



## STOCK STATUS UPDATE OF 4VWX HERRING FOR THE 2018/2019 FISHING SEASON

### Context

Maritimes Fisheries and Oceans Canada (DFO) Resource Management has requested that DFO Science provide an update on the science advice for North Atlantic Fisheries Organization (NAFO) Divisions 4VWX Atlantic Herring<sup>1</sup> (*Clupea harengus*) management unit in support of the 2018/2019 fishery. The last assessment of 4VWX herring stock was conducted in March 2018 (DFO 2018). The biological and fishery information of the 4VWX herring stock forms the basis for establishing harvest levels for the 2018/2019 fishery, as required in the Integrated Fisheries Management Plan (IFMP). A review and update of biological and fishery information of the 4VWX herring stock are provided in this Science Response.

This Science Response Report results from the Science Response Process of May 8, 2019, on the Stock Status Update of Herring in Northwest Atlantic Fisheries Organization (NAFO) Fishing Area 4VWX.

### Background

The 4VWX herring management unit contains a number of spawning areas, separated to various degrees in space and time. For the purposes of evaluation and management, the 4VWX herring fishery is divided into four components (see the Appendix for map of place names):

- Southwest Nova Scotia/Bay of Fundy (SWNS/BoF) spawning component (includes Scots Bay, German Bank, and Trinity Ledge)
- Offshore Scotian Shelf spawning component (includes The Patch and Western Hole)
- Coastal Nova Scotia spawning component (includes South Shore, Eastern Shore, and Cape Breton)
- Southwest New Brunswick (SWNB) migrant juveniles (NB weirs)

Each component, except SWNB migrant juveniles, has several spawning areas, and there is mixing of fish among spawning components outside of the spawning period. The Total Allowable Catch (TAC) for the SWNS/BoF has been 42,500 t since 2017. The Offshore Scotian Shelf has an allocation of 12,000 t, and the coastal NS fishing areas have allocations based on the recent 5-year average of observed spawning stock biomass (SSB<sup>2</sup>).

The 2003 (Evergreen) Scotia-Fundy Herring Integrated Fisheries Management Plan (IFMP) set out principles, conditions, and management measures for the 4VWX herring fisheries (DFO 2003). The main principle stated in the plan is “the conservation of the herring resource and the preservation of all of its spawning components”. The three conservation objectives are: to maintain the reproductive capacity of herring in each management unit, to prevent growth

<sup>1</sup> Throughout this document 4VWX Atlantic Herring is referred to as 4VWX herring.

<sup>2</sup> Throughout this document, spawning stock biomass (SSB) refers to the spawning stock biomass observed at the time of the acoustic surveys.

overfishing, and to maintain ecosystem integrity/ecological relationships (“ecosystem balance”). Progress against these conservation objectives was evaluated during the March 2018 assessment (DFO 2018). A review of the assessment framework was conducted in 2006/2007 (DFO 2007), followed by a framework meeting in 2011 to review the models. An analytical model was not chosen; however, recommendations for the assessment methodology were provided (DFO 2011). In 2012, a Lower Reference Point (LRP) for the SWNS/BoF Herring spawning component (German Bank and Scots Bay) was identified as the 2005-2010 average acoustic survey biomass (371,067 t), below which the risk of serious harm is unacceptable (Clark et al. 2012). At the 2018 assessment, changes to the method for assessing acoustic SSB turnover on the Scots Bay and German Bank spawning grounds were presented and accepted. This change resulted in revised SSB estimates over the entire time series, including the LRP of 316,316 t (DFO 2018). Following the 2018 assessment, the LRP has since been updated to 317,846 t due to a calculation error. The total SSB in these two areas is evaluated based on the 3-year moving average of acoustic biomass with respect to this LRP (DFO 2018).

Landings from the 4VWX herring fishery have always been dominated by purse seine (e.g., 81 to 99%, 1981 – 2018). Other gear types include weir, gillnet, shutoff, and trap.

## Analysis and Response

### Landings

The landings for the period October 15, 2017, to October 14, 2018, (the 2017/2018 quota year) were 40,126 t against a TAC of 42,500 t for the SWNS/BoF component (Table 1).

*Table 1. Reported landings (rounded to thousands of tonnes) and total allowable catch for the 4VWX herring management unit by component from 2010 to 2018 with decadal averages from 1970 to 2009.*

Year	Average 1970-79	Average 1980-89	Average 1990-99	Average 2000-09	2010	2011	2012	2013	2014	2015	2016	2017	2018
4WX SW Nova Scotia TAC <sup>1</sup>	106	106	112	69	55	50	50	50	50	50	50	42.5	42.5
4WX SW Nova Scotia <sup>1</sup>	131	131	96	66	46	50	48	47	50	49	50	39	40
4VWX Coastal NS <sup>2</sup>	<1	<1	4	7	6	4	3	4	5	5	8	8	10
Scotian Shelf Banks <sup>2</sup>	38	<0.1	13	6	12	10	1	2	<0.1	2	1	4	3
SW New Brunswick <sup>2</sup>	26	24	24	15	11	4	1	6	2	<0.2	4	2	12
<b>Total Landings</b>	<b>172</b>	<b>155</b>	<b>137</b>	<b>93</b>	<b>74</b>	<b>68</b>	<b>52</b>	<b>58</b>	<b>57</b>	<b>56</b>	<b>63</b>	<b>53</b>	<b>65</b>

1 - Quota year from October 15<sup>th</sup> of the preceding year to October 14<sup>th</sup> of the current year

2 - Calendar year from January 1<sup>st</sup> to December 31<sup>st</sup>

Additional landings of 24,466t were taken in the non-quota stock components (outside the SWNS/BoF area) for a total of 64,593t. There was a six-fold increase in the SWNB weir and shutoff landings (Table 1). Landings decreased for the Offshore Scotian Shelf and remained below the 12,000 t allocation for the area. Within the SWNS/BoF component, there was a 2% increase (to 36%) in catches from the German Bank area defined as the acoustic catch box. There has been a concerted effort by the purse seine fleet to keep the percentage of the TAC caught in this box below 40% since 2014. Landings by defined fishing grounds decreased in 2018 from Gannet Dry Ledge, Scots Bay, Trinity and Long Island, and increased from German Bank, Grand Manan, Lurcher, and NB Coastal.

**Southwest Nova Scotia/Bay of Fundy**

**Age Structure**

The 2018 fishery landings (by number) were dominated by Age 2 fish (45%) with Ages 3 (13%), 4 (16%), and 5 (17%) making up the other larger age groups (Figure 1). Most 2-year old fish were taken from the Grand Manan Banks, Grand Manan, Long Island Shore and Trinity fishing grounds. The reliance of the fishery on these younger age groups is continued cause for concern because many of these fish are still immature. On Scots Bay and German Bank, the landings were dominated by mature fish (Ages 3+). The percentage by numbers of Ages 4 and 5 in the catches were largest in the months of September and October, particularly in the Scots Bay, German Bank, and Gannet/Dry Ledge fishing grounds.

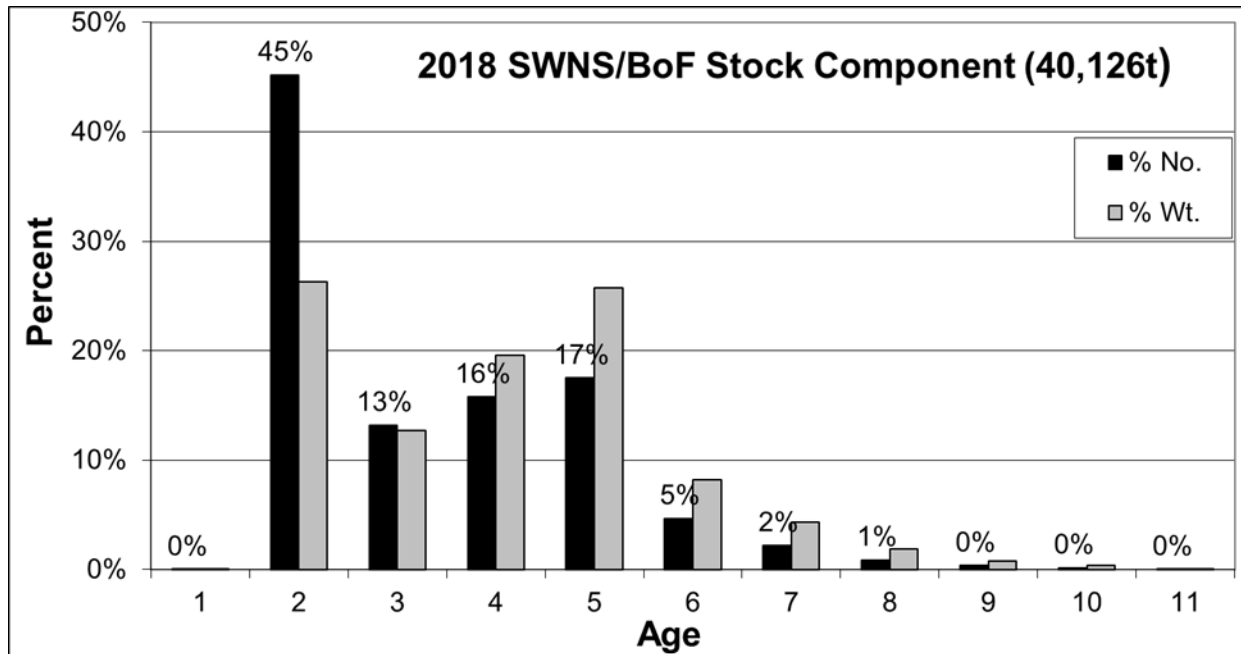


Figure 1. Fishery catch-at-age (percentage numbers and percentage weight) for Southwest Nova Scotia/Bay of Fundy spawning component (2017-2018 quota year).

An important feature of the 2018 catch-at-age is the dominance of Age 5 (17%) with apparent tracking from the dominant Age 2 in 2015 (40%) (Figure 2). There was also a general decrease in numbers and weight for Ages 3, 4, and 6+ compared to 2017. The percentage by numbers of Ages 6+ decreased in 2018 compared to the previous 3 years. Based on the age structure, the total number of fish removed by the fishery in 2018 was estimated to be 424 million fish, which is 13% more than in 2017. In 2018, a greater number of Ages 2 and 5 fish were landed than in 2017, but the numbers of Age 6+ fish in the commercial landings are less than those in the 1965 – 1995 time period (Figure 2).

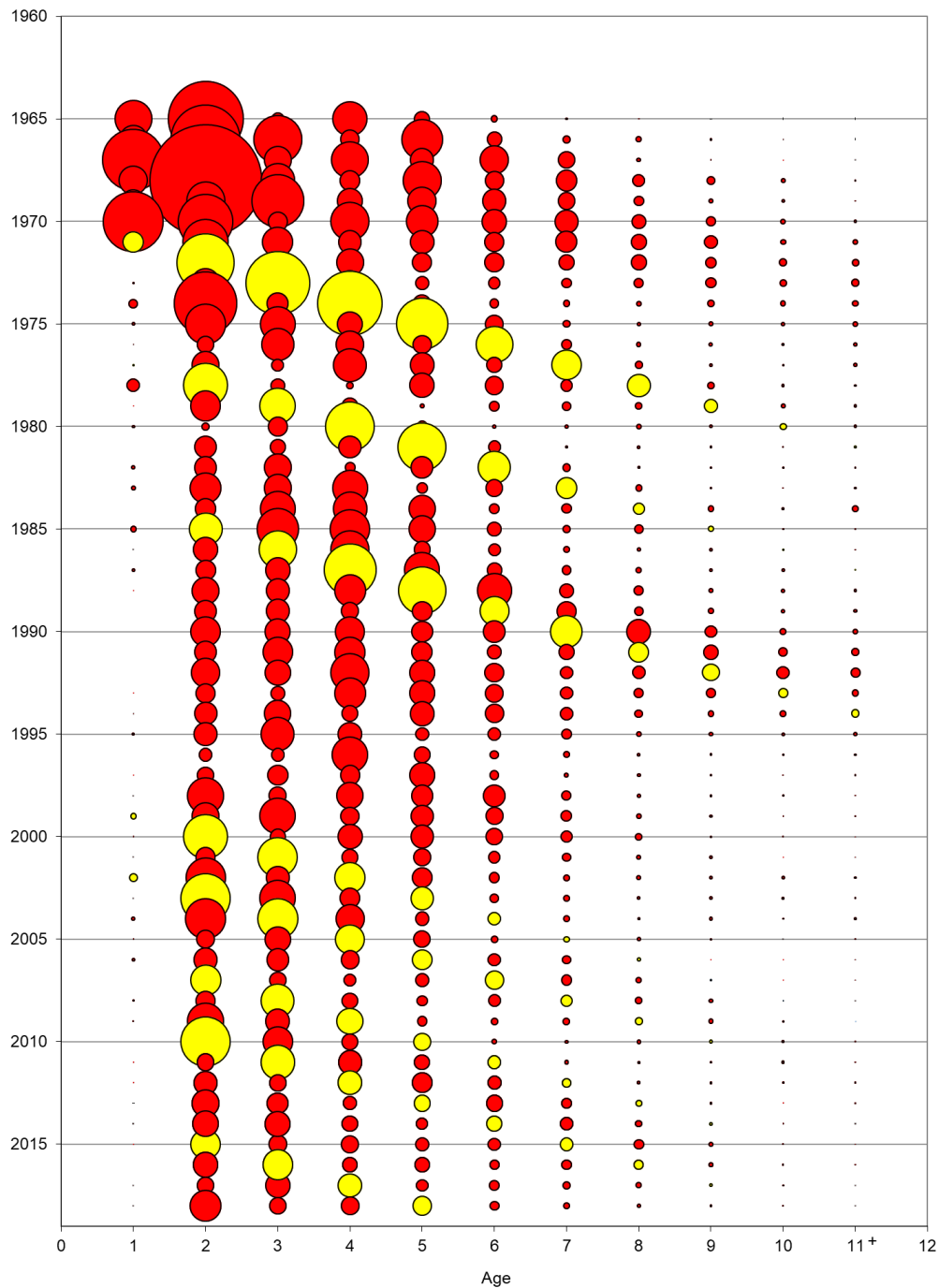


Figure 2. Numbers-at-age in the commercial landings for Southwest Nova Scotia/Bay of Fundy spawning component from 1965 – 2018 by quota year. The size of the bubble is proportional to the numbers by age and year. Selected year classes from 1970, 1976, 1983, 1998, 2001, 2005, 2008, and 2013 are shown in yellow.

### Acoustic Surveys

The results of the 2018 acoustic surveys for the SWNS/BoF component are summarized in Table 2. Inbox and outbox refers to survey tracks within and outside the designated survey

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boxes, respectively. There were 8 surveys in Scots Bay, 6 on German Bank, 5 on Trinity Ledge, and 4 in the Spectacle Buoy area. A seventh survey conducted on German Bank was excluded because it was conducted less than 10 days after the previous survey.

The overall acoustic biomass estimates (Scots Bay, Trinity Ledge, Spectacle Buoy, and German Bank) decreased from 330,350 t (95% C.I.: +/- 24,989 t) in 2017 to 251,368 t (95% confidence interval (C.I.): +/- 26,331 t) in 2018. The overall acoustic biomass estimate is 31% below the long-term average (1999-2018) of 365,668 t. Most of the decrease occurred on German Bank with 94,869 t (95% C.I.: +/- 22,297 t) in 2018 down from 165,792 t (95% C.I.: +/- 43,394 t) in 2017. This decline is concerning as it continues the decreasing long-term trend since 2007 and is now at a historical low. There was little change in the biomass estimate for Scots Bay. Overall, the acoustic catch-at-age showed a decrease in percent by numbers of Ages 3 and 4 with similar percentages for Ages 5+ compared to 2017.

*Table 2. Acoustic surveys spawning biomass index for Southwest Nova Scotia/Bay of Fundy spawning component average for 1999 – 2004 and biomass for 2005 to 2018 (rounded to thousands of tonnes).*

Location	Avg. 1999 - 2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Avg. 2005- 2010	Avg. 1999 - 2018
Scots Bay (inbox)	121	20	31	45	21	72	37	91	123	59	187	228	98	133	129	38	100
Scots Bay (outbox)	0	0	0	1	0	5	10	32	38	8	4	21	3	9	10	4	12
<b>Scots Bay total</b>	121	20	31	46	21	78	47	123	161	66	191	249	101	142	140	40	107
German Bank (inbox)	304	219	250	440	214	323	192	249	219	200	188	140	163	166	95	273	244
German Bank(outbox)	-	-	4	4	2	1	16	9	7	9	2	-	-	-	-	-	-
<b>German Bank total</b>	304	219	254	444	216	324	208	258	226	209	190	140	163	166	95	278	247
<b>German + Scot</b>	425	239	285	490	237	402	255	381	387	275	381	390	264	308	235	318	354
Trinity Ledge	9	11	16	3	1	2	2	7	3	1	5	1	1	14	7	6	6
Spec Buoy (spring)	-	1	-	-	-	-	2	0	-	-	-	-	-	-	-	-	-
Spec Buoy (fall)	88	-	-	-	-	-	-	-	-	-	-	-	-	9	10	-	-
<b>Overall Stock Area</b>	523	251	301	493	237	403	259	388	390	276	386	390	265	330	251	324	366
Seal Island	6	-	10	-	-	-	-	1	-	-	-	-	-	-	21	-	-
Browns Bank	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Total All Areas</b>	573	251	311	493	237	403	259	390	390	276	386	390	265	330	272	327	371
<b>Overall SE (t)</b>	19	27	17	29	21	22	8	20	8	15	20	14	9	13	13		
<b>Overall SE (%)</b>	5%	13%	6%	7%	10%	6%	4%	6%	2%	6%	5%	4%	4%	5%	5%		

\* Note: Average 2005 – 2010 = Limit Reference Point (German Bank and Scots Bay total only). Number for Scots Bay and German Bank are adjusted for turnover.

Dash (-) = no data for that year in that category or in the case of averages = insufficient data

Zero = surveys conducted but the numbers recorded were either 0 or less than 500t (rounds to 0 thousand t)

**Limit Reference Point**

The annual acoustic survey SSB estimates for 2016, 2017, and 2018 are below the LRP. In 2018, the acoustic survey estimate for Scots Bay and German Bank decreased from 307,758 t (2017) to 234,520 t. The 3-year moving average decreased from 2017 (320,476 t) to 2018 (268,808 t), and is now below the LRP, in the Critical Zone (Figure 4). The DFO Precautionary Approach strategy (DFO 2006) states when a stock is in the Critical Zone, productivity is sufficiently impaired to cause serious harm.

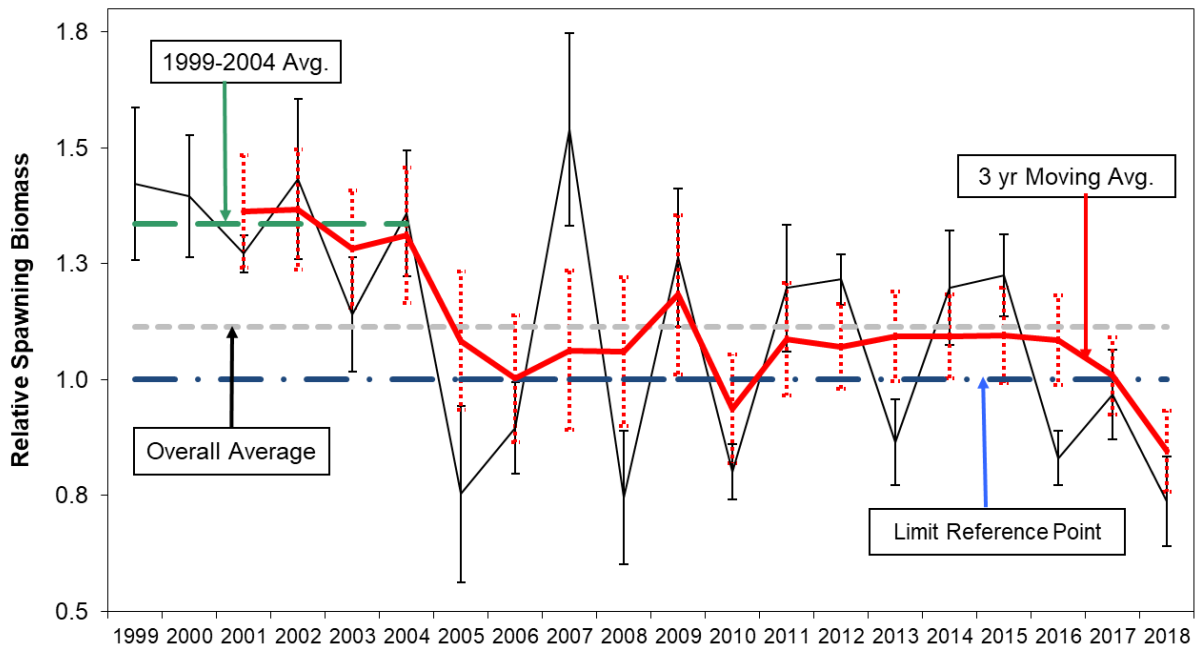


Figure 3. Relative spawning stock biomass index (with 95% confidence intervals), the calculated 3-year moving average, the overall average since 1999, the 1999 – 2004 average, and the limit reference point for the Southwest Nova Scotia/Bay of Fundy spawning component (German Bank and Scots Bay) .

### Offshore Scotian Shelf Component

In 2018, offshore landings decreased from 3,945 t in 2017 to 2,926 t (Table 1), and they are below the allocation limit of 12,000 t. Landings were primarily caught by purse seiners in May, June, and July, in the vicinity of The Patch (see map in the Appendix). The commercial catch was comprised primarily of adult herring with ages 4 – 7 dominating by numbers (90%) and weights (87%). A by-catch of 17 t was reported from groundfish otter trawl fisheries for Silver Hake on the Scotian Shelf.

### Coastal Nova Scotia (South Shore, Eastern Shore and Cape Breton) Spawning Component

Allocations for the coastal NS spawning component are based on the recent 5-year average of observed acoustic SSB, where available. Landings in the Little Hope/Port Mouton area increased from 5,557 t (2017) to 7,353 t (2018) against the 2018 allocation of 7884 t (Table 3). In the Eastern Shore area, landings increased from 2,259 t (2017) to 2,553 t (2018) against the 2018 allocation of 3,960 t. In Glace Bay, landings of 9 t were reported in 2018. The Bras d'Or Lakes area remained closed to herring fishing. In 2018, the catch for the coastal component consisted primarily of adult herring. This gillnet fishery is size selective with a substantial proportion of the catch (99% by numbers) Age 4 and older. The dominant class was Age 6 at 34% by number.

In 2018, the SSB for the Little Hope/Port Mouton area increased to a record high of 168,164 t and is above the recent 5-year average of 97,572 t (Table 4). The SSB in the Halifax/Eastern Shore area decreased from 58,681 t (2017) to 42,416 t (2018), which is below the recent 5-year

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average of 46,711 t. As in previous years, caution is warranted in applying the survey SSB as an absolute tonnage of herring in the water.

Since 2013, no survey has been completed in Glace Bay.

*Table 3. Recorded landings and allocations (tonnes) of herring from major gillnet fisheries on the Coastal Nova Scotia spawning component average for 1999 to 2009 and biomass for 2010 – 2018.*

Landings and Allocations (t)		Avg. 98-09	2010	2011	2012	2013	2014	2015	2016	2017	2018
Little Hope/Port	Catch	2,545	3,106	2,576	2,150	2,499	3,596	4,160	5,943	5,557	7,353
Mouton	Allocation	2,559	2,454	2,094	2,188	2,387	3,577	3,772	6,151	6,803	7,884
Halifax/Eastern	Catch	2,914	2,302	908	771	1,390	1,163	1,001	1,837	2,259	2,553
Shore	Allocation	3,218	4,373	4,188	2,920	2,427	1,959	1,066	1,884	2,856	3,960
Glace Bay	Catch	1,003	11	0	7	2	1	0	4	0	9
Bras d'Or Lakes	Catch	18	0	0	0	0	0	0	0	0	0

*Table 4. Estimated herring acoustic spawning stock biomass (SSB) (tonnes) average for 1998-2009, biomass for 2010 to 2018 and recent 5-year average for the Coastal Nova Scotia spawning component areas.*

Acoustic Survey SSB (t)	Avg. 98-09	2010	2011	2012	2013	2014	2015	2016	2017	2018	Avg. last 5 years
Little Hope (SSB)	25,892	26,700	28,796	12,756	73,992	46,077	145,395	61,408	66,815	168,164	97,572
Allocation	2,559	2,454	2,177	2,255	2,421	3,577	3,772	6,151	6,803	7,884	5,637
Halifax (SSB)	36,438	27,700	5,498	3,668	6,870	9,586	68,562	54,312	58,681	42,416	46,711
Allocation	3,218	4,373	4,097	3,041	2,630	2,240	1,066	1,884	2,856	3,960	2,401
Glace Bay	8,303	8	51	-	50	-	-	-	-	-	-
Bras d'Or Lakes	300	-	-	-	-	-	-	-	-	-	-

Dash (-) = no survey

**Southwest New Brunswick Migrant Juveniles**

Landings from the New Brunswick weir and shutoff fishery increased from 2,102 t in 2017 to 11,574 t in 2018. Landings from shutoffs were the highest since the 1970s. In 2018, 92% of herring landed were Age 2.

**Conclusions**

**Southwest Nova Scotia / Bay of Fundy Spawning Component**

The overall acoustic spawning stock biomass estimate for the SWNS/BoF spawning component decreased by 24% in 2018 relative 2017. Although there is uncertainty associated with the annual acoustic biomass estimates (DFO 2015), longer-term trends in biomass are evident. The 3-year moving average decreased again in 2018 and is now below the LRP, in the Critical Zone. The long-term trend on German Bank has decreased since 2007, while the trend in Scots Bay has been gradually increasing since 2005. The German Bank SSB is at a historical low. The trends indicate that continued caution is warranted. The SSB for Trinity Ledge remains low relative to the early 2000s, but there are some positive indications of growth in the biomass estimates.

The precautionary approach requires that exploitation must be kept at the lowest possible level to promote stock growth and contribute to rebuilding the stock above the Critical Zone.

The 2018 fishery landings (by number) were dominated by Age 2 fish (45%). The reliance of the fishery on younger age groups is cause for concern because many of these fish are below size-at-maturity. Preventing fishing mortality below size-at-maturity may enhance stock recovery.

Overall, the broad age ranges observed in the commercial catch indicates that this conservation objective is generally being met. A summary of the observations and conclusions for each of the corresponding objectives in the IFMP are presented in Table 5. Table 6 summarizes the observations and conclusions on the short-term rebuilding plan objectives for SWNS/BoF spawning component in 2018.

*Table 5. Observations and conclusions on conservation objective elements from the management plan for SW Nova Scotia / Bay of Fundy spawning component in 2018.*

Objectives in Management Plan	2018: Observations and Conclusions
Persistence of all spawning components	Spawning was observed in Scots Bay and German Bank. Spawning activity was documented on Seal Island, the last time it was surveyed was in 2011. There was a decrease in in the amount of documented spawning biomass on Trinity Ledge in 2018 and an increase in the Spectacle Buoy area.
Maintain biomass of each component	There was a decrease on German Bank and little change in Scots Bay. While there is some uncertainty in the acoustic biomass estimates, the 2018 data indicate a decrease. There continues to be an increasing trend in Scots Bay since 2005 and a decreasing trend on German Bank since 2007. In 2018, German Bank biomass decreased to historical low. The biomass for Trinity Ledge remains low relative to values observed in the early 2000s. For Spectacle Buoy, 2018 was the second year of documented biomass since 2006.
Maintain broad age composition	Currently, broad ranges of ages are in the commercial landings (2-9), as well as in the acoustic surveys catch-at-age (3 – 11). The percentage (by number) of 2-year olds caught in the fishery increased in 2018. The reliance of the fishery on younger age groups is cause for concern because many of these fish are below size-at-maturity. Preventing fishing mortality below size-at-maturity may enhance stock recovery. There are indications of a strong 2013 year class progressing through the fishery.
Maintain long spawning period	Start of spawning in 2018 for Scots Bay was two weeks earlier than in the past while German Bank was about the same as in the past based on survey and sampling. An earlier end date was observed on German Bank. Spawning occurred on Trinity Ledge early-August to mid-September and late August to late September in the Spectacle Buoy area.
Fishing mortality at or below $F_{0.1}$	Fishing mortality could not be determined. Relative exploitation rates based on acoustic SSB and landings increased to just above the long-term average.
Maintain spatial and temporal diversity of spawning	Spawning in the German Bank area displayed an earlier end date in 2018. Spatially, spawning in the German Bank area had a similar distribution to previous years. In 2018, duration of spawning in Scots Bay was similar to previous years. Spatially, the Scots Bay area had a similar distribution to previous years. Generally, spawning periods are being maintained both temporally and spatially on the two major spawning grounds. Trinity Ledge and Spectacle Buoy spawning areas continue to show improvement in space and time.
Maintain biomass at moderate to high levels	The overall acoustic biomass estimates decreased to 31% below the long-term average (1999 – 2018). Little change in biomass was observed in Scots Bay; however, the German Bank biomass continues the decreasing long-term trend since 2007 and is now at a historical low.
Maintain 3-year moving average above the limit reference point	The 3-year moving average for the acoustic surveys estimate (Scots Bay and German Bank combined) decreased in 2018 resulting in a downward trend in the last two years. This trend has resulted in the average now being in the Critical Zone. The precautionary approach requires that exploitation must be kept at the lowest possible level until the stock is out of the Critical Zone. Harvest rate must be kept to the lowest possible level to promote stock growth and contribute to rebuilding the stock above the Critical Zone.



*Table 6. Observations and conclusions on short-term rebuilding plan objectives for SW Nova Scotia / Bay of Fundy spawning component in 2018.*

<b>Short-term Rebuilding Plan Objectives</b>	<b>2018: Observations and Conclusions</b>
Rebuild the herring resource to an interim target of the 2001-2004 SSB level	Not being met. Stock now below the LRP.
Have a statistically significant positive trajectory in the reference point indicator	Not being met.
Limit small fish removals to increase productivity of the resource	The removal of small fish continues to be a concern as 45% of the fish landed are Age 2.
Maintain spatial and temporal objectives related to spawning grounds	This objective is mostly being met. There is continued spawning both temporally and spatially on German Bank and in Scots Bay and some improvements on Trinity Ledge.
Maintain biomass of each component	There was a decrease on German Bank and little change in Scots Bay. There continues to be an increasing trend in Scots Bay since 2005 and a decreasing trend on German Bank since 2007.

### **Offshore Scotian Shelf Spawning Component**

There was a decrease in the landings from the offshore banks from 3,945 t in 2017 to 2,926 t in 2018, well below the allocation limit of 12,000 t. In the absence of recent information about stock status, there is no basis for evaluating the current catch allocation of 12,000 t. Structured acoustic surveys are needed to obtain data on the stock in the offshore area.

### **Coastal Nova Scotia (South Shore, Eastern Shore and Cape Breton) Spawning Component**

The SSB for the Little Hope/Port Mouton area increased to an all time record high of 168,164 t while there was a decrease in the biomass estimates for Eastern Shore to 42,416 t. There has been no research or acoustic surveys completed in the Bras d'Or Lakes since 2000.

### **Southwest New Brunswick Migrant Juveniles**

The landings in the weir and shut-off fishery increased to 11,574 t. The degree to which this reflects abundance is unknown.

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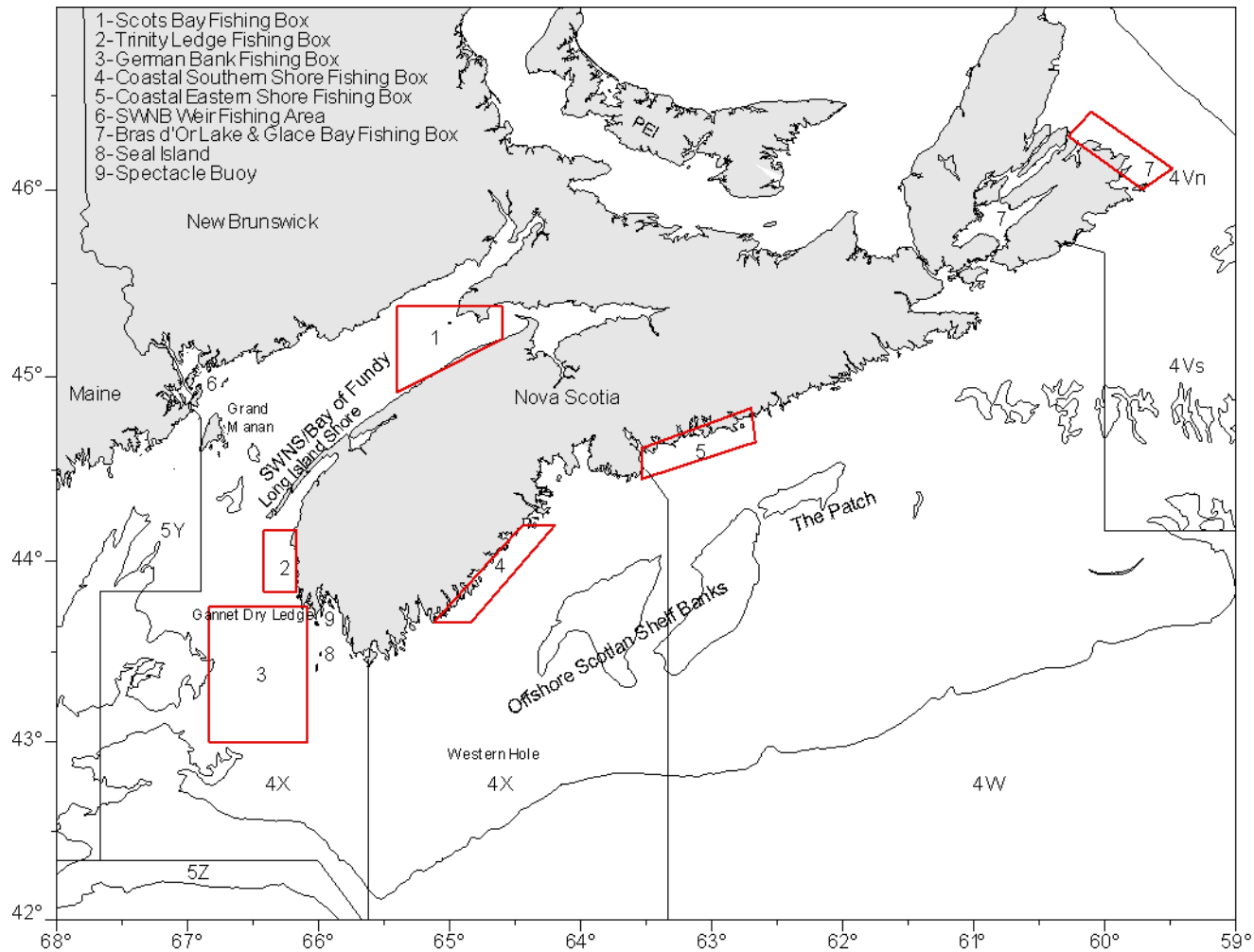
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**Sources of Information**

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### Appendix

Appendix 1. Place names and fishing locations for Southwest Nova Scotia/Bay of Fundy, coastal NS (South Shore, Eastern Shore, Cape Breton), Offshore Scotian Shelf and SWNB weirs. The vertical line between the two 4X labels indicates the outer boundary of the SWNS/BoF stock component.



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