types observed but highest concentrations over sand & shell hash during the fall survey, coarse sand in spring.	Stony bottom during spawning.[10] During feeding period, prefer complex relief of rocks, rarely in algal growths or even-silted sand, usually observed in shelters.[7] Shelters located on 15 to 30° slopes, with good water circulation, slightly silted bottom, 1 to 5 openings.[7] Occupy most convenient shelter, do not retain same shelter & do not protect them.[7] May have colonial settlements.[7]

2. Distribution

2.1 Global range

Wolffish (Family Anarhichadidae) inhabit a wide range of northern latitudes and moderately deep waters in the Atlantic, Pacific, and Arctic Oceans. The genus *Anarhichas* is widely distributed in both the eastern and western North Atlantic, the three species having somewhat overlapping distributions. In addition to its distribution in the northwest Atlantic, Northern Wolffish occurs in the eastern Atlantic including Greenland, Iceland, the Faroes, Finnmarken, Murman Coast, and Novaya Zemlya. Spotted Wolffish occurs in the eastern Atlantic from Greenland, Iceland, the Faroes, Spitsbergen, White Sea, off the Murman coast, around Scotland, and on the Norwegian Coast south to Bergen. Atlantic Wolffish occurs in the eastern Atlantic from Greenland, Iceland, the Faroes, Spitsbergen, White Sea, Murman Coast, south to the British Isles, and the western coast of France (Scott and Scott 1988).

2.2 Eastern Canadian range

Northern, Spotted and Atlantic Wolffish occur in the western North Atlantic from the Davis Strait to the Gulf of Maine. The distribution of Atlantic Wolffish extends south of eastern Canadian waters, as far south as Cape Hatteras.

More specifically, Northern Wolffish occurs from as far north in the Davis Strait at Lat. 72°N off Nunavut (northern limit), off southwest Greenland, on the northeast Newfoundland and Labrador Shelves (center of concentration), on the Flemish Cap, in the Gulf of St. Lawrence (uncommon), on the Grand Banks, and rarely on the Scotian Shelf (Banquereau and Sable Island Bank), Lat. 42°N. Similarly, Spotted Wolffish occurs off west Greenland (northern limit at about Lat. 72°N), on the northeast Newfoundland and Labrador Shelves (center of concentration), the Grand Banks, on the Flemish Cap, in the Gulf of St. Lawrence and on the Scotian Shelf. Atlantic Wolffish has a slightly more southern distribution occurring from west Greenland, on the northeast Newfoundland and Labrador Shelves, in the Gulf of St. Lawrence, on the Grand Banks, on the Scotian Shelf, in the Bay of Fundy, and in the Gulf of Maine (Scott and Scott 1988; Simpson and Kulka 2002). Atlantic Wolffish is common in the Gulf of St. Lawrence, on the Scotian Shelf and in the Gulf of Maine, where the other two species are uncommon or rare. Refer to appendix C: figures 2 to 7 for maps of the distribution of species from the Grand Banks to the Labrador Shelf, the center of their concentration.

2.3 Percentage of global distribution in eastern Canadian waters

Percentage of global distribution occurring in eastern Canadian waters is not known for any of the species. In Canadian Atlantic waters, each of the species occupies an area of about 500,000 km^2, a significant portion of the global distribution. Although the three species of wolffish are widely distributed in the western Atlantic and thus constitute a significant portion of the global population, Atlantic Wolffish is more densely concentrated to the south and east of Greenland (east of Canada's territorial limit) where they are dense enough to be the target of a directed commercial fishery.

2.4 Distribution trends in eastern Canadian waters

Fisheries and Oceans Canada (DFO) carried out standard stratified random surveys in the Canadian Atlantic. However, the resulting survey series constitute relative indices because the catchability of wolffish (and other species) is unknown and the series are not comparable among DFO Regions because of different gears and protocols used. The center of distribution of the two Threatened wolffish species is thought to be the Newfoundland and Labrador Region. As well, the greatest decline occurred in this area. As such, this document is focused mainly on the Newfoundland and Labrador Region.

On the Grand Banks to the Labrador Shelf between 1977 and 2011, Newfoundland and Labrador regional fall research surveys recorded catches of all three species of wolffish widely distributed throughout the Labrador and northeast Newfoundland Shelves to the southern Grand Banks, the center of their distribution in Canadian waters (Simpson and Kulka 2002; Kulka et al. 2004; Simpson et al. 2012, 2013).

The area surveyed in the fall covers two distinct areas of distribution based on habitat characteristics. The northern area covers the southern Labrador Shelf and the northeast Newfoundland Shelf. All three wolffish species were present along the entire shelf to the coast, particularly prior to the decline. This area comprises mainly rocky substrate. To the south on the Grand Banks, the three species inhabit only the periphery of the bank along the shelf edge, with the exception of Atlantic Wolffish that forms a concentration on the southern Grand Banks where the bottom is mainly pebble, sand, and mud. Appendix C: figures 2, 4 and 6, show the change in distribution between the early 1980s and the 1990s. These aggregate plots of wolffish distributions for the time periods 1980 to 1984, 1985 to 1993 and 1994 to 2001 show a declining distribution in both intensity (lower catch rates) and extent of the distribution of the three wolffish species. This reduction in the area occupied coincides with an observed decline in the biomass and abundance estimates of these species (Simpson and Kulka 2002; Kulka et al. 2004). Appendix C: figures 3, 5 and 7 illustrate the changes in distribution of wolffish from 1977 to 2009 (Simpson et al. 2012). During the last decade, overall results indicate an increase in distribution of all three wolffish species, in most areas surveyed (Simpson et al. 2013).

In years when the Flemish Cap was sampled, the three wolffish species were also found in abundance there. For Northern Wolffish, large catches occurred throughout the northeast Newfoundland Shelf and the Labrador Shelf during the early 1980s. However, from 1986 to 2005, the distribution of larger catches of Northern Wolffish was increasingly limited to the shelf edge throughout the entire survey area. Similar to the distribution of Northern Wolffish, the catches of Spotted and Atlantic Wolffish were increasingly limited to the periphery of the northeast Newfoundland and Labrador Shelves and the Grand Banks from the mid-1980s to the very early 2000s (Kulka et al. 2004; Simpson et al. 2012). By this time, the distribution of all three species of wolffish contracted relative to their distributions during the 1970s and early 1980s. Trends have reversed in recent years, with the distribution of Spotted and Atlantic Wolffish increasing since the early 2000s and the distribution of Northern Wolffish increasing since 2005 (Simpson et al. 2012, 2013).

Atlantic Wolffish has a distinguishing feature in terms of its distribution on the Grand Banks. In addition to large catches on the bank edges, as is the case for all three species, Atlantic Wolffish is also captured in shallower waters on the southern Grand Banks, a circular on-shelf concentration, where the other two species are not found (appendix C: figures 2, 4 and 6).

Between 1980 and 1984, Northern Wolffish were widely distributed throughout the area north of the Grand Banks covering much of the shelf, the eastern Grand Banks shelf edge and the Flemish Cap. From 1985 to 1993, there was a decline in the extent and intensity of the distribution of Northern Wolffish (Kulka 2004). From the mid-1990s to the mid-2000s, Northern Wolffish were concentrated only on the shelf edge, the edge of the southern Grand Banks and the Flemish Cap. However, since 2005, survey catches of Northern Wolffish have expanded over the same historical areas, suggesting a reversing trend from population decline (Simpson et al. 2012, 2013).

Prior to 1986, Spotted Wolffish were extensively distributed north of the Grand Banks covering much of the shelf, with a few occurrences along the eastern Grand Banks shelf edge and the Flemish Cap. Between 1985 and 1993, previously observed areas of high density had disappeared, the distribution reduced to low density concentrations along the shelf edge and in deep channels. During the late 1990s, there were no significant concentrations of Spotted Wolffish compared to previous time periods (Kulka et al. 2004). However, beginning in 2000, the declining trend reversed as survey catches of Spotted Wolffish increased over historical areas of the continental shelf (Simpson et al. 2012, 2013).

Similar to the pattern observed for Northern Wolffish during 1980 to 1984 north of the Grand Banks, Atlantic Wolffish were widely distributed covering much of the northeast Newfoundland and Labrador shelves. In addition, a separate aggregation of Atlantic Wolffish centered at Lat. 44°N, west of the Southeast Shoal on the tail of the Grand Banks was also apparent, well separated from the concentrations on the Labrador Shelf. During the mid-1980s and through the 1990s, there was a reduction in the extent and density of the northern component of Atlantic Wolffish; however, the southern Grand Banks concentration remained relatively unchanged or increased slightly (Kulka et al. 2004; Simpson et al. 2012, 2013). Since 2000, there has been an expansion of survey catches for Atlantic Wolffish over the same historical areas. These distribution patterns are similar to those for Atlantic Wolffish during the 1980s, and also indicate a reversal of population decline (Simpson et al. 2012, 2013).

At their center of concentration (Grand Banks, northeast Newfoundland Shelf and southern Labrador Shelf), both the relative and absolute area occupied by high, medium and low density concentrations of all three species declined from the high density periods of 1980 to 1984 relative to the low density periods, 1995 to 2001 (appendix C: figure 8 upper panel; refer to Simpson and Kulka 2002 for a definition of density levels). The decline in the area occupied by high densities of wolffish was most pronounced for Northern Wolffish (55%), and least pronounced for Atlantic Wolffish (38%) (Simpson and Kulka 2002; Kulka et al. 2004). The area occupied by high density Spotted Wolffish concentrations declined by 47%. The middle panel of appendix C: figure 8, shows that the overall area of occupancy also declined, from the 1980s to the early 2000s, for the three species, but was most pronounced for Northern Wolffish, and least pronounced for Atlantic Wolffish. The concentration of Atlantic Wolffish on the southern Grand Banks actually increased slightly (appendix C: figure 8 lower panel).

Appendix C: figures 9, 10 and 11 illustrate the changing trends in area of occupancy of each species in Northwest Atlantic Fisheries Organization (NAFO) Divisions 2J3K (spring) and 3LNO (fall and spring), from 1971 to 2010 (from Simpson et al. 2012). The clearest trend in area of occupancy for all species is shown in NAFO Divisions 2J3K. In this area, there was a substantial decline in area occupied from the late 1970s to the mid-1990s for Spotted and Atlantic Wolffish*,* and to the early 2000s for Northern Wolffish*,* followed by an increase in area occupied for all species. Northern Wolffish showed the largest decline in area of occupancy (>99%), decreasing steadily from 76% in 1977 to <1% in 2003, with trends then reversing to 11% to 20% in recent years. Spotted Wolffish decreased from 57% in 1978 to 4% in 1994, before increasing to 6% in 1996 and 32% in 2008. Atlantic Wolffish decreased from 68% in 1979 to 10% in 1994, but then showed the greatest increase of all species, rising to 30% in 1995 and 47 % in 2007 (Simpson et al. 2012).

Of the three species of wolffish in Newfoundland and Labrador waters, the indices of relative abundance and distribution have varied the least for Atlantic Wolffish, especially on the Grand Banks (1975 to 2010) and northeast Newfoundland and Labrador shelves (1995 to 2009). In contrast, Northern Wolffish underwent the greatest decline in indices of area occupied and relative abundance, during the same time period. All species have shown increases in indices of relative abundance and distribution since the early 2000s, returning to several historical areas, and showing patterns of distribution similar to that observed during periods of high abundance. Overall, the three species of wolffish in Newfoundland and Labrador waters have all shown signs of stock recovery in the last decade (Simpson et al. 2012).

Surveys were sporadic in the Arctic, but fisheries in the Davis Strait as far north as Lat. 72°N occasionally capture Northern and Spotted Wolffish, describing the northern limit of the distribution (Kulka et al. 2004). DFO surveys in the Arctic region, although limited, have shown that all three species have been found in NAFO Subarea 0. They are close to the boundary of NAFO Subarea 1 (Greenland waters) and NAFO Division 2G and could possibly be extensions of the stock from these areas. Area of occupancy generally remained the same for all wolffish species over time (Simpson et al. 2012, 2013; DFO 2013).

Annual DFO summer surveys (1970 to 2010) on the Scotian Shelf have shown that Northern and Spotted Wolffish are near the southern limit of their range in this area (McRuer et al. 2000; Simon et al. 2012). Both species are rare, with catches mainly on the eastern Scotian Shelf, with some along the shelf edge. In comparison, Atlantic Wolffish are found throughout the entire Maritimes region (McRuer et al. 2001; Simon et al. 2012). The two primary areas of concentration of Atlantic Wolffish are located on the Scotian Shelf; one on the east (NAFO Divisions 4VW) and one on the west (NAFO Division 4X, primarily Brown's Bank). Area of occupancy, for Atlantic Wolffish in this area, has declined steadily since the 1970s with the greatest decrease occurring in the western Scotian Shelf (NAFO Division 4X) (Simon et al. 2012).

Annual surveys in the Gulf of St. Lawrence (1978 to 2012) have shown that all three wolffish species are found in this region (McRuer et al. 2000; Dutil et al. 2011b; Simpson et al. 2013). Northern Wolffish are rare, with most catches off the southwest coast of Newfoundland and a few on the continental slope along the Laurentian Channel. Spotted Wolffish are less rare, and are most commonly found in the northeastern Gulf, on the shelf off Newfoundland's west coast, and the slopes of the Esquiman Channel. Both Northern and Spotted Wolffish are virtually absent in the southern Gulf. Distribution of Atlantic Wolffish is more extensive in this region. They avoid deep channels and the upper slopes of channels and shelves, such as the shelf off Newfoundland's west coast and the northeastern Gulf. The relative occurrence of Atlantic Wolffish is generally low in the southern Gulf, with most catches along the 200 m isobath, as well as some catches on the Magdalen Shallows. Spotted and Atlantic Wolffish show the largest degree of overlap in spatial distribution, with Atlantic Wolffish found closer to the coastline and avoiding deep channels. Relative occurrences for all species do not show any significant trends over time (Dutil et al. 2011b; Simpson et al. 2013).

Wolffish young of the year (YOY), identified as Atlantic Wolffish, were captured in International Young Gadoids Pelagic Trawl (IYGPT) sets conducted from 1996 to 2000 (August and September). They were widely distributed offshore on the northeast Newfoundland and Labrador Shelf (Simpson and Kulka 2002; Simpson et al. 2012). It is possible that some of the YOY taken in the survey comprised other species of wolffish since fish of that size are difficult to distinguish to the species level. Small (<55 cm in length) wolffish, captured in the fall trawl surveys were also found to be distributed extensively in similar offshore areas. Overall, there is considerable overlap in the distribution of small and large (> 55 cm) Spotted and Atlantic Wolffish including YOY. In the case of Atlantic Wolffish, there was an increase in the size of catches of small fish from 1995 to 2000 along the edge of the northern shelf and on the southern Grand Banks. However, for Spotted Wolffish, there was no apparent increase in the proportion of small fish in this same time period.

3. Population abundance

3.1 Global range

Wolffish are distributed in the northeast Atlantic off Greenland and they are the target of a significant fishery in parts of the north Atlantic, primarily in the northeast Atlantic off Greenland (Möller and Rätz 1999). However, because of different survey gears and protocols used in different parts of the range of wolffish, relative population abundance among various parts of its range cannot be determined at this time.

3.2 Population sizes and trends in eastern Canadian waters

Biomass and abundance estimates for wolffish at the center of their abundance, the Grand Banks to Labrador Shelf, were derived from Newfoundland and Labrador regional fall research surveys (Simpson and Kulka 2002; Simpson et al. 2012, 2013) conducted between 1977 and 2011 (Grand Banks, Northeast Newfoundland Shelf, and South Labrador Shelf) and spring research surveys between 1971 and 2012 (Grand Banks and St. Pierre Banks only). Neither of these fall or spring surveys covered the Gulf of St. Lawrence, the Scotian Shelf or the Northern Labrador Shelf into Davis Strait, although all but the Davis Strait is surveyed at other times with different gears. Thus, the spring and fall series are not comparable and neither covers the entire range of wolffish species in Canadian Atlantic waters. The fall survey series is the best measure of wolffish relative abundance as it extends over the area where all three species are at the center of their distribution (Simpson and Kulka 2002). Thus, the fall survey is used to describe trends in abundance. Although surveys on the northern Labrador Shelf have been infrequent, the wolffish species there appear to have undergone a similar if not greater pattern of decline from the early 1980s to the mid-1990s, as described below for areas directly to the south.

The magnitude of the Newfoundland and Labrador fall indices after 1995 is not comparable to that of the pre-1995 period due to a change in gear type used during the surveys. Catchability conversion factors between the Engel (pre-1995) and Campelen (current) trawl gear are not available for wolffish species. The gear change is delineated in appendix C: figures 12, 13 and 14 by a gray vertical bar to distinguish the two series. The area surveyed in the fall is divided into two areas based on distinct distribution characteristics (described above) and habitats. The northern area (2J+3K in appendix C: figures 12, 13 and 14) covers the southern Labrador Shelf and the northeast Newfoundland Shelf and the southern area covers the Grand Banks (3LNO in appendix C: figures 12, 13 and 14). In both the northern and southern parts of the survey, the indices declined by more than 90% for all three species, since the 1980s (appendix C: figures 12, 13 and 14).
Appendix C: figures 15, 16 and 17 illustrate the changes in indices of relative abundance (number of fish/tow) for each wolffish species, during spring (NAFO Divisions 3Ps and 3LNO) and fall (2J3K and 3LNO) surveys, from 1971 to 2010 (from Simpson et al. 2012). These figures contain the most recent wolffish abundance information.

From the Grand Banks to Labrador Shelf, Northern Wolffish underwent the most significant decline of the three species (appendix C: figure 12), greatest in the north (2J3K) and steepest between 1984 and 1994. Northern Wolffish underwent a less precipitous decline in the south (3LNO). Note that the southern area was not surveyed in the fall prior to 1981. As a result of different decline rates between north and south, after 1991, Northern Wolffish actually had a higher abundance in 3LNO than in 2J3K whereas, prior to that time, abundance to the north was about 5 to 6 times greater. From 1995 to 2001, the indices for Northern Wolffish, both north and south, were stable.

Similar trends are shown for relative abundance (number of fish/tow) of Northern Wolffish (appendix C: figure 15), in the same areas and time period. In 2J3K, the highest catches (up to 5 fish/tow) occurred prior to the mid-1980s, with a decline to very low levels in the mid-1990s to early 2000s, and small increases in more recent years. In 3LNO, the catches were higher prior to the mid-1980s, declining to low values during the 1990s (spring), but with signs of improvement in recent years (fall and spring) (Simpson et al. 2012).

Spotted Wolffish underwent a decline that was nearly as dramatic as Northern Wolffish (appendix C: figure 13). However, in contrast, biomass was approximately equal in the northern and southern areas prior to the decline (appendix C: figure 13). The decline rate was about the same in both areas, unlike Northern Wolffish, and thus it retained about equal proportions of biomass between areas over the period of decline. From 1995 to 2001, the indices, and particularly abundance, have undergone a substantial increase, more than doubling numbers of wolffish between 1995 and 2001. This suggests improved recruitment and improved survival. However, it should be noted that since 1993, deep strata (and inshore strata) have been successively added to the surveys. The portion of the increase in the indices that is attributable to an increased survey area is uncertain (a subject for future research).

In 2J3K (fall), catches of Spotted Wolffish were highest (up to 1.5 fish/tow) during the late 1970s (appendix C: figure 16). The relative abundance declined steadily through the 1980s, dropping to very low levels of 0.2 fish/tow by 1995, at which point the gear change occurred. The index increased through the Campelen series, peaking in 2008 with 0.56 fish/tow. In 3LNO (spring), catches of Spotted Wolffish were higher prior to the early 1980s, and decreased to low values during the 1980s and mid-1990s. Catches (spring and fall) increased since the introduction of the Campelen gear and peaked in 2006 (Simpson et al. 2012).

Overall, the observed decline in Atlantic Wolffish biomass was not as great as for the other species, but was on a similar scale in the north (2J3K) where most of the decline occurred for this species (appendix C: figure 14). To the south (3LNO), the indices tended to be stable between 1981 and 1994. However, the fish that were located on the shelf edge of the Grand Banks did decline slightly, whereas the concentration on the southern bank actually increased slightly. After 1994 (and the change in survey gear to Campelen), the indices for Atlantic Wolffish increased steadily, particularly to the south, in terms of biomass.

Trends in Atlantic Wolffish indices of relative abundance were similar to those for Northern Wolffish (appendix C: figure 17). In 2J3K, the highest catches (up to 8.3 fish/tow) occurred in the late 1970s, with a decline to low levels in the mid-1990s. The index increased with the introduction of the Campelen gear in 1995, and has changed very little since then. Spring and fall indices in NAFO Divisions 3LNO show little variability for all periods, except for some increases since the mid-2000s (Simpson et al. 2012).

Spring surveys (starting in 1971) covered only the Grand Banks, but this spatially restricted series is longer than that of the fall series. The biomass and abundance spring indices for all three species of wolffish fluctuated over the survey period, increasing during the 1970s, declining in the early 1980s, increasing in the late 1980s and declining again in the early 1990s (Simpson and Kulka 2002). Since 1996, the spring abundance and biomass indices have generally varied without trend (Simpson et al. 2012). For both spring and fall surveys, the magnitude of the indices from fall 1995 are not comparable to earlier years due to the change in survey gear.

Relative size (total biomass/total number) was calculated for all three wolffish species based on DFO fall Research Vessel (RV) surveys from 1977 to 2001. The relative size of Northern Wolffish increased during 1981 to 1991 in the north (2J3K), but declined thereafter (Simpson and Kulka 2002). For Spotted Wolffish, the relative size of fish in the north was greater than in the south. Associated with the decline in abundance and biomass, the relative size of Atlantic Wolffish also declined in the northern area (2J3K). Throughout all of the survey periods, relatively larger Atlantic Wolffish were captured in the southern areas (particularly on the bank) than to the north. The relative size of all three wolffish species measured during the surveys was smaller during the period of 1995 to 2001 across all areas. This is likely a result of changing to the Campelen survey gear that has a higher catchability for smaller fish. However, a proportionately greater increase in abundance than in biomass after 1995 observed in all three species, to differing extents, suggests that there may be improved recruitment in recent years as well.

The abundance of all species of wolffish in annual DFO summer surveys (1970 to 2010) and other surveys on the Scotian Shelf is low (McRuer et al. 2000; Simon et al. 2012). Northern and Spotted Wolffish are rare, with catches mainly on the eastern Scotian Shelf, and some along the shelf edge. Abundance has been very low in all surveys with both species occurring in less than 0.5% of sets. Atlantic Wolffish were the most common species, and were captured in 19.2% of sets in DFO summer RV surveys. They are found throughout the Maritimes, with two main concentrations on the Scotian Shelf; one on the east (NAFO Divisions 4VW) and one on the west (NAFO Division 4X, primarily Brown's Bank). Trends in abundance on the eastern and western portions of the shelf differ when examined separately for mature (>53cm) and immature length groups. On the eastern shelf, mature Atlantic Wolffish declined by 99% since 1970, while immature Atlantic Wolffish have increased in the same time period. On the western shelf, mature abundance declined by 81% since 1970, and immature abundance declined by a similar amount in the same time period. Overall abundance of Atlantic Wolffish (all lengths) on the Scotian Shelf has declined since 1990 (Simon et al. 2012; Simpson et al. 2013).

The abundance of wolffish in annual DFO RV surveys of the Gulf of St. Lawrence (1978 to 2012) is relatively low, with most catches in the northern Gulf (McRuer et al. 2000; Dutil et al. 2011b; DFO 2013). Northern Wolffish is the rarest, with only 102 occurrences reported over the survey time period. Relative occurrence has been consistently low, with some higher values before 1990 (DFO RV and Sentinel Surveys). Although not as rare as Northern Wolffish, the abundance of Spotted Wolffish is also low in this area, with 248 occurrences reported in DFO RV surveys. Relative occurrence (DFO RV and Sentinel Surveys) of Spotted Wolffish is more variable than Northern Wolffish, with higher values after 1990. Atlantic Wolffish is the most abundant wolffish species in the region with 1,306 occurrences reported in the DFO RV surveys. Relative occurrence (DFO RV and Sentinel Surveys) of Atlantic Wolffish has been higher than that of the other two species. Overall, relative occurrences for all species of wolffish in the Gulf do not suggest any significant trends over time (Dutil et al. 2011b; DFO 2013).

DFO surveys in the Arctic region, though sporadic, have shown that all three species have been found in NAFO Subarea 0 at low abundance (Simpson et al. 2012).

3.3 Percentage of global population in eastern Canadian waters

Different survey gears are used in different parts of the world (and in different parts of eastern Canada) to quantify population size and examine changes over time. Therefore, relative proportions of populations occurring in various parts of the range of the wolffish species in the Atlantic cannot be determined, although the Canadian Atlantic component certainly represents a significant proportion of the global population. Percentages of the global populations in eastern Canadian waters are not known at the present time.

4. Biological limiting factors

Based on observed growth and fecundity of Atlantic Wolffish in U.S. waters, Musick (1999) described the reproductive productivity of wolffish as “low”. The testes of these species are relatively small, sperm and egg production are low, fertilization is internal and eggs and larvae are large. Although fecundity is low, internal fertilization (Pavlov 1994), nesting habits and egg guarding behaviour in Atlantic Wolffish (Keats et al. 1985) effectively increases potential for survival of individuals during the early life stages.

Many demersal fish species in eastern Canadian waters have undergone similar changes in distribution and population decline over the same time period, but there is little consensus in the literature as to the proximal cause for these multi-species declines. The patterned declines and the contraction of distributions to deeper waters observed with wolffish have also been observed in other species during the same time period (Atkinson 1994; Kulka et al. 1995).

Attempts to relate changes in population size and distribution to environmental signals have been met with little success. As well, over-fishing hypotheses have not been fully satisfactory in many instances in explaining the declines. Although bycatch mortality clearly has contributed to the declines, evidence of over-fishing as the proximal cause is lacking for non-commercial species (Simpson and Kulka 2002). For wolffish, the greatest declines occurred where fishing effort was low and the remaining concentrations largely coincide with the most heavily fished areas (Kulka and Simpson 2004). Future research may reveal the importance of environmental factors in the decline.

Estimating the status of populations can be problematic due to incomplete coverage of the population range. In addition, although the period in which standard stratified random fall surveys have been done (1977 to present) may be sufficient to provide information on long term trends for these long lived species, the surveys started when the survey index was at a maximum and it is unknown if this was a normal fluctuation or a result of other factors. Marine fish undergo natural fluctuations often resulting from variable recruitment and thus peaks and valleys over the long term are the norm. Fluctuating trends are apparent for virtually all monitored species. To pick a point in time when a population is at its peak and compare it to the low point in the trend may not be a valid measure of risk of extinction. Not enough is known about the long term population trends of these species, or the environmental influences to fully understand how critical the abundance levels reached in the mid-1990s are to the survival of the species in Canadian waters.

Fishing pressure accentuates the downward component of fluctuations caused by natural influences even when the exploitation rate is relatively low. It is unknown how much of the precipitous declines observed between the early 1980s and the mid-1990s is attributable to natural fluctuation and how much is attributable to an anomalous event caused by extraordinary circumstances (natural or anthropogenic, or both). Nonetheless, attention must be paid to the declining biomass trends and the reduction in extent of the distribution in the 1980s and 1990s, particularly in the north.

The apparent increase in biomass and abundance since the mid-1990s, for Spotted and Atlantic Wolffish is an encouraging sign. Whether this increase resulted from more favourable environmental conditions or reduced fishing pressure in the 1990s, or a combination of effects, is unclear. Since improvements in biomass and abundance indices are very slight, several additional years of research survey data are required to confirm whether recovery is taking place. Furthermore, with any apparent increase in biomass, it seems likely that the extent of the wolffish distributions would also increase within the range previously observed in the absence of an environmental shift that might prevent a re-colonization (Simpson and Kulka 2002).

5. Threats

The magnitude of the role of natural vs. anthropogenic effects is poorly understood. It seems likely that a combination of natural and human induced mortality, perhaps in combination with poor recruitment, have been the cause for wolffish population decline.

There is the potential to influence some of the anthropogenic activities that have an impact on wolffish populations. To do this, we need to know which activities constitute a threat to the populations and their habitat, and how to change or curtail these activities in order to lessen their impacts and, at the same time, increase the chances of recovery of the wolffish populations.

The current level of knowledge limits the effectiveness and scope of Canadian recovery initiatives. Population structure, absolute estimates of population size, and relative contribution of threats to the decline are unknown. Knowledge of exactly how habitat has been and is being utilized and to what extent available habitat is critical to the species survival or recovery is not available (Kulka et al. 2004). With development of that knowledge, a better understanding of the threats can be achieved, and measures required to mitigate factors limiting recovery can be refined.

Preliminary information on total removals of wolffish species combined is provided in Simpson and Kulka (2002), but a breakdown of species by fishery is required to evaluate the potential impact on each species. Possible bottom alteration due to fishing activities on or near wolffish habitat needs to be better quantified; there is currently little or no information on the effects of bottom trawling, although trawled locations have been delineated by Kulka and Pitcher (2001). The effects of bilge and ballast water are unknown. Pollution from land-based sources that could affect the well-being of the species needs to be identified and, to the extent possible, mitigated. Offshore exploration for minerals, oil and other resources needs to be carried out with environmental protection in mind.

Linking stewardship to recovery activities, communication and education programs needs to be specific and understandable for each stakeholder. If these initiatives are ineffective, cooperation from legislators, scientists, industry and all other stakeholders in the protection of an incidentally caught fish with low perceived economic value will be difficult to foster and promote. As a result, it is a concern that currently known threats will not be properly mitigated and suspected threats will not be studied to determine their relative effects.

There is a need to delineate temporal and spatial effects of threats and the intensity of these threats on the various life stages of wolffish and their habitats. Regional cooperation to protect these species and their habitat must be implemented.

5.1 Fishing

The impact of incidental capture of wolffish in many fisheries is thought to be the leading cause of human induced mortality. However, the proportion of mortality due to fishing activities that contributes to total mortality and to the decline of these species is unclear.

Prior to the 2004 requirement to release Threatened wolffish species taken incidentally in Canadian fisheries, wolffish catches and landings were unregulated. There is no directed fishery for wolffish in Canadian waters, but their extensive distributions which overlap fishing grounds have made them a common bycatch in many Atlantic fisheries.

Kulka (1986) and Simpson and Kulka (2002) noted that nearly all bycatch of Northern Wolffish were discarded and about half of the other two species were retained, thus landing statistics underestimate actual catches. Reported catches of wolffish were considerably higher in the 1960s and early to mid-1970s prior to the period of decline (Simpson and Kulka 2002). Trawl effort in the years just preceding and during the decline was considerably lower and has remained low since. During the 1980s, Canadian catches, including amounts discarded at sea, exceeded 1,000 tonnes in most years. Catches then declined after 1991, when many demersal fisheries were closed. Kulka and Pitcher (2001) showed that about 20% of the shelf area on the Grand Banks to Labrador Shelf was trawled annually during the early 1980s, dropping to about 5% in the 1990s. Since the early 1990s, the reduced effort has resulted in less bycatch of wolffish, subsequently benefiting the species.

A greater proportion of Atlantic and Spotted Wolffish was retained in the 1990s. On the Grand Banks to Labrador Shelf, reported Canadian landings were only 23 tonnes in 1996, but increased to 157 tonnes in 1997, 155 tonnes in 1998, 315 tonnes in 1999, and 369 tonnes in 2000. Recent increases were due mainly to bycatch from the cod longline fishery south of the island of Newfoundland. About 250 tonnes were also taken in the yellowtail fishery on the Grand Banks, but all were discarded. In the areas south of the Grand Banks, from the Gulf of St. Lawrence, Scotian Shelf, Bay of Fundy, and Gulf of Maine, wolffish landings (almost exclusively Atlantic Wolffish) were 1,000 to 1,500 tonnes in the 1960s, increasing to about 2,000 tonnes between 1968 and 1979 and peaking at about 4,000 tonnes in 1983 (all countries included). Landings dropped steadily to 1,000 tonnes in the early 1990s and were estimated to average about 625 tonnes in the early 2000s, prior to mandatory release of the Threatened species. Canadian landings represent approximately 55% of this total, with the remainder consisting mostly of U.S. landings from the Gulf of Maine area. Canadian landings of wolffish since 1986 were primarily from the southwest Scotian Shelf and constituted 81% of the total, with the western Gulf of St. Lawrence contributing 10% and the remainder spread out among other areas (McRuer et al. 2000). Since 2004, all Spotted and Northern Wolffish taken incidentally in Canadian waters must be released in a manner that maximizes chance of survival.

Commercial landing statistics lump all wolffish together under the general category “catfish” that includes Spotted and Atlantic Wolffish. However, fishery observer records do differentiate by species indicating that since the late 1990s, about 80% of the catch of the two Threatened species, Spotted and Northern Wolffish occurs in the Greenland Halibut (*Reinhardtius hippoglossoides*) directed fisheries on the Labrador Shelf and Grand Banks (Kulka and Simpson 2004). Commercial log data are thought to underreport catch rates for all three species, as indicated by fishery observer data from various fisheries.

Areas of greatest decline for all three species, on the inner northeast Newfoundland and Labrador Shelf (where wolffish formed high density concentrations in the 1970s) are areas where trawling seldom or never occurs (Kulka and Pitcher 2001) or any other form of fishing seldom takes place. Some of the most intense fishing effort during the 1970s through the early 1990s was located on the shelf edge, north of the Grand Banks where significant concentrations of the wolffish species still occur and where the vestiges of some commercial species such as cod were concentrated just prior to their collapse (Rose and Kulka 1999). Thus, it is the most intensely trawled areas along the shelf edge from the northern Labrador Shelf to the Grand Banks where the three wolffish species continue to be most abundant. Considering these species undertake limited movements (Templeman 1984), and given the mismatch in area of greatest decline for wolffish and trawling activity, while certainly contributing to the total mortality, the evidence is contrary to the hypothesis that trawling is the only or perhaps the proximal cause for the decline in wolffish (Kulka et al. 2004). This suggests significant non-fishery influences coupled with fishery related mortality contributing to the distribution and abundance changes observed.

A significant proportion of fishing mortality for wolffish occurs outside of Canada's territorial limit. Non-Canadian bycatch of wolffish in the NAFO Regulatory Area (NRA) are thought to be underreported (Simpson and Kulka 2002). Depths fished and amount of fishing effort in the NRA suggest that those bycatches could constitute a substantial proportion of the mortality since those captures are unregulated and most of the fish are retained for commercial purposes. Fish taken there are probably part of the same population that inhabits Canadian waters.

Harvesting technology, specifically bottom trawling and dredging, have been identified by COSEWIC as possible causes of wolffish habitat alteration. Incremental losses of nesting and shelter habitat (habitat alterations, degradation and associated fragmentation) due to fishing are potential threats to the recovery of wolffish species, a family of fish that apparently have limited dispersal and possible nesting requirements. However, for practical reasons, trawling operations avoid rocky areas since trawling in such areas leads to the destruction of expensive gear. This affords a level of protection for rocky habitats. Also, as noted previously, areas of greatest decline do not correspond with locations of most intense trawling.

5.2 Offshore oil and gas exploration and production

Increased exploration and production of petroleum resources in eastern Canadian waters increases the possibility of oil spills, offshore well blowouts, tanker spills and other potential disasters. These accidents release petrochemicals, dissolved metals (which can result in toxic metal ingestion) and other solids into the ecosystem. In addition, exposure to these and other potential pollutants may result in direct mortality or a host of sub-lethal impairments to wolffish, their prey and their ecosystem (for example, slower growth, decreased resistance to disease).

With any petroleum development, there is always the chance of a major release of either oil or gas into the environment from a spill associated with the storage and movement of the product after extraction or a blowout during drilling. Well blowouts and major spills have the potential to release hydrocarbons at a rate faster than natural ecosystems can accommodate them, and affect organisms not previously exposed to oil-derived hydrocarbons in concentrations greater than trace amounts.

The amount of oil reaching bottom sediments depends on numerous factors including the volume of the blowout, type of blowout (platform or sea floor), hydrocarbon composition, wind, currents and water column structure, depth of water and degree of water column mixing. Transport mechanisms include adherence to particles, incorporation into zooplankton fecal pellets, direct sedimentation of weathered oil particles and vertical mixing.

It remains very difficult to show the impacts of oil-induced mortality on early life stages of finfish and invertebrate resources because of their large and variable natural mortality. The effects of oil on adult fish in the field are difficult to study and therefore knowledge is incomplete (DFO 2011a). Any mortality of benthic species induced by a single event would probably be limited in both extent and time (Boudreau et al. 1999). If regulations and guidelines are followed, the impacts of accidental events are likely to be negligible for wolffish or other species. As well, the only near-surface stage of the wolffish life cycle is the larval stage and thus, this is the only part of the life cycle that could be potentially affected by the release of hydrocarbons.

Release of hydrocarbons is not the only potential issue. The debris generated from drilling operations has two major components; muds and cuttings. Muds tend to be finer, less dense material, while cuttings are generally coarser and heavier pieces of rock about the size of sand grains (Boudreau et al. 1999). The most obvious impacts of exploratory drilling on the environment have been associated with drilling muds. Drill muds are used by the oil and gas industry to cool and lubricate drill bits, help balance hydrostatic pressure and transport cuttings to the surface (DFO 2011a). There are three classes of muds: water-based muds (WBM), oil-based muds (OBM) (permitted in only exceptional circumstances (National Energy Board et al. 2010)), and synthetic-based muds (SBM) (designed to be less toxic and more environmentally friendly than OBM (DFO 2011a)). The discharge of OBMs and SBMs is prohibited offshore Newfoundland and Labrador and Nova Scotia; however, treated SBM cuttings can be discharged to the sea. WBMs and their cuttings can also be discharged (National Energy Board et al. 2010). Once discharged, there are a number of different processes that act on them that determine their fate and potential impacts on the environment.

The circulation and Benthic Boundary Layer Transport (BBLT) determines the fate of fine particles of drilling mud, the key determinants of dispersion, and how impacts might change with seasons (Hannah et al. 1995; Hatch Associates Ltd. and Griffiths Muecke Associates 2000). Discharged drilling muds can accumulate in low energy systems to smother benthic organisms near the rig and result in their suffocation. Similarly, with high settling velocity of cuttings, there is reason to believe that smothering might kill significant numbers of slow moving or sessile organisms in the area directly under a drill rig (Boudreau et al. 1999; DFO 2011a).

A synthetic based drilling fluid (IA-35) is presently being used in the Newfoundland and Labrador offshore. Toxicity studies carried out on scallops, as well as selected studies with plankton and fish larvae, indicate a very low potential for acute toxicity (Armsworthy et al. 2000; Cranford et al. 2000; Payne et al. 2001). The acute toxicity data available for both synthetic and water-based fluids indicates that discharges from platforms into well-mixed waters should result in little or no chemically mediated acute effect (Neff 1987; GESAMP 1993; Payne et al. 1995). It has been demonstrated that cuttings have a very low acute toxicity as well (Payne et al. 2001).

In summary, operational discharges would cause some biological effects over relatively short time periods, and small distances from the discharge point. Smothering of benthic organisms by deposited mud and cuttings would not be anticipated outside an estimated 0.5 km radius from the rig (DFO 2011a). The use of lower toxicity, water-based drilling muds should minimize the direct mortality of organisms, as would the use of low toxicity oil for lubrication and a spotting fluid. The zone of impact around a rig would vary with location time and quantity of discharge. Impacts would disappear rapidly once drilling ceases (DFO 2011a). It is anticipated that the dispersed muds, cuttings, and associated hydrocarbons would cause localized sublethal effects for some bottom dwelling organisms. Because of the large degree of spatial and temporal variability in natural populations, and the limitations of current sampling methods, it is expected that it would be very difficult to detect the net result of any impact at the population level (Boudreau et al. 1999). Thus, any potential effects on wolffish would be highly localized and insignificant to the population as a whole.

5.2.1 Seismic activities

Eastern Canadian waters are a region of intense exploration for petroleum-related resources. To identify probable oil and gas reserves, the offshore oil and gas industry uses seismic exploration techniques to evaluate the geology that underlies the sea. This involves the use of towed arrays of airguns, cylinders of compressed air under high pressure (about 2000 psi). The array, containing multiple cylinders, is repetitively discharged to generate a pressure pulse every 10 to 15 seconds (DFO 2011a).

No research has been carried out on the effects of seismic activity on wolffish species; however, Sverdrup et al. (1994) suggest that airgun blasts constitute a highly unphysiological sensory stimulus to fish. The noise from airguns generates a compression and decompression wave in the water that, at close range, is sufficient to kill fish at certain life stages (Boudreau et al. 1999; Payne 2004). At less than about 5 m, air guns have the potential to cause direct physical injury to fish, eggs and larvae. However, Payne (2004) provides a literature review that suggests that injury to fish eggs and larvae even at close range is limited. It is likely that fish would be driven away from the noise prior to coming close to the air guns, so the risk of physical injury would be greatest for those organisms that cannot swim away from the approaching sound source, especially eggs and larvae. If seismic operations are conducted in areas where larvae are aggregated, then higher levels of mortality may occur. However, the level of mortality for marine fish is not regarded as having significant effects on recruitment to a stock (Dalen et al. 1996; Payne 2004). In the case of wolffish, adults and eggs are generally found on or near bottom at distances of 100 to 900 m away from the surface. Hence, direct physical impact on these life stages will likely be minimal or non-existent. It is the near surface larval stages that could potentially be directly affected by seismic activity. Seismic activity synchronized with periods of larval hatching has the greatest potential for harm.

Little is known about the behavioral effects that may occur at greater distances from the air gun noise source. It is possible that wolffish adults guarding nests could leave the area of disturbance to the detriment of the egg cluster. However, no information exists for wolffish to confirm the potential effects.
The impact of seismic activity and other exploration methods used to research offshore resources needs to be quantified with respect to wolffish and their habitat. There are no documented cases of mortality of any fish species upon exposure to seismic sound under field operating conditions (DFO 2004a). Nothing is known about the possible

effect on wolffish species at any stage of their life history, and currently there is scientific uncertainty regarding the potential impacts of seismic activity on marine organisms in general. Any knowledge gained by scientists must be provided as guidance to the industry.

5.3 Ocean dumping

5.3.1 Sewage sludge

Sewage sludge may be disposed of in the marine environment by coastal dumping or pipeline discharge, and has a known impact on both planktonic and coastal benthic communities. Sewage sludge contains bacteria and viruses, that are known to be toxic to shellfish, but their effect on wolffish is unknown. As much of this dumping is coastal, it is thought that the effect on widely distributed wolffish would be minimal. However, the potential for these effects needs to be evaluated and, if identified as harmful, impacts must be mitigated.

5.3.2 Fish waste

During the processing of fish and other marine organisms, a large volume of wastes are generated, including fish heads, tails, guts and internal organs. Fish waste can amount up to 75% of the weight of a fish before processing, depending on the species and process. Various chemicals, primarily heavy metals and chlorinated hydrocarbons contained in the fish waste, may be accumulated in marine sediments, and subsequently released into the water column under specific circumstances, thereby becoming available to marine organisms.

Fish and other marine organisms may contain various chemicals, such as heavy metals, antibiotics and hormones. Concerns appear warranted regarding the overuse and misuse of certain chemicals, for which a proper risk assessment has not been made in relation to the marine environment. However, these issues apply mainly to coastal habitat and particularly to aquaculture species.

Various chemicals contained in fish waste, as well as disease vectors and non-indigenous species, may have adverse impacts on wild fish populations consuming the fish waste. The chemicals may accumulate in the marine sediment, affecting benthic flora and fauna. In the past, it was common practice to dispose of such waste at sea, with the risk of overloading the ecosystem.

The effects on wolffish from the above mentioned are unknown, but are likely minimal since most of these effects are localized and coastal, whereas wolffish tend to be widely distributed.

5.3.3 Dredging spoils

It has been shown that dredge spoils dumped in the ocean reaches the bottom, but not necessarily at the exact location where it was discharged, and that it can have significant effects on the metabolism, diet, and composition of organisms that live there. The movement of dredge spoils from dumping can have multiple impacts on a series of adjacent habitats over time. The distance traveled by various particle types depends primarily on the size and density of the material, current velocities and weather patterns. The smothering of sedentary, bottom dwelling organisms is a primary concern associated with the deposition of dredge spoils. Contaminants that may be introduced to the sediments from dumping can also penetrate to a depth of 5 cm below the sea floor as organisms living in the sediments burrow through them.

For wolffish, it seems likely that the impact of dumped dredge spoils would be minimal since the area impacted would be very confined. Wolffish and their habitat should be considered valued environmental components and reported on when decisions are being made with regard to offshore activities requiring environmental assessments.

5.4 Military activity

Military activity has and continues to take place in many areas of eastern Canadian waters. Little is known of the impacts of these activities and their effects on wolffish and their habitat. These effects need to be evaluated and potential impacts mitigated.

5.5 Cables and pipelines

The placement of physical structures on or in the bottom substrate/water column could affect wolffish habitat although in a spatially limited manner. Given the widespread distribution of wolffish, impacts associated with these activities are likely minimal but need to be quantified.

5.6 Marine and land-based pollution

Any human activity, even if marginal, that has the potential to cause degradation to wolffish habitat needs to be identified, undergo cleanup where appropriate, and have prevention measures put in place. Associated land-based forms of pollution including runoff that contain excess nutrients, sediments, pathogens, pharmaceuticals (for example, antibiotics), persistent toxins or oil may significantly affect the marine ecosystem. The magnitude of change and its form depends on many factors including the types of dissolved or suspended particles, such as non-biodegradable organic chemicals. These pollutants may adversely affect the reproductive capabilities of wolffish, their prey, and surrounding vegetation, as well as interfere with their general health.

5.7 Global climate change

The role of climate change as a factor in the decline of wolffish populations is currently unknown. Atmospheric changes may lead to changes in ocean productivity, species composition and habitat. Alterations in the chemical, biological, and physical composition of habitats may influence population reproduction, mortality rates, and individual behaviour. Historical data sources could be used to examine relationships between climate and trends in the distribution and abundance of wolffish. The investigation of climate change as a factor in the decline of wolffish is not a trivial task. It may be that no definitive answers will be found.

5.8 Natural mortality (parasites, disease, predation and environment)

As with the vast majority of marine species, little is known of the effects of parasites, diseases, predation or environmental conditions on the survival of wolffish species.

Pathological conditions and causal factors need to be identified as well as potential predators. Natural mortality may have played a significant role in the decline of these species; however, these processes are poorly understood.

5.9 Summary of threats

Impact of incidental capture of wolffish in many fisheries is thought to be the leading cause of human induced mortality. However, the live release of Northern and Spotted Wolffish mitigates the effect of incidental capture to some degree (see part B, section 5.3). The effects of other potential sources of harm (for example, habitat alteration/destruction, oil exploration and production, pollution, shipping, cables and lines, military activities, ecotourism and scientific research) on the ability of wolffish to survive and recover have not been quantified.

It is also recognized that non-human elements (environmental influences) may have played a role in the decline of the species and these effects cannot be controlled/mitigated. These environmental effects may continue to play an unpredictable role in the future. Thus, this document addresses anthropogenic influences only.

6. Critical habitat

6.1 General description of critical habitat

Critical habitat is defined in SARA (2002) section 2(1) as "…*the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in a recovery strategy or in an action plan for the species*." [s. 2(1)]

SARA defines habitat for aquatic species at risk as "… *spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced*." [s. 2(1)]

As per paragraph 41(1)(c) of SARA, a recovery strategy must include, "*an identification of the species' critical habitat, to the extent possible, based on the best available information, including the information provided by COSEWIC, and examples of activities that are likely to result in destruction*".

For Northern and Spotted Wolffish, critical habitat is identified to the extent possible, using the best available information, and provides the functions and features necessary to support the species' life cycle processes. Critical habitat was delineated using the Area of Occurrence Approach. Critical habitat is not comprised of the entire area within the identified boundaries and it is assumed that within this area, the functions and features necessary for the species' survival or recovery exist. The Schedule of Studies (table 6) provided in section 6.4 outlines the research required to further refine the species' critical habitat.

Critical habitat has not been identified for Atlantic Wolffish as this species is listed as Special Concern and therefore identification of critical habitat is not required.

6.2 Information and methods used to identify critical habitat

Northern and Spotted Wolffish are considered ‘data poor’ species. Specifically, basic information concerning the biology (for example, fecundity, diet), behaviour, population dynamics (for example, stock-recruitment relationships, mortality/growth rates), distribution and demographics (for example, abundance, numbers at age, population units) are only partially understood. Similarly, since data on wolffish-habitat relationships are gathered through remote sensing and bottom trawl surveys, there is a ‘disconnect’ between spatial scales: habitat data are often gathered at the spatial scale of square kilometers; whereas wolffish are thought to be mainly associated with the habitat at the scale of meters. In addition, there is limited knowledge, especially in the offshore, on how specific habitat features (for example, rock crevices, hard coral communities, marine macrophytes) influence a wolffish’s affinity for specific locations in the habitat, or what functional role specific habitat features play in supporting/maintaining the life cycle processes of Northern and Spotted Wolffish.

Gulf of St. Lawrence

This section outlines methodology for identifying critical habitat for Northern Wolffish (figure 1, polygons 6 and 7) and Spotted Wolffish (figure 2, polygons 5 to 7).

Determining critical habitat for wolffish does not require complete certainty (DFO 2011b), but rather the best available knowledge (DFO 2007, 2011b). The study by Dutil et al. (2013a) used DFO Gulf of St. Lawrence groundfish survey data from 1971 to 2008 to compare patterns of wolffish distribution with the spatial distribution of benthic habitats. This study focused on ‘hotspots’ and habitat categories rather than attempting to define exact locations.

Dutil et al. (2011a) proposed a large-scale (that is, megahabitat) hierarchical classification of the seafloor as a foundation for mapping and describing marine habitats of the St. Lawrence Estuary and Gulf. The study area was divided into a grid of 100 km² (10 X 10 km) cells. This classification was based on various physiographic and oceanographic characteristics of the area, and includes information on salinity, temperature, dissolved oxygen, depth, seafloor slope, variability in landscape, and sediments. Cluster analysis grouped the cells into four deep water and nine shallow water habitats for a total of 13 different megahabitats.

To study the spatial distribution of the three wolffish species in the St. Lawrence Estuary and Gulf, Dutil et al. (2013a, b) aggregated wolffish catch and effort data on the habitat classification grid. This catch and effort data was collected during annual bottom trawl surveys from 1971 to 2008 in the northern Gulf and from 1978 to 2008 in the southern Gulf, during which wolffish were identified to species, and catch was reported by weight. Corrections for fishing gear catchability were not possible. As a result, presence-absence data were used to calculate frequency of occurrence (number of sets with species present) and level of effort (total number of sets) in each cell. Various methods were then used to describe the spatial distribution of catches and expressed as area of occupancy, density and ‘hotspots’.

Newfoundland and Labrador Shelves

This section outlines methodology for identifying critical habitat for Northern Wolffish (figure 1, polygons 1 to 5) and Spotted Wolffish (figure 2, polygons 1 to 4).

Research survey datasets for Northern and Spotted Wolffish were analyzed based on the number of wolffish present at sea bottom temperature and depth. Sea bottom temperature values were derived from research surveys conducted in the fall (1977 to 2013) and spring (1971 to 2013). Depth values were based on the General Bathymetric Chart of the Ocean (GEBCO) which is composed of depth data collected on a two minute grid worldwide. Species were analyzed separately for the spring and the fall to determine their preferred temperature and depth.

The values for temperature and depth were extracted to a raster with cell size of 10 km by 10 km (100 km^2) for analysis within the exclusive economic zone of Canada in the Newfoundland and Labrador Shelves area. The areal coverage includes NAFO zones 2G, 2H, 2J, 3K, 3L, 3N, 3O, 3Ps, and 3Pn. The number of species present were counted for each temperature and depth value and separated into ranges based on the frequency of occurrence for both Northern and Spotted Wolffish in the fall and in the spring. The following percentiles were used to divide the data into meaningful ranges: 1%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 99%. The ranges were then ranked from 0 to 5. A very narrow range suggested a higher concentration of wolffish within the bounds of those values which define each percentile.

The rankings for depth and temperature were summed together separately by species/season to produce the resulting heat maps with the highest possible value of 10 which indicates optimal (value of 5) temperature range and depth in the same location and the lowest possible value of 0 where there were no wolffish present in that temperature/depth range. The resulting maps exclude 0 values and indicate where wolffish are most likely to occur based on temperature and depth.

Maps for spring and fall were overlaid onto a single map which represents critical habitat for Northern and Spotted Wolffish on a year-round basis.

Critical habitat presented in figures 1 and 2 represents sufficient habitat necessary for the recovery of Northern and Spotted Wolffish, respectively. Appropriate temperatures and depths as listed in tables 4 and 5 represent where critical habitat is found within polygons.

6.3 Identification of critical habitat

Geographic identification

The following locations of critical habitat functions, features and attributes have been identified using the Area of Occurrence Approach. The Area of Occurrence Approach acknowledges that critical habitat is not comprised of the entire area within the identified boundaries; however, the best available information indicates that within the identified area, the functions and features necessary for the species' survival or recovery exist.

The areas presented in tables 2 and 3, and figures 1 and 2, are those that the Minister of Fisheries and Oceans considers necessary to support the species' recovery objectives.

Table 2. Coordinates for Northern Wolffish critical habitat.

Polygon	Latitude	Longitude	Area (km^2)
1	55.635	-56.827	10,912.70
1	55.549	-57.012	10,912.70
1	55.997	-58.472	10,912.70
1	55.347	-58.698	10,912.70
1	56.245	-60.002	10,912.70
1	56.414	-59.689	10,912.70
1	56.146	-59.329	10,912.70
1	56.620	-57.996	10,912.70
1	56.277	-58.004	10,912.70
1	56.281	-57.474	10,912.70
2	53.073	-54.674	28,927.37
2	53.355	-53.402	28,927.37
2	54.341	-53.967	28,927.37
2	54.956	-55.227	28,927.37
2	54.490	-56.113	28,927.37
2	54.636	-56.602	28,927.37
2	55.376	-55.325	28,927.37
2	54.689	-53.137	28,927.37
2	53.048	-52.021	28,927.37
2	52.536	-53.719	28,927.37
3	50.201	-53.422	36,670.56
3	50.553	-54.113	36,670.56
3	51.155	-53.500	36,670.56
3	51.395	-54.288	36,670.56
3	52.209	-54.099	36,670.56
3	52.937	-51.750	36,670.56
3	51.976	-50.614	36,670.56
3	50.973	-52.880	36,670.56
4	48.942	-50.177	33,604.29

4	49.080	-52.369	33,604.29
4	49.250	-52.339	33,604.29
4	49.687	-52.092	33,604.29
4	51.426	-50.978	33,604.29
4	51.680	-50.392	33,604.29
4	50.367	-50.607	33,604.29
4	49.919	-49.943	33,604.29
4	49.041	-49.924	33,604.29
4	48.459	-49.396	33,604.29
4	48.034	-48.436	33,604.29
4	47.975	-47.750	33,604.29
4	47.798	-47.740	33,604.29
4	47.878	-48.590	33,604.29
4	48.278	-49.473	33,604.29
5	47.259	-59.312	61,08.89
5	47.333	-59.210	61,08.89
5	46.891	-58.149	61,08.89
5	45.896	-57.174	61,08.89
5	45.561	-57.329	61,08.89
5	46.754	-58.479	61,08.89
6	48.590	-60.861	806.70
6	48.321	-60.904	806.70
6	48.349	-61.308	806.70
6	48.529	-61.281	806.70
6	48.520	-61.146	806.70
6	48.609	-61.132	806.70
7	47.840	-59.360	1,201.63
7	47.881	-59.894	1,201.63
7	48.150	-59.845	1,201.63
7	48.105	-59.310	1,201.63

Table 3. Coordinates for Spotted Wolffish critical habitat.

Polygon	Latitude	Longitude	Area (km^2)
1	53.334	-53.539	11,985.54
1	53.763	-53.363	11,985.54
1	54.440	-53.967	11,985.54
1	54.812	-54.660	11,985.54
1	54.831	-56.069	11,985.54
1	55.366	-56.099	11,985.54
1	54.886	-53.985	11,985.54
1	54.595	-53.341	11,985.54
1	53.497	-52.548	11,985.54
1	53.517	-53.125	11,985.54
2	47.278	-47.760	76,847.08
2	48.635	-50.849	76,847.08
2	48.398	-52.702	76,847.08
2	49.269	-52.754	76,847.08
2	49.601	-52.120	76,847.08
2	50.816	-51.863	76,847.08
2	51.223	-51.400	76,847.08
2	51.862	-52.090	76,847.08
2	50.919	-53.339	76,847.08
2	50.232	-53.429	76,847.08
2	50.272	-54.020	76,847.08
2	50.972	-53.919	76,847.08
2	51.506	-53.083	76,847.08
2	52.875	-53.098	76,847.08
2	53.132	-52.006	76,847.08
2	51.958	-51.078	76,847.08
2	51.306	-50.269	76,847.08
2	50.870	-50.784	76,847.08
2	50.338	-50.854	76,847.08
2	49.842	-50.089	76,847.08
2	49.126	-50.262	76,847.08
2	48.698	-49.925	76,847.08
2	48.159	-48.809	76,847.08
2	47.977	-47.736	76,847.08
3	47.362	-57.689	650.68
3	47.368	-57.430	650.68
3	47.187	-57.428	650.68
3	47.177	-57.561	650.68
3	46.919	-57.690	650.68
3	46.913	-57.794	650.68

3	47.085	-57.706	650.68
4	47.598	-58.769	566.86
4	47.621	-58.488	566.86
4	47.359	-58.481	566.86
4	47.360	-58.740	566.86
5	48.116	-59.444	1,209.61
5	48.150	-59.845	1,209.61
5	48.508	-59.780	1,209.61
5	48.474	-59.375	1,209.61
6	49.269	-59.080	1,414.15
6	49.000	-59.134	1,414.15
6	49.012	-59.271	1,414.15
6	48.922	-59.288	1,414.15
6	48.956	-59.697	1,414.15
6	49.225	-59.646	1,414.15
6	49.214	-59.509	1,414.15
6	49.304	-59.491	1,414.15
7	49.617	-59.991	910.40
7	49.649	-60.406	910.40
7	49.918	-60.359	910.40
7	49.886	-59.941	910.40

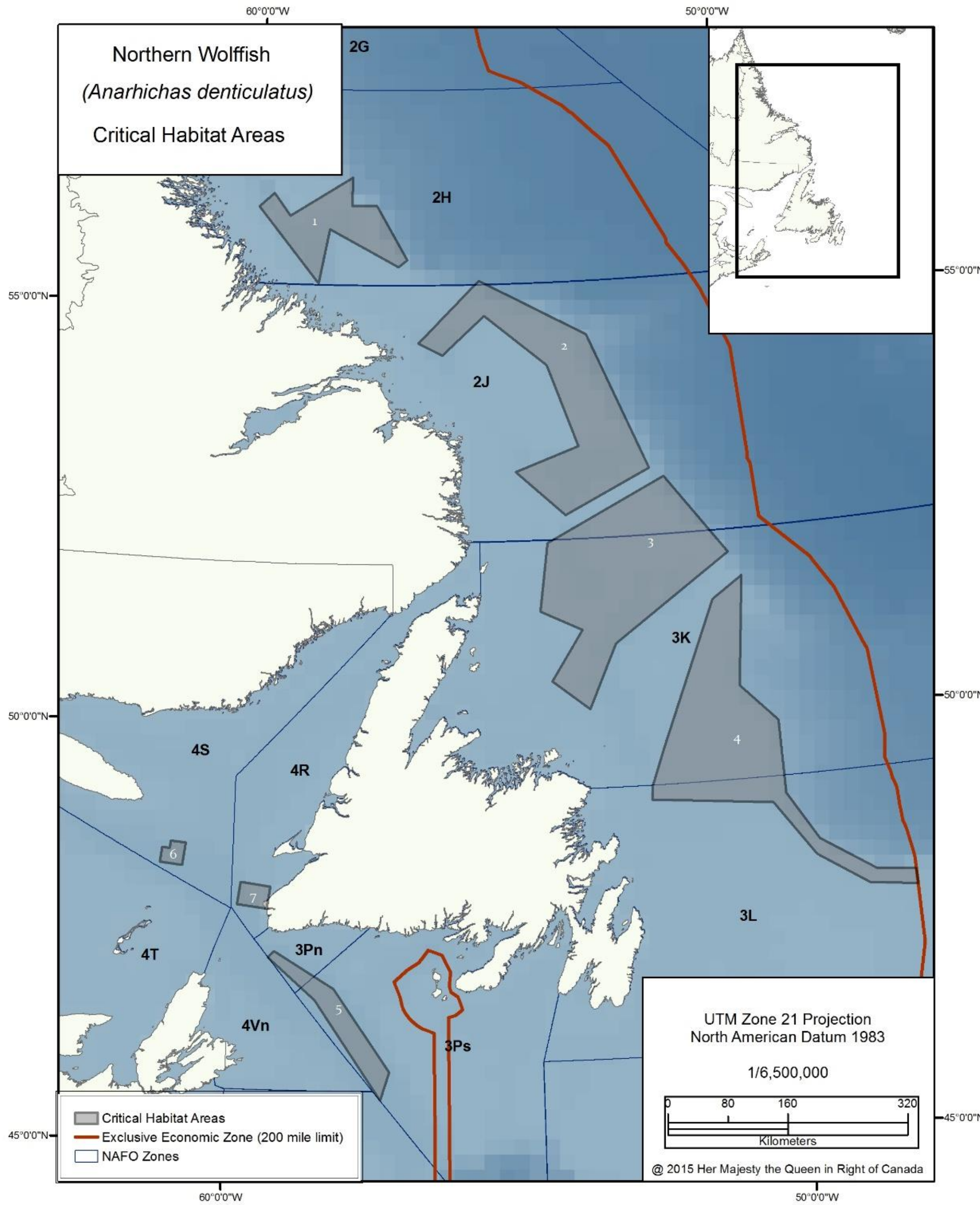

Figure 1. Map of Northern Wolffish critical habitat.

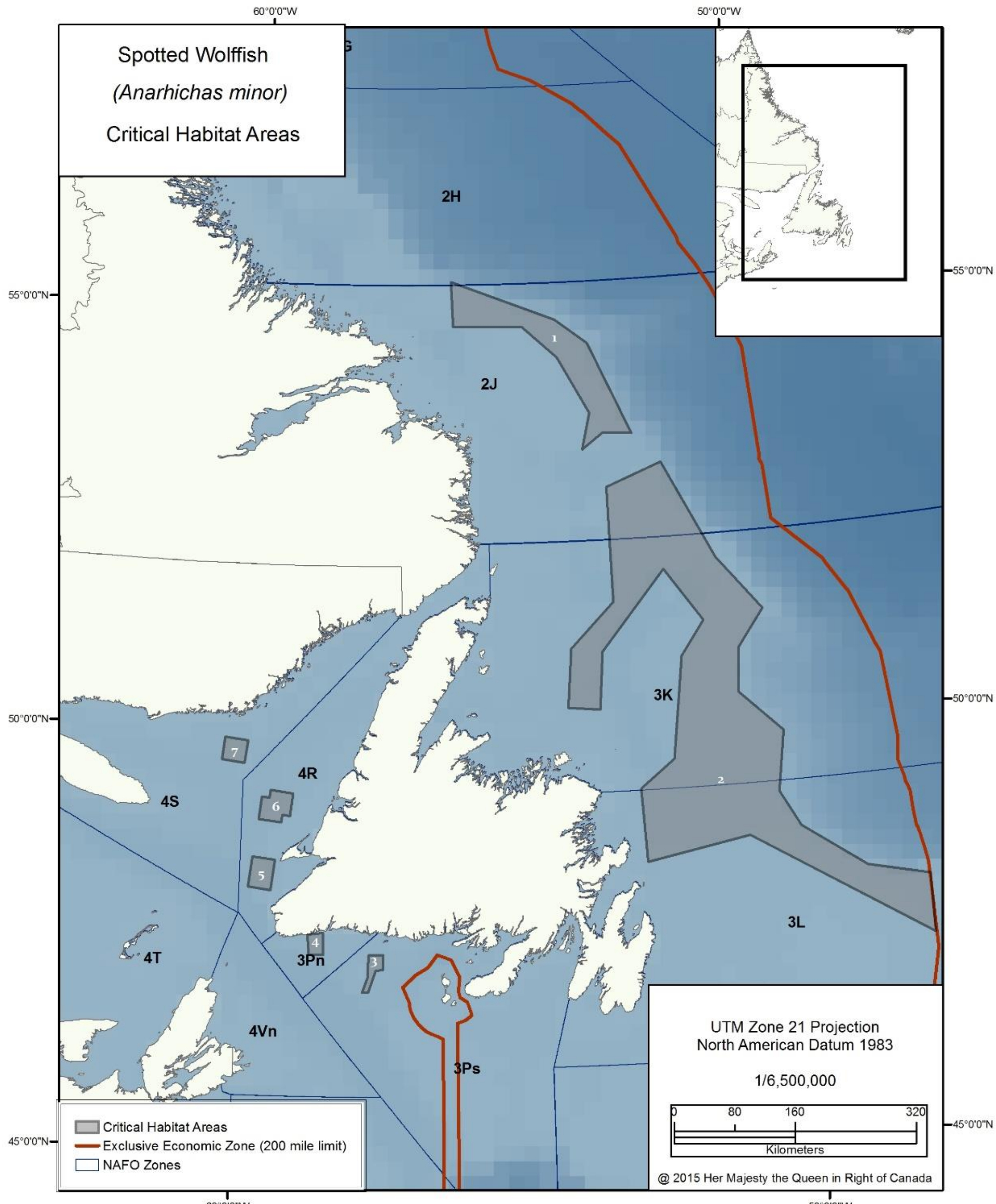

Figure 2. Map of Spotted Wolffish critical habitat.

Biophysical identification

Tables 4 and 5 summarize the best available knowledge of the functions, features and attributes of critical habitat to support all life stages of Northern and Spotted Wolffish. Note that not all attributes in tables 4 and 5 must be present in order for a feature to be identified as critical habitat. If the features, as described in tables 4 and 5, are present and capable of supporting the associated function(s), the feature is considered critical habitat for the species, even though some of the associated attributes might be outside of the range indicated in the table.

Table 4. General summary of the potential biophysical functions, features, attributes and location of critical habitat necessary for Northern Wolffish survival or recovery.

Geographic location	Life stage (if more than one)	Function	Feature(s)	Attribute(s)
Gulf of St. Lawrence (polygons 6 & 7)	All	All portions of life history[1]	Deep-water steep sloped habitat Channels offshore	• Poorly diversified habitats • Fine sediments • Depths >200 m, aggregations at depths 250 to 300 m • Low oxygen saturation • Temperature ranges 3 to 5ºC • High salinity 34 psu
Newfoundland and Labrador Shelves (polygons 1 to 5)	All	All portions of life history[1]	Edge of the Grand Banks and Labrador Shelf Deep channels	• Depths 118 to 636 m [2] • Temperature ranges 2.3 to 5.1ºC[3]

[1] This species does not undergo large scale movements therefore all portions of life history are carried out in the same location.
[2] Spring and Fall depth ranges have been combined into a single value to represent a year-round range.
[3] Spring and Fall temperature ranges have been combined into a single value to represent a year-round range.

Table 5. General summary of the potential biophysical functions, features, attributes and location of critical habitat necessary for Spotted Wolffish survival or recovery.

Geographic location	Life stage (if more than one)	Function	Feature(s)	Attribute(s)
Gulf of St. Lawrence (polygons 5 to 7)	All	All portions of life history[1]	Deep water shelf habitat Relatively cold shallow to mid-depth habitat Deep-water steep sloped habitat (less intensively)	• Large habitat and relief diversity • Coarse sediments and rocky outcrops • More often found on plateaus than in channels while avoiding surface waters (<40 km from coast) • Depths 80 to 260 m, aggregations at depths 180 to 240 m • Intermediate salinities • Intermediate oxygen levels • Temperature ranges 2 to 4°C
Newfoundland and Labrador Shelves (polygons 1 to 4)	All	All portions of life history[1]	Edge of the Grand Banks and Labrador Shelf Deep channels	• Depths 82 to 346 m [2] • Temperature ranges 0.1 to 4.2°C[3]

6.4 Schedule of studies to identify critical habitat

Further research is required to refine critical habitat features that are necessary to support recovery objectives, and to protect critical habitat from destruction. This additional work includes the following studies (table 6):

Table 6. Schedule of studies to identify critical habitat.

Description of study	Rationale	Timeline*
Research aspects of Spotted Wolffish life history as revealed by rearing and farming observations.	The ability to observe certain characteristics of life history in nature is very difficult. Laboratory investigation would be a more appropriate use of resources.	2025
Carry out new field studies to study seasonal movements and habitat associations using new technologies (data storage tags, popup tags, etc.).	Individual level studies can provide information on habitat associations whereas large scale bottom trawl methods cannot.	2021
Use laboratory studies to improve knowledge of wolffish physiology.	In the past, there has been a great deal of work done on Spotted Wolffish. Additional work is required on Northern Wolffish.	2025
A comparison of Spotted Wolffish growth rate in the northern Gulf of St. Lawrence with the Labrador Shelf and Grand Banks (through the comparison of growth rate at age using otoliths).	There is evidence that low values of dissolved oxygen (hypoxia) (<70% sat) slows growth rate in the laboratory. Many sites where Spotted Wolffish are found in the northern Gulf of St. Lawrence have oxygen levels that are lower than 70% (much lower). It is currently not known if the species would respond the same in the field as it did during laboratory testing.	2025

*Estimated completion date.

6.5 Examples of activities likely to result in the destruction of critical habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a recovery strategy or action plan. For Northern and Spotted Wolffish critical habitat, this will be accomplished through a SARA Critical Habitat Order made under subsections 58(4) and (5), which will invoke the prohibition in subsection 58(1) against the destruction of the identified critical habitat.

The following examples of activities likely to result in the destruction of critical habitat (table 7) are based on known human activities that are likely to occur in and around critical habitat and would result in the destruction of critical habitat if unmitigated. The list of activities is neither exhaustive nor exclusive. The absence of a specific human activity from this table does not preclude or restrict the Department’s ability to regulate that activity under SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition, and does not mean the activity will inevitably result in destruction of critical habitat. Every proposed activity must be assessed on a case-by-case basis and site-specific mitigation will be applied where it is available and reliable. Where information is available, thresholds and limits have been developed for critical habitat attributes to better inform management and regulatory decision making. However, in many cases, knowledge of a species and the thresholds of tolerance of its critical habitat to disturbance from human activities is lacking and must be acquired.

Activities likely to destroy critical habitat in the Gulf of St. Lawrence (polygons 6 and 7 for Northern Wolffish and 5 to 7 for Spotted Wolffish) include but are not limited to, benthic habitat destruction and contaminants.

Activities likely to destroy critical habitat in the Newfoundland and Labrador Shelves area (polygons 1 to 5 for Northern Wolffish and 1 to 4 for Spotted Wolffish) include but are not limited to activities that alter the thermal habitat and activities that cause habitat destruction that alters depth and subsequently alters the thermal habitat.

Table 7. Examples of activities likely to destroy critical habitat.

Geographic location	Threat	Activity	Affect-pathway	Function affected	Feature affected	Attribute affected
Gulf of St. Lawrence (polygons 6 and 7 for Northern Wolffish and 5 to 7 for Spotted Wolffish)	Benthic habitat destruction	Activities that impact the benthic environment	Destruction of benthic habitat can result in damage to spawning and rearing areas, egg masses and adult wolffish habitat	All portions of life history	Benthic environment	Bottom substrate
Gulf of St. Lawrence (polygons 6 and 7 for Northern Wolffish and 5 to 7 for Spotted Wolffish)	Contaminants	Deposition of contaminants in the benthic environment Release of contaminants into the pelagic environment	Reduced water and sediment quality resulting in a decrease in young-of-the-year health and increase in mortality	All portions of life history	Benthic environment Upper water layer	Water quality
Newfoundland and Labrador Shelves (polygons 1 to 5 for Northern Wolffish and 1 to 4 for Spotted Wolffish	Thermal habitat alteration	Activities that impact the thermal habitat	Alteration of thermal habitat can result in decreased survival of wolffish	All portions of life history	Thermal environment	Temperature
Newfoundland and Labrador Shelves (polygons 1 to 5 for Northern Wolffish and 1 to 4 for Spotted Wolffish	Habitat destruction	Destruction of habitat causing a change in depth that could result in alteration of thermal habitat	Changes in depth can result in changes to thermal habitat which can decrease survival of wolffish	All portions of life history	Thermal environment	Depth/ temperature

7. Ecological role

Eggs, larvae and juveniles of wolffish are susceptible to predation by a number of species, although for at least one of the species (Atlantic Wolffish) the eggs are guarded by the adult males until hatching. Adults have fewer predators given their size and substantial teeth. They may also spend a part of their time in rock crevices. The role of each wolffish species as a forage fish is undetermined, though they do appear to be a food source for several species as larvae and young. Northern Wolffish in the northeast Atlantic has been observed defending a territory around bait on the bottom from cod and haddock; acoustic tracking over time showed that the size of that territory was quite restricted (Godø et al. 1997).

8. Importance to people

Historically, there were no significant directed fisheries for wolffish in Canadian waters and, prior to March 2003, the only applicable regulation regarding wolffish was contained in the 1985 Atlantic Fishery Regulations that mandated fishers to retain and land all wolffish bycatch.

Following the decline of many traditionally fished species in the early to mid-1990s, Spotted and Atlantic Wolffish, as well as other “non-traditional” species, were considered as potential candidates for new directed fisheries. Of the three wolffish species, only Spotted and Atlantic Wolffish have commercial value and as a result of concerted marketing efforts in the 1990s, commercial interest in wolffish had increased. Product demand had improved its market value in the late 1990s. Increasingly, Spotted and Atlantic Wolffish were processed into frozen or fresh fillets. In addition, it was known that the skin of Spotted Wolffish could be tanned and used for leather. Since Northern Wolffish has no commercial value, it was discarded and not reported to DFO. Northern Wolffish are occasionally consumed by Greenlanders, though their gelatinous flesh is not generally favored and its skin is not suitable for secondary processing (COSEWIC 2001a).

Experimental fishing, however, did not identify areas where catch rates were sufficiently high to warrant directed commercial exploitation. Therefore, all three species were caught in mixed fisheries or incidentally through targeted fisheries, primarily for Greenland Halibut but also with other demersal fisheries such as Atlantic Cod (*Gadus morhua*), and Yellowtail Flounder (*Limanda ferruginea*). Invertebrate fisheries for species such as shrimp and crab incidentally capture wolffish as well.

Mandatory release of Spotted and Northern Wolffish in a manner that maximizes chance of survival has been instituted through license amendments in all Atlantic Regions of DFO as of 2004. Consequently, fishers, if previously retaining Spotted Wolffish for market purposes, may notice a decrease in the total landed value of their catch as they are now required to return that species to the ocean at the point of capture. The greatest captures of wolffish for commercial trade were reported from the south coast of Newfoundland and from Nova Scotia. However, nearly all of the captures from those areas were Atlantic Wolffish.

Information on landings and value up to 2003 can be found in the 2008 version of this recovery strategy and management plan which is available on the Species at Risk Public Registry.

9. Biological and technical feasibility of recovery

Natural history strategies such as relatively slow growth, nesting habits (Atlantic Wolffish), and limited dispersal in conjunction with potential impacts of human activity and changing environmental limitations have the potential to curtail the recovery ability for wolffish species. As such, research needs to be undertaken to define the relationship between wolffish and their environment. However, assuming that anthropogenic threats can be identified and mitigated through implementation of this recovery strategy and management plan, recovery is considered feasible based on the following criteria:

- individuals capable of reproduction are currently available to improve the population abundance
- based on current knowledge of habitat requirements, sufficient suitable habitat is currently available to support these species
- significant anthropogenic threats to these species, as described in this document, may be mitigated through recovery actions
- necessary recovery techniques to address these significant anthropogenic threats do exist and have been demonstrated to be effective

Biological and technical feasibility of these species may also be influenced by unanticipated environmental effects that could unpredictably alter the course of recovery.

10. Recommended scale for recovery

When this recovery strategy was first developed, the recovery team chose to incorporate the three wolffish species into a single “multi-species” recovery strategy and management plan because of their similar distribution, life history, ecology and taxonomy. One document inclusive of both Threatened species, as well as the Special Concern species, was believed to be the most efficient and least repetitive approach.

Maximizing the likelihood of survival when releasing the two Threatened wolffish species is a fisheries license requirement. As well, various moratoria on groundfish put in place during the 1990s, and current fisheries closures leading to decreased effort, contribute to recovery. Reducing directed groundfish fisheries has indirectly protected wolffish, a primary source of incidental bycatch of all three species.

In all DFO Regions where wolffish are present, it is recommended, at the time of publication of this document, that the scale of recovery effort incorporate an ecosystem approach and that it be implemented in parallel with future conservation objectives of fisheries management, integrated management plans, Marine Protected Area Networks and other industrial activities.
Due to the distribution of wolffish, recovery must be considered at both national and international scales. For example, the capture of wolffish in international waters adjacent to Canadian waters may influence the state of wolffish populations in Canada.

Part B: recovery

1. Overview

This document is the first component of a framework to promote the conservation and recovery of three wolffish species in eastern Canadian waters. The second component, the action plan (as outlined in part B, section 7) has been completed in 2020 as well. Where an activity has already been initiated to address the objectives laid out in this document, these actions are duly noted in part B, section 5, actions completed or underway.

The Recovery Team who developed the 2008 recovery strategy and management plan determined that it was best to incorporate both Threatened wolffish species into a single "multi-species" document and to include Atlantic Wolffish, a species of Special Concern, due to their similar life histories, ecology and taxonomy. As such, this document represents both a Recovery Strategy for Northern and Spotted Wolffish, as well as a Management Plan for Atlantic Wolffish. As SARA prohibitions are not applicable to Special Concern species, conservation and recovery activities described in this document should be viewed as recommendations only for Atlantic Wolffish. However, implementing these activities could in some instances also benefit Northern and Spotted Wolffish.

2. Goals, objectives and strategies

2.1 The recovery and management goal

The goal of this recovery strategy and management plan is to increase the population levels and distribution of Northern, Spotted and Atlantic Wolffish in eastern Canadian waters such that the long-term viability of these species is achieved. This will be accomplished by addressing the objectives and strategies outlined below.

2.2 Recovery and management objectives

The recovery strategy and management plan for wolffish species in eastern Canadian waters puts forth five broad, inter-related objectives. All relate to activities that may be mitigated through human intervention.

Objective 1: enhance knowledge of the biology and life history of wolffish species

Objective 2: identify, conserve and/or protect wolffish habitat required for viable population sizes and densities

Objective 3: reduce the potential of wolffish population declines by mitigating human impacts

Objective 4: promote wolffish population growth and recovery

Objective 5: develop communication and education programs to promote the conservation and recovery of wolffish populations

Each of these broad objectives is designed to achieve the goals of this document. As this recovery strategy and management plan is considered to be adaptive (that is, a living document), objectives and strategies can be added or revised as new knowledge becomes available.

The following sections elaborate on the above objectives and link them with recovery strategies that include specific actions required for implementing this document. The order in which the strategies are presented does not reflect a ranking of importance. Rather, all strategies are considered critical to the recovery process and are recommended to be carried out in an integrated manner. The consequent activities (actions) of the recovery action plan will result in the implementation of the recovery strategies and objectives.

In general, the recovery of a species at risk involves a multi-faceted approach that takes into consideration individual populations, the number and nexus of these populations, and the creation of adequate population levels to withstand events such as environmental shifts and climate change. According to the National Recovery Working Group, establishing a sustainable population requires:

- enough breeding adults to be considered sustainable in the long term
- Sufficient quality habitat available or potentially available to maintain sustainable population numbers
- adequate or improving demographic parameters (for example, sex ratio, birth and death rates)
- mitigation against and control of human threats to the population, particularly those that initially contributed to the species’ decline.

2.3 Recovery strategies and specific actions to meet recovery objectives for wolffish species

Five strategies constitute the basis of a framework for recovery: research, habitat conservation and protection, mitigation of human activities, promotion of public knowledge and stakeholder participation in the recovery of wolffish populations and the conservation and protection of their habitat, and monitoring of human activities. Associated specific actions required to achieve species recovery and anticipated outcomes of those actions are listed in table 8.

Table 8. Linking recovery objectives to strategies and specific actions required to promote recovery of wolffish species.

Priority	Recovery objective	Recovery strategy	Recovery actions	Anticipated effect
Necessary Ongoing	1, 2, 4	A. Research	Conduct directed research on: 1. life history 2. population structure 3. identification of limit reference points 4. ecosystem interactions	Better adaptive management decisions
Necessary Ongoing	2, 4, 5	B. Habitat conservation and protection	1. identify habitat 2. define measures to conserve and/or protect wolffish habitat	Increase potential of spawning, rearing, feeding, and other life processes
Urgent	3, 4, 5	C. Mitigate human activities	1. identify and mitigate impacts	Direct benefit to species numbers, reducing mortality at all life stages
Necessary Ongoing	3, 4, 5	D. Promote public knowledge and stakeholder participation in the recovery of wolffish populations and the conservation and protection of their habitat	Through: 1. education 2. stewardship 3. consultation 4. cooperation	Support for management measures and other recovery strategies
Ongoing	3, 4	E. Monitor human activities	1. monitor wolffish spatial and temporal abundance patterns 2. monitor spatial and temporal patterns in natural and human induced mortality	Better adaptive management decisions

2.4 Recovery strategy A : conduct research (objectives 1, 2, 4)

Objective 1: enhance knowledge of the biology and life history of wolffish
Objective 2: identify, conserve and/or protect wolffish habitat required for viable population sizes and densities
Objective 4: promote wolffish population growth and recovery

2.4.1 Recovery action A1 : study life history

Although the subject of considerable research in the Northeast Atlantic, work on the life history of wolffish species residing in Canadian Atlantic waters has been limited, perhaps because they are not the target of a commercial fishery. There is much to learn about how wolffish in the eastern Canadian marine ecosystem reproduce, live, grow, and die.

This basic knowledge is the foundation for understanding the population status of wolffish species and subsequently being able to formulate actions required to conserve the species and their habitat so that they are no longer at risk. The recovery objectives are broad and limitations exist for setting specific measurable objectives without having more complete information about the species; thus the objective for research.

Conduct directed research to study wolffish life history by expanding on available Canadian and international research in the following areas:

- reproductive biology
- age, growth, and longevity
- diet and niche
- natural mortality (health condition, diseases, parasites, environmental effects, and anthropogenic interactions)
- traditional user knowledge

2.4.2 Recovery action A2 : study population structure within eastern Canadian waters

Identification of wolffish population structure, including Designatable Units (DUs), is fundamental to wolffish management. The observed population trends show very different patterns among areas, the decline being greatest on the Labrador Shelf. In contrast, the index of immature individuals on the Scotian Shelf increased to its highest values in the time series in the early 1990s, and has since shown only a slight decline (Simon et al. 2012). Understanding the reasons for these spatial differences and defining the population unit(s) are key to formulating appropriate recovery and management strategies and actions. To determine spatial variation in the population structure of the wolffish species in eastern Canadian waters, research needs to be conducted on:

- age/sex population structure
- migration/seasonal movements and distribution
- wolffish habitat utilization during various life history stages including spawning, nursery, rearing areas, and adult feeding
- wolffish abundance with respect to modeling and forecasting abundance; and
- genetic, morphometric and meristic characteristics to determine if wolffish form a single DU or multiple DUs as a basis for management

2.4.3 Recovery action A3 : identify biological reference points

Fisheries management regimes require the use of a combination of quantitative and qualitative biological reference points (BRP’s) such as biomass estimates or indices that might be considered indicators of a recovered population.

Insufficient data exist for the determination of wolffish BRP’s and these deficiencies require research on their own and with respect to those fisheries in which they are incidentally caught.

In the case of wolffish and other poorly understood species, estimates of population growth and viability under various levels of bycatch will be difficult, if not impossible to determine. In particular, obtaining a measure of natural mortality and longevity is problematic for most marine fish species, including wolffish. In addition, in the case of wolffish, obtaining an accurate estimate of fishing mortality that is required to assure viability is problematic when wolffish are captured in such a diversity of fisheries.

Absolute catch is not known, though estimates of total removals can be computed, and subsequently used in the development of allowable harm strategies.

Currently, the best available information for the development of BRPs comes from the annual spring and fall research surveys from which biomass indices can be developed. While problematic, due to the lack of understanding of wolffish population dynamics, development of potential BRPs based on historic patterns of wolffish abundance and spatial distribution should be modeled. Given the fluctuations that occur in wolffish populations as indicated by research surveys, any abundance and distribution targets that are developed should attempt to incorporate this variability. For example, to develop crude initial reference levels, a calculation of the average biomass, corrected for the change in gear, for the years when the population was greatest may provide a target biomass index. Similar approaches to modeling of the spatial distribution of wolffish should also be conducted. Spatially, the extent/range of the populations can be used through a presence/absence area estimate, GIS spatial analysis, or other methods. Note again that determining the baseline is problematic and the temporal variation in these parameters should be considered. Since data are not available to define a virgin population, a 50% rule (or some variation upon this) could be employed until more explicit methods are identified. In the future, more refined models should incorporate age-structured population dynamics as additional information on population age-structure and maturity is acquired. With additional data and modeling, the spawning stock biomass and recruitment indices can be employed in the development of BRPs.

Alternatively, consideration should be given to the imposition of a catch limit for each species based on an exploitation index derived from a ratio of catch to biomass index. Further research would be required to determine what level of exploitation would not deter recovery.

2.4.4 Recovery action A4 : study ecosystem interactions

Altering the species composition, by extinction or decrease in biomass and/or distribution of a wolffish species, within the eastern Canadian marine ecosystem would have unknown effects that could escalate through the ecosystem. For example, they may be the direct prey or predator of commercially important species or wolffish may prey on species that are predators of commercial species. These relationships are poorly understood for wolffish (as for most other marine species). Regardless of their relationship with other species, the disappearance of a wolffish species is a loss to the genetic diversity of the eastern Canadian marine ecosystem. The following research should be conducted to more fully understand wolffish status and its relationships with other species within the eastern Canadian marine ecosystem:

- predator/prey interactions
- ocean habitat associations
- abundance in relation to other species
- ecological linkages
- the effects of temporal ecosystem disruptions/alterations to critical life history periods of wolffish and their predators and prey
- possible effects of marine environmental shifts on life history

2.5 Recovery strategy B : habitat conservation and protection (objectives 2, 4, 5)

Objective 2: identify, conserve and/or protect wolffish habitat required for viable population sizes and densities
Objective 4: promote wolffish population growth and recovery
Objective 5: develop communication and education programs to promote the conservation and recovery of wolffish populations and their habitat

2.5.1 Recovery action B1 : identify habitat, including critical habitat

Knowledge of wolffish habitat and how it is utilized is extremely limited. This is not unique to wolffish and is generally the case for most marine fish species.

Wolffish historic geographic range defines its potential habitat in eastern Canadian waters (refer to part A). Preliminary research has been conducted to identify habitat associations with regard to depth, temperature, substrate, and different life history periods (refer to table 1). However, the amount of ocean habitat required on spatial and temporal scales at different periods of the life history for the recovery and survival of wolffish species is not currently known. In addition, changes in wolffish abundance and distribution and seasonal fluctuations may be related to water temperature. Ocean ecosystem habitat complexities for wolffish are not fully understood, therefore species-specific research should be conducted in the following areas:

- habitat characteristics and the environmental factors that control or limit distribution, abundance, growth, reproduction, mortality and productivity of wolffish
- the physical, chemical and biological characteristics of the ocean ecosystem where wolffish occur
- spatial and temporal foraging and shelter/resting areas to determine habitat associations
- current and historic geographic range and stock size to determine spawning grounds, rearing areas, feeding grounds and the locations of important life history processes
- the definition of critical habitat as it pertains to marine finfish, in particular wolffish, in eastern Canadian waters in order to determine priority habitat sites. A schedule of studies to identify critical habitat is outlined in table 6

2.5.2 Recovery action B2 : define measures to conserve and/or protect wolffish habitat

Effective conservation requires conservation and/or protection of habitat from the unintended effects of human activities on the eastern Canadian marine ecosystem. Legislation, policy, regulations, partnership agreements and stewardship are examples of mechanisms currently in place that can be utilized to protect wolffish and their habitat. Wolffish interact with many different species and these interactions may be critical to their survival, therefore an ecosystem-based approach is recommended. Research should be conducted in the following areas:

- threats to wolffish habitat (natural and human induced)

- existing or potential activities that may threaten wolffish habitat and the extent to which they can be mitigated
- prioritization of the spatial and temporal habitat needed to be protected to achieve the goal of population recovery
- potential use of various management options as methods for the conservation and/or protection of wolffish habitat

2.6 Recovery strategy C : mitigate human activities (objectives 3, 4, 5)

Objective 3: reduce the potential of wolffish population declines
Objective 4: promote wolffish population growth and recovery
Objective 5: develop communication and education programs to promote the conservation and recovery of wolffish populations

2.6.1 Recovery action C1 : identify and mitigate impacts of human activity

It is important for the recovery of wolffish species that the unintended human impacts on their populations and their habitats caused by fishing, offshore oil and gas activities and other potentially detrimental activities be identified and mitigation measures put in place. In addition, military activities, ocean dumping, land-based and atmospheric pollution, and global climate change are emerging issues, all of which may potentially affect the eastern Canadian marine ecosystem and subsequently wolffish populations. Current legislative and regulatory policies that conserve and protect wolffish and their habitat must function in concert with non-legislative mitigation measures. Research should be conducted where possible to:

- identify human impacts on all life stages of wolffish populations and their habitat on spatial, temporal and seasonal scales
- identify impacts and estimate their degree of severity or level of risk associated with their likelihood of occurrence
- identify how impacts can be mitigated both inside and outside the Canadian Exclusive Economic Zone (EEZ)
- harmonize international, national, and provincial regulatory changes as they relate to wolffish conservation and incorporate education and stewardship as ways to mitigate human activities
- continue to institute mandatory release of the two Threatened wolffish species taken incidentally in all commercial fisheries in a manner that maximizes chance of survival
- assess the post-release survival of wolffish and eventually the effectiveness of mandatory release
- promote modifications to gear and methods to avoid the catch of wolffish where practical
- explore modification of gear/methods to reduce the potential impact on wolffish habitat

2.7 Recovery strategy D : promote knowledge and stakeholder participation in the recovery of wolffish populations and habitat conservation and/or protection (objectives 3, 4, 5)

Objective 3: reduce the potential of wolffish population declines
Objective 4: promote wolffish population growth and recovery
Objective 5: develop communication and education programs to promote the conservation and recovery of wolffish populations

2.7.1 Recovery action D1 : education and communication

A key part of the strategy is to increase resource user knowledge and awareness of the plight of wolffish species, their population status, current threats and the actions required to ensure their recovery and long-term conservation. Publication of articles in local and regional newspapers and fishing related magazines, the distribution of wolffish identification material and information on species at risk to the fishing industry, and creation and distribution of posters along with the production of other educational and advisory materials, could all be used to reach a wide audience, specifically harvesters. These materials should be available to the general public as well.

An educational program with both a regional and local component should include the following:

- the development of a comprehensive community education strategy aimed at resource users including:
    - identification of wolffish to species level (identification cards), general biology of wolffish and its historic population levels
    - safe handling of incidentally captured wolffish in order to successfully release them live into their environment
    - awareness of SARA and its importance to the conservation of wolffish
- enhancement of consultative activities including the production of related education and advisory activities
- encourage resource user community involvement in the implementation of this recovery strategy and management plan

2.7.2 Recovery action D2 : stewardship

Stewardship, simply stated, means Canadians, including landowners, private companies, volunteer community organizations, and individual citizens, are caring for our land, air and water, sustaining the natural processes on which life depends. Environmental stewardship can be described as the active expression of responsibility to ensure a healthy, diverse, and sustainable environment for present and future generations. Implementing stewardship activities is therefore a high priority of this strategy and plays an important part in the conservation and protection of wolffish species and their ocean habitat. Consultation with applicable regional fishery groups will foster and maintain their involvement in recovery actions. Such resource user community involvement and support is critical to the success of the recovery of the wolffish species. This participation will serve as a basis for wolffish stewardship programs. Stewardship initiatives should:

- promote the quick and safe release of incidentally caught wolffish to site of capture
- promote the accurate reporting of wolffish catches and subsequent release;
- promote the identification of human impacts that may affect wolffish and their habitat
- initiate programs that implement stewardship activities with stakeholders;
- provide technical and scientific information to conservation stewards;
- enhance consultation activities including the production of related education and advisory materials
- encourage resource user cooperation and community involvement in the implementation of this recovery strategy and management plan

2.7.3 Recovery action D3 : consultation and cooperation with harvesters, processors, scientists, regulators, enforcement, observers, dockside monitors, governments, Indigenous groups and other ocean users

Consultation with resource users is a key component of the recovery process, required to ensure user involvement in recovery actions. Resource users interact daily with the incidental catch of wolffish species; thus, they are provided with a knowledge base from which to design fishing gear to catch fewer wolffish as well as identify methods to safely release them. Such gear modification can be designed to avoid capture through harvesting strategies aimed at reducing encounter rates between wolffish and fishing gear. Therefore, it is important to foster ongoing consultation with resource users and all relevant Canadian jurisdictions. A comprehensive plan for realization of wolffish recovery includes consultation and cooperation amongst a diverse user group (located in each Atlantic Province) including but not limited to:

- Any individuals or groups who may be affected by or may be useful assets in the process of wolffish species recovery and their long-term conservation and protection:
  - fishing industry
  - fishery observers
  - Indigenous groups
  - provincial and territorial jurisdictions
  - federal departments
  - international regimes
  - academic institutions

2.8 Recovery strategy E : monitoring human activities and wolffish species (objectives 3, 4)

Objective 3: reduce the potential of wolffish population declines
Objective 4: promote wolffish population growth and recovery

2.8.1 Recovery action E1 : monitor wolffish spatial and temporal abundance patterns

Monitoring the abundance of wolffish species in eastern Canadian waters is essential to ensure that any improvement or deterioration of their status is detected as expediently as possible. This is essential if adaptive management is to be undertaken and be effective. Population size and structure needs to be monitored to discern trends, understand mortality patterns and identify recruitment problems.

Currently, research surveys, particularly stratified-random bottom trawl surveys, are used to obtain fishery independent estimates of stock size and to provide quantitative estimates of recruitment. These data provide a basis for interpretation of abundance and distribution patterns that may provide some basis for defining adaptive management measures and recovery actions.

One of the primary objectives for monitoring wolffish spatial and temporal abundance patterns is to determine the effectiveness of any mitigation measures that have been implemented. Basic monitoring allows or enables early identification of unforeseen problems so that corrective measures can be undertaken in order to avoid further impacts. This ensures proper management (that is, conservation and protection) of fish and their habitat.

Therefore, the recommended actions are to:

- utilize research survey data to examine historical, current and future spatial and temporal abundance patterns of each wolffish species
- utilize harvester's knowledge to gather spatial and temporal abundance patterns of each wolffish species

2.8.2 Recovery action E2 : monitor spatial and temporal patterns in natural and human induced mortality

By integrating research survey data with fisheries observer, statistical, dockside monitor and fishing logbook data, changes in wolffish distribution and abundance patterns can be examined to provide a basis for defining appropriate adaptive management measures and recovery actions. This integration of data will aid in the establishment of performance measures to evaluate:

- effectiveness of recovery actions on wolffish and their habitat, in particular, effectiveness of releasing wolffish back into their environment
- management methods on the conservation and protection of wolffish;
- habitat protection on the conservation of wolffish
- education, stewardship, consultation and cooperation on the conservation of wolffish

3. Permitted activities

Subsection 83(4) of SARA allows for certain activities to be exempt from the general prohibitions of SARA, provided the activities are permitted in recovery strategies, action plans or management plans. In order for this section to be applicable, individuals must be authorized under an Act of Parliament, such as the *Fisheries Act*, to carry out such activities. Section 83(4) can be used as an exemption to allow activities, which have been determined to not jeopardize the survival or recovery of the species.

A Zonal Advisory Process (ZAP) held in St. John's, Newfoundland and Labrador in May 2004 provided an opportunity to review scientific advice regarding the determination of allowable harm for both wolffish species that are currently listed as Threatened, Northern and Spotted Wolffish. Participants of the review included individuals from government, industry and other non-governmental organizations (NGOs). The advice resulting from this meeting was summarized in an allowable harm assessment report (DFO 2004b).

The allowable harm assessment concluded that recent (2000 to 2002) levels of mortality did not impair the ability of the species to recover. However, all efforts should be taken to enhance the survival in the fisheries, primarily through mandatory release of wolffish in a manner that will increase the chance of survival. This document adopts that conclusion and, in accordance with subsection 83(4) of SARA, permits fishers authorized under the *Fisheries Act* who are engaged in commercial or recreational fishing or in an Indigenous food, social and ceremonial (FSC) fishery for groundfish, shellfish and pelagic species (including emerging fisheries) that may incidentally kill, harm, harass, capture or take Northern or Spotted Wolffish to carry out these activities under the following conditions:

- every person on board the fishing vessel who incidentally catches Northern or Spotted Wolffish while conducting fishing activities must return them to the place from which they were taken, and where they are alive, in a manner that causes them the least harm
- commercial fishers are required to collect and subsequently report information to DFO for each fishing trip where Northern or Spotted Wolffish is caught, utilizing the standard logbook/logsheet protocol specified for the target species, vessel class or licence in question

In accordance with subsection 83(4) of SARA, this document also permits scientific research activities that are authorized under the *Fishery (General) Regulations*, SOR/93-53 for the purpose of monitoring and sampling various aquatic species, including wolffish. Scientific research was identified in the allowable harm assessment as having negligible impacts on the ability of both Northern and Spotted Wolffish to survive and recover (DFO 2004b).

In assessing allowable harm, the longer the timeframe being examined, the more uncertainty there is in projecting impacts of exploitation on the survival or recovery of a population. Given this uncertainty, the allowable harm assessment for Northern and Spotted Wolffish will be re-evaluated, incorporating any relevant new data. Current monitoring of incidental capture through both logbook data and at-sea observers will continue and will be used to assess the effectiveness of those conservation measures outlined above.

While Atlantic Wolffish has been listed on SARA Schedule 1 as a species of Special Concern (that is, SARA prohibitions do not apply), it is recommended that live release protocols and reporting, as outlined above for Northern or Spotted Wolffish, also apply to this species. However, the implementation of this recommendation is at the discretion of the DFO regions, and should be approached as a voluntary measure to be used in cooperation with other *Fisheries Act* requirements.

4. Potential impacts of the recovery strategy on other species/ecological processes

This recovery strategy and management plan recognizes the importance of the entire marine ecosystem. Multi-species approaches to conservation are known to be difficult due to the diverse interactions between species and their habitats that occur within a marine ecosystem. Recovery activities such as increased habitat protection and/or conservation and implementation of mitigative measures to reduce human induced impacts may also benefit other species that co-occur with wolffish in eastern Canadian waters. The extent of such benefits is not yet completely understood. Collection of data to evaluate and model ecosystem interactions may help to address this unknown. In addition, stakeholder awareness and understanding of marine biodiversity and Threatened species would be heightened through stated protection and/or conservation efforts for the wolffish.

5. Actions completed or underway

A multi-stakeholder Recovery Team was formed in 2007 and the following initiatives were initiated or have been completed:

- prepare a wolffish recovery strategy and management plan (this document);
- update current knowledge, summarized in this document;
- define goals, objectives, strategies and actions for the wolffish recovery process (this document);
- a wolffish release program as a condition of license to examine the survival of released fish, Instituted in eastern Canada in 2003 to 2004 and is complete for certain fisheries;
- commence a program of research (instituted in 2002) that will provide the information required to facilitate effective recovery work. Research is underway (and is complete in some cases) to examine habitat associations, population structure, distribution and abundance, movements/migrations, life history, and diet and feeding;
- increase understanding of the allowable harm permitting process, an allowable harm assessment has been undertaken and information has been provided to license holders for fisheries where wolffish may be taken as bycatch; and
- commence an education and communication program and promote stewardship geared mainly toward resource users but also the public in general education programs on species at risk issues in general and wolffish specifically have taken the form of meetings with fishers and information materials have been disseminated widely.

Intra-Departmental Collaboration has been promoted through:

- cooperation between various Atlantic Canadian Regional DFO jurisdictions in terms of recovery and regulatory initiatives
- sharing data between Atlantic Canadian Regional DFO jurisdictions
- preparation of preliminary economic profiling by regional DFO Policy and Economic Branches

Federal, Provincial, and Indigenous collaboration has been promoted through:

- continuing consultation and cooperative exchange with other federal departments (that is, Environment and Climate Change Canada, Parks Canada)
- continuing consultation and cooperative exchange with provincial and territorial representatives, as appropriate
- presentation of the strategy to applicable wildlife management boards and continuing dialogue with Indigenous groups

Industry and public involvement has been promoted through:

- cooperative research initiatives
- education and communication with stakeholders
- stewardship initiatives

The above description of recovery related activities already under way, as promoted in draft versions of this document, indicates that the team and a host of other participants have already made significant progress in terms of recovery efforts. Progress is particularly reflected in the institution of an Atlantic release program and in research, education and stewardship initiatives presently being undertaken. Activities are elaborated in the following sections.

5.1 Recovery strategy A : conduct research

Research under way includes:

- trends in abundance, distribution, stock (subpopulation) structure and life history
- analysis of fishing databases, including SARA logs, observer records, Zonal Interchange Format (ZIF) data and NAFO landings data to estimate impact of fisheries bycatch
- definition of habitat associations and critical habitat including, temperature preferences, bottom type, depth, dissolved oxygen, etc.
- aging and maturity
- identification of gaps in current knowledge

5.2 Recovery strategy B : habitat conservation and protection

See section 6 for details on Northern and Spotted Wolffish critical habitat and its protection.

5.3 Recovery strategy C : mitigate human activities

The Recovery Team recommended the quick release of all wolffish, alive wherever possible, caught incidentally by harvesters. Although Northern and Spotted Wolffish have been declared Threatened species by COSEWIC, these fish were still caught incidentally in many fisheries. Federal policy previously specified that they must be brought into port where fish processors either process them or discard them. In November 2002, the Recovery Team recommended that wolffish no longer be brought into port but rather be released in a manner that maximizes chance of survival.

Wolffish have been described as a “hardy species” that tend to be lively even after capture and have a good chance of survival if released quickly. Therefore, as of 2003 to 2004, allowable harm permits have been issued to allow harvesters the incidental capture of wolffish. Permit requirements specify that harvesters estimate the weight of their wolffish catch by species and release them quickly and safely at the capture site. In 2004, DFO undertook an allowable harm assessment for wolffish. In summary, the conclusions from that process are as follows:

“Given that mortality due to fishing is considered the dominant source of human induced mortality for Northern and Spotted Wolffish and that the populations of both species have been steady or increasing prior to any prohibitions, it appears that the recent (2000 to 2002) level of mortality does not impair the ability of the species to recover. However, all efforts should be taken to enhance survival in the fisheries, primarily through mandatory release of wolffish in a manner that will increase the chance of survival. This can only be accomplished through education and permit conditions requiring the release of wolffish in a manner that will enhance their survival. As well, any gear modifications that lead to a reduction in the bycatch of wolffish (for example the Nordmore grate employed in shrimp fishery) should be employed wherever possible. Should there be a large increase in the size of any fisheries that take significant amounts of wolffish, other options may have to be considered. Finally, it is critical that the populations and sources of harm be monitored to ensure that recovery continues to take place”.

Refer to DFO (2004b) and Kulka (2004) and Kulka and Simpson (2004) for further details.

Survival of released fish has been evaluated and preliminary observations suggest that wolffish released in an appropriate manner (placed back in the water quickly and with minimal handling, gills undisturbed) appear to have a high chance of survival. In a study by Grant et al. (2005), Atlantic Wolffish, caught as bycatch in the commercial yellowtail fishery, showed high survival rates when returned to the ocean following up to 2.5 hours out of the water. Similar studies have not been conducted on Spotted or Northern Wolffish and these species are at highest concentrations in much deeper areas. Benoit et al. (2010) investigated the factors that affect pre-discard condition of Spotted and Atlantic Wolffish (and other species), and found a correlation between body size and good condition. This study however, only included fish harvested at isobath <200 m. In addition, programs educating fishers in best practices for release are also under way.

5.4 Recovery strategy D : promote knowledge and stakeholder participation in the recovery of wolffish populations and habitat conservation and protection

A variety of promotional items and information materials have been developed by DFO and others to help increase awareness of wolffish. These items include brochures, factsheets, posters, and DVDs that are distributed to fish harvesters and fish plant workers, to students during school visits, and the general public during trade shows and Ocean's Day events. Much of this information is also easily available to the public via the SARA Public Registry and DFO websites. Wolffish have also been included in Species at Risk products including SARA identification cards, portable displays, calendars, SARA art project/shows, school education kits aimed at grades 4 to 6, and various promotional items.

DFO and various NGOs have been engaging stakeholders such as fish harvesters and plant workers, as well as the general public, to educate and inform them about the status of the species. For example, DFO Fishery Officers, while on direct patrol as well as during various meetings, continue to educate fish harvesters on the importance of accurate recording and reporting of wolffish catches. The DVD, *Wolffish – A Balance of Life*[4], is another useful tool which introduces viewers to these species. It dispels many myths about wolffish and explains their important role in the ecosystem, while providing a fish harvester's view of the species.

Knowledge and stewardship have also been the focus of several Habitat Stewardship Program (HSP) initiatives. Direct interaction with stakeholders is a cornerstone of these initiatives.

Since 2002, education and stewardship programs have focused on mitigating wolffish threats. The following documents have been developed to aid in the correct handling and release of wolffish:

Tips for Handling and Releasing Wolffish: Crab Fishing
Tips for Handling and Releasing Wolffish: Gillnetting
Tips for Handling and Releasing Wolffish: Hook and Line Fishing
Tips for Handling and Releasing Wolffish: Otter Trawl Fishery
Tips for Handling and Releasing Wolffish: Shrimp Fishing

A video, "Handling and Releasing Wolffish" was also developed by DFO and was widely distributed.

5.5 Recovery strategy E : monitoring human activities and wolffish species

As part of a larger research initiative to estimate the effect of fishing activity on wolffish populations, observer coverage has been enhanced for fisheries where the majority of incidental catch of wolffish species has been identified, such as the Greenland Halibut directed fisheries. Observer education and training has been undertaken to improve species identification and to provide for more detailed information collection and to pass

[4] Wolffish – A Balance of Life. Intervale Associates Inc. 2007

this information on to harvesters. These data will be used to estimate removals by species which is the basis for estimating mortality related to fishing. A requirement for recording wolffish by species in log books has been instituted. Voluntary collection of Atlantic Wolffish landing data (by species for weight and size) at fish processing plants was instituted.

6. Evaluation of recovery and conservation initiative

Evaluation of recovery criteria will most likely be based on the results of demographic analyses as outlined in this document. Demographic data on reproduction, age, growth, and mortality will be based on best available scientific knowledge to estimate the level of increase or decrease in wolffish populations when compared to their status as designated by COSEWIC in 2001. Such data provides a means of documenting the recovery or lack thereof, for wolffish populations in eastern Canadian waters, thereby determining the efficacy of the recovery efforts.

Throughout implementation of the recovery strategy and management plan, the following questions can be utilized to evaluate progress on meeting the stated recovery goal and objectives and adjust performance measures as appropriate:

- Have estimates of biomass and Recovery Reference Points been researched?
- Have the distribution and population size increased? If so, have Recovery Reference Points been reached or exceeded?
- Have historic and present threats to wolffish populations and their habitat been fully identified, defined, and mitigated?
- Have the recommended fishery management strategies been implemented? Are they effective in reducing mortality?
- Has habitat necessary for the survival and recovery of the species (that is, critical habitat) been defined and accounted for in any recovery initiatives or management strategies?
- Are stakeholders involved in the recovery activities? Are the stewardship and education initiatives achieving the desired results?

7. Statement on action plan

An action plan has been drafted and was finalized in 2020. The action plan provides specific details for recovery implementation including measures to monitor and implement recovery, address threats, and achieve recovery objectives.

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Appendix A: record of cooperation and consultation

The Recovery Team includes representatives from industry, academia, and the provincial and federal governments. The populations of wolffish, in particular, the two Threatened species, are concentrated largely from the Grand Banks to the Labrador Shelf, which is the jurisdiction of DFO Newfoundland and Labrador Region, and waters adjacent to the province of Newfoundland and Labrador. Thus, the majority of representation on the team was from this area. Industry was represented by leaders of both the inshore and offshore sectors. All sectors of DFO Newfoundland and Labrador were represented on the team. Each team member consulted extensively within their jurisdiction ensuring broad consultation such that key stakeholders were aware of and had the opportunity to input into the recovery strategy.

The three species of wolffish are occasionally encountered in the Davis Strait. Thus, during development, elements of the recovery strategy and management plan were presented to the Nunavut Wildlife Management Board, and the Board was regularly informed of progress by the Team's DFO Central and Arctic member. Upon review of the 2008 recovery strategy and management plan, the Nunavut Wildlife Management Board approved the document in January 2007. A presentation was also made to the Conne River Band (Newfoundland and Labrador) on the recovery strategy and management plan for wolffish species, and on species at risk issues in general. As well, the National Aboriginal Council on Species at Risk (NACOSAR) was informed through David Cole about the activities of the team. Further, various Indigenous owned fishing enterprises and Fisheries Product International (FPI) have been involved in recovery initiatives related to quantifying harm.

The team members, in the preparation of this national wolffish recovery strategy and management plan, informed and received feedback from their respective jurisdictions. In early 2007, the document was also forwarded to the Governments of Newfoundland and Labrador, Nova Scotia, Prince Edward Island, New Brunswick, Quebec, Nunavut and Northwest Territories for review. Resulting comments were incorporated where applicable.

The team wishes to thank the numerous reviewers of this document, from various sectors of the Newfoundland and Labrador Region, from other Atlantic Regions and NHQ. Special thanks goes to MEHM staff who worked on several sections related to habitat and CEAA and Policy and Economics staff from Newfoundland and Labrador, Quebec and Maritimes Regions who provided detailed economic analyses to ensure best knowledge was included. The collective input of reviewers and contributors has ensured compliancy with SARA and has greatly enhanced the quality of a document that deals with a wide range of subject matter.

2020 update

The updated *Recovery Strategy for Northern Wolffish (Anarhichas denticulatus) and Spotted Wolffish (Anarhichas minor), and Management Plan for Atlantic Wolffish (Anarhichas lupus) in Canada* was developed in consultation with multiple stakeholders. DFO provided the following groups with the opportunity to review and comment on the updated document.

Newfoundland and Labrador Region

Canadian Association of Petroleum Producers
Department of Fisheries and Aquaculture
Environment and Climate Change Canada
Fish Food and Allied Workers Union
Groundfish Enterprise Allocation Council/ Canadian Association of Prawn Producers
Innu Nation
Miawpukek First Nation
Nunatsiavut Government
NunatuKavut Community Council Inc.
Parks Canada
Qalipu Mi'kmaq First Nation Band
Transport Canada

Maritimes Region

Acadia First Nation
Annapolis Valley First Nation
Atlantic Canadian Mobile Shrimp Association
Atlantic Herring Co-op
Bear River First Nation
Buctouche First Nation
Canadian Council of Professional Fish Harvesters
Canada-Nova Scotia Offshore Petroleum Board
Canadian Wildlife Federation
Clearwater Seafoods
Connors Bros.
Confederacy of Mainland Mi’kmaq
Conservation Council of New Brunswick
Dalhousie University
Eastern Fishermen's Federation
Grand Manan Fishermen's Association
Guysborough Inshore Fishermen's Association
Indian Island First Nation
Kingsclear First Nations
Louisbourg Seafoods
Maritime Aboriginal Peoples Council
Maliseet Nation Conservation Council
Membertou First Nation
Metepenagiag Mi’kmaq Nation
Millbrook First Nation
Native Council of Nova Scotia
New Brunswick Department of Agriculture
New Brunswick Department of Aquaculture and Fisheries
New Brunswick Department of Energy and Mines
Nova Scotia Department of Natural Resources
Nova Scotia Fish Packers
Oromocto First Nation
Pabineau First Nation
Paq’tnkek Mi’kmaw Nation
Pictou Landing First Nation
Potlotek First Nation
Premium Seafoods Group
Richmond County Inshore Fishermen's Association
Scotia-Fundy Inshore Fishermen's Association
Seafood Producers Association of Nova Scotia
Shelburne County Quota Group
Sipekne’katik Band
St. Mary's First Nation
The Lobster Council of Canada

Eastern Shore Fishermen's Protective Association
Ecology Action Centre
Eel Ground First Nation
Eel River Bar First Nation
Esgenoôpetitj First Nation
Eskasoni First Nation
Fort Folly First Nation
Fundy North Fishermen's Association
Gespe'gewaq Mi'gmaq Resource Council
Glooscap First Nation
New Brunswick Department of Natural Resources
Northern Harvest Sea Farms
North of Smokey Fishermen's Association
North Shore Micmac District Council
Nova Scotia Department of Energy
Nova Scotia Department of Fisheries and Aquaculture
The New Brunswick Aboriginal Peoples Council
Tobique First Nation
Unama'ki Institute of Natural Resources
Wagmatcook First Nation
Waycobah First Nation
Woodstock First Nation
World Wildlife Fund-Canada

Gulf Region

Abegweit First Nation
Elsipogtog First Nation
Lennox Island First Nation
Madawaska First Nation
Mi'kmaq Confederacy of PEI
Native Council of PEI
PEI Department of Agriculture and Forestry
PEI Department of Aquaculture and Rural Development
PEI Department of Fisheries

Québec Region

Agence Mamu Innu Kaikusseht
Alliance des Pêcheurs Professionnels du Québec
Association de gestion halieutique autochtone Mi'kmaq et Malécite
Association des capitaines propriétaires de la Gaspésie
Association des pêcheurs de la Basse Côte-Nord
Association des pêcheurs de la Côte-Nord inc.
Association des pêcheurs polyvalents de Old Fort à Blanc-Sablon
Conseil des Innus de Pakua Shipu
Conseil des Innus de Pessamit
Conseil des Innus de Ekuanitshit
Conseil des Montagnais de Natashquan
Conseil des Montagnais d'Unamen Shipu
Conseil Innu Takuaikan Uashat mak Mani-Utenam
Fédération des pêcheurs semi-hauturiers du Québec (FPSHQ)
La Nation Micmac de Gespeg
Listuguj Mi'gmaq Government
Makivik Corporation
Micmacs of Gesgapegiag
Mi'gmawei Mawiomi Secretariat
Pêcheries Shipek
Première Nation Malécite de Viger
Professionnels du Québec
Regroupement des pêcheurs professionnels des Îles-de-la-Madeleine

Conseil de la Première Nation des Innus d'Essipit

Institut de développement durable des Premières Nations du Québec et du Labrador

Regroupement des pêcheurs professionnels du Nord de la Gaspésie

Central and Arctic Region

Amaruq Hunters and Trappers

Arctic Fishery Alliance

Baffin Fisheries Coalition

Cumberland Sound Fisheries

Department of Fisheries and Sealing

Government of Nunavut

Nunavut Wildlife Management Board

Mayukalik Hunters and Trappers

Mittimatalik Hunters and Trappers

Nangmautaq Hunters and Trappers

Nattivak Hunters and Trappers

Nunavut Inuit Wildlife Secretariat

Nunavut Offshore Allocations Holders Association

Nunavut Tunngavik Inc.

Pangnirtung Hunters and Trappers

Qikiqtaaluk Corporation

Qikiqtaaluk Wildlife Board

Umiat Corporation (Pangnirtung)

Appendix B: authors

This recovery strategy and management plan was prepared by D. Kulka, C. Hood and J. Huntington, through the advice of the Wolffish Recovery Team, on behalf of Fisheries and Oceans Canada. The Wolffish Recovery Team members included:

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David Kulka (co-chair), DFO, St. John's, NL
John Angel, Canadian Association of Prawn Producers
Sharmane Allen, DFO, St. John's, NL
Wade Barney, DFO, St. John's, NL
John Boland, Fish, Food and Allied Workers Union
Carole Bradbury, DFO, St. John's, NL
Joe Brazil, Newfoundland and Labrador Department of Environment and Conservation
Gerald Brothers, DFO, St. John's, NL
Scott Campbell, DFO, St. John's, NL
Bruce Chapman, Groundfish Enterprise Allocation Council
David Coffin, Newfoundland and Labrador Department of Fisheries and Aquaculture
Karen Ditz, DFO, Iqaluit, NU
Tom Hurlbut, DFO, Moncton, NB
George Rose, Memorial University, St. John's, NL
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Jason Simms, DFO, St. John's, NL
Dena Wiseman, DFO, St. John's, NL
Larry Yetman, DFO, St. John's, NL

Appendix C: figures

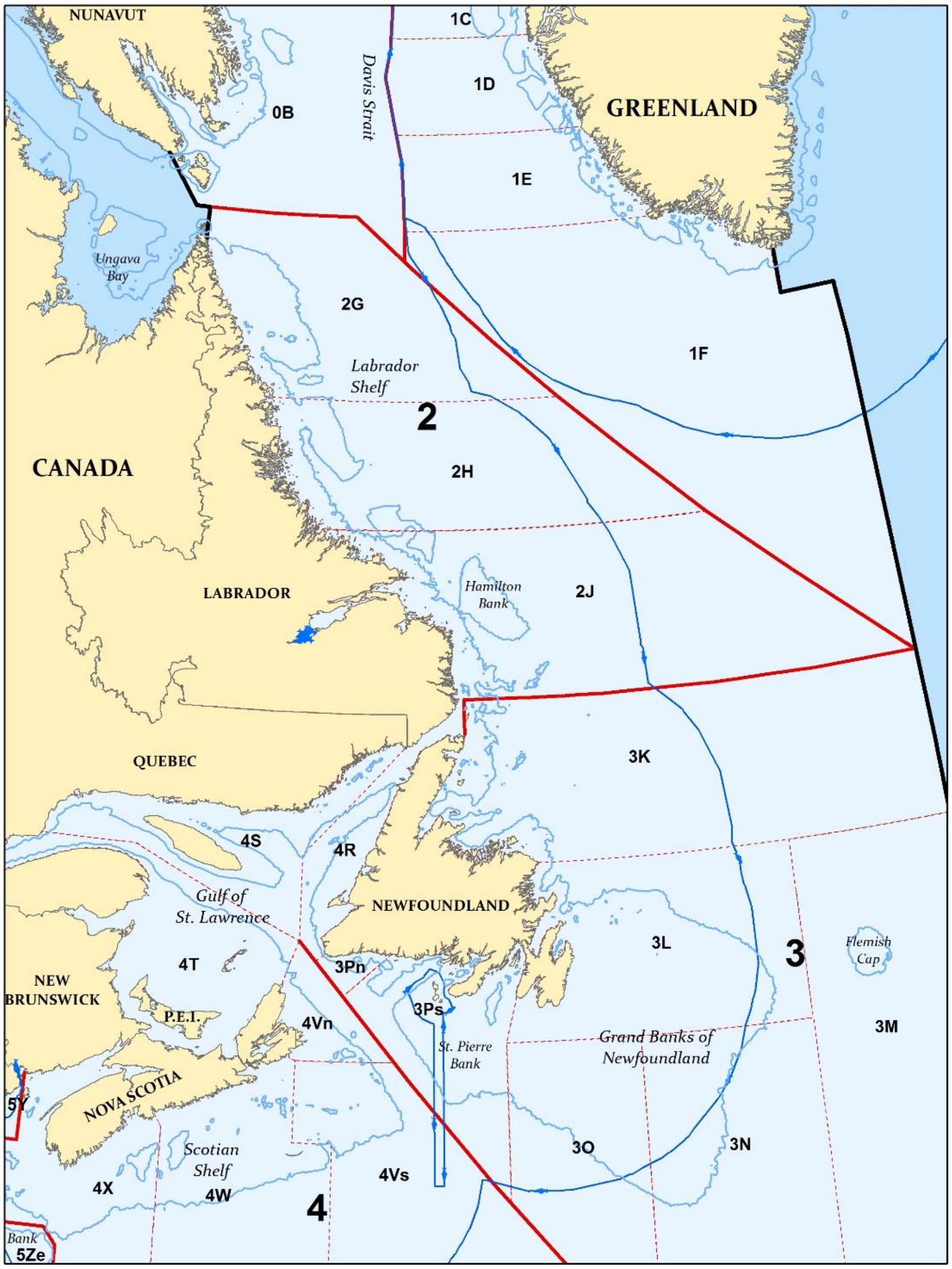

Figure 1. Map of Georges Bank to the Davis Strait, covering the distribution of wolffish species and showing various banks, basins and NAFO Divisions.

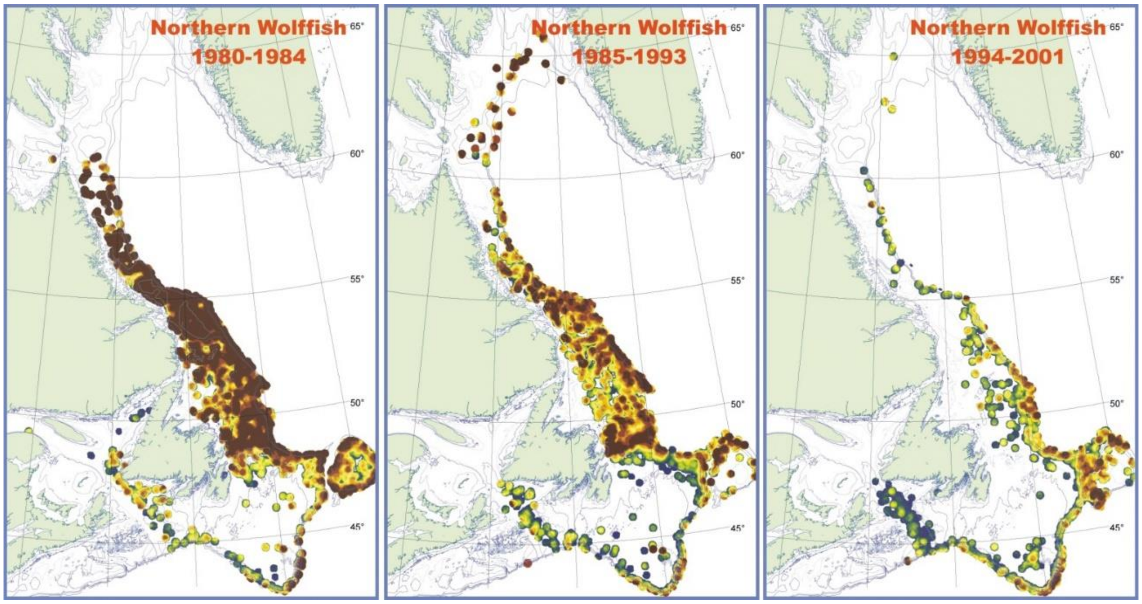

Figure 2. Change in the distribution of Northern Wolffish between 1980 and 2001 based on fall research surveys, Newfoundland and Labrador Region. Red shades depict areas of highest density, shading through yellow to green to blue as areas of lowest density. Sampling north of Lat.60°, in the Gulf of St. Lawrence and on the Scotian Shelf is incomplete.

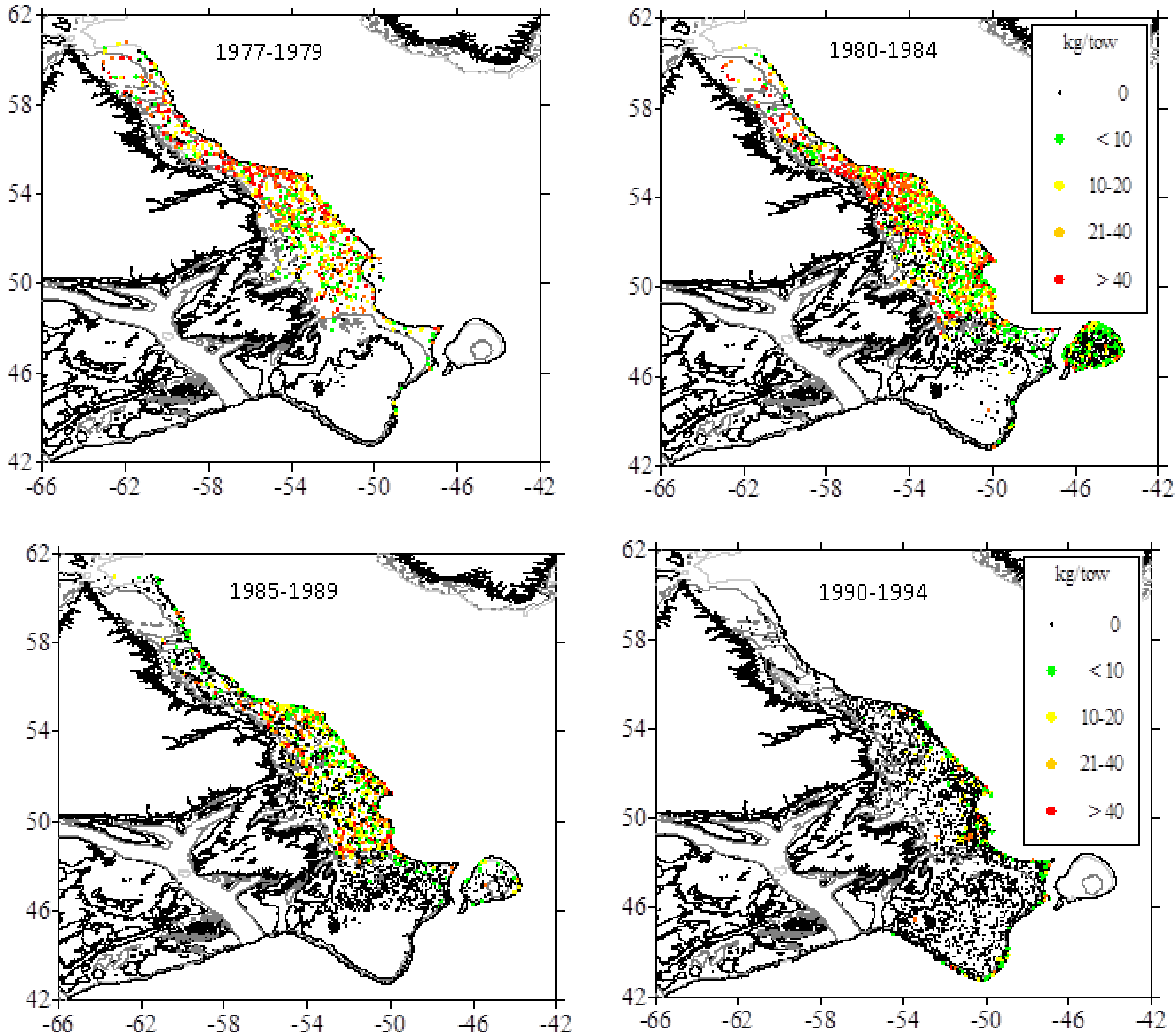

Figure 3. Geographic distribution of fall DFO Research Vessel survey catch rates (kg/tow) for Northern Wolffish in the Newfoundland and Labrador Region, 1977 to 2009.

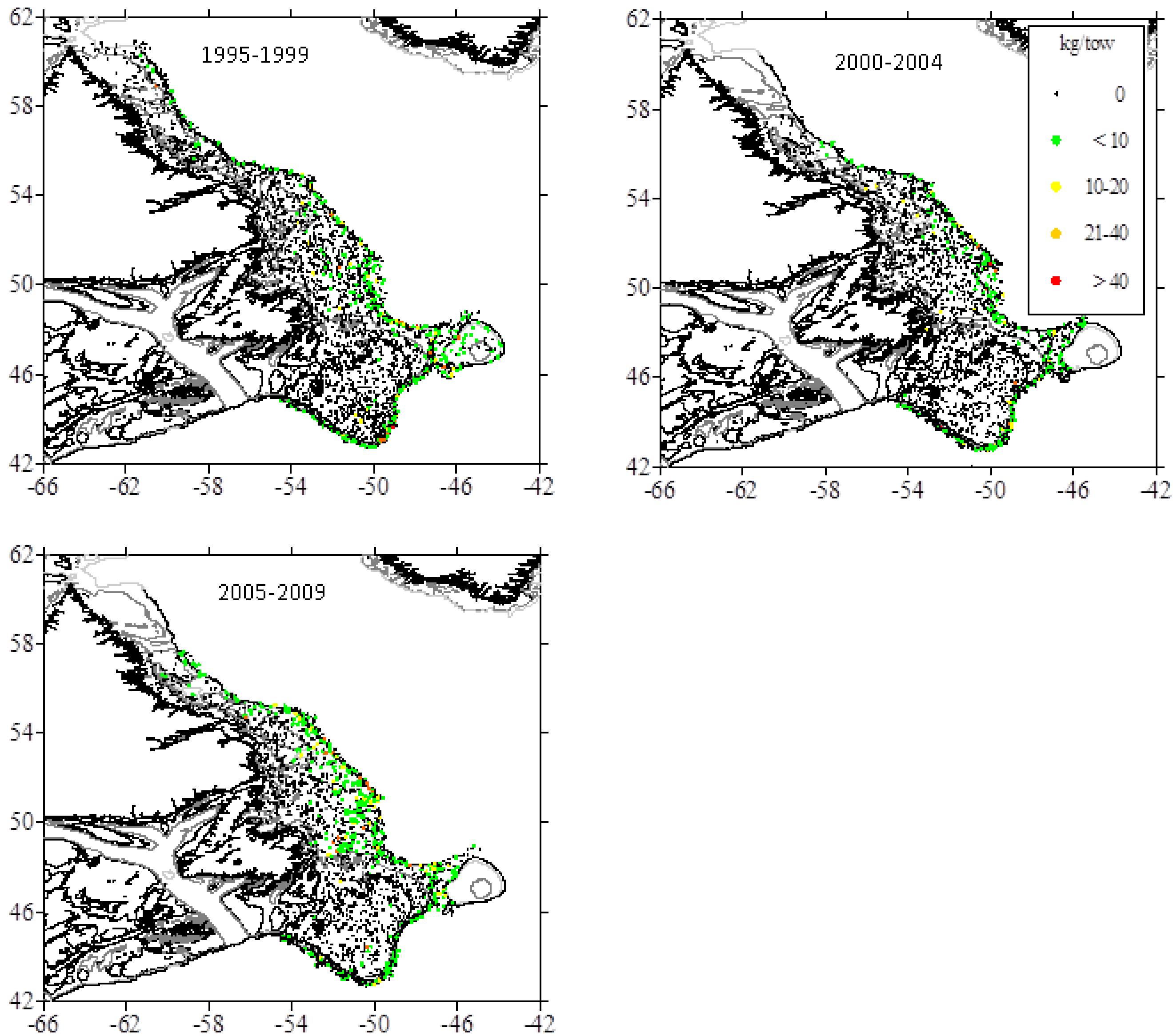

Figure 3 (con't). Geographic distribution of fall DFO Research Vessel survey catch rates (kg/tow) for Northern Wolffish in the Newfoundland and Labrador Region, 1977 to 2009.

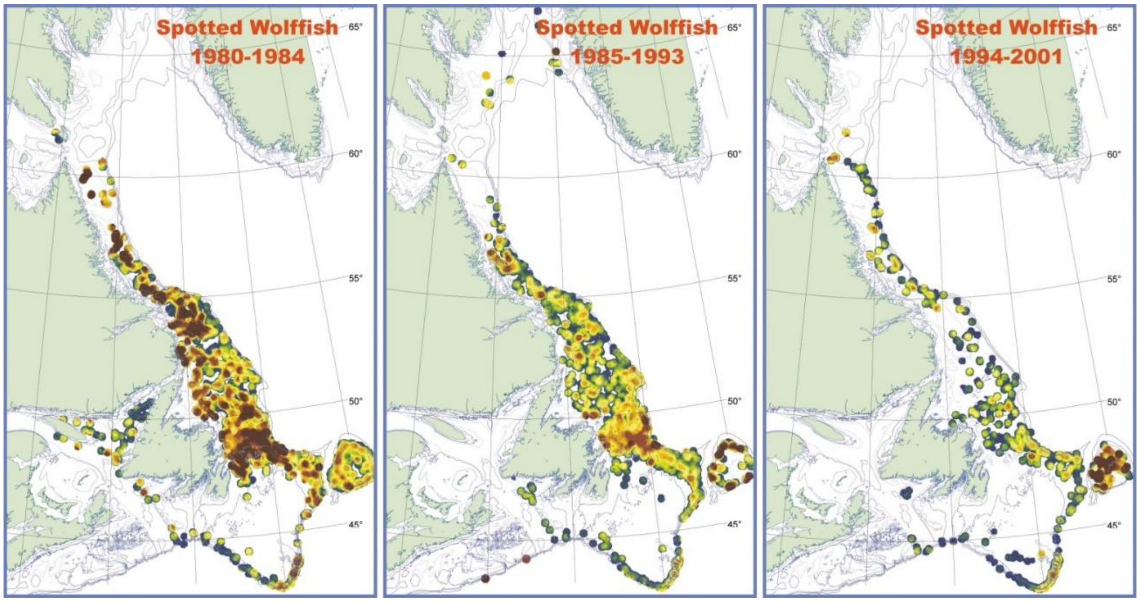

Figure 4. Change in the distribution of Spotted Wolffish between 1980 and 2001 based on fall research surveys, Newfoundland and Labrador Region. Red shades depict areas of highest density, shading through yellow to green to blue as areas of lowest density. Sampling north of Lat. 60º, in the Gulf of St. Lawrence and on the Scotian Shelf is incomplete.

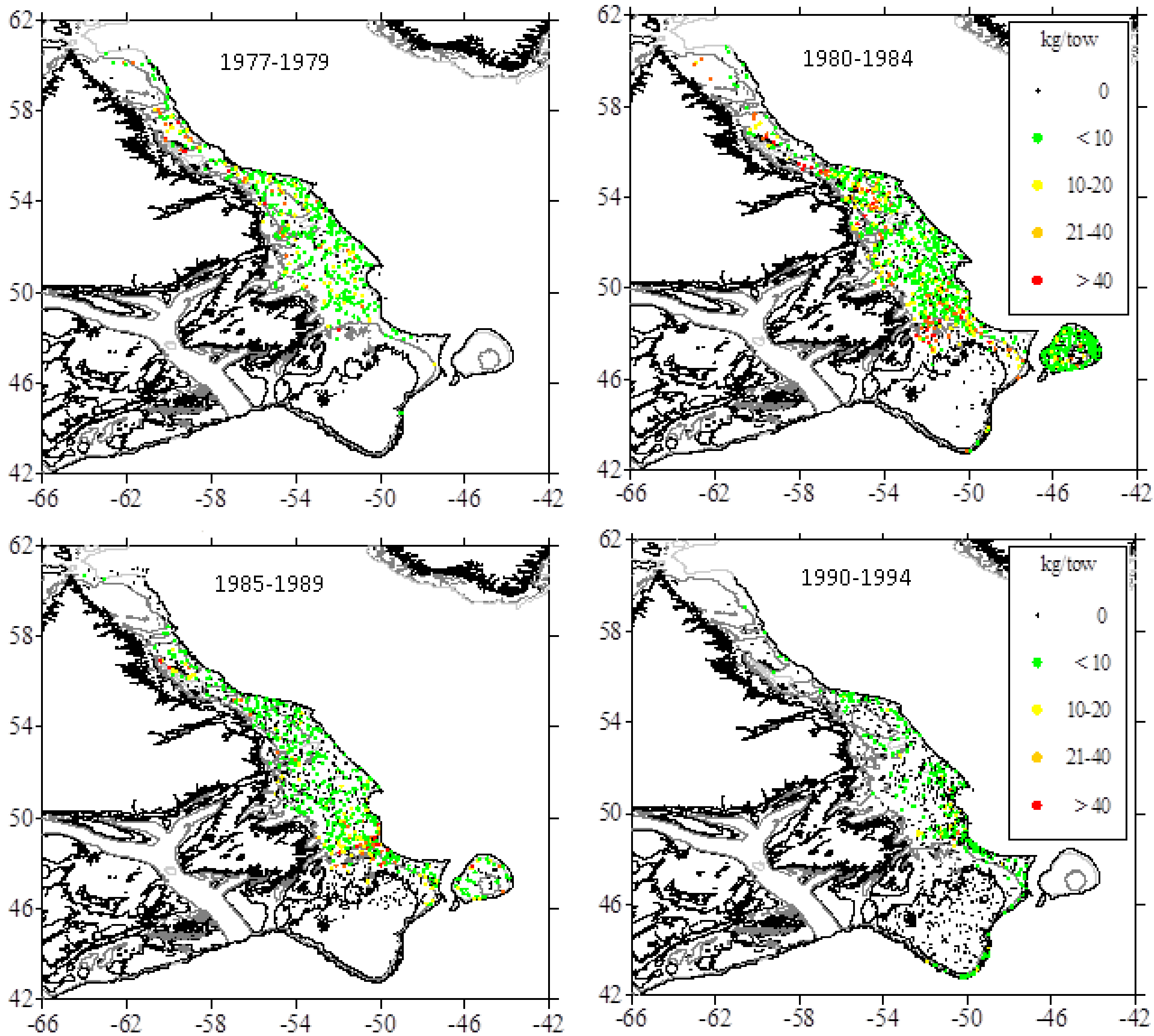

Figure 5. Geographic distribution of fall DFO Research Vessel survey catch rates (kg/tow) for Spotted Wolffish in the Newfoundland and Labrador Region, 1977 to 2009.

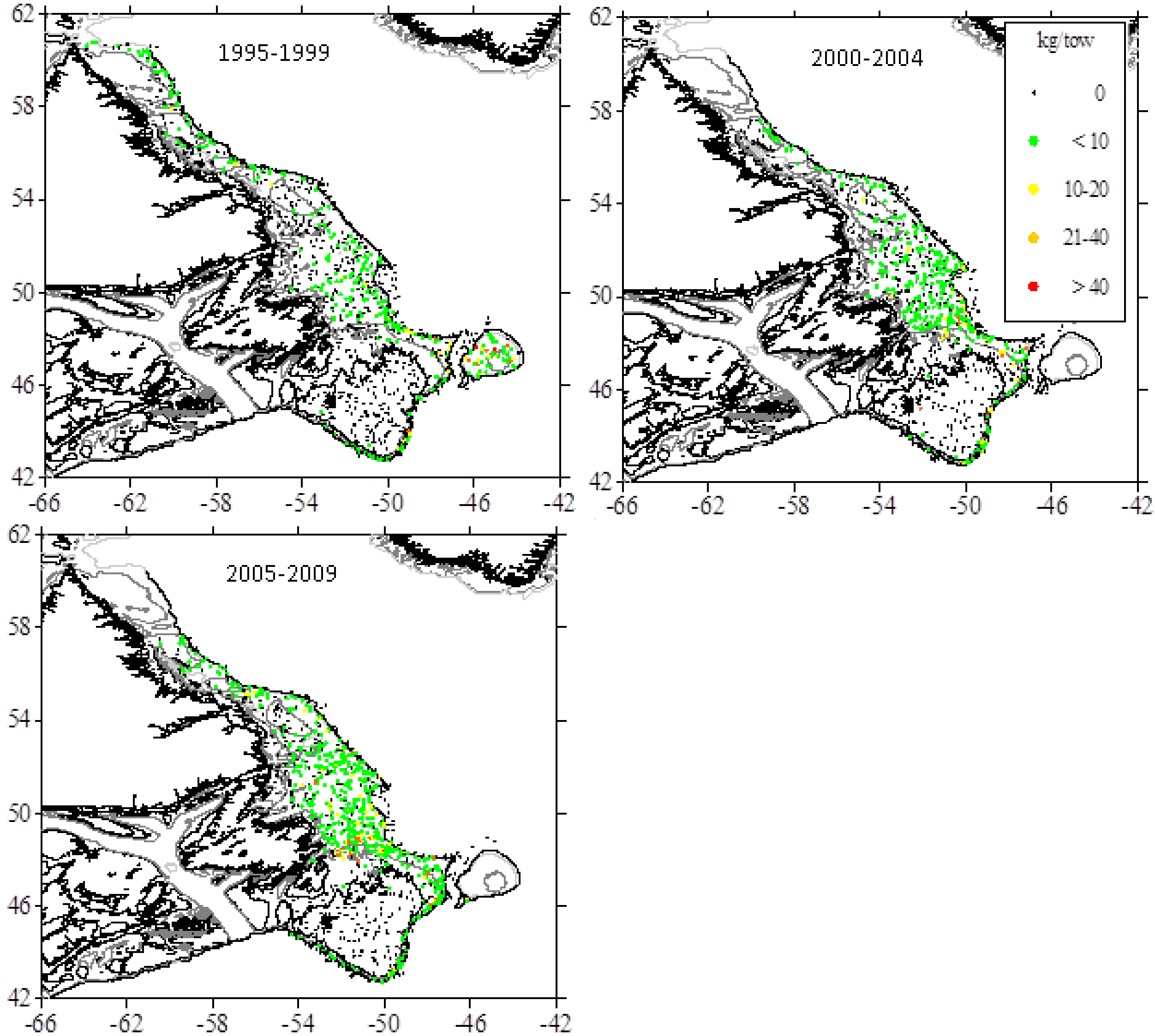

Figure 5 (con't). Geographic distribution of fall DFO Research Vessel survey catch rates (kg/tow) for Spotted Wolffish in the Newfoundland and Labrador Region, 1977 to 2009.

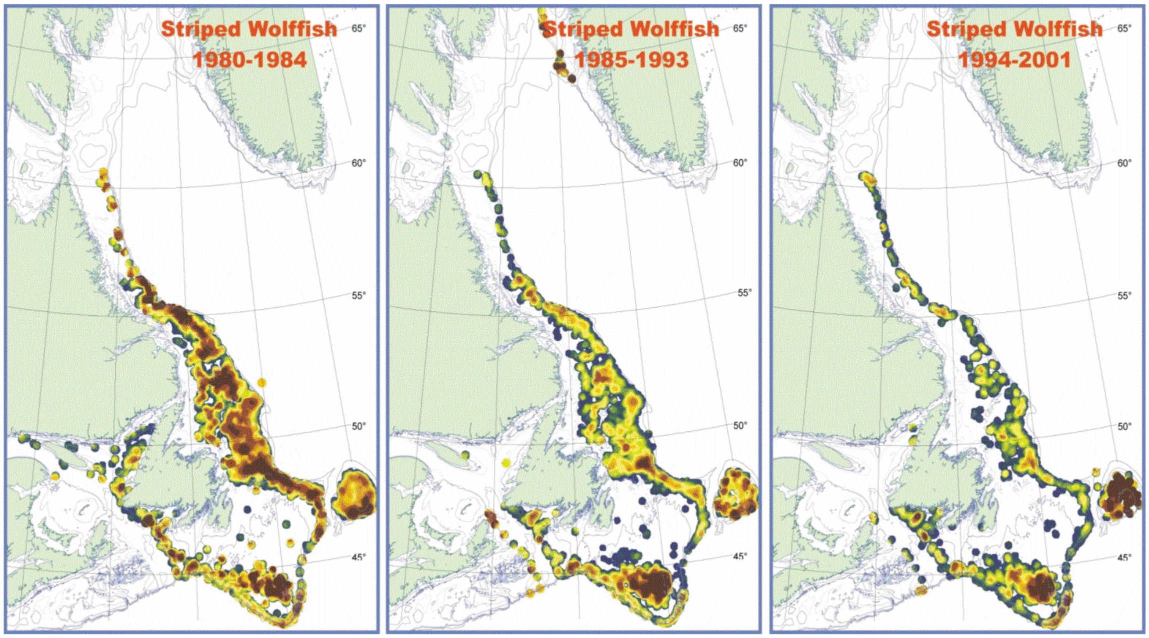

Figure 6. Change in the distribution of Atlantic Wolffish between 1980 and 2001 based on fall research surveys, Newfoundland and Labrador Region. Red shades depict areas of highest density, shading through yellow to green to blue as areas of lowest density. Sampling north of Lat. 60°, in the Gulf of St. Lawrence and on the Scotian Shelf is incomplete.

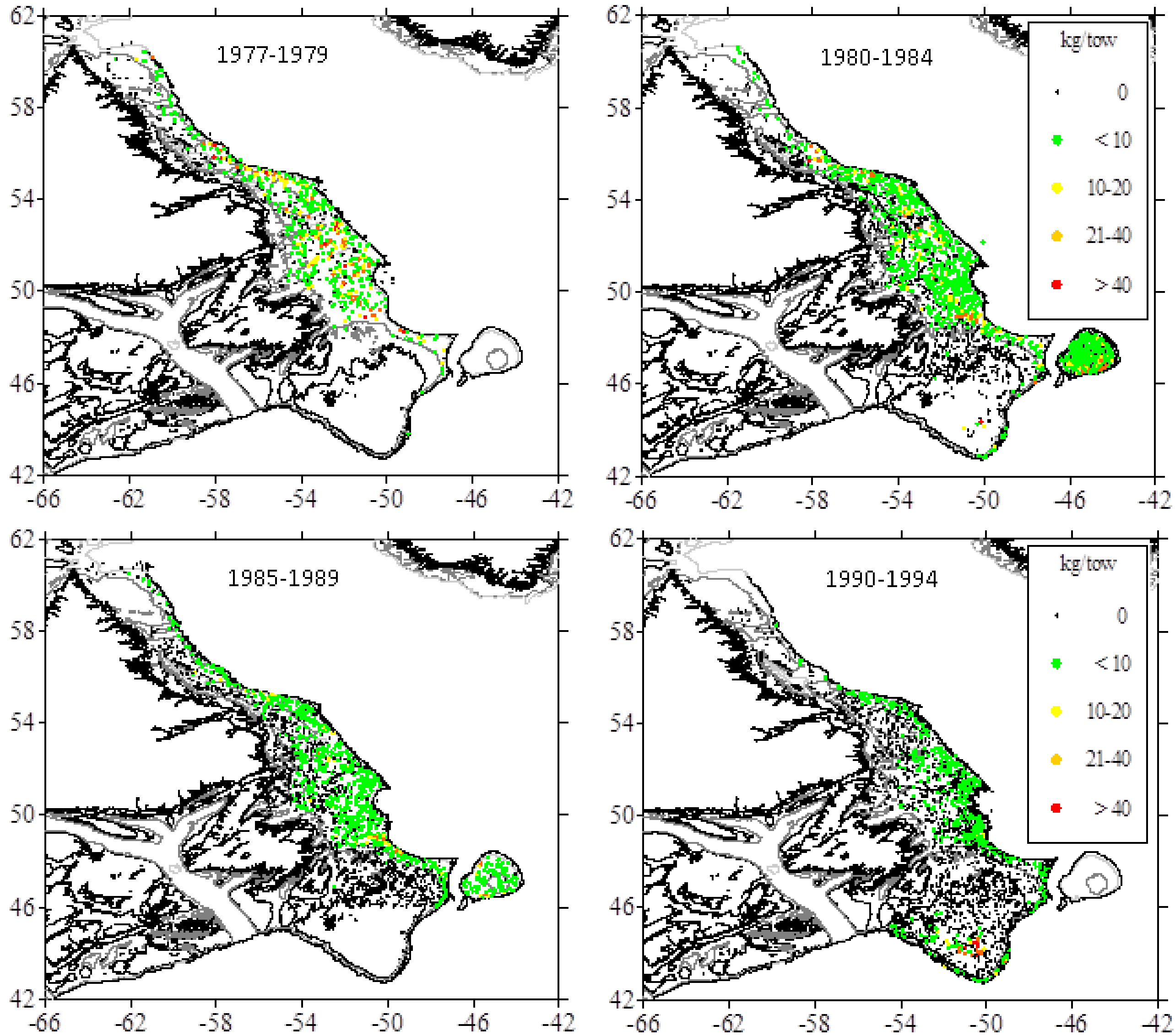

Figure 7. Geographic distribution of fall DFO Research Vessel survey catch rates (kg/tow) for Atlantic Wolffish in the Newfoundland and Labrador Region, 1977 to 2009.

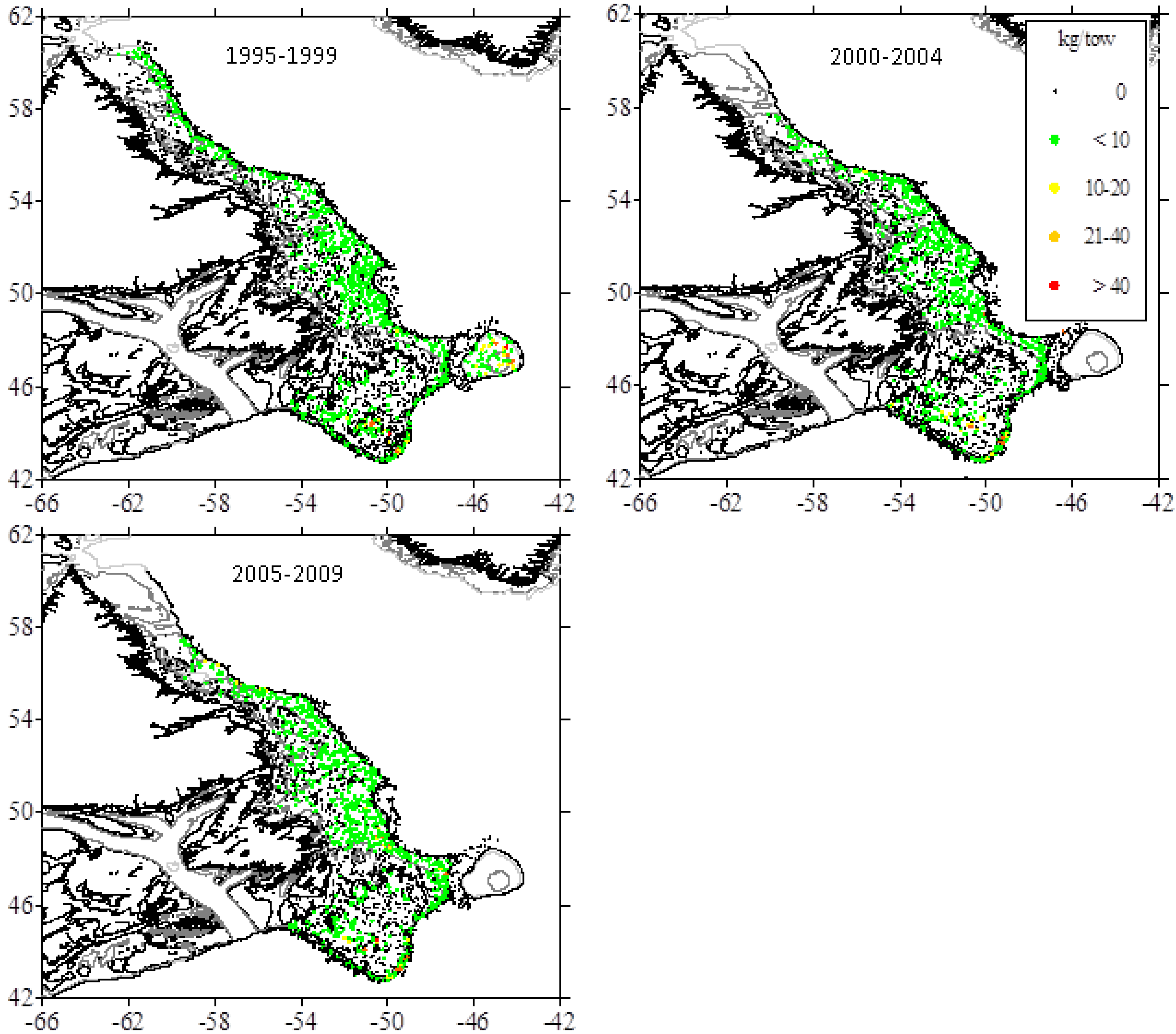

Figure 7 (con't). Geographic distribution of fall DFO Research Vessel survey catch rates (kg/tow) for Atlantic Wolffish in the Newfoundland and Labrador Region, 1977 to 2009.

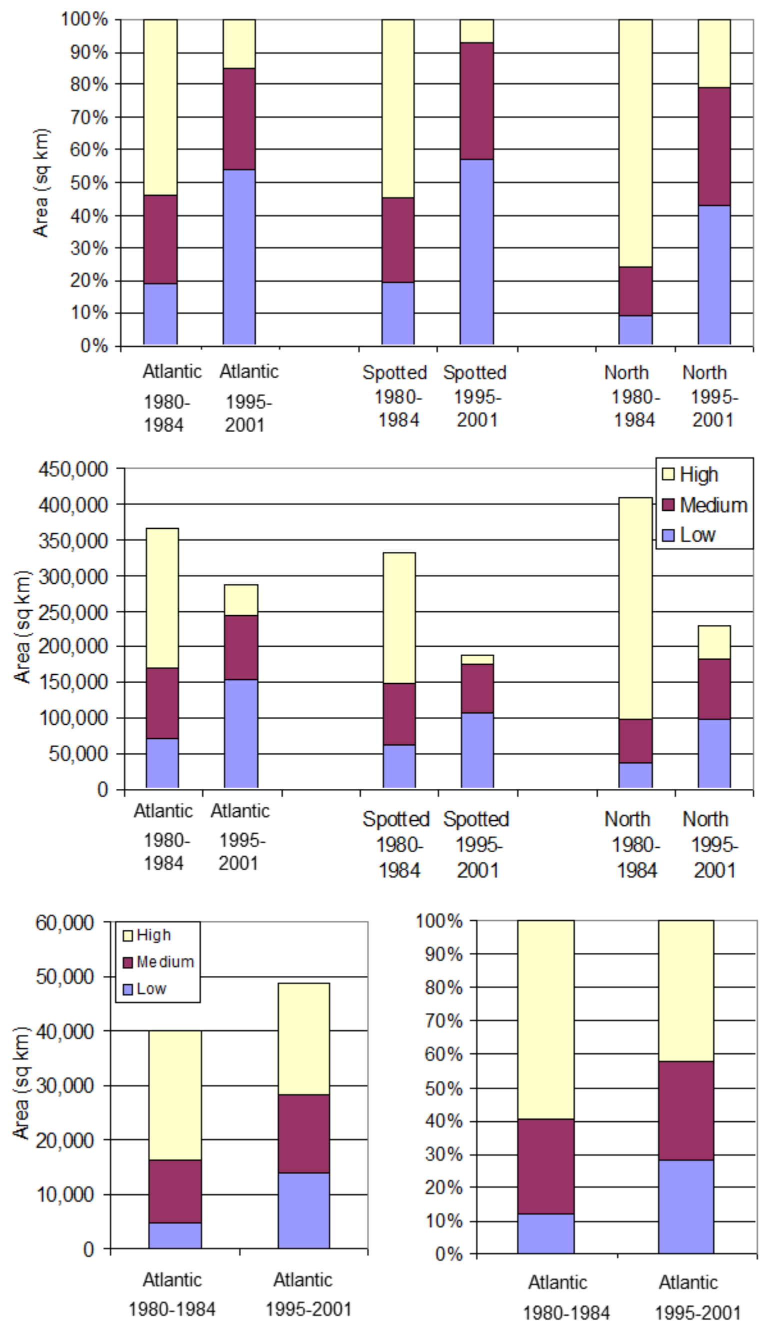

Figure 8. Change in the area of occupancy of Northern, Spotted and Atlantic Wolffish between 1980 and 2001 based on fall research surveys, Newfoundland and Labrador Region (includes the Grand Banks, northeast Newfoundland Shelf and southern Labrador Shelf).

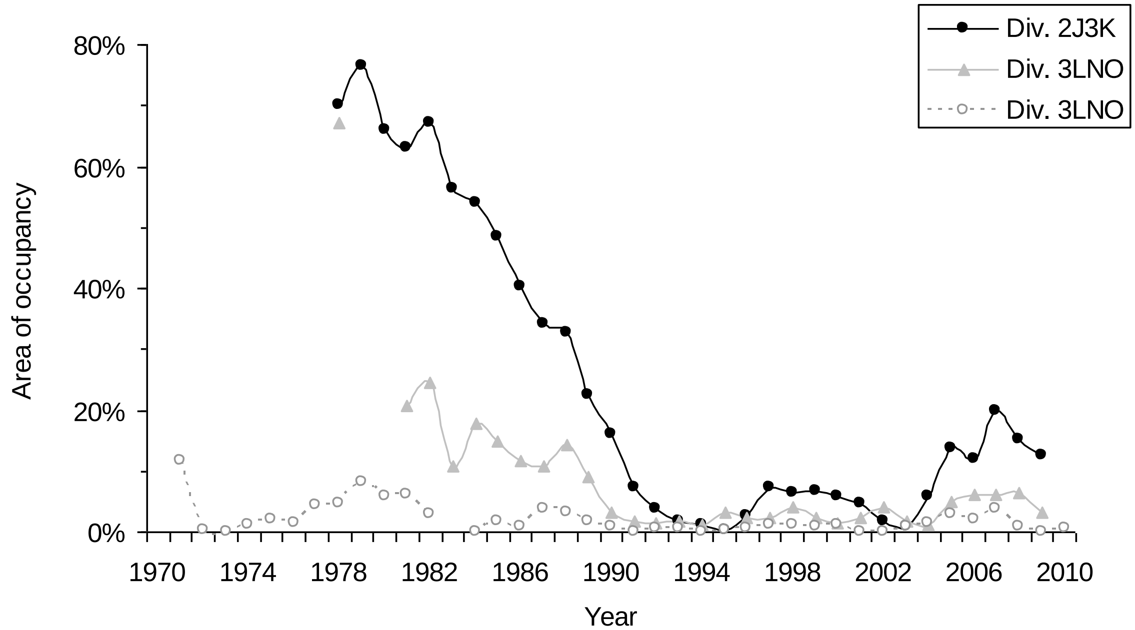

Figure 9. Area of occupancy for Northern Wolffish in NAFO Divisions 2J3K and 3LNO in spring (1971 to 2010; open symbol) and fall (1978 to 2009; closed symbol). Survey trawl gear changed from Yankee to Engel in 1983, and from Engel to Campelen in fall 1995 and spring 1996.

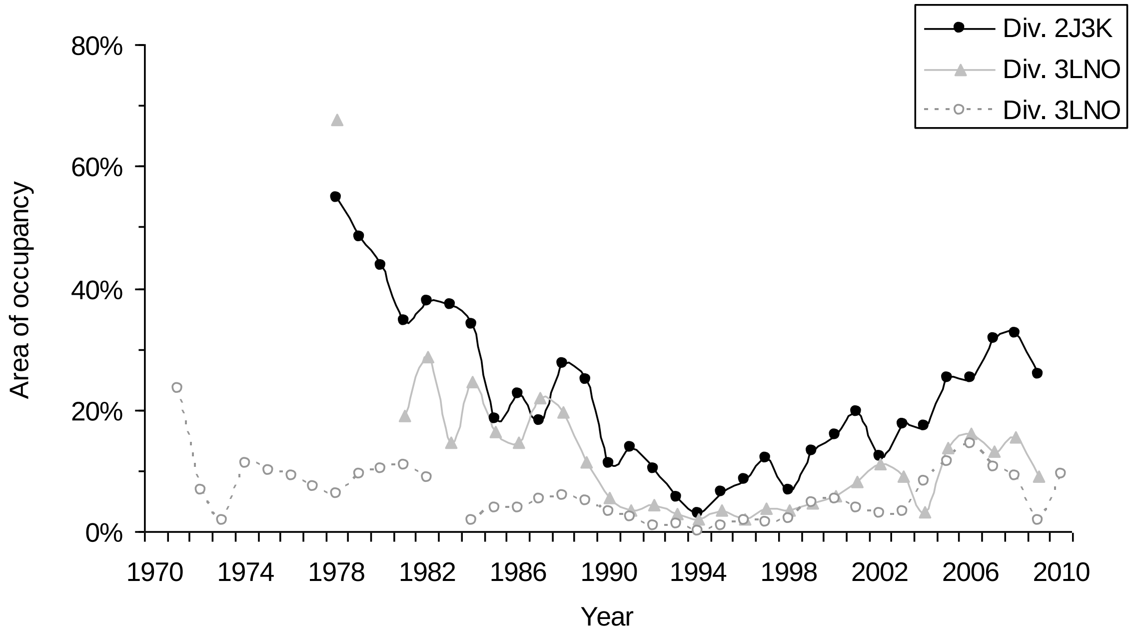

Figure 10. Area of occupancy for Spotted Wolffish in NAFO Divisions 2J3K and 3LNO in spring (1971 to 2010; open symbol) and fall (1978 to 2009; closed symbol). Survey trawl gear changed from Yankee to Engel in 1983, and from Engel to Campelen in fall 1995 and spring 1996.

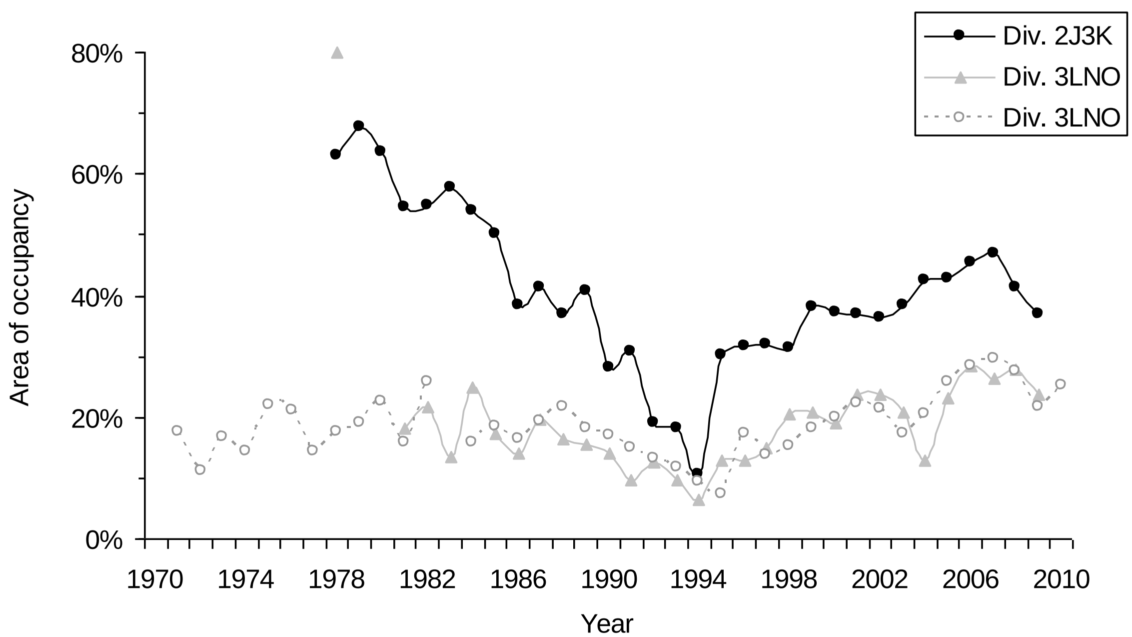

Figure 11. Area of occupancy for Atlantic Wolffish in NAFO Divisions 2J3K and 3LNO in spring (1971 to 2010; open symbol) and fall (1978 to 2009; closed symbol). Survey trawl gear changed from Yankee to Engel in 1983, and from Engel to Campelen in fall 1995 and spring 1996.

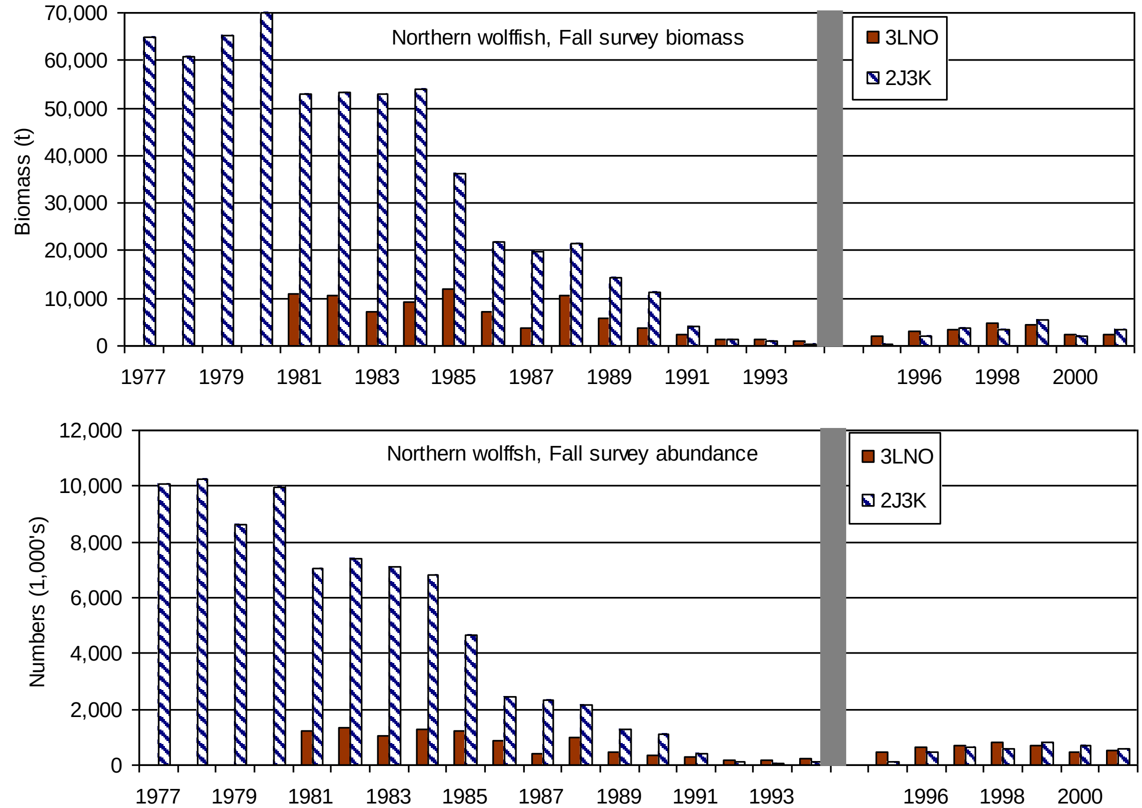

Figure 12. Trends in abundance (lower panel) and biomass (upper panel) indices for Northern Wolffish from 1977 to 2001. Indices were derived from fall Newfoundland and Labrador research surveys. The northern area (2J3K) trend is shown separately from the southern area (3LNO). The dark vertical bar separates the two time series. Engel trawl was used prior to the fall of 1995, Campelen in subsequent years after (Simpson and Kulka 2002).

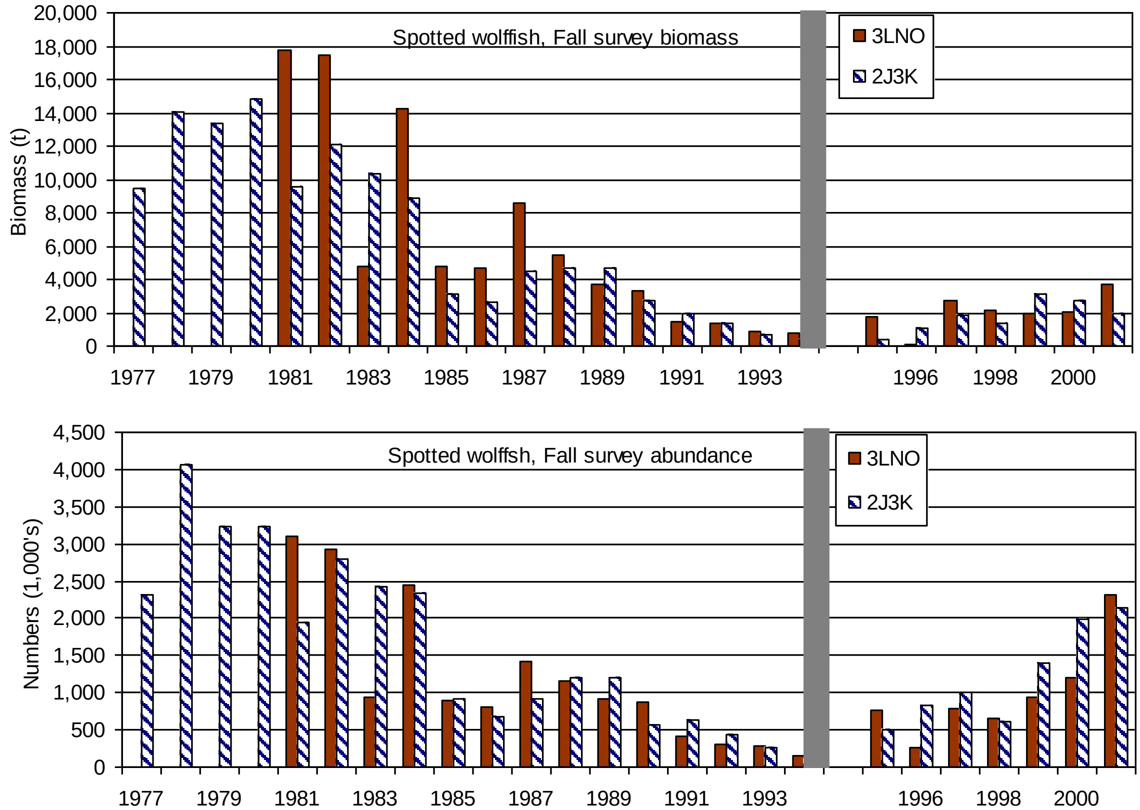

Figure 13. Trends in abundance (lower panel) and biomass (upper panel) indices for Spotted Wolffish from 1977 to 2001. Indices were derived from fall Newfoundland and Labrador research surveys. The northern area (2J3K) trend is shown separately from the southern area (3LNO). The dark vertical bar separates the two time series. Engel trawl was used prior to the fall of 1995, Campelen in subsequent years (after Simpson and Kulka 2002).

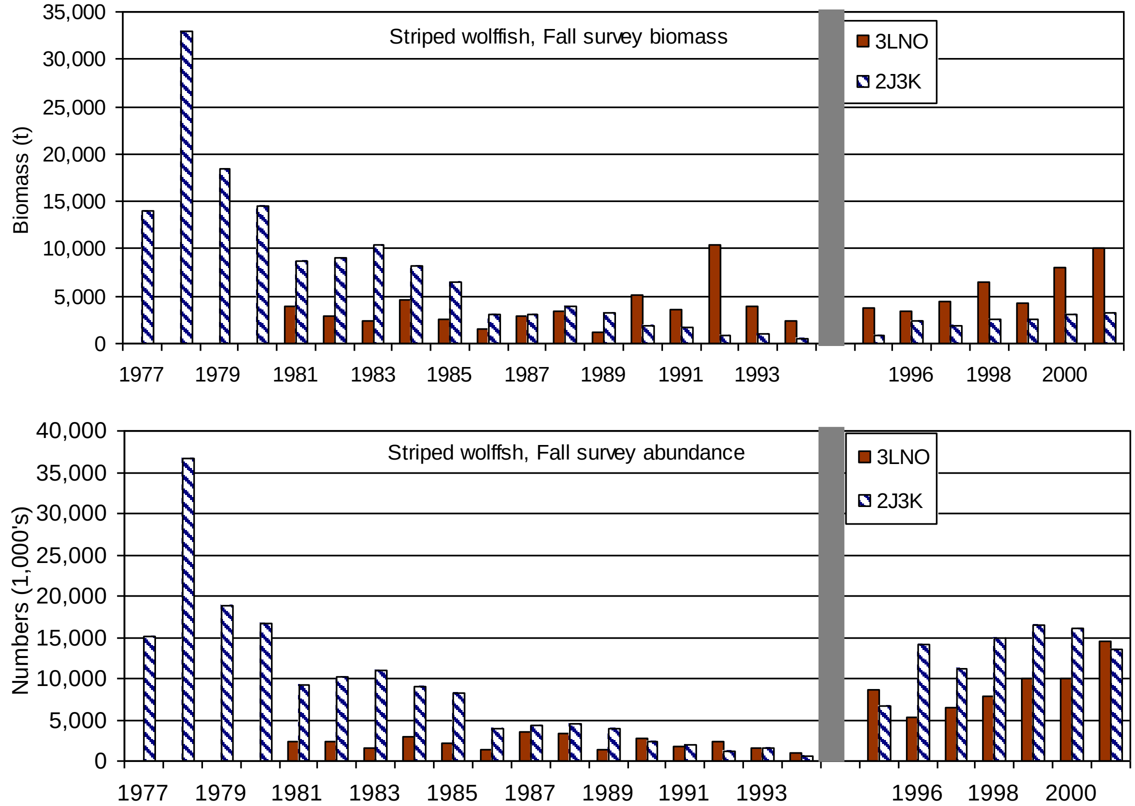

Figure 14. Trends in abundance (lower panel) and biomass (upper panel) indices for Atlantic Wolffish from 1977 to 2001. Indices were derived from fall Newfoundland and Labrador research surveys. The northern area (2J3K) trend is shown separately from the southern area (3LNO). The dark vertical bar separates the two time series. Engel trawl was used prior to the fall of 1995, Campelen in subsequent years after (Simpson and Kulka 2002).

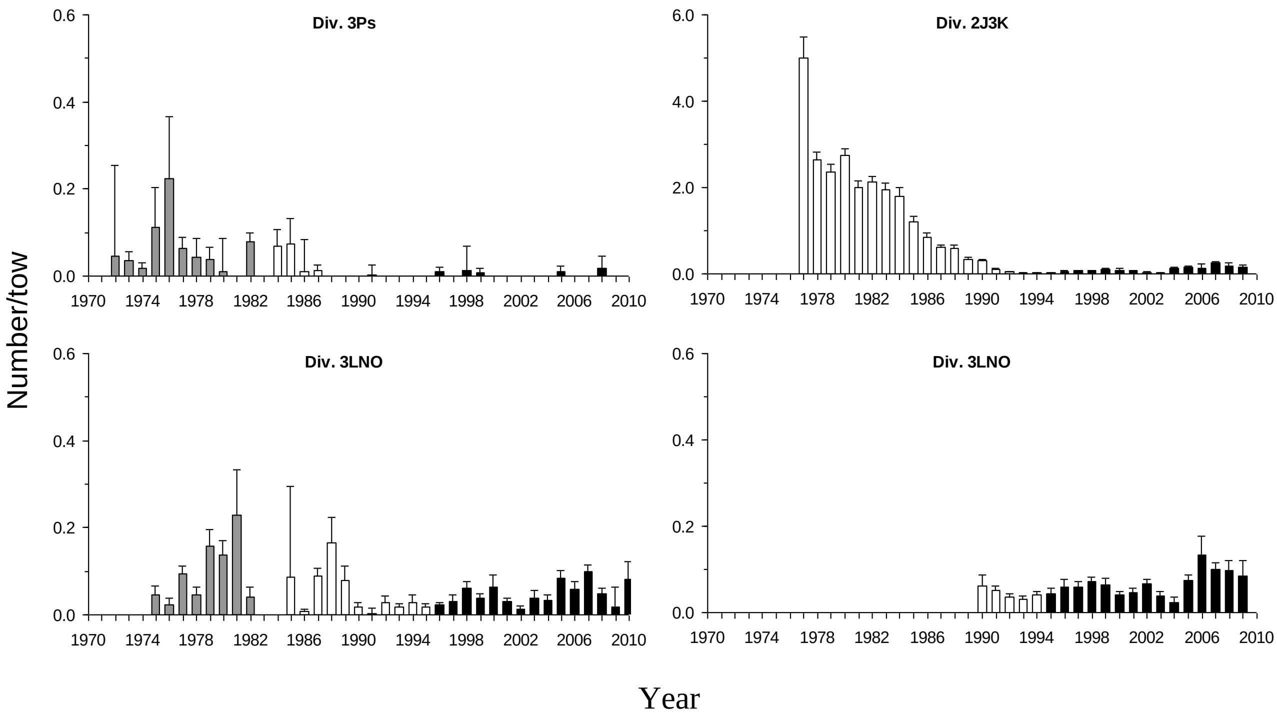

Figure 15. Research survey standardized indices of relative abundance for Northern Wolffish in NAFO Divisions 3LNO and Subdivision 3Ps in spring (left column), and Divisions 2J3K and 3LNO in fall (right column). T-bar = 1 SE. Survey trawl gear changed from Yankee (grey bar) to Engel (white bar) in 1983, and from Engel to Campelen (black bar) in fall 1995 and spring 1996.

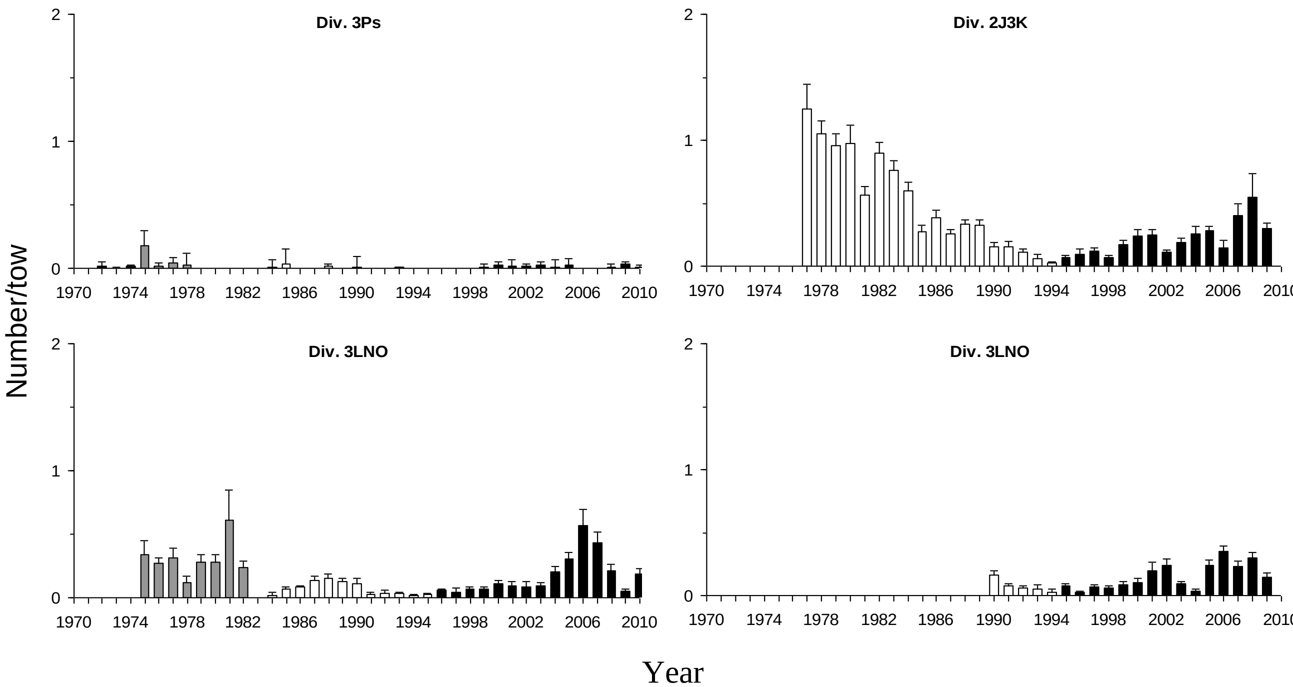

Figure 16. Research survey standardized indices of relative abundance for Spotted Wolffish in NAFO Divisions 3LNO and Subdivision 3Ps in spring (left column), and Divisions 2J3K and 3LNO in fall (right column). T-bar = 1 SE. Survey trawl gear changed from Yankee (grey bar) to Engel (white bar) in 1983, and from Engel to Campelen (black bar) in fall 1995 and spring 1996.

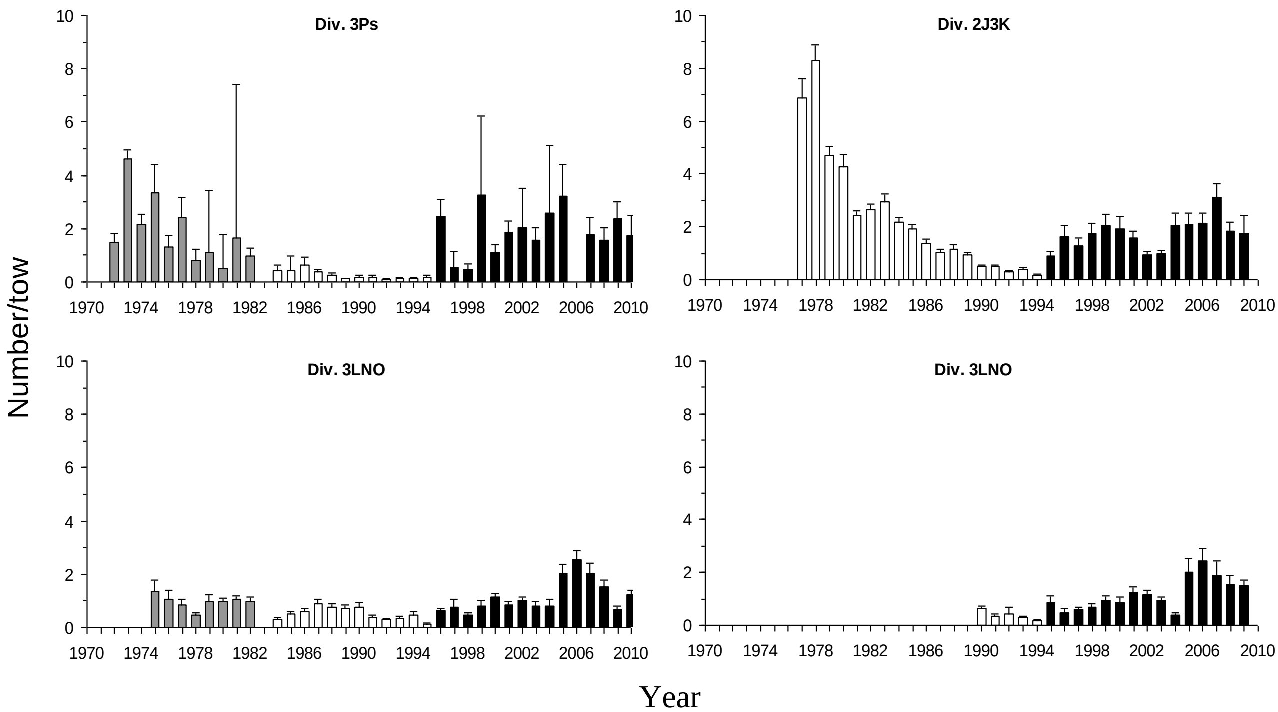

Figure 17. Research survey standardized indices of relative abundance for Atlantic Wolffish in NAFO Divisions 3LNO and Subdivision 3Ps in spring (left column), and Divisions 2J3K and 3LNO in fall (right column). T-bar = 1 SE. Survey trawl gear changed from Yankee (grey bar) to Engel (white bar) in 1983, and from Engel to Campelen (black bar) in fall 1995 and spring 1996.