

Northwest Atlantic



Fisheries Organization

Serial No. N723

NAFO SCS Doc. 83/VI/18

SCIENTIFIC COUNCIL MEETING - JUNE 1983

Report of the Ad hoc Working Group on Herring Tagging

by

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**Report of the 'ad hoc' Working Group on Herring Tagging**

At the request of NAFO, an 'ad hoc' Working Group was set up to discuss the results of herring tagging experiments in NAFO areas 4, 5, and 6. The meeting was held in Quebec City, Quebec, Canada, on 12-14 January, 1982. Attendees, and their affiliations are given in Appendix 5.

Preamble

It was noted, by the convener, that almost all the data being presented were unpublished and, in some cases, preliminary in nature. It was agreed, and emphasized that it was the responsibility of each laboratory to conduct a full analysis of, and publish, their tagging experiments results. It was generally agreed that the available data did provide a reasonably reliable picture of herring movement in NAFO areas 4, 5, and 6, as well as insight into aspects of "homing" behavior in herring. It was further suggested, and agreed in principle, that attempts for simultaneous publication by the laboratories involved would be advantageous.

History of Tagging in NAFO Areas 4, 5, and 6

Tagging herring in the NAFO area was first successfully attempted in 1970 in the Gulf of St. Lawrence (NAFO Div. 4T) using internal magnetic tags. Attempts to elucidate herring movements and stock relationships on the Scotian Shelf-Georges Bank-Gulf of Maine areas first began in November, 1973, using a T-bar anchor tag.

The 1973 work, and several additional experiments in 1974, was concentrated on the herring populations in the Bay of Fundy being exploited by Canadian purse seine and fixed gear fisheries. The potential value of tagging work in elucidating herring movements and assisting in the

definition of management areas by demonstrating stock relationships was quickly demonstrated by the recovery information obtained from these studies. In 1975, based on the tagging information, the Assessments Subcommittee of ICNAF (International Commission for the Northwest Atlantic Fisheries) recommended, and the Commission accepted, that the herring management structure in NAFO Subarea 4 be changed. As a result of this recommendation, two management units were altered substantially: the existing management area of Division 4VW was split so that Division 4V would be managed as a discrete area and the Subdivision 4W was combined with the existing management area 4XW to form a new management area, Division 4WX.

In 1976, largely due to the proven feasibility of tagging herring from the 1973-74 experiments, ICNAF set up an 'ad hoc' Working Group on International Herring Tagging. The purpose of this group was to develop an International tagging program to elucidate stock relationships in Subareas 4, 5, and 6. The primary objective was to describe the seasonal migration and inter-mixture of adult and juvenile stages of the herring stocks. Specific objectives were defined as:

1. define the feeding, spawning, and overwintering areas;
2. define recruitment migrations from juvenile fisheries;
3. define quantitatively the proportion of inter-mixing of stocks present in feeding and overwintering areas; and
4. provide estimates of mortality rates.

The efforts of the ICNAF Working Group resulted in the development of several International and National tagging programs such that during the period 1973-81, in excess of 500,000 herring have been tagged in NAFO Subareas 4, 5, and 6 (Appendix 1). With the demise of ICNAF, there was no established forum to further co-ordinate herring tagging projects and jointly analyse results. In 1981, NAFO constituted the current Working Group to review the results and assess the success of the tagging studies.

In discussion, the Working Group felt that the specific objectives one and two were attainable and that the current information provided much of what was required to address these issues. Due to the stock collapse on Georges Bank however, an important omission will be information on the movements of the Georges Bank populations and their contribution to other adult and juvenile fisheries. It was felt that obtaining quantitative

estimates on intermixing proportions would be difficult with the present data. This is largely due to the fact that it will be difficult to standardize the catch rates of the various gears and fisheries. Yet standardization is an important consideration in trying to determine the relative significance of total tag recoveries from two or more disparate geographical areas and fisheries in terms of proportional contributions to areas of stock intermixing. Finally it was felt that it would be almost impossible to get mortality rates estimates from the current data since: 1) a very small proportion of the estimated population numbers in the NAFO area has been tagged (i.e. 500,000 tagged versus population estimates of several billions); 2) they are not closed populations and hence immigration and emigration would confound the results; and 3) the exploitation rates of the various fisheries are different and difficult to standardize, again factors which would confound mortality estimates.

The Working Group noted that there is a major basic assumption in the interpretation of tagging studies results which must be acknowledged. Information on the movement of tagged fish largely comes from tags recovered in the commercial fisheries, and the commercial fisheries are seasonal in nature. Thus it must be assumed, that exploitation of Northwest Atlantic herring has developed to the extent that all major seasonal herring concentrations are being exploited by a fishery (except in northern areas such as the Gulf of St. Lawrence where ice formation may preclude winter fisheries). The corollary to this assumption is that if there is no fishery in a particular area and season, it is because there are no fish there to be exploited. A short description of the nature and seasonality of the herring fisheries in NAFO areas 4-6 is given in Appendix 4.

#### Logistics of Tagging Studies

Although a number of different tags have been used for tagging herring, the external anchor tag is now almost exclusively used in the Northwest Atlantic. A major reason for the popularity of this tag is the fact that it is applied by means of a tagging gun and thus large numbers of herring can be marked in relatively short periods of time. The tagging method, the potential effect of the tag on the fish, and the techniques used to capture live fish are discussed by Stobo, 1976 (ICNAF Res. Doc. 76/101, serial no. 3924). It is important to note that herring descale

easily, and thus any capture technique which results in severe crowding, will result in substantial loss of scales and an attendant increase in tagging mortality.

#### Discussion of Recovery Results

Tagging experiments were conducted on various stages of the life history and seasonal phase (Figure 1). The Working Group decided that some categorization was necessary in order to associate biological meaning to the observed recovery information. Each tagging experiment was therefore assigned to one of the following categories, and the observed movements interpreted accordingly. The categories were:

- i) Overwintering
- ii) Spring Migration
- iii) Summer Feeding
- iv) Spawning
- v) Fall Migration

It was agreed that only category (iv) fish could provide information on stock discreteness. It was further emphasized that to attain reliable information on the movement of a particular stock (i.e. stock identification) 90-95% of the fish must be at sexual maturity stage 6 (ripe and running). The results of tagging experiments have shown that if the proportion of sexually non-mature fish is higher than 5-10%, the concentration may be a mixture of more than one stock, and the admixture of stocks will persist until commencement of spawning. The remaining 4 categories provide insight into the movements and mixtures of herring concentrations during other phases of their life history.

Again, in order to facilitate the analysis, NAFO areas 4-6 were subdivided into 15 geographic regions (Appendices 2 and 3) and release and recovery information summarized into these geographic units.

The basic release and recovery information from all tagging experiments conducted in NAFO areas 4-6 between 1973 and 1981 are given in Tables 1 and 2. In Table 1, the information is summarized to provide the number of separate tagging experiments (release sites) in each geographic region for each of the 5 seasonal phases of the herring annual cycle, the total number of fish tagged in each region and the tags recovered. The recovery rate (longer term recoveries) varies from 0 to 5.05% (summer

feeding; Regions 7-10), and emphasizes the low recovery rate which one must accept in herring tagging experiments. Consideration of the total recoveries in calculating recovery rate is inappropriate since many of the recovered tags included in that value were from fish caught shortly after release. In Table 2, the information is further partitioned to show the results also by life history stage. The recovery rates vary from 0 to 5.42% (juveniles; summer feeding; Regions 7, 10) but the experiment on adult fish (summer feeding; Regions 5-6) resulted in a rather similar recovery rate (4.94%). Experiments on spawning fish consistently yielded recovery rates less than 2%; it may be that the tagging stress experienced by the fish, added to the stress on the fish as a result of spawning, substantially increases mortality. Recovery results from many experiments on non-spawning fish however, yield equally low recovery rates. Thus any conclusions, pertaining to a greater mortality associated with experiments on any particular seasonal phase or life history stage from these experiments, are merely speculative.

#### Overwintering

There were 4 regions in which tagging experiments were conducted on overwintering fish: areas 5, 10, 13, and 14 (Figure 1). It was noted that there are 3 additional regions in which overwintering herring concentrations are known to exist: Long Island and Rhode Island (area 1), Massachusetts Bay (area 3), and the New Brunswick side of the Bay of Fundy (area 9). The last area poses special difficulties because the size of overwintering herring in this area are quite small (10-15 cm total length). The recovery information is presented in Figures 2, 3, and 4.

The movement of juveniles (Figure 2) appears to be restricted. In both tagging areas, the majority of recoveries were made in the region of release in the same or subsequent years. The region 10 fish exhibited considerable movement throughout the Bay of Fundy and around southwest Nova Scotia with some tendency to expand their distribution during the summer period (April-Sept.) and contract their distribution during winter (Oct.-March). The experiment conducted in region 5 was small and very limited movement occurred. More overwintering tagging experiments in western Maine might improve the information from that area although a better strategy might be to tag further to the southwest. It should be noted that most of the Maine tagged fish, and some of the region 10 fish, were quite small (total length approximately 12 cm).

The region 13 experiments were conducted on a mixture of adults and juveniles and the results (Figure 3) indicate a much wider dispersion. The majority of fish appear to move into the southwest Nova Scotia - Bay of Fundy area (regions 9-11) in summer and return to the Chedabucto Bay area (region 13) in winter. There appears to be a limited movement of fish from the Chedabucto Bay area into the Gulf of Maine and Gulf of St. Lawrence. It appears that the Chedabucto Bay area is the overwintering area for many fish residing off southwest Nova Scotia in summer, and possibly is the overwintering area for the southwest Nova Scotia spawning stock. If so, then there must be some "leakage" into adjacent areas.

The Sydney Bight (region 14) tagging experiments were conducted on adult fish and the results again show a wide dispersion (Figure 4). The summer distribution, although concentrated in regions 14 and 15, appears to extend into the Bay of Fundy. In winter the distribution is concentrated in the northern regions (13, 14, 15). No recoveries were made from these experiments in the Gulf of Maine. A more detailed examination of the data suggests that region 14 is a transition area with the majority of herring in the northern part of the region moving into the Gulf in summer, while the majority of those in the southern part move to eastern and southern Nova Scotia and the Bay of Fundy.

The data from the overwintering experiments in regions 1 and 10 are not discussed since no recoveries were made from the region 1 experiment and all the recoveries from the region 10 experiment were made in regions 10 and 11.

#### Spring Migration

There were 5 regions in which tagging experiments were conducted during spring migration: areas 2, 3, 4, 11, and 12 (Figure 1). The results of experiments in regions 3 and 4 were combined due to the similarities in movements.

The region 2 experiments were conducted on adults in the Great South Channel area. The results from these experiments (Figure 5) suggest that the fish are concentrated in the southern regions in the January-March period then move eastward, distributing themselves primarily along the western Maine coast, but extending the movement to the entrance to the Bay of Fundy during the remainder of the year.

The results of the regions 3 and 4 experiments, also conducted on

adults, exhibit a similar pattern of movement (Figure 6) as those of region 2 except that they appear to commence the spring migration earlier and move farther east, as far as region 13. As a result, it appears that larger proportion of these fish, than those from region 2, are found at the entrance to the Bay of Fundy in the summer and autumn.

The experiments conducted on spring migrants in regions 11 and 12 are presented separately because the region 11 experiments were conducted on juveniles while the region 12 experiment was on a mixed group. The results (Figure 7) suggest that during the summer and fall the mixed group is located off southwest Nova Scotia, while in winter it moves eastward to areas 13 and 15; there were however, a limited number of returns from this experiment. The juveniles (Figure 8) exhibit a similar pattern, except that the winter movement eastward is much less pronounced.

The data from all the spring migration tagging studies suggest that the entrance to the Bay of Fundy is an area of summer convergence for at least a portion of the herring populations in the Gulf of Maine and southern Nova Scotia area.

#### Summer Feeding

There were 6 regions in which tagging experiments were conducted during the summer period: areas 5, 6, 7, 10, 11, and 13 (Figure 1). Also, since this is the time when herring are the most accessible, experiments were extensive and conducted on juveniles, adults, and mixed groups of fish.

Juveniles, adults, and mixed groups of fish tagged in regions 5 and 6 during the summer feeding period appear to undergo similar subsequent movements (Figures 9, 10, 11). They appear to remain highly concentrated in regions 5 and 6 between April and December, with some tendency to move eastward towards the entrance of the Bay of Fundy in summer-fall and subsequently southwest for the January to March period.

Adults tagged in region 7 during the summer feeding period appear to disperse rather widely in regions 5 to 11 between April and December, although few were recovered in the upper reaches of the Bay of Fundy (Figure 21). During this period, they remain concentrated in the area of release but also concentrate in region 10. During the January to March period, they appear predominately in the southern areas (regions 1-4) suggesting an overwintering movement to the southwest. Mixed groups of fish tagged in regions 7 and 10 during this period also distribute widely

in regions 5 to 11 between April and December but show a greater tendency to move into the upper reaches of the Bay of Fundy (Figure 13). The recoveries during the January to March period are few for this group and thus may be of limited interpretive value; but these recoveries suggest overwintering movement eastward to region 14 as well as southwest to region 4. Movement into regions 1-3 were not demonstrated by this group. Juveniles tagged in regions 7 and 10 during this period (Figure 14) exhibit similar movement to the mixed group except that they have also been recovered near both extremes of the distributional area (regions 1 and 14) in most seasons. There appears to be a tendency to concentrate around the entrance to the Bay of Fundy throughout the year, but primarily during the April to December period. During January to March there appears to be 3 concentrations: a large one at the entrance to the Bay of Fundy, another major group southwest and spread through regions 1, 3, and 4 and a smaller concentration in region 13. The overall results from the tagging experiments in regions 7 and 10 suggest that the entrance to the Bay of Fundy, especially regions 7 and 10, is a summer feeding area for a mixture of juveniles and adults which remain there for much of the summer-autumn period. The majority of adults tagged in these 2 areas appear to move southwest into the Cape Cod area to overwinter, while many of the juveniles stay in the Bay of Fundy over the winter while others move southwest towards Cape Cod, and a smaller number move northeast towards Cape Breton.

Mixed groups of herring tagged in region 11 during the summer feeding period (Figure 15) appear to remain primarily within, and around the entrance to the Bay of Fundy during the April to December period, although a small proportion disperses as far south as region 2 and as far north as region 15. In the latter part of the year, most of these fish appear to leave the Bay of Fundy area with the majority moving northeast towards Cape Breton and a smaller number moving to the Cape Cod area to overwinter.

Adults tagged in region 13 during the summer feeding period did not move farther south than region 10. During the summer period they appear to have remained concentrated in region 13, although some movement was exhibited towards southwest Nova Scotia. In the October to December period, a substantial proportion appear to have moved into the Bay of Fundy area, although many are still found in region 13. These observations suggest that a component of the herring found in region 13 in summer are



resident in the area while another component moves to the Bay of Fundy.

#### Spawning

There were 6 regions in which tagging experiments were conducted in the summer or autumn, on spawning groups of herring: areas 2, 3, 4, 7, 9, and 11 (Figure 1).

The spawning group tagged in the Cultivator's Shoals area (region 2) exhibited very limited movement based on only 14 recoveries from over 30,000 fish tagged (Figure 17). Few conclusions can be drawn from this experiment other than some of the fish moved into the western Gulf of Maine during the first half of the year.

Results from the Jeffrey's Ledge-Nantucket Shoals spawning groups tagging experiments (figure 18) also exhibit rather limited movement outside the area of tagging. There appears to be some tendency to move eastward towards the Bay of Fundy in the latter half of the year, but the movement must occur between July and September since they spawn in the Jeffrey's Ledge-Nantucket area in September-October. It is tenuous to suggest that they move southwest into regions 1 and 2 to overwinter from the limited number of recoveries.

The experiment on the Cutler-Grand Manan spawning group was a small experiment and resulted in less than 700 tags being applied (Figure 17). The results suggest that these fish primarily stay on the Maine/New Brunswick side at the entrance to the Bay of Fundy during the latter half of the year and there is some suggestion of movement southwest during the winter period. It is interesting to note that there were no recoveries made in the upper reaches of the Bay of Fundy, off southwest Nova Scotia, or farther east from these tagging experiments in the Gulf of Maine.

The tagging experiment in region 9 was on the summer spawning Scott's Bay population. No recoveries have been made during the first half of the year. These fish appear to disperse throughout the Bay of Fundy (Figure 19) and its approaches during the August-October period, but with a predominate distribution at the entrance to the Bay on the Nova Scotia side. They appear to leave the Bay of Fundy area by November, and there appears to be a tendency to move eastward after leaving the Bay of Fundy, there is no indication that they move into the Gulf of Maine.

Spawning fish tagged in region 11 appear to disperse more than any other group (Figure 20). During the April to December period they appear

to be heavily concentrated within the Bay of Fundy and off southwest Nova Scotia (regions 9, 10, and 11) although a few recoveries have been made as far southwest as Cape Cod and northeast as the Gulf of St. Lawrence during this period. During the January to March period there are few of these fish in the Bay of Fundy area; the majority appear to have moved northeast to overwinter in region 13 with a much smaller component overwintering in the western Gulf of Maine.

#### Fall Migration

There were 4 regions in which tagging experiments were conducted during the fall migration period: areas 4, 5, 6, and 7 (Figure 1). Adults, juveniles, and mixed groups were tagged during these periods. Since the resultant recoveries exhibit highly similar patterns, the results of all fall migration experiments have been combined in Figure 21. Herring tagged during fall migration in regions 4-7 appear to concentrate in the western portion of the Gulf of Maine (mainly region 4) during the January to March period. During the April to June period there is a movement northwest which extends to the entrance of the Bay of Fundy, but the majority of fish appear to still be in the western Gulf of Maine area. The movement toward the Bay of Fundy continues in the July to September period, but the major concentrations remain in the Gulf of Maine and during the October to December period the movement is southwest again.

#### Summary of Movements

##### Juveniles

Herring tagged as juveniles all exhibit a tendency to remain concentrated in the area of tagging probably due to their size. Results from such experiments in regions 5, 6, and 7 during all seasons further exhibits a net movement eastward towards the entrance to the Bay of Fundy in the April-September period followed by a westward movement towards Cape Cod during the October-March period. They appear to have moved no farther eastward than southwest Nova Scotia and very few recaptures are made in the upper reaches of the Bay of Fundy. Their movement southwest is more pronounced with a substantial number of recoveries being made south of Cape Cod. Results from experiments in region 10 during all seasons exhibit a greater dispersal with recoveries south of Cape Cod and eastern Nova Scotia (regions 13 and 14). During the whole year these fish remain heavily concentrated in the area of release on the New Brunswick side of

the Bay of Fundy. During the April-September period they are distributed extensively within, and around, the entrance to the Bay of Fundy as well as exhibiting movement into the central Maine coastal area (regions 5-6). During the October-March period, although the majority of these fish remain on the New Brunswick side of the Bay of Fundy, a substantial component moves to the western Gulf of Maine and Cape Cod to overwinter while another smaller, but still significant, component moves eastward to overwinter in the Chedabucto Bay area (region 13). Results from experiments in regions 11 and 12 exhibit a directed movement to the Bay of Fundy area during the April-September period. This westward movement by this group demonstrates further that the Bay of Fundy is a summer gathering place for juvenile herring found both east and west of it during other times of their annual migratory cycle.

#### Adults

Herring tagged as adults exhibit more directed movement as a group than do the juveniles. Adults tagged in the Cape Cod area and Gulf of Maine exhibit a strong movement eastward resulting in a distribution during the April to September period between the region of the central Gulf of Maine and southwest Nova Scotia. The greatest concentration appears to be in central and western Maine (regions 6-7) but with substantial concentrations also at the entrance to the Bay of Fundy (regions 10-11); relatively few recoveries were made from the upper reaches of the Bay of Fundy. This eastward movement appears to concentrate the adults in eastern Maine and the New Brunswick side of the Bay of Fundy (regions 7 and 10) in late summer, then a reverse movement commences, which results in a January-March concentration in the western Gulf of Maine, Cape Cod area, and farther south. Adults tagged in eastern Nova Scotia (regions 13-14) appear to undertake an opposing movement to Gulf of Maine fish, although even between these two eastern Nova Scotia regions they behave somewhat differently. Adults tagged near Chedabucto Bay (region 13) exhibit a distinct movement towards the Bay of Fundy during the April to September period such that in the late summer and early autumn, most of these herring appear to be off southwest Nova Scotia and in the upper reaches of the Bay of Fundy. Only one recovery was made on the New Brunswick side of the Bay of Fundy, thus suggesting very limited movement there from the Chedabucto Bay area. Subsequent movement appears to be eastward again towards eastern

Nova Scotia, although the number of recoveries on which to base this movement are limited. Adults from region 14 exhibit a somewhat dual movement to summer feeding areas. Although a directed movement is observed towards the Bay of Fundy during April to September, an even greater movement is observed into the Gulf of St. Lawrence (region 15). Again no recoveries were made in the Bay of Fundy area on the New Brunswick side, nor any farther west. In the October-March period a reverse movement occurs from the Bay of Fundy and Gulf of St. Lawrence, resulting in fish being concentrated in the eastern Nova Scotia regions over the winter.

#### Mixed Groups

The results from tagging experiments on mixed groups of fish are comparable to those observed for juveniles and adults when combined. Mixed groups tagged in western Gulf of Maine exhibit a tendency to move eastward towards the Bay of Fundy in the summer and westward towards the Cape Cod area in winter; they appear to reach the most westerly point of their migrations in the January to March period, and their most easterly point in the August-October period. Mixed groups tagged in eastern Gulf of Maine and in New Brunswick near the entrance to the Bay of Fundy exhibit somewhat similar movement. The movement is modified however in that more move into the upper reaches of the Bay of Fundy and a significant proportion more overwinter off eastern Nova Scotia. Mixed groups tagged off southwest Nova Scotia are concentrated in, and around, the Bay of Fundy area during summer, and although a proportion moves westward to overwinter, a considerably greater proportion moves eastward. Results from tagging experiments on mixed groups in eastern Nova Scotia indicate similar movements to the adults with a dominant summer movement towards the Bay of Fundy, but also significant movement into the Gulf of St. Lawrence. Relatively few recoveries were made in the Gulf of Maine. During winter these fish were concentrated in eastern Nova Scotia.

#### Persistence of Migratory Patterns

The results of the tagging experiments strongly suggest that there is a strong persistence in the annual migratory pattern exhibited by herring in NAFO Subareas 4 and 5 (it was agreed not to use the term "homing" due to the continuing debate on the biological meaning of that word).

In order to illustrate this persistence, the results of the tagging experiments on spawning fish off southwest Nova Scotia and on fish

overwintering in the Chedabucto Bay area are presented to indicate yearly recovery patterns in Figures 22-25. The recoveries made during the season of tagging are excluded. As can be seen from the distribution of summer recoveries from the southwest Nova Scotia experiments (Figure 22), the majority of recoveries in successive summers following release are in and around, the Bay of Fundy which is the feeding and pre-spawning area for the southwest Nova Scotia spawning group. In the first summer after release 95% of the recoveries were made in the Bay of Fundy environs and 77% were made in the area of release, off southwest Nova Scotia. In subsequent summers, between 83% and 100% of the recoveries were made in the Bay of Fundy environs with 44% to 100% being made in the area of release, off southwest Nova Scotia. The winter recoveries from these experiments (Figure 23) show a consistent pattern of movement year after year with the greatest proportion of recoveries (67-86%) being made in the Chedabucto Bay area. Considering the earlier tagging results showing that the Bay of Fundy in summer, and the Chedabucto Bay area in winter, are areas of mixing, the tendency for the tagged fish to return to the summer feeding area and also the overwintering area appears quite strong.

The recoveries of fish tagged off Chedabucto Bay during the winter fishery in 1977 and 1978 (Figures 24 and 25) again indicate a tendency for herring to maintain a consistent migration pattern from year to year. During the first and second winters after tagging, over 93% of the recoveries were made off eastern Nova Scotia, with over 58% being taken in the area of release. The summer distributions indicate a consistent major movement (over 85% of all recoveries) into the Bay of Fundy area during the two successive summers. There is only a very limited movement into the Gulf of Maine area. These data suggest that between 77-100% of the fish tagged off southwest Nova Scotia return there in successive summers and that between 67-86% of the fish overwinter in the Chedabucto Bay area. The results from the tagging studies off Chedabucto Bay suggest that between 85-90% of these fish use the Bay of Fundy area as a feeding and spawning area. These results suggest that herring do maintain a consistent migratory pattern.

### Conclusions

1. For the major spawning groups for which there are significant returns (Jeffrey's Ledge and southwest Nova Scotia) straying does not seem to be a major feature of the behaviour of herring.
2. "Homing" is apparently a major feature associated with southwest Nova Scotia, and possibly the Jeffrey's Ledge complex also.
3. Herring tagged in the area of Cape Cod and western Gulf of Maine appear to distribute themselves along the Maine coast and at the entrance to the Bay of Fundy (mainly on the New Brunswick side) during summer and autumn and overwinter in the western portion of Subarea 5. The further east the tagging experiment is conducted during any particular phase of the annual cycle (e.g. feeding concentration in region 6 versus 3), the further east that group reaches during the summer-autumn movement.
4. The Bay of Fundy and entrance areas appear to support concentrations of herring in summer from the Gulf of Maine and southern and eastern Nova Scotia.
5. Herring tagged between Chedabucto Bay and the Bay of Fundy move westward to the Bay of Fundy (distribution mainly on the Nova Scotia side) in summer and overwinter off eastern Nova Scotia.
6. Herring tagged in the Sydney Bight area of eastern Nova Scotia appear to undertake a major summer movement into the Gulf of St. Lawrence and a somewhat lesser one towards the Bay of Fundy. These diverging summer movements suggest that the Sydney Bight area is an overwintering area for Gulf of St. Lawrence and Nova Scotia populations.
7. The summer concentrations of juveniles along the coast of eastern Maine and southwestern New Brunswick are a mixture of Gulf of Maine and Nova Scotia populations.
8. The group acknowledged that the results of the various tagging experiments pertain primarily to the stock relationships with the exclusion of the Georges Bank stock (due to its collapse). The extent of intermixing of that stock with the more coastal populations cannot be assessed at this time.

### Recommendations

1. Additional analysis of short-term movements particularly for tagging experiments on summer feeding groups which may provide further

insights into the population relationship during periods of high mixing and non-directed movement.

2. Due to the mixing inherent in summer distributions, dispersion of tagged fish could be expected to indicate chaotic dispersion and thus such tagging experiments should be interpreted cautiously.
  3. Summer distributions frequently have an admixture of many size groups. Since migratory patterns may be size associated, recovery information from experiments on mixed groups may be difficult to interpret. Thus tagging experiments, if conducted on such groups, should be organized to tagging only the adults or juveniles (i.e. cull out the undesired size groups).
  4. The group agreed that future tagging experiments should be prioritized. The phases in the annual cycle were as follows: 1) spawning groups (ripe and running); 2) overwintering; 3) fall migration; 4) spring migration; and 5) summer feeding. The conclusions drawn by the group was that the highest priority should be given to tagging spawning fish (with care being exercised to ensure that almost all these fish were at stage 6 of the maturity cycle). Tagging spawning fish is essential for stock discrimination studies since these are the only tagging experiments from which recovery information can be interpreted as showing stock movement. At other times in the annual cycle, stock components are, to varying degrees, intermixed, hence the results of such experiments describe herring movements but not necessarily discrete stock movements. Tagging summer feeding distributions was accorded the lowest priority because the stocks appear to be most highly mixed during this phase of the annual cycle, in addition to the fact that these groups of fish remain in the region of tagging for the remainder of the summer; hence the majority of tags from these experiments are recovered in the area of tagging during the same season (i.e. substantial cost in terms of reward payments for limited information on stock movement). The life history categories were prioritized as follows: 1) adults; 2) juveniles; and 3) mixed groups (with culling for large versus small fish). Tagging adults was emphasized for stock differentiation since juveniles do not generally migrate as far and the size of these tagged groups will incur greater decreases due to natural mortality before they will be observed on the spawning grounds.
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5. The group further agreed that future experiments should be directed at the following areas, times, etc., in order to augment current results.

<u>Category</u>	<u>In Order of Priority</u>
spawning	2*, 4, 7, 10
overwintering	1, 3, 4
fall migration	none
spring migration	1, 2, 3, 4
summer feeding	4, 2*

\*when, and if, the Georges Bank stock recovers.

6. It was acknowledged that some consideration had to be given to the fishing effort associated with the recoveries obtained from the various geographic areas. Although appropriate weighting of the significance of tags between areas would be difficult due to a lack of fisheries information, it was suggested that future analyses should attempt such considerations.
7. It was also suggested that the migratory patterns exhibited by herring in Subareas 4 and 5 may be influenced by hydrographic conditions; review of pertinent oceanographic data could provide insights into underlying mechanisms influencing these movements.



Table 1. Release and recovery information for herring tagging operations during the period 1973-81. The data are grouped geographically (see Figure 1) by designated seasonal phase.

Seasonal Phase/ Region <sup>1</sup>	No. release sites	Total number tagged	Recoveries	
			Total	Longer Term <sup>2</sup>
<u>Overwintering</u>				
Region 1	1	32	0	0
5	1	1000	15	15
10	9	19846	477	287
13	25	31314	1024	396
14	29	18031	1219	748
<u>Spring Migration</u>				
Region 2	1	23179	262	262
3-4	1	10973	490	490
11-12	5	23955	108	92
<u>Summer Feeding</u>				
Region 5-6	36	79917	4618	2765
7-10	45	99830	7573	5038
11	20	59442	1479	633
13	2	7286	115	94
<u>Spawning</u>				
Region 2	2	30443	14	14
4	6	22673	305	302
7,10	1	692	25	21
9	6	3708	404	45
11	18	54266	1487	750
<u>Fall Migration</u>				
Region 4	1	1094	183	30
5-6	5	9818	650	299
7,10	2	8626	94	63

<sup>1</sup> Regions where no tagging was done during a particular phase are excluded. Regions are grouped in cases in which tagging operations apply to more than one area.

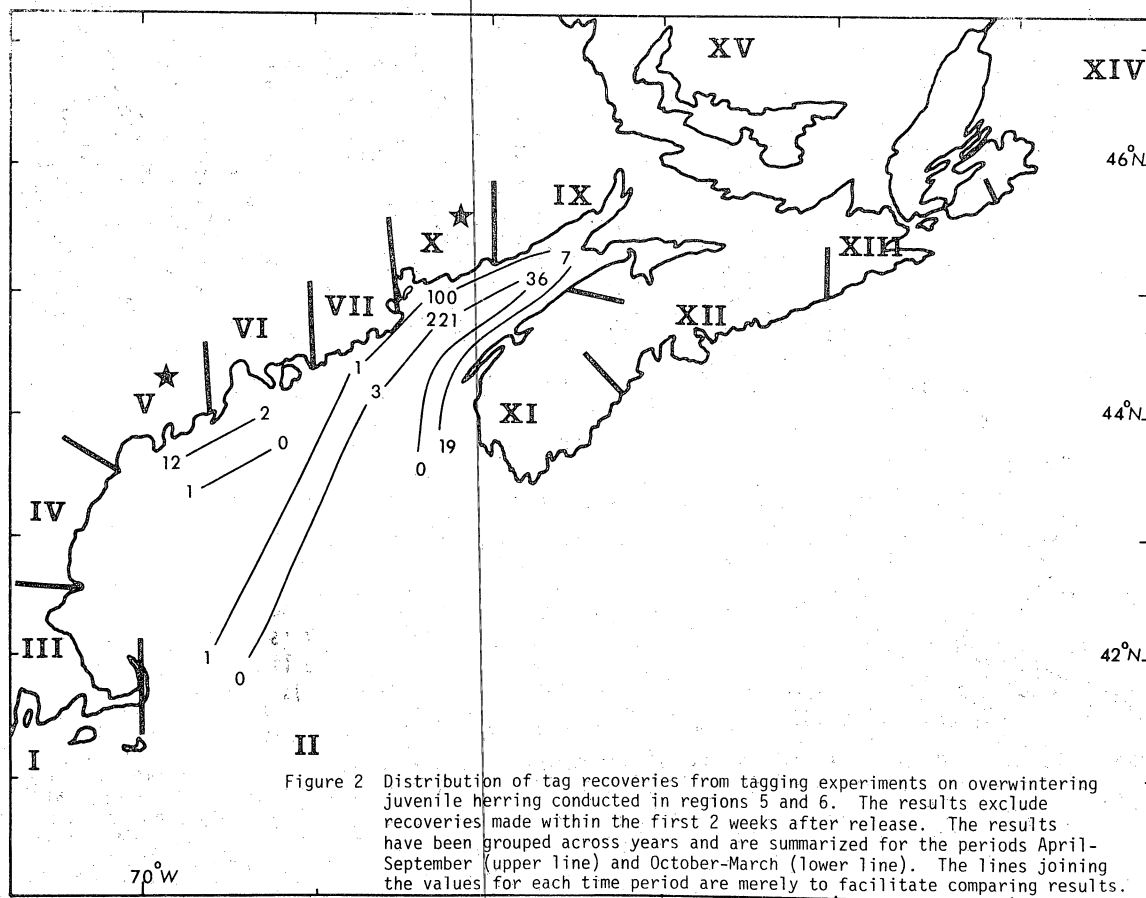
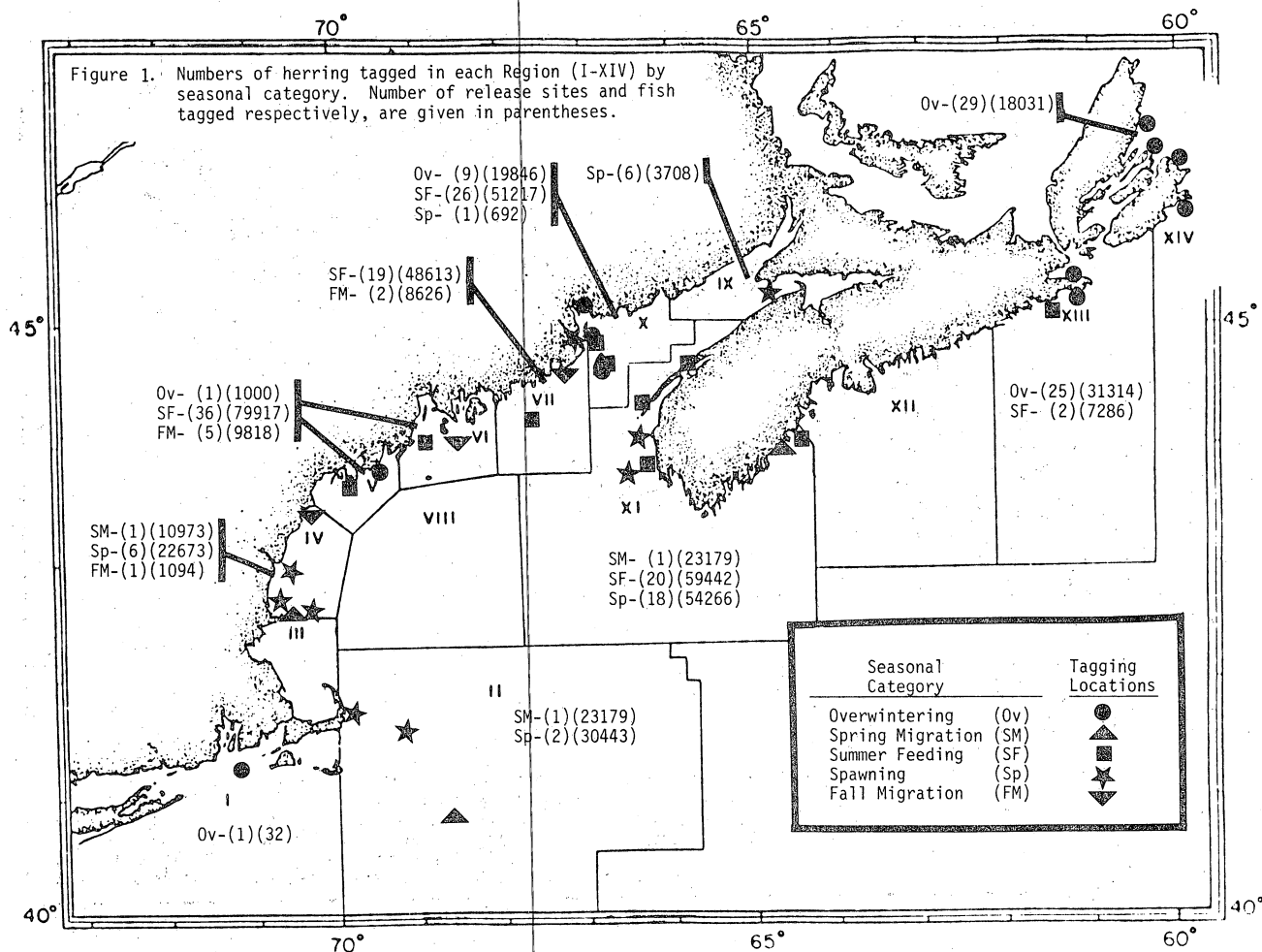
<sup>2</sup> In order to discriminate between immediate recoveries and those depicting movement or migration, all recoveries occurring within 2 weeks of tagging were excluded in the "Longer Term" tally.

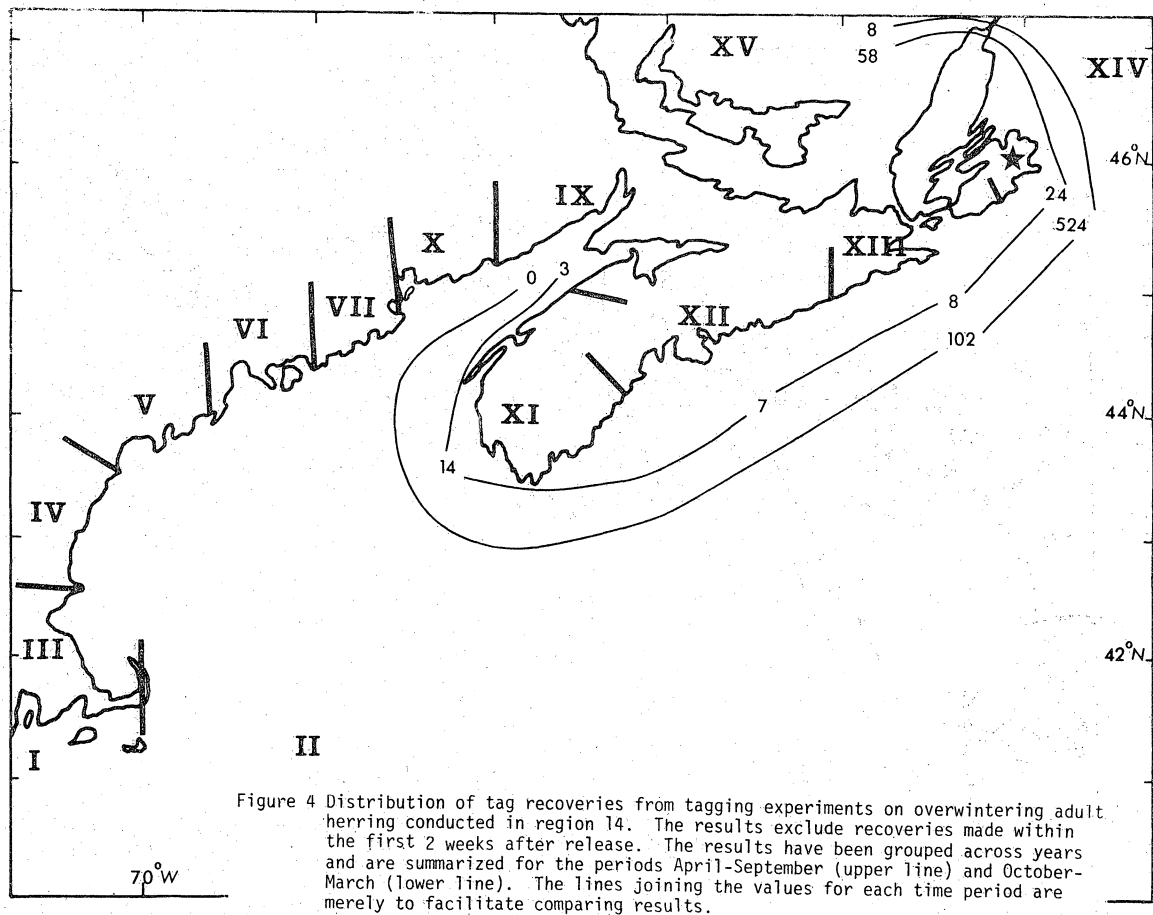
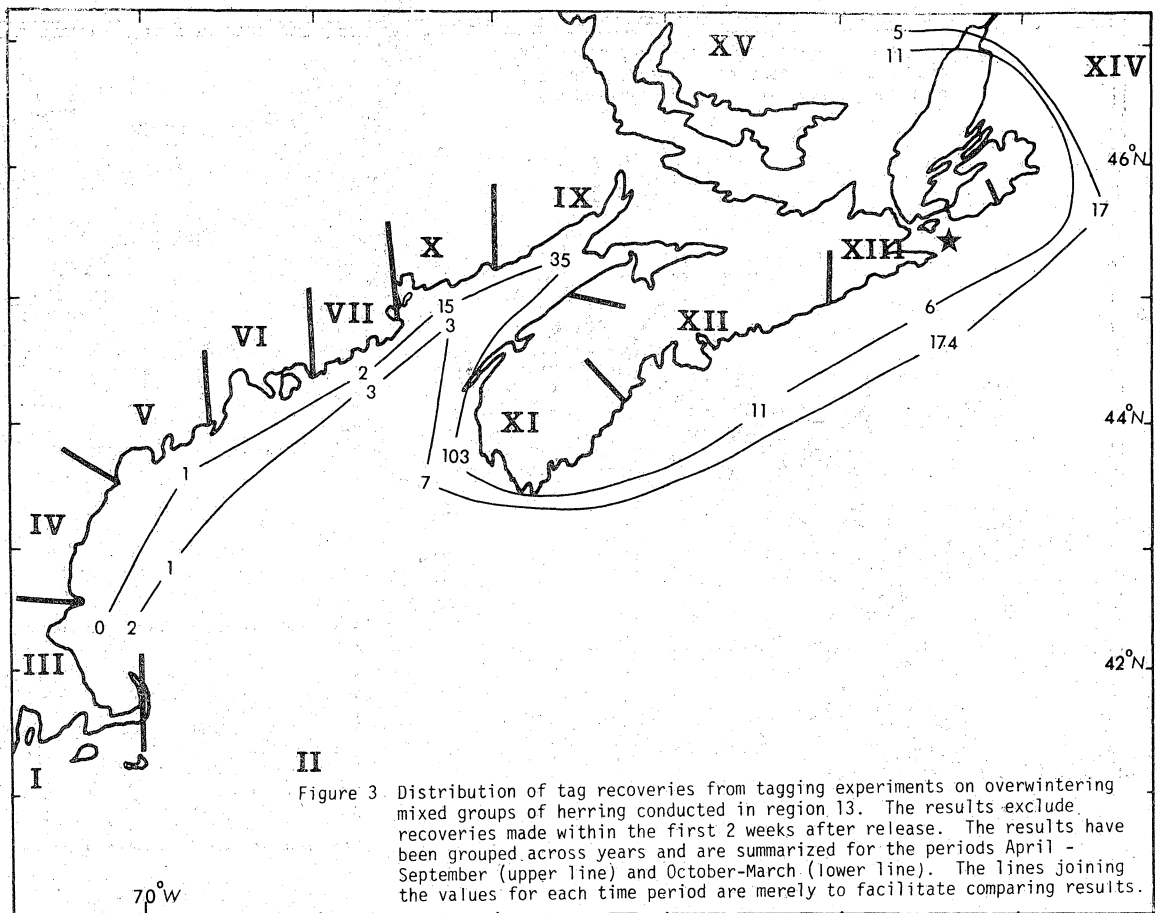
Table 2. Release and recovery information for herring tagging operations during the period 1973-81. The data are grouped geographically (see Figure 1) by designated seasonal phase as well as by stage in the life cycle (juveniles (J); adults (A); mixture of adults and juveniles (M)).

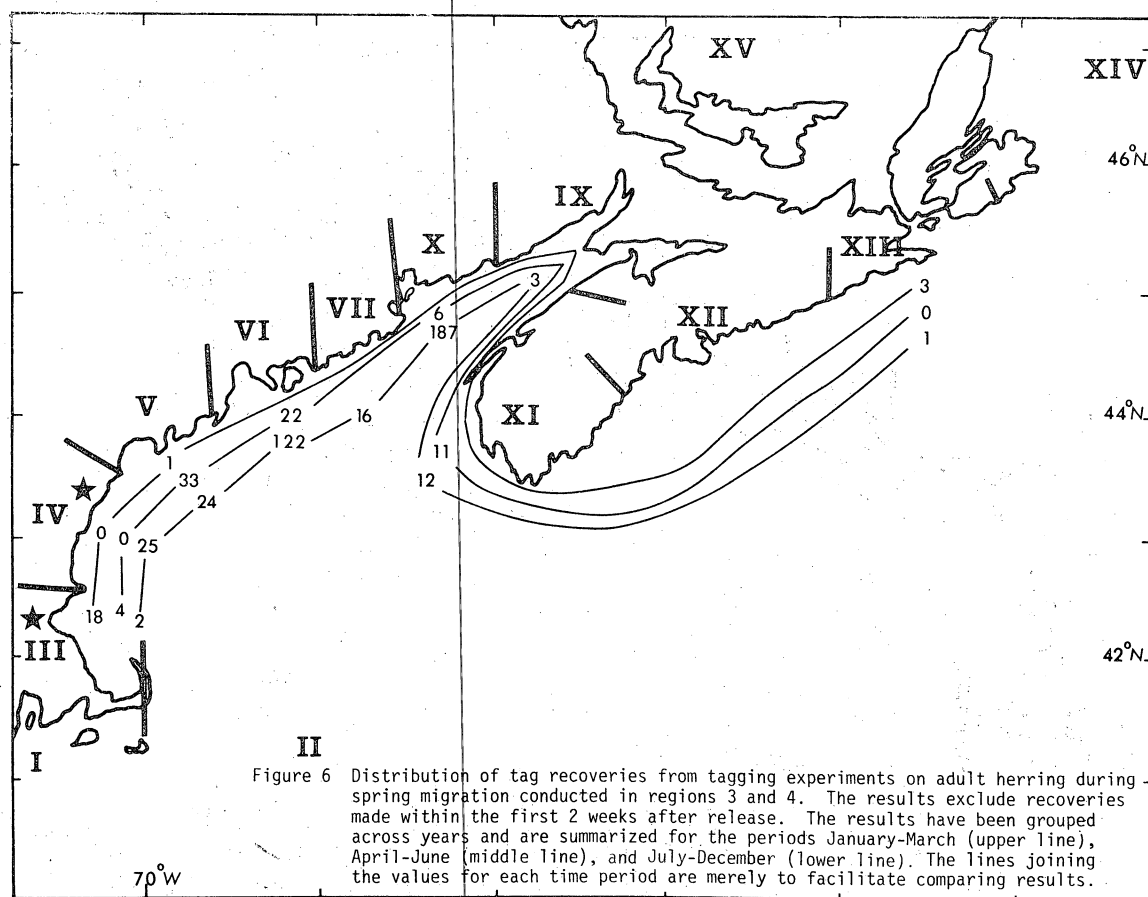
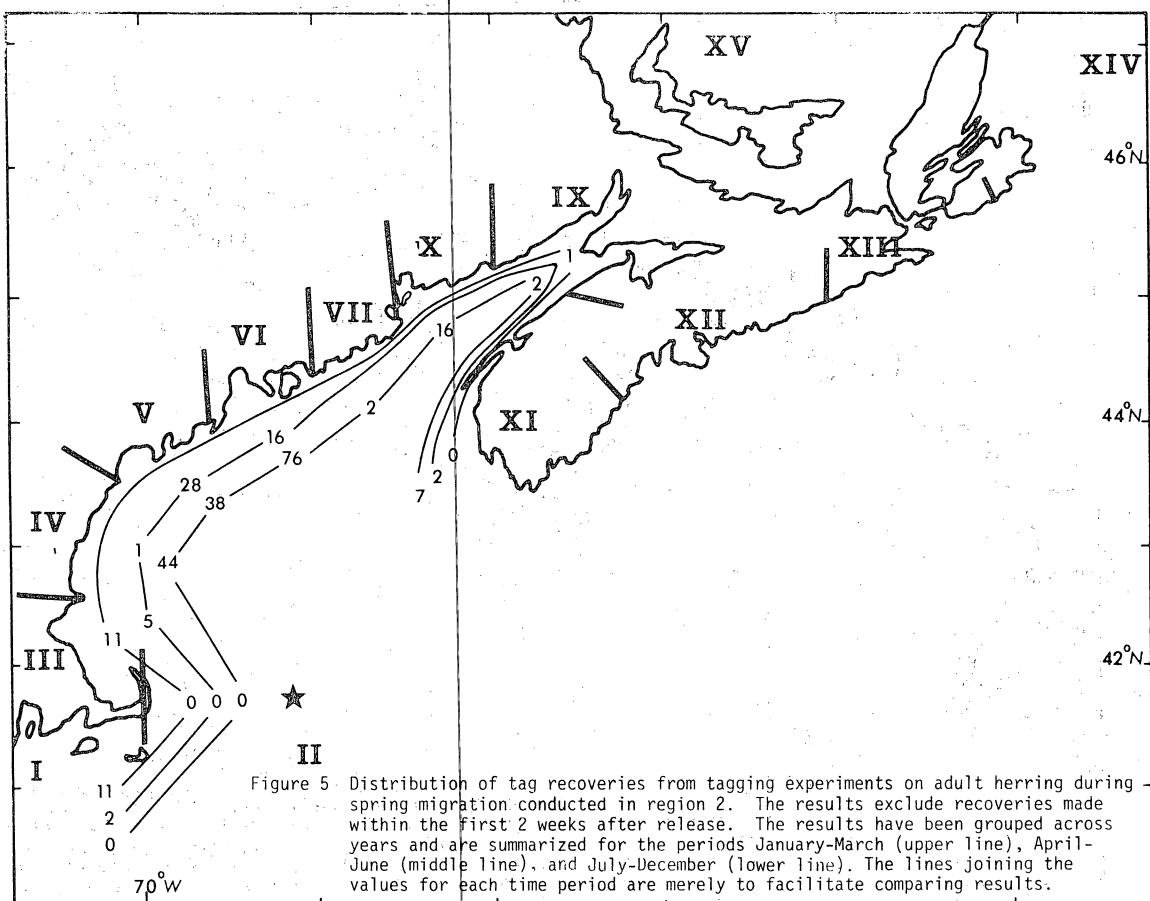
Seasonal Phase/ Region <sup>1</sup>	No. release sites			Total no. tagged			No. Recovered					
	J	A	M	J	A	M	Total			Longer Term <sup>2</sup>		
							J	A	M	J	A	M
<u>Overwintering</u>												
Region 1	-	1	-	-	32	-	-	0	-	-	0	-
5	1	-	-	1000	-	-	15	-	-	15	-	-
10	8	-	1	19056	-	790	475	-	2	392	-	2
13	-	-	25	-	-	31314	-	-	1024	-	-	396
14	-	29	-	-	18031	-	-	1219	-	-	748	-
<u>Spring Migration</u>												
Region 2	-	1	-	-	23179	-	-	262	-	-	262	-
3-4	-	1	-	-	10973	-	-	490	-	-	490	-
11-12	4	-	1	20316	-	3639	95	-	13	81	-	11
<u>Summer Feeding</u>												
Region 5-6	26	5	5	65907	6273	7737	3290	611	717	2333	310	122
7,10	29	7	9	61025	20485	18320	5147	897	1529	3309	742	985
11	-	-	20	-	-	59442	-	-	1479	-	-	633
13	-	2	-	-	7286	-	-	115	-	-	94	-
<u>Spawning</u>												
Region 2	-	2	-	-	30443	-	-	14	-	-	14	-
3-4	-	6	-	-	22673	-	-	305	-	-	302	-
7	-	1	-	-	692	-	-	25	-	-	21	-
9	-	6	-	-	3708	-	-	404	-	-	45	-
11	-	18	-	-	54266	-	-	1487	-	-	750	-
<u>Fall Migration</u>												
Region 4	-	-	1	-	-	1094	-	-	183	-	-	30
5-6	2	-	3	3097	-	6721	301	-	349	121	-	178
7	-	1	1	-	4998	3628	-	56	38	-	25	38

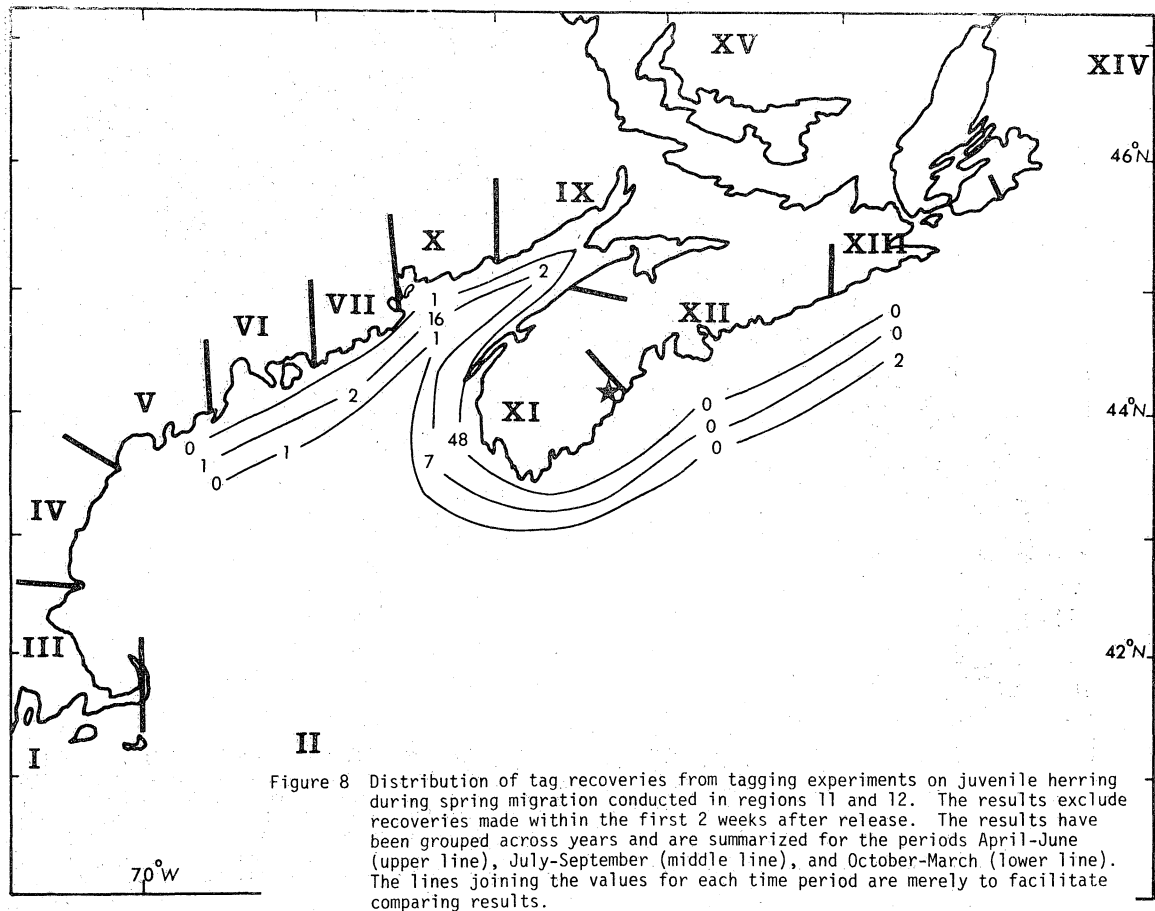
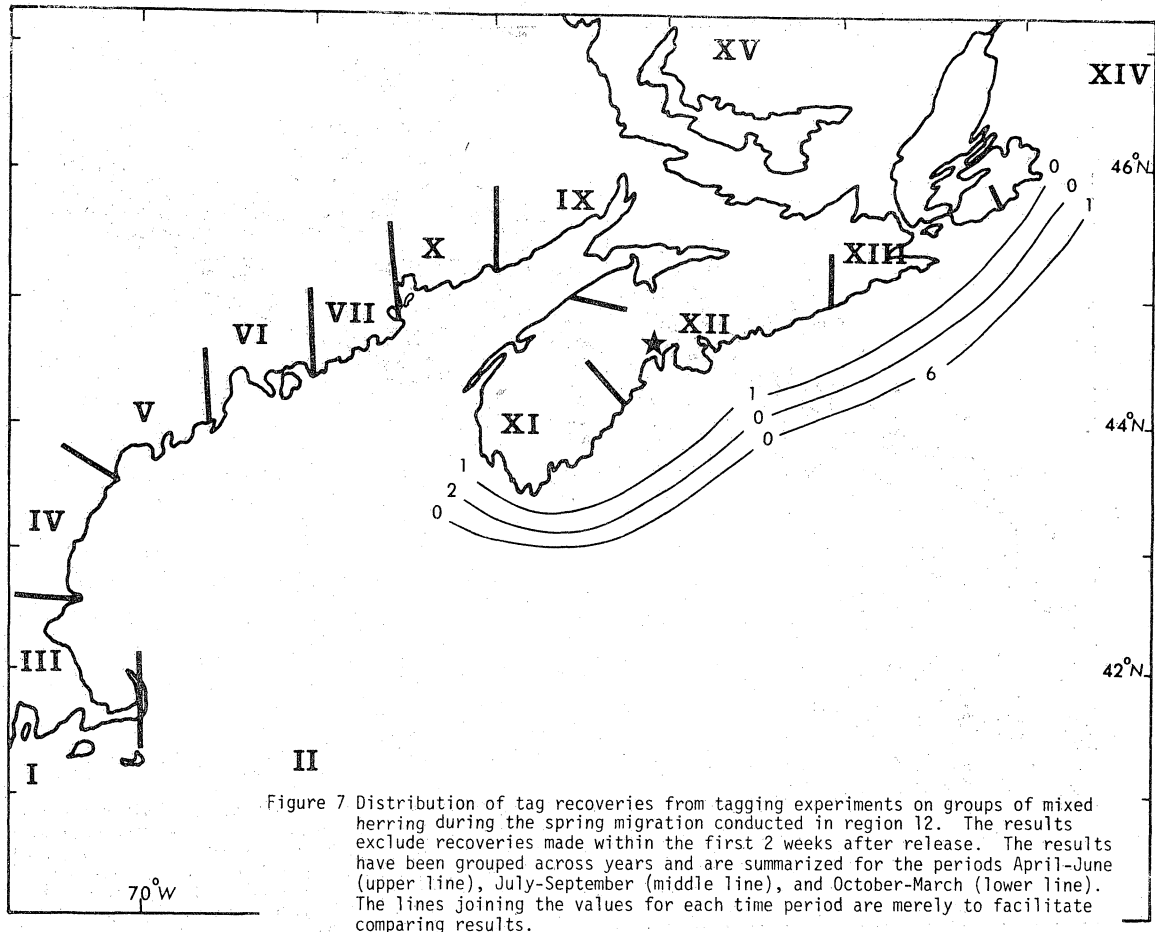
<sup>1</sup>Regions where no tagging was done during a particular phase are excluded. Regions are grouped in cases in which tagging operations apply to more than one area.

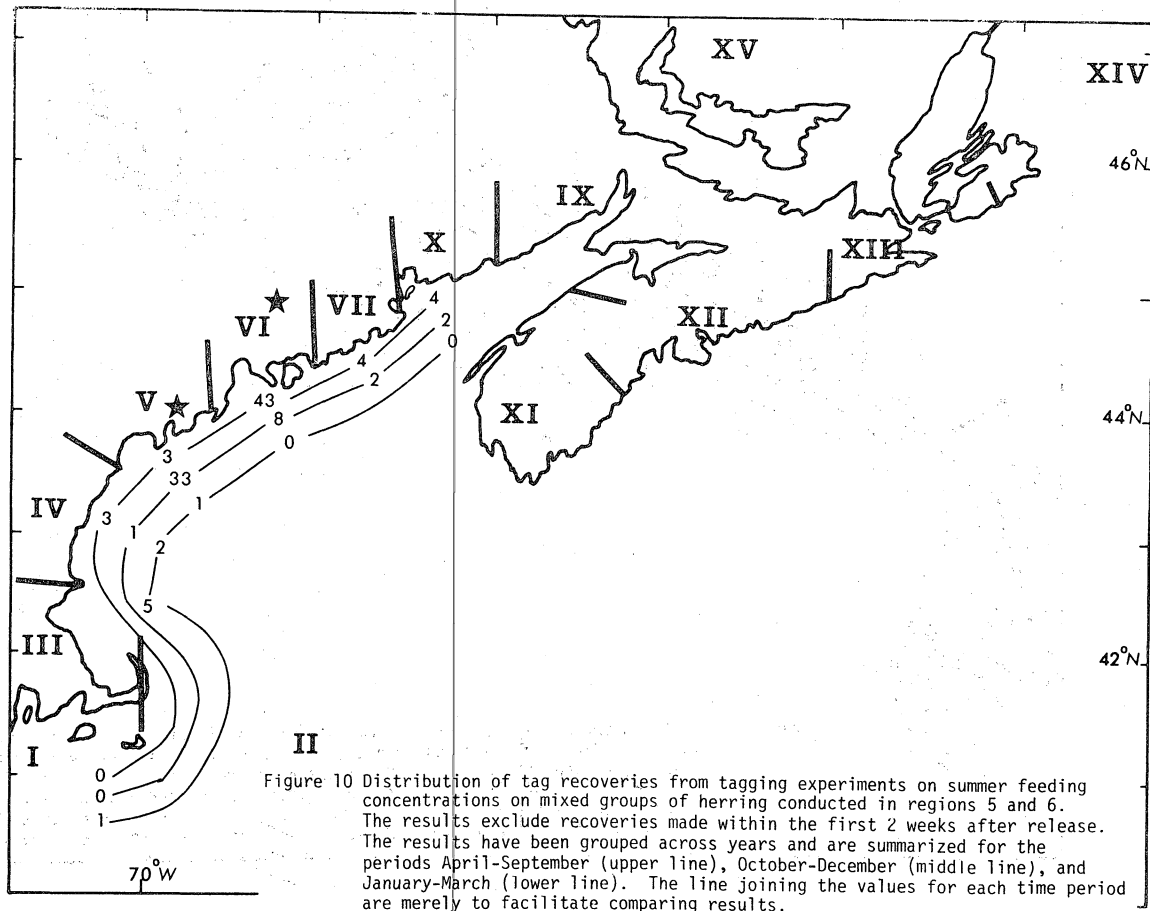
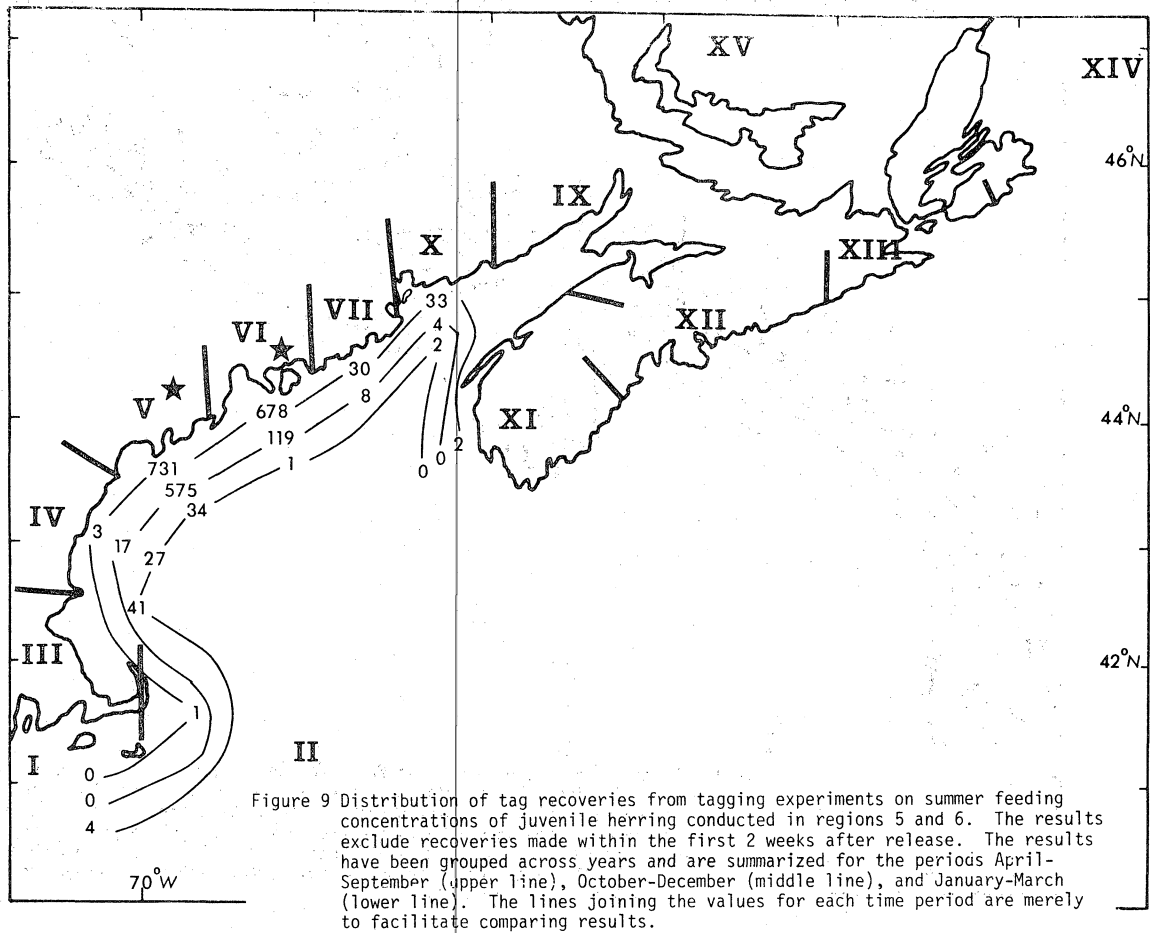
<sup>2</sup>In order to discriminate between immediate recoveries and those depicting movement or migration, all recoveries occurring within 2 weeks of tagging were excluded in the "Longer Term" tally.

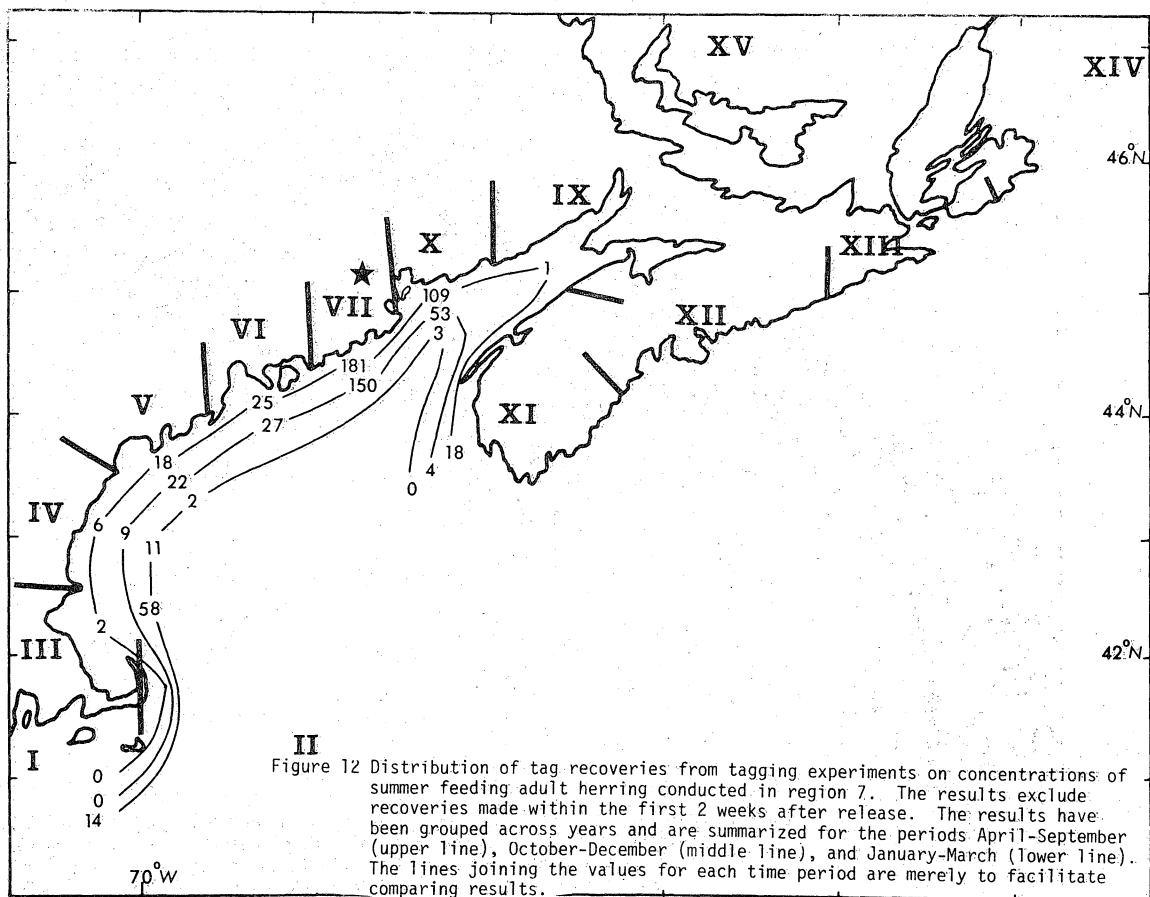
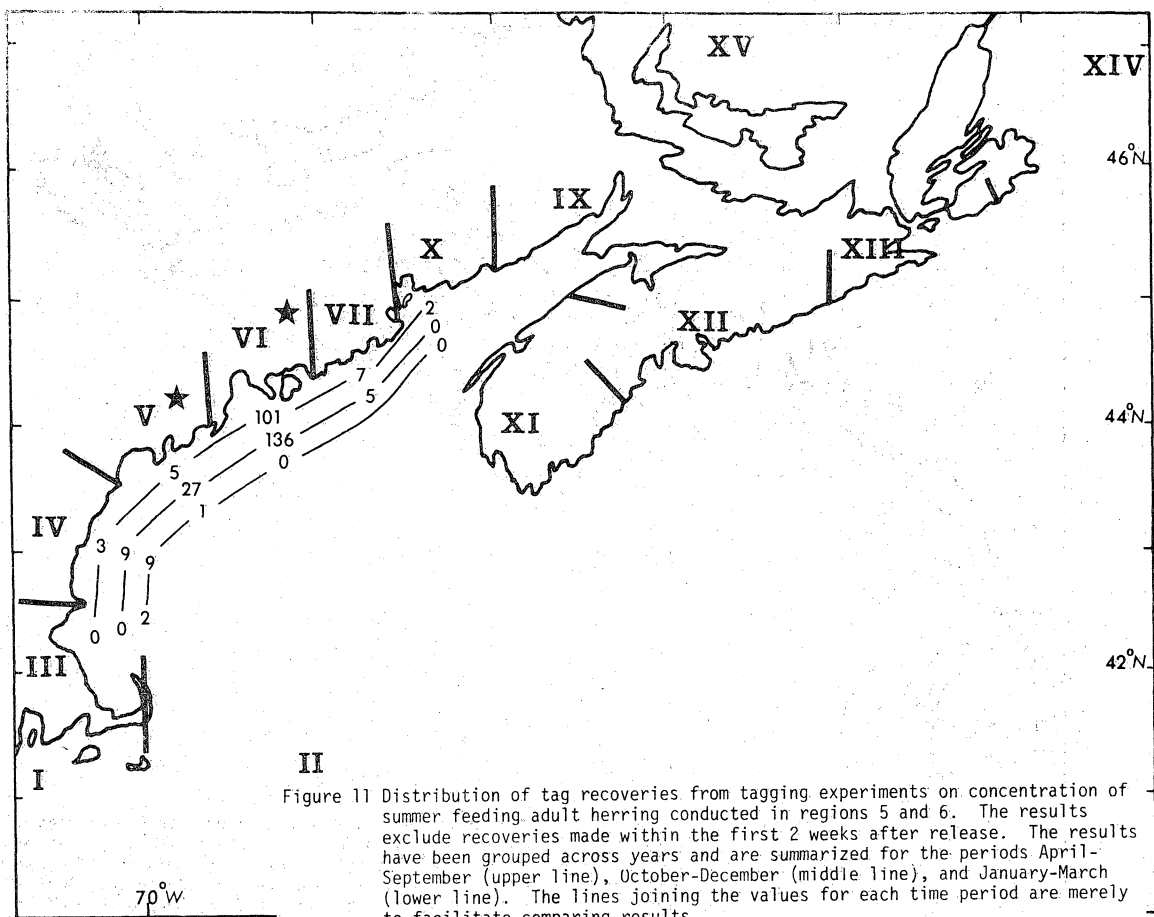




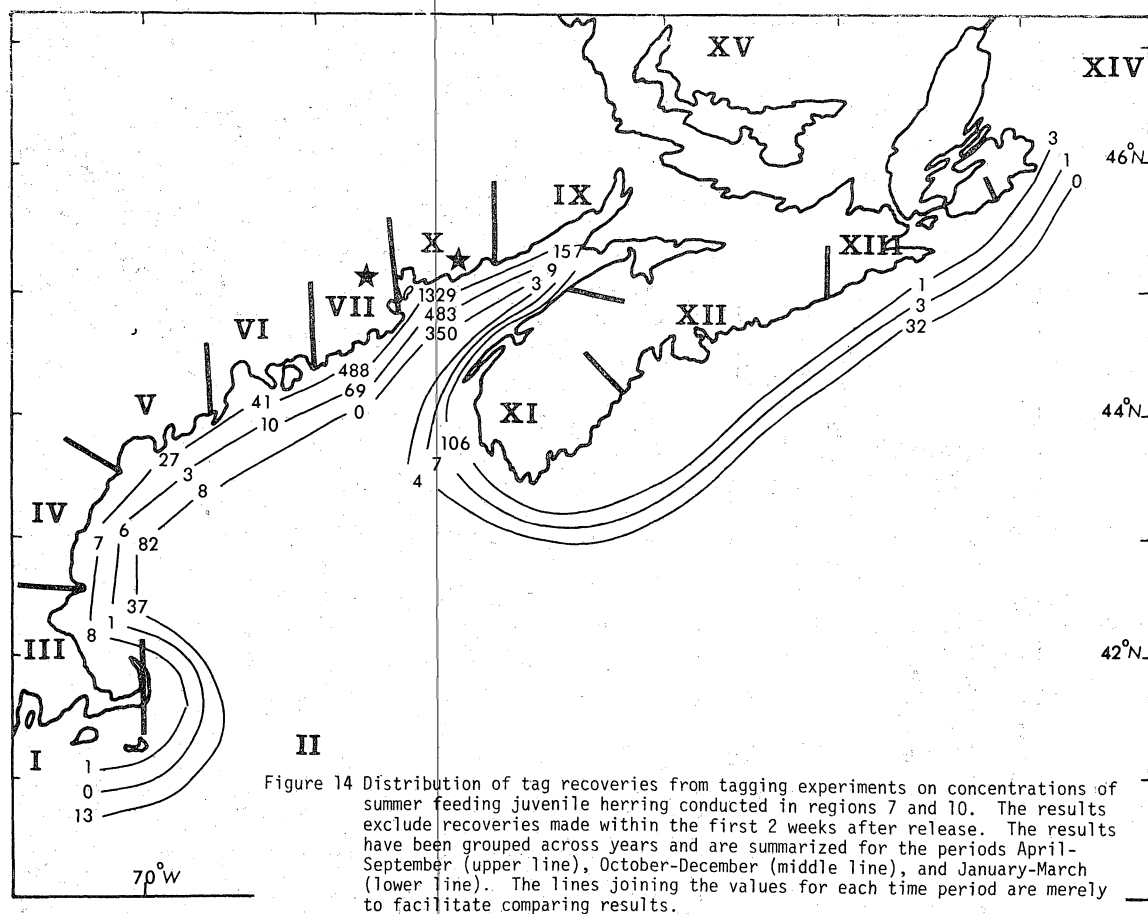
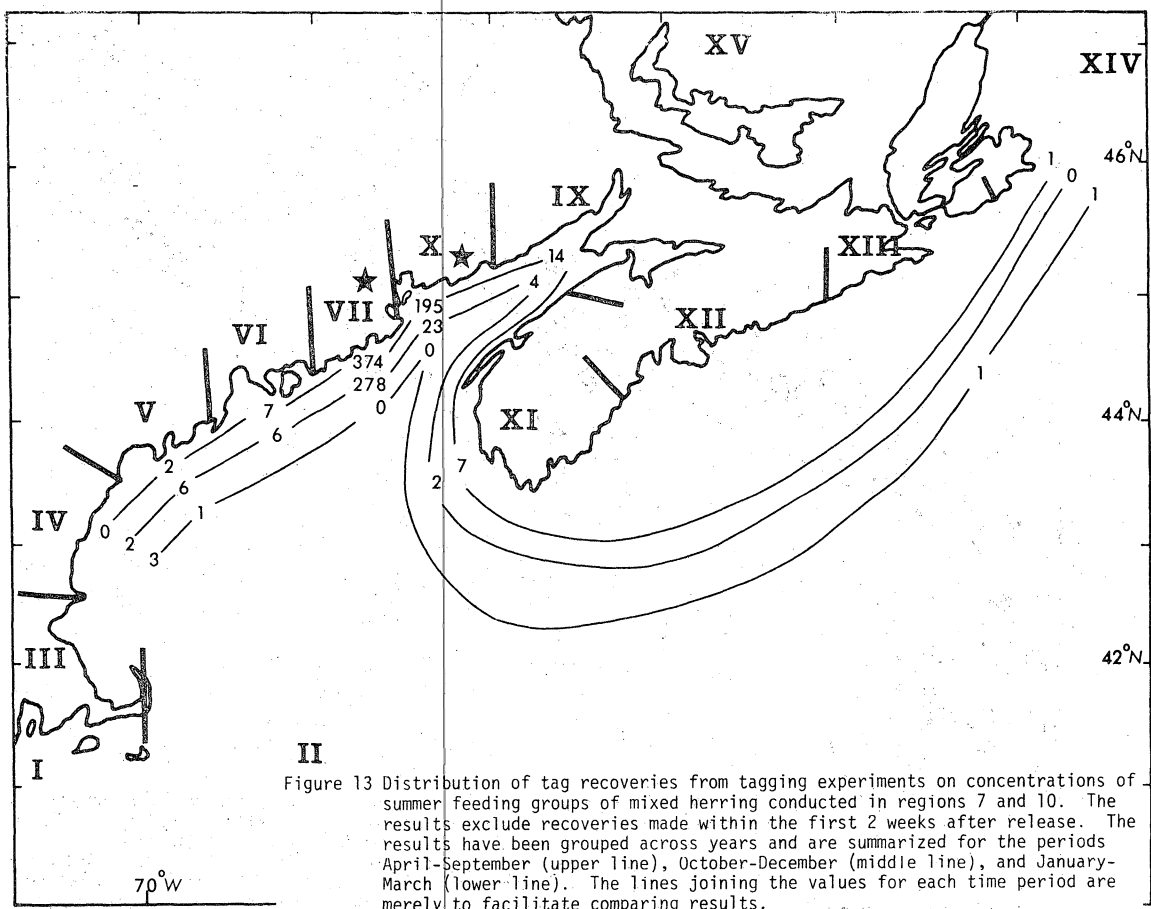


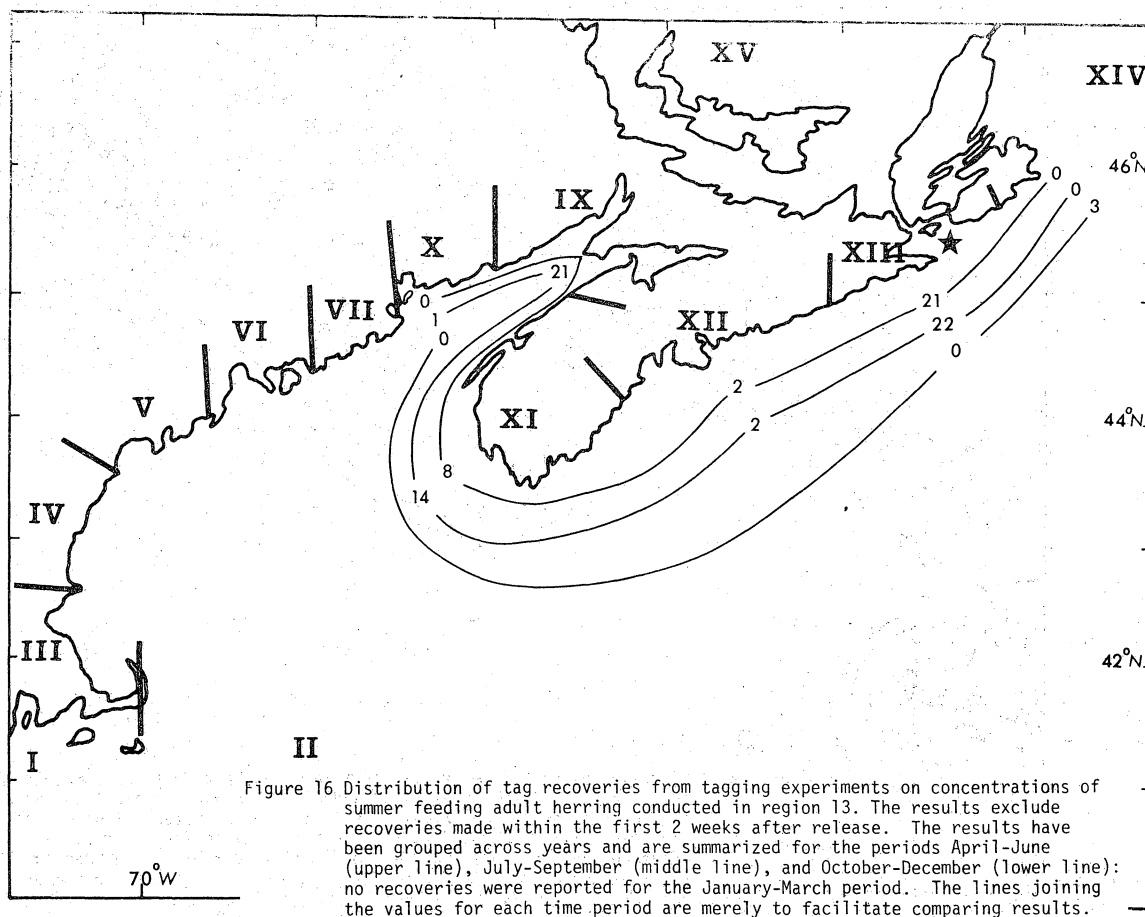
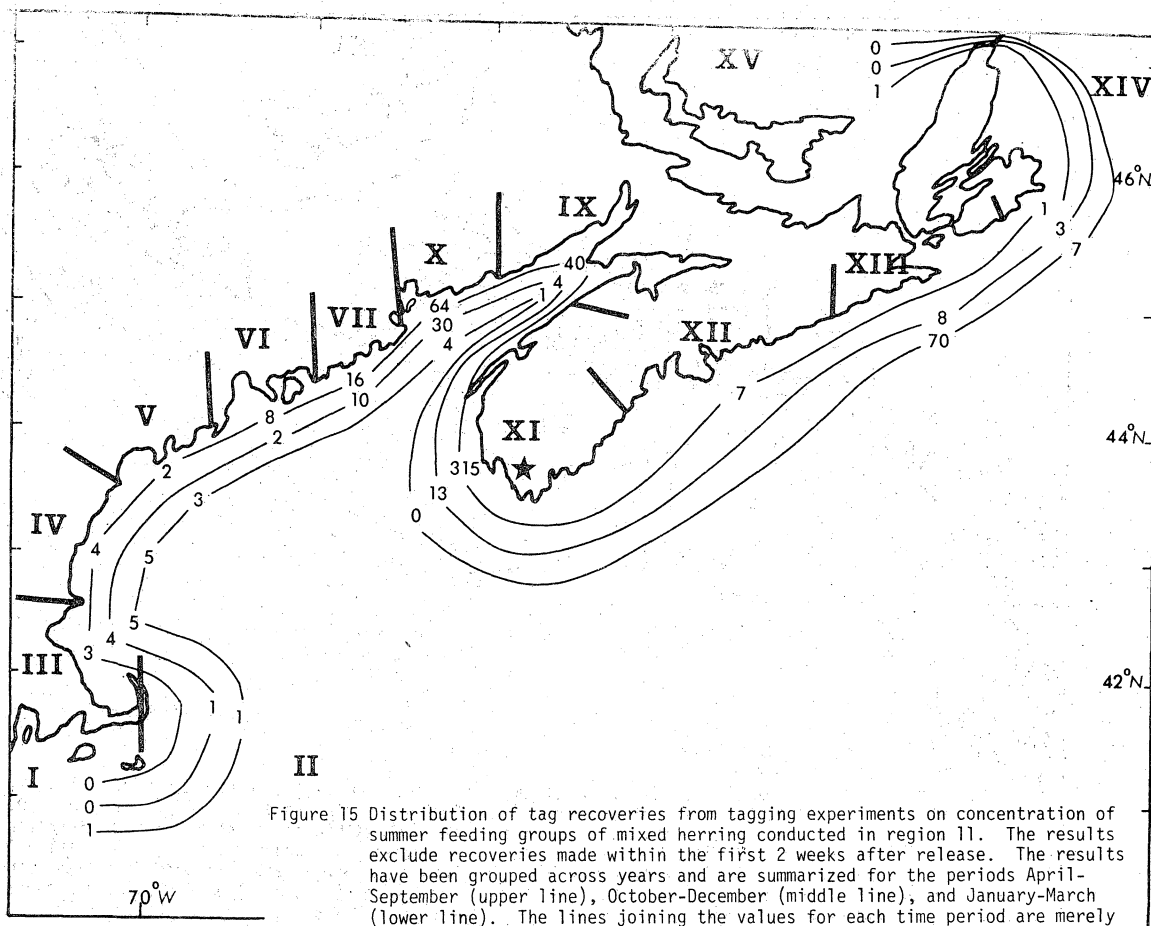


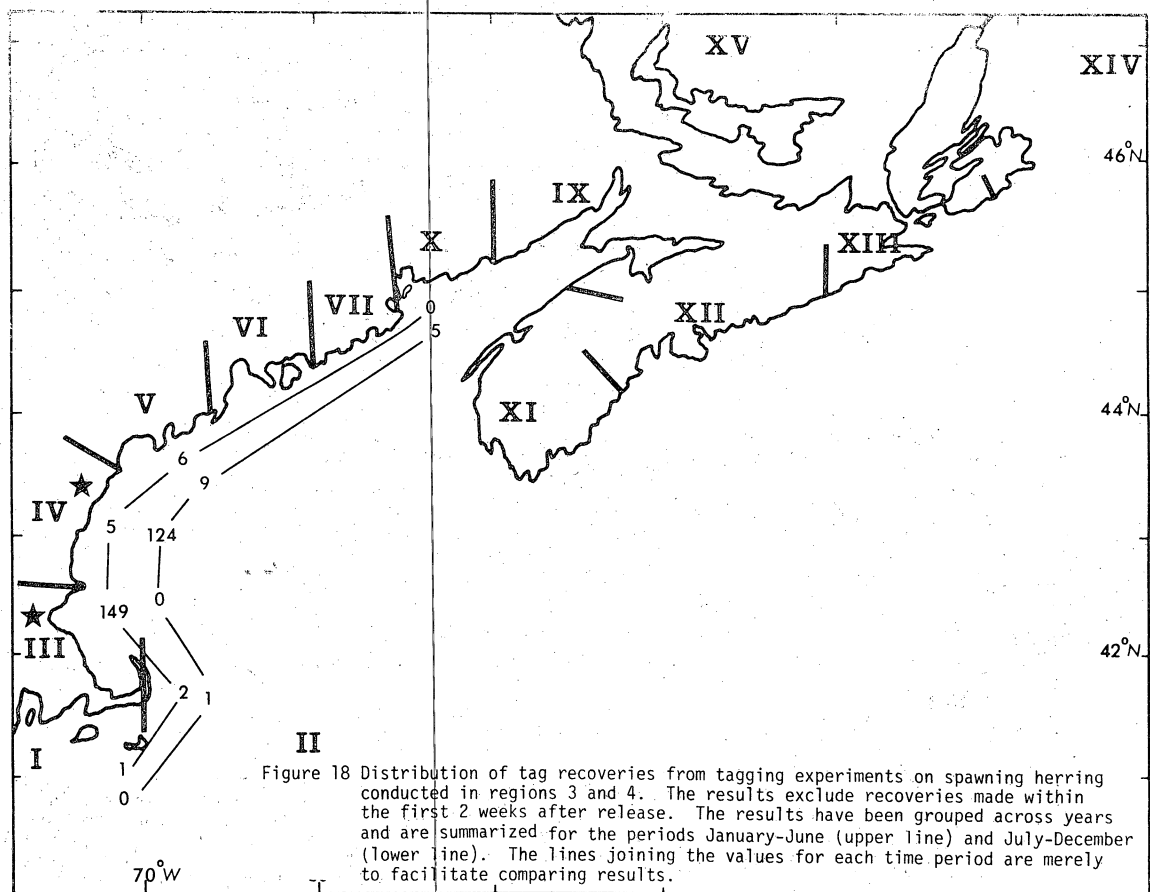
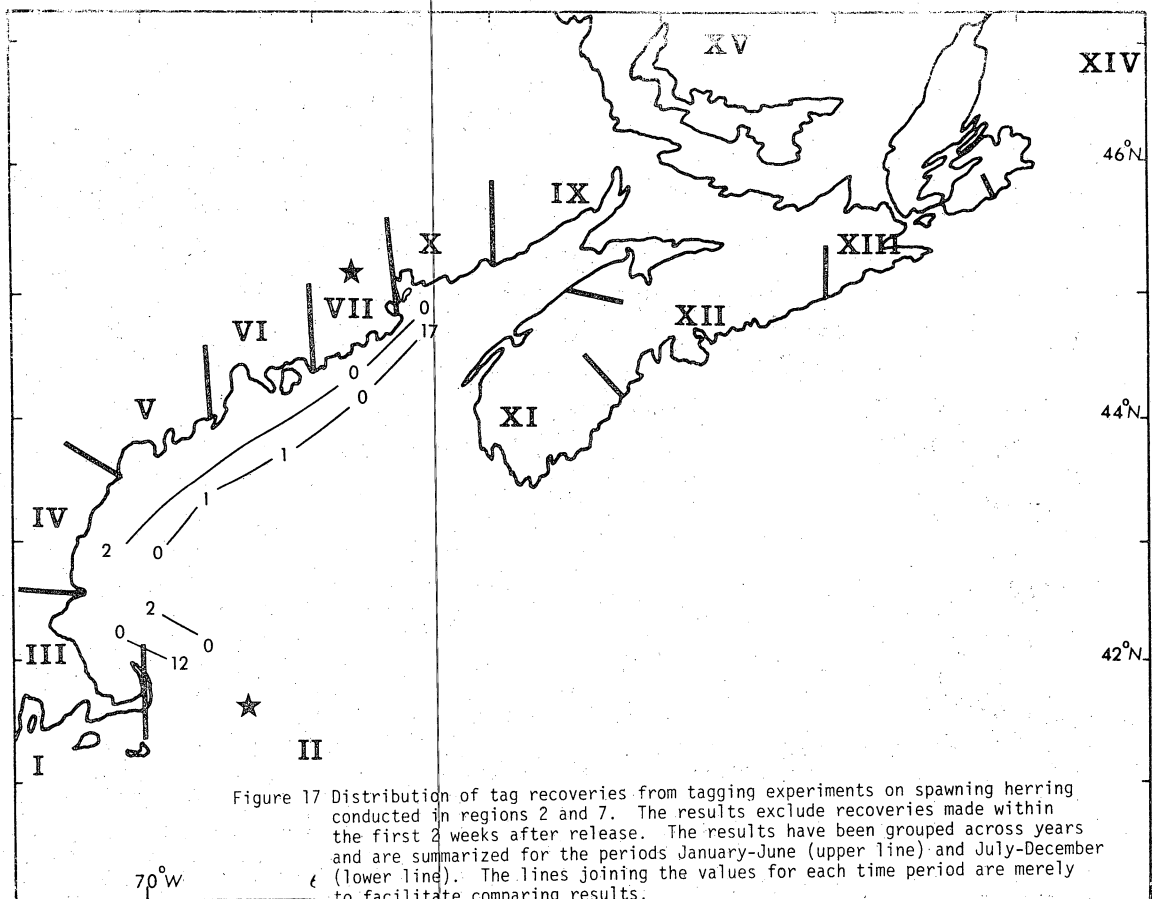


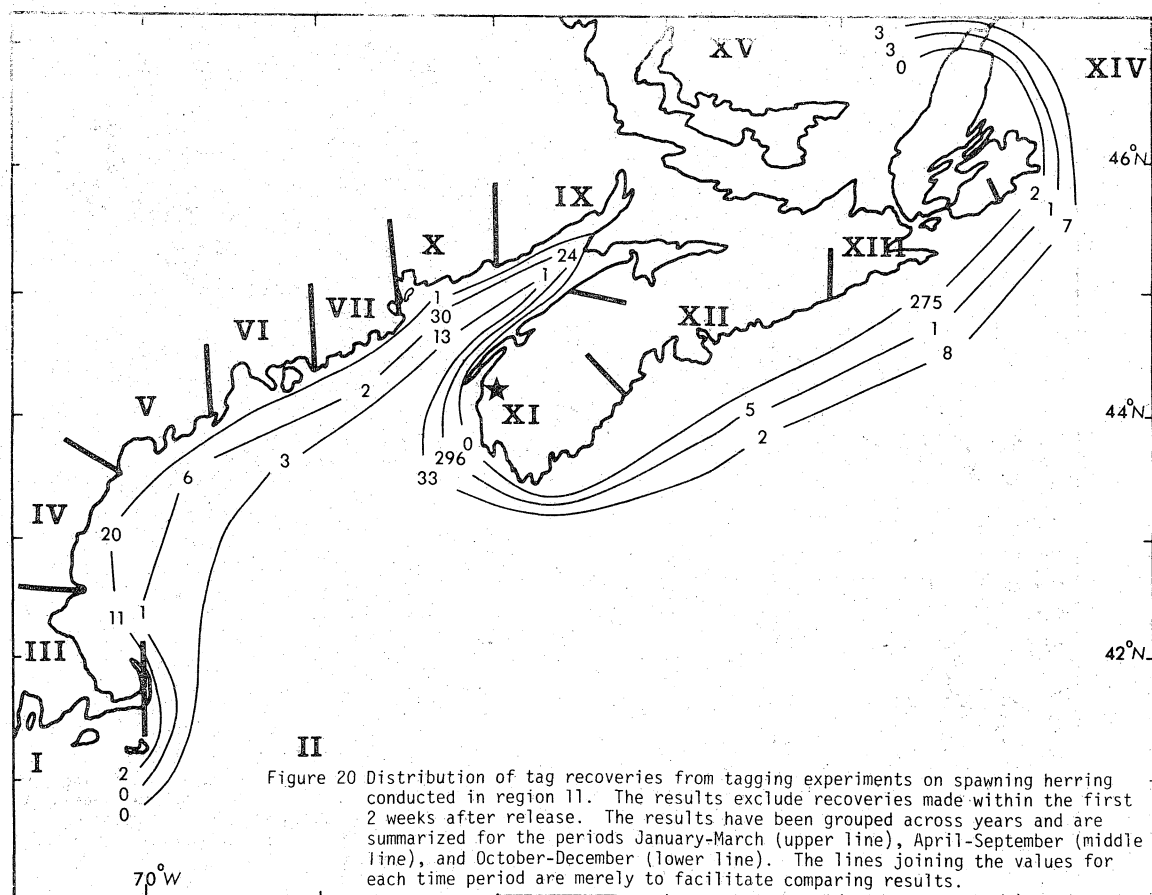
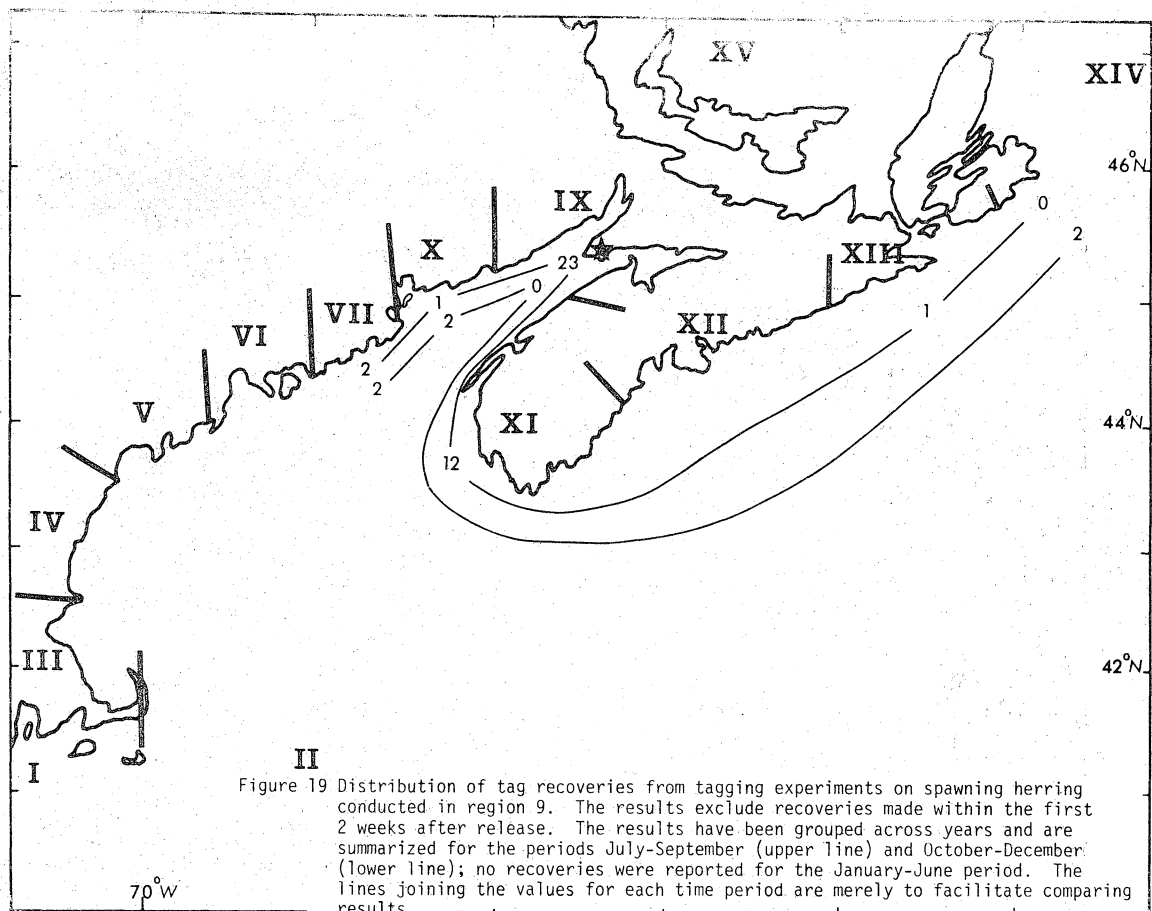


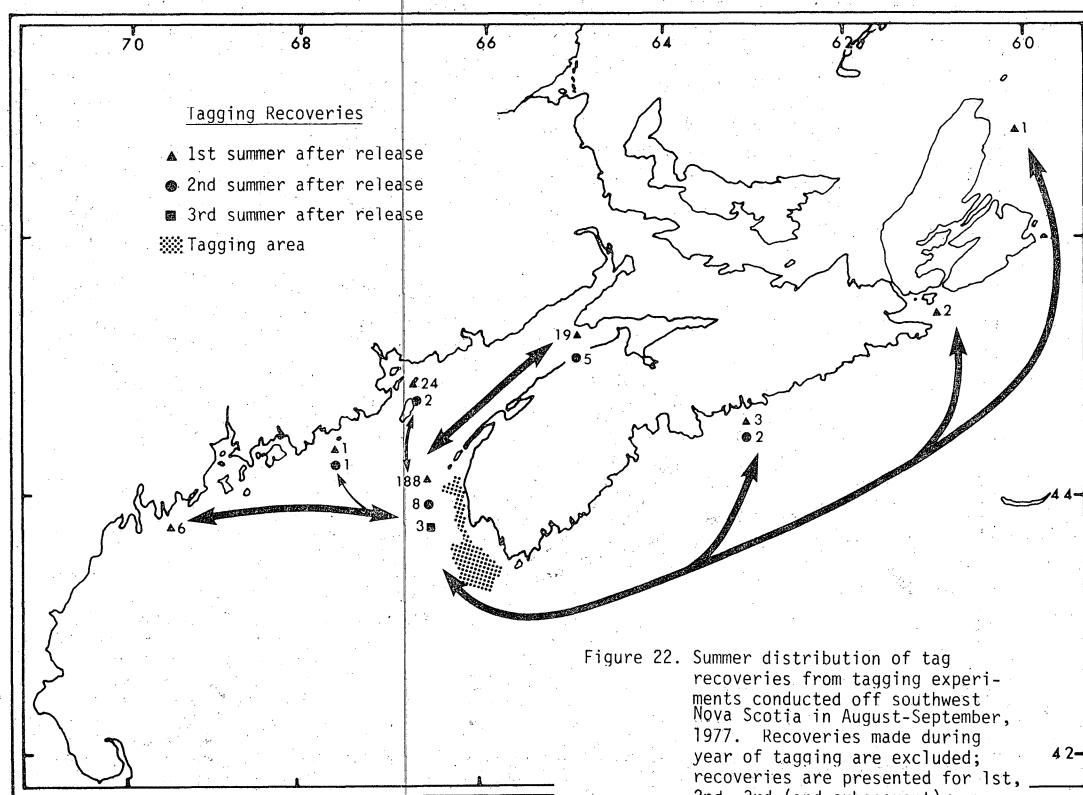
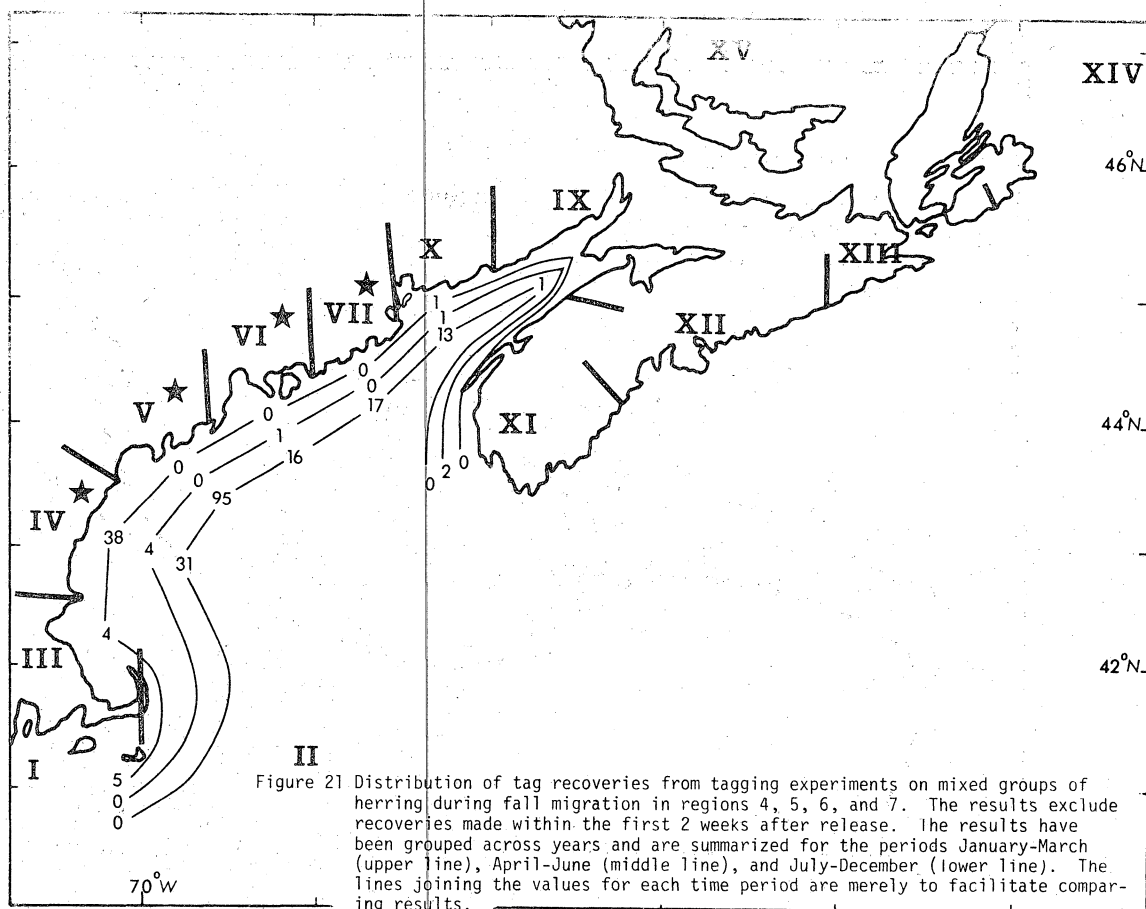


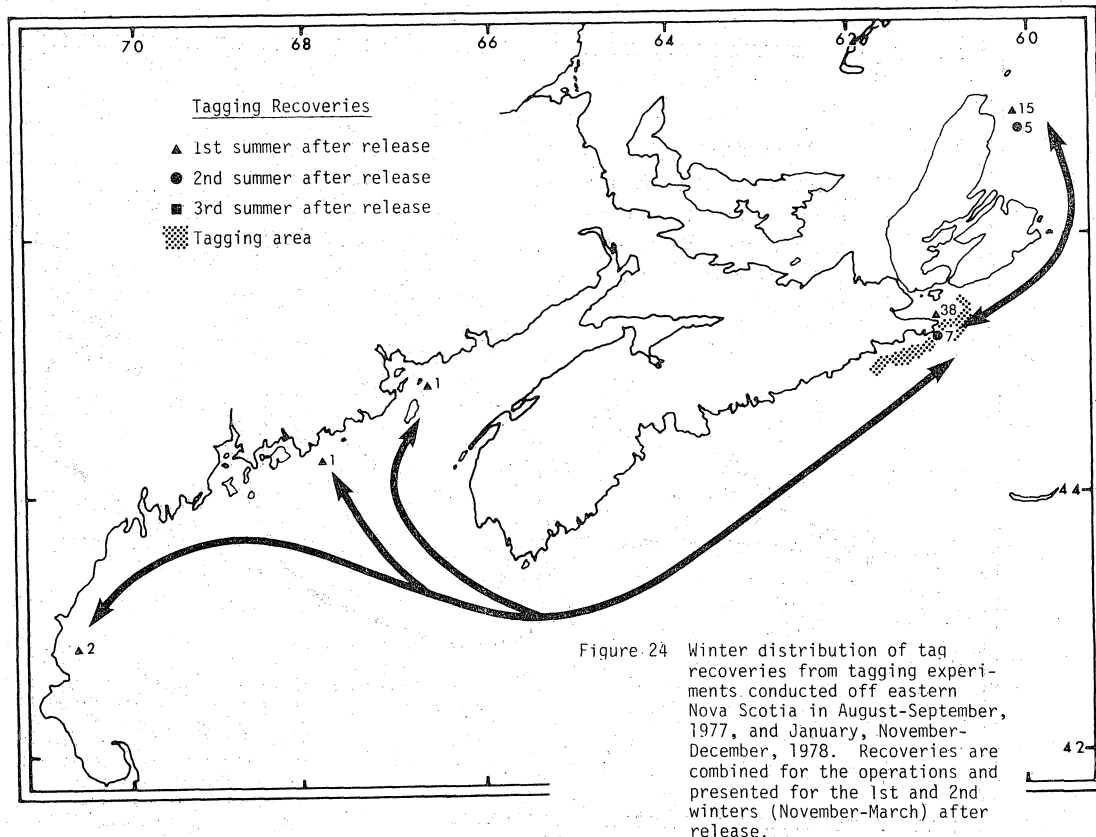
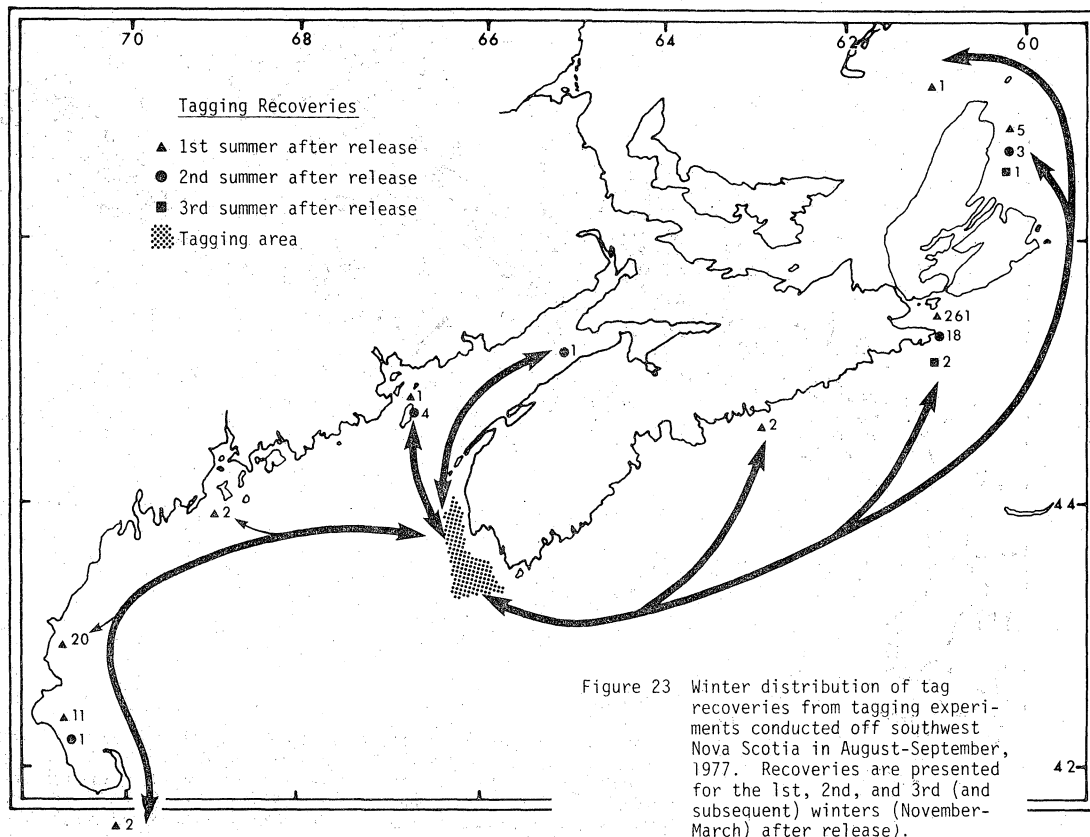


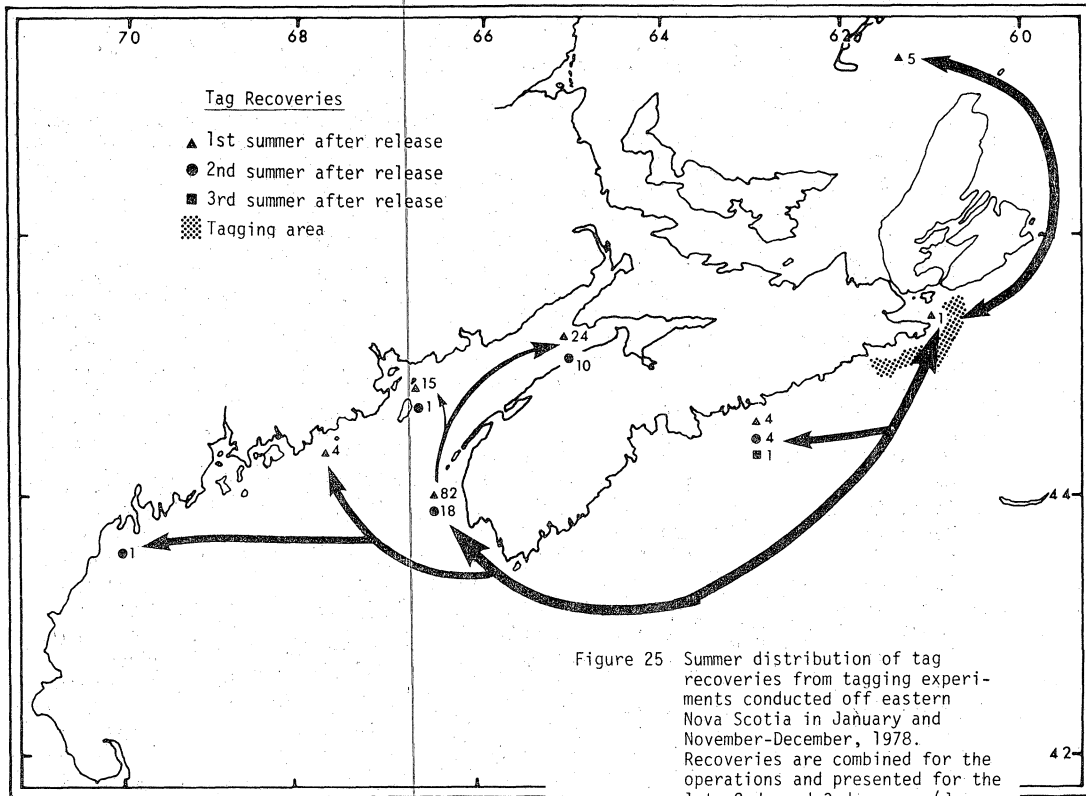












**Appendix 1.** Listing of herring tagging activities from 1973-81 in the Northwest Atlantic giving location, date, and numbers tagged (source: ICNAF/NAFO Circular Letter series).

<u>Date</u>	<u>Location</u>	<u>No. Herring<sup>1</sup> tagged</u>	<u>Agency<sup>2</sup></u>
Nov. 21-Dec.5/73	Grand Manan	10,868	DFO, St. Andrews
Jan. 29-30/76	45°21'15"N 61°15'45"W	3,000	DFO, St. Andrews
Feb. 8/76	45°21'15"N 61°15'45"W	2,150	DFO, St. Andrews
Feb. 8-9/76	45°21'32"N 61°15'15"W	3,843	DFO, St. Andrews
Feb. 10/76	45°21'30"N 61°09'45"W	3,199	DFO, St. Andrews
Feb. 12/76	45°21'30"N 61°09'45"W	3,625	DFO, St. Andrews
Feb. 13/76	45°21'30"N 61°09'45"W	6,650	DFO, St. Andrews
May 12/76	47°23'00"N 61°47'00"W	(2,000)	DFO, St. Andrews
May 12/76	47°22'00"N 61°51'00"W	(1,652)	DFO, St. Andrews
May 14/76	47°23'00"N 61°47'00"W	(500)	DFO, St. Andrews
May 15/76	47°23'00"N 61°47'00"W	(3,374)	DFO, St. Andrews
May 17/76	47°23'00"N 61°47'00"W	(2,350)	DFO, St. Andrews
April 29/76	St. Georges Bay	(6,400)	DFO, St. John's
May 2/76	47°41'00"N 60°35'30"W	(1,900)	DFO, St. John's
May 11/76	47°41'00"N 60°35'30"W	(1,900)	DFO, St. John's
Aug.26-Sept.6/76	W. Gulf of St. Lawrence	(27,975)	DFO, St. Andrews
Sept. 16/76	41°45'N 68°58'W	4,800	NMFS, Woods Hole
Sept. 17/76	41°43'N 68°56'W	5,132	NMFS, Woods Hole
Sept. 18/76	41°35'N 68°55'W	3,524	NMFS, Woods Hole
Sept. 19/76	41°44'N 68°49'W	5,443	NMFS, Woods Hole
Sept. 23/76	41°38'N 68°51'W	5,993	NMFS, Woods Hole
Sept. 27/76	41°35'N 68°57'W	4,511	NMFS, Woods Hole
Oct. 8/76	42°39'N 70°30'W	3,466	NMFS, Woods Hole
Oct. 9/76	42°50'N 70°19'W	3,661	NMFS, Woods Hole
Oct. 11/76	42°39'N 70°30'W	3,566	NMFS, Woods Hole
Nov. 10/76	41°29'N 71°14'W	32	NMFS, Woods Hole
Jan. 16-17/77	45°20'N 60°34'W	1,025	DFO, St. Andrews
May 7/77	40°31'N 69°12'W	6,430	NMFS, Woods Hole
May 11/77	40°28'N 69°09'W	2,507	NMFS, Woods Hole
May 13/77	40°33'N 69°20'W	3,805	NMFS, Woods Hole
May 15/77	40°27'N 69°20'W	10,437	NMFS, Woods Hole
March 8/77	43°45'N 69°41'W	1,000	DMR, Maine
May 1/77	42°41'N 70°29'W	10,973	NMFS, Woods Hole
Sept. 23/77	41°38'N 69°41'W	645	NMFS, Woods Hole
Sept. 25/77	41°38'N 69°45'W	298	NMFS, Woods Hole
June 28/77	3 mi. S.W. Trinity	95	DFO, St. Andrews
June 28/77	12 mi. S. Lurcher	141	DFO, St. Andrews
July 6/77	Mill Cove, Campobello	1,668	DFO, St. Andrews
July 7/77	Mill Cove, Campobello	1,750	DFO, St. Andrews
July 15/77	Mill Cove, Campobello	1,225	DFO, St. Andrews
July 18/77	Mill Cove, Campobello	647	DFO, St. Andrews
July 19/77	Head Harbour Island	1,254	DFO, St. Andrews
Aug. 8/77	Bliss Island Light	2,846	DFO, St. Andrews
Aug. 10/77	Back of Man of War Is.	200	DFO, St. Andrews
Aug. 10/77	½ mi. S.W. Crow Island	1,600	DFO, St. Andrews
Aug. 11/77	1 mi. S.W. Whitehead	1,175	DFO, St. Andrews
Aug. 12/77	Off Eagle Island	2,096	DFO, St. Andrews
Aug. 16/77	St. Andrews Pt.- Minister's Is.	4,874	DFO, St. Andrews
Aug. 18/77	E. of Tongue Shoal (St. Andrews Pt.)	3,100	DFO, St. Andrews
Aug. 29/77	1½-2 mi. N.W. Seal Is.	3,997	DFO, St. Andrews
Aug. 30/77	2 mi. W. of West Head	6,491	DFO, St. Andrews
Aug. 30/77	1½ mi. ESE Trinity Buoy	2,999	DFO, St. Andrews
Aug. 31/77	1½ mi. SE Trinity Buoy	2,347	DFO, St. Andrews
Aug. 31/77	2 mi. W. of Seal Is.	5,492	DFO, St. Andrews
Aug. 31/77	ESE Trinity Bay - NW Cape St. Mary	2,828	DFO, St. Andrews
Sept. 1/77	2 mi. W. of West Head	4,500	DFO, St. Andrews
Sept. 1/77	1½ mi. ESE Trinity Buoy	4,650	DFO, St. Andrews
Sept. 5/77	½ mi. N. of Seal Is.	3,996	DFO, St. Andrews



Appendix 1. Cont'd.

<u>Date</u>	<u>Location</u>	<u>No. Herring<sup>1</sup> tagged</u>	<u>Agency<sup>2</sup></u>
Sept. 6/77	1½ mi. SE Gannet Rock	2,000	DF0, St. Andrews
Sept. 6/77	2 mi. E. Green Is.	1,125	DF0, St. Andrews
Sept. 7/77	1 mi. S. Green Is.	1,050	DF0, St. Andrews
Sept. 7/77	3 mi. SSE Seal Is.	3,825	DF0, St. Andrews
Sept. 7/77	1 mi. NE Gannet Rock	3,494	DF0, St. Andrews
Sept. 8/77	2 mi. SE Gannet Rock	3,375	DF0, St. Andrews
Sept. 9/77	Trinity Buoy	2,500	DF0, St. Andrews
Nov. 28/77	4½ mi. off Low Pt.	588	DF0, St. Andrews
Dec. 4/77	2 mi. off Little Larraine	715	DF0, St. Andrews
Dec. 5/77	2 mi. South Cape Morien	435	DF0, St. Andrews
Dec. 14-15/77	Glance Bay Buoy	650	DF0, St. Andrews
Dec. 5/77	3/4 mi. S. Glance Bay Buoy	207	DF0, St. Andrews
Dec. 5/77	1½ mi. E. Glance Bay Buoy	487	DF0, St. Andrews
May 22/77	Linekin Bay, Maine	1,000	DMR, Maine
May 23/77	Boothbay Harbour, Maine	1,000	DMR, Maine
June 20/77	Greenland Cove, Maine	1,000	DMR, Maine
June 27/77	Long Cove, Maine	1,500	DMR, Maine
July 6/77	Gunpoint Cove, Maine	2,500	DMR, Maine
July 12/77	Bois Bubert, Maine	2,000	DMR, Maine
July 27/77	Howard Cove, Maine	1,000	DMR, Maine
July 28/77	Sand Cove, Maine	2,800	DMR, Maine
Oct. 11/77	Metinic Island, Maine	800	DMR, Maine
Oct. 27/77	Southport Island, Maine	1,196	DMR, Maine
Nov. 3/77	North Lubec	2,200	DMR, Maine
Jan. 13/78	Cape Canso	525	DF0, St. Andrews
Jan. 13/78	E. of Cape Canso	17	DF0, St. Andrews
Jan. 17/78	15 mi. E. of Cape Canso	525	DF0, St. Andrews
Jan. 13/78	15 mi. E. of Cape Canso	1,127	DF0, St. Andrews
Jan. 17/78	8 mi. E. of Cape Canso	705	DF0, St. Andrews
Jan. 23/78	6 mi. SE of White Hd, CB	670	DF0, St. Andrews
Jan. 29/78	2½ mi. NE C A Buoys	829	DF0, St. Andrews
Feb. 3/78	Perry Shore	50	DF0, St. Andrews
Mar. 24/78	1 mi. NW Lettite Passage- (Passamaq)	3,950	DF0, St. Andrews
Apr. 17/78	Liverpool Bay	6,000	DF0, St. Andrews
Apr. 19/78	Liverpool Bay	4,000	DF0, St. Andrews
From May 11- June 9/78	Isle-Verte, Quebec	(29,217)	DF0, Quebec City
Oct. 16/78	2 mi. ESE Thacker's Is.	1,500	NMFS, Woods Hole
Nov. 1/78	42°53'N 70°12'W	500	NMFS, Woods Hole
Nov. 2/78	42°50'N 70°12'W	2,000	NMFS, Woods Hole
Nov. 3/78	42°50'N 70°15'W	2,000	NMFS, Woods Hole
Nov. 9/78	42°52'N 70°15'W	4,000	NMFS, Woods Hole
July 7/78	44°45'N 65°50'W	4,000	DF0, St. Andrews
July 28-29/78	44°39'N 65°45'W	5,992	DF0, St. Andrews
July 20/78	44°40'N 65°50'W	2,225	DF0, St. Andrews
July 21-26/78	44°39'N 65°45'W	2,880	DF0, St. Andrews
Aug. 28/78	44°37'N 66°55'W	375	DF0, St. Andrews
Oct. 18/78	46°20'N 62°15'W	(2,500)	DF0, St. Andrews
Oct. 25/78	46°20'N 62°15'W	(5,500)	DF0, St. Andrews
Nov. 6/78	46°28'N 60°15'W	233	DF0, St. Andrews
Nov. 9/78	46°24'N 60°14'W	186	DF0, St. Andrews
Nov. 11/78	45°10'N 61°06'W	364	DF0, St. Andrews
Nov. 17-18/78	46°23'N 60°06'W	344	DF0, St. Andrews
Nov. 19-22/78	46°22'N 59°58'W	1,762	DF0, St. Andrews
Dec. 6-7/78	45°10'N 61°04'W	676	DF0, St. Andrews
Nov. 30/78	46°28'N 60°22'W	653	DF0, St. Andrews
Dec. 2/78	46°32'N 60°23'W	816	DF0, St. Andrews
Dec. 7-8/78	45°10'N 61°25'W	332	DF0, St. Andrews
Dec. 7/78	45°04'N 61°34'W	538	DF0, St. Andrews
Dec. 4/78	45°04'N 61°34'W	646	DF0, St. Andrews
Dec. 9/78	45°03'N 61°20'W	224	DF0, St. Andrews
Dec. 13/78	45°21'N 60°45'W	356	DF0, St. Andrews
Dec. 7-8/78	45°10'N 61°04'W	219	DF0, St. Andrews

Appendix 1. Cont'd.

<u>Date</u>	<u>Location</u>	<u>No. Herring<sup>1</sup> tagged</u>	<u>Agency<sup>2</sup></u>
Dec. 9/78	46°04'N 61°34'W	48	DFO, St. Andrews
Dec. 13/78	45°22'N 60°48'W	325	DFO, St. Andrews
Feb. 21/78	Passamaquoddy Bay	1,500	DMR, Maine
Aug. 7-9/78	Tenants Harbour	2,998	DMR, Maine
Aug. 21/78	White Island	537	DMR, Maine
Aug. 31/78	Boat Cove, Lubec	513	DMR, Maine
Sept. 7/78	Boston Is. Sheepscot R.	2,450	DMR, Maine
Sept. 18-23/78	Metinic Bell	4,800	DMR, Maine
Sept. 26/78	Muscongus Bay	5,200	DMR, Maine
March 28/79	Liverpool Harbour	7,078	DFO, St. Andrews
March 29/79	Liverpool Harbour	3,275	DFO, St. Andrews
June 1-6/79	1½ mi. off Seawall Head of St. Mary's Bay, N.S.	9,087	DFO, St. Andrews
Sept. 24/79	Shag Rock, Seal Rock, Grand Manan	1,475	DFO, St. Andrews
Sept. 25/79	Seal Cove, Grand Manan	1,425	DFO, St. Andrews
Oct. 1/79	Seal Cove, Grand Manan	2,025	DFO, St. Andrews
Dec. 10/79	Cape Dauphin, C.B.	346	DFO, St. Andrews
Dec. 11/79	3/4mi. off Ingonish Is. Cape Breton	642	DFO, St. Andrews
Dec. 11/79	S of Ingonish Bay, C.B.	408	DFO, St. Andrews
Dec. 12/79	3/4mi. NE Cape Smokey, Cape Breton	92	DFO, St. Andrews
Dec. 13/79	S of Ingonish Bay, C.B.	619	DFO, St. Andrews
Dec. 15/79	Little Lorraine, C.B.	250	DFO, St. Andrews
Dec. 11/79	Ingonish Bay, C.B.	958	DFO, St. Andrews
Dec. 11/79	Ingonish Island, C.B.	50	DFO, St. Andrews
Dec. 11/79	3/4mi. NE Cape Smokey, Cape Breton	130	DFO, St. Andrews
Dec. 12/79	S of Ingonish Bay, C.B.	1,294	DFO, St. Andrews
May 11-24/79	Carleton, Quebec	(549)	DFO, Quebec City
Aug. 11/79	Blanc-Sablon, Quebec	(5)	DFO, Quebec City
Jan. 3/80	3/4mi. off Wreck Cove, Cape Breton	431	DFO, St. Andrews
Jan. 3/80	N Ingonish Bay, C.B.	426	DFO, St. Andrews
Jan. 3/80	Cape Smokey, C.B.	202	DFO, St. Andrews
Jan. 5/80	N Ingonish Bay, C.B.	2,086	DFO, St. Andrews
Jan. 5/80	S Ingonish Bay, C.B.	294	DFO, St. Andrews
Jan. 6/80	N Ingonish Bay, C.B.	335	DFO, St. Andrews
Jan. 7/80	N Ingonish Bay, C.B.	2,468	DFO, St. Andrews
Apr. 16/80	NW Cove, St. Margaret's Bay	3,639	DFO, St. Andrews
May 12-13/80	45°21'N 61°11'W	7,286	DFO, St. Andrews
Sept. 13/79	Liverpool Harbour	(2,651)	NSDF, Halifax
Apr. 26/80	Bras d'Or Lake, West Bay	(600)	NSDF, Halifax
June 19-24/80	Iles Verte, P.Q.	(4,996)	DFO, Quebec City
Feb. 14/80	44°29'N 63°30'W	390	DFO, St. Andrews
Feb. 15/80	44°28'N 63°30'W	128	DFO, St. Andrews
June 22/80	43°40'N 65°04'W	10,036	DFO, St. Andrews
July 20-23/80	45°14'N 65°01'W	2,757	DFO, St. Andrews
July 24/80	45°04'N 65°04'W	399	DFO, St. Andrews
July 27/80	44°55'N 65°20'W	1,025	DFO, St. Andrews
July 21-22/80	45°19'N 64°57'W	550	DFO, St. Andrews
July 24/80	45°10'00"N 64°57'00"W	9,515	DFO, St. Andrews
Sept. 15/80	45°11'30"N 67°09'50"W	4,350	DFO, St. Andrews
Sept. 16/80	45°10'05"N 67°08'50"W	4,940	DFO, St. Andrews
Oct. 29/81	46°21'00"N 62°15'30"W	6,847	DFO, St. Andrews
Oct. 31/81	46°21'00"N 62°15'30"W	3,451	DFO, St. Andrews
June 19-24/80	Ile Verte, Quebec	(5,000)	DFO, Quebec City

Appendix 1. Cont'd.

<u>Date</u>	<u>Location</u>	<u>No. Herring<sup>1</sup> tagged</u>	<u>Agency<sup>2</sup></u>
Oct. 27/81	48°00'14"N 65°14'30"W	(7,000)	DFO, Quebec City
Oct. 28/81	48°23'46"N 64°26'20"W	(2,013)	DFO, Quebec City
Oct. 29/81	47°52'56"N 65°26'54"W	(3,275)	DFO, Quebec City
Oct. 30/81	48°48'06"N 64°11'56"W	(2,000)	DFO, Quebec City
Oct. 30/81	48°48'12"N 64°11'48"W	(1,100)	DFO, Quebec City
Nov. 1/81	48°47'50"N 64°11'42"W	(575)	DFO, Quebec City
Nov. 1/81	48°50'10"N 64°10'16"W	(1,075)	DFO, Quebec City
<hr/>			
Total Herring Tagged -- 1973 - 1981: 484,380			
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<sup>1</sup> The figures in brackets indicate tagging operations not included in the current analysis.

<sup>2</sup> Names of agencies involved:

- DFO - Department of Fisheries and Oceans, Canada  
Laboratories at St. Andrews, New Brunswick;  
St. John's, Newfoundland; and Quebec City, Quebec.
- NMFS - National Marine Fisheries Service, USA  
Laboratory at Woods Hole, Massachusetts.
- DMR - Department of Marine Resources, State of Maine, USA  
Laboratory at Boothbay Harbour, Maine.
- NSDF - Nova Scotia Department of Fisheries  
Laboratory in Halifax, Nova Scotia, Canada.

**Appendix 2.** International herring tagging project release and recovery areas.

U.S. AREAS

<u>AREA 1</u>	starts	41°31'N/72°00'W 40°00'N/70°00'W	to to	40°00'N/72°00'W 41°36'N/70°00'W	to ENDAT
<u>AREA 2</u>	starts	41°36'N/70°00'W 40°00'N/66°55'W 40°30'N/65°40'W 42°00'N/65°50'W 42°10'N/66°00'W 42°20'N/70°00'W	to to to to to to	40°00'N/70°00'W 40°30'N/66°55'W 42°00'N/65°40'W 42°10'N/65°50'W 42°20'N/66°00'W 42°00'N/70°00'W	to to to to to ENDAT
<u>AREA 3</u>	starts	42°35'N/70°42'W 42°00'N/70°00'W	to ENDAT	42°35'N/70°00'W	to
<u>AREA 4</u>	starts	42°35'N/70°42'W 43°16'N/69°49'W	to to	42°35'N/70°00'W 43°34'N/70°12'W	to ENDAT
<u>AREA 5</u>	starts	43°34'N/70°12'W 43°41'N/69°15'W	to to	43°16'N/69°49'W 43°55'N/69°15'W	to ENDAT
<u>AREA 6</u>	starts	43°55'N/69°15'W 43°50'N/68°03'W	to to	43°41'N/69°15'W 44°20'N/68°04'W	to ENDAT
<u>AREA 7</u>	starts	44°20'N/68°04'W 43°50'N/66°55'W 44°49'N/66°57'W	to to ENDAT	43°50'N/68°03'W 44°49'N/66°55'W	to to
<u>AREA 8</u>	starts	43°50'N/67°50'W 43°41'N/69°15'W 42°35'N/70°00'W 42°20'N/67°50'W	to to to to	43°50'N/68°03'W 43°16'N/69°49'W 42°20'N/70°00'W 43°50'N/67°50'W	to to to ENDAT

CANADIAN AREAS

<u>AREA 9</u>	starts	45°15'N/66°00'W 45°00'N/65°10'W	to ENDAT	45°00'N/66°00'W	to
<u>AREA 10</u>	starts	44°49'N/66°57'W 44°20'N/66°55'W 44°40'N/66°30'W 44°50'N/66°00'W 45°00'N/65°40'W 45°15'N/66°00'W	to to to to to ENDAT	44°49'N/66°55'W 44°20'N/66°30'W 44°40'N/66°00'W 44°50'N/65°40'W 45°00'N/66°00'W	to to to to to
<u>AREA 11</u>	starts	45°00'N/65°10'W 44°50'N/65°40'W 44°40'N/66°00'W 44°20'N/66°30'W 43°50'N/66°55'W 42°20'N/67°50'W 44°00'N/64°20'W	to to to to to to to	45°00'N/65°40'W 44°50'N/66°00'W 44°40'N/66°30'W 44°20'N/66°55'W 43°50'N/67°50'W 42°20'N/64°20'W 44°12'N/64°33'W	to to to to to to ENDAT

AREA 12

starts	44°12'N/64°33'W	to	44°00'N/64°20'W	to
	43°00'N/64°20'W	to	43°00'N/62°10'W	to
	45°58'N/62°10'W	ENDAT		

AREA 13

starts	45°58'N/62°10'W	to	43°00'N/62°10'W	to
	43°00'N/60°20'W	to	45°43'N/60°20'W	ENDAT

AREA 14

starts	45°43'N/60°20'W	to	43°00'N/60°20'W	to
	43°00'N/58°00'W	to	46°00'N/58°00'W	to
	46°50'N/58°50'W	to	47°30'N/57°35'W	ENDAT
with its N.W. boundary defined by a line across the Cabot Strait at:				
starts	46°50'N/60°20'W	to	47°30'N/59°35'W	to
	47°40'N/59°20'W	ENDAT		

AREA 15

Areas within the River and Gulf of St. Lawrence bounded by a line across the Cabot Strait at:

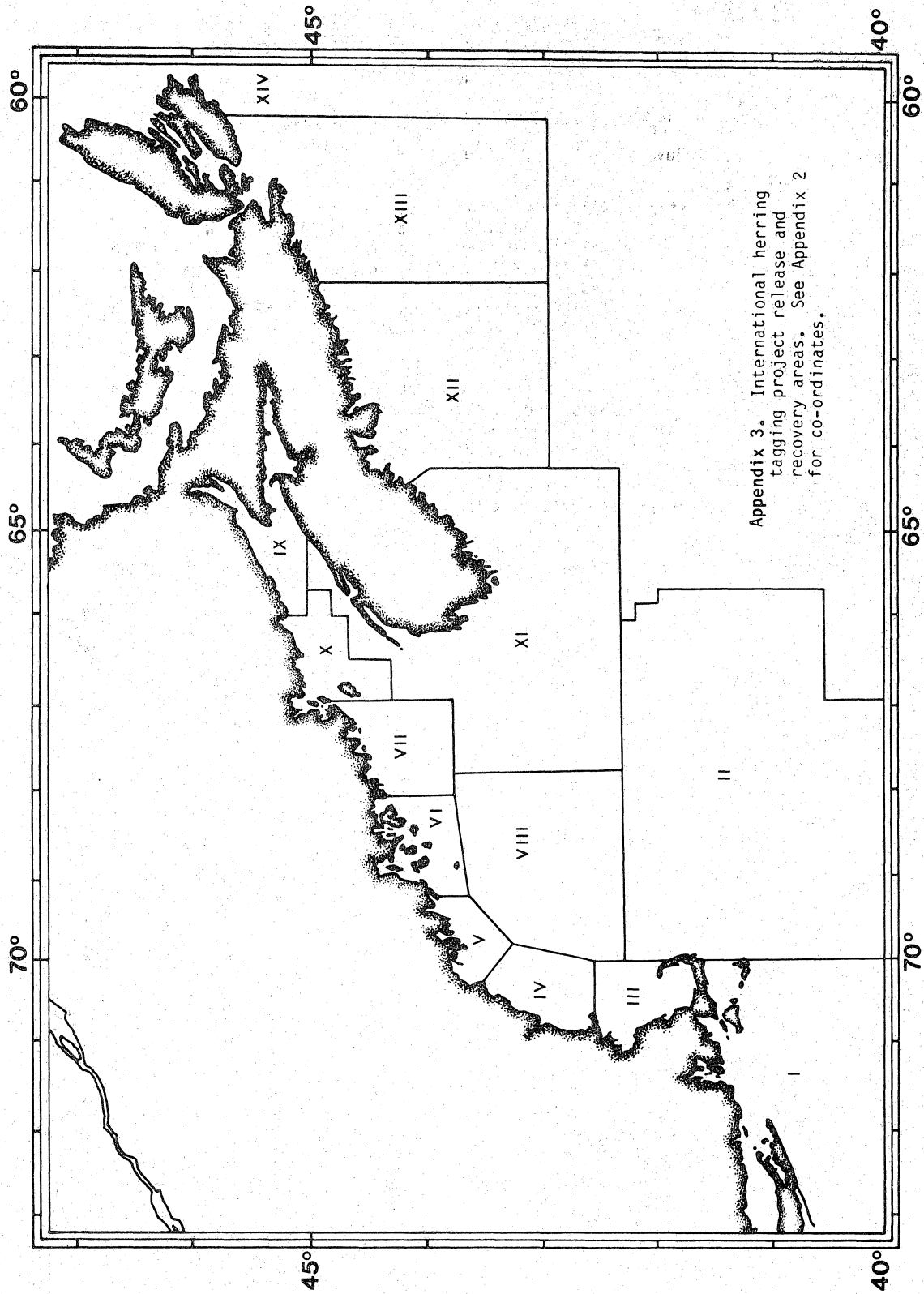
starts	46°50'N/60°20'W	to	47°30'N/59°35'W	to
	47°40'N/59°20'W	ENDAT		

and a line across the Belle Isle Straits at:

starts	51°23'N/56°30'W	to	51°40'N/56°31'W	ENDAT
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and a line across the St. Lawrence River at:

starts	47°40'N/70°00'W	to	47°55'N/70°00'W	ENDAT
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**Appendix 4. Description of the herring fisheries in tag recovery regions I-XIV.**

Region I. The fishery is conducted during the winter/spring (December-April) period principally by pair trawlers in southern New England coastal waters. The fishery is directed towards age 3 and older herring.

Approximately 50% of the age 3 fish landed are below 23 cm in length.

Region II. No significant herring fishing has occurred since 1976 when the Georges Bank stock collapsed.

Region III. The fishery is conducted by pair trawlers and purse seiners with the former being the dominant gear type utilized. The season runs from January to April and the fishery is directed towards age 3 and older fish. Approximately 70% of the age 3 fish landed are below 23 cm in length.

Region IV. The fishery is basically on August-November fishery but catches may begin as early as March when herring apparently begin to migrate northward. Few catches are made in May and June. Purse seines are the principal gear employed but pair trawlers are also utilized. During the August-October period the fishery operates on both pre-spawning and spawning fish, ages 3 and older. These fish are all greater than 23 cm in length.

Region V - VII. The fishery usually begins in late May and generally extends into November. The fishery is generally most intense during the months of July to September in all three areas. In Regions 5 and 6 stop seines and purse seines are utilized whereas in Region 7 stop seines and weirs are the dominant gear types and purse seines are used occasionally (only legal after October 15). The fishery in these three regions (5-7) are selective for age 2 fish, although all ages are harvested. Age 3 fish are all below 23 cm in length during the start of the fishery, and as the season progresses the size of the age 3 fish gradually increases.

Region VIII. There is no herring fishery in Region 8.

Region IX. The fishery is conducted in June and July by purse seiners and primarily exploits spawning fish; some pre-spawners are also taken.

Region X. The fishery is conducted primarily from April to November although in some years a winter fishery also occurs. Both fisheries exploit juvenile fish which are mainly less than 23 cm in length. The

April to November fishery is conducted by weirs (area closed to purse seiners during this period) and is mainly dependent on age 2 and 3 herring. The winter fishery, conducted by purse seiners primarily on age 2 fish, has been sporadic in recent years and annual catches appear to be related to the size of recruiting year classes.

Region XI. The fishery is basically an April to October fishery and is conducted mainly by purse seiners, weirs, and gillnets. The gillnet fisheries exploit primarily spawning fish although in some years pre-spawning adults are also taken. The weir fishery is restricted to the Bay of Fundy and is dependent on age 2, 3, and 4 fish. About 50% of these are less than 23 cm in length. The purse seine fishery exploits summer feeding aggregations of juvenile and adult fish as well as pre-spawning and spawning adults. The fishery is most intense during August and September as the fish concentrate near, and on, the spawning beds. In recent years the mean size of the fish has increased since market demand for adult fish has increase and a historic meal fishery has been terminated.

Region XII. The fisheries are basically localized summer gill net fisheries apparently exploiting small localized stocks. Gill nets are the principal gear, annual catches are relatively small, and primarily of fish greater than 23 cm in length.

Region XIII. Although a small summer gillnet fishery occurs, the principal fishery occurs in winter (November-March). The catch is taken almost exclusively by purse seines. The fishery is directed towards age 3 and older fish, and although all ages are harvested, over 70% are greater than 23 cm in length.

Region XIV. The principal fishery, in recent years, has been a purse seine fishery exploiting over-wintering adult fish. This winter fishery occurs from November to January and over 85% of the fish are greater than 23 cm in length. There is a small gillnet and trap fishery which occurs in April on pre-spawning and spawning fish. These fish are all greater than 23 cm.



**Appendix 5.** List of attendees to 'ad hoc' Working Group on Herring Tagging meeting.

W.T. Stobo (convener)  
C. Walton (rapporteur)  
V. Anthony  
L. Cleary  
T. Creaser  
M. Fogarty  
J. Gagné  
M. Hunter  
D. Libby  
H. Powles  
M. Sissenwine  
G. Waring

DFO<sup>1</sup>, Dartmouth, Canada  
DMR<sup>2</sup>, Boothbay Harbour, USA  
NMFS<sup>3</sup>, Woods Hole, USA  
DFO, Quebec City, Canada  
DMR, Boothbay Harbour, USA  
NMFS, Woods Hole, USA  
DFO, Dartmouth, Canada  
DMR, Boothbay Harbour, USA  
DMR, Boothbay Harbour, USA  
DFO, Quebec City, Canada  
NMFS, Woods Hole, USA  
NMFS, Woods Hole, USA

- 1 Department of Fisheries and Oceans
- 2 State of Maine Department of Marine Resources
- 3 National Marine Fisheries Service

