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## **1997 EVALUATION OF THE STOCK STATUS OF 4WX HERRING**

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Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

## **Abstract**

The 4WX management area contains a number of herring spawning areas which are grouped for assessment and management into three units: Southwest Nova Scotia/Bay of Fundy, Offshore Scotian Shelf Banks, and Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia spawning components. In addition there are migrant herring from neighboring units, including juveniles taken in the Bay of Fundy (New Brunswick) weir fishery.

The SW Nova Scotia spawning component has declined in recent years. Landings in 1996 were the lowest in three decades, reflecting the lowest quota on record for this fishery. The fishery exhibited a poor age composition, dominated by a single (1992) year-class. Continuation of "in-season" management led to over 800 hrs. of surveying by industry vessels. The 190,000 t of spawning herring documented in this way was used as an estimate of minimum SSB. A sequential population analysis calibrated with larval abundance indicated about 300,000 t, but was considered a poor estimate of stock size, due to a weak fit to the tuning index.

Most of the 4VWX Coastal Nova Scotia spawning component suffers from poor documentation of the fishery (especially bait landings) and insufficient information to assess stock status. A study of the Bras D'Or Lakes spawning component suggests a decline in stock status.

## **Résumé**

La zone de gestion 4WX abrite diverses zones de frai du hareng qui sont regroupées, à des fins d'évaluation et de gestion, en trois unités : le sud-ouest de la Nouvelle-Écosse et la baie de Fundy; les bancs du large du plateau néo-écossais et la zone côtière de la Nouvelle-Écosse (côte sud, côte est et Cap-Breton). On compte aussi des harengs en migration d'unités voisines, dont des juvéniles capturés par les pêcheries fixes de la baie de Fundy (Nouveau-Brunswick).

La composante de frai du sud-ouest de la Nouvelle-Écosse s'est appauvrie au cours des années. Les débarquements de 1996 ont été les plus faibles des trois dernières décennies et reflètent le quota le moins élevé jamais accordé pour cette pêche. Le stock ne présentait pas une bonne composition par âges, les captures étant dominées par une seule classe d'âge (1992). Le maintien de la gestion « en cours de saison » a donné lieu à plus de 800 heures de relevés par des bateaux de l'industrie. Les géniteurs ainsi dénombrés, dont le volume atteignait 190 000 tonnes, ont été utilisés pour estimer une biomasse minimum du stock de géniteurs. Une analyse séquentielle de population étalonnée par l'abondance larvaire donne une valeur de 300 000 tonnes environ, mais cette valeur de la biomasse du stock est considérée comme peu valable à cause d'une mauvaise concordance avec l'indice d'ajustement.

La plus grande partie de la composante de frai de la zone côtière de la Nouvelle-Écosse de 4VWX se caractérise par un manque de renseignements sur la pêche (notamment des débarquements destinés à servir d'appâts) et de données pour l'évaluation de l'état du stock. Une étude de la composante de frai aux lacs Bras d'Or porte à croire à un déclin du stock.

## Background and Context

The 1996 fisheries were undertaken within a context of biological uncertainty and concern. The 1996 stock status evaluation based on the 1995 fishery (Anon 1996; Stephenson et. al. 1996), confirmed the view of the previous year that the SSB of the major SW Nova Scotia spawning component had decreased substantially since a high in 1989, and the current stock size was uncertain. Observations from the 1995 fishery, while improved over the previous year, were mixed. Of concern was the reliance on recruiting yearclasses, the lack of fish in one traditional spawning area (Seal Island), and lack of aggregations in some traditional summer feeding and pre-spawning areas. The evaluation indicated an SSB in 1996 of 100,000 to 200,000 t (for the SW Nova spawning component). The TAC for this portion of the fishery was reduced further, to 50,000 t for 1996 (although 57,000 t was allocated) - only one third of what it had been two years earlier (1994), and the lowest ever for this fishery. Management extended the initiatives of in-season management, and of management of individual spawning components, so as to be able to react quickly and appropriately to signals from the fishery.

The year also saw considerable changes in fishing pattern. There was further exploration by the purse seine sector of herring on offshore (>25 mi.) Scotian Shelf Banks. There was also a considerable expansion of the gillnet fishery, including the re-emergence of the SW Nova Scotia gillnet fishery and the initiation of a gillnet roe fishery east of Halifax.

## Stock Structure and Management units

Biological evaluations and management are based on management of complex populations/stocks. While it has long been recognized that there is additional structure within management units, there is increasing awareness of the need to extend management consideration to the individual spawning group level. Recent history in SW Nova Scotia, has shown the problem of disproportionately high effort applied to one component of a stock complex (e.g. depletion of the Trinity Ledge spawning group). There is considerable concern within the industry over what is seen as the potential erosion of spawning components. There is the real possibility of sequential erosion of spawning groups within management complexes, while apparently remaining within an overall safe fishery limit. Persistence of the full diversity of spawning stocks within each management unit must be a principle of management. The challenge is to develop management approaches which are able to ensure the maintenance of all spawning components at sustainable levels. This is complicated by the fact that some spawning areas are not well documented.

The area covered by the 4WX management unit is known to contain a number of spawning areas separated to various degrees in space and time. Spawning units in close proximity, with similar spawning times, and which share a larval distribution area (e.g. Trinity Ledge and German Bank in SW Nova Scotia) are considered part of the same complex - and undoubtedly have much closer affinity than spawning units which are widely separated in

space or time, and do not share a common larval distribution (e.g. SW Nova autumn spawners vs. Bras d'Or Lakes spring). Some of these are large and offshore (e.g. German Bank), whereas others are small, and more localised spawning locations, sometimes very near shore in small embayments (e.g. Advocate, N.S.). The situation is complicated further by the fact that herring tend to migrate long distances, and to mix with members of other spawning groups outside of the spawning season. Further, some spawning areas, (such as Trinity Ledge, German Bank) are known from fishery sampling, tagging, etc. to have formed the basis for major historical fisheries, while others have not.

The purposes of this evaluation, the 4WX fisheries are divided into four components:

*A) SW Nova Scotia spawning component:*

Based on major spawning areas off SW Nova Scotia, this component has formed the basis for the large "stock" fishery, managed under TAC for many years. Fishing has taken place on the spawning grounds, on these fish in pre-spawning and feeding aggregations, and historically on the same fish (demonstrated by tagging) in overwintering areas in eastern Nova Scotia.

In the SW Nova Scotia fishery, an attempt is being made to spread the fishing effort among spawning groups in proportion to their relative size. A working group of the Scotia-Fundy Herring Advisory Committee (SFHAC) established in 1994 compiled biological and industry knowledge about the relative size of spawning groups, and led to the first, tentative breakdown of the summer quota among spawning areas. Since that time management has moved more and more to consideration of individual spawning units. In 1995 and 1996 there were sonar/sounder surveys of major spawning areas, and fishing was only allowed on a portion of what had been documented in each area.

Current fishery segments

4Xqr (Bay of Fundy/SW Nova) summer purse seine  
4Xs fall (Bay of Fundy) purse seine  
4X (Bay of Fundy) midwater trawl  
4X (SW Nova) summer gillnet  
4X (Nova Scotia) summer weir  
4W (Chedabucto Bay) winter purse seine  
4X (Halifax) winter purse seine\* (*subject of debate*)

*B) Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia Spawning component:*

Many spawning locations (both spring and fall) are known to have existed historically along the coast of Nova Scotia. They have been fished traditionally by inshore geartypes (gillnet, trap) for bait, subsistence use, and sale but are poorly documented. These are presumed not

to have contributed to the traditional SW Nova Scotia fishery, and traditionally such these stocks have been excluded from the management plan.

Current fishery segments:

4WX South Shore and Eastern Shore Nova Scotia trap and gillnet  
4X (Halifax) winter purse seine\* (*subject of debate*)

*C) Offshore (>25 mi.) Scotian Shelf Banks spawning component:*

Herring were taken on the offshore Scotian Shelf by foreign fisheries prior to the extension of jurisdiction, when these fish were presumed to be part of an overall 4WX stock. Evidence of increasing presence of herring (e.g. in research vessel surveys) and of spawning offshore within the past decade has suggested that there is a discrete offshore spawning component.

The presence of spawning herring in catches in 1986 and of larvae in scientific surveys (1991-93), the consistent presence of large herring on the Scotian Shelf in summer trawl surveys, and broad age distribution of the catch are all consistent with the separate management treatment of the offshore banks.

Current fishery segments:

4WX (offshore) purse seine

*D) SW New Brunswick migrant juveniles:*

The SW New Brunswick weir and shutoff fishery has relied, for over a century, on the aggregation of large numbers of juveniles in that area of the mouth of the Bay of Fundy. These have traditionally been considered to be a mixture dominated by fish originating from Subarea 5 spawning components.

Current fisheries:

4X (NB) weir and shutoff (*juveniles only*)

**Management changes**

Finalization of the management plan for the 1996 fishery was delayed until late spring in order to incorporate the results of the 1996 stock status evaluation.

An "in-season" management approach has been implemented in the 4WX herring fishery during the past two years. Under this approach a number of decisions within the overall management plan have been delegated to a team, made up of participants in the fishery and members of DFO, to be made during the season on the basis of the best available information. Observations from the fishery have been monitored and discussed routinely so that management could be modified quickly according to negative or positive signals from the fishery. Decisions have related primarily to the spatial and temporal distribution of fishing within the quota. In particular, there has been an attempt to ensure that fishing has been distributed appropriately among various components of the stock (particularly among spawning components) according to the relative size and current state of each component.

In-season management has resulted in an increase in the quantity, quality, and availability of information from the fishery. Surveys have been implemented, sampling has increased, and data handling procedures have been changed to allow more rapid summary of results. Several segments of the fishery have operated under a cautious "survey, assess, then fish" protocol, in which preconditions had to be met before that part of the fishery was allowed to take place. This demanded a very high level of commitment, involvement and cooperation from all participants in the fishery management process, and led to improved effectiveness of management and care for the resource.

### **Landings in the 1996 4WX fisheries**

Total of 87,443 t was recorded in the 1996 calendar year from the combined 4WX fisheries (Table 1).

Landings from the SW Nova Scotia component were (58,068t) were the lowest in three decades (Table 2), as a result of the low quota.

Landings by gillnet and trap along the coast of Nova Scotia included a new fishery on spawning fish east of Halifax (1296 t, October). The relatively small amount of additional landings recorded (192 t) is thought to be the result of a problem with landings documentation especially in the bait fishery.

Purse seine activity on the offshore Scotian Shelf resulted in landings of 11,745 t.

The NB weir and shutoff fishery total of 15,913 t was well below average (about 25,000 t) and continued a decline since 1992.

### **Biological Sampling**

The distribution of samples is summarized in Table 3. As in other years sampling was conducted by St. Andrews Biological Station staff at sea and in port sampling, other

DFO port sampling staff, observers, vessel crew and processing plant staff. However, the level of biological sampling increased in 1996 as the result of a new collaborative initiative with the processing sector. At the invitation of members of the herring processing industry, a new program of biological sampling by industry personnel was developed and implemented at major herring processing facilities in the Scotia-Fundy area. In this program, all commercial landings of herring at participating plants in New Brunswick and Nova Scotia were sampled by plant employees for length and subsamples taken for further analysis according to criteria established by DFO. Most samples, in this first experimental year, were collected in NAFO area 4Xs (along the coast of southwest N.B.) due to the early participation and comprehensive coverage by Connors Bros. Ltd. plants in that area but other areas received enhanced sampling coverage later in the fishing season.

## **A) SW Nova Scotia/Bay of Fundy Spawning Component**

### 1996 fishery

The TAC for this component was reduced from 80,000 t in 1995 to 50,000 t in 1996. Although 57,000 t was allocated, it was still the lowest quota ever for this fishery. An "in-season" management scheme first implemented in the 4WX herring fishery during 1995 encouraged survey and evaluation prior to fishing to ensure that fishing was distributed appropriately among various components of the stock (particularly among spawning components) according to the relative size and current state of each component. This was continued, and extended in 1996, so as to be able to react quickly to signals from the fishery.

As a result of the low quota, landings from the SW Nova Scotia component (58,068 t) were the lowest in three decades. The amount taken by purse seine and a single midwater trawl (48,252 t) was the lowest since 1979. For the first time in several years, a substantial quantity (6340 t) was taken by gillnet. Nova Scotia weirs took 3,476 t, continuing an increasing trend which began in 1991.

In-season management has resulted in an increase in the quantity, quality, and availability of information from the fishery. Surveys have been implemented, sampling has increased, and data handling procedures have been changed to allow more rapid summary of results. Several segments of the fishery have operated under a "survey, assess, then fish" protocol, in which predefined conditions had to be met before that part of the fishery was allowed to take place.

The distribution of herring as reflected by the fishery during summer feeding and pre-spawning period seemed normal. Surveys and fishing showed good abundance of herring on Scots Bay, and German Bank spawning grounds, and the return of spawners to Trinity Ledge and Lurcher Shoal. There was an absence of spawning, however, at Seal Island,

and low abundance in the overwintering area of Chedabucto Bay, where only 2,000 t was taken.

#### Catch at age

The 1992 year-class (age 4) dominated all fisheries on the SW Nova Scotia spawning component except for midwater trawl (Table 4). The 1992 year-class made up a disproportionately large portion of the catch by number (61%) and weight (60%). It was followed in relative importance by the 1991 year-class (age 5) at 13% by number and 16% by weight. These same year-classes had also dominated the 1995 fishery. The dominance of a single year-class in this fishery is quite different from the usual more balanced age distribution (as shown in the average of 1986-95) and from lightly fished areas nearby (coastal Nova Scotia (Table 5), offshore Scotian Shelf banks (Table 6)), and is considered an undesirable situation.

Although there was fleet avoidance of younger fish (because of the low quota), the 1993 year-class was poorly represented in the catch, and may be weak. The relatively low proportion at age 2 in the catch may indicate that the 1994 year-class, which originated in the year of the warm water temperature anomaly and extremely low larval herring abundance, is also relatively weak.

#### Research and survey data

##### i) Larval abundance

The larval abundance index, as traditionally calculated, was 9.5 (larvae per m<sup>2</sup>); lower than that of 1995, but above that of 1994 which was the lowest observed since 1981 (Table 7). An initial attempt was made to improve the use of the larval abundance index in tuning by partitioning the index according to the age composition in the spawning stock, and this warrants further investigation.

##### ii) In-season surveys

Building on trials undertaken in 1995, an expanded series of surveys was undertaken of major spawning areas and some other major fishing areas using commercial vessels. Sonars and sounders were used by both the purse seine and later the gillnet fleet to document number, location and approximate size of herring schools. In the most successful of these surveys, many vessels worked together to provide comprehensive coverage of the target areas. During 1996 almost 800 hours of surveying was undertaken by industry vessels: 610 hours by the purse seine sector, and 180 hours by the gillnet sector. The 13 surveys undertaken on spawning grounds of the SW Nova component documented 190,000 t of spawning herring. Survey methods are still under development, and more quantitative rigor is required in several aspects of these surveys, however they were considered to represent a



minimum biomass estimate. Surveys did not cover the entire spawning season or all spawning locations, and conservative density values were used in contouring.

Spawning Area	Survey Date	Estimated Biomass (t)
Scots Bay	24-Jul-96	1,000
	31-Jul-96	43,000
Trinity Ledge	14-Aug-96	3,300
	27-Aug-96	10,400
	5-Sep-96	10,500
	11-Sep-96	5,000
Lurcher Shoal	24-Sep-96	18,000
German Bank	28-Aug-96	8,000
	11-Sep-96	12,800
	30-Sep-96	74,000
Seal Island	11-Sep-96	2,500
Spectacle Grounds	11-Sep-96	6,500
<b>Total biomass</b>		<b>195,000</b>

### Population analysis

An analytical assessment, similar in structure to that used in the previous two assessments was attempted. Larval abundance was related to spawning stock biomass (SSB) from which the larvae were derived. The analysis (Appendix 1) suggests a SSB of about 300,000 t, but there is large uncertainty in parameter estimates due to weak fit to the tuning index, especially in the last three years, and there was concern that the predicted population estimate was too high.

The analytical assessment (considered to be an overestimate), and the 190,000 t documented in survey (considered a minimum) were thought to bracket the actual SSB.

### Major Sources Of Uncertainty

At present, there is a lack of a reliable indicator of abundance for this stock. There have been difficulties using the larval abundance index, and there is no other time series. The sudden drop in larval abundance index in 1994, and relatively low values of the last three years compared to the previous three years is difficult to explain. Acoustics, although promising, are under development. There is need for improved quantification and objectivity in industry acoustic (sonar/sounder) surveys.

### Outlook

The fishery continues to rely primarily upon a single year-class (1992) and recruiting year-classes (1993 and 1994) may be relatively weak. There is a need to rebuild spawning stock biomass and to broaden age structure in the population and therefore it is appropriate to fish below the  $F_{0.1}$  level for several years. A fishery at the status quo catch (57,000 t) is considered unlikely to exceed  $F_{0.1}$  reference levels, but may result in a decrease in SSB if recruitment is poor. The in-season management approach should help protect individual spawning areas.

### **Ecosystem Considerations**

Herring is a prominent species in the diets of many other fish, birds, and marine mammals, and should be managed with these interactions in mind. At present, a natural mortality rate of 0.2 is assumed to account for these interactions. Low fat content and poor condition in herring observed in 1994, thought to be related to an environmental anomaly, have not been observed since that time.

### **Management Considerations**

In 1996, 20% of surveyed biomass was used as the target percentage in the "survey, assess, then fish" protocol. This target harvest percentage on spawning grounds should be reviewed, to take into consideration the harvest of those spawners taken outside of the spawning season.

## **B) 4VWX Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia Spawning component:**

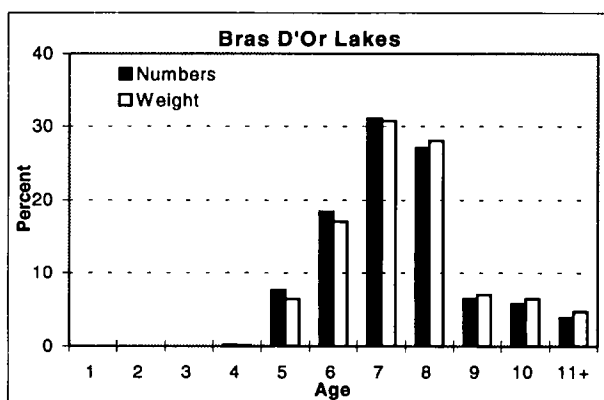
### **The Fishery**

Although the fishery operates throughout coastal waters of 4VWX, very limited information is available except in two areas. Landings by gillnet and trap along the coast of Nova Scotia included a new fishery on spawning fish east of Halifax (1300 t, October) and a well documented fishery in the Bras D'Or Lakes (spring, 170 t). The relatively small amount of additional landings recorded from the remainder of the coast (190 t) is thought to be the result of poor catch reporting, for a considerable amount of herring is known to have been landed for bait and local use. There is a large latent effort in the gillnet sector. The 2000 licenses on record for 1996 allow almost 1000 miles of gillnet to be set. Records indicate that fewer than 200 licenses were active in 1996; however, this is a substantial increase from the 30-40 which were active over the past seven years.

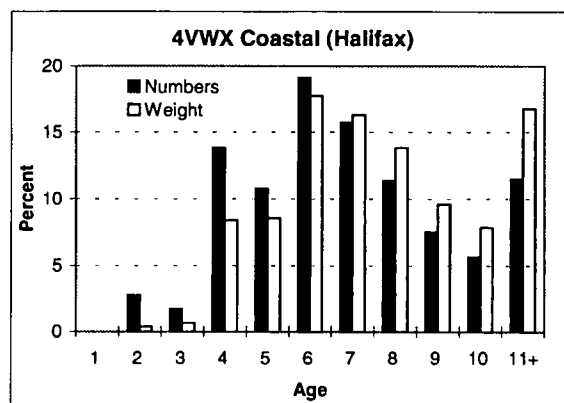
The winter purse seine catches off Halifax in the past two years contained mostly small, overwintering fish, which may have included fish from this coastal spawning component.

### Resource Status and Outlook

A specific study of herring, and the herring fishery, in the Bras D'Or Lakes began in 1996. The fishery of approximately 170 t was dominated by the 1989 (age 7) and 1988 (age 8) year-classes. The 1990 and 1991 year-classes were poorly represented in the catch, and may be relatively weak. A survey of fishers indicated that there had been a decrease in abundance of herring in the lakes in recent years, that spawning in 1996 was restricted to only a few of the traditional spawning grounds, and that fishing effort had increased and become more concentrated.



The new gillnet fishery east of Halifax took fish with a broad age distribution. The catch was dominated by 1990 and 1989 year-classes (ages 6 and 7), but had high proportion of age 11+. An industry survey of the area in October estimated about 40,000 t.



Aside from the two areas mentioned above, there is little information, and no basis for evaluation of these stocks.

### Management Considerations

There is concern that the winter purse seine fisheries near the coast may take an unknown proportion of fish from this component, along with overwintering fish from other areas, at some times and places. This issue is discussed in more detail in a 1997 Fishery Status Report entitled "Decision rules for management of overwintering fisheries" (Anon 1997).

The reduction in spawning areas, and increase in effort in the Bras D'Or Lakes are cause for concern. Effort in the Bras D'Or Lakes commercial and bait fisheries should be reduced, so as to reduce landings of this spawning group.

No coastal spawning area should have a large effort increase until much more information is available on the state of that spawning group. There should be no new fisheries developed when there is uncertainty regarding stock composition and degree of mixing.

There is urgent need for improvement of the monitoring of existing fisheries and documentation of spawning groups.

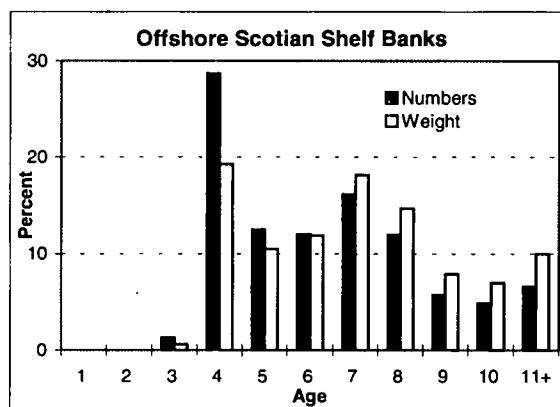
### **C) Offshore (>25 mi.) Scotian Shelf Banks spawning component:**

#### The Fishery

A foreign fishery during the period 1963-1974 is estimated to have taken as much as 60,000 t in a single year from the offshore Scotian Shelf banks (Stephenson et. al. 1987). Since the extension of jurisdiction, there has been little herring catch or effort. The 1996 fishery began May 22, and continued to June 24. Landings of 11,750 t were primarily from "The Patch" located approximately 50 mi. southeast of Halifax, with some catch from other banks.

#### Resource Status and Outlook

The 1996 landings from the offshore banks had a broad age distribution, dominated by the 1992 year-class (age 4), followed by the 1989 year-class (age 7) (Table 6). A single industry sonar/sounder survey in June 1996 covered a large area, but documented only a moderate amount of herring on Emerald/Western banks and a dense aggregation on French Bank (located about 30 mi. south of Country Harbour).



Although insufficient information is available to evaluate stock size, there have been several encouraging signs regarding the state of herring on offshore banks. The July research bottom trawl survey showed little herring on the Scotian Shelf during the late 1970's and early 1980's, increasing amounts during the late 1980's and relatively widespread distribution in recent years (Fig. 1; Table 7). Spawning was documented in industry samples from Western Bank in 1986, and larvae have been present in occasional ichthyoplankton surveys.

#### Management Considerations

Foreign fisheries took relatively large amounts (as much as 60,000 t in a year) from the offshore Scotian Shelf banks during the period 1963-1973. These fisheries did not sustain large catches over a number of years and the average recorded catch for the 1970-73 period was 30,000 t. Industry, science and management are encouraged to work together to develop a medium term strategy for assessment and exploitation of the herring on the Scotian Shelf outer banks.

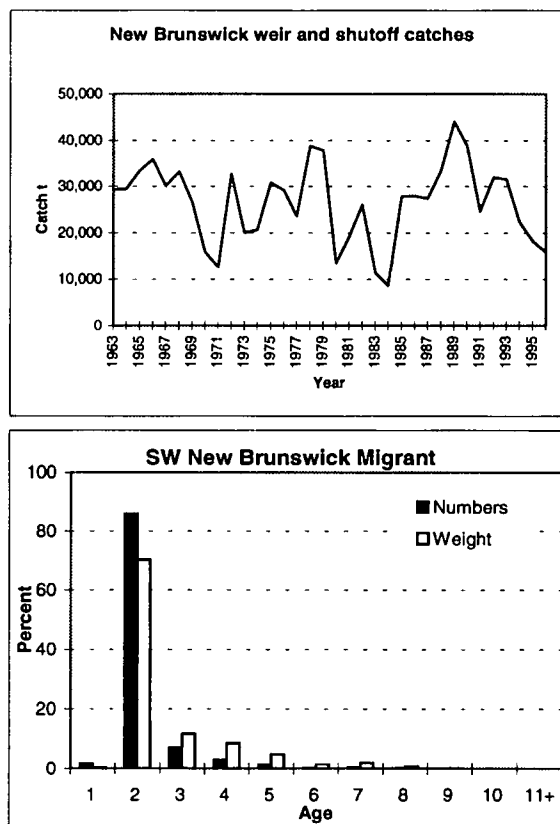
### **D) SW New Brunswick migrant juveniles:**

#### The Fishery

The 1996 catch (15,900 t) in weir and shutoff fisheries was below average and the lowest on record since 1984 (8,700 t). The decline in catch is thought to be the product of a decrease in the number of active weirs and a lack of fish available to the gear. Purse seiners fishing in the Grand Manan area in 1996 observed substantial amounts of juvenile (ages 2 and 3) herring. Landings from this fishery are included in the U.S. coastal Maine complex (Subarea 5) which is considered to be at high abundance.

#### Resource Status and Outlook

There has been a 50% decline in total catch in the past 3 years which may be cause for concern. Catch at age has been dominated, as in previous years, by age 2 (86% number; 70% weight) with some age one, three, and a few older ages (4+) (Table 8).



No separate evaluation of this fishery was made.

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Table 1. 1995-1996 reported monthly 4WX herring landings (t) by stock component and major fishery  
(Source: DFO Scotia-Fundy Region Statistics Division.)

A- 4WX (SW Nova Scotia)		1995			1996												1996			15 mo.	Quota
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Calendar Totals	Totals	Quota Totals*		
1. 4W Purse Seine	Note 1		2049													1731	28	1759	3808	2049	
2. 4Xs Fall Purse Seine	Note 2																				
3. 4X Winter Purse Seine	Note 3,6\	1682	686	36	901									2671	255			3826	6230	3305	
4. 4Xqr Summer Purse Seine	Note 4.	5575							55	1618	12559	11239	11149	6089				42708	48283	42708	
5. 4X Midwater Trawl					167	23												190	190	190	
6. 4X Summer Gillnet (stock)		35									253	3320	2755	11				6340	6375	6340	
7. 4Xr Summer (N.S.) Weir									430	1267	1232	358	188					3476	3476	3476	
Stock Totals		7292	2735	36	1068	23			485	2885	14045	14917	14093	8771	1986	28		58299	68362	58068	
B- Coastal south & eastern shore Nova Scotia																					
1. 4X Trap									20	52	1				0			73	73		
2. 4X Misc. Gears									0	0	4	43	38	1	15			101	101		
3. 4W Gillnet							5	6			1	1		1296				1308	1308		
4. 4W Misc. Gears (Trap)		3						1	0			3						4	7		
Coastal N.S. Totals		3					5	27	52	6	47	38	1297	15				1486	1489		
C- Offshore Scotian Shelf																					
1. Purse Seine									2382	9363								11745	11745		
D- southwest New Brunswick Juvenile Fisheries																					
1. 4X (N.B.) Weir		877	10						19	676	4819	7767	1917	518	65			15781	16668		
2. 4X (N.B.) Shutoff												42			90			132	132		
Non-Stock Totals		877	10						19	676	4819	7809	1917	518	155			15913	16800		
Total 4WX Landings		8172	2745	36	1068	23		5	2912	12976	18870	22773	16048	10585	2155	28		87443	98396	58068	
* Reported landings against the annual plan quotas (shaded blocks) correspond to catches made in the seasonal periods (Notes 1-5).																					
** Non-Stock totals are for the calendar year January 1, 1995 to December 31, 1995.																					
NOTES																					
1. Quota period is November 1, 1995 to March 1, 1996										4. Quota period is April 1, 1996 to October 15, 1996											
2. Quota period is October 15, 1995 to December 31, 1995										5. Inshore/Fixed and Misc Gear allocation is for the calendar year.											
3. Quota period is January 1, 1996 to February 28, 1996										6. Predominantly from Halifax area in Jan. 1996											

Table 2. Historical series of nominal and adjusted annual landings (t) by major gear components and seasons of the 4WX herring fishery 1963-1996.

Year <sup>^</sup>	Stock Fisheries - Nominal Landings						4WX Stock Nominal Landings	4WX Stock Adjusted Landings <sup>**</sup>	4WX Stock TAC	Non-Stock 4Xs Weir and Shutoff	Total 4WX Adjusted Landings
	4W	4Xs	4Xqr	4X	4Xr	4WX					
	Winter Purse seine	Fall&Winter Purse seine	Summer Purse seine	Summer Gillnet	Summer Weir	Other*					
1963		6,871	15,093	2,955	5,345		30,264	30,264		29,366	59,630
1964		15,991	24,894	4,053	12,458		57,396	57,396		29,432	86,828
1965		15,755	54,527	4,091	12,021		86,394	86,394		33,346	119,740
1966		25,645	112,457	4,413	7,711		150,226	150,226		35,805	186,031
1967		20,888	117,382	5,398	12,475		156,143	156,741		30,032	186,773
1968		42,223	133,267	5,884	12,571		193,945	196,362		33,145	229,507
1969	25,112	13,202	84,525	3,474	10,744		137,057	150,462		26,539	177,001
1970	27,107	14,749	74,849	5,019	11,706		133,430	190,382		15,840	206,222
1971	52,535	4,868	35,071	4,607	8,081		105,162	129,101		12,660	141,761
1972	25,656	32,174	61,158	3,789	6,766		129,543	153,449		32,699	186,148
1973	8,348	27,322	36,618	5,205	12,492		89,985	122,687		19,935	142,622
1974	27,044	10,563	76,859	4,285	6,436		125,187	149,670		20,602	170,272
1975	27,030	1,152	79,605	4,995	7,404		120,186	143,897		30,819	174,716
1976	37,196	746	58,395	8,322	5,959		110,618	115,178		29,206	144,384
1977	23,251	1,236	68,538	18,523	5,213		116,761	117,171	109,000	23,487	140,658
1978	17,274	6,519	57,973	6,059	8,057		95,882	114,000	110,000	38,842	152,842
1979	14,073	3,839	25,265	4,363	9,307		56,847	77,500	99,000	37,828	115,328
1980	8,958	1,443	44,986	19,804	2,383		77,574	107,000	65,000	13,525	120,525
1981	18,588	1,368	53,799	11,985	1,966		87,706	137,000	100,000	19,080	156,080
1982	12,275	103	64,344	6,799	1,212		84,733	105,800	80,200	25,963	131,763
1983	8,226	2,157	63,379	8,762	918		83,442	117,400	82,000	11,383	128,783
1984	6,336	5,683	58,354	4,490	2,684		77,547	135,900	80,000	8,698	144,598
1985	8,751	5,419	87,167	5,584	4,062		110,983	165,000	125,000	27,863	192,863
1986	8,414	3,365	56,139	3,533	1,958		73,409	100,000	97,600	27,883	127,883
1987	8,780	5,139	77,706	2,289	6,786		100,700	147,100	126,500	27,320	174,420
1988	8,503	7,876	98,371	695	7,518	1,690	124,653	199,600	151,200	33,421	233,021
1989	6,169	5,896	68,089	95	3,308		83,557	97,500	151,200	44,112	141,612
1990	8,316	10,705	77,545	243	4,049	1,769	102,627	172,900	151,200	38,778	211,678
1991	17,878	2,024	73,619	538	1,498	1,453	97,010	130,800	151,200	24,576	155,376
1992	14,310	1,298	80,807	395	2,227	1,190	100,227	136,000	125,000	31,967	167,967
1993	10,731	2,376	81,478	556	2,662	660	98,464	105,089	151,200	31,573	136,662
1994	9,872	3,174	64,509	339	2,045	161	80,099	80,099	151,200	22,241	102,340
1995	3,191	7,235	48,481	302	3,049	209	62,499	62,499	80,000	18,248	80,747
1996	2,049	3,305	42,708	6,340	3,476	190	58,068	58,068	57,000	15,913	73,981
<sup>^</sup> Annual landings by purse seiners are defined for the annual plan period from October 15 of the preceding year to October 14 of the current year. All landings by other geartypes are for the calendar year. * Includes 4Xs stock catches taken by single midwater trawl, and 4WX stock catches by gillnets, traps, foreign trawlers, and miscellaneous gears. ** Adjusted totals includes misreporting adjustments for 1978-1984 (Mace 1985).											



Table 3. 1996 herring biological sampling summary by area and gear component.

Year	Gearname	Month	Number LF Samples	Number Fish Measured	Number Detail Samples	Number Fish Process	Number Fish Aged		
96	4Vn Purse Seine	10	1	169	-	-	-		
		11	6	1,884	-	-	-		
		12	3	1,135	-	-	-		
96	4W Purse Seine	5	4	804	2	85	85		
		6	54	10,680	10	418	410		
		11	20	2,758	5	132	132		
		12	3	238	1	19	19		
		96	5Y USA Purse Seine	6	3	333	-	-	-
				7	4	432	-	-	-
8	2			234	-	-	-		
9	16			1,853	-	-	-		
10	14			1,580	-	-	-		
11	3			360	-	-	-		
12	2			229	-	-	-		
96	5Z CAN Purse Seine	7	1	309	1	18	18		
96	Gillnet	4	29	5,266	11	280	248		
		5	6	615	3	84	82		
		6	4	815	3	113	113		
		7	2	355	2	60	60		
		8	4	726	4	129	127		
		9	6	865	4	122	122		
		10	2	221	1	34	34		
96	Midwater Trawl	6	4	414	-	-	-		
		7	6	692	-	-	-		
		8	6	634	-	-	-		
		9	11	1,213	-	-	-		
		10	9	982	-	-	-		
		11	2	260	-	-	-		
		12	4	432	-	-	-		
96	N.B. Midwater Trawl	1	1	262	1	18	18		
96	N.B. Purse Seine	7	46	5,428	7	189	187		
		8	13	1,652	6	125	124		
		9	26	2,904	6	134	134		
		10	46	6,298	8	133	132		
		11	7	917	-	-	-		
96	N.B. Shut-off	8	1	118	-	-	-		
		11	3	417	2	30	30		
96	N.B. Weirs	6	23	2,679	9	163	163		
		7	135	14,899	9	141	138		
		8	206	23,017	6	205	203		
		9	68	7,726	5	112	112		
		10	22	2,558	4	58	57		
		11	2	249	-	-	-		
96	N.S. Purse Seine	1	9	2,070	7	315	313		
		6	29	3,615	9	357	355		
		7	31	5,113	15	502	501		
		8	19	2,857	10	376	361		
		9	34	4,857	7	301	299		
		10	19	2,644	3	143	133		
96	N.S. Weirs	6	29	3,356	10	334	330		
		7	27	2,893	5	171	171		
		8	11	1,254	1	33	33		
		9	2	240	-	-	-		
96	Resrch. MW Trawl	6	1	238	1	35	35		
		7	1	131	1	25	25		
96	Resrch. Otter Trawl	2	8	1,485	8	233	232		
		3	6	141	6	119	117		
		6	3	512	3	71	71		
		7	48	698	48	758	754		
96	Shut-off	6	2	201	-	-	-		
96	Trap	10	1	98	-	-	-		
96	Weir	6	2	201	1	24	24		
		8	1	102	-	-	-		
1996 Totals			1,113	138,318	245	6,599	6,502		

Table 4. Catches by age in numbers (thousands) and weight (t) from stock gear components of the 1996 4WX herring fishery.

Catch Nos. ('000s)	1	2	3	4	5	6	7	8	9	10	11+	Total
4W Purse Seine	-	-	125	13,167	1,387	217	197	165	443	255	207	16,163
4X N.S. P.Seine	-	14,411	27,324	178,569	34,366	11,755	6,593	2,054	1,068	749	845	277,734
4X N.B. P.Seine	-	95	2,935	32,210	11,136	1,009	160	56	5	41	-	47,647
4X N.S. Gillnet	-	-	234	17,308	5,796	3,678	2,006	972	257	252	535	31,038
4X N.S. Weirs	-	11,437	7,009	14,809	1,849	203	195	53	9	13	18	35,595
4X Midwater Trawl	-	11,553	88	-	-	-	-	-	-	-	-	11,641
Total Nos. by Age	0	37,496	37,715	256,063	54,534	16,862	9,151	3,300	1,782	1,310	1,605	419,818

% Catch Nos.	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11 +	Total
4W Purse Seine	0	0	1	81	9	1	1	1	3	2	1	100
4X N.S. P.Seine	0	5	10	64	12	4	2	1	0	0	0	100
4X N.B. P.Seine	0	0	6	68	23	2	0	0	0	0	0	100
4X N.S. Gillnet	0	0	1	56	19	12	6	3	1	1	2	100
4X N.S. Weirs	0	32	20	42	5	1	1	0	0	0	0	100
4X Midwater Trawl	0	99	1	0	0	0	0	0	0	0	0	100
Overall % Nos. by A	0	9	9	61	13	4	2	1	0	0	0	100

Catch Weight (t.)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11 +	Total
4W Purse Seine	0	0	8	1,428	208	42	44	41	127	82	69	2,049
4X N.S. P.Seine	0	658	2,851	26,614	6,485	2,746	1,764	629	364	274	326	42,709
4X N.B. P.Seine	0	3	167	1,994	953	134	29	12	1	11	0	3,305
4X N.S. Gillnet	0	0	32	3,008	1,160	874	545	318	96	94	213	6,339
4X N.S. Weirs	0	387	633	1,986	340	47	50	16	3	5	8	3,475
4X Midwater Trawl	0	186	4	0	0	0	0	0	0	0	0	190
Totals Catch t. by	0	1,234	3,694	35,030	9,146	3,842	2,432	1,015	592	465	616	58,067

% Catch Weight (t.)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11 +	Total
4W Purse Seine	0	0	0	70	10	2	2	2	6	4	3	100
4X N.S. P.Seine	0	2	7	62	15	6	4	1	1	1	1	100
4X N.B. P.Seine	0	0	5	60	29	4	1	0	0	0	0	100
4X N.S. Gillnet	0	0	1	47	18	14	9	5	2	1	3	100
4X N.S. Weirs	0	11	18	57	10	1	1	0	0	0	0	100
4X Midwater Trawl	0	98	2	0	0	0	0	0	0	0	0	100
Overall % by Age	0	2	6	60	16	7	4	2	1	1	1	100

Table 5. Coastal (south and eastern shore) Nova Scotia catch at age in numbers (thousands) and weight (t) for the 1996 fishery.

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+	Total
Catch Nos. ('000s)	0	154	96	767	597	1,059	873	630	417	312	637	5,542
Catch Weight (t.)	0	5	10	125	127	264	242	206	142	116	250	1,486
% catch numbers	0	3	2	14	11	19	16	11	8	6	11	100
% catch weight	0	0	1	8	9	18	16	14	10	8	17	100
Average weight (gm)	0	34	99	163	213	249	277	326	342	371	391	
Average length (cm)	0.0	17.4	23.7	27.7	30.2	31.8	32.9	34.6	35.1	36.0	36.0	

Table 6. Offshore Scotian Shelf catch at age in numbers (thousands) and weight (t) for the 1996 herring fishery.

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+	Total
Catch Nos. ('000s)	0	0	668	13,952	6,079	5,845	7,833	5,809	2,774	2,390	3,201	48,551
Catch Weight (t.)	0	0	77	2,258	1,235	1,398	2,130	1,726	924	823	1,175	11,745
% catch numbers	0	0	1	29	13	12	16	12	6	5	7	100
% catch weight	0	0	1	19	11	12	18	15	8	7	10	100
Average weight (gm)	0	0	115	162	203	239	272	297	333	344	367	
Average length (cm)	0.0	0.0	24.6	27.5	29.7	31.4	32.7	33.7	35.0	35.4	36.2	

Table 7. Herring abundance indices; larval abundance index (average number of larvae per m2 from 79 index stations), and herring by-catch (stratified numbers per tow) from July groundfish survey.

Larval Herring Bongo Survey					Herring groundfish by-catch (mean numbers per tow)								Mean Weight (kg per tow)			
		No. per m2 to bottom		N	4WX Area Combined				4W Area Only		4X Area Only		4W Area Only		4X Area Only	
Year	Cruise	Mean	SE		Cruise	Mean#	SE	N	Mean#	SE	Mean#	SE	MeanWt	SE	MeanWt	SE
70					A175/176	4.1	1.5	95	4.9	2.4	1.6	0.6	1.5	0.7	0.5	0.2
71					A188/189	4.0	1.9	86	2.6	1.2	3.6	2.6	0.7	0.4	1.3	1.0
72	P109	9.4	1.8		A200/201	1.4	0.6	105	1.7	1.0	0.5	0.1	0.5	0.4	0.1	0.0
73	P127	6.6	1.3		A212/213	0.9	0.3	96	0.4	0.3	1.0	0.4	0.1	0.1	0.2	0.1
74	P147	49.5	10.9		A225/226	0.7	0.3	102	0.2	0.0	1.0	0.4	0.1	0.0	0.2	0.1
75	P160	11.7	1.5	58	A236/237	0.9	0.4	104	0.8	0.4	0.7	0.4	0.3	0.2	0.2	0.1
76	P175	13.5	2.9		A250/251	0.4	0.2	103	0.1	0.1	0.5	0.3	0.0	0.0	0.1	0.1
77	P190	6.3	1.0		A265/266	0.5	0.3	106	0.0	0.0	0.8	0.5	0.0	0.0	0.1	0.0
78	P207	4.5	0.5	77	A279/280	0.3	0.3	103	0.5	0.5	0.1	0.0	0.3	0.3	0.0	0.0
79	P232	7.1	2.1		A292/293	0.6	0.5	106	0.0	0.0	1.0	0.7	0.0	0.0	0.2	0.1
80	P246	26.2	6.7		A306/307	0.5	0.5	105	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0
81	P263	2.7	0.3	78	A321/322	1.5	1.4	104	0.0	0.0	2.3	2.1	0.0	0.0	0.4	0.4
82	P280	10.6	1.2	77	H080/081	1.5	0.9	108	0.5	0.3	1.9	1.4	0.2	0.1	0.5	0.4
83	P298	13.9	1.6	74	N012/013	2.4	0.8	106	2.6	1.2	2.2	1.0	0.8	0.4	0.2	0.1
84	P315	12.7	1.4	78	N031/032	7.0	3.5	102	3.3	1.2	10.5	6.8	1.0	0.4	3.1	2.2
85	P329	40.8	4.6	79	N048/049	3.4	1.8	111	6.6	3.8	0.3	0.1	2.1	1.2	0.1	0.0
86	P344	18.9	2.1	78	N065/066	23.2	14.9	118	30.8	26.7	16.0	14.3	9.4	8.3	3.1	2.8
87	P361	27.9	3.2	78	N085/087	10.4	5.6	135	17.0	11.3	4.0	1.8	3.9	2.0	0.5	0.2
88	P377	100.7	11.5	76	N105/106	2.1	0.6	127	2.7	1.2	1.5	0.5	0.7	0.3	0.2	0.1
89	P391	54.5	6.1	79	N123/124	8.4	1.8	124	11.8	3.4	4.5	1.2	3.9	1.2	1.0	0.3
90	P408	27.2	3.1	79	N139/140	5.6	1.9	156	7.4	3.6	3.4	1.0	2.2	1.0	0.7	0.3
91	P422	48.2	5.5	78	N154/H231	10.6	5.8	137	13.0	8.8	5.0	1.8	4.3	2.9	1.2	0.4
92	P437	57.0	6.4	79	N173/174	16.5	4.9	136	16.2	6.6	40.8	15.7	5.0	2.2	5.5	2.6
93	P451	55.0	6.2	78	N189/190	18.7	4.5	137	6.3	2.5	30.4	8.5	2.0	0.8	7.1	2.0
94	N211	5.4	0.7	77	N211/222	76.4	30.2	140	108.4	58.9	45.9	18.4	29.1	13.5	8.3	3.4
95	N232	20.3	4.6	78	N226/227	63.5	24.2	140	100.5	47.9	28.4	12.8	27.1	11.9	7.5	3.9
96	N252	9.5	1.6	77	N246/247	40.2	14.2	135	53.2	24.5	27.1	14.1	13.6	6.5	6.3	3.3

Table 8. Catches at age in numbers (thousands) and weight (t) for the 1996 southwest New Brunswick juvenile herring fisheries.

Catch Nos. ('000s)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+	Total
4X N.B. Weirs	4,974	266,864	22,330	9,326	4,294	1,147	1,273	426	38	9	2	310,683
4X N.B. shutoff	377	2,567	60	16	8	0	0	0	0	0	0	3,028
Total Nos. by Age	5,351	269,431	22,390	9,342	4,302	1,147	1,273	426	38	9	2	313,711
% Catch Nos.	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+	Total
4X N.B. Weirs	2	86	7	3	1	0	0	0	0	0	0	100
4X N.B. shutoff	12	85	2	1	0	0	0	0	0	0	0	100
Total Nos. by Age	2	86	7	3	1	0	0	0	0	0	0	100

Catch Weight (t.)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+	Total
4X N.B. Weirs	61	11,059	1,846	1,364	758	246	310	121	12	3	1	15,781
4X N.B. shutoff	8	115	5	3	1	0	0	0	0	0	0	132
Total Catch t. by Age	69	11,174	1,851	1,366	759	246	310	121	12	3	1	15,913
% Catch Weight (t.)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+	Total
4X N.B. Weirs	0	70	12	9	5	2	2	1	0	0	0	100
4X N.B. shutoff	6	87	4	2	1	0	0	0	0	0	0	100
Total Catch t. by Age	0	70	12	9	5	2	2	1	0	0	0	100

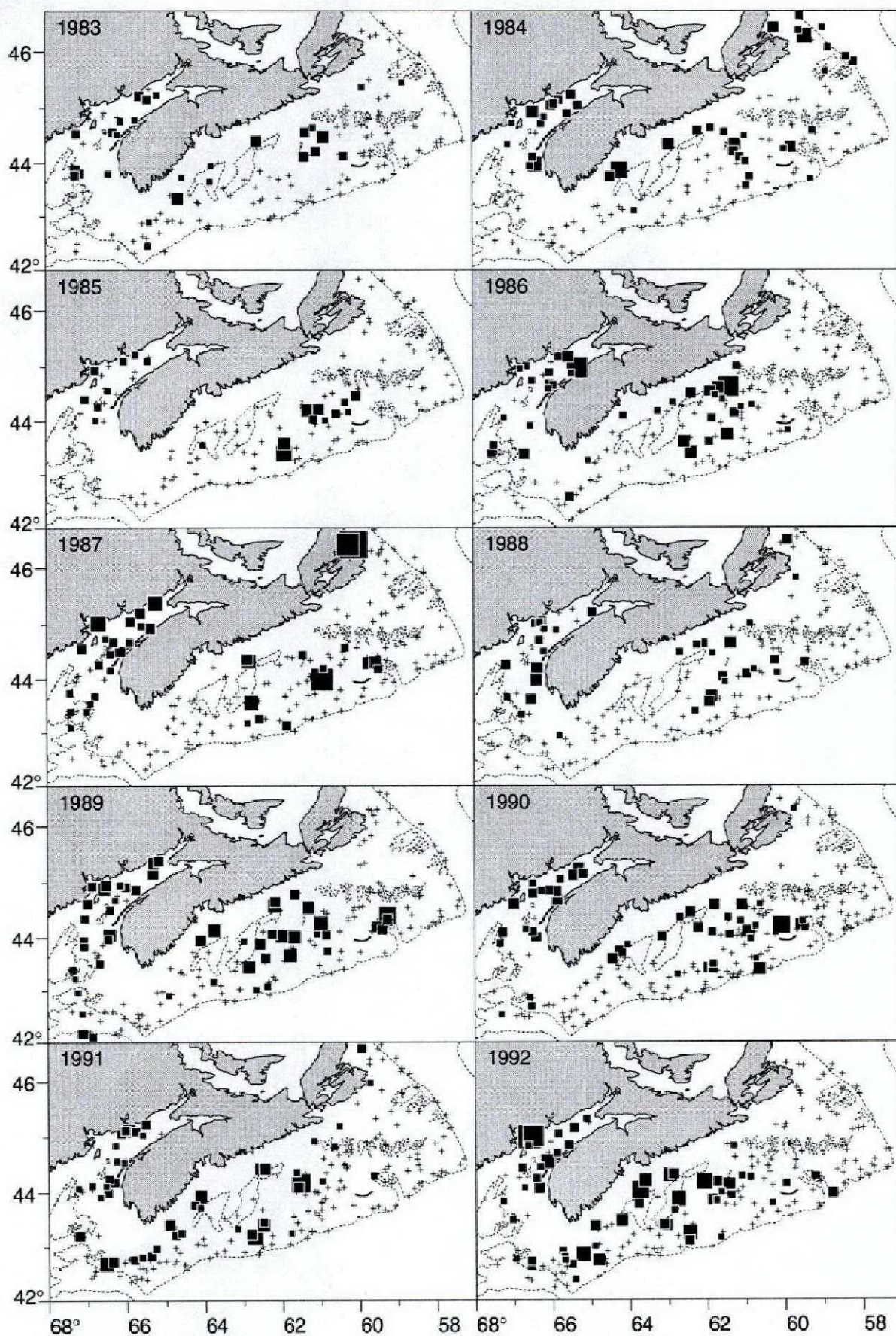
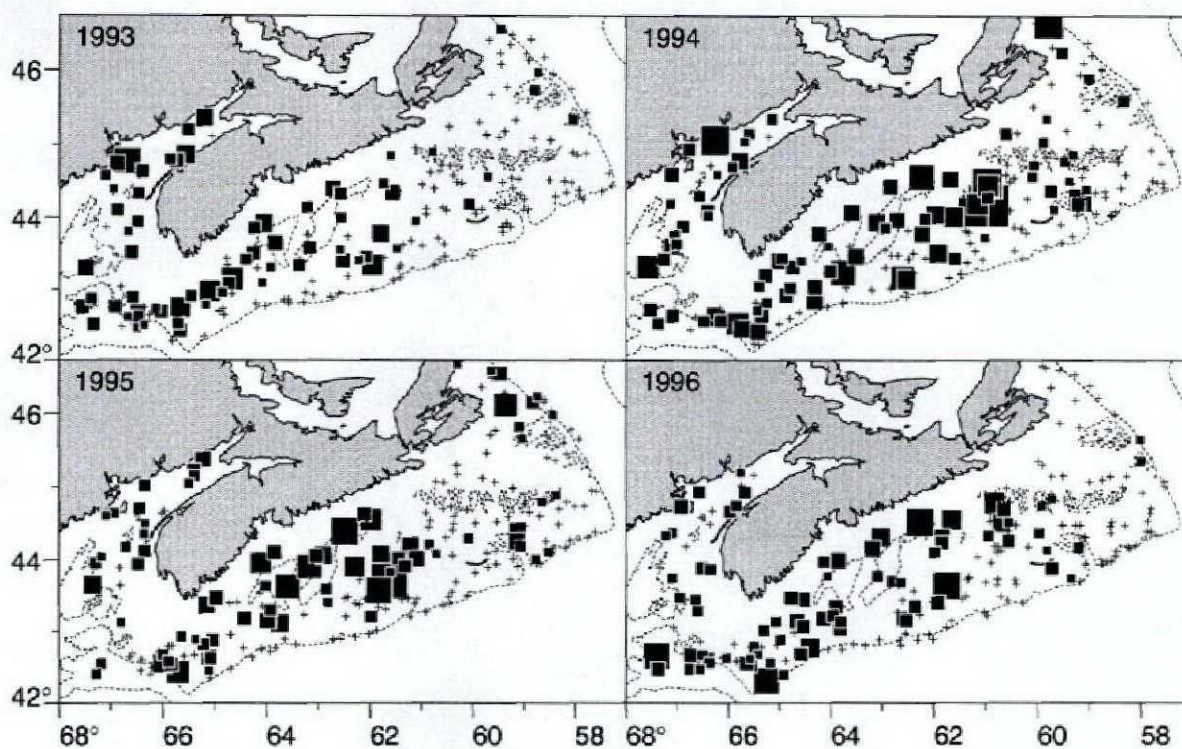


Figure 1. 1983-96 herring catches (numbers per standard tow) in summer ground trawl survey data.





Mean Numbers per Tow

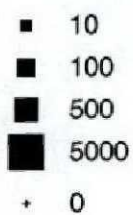


Figure 1. continued.

# Appendix 1. 4WX herring ADAPT output: larval index aggregate series

Catch	1	2	3	4	5	6	7	8	9	10
1965.00	270378	1084719	34835	234383	49925	10592	1693	561	54	37
1966.00	154323	914093	448940	73382	321857	45916	13970	7722	1690	215
1967.00	722208	613970	153626	266454	110051	159203	57948	4497	409	296
1968.00	164703	2389061	224956	83109	290285	73087	90617	31977	15441	5668
1969.00	108875	290329	531812	132319	162439	112631	62506	22595	6345	2693
1970.00	699720	576896	76532	286278	201215	120280	111937	41257	21271	7039
1971.00	87570	404224	183896	106630	113566	75593	93620	50022	36618	7536
1972.00	0	649254	71984	148516	77207	75384	49065	48700	26055	13792
1973.00	1018	167454	781061	130851	40128	30334	22046	20249	23871	11630
1974.00	18411	766064	93606	803651	68276	19093	10232	6565	12786	7102
1975.00	3199	317641	239827	124599	514605	66302	12298	4409	4778	3847
1976.00	240	55596	206535	153782	68804	268839	21460	5571	3951	2059
1977.00	1170	153921	31572	218478	119234	51173	177247	13977	3170	1415
1978.00	35381	383611	40887	12906	122108	68410	31088	108975	11082	2425
1979.00	342	183982	250393	54620	5430	23142	18255	11836	41389	4527
1980.00	2339	12503	80518	474091	27930	4373	4692	6560	2985	10641
1981.00	0	103051	50883	102743	451482	32978	2418	2767	1917	538
1982.00	3589	102133	150764	22640	98206	211043	14627	2080	1354	1250
1983.00	5488	191682	150328	244007	24483	60678	89982	10352	1728	642
1984.00	0	88433	243542	224354	146096	22716	21654	28299	9515	2183
1985.00	9022	216740	337591	302782	147670	42404	14075	18178	7997	1201
1986.00	63	125300	275903	292792	56937	31599	10770	4320	2942	1356
1987.00	2300	82940	126436	527443	242597	45933	19481	7292	3361	3120
1988.00	151	148399	113208	195096	434192	236089	42533	21208	4186	3797
1989.00	8	101788	114095	61842	79451	169023	76684	18303	8270	3814
1990.00	0	178532	130176	171560	89922	101066	201901	116788	31466	10572
1991.00	0	96960	179463	183647	88431	41352	50380	80732	45516	18291
1992.00	9	168561	132642	286923	126510	75473	34458	35369	59136	34558
1993.00	166	76405	43766	194198	130713	67708	33820	21481	21893	20684
1994.00	151	103885	142260	53700	118015	72512	36059	14889	8706	10447
1995.00	1831	113457	219777	112245	36784	36402	22127	6474	4217	2957
1996.00	0	37496	37715	256063	54534	16862	9151	3300	1782	1310
1997.00										

Data imported from file : D:\MIKE\TABLES97\C4WX.TAB

Larval	3	4	5	6	7	8	9	10	11
1973.00	9.40								
1974.00	6.60								
1975.00	49.50								
1976.00	11.70								
1977.00	13.50								
1978.00	6.30								
1979.00	4.50								
1980.00	7.10								
1981.00	26.20								
1982.00	2.70								
1983.00	10.60								
1984.00	13.90								
1985.00	12.70								
1986.00	40.80								
1987.00	18.90								
1988.00	27.90								
1989.00	100.70								
1990.00	54.50								
1991.00	27.20								
1992.00	48.20								
1993.00	57.00								
1994.00	55.00								
1995.00	5.40								
1996.00	20.35								
1997.00	9.52								

Data imported from file : D:\MIKE\TABLES97\L4WX.TAB

Weights (begining of year calculated)	3	4	5	6	7	8	9	10	11
1973.00	0.07	0.14	0.21	0.24	0.27	0.31	0.34	0.37	0.39
1974.00	0.06	0.14	0.17	0.23	0.26	0.30	0.34	0.36	0.41
1975.00	0.07	0.14	0.19	0.22	0.25	0.30	0.34	0.36	0.35
1976.00	0.05	0.12	0.20	0.23	0.26	0.29	0.36	0.38	0.40
1977.00	0.06	0.14	0.18	0.25	0.27	0.30	0.32	0.40	0.43
1978.00	0.09	0.14	0.20	0.24	0.29	0.31	0.34	0.36	0.43
1979.00	0.06	0.14	0.20	0.24	0.27	0.31	0.34	0.37	0.44
1980.00	0.07	0.14	0.19	0.24	0.27	0.30	0.34	0.37	0.41



# Appendix 1. 4WX herring ADAPT output: larval index aggregate series

1981.00	0.07	0.14	0.19	0.24	0.27	0.30	0.34	0.37	0.41
1982.00	0.07	0.14	0.19	0.24	0.27	0.30	0.34	0.37	0.41
1983.00	0.07	0.14	0.19	0.24	0.27	0.30	0.34	0.37	0.41
1984.00	0.07	0.15	0.20	0.24	0.27	0.29	0.32	0.36	0.41
1985.00	0.07	0.16	0.22	0.25	0.29	0.31	0.32	0.37	0.37
1986.00	0.08	0.15	0.22	0.26	0.29	0.32	0.35	0.37	0.53
1987.00	0.07	0.14	0.19	0.24	0.27	0.30	0.32	0.35	0.43
1988.00	0.07	0.12	0.17	0.22	0.26	0.29	0.31	0.33	0.35
1989.00	0.04	0.12	0.18	0.22	0.26	0.29	0.31	0.34	0.35
1990.00	0.06	0.11	0.18	0.22	0.25	0.28	0.31	0.33	0.37
1991.00	0.06	0.12	0.17	0.21	0.24	0.26	0.29	0.32	0.34
1992.00	0.07	0.12	0.16	0.20	0.23	0.26	0.28	0.31	0.32
1993.00	0.05	0.12	0.17	0.20	0.23	0.27	0.29	0.31	0.32
1994.00	0.05	0.12	0.16	0.20	0.22	0.25	0.28	0.30	0.34
1995.00	0.05	0.10	0.16	0.20	0.22	0.26	0.28	0.31	0.31
1996.00	0.06	0.10	0.15	0.21	0.24	0.28	0.31	0.33	0.35
1997.00	0.06	0.11	0.16	0.20	0.23	0.26	0.29	0.31	0.33

Data imported from file : D:\MIKE\TABLES97\W4WX3-11.TAB

## Maturity

	3	4	5	6	7	8	9	10	11
1973.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1974.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1975.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1976.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1977.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1978.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1979.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1980.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1981.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1982.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1983.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1984.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1985.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1986.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1987.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1988.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1989.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1990.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1991.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1992.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1993.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1994.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1995.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1996.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00
1997.00	0.00	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00

Data imported from file : D:\MIKE\TABLES97\M4WX.TAB

Ages for which abundance will be estimated

5

Initial values

10000

Ages for which abundance will be calculated using PR

3 4 6 7 8 9 10

PR for these yearclasses in the previous time period

0.3 0.6 1 1 1 1 1

Estimated ages used in the PR calculations

5

PR for these estimated yearclasses in the previous time period

1

Ages assigned a fixed value

1 2

Assigned abundance for these ages

1000000 1000000

Ages being averaged for oldest age F

6 7 8

PR multiplier for oldest age F

1

Natural mortality

0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2

Models selected

Larval 3 4 5 6 7 8 9 10 11 Proportional

# Appendix 1. 4WX herring ADAPT output: larval index aggregate series

LAMBDA 1.00000E-3  
 RSS 1.55305E1  
 NPHI 1.55305E1

Parameters  
 1.41680E1 -9.55021E0

RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN 0.00001

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.003172  
 MEAN SQUARE RESIDUALS ..... 0.675240

Estimates for index catchability parameters

PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
-----	-----	-----	-----	-----
-9.550E0	1.825E-1	-1.911E-2	-4.218E-3	4.416E-4

Terminal year-class abundance

PAR. EST.	STD. ERR.	REL. ERR.	BIAS	REL. BIAS
-----	-----	-----	-----	-----
1000000	0	0.00	0	0.00
1000000	0	0.00	0	0.00
733827	419286	0.57	110410	0.15
360467	210750	0.58	55562	0.15
1422653	857386	0.60	226674	0.16
302984	182599	0.60	48275	0.16
93683	56460	0.60	14927	0.16
50842	30641	0.60	8101	0.16
18334	11050	0.60	2921	0.16
9901	5967	0.60	1577	0.16
7278	4386	0.60	1160	0.16
4958	2549	0.51	669	0.13
8709	2998	0.34	774	0.09
21276	3959	0.19	1023	0.05
44948	4614	0.10	1189	0.03
34994	1877	0.05	481	0.01
14999	551	0.04	141	0.01
15822	349	0.02	89	0.01
9367	190	0.02	49	0.01
14213	216	0.02	55	0.00
6003	71	0.01	18	0.00
2178	24	0.01	6	0.00
3154	19	0.01	5	0.00
674	2	0.00	1	0.00
2053	3	0.00	1	0.00
1037	1	0.00	0	0.00
18166	15	0.00	4	0.00
2765	1	0.00	0	0.00
1587	0	0.00	0	0.00
1848	0	0.00	0	0.00
3648	0	0.00	0	0.00
5584	0	0.00	0	0.00
12621	0	0.00	0	0.00
13123	0	0.00	0	0.00
13095	0	0.00	0	0.00
10341	0	0.00	0	0.00
11490	0	0.00	0	0.00
6191	0	0.00	0	0.00
7619	0	0.00	0	0.00
549	0	0.00	0	0.00
626	0	0.00	0	0.00
282	0	0.00	0	0.00
0	0	1.00	0	1.00

Population Numbers

	1	2	3	4	5	6	7	8	9	10	11
1965.00	3519815	3855302	997927	1315177	349389	91813	41148	4346	1282	385	0
1966.00	2744237	2637899	2182573	785586	865817	241085	65624	32161	3052	1001	282
1967.00	6079238	2107535	1340494	1383120	577015	420626	156068	41164	19391	995	626
1968.00	1286748	4326386	1174413	959039	892657	373396	201831	75881	29649	15506	549
1969.00	1753792	905094	1416147	759115	710245	470528	239954	84291	33533	10516	7619
1970.00	2301352	1337649	480640	683224	502405	435467	284006	140309	48719	21745	6191
1971.00	7465244	1256341	579488	324602	303370	231291	248526	132346	77846	20877	11490
1972.00	1138738	6032937	666076	309498	170148	146681	121579	119645	63566	31046	10341

# Appendix 1. 4WX herring ADAPT output: larval index aggregate series

1973.00	2344101	932320	4354089	480449	120860	70343	52905	55642	54390	28737	13095
1974.00	1626248	1918268	612605	2861842	275850	62973	30476	23599	27417	23198	13123
1975.00	247113	1314831	885061	417259	1621534	164495	34426	15779	13426	11032	12621
1976.00	723758	199430	791022	509247	229806	866020	75356	17167	8960	6711	5584
1977.00	4143916	592346	113361	462107	278943	126405	467854	42431	9059	3805	3648
1978.00	1345207	3391695	346703	64464	183322	121783	57709	224344	22207	4576	1848
1979.00	456703	1069417	2431123	247007	41168	42028	38855	19568	86449	8299	1587
1980.00	1592311	373608	709946	1764700	153120	28813	13815	15515	5513	33841	2765
1981.00	1676022	1301561	294597	508682	1019027	100228	19652	7104	6837	1856	18162
1982.00	2326411	1372211	972680	195392	324049	430888	52489	13911	3340	3876	1037
1983.00	4160953	1901462	1031343	660596	139568	177188	164515	29841	9516	1523	2053
1984.00	5061218	3401743	1383972	708990	322310	92231	90681	54602	15154	6236	673
1985.00	1858104	4143775	2705266	913886	379231	133387	55100	54781	19487	3969	3149
1986.00	1082548	1513138	3197041	1910676	476749	178310	71174	32467	28553	8801	2172
1987.00	1437275	886259	1125845	2368698	1300652	339016	117546	48573	22689	20725	5985
1988.00	1445189	1174664	650821	807801	1465085	846573	236182	78700	33201	15549	14158
1989.00	1809277	1183084	828013	430943	486034	809837	481136	155088	45387	23411	9318
1990.00	1337141	1481304	876831	575136	297122	326397	511014	324871	110480	29717	15733
1991.00	807182	1094758	1051897	600645	316920	162574	176560	237695	161353	62205	14858
1992.00	1386863	660865	808875	699665	326991	180072	95952	99328	122240	91240	34513
1993.00	3676174	1135459	389631	542827	316181	154471	79939	47688	49633	47316	43759
1994.00	770044	3009647	860705	279555	270440	141955	65960	35209	19854	21072	20253
1995.00	982534	630323	2370308	576605	180562	115942	51588	21908	15513	8475	7935
1996.00	1221403	802777	413950	1742469	371095	114743	62271	22456	12126	8914	4289
1997.00	1000000	1000000	623416	304905	1195980	254709	78756	42741	15413	8323	6119

## Fishing Mortality

	1	2	3	4	5	6	7	8	9	10
1965.00	0.088	0.369	0.039	0.218	0.171	0.136	0.046	0.153	0.048	0.112
1966.00	0.064	0.477	0.256	0.109	0.522	0.235	0.266	0.306	0.921	0.269
1967.00	0.140	0.385	0.135	0.238	0.235	0.534	0.521	0.128	0.024	0.395
1968.00	0.152	0.917	0.236	0.100	0.440	0.242	0.673	0.617	0.837	0.511
1969.00	0.071	0.433	0.529	0.213	0.289	0.305	0.337	0.348	0.233	0.330
1970.00	0.405	0.637	0.193	0.612	0.576	0.361	0.564	0.389	0.647	0.438
1971.00	0.013	0.435	0.427	0.446	0.527	0.443	0.531	0.533	0.719	0.502
1972.00	0.000	0.126	0.127	0.740	0.683	0.820	0.582	0.588	0.594	0.663
1973.00	0.000	0.220	0.220	0.355	0.452	0.636	0.607	0.508	0.652	0.584
1974.00	0.013	0.574	0.184	0.368	0.317	0.404	0.458	0.364	0.710	0.409
1975.00	0.014	0.308	0.353	0.396	0.427	0.581	0.496	0.366	0.493	0.481
1976.00	0.000	0.365	0.338	0.402	0.398	0.416	0.374	0.439	0.656	0.410
1977.00	0.000	0.336	0.364	0.725	0.629	0.584	0.535	0.447	0.483	0.522
1978.00	0.029	0.133	0.139	0.248	1.273	0.942	0.882	0.754	0.784	0.859
1979.00	0.001	0.210	0.120	0.278	0.157	0.913	0.718	1.067	0.738	0.899
1980.00	0.002	0.038	0.133	0.349	0.224	0.183	0.465	0.619	0.889	0.422
1981.00	0.000	0.091	0.211	0.251	0.661	0.447	0.146	0.555	0.367	0.382
1982.00	0.002	0.086	0.187	0.136	0.404	0.763	0.365	0.180	0.585	0.436
1983.00	0.001	0.118	0.175	0.518	0.214	0.470	0.903	0.478	0.223	0.617
1984.00	0.000	0.029	0.215	0.426	0.682	0.315	0.304	0.830	1.140	0.483
1985.00	0.005	0.059	0.148	0.451	0.555	0.428	0.329	0.452	0.595	0.403
1986.00	0.000	0.096	0.100	0.185	0.141	0.217	0.182	0.158	0.120	0.186
1987.00	0.002	0.109	0.132	0.280	0.229	0.161	0.201	0.180	0.178	0.181
1988.00	0.000	0.150	0.212	0.308	0.393	0.365	0.221	0.350	0.149	0.312
1989.00	0.000	0.100	0.164	0.172	0.198	0.260	0.193	0.139	0.224	0.197
1990.00	0.000	0.142	0.178	0.396	0.403	0.414	0.565	0.500	0.374	0.493
1991.00	0.000	0.103	0.208	0.408	0.365	0.327	0.375	0.465	0.370	0.389
1992.00	0.000	0.328	0.199	0.594	0.550	0.612	0.499	0.494	0.749	0.535
1993.00	0.000	0.077	0.132	0.497	0.601	0.651	0.620	0.676	0.657	0.649
1994.00	0.000	0.039	0.201	0.237	0.647	0.812	0.902	0.620	0.651	0.777
1995.00	0.002	0.220	0.108	0.241	0.253	0.422	0.632	0.391	0.354	0.481
1996.00	0.000	0.053	0.106	0.176	0.176	0.176	0.176	0.176	0.176	0.176

Appendix 1. 4WX herring ADAPT output: larval index aggregate series

