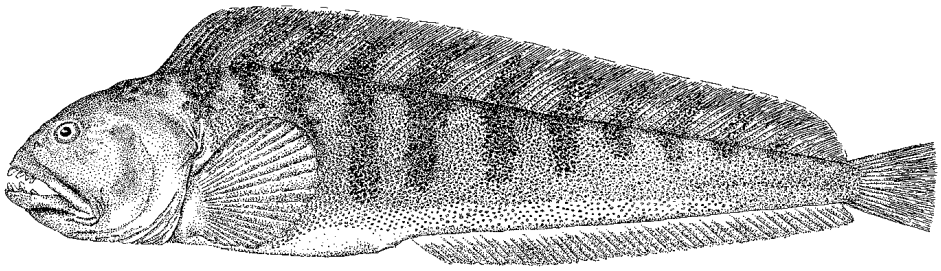
COSEWIC
Assessment and Status Report

on the

Atlantic Wolffish
Anarhichas lupus

in Canada



SPECIAL CONCERN
2000

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE IN
CANADA

COSEPAC
COMITÉ SUR LA SITUATION DES
ESPÈCES EN PÉRIL
AU CANADA

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

Please note: Persons wishing to cite data in the report should refer to the report (and cite the author(s)); persons wishing to cite the COSEWIC status will refer to the assessment (and cite COSEWIC). A production note will be provided if additional information on the status report history is required.

COSEWIC 2000. COSEWIC assessment and status report on the Atlantic wolffish *Anarhichas lupus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 21 pp. (www.sararegistry.gc.ca/status/status_e.cfm)

O'Dea, N.R. and R.L. Haedrich. 2000. COSEWIC status report on the Atlantic wolffish *Anarhichas lupus* in Canada, *in* COSEWIC assessment and status report on the Atlantic wolffish *Anarhichas lupus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-21 pp.

For additional copies contact:

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

Tel.: (819) 997-4991 / (819) 953-3215
Fax: (819) 994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le loup atlantique (*Anarhichas lupus*) au Canada

Cover illustration:
Atlantic wolffish — fom Scott and Scott, 1988.

Catalogue No. CW69-14/262-2003E-IN
ISBN 0-662-33622-4


Recycled paper

COSEWIC
Assessment Summary

Assessment Summary – November 2000

Common name
Atlantic wolffish

Scientific name
Anarhichas lupus

Status
Special Concern

Reason for designation
The total population of this large, solitary, slow-growing, late-maturing, nest-building benthic fish has declined significantly since the 1970s. Apparent threats are related to fishing and habitat alteration, perhaps compounded by environmental change.

Occurrence
Atlantic Ocean

Status history
Designated Special Concern in November 2000. Assessment based on a new status report.

COSEWIC
Executive Summary

Atlantic Wolffish
Anarhichas lupus

Description

Wolffish are characterized by the prominent, canine-like teeth in the front of the jaws, the elongate body, and the lack of pelvic fins. The Atlantic wolffish, *Anarhichas lupus*, is a large, bottom-dwelling predatory fish and is distinguished from the other two Atlantic species by the dark transverse bars on the body, the firm musculature, and the arrangement of the teeth on the roof of the mouth.

Distribution

The Atlantic wolffish occurs in continental shelf waters across the North Atlantic from northern France to Cape Cod. In the western North Atlantic, its greatest abundance occurs off northeast Newfoundland.

Habitat

The Atlantic wolffish lives among boulder fields on rocky or hard clay bottoms of the continental shelf. It can be found as deep as 500 m in cold to cool ocean waters.

General Biology

Spawning occurs late in the year. The large eggs are deposited in a large mass on the sea bottom, and are guarded by the male until they hatch. The young remain mostly associated with the bottom and do not disperse very far. The adults appear only to make limited seasonal migrations from deep to shallower water. Growth rates are slow. Apparently different temperature and depth preferences, and different spawning times, suggest that discrete regional populations may be the rule. Wolffish feed primarily on hard-shelled benthic invertebrates such as echinoderms, molluscs and crustaceans.

Population Size and Trends

Scientific surveys from most parts of the western Atlantic range indicate declines in abundance over the past 20 years. Since 1978, catch rates in Newfoundland waters are down by 91% over two wolffish generations, and for all Canadian waters numbers

are down by 87%. Mean size has also declined over time, and is now smaller than the size at maturity off Newfoundland. Numbers have declined steadily, the number of locations where the species occurs has declined, and the range where the species is abundant may be shrinking. Slow growth, a nesting habit, and limited dispersal make rescue unlikely. Nearby extra-territorial populations are experiencing the same difficulties as Canadian ones. Bottom trawling and dredging have probably damaged habitat. Future monitoring will be difficult.

Limiting Factors and Threats

Atlantic wolffish figure in commercial landings, at one time as a target species but now only as by-catch. Canada and Greenland have been the major countries involved since 1980, and Portugal was important in the 1990s. Landings in the western Atlantic peaked in 1979 at around 22,000 tonnes but fell steadily to under 2,000 by 1996. Even removals as by-catch have a negative impact on wolffish populations, and bottom trawling which destroys and disrupts habitat is probably detrimental as well.

Existing Protection

Because the Atlantic wolffish is not at present the target of a directed fishery in the western Atlantic, it is unmanaged and there are no specific mechanisms, such as total allowable catch limits, in place that afford it protection.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* 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.

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.

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.

COSEWIC Status Report

on the

Atlantic Wolffish
Anarhichas lupus

in Canada

Niall R. O'Dea[1]
Richard Haedrich[1]

2000

[1]Memorial University of Newfoundland
Department of Biology
4 Clarke Place
St. John's, NL
A1C 5S7

TABLE OF CONTENTS

List of figures

List of tables

SPECIES INFORMATION

Name and Classification

The wolffishes, family Anarhichadidae, are large blenny-like marine fishes which inhabit moderately deep waters of the North Atlantic and North Pacific oceans. They are named for the characteristic large, conical, canine-like teeth employed in consuming the benthic crustaceans and invertebrates which are their chief food source. Three species of wolffish occur in the Canadian Atlantic areas, and two of these, the spotted wolffish (*Anarhichas minor* Olafsen, 1774) and the Atlantic wolffish (*Anarhichas lupus* Linnaeus 1758), are of some commercial importance. The latter is the subject of this report.

Description

The Atlantic wolffish is an elongate, laterally compressed fish with a heavy head, blunt snout and rounded profile (Figure 1). It can reach a length of 150 cm and a weight of almost 20 kg. In common with all wolffish, it has distinctive and prominent large canine-like teeth in the front of the jaws and flattened, grinding teeth behind. There are no pelvic fins. Atlantic wolffish vary in colour, depending on their surroundings, from slaty blue to dull olive green to purplish brown, and there are dark transverse bars on the body (Whitehead *et al.*, 1986; Scott and Scott, 1988).

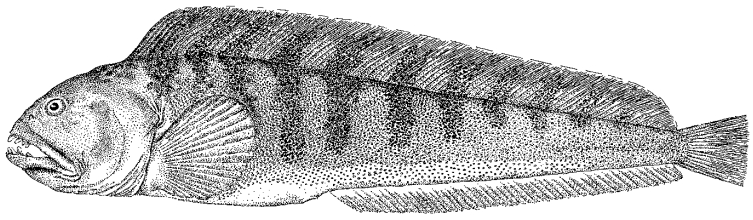


Figure 1. The Atlantic wolffish, *Anarhichas lupus* Linnaeus 1758. From Scott and Scott, 1988, p. 432.

The Atlantic wolffish can be distinguished from the other two wolffishes of the region by the nine to thirteen 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 (*Anarhichas denticulatus* Krøyer, 1844), and the grinding teeth on the vomer extend to the rear of the mouth behind the rows of palatine teeth (Barsukov *in* Whitehead *et al.*, 1986).

DISTRIBUTION

Global Range

Adapted to a broad range of depth and temperature, the Atlantic wolffish is widely distributed on both sides of the North Atlantic. In the eastern North Atlantic it is found from Iceland, the Faeroes, Spitzbergen, the White Sea, and Murman coast, south to the British Isles and the western coast of France. In the western North Atlantic, it is found off west Greenland and southern Labrador, in the Strait of Belle Isle and the Gulf of St. Lawrence, off the east and west coasts of Newfoundland and on the Grand Banks. Its most southerly range extends from the Scotian Shelf to the Gulf of Maine with occasional strays off New Jersey (Scott and Scott, 1988). Thus the Atlantic wolffish is basically a coldwater fish, and Mahon *et al*. (1998) have identified it as a characteristic member of the "northern, cold, deep, aggregated" demersal fish assemblage that occurs on the continental shelves off northeastern Newfoundland and southern Labrador.

The Atlantic wolffish appears in the important regional ichthyofaunal compendia of the North Atlantic: “The Fishes of the British Isles and North West Europe” by Wheeler, 1969, pp. 449-452; “Fishes of the North-eastern Atlantic and the Mediterranean” by Whitehead *et al.*, 1986 as Clofnam species 165.1.1 on p. 1115; “Atlantic Fishes of Canada” by Scott and Scott, 1988, pp. 432-434; and “Fishes of the Gulf of Maine” by Bigelow and Schroeder, 1953, pp. 503-507. These accounts each include keys, an illustration, distribution map and information on biology and relation to man as well as references.

Canadian Range

The ECNASAP (East Coast of North America Strategic Assessment Project) on-line Groundfish Atlas (http://www-orca.nos.noaa.gov/projects/ecnasap/ecnasap.html) summarizes twenty years of distributional data from scientific research surveys conducted in the western North Atlantic in the map ATLWOL, reproduced here as Figure 2. ECNASAP is a joint US/Canada data synthesis and mapping project concerned with living marine resources and their habitats. The map shows that the distribution of Atlantic wolffish in the western Atlantic is predominately Canadian. Within that area, it is most prevalent and abundant on the deep shelf off northeastern Newfoundland and Labrador.

HABITAT

Definition

The Atlantic wolffish is found principally in the deep waters of the continental shelf on rocky or hard clay bottoms, and only occasionally on sand or mud. Like other wolffish species, its migrations are local and limited (Templeman, 1984) and it does not form large schools. It is, however, known to perform small seasonal inshore-offshore

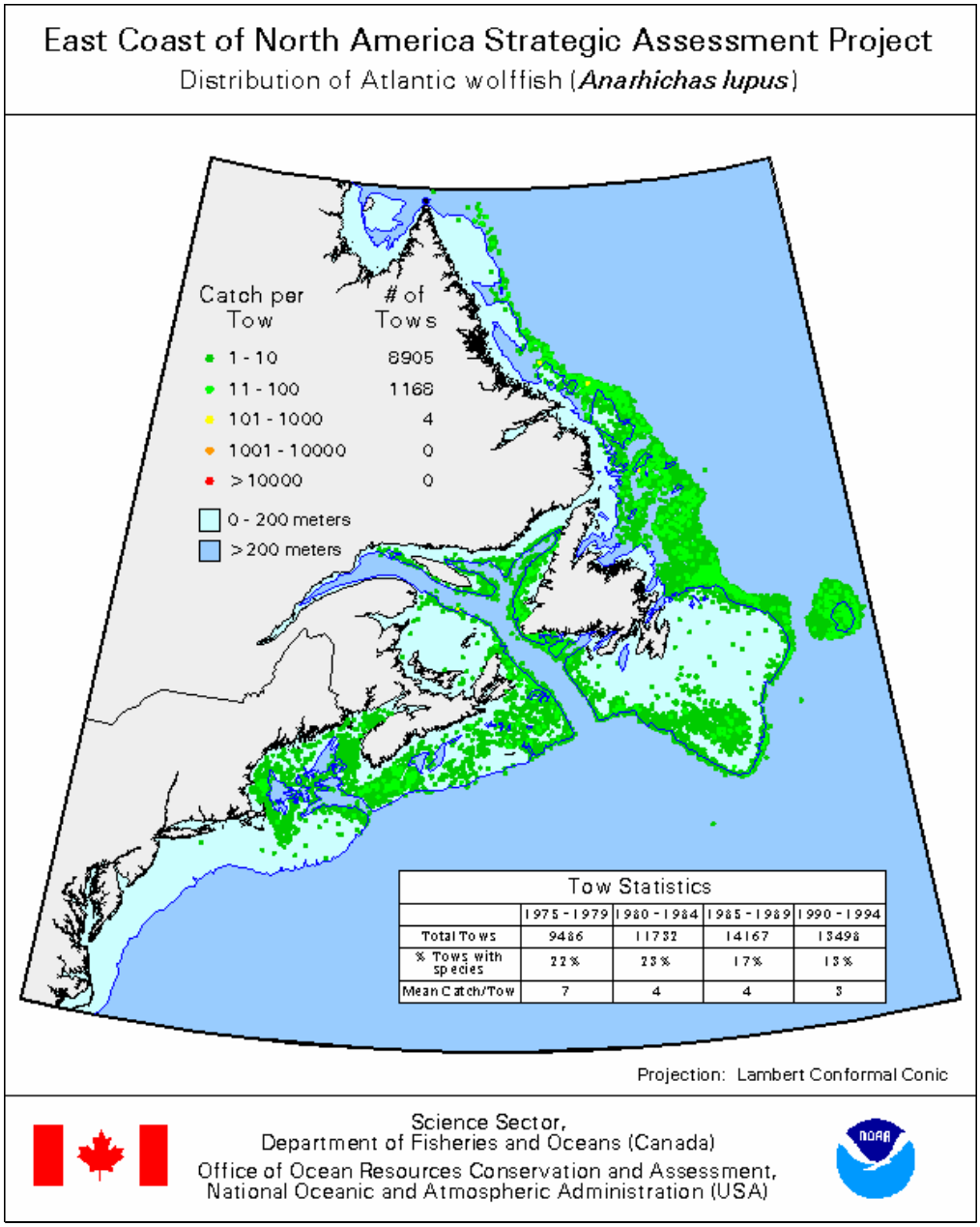


Figure 2. Composite map of the western Atlantic distribution of *Anarhichas lupus*, from the ECNASAP website - http://www-orca.nos.noaa.gov/projects/ecnasap/maps/atlwol.gif

migrations (Keats et al., 1985). It is found anywhere from very shallow water to 500 m deep and is said to prefer depths between 100 and 150 m; this apparent preference, however, varies depending on the locality. The Atlantic wolffish is a cool to cold water fish, tolerating a broad temperature range of -1°C to 10°C, though preferring temperatures between -0.4°C and 6°C. These preferred temperature ranges can also vary with locality.

Trends

In addition to temperature and depth information, the DFO scientific survey trawl data also report the positions of all stations where a species is taken. This information can be used to develop a picture of trends over time in the range occupied. In 1984 the wolffish was widespread on the deep shelf off northeastern Newfoundland but by 1993 its range had contracted mostly to a band offshore along the edge of the shelf. In maps provided by DFO (2000, *in Litt.*) Atlantic wolffish appear to have moved to deeper, more peripheral portions of the range on the Scotian Shelf; maps for the Gulf of St. Lawrence show little pattern, but do make clear how rare the species is there in general.

Another indicator of the possibly shrinking range of this species, the percentage of all annual survey stations where the Atlantic wolffish was actually caught, is shown for all Canadian areas in Figure 3; the percentage declined steadily from near 35% in 1978 to about 10% in 1994. For the area off Newfoundland, the Atlantic wolffish occurred in 88% of the stations where it was expected (according to preferred depth and temperature ranges) in 1978, and that level of occurrence continued until about 1985. After 1985, the percentage declined steadily to only 33% in 1993.

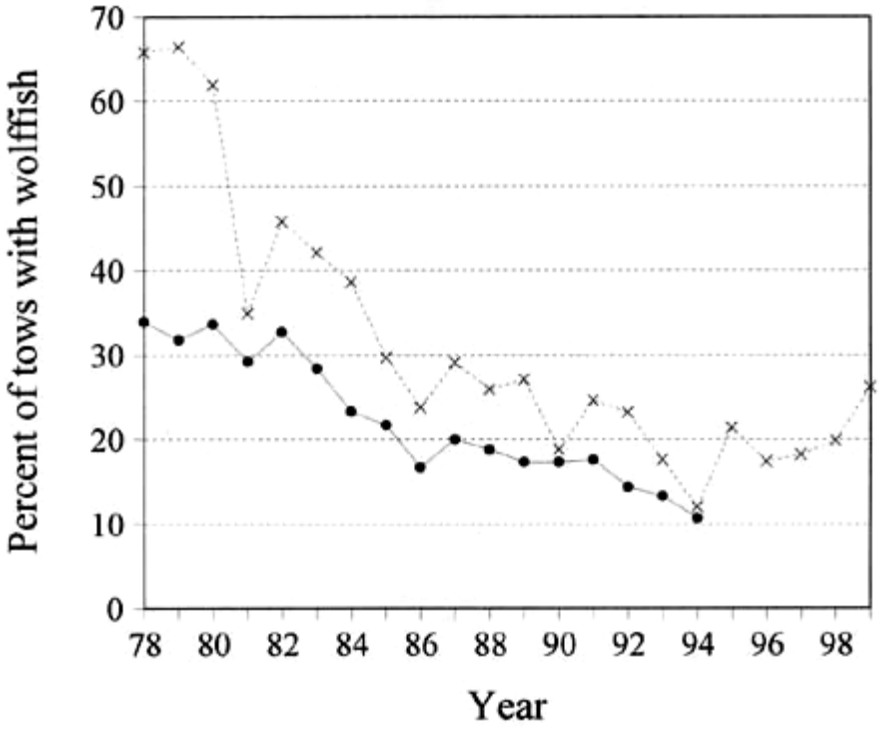


Figure 3. Percentage of scientific survey stations that captured Atlantic wolffish, *Anarhichas lupus*, 1978-1999. Solid line, circles: Canadian waters, ECNASAP data. Dotted line, X's: Newfoundland waters only, data provided by DFO in September 2000. Note sampling protocol changed in 1995.

GENERAL BIOLOGY

Reproduction

Spawning in the Atlantic wolffish appears to vary greatly in time and place. Off the east coast of Newfoundland some Atlantic wolffish migrate to shallow inshore waters in spring, spawning in September with hatching occurring by mid-December (Keats *et al.*, 1985). In both the Gulf of Maine (Nelson and Ross, 1992) and eastern Newfoundland (Keats *et al.*, 1986), it is thought that only fish over 50 cm and sexually mature move inshore, while smaller, juvenile fish remain in deep water. In Greenland the maximum number of spawners was observed by Beese and Kandler (1969) in September and October. In Iceland the situation is quite different from that in Newfoundland; Jónsson (1982) reports that the Atlantic wolffish moves from shallow into deeper waters to spawn from September to December or January, subsequently returning to shallow waters to feed. Similarly, spawning and feeding are exclusive events in the White Sea, with spawning occurring in the deep waters between 70 m and 300 m from August through September (Pavlov and Novikov, 1993). Keats *et al*. (1985: 2567) point out that the literature "suggests geographical and depth-related variability in the reproductive season of Atlantic wolffish". As such, discrete geographical populations of Atlantic wolffish on the large-scale may have distinct and different life histories, a possibility that requires further study.

Wolffish lay some of the largest eggs of any fish known – up to 6.0 mm in diameter. The eggs are deposited in a large mass on the bottom and are guarded by the male. Larvae remain mostly close to the bottom, rarely swimming to the surface and tending to remain close to the site of hatching.

Compounded, limited adult migrations and the restricted dispersal of larvae from their hatching site are potential risk factors for the survival of Atlantic wolffish populations on the smaller scale. If the population of a given region is decimated through environmental or anthropogenic causes, it is unlikely to be replenished by populations from elsewhere. The broad range of temperature and depth to which the Atlantic wolffish appears to be adapted may be indicative of the unique depth and temperature regimes of discrete and separate, rather than confluent, populations.

Growth rates of the Atlantic wolffish in Canadian Atlantic waters are unknown and there are little data available for other areas. In Europe, it takes three years to reach 25 cm (Wheeler, 1969), and Scott and Scott (1988) report that growth rates in Atlantic Canada are slow after the first summer. It is known that growth slows even further at five to six years of age when energy is diverted to gonadal development (Nelson and Ross, 1992). Off eastern Newfoundland the Atlantic wolffish reaches maturity between 43 and 67 cm (weights of 0.56 and 2.39 kg); fifty percent of individuals between 52 and 60 cm (1.02 and 1.57 kg) are mature (Templeman, 1986). Fish of this size are 8 to 10 years old. Atlantic wolffish are known to reach 152 cm in length and specimens aged to twenty years have been taken off Iceland (Scott and Scott, 1988).

Nutrition and Interspecific Interactions

The Atlantic wolffish feeds primarily on hard-shelled benthic invertebrates such as echinoderms, molluscs, and crustaceans. It is thought to be a key player in the ecosystem, known to control the density and spatial distribution of species such as green sea urchins (Hagen and Mann, 1992), crabs (Witman and Sebens, 1992) and giant scallops (Stokesbury and Himmelmann, 1995). The Atlantic wolffish also consumes small amounts of fish, particularly redfish. Young wolffish eat echinoderms almost exclusively but this food source becomes less important as the fish grows. While mature males reduce feeding close to spawning time and until their egg-guarding duties have ceased, females reduce feeding as gonads mature, but resume feeding immediately following spawning (Keats *et al.*, 1985). Little is known about what preys on the Atlantic wolffish itself, but juvenile specimens have been reported in the stomach contents of cod (Scott and Scott, 1988).

POPULATION SIZE AND TRENDS

For evaluation by COSEWIC, far and away the most important data for marine fishes are those which document numerical decline. There is a wealth of such data. They come from regular scientific surveys conducted by government agencies and expressly designed to monitor changes in abundance of demersal fishes. The same data can also be used to to generate secondary but also useful information on possible changes in the number of fish per trawl, the mean size of the fish and the range and habitat.

Data from random-stratified scientific survey trawls off eastern Newfoundland (Atkinson, 1994) were provided by Canada's Department of Fisheries and Oceans and summarized by Villagarcía (1995; see also Haedrich and Barnes, 1997). The surveys are intended mainly to assess the size of commercial fish stocks, but they also catch most species in the demersal fish community (Brown *et al.*, 1996). The number of individual trawls made (the number of stations) in any one year can be well over a thousand. Subsequently, in July to September 2000, DFO made large amounts of trawl survey data and analyses available from all Canadian areas specifically for this wolffish assessment.

The number/tow (which fishery biologists refer to as the "catch per unit effort" or CPUE) from scientific surveys is used as an index of population size. Over the period from 1978 to 1993, this index was calculated as the total number of Atlantic wolffish caught off Newfoundland in a year divided by the total number of stations sampled at appropriate depth and temperature ranges for the species in that year. The appropriate depth and temperature ranges for the Atlantic wolffish are determined using the niche axis approach developed by Fischer and Haedrich (2000) and represent the ranges of those two environmental parameters within which the wolffish is most likely to be encountered, i.e. 100 to 400 m for depth and greater than or equal to -0.5°C for temperature.

The scientific survey data from Newfoundland indicate a sharp decline in the Atlantic wolffish population. In 1978, the number/tow averaged 10.5 individuals caught in each tow. The following year it dropped more than 25% to 7.1 individuals per tow. It

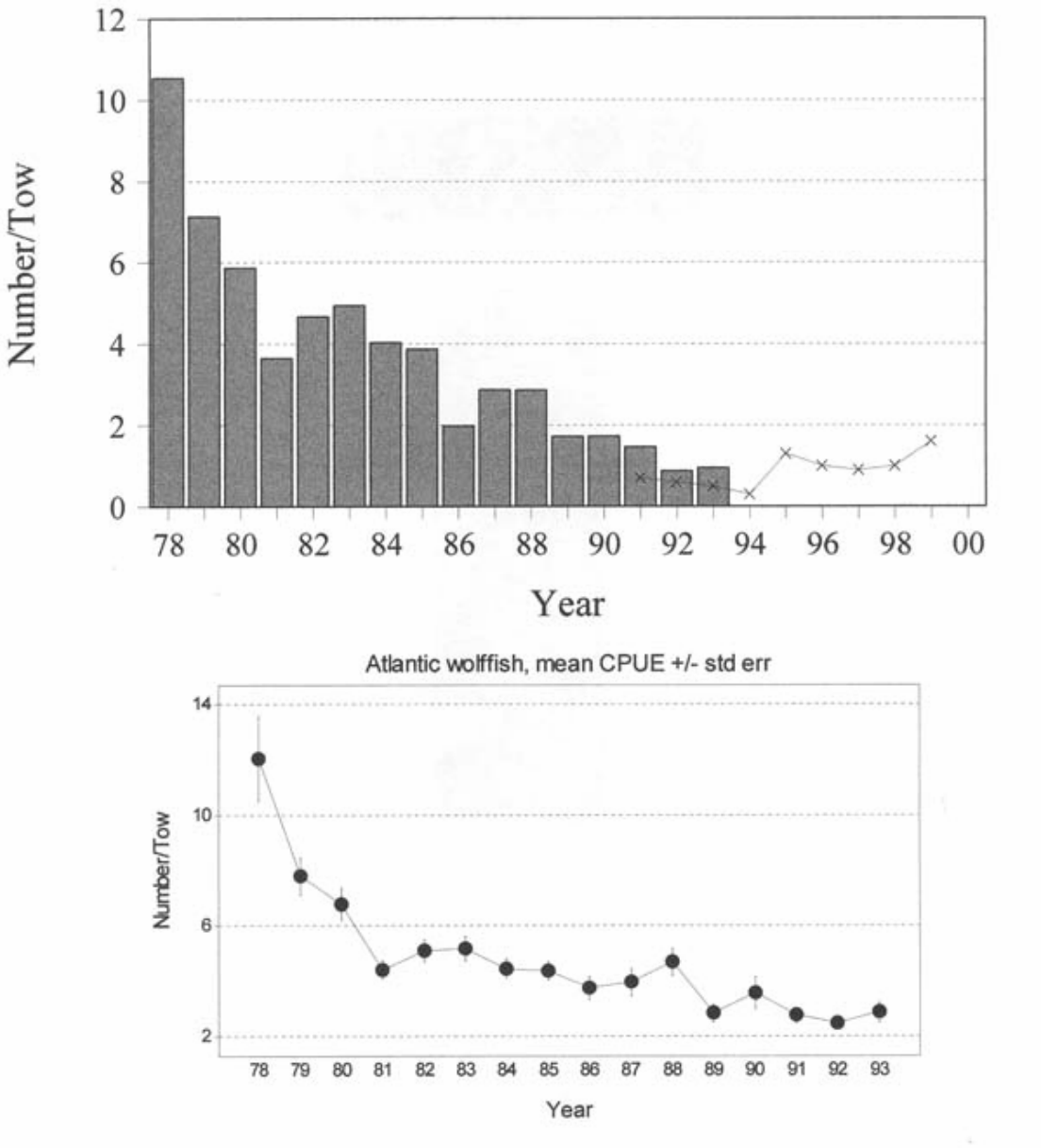


Figure 4. Top - Bars: CPUE (Σno./Σstn in each year) for Atlantic wolffish, *Anarhichas lupus*, caught in tows within appropriate depth and temperature ranges, 1978-93; Line, X's - same, all stations (data provided by DFO in September 2000). Bottom - mean CPUE ± std error for all positive tows. Eastern Newfoundland, 1978-1993, DFO Fall Survey Data.

then continued to decline steadily, and by 1993 had fallen to just 0.96 individuals per tow. Over the full period from 1978 through 1993, 16 years or about two wolffish generations, the number/tow declined by 91% (Figure 4). Kulka and DeBlois (1997) note the same general decline for all Newfoundland statistical areas in the period from 1987 to 1995. Since 1995, scientific survey data that include information on Atlantic

wolffish have been to be gathered by DFO. For the Scotian Shelf and Gulf of St. Lawrence, recent catch rates are comparable to ones observed earlier (Figure 5) and are low. In the northern Gulf, Atlantic wolffish are also not very abundant (DFO 2000, *in Litt.*); the average catch rate for 1990-99 is 0.42 fish per tow. As the graphs clearly show, the abundance of Atlantic wolffish in these more western regions has been low throughout the whole of the past 20 years, and has not shown the decline apparent off Newfoundland where the wolffish was once much more abundant than it is today (Figure 5) and where, as the ECNASAP map (Figure 2) shows and Mahon *et al.* (1998) indicate, this species assumes its greatest importance in the Northwest Atlantic.

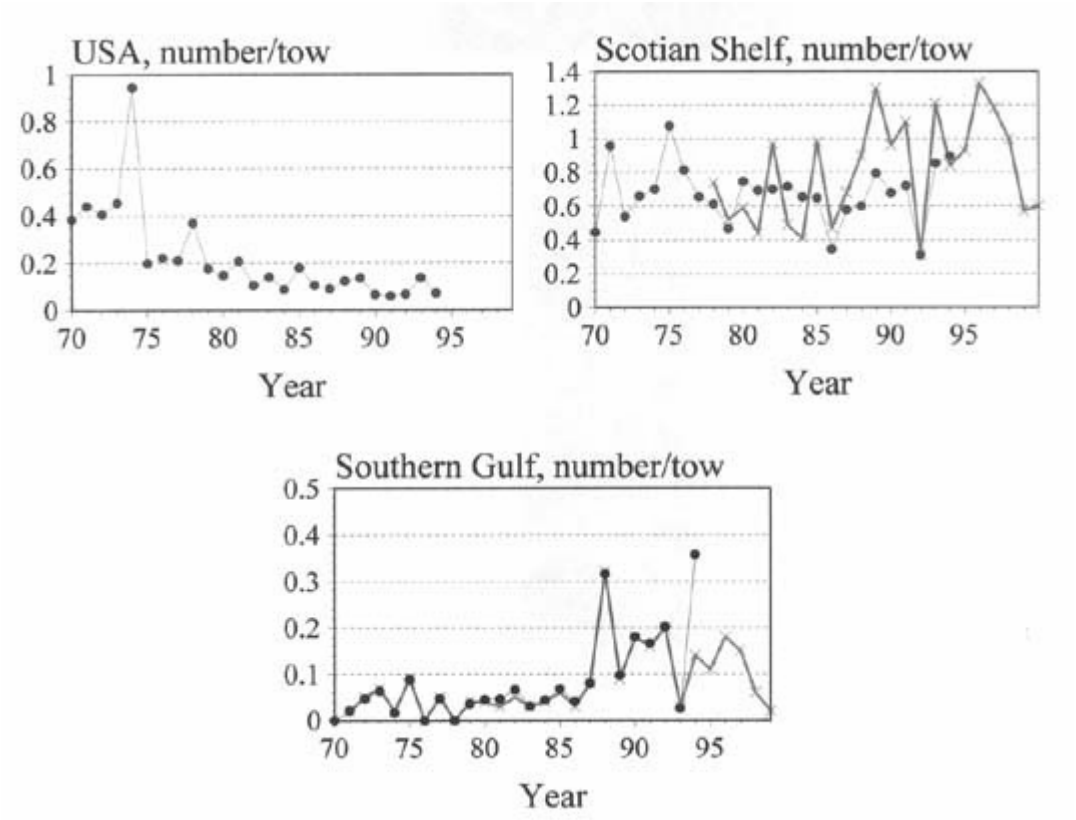


Figure 5. Number of Atlantic wolffish, *Anarhichas lupus*, caught per tow for all tows in the Gulf of Maine (USA) Scotian Shelf and southern Gulf of St. Lawrence, 1970-1999. Circles: ECNASAP data; X's, heavy line: data provided by DFO in July 2000. Note that Y-axis scales differ, and are much smaller than comparable survey catch rates off eastern Newfoundland (Figure 2).

DFO's main population assessment tool is the STRAP computer program. This analysis takes catches from at least two trawls within defined strata, scales them according to the total area of the stratum (within which the species is assumed to be uniformly abundant), and calculates an estimated number of fish presumed present. To get a total, those numbers are summed across all strata where the fish was encountered. The size of a single stratum can range from 30 to 2,817 square nautical miles (average = 697) and, because a single survey trawl sample covers about

0.009 square nautical miles and there are on average 2 trawls per stratum, the scale-up is prodigious (Schneider *et al.,* 1999).

The summed estimates from STRAP analysis results for Atlantic wolffish in all Canadian waters across the period 1978 to 1999 are shown in Figure 6 (see also Table 1). Because the sampling protocol changed in 1995, values from Newfoundland areas after 1994 are divided by a correction factor for comparability. For demersal species like wolffish, that factor ranges in general from 3.1 for adults to 10.7 for juveniles (Bundy *et al*., 2000). Calculated for the Atlantic wolffish alone using Bundy *et al.*'s (2000) formula, the factor is 4.85. The STRAP results also indicate a large decline in the wolffish population, down 87% over the 16 years from 1978 to 1994 (about two wolffish generations, and with no change in sampling proocol). From 1978 to 1999 (a little less than 3 wolffish generations, 1995-99 Newfoundland catches adjusted by 4.85), the decline indicated is 83%. Despite the debatable value of STRAP's absolute numbers, the annual estimates turn out to be well-correlated (r = 0.93) with the simple metric we prefer, the number/tow.

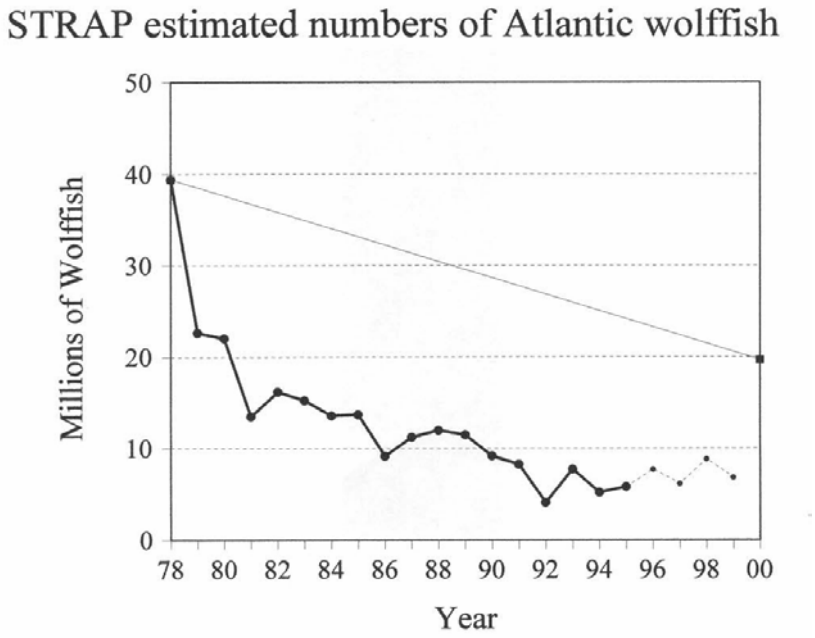


Figure 6. Twenty years of STRAP analyses for Atlantic wolffish, Canadian waters. Solid line, filled circles: Engels trawl estimates. From 1978 to 1994 (16 years, i.e. about two wolffish generations) there was no change in sampling method, and the decline is 87%. Dotted line, small dots: corrected estimates from Campelen trawls using the factor 4.85 (see p. 5), 1995-1999. Based on information provided by DFO in September 2000. Straight line shows the COSEWIC endangered criterion.

Table 1. An example of STRAP results: DFO's estimated numbers of Atlantic wolffish in Division 2J, the area off Newfoundland where the species is most abundant.

This information, the result of the Department's standardly applied STRAP analysis, was provided by DFO in July and September 2000. Numbers after the sampling protocol changed are uncorrected here; the general correction factor is to divide the raw numbers by 3.11 for adults and 10.7 for juveniles (Bundy *et al.*, 2000). The Campelen trawl (bigger net, smaller mesh, faster tow, shorter time) used after 1994 should catch relatively many more small juveniles, and it apparently does. Adherance to the precautionary principle focuses attention on the minimum number of fish estimated to be present.

Estimated number of Atlantic wolffish – Division 2J			Number actually caught in survey	Mean size, gm
Year	Maximum	Minimum		
1986	4581735.62	2292257.93	218	842
1987	3091369.43	1512736.74	159	777
1988	3282358.53	1363584.85	136	931
1989	2635004.51	1393533.15	116	827
1990	1714987.77	837048.57	272	815
1991	880071.5	454471.99	72	835
1992	916714.29	340006.65	65	613
1993	1443274.42	254094.73	44	530
1994	727737.26	-297524.33	15	854
⇓ Sampling protocol changes ⇓				
1995	2545860.44	452158.32	38	144
1996	12792366.97	-580893.96	167	151
1997	12523724.46	3497354.52	224	165
1998	15502431.57	2873008.9	253	122
1999	16383608.14	2803332	274	125

From 1978 to 1993, the relative frequency of high survey catch rates off Newfoundland declined, and conversely low catch rates were on the rise (Figure 7). In 1978, catches of five or less wolffish in a tow constituted less than 40% of all catches; by 1984 the frequency of low catches ($\leq$5) had risen to more than 70%, and in 1993 it was almost 90%. The increased frequency of low catch rates is another indication of declining population density.

The trend to a declining mean size of fish, considered together with the declining numbers, is yet another indication that wolffish populations are in trouble. These trends vary according to area, but all are down (Figure 8). The average size of Atlantic wolffish from the Scotian Shelf and Southern Gulf of St. Lawrence, while showing inter-annual variation, declined overall by 50% or more from the mid-1980s to the present; the trend lines are essentially the same. Off Newfoundland, mean wolffish size declined from around a kilo in 1978 to near 700 gm in 1993 (Figure 8). Fish of that size are probably not yet mature. In the Northern Gulf, the average size in the period 1990-99 is less than 500 gm.

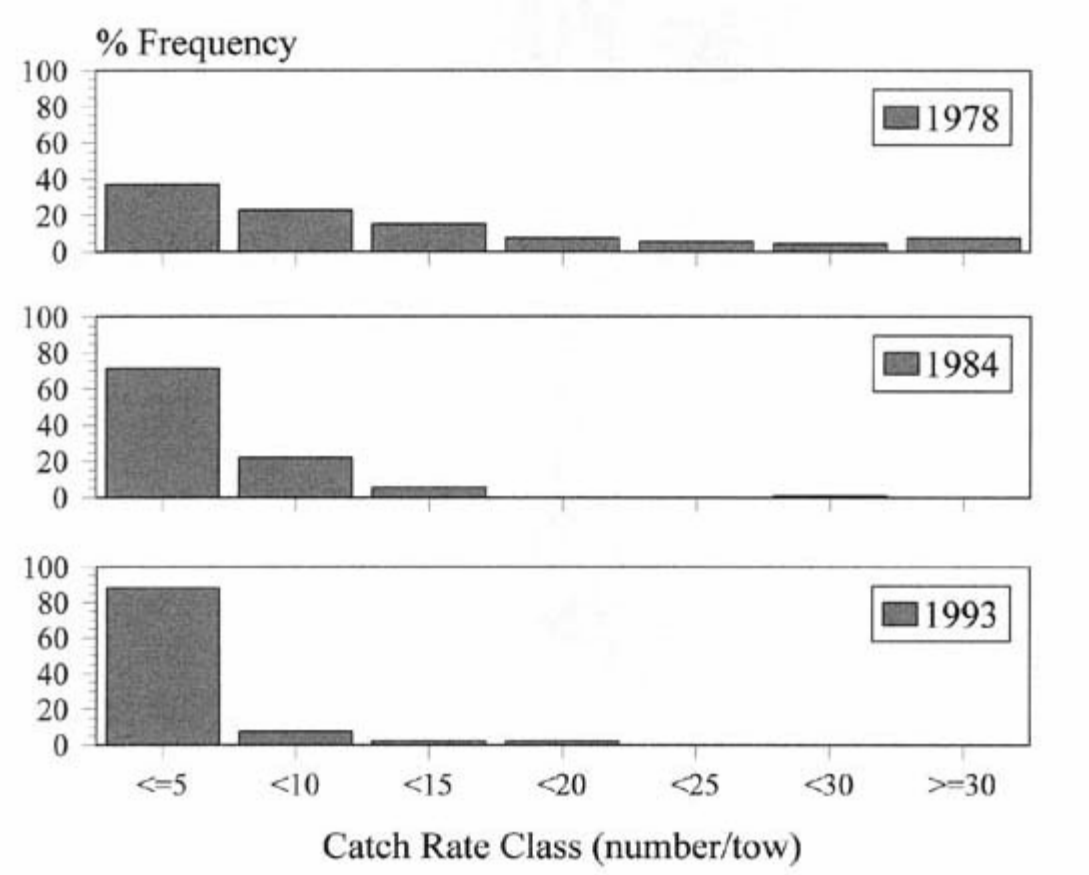


Figure 7. Percent frequency of large and small catches of Atlantic wolffish, *Anarhichas lupus*, by catch rate classes of 5, off eastern Newfoundland, 1978-1993. DFO Nfld Fall Survey Data.

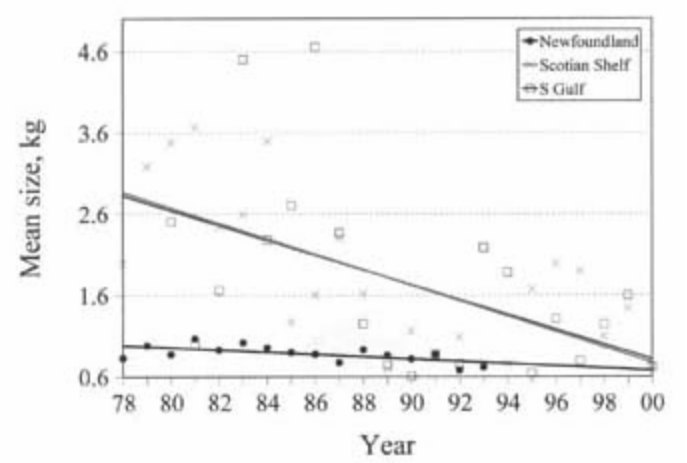


Figure 8. Mean body size (Σwt/Σno. in each year) of Atlantic wolffish, *Anarhichas lupus*, from Canadian waters (Circles: Newfoundland; X's: Scotian Shelf; Squares: Southern Gulf of St. Lawrence), 1978-2000. Lines show the trends in each dataset; the Scotian Shelf and Southern Gulf lines are almost identical. Information provided by DFO in August and September 2000.

To the north in Greenland waters, scientific trawl surveys (Rätz, 1997; Möller and Rätz, 1999) have been done differently than in the US and Canada, so CPUEs are not directly comparable. Biomass and abundance of Atlantic wolffish off East Greenland increased somewhat from 1982 to 1998, but off West Greenland (the region nearest to Canada), biomass has declined by about an order of magnitude and numbers are down by about half. Mean age in the whole Greenland population in 1998 (= 4 yr) is half of what it was in 1982 (Möller and Rätz, 1999), so the picture appears to be quite similar to that seen off Newfoundland. To the south, Atlantic wolffish have never been very abundant in US waters. There, wolffish did experience a significant decline in the mid-70s (Figure 5), several years before one of much greater magnitude in Atlantic Canada.

LIMITING FACTORS AND THREATS

There are no direct studies of factors responsible for the declines observed in wolffish abundance. Following the northern cod collapse off Newfoundland in 1992, a number of causes for the cod decline were suggested, including especially environmental changes. On a community level, similar declines in both commercial and non-commercial fish species there seemed difficult to understand without invoking such causes (Gomes *et al.*, 1995). The emerging consensus since then, however, is that while environment may have played some role, overfishing was clearly the major cause of the declines observed in most groundfish species (Sinclair and Murawski, 1997; Villagarcía *et al.*, 1999). And, when assessed over only a slightly longer time scale, fishing in the area is argued to have been responsible for the extraordinary decline of the large and once abundant and widely distributed barndoor skate, *Raja laevis* (Casey and Myers, 1998).

The Atlantic wolffish has been landed from commercial fisheries for many years. Once a directed target of the western Greenland fishery, it is now taken incidentally as by-catch only. There, Möller and Rätz (1999) report that calculated wolffish mortality is positively correlated with commercial landings of cod and shrimp. This indicates that fishing for other species can have a negative impact on wolffish through removal in the by-catch. There is no directed fishery for the Atlantic wolffish in Canadian waters, though it is taken as by-catch by offshore trawlers. Recently, wolffish filets have begun to appear on occasion in St. John's fish shops.

In fisheries data compiled by the Food and Agriculture Organization of the United Nations (FAO), wolffish landings for the western North Atlantic are reported for the whole family (3 species) rather than for each individual species; the Atlantic wolffish comprises the majority of those landings in Canada (Kulka and DeBlois, 1997). While the eastern North Atlantic wolffish fishery (apparently focused more on the spotted wolffish, *A. minor*; Wheeler, 1969) has had annual landings of around 30,000 tonnes since the late 1950s, with two peaks of over 50,000 tonnes in 1962 and 1974, the western North Atlantic fishery has always been smaller. Northwest Atlantic landings (Figure 9) hovered around 5,000 tonnes through the 1950s and then rose through the 1960s and 1970s to a peak of 22,000 tonnes in 1979. Landings then declined steadily through the 1980s and 1990s; in 1984 they stood at 6,000 tonnes and by 1996 had fallen to 1,700 tonnes.

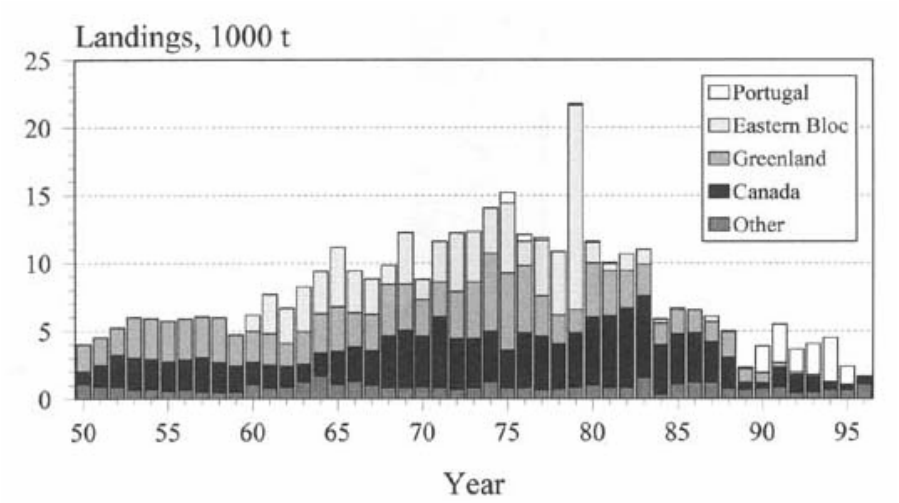


Figure 9. History of the northwest Atlantic fishery for Atlantic wolffish, *Anarhichas lupus*, 1950-1996. FAO Data.

The principal northwest Atlantic countries involved throughout in the history of the wolffish fishery have been Canada and Greenland, each with about a third of the landings from 1950 through 1996. The Soviet Union and East Germany also played significant roles in this fishery through the 1960s and 1970s, with East Germany responsible for almost 70% of 1979's record catch. The Soviet Union and East Germany were essentially out of the picture by the early 1980s, and by 1990 Greenland had seriously curtailed its fishing efforts as well. In recent years, from 1990 through 1996, Portugal has become the major participant in a much reduced fishery.

Apart from the direct adverse impact of fisheries on Atlantic wolffish, human activities also have indirect and detrimental effects on this species. The groundfish trawls, generally otter trawls, in which wolffish are caught also result in incidental mortality and damage to fish which come in contact with the mobile fishing gear but are not caught. Perhaps even more importantly, the steel doors or otterboards of the net, along with heavy bottom lines and rollers, scour the seabed as they are dragged across it (Watling and Norse, 1998). This practice may cause significant habitat damage by removing or re-distributing the rocks and boulders under which these fish shelter, spawn and build nests. Studies on Georges Bank (Collie *et al*., 1997) and in the Gulf of Maine (Auster *et al*.1996), areas within the southern limit of the Atlantic wolffish's range, show the considerable degree of damage that can result from bottom dragging there. Jennings and Kaiser (1998) provide an excellent overview of the entire question of fishing impacts on habitat; they point out that these can vary quite a bit depending on local conditions, but suggest that the greatest and most lasting impacts are most likely to occur on hard substrates in deep water, i.e. just those habitats favoured by the Atlantic wolffish.

Bottom trawling for fish and dredging for scallops and clams, in addition to digging up and disrupting bottom habitats, also resuspends bottom sediments, which can

smother spawning areas and damage gills. Resuspension of sediments may change the sediment chemistry or release settled toxic heavy metals. Other human activities such as channel dredging and aggregate extraction may do considerable harm to bottom habitats by destabilizing the seabed, increasing erosion, and polluting previously healthy areas (Messieh *et al.*, 1991).

The period since 1992 is an anomalous one for all Canadian waters. Relative to the past, fish populations are at an all-time low. For that reason, bans on fishing (moratoria) have been in effect in most regions for various periods of time, and these continue. Fishing predation is thus much relaxed, and populations should do better as long as that situation continues, which will not be forever. A cornerstone in the Fisheries Resource Conservation Council's approach to management (this quasi-independent group advises the Minister on the status of commercial fish stocks) is adherence to the precautionary principle (FRCC, 1996). That principle — when in doubt, err on the side of the fish — should also apply in regard to COSEWIC status.

SPECIAL SIGNIFICANCE OF THE SPECIES

The Atlantic wolffish is a commercially important species with flesh that is white, flaky and of good quality. While not the target of a directed fishery, it is valuable as by-catch. Additionally, it is thought to play a significant role in controlling the density and distribution of many benthic invertebrates. This is a double-edged sword in its relation to man, since it may control populations of pest species such as *Cancer irroratus* (Witman and Sebens, 1992) and *Strongylocentrotus droebachiensis* (Hagen and Mann, 1992) but may also be detrimental to populations of commercially valuable species such as the giant scallop, *Placopecten magellanicus* (Stokesbury and Himmelmann, 1995). Juvenile Atlantic wolffish also appear to be a food source for Atlantic cod.

EVALUATION AND PROPOSED STATUS

Existing Legal Protection or Other Status

Because the Atlantic wolffish is not at present the target of a directed fishery in the western Atlantic it is unmanaged and there are no specific mechanisms, such as total allowable catch limits, in place that afford it protection. However, the Canadian Atlantic groundfish moratorium imposed in 1992 in response to the collapse of Atlantic cod, *Gadus morhua*, may have provided some temporary indirect protection for the wolffish by reducing overall trawling pressure. The Atlantic wolffish currently has no status under IUCN.

The biology of the Atlantic wolffish may provide it with some limited protection. As a benthic organism which feeds on the bottom, it is unlikely to be caught in trawls above the ocean floor. Additionally, it frequents caves and crevices between and under large rocks, potentially affording at least some protection from bottom trawls and dredges.

TECHNICAL SUMMARY

Atlantic wolfish
Anarchichas lupus Linnaeus 1758 Loup d'Atlantique

Distribution	
• *extent of occurrence (sq km)*	> 10^6 km^2
• *area of occupancy (sq km)*	Unknown
• *range jurisdictions (occurs in which provinces& territories?)*	NF,NS,NB,PEI,QC, Nunavut
Population information	
• *total number of individuals in Canadian population*	Many
• *number of mature individuals (capable of reproduction) in the Canadian population*	Unknown
• *generation time (indicate years, months, days, etc.)*	6 years
• *population trend (decline, stable, increase, unknown)*	Decline
• *if in decline, % decline over 10 years or 3 generations whichever is greater (or specify if for shorter time period)*	91% since 1978 in area of greatest abundance
• *number of sub-populations (geographically or otherwise distinct groups between which there is little exchange i.e. <= 1 successful migrant / year)*	Unknown
• *number of individuals in each sub-population*	Unknown
• *number of extant sites*	Unknown
• *number of historic sites from which species has been extirpated*	In 1994, found in *ca*. 10% of survey sites
• *is the population severely fragmented (most individuals found within small and relatively isolated sub-populations)?*	Yes
• *does the species undergo extreme fluctuations (population size or distribution area varies widely, rapidly, and frequently (typically > 1 order of magnitude)?*	No
Threats (actual or imminent threats to populations or habitats)	
Anthropogenic influence: aggressive fishing for other species where wolffish is taken as by catch and probably dies.	
Habitat loss: nesting and shelter habitat can be extensively damaged by bottom trawls	
Rescue Effect (immigration from an outside source)	
• *does species exist elsewhere (in Canada or outside)?*	Yes
• *status of the outside population(s)?*	Declining
• *is immigration possible?*	Yes
• *would immigrants be adapted to survive here?*	Probably
• *is there sufficient habitat for immigrants here?*	Unknown
Quantitative Analysis: available from scientific survey data, including joint US-Canada East Coast of North America Strategic Assessment Project (ECNASAP) database	
Sources of Information: ECNASAP database; DFO scientific survey cruises 1978-2000. Literature cited in report.	

ACKNOWLEDGEMENTS

Our research was supported in part by an undergraduate research award (NRO) and an operating grant (RLH) from NSERC, the Natural Sciences and Engineering Research Council of Canada. We thank David Kulka, DFO St. John's, for help in obtaining and understanding recent assessment data, and Ivone Figueiredo, IPIMAR Lisbon, for discussions on the statistical ins and outs of fisheries analyses. Kelly Barringon helped immensely with a final data reduction. The data and supporting materials used in the preparation of this report have been deposited in the Newfoundland Archive, Memorial University of Newfoundland.

LITERATURE CITED

Atkinson, D.B. 1994. Some observations on the biomass and abundance of fish captured during stratified random bottom trawl surveys in NAFO divisions 2J and 3KL, Autumn 1981-1991. *NAFO Scientific Council Studies* 21: 43-66.

Auster, P.J., R.J. Malatesta, R.W. Langton, L. Watling, P.C. Valentine, C.L. Donaldson, E.W. Langton, A.N. Shepard and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): implications for conservation of fish populations. *Reviews in Fisheries Science* 4: 185-202.

Beese, G. and R. Kandler. 1969. Beiträge zur Biologie der drei nordatlantischen Katfischarten *Anarhichas lupus* L., *A. minor* Olafs. und *A. denticulatus. Berichte. Deutscher Wissenschaftliche Kommission fuer Meeresforschung* 20: 21-29.

Bigelow, H.B. and W.C. Schroeder. 1953. *Fishes of the Gulf of Maine*, United States Government Printing Office, Washington DC, 577 pp.

Brown, S.K., R. Mahon, K.C.T. Zwanenberg, D.B. Atkinson, K.R. Buja, L. Claflin, G.D. Howell, M.E. Monaco, R.N. O'Boyle and M. Sinclair, M. 1996. *East coast of North America demersal fishes: initial explorations of biogeography and species assemblages*. National Oceanic and Atmospheric Administration, Silver Spring, Md., and Department of Fisheries and Oceans, Dartmouth, NS, 109 pp.

Bundy, A., G.R. Lilly and P.A. Shelton. 2000. A mass balance model of the Newfoundland-Labrador Shelf. *Canadian Technical Report of Fisheries and Aquatic Sciences* no. 2310: xiv + 157 pp.

Casey, J.M and R.A. Myers. 1998. Near extinction of a large, widely distributed fish. *Science* 281: 690-692.

Collie, J.S., G.A. Escanero and P.C. Valentine. 1997. Effects of bottom fishing on the benthic megafauna of Georges Bank. *Marine Ecology Progress Series* 155: 159-172.

DFO 2000. Letter and attached detailed comments from Howard Powles, Director Fisheries Research Branch, commenting on the Atlantic wolffish draft report, January 31, 2000.

Fischer, J. and R.L. Haedrich. 2000. The realized annual niche space of common fish species off Newfoundland. *NAFO Scientific Council Studies* 33: 11-28.

Frank, K.T., J.E. Carscadden and J.E. Simon. 1996. Recent excursions of capelin (*Mallotus villosus*) to the Scotian Shelf and Flemish Cap during anomalous

hydrographic conditions. *Canadian Journal of Fisheries and Aquatic Sciences* 53: 1473-1486.
FRCC (Fisheries Resource Conservation Council) (1996) *Building the Bridge: 1997 Conservation Requirements for Atlantic Groundfish*. Report to the Minister. Department of Fisheries and Oceans, Ottawa.
FRCC (Fisheries Resource Conservation Council) (2000) *2000 Conservation requirements for groundfish stocks on the Scotian Shelf and in the Bay of Fundy (4VWX), in sub-areas 0, 2 + 3 and redfish stocks*. FRCC.2000.R.1. Report to the Minister. Department of Fisheries and Oceans, Ottawa.
Gomes, M.C., R.L. Haedrich and M.G. Villagarcía. 1995. Spatial and temporal changes in the groundfish assemblages on the NE Newfoundland/Labrador Shelf, Northwest Atlantic, 1978–1991. *Fisheries Oceanography* 4(2): 85–101.
Goode, G.B. and T.H. Bean. 1895. *Oceanic Ichthyology*, US Government Printing Office, Washington DC, 533 pp. + 417 figs.
Haedrich, R.L. and S.M. Barnes. 1997. Changes over time of the size structure in an exploited shelf fish community. *Fisheries Research* 31: 229-239.
Haedrich, R.L., J. Fischer and N.V. Chernova. 1997. Ocean temperatures and demersal fish abundance on the northeast Newfoundland continental shelf. *Proceedings, 30th European Marine Biology Symposium,* Southampton UK, September 1995*,* pp. 211–222.
Hagen, N.T. and K.H. Mann. 1992. Functional response of the predators American lobster *Homarus americanus* (Milne-Edwards) and Atlantic wolffish *Anarhichas lupus* (L.) to increasing numbers of the green sea urchin *Strongylocentrotus droebachiensis*. *Journal of Experimental Marine Biology and Ecology* 159(1): 89-112.
Hutchings, J.A. 2000. Collapse and recovery of marine fishes. *Nature* 406: 882-885, 24 August 2000.
Jennings, S. and M.J. Kaiser. 1998. The effects of fishing on marine ecosystems. *Advances in Marine Biology* 34: 201-352.
Jónsson, G. 1982. Contribution to the biology of catfish (*Anarhichas lupus*) at Iceland. *Rit Fiskideildar* 6: 2-26.
Keats, D.W., G.R. South and D.H. Steele. 1985. Reproduction and egg guarding by Atlantic wolffish (*Anarhichas lupus*: Anarhichadidae) and ocean pout (*Macrozoarces americanus*: Zoarcidae) in Newfoundland (Canada) waters. *Canadian Journal of Zoology* 63 (11): 2565-2568
Keats, D.W., G.R. South and D.H. Steele. 1986. Where do juvenile Atlantic wolffish, *Anarhichas lupus*, live? *Canadian Field Naturalist* 100 (4): 556-558.
Kulka, D.W. and E.M. DeBlois. 1997. Non-traditional groundfish species on Labrador Shelf and Grand Banks: Wolffish, Monkfish, White Hake, and Winter (Blackback) Flounder. *DFO Atlantic Fisheries Res. Doc*. 96/97, 49 pp.
Mahon, R., S.K. Brown, K.C.T. Zwanenburg, D.B. Atkinson, K.R. Buja, L. Claflin, G.D. Howell, M.E. Monaco, R.N. O'Boyle and M. Sinclair. 1998. Assemblages and biogeography of demersal fishes of the east coast of North America. *Canadian Journal of Fisheries and Aquatic Sciences* 55: 1704-1738.

Messieh, S.N., T.W. Rowell, D.L. Peer, D.L. and P.J. Cranford. 1991. The effects of trawling, dredging and ocean dumping on the eastern Canadian continental shelf seabed. *Continental Shelf Research* 11 (8-10): 1237-1263.

Musick, J.A. 1999. Criteria to define extinction risk in marine fishes. *Fisheries* 24(12): 6-14.

Möller, V. and H.J. Rätz. 1999. Assessment of Atlantic wolffish (*Anarhichas lupus* L.) off west and east Greenland, 1982-98. *NAFO SCR Doc.* 99/37, ser. No. N4095, 14 pp.

Nelson, G.A. and M.R. Ross. 1992. Distribution, growth and food habits of the Atlantic wolffish (*Anarhichas lupus*) from the Gulf of Maine-Georges Bank region. *Journal of Northwest Atlantic Fishery Science* 13: 53-61.

Pavlov, D.A. and G.G. Novikov. 1993. Life history and peculiarities of common wolffish (*Anarhichas lupus*) in the White Sea. *ICES Journal of Marine Science* 50 (3): 271-277.

Rätz, H.J. 1997. Structures and changes of the demersal fish assemblage off Greenland, 1982-96. *NAFO Scientific Council Studies* 32: 1-15.

Schneider, D.W., T. Bult, R.S. Gregory, D.A. Methven, D.W. Ings and V. Gotceitas. 1999. Mortality, movement, and body size: critical scales for Atlantic cod (*Gadus morhua*) in the northwest Atlantic. *Canadian Journal of Fisheries and Aquatic Sciences* 56(Suppl. 1): 180-187.

Scott, W.B. and M.G. Scott. 1988. Atlantic Fishes of Canada. *Canadian Bulletin of Fisheries and Aquatic Sciences* 219, 731 pp.

Sinclair, Alan F. and Steven A. Murawski. 1997. Why have groundfish stocks declined? pp. 71–93 *in*: J. Boreman, B.S. Nakashima, J.A. Wilson and R.L. Kendall (eds.), *Northwest Atlantic Groundfish: Perspectives on a Fishery in Collapse*. Bethesda: American Fisheries Society.

Stokesbury, K.D.E. and J.H. Himmelmann. 1995. Biological and physical variables associated with aggregations of the giant scallop *Placopecten magellanicus*. *Canadian Journal of Fisheries and Aquatic Sciences* 52 (4): 743-753.

Templeman, W. 1984. Migrations of wolffishes, *Anarhichas* sp., from tagging in the Newfoundland area. *Journal of Northwest Atlantic Fisheries Science* 5: 93-97.

Templeman, W. 1986. Some biological aspects of Atlantic wolffish (*Anarhichas lupus*) in the northwest Atlantic. *Journal of Northwest Atlantic Fisheries Science* 7 (1): 57-66.

Villagarcía, M.G. 1995. Structure and Distribution of Demersal Fish Assemblages on the Northeast Newfoundland/Labrador Shelf. M.Sc. Thesis, Department of Biology, Memorial University of Newfoundland, St. John's, 89 pp.

Villagarcía, M.G., R.L Haedrich and J. Fischer. 1999. Groundfish assemblages of eastern Canada examined over two decades. pp. 239-259 *in:* D. Newell and R.E. Ommer (eds.), *Fishing Places, Fishing People*. University of Toronto Press, Toronto.

Watling, L. and E.A. Norse. 1998. Disturbance of the seabed by mobile fishing gear: A comparison to forest clearcutting. *Conservation Biology* 12 (6): 1180–1197.

Wheeler, A. 1969. The Fishes of the British Isles and North West Europe. Michigan State University Press, East Lansing MI, 613 pp.

Whitehead, P.J.P., M.L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese. (eds) 1986. *Fishes of the North-eastern Atlantic and the Mediterranean*, Unesco, Paris, vol. 3, 1115.

Witman, J.D. and K.P. Sebens. 1992. Regional variations in fish predation intensity: A historical perspective in the Gulf of Maine. *Oecologia (Heidelberg)* 90 (3): 305-315.

THE AUTHORS

Niall O'Dea is an undergraduate student at Memorial University of Newfoundland studying concurrently for a Bachelor of Science, Honours, in biology and a Bachelor of Arts in philosophy. His interest is in issues related to biodiversity and to species, and, more specifically, in how these amorphous concepts can be better understood, valuated, and quantified to achieve practical and critically important conservation objectives. For the summer of 1999, and for the previous summer as well, his research was funded by an Undergraduate Research Award from Canada's Natural Sciences and Engineering Research Council (NSERC). In 2000, he was nominated a Rhodes Scholar and will continue his studies at Oxford University.

Richard Haedrich is an ichthyologist and biological oceanographer. His degrees are from Harvard (A.B., 1961; A.M., 1963; Ph.D., 1966) where his Ph.D. thesis concerned the systematics and zoogeography of the stromateoid fishes. He spent a year in Denmark as a Fulbright Fellow doing further systematic research, and then returned to a position as a research scientist at the Woods Hole Oceanographic Institution. In 1979, he left Woods Hole to join Memorial University of Newfoundland, where he has been a Professor in Biology and Ocean Sciences and was appointed recently to the rank of University Research Professor. He is the author of over 120 publications, with recent topics focused on community changes in the fishery ecosystem of Newfoundland before, during and after its major collapse. With Nigel Merrett of the Natural History Museum, London, he is co-author of the 1997 book *Deep-Sea Fish and Fisheries*.