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

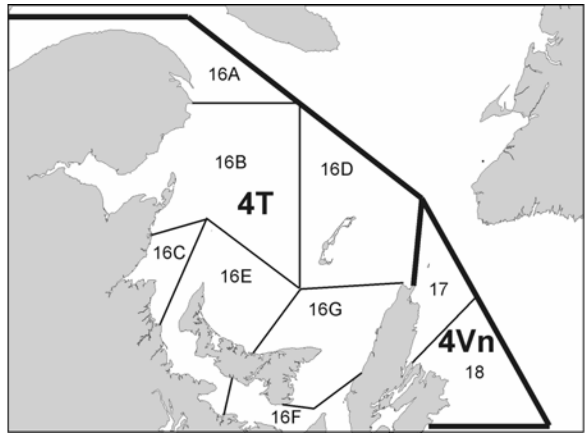


Figure 1. NAFO divisions 4T and 4Vn with corresponding herring management zones.

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. In the past two years, spring herring have been sold primarily for bait but historically were also used for the bloater (smoked herring) and filet markets. Fall landings are primarily driven by the roe, bloater and filet markets. TAC management was initiated in 1972. Currently there are approximately 2,840 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 March 9 and 10, 2010 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 2010 fishery. Participants included DFO scientists and fishery managers, representatives of the industry, provincial governments.

SUMMARY

Spring Spawner Component

- Reported landings of the spring spawner component in both the spring and the fall fisheries in 2009 were 1,667 t. The spring spawner TAC was 2,500 t.
- The opinions of fixed gear harvesters from the telephone survey was that abundance of spring herring in 2009 was higher than 2008.
- Mean gillnet catch rate in 2009 was higher than 2008, but similar to values since 2004. The index has been declining since 1997 and remains at a low level in the series that starts in 1990.
- The 2009 acoustic index was higher than 2008 but remains low in the series that starts in 1994.
- Overall spawning stock biomass has declined since 1995 and remains at a low level.
- The current estimate of age 4+ spawning stock biomass (SSB) of 28,200 t is above the limit reference point (LRP) of 22,000 t but below the upper stock reference (USR) of 54,000 t. When the SSB declines below the USR, a harvesting strategy compliant with the Precautionary Approach (PA) would reduce the exploitation rate to promote stock growth to above the USR.
- The estimated exploitation rate in 2009 was 8% and below the removal reference level of 27%. The realized reduced exploitation rate on this component since 2007 is consistent with the PA.
- The abundances of recruiting year-classes (at age 4) after the 1991 year-class have been average or below average.
- A catch option of about 1,100 t in 2010 would provide a 50% probability of at least a 5% increase in biomass in 2011.
- Projections for the fisheries over the next two years (2010-2011) show that the probability of a 5% increase in biomass from 2010 to 2012 is 62% with annual catches of 2,000 t or less in 2010 and 2011.

Fall Spawner Component

- Reported landings of the fall spawner component in both the spring and the fall fisheries in 2009 were 46,747 t. The fall spawner TAC was 65,000 t.
- The opinion of fixed gear harvesters from the telephone survey is that the abundance of fall herring has been decreasing since 2006, with a slight increase in 2009.
- Mean gillnet catch rate in 2009 was slightly higher than 2008 but was lower than the previous three years.
- The exploitation rate in 2009 was 19%, below the $F_{0.1}$ reference level of 25%.
- Estimated recruitment at age 4 was above average from 1999 to 2005, and again in 2008 and 2009.
- Overall, the stock remains at a high level of abundance relative to the late 1970’s and early 1980’s.
- The 2010 beginning-of-year spawning stock biomass is estimated to be about 307,400 t, above the upper stock reference (USR) level of 172,000 t.
- For 2010, a catch option of 67,700 t corresponds to a 50% chance that exploitation rate would be above the reference removal rate. There is a low probability (< 25%) of a decline in biomass from 2009 for catch options less than 42,000 t.
- Projections for the fisheries over the next two years (2010-2011) show that the probability of a decline in biomass of more than 10% from 2010 to 2012 is low (≤10%) with annual catches of 50,000 t or less, rising to nearly 100% with catches of 60,000 t or more.

BACKGROUND

Species Biology

Atlantic herring (*Clupea harengus*) 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 10 m in April-May, but may extend into June in some areas. Fall spawning occurs mainly from mid-August to October at depths of 5 to 20 m. 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 2009 spring fishery (January – June).

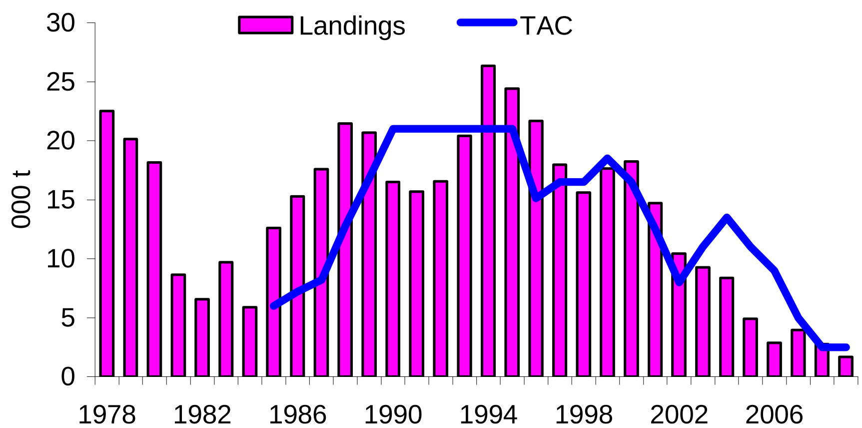
Area	Spring Fishery TAC	Total Reported Landings (t)	Spring Spawner Component Landings (t)	Fall Spawner Component Landings (t)	% Spring Spawner
Gillnet					
[a] Isle Verte 16A	4	8	8	0	--
[a] Chaleur Bay 16B	95	207	200	7	--
Escuminac 16C	130	3	3	0	--
[a] Magdalen Islands 16D	22	41	41	0	--
[a] Southeast NB – West PEI 16E	605	939	939	0	--
[a] 16F	7	29	3	26	--
[a] 16G	9	23	1	22	--
Reserve, 4Vn and June (16A-G)	1,049	[b]	[b]	[b]	--
Total Gillnet	**1,921**	**1,249**	**1,194**	**55**	**96**
Seiners (>65') 4T	**579**	**0**	**0**	**0**	**0**
Grand Total	**2,500**	**1,249**	**1,194**	**55**	**96**

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

The 2009 TAC for the spring spawner component was 2,500 t, the same as in 2008 (Figure 2). The combined 2009 landings of the spring spawner component in both the spring and the fall fisheries were 1,667 t, including 409 t caught by the seiners in the fall fishery. There was no seiner effort in the spring fishery.

Table 2. TAC, allocations and landings in the 2009 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	136	13	13	0	--
Chaleur Bay 16B	23,503	19,534	19,534	0	--
Escuminac-West PEI 16CE	8,692	8,545	8,520	25	--
Magdalen 16D	325	117	117	0	--
Pictou 16F	8,508	8,350	8,350	0	--
Fisherman's Bank 16G	8,508	8,463	8,424	39	--
Reserve	93				
4Vn (Area 17)	325	--	--	--	--
Total Gillnet	**50,090**	**45,022**	**44,958**	**64**	**99.9**
Seiners (>65') 4T	**14,910**	**2,145**	**1,736**	**409**	**81**
Grand Total	**65,000**	**47,167**	**46,694**	**473**	**99**



Year	Average 1990-2005	2006	2007	2008	2009
TAC ('000 t)	17	9	5	2.5	2.5
Landings ('000 t)	16	2.8	4.1	2.8	1.7

Figure 2. Total landings of the Atlantic herring spring spawner component and TAC (000 t) from NAFO Div. 4T.

The catch-at-age of the 2009 spring spawner component was composed mostly of ages 3, 5 and 6, 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). Differences in weights at age between gears are due to differences in timing of the fisheries.

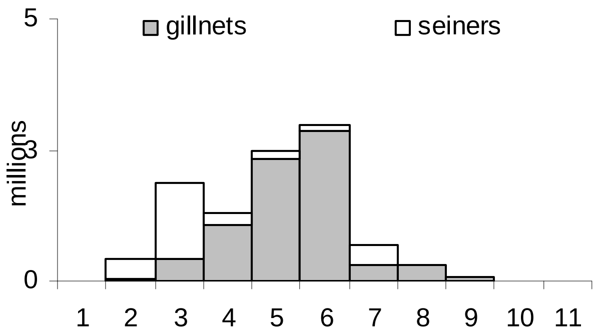


Figure 3. Spring spawner 2009 catch-at-age (millions of fish).

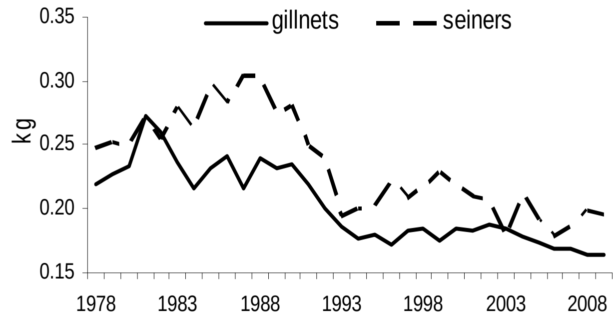


Figure 4. Weight (kg) of 5-year-old spring spawners.

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 was at a peak in 1998 and declined continually until 2008. There was an improved perspective in 2009 (Figure 5).

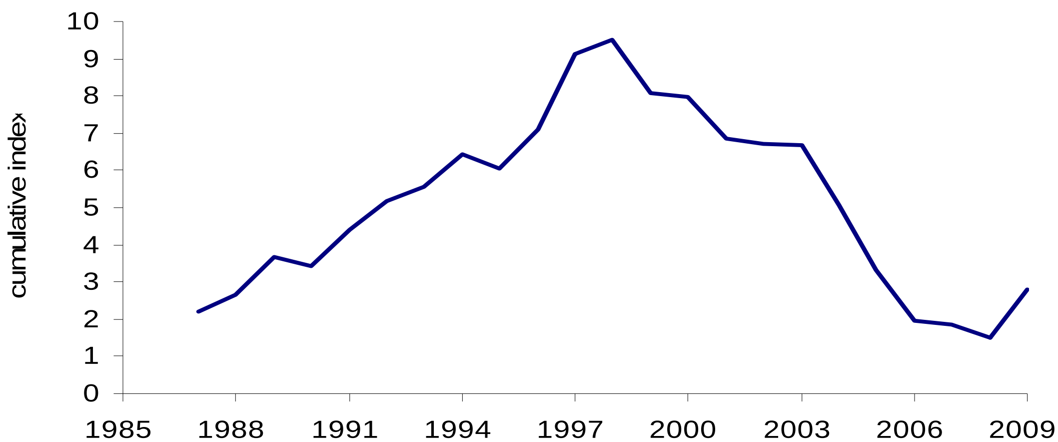
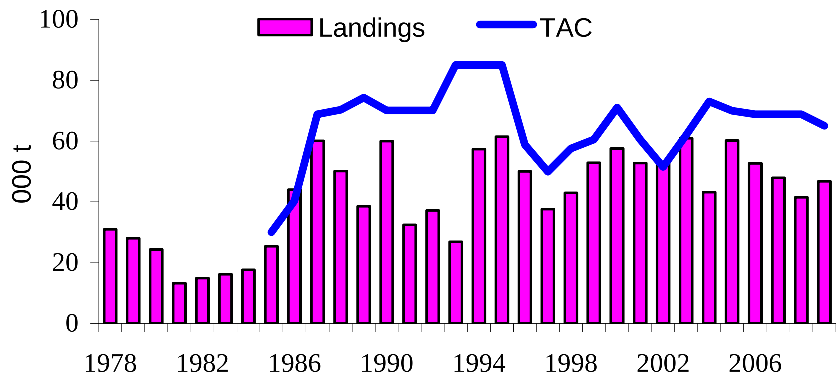


Figure 5. Cumulative index of telephone survey spring spawner opinion on abundance.

The TAC for the fall spawner component in 2009 was 65,000 t, compared to 68,800 t in 2008 (Figure 6). The combined 2009 landings of the fall spawner component in both the spring and fall fisheries were 46,747 t.



	Average				
Year	1990-2005	2006	2007	2008	2009
TAC ('000 t)	67.7	68.8	68.8	68.8	65
Landings ('000 t)	51	52.9	48.1	41.5	46.7

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

In 2009, 73% of the fall TAC was attained; seiners caught 14% of their allocation while the gillnet fleet caught 88% of their allocation (Table 2). In the landings of the fall spawner component, the 2004 year-class (age 5), the 2005 year-class (age 4) and the 2002 year-class (age 7) were dominant in the 2009 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). Differences in weights at age between gillnet and seiner catches are due to the type of fish captured, pre-spawning in gillnets, post-spawning in seiner catches.

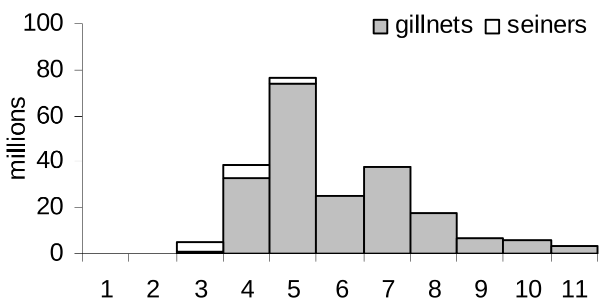


Figure 7. Fall spawner 2009 catch-at-age (millions of fish).

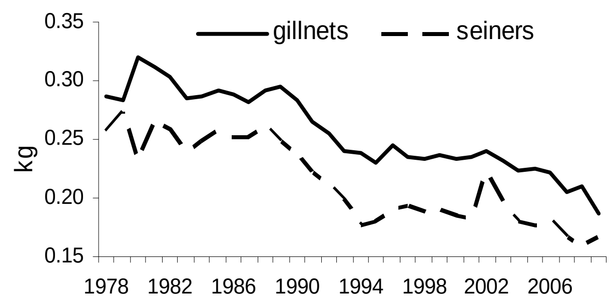


Figure 8. Weight (kg) of 5-year-old fall spawners.

The fall cumulative index from the gillnet telephone survey has been variable but increasing over the time series until 2006 (Figure 9).

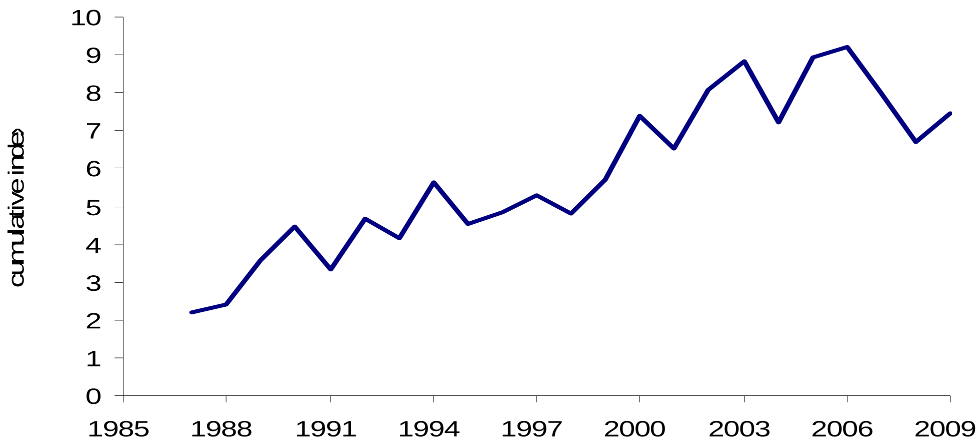


Figure 9. Cumulative index of the telephone survey fall spawner opinion on abundance.

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) and logbook data where available. 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 2009 was slightly higher than 2008, but similar in value since 2004. The index has been declining since 1997 and remains at a low level in the series that starts in 1990.

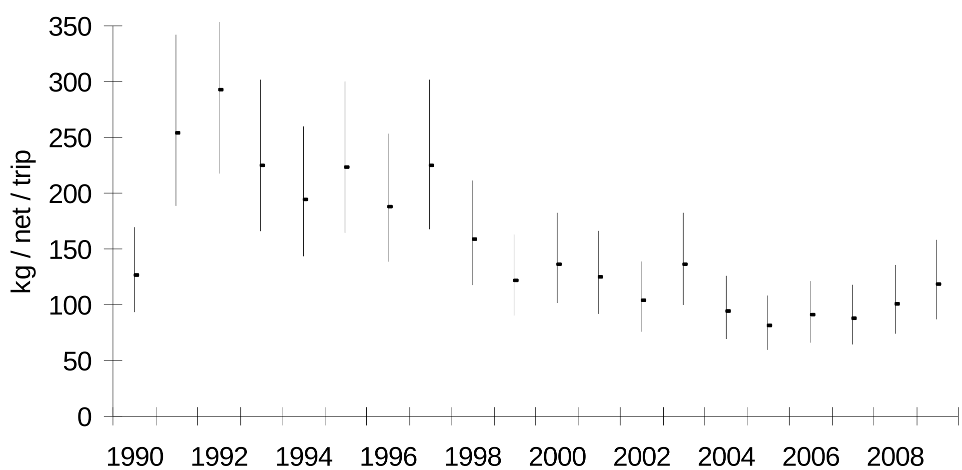


Figure 10. Spring spawner CPUE index (kg/net/trip).

The 2009 acoustic survey abundance index (Figure 11) of the spring spawner component ages 4 to 8 was slightly higher than 2008 but remains low in the series that starts in 1994.

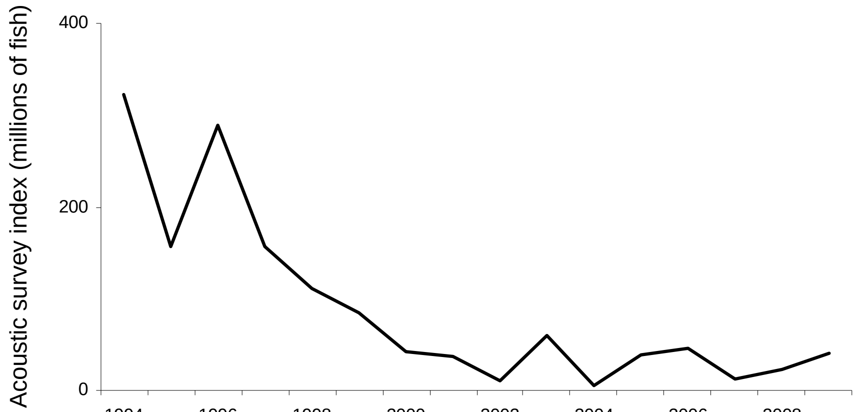


Figure 11. Spring spawner component acoustic survey index (millions of fish) for ages 4 to 8 years.

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, with a slight improvement in 2009.

Population biomass (Figure 12) has declined since 1995 and remains at a low level since 2004. Age 4+ spawning biomass is estimated at 28,200 t for the beginning of 2010. The abundances of the year-classes (at age 4) after the 1991 year-class were average or below average (102.6 million). Age 4 abundance in 2010 is estimated by multiplying the spawning stock biomass (SSB) in 2006 by the 2005-2009 average recruitment rate (age-4 abundance in year t / SSB in year t-4). The updated model value for 2009 was 27,200 t, 6,868 t higher than the previous year's assessed value. The increase is due to higher than average estimated abundance of age 4 for 2009. The errors in the model are high but within acceptable levels. Both the gillnet CPUE and the acoustic survey indices indicate a decline in the biomass since the 1990's, however, the CPUE index indicates a less steep decline than the acoustic survey.

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 in 2009 was 8% (Figure 13). Exploitation rates were above the reference level from 1999 to 2005, below in 2006, above in 2007 and below in 2008 and 2009.

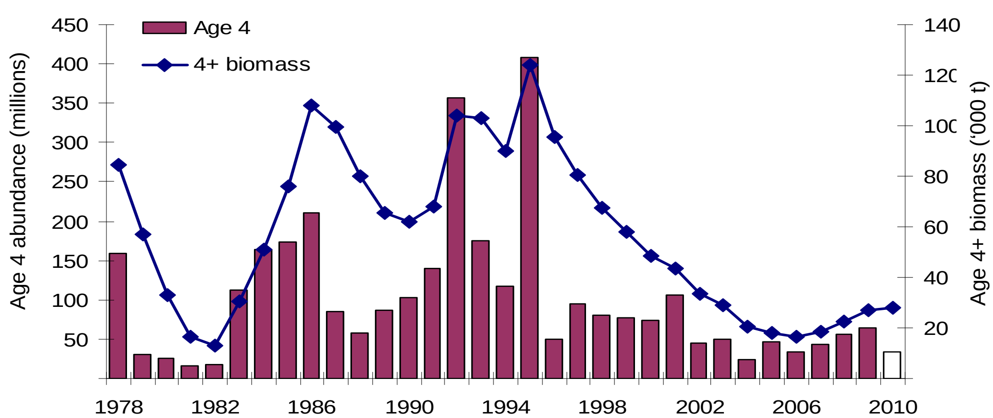


Figure 12. Spring spawner component age 4 numbers (millions of fish) and age 4+ biomass ('000 t). The value for age 4 in 2010 is an estimate based on an average recruitment rate of the previous five years.

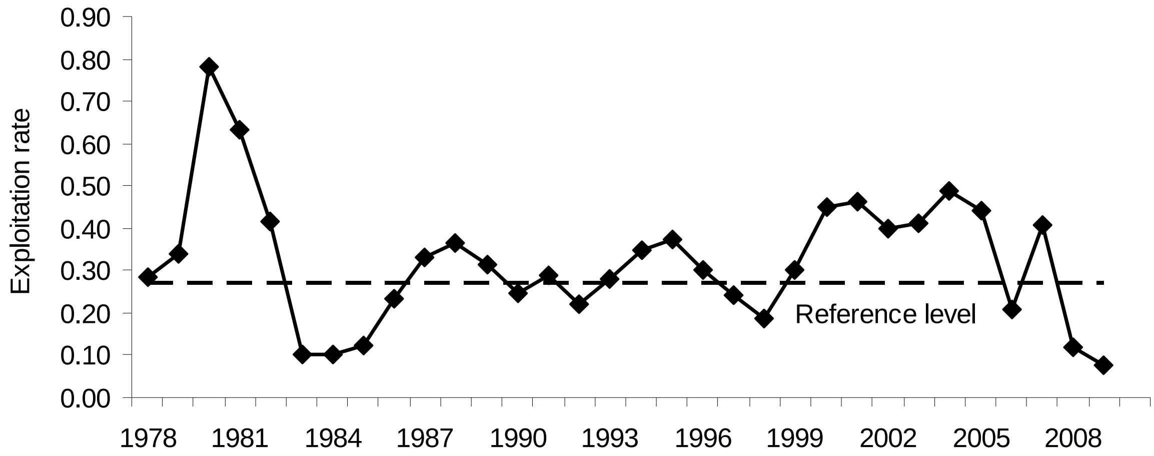


Figure 13. Spring spawner exploitation rates (ages 6 to 8).

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. 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 2010, 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 can be used in the application of a Precautionary Approach (PA) framework for southern Gulf of St. Lawrence herring.

The current estimate of age 4+ spawning stock biomass (SSB) of 28,200 t is above the LRP (Figure 14) but below the upper stock reference (USR). Spawning stock biomass values below the USR represent undesirable stock levels. When the SSB declines below the USR, a harvesting strategy compliant with the PA would reduce the exploitation rate to promote stock growth to above the USR. The realized reduced fishing rate on this component since 2007 is consistent with the PA.

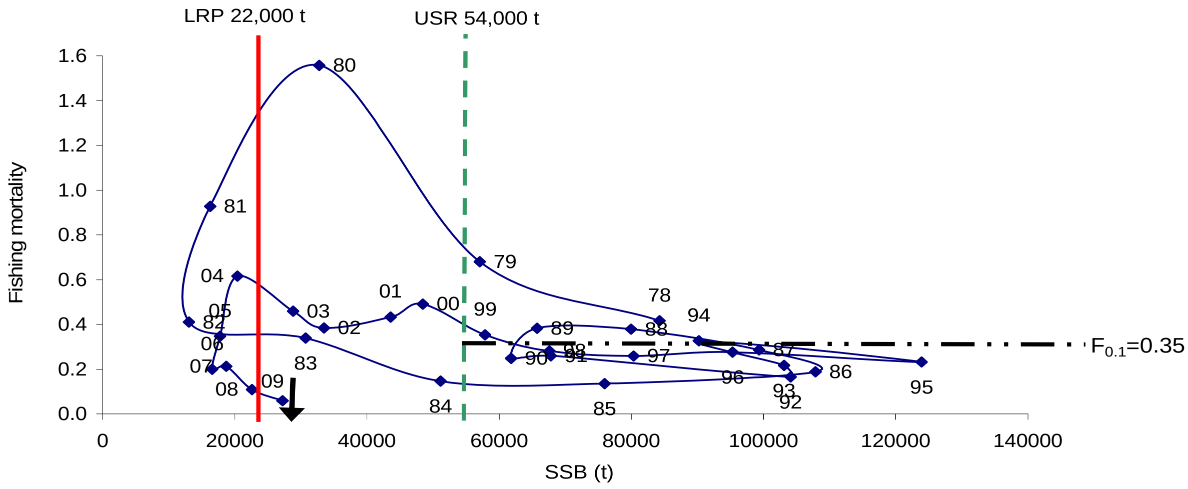


Figure 14: Spring spawner component biomass (ages 4+) and fishing rate (ages 4-10) trajectory and reference points. The arrow represents 2010 SSB estimate of 28,200 t.

Catch options for 2010 were assessed relative to the following consequences on biomass in 2011: the probability of a decrease, the probability of a 5% or greater decrease, and the probability of at least a 5% increase (Figure 15). Catch options less than 2,000 t would provide a low probability (<20%) of further decline in biomass, a catch option of 3,200 t would provide a high probability (83%) of further decline in biomass and a catch option of 1,010 t would provide a 54% probability of a 5% increase in biomass (Table 3).

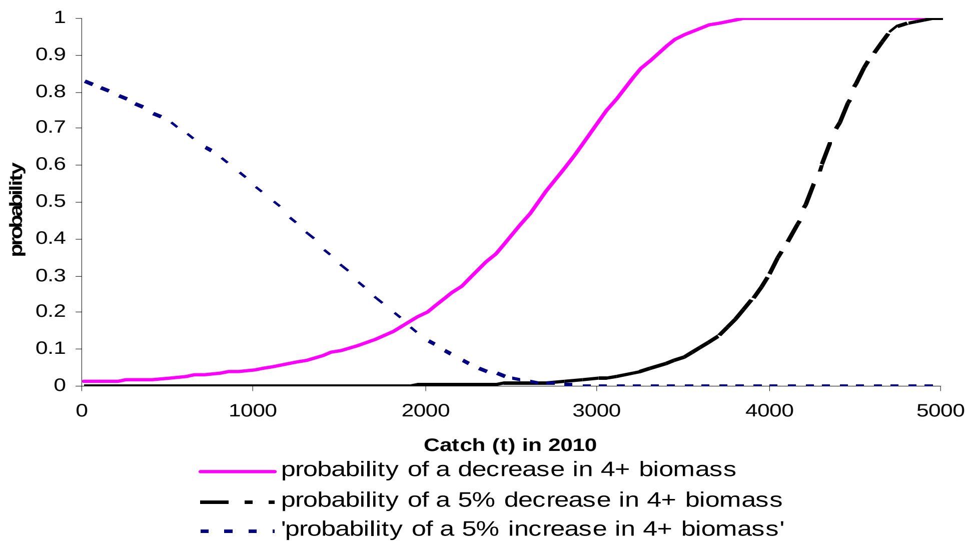


Figure 15. The 4T herring spring spawner component risk analysis for catch options in 2010.

Table 3. Probability of an increase of at least 5% in the spring spawner biomass for different catch options in 2010).

Catch (t)	0	500	1,000	1,500	2,000	2,500
Probability (%)	82	71	54	32	12	2

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 areas that were 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.

Projections over the next two years were conducted by projecting the population forward from the beginning of 2010 to the beginning of 2012 for different catch options (same levels over the two years), taking into account uncertainty in the population abundance at age in 2010. The probability of a decline in biomass from 2010 to 2012 was low (<10%) with fixed catches of 2,000 t or less during 2010 and 2011, but high (>90%) with catches of 4,000 t or more. The probability that SSB would increase by more than 5% from 2010 to 2012 was near zero (<0.5%) with fixed catches of 4,000 t or more in both years, increasing to 15% with catches of 3,000 t, 62% with catches of 2,000 t and 90% with catches of 1,000 t (Figure 16).

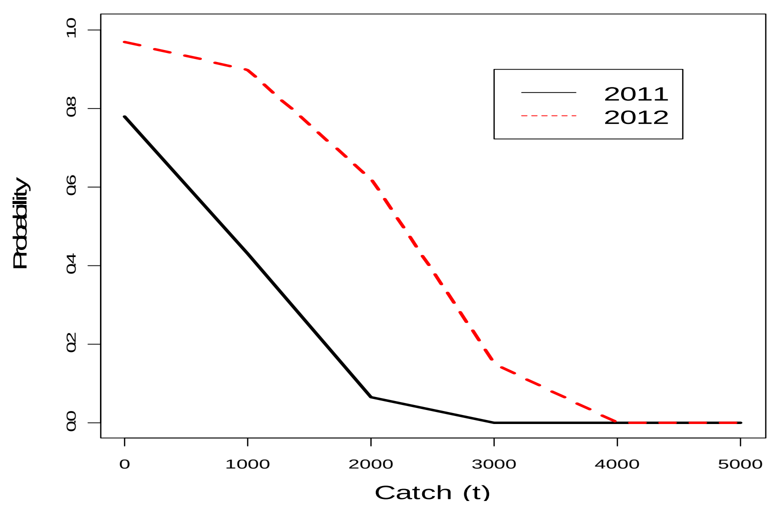


Figure 16. Probability that spawning stock biomass (SSB) of the spring-spawning stock component in 2011 and 2012 will increase by more than 5% relative to 2010 for fixed catch options in the 2010 and 2011 fishing years of 0 to 5,000 t (by 1,000 t increments).

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 (number of nets and hauls) derived from DMP data and a telephone survey of 20 to 25% of the active gillnet fishers (Figure 17). The effort information in this index used the product of hauls and nets (haul-net). This index covers the entire gillnet fleet and extends from 1986 to 2009. The mean CPUE for 2009 was slightly higher than 2008, but remains lower than the previous three years.

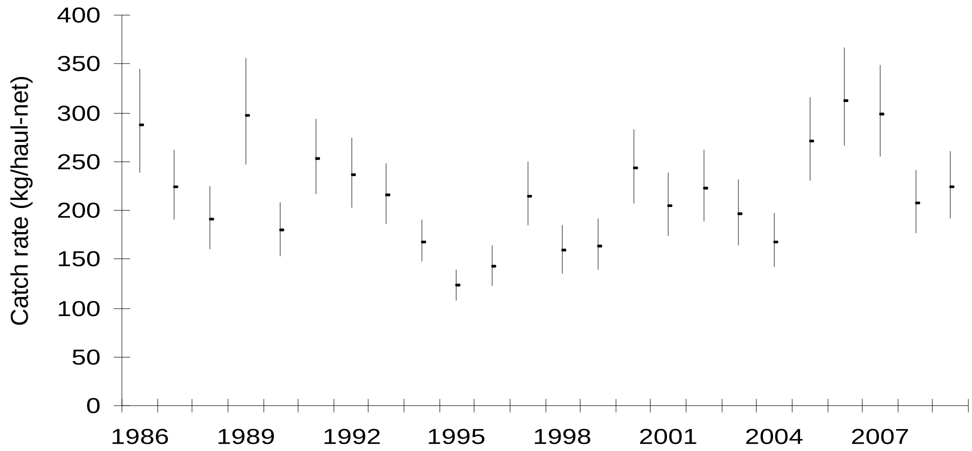


Figure 17. Fall spawner catch rate (CPUE) index (kg/ haul-net).

Recruitment estimates (age 4, Figure 18) suggest that the abundance of the 2000, 2001, 2004 and 2005 year-classes is above the average of 344 million. Age 4 abundance in 2010 is estimated by multiplying the spawning stock biomass (SSB) in 2006 by the 2007-2009 average recruitment rate (1.6) (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 18). The 2010 beginning-of-year age 4+ spawning biomass is estimated to be about 307,400 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 19).

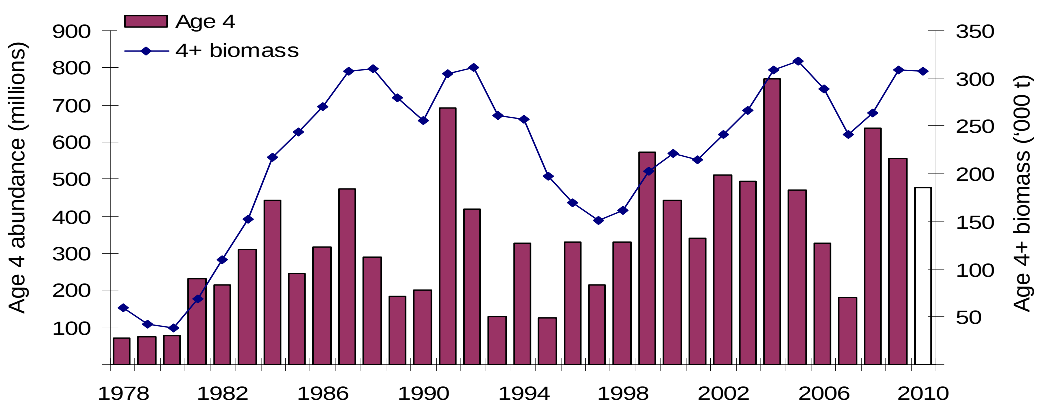


Figure 18. Fall spawner component age 4 numbers (millions of fish) and age 4+ biomass ('000 t). The value for age 4 in 2010 is an estimate based on an average recruitment rate of the previous three years.

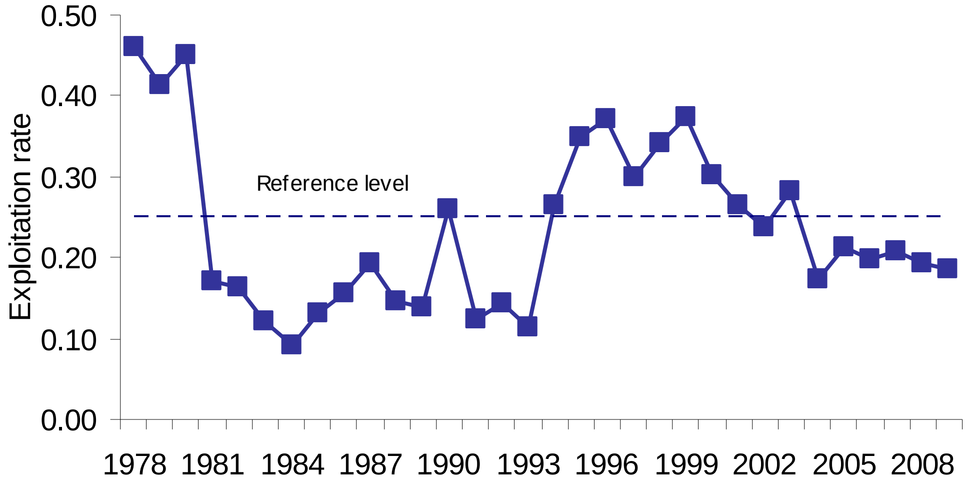


Figure 19. Fall spawner exploitation rate (age 5+).

Sources of Uncertainty

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 2010, components that are exploited by the fisheries. Retrospective patterns were present with the addition of the 2009 data, suggesting an overestimation before 2004 and an underestimation since 2005. No adjustments of population estimates were made to the beginning of 2010 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 (344 million) from 1999 to 2005, and again in 2008 and 2009 (Figure 19). The current estimate of spawning stock biomass (SSB) of 307,400 t is above the upper stock reference point of 172,000 t (Figure 20).

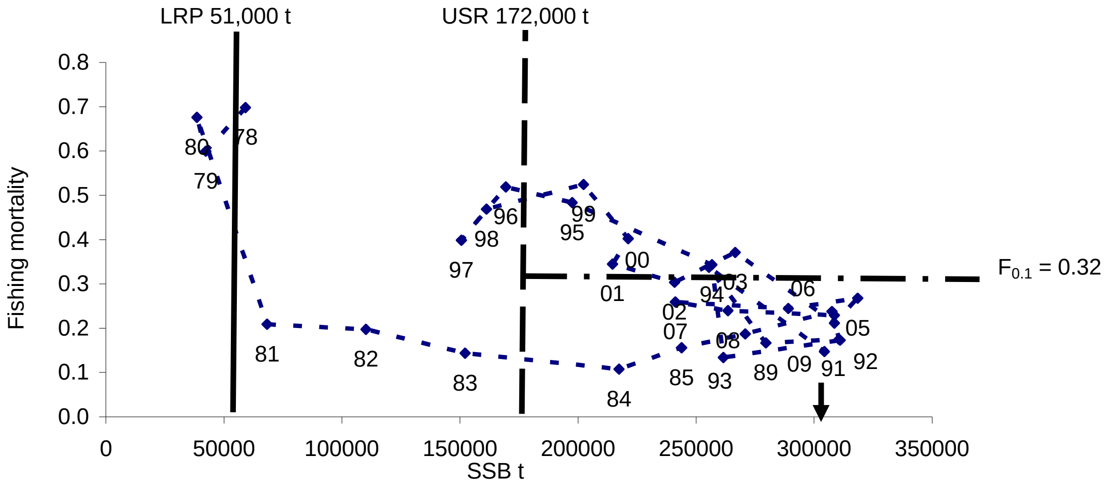


Figure 20. Fall spawner component biomass (ages 4+) and fishing rate (ages 5-10) trajectory and reference points. The arrow indicates the 2010 SSB estimate of 307,400 t.

The risk analysis of catch options for 2010 considered the probabilities of exceeding $F_{0.1}$, and those of obtaining no decline and a 5% decline in biomass (Figure 21). Fishing at $F_{0.1}$ is usually considered a safe exploitation rate when the stock is healthy. For 2010, a catch option of 67,700 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 10% decline in 4+ spawning biomass for 2011. There is a low probability (< 25%) of a decline in biomass for catch options less than 42,000 t.

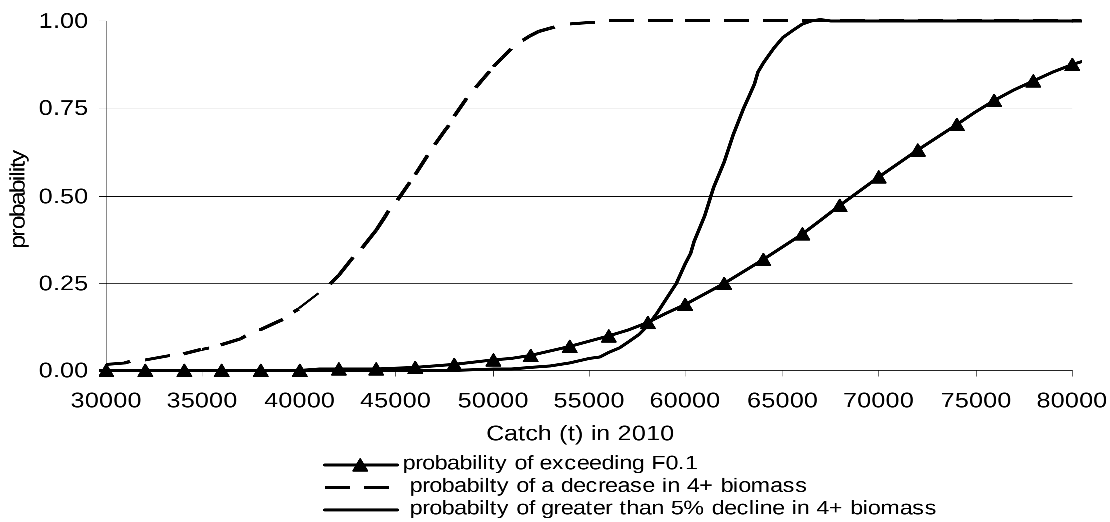


Figure 21. The 4T herring fall spawner component risk analysis for catch options in 2010.

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.

Projections of population abundance over the next two years were conducted from the beginning of 2010 to the beginning of 2012 for different catch options (fixed at the same level in both years), taking into account uncertainty in the population abundance at age in 2010. The probability of a decline of more than 10% was low (≤10%) with catches of 50,000 t or less in 2010 and 2011, rising to 60% with catches of 55,000 t and nearly 100% with catches of 60,000 t or more (Figure 22). The probability that the fully-recruited fishing mortality would exceed $F_{0.1}$ in 2011 is <1% with catches of 50000 t or less, 13% with catches of 60,000 t, and 33% with catches of 65000 t (Figure 23).

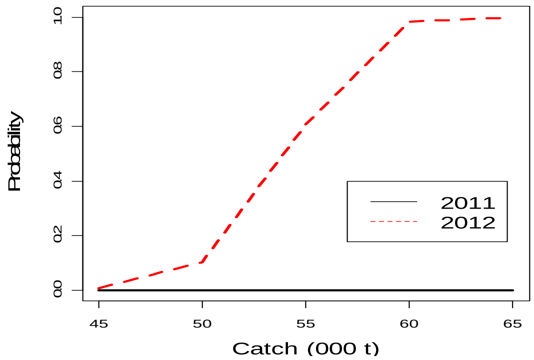


Figure 22. Probability that spawning stock biomass (SSB) of the fall-spawning stock component will decrease by more than 10% in 2011 and 2012 relative to 2010 at fixed catch levels in 2010 and 2011.

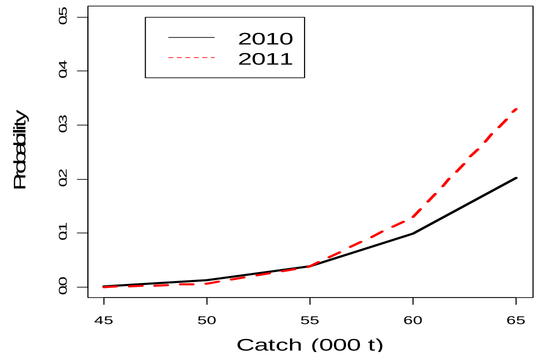


Figure 23. Probability that fully-recruited fishing mortality on the fall-spawning stock component will exceed $F_{0.1}$ at fixed catch levels in 2010 and 2011.

OTHER CONSIDERATIONS

A number of comments were provided by fishers during the gillnetter telephone survey and by participants at the science review. During the fall fishery, herring were located in deeper water and the fish were smaller. There were concerns about the decrease in abundance (in some areas), the season opening too late, an increase in daytime fishing and too many seals. Other comments touched on changes in water temperature that affect where and when herring spawn and increased abundance of predators.

Despite large reductions in catches of the spring spawner component, the spawning stock biomass and the recruitment rate remains low. Ecosystem changes have been noted in the southern Gulf and industry participants provided observations of changes they have noted, including 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.

Ecosystem characteristics

There has been a general warming trend in the monthly sea surface temperatures of May and September over the Magdalen Shallows (most of area 4T) over the period 1985 to 2009 (Figure 24). Temperatures in May, corresponding to the spring spawning period, were generally below average (average over 1985 to 2009) prior to 1998 and warmer than average afterward. For September, corresponding to the fall spawning period, temperatures were cooler in the 1980s and have been at or above average since (Figure 24). Temperatures at 10 m depth in June in the western portion of the Magdalen Shallows were coolest prior to 1980 but have been at or above average (warmer) over the past twenty years (Figure 25). This period corresponds to the spawning period and initial growth period for spring spawned herring, but the consequences of these changes to spring herring recruitment are unknown.

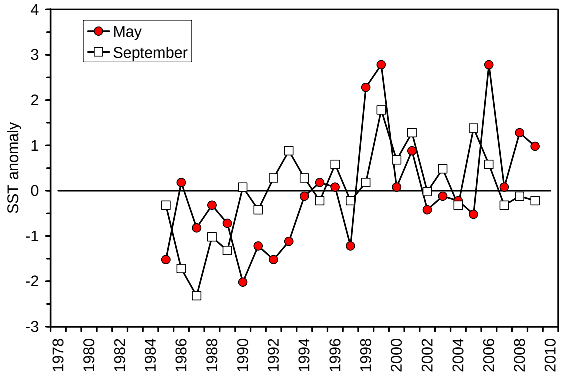


Figure 24. Sea surface temperature (SST) anomalies for the Magdalen Shallows portion of the southern Gulf, 1985 to 2009. The anomalies show the difference between the average SST for the month in the year relative to the average temperatures over the time period 1985 to 2009.

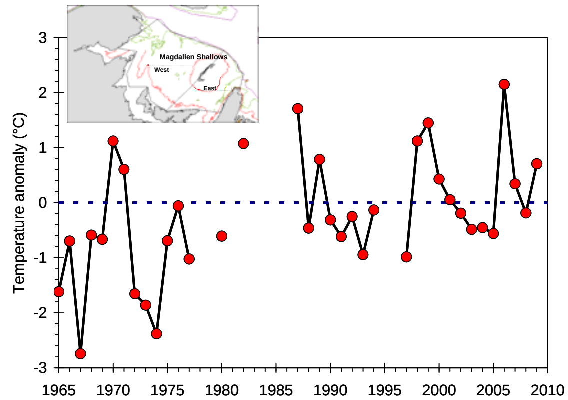


Figure 25. Temperature anomaly (from average 1971 to 2000) of water temperatures at 10 m depth in the western portion of the Magdalen Shallows (southern Gulf) as measured during mackerel egg surveys of June.

The proportion of the total herring biomass in the southern Gulf composed of the spring spawner component has decreased over the time period 1978 to 2010, from a peak of over 50% at the end of the 1970s to just over 5% in 2005 and 2006 (Figure 26). A general warming trend in the annual temperature anomalies has been suggested as favouring autumn spawners (Melvin et al. 2009).

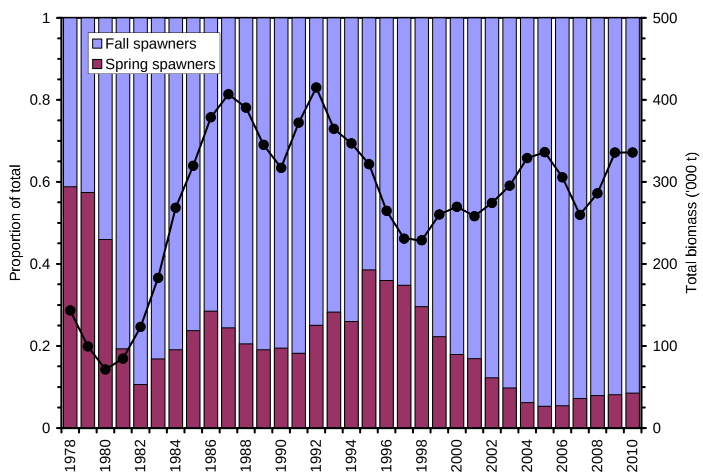


Figure 26. Proportion of total biomass of herring (ages 4+) in the southern Gulf composed of spring spawning and fall spawning components, and total biomass (t), 1978 to 2010.

While surface temperatures have generally increased over time, bottom temperatures in the southern Gulf have been characterized by periods of cooler water conditions, the longest period during the late 1980s to mid 1990s (Figure 27). Increased relative abundance of fish species with a more characteristic arctic distribution (for ex. capelin) was noted during the periods of cooler water conditions. Temperatures have increased over the past decade but equally warm conditions were recorded in the late 1960s and early 1980s.

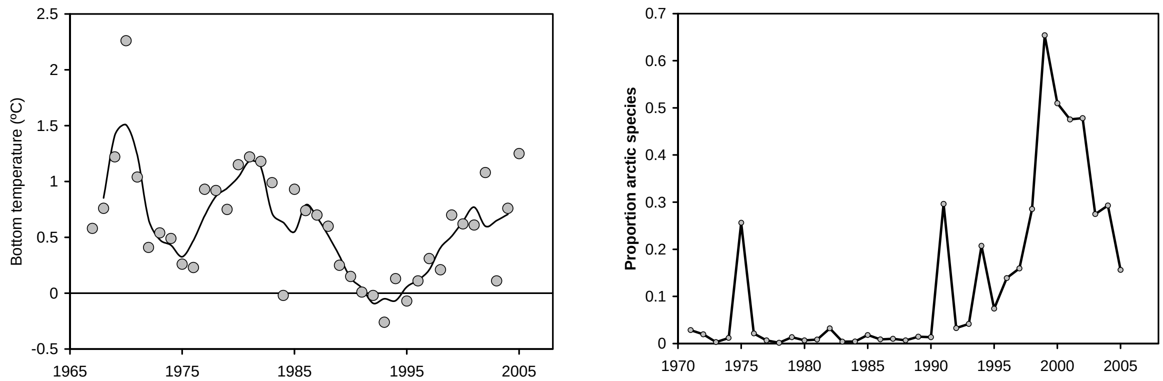


Figure 27. Mean bottom temperatures (60-120 m) in September (left panel) and relative abundance of arctic species in the multi-species survey (right panel) (Benoît and Swain 2006).

There have been some important changes in the fish community of the southern Gulf of St. Lawrence over the past 38 years. The most important change has been the decline of piscivorous fishes, primarily Atlantic cod, which during the 1980s were at high abundance and have declined to the lowest levels of the time series since the early 1990s. Based on the September multi-species survey, declines in the indices of a number of other species were also observed including white hake and American plaice (Hurlbut et al. 2009). Fishing is believed to be the strongest cause of declines in the late 1980s and early 1990s. However, fishing likely cannot explain subsequent continued declines or lack of recovery of numerous groundfish species because fishing mortalities have remained relatively low (Benoît and Swain 2008). The reduction of the abundance of the numerous predator species in the southern Gulf has been associated with an increased abundance of small-bodied species, a phenomenon known as predator release (Benoît and Swain 2008). Estimated mortality rates of juvenile stages of several larger-bodied fish species have declined, consistent with the predator release hypothesis. Herring would also have benefited from the reduced abundance of these fish predators. However, increased abundance of other herring predators may have compensated for some of the reduced predation mortality, for example the abundance of grey seals that breed in the southern Gulf has increased more than two-fold over the same time period. Predation by grey seals may explain the recent diminished status of many groundfish species in the southern Gulf (Benoît and Swain 2008).

Interactions between pelagic fish and groundfish recruitment have been noted. A negative association between Atlantic cod recruitment rate and pelagic fish (herring and mackerel) abundance in the southern Gulf has been reported in the literature (Swain and Sinclair 2000); the recruitment rate for cod was highest during the 1973 to 1983 time period which corresponded to the period of lowest abundance of these pelagic species (Figure 28).

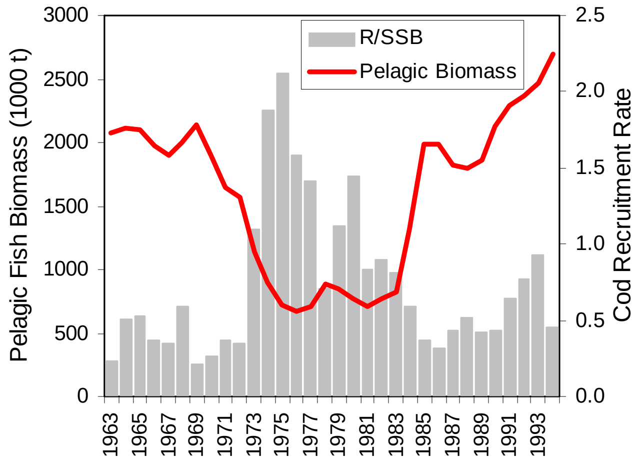


Figure 28. The recruitment rate for southern Gulf Atlantic cod and the corresponding pelagic fish biomass (herring and mackerel) for the 1963 to 1994 time period (from Swain and Sinclair 2000).

In conclusion, there have been strong size-structured shifts in the species composition of the marine fish community of the southern Gulf since 1971. Changes in water temperature, fishing pressure and predation (by fish and grey seals) all appear to have contributed. Whereas fishing mortality on most demersal fishes has decreased to very low levels in the recent years, total mortality on larger fish in several species has increased. Conversely, natural mortality has decreased on small fish and juveniles. Herring are an important component of the southern Gulf fish community, although the spring component represents a lower proportion of the total herring biomass than in the late 1970s. The causes of the reduced abundance of the spring component are presently unknown but a number of associations merit further investigation.

SOURCES OF INFORMATION

Benoît, H. P. and Swain, D. P. 2008. Impacts of environmental change and direct and indirect harvesting effects on the dynamics of a marine fish community. Can. J. Fish. Aquat. Sci. 65: 2088-2104.

DFO. 2007. Size at 50% maturity for southern Gulf of St. Lawrence herring (NAFO 4T). DFO Can. Sci. Advis. Sec. Sci. Resp. 2007/019.

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

Hurlbut, T., Morin, R., Surette, T., Swain, D.P., Benoît, H.P., and LeBlanc, C. 2009. Preliminary results from the September 2008 bottom-trawl survey of the southern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/029. iv +51 p.

LeBlanc, C.H., C. MacDougall, C. Bourque, R. Morin, and D. Swain. 2009. Assessment of the NAFO Division 4T southern Gulf of St. Lawrence herring stocks in 2008. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/049. iv + 175 p.

Melvin, G.D., Stephenson, R.L., and Power, M.J. 2009. Oscillating reproductive strategies of herring in the western Atlantic in response to changing environmental conditions. ICES J. Mar. Sci. 66: 1784-1792.

Swain, D. P. and Sinclair, A. 2000. Pelagic fishes and the cod recruitment dilemma in the Northwest Atlantic. Can. J. Fish. Aquat. Sci. 57: 1321-1325.

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