Fisheries and Oceans Canada | Pêches et Océans Canada

Canadian Stock Assessment Secretariat
Research Document 99/138

Not to be cited without
permission of the authors[1]

Secrétariat canadien pour l'évaluation des stocks
Document de recherche 99/138

Ne pas citer sans
autorisation des auteurs[1]

Report of the 1998-1999 4VWX herring and mackerel tagging program and plans for 1999-2000

by

S. D. Paul

Marine Fish Division
Maritimes Region, Science Branch
Biological Station
St. Andrews, New Brunswick E5B 2L9

[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

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

ISSN 1480-4883
Ottawa, 1999
Canada

ABSTRACT

A comprehensive tagging program was implemented by the Pelagics Research Council in collaboration with the Department of Fisheries and Oceans to provide essential information on stock intermixing and migration patterns of 4WX herring and 4VWX mackerel. In 1998-1999, 26,230 herring were tagged on major spawning grounds and from an overwintering aggregation. In addition, 10,859 mackerel were tagged in two locations along the southern and eastern coasts of Nova Scotia.

During the initial year of recoveries, tagged herring were recaptured near the application site. Preliminary short-term returns show that herring may be staying on the spawning ground for longer than the assumed 7-10 days of spawning activity. Tagged mackerel were recaptured along the southern and eastern coasts of Nova Scotia throughout the summer and fall.

It is recommended that tagging be performed during designated tagging trips - where three times more tags, on average, can be applied during a designated trip than during a regular fishing trip. Future tagging experiments for herring should be conducted on the spawning grounds, on overwintering aggregations, and on summer mixing areas of interest. Juvenile and adult mackerel tagging should continue, and results studied in association with hydrographic conditions, which are related to migration patterns. Tagging mortality, tag shedding and tag recovery studies would provide important information affecting tag return rates.

RÉSUMÉ

Un programme de marquage détaillé a été mis en œuvre par le conseil de recherche sur les poissons pélagiques en collaboration avec le ministère des Pêches et des Océans dans le but d'obtenir des renseignements essentiels sur le mélange des stocks et des patrons de migration du hareng de 4WX et du maquereau de 4VWX. En 1998 et 1999, 26 230 harengs ont été marqués sur les principaux fonds de frai ainsi qu'à partir d'une concentration d'hivernage. En outre, 10 859 maquereaux ont été marqués en deux endroits le long des côtes sud et est de la Nouvelle-Écosse.

Au cours de la première année de récupération, les harengs marqués étaient recapturés à proximité des lieux de marquage. Des résultats préliminaires portant sur une courte période indiquent que les harengs pourraient demeurer dans les aires de frai pendant plus longtemps que les 7 à 10 jours supposés du frai. Des maquereaux marqués ont été recapturés le long des côtes sud et est de la Nouvelle-Écosse pendant tout l'été et l'automne.

Il est recommandé que le marquage soit effectué dans le cadre de sorties prévues à cette fin car trois fois plus d'étiquettes peuvent, en moyenne, être placées pendant une telle sortie comparativement à une sortie de pêche ordinaire. Les prochaines expériences de marquage du hareng devraient porter sur les aires de frai, les zones de concentration d'hivernage et les zones de mélange d'été présentant un intérêt. Le marquage des maquereaux juvéniles et adultes devrait être poursuivi et les résultats étudiés dans le contexte des conditions hydrographiques liées aux patrons de migration. Des études sur la mortalité due au marquage, la perte d'étiquettes et la récupération des étiquettes permettraient d'obtenir d'importants renseignements influant sur le taux de récupération des étiquettes.

INTRODUCTION

The Pelagics Research Council (PRC) was formed by herring and mackerel industry interests in NAFO Divisions 4WX in 1996 to sponsor and promote fisheries research. In 1998, the PRC initiated an extensive herring and mackerel tagging study in collaboration with the Science Branch of the Department of Fisheries and Oceans, and extended the program to include mackerel in Division 4V.

The primary objective for this study is to provide insight into herring stock structure issues and herring and mackerel migration patterns. Such knowledge will be useful in the evaluation of stock status for herring and mackerel, and in preserving spawning components of herring.

BACKGROUND AND RATIONALE - HERRING

Early tagging studies on herring were restricted to short term studies and relatively small numbers of herring, and showed only local movements. With the development of the external anchor tag in the early 1970's, studies could be conducted over longer time periods, and large numbers of fish could be tagged over a short time frame. Canada began tagging herring in 1973 (Stobo et al. 1975). In 1976 The International Herring Tagging Program (IHTP), initiated by ICNAF (International Commission for the Northwest Atlantic Fisheries), was responsible for studies that tagged over 500,000 herring in Subareas 4 and 5 and statistical area 6 between 1976 and 1981 (Stobo 1982).

The information gained from IHTP was influential in establishing the view of herring stock structure and migration which is in place today. It showed that herring undertake distant migrations with different stages of their life cycle, but that there is year to year consistency in overwintering, summer feeding and particularly spawning locations.

The last major tagging initiative occurred over two decades ago and since then there have been major changes in herring distribution and the relative abundance of spawning components within the region. There has been a resurgence of fish from Georges Bank and on the Scotian Shelf, as well as some changes in stock size such as the Lurcher Shoal and Seal Island spawning components, which could indicate some changes in population structure. In addition, the distribution of herring in at least one overwintering area (Chedabucto Bay) has changed in recent years. There have been fewer fish in Chedabucto Bay, and they seem to be leaving the Bay earlier. At the same time, substantial aggregations have been found off Chebucto Head near Halifax, sparking questions regarding the origin of these fish. Renewed tagging studies have been requested by the 4VWX herring industry, and recommended as a research priority at the Canada/US Herring Stock Assessment and Research Priorities workshop (Mooney-Seus et al. 1998).

A limited amount of tagging was undertaken in the 4WX5Z area in an ad hoc manner from 1992-1996 in an attempt to address stock structure issues, however, in five areas of interest only 4,206 tags were applied over five years. Very few tags were recovered from these experiments, likely due to low application coverage. Figures A1-A10 summarize release and recovery information for each experiment undertaken (Appendix I).

In recent years, thinking has evolved regarding stock structure, such that more interest has been placed on individual spawning aggregations. These areas are now considered on a much finer scale than were previously, and the maintenance of all spawning components is an explicit conservation objective (Stephenson et al. 1998). In addition, there is considerable interest in areas such as the offshore Scotian Shelf, coastal Nova Scotia and Georges Bank, which were not the subject of tagging interest in previous studies.

BACKGROUND AND RATIONALE - MACKEREL

Mackerel in 4VWX waters are considered a northern population which are thought to migrate from spawning grounds in the Gulf of St. Lawrence to overwintering areas in US waters, then back to the spawning area in the spring via a route along inshore and offshore coastal Nova Scotia.

Early tagging studies on Atlantic mackerel using a variety of markers were undertaken in NAFO subareas 4 and 5 between 1925 - 1928 and analyzed by Sette (1950). The results suggested that two populations (a northern and a southern) exist.

An eight year study of some aspects of life history and population biology was carried out during 1965-1973 (MacKay, 1973). Tagging studies were performed in Southwest Nova Scotia and St. Margarets Bay from 1965-1968 using ring or barb tags. Results further suggested the existence of two spawning populations, and shed light on migration patterns.

The northern population engages in a spring migration along the coast of Nova Scotia in a series of waves to the spawning ground in the Gulf of St. Lawrence, where spawning occurs June - July over the Magdalen Shallows (MacKay, 1979). The aggregations stay in this location during the summer, but are later found throughout the Gulf of St. Lawrence, and are known to cross the Belle Isle Strait to migrate to the east coast of Newfoundland. Sette (1950) suggested, on the analysis of winter catch and tag return data, that Atlantic mackerel overwinter at mid-depths along the Continental Shelf from Sable Island to Cape Hatteras.

Migration is known from fishermen's observations and the study of satellite images to be controlled by changes in photoperiod and temperature. Water temperature at the mouth of the Gulf of St. Lawrence is believed to influence spring migration. Small catches which were observed several years ago in the Gulf of St. Lawrence have been linked to abnormally cold water temperatures (MacKay 1979). Tagging adult mackerel in opportunistic areas along the coast of Nova Scotia would verify the local or regional pattern of the migration, and provide an opportunity to associate this pattern with water temperatures in the region. In addition, the

juvenile component of the northern stock migrates along the Nova Scotia shore later in the season, which is demonstrated by local catches. These young mackerel are believed to spend the summer off Nova Scotia, and will also migrate to the Gulf of St. Lawrence under warm water conditions (MacKay 1979). Tagging juvenile mackerel would provide documentation of this movement.

MATERIALS AND METHODS

Herring and mackerel were tagged with yellow external FD-98 Anchor tags from Floy Tag and Manufacturing Inc. In an attempt to reduce reporting bias in any transboundary experiments, tags were labeled with a dual Canada/USA address as follows -

DFO/SABS NB E0G 2X0
DMR PO 8 W BOOTHBAY Hbr ME 04575.

Herring were caught by purse seine, and mackerel were caught in traps, during fishing trips and designated tagging trips and dipped into a holding tank with running seawater. The tag was inserted into the musculature at the base of the dorsal fin using Floy tagging guns. The needle of the gun was inserted so that the anchor would lie between two fin ray spines, decreasing the chances that the tag would be lost. Upon tagging, fish were returned to the water individually, or in small groups. A length frequency sample of 100-200 fish was taken and a detail sample was frozen and analyzed in the herring laboratory in St. Andrews, NB and the mackerel lab at the Maurice Lamontagne Institute. Fish which appeared unhealthy or lethargic, or suffered substantial scale loss, were not tagged.

On the spawning grounds, only herring which were “ripe and running” were tagged. This protocol was adopted in order to ensure that the tagged fish were actually spawning in the application area, and not part of a migratory school. In cases where herring from mixed spawning and migratory schools were caught, fish from the catch were not tagged, or in cases with a low proportion of mixing, the “ripe and running” herring were separated from the immature fish and tagged.

As incentive for returning tags, an annual draw for $1000.00, for each species, will be held in the spring and each tag returned will be entered in the draw as one ticket. A protocol was set up in many processing plants to facilitate tag recovery, and the program was extensively advertised within the 4VWX area using posters and news articles.

RESULTS AND DISCUSSION - HERRING

Over 26,000 herring were tagged on spawning and overwintering grounds in NAFO Divisions 4WX during 1998-1999. Table 1 and Figures 1-4 show release and recovery information to March 1, 1999, as well as fish length and maturity, or age, from sampling. An explanation of maturity stages and growth for herring are presented in Appendix II.

Table 1. Application and recovery (to Mar. 1, 99) information for herring tagging 1998-1999.

Area	Date	Length (cm)	# Fish Tagged	Recoveries
Scots Bay	Aug 23 - 25, 98	22.5 - 32.5	2,346	23
Trinity Ledge	Aug 27 - Sep 25, 98	22.5 - 32.5	4,510	2
German Bank	Aug 20 - Sep 22, 98	17.5 - 35.0	9,068	28
Chebucto Head	Jan 21- 26, 99	16.0 - 30.0	10,306	0
			26,230	

As expected for the initial year of returns, the tags were recovered near the application sites. The recaptures show that the tagged fish are surviving the initial shock of being caught and tagged, and that advertising efforts with respect to tag recovery have been effective.

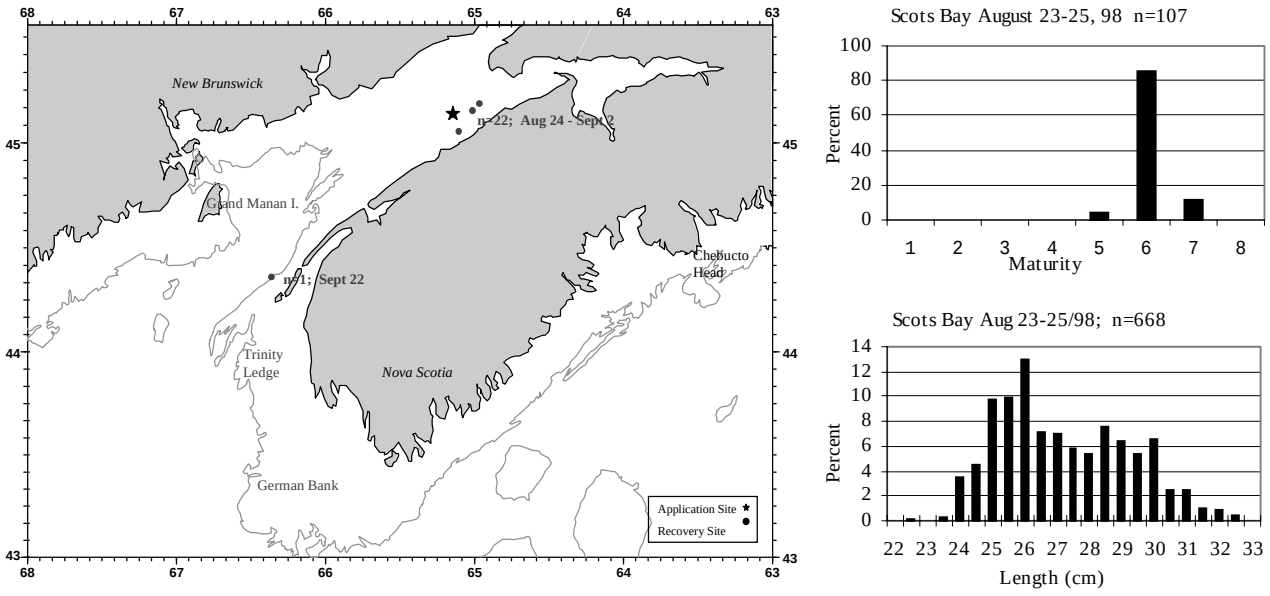

Figure 1. Application (n=2,346) and recovery (n=23) data from Scots Bay tagging August 23-25, 1998, as well as maturity and length data for fish collected at the tagging site.

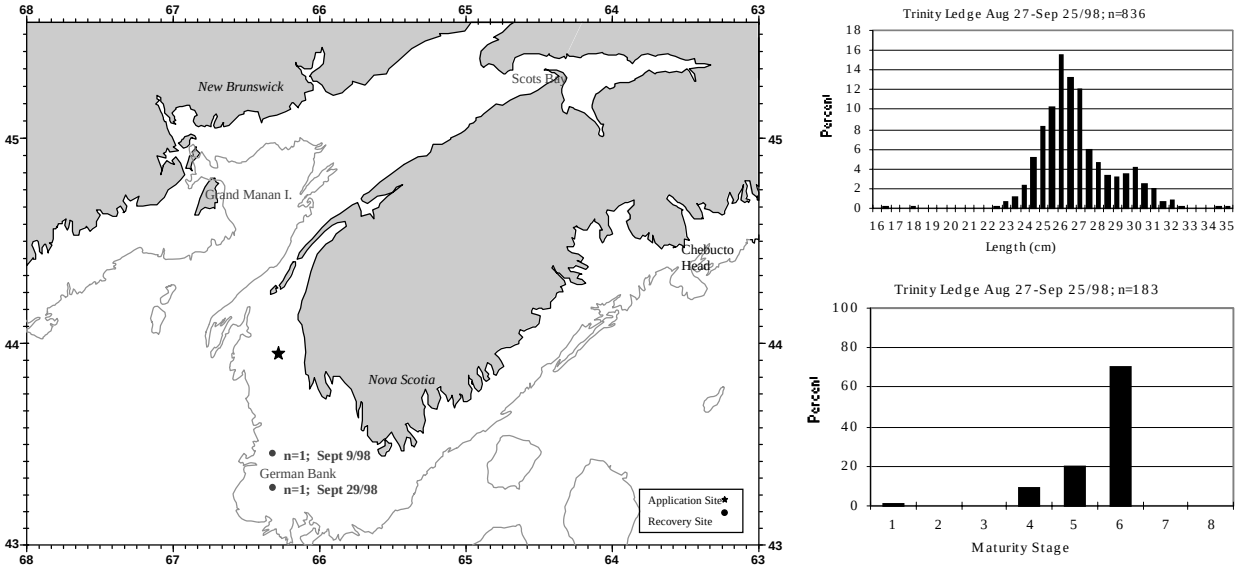

Figure 2. Application (n=4,510) and recovery (n=2) data from Trinity Ledge tagging August 27 - September 25, 1998, as well as length and maturity data for fish collected at the tagging site.

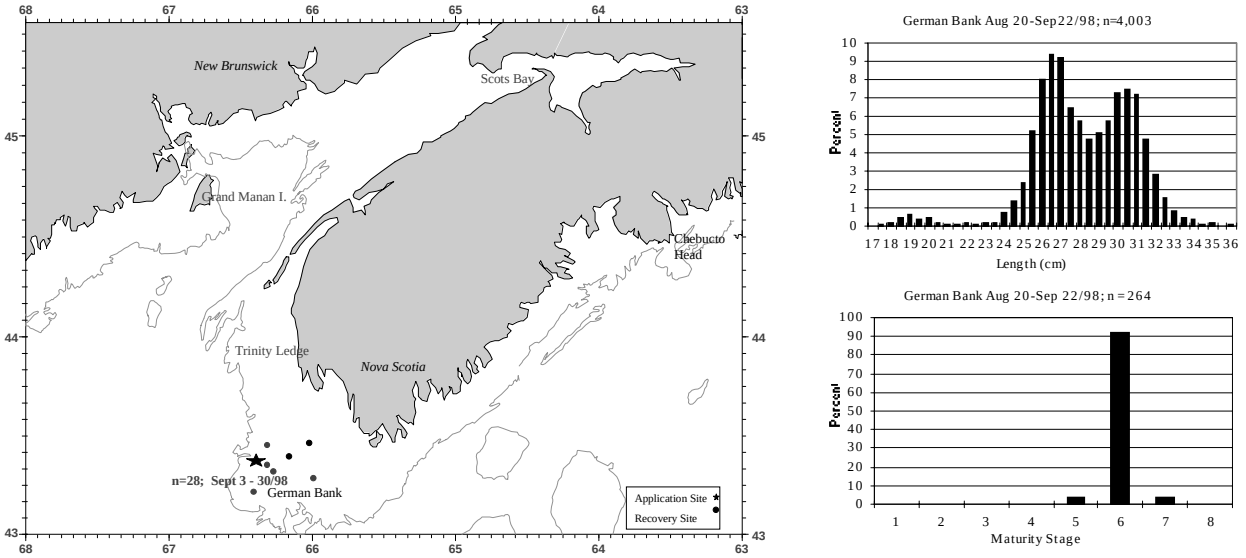

Figure 3. Application (n=9,068) and recovery (n=28) data from German Bank tagging August 20 - September 22, 1998, as well as length and maturity data for fish collected at the tagging site.

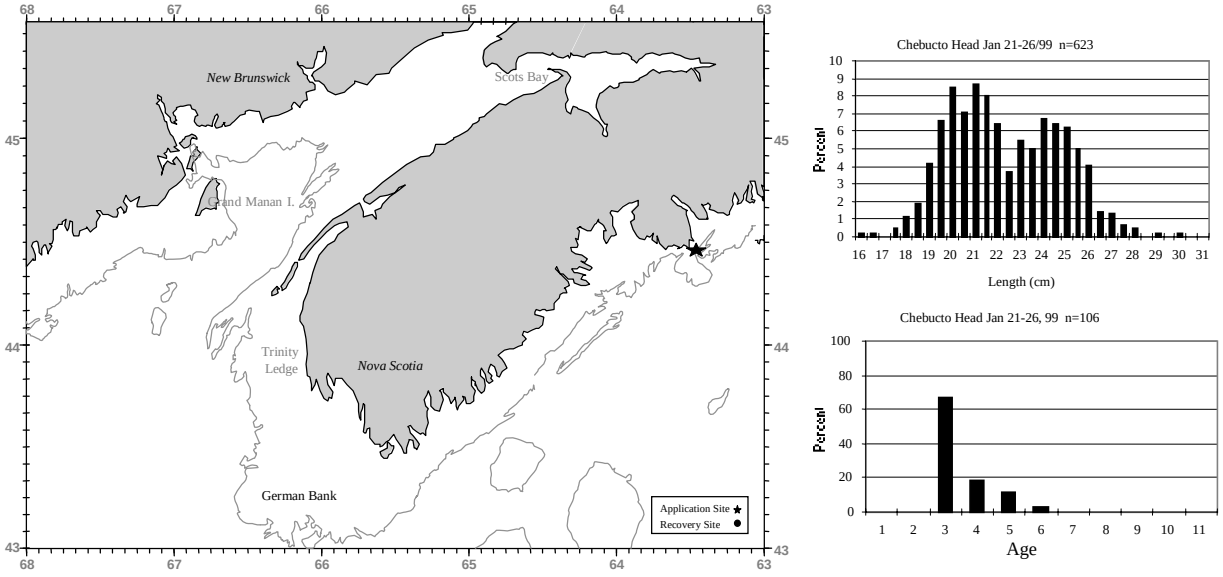

Figure 4. Application (n=10,306) and recovery (n=0) data for Chebucto Head tagging on January 21 - 26, 1999, as well as length and age data for fish collected at the tagging site. Age data is shown in substitution for maturity since the majority of fish were immature.

SHORT-TERM RECOVERIES - HERRING

Herring aggregate on spawning grounds and spawn in events which have been referred to as “waves”. These observations are assumed from fishermen’s recordings and literature reports to take place within a 7-10 day period (Stephenson et al. 1998, 1999), but this has not been fully substantiated.

The turnover rate of herring on spawning grounds is of great importance to current assessment methods which involve repeated acoustic surveys of spawning grounds (Melvin et al. 1999). Tagging and subsequent recovery of herring on spawning grounds offers a potential test of the residence time, or turnover rate. Although the total number of returns from each tagging experiment is small, there is sufficient information to show preliminary results of turnover rate in Scots Bay and on German Bank.

Of 22 recovered tags from the Scots Bay experiment which were caught on the same spawning ground, four (18% of recoveries; 0.2% of tags released) were recaptured more than seven days, but not more than ten days, after release. Of 28 herring from the German Bank experiment which were recaptured on the same spawning ground, four (14%; 0.04% of tags released) were caught more than seven days (Table 2), and seven (25%; 0.08% of tags released) were caught more than 10 days after release (Table 3).

Table 2. Herring tags recovered 7-10 days after release on the same spawning ground.

Application				Recovery					
Date	Location	Lat	Long	Date	Location	Lat	Long	Days	Comments
23-Aug-98	Scots Bay	4508	6505	2-Sep-98	Scots Bay	4511	6500	10	28.0 cm, Leroy and Barry
23-Aug-98	Scots Bay	4508	6505	31-Aug-98	Scots Bay	4510	6500	8	28.5 cm; Leroy and Barry
23-Aug-98	Scots Bay	4508	6505	31-Aug-98	Scots Bay	4510	6500	8	29.0 cm; Leroy and Barry
23-Aug-98	Scots Bay	4508	6505	2-Sep-98	Scots Bay	4511	6500	10	26.0 cm; Leroy and Barry
1-Sep-98	German Bank	4327	6621	9-Sep-98	German Bank	4327	6620	8	Sealife II
2-Sep-98	German Bank	4327	6622	12-Sep-98	German Bank	4329	6622	10	Seacord no 1
3-Sep-98	German Bank	4327	6621	12-Sep-98	German Bank	----	----	9	10" (25.5cm), 147g, Schooner
13-Sep-98	German Bank	4327	6622	22-Sep-98	German Bank	4332	6622	9	Seacord no 1

Table 3. Herring tags recovered >10 days after release on the same spawning ground.

Application				Recovery					
Date	Location	Lat	Long	Date	Location	Lat	Long	Days	Comments
1-Sep-98	German Bank	4327	6621	17-Sep-98	German Bank	----	----	16	----
1-Sep-98	German Bank	4327	6621	23-Sep-98	German Bank	----	----	22	9.5"(24cm), Comeau & Saulnier
1-Sep-98	German Bank	4327	6621	16-Sep-98	German Bank	----	----	15	----
3-Sep-98	German Bank	4327	6621	17-Sep-98	German Bank	----	----	14	Sable Fish Packers
3-Sep-98	German Bank	4327	6621	15-Sep-98	German Bank	----	----	12	9.5"(24cm), Comeaus & Saulnier
8-Sep-98	German Bank	4326	6620	28-Sep-98	German Bank	----	----	20	----
9-Sep-98	German Bank	4326	6620	23-Sep-98	German Bank	----	----	14	----

During tagging trips, every effort was made to tag only ripe and running herring, and detail samples from these trips show that the herring tagged were primarily at stage six (Figure 5). There are tagging events on German Bank for which there is no detail sample. For these dates, it is possible to refer to maturity information taken from adjacent days, where available, when tagging occurred in the same location (Table 4).

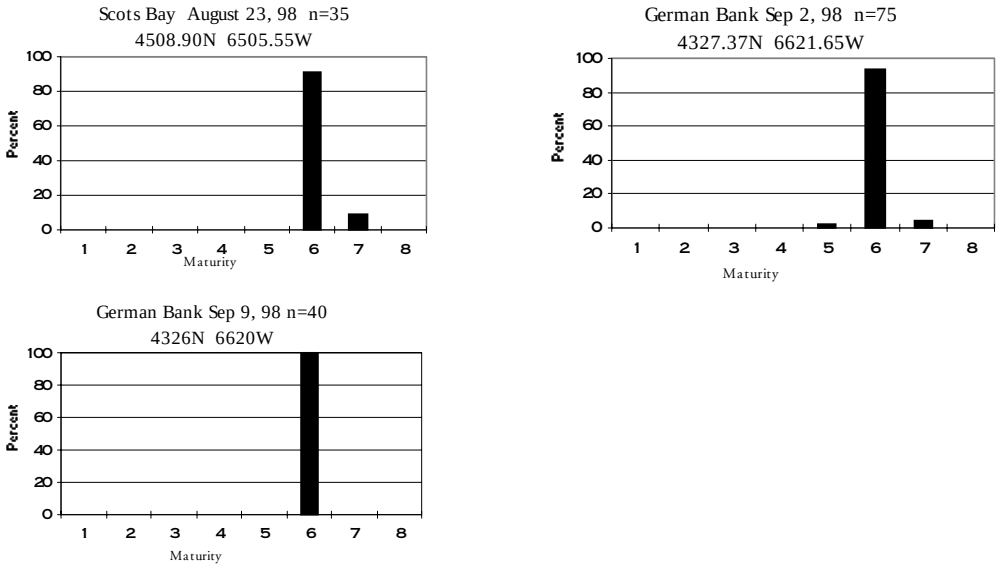

Figure 5. Maturity data from samples taken on tagging nights where recoveries were made on the same spawning ground > 7 days.

Table 4. Description of tagging events 1998-1999.

Area	Date	Vessel	Latitude	Longitude	Comments
Scots Bay	23-Aug-98	Canada 100	4508.90	6505.55	survey night
	25-Aug-98	Margaret Elizabeth	4507.00	6507.00	DNA sampling
Trinity Ledge	27-Aug-98	Tasha Marie	4400.84	6619.06	Mixed sizes and maturities
	11-Sep-98	Fundy Mistress	4359.00	6619.89	designated
	12-Sep-98	Fundy Mistress	4400.49	6618.61	designated
	25-Sep-98	Silver Harvester	4358.79	6617.68	designated
German Bank	20-Aug-98	Island Pride	4328.50	6622.00	all ripe and running
	31-Aug-98	Sealife II	4326.21	6621.00	all running
	1-Sep-98	Island Pride	4327.00	6621.00	all ripe and running
	2-Sep-98	Island Pride	4327.37	6621.65	all ripe and running
	3-Sep-98	Island Pride	4327.00	6621.00	all ripe and running
	8-Sep-98	Leroy & Barry	4326.28	6620.49	
	9-Sep-98	Lady Noreen	4326.00	6620.00	all ripe and running
	9-Sep-98	Mari-Lynn Anita	4328.00	6617.00	all ripe and running
	9-Sep-98	Lady Melissa	4326.43	6620.57	
	13-Sep-98	Lady Melissa	4326.66	6622.00	70% fish ripe and running
	14-Sep-98	Lady Melissa	4328.68	6620.50	80% fish ripe and running
	20-Sep-98	Lady Noreen	4327.65	6620.72	70% ripe and running
	21-Sep-98	Sealife II	4328.00	6620.00	80% ripe and running
	21-Sep-98	Lady Noreen	4327.83	6621.00	75% ripe and running
	22-Sep-98	Sealife II	4327.72	6620.80	v. few tagged, vessel problems
	22-Sep-98	Lady Noreen	4327.84	6620.95	85% ripe and running
Chebucto Head	21-Jan-99	Seacord no. 1	4428.66	6331.30	small fish, v. large aggregation
	22-Jan-99	Seacord no. 1	4427.00	6331.00	small fish, v. large aggregation
	26-Jan-99	Seacord no. 1	4429.50	6330.32	gut empty, lg'r fish, v. lg aggregation

These findings, although preliminary, suggest that there may be cause to question the assumption that herring stay on the spawning grounds for less than ten days during spawning. The total number of returned tags from each experiment is low at this time, however, next year, with an additional season of data, more concrete conclusions might be drawn.

RESULTS AND DISCUSSION - MACKEREL

Over 10,000 juvenile and adult mackerel were tagged along coastal Nova Scotia in NAFO Divisions 4VWX in 1998. Table 5 and Figures 6-9 show release and recovery information to March 1, 1999, as well as fish length data from sampling during tagging trips.

Table 5. Application and recovery (to Mar. 1, 99) information for mackerel tagging 1998.

Area	Date	Length (cm)	# Fish Tagged	Recoveries
Aspy Bay	June 19-25, 98	27.0 - 40.5	788	3
St. Margarets Bay	July 8 - 23, 98	21.0 - 34.5	10,071	42
			10,859	

Size, rather than age, is the determining factor for sexual maturity in mackerel. At 34.0 cm, 100% of mackerel are sexually mature (Gregoire 1997).

Tagging in Aspy Bay (Fig. 6) was conducted during regular fishing trips. The fishing vessel was small, and for that reason there was room for only a small tank in which to hold the fish. This resulted in very low application coverage in this area, which likely explains the low number of returns to date.

Results from the St. Margarets Bay experiment (Fig. 7) show that the small, or juvenile, mackerel spent the summer off Nova Scotia, and close to shore, which is consistent with the current view. One mackerel was caught during the winter in US waters (Fig. 9). In the future it will be interesting to look at the temperature and wind conditions that prevailed during the migrations.

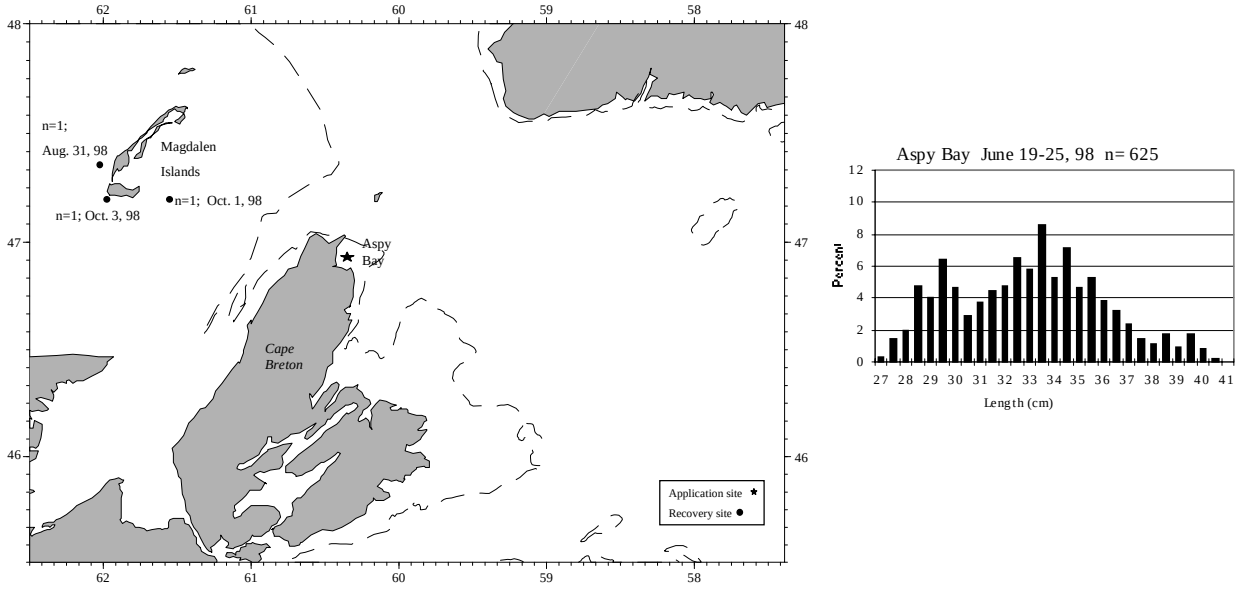

Figure 6. Application (n=788) and recovery (n=3) data from Aspy Bay mackerel tagging June 19-25, 1998.

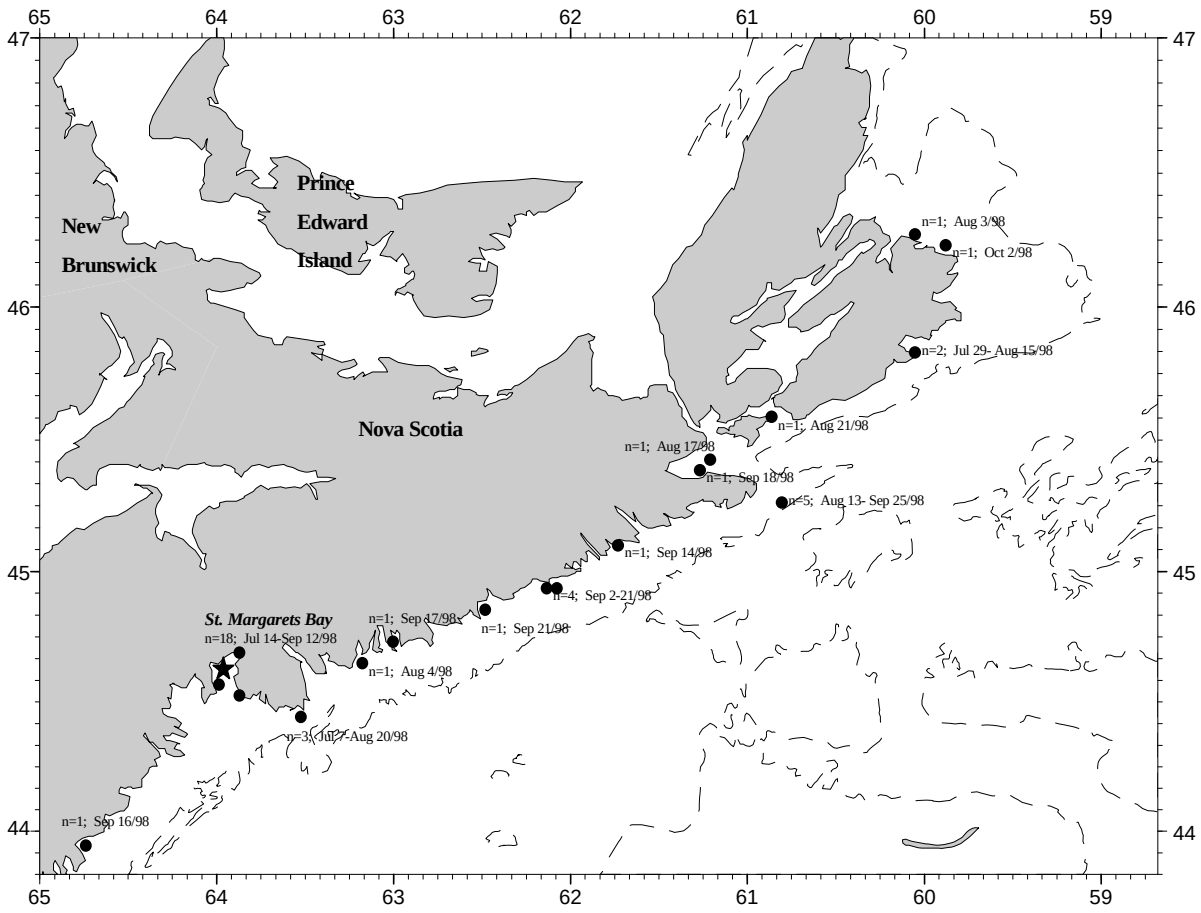

Figure 7. Application (n=10,071) and summer/fall recovery sites (n=42) from St. Margarets Bay mackerel tagging July 8-23, 1998.

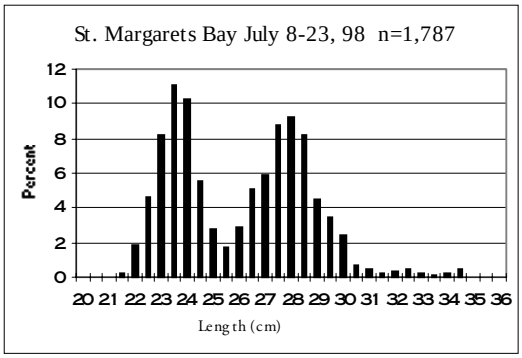

Figure 8. Length data from St. Margarets Bay tagging July 8-23/98.

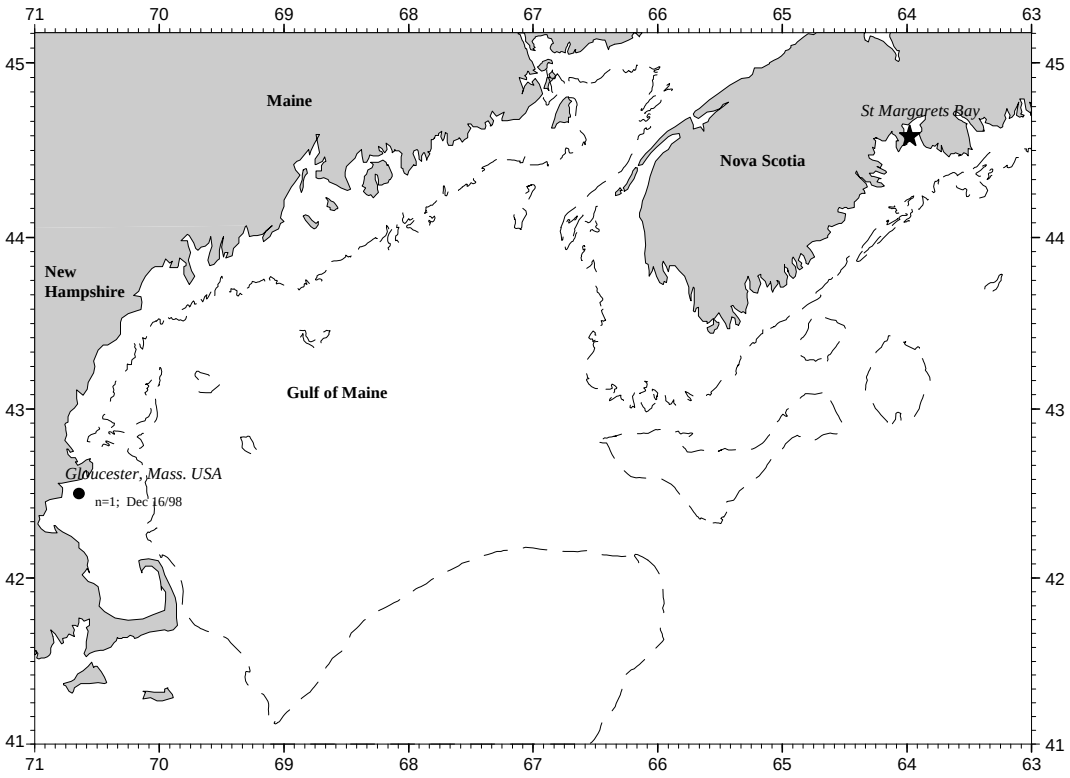

Figure 9. Winter recaptures from St. Margarets Bay mackerel tagging (n=10,071) July 8-23, 1998.

RECOMMENDATIONS

It is suggested that tagging in 1999/2000 be conducted only on designated trips. The number of herring tags applied by 2-3 people in one night increases by more than three times when conducted during designated trips rather than fishing trips (Table 6). In addition, there is a tendency for vessel crew members to participate in tagging during designated trips, since there are no fishing operations taking place. This would allow for more efficient use of time, which could be applied to conduct tagging operations in other areas during the fishery, and to conduct experiments on tag loss, mortality and recovery during the season.

Table 6. A description of the number of tags applied during specified trips.

Trip Description	# Vessels	# Tagged	**Avg. # Tagged/Vessel**
Fishing	16	9,154	572
Survey	3	2,796	932
Designated	8	14,280	1,785

It is recommended that while tagging herring on spawning grounds during 1999, the rigorous protocol on tagging only ripe and running herring, which was established during the past season, be continued.

Advertising efforts should remain strong for the upcoming year in order to maximize recovery rate. Efforts should be increased in processing plants with an established contact person in each plant responsible for the collection of recovered tags, if possible.

FURTHER STUDIES - HERRING

Proposed objectives for 1999 & 2000 - To continue tagging efforts with the following priorities:

- Canada / US transboundary stocks

Herring stock structure remains an unresolved issue in both Canadian and US herring assessments and management. Further understanding is required in order to enhance complimentary Canada & US approaches, particularly with respect to transboundary stocks.

The results of previous tagging studies are outdated, with the last experiment nearly twenty years ago, and the study was undertaken during the period of collapse of the Georges Bank stock (1977). There is the need for another tag experiment addressing the issues of stock structure and mixing at scales that are relevant to the present management regime.

For 1999 it is proposed that the program be extended to include collaborative application of tags in both Canadian and US waters.

- Bras D'Or lakes & Glace Bay (4Vn) / 4T

Historically the inshore herring fishery in Cape Breton has been an important source of food and bait. In recent years, with the development of the Japanese roe market, there has been increased interest in developing a fishery for roe fish on the spawning grounds, particularly in the area off Glace Bay and Port Morien.

There are a number of herring stocks which spawn in Cape Breton waters. In addition, herring are thought to migrate from adjacent areas (4T and 4W) to overwinter in the 4Vn area. Recent concern over the state of local stocks and the advent of new fisheries have demonstrated that there is a need for new research in this area, particularly on stock structure and movement.

In the past five years, there has been considerable concern expressed over the status of the Bras d'Or Lakes spawning group and a new fall gill net fishery off Glace Bay has begun. In 1999, it is proposed that a tagging program be instigated in the Bras d'Or Lakes and for the fall herring fishery off Glace Bay. The last tagging initiative occurred over two decades ago and involved less than 500 fish in the Bras d'Or Lakes. No tagging has been conducted on the Glace Bay gillnet fishery.

For 1999, it is proposed that herring be tagged on spawning grounds (Bras d'Or Lakes and 4T in spring, off Glace Bay in the fall) and in the 4Vn winter fishery to determine extent of movement and migration patterns, and fidelity to spawning grounds.

- 4WX spawning grounds

Stock structure has been a topic of debate for many years. Evidence of homing behavior has been demonstrated by previous tagging studies and by the regularity of spawning, both in geographical locality and in timing. This has led to the view that Atlantic herring migrate back to the same spawning ground year after year with very little straying.

In recent years, there has been a scientific focus on protecting individual known spawning grounds from disproportionate erosion by fishing, with the view that each is a distinct population. If each spawning ground is occupied by a distinct population, ripe and running herring that are tagged on the spawning ground would be expected to be recaptured in the release site during subsequent roe fisheries.

* Scots Bay
* Trinity Ledge
* German Bank

- Spectacle Buoy
- Little Hope
- Eastern Passage

- Overwintering grounds

An important overwintering area (Chedabucto Bay) was demonstrated to exist by previous tagging studies, and the management structure of the time was changed as a result. Presently, this area is managed with the assumption that stock structure has not changed since previous tagging studies were undertaken over twenty years ago. There are no observations to confirm this.

The size of some stocks, such as Lurcher Shoal and Seal Island, may have been drastically reduced since the previous studies. In addition, the Georges Bank and offshore Scotian Shelf complexes have undergone a resurgence and their stock structure is largely undocumented. Finally, the observation that the aggregation in Chedabucto Bay has been declining in size and leaving the Bay earlier, at the same time that large aggregations are observed in Chebucto Head, suggests a critical change in migration patterns.

- Chedabucto Bay
- Chebucto Head
- Grand Manan

- Summer mixing areas of interest

Aggregations of juvenile herring and of pre-spawning adults in the mouth of the Bay of Fundy are assumed to be mixtures of fish from several spawning grounds. Tagging fish from these mixing areas would help define the degree of mixing in support of management decisions.

- Grand Manan Ledges
- NB weir fishery
- Long Island Shore

- Exploratory areas

Observations of mixed aggregations of herring on Browns Bank in the spring, and of spawning fish in this area in the fall, from purse seine fishermen and associations has sparked interest in Browns Bank as an exploratory area for tagging. As well, tagging herring on the offshore Scotian Shelf banks during the fall spawning season would be beneficial if the opportunity arises.

- Browns Bank (spring & fall)
- Offshore Scotian Shelf banks

- Experiments

Tagging Mortality and Tag Shedding Study

Once fish are tagged and released, the most important component of a tagging study is the recovery of tags. Many things can affect the rate of recovery, but of most interest are mortality due to tagging and the amount of tags that are lost, or shed, after tagging. An estimation of tagging mortality and tag loss would give an indication of expected recovery rates, and would be an important part of analyzing recovery data.

A study of mortality and loss of tags due to shedding will provide insight on the recovery rates that can be expected from this tagging program. Herring will be held in a weir for the purpose of studying tagging mortality and tag shedding rate. Mortality will be calculated and compared to that of a control group, and fish will be examined for tagging wounds to determine the number of fish that lose, or shed, their tags.

Tag Recovery Study

Knowledge of the number of tags that are lost, or overlooked, during recapture and processing would be valuable in estimating expected return rates. Seeding tagged fish into different stages of handling and processing of the catch would provide insight into the amount of tags that are lost during these stages, and the proportion of recoveries that can be expected. Fish will be tagged at a processing plant and added to the processing lines to determine recovery rate.

FURTHER STUDIES - MACKEREL

Proposed objectives for 1999 - 2000 - to continue tagging efforts with the following priorities:

- Regional migration pattern of adult mackerel

Adult mackerel should be tagged throughout the spring during the migration to the spawning area in the Gulf of St. Lawrence, to determine the association between migration routes and environmental variables.

- Regional migration pattern of juvenile mackerel

Juvenile mackerel should be tagged along the coast of Nova Scotia during their migration which follows that of the adults, to determine the association between migration routes and environmental variables.

- Experiments

Tagging Mortality and Tag Shedding Study

A study similar to the one described for herring in this document would provide insight into the mortality of mackerel due to tagging, and the amount of tag shedding following a tagging experiment.

ACKNOWLEDGEMENTS

I would like to acknowledge the following people and organizations for contributions that have led to the successful first year of this program -- the 4VWX herring stock assessment team at the Biological Station in St. Andrews, New Brunswick - Rob Stephenson, Mike Power, Kirsten Clark, Gary Melvin and Jack Fife; the PRC technicians responsible for tagging over 37,000 fish - Sue Boates, Heather Boyd, Melanie Fredette, Lei Harris, Andrew Ing, Denise Rogers, Travis Scheidl and David Vessie; from the Maurice Lamontagne Institute in Mont Joli, Québec - Francois Grégoire (DFO) for his knowledge and comments on mackerel stock structure and behaviour, and Denis Bernier (PRC) for participating in the mackerel tagging operations and sharing sampling information; fishing associations and organizations - Southwest Seiners, Atlantic Herring Coop, Nova Scotia Mackerel Association, and Aspy Bay Fisheries; and the herring and mackerel fishermen in 4VWX who have participated in the program.

REFERENCES

Grégoire, F. 1997. Atlantic mackerel in the Northwest Atlantic. DFO Science Stock Status Rep., B4-04: 9p.

MacKay, K. T. 1973. Aspects of the Biology of Atlantic Mackerel in ICNAF Subarea 4. Int. Comm. Northw. Atlant. Fish. Res. Doc. 73/70.

MacKay, K. T. 1979. Synopsis of biological data of the northern population Atlantic mackerel *Scomber scombrus*. Fish. Mar. Serv. Tech. Rep. 885: vi + 26p.

Melvin, G. D. and M. J. Power. 1999. An Acoustic Survey Design for 4WX Herring Spawning Components. DFO Canadian Stock Assessment Secretariat Res. Doc., 99/63.

Mooney-Seus, M.L., J. S. Goebel, H. C. Tausig and M. S. Sweeney. 1998. Herring stock assessment and research priorities workshop. New England Aquarium Aquatic Forum Series Report, 98-01: 323p. + xxviii.

Sette, O. E. 1950. Biology of the Atlantic Mackerel (*Scomber scombrus*). Part 2. Migration and Habits. U. S. Fish & Wildlife Serv., Fish. Bull. 38(50): 149 - 237.

Stephenson, R. L., M. J. Power, K. J. Clark, G. D. Melvin, F. J. Fife and S. D. Paul. 1998 . 1998 Evaluation of the Stock Status of 4WX herring. DFO Canadian Stock Assessment Secretariat Res. Doc.., 98/52: 58p.

Stephenson, R.L., M. Power, K. Clark, G. Melvin, J. Fife, S. Paul, L. Harris and S. Boates. 1999. 1999 Evaluation of 4VWX herring. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/64.

Stobo, W.T., J. S. Scott and J. J. Hunt. 1975. Movements of herring tagged in the Bay of Fundy. Annu. Meet. Int. Comm. Northw. Atlant. Fish Res. Doc. 75/38. 24 p.

Stobo, W. T. 1982. Tagging studies on Scotian Shelf herring. Annu. Meet. Int. Comm. Northw. Atlant. Fish. SCR Doc 82/IX/108, Serial No. N617; 16pp.

APPENDIX I

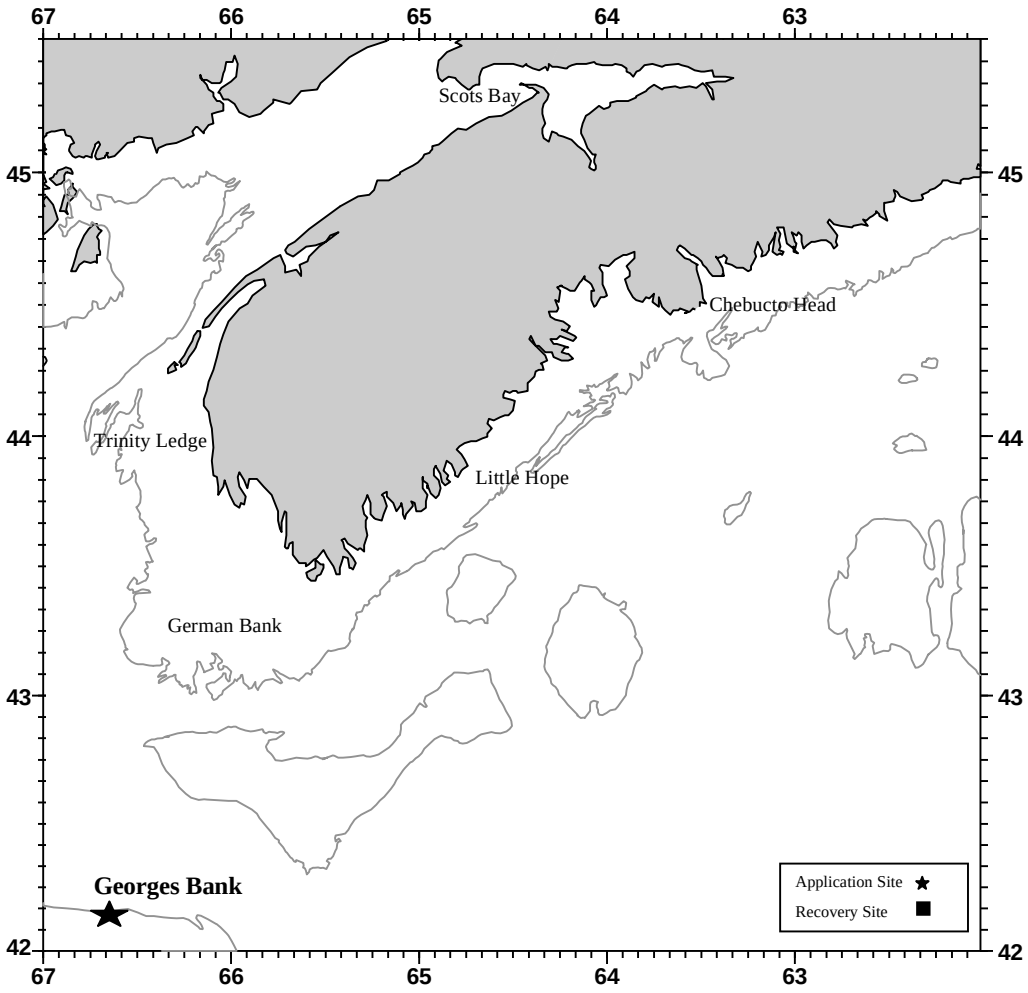

Figure A1. Tag application (n=800) and recovery (n=0) sites from Georges Bank tagging on October 15, 1992.

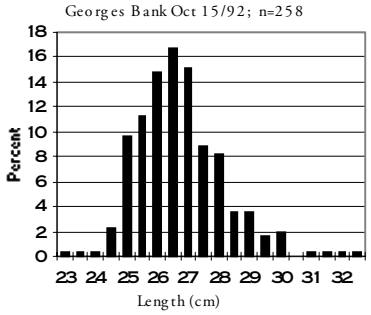

Figure A2. Length data from Georges Bank tagging on October 15/92; Maturity information is unavailable.

APPENDIX I

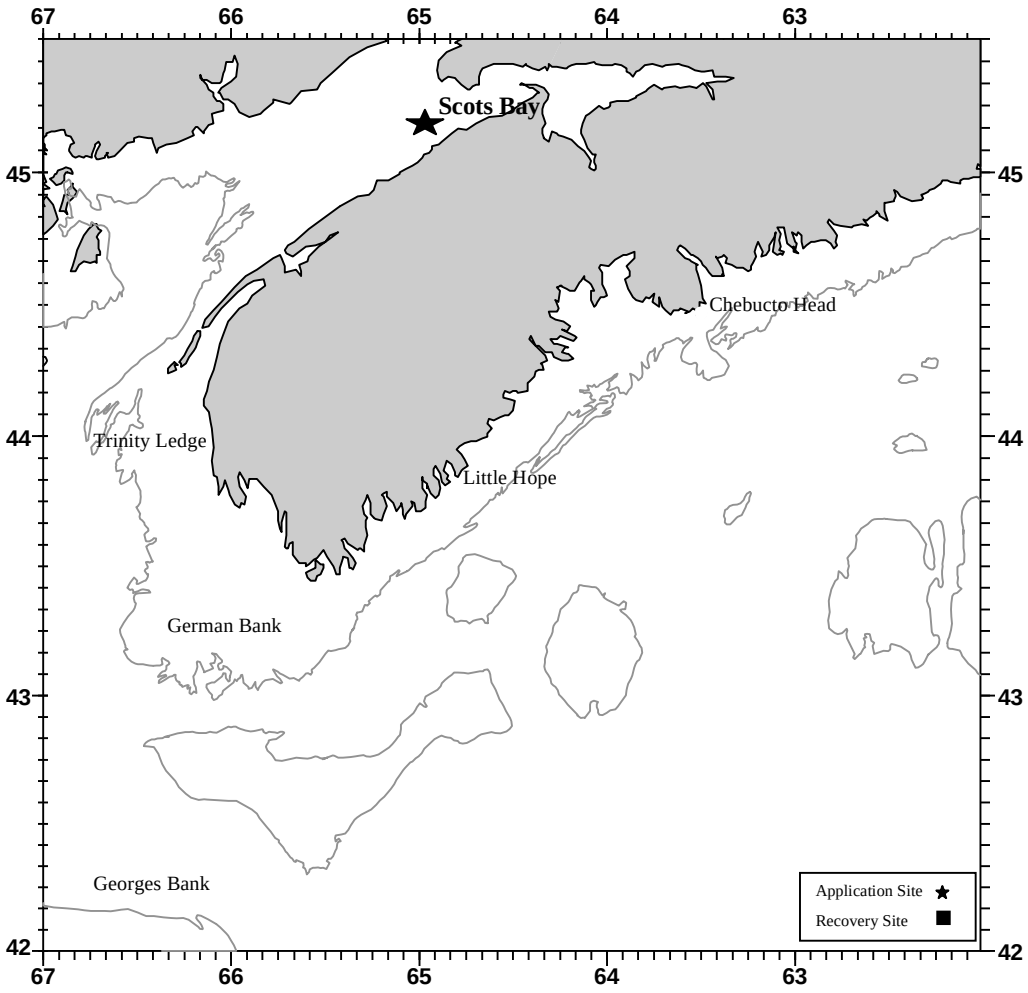

Figure A3. Tag application (n=260) and recovery (n=0) sites from Scots Bay tagging on August 9, 1995.

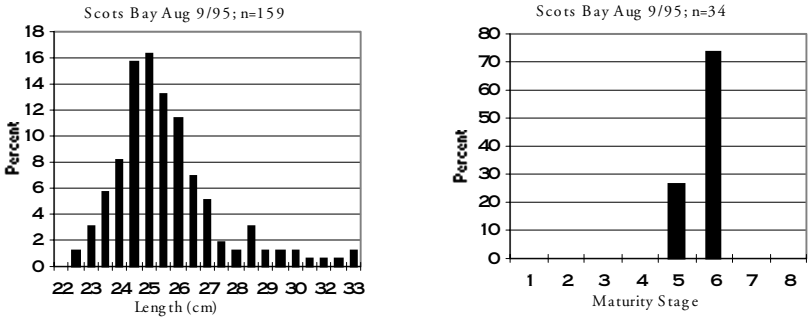

Figure A4. Length and maturity data from Scots Bay tagging on Aug 9/95.

APPENDIX I

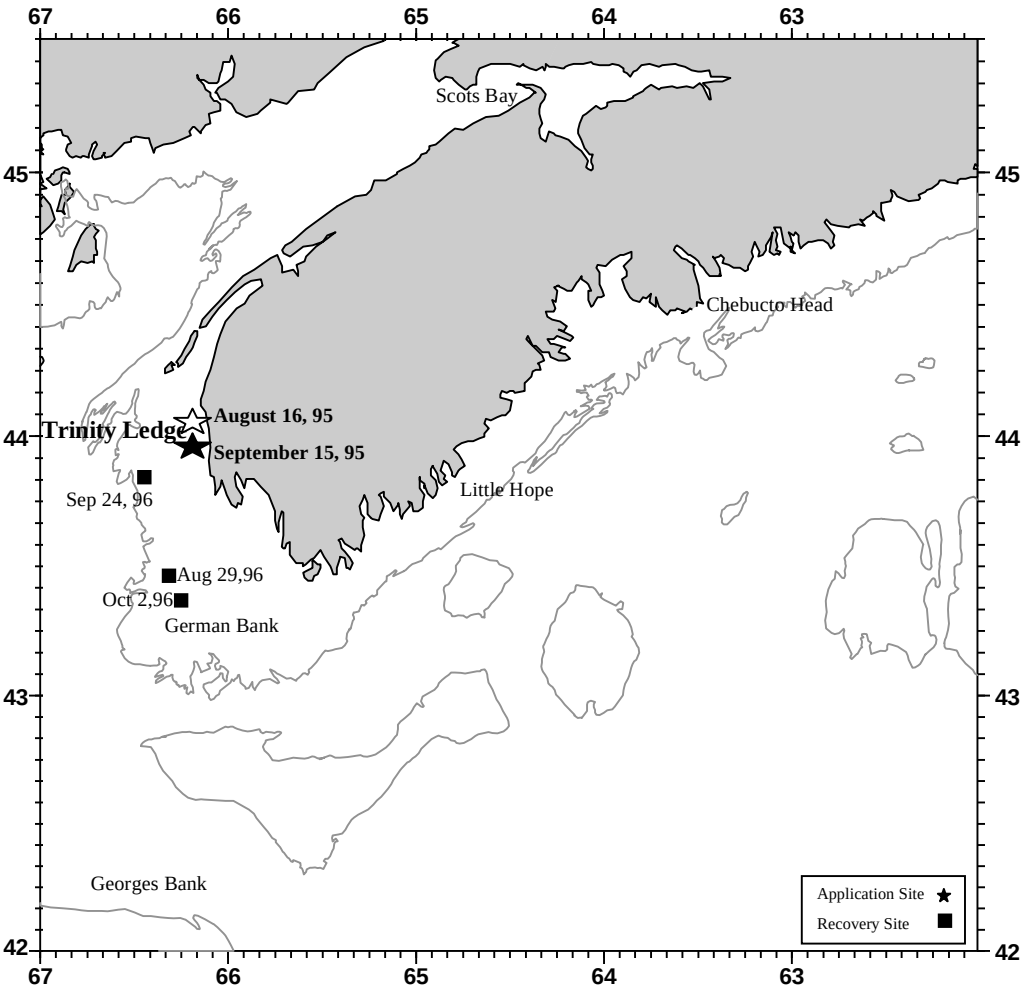

Figure A5. Tag application (n=581) and recovery (n=3) sites from Trinity Ledge tagging on August 16 (☆) & September 15 (★), 1995.

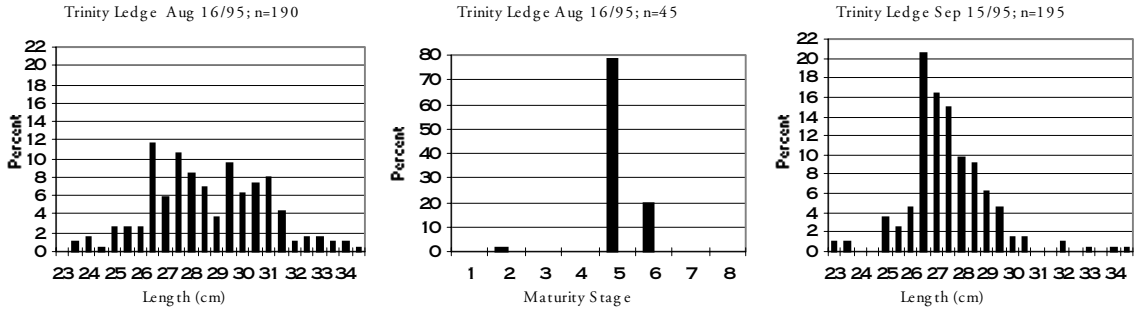

Figure A6. Length and maturity data from Trinity Ledge tagging August and September, 1995. Maturity information is unavailable from September 15/95.

APPENDIX I

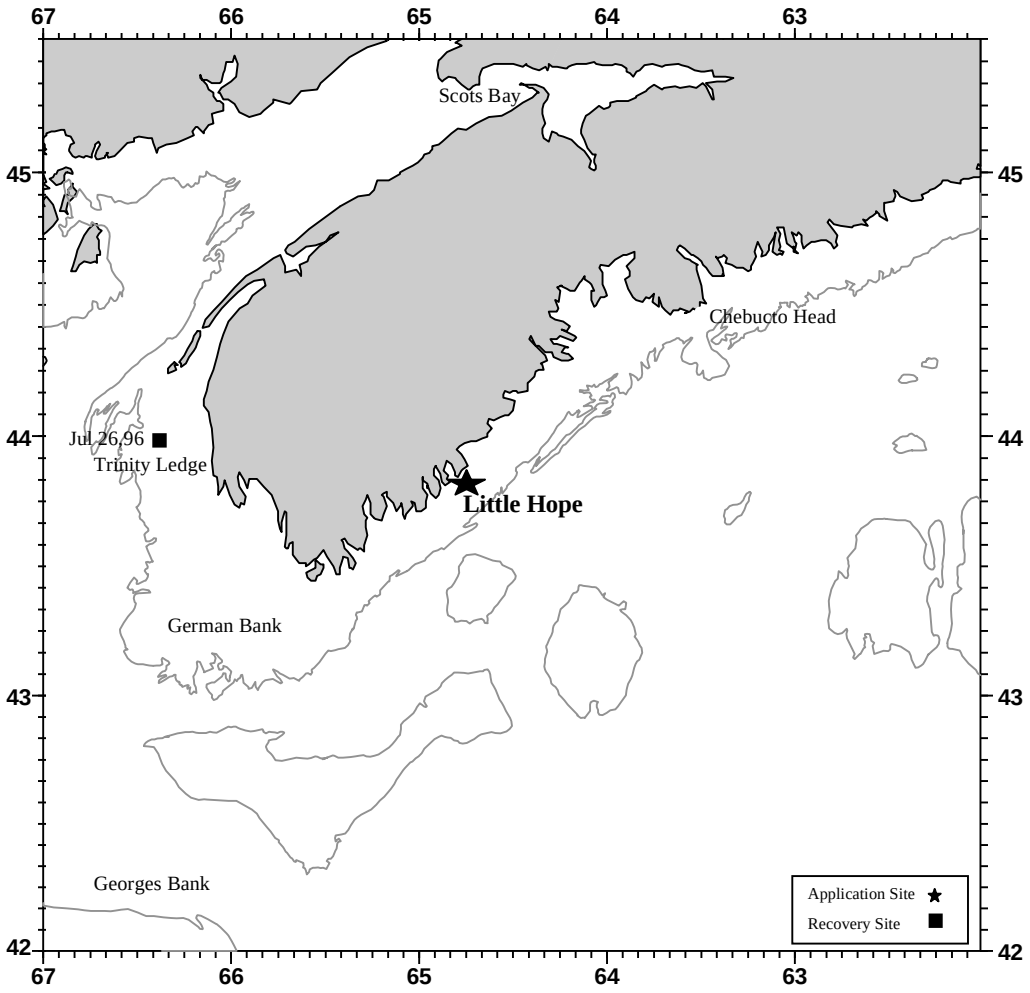

Figure A7. Tag application (n=525) and recovery (n=1) sites from Little Hope tagging on October 3, 1995.

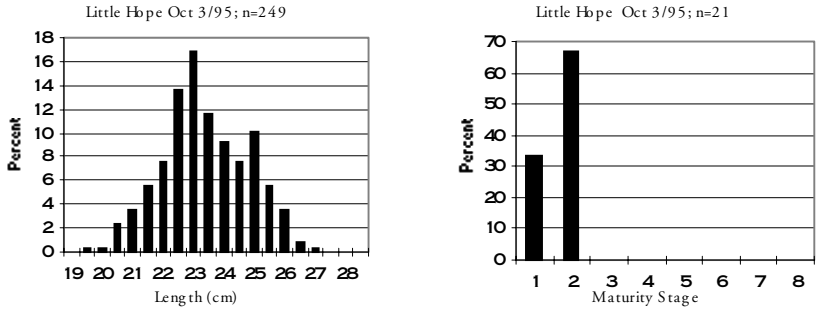

Figure A8. Length and maturity data from Little Hope tagging, Oct 3/95.

APPENDIX I

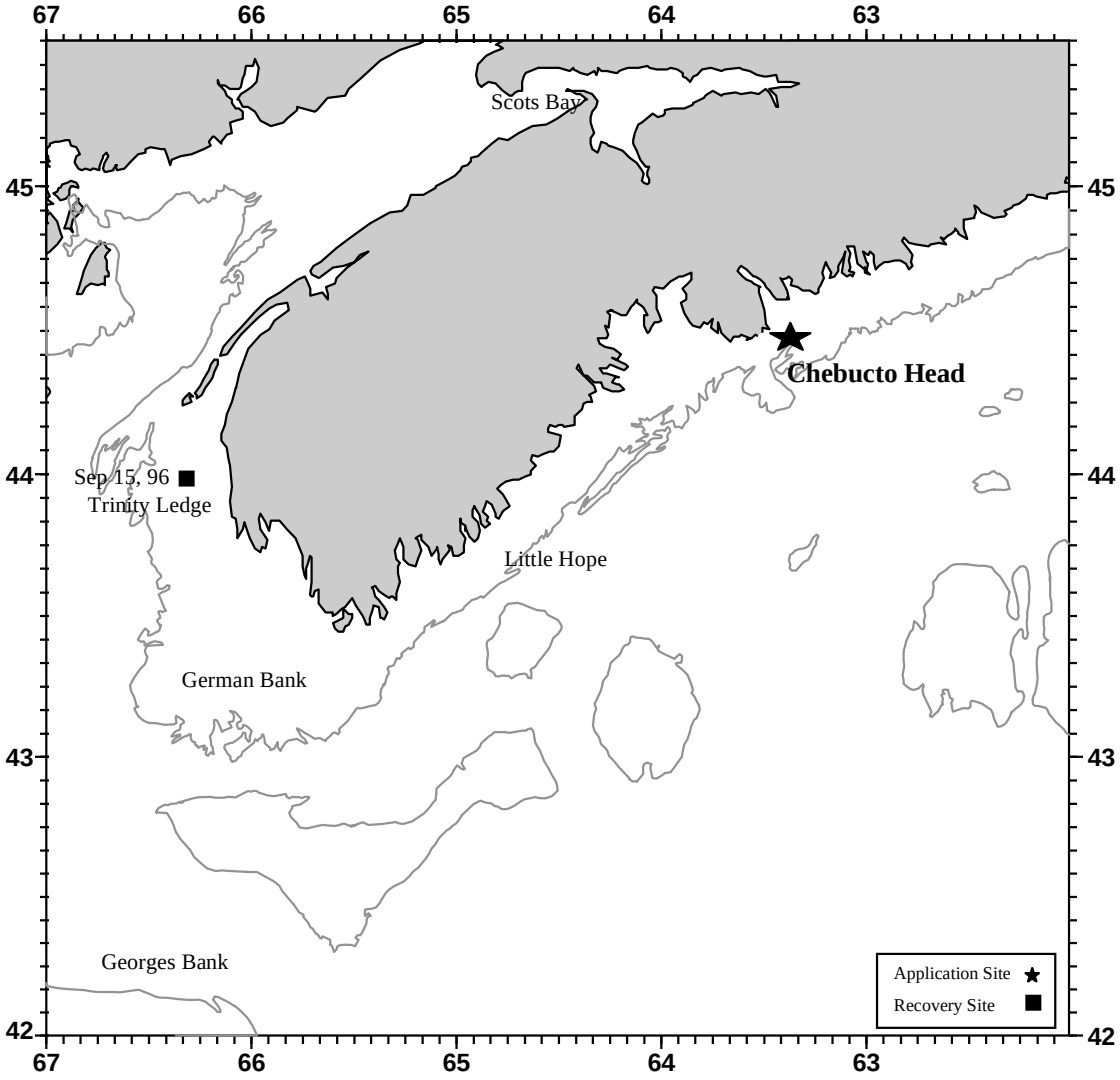

Figure A9. Tag application (n=2,040) and recovery (n=1) sites from Chebucto Head tagging on January 14-15, 1996.

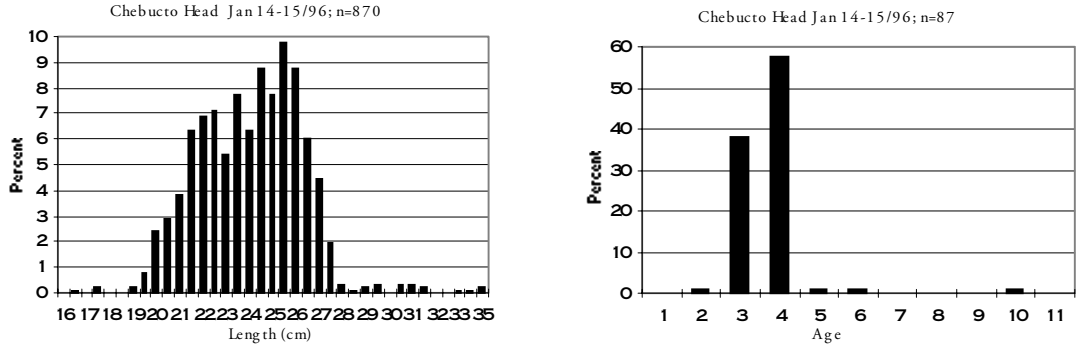

Figure A10. Length and age data from Chebucto Head tagging, Jan 14-15/96.

APPENDIX II

Table A11. Maturity staging for herring as applied by the St. Andrews Biological Station investigation.

Stage	Males	Females
1	Virgin herring. Testes very small, threadlike, whitish or grey-brown.	Virgin herring. Ovaries very small 1-3mm broad, wine-red or pinkish color.
2	Virgin herring with small sexual organs. Width of testes about 3-8 mm. Wedge shaped with a knife edge in cross section and reddish grey in color.	Virgin herring with small sexual organs. Width of ovaries about 3-8mm, eggs not visible to naked eye but can be seen with magnifying glass, oval in cross-section, wine-red or pinkish.
3	Testes about half the length of body cavity. Width of testes between 1-2 cm, reddish grey or greyish color, double lobe at distal end.	Ovaries about half the length of body cavity. Width between 1-2 cm, distal end is torpedo shaped, eggs small but can be distinguished with naked eye, overall color is orange.
4	Testes almost as long as body cavity and whitish in color.	Ovaries almost as long as body cavity. Eggs larger, varying in size, eggs opaque. Overall color is orange or pale yellow.
5	Testes fill body cavity, testes milk white. Sperm does not flow but can be sometimes be extruded by firm pressure.	Ovaries fill body cavity. Yellowish in color. Eggs large, round; some transparent but do not flow with pressure.
6	Testes ripe, white color and sperm flows freely.	Ovaries ripe. Eggs transparent and flowing freely.
7	Spent herring. Testes baggy and bloodshot but may contain remains of whitish sperm.	Spent herring. Ovaries baggy and bloodshot, empty or containing only a few residual eggs.
8	Recovering spent. Testes firm and larger than virgin herring at stage 2. Walls of testes striated, blood vessels prominent, testes dark wine-red in color. (This stage passes into Stage 3)	Recovering spent. Ovaries firm and larger than virgin herring at stage 2. Eggs not visible to naked eye. Walls of ovary striated, blood vessels prominent, dark wine-red in color. (This stage passes into Stage 3)
0	Unable to determine stage.	Unable to determine stage.

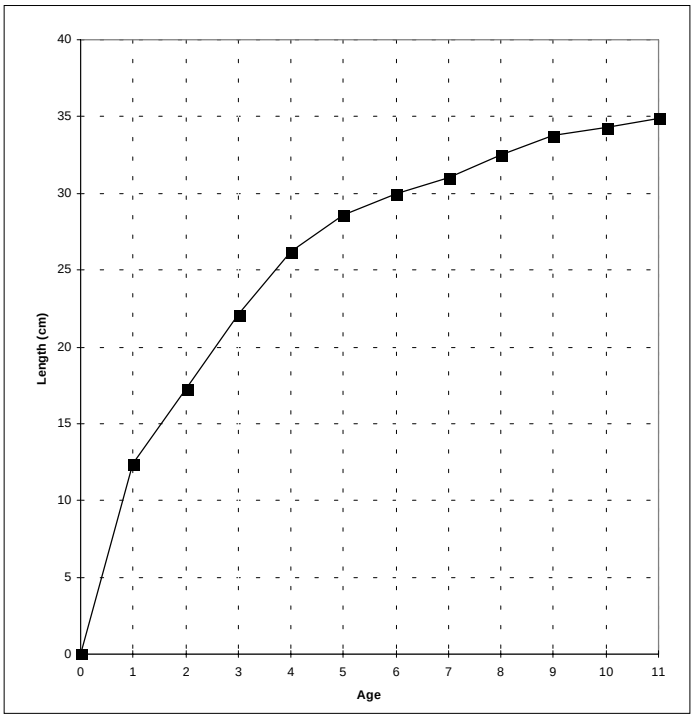

Figure A12. Growth of a herring - length in centimetres.