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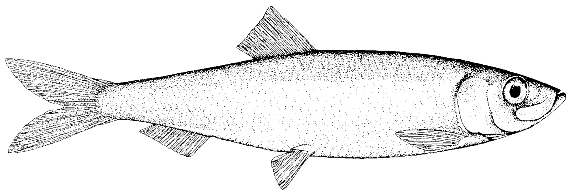
DFO Sciences

Laurentian Region

Stock Status Report B4-01 (1999)



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 St. John Bay. 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.

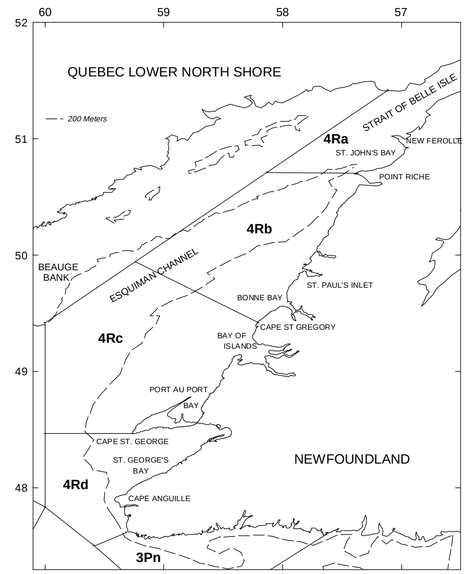


Figure 1. Western Newfoundland (NAFO Division 4R) unit areas.

Summary

- The 1999 assessment indicates that the status of the spring-spawning stock is in danger of collapse while the autumn spawning stock is declining gradually while the exploitation rate has been slowly increasing.
- Apart from the 1990 yearclass, recruitment to the **spring-spawning stock** has been below average since the 1987 yearclass.
- The spring-spawner spawning-stock biomass (SSB) has declined to an historical low of 14,000 t in 1999.
- If the spring-spawner $F_{0.1}$ catch of 2,300 t is caught in 1999, there would be a 40% risk that the SSB would increase by 20% by the year 2000, although the minimum SSB target of 38,000 cannot be achieved even without fishing.
- Recruitment to the **autumn-spawning stock** has been above average since the large 1979 yearclass, which has kept this stock at an intermediate level.

- The autumn-spawner SSB has been declining slowly, from 80,000 t in 1984 to 42,000 t in 1998.
- An autumn-spawner $F_{0.1}$ yield for 1999 would be approximately 9,000 t and would result in a 90% risk that the spawning-stock biomass will decrease by 10%, although there is a 70% probability that the SSB will not decline below 35,000 t.
- It is essential that fishing effort be reduced and be shifted to the north as much as possible to avoid directed fishing on the spring-spawning stock.

The fishery

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 1986, total herring **landings** from the west coast of Newfoundland averaged 17,300 t (from 12,400 t to 26,400 t) as compared to an average of 14,100 t for the previous decade (Figure 2).

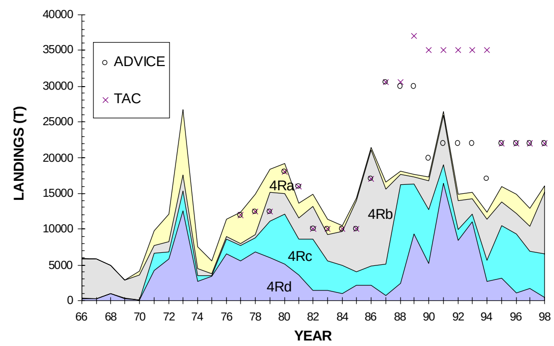


Figure 2. Cumulative commercial herring landings (t) by unit area from 1966 to 1998. (TAC and assessment advice are indicated).

From 1984 to 1987, up to 80% of the **purse seine** catches were taken from October to December on over-wintering concentrations of herring in areas 4Rb and 4Rc. 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 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 closed to commercial fishing during the spawning season. Between 1997 and 1998, there was a general displacement of the purse seine fleet towards the north. After an

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*
Large purse seine	*16353*	*16660*	*16301*	*25594*	*10277*	*11309*	*17634*	*10814*	*9473*	*7751*	*9468*
Small purse seine					*4390*	*3752*	*3854*	*3392*	*3072*	*3053*	*3859*
*Gillnet**	*1792*	*1027*	*983*	*842*	*669*	*247*	*893*	*1806*	*2279*	*2156*	*2803*
Total	*18145*	*17687*	*17284*	*26437*	*15336*	*15308*	*12380*	*16012*	*14824*	*12960*	*16123*

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

initial concentration in the southern bays in May of 1998, fishing activity was centered around Bonne Bay for the rest of the year. There was also an increase in activity in 4Ra in August, entirely on autumn spawners. It would appear from this displacement that herring densities were higher in the north than in the south.

There has also 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 3,900 t annually.

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 2,800 t in 1998.

Resource status

Biological Indicators

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 stock, 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 45% at present.

Since the mid-1980's, only the 1980, 1982, 1987 and 1990 spring-spawner yearclasses have been important contributors to the total catch. The 1990 yearclass appeared for the first time in the gillnet catches inside of St. George's Bay and Port-au-Port Bay in the spring of 1996. In late 1998, the 1994 cohort was the dominant yearclass in the purse seine catches.

Since 1983, the 1979, 1986, 1988 and 1990 autumn-spawning yearclasses have been the most important contributors to the fishery for this stock. The 1979 yearclass was still dominant in 4Ra in 1997.

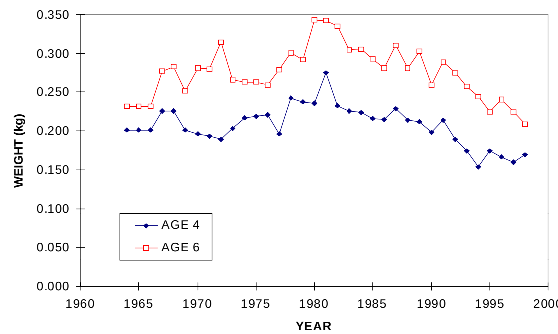


Figure 3. Mean weight at age 4 and 6 for spring-spawning herring in late fall (Oct-Dec) from 1964 to 1998.

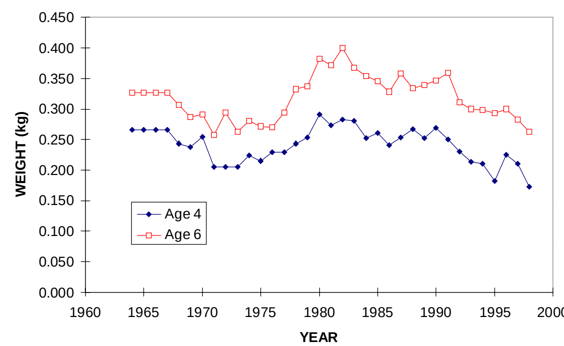


Figure 4. Mean weight at age 4 and 6 for autumn-spawning herring in late fall (Oct-Dec) from 1964 to 1998.

There has been a more or less constant decline in the **weight at age** of both spring and autumn spawners since the early 1980s (Figure 3 and 4). The overall **condition** (weight vs. length) of west coast of Newfoundland herring showed a major decrease in 1993 and 1994 (Figure 5), 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 28 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.

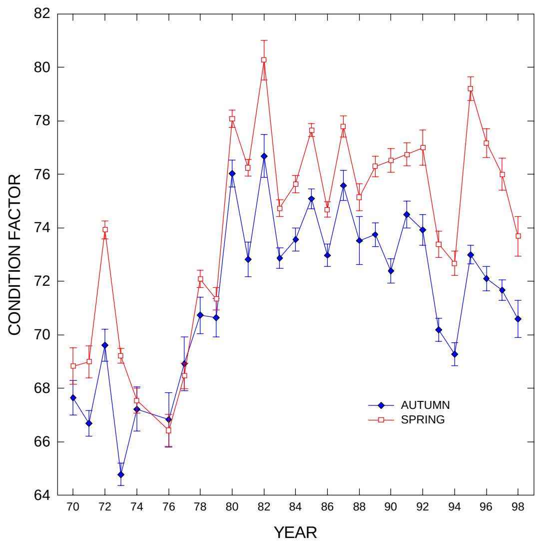


Figure 5. Condition factor for spring- and autumn-spawning herring in late fall (Oct-Dec) from 1970 to 1998.

Four species of seals: grey seals (*Halichœrus grypus*), harbour seals (*Phoca vitulina*), harp seals (*Phoca groenlandica*) and hooded seals (*Cystophora cristata*) occur in the northern Gulf of St. Lawrence. Harp seals and grey seals are the most important **seal predators** owing to their abundance (harp seals), or time of residency in this area and possibly high incidence of herring in the diet (grey seals). Pinniped consumption of herring in 4R has most likely increased over the past decade with the growth of the harp seal population. Annual consumption was estimated to have now reached in the order of tens of thousands of tons, and is most likely concentrated on young herring. These estimates should be considered as very tentative, as many uncertainties are involved in the calculations. The scarcity of comprehensive diet information for pinnipeds in the northern Gulf, as well as their resident times are two of the major factors limiting attempts to quantify fish consumption in this area. However, the true impact of predation on 4R herring stocks cannot be evaluated until predation is considered within the context of total natural mortality.

Abundance indicators

Comments collected from written **questionnaires** sent to all licensed inshore herring fishermen in 4R as well as comments collected from **index-fisherman logbooks** indicated some improvement in the abundance of spring spawners around Port-au-Port Bay, St. George's Bay and Bay of Islands in 1996 relative to 1995, although it was felt that spawning activity had not yet improved significantly. The 1990 spring-spawner yearclass, which had been captured in the fall purse seine fishery since 1994, had started to spawn in these southern bays. These observations are consistent with the catch rate data from index-fishermen in these areas. However, comments were generally negative in 1997 and 1998, indicating that the improvement was short lived, and there was a widespread opinion that the herring was small. Index fishermen logbooks stated that herring were scarce, schools were small and catches were the lowest seen for many years.

North of Point Riche in 4Ra, the general opinion was that herring abundance was average to good in 1995 and 1996 especially in the summer and fall, although along the Labrador coast of the Strait of Belle Isle, comments indicated that the stock was in decline. Opinions were increasingly pessimistic in 1997 and 1998, although spawning was noted throughout St. John and St. Margaret Bays, around Ferolle Point. Fishermen noted that the herring showed a mixture of large and small sizes.

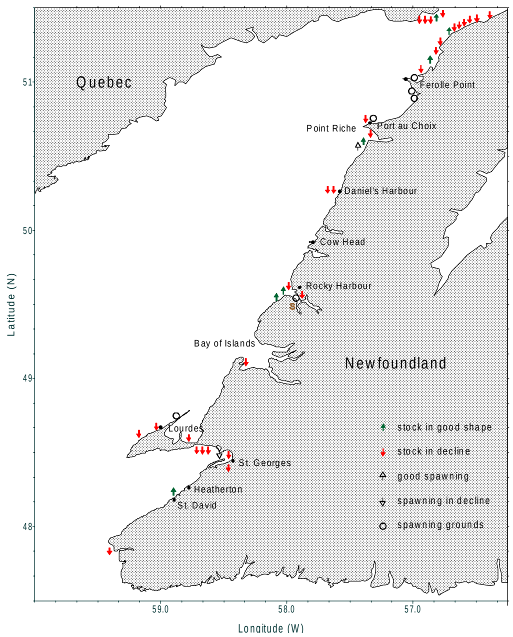


Figure 6. Distribution of inshore fishermen's opinions concerning the state of the herring stocks and spawning in 1998 from written questionnaires.

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

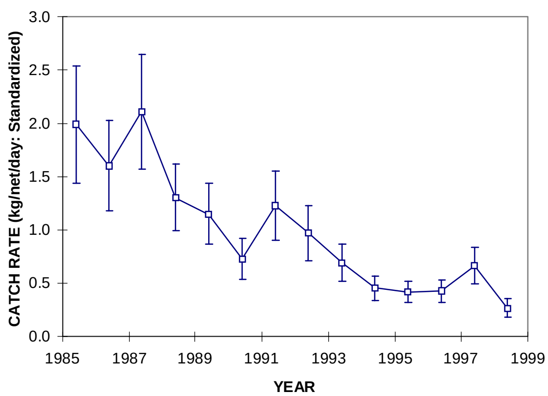


Figure 7. Standardized catch rates for spring-spawning herring from index-fisherman logbooks between 1985 and 1998.

The autumn-spawning index-fisherman catch-rate index seemed to reflect the strong recruitment of the 1986 yearclass and was well above the 10-year average. Its subsequent sharp decline in 1992 and 1993 was unexpected given the low fishing effort on this stock. In addition, the recent recruitment of the 1988 and 1990 yearclasses has not been reflected in the index, which puts in doubt its usefulness as a measure of abundance. This index-fisherman catch-rate series has become less reliable due to (1) a decrease in participation in the program (two to four logbooks annually since 1993) and (2) the decrease in availability to inshore gillnets as the herring have moved farther offshore.

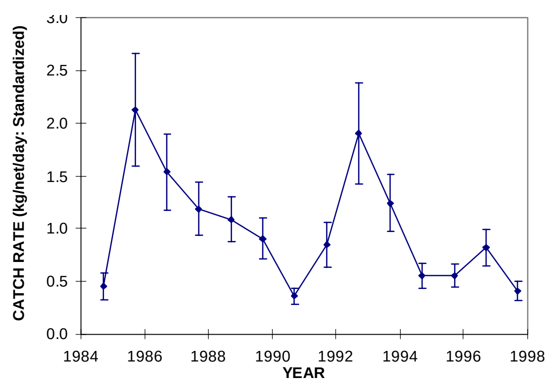


Figure 8. Standardized catch rates for autumn-spawning herring from index-fisherman logbooks between 1984 and 1997.

Fall **acoustic surveys** have been conducted on a biennial basis since 1989 with the last survey in 1997. The 1995 and 1997 surveys were undertaken in close collaboration with the west coast large seiner fleet. This survey included the entire west coast of Newfoundland from St. George's Bay to the Strait of Belle Isle which adequately covered the stock area.

The 1997 total spawning-stock biomass estimate of 67,000 t (19,500 t of spring spawners and 47,500 t of autumn spawners) was a decrease over the 1995 estimate of 86,000 t (38,000 t of spring spawners and

48,000 t of autumn spawners)(Figure 9). In 1995, 64% of the herring biomass surveyed was in the two most northerly strata, while in 1997, 80% was in the most northerly stratum. The last 4 surveys have shown a constant decline in the spring-spawners spawning biomass, while the autumn spawners appeared to be stable over the last three surveys.

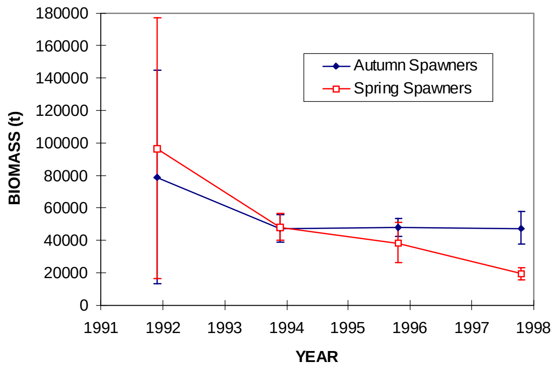


Figure 9. Biomass estimates of spring- and autumn-spawning herring from 1991 to 1997 from the biennial acoustic survey.

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 1998) and the last 4 biennial acoustic surveys (1991 to 1997). This analysis revealed that the 5+ **fishing mortality** has risen more or less steadily on this stock since 1987 (Figure 10). Although the fishing mortality had remained around the $F_{0.1}$ target level of 0.3 in recent years, it rose sharply to 0.45 in 1998, mainly due to the concentration of fishing on spring spawners in the southern bays in the spring

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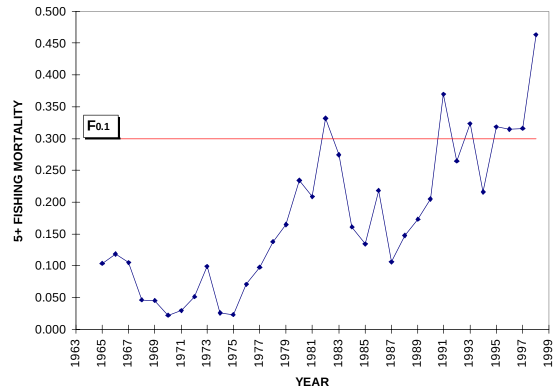

Figure 10. Annual instantaneous fishing mortality (5+) for spring-spawning herring from 1965 to 1998.

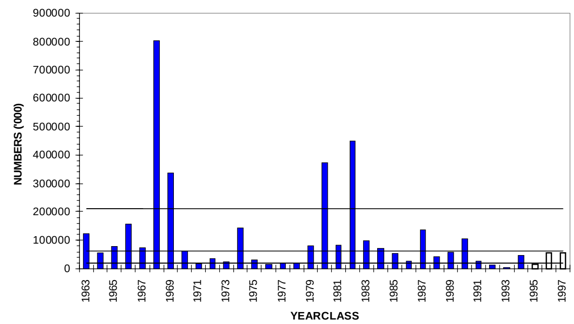

Figure 11. Estimates of recruitment at age 2 for spring-spawning herring for yearclasses 1963 to 1994. Lines represent mean recruitment at low, medium and high levels. (yearclasses 1995 to 1997 are fixed at low and medium recruitment).

This analysis showed that, apart from the 1990 yearclass, **recruitment** has been below average since the 1987 yearclass (Figure 11). Even the 1994 yearclass, which was a significant portion of the 1998 catch at age, appears to be below average. The **spawning-stock biomass** has therefore declined to an historical low of 14,000 t in 1999 (Figure 12). 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.

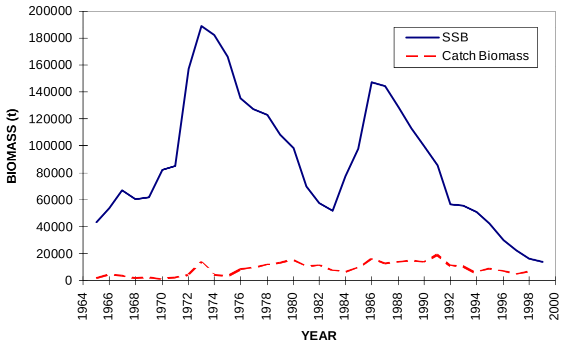

Figure 12. Spawning-stock biomass and catch biomass for spring-spawning herring from 1965 to 1999.

Because of the uncertainties with the index-fisherman catch rate, the **autumn-spawner** sequential population analysis used only the acoustic survey abundance index. As this index was last estimated in 1997 and is still a short time series, the autumn-spawning population was estimated only up to 1998 and was less certain than the spring-spawner analysis. The analysis indicated that the 6+ **fishing mortality** had risen slowly since 1985 but was still below the $F_{0.1}$ target of 0.3 (Figure 13).

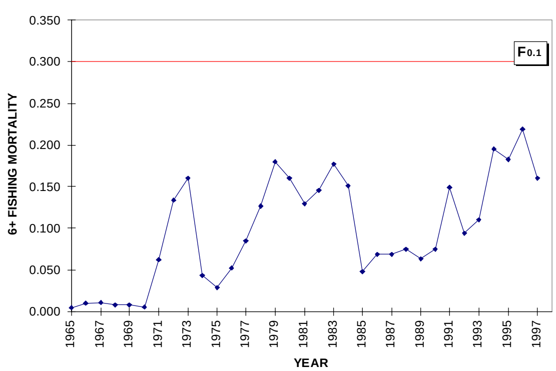

Figure 13. Annual instantaneous fishing mortality (6+) for autumn-spawning herring from 1965 to 1997.

The **spawning-stock biomass** has been declining slowly since 1984, and was estimated to be 42,000 t in 1998 (Figure 14). The **population estimates** showed a well balanced age structure with an above-average 1994 yearclass dominating the 1998 population. **Recruitment** has been above average since the large 1979 yearclass which has kept this stock at an intermediate level (Figure 15).

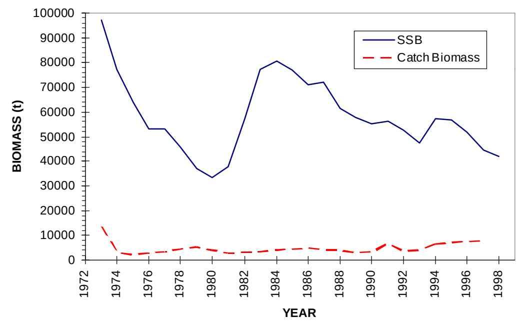

Figure 14. Spawning-stock biomass and catch biomass for autumn-spawning herring from 1973 to 1998.

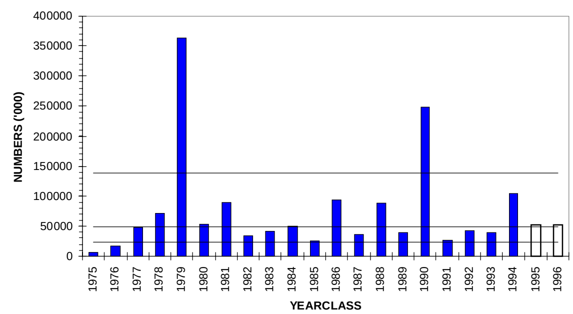

Figure 15. Estimates of recruitment at age 2 for autumn-spawning herring for yearclasses 1975 to 1994. Lines represent mean recruitment at low, medium and high levels. (yearclasses 1995 to 1996 are fixed at medium recruitment).

Results from these assessments indicated that the spring-spawner analysis does not suffer from a **retrospective pattern** (a discrepancy between past assessments of stock status and current estimates using additional data). The acoustic time series was too short to conduct a retrospective analysis for the autumn-spawner stock.

Outlook

A calculated **$F_{0.1}$ yield** for the **spring-spawner stock** in 1999 would be approximately 2,300 t. However, **uncertainty** about yearclass abundance creates uncertainty in forecasted yields. This uncertainty is expressed as the risk of not achieving various reference targets. For example, a 1999 catch of 6,500 t (the 1998 spring-spawner catch) would result in a 100% risk of a further decrease in the spawning-stock biomass (Figure 16). A catch of 2,300 t would result in a 40% risk that even a 20% increase in mature biomass would not be achieved by the year 2000 (from 14,000 t to 17,000 t). The minimum SSB target of 38,000 t cannot be achieved in 2000 even without fishing. A catch of 2,300 t therefore cannot be recommended if the primary objective is to rebuild this stock.

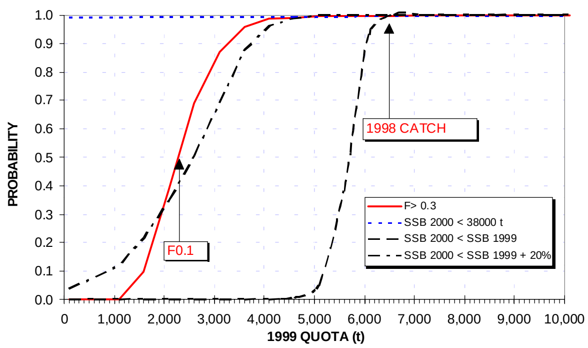

Figure 16. Risk analysis for spring-spawning herring with the probability of not reaching various objectives given various quotas in 1999 assuming medium recruitment.

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 1998, 1999 and 2000 is unknown, medium recruitment was assumed for the projections. If however, the recruitment of these yearclasses is low, as has been observed since the 1990 yearclass, the calculated $F_{0.1}$ yield in 1999 would be around 1,200 t, and would result in a 70% risk of the SSB not increasing by even 10%.

A calculated $\mathbf{F_{0.1}}$ **yield** in 1999 for the **autumn-spawning stock** would be approximately 9,000 t (close to the 1998 autumn-spawner catch), although the flatness of the probability curve indicates that there is much uncertainty around this value (Figure 17). With this yield, there is a 90% risk that the spawning-stock biomass will decrease by at least 10%, but a 70% risk that the SSB will not decline below 35,000 t (the lowest observed value since 1973). Additional uncertainty arises because these projections are two years into the future (from 1998 to 2000) and because medium recruitment at age 2 is assumed for 1997 through to 2000.

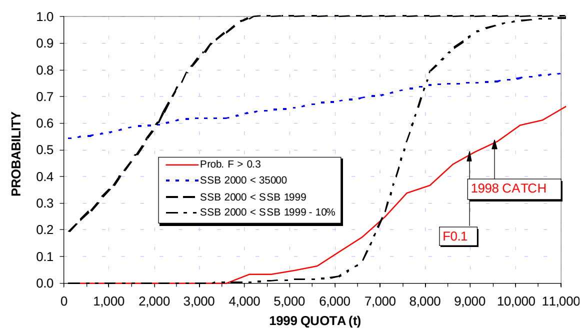

Figure 17. Risk analysis for autumn-spawning herring with the probability of not reaching various objectives given various quotas in 1999 assuming medium recruitment.

Management considerations

The 1999 assessment of western Newfoundland herring indicates that in general, fishing mortality on these stocks has been increasing over the past 12-15 years and had been around $F_{0.1}$ for the spring spawners between 1991 and 1997. The closure of St. George's Bay and Port-au-Port Bay in 1995 had the desired affect of slowing the decline of this stock by concentrating fishing on the autumn spawners, of decreasing the quantity of spring spawners in the total catch and of allowing these fish to spawn undisturbed. However, the present analyses show that the resumption of fishing in these southern bays in 1998 was premature, and that the concentrated harvesting of spring spawners in the spring fishery resulted in a sharp increase in fishing mortality.

Comments received from index fishermen and questionnaires suggested that there was some improvement in abundance in 1996 in St. George's Bay and Port-au-Port Bay. The 1990 yearclass caused an increase in the spring-spawner gillnet catch rates between 1996 and 1997 when it recruited to this fishery. However, both the index-fisherman catch rates and the majority of the questionnaire comments have subsequently indicated that the increase was short-lived, and that the stock has continued to decline since 1997 and has now reached an historical low. It is projected that the 1994 yearclass will not be sufficient to bolster the spring-spawning stock.

The present analyses have shown that recruitment to the spring-spawning stock has been consistently below average since the 1990 yearclass, which was the last of any significance. Throughout the past 30 years, this stock has been supported by exceptionally large yearclasses which appear on roughly a 10-12 year cycle. As over 15 years have passed since the last large recruitment pulse (1980 and 1982 yearclasses), 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 yearclass decreases sharply below about 50,000 t (Bbuf) (Figure 18). Although the estimates are subject to large uncertainties, increased consumption of herring by seals may have helped to reduce the productivity of this stock over the past decade.

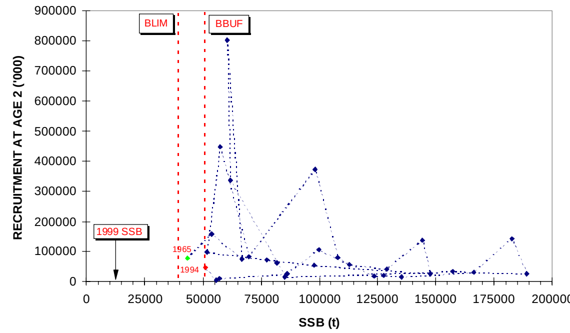

Figure 18. Stock-recruitment relationship, minimum spawning-stock biomass (Blim) and buffer spawning-stock biomass (Bbuf) for spring-spawning herring from 1965 to 1994.

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 yearclass appearing as very strong and the 1994 yearclass as above average.

Although the autumn-spawners are at an intermediate stock size, they are declining slowly and will not be able to support the present TAC of 22,000 t, nor recent catch levels (between 12,000 and 16,000 t). Fishing of 4R herring will therefore have to be reduced to a sustainable level. Precautionary principles suggest that this would be no more that 9,000 t for the autumn-spawners and that no directed fishery be prosecuted on concentrations of spring spawners. It is recommended that a harvest limit be imposed 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 reduced and spreadout 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.

The present analyses indicate that the spring-spawning stock has declined to a point where fishing must be curtailed to avoid a collapse. This dangerous reduction in the SSB has occurred even though the average fishing mortality has been around the $F_{0.1}$ target of 0.3 since 1991. The autumn-spawning stock has been declining gradually while the exploitation rate has been increasing since the mid-1980's. These divergent trends have occurred despite above-average recruitment over the past 15 years and a fishing mortality well below the $F_{0.1}$ target. This suggests that the target exploitation rate may be too high for these stocks and should be re-evaluated.

Finally, an analysis was conducted at the request of Industry to re-examine the minimum size limit of 26.5 cm fork length imposed on 4R herring catches. The main reason for this regulation was to protect juvenile fish and to allow maturing herring to spawn undisturbed at least once before recruiting to the fishery. The analysis evaluated the percent maturity at length for each stock and concluded that on average, 80% of spring- and autumn-spawners are mature at 25.0 and 25.5 cm fork length, respectively. Although this suggests a lowering of the minimum size limit to 25.5 cm may be justified, the present low spring-spawner stock size would argue against an increase in the targeting of young fish at this time.

For more information:

McQuinn, I.H. and L. Lefebvre. 1999. An Assessment and Risk Projections of the West Coast of Newfoundland (NAFO Division 4R) Herring Stocks (1965 to 2000). DFO Atlantic Fisheries Res. Doc. 99/--.

McQuinn, I.H. and L. Lefebvre. 1999. An Evaluation of the Western Newfoundland Herring Acoustic Abundance Index from 1989 to 1997. DFO Atlantic Fisheries Res. Doc. 99/--.

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