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Canadian Science Advisory Secretariat  
Science Response 2020/050

Maritimes Region

## STOCK STATUS UPDATE OF 4VWX HERRING FOR THE 2019/2020 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 2019/2020 fishery. The last full assessment of the 4VWX Herring stock was conducted in March 2018 (DFO 2018), and an update was conducted in May 2019 (DFO 2020). The biological and fishery information for the 4VWX Herring stock forms the basis for establishing harvest levels for the 2019/2020 fishery, as required in the Integrated Fisheries Management Plan (IFMP). A review and update of biological and fishery information for the 4VWX Herring stock are provided in this Science Response.

This Science Response Report results from the Science Response Process of April 23, 2020, 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 (NS) spawning component (includes South Shore, Eastern Shore, and Cape Breton), and
- 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 was 35,000 t in 2019. 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 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

<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.

spawning components". The three conservation objectives are: to maintain the reproductive capacity of Herring in each management unit, to prevent growth 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 another framework meeting in 2011 to review assessment models. An analytical model was not chosen at that time; however, recommendations for the assessment methodology were provided (DFO 2011). In 2012, a Limit Reference Point (LRP) for the SWNS/BoF Herring spawning component (German Bank and Scots Bay) was defined 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, revisions to the method for estimating acoustic SSB turnover on the Scots Bay and German Bank spawning grounds was presented and accepted. This revision resulted in revised SSB estimates over the entire time series, including the LRP of 316,316 t<sup>3</sup> (DFO 2018). The total SSB in these two areas is estimated based on the 3-year moving average of acoustic biomass with respect to this LRP (DFO 2018).

Landings from the Herring fishery in 4VWX have always been dominated by purse seine (e.g., 81–99%, 1981–2019). Other gear types include weir, gillnet, shutoff, and trap net.

## Analysis and Response

### Landings

The landings for the period October 15, 2018, to October 14, 2019, (the 2018/2019 quota year) were 29,104 t against a TAC of 35,000t 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 2019 with decadal averages from 1970 to 2009.*

Year	Avg. 1970–79	Avg. 1980–89	Avg. 1990–99	Avg. 2000–09	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
4WX SWNS/BoF TAC <sup>1</sup>	106	106	112	69	55	50	50	50	50	50	50	42.5	42.5	35
4WX SWNS/BoF <sup>1</sup>	131	131	96	66	46	50	48	47	50	49	50	39	40	29
4VWX Coastal NS <sup>2</sup>	<1	<1	4	7	6	4	3	4	5	5	8	8	10	13
Offshore Scotian Shelf <sup>2</sup>	38	<0.1	13	6	12	10	1	2	<0.1	2	1	4	3	6
SW New Brunswick <sup>2</sup>	26	24	24	15	11	4	1	6	2	<0.2	4	2	12	5
Total Landings	172	155	137	93	74	68	52	58	57	56	63	53	65	53

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

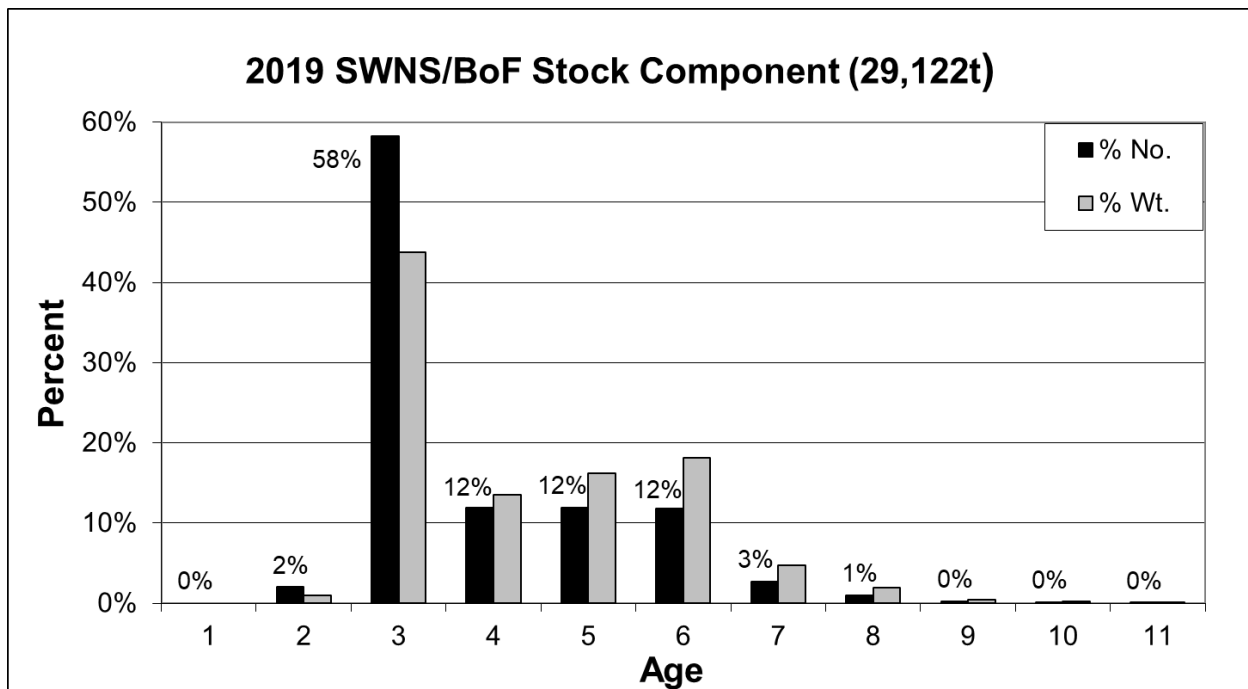
<sup>2</sup> - Calendar year from January 1<sup>st</sup> to December 31<sup>st</sup>

Additional landings of 24,230 t were taken in the non-quota stock components (outside the SWNS/BoF area) for a total of 53,334 t for all of 4VWX. Landings for SWNB weirs and shutoffs were lower in 2019 (5,055 t) compared to 2018 (a ten year high of 11,574 t) (Table 1). Landings were higher for the Offshore Scotian Shelf and remained below the 12,000 t allocation for the area. Within the SWNS/BoF component, catches were 17% lower (drop to 19%) from the German Bank Fishing Box (Appendix 1). 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 were lower relative to 2018 from Grand Manan, Long Island, German Bank, and Seal Island, and were higher from N.B Coastal, Trinity Ledge, Lurcher, and Gannet Dry Ledge.

<sup>3</sup> Due to calculation error, this value was revised to 317,846 t.

**Southwest Nova Scotia/Bay of Fundy****Age Structure**

The 2019 fishery landings (by number) were dominated by Age 3 fish (58%) with Age 4 (12%), Age 5 (12%), and Age 6 (12%) making up the other larger age groups (Figure 1). Most 3-year old fish were taken from the fishing grounds of Grand Manan Banks, Grand Manan, New Brunswick (N.B.) Coastal, Long Island Shore, and Trinity Ledge. This age group makes up 88–90% of the landings (by number) on the Grand Manan, Grand Manan Banks, and N.B. Coastal fishing grounds. On Scots Bay and German Bank, the landings had a wider range of mature (ages 3+) fish ages, with Age 5 and Age 6 making up 46% and 53% of landings, respectively. The percentage-by-numbers of Age 4 and Age 5 in the catches was greatest in the months of August and September.



*Figure 1. Fishery catch-at-age (percentage numbers and percentage weight) for Southwest Nova Scotia/Bay of Fundy spawning component (2018–2019 quota year).*

An important feature of the 2019 catch-at-age is the dominance of Age 3 (58%) with apparent tracking from the dominant Age 2 in 2018 (45%) (Figure 2). Age 6 fish remain relatively abundant within the age structure (12%), an increase from 2018 where Age 6 fish made up only 5% by number. Based on the age structure, the total number of fish removed by the fishery in 2019 was estimated to be 272 million fish, which is 36% less than in 2018. In 2019, Age 2 fish landings by number were 2% of the total landings, compared to 45% of the total landings in 2018. This represents the lowest number of Age 2 fish landed in the fishery since 1980.

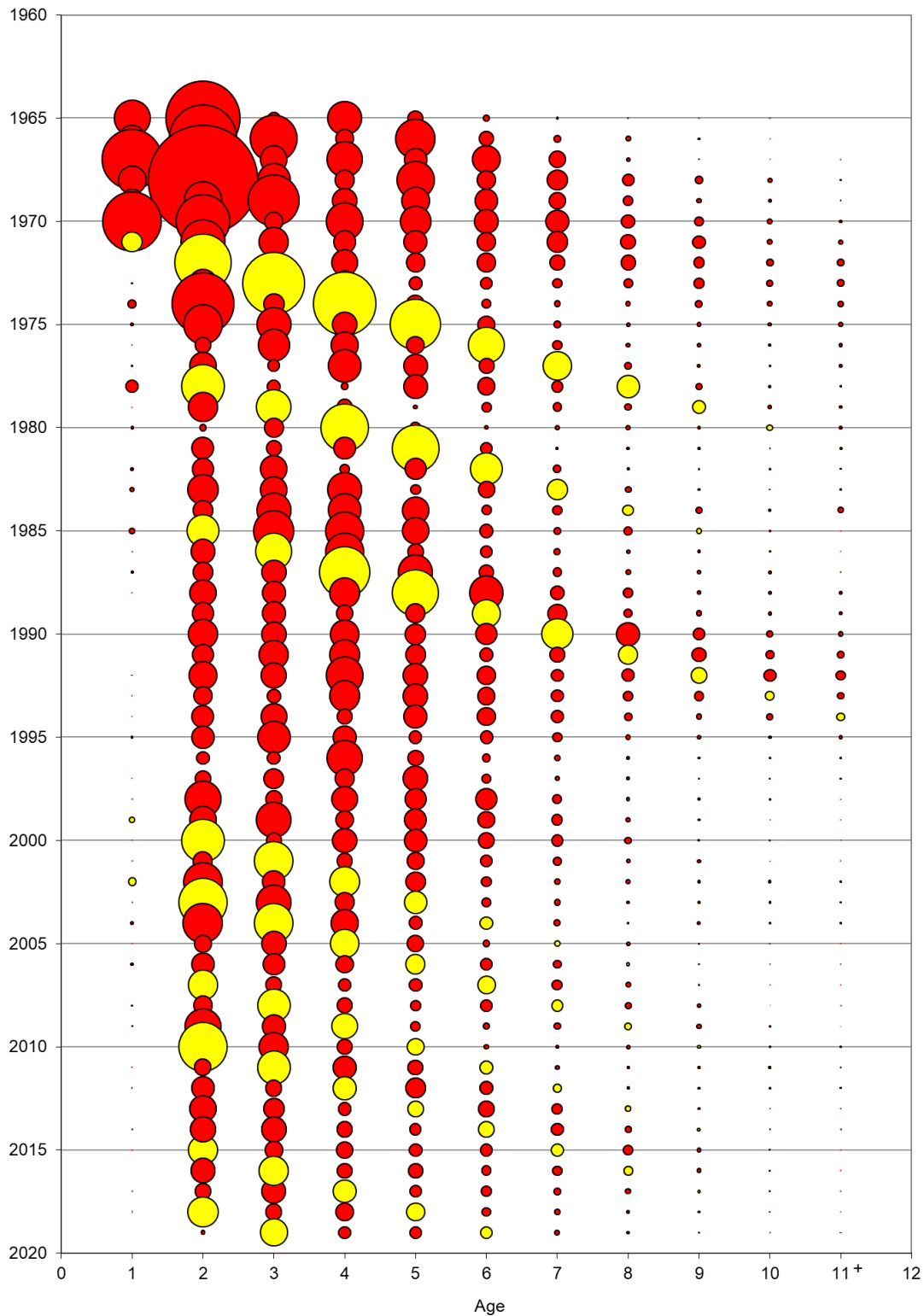


Figure 2. Numbers-at-age in the commercial landings for Southwest Nova Scotia/Bay of Fundy spawning component from 1965–2019 by quota year. The size of the bubble is proportional to the numbers by age and year. Selected year-classes from 1970, 1976, 1983, 1998, 2001, 2005, 2008, 2013, and 2016 are shown in yellow.

**Acoustic Surveys**

The results of the 2019 acoustic surveys for the SWNS/BoF component are summarized in Table 2. Inbox and outbox refer to survey tracks within and outside the designated survey boxes, respectively. There were 8 surveys in Scots Bay, 7 on German Bank, 6 on Seal Island, 5 on Trinity Ledge, and 6 in the Spectacle Buoy area. A seventh survey conducted near Spectacle Buoy 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) was 322,895 t (95% C.I.: +/- 17,243 t), which is higher than the 251,368 t (95% C.I.: +/- 26,331 t) estimated in 2018. The overall acoustic biomass estimate is 11% below the long-term average (1999–2019) of 363,631 t, which is up from 31% below in 2018. Most of the increase in biomass was observed on German Bank, with 147,138 t (95% C.I.: +/-33,519 t) in 2019 up from the historic low of 94,869t (95% C.I.: +/-22,297t) in 2018. The 2019 German Bank biomass estimate is still 40% below the long-term average (1999–2019). There was little change in the total biomass estimate for Scots Bay; however, the percentage of the total biomass documented outside of the survey box was high (40%) relative to past years. For a second year, surveys were completed on Seal Island, and 30,277 t (95% C.I.: +/-6,966t) was documented. The highest biomass since 1999, 19,528t (95% C.I.: +/-4,532 t), was documented on Trinity Ledge.

*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 2019 (rounded to thousands of tonnes).*

Location	Avg. 1999 - 2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avg. 2005 - 2019	Avg. 1999 - 2019
Scots Bay (inbox)	121	20	31	45	21	72	37	91	123	59	187	228	98	133	129	80	38	99
Scots Bay (outbox)	0	0	0	1	0	5	10	32	38	8	4	21	3	9	10	53	4	15
<b>Scots Bay total</b>	121	20	31	46	21	78	47	123	161	66	191	249	101	142	140	133	40	108
German Bank (inbox)	304	219	250	440	214	323	192	249	219	200	188	140	163	166	95	147	273	240
German Bank(outbox)	-	-	4	4	2	1	16	9	7	9	2	-	-	-	-	-	6	6
<b>German Bank total</b>	304	219	254	444	216	324	208	258	226	209	190	140	163	166	95	147	278	242
<b>German + Scots</b>	425	239	285	490	237	402	255	381	387	275	381	390	264	308	235	280	318	350
Trinity Ledge	9	11	16	3	1	2	2	7	3	1	5	1	1	14	7	20	6	7
Spec Buoy (spring)	1	1	-	-	-	-	2	0	-	-	-	-	-	-	-	-	1	1
Spec Buoy (fall)	88	-	-	-	-	-	-	-	-	-	-	-	-	9	10	23	-	26
<b>Overall Stock Area</b>	523	251	301	493	237	403	259	388	390	276	386	390	265	330	251	323	324	364
Seal Island	6	-	10	-	-	-	-	1	-	-	-	-	-	-	21	30	10	11
Browns Bank	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	26
<b>Total All Areas</b>	573	251	311	493	237	403	259	390	390	276	386	390	265	330	272	353	327	371
<b>Overall SE (t)</b>	19	27	17	29	21	22	8	20	8	15	20	14	9	13	13	8		
<b>Overall SE (%)</b>	5%	13%	6%	7%	10%	6%	4%	6%	2%	6%	5%	4%	4%	5%	5%	2%		

\* 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.

- = no data for that year in that category

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

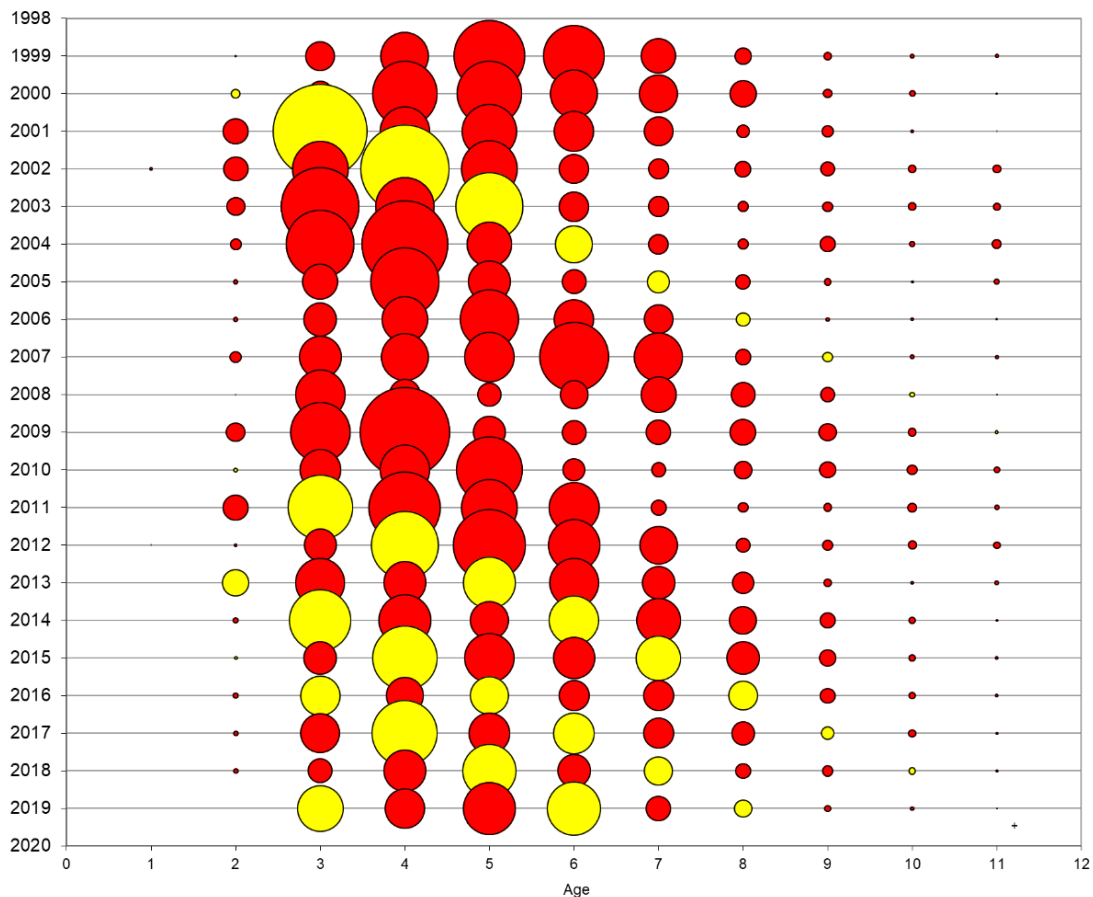


Figure 3. Numbers-at-age in the acoustic surveys spawning biomass index for the Southwest Nova Scotia/Bay of Fundy spawning component from 1999–2019. The size of the bubble is proportional to the numbers by age and year. Selected year-classes from 1998, 2008, 2011, 2013, and 2016 are shown in yellow.

As in the fishery catch-at-age (Figure 2), an important feature of the 2019 acoustic catch-at-age is relatively strong Age 3 (20%), shown in Figure 3. This represents an increase from 2018 where Age 3 fish made up only 8% (Figure 3). Age 5 and Age 6 fish remain relatively abundant within the age structure (27% each).

In 2019, the relative exploitation rate for Southwest Nova Scotia/Bay of Fundy spawning component estimated from acoustic SSB and landings was 12%, compared to a long term (1999–2019) average of 16% and remains consistent with exploitation rates seen in the past five years (12–19%).

### Stock Status

The annual acoustic survey SSB estimates for the past four years have been below the LRP. In 2019, the acoustic survey estimate for Scots Bay and German Bank increased from 234,520 t in 2018 to 280,470 t in 2019. The 3-year moving average increased slightly from 2018 (268,808 t) to 2019 (274,250 t), and remains below the LRP, in the Critical zone (Figure 4). The DFO Precautionary Approach strategy (DFO 2006) states that when a stock is in the Critical zone, productivity is sufficiently impaired to cause serious harm.

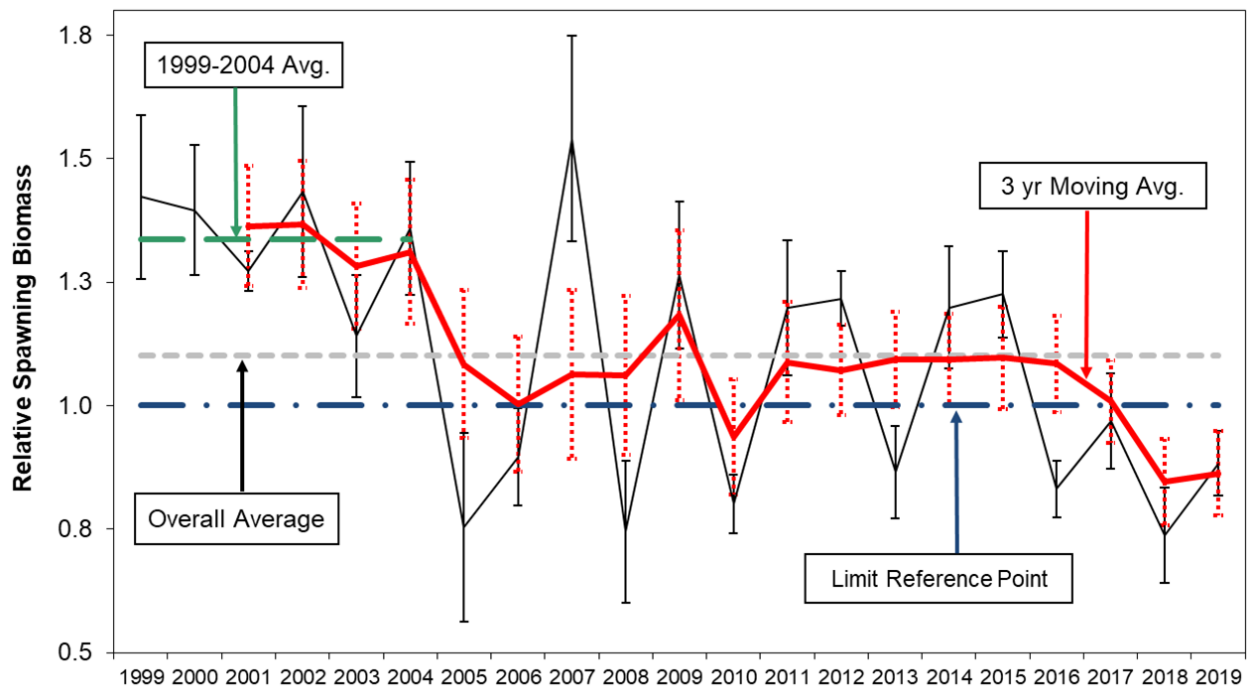


Figure 4. Relative spawning stock biomass index (with 95% confidence intervals), the calculated 3-year moving average, the overall average since 1999, the 1999–2004 average, and the Limit Reference Point for the Southwest Nova Scotia/Bay of Fundy spawning component (German Bank and Scots Bay).

### Offshore Scotian Shelf Component

In 2019, offshore landings were 5,896 t, which is higher than the 2,926t landed in 2018 (Table 1). These landings remain below the allocation limit of 12,000 t. Landings were primarily caught by purse seiners in July, in the vicinity of Western Hole (Appendix 1). The commercial catch was comprised primarily of adult Herring, with ages 4–7 years, dominating by numbers (88%) and weights (90%). A by-catch of 10 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 were 8,707 t against the 2019 allocation of 9,757 t. The 2019 landings were higher than the 7,353 t landed in 2018 (Table 3). In the Eastern Shore area, landings were 4,544 t (2019) against the 2019 allocation of 4,671 t. The 2019 landings were higher than the 2,553 t landed in 2018 (Table 3). In Glace Bay, landings of 1 t were reported in 2019. The Bras d'Or Lakes area remained closed to Herring fishing. In 2019, the catch for the coastal component consisted primarily of adult Herring. This gillnet fishery is size selective with a substantial proportion of the catch (97% by numbers) Age 5 and older. The dominant class was Age 6 at 40% by number.

In 2019, the SSB for the Little Hope/Port Mouton area decreased to 92,019 t from 168,164 t in 2018 and is below the recent 5-year average of 106,760 t (Table 4).

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The highest biomass since 1998 (141,198 t) was documented in the Halifax/Eastern Shore area and is above the recent 5-year average of 73,034 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 2010–2019.*

		Avg.										
Landings and Allocations (t)		98–09	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Little Hope/Port	Catch	2,545	3,106	2,576	2,150	2,499	3,596	4,160	5,943	5,557	7,353	8,707
Mouton	Allocation	2,559	2,454	2,094	2,188	2,387	3,577	3,772	6,151	6,803	7,884	9,757
Halifax/Eastern	Catch	2,914	2,302	908	771	1,390	1,163	1,001	1,837	2,259	2,553	4,544
Shore	Allocation	3,218	4,373	4,188	2,920	2,427	1,959	1,066	1,884	2,856	3,960	4,671
Glace Bay	Catch	1,003	11	0	7	2	1	0	4	0	9	1
Bras d'Or Lakes	Catch	18	0	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 2019 and recent 5-year average for the Coastal Nova Scotia spawning component areas.*

		Avg.											Avg. last
Acoustic Survey SSB (t)		98–09	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	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	92,019	106,760
Allocation		2,559	2,454	2,177	2,255	2,421	3,577	3,772	6,151	6,803	7,884	9,757	-
Halifax (SSB)		36,438	27,700	5,498	3,668	6,870	9,586	68,562	54,312	58,681	42,416	141,198	73,034
Allocation		3,218	4,373	4,097	3,041	2,630	2,240	1,066	1,884	2,856	3,960	4,671	-
Glace Bay		8,303	8	51	-	50	-	-	-	-	-	-	-
Bras d'Or Lakes		300	-	-	-	-	-	-	-	-	-	-	-

"-" = no survey

## Southwest New Brunswick Migrant Juveniles

Landings from the New Brunswick weir and shutoff fishery were 5,055 t in 2019, which is lower than the 11,574 t landed in 2018. In 2019, the number of Age 2 Herring landed decreased to 35% from 92% in 2018. Age 3 fish made up 61% of Herring landed.

## Conclusions

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

The overall acoustic SSB estimate for the SWNS/BoF spawning component increased by 28% in 2019 relative to 2018. Although there is uncertainty associated with the annual acoustic biomass estimates (DFO 2015), longer-term trends in biomass are evident. The SSB index (German Bank and Scots Bay) 3-year moving average increased slightly in 2019, but it remains below the LRP in the Critical zone. Despite the increase in the German Bank SSB, the long-term trend on German Bank since 2007 is a decrease in SSB. SSB in Scots Bay has been gradually increasing since 2005, though this appears to have leveled off in recent years. These trends indicate that continued caution is warranted. The SSB for Trinity Ledge increased to a biomass not seen since the early 2000s.

The 2019 fishery landings (by number) were dominated by 3-year olds (58%). The percentage of 2-year old fish (by number) landed in the fishery decreased from 45% (2018) to 2% (2019). On fishing grounds where a high proportion of Age 2 fish are typically landed, such as Grand Manan and Grand Manan Banks, Age 2 fish made less than 5% of the landings by number. This



is the lowest by number of Age 2 fish landed since 1980, possibly indicative of a poor recruitment event.

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 an absolute minimum to promote stock growth and contribute to rebuilding the stock above the Critical zone.

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 conclusions on the short-term rebuilding plan objectives for SW Nova Scotia/Bay of Fundy spawning component in 2019.

*Table 5. Observations and conclusions on conservation objective elements from the management plan for SW Nova Scotia / Bay of Fundy spawning component in 2019.*

Objectives in Management Plan	2019: Observations and Conclusions
Persistence of all spawning components	Spawning was observed in Scots Bay and German Bank. There was an increase in spawning biomass documented on Trinity Ledge, Spectacle Buoy area and the Seal Island area.
Maintain biomass of each component	There was an increase on German Bank and little change in Scots Bay. While there is some uncertainty in the acoustic biomass estimates, and the 2019 data indicate a slight increase, the biomass for both spawning grounds remain low. There is an increasing trend in Scots Bay since 2005 and a decreasing trend on German Bank since 2007. In 2018, German Bank biomass decreased to a historical low. The biomass for Trinity Ledge has increased to values observed in the early 2000s. For Spectacle Buoy, 2019 was the third 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 (3–8). The percentage (by number) of 2-year olds caught in the fishery decreased to a twenty-year low in 2019. There are indications of strong 2013 and 2016 year classes progressing through the fishery.
Maintain long spawning period	Start of spawning in 2019 for Scots Bay and German Bank was about the same as in the past few years based on survey and sampling. Spawning was observed on Trinity Ledge early August to mid September and early August to late September in the Spectacle Buoy area.
Fishing mortality at or below $F_{0.1}$	Fishing mortality could not be determined. The relative exploitation rate of 12% based on acoustic SSB and landings was below the long-term average of 16%.
Maintain spatial and temporal diversity of spawning	Spatially, spawning in the German Bank area had a similar distribution to previous years. In 2019, 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, Spectacle Buoy, and Seal Island spawning areas continue to show improvement in space and time.
Maintain biomass at moderate to high levels	The overall acoustic biomass estimates increased to 11% below the long-term average (1999–2019). Little change in biomass was observed in Scots Bay. Despite the increase in acoustic biomass in 2019 for German Bank, a long-term decreasing trend in biomass since 2007 remains.
Maintain 3-year moving average above the Limit Reference Point	The 3-year moving average for SSB (Scots Bay and German Bank combined) increased slightly in 2019, but the average remains below the LRP 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 an absolute minimum 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 2019.*

Short term Rebuilding Plan Objectives	2019: Observations and Conclusions
Rebuild the Herring resource to an interim target of the 2001–2004 SSB level	Not being met. Stock remains 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 58% of landings (by number) are Age 3, of which only approximately 50% have reached sexual maturation.
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 and Seal Island.
Maintain biomass of each component	There was little change in German Bank and 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 an increase in the landings from the offshore banks from 2,926 t in 2018 to 5,896 t, 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 Eastern Shore area increased to the highest of the time series at 141,198 t, while there was a decrease in the biomass estimates for the Little Hope/Port Mouton area to 92,019 t, which remains high. 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 decreased to 4,823 t. The degree to which this reflects abundance is unknown.

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## Appendix

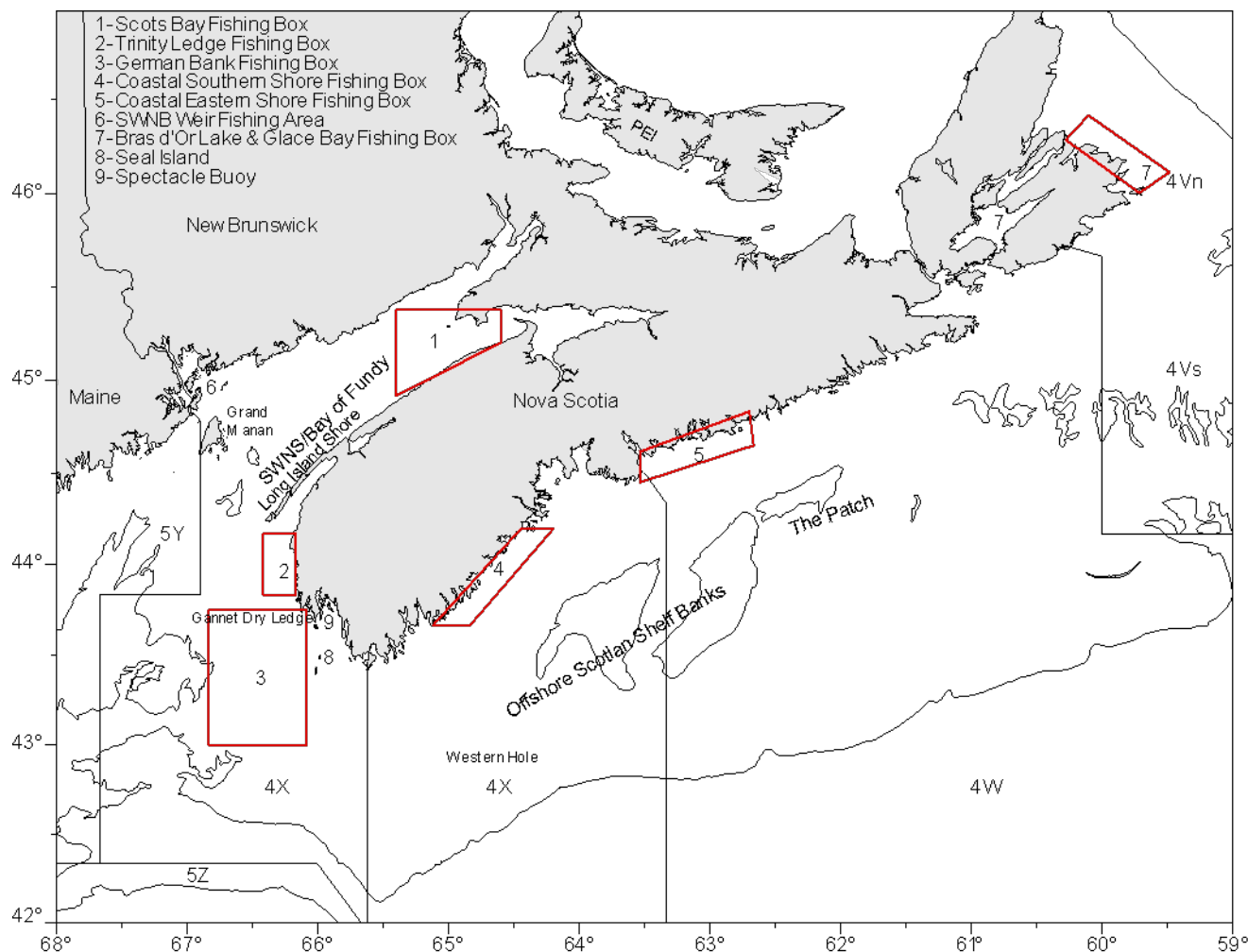


Figure A1. Place names and fishing locations for Southwest Nova Scotia/Bay of Fundy, coastal NS (South Shore, Eastern Shore, Cape Breton), Offshore Scotian Shelf, and SWNB weirs. The vertical line between the two 4X labels indicates the outer boundary of the SWNS/BoF stock component.

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