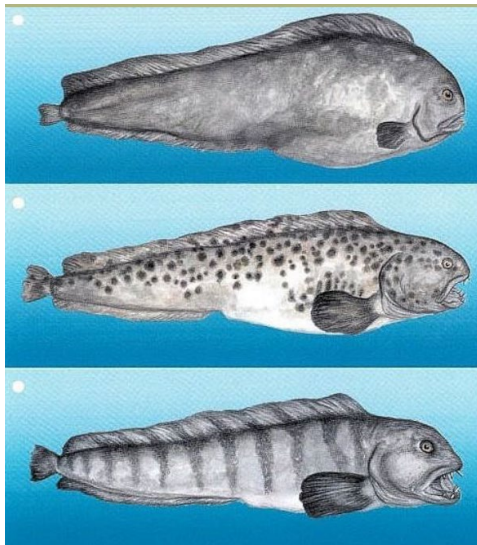




Newfoundland and Labrador, Ontario and Canadian Science Advisory Secretariat  
Prairie, Arctic, Gulf, Maritimes, and Quebec Regions Science Advisory Report 2024/010

# UPDATED ASSESSMENT OF NORTHERN WOLFFISH, SPOTTED WOLFFISH, AND ATLANTIC WOLFFISH RELATED TO POPULATION STATUS, LIFE HISTORY, AND HABITAT



*Anarhichas denticulatus* (Northern Wolffish), *A. minor* (Spotted Wolffish), and *A. lupus* (Atlantic Wolffish) DFO (2020).

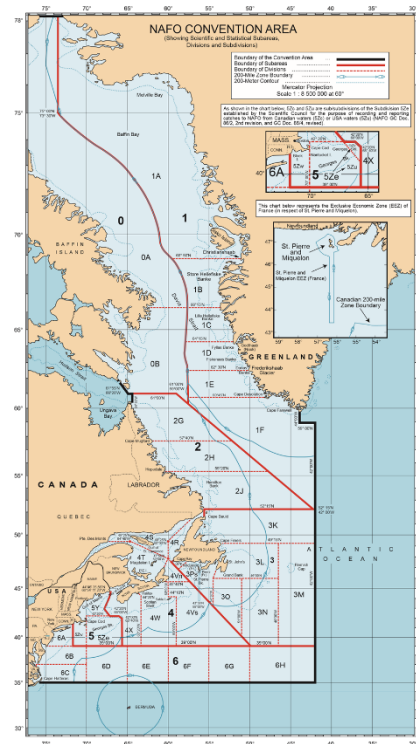


Figure 1. Map of the study area (NAFO Div. 0AB2GHJ3KLNOPs4VWX5Y5Ze).

### 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 re-assessed the status of the three wolffish species in 2012, and upheld the designations of Threatened for Northern Wolffish and Spotted Wolffish, and Special Concern for Atlantic Wolffish.

This Science Advisory Report is from the January 17-18, 2023 Zonal Peer Review on the updated assessment of Northern Wolffish, Spotted Wolffish, and Atlantic Wolffish related to population status, life history, and habitat. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

## SUMMARY

- An update of the 2014 assessment of wolffish was conducted to detect changes in population status, life history, habitat use, and fisheries interactions.
- The data used to assess changes in population status originate from numerous research vessel (RV) surveys with their own spatial and temporal coverage and constraints. Within all surveys, individual catches of wolffish were highly variable with a large number of zero catches resulting in very large confidence intervals around all indices of stock size.
- Since the last assessment, population status for all three wolffish species throughout Canadian Atlantic and Arctic waters remains largely unchanged and has shown little recovery.
- Increases in abundance have occurred since the late-1990s for Northern and Spotted Wolffish in Northwest Atlantic Fisheries Organization (NAFO) Divisions (Div.) 2H and 2J3K, where the majority of both populations reside.
- New parameters were estimated using models for age/length-at-maturity and growth. These parameter estimates were generally consistent with the range of values found in published studies.
- Wolffish are demersal fish species found over all bottom types. The three wolffish species occupy varying depth ranges in different regions. The majority of Northern Wolffish occur at depths down to 1,500 m. The majority of Spotted Wolffish and Atlantic Wolffish are restricted to depths less than 1,000 m, and inhabit nearshore waters seasonally. Wolffish thermal ranges vary among geographic regions. Spotted Wolffish have been observed more frequently at higher temperatures than Atlantic and Northern Wolffish where they co-occur.
- Current monitoring tools and programs are inadequate in most Canadian Atlantic and Arctic commercial fisheries to determine the scale of interactions, discard mortality, and total bycatch of wolffish by species.

## INTRODUCTION

The previous Zonal Peer Review (ZPR) on the status of Northern Wolffish (*Anarhichas denticulatus*), Spotted Wolffish (*A. minor*), and Atlantic Wolffish (*A. lupus*) inhabiting Canadian Atlantic and Arctic waters was conducted in 2014 (Collins et al. 2015).

The three species of wolffish were added to Schedule 1 of Canada's *Species at Risk Act* (SARA) in 2003, with Atlantic Wolffish being assessed as Special Concern and both Northern Wolffish and Spotted Wolffish being assessed as Threatened, due to major declines in abundance (>90%) and reductions in the area of occupancy over 2–3 generations. The status of these species was re-assessed and confirmed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2012. There have been some increases in Spotted Wolffish abundance and area of occupancy over most of its Canadian range (COSEWIC 2012a); Northern Wolffish have experienced small increases in abundance and area occupied since about 2002 (COSEWIC 2012b); and, while continued declines in Atlantic Wolffish abundance have occurred in the southern Gulf of St. Lawrence (sGSL) and on the Scotian Shelf, there have been overall increases in this species' abundance and area of occupancy (COSEWIC 2012c).

The objective of this Science Advisory Report is to provide an updated assessment of Northern Wolffish, Atlantic Wolffish, and Spotted Wolffish through analyses of the most recent data on

population status, life history, habitat use, and interactions with commercial fisheries in the NAFO Subareas encompassing the following Fisheries and Oceans Canada (DFO) Regions: Newfoundland and Labrador (Div. 2GHJ3KLNO and Subdivision [Subdiv.] 3Ps), Quebec (Div. 4RS + St. Lawrence Estuary), Gulf (Div. 4T), Maritimes (Div. 4VWX5Y, and Subdiv. 5Ze), and Arctic (Div. 0AB) (Fig. 1).

## **Geographic Range and Designatable Unit**

Wolffish (Genus *Anarhichas*) inhabit both sides of the North Atlantic Ocean. In Canadian Atlantic and Arctic waters, Northern Wolffish, Atlantic Wolffish and Spotted Wolffish are found from the Davis Strait to the Maritimes provinces; the distributions of the three species overlap to some extent across their geographic range (DFO 2020). Tagging studies have indicated that the three species are largely sedentary, with most individuals being recaptured at scales of tens of kilometers or less from the release site, and a minority of individuals being recaptured at scales of hundreds of kilometers (Templeman 1984, Riget and Messtorff 1988, Simpson et al. 2015).

The COSEWIC considers each wolffish species in Canadian Atlantic and Arctic waters as a single population or Designatable Unit.

## **Habitats**

Wolffish are demersal fish species found over all bottom types, including hard bottom with complex relief; Atlantic Wolffish presence in soft sediments like sand and mud is infrequent, whereas the highest concentrations of Northern Wolffish and Spotted Wolffish are found over sand, shell hash and coarse sand (Rountree 2002, Kulka et al. 2004, DFO 2020, DFO 2022).

The three wolffish species occupy varying depth ranges across their geographic boundaries. In Canadian Atlantic and Arctic waters, Northern Wolffish inhabit depths of up to 1,500 m; Spotted Wolffish and Atlantic Wolffish inhabit depths of almost 1,000 m; Atlantic Wolffish and Spotted Wolffish also inhabit nearshore waters seasonally (Kulka et al. 2004, DFO 2020 and references therein).

Wolffish thermal ranges vary with geographic region. In Newfoundland and Labrador (NL) waters, Northern Wolffish and Spotted Wolffish are more common at temperatures between 1.5 to 5°C and Atlantic Wolffish between -1.5 and 4°C (Kulka et al. 2004, DFO 2020). Atlantic Wolffish in the Maritimes Region tolerate a wider range of temperatures, from -1 to 10°C (DFO 2022).

## **Trophic Interactions**

Wolffish species are members of the demersal fish assemblage, occupying a broad range of ecological niches. The diet of Northern Wolffish in Canadian waters consists primarily of pelagic and benthic fish, and shellfish; Atlantic Wolffish prefer crabs and echinoderms; and Spotted Wolffish favour shrimp and echinoderms (Simpson et al. 2013a). The preference for specific prey groups suggests that the three wolffish species exploit different trophic niches despite the overlap in distribution across their geographic range.

Natural predators of wolffish include Greenland Shark (*Somniosus microcephalus*), finfish species such as Whiting (*Merlangius merlangus*) and Grey Gurnard (*Eutrigla gurnardus*), and marine mammals such as Harbour Porpoise (*Phocoena phocoena*) (Hislop et al. 1991, De Gee and Kikkert 1993, Leclerc et al. 2012, Andreassen et al. 2017).

## **Species Biology**

The maximum reported length and age is 180 cm (total length) and 14 years for Northern Wolffish; 150 cm and 22 years for Atlantic Wolffish; and 180 cm and 21 years for Spotted Wolffish (Nelson and Ross 1992, O’Dea and Haedrich 2001a, 2001b, Simpson et al. 2013b).

Reproduction of wolffish species occurs through internal fertilization, and the eggs are relatively large with a prolonged incubation period. Fecundity is low, ranging between approximately 2,400 and 35,000 eggs (Barsukov 1959, Templeman 1986a, 1986b, Simpson et al. 2013b). All species reach maturity by age 5 or 6, but the length-at-maturity differs among species: 54 cm for Northern Wolffish, 60 cm for Atlantic Wolffish, and 75–80 cm for Spotted Wolffish.

## **ASSESSMENT**

### **Surveys**

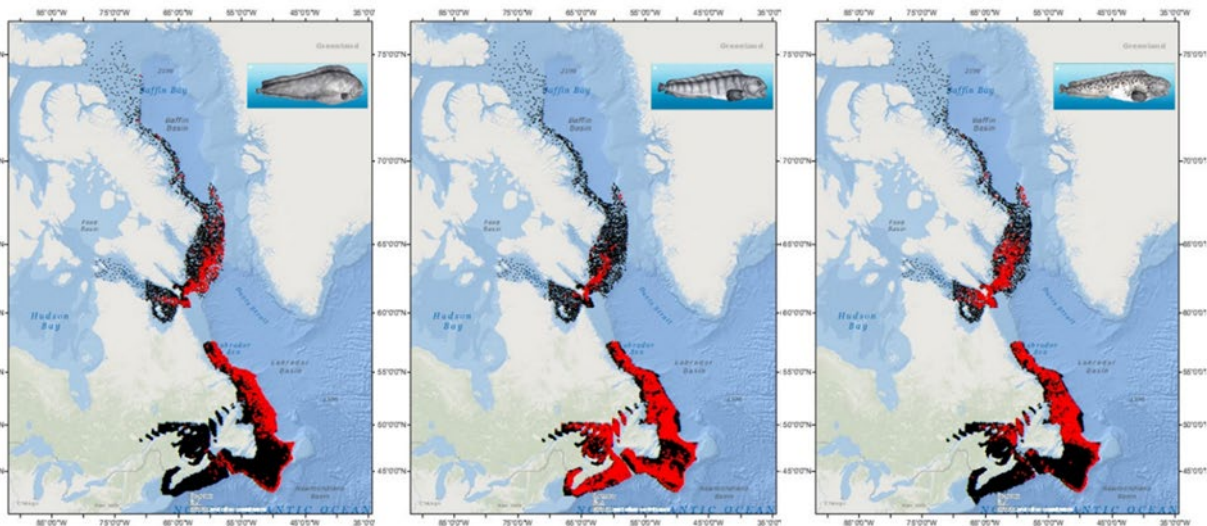
Indices of abundance, biomass, and distribution of wolffish were obtained from depth stratified random surveys covering the various DFO Regions. Catch rates (no. fish/tow; kg/tow) were standardized with regard to tow time and speed. Estimates of trawlable biomass and abundance were calculated by extrapolating catch rate to the total number of trawlable units in the survey strata, and scaled by strata area. In addition, during spring and fall surveys conducted in 2001–03 in the NL Region, a total of 1,460 wolffish specimens were frozen aboard the vessels and subsequently transported and processed at the Northwest Atlantic Fisheries Centre in St. John’s. Collected data included total length, whole weight, sex, maturity stage, and otoliths (which were used to derive a putative age). This dataset was used to estimate age-length relationships, as well as maturity stages in relation to wolffish age and size. Three growth models (von Bertalanffy [VBL], Gompertz, Logistic) were evaluated to describe the age-length relationship of wolffish. The best-fitting model was selected based on achieving the convergence criterion (i.e., lowest residual sum of squares), and a graphic analysis of the observed and estimated curves. Maturity stage determination of female wolffish followed the approach proposed by Gunnarsson et al. (2008), and Gunnarsson et al. (2016). Maturity ogives for age or length were specified from logistic regression models, from which the age ( $A_{50}$ ) and length ( $L_{50}$ ) at 50% mature were predicted.

Several research vessels (RVs) and fishing gears have been employed over the extent of the surveys covering the various DFO Regions, along with changes to portions of the original stratification scheme. Detailed information on changes in RV surveys can be found in Collins et al. (2015) and references therein. Except for the surveys conducted in the Gulf of St. Lawrence and Estuary (Benoît 2006, Bourdages et al. 2007), and the Scotian Shelf (Hugues Benoît, pers. comm.), no conversion factors have been estimated for wolffish between the different fishing vessels and gears employed over the extent of the time series; survey data from different vessels and gears therefore are not directly comparable, and thus constitute independent time series.

### **Distribution**

The geo-referenced distribution of RV survey catch rates (Fig. 2) indicates that the three wolffish species overlap in Div. 0AB, but Atlantic Wolffish were encountered less frequently in Div. 0A, and in a more concentrated geographic area of Div. 0B than either Northern Wolffish or Spotted Wolffish. Northern Wolffish were found mostly in Div. 2J3K, particularly along the shelf edge and to a lesser extent over the continental shelf; in Div. 3LNO the distribution is concentrated within

a very narrow band along the shelf edge, except over the shelf in the Bonavista Corridor, but Northern Wolffish were almost absent on the Grand Banks and in Subdiv. 3Ps. The distribution of Atlantic Wolffish overlaps that of Northern Wolffish to a large extent in both Div. 2J3K and Div. 3LNO; in addition, Atlantic Wolffish were found more frequently in inshore areas (Div. 3K), over the southern Grand Bank (Div. 3NO), and in Subdiv. 3Ps, except the Laurentian Channel. The distribution of Spotted Wolffish was also very similar to that of Northern Wolffish. The presence of Northern Wolffish in the northern Gulf of St. Lawrence (nGSL) was very rare, suggesting that sightings of this species may only have been occasional in this portion of the Northwest Atlantic Ocean. Atlantic Wolffish were commonly found along the west coast of Newfoundland, particularly in Subdiv. 4Rb, 4Rc and 4Rd, but positive observations were also made along the coasts of Anticosti Island and off Quebec’s North Shore in Div. 4S. Similar to Atlantic Wolffish, there were positive observations of Spotted Wolffish in Subdiv. 4Rb and 4Rd, as well as in more offshore locations in Div. 4S, but the latter species did not occur in Subdiv. 4Rc. Wolffish species were mostly absent from RV survey tows conducted in the St. Lawrence estuary. Northern Wolffish were found mostly along the slopes of the Laurentian Channel in Div. 4T, and were very rare over the shallow water areas of Div. 4T, while Atlantic Wolffish were more widely distributed along the slope of the Laurentian Channel and in the nearshore waters of Div. 4T. Spotted Wolffish had a similar distribution to that observed for Northern Wolffish. Northern Wolffish and Spotted Wolffish were nearly absent on the Scotian Shelf and the Bay of Fundy, except for a few observations in Div. 4VW. In contrast, Atlantic Wolffish were found throughout the Scotian Shelf and Bay of Fundy.



*Figure 2. Range of Northern Wolffish (left panel), Atlantic Wolffish (center panel), and Spotted Wolffish (right panel) distribution in Canadian Atlantic and Arctic waters. Red dot = species is present and black dot = absent in RV survey fishing tows (1971–2021).*

## **Indices of Stock Size**

### **Arctic**

Catch rates for all three species varied without trend across the time series, but Northern Wolffish tended to be observed more frequently in the RV survey, while Spotted Wolffish were



encountered in greater numbers in the Northern Shrimp Research Foundation (NSRF) survey (Figs. 3–5).

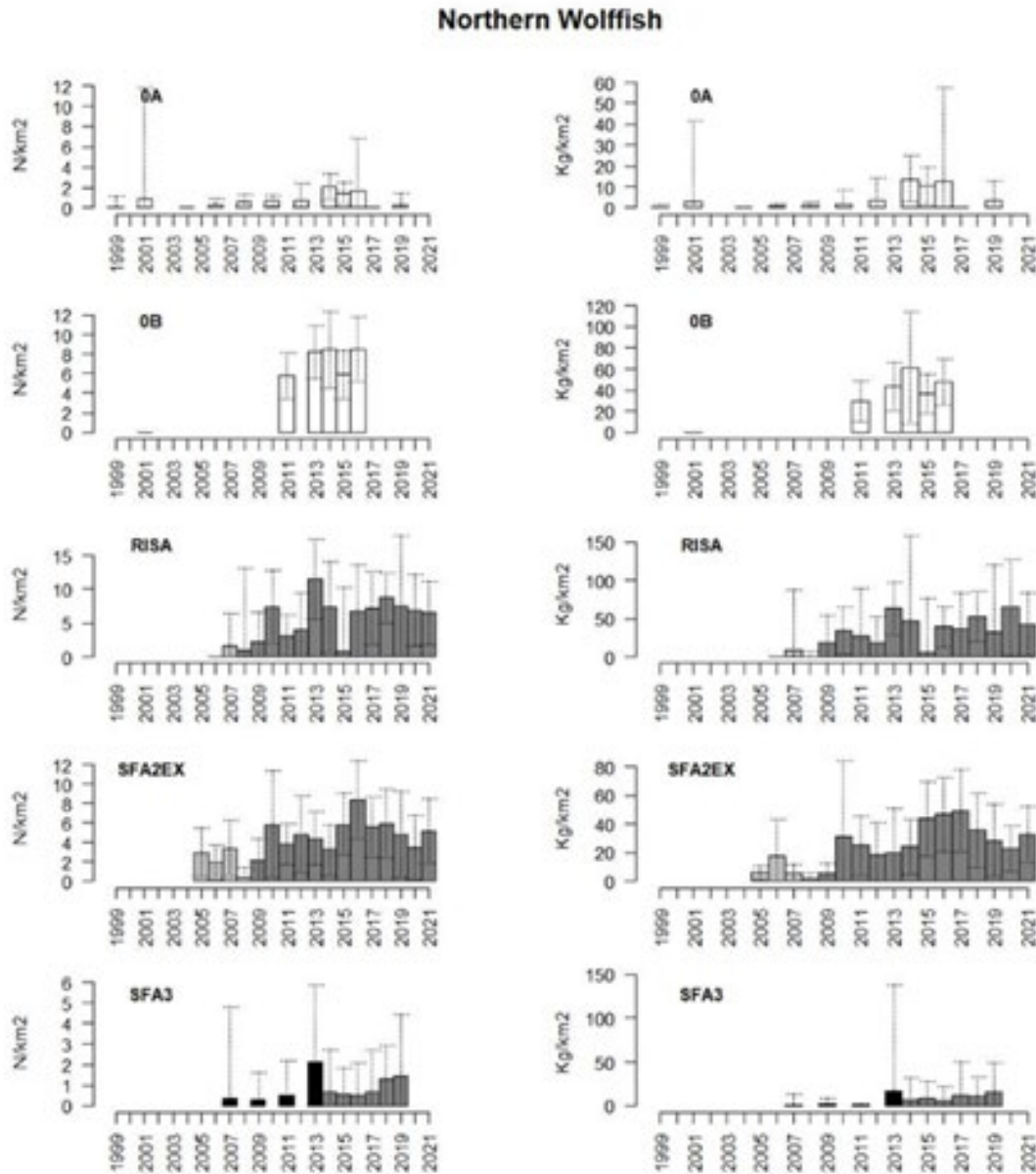


Figure 3. Standardized catch rates (Number and kg per km<sup>2</sup>) of Northern Wolffish in the RV survey in NAFO Div. 0A and 0B, the Resolution Island Survey Area (RISA), and NSRF survey in Shrimp Fishing Areas (SFA) 2 and 3. Horizontal line indicates fishing occurred but there was no catch, blanks indicate no fishing occurred that year in that area. Colour of bars denotes gear type; White = Alfredo; Light Grey = Standard Campelen; Dark Grey = Modified Campelen; Black = Cosmos.

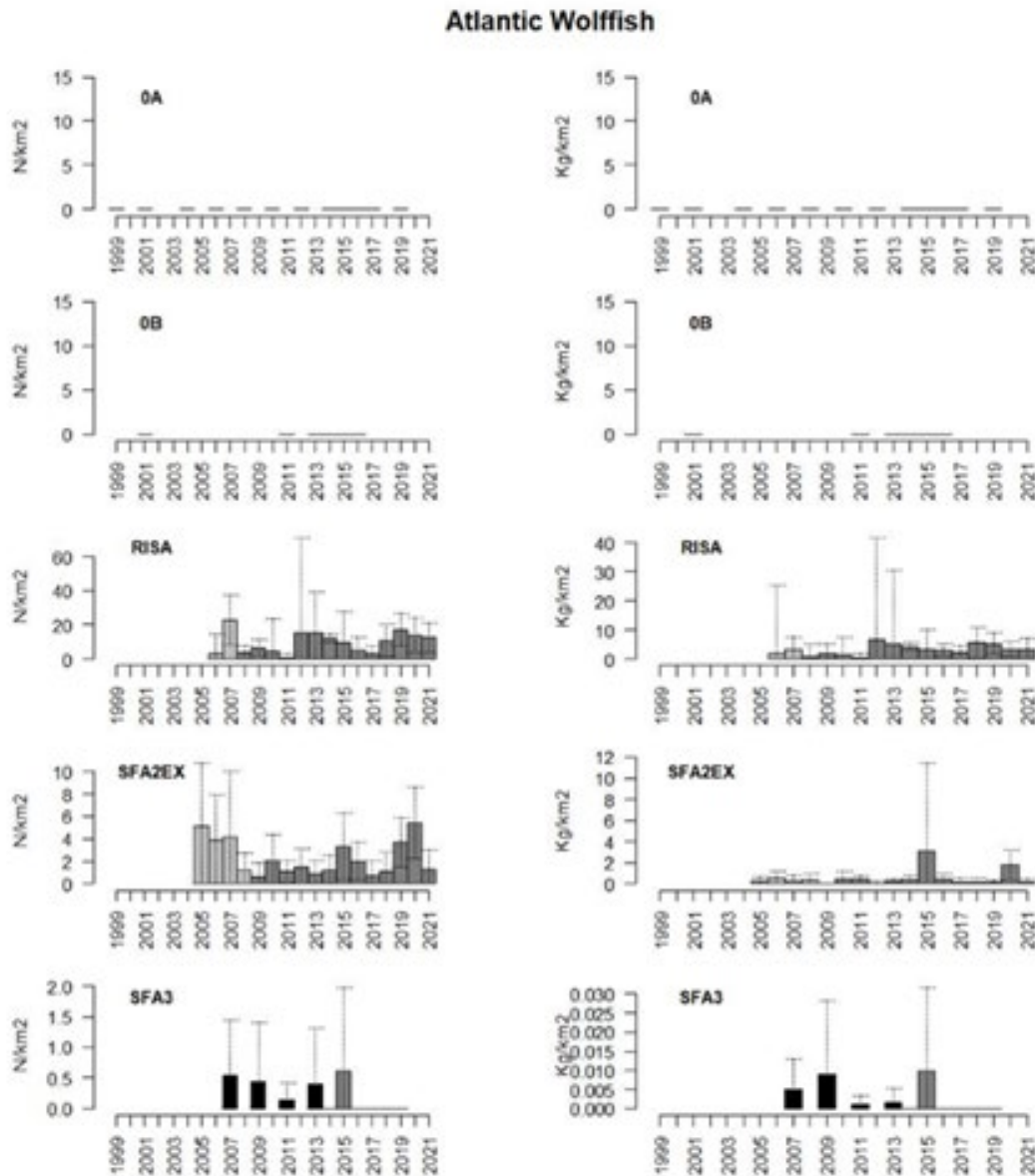


Figure 4. Standardized catch rates (Number and kg per km<sup>2</sup>) of Atlantic Wolffish in the RV survey in NAFO Div. 0A and 0B, the Resolution Island Survey Area (RISA), and NSRF survey in Shrimp Fishing Areas (SFA) 2 and 3. Horizontal line indicates fishing occurred but there was no catch, blanks indicate no fishing occurred that year in that area. Colour of bars denotes gear type; White = Alfredo; Light Grey = Standard Campelen; Dark Grey = Modified Campelen; Black = Cosmos.

Spotted Wolffish

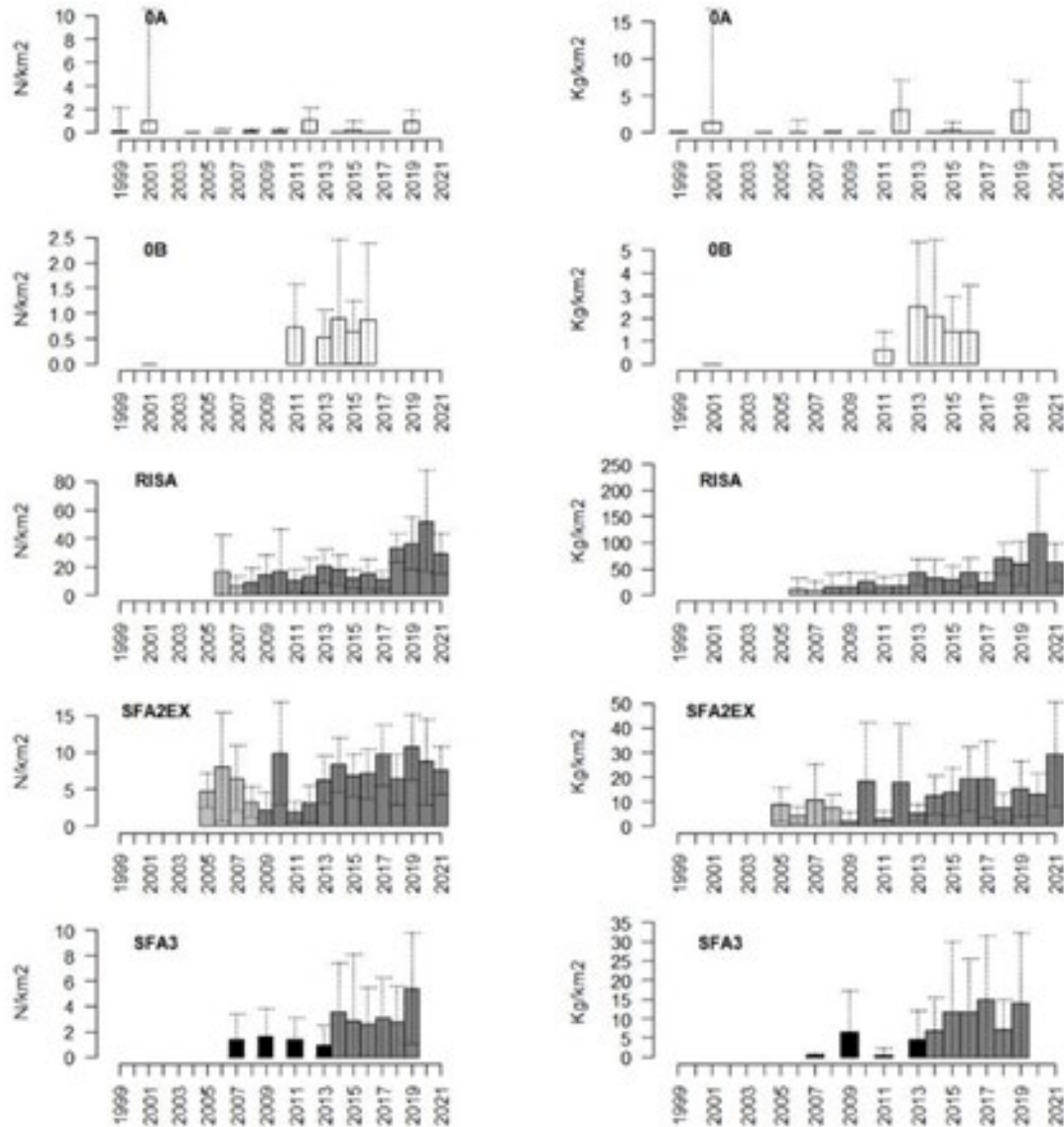


Figure 5. Standardized catch rates (Number and kg per km<sup>2</sup>) of Spotted Wolffish in the RV survey in NAFO Div. 0A and 0B, the Resolution Island Survey Area (RISA), and NSRF survey in Shrimp Fishing Areas (SFA) 2 and 3. Horizontal line indicates fishing occurred but there was no catch, blanks indicate no fishing occurred that year in that area. Colour of bars denotes gear type; White = Alfredo; Light Grey = Standard Campelen; Dark Grey = Modified Campelen; Black = Cosmos.



**Newfoundland and Labrador**

Estimates of abundance and biomass of Northern Wolffish were highest in Div. 2J3K when compared with other NAFO Divisions (Fig. 6). The estimated abundance and biomass in Div. 2H peaked at 1.2 million fish and 7,300 t in 2013. The estimated abundance and biomass in Div. 2J3K reached nearly 11 million individuals in 1978 and 74,000 t in 1980, and remained below 5 million fish and 22,000 t since then. Abundance and biomass indices in Div. 3LNO ranged mostly between 0.5–1 million fish and 2,500–11,000 t. In Subdiv. 3Ps, abundance and biomass estimates peaked at 133,000 fish (1996) and 450 t (2019) respectively, but these values were generally much smaller throughout the time series.

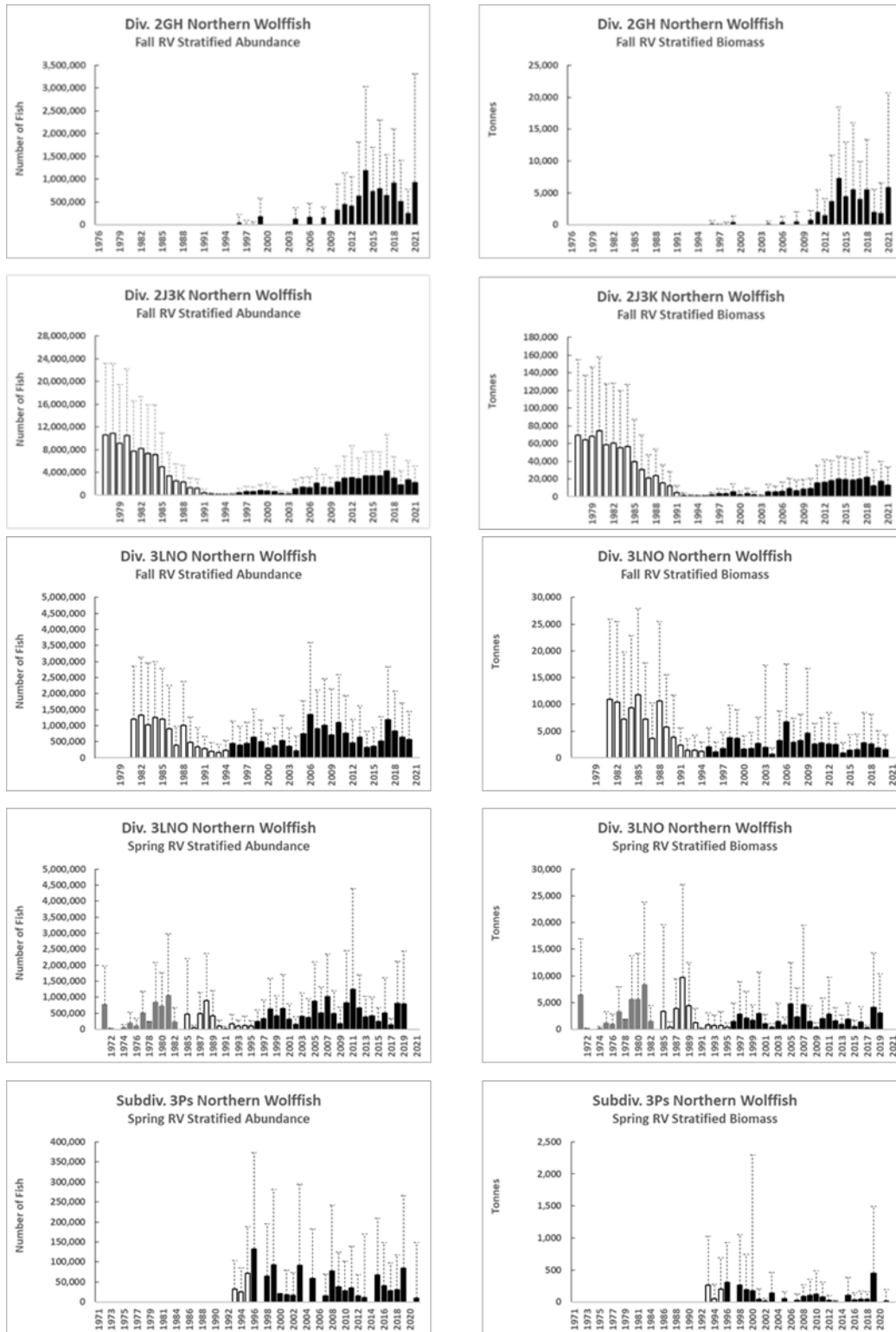


Figure 6. Abundance and biomass estimates of Northern Wolffish in Div. 2H, 2J3K, 3LNO, and Subdiv. 3Ps. Yankee (grey bar), Engel (open bar), and Campelen time series (black bar). T-bars = +95% Confidence Intervals (CIs).

As with Northern Wolffish, estimates of abundance and biomass of Atlantic Wolffish were highest in Div. 2J3K (Fig. 7). The RV survey stratified abundance and biomass estimates varied mostly between 7–10 million fish and 2,000 t in Div. 2H during the last decade. Abundance and biomass estimates peaked at 33 million fish and 30,000 t in 1978 in Div. 2J3K, prior to indicating a near-collapse by 1994 at just 0.6 million fish (440 t). Abundance estimates increased by ten-fold after introducing the Campelen trawl: from 0.6 million fish (937 t) before 1995 to 6.6 million fish (9,300 t) after 1995, ranging between 10–30 million fish thereafter. Similar patterns were observed in other NAFO Divisions. Abundance and biomass estimates in Div. 3LNO (spring and fall) varied without trend, ranging between 0.8–5.5 million fish (1,200–20,000 t) annually (Yankee and Engel time series). Estimated abundance was considerably higher after 1995–96 (2.6–27 million fish), compared to changes in biomass (1,800–27,000 t). The lowest abundance and biomass estimates for Atlantic Wolffish were observed in Subdiv. 3Ps (0.1 million fish [1994]–5.9 million fish [1999]; 181 t [1997]–6,000 t [2004]).

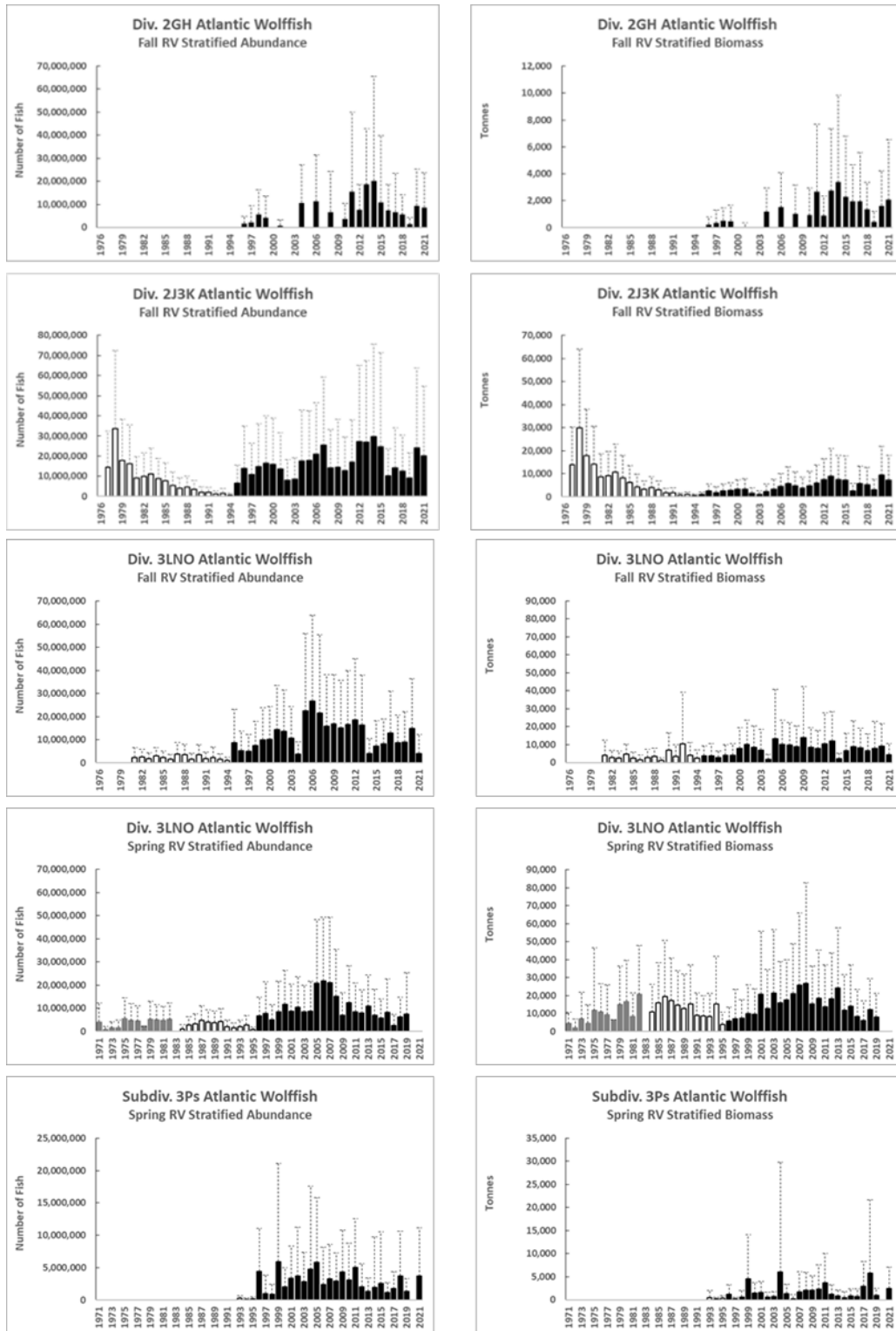


Figure 7. Abundance and biomass estimates of Atlantic Wolffish in Div. 2H, 2J3K, 3LNO, and Subdiv. 3Ps from annual DFO-NL Spring and Fall surveys. Yankee (grey bar), Engel (open bar), and Campelen time series (black bar). T-bars = +95% CIs.

Abundance and biomass estimates of Spotted Wolffish in Div. 2H experienced a substantial increase from approximately 1 million fish (1,300 t) in 2011 to 4.2 million fish (9,700 t) in 2021, the highest values of the time series (Fig. 8). Abundance and biomass estimates in Div. 2J3K declined from nearly 4.3 million fish (16,000 t) in the late 1970s to 100,000 fish (430 t) in 1994; the trend reversed after the introduction of the Campelen trawl, peaking at 4.8 million fish (2014) and 16,000 t (2013); levels that have been maintained up to 2021. The fall abundance and biomass estimates in Div. 3L declined from almost 3 million fish (18,000 t) in 1981 to 1 million fish (3,800 t) in 1989, with the addition of surveys into Div. 3NO, the fall abundance and biomass in Div. 3LNO combined had declined to 160,000 fish (790 t by 1994). Abundance of Spotted Wolffish has since increased; however, fall biomass remains low, ranging between 290–3,900 t annually. Abundance and biomass estimates in Div. 3LNO (spring) reached nearly 5 million fish (2006) and 16,000 t (2007), but generally varied without trend at considerably lower levels. As with the other two wolffish species, the lowest estimates of abundance and biomass were observed in Subdiv. 3Ps (4,800 fish [1995]–64,000 fish [2009], 1 t [2004]–158 t [2019]).



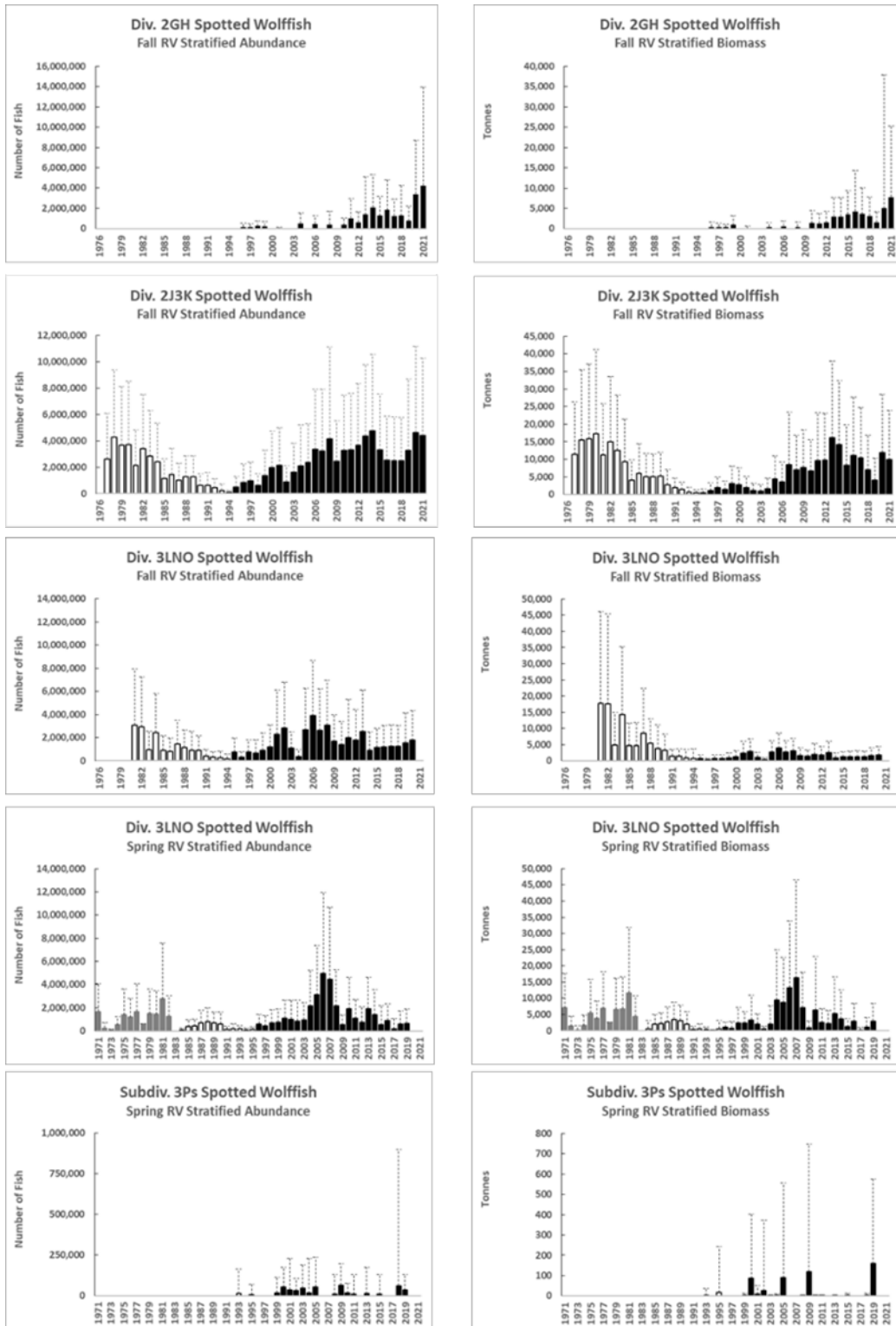


Figure 8. Abundance and biomass estimates of Spotted Wolffish in Div. 2H, 2J3K, 3LNO, and Subdiv. 3Ps from annual DFO-NL Spring and Fall surveys. Yankee (grey bar), Engel (open bar), and Campelen time series (black bar). T-bars = +95% CIs.

Mean length-at-age was not significantly different between male and female wolffish, regardless of species (Fig. 9). The total length of age eight Northern Wolffish averaged 63 cm total length, but only 41 cm for both Atlantic Wolffish and Spotted Wolffish, whereas age 16 wolffish of all species had a mean length of approximately 80 cm, suggesting that Northern Wolffish have a higher growth rate at younger ages when compared to the other two species.

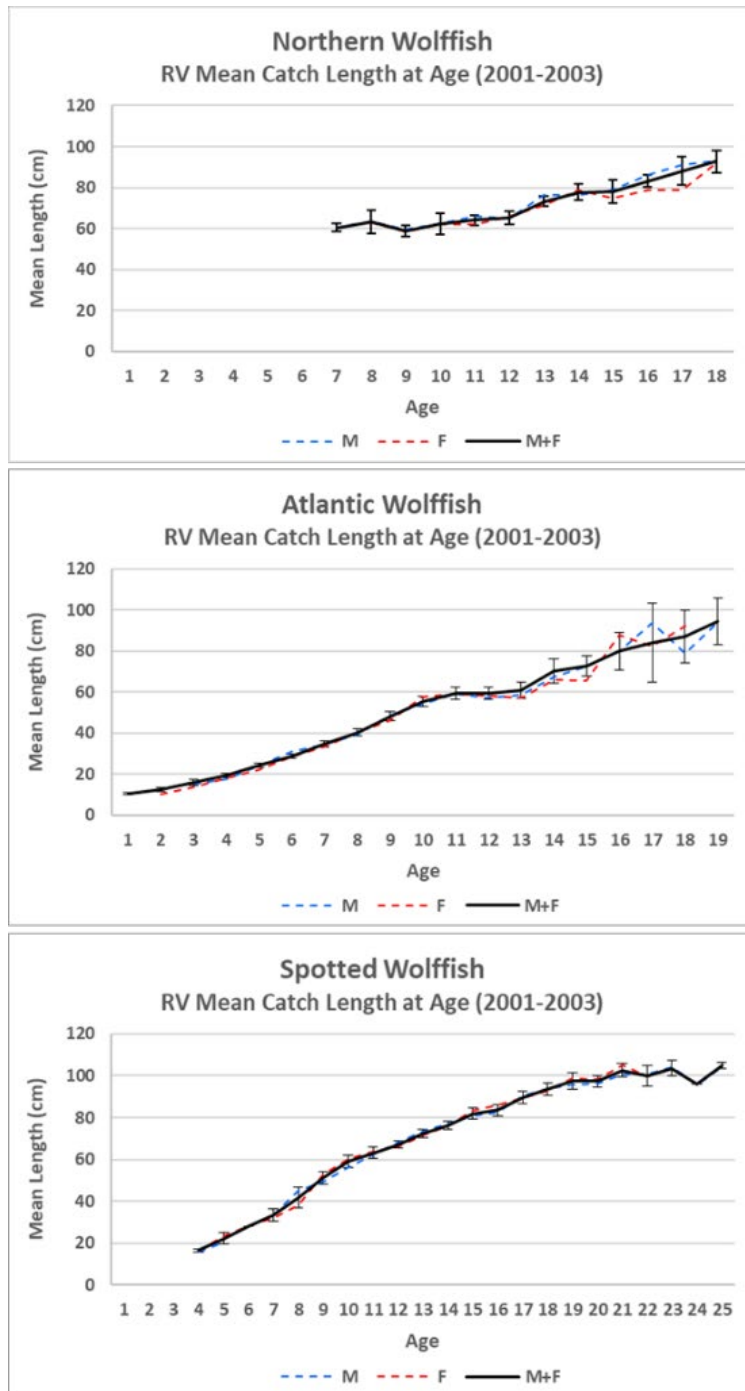


Figure 9. Mean length-at-age of wolffish from RV Spring and Fall survey catch in the NL Region (2001–03). M = male, F = female, T-bars = +/- 95% CIs.

The VBL growth model provided the best predictive accuracy of all the models tested for each of the three species (Fig. 10). Model parameters  $L_{inf}$  (asymptotic length),  $K$  (Brody growth rate coefficient), and  $t_0$  (theoretical age at which length = 0) for each species were in most cases comparable to those from the available literature and online databases (Table 1). According to the VBL model, the growth rate of age nine wolffish (all species) was 5 cm/year, and decreased gradually to 3 cm/year for Northern Wolffish and Atlantic Wolffish, and 4 cm/year for Spotted Wolffish by age 18. The asymptotic (total) length was 127 cm Northern Wolffish, 150 cm for Atlantic Wolffish, and 184 cm for Spotted Wolffish, whereas the maximum length observed from the research survey catch was 132 cm, 131 cm, and 147 cm, respectively.

*Table 1. Parameter estimates of the VBL growth function for female wolffish in Newfoundland and Labrador waters (Div. 2J3KLNO and Subdiv. 3Ps).*

Species	Model					$L_{inf}$ (cm)	K	$t_0$	References
	Function	DF	RSS	F Value	Pr > F				
Northern Wolffish	VBL	88	3,870.4	4,834.06	<0.0001	127	0.061	-1.276	Fishbase.org ( $L_{inf}$ =150 cm, $K$ =0.098, $t_0$ =-2.94)
Atlantic Wolffish	VBL	518	27,910.2	8,789.96	<0.0001	150	0.044	0.632	Fishbase.org ( $L_{inf}$ =158 cm, $K$ =0.043, $t_0$ =-0.39, -0.43) Nelson and Ross 1992 ( $L_{inf}$ =162 cm, $K$ =0.04, $t_0$ =-0.43)
Spotted Wolffish	VBL	416	25,164.4	40,431.1	<0.0001	184	0.037	-0.4	Fishbase.org ( $L_{inf}$ =181 cm, $K$ =0.061) Gunnarsson et al. 2008 ( $L_{inf}$ =106 cm, $K$ =0.043, $t_0$ =0.486)

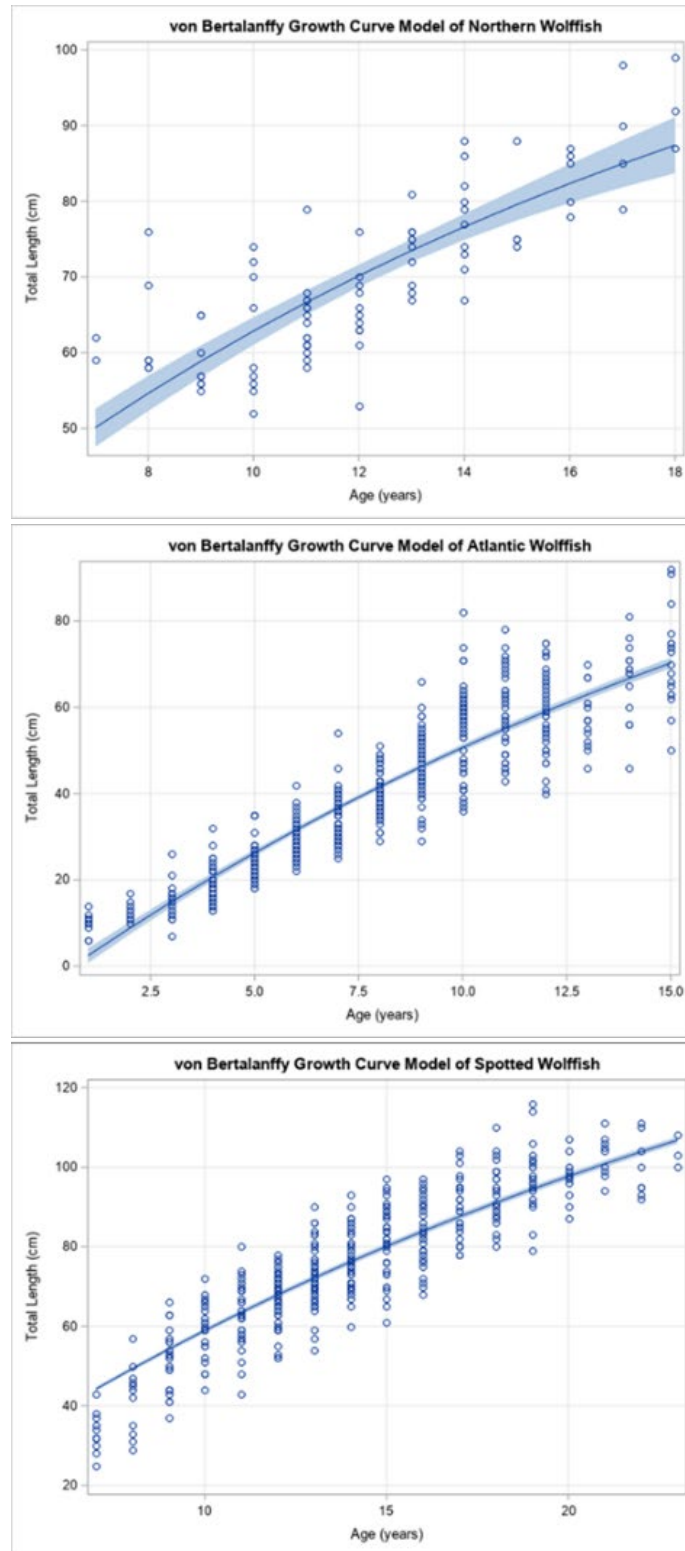


Figure 10. Observed length-at-age (circles) and predicted mean length-at-age of three wolffish species from RV Spring and Fall survey catch in the NL Region (2001–03). The predicted curves were fitted using a VBL function. Blue area = 95% CIs.

The maturity parameters for female wolffish estimated by the logistic models were significant in all cases (Table 2).

*Table 2. Estimates of age ( $A_{50}$ ) and length ( $L_{50}$ ) at 50% maturity of the Logistic Regression Function (Logit) for female wolffish in Newfoundland and Labrador waters (Div. 2J3KLNO and Subdiv. 3Ps).*

Species	Function	n	Parameter	Estimate	SE	Pr > ChiSq	References
Northern Wolffish	Logit	20	Intercept	-15.7320	7.8437	0.0449	COSEWIC 2012 ( $L_{50}$ = 75.2 cm, $A_{50}$ = 5.8 y.o.) Simpson et al. 2012 ( $A_{50}$ = 5 to 6 y.o.)
			Length	0.1953	0.0921	0.0339	
			$L_{50}$ (cm)	80.6	-	-	
		20	Intercept	-6.6937	3.2178	0.0375	
			Age	0.6594	0.3418	0.05	
			$A_{50}$ (Years)	10.5	-	-	
Atlantic Wolffish	Logit	47 3	Intercept	-6.1581	0.5511	<0.0001	Templeman 1986a ( $L_{50}$ = 51.4 to 68.2 cm) McRuer et al. 2000 ( $L_{50}$ = 55 cm, $A_{50}$ = 10 y.o.) McBride et al. 2022 ( $L_{50}$ = 53 cm, $A_{50}$ = 6.7 y.o.)
			Length	0.1226	0.0123	<0.0001	
			$L_{50}$ (cm)	50.7	-	-	
		45 2	Intercept	-5.3869	0.4937	<0.0001	
			Age	0.5205	0.0534	<0.0001	
			$A_{50}$ (Years)	10.4	-	-	
Spotted Wolffish	Logit	94	Intercept	-6.0785	1.2485	<0.0001	Gunnarsson et al. 2008 ( $L_{50}$ =82.7 cm, $A_{50}$ =9.1 y.o.) Templeman 1986b ( $L_{50}$ = 81 to 86 cm) Simpson et al. 2012 ( $A_{50}$ = 5 to 6 y.o.)
			Length	0.0822	0.0177	<0.0001	
			$L_{50}$ (cm)	74.0	-	-	
		90	Intercept	-10.0876	2.4879	<0.0001	
			Age	1.2763	0.3174	<0.0001	
			$A_{50}$ (Years)	7.5	-	-	

The  $L_{50}$  and  $A_{50}$  were 80.6 cm and 10.5 years for Northern Wolffish, 50.7 cm and 10.4 years for Atlantic Wolffish, and 74 cm and 8 years for Spotted Wolffish (Fig. 11). In general, these estimates were consistent with the range of values found in published studies.



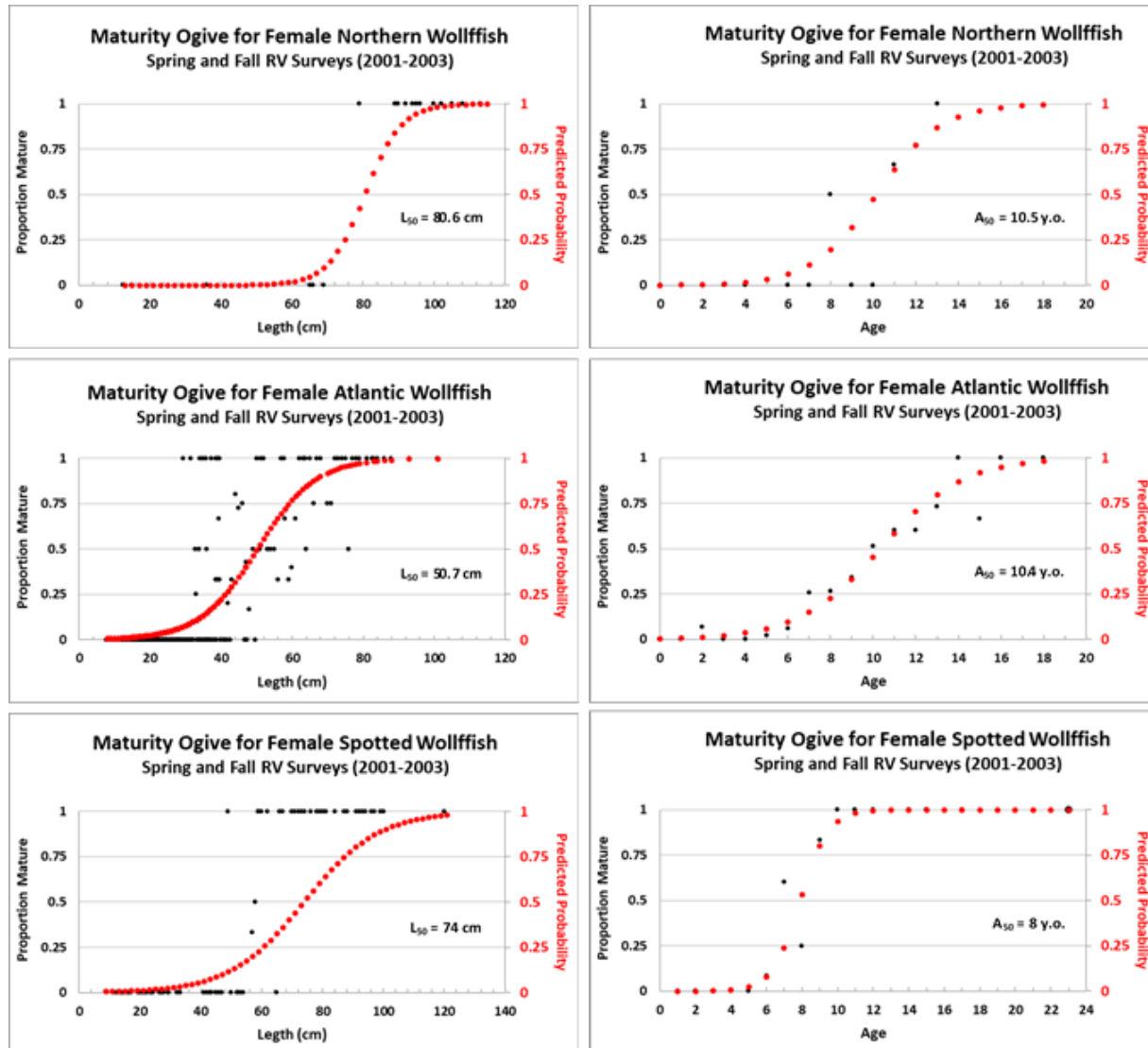


Figure 11. Proportion of mature female wolffish at length and at age from catches during Spring and Fall RV surveys in the NL Region (2001–03). The predicted curves were fitted using a Logit Function.

### Northern Gulf of St. Lawrence

The abundance and biomass estimates peaked at around 20 million fish (3,501 t) for Atlantic Wolffish in 1997, 794,000 fish (1,275 t) for Spotted Wolffish in 2004, and 32,900 fish (49.6 t) for Northern Wolffish in 2012 (Fig. 12). While these extrapolated numbers may be informative to some degree, their interpretation must be made with caution given the wide confidence intervals associated with these years.

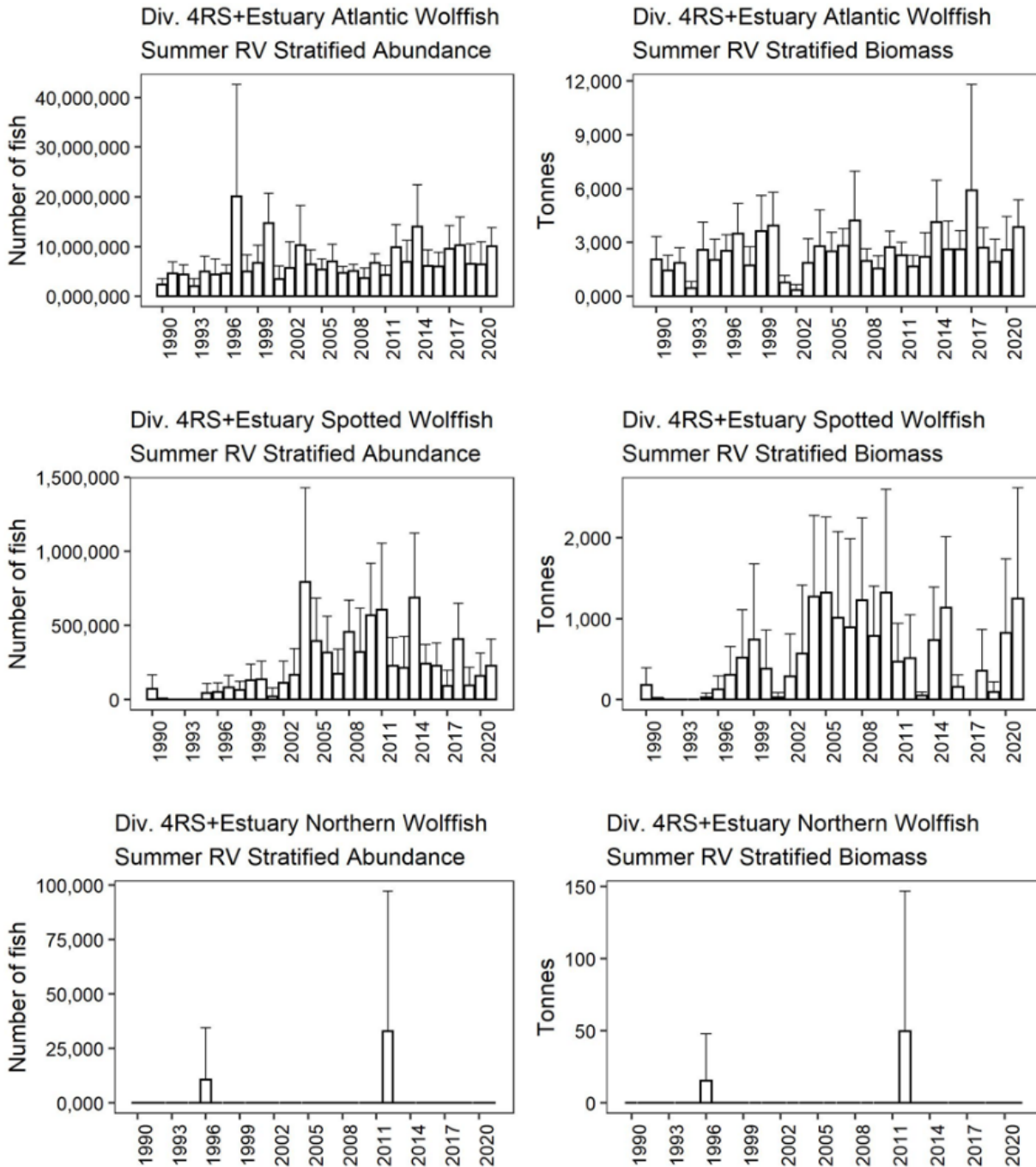


Figure 12. Estimates of total abundance and biomass of Atlantic Wolffish, Spotted Wolffish, and Northern Wolffish in Div. 4RS and the St. Lawrence Estuary. T-bars = + 95% CI.

**Southern Gulf of St. Lawrence**

The estimated abundance and biomass of Northern Wolffish in Div. 4T reached approximately 138,000 individuals (116 t) in 1986 (Fig. 13). Of note, the estimates are based on a total annual

catch of seven specimens during the 1986 survey edition, and no Northern Wolffish were caught in the sGSL RV survey in the past 11 years. The estimated biomass of Atlantic Wolffish in Div. 4T peaked at 435 t for approximately 240,000 individuals in 1988, but has remained low (between 2 and 50 t) for the past 10 years. The estimated biomass of Spotted Wolffish in Div. 4T also reached its maximum in 1988 at 447 t, but the estimated number of individuals peaked in 2009 at 26,000. High levels of variance are explained by the low numbers of individuals caught. Overall, the estimated biomass has remained low (between 2 and 58 t) for the past 10 years.

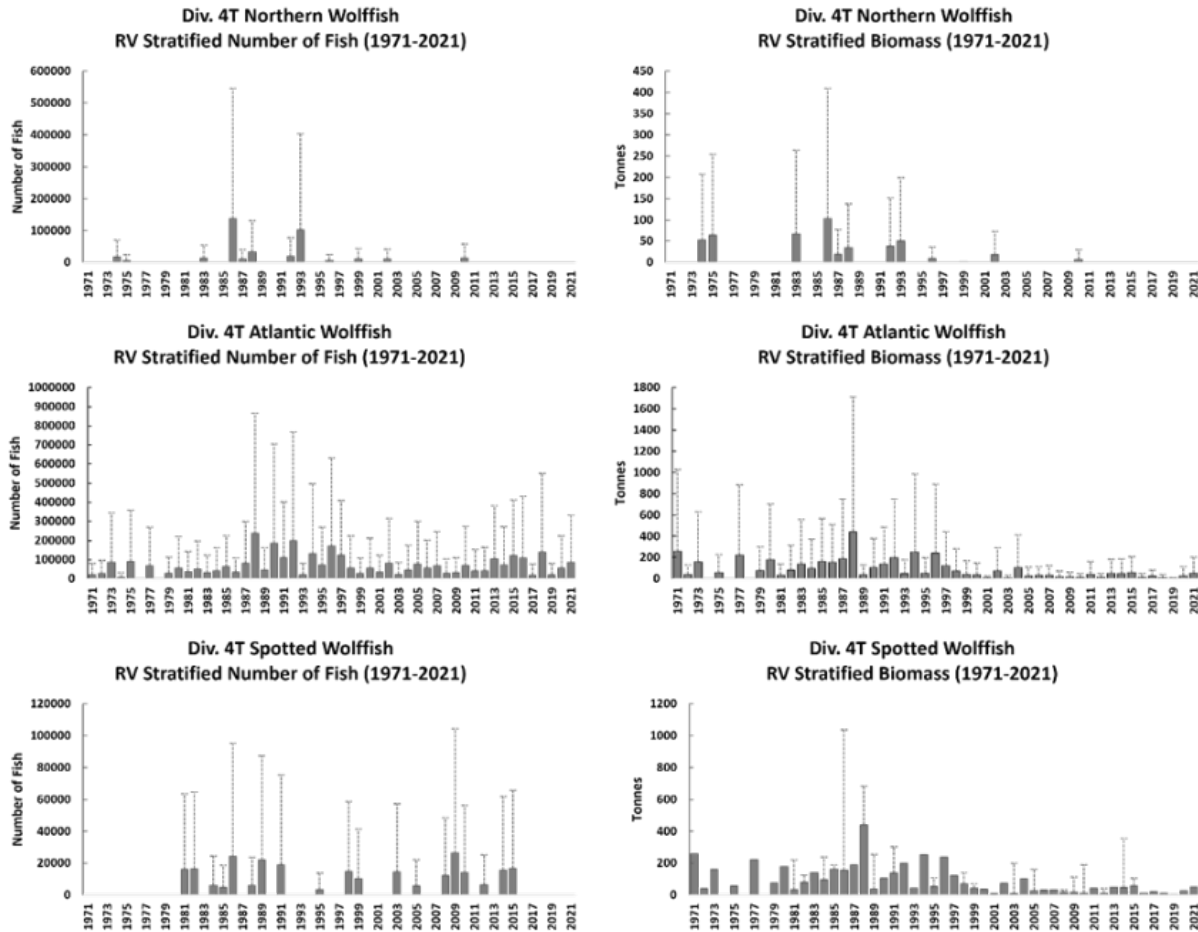


Figure 13: Abundance and biomass estimates of Northern Wolffish, Atlantic Wolffish, and Spotted Wolffish in Div. 4T. T-bars = + 95% CI.

### Maritimes

Stratified biomass of Northern Wolffish peaked in 1981 at 1,421 t; for Spotted Wolffish it peaked in 1991 at 622 t (Fig. 14). Atlantic Wolffish biomass on the Scotian Shelf peaked in 1975 at 11,338 t. Biomass was generally stable in the 1970s and 1980s, but has since declined by 91%. Abundance of Atlantic Wolffish peaked again in the late-1990s to early-2000s (6 million fish), although with high interannual variability. This period was followed by rapid decline, and abundance remains low to present day.

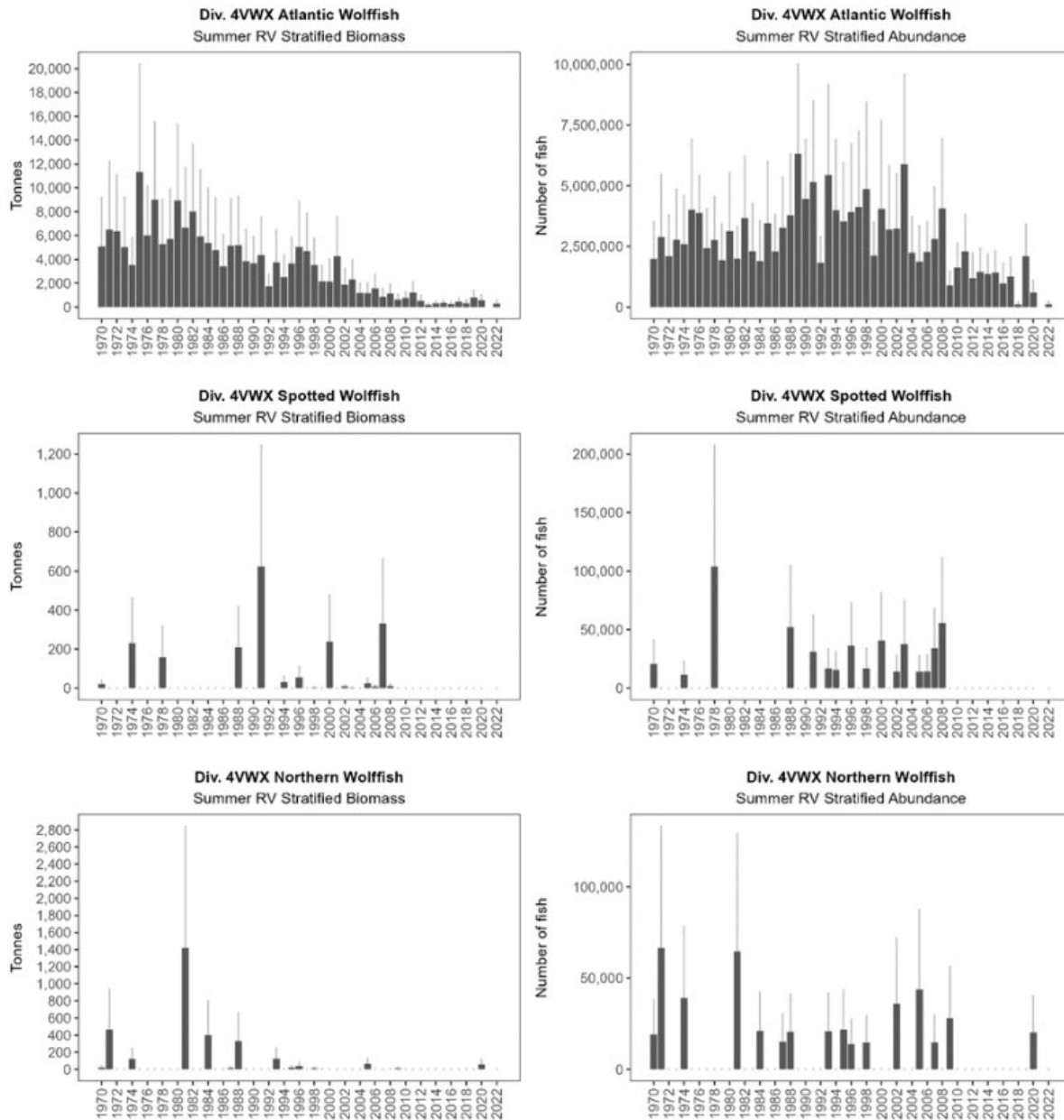


Figure 14. Stratified biomass and abundance of Atlantic Wolffish, Spotted Wolffish, and Northern Wolffish from the Maritimes Summer RV survey in Div. 4VWX, 1970–2022.

Distribution of Atlantic Wolffish on Georges Bank is primarily concentrated in strata 2 of Div. 5Z. Abundance was variable from 1987 to the early 2000s, with peaks of 156,000 fish and 171,000 fish in 1987 and 1996, respectively (Fig. 15). Stratified biomass decreased since the early 1990s and has remained consistently near zero since the late 2000s. This corresponds to a 99.9% decrease in biomass over the survey period, most of which occurred from 1987 to 2010. No Atlantic Wolffish were caught in 2009, 2010, 2013, 2015, 2017, and 2019.

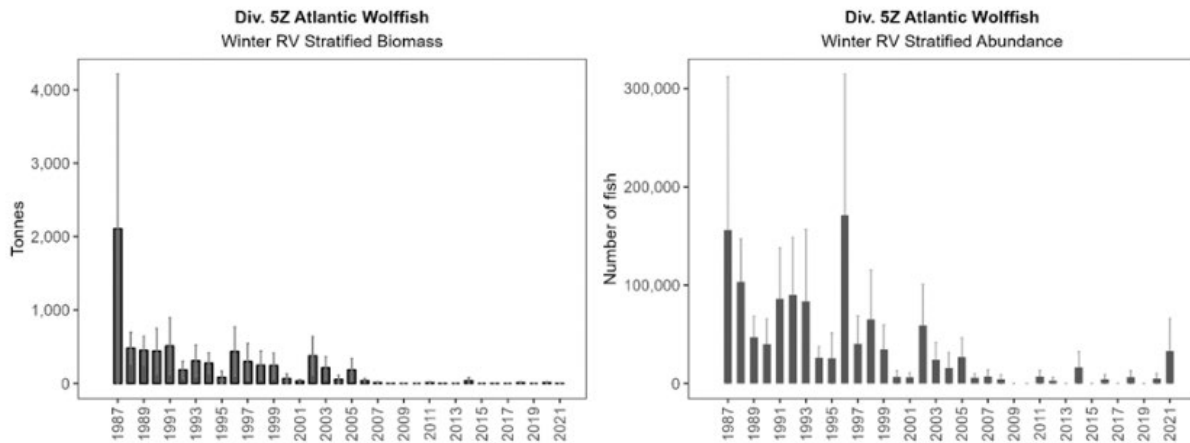


Figure 15. Estimates of biomass and abundance of Atlantic Wolffish from the Maritimes Winter RV survey in Strata 5Z1 to 5Z4 of Div. 5Z, 1987–2021.

### Commercial Fisheries Removals

Removal information from commercial fisheries is generally available as either unspciated wolffish landings or spciated Atlantic Wolffish, Spotted Wolffish, and Northern Wolffish landings from several sources. These include the NAFO STATLANT-21A database (1960–2021), as reported by Canada and other NAFO-member countries; the DFO Zonal Interchange File Format (ZIFF, 1985–2021); and the DFO Maritimes Fisheries Information System (MARFIS, 2002–21), both as reported by Canadian fishers. Spciated wolffish catch and discard data are available from the Canadian At-Sea Fisheries Observers Program (ASFO, 1985–2021), SARA logbooks from vessels greater than 35 ft in the NL Region (2008–19), and groundfish fisheries in the Maritimes Region (2005–22). Discards are rarely reported to NAFO or the DFO Statistics Branch (for ZIFF and MARFIS), and the most reliable source of data on discarding at sea comes from the ASFO Program. However, generally a very small percentage of the actual trips and sets that occur in most fisheries have ASFO coverage, which makes comparison between years and areas difficult given the variation in observer coverage among different fisheries.

#### Arctic

NAFO STATLANT-21A database reported only eight records of unspciated wolffish catch, with the most recent report from 1993. A small number of individuals were also recorded in the DFO-NL ZIFF. ASFO data were available from vessels fishing in Div. 0AB; primarily from mobile gear fisheries targeting Greenland Halibut and *Pandalus* shrimp.

Of the three species, recorded catch of Northern Wolffish was consistently the highest, peaking at just under 100 t in 2019 (Fig. 16). Total recorded catch and frequency of encounters have been increasing for Northern Wolffish across the time series, but interpretation of the data should be considered with caution, as they are not scaled to observer coverage or contributions from different target fisheries. For both Spotted and Atlantic Wolffish, total reported catch remained low across the time series, with less than 3 t reported in most years, but there was a spike in reported landings for both species from 2009–13.



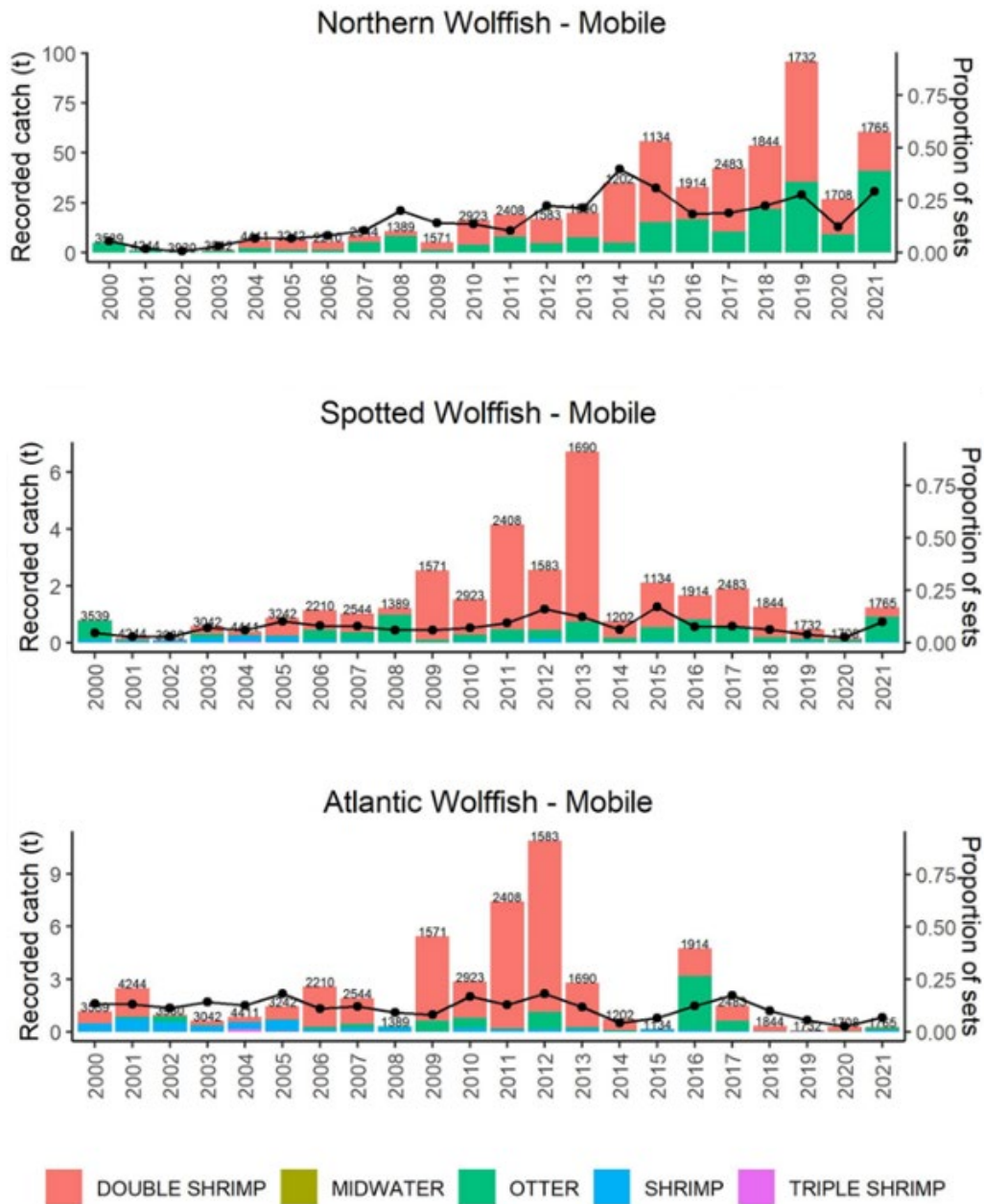


Figure 16. Recorded catch (t) of Northern, Spotted, and Atlantic Wolffish from the ASFO database from mobile gear fisheries in Div. 0AB. The black line indicates the proportion of sets where wolffish were observed with the number above each bar indicating the number of sets with observer data.

### Newfoundland and Labrador

According to NAFO STATLANT-21A database, landings of unspeciati wolffish increased from 835 t in 1960 to a peak of 6,660 t in 1975, and then gradually declined thereafter with landings of 30 t or less during the period 2013–21 (Fig. 17). Removals occurred mostly in Div. 3LNO, except during the period 1972–75, when most removals took place in Div. 2J3K. Removals in any given year from Subdiv. 3Ps and Div. 2GH never exceeded 850 t and 385 t, respectively.

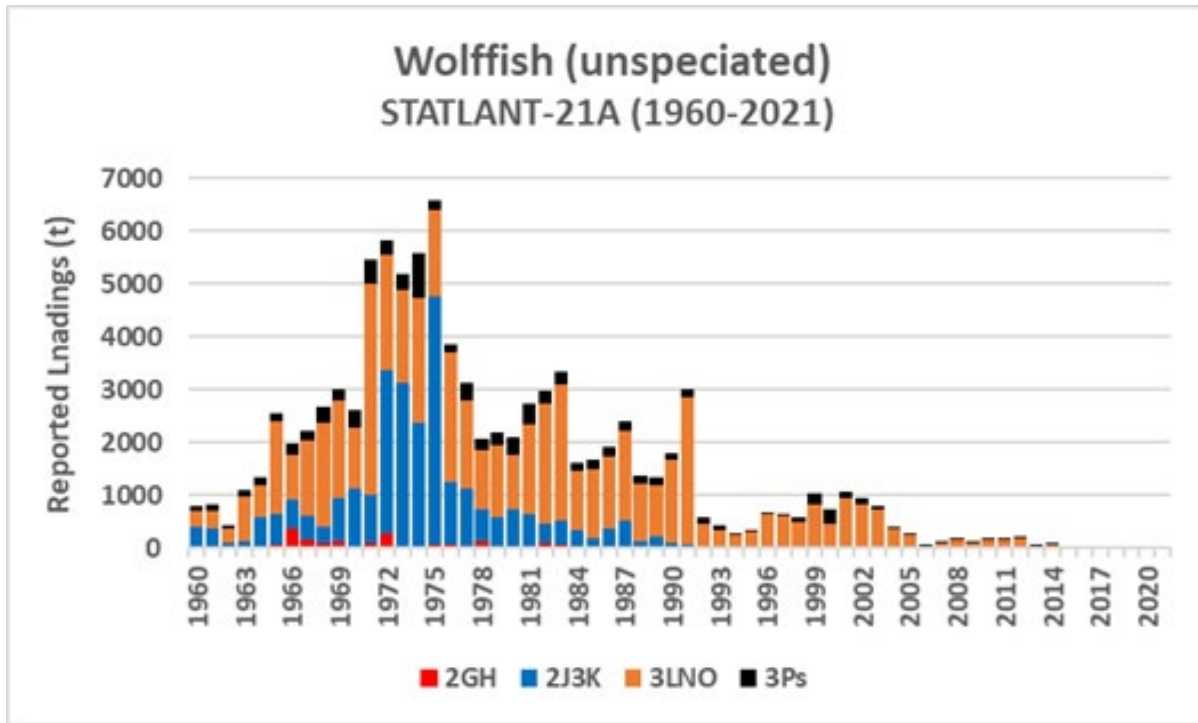


Figure 17. Reported landings of wolffish from NAFO STATLANT-21A database (1960–2021).

The reported unspeciatiated wolffish landings from the ZIFF database ranged mostly between 150–416 t prior to 2003. Landings dropped by ten-fold or more thereafter, once the SARA listing of wolffish species came into effect and mandatory discard rules were enacted. Initially, most landings were from Div. 3LNO, but have shifted to Subdiv. 3Ps since 1995. In Div. 2GH and Div. 2J3K, the reported annual landings were very low (<30 t) throughout the time series (Fig. 18). However, the absence of speciatiated wolffish landings in commercial fisheries (except for limited ASFO records), in addition to unreported discards at sea and misreporting of species caught, limits the evaluation of wolffish mortality in commercial fisheries (DFO 2015).

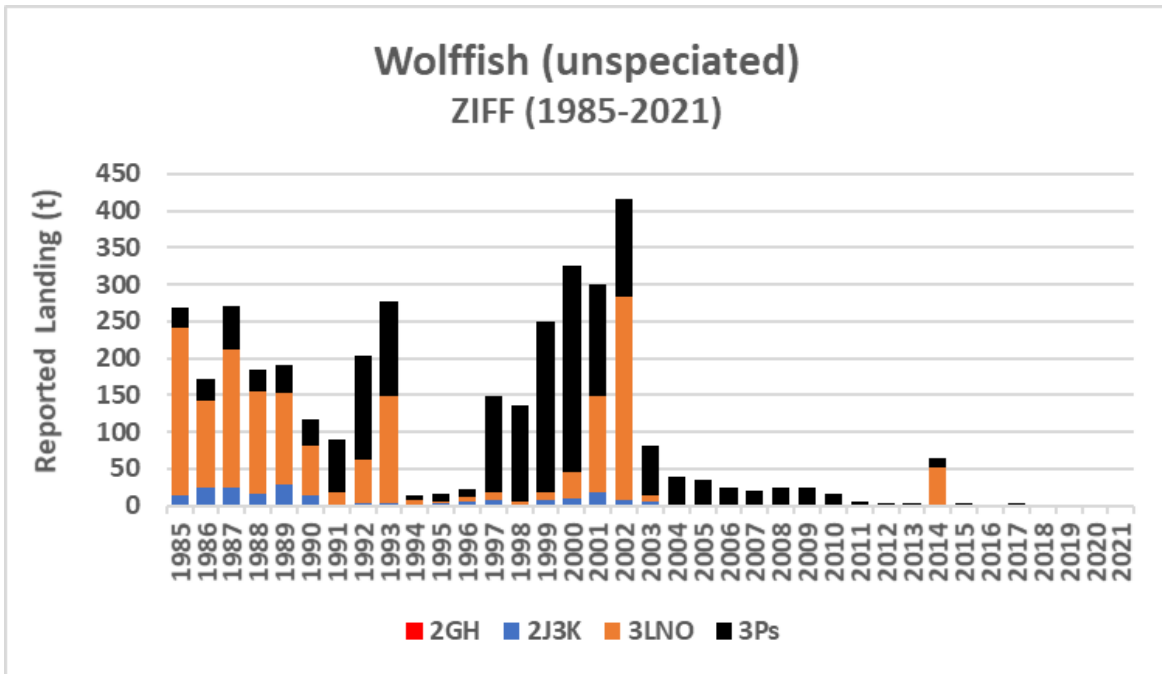


Figure 18. Reported landings of unspciated wolffish from the DFO-NL ZIFF database (1985–2021).

The ASFO data show that reported landings of Northern Wolffish occurred mostly in Div. 2J3K; catch typically ranged between 150–300 t annually during the period 1985–92, except in 1987 (530 t), but dropped to less than 50 t from 1993 onwards (Fig. 19). However, comparison between years and areas using ASFO catch data is difficult given the variation in observer coverage among different fisheries. Annual catches of Atlantic Wolffish in Div. 3LNO were less than 40 t, except in 2001–06 (55–240 t). Spotted Wolffish catches occurred in both Div. 2J3K and Div. 3LNO during most years, ranging between 55–190 t until 1992; catches declined to less than 20 t thereafter.

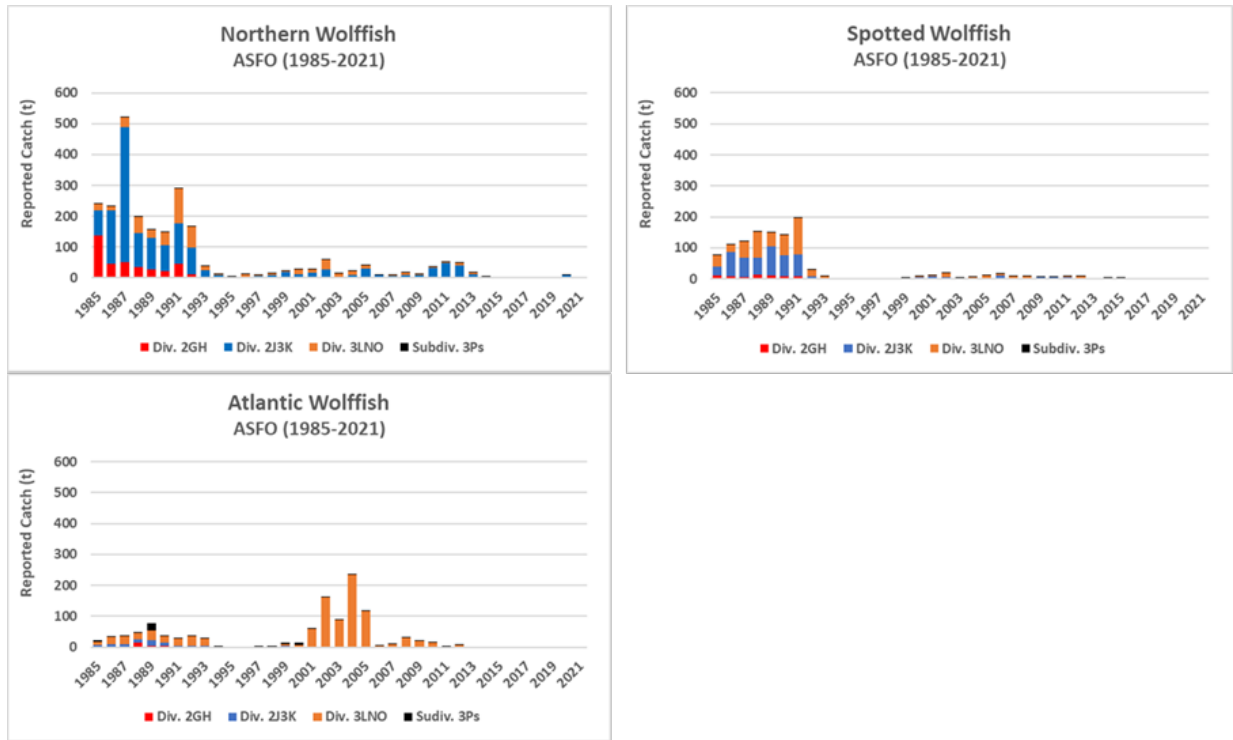


Figure 19. Reported catch (t) of wolffish, by species, from the ASFO database (1985–2021). Data are not scaled by observer coverage.

In the SARA logbooks, the majority of wolffish (all species) captured by mobile fishing gears in the NL Region were recorded as dead upon release (2008–19), whereas the majority were released alive for fixed gears (Fig. 20).

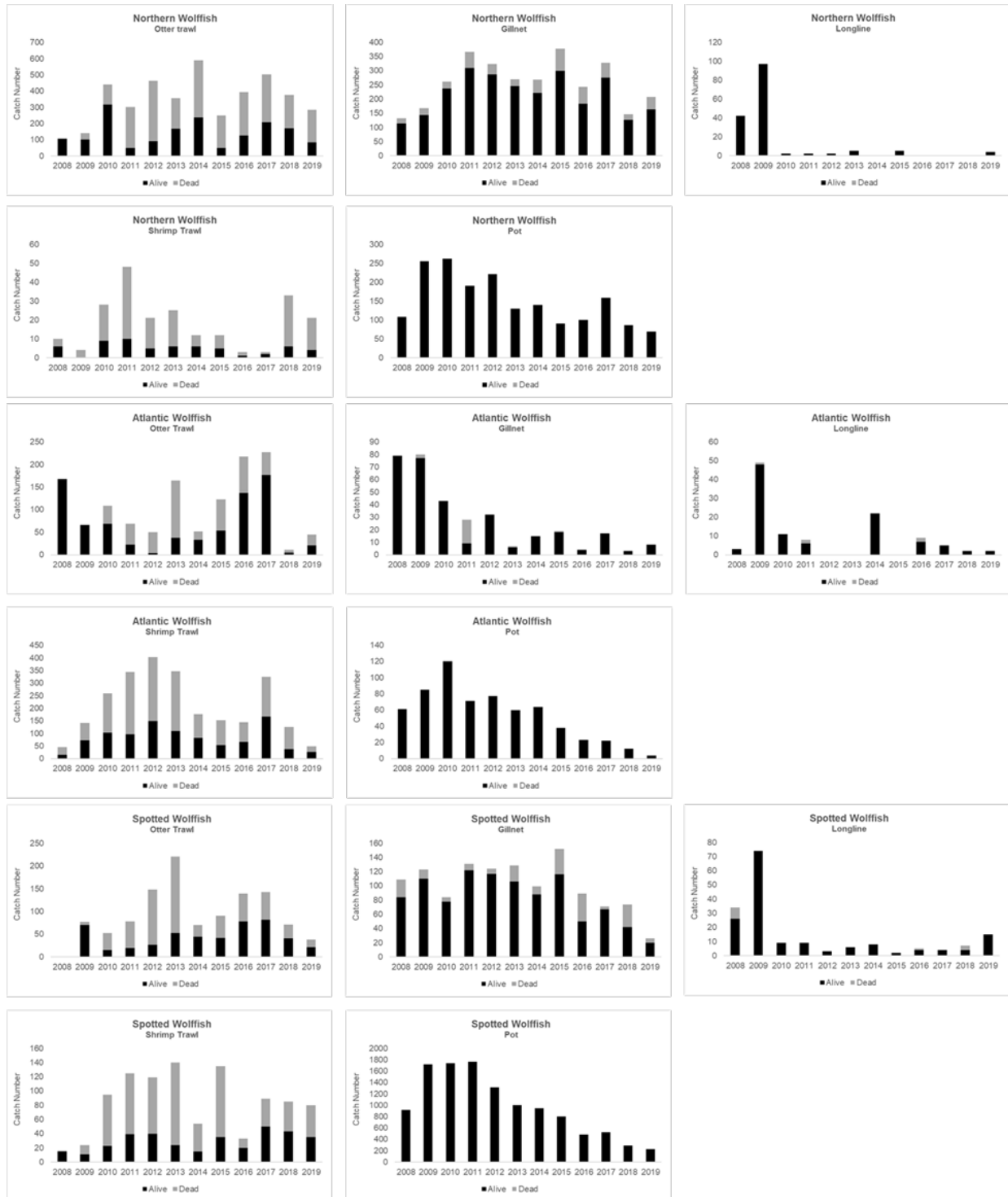


Figure 20. Reported catch and release of wolffish in the NL Region, by species and gear type, from the SARA logbooks (2008–19).

**Northern and Southern Gulf of St. Lawrence**

According to NAFO STATLANT-21A database, total reported landings of wolffish in the Gulf of St. Lawrence (all gears combined) were largely dominated by unspciated and Atlantic Wolffish from the west coast of Newfoundland (Fig. 21). For unspciated wolffish, reported landings peaked at 742 t in 1983, declined to very low values (<10 t) until the early to mid-1990s, and have remained at zero since 2011. Landings records for Atlantic Wolffish, available from 2004–18, reached a maximum of 18 t in 2010.

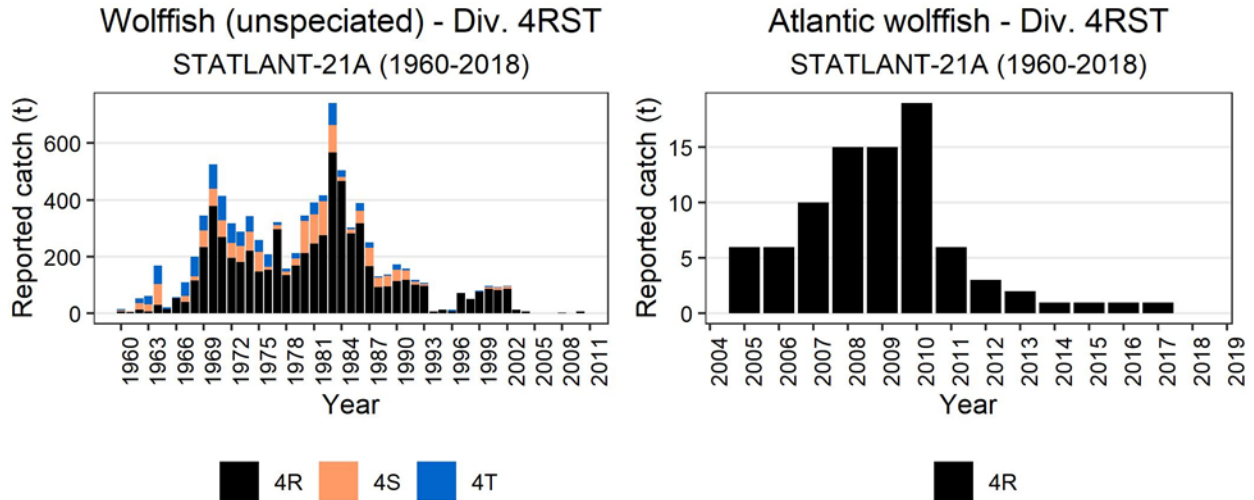


Figure 21. Reported landings of unspciated wolffish and Atlantic Wolffish in the Gulf of St. Lawrence (Div. 4RST) from the NAFO STATLANT-21A database (1960–2018).

Trends in DFO ZIFF landings exhibited similar patterns as those in NAFO STATLANT-21A data (Fig. 22), with reported landings for unspciated wolffish and Atlantic Wolffish peaking in the mid-1980s (>300 t) and in 2010 (>15 t), respectively. Most landings originated from Div. 4R.

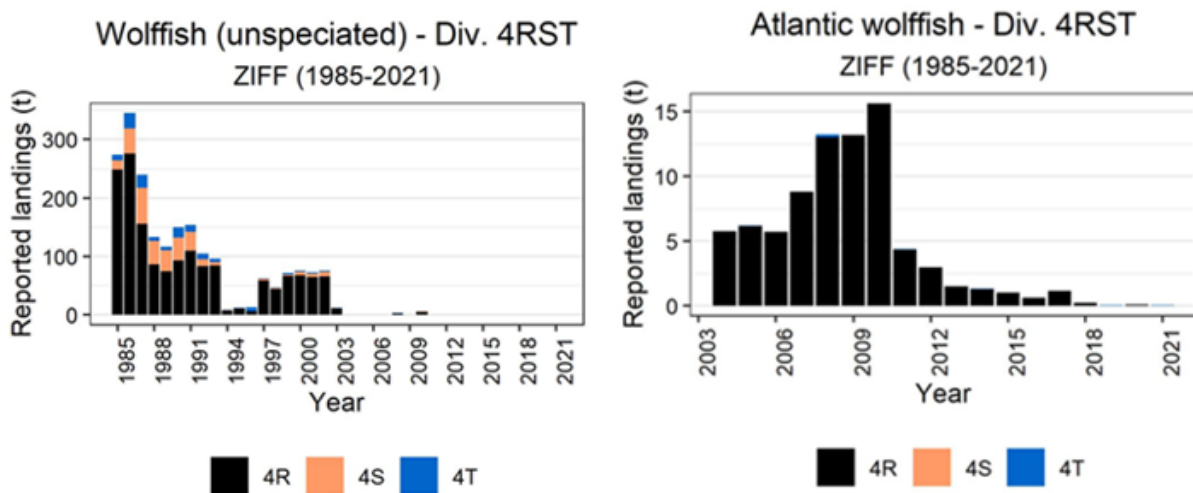


Figure 22. Total reported Canadian landings of unspciated wolffish and Atlantic Wolffish in the Gulf of St. Lawrence (Div. 4RST) from the ZIFF database.

ASFO records of unspiciated wolffish in the nGSL were negligible (<2 t) and restricted to a small number of years prior to 2000 (Fig. 23). Catches of Atlantic Wolffish and Spotted Wolffish peaked in the late-1980s and in the mid to late 2000s. For Northern Wolffish, there were records in the late-1980s, but observations remained relatively rare (<0.1 t) thereafter.

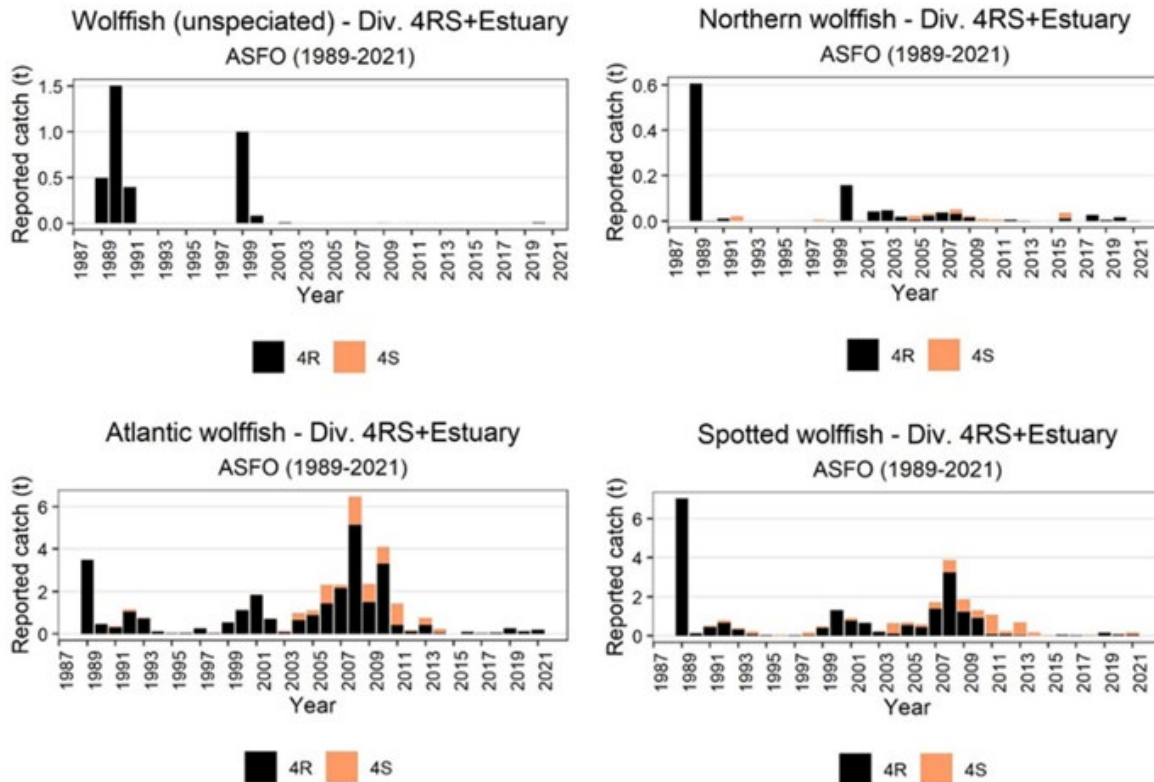


Figure 23. Total reported catch of unspiciated, Atlantic, Spotted, and Northern Wolffish in the northern Gulf of St. Lawrence (Div. 4RS) from the ASFO database (1989–2021).

ASFO reported catch of Northern Wolffish in the sGSL was very low from 1989 to 2013 (<1,000 kg; with <100 kg recorded in 15 of those years, Fig. 24). Starting in 2013, Northern Wolffish catch increased and peaked at 6,336 kg in 2015, before slowly decreasing to the current level of around 1,000 kg. For Atlantic Wolffish, the reported catch peaked in 2008, at 5,175 kg, but varied between 200 and 2,000 kg for most years. For Spotted Wolffish, the reported catch was generally low (<1,000 kg), and peaked at 7,045 kg in 1989.

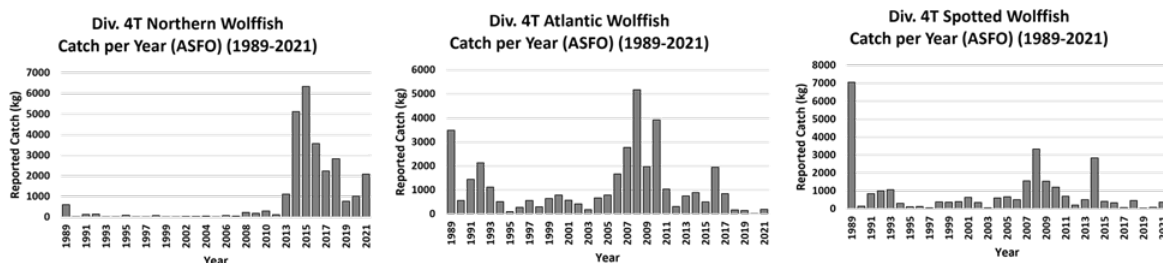


Figure 24. Total reported catch of Northern, Atlantic, and Spotted Wolffish in the southern Gulf of St. Lawrence (Div. 4T) from the ASFO database (1989–2021).



**Maritimes**

Domestic landings of wolffish (also reported as catfish) reported in the MAFIS database in Div. 4VW and Div. 5ZY (2001–21) have remained at low levels (3–11 t) since 2008 (Fig. 25). Landings in Div. 4X peaked in 2002 at about 150 t and declined thereafter, with an average of 10 t over the past decade.

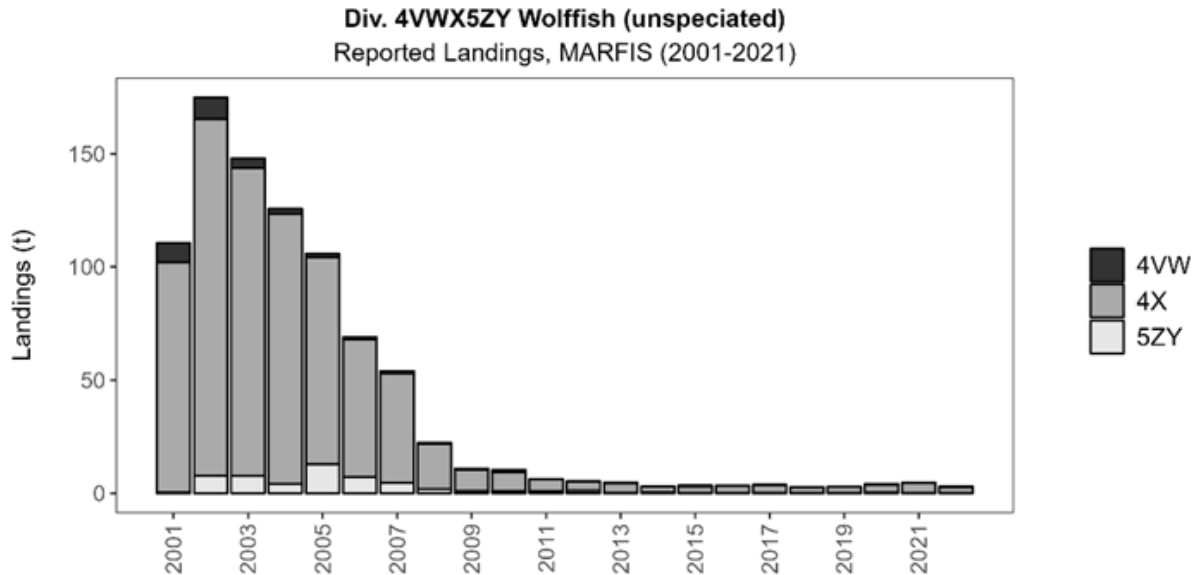


Figure 25. Commercial landings of wolffish (unspiciated) from Div. 4VWX5ZY as reported from the MAFIS database (2001–22).

The ASFO reported catch of Atlantic Wolffish during domestic commercial fishing activities peaked near 20 t in 1985, but has decreased since 2000, with an average estimated weight of 1.56 t per year over the last decade (Fig. 26). These data are not scaled by fishery landings or effort. Catches of Northern Wolffish briefly increased in the early-2000s but have remained below 3 t over the last ten years, whereas catches of Spotted Wolffish have remained below 3 t annually throughout the time series. Initially wolffish were retained, but they have been discarded since 2002.

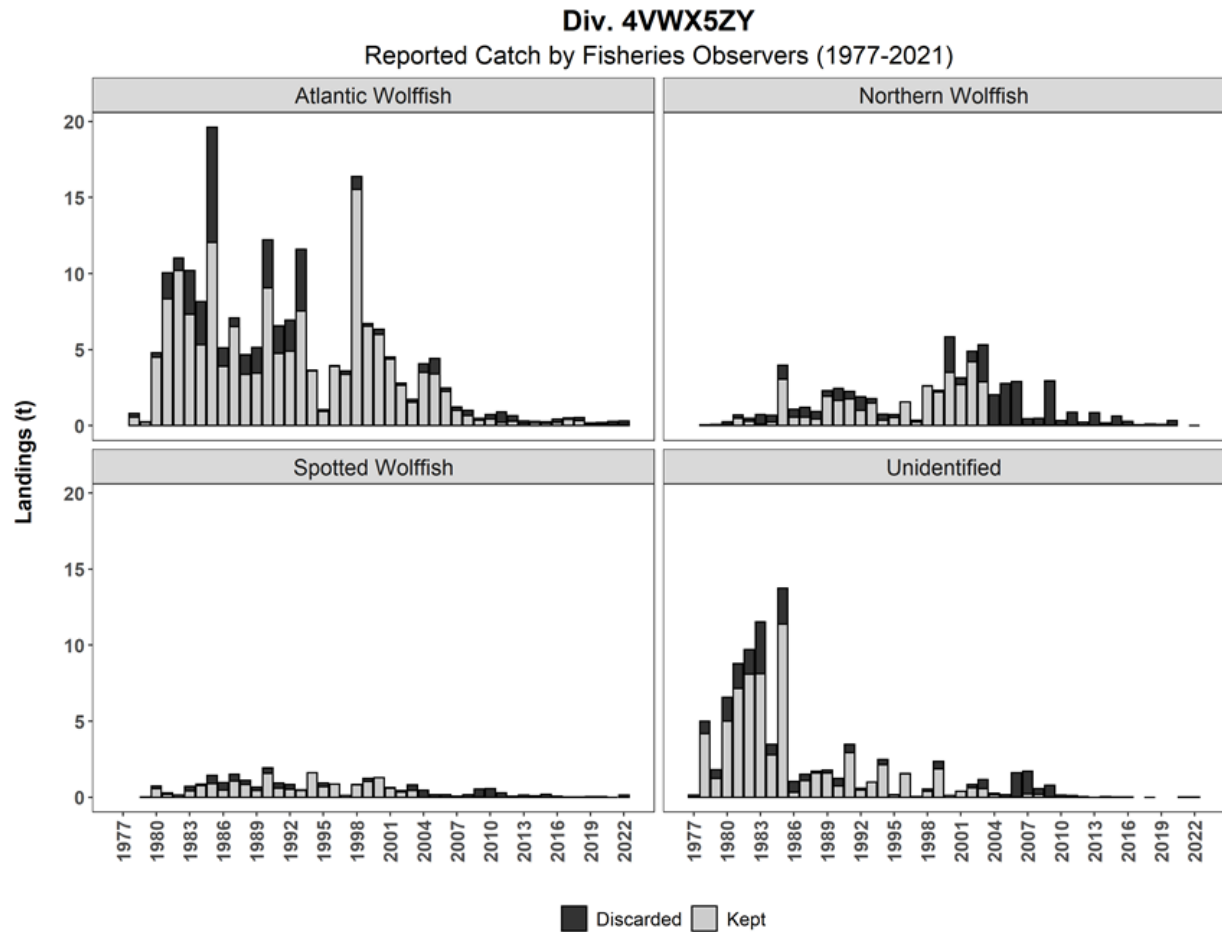


Figure 26. Cumulative catch (retained + discarded) of wolffish from Div. 4VWX and Div. 5ZY reported by the Canadian ASFO Program, 1977–2022.

Interactions between fisheries and the three species of wolffish as recorded in SARA logbooks indicate that Atlantic Wolffish form only a small proportion of the records, since fisheries are not required to record them (Table 3).

Table 3. Interactions by wolffish species (kg) as recorded in SARA logbooks from fishing locations in Div. 4VWX (- indicates no data). Data for 2019–22 are preliminary.

Years	Northern Wolffish	Spotted Wolffish	Atlantic Wolffish	Unspecified Wolffishes	Total (kg)
2006	2,457	113	214	-	2,784
2007	18,691*	400	105	24	19,220
2008	5,075	379	488	10	5,952
2009	2,152	826	24	-	3,002
2010	1,047	546	-	-	1,593

Years	Northern Wolffish	Spotted Wolffish	Atlantic Wolffish	Unspecified Wolffishes	Total (kg)
2011	667	506	40	9	1,222
2012	525	251	<1	350	1,126
2013	1,326	290	20	544	2,180
2014	1,246	337	14	<1	1,597
2015	402	400	16	5	823
2016	560	138	250	-	948
2017	352	176	-	-	528
2018	532	45	-	-	577
2019	788	250	-	-	1,038
2020	674	284	-	-	958
2021	584	73	-	-	657
2022	61	460	-	-	521
<b>Total (kg)</b>	<b>37,139</b>	<b>5,474</b>	<b>1,171</b>	<b>942</b>	<b>44,726</b>

\*A single trip in 4VW recorded 13,000 kg

The proportion of records of Northern Wolffish and Spotted Wolffish are surprising, particularly the observations of these species in relatively shallow, coastal fisheries targeting Sea Scallop and Lobster (Table 4). Northern Wolffish and Spotted Wolffish are more northern, deeper-dwelling species that are uncommon on the Scotian Shelf (Scott and Scott 1988, Simon et al. 2012); therefore, those records may be misidentified Atlantic Wolffish.

*Table 4. Wolffish bycatch (kg) in different fisheries, as recorded in SARA logbooks from fishing locations in Div. 4VWX (- indicates no data). Data for 2019–22 are preliminary.*

Years	Snow Crab	Groundfish	Lobster	Sea Scallop	Tuna	Total (kg)
2006	-	1,637	-	-	-	1,637
2007	-	59,895*	-	-	227	60,122
2008	-	5,953	-	-	-	5,953
2009	-	9,529	-	-	-	9,529
2010	-	1,621	<1	-	-	1,621
2011	-	1,374	173	-	-	1,547
2012	-	1,116	33	-	-	1,149

Years	Snow Crab	Groundfish	Lobster	Sea Scallop	Tuna	Total (kg)
2013	-	2,597	53	-	-	2,650
2014	<1	2,437	20	-	-	2,457
2015	-	1,663	18	3	-	1,684
2016	-	1,459	22	-	-	1,481
2017	26	1,615	95	<1	-	1,736
2018	-	634	102	20	-	756
2019	71	1,202	40	5	-	1,318
2020	16	8,224	103	20	-	8,363
2021	32	5,387	76	-	-	5,495
2022	-	431	23	2	300	756
<b>Total (kg)</b>	<b>145</b>	<b>106,774</b>	<b>758</b>	<b>50</b>	<b>527</b>	<b>108,254</b>

\*A single trip recorded 13,000 kg

### **Spatial Distribution of Reported Wolffish Catches**

Despite the broad distribution of fishing sets by various commercial fleets throughout the study area, the spatial distribution of the reported catch from the ASFO database indicate that Northern Wolffish interactions with commercial fleets (both mobile and fixed gear) occurred mostly along the continental shelf slope and deep channels across the shelf (Hawke Channel, Cartwright Saddle) in Div. 2J3K, and over the Southeast Shoal (mobile gears only) and southwest slope of the Grand Bank in Div. 3LNO. Very few interactions between Northern Wolffish and both mobile and fixed gears occurred in the southern Gulf Region, mostly in nearshore areas along the Gaspé Peninsula and Cape Breton in Div. 4T. Some interactions, particularly with fisheries deploying fixed gears, were observed along the shelf in Div. 0B, and with both mobile and fixed gears in the Maritimes Region, mostly in the southern area of the Scotian Shelf in Div. 4X, and the northern slope of Georges Bank in Subdiv. 5Ze (Fig. 27).

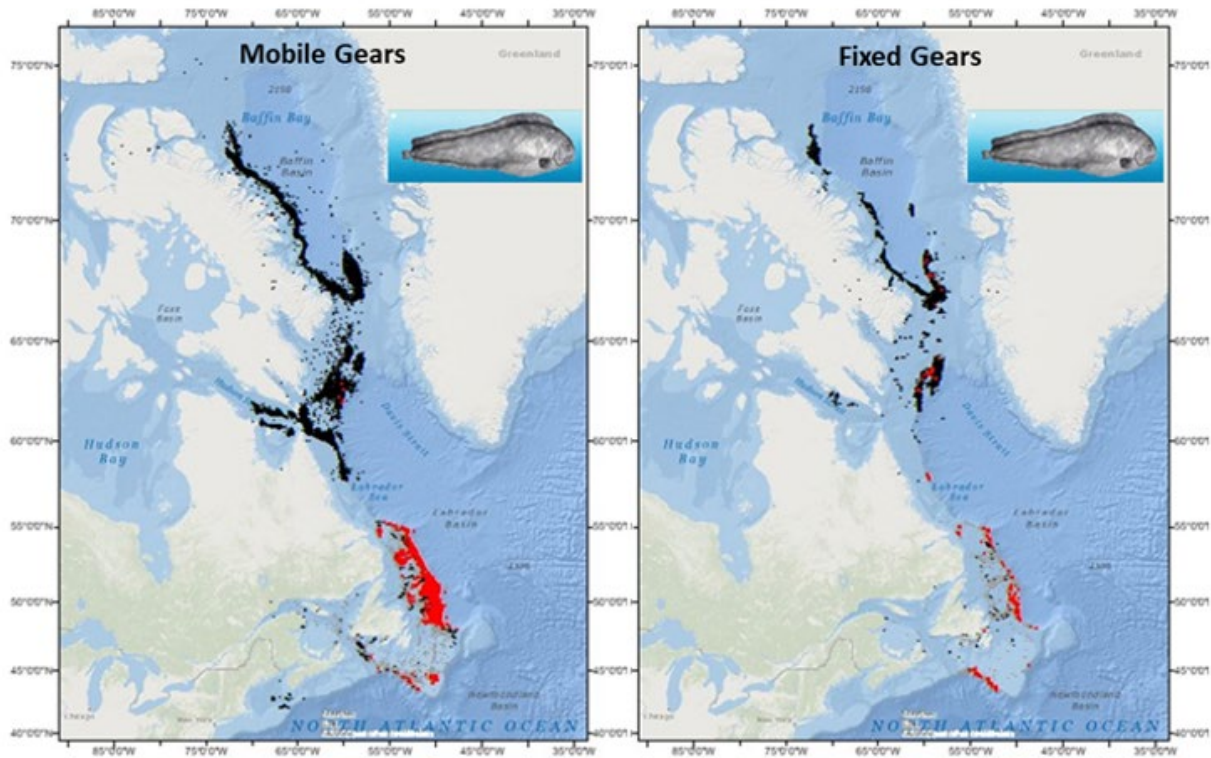


Figure 27. Distribution of commercial sets (all fisheries) from the ASFO database (1985–2021) by mobile gears (left panel) and fixed gears (right panel) where Northern Wolffish were absent (black dots) or present (red dots).

For Atlantic Wolffish, interactions with commercial fleets deploying mobile gears occurred on the Southeast Shoal of the Grand Bank, along the edge of the Green Bank and Halibut Channel in Subdiv. 3Ps, and along the continental slope of the northern Grand Bank, Hawke Channel, and Div. 0B. Interactions with fixed gear fleets occurred on the Burgeo Bank and along the southwest coast of Newfoundland in Subdiv. 3Ps. Interactions between Atlantic Wolffish and commercial fleets in Div. 4T (both mobile and fixed gear) occurred mainly along the slope of the Laurentian Channel, nearshore areas along the Gaspé Peninsula and Cape Breton, and in the Bay of Fundy, in the Maritimes Region (Fig. 28).

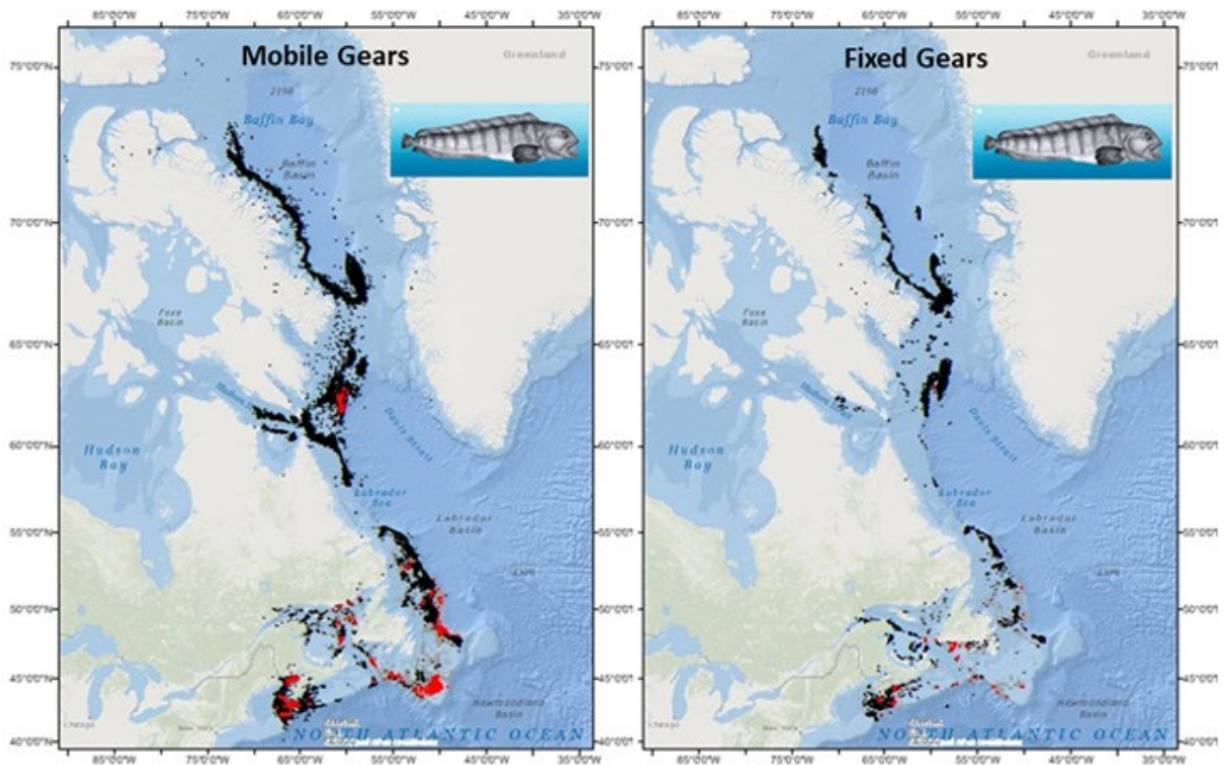


Figure 28. Distribution of commercial sets (all fisheries) from the ASFO database (1985–2021) by mobile gears (left panel) and fixed gears (right panel) where Atlantic Wolffish were absent (black dots) or present (red dots).

Interactions between Spotted Wolffish and mobile gears occurred along the shelf edge of the northern Grand Bank and Bonavista Corridor in Div. 3LNO and along the shelf edge and Hawke Channel in Div. 2J3K and Div. 0B. Interactions with fixed gears were predominantly centered in the Bonavista Corridor and along the Hawke Channel, mainly along the slope of the Laurentian Channel, and nearshore areas along the Gaspé Peninsula and Cape Breton in Div. 4T (mobile fleet only). No ASFO records are available for Spotted Wolffish in the Maritimes Region (Fig. 29). As with all fishery-dependent data, the information on spatial distribution is more indicative of the distribution of fishing effort than the distribution of the bycatch species.



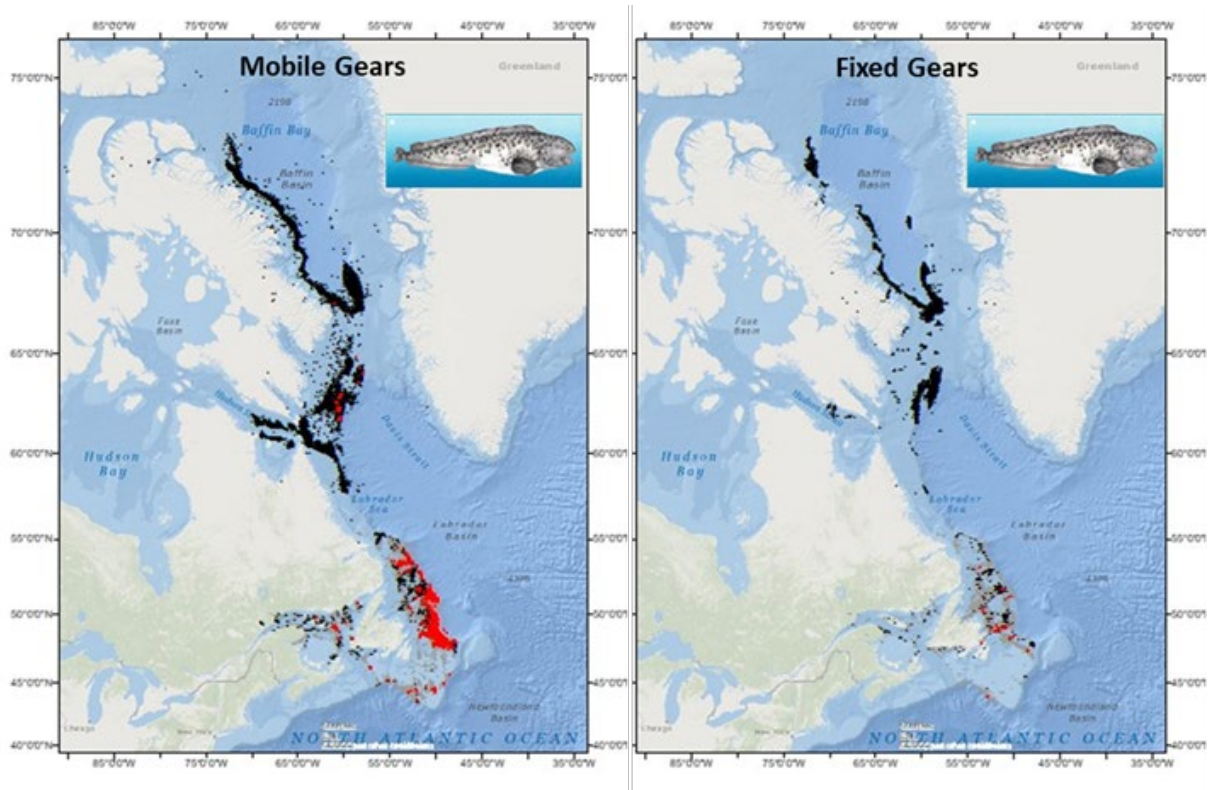


Figure 29. Distribution of commercial sets (all fisheries) from the ASFO database (1985–2021) by mobile gears (left panel) and fixed gears (right panel) where Spotted Wolffish were absent (black dots) or present (red dots).

### Sources of Uncertainty

- Commercial wolffish landings are rarely identified to species when reported in Canadian and other fisheries. Canadian At-Sea Fisheries Observers constitute the sole source of total catch data by species, including discards at sea. However, in many Canadian Atlantic and Arctic fisheries, annual observer coverage is likely too low or not sufficiently representative to accurately estimate wolffish bycatch.
- Although Canada’s SARA requires mandatory release of Northern Wolffish and Spotted Wolffish caught in Canadian waters as a conservation measure, levels of post-release mortality are unknown in different fisheries (i.e., “live” release does not guarantee post-release survival).
- There is currently no stock assessment model available due to the lack of relevant information/data on wolffish in Canadian Atlantic and Arctic waters such as stock structure, size/age composition of population, age-at-maturity, recruitment, and natural/fishing mortality. In addition, the very limited/lack of survey gear conversion factors and information on RV trawl catchability in regions outside the nGSL and Scotian Shelf limits the temporal extent of the existing survey data.
- There is limited knowledge about aspects of habitat associations not covered in the present study (e.g., breeding, nursery areas).

## CONCLUSION

The analysis of the RV survey catch data indicate that the majority of the Northern Wolffish and Spotted Wolffish populations are centered in Div. 2J3K, with Atlantic Wolffish centered in Div. 2J3K and 3LNO. There were noticeable increases in stock size (all species) since the mid-2000s when compared to the 1990s in the NL Region. These findings are consistent with results from previous studies (COSEWIC 2012a, 2012b, 2012c, Collins et al. 2015, DFO 2015), and suggest that these bioregions contain optimal habitats for wolffish populations.

As expected, most reported wolffish interactions with commercial fisheries occurred in the bioregions where the stocks are centered, primarily along the slopes of the continental shelf and deep channels, and to a lesser extent over the southern Grand Bank and the remaining portions of the study area. The majority of wolffish (all species) captured by mobile gears in the NL Region were recorded as dead upon release in the SARA logbooks (2008–19), whereas the opposite was observed in the case of fixed gears. These findings are likely relevant to the management and conservation, as well recovery strategies, of wolffish species in Canadian Atlantic and Arctic waters.

## LIST OF MEETING PARTICIPANTS

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Brynn Devine	Oceans North
Rasmus Nygaard	Greenland Institute of Natural Resources

## SOURCES OF INFORMATION

This Science Advisory Report is from the January 17-18, 2023 Zonal Peer Review on the updated assessment of Northern Wolffish, Spotted Wolffish, and Atlantic Wolffish related to population status, life history, and habitat. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

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