

No to be cited without prior reference to the authors

Theme Session on Cooperative Research with the Fishing Industry: Lessons Learned CM 2000 / W:20

Title: The Scotian Shelf and Southern Grand Banks Atlantic halibut (*Hippoglossus hippoglossus*) survey – Collaboration between the fishing and fisheries science communities.

K.C.T. Zwanenburg and S. Wilson

Since 1970 Canada has engaged in standardized otter trawl surveys to provide estimates of fish population abundance on the Scotian shelf. These surveys give highly variable abundance estimates for Atlantic halibut (*Hippoglossus hippoglossus*), a valuable, commercially exploited species. The groundfish surveys were not designed to estimate abundance of this non-schooling species and do not cover the entire geographic range of the population. In 1998 a longline survey for Atlantic halibut was implemented. The survey is a collaboration between Canada's Department of Fisheries and Oceans (DFO) and the community of expert halibut fishermen that exploit this species on the Scotian Shelf and Southern Grand Banks. A self-funding, long-term (10 year plus), two-stage design consisting of stratified random and commercial index phases was adopted. The stratified random phase provides unbiased estimates of population abundance while the commercial index phase provides estimates of commercial catch per unit effort. The ongoing survey has already provided a wealth of information on halibut distribution, population size and age structure ($n \approx 12,000$ fish measured), and diet composition. We give an overview of project design and implementation, the manner in which the project has provided fishermen with a voice in the resource management arena, and a summary of the biological results to date.

Address

Marine Fish Division
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
Canada, B2Y 4A2

Telephone

902-426-3310

E-mail

Zwanenburgk@mar.dfo-mpo.gc.ca

INTRODUCTION

Atlantic halibut (*Hippoglossus hippoglossus*), the largest of the world's flatfishes, occurs from the coast of Virginia in the south to the waters off Disko Bay, Greenland, in the north and occurs widely along Canada's east coast. Halibut have been fished here for several hundred years. Landings have been systematically recorded for the east coast of Canada since 1883 and have averaged about 2000t per year (Figure 1) with a current landed value of approximately \$Can 15 million. Halibut are wide ranging, some travelling hundreds of kilometres after tagging with one even travelling from the Gulf of St. Lawrence to the coast of Iceland, a distance of over 2500 km (McCracken and Martin 1955). This mobility makes determination of population structure for management purposes problematic and current management units are relatively arbitrary. Unlike most other commercially exploited demersal fish halibut are not a schooling species making it difficult to derive fishery independent estimates of population abundance from standard groundfish otter trawl surveys. In addition, landings of halibut are dominated by small longlining vessels, which land small quantities per trip in remote ports making it difficult to sample to determine the biological characteristics (length / age / maturity etc) of these catches.

There is substantial disagreement between fisheries scientists and halibut fishermen regarding the status of this species. Fishermen consider that halibut have increased in abundance in recent years and that higher total allowable catches are warranted. The scientific assessment of this resource, although indicating high mortality rates, recognized the above shortcomings in information on which the assessment was based (Zwanenburg et al 1997), the key deficiencies being in the fishery independent estimates of abundance, and in the biological characterization of catches. In light of this the Fisheries Resource Conservation Council (FRCC) recommended that "a joint DFO [Canadian Department of Fisheries and Oceans] / Industry study be conducted to assist in the overall assessment process such as appropriate biological sampling, a tagging / movement component, identification of stock sub-components and identification of alternative survey indices. . .".

A series of meetings between fisheries scientists and halibut fishermen were held from January to April of 1998 to discuss the survey design, implementation, logistics, participation criteria and selection process, sampling design and onboard survey protocols, and data streams and data storage specifications of a longline survey of the Southern Grand Banks / Scotian shelf halibut population (Figure 2). The first survey was implemented in the summer of 1998 and the third year of this survey has recently been completed. We describe the process by which the design and implementation of this survey was accomplished and provide an overview of important results from its first two years.

Process and Discussions leading to establishment of the Survey

Although the need for the halibut survey was evident, the process by which to design and implement it in an effective and successful manner was less evident. One of the key

factors contributing to its eventually successful implementation was that there was never a question of how the survey was to be funded. From the outset DFO agreed that the fish caught during the survey would be used as payment to the participants for conducting the survey. In addition, to avoid conflicts with non-participants, the quantity of halibut caught by the survey was not counted against the total allowable catch (TAC) but was to be treated as an annual overrun of the TAC. These were key concessions in that halibut has a very high landed value relative to other demersal fishes (\$Can 7.00 – 13.00 per kg landed) so that the revenue generated by even small (by industry standards) catches would be sufficient to make participation in the survey economically feasible. To allow the catches to be taken as an overrun of the TAC prevented a backlash from other fishermen. Since the overrun, which has amounted to only about 10% of the TAC each year, is small, its potential impact on the viability of the population as a whole is outweighed by the increase in our knowledge base that it has generated. DFO Science has recommended that catches of halibut resulting from this survey are not to exceed 100 t in any year.

Initial discussions on this proposal were initiated by a small number of fishermen who make a substantial part of their income from fishing halibut. Initiating such discussion was greatly facilitated by the **previous** establishment of the Fishermen and Scientists Research Society (FSRS). This non-profit organization was formed in 1994 to obtain a more accurate indicator of the health of fish stocks and determine the viability of methods of cooperation with respect to fishermen's participation in the stock assessment process, and 'how they could help to develop a sound information base that would lead to more effective resource management. This organization now has some 200 fishermen and 50 scientist members and recently held its 7th annual general meeting where the results of an array of co-operative research ventures were presented. The Society has been instrumental in advancing the degree and effectiveness of communication and co-operation between fishermen and scientists. It has also managed and conducted a **longline** survey of the eastern **Scotian** Shelf since its inception. The climate created by the Society, including the experience gained by the operation of the eastern shelf **longline** survey, set the stage for discussions of the halibut survey. **Initially** these discussions were with the FRCC and then with the working scientist. Initially we considered that the FSRS would be the ideal organization to implement and manage the halibut survey

Even though the proper- climate existed between fishermen and government scientists, there were difference of opinion and rivalries between the participating fishing communities. Fishermen members of the FSRS were mainly from communities adjacent to the Eastern **Scotian** Shelf, while the community of expert halibut fishermen resided all along the coast of Nova Scotia and southern Newfoundland. Fishermen from areas where the Society had few or no members were mistrustful of the Society and felt that it was merely a scheme by fishermen from the eastern shore (or even within the Society) to obtain a greater share of the catch. Also, because a number of government scientists are members of the Society they felt that DFO would have too much control over the survey and that fishermen themselves should be managing all but the scientific aspects. They demanded ownership. This demand for ownership of the process was shared by most fishermen and eventually united them to the point where they could work together despite

regional rivalries. **The outcome** of these discussions was that the FSRS would not manage the survey, that the fishermen themselves would manage all the logistics and finances within a separate organization, and that the DFO scientist would be responsible for ensuring that the design of the survey would generate scientifically defensible information. The DFO science staff would also be responsible for analysing the data from the survey and presenting results to fishermen participants and in other suitable for a. With these agreements reached the remaining discussions were more **focussed** and aimed specifically at resolving the details of the management structure, and the design of the survey itself.

Due to distances and logistical necessities two separate regional offices were established to oversee the survey each with an area coordinator appointed by the fishermen. It was also agreed that an equal number of fishermen from each area would be selected as participants. The coordinators assumed responsibility for advertising the survey in their respective areas to solicit participants in addition to those who had participated in the initial discussion. They developed application forms to ensure that each applicant met the criteria established for participants during the initial deliberations. These criteria were t h a t :

Participants must fish from a vessel that is less than 65' (20 m) LOA (length overall), and must have a current Canadian Steamship Inspection Certificate, or a Canadian Coast Guard Safety Certificate. The vessel must be equipped with sufficient halibut gear to complete both the random stratified and commercial index phases of the survey.

Participants must have a verifiable history as a halibut fisherman and must be a licensed fishermen at the time of application. This means that the individual skipper of the vessel applying must personally have extensive experience in the fishery rather than a fishing history that came with the -vessel. The applicant, in addition to a catch history showing that they are experienced halibut fishermen, must provide three (3) reference from the local community that will verify that the historical catches were made by the applicant. A copy of the applicant's DFO history sheet showing the captain's history may be attached, however this is optional. Participants with vessels over 45' (15 m) will be required to provide a copy of their 1998 halibut quota.

Participants must indicate the fishing grounds where they traditionally fished for halibut with an order of preference for each of the areas indicated.

Participants must be willing to sign a waiver allowing for a check of their fisheries violations record. A record of violations pertaining particularly to offenses such as misreporting, fishing in closed areas or falsification of log record information may be considered indicative of being unsuitable for participation in the survey.

A contract must be signed by each successful applicant outlining obligations and requirements. The requirements included but were not limited to

- i. That the participant be willing to pay for carrying certified fisheries observers during any or all survey fishing activities,
- ii That the participant be willing to complete his / her allotted stratified random survey sets, and that this shall entitle the participant to a predetermined number of commercial index days,
- iii. That the participant be willing to complete all stratified random and commercial index sets using the fishing protocols outlined below.

Once all applications were received, a selection board consisting of an independent chair, a representative from DFO (non-voting), and representatives from local fishing communities and other community organizations was used to select participating vessels for the halibut survey. The Board reviewed all applications submitted and decided which were the most suitable with regard to the established criteria.

Objectives of the halibut survey

The overall objective of the survey was to develop indices of halibut abundance, using experienced halibut fishermen, and to increase the overall knowledge base for this species. Most biological on distribution and abundance had previously been collected from DFO's otter trawl surveys, **This** gear and distribution of fishing effort for these surveys are less than ideal and generate highly variable information for halibut. By using a gear type more suited to capturing halibut, the survey would augment available information on geographic distribution, size and age composition, sex ratios, maturity stages. Otter trawl based **estimates of** abundance and distribution show a high degree of interannual variability, which makes it difficult to determine trends from year to year. The number of fish caught annually by DFO otter trawl surveys was small which also made it difficult to determine size and age composition, sex ratios, or maturity stages. The larger number of fish caught **in-the longline** survey would allow for improved estimates of these population parameters. Since the population area is large and spans several different jurisdictions within DFO, the area has never been covered by a single trawl survey within a short period of time. Estimates of population abundance or other parameters were of necessity, derived by combining information from surveys that were conducted at different times of year, with different survey vessels and gears. The halibut survey would cover the entire putative population area in a single **8-week** period.

There were also a number of ancillary objectives including collection of information on conversion factors between processed and live weight of Atlantic Halibut. Information on by-catch, oceanographic conditions and predator-prey relationships would be gathered to

allow for a more “ecosystem ‘based’” perspective in the determination of halibut stock status.

In addition to improving the knowledge base for this species it was intended that the interaction between fisheries scientists and this sector of the fishing industry would develop effective working relationships between the two groups and engender a sense of ownership on the part of the fishermen. This implies ownership not only of the resource but ownership of the responsibility for its sustainable use in an ecosystem context.

General Design

To satisfy both the desires of the fishermen participants to contribute their knowledge and experience to determining halibut abundance, and the necessities of statistical **rigor**, the halibut longline survey was designed as two phases. The first is a stratified random phase ‘using historical catch rates as the stratifying variable and the second a commercial index fishery. The stratified random phase was designed to give an unbiased annual estimate of halibut abundance and the commercial index phase was designed to allow participating fishermen to contribute their knowledge and fishing skills to developing an annual, standardized estimate of commercial catch per unit of effort

Stratification

The stratification variable used in the stratified random phase of the halibut survey was historical fishing success as measured by either catch or catch per unit of effort. All reported commercial halibut fishing sets completed between 1995 and 1997 were mapped using the SPANS (Tydac Ltd.) potential mapping option, and these results were used to stratify the stock area into low, medium, and high catch areas. A total of 220 stratified random sets were allocated to these areas at a ratio of **5:7:10**, for a total of 50 sets in the low catch, 70 sets in the medium catch and 100 sets in the high catch areas. The sets were further stratified by **NAFO** area ~~with sets~~ allocated proportional to the amount of each catch area in each **NAFO** area. This resulted in an over representation of the Grand Banks relative to available fishing effort (not enough vessels had the ability to fish the Grand Banks) so that the allocation to **NAFO** area 3N0 and **3Ps** was reduced to a total of 30 sets. The remaining sets were proportionally allocated over Divisions **4Vn**, **4VsW** and **4x**.

Catch and effort information for years prior to 1994 are not georeferenced and were not considered. The distribution of catches show that the shelf edge ranging from the eastern end of George’s Bank to the Canadian side of the tail of the Grand Banks, represent the areas of highest halibut catch.

Time Series

In order for the survey to become a reliable indicator of stock abundance it is essential that the survey be put in place with a view to the long-term sustainability. A survey such

as this begins to pay dividends as an indicator of abundance only when it has been in place for a number of years, with a consistent design. Significant changes in design from year to year will erode the efficacy of the survey as an index of abundance. It thus becomes important that the initial design agreed upon by the participants is carefully planned. The time frame agreed upon for the halibut survey was 5 – 10 years.

Timing of the Survey

In order for the survey to be a reliable and comparable indicator of halibut abundance it must be conducted over the entire stock area within the shortest possible time. During the development of the survey it was indicated that different portions of the stock area were traditionally fished at different times of the year. It was proposed that this be used as the basis for the survey timing. Extending the survey over the entire year or a significant portion of the year would allow for migration of fish to confound the estimates of abundance. This may have resulted in “double counting” if fish migrate from survey area to survey area in the sequence in which they are fished, or to significant underestimates if fish migrate so as to avoid the area being fished at any particular time.

It was agreed that the stratified random and commercial index phases of the survey be conducted within a 2 months (8 week) time frame mid May to mid July. The actual dates for the survey has been May 22 to July 22 in each of the three years. For both the stratified random and commercial index phases (see below), vessels operate under a Halibut Survey Condition of License issued by the Department of Fisheries and Oceans. Once a vessel begins the Halibut Survey, it is required to complete its work before resuming activity under any other condition of license.

Catch Per Unit Effort and Fishing Protocols

An important concept in gauging how a fish stock is responding to fishing pressure is the Catch Per Unit Effort (CPUE). Simply put, this is how much fish can be caught for a given amount of fishing effort, often defined as # of hooks, length of tow or time spent fishing. In the Stratified Random phase of the halibut survey, the CPUE is standardized as much as possible (i.e.: all vessels fish the same number of hooks for approximately the same length of time at every predetermined location). This gives us a fair representation of how many fish were available to the fishery at each random sample station at a particular time.

Fishing protocols for the stratified random phase were that;

The coordinators of the survey contract a total 22 **longline** vessels meeting the selection criteria and each vessel will complete a minimum of 10 stratified random survey sets

Fishing will be at predetermined stratified random stations.

Each station will be fished with a single set consisting of 1000, # 14 or larger circle hooks set consecutively and baited with a recorded bait type. (The bait type used is to be recorded under “comments on the set”)

Each stratified random set as defined above, will be set within 1.5 miles (changed to 3 miles in 2000) in any direction of the predetermined set location. In other words each set location actually defines a 3 (6) mile diameter circle within which the set must be made.

Gear will be set between 4:00 AM and 12:00 noon of the same day, and soak time (time the set fishes) will be no less than 6 hours and no more than 12 hours

There will be a minimum of 220 stratified random sets fished in each survey year. This translates to a minimum of 10 stratified random stations per participating vessel.

During the stratified random phase, vessels which have been assigned sets which fall inside the Browns Bank, or Emerald / Western Bank closed areas, will be **allowed** to fish these sets as outlined above in this section.

For the commercial index phase the protocols were that;

Each vessel will be permitted to fish for a maximum of 8 days for completion of the 10 stratified random sets fished as outlined above.

Vessels can set a maximum of 7,000 hooks per day (minimum #14 hook). A fishing day is based on any calendar day on which gear is set.

Vessels -will fish as if they were fishing commercially except they are not permitted to fish inside ~~existing closed~~ area (Browns Banks, and Emerald Western Bank Closures).

Biological Observers

—

It was agreed that in 1998 all survey activities would require (as a condition of license) the presence of certified **onboard** fisheries observers. This requirement was agreed to both to ensure that an independent observer could verify information collected by the survey and that the requisite biological information would be collected for all survey activities. The requirement for observer coverage was reduced in subsequent years such that presently all stratified random survey activities are observed but a smaller percentage of commercial index sets are observed. Captains of participating vessels are responsible for arranging and paying for **observers** directly.

Fisheries observers are widely deployed on both foreign vessels fishing in Canadian waters and on domestic vessels fishing. On domestic vessels they are deployed to fisheries for which ancillary biological information is required or where a particular

regulatory issue requires on-board enforcement. Observers are certified through a DFO controlled program and are deployed and regulated through a private sector company. Data collection forms are consistent with DFO Science data formats and information is edited and entered into the database by the observer company.

Observers were required to fill out a situation report on each trip for which they are present. Observer will be responsible for carrying out all biological sampling including the recording of all data, and proper labeling of all sample materials collected outlined in the survey manual

Hailing

Vessels will be required to hail out (inform) prior to sailing to the Appropriate Coordinating Office and to hail in prior to landing. Hail Outs will consist of the name of the vessel, the time and date of sailing; the station #'s planned it plans to complete and the expected time of landing.

Dockside Monitoring

All landings made in either the stratified random or the commercial index phases of the survey must be certified through the dockside monitoring program. These programs were set up by DFO to improve the accuracy and quality of landings information collected for all fish resources. The program requires that all fish landings be weighed and verified with regard to species composition by and independent weighmaster

All completed weigh-out forms must be transmitted from the Dockside Monitoring Company to the appropriate coordinating office and then to the Scientific Authority within 12 hours of landing.

All landings made in either the stratified random or the commercial phases must be tallied (summed) daily between the two coordinating offices and the Scientific Authority. If the sum of the halibut landings reaches 100 t prior to the closing date of the survey, or prior to all participants completing their stratified random or commercial index activities, the conditions of license will be revoked and the survey will be terminated for the current year.

The survey regional coordinating offices will pay for DMP charges and then charge these costs to individual participants

Payment

Vessels will contribute **2%** of **their** gross halibut stock with the appropriate coordinator **upon** settlement of each **trip**. This 'tax' was applied to all participants both to pay for the costs of coordination activities and to ensure that no participant would lose money as a result of participating in the survey. If any participant lost money as a result of

participation it was agreed that these tax monies would be used to redeem at least the money spent (outlay) in participating.

Setting Up Vessels for Sampling

It is important that skippers and crews in cooperation with the observer, of participating vessels take the time to set up a sampling/work station which allows them to sample fish with the least hindrance to normal fishing procedures. The detailed biological sampling requirements will not be outlined in the present document but a copy of the survey manual which outlines these is available from the authors on request.

Survey Results to 1999

Although the survey has been carried out for the past two years, it was recognized from the outset that this survey would only become a reliable index of stock abundance when it had been in place for a number of years (5 or more) with a consistent design. Significant changes in design from year-to-year **would** decrease the efficacy of the survey as an index of abundance. In 1998, during its first year, the survey was not able to cover the entire stock area as a result of limited access to Sub-area 3 (Southern Grand Banks, see Figure 2). This access issue was resolved in 1999. The estimates of halibut population and abundance are therefore not strictly comparable between the two years for the stock as a whole. Subsequent years of information will provide the time-series of the halibut abundance index necessary to determine the trajectory of this population.

Although it is premature to use the survey as an indicator of population abundance, it has been extremely successful in generating a wealth of information on the distribution and biology of this valuable species.

I Preliminary Abundance Indices

The overall survey results are given in the table below. The results are presented for the stratified random and commercial index phases together. These results are preliminary and may change because of data editing.

For the stratified survey the average should really be calculated per stratum to provide an area weighted average catch per unit of effort. However due to changes in survey distribution between 1998 and 1999 (a reduction of coverage in the Bay of Fundy and an increase in coverage of the Southern Grand Banks) such estimates are not warranted at this time. Stratified estimates will be calculated when survey design has been stabilized for a number of years. It is very encouraging that the results are relatively consistent between years and that the estimates have (as far as survey results go) reasonable confidence intervals. This indicates that the average catch will be comparable between years to determine the population trajectory once more surveys are completed. The geographic distribution of stratified random sets for 1998 and 1999 (Figure 3) show the

relative paucity of sets on the southern Grand Banks in 1998 and the improved coverage in 1999.

The results of the commercial index should also be considered preliminary. Again the results appear to be relatively consistent between years which indicates that comparison of these catch rates from year to year will allow us to draw conclusions about population trajectories. The distribution of commercial sets (Figure 4) describes a relatively small preferred area for fishing consistent with the geographic distribution of halibut derived from trawl survey results (Figure 5).

In the initial discussion about survey design there was significant skepticism, on the part of fishermen participants, about the ability of the stratified random phase of the survey to tell us anything useful. However, in the two years, the stratified results identify the same areas of high catch rates as the commercial index. By this we mean that if we compare the stratified random results to the commercial index results, the high catch rates are found in more or less that same areas in each year of the survey. Figures 6 and 7 give the halibut catch rates of the stratified and commercial index sets for 1999 as an example. This result alone significantly increased the level of confidence in and acceptance of the stratified random survey results among fishermen participants.

Halibut Survey Results (Preliminary)

(Kilograms per 1000 hooks)

		min	max	mean	upper	sdev
stratified	1998	0	676	49.8	237.4	93.8
stratified	1999	0	1338	59	380.6	160.8
commercial	1998	0	1090	116.5	336.9	110.2
commercial	1999	0	1350	113.2	349.6	118.2

II **Processed weight to live weight conversion factors.**

The survey participants in 1998 conducted a conversion factor study. The results of this study have been analyzed and reviewed (Zwanenburg and Wilson 1999). They were accepted by DFO management and implemented in 2000. The overall impact of these changes in conversion factor is to reduce the conversion factor from processed to live weight thereby effectively increasing the total allowable catch.

.111 **Estimation of halibut size / age distribution.**

One of the most significant knowledge gaps for this species is information on the size / age composition. Trawl survey catch only a few fish per year and the length frequencies estimated from these surveys are incomplete and difficult to interpret (Figure 8). The halibut survey has provided a very good estimate of the length frequency distribution for this population (Figure 9). We are in the process of carrying out an age validation experiment. Initial results using radionuclides give some indication that the rings observed in halibut represent annual rings. If this is confirmed we can determine ages from otoliths to estimate population age structure and mortality.

IV By-catch, halibut as part of an ecosystem

Canada has a stated desire to manage fisheries from a more ecosystem-based perspective. Although the exact definition of this continues to be debated, it is certain that there will be an increased recognition of harvested species as part of an integrated and interconnected ecosystem rather than as isolated entities. Knowledge about the impact, of fisheries on non-target species and on the physical environment will become increasingly important.

The halibut survey has generated valuable information on by-catch rates for species caught during the halibut fishery. The careful weighing, counting and measuring of all species caught during the surveys allows us to determine the by-catch profile of the survey. The data collected allows us to estimate by-catch rates for all species caught and thereby to start making some estimates of the “ecological costs” of the survey, at least in terms of direct impacts on other fish species. For example in 1999, the by-catch rate of cod in the survey was 32% of the halibut catch (3211 kg of cod for every 10,000 kg of halibut) while in 1999 this rate was only 18% (1852 kg of cod for every 10,000 kg of halibut). We could estimate this by-catch rate for each non-target species and determine the by-catch profile for the survey as a whole. If the survey were sufficiently representative of the fishery as a whole this would allow us to estimate the by-catch profile for the halibut fishery. An overall by-catch profile for the halibut survey shows the diversity of organisms caught (Figure 10). Spatial analysis of these by-catch rates show that they vary spatially within the halibut management unit for each by-catch species. Such spatial variation in by-catch rates could provide the basis for management options aimed at reducing by-catch of key species.

V Diet composition

Since halibut are important predators within the Scotian shelf and Grand Banks ecosystems, information on what and how much they eat, and what eats them, is important to understanding ecosystem structure and function. Several hundred halibut stomachs have been collected and are being analyzed and a subset of these results are presented below. This diet information will provide initial estimates of the predator prey relationships for this species. These data will also be used as input to an ECOPATH model of the Scotian shelf presently under development.

VI Information on other species

The halibut survey has also generated a wealth of information on the distribution, abundance, and size structure of a number of other species not effectively surveyed by trawl gear. Commercially important examples include white hake (*Urophycis tenuis*), cusk (*Brosme brosme*), and a number of other species. These data will be used to supplement the results of the trawl surveys in assessing both the status of these stocks and to help in the understanding of the ecosystem as a whole.

The size frequencies of cod, cusk, and, white hake caught during the survey are given in show the presence of more large fish than do the trawl surveys for these three species. Part of this is due to the large hooks used in the survey (selection) and part by the deeper water surveyed (the DFO trawl surveys only fishes to 200 fm while the halibut survey fishes to depths of 400 fm [800 m] and deeper). These larger fish are rare or absent in the trawl surveys. Their presence is important to the recruitment potential for these species.

VII Tagging Studies

In addition to the halibut survey per se, a halibut mark and recapture program has been in place since the early 1990's. This program is ongoing and has resulted in the release of about 2000 tagged halibut and the recapture of about 200 of these (Figure 12). Volunteers including the participants in the halibut survey have done all tagging. The results to date indicate that halibut become more sedentary as they get older, and that younger fish are very wide ranging (1 000+ km or more). These results which are consistent with previous studies (Stobo et al 1988) will help in the definition of population boundaries.

Conclusions

Although the full value of the halibut survey will not be realized for another 3 or more years, it has already been immensely successful in increasing the knowledge base for this species and in fostering an effective working relationship between halibut fishermen and fisheries scientists. Key to the success of this initiative to this point is the degree of ownership by the fisherman participants, the use of trained observers to collect the requisite biological information and the feedback of results to survey participants.

Literature Cited

McCracken, F. D. and Martin. W. R. 1955. Recent recoveries of tagged halibut. Fisheries Research Board of Canada Progress Report Atlantic Coast Station No. 6 1: 3-4.

Stobo. W.T., Neilson, J.D., and Simpson, P.G. 1988. Movements of Atlantic halibut (*Hippoglossus hippoglossus*) in the Canadian North Atlantic. Canadian Journal of fisheries and Aquatic Sciences. Vol. 45: 484 - 491.

Zwanenburg, K., G. Black, P. Panning, R. Branton, and S. Wilson. 1997 Atlantic Halibut (*Hippoglossus hippoglossus*) on the **Scotian** Shelf and Southern Grand Banks: Evaluation of Resource Status. Canadian Stock Assessment Secretariat Research Document 97 / 50.

Zwanenburg, K. and S. Wilson 2000. Halibut survey on the Southern Grand Banks and **Scotian** Shelf – Participants Manual. 30 pages.

Zwanenburg, K, and S. Wilson. 1999. Processed weight to live-weight conversion factors for Atlantic halibut (*Hippoglossus hippoglossus*) of the **Scotian** Shelf and southern Grand Banks. Canadian Stock Assessment Secretariat Research Document 99/157.

List of figures

Figure 1. Halibut landings by NAFO statistical area from the East Coast of Canada

Figure 2. Geographic area of the halibut survey. The survey covers all waters to a depth of approximately 500 fm (1000 m) in NAFO statistical areas 3NOP4VWX.

Figure 3. Station locations for the stratified random phase of the halibut **longline** survey for 1998 and 1999. Note the increased coverage on the southern Grand Banks and the reduction in coverage of the Bay of Fundy in 1999. Survey protocols dictated that fishing must occur within 3 nm of the specified location.

Figure 4. Station locations for the commercial index phase of the halibut survey for 1998 and 1999. Note that the overall location of fishing activities is quite consistent between years and that the preferred area corresponds to the areas of high halibut abundance as defined by the long-term results of DFO trawl surveys (compare to Figure 5).

Figure 5. Average halibut catch per standard survey set for the DFO summer surveys A) average catch for the period 1970 – 1999 aggregated by 20 minute square, and B) average catch per set aggregated by 10 minute square for the 1999 survey.

Figure 6. Results (expressed as kg of halibut caught per 100 hooks set) for the 1998 commercial index phase of the **longline** halibut survey.

Figure 7. Results (expressed as kg of halibut caught per 100 hooks set) for the 1998 stratified random phase of the **longline** halibut survey.

Figure 8. Length frequencies of halibut caught during the 1997 through 1999 'DFO summer otter trawl surveys of the **Scotian Shelf**

Figure 9. Length frequency of halibut caught during the 1999 **longline** halibut survey. Note the greatly improved estimate of population length frequency estimated by the **longline** survey relative to the results of the DFO summer trawl survey (Figure 8).

Figure 10. Proportional **fish** species composition of the 1998 halibut **longline** survey.

Figure 11. Release and recapture locations for halibut tagged during the **Scotian Shelf** Grand Banks halibut-tagging project. The arrowhead indicates the point of recapture.

Table 1. Diet composition (frequency of occurrence) for 100 halibut collected during the 1998 halibut longline survey.

ITEM	Type	Total
Bait	Mackerel	2
Bait Total		2
Crustacean	Amphipod	3
	Crab (Cancer sp.)	4
	Crab (Hermit)	5
	Crab (Hyas sp.)	13
	Lobster (Munida sp.)	2
	Parts	2
	Snow crab	7
Crustacean Total		36
Echinoderm	Brittlestar	2
	Sea Urchin	2
Echinoderm Total		4
Fish	American Plaice	4
	Argentine	2
	Cod	6
	Flounder sp.	4
	Haddock	2
	Herring	1
	Mackerel	10
	Monkfish	2
	Parts	2
	Pollock	1
	Red Hake	4
	Redfish	57
	Sandlance	15
	Silver Hake	8
	Unidentified	16
	White Hake	4
	Witch Flounder	2
	Yellow Tail Flounder	1
Fish Total		141
Fish eggs	Unidentified	2
Fish eggs Total		2
Fish fluid	Unidentified	0
fluid Total		0
Inorganic debris	Rock	10
	Unidentified	0
Inorganic debris Total		10
Mollusc	Bivalve	2
	Operculum	1
	Sea Scallop	2
	Shell Fragments	4
	Squid (beaks)	1
Mollusc Total		10
Nematode	Unidentified	1
Nematode Total		1
Polychaete	Trumpet Worm	1
Polychaete Total		1
seaweed	Unidentified	4
Seaweed Total		4
Grand Total		211

Figure 1. Halibut landings from the east coast of Canada since 1883

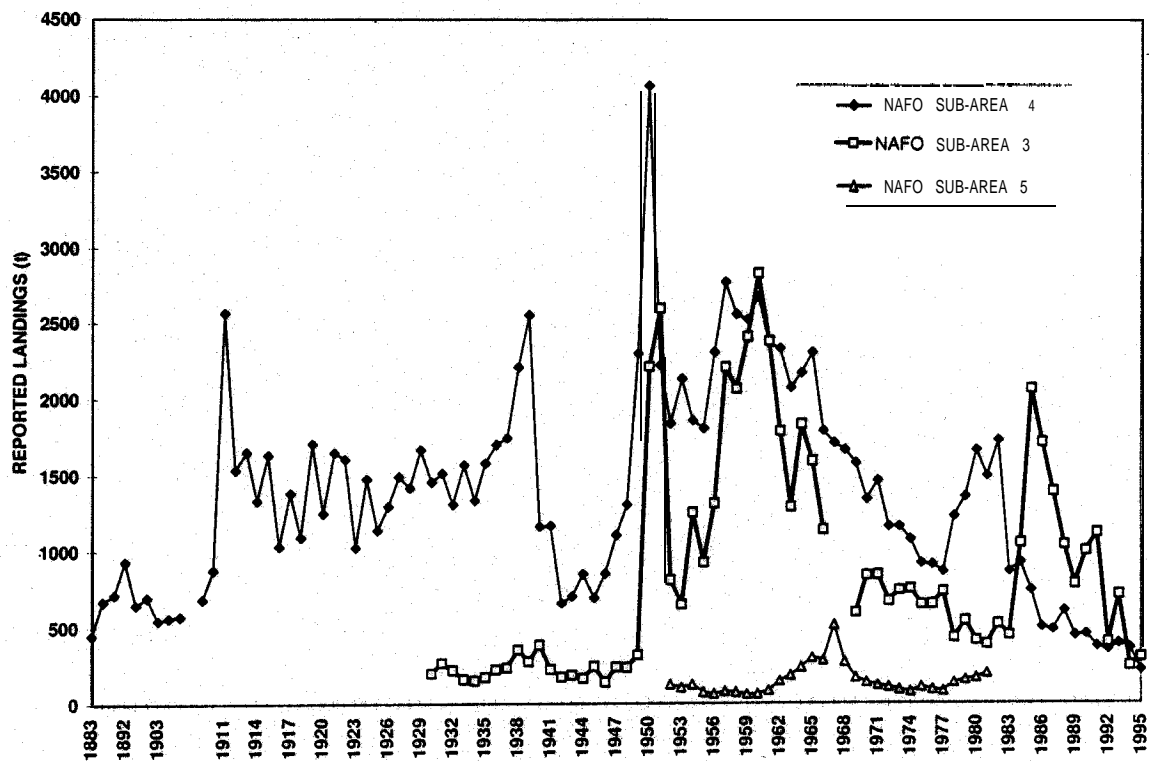


Figure 1

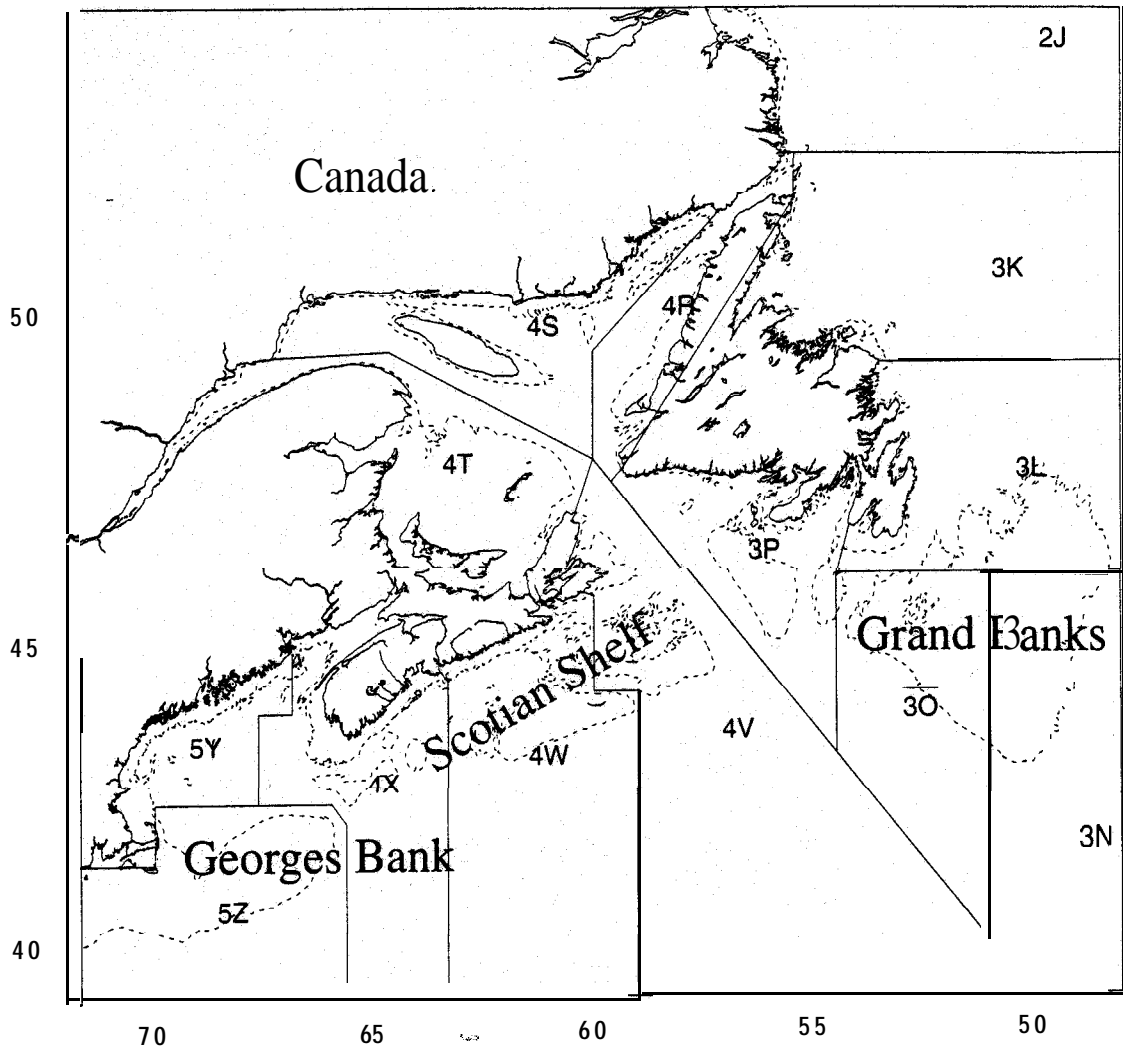


Figure 2. The area covered by the halibut survey includes the Scotian Shelf and Southern Grand Banks (NAFO Divisions 3NOP4VWX)

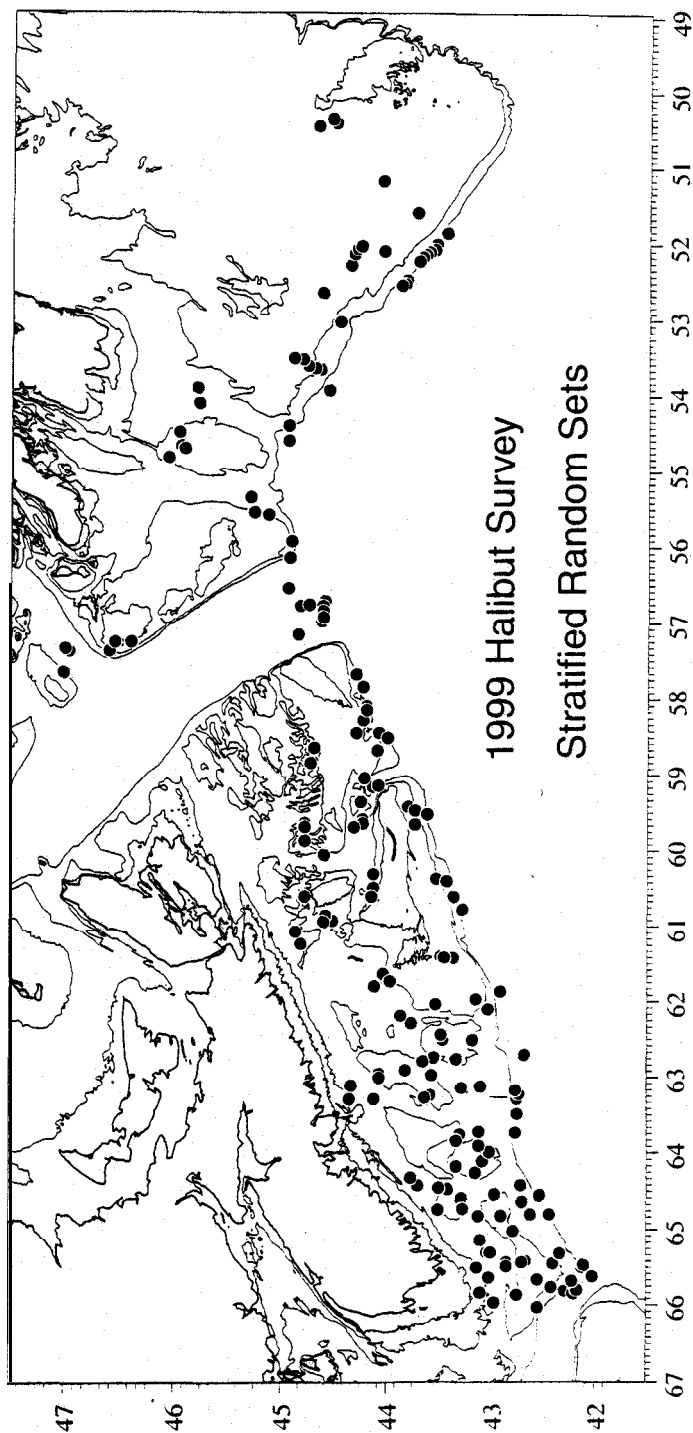
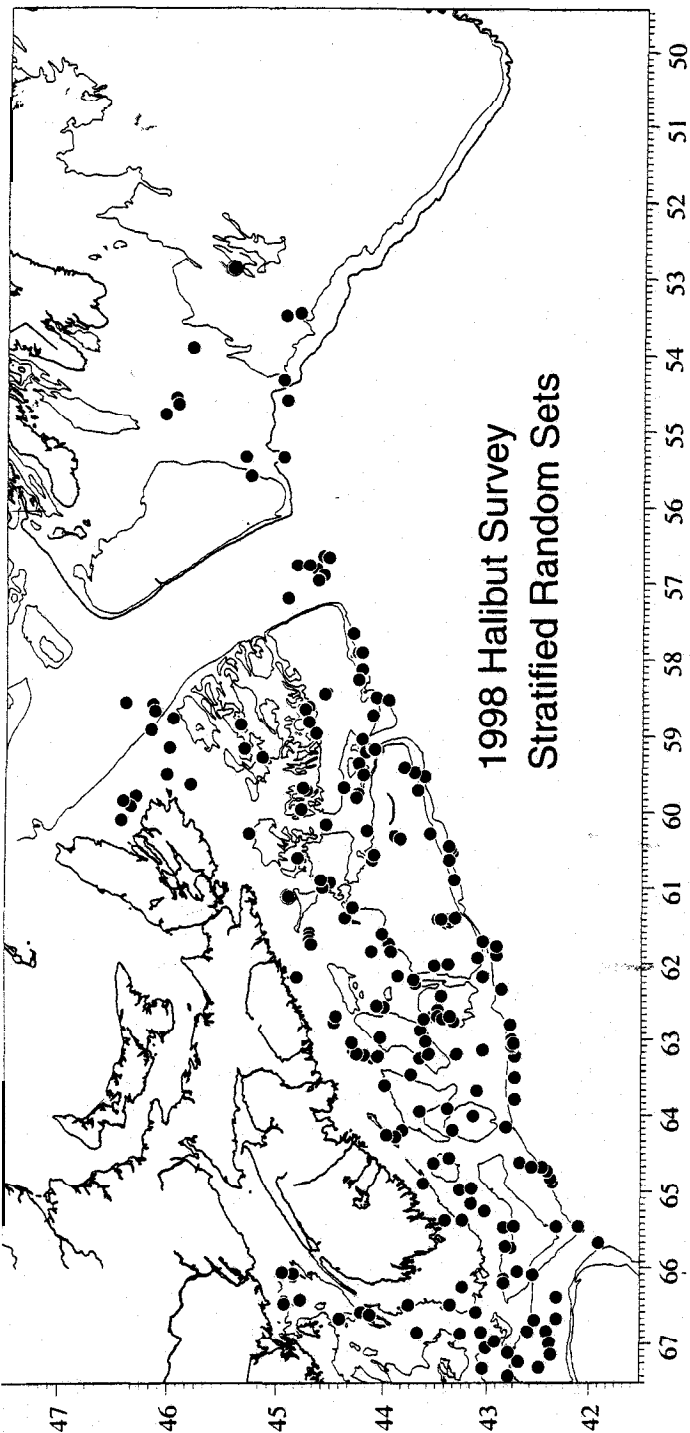


Figure 3

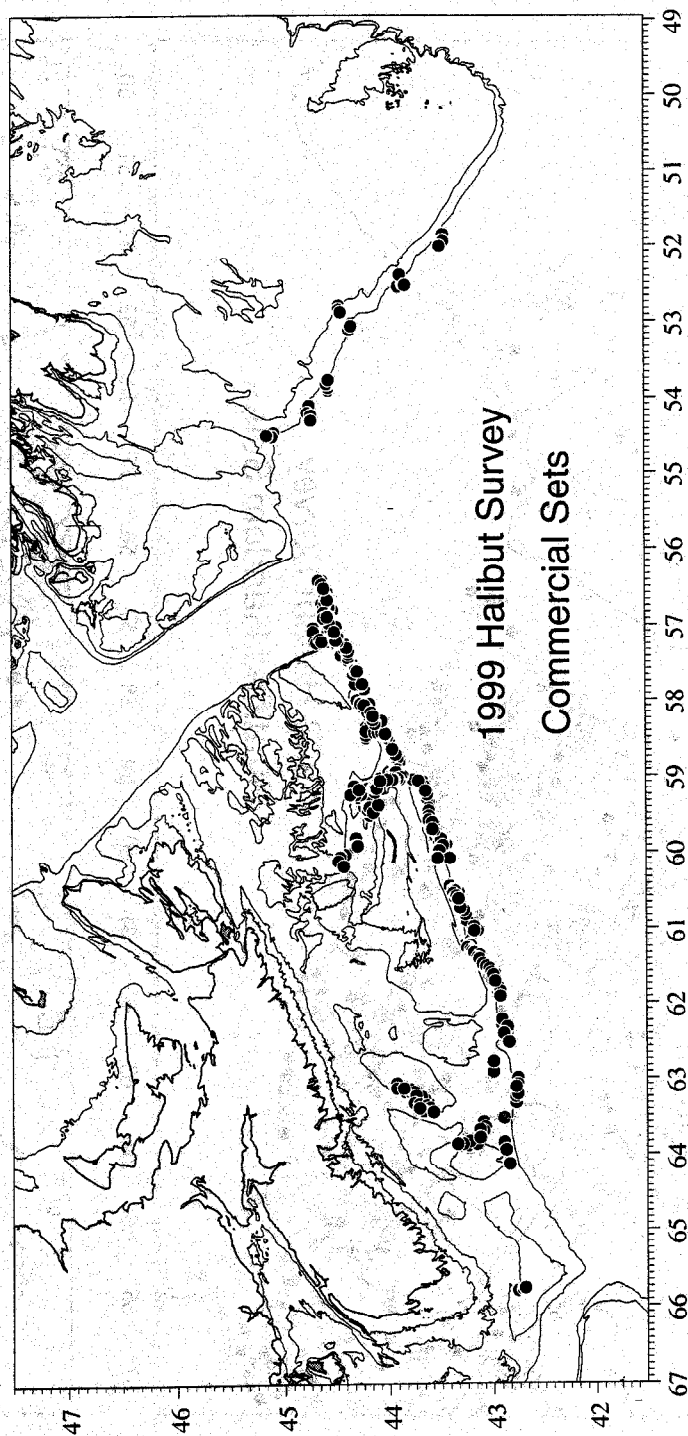
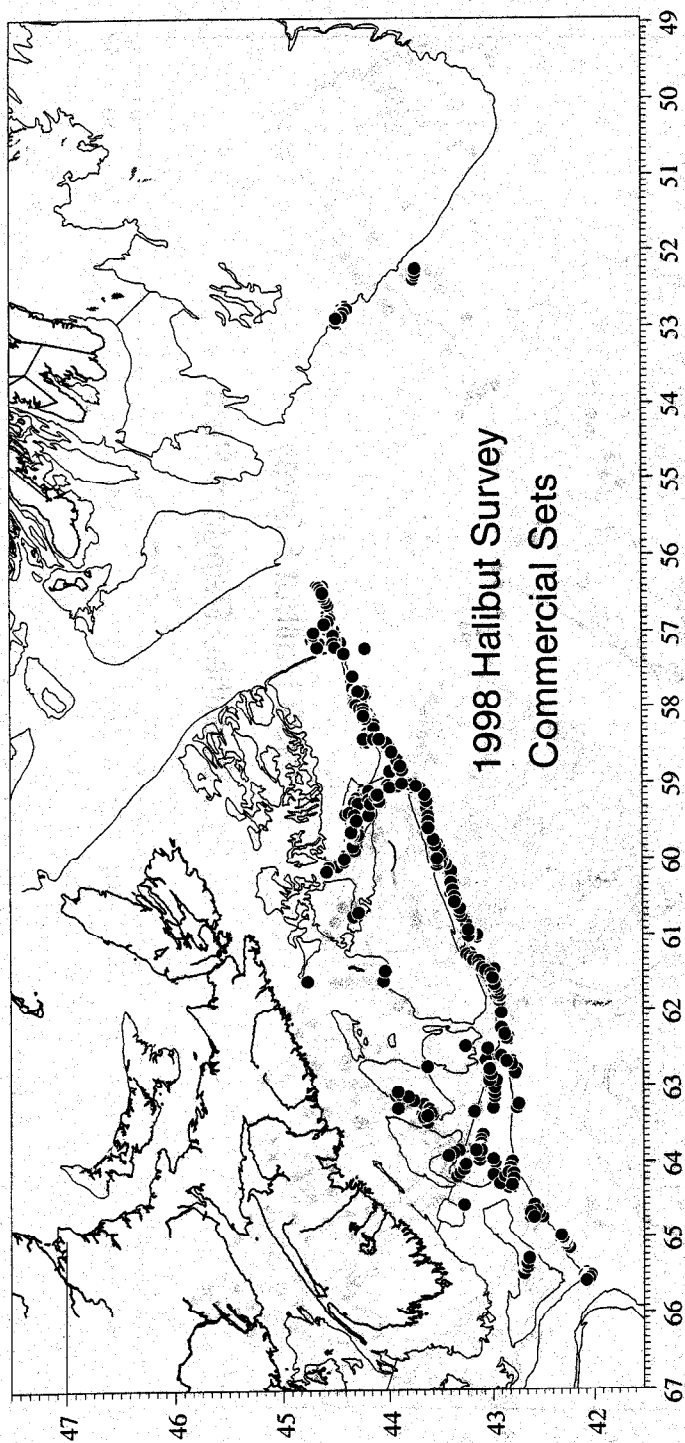
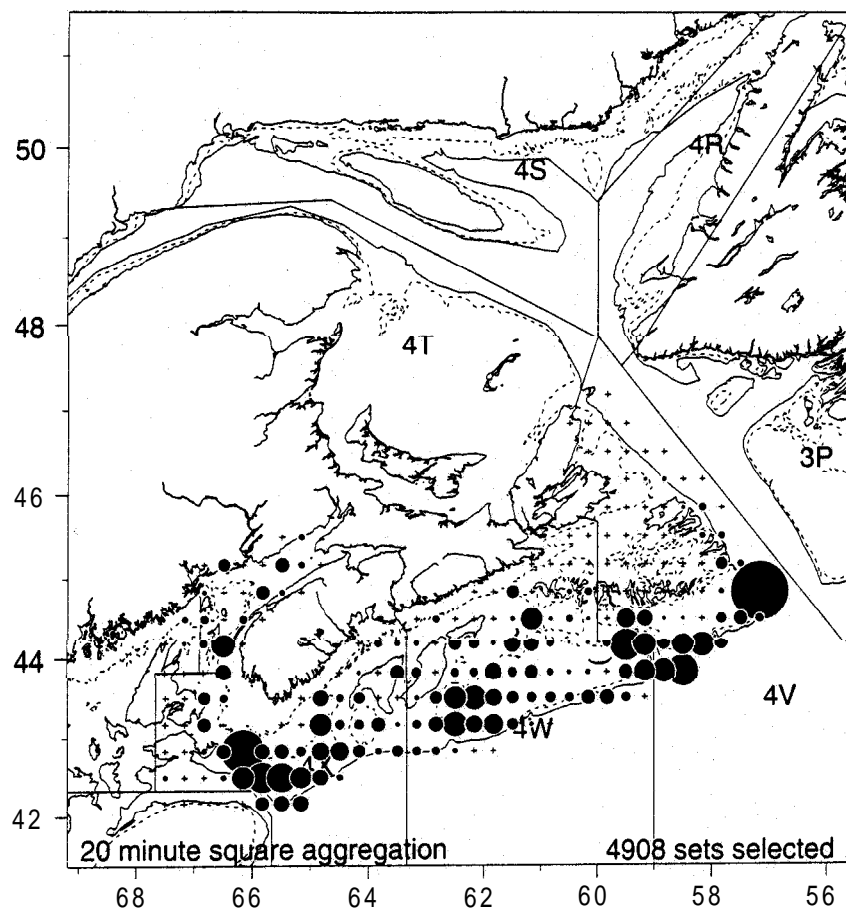
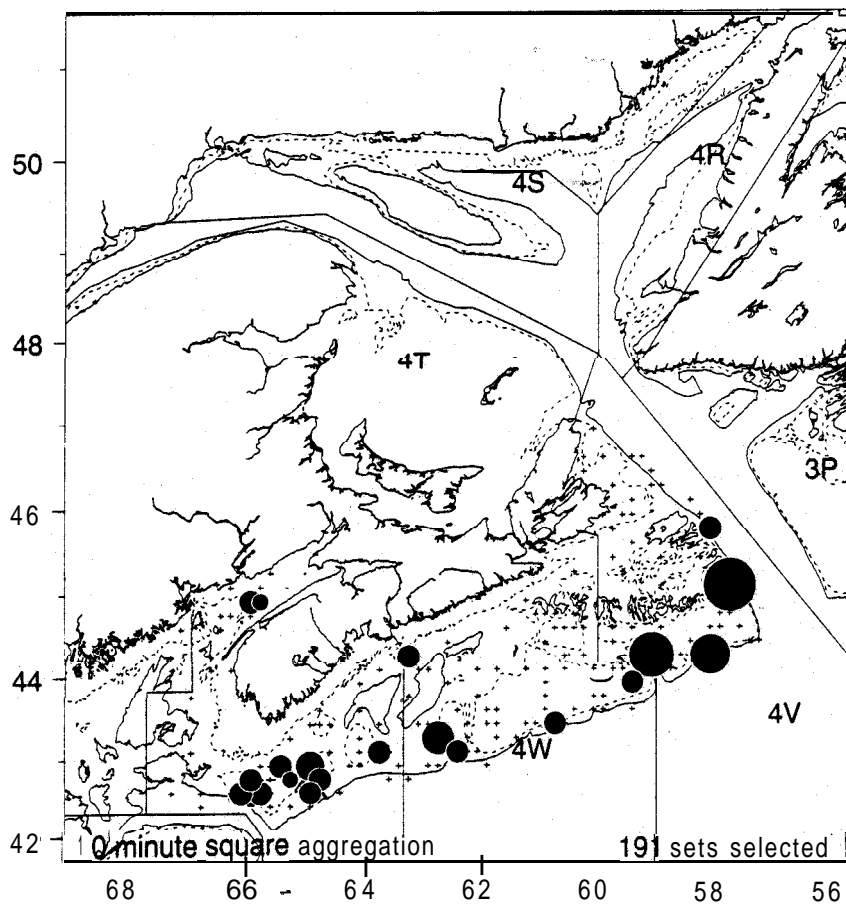


Figure 4



A. Halibut (Atlantic) Summer Survey
1970 - 1999 Total numbers caught



B. Halibut (Atlantic) Summer Survey
1999 Total numbers caught

Figure 5

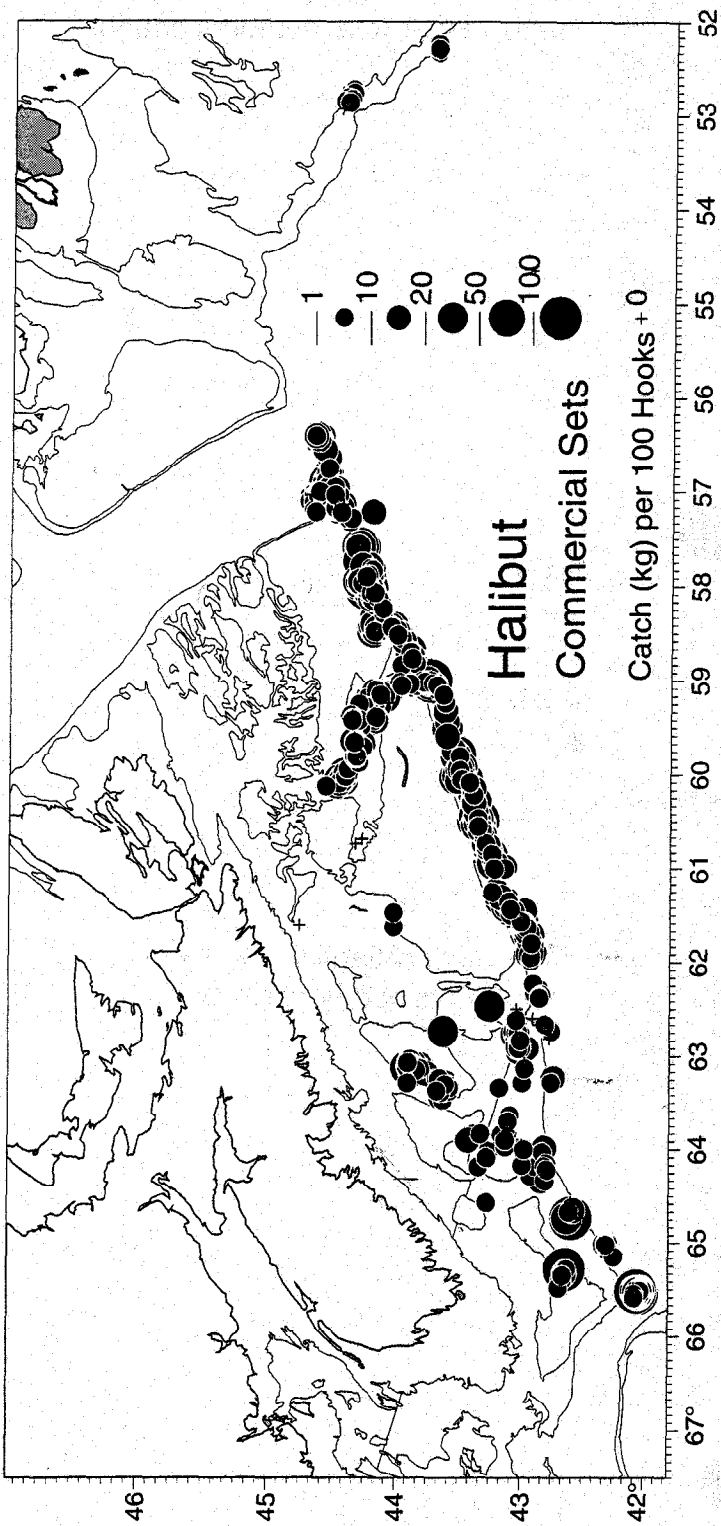


Figure 6

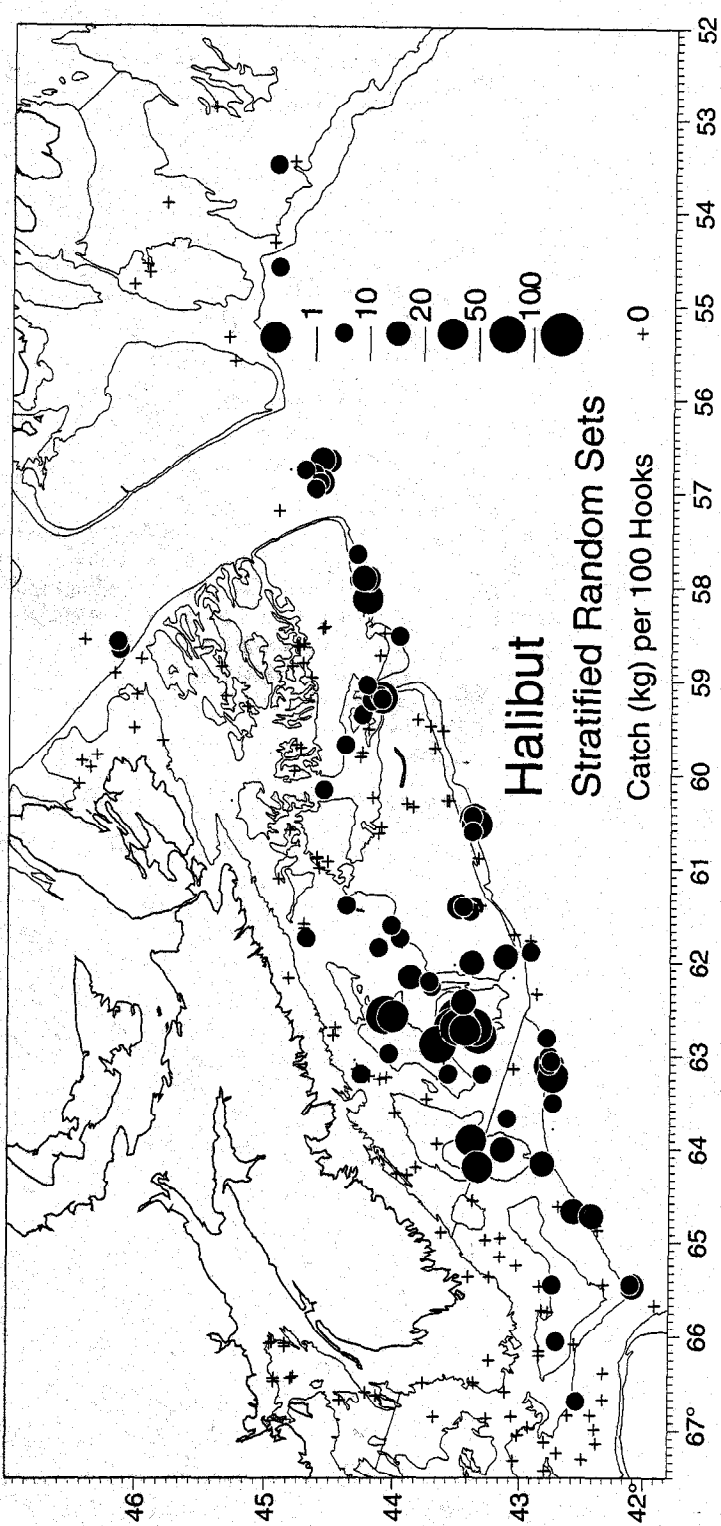


Figure 7

Figure 8 Trawl survey results

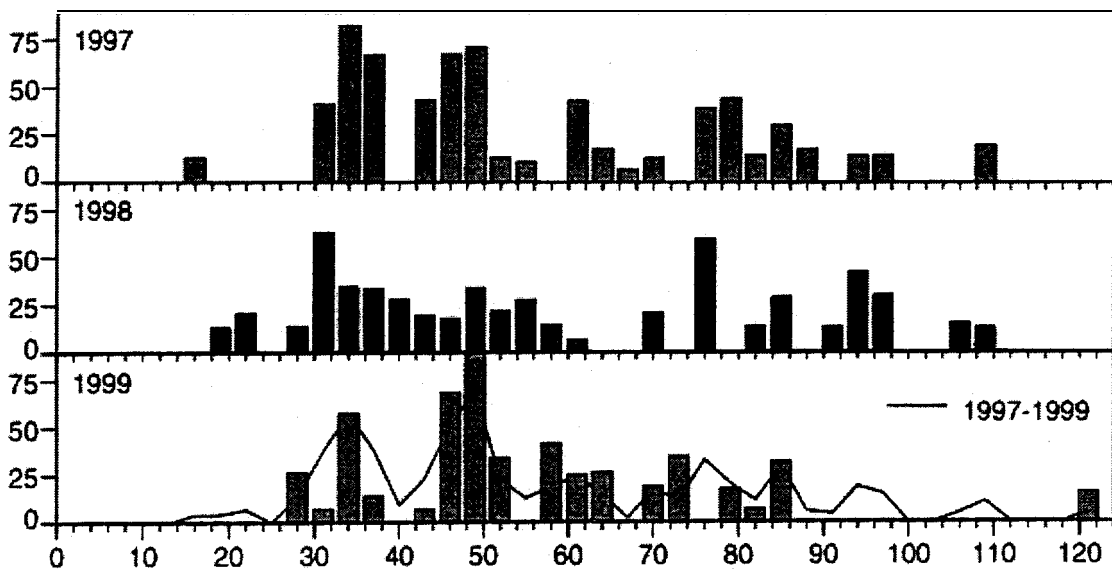
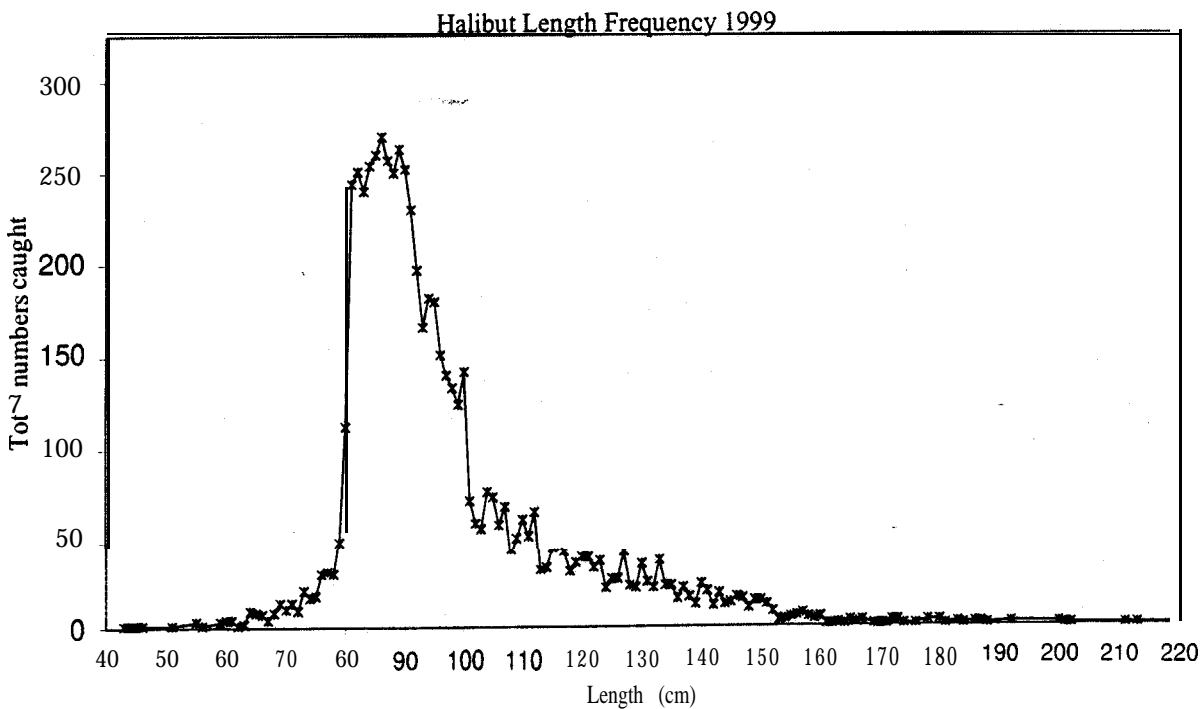


Figure 9 Halibut longline survey results



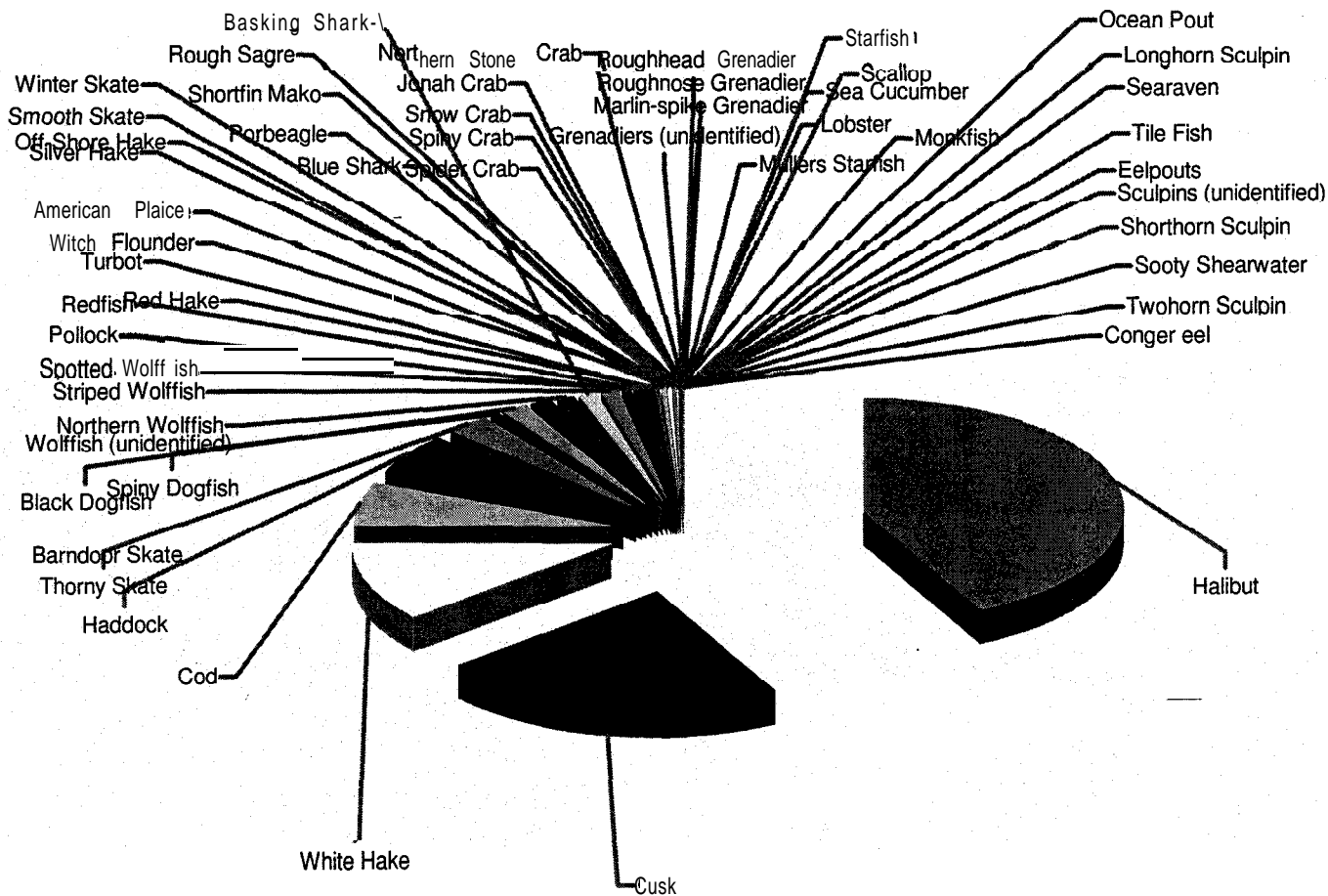
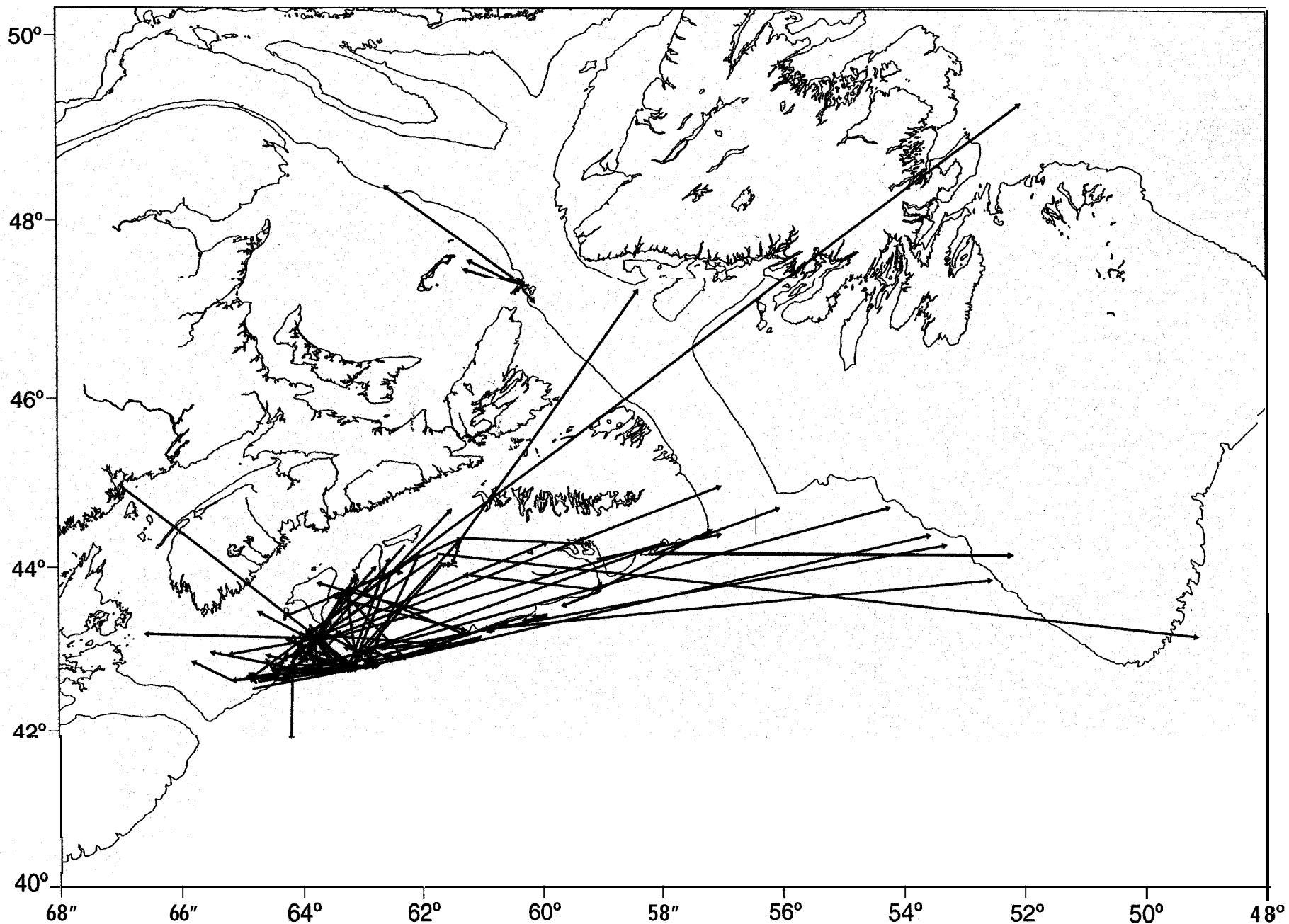


Figure 10



Halibut Tagging Project: Release-Recovery Arrows. All data through Spring 2000. (n=177)