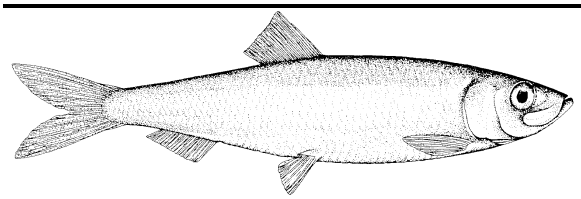

West Coast of Newfoundland Atlantic Herring (Division 4R)

Background

*Herring (*Clupea harengus*) are found throughout the waters of the northwest Atlantic from Labrador to Cape Hatteras. In Canada, they are fished mainly in southwestern Nova Scotia and the Bay of Fundy, within the Gulf of St. Lawrence, and in eastern and southern Newfoundland. Both spring- and autumn-spawning herring are found along the west coast of Newfoundland (4R). Each seasonal-spawning population is considered to be a separate stock for fisheries management.*

The herring is a migratory species which over the course of a year, will travel extensively throughout its area of distribution, from traditional nearshore spawning grounds to feeding and overwintering areas, repeating these patterns year after year with considerable regularity. The major spring-spawning areas in 4R are located at the southern end of the coast in and around St. George's Bay (4Rd) and Port-au-Port Bay (4Rc) although several other spawning sites are known along the coast towards the north in the other major bays. Mature herring arrive and congregate in these areas from the end of April to the middle of June. Autumn spawning is concentrated mainly north of Point Riche (4Ra) from mid-July to mid-September. At other times of the year, these two spawning stocks are mostly found in mixed schools in either feeding or overwintering areas. The major feeding areas (off St. George's Bay in the spring, off Point Riche and in the Strait of Belle Isle in the summer, and in and around the major bays in the fall) are associated with concentrations of copepods (red-feed) and/or euphausiids (krill) which are their main food items. They are believed to overwinter in the deeper waters of the Esquiman Channel.

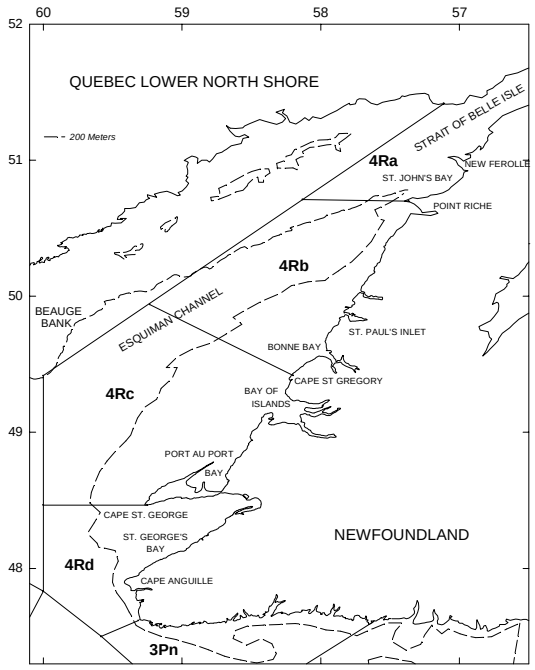

Figure 1. Western Newfoundland (NAFO Division 4R) unit areas.

Summary

- The **spring-spawner** spawning-stock biomass (SSB) rose from 28,600 t in 1999 to 33,000 t in 2000.
- The spring-spawning stock is still below 38,000 t (20% of historical high) and needs to rebuild before directed fishing can be recommended.
- The 1994, 1995 and 1996 year-classes appear to be average in size, supporting the slow increase in stock biomass.
- If the spring-spawner $F_{0.1}$ yield of 3,400 t is caught in 2000, there would be a 80% risk that the SSB would not increase by even 10% by the year 2001. In addition, there is a good probability (30%) that the minimum SSB limit of 38,000 would not be achieved in 2001 at a 3,400 t catch level.
- The **autumn-spawner** SSB declined slowly between 1995 and 1999, when it was estimated to be 52,000 t. and has risen to

54,000 t in 2000, while the fully-recruited fishing mortality slowly increased to the $F_{0.1}$ target level in 1997, and has since declined.

- Recruitment to the autumn-spawning stock has been average to good since the large 1986 year-class, which has kept this stock at a healthy level.
- An autumn-spawner $F_{0.1}$ yield for 2000 would be approximately 12,000 t and would result in a 40% risk that the spawning-stock biomass will decrease by 10%, but a very small risk that the SSB will decline below 34,000 t (lowest observed value).

The fishery

Nominal catches

The herring stocks in 4R are exploited both in mixed schools and singularly in spawning aggregations from April to December mainly by large (>75') purse seiners, small (<65') purse seiners and to a lesser extent by fixed gillnetters. Since 1985, the proportion of the total catch taken by all purse seines has been in excess of 80%, and even reached 98% in 1993.

Since 1988, total herring **landings** from the west coast of Newfoundland averaged 16,300 t (from 12,400 t to 26,400 t) as compared to an average of 14,100 t for the previous decade.

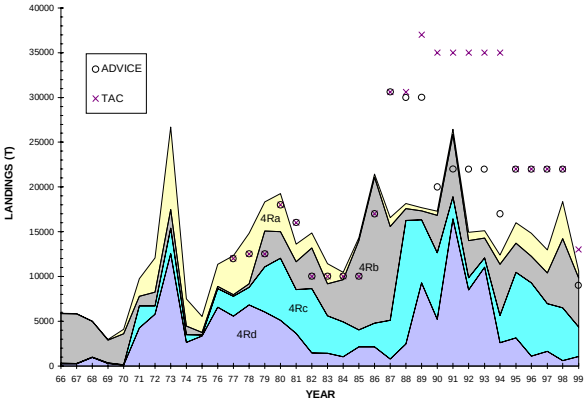

Figure 2. Cumulative commercial herring landings (t) by unit area from 1965 to 1999. (TAC and assessment advice are indicated).

The Purse Seine Fleet

In 1988, the development of an over-the-side market to Russian vessels contributed to a considerable increase in landings in the spring fishery from 4Rc and 4Rd, from approximately 2,000 t in 1987 to 12,400 t in 1991. This spring **large purse-seine** fishery accounted for over 70% of the total catch in 1990 and 1993. This proportion has diminished to below 40% since 1994 when St. George's and Port-au-Port Bays were

West coast of Newfoundland herring landings (t) by gear sector since 1988.

	Year											
Gear	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999***
Large purse seine	*16353*	*16660*	*16301*	*25594*	*10277*	*11309*	*17634*	*10814*	*9473*	*7751*	*9468*	*7059*
Small purse seine					*4390*	*3752*	*3854*	*3392*	*3072*	*3053*	*4435*	*2455*
*Gillnet**	*1792*	*1027*	*983*	*842*	*669*	*247*	*893*	*1806*	*2279*	*2156*	*4455*	*1071*
Total	*18145*	*17687*	*17284*	*26437*	*15336*	*15308*	*12380*	*16012*	*14824*	*12960*	*18358*	*10588*

** includes bar seine and cod trap*
*** Preliminary statistics*

closed to commercial fishing during the spawning season. In 1999, fishing activity was centered around Bonne Bay and the Bay of Islands.

There has been an increase in the activity of the **smaller purse seiners** along the west coast since 1989 where annual landings, which previously had not exceeded 800 t, reached 4,400 t in 1992. From 1993 to 1998, this fleet has landed from 3,100 t to 4,400 t annually. The 1999 landings decreased to 2,500 t mainly due to the closure of the spring fishery.

The Gillnet Fleet

Due to a limited market demand for gillnetted herring, reported landings from **fixed gear** have generally been below 10% of the total 4R landings since 1985. A market has recently developed in 4Ra which has resulted in a steady increase in total gillnet landings from 800 t in 1994 to 4,200 t in 1998. Preliminary statistics indicate a marked decrease to 1,100 t in 1999, although some landings may not yet be accounted for.

Resource status

Biological Indicators

Spawning Stock Proportions in the Catch

Historically, spring spawners have been dominant in the catch, averaging 72% of the catch in numbers, although this percentage has decreased to less than 50% in the last 4 years. This is due mainly to a decrease in the concentration of fishing on the spring spawning component, as well as by a decrease in the spring-spawning stock itself, relative to the autumn spawners. In the late-fall purse-seine fishery, there has been a trend of decreasing percentage spring spawners, from 75% in 1987 to 20% at present.

Age Composition of the Catch

Between 1990 and 1997, only the 1987 and 1990 spring-spawner year-classes had been important contributors to the total spring-spawner catch. Since 1998, the 1994, 1995 and 1996 have recruited to the purse seine fishery, and comprised 72% of the spring-spawner catch in 1999.

Several above average to good year-classes (1986, 1988, 1990) have appeared in the autumn-spawner catch since 1990 in addition to the 1979 year-class, which was still dominant in 4Ra in 1997. In 1999, the catch was spread over 4 major year-classes (1990, 1993, 1994 and 1995).

Weight at Age and Biological Condition

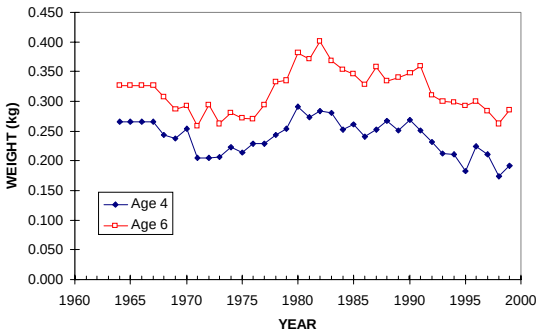

Figure 3. Mean weight at age 4 and 6 for spring-spawning herring in late fall (Oct-Dec) from 1964 to 1999.

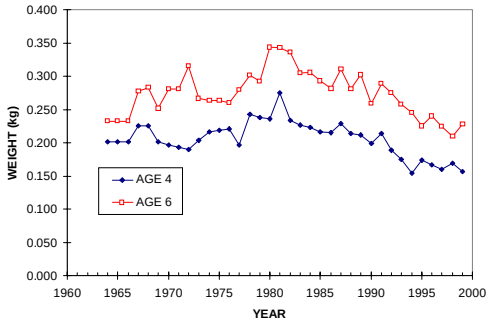

Figure 4. Mean weight at age 4 and 6 for autumn-spawning herring in late fall (Oct-Dec) from 1964 to 1999.

There has been a more or less constant decline in the **weight at age** of both spring and autumn spawners since the early 1980s. The overall **condition** (weight vs. length) of west coast of Newfoundland herring showed a major decrease in 1993 and 1994, corresponding with a general decrease in annual water temperatures noted for the northern Gulf of St. Lawrence. However, when put into the context of the last 29 years, average condition was much lower from 1973 to 1976. In 1995, overall condition rebounded to the high values seen throughout the 1980's, but has declined steadily since, indicating a return to poor feeding conditions. Condition increased in 1999 for the spring spawners, and was stable for the autumn spawners.

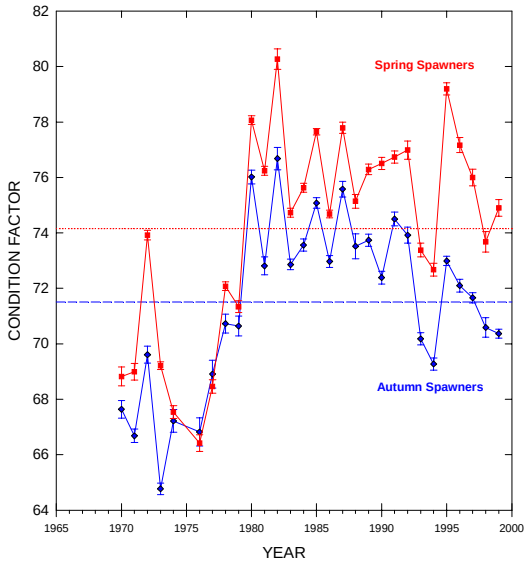

Figure 5. Condition factor for spring- and autumn-spawning herring in late fall (Oct-Dec) from 1970 to 1999.

Abundance indicators

Questionnaires and Logbook Comments

Comments collected from written **questionnaires** sent to all licensed inshore herring fishermen in 4R as well as comments collected from **index-fisherman logbooks** indicated that opinions were mixed as to whether there was an improvement in the abundance of spring spawners around Port-au-Port Bay, St. George's Bay and Bay of Islands in 1999 relative to 1998, although it was felt that spawning activity had not yet improved significantly. These observations are consistent with the catch rate data from index-fishermen in these areas, as well as comments from the index-fishermen to the effect that there has not been a significant improvement in spawning.

North of Point Riche in 4Ra, the general opinion has been somewhat pessimistic since 1997, although the majority of responses came from the Strait of Belle Isle. Spawning was noted throughout St. John and St. Margaret Bays, around Ferolle Point. Fishermen noted that their catches showed a mixture of large and small herring.

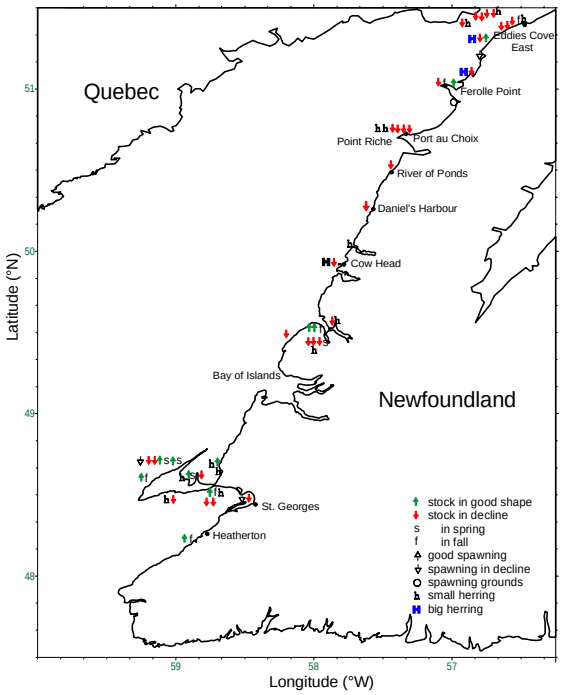

Figure 6. Distribution of inshore fishermen's opinions concerning the state of the herring stocks and spawning in 1999 from written questionnaires.

Index-Fisherman Catch Rates

The standardized spring-spawner **gillnet catch rates** from index fishermen (IF) indicated a systematic decline since 1987. This catch-rate index increased slightly in 1991 and 1997, with the recruitment of the 1987 and 1990 year-classes to this fishery, although neither year-class was sufficiently abundant in the southern bays to reverse the declining trend. This index reached an historical low in 1998 and was stable in 1999.

This year, a dozen additional industry logbooks (IL) were supplied voluntarily to DFO by gillnet fishermen in St. George's Bay for 1999. When these logbooks were included in the catch-rate standardization, the 1999 catch rate showed an increase relative to 1998, but was nonetheless the second lowest of the series.

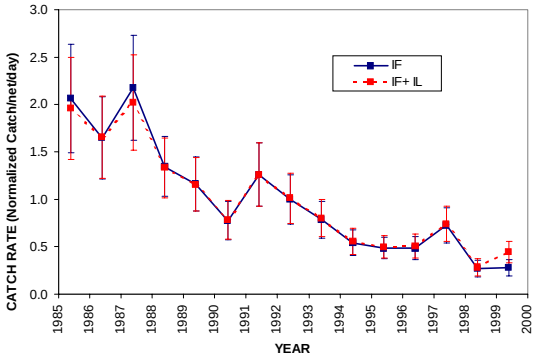

Figure 7. Normalized catch rates for spring-spawning herring from index-fisherman logbooks (IF) between 1985 and 1999, and industry logbooks (IL) in 1999.

Due to the decrease in participation in the autumn index-fisherman program (three or fewer logbooks annually since 1994), only the data from 1984 to 1993 were used for the autumn-spawning index-fisherman catch-rate series for the calibration of the VPA. This index reflected the strong recruitment of the 1979 and 1986 year-classes.

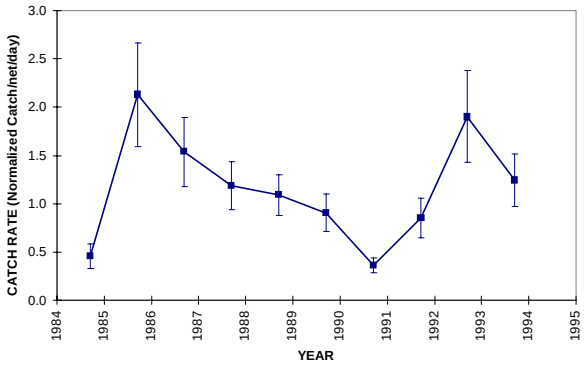

Figure 8. Normalized catch rates for autumn-spawning herring from index-fisherman logbooks between 1984 and 1993.

Acoustic Surveys

Fall **acoustic surveys** have been conducted on a biennial basis since 1989 with the last survey in 1999. This survey includes the entire west coast of Newfoundland from St. George's Bay to the Strait of Belle Isle. However, in 1999, St. George's Bay was not sampled due to bad weather.

The 1999 total herring biomass estimate of 96,500 t (27,800 t of spring spawners and 68,700 t of autumn spawners) was a increase over the 1997 estimate of 87,900 t (23,900 t of spring spawners and 64,000 t of autumn spawners). In 1997, 80% of the herring biomass surveyed was in the most northerly stratum, while in 1999, 81% was either on Bonne Bay Bank or north of Point Riche, where autumn spawners were dominant. Several concentrations of juveniles were located near the Strait of Belle Isle. The 1999 survey showed an increase in both the spring- and autumn-spawner total biomass for the first time since these surveys have been conducted.

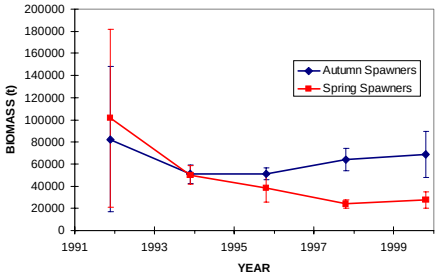

Figure 9. Biomass estimates of spring- and autumn-spawning herring from 1991 to 1999 from the biennial acoustic survey.

Sequential Population Analysis

The stock status assessment was based on a **sequential population analysis** (SPA) for the **spring-spawning stock** using the commercial catch at age, and abundance trends from both the index-fisherman catch rates (1985 to 1999) and the last 5 biennial acoustic surveys (1991 to 1999). This analysis revealed that the 8+ **fishing mortality** had risen more or less steadily on this stock between 1987 and 1991, and then fluctuated between 0.3 and 0.5 until 1998. The fishing mortality fell below the $F_{0.1}$ target level of 0.3 in 1999, mainly due to the restriction of fishing on spring spawners in the southern bays in the spring.

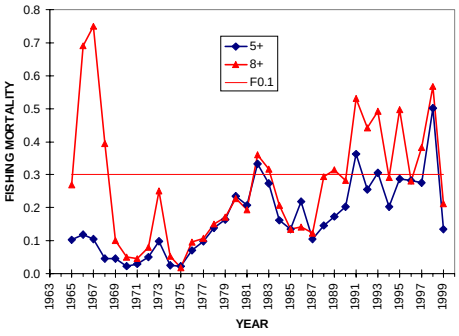

Figure 10. Annual instantaneous fishing mortality (5+,8+) for spring-spawning herring from 1965 to 1999.

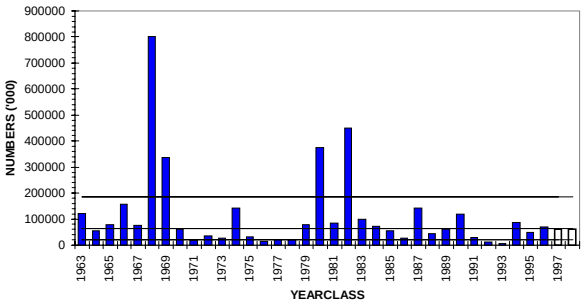

Figure 11. Estimates of recruitment at age 2 for spring-spawning herring for year-classes 1963 to 1996. Lines represent mean recruitment at low, medium and high levels (year-classes 1997 and 1998 are fixed at medium recruitment).

This analysis showed that, apart from 1987 and 1990 year-classes, **recruitment** had been below average for a decade. However, the 1993, 1994 and 1995 year-classes appear to be of average size as opposed to the low values for the 3 previous years. The **spawning-stock biomass** therefore declined to an historical low of 27,000 t in 1998 but increased to 33,000 t in 2000. If 20% of the virgin stock size is considered as the biological reference point for a stock in danger of collapse as suggested by the FFRC, that level would be 38,000 t for this stock. This assumes that the virgin stock size is equal to the maximum observed SSB, which was 190,000 in 1973.

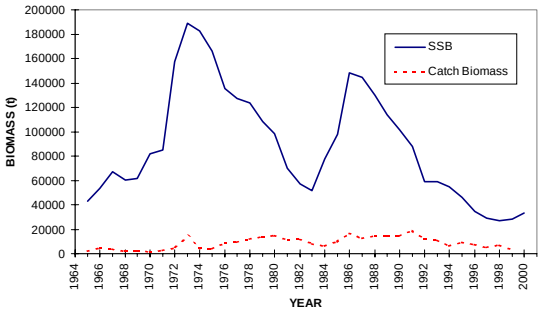

Figure 12. Spawning-stock biomass and catch biomass for spring-spawning herring from 1965 to 2000.

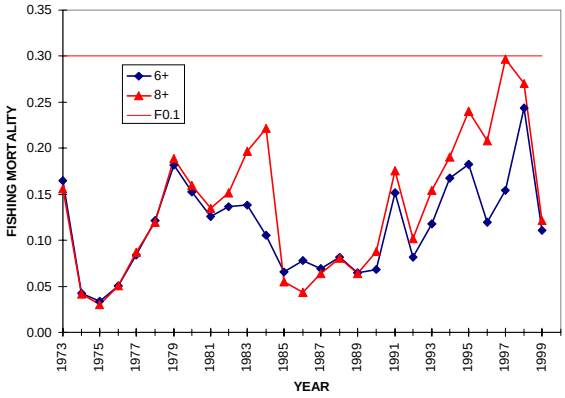

Figure 13. Annual instantaneous fishing mortality (6+,8+) for autumn-spawning herring from 1973 to 1999.

The **autumn-spawner** sequential population analysis used the acoustic survey abundance index and the index-fisherman catch-rate index from 1984 to 1993. The analysis indicated that the 8+ **fishing mortality** had risen slowly since 1989, and reached the $F_{0.1}$ target of 0.3 in 1997. The **spawning-stock biomass** declined slowly between 1995 and 1999, when it was estimated to be 52,000 t and has risen to 54,000 t in 2000. The **population estimates** showed a well balanced age structure with 4 year-classes dominating the 2000 population. **Recruitment** has been average to good since the large 1986 year-class. The 1994 to 1996 year-classes were estimated to be strong, which has kept this stock at a high stock level.

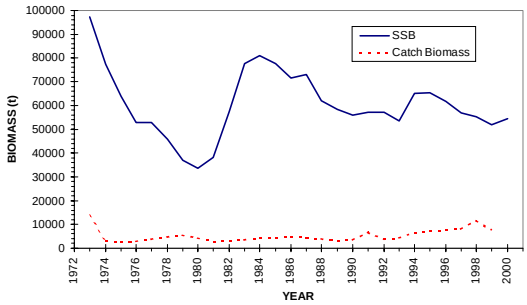

Figure 14. Spawning-stock biomass and catch biomass for autumn-spawning herring from 1973 to 1999.

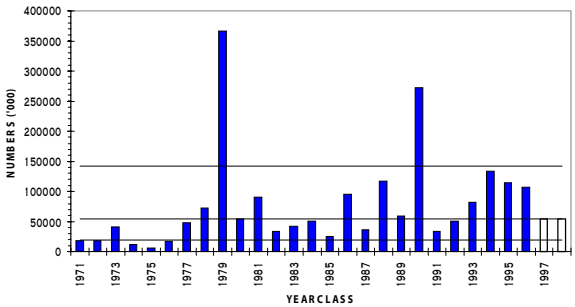

Figure 15. Estimates of recruitment at age 2 for autumn-spawning herring for year-classes 1971 to 1996. Lines represent mean recruitment at low, medium and high levels (year-classes 1997 and 1998 are fixed at medium recruitment).

Outlook

Spring Spawners

The spring-spawning stock is still below 38,000 t (20% of historical high) and needs to rebuild before directed fishing can be recommended. However, **uncertainty** about year-class abundance creates uncertainty in forecasted yields. This uncertainty is expressed as the risk of not achieving various reference targets. For example, a 2000 catch of 3,400 t (the 1999 spring-spawner catch and the calculated **$F_{0.1}$ yield**) would result in a 80% risk that the spawning-stock biomass would not increase by even 10% by 2001. There is also a good probability (30%) that the minimum SSB limit of 38,000 would not be achieved in 2001 at this catch level. A catch of 3,400 t therefore cannot be recommended if the primary objective is to rebuild this stock.

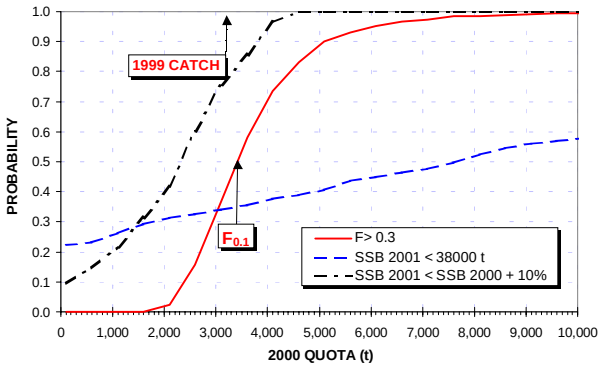

Figure 16. Risk Analysis for spring-spawning herring with the probability of not reaching various objectives and limits given various quotas in 2000 assuming medium recruitment.

These uncertainty calculations do not include variations in catch at age, partial recruitment to the fishery, natural mortality or future recruitment. In particular, because the recruitment of age 2 fish in 1999, 2000 and 2001 is unknown, average recruitment was assumed for the projections. Therefore, if the actual recruitment for these year-classes deviates significantly, either higher or lower, the resulting risk projections would be affected accordingly.

Autumn Spawners

An estimated (50% probability) **$F_{0.1}$ yield** in 2000 for the **autumn-spawning stock** would be approximately 12,000 t, although the flatness of the probability curve indicates that there is much uncertainty around this value. With this yield, there is a 40% risk that the spawning-stock biomass will decrease by 10%, but very little risk that the SSB will decline below 34,000 t (the lowest observed value since 1973). Additional uncertainty arises because average recruitment at age 2 is assumed for 1999 through to 2001.

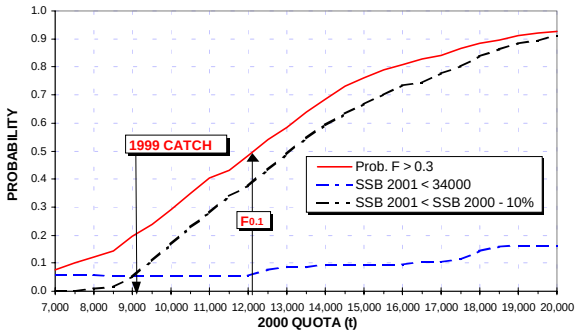

Figure 17. Risk Analysis for autumn-spawning herring with the probability of not reaching various objectives and limits given various quotas in 2000 assuming medium recruitment.

Management considerations

The 2000 assessment of western Newfoundland herring indicates that in general, fully-recruited fishing mortality has been increasing over the past 12-15 years on these stocks and had been well above $F_{0.1}$ for the spring spawners between 1991 and 1998.

Comments received from index fishermen and questionnaires suggested that there was some improvement in abundance in 1999 in St. George's Bay and Port-au-Port Bay but that there are few signs of strong spawning activity in the inshore. The moderately strong 1994 to 1996 year-classes should be entering this fishery over the next 2 to 3 years, at which time their impact on spawning in the southern bays can be quantified through the index-fisherman program.

Throughout the past 30 years, **the spring-spawning stock** has been supported by exceptionally large year-classes which appear on roughly a 10-12 year cycle. As over 16 years have passed since the last large recruitment pulse (1980 and 1982 year-classes), the production of this stock (growth and recruitment) has not kept up with removals (catches and natural mortality). In addition, the pattern of **recruitment against spawning-stock**

biomass indicates that the chances of this stock producing a strong year-class decreases sharply below about 50,000-60,000 t.

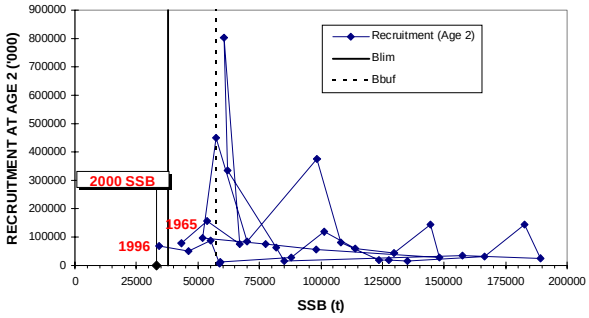

Figure 18. Stock-recruitment relationship, minimum spawning-stock biomass (Blim) and buffer spawning-stock biomass (Bbuf) for spring-spawning herring from 1965 to 1996. The spawning-stock biomass in 2000 is indicated.

The **autumn-spawning stock** has historically received less fishing effort and has constituted less of the total catch (<28%) than the spring spawners because it is distributed more in the northern areas farther from the principle landing ports. This has resulted in a wider age distribution in this stock, with the 1990 year-class appearing as very strong and the 1994, 1995 and 1996 year-classes as above average to good. Due to the recruitment of these three above average year-classes, the autumn-spawning stock status can be considered healthy and is presently well above the minimum limit where a the chances of the stock producing a strong year-class may be reduced.

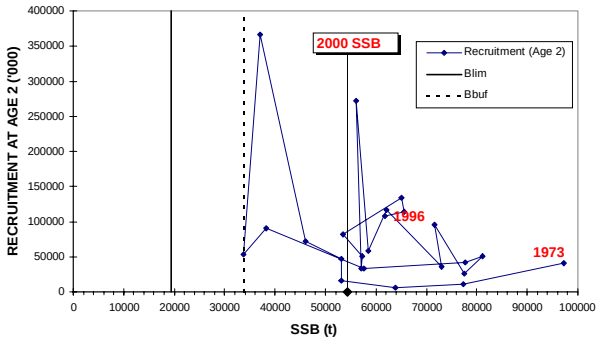

Figure 19. Stock-recruitment relationship, minimum spawning-stock biomass (Blim) and buffer spawning-stock biomass (Bbuf) for autumn-spawning herring from 1965 to 1996. The spawning-stock biomass in 2000 is indicated.

Precautionary principles suggest that the 2000 yield would be 12,000 t for the autumn-spawners and that no directed fishery be prosecuted on concentrations of spring spawners. It is recommended that the harvest restrictions be continued for the southern end of 4R. To avoid a repetition of intensive fishing on any other component, either spring- or autumn-spawning, it is recommended that fishing effort be spread out along the remainder of the coast and throughout the year as much as possible. The continuation and enhancement of the index-fisherman program in St. George's Bay and Port-au-Port Bay is essential for the close monitoring of spawning activity in this area and as a spring-spawner abundance index.

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McQuinn, I.H. and L. Lefebvre. 2000. An Assessment and Risk Projections of the West Coast of Newfoundland (NAFO Division 4R) Herring Stocks (1965 to 2001). DFO Atlantic Fisheries Res. Doc. 2000/--.

For more information :

Ian McQuinn
Maurice Lamontagne Institute
850 route de la Mer
P. O. Box 1000
Mont-Joli, Quebec
G5H 3Z4
Tel: (418) 775-0627
Fax: (418) 775-0740
E-mail:mcquinni@dfo-mpo.gc.ca

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Regional Stock Assessment Office,
Department of Fisheries and Oceans,
Maurice-Lamontagne Institute,
P.O. Box. 1000, Mont-Joli,
Quebec, Canada
G5H 3Z4

Email: Stocksrl@dfo-mpo.gc.ca

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