COSEWIC
Assessment and Status Report

on the

Atlantic Wolffish
Anarhichas lupus

in Canada

Photo ©Andrew Martinez

SPECIAL CONCERN
2012

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON
K1A 0H3

Tel.: 819-953-3215
Fax: 819-994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

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Atlantic Wolffish — Photo ©Andrew Martinez.

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COSEWIC
Assessment Summary

Assessment Summary – November 2012

Common name
Atlantic Wolffish

Scientific name
Anarhichas lupus

Status
Special Concern

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 in areas to the east and north.

Occurrence
Arctic Ocean, Atlantic Ocean

Status history
Designated Special Concern in November 2000. Status re-examined and confirmed in November 2012.

COSEWIC
Executive Summary

Atlantic Wolffish
Anarhichas lupus

Wildlife Species Description and Significance

The Atlantic Wolffish, *Anarhichas lupus,* is a large-bodied, bottom-dwelling fish with prominent canine-like teeth. It has dark bars on its body that distinguish it from the other wolffish species. This species is taken as bycatch in a wide range of fisheries and was of commercial interest in the 1990s. A very limited commercial fishery persists, with the largest catches reported off Nova Scotia and south of Newfoundland.

Distribution

The Atlantic Wolffish inhabits northern regions on both sides of the North Atlantic and in the Arctic. In Canadian waters, it is distributed from the Canadian portion of the Gulf of Maine to offshore of Baffin Island, including the Bay of Fundy, Scotian Shelf, Grand Banks off Newfoundland, Gulf of St. Lawrence, northeastern Newfoundland and the Labrador Sea. It is most abundant off northeastern Newfoundland, on the Labrador Shelf and in the southern Grand Banks off Newfoundland. Although there is evidence of genetic differentiation in parts of its range, the information available to date does not support a division of the species into separate designatable units.

Habitat

The eggs of Atlantic Wolffish are deposited in crevices on rocky bottoms. The larvae are planktonic before becoming established on the bottom. Juveniles and adults are found primarily in the waters of the continental shelf on rocky or sandy bottoms. The fish tolerate a broad temperature range (from -1.5^{o}C to 13^{o}C), although they concentrate in a narrower range and water temperature is thought to be a major factor determining habitat selection.

Biology

The size at which 50% of females reach sexual maturity is 51.4 cm in the northern part of the range and 68.2 cm in the south. The age at which 50% of the female population reaches sexual maturity is between 8 and 15 years. These population parameters are based on old data as no recent estimates are available.

Wolffish have internal fertilization. Spawning is thought to occur in the fall and the eggs are guarded by the male until they hatch. Females spawn multiple times over their lifetime and egg production is low. Larvae hatch at a length of over 20 mm and remain near the bottom until the yolk sac is absorbed. Adults can reach up to 152 cm in length. Generation time is estimated to be 15 years for this species. Adults are fairly sedentary but juveniles are capable of wide dispersal. This species feeds primarily on invertebrates and, to a lesser extent, fish. Although juvenile wolffish have been found in the stomachs of seals and carnivorous fish species, larger individuals probably have few predators.

Population Sizes and Trends

The total number of Atlantic Wolffish in Canadian waters has been estimated at 49 million, including about 5 million mature individuals. There have been declines in both abundance and area occupied over most of its range since the 1970s or 1980s until the mid-1990s. Since then there has been a significant upward trend in abundance and distribution over much of its range, including the waters off the southern Labrador Shelf, which is the historical stronghold of this species. In contrast, adults (but not juveniles) on the Scotian Shelf have continued to decline in abundance and range size.

In the Gulf of Maine outside Canadian waters, the Atlantic Wolffish is at the southern limit of its range and is generally rare and unlikely to provide a source of fish that could rescue adjacent Canadian waters. Off western Greenland, its population is estimated at several million and on the Flemish Cap, abundance was estimated at over 10 million in 2006.

Threats and Limiting Factors

Commercial fishing (directed and bycatch) has been a threat to this species. Recorded catches were relatively high in the 1970s, but declined considerably in the 1990s in Canadian waters due to the closure of several groundfish fisheries. Climate change and its effects on water temperatures may also affect the distribution and abundance of this species.

Protection, Status and Ranks

The Atlantic Wolffish was first assessed as Special Concern by COSEWIC in November 2000 and was subject to a Management Plan. The status was confirmed in 2012 by COSEWIC. It is also listed as likely to be designated threatened or vulnerable under Quebec's *Act Respecting Threatened or Vulnerable Species* (Loi sur les espèces menacées ou vulnérables; R.S.Q., c E-12.01). A petition to list Atlantic Wolffish under the US *Endangered Species Act* was not accepted. Canada's small marine protected areas network protects fish in a very small proportion of their range, and some areas are currently subject to a closure to bottom-trawling.

TECHNICAL SUMMARY – CANADIAN RANGE

Anarhichas lupus
Atlantic (Striped) Wolffish *Loup atlantique*
Range of occurrence in Canada: Eastern Arctic Ocean and the Atlantic Ocean (including the Bay of Fundy, Scotian Shelf, Grand Banks off Newfoundland, Gulf of St. Lawrence, northeastern Newfoundland and the Labrador Sea)

Demographic Information

Generation time (average age of parents in the population)	15
Is there a continuing decline in the number of mature individuals?	No
Estimated percent of continuing decline in the total number of mature individuals within 5 years or 2 generations	N/A
Estimated percent change in the total number of mature individuals over the last 10 years, or 3 generations. Strong declines from the 1980s until the mid-1990s over much of the range. Numbers have been increasing in most areas since then, but they remain low compared to the start of the surveys.	Variable, overall declines
Projected percent change in the total number of mature individuals over the next 10 years or 3 generations.	Unknown
Percent reduction or increase in the total number of mature individuals over any 10 year or 3 generation period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and have they ceased?	Yes
Are there extreme fluctuations in the number of mature individuals?	No

Extent and occupancy information

Estimated extent of occurrence within Canada's extent of jurisdiction 2.792 million km²	1.807 million km² (excluding major land masses)
Index of area of occupancy (IAO) [Using a 2 × 2 grid]	37,332 km^2
Is the total population severely fragmented?	No
Number of locations∗ Threats include bycatch mortality in diverse fisheries over a large region.	Multiple, but exact number unclear
Is there a continuing decline in the extent of occurrence?	No
Is there a continuing decline in the index of area of occupancy?	No, increases in some but not all areas
Is there a continuing decline in the number of populations?	No
Is there a continuing decline in the number of locations*?	No
Is there a continuing decline in the area, extent or quality of habitat?	No
Are there extreme fluctuations in the number of populations?	No
Are there extreme fluctuations in the number of locations∗?	Probably not
Are there extreme fluctuations in the extent of occurrence?	No
Are there extreme fluctuations in the index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N mature individuals
Canadian Population	> 5 million

∗ See definition of "location."

Quantitative Analysis

Probability of extinction in the wild is at least 20% within 20 years or 5 generations, or 10% within 100 years.	**Analysis not done**

Threats (actual or imminent, to populations or habitats)

Commercial fisheries (mainly bycatch), environmental fluctuations, climate change

Rescue Effect (immigration from outside Canada)

Status of outside populations Large populations to the north and east, some declines but not strong trends	
Is immigration known or possible?	Possible
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Possible, but unlikely from south

Status History

Designated Special Concern in November 2000. Status re-examined and confirmed in November 2012.

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** n/a
Reasons 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.	

Applicability of Criteria

Criterion A: Time series are too short to calculate trends over three generations, and inferences are hampered by changes in gear used by survey vessels. Criterion A1b could be used because fisheries bycatch mortality is reversible and reasonably well understood and no longer causing declines. Long-term population trends probably meet Threatened under criterion, but the species is designated Special Concern because there have been increases in abundance and area of occupancy since the mid-1990s, in parallel with a reduction in the threat due to fisheries bycatch.
Criterion B: Does not apply because the extent of occurrence greatly exceeds 20,000 km² and the area of occupancy greatly exceeds 2,000 km².
Criterion C: Does not apply because the number of mature individuals greatly exceeds 10,000.
Criterion D: Does not apply because the number of mature individuals greatly exceeds 1,000 and the area of occupancy is very large.
Criterion E: Not undertaken.

PREFACE

In 2000, the Atlantic Wolffish (*Anarhichas lupus*) was assessed by COSEWIC as being of Special Concern, due largely to the high rate of decline in its abundance in the 1980s and 1990s. This report updates the status of this species based on recent abundance and distribution data that have become available since the last assessment. Some new information on habitat and population structure has also been included in the assessment.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2012)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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TABLE OF CONTENTS

List of Figures

List of Tables

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Class: Actinopterygii

Order: Perciformes

Family: Anarhichadidae

Latin name: *Anarhichas lupus* (Linnaeus 1758)

Common names:
English – Atlantic Wolffish
Also: Striped Wolffish, Catfish, Ocean Whitefish
French – Loup atlantique
Also: Loup de l’Atlantique, poisson-loup, loup de mer à peau mince, chat de mer, blennie-loup

Morphological Description

Members of the family Anarhichadidae are large marine fish that get their common name from their large conical canine-like teeth. There are three species of wolffish in the Canadian Atlantic and adjacent Arctic waters: the Atlantic Wolffish (*Anarhichas lupus*), which is the subject of this report, and the Spotted (*Anarhichas minor*) and Northern Wolffish (*Anarhichas denticulatus*).

The Atlantic Wolffish has an elongate body with large pectoral fins, and a large head with a rounded snout (Figure 1). It can reach a length of over 150 cm and a weight of 24 kg. In common with all wolffish species, it has prominent canine-like teeth in the front of the jaws, and flattened, grinding (vomerine) teeth behind. Wolffish species are distinguished from other fish by a continuous dorsal fin and the absence of pelvic fins. This species varies in colour from slate blue to dull olive green to reddish brown, and there are dark transverse bars on the body (Whitehead *et al.* 1986, Scott and Scott 1988).

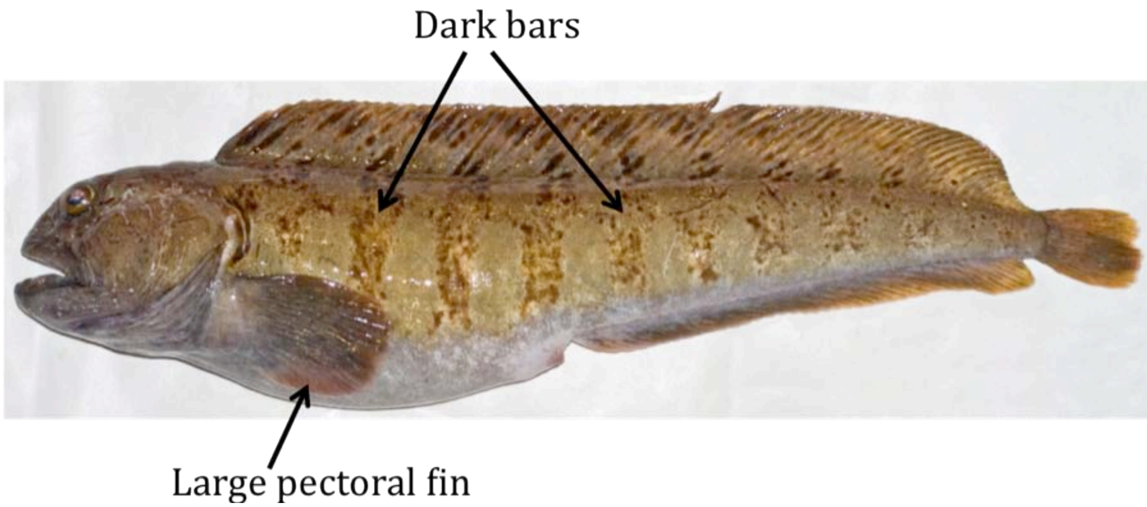


Figure 1. Atlantic Wolffish (*Anarhichas lupus*) and distinguishing morphological features. Photo credit: C. Nozères, Department of Fisheries and Oceans.

The Atlantic Wolffish can be distinguished from the other two wolffish species of the northwestern Atlantic by the 9 to 13 irregular and broken dark transverse bars on its body, some of which extend onto the dorsal fin. As well, its musculature is firm, not jelly-like as in the Northern Wolffish, and the grinding teeth on the vomer[1] extend to the rear of the mouth, farther back than the palatine teeth do[2] (Barsukov 1959 *in* Whitehead *et al.* 1986, Kulka *et al*. 2007). The position of these vomerine teeth can be used to distinguish between the three wolffish species.

Population Spatial Structure and Variability

Dispersal by eggs is not possible because eggs are deposited on the bottom (Keats *et al.* 1985, Scott and Scott 1988), and the larvae stay close to the nest (Bigelow and Schroeder 1953). However, the larvae can rise to near surface waters where they may disperse (Kulka *et al*. 2004), though they are negatively buoyant and sink to the bottom when they stop swimming (Mokness and Pavlov 1996), which could limit dispersal. Adults are generally considered sedentary (see section “Dispersal and Migration”).

Genetic differences among the three species of wolffish of the northwestern Atlantic were evaluated on the basis of their mitochondrial DNA genomes (Johnstone *et al.* 2007, McCusker and Bentzen 2010a) and nuclear genetic markers (McCusker *et al*. 2008, McCusker and Bentzen 2010a). These studies showed that the three wolffish species in the Atlantic are distinct from each other, with the Atlantic Wolffish more closely related to the Spotted Wolffish than to the Northern Wolffish.

[1] The vomer is a single, median bone that forms the inferior and posterior portion of the nasal septum.
[2] Palatine teeth are those that grow on the sides of the palate towards the centre of the jaw, rather than on the dental arch.

McCusker and Bentzen (2010b) used microsatellites and amplified fragment length polymorphism (AFLP) markers to study the population genetic structure of Atlantic Wolffish throughout its North Atlantic range, including six areas within Atlantic Canada (Table 1). Genetic differentiation was weak to non-existent across much of the trans-Atlantic range of the species; however, sample locations in Atlantic Canadian waters were significantly differentiated from all locations elsewhere across the species' range (Table 2). In addition, there were significant genetic differences among some locations within Atlantic Canada, particularly between the Grand Banks and other locations to the south and west (Table 2).

Table 1. Atlantic Wolffish sample details for microsatellite analysis in McCusker and Bentzen (2010b).

Label	Location	NAFO/ICES	Years	n
SS-02	Scotian Shelf	4VWX	2002	75
SS-04	Scotian Shelf	4VWX	2004	79
SG	Southern Gulf of St. Lawrence	4T, 4Vn	2002, 2004	64
NG	Northern Gulf of St. Lawrence	4RS	2004	63
SNF	Southern Newfoundland	3OP	2002, 2003	74
SGB	SE Grand Banks	3N	2001–2003	64
NGB	NE Grand Banks	3L	2001–2003	68
WG	West Greenland	1ABCDE	2004	83
EG	East Greenland	XIVb	2004	44
I-02	Iceland	Va	2002	96
I-04	Iceland	Va	2004	94
Sp	Spitsbergen	IIa2	2004	34
Bar	Barents Sea	IIa2	2004, 2005	111
NS	North Sea	IVb	2002, 2004	66
R-05	Rockall Bank	VIb2	2005	34
R-06	Rockall Bank	VIb2	2006	75

Table 2. Atlantic Wolffish F_{st} microsatellite analysis in McCusker and Bentzen (2010b). Location names correspond to Table 1.

	SS-02	SS-04	SG	NG	SNF	SGB	NGB	WG	EG	I-02	I-04	Sp	Bar	NS	R-05	R-06
SS-02		0.124	0.058	0.027	0.602	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SS-04	0.002		0.206	<0.001	0.609	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SG	0.001	0.002		<0.001	0.468	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
NG	0.005	0.006	0.011		<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SNF	-0.002	-0.001	0	0.007		0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SGB	0.002	0.007	0.011	0.007	0.003		0.404	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001
NGB	0.008	0.01	0.02	0.01	0.008	-0.001		0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
WG	0.019	0.02	0.031	0.016	0.019	0.007	0.004		0.819	0.248	0.1	0.277	0.074	0.002	<0.001	<0.001
EG	0.02	0.026	0.036	0.021	0.022	0.011	0.009	-0.001		0.504	0.732	0.463	0.738	0.307	<0.001	<0.001
I-02	0.016	0.02	0.03	0.015	0.018	0.007	0.007	0	-0.001		0.973	0.153	0.251	0.002	<0.001	<0.001
I-04	0.015	0.021	0.03	0.015	0.018	0.006	0.006	0.001	0	-0.002		0.181	0.348	0.109	0.001	<0.001
Sp	0.018	0.021	0.032	0.014	0.017	0.007	0.008	0	-0.002	0.003	0.003		0.487	0.303	0.008	<0.001
Bar	0.016	0.021	0.032	0.013	0.018	0.008	0.007	0.002	0	0.002	0.001	-0.002		0.098	<0.001	<0.001
NS	0.017	0.022	0.033	0.013	0.02	0.012	0.01	0.005	0.001	0.003	0.002	0	0		<0.001	<0.001
R-05	0.025	0.03	0.037	0.027	0.026	0.016	0.019	0.005	0.005	0.008	0.005	0.005	0.007	0.008		0.72
R-06	0.027	0.032	0.035	0.027	0.029	0.019	0.022	0.011	0.01	0.01	0.008	0.012	0.013	0.01	0	

Designatable Units

Although the results of McCusker and Bentzen (2010b) provide evidence for the existence of two or three genetically distinguishable populations of Atlantic Wolffish in Atlantic Canada, there is no evidence that these populations meet any of the COSEWIC 'significance' criteria needed for them to merit recognition as distinct DUs. For example, there is no evidence of distinct evolutionary lineages, adaptive genetic differences, distinctly different environments, or major spatial disjunctions that could be interpreted as evidence of significance. Accordingly, Atlantic Wolffish in Atlantic Canada are treated as a single designatable unit.

Special Significance

Atlantic Wolffish can occur in fairly dense concentrations and were of commercial interest in the 1990s. A small fishery for this species has persisted on the south coast of Newfoundland. Both Newfoundland and Maritimes Regions allow bycatch of this species to be landed. They can be filleted and sold fresh or frozen. The skin of these species can also be tanned and marketed. However, a large directed commercial fishery for these species is not currently possible due to the lack of sufficient concentrations. In 2008, their landings in Newfoundland totalled 7,743 kg for a landed value of $2,653 (Fisheries and Oceans Canada 2010). This species is popular with recreational divers.

This species is caught in mixed fisheries or as bycatch in many other fisheries such as Atlantic Halibut, *Hippoglossus hippoglossus*, Atlantic Cod, *Gadus morhua*, and Yellowtail Flounder, *Limanda ferruginea* (Kulka *et al.* 2007, Fisheries and Oceans Canada 2011). The largest catches are reported off the southern coast of Newfoundland and in Nova Scotia. In Newfoundland, landings have been recorded for all wolffish species combined. It is legal to land Atlantic Wolffish as this is not prohibited by the status of “Special Concern” on SARA Schedule 1.

The ecological role of the Atlantic Wolffish is difficult to assess owing to lack of available information. They feed on a variety of invertebrates and fish, and their larvae and juveniles are believed to be subject to predation by several species of fish.

DISTRIBUTION

Global Range

The Atlantic Wolffish is widely distributed on both sides of the North Atlantic and in the Arctic. In the northeastern Atlantic, it occurs from Iceland, the Faroe Islands, and the North Sea to the Barents Sea and the White Sea (Scott and Scott 1988) (Figure 2). In the western North Atlantic, it occurs nearly continuously from Davis Strait to Cape Hatteras (Kulka *et al.* 2007).

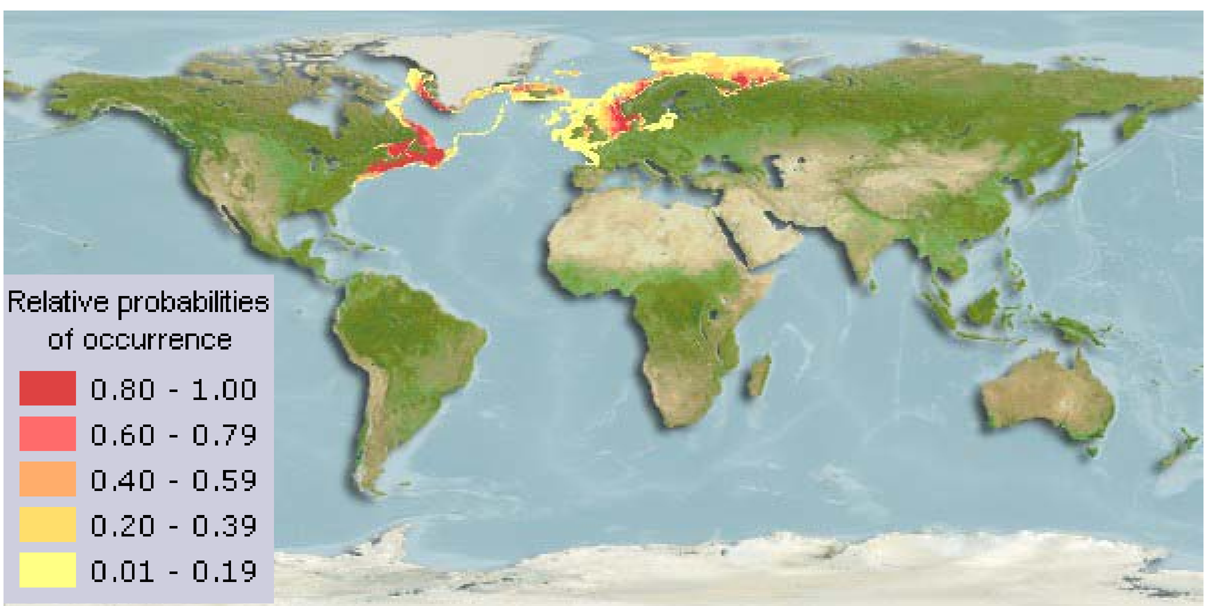


Figure 2. Potential global range of the Atlantic Wolffish. Source: Kaschner *et al.* (2008).

Search Effort

Table 3 presents the sources used to determine the distribution of the Atlantic Wolffish in Canadian waters. Fisheries and Oceans Canada (DFO) research trawl surveys provide the primary source of information (see “Sampling Effort and Methods”). However, these surveys do not cover shallow coastal waters (less than 40 m depth), where the Atlantic Wolffish occurs (Kulka *et al.* 2004). Similarly, some rocky sectors are not covered by the surveys due to the risk of damage to bottom trawl gear. Figure 3 shows the locations of the areas mentioned in this report, and Figure 4 shows the NAFO Divisions.

Table 3. Information sources used to determine the distribution of the Atlantic Wolffish in Canadian waters

Regions	Information source
Newfoundland & Labrador region (Labrador Shelf, northeastern and southern Newfoundland)	Department of Fisheries and Oceans Canada spring research trawl survey 1971-2010
	Department of Fisheries and Oceans Canada fall research trawl survey 1977-2009
Gulf of St. Lawrence	Department of Fisheries and Oceans Canada Northern Gulf research trawl survey 1971-2007
	Department of Fisheries and Oceans Canada Southern Gulf research trawl survey1978-2009
	Sentinel Fisheries Program 1996-2008
Maritimes region (Scotian Shelf, Bay of Fundy, Gulf of Maine)	Department of Fisheries and Oceans Canada Maritimes summer research trawl survey 1971-2009
Arctic Ocean	Department of Fisheries and Oceans Canada 0A and 0B surveys 1999-2008

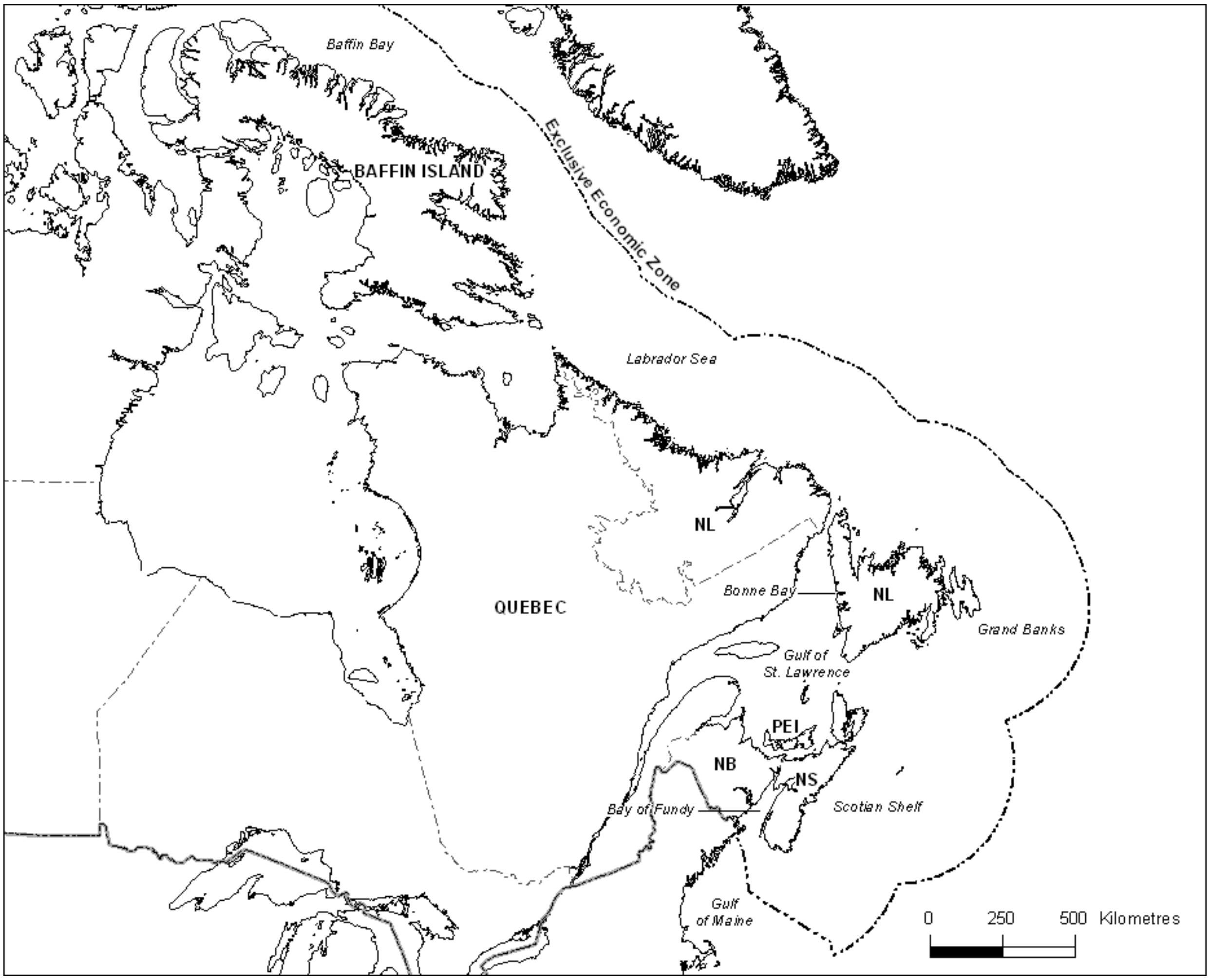


Figure 3. Map of geographic locations mentioned in this document.

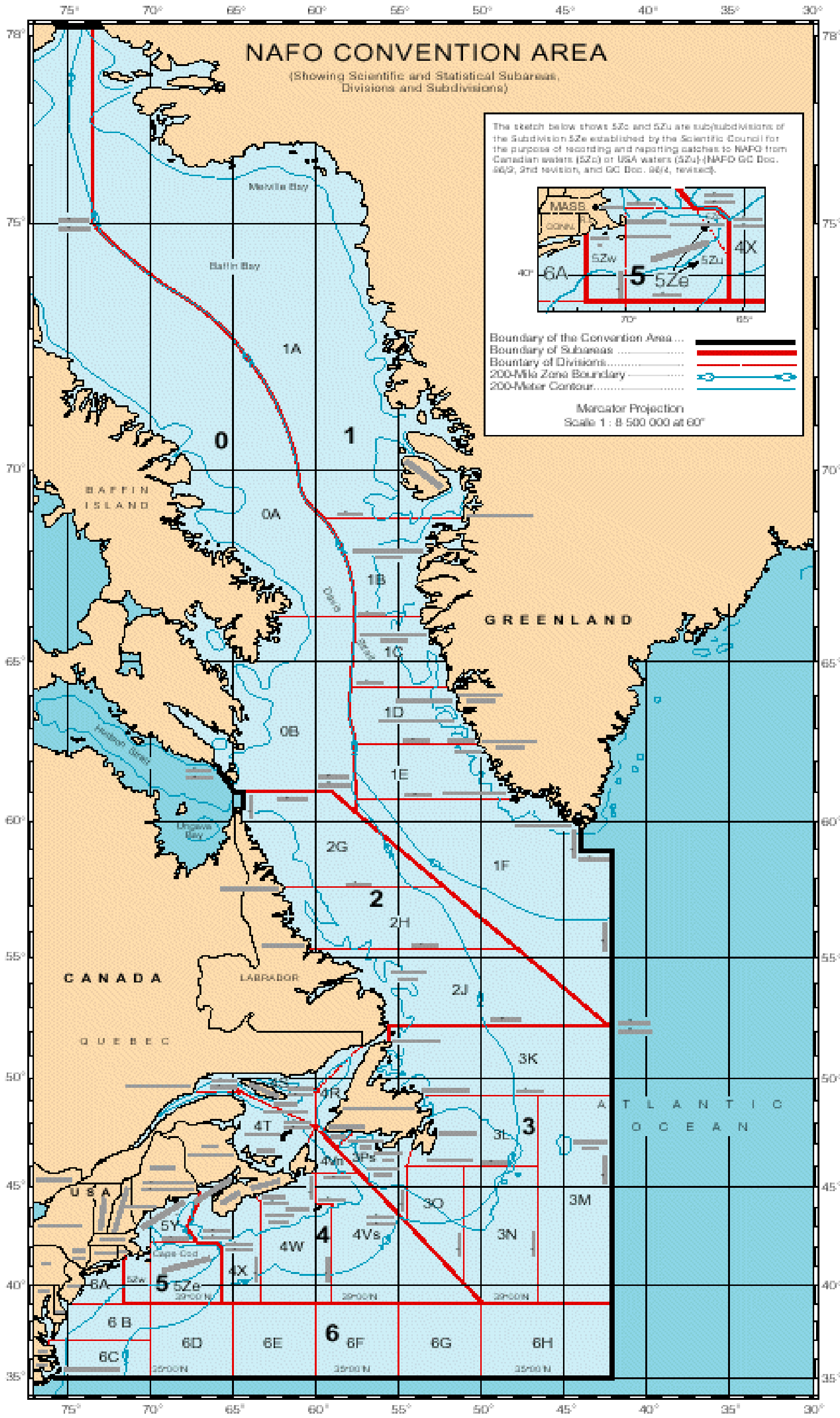


Figure 4. Northwest Atlantic Fisheries Organization (NAFO) Convention Areas.

In recent years, additional surveys have been conducted in collaboration with the fishing industry, such as the Groundfish Sentinel Program, which conducts mobile gear surveys (bottom trawl) and fixed gear surveys (longline and gill net). The Canadian At-Sea Fisheries Observer Program is also a source of information on the distribution of marine fish species and composition of commercial catches, but the data are not directly comparable to DFO's research trawl surveys and are therefore not included here. Other occasional studies covering small areas in coastal environments include an inventory of sites on the Gaspé Peninsula coast in Quebec (Laroque *et al*. 2008), and a study of fish communities in Bonne Bay, Newfoundland (Currie *et al*. 2009).

Canadian Range

In Canadian waters, the Atlantic Wolffish occurs off Baffin Island, in the Labrador Sea, off Newfoundland, in the Gulf of St. Lawrence, on the Scotian Shelf, in the Bay of Fundy and Gulf of Maine (Figure 5). This species is very rare in the northern part of its range (the Arctic). It is most abundant in the waters of the continental shelf, off northeastern Newfoundland, on the Labrador Shelf and in the Grand Banks off Newfoundland.

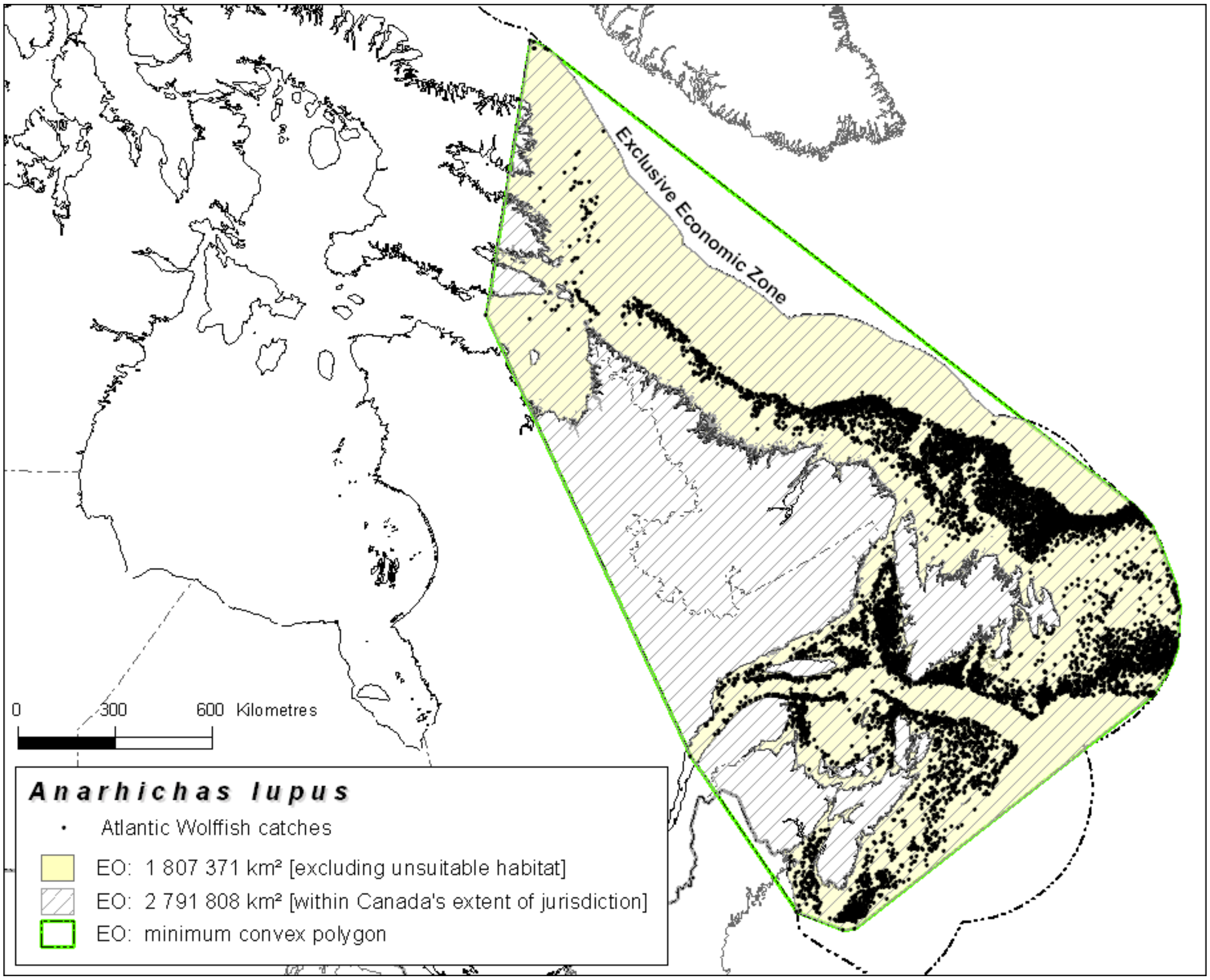


Figure 5. Extent of occurrence in Canada of Atlantic Wolffish based on Department of Fisheries and Oceans Canada research trawl survey catches.

In the Gulf of St. Lawrence, it occurs primarily in coastal areas and on the edge of deep channels and avoids the bottoms of deep channels (Dutil *et al*. 2010). The highest concentrations are off western Newfoundland (Dutil *et al*. 2010, Ouellet *et al*. 2010). It has also been reported in Bonne Bay in Gros Morne National Park in western Newfoundland (Currie *et al.* 2009), in the Saguenay–St. Lawrence Marine Park, and Forillon National Park in Quebec.

Extent of Occurrence and Area of Occupancy

Distribution indices were calculated by the COSEWIC Secretariat. The extent of occurrence was determined by calculating the area of the minimum convex polygon encompassing regions well covered by research trawl surveys in Canada, excluding major land masses (Figure 5). The extent of occurrence in the entire Canadian range is estimated at 2.792 million km^2. This area includes some major landmasses. If these are excluded, the figure is 1.807 million km^2.

An index of area of occupancy was calculated using kriging based on a 2-km × 2-km cell grid of the entire area inhabited by Atlantic Wolffish (Figure 6). This index for the entire Canadian range is estimated at 37,332 km^2.

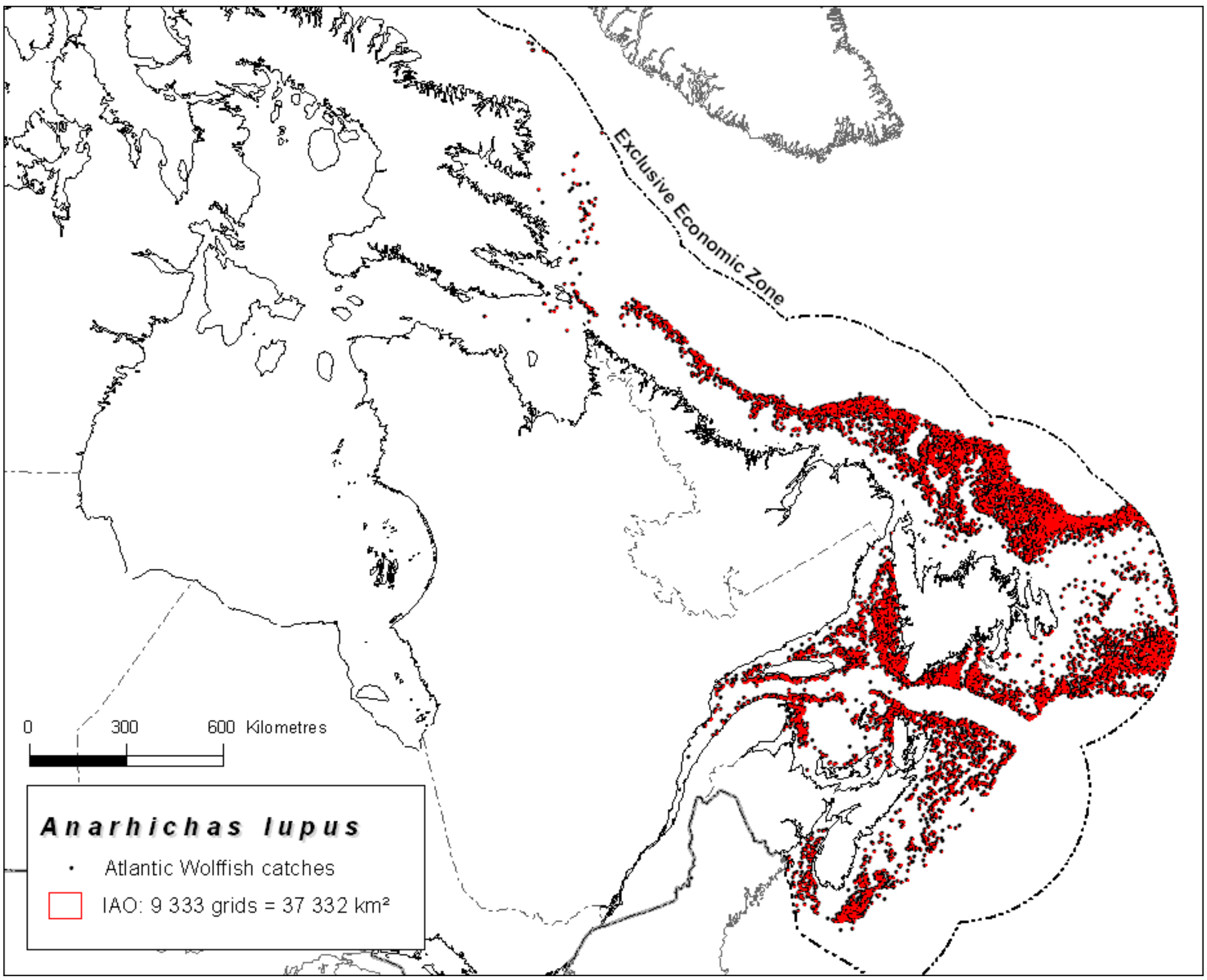


Figure 6. Index of area of occupancy in Canada of Atlantic Wolffish based on Department of Fisheries and Oceans Canada research trawl survey catches.

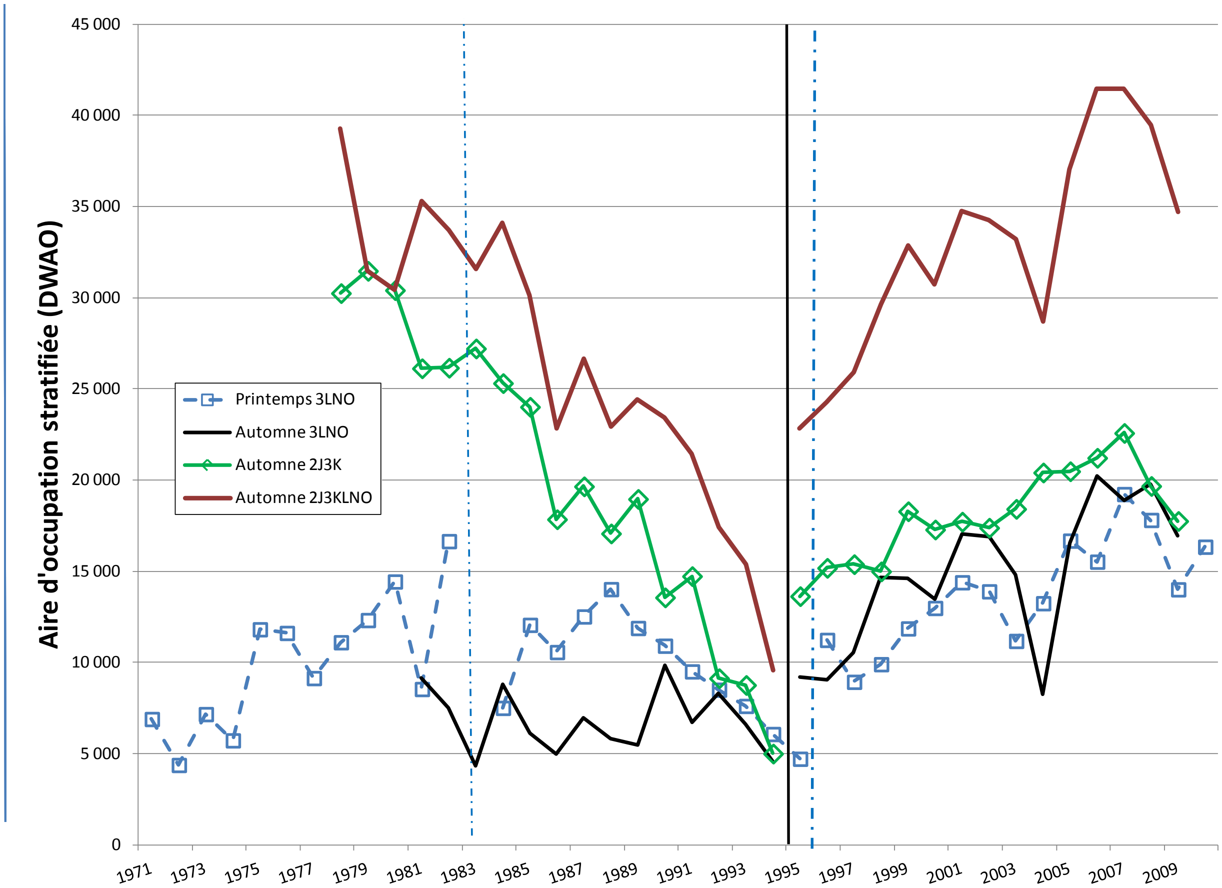
The design-weighted area of occupancy (DWAO) index was calculated by DFO as follows:

$$A_t = \sum_{i=1}^{n} A_i I \quad \text{where } I = 1 \text{ if } Y_i > 0, 0 \text{ otherwise}$$

where n is the number of tows in the survey, Y_i is the number of individuals caught in tow i, and A_i is the area of the stratum fished by tow i divided by the number of sites fished in the stratum.

Labrador Shelf and Newfoundland Grand Banks

The area of occupancy index for the Labrador Shelf (Div. 2J3K), which includes the majority of the population, was calculated for the Newfoundland and Labrador region (fall and spring research trawl surveys). This index declined from the 1980s to the mid-1990s, but has increased since 1995 (Figure 7, Simpson *et al.* 2011). On the Newfoundland Grand Banks (Div. 3LNO, see Figure 7), the index calculated in the spring and fall shows no decline in the 1980s and 1990s, and an increase since the mid-1990s. It is important to bear in mind that due to gear changes, different data series values and trends cannot be compared directly.

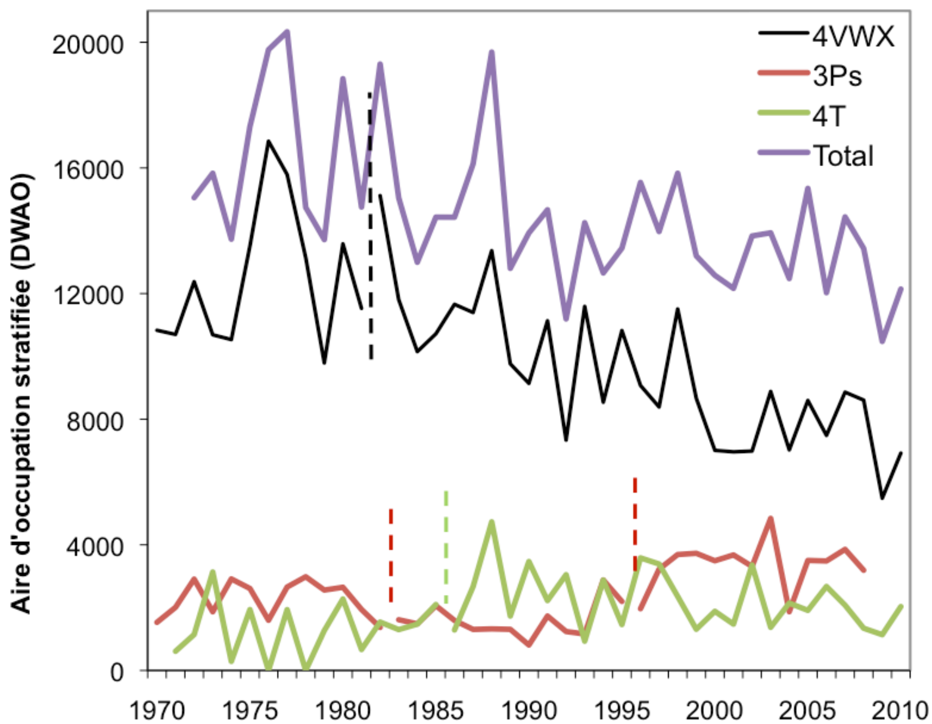


Translation of text in figure:
Aire d'occupation stratifiée (DWAO) = Stratified area of occupancy (DWAO)
Printemps 3LNO = Spring 3LNO
Automne 3LNO = Fall 3LNO
Automne 2J3K = Fall 2J3K
Automne 2J3KLNO = Fall 2J3KLNO

Figure 7. Index of area of occupancy (DWAO) of the Atlantic Wolffish for the Newfoundland Grand Banks (3LNO) and the Labrador Sea (2J3K) based on Newfoundland spring and fall research trawl surveys. The vertical lines indicate a fishing gear change (blue line for the spring, black for fall). During fall, only Division 3L was surveyed prior to 1990. From Simpson *et al.* (2011).

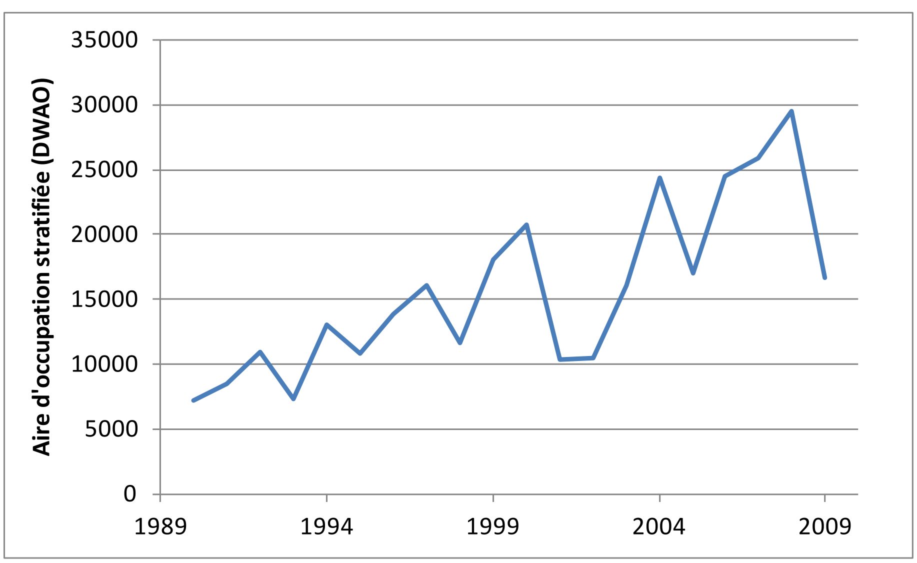
Scotian Shelf, Southern Newfoundland and Gulf of St. Lawrence

The area of occupancy index was calculated from Maritimes summer research trawl surveys (Simon *et al.* 2011). There was a general downward trend in the Scotian Shelf (Div. 4VWX) since the 1970s (Figure 8), falling from close to 17 000 km^2 in 1976 to 5,484 km^2 in 2009. In 2010, the value was 6,919 km^2. In southern Newfoundland waters (Div. 3Ps) and the Southern Gulf of St. Lawrence (Div. 4T), the index shows some variation without trends since 1971 (Figure 8). In contrast, the Northern Gulf of St. Lawrence has shown an increasing trend in DWAO since the early 1990s (Figure 9). The index value went from 7,216 km^2 in 1990 to 16,662 km^2 in 2009.



Translation of text in figure:
Aire d'occupation stratifiée (DWAO) = Stratified area of occupancy (DWAO)

Figure 8. Index of area of occupancy (DWAO) of Atlantic Wolffish for the Scotian Shelf (NAFO Divisions 4VWX), Southern Newfoundland (3Ps), and the Southern Gulf (4T). The vertical lines indicate a fishing gear change. From Simon *et al.* (2011).



Translation of text in figure:
Aire d'occupation stratifiée (DWAO) = Stratified area of occupancy (DWAO)

Figure 9. Index of area of occupancy (DWAO) of Atlantic Wolffish for the Gulf of St Lawrence (NAFO Division 4RST). From Bourdage and Ouellet (in prep.).

HABITAT

Habitat Requirements

Habitat associations of Atlantic Wolffish in terms of temperature, depth and bottom type were described by Kulka *et al.* (2004) and Simpson *et al.* (2011). This species occupies different habitats depending on its life stage: the eggs are deposited on the bottom, the larvae are pelagic, and the juveniles and adults inhabit near-bottom waters. In near-shore waters, the eggs are deposited in crevices on rocky bottoms (Keats *et al.* 1985). The larvae are pelagic until they reach between 30 and 35 mm (Wiseman 1997 *in* Kulka *et al*. 2007). Juvenile Spotted Wolffish have been observed to use shelters (Lachance *et al.* 2010), and this may be the case with Atlantic Wolffish too.

Juveniles and adults occur on the continental shelf on rocky or sandy bottoms. From diver observations, Atlantic Wolffish has not been observed on soft substrate such as clay or mud in inshore water and they appear to depend on boulders or caves for spawning (Kulka *et al.* 2004).

The fish are found from near-shore to depths of 918 m (Kulka *et al.* 2004, 2007). In Newfoundland waters, abundance peaks at 250 m year-round (Kulka *et al.* 2004). Of the three wolffish species, only the Atlantic Wolffish occurs frequently in depths less than 100 m. On the Scotian Shelf and Grand Banks off Newfoundland and in the Gulf of St. Lawrence, they typically occupy depths of less than 150 m. On the Scotian Shelf, they are commonly observed at depths between 100 and 350 m (McRuer *et al.* 2000).

Temperature is believed to be the primary factor determining habitat selection in this species (Kulka *et al.* 2004). They are most abundant in shelters located below the thermocline and the influence of tidal and coastal currents (Dutil *et al.* 2010). Other types of structured bottoms could also provide refuge, such as bottoms covered with dense vegetation or soft bottoms with considerable relief.

From Newfoundland research surveys, the highest densities of Atlantic Wolffish are at temperatures of 1.5°C to 4°C (Kulka *et al.* 2004). On the Scotian Shelf, the temperature range where the species occurs is 1-9 ^{o}C (Simon *et al.* 2011), although the preferred range is similar to that observed further north. Divers do not observe Atlantic Wolffish at temperatures above 10°C and the fish can tolerate temperatures below 0°C (Kulka *et al.* 2004). On the Scotian Shelf and likely across its range, they occur in waters with salinity between 32 and 34 ‰ (Albikovskaya 1982). Kulka *et al.* (2004) noted absence of wolffish in waters with low salinity based on diving observations.

Habitat Trends

An episode of particularly cold water temperatures was recorded in the late 1980s and early 1990s (Colbourne *et al.* 1997). Figure 10 shows Arctic Oscillation (AO) and North Atlantic Oscillation (NAO) from 1950 to 2010 (Yashayaev and Greenan 2011). A positive index is associated with colder than usual conditions in the northern Labrador Sea. The index for the end of 1980 to mid-1990 showed higher values since 1950. Although the latter part of this cooling period coincided with the rapid contraction in range of wolffish species (Kulka *et al.* 2004), contractions in area of occupancy began well before then (Fig. 7). Shallower waters may have been abandoned in favour of deeper, warmer waters, though this is conjecture.

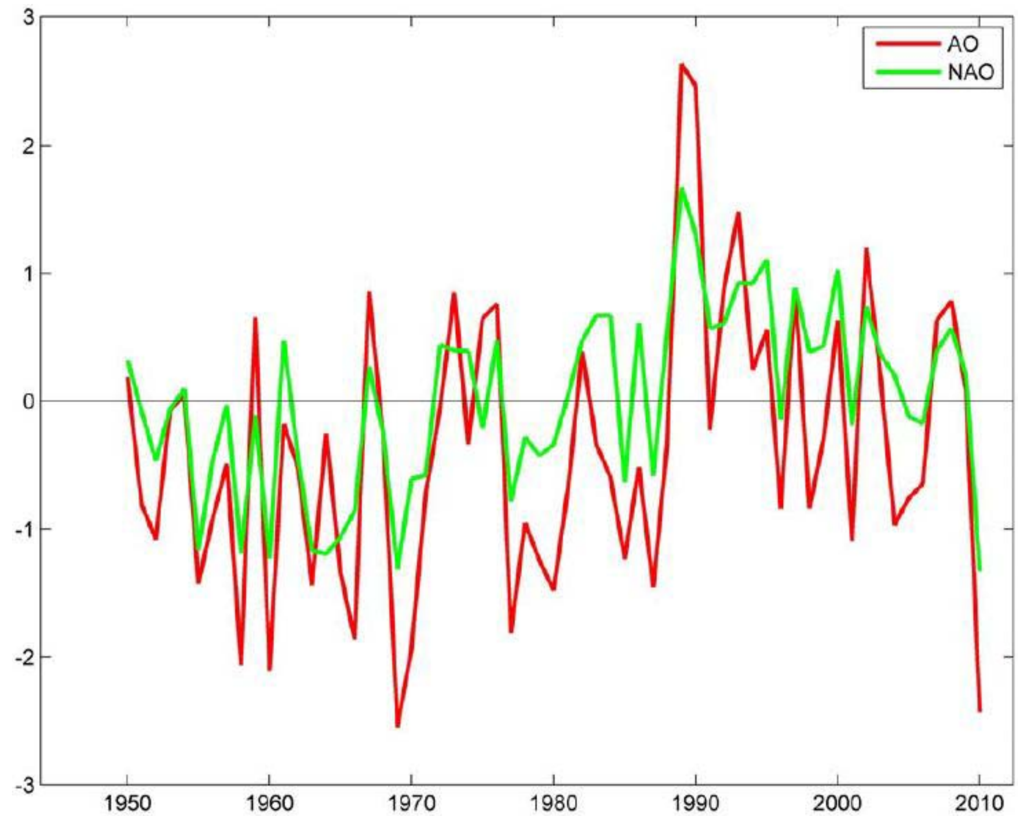


Figure 10. Winter Arctic Oscillation (AO) and North Atlantic Oscillation (NAO) indices with 1950-2000 as base period. Data are for the Jan-Mar winter period. Source: Yashayaev and Greenan (2011).

Long-term future trends in water temperature are uncertain. Global climate change will likely affect the habitat and distribution of Atlantic Wolffish. The increase in temperature in the northwest Atlantic may result in a northward shift of several marine fish species, including Atlantic Wolffish (Gucinski *et al.* 1990), as has been documented in many species in the northeastern Atlantic (Perry *et al.* 2005).

BIOLOGY

More is known about the biology of the Atlantic Wolffish than of the Spotted and Northern Wolffish, mainly because of its coastal distribution, which has also facilitated dive observations. Key studies come from Templeman (1984, 1985, 1986), McRuer *et al*. (2000), and Simpson and Kulka (2002). There are ongoing studies in Quebec (see Dutil *et al*. 2010, Lachance *et al*. 2010, Laroque *et al.* 2008). Laboratory studies have been done by Johannessen *et al.* (1993) and Lachance *et al.* (2010). Finally, a summary of the known aspects of the biology of wolffish was presented by Kulka *et al*. (2007).

Life Cycle and Reproduction

In the waters off Newfoundland and Labrador, Templeman (1986) determined that the size at which 50% of females reach sexual maturity (L50) is 51.4 cm in the northern part of the range (Labrador Sea and eastern Newfoundland, NAFO Divisions 2GH+3K) and 68.2 cm in the southern part of the range (southern Grand Banks Div. 3NOPs). The difference could be related to variation in water temperature, which affects growth.

According to a growth curve constructed using the Gompertz function with individuals from the Gulf of Maine (Nelson and Ross 1992), the age at sexual maturity (A50) is approximately 8 years in the southern part of the range. Curves based on von Bertalanffy equations by McRuer *et al.* (2000) suggest the age at sexual maturity is between 10 and 15 years in the Scotian Shelf, based on data from Greenland by Beese and Kändler (1969) and from the Gulf of Maine by Nelson and Ross (1992). Some of the population parameters assessed by Templeman were based on specimens caught between 1946 and 1967, and they may not apply to recent populations.

A recent examination of the Canadian RV database on the Scotian Shelf revealed that, from 48 individuals of Atlantic Wolffish, all individuals less than 24 cm were immature, while all fish greater than 38 cm were mature, based on visual inspection of the reproductive organs (Simon *et al.* 2011). However, the low number of fish makes length at 50% maturity imprecise. Moreover some uncertainty about maturity staging of wolffish may have underestimated the length at first maturity (Simon *et al.* 2011).

Simon *et al.* (2011) developed a logistic maturity ogive for female Atlantic Wolffish based on the US NMFS surveys. They suggested a length at maturity of approximately 35 cm, which is similar to the Scotian Shelf estimates reported above. Given the uncertainty in estimating maturity of wolffish, Simon *et al.* (2011) adopted the same length of 50% maturity as McRuer *et al.* (2000) and Simpson and Kulka (2002), which is based on work by Templeman (1986) reported above, namely 51 cm.

Atlantic Wolffish are typically solitary except during pair formation in the spawning season. They have internal fertilization (Johannessen *et al.* 1993) and spawning can occur in shallow water (<150 m) in crevices and rock refuges, and also in deeper waters (150 to 200 m) (Saemundsson 1949 *in* McRuer *et al.* 2000). Little is known about spawning activities in deep waters. Off the coast of Newfoundland, spawning is believed to occur in the fall (Templeman 1984).

Atlantic Wolffish are iteroparous, with females producing a small number of eggs relative to other large-bodied teleosts. In one study, fecundity increased exponentially with fish length: the average number of eggs was 2,440 at 40 cm and 35,320 at 120 cm (Templeman 1986). Egg survival is probably high due to their large size (5.5 - 6.5 mm according to Bigelow and Schroeder 1953 *in* McRuer *et al.* 2000). In addition, the eggs adhere to the substrate and are guarded by the male until they hatch, which increases their survival (Keats *et al.* 1985).

Laboratory studies have shown that Atlantic Wolffish hybridize with Spotted Wolffish, a closely related species (Gaudreau 2009). However, there is no genetic evidence of hybridization in the wild (see McCusker and Bentzen 2008). The existence of hybrids is possible given that the ranges of the two species overlap, and this has been proposed by Luhmann (1954) on the basis of morphological characters.

The incubation period of the Atlantic Wolffish is unknown. However, in the Spotted Wolffish, the species most closely related to the Atlantic Wolffish, hatching is believed to occur after 800 to 1000 degree-days (Falk-Petersen and Hansen 2003). Newly hatched larvae are over 20 mm in size (Wiseman 1997 *in* Kulka *et al.* 2007) and remain close to the bottom until the yolk sac is absorbed. They then move to near-surface waters and drift with the current, but generally do not move far from where they were hatched (McRuer *et al.* 2000).

Growth is rapid in the initial years of life, but then slows considerably when the fish divert energy toward gonad development (Nelson and Ross 1992). In the Gulf of Maine, the average size of fish captured ranged from 4.7 cm at age 0 to 98.0 cm at age 22 (maximum age recorded in the study) (Nelson and Ross 1992). The maximum size observed by Templeman (1986) was 127 cm in males and 121 cm in females. According to Barsukov (*in* McRuer *et al.* 2000), the Atlantic Wolffish can reach up to 152 cm.

Generation time is defined by COSEWIC as the average age of parents of the current cohort:

$$G = A + 1/M,$$

where A is age at which 50% of females are mature and M is the instantaneous rate of natural mortality. From McRuer *et al.* (2002) data, a minimum A of 10 years would be calculated. An assumed M value for a fish that can reach a maximum age around 22 years would generally be 0.2. Generation time would then be approximately 15 years.

Physiology and Adaptability

Atlantic Wolffish have been found in a wide range of water temperatures (from -1.5°C to 10°C) (Albikovskaya 1982, Beese and Kandler 1969 *in* Kulka *et al.* 2007), with concentrations in the middle of that range (Kulka *et al.* 2004). Dive observations suggest they do not tolerate brackish or fresh water (Kulka *et al.* 2004).

Dispersal and Migration

Adult Atlantic Wolffish do not move far. Templeman (1984) reported the results of a tagging study conducted between 1962 and 1966. A total of 398 Atlantic Wolffish were tagged and 20 individuals were recaptured. Most individuals were recaptured within a short distance of the original tagging site (approximately 8 km on average, all wolffish species combined). Short migrations have also been observed in the eastern Atlantic (Hansen 1958 and Jónsson 1982 *in* Templeman 1984) and off West Greenland (Riget and Messtorff 1988). However, migrations of several hundred km have been observed in the studies reported. Atlantic Wolffish can conduct short (few km) seasonal migrations between offshore waters and shallow waters (<120 m deep) for spawning (Nelson and Ross 1992). Eggs cannot disperse because they are deposited on the bottom. However, Kulka *et al*. (2004) showed that larvae and small juveniles were widespread in the upper water column, allowing for dispersal at that stage.

Interspecific Interactions

Templeman (1985) showed that Atlantic Wolffish feed primarily on invertebrates (85% of diet by volume) and, to a lesser extent, fish (15%). Most invertebrates consumed are whelks, sea urchins, hermit crabs, other crabs and scallops. Redfish was the main fish species eaten, though fish were a negligible part of the diet in the Maritimes Region (Simon *et al.* 2010). Recent data also indicate the importance of invertebrates (mostly crabs and echinoderms) in the diet (Simpson *et al.* 2011). Smaller Atlantic Wolffish consume a large proportion of invertebrates and a lower proportion of fish (Templeman 1985). As they mature, a higher proportion of fish are eaten.

There is little information on the predators of Atlantic Wolffish. However, juveniles have been found in the stomachs of Harbour Seals, *Phoca vitulina* (Andersen *et al.* 2004). In addition, Mikkelsen *et al*. (2002) found that the Atlantic Wolffish is an important prey species of Grey Seals, *Halichoerus gripus*, in the waters of the Faroe Islands. Although wolffishes generally account for only a small fraction of the diet of seals, it is estimated that four seal species (Harp Seal (*Phagophilus groenlandicus*), Hooded Seal (*Crystophora cristata*), Grey Seal and Harbour Seal) consumed close to 6000 t of wolffishes in 1996 in the Canadian Atlantic (Hammill and Stenson 2000). The Harp Seal is the most significant predator because of its high abundance. Wolffishes have also been found in the stomachs of Atlantic Cod (Saemundsson 1949 *in* McRuer *et al*. 2000, Simon *et al.* 2011), Atlantic Halibut (*Hippoglossus hippoglossus*) (Chabot pers. comm. 2010, Simon *et al.* 2011), Sea Raven (*Hemitripterus americanus*), Spiny Dogfish (*Squalus acanthius*), Longhorn Sculpin (*Myoxocephalus scorpius*), White Hake (*Urophycis tenuis*), and Haddock (Simon *et al.* 2011).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Changes in Atlantic Wolffish abundance were assessed using the results of DFO research trawl surveys, which assess the abundance of several groundfish and invertebrate species (Table 4). It should be noted throughout that there are regional differences in gear as well as changes over time in some areas, which preclude direct comparisons.

Table 4. Research surveys used in this report to determine Atlantic Wolffish abundance trends.

Survey	NAFO Division	Year	Gear
Department of Fisheries and Oceans research trawl surveys			
Summer survey (Maritimes)	4V, 4W and 4X	1970–1981	Yankee 36 trawl
		1982 to present	Western IIA trawl
Northern Gulf survey	4RS and deep areas of 4T	1990–2003	URI 81'/114 trawl
		2004 to present	Campelen trawl
Southern Gulf survey	4T	1971–1985	Yankee 41.5 trawl
		1986 to present	Western IIA trawl
Spring surveys (Newfoundland & Labrador)	3N, 3O, 3Ps and 3L	1971–1982	Yankee 41.5 trawl
		1983–1995	Engel 45 trawl
		1996 to present	Campelen trawl
Fall surveys (Newfoundland & Labrador)	2G, 2H, 2J, 3N, 3O, 3K and 3L	1977–1994	Engel 45 trawl
		1995 to present	Campelen trawl

The research trawl surveys, some of which have been conducted for over 40 years, use a stratified random sampling protocol. Collectively, they cover a large range of demersal species in Canada (and even some international waters in 3LNO). Essentially, only coastal areas or regions at the northern limit of the species' range (NAFO Subarea 0) are not covered or only sparsely by the research surveys. Coverage is weaker in northern regions, with surveys conducted by DFO in Baffin Bay (NAFO Subarea 0A) in 1999, 2001, 2004, 2006, and 2008 and in Davis Strait (Subarea 0B) in 2000 and 2001.

The results of the surveys are extrapolated to the entire area covered and presented in the form of "minimum trawlable abundance" estimates. These estimates underestimate actual abundance because some areas where wolffish live are not surveyed (near-shore, northern areas, and rocky substrates), and the fishing gear does not capture all fish within the trawl footprint. Thus, some fish may avoid or escape from the trawl or may occur in areas unreachable by the trawl (e.g., crevices in rocks).

DFO has conducted spring and fall research trawl surveys on the Grand Banks, off Newfoundland and in the Labrador Sea since the early 1970s. There have been vessel and gear changes (Table 4), and the area covered has varied in some locations. Similarly, some areas have not been surveyed in some years. Table 5 shows the NAFO subdivisions covered by surveys from 1971 to 2010.

Table 5. DFO-NL research trawl surveys were conducted in spring on the Grand Banks (Div. 3LNOPs; refer to Fig. 4) and Fall/Winter on the Labrador Shelf to Grand Banks (Div. 2GHJ3KLNO). Dark boxes indicate a survey was undertaken.

Year	NAFO Division										
	Fall research trawl survey							Spring research trawl survey			
	2G	2H	2J	3K	3L	3N	3O	3L	3N	3O	3Ps
1971								■	■	■	
1972								■	■		■
1973								■	■	■	■
1974								■	■		■
1975								■	■	■	■
1976								■	■	■	■
1977			■	■				■	■	■	■
1978	■	■	■	■				■	■	■	■
1979	■	■	■	■				■	■	■	■
1980			■	■				■	■	■	■
1981	■	■	■	■	■			■	■	■	■
1982			■	■	■			■	■	■	■
1983			■	■	■						■
1984			■	■	■			■	■	■	■
1985			■	■	■			■	■	■	■
1986			■	■	■			■	■	■	■
1987	■	■	■	■	■			■	■	■	■
1988	■	■	■	■	■			■	■	■	■
1989			■	■	■			■	■	■	■
1990			■	■	■	■	■	■	■	■	■
1991	■	■	■	■	■	■	■	■	■	■	■
1992			■	■	■	■	■	■	■	■	■
1993			■	■	■	■	■	■	■	■	■
1994			■	■	■	■	■	■	■	■	■
1995			■	■	■	■	■	■	■	■	■
1996	■	■	■	■	■	■	■	■	■	■	■

Year	NAFO Division										
	Fall research trawl survey							Spring research trawl survey			
	2G	2H	2J	3K	3L	3N	3O	3L	3N	3O	3Ps
1997											
1998											
1999											
2000											
2001											
2002											
2003											
2004											
2005											
2006											
2007											
2008											
2009											
2010											

Figure 11 presents the size frequencies of catches in the Newfoundland fall research trawl surveys from 1981-1994 and 1995-2010. This shows that small sizes (under 20 cm) have been caught to a larger extent since the gear change in 1995 to Campelen from Engel.

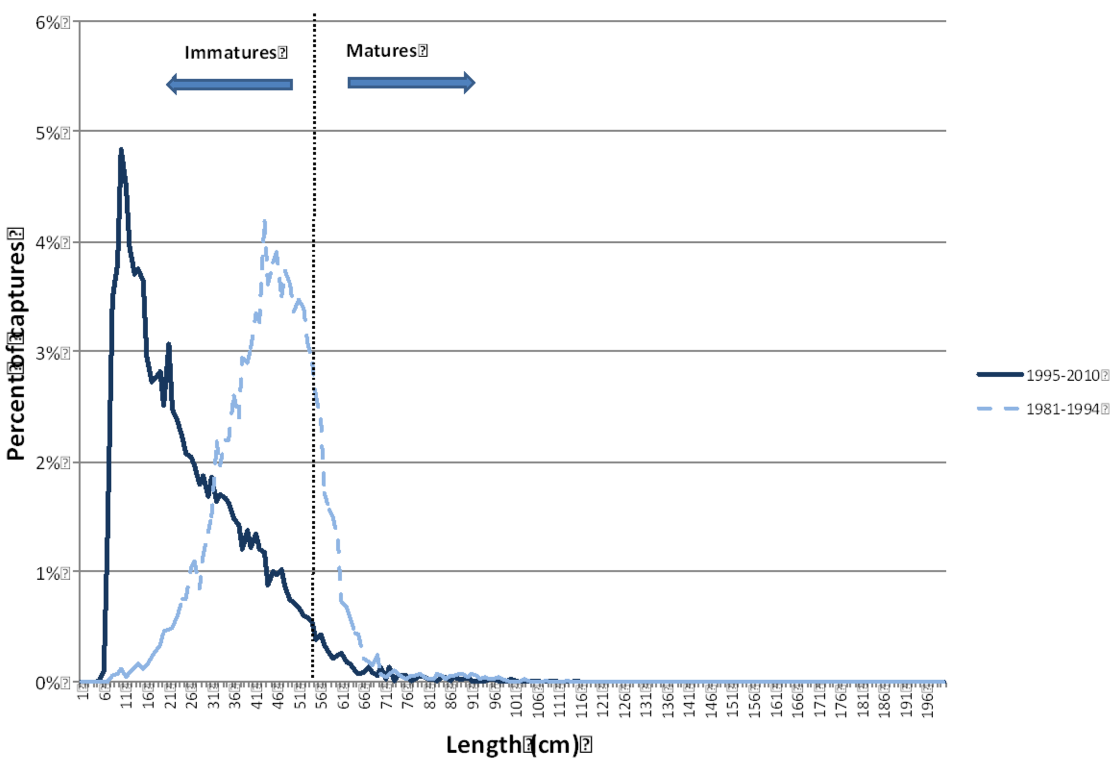


Figure 11. Length frequency of Atlantic Wolffish based on raw catch data from the Newfoundland and Labrador fall research trawl surveys from 1981 to 1994 and 1995 to 2010. Individuals ≥ 51 cm were considered mature. Source: Data provided by Mark Simpson, pers. comm. 2010 and 2012.

Research trawl surveys began in 1970 in the Scotian Shelf and Bay of Fundy (NAFO Divisions 4VWX, Maritimes summer research trawl surveys). There was a gear change in 1982, when the Yankee 36 was replaced by the Western IIa trawl, which may affect catch rates.

Two research trawl surveys are done in the Gulf of St. Lawrence. One covers Divisions 4R and 4S including the Esquiman Channel in Division 4T (northern Gulf research trawl survey) and the other is in Division 4T (southern Gulf research trawl survey).

For the northern Gulf research trawl survey, the vessel CCGS *Alfred Needler* equipped with a URI 81'/114' bottom trawl was used from 1990 to 2003 and then replaced by the CCGS *Teleost* equipped with a shrimp trawl. In the southern Gulf, research trawl surveys have been conducted in September since 1971. A gear change from the Yankee 36 to the Western IIA occurred in 1985.

Abundance

Abundance can be estimated as stratified random estimates from research trawl survey data (Table 6). The number of Atlantic Wolffish individuals in Canadian waters is estimated to exceed 49 million. This is a conservative estimate, given that the surveys do not catch all individuals in the trawl area, some areas are not covered (e.g., rocky bottoms and coastal zones) and estimates are not available in some low-abundance regions, such as the Canadian Arctic. The number of mature individuals is estimated to exceed 5 million (Table 6).

Table 6. Current minimum trawlable abundance estimates of Atlantic Wolffish (total and mature populations) in each NAFO Division based on DFO research trawl surveys. Values are not comparable between surveys due to different catchability of the different gears used. Individuals > 51 cm total length are considered mature, except those from the Maritimes summer survey (> 67 cm).

NAFO Division	Total Abundance[1] (millions)	Abundance of Mature Individuals (millions)	Survey
2G	2.95[2] [1999]	0.55	Newfoundland & Labrador fall survey
2H	6.69[2] [2008]	1.24	
2J	10.92[2] [2009]	2.02	
3K	3.54[2] [2009]	0.66	
3L	9.38[2] [2009]	1.74	
3N	3.53[2] [2009]	0.65	
3O	3.80[2] [2009]	0.70	
Subtotal	40.81	4.01	
3Ps	3.17[2] [2010]	0.59	Newfoundland & Labrador spring survey
4VWX	1.62[3] [2010]	0.02	Maritimes summer survey
4T	0.07[4] [2010]	Very low	Southern Gulf survey (September)
Subtotal	4.86	0.61	

NAFO Division	Total Abundance[1] (millions)	Abundance of Mature Individuals (millions)	Survey
4RS	3.98[5] [2010]	0.45	Northern Gulf survey (Summer)
Total	**>49.62**	**>5.07**	

[1] The year of the most recent assessment is in square brackets.
[2] Simpson *et al.* 2011.
[3] Simon *et al.* 2011
[4] Hugues Benoit, pers. comm. 2012
[5] Bourdage and Ouellet, in prep.

Fluctuations and Trends

Labrador Shelf and Grand Banks

Maximum abundance of this species in Canada is concentrated in this region (2J3KLNO). Abundance indices generally declined from the 1970s to the mid-1990s. Since then, there has been a strong increase.

The relative abundance index estimated from the fall research trawl survey fell from 1978 to 1994 in NAFO Divisions 2J3K (southern Labrador Sea and eastern Newfoundland) (Table 7, Figure 12). However, since 1995, an upward trend has been observed. The gear changed in 1995, which prevents the two series (1977 to 1995 and 1996 to 2009) from being compared directly. Figure 13 presents the total abundance of NAFO Divisions 2J3KL, which have been systematically surveyed since 1981. A marked decrease in the abundance indices occurred, from 11.76 million in 1981 to 0.98 million in 1994. The rates of decrease were 91% and 96% from 1981 to 1994 for total and mature populations respectively (Table 8, Figure 14). A marked increase occurred from 1995 to 2007 (from 10.37 to 42.51 million), and the abundance index decreased afterward (23.83 million in 2009). The rate of increase is 150% and 294% since 1995 for total and adult populations, respectively (Table 8), primarily in NAFO Divisions 2J and 3L (Figure 12). In the other divisions, the indices varied, but without clear trends. There has also been an increase in the adult population since 1996 (Figures 13 and 14).

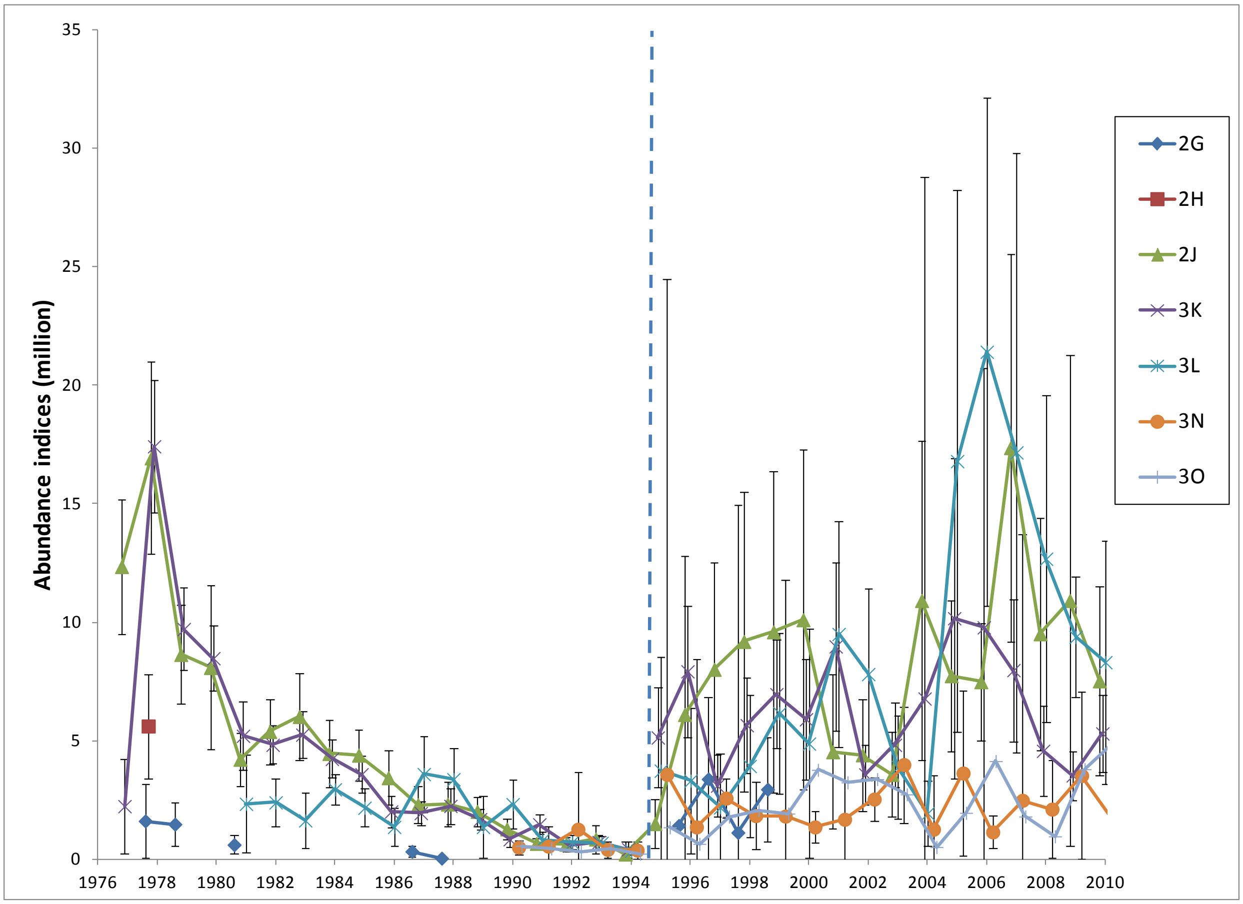
Table 7. Atlantic Wolffish abundance indices for the Grand Banks and southern Labrador Shelf based on Newfoundland & Labrador fall research trawl survey data. (Totals for 3LNO are presented for the spring survey in Table 9.)

YEAR	ABUNDANCE INDEX (MILLIONS)*								
	2G	2H	2J	3K	3L	3N	3O	2J3KL	Mature 2J3KL**
1977			12.35	2.24					
1978	1.61	5.62	16.94	17.42					
1979	1.48	4.77	8.64	9.71					
1980			8.09	8.48					
1981	0.61	2.42	4.21	5.21	2.34			11.76	4.28
1982			5.39	4.83	2.40			12.61	3.67
1983			6.02	5.26	1.64			12.91	4.77
1984			4.46	4.23	2.95			11.64	4.15
1985			4.39	3.58	2.17			10.14	2.07
1986			3.44	2.01	1.36			6.81	1.49
1987	0.33	0.40	2.30	1.95	3.59			7.84	1.12
1988	0.04	0.92	2.32	2.25	3.37			7.94	1.75
1989			2.01	1.69	1.36			5.06	0.88
1990			1.28	0.84	2.32	0.50	0.56	4.44	0.69
1991		0.13	0.67	1.47	0.81	0.55	0.45	2.94	0.57
1992			0.63	0.57	0.71	1.26	0.31	1.91	0.24
1993			0.85	0.72	0.69	0.41	0.45	2.26	0.33
1994			0.22	0.42	0.35	0.38	0.23	0.98	0.22
Survey Gear Change									
1995			1.50	5.13	3.73	3.58	1.35	10.37	0.51
1996	1.42	1.69	6.11	7.93	3.31	1.36	0.65	17.35	0.24
1997	3.38	2.26	8.01	3.10	2.18	2.58	1.80	13.30	0.82
1998	1.13	5.65	9.19	5.65	3.93	1.84	2.07	18.77	1.21
1999	2.95	4.10	9.59	6.96	6.16	1.82	1.93	22.72	1.21
2000			10.10	5.90	4.88	1.36	3.77	20.88	1.37
2001		0.73	4.53	8.98	9.50	1.68	3.24	23.01	1.98
2002			4.40	3.58	7.81	2.54	3.38	15.79	0.00
2003			3.58	4.82	3.89	3.99	2.74	12.29	1.07
2004		10.66	10.92	6.78	1.94	1.26	0.51	19.63	0.30
2005			7.74	10.17	16.80	3.63	1.96	34.70	1.84
2006		11.40	7.49	9.78	21.41	1.15	4.14	38.68	1.50
2007			17.37	7.98	17.17	2.48	1.80	42.51	1.92
2008		6.69	9.51	4.57	12.68	2.11	0.96	26.76	2.02
2009			10.92	3.54	9.38	3.53	3.80	23.83	2.56

*Blanks indicate that no survey was conducted.
** Abundance of mature is based on the proportion of fish > 51 cm in Newfoundland & Labrador fall research trawl survey catches each year

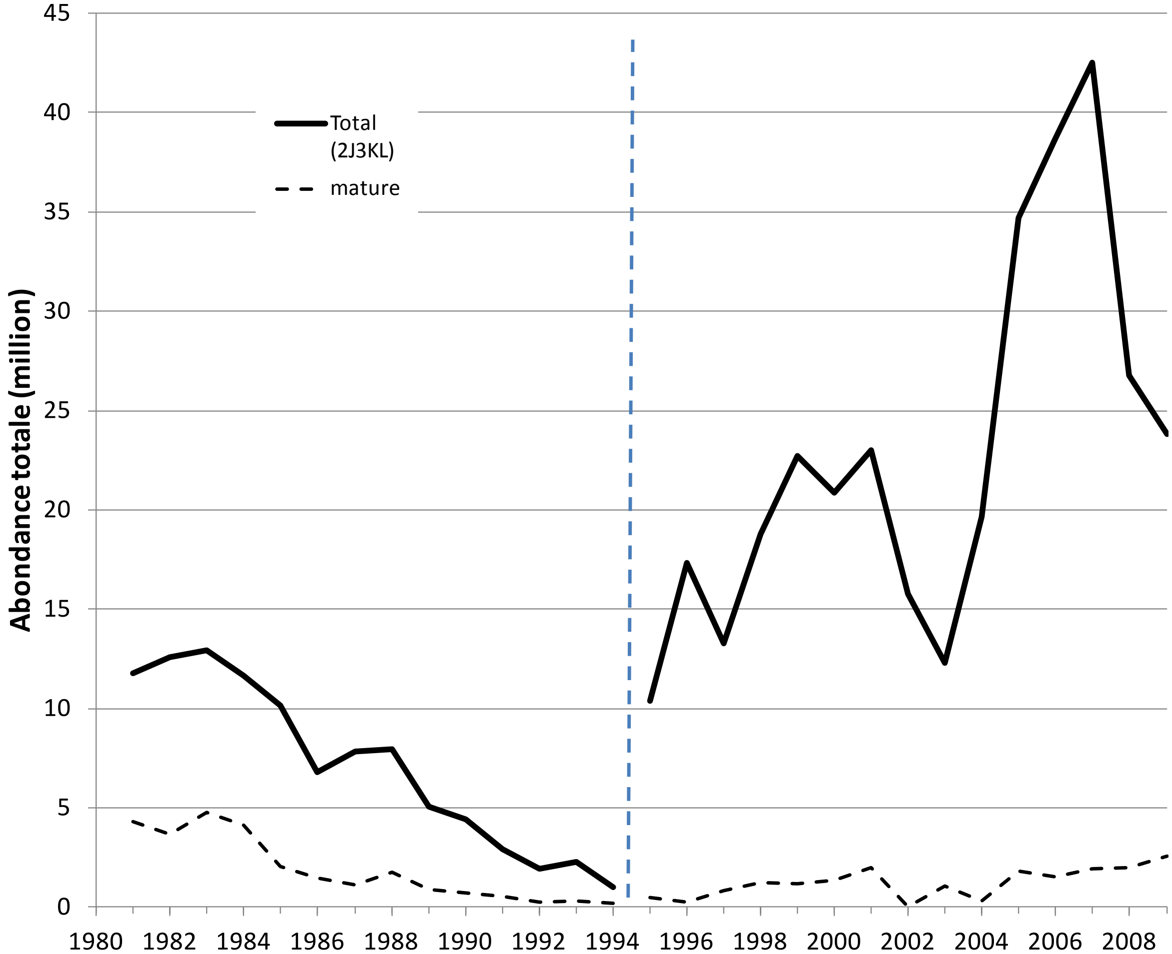
Table 8. Trends in Atlantic Wolffish abundance indices based on research trawl survey data.

				Rate of change	Natural log regression parameters			
Survey	**NAFO divisions**	**Years**	**Total/mature**	**%**		**R^2**	***P*-values**	**Slope**
Newfoundland & Labrador Fall Survey	2J3KL S. Labrador Shelf	1981-1994	Total	-91	13	0.88	0.001	-0.18
			Mature	-96	13	0.93	<0.001	-0.25
		1995-2009	Total	150	14	0.50	<0.003	0.07
			Mature	294	14	0.38	0.018	0.10
Newfoundland & Labrador Spring Survey	3LNO Grand Banks	1971-1982	Total	219	11	0.36	0.040	0.11
		1984-1995	Total	-44	11	0.12	0.278	-0.05
			Mature	-70	11	0.40	0.027	-0.10
		1996-2010	Total	124	14	0.33	0.026	0.05
			Mature	247	14	0.53	0.003	0.09
Maritimes Summer Survey	4VWX Scotian Shelf	1970-1981	Total	-0.2	11	$5X10^6$	0.994	-0.0002
			Mature	79	11	0.21	0.132	0.05
		1982-2010	Total	-27	298	0.05	0.258	-0.01
			Mature	-96	28	0.61	<0.001	-0.11
Newfoundland & Labrador Spring Survey	3Ps S. Newfoundland	1971-1982	Total	-36	10	0.11	0.313	-0.04
		1984-1995	Total	-77	11	0.62	0.002	-0.13
			Mature	-87	11	0.73	0.000	-0.19
		1996-2010	Total	92	14	0.14	0.195	0.47
			Mature	226	14	0.30	0.042	0.08
Southern Gulf Survey	4T S. Gulf	1971-1985	Total	65	14	0.02	0.641	0.11
		1986-2010	Total	-60	24	0.18	0.045	-0.04
Northern Gulf Summer Survey	4RST N. Gulf	1990-2009	Total	56	19	0.07	0.264	0.02
			Mature	150	16	0.10	0.216	0.05



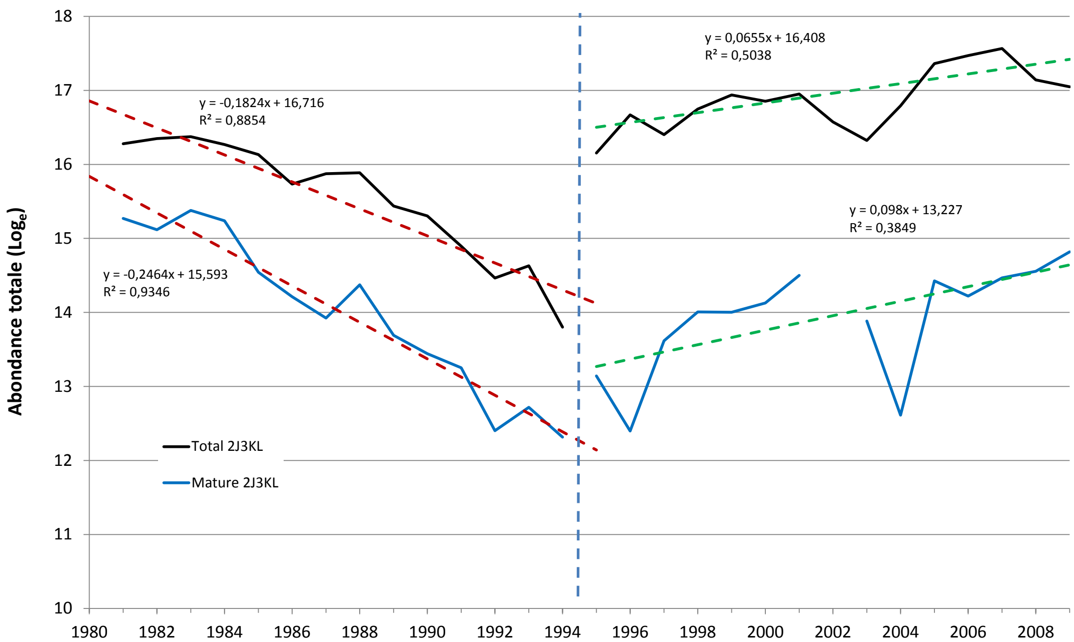
Translation of text in figure: Total abundance (millions)

Figure 12. Atlantic Wolffish abundance estimates (± CI) from Newfoundland and Labrador fall research trawl surveys for the Grand Banks (3LNO) and southern Labrador Shelf (2J3KL). The dotted vertical line indicates a fishing gear change.



Translation of text in figure:
Abondance totale (million) = Total abundance (millions)

Figure 13. Atlantic Wolffish abundance (total and mature fish ≥ 51 cm) based on Newfoundland and Labrador fall research trawl surveys for the southern Labrador Shelf (NAFO Divisions 2J3KL) from 1981 to 2009. The vertical line indicates a fishing gear change.



Translation of text in figure:
Abondance totale (Log$_e$) = Total abundance (log$_e$)

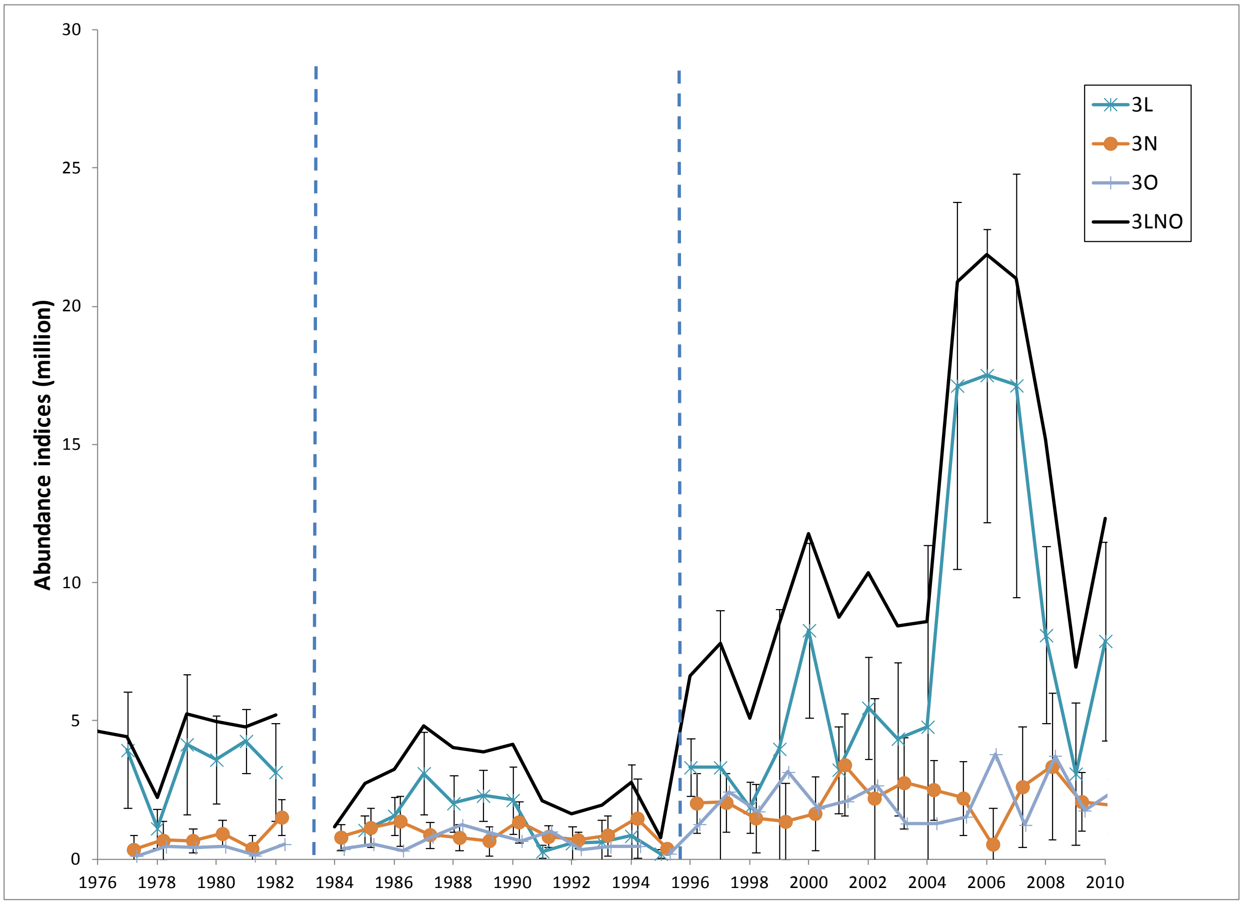
Figure 14. Natural log of Atlantic Wolffish abundance estimates from Newfoundland fall research trawl surveys for the southern Labrador Shelf (NAFO Divisions 2J3KL). Fitted regressions are shown. The vertical line indicates a gear change.

For the Grand Banks (Div. 3LNO), the spring research trawl surveys show some variability without trend in the period from 1971-1982 and 1984-1994 (Table 9, Figure 15). Since then, abundance has increased considerably, and the values recorded in recent years are by far the highest since the start of the data series in 1996, though the Campelen trawl used since the mid-1990s has higher catchability. Total abundance was estimated at 21.87 million in 2007 (maximum), compared to 5.10 million in 1998 (minimum). The rate of increase was 247% for the mature population from 1996 to 2010 (Figure 16, Table 8). This increase occurred primarily in Division 3L (northern Grand Bank). The three data series (1971-1982, 1983-1995 and 1996 to the present) cannot be compared directly due to the gear changes.

Table 9. Atlantic Wolffish abundance indices for the Grand Banks based on Newfoundland spring research trawl survey data.

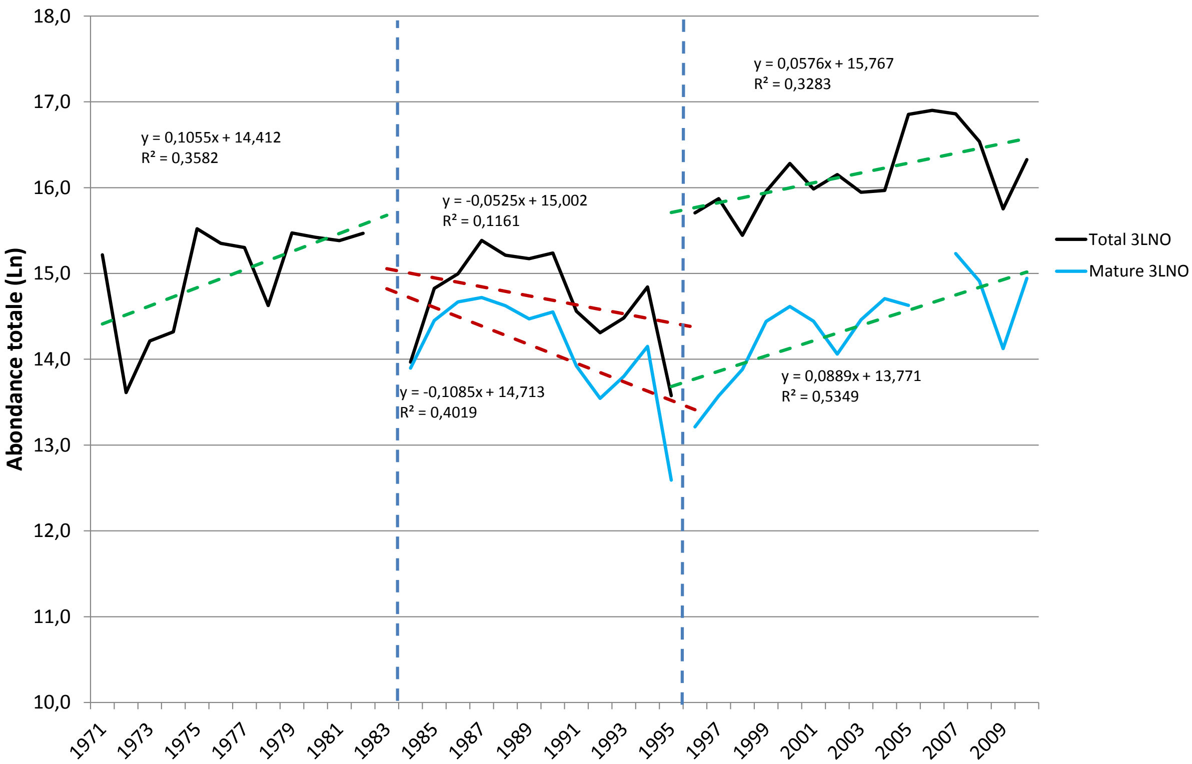
YEAR	ABUNDANCE INDEX (MILLIONS)*					
	3L	3N	3O		**Total**	**Total Mature****
1971	4.02	0.04				
1972	0.32	0.50				
1973	0.38	0.56	0.56		1.49	
1974	1.30	0.36			1.66	
1975	4.50	0.75	0.25		5.50	
1976	2.91	0.50	1.23		4.64	
1977	3.95	0.35	0.12		4.42	
1978	1.11	0.68	0.45		2.25	
1979	4.15	0.68	0.41		5.24	
1980	3.60	0.93	0.45		4.98	
1981	4.27	0.40	0.13		4.80	3.02
1982	3.15	1.52	0.55		5.22	2.96
1983	**Survey Gear Change**					
1984	0.00	0.80	0.37		1.16	1.08
1985	1.05	1.14	0.55		2.74	1.89
1986	1.57	1.38	0.31		3.26	2.35
1987	3.11	0.89	0.81		4.81	2.47
1988	2.02	0.79	1.23		4.04	2.24
1989	2.29	0.67	0.92		3.88	1.92
1990	2.14	1.35	0.66		4.15	2.09
1991	0.28	0.82	1.00		2.10	1.11
1992	0.58	0.70	0.36		1.64	0.76
1993	0.63	0.87	0.45		1.95	0.99
1994	0.84	1.48	0.47		2.79	1.40
1995	0.20	0.39	0.20		0.79	0.29
Survey Gear Change						
1996	3.32	2.03	1.27		6.62	0.55
1997	3.32	2.05	2.44		7.82	0.79
1998	1.88	1.49	1.73		5.10	1.07
1999	3.99	1.37	3.15		8.51	1.87
2000	8.28	1.66	1.83		11.77	2.22
2001	3.24	3.42	2.10		8.75	1.87
2002	5.48	2.21	2.67		10.36	1.28
2003	4.36	2.77	1.29		8.42	1.90
2004	4.79	2.52	1.30		8.61	2.44
2005	17.13	2.21	1.54		20.88	2.25
2006	17.51	0.54	3.80		21.85	**3.75**
2007	17.14	2.62	1.24		21.00	4.12
2008	8.10	3.35	3.74		15.20	2.99
2009	3.09	2.08	1.76		6.93	1.36
2010	7.89	1.96	2.47		12.32	3.09

*Blanks indicate that no survey was conducted.
** Abundance of mature is based on the proportion of fish ≥ 51.0 cm in Newfoundland & Labrador spring research trawl survey catches each year



Translation of text in figure: Total abundance (millions)

Figure 15. Atlantic Wolffish abundance estimates (± 1 CI) for the Grand Banks (NAFO Division 3LNO) based on Newfoundland spring research trawl surveys. Vertical lines indicate a fishing gear change. The “total” line indicates the sum of the abundances for all divisions only when all divisions were surveyed. Source: Raw data provided by Mark Simpson, pers. comm., 2010.



Translation of text in figure:
Abondance totale = Total abundance (Ln)

Figure 16. Natural log of Atlantic Wolffish abundance estimates for the Grand Banks (NAFO Division 3LNO) based on Newfoundland spring research trawl surveys. Fitted regressions are shown. The vertical lines indicate fishing gear changes.

Scotian Shelf, Southern Newfoundland and Gulf of St. Lawrence

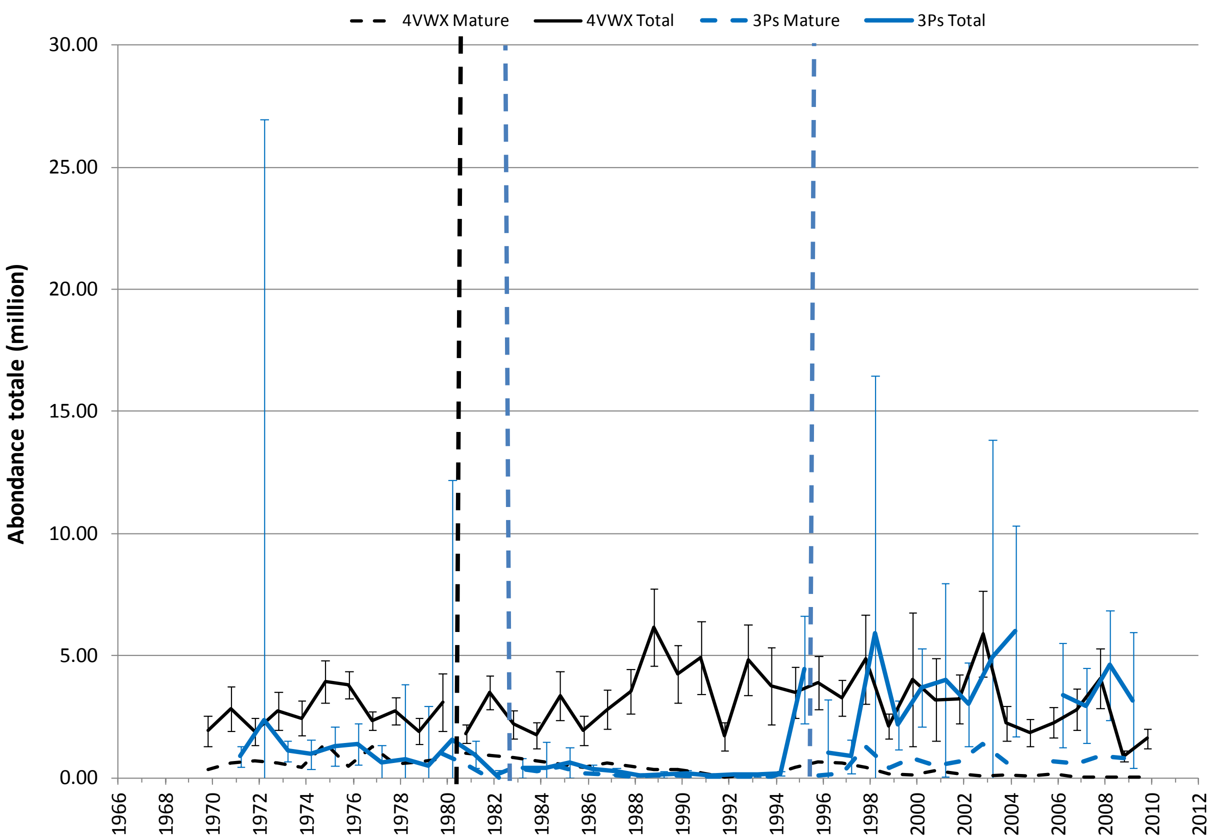
In the southern part of the Canadian range, Atlantic Wolffish abundance estimates from the Maritimes research trawl survey show considerable interannual variability (Table 10, Figure 17). There was no clear trend from 1971 to 1981. However, in the 1980s, total abundance increased from 1.75 million in 1984 to over 6 million in 1989. Since 1990, estimates have fluctuated from year to year with no particular trend, except in the last two years (2009 and 2010), when the lowest abundance estimates were recorded since the surveys began in 1982 (0.89 and 1.62 million, respectively) (Figure 17). From the whole 1982-2010 series, total abundance varied without trend (Table 8 and Figure 18).

Table 10. Atlantic Wolffish abundance indices from the Scotian Shelf, Southern Gulf, and Southern Newfoundland based on the Maritime summer research trawl survey data (Div. 4VWX and Subdivision 5Y), or Newfoundland spring research trawl survey data (Subdivision 3Ps) and Southern Gulf research trawl survey (Div. 4T) and the Northern Gulf summer research trawl survey data (Division 4RST).

YEAR	ABUNDANCE INDEX (MILLIONS)						
	4VWX5Y		3PS		4T	4RST	
	Adults*	Total	Adults	Total	Total	Adults	Total
1970	0.35	1.93					
1971	0.60	2.84			0.02		
1972	0.70	1.91		0.88	0.03		
1973	0.61	2.74		2.36	0.09		
1974	0.45	2.45		1.10	0.01		
1975	1.39	3.95		0.97	0.09		
1976	0.48	3.81		1.29	0.00		
1977	1.30	2.34		1.38	0.07		
1978	0.57	2.74		0.63	0.00		
1979	0.64	1.91		0.75	0.03		
1980	0.80	3.09		0.50	0.06		
1981	0.99	1.82	0.98	1.55	0.04		
	Survey Gear Change						
1982	0.93	3.50	0.55	0.96	0.06		
1983	0.82	2.19	Survey Gear Change		0.03		
1984	0.69	1.75	0.39	0.42	0.04		
1985	0.56	3.38	0.27	0.39	0.06		
					Survey Gear Change		
1986	0.41	1.93	0.45	0.62	0.03 Survey		
1987	0.59	2.81	0.19	0.37	0.08		
1988	0.47	3.55	0.14	0.26	0.24		
1989	0.34	6.16	0.05	0.11	0.05		
1990	0.33	4.25	0.08	0.15	0.19	2.43	0
1991	0.21	4.91	0.10	0.18	0.11	4.66	0.167
1992	0.04	1.70	0.05	0.10	0.20	4.41	0
1993	0.12	4.82	0.06	0.13	0.02	2.05	0.060
1994	0.11	3.76	0.06	0.13	0.13	4.97	0.883
1995	0.44	3.48	0.07	0.18	0.07	4.41	0.424
			Survey Gear Change				
1996	0.65	3.91	0.37	4.44	0.17	4.69	0.573
1997	0.59	3.29	0.11	1.05	0.12	20.23	1.477
1998	0.41	4.86	0.19	0.89	0.06	5.01	0.388
1999	0.18	2.11	1.31	5.95	0.03	6.63	1.472
2000	0.10	4.04	0.41	2.17	0.06	14.61	1.237
2001	0.29	3.19	0.79	3.71	0.03	3.54	0.184
2002	0.17	3.23	0.49	4.01	0.08	5.62	0
2003	0.08	5.89	0.68	3.02	0.02	10.33	0.626
2004	0.12	2.24	1.40	4.93	0.04	6.16	0.790
2005	0.07	1.86	0.65	6.02	0.08	5.45	0.618
2006	0.15	2.27			0.06	7.04	0.782

YEAR	ABUNDANCE INDEX (MILLIONS)						
	4VWX5Y		3PS		4T	4RST	
	Adults*	Total	Adults	Total	Total	Adults	Total
2007	0.03	2.80	0.67	3.39	0.06	4.73	1.135
2008	0.01	4.07	0.58	2.96	0.03	5.16	0.322
2009	0.01	0.89	0.91	4.63	0.03	3.98	0.457
2010	0.02	1.62	0.80	3.17	0.07		

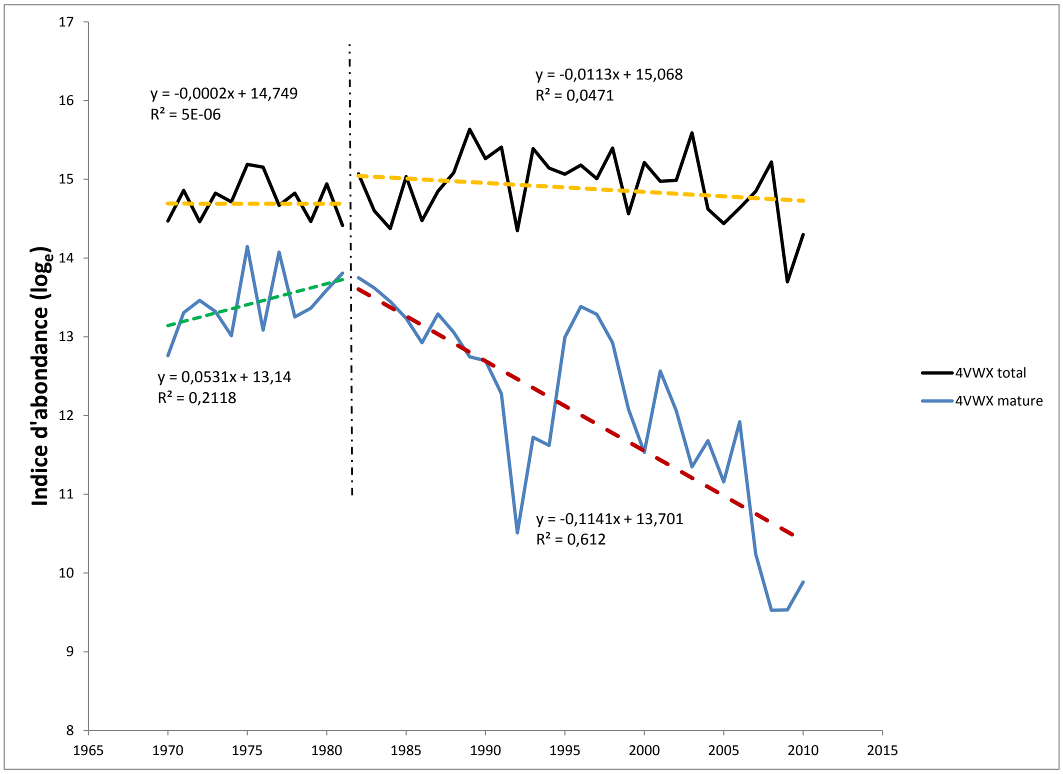
Sources : Simon *et al*. 2011, Simpson *et al.* 2011, Hugues Benoit, pers. comm. 2012, Bourdage and Ouellet, in prep.
* Abundance of mature is based on the proportion of fish ≥ 51.0 cm in Northern Gulf research trawl survey catches each year



Note: Black vertical dotted line indicates a fishing gear change in 4VWX and blue vertical dotted lines indicate a vessel change in 3Ps.

Translation of text in figure:
Abondance totale (million) = Total abundance (millions)

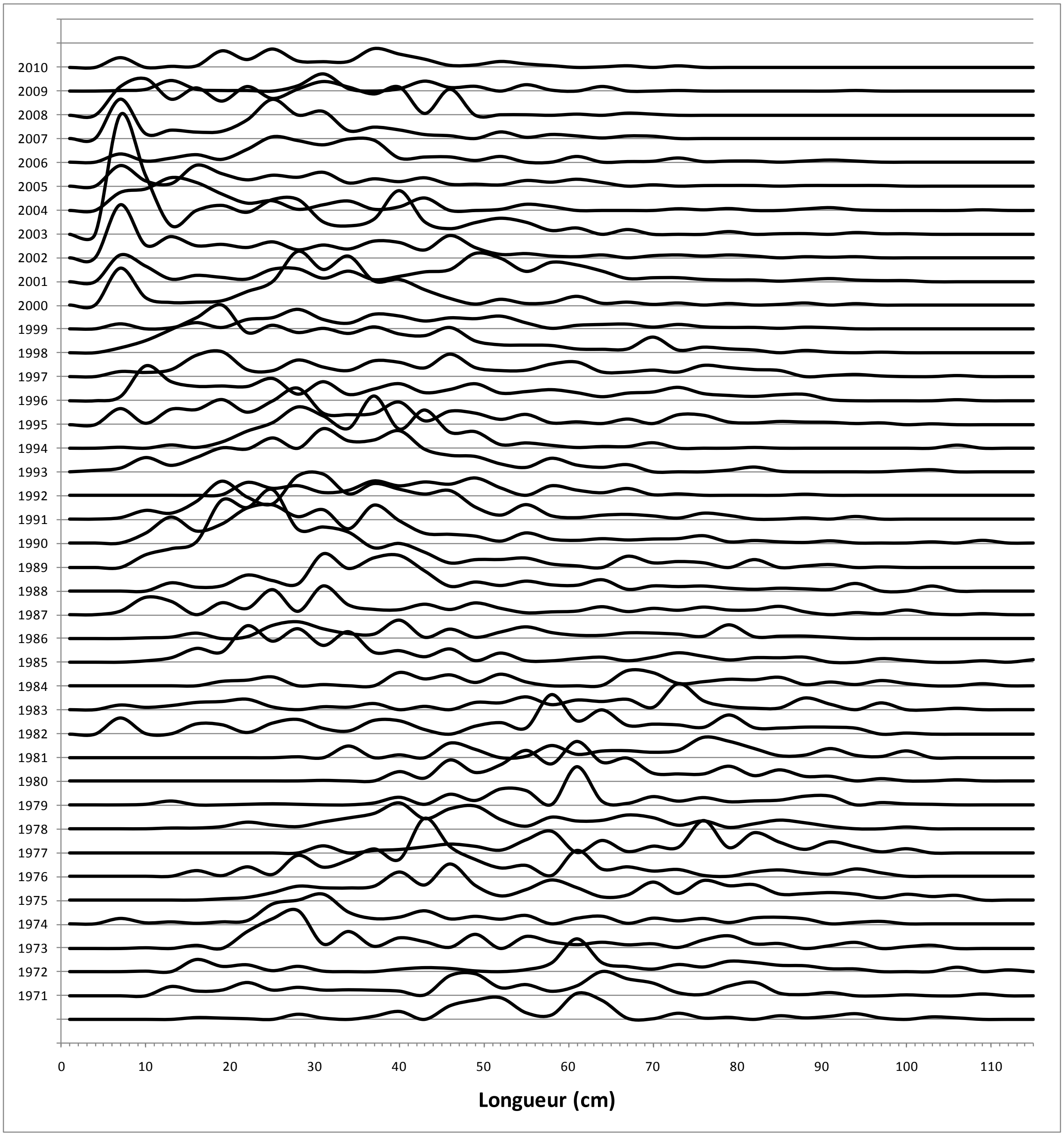
Figure 17. Mature and total Atlantic Wolffish abundances (± CI) estimated from the Maritimes summer research trawl survey on the Scotian Shelf and part of the Gulf of Maine (NAFO Divisions 4VWX) and of Southern Newfoundland (NAFO Division 3Ps). Sources: 4VWX from Simon *et al.* (2011), 3Ps from Simpson *et al.* (2011).



Translation of text in figure:
Indice d'abondance (log$_e$) = Abundance index (log$_e$)

Figure 18. Natural log of Atlantic Wolffish abundance estimates for the Scotian Shelf (NAFO Division 4VWX) based on Maritimes research trawl surveys. Fitted regressions are shown. The vertical line indicates a fishing gear change.

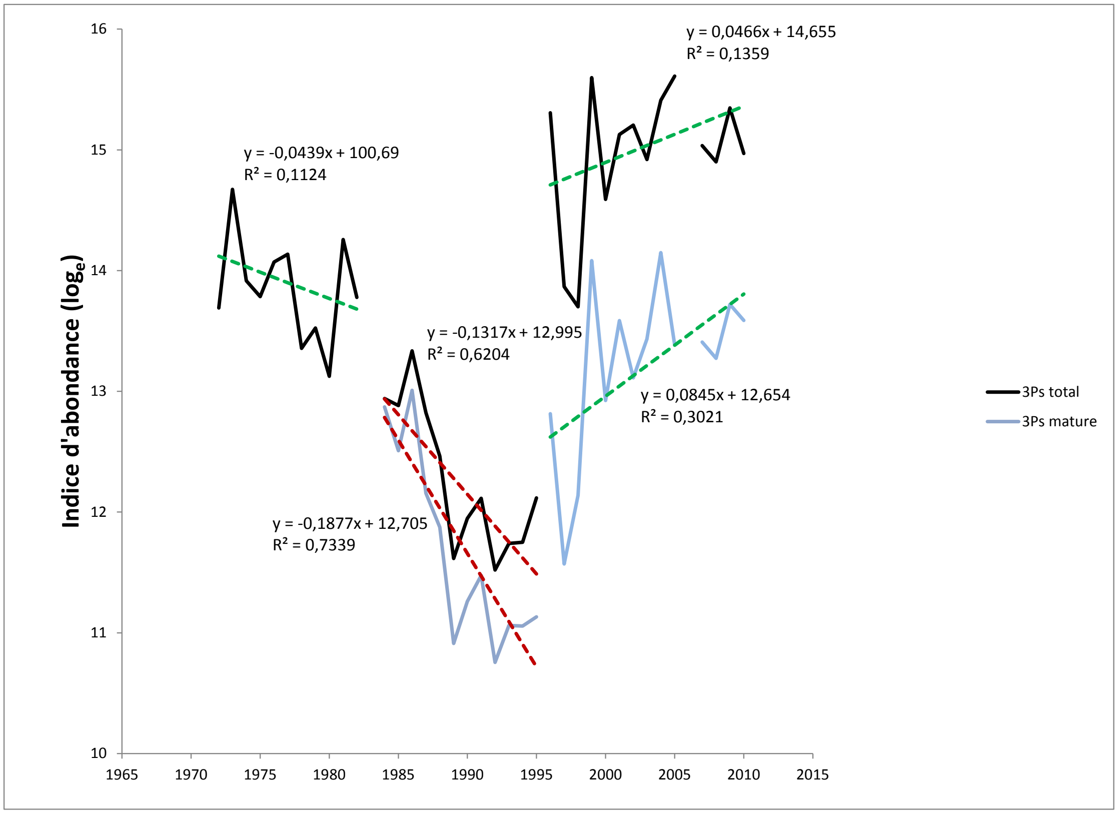
The abundance of mature individuals in the surveys declined sharply at the end of the 1971-1981 series and from 1982 to the start of the 1990s, and again from 1996 (0.65 million) to 2010 (0.02 million) (Table 10 and Figure 18). There was an annual rate of decrease of 27% and 96% from 1982 to 2010 for the total and adult population, respectively (Table 8 and Figure 18). An analysis of length frequencies (Figure 19) shows that catches of large Atlantic Wolffish have declined and catches of smaller individuals apparently increased since the 1980s.



Translation of text in figure:
Longueur (cm) = Length (cm)

Figure 19. Length frequency of Atlantic Wolffish from the Scotian Shelf Maritimes summer research trawl survey (based on total stratified random sampling abundance estimates). See text for caveats about gear changes.

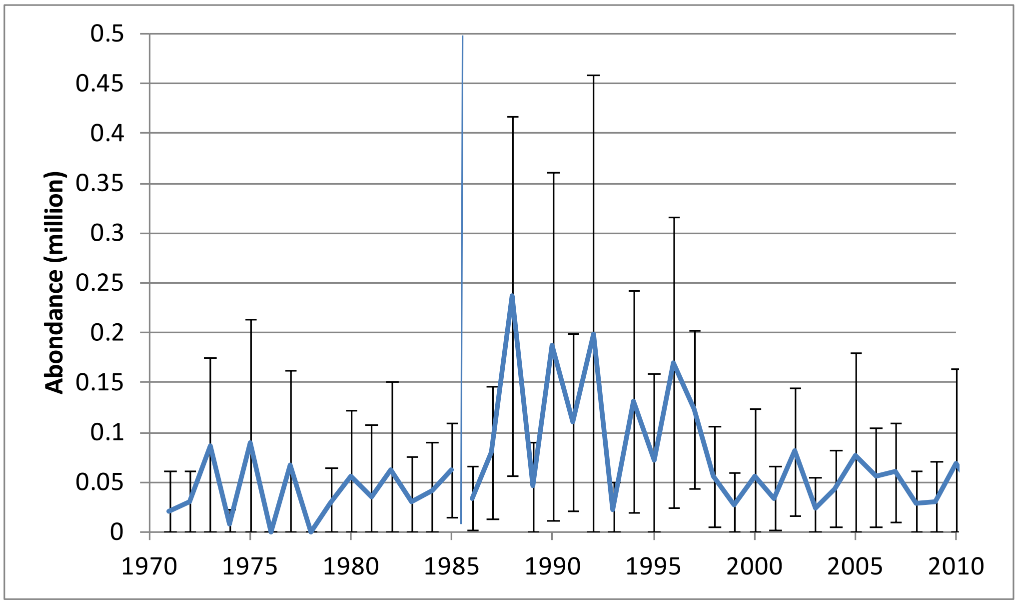
In southern Newfoundland (subdiv. 3Ps), there were no trends in abundance from 1971-1982 followed by a decrease from 1984 to 1995 (Table 10, Figures 17 and 20). From 1985 to 1995, the rate of decline was 87% for mature individuals (Table 8). The annual rate of decline was 13% (Table 8 and Figure 20). Adults showed a similar pattern for that period, with an increase since 1998 (Figures 17 and 20). The abundance index rose from 0.89 and 0.19 million in 1998 to 3.17 and 0.80 million in 2010 for total and mature populations, respectively.



Translation of text in figure:
Indice d'abondance ($\log_e$) = Abundance index ($\log_e$)

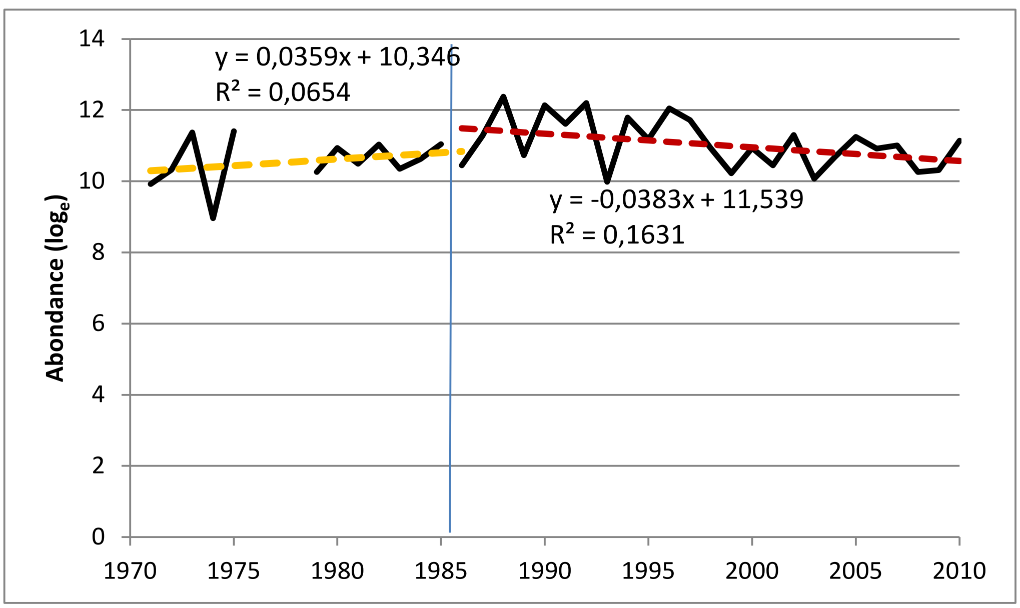
Figure 20. Natural log of Atlantic Wolffish abundance estimates for southern Newfoundland (NAFO Division 3Ps) based on Newfoundland spring research trawl surveys. Fitted regressions are shown. The breaks are due to fishing gear changes.

The abundance of Atlantic Wolffish is low in the southern Gulf of St. Lawrence (Table 10 and Figure 21). Some annual variations occurred from 1971 to 1985, but without trend. From 1986 to 2012, there was a decline of 60% (Table 8, Figure 22). In the Northern Gulf, the abundance index varied from 2.05 to 20.23 million without trend from 1990 to 2010 (Table 10; Figures 23 and 24). There was an increase of 150% for the mature population, but the trend is not significant (P = 0.216; Table 8).



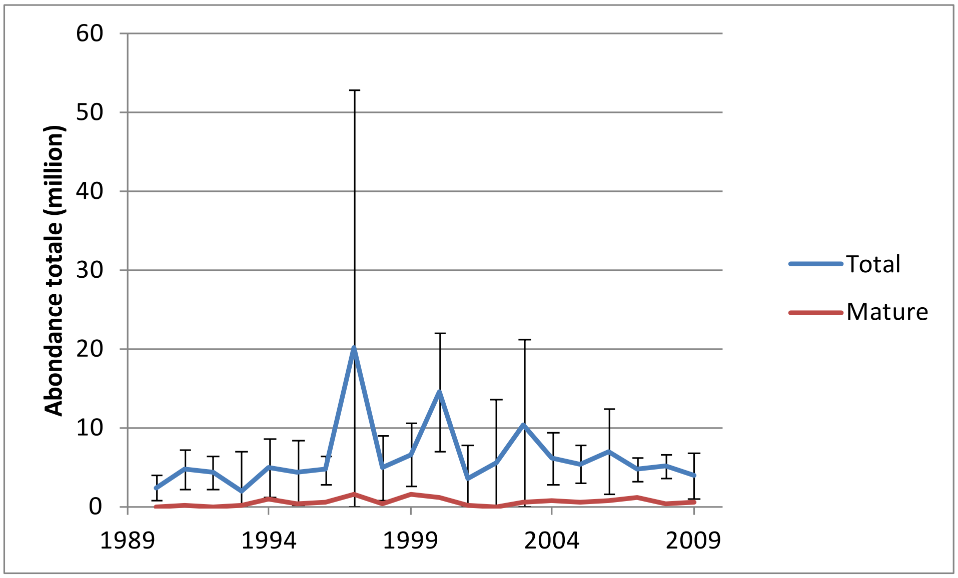
Translation of text in figure:
Abondance (million) = Abundance (millions)

Figure 21. Total Atlantic Wolffish abundance (± 1 CI) for the Southern Gulf (NAFO Division 4T). The vertical line indicates a fishing gear change. There were too few adults to allow them to be depicted separately (Table 6). Source: Benoit, H. pers. comm. (2012).



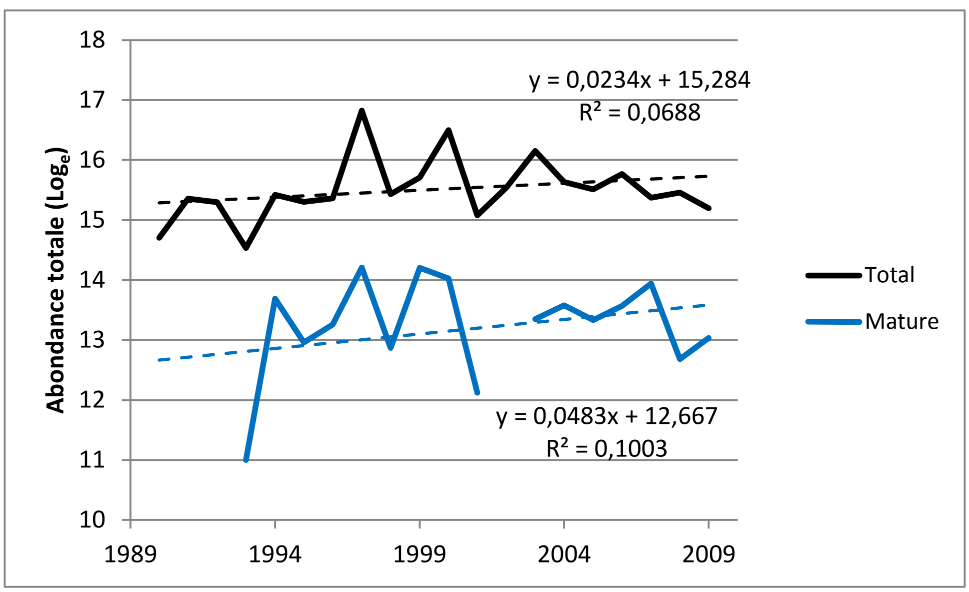
Translation of text in figure:
Abondance (log$_e$) = Abundance (log$_e$)

Figure 22. Natural log of Atlantic Wolffish abundance estimates from Southern Gulf research trawl surveys for NAFO Division 4T. Fitted regressions are shown. The vertical line indicates a fishing gear change. There were too few adults to allow them to be depicted separately (Table 6).



Translation of text in figure:
Abondance totale (million) = Total abundance (millions)

Figure 23. Atlantic Wolffish abundance estimates (± 1 CI) from summer research trawl surveys for the Gulf of St. Lawrence (NAFO Division 4RST). The abundance of mature fish is based on the proportion of fish ≥ 51 cm.



Translation of text in figure:
Abondance totale (Log_e) = Total abundance (log_e)

Figure 24. Natural log of Atlantic Wolffish abundance estimates from summer research trawl surveys for the Gulf of St. Lawrence (NAFO Division 4RST). Fitted regressions are shown.

Summary for Canada

Over much of its range, including its historical stronghold in waters east and south of Newfoundland, this species underwent strong declines from the 1980s until the mid-1990s, followed by increases. These trends largely match those for the area occupied. Recovery has not been as strong in the southern part of its range. Data are insufficient to establish status in the northern-most portion of its Canadian range, in Davis Strait.

Differences among regions in survey methods and changes in gear over time preclude formal calculations of an overall trend for this species in Canada. However, a general indication is needed to assess this species' overall status. We can get a rough approximation by weighting the rates of change of each area by the number of fish in that area at the start of its time series.

The southern Labrador Shelf (2J3KL) was the historical stronghold, with about 4.2 million mature individuals over the first three years of the time series at the start of the 1980s. These fish declined by about 96% up to the time of the gear change in the mid-1990s (Table 8). The remaining 4% of fish then increased to about 15% of the original numbers at the start of the 1980s, which means an overall decline of about 85%. Some of the apparent increase was probably driven by higher catchability of the gear used in the second half of the time series, though this is partly accounted for in the above calculation by multiplying the fish that remained prior to the gear change by the rate of increase afterward. Fish on the Grand Banks (3LNO) historically numbered only around 1.8 million, and they declined in the first half of the time series by about 70%. They then rebounded toward their original number, with the same caveat about higher catchability of the survey trawl. Fish in the next three areas (Scotian Shelf 4VWX, southern Newfoundland 3Ps, and the Gulf of St Lawrence 4T and 4RST) were progressively less numerous than in the two preceding areas, so their trends have less impact on the overall conclusions.

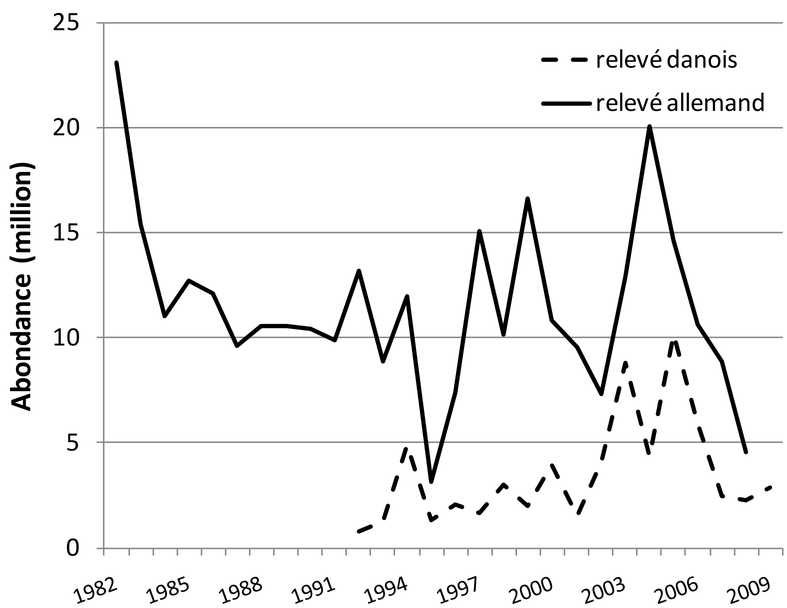
When the trends for all six regions are combined in this way, the overall rate of decline for Atlantic Wolffish is about 60% over 30 years, which is two generations. It should be emphasized that these are back-of-the-envelope calculations, intended only to give a general impression of the magnitude of decline relative to the ranges that are used by IUCN criteria.

Rescue Effect

South of Canada, Atlantic Wolffish is found in the Gulf of Maine and on Georges Bank in low densities, where surveys indicate a decline over the past two to three decades (Keith and Nitschke 2008). The possibility of rescue is from US waters is therefore limited at best.

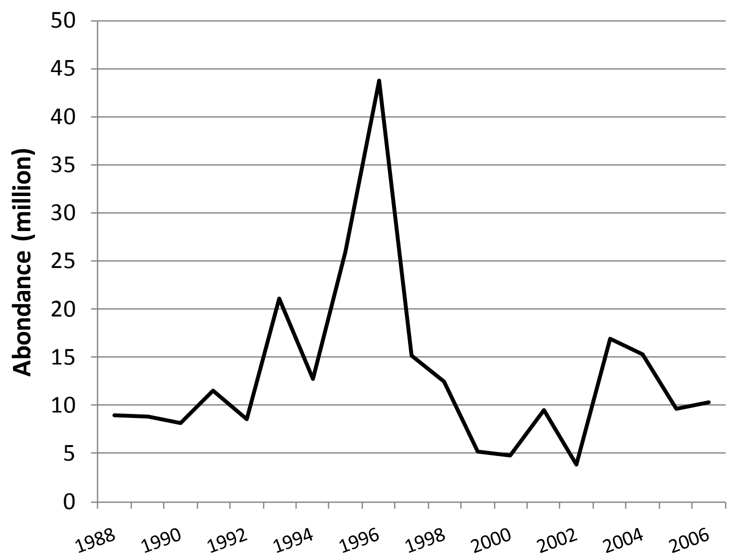
Abundance off West Greenland was estimated at 2.8 million in 2009 from a Northern Shrimp (*Pandalus borealis*) research survey conducted by a Danish team (Nygaard and Jørgensen 2010). Abundance increased from the start of the survey (1992) to 2005, but has since declined (Figure 25). Estimates from a bottom trawl survey conducted by a German research institute off west Greenland (NAFO Divisions 1C to 1F) (Figure 25) show fluctuations in abundance since the 1980s, but with no clear trend (Fock and Stransky 2009). However, in recent years, abundance has declined.

To the east, this species is found in several NAFO divisions that are partially (Divisions 3NO) or entirely (3M) in international waters (see Figure 2). On the Flemish Cap (NAFO Division 3M), abundance was estimated at over 10 million in 2006 (Figure 26, Gonzáles-Troncoso and Paz 2007). The abundance index has declined since 1996, but remains close to the values recorded in the 1980s. Rescue from the east is possible, but given the sedentary nature of adults, this would need to come from dispersal of larvae.



Translation of text in figure:
Abondance (million) = Abundance (millions)
Relevé danois = Danish survey
Relevé allemande = German survey

Figure 25. Atlantic Wolffish abundance indices based on two surveys conducted west of Greenland. Coverage of the Danish survey (Nygaard and Jørgensen 2010) varied over time. The German survey (Fock and Stransky 2009) covered NAFO Divisions 1C to 1F. The two surveys followed different protocols and used different gear.



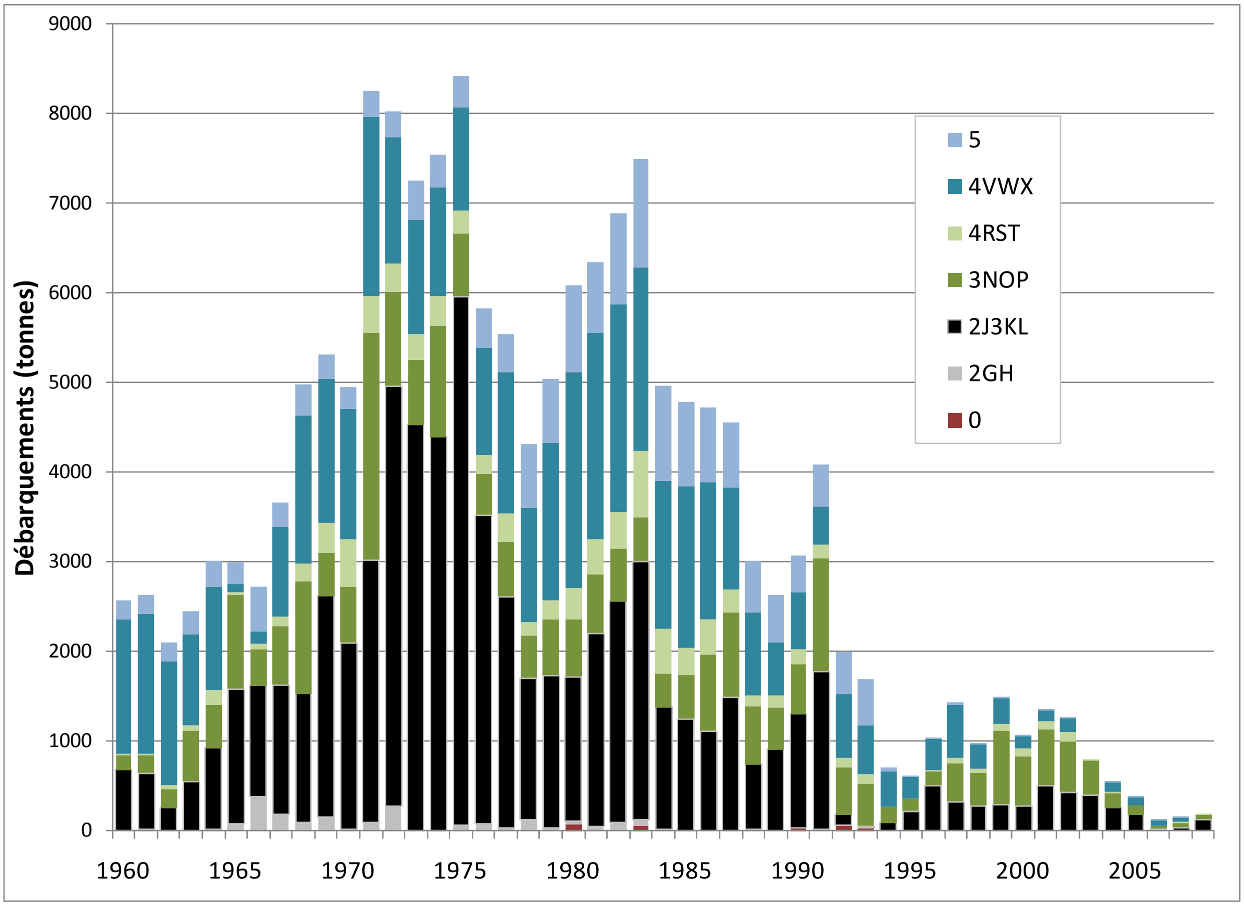
Translation of text in figure:
Abondance (million) = Abundance (millions)

Figure 26. Atlantic Wolffish abundance estimates from surveys on the Flemish Cap (NAFO Division 3M). Source: González-Troncoso and Paz (2007).

THREATS AND LIMITING FACTORS

Commercial Fishery and Bycatch

Wolffish are caught primarily as bycatch in other fisheries, including outside Canadian waters. Landings statistics (including directed fishery and bycatch) are recorded for all wolffish species combined. However, the Northern Wolffish has usually been discarded at sea and, since 2003, the release of catches of threatened wolffish species (Spotted and Northern) has been mandatory. Therefore, landings statistics from 2003 to 2010 are nearly all for Atlantic Wolffish. The data in this report include all wolffish landings taken from NAFO (2010) (Figure 27).



Translation of text in figure:
Débarquments (tonnes) = Landings (tonnes)

Figure 27. Reported wolffish (unspecified species) landings in NAFO divisions located partly or entirely in Canadian waters. Source: NAFO (2010).

Reported wolffish catches were relatively high in the 1970s and declined in the 1990s. Since 2006, the lowest values since the start of the data series have been recorded, probably partly due to the requirement to release Northern and Spotted Wolffish under SARA. Although reported wolffish catches once exceeded 8000 t, current values are approximately 200 t annually.

Most catches come from Divisions 2J3KL (southern Labrador Sea and northeastern Newfoundland) and 4VWX (southern slope of the Laurentian Channel and Scotian Shelf) (Figure 27). Since the 1990s, a large proportion of catches have come from Divisions 3NOPs, namely southern Newfoundland and the Grand Banks, where there is a small directed fishery. In addition, records from Shrimp Fishing Areas 0-3 (from east of Baffin Island to waters around the Ungava Peninsula) show that 11-32% of sets catch one or more of this species (depending on the area and year) (Siferd 2010).

Commercial log data under-report wolffish catch rates (Kulka *et al.* 2007), and close to half of Atlantic Wolffish bycatch in Canada is believed to be discarded without being reported (Simpson and Kulka 2002). Landed values therefore underestimate actual catches. Wolffish caught by trawls are generally more vigorous than most other fish species and their survival rate following release may therefore be higher (Grant *et al.* 2005).

Effects on wolffish from disturbance or alteration of ocean bottoms by repeated use of mobile gear (primarily bottom trawls and dredges) are unknown. Bottom trawls rarely sample rocky bottoms due to the high risk of gear damage. This habitat is important to Atlantic Wolffish.

Due to the significant decline in Atlantic Wolffish catches and in fishing intensity in general, the fishery currently poses a much less serious threat than during the 1970s and 1980s (Kulka and Pitcher 2001). Fishing has been suggested to have been the main cause of the decline of wolffish species (O'Dea and Haedrich 2001) but this has been disputed by Kulka *et al*. (2004), who suggested wolffish declines in unfished areas were as great as or greater than those in heavily fished locations.

Environmental Factors

An episode of cold temperatures from the late 1980s to early 1990s (Colbourne *et al.* 2004) coincided with part of the period of decline in wolffish species, though declines preceded that temperature change. No cause-effect linkages have been shown between cold temperatures and wolffish population changes.

Climate change related to human activities could affect the distribution and abundance of marine species due to changes in the marine environment. Temperature increases are expected to become more pronounced in northern zones, where Atlantic Wolffish are found (Trenberth *et al.* 2007). As a general rule, movements will be towards the poles, increasing the range of warm-water species and decreasing the range of cold-water species (Perry *et al.* 2005, Cochrane *et al.* 2009). The distribution of boreal and subarctic species, such as wolffish, could shift northward (Gucinski *et al.* 1990).

<u>Number of Locations</u>

Following IUCN guidelines, COSEWIC defines the number of locations according to the threats. Since the main recognized threat is bycatch in fisheries, this species can be considered to occupy a large number of locations, as the different fisheries occur across a wide geographic area and are managed separately.

PROTECTION, STATUS AND RANKS

Legal Status and Protection

The Atlantic Wolffish was first designated a species of Special Concern by COSEWIC in November 2000 and the status was confirmed in 2012. The species is listed under the federal *Species at Risk Act* (SARA). It may also receive some habitat protection under the federal *Fisheries Act*, as there is a small fishery for it, but the extent of such protection is unclear.

As a species of Special Concern, the *Species at Risk Act*'s prohibitions do not apply to the Atlantic Wolffish. However, the related Management Plan (Kulka *et al*. 2007) recommends that live release protocols and reporting in fisheries logbooks apply to this species. The implementation of this recommendation is at the discretion of Fisheries and Oceans Canada. There are no specific protection provisions or catch limits for Atlantic Wolffish under Canada's *Fisheries Act*. Provisions to protect other species targeted in fisheries which take Atlantic wolffish as bycatch may provide some protection.

This species is listed as likely to be designated threatened or vulnerable under the Quebec's *Act Respecting Threatened or Vulnerable Species* (Loi sur les espèces menacées ou vulnérables; R.S.Q., c E-12.01). This status does not carry any substantive protections. The US National Marine Fisheries Service received a petition to list Atlantic wolffish under the *Endangered Species Act* in 2008. Following preparation of a status review report, NMFS rejected the proposal (November 2009) (US Federal Register 2009). There is no mention of this species in the CITES appendices.

Non-Legal Status and Ranks

The species has not been ranked at the global or Canadian level by NatureServe, and is listed between Vulnerable and Apparently Secure (S3S4) by Quebec. It has not been assessed by the International Union for the Conservation of Nature (IUCN).

Habitat Protection and Ownership

In the Canadian portion of the northwest Atlantic there are five small marine protected areas as well as a few other areas closed to trawling. However, the area of protection for Atlantic Wolffish is very small compared to its widespread distribution and habitat requirements. The effects of these closures on fish that live in the protected and closed areas are unknown, and their overall impacts on the population are apt to be very limited.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Red Méthot received a Master's degree in Oceanography from the Institut des Sciences de la Mer (ISMER) in 2002. His studies were focused on the spatial and temporal aspects of cod reproduction in the context of stock management. Following his studies, he worked for Fisheries and Oceans Canada on fisheries-related projects. The writer works at Golder Associates as an oceanographer and ichthyologist. He is regularly involved in fish population monitoring studies and environmental impact assessments in Canada and abroad.