

Herring Science Council

Presentation to the Fisheries Resource Conservation Council

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1. Introduction

The Herring Science Council coordinates the mobile gear herring industry's contribution to DFO's scientific data collection and assessment process. A large proportion of the data upon which the annual assessment depends is generated by the purse seine industry through the HSC. In a clear way, the HSC enables decision-making in the management of the 4VWX herring resource.

The HSC wishes to bring to the FRCC's attention:

- our history and, briefly, that of the herring industry in the Bay of Fundy area,
- our involvement in the scientific processes in 4VWX herring,
- our involvement in mobile gear fishery management measures to achieve science-based outcomes for the stock,
- our understanding of the status of the 4VWX herring resource,
- our focus on and plans to resolve scientific assessment issues within the 4VWX resource, and
- our assessment of the near future of 4VWX herring.

2. Background

The HSC brings together the harvesting and processing industry in the mobile gear 4VWX herring fishery to participate in the scientific assessment of the 4VWX herring resource. Fishermen participate through Atlantic Herring Cooperative Ltd. and South West Seiners Ltd. Processors participate through the Seafood Producers Association of Nova Scotia and the Nova Scotia Fish Packers Association. The HSC has been active since 2001 when a predecessor organization, the Pelagic Research Council, was wrapped up after four years.

The HSC assumed the herring related functions of the PRC, which are, in brief:

- to complete acoustic surveys of the 4VWX herring stock using specialized acoustic data recording systems,
- to edit the acoustic data using specialized software and provide edited data to DFO herring scientists based at the St. Andrews Biological Station (SABS), and

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- to undertake other herring related research initiatives.

At its inception the PRC purchased four Femto acoustic data recording systems to compliment two systems owned by SABS. Five of these units were deployed on purse seiners while the sixth was a portable unit available for scientists to undertake additional research. The PRC also purchased a specialized research sonar, a Simrad SM 2000, which was used by Dr. Gary Melvin at SABS to perform detailed studies of the behaviour of herring *in situ*.

All PRC equipment was transferred to HSC ownership in 2001. The HSC and some vessel owners have regularly been purchasing additional acoustic data recording units over the years. In sum, at present, including the two (now upgraded) units owned by SABS, there are nine Femto DE 9320 acoustic data logging systems and two Simrad ES60 echosounders with recording capability on 10 purse seiners. One purse seiner has recently upgraded to both types of units so we are considering placing its Femto unit on another seiner which would mean in 2008 there will be 11 seiners with acoustic data recording units out of the 16 purse seiners currently active in the SWNS/Bay of Fundy area.

3. The History of the 4VWX Herring Fishery

Herring is a large and important resource and fishery around SWNS and in the Bay of Fundy. The commercial fishery has survived for well over one century and likely longer. Purse seining started in the late 1800s for herring and became the main harvesting method in the post-war period. Since the assumption of Canadian jurisdiction over the outer portions of the Bay of Fundy and waters off southwest Nova Scotia in 1977, landings in the area have been dominated by purse seine vessels. In 1983 a split in the Atlantic Canadian herring fleet between vessels based in 4VWX and the Gulf of St. Lawrence was initiated by DFO. In that year industry and DFO adopted the first ten year management plan for the 4VWX fleet that allocated 80 percent of the TAC to the mobile gear fleet and the remaining 20 percent to the fixed gear fleet based on history. This split has been entrenched for 25 years. Also entrenched is the fact that the purse seine fleet has landed well over 95 percent of the Bay of Fundy/SWNS stock component in 4VWX in many years due to transfers. The HSC does not participate in allocation discussions and only addresses management issues when there are science elements. We will discuss measures adopted to achieve science outcomes later in our presentation.

At the time of the 1983 management plan there were 40 seiners active in the 4VWX fishery. There are now 16 active seiners and the total number of days fishing per year has dropped dramatically. The self-rationalization from 1983 to 2008, while mandated by the resource and the economics of the herring industry, was achieved primarily through the instillation of an Individual Transferable Quota system. The 4VWX mobile gear herring fleet was the first fleet in Canada to adopt this type of quota management regime, and it has performed well to achieve hard-earned-by-rationalization without government financial incentives.

Our primary message is that without any externally provided support, the 4VWX mobile gear herring industry has adapted to quota fluctuations including severe drops, rationalized and managed to sustain itself as an economic contributor to coastal economies of SWNB and SWNS. Survival is not easy and the past few years of historically low TACs have taken their toll. Nevertheless, the HSC and the industry take the long-term view that requires a healthy 4VWX herring resource and demands participants to work cooperatively to its growth. We have a positive view of the near and long-term future – we have turned an important corner.

4. HSC Involvement in the Annual Stock Assessment

The purse seiners and the plants that participate through the HSC provide, we believe, the largest contribution by industry to the essential scientific information of any single stock in Canada.

Each and every year since 1999 when structured surveys of the 4VWX spawning biomass were initiated by the PRC and then expanded over the past seven years under the HSC, purse seiner vessel owners and crew along with plant owners and workers provide the following services to the scientific assessment of the 4VWX herring resource:

- a. Acoustic Data Collection – Each year the purse seine vessels conduct numerous structured surveys of the biomass of spawning herring on Scots Bay, German Bank and, depending upon the year, on other spawning grounds including Trinity Ledge, Seal Island, Spectacle Buoy and Browns Bank. Structured surveys are events in which the available seiners line up at one end of a box mapped out on the spawning grounds by DFO science where historically 95 percent of the spawning activity in the area has occurred. Anywhere from three to eight vessels in Scots Bay or six to 12 vessels on German Bank spread out evenly along one edge of the box. These vessels steam at about 8 knots in straight lines pre-assigned by HSC and/or SABS to the other end of the box, which is 20 miles in German Bank and 18-22 miles in Scots Bay, turn, steam to a second pre-determined line and proceed all the way back to the starting point. These vents take between 4 and seven hours depending upon weather, tides and the location.

Structured surveys evenly cover an area of 636 km² in Scots Bay and 646 km² on German Bank. The crew on each vessel keeps a written deck sheet of visual sightings of herring aggregations at ten minute intervals and when aggregations start and stop. The density of aggregations (light, medium, heavy), exact location, depth and water temperature are also noted. This information is used to provide additional information to the acoustic data and to confirm evidence of fish throughout the spawning (survey) box.

Each survey routinely involves three to eight vessels with acoustic data recording devices. This digital information is downloaded by shore personnel and transferred to trained technicians for editing. In 2007 HSC contracted Allen

Clay of Femto Electronics to edit all data, whereas in all previous years a technician on staff with HSC completed this step. The data is edited with a specialized software tool called Hydroacoustic data Processing System (HDPS), which is proprietary software owned by Femto Electronics and used by the HSC and SABS personnel under licence. The software has tools that remove all echosounder signal return that is not herring from the acoustic data. This step ensures that the quantification and calculations from the acoustic data only includes herring.

Edited data from each seiner active on the survey is then transferred to SABS for analysis by Michael Power and Gary Melvin. They double-check the editing, analyze each line and combine each seiner's result into one complete understanding of each survey. This step was explained to the FRCC by Gary Melvin and Mike Power in their presentation in Montreal.

Typically there are three to five surveys on Scots Bay in a given year and four to five surveys on German Bank, spaced about two weeks apart and the cumulative result of these surveys provides an indication of the spawning stock biomass (SSB) in the Bay of Fundy/SWNS stock for the given year. Additionally, during German Bank surveys a purse seiner or two with recording devices and seiners without recorders are sometimes sent by the HSC to other known spawning grounds in the SWNS area. This occurs when we have indications of spawning activity in the other areas and when there at least a sufficient number of seiners to properly survey German Bank. In some years the results from these surveys on other grounds significantly increases the overall SSB information.

The table below shows the number of vessel nights for surveys on each main area for all HSC structured surveys since 2001.

Year	Scots Bay	German Bank	Total
2001	23	54	77
2002	38	18	56
2003	30	37	67
2004	50	28	78
2005	21	32	53
2006	14	33	47
2007	16	38	54

Finally, acoustic recordings by purse seiners on almost any fishing night can be analyzed and, depending upon the result, can be used to augment our understanding of the overall spawning biomass in a given year or, sometimes, to replace a survey result. Purse seine captains have been provided instructions on how to properly survey aggregations of herring on these fishing nights so the information can be analyzed and considered for inclusion.

In 2006 and 2007 all surveys have been conducted as non-fishing events, meaning that the vessels spend the night surveying not fishing. In previous

years a mixture of fishing and non-fishing surveys was used, the difference being that on some nights the purse seiners were permitted to fish following completion of the survey. A non-fishing survey is expensive. The largest component is vessel costs including fuel plus editing by HSC or a contractor. We calculated the cost of surveying in 2006, including vessel and editing time to be over \$500,000 including monetary and in-kind contributions. This number varies by year according to the number of vessel nights involved, whether surveys permit fishing and operating costs. The fact the HSC members expend so much time, effort and funding demonstrates the importance of the surveys to the annual assessment and to the HSC.

- b. Plant Sampling – We have been told that the 4VWX herring fishery has the highest level of sampling of any stock in the world. True or not, the time and effort expended by herring processing plants to take representative samples of the herring processed each day is impressive.

Plant sampling and sampling information is collected in two fashions. First, herring in amounts of 100 – 200 fish are taken randomly when the herring is delivered to the plants. The length and weight of each fish is measured and recorded. This information is submitted to SABS on a daily basis from three plants. The fish are then frozen and picked up every few months by SABS personnel for further analysis if necessary.

Second, additional sampling information is collected during roe season. When the seiners harvest roe herring information related to the maturity stage of the roe and to the fat content of the herring is recorded by the plants. This information is included on the sheet sent to SABS.

Industry has provided most of the samples used in the annual assessment since 1997, as shown in the table on the next page excerpted from the annual assessment.

- c. Tagging – DFO and HSC and upon occasion other entities involved in herring in the Bay of Fundy/Gulf of Maine area have conducted scientific tagging programs. These programs use HSC, DFO or other funding to purchase tags and, occasionally, hire technicians to tag. Purse seiners, however, routinely offer their vessels and time to carry taggers to the fishing grounds and hold fish in the seine while tagging occurs.

Tags are mostly always retrieved in processing plants by plant workers trained to keep an eye out for the small brightly coloured tags. In order to increase the interest and likelihood of finding tags in processing plants the HSC and other industry groups offer a small reward on a per tag or seasonal draw basis.

Tagging programs provide evidence of the movement of herring in the waters of 4VWX. Current areas of tagging program focus are defining the sub-stocks in the 4VWX zone and understanding the movement of herring onto and off of the spawning grounds.

Year	Sample Source					Total
	Commercial	Industry	Observer	OSS	Research	
1990	422			185		607
1991	448			167	1	616
1992	330			205	1	536
1993	183			421		604
1994	223			228	14	465
1995	138			244	108	490
1996	127	868	49		69	1,113
1997	78	1,443			114	1,635
1998	225	1,376			98	1,699
1999	49	1,388	89		198	1,724
2000	34	1,387	108		177	1,706
2001	47	1,455	96		190	1,788
2002	17	1,339	84		181	1,621
2003	58	1,292	56		199	1,605
2004	50	1,270	60		105	1,485
2005	48	1,017	23		152	1,240
2006	33	1,049	70		99	1,251
2007	10	1,139	29		137	1,315
Average	140	1,252	66	242	115	1,183

- d. Additional Efforts – Purse seine vessels often take SABS personnel on fishing excursions in order to help the scientists understand the status of the resource in a real time perspective. SABS scientists spent a total of three or four nights on seiners in 2007, which represented an improvement over the previous few years when tight science budgets and scientists’ time availability permitted less interaction. We anticipate new research programs we have proposed will assist the frequency of scientists interacting with the fishermen.

In sum, when you consider the amount of information used by DFO Science to assess 4VWX herring and the percentage of the information that originates from HSC activities, the purse seine herring industry in 4VWX has an impressive record of providing essential information to the annual assessment.

5. HSC Involvement in Management Measures

The HSC does not routinely engage in management issues in 4VWX herring. However, a number of management measures have been established to achieve science outcomes or involve science in achieving management outcomes. The HSC discusses these as part of the overall Mobile Gear Working Group under the Scotia-

Fundy Herring Advisory Committee. The HSC participates in the administration of some of the measures to assist with compliance. The types of measures are:

- a. In-season management – The Bay of Fundy/SWNS herring fishery was the first to introduce in-season management measures to protect components of the stock from selective exploitation. Protecting spawning components is an objective in the management plan. In practical terms this means that the roe fishery cannot remove more than 20 percent of the observed biomass in any year. In order to achieve this biomass results from individual surveys have been reviewed by industry and science within two weeks of the survey for most years since 1997 so that catches did not exceed the 20 percent reference level. In recent years, however, with improved knowledge of surveying and excellent daily catch information, HSC and DFO have moved to a less time-sensitive approach. Initial surveys are reviewed to understand if sufficient biomass exists to warrant the current level of fishing effort on the grounds in question.

The ability of fisheries management to employ tools such as in-season management rests solely on the acoustic recording devices, the structured surveys performed by HSC/industry vessels, prompt data downloading and editing by HSC.

- b. Catch limits in specific areas – Industry and fisheries management have been working together to ensure harvests are not accentuated on specific components of the stock or areas when a component requires additional protection. One recent instance did not involve the HSC, which was a reference level of harvests in some areas of the Bay of Fundy in order to limit the overall quantity of small herring removed. This measure was adopted in 2006 following two years when markets and small herring availability combined to increase the proportion of the catch less than 23 cms to a high level. The measures in place in 2006 and 2007 worked, along with the growth of the stock and reduced TAC, such that in 2007 there were one-half the number of fish less than 23 cms landed (411 million) compared to 2004 (821 million).

Another instance of limiting catch in a specific area for scientific reasons relates to Scots Bay. This area showed poor acoustic survey results in 2005 following a few years of average biomass results around 130,000 tonnes. In order to protect the low level of the Scots Bay spawning component a maximum of 5,000 tonnes was permitted from the area in both 2006 and 2007. The stock assessment still required spawning biomass information from Scots Bay, which is only derived from acoustic surveys. Thus, the HSC stepped in to manage catches in Scots Bay with a weekly limit voluntarily accepted by the purse seiners in order to ensure the harvest was spread through the usual season and to ensure catch limit remained to undertake all the structured surveys. Though no fishing is permitted on Scots Bay surveys, most seiners stay over until the next night to harvest a small amount of fish. Without measures to limit the catch it would be more difficult to complete the surveys. This approach has worked well for two years running and is a good example of HSC and industry working cooperatively to help science.

6. HSC Understanding of the Status of the 4VWX Resource

The FRCC has received a comprehensive report on the status of the various stocks in 4VWX and it is not our intention to repeat this information. Yet, the science report provided in Montreal used the 2007 assessment based on the 2006 fishery. On March 17 in Moncton science presented the 2008 assessment using information from the 2007 fishery and data collected by HSC. The research document and the SAR are not yet final and will be available shortly, we understand. Today, however, we would like to raise a number of significant changes in the stock observed in 2007 that demonstrate the resource is improving and that the effect of measures taken in recent years is now taking hold.

- a. Improving biomass. The inability of science to properly age herring, which we will discuss below, and the resulting inability to prepare a VPA for the Bay of Fundy do not permit a full determination of spawning or total biomass for 2008. Nevertheless, there are strong indications that the Bay of Fundy/SWNS stock is increasing and was not as low as previous assessments indicated. These indications are:
 - i. Fishing mortality, though not calculated, is assumed to be down, possibly around the level of $F_{0.1}$.
 - ii. The relative exploitation rate, which is catch as a proportion of the (absolute) acoustic SSB, is less than 15 percent and is at its lowest level since before 1999.
 - iii. The spawning stock survey result increased by about 100,000 tonnes on the main spawning areas (German Bank and Scots Bay) and overall is just 12 percent below the average of 1999-2007 time series. The total acoustic SSB represents a significant 64 percent increase from the recent low in 2005.
 - iv. Two of the German Bank surveys approached the single highest result in the full nine year time series at 192,000 and 229,000 tonnes. (These number are calculated using the calibration integration factor, which is believed to more accurately reflect the biomass than not using the CIF, in which case the numbers were 134,000 and 154,000 tonnes.) This excellent showing of fish was also observed by SABS scientists when they spent a night with a few seiners a few days in advance of the first of the two surveys.
- b. Improving size of herring. There is an increase in the catch of larger herring (greater than 30 cm) to five percent of the harvest. This remains below the level of the early 1990s, a hallmark period due to the very strong 1983 year class, but represents an improvement nonetheless. Recent assessments have

commented on a lack of older fish in the population and that the year classes were being truncated. We have two comments on the improved size.

- i. Measures to reduce catches overall (TACs) and catch of small fish in particular (in-season management measures) over the past three years have significantly contributed to the current improvement.
- ii. The availability of larger herring in 2007 initially seemed out of proportion to what would be available given the catches of previous years, which seemed to be supported by preliminary catch statistics and was the view from those on the water. SABS undertook to review the issue for RAP. The scientists concluded that growth patterns from the 1987 to 1999 period can account for the percentage of larger herring in the 2007 catch. Growth rates from the 2000 - 2006 period do not permit this conclusion, but these rates are hindered by the incorrect ageing now understood to have occurred at this time. Industry had a suspicion that the availability of larger herring could have been the result of larger fish returning to the area that were not available in recent years, however, the DFO study has not suggested the more likely notion is that growth can account for the size of herring caught in 2007.

The size distribution of the Bay of Fundy/SWNS stock is headed in the right direction based on the catch of the past two years. The corrected ageing may confirm that in fact the age distribution is also headed in the right direction.

- c. Ease of fishing – normal fish behaviour. Captains reported a relative ease to locate the size and condition of herring almost every night that had been requested by their market. This reflects two elements of an improved picture:
 - i. There was a good range of fish in a variety of sizes throughout the area in the typical pattern where herring are expected to show.
 - ii. The fish were aggregating and coming up off bottom in most areas in a typical pattern. In recent years fish have been staying closer to bottom, deeper and more difficult to catch. 2007 was far more typical. The causes are not well understood but could include water temperature, predators and the availability of feed.

For purse seiners based in southwest New Brunswick that primarily focus on various waters of the Bay of Fundy, the possible exception to this picture was that herring in the Long Island Shore area stayed deep, only coming up briefly in the pattern more typical of the previous three years. Seiners based in SWNS experienced a normal harvest year in SWNS, but the spring fishery on the Outer Banks fishery was poor due to herring staying deep and weather.

In general, a range of important factors contribute to herring growth, stock development and the health of a population. It is clear, however, that a significant reason for the improved outlook for Bay of Fundy/SWNS herring is due to effort

reductions over the past three years. There has been a decline in the number of active seiners and a reduced number of days fished. In 2007 seiners and their managers adopted operational measures to share time on the water. For instance, three seiners that harvest for one plant each took every third week off during the July to October period so that only two were active at any one time. Three seiners that land fish for another two plants were held under tight restrictions on a per night basis and occasionally took a week off. Two other vessels that land for one of these plants took a few weeks off during this period. In this way the number of days fished was very low in 2006-07. Given the positive outlook, the seiners are anticipating a bit more flexibility in the coming years.

7. Issues in the 4VWX Herring Assessment

A number of issues in the assessment of herring in 4VWX have arisen in recent years and the industry has been working through the HSC to develop solutions. We will describe the background, a Framework Assessment undertaken for these stocks, problems that have been highlighted, and the research being proposed to address these topics.

- a. Background. Prior to 1998 the index of abundance for tuning the 4VWX herring VPA was the larval abundance index (LAI) developed from the DFO annual survey, but in that year the LAI was abandoned due to its poor correlation with abundance. Science initiated a greater reliance on the acoustic surveys of spawning grounds conducted by purse seine vessels with specialized acoustic recording equipment. Between 1999 and 2003 the 4VWX stock was assessed using acoustic data as an absolute measure of spawning biomass. SSB was a summation of abundance observed in individual surveys using a standard size dependent target strength equation, due to the lack of an acoustic time series. The first VPA using an acoustic index in 2004 found a significant difference in the VPA, SSB and the acoustic biomass estimate. In essence, the VPA was estimating a SSB at around 100,000t while the acoustic surveys showed over 400,000t. VPA estimates of fishing mortality (F) were also found to be extremely high and well above $F_{0.1}$.

A number of sources of uncertainty were identified for both the VPA and the acoustic surveys that might help to explain the discrepancy in estimated biomass between the two methods. These included:

- i. The accuracy of the acoustic systems in biomass calculations;
- ii. The indication from tagging returns that the surveys are not simply additive due to the time of turnover by herring on the spawning grounds, yet surveys may also miss spawning herring that arrive and depart the grounds between surveys;

- iii. Observations of herring close to bottom, which may lead to an under-estimation of biomass from acoustic surveys due to the difficulty in separating fish from bottom;
- iv. The linkages between different herring components fished in the Bay of Fundy, the Scotian Shelf, coastal areas and in the US; and
- v. Discrepancy in ageing herring.

The lack of agreement between these two assessment tools, the rapid dissolution of the support for an absolute acoustic biomass (considering this approach was developed jointly between SABS and industry) and the very low levels of biomass delivered by the VPA led to the need for a comprehensive review of the science underpinnings and assessment approach of 4VWX herring – a Framework Assessment.

- b. Framework Assessment. In 2006/2007 two Framework Assessment meetings involving industry and DFO Science were held to evaluate the assessment input parameters and the various indices of abundance including the acoustic survey methodology – in essence to fully outline the sources of uncertainty. A number of recommendations (56) for research and analysis were identified to improve the input parameters and the uncertainty of issues.

A Research Priorities and Planning meeting was also held on February 15, 2007 to review the recommendations and to prioritize research activities. Of the 56 recommendations/activities that were listed, 25 were identified as high priority, 14 as medium, and 17 as low priority. A spreadsheet showing the prioritized list of research topics was provided to the FRCC in Montreal by SABS herring biologists.

- c. Ageing. During this period a serious inconsistency in assigned herring ages between research institutes was also identified as a potential source of uncertainty in the VPA. This has since been the subject of an extensive DFO led review involving a bomb radio carbon assay and dominant year tracking. In March of this year the results were reported at RAP. In essence, the results show that SABS has been underestimated the age of herring by an average of two years with the discrepancy starting as early as age four. SABS will now proceed to re-assess a representative sample of all herring otoliths from 1999 onward to re-calculate the catch at age matrix. The third Framework Assessment meeting will be scheduled once the new results are available. It is anticipated that the assessment model, or a range of models, to be adopted for 4VWX herring will be chosen and be in place for the 2009 RAP.
- d. Proposals for new research. There were four key topic areas identified through the Framework Assessment, not including ageing, each of which covers one or more of the high priority recommendations arising from the Framework. These four topics are the subject of a 2007 proposal that was jointly prepared by HSC

and DFO Science. The cooperative manner in which the proposal was developed is a testament to the close working relationship between industry and SABS.

The 2007 proposal has helped place herring among the small pelagic stocks that may receive attention in upcoming rounds of funding for science priorities. We are hopeful to have some of these important topics studied. These issues have been vexing the assessment of 4VWX herring for up to ten years. The four topics areas highlighted in the Framework and in recent proposals are:

- i. *Target Strength*. Target Strength (TS) is the acoustic backscatter associated with an individual fish and is generally expressed as a function of length. It is also extremely variable and affected by fish depth, behaviour and physiological state. The degree of variability may be as much as a factor of three or four. Accurate estimates of target strength are essential for both relative and absolute acoustic biomass estimates. The current practice is to use a standard equation for all situations that incorporates only length as a dependent variable. We have proposed to purchase a specialized scientific sounder and hire or assign scientists and technicians to undertake numerous studies of TS for 4VWX herring. The studies will make use of weirs that may hold roe herring, herring in seines and possibly purpose-built equipment to look at individual herring in various orientations. The goal is to develop a proper TS equation for 4VWX herring for utilization in analyzing the acoustic surveys and calculating SSB.
- ii. *Acoustic Blind Spots (bottom and surface)*. Characteristically, herring are found close to bottom during the day and then move up off the bottom just after dark and are easily detected acoustically, until they move above the hull depth of the survey vessel or descend back into the bottom layer. However, over the past few years herring have been remaining deep and close to bottom, though as described earlier in 2007 there have been observations of a more typical pattern of diurnal behaviour. There is concern about near bottom distribution of spawning herring, the inability of acoustic technology to detect fish close to the bottom, and the effects of these potentially undetected herring on biomass estimates. SABS undertook quick review of herring distribution in acoustic survey records on the spawning grounds that indicated a much larger proportion of the backscatter was being observed in the bottom few meters during the mid-1990s than in previous years. This confirmed industry's observations. The research question proposed to be addressed is how much fish are being missed in acoustic surveys.

The primary means proposed to explore these issues is through a series of underwater video camera experiments and use of submersible echosounder technology.

- iii. *Timing and Turnover of Spawning Herring*. Atlantic herring characteristically demonstrate fidelity to a spawning ground, and once mature, return annually to the same location to reproduce. Herring are also known to move onto the

spawning grounds in waves (large groups or aggregations), spawn, and leave. The timing and duration of these waves onto and off of the spawning ground is irregular and unknown. Currently acoustic surveys are separated by two weeks and the summation of all surveys is used as a relative index of abundance. The Framework Assessment identified this as a source of uncertainty due to double-counting as well as potentially missing waves of herring that come and go within two weeks. To move closer to having an acoustic biomass as the absolute number, better knowledge of turnover time is essential. Generally, the behaviour of herring throughout the spawning period is an important missing element.

Over the past 5 years several intermittent and ad hoc tagging studies have been undertaken to document the turnover time of herring in Scots Bay and on German Bank during the spawning season. New research being proposed would include a multi-year tagging program to fully address this question and augment recent ad hoc tagging efforts. Also, the video work proposed under the blind spot analysis will incorporate elements that could assist our understanding of the reproductive state and the behaviour of all herring on the grounds during acoustic surveys. Finally, the HSC has contributed to a study of the fat (lipid) content of Bay of Fundy/SWNS herring being conducted by a graduate student to investigate the timing of changes in herring fat content through the roe season. It is possible lipid counts are an indicator of the timing of spawning.

- iv. *Linkages between Stock Components.* Since the mid-1990's the herring in the Bay of Fundy/Scotian Shelf area has been separated into four major components for assessment and management purposes; SWNS/Bay of Fundy, coastal Nova Scotia, the offshore banks and the SWNB juveniles, each with different management approaches. The Framework Assessment reviewed stock structure and suggested current boundaries were appropriate to separate the spawning components and manage the various fisheries. It also concluded that some degree of mixing (likely small) does occur between the components. Tag returns from earlier programs continue to come in that imply mixing may be larger than otherwise expected.

It has been assumed that the herring on the offshore banks represent a mixed origin group of fish, with some originating from spawning grounds on the offshore banks during the summer. With the prospect of increased and on-going fishing effort on the offshore banks it would be counter productive to simply unknowingly shift this effort from SWNS and the Bay of Fundy if linkages are in fact greater than currently assumed. There is a real need to understand the linkages between the various components to properly manage the overall 4VWX herring fishery.

The work on linkages involves four proposed studies:

- tagging focussed on the linkages (which may be achievable in part through tagging for turnover purposes),

- meristic and morphometric studies, which are investigations of the differences in herring in these sub-stocks in number of hard body parts and body shape, respectively,
- combined larval/plankton (research vessel) trawl survey in combination with a seiner or two to locate and characterize the spawning activity that occurs on the Scotian Shelf, and
- possibly renew some genetic studies given advances in research technologies since the last series of such studies in the 1990s.

While all these topics are important, the list is presented with a notion of priority. Once the ageing is fixed, we expect acoustic data from the surveys will remain the main tuning index or trend indicator in whatever model(s) is chosen for Bay of Fundy/SWNS herring in the last of three Framework Assessment meetings. Whereas acoustic surveys are generally accepted as a relative index of the SSB, we anticipated that new research related to the uncertainties will enable the acoustic biomass calculation to be or approximate an absolute biomass number and be incorporated into the assessment model as such.

Generally, however, we are working to resolve as many of issues in 4VWX herring related to the stock structure and the annual assessment of the stock as possible. The four topics above were all in the high priority list arising from the Framework Assessment (in addition to ageing). Each will augment our understanding of the methodology we use to assess the resource and help us better understand the resource itself. The HSC and industry is committed to completing this research so that we can effectively and efficiently sustain the 4VWX resource and fishery in partnership with DFO.

8. Where 4VWX Herring and the HSC are Headed

The HSC is committed to long term growth of the 4VWX herring resource. Our goal is clear: maximum economic output (yield) within the bounds of the conservation objectives in the 4VWX Herring Management Plan.

Are we headed in the right direction? In our view, the answer is clearly yes.

The HSC has managed to continue our extensive science efforts during this difficult economic period of reduced effort. This is itself a demonstration of the seriousness with which industry shares in the custody of the resource.

In 2007 we observed encouraging signs that the combined efforts of industry, the HSC and DFO-SABS are starting to work. The biomass has grown and the herring are growing, as indicated by the major increases in acoustic survey numbers and the improved percentage of larger fish in the catch statistics. Biomass will continue to grow under a similar regime that recognizes the improvements already observed while providing higher yield for the fishery.

The good in-coming year class(es) will be with us for a long time, providing it is (they are) properly protected and shepherded into the SSB.

We remain optimistic that the on-going research questions we have proposing for years may soon be the subject of joint research programs in which the HSC and SABS continue to foster our string relationship. We seek to improve our science and adopt of path of continuous improvement.

With improved knowledge and methods to incorporate this knowledge in the assessment there is a stronger likelihood that some of the difficulties of the recent years may be behind us. Of the many elements raised here today that require new research, we have a sincere focus on the need for a repeatable measure of (close to) absolute biomass and knowledge to incorporate this methodology into the assessment.

We anticipate that the close working relationship between industry and DFO, exemplified by the relationship between HSC and SABS, will continue and will lead to greater levels of mutual understanding in the management of the 4VWX resource. Gary Melvin and Michael Power told you in Montreal that:

The 4VWX herring fishery has had a long history of adopting dynamic and innovative approaches to management. ... There has also been a strong collaborative and cooperative approach to scientific research and management between DFO and the herring industry in the Maritimes Region.

These are our hallmarks and they will guide the mobile gear industry in the Bay of Fundy and in SWNS forward as they guide us today.

In summary, we would like to emphasize four points that we trust have come out in our presentation today:

- ➔ Close collaboration between scientists and HSC -- DFO and industry;
- ➔ Completing new research to provide improved knowledge about the resource and our assessment of it – questions that have been lingering for years;
- ➔ The optimism we have for the 4VWX herring resource given the recently improved outlook for the Bay of Fundy/SWNS stock; and
- ➔ Our interest in continuing strong in-season management that ensures the science objectives of 4VWX herring are being met.

9. Topics of Particular Interest to the FRCC

We have presented a comprehensive overview of science issues involved in the management of 4VWX herring. Our entire premise is conservation of the stock and sustainability of the resource. We believe the Council will look very favourably on

the efforts of the HSC and of industry in the Bay of Fundy/SWNS area to achieve our goals.

In this sense our interest coincides with the overarching focus of Council as explained in the Minister's initial release and the Council's letter to stakeholders, which is:

Develop a long-term strategic approach to the sustainability of the Atlantic herring fisheries and the conservation of the resource.

We've been at this for seven years under the umbrella of the HSC, longer considering the PRC. Yet, as we've outlined here, science and assessment issues remain. The research we have proposed will go a long way toward understanding our issues. Even so, we believe we are on the right track when it comes to ensuring 4VWX herring is sustainable.

We note the Council has outlined a few topics of particular interest in the material related to your current investigation. While we feel a good portion of our presentation addresses aspects of these topics, we will wrap up by referencing a few specific elements on your topics.

FRCC topics:

- major risk factors and threats to the sustainability of the fishery

The HSC is focussed on identifying risks and threats to the 4VWX herring fishery and all our efforts outlined above are involved in reducing and managing those threats. Two elements are of particular concern:

- Knowledge. Management is founded on the best knowledge of the stock and the fishery. We have learned in recent years that science and industry require the best tools available in order to set management in the right path. Circumstances change and new approaches have to be developed, studied and tested to ensure they match the circumstances. We need knowledge of how our assessment tools work, their weaknesses and strengths, so industry and SABS can translate that into management. The low TACs in recent years in part demonstrate that we lack sufficient knowledge. The yield from the fishery is less than optimal.

We have proposed a research program jointly developed with SABS to address our knowledge gaps. We remain optimistic that this research can be initiated after having waiting for years.

- DFO resources. The level of A-base funding allocated to core fisheries science and to assessment fisheries science has been dropping for decades. In order to achieve have the 4VWX fishery and the resource in which we depend contribute effectively to Canada, DFO needs to accept that core components of fisheries and marine biology research cannot be ignored. Resources (i.e. money for people and research) need to be

applied, much as it was following the assumption of Canadian jurisdiction over the EEZ in 1977.

- existing best practices as well as new solutions or opportunities that would reduce risk factors and address problem areas

Three current practices are important for HSC to maintain, as well outlined above:

- strong collaboration between the HSC and SABS (industry and DFO);
- HSC continuing to complete surveys, edit data, sample in plants and, in general, provide the information that underpins the assessment of 4VWX herring; and
- a continuation of in-season management.

- scientific information requirements

Science information requirements in 4VWX herring have been fully canvassed in our presentation.

- adjustments required to management measures

The HSC does not participate in management issues nor discuss management measures, except measures that have science outcomes. Given the solid growth, no current science based management measures would seem to require adjustment.

- handling practices

The HSC does not delve into handling practices. It is assumed the handling practices in the purse seine fishery are consistent with the world standard for purse seine fisheries.

- management and stewardship initiatives

The HSC does not participate in management issues nor discuss management initiatives, except initiatives that have science outcomes. We have outlined our approach to improving the science knowledge base in 4VWX herring. The HSC is a clear and comprehensive example of the purse seine industry's prime initiative in the stewardship of the 4VWX herring resource.

- role of herring in the ecosystem

Ecosystem issues have only entered discussions of 4VWX herring in recent years and are far from systematic or well understood. It is obvious that herring stocks need a healthy ecosystem to survive and grow and that other species need herring for the same reason. The HSC is still working through a comprehensive understanding of ecosystem impacts on the science of our fishery and on the 4VWX stock. Our preliminary thoughts are:

- Herring is a species that other fish consider food but needs food itself, including a healthy primary production system. It is a misnomer to isolate herring and selected other species as “forage” species in an ecosystem that is far from one-dimensional. Many fish and other organisms are food and many can be considered to be foraged for.
- Natural mortality (M) is an on-going consideration in stock assessments, though its calculation in current 4VWX models is set. Of the 56 research concerns science and industry highlighted in the Framework Assessment, there is no mention of M and there was little discussion during the process. The current approach to considering the ecosystem in 4VWX herring appears to be working.
- The levels of F (fishing removals) are improving (that is, reducing) even though a number for F will remain elusive until new population models are adopted. It thus seems that even relatively low levels of herring in the 4VWX area can engender good biomass growth. A lack of biomass dependent growth is corroborated by 5Z (Georges Bank), though the levels there were extreme compared to the recent 4VWX experience. It may be that herring and ecosystem considerations are independent of one another so long as a minimum level of herring survives. Finally, it would seem prudent to retain today’s regime that emphasizes conservation and sustainability, and an assumption that a larger biomass of herring is better for everyone. This ought to be sufficient for the time being, as we strive toward improved knowledge of the resource on which we depend.

10. Conclusion

We thank the FRCC for this time to provide our perspectives on the science elements of the conservation and sustainability of 4VWX herring.

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Herring Science Council
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