West Coast of Newfoundland Atlantic Herring (Division 4R)

Background

Herring (Clupea harengus harengus) is a pelagic fish that frequents cold Atlantic waters. Its distribution in Canada extends from the coasts of Nova Scotia to the coasts of Labrador. It travels in tight schools, feeding primarily on plankton (copepoda and euphausiacea), spawning near the coast and wintering in open sea in deeper waters. Most herring reach sexual maturity at four years, at a length of about 25 cm. During spawning, eggs attach to the bottom, forming a carpet several centimetres thick, at specific locations which are visited every year. Unlike other pelagic species, herring populations are characterized by two spawner components. The spring component herring generally lay eggs in April and May and the fall component herring in August and September. These two components are generally from separate stocks.

*In Canadian waters, herring are also harvested commercially, mainly southwest of Nova Scotia, in the Bay of Fundy, in the southern Gulf of St Lawrence and on the North Shore of Quebec. Large catches are also made on the west coast of Newfoundland. This region, associated with **NAFO** (**N**orthwest **A**tlantic **F**isheries **O**rganization) Division 4R, more specifically extends from unit area 4Ra in the north to area 4Rd further south (Figure 1). The main gear used is the purse seine, with average annual landings of 12,200 t for large seiners (>65') and 2,882 t for small seiners (<65'). The seine fishery is followed by the gillnet fishery, whose corresponding landings average 1,512 t per year. The west coast of Newfoundland fishery is managed by a **TAC** (**T**otal **A**llowable **C**atch) for both spawning stocks together. On account of the low biomasses calculated for the last few years, however, rigorous management measures have been applied to the spring stock to allow it to rebuild.*

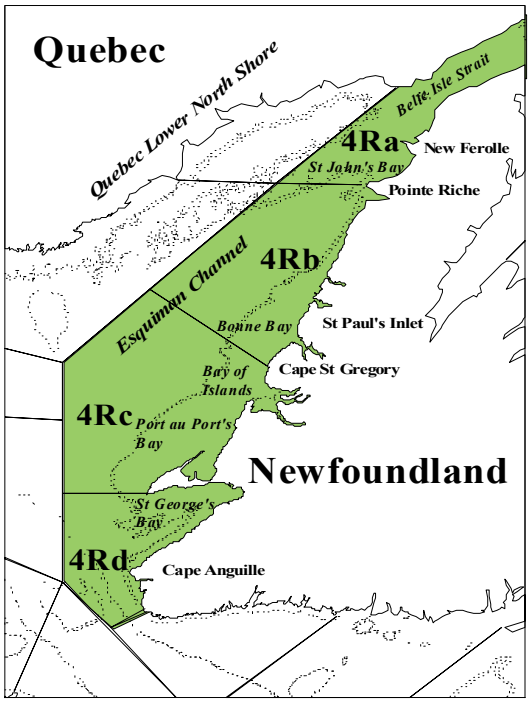

Figure 1. Map of unit areas of Division 4R on the west coast of Newfoundland (Division 4R is defined by the coloured area).

Summary

- In 2001, preliminary herring landings for the west coast of Newfoundland totalled 11,726 t, which is slightly below the 12,916 t recorded in 2000 and the **TAC** of 15,000 t. Most of these landings were made in unit area 4Rc in the fall.
- The condition of the spring and fall spawners has been improving since 1998. The values observed in 2001 far exceed the averages calculated for the period between 1970 and 2000.
- The abundance index of spring spawners from the gillnet fishery has been on the rise since 1998. In 2001, this index

reached a level identical to that observed in the early 1990s. This increase is attributable to the presence of the 1994, 1995 and 1996 year-classes, whose abundance is slightly above average.

- Use of the gillnet abundance index in the **SPA** (**S**equential **P**opulation **A**nalysis) shows that the biomass of the spring spawner herring stock rose from 34,632 t in 1997 to 55,411 t in 2001. If catches in 2002 were to be 6,800 t, there would be less than a 10% probability of a biomass increase in 2003. That probability would rise to 50% with catches in the neighbourhood of 5,800 t. Finally, with catches of 3,400 t in 2002, the likelihood of a 5% biomass increase in 2003 would be 60%.
- However, the spring spawner stock projections have been based on an average abundance value assigned to the 1998-to-2000 year-classes. Those classes could not be estimated with precision by **SPA** for lack of an independent fishing survey. Given that these year-classes made up over 30% of the mature biomass in 2001, a higher degree of uncertainty must be associated with the projections determined by the risk analysis.
- For the fall spawner stock, the only abundance index available is from the acoustic survey. Since there was no survey in 2001 and it was not possible to calculate the size of this spawning stock, no assessment advice can really be formulated as to the acceptable catch level in 2002.

The Fishery

Nominal Catches

Herring stocks on the west coast of Newfoundland are harvested separately during spawning gatherings or collectively when the stocks are mixed between the months of April and December. They are harvested chiefly by a fleet of large (>65') and small (<65') seiners, and by a large number of fishermen using gillnets. Between 1990 and 2000, landings associated with these three types of gear averaged 16,593 t per year (Table 1). Average annual landings have been 12,200 t for large purse seiners, 2,882 t for small purse seiners and 1,512 t for gillnetters.

In 2001, preliminary herring landings for the west coast of Newfoundland totalled 11,726 t, which is slightly below the 12,916 t recorded in 2000 and the **TAC** of 15,000 t (Table 1). Most of these landings were made in the fall in unit area 4Rc (Figures 1 and 2).

Since 1985, total herring landings have posted a net downward trend (Figures 2 and 3). Until 1993, most of them were

Table 1. West coast of Newfoundland herring: Landings (t) by NAFO unit area and fishing gear since 1990.

ZONE AND GEAR	YEAR												AVERAGE
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001**	(1990-2000)
4Ra	457	576	902	852	1 017	2 283	2 584	2 572	4 128	1 653	1 981	1 451	**1 728**
4Rb	4 191	6 948	4 147	2 218	5 711	3 273	2 952	3 451	7 729	4 766	2 995	2 102	**4 398**
4Rc	7 434	2 493	1 391	1 030	3 052	7 321	8 173	5 300	5 891	3 088	6 469	6 581	**4 695**
4Rd	5 202	16 420	8 896	11 211	2 599	3 133	1 115	1 637	611	1 201	1 471	1 591	**4 863**
Gillnet*	983	842	669	247	893	1 806	2 279	2 156	4 455	962	1 336	1	**1 512**
Small seiner	0	0	4 390	3 752	3 854	3 392	3 072	3 053	4 435	2 599	3 153	3 381	**2 882**
Large seiner	16 301	25 594	10 277	11 309	17 634	10 814	9 473	7 751	9 468	7 147	8 427	8 344	**12 200**
GRAND TOTAL	**17 284**	**26 436**	**15 336**	**15 308**	**22 381**	**16 012**	**14 824**	**12 960**	**18 358**	**10 708**	**12 916**	**11 726**	**16 593**

* Include bar senne and cod traps

** Preliminary data

associated with the spring spawner stock. Since 1991, the proportion of this stock captured on an annual basis has been in the order of 15 % (Figure 3).

Description of Catches

For west coast of Newfoundland herring, the demographic structure of the two spawner stocks is characterized by the periodic presence of a dominant year-class. It is possible to track their development by examining catch-at-age or annual length frequencies. For spring spawners, the year-classes that have dominated the fishery since the late 1960s are those from 1968, 1974, 1980, 1982, 1987, 1990, 1994 and 1996 (Figure 4A). For fall spawners, the year-classes of 1979, 1988, 1990 and 1995 are those that have dominated catches since the early 1980s (Figure 4B). For that same spawner stock, the 1970s were characterized by the presence of a great number of fish aged 11 or over. The abundance of these old fish could be explained by the low exploitation rates directed at that time to this spawner stock.

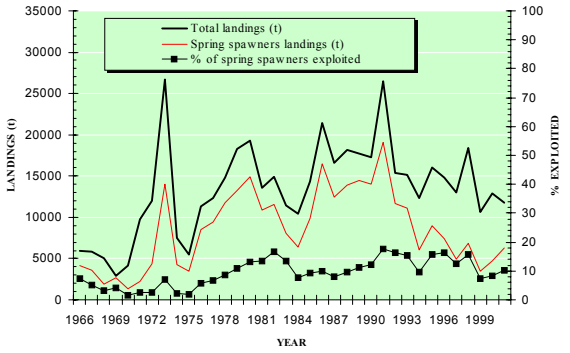

Figure 3. Herring landings (t) (total and spring spawners) between 1966 and 2001, and % of the spring spawner spawning biomass exploited annually.

The average age of herring caught commercially gradually diminished through the nineties. In 2001, the age of the spring spawners was slightly higher than the value calculated in 2000. However, the reverse situation was observed for the fall stock.

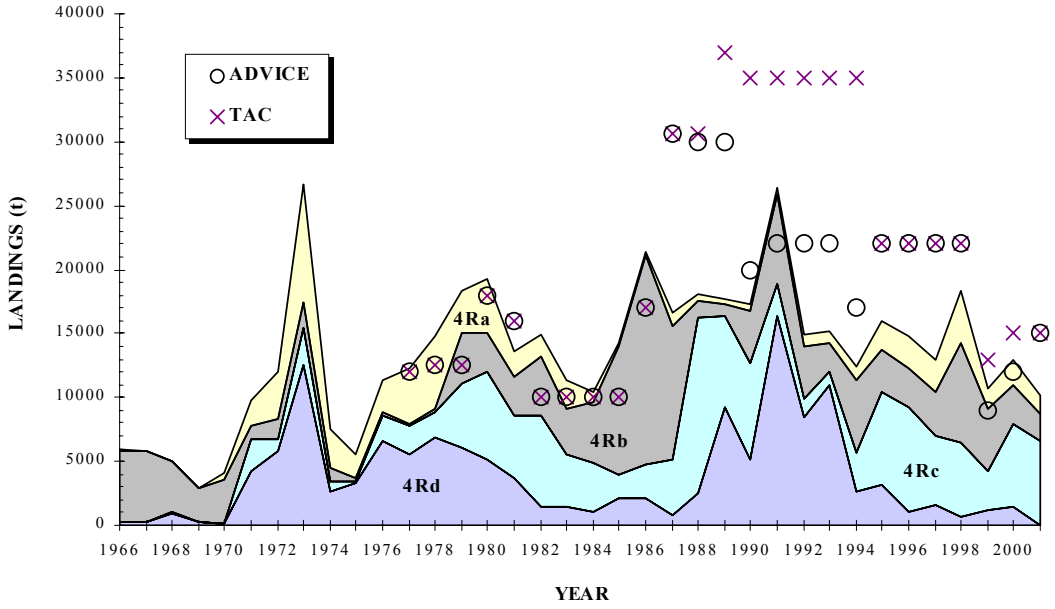

*Figure 2. Cumulative commercial herring landings (t) for unit areas of Division 4R, 1966 to 2001 (**TAC** and scientific advices shown).*

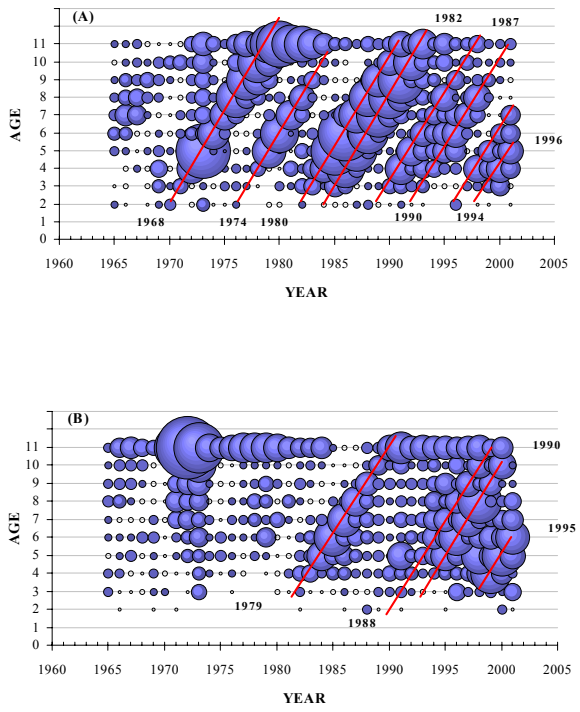

Figure 4. Catch-at-age (%) of spring spawners (A) and fall spawners (B) for year-classes sampled since 1965 (dominant year-classes are also shown; age group 11 represents all fish aged 11 or over).

Biology of the Resource

Spawning Grounds

The main spawning grounds of the spring stock are at the southern end of the west coast of Newfoundland, in St George's Bay (Figure 1) and environs. This stock also has other spawning areas in the large bays further north. Adult herring assemble in these bays from late April until mid-June.

Fall herring spawn mainly north of Pointe Riche, in unit area 4Ra (Figure 1), from mid-July to mid-September. At other times of the year, these herring can be found in the company of spring spawners in the feeding and wintering areas. The chief feeding areas are St George's Bay in spring, near Pointe Riche and the Strait of Belle Isle (Figure 1) in summer, and in the principal bays in fall.

Winter survey catches in the northern Gulf of St Lawrence in the eighties and early nineties indicate that herring winter in the deep waters of the Esquiman Channel (Figure 1).

Growth

For west coast of Newfoundland herring, growth in length or weight is almost linear between the ages of 2 and 11. In 2001, the mean weight of a two-year-old spring herring was 0.101 kg, versus 0.433 kg at 11 years (Figure 5A). For fall herring, mean weights at the same ages were 0.078 kg and 0.368 kg respectively (Figure 5B). For the two spawner stocks, mean weights measured in the 1990s and in 2000 and 2001 were below those in the 1980s.

Since 1998, there have been more spring spawner herring in the samples from the gillnet fishery conducted in May and June in

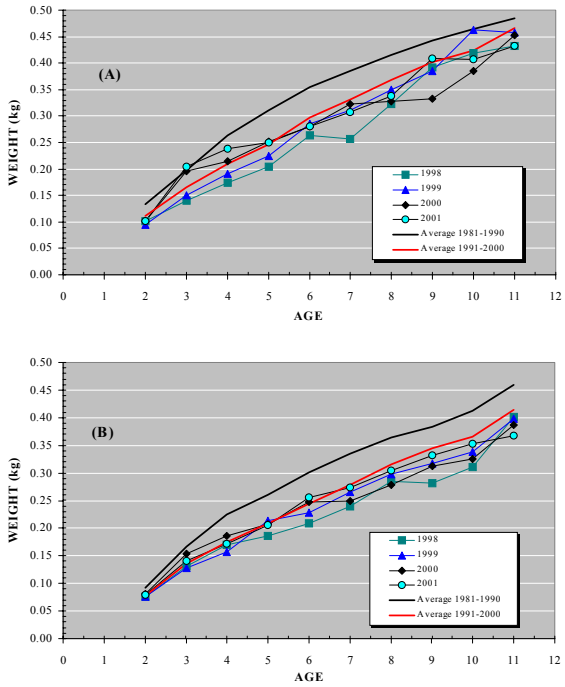

Figure 5. Mean weight-at-age (kg) of spring spawners (A) and fall spawners (B) calculated since 1981 from biological data collected at dockside (fourth quarter).

unit area 4Ra. However these herring grow more slowly than those from the same spawner stock that were sampled in the same months further south in unit area 4Rd.

Gonadosomatic Index

In the spring, the two herring spawner stocks on the west coast of Newfoundland can easily be distinguished by the degree of maturity of their gonads and the corresponding gonadosomatic indices. For spring spawners, that index reaches a maximum of about 20% around April 10 (day 100 of the year) (Figure 6A). Following spawning, which occurs quickly, the gonadosomatic index decreases and stays at below 5% between June 15 (day 166) and September 15 (day 258). It subsequently increases gradually to values between 10% and 15% around December 15 (day 349).

For fall spawners, the gonadosomatic index is generally below 5% until the end of May (day 151) (Figure 6B). It then increases rapidly, reaching values between 15% and 20% between July 15 (day 196) and September 15 (day 258). After that date, the index falls quickly to values below 5% around the end of September (day 273).

In 2001, seine fishermen on the west coast of Newfoundland observed herring at the spawning stage virtually all through the fishing season, ie, from April to September. Examination of Figure 6A shows that spawning of the spring stock in 2001 took place later than in past years. It is this delay, combined with the spawning of the fall stock (Figure 6B), that would explain the presence of mature herring all through the fishing season.

Condition

The condition of the spring and fall spawners improved again in 2001 (Figure 7). These new condition values for

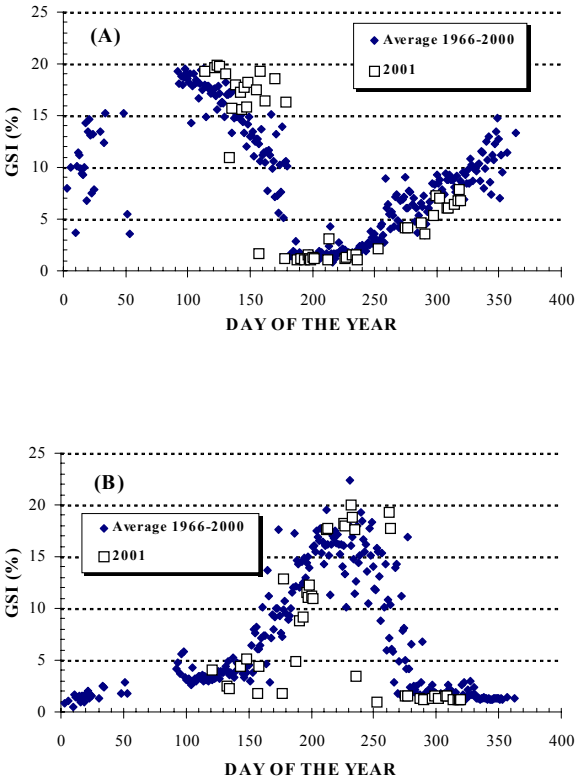

Figure 6. Mean daily values of gonadosomatic index (%) for spring spawners (A) and fall spawners (B) calculated since 1966.

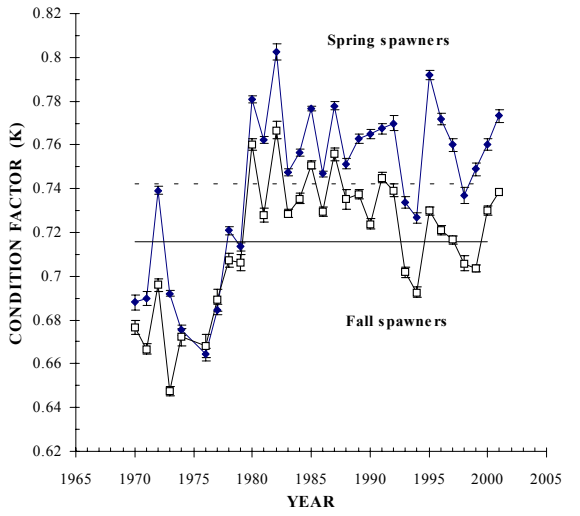

Figure 7. Mean annual condition factors (with standard errors) for spring and fall spawners, calculated from October to December (mean values calculated for the two stocks for the 1970 to 2000 period are indicated by the horizontal lines).

herring are superior to the historical averages, and of the same order of magnitude as those measured in the 1980s.

Maturity

Sexual maturity is reached at 4 years for almost all herring in the spring and fall spawner stocks (Figure 8). In 2000 and 2001, the maturity percentages at ages three and four were nearly 80% and over 95% for the spring spawners (Figure 8A), and slightly over 70% and close to 100% for the fall spawners (Figure 8B). For both these stocks, age at sexual maturity has diminished in recent years compared with the 1960s and 1970s.

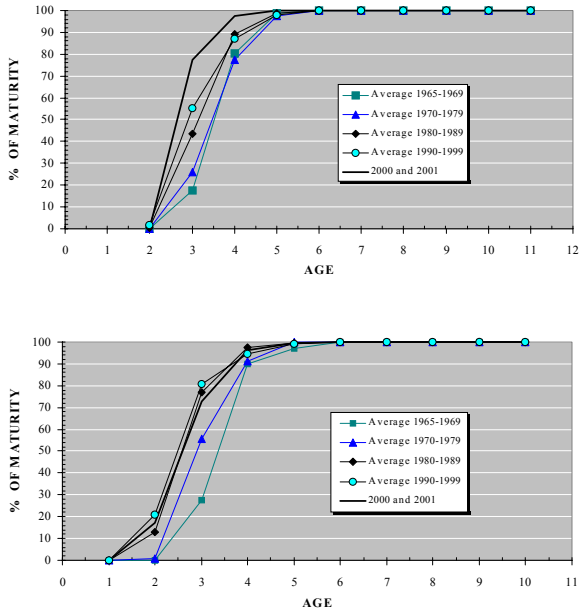

Figure 8. Mean maturity percentages at age for spring spawners (A) and fall spawners (B) calculated since 1965.

Industry Comments

The main comments derived from the questionnaires distributed each year to the gillnet fishermen can be summarized, for the 2001 season, as follows: (1) a general decline in abundance of fall spawners north of Bonne Bay, (2) healthy spawning north of Pointe Riche, (3) a reduction of spring spawning in Bay of Islands associated with an increase in the abundance and size of fall spawners, (4) healthy spawning and a general increase in spring abundance in Port au Port Bay, and finally (5) reduced abundance and spawning in St George's Bay.

At a meeting with members of the industry, the latter mentioned that herring had been very abundant in the fall. However the fishery was halted early because of the speed at which catches were being made and to ensure that the **TAC** was not exceeded.

Resource Status

Abundance Indices

There are two indices at present, one associated with the commercial gillnet fishery (index fishermen and industry logbooks) and the other from a fall biennial acoustic survey. According to that survey, the spring spawner biomass in 1999 was 27,800 t, versus 68,700 t for fall spawners (Figure 9). Between 1991 and 1997, the spring spawner biomass diminished steadily, unlike the fall component which even posted

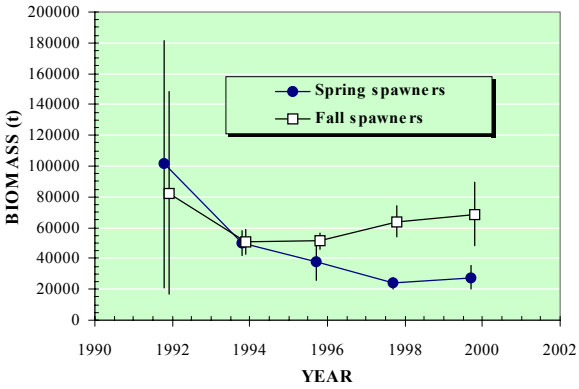

Figure 9. Biomasses (t) of spring and fall spawner herring (with standard errors) calculated since 1991 using data collected during a biennial acoustic survey.

a slight upward trend between 1993 and 1999.

The normalized gillnet catch rates for spring spawners were in systematic decline between 1985 and 1998, and then rose until 2001 (Figure 10). The level reached in 2001 was identical to that observed in the early 1990s.

Unfortunately, the index fishermen's index for fall spawners was terminated in 1993 because of the very low number of participants. However, efforts are under way to construct another abundance index for this spawning stock, this one based on commercial fishery data.

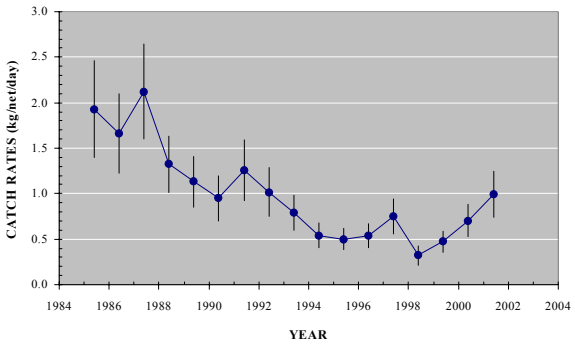

Figure 10. Normalized catch rates (with 95% confidence intervals) (kg/net/day) for spring spawner herring calculated from fishing and effort data from the logbooks of index fishermen and the industry.

Analytical Assessment

A **S**equential **P**opulation **A**nalysis (**SPA**) has been carried out for spring spawners; it draws its abundance index from data from the acoustic survey conducted between 1991 and 1999 and the normalized catch rates derived from index fishermen and a number of commercial fishermen making voluntary use of logbooks.

This analysis shows that the end of 1960s and mid-1980s were characterized by significant increases in the numbers and spawning biomass of herring (Figure 11).

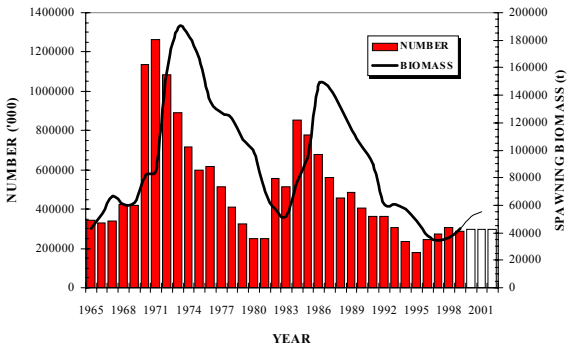

*Figure 11. Spawning biomass and number of spring spawner herring calculated by the **SPA** for the years 1965 to 2002 (data incomplete for 2000 to 2002).*

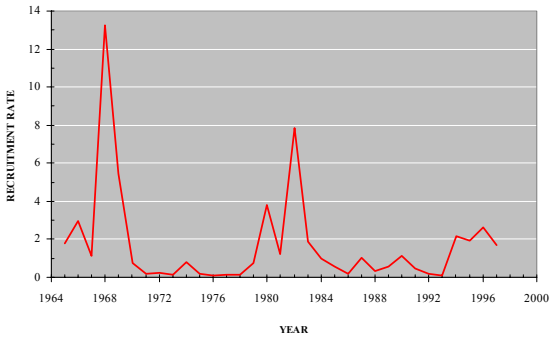

Figure 12. Recruitment rates of spring spawner herring for the 1965-1997 year-classes (recruitment rate is defined as the ratio of the number of recruits at age 2 to the spawning biomass that produced those recruits).

High recruitment rates were observed during both these periods (Figure 12), associated with the 1968, 1969, 1980 and 1982 year-classes (Figure 13). At two years, the abundance of the 1994, 1995 and 1996 year-classes was above average and of the same order of magnitude as the 1963, 1966, 1974, 1987 and 1990 year-classes. The 1994 to 1996 year-classes are also responsible for the recent increase in spawning biomass, which has risen from 34,632 t in 1997 to 55,411 t in 2001 (Figure 11).

The **SPA** also shows that fishing mortality for older individuals (8 years +) exceeded the $\mathbf{F_{0.1}}$ threshold in the mid-1960s, in 1982

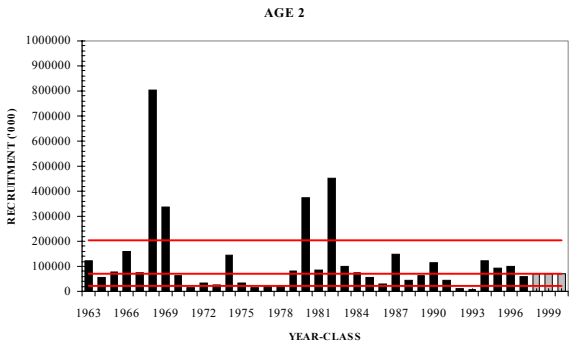

Figure 13. Estimated recruitment at age 2 of spring spawner herring for the 1963-2000 year-classes. The horizontal lines represent three levels of recruitment: low, average and high (the 1998, 1999 and 2000 year-classes have been set at an average recruitment level).

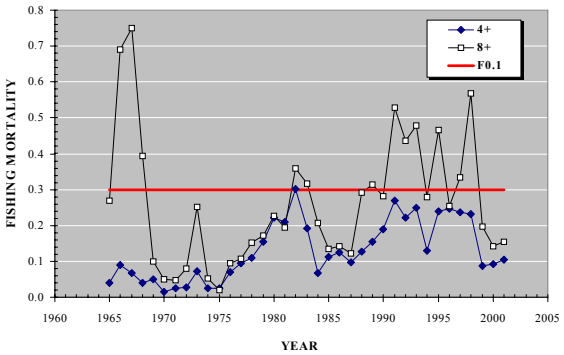

Figure 14. Instantaneous fishing mortality rates (ages 4+ and 8+ weighted by numbers at age) for spring spawner herring, 1965 to 2001.

and 1983, and almost all through the nineties (Figure 14). In response to the rigorous management measures applied since 1998, a substantial drop in this mortality was recorded in 1999, for old as well as younger individuals.

Outlook

Spring Spawners

The situation of this spawning stock has improved since the last analytical assessment in 1999. The spawning biomass of 55,141 t calculated in 2001 now exceeds the acceptable minimum limit ($\mathbf{B_{LIM}}$) of 38,000 t and is close to the established buffer limit ($\mathbf{B_{BUF}}$) of 58,000 t. In this case, $\mathbf{B_{LIM}}$ has been defined as 20% of the maximum spawning biomass of all the historical series and $\mathbf{B_{BUF}}$ to the spawning biomass that produced the last abundant year-class. For 2002, catches associated with $\mathbf{F_{0.1}}$ and no biomass reduction have been estimated at 6,800 t and 5,800 t respectively (Figure 15).

This risk analysis also presents more optimistic results than the previous one in 1999. For example, for allocated catches of

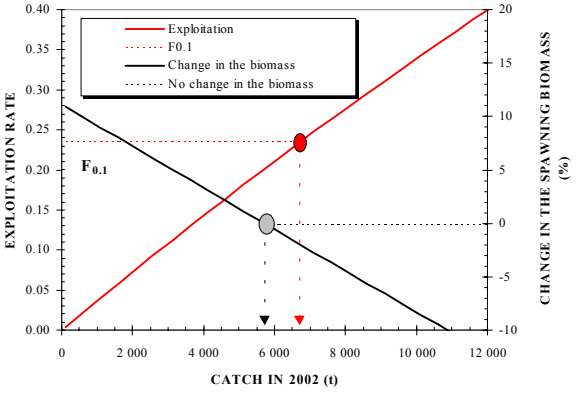

Figure 15. Determination of catches of spring spawner herring in 2002 for various exploitation rates and changes in spawning biomass.

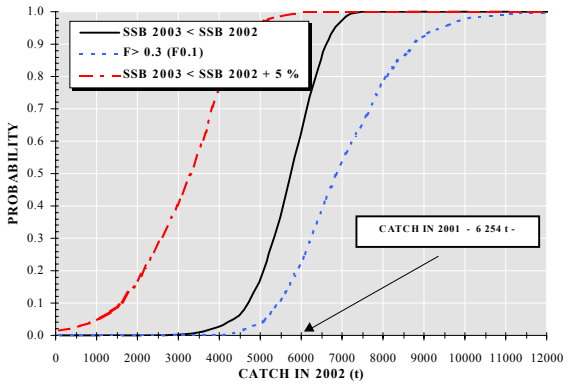

Figure 16. Risk analysis for various changes in mature biomass of spring spawner herring, by catch level in 2002 (probabilities of exceeding $F_{0.1}$ are also shown).

3,400 t in 2000, the probability of exceeding $\mathbf{F_{0.1}}$ in 2001 was 50%. If the same catches were to be made in 2002, that probability would fall to 0%, and the probability of seeing a 5% biomass increase between 2002 and 2003 would be 60% (Figure 16). If herring catches in 2002 were to be 6,800 t, a figure similar to 2001 catches and associated with $\mathbf{F_{0.1}}$, the probability of a biomass increase in 2003 would be less than 10%, rising to 50% with catches in the neighbourhood of 5,800 t.

The projections for this spawning stock have to be interpreted with caution, however, since they have been based on an average abundance value assigned to the 1998 to 2000 year-classes. Those classes could not be estimated with precision by **SPA** for lack of an independent fishing survey. What is more, the only index available in 2001, the gillnet index, does not give an accurate measurement of juvenile herring. Given that these year-classes make up over 30% of the mature biomass calculated in 2001, a higher degree of uncertainty should be associated with the results of the risk analysis.

Fall Spawners

Unfortunately, the spawning biomass of fall herring could not be estimated in 2001 for lack of an acoustic survey. No assessment advice different from the previous advice can really be formulated with regard to an acceptable catch level in 2002.

Management Considerations

The spring herring stock is characterized by the periodic arrival of dominant year-classes, some being exceptionally strong. Such year-classes last appeared in 1980 and 1982. Since then, this stock's production has depended on year-classes of very low or average abundance. The probability of this stock producing a very strong year-class is clearly lower for spawning biomasses under 58,000 t or $\mathbf{B_{BUF}}$ (Figure 17). According to the **SPA**, the spawning biomasses of this stock have been below the $\mathbf{B_{BUF}}$ value since 1994.

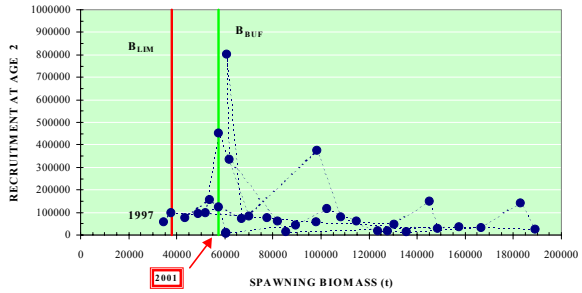

Figure 17. Stock-recruitment ratio for spring spawner herring, 1965 to 1997 (2001 biomass is indicated, as well as $\boldsymbol{B_{LIM}}$ and $\boldsymbol{B_{BUF}}$ limits).

Despite an improvement in the situation, the present advice recommends prudence. The recent increase in spawning biomass of the spring spawner stock is the result of application of some very strict management measures and slightly above-average recruitment between 1994 and 1996. Furthermore, in the absence of an acoustic survey, we have no real indication as to the strength of the most recent year-classes.

This advice also recommends that fishing effort be dispersed along the coast and staggered throughout the year. It is also essential to maintain the index fishermen's program and to encourage a greater number of fishermen to make use of logbooks.

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