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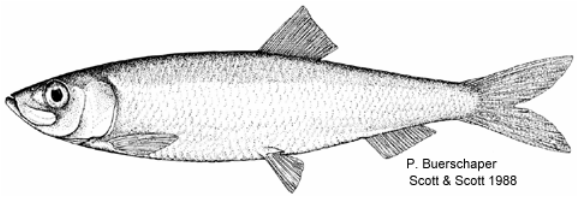
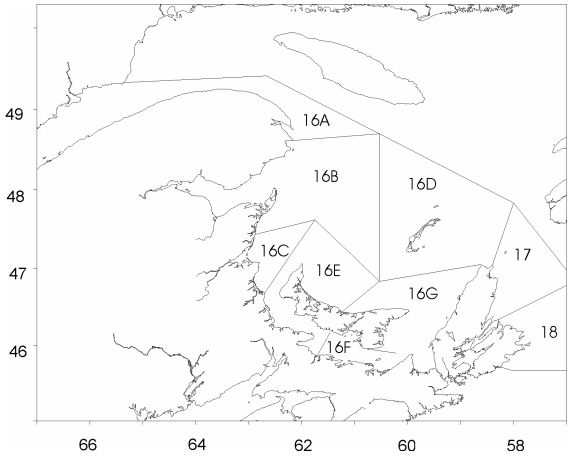
Canadian Science Advisory Secretariat
Science Advisory Report 2007/005

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





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. Available information suggests that adults overwinter off the east coast of Cape Breton primarily in NAFO area 4Vn. Studies in the early 1970's indicated that southern Gulf herring also overwintered off the south coast of Newfoundland.

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 and otolith shape type.

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 3,250 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 are required on an annual basis and form a part of the information base 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 7–8 of March, 2007 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 2007 fishery. Participants included DFO scientists and fishery managers, representatives of the industry, provincial governments and non-DFO scientists.

SUMMARY

Spring Spawner Component

- The 2006 landings of the spring spawner component in both the spring and the fall fisheries were 2,148t against the spring spawner TAC of 9,000t.
- Mean inshore gillnet catch rate in 2006 was the lowest in the series that starts in 1990.
- The 2006 acoustic survey index of abundance remains near the lowest in the series that starts in 1994.
- The 2006 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.
- The population model outputs are considered unreliable. Biomass in 2007 is considered overestimated, given the decline in abundance indices and the inability to catch the TAC in recent years.
- To describe stock status, emphasis was put on the abundance indices trends and recent year's catches versus TAC levels.
- The model estimate of Age 4-10 biomass, which is considered an overestimate, is well below the Upper Stock Reference (USR) of 54,000t. Consistent with the precautionary approach, harvesting strategies that promote rebuilding should be adopted. Catch levels in 2007 should be less than in 2006.

Fall Spawner Component

- Reported 2006 landings of the fall spawner component in both the spring and the fall fisheries were 52,214t against the fall spawner TAC of 68,800t.
- Mean inshore gillnet catch rates in 2006 were the highest in the time series that starts in 1978.
- The 2006 abundance index of fall herring calculated from the opinions of harvesters contacted in the telephone survey was the highest in the time series that starts in 1987.
- Recruitment estimates from the model analysis indicate that the 1995, 1998 and 2000 year-classes are above average.
- The 2007 beginning-of-year Age 4+ spawning biomass is estimated to be about 316,100t, well above the Upper Stock Reference of 172,000t, and remains amongst the highest since 1978.
- The fully recruited (Age 5+) exploitation rate in 2006 was below the $F_{0.1}$ target.
- The catch at $F_{0.1}$ for 2007 is 75,500t. This would result in an estimated 20% decline in biomass for 2008.

BACKGROUND

Species Biology

Herring are a pelagic species which form schools during feeding and spawning periods. Herring in the southern Gulf of St. Lawrence 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 produce more eggs than small females. First spawning occurs primarily at age four. In recent years, the largest spring spawning populations are in the Northumberland Strait and Magdalen Islands areas and the largest fall spawning populations 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.

2006 SPRING FISHERY

Area	Spring Spawner Component Final Allocation and Season TAC	Spring Season Landings (t)	Spring Spawner Component Landings in the Spring Season (t)	Fall Spawner Component Landings in the Spring Season (t)
INSHORE				
Isle Verte 16A	29	5	5	0
Chaleur Bay 16B (Jan-June 15)	528	*529	516	31
Escuminac 16C (Jan-June 15)	912	35	35	2
Magdalen Islands 16D (Jan-June15)	1,730	* 160	160	0
Southeast NB – West PEI 16E (Jan-June15)	3,072	438	363	0
16F (Jan-May)	195	193	81	84
16G(Jan-May)	84	82	34	40
June (16A-G), Reserve and 4Vn	381	616	225	481
Total Inshore	**6,931**	**2,058**	**1,419**	**638**
Seiners (>65') 4T	**2,069**	**0**	**0**	**0**
Grand Total	**9,000**	**2,058**	**1,419**	**638**

**16D and part of 16B (Gaspésie) landings include bait fishery catches not counted against the spring TAC*

2006 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)
INSHORE				
Isle Verte 16A	144	0	0	0
Chaleur Bay 16B	24,976	23,749	23,749	0
Escuminac-West PEI 16CE	9,200	8,124	8,124	0
Magdalen 16D	344	0	0	0
Pictou 16F	9,005	8,981	8,981	0
Fisherman's Bank 16G	9,005	8,297	8,297	0
4Vn (Area 17)	344	0	0	0
Total Inshore	**53,018**	**47,151**	**47,151**	**0**
Seiners (>65') 4T	**15,782**	**5,154**	**4,425**	**729**
Grand Total	**68,800**	**52,305**	**51,576**	**729**

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.

2006 Percentage of Spring and Fall Spawning Components

		Spawning Group %	
Season	**Gear**	**Spring**	**Fall**
Spring	Inshore	69	31
	Seiner	0	0
Fall	Inshore	0	100
	Seiner	14	86

The 2006 TAC for the spring spawner component was 9,000t compared to 11,000t in 2005 (Figure 1). The combined 2006 **landings of the spring spawner component** in both the spring and the fall fisheries were 2,148t.

Total Spring Component Landings (000s t)

Year	Average 90-2002	2003	2004	2005	2006
TAC	17.5	11.0	13.5	11.0	9.0
Landings	18.7	9.3	8.4	5.1	2.1

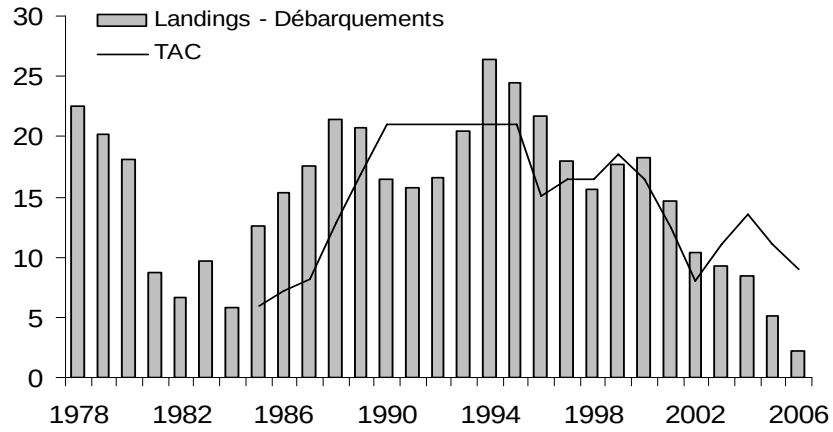


Figure 1. 4T Total Spring Spawner Component Landings and TAC (000t).

The 2006 spring spawner component TAC was not reached. There was no spring seiner effort. In the gillnet fishery, Escuminac (16C) caught only 4% of their allotted quota, while the Magdalen Islands (16D) caught 9% and Northumberland Strait (16E) caught 14% of their allotted quotas.

The **catch-at-age** of the 2006 **spring spawner component** was dominated by the 2001 (Age 5) and the 2002 (Age 4) year-classes (Figure 2). Since 1990, average **weights-at-age** for the spring spawner component have been below those observed during the 1980s (Figure 3).

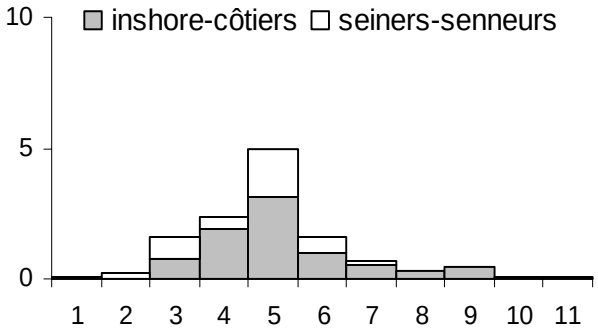


Figure 2. Spring Spawner 2006 Catch-at-Age (millions of fish).

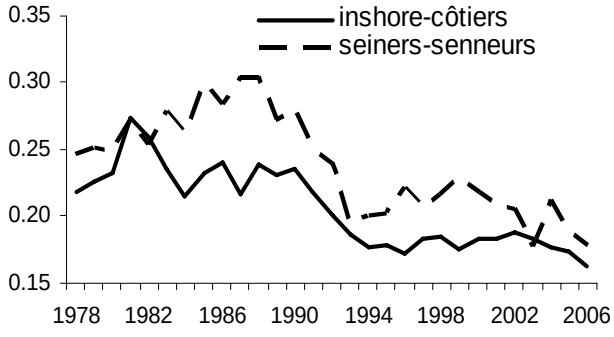


Figure 3. Weight (kg) of 5-Year-Old Spring Spawners.

The TAC for the fall spawner component in 2006 was 68,800t, compared to 70,000t in 2005 (Figure 4). The seiner allocation for 4Vn (Area 17) is included with the fall spawner component. The combined 2006 **landings of the fall spawner component** in both the spring and fall fisheries were 52,214t. There was no fishery in the 4Vn (Area 17) overwintering area by the purse seine fleet.

Total Fall Component Landings (000s t)

Year	Average 90-2002	2003	2004	2005	2006
TAC	67.5	62.0	73.0	70.0	68.8
Landings	50.2	60.9	43.2	59.9	52.2

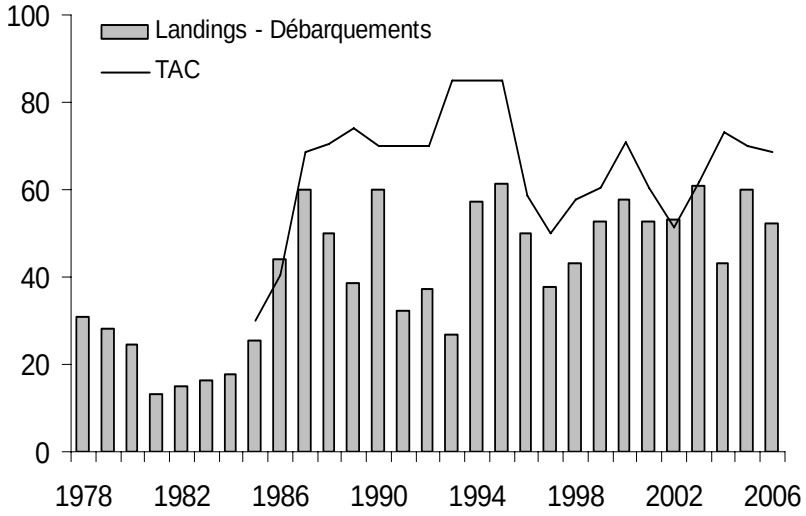


Figure 4. 4T Total Fall Spawner Component Landings and TAC (000t).

In 2006, the fall spawner TAC was not attained mostly because seiners caught only approximately 33% of their share of the allocation. For the **fall spawner component,** the 2000 year-class (Age 6) was dominant in the 2006 **catch-at-age** (Figure 5). Since 1990, the **average weights-at-age** for the fall spawner component have been below those observed during the 1980s (Figure 6).

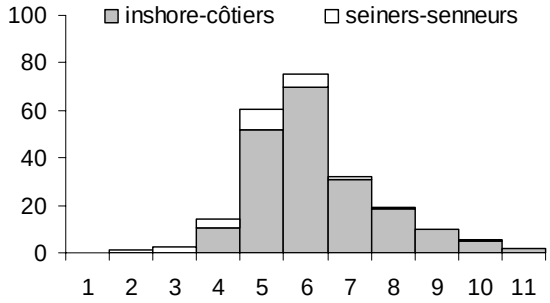


Figure 5. Fall Spawner 2006 Catch-at-Age (millions of fish).

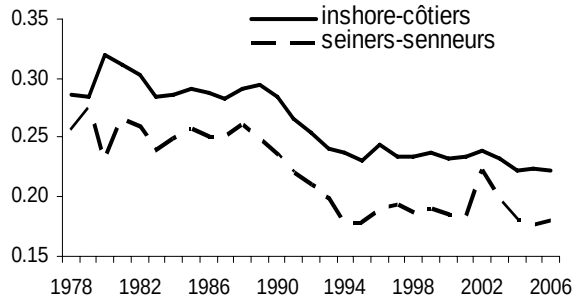


Figure 6. Weight (kg) of 5-Year-Old Fall Spawners.

ASSESSMENT

Spring Spawner Component

Stock Trends and Current Status

The determination of resource status of 4T spring spawning herring was attempted using a population analysis model calibrated on the age-disaggregated gillnet catch rate (CPUE) and acoustic survey indices, plus the telephone survey abundance opinion as an aggregated biomass index. The model fit was unreliable and the residuals indicate large year effects that

put into doubt its use as a true indicator of current biomass levels. To describe stock status, emphasis was put on the abundance indices trends and recent year's catches versus TAC levels.

The spring CPUE analysis included dockside monitoring data from all areas with recorded landings data. Effort was calculated using the average number of nets used in each area, as determined by the telephone survey. 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 2006** (Figure 7) was the lowest in the series that starts in 1990.

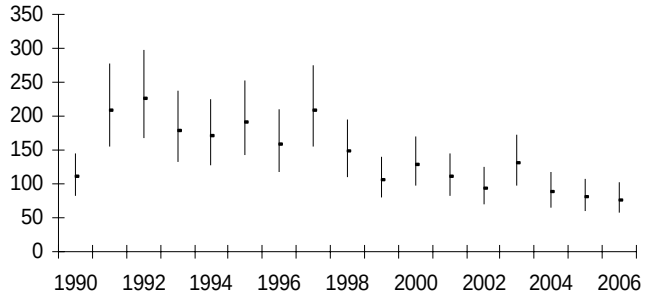


Figure 7. Spring Spawner CPUE index (kg/net/trip).

The 2006 **acoustic survey abundance** (Figure 8) of the Age 4+ spring spawner component was similar to 2005, as was the combined abundance for ages 2 to 8. The 2006 acoustic index remains near the lowest in the series.

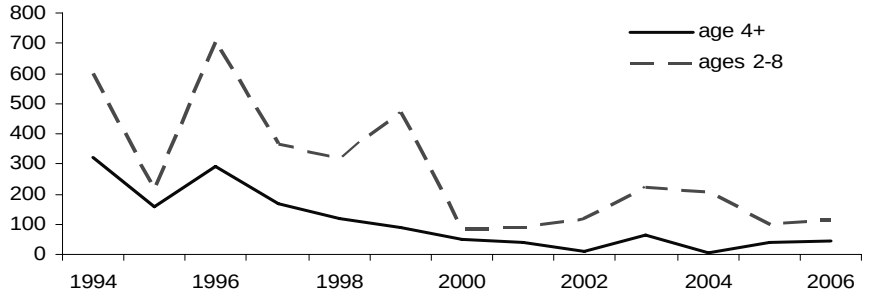


Figure 8. Spring Spawner Component Acoustic Survey Index (millions of fish).

The **telephone survey** respondents are asked to relate the abundance of herring in the current year to the abundance in the previous year. The annual responses were then added cumulatively, weighted by the catch by area, to give a trend of biomass abundance from 1987 to the current year. The index reached a peak in 1998 and has been in a decreasing trend since (Figure 9). The 2006 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.

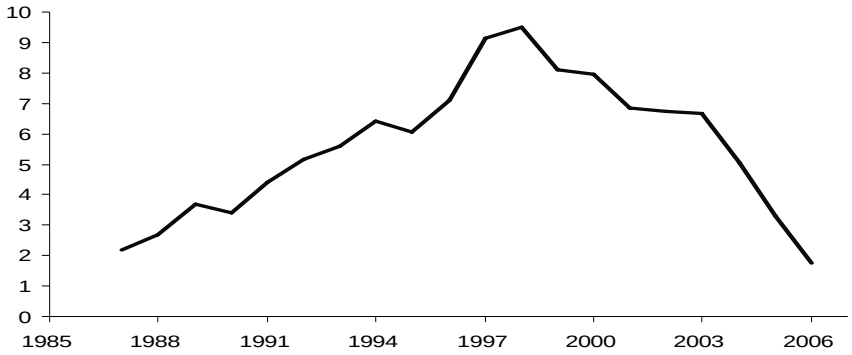


Figure 9. Telephone survey Spring Spawner abundance opinion index.

All three indices indicate a marked downward trend in abundance since the mid-1990's up to and including 2006.

Model outputs for the spring component are presented for illustrative purposes only. **Population biomass** (Figure 10) has declined from 1995 to 2004, and increased since 2005. This does not coincide with the trends in the abundance indices since 2005. The model output Age 4-10 spawning biomass is estimated at 35,500t for the beginning of 2007. However, this is likely an overestimate. The target **exploitation rate** at $F_{0.1}$ for the spring spawner component is about 27% over fully recruited ages 6 to 8. The estimated exploitation rate (Figure 11) has been above the target in recent years but below the target in 2006. This is likely an underestimate given the declining indices and the inability to catch the TAC in recent years.

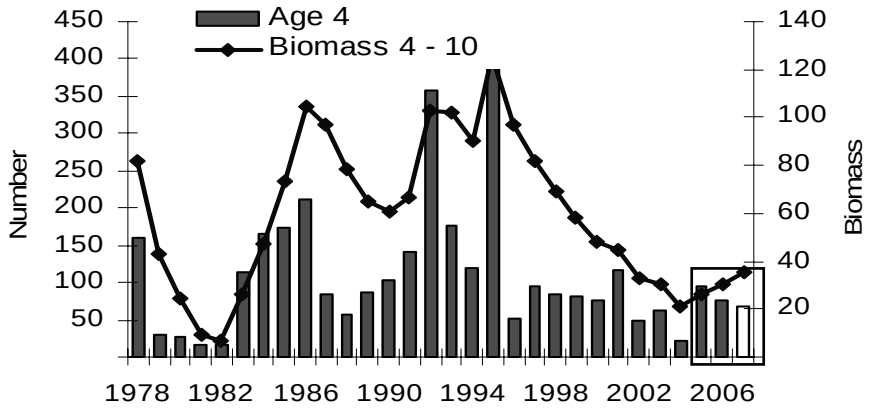


Figure 10. Spring Spawner Component Age 4 Numbers (millions of fish) and Age 4 to 10 Biomass (000t). Age 4 in 2007 is the geometric mean of 1996-2006. Box indicates uncertainty of the estimates.

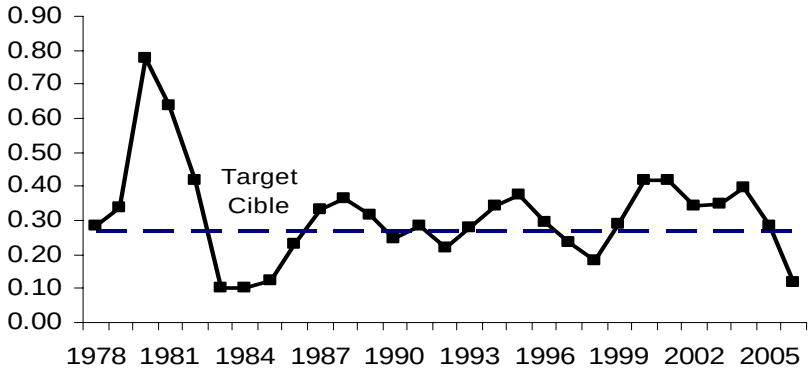


Figure 11. Spring Spawner Exploitation Rates (ages 6 to 8).

Sources of Uncertainty

Recent gillnet catch rates are the lowest in the time series that starts in 1990 and are a **source of uncertainty**. Views from fish harvesters in the traditionally important areas in terms of landings (e.g. 16 C and E) are that catch rates may represent an overestimate. In particular, the amount of effort used may be underestimated as trips with no catch do not have to be reported. All three abundance indices indicate a continued decline in abundance from 2005 to 2007 contrary to the population model estimates. There are no recruitment estimates for ages 2 to 4 for 2007, and the error associated with the estimate for Age 5 is large. The discrepancy of views between the model outputs since 2005 and both the abundances indices and fishery catches is a major source of uncertainty. It is believed that the model is overestimating the spawning stock biomass and underestimating the fishing mortality.

Conclusions and Advice

The upper stock reference (USR) biomass level for spring spawning herring is 54,000t. Below this level of biomass, the application of the precautionary approach requires that the exploitation rate be reduced below $F_{0.1}$ and harvest strategies that promote rebuilding be adopted. The model estimate of Age 4-10 biomass, which is considered an overestimate, is well below the USR. Catch levels in 2007 should be less than in 2006.

There is concern about the very large declines, as reflected by catches, in some areas. Specifically, landings in the Escuminac gillnet fishery (herring fishing area 16C) were only 4% of their allotted quota, while the Magdalen Islands (16D) caught 9% and Northumberland Strait (16E) caught 14% of their allotted quotas. These areas were the locations of important spawning grounds and historically supported a large spring fishery. Given the current state of the spring spawner component, harvesting strategies that promote rebuilding should be considered.

Fall Spawner Component

Stock Trends and Current Status

The **acoustic survey** in 2006 indicates that abundance was higher than in 2005. For the fall spawning component, this index is not used to calibrate the population analysis because it does not follow year-class strength consistently.

Resource status of the 4T fall spawning herring was determined using a population analysis model calibrated on both the age-disaggregated gillnet catch rate (CPUE) index and the telephone survey abundance opinion as an aggregated biomass index. The model outputs were accepted as current indicators of stock status.

The age-disaggregated **gillnet catch rate** (CPUE) index is based on fishery data of inshore catches determined from purchase slips and the Dockside Monitoring Program (DMP) combined with effort information derived from DFO data and a telephone survey of approximately 25% of the active inshore fishers (Figure 12). This index covers the entire inshore fleet and extends from 1978 to 2006. The mean CPUE for 2006 was the highest in the time series.

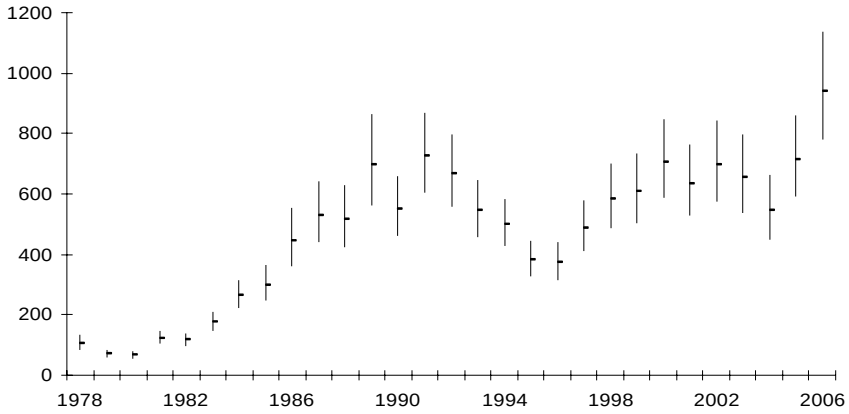


Figure 12. Fall Spawner CPUE index (kg/net/trip).

The **telephone survey** respondents are asked to relate the abundance of herring in the current year to the abundance in the previous year. The annual responses were then added cumulatively, weighted by the catch by area, to give a trend of biomass abundance from 1987 to the current year. The 2006 abundance index of fall herring calculated from the opinions of harvesters contacted in the telephone survey was the highest in the time series that starts in 1987 (Figure 13).

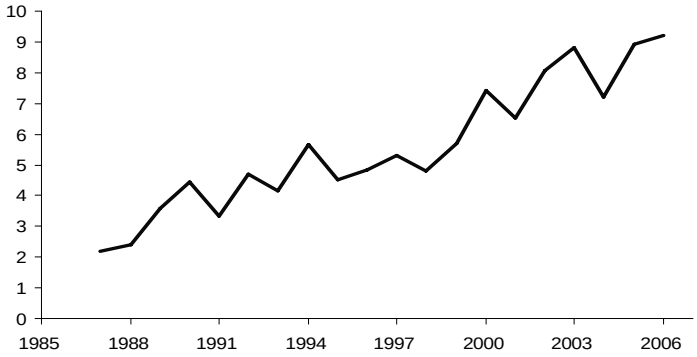


Figure 13. Telephone survey Fall Spawner abundance opinion index.

Retrospective patterns (in this case, a tendency to overestimate stock abundance) were present in assessments prior to 2005 and were compensated for by reducing the estimated numbers. Since the last assessment, there has been no retrospective patterns and no reduction of population estimates has been necessary for the beginning of 2007 (Figure 14).

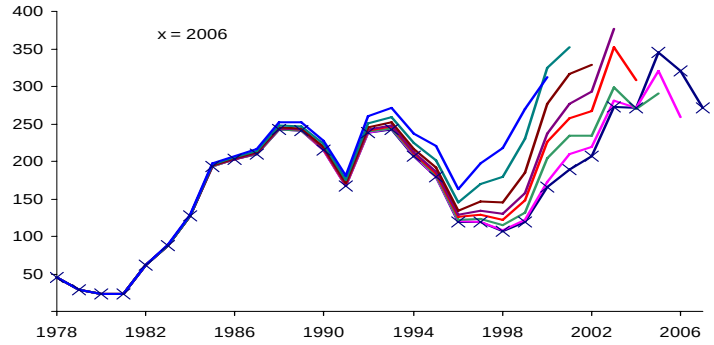


Figure 14. Fall Spawner Age 5 – 11 biomass (000t) retrospective.

Recruitment estimates (Age 4) from the analysis (Figure 15) suggest that the abundance of the 1995, 1998 and 2000 year-classes is above average and that overall abundance is currently high. The analysis indicates that **spawning population biomass** (Figure 15) of Age 4+ fall component peaked in 2004, when the large 1998 and 2000 year-classes were contributing to the fishery. The 2007 beginning-of-year Age 4+ spawning biomass is estimated to be about 316,100t and remains amongst the highest since 1978, well above the upper stock reference (USR) biomass level of 172,000t. The target **exploitation rate** ($F_{0.1}$) (Figure 16) for fall spawner component is about 25% for fully recruited age-groups (5+). Exploitation rate remains below the target.

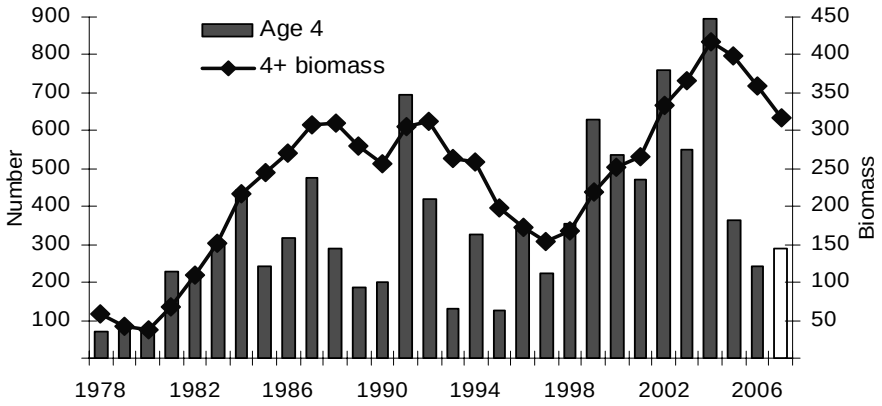


Figure 15. Fall Spawner Component Age 4 Numbers (millions of fish) and 4+ biomass (000t). Age 4 in 2007 is the geometric mean of 1978-2006.

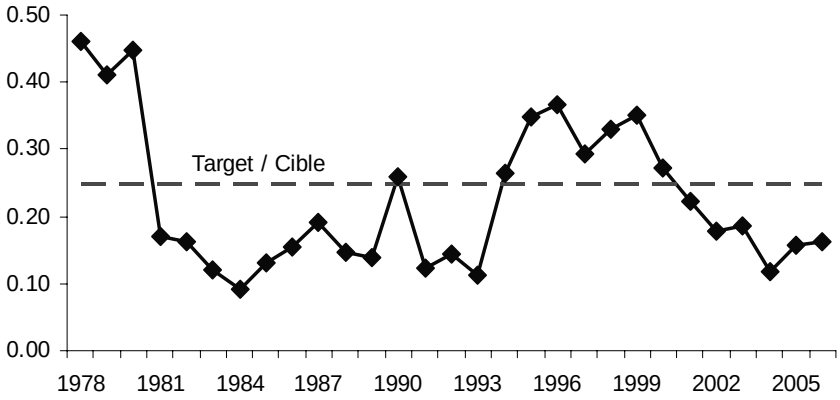


Figure 16. Fall Spawner Age 5+ Exploitation Rate.

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 searching behaviour could positively influence CPUE. There is uncertainty whether changes in the opinion index are proportional to changes in population biomass. The appropriate way of including this index to calibrate the population model requires further research. There is uncertainty about the recent year-classes (2003-2005) as there are no estimates of recruitment prior to Age 5 in 2007.

Conclusions and Advice

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 2004, but below average in 2006. The current estimate of spawning stock biomass (316,000t) is well above the upper stock reference point of 172,000t. The $F_{0.1}$ estimation of fall spawner catch for 2007 is 75,500t. Fishing at the $F_{0.1}$ level will result in a 20% decline in 4+ spawning biomass for 2008. Fishing at $F_{0.1}$ is usually considered a safe exploitation rate when the stock is healthy.

It is possible to estimate the uncertainties regarding stock size and then use these in **risk analysis** (Figure 17). This analysis can provide some guidelines for decision making. The risk analysis considered the probability of exceeding $F_{0.1}$, and those of obtaining a 5% or a 10% decline in biomass. For example, it indicates that a low probability of a 10% decline in biomass corresponds to a catch of less than 50,000t.

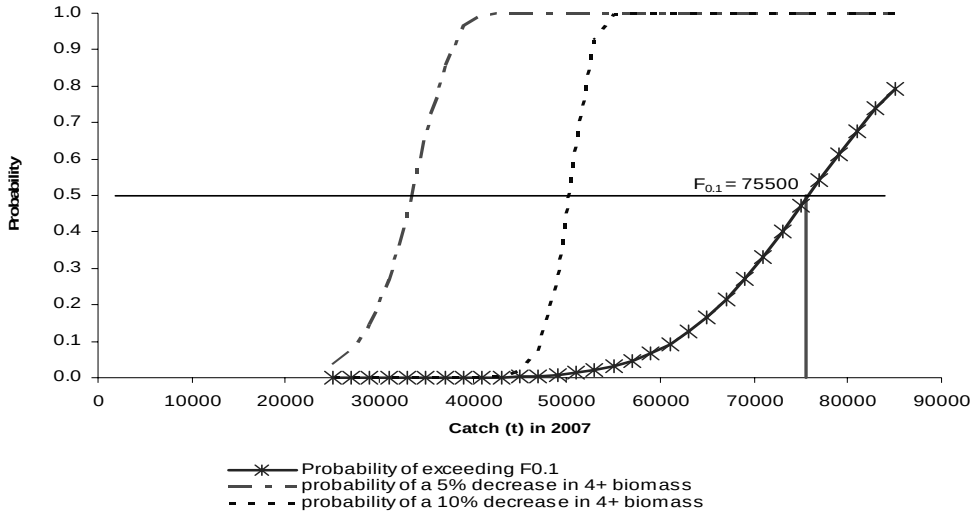


Figure 17. Risk Analysis for the Fall Component.

This risk analysis includes uncertainties in population estimates but not those associated with the retrospective pattern, natural mortality, weight at age or partial recruitment.

SOURCES OF INFORMATION

DFO, 2005. Spawning Stock Biomass Reference Points for Southern Gulf of St. Lawrence Herring. DFO Can. Sci. Advis. Sec. Advis. Rep. 2005/070.

FOR MORE INFORMATION

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