



Fisheries and Oceans
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Canadian Science Advisory Secretariat (CSAS)

Research Document 2014/034

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

Assessment of Northern Wolffish, Spotted Wolffish, and Atlantic Wolffish in the Atlantic and Arctic Oceans

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

[http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca](http://www.dfo-mpo.gc.ca/csas-sccs/csas-sccs@dfo-mpo.gc.ca)



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ISSN 1919-5044

Correct citation for this publication:

Collins, R.K., Simpson, M.R., Miri, C.M., Mello, L.G.S., Chabot, D., Hedges, K., Benoît, H., McIntyre, T.M. 2015. Assessment of Northern Wolffish, Spotted Wolffish, and Atlantic Wolffish in the Atlantic and Arctic Oceans. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/034. iv + 86 p.

ABSTRACT

This paper presents the most recent information on trends in abundance, distribution, and fishery removals of *Anarhichus denticulatus* (Northern Wolffish), *A. minor* (Spotted Wolffish), and *A. lupus* (Atlantic Wolffish) in the Northwest Atlantic and Arctic Oceans in support of an allowable harm assessment of these species. Previously, all three species were listed on Schedule 1 of Canada's *Species at Risk Act* (SARA) as being at risk, due to significant declines in relative abundance indices and reduction in area occupied during the 1980s and early 1990s. Their SARA status was upheld in November 2012 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

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 and early 2000s. 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 Div. 2J3K, where the majority of the population resided, remain low in 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 EEZ. The current level of observer coverage in three major mobile gear fisheries in NL (Greenland Halibut; Yellowtail Flounder; offshore shrimp) which were simulated is 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 in most cases.

Évaluation du loup à tête large, du loup tacheté et du loup atlantique des océans Atlantique et Arctique

RÉSUMÉ

Ce document présente les renseignements les plus récents sur les tendances concernant l'abondance, l'aire de répartition et les prélèvements par la pêche du *Anarhichus denticulatus* (loup à tête large), du *A. minor* (loup tacheté) et du *A. lupus* (loup atlantique) dans l'océan Atlantique Nord-Ouest et l'océan Arctique, à l'appui d'une évaluation des dommages admissibles concernant ces espèces. Auparavant, ces trois espèces étaient inscrites à l'annexe 1 de la Loi sur les espèces en péril (LEP) du Canada comme espèces en péril en raison des diminutions importantes des indices d'abondance relatifs et des réductions de l'occupation des zones habitées dans les années 1980 et au début des années 1990. Leur statut selon la LEP a été confirmé en novembre 2012 par le Comité sur la situation des espèces en péril au Canada (COSEPAC).

Les indices d'abondance des trois espèces de loup de mer dans les eaux canadiennes de l'Atlantique et de l'Arctique sont stables ou plus élevés depuis le milieu des années 2000 par rapport aux années 1990 et au début des années 2000. Cependant, il existe des zones où les prises sont sporadiques parce que les espèces sont rares et représentent une petite partie de l'ensemble de la population. Bien qu'il y ait eu des augmentations de l'abondance dans certaines zones, les niveaux pour le loup à tête large et le loup tacheté dans la division 2J3K, où la majorité de la population résidait, demeurent faibles par rapport aux valeurs historiques.

En raison d'une réduction globale de l'effort de pêche depuis les années 1990, et de la remise à l'eau obligatoire du loup à tête large et du loup tacheté depuis 2003, la mortalité due à la pêche de ces deux espèces a été réduite dans la zone économique exclusive du Canada. Le niveau actuel de présence d'observateurs dans trois grandes pêches aux engins mobiles à Terre-Neuve-et-Labrador (flétan du Groenland, limande à queue jaune, pêche hauturière à la crevette) qui ont été simulées, est adéquat et efficace pour déterminer les dommages causés au loup de mer, là où il représente une prise accessoire commune. La présence d'observateurs n'a pas pu être évaluée dans le cadre d'autres pêches en raison du manque de données appropriées dans la plupart des cas.

INTRODUCTION

Three wolffish species are found in both Canadian Atlantic and Arctic waters: *Anarhichas denticulatus* (Northern Wolffish), *A. minor* (Spotted Wolffish), and *A. lupus* (Atlantic Wolffish). The first two species were designated “Threatened” by COSEWIC under Canada’s *Species at Risk Act* in 2001, and Atlantic Wolffish was designated “of Special Concern”. The primary reasons for listing wolffish as species at risk include greater than 90 % declines in abundance indices over 2-3 generations (1980s-90s) throughout a considerable portion of their range (i.e., waters off Newfoundland and Labrador), concurrent with substantial reductions in extent of distribution.

The Recovery Strategy for Northern Wolffish and Spotted Wolffish, and Management Plan for Atlantic Wolffish in Canada were published on the SARA public registry in February 2008. In September 2010, a zonal pre-COSEWIC assessment of the three wolffish species was held to review the available data (Dutil et al. 2011; Simpson et al. 2012; Simon et al. 2012). In November 2012, COSEWIC re-evaluated the status of wolffish in Atlantic Canada, and concluded that, despite signs of population recovery, Northern Wolffish and Spotted Wolffish remain listed as Threatened under SARA, while Atlantic Wolffish is still of Special Concern. Fisheries and Oceans Canada (DFO), as the responsible jurisdiction, is therefore obliged under SARA to undertake a number of actions, some of which require updated scientific information on the status of these wolffish species, threats to survival, and feasibility of recovery.

In particular, Allowable Harm Assessments are used to inform management decisions in regard to the level of harm that an aquatic Species at Risk can withstand without jeopardizing its recovery. Prior to issuing a SARA permit, SARA requires that the conditions outlined in Section 73 of SARA be met. Allowable harm advice is also useful in the development of recovery plans, socio-economic analysis, and listing decisions.

STATUS ASSESSMENT METHODS

ABUNDANCE AND RANGE

Detailed descriptions of the indices of wolffish abundance (mean number per tow) and range (based on point maps of geographic distribution of recent catch rates from DFO research surveys), as well as various surveys from which they are derived, are provided in Chadwick et al. (2007) and Simpson et al. (2013); as well as in Dutil et al. (2011) for Quebec Region, Simpson et al. (2012) for Newfoundland and Labrador Region, and Simon et al. (2012) for Maritimes Region. Updates of these indices for Central and Arctic Region, Newfoundland and Labrador Region, Quebec and Gulf Regions, and Maritimes Region are presented here.

MORTALITY AND ALLOWABLE HARM

Fishing Mortality

Commercial fisheries removals of three species of wolffish in the Northwest Atlantic Fisheries Organization (NAFO) Subareas 0 and 2, Div. 3KLNOP, Div. 4RST, Div. 4VWXY, and Div. 5Z were examined for 1960-2012, using commercial data available in several databases: the NAFO STATLANT-21A unspiciated wolffish landings (1960-2012), reported by NAFO-member countries fishing mainly outside Canada’s Exclusive Economic Zone (EEZ); DFO-NL Zonal Interchange File Format (ZIFF) unspiciated wolffish landings (1985-2012) and DFO-Maritime Fisheries Information System (MARFIS) unspiciated wolffish landings (2002-12), reported by Canadian fishers (as recorded in their logbooks and on fish plants’ purchase slips) operating in Canada’s EEZ; and Canadian At-Sea Fisheries Observers’ (ASFO) spiciated catch and

discards data (1978-2012), collected on a set-by-set basis in a standardized format on board commercial fishing vessels. It must be noted that discards (even of target species) are never reported to NAFO or to DFO Statistics Branch (for ZIFF; MARFIS). Therefore, the only reliable source of data on discarding at sea comes from Canadian Fisheries Observers.

With NAFO-reported data, total reported landings of unspciated wolffish were compiled by year and Subarea/Division/Subdivision. With ZIFF and MARFIS data, total reported landings of unspciated wolffish were calculated by year, Subarea/Division/Subdivision, fishery type (i.e., bycatch or directed wolffish fisheries), and fishing gear type. Incomplete data for 2013 were also included.

In addition, total catch and/or point maps of geographic distribution of recent catches from Canadian Fisheries Observers data were plotted for Subarea 0, Div. 2J3KLNOP, Div. 4RST, and Div. 4VWX5Y.

To estimate total bycatch of wolffish by species in various Newfoundland and Labrador fisheries, a method based on Campana et al. 2011 was used with the ASFO-NL database for 1985-2012. Reported landings of the target species by fishery (summed by year) in ZIFF-NL was divided by the observed kept weight of this target species by year (e.g., Greenland Halibut; shrimp spp.; Snow Crab; Yellowtail Flounder). This factor was then multiplied by the observed catch weight (=kept+discards) of wolffish by species in each fishery by year in order to “bump up” wolffish bycatch estimates to the entire fishery. However, a lack of comparable data between ZIFF-NL and ASFO-NL for each fishery in some years restricted the application of this method. Although the ASFO-NL database contained adequate records of wolffish kept and discard weights for several fisheries in particular years, the ZIFF-NL database either had no reported landings of the target species in those fisheries, or contained landings of said target species in years other than those covered by the ASFO-NL. This situation also precluded inclusion of the temporal variables “quarter” (Campana et al. 2011) and “month” (Hanke et al. 2012) while applying this method to NL commercial data. In addition, given that the ZIFF-NL database does not contain a variable to indicate the number of sets fished, ZIFF total landings of each target species could not be weighted by this variable (as per Campana et al. 2011), and a decision was also made to not weigh any data (e.g., ZIFF) by the amount of gear fished, because this exercise would further limit the number of wolffish total bycatch estimates by year. It must be noted that wolffish bycatch estimates presented here cannot be validated.

In addition to NAFO, ZIFF/MARFIS, and Canadian Fisheries Observers data, SARA logbook data from NL fishers aboard > 35 foot vessels fishing in Canada’s EEZ were analysed to evaluate the physical condition of bycaught wolffish upon release at sea. The proportion of wolffish released alive (by species) was calculated as a percentage of the total number of wolffish caught for each available year (2004-13).

Observer Coverage

To assist in providing advice on current and future (“target”) levels of at-sea Observer coverage, a method based on Haigh et al. 2002 was used to simulate various levels of Observer coverage (5, 10, 15,..., 95 %) for each of three major NL fisheries in which wolffish were bycaught: Div. 2J3KL Turbot (2000-12), Div. 3NO Yellowtail (1998-2003), and offshore shrimp (*Pandalus borealis* and *P. montagui*; 1998-2011). For each wolffish species, a simple random sampling method was applied, using data only from ASFO-NL trips in which all sets were directly observed (i.e., no “logged” data). For each level of coverage, 500 random trials were performed without replacement (i.e., observers do not observe a set more than once), beginning with a sample size (number of sampled sets) reflecting that particular coverage level (e.g., 5 % of the total number of sets observed in a fishery for which a 5 % level of coverage is simulated). For each trial, sampled catch (weight in kilograms) was “bumped up” by the level of Observer

coverage to a total catch estimate. A distribution of total catch estimates was generated for each level of Observer coverage, and a Coefficient of Variation (CV; or variability of the total catch estimates) was calculated. The CV is a standard tool used by fisheries managers to assist in making decisions regarding target catch quotas, bycatch “tolerance” for threatened or rare marine species, target levels of future Observer coverage, and compliance (Haigh et al. 2002; Agnew et al. 2010; NERO/NOAA Fisheries 2013).

RESULTS AND DISCUSSION

ABUNDANCE AND RANGE

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 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 those areas (Simpson et al. 2013). Recent catches of Northern and Spotted Wolffish were limited to southern areas in Div. 0A, but occurred throughout Div. 0B (Fig. 1; Fig. 2). Spotted Wolffish were also caught in Div. 2G and Hudson Strait, but catches of Northern Wolffish were very limited in Hudson Strait, and none were caught in Div. 2G. Atlantic Wolffish were caught in research surveys in Div. 0B, Div. 2G, and Hudson Strait (Fig. 3; Simpson et al. 2013).

In 2012, a total of 7 Northern Wolffish were captured, with 5 recorded in Div. 0A, and 2 in SFA 1. A total of 16 Spotted Wolffish were captured, with 7 recorded in Div. 0A, and 9 in SFA 1. Only 3 Atlantic Wolffish were caught in SFA 1.

In 2013, a total of 52 Northern Wolffish were captured, with 47 recorded in Div. 0B, and 5 in SFA 3. A total of 7 Spotted Wolffish were captured, with 5 recorded in Div. 0B, and 2 in SFA 3. Only 1 Atlantic Wolffish was caught, in SFA 3.

Newfoundland and Labrador

Abundance indices for Northern Wolffish in Div. 2GH have been sporadic throughout the fall survey time series, though the index in Div. 2H has been consistent and stable over the past three years (Fig. 4). Division 2G was last surveyed in 1999. Since 1995, the fall survey abundance index in Div. 2J3K increased slightly (Fig. 5). Survey abundance indices in Div. 3LNO, during fall and spring, have been relatively stable since in the introduction of the Campelen trawl, while the spring survey index in Subdiv. 3Ps has varied without trend (Fig. 5; Fig. 6).

Recent fall (2009-12) and spring (2009-13) survey catches of Northern Wolffish are illustrated in Figs. 7 and 8. During fall surveys, Northern Wolffish occur mainly in Div. 2J3K and, less frequently, in the deeper waters of the shelf slope in Div. 3LNO. During spring surveys, this species rarely occurs in Div. 3LNO and Subdiv. 3Ps. Where catches do occur, they are often limited to deeper waters of the shelf slope.

Abundance indices for Spotted Wolffish in Div. 2GH have been sporadic throughout the fall survey time series, though the index in Div. 2H has been consistent and stable over the past three years (Fig. 9). Division 2G was last surveyed in 1999. Since 1995, the abundance index for Spotted Wolffish generally increased in the fall survey of Div. 2J3K (Fig. 10). The fall and spring survey abundance indices in Div. 3LNO have generally been higher since the mid-2000s, as compared to the 1990s and early 2000s (Fig. 10; Fig. 11). The spring survey abundance index in Subdiv. 3Ps has varied without trend since the introduction of the Campelen trawl (Fig. 11).

Recent fall (2009-12) and spring (2009-13) survey catches of Spotted Wolffish are illustrated in Figures 12 and 13. During fall surveys, they occur mainly in Div. 2J3K, as well as on the shelf slope and banks in the northern part of Div. 3L. They are sometimes caught in the deeper waters of the shelf slope in Div. 3NO. During spring surveys, this species rarely occurs in Div. 3LNO and Subdiv. 3Ps. Where catches do occur, they are often limited to deeper waters of the shelf slope.

Abundance indices for Atlantic Wolffish in Div. 2GH have been sporadic throughout the fall survey time series (Fig. 14). Division 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 has generally been higher since the mid-2000s (Fig. 15). The spring survey abundance index for Atlantic Wolffish in Div. 3LNO peaked between 2005 and 2007 but, overall, has been generally stable since the introduction of the Campelen trawl (Fig. 16). The spring survey abundance index in Subdiv. 3Ps has varied without trend (Fig. 16).

Recent fall (2009-12) and spring (2009-13) survey catches of Atlantic Wolffish are illustrated in Figures 17 and 18. In fall, Atlantic Wolffish are found throughout Div. 2J3K and Div. 3LNO. In spring, Atlantic Wolffish are found throughout Div. 3LNO, and in shallower waters of Subdiv. 3Ps.

Quebec and Gulf

In the northern Gulf of St. Lawrence, wolffish species status is based on indices obtained from two surveys in Div. 4RS: the mobile Sentinel Fishery survey (1995–2013); and the DFO research survey conducted in late summer (1990–2013). Northern Wolffish are captured sporadically in both surveys (Fig. 19; Fig. 20; Fig. 21). The abundance index for Spotted Wolffish from the mobile sentinel survey varied without trend from 1995 to 2009, but remained low for the past 4 years (Fig. 22). The DFO survey index for Spotted Wolffish also indicates a decrease in abundance in recent years (since 2011; Fig. 23). Recent catches are plotted in Figure 24. In this area, Atlantic Wolffish are more abundant than the other two species. The sentinel fishery survey index has declined in recent years, and the 2013 value represents the lowest in the series (Fig. 25). The survey abundance index varied without trend (Fig. 26). Recent catches are plotted in Figure 27. Overall, there is no marked trend in any of the indices for these species.

In the southern Gulf of St. Lawrence (sGSL), Northern Wolffish are only caught sporadically in the September research survey in Div. 4T (Fig. 28). Typically, only a single fish is caught, though there were 11 caught in 1986 and 10 in 1993. Nonetheless, this does not provide the basis for a useful index of relative abundance. Catches of Northern Wolffish in the September survey are generally made in the Laurentian channel, and along its slope (Fig. 29).

Spotted Wolffish were never caught in the Div. 4T survey prior to 1981, and 1 or 2 individuals have been captured sporadically in a little over half of the years since (Fig. 30). This does not provide the basis for a useful index of relative abundance. Catches of Spotted Wolffish in the September research survey are generally made along the edge of the Laurentian channel (Fig. 31).

Atlantic Wolffish are the most commonly captured of the three species in Div. 4T. While they are captured nearly every year, the number caught is generally low (Fig. 32). Mean abundance of Atlantic Wolffish in the September research survey was at a relatively low level from 1971 to the late 1980s, at a relatively elevated level through to the mid 1990s, returning to a lower level from the late 1990s to the present. In recent years, Atlantic Wolffish have been typically caught in one or two sets per survey, generally along the edge of the Laurentian Channel but also in other areas (Fig. 33). Though the data are somewhat sparse, there is no strong evidence of a change in distribution between decades (Fig. 34).

In the sGSL in September, all three wolffish species have favored the deeper depths available in the ecosystem (Fig. 35). Atlantic and Spotted Wolffish prefer more intermediate depths (approximately 100-200 m), while Northern Wolffish prefer deeper depths.

Maritimes

Northern Wolffish and Spotted Wolffish occur infrequently during the DFO research surveys in this region (Fig. 36; Fig. 37). In Div. 4VWX5Y, the abundance index for Atlantic Wolffish has remained below the long-term average since 2009 (Fig. 38). In 5Z (Georges Bank), where Atlantic Wolffish are less frequently caught, the abundance index has remained low since 2006 (Fig. 39). The most persistent concentrations of Atlantic Wolffish occur on the eastern Scotian Shelf, in Div. 4V, and western Scotian Shelf, in Div. 4X (Fig. 40).

MORTALITY AND ALLOWABLE HARM

Commercial Fisheries Removals

Commercial fisheries data for wolffish are unspciated (except for Canadian Fisheries Observers' data): all three species are recorded by fishers as "Catfish" or "wolffish-unspecified". Due to the listing of the three species of wolffish on Schedule 1 of Canada's SARA in 2003, and subsequent mandatory release of both Northern Wolffish and Spotted Wolffish in Canadian waters, reported landings have drastically decreased and consisted solely of Atlantic Wolffish. It should be noted that wolffish survival upon release is contingent upon a variety of factors, including physiological stress due to exposure to varying ambient temperatures and water pressures during fishing gear retrieval (especially from greater depths), trawl tow duration and total catch weight (Grant and Hiscock 2014), and handling time by fishers. "Live" release also does not guarantee post-release survival. It must be noted that the following results do not account for all wolffish mortalities due to Canadian fishing activities, and do not include mortalities that occur regularly in fisheries conducted outside Canada's EEZ.

Throughout the entire Canadian zone of interest (NAFO Subarea 0 and Divisions 2GH, 2J3K, 3LNO, 3P, 4RST, 4VWX, 5YZ), total NAFO-reported landings of unspciated wolffish continued to decline to 4,129 t over 2004-12, with 209 t reported for 2012 (Fig. 41). In 2013, a preliminary estimate available for Div. 3LNOP was 74 t. In Div. 4RST, Canadian reported landings remained near zero since 2003. In Div. 4VWX, reported landings decreased to near zero by 2009. In Div. 5YZ, landings were insignificant since 2002. For an historical description of reported annual landings by Division, refer to Simpson et al. (2013).

According to ZIFF data, wolffish were always reported as bycatch in Canadian fisheries targeting other species in Subareas 2 and 3 from 1993 to 2013 (Fig. 42). Reported landings for all areas declined by 2004, and totaled 13 t over 2011-13.

With the passage of SARA and the requirement for live release (except in a very specific case of a limited fishery for Atlantic Wolffish), Canadian reported landings of unspciated wolffish in Subarea 2 and Div. 3KLNO of Canada's EEZ decreased to zero by 2004 and, in Div. 3P amounted to just 13 t from 2011-13 (Fig. 43). Reported landings from bottom trawls and gillnets became negligible by 2004 (Fig. 44). As well, reported landings of wolffish in Canada's EEZ have primarily been associated with longline fisheries, and have since become negligible (Fig. 44). For an historical description of reported annual landings by gear type, see Simpson et al. (2013).

Recent (2009-12) at-sea spciated catch data collected by Canadian Fisheries Observers in Div. 0A and Div. 0B are presented for Northern Wolffish (Fig. 45), Spotted Wolffish (Fig. 46), and Atlantic Wolffish (Fig. 47). Small catches of all three species of wolffish occurred in Divisions 0A and 0B. For all species, some catches occurred in waters immediately adjacent to

Greenland waters in NAFO subarea 1, suggesting that Canadian stocks in Div. 0A and 0B are not independent of those stocks. Catches of Spotted wolffish and Atlantic wolffish also occurred in some inshore bay areas, while captures of Northern wolffish were exclusive to the offshore area.

At-sea speciated wolffish catch data collected by Canadian Fisheries Observers in Div. 2GHJ3KLNOP (in Canada's EEZ) suggested that Northern Wolffish was the predominant wolffish species caught from 2011-12 (Fig. 48). In 2003-10, total catch was estimated at 587 t and 1,136 t for 2011-12, mainly in Div. 2J. Bycatch of Spotted Wolffish over 2003-10 totalled 280 t and 183 t in 2011-12, predominantly in Div. 3KL. Observer data also indicated that catches of Atlantic Wolffish were highest in 2001-05 with a total estimate of 1,856 t almost exclusively from Div. 3N, then decreased to 511 t over 2006-12. Distributions of recent catches of each species are presented in Figures 49, 50, and 51. For an historical description of observed catches by wolffish species and NAFO division, refer to Simpson et al. (2013).

At-sea speciated wolffish catch data collected by Canadian Fisheries Observers in Div. 4RST indicated that Northern Wolffish is rarely caught, relative to the other two species (Tables 2, 3, 4). Between 2007-08, peak catches of Spotted and Atlantic Wolffish were reported in Div. 4R and Div. 4S (Fig. 52; Fig. 53); high catches of Atlantic Wolffish were reported in Div. 4T in 2008 (Fig. 54). Since then, catches of these two species have declined considerably throughout Div. 4RST. Distributions of recent catches of all three species, as recorded by observers, are presented in Figures 55, 56, and 57.

Recent (2009-12) at-sea speciated catch data collected by Canadian Fisheries Observers in Div. 4VWX5Y is presented for Northern Wolffish (Fig. 58; Fig. 61), Spotted Wolffish (Fig. 59; Fig. 62), and Atlantic Wolffish (Fig. 60; Fig. 63). Spotted Wolffish are rarely captured and appear mainly in deeper waters along the shelf edge. Atlantic Wolffish however is more widespread and occurs in shallower waters. In the case of Atlantic Wolffish, captures were concentrated mainly in 4X, 4Vs and 4Vn with relatively few captures in 4Vw. Northern Wolffish are more commonly captured along the shelf edge in deeper waters.

Based on ASFO-NL data scaled up to entire fisheries conducted in NL waters, catches of Northern Wolffish occurred primarily in the Div. 2J3KL Greenland Halibut trawl fishery, mainly with a total estimate of 336 t bycaught in Div. 3L over 2000-04 and 302 t in Div. 2J in 2010-12 (Fig. 64). This wolffish species was also captured in the Div. 3K Snow Crab pot fishery, especially in 1998-2001 with a total of 495 t estimated (Fig. 65). In the offshore shrimp fishery, retention of mature Northern Wolffish in trawl gear became insignificant since 1993, when a "groundfish excluder" (i.e., a Nordmore grate installed below a "bycatch exit window" cut into a trawl's netting) was introduced to this fishery, and some > 100 ft. shrimp vessels voluntarily began using it (Fig. 66). Note that as of 1997, this groundfish excluder was made mandatory for all shrimp trawls fishing in all areas at all times. Although wolffish young-of-the-year are retained by shrimp trawl gear because they are small enough (i.e., 5-25 cm Total Length; Simpson et al. 2013) to pass through an excluder's bar spacing, annual estimates rarely reached 0.3 t. In the Div. 3NO Yellowtail Flounder trawl fishery, Northern Wolffish bycatch was negligible in 1985-2012 (Fig. 67).

Scaled-up Spotted Wolffish bycatch estimates suggested that this species was primarily bycaught in the Div. 3KL Snow Crab pot fishery, with a total of 638 t in Div. 3K over 1999-2012 and 165 t in Div. 3L during 2004-12 (Fig. 68). Concerning the Div. 2J3KL Greenland Halibut trawl fishery, Spotted Wolffish was mainly caught in Div. 3L during 2000-03, and seemed insignificant as bycatch since then (Fig. 69). With the mandatory adoption in 1997 of groundfish excluders for shrimp trawls, retention of Spotted Wolffish in the shrimp fishery was reduced to young-of-the-year since then, and infrequently reached 1 t annually (Fig. 70; Simpson et al.

2013). This wolffish species was apparently rarely captured in the Div. 3NO Yellowtail Flounder trawl fishery in 1985-2012 (Fig. 71).

Atlantic Wolffish appeared to have been caught primarily in the Div. 3N Yellowtail Flounder trawl fishery, with total scaled-up estimates of 761 t in 2001-05 and 178 t over 2008-10 (Fig. 72). Regarding the Div. 3KL Snow Crab pot fishery, bycatch estimates indicated that this wolffish species was captured in Div. 3K over 1998-2003 (83 t), then mainly in Div. 3L during 2004-11 (15 t; Fig. 73). As of 1997 in the offshore shrimp trawl fishery, bycatch of Atlantic Wolffish young-of-the-year averaged 4 t annually, while mature individuals were not retained (Fig. 74; Simpson et al. 2013). In the Div. 2J3KL Greenland Halibut trawl fishery, Atlantic Wolffish bycatch was negligible in 1985-2012 (Fig. 75).

Species at Risk Act logbook data from NL fishers aboard > 35 foot commercial vessels fishing in Canada's EEZ are presented in Table 5. The percentage of Northern Wolffish released alive at sea increased from 58 % in 2004 to over 90 % annually from 2005-09. It has declined considerably since then, to 20 % in 2012. In contrast, over 90 % of Spotted Wolffish caught in 2004-11 were released alive. For Atlantic Wolffish, which can be commercially retained under SARA, the percentage released alive during 2005-10 varied between 68 % and 95 % annually, but has declined since then to about 25 % in 2012. The number of Northern, Spotted, and Atlantic Wolffish being recorded in SARA logbooks has increased since 2004. Incomplete data for 2013 indicated that recorded catches totaled 13,149 Northern Wolffish (30 % dead), 8,661 Spotted Wolffish (39 % dead), and 4,738 Atlantic Wolffish (73 % dead).

Observer Coverage

The simulation of various levels of Observer coverage for the Div. 2J3KL Turbot, Div. 3NO Yellowtail, and offshore shrimp fisheries generated different Coefficients of Variation (CV) between each wolffish species, and were fisheries-specific. Using the CV30 (i.e., 30 %) precision standard set by NOAA Fisheries in the 2010 Amendment-16 of the US Northeast Multispecies (groundfish) Fishery Management Plan (NERO/NOAA Fisheries 2013), simulation results for Northern Wolffish indicated that an "actual" Observer coverage level of at least 5 % in the 2J3KL Greenland Halibut trawl fishery achieves a CV~20 %, which is better than the NOAA CV30 standard (Table 6; Fig. 76). Concerning Spotted Wolffish bycatch in this fishery, a minimum of 10 % "actual" coverage results in a CV~28 %, while 20 % Observer coverage provides a CV~9 % (i.e., far better than the CV30 standard). In the 100 % observed ASFO-NL Turbot trips used for this simulation exercise, no Atlantic Wolffish were caught. It should be noted that "actual" percent coverage often differs from "target %" (i.e., the latter is requested of Observer contracting companies by government fisheries managers), the risk of an imprecise or unreliable estimate increases non-linearly with the CV, and gains in information and precision decrease as the percent of Observer coverage increases.

For the Div. 3NO Yellowtail trawl fishery, simulation results for both Northern and Spotted Wolffish suggested that at least 90% of these trips could have Canadian Fisheries Observers on board, in order to achieve CVs of approximately 29 % and 35 %, respectively (Table 7; Fig. 77). However, both species are rarely caught in this fishery. Concerning Atlantic Wolffish bycatch, a minimum of 25 % actual coverage results in a CV~28%, while 45 % Observer coverage provides a CV~17 % (i.e., better than the CV30 standard). This species continues to be caught in trawls targeting Yellowtail Flounder.

For the offshore shrimp trawl fishery, simulation results indicated that an actual Observer coverage level of at least 20 % for Northern Wolffish and 15 % for Spotted Wolffish achieves CVs of approximately 29 % and 28 %, respectively, while 45 % coverage achieves a CV~14 % (Table 8; Fig. 78). Regarding Atlantic Wolffish bycatch in this fishery, a minimum of 5% actual

coverage results in a CV~21 %, while 20 % Observer coverage provides a CV~10 % (i.e., far better than the CV30 standard).

Canadian Fisheries Observers reported wolffish bycatch in Div. 2J3KLNO and Subdiv. 3Ps from seven different commercial fleets and thirteen fishing gear types over 2007-12. In total, 33 %, 26 %, and 10 % of all bycatch were from vessels of 2000 + t, 1,000-1,999 t, and 150-499 t (respectively) using bottom trawl gear. The remaining fleets and gears each contributed 5 % or less to the bycatch total.

Almost all incidental catches of Northern Wolffish occurred along the continental shelf edge in Div. 2J3KL and very few wolffish catches were recorded in Div. 3NO and Subdiv. 3Ps, despite the widespread distribution of fishing effort by the various commercial fleets (Fig. 49). The distribution of catch per tow from both spring and fall DFO research surveys in 2009-12 showed very similar patterns (Fig. 7; Fig. 8).

Bycatch of Atlantic Wolffish in Div. 2J3KL by the various commercial fleets showed a similar spatial pattern as described for Northern Wolffish (i.e., along the shelf edge), but catches were also reported along the deep channels on the shelf (Div. 2J3K), and over the southeast Grand Bank (Div. 3N) in 2009-10 (Fig. 51). Research survey indices frequently corroborated with the patterns seen in the Observers data: i.e., spring and fall survey catches were more frequent along the shelf edge (Div. 2J3KLN), and through the channels on the shelf (Div. 2J3KL; Fig. 17; Fig. 18). In addition, Atlantic Wolffish were caught in shallow waters (Div. 3NO).

Distribution of incidental catches of Spotted Wolffish (based on Observers data) was similar to that observed for Atlantic Wolffish in Div. 2J3KL (along the shelf edge and deep channels on the shelf) and, as for Northern Wolffish, few catches were reported in Div. 3NO and Subdiv. 3Ps (Fig. 50). Research survey catch distribution patterns in Div. 2J3K (fall) were dissimilar when compared with the other two wolffish species, showing that most Spotted Wolffish were caught across the shelf, but catches were consistent with Observers data in Div. 3NO and Subdiv. 3Ps, as few Spotted Wolffish were caught during spring and fall surveys, particularly along the edges of the Grand Bank (Fig. 12; Fig. 13).

Qualitatively, distribution patterns of the three wolffish species as inferred from Observers data corresponded fairly well with the equivalent patterns of the research survey data. This suggests that levels of fisheries coverage by the Canadian Fisheries Observer Program in 2007-12 was able to detect trends in wolffish distribution over space and time.

Despite its limitations, the Canadian Fisheries Observer Program in 2007-12 seemed to provide relevant information for assessing levels of harm to wolffish due to fishing in Canada's EEZ.

Anthropogenic Impacts/Considerations

A list of potential anthropogenic sources of wolffish mortality, other than fishing, is provided in Table 9.

CONCLUSIONS

Research vessel estimates of abundance, and biomass, in the surveyed areas mainly continue to persist at low levels relative to historic time periods. In recent years, there was an indication of increased abundance in some historic areas. However, wolffish distributions are not as widespread as observed in early decades.

Wolffish landings continue as bycatch in numerous fisheries, though reported landings are currently low relative to historic levels. Under SARA, mandatory release is required for both Northern Wolffish and Spotted Wolffish caught in Canadian waters.

ACKNOWLEDGEMENTS

We thank DFO staff who participated in Canadian research surveys, and Canadian Fisheries Observers who collected data and specimens aboard commercial fishing vessels under difficult conditions over many years.

REFERENCES

- Agnew, D.J., Grove, P., Peatman, T., Burn, R., and Edwards, C.T.T. 2010. Estimating optimal observer coverage in the Antarctic krill fishery. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Science vol. 17: 139-154.
- Benoît, H.P., and Swain, D.P.. 2003. Accounting for length-and depth-dependent diel variation in catchability of fish and invertebrates in an annual bottom-trawl survey. ICES J. Mar. Sci. 60: 1298-1317
- Campana, S.E., Brading, J., and Joyce, W. 2011. Estimation of Pelagic Shark Bycatch and Associated Mortality in Canadian Atlantic Fisheries. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/067. vi+19 p.
- Chadwick, E.M.P. Brodie, W., Colbourne, E., Clark, D., Gascon, D., and Hurlbut, T. 2007. History of annual multi-species trawl surveys on the Atlantic coast of Canada. Atlantic Zone Monitoring Program (AZMP) Bulletin 6: 25-42.
- 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.
- Grant, S.M., and Hiscock, W. 2014. Post-capture survival of Atlantic Wolffish (*Anarhichas lupus*) captured by bottom otter trawl: Can live release programs contribute to the recovery of species at risk? Fish. Res. 151: 169-176.
- Haigh, R., Schnute, J., Lacko, L., Eros, C., Workman, G., and Ackerman, B. 2002. At-sea observer coverage for catch monitoring of the British Columbia hook and line fisheries. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/108. 55p.
- Hanke, A.R., Andrushchenko, I., and Croft, G. 2012. Observer Coverage of the Atlantic Canadian Swordfish and Other Tuna Longline Fishery: An Assessment of Current Practices and Alternative Methods. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/049. iii+84 p.
- Hurlbut, T., and Clay, D. 1990. Protocols for research vessel cruises within the Gulf Region (demersal fish) (1970-1987). Can. Manuscr. Rep. of Fish. Aquat. Sci., 2082: 143 p.
- NERO/NOAA Fisheries. 2013. [Summary of analyses conducted to determine at-sea monitoring requirements for multispecies sectors - Fishing Year 2013](#). Northeast Regional Office, National Oceanic and Atmospheric Administration. 228 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 (*Anarhichus 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., Chabot, D., Hedges, K., Simon, J., Miri, C.M., and Mello, L.G.S. 2013. 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.

TABLES

Table 1. DFO bottom trawl research surveys conducted in Newfoundland and Labrador waters (NAFO Div. 2HJ3KLMNO and Subdiv. 3Ps) in 1971-2013. Various vessels and fishing gear were used: A.T. Cameron, *Gadus Atlantica*, Wilfred Templeman, Alfred Needler, Teleost; gear: Yankee 41.5 otter trawl (yellow cell=Y), Engel 145 otter trawl (green cell=E), Campelen 1800 shrimp trawl (brown cell=C). Empty cell (-): no survey was conducted. Fall/winter surveys (*). Spring survey in 2006 was incomplete (INC); those data were not included in the analyses.

Spring Survey Series

Year	3L	3N	3O	3Ps
1971	Y	Y	Y	-
1972	Y	Y	-	Y
1973	Y	Y	Y	Y
1974	Y	Y	-	Y
1975	Y	Y	Y	Y
1976	Y	Y	Y	Y
1977	Y	Y	Y	Y
1978	Y	Y	Y	Y
1979	Y	Y	Y	Y
1980	Y	Y	Y	Y
1981	Y	Y	Y	Y
1982	Y	Y	Y	Y
1983	-	-	-	E
1984	E	E	E	E
1985	E	E	E	E
1986	E	E	E	E
1987	E	E	E	E
1988	E	E	E	E
1989	E	E	E	E
1990	E	E	E	E
1991	E	E	E	E
1992	E	E	E	E
1993	E	E	E	E
1994	E	E	E	E
1995	E	E	E	E
1996	C	C	C	C
1997	C	C	C	C
1998	C	C	C	C
1999	C	C	C	C
2000	C	C	C	C
2001	C	C	C	C
2002	C	C	C	C
2003	C	C	C	C
2004	C	C	C	C
2005	C	C	C	C
2006	INC	INC	INC	-
2007	C	C	C	C
2008	C	C	C	C
2009	C	C	C	C
2010	C	C	C	C
2011	C	C	C	C
2012	C	C	C	C
2013	C	C	C	C

Fall Survey (+3M Winter) Series

Year	2G	2H	2J	3K	3L	3M*	3N	3O
1971	-	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-
1977	-	-	E	E	-	Y	-	-
1978	E	E	E	E	-	E	-	-
1979	E	E	E	E	-	E	-	-
1980	-	-	E	E	-	E	-	-
1981	E	E	E	E	E	E	-	-
1982	-	-	E	E	E	E	-	-
1983	-	-	E	E	E	E	-	-
1984	-	-	E	E	E	E	-	-
1985	-	-	E	E	E	E	-	-
1986	-	-	E	E	E	-	-	-
1987	E	E	E	E	E	-	-	-
1988	E	E	E	E	E	-	-	-
1989	-	-	E	E	E	-	-	-
1990	-	-	E	E	E	-	E	E
1991	E	E	E	E	E	-	E	E
1992	-	-	E	E	E	-	E	E
1993	-	-	E	E	E	-	E	E
1994	-	-	E	E	E	-	E	E
1995	-	-	C	C	C	-	C	C
1996	C	C	C	C	C	C	C	C
1997	C	C	C	C	C	C	C	C
1998	C	C	C	C	C	C	C	C
1999	C	C	C	C	C	C	C	C
2000	-	-	C	C	C	C	C	C
2001	-	C	C	C	C	C	C	C
2002	-	-	C	C	C	C	C	C
2003	-	-	C	C	C	C	C	C
2004	-	C	C	C	C	-	C	C
2005	-	-	C	C	C	-	C	C
2006	-	C	C	C	C	C	C	C
2007	-	-	C	C	C	C	C	C
2008	-	C	C	C	C	-	C	C
2009	-	-	C	C	C	-	C	C
2010	-	C	C	C	C	-	C	C
2011	-	C	C	C	C	-	C	C
2012	-	C	C	C	C	-	C	C
2013	-	-	-	-	-	-	-	-

Table 2. Catch of Northern Wolffish by unit area in Div. 4RST, as recorded by Canadian Fisheries Observers.

Year	4Ra	4Rb	4Rc	4Rd	4Si	4Ss	4Sv	4Sw	4Sx	4Sy	4Sz	4Tf	4Tg	4Th	4Tj	4Tk	4Tl	4Tm	4Tn	4To	4Tp	4Tq
1987	.	.	0	.	0	0	.	.	0	.	.	0	0	.	.	0	0	.	0	.	.	.
1988	.	0	0	0	0	0	.	.	0	.	.	0	0	.	.	0	.	.	0	.	.	.
1989	0	460	145	0	.	0	.	.	.	.	.	0	0	.	.	.	.	.	0	.	.	.
1990	.	0	2	0	0	0	0	.	0	0	0	0	0	.	.	0	0	.	0	0	.	.
1991	0	0	0	10	0	0	0	.	0	0	3	0	15	.	.	0	0	0	0	43	0	0
1992	0	0	0	0	6	5	0	0	8	0	1	39	13	.	.	4	0	0	43	1	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	0	0	0	0	0	0	3
1994	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0
1995	.	0	0	0	0	0	.	.	0	.	0	1	0	.	0	0	0	0	0	0	0	0
1996	.	0	0	.	0	0	0	.	0	0	0	0	0	0	0	0	0	0	0	11	0	0
1997	.	0	0	0	0	0	0	0	0	0	0	0	0	.	0	0	0	0	0	0	0	0
1998	.	0	0	0	0	0	0	0	6	0	0	5	2	.	0	0	0	0	64	0	0	0
1999	.	0	0	0	0	0	0	0	0	0	0	0	0	.	0	0	0	0	0	2	0	0
2000	.	0	0	0	0	0	0	0	0	0	0	3	0	.	0	0	0	0	7	0	0	0
2001	.	0	0	0	0	0	0	0	0	0	0	0	0	.	0	0	0	0	0	0	0	0
2002	.	0	0	0	0	0	0	0	0	0	0	4	0	.	0	0	0	0	12	0	0	0
2003	.	0	0	21	0	0	0	.	0	0	0	0	0	.	0	0	0	0	0	0	0	0
2004	.	0	0	4	0	0	0	0	0	0	0	41	3	.	0	0	0	0	1	0	0	0
2005	0	1	0	0	0	20	0	0	0	0	0	0	0	.	0	0	0	0	0	0	0	0
2006	0	0	7	3	0	0	3	0	9	0	0	30	0	.	0	2	2	0	0	0	0	0
2007	.	4	16	15	0	5	0	0	0	0	0	0	0	.	0	0	0	.	14	0	.	0
2008	1	0	0	20	0	0	8	3	0	8	0	0	0	.	0	3	0	0	3	0	0	0
2009	0	0	0	0	0	0	0	0	8	0	0	0	0	.	0	0	0	0	0	0	0	0
2010	.	0	0	.	0	0	5	0	2	0	0	0	0	.	0	0	0	0	0	1	0	0
2011	.	0	0	.	0	0	0	0	0	0	0	0	0	.	0	0	0	.	0	0	0	0
2012	.	0	0	0	0	0	0	0	0	0	0	0	0	.	0	0	0	0	12	0	0	0
2013	.	0	0	.	0	0	0	.	0	.	0	0	0	.	.	0	0	0	0	0	0	0

Table 3. Catch of Spotted Wolffish by unit area in Div. 4RST, as recorded by Canadian Fisheries Observers.

Year	4Ra	4Rb	4Rc	4Rd	4Si	4Ss	4Sv	4Sw	4Sx	4Sy	4Sz	4Tf	4Tg	4Th	4Tj	4Tk	4Tl	4Tm	4Tn	4To	4Tp	4Tq
1987	.	.	0	.	0	0	.	.	0	.	.	0	0	.	.	0	0	.	0	.	.	.
1988	.	0	0	0	0	0	.	.	0	.	.	0	0	.	.	0	.	.	0	.	.	.
1989	0	350	6659	29	.	0	.	.	.	.	.	0	0	.	.	.	0	.	0	.	.	.
1990	.	21	87	5	2	0	0	.	14	5	1	0	0	.	.	0	0	.	8	3	.	.
1991	80	149	50	152	21	15	0	.	19	8	20	114	16	.	.	15	5	33	84	59	0	0
1992	0	167	438	42	72	32	5	0	20	0	0	45	16	.	.	49	0	0	61	20	0	0
1993	38	100	14	167	10	20	0	0	6	0	25	3	0	.	.	15	3	195	340	103	0	5
1994	.	0	42	19	16	18	0	0	109	0	6	12	2	0	7	20	0	0	0	40	0	2
1995	.	0	0	23	0	25	.	.	0	.	0	25	0	.	0	0	0	0	5	19	4	0
1996	.	0	0	.	0	3	0	.	40	0	0	38	14	0	0	14	0	0	0	13	0	2
1997	.	2	13	0	0	2	0	0	0	0	0	21	11	.	0	0	0	0	0	0	0	0
1998	.	18	0	2	0	119	10	0	18	0	1	6	26	.	0	43	0	0	59	6	0	0
1999	.	0	254	0	0	58	0	0	31	0	0	10	5	.	0	0	0	0	3	9	0	2
2000	.	0	327	2	0	9	0	0	8	3	0	9	5	.	0	0	0	0	16	8	0	0
2001	.	372	78	19	0	9	0	0	126	0	0	16	1	.	0	0	0	0	2	0	0	0
2002	.	269	36	35	0	2	0	0	0	0	0	8	4	.	0	0	0	0	0	0	0	0
2003	.	0	0	13	14	2	0	.	3	0	0	2	5	.	0	13	0	0	0	3	0	0
2004	.	0	0	1	18	52	252	0	197	22	0	24	11	.	0	10	0	0	8	0	0	0
2005	0	0	86	337	53	30	14	0	20	0	29	26	0	.	0	15	0	0	59	0	0	1
2006	0	0	132	153	0	0	32	0	0	0	11	97	7	.	0	0	0	0	80	2	0	0
2007	.	288	274	348	0	48	0	0	223	0	4	4	0	.	0	0	0	.	36	0	.	0
2008	0	357	260	1979	3	12	132	0	416	85	6	29	0	.	0	22	0	0	17	0	0	0
2009	0	608	78	34	7	0	476	0	162	0	0	46	4	.	0	10	0	0	106	0	0	0
2010	.	617	219	.	3	42	162	3	24	0	0	4	0	.	0	39	0	0	37	0	0	0
2011	.	18	1	.	0	25	151	0	449	52	0	0	0	.	0	0	0	.	0	0	0	0
2012	.	4	5	0	25	0	9	0	126	0	0	0	0	.	0	9	0	0	2	0	0	0
2013	.	0	0	.	0	0	0	.	0	.	0	0	0	.	.	8	0	0	8	0	0	0

Table 4. Catch of Atlantic Wolffish by unit area in Div. 4RST, as recorded by Canadian Fisheries Observers.

Year	4Ra	4Rb	4Rc	4Rd	4Si	4Ss	4Sv	4Sw	4Sx	4Sy	4Sz	4Tf	4Tg	4Th	4Tj	4Tk	4Tl	4Tm	4Tn	4To	4Tp	4Tq
1987	.	.	0	.	0	0	.	.	0	.	.	0	0	.	.	0	0	.	0	.	.	.
1988	.	0	0	0	0	0	.	.	0	.	.	0	0	.	.	0	.	.	0	.	.	.
1989	0	207	3115	159	.	0	.	.	.	.	.	0	0	.	.	.	0	.	0	.	.	.
1990	.	110	310	18	3	0	0	.	10	26	3	9	0	.	.	5	0	.	63	2	.	.
1991	0	3	144	134	12	33	0	.	2	34	0	666	92	.	.	12	1	0	194	33	0	0
1992	0	82	881	72	71	35	4	0	8	2	7	29	246	.	.	103	10	0	342	10	0	7
1993	158	497	24	43	2	21	0	0	1	0	23	67	17	.	.	24	0	0	117	95	0	16
1994	.	8	48	44	0	1	0	0	4	0	4	62	24	0	0	22	0	0	0	21	2	2
1995	.	0	6	0	0	0	.	.	0	.	10	21	8	.	0	0	0	0	10	0	0	0
1996	.	7	31	.	0	0	10	.	0	0	0	59	149	0	0	10	0	0	0	13	0	0
1997	.	8	225	0	0	5	0	0	0	0	0	66	118	.	3	9	10	0	55	15	0	0
1998	.	1	1	11	1	15	1	0	0	1	0	123	125	.	0	13	1	0	40	3	0	0
1999	.	0	350	0	3	2	0	0	51	0	0	10	215	.	0	1	3	0	18	1	0	0
2000	.	0	525	24	0	14	6	0	0	3	0	77	88	.	0	1	0	0	42	22	0	0
2001	.	381	112	0	0	9	0	0	5	0	3	30	14	.	0	12	0	0	9	0	0	0
2002	.	177	85	59	0	0	0	0	4	0	0	73	12	.	0	0	2	0	36	0	0	0
2003	.	0	0	12	7	49	0	.	11	0	1	35	40	.	0	0	10	0	33	1	0	0
2004	.	0	4	20	0	44	110	1	177	0	0	131	28	.	2	2	4	0	178	2	0	0
2005	0	0	67	252	83	2	127	0	23	0	0	68	27	.	0	50	2	0	175	0	0	0
2006	0	0	267	306	0	0	875	0	0	0	8	126	10	.	2	0	4	0	85	6	0	0
2007	.	414	611	436	0	17	0	0	112	0	26	203	6	.	2	0	0	.	748	0	.	20
2008	0	767	1601	1302	1	5	915	0	361	60	3	37	2	.	0	0	0	0	146	0	0	0
2009	1	603	306	48	0	0	785	0	74	0	1	39	3	.	0	0	0	0	121	0	0	0
2010	.	1890	1196	.	2	26	576	8	50	0	0	12	0	.	0	32	0	0	79	0	0	0
2011	.	154	0	.	2	8	531	4	167	124	0	29	3	.	0	0	0	.	58	0	0	0
2012	.	1	0	3	7	18	26	0	16	0	0	18	21	.	0	5	0	0	31	0	0	0
2013	.	46	255	.	0	2	126	.	0	.	0	0	0	.	.	1	0	0	1	0	0	0

Table 5. Condition of wolffish captured and released in NL commercial fisheries in Canada's EEZ, as recorded in SARA logbooks. Data for 2013 are incomplete. Post-release survival is unknown.

Northern Wolffish

Condition	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Alive	18	121	1118	1402	1482	3535	4258	2967	2179	9142
Dead	13	1	78	67	56	314	4775	8899	8663	4007
% Alive	58	99	94	95	96	92	47	25	20	70

Spotted Wolffish

Condition	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Alive	52	888	1913	6896	5732	14347	11542	11120	8350	5311
Dead	0	41	28	64	249	91	417	600	1712	3350
% Alive	100	96	99	99	96	99	97	95	83	61

Atlantic Wolffish

Condition	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Alive	.	450	1023	1103	865	2237	2482	3674	1871	1294
Dead	.	58	51	99	397	430	1177	8076	5501	3444
% Alive	.	89	95	92	69	84	68	31	25	27

Table 6. Results of simulating ASFO coverage for the Div. 2J3KL Greenland Halibut fishery in 2000-12, using a simple random sampling method.

Bycatch Species: Northen Wolffish

Fishery	Observer Coverage (%)	CV (%)	Observed Sets (n)	Sampling Wt. (kg)	N	Total Sample Size	Mean Wt.
2J3KL Turbot	5	20.1	47	20	500	23500	115029
2J3KL Turbot	10	13.5	94	10	500	47000	115488
2J3KL Turbot	15	10.8	142	6.7	500	71000	114669
2J3KL Turbot	20	8.6	189	5	500	94500	113678
2J3KL Turbot	25	7.4	236	4	500	118000	113946
2J3KL Turbot	30	7.4	283	3.3	500	141500	114044
2J3KL Turbot	35	6.2	330	2.9	500	165000	114282
2J3KL Turbot	40	5.5	378	2.5	500	189000	114597
2J3KL Turbot	45	4.8	425	2.2	500	212500	113886
2J3KL Turbot	50	4.6	472	2	500	236000	113759
2J3KL Turbot	55	3.9	519	1.8	500	259500	113878
2J3KL Turbot	60	3.7	566	1.7	500	283000	113405
2J3KL Turbot	65	3.3	614	1.5	500	307000	113667
2J3KL Turbot	70	3.2	661	1.4	500	330500	113812
2J3KL Turbot	75	2.5	708	1.3	500	354000	113861
2J3KL Turbot	80	2.1	755	1.3	500	377500	113933
2J3KL Turbot	85	1.9	802	1.2	500	401000	113743
2J3KL Turbot	90	1.5	850	1.1	500	425000	113704
2J3KL Turbot	95	1.1	897	1.1	500	448500	113822

Bycatch Species: Spotted Wolffish

Fishery	Observer Coverage (%)	CV (%)	Observed Sets (n)	Sampling Wt. (kg)	N	Total Sample Size	Mean Wt.
2J3KL Turbot	5	41.3	47	20	500	23500	2915
2J3KL Turbot	10	28.3	94	10	500	47000	2855
2J3KL Turbot	15	23.4	142	6.7	500	71000	2932
2J3KL Turbot	20	19.1	189	5	500	94500	2918
2J3KL Turbot	25	16	236	4	500	118000	2932
2J3KL Turbot	30	14.4	283	3.3	500	141500	2956
2J3KL Turbot	35	12.5	330	2.9	500	165000	2943
2J3KL Turbot	40	11.4	378	2.5	500	189000	2935
2J3KL Turbot	45	10.6	425	2.2	500	212500	2942
2J3KL Turbot	50	9.2	472	2	500	236000	2940
2J3KL Turbot	55	8.7	519	1.8	500	259500	2935
2J3KL Turbot	60	7.6	566	1.7	500	283000	2940
2J3KL Turbot	65	6.7	614	1.5	500	307000	2936
2J3KL Turbot	70	6.2	661	1.4	500	330500	2930
2J3KL Turbot	75	5.3	708	1.3	500	354000	2940
2J3KL Turbot	80	4.7	755	1.3	500	377500	2943
2J3KL Turbot	85	4.1	802	1.2	500	401000	2939
2J3KL Turbot	90	3	850	1.1	500	425000	2947
2J3KL Turbot	95	2.2	897	1.1	500	448500	2939

Table 7. Results of simulating ASFO coverage for the Div. 3NO Yellowtail Flounder fishery in 1998-2003, using a simple random sampling method.

Bycatch Species: Northern Wolffish

Fishery	Observer Coverage (%)	CV (%)	Observed Sets (n)	Sampling Wt. (kg)	N	Total Sample Size	Mean Wt.
3NO Yellowtail	5	466.9	28	19.7	500	14000	37
3NO Yellowtail	10	273.6	55	10	500	27500	53
3NO Yellowtail	15	222.3	83	6.7	500	41500	52
3NO Yellowtail	20	170.8	110	5	500	55000	60
3NO Yellowtail	25	159.7	138	4	500	69000	53
3NO Yellowtail	30	140.1	166	3.3	500	83000	53
3NO Yellowtail	35	126.3	193	2.9	500	96500	53
3NO Yellowtail	40	102.9	221	2.5	500	110500	59
3NO Yellowtail	45	99	248	2.2	500	124000	55
3NO Yellowtail	50	89	276	2	500	138000	55
3NO Yellowtail	55	80.6	304	1.8	500	152000	55
3NO Yellowtail	60	77.5	331	1.7	500	165500	52
3NO Yellowtail	65	63.3	359	1.5	500	179500	56
3NO Yellowtail	70	57.2	386	1.4	500	193000	56
3NO Yellowtail	75	50.1	414	1.3	500	207000	56
3NO Yellowtail	80	47.2	442	1.3	500	221000	54
3NO Yellowtail	85	36.7	469	1.2	500	234500	56
3NO Yellowtail	90	29.1	497	1.1	500	248500	55
3NO Yellowtail	95	16.4	524	1.1	500	262000	56

Bycatch Species: Spotted Wolffish

Fishery	Observer Coverage (%)	CV (%)	Observed Sets (n)	Sampling Wt. (kg)	N	Total Sample Size	Mean Wt.
3NO Yellowtail	5	478.1	28	19.7	500	14000	37
3NO Yellowtail	10	287.7	55	10	500	27500	49
3NO Yellowtail	15	234.6	83	6.7	500	41500	46
3NO Yellowtail	20	199	110	5	500	55000	46
3NO Yellowtail	25	170.6	138	4	500	69000	46
3NO Yellowtail	30	136.4	166	3.3	500	83000	52
3NO Yellowtail	35	137.6	193	2.9	500	96500	45
3NO Yellowtail	40	119.6	221	2.5	500	110500	46
3NO Yellowtail	45	111.1	248	2.2	500	124000	45
3NO Yellowtail	50	105	276	2	500	138000	43
3NO Yellowtail	55	90.2	304	1.8	500	152000	45
3NO Yellowtail	60	83.8	331	1.7	500	165500	44
3NO Yellowtail	65	72.8	359	1.5	500	179500	45
3NO Yellowtail	70	73.5	386	1.4	500	193000	42
3NO Yellowtail	75	58.7	414	1.3	500	207000	45
3NO Yellowtail	80	50.4	442	1.3	500	221000	45
3NO Yellowtail	85	42.7	469	1.2	500	234500	45
3NO Yellowtail	90	34.8	497	1.1	500	248500	45
3NO Yellowtail	95	21	524	1.1	500	262000	45

Bycatch Species: Atlantic Wolffish

Fishery	Observer Coverage (%)	CV (%)	Observed Sets (n)	Sampling Wt. (kg)	N	Total Sample Size	Mean Wt.
3NO Yellowtail	5	67.3	28	19.7	500	14000	6282
3NO Yellowtail	10	46.9	55	10	500	27500	6114
3NO Yellowtail	15	38.2	83	6.7	500	41500	6135
3NO Yellowtail	20	32.8	110	5	500	55000	6106
3NO Yellowtail	25	28.5	138	4	500	69000	6189
3NO Yellowtail	30	24.9	166	3.3	500	83000	6190
3NO Yellowtail	35	22.3	193	2.9	500	96500	6250
3NO Yellowtail	40	19.8	221	2.5	500	110500	6200
3NO Yellowtail	45	16.7	248	2.2	500	124000	6392
3NO Yellowtail	50	16.6	276	2	500	138000	6345
3NO Yellowtail	55	14	304	1.8	500	152000	6234
3NO Yellowtail	60	12.9	331	1.7	500	165500	6375
3NO Yellowtail	65	11.8	359	1.5	500	179500	6335
3NO Yellowtail	70	10.4	386	1.4	500	193000	6355
3NO Yellowtail	75	9.3	414	1.3	500	207000	6344
3NO Yellowtail	80	7.8	442	1.3	500	221000	6355
3NO Yellowtail	85	6.5	469	1.2	500	234500	6335
3NO Yellowtail	90	5	497	1.1	500	248500	6326
3NO Yellowtail	95	3.7	524	1.1	500	262000	6306

Table 8. Results of simulating ASFO coverage for the shrimp fishery (*Pandalus borealis* and *P. montagui*) in 1998-2011, using a simple random sampling method.

Bycatch Species: Northern Wolffish

Fishery	Observer Coverage (%)	CV (%)	Observed Sets (n)	Sampling Wt. (kg)	N	Total Sample Size	Mean Wt.
Shrimp	5	64.7	384	20	500	192000	83
Shrimp	10	46.1	768	10	500	384000	85
Shrimp	15	35.7	1153	6.7	500	576500	86
Shrimp	20	29.5	1537	5	500	768500	83
Shrimp	25	25.1	1921	4	500	960500	83
Shrimp	30	20.8	2305	3.3	500	1152500	83
Shrimp	35	19.3	2689	2.9	500	1344500	83
Shrimp	40	18.8	3073	2.5	500	1536500	83
Shrimp	45	15	3457	2.2	500	1728500	83
Shrimp	50	14.3	3842	2	500	1921000	82
Shrimp	55	12.3	4226	1.8	500	2113000	83
Shrimp	60	12.5	4610	1.7	500	2305000	83
Shrimp	65	10.4	4994	1.5	500	2497000	83
Shrimp	70	8.9	5378	1.4	500	2689000	83
Shrimp	75	8.4	5762	1.3	500	2881000	83
Shrimp	80	7.4	6146	1.3	500	3073000	83
Shrimp	85	6.5	6531	1.2	500	3265500	83
Shrimp	90	5.3	6915	1.1	500	3457500	83
Shrimp	95	3.4	7299	1.1	500	3649500	83

Bycatch Species: Spotted Wolffish

Fishery	Observer Coverage (%)	CV (%)	Observed Sets (n)	Sampling Wt. (kg)	N	Total Sample Size	Mean Wt.
Shrimp	5	54.5	384	20	500	192000	180
Shrimp	10	37.2	768	10	500	384000	183
Shrimp	15	27.7	1153	6.7	500	576500	185
Shrimp	20	23.6	1537	5	500	768500	185
Shrimp	25	20.7	1921	4	500	960500	182
Shrimp	30	18.6	2305	3.3	500	1152500	183
Shrimp	35	16.5	2689	2.9	500	1344500	185
Shrimp	40	14.7	3073	2.5	500	1536500	184
Shrimp	45	13.3	3457	2.2	500	1728500	181
Shrimp	50	12.1	3842	2	500	1921000	181
Shrimp	55	10.7	4226	1.8	500	2113000	185
Shrimp	60	9.9	4610	1.7	500	2305000	182
Shrimp	65	9	4994	1.5	500	2497000	182
Shrimp	70	8	5378	1.4	500	2689000	183
Shrimp	75	6.8	5762	1.3	500	2881000	183
Shrimp	80	6	6146	1.3	500	3073000	183
Shrimp	85	5	6531	1.2	500	3265500	183
Shrimp	90	4.1	6915	1.1	500	3457500	183
Shrimp	95	2.8	7299	1.1	500	3649500	183

Bycatch Species: Atlantic Wolffish

Fishery	Observer Coverage (%)	CV (%)	Observed Sets (n)	Sampling Wt. (kg)	N	Total Sample Size	Mean Wt.
Shrimp	5	21.5	384	20	500	192000	1365
Shrimp	10	15.3	768	10	500	384000	1356
Shrimp	15	13	1153	6.7	500	576500	1357
Shrimp	20	10.3	1537	5	500	768500	1357
Shrimp	25	9.5	1921	4	500	960500	1354
Shrimp	30	7.6	2305	3.3	500	1152500	1356
Shrimp	35	7.2	2689	2.9	500	1344500	1350
Shrimp	40	6.6	3073	2.5	500	1536500	1356
Shrimp	45	6.1	3457	2.2	500	1728500	1357
Shrimp	50	5.5	3842	2	500	1921000	1347
Shrimp	55	5	4226	1.8	500	2113000	1348
Shrimp	60	4.4	4610	1.7	500	2305000	1349
Shrimp	65	3.9	4994	1.5	500	2497000	1353
Shrimp	70	3.3	5378	1.4	500	2689000	1350
Shrimp	75	3.2	5762	1.3	500	2881000	1351
Shrimp	80	2.6	6146	1.3	500	3073000	1351
Shrimp	85	2.1	6531	1.2	500	3265500	1351
Shrimp	90	1.7	6915	1.1	500	3457500	1352
Shrimp	95	1.1	7299	1.1	500	3649500	1351

Table 9. Potential anthropogenic sources of wolffish mortality (other than fishing).

Activity or Event	Impact
Seismic surveys	Unknown
Oil and gas drilling	Unknown
Aquaculture siting	Unknown
Pollution	Unknown
Introductions of non-native or invasive species	Unknown
Ecosystem and climate change	Unknown
Shipping, transport and noise	Unknown

FIGURES

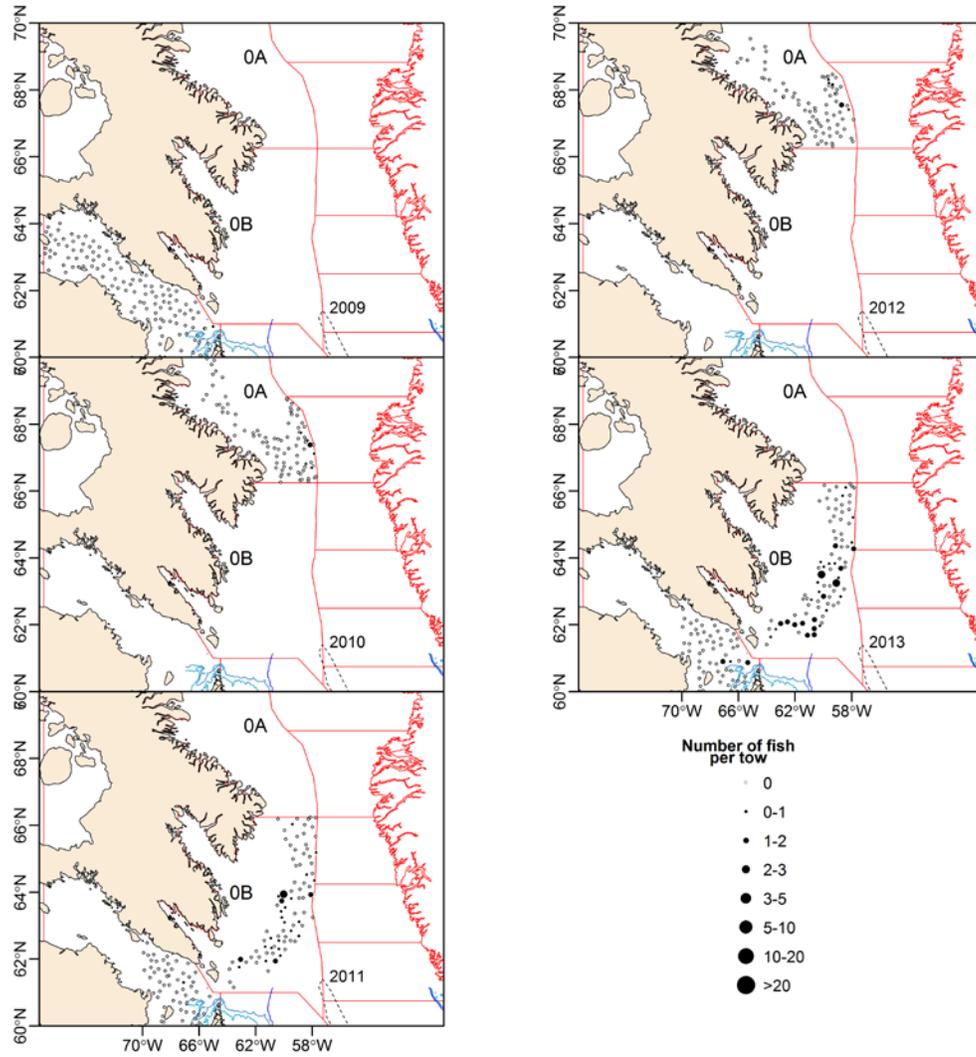


Figure 1. Distribution of recent catches of Northern Wolffish, based on DFO - Central and Arctic Region research surveys in 2009-13.

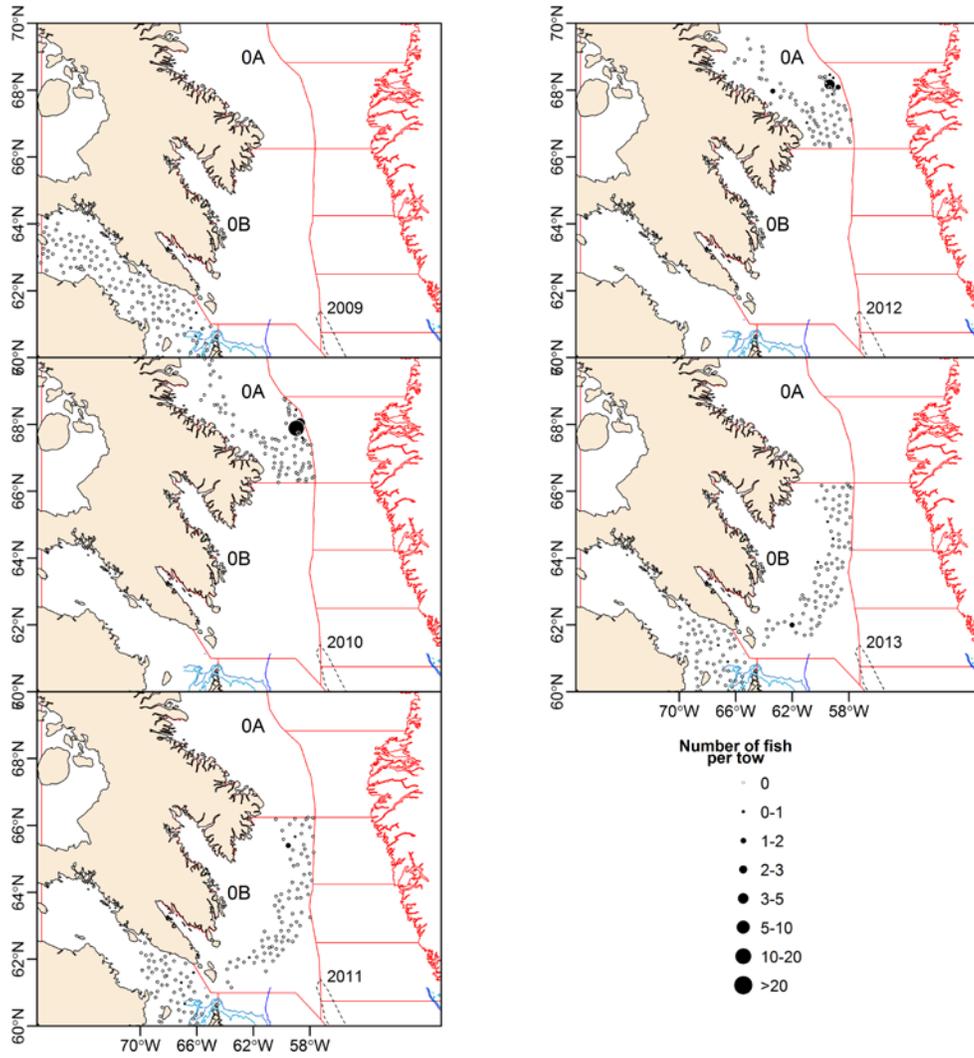


Figure 2. Distribution of recent catches of Spotted Wolffish, based on DFO - Central and Arctic Region research surveys in 2009-13.

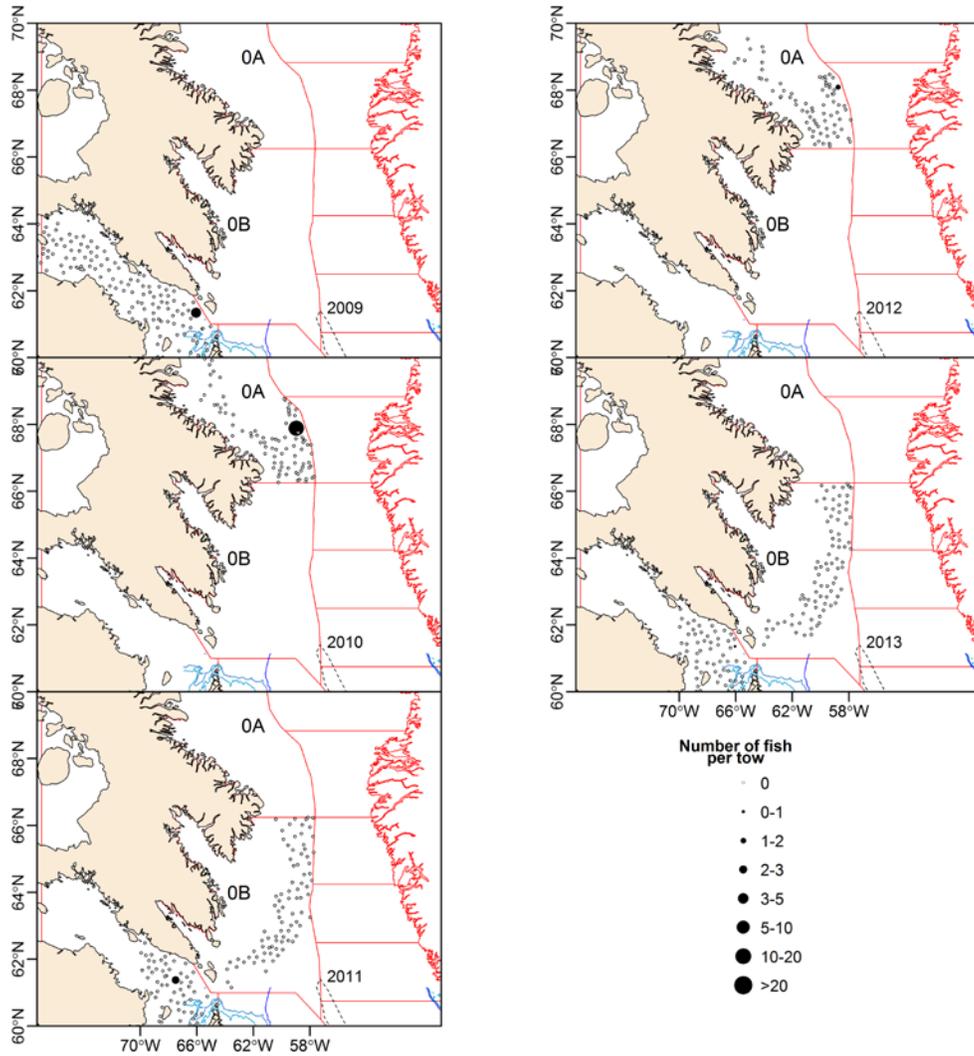


Figure 3. Distribution of recent catches of Atlantic Wolffish, based on DFO - Central and Arctic Region research surveys in 2009-13.

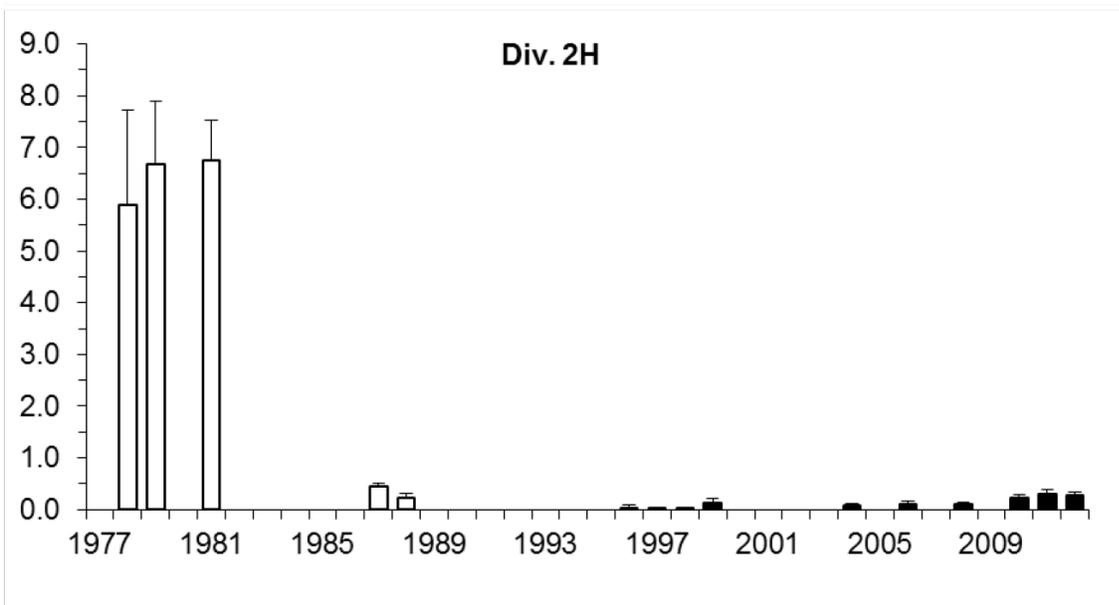
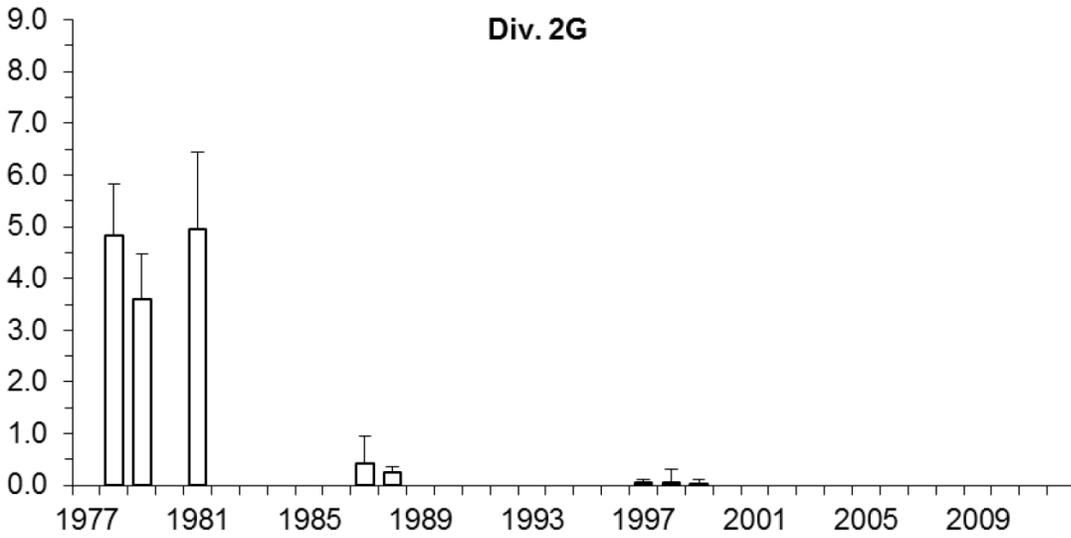


Figure 4. Research survey indices (mean number per tow) for Northern Wolffish in Div. 2G and Div. 2H in fall, 1977-2012. T-bar = 1 SE. Survey trawl gear changed from Engel (white bar) to Campelen (black bar) in fall 1995.

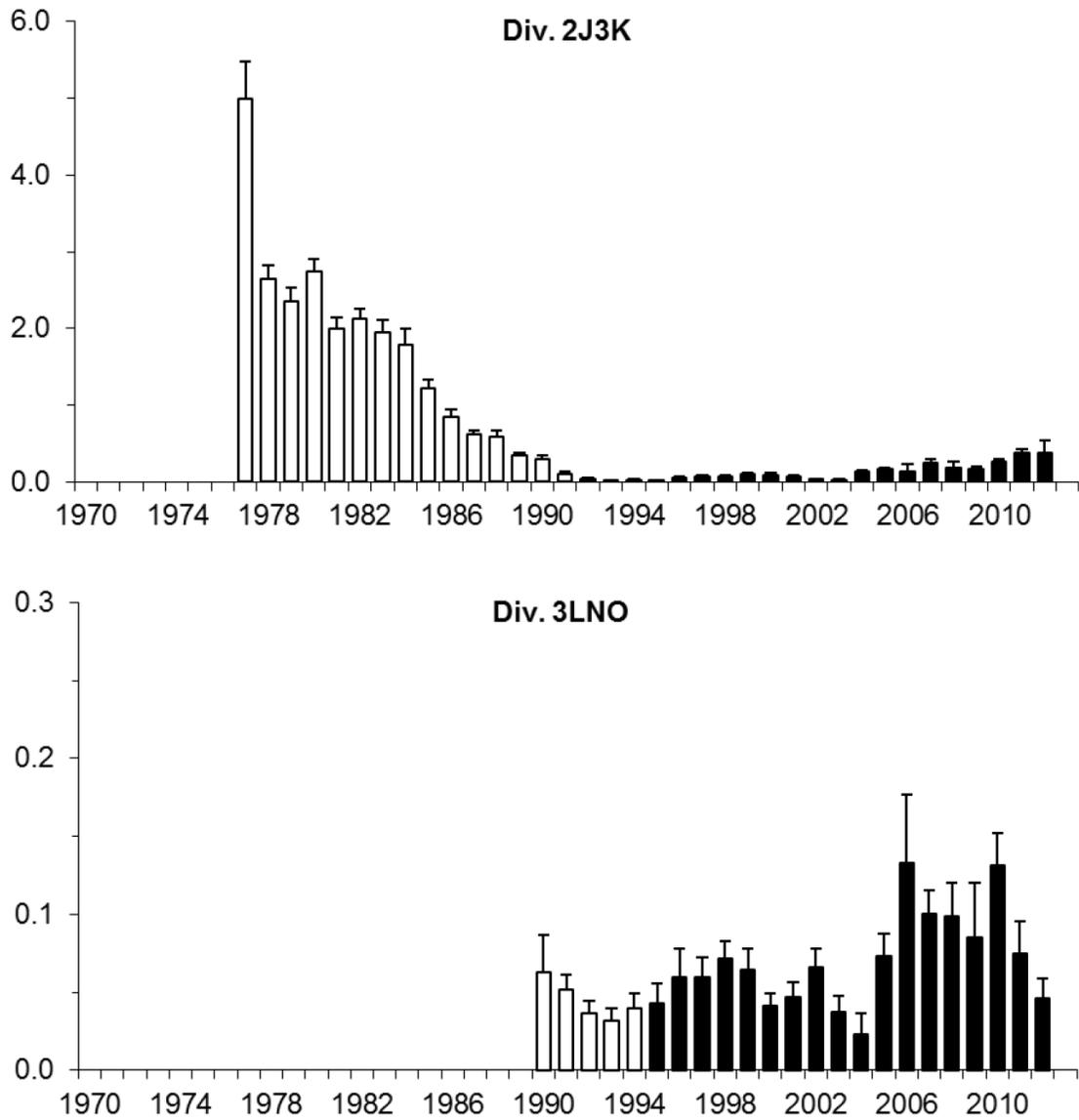


Figure 5. Research survey indices (mean number per tow) for Northern Wolffish in Div. 2J3K and Div. 3LNO in fall, 1977-2012. T-bar = 1 SE. Survey trawl gear changed from Engel (white bar) to Campelen (black bar) in fall 1995.

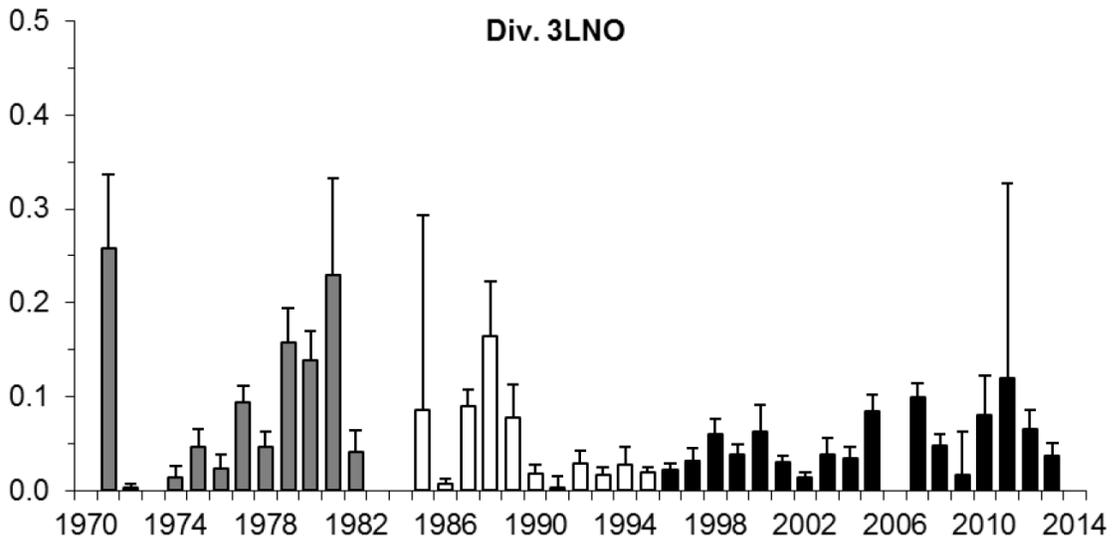
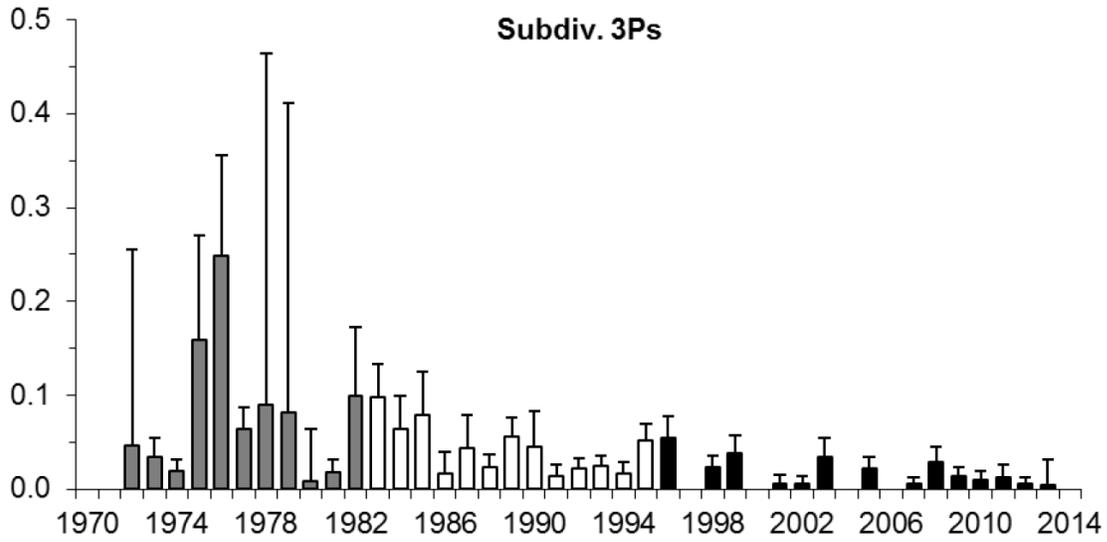


Figure 6. Research survey indices (mean number per tow) for Northern Wolffish in Subdiv. 3Ps and Div. 3LNO in spring, 1971-2013. T-bar = 1 SE. Survey trawl gear changed from Yankee (grey bar) to Engel (white bar) in 1983, and from Engel to Campelen (black bar) in spring 1996.

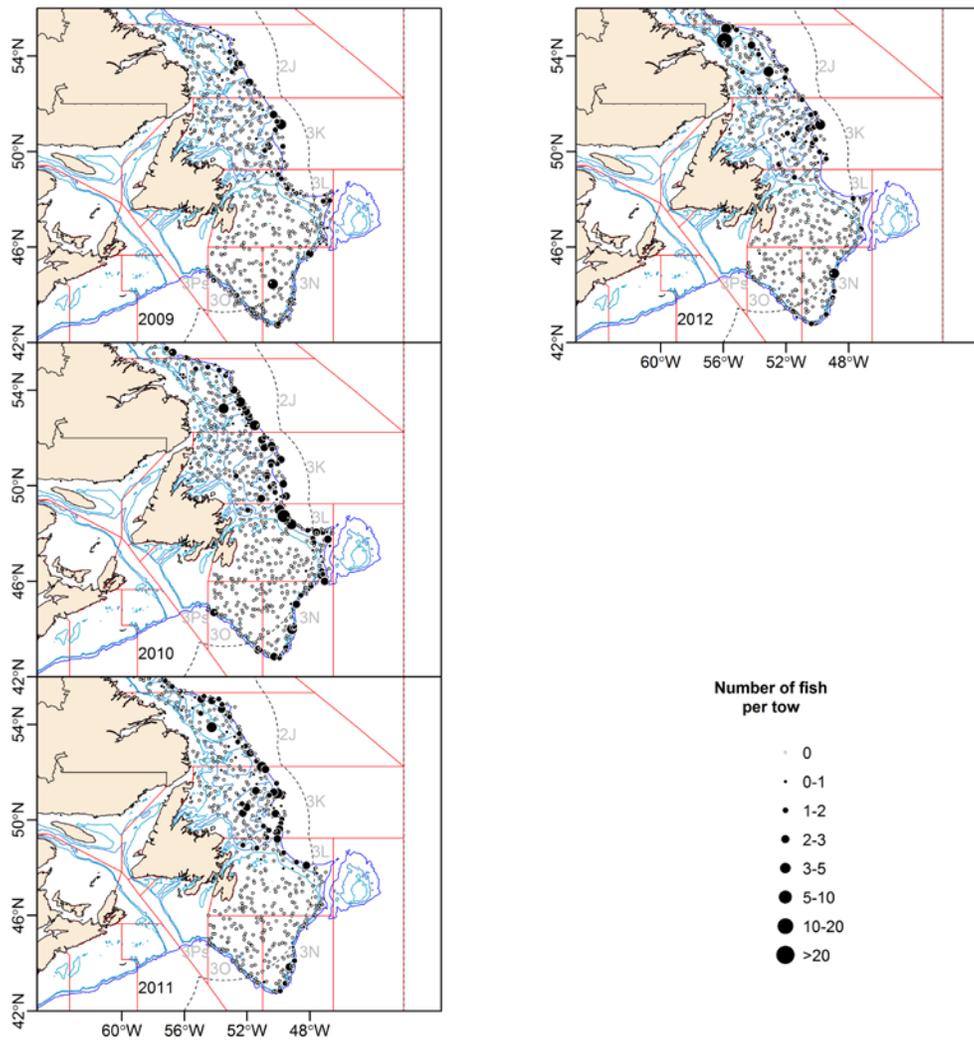


Figure 7. Distribution of recent catches of Northern Wolffish, based on DFO-NL fall research surveys in 2009-12.

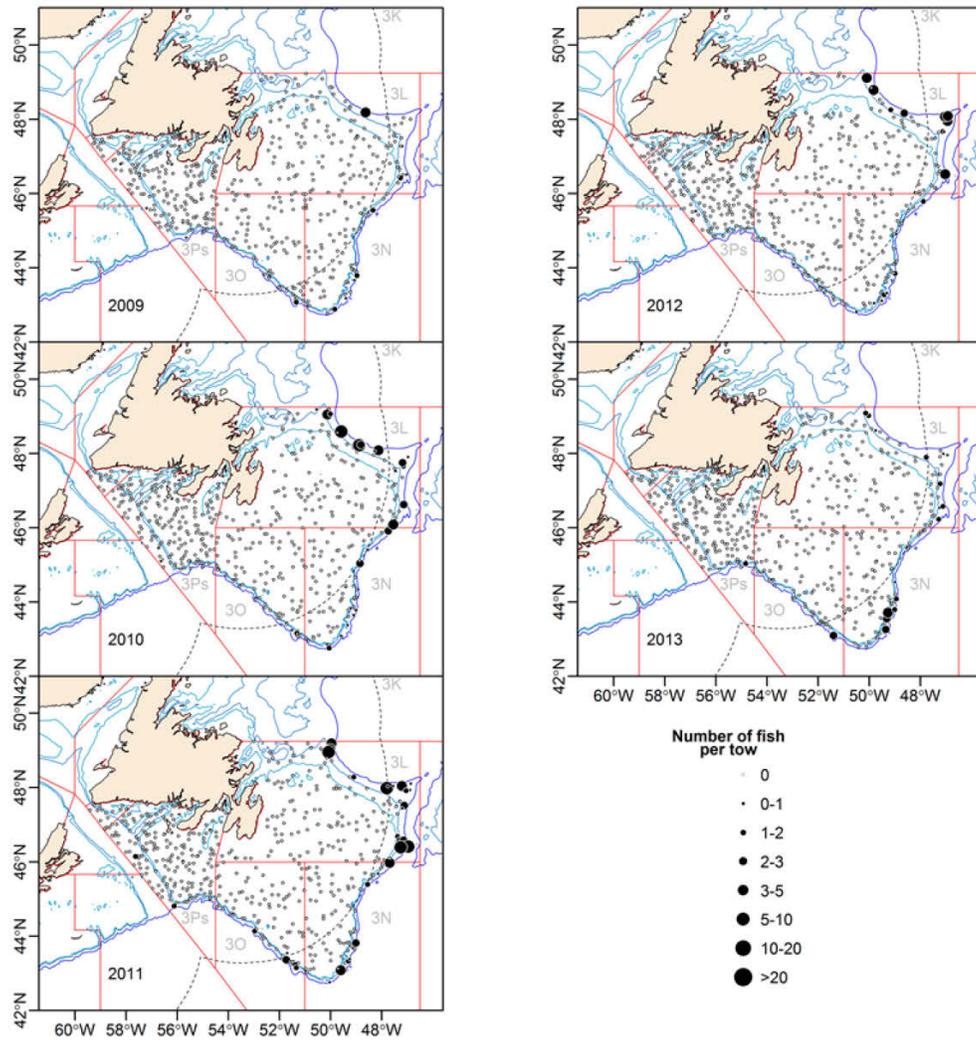


Figure 8. Distribution of recent catches of Northern Wolffish, based on DFO-NL spring research surveys in 2009-13.

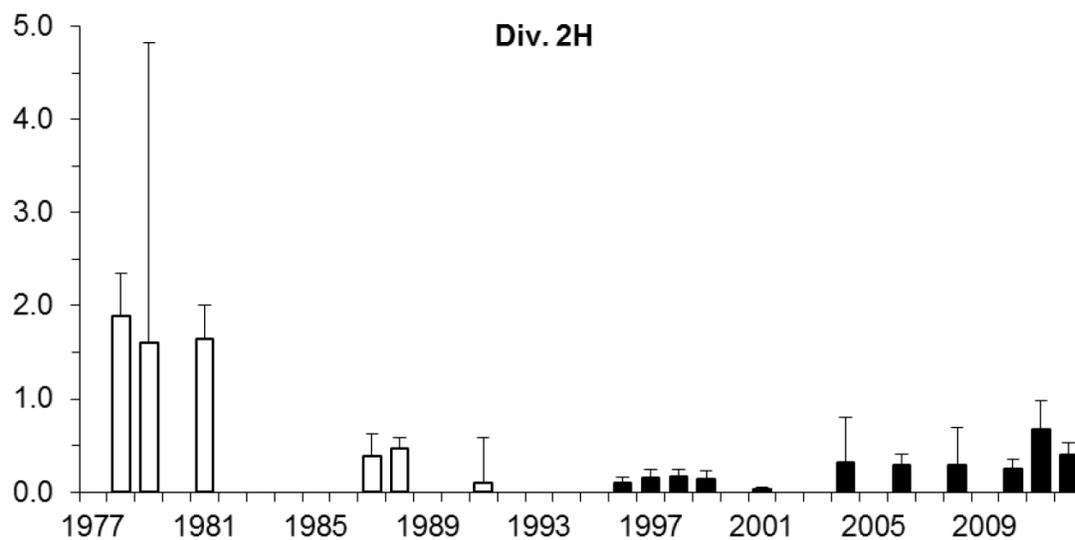
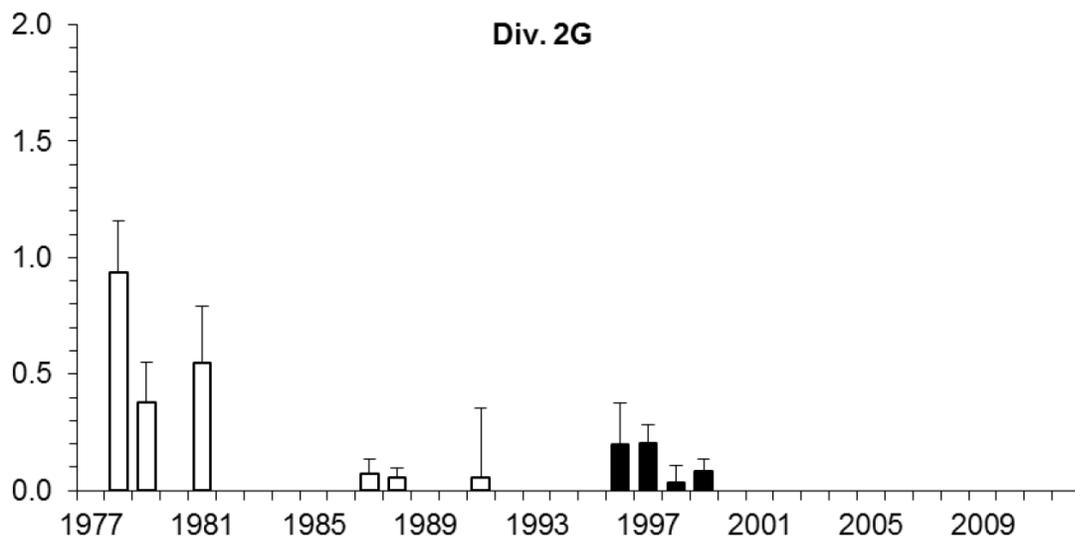


Figure 9. Research survey indices (mean number per tow) for Spotted Wolffish in Div. 2G and Div. 2H in fall, 1977-2012. T-bar = 1 SE. Survey trawl gear changed from Engel (white bar) to Campelen (black bar) in fall 1995.

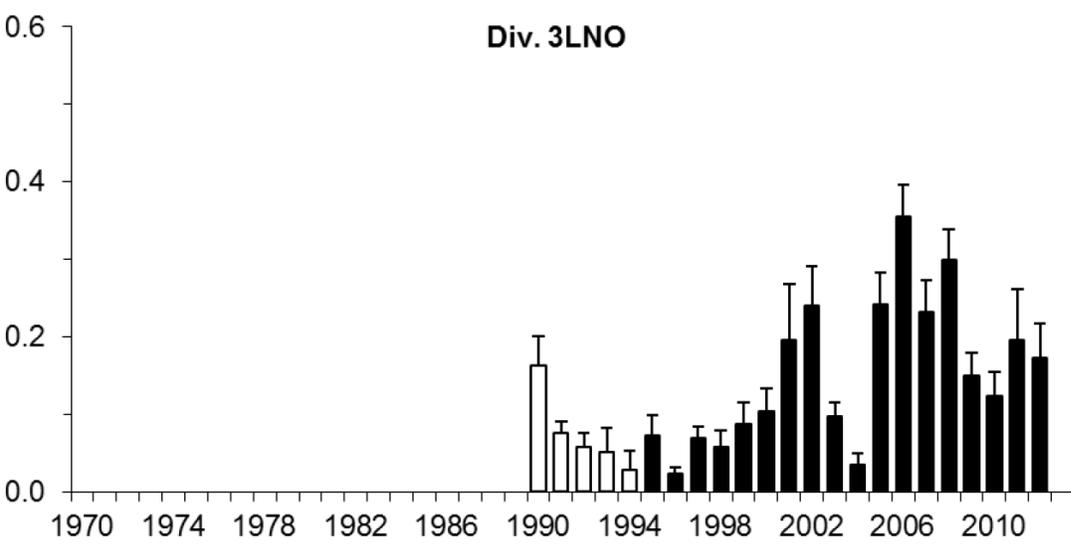
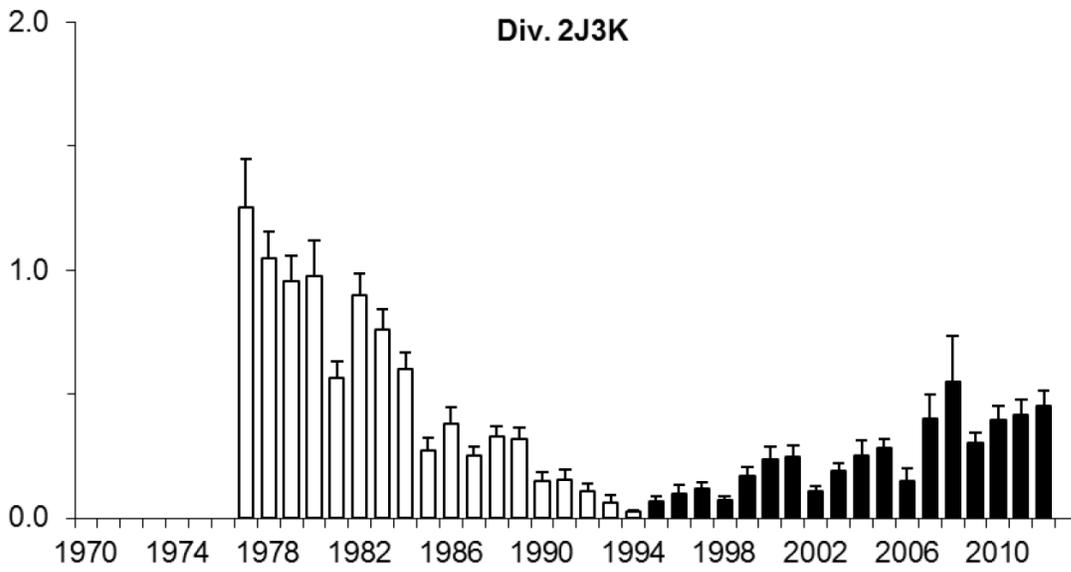


Figure 10. Research survey indices (mean number per tow) for Spotted Wolffish in Div. 2J3K and Div. 3LNO in fall, 1977-2012. T-bar = 1 SE. Survey trawl gear changed from Engel (white bar) to Campelen (black bar) in fall 1995.

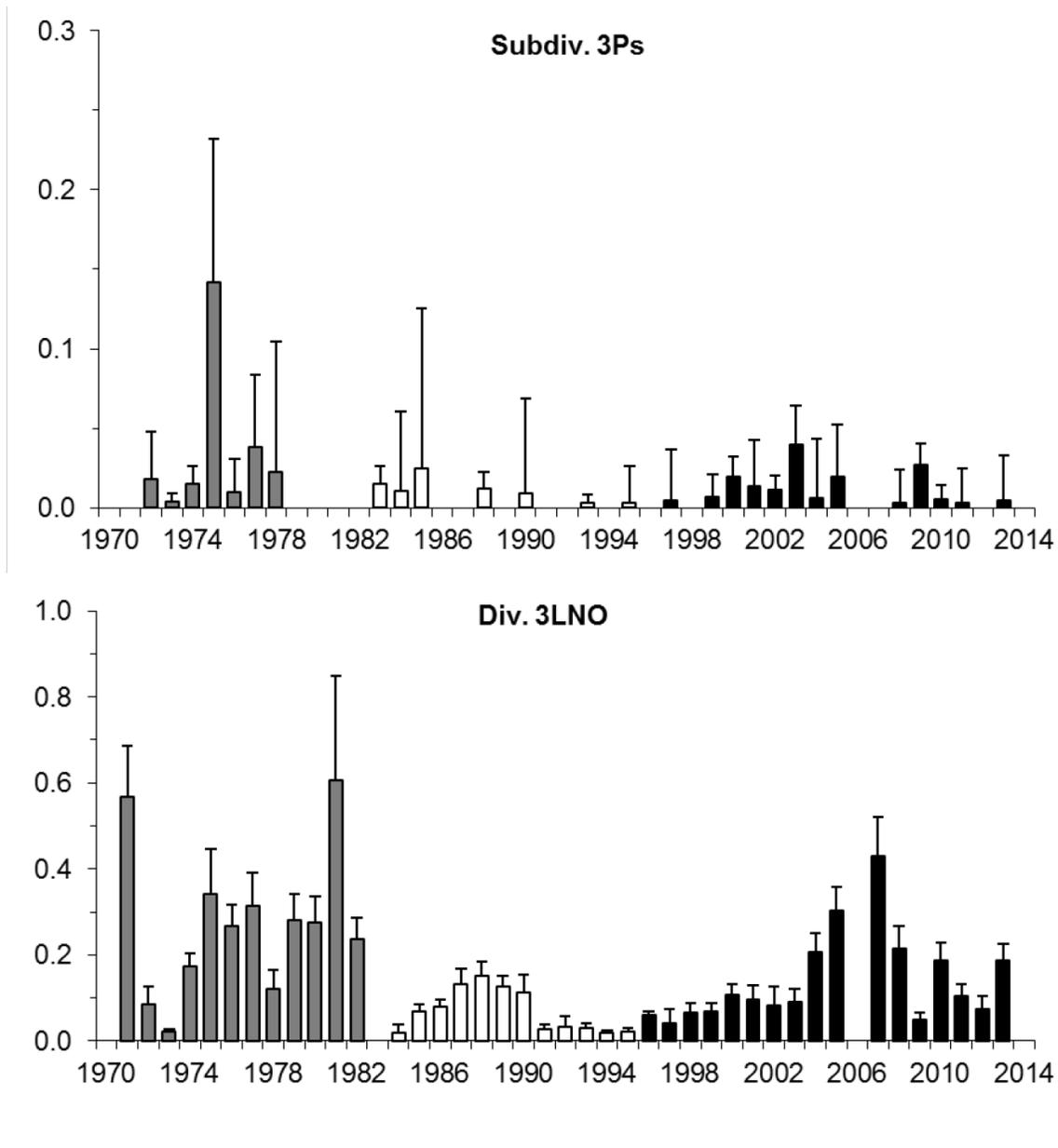


Figure 11. Research survey indices (mean number per tow) for Spotted Wolffish in Subdiv. 3Ps and Div. 3LNO in spring, 1971-2013. T-bar = 1 SE. Survey trawl gear changed from Yankee (grey bar) to Engel (white bar) in 1983, and from Engel to Campelen (black bar) in spring 1996.

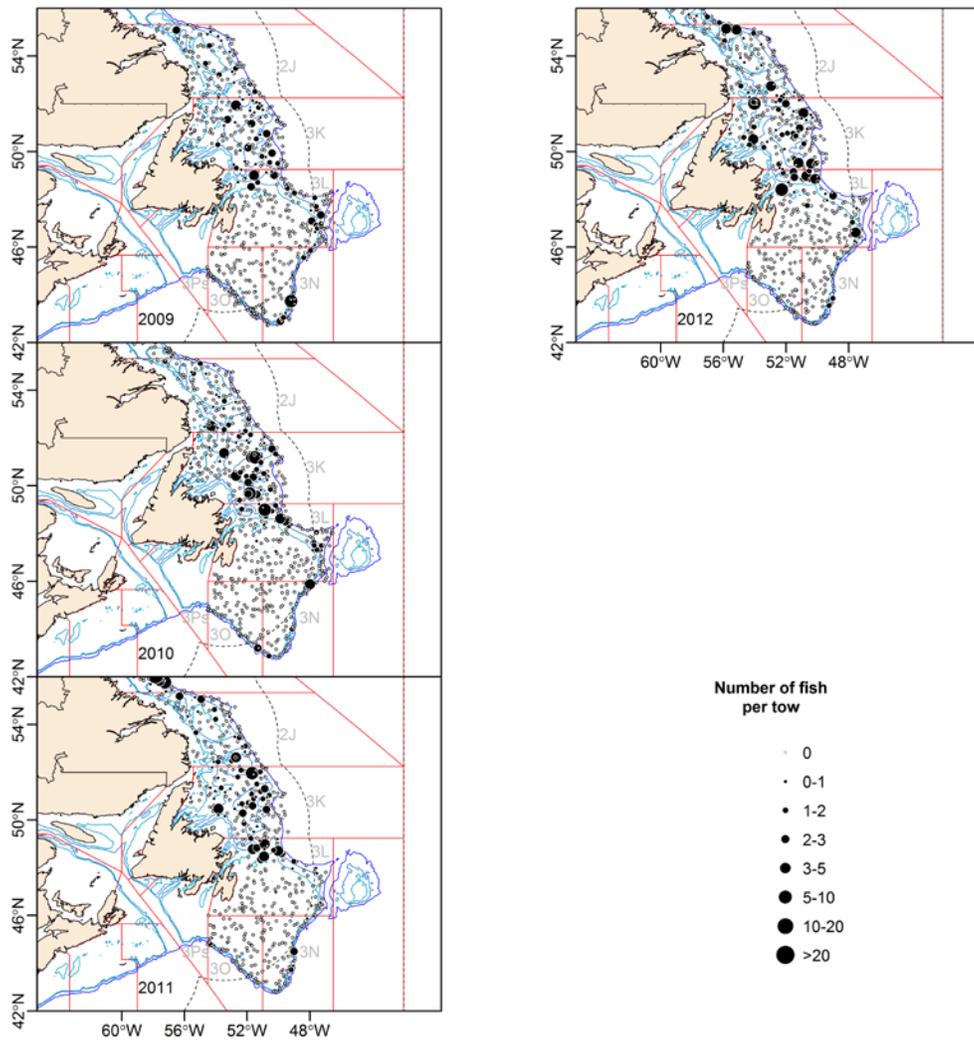


Figure 12. Distribution of recent catches of Spotted Wolffish based on DFO-NL fall research surveys in 2009-12.

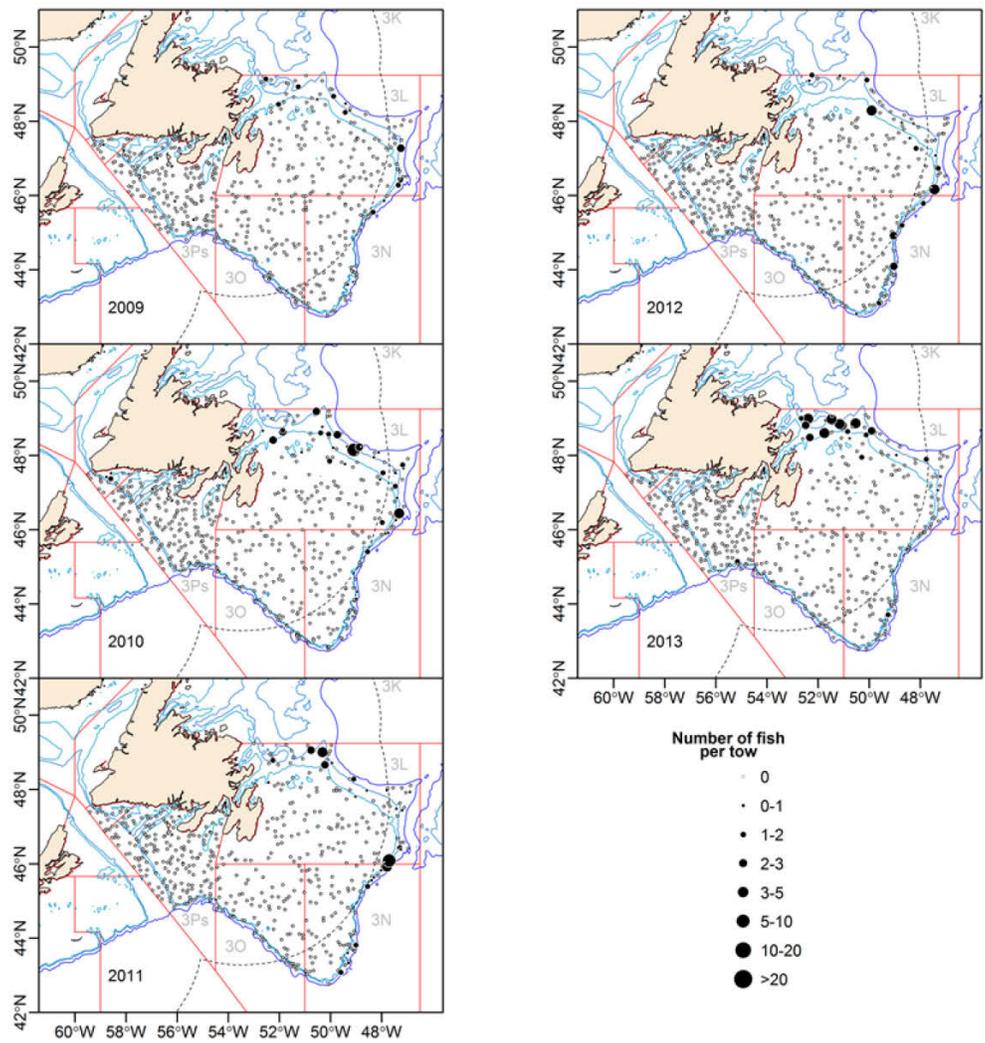


Figure 13. Distribution of recent catches of Spotted Wolffish based on DFO-NL spring research surveys in 2009-13.

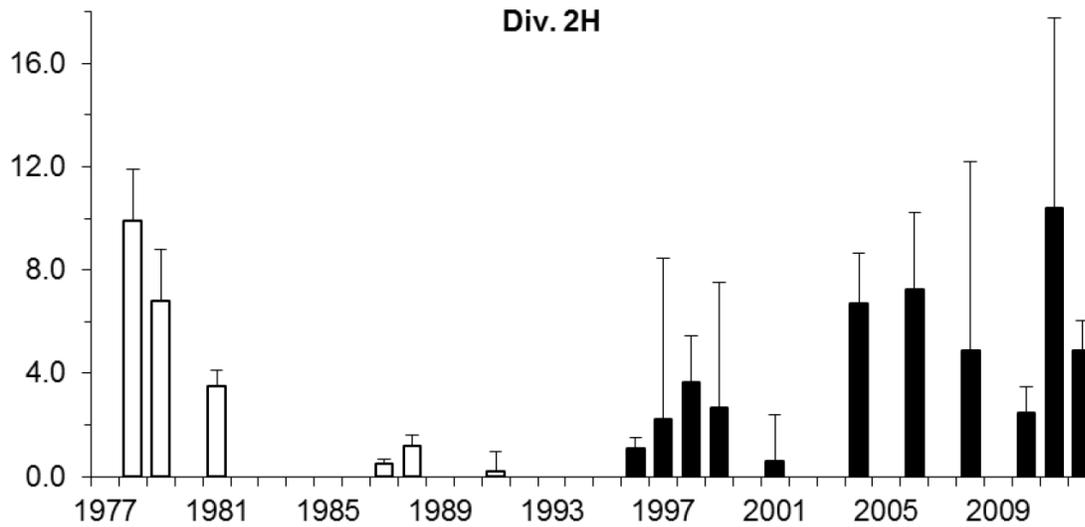
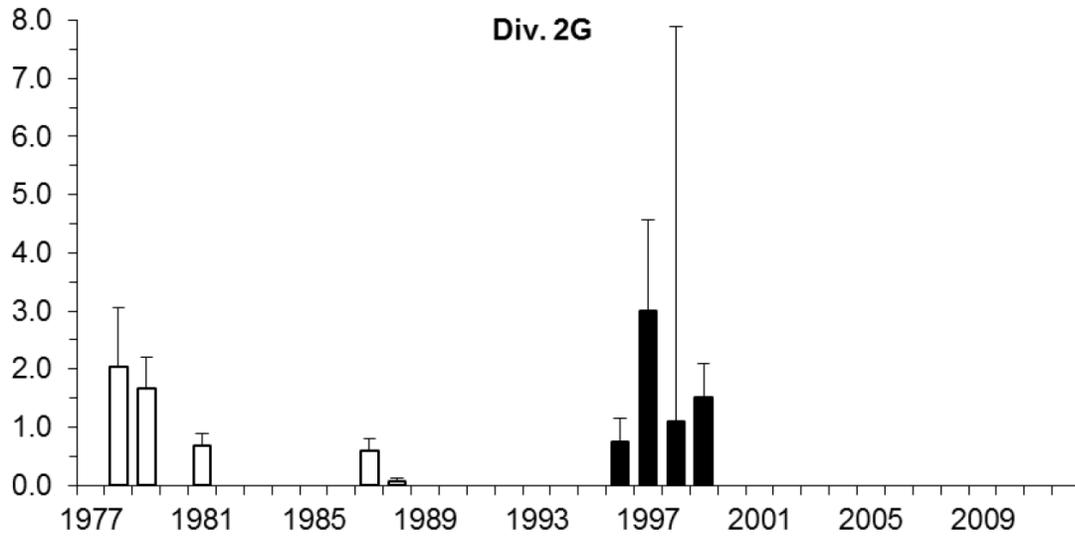


Figure 14. Research survey indices (mean number per tow) for Atlantic Wolffish in Div. 2G and Div. 2H in fall, 1977-2012. T-bar = 1 SE. Survey trawl gear changed from Engel (white bar) to Campelen (black bar) in fall 1995.

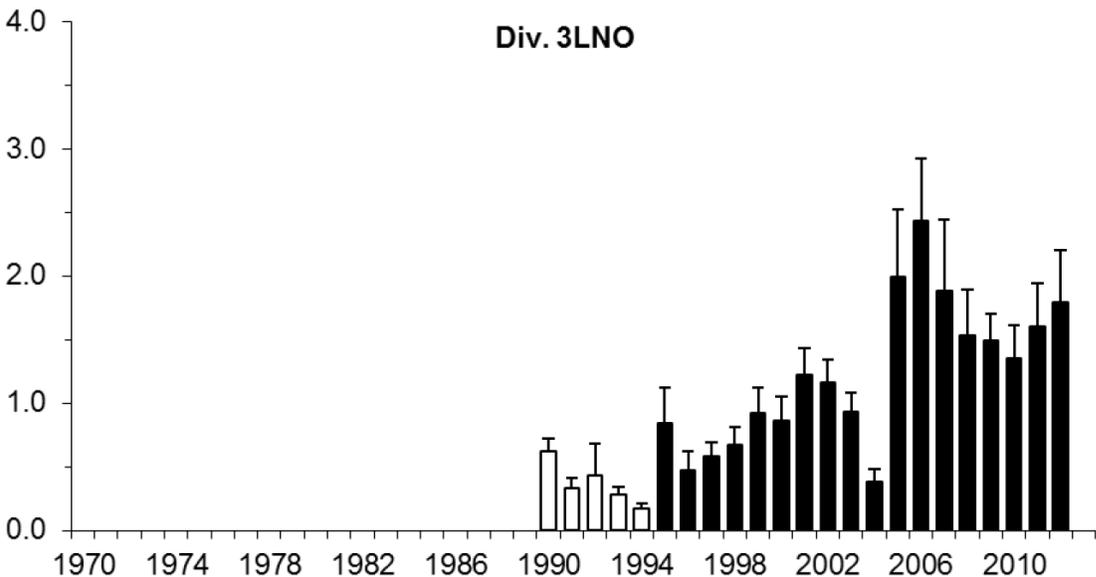
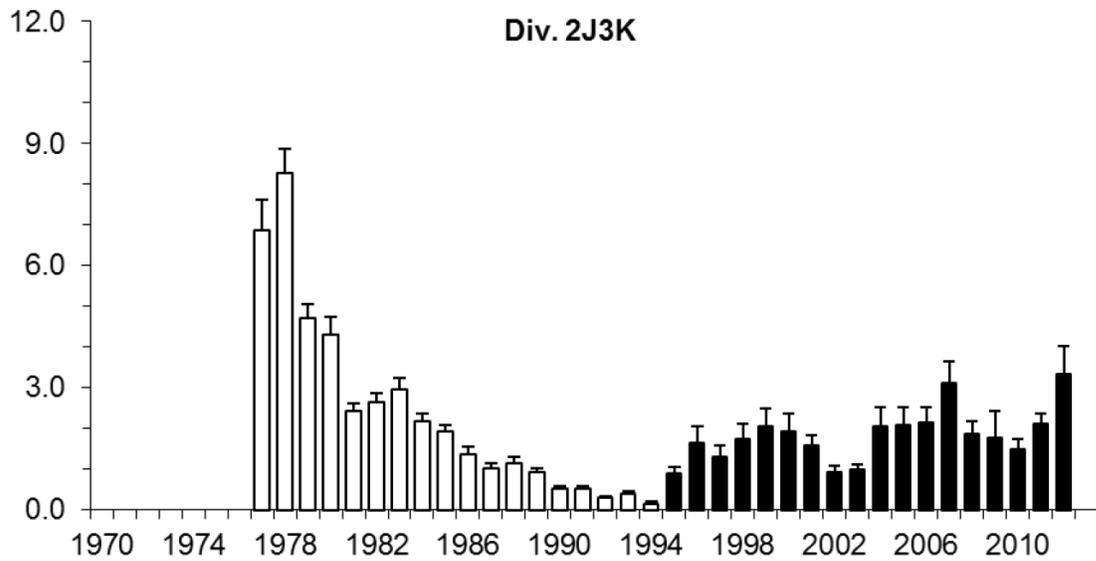


Figure 15. Research survey indices (mean number per tow) for Atlantic Wolffish in Div. 2J3K and Div. 3LNO in fall, 1977-2012. T-bar = 1 SE. Survey trawl gear changed from Engel (white bar) to Campelen (black bar) in fall 1995.

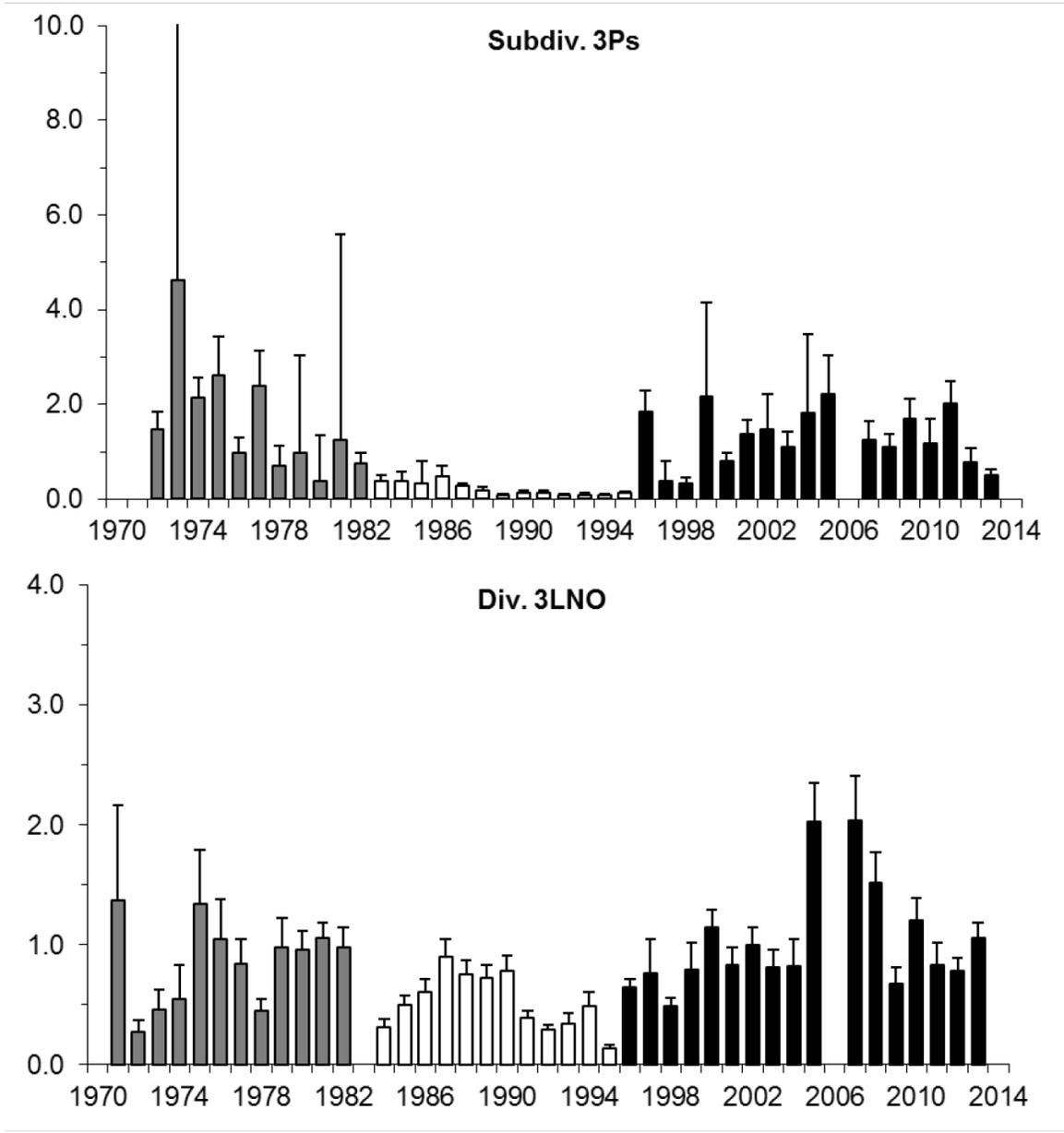


Figure 16. Research survey indices (mean number per tow) for Atlantic Wolffish in Subdiv. 3Ps and Div. 3LNO in spring, 1971-2013. T-bar = 1 SE. Survey trawl gear changed from Yankee (grey bar) to Engel (white bar) in 1983, and from Engel to Campelen (black bar) in spring 1996.

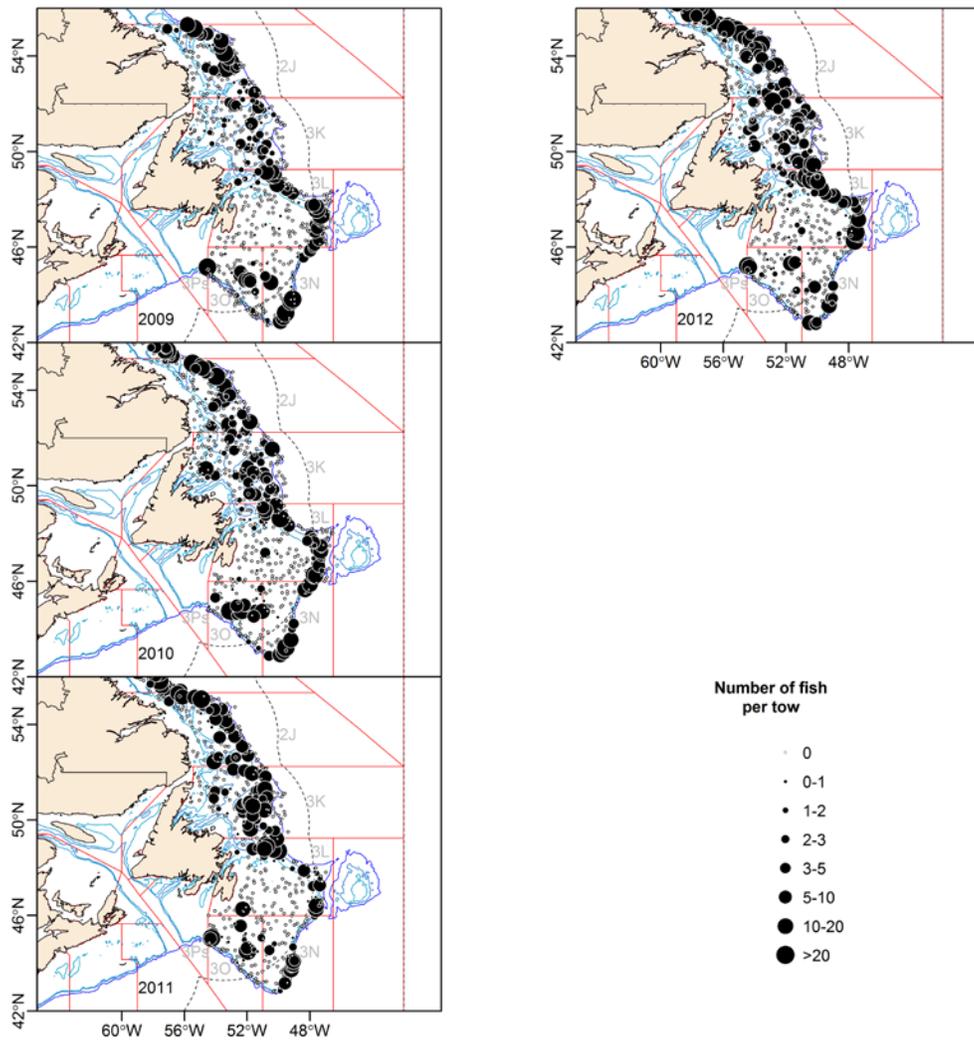


Figure 17. Distribution of recent catches of Atlantic Wolffish based on DFO-NL fall research surveys in 2009-12.

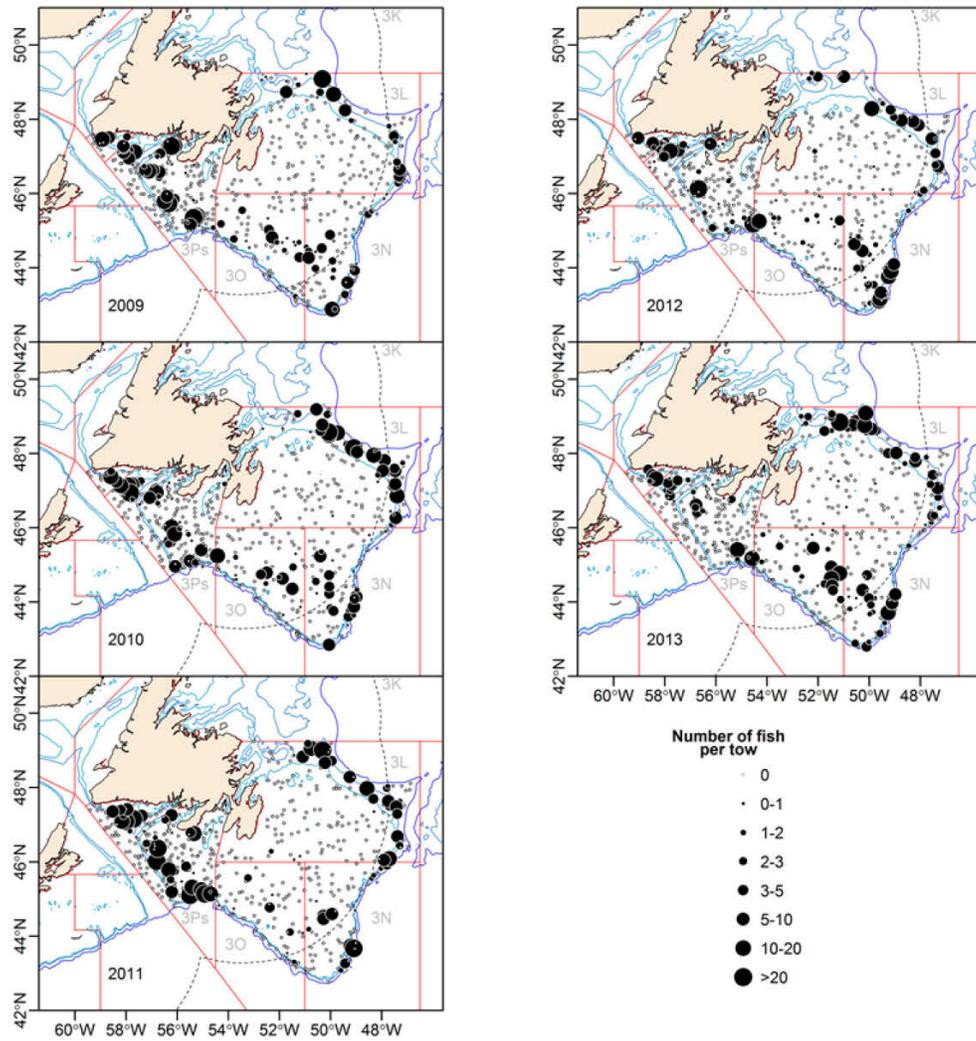


Figure 18. Distribution of recent catches of Atlantic Wolffish based on DFO-NL spring research surveys in 2009-13.

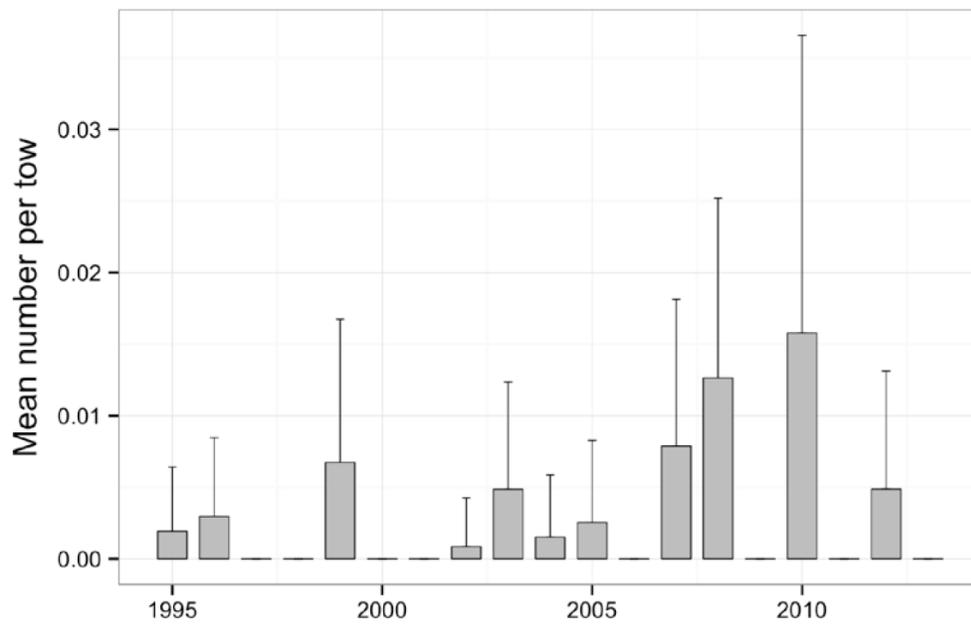


Figure 19. Abundance indices (mean number per tow) for Northern Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during mobile sentinel surveys, 1995-2013. Error bars are upper 95% confidence intervals.

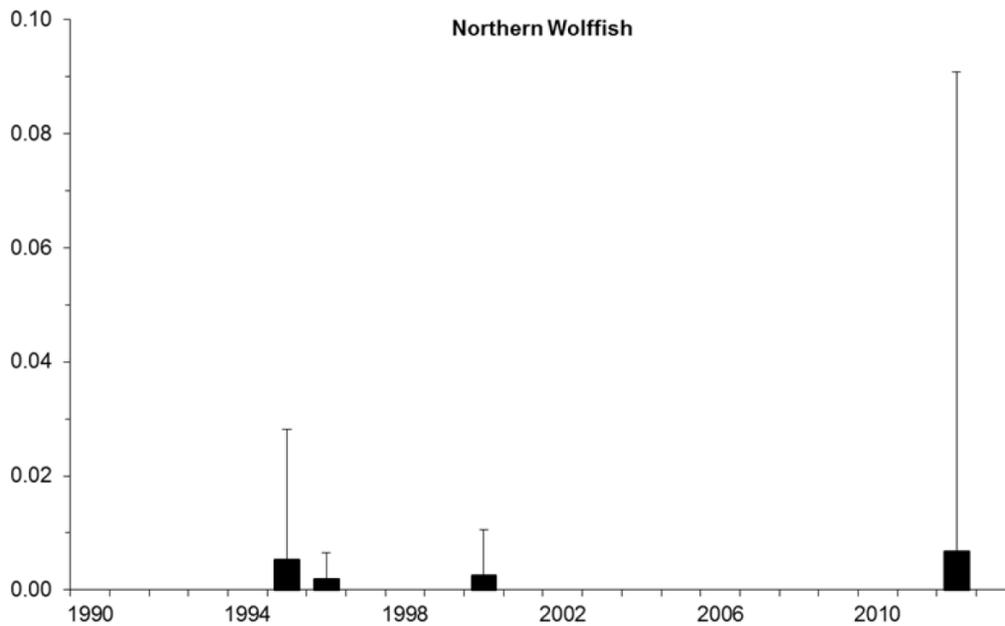


Figure 20. Abundance indices (mean number per tow) for Northern Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during DFO research surveys, 1990-2013. Error bars are upper 95% confidence intervals.

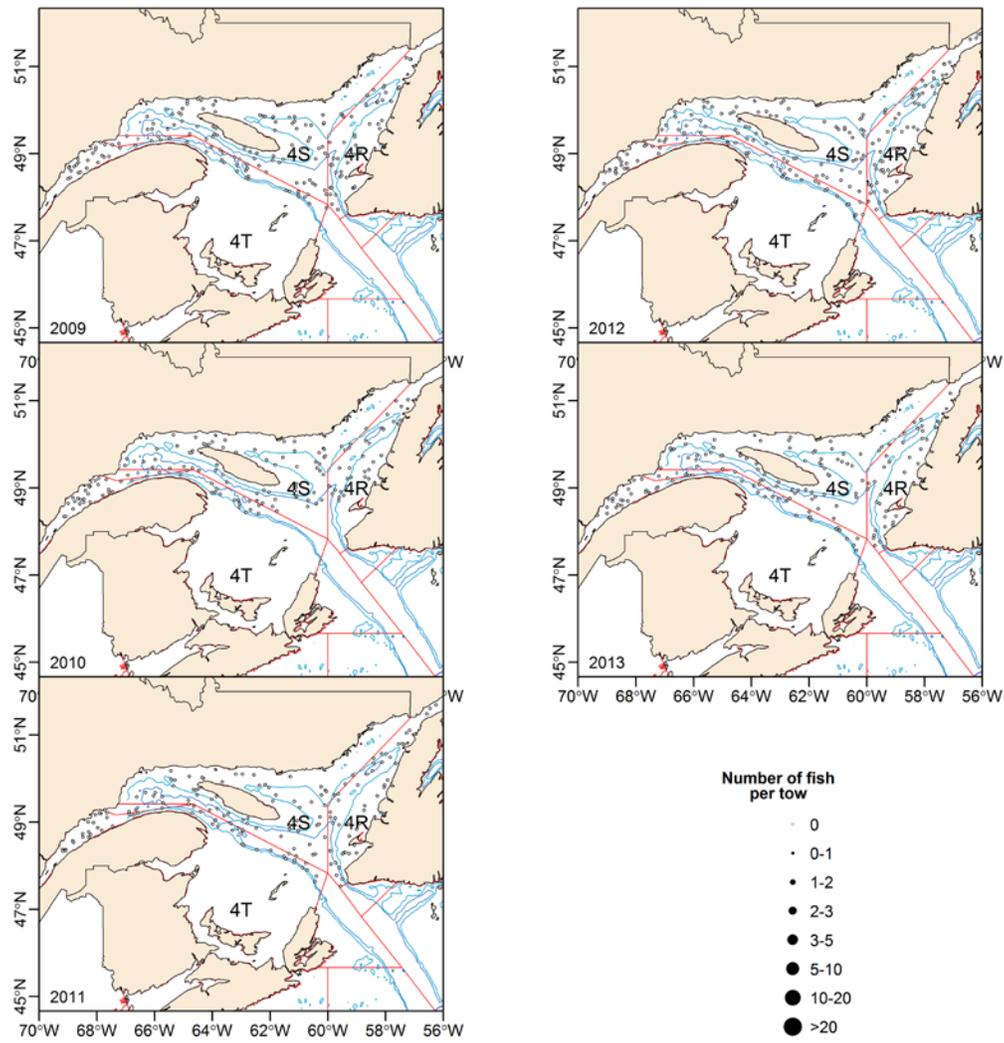


Figure 21. Distribution of recent catches of Northern Wolffish, based on DFO research surveys in Div. 4RS in 2009-13.

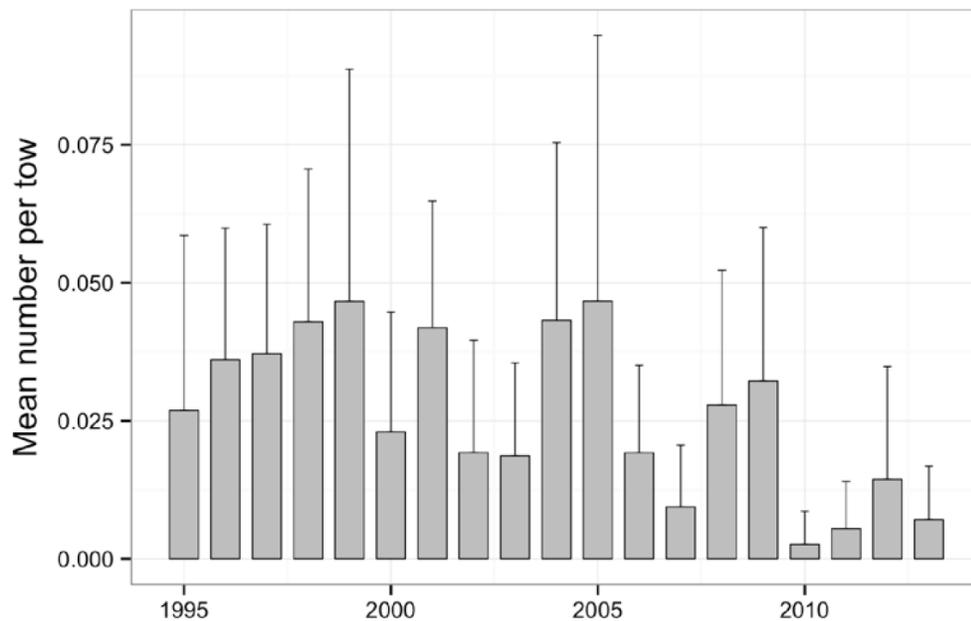


Figure 22. Abundance indices (mean number per tow) for Spotted Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during mobile sentinel surveys, 1995-2013. Error bars are upper 95% confidence intervals.

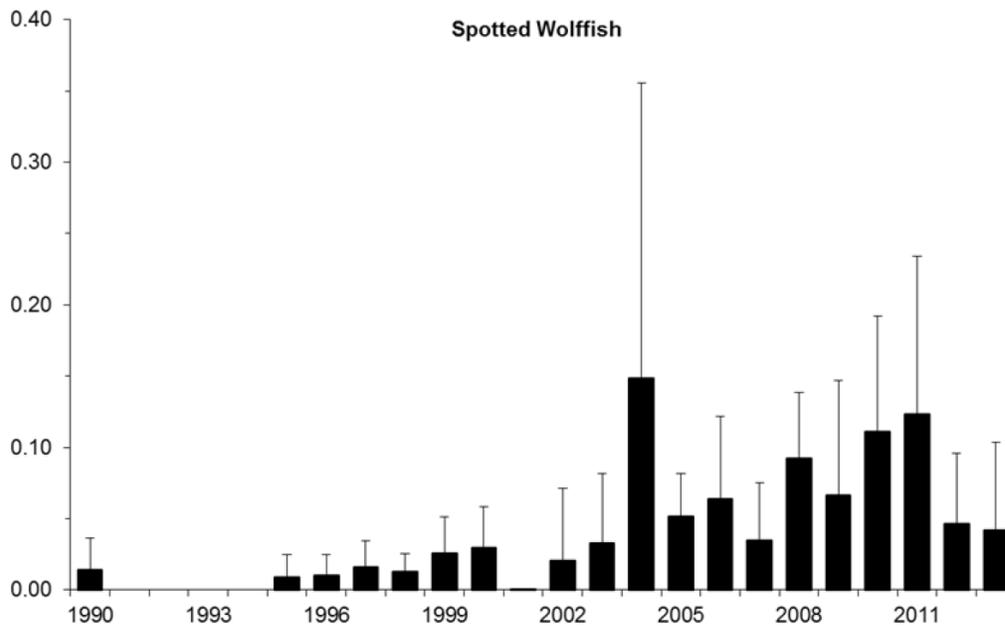


Figure 23. Abundance indices (mean number per tow) for Spotted Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during DFO research surveys, 1990-2013. Error bars are upper 95% confidence intervals.

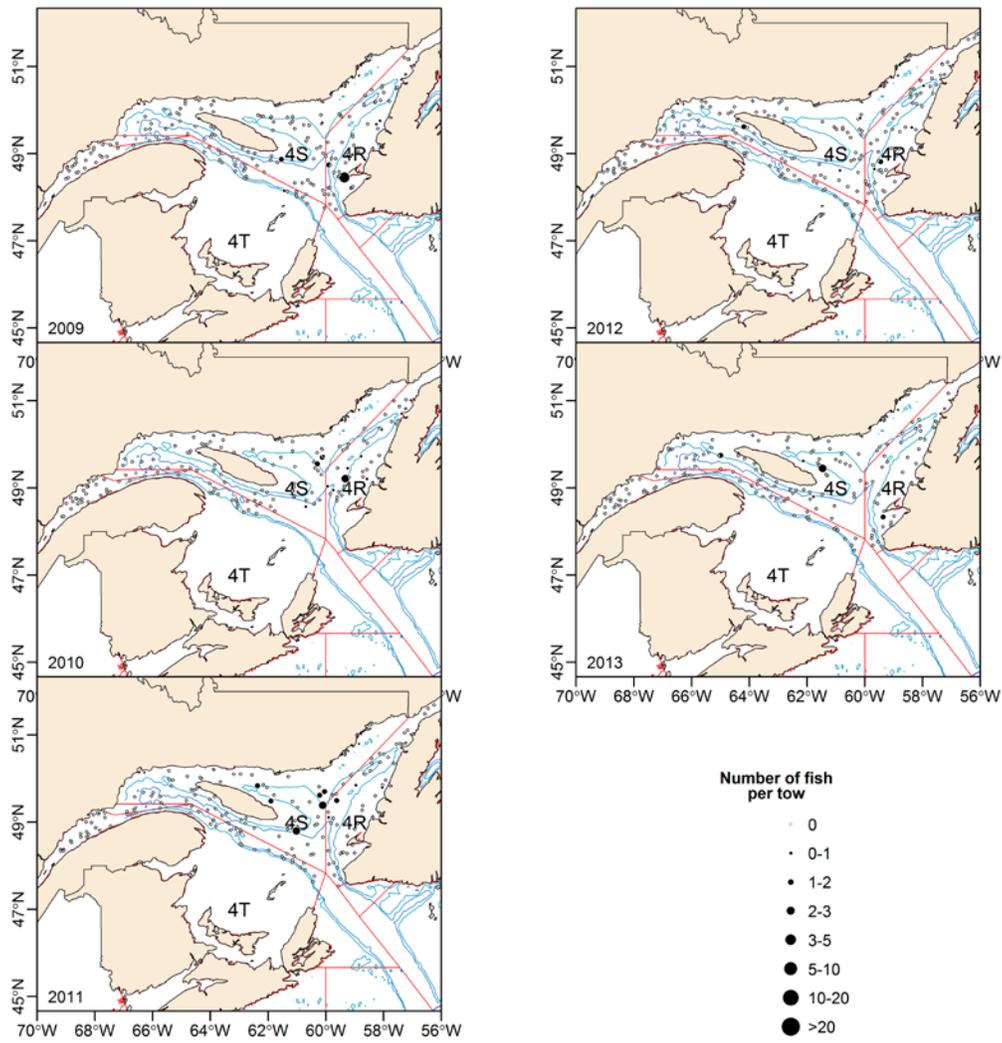


Figure 24. Distribution of recent catches of Spotted Wolffish, based on DFO research surveys in Div. 4RS (northern Gulf of St. Lawrence) in 2009-13.

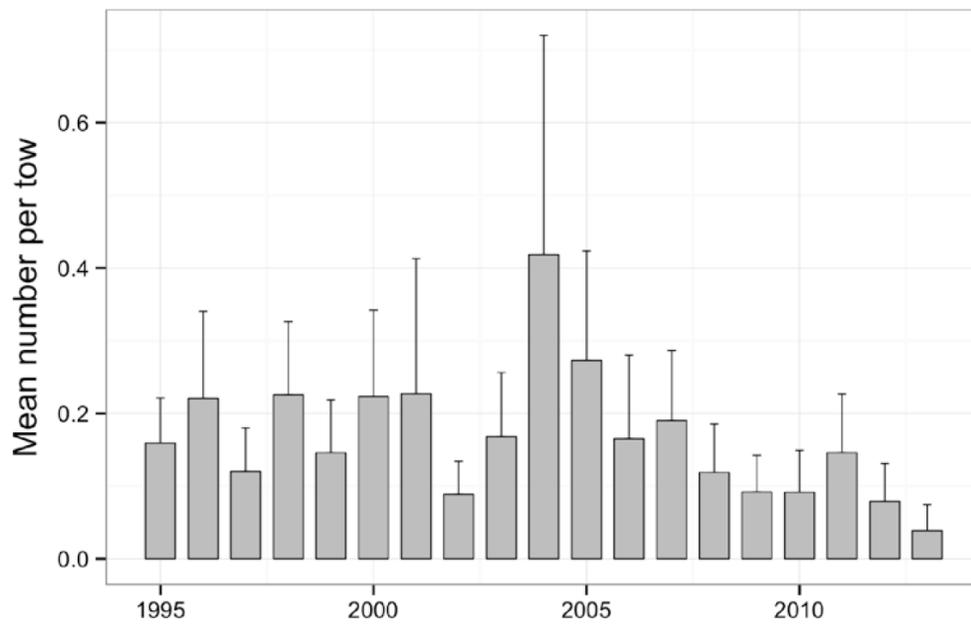


Figure 25. Abundance index (mean number per tow) for Atlantic Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during mobile sentinel surveys, 1995-2013. Error bars are upper 95% confidence intervals.

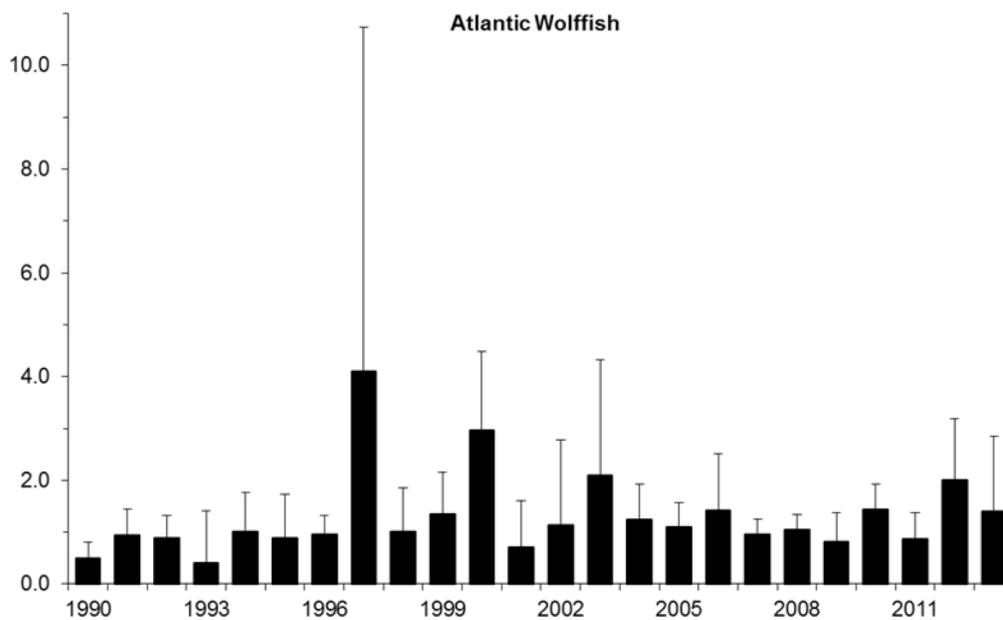


Figure 26. Abundance index (mean number per tow) for Atlantic Wolffish in Div. 4RS (northern Gulf of St. Lawrence) during DFO research surveys, 1990-2013. Error bars are upper 95% confidence intervals.

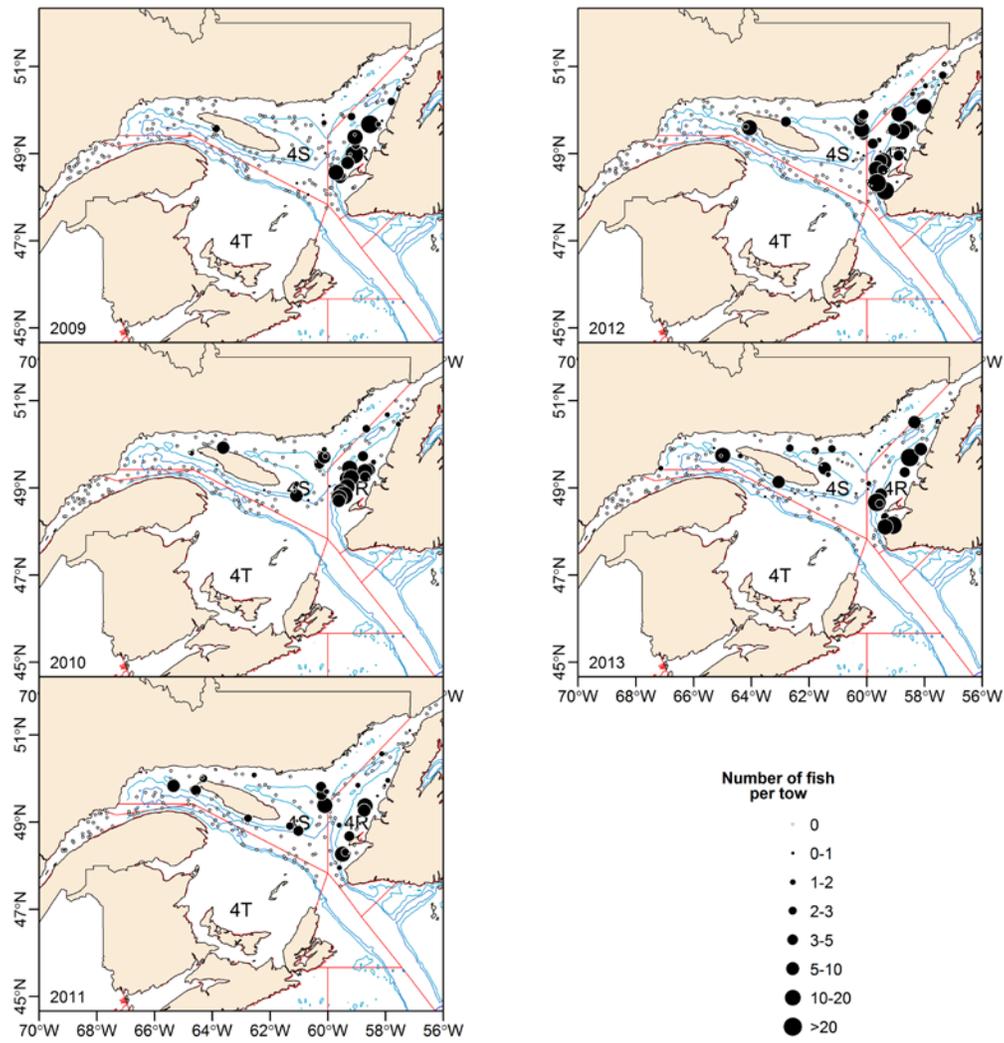


Figure 27. Distribution of recent catches of Atlantic Wolffish, based on DFO research surveys in Div. 4RS (northern Gulf of St. Lawrence) in 2009-13.

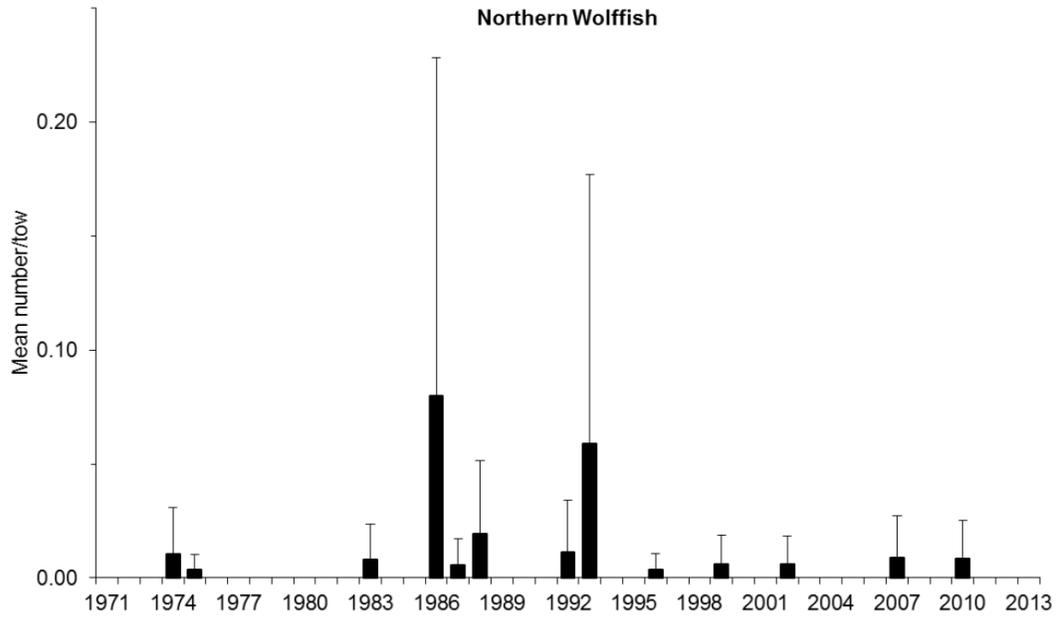


Figure 28. Abundance index (mean number per tow) for Northern Wolffish in Div. 4T (southern Gulf of St. Lawrence) from the September research survey, 1971-2013. Error bars are upper 95% confidence intervals.

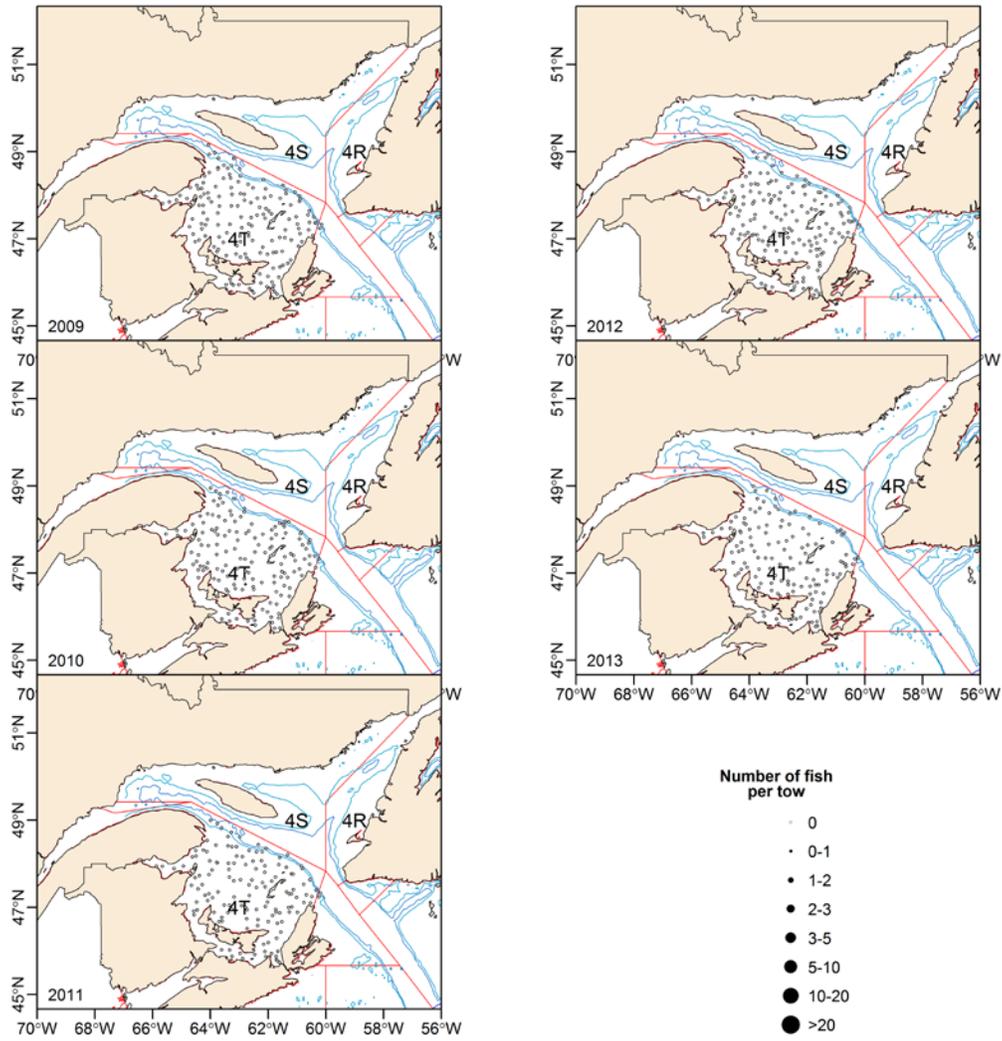


Figure 29. Distribution of recent catches of Northern Wolffish, based on DFO research surveys in Div. 4T (southern Gulf of St. Lawrence) in 2009-13.

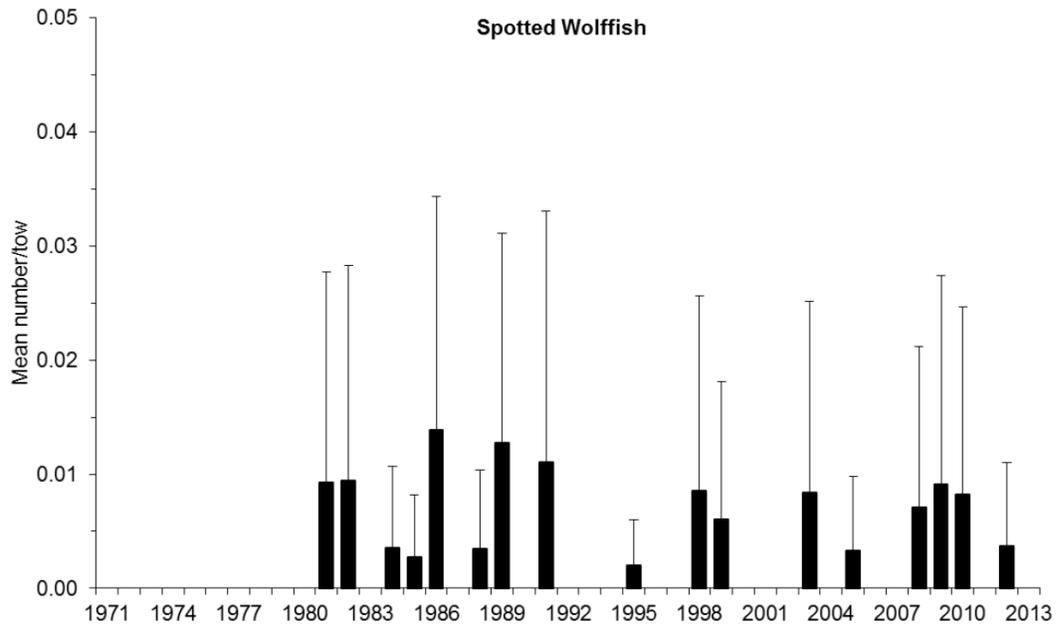


Figure 30. Abundance index (mean number per tow) for Spotted Wolffish in Div. 4T (southern Gulf of St. Lawrence) from the September research survey, 1971-2013. Error bars are upper 95% confidence intervals.

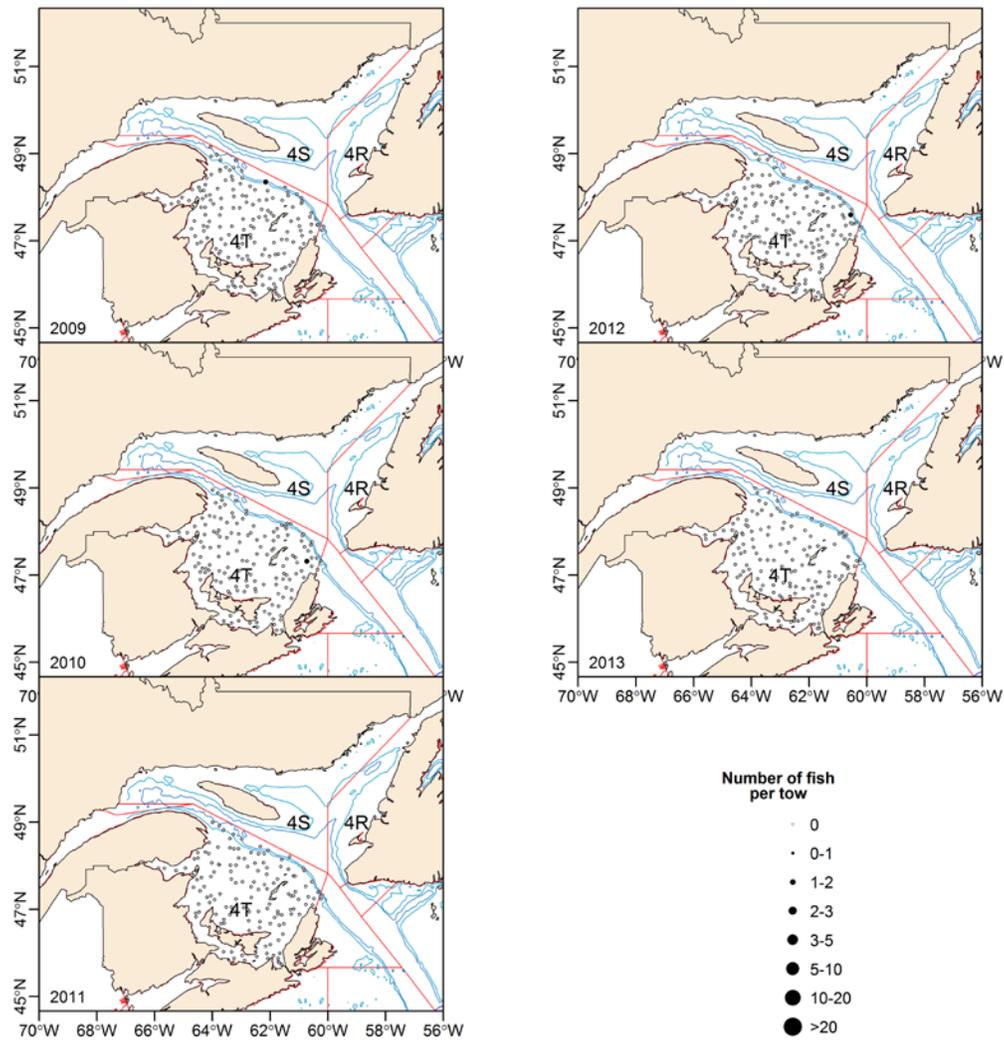


Figure 31. Distribution of recent catches of Spotted Wolffish, based on DFO research surveys in Div. 4T (southern Gulf of St. Lawrence) in 2009-13.

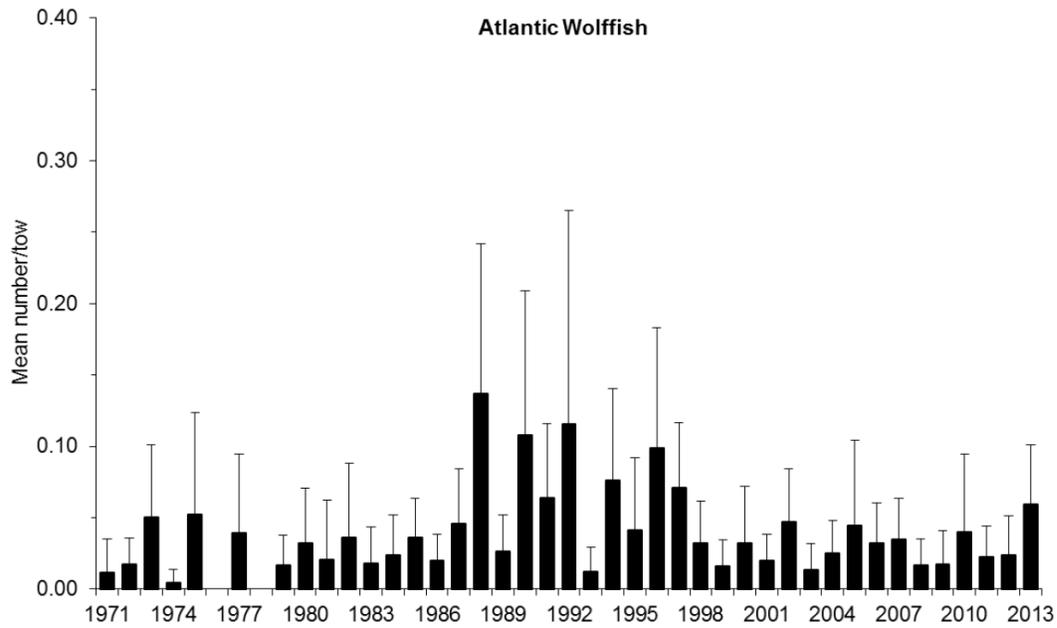


Figure 32. Abundance index (mean number per tow) for Atlantic Wolffish in Div. 4T (southern Gulf of St. Lawrence) from the September research survey, 1971-2013. Error bars are upper 95% confidence intervals.

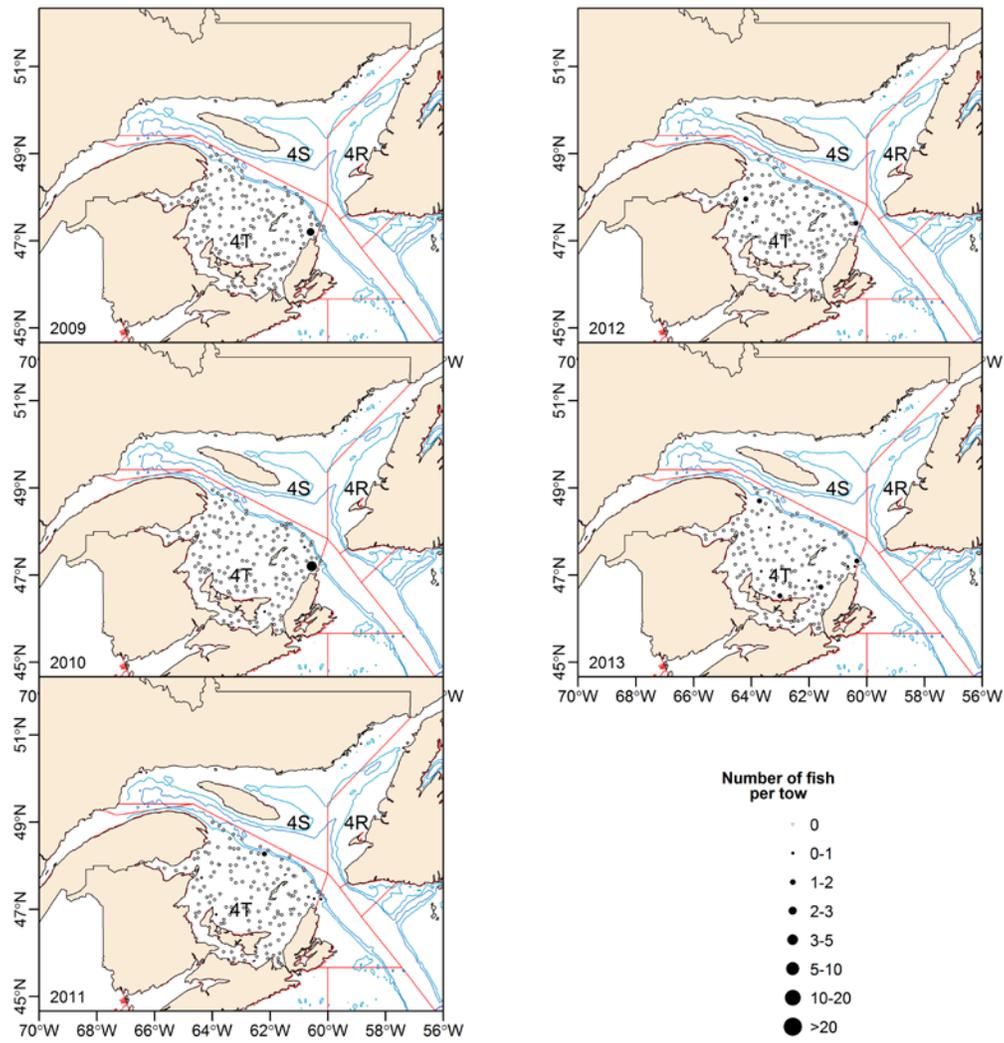


Figure 33. Distribution of recent catches of Atlantic Wolffish, based on DFO research surveys in Div. 4T (southern Gulf of St. Lawrence) in 2009-13.

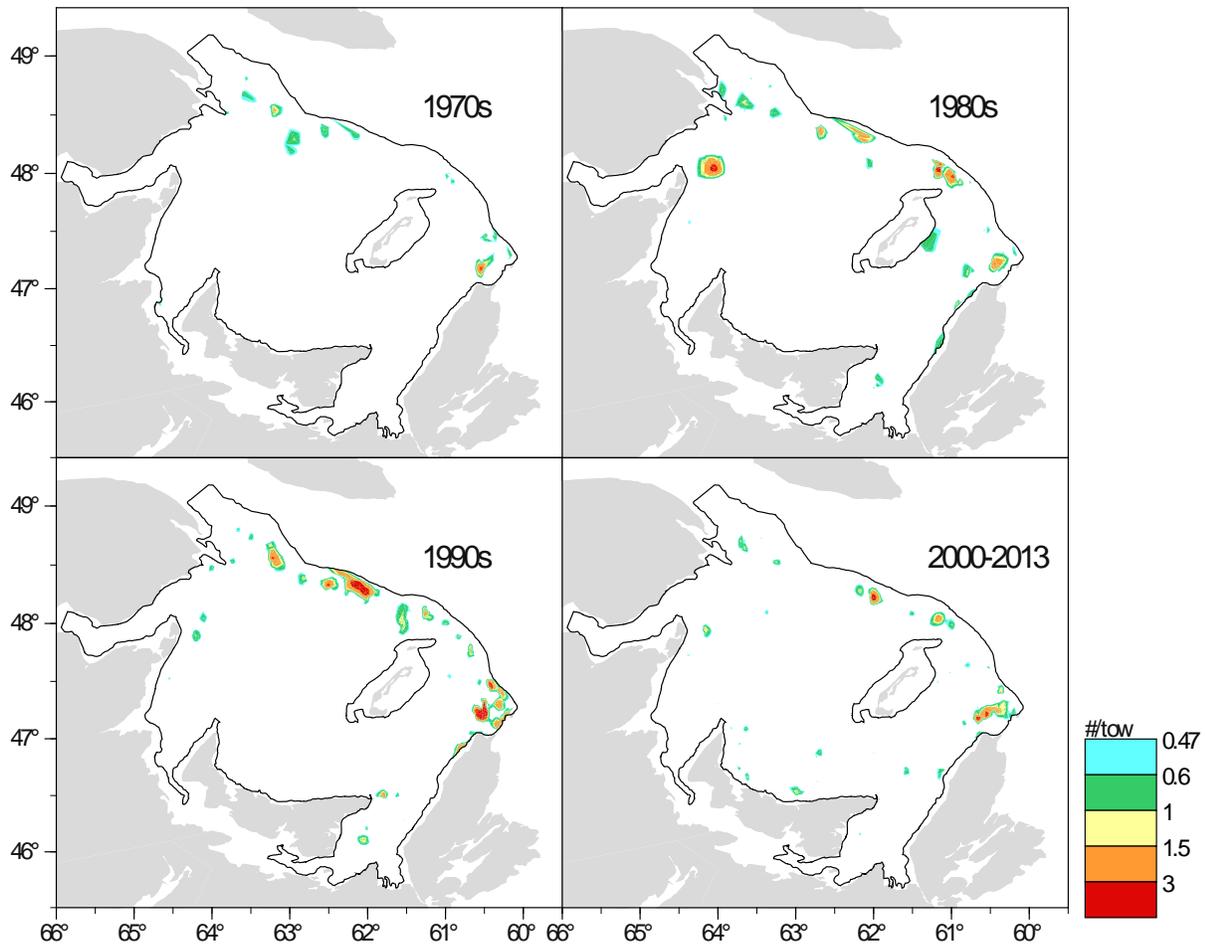


Figure 34. Distribution of Atlantic Wolffish catches (numbers/tow) in the Div. 4T (southern Gulf of St. Lawrence) DFO September research survey by decade. Contour levels are based on the 10, 25, 50, 75, and 90th percentiles of non-zero catches.

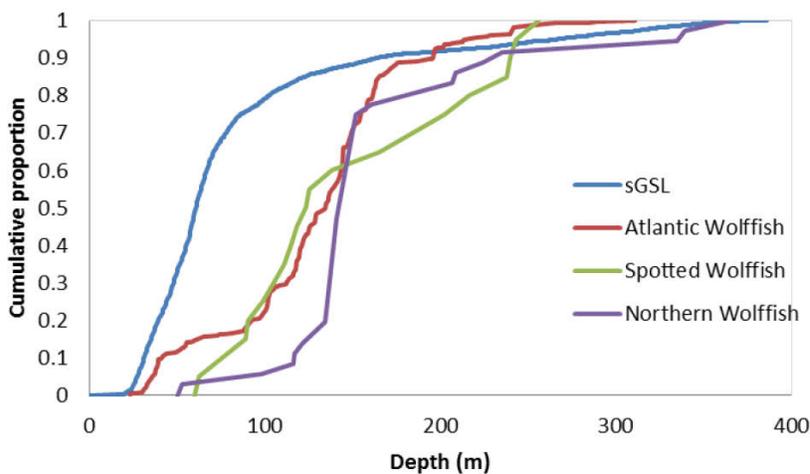


Figure 35. Cumulative distribution functions of the depths available in the southern Gulf of St. Lawrence (blue line) and the depths occupied by Atlantic (red line), Spotted (green line) and Northern (purple) wolffishes as perceived by the September research survey.

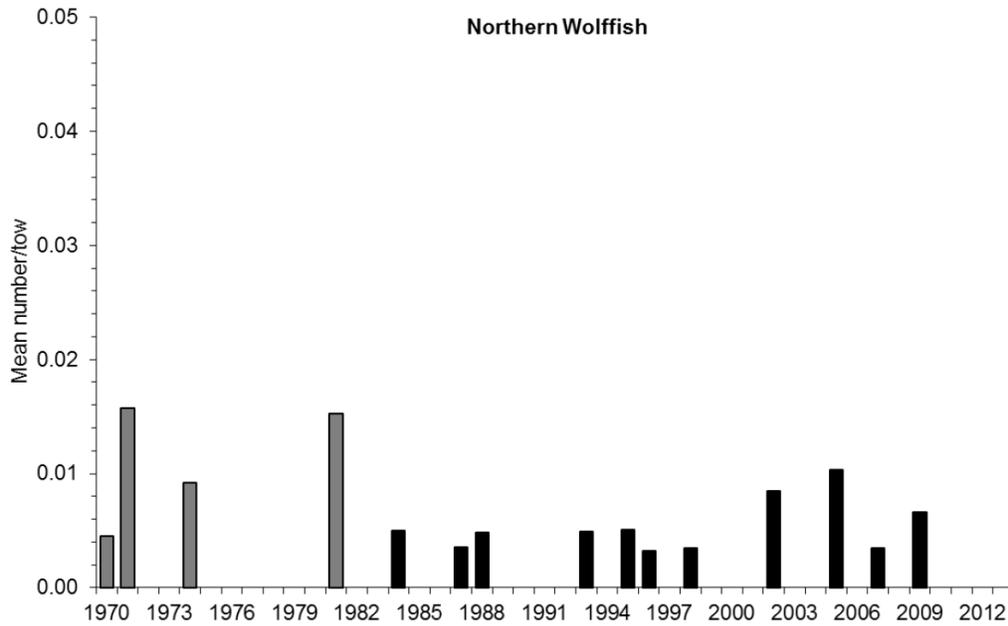


Figure 36. Abundance index (mean number per tow) for Northern Wolffish in Div. 4VWX from the DFO-Maritimes research survey, 1970-2013. Survey trawl gear changed from Yankee 36 to Western IIA in 1982.

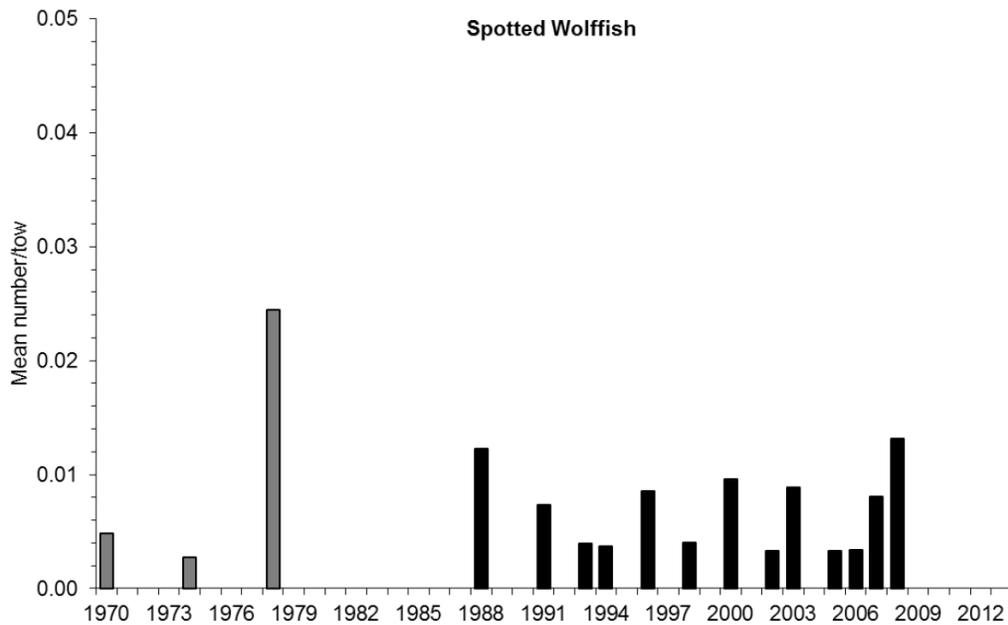


Figure 37. Abundance index (mean number per tow) for Spotted Wolffish in Div. 4VWX from the DFO-Maritimes research survey, 1970-2013. Survey trawl gear changed from Yankee 36 to Western IIA in 1982.

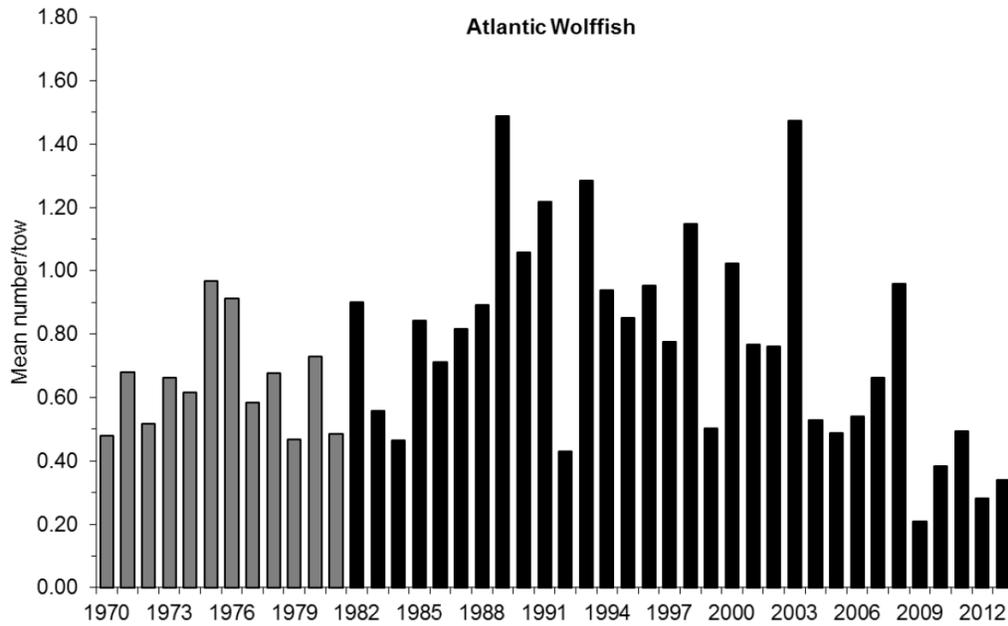


Figure 38. Abundance index (mean number per tow) for Atlantic Wolffish in Div. 4VWX from the DFO-Maritimes research survey, 1970-2013. Survey trawl gear changed from Yankee 36 to Western IIA in 1982.

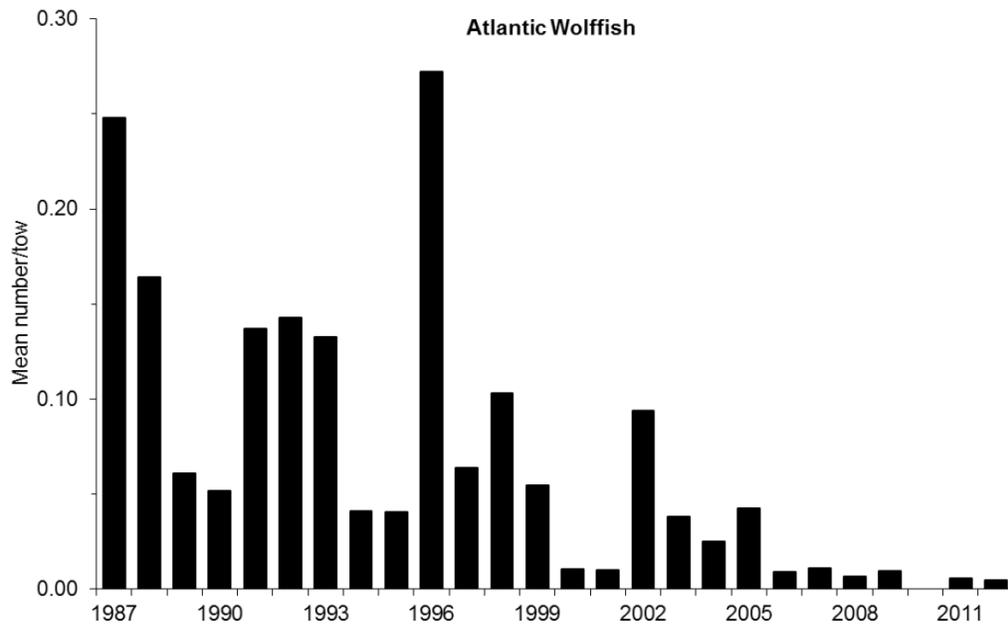


Figure 39. Abundance index (mean number per tow) for Atlantic Wolffish on Georges Bank, from the DFO-Maritimes research survey, 1987-2012.

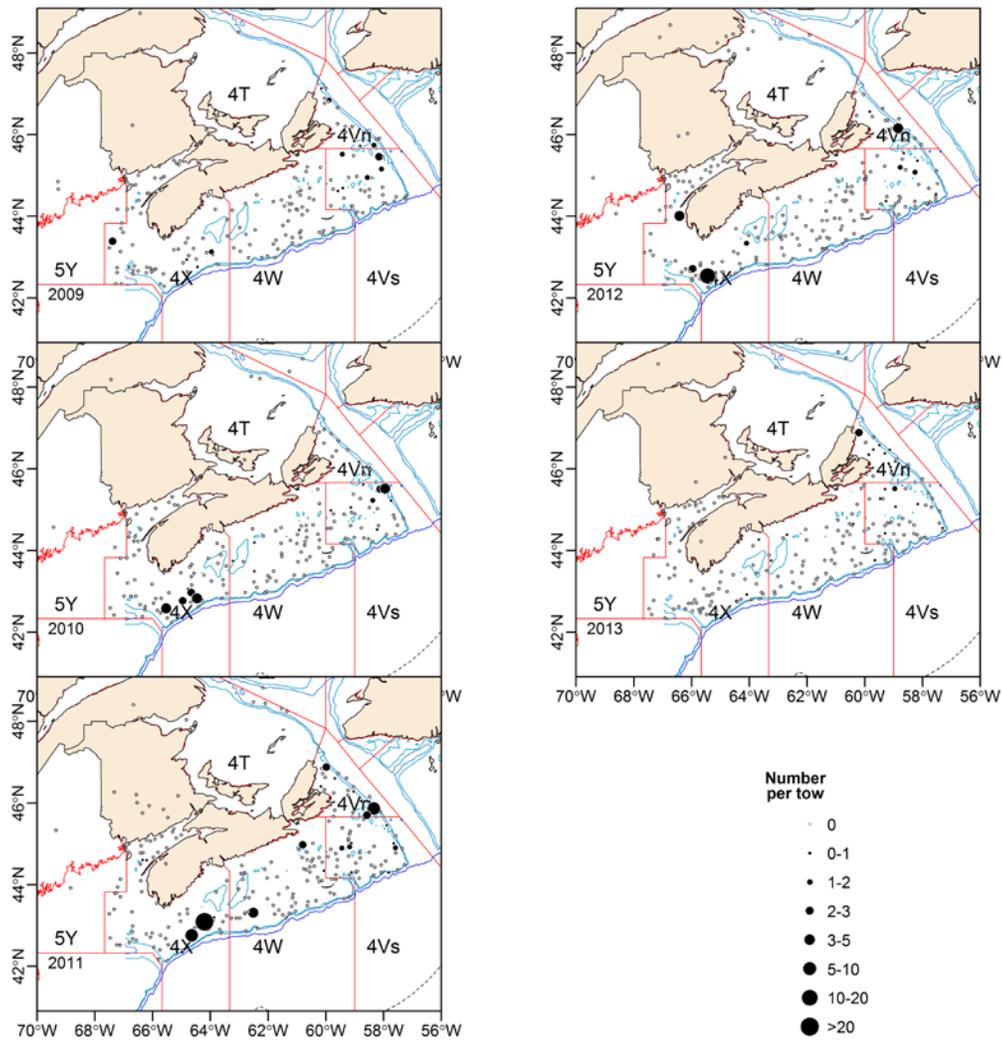


Figure 40. Distribution of recent catches of Atlantic Wolffish from DFO - Maritimes research surveys in Div. 4VWX5Y, 2009-13.

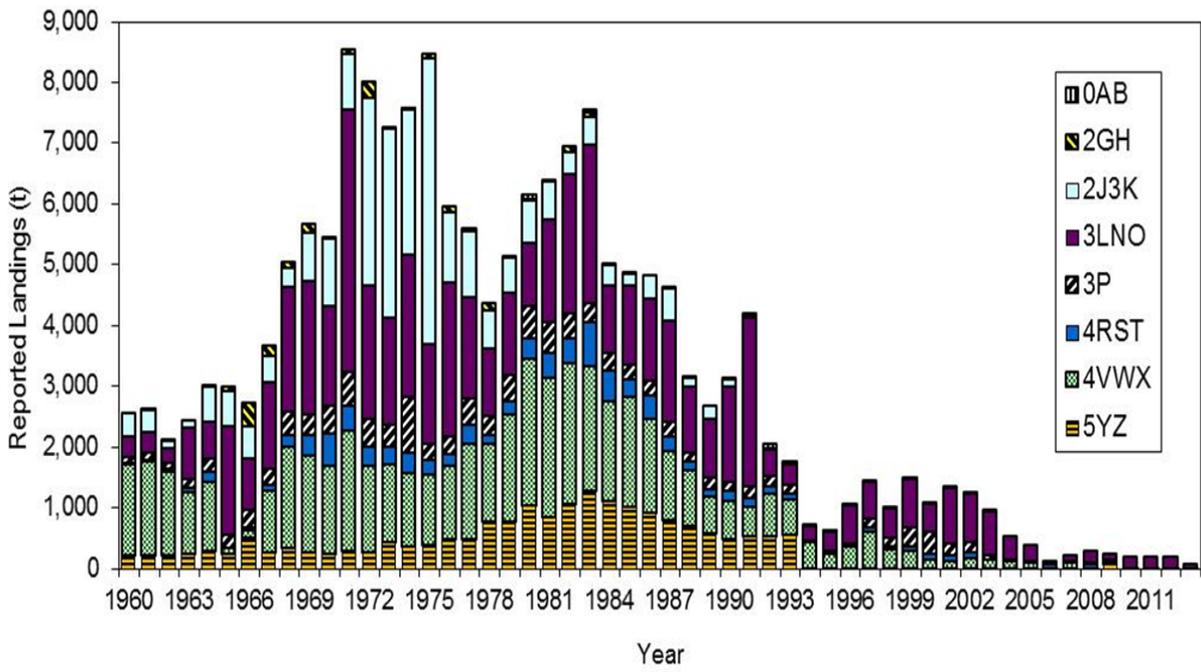


Figure 41. Reported landings of wolffish (unspeciated; in tons) in 1960-2013 from NAFO, ZIFF, and MAFIS databases.

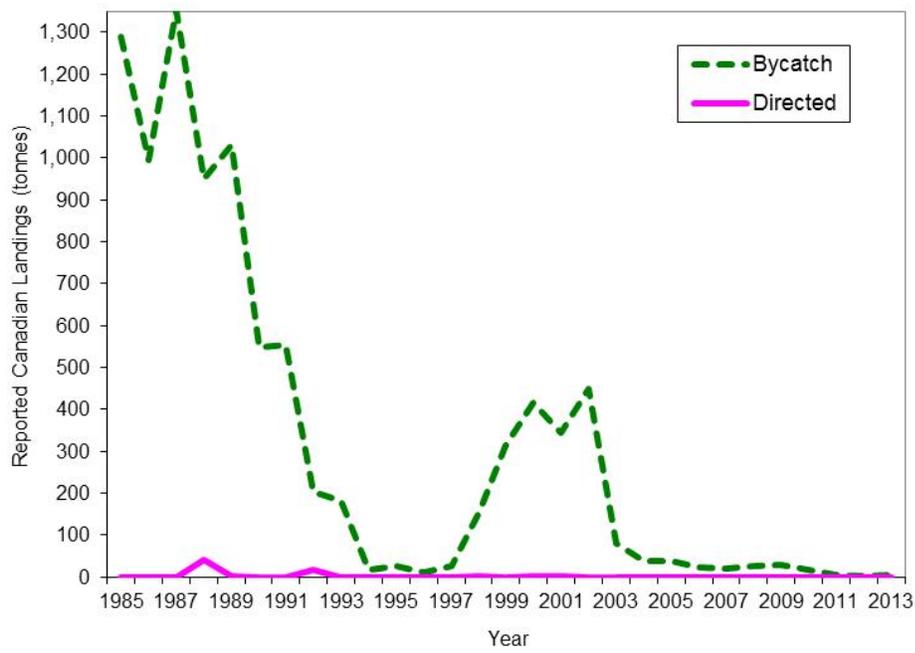


Figure 42. DFO-NL ZIFF-reported directed and bycatch wolffish landings (unspeciated; in tons) in Div. 2GHJ3KLNOP in Canada's EEZ in 1985-2013.

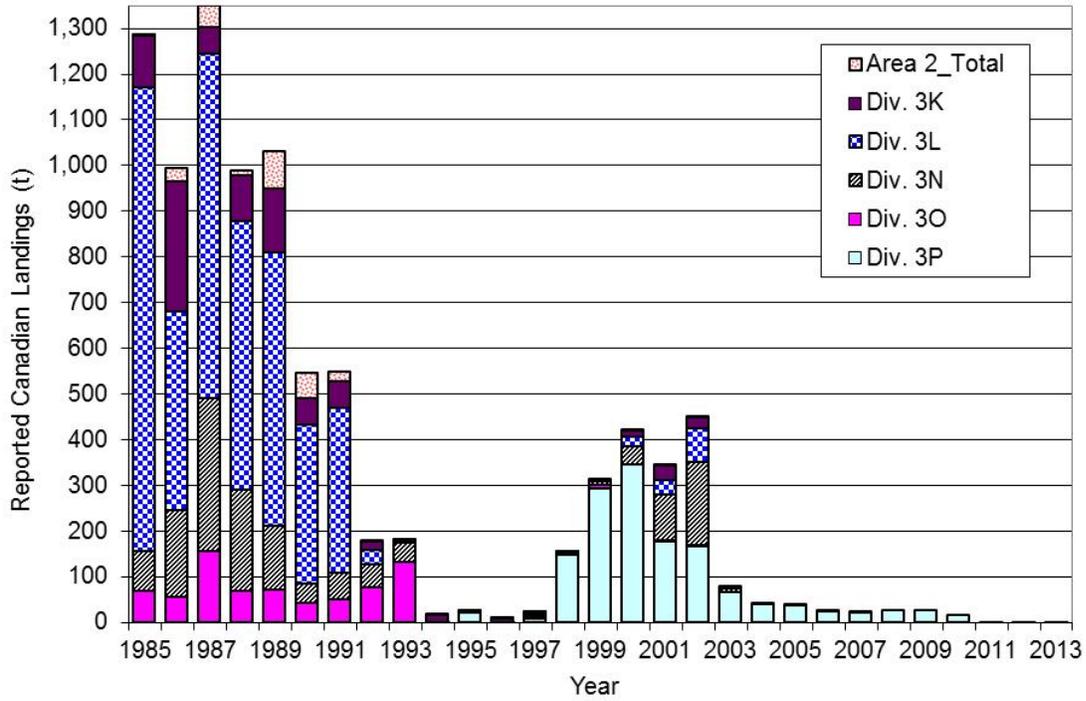


Figure 43. DFO-NL ZIFF-reported wolffish landings (unspeciated; in tons) in Subarea 2 and Div. 3KLNOP (in Canada's EEZ) in 1985-2013.

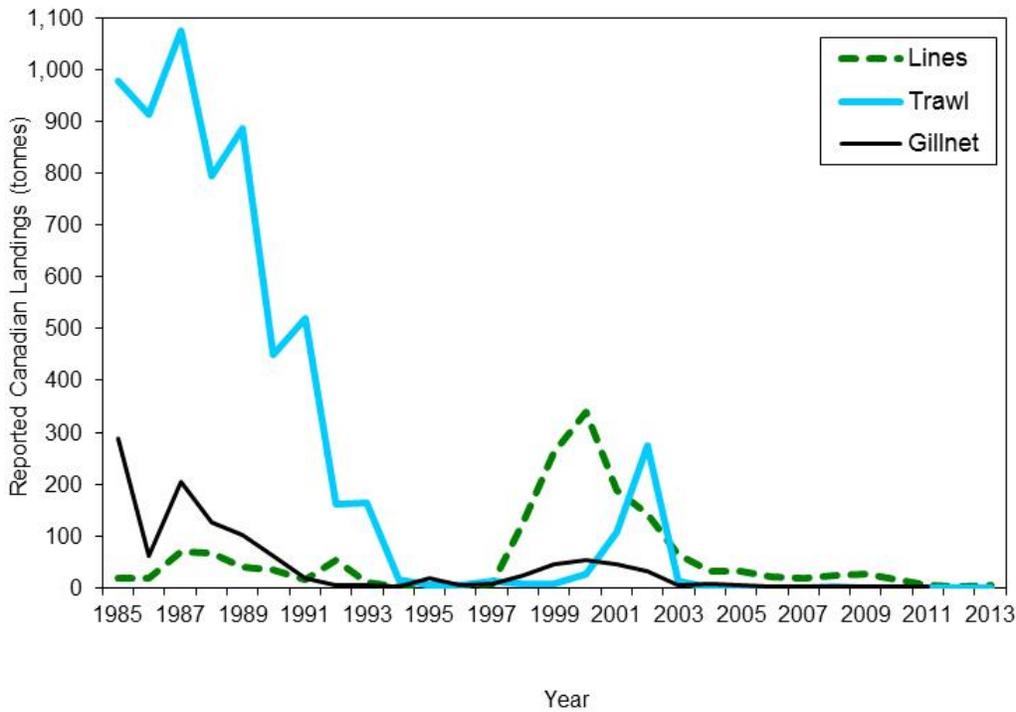


Figure 44. DFO-NL ZIFF-reported wolffish landings (unspeciated; in tons) by gear type in Div. 2GHJ3KLNOP (in Canada's EEZ) in 1985-2013.

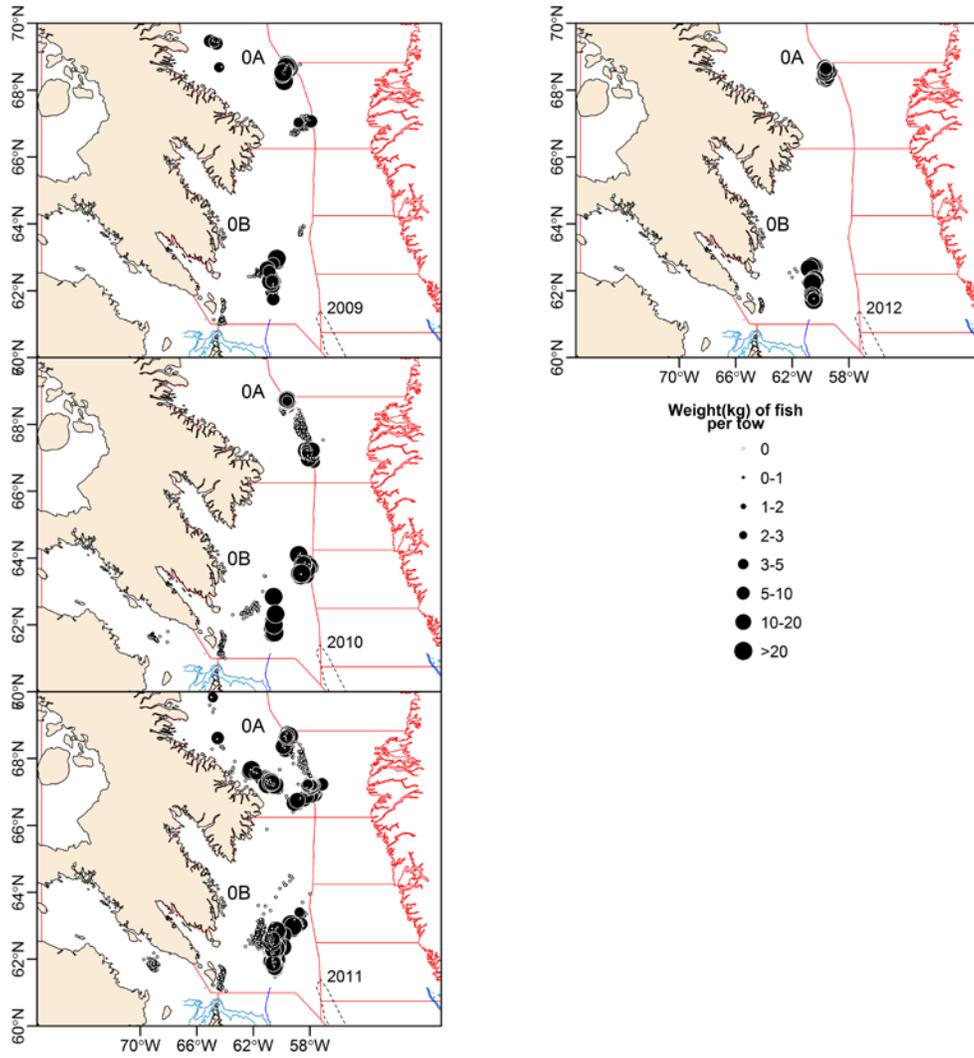


Figure 45. Distribution of recent catches of Northern Wolffish in 2009-12 as recorded by Canadian Fisheries Observers in Subarea 0 (Central and Arctic Region).

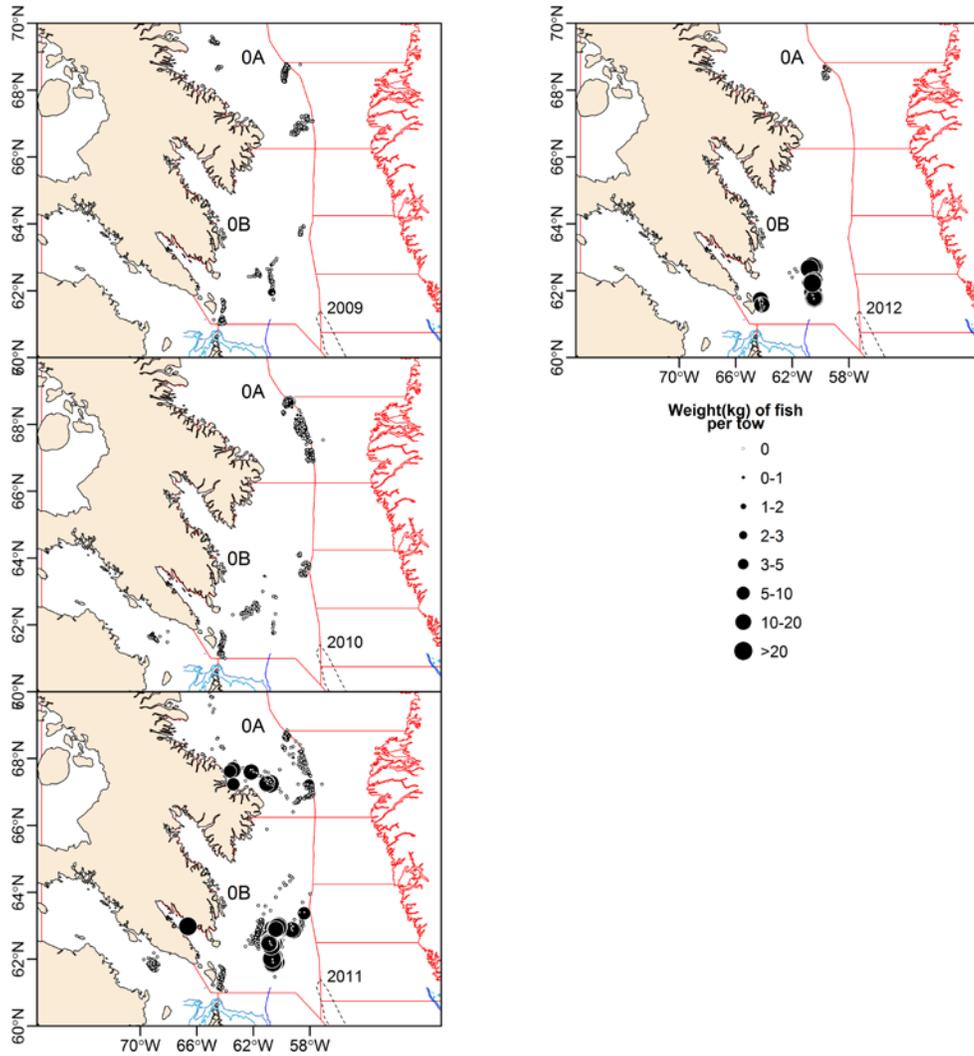


Figure 46. Distribution of recent catches of Spotted Wolffish in 2009-12 as recorded by Canadian Fisheries Observers in Subarea 0 (Central and Arctic Region).

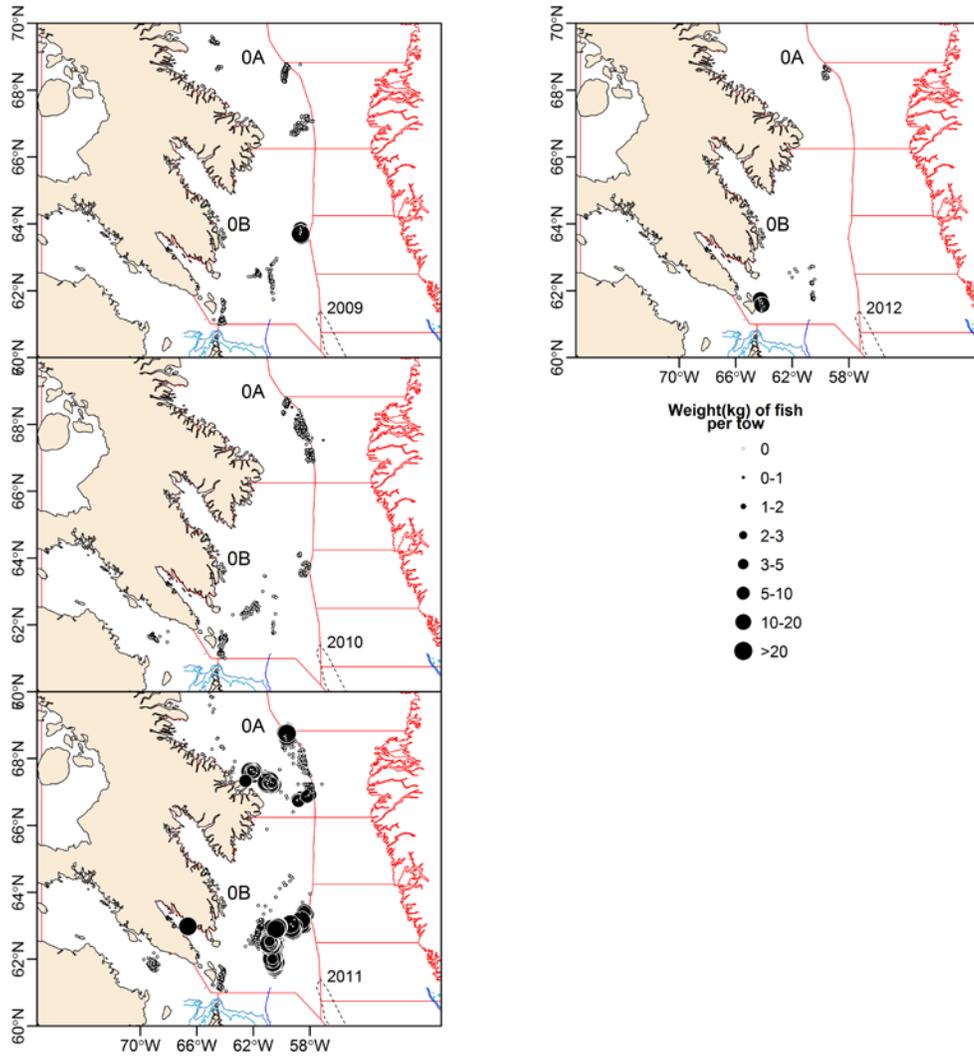


Figure 47. Distribution of recent catches of Atlantic Wolffish in 2009-12 as recorded by Canadian Fisheries Observers in Subarea 0 (Central and Arctic Region).

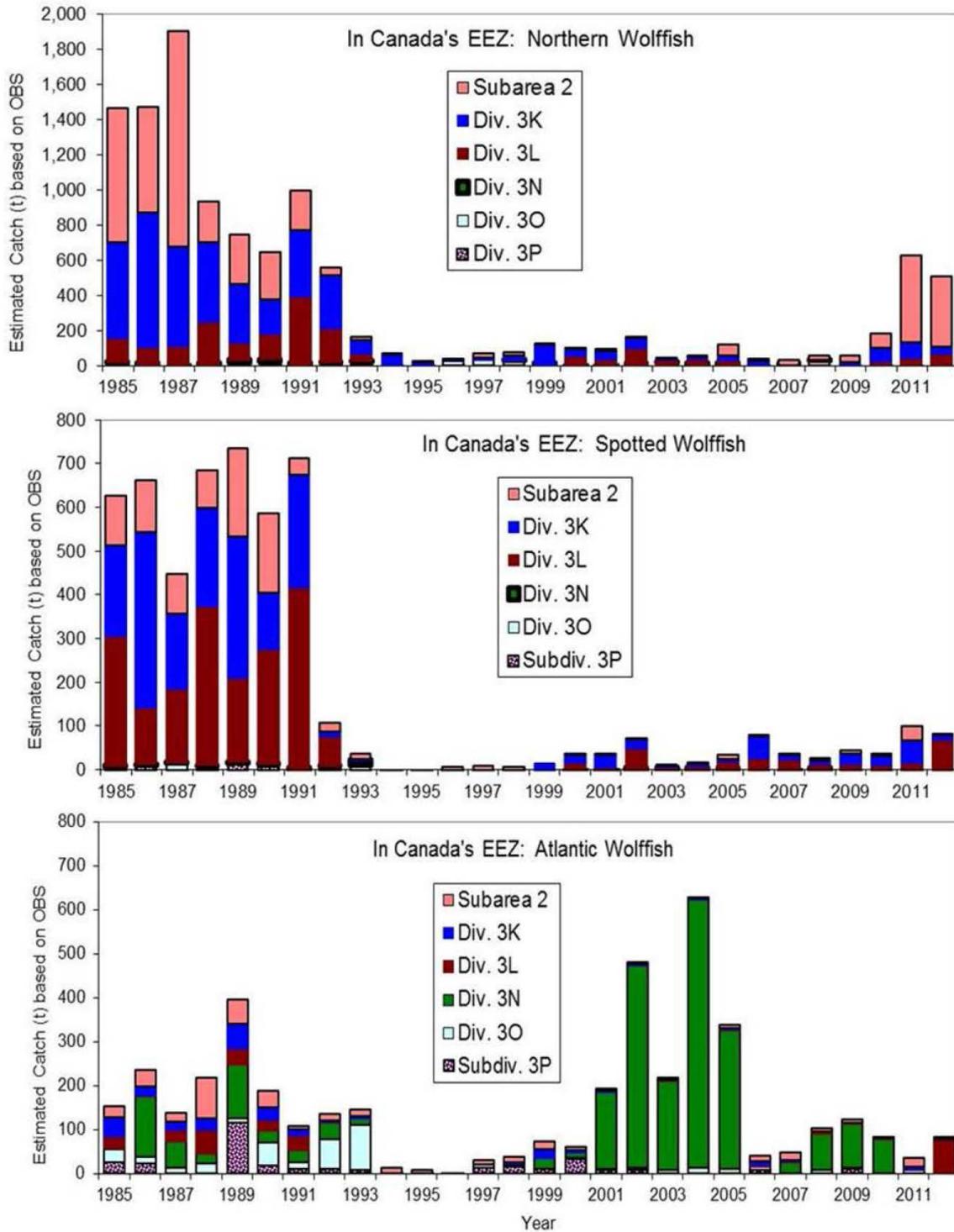


Figure 48. Speciated wolffish at-sea catch estimates (in tons) from various commercial fisheries in Subarea 2 and Div. 3KLNOP (in Canada's EEZ) in 1985-2012. Data are from Canadian Fisheries Observers and include discards at sea.

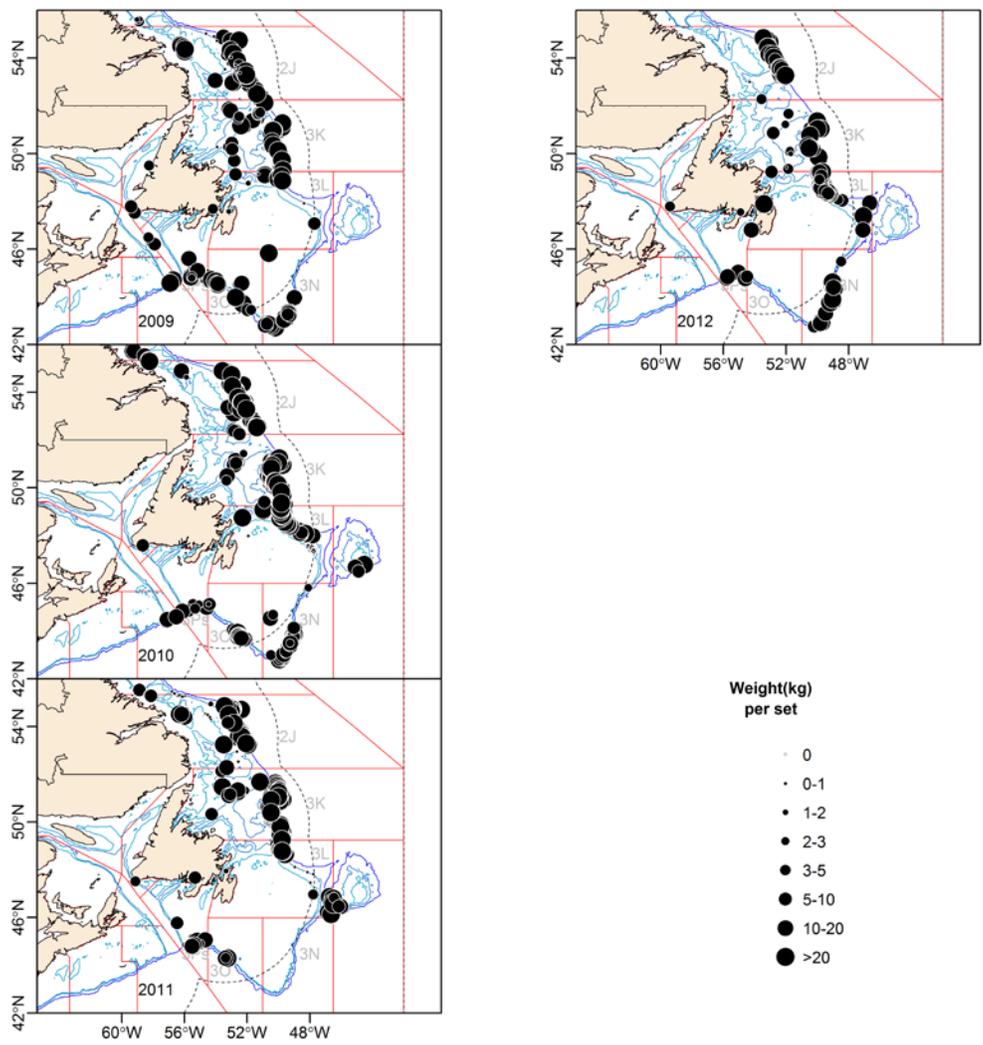


Figure 49. Distribution of catches of Northern Wolffish in 2009-12 as recorded by Canadian Fisheries Observers in Div. 2J3KLNOP4R (NL Region). Zero catches are not shown.

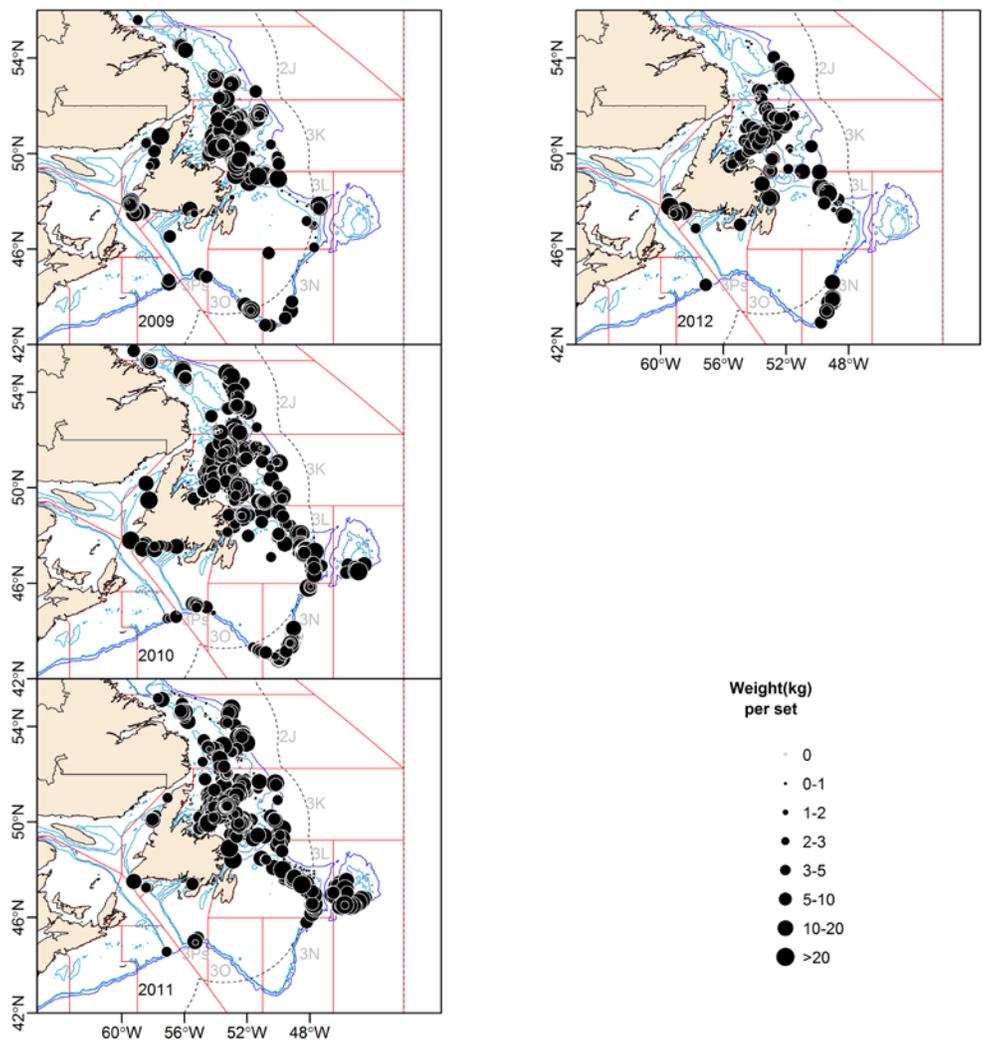


Figure 50. Distribution of catches of Spotted Wolffish in 2009-12 as recorded by Canadian Fisheries Observers in Div. 2J3KLNOP4R (NL Region). Zero catches are not shown.

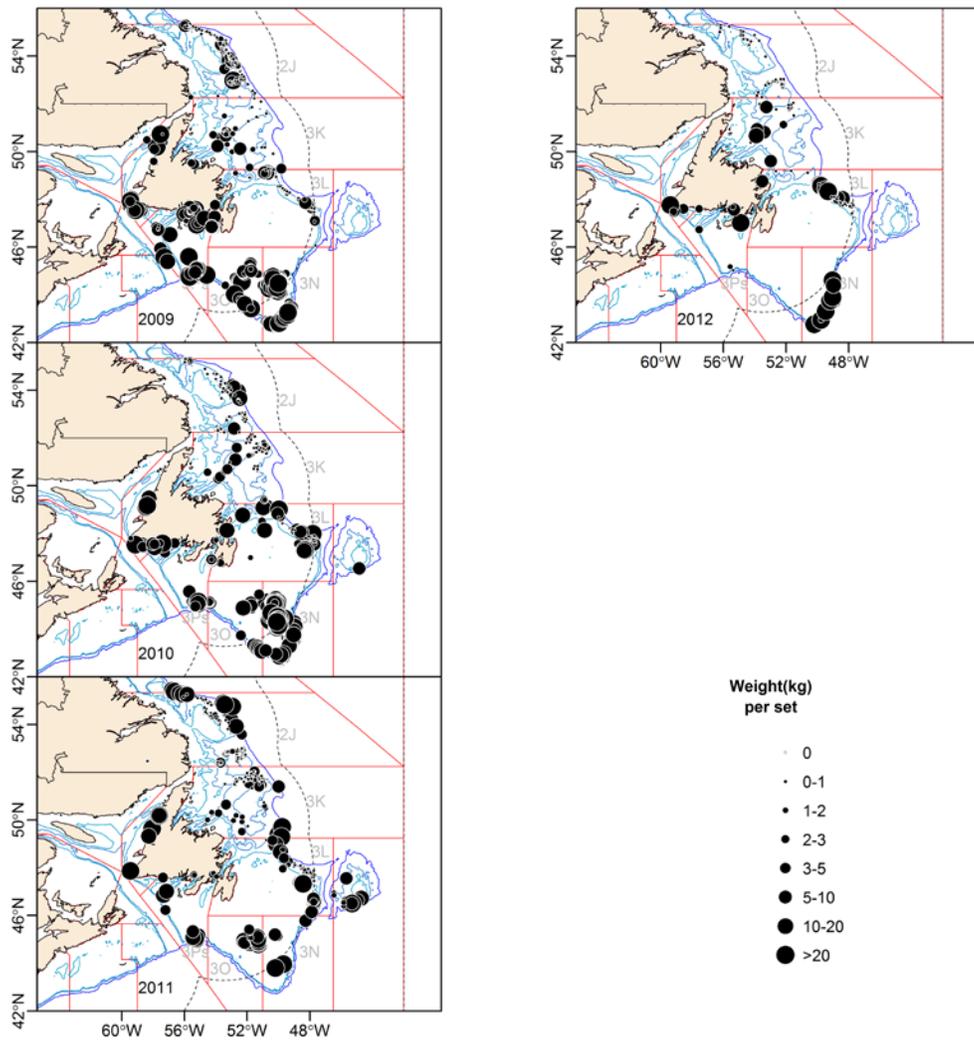


Figure 51. Distribution of catches of Atlantic Wolffish in 2009-12 as recorded by Canadian Fisheries Observers in Div. 2J3KLNOP4R (NL Region). Zero catches are not shown.

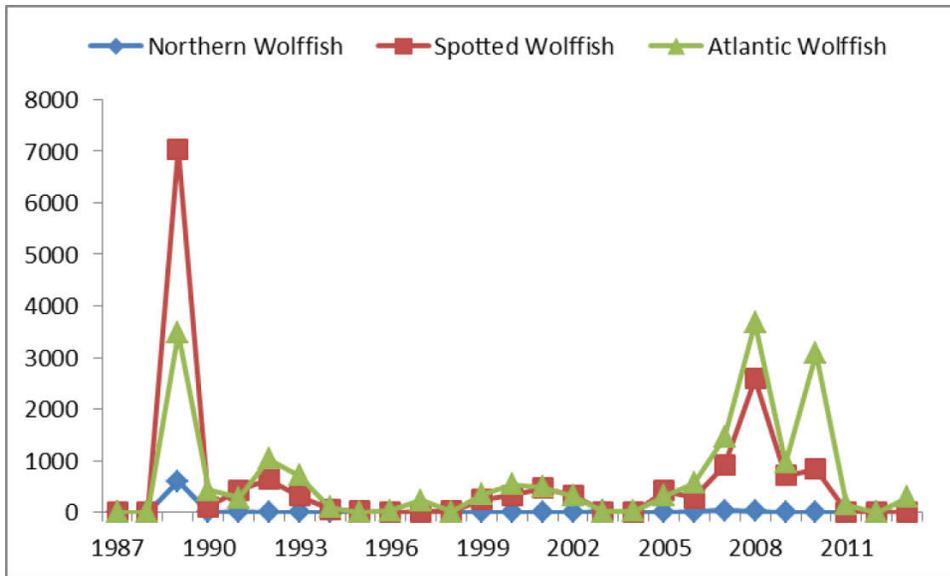


Figure 52. Total observed catch (numbers of kept + discards) of wolffish, as recorded by Canadian Fisheries Observers, in Div. 4R (Quebec Region).

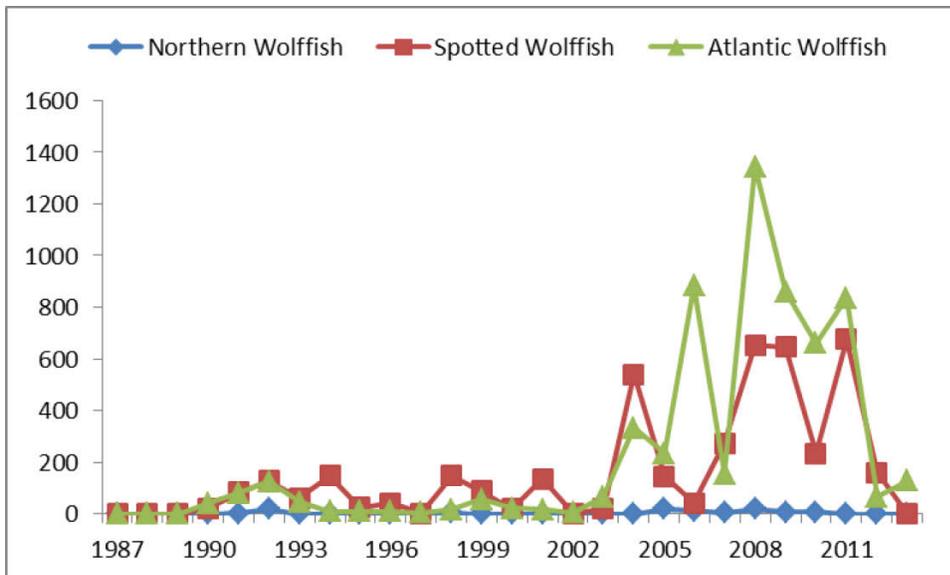


Figure 53. Total observed catch (numbers of kept + discards) of wolffish, as recorded by Canadian Fisheries Observers, in Div. 4S (Quebec Region).

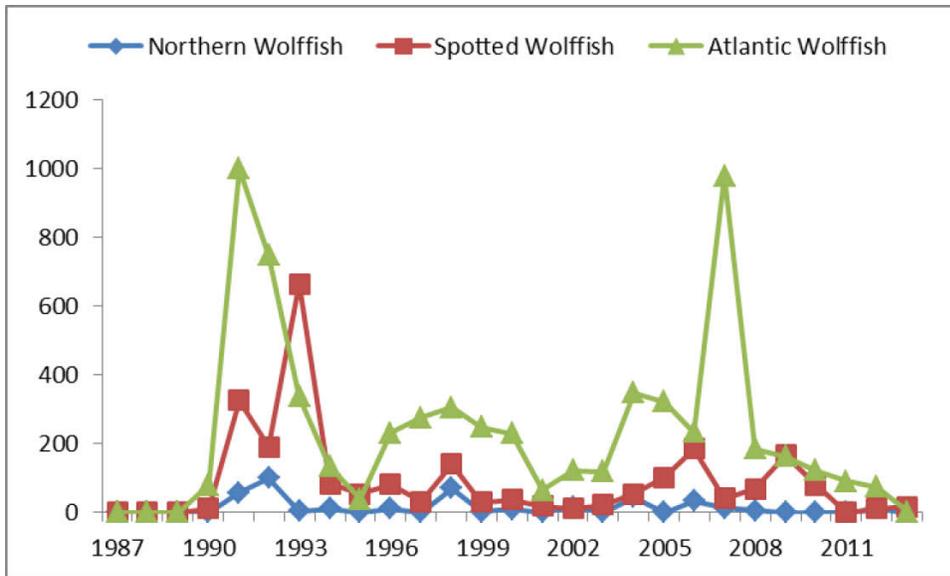


Figure 54. Total observed catch (numbers of kept + discards) of wolffish, as recorded by Canadian Fisheries Observers, in Div. 4T (Gulf Region).

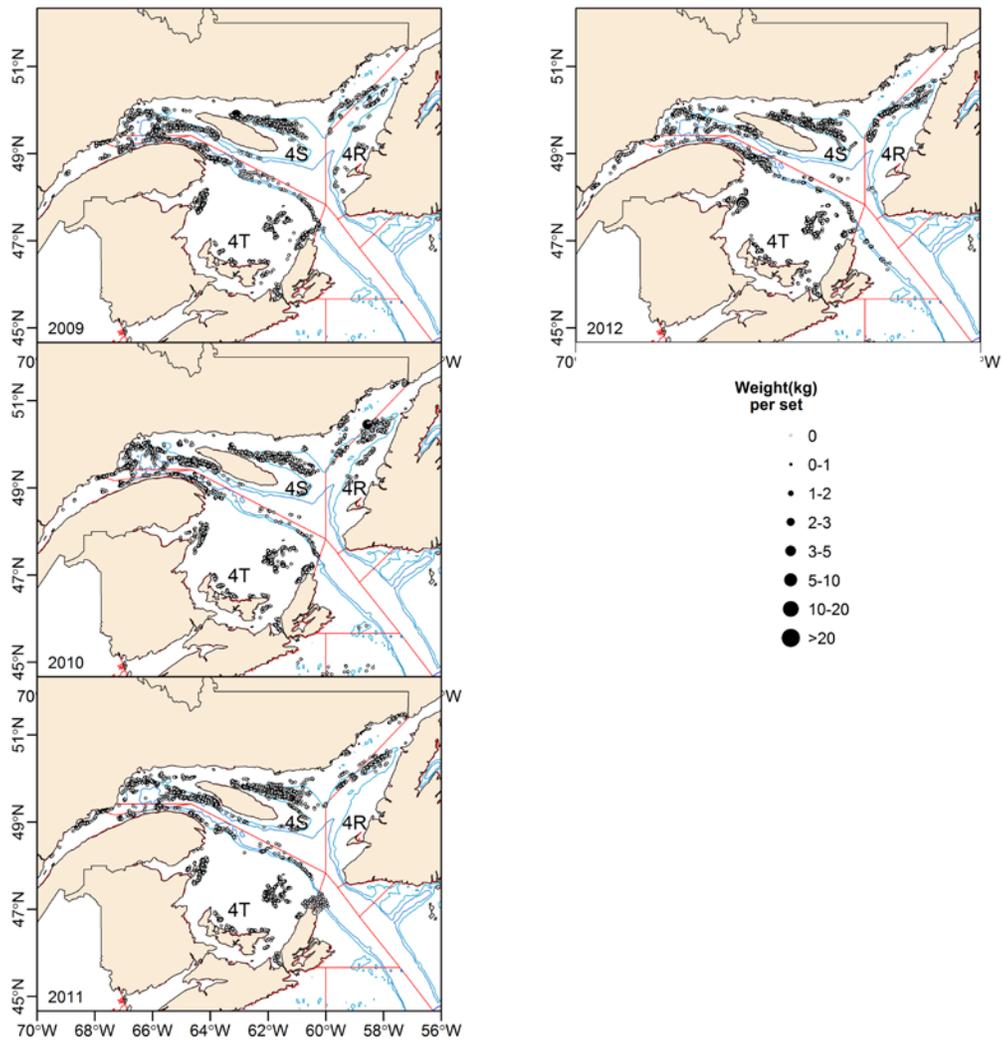


Figure 55. Distribution of recent catches of Northern Wolffish as recorded by Canadian Fisheries Observers in Div. 4RST (Quebec and Gulf Regions).

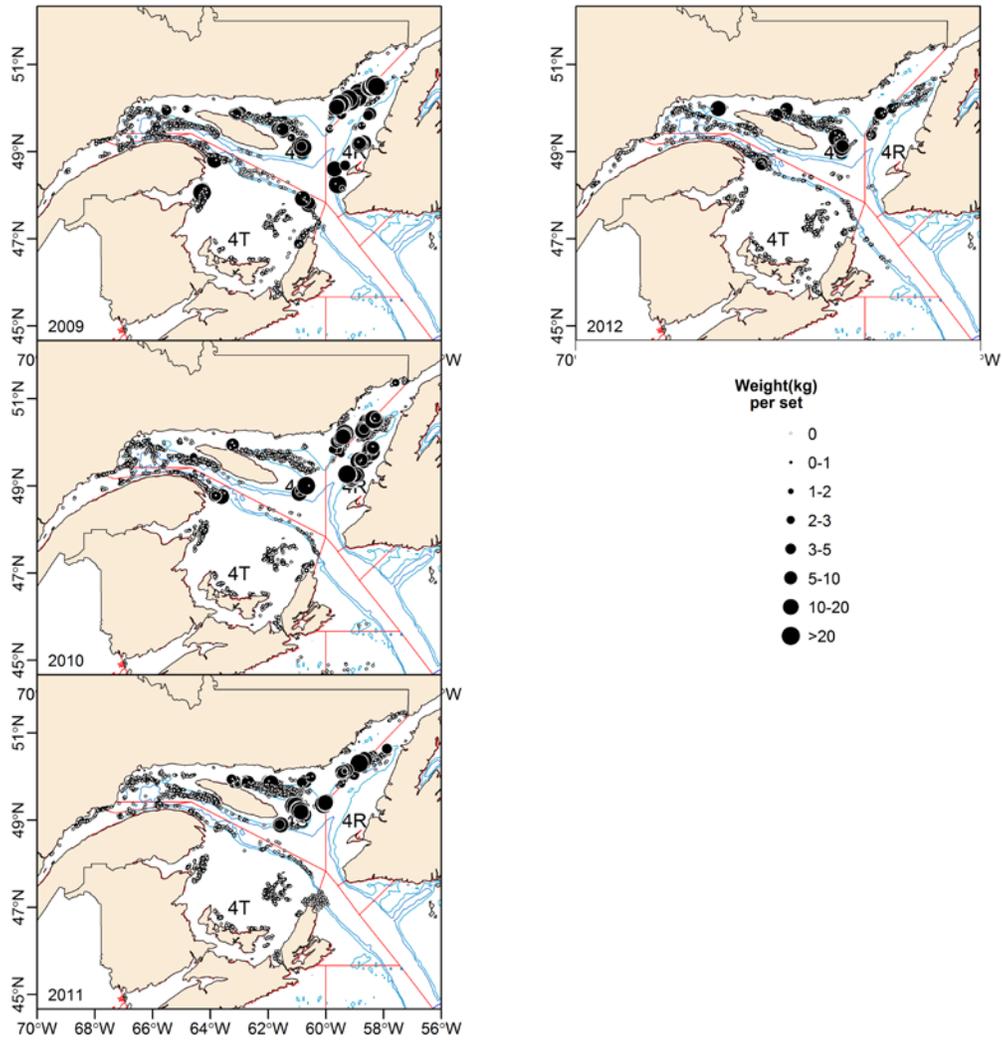


Figure 56. Distribution of recent catches of Spotted Wolffish as recorded by Canadian Fisheries Observers in Div. 4RST (Quebec and Gulf Regions).

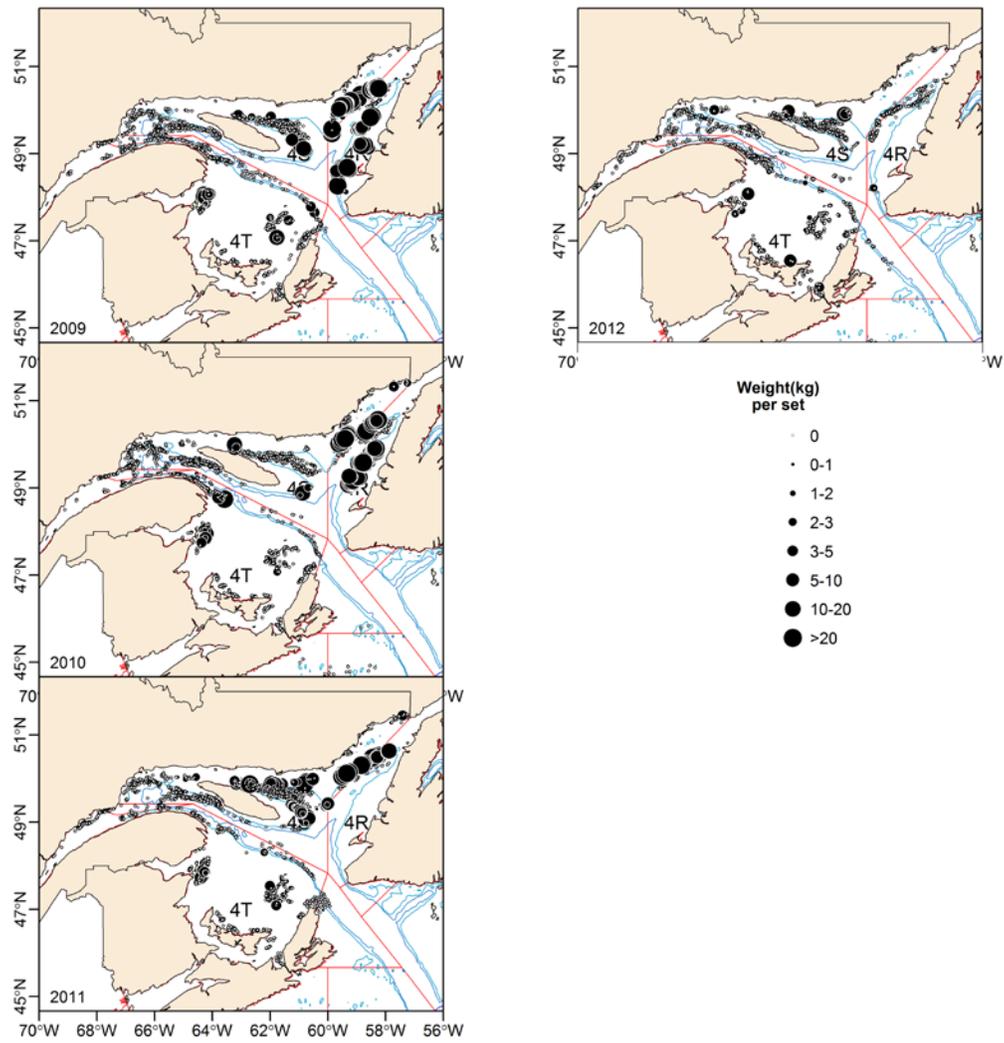


Figure 57. Distribution of recent catches of Atlantic Wolffish as recorded by Canadian Fisheries Observers in Div. 4RST (Quebec and Gulf Regions).

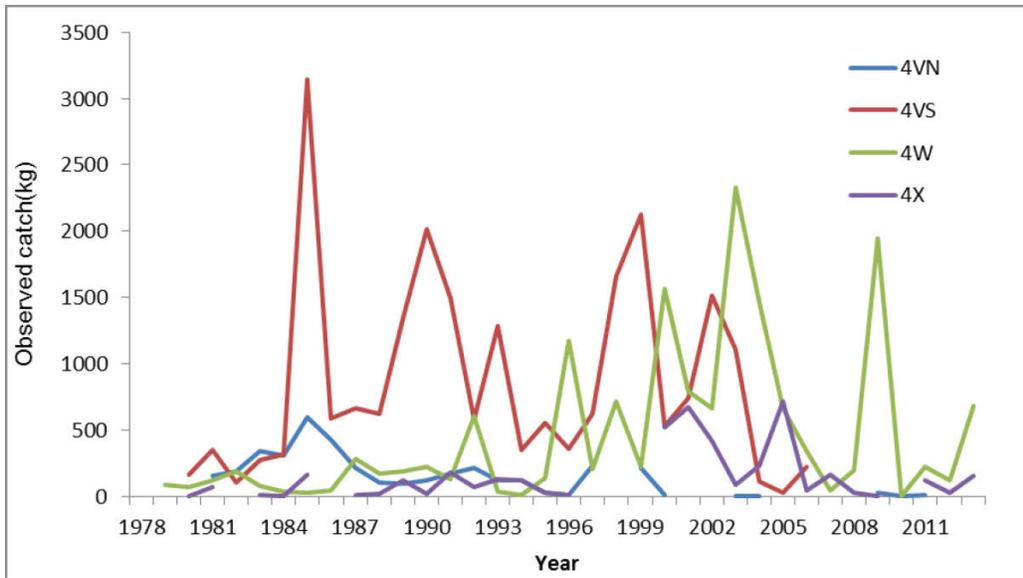


Figure 58. Total observed catch (numbers of kept + discards) of Northern Wolffish, as recorded by Canadian Fisheries Observers (Maritimes Region).

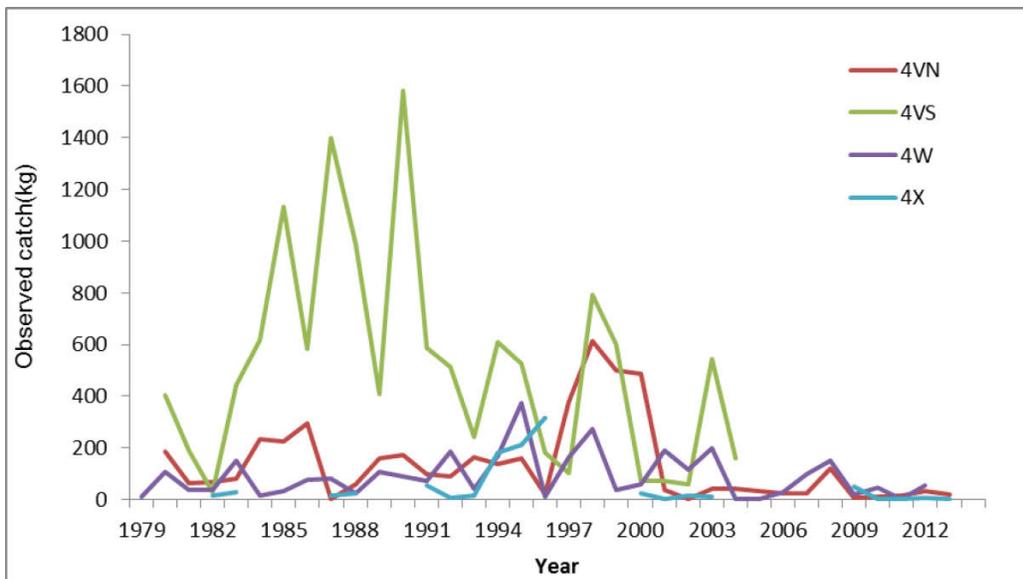


Figure 59. Total observed catch (numbers of kept + discards) of Spotted Wolffish, as recorded by Canadian Fisheries Observers (Maritimes Region).

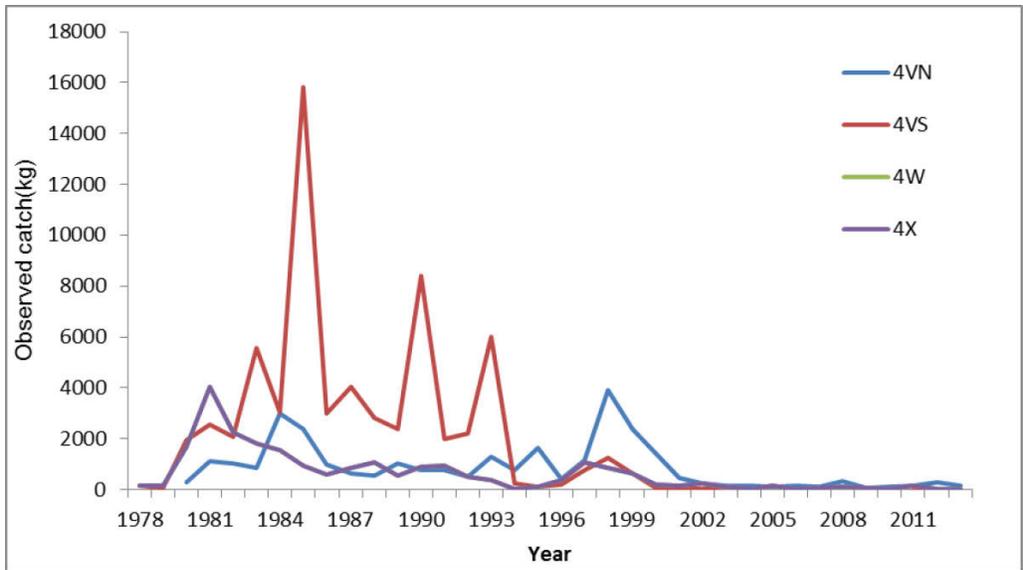


Figure 60. Total observed catch (numbers of kept + discards) of Atlantic Wolffish, as recorded by Canadian Fisheries Observers (Maritimes Region).

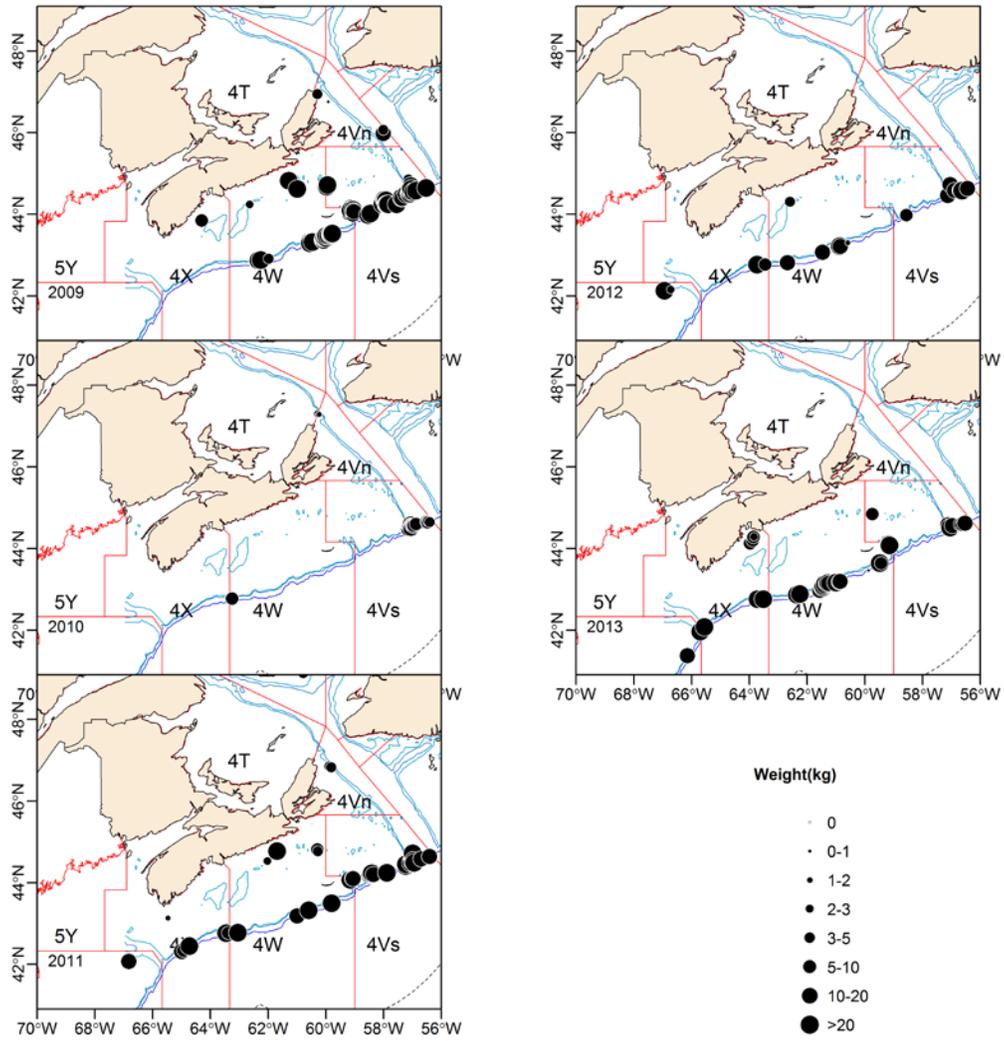


Figure 61. Distribution of recent catches of Northern Wolffish as recorded by Canadian Fisheries Observers in Div. 4VW5Y.

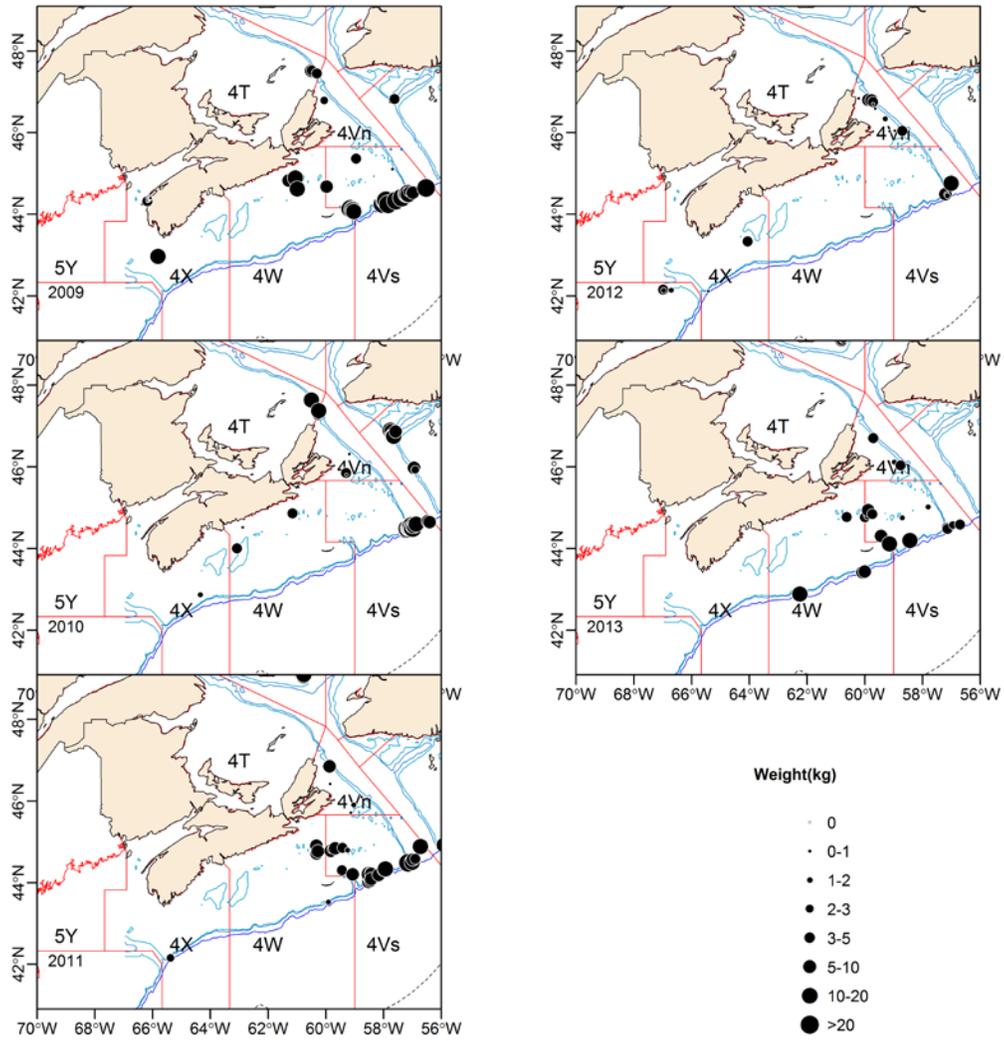


Figure 62. Distribution of recent catches of Spotted Wolffish as recorded by Canadian Fisheries Observers in Div. 4VWX5Y.

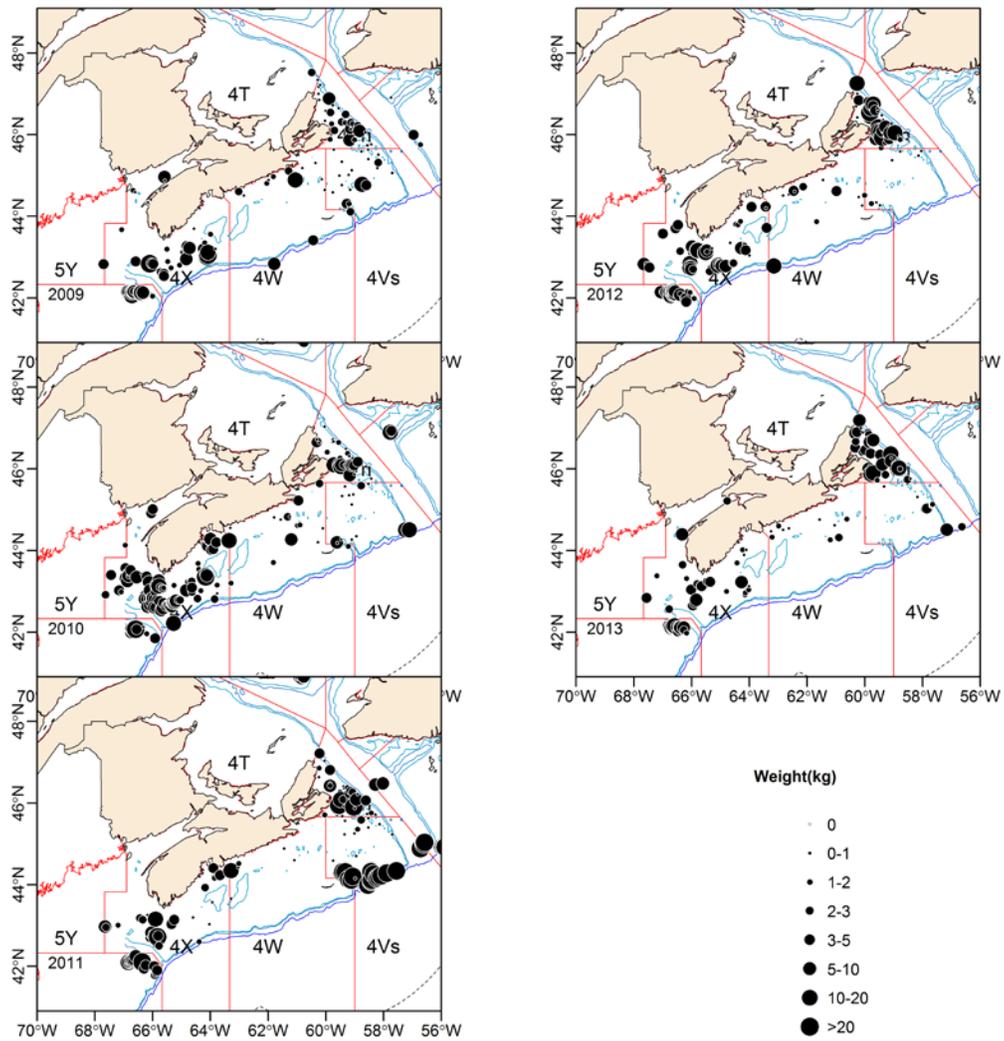


Figure 63. Distribution of recent catches of Atlantic Wolffish as recorded by Canadian Fisheries Observers in Div. 4VWX5Y.

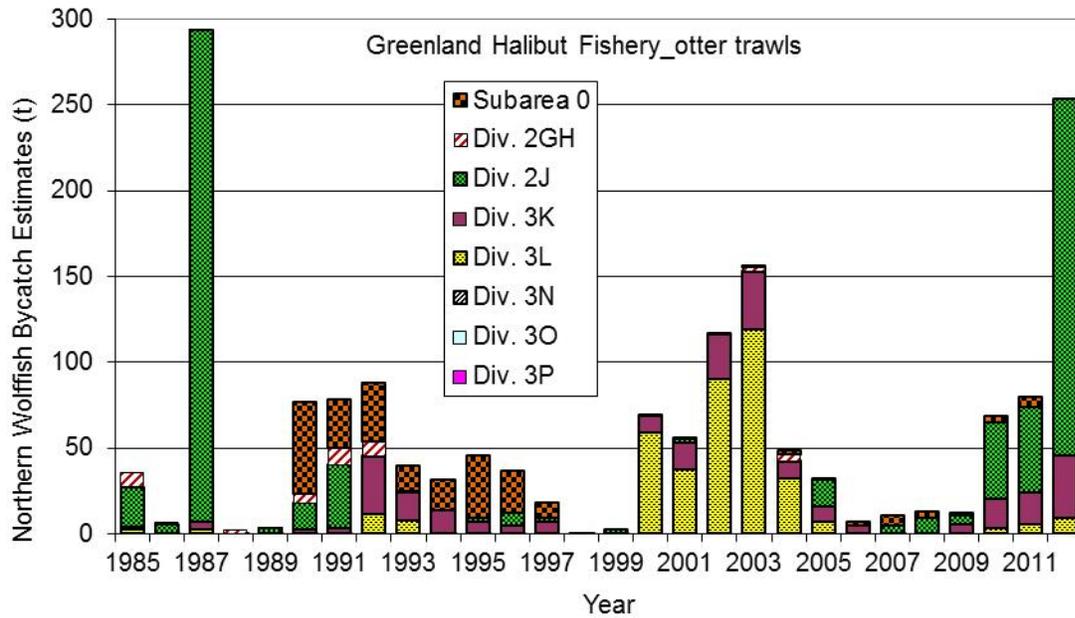


Figure 64. Estimated annual total bycatch (tons) of Northern Wolffish in the Greenland Halibut fishery in Subareas 0 and 2, and Div. 3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

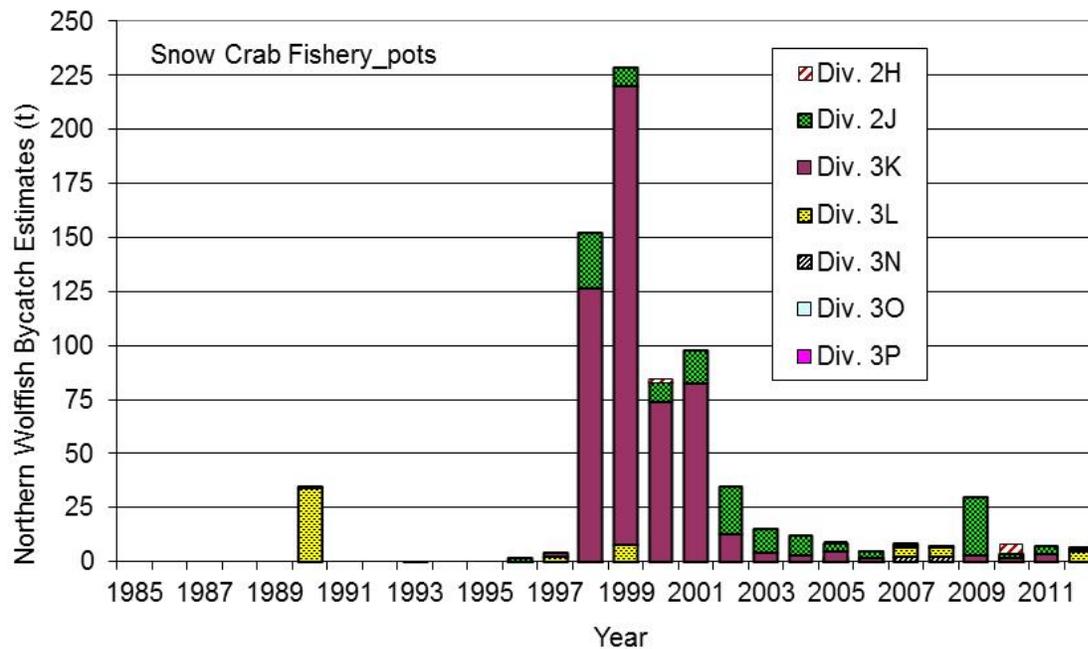


Figure 65. Estimated annual total bycatch (tons) of Northern Wolffish in the Snow Crab fishery in Subarea 2 and Div. 3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

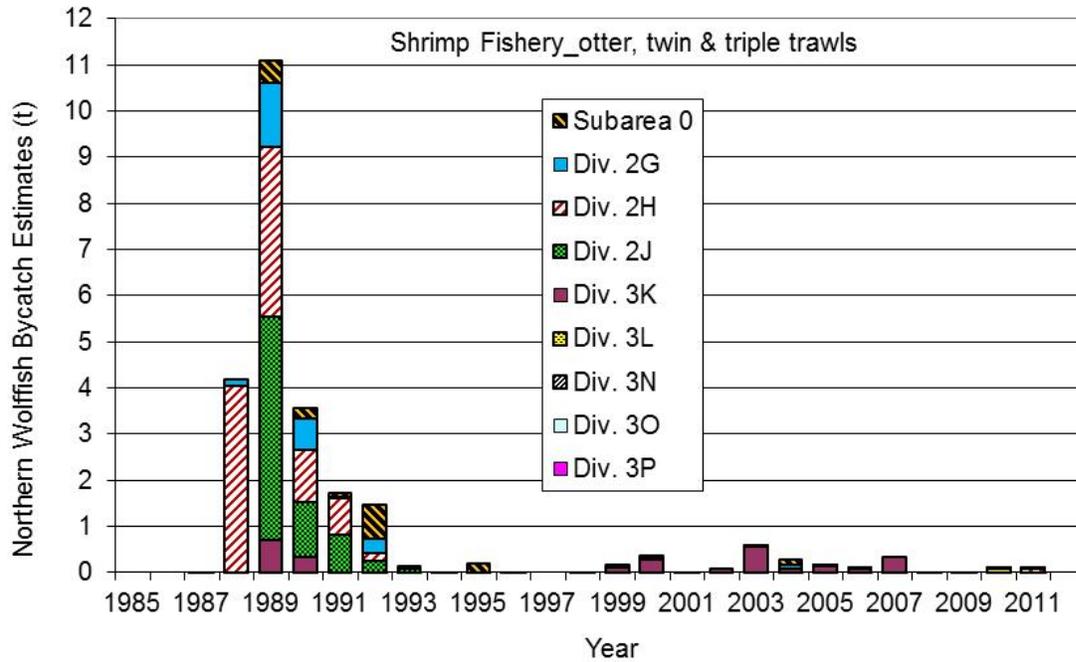


Figure 66. Estimated annual total bycatch (tons) of Northern Wolffish in the shrimp fishery in Subareas 0 and 2, and Div. 3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

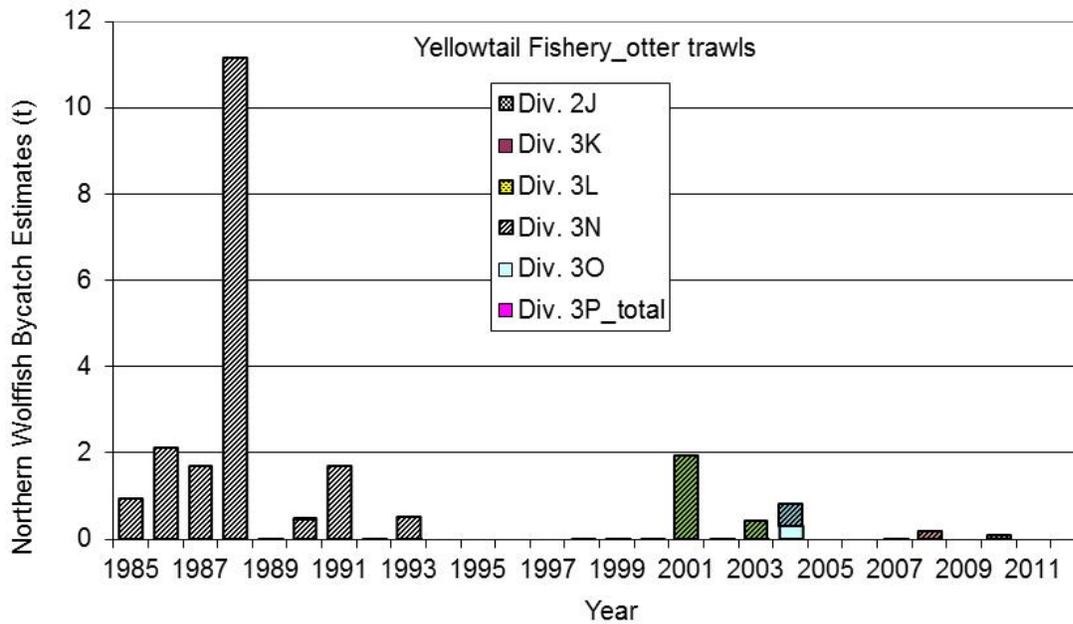


Figure 67. Estimated annual total bycatch (tons) of Northern Wolffish in the Yellowtail Flounder fishery in Div. 2J3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

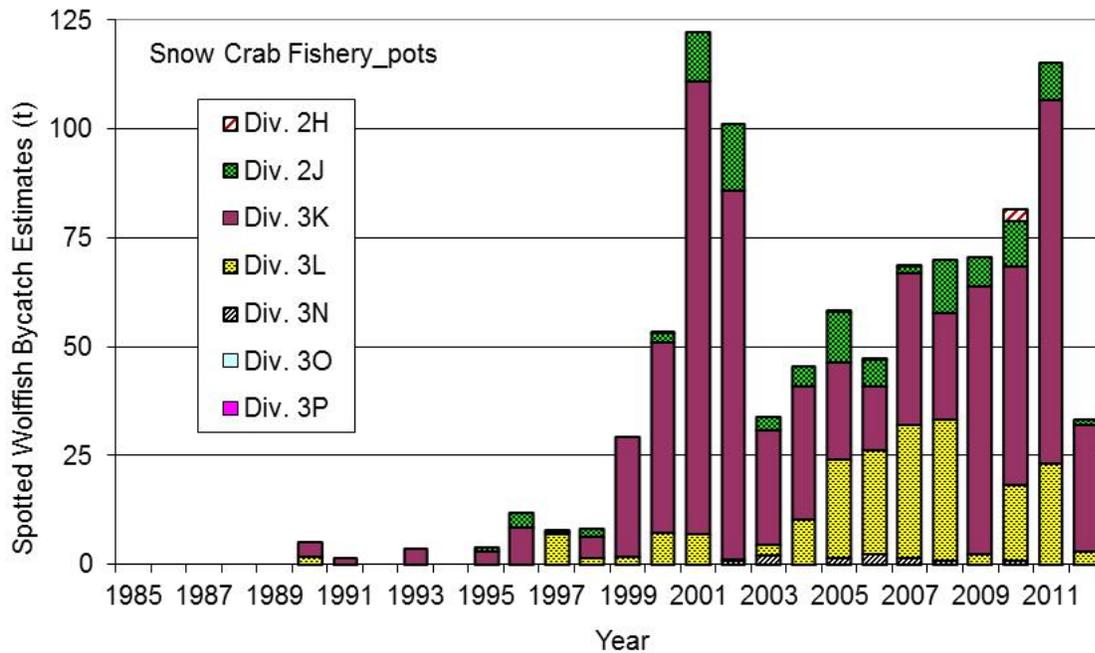


Figure 68. Estimated annual total bycatch (tons) of Spotted Wolffish in the Snow Crab fishery in Subarea 2 and Div. 3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

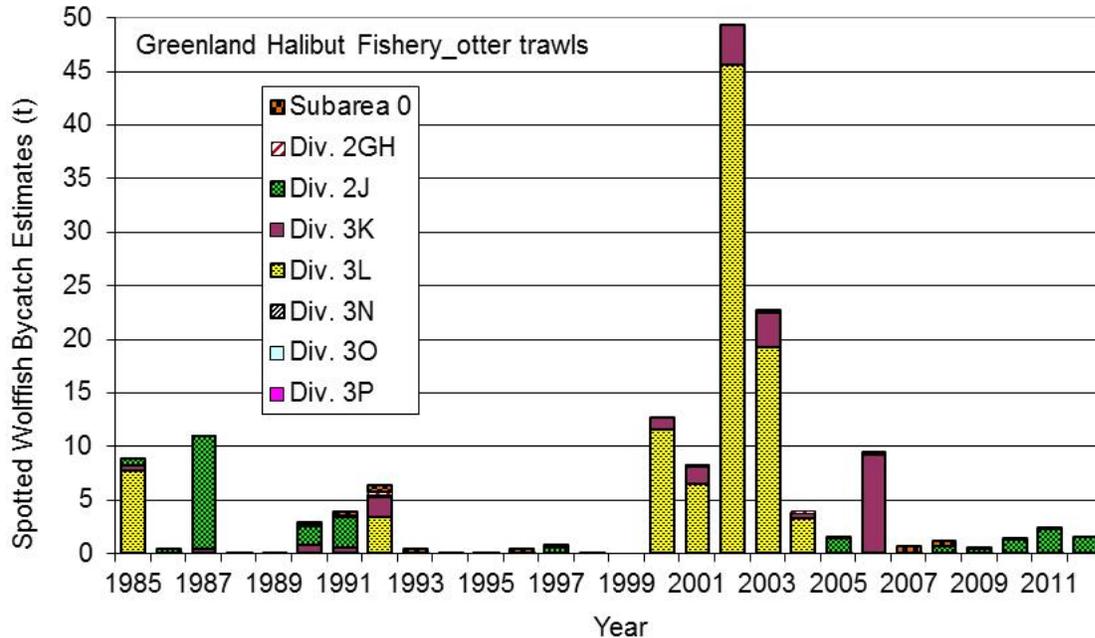


Figure 69. Estimated annual total bycatch (tons) of Spotted Wolffish in the Greenland Halibut fishery in Subareas 0 and 2, and Div. 3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

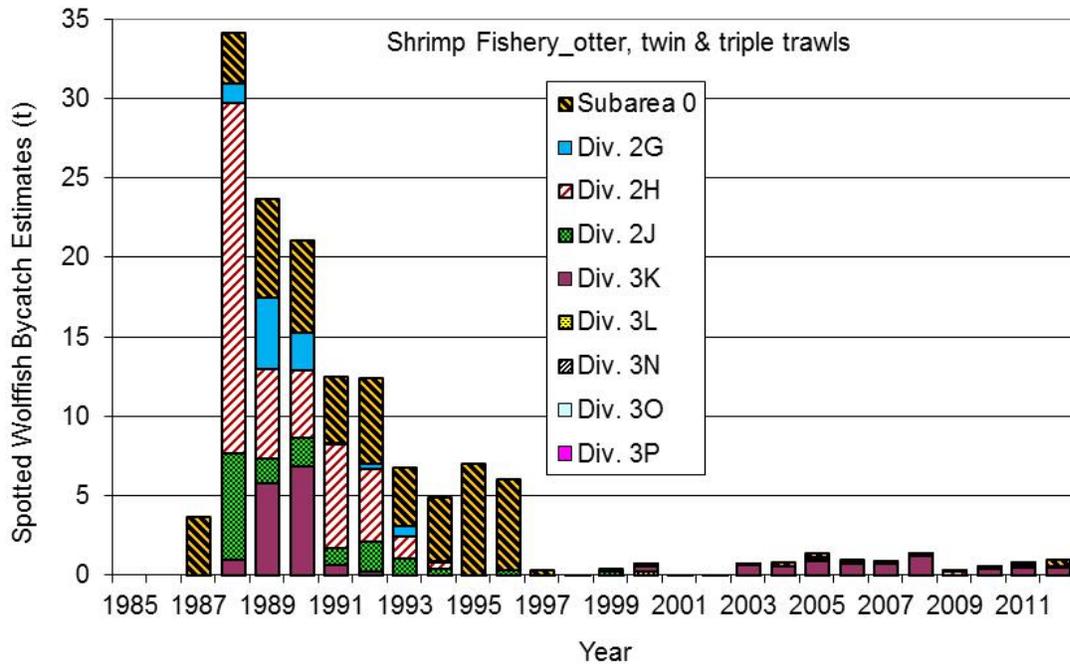


Figure 70. Estimated annual total bycatch (tons) of Spotted Wolffish in the shrimp fishery in Subareas 0 and 2, and Div. 3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

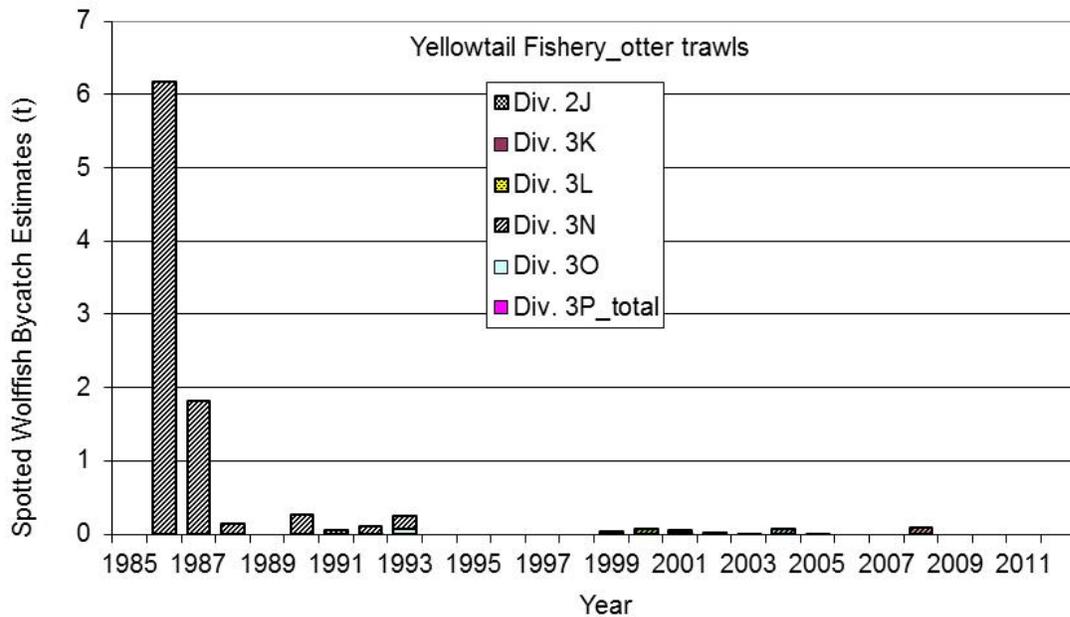


Figure 71. Estimated annual total bycatch (tons) of Spotted Wolffish in the Yellowtail Flounder fishery in Div. 2J3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

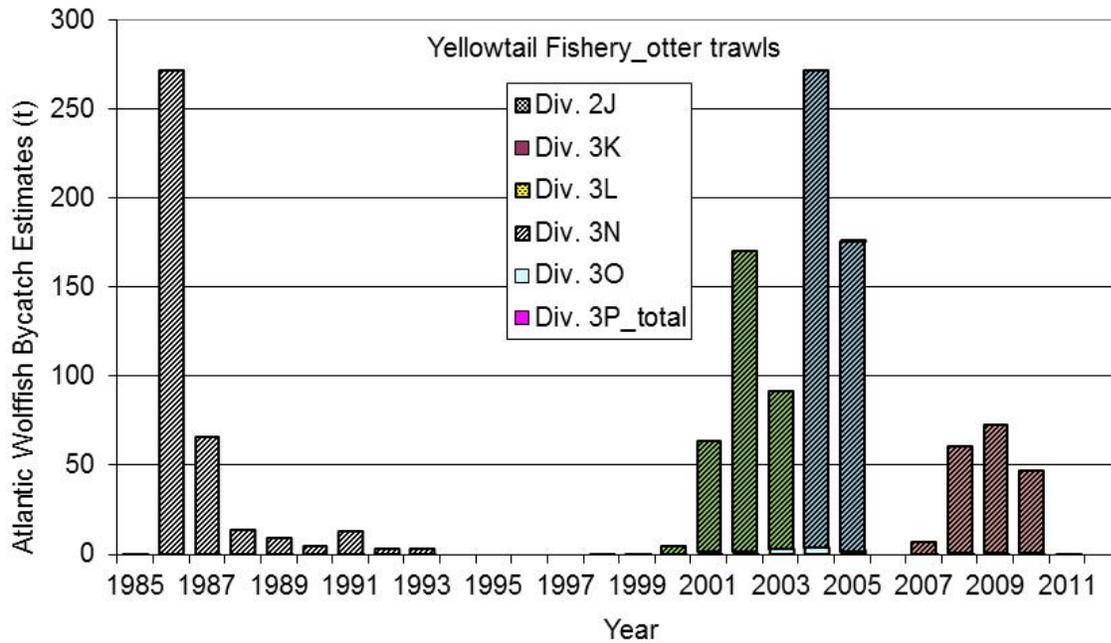


Figure 72. Estimated annual total bycatch (tons) of Atlantic Wolffish in the Yellowtail Flounder fishery in Div. 2J3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

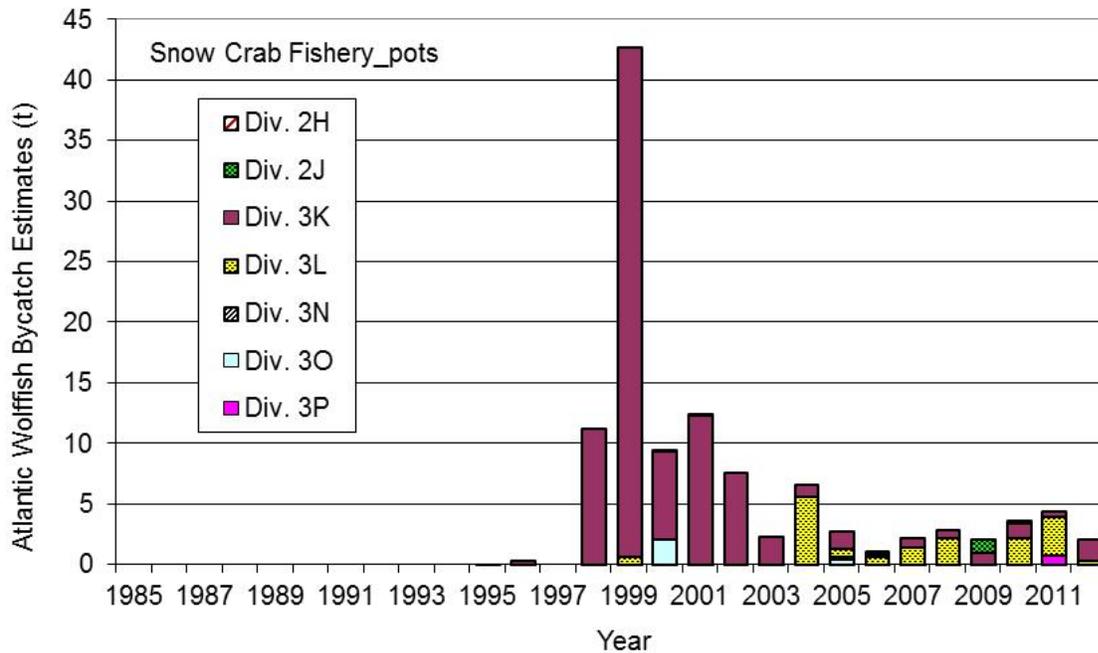


Figure 73. Estimated annual total bycatch (tons) of Atlantic Wolffish in the Snow Crab fishery in Subarea 2 and Div. 3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

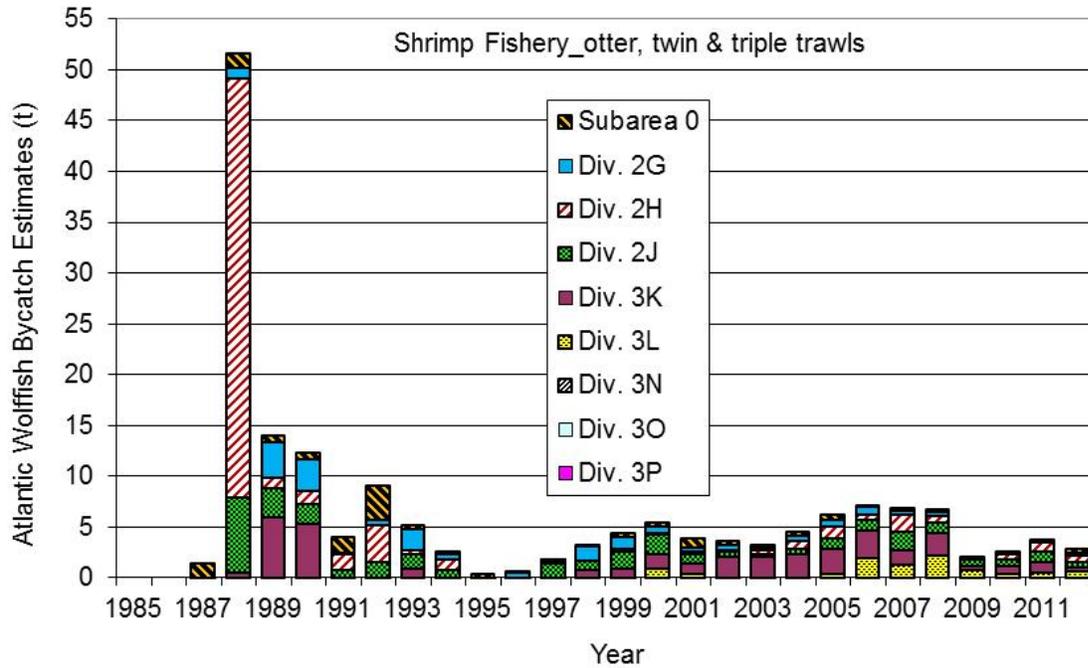


Figure 74. Estimated annual total bycatch (tons) of Atlantic Wolffish in the shrimp fishery in Subareas 0 and 2, and Div. 3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

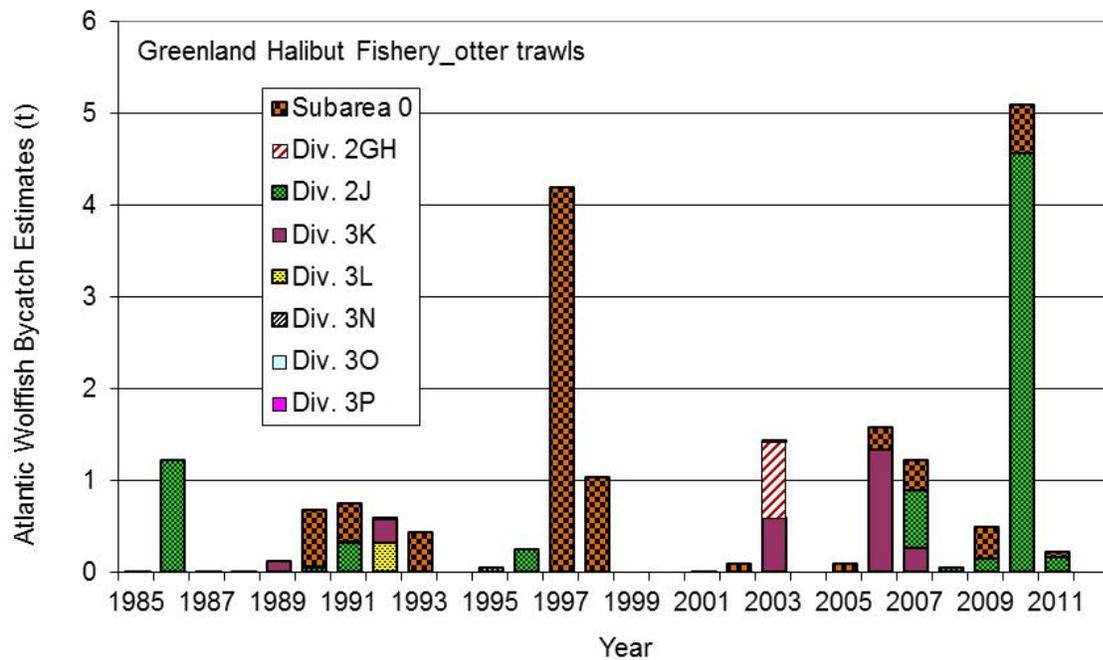


Figure 75. Estimated annual total bycatch (tons) of Atlantic Wolffish in the Greenland Halibut fishery in Subareas 0 and 2, and Div. 3KLNOP in Canada's EEZ, 1985-2012. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years.

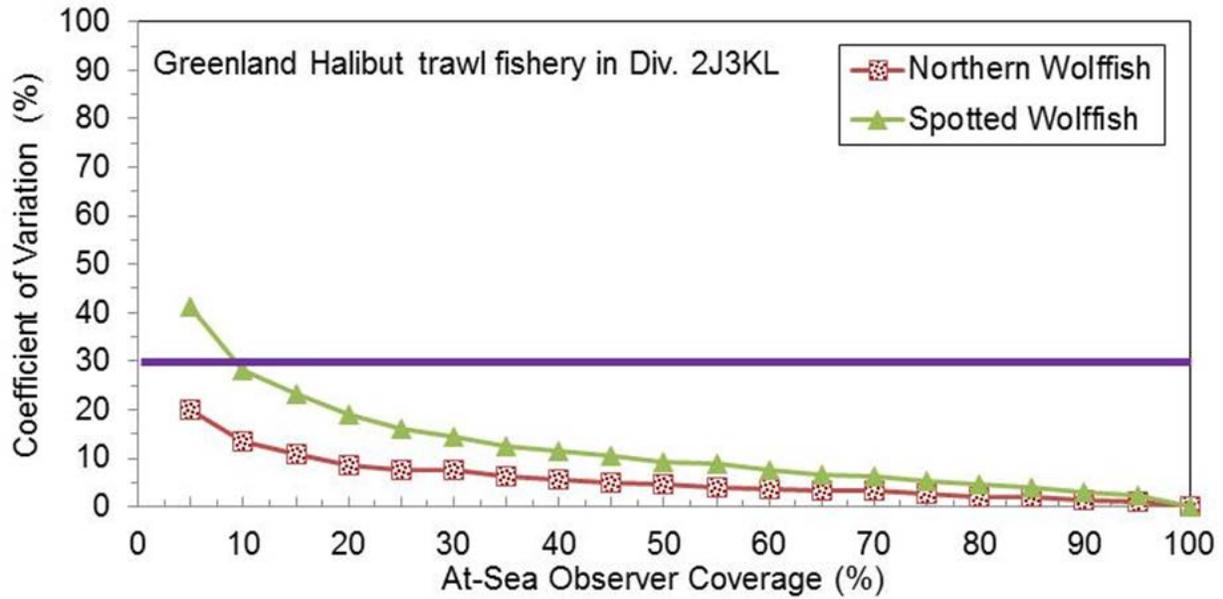


Figure 76. Coefficients of Variation for each wolffish species in 100% observed sets from the Greenland Halibut fishery in Div. 2J3KL, 2000-12. For each level of simulated ASFO coverage, available sets were randomly sampled 500 times without replacement. Note that Atlantic Wolffish was not caught in this fishery.

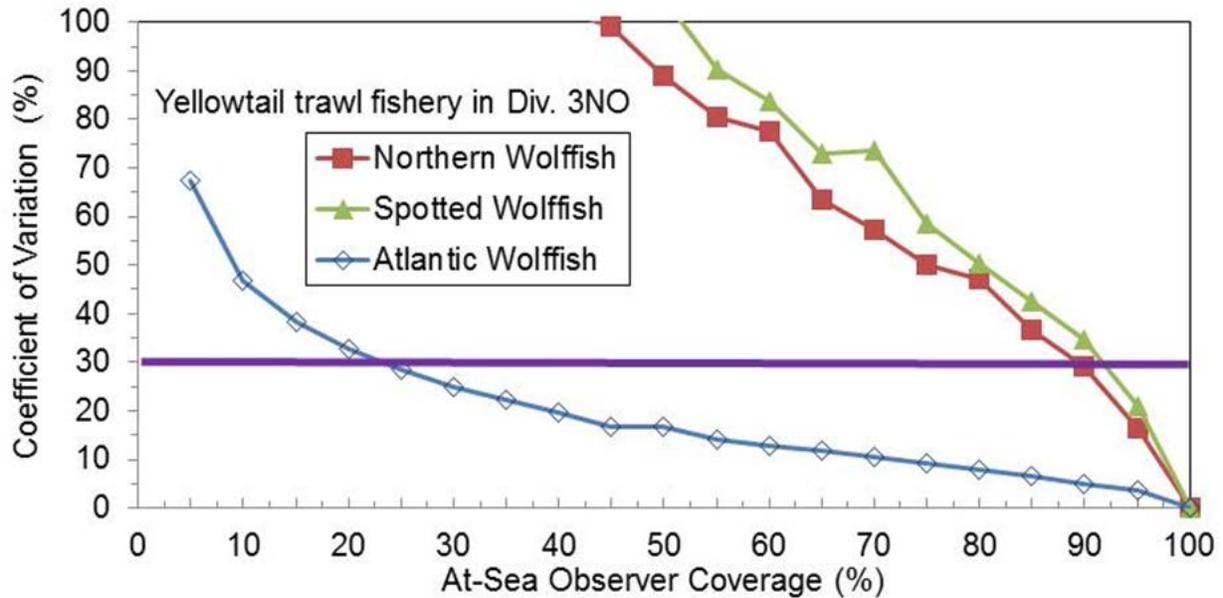


Figure 77. Coefficients of Variation for each wolffish species in 100% observed sets from the Yellowtail Flounder fishery in Div. 3NO, 1998-2003. For each level of simulated ASFO coverage, available sets were randomly sampled 500 times without replacement.

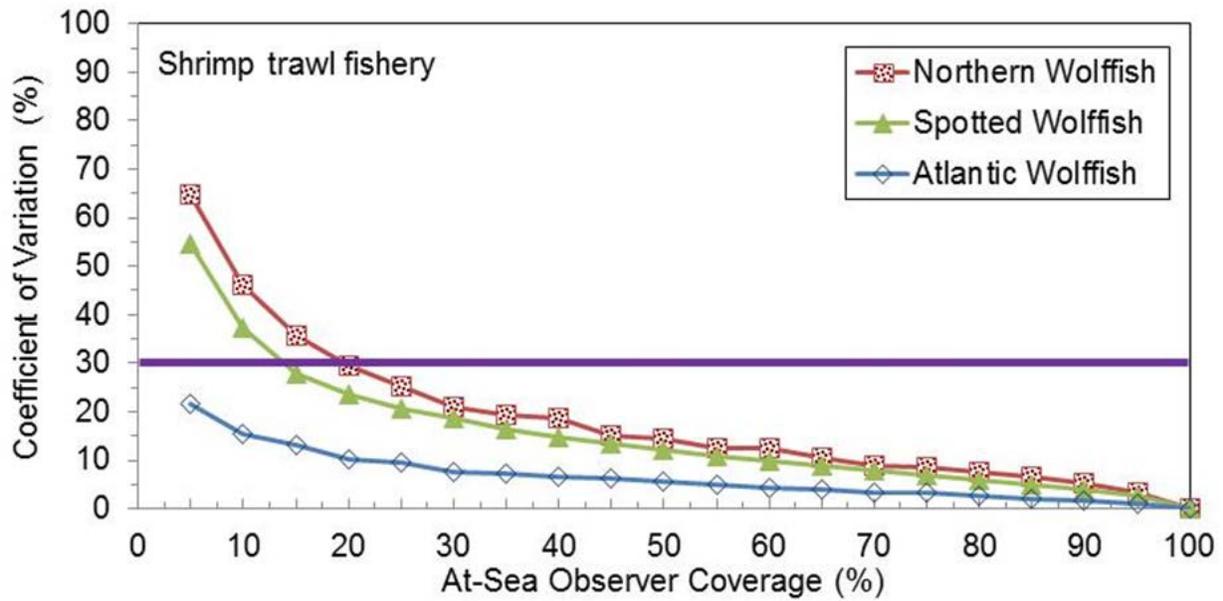


Figure 78. Coefficients of Variation for each wolffish species in 100% observed sets from the shrimp fishery (*Pandalus borealis* and *P. montagui*) in Subareas 0 and 2 and Div. 3K, 1998-2011. For each level of simulated ASFO coverage, available sets were randomly sampled 500 times without replacement.