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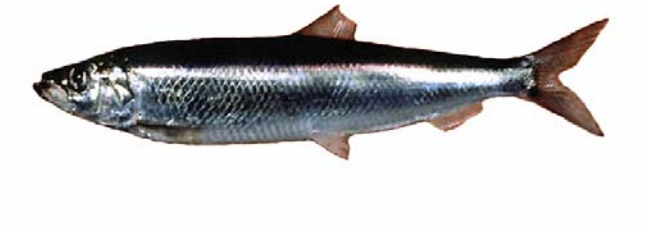
Canadian Science Advisory Secretariat
Science Advisory Report 2008/019

ASSESSMENT OF HERRING IN THE SOUTHERN GULF OF ST. LAWRENCE (NAFO DIV. 4T)



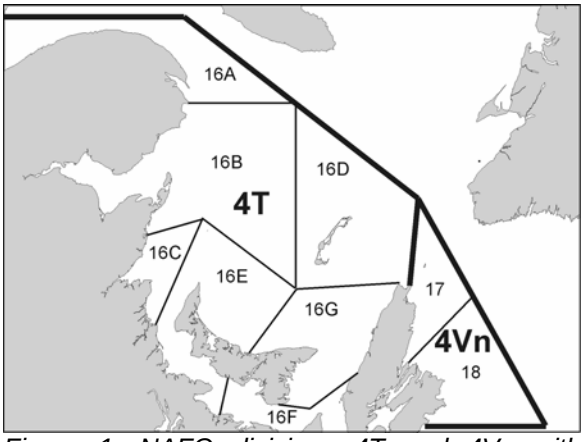


Figure 1. NAFO divisions 4T and 4Vn with corresponding herring management zones.

Context

The stock area for southern Gulf of St. Lawrence herring extends from the north shore of the Gaspé Peninsula to the northern tip of Cape Breton Island and includes the Magdalen Islands (Figure 1). Available information suggests that adults overwinter off the east coast of Cape Breton primarily in NAFO division 4Vn. Studies in the early 1970's indicated that southern Gulf herring also overwintered off the south coast of Newfoundland, but an exploratory fishery in 2006 has found no concentrations there.

Southern Gulf of St. Lawrence herring are harvested by an inshore gillnet fleet on spawning grounds and a purse seine fleet (vessels >65') in deeper water. The percentage of spring and fall spawner component in the catch varies according to season and gear type. As a result, landings during the fall and spring fisheries must be separated into the appropriate spring and fall spawning groups to determine if the Total Allowable Catch (TAC) for these groups has been attained. Spawning group assignment is done using a gonado-somatic index to assign maturity stage and a monthly key that links maturity stage and month to spawning group. Juvenile spawning group assignment is done by size at capture, otolith shape type and size of first annuli.

The inshore fleet harvests almost solely the spring spawner component in the spring, except for June, and almost solely the fall spawner component in the fall. The purse seine fleet harvests a mixture of spring and fall spawner component during their fishery. Spring herring are sold primarily for bait, to the bloater (smoked herring) and filet markets. Fall landings are primarily driven by the roe and filet markets. TAC management was initiated in 1972. Currently there are approximately 3,000 inshore licenses and 11 seiner licenses (>65'), 6 from 4T and 5 from 4R.

Assessments of the spring and fall spawning herring from the southern Gulf of St. Lawrence NAFO division 4T are required on an annual basis and form a part of the information used to establish the TAC. In December 2005, a meeting on the assessment framework was held to determine spawning stock biomass reference points, to update the $F_{0.1}$ calculations and the methodology for short term projections. A meeting of the Regional Advisory Process was held during 17–20 of March, 2008 in Moncton, N.B. to assess the status of the spring and fall spawner components of 4T herring in support of the management of the 2008 fishery. Participants included DFO scientists and fishery managers, representatives of the industry, provincial governments and non-DFO scientists.

SUMMARY

Spring Spawner Component

- Reported 2007 landings of the spring spawner component in both the spring and the fall fisheries were 3,789 t against the spring spawner TAC of 5,000 t.
- Mean inshore gillnet catch rate in 2007 remains one of the lowest in the series that starts in 1990.
- The 2007 acoustic survey index of abundance was the lowest in the series that starts in 1994.
- The 2007 index from the opinions of harvesters contacted in the telephone survey on the abundance of spring herring was the lowest in the time series that starts in 1987.
- The abundances of year-classes after 1991 were average or below average.
- Age 4-10 spawning biomass is estimated at 20,500 t for the beginning of 2008.
- The estimated exploitation rate in 2006 and 2007 was below the reference level.
- Overall spawning stock biomass has declined since 1995 and remains at a low level since 2004.
- The current estimate of age 4-10 biomass (20,500 t) is below the limit reference point (LRP). At this level of biomass, the precautionary approach requires that removals from the stock should be kept to the lowest level possible.
- Even in the absence of any removals of the spring spawning component, there is a 50% probability that the biomass in 2009 will be below the limit reference level of 22,000 t. Catch options less than 1,500 t would provide a low probability (<25%) of further decline in biomass.

Fall Spawner Component

- Reported 2007 landings of the fall spawner component in both the spring and the fall fisheries were 47,621 t against the fall spawner TAC of 68,800 t.
- Mean inshore gillnet catch rates in 2007 were lower than 2006 but remain among the highest in the time series that starts in 1978.
- The 2007 index from the opinions of harvesters contacted in the telephone survey on the abundance of fall herring has been increasing since 1987.
- The 1998 and 2000 year-classes are above average.
- Overall, the stock remains at a high level of abundance relative to the late 1970's and early 1980's.
- The 2008 beginning-of-year spawning stock biomass is estimated to be about 302,000 t, well above the upper stock reference (USR) biomass level of 172,000 t.
- The exploitation rate in 2007 was below the $F_{0.1}$ reference level.
- For 2008, a catch option of 69,000 t corresponds to a 50% chance that F would be above the $F_{0.1}$ removal rate. On the other hand, there is a low probability (< 25%) of a decline in biomass for catch options less than 50,000 t.

BACKGROUND

Species Biology

Herring are a pelagic species which form schools particularly during feeding and spawning periods. Herring in the southern Gulf of St. Lawrence (sGSL) consist of a spring spawner component and a fall spawner component. Spring spawning occurs primarily at depths less than 10m in April-May, but extends into June. Fall spawning occurs mainly from mid-August to

October at depths of 5 to 20m. Eggs are attached to the bottom and large females can produce up to 360,000 eggs. First spawning occurs primarily at age four. The fork length at 50% maturity (L_{50}) is estimated at 23.5 cm for sGSL herring (DFO 2007). In recent years, the largest spring spawning areas are in the Northumberland Strait and the largest fall spawning areas are in coastal waters off Miscou and Escuminac N.B., North Cape and Cape Bear P.E.I., and Pictou N.S.

Fishery

In **the fishery**, the catch allocations for the fall and spring seasons are based on the TACs set for each spawning component. Landings are compiled by fishing season (Tables 1 and 2). The TAC has been set separately for spring and fall spawner components since 1985. As in previous years, for both components, 77% of the TAC is allocated to the inshore fleet and 23% to the seiner (>65') fleet.

Table 1. TAC, allocations and landings in the 2007 spring fishery.

Area	Spring Spawner Component Final Allocation and Season TAC	Spring Season Reported Landings (t)	Spring Spawner Component Landings in the Spring Season (t)	Fall Spawner Component Landings in the Spring Season (t)	% Spring Spawner
Inshore		[b] Jan - May	January-June	January-June	
Bait allocation removed from TAC	500	--	--	--	--
Isle Verte 16A	5	5.3	5.1	0.2	--
[a] Chaleur Bay 16B (Jan-May)	115	[b] 470.4	431.6	44.2	--
[a] Escuminac 16C (Jan- May)	34	[b] 129.8	128.7	1.1	--
Magdalen Islands 16D (Jan- May)	142	[b] 21.1	21.1	0	--
[a] Southeast NB – West PEI 16E (Jan- May)	444	[b] 815.2	850.0	7.5	--
[a] 16F (Jan-May)	43	[b] 7.3	84.5	83.1	--
[a] 16G(Jan-May)	36	[b] 9.0	118.0	115.3	--
Reserve, 4Vn and June (16A-G)	2,532	433.3	[c]	[c]	--
Total Inshore	**3,851**	**1,890**	**1,639**	**251**	**87**
Seiners (>65') 4T	**1,149**	**0**	**0**	**0**	**0**
Grand Total	**5,000**	**1,890**	**1,639**	**251**	**87**

[a] *Areas that used the reserve after initial TAC was reached.*
[b] *Landings from January to May only*
[c] *Partitioned in areas above by spawning component.*

Table 2. TAC, allocations and landings in the 2007 fall fishery.

Area	Fall Spawner Component Final Allocation and Season TAC	Fall Season Landings (t)	Fall Spawner Component Landings in the Fall Season (t)	Spring Spawner Component Landings in the Fall Season (t)	% Fall Spawner
Inshore					
Isle Verte 16A	144	14	7	7	--
Chaleur Bay 16B	24,976	19,730	19,727	3	--
Escuminac-West PEI 16CE	9,200	7,120	7,120	0	--
Magdalen 16D	344	32	32	0	--
Pictou 16F	9,005	8,711	8,711	0	--
Fisherman's Bank 16G	9,005	7,315	7,315	0	--
4Vn (Area 17)	344	--	--	--	--
Total Inshore	**53,018**	**42,922**	**42,912**	**10**	**100**
Seiners (>65') 4T	**15,782**	**6,599**	**4,459**	**2,140**	**68**
Grand Total	**68,800**	**49,521**	**47,371**	**2,150**	**96**

The 2007 TAC for the spring spawner component was 5,000 t compared to 9,000 t in 2006 (Figure 2). The combined 2007 **landings of the spring spawner component** in both the spring and the fall fisheries were 3,789 t, including 2,140 t caught by the seiners in the fall fishery. There was no seiner effort in the spring fishery.

Year	Average 90-2003	2004	2005	2006	2007
TAC (000 t)	17	13.5	11	9	5
Landings (000 t)	18	8.4	5.1	2.9	3.8

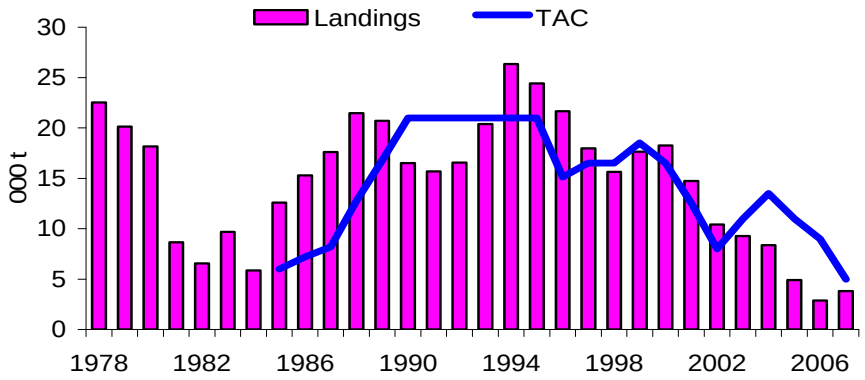


Figure 2. 4T total spring spawner component landings and TAC (000 t).

The **catch-at-age** of the 2007 **spring spawner component** was composed almost equally of ages 2 to 6 (Figure 3). Since 1990, average **weights-at-age** for the spring spawner component have been below those observed during the 1980s (Figure 4).

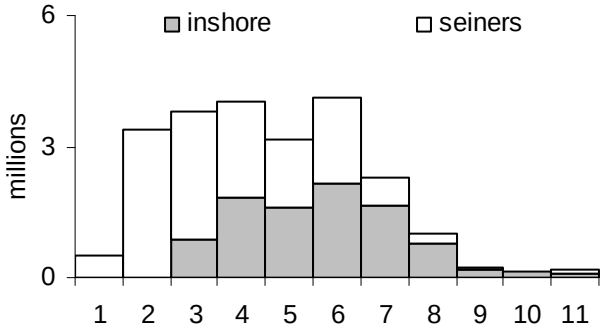


Figure 3. Spring spawner 2007 catch-at-age (millions of fish).

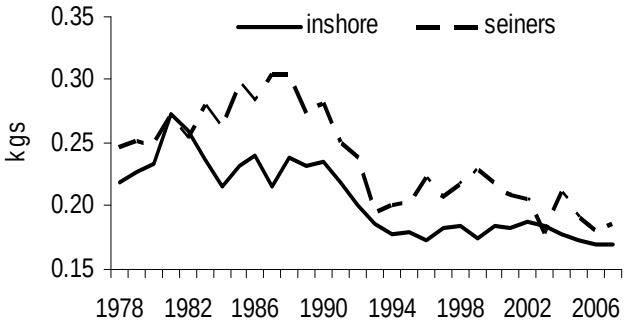


Figure 4. Weight (kg) of 5-year-old spring spawners.

The TAC for the fall spawner component in 2007 was 68,800 t, the same as in 2006 (Figure 5). The seiner allocation for 4Vn (Area 17) is included with the fall spawner component. The combined 2007 **landings of the fall spawner component** in both the spring and fall fisheries were 47,621 t. There was no fishery in the 4Vn (Area 17) overwintering area by the purse seine fleet.

Year	Average 90-2003	2004	2005	2006	2007
TAC (000 t)	67.1	73	70	68.8	68.8
Landings (000 t)	51	43.2	59.9	52.7	47.6

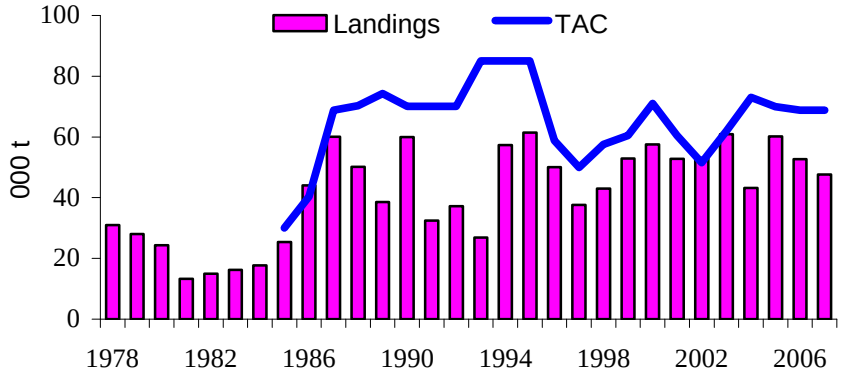


Figure 5. 4T total fall spawner component landings and TAC (000 t).

In 2007, 69% of the fall TAC was attained; seiners caught 42% of their allocation while the inshore fleet caught 81% of their allocation. For the seiner fleet, a deduction from the quota is applied when the catches of fish less than 24.5 cm fork length exceed 10% by number. In 2007, the deduction amounted to 6,450 t. In the landings of the **fall spawner component,** the 2000 year-class (age 7) and the 2001 year-class (age 6) were dominant in the 2007 **catch-at-age** (Figure 6). Since 1990, the **average weights-at-age** for the fall spawner component have been below those observed during the 1980s (Figure 7).

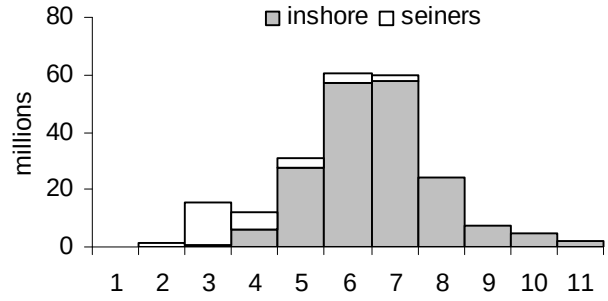


Figure 6. Fall spawner 2007 catch-at-age (millions of fish).

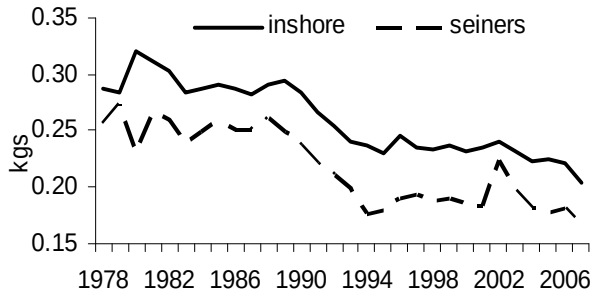


Figure 7. Weight (kg) of 5-year-old fall spawners.

ASSESSMENT

Spring Spawner Component

Stock Trends and Current Status

The determination of resource status of 4T spring spawning herring was derived using a population analysis model calibrated using the age-disaggregated gillnet catch rate (CPUE) and acoustic survey indices, plus the telephone survey opinion of abundance as an aggregated biomass index.

The spring CPUE analysis included dockside monitoring (DMP) catch data from all areas. Effort was calculated using the average number of nets used in each area obtained either from the telephone survey or DMP data. The spring CPUE analysis excluded June data as a large proportion of June catches are of the fall spawner component. CPUE was defined as kg/net/trip. **Mean spring spawner gillnet catch rate in 2007** (Figure 8) was among the lowest in the series that starts in 1990.

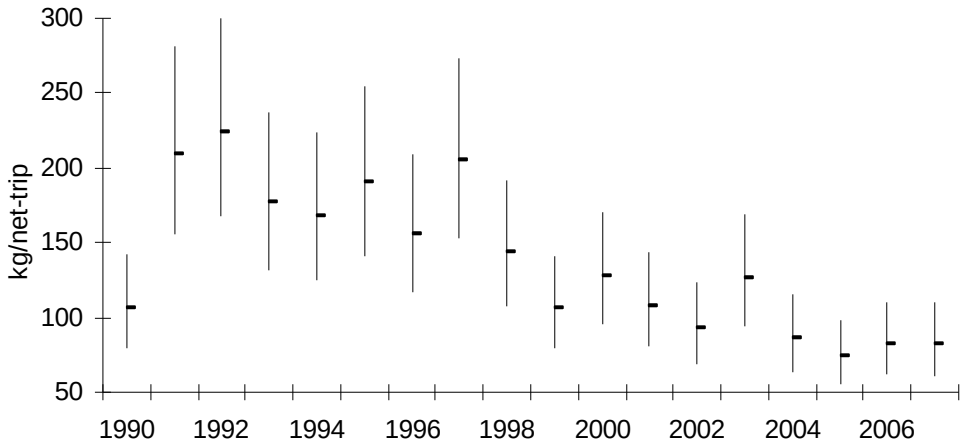


Figure 8. Spring spawner CPUE index (kg/net/trip).

The 2007 **acoustic survey abundance** (Figure 9) of the age 4+ spring spawner component was slightly lower than 2006, as was the combined abundance for ages 2 to 8. The 2007 acoustic index is the lowest in the series.

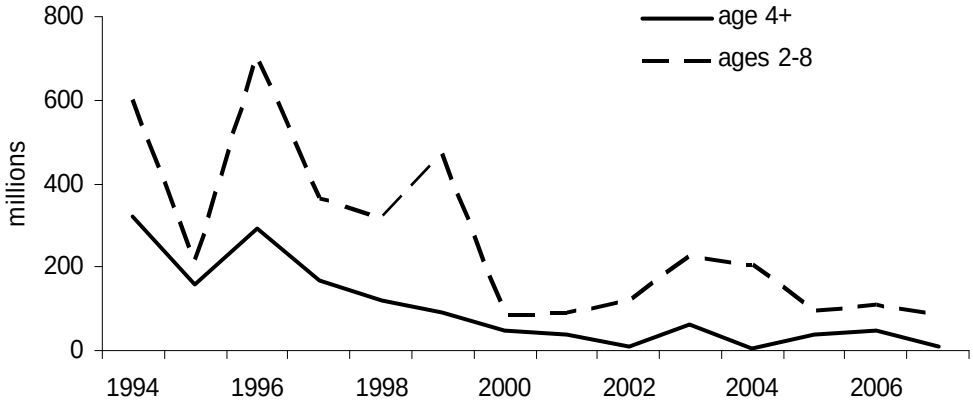


Figure 9. Spring spawner component acoustic survey index (millions of fish).

The **telephone survey** respondents are asked to relate the abundance of herring in the current year to the abundance in the previous year. This survey is used to provide an index of harvester opinions on the relative abundance of spring herring. The index reached a peak in 1998 and has been decreasing since (Figure 10). The 2007 abundance index of spring herring calculated from the opinions of harvesters contacted in the telephone survey was the lowest in the time series that starts in 1987.

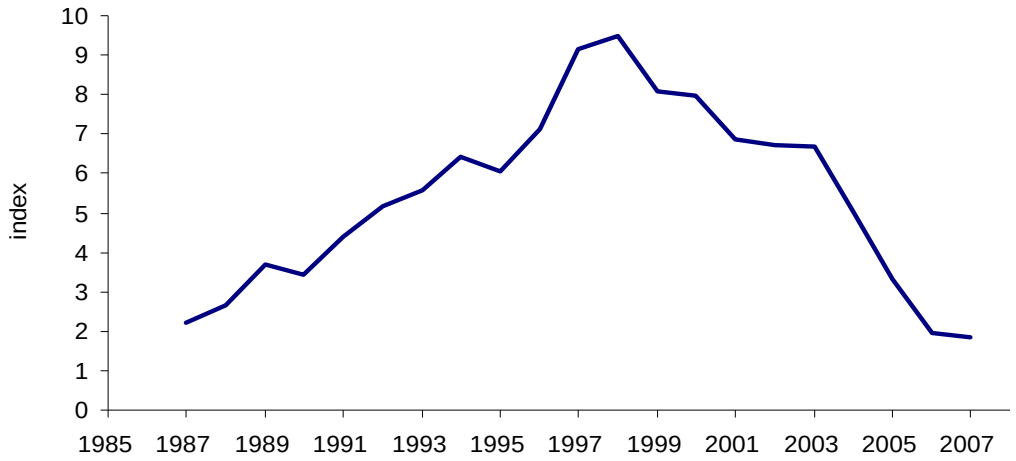


Figure 10. Telephone survey spring spawner opinion on abundance index.

All three indices indicate a marked downward trend in abundance since the mid-1990's up to and including 2007.

Population biomass (Figure 11) has declined since 1995 and remains at a low level since 2004. Age 4-10 spawning biomass is estimated at 20,500 t for the beginning of 2008. The abundances of year-classes after 1991 were average or below average. Age 4 in 2008 is estimated by multiplying the spawning stock biomass (SSB) in 2004 by the 2003-2007 average recruitment rate (age-4 abundance in year t / SSB in year t-4) instead of using a long term average as was the case in previous assessments.

The reference level **exploitation rate** at $F_{0.1}$ for the spring spawner component is about 27% for fully recruited ages 6 to 8. The estimated exploitation rate (Figure 12) was above the reference level from 1999 to 2005, but was below in 2006 and 2007.

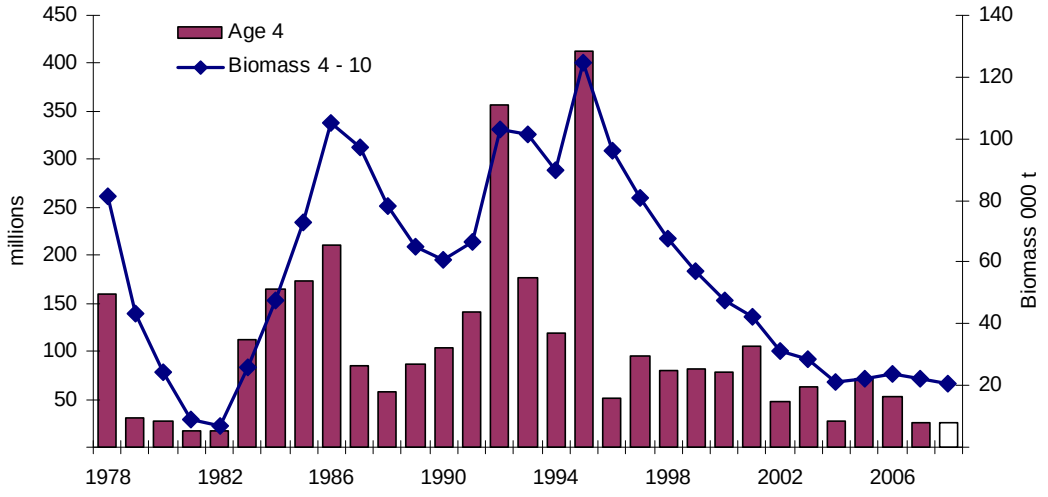


Figure 11. Spring spawner component age 4 numbers (millions of fish) and age 4 to 10 biomass (000 t).

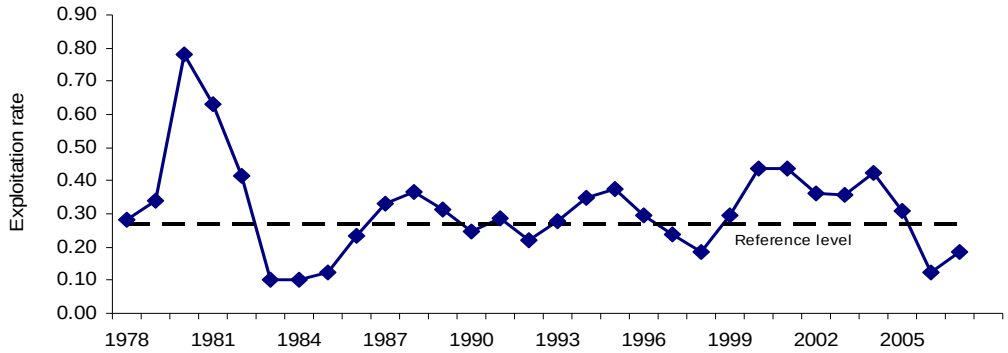


Figure 12. Spring spawner exploitation rates (ages 6 to 8).

Sources of Uncertainty

Catches of spring spawning herring used for bait (personal use licence) are not fully accounted for in the landings statistics. Recent gillnet catch rates remain near the lowest in the time series that starts in 1990 and are a source of uncertainty. Fishermen from the traditionally important areas in terms of landings suggest that the calculated catch rates may represent an overestimate. Trips with no catch are not documented and therefore not incorporated in the effort data. There are no recruitment estimates for ages 2 to 4 for 2008, components that are exploited by the fisheries.

Conclusions and Advice

For the spring component, the limit reference point (LRP) and interim upper stock reference (USR) points are 22,000 and 54,000 t respectively (DFO 2005). The removal rate reference has been set at $F_{0.1}$, which corresponds to F = 0.35 (about 27% exploitation rate over fully recruited ages 6 to 8). It is recommended that these reference points be used in the application of a Precautionary Approach framework for southern Gulf of St. Lawrence herring.

The current estimate of age 4-10 spawning stock biomass (SSB) of 20,500 t is below the LRP (Figure 13). At this level of biomass, the precautionary approach requires that removals from the stock should be kept to the lowest level possible.

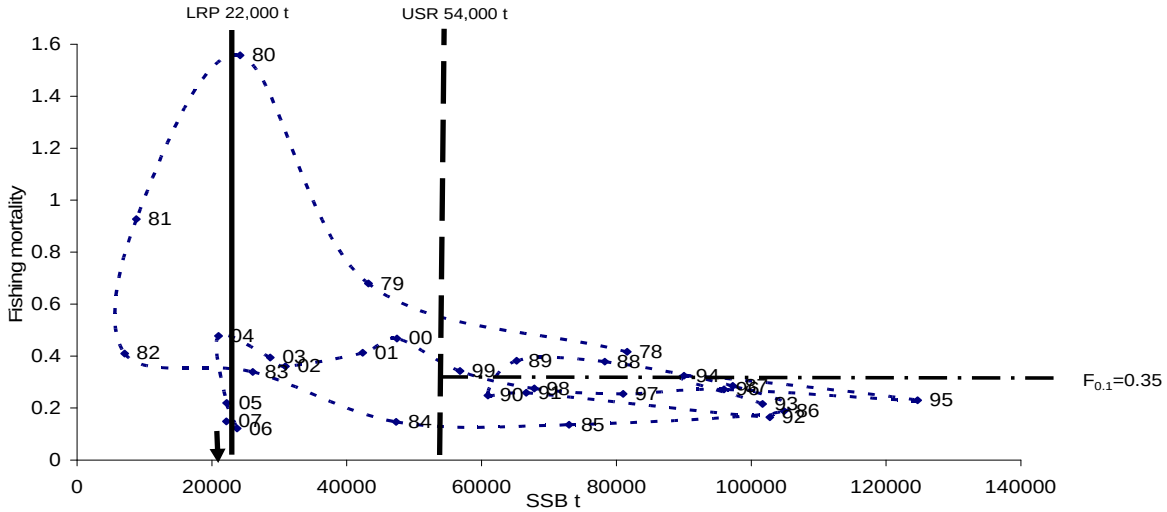


Figure 13. Spring spawner component biomass trajectory and limit reference points. Arrow represents 2008 SSB estimate.

The **risk analyses** (Figure 14) conducted were: 1) the probability of a decline in biomass, 2) the probability of spawning stock biomass being lower than 22,000 t (LRP). Even in the absence of any removals of the spring spawning component, there is a 50% probability that the biomass in 2009 will be below the limit reference point of 22,000 t. Catch options less than 1,500 t would provide a low probability (<25%) of further decline in biomass (Table 3).

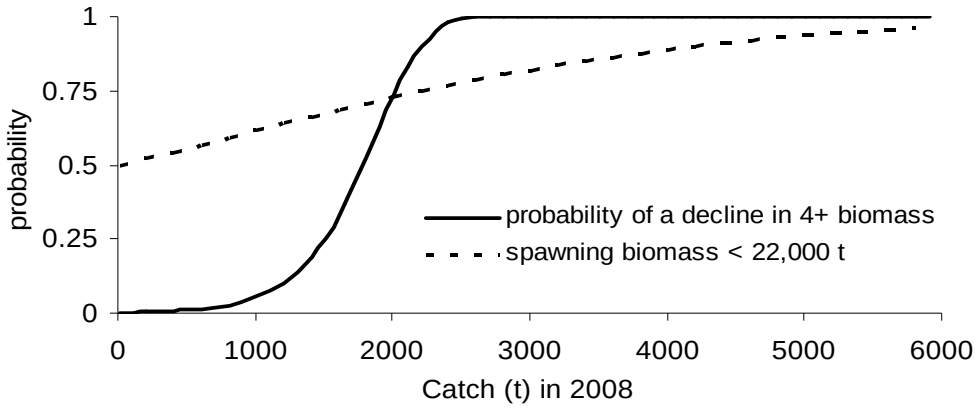


Figure 14. Spring spawner component risk analysis.

Table 3. Probability of a decline in spring biomass for different catch levels in 2008.

Catch (t)	1,200	1,300	1,400	1,500	1,600	1,700	1,800
Probability (%)	10	14	19	25	32	41	51

These risk analyses include uncertainties of the population estimates but not those associated with natural mortality, weight at age, partial recruitment and uncertainties around the age 4 abundance.

There is concern about the low abundance of herring in most areas. Specifically, there have been large declines in landings in the Escuminac, Northumberland Strait and Magdalen Islands gillnet fisheries in the past few years. These areas were the locations of important spawning grounds and historically had supported a large spring fishery. There has been a drop in relative catches of older fish in the last five years, but it is not similar to the 1982-86 period, when older fish were missing from the spring herring component. In those years, good recruitment revived the fishery; however, the abundance of year-classes produced after 1991 has been average or below average.

Given the current low abundance of the spring spawner component, which is below the limit reference point, harvesting strategies that promote rebuilding should be implemented.

Fall Spawner Component

Stock Trends and Current Status

For the fall spawning component, the acoustic survey index is not used to calibrate the population analysis because it does not track year-class strength consistently. Resource status of the 4T fall spawning herring was determined using a population analysis model calibrated with the age-disaggregated gillnet catch rate (CPUE) index and the telephone survey opinions on abundance that is used as an aggregated biomass index.

The age-disaggregated **gillnet catch rate** (CPUE) index is based on fishery data of inshore catches determined from purchase slips and the DMP combined with effort information derived from DFO data and a telephone survey of approximately 20% of the active inshore fishers (Figure 15). This index covers the entire inshore fleet and extends from 1978 to 2007. The mean CPUE for 2007 was lower than 2006 but remains among the highest in the time series.

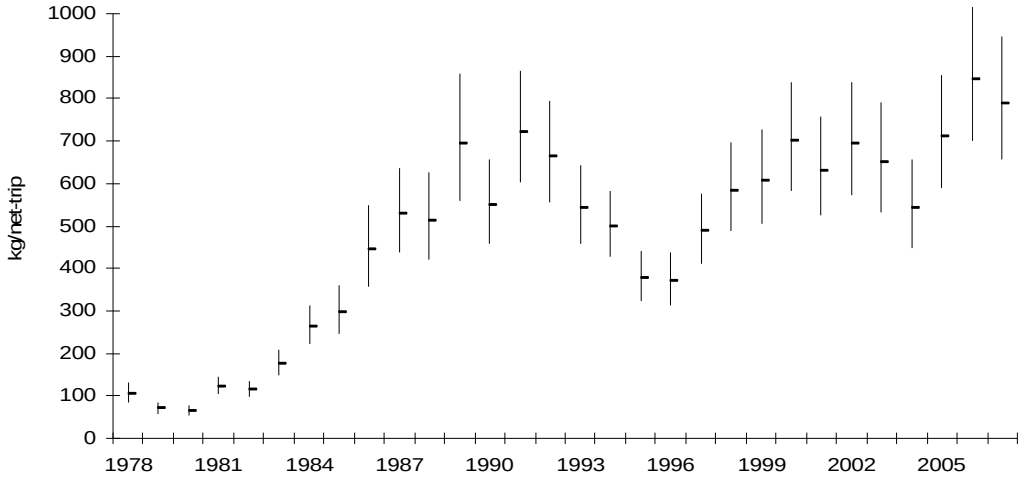


Figure 15. Fall spawner CPUE index (kg/net/trip).

The **telephone survey** respondents are asked to relate the abundance of herring in the current year to the abundance in the previous year. This survey is used to provide an index of harvester opinions on the relative abundance of fall herring. The index has been increasing since 1987 (Figure 16).

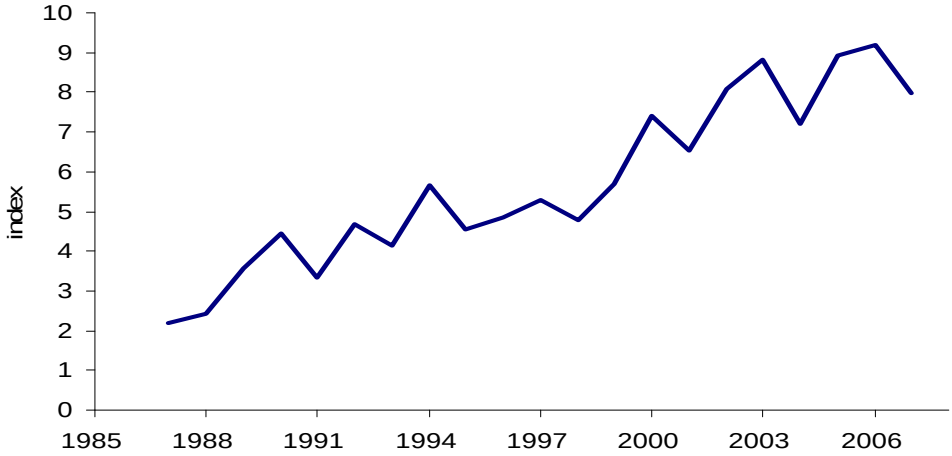


Figure 16. Telephone survey fall spawner opinion on abundance index.

Recruitment estimates (age 4, Figure 17) suggest that the abundance of the 1998 and 2000 year-classes is above average. Age 4 in 2008 is estimated by multiplying the spawning stock biomass (SSB) in 2004 by the 2005-2007 average recruitment rate (age-4 abundance in year t / SSB in year t-4) instead of using a long term average as in previous assessments.

The analysis indicates that **spawning population biomass** of age 4+ fall component peaked in 2005, when the large 1998 and 2000 year-classes were contributing to the fishery (Figure 17). The 2008 beginning-of-year age 4+ spawning biomass is estimated to be about 302,000 t, well above the upper stock reference (USR) biomass level of 172,000 t. The reference level

exploitation rate ($F_{0.1}$) for fall spawner component is about 25% for fully recruited age-groups (5+). Exploitation rate remains below the reference level (Figure 18).

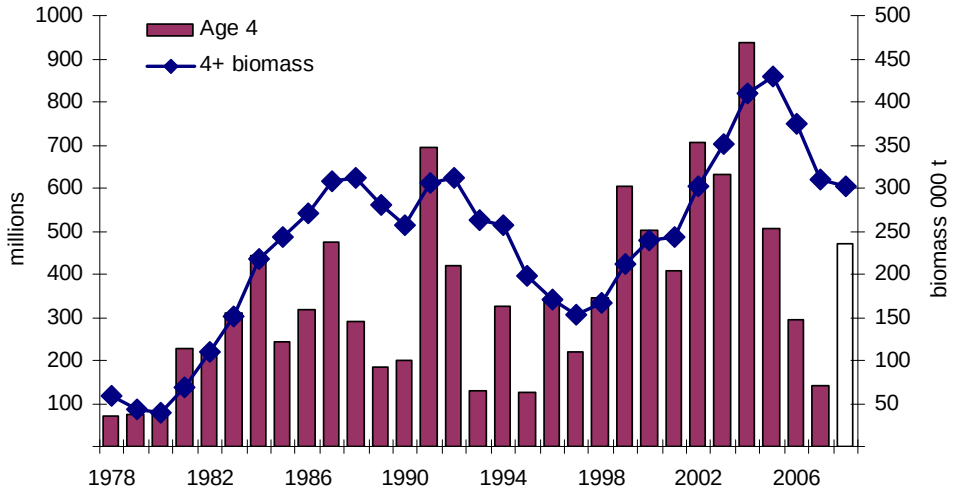


Figure 17. Fall spawner component age 4 numbers (millions of fish) and 4+ biomass (000 t).

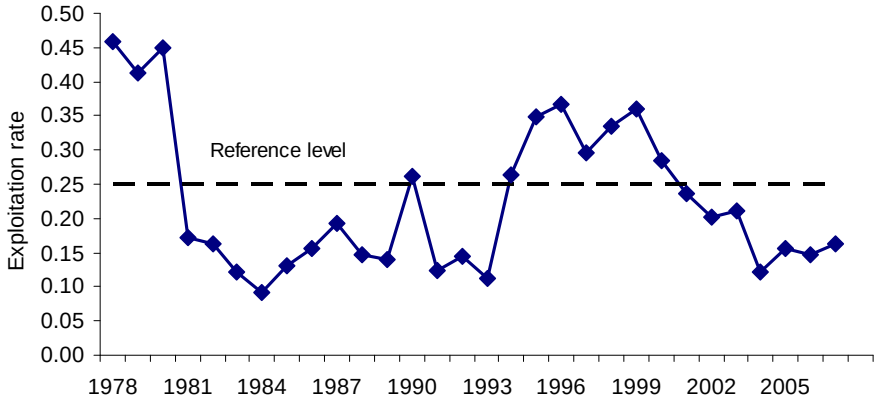


Figure 18. Fall spawner age 5+ exploitation rate.

Sources of Uncertainty

While catch rates from the gillnet fishery continue to be among the highest in the series, there is concern that catch rates may not accurately track population biomass because of the nature of the fishery. For example, boat limits and saturation of nets may impact CPUE negatively, while improved fishing technology could positively influence CPUE. Trips with no catch are not documented and therefore not incorporated in the effort data. In addition, there is a trend towards using gillnets with smaller mesh size that is not accounted for in the CPUE calculations.

There are no recruitment estimates for ages 2 to 4 for 2008, components that are exploited by the fisheries. Retrospective patterns were present with the addition of the 2007 data, suggesting an overestimation before 2004 and an underestimation since 2005. No adjustments of population estimates were done for the beginning of 2008.

Conclusions and Advice

For the fall spawning component, the limit reference point (LRP) and interim upper stock reference (USR) are 51,000 and 172,000 t respectively (DFO 2005). The removal rate reference

has been set at $F_{0.1}$, which corresponds to F = 0.32 or about 25% of the fully-recruited age-groups 5+.

Overall, the stock appears to remain at a high level relative to the late 1970's and early 1980's. Estimated recruitment at age 4 was above average from 1999 to 2005, but below average in 2007. The current estimate of spawning stock biomass (SSB) of 302,000 t is well above the upper stock reference point of 172,000 t (Figure 19).

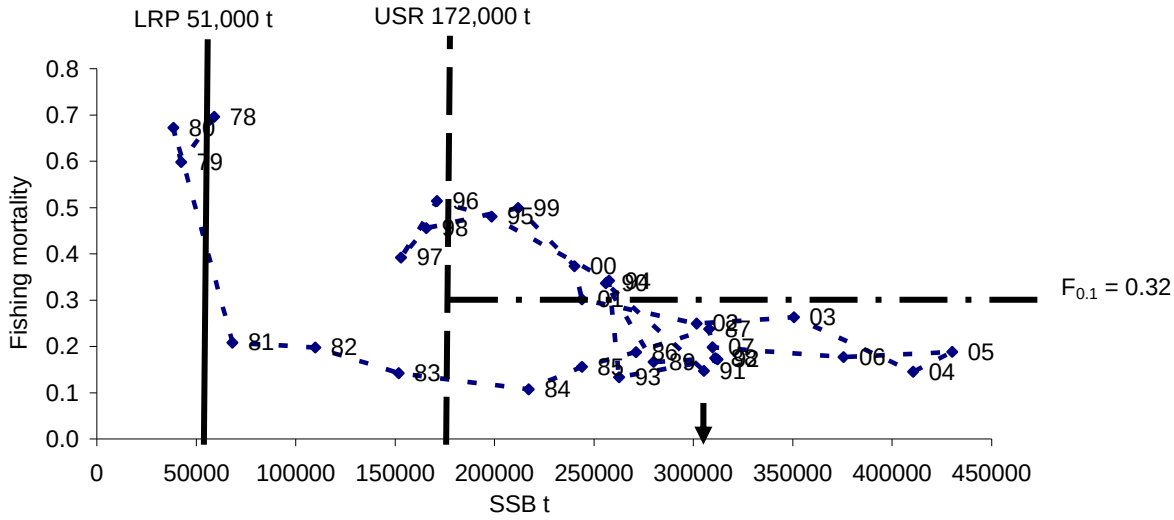


Figure 19. Fall spawner component biomass trajectory and limit reference points. Arrow indicates 2008 SSB.

It is possible to estimate the uncertainties regarding stock size and then use these in **risk analysis** (Figure 20). This analysis can provide some guidelines for decision making. For 2008, a catch option of 69,300 t corresponds to a 50% probability that F would exceed the $F_{0.1}$ removal rate. Fishing at $F_{0.1}$ is usually considered a safe exploitation rate when the stock is healthy. The risk analysis considered the probability of exceeding $F_{0.1}$, and those of obtaining no decline and a 5% decline in biomass. There is a low probability (< 25%) of a decline in biomass for catch options less than 50,000 t (Table 4). A catch of 69,300 t will result in a 50% probability of about a 7% decline in 4+ spawning biomass for 2009.

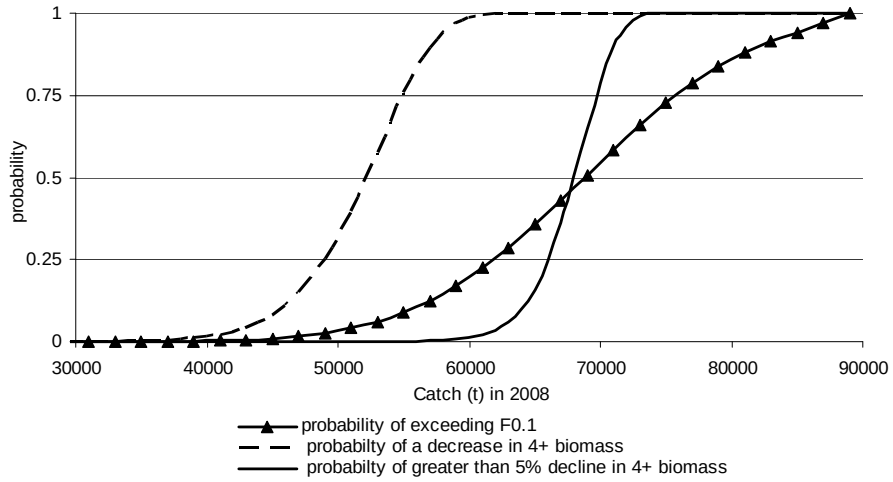


Figure 20. Risk analysis for the 4T herring fall spawning component.

Table 4. Probability of a decline in fall spawning herring biomass for different catch levels in 2008.

Catch (t)	43,000	45,000	47,000	49,000	51,000	53,000
Probability (%)	4	8	15	25	40	58

These risk analyses include uncertainties of the population estimates but not those associated with natural mortality, weight at age, partial recruitment and uncertainties around the age 4 abundance.

OTHER CONSIDERATIONS

The opinion survey from industry on the changes in abundance relative to the previous year is an important qualitative indicator for this assessment and corroborates the quantitative CPUE indices in both the spring and fall spawner assessments, as well as the acoustic index for the spring component. However, the appropriateness of incorporating this qualitative index in the population model requires further analysis. In particular, it is unclear whether changes in this index are proportional to abundance.

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