Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences

Newfoundland and Labrador, Maritimes, Gulf, Quebec, and Central and Arctic Regions

Canadian Science Advisory Secretariat
Science Advisory Report 2014/022

WOLFFISH IN THE ATLANTIC AND ARCTIC REGIONS

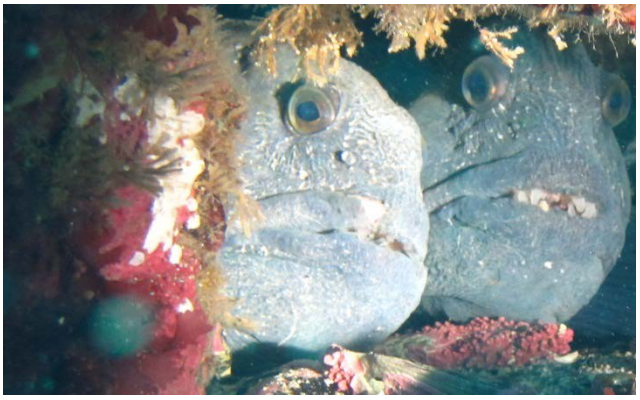

Photo by Trevor Maddigan, DFO-NL Region

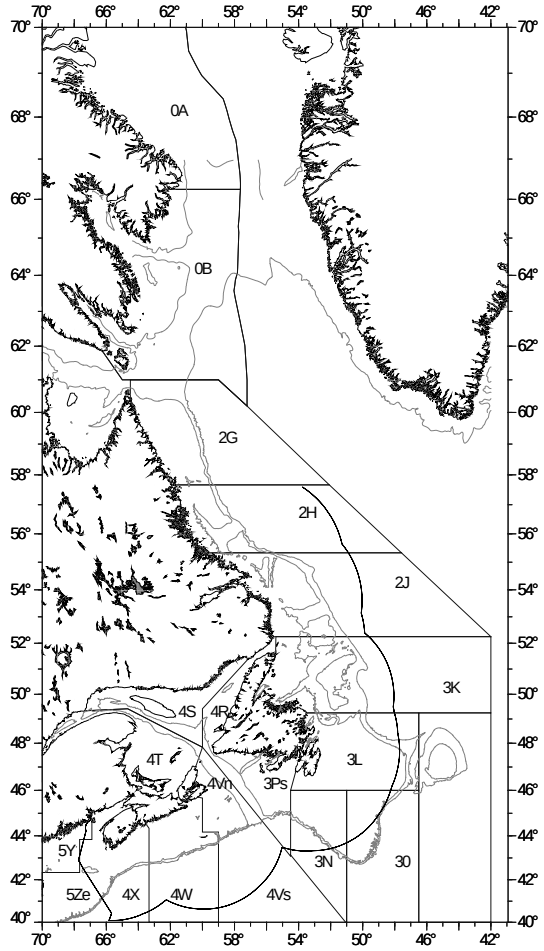

Figure 1. Map of the relevant portion of the NAFO Convention Area.

Context

Three wolffish species are found in Canadian Atlantic and Arctic waters: Anarhichas denticulatus *(Northern Wolffish),* A. minor *(Spotted Wolffish), and* A. lupus *(Atlantic Wolffish).The first two species were designated as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2001, while Atlantic Wolffish was designated as Special Concern. Upon passage of the* Species at Risk Act *(SARA) in June 2003, these species were listed on Schedule 1 of SARA.*

COSEWIC recently (November, 2012) re-assessed the status of the three wolffish species, and upheld the designations of Threatened for Northern Wolffish and Spotted Wolffish, and Special Concern for Atlantic Wolffish.

This Science Advisory Report was generated by the February 26-27, 2014 Zonal Assessment of Northern, Spotted and Atlantic Wolffish to update and support specific processes with regards to recovery targets, allowable harm and other related aspects of SARA. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule.

Canada

SUMMARY

- Abundance indices for all three wolffish species throughout Canadian Atlantic and Arctic waters have been stable or at higher values since the mid-2000s compared to the 1990s. However, there are areas where catches are sporadic because the species are scarce and represent a minor portion of the overall population.
- Although some increases in abundance have occurred in some areas, levels for Northern and Spotted Wolffish in the Northwest Atlantic Fisheries Organization (NAFO) Div. 2J3K, where the majority of both populations resided, remain low relative to historic values.
- Due to an overall reduction in fishing effort since the 1990s, and mandatory release of both Northern Wolffish and Spotted Wolffish since 2003, mortality due to fishing of these two species has been reduced in Canada's Exclusive Economic Zone (EEZ).
- Proposed interim recovery targets consistent with Fisheries and Oceans Canada's (DFO) Precautionary Approach Framework were proposed but rejected based on concerns related to survey gear conversion factors. Further research should be conducted to determine a method of combining survey time series.
- The current levels of Canadian fisheries observer coverage in three major trawl fisheries in Newfoundland and Labrador (Greenland Halibut; Yellowtail Flounder; offshore Northern Shrimp) are adequate and effective in the determination of harm on wolffish, where they are a common bycatch species. Observer coverage could not be evaluated in other fisheries due to the lack of appropriate data.
- The maximum allowable harm that these species can sustain (while not jeopardizing their survival or recovery) could not be adequately quantified due to limitations in population modeling and uncertainty of their population dynamics. However, given levels of harm that occurred over the past decade, the decline in wolffish abundance has not continued, and has reversed in many areas, which suggests that the current harm is sustainable assuming that future stock productivity is similar to that observed in recent time periods.

INTRODUCTION

Wolffish (family Anarhichadidae) inhabit a wide range of northern latitudes and depths in the Atlantic and Pacific Oceans (Scott and Scott 1988). Three wolffish species are found in the Canadian Atlantic and Arctic waters: *Anarhichas denticulatus* (Northern Wolffish), *A. minor* (Spotted Wolffish), and *A. lupus* (Atlantic Wolffish). The first two species were designated as Threatened by the Committee on the Status of Endangered Wildlife in Canada in 2001 (COSEWIC 2001a,b), while Atlantic Wolffish was designated as Special Concern in 2000 (COSEWIC 2000). In September 2010, a zonal review of available data was presented (Dutil et al. 2011; Simon et al. 2012; Simpson et al. 2012). In November 2012, COSEWIC re-evaluated the status of wolffish in Canada, and concluded that, despite signs of population recovery, Northern Wolffish and Spotted Wolffish remain Threatened, while Atlantic Wolffish remains a species of Special Concern (COSEWIC 2012). A Recovery Strategy/Management Plan was developed for the Northern Wolffish, Spotted Wolffish, and Atlantic Wolffish (Kulka et al. 2004, 2007; DFO 2013). In January of 2013, Northern Wolffish, Spotted Wolffish, and Atlantic Wolffish were assessed zonally with respect to their population status, life history, and habitat (Simpson et al. 2013a,b,c).

This paper provides an update on the distribution and abundance indices for Northern Wolffish, Spotted Wolffish, and Atlantic Wolffish, estimates fisheries removals, and evaluates Canadian Fisheries Observer coverage with respect to allowable harm of wolffish in Canada's EEZ.

Species Biology

General species biology has been described at length in previous research documents (Dutil et al. 2011; Ouellet et al. 2011; Simon et al. 2012; Simpson et al. 2012; Simpson et al. 2013a,b,c) and is not repeated here.

ASSESSMENT

Distribution and Abundance

Overall, abundance indices for all three wolffish species throughout Canadian Atlantic and Arctic waters have been stable or at higher values since the mid-2000s compared to the 1990s. However, there are areas where catches are sporadic because the species are scarce and represent a minor portion of the overall populations. Although some increases in abundance have occurred in some areas, levels for Northern Wolffish and Spotted Wolffish in Div. 2J3K, where the majority of both populations resided, remain low relative to historic values.

Central and Arctic

The three wolffish species are found in NAFO Subarea 0. However, abundances are low, and no directed fishery has ever occurred. Research surveys conducted by DFO from 1978-2013 caught Northern, Spotted, and Atlantic Wolffish in Subarea 0, but close to the boundaries of Subarea 1 (Greenland waters) and Div. 2G, possibly reflecting extensions of stocks from one or both of these areas.

Newfoundland and Labrador

Information on the resource status of wolffish in Newfoundland and Labrador waters is collected during annual DFO spring and fall research surveys. All three wolffish species continue to show their highest densities and cover their largest areas on the northeast Newfoundland and southern Labrador shelves.

Abundance indices for Northern Wolffish in Div. 2GH have been sporadic throughout the fall survey time series; although the index in Div. 2H was consistent and stable over the past three years. Div. 2G was last surveyed in 1999. Since 1995, the fall survey abundance index for this species in Div. 2J3K increased slightly (Fig. 2). Survey abundance indices in Div. 3LNO during fall and spring were relatively stable since the introduction of the Campelen trawl. The spring survey index in Subdiv. 3Ps varied without trend (Fig. 2).

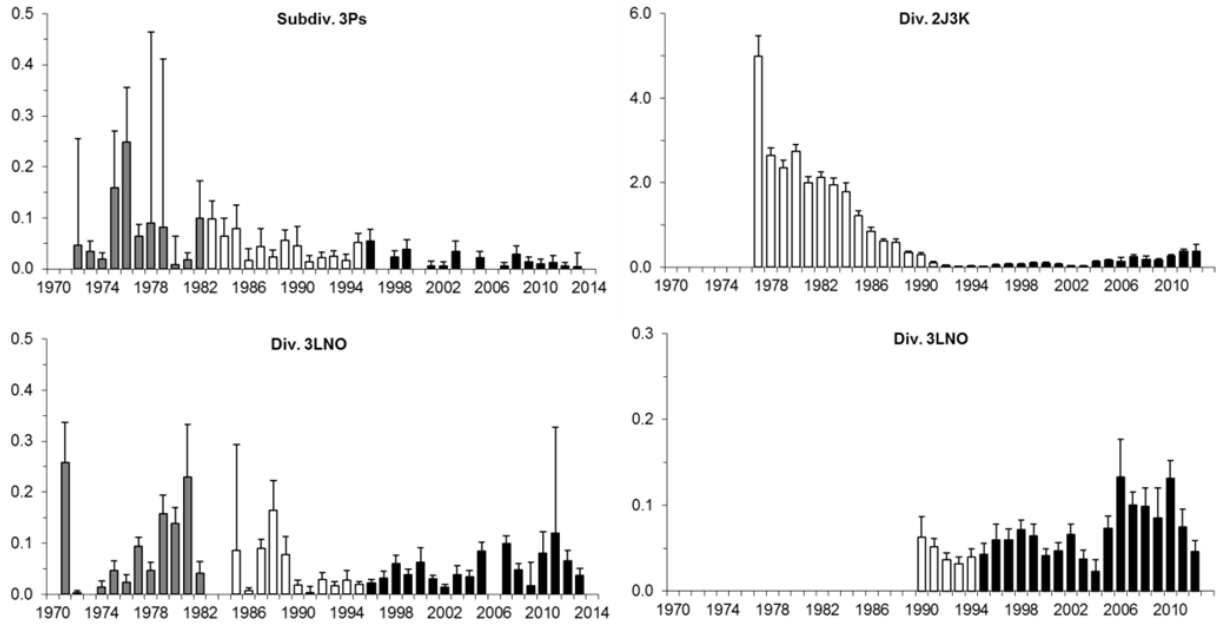

Figure 2. Abundance indices (mean number per tow) for Northern Wolffish in Div. 2J3K, Div. 3LNO, and Subdiv. 3Ps during DFO spring (left column) and fall (right column) research surveys. Different trawl gears are represented by bar colour (grey=Yankee; white=Engel; black=Campelen). T-bar = 1 SE.

Abundance indices for Spotted Wolffish in Div. 2GH have been sporadic throughout the fall survey time series, although the index in Div. 2H was consistent and stable over the past three years. Div. 2G was last surveyed in 1999. Since 1995, the abundance index for this species generally increased in the fall survey of Div. 2J3K (Fig. 3). The fall and spring survey abundance indices in Div. 3LNO were generally higher since the mid-2000s, relative to the 1990s and early 2000s. The spring survey index in Subdiv. 3Ps varied without trend since introduction of the Campelen trawl (Fig. 3).

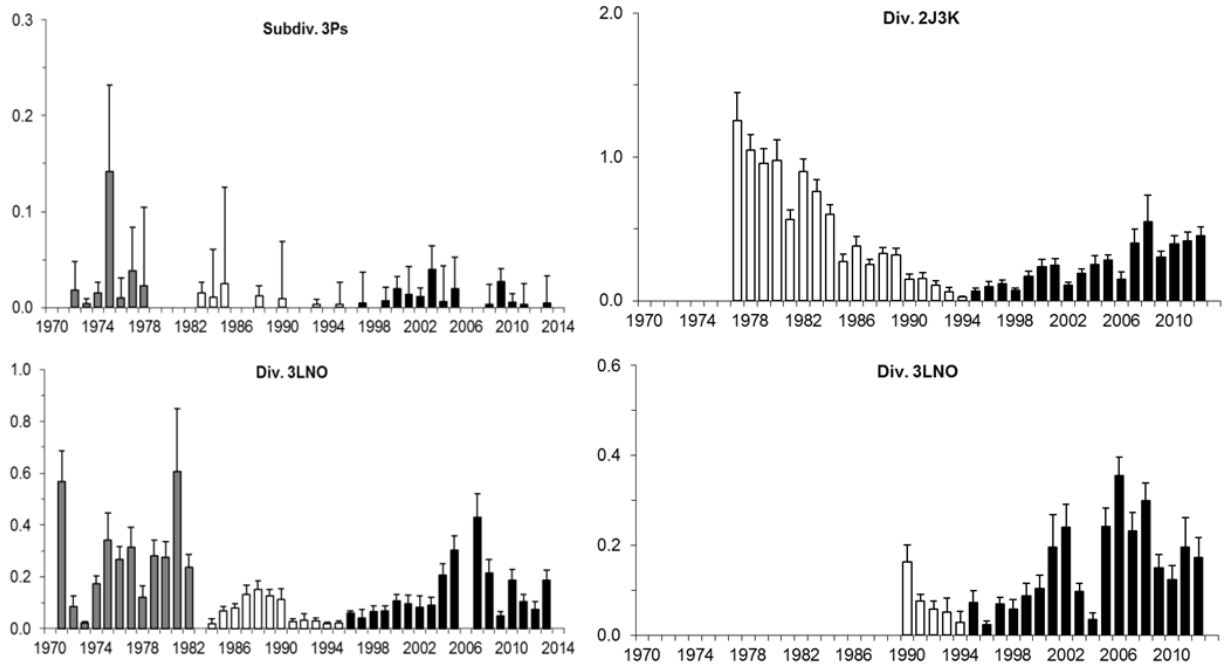

Figure 3. Abundance indices (mean number per tow) for Spotted Wolffish in Div. 2J3K, Div. 3LNO, and Subdiv. 3Ps during DFO spring (left column) and fall (right column) research surveys. Different trawl gears are represented by bar colour (grey=Yankee; white=Engel; black=Campelen). T-bar = 1 SE.

Abundance indices for Atlantic Wolffish in Div. 2GH were sporadic throughout the fall survey time series. Div. 2G was last surveyed in 1999. Since 1995, the fall survey abundance index for Atlantic Wolffish in Div. 2J3K has been relatively stable, while the fall index in Div. 3LNO was generally higher since the mid-2000s (Fig. 4). The spring survey abundance index for this species in Div. 3LNO peaked between 2005 and 2007 but, overall, was generally stable since introduction of the Campelen trawl. This index varied without trend in Subdiv. 3Ps (Fig. 4).

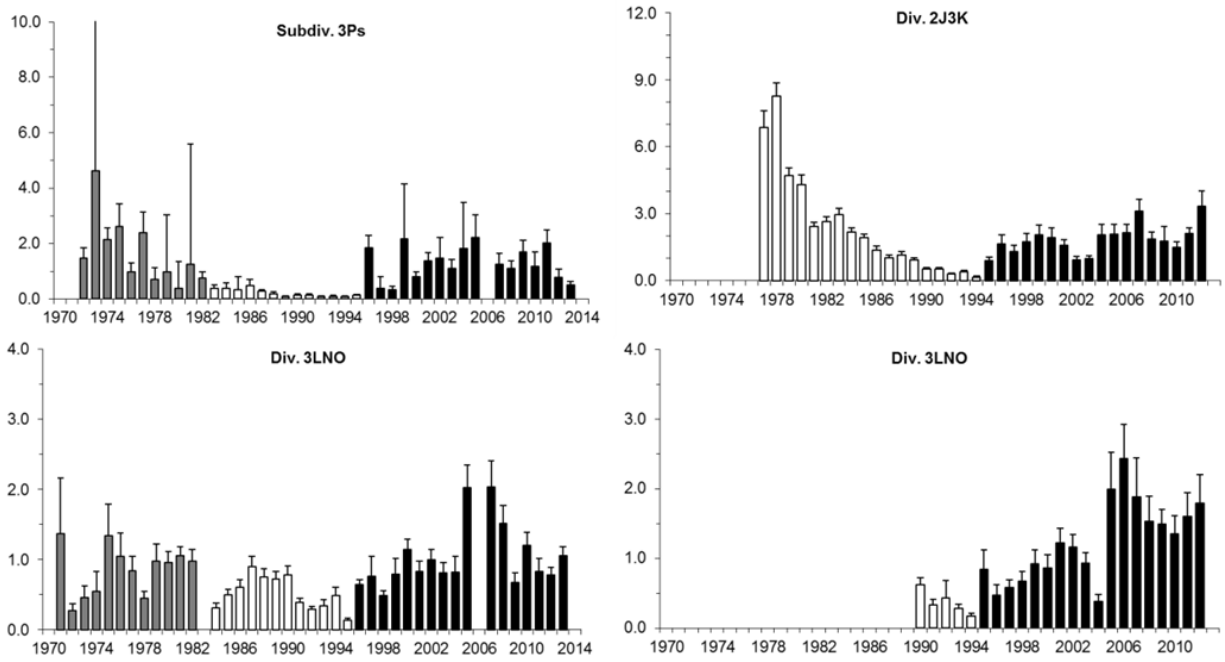

Figure 4. Abundance indices (mean number per tow) for Atlantic Wolffish in Div. 2J3K, Div. 3LNO, and Subdiv. 3Ps during DFO spring (left column) and fall (right column) research surveys. Different trawl gears are represented by bar colour (grey=Yankee; white=Engel; black=Campelen). T-bar = 1 SE.

Gulf and Quebec - Gulf of St. Lawrence (GSL)

Northern Wolffish have never been abundant in the GSL during the surveyed period, 1990-2013. It was virtually absent from the southern GSL, except for a few catches on slopes of the Laurentian Channel. Most individuals were captured on slopes or on the shelf off of the southwest coast of Newfoundland. Northern Wolffish were caught only occasionally during summer surveys of the northern GSL (Div. 4RS); thus, no trend was apparent (Fig. 5).

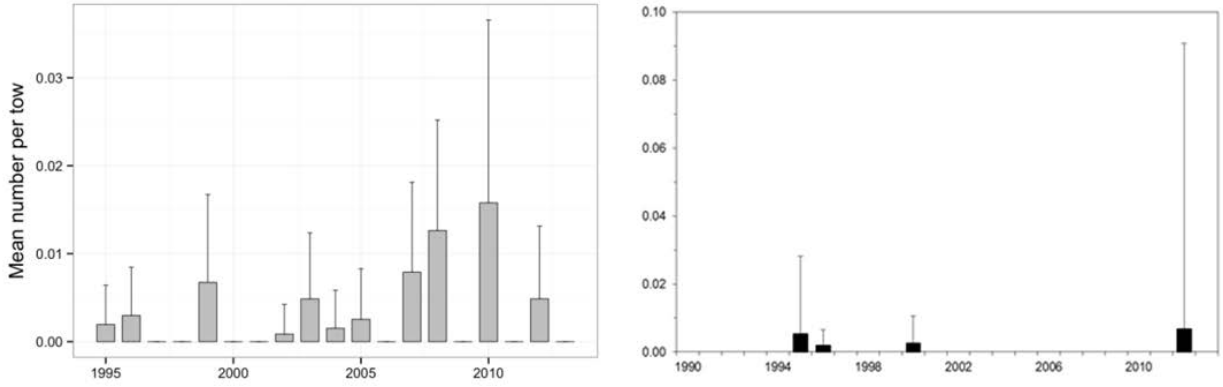

Figure 5. Abundance indices (mean number per tow) for Northern Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during mobile sentinel surveys, 1995-2013 (left), and DFO research surveys (right), 1990-2013. Error bars are upper 95 % confidence intervals. The gear and vessel for the DFO research survey changed in 2005.

Although less rare than Northern Wolffish, most catches of Spotted Wolffish were recorded in the northeastern part of the GSL, on the slopes of the Esquiman Channel, and on the shelf off of the west coast of Newfoundland. In combination, the two surveys did not indicate any catch trends (Fig. 6).

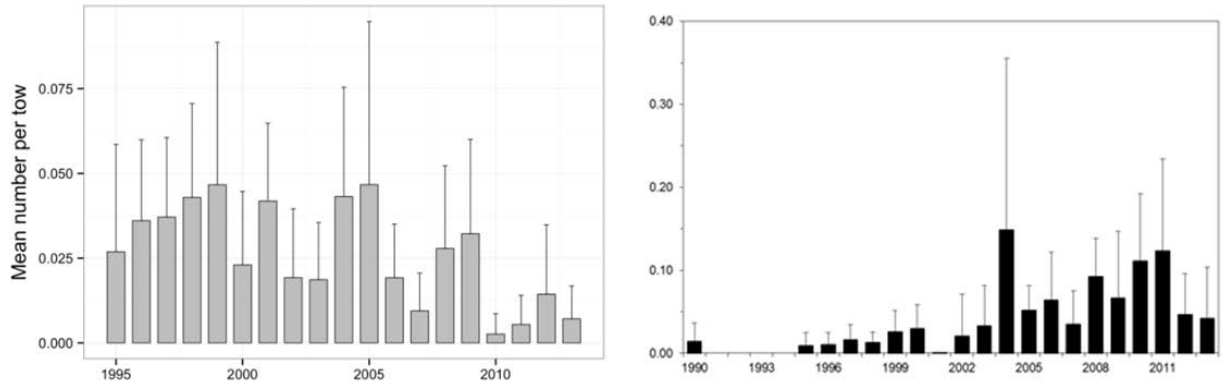

Figure 6. Abundance indices (mean number per tow) for Spotted Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during mobile sentinel surveys, 1995-2013 (left), and DFO research surveys (right), 1990-2013. Error bars are upper 95 % confidence intervals. The gear and vessel for the DFO research survey changed in 2005.

Atlantic Wolffish are more widespread in the GSL, except in the Estuary. This species was most abundant on upper slopes of deep channels and on the shelves, especially the shelf off of Newfoundland's west coast. Spotted and Atlantic Wolffish showed a large degree of spatial overlap, with Atlantic Wolffish occurring more closely to coastlines, and avoiding deep channels. No trend in Atlantic Wolffish catch rates was apparent (Fig. 7).

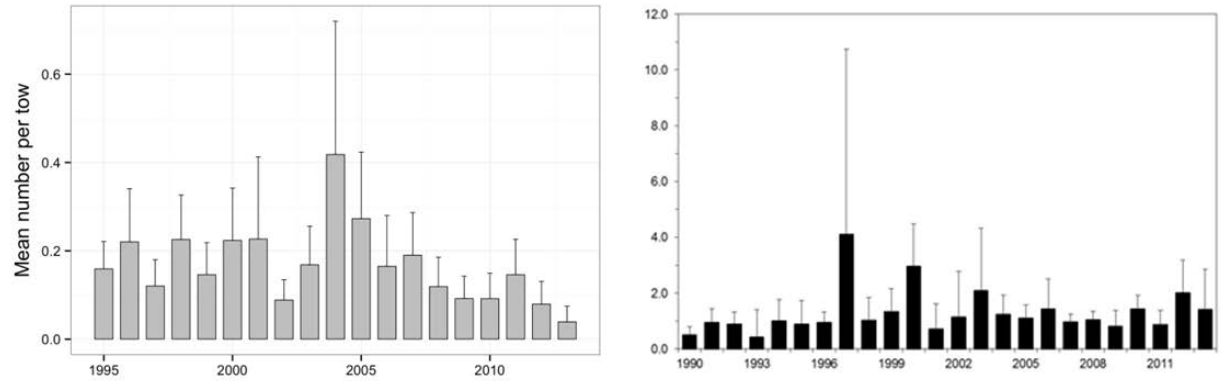

Figure 7. Abundance indices (mean number per tow) for Atlantic Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during mobile sentinel surveys, 1995-2013 (left), and DFO research surveys (right), 1990-2013. Error bars are upper 95 % confidence intervals. The gear and vessel for the DFO research survey changed in 2005.

In the southern Gulf of St. Lawrence (sGSL) in Div. 4T, catches of Northern Wolffish and Spotted Wolffish are rare, and no trends are evident (Fig. 8).

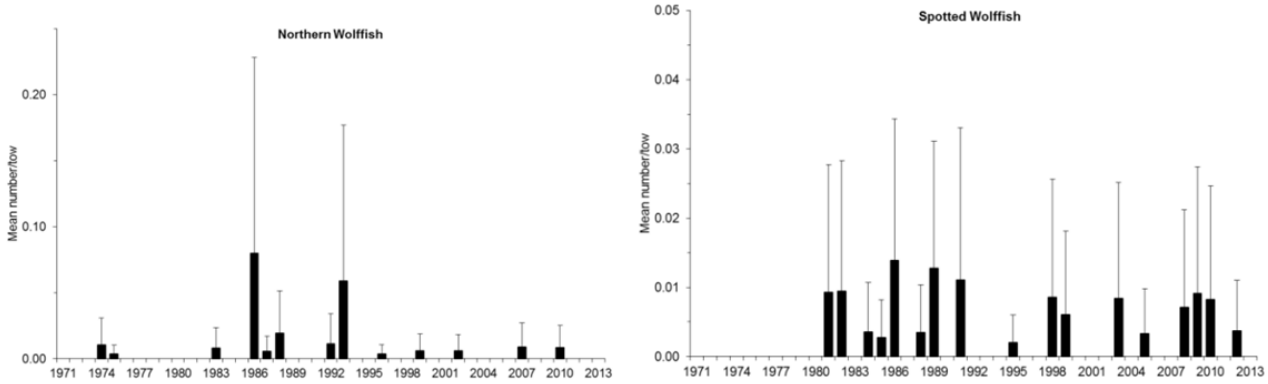

Figure 8. Abundance indices (mean number per tow) for Northern Wolffish (left) and Spotted Wolffish (right) in Div. 4T (southern Gulf of St. Lawrence) from the DFO September research survey, 1971-2013. Error bars are upper 95 % confidence intervals. The gear and vessel changed in 2005.

In Div. 4T, Atlantic Wolffish was the most commonly caught of the three species. The mean abundance index in the DFO September research survey was at a relatively low level from 1971 to the late 1980s, at an elevated level to the mid-1990s, then returned to a lower level from the late 1990s to present (Fig. 9). In recent years, Atlantic Wolffish were typically caught in one or two sets per survey - generally along the edge of the Laurentian Channel, but also in other areas.

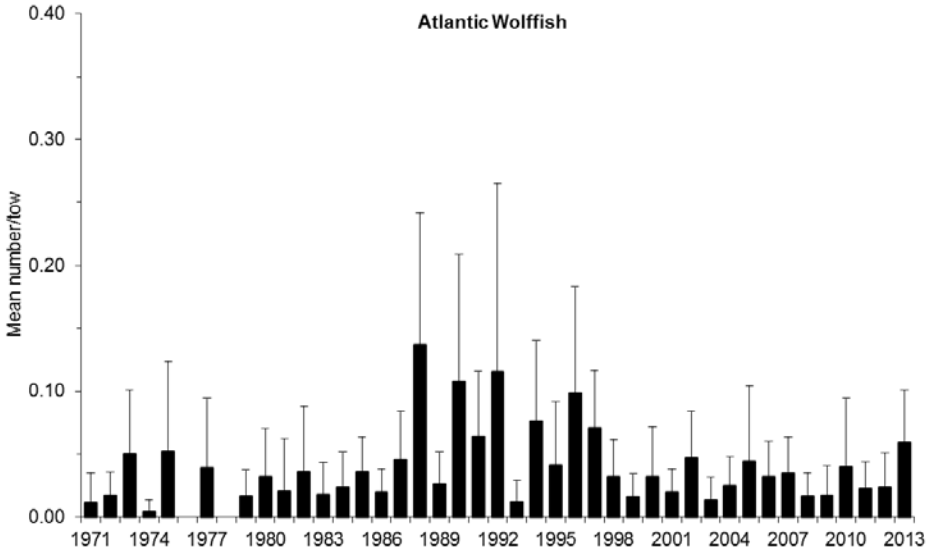

Figure 9. Abundance indices (mean number per tow) for Atlantic Wolffish in Div. 4T (southern Gulf of St. Lawrence) from the DFO September research survey, 1971-2013. Error bars are upper 95 % confidence intervals. The gear and vessel changed in 2005.

Maritimes

The DFO summer survey has been conducted annually on the Scotian Shelf (Div. 4VWX) since 1970, using a stratified random design based on depth and geographic area. In 1970-1981, this

survey was conducted using a Yankee 36 trawl, and was replaced in 1982 by the Western IIA as standard survey gear. No conversion factors were applied to these data.

The composite distribution pattern revealed two primary areas of wolffish concentration: on the eastern Scotian Shelf (including Subdiv. 4Vn), and on the western Scotian Shelf (Div. 4X; primarily Brown's Bank).

Mean number per tow for Atlantic Wolffish in Maritime waters has declined since the mid-1990s (Fig. 10). Estimates for the past four years remained below the long term average.

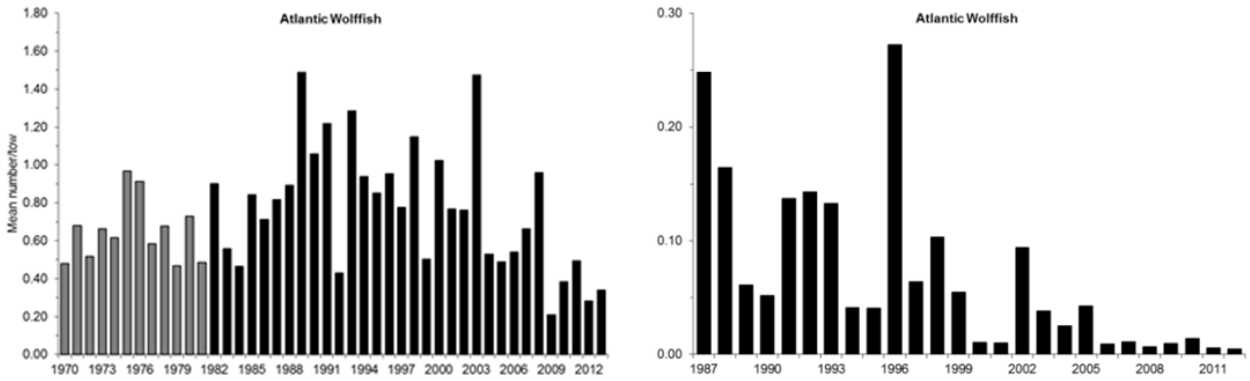

Figure 10. Abundance indices (number per tow) for Atlantic Wolffish in Div. 4VWX (left) and on Georges Bank (right) during research surveys. Different trawl gears are represented by bar colour (grey=Yankee; black=Western).

Northern Wolffish and Spotted Wolffish are infrequently captured in the Div. 4VWX summer research survey. There were also records of this species on the outer edge of the Scotian Shelf in Div. 4WX. Spotted Wolffish were restricted to Subdiv. 4Vn and 4Vs, with some records on the eastern edge of Div. 4W. Neither Northern Wolffish nor Spotted Wolffish were captured in recent years.

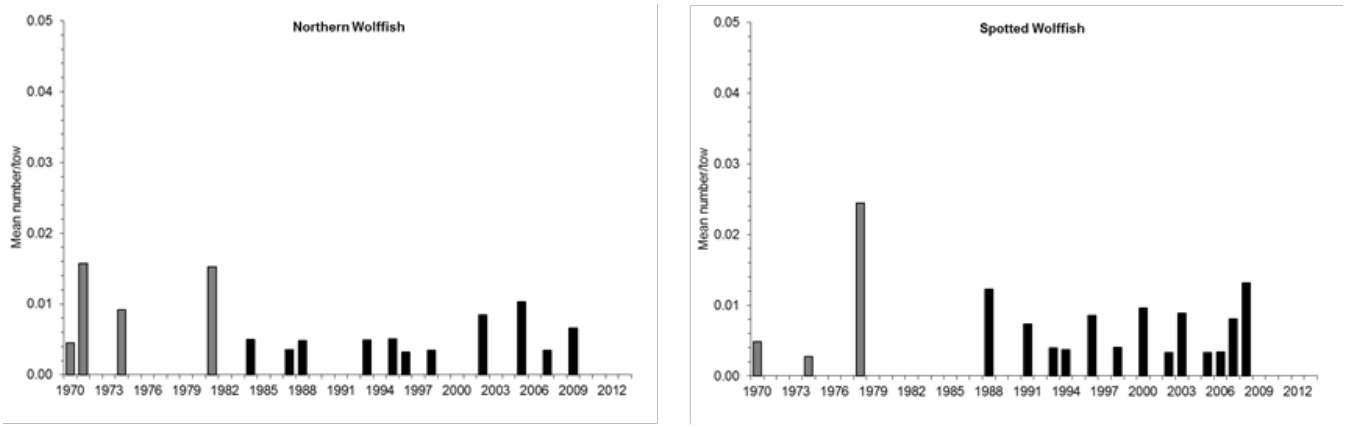

Figure 11. Abundance indices (mean number per tow) for Northern Wolffish (left) and Spotted Wolffish (right) in Div. 4VWX from the DFO Maritimes research survey, 1970-2013. Different trawl gears are represented by bar colour (grey=Yankee; black=Western).

Recovery Targets

Empirical Biological Reference Points (BRPs) were previously considered appropriate as interim recovery targets for wolffish, given the lack of a quantitative model for these species. In this assessment, various proxies for Biomass at Maximum Sustainable Yield (B_{MSY}) were calculated using:

(1) the complete time-series;

(2) the period of highest productivity (i.e., successive years of high stock biomass);

(3) the highest annual biomass estimate (B_{MAX});

(4) the top three biomass estimates;

(5) B_{MAX} plus the biomass estimates for year t±1 ($B_{MAX}+B_{t±1}$);

(6) $B_{MAX}+B_{t±2}$; and

(7) $B_{MAX}+B_{t±3}$.

In each case, recovery targets were calculated as 40 % and 80 % of B_{MSY}, respectively.

However, proposed interim recovery targets consistent with the DFO Precautionary Approach Framework were rejected based on concerns related to research survey gear conversion factors. Further research should be conducted to determine a statistically acceptable method for combining survey time series.

Fishery Removals and Mortality

Landings

Reported landings of wolffish peaked at 8,500 t in 1971 throughout the entire Canadian zone of interest (NAFO Subarea 0 and Divisions 2GH, 2J3K, 3LNO, 3P, 4RST, 4VWX; 5YZ), then subsequently declined (Fig. 12). Since 2003, with the passage of Canada's *Species at Risk Act* (SARA), landings have consisted solely of Atlantic Wolffish due to mandatory release of both Northern Wolffish and Spotted Wolffish. It is thus assumed that fishing mortality of Northern and Spotted Wolffish has been reduced in Canada's EEZ.

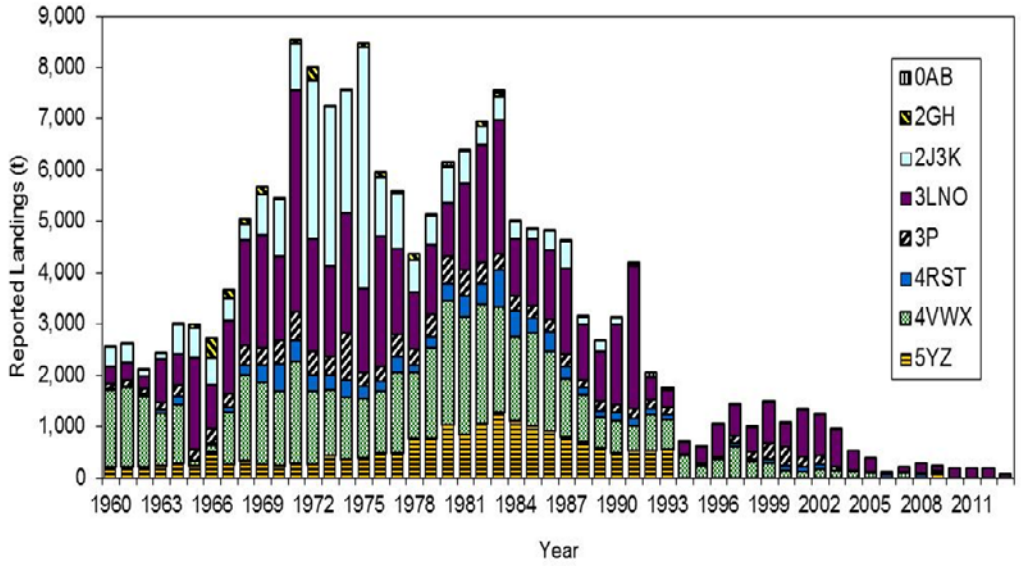

Figure 12. Reported landings of unspeciated wolffish in 1960-2013 from NAFO, DFO-NL Zonal Interchange File Format (ZIFF), and DFO-Maritimes fisheries (MARFIS) databases.

Based on Canadian at-sea Fisheries Observers' data, scaled up to entire fisheries conducted in Newfoundland and Labrador waters, catches of Northern Wolffish occurred primarily in the Div. 2J3KL Greenland Halibut trawl fishery. This species was also captured in the Div. 3K Snow Crab pot fishery. In the offshore shrimp fishery, retention of mature Northern Wolffish in shrimp trawls became insignificant after 1993, when a groundfish excluder (e.g., Nordmore grate) was introduced and some >100 foot shrimp vessels began using it. In 1997, this groundfish excluder became mandatory for all shrimp trawls fishing in all areas at all times. Northern Wolffish bycatch was negligible in the Div. 3NO Yellowtail Flounder trawl fishery.

Spotted Wolffish were primarily caught in the Div. 3KL Snow Crab pot fishery. In the Div. 2J3KL Greenland Halibut trawl fishery, Spotted Wolffish were mainly caught in Div. 3L during 2000-03, but appeared insignificant since then. This species was rarely captured in the Div. 3NO Yellowtail Flounder trawl fishery in 1985-2012.

Atlantic Wolffish were primarily captured in the Div. 3N Yellowtail Flounder trawl fishery, and in the Div. 3KL Snow Crab pot fishery. Bycatch in the Div. 2J3KL Greenland Halibut trawl fishery was negligible.

SARA logbook data from NL fishers aboard >35 foot commercial vessels fishing in Canada's EEZ are presented in Tables 1a-1c. The percentage of Northern Wolffish released alive at sea increased from 58 % in 2004 to over 90% annually from 2005-09. It has declined to 20 % in 2012. In contrast, over 90 % of Spotted Wolffish caught from 2004-11 was released alive. For Atlantic Wolffish, which can be commercially retained under SARA, the percentage released alive from 2005-10 varied between 68 % and 95 % annually, but then declined to about 25 % in 2012. The number of Northern, Spotted, and Atlantic Wolffish recorded in SARA logbooks increased since 2004. Data for 2013 were incomplete as of February 2014, and indicated that recorded catches totalled 13,149 Northern Wolffish (30 % dead), 8,661 Spotted Wolffish (39 % dead), and 4,738 Atlantic Wolffish (73 % dead).

Table 1a. Condition of Northern Wolffish (numbers) when released at-sea by NL fishers from 2004-13. Data as of February, 2014.

Condition	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Alive	18	121	1,118	1,402	1,482	3,535	4,258	2,967	2,179	9,142
Dead	13	1	78	67	56	314	4,775	8,899	8,663	4,007
% Alive	**58**	**99**	**94**	**95**	**96**	**92**	**47**	**25**	**20**	**70**

Table 1b. Condition of Spotted Wolffish (numbers) when released at-sea by NL fishers from 2004-13. Data as of February, 2014.

Condition	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Alive	52	888	1,913	6,896	5,732	14,347	11,542	11,120	8,350	5,311
Dead	0	41	28	64	249	91	417	600	1,712	3,350
% Alive	**100**	**96**	**99**	**99**	**96**	**99**	**97**	**95**	**83**	**61**

Table 1c. Condition of Atlantic Wolffish (numbers) when released at-sea by NL fishers from 2004-13. Data as of February, 2014.

Condition	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Alive	-	450	1,023	1,103	865	2,237	2,482	3,674	1,871	1,294
Dead	-	58	51	99	397	430	1,177	8,076	5,501	3,444
% Alive	**-**	**89**	**95**	**92**	**69**	**84**	**68**	**31**	**25**	**27**

Observer Coverage

To assist in providing advice on future levels of Canadian at-sea Fisheries Observer coverage for NL waters, simulations were conducted for each of three major NL fisheries with wolffish bycatch: Div. 2J3KL Greenland Halibut, Div. 3NO Yellowtail Flounder, and offshore shrimp (*Pandalus borealis* and *P. montagui*).

The simulation of various levels of at-sea Observer coverage for the Div. 2J3KL Greenland Halibut (Fig. 13), Div. 3NO Yellowtail Flounder (Fig. 14), and offshore shrimp (Fig. 15) fisheries generated different Coefficients of Variation (CV) between each wolffish species, and for each fishery. Using the CV30 (i.e., CV = 30 %) precision standard set by the National Oceanic and Atmospheric Administration (NOAA, USA), simulation results for Northern Wolffish indicated that an observer coverage level of at least 5 % in the Div. 2J3KL Greenland Halibut trawl fishery achieved the minimum standard (Fig. 13). Concerning Spotted Wolffish bycatch in this fishery, 10% coverage met the CV30 standard. The risk of an imprecise or unreliable estimate of bycatch increased non-linearly with the CV.

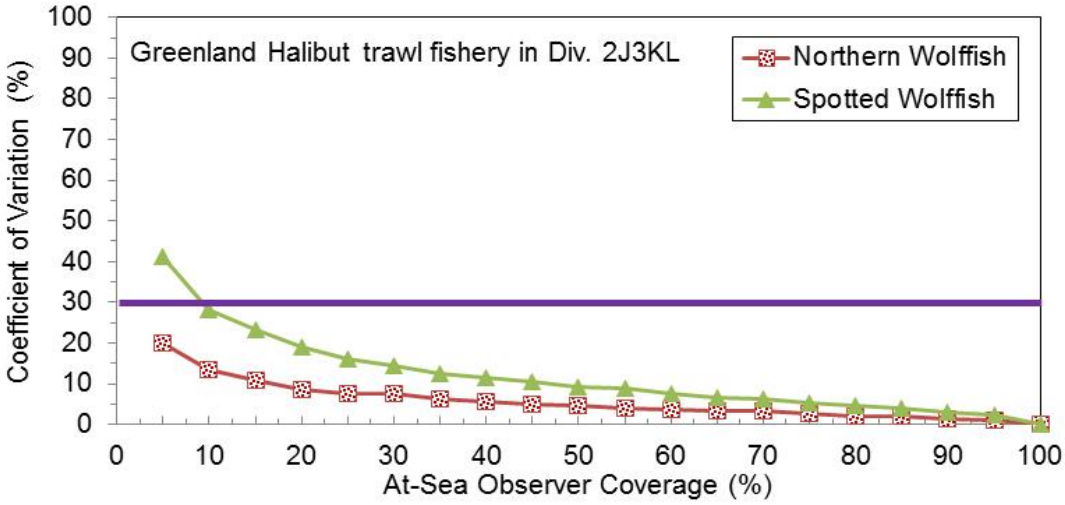

Figure 13. Coefficients of Variation for each wolffish species in 100% observed sets from the Greenland Halibut (Turbot) fishery in Div. 2J3KL, 2000-12. For each level of simulated observer coverage, available sets were randomly sampled 500 times without replacement. Note that Atlantic Wolffish was not caught in this fishery.

For the Div. 3NO Yellowtail Flounder trawl fishery, simulation results for Northern Wolffish and Spotted Wolffish suggested that at least 90 % of these trips should have observers on board, in order to achieve the CV30 standard (Fig. 14). However, both species were rarely caught in this shallow water fishery. With respect to Atlantic Wolffish bycatch, a minimum of 25 % coverage was required to meet the CV30 standard.

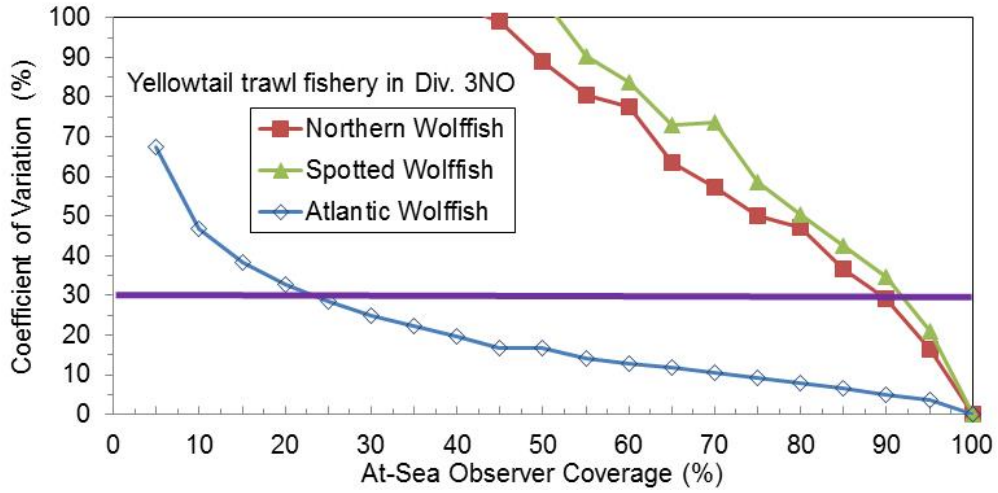

Figure 14. Coefficients of Variation for each wolffish species in 100% observed sets from the Yellowtail Flounder fishery in Div. 3NO, 1998-2003. For each level of simulated observer coverage, available sets were randomly sampled 500 times without replacement.

For the offshore shrimp trawl fishery in Subareas 0 and 2 and Div. 3K, simulation results indicated that at-sea observer coverage levels of at least 20% for Northern Wolffish, and 15 % for Spotted Wolffish achieved the CV30 standard (Fig. 15). Regarding Atlantic Wolffish bycatch in this fishery, a 5 % Observer coverage level met the CV30 standard.

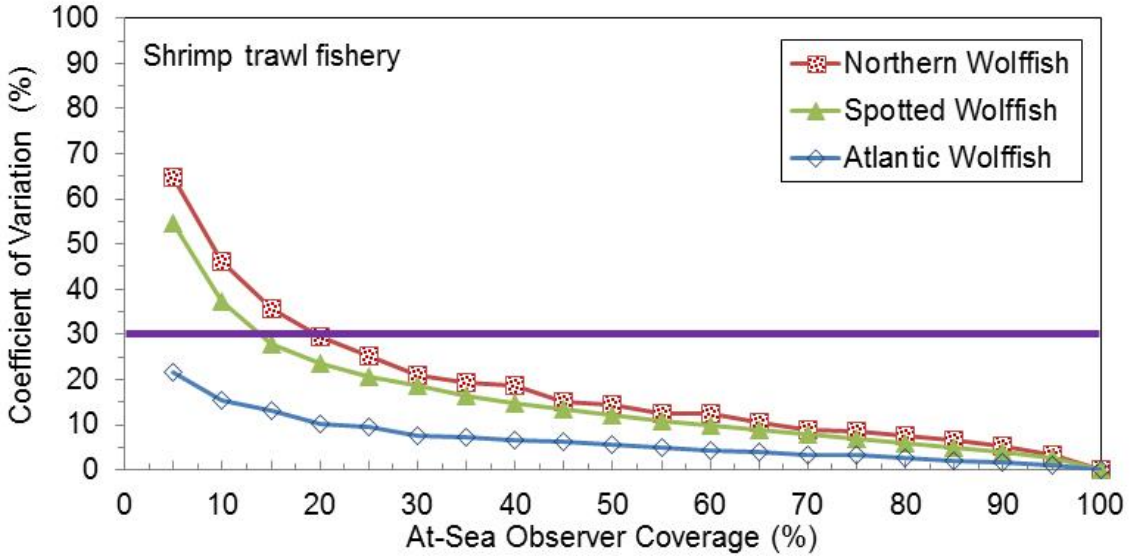

Figure 15. Coefficients of Variation for each wolffish species in 100% observed sets from the shrimp fishery (Pandalus borealis and P. montagui) in Subareas 0 and 2 and Div. 3K, 1998-2011. For each level of simulated observer coverage, available sets were randomly sampled 500 times without replacement

In summary, simulation results suggested that current levels of at-sea observer coverage in three major trawl fisheries in NL (Greenland Halibut, Yellowtail Flounder, offshore shrimp) are adequate and effective in the determination of harm on wolffish, where they are common bycatch species. Observer coverage could not be evaluated for other NL fisheries due primarily to a lack of appropriate data, especially for NL inshore fisheries, which do not have observer coverage. In Canadian Arctic waters, the Greenland Halibut trawl and shrimp trawl fisheries currently have 100 % observer coverage; very few wolffish are encountered as bycatch in small-scale fisheries there, which precludes any simulation of observer coverage. Furthermore, simulations could not be conducted for Gulf of St. Lawrence inshore fisheries, which have 5 % observer coverage, or less.

Sources of Uncertainty

There is a paucity of data regarding wolffish in Canadian waters. Information on age and growth, reproduction, mortality, movements, and stock structure is currently not available.

Lack of speciated commercial wolffish landings (except for Canadian Fisheries Observers' data), unreported discards at sea, and misreporting of fishing locations and/ or species caught, limits the evaluation of wolffish mortality in commercial fisheries.

In commercial SARA logbooks, wolffish condition (alive *versus* dead) is poorly defined for fishers. Furthermore, wolffish survival after capture is probably affected by physical factors, such as internal physiological stress due to encountering significant differences in water temperature and pressure during fishing gear retrieval, and wolffish handling time by fishers aboard vessels. Live release also does not guarantee post-release survival. Although completion of SARA logbooks is a condition of some commercial fishing licences for Canadian waters, these data do not represent all wolffish fishing mortalities, and do not reflect the mortality that regularly occurs outside Canada's EEZ.

Although relevant data are currently unavailable, other potential anthropogenic sources of harm to wolffish are seismic surveys, oil and gas exploration/ production, water pollution, aquaculture siting, introductions of invasive species, shipping noise, ecosystem perturbations, and climate change.

CONCLUSION

DFO research survey indices of wolffish abundance and biomass in some surveyed areas remain low relative to historic levels. Furthermore, areas historically occupied by these stocks have decreased. In recent years, there were indications of increased abundance in some areas.

Wolffish landings have historically been reported primarily as bycatch. Reported landings are currently low relative to historic levels, and live release of Northern Wolffish and Spotted Wolffish caught in Canadian waters is mandatory under SARA.

The maximum allowable harm that these species can sustain (while not jeopardizing their survival or recovery) could not be adequately quantified due to limitations in population modeling and uncertainty in their population dynamics. However, given the estimated levels of harm over the past decade, the decline in wolffish abundance did not continue and has reversed in many areas. This suggests that current levels of harm are sustainable assuming that future productivity of wolffish populations will be similar to that observed in recent time periods.

SOURCES OF INFORMATION

This Science Advisory Report is from the February 26-27, 2014 Zonal Assessment of Northern, Spotted and Atlantic Wolffish to update and support specific processes with regards to recovery targets, allowable harm and other related aspects of SARA. Additional publications from this process will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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 p.

COSEWIC. 2001*a*. COSEWIC assessment and status report on the Northern Wolffish *Anarhichas denticulatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 21 p.

COSEWIC. 2001*b*.COSEWIC assessment and status report on the Spotted Wolffish *Anarhichas minor* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 22 p.

COSEWIC. 2012. COSEWIC assessment and status report on the Atlantic Wolffish *Anarhichas lupus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 56 p.

DFO. 2013. Report on the Progress of Implementation of the Recovery Strategy for Northern Wolffish (*Anarhichas denticulatus*) and Spotted Wolffish (*Anarhichas minor*), and Management Plan for Atlantic Wolffish (*Anarhichas lupus*) in Canada for the Period 2008-2013. Species at Risk Act Recovery Strategy Report Series. Fisheries and Oceans Canada, Ottawa. vi + 16 p.

Dutil, J.-D., Proulx, S., Hurtubise, S., and Gauthier, J. 2011. Recent findings on the life history and catches of Wolffish (*Anarhichas* sp.) in research surveys and in the Sentinel Fisheries and Observer Program for the Estuary and Gulf of St-Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/126: x + 71 p.

Kulka, D.W., Hood, C., and Huntington, J. 2004. The Wolffish recovery team national recovery plan for the Northern Wolffish, *Anarhichas denticulatus*, and Spotted Wolffish, *Anarhichas minor*, in Eastern Canadian Waters. National Recovery Plan. Recovery of Nationally Endangered Wildlife (RENEW). Ottawa, ON. 108 p.

Kulka, D., Hood, C., and Huntington, J. 2007. Recovery Strategy for Northern Wolffish (*Anarhichas denticulatus*) and Spotted Wolffish (*Anarhichas minor*), and Management Plan for Atlantic Wolffish (*Anarhichas lupus*) in Canada. Fisheries and Oceans Canada - NL Region. St. John's, NL. x + 103 p.

Ouellet, J.-F., Dutil, J.-D., and Hurlbut, T. 2011. Wolffish (*Anarhichas* sp.) landings in the estuary and Gulf of St. Lawrence (1960-2009) recorded in commercial fisheries statistics. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/125: viii + 30 p.

Scott, W.B., and Scott, M.G. 1988. Atlantic fishes of Canada. Can. Bull. Fish. Aquat. Sci. 219. 731 p.

Simon, J., Rowe, S., and Cook, A. 2012. Pre-COSEWIC Review of Atlantic Wolffish (*Anarhichas lupus*), Northern Wolffish (*A. denticulatus*), and Spotted Wolffish (*A. minor*) in the Maritimes Region. DFO. Can. Sci. Advis. Sec. Res. Doc. 2011/088: vi + 73 p.

Simpson, M.R., Mello, L.G.S., Miri, C.M., and Treble, M. 2012. A pre-COSEWIC assessment of three species of Wolffish (*Anarhichas denticulatus*, *A. minor*, and *A. lupus*) in Canadian waters of the Northwest Atlantic Ocean. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/122. iv+ 69 p.

Simpson, M.R., Sherwood, G.D., Mello, L.G.S. Miri, C.M., and Kulka, D.W. 2013*a*. Feeding habits and trophic niche differentiation in three species of Wolffish (*Anarhichas sp.*) inhabiting Newfoundland and Labrador waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/056. v + 29 p.

Simpson, M.R., Mello, L.G.S. and Miri, C.M. 2013*b*. Morphometric and meristic variability of Wolffish (*Anarhichas* sp.) in Newfoundland and Labrador waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/085. iv + 34 p.

Simpson, M.R., Chabot, D., Hedges, K., Simon, J., Miri, C.M., and Mello, L.G.S. 2013*c*. An update on the biology, population status, distribution, and landings of Wolffish (*Anarhichus denticulatus*, *A*. *minor*, and *A*. *lupus*) in the Canadian Atlantic and Arctic Oceans. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/089. v + 82 p.

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