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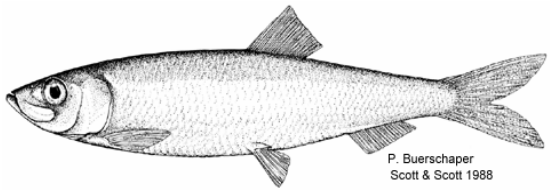
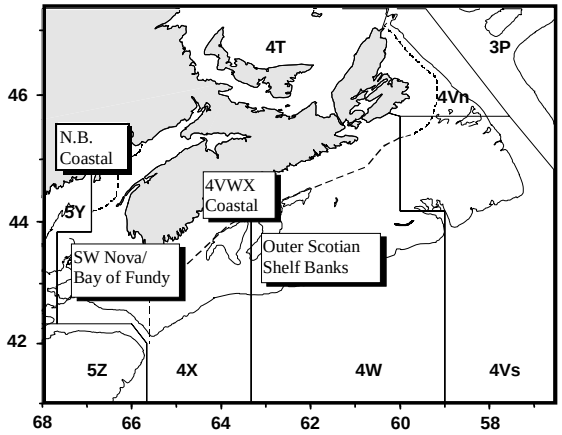
Canadian Science Advisory Secretariat
Science Advisory Report 2005/033 (Revised)

STOCK ASSESSMENT REPORT ON 4VWX HERRING





Context

Atlantic herring is a pelagic species found on both sides of the North Atlantic. Herring spawn in discrete locations, to which they are presumed to home. Herring first mature and spawn at three or four years of age (23 to 28 cm or 9 to 11 in), then begin a predictable annual pattern of spawning, overwintering, and summer feeding, which often involves considerable migration and mixing with members of other spawning groups. Most fishing takes place on dense summer feeding, overwintering, and spawning aggregations.

The 4VWX management unit contains a number of spawning areas, separated to various degrees in space and time. Spawning areas in close proximity with similar spawning times, and which share a larval distribution area, are considered part of the same complex. These undoubtedly have much closer affinity than spawning areas that are widely separated in space or time, and do not share a common larval distribution. Some spawning areas are large and offshore, whereas others are small and more localized, sometimes very near shore or in small embayments. The situation is complicated further as herring migrate long distances and mix outside of the spawning period both with members considered part of the same complex and with members of other spawning groups. For the purposes of evaluation and management, the 4VWX herring fisheries are divided into four components:

1. *SW Nova Scotia/Bay of Fundy spawning component*
2. *Offshore Scotian Shelf banks spawning component*
3. *Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia spawning component; and*
4. *SW New Brunswick migrant juveniles.*

Each component has several spawning areas, and there is mixing of fish among spawning components. Industry and management have explored means of managing the complexity within each component (such as distributing fishing effort among spawning areas according to their relative size) and of taking appropriate account of interaction among components (such as fishing restrictions on some areas of mixing).

Fisheries in the 4VWX area in recent years have been dominated by purse seine, weir and gillnet, with relatively minor landings by shutoff and trap.

Since 1995, the herring stock assessment and related research have been enhanced by a number of projects undertaken with the assistance of the fishing industry. These include industry sampling of biological characteristics of the catch, as well as acoustic surveys using industry vessels and tagging.

SUMMARY

SW Nova Scotia/Bay of Fundy

- Age range in the catch remained reduced, with a further decline in the proportion of ages 5+ in the fishery.
- Acoustic surveys of spawning grounds indicate a relatively stable spawning stock biomass (SSB) in recent years.
- Combination of the absolute SSB estimate from acoustic surveys with fishery catch at age data in a virtual population analysis (VPA) implies a rapid and substantial biomass increase (5-fold over the past 5 years) which has not been seen in the surveys and is inconsistent with the truncated age composition.
- A VPA calibrated with the trend in acoustic surveys suggests a relatively stable SSB of less than 200kt and a high fishing mortality (F).
- Catches of less than about 25,000t would be required to have a low to neutral risk of exceeding $F_{0.1}$.
- Because of anticipated recruitment, catches as high as 40,000t to 50,000t would result in a neutral to high chance of a substantial (40%) biomass increase.
- Several conservation objectives specified for this fishery are not being met.

Offshore Scotian Shelf Banks

- Since 1996, a fishery has taken place on feeding aggregations on the offshore banks, primarily in May and June, with catches ranging from 2,000 to 20,000t and 2004 landings of 4,000t.
- The summer bottom trawl research survey demonstrated that there was considerable abundance of herring widely spread over the offshore banks of the Scotian Shelf.
- The initial catch allocation for 2005 should not exceed the 12,000t reference value used in recent fishing plans.

Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia

- There was a reduction in surveyed acoustic biomass in both Little Hope and Halifax areas and no survey was done in the Glace Bay area.
- Management approaches and recent research efforts have improved knowledge in three areas (Little Hope/Port Mouton, Halifax/Eastern Shore and Glace Bay), but there has been no increase in knowledge in adjacent areas.
- There should be no new fisheries developed when there is uncertainty regarding stock composition and degree of mixing.

SW New Brunswick Migrant Juvenile

- Landings were the highest since 1994 but there has been a trend of decreasing landings in this fishery over the past decade.

DESCRIPTION OF THE ISSUE

A meeting of the Regional Advisory Process on Maritimes Herring was held in St. Andrews N.B., 29-31 March 2005. The purpose of this meeting was to review and evaluate biological and fishery information on 4VWX herring stock status as a basis for establishing the final quota for

the 2004/2005 fisheries, as required in the Integrated Fisheries Management Plan. The terms of reference included an evaluation of the SW Nova Scotia spawning component, and compilation and review of information regarding the offshore Scotian Shelf and the coastal Nova Scotia spawning components. Participants included DFO scientists, fishery managers, representatives of the industry, provincial government and non-DFO scientists.

The 2003-2006 Scotia-Fundy Herring Integrated Fisheries Management Plan (DFO 2003) set out principles, conditions, and management measures for the 4VWX herring fisheries. The main principle stated in the plan is "*the conservation of the herring resource and the preservation of all of its spawning components*".

Three conservation objectives developed and reviewed in 1997 appear in the plan:

1) To maintain the reproductive capacity of herring in each management unit through:
- persistence of all spawning components in the management unit;
- maintenance of biomass of each spawning component above a minimum threshold;
- maintenance of a broad age composition for each spawning component; and
- maintenance of a long spawning period for each spawning component.

2) To prevent growth overfishing:
- continue to strive for fishing mortality at or below $F_{0.1}$

3) To maintain ecosystem integrity/ ecological relationships ("ecosystem balance").
- maintain spatial and temporal diversity of spawning
- maintain herring biomass at moderate to high levels

Progress against these objectives was evaluated at this meeting.

SW NOVA SCOTIA/BAY OF FUNDY

ASSESSMENT

The Fishery

Landings in 2004 were 78,000t against a TAC of 83,000t (Figure 1).

Landings (thousands of tonnes)

Year	Average 1980-89	Average 1990-99	2000	2001	2002	2003	2004
4WX SW NS TAC	106	112	100	78	78	93	83
4WX SW NS	131	96	85	72	77	89	78
4VWX Coastal NS	<1	4	4	6	10	9	7
Scotian S. Banks	<0.1	13	2	12	7	1	4
SW NB	24	24	17	20	12	9	21
Total Landings	155	137	108	110	106	108	110

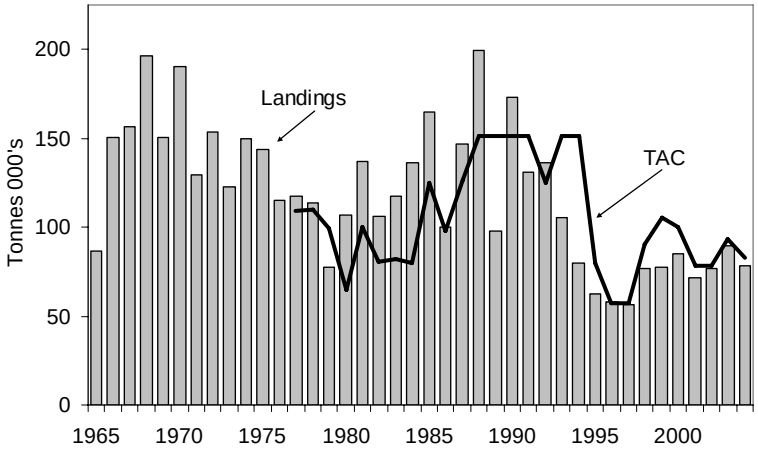


Figure 1. Landings and TAC for the SW Nova Scotia/Bay of Fundy spawning component.

The 2001 year-class (at age 3) dominated the catch at age by weight (about 36% of the weight of herring landed). The 2001 and 2002 year-classes were similar by number (35-36%) in the catch. The pattern of dominance by age 2 and 3 fish was seen across all gear components except gillnet where age 5 fish were most prominent by number and weight, reflecting the selectivity of the gear.

Age range in the catch remained reduced, with a further decline in the proportion of ages 5+ in the fishery (Figure 2).

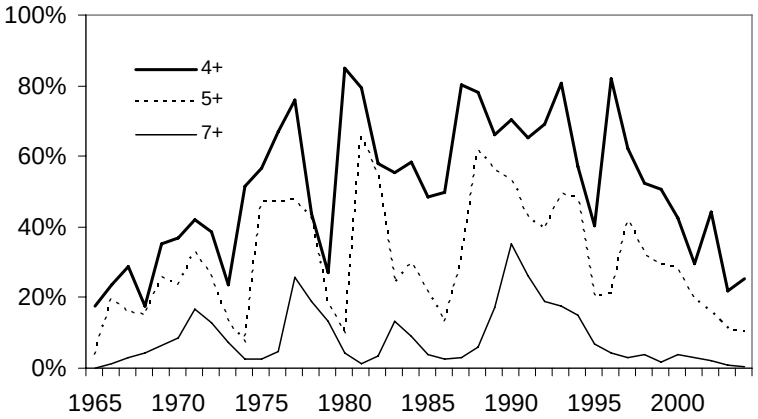


Figure 2. Overall proportions of 4+, 5+ and 7+ herring in the catch at age from the SW Nova Scotia/Bay of Fundy spawning component.

Acoustic Surveys

Automated acoustic recording systems deployed on commercial fishing vessels were used to document the distribution and abundance of herring in both structured industry vessel surveys and fishing excursions. Scheduled surveys were conducted at approximately 2-week intervals on the main spawning components and the spawning stock biomass for each component was estimated by summing these results.

In 2004, four surveys were conducted in Scots Bay and three on German Bank. Survey coverage was good and was consistent with recent years. Additional acoustic data from fishing

nights in Scots Bay and German Bank were examined. The survey biomass estimate (approximately 480,000t) was similar to that of recent years (Figure 3).

Acoustic Survey SSB (000's t)

Location	1999	2000	2001	2002	2003	2004
Scots Bay	41	106	164	141	134	108
Trinity Ledge	4	1	15	8	15	7
German Bank	461	356	191	393	344	368
Spec.* (spring)			1		1	
Subtotal	506	463	370	542	493	482
Spec.* (fall)			88			
Seal Island			3	1	12	
Browns Bank			46			
Overall SSB	506	463	507	543	505	482
Standard Error (SE)	19%	14%	10%	9%	17%	14%

* Spec. - Spectacle Buoy

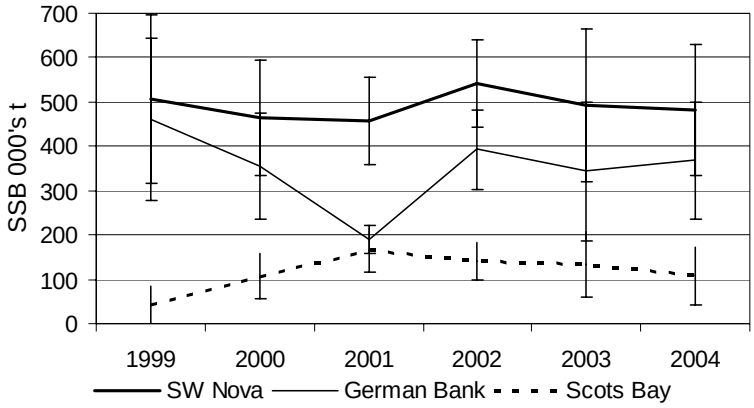


Figure 3. SSB from acoustic surveys for the SW Nova Scotia/Bay of Fundy spawning component with 95% confidence interval.

The documented amount of spawning fish on Trinity Ledge was lower than in the past three years but survey coverage was limited. There were no surveys and no reports of spawning herring on Lurcher or Seal Island spawning grounds. The spawning period in Scots Bay was the longest recorded. The duration of spawning on German Bank was contracted and there was the suggestion that spawning may have been influenced in this one year by adverse environmental conditions. No structured surveys occurred on German Bank in October.

Population Model (VPA)

Acoustic survey results have been used in previous assessments as absolute estimates of SSB and approximately 500kt have been recorded in each of the past six years. However, there are several indicators that SSB is not this high. An SSB of about 500kt would have been expected to result in substantial growth of the population since the late 1990s, improved age composition and low fishing mortality, given reasonable recruitment and the landings of recent years (less than 80kt in 2004). Such growth in the population and expansion of age composition has not been observed in the surveys or fishery. In recent assessments, it has been noted that the declining proportion of older fish in the population suggested that the total mortality on this stock was much higher than that implied by the ratio of catches to acoustic SSB. Total mortality

calculated from acoustic survey numbers at age is high. Further, combination of the absolute SSB estimate from acoustic surveys with fishery catch at age data in a virtual population analysis (VPA) implies a rapid and substantial biomass increase (5-fold over the past 5 years) which has not been seen in the surveys and is inconsistent with the truncated age composition. SSB levels of over 400kt have only been seen a few times over the 40 year history of this fishery. It is therefore apparent that the absolute SSB from acoustic surveys result in an overestimate. Potential reasons for an overestimate of SSB include uncertainty regarding the residence time on spawning grounds, the possibility of double counting and inappropriate target strength coefficient for converting backscatter signal to biomass.

Use of the acoustic survey data as a relative index of abundance results in a more consistent analysis. Acoustic surveys of spawning grounds indicate a relatively stable spawning stock biomass (SSB) in recent years. A VPA was calibrated with the trend in age structured acoustic survey results, using fishery catch statistics and sampling for size and age composition of the catch for the years 1965-2004 as basic input. These VPA results suggest a relatively stable SSB of less than 200kt and a high F (much greater than $F_{0.1}$) in recent years (Figure 4). This scenario matches observations from the survey (relatively constant SSB) and the fishery (including little increase in biomass and a reduced age composition).

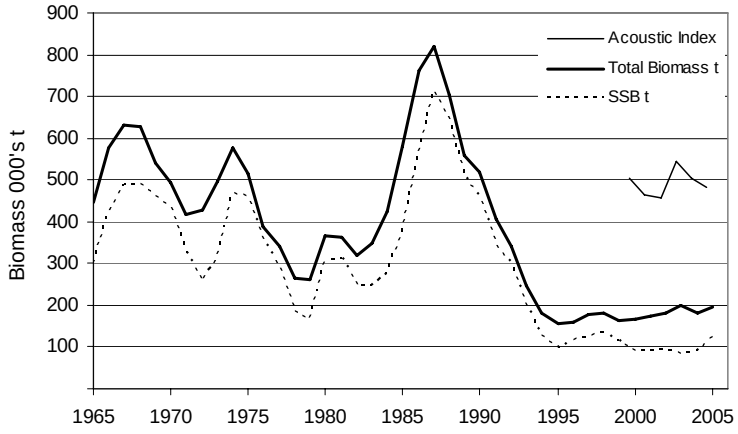


Figure 4. SSB and total biomass from calibrated VPA with acoustic index as proportional to population numbers for the SW Nova Scotia/Bay of Fundy spawning component.

CONCLUSIONS AND ADVICE

Projection results and risk analysis are provided in terms of the consequences of various catch quotas (yield) (Figure 5). Catches of less than about 25,000t would be required to have a low to neutral risk of exceeding $F_{0.1}$. Because of anticipated recruitment, catches as high as 40,000t to 50,000t would result in a neutral to high chance of a substantial (40%) biomass increase. A harvest strategy that allows rapid population rebuilding is recommended.

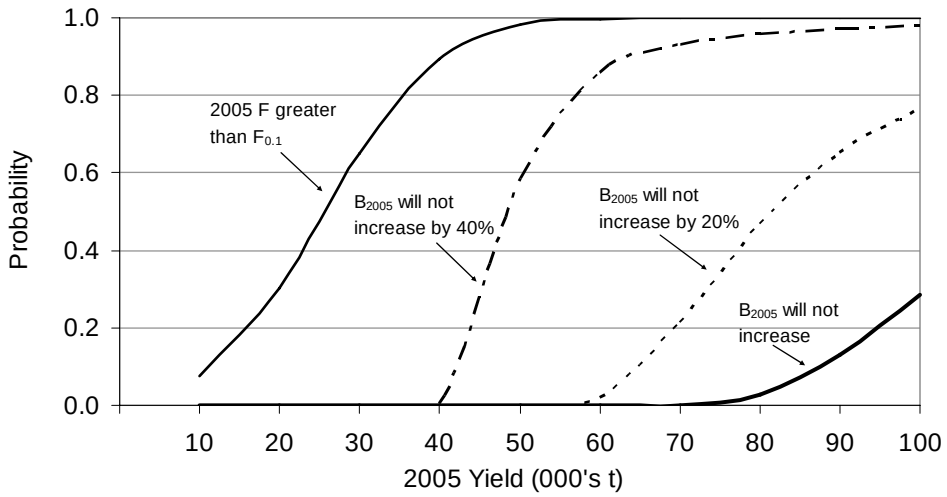


Figure 5. Projection risks for the SW Nova Scotia/Bay of Fundy spawning component.

Progress against conservation objectives is outlined below. Several conservation objectives specified for this fishery are not being met.

Objective	2004 observations
Persistance of all spawning components	Trinity reduced from 2003. No surveys or reports of spawning on Seal Island or Lurcher grounds.
Maintain biomass of each spawning component	German Bank and Scots Bay have stable biomass. Trinity at low biomass. No observations from Seal Island or Lurcher.
Maintain broad age composition	Further decline in proportion of older ages.
Maintain long spawning period	German Bank spawning period shorter than in past. Scots Bay spawning period was the longest observed.
Fishing mortality at or below $F_{0.1}$	Fishing mortality is much higher than $F_{0.1}$
Maintain spatial and temporal diversity of spawning	Insufficient spawning in some areas. Little change from 2003.
Maintain biomass at moderate to high levels	SSB appears stable, but is low.

OTHER CONSIDERATIONS

About half of the catch biomass in recent years has been comprised of ages 2 and 3, and the abundance of these recruiting ages is uncertain. The acoustic index provides information on only about 50% of the total biomass, with that of younger ages based primarily on estimates.

There has been targeting of young fish, and the high proportion of juveniles in the catch results in reduced yield. The average weight of herring landed from this component has decreased by about half (167g to 83g) over the past decade.

Although there has been limited fishing on Trinity Ledge in recent years, the exploitation rate (including the catch of these fish outside of the spawning area) appears to be impairing recovery.

This assessment has confirmed a further deterioration in the state of the resource noted in the previous assessment. However, the change in use of acoustics as a relative rather than absolute abundance index has resulted in large change in the perception of the resource. As indicated earlier, the apparent absolute SSB is inconsistent with most other information. Possible reasons for the overestimate of SSB by the acoustic surveys have been proposed but more work is required.

ADDITIONAL STAKEHOLDER PERSPECTIVES

Industry concerns on this assessment are given below:

> *"Industry cannot accept at this time that the acoustic survey results have been overstated by greater than 500% between 1999-2004. Industry believes it is inconsistent with the observations in the fishery over the same period.*
>
> *Prior to science designing and implementing acoustic surveys, the primary indicator of stock abundance was the larval survey. This survey had a significant time series running from 1972 to 1998. The larval survey was discontinued as it was considered a poor indicator of abundance. The 1998 SSR states:*
>
> > *"The same analytical assessment (SPA) model used in recent years, which uses larval abundance as an index of spawning stock abundance, was attempted. The analysis showed a weak relationship between the larval abundance index and SSB, poor model resolution, and a strong retrospective pattern, and was not considered to give valid estimates of recent stock size. There remains the need for a more reliable indicator of abundance in order to undertake this type of analysis for this stock."*
>
> *It was felt that acoustic surveys were a better indicator of abundance and were accepted as the only indicator of abundance available. Since accepting acoustic surveys, scientific protocols have been established, thoroughly reviewed and accepted at RAP. Survey design and target strength has been repeatedly tested, refined and accepted all in an effort to improve accuracy. In fact the 2005/02 working paper "Summary of the 2004 herring acoustic surveys in NAFO divisions 4VWX", states on page 13:*
>
> > *"In 1999 spawning areas were defined and survey protocols were established to make estimates more representative of the actual SSB rather than a minimum observed value."*
>
> *Further our review of SSR documents from 2001-2004 does not indicate that acoustic survey results were grossly over estimated. Results were accepted as minimum observed biomass.*
>
> *If valid, the 2005 RAP results have reduced the reliability of the acoustic surveys to that of the earlier larval surveys. This highlights the need to have more than one indicator of abundance to allow appropriate stock decisions.*

For industry to understand and accept the dramatic shift in the acoustic numbers will require a review of all input data and assumptions used to tune the VPA.

Secondly, it will require a complete review of all elements of the acoustic surveys to explain the 500% reduction in the output numbers.

Until these steps are complete, the SSR should remain a draft document."

ASSESSMENT, CONCLUSIONS AND ADVICE FOR OTHER COMPONENTS

Offshore Scotian Shelf

Since 1996, a fishery has taken place on feeding aggregations on the offshore banks, primarily in May and June, with catches ranging from 2,000 to 20,000t and 2004 landings of 4,000t. Fishing took place in June, in the vicinity of the Patch, the Bullpen and MacKenzie Spot.

The 1999 to 2001 year-classes (ages 3 to 5) made up most of the age composition of the Scotian Shelf fishery, with age 5 dominating in both number and weight.

There were no industry surveys of the area in 2004. The summer bottom trawl research survey demonstrated that there was considerable abundance of herring widely spread over the offshore banks of the Scotian Shelf. Information from previous assessments indicated the presence of at least some autumn spawning on Western Bank in recent years. There is little new information to add and no reason to change the previous recommendation that the initial catch allocation for 2005 should not exceed the 12,000t reference value used in recent fishing plans.

Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia

There is no overall quota for the coastal Nova Scotia spawning component and, apart from four areas (mentioned below), the size and historical performance of various spawning groups are poorly documented. In addition to traditional fisheries for bait and personal use, there have been directed roe fisheries on the spawning grounds in recent years.

Recorded landings (t) of herring from major gillnet fisheries on the Coastal Nova Scotia spawning component.

Landings (000's t)

	1996	1997	1998	1999	2000	2001	2002	2003	2004
Little Hope/Port Mouton		0.5	1.2	2.9	2.0	2.9	4.0	4.5	1.3
Halifax/Eastern Shore	1.3	1.5	1.1	1.6	1.4	1.9	3.3	2.7	4.2
Glace Bay		0.2	1.7	1.0	0.8	1.2	3.1	1.9	1.5
Bras d'Or Lakes[1]	0.2	0.2	0.1	0.0	0.1		0.0	0.0	
Total	1.5	2.3	4.1	5.6	4.3	6.0	10.4	9.2	6.9

[1]Bras d'Or Lakes fishery closed in 2004

As the inshore roe fisheries off Glace Bay, East of Halifax and Little Hope have developed, participants have contributed to sampling and surveying and the fisheries have attempted to follow the 'survey, assess, fish' protocol.

Summary of the estimated spawning biomass of herring from major gillnet fisheries in the Coastal Nova Scotia spawning component.

Acoustic Survey SSB (000's t)

Survey SSB (t)	1998	1999	2000	2001	2002	2003	2004
Little Hope/Port Mouton	14.1	15.8	5.2	21.3	56.0	63.7	15.6
Halifax/Eastern Shore	8.3	20.2	10.9	16.7	41.5	77.4	18.2
Glace Bay		2.0		21.2	7.7	31.5	
Bras d'Or Lakes		0.5	0.1				

There was a reduction in surveyed acoustic biomass in both Little Hope and Halifax areas and no survey was done in the Glace Bay area. In both areas, the reduction was attributed in part to difficulties of surveying in adverse weather conditions in 2004. Although the results of acoustic surveys are reported here as absolute abundance, the discussion in the SW Nova Scotia/Bay of Fundy component suggested that they may be overestimates of SSB.

Management approaches and recent research efforts have improved knowledge in three areas (Little Hope/Port Mouton, Halifax/Eastern Shore and Glace Bay), but there has been no increase in knowledge in adjacent areas. Individual spawning groups within this component are considered vulnerable to fishing because of their relatively small size and proximity to shore. As in the past five years, it is recommended that no coastal spawning areas should experience a large effort increase until much more information is available on the state of that spawning group, and there should be no new fisheries developed when there is uncertainty regarding stock composition and degree of mixing.

It has been noted since 1997 that the status of herring in the Bras d'Or Lakes is cause for concern. It is therefore appropriate to reiterate that no fishing should take place on this spawning component.

SW New Brunswick Migrant Juveniles

Approximately 20,700t of herring, considered to be a mixture of fish originating primarily from NAFO Subarea 5, were landed in the traditional New Brunswick weir and shutoff fishery in 2004. Landings were the highest since 1994 but there has been a trend of decreasing landings in this fishery over the past decade.

SOURCES OF INFORMATION

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