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**Updated Estimates of Harp Seal Bycatch and Total Removals in the Northwest  
Atlantic**

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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.

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## ABSTRACT

Accurate estimates of mortality are critical in order to determine the abundance of any population. Mortality of Northwest Atlantic Harp Seals (*Pagophilus groenlandicus*) can be divided into 'unidentified' (or unreported) mortality which is estimated by a population model: ice-related mortality and human-induced mortality. The latter mortality consists of subsistence hunts in Greenland and the Canadian Arctic, a commercial hunt in Atlantic Canadian waters, as well as seals that are killed but not landed or reported during hunting ('struck and lost') and bycatch in commercial fishing gear. Commercial and subsistence hunts account for the majority of the removals.

The level of Canadian commercial catches have varied considerably with catches averaging approximately 288,000 Harp Seals annually prior to the introduction of quotas in 1972. Between 1972 and the demise of the large vessel hunt in 1982, an average of 166,000 seals were taken annually. Catches decreased after 1982 and remained low, averaging approximately 52,000 per year until 1995, at which time interest in the hunt increased significantly. Annual catches consisting primarily of young of the year (YOY) increased to an average of 272,600 between 1996 and 2006. Since then catches have declined, averaging 63,000 per year between 2009 and 2019. Since 1980 Greenland catches increased relatively steadily to a peak of approximately 100,000 in 2000. Between 2011 and 2017, catches have declined with an average of 60,000 seals reported annually.

Catches in the Canadian Arctic are not well documented but appear to be low with likely fewer than 1,000 Harp Seals taken annually in recent years. Estimates of Harp Seal bycatch in the Newfoundland Lumpfish (*Cyclopterus lumpus*) fishery increased from less than 1,000 per year in the early 1970s to a peak of 46,400 in 1994, declining to approximately 5,000 by 2003. Based on published bycatch rates in the Newfoundland Lumpfish fishery and data on Lumpfish landings, bycatch appeared to have increased again in the mid 2000s to approximately 35,000. Since then, Lumpfish landings have declined significantly and the bycatch of Harp Seals was estimated to be 555 in 2018.

Low numbers of Harp Seals are also caught in United States (U.S.) fisheries. Combining these various sources of human induced mortality results in estimates of total removals. Between 1952 and 1982, approximately 395,000 Harp Seals were killed annually. This declined to 177,000 per year between 1983 and 1995. With the renewed interest in hunting in Canada and increased catches in Greenland, the average annual removal from 1996-2006 was 476,000. Since 2008, reduced catches, particularly in Canada has lowered the annual total removals to approximately 200,000 Harp Seals per year. The greatest uncertainty in these estimates are associated with the bycatch in Newfoundland fisheries, the Greenland catch as well as struck and lost rates, although changes in the latter are unlikely to affect the abundance estimates significantly.

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## INTRODUCTION

In order to estimate the abundance of any population, it is critical that the information available on the level of mortality is accurate. For many seal species, abundance is estimated using a population model that incorporates estimates of reproductive rates, pup production and mortality. In the case of the Northwest Atlantic Harp Seal (*Pagophilus groenlandicus*), mortality consists of identified human induced mortality, estimated environmentally mediate (ice) mortality of young of the year (YOY) and unidentified mortality (often referred to as 'natural' mortality, (M) which is estimated by the model (e.g., Hammill et al. 2015). The sources of mortality directly due to humans that have been identified are the commercial and personal use seal hunt in Atlantic Canada (referred to as 'Front' and 'Gulf'), the subsistence/commercial harvests in Greenland and the Canadian Arctic, animals that are killed but not landed during commercial or subsistence hunts and therefore are not accounted for in the catch statistics (referred to as 'struck and lost'), and incidental catches in commercial fishing gear (i.e., bycatch). Data on the levels of various components of this mortality have been compiled previously (e.g., Stenson et al. 1996, Lavigne 1999, Stenson et al. 2000, Walsh et al. 2000, Sjare and Stenson 2002, Stenson 2009) and summarized up to 2013 by Stenson (2014).

The objective of this study is to update available estimates of Canadian and Greenland catches, bycatch, and struck and lost to produce an estimate of human-induced removals for Northwest Atlantic Harp Seals up to 2019. These data will be used as input into a population model to assess the current abundance of Northwest Atlantic Harp Seals.

## DATA AND DISCUSSION

### COMMERCIAL AND SUBSISTENCE CATCHES

#### Canadian Catches

Northwest Atlantic Harp Seals are taken in the commercial hunt in Canadian Atlantic waters off southern Labrador and/or the northeast coast of Newfoundland ('the Front', Northwest Atlantic Fisheries Organization [NAFO] Divisions 2J and 3KL), in the southern Gulf of St. Lawrence ('the Gulf', NAFO Division 4T) and in the northern Gulf of St. Lawrence (NAFO Division 4RS). Although Harp Seals have been harvested commercially in Atlantic Canada since the 1700s, the highest level of catches occurred in the early to mid-1800s with an average of over 470,000 seal skins exported annually from Newfoundland between 1840 and 1850 (Ryan 1994, Hammill et al. 2011). Following this period, catches declined significantly to a low of 15,300 per year during World War II (Fig. 1).

Prior to the imposition of quotas in 1972 (Table 2), catches at the Front and in the Gulf were highly variable, ranging from 188,000-389,000 annually (average 288,000; SD=52,700; Table 1, Fig. 2). Between 1972 and 1982, the varying total allowable catch (TAC) (ICES 2019) resulted in an average annual catch of 166,000 (SD=21,300; range 124,000-202,000). From 1983 through 1995, annual catches were reduced (average 52,000; SD=21,300; range 19,000-94,000). In 1996 however, catches increased significantly (243,000) and, with the exception of 2000, continued to increase, reaching a maximum of almost 366,000 in 2004. From 2003-2005, the TAC for Harp Seals in the Canadian commercial hunt was based upon a management plan that allowed for a total of 975,000 seals over three years with a maximum of 350,000 in any one year. Since then, TACs have been set annually to ensure that the population did not decline below the precautionary reference level (i.e.,  $N_{70}$  or 70% of the maximum population size) within a 15 year period (Hammill and Stenson 2007). Between 1996 and 2006, an average of 272,671 (SD=73,016) seals were taken annually.

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Catches have steadily declined since 2006 when a catch of 354,867 Harp Seals were reported (Table 1, Fig. 2). However, the statistics for this year assumed that 2,000 seals were taken in the Canadian Arctic which was double the level assumed to occur by Stenson (2014). In subsequent years, Arctic catches were not included in the reported estimates. Catches were significantly reduced in 2007 (224,745, 83% of TAC) due to ice conditions, while low prices and ice conditions resulted in lower catches in 2008 with only 79% (217,850) of the TAC taken. Since 2009 Harp Seal catches have remained below 100,000 annually, averaging ~63,000 animals per year (Table 1). Catches declined to 35,382 (8% of the TAC) in 2015 after which they increased to 68,380 (17% TAC) in 2016 and 81,742 (20.5% TAC) in 2017. Catches declined again in the most recent years with 61,022 (15.25% TAC) seals reported taken in 2018 and a preliminary estimate of 32,038 (8% TAC) in 2019.

The catch statistics provided by International Commission for the Northwest Atlantic (ICNAF), NAFO, and Fisheries and Oceans Canada (DFO) Statistical Branch are reported according to pelage type. Based upon these reports, Front and Gulf catches can be split into YOY (age class 0) and seals one year of age and greater (1+; see Table 1). For most years, the numbers of YOY seals taken annually were obtained directly from these data.

In 1998 and 1999 a portion of the catch was not identified according to pelage. The age of 7% of the catch was not identified in 1998 so it was assumed that the proportion of YOY in this catch was the same as for the remainder of the catch for which ages were available. In 1999, approximately 22% of the catch did not have assigned ages. As these animals were all from the Gulf of St. Lawrence, the age structure of seals taken by the small boats in the Gulf (which were reported by age) was used. YOY accounted for 98% of these seals which was consistent with reports from the area. Since 2016, catches were listed as unspecified until the sales slips were compared and age class identified. In each of the subsequent years, a small proportion of the catches were not specified. These seals were assigned to an age class based upon the reported age classes for catches in the same area and month.

During the 1950s and early 1960s the proportion of YOY in the catch ranged from 47% to 89%, per year although in most years YOY made up 60-80% of the catch (Table 1). From 1963-83 YOY accounted for over 78% of the catch in practically every year. The majority of these young were whitecoats taken during the large vessel hunt on the whelping concentrations. The proportion of YOY in the annual catch remained relatively high (70-80%) during the mid to late 80s but was reduced to 40-60% per year during the first half of the 1990s (Table 1, Fig. 3). Since the late 1990s, over 97% of the annual catch has been YOY with beaters accounting for 100% of the harvest in some years. Since 2016, however, the proportion of seals one year and older (1+) in the catch has increased with the proportion of YOY in the catch averaging 90% annually.

### **Greenland Catches**

The Joint International Council for the Exploration of the Sea (ICES)/NAFO Working Group on Harp and Hooded Seals (WGHARP) examined the issue of stock identity of the Greenland harvest and concluded that all catches from west Greenland, and half of the catch from south-east Greenland should be considered to have come from the Northwest Atlantic Harp Seal stock (e.g., ICES 2008). Greenland catches for the years 1952 and 1953 were taken from Bowen (1982) and for 1954-2017 from ICES (2019). No data are available between 1988-92 and, following Stenson (2014), catches were estimated by linear interpolation between the available data.

Prior to 1975 reported catches of Northwest Atlantic Harp Seals varied from 4,000-19,000 (average 10,000; SD=4,000) per year with generally slightly higher catches in the 1950s than in

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the 1960s and early 1970s (Table 3, Fig. 3). From the mid 1970s up to 1996, catches increased relatively consistently from approximately 7,000 in 1975 to approximately 100,000 in 2000. In the following decade, annual catches declined, averaging approximately 80,000 seals from 2001-2010 and approximately 60,000 between 2011 and the latest reports in 2017. In order to estimate total removals in 2018 and 2019, we assumed the average catch of the previous five years (58,614). Since 2008, the number of Harp Seals caught in Greenland have been at a similar level to Canadian catches over the same time period.

### **Canadian Arctic**

Ringed Seals are the primary species of seals caught in the Canadian Arctic and there is very little information on the level of Harp Seal catches in the area. Information on historical catches in Nunavut were described by Stenson (2009) and there are no new data available. There are no estimates of catches in northern Quebec but the numbers are thought to be extremely small (M. Hammill, DFO, Quebec Region, pers. com.). As in Stenson (2009, 2014), we assumed that subsistence catches in the Canadian Arctic have remained at approximately 1,000 seals per year (Table 3, Fig. 3).

### **BYCATCH**

Harp Seals are caught in commercial fishing gear, particularly bottom set gillnets, in many parts of their range (Woodley and Lavigne 1991, Lien et al. 1994, Read 1994). A phone survey of fishermen to determine the level of bycatch of marine mammals indicated that while the occasional seal was caught in fishing gear, the primary source of mortality in Atlantic Canada is the spring Newfoundland Lumpfish (*Cyclopterus lumpus*) fishery which began in 1968 (Stenson unpublished data). This is likely due to the timing of the fishery with respect to the annual migratory pattern of Harp Seals and the large size (10.5 inch/26.7 cm) of mesh used for Lumpfish.

Sjare et al. (2005) provided estimates of Harp Seal bycatch in the Newfoundland Lumpfish fisheries from 1970-2003. These estimates were based upon reported landings of Lumpfish roe as a measure of fishing effort and estimates of seal bycatch rates obtained from a bycatch logbook monitoring programme that was carried out by the DFO, Marine Mammal Section, from 1989 to 2003. The data were split into three areas; Northeast Coast (NAFO areas 3K and 3L except 3Lq), South Coast (NAFO areas 3Pn, 3Ps and 3Lq) and the West Coast (NAFO area 4R). Harp Seal bycatch per tonne of Lumpfish roe was calculated for each area based on the logbook data on the weight of Lumpfish roe landed and the number of seals caught per trip. These estimates were used to hind-cast from 1988 to 1970 based on Lumpfish roe landings over that time period and the average number of seals taken per tonne of roe from 1989 to 1991.

In previous assessments (e.g., Stenson 2014; Hammill et al. 2015), we incorporated these estimates up to 2003 and then applied an average of the last five years (12,290) to the period 2004 onward. Since 2003 there have been significant changes in the Lumpfish fishery, therefore, we felt it necessary to revisit the estimates.

In the absence of new logbook data on catch rates, we used the bycatch rates estimated by Sjare et al. (2005; Table 4) and updated Lumpfish roe landing spanning 1970 through 2018 (Table 5). As in Sjare et al. (2005) we used the average of the bycatch rates from 1989 to 1991 from each area to hind-cast the 1970-1988 period. We then used the average rates of Harp Seal bycatch from 1999 to 2003 (i.e., the last five years) for the subsequent years. This assumes that the rate (i.e., number of seals caught per tonne of roe) has remained the same and that changes in fishing effort are reflected by changes in roe landings. An examination of

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the landings per trip data, obtained from DFO Statistics Branch, from 1998-2018 indicated that the landings per fishing trip varied among years but no trend was observed.

Sjare et al. (2005) estimated the proportion of YOY seals caught from 1989 to 2000 using age class records provided by fishers over that time period. As in the Sjare et al. (2005), the average age classes from 1989 to 1991 were applied to the 1970-1988 period while averages for 1996 to 2000 were applied to 2000 onward (Table 6).

Bycatch was low until the early 1990s due to limited effort in the fishery (Table 7, Fig. 4). However, in the mid-1990s effort increased dramatically and catches rose to over 45,000 seals in 1994. By the late 1990s, bycatch dropped dramatically. However, it rose again briefly before dropping again in the early 2000s. Another peak (~35,000) in bycatch occurred in the mid-2000s before declining. Since 2010, bycatch has remained low. In 2018 it was estimated to be 555 seals.

In addition to estimated bycatch in the Newfoundland Lumpfish fishery, we also included estimates of bycatch in the northeast U.S. fisheries (Waring et al. 2006, 2011, 2013; Hayes et al. 2019). Catch data since 1994 were obtained by independent fisheries observers in the Northeast Multispecies Sink Gillnet, Mid-Atlantic Coastal Gillnet and North Atlantic Bottom Trawl fisheries. The majority of catches observed were in the sink gillnet fishery while only occasional catches occurred in other fisheries. Generally, with the exception of few years, only small numbers of Harp Seals were caught in U.S. fisheries (Table 8). Catches in 2017- 2019 were assumed to be equal to the average catches for the previous five years (57 seals). The proportion of young seals in the U.S. catches was assumed to be the same as that observed in the Newfoundland Lumpfish fishery.

## **STRUCK AND LOST**

During any hunt, some animals may be killed and either not recovered or reported. (i.e., 'Struck and Lost' [S&L]). The level of S&L will vary with the hunting method, skill of the hunter, location (e.g., on ice or in the water), weather conditions, age and condition of the seal, and the time of year, which is correlated with the thickness of the blubber layer in seals that lay down seasonal energy reserves (Sergeant 1991, Lavigne 1999, NAMMCO 2006). Lavigne (1999) reviewed available data on loss rates in older seals while Rowsell (1977) provided some data on loss rates for young Harp Seals (beaters) taken on the ice. Sjare and Stenson (2002) estimated S&L rates in the Canadian commercial Harp Seal hunt between 1998 and 1999. DFO (1999) recommended that S&L should be specifically identified as a removal for the purposes of assessing the population, even though it is unlikely to significantly impact the population estimates *per se*. This is because changes in the 'natural' mortality estimated by the model will be adjusted to account for differences in S&L levels.

Following the recommendations of DFO (2000) and following Stenson (2014), we assumed that recovery (and reporting) rates were 99% for YOY seals killed in southern Canadian waters prior to the end of the large vessel hunt in 1982 and 95% for YOY after this whitecoat hunt ended. The recovery rate for 1+ seals taken in southern Canadian waters and all seals taken in Greenland or the Canadian Arctic was assumed to be 50% (Table 9).

## **TOTAL REMOVALS**

The total level of human induced mortality of Northwest Atlantic Harp Seals was determined by combining the estimates of reported Canadian and Greenland catches, S&L, and incidental catches in commercial fisheries (Table 10, Fig. 5). Until the past decade, removals of Northwest Atlantic Harp Seals were driven primarily by catches in Canada. Between 1952 and the imposition of Canadian quotas in 1971, total removals averaged 395,000 seals per year. With



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restrictions on catches in Canada, catch levels declined to an annual average of 230,000 for the 1972-1982 period. The end of the large vessel hunt in 1982 reduced the importance of the Canadian hunt while the Greenland component, particularly when S&L is considered, increased (1983-1995, average=177,000 per year). Increased catches in all areas significantly increased the total removals between 1996 and 2008, with an annual average removal of 476,000 seals. Since 2008, reduced Canadian catches have lowered total removals again to an average of 200,000 Harp Seals per year, of which approximately 40% are YOY.

These estimates of removals may be impacted by a number of factors, particularly uncertainty in the estimated bycatch in the Newfoundland Lumpfish and other fisheries, the reported catch in the Greenland catch, and struck and lost rates in the Arctic and Greenland hunts. Given the number of seals taken in Greenland and the unknown age structure of this catch, errors can have a significant impact. Ugarte and Jakobsen (2006) presented preliminary data that suggested that our assumed level of S&L in the Greenland hunt may be an overestimate. However, final estimates of Greenland S&L are not available. Additional data on S&L would allow us to improve these assumptions although changing S&L is unlikely to change our understanding of the abundance significantly (Stenson et al. 1999). We have revised the estimated bycatch levels in the Newfoundland Lumpfish fishery downward due to significantly lower fishing effort in recent years. However, bycatch may also occur in other fisheries. Efforts are underway to estimate bycatch of Harp Seals in other Canadian fisheries but they appear to be only occasional as most of the fisheries occur after Harp Seals have migrated to their northern feeding grounds.

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## TABLES

Table 1. Reported Canadian catches of Harp Seals off Newfoundland and in the Gulf of St. Lawrence, Canada ("Gulf" and "Front"), 1946–2019<sup>a,b</sup>. Catches from 1995 onward include catches under the personal use licences. YOY=Young of Year.

Year	Large Vessel Catch				Landsmen Catch <sup>c</sup>				Total Catches			
	YOY	1+	Unk	Total	YOY	1+	Unk	Total	YOY	1+	Unk	Total
1946-50	108,256	53,763	0	162,019	44,724	11,232	0	55,956	152,980	64,995	0	217,975
1951-55	184,857	87,576	0	272,433	43,542	10,697	0	54,239	228,399	98,273	0	326,672
1956-50	175,351	89,617	0	264,968	33,227	7,848	0	41,075	208,578	97,466	0	306,044
1961-65	171,643	52,776	0	224,419 <sup>d</sup>	47,450	13,293	0	60,743	219,093	66,069	0	285,162
1966-70	194,819	40,444	0	235,263	32,524	11,633	0	44,157	227,343	52,077	0	279,420
1971-75	106,425	12,778	0	119,203	29,813	12,320	0	42,133	136,237	25,098	0	161,336
1976	93,939	4,576	0	98,515	38,146	28,341	0	66,487	132,085	32,917	0	165,002
1977	92,904	2,048	0	94,952	34,078	26,113	0	60,191	126,982	28,161	0	155,143
1978	63,669	3,523	0	67,192	52,521	42,010	0	94,531	116,190	45,533	0	161,723
1979	96,926	449	0	97,375	35,532	27,634	0	63,166	132,458	28,083	0	160,541
1980	91,577	1,563	0	93,140	40,844	35,542	0	76,386	132,421	37,105	0	169,526
1981 <sup>d</sup>	89,049	1,211	0	90,260	89,345	22,564	0	111,909	178,394	23,775	0	202,169
1982	100,568	1,655	0	102,223	44,706	19,810	0	64,516	145,274	21,465	0	166,739
1983	9,529	1,021	0	10,550	40,529	6,810	0	47,339	50,058	7,831	0	57,889
1984	95	549	0	644 <sup>e</sup>	23,827	7,073	0	30,900	23,922	7,622	0	31,544
1985	0	1	0	1 <sup>e</sup>	13,334	5,700	0	19,034	13,334	5,701	0	19,035
1986	0	0	0	0	21,888	4,046	0	25,934	21,888	4,046	0	25,934
1987	2,671	90	0	2,761	33,657	10,356	22	44,035	36,350	10,446	0	46,796
1988	0	0	0	0	66,972	13,493	13,581	94,046	66,972	27,074	0	94,046
1989	1	231	0	232 <sup>e</sup>	56,345	5,691	3,036	65,072	56,346	8,958	0	65,304
1990	48	74	0	122 <sup>e</sup>	34,354	23,725	1,961	60,040	34,402	25,760	0	60,162
1991	3	20	0	23 <sup>e</sup>	42,379	5,746	4,440	52,565	42,382	10,206	0	52,588
1992	99	846	0	945 <sup>e</sup>	43,767	21,520	2,436	67,723	43,866	24,802	0	68,668
1993	8	111	0	119 <sup>e</sup>	16,393	9,714	777	26,884	16,401	10,602	0	27,003
1994	43	152	0	195 <sup>e</sup>	25,180	34,939	1,065	61,184	25,223	36,156	0	61,379
1995	21	355	0	376 <sup>e</sup>	33,615	31,306	470	65,391	34,106	31,661	0	65,767
1996	3	186	0	189 <sup>e</sup>	184,853	57,864	0	242,717	184,856	58,050	0	242,906
1997	0	6	0	6 <sup>e</sup>	220,476	43,728	0	264,204	220,476	43,734	0	264,210
1998	7	547	0	554 <sup>e</sup>	0	0	282,070	282,070	7	547	282,070	282,624
1999	26	25	0	51 <sup>e</sup>	221,001	6,769	16,782	244,552	221,027	6,794	16,782	244,603
2000	16	450	0	466 <sup>e</sup>	85,035	6,567	0	91,602	85,485	6,583	0	92,068
2001	0	0	0	0	214,754	11,739	0	226,493	214,754	11,739	0	226,493
2002	0	0	0	0	297,764	14,603	0	312,367	297,764	14,603	0	312,367
2003	0	0	0	0	280,174	9,338	0	289,512	280,174	9,338	0	289,512
2004	0	0	0	0	353,553	12,418	0	365,971	353,553	12,418	0	365,971
2005	0	0	0	0	319,127	4,699	0	323,826	319,127	4,699	0	323,826
2006	0	0	0	0	346,426	8,441	0	354,867	346,426	8,441	0	354,867
2007	0	0	0	0	221,488	3,257	0	224,745	221,488	3,257	0	224,745
2008	0	0	0	0	217,565	285	0	217,850	217,565	285	0	217,850
2009	0	0	0	0	76,668	0	0	76,668	76,668	0	0	76,668
2010	0	0	0	0	68,654	447	0	69,101	68,654	447	0	69,101
2011	0	0	0	0	40,371	18	0	40,389	40,371	18	0	40,389
2012	0	0	0	0	71,319	141	0	71,460	71,319	141	0	71,460
2013	0	0	0	0	94,310	3,612	0	97,922	94,310	3,612	0	97,922
2014	0	0	0	0	59,616	50	0	59,666	59,616	50	0	59,666
2015	0	0	0	0	35,302	80	0	35,382	35,302	80	0	35,382
2016	0	0	0	0	51,854	7,087	9,419 <sup>f</sup>	68,360	51,854	7,087	9,419	68,360
2017	0	0	0	0	58,234	10,062	13,446 <sup>f</sup>	81,742	58,234	10,062	13,446	81,742
2018	0	0	0	0	53,222	4,728	3,072 <sup>f</sup>	61,022	53,222	4,728	3,072	61,022
2019	0	0	0	0	0	0	32,038 <sup>g</sup>	32,038	0	0	32,038	32,038

<sup>a</sup> For the period 1946-1975 only 5-years averages are given.

<sup>b</sup> All values prior to 1990 are from NAFO except where noted, recent data from DFO Statistics Branch.

<sup>c</sup> Landsmen values include catches by small vessels (<150 gr tons) and aircraft.

<sup>d</sup> NAFO values revised to include complete Quebec catch (Bowen, W.D. 1982).

<sup>e</sup> Large vessel catches represent research catches in Newfoundland and may differ from NAFO values.

<sup>f</sup> Unspecified catches will be assigned to age class at a later date.

<sup>g</sup> Preliminary data.

*Table 2. Major management measures implemented for Harp Seals in Canadian waters, 1961–2019.*

<b>Year</b>	<b>Management Measure</b>
1961	Opening and closing dates set for the Gulf of the St. Lawrence and Front areas.
1964	First licensing of sealing vessels and aircraft. Quota of 50,000 set for southern Gulf (effective 1965).
1965	Prohibition on killing adult seals in breeding or nursery areas. Introduction of licensing of sealers. Introduction of regulations defining killing methods.
1966	Amendments to licensing. Gulf quota areas extended. Rigid definition of killing methods.
1971	TAC for large vessels set at 200,000 and an allowance of 45,000 for landsmen.
1972-1975	TAC reduced to 150,000, including 120,000 for large vessel and 30,000 (unregulated) for landsmen. Large vessel hunt in the Gulf prohibited.
1976	TAC was reduced to 127,000.
1977	TAC increased to 170,000 for Canadian waters, including an allowance of 10,000 for northern native peoples and a quota of 63,000 for landsmen (includes various suballocations throughout the Gulf of St. Lawrence and northeastern Newfoundland). Adults limited to 5% of total large vessel catch.
1978-1979	TAC held at 170,000 for Canadian waters. An additional allowance of 10,000 for the northern native peoples (mainly Greenland).
1980	TAC remained at 170,000 for Canadian waters including an allowance of 1,800 for the Canadian Arctic. Greenland was allocated additional 10,000.
1981	TAC remained at 170,000 for Canadian waters including 1,800 for the Canadian Arctic. An additional allowance of 13,000 for Greenland.
1982-1987	TAC increased to 186,000 for Canadian waters including increased allowance to northern native people of 11,000. Greenland catch anticipated at 13,000.
1987	Change in Seal Management Policy to prohibit the commercial hunting of whitecoats and hunting from large (>65 ft) vessels (effective 1988). Changes implemented by a condition of licence.
1992	First Seal Management Plan implemented.
1993	Seal Protection Regulations updated and incorporated in the Marine Mammal Regulations. The commercial sale of whitecoats prohibited under the Regulations. Netting of seals south of 54°N prohibited. Other changes to define killing methods, control interference with the hunt and remove old restrictions.
1995	Personal sealing licences allowed. TAC remained at 186,000 including personal catches. Quota divided among Gulf, Front and unallocated reserve.
1996	TAC increased to 250,000 including allocations of 2,000 for personal use and 2,000 for Canadian Arctic.
1997	TAC increased to 275,000 for Canadian waters.
2000	Taking of whitecoats prohibited by condition of license
2003	Implementation of three year management plan allowing a total harvest of 975,000 over three years with a maximum of 350,000 in any one year.
2005	TAC reduced to 319,517 in final year of three year management plan
2006	TAC increased to 335,000 including a 325,000 commercial quota, 6,000 original initiative, and 2,000 allocation each for Personal Use and Arctic catches
2007	TAC reduced to 270,000 including 263,140 for commercial, 4,860 for Aboriginal, and 2,000 for Personal Use catches
2008	TAC increased to 275,000 including a 268,050 for commercial, 4,950 for Aboriginal and 2,000 for Personal Use catches. Implementation of requirement to bleed before skinning as a condition of licence.
2009	TAC increased to 280,000 based upon allocations given in 2008 plus an additional 5,000 for market development. Additional requirements related to humane killing methods were implemented.
2010	TAC increased to 330,000.
2011	TAC increased to 400,000.
2017	TAC no longer announced. Catches monitored.

Table 3. Reported catches of Harp Seals in the northwest Atlantic for 1952-2019. Estimated catches are indicated by shading and symbol (\*). The Greenland catches are made up of the Table 6 West Greenland catches and 1/2 of the SE Greenland. The other half of the SE Greenland and the NE Greenland are assigned to the West Ice population.

Year	Front & Gulf	Canadian Arctic	Greenland	NW Atlantic Total
1952	307,108	1,784(*)	16,400(*)	325,292
1953	272,886	1,784(*)	16,400(*)	291,070
1954	264,416	1,784(*)	19,150	285,350
1955	333,369	1,784(*)	15,534	350,687
1956	389,410	1,784(*)	10,973	402,167
1957	245,480	1,784(*)	12,884	260,148
1958	297,786	1,784(*)	16,885	316,455
1959	320,134	1,784(*)	8,928	330,846
1960	277,350	1,784(*)	16,154	295,288
1961	187,866	1,784(*)	11,996	201,646
1962	319,989	1,784(*)	8,500	330,273
1963	342,042	1,784(*)	10,111	353,937
1964	341,663	1,784(*)	9,203	352,650
1965	234,253	1,784(*)	9,289	245,326
1966	323,139	1,784(*)	7,057	331,980
1967	334,356	1,784(*)	4,242	340,382
1968	192,696	1,784(*)	7,116	201,596
1969	288,812	1,784(*)	6,438	297,034
1970	257,495	1,784(*)	6,269	265,548
1971	230,966	1,784(*)	5,572	238,322
1972	129,883	1,784(*)	5,994	137,661
1973	123,832	1,784(*)	9,212	134,828
1974	147,635	1,784(*)	7,145	156,564
1975	174,363	1,784(*)	6,752	182,899
1976	165,002	1,784(*)	11,956	178,742
1977	155,143	1,784	12,866	169,793
1978	161,723	2,129	16,638	180,490
1979	160,541	3,620	17,545	181,706
1980	169,526	6,350	15,255	191,131
1981	202,169	4,672	22,974	229,815
1982	166,739	4,881	26,927	198,547
1983	57,889	4,881(*)	24,785	87,555
1984	31,544	4,881(*)	25,829	62,254
1985	19,035	4,881(*)	20,785	44,701
1986	25,934	4,881(*)	26,099	56,914
1987	46,796	4,881(*)	37,859(*)	89,536
1988	94,046	4,881(*)	40,415(*)	139,342
1989	65,304	4,881(*)	42,971(*)	113,156
1990	60,162	4,881(*)	45,526(*)	110,569
1991	52,588	4,881(*)	48,082(*)	105,551
1992	68,668	4,881(*)	50,638(*)	124,187
1993	27,003	4,881(*)	56,319	88,203
1994	61,379	4,881(*)	57,373	123,633
1995	65,767	4,881(*)	62,749	133,397
1996	242,906	4,881(*)	73,947	321,734

Year	Front & Gulf	Canadian Arctic	Greenland	NW Atlantic Total
1997	264,210	2,500 <sup>a</sup>	68,816	335,526
1998	282,624	1,000 <sup>a</sup>	81,273	364,897
1999	244,552	500 <sup>a</sup>	93,120	338,172
2000	92,055	400 <sup>a</sup>	98,463	190,918
2001	226,493	600 <sup>a</sup>	85,428	312,521
2002	312,367	1,000(*)	66,735	380,102
2003	289,512	1,000(*)	66,149	356,661
2004	365,971	1,000(*)	70,587	437,558
2005	323,826	1,000(*)	91,688	422,517
2006	354,867	1,000(*)	94,034	449,901
2007	224,745	1,000(*)	82,826	308,571
2008	217,850	1,000(*)	80,444	299,294
2009	76,668	1,000(*)	71,862	149,530
2010	69,101	1,000(*)	90,909	160,006
2011	40,389	1,000(*)	73,462	114,851
2012	71,460	1,000(*)	54,660	127,120
2013	97,922	1,000(*)	65,241	164,163
2014	59,666	1,000(*)	63,028	123,694
2015	35,382	1,000(*)	61,767	98,149
2016	68,360	1,000(*)	56,730	124,880
2017	81,360 61,022	1,000(*)	48593	130,258
2018	61,022 32,038	1,000(*)	58,614 <sup>b</sup> (*)	120,636(*)
2019 <sup>c</sup>	32,038	1,000(*)	58,614 <sup>b</sup> (*)	91,652(*)

<sup>a</sup> Rounded

<sup>b</sup> Average of catches 2013-17

<sup>c</sup> Preliminary data

*Table 4. Number of Harp Seals caught per tonne of Lumpfish roe. Taken from Sjare et al. (2005). Catch rates applied from 2003-2018 are the average of the final five years (1999-2003).*

Year	NE Coast	S Coast	W Coast
Pre 1989	3.03	5.21	3.97
1989	3.71	3.71	3.71
1990	1.69	4.04	6.59
1991	2.63	5.70	4.06
1992	12.72	9.34	11.75
1993	15.91	4.34	35.37
1994	34.26	22.04	94.70
1995	32.47	10.14	28.80
1996	40.61	12.35	15.14
1997	21.23	3.59	10.28
1998	2.90	2.90	2.90
1999	18.30	1.86	4.67
2000	8.96	2.62	5.07
2001	11.50	22.85	61.62
2002	51.54	53.14	69.24
2003	20.75	6.03	2.20
Post 2003	22.21	17.30	28.56

Table 5. Reported landings (tonnes) of Lumpfish roe in Newfoundland 1970-2018.

Year	NE Coast	S Coast	W Coast
1970	23,162	726	705
1971	99,706	-	56,212
1972	201,316	-	3,170
1973	152,561	627	427
1974	60,338	-	-
1975	94,051	5	26
1976	190,811	501	129,456
1977	401,397	-	104,933
1978	766,821	102,092	131,156
1979	633,020	244,617	103,454
1980	110,078	453,407	29,825
1981	164,785	635,551	93,356
1982	100,463	591,834	107,972
1983	151,323	734,994	181,662
1984	231,243	510,540	196,960
1985	549,130	514,064	162,420
1986	895,991	651,510	-
1987	2,179,913	826,281	77
1988	1,614,327	673,062	-
1989	1,582,922	746,845	-
1990	835,161	336,104	-
1991	1,043,345	1,045,286	100
1992	1,438,489	506,798	363
1993	869,547	1,566,793	179,279
1994	492,958	1,023,444	77,062
1995	233,423	816,312	140,355
1996	369,441	752,031	347,489
1997	378,163	1,631,922	475,868
1998	172,014	965,979	400,716
1999	546,648	1,599,345	665,496
2000	865,475	922,361	261,565
2001	488,299	289,587	125,875
2002	140,454	15,300	21,536
2003	152,130	362,009	47,761
2004	746,359	939,011	96,130
2005	559,392	561,952	146,947
2006	284,540	707,379	106,221
2007	200,517	185,768	56,922
2008	157,712	26,776	101,547
2009	65,637	2,735	9,959
2010	91,295	10,844	50,996
2011	51,855	272	32,927
2012	50,185	706	61,607
2013	87	-	5,363
2014	4,969	-	34,978
2015	4,698	-	28,577
2016	5,504	817	13,347
2017	1,838	1,865	3,371
2018	8,314	508	12,642



Table 6. Proportion of Harp Seal by-catch that consisted of YOY Harp Seals from the northeast, south and west coast regions of Newfoundland from 1970 to 2018, based upon Sjare et al. (2005). Proportion of YOY prior to 1989 are the mean of 1989-91 estimates for each region; estimates for post 2000 are the mean of estimates 1996-2000.

Year	NE Coast	S Coast	W Coast
Pre 1989	0.77	0.92	0.93
1989	0.90	0.95	0.95
1990	0.60	0.83	0.85
1991	0.80	0.99	0.99
1992	0.66	0.96	0.92
1993	0.60	0.77	0.90
1994	0.48	0.95	0.90
1995	0.38	0.93	0.79
1996	0.16	0.56	0.62
1997	0.47	0.92	0.92
1998	0.73	0.82	0.73
1999	0.41	0.90	0.97
2000	0.79	1.00	1.00
Post 2000	0.51	0.84	0.85

Table 7. Estimated bycatch of Harp Seals in the Newfoundland Lumpfish fishery, 1920-2018.

Year	Northeast Coast			South Coast			West Coast			Total		
	YOY	1+	Total	YOY	1+	Total	YOY	1+	Total	YOY	1+	Total
1970	54	16	70	3	0	4	3	0	3	60	17	77
1971	233	69	302	-	-	-	208	16	223	440	85	525
1972	470	140	610	-	-	-	12	1	13	481	141	623
1973	356	106	462	3	0	3	2	0	2	361	107	467
1974	141	42	183	-	-	-	-	-	-	141	42	183
1975	219	66	285	0	0	0	0	0	0	220	66	285
1976	445	133	578	2	0	3	478	36	514	926	169	1,095
1977	936	280	1216	-	-	-	387	29	417	1,324	309	1,633
1978	1,789	534	2,323	489	43	532	484	36	521	2,763	613	3,376
1979	1,477	441	1,918	1,172	102	1,274	382	29	411	3,031	572	3,603
1980	257	77	334	2,173	189	2,362	110	8	118	2,540	274	2,814
1981	384	115	499	3,046	265	3,311	345	26	371	3,775	406	4,181
1982	234	70	304	2,837	247	3,083	399	30	429	3,470	347	3,817
1983	353	105	459	3,523	306	3,829	671	50	721	4,547	462	5,009
1984	540	161	701	2,447	213	2,660	727	55	782	3,714	429	4,143
1985	1,281	383	1,664	2,464	214	2,678	600	45	645	4,345	642	4,987
1986	2,090	624	2,715	3,123	272	3,394	-	-	-	5,213	896	6,109
1987	5,086	1,519	6,605	3,961	344	4,305	0	0	0	9,047	1,864	10,910
1988	3,766	1,125	4,891	3,226	281	3,507	-	-	-	6,993	1,406	8,398
1989	5,285	587	5,873	2,632	139	2,771	-	-	-	7,918	726	8,643
1990	847	565	1,411	1,127	231	1,358	-	-	-	1,974	795	2,769
1991	2,195	549	2,744	5,899	60	5,958	0	0	0	8,094	608	8,703
1992	12,076	6,221	18,298	4,544	189	4,733	4	0	4	16,624	6,411	23,035
1993	8,301	5,534	13,834	5,236	1,564	6,800	5,707	634	6,341	19,244	7,732	26,975
1994	8,107	8,782	16,889	21,429	1,128	22,557	6,568	730	7,298	36,103	10,640	46,743
1995	2,880	4,699	7,579	7,698	579	8,277	3,193	849	4,042	13,771	6,127	19,899
1996	2,400	12,603	15,003	5,201	4,087	9,288	3,262	1,999	5,261	10,863	18,688	29,552
1997	3,773	4,255	8,028	5,390	469	5,859	4,501	391	4,892	13,664	5,115	18,779
1998	364	135	499	2,297	504	2,801	848	314	1,162	3,510	953	4,462
1999	4,101	5,902	10,004	2,677	297	2,975	3,015	93	3,108	9,793	6,293	16,086
2000	6,126	1,628	7,755	2,417	-	2,417	1,326	-	1,326	9,869	1,628	11,497
2001	2,864	2,752	5,615	5,558	1,059	6,617	6,593	1,163	7,756	15,015	4,974	19,989
2002	3,692	3,547	7,239	683	130	813	1,267	224	1,491	5,642	3,901	9,543
2003	1,610	1,547	3,157	1,834	349	2,183	89	16	105	3,533	1,912	5,445
2004	8,454	8,123	16,577	13,646	2,599	16,245	2,334	412	2,745	24,433	11,134	35,567
2005	6,336	6,088	12,424	8,166	1,555	9,722	3,567	630	4,197	18,070	8,273	26,343
2006	3,223	3,097	6,320	10,280	1,958	12,238	2,579	455	3,034	16,081	5,510	21,591
2007	2,271	2,182	4,453	2,700	514	3,214	1,382	244	1,626	6,353	2,940	9,293

-	Northeast Coast			South Coast			West Coast			Total		
Year	YOY	1+	Total	YOY	1+	Total	YOY	1+	Total	YOY	1+	Total
2008	1,786	1,716	3,503	389	74	463	2,465	435	2,900	4,641	2,226	6,866
2009	743	714	1,458	40	8	47	242	43	284	1,025	765	1,790
2010	1,034	994	2,028	158	30	188	1,238	218	1,456	2,430	1,242	3,672
2011	587	564	1,152	4	1	5	799	141	940	1,391	706	2,097
2012	568	546	1,115	10	2	12	1,496	264	1,759	2,074	812	2,886
2013	1	1	2	-	-	-	130	23	153	131	24	155
2014	56	54	110	-	-	-	849	150	999	905	204	1,109
2015	53	51	104	-	-	-	694	122	816	747	174	920
2016	62	60	122	12	2	14	324	57	381	398	119	518
2017	21	20	41	27	5	32	82	14	96	130	40	169
2018	94	90	185	7	1	9	307	54	361	408	146	555

Table 8. Estimated bycatch of Harp Seals in the northeast U.S. Estimated bycatch 2017-2019 is the average of estimates 2012-2016. (from Waring et al. 2006, 2011, 2013; Hayes et al. 2019)

Year	Bycatch
1994	861
1995	694
1996	89
1997	269
1998	95
1999	81
2000	24
2001	75
2002	0
2003	0
2004	303
2005	35
2006	65
2007	157
2008	414
2009	485
2010	285
2011	17
2012	0
2013	22
2014	57
2015	119
2016	85
2017	57
2018	57
2019	57

Table 9. Proportion of seals recovered (and reported) for young of the year (YOY) and older (1+) animals.

-	Harvest Area			
-	Front & Gulf		Canadian Arctic & Greenland	
Year	YOY	1+	YOY	1+
1952-1982	0.99	0.50	0.50	0.50
1983-2009	0.95	0.50	0.50	0.50

Table 10. Estimated total removals of Harp Seals in the northwest Atlantic for 1952-2019.

Year	Reported	Bycatch	Struck and Lost	Total
1952	325,292	0	129,230	454,522
1953	291,070	0	95,095	386,165
1954	285,350	0	112,084	397,434
1955	350,687	0	100,938	451,627
1956	402,167	0	64,218	466,383
1957	260,148	0	96,381	356,529
1958	316,455	0	176,883	493,340
1959	330,846	0	94,426	425,274
1960	295,288	0	140,697	435,983
1961	201,646	0	34,532	236,181
1962	330,273	0	125,277	455,550
1963	353,937	0	86,250	440,185
1964	352,650	0	88,959	441,607
1965	245,326	0	64,414	309,740
1966	331,980	0	83,382	415,361
1967	340,382	0	65,438	405,821
1968	201,596	0	46,718	248,315
1969	297,034	0	66,051	363,086
1970	265,548	77	50,313	315,938
1971	238,322	525	29,870	268,719
1972	137,661	623	22,031	160,315
1973	134,828	467	37,486	172,782
1974	156,564	183	42,899	199,647
1975	182,899	285	43,681	226,865
1976	178,742	1,095	47,991	227,828
1977	169,793	1,633	44,094	215,518
1978	180,490	3,376	65,474	249,342
1979	181,706	3,603	50,585	235,895
1980	191,131	2,814	60,048	253,994
1981	229,815	4,181	53,222	287,216
1982	198,547	3,817	54,740	257,102
1983	87,555	5,009	40,131	132,694
1984	62,254	4,143	39,591	105,987
1985	44,701	4,987	32,069	81,757
1986	56,914	6,109	36,178	99,199
1987	89,536	10,910	55,099	155,547
1988	139,342	8,398	75,895	223,634
1989	113,156	8,643	59,775	181,574
1990	110,569	2,769	77,978	191,317
1991	105,551	8,703	65,400	179,654
1992	124,187	23,035	82,629	229,852
1993	88,203	26,975	72,665	187,845
1994	123,633	47,604	99,738	270,974
1995	133,397	20,593	101,086	255,075
1996	321,734	29,641	146,607	497,981
1997	335,526	19,048	126,654	481,229
1998	364,897	4,557	126,726	496,181
1999	338,172	16,167	113,036	467,376
2000	190,918	11,521	110,358	312,799
2001	312,521	20,064	109,069	441,653
2002	380,102	9,543	98,009	487,655
2003	356,661	5,445	91,233	453,340
2004	437,558	35,870	102,613	576,040
2005	422,517	26,378	115,759	564,652

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<b>Year</b>	<b>Reported</b>	<b>Bycatch</b>	<b>Struck and Lost</b>	<b>Total</b>
<b>2006</b>	449,901	21,656	121,707	593,264
<b>2007</b>	308,571	9,450	98,740	416,759
<b>2008</b>	299,294	7,280	93,180	399,755
<b>2009</b>	149,530	2,275	76,897	228,700
<b>2010</b>	160,006	3,957	94,965	258,930
<b>2011</b>	114,851	2,114	76,605	193,570
<b>2012</b>	127,120	2,886	59,554	189,561
<b>2013</b>	164,163	177	74,817	239,157
<b>2014</b>	123,694	1,166	67,216	192,075
<b>2015</b>	98,149	1,039	64,705	163,895
<b>2016</b>	124,880	603	67,075	192,559
<b>2017</b>	130,258	226	63,686	194,169
<b>2018</b>	120,636	612	67,455	188,703
<b>2019</b>	91,652	711 <sup>a</sup>	63,313	155,677

<sup>a</sup> Average bycatch 2014-2018 in Canadian and U.S. fisheries

## FIGURES

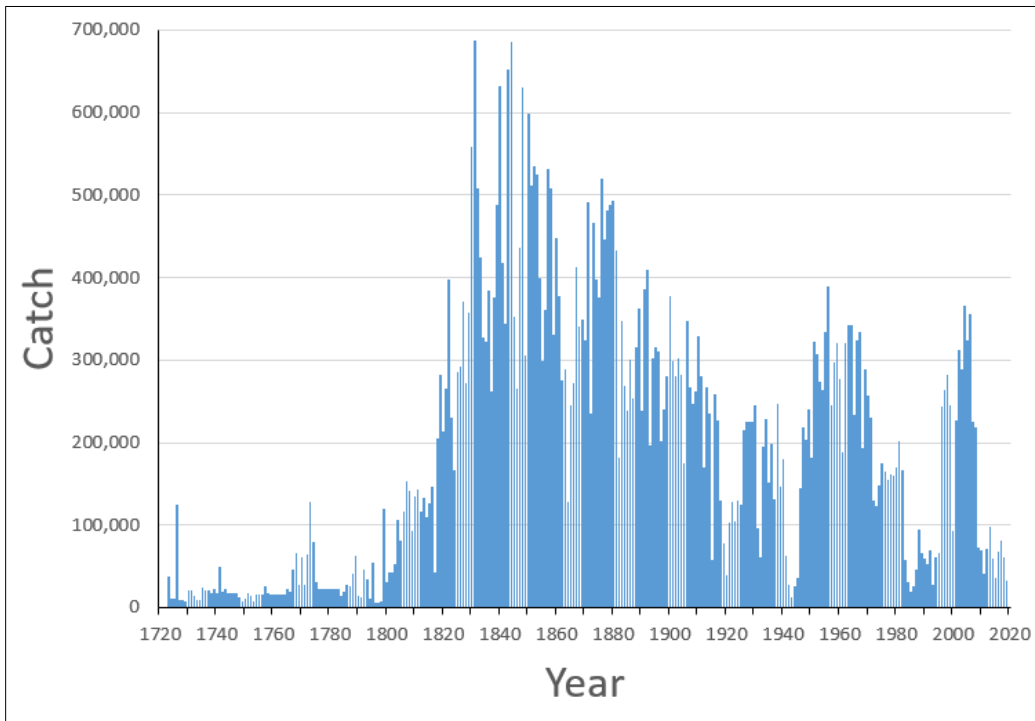


Figure 1. Historical catches of Northwest Atlantic Harp Seals in Canada (including Newfoundland).

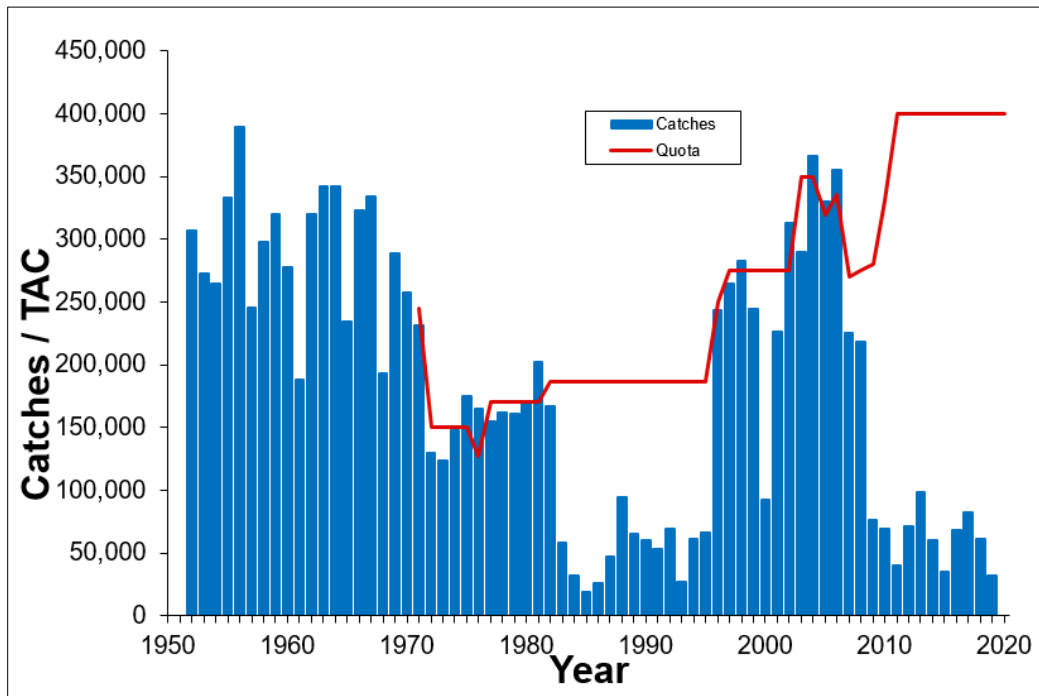


Figure 2. Catches and quotas 1952-2019, Front and Gulf.

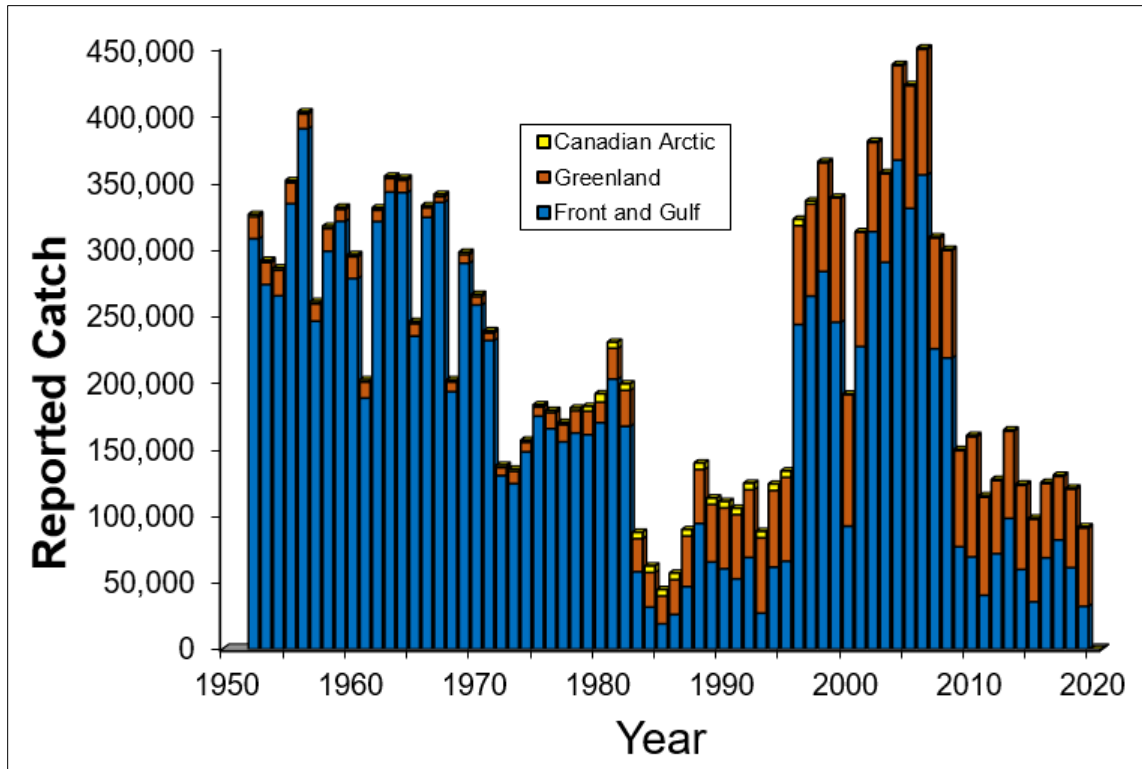


Figure 3. Reported catches of Northwest Atlantic Harp Seals.

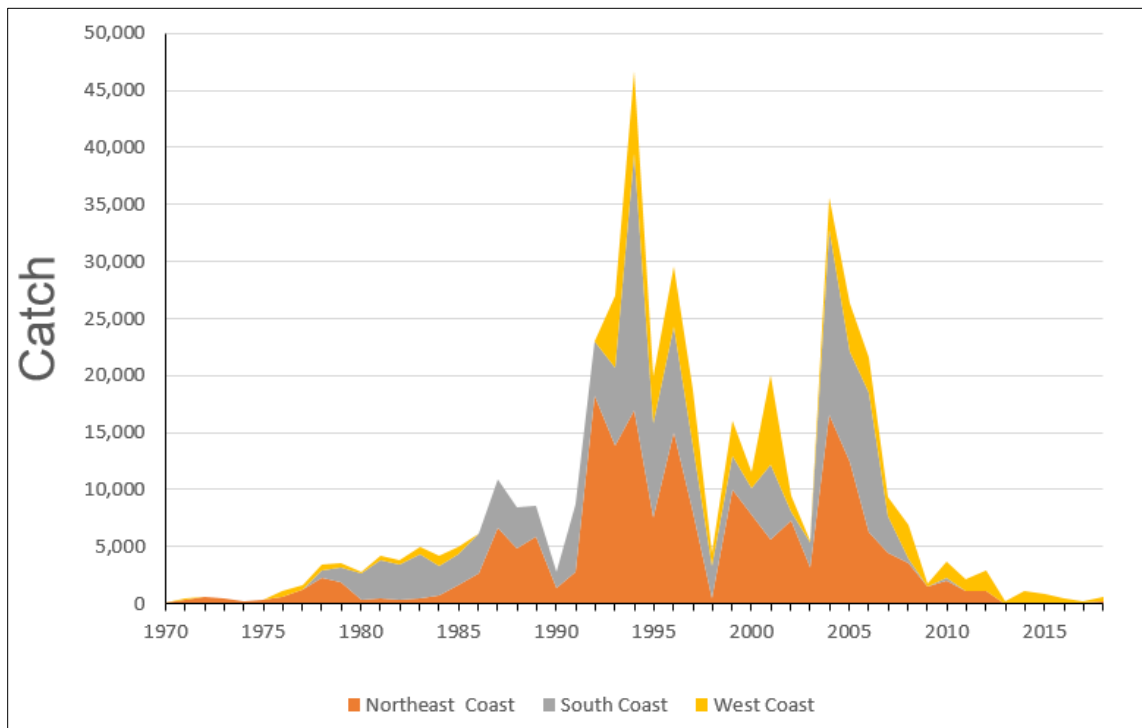


Figure 4. Estimated bycatch of Harp Seals in the Newfoundland Lumpfish fishery.

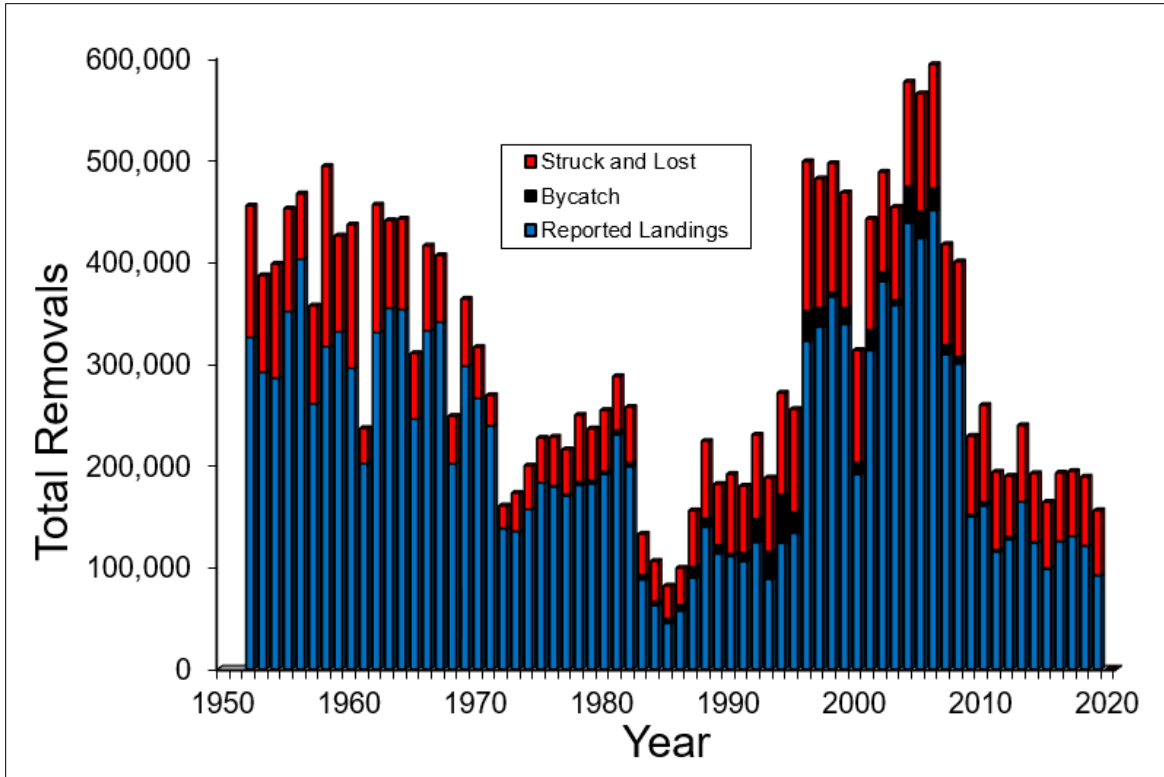


Figure 5. Estimated total human induced mortality of Northwest Atlantic Harp Seals.