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Canadian Science Advisory Secretariat
Science Advisory Report 2009/032

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

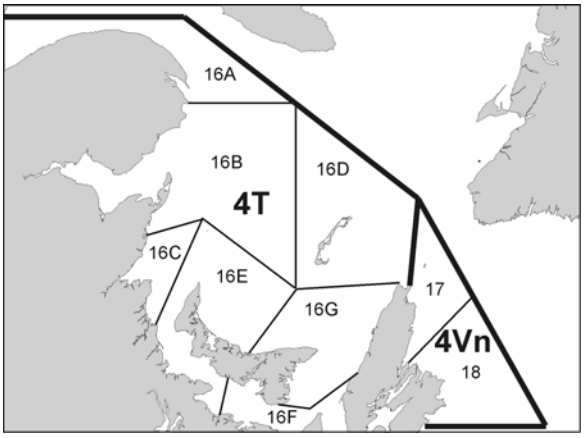

Figure 1. NAFO divisions 4T and 4Vn with corresponding herring management zones.

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, including 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 a 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 gillnet 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 2,900 gillnet 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 11–12 of March, 2009 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 2009 fishery. Participants included DFO scientists and fishery managers, representatives of the industry, provincial governments and non-DFO scientists.

May 2009

Canada

SUMMARY

Spring Spawner Component

- Reported landings of the spring spawner component in both the spring and the fall fisheries in 2008 were 2,755 t. The spring spawner TAC was 2,500 t.
- The cumulative index of the opinions of harvesters on the abundance of spring herring in 2008 was the lowest in the time series that starts in 1987.
- Mean gillnet catch rate in 2008 was higher than 2007, but similar to the values from 2004 to 2006. The index has been declining since 1997 and remains at a low level in the series that starts in 1990.
- The 2008 acoustic index was one of the lowest in the series that starts in 1994.
- The estimated exploitation rate was below the reference level in 2008.
- The abundances of year-classes after 1991 have been average or below average.
- Overall spawning stock biomass has declined since 1995 and remains at a low level since 2004.
- The current estimate of age 4+ biomass (20,300 t) is below the limit reference point (LRP, 22,000 t). 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 65% probability that the biomass in 2010 will be below the LRP. Catch options less than 1,100 t would provide a low probability (<25%) of a decline in biomass from 2009.

Fall Spawner Component

- Reported landings of the fall spawner component in both the spring and the fall fisheries in 2008 were 41,471 t. The fall spawner TAC was 68,800 t.
- The cumulative index from the opinions of harvesters on the abundance of fall herring has been decreasing since 2006, although the index is higher than it was prior to 2000.
- Mean gillnet catch rate in 2008 was lower than the previous three years.
- The exploitation rate in 2008 was below the $F_{0.1}$ reference level.
- Estimated recruitment at age 4 was above average from 1999 to 2005, and again in 2008.
- Overall, the stock remains at a high level of abundance relative to the late 1970's and early 1980's.
- The 2009 beginning-of-year spawning stock biomass is estimated to be about 285,500 t, above the upper stock reference (USR) level of 172,000 t.
- For 2009, a catch option of 65,500 t corresponds to a 50% chance that F would be above the $F_{0.1}$ removal rate. There is a low probability (< 25%) of a decline in biomass from 2009 for catch options less than 33,000 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

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

Table 1. TAC, allocations and landings in the 2008 spring fishery (January – June).

Area	Spring Fishery TAC	Total Reported Landings (t)	Spring Spawner Component Landings (t)	Fall Spawner Component Landings (t)	% Spring Spawner
Gillnet					
[a] Isle Verte 16A	4	13	12	1	--
[a] Chaleur Bay 16B	95	423	411	12	--
Escuminac 16C	130	30	13	17	--
[a] Magdalen Islands 16D	22	63	60	3	--
[a] Southeast NB – West PEI 16E	605	825	823	2	--
[a] 16F	7	67	34	33	--
[a] 16G	9	54	5	49	--
Reserve, 4Vn and June (16A-G)	1,049	[b]	[b]	[b]	--
Total Gillnet	**1,921**	**1,475**	**1,358**	**117**	**92**
Seiners (>65') 4T	**579**	**0**	**0**	**0**	**0**
Grand Total	**2,500**	**1,475**	**1,358**	**117**	**92**

[a] *Areas that used the reserve after initial TAC was reached.*
[b] *Partitioned in areas above*

Table 2. TAC, allocations and landings in the 2008 fall fishery (July – December).

Area	Fall Fishery TAC	Total Reported Landings (t)	Fall Spawner Component Landings (t)	Spring Spawner Component Landings (t)	% Fall Spawner
Gillnet					
Isle Verte 16A	144	11	11	0	--
Chaleur Bay 16B	24,976	18,762	18,762	0	--
Escuminac-West PEI 16CE	9,200	7,682	7,682	0	--
Magdalen 16D	344	62	60	2	--
Pictou 16F	9,005	5,332	5,332	0	--
Fisherman's Bank 16G	9,005	6,691	6,668	23	--
4Vn (Area 17)	344	--	--	--	--
Total Gillnet	**53,018**	**38,541**	**38,516**	**25**	**99.9**
Seiners (>65') 4T	**15,782**	**4,211**	**2,839**	**1,372**	**67**
Grand Total	**68,800**	**42,752**	**41,355**	**1,397**	**97**

The 2008 TAC for the spring spawner component was 2,500 t compared to 5,000 t in 2007 (Figure 2). The combined 2008 **landings of the spring spawner component** in both the spring and the fall fisheries were 2,755 t, including 1,372 t caught by the seiners in the fall fishery. There was no seiner effort in the spring fishery.

Year	Average 90-2004	2005	2006	2007	2008
TAC (000 t)	17	11	9	5	2.5
Landings (000 t)	17	5.1	2.9	3.8	2.8

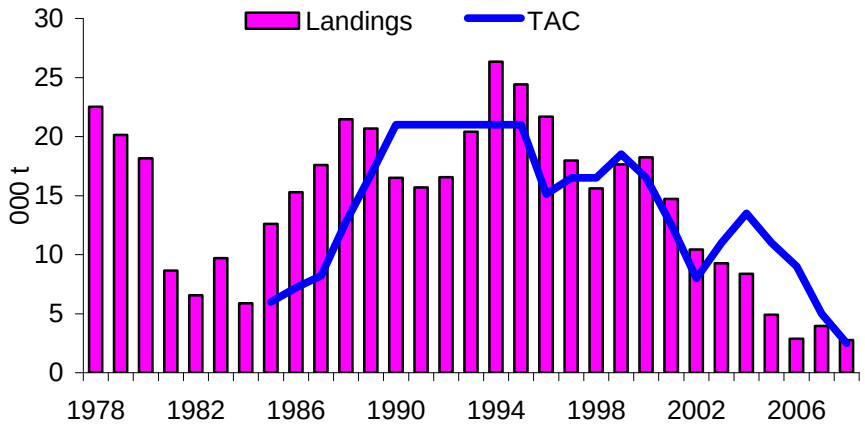

Figure 2. 4T total spring spawner component landings and TAC (000 t).

The **catch-at-age** of the 2008 **spring spawner component** was composed almost equally of ages 2 to 5, with few fish older than age 9 (Figure 3). Since 1990, the spring spawner component average **weights-at-age** 5 in the fishery have been below those observed during the 1980s (Figure 4).

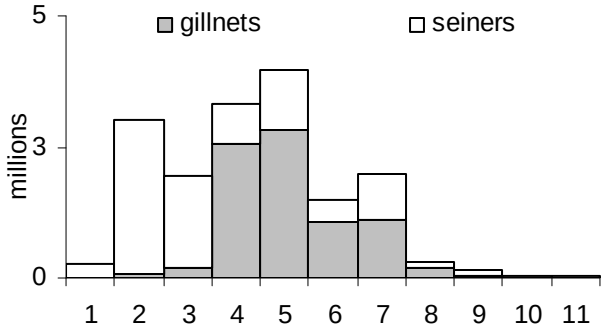

Figure 3. Spring spawner 2008 catch-at-age (millions of fish).

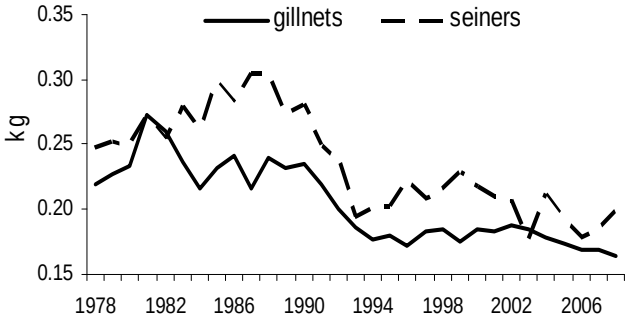

Figure 4. Weight (kg) of 5-year-old spring spawners.

The gillnetter **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 cumulative index reached a peak in 1998 and has been decreasing since (Figure 5). The 2008 cumulative index was the lowest in the time series that starts in 1987.

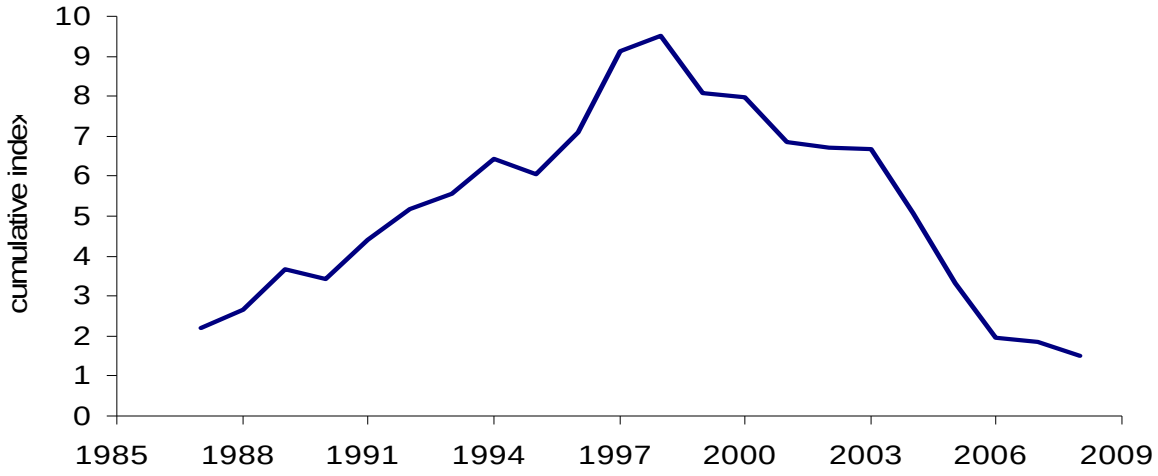

Figure 5. Telephone survey spring spawner opinion on abundance cumulative index.

The TAC for the fall spawner component in 2008 was 68,800 t, the same as in 2007 (Figure 6). The combined 2008 **landings of the fall spawner component** in both the spring and fall fisheries were 41,472 t.

Year	Average 90-2004	2005	2006	2007	2008
TAC (000 t)	67.5	70	68.8	68.8	68.8
Landings (000 t)	50.5	59.9	52.7	47.6	41.5

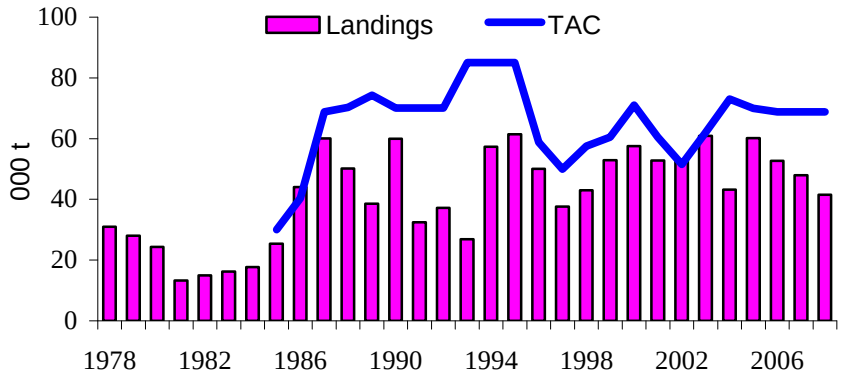

Figure 6. 4T total fall spawner component landings and TAC (000 t).

In 2008, 62% of the fall TAC was attained; seiners caught 27% of their allocation while the gillnet fleet caught 73% of their allocation (Table 2). In the landings of the **fall spawner component,** the 2000 year-class (age 8) and the 2004 year-class (age 4) were dominant in the 2008 **catch-at-age** (Figure 7). Since 1990, the fall spawner component **average weights-at-age** 5 in the fishery have been below those observed during the 1980s (Figure 8).

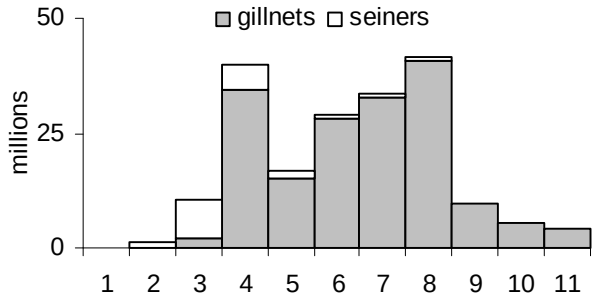

Figure 7. Fall spawner 2008 catch-at-age (millions of fish).

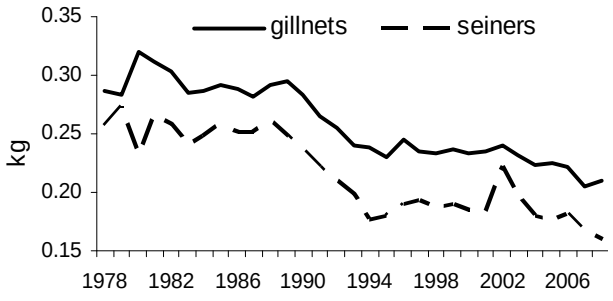

Figure 8. Weight (kg) of 5-year-old fall spawners.

The gillnetter **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 cumulative index has been decreasing since 2006, although the index is higher than prior to 2000 (Figure 9).

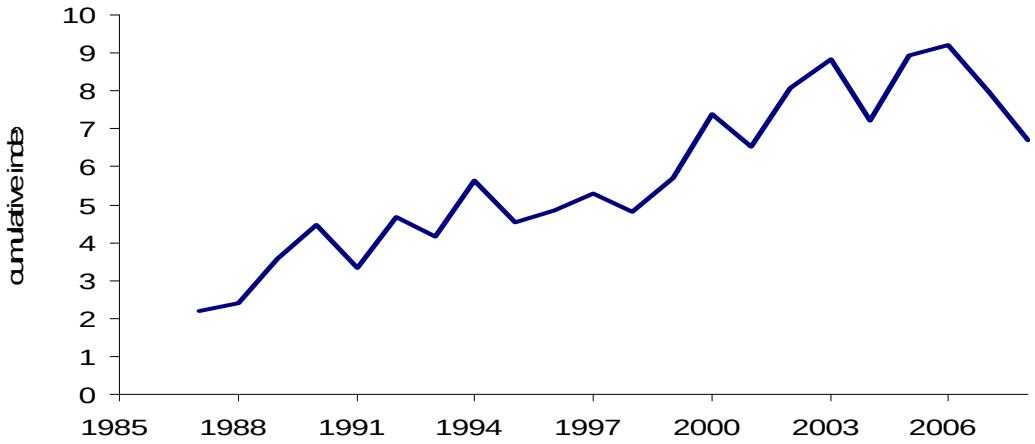

Figure 9. Telephone survey fall spawner opinion on abundance cumulative index.

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.

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** (Figure 10) in 2008 was higher than 2007, but similar to the values from 2004 to 2006. The index has been declining since 1997 and remains at a low level in the series that starts in 1990.

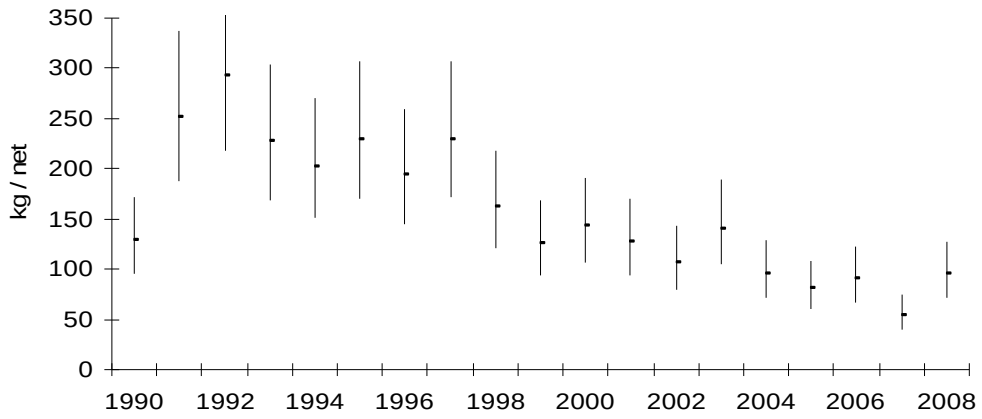

Figure 10. Spring spawner CPUE index (kg/net).

The 2008 **acoustic survey abundance** index (Figure 11) of the spring spawner component ages 4 to 8 was one of the lowest in the series.

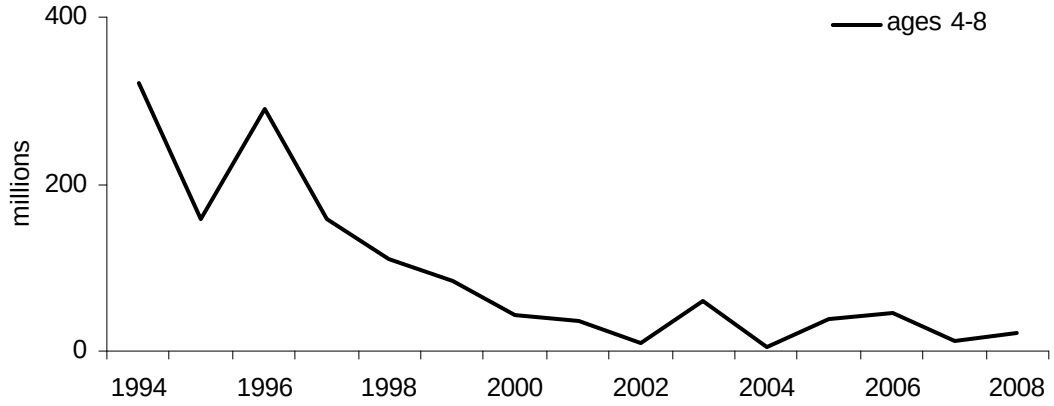

Figure 11. Spring spawner component acoustic survey index (millions of fish).

The gillnet catch rate and acoustic survey indices indicate a marked downward trend in abundance since the mid-1990's up to and including 2008.

Population biomass (Figure 12) has declined since 1995 and remains at a low level since 2004. Age 4+ spawning biomass is estimated at 20,300 t for the beginning of 2009. The abundances of year-classes after 1991 were average or below average. Age 4 abundance in 2009 is estimated by multiplying the spawning stock biomass (SSB) in 2005 by the 2004-2008 average recruitment rate (age-4 abundance in year t / SSB in year t-4).

The reference level **exploitation rate** at $F_{0.1}$ for the spring spawner component is about 0.27 for fully recruited ages 6 to 8. The estimated exploitation rate (Figure 13) was above the reference level from 1999 to 2005, below in 2006, above in 2007 and below in 2008.

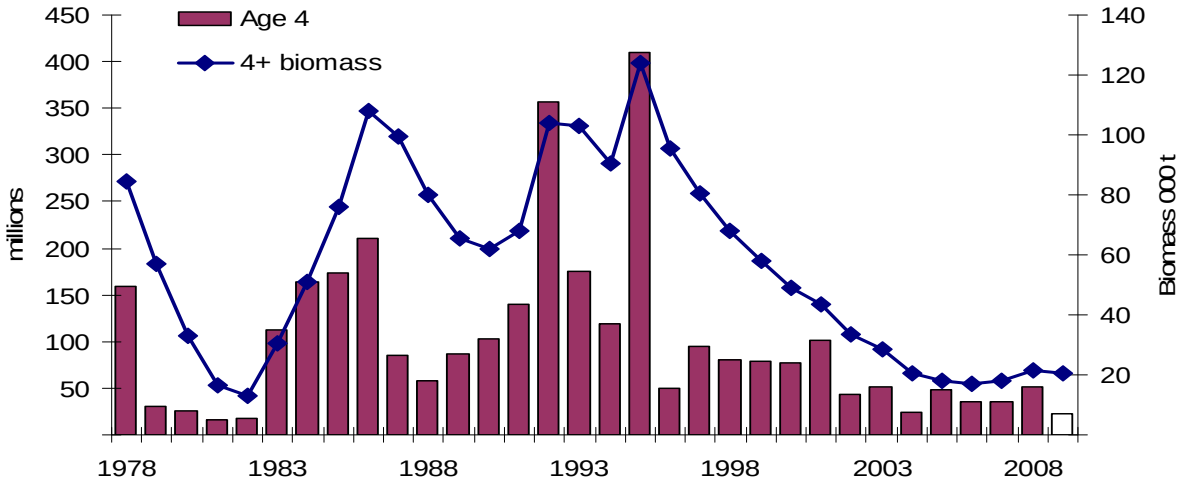

Figure 12. Spring spawner component age 4 numbers (millions of fish) and age 4+ biomass (000 t).

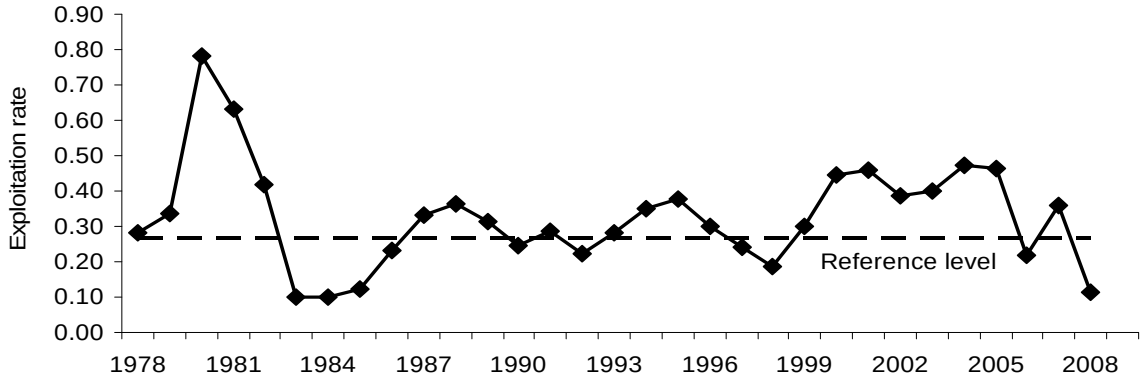

Figure 13. Spring spawner exploitation rates (ages 6 to 8).

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. Gillnet fishermen from the traditionally important areas in terms of landings suggest that the calculated catch rates are overestimated in recent years. Trips with no catch are not documented prior to 2006 and therefore not incorporated in the effort data. There are no indices of recruitment for ages 2 to 4 for 2009, 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). These reference points are used in the application of a Precautionary Approach framework for southern Gulf of St. Lawrence herring.

The current estimate of age 4+ spawning stock biomass (SSB) of 20,300 t is below the LRP (Figure 14). At this level of biomass, the precautionary approach requires that removals from the stock should be at to the lowest level possible.

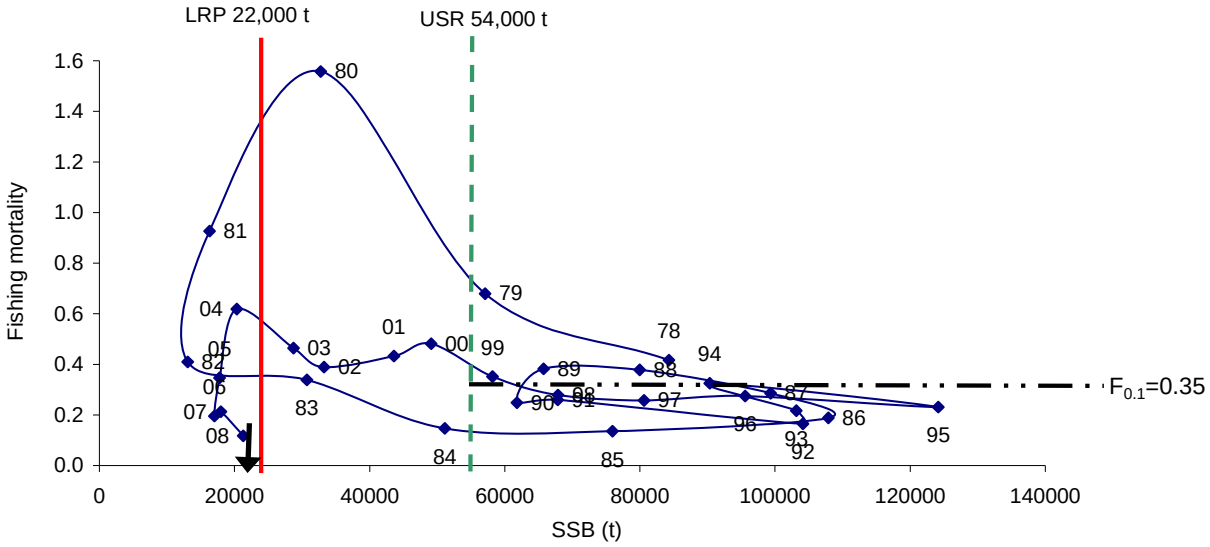

Figure 14. Spring spawner component biomass trajectory and limit reference points. Arrow represents 2009 SSB estimate.

The **risk analyses** (Figure 15) 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 65% probability that the biomass in 2010 will be below the limit reference point of 22,000 t. Catch options less than 1,100 t would provide a low probability (<25%) of further decline in biomass (Table 3).

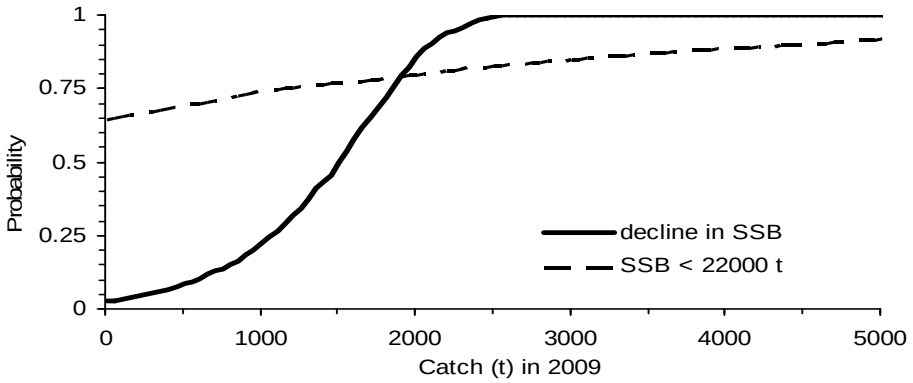

Figure 15. Spring spawner component risk analysis.

Table 3. Probability of a decline in spring biomass for different catch levels in 2009.

Catch t	1,000	1,100	1,200	1,300	1,400	1,500	1,600
Probability (%)	22	26	32	37	43	50	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.

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 are very few catches of herring older than age 8 years since 2006. The stock has experienced comparable age truncation in the past (1982-86). In those years, good recruitment rebuilt the spawning stock biomass (SSB); 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.

Projections were conducted of the probability of recovery in the medium term (10 years) of the spring spawner component to a level above the limit reference point (LRP 22,000 t) for different catch level options (Table 4). The spring spawning component is also captured in the fall fishery; therefore a catch of 0 t may not be feasible. An annual catch of 1,000 t would result in a 60% probability that the SSB > LRP by 2019.

Table 4. Spring spawner component 10 year projection.

Annual catch (t)	Probability (SSB > 22,000 t in 2019)
0	0.972
1,000	0.604
2,000	0.228
3,000	0.037

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.

The age-disaggregated **gillnet catch rate** (CPUE) index is based on fishery data of gillnet catches determined from purchase slips and dockside monitoring data (DMP) combined with effort information (hauls) derived from DMP data and a telephone survey of a sample (20%) of the active gillnet fishers (Figure 16). The effort information used in this index is different than previous years as it used hauls instead of nets. This index covers the entire gillnet fleet and extends from 1986 to 2008. The mean CPUE for 2008 was lower than the previous three years.

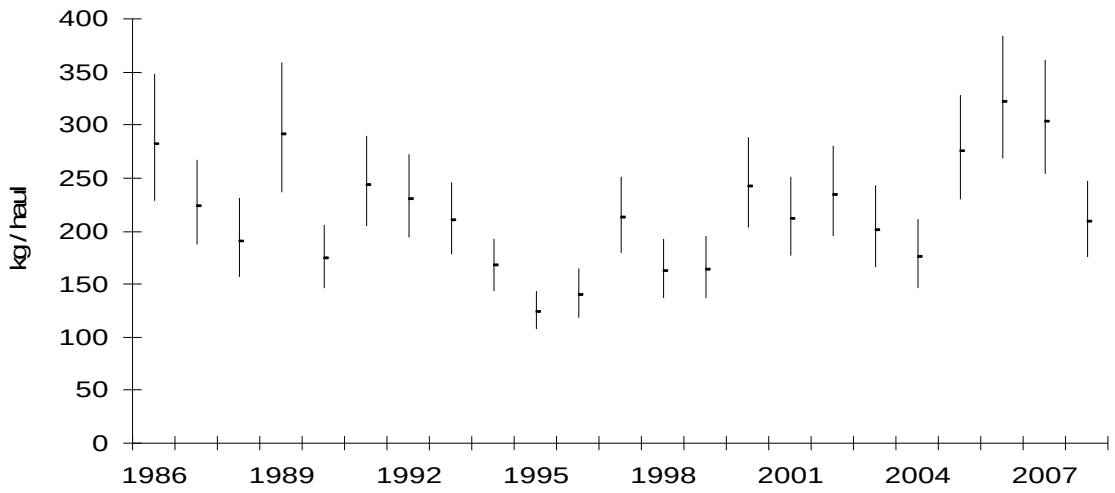

Figure 16. Fall spawner CPUE index (kg/ haul).

Recruitment estimates (age 4, Figure 17) suggest that the abundance of the 2000 and 2004 year-classes is above average. Age 4 in 2009 is estimated by multiplying the spawning stock biomass (SSB) in 2005 by the 2006-2008 average recruitment rate (age-4 abundance in year t / SSB in year t-4).

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 2009 beginning-of-year age 4+ spawning biomass is estimated to be about 285,500 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 0.25 for fully recruited age-groups (5+). Exploitation rate remains below the reference level (Figure 18).

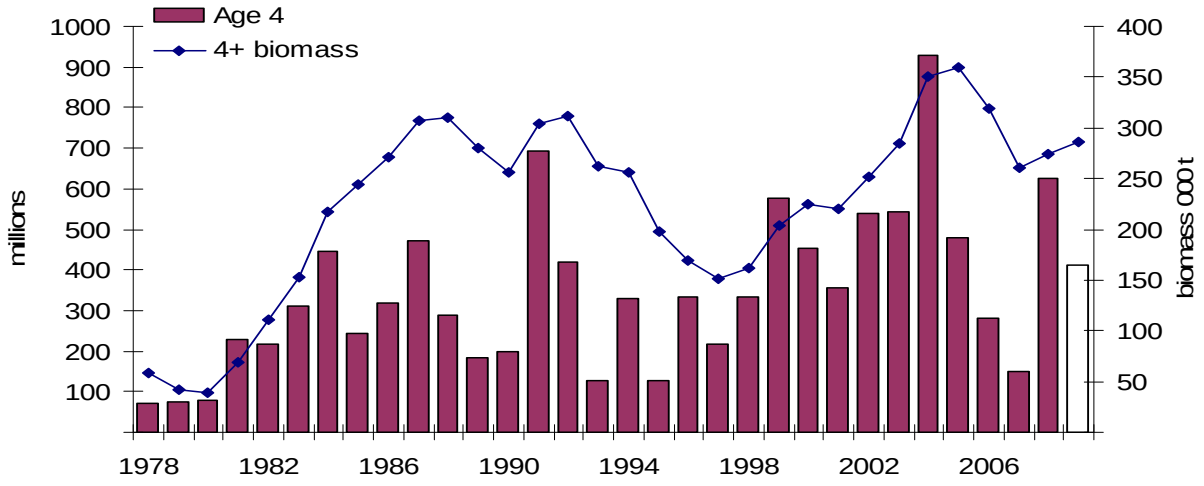

Figure 17. Fall spawner component age 4 numbers (millions of fish) and 4+ biomass (000 t).

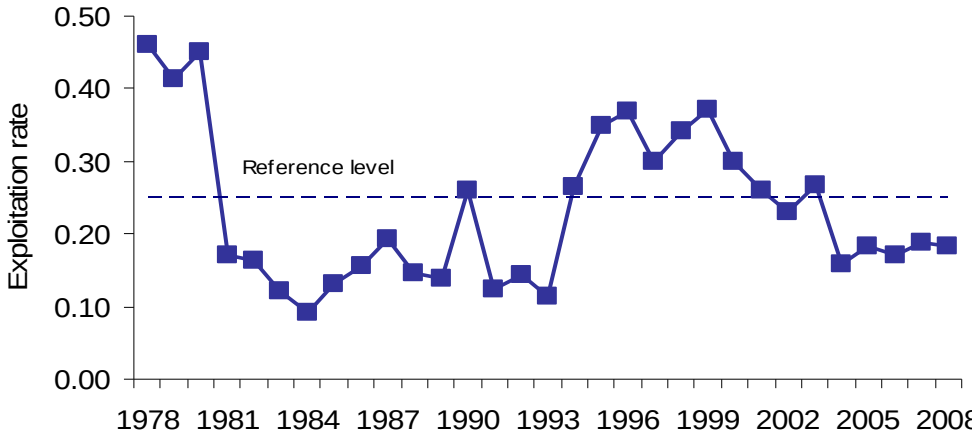

Figure 18. Fall spawner age 5+ exploitation rate.

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. 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 prior to 2006 and therefore not incorporated in the effort data. There are potential inconsistencies in the reporting of effort data (number, hauls, length, and depth of gillnets). 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 indices of recruitment for ages 2 to 4 for 2009, components that are exploited by the fisheries. Retrospective patterns were present with the addition of the 2008 data, suggesting an overestimation before 2004 and an underestimation since 2005. No adjustments of population estimates were made to the beginning of 2009 estimates.

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, and again in 2008, but below average in 2007 (Figure 17). The current estimate of spawning stock biomass (SSB) of 285,500 t is above the upper stock reference point of 172,000 t (Figure 19).

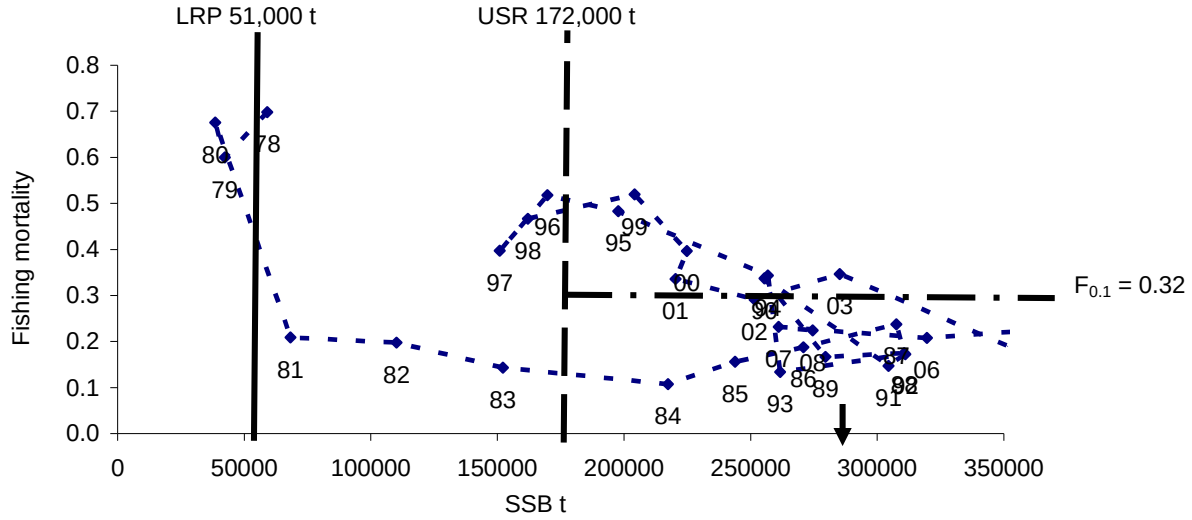

Figure 19. Fall spawner component biomass trajectory and limit reference points. Arrow indicates 2009 SSB.

It is possible to estimate the uncertainties regarding stock size and then use these in **risk analysis** (Figure 20). The risk analysis considered the probabilities of exceeding $F_{0.1}$, and those of obtaining no decline and a 5% decline in biomass. Fishing at $F_{0.1}$ is usually considered a safe exploitation rate when the stock is healthy. For 2009, a catch option of 65,500 t corresponds to a 50% probability that F would exceed the $F_{0.1}$ removal rate. This catch level corresponds to a 50% probability of about a 12% decline in 4+ spawning biomass for 2010. There is a low probability (< 25%) of a decline in biomass for catch options less than 33,000 t.

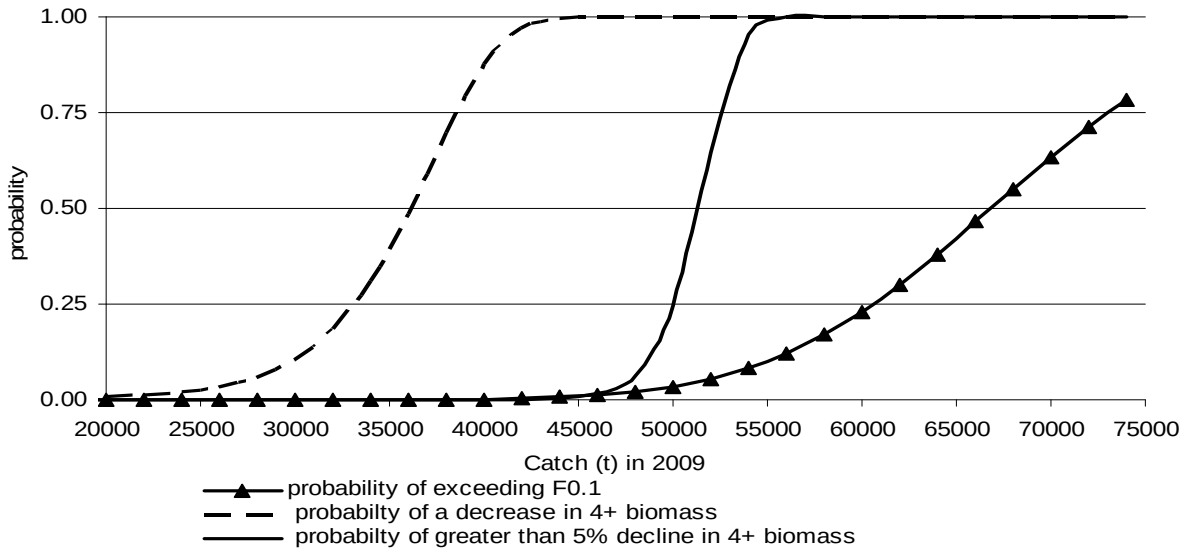

Figure 20. Risk analysis for the 4T herring fall spawning component.

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

Despite large reductions in catches of the spring spawner component, the spawning stock biomass remains below the limit reference point and the recruitment rate remains low. The assessment does not provide any information on changes in the ecosystem which may be conditioning the recruitment rates for the spring spawner component. Ecosystem changes have been noted in the southern Gulf and industry participants provided observations of changes they have noted, including higher tides and rising sea levels, increased abundance of other forage species such as capelin, and increasing abundance of grey seals. Many of these and presumably other factors may be contributing to the sustained low recruitment rates.

Several indicators presented by industry participants were suggested as providing a less positive view of SSB for the fall spawner component than the values provided by the assessment model. The failure of the industry to catch the quota over the past several years, reports of fish being difficult to find and catch, changes in water temperature that affect where and when they spawn and increased abundance of predators are all indicators presented in support of a lower abundance of the fall spawner component and suggest a more cautious approach to exploitation.

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