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

DFO Atlantic Fisheries
Research Document 96/45

Ne pas citer sans
autorisation des auteurs[1]

MPO Peches de l'Atlantique
Document de recherche 96/45

Northern Cod Stock Assessment: What Can be Learned from Interviewing Resource Users?

by

Barbara Neis and Larry Felt,
Dept. of Sociology,
Memorial University ,St. John's Newfoundland A1C 5S7

David C. Schneider and Richard Haedrich,
Dept. of Biology,
Memorial University
St. John's Newfoundland A1B 3X7

Jeff Hutchings,
Dept. of Biology,
Dalhousie University, Halifax N.S. B3H 4J1

Johanne Fischer, Eco-Research Project,
202 Elizabeth Ave., Memorial University, St. John's, Nf.
A1B

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

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

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

Les Documents de recherche sont publiés dans la langue officielle utilisé dans le manuscrit envoyé au secrétariat.

Abstract

Fishers have detailed knowledge of their resources and their environment, but this knowledge is very different from that which is generally used in stock assessments. This document presents preliminary findings from interviews with inshore and longliner fishers in the area between Princeton, Bonavista Bay and Dildo, Trinity Bay. We highlight four areas in which these fishers' knowledge of their resources, if gathered in a systematic fashion, could contribute to northern cod stock assessments. These areas include: cod stock structure, changes in catchability, information on abundance in a closed fishery, and potential impacts of a reopened caplin fishery on northern cod stock recruitment.

Résumé

Les pêcheurs connaissent très bien les ressources et leur milieu, mais ces connaissances sont très différentes de celles qui sont actuellement utilisées pour évaluer les stocks. Le présent document décrit les résultats d'entrevues avec les pêcheurs côtiers et les palangriers de la région s'étendant entre Princeton, dans la baie Bonavista, et Dildo, dans la baie de la Trinité. Nous soulignons quatre domaines où les connaissances des pêcheurs sur les ressources, si elles étaient recueillies de façon systématique, pourraient contribuer à l'évaluation du stock de morue du Nord. Ces domaines sont : la structure du stock de morue, les changements dans la capturabilité, l'information sur l'abondance dans une pêcherie fermée et les répercussions possibles de la réouverture de la pêche du capelan sur le recrutement du stock de morue du Nord.

Northern Cod Stock Assessment: What Can Be Learned from Interviewing Resource Users ?[1]

Fishers develop detailed knowledge of their resources and their environments. Their knowledge differs significantly, however, from that generally associated with stock assessment science. Because of these differences, it is not clear how to introduce data derived from fishers' observations into stock assessment. This document provides a preliminary discussion of results related to northern cod from research on the Bonavista headland and Trinity Bay inshore and nearshore (longliner) fisheries. This research was designed to gather fishers' observations about the fishery and fish ecology over the course of their fishing careers. We draw on these data to illustrate some ways fishers' knowledge could be incorporated into northern cod stock assessments. We address four issues: cod stock structure; changes in effort and catchability; perceptions of current abundance; and potential impacts on cod stock recruitment resulting from a reopening of the caplin fishery.

Methods

During the summer and fall of 1995, 56 interviews were completed with fishers living in coastal communities between Princeton, Bonavista Bay and Dildo, Trinity Bay (Figure 1). In the Bonavista area, fishers were sampled from a list of union members and we attempted to stratify the sample by age (including some older, retired fishers), vessel size, gear and species harvested. In other areas, the sample was constructed from names of fishers recommended by others (snowball sample). Sampling was guided by an attempt to cover the full study area and most of the key fishing communities within it, as well as by the willingness of fishers to participate. Bonavista has, by far, the largest and most diverse community of fishers in the study area. This accounts for the decision to interview 15 fishers in this area. Almost all of the interviews between Chance Cove and Dildo were with owners of 35 foot longliners. Recent discussions with local fishermen suggest that there are some smaller and larger vessel fishers in the area. These groups are underrepresented in the sample in this area. (Our final sample will include approximately 15 interviews with offshore draggermen and skippers).

The interviews were semi-structured, guided by an interview schedule and a shorter questionnaire. They lasted from 1 1/2 to 4

---

[1]This research was made possible by a three year Strategic Science and Technology Grant from the Social Science and Humanities Research Council and by support from Tricouncil Ecoresearch Programme grant # 334-884. We are grateful for this support.

hours. Most were taped and subsequently transcribed. The interviews opened with basic demographics, training, and effort and catch data from key points in their fishing careers. Data were collected on all of the licenses, vessels, engines, gear, and equipment ever used. Fishers were also asked to describe a typical fishing season --timing, place, gear fished, landings--at different points in their careers. They were encouraged to pinpoint periods of observed changes in their fishery and to provide explanations for these changes. The most detailed data collected concerned the cod fishery and cod ecology, but data on fisheries for other species were also collected (see, for example, Neis et al., 1996). Fishers were asked to describe the timing and direction of cod migrations in their area, the timing and location of observed spawning cod, and colour and diet of cod they encountered. Data related to fishing locations, gear type, fish migrations and spawning and other ecological attributes were recorded on mylar overlays on regional charts. These data will be archived as a part of the Tri-council Eco-Research project under project safe-keeping protocols. This document presents preliminary results from an analysis of some of the data on cod contained in the interview transcripts and questionnaires. The methodology associated with each research question is summarized below.

Stock Structure:

A sample of the transcripts from Dildo to Princeton was examined for references to cod ecology: fishers' categories for cod and their related discussions of the timing and direction of migrations, seasonal locations, spawning, diet and related information. If fishers described spawning, they were asked if the fish they were catching were "running". This section of the report provides a general summary of some of the themes in these observations (We have not had the opportunity to review all of the transcripts or quantify the observations).

Catchability:

The analysis of fishing effort, catchability and catches is derived from the short questionnaire summary of the interviews. In some cases, these data have been supplemented with information from the transcripts. We divided fishers into those fishing on vessels <35 feet (n=39) and those on vessels 36-65 feet (n=8) who engaged in the cod fishery. Three fishers who fished for significant periods of time in both sectors (a third fishing strategy) were removed from the analysis.

Vessels under 35 feet:

Inshore (<35 foot) fishers (n=40) were divided into 3 generations on the basis of their period of entry into the fishery (1920-1930s; 1940s-1960s; 1970s-1980s) and their careers were divided into three periods: start, mid and end. Average horsepower and vessel capacity were calculated for each generation and each period. Average number of codnets (gillnets used for cod), average number of traps per crew and total number of traps were also calculated for each generation and each career phase.

Because of differences in career length between the different generations and in order to make comparisions between variables, we computed % change per year in the following variables: boat length (feet), boat capacity (pounds), engine size (horsepower), codnets (maximum number of nets at one time), traps (number owned). Percent change per yr was calculated for two intervals: start of career (year) to mid career (year), and mid-career to late (year of retirement or moratorium). Hutchings (reported in Neis et al, 1996) has plotted changes in the total number of gillnets and traps owned by fishers in this sample between 1980 and 1992.

For boat length BL the change was calculated:

$$\% \text{ BL/yr} = (BL_{mid} - BL_{start})\ (BL_{start})^{-1}\ (Yr_{mid} - Yr_{start})^{-1}$$

$$\% \text{ BL/yr} = (BL_{end} - BL_{mid})\ (BL_{mid})^{-1}\ (Yr_{end} - Yr_{mid})^{-1}$$

Both were then plotted against Yr_{mid}. Similar calculations and plots were made for capacity, engine size, codnets, and traps.

Fishers were asked to describe a good, average and poor season at different phases in their careers and, where possible, they provided remembered real landings for years just prior to the moratorium. These were plotted by year. Changes in CPUE between earlier and more recent years in their career were plotted for 6 inshore fishers who used cod gillnets and 8 inshore trap fishers. These were the only fishers who provided sufficiently detailed and comparable data to permit these calculations.

Vessels over 35 feet (n=7):

The gillnet subsample consisted of 9 fishers utilizing primarily gillnets. Boat size ranged from 38 feet to 64 feet. Since information was incomplete for two fishers, analysis was based on a subsample of 7. Changes in boat size, horsepower, capacity, gear amounts and catch per unit of effort for each fisher during their career in the gillnet fishery were examined. Percent changes are computed by calculating the difference between initial gillnet vessel and gear and the one possessed at either time of retirement or moratorium. This difference is expressed as a percentage of the initial level (as in Table 1). Changes in the spatial scale of effort were also compared with changes in the spatial scale of gillnet fishing for the northeast coast calculated by Hutchings (reported in Neis et al., 1996) from purchase slip data.

Current abundance and potential risks to cod in a reopened caplin fishery:

The transcripts contain a number of comments concerning the abundance of cod in Bonavista and Trinity Bays on the eve of the moratorium and in recent years. Fishers were also asked to comment on current abundance in recent feedback meetings in Bonavista, Clarenville and Long Cove. In both interviews and feedback meetings, some fishers extensively involved in the caplin trap fishery at the bottom of Trinity Bay expressed concern about the impact of this fishery on juvenile cod. Their concerns are summarized and analysed.

Results

1. Stock structure

Until recently, northern cod stock assessments have relied primarily on offshore autumn sampling. If some cod populations remain in the bays or migrate from offshore to inshore during the fall and winter, the status of these populations may not be accurately represented by an offshore survey. Such populations may differ in terms of their abundance and growth rates from those that migrate offshore to spawn, or live offshore year-round.

When fishers describe the fish they harvest, some use the terms "stock" and "bay stock" but it is more common for them to talk about different kinds of cod. Fishers tended to distinguish between the following types of cod: "herring fish", "caplin fish", "sunburnt fish" or fish that are "blackbacked", "deepwater" or "paler fish", "shoalwater fish" (browner), "mother fish" and "foxy" or "Iron ore fish". They distinguish between these different kinds of cod on the basis of their diet, the timing of their arrival, spawning, the depth at which they are harvested and, in some cases, their colour. Some of these types of cod differ in the timing of their spawning behaviour.

Herring fish are cod whose migrations are associated with the timing and location of herring migrations. They are primarily harvested in April and May at the bottom of the bays, and somewhat later further out. One fisher said their migration out of the bay might end just north of the Melrose area on the western side of Trinity Bay. At this point, they would return to the bottom of the bay. The arrival of these cod on local fishing grounds precedes the arrival of the caplin.

The clearest picture of the presence and movements of the herring fish emerged in interviews towards the bottom of Trinity Bay and in the Princeton area in Bonavista Bay. They are described as moving into the arms and reaches in the fall, following the herring. Evidence for their arrival included the suggestion that fall fisheries improved in the quantity and quality of fish (condition) as the fall progressed. Fishers believe the herring fish overwinter in some arms and reaches, often in very shoal water and sometimes under the ice. Cod have been gillnetted through the ice in recent years in such areas as Dildo, Hillview and Smith Sound, Trinity Bay and Southern Bay, Bonavista Bay (Figure 2). Scuba divers described post moratorium sightings of cod aggregations in winter in some these areas in feedback meetings in the spring of 1996.

The herring fish fishery appears to have been particularly important at the bottom of Trinity Bay, and perhaps Bonavista Bay, but also appears to have played a role in the Bonavista headland fishery. Some fishers maintained that the herring fish had been significantly overfished during the 1980s, accounting for the failure of their spring fishery. This might also explain why fishers further out the bay appeared less aware of this fishery. Migrations may be density dependent.

The herring fish spawn in Trinity and Bonavista Bays rather than offshore. Four (possibly 5) different spawning aggregations have been identified from the transcripts (see Figure 3). In Trinity Bay, spawning cod were harvested in a winter gillnet fishery during January and February in the deep water off Chance Cove in the late 1970s and early 1980s. A late fall lull in the Chance Cove fishery preceded their arrival onto these grounds or, perhaps, into the depth where gillnets are located. This fishery ended with ice formation in the area, usually in February. According to one fisher, landings from this fishery could be as important as those in their summer fishery during the years when it was prosecuted. After spawning, the Chance Cove fish are believed to disperse, following the herring across the bottom of Trinity Bay in the deeper water around Bellevue Peninsula and down into Chapel Arm. They provided the basis for a late April-early May trap fishery in this area that fishers say could produce 1/3rd of total annual cod landings from these grounds. Some of these herring fish may have also moved up the west and east sides of Trinity Bay.

Fishers maintain the Smith Sound spawning aggregation also includes herring fish. These fish are believed to leave the different arms and reaches, including Southwest Arm and the more shoal areas of Smith Sound, to join this spring spawning aggregation(this does not preclude some of these fish coming from the deep channel that runs up Trinity Bay and into Smith Sound). The aggregation disperses after spawning as these cod follow the herring, and then the caplin, up and down the western side of Trinity Bay. Tags from Smith Sound are reported to have been returned from the New Bonaventure area and from south of Smith Sound.

A third Trinity Bay spawning aggregation that may have consisted of herring fish and was also targetted by a gillnet fishery, was described as located off of Hopeall Head on the east side of Trinity Bay. These large, spawning fish were harvested between May and July in 50-60 fathoms of water-back in the 1960s nd early 1970s.

In a recent feedback meeting, one fisher described catching autumn spawning cod in a trap fishery in Chapel Arm. This might represent a fourth aggregation, or perhaps late summer spawning cod responding to late caplin migrations in recent years. Some fishers said that you could get a spawny cod (running) almost anytime in the spring and summer.

The herring fish that overwinter in Southern Bay, Bonavista

Bay appear to spawn in this area before migrating out into the bay in the spring. They are harvested in an April-May trap fishery near the mouth of the arm during which some are spawning, and somewhat later further out the coast towards King's Cove and Bonavista.

Some fishers said they had not seen spawning fish in several years. This seemed to be associated with the disappearance of large fish.

The caplin fish are the fish that arrive on the fishing grounds with the migrating caplin. Some of these fish seem to be the herring fish. Most are from offshore and perhaps deeper in the bay and migrate down the deep channels into Trinity Bay and perhaps in over the Bonavista and Melrose grounds before dispersing along the coast in pursuit of the caplin. At the bottom of Trinity Bay, these fish are central to a quite distinct summer fishery (in recent years, perhaps a fall trap fishery) that occurs following a lull in the early trap fishery. Caplin fish from offshore areas appear to be particularly important in the headland fisheries around the Bonavista area. We have not yet analysed the headland fishers' descriptions of the types of cod upon which their fishery depended. Blackbacked fish are generally described as offshore northern cod.

Some fishers also distinguish between deep- and shoalwater fish. Deepwater fish tend to be larger and paler than shoalwater fish (smaller and browner or blackbacked). The Chance Cove spawning aggregation was a deepwater fish that contributed to the inshore trap and gillnet fisheries. Some deepwater fish are harvested in larger (up to 20 fathoms deep traps) set in deeper water. A Chance Cove fisher said that when the winter, deepwater fishery declined, so did the summer fishery (Chance Cove) suggesting these deeper water fish might migrate to shoaler water in the summer.

"Shoalwater" fish are reported to have been particularly abundant in recent years and the adjustment of fishing gear to target these fish might partly explain relatively large inshore trap landings in some areas in the late 1980s and early 1990s. Shoalwater fish may include the herring fish from the reaches and arms that overwinter in shoaler water. One fisher observed that when he started trap fishing in the late 1970s, other fishers were using relatively shoal traps. On the basis of fishing experience in the 1960s, his father suggested he try deeper traps. He did this and had a lot of success with these deeper traps until about 1987. In the years just prior to the moratorium, cod appeared to be closer to the surface again, as in the 1970s. He theorized that the gillnet fisheries had caught up all of the deepwater fish in the bay and that all that was left was shoalwater fish. He thought, however, that as those fish aged, they would tend to settle out and might repopulate the deeper areas.

Some fishers also talked about "mother fish". This category seems to include large, pale cod that lived in deep holes in the arms and in the deeper areas of the bay. These fish fed on small spawny female crabs and other deepwater food, including so-called "sucker rocks" or "bakeapples", a type of sea anemone. The mother fish often had large roes in them when harvested. They may have been fished lightly in the pre-World War II period by some fishers using baited trawl. They are believed to have been "fished out" with the introduction of longlines and gillnets after the Bonavista longliner experiments in the early 1950s, and with the arrival of draggers. When this occurred, some fishers gave up trawling and gillnetting in the deeper areas of the bays and arms and concentrated on more traditional, shoaler grounds, other species such as turbot and deepwater flounder, and on their trap fisheries. Older fishers identified the harvesting of the mother fish as a harbinger of the decline of the cod fisheries. These fish may have been relatively stationary (see Hutchings et al., 1996).

Several fishers also described the presence of some "foxy" or reddish cod in their trap catches. They generally said there would be only a few of these in their catches. However, one fisher in the Melrose area said that there was a population of "iron ore" or reddish cod in the fishery in that area. Foxy cod tend to be relatively small--15-16 inches. Some also referred to variations in the abundance of foxy tomcods in their areas.

In recent feedback meetings, fishers expressed a desire for more tagging research in their areas, including tagging during the winter. They felt that fishers could do this tagging and that it should have been part of the sentinel fishery.

2. Changes in catchability

Resource users are often the only source of data on a key piece of information in any stock assessment based on catch statistics, with vessel efficiency q defined as:

$$C = q\ V\ B$$

Here C is annual catch (tonnes per year), V is number of vessels, and B is stock biomass (tonnes). Unrecognized changes in catchability will bias any attempt to estimate stock size from catch data, including the use of VPA (via assumptions concerning terminal mortality). The effect of an unrecognized increase in terminal F will be an overestimation of stock size. The need for information on trends in effort ($q * V$) has long been known (e.g. Pope 1977). The question is how to accomplish this in a timely fashion.

We have attempted to quantify some changes in catchability. These include changes in vessel length, capacity, and engine horsepower; and gear changes in numbers of codnets and traps. We also present a summary of other innovations to illustrate the wide range of changes in fishery strategies that appear to have influenced catchability engaged in by these fishers during their careers. Finally, we present some data on catches and changes in catch rates or CPUE that are almost uniformly negative.

Figure 4 compares the average horsepower and vessel capacity of first, second and third generation fishers at three points in their careers. Horsepower increased for all three generations but increased most for the second generation. Vessel capacity also increased for all three generations but tended to level off for first generation fishers around mid career. Vessel capacity increased more for third generation fishers than for those in the second generation. Figure 5 shows changes in the average number of codnets and traps for different generations of fishers. Around the middle of their careers, the number of codnets fished by first generation fishers increased substantially (this may be related to the introduction of monofilament nets). Second generation fishers increased the number of codnets they were fishing throughout their careers but the number of codnets owned by third generation fishers (who would still be fishing if it were not for the moratorium)levelled off and began to decline at mid career. All three generations increased the number of traps they were fishing but the rate and extent of total increase was substantially less for first generation fishers.

Figure 6 compares annual changes in boat length, vessel capacity and horsepower for the periods from start to mid and mid to late in fishers' careers. This figure shows that changes in vessel capacity and particularly engine horse power were substantially greater than those in vessel length and were greatest in recent years. A similar analysis of changes in codnets and traps per year for start to mid and mid to late career (Figure 7) indicates the greater annual increase in numbers of codnets and traps that occurred in recent years including the decline in gillnets used by some fishers in the late 1980s. Figure 8 illustrates the extent of the change in numbers of traps and gillnets that occurred in the 1980s among both larger and smaller vessel owners. The total number of gillnets owned by 32 fishers almost doubled and the total number of traps increased by about one-third. Figure 9 shows reported poor, average, good and actual catches for some fishers by year. There are no clear trends in these catches suggesting that increased catchability did not result in larger landings. Tables 1 and 2 show percent changes in CPUE for cod traps and codnets among inshore fishers. With one exception, these changes are negative and substantial ranging from -13 to -100% for traps and -48 to -100 percent for codnets. One trap fisher gave up fishing traps altogether. Several gillnet fishers (not all indicated) gave up fishing codnets altogether because catches were so poor.

Changes in boat size, horsepower, capacity, gear amounts and catch per unit of effort during the careers of 7 longliner (35-65 foot) fishers were examined. Results are summarized in Table 3. Increases in boat length during their career varied from -36 to +32%. The negative value was the result of a longliner skipper abandoning his longliner when confronted with lower catches and the requirement to fish away from his home area. Horsepower and capacity increased more than boat length with again, the exception of the fisher who abandoned longlining. Number of nets increased in all cases. Increases varied from 20 to 300% during their careers.

In addition to the move to larger, more powerful vessels and increased gear, a clear spatial shift also occurred in this sector. The four skippers with the largest vessels at the time of the moratorium (1992), began their longliner careers fishing between eight and twenty miles from their homeport. As boat, horsepower, gear and capacity increased, fishing grounds shifted to fifty to eighty miles offshore and, a few years later, to distances often in excess of one hundred miles, to an area known as the Virgin Rocks and beyond. Figure 10 summarizes this spatial shift. The pattern is similar to that identified by Hutchings (in Neis et al., 1996) from an analysis of the purchase slip data for vessels in this length category (see Figure 11).

As indicated in Table 3, all longliner fishers (35-65 feet) experienced a reduction in catch/net, with these reductions varying from 18 to 64%.

Declining landings in the 1970s and mid- to late-80s seem to have triggered fisheries innovations other than simple increases in gear amounts, vessel length and capacity, and engine horsepower. During the interviews and subsequent feedback meetings, fishers described a variety of other innovations that are relevant to an assessment of changes in catchability. The introduction of sounders made it easier for them to fish larger numbers of traps by allowing them to avoid zero or small hauls. Loran C and GPS technologies allowed them to fish more efficiently in new areas (making it easy to find fishing grounds and gear) as well as during foggy weather and at night. These technologies also permit them to fish larger numbers of gillnets. Mesh size in gillnets also declined in the late 1970s and early 1980s.

Most trap fishermen changed the design of their traps from traditional to modified (winged), japanese or long range traps (a Labrador design) in the 1970s and 1980s. They also introduced power blocks. These changes, often associated with reductions in mesh size outside of the drying twine, are believed to have increased their catches by retaining smaller fish and allowing them to fish more traps efficiently by holding fish better. There also appears to have been a tendency in some areas to fish larger, deeper traps and to change the spatial scale of the trap fishery. Some fished larger areas adjacent to their local communities. Some fishers at the bottom of Trinity Bay moved to St. Mary's Bay to fish in the late 1980s and early 1990s, and some from the middle of the bay (New Bonaventure area) moved to Labrador in the late 1980s. Fishers in Bonavista Bay are also reported to have moved to the Bonavista headland (the only area with fish) in the year or two prior to the moratorium. Power blocks made it easier to move traps more frequently in search of fish and japanese and long range traps could be placed in berths that were not easily fishable with traditional or modified traps thus allowing them to intensify effort on local grounds.

In summary, capacity and horsepower of inshore vessels increased slowly in the 1960s, more rapidly in the 1970s, and still more rapidly in the 1980s. The number of traps per person increased steadily in the 1970s and 1980s and there were significant changes in mesh size and design. Codnets per boat increased in the 1970s more than afterward and mesh size was reduced to 5 1/2 inches. A large number of other variables, including better electronic gear, increased skill in catching fish. Catchability per boat increased from 1950 through 1990, with the largest changes in the 1980s. During this period of accelerating capacity, power, and skill, catch remained unchanged and catch rates declined.

Interviews can be used to provide timely information on changes in catchability and terminal mortality. The interviews and subsequent public meetings with both groups of fishers suggest that the above fisheries innovations can best be explained by a number of factors. Lower resource abundance is one important factor with fishers reporting fewer and generally smaller fish after gillnet grounds had been fished for a few years, and pressure to change gear structure and the spatial scale of their fishing effort. Other factors included the need to provide for greater comfort and safety as the spatial scale of fishing expanded and what might be termed a `colleague effect' which refers to fishers feeling pressure to keep up with their colleagues in the move to bigger boats even if they don't fully feel a need to increase capacity and gear (not all fishers substantially changed their fishery/gear). A number of fishers alluded to the role of governments, particularly the Provincial government, in encouraging the trend to larger boats through various loan and subsidy programs.

Current cod abundance:

We have examined some of the transcripts and our reports on feedback meetings for indications on current cod abundance. There was no clear consensus among fishers concerning the current trends in abundance of northern cod in Bonavista and Trinity Bays. One fisher, for example, commented that "There is just as much cod now in Trinity Bay since the moratorium came in as there ever was...Since my time as an inshore fisherman I have never seen as much cod as I am seeing now." This fisher had experienced large catches of cod as bycatch in his backback flounder nets. In contrast, another fisher commented "I think it's going to be a long time for it to come back. But what's bothering me is those people are saying there's a lot of fish there and we should open it up and stuff and I don't think the fish is going to be there. They think, they don't understand how much fish it would take to make a fishery or if not put it right back where it started from again." Some felt the bay stocks were gone and the cod that was out there came from offshore. Others felt that the fish in the bays was from the recovering bay stocks.

There may be several reasons for the lack of consensus on current cod abundance. All acknowledged that with the closure of the cod fishery it was harder to know how much cod was around. The indicators of abundance that they used took the form of observations on cod abundance prior to the moratorium and extrapolation from these; observed bycatch in lobster pots, and in herring, flounder, turbot and lump nets; sounder observations of cod from vessels; observations during scuba dives for Hibernia and sea urchins; and angler catches from the shore. Some fishers had good landings in trap fisheries in the years just prior to the moratorium. These cod were small in size. Some reduced the mesh in their traps when they contrasted the apparently large volume of cod in their traps with the small amount that remained in the drying twine after they hauled. An indication of large amounts of very small fish prior to the moratorium, and observed large escapages, leads some to believe that the cod they are now catching as bycatch are these same small fish that have since grown considerably. Comments emphasized the novelty of catching large cod in lobster pots and in larger mesh flounder and lumpnets. These bycatches were, fishers say, rare or nonexistent prior to the moratorium.

Fishers emphasize that the cod that have been around during the fishing season since the moratorium are in very shoal water (lobster pots and blackback flounder nets are placed in shoal water and anglers are able to harvest them from the rocks onshore). One explanation for the novel presence of cod--particularly large cod--in lobster pots was that they were hungry. Others seem to think that this is an indication of greater abundance, pointing out that these cod are large and fat. A third possibility, suggested by a fisheries scientist, is that in the absence of a direct cod fishery, these cod are less likely to be intercepted before reaching shoal water. Observations of cod in the arms and reaches by urchin divers indicate the presence of some aggregations in deeper water during the winter.

Fishers' assessments of abundance appear to be linked to a perceived contrast between DFO northern cod stock assessments and their own observations. Experience with large bycatches, and observations of relatively large cod are contrasted to survey results that suggest cod are rare offshore. This contrast may be explained by the presence of bay stocks that are healthier than offshore stocks. One fisher explained the contrast by arguing that northern cod had moved into the bays in response to the impacts of trawling on their spawning grounds. According to this fisher, they like the seaweed and related habitat that still exists in the bays and won't move offshore again until this habitat recovers from the effects of trawling.

We hypothesize that assessments of the health of local cod populations may also be affected by the extent of a fisher's effort prior to the moratorium. For example, one fisher who did not feel there was enough cod for a fishery, emphasized that with current trap technology and power blocks, one crew could fish up to 15 traps. He has five traps and plans to convert them to japanese traps. He also felt that there had been very little reduction of capacity in the industry despite government programs with this goal. From this perspective, a lot of cod and/or good prices would be necessary before a reopened fishery could be successful. In contrast, those who fished hook and line or are arguing that a reopened fishery should be restricted to a hook and line fishery, have a different sense of the abundance necessary for a reopened fishery, and hence may be more likely to argue current abundance could support it.

Potential impacts on cod recruitment associated with the reopening of the caplin trap fishery:

Several fishers had been heavily involved in the caplin trap fishery throughout the 1980s. Many of these fishers expressed concern about the impact of this fishery on juvenile cod. Caplin (and squid traps) have very small mesh (inch and a quarter). Fishers suggested that juvenile cod tend to accumulate in the caplin traps and large amounts can be destroyed in this fishery. Some fishers suggested this bycatch was responsible for the disáppearance of tomcods from "around the wharfs and everywhere" in the 1980s. Some suggested these tom cods have appeared again since the closure of the caplin fishery. The accumulation of juvenile cod in caplin traps was described as greatest at night, so that juvenile cod were most abundant in the first haul in the morning.

Most fishers felt that juvenile cod in caplin traps represented a significant bycatch problem. It was suggested it may have contributed to the depletion of the "bay" stock of cod at the bottom of Trinity Bay. Fishers reported communicating their concerns about this bycatch problem to DFO and one reported that some research had been done, but that management had taken no action. One suggested that caplin traps should be replaced with bar seines, which do not have the same bycatch problem.

When asked, in recent followup meetings, about the potential risk to juvenile cod that could result from the reopening of the caplin fishery in their area, some argued that the bycatch problem could be avoided because cod and capelin tend to separate out in the traps and the juvenile cod could be "rolled over the heads" rather than landed and destroyed. Some pointed out, however, that juvenile cod, unlike crab, are very delicate. It seemed to be generally accepted that the juvenile cod would be protected by separation in this manner only if the destruction of juvenile cod was regulated through monitoring of some kind. The TAC system tends to discourage protection of the juvenile cod because protection can slow down catches thus reducing conservationist crews' share of the TAC. Where plants are willing to accept capelin mixed with juvenile cod, there has been no incentive (other than fishers' concerns about conservation) to take the extra time and effort required to protect the juvenile cod. Some fishers emphasized that the impact of juvenile cod bycatches was probably small, when compared to the discarding of small cod in the trap and offshore dragger fisheries.

Discussion:

The purpose of this document is to report on what can be learned about issues related to stock structure, stock status, catchability and potential threats to recruitment for the northern cod stocks by interviewing fishers, with a view toward involving them in the gathering and assembly of information relevant to assessing stock status.

Fishers' knowledge has a high degree of complexity. Unlike research vessel survey data, their data are not standardized in terms of temporal scale, territorial coverage or technology, and are subject to biased reporting in regulated fisheries. When these data are being used to reconstruct past patterns and events, they are also subject to the effects of selective and limited memory. In contrast to stock assessment science, fishers' knowledge of fish stocks is primarily acquired to optimise catches while minimising effort. Therefore, they tend to closely observe those environmental features which are linked to fishing success: seasonal movements, habitat preferences, feeding behaviour and abundance dynamics; as well as those physical attributes of fishing grounds that affect fish distribution, the performance of gear and fishing time: wind direction, currents, water temperature and clarity, bottom characteristics and local assemblage structures (related to bycatch and discarding), as well as gear fouling (i.e. slub on their nets).

There are strengths and weaknesses to both types of data and the development of methodologies that can facilitate the use of both in stock assessment could potentially result in more effective stock assessments. This document has argued that data gathered interviewing fishers, combined where possible with scientific data can 1) contribute to our knowledge of cod behaviour, ecology and stock structure; 2) help us understand trends in catchability; 3) inform future scientific research (for example, tagging studies); 4) increase awareness of current stock abundance in inshore areas where limited data are available and 5) increase awareness of interfishery interactions, such as the potential impact on northern cod recruitment of a juvenile cod bycatch in the caplin fishery.

Resource users are likely to develop a detailed, small-scale understanding of population, while scientific management typically aims at a larger scale estimate of the entire stock. This mismatch in spatial scale leads to different perceptions of the status of a stock. Resource users are unlikely to assent to a statement of large scale status that conflicts with their own direct experience and disagreements between local and larger scale perceptions of stock status could indicate the need for nested assessments at different spatial scales (local seasonal, regional annual, etc) and multiple methodologies. Strengthening linkages between fishers and scientists and finding ways to make comparisons between the data bases upon which each group is drawing could improve the potential for more informed and more easily accepted decisions on stock status and management.

Identifying ways to systematically gather and combine data from fishers with other stock assessment data is perhaps particularly critical in contexts such as that which currently characterizes northern cod. The northern cod stocks have been heavily overfished, but there is mounting evidence of regional differences in levels of abundance. The data base for northern cod stock assessment science is particularly weak in areas where fishers' maintain stocks are recovering rapidly (in the bays) and hence where the pressure to reopen the fishery will be strongest. The future fishery is also likely to be concentrated in the inshore.

Because fishing capacity in the industry is such that rapid stock depletion could accompany any reopened fishery there is an urgent need for a cautionary approach, and for rapid feedback from industry participants to scientists and managers when the fishery is reopened. The creativity of fishers and their daily presence on the water, interacting with the resource, suggests that they could play an important role in facilitating this rapid feedback. Established lines of communication and methodologies for incorporating fishers' knowledge (through a logbook program, sentinel fishery and regular interviews) could improve the potential for such rapid feedback. Careful reconstruction of the history of local fisheries including seasons, population structure, changes in catchability and interfisheries effects,through interviews, document analysis (purchase slip data), comparison with scientific data and some scientific research could provide the basis for greater utilization of fishers in stock assessment in the future.

Finally, new management initiatives may well be introduced in the fishery of the future (i.e. marine protected areas) resulting in changes in the nature and quality of data required for stock assessment. Fishers' knowledge may represent a key source of data and hypotheses for the development of new data bases to meet these demands.

References

Hutchings, Jeffrey, B. Neis and P. Ripley, 1996. "The `nature' of cod (Gadus morhua): Perceptions of stock structure and cod behaviour by fishermen, `experts' and scientists from the Nineteenth century to the present" in Daniel Vickers, [ed.] Proceedings of Marine Resources and Human Societies in the North Atlantic Since 1500. St. John's: ISER, Memorial University.

Neis, Barbara, J. Hutchings, R. Haedrich, D.C. Schneider and L. Felt, 1996. Scientific debates, lumpy lumpfish and slubby nets: fishers' vernacular knowledge and adaptive management, paper presented to the American Fisheries Society Meetings, Tampa, Florida, revised and submitted to the CJFAS.

Pope, J.G. 1977. Estimation of fishing mortality, its precision and implications for the managment of fisheries. Pp 63-76 in J.H. Steele (ed) Fisheries Mathematics. London: Academic Press.

TABLE 1: PERCENTAGE CHANGE IN TRAP CATCH RATES								
fisher id #	initial year	initial catch	initial traps	final year	final catch	final traps	%chng traps	%chng CPUE
35	1950s	13000/hl	2	1989	2500/hl	2	0	-81
38	1972	20000	1	1989	25000	2	+100	-37.5
39	1960s	150000	3	1991	200000	3	0	+33
44	1978	115000	4	1989	150000	6	+50	-13
48	1974	55000	3	1990	45000	5	+67	-51
52	1974	55000	2	1987	60000	4	+100	-45
53	1978	70000	2	1989	65000	4	+100	-54
54	1979	2-300/dy	1	1989	0	0	-100	-100

TABLE 2: PERCENTAGE CHANGE IN CODNET CATCH RATES, <35 FOOT								
fisher id #	Initial year	Initial Catch	Initial # Nets	Final year	Final catch	Final # nets	% chng nets	% chng CPUE
19	1983	5000	30	1991	20	3	-90	-96
28	1975	5000	12	1985	500	40	+233	-97
31	1973	5000	10	1990	0	0	-100	-100
32	1985	350	15	1991	300	30	+100	-57
35	1970s	250	20	1990	125	20	0	-48
47	1978	20000	100	1990	1750	35	-65	-75

TABLE 3: PERCENTAGE CHANGE IN CATCHABILITY AND CATCH RATES, > 35 FOOT						
Fisher Id	First Entry in gillnet fishery	Boat Length	Horsepower	Capacity	Gear (Nets)	Catch/Net
27	1979	+ 32%	+200%	+700%	+225%	-25%
21	1972	+ 20%	+ 67%	+ 70%	+300%	-31%
23	1978	0%	+55%	0%	+150%	-54%
14	1976	+19%	+27%	+ 35%	+300%	-62%
24	1967	- 36%	-83%	+ 16%	+ 50%	-57%
41	1976	+ 3%	+46%	+109%	+200%	-18%
28	1988	0%	0%	+ 90%	+ 20%	-64%

Figure Captions

Figure 1: Geographic distribution of 56 interviews with inshore and longliner fishers around the Bonavista Peninsula and across the bottom of Trinity Bay.

Figure 2: Locations where winter gillnetting of cod through the ice is reported to have occurred in recent years.

Figure 3: Locations where spawning aggregations of cod are reported to have been intercepted by fisheries.

Figure 4: Changes in average engine horsepower and vessel capacity for three generations of fishers.

Figure 5: Changes in average number of numbers of cod gillnets and cod traps and changes in total number of traps for three generations of fishers.

Figure 6: Percent change per year in boat length, vessel capacity and engine horsepower, start- to mid-career and mid- to late-career.

Figure 7: Percent change per year in numbers of codnets and traps start- to mid-career and mid- to late-career.

Figure 8: Changes in nominal effort - gillnets (top) and traps (bottom) for 40 fishers around the Bonavista Peninsula. Dashed lines: all fishers, solid lines: those who fished every year from 1980-1992.

Figure 9: Poor, average, good and final landings estimates (pounds) reported by interviewed fishers vessels <35 foot, 1920s to 1990s. Quintals (112 pounds dried cod) converted to 500 pounds round weight/quintal.

Figure 10: Spatial shifts in longliner (> 35foot) gillnet fishery 1970-1991 reported by interviewed fishers.

Figure 11: Spatial distribution of gillnet catches of northern cod in selected years prior to (1985) and following (1989-1991) the expansion of the gillnet fishery to offshore waters. The four sizes of symbols, beginning with the smallest, represent catches of 1-100 t, 100-1000 t, 1000-10000 t, and > 10000 t (to a maximum of 18,000 t). Depth contours are 200 m and 400 m isobaths.

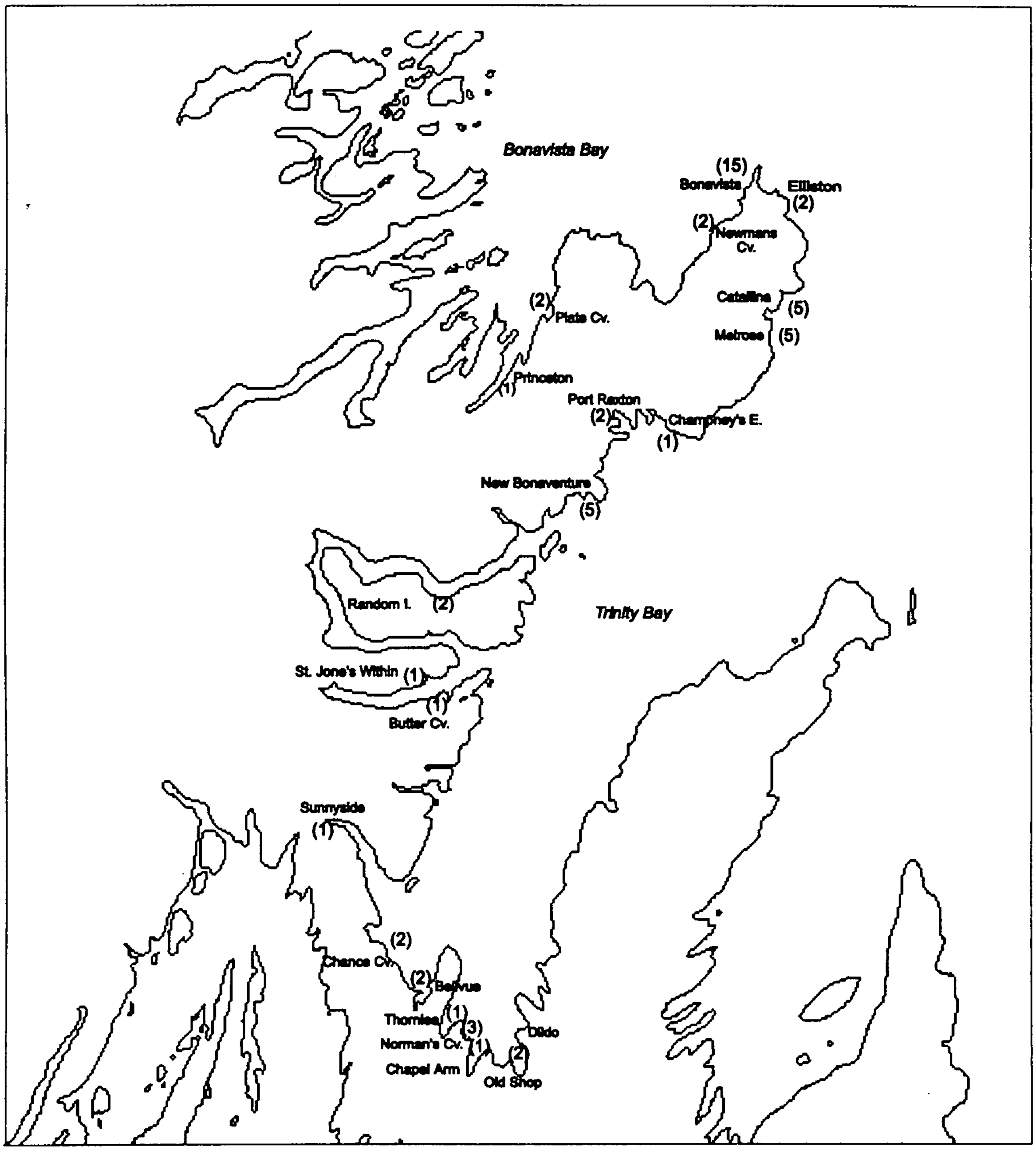


Figure 1: Geographic distribution of 56 interviews with inshore and longliner fishers around the Bonavista Peninsula and across the bottom of Trinity Bay.

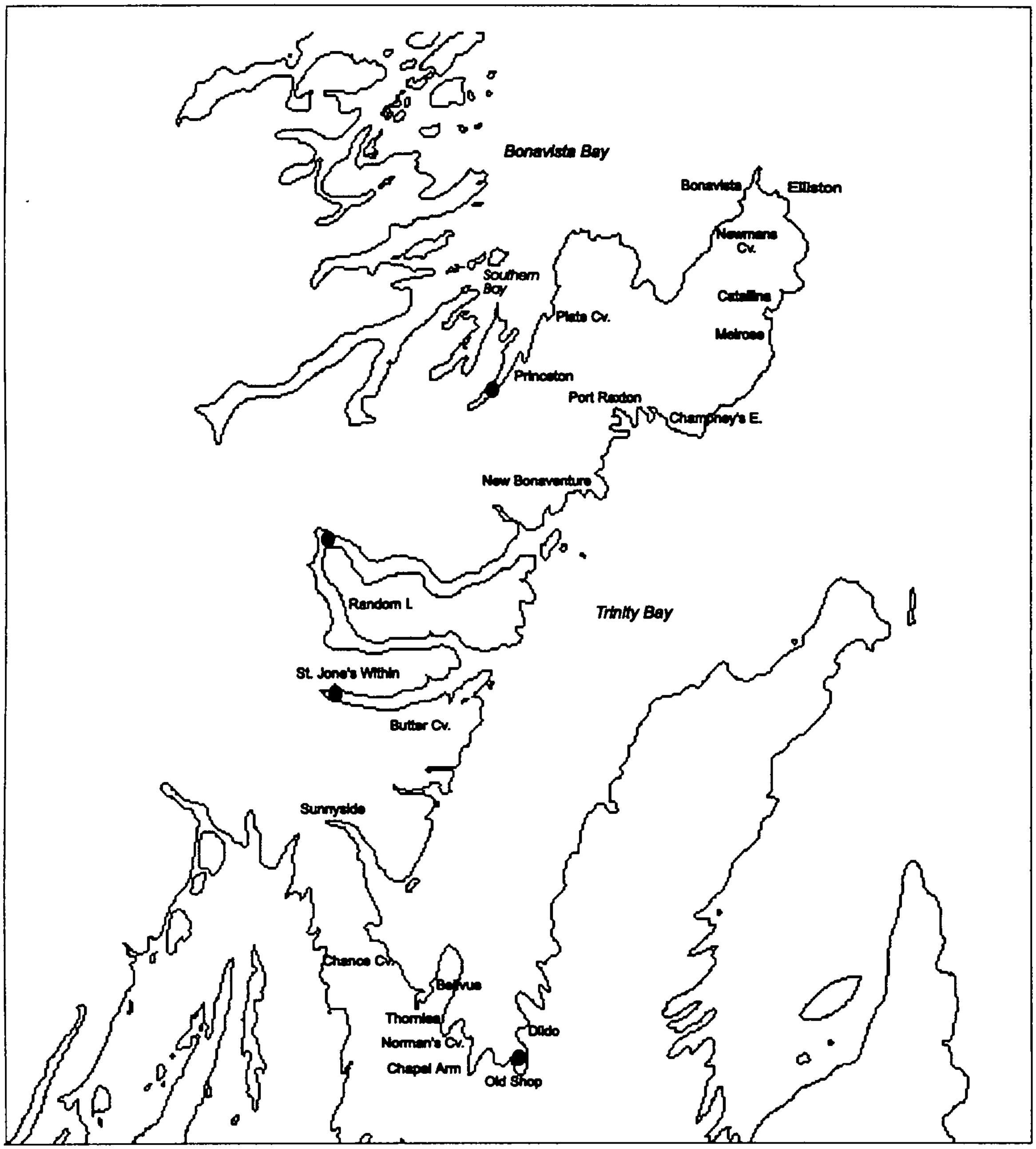


Figure 2: Locations where winter gillnetting of cod through the ice is reported to have occurred in recent years.

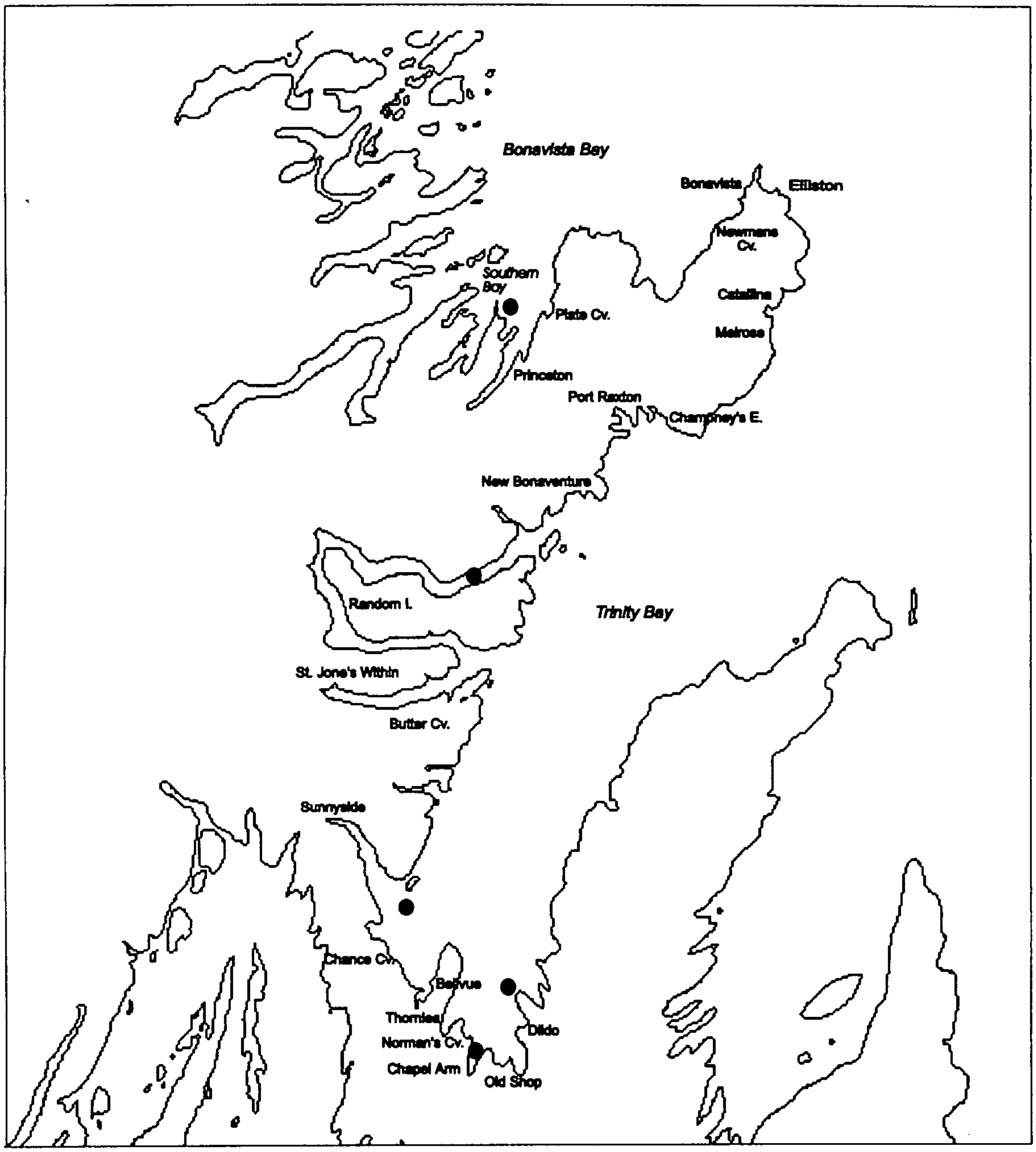
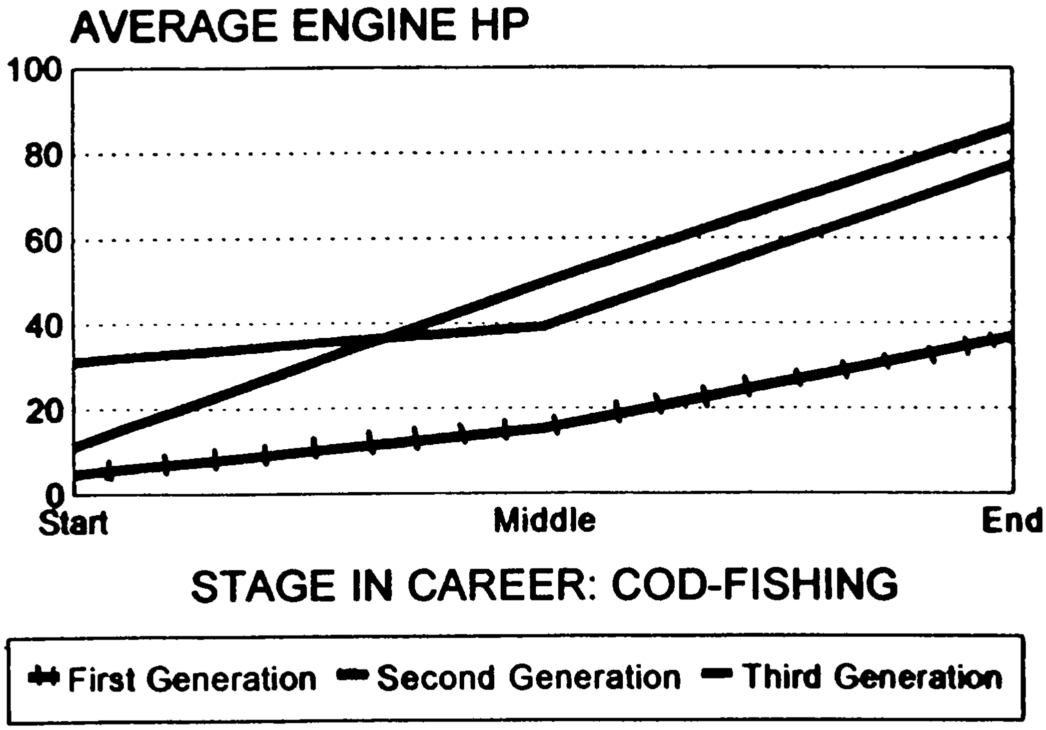


Figure 3: Locations where spawning aggregations of cod are reported to have been intercepted by fisheries.

Figure 4

Change in effort - engine horsepower
Are there differences between generations?



Change in effort - vessel capacity
Are there differences between generations?

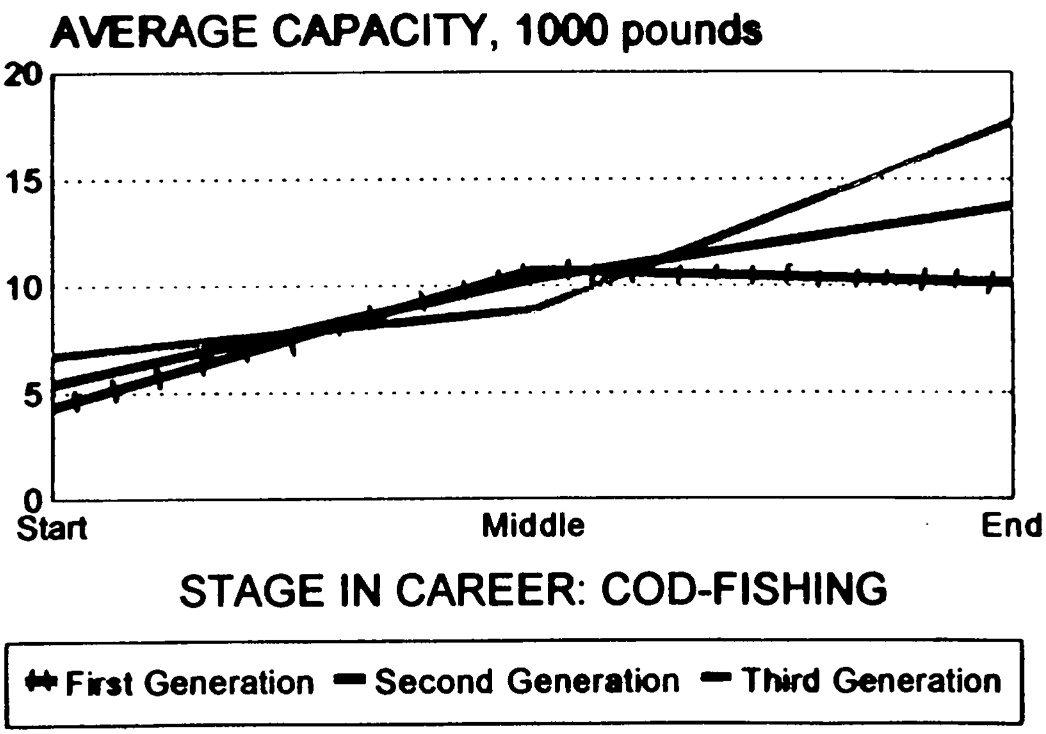
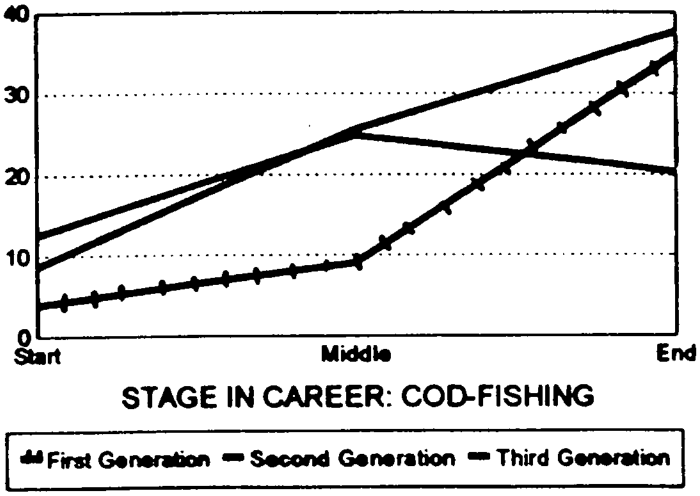
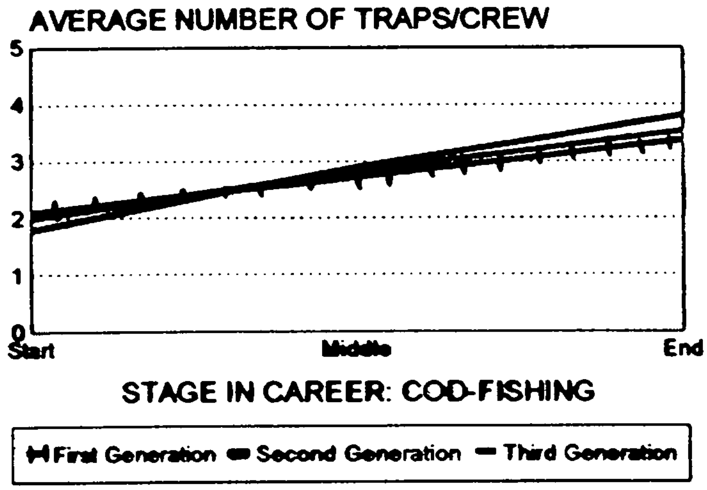


Figure 5

Change in effort - codnets
Are there differences between generations?



Change in effort - traps, all types
Are there differences between generations?



Change in effort - traps, all types
Are there differences between generations?

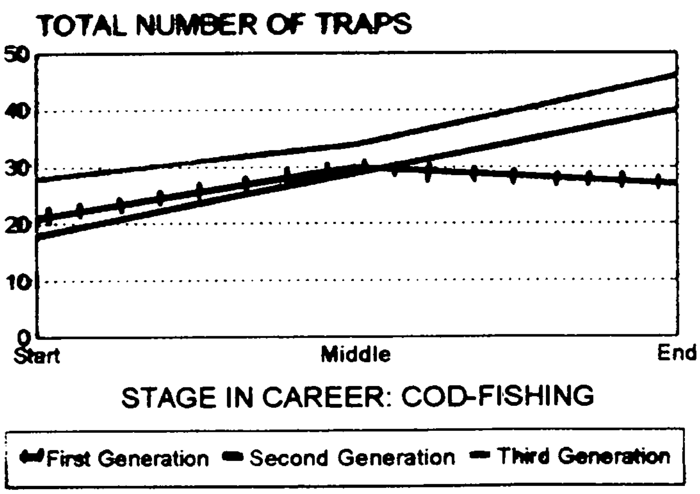
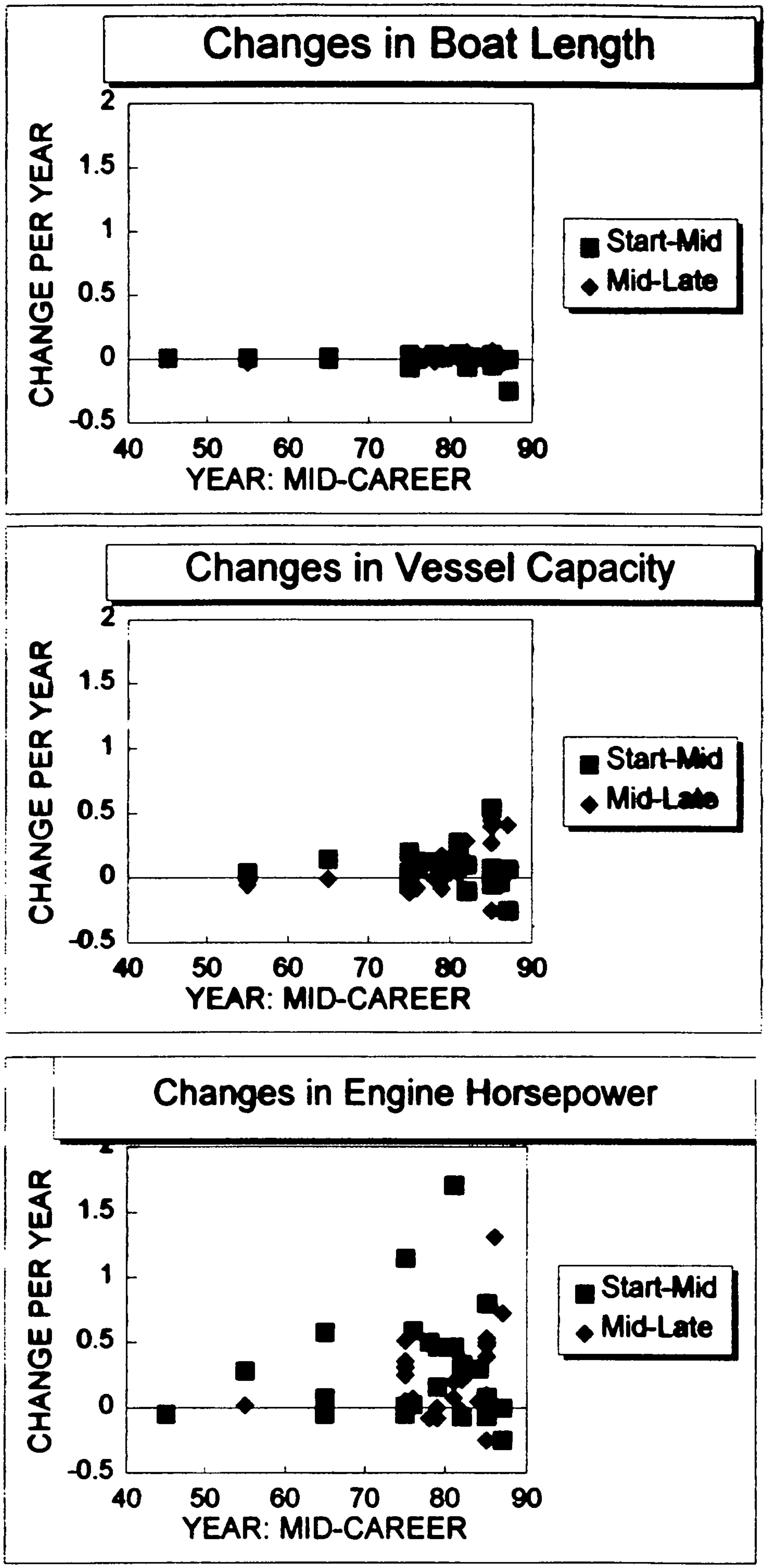
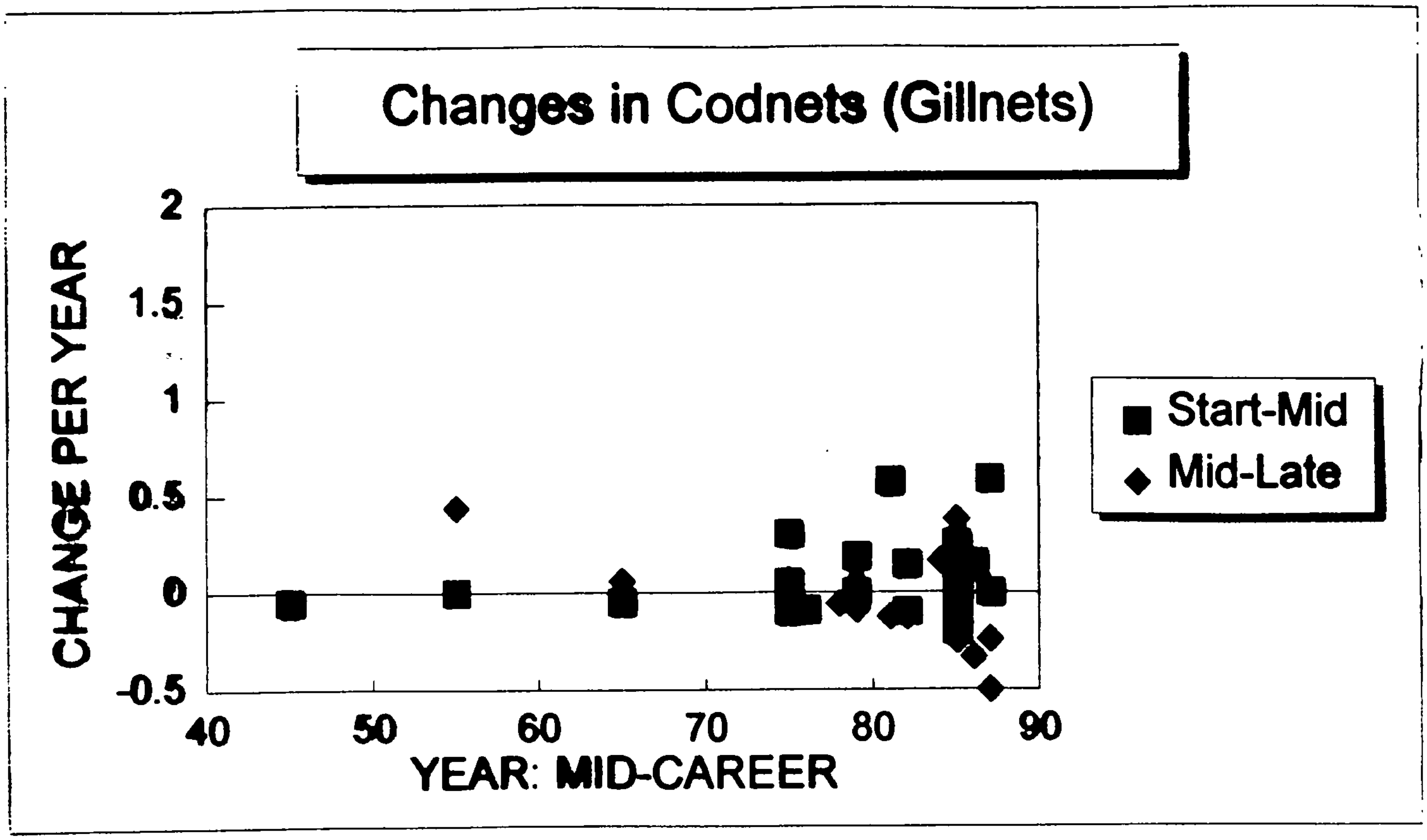


Figure 6

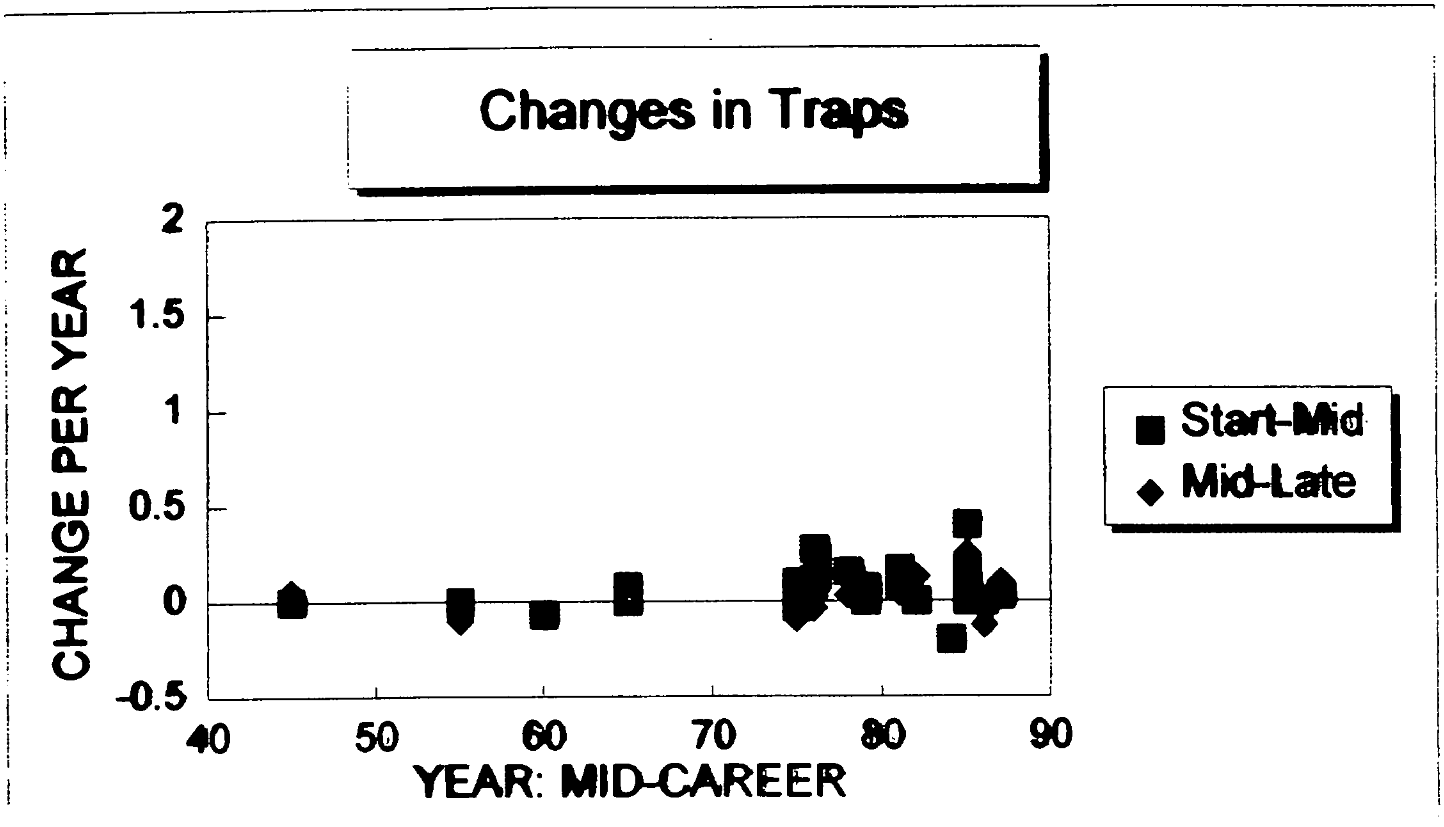


Changes in Boat Length
CHANGE PER YEAR
YEAR: MID-CAREER
Start-Mid
Mid-Late
Changes in Vessel Capacity
CHANGE PER YEAR
YEAR: MID-CAREER
Start-Mid
Mid-Late
Changes in Engine Horsepower
CHANGE PER YEAR
YEAR: MID-CAREER
Start-Mid
Mid-Late

Figure 7



Changes in Codnets (Gillnets)
CHANGE PER YEAR
2
1.5
1
0.5
0
-0.5
40
50
60
70
80
90
YEAR: MID-CAREER
Start-Mid
Mid-Late



Changes in Traps
CHANGE PER YEAR
2
1.5
1
0.5
0
-0.5
40
50
60
70
80
90
YEAR: MID-CAREER
Start-Mid
Mid-Late

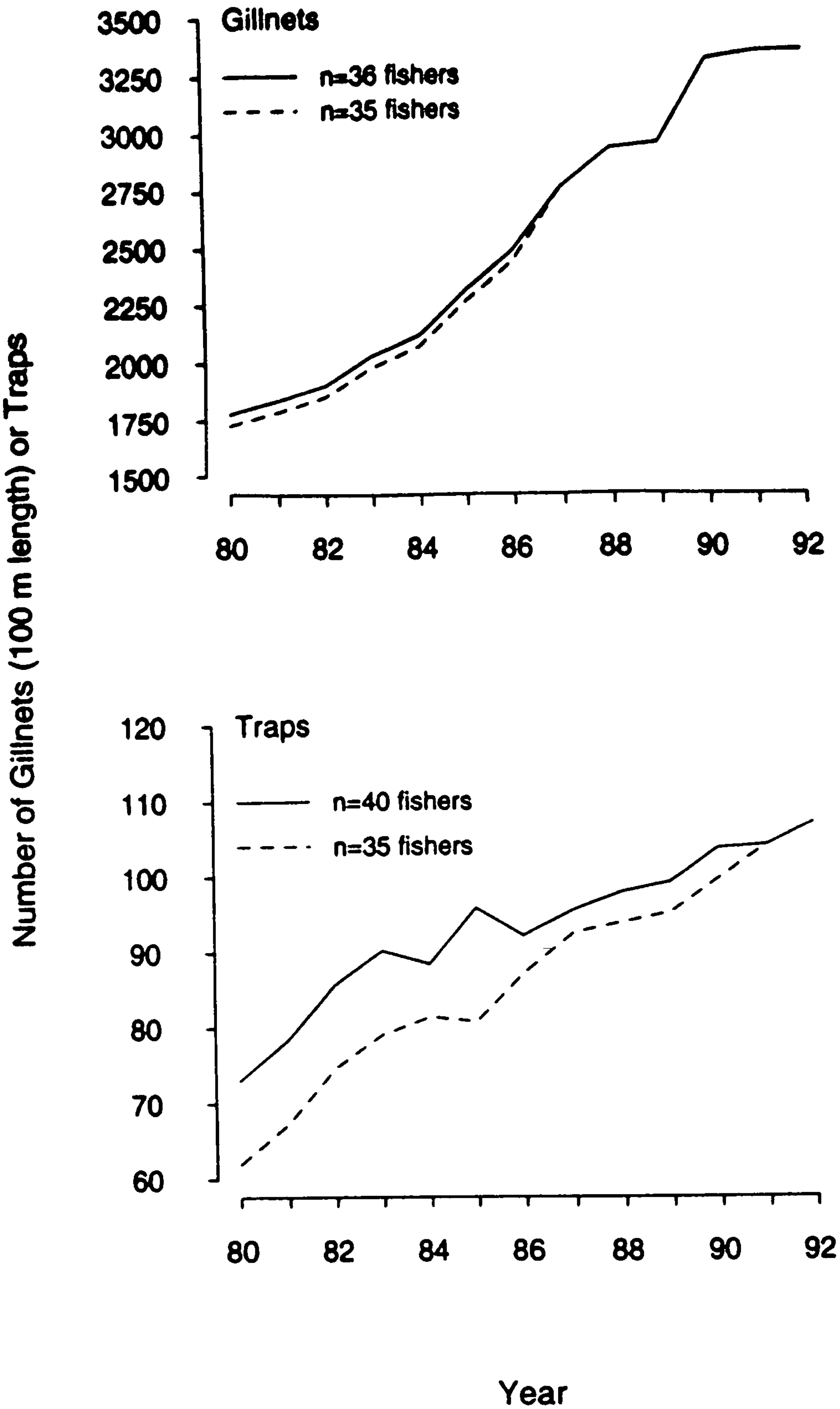
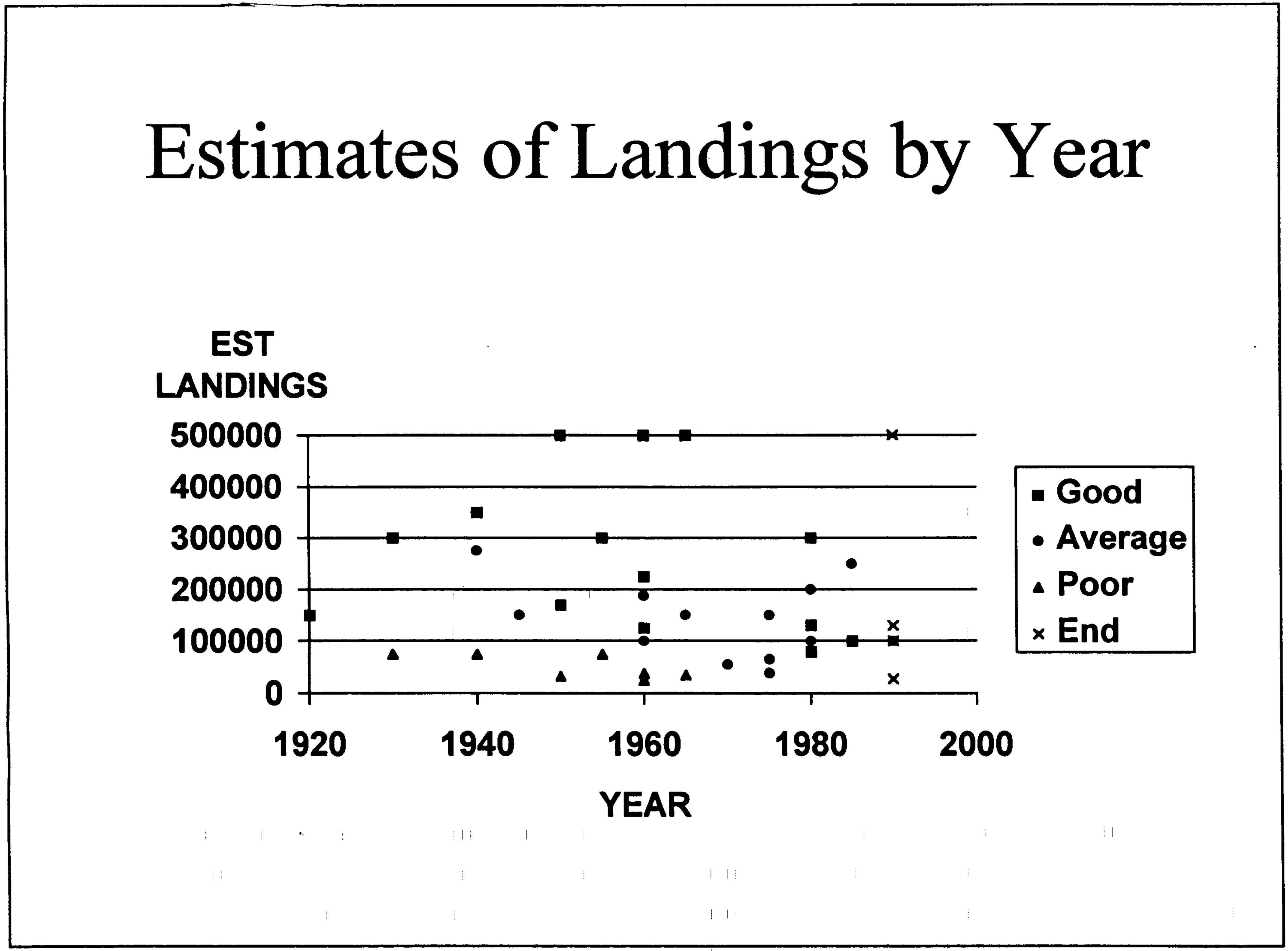

Number of Gillnets (100 m length) or Traps
Gillnets
n=36 fishers
n=35 fishers
3500
3250
3000
2750
2500
2250
2000
1750
1500
80
82
84
86
88
90
92
Traps
n=40 fishers
n=35 fishers
120
110
100
90
80
70
60
80
82
84
86
88
90
92
Year

Figure 8

Figure 9


Estimates of Landings by Year
EST LANDINGS
500000
400000
300000
200000
100000
0
1920
1940
1960
1980
2000
YEAR
Good
Average
Poor
End

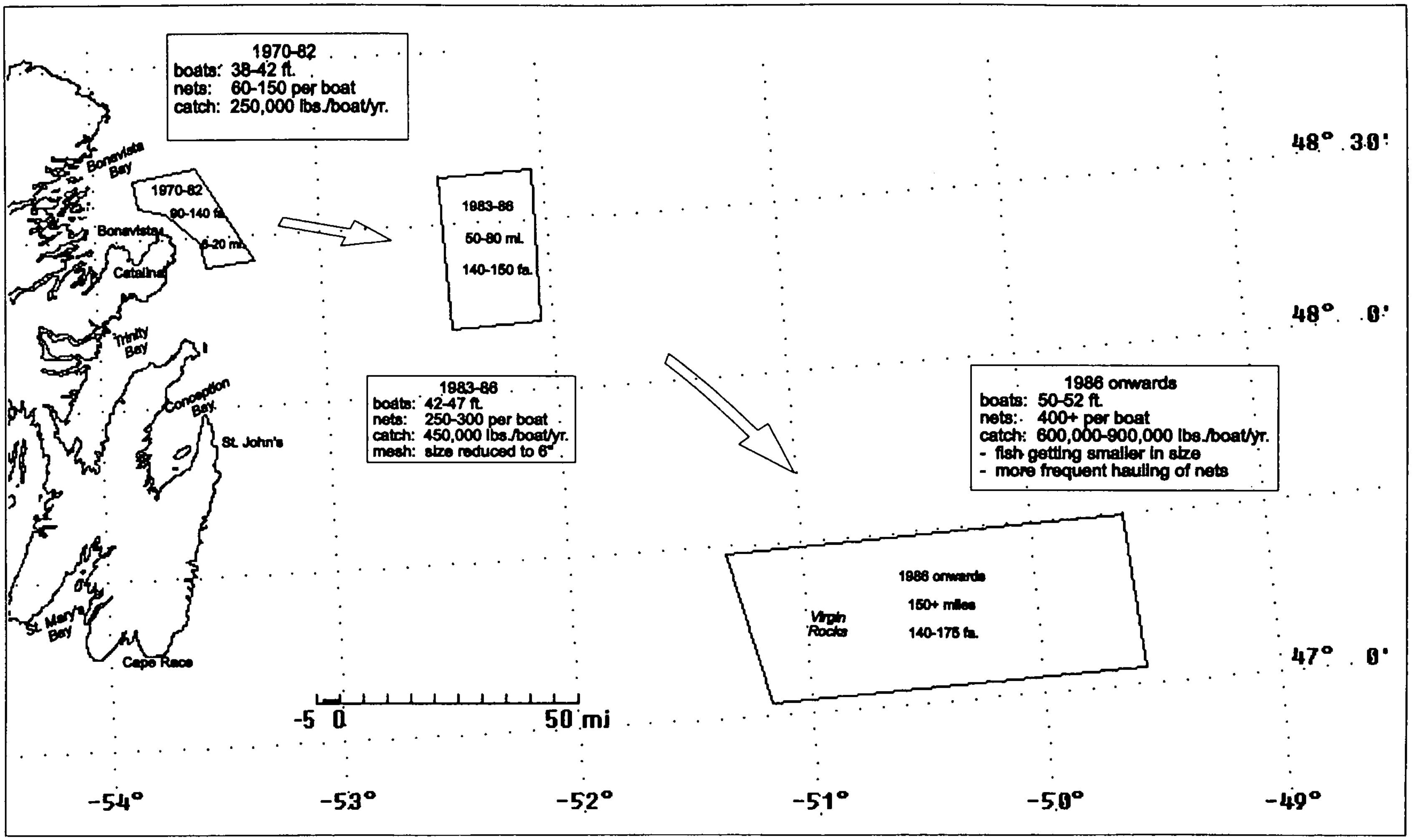


Figure 10

Spatial shifts in fishing effort for selected gillnet fishers from the Bonavista headland area, 1970-1990

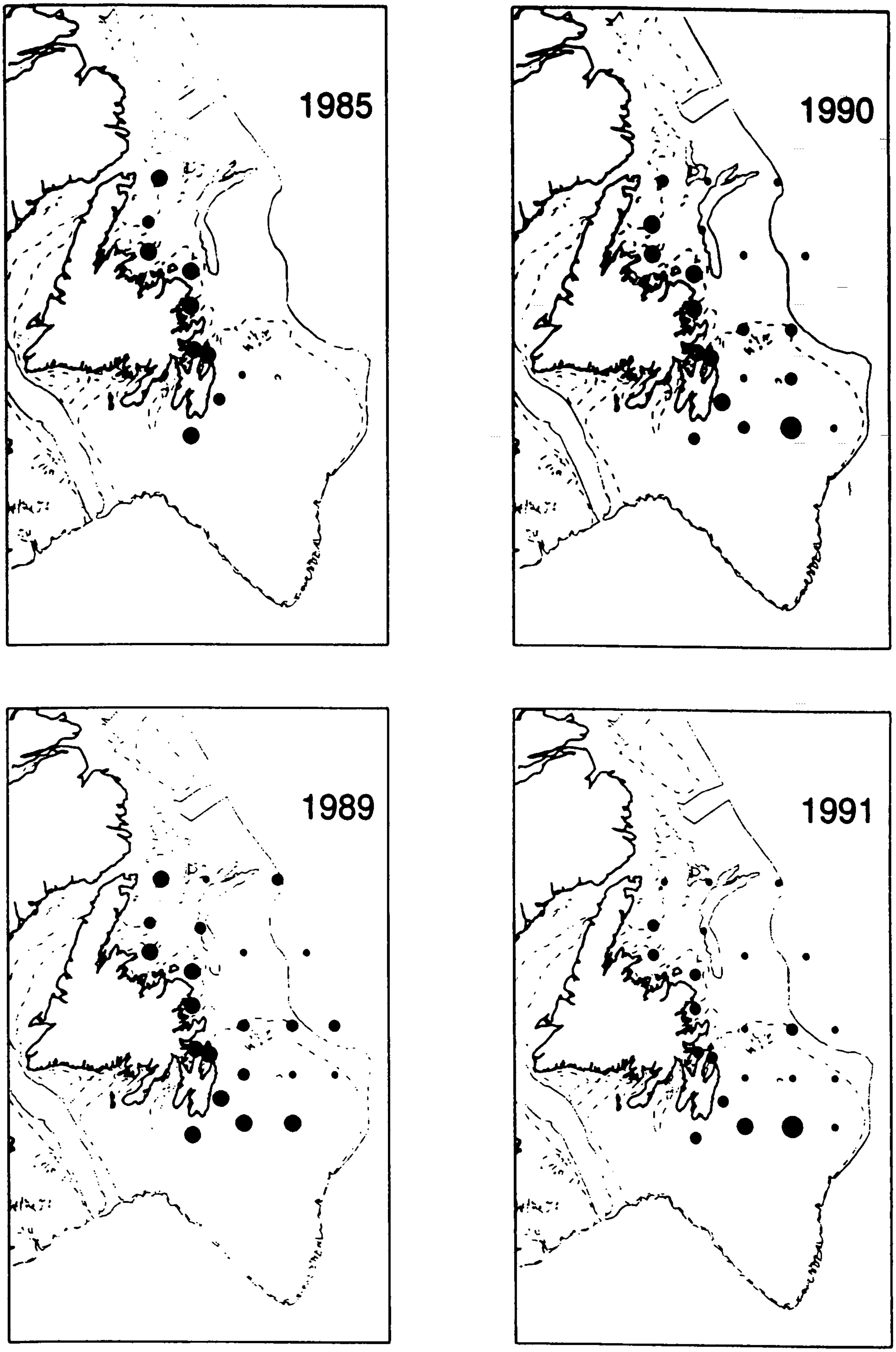


Figure 11