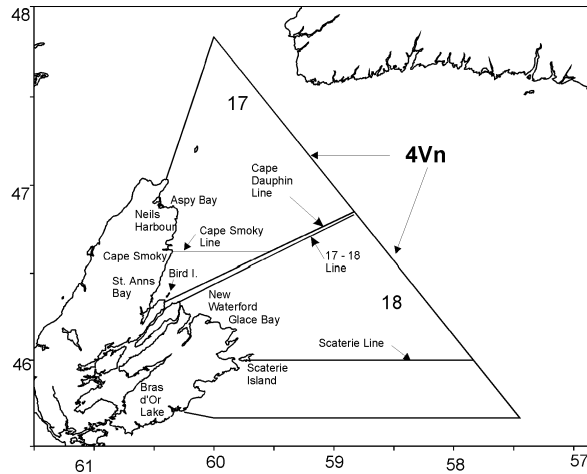




## Decision Rules: 4T Overwintering Herring Fishery in 4Vn



### Summary

- **Where to fish?** (Decision Rule 4): The general principle of fishing in areas where stocks are randomly mixed is most likely to be met in northern areas of 4Vn. Risk of fishing in areas where small vulnerable local stocks are concentrated is greater between Cape Smoky and Cape Dauphin, than north of Cape Smoky. Fishing below Cape Smoky increases the proportion of spring spawners in the catch. Therefore, given the declining situation in the Bras d'Or Lakes, the Cape Smoky line is appropriate at this time.
- **Amount of fish to catch?** (Decision Rule 1): Computer simulations indicated that Decision Rule 1, "overwinter catch not to exceed recent average landings", is still appropriate and would limit exploitation rates on local stocks within conservation target levels.

### Background

The objective of these Decision Rules is to allow a mixed stock fishery, where information on contributing stocks is incomplete, to proceed and still limit exploitation rates on all stocks within conservation target levels. For herring, in the Maritimes Region, these range from about 20% to 25%, averaged over the principal ages in a fishery.

The situation often encountered in a mixed stock fishery is that of a large stock migrating into an area which has one or more smaller local spawning stocks. In some cases, there may also be large or small fish stocks migrating into the mixed stock fishery from several areas. The ideal situation would be if the origin of all fish caught in a mixed stock fishery could be positively identified to stock origin, the size of each of these stocks was known, and removals of fish from these stocks in other fisheries was known. In this situation, determining the exploitation rates would simply be a matter of adding up the catches for each stock, dividing by the population size, and comparing these to the conservation targets. Decisions could then be made to alter the fishery to reduce exploitation where it was too high or to make available other fishing opportunities in under-utilized areas. Often, however, the origin of the contributing stocks is not known, the size of each potentially contributing stock is also not known, and information on removals of stocks from other fisheries is incomplete. In these cases, advice for harvest decisions depends on identifying the probability that target fishing mortalities will be exceeded on individual stocks in particular situations.

Once these probabilities are evaluated, specific operational considerations, or Decision Rules, can be established to ensure that the large stock predominates in the catch and that conservation objectives for all stocks are met. The results of the fishery are then evaluated against the Decision Rule objectives at a stock assessment review meeting, and any changes required to meet those objectives are recommended.

Previous documents (Anon., 1997) have indicated the general principles that would guide the assessment of the probabilities of exceeding target fishing mortalities on individual stocks. These were:

1. If mixing is random:
  - Exploitation rates will on average be equal among all stocks, regardless of number of stocks.
  - Exploitation rates will be more variable on the smaller stocks
2. If mixing is not random and fishing occurs where small stocks are concentrated:
  - exploitation rates on small stocks will be much higher than those expected on the larger stocks.

It is thus important to identify situations which would lead to very high exploitation rates on the smaller, more vulnerable, stocks in an area. To identify these situations, information on the relative sizes of the contributing stocks, areas where small stocks are concentrated, and differences in biological characteristics, so that mixtures can be evaluated, are required. One way to ensure a reduction in probability of high exploitation on small stocks is to limit fishing activity to areas where small portions of large

aggregations could be harvested rather than large portions of small aggregations.

The 4T overwintering fishery in 4Vn is one that does not fit the ideal. The characteristics of the overwintering fishery and the large 4T migrating stock are relatively better known and defined than the information on the abundance, catches, and biological characteristics of local stocks. As a result, the 4T overwintering fishery in 4Vn is a case where specific rules are needed in order to allow the fishery to proceed in such a manner that the uncertainties are taken into account, that the large migrating 4T stock predominates in the catch, and that exploitation rates on local stocks are limited to conservation target levels.

The Decision Rules derived in this document refer specifically to the 4T herring overwintering fishery in 4Vn. These principles, however, apply generally to mixed stock fisheries and, combined with the examples from this overwintering fishery, may be used to guide the development of Decision Rules for other mixed stock fisheries.

### ***Decision Rules for 4T herring overwintering fishery in 4Vn***

Four decision rules were developed to guide the 1997 4T herring overwintering fishery in 4Vn (Anon., 1997):

**How many fish to catch?** (Decision Rule 1): Overwinter catch not to exceed recent average landings, for example 1990-1996.

**When to start?** (Decision Rule 2): Starting date: November 1

**Size of fish to catch?** (Decision Rule 3): No more than 10% of catch by number can be below 24.5 cm fork length.

**Fishing Area?** (Decision Rule 4): Restrict fishing to the area of the 4T stock winter distribution, position of boundary to be determined among science, management, and industry.

This Fishery Status Report examines Fishing Area (Decision Rule 4) because it was not previously resolved (Anon., 1997). It also re-examines How Many Fish to Catch (Decision Rule 1) because this rule may be affected by the decision on where to fish. There is no additional information at this time that warrants a re-examination of **When to Start** (Decision Rule 2) and **Size of fish to catch** (Decision Rule 3).

### *Overview of the Overwintering Fishery*

Catches in the 4T herring overwintering fishery in 4Vn in 1997 were 3605t of which 96% were fall spawners. Landings, for both spawning groups combined, from 1978 to 1997, ranged from 2600t to 4700t. From 1978 to 1986, fall spawners ranged from 50% to 80% of the catch. In recent years, from 1987 to 1997, a higher proportion, 80 % to 96%, of the catch has been fall spawners. A survey conducted by a purse seiner to investigate biomass south of Cape Smoky resulted in an additional catch of 59t in this area as compensation for survey costs. Fall spawners were 95% of the survey catch.

### **Seiner (>65') catch (t) in 4Vn since 1978.**

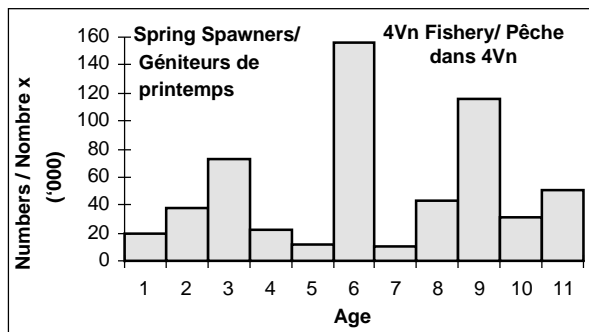
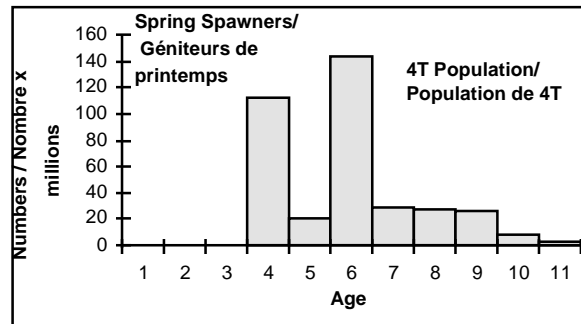
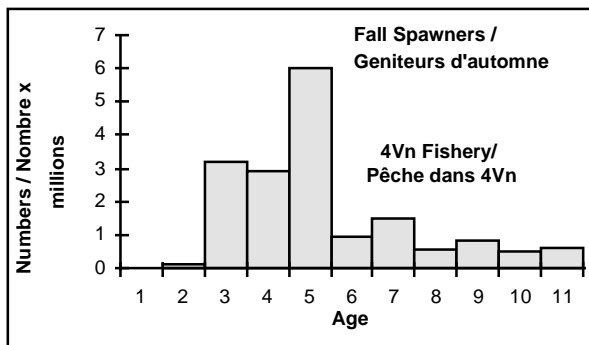
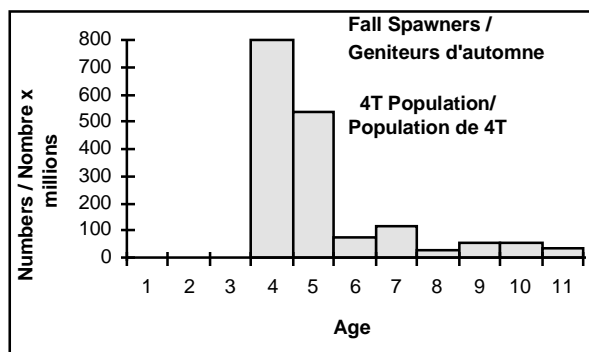
Year	Fall Spawners	Spring Spawners	Total	TAC	Percent Fall Spawners
78	1833	808	2641	8000	69
79	1418	1496	2913	3000	49
80	2981	870	3852	4500	77
81	2120	1162	3282	3000	65
82	2150	1373	3523	3000	61
83	2808	1167	3976	5000	71
84	3000	1004	4005	3500	75
85	2822	778	3600	3500	78
86	3105	1214	4319	4200	72
87	2093	279	2372	4200	88
88	2438	138	2576	4200	95
89	1959	159	2117	4200	93
90	3942	721	4663	4200	85
91	3871	921	4792	4200	81
92	3955	292	4247	4200	93
93	3722	219	3940	4200	94
94	2968	276	3244	4200	91
95	3990	153	4142	4200	96
96	3543	734	4276	6423	83
97	3462	143	3605	4200	96

The fishery began on November 1 and ended November 22. Since 1990, this fishery has been completed by the end of November. The exception was 1996, when one night of fishing occurred on December 3-4. Peak landings, in 1997, occurred on November 12. At least one sample was collected each day of the fishery except November 8.

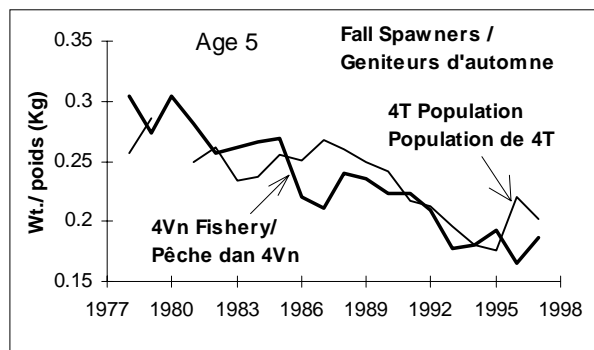
In 1997, fishing was restricted to north of Cape Smoky, for the first time, for the duration of the overwintering fishery. An additional change, made in 1997, was that seiners were permitted to fish in 4T and 4Vn during the overwintering fishery. The restriction, to north of Cape Smoky, was put in place because of concern over potential catches of Bras d'Or Lake herring, when higher than average percentages of spring spawners were caught during fishing in the St. Ann's Bay-Bird Islands area on December 3-4, 1996. While, most of the fishing in 1996

occurred in Aspy Bay, the fishing on December 3-4, occurred in St. Ann's Bay and 32% of the catch were spring spawners. After this date, fishing was restricted to north of Cape Smoky and no additional fishing occurred in 1996.

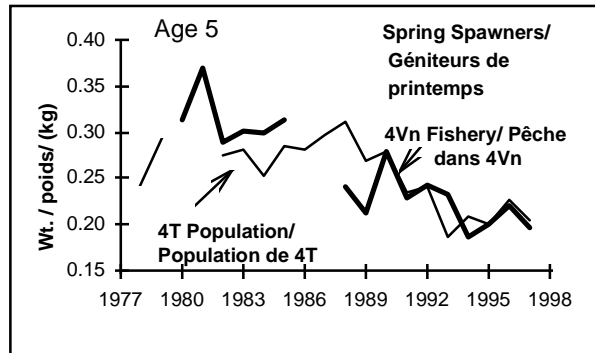
The 1990 and 1992 year-classes that were dominant in the 4T fall spawner population were also important in the large seiner catch in 1997. The 1993 year-class which is estimated to be very large in the 4T population is not as evident in the overwintering catch. The requirement to release all fish < 24.5 cm fork length, which includes a portion of age 4 herring, is consistent with this difference between the age 4 population and the age 4 overwintering catch.



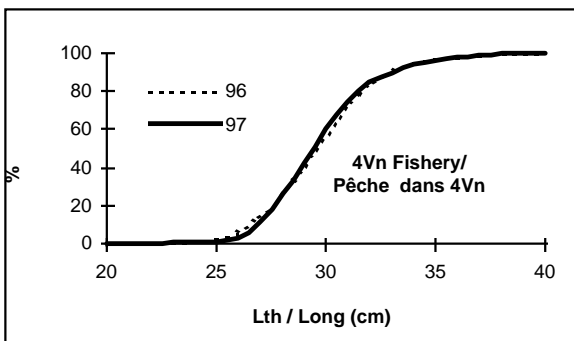
Average mean weight at age, for example 5 year-olds, was slightly higher in 1997 than 1996 for fall and spring spawners and similar to those of the 4T population weight-at-age. Declines in mean weight-at-age were similar in the 4T population and the overwintering catch.



The 1991 spring spawner year-class, age 6, which was dominant in 4T, was also dominant in 4Vn overwintering catches in 1997.



Cumulative percentages at length were similar in 1997 to 1996 and indicate that Decision Rule 2, established in 1996 to limit the numbers of immature fish being caught, is still applicable.



### ***Fishing Area (Decision Rule 4)***

The following questions need to be answered to determine where to fish:

1. What is the location of the large 4T migrating stock during the timing set by Decision Rule 2 for the overwintering fishery? Decision Rule 4 requires that the overwintering fishery be restricted to this area.
2. What local stocks are in the area of the overwintering fishery and what is their relative size compared to the 4T migrating stock? The general principles require this information in order to determine the probability that fishing in a particular area will be on a random mixture of stocks or

is in an area where concentrations of small local stocks are likely to be encountered.

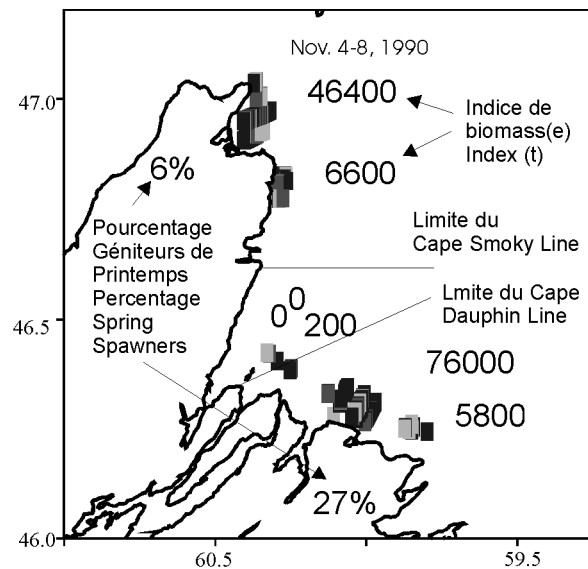
3. What are the biological characteristics of the local stocks? This information will help assess the effects of all current fishing practices on these populations.
4. What are the biological characteristics of local 4Vn stocks compared to the large 4T migrating stock? This comparison will help determine the probability of mixture type and the probability that these fish make up a large proportion of the overwintering catch.

These questions and issues are dealt with collectively below.

### **Location of major concentrations during the time of the overwintering fishery**

Determining the location of the major concentrations during the overwintering fishery indicates the areas where the large 4T migrating stock is likely to be during the fishery and where the requirement for random mixing is most likely to be met.

Historical information from the fishery and acoustic surveys identifies areas where herring are concentrated after the November 1 fishery starting date. Acoustic survey results, using research vessels from 1990 to 1997, and a purse seiner in 1997, indicate two areas of fish concentration, one in Aspy Bay and one off New Waterford-Glace Bay south of the Cape Dauphin Line, with low biomass indices for the St. Ann's Bay-Bird Islands area (for example see 1990 acoustic survey).



Examination of spawning group identifies areas where mixtures of 4T and local stocks are most likely to occur. The percentage of spring spawners in the surveys, has always been less than 10% in the Aspy Bay area but has been as high as 27% south of Cape Dauphin.

The overwintering fishery shows this same pattern. In Aspy Bay, where most of the fishing has occurred recently, the percentage of spring spawners has been less than 10% except for 1996. In 1997, fishing occurred exclusively in Aspy Bay and the percentage of spring spawners was 4%. When fishing has occurred in the St. Ann's Bay-Bird Islands area, the percentage of spring spawners is higher than in Aspy Bay but is still similar to the percentage of spring spawners in the 4T population.

**Percentage of spring spawners in 4T overwintering fishery in 4Vn and 4T population.**

Year	Seiners		Pop
	Aspy Bay	Bird St. Ann's	4T Pop
92	6	24	29
93	6	13	35
94	9		30
95	4		46
96	15	32	35
97	4		27
Ave	7	23	34

These results indicate that for areas north of the Cape Dauphin Line:

- The requirement for random mixing and the location of the 4T migrating stock is most likely to be met north of Cape Smoky.
- The higher percentage of spring spawners, south of Cape Smoky and lower biomass near St. Ann's Bay-Bird Islands area, indicate that the area south of Cape Smoky is more likely to be a mixture of 4T and local stocks than north of Cape Smoky.

#### **Location of major concentrations at times other than the overwintering fishery**

Examinations of major concentrations at times other than the overwintering fishery provides information on the locations and relative sizes of local stocks compared to the larger 4T migrating stock.

A comparison of the January, July, and September bottom trawl surveys provides information on the relative size of the migrating 4T stock compared to local stocks. This comparison is useful because during the January survey the entire 4T stock is in the overwintering area, and during July and September all herring observed are assumed to be of local origin.

January bottom trawl surveys to investigate winter fish distributions generally found herring in distinct concentrations in the north, middle, and southern portions of 4Vn. Herring were observed in the July and September bottom trawl surveys only in the St. Ann's Bay-Bird Islands area and south of the Cape Dauphin Line. No major concentrations were observed north of Cape Smoky.

Estimates of minimum trawlable biomass of local 4Vn herring are available from the July and September surveys. These biomass estimates are minimum because only the offshore areas were surveyed and some of the local herring biomass would be in inshore areas, that are not accessible to the bottom trawls used on these surveys. Minimum trawlable biomass in the July survey ranged from 0 to 39,000 tonnes from 1970 to 1996 and from 5,000 to 9,000 tonnes in the September survey. In comparison, acoustic survey estimates ranged from 4,000 to 440,000 tonnes during 1984-97.

**Biomass estimates (t) from bottom trawl and acoustic surveys, 1984-1997.**

	Bottom Trawl		Acoustic
	Biomass (t)		Biomass (t)
Year	July	Sep	Sep-Nov Dates
84	1940		75724 Nov 17-26
85	0		106865 Nov 23-26
86	230		127708 Dec 1-12
87	39345		443058 Nov 17-24
88	81		172886 Nov 21-22
89	0		No survey
90	9		135249 Nov 4-8
91	4997		4418 Oct. 21-23
92	0		44845 Oct. 14-22
93	417		12512 Oct 15-20
94	8788	8773	No survey
95	1773	5201	7295 Sep 24-26
96	0		21804 Oct. 14-16
97	n/a		17463 Oct. 9-11

Ages of fall spawners in the 4Vn September 1994 and 1995 surveys do not show any sign of the large 1990 year-class that was dominant in the 4T population and 4T portion of the September bottom trawl survey in those years. Maturity stages of these fish were greater than 90% spent fish. These maturity stages suggest that these fish are of local origin.

Local fisheries also provide information on the location of concentrations at times other than the overwintering fishery. Catches of herring have occurred in trapnets set in Aspy Bay during May, June, and July from 1989 to 1997. Ages of spring and fall spawners in these trapnets have a similar age distribution to 4T, except for 1995.

The distribution of lobster licenses indicates that most of the effort for herring as bait is probably south of Cape Smoky. This situation depends on the assumption that fishing and catch of herring for bait is directly related to the number of lobster licenses in each area. This license distribution is important because the lobster fishery was reported, at a workshop held in Sydney, Feb. 1997, to last about 50 days and requires about 300 pounds/day of bait per license. If this amount were all herring and were harvested locally, then the total herring catch in the bait fishery could be as high as 3500 tonnes.

Historical tagging studies also indicate areas where local stocks may be vulnerable during the overwintering fishery. From April 14 - May 1, 1981, 2975 herring were tagged in St. Ann's Bay. Of the 38 tags recovered, 8 were recovered from Bras d'Or lakes during the spring in 1981 and 1982 combined and 26 from the purse seine fishery during October to December of 1981. Although unadjusted for effort, these results indicate the presence of Bras d'Or Lake herring in the St. Ann's Bay area during the time of the overwintering fishery.

**Number, location, and timing of tags recovered from St. Ann's Bay experiment.**

Recovery Location	1981-1982		1981	Total
	Ap-June	July-Sep	Oct. - Dec	
4Vn	1		25	26
Bras d'Or	8			8
4Wa		1		1
4T	2	1		3

Thus, an overwintering fishery in St. Ann's Bay has the potential for catching local stocks from Bras d'Or Lake.

A number of points are relevant with respect to the potential impact of a fishery in this area would have on Bras d'Or Lake herring.

First, the Bras d'Or Lake spring spawning component has declined in recent years. Herring have been absent from traditional spawning beds, low larval densities are observed during surveys, and fishing effort in the lake has increased and become more concentrated in the last two years.

Second, the age structure of spring spawners caught in the St. Ann's Bay area in 1996 suggests that 4T spring spawners would predominate in catches from this area. For example, age structure of spring herring caught in Aspy Bay were similar to those caught in St. Ann's Bay-Bird Islands area in 1996. These ages were also similar to those expected from examinations of the 4T spring spawner population age structure. Dominant year-classes of spring spawners in the overwintering catch, with considerations for gillnet mesh sizes were different from those in the Bras d'Or Lake population.

Third, herring have occasionally been taken under the ice in Bras d'Or Lake, indicating that not all Bras d'Or Lake herring overwinter in 4Vn.

These similarities and differences, while suggesting a predominance of 4T spring spawners in the St. Ann's Bay-Bird Islands

area catch in 1996, do not guarantee a reduction in the risk to local spring stocks from fishing in this area.

The general principle of fishing in areas where stocks are randomly mixed is most likely to be met in northern areas of 4Vn. Risk of fishing in areas where small vulnerable local stocks are concentrated is greater between Cape Smoky and Cape Dauphin, than north of Cape Smoky. Fishing below Cape Smoky increases the proportion of spring spawners in the catch. Therefore, given the declining situation in the Bras d'Or Lakes, the Cape Smoky line is appropriate at this time.

### ***How many fish to catch (Decision Rule 1)***

Decision Rule 1 states that the "overwintering catch not to exceed recent average landings, for example, 1990-1996". The relevant points leading to this conclusion were that the presence of a high proportion of 11+ herring, of unknown stock origin, in northern local coastal fall fisheries (Neil's Harbour) and the continued presence of local fisheries, suggested that fishing levels, since 1983, had not been detrimental to local spawning components. While, this was recognized as a weak biological rationale for advice, it was stated that until additional information becomes available on the 4Vn spawning components, it would form the current advice for catch allocations.

There is no additional information that can be used to directly assess fishing mortalities on the Neil's Harbour local stock. As a result, the general principles cited above are used to assess the effect that various harvest levels in the overwintering fishery may have on these stocks.

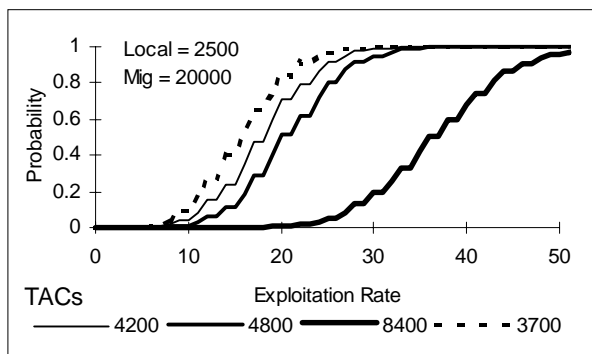
The magnitude of the effects that would result under different TACs and assumptions about



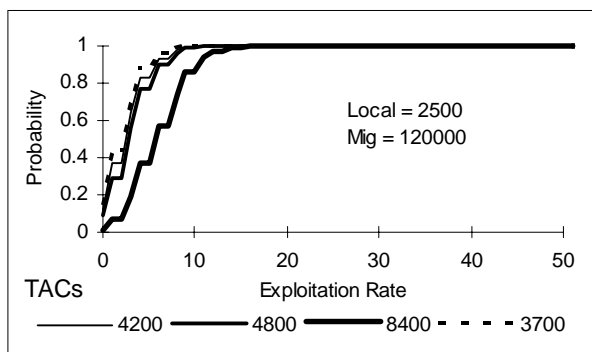
school size and mixing of stocks was investigated using a computer simulation model. This model examined the relative changes in exploitation rate that would result from a range of TAC levels, under different migratory situations for the 4T stock, different local stock sizes, and an assumed school size of 40t. It was assumed that varying levels of the 4T stock had migrated to 4Vn for the fishery. These levels were 20,000t, 40,000t, and 120,000t out of the current estimated 4T fall spawner stock size of 350,000t. It was assumed that local stocks were 2,500t, 5,000t, 10,000t, and 20,000t. The TAC varied from 3,700t, 4,200t, 4,800t, and 8,400t and did not depend on the size of the 4T stock. The 8,400t level was chosen so that an extreme situation could be examined.

Results of these simulations indicate, that when a small proportion of the 4T stock has migrated to 4Vn, exploitation rates on local stocks between 10 and 30% can be expected. These exploitation rates would be due to the overwintering fishery and would be additional to exploitation rates from other fisheries. This situation has been recognized and was the reason that November 1 was the chosen starting date, ensuring that most of the 4T migration is underway before fishing starts.

The worst situation develops when the local stock size is smallest, and so the consequences of differing levels of TAC were examined assuming the local stock size is 2,500t. Two levels of 4T migration were examined, a low level, 20,000t and a higher level, 120,000t. These results indicate that local stock exploitation rates will exhibit greater variation at low 4T migration levels.



At the higher 4T migration, 120,000 t, there was little relative difference among the 3,700 - 4,800 t TAC. Exploitation rates resulting from the 8400t TAC, as expected, were about twice as great as the lower rates.



The risk of exceeding target fishing levels increases when fishing occurs before the large migratory stock is well underway. Acoustic and bottom trawl surveys conducted since 1984 indicate the 4T migration is well established by November 1. As a result, November 1 (Decision Rule 2) was chosen as the starting date for the 4Vn overwintering fishery. Under these conditions, expected exploitation rates on local stocks would be below target fishing levels and there would be little difference in risk of exceeding fishing mortality targets between TACs of 3,700 to 4,800t in northern fishing areas. These results support the continued application of Decision Rule 1 "overwinter catch not to exceed recent averages".

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