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The 1995 review of the Canadian Offshore Lobster Fishery - LFA 41

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

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ABSTRACT

The Canadian offshore lobster fishery (LFA 41) fishes the outer shelf from south of Baccaro Bank to Truxton Swell in the Gulf of Maine, and along the outer edge of Georges Bank. The fishery began in 1971 and the fleet expanded to eight by 1975. In 1976 a 408 t quota was placed on 6 vessels fishing 4X and two vessels were restricted to 5Ze. Following the ICJ decision in 1985 Enterprise Allocations; and a Total Allowable Catch of 720 t applied to 4X and 5Ze were introduced. The removal of American effort in 1985 and introduction of larger vessels, opened new grounds and increased the fleets flexibility, resulting in increased fishing effort in the area southwest of Browns Bank and in Crowell Basin.

The stock status evaluations are based on trends in landings, and catch rate calculated from compulsory daily logbooks, size structure of the commercial catch from at-sea sampling, and relative abundance based on lobster by-catch in the American National Marine Fisheries Service spring and fall groundfish surveys on Georges Bank and in the Gulf of Maine.

Catch rates have remained relatively stable on most grounds though their value as a long term indicator has been reduced in recent years due to changes in fishing strategy, and improved compliance in reporting daily trap hauls. The sizes of lobster in the catch have remained stable on the different grounds since the fishery began in 1971. While part of the stability may reflect trap and behavioural selectivity, the lack of any change over the 23 years of fishing suggest that the fishery is removing a small percentage of the lobsters available. NMFS trawl surveys suggest that the abundance of lobsters in deep water (>100 m) areas of the Gulf of Maine and Georges Bank was lower in the late 1960s and increased during the 1970s. The increase may be related to warmer water temperatures during the 1970s. Inshore lobster vessels fishing just inside the offshore line west of Browns Bank are also targeting the same lobsters as the offshore vessels. Their landings, estimated to be 50-70 t, needs to be considered when evaluating the offshore resource.

The short-term outlook is for continued high landings in the 1994-95 season. In the longer term, landings will continue to vary with availability, catchability and effort. Long-term environmental changes such as the cooling trend during the 1960s would reduce growth rates and could effect reproduction, migration patterns and distribution. To avoid an over concentration of landings from any one area which could reduce the reproductive potential of the stock, biologists believe that landings should be distributed over the various grounds.

Document includes references to tables and figures containing information considered confidential by the two enterprises involved. These data are not included in this public document but can be made available by the author with prior written permission from both enterprises: Clearwater Atlantic Seafoods Inc., Bedford, N.S., and Donna Rae Ltd., Lockeport, N.S.

RÉSUMÉ

Au Canada, la zone de pêche hauturière du homard (ZPH 41) se trouve dans la partie extérieure de la plate-forme, du sud de Baccaro Bank à Truxton Swell, dans le golfe du Maine, et longe le bord extérieur du banc Georges. La pêche dans ce secteur a commencé en 1971, et la flotte comptait 8 bateaux en 1975. Un an plus tard, 6 bateaux pêchant dans 4X se sont vu imposer un quota de 408 t; 2 autres ont été confinés à 5Ze. En 1985, à la suite d'une décision rendue par la CIJ, on a introduit des allocations d'entreprise, et on a fixé à 720 t le total des captures admissibles dans 4X et 5Ze. Par suite du retrait de l'effort américain en 1985 et de l'introduction de bateaux plus grands, la flotte a accru sa souplesse et a pu explorer de nouveaux lieux de pêche, ce qui a permis d'accroître l'effort de pêche dans la zone située au sud-ouest du banc Browns et dans le bassin Crowell.

Les évaluations sur l'état des stocks sont fondées sur les tendances des débarquements; le taux de prise est calculé à partir des données obligatoirement consignées dans les journaux de pêche quotidiens; la structure selon la taille des prises commerciales est déterminée en fonction des échantillons prélevés en mer, et l'abondance relative, en fonction des prises accidentelles de homard notées dans les relevés de recherche sur le poisson de fond du banc Georges et du golfe du Maine, relevés effectués au printemps et à l'automne par l'American National Marine Fisheries Service (NMFS).

Les taux de prise sont demeurés relativement stables dans la plupart des lieux de pêche, même si ces indicateurs à long terme ont perdu de la valeur depuis quelques années, par suite de changements à la stratégie de pêche et d'un accroissement du nombre de casiers relevés. Dans tous les lieux de pêche, les homards capturés sont à peu près de la même taille depuis 1971. Si cette stabilité est en partie attribuable à la sélectivité des casiers et au comportement, elle peut également signifier que les pêcheurs ne capturent qu'un petit pourcentage des homards de ces eaux. Les relevés de recherche au chalut du NMFS révèlent que les homards des eaux profondes (>100 m) du golfe du Maine et du banc Georges étaient plus abondants dans les années 70 qu'à la fin des années 60. Cette augmentation pourrait être reliée au réchauffement des températures au cours des années 70. La flotte côtière qui pêche tout près de la ligne extracôtière, à l'ouest du banc Browns, cible les mêmes homards que la flotte hauturière. Ses débarquements, estimés à 50-70 tonnes, doivent être pris en considération dans l'évaluation de la ressource hauturière.

Pour 1994-1995, on s'attend à des débarquements abondants. À long terme, les débarquements continueront de varier selon la disponibilité, le potentiel de capture et l'effort. Des changements écologiques à long terme, tels que le refroidissement observé pendant les années 60, pourraient réduire les taux de croissance et nuire à la reproduction, aux cycles migratoires et à la distribution. Pour éviter une surconcentration des débarquements de homard provenant d'une zone donnée et, par conséquent, une réduction du potentiel reproducteur de l'espèce, les biologistes estiment que la flotte devrait être répartie dans les divers lieux de pêche.

Ce document renvoie à des tableaux et à des chiffres qui contiennent de l'information considérée comme confidentielle par les deux entreprises concernées. Ces données ne figurent pas dans le document public, mais peuvent être fournies par l'auteur, avec la permission écrite des deux entreprises : Clearwater Atlantic Seafoods Inc. de Bedford (Nouvelle-Écosse), et Donna Rae Ltd., de Lockeport (Nouvelle-Écosse).

RESTRICTIONS ON OFFSHORE LOBSTER FISHERIES DATA PUBLICATION

In fisheries with only 2 enterprises, publication of detailed information could give the competing enterprise insight into each others operations. This could result in an unfair advantage for one of the enterprises. To avoid this permission must be obtained from the two enterprises prior to publishing the information. For this report the two enterprises set the following restrictions

Clearwater Atlantic Seafoods Inc., Bedford, N.S., approved publication of all data except landings, effort and CPUE for Crowell Basin which represents the landings of a single vessel. Data from all other areas and amalgamated areas which include Crowell Basin data are presented.

Donna Rae Ltd., Lockeport, N.S., has only a one license that fishes only Southwest Browns. They requested that information from Southwest Browns containing their landings and effort information not be published.

The full data set was reviewed during the Regional Assessment Process but can be made public only with the written permission of both enterprises.

INTRODUCTION

Lobsters inhabit the coastal regions of North America from southern Labrador to Maryland and offshore along the outer continental shelf from The Gully on the Scotian Shelf to off North Carolina (Fig. 1). Lobsters are found from the low water line to depths of 700 m (Cooper and Uzmann 1980; Pezzack, *et al.* 1992) .

The major commercial concentrations occur in the coastal regions of the southern Gulf of St. Lawrence and the Gulf of Maine. The major commercial offshore concentrations occur along the slope from Baccaro Bank to Hudson Canyon and in the deep basins of the Gulf of Maine (Cooper and Uzmann 1980; Ennis 1986; Pezzack 1993)

The Canadian offshore lobster fishery operates in LFA 41 (Fig. 2) along the edge of the Scotian Shelf, from south of Baccaro Bank to Truxton Swell in the Gulf of Maine, and along the outer edge of Georges Bank as far south as the International Court of Justice (ICJ) line. The fishery began in 1971 when licenses were made available to vessels displaced by the closure of the swordfish fishery. Five licenses were issued in 1972, and the fleet expanded to eight before new entries were stopped in 1975. The development of the fishery has been monitored (Pezzack and Duggan 1985; Pezzack and Duggan 1987; Pezzack and Duggan 1988) and the major milestones are summarized in Table 1.

An Offshore Lobster Management Plan was introduced in 1985. The major points of the plan were:

- 1) the introduction of Enterprise Allocations (EA);
- 2) a Total Allowable Catch (TAC) of 720 t applied to 4X and 5Ze, and equally divided between licenses;
- 3) a TAC season set from August 1 to July 31 (later changed to Oct. 16 to Oct. 15).

The increased TAC, introduction of EAs, and change in season were introduced to increase the profitability of the existing fishery, which economic analyses indicated was low (pers. comm. J. Nelson, Economics Branch, DFO Halifax). No new licenses were issued. Following a review of the

potential for fishing in NAFO 4W (Pezzack 1987; Pezzack and Duggan 1987) in 1987 the Minister issued 4 new licenses to fish both 4W and 4X/5Ze and set a 360 t TAC for 4W. These licenses were never activated and the Minister withdrew them in 1988 following protest from the inshore fishers.

The offshore fishery (LFA 41) has been a contentious issue with inshore fishers since it began in 1971. Concerns have been raised on the impact of the offshore lobster fishery on the broodstock potentially sustaining the inshore population and /or on the removal of the seasonally migratory adult component to the inshore area. Current lines of evidence suggest that the offshore fishery has not had any perceptible effects on the inshore fishery thus far, and that the most likely impact would be in the reduction of larvae transported from Browns Bank to the inshore area. The impact of exploitation of lobsters from Georges Bank and the eastern Scotian Shelf on the inshore fishery was deemed to be small (Pezzack, *et al.* 1992)

The fishery was last formally reviewed in 1988 (Pezzack and Duggan 1988) though annual updates have been produced for the Offshore Lobster Advisory Committee and in the form of annual summary sheets (1993-95).

The purpose of this paper is to:

- 1) Update information on the offshore fishery which was last reviewed at CAFSAC in 1988;
- 2) Evaluate the importance of recent shifts in fishing grounds;
- 3) To determine if there is a need to review the present TAC and regulations.

Industry Concerns on State of the Stock and Scientific Assessment:

During the annual Offshore Lobster Advisory Committee meeting, industry representatives were asked for their views and concerns on the state of the lobster stocks and the scientific assessment of the stocks. The following are the consensus opinions of the representatives of the two enterprises:

- 1) Based on DFO assessment and observations from fishing activities, it is felt that the offshore lobster resource remains in good shape.
- 2) Industry is concerned with the continued increase of midshore effort just inside the 50 mile line separating inshore and offshore districts. The impact of this increased effort on offshore stocks and landings is not known. They request that it be more closely monitored and considered during future assessments.
- 3) Industry expressed their approval and appreciation of the high quality of the scientific assessments, but are concerned that cuts to DFO science will effect the nature and quality of future science activities. They are concerned that this will reduce DFO's ability to fulfil its mandate to provide the information needed to manage the fishery.

METHODS AND DATA INPUT

Fishery Data

Landings, effort (trap hauls (TH) and days fished) and location information were obtained from:

Compulsory log books 1972-1993;
Sales slips 1972-1993
Dockside monitoring (replaces logs and sales slips) 1994

Landings, location and days fished are accurately reported, but in some cases trap hauls were under reported while the fishery was under a trap limit (1977-1993). Observations during at-sea sampling indicated that trap hauls were under reported in the logs, but there was insufficient coverage to provide a correction factor that could be applied to all vessels over the entire year.

Effort measured in days fished are accurately reported but fishing power has increased since the early 1980s. Both the introduction of larger vessels in the early and mid 1980s and the use of shorter trips has increased the number of trap hauls (TH) per day (Fig. 3).

Effort in TH and calculated CPUE values provide relative indices but as stated are subject to error and their value as a long term indicator has been reduced in recent years due to changes in fishing strategy, trap design, vessel size and fishing power, and improved compliance in reporting daily trap hauls.

Size Structure of Commercial Catch

Population size structure is monitored through at-sea samples of the commercial catch, distribution of catch into market size groups (cull groups) reported in sales slips (1972-1993) and Dockside Monitoring (1994). At-sea samples are taken periodically from each area and provide detailed information on the size structure of the catch, including sublegals and egg bearing females. At-sea samples measure lobsters from every trap or every second or third trap (frequency based on catch rates and ability of sampler to accurately measure what is being caught). Carapace length, sex and egg stage (if present) are recorded. Sample size ranged from 600-2600 lobsters. Cull groups data available for all trips gives breakdown of the landings by 1-3 lb., 3-8 lb., +8 lb. and culls (missing claws).

Relative Estimates of Abundance

Estimation of overall abundance is not possible from the available fishery data. Long term trends in relative abundance can be obtained from the lobster by-catch in National Marine Fishery Service, Woods Hole, Mass. (NMFS) autumn (Sept.) and spring (March) groundfish trawl surveys (1968-1994). The American groundfish trawl survey has been used by American biologists in recent lobster assessments. From the beginning lobster bycatch was an integral part of the data collected, with length, weight and sex recorded. Until 1986 their surveys included Browns Bank and parts of the Scotian Shelf.

The mean catch per tow data (based on Delta Mean (Pennington 1983) data was obtained for strata 16-22 (Georges Bank), 29-30, 36 (Northeast Channel, Crowell and Jordan Basin) (Fig. 4).

Assessment Areas

The offshore lobster data has traditionally been reported by NAFO subareas 4X and 5Ze. Early in the monitoring of the fishery area differences were observed that did not correspond to these NAFO areas and 3 fishing areas were defined: Southwest Browns, Southeast Browns and Georges Bank (Fig. 5).

Changing fishing patterns in the mid 1980's opened new grounds and further subdivisions were made. Recent data are reported by 5 areas Crowell Basin, Southwest Browns, Georges Basin, Southeast Browns and Georges Bank (Fig. 6). Pre 1981 data are reported by the 3 areas.

Reporting Periods

The fishery operated on a calendar year basis between 1971-1985 and for long term trends is still reported in this manner. Since 1986 the TAC season has been Oct. 16-Oct. 15. Landings are presented on both a calendar year basis, to allow longer term comparison, and October-October to reflect the TAC year.

RESULTS

Catch and effort

There are wide size ranges in the offshore [Crowell Basin 60-180 mm CL (median 110 mm CL) Georges Bank 60-220 mm CL (median 120 mm CL)] which represent a large number of year classes. Landings are not, as they are in the inshore fisheries, based on the annual recruitment of lobsters into the first legal size group (81-93 mm CL). Thus short term variations in offshore landings are due to changes in availability (distribution), catchability and effort, more than to changes in recruitment or overall abundance.

Overall landings increased rapidly in the early years of the fishery, reaching 678 t in 1976. Following the imposition of the 4X quota in 1977 landings dropped in 4X and increased in 5Ze (Fig. 7). Landings remained relatively stable until 1981 and declined between 1982 and 1984 reaching a low of 440 t. Landings increased sharply in 1985 to over 700 t following the ICJ decision that removed American vessels fishing parts of Georges Bank and Georges and Crowell Basin and the introduction of the new 720 t TAC for 4X/5Ze. The TAC was met in the first two seasons (1985-86, 1986-87). While landings increased on all grounds most of the increase was due to higher landings in Georges Basin (Fig 8).

Landings declined between 1987 and 89 as catches declined in the Georges Basin and Southeast Browns areas. Since 1990 landings have increased due largely to increases in Crowell Basin, Georges Basin and recently Southeast Browns (Fig. 8). Fall 1994 landings were very high and by Jan. 15 over 50% of the 1994-95 TAC had been taken.

Annual CPUEs are calculated as mean kg/TH and mean kg (,000)/day (Fig. 9,10) for each of the five assessment areas. Their value as a long term indicator of stock abundance have been reduced in recent years due to changes in fishing strategy, trap design, and improved compliance in reporting daily trap hauls. They are however useful in providing a relative indicator of trends on the various grounds. The increased reporting of actual trap hauls over the last two years would result in lower CPUE values if the true CPUE values remained constant. Thus the steady increases in Crowell Basin CPUEs suggest that the catch rate has increased, and the increase in CPUE may be greater than indicated by the data. Similarly, the lack of any significant change in Southwest Browns and Georges Basin CPUE over the same period suggest that the CPUE may also have increased in those areas.

Fishing Patterns

During the 1970s and early 1980s vessels generally fished a single ground (Table 2) and moved very little. Crowell Basin was fished part of the year by a single vessel, Georges Bank by two vessels, Southwest Browns by two vessels and Southeast Browns by two - three vessels. The introduction of larger steel hulled vessels in the early 1980s allowed vessels to move gear between grounds more easily. Removal of American effort and the dropping of the restriction on the two vessels assigned to 5Ze further allowed vessels to change grounds and fish more than one area at a time.

Following the ICJ decision fishing effort increased in Crowell and Georges Basins as effort shifted away from the slope region of Southeast Browns and Georges Banks (Fig. 11). The Basin areas, which are easier to fish than the slope regions, yield a more valuable smaller lobster. Georges Basin landings increased from 34.5 t in 1984 to 267.9 t in 1985. Following several high years, landings dropped to 42.7 t in 1989. Landings subsequently increased and have been > 100 t in the 1990's. Crowell Basin in

1994 were 4.4 times those of 1982. Prior to the ICJ decision both these areas were fished by American vessels.

The Southwest Browns fishing grounds were not fished by American vessels and no new grounds in this area were opened by the ICJ decision. The reported effort (TH) declined during the mid 1980s but has increased steadily since 1987. Landings ranged between 100 and 180 t between 1995 and 1989, and were slightly above 200 t in 1990, but returned to the levels of the late 1980's in 1994. Reported CPUE (kg/TH) has declined slightly since 1990 but remain close to the 1981-1990 average (Fig. 9). CPUE (kg/day) has increased since 1988 (Fig. 10) and is likely due to the change in vessels fishing this ground.

The proportion of the total offshore landings from the grounds west of Browns Bank, that includes Southwest Browns, Crowell and Georges Basin increased from <25 % in 1981 and to over 60% in the 1990s (Fig. 12). Much of this was due to the removal of American effort and the subsequent change in fishing strategy. It is impossible to determine what was removed by the Americans prior to 1985 and whether or not removal rates are higher now than in the past.

In setting the 1985 TAC, 508 t came from 4X (408 t 4X quota plus 100 t of an estimated 200 t being fished by American vessels) and 212 t from Georges Bank (based on historic landings). The ratio of 4X:5Ze landings was 2.4:1 (4X:5Ze). Over the last three seasons (1991-92, 1992-93, 1993-94) the ratio has been 3.1:1, 2.5:1 and 2.9:1.

Inshore lobster fishing effort has increased in the area west of Browns Bank and just inside the offshore line. These vessels harvest the same stock as the offshore vessels, but in the past their landings have not been considered in the offshore assessment. Between 1990-94 four to six vessels fished inside the offshore line with total reported annual landings between 45-67 t. There are indications that the number of inshore vessels in this area has increased in 1995. (Duggan and Pezzack 1995)

Size Composition

Since the mid 1980s, the fishery has targeted areas with smaller lobsters as seen in the overall size composition obtained from the sales slip data (Fig. 17). The proportion of the catch in the 1-3 lb. size group increased from 26% in 1982 to 58% in 1991. The shift was due to a movement of effort from the outer slope (Southeast Browns, Georges Bank), that has a large average size, to Southwest Browns and the Basins of the Gulf of Maine that have a smaller average size (Fig. 13-15). Similarly the decrease in 1-3 pound sizes over the last three years reflects the recent increased landings from Georges and Southeast Browns.

On the individual fishing grounds there has been no significant shift in the median size or overall size structure (Fig. 13-15) over the sampling period. Some small differences have been observed between the samples. Fewer very large sizes (> 160 mm CL) were caught in Corsair Canyon during the 1980s samples than in 1972. One reason was the elimination of top entry traps in the mid 1970s. The top entry traps with 250 mm entry rings had higher catches of the very large sizes (Pezzack and Duggan 1995). The numbers of smaller sizes on Southwest Browns Bank increased in the early 1980s. The increase could be due to a change in trap design (vessels began to target the smaller sizes and some fishers decreased the trap entrance size) and increased recruitment due to the general recruitment pulse observed elsewhere (Pezzack 1993).

Gear selectivity and size related catchability and distribution could result in a size structure in the

catch different from that of the population (Smith 1944; Miller 1989; Pezzack and Duggan 1995). If the difference is large, changes in the population size structure would be hard to detect. Very large sizes (>165 mm CL) are believed to be under sampled due to physical restraints of the traps. Smaller sizes are under-sampled because of behavioural and distributional differences. The offshore fishery targets the migratory population and depend upon lobsters moving some distance to the traps. For this reason 5-6 days is the most effective set-over time for the traps. Immature sizes (<95 mm CL) are less migratory (Campbell 1986; Campbell and Stasko 1986) and sublegal sizes (<81 mm CL) are more confined to shelter and less likely to undertake movements across open bottom. In addition, immature sizes, though caught in deep water, were found in greatest numbers (Fig. 16b) in the shoal area of Browns Bank (less than 50 m), an area not fished.

NMFS Trawl Survey Results

Trawl gear is not designed to sample lobsters and the catch rates are highly variable. For this reason long term trends and not year to year changes should be looked at. Mean (delta distribution mean) numbers per tow are presented for strata 16, 19 and 20 on eastern Georges Bank, 29 and 30 in the Georges Basin-Northeast Channel and 31 and 32 (not sampled after 1986) on and around Browns Bank (Fig. 18-19). The data was smoothed using the Lowess method (Cleveland 1979) to indicate the general trends in catch rates.

Georges Bank shallow water stratum has higher autumn catch rates than the spring. This is consistent with the seasonal migrations observed in tagged animals. (Cooper and Uzmann 1971; Uzmann, *et al.* 1977; Cooper and Uzmann 1980; Pezzack and Duggan 1986; Pezzack and Duggan 1987).

Catch rates from the Browns Bank and the deep water of the Northeast Channel (Fig. 18) indicate a population that grew in the early 1970s, but there is no consistent trend since. A more consistent upward trend is seen in the autumn samples from Georges Bank suggesting the population has increased during the 1970s and 80s in spite of fishing pressure.

Environmental Conditions

The offshore habitat includes the deep water slope and basins with relatively stable annual temperatures of 7-10°C, Browns Bank that varies seasonally from 4-12°C and Georges from 4-16°C. (Colton and Stoddard 1973; Mountain and Holzwarth 1989). Mature lobsters migrate to the deep water in winter and the shallow water in summer to take advantage of the temperatures available. Changes in the timing of shallow water warming may affect the timing and rate of the migration on and off the banks and thus affect distribution and catch rates.

A general cooling trend in the Gulf of Maine from the late 1950s to the mid 1960s resulted in temperatures averaging 3-4°C cooler in the basins and 4-6°C cooler on Georges Bank (Mountain 1982). Data from Prince Station 5 (Fig 20; long term temperature monitoring station in the Bay of Fundy monitored from the Biological Station, St. Andrews, N.B.) shows the long term trends in the Gulf of Maine and indicates cooling from the late 1970s to the early 1990s with temperatures reaching those of the 1960s. Temperatures increased rapidly over the last few years and are now higher than average.

Long term changes in bottom water conditions must be considered in assessing the offshore fishery. The effect of the cooler temperatures during the 1960s on distribution, growth and reproduction are not known, but the NMFS trawl data suggest abundance was lower.

Resource Status

Following the 1984 Gulf of Maine Boundary settlement which removed American vessels from the present offshore district, a single 4X/5Ze TAC operated under an Enterprise Allocation (EA) program was introduced to replace the boat quota that had applied only to 4X. The removal of American effort, increased TAC and introduction of larger vessels opened new grounds and increased the fleets flexibility. Individual vessels now fish different areas simultaneously and move gear between them as catch rates change. The result has been increased fishing effort in the area southwest of Browns Bank and in Crowell Basin.

Concerns over a possible link between inshore and offshore lobsters has influenced the management of the fishery. Limiting the fishery to 8 licences, the TAC and the closure of Browns Bank, were designed to preserve the reproductive potential of what was perceived as a potential brood stock for the larger more valuable inshore fishing grounds. There are no indications to date that the offshore fishery has had any impact on the inshore fishery, and the information available can neither prove nor disprove a link between them. It is suggested that if a link does exist it is likely through exchange of larvae from Browns Bank and not from Georges Bank or the upper slope of the Scotian Shelf (Pezzack et al. 1992).

The present distribution of offshore landings between Browns and Georges Bank is similar to that used in the original allocation of the 720 t TAC. Biologists believe that landings should be distributed over the various grounds to avoid an over-concentration of landings from any one area which could reduce the reproductive potential of the stock.

The short term outlook is for continued high landings in the 1994-95 season. In the longer term, landings will continue to vary with availability, catchability and effort.

In the long term environmental changes such as the cooling trend during the 1960s may have important implications to the fishery. Lobsters are present in the offshore basins and banks because of the year-round warm water and a change in temperature could result in changes in distribution and productivity.

CONCLUSIONS

1. The indices available to evaluate the offshore indicate that little has changed over the last 15 years. Catches have remained at or near TAC levels and the size structure of the catch is unchanged. NMFS groundfish trawl data suggest abundance has increased since the late 1960s. The short term outlook is for high landings in the 1994-95 season. In the longer term landings will likely continue to vary with availability, catchability and effort. The recent stability has however been during a period when all lobster stocks have been high (Pezzack 1993)
2. The value of catch rates as a long term indicator have been reduced in recent years due to changes in fishing strategy, trap design, vessel size and fishing power, and improved compliance in reporting daily trap hauls. Since more accurate reporting of trap hauls would have the effect of lowering the value of calculated CPUE (kg/TH), the lack of decrease in Southwest Browns and Georges Basin and the increase in Crowell Basin are positive signs.
3. The pattern of fishing changed following the introduction of larger vessels, exclusion of American effort following the ICJ decision and the increase in the TAC. The fleet has increased flexibility and now fishes the entire area, fishing different areas simultaneously and moving gear as catch rates change.

4. NMFS trawl surveys suggest that the abundance of lobsters in deep water areas of the Gulf of Maine and Georges Bank was lower in the late 1960s and increased during the 1970s. The increase may be related to warmer water temperatures during the 1970s. Long term oceanographic changes must also be considered as they could have implications to the offshore fishery. The cause of the shifts in bottom water masses are not fully understood nor are they predictable. If conditions similar to the 1960s re-occur, offshore productivity and landings could be affected.
5. The sizes of lobster in the catch have remained stable on the different grounds since the fishery began in 1971. While part of the stability may reflect trap and behavioural selectivity (lobsters of certain sizes are more likely to be caught than others; Pezzack and Duggan 1995), the lack of any change over the 23 years of fishing suggest that the fishery is removing a small percentage of the lobsters available, possibly 15-25% each year.
6. Concern over the potential link between inshore and offshore lobsters has influenced the management of the fishery. The closure of Browns Bank since 1979, the TAC and limiting the fishery to 8 licences were all to prevent over-exploitation of what was perceived to be a potential brood stock for the inshore areas. There are no indications to date that the offshore fishery has had any impact on the inshore fishery. Available information can neither prove nor refute a link between coastal inshore and offshore areas, but it suggests that if a link with the inshore does exist it is more likely from Browns Bank and not Georges Bank or the upper slope of the Scotian Shelf (Pezzack, *et al.* 1992).
7. Effort and landings in the area west of Browns Bank has increased since 1984 and accounts for all of the increase in landings under the TAC introduced in 1985. In setting the 1985 TAC, approximately 508 t came from 4X (408 t 4X quota plus 100 t of an estimated 200 t being fished by American vessels) and 212 t from Georges Bank (based on historic landings), a ratio of 2.4:1 (4X:5Ze). Over the last three seasons (1991-92, 1992-93, 1993-94) the ratio has been 3.1:1, 2.5:1 and 2.9:1.
8. Inshore lobster vessels fishing just inside the offshore line west of Browns Bank are targeting the same lobsters as the offshore vessels. Their landings, estimated to be 50-70 t, needs to be considered when evaluating the offshore resource.

RECOMMENDATIONS

1. No management changes are recommended.
2. Discussions with the enterprises are recommended to develop harvest plans that will prevent the possibility of an over concentration of landings from any one area that could reduce the reproductive potential of the stock. While the potential exist for over concentration on one component of the fishery the limited space on the fishing grounds limits effort. The 1985 Management plan set up a single TAC for the offshore fishery based on historic allocations and landings. It did not differentiate between the Georges and Browns Bank stocks though they have different potential relationships to the inshore fishery. There has been recent increases in effort on Georges Bank and Southeast Browns areas after several years of lower fishing activity, and the present distribution of landings between 4X and 5Ze is similar to that used to set the 720 t TAC
3. Long term environmental changes such as the cooling during the 1960s may have important implications to the fishery and should be considered in future assessments
4. The inshore vessels fishing just inside the offshore line between Browns Bank and Truxton Swell are

exploiting the same lobsters as the offshore and their landings should be considered in future off-shore assessments.

REFERENCES

- Anonymous 1989. The Scotia-Fundy lobster fishery. Phase I: Issues and considerations. Summary report. Communication Branch, Dept. Fisheries and Oceans, Scotia-Fundy region, P.O. Box 550, Halifax, N.S. B3J 2S7.
- Campbell, A. 1986. Migratory movements of ovigerous lobsters, *Homarus americanus*, tagged off Grand Manan, Canada. Can. J. Fish. Aquat. Sci. 43: 2197-2205.
- Campbell, A. and A.B. Stasko. 1986. Movement of lobster (*Homarus americanus*), tagged in the Bay of Fundy, Canada. Mar. Biol. 92: 393-404.
- Cleveland, W.S. 1979. Robust locally weighted regression and smoothing scatterplots. JASA 74: 829-836.
- Colton, J.B. and R.R. Stoddard. 1973. Bottom-water temperatures on the continental shelf, Nova Scotia to New Jersey. NOAA Tech. Rpt. NMFS-CIRC-376: 55p.
- Cooper, R.A. and J.R. Uzmann. 1971. Migration and growth of deep-sea lobsters, *Homarus americanus*. Science (Wash., D.C.) 171: 288-290.
- Cooper, R.A. and J.R. Uzmann. 1980. Ecology of adult and juvenile Homarus. pp. 97-142. In The biology and management of lobsters. Vol. 2. J.S. Cobb and B.F. Phillips (eds.). Academic Press, New York, N.Y.
- Duggan, D.R. and D.S. Pezzack. 1995. The midshore lobster fishery off southwestern Nova Scotia: Inception, development, and current status. DFO Atlantic Fisheries Res. Doc. 95/46, 38p.
- Ennis, G.P. 1986. Stock definition, recruitment variability, and larval recruitment processes in the North American lobster *Homarus americanus*: a review. J. Fish. Aquat. Sci. 43: 2072-2084.
- Miller, R.J. 1989. Catchability of American Lobster (*Homarus americanus*) and Rock Crab (*Cancer irroratus*) by trap. Can. J. Fish. Aquat. Sci. 46: 1652-1657.
- Mountain, D.G. 1982. Oceanographic conditions in NAFO Subareas 5 and 6 during 1970-79. Northw. Atl. Fish. Org. Sci. Coun. Studies 5: 95-100.
- Mountain, D.G. and T.J. Holzwarth. 1989. Surface and bottom temperature distribution for the northeast continental shelf. NOAA Tech. Mem. NMFS-F/NEC-73 : 32p.
- Pennington, M. 1983. Efficient estimators of abundance, for fish and plankton surveys. Biometrics 39: 281-289.
- Pezzack, D.S. 1987. Offshore lobster stocks in NAFO Subarea 4W: potential for a new fishery. Can Atl. Fish. Sci. Adv. Comm. Res. Doc. 87/78: 16.
- Pezzack, D.S. 1993. A review of lobster (*Homarus americanus*) landing trends in the Northwest Atlantic, 1947-86. J. Northw. Atl. Fish. Sci. 14: 1115-127.
- Pezzack, D.S. and D.R. Duggan. 1985. The Canadian offshore lobster fishery 1971-1984, catch history, stock condition and management options. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 85/89:

- Pezzack, D.S. and D.R. Duggan. 1986. Evidence of migration and homing of lobsters (*Homarus americanus*) on the Scotian Shelf. Can. J. Fish. Aquat. Sci. 43: 2206-2211.
- Pezzack, D.S. and D.R. Duggan. 1987. Canadian Offshore Lobster Fishery, 1985-86, and assessment of the potential for future increases in catch. Can. Atl. Fish. Adv. Comm. Res. Doc. 87/79: 25.
- Pezzack, D.S. and D.R. Duggan. 1988. An assessment of the Canadian offshore lobster fishery (LFA 41) for 1986-87. CAFSAC Res. Doc 88/65:
- Pezzack, D.S. and D.R. Duggan. 1995. Offshore lobster (*Homarus americanus*) trap-caught size frequencies and population size structure. ICES Mar. Sci. Symp., 199:129-138.
- Pezzack, D.S., M.J. Tremblay, C. Hudon and R.J. Miller. 1992. The inshore-offshore lobster issue in Southwestern Nova Scotia. Can. Manuscr. Rep. Fish. Aquat. Sci. 2165 23p.
- Smith, G.F.M. 1944. The catchability of lobsters. J. Fish. Res. Board Can. 6: 291-301.
- Stasko, A.B. 1978. Inshore-offshore S.W. Nova Scotia lobster stock interaction: A hypothesis. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 78/37: 10.
- Uzmann, J.R., R.A. Cooper and K.J. Pecci. 1977. Migration and dispersion of tagged American lobsters, *Homarus americanus*, on the southern New England continental shelf. NOAA Tech. Rep. NMFS SSRF 705:
- Wilder, D.G. 1974. Inshore and offshore lobster stocks. Fish. Res. Board Can. MS Rep. 1293: 14.

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We thank Dr. Peter Lawton reviewing an earlier draft of this report, and the offshore lobster licence owners and their captains for supplying valuable information over the years. We also thank Dr. D. Wilder and Donald Graham for the foresight in taking at-sea samples during the first years of the fishery. These provide a valuable baseline for comparing later samples.

Table 1: Chronology of Scientific Advice and Management Actions in the Offshore Fishery

- 1971 - Offshore lobster licenses were made available to 56 swordfish boats after that fishery was closed due to what was thought to be higher than acceptable mercury levels in swordfish. Inshore and offshore fleets were restricted to inside and outside a line drawn approximately 50 nautical miles (92 km) (Fig. 2) from shore (Wilder 1974) .
- 1974 - Wilder (1974) advised that inshore and offshore lobsters did not mix, based on evidence of size differences and movement of tagged animals.
- 1975-6- Inshore fishermen strongly objected to increased landings and effort by the offshore fleet. Consequently, the offshore fleet was frozen at the existing 8 licenses, and a 9 month season, a 1000 trap per vessel limit. A 408 t quota was established for NAFO 4X (Fig. 5) Six vessels given 68 t each in 4X and two vessels were restricted to 5Ze (Georges Bank). No quota were imposed on catches from Georges because that stock was shared with the unregulated U. S. fishery (Stasko 1978; Pezzack and Duggan 1985). The quota was based on the previous years landings and was designed to cap landings at the 1976 level.
- 1978 - Stasko (1978) hypothesized that adult lobsters might migrate from inshore to Browns Bank, and release larvae that drift back inshore.
- 1979 - Browns Bank was closed to lobster fishing (Fig. 2) to protect a spawning area hypothesized by Stasko (Pezzack and Duggan 1985).
- 1985 - Following the ICJ decision on the Canada/USA boundary in the Gulf of Maine, each of the 8 offshore licenses was given a quota of 90 t, for a TAC of 720 t for 4X and 5Ze combined and the restriction of two licenses to 5Ze was dropped. The new TAC of 720 t was set based on the existing 4X quota, the average landings by the vessels fishing 5Ze and a portion of the estimated catch previously taken by the American fleet (Pezzack and Duggan 1987; Pezzack and Duggan 1988) The closed season was removed, but the trap limit remained. Pezzack and Duggan (1988) advised that the trap limit had little conservation value because catches are quota limited,.
- 1986 - TAC season adjusted to Oct. 15-Oct. 16 and EA program begun.
- 1987 - Pezzack (1987) advised that the exchange of commercial-sized lobsters between the edge of the Scotian Shelf between La Have and Banquereau Bank and the inshore zone was unlikely and that there was potential for an experimental fishery in NAFO 4W.
- Jan., 1988 - The Minister of Fisheries announced the addition of four licenses and 360 t of TAC to the offshore.
- April, 1988 - The Minister of Fisheries suspended the new licenses after strong objections from inshore lobster fishermen.
- April, 1988 - The Scotia-Fundy Lobster Study was initiated because of the above objections as well as recent requests from non-license holders for more inshore licenses (Anonymous 1989) .
- 1990 - License holders recommended no increase in inshore or offshore licenses (meetings discussing the Scotia-Fundy Lobster Study).
- 1992 - Report on Inshore/Offshore issue (Pezzack, *et al.* 1992) presented evidence that suggested the offshore fishery had not had any perceptible effects on the inshore fishery thus far. The report concluded available information can neither prove nor refute a link between coastal inshore and offshore areas, but if a link does exist it is more likely through larval transport from Browns Bank and not Georges Bank or the upper slope of the Scotian Shelf (Pezzack, *et al.* 1992).
- 1994- Trap limit removed because vessels were already fishing under a TAC and EA.

Table 2: Changes in fishing methods

1972 to 1982 -	<ul style="list-style-type: none"> 8 wooden vessels 17-28 meters vessel crew of 5-8 men strings of 50 wooden traps each fishing depths of 90-450 meters fishing trips of 10-14 days duration 5-7 days between trips fish one area but vary depths throughout season fishing restricted by weather - especially in winter months
1982 - 1988	<ul style="list-style-type: none"> wooden vessels beginning to be replaced by larger steel ones total number of traps per vessel increasing number of traps per string increasing total fishing area increasing (especially after ICJ decision) some vessels fishing more than one area simultaneously (seasonally) fishing less restricted by weather duration of fishing trips decreasing 5-7 days between trips conversion to wire traps
1988 - present	<ul style="list-style-type: none"> 7 steel vessels 23-37 meters (1 wooden seasonal) vessel crew of 5-8 men strings of 80-120 wire traps each fishing trips of 3-5 days duration 5-7 days between trips fishing depths 90-450 meters up to 3 areas fished simultaneously throughout the year little restriction of fishing due to weather able to move more gear, more quickly

Table 3. Annual offshore lobster landings (t) by NAFO subareas

Year	No. of vessels	Browns Bank (4X)	Georges Bank (5Ze)	Total (Jan.-Dec.)	TAC
1971	5	8	92	100	
1972	6	180	154	334	-
1973	7	317	176	493	
1974	6	281	135	416	
1975	8	372	173	545	
1976	7	496	182	678	
1977	8	358	277	635	408 (4X)
1978	8	381	303	684	408 (4X)
1979	8	373	236	609	408 (4X)
1980	8	357	192	549	408 (4X)
1981	7	382	190	572	408 (4X)
1982	8	284	174	458	408 (4X)
1983	8	328	154	482	408 (4X)
1984	7	276	164	440	408 (4X)
1985	8	577	201	778	720 *
1986	8	578	222	799	720 *
1987	7	397	221	618	720 *
1988	6	341	185	526	720 *
1989	6	346	102	449	720 *
1990	6	469	98	567	720 *
1991	5	519	146	665	720 *
1992	5	438	146	584	720 *
1993	5	472	184	656	720 *
1994	6	597	181	778	720 *

* TAC season does not correspond to reporting period for annual landings

Table 4: TAC season catch and effort by NAFO subareas

Season	No. of vessels	Browns Bank (4X)	Georges Bank (5Ze)	Total	TAC mt
85-86*	8	627	222	849*	870*
86-87	8	469	248	717	720
87-88	7	411	173	584	720
88-89	7	276	130	406	720
89-90	6	418	111	529	720
90-91	5	579	135	714	720
91-92	5	461	150	610	720
92-93	5	387	155	542	720
93-94	5	521	179	700	720

* 1985-86 a 14.5 months Aug. 1, 1985-Oct. 15, 1986

Table 5 Annual catch, effort and CPUE 1981-1994 by offshore lobster assessment areas

Year	CROWELL BASIN			SW BROWNS			GEORGES BASIN			SE BROWNS			GEORGES BANK		
	C t	E TH	CPUE kg/TH	C t	E TH	CPUE kg/TH	C t	E TH	CPUE kg/TH	C t	E TH	CPUE kg/TH	C t	E TH	CPUE kg/TH
1981						2.8	13.9	8.1	1.7	246.5	60.6	4.1	189.8	48.3	3.9
1982						1.9	7.8	3.7	2.1	144.5	78.5	1.8	166.2	60.6	2.7
1983						2.2	9.6	10.6	0.9	115.0	51.6	2.2	154.0	80.5	1.9
1984						1.8	34.5	18.7	1.8	120.9	49.0	2.5	146.3	66.6	2.2
1985						3.0	267.9	86.0	3.1	207.8	74.2	2.8	113.5	43.0	2.6
1986						2.7	234.9	83.3	2.8	169.4	51.5	3.3	156.3	52.1	3.0
1987						3.1	190.3	67.9	2.8	114.9	32.0	3.6	152.2	40.1	3.8
1988						1.9	110.0	37.6	2.9	98.4	35.1	2.8	138.1	51.5	2.7
1989						2.9	42.7	24.2	1.8	56.0	20.1	2.8	84.4	43.0	2.0
1990						3.2	64.0	27.9	2.3	107.5	38.8	2.8	87.0	38.3	2.3
1991						2.8	172.9	44.8	3.9	100.3	33.5	3.0	130.6	35.9	3.6
1992						2.4	140.0	42.9	3.3	74.1	29.1	2.6	129.7	38.4	3.4
1993						2.6	103.9	37.6	2.8	100.5	53.0	1.9	163.7	58.1	2.8
1994						2.4	113.2	39.4	2.6	189.5	103.4	1.8	156.8	69.8	2.3

Table 6: TAC season catch, effort and CPUE 1981-1994 by offshore lobster assessment areas

Year	CROWELL BASIN			SOUTHWEST BROWNS			GEORGES BASIN			SOUTHEAST BROWNS			GEORGES BANK		
	C	E	CPUE	C	E	CPUE	C	E	CPUE	C	E	CPUE	C	E	CPUE
85-86*							260.1	94.4	2.8	201.1	63.5	3.2	137.3	52.9	2.6
86-87							178.0	63.2	2.8	141.4	38.5	3.7	182.9	44.6	4.1
87-88							152.7	47.2	3.2	99.7	36.9	2.7	120.5	45.7	2.6
88-89							37.6	23.8	1.6	57.3	21.0	2.7	114.3	52.4	2.2
89-90							59.9	28.3	2.1	101.7	34.5	3.0	96.9	43.6	2.2
90-91							187.5	47.4	4.0	105.0	38.3	2.7	120.0	33.4	3.6
91-92							127.9	39.5	3.2	75.0	29.1	2.6	133.9	38.9	3.4
92-93							104.2	38.0	2.7	74.7	41.8	1.8	134.4	50.4	2.7
93-94							127.8	39.4	2.7	168.4	95.7	1.8	154.6	67.7	2.3

Table 7: History of changes in offshore lobster fishing grounds

1971	Corsair to Welkers Canyons on Georges Bank, and Southeast Browns Bank
1972-73	Corsair Canyon on Georges Bank, southeast Browns Bank and some effort on southwest Browns Bank
1974-75	Some effort on Truxton Swell, with other areas unchanged
1976	Quota introduced in 4X and two licenses restricted to NAFO area 5Ze. Some effort on northeast Georges Bank, other areas unchanged
1979	Browns Bank Closed Area introduced eliminating the rich ground on southern Browns Bank
1980-81	Effort concentrated on Southeast and Southwest Browns and Georges Bank
1982-84	Increased effort in the Crowell Basin area (5-10 American vessels also in area)
1984-85	More directed effort in the Crowell and Georges Basins area ICJ decision removes American effort from Georges and Fundian Channel
1985-87	E.A. program in place, restriction of two licenses to NAFO area 5Ze removed increased effort in the Crowell - Georges Basins area, some from the vessels previously restricted to 5Ze
1987-88	Reported effort evenly distributed over the five offshore areas
1989-92	Gradual shift of effort away from Georges Bank and Southeast Browns to the areas to the west of the Browns Bank closed area
1992-94	Marked increase in effort on Southeast Browns during the 1993-94 season.

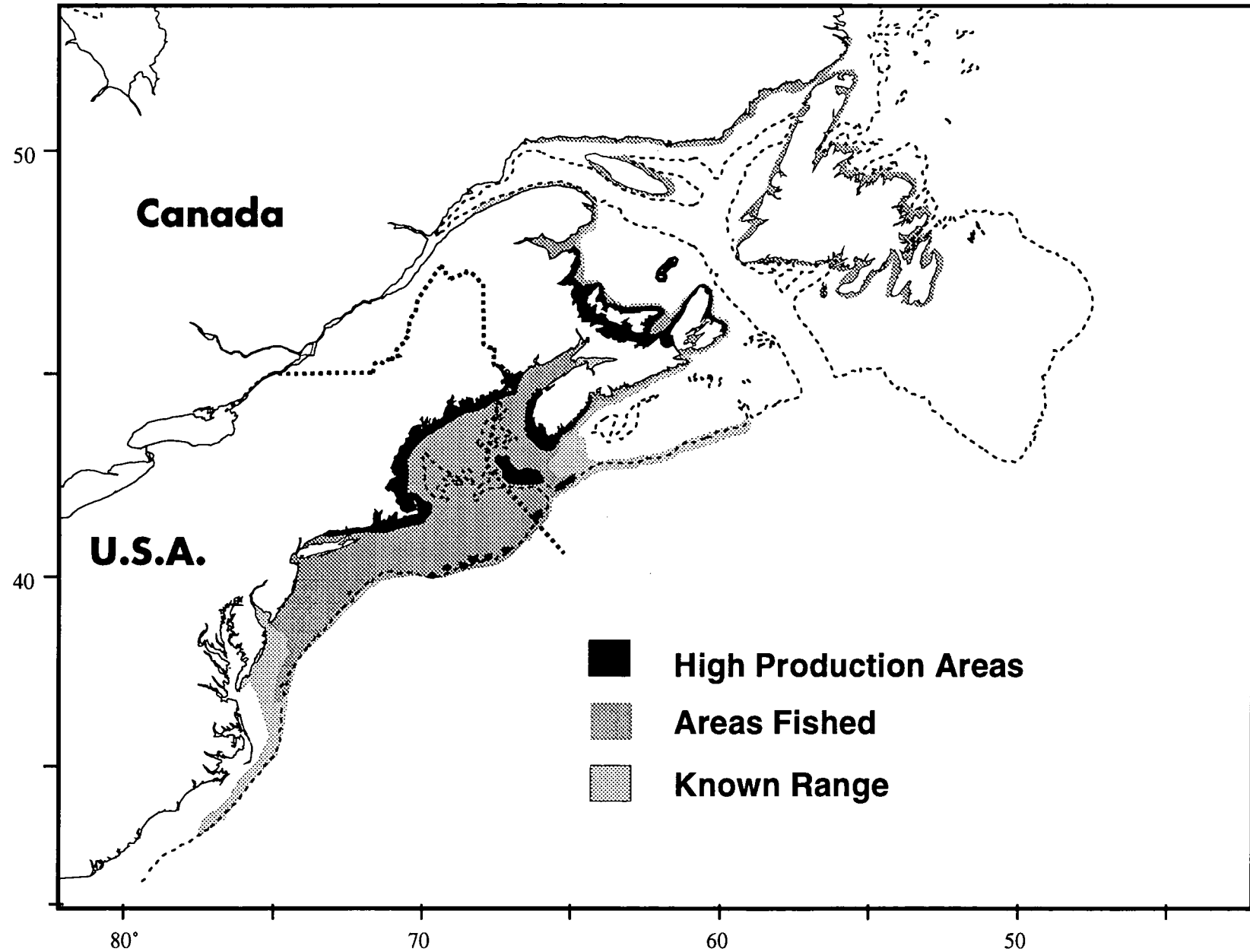


Figure 1: Lobster (*Homarus americanus*) range and fishing areas

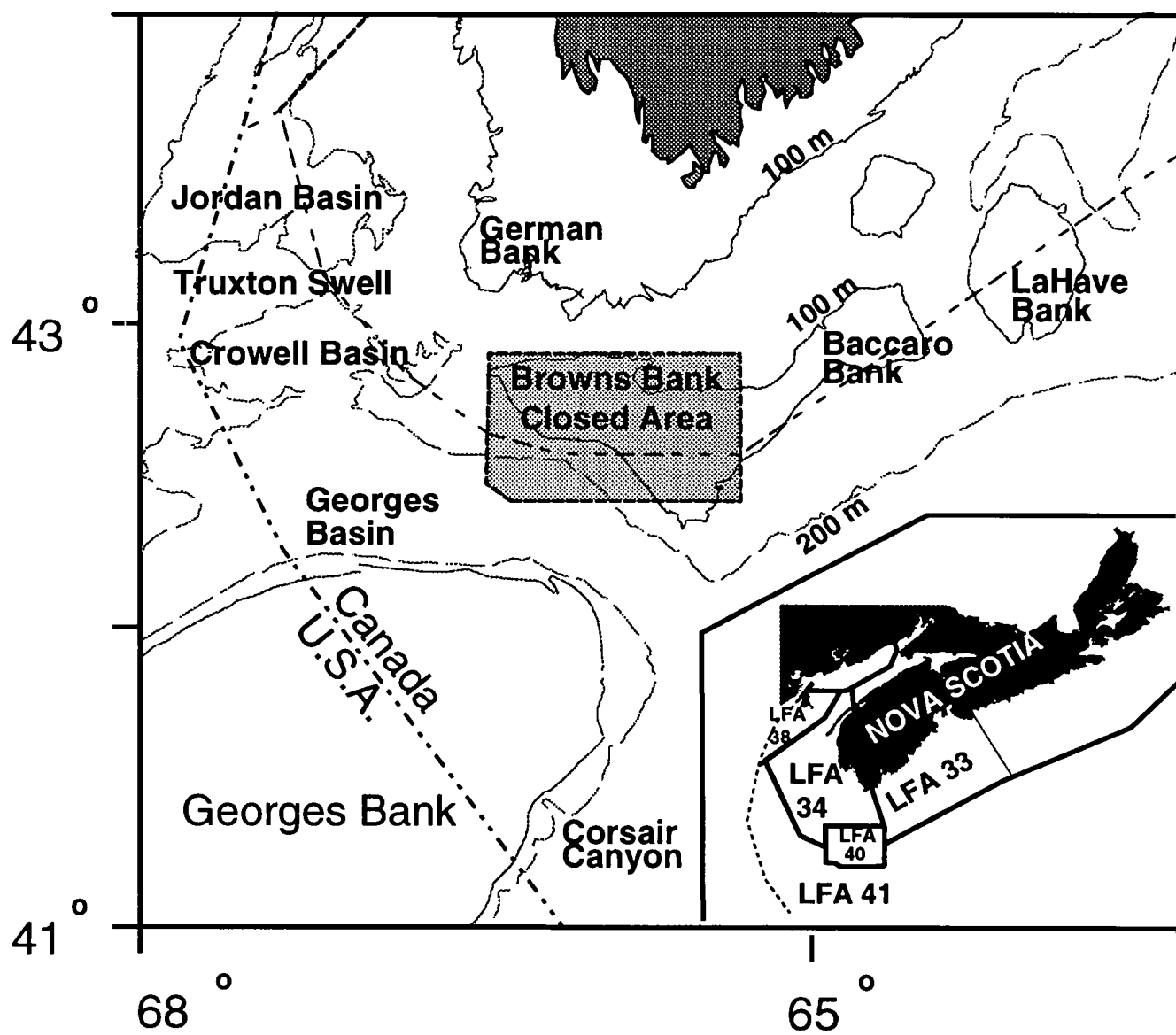
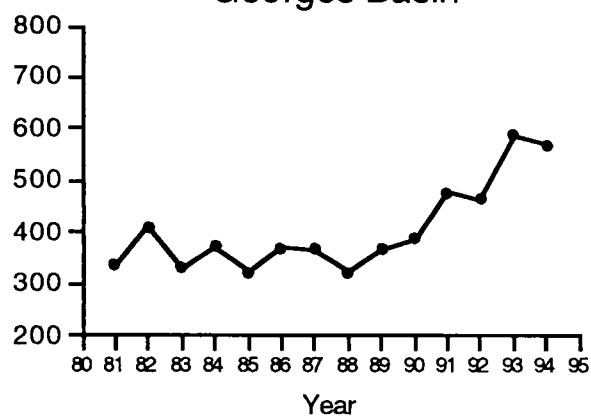


Figure 2: Southwestern Nova Scotia lobster fishing areas and place names

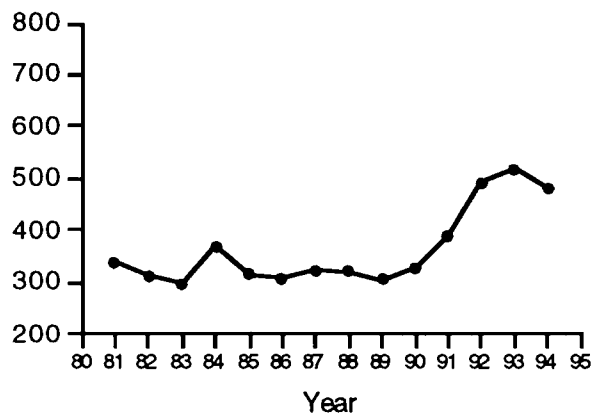
SW Browns Confidential

Crowell Basin Confidential

Georges Basin



S.E. Browns Bank



Georges Bank

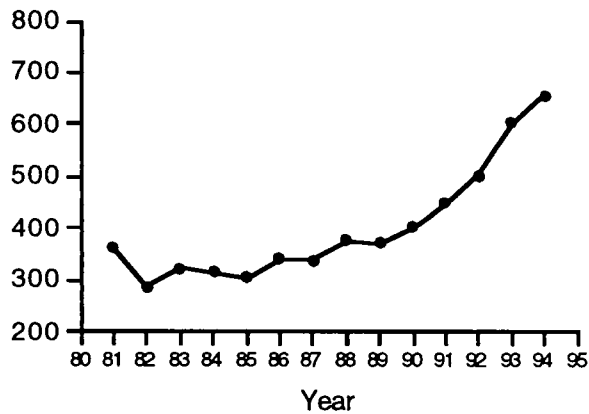


Figure 3: Mean trap hauls per day 1981-1994, by offshore lobster assessment areas.

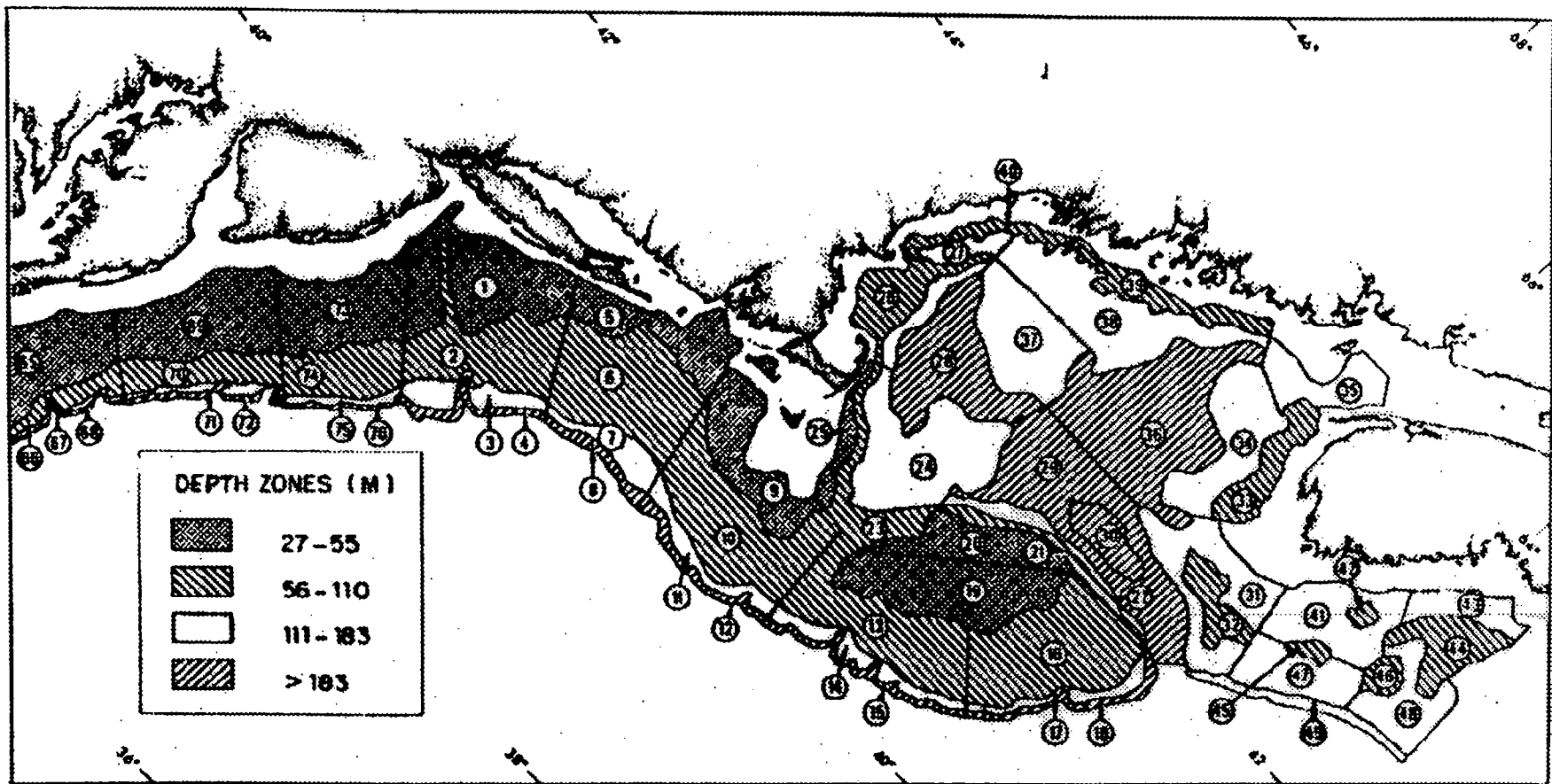


Figure 4: National Marine Fisheries Service, Northeast Fisheries Center bottom trawl survey strata. (from NOAA Technical Memorandum NMFS-F/NEC-52)

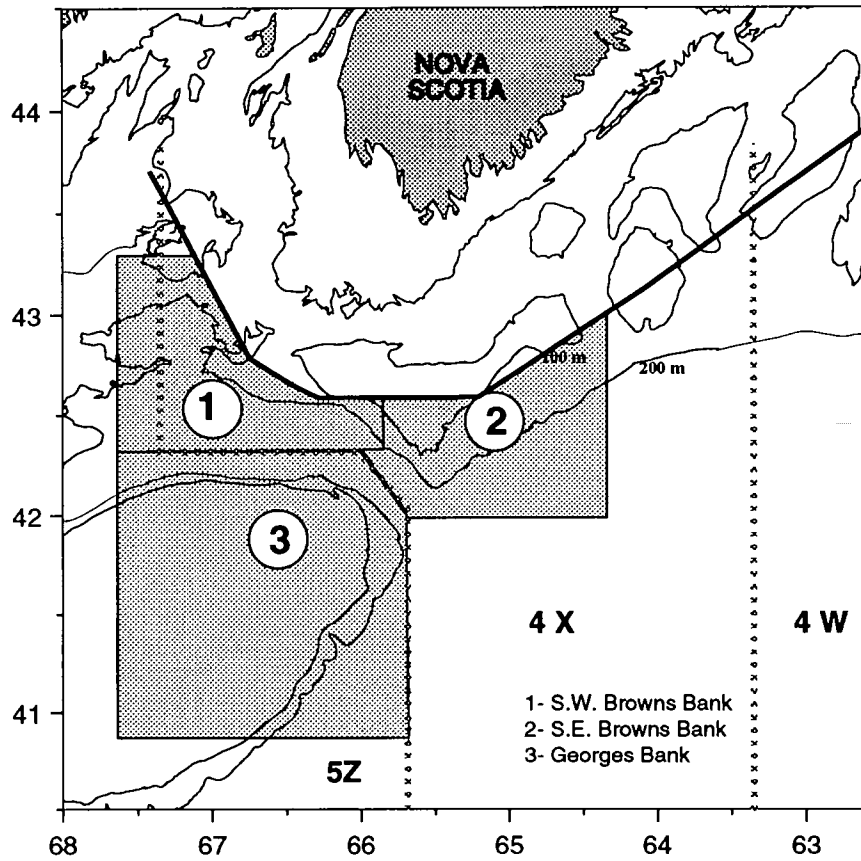


Figure 5: Original offshore lobster assessment areas (pre 1985) with NAFO subareas 4X, 4W, and 5Ze

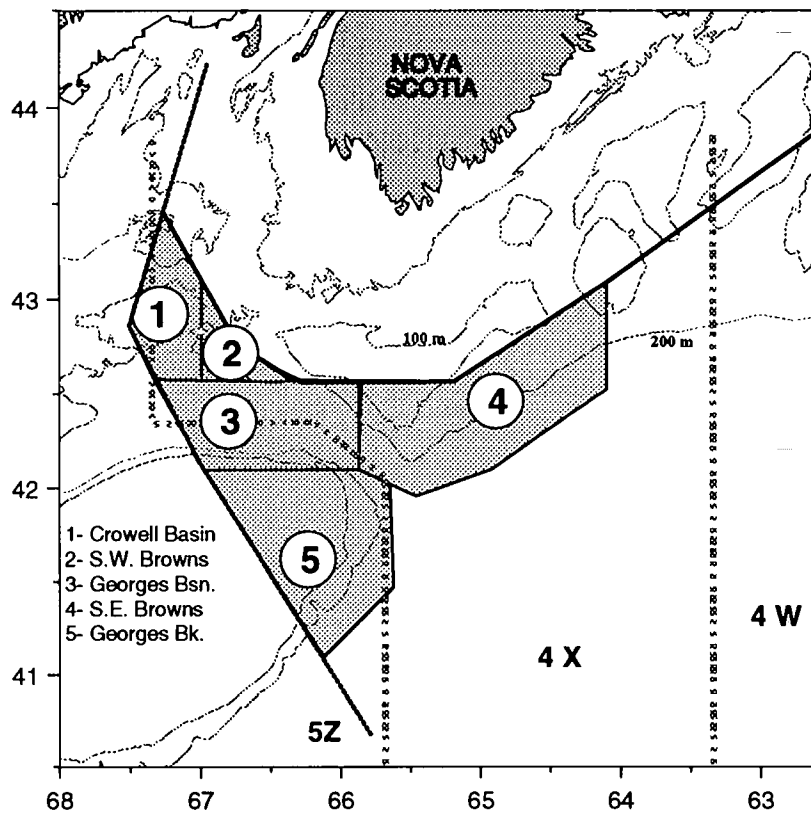


Figure 6: Offshore lobster assessment areas 1985-1994, with NAFO subareas 4X, 4W, and 5Ze

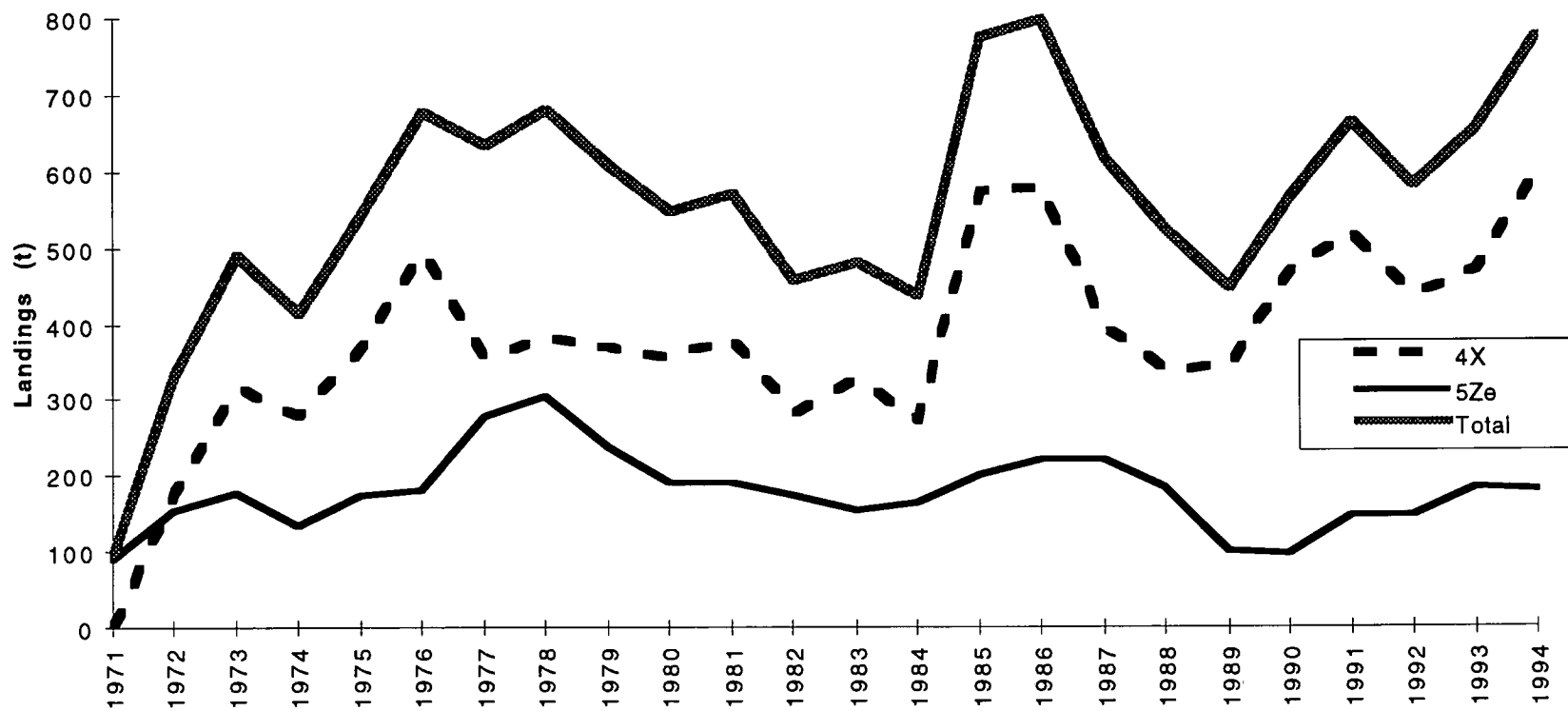
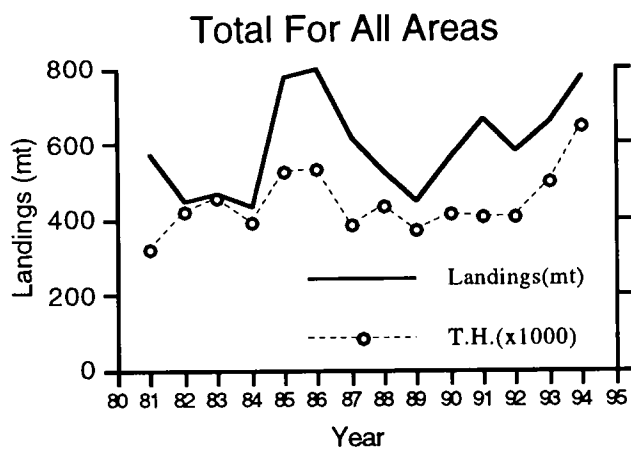


Figure 7: Annual landings (metric tons) 1971-1994, by NAFO subareas



Crowell Basin Confidential

SW Browns Confidential

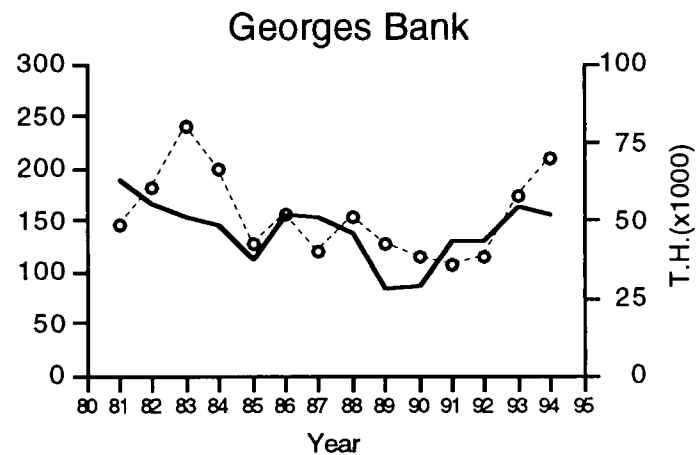
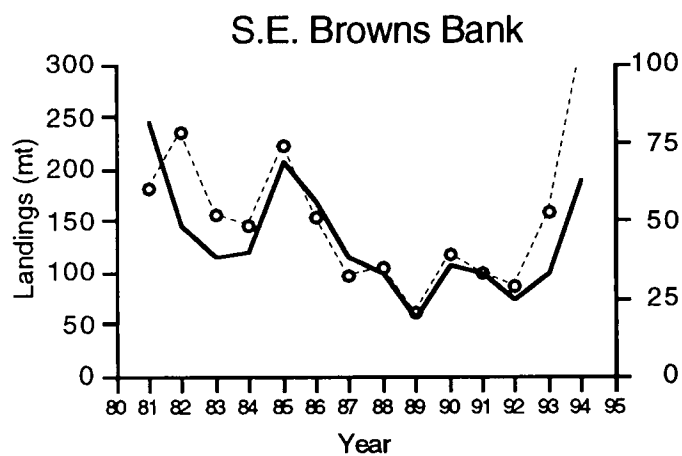
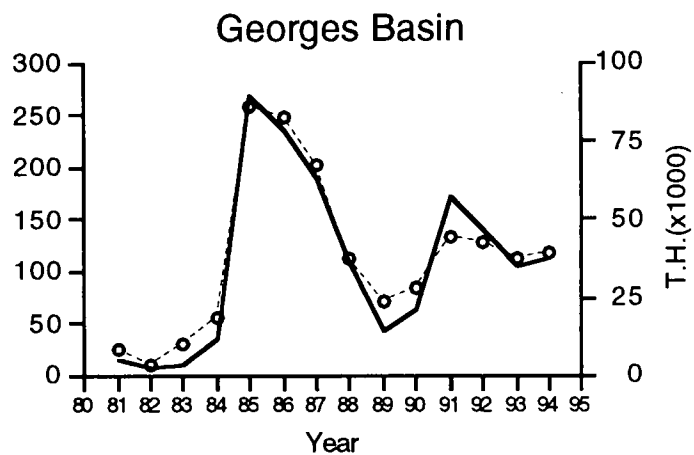


Figure 8: Annual landings (metric tons) and effort (trap hauls x 1000) 1981-1994, by offshore lobster assessment areas.

Crowell Basin Confidential

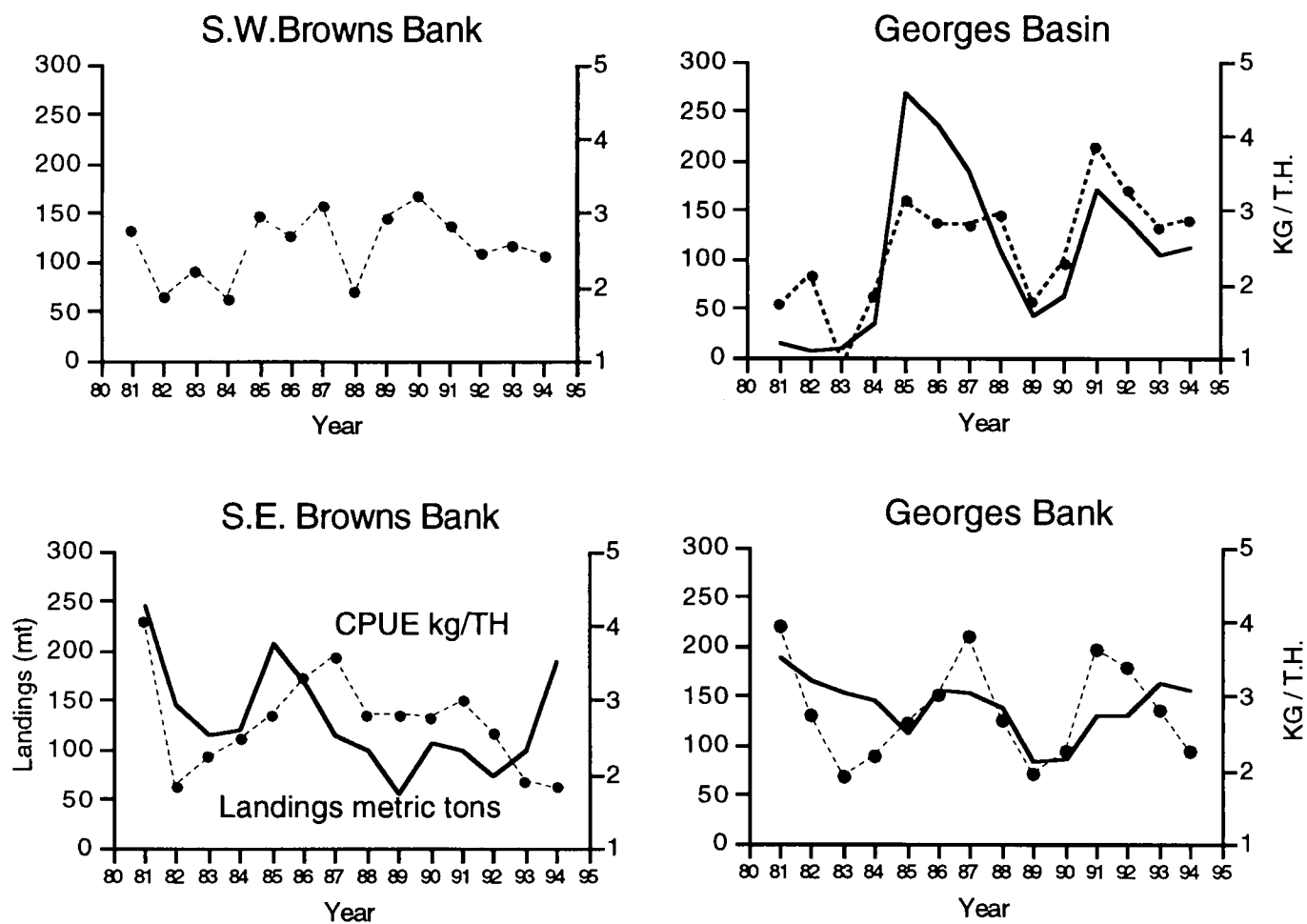


Figure 9: Annual landings (metric tons) and CPUE (kg/ trap hauls) 1981-1994, by offshore lobster assessment areas.

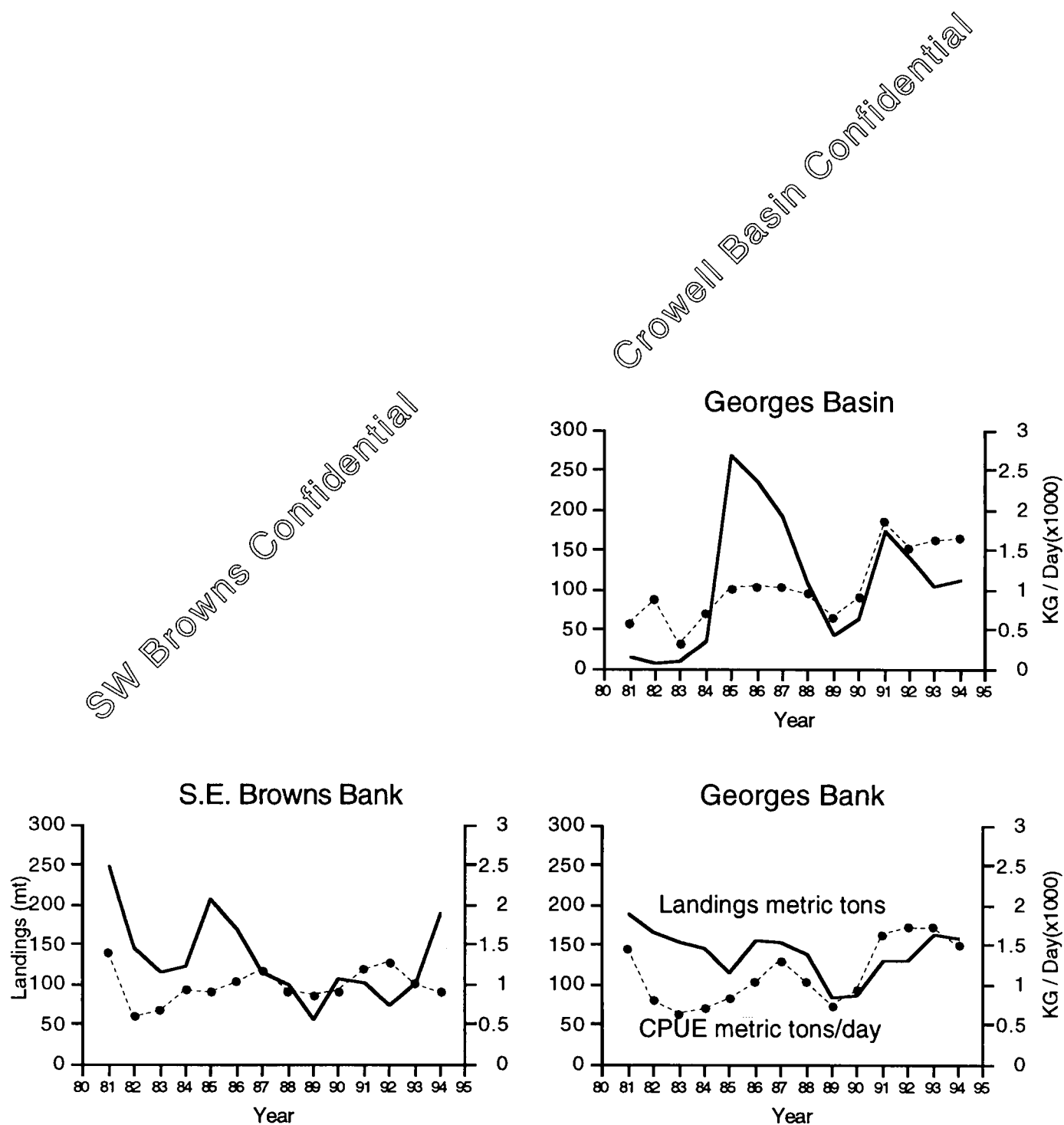
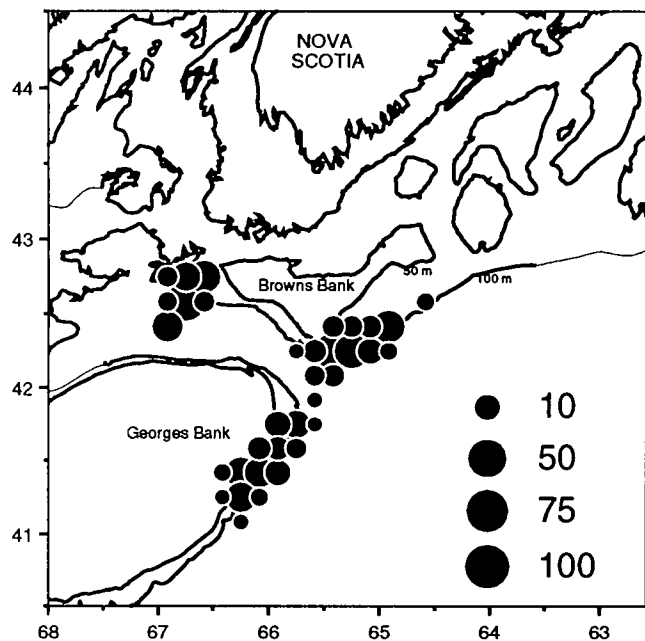
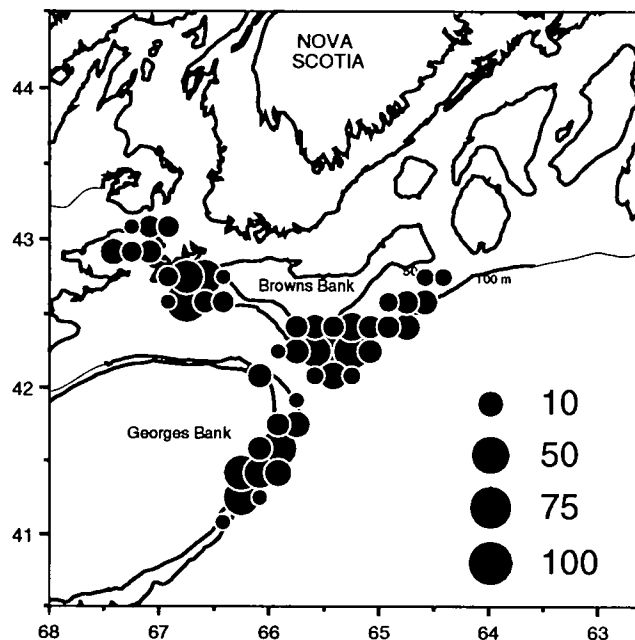


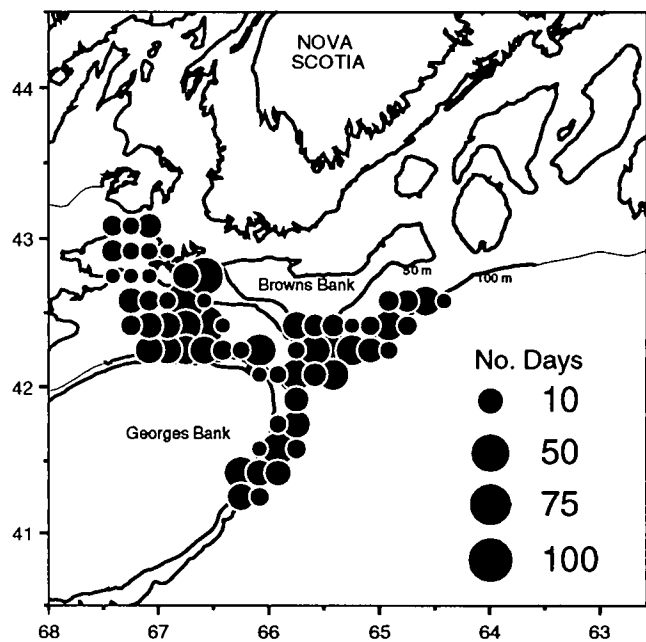
Figure 10: Annual landings (metric tons) and CPUE (kg/day x 1000) 1981-1994, by offshore lobster assessment areas.



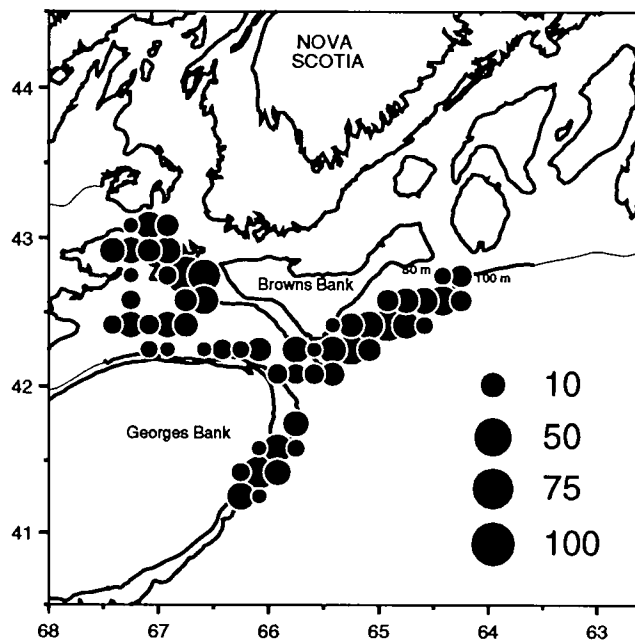
Number of Days by 10' squares -1981



Number of Days by 10' squares -1982



Number of Days by 10' squares -1985



Number of Days by 10' squares -1994

Figure 11: Offshore lobster fishing locations given as number of days fished per 10 minute square. Note this represents reported days fished and does not necessarily reflect abundance.

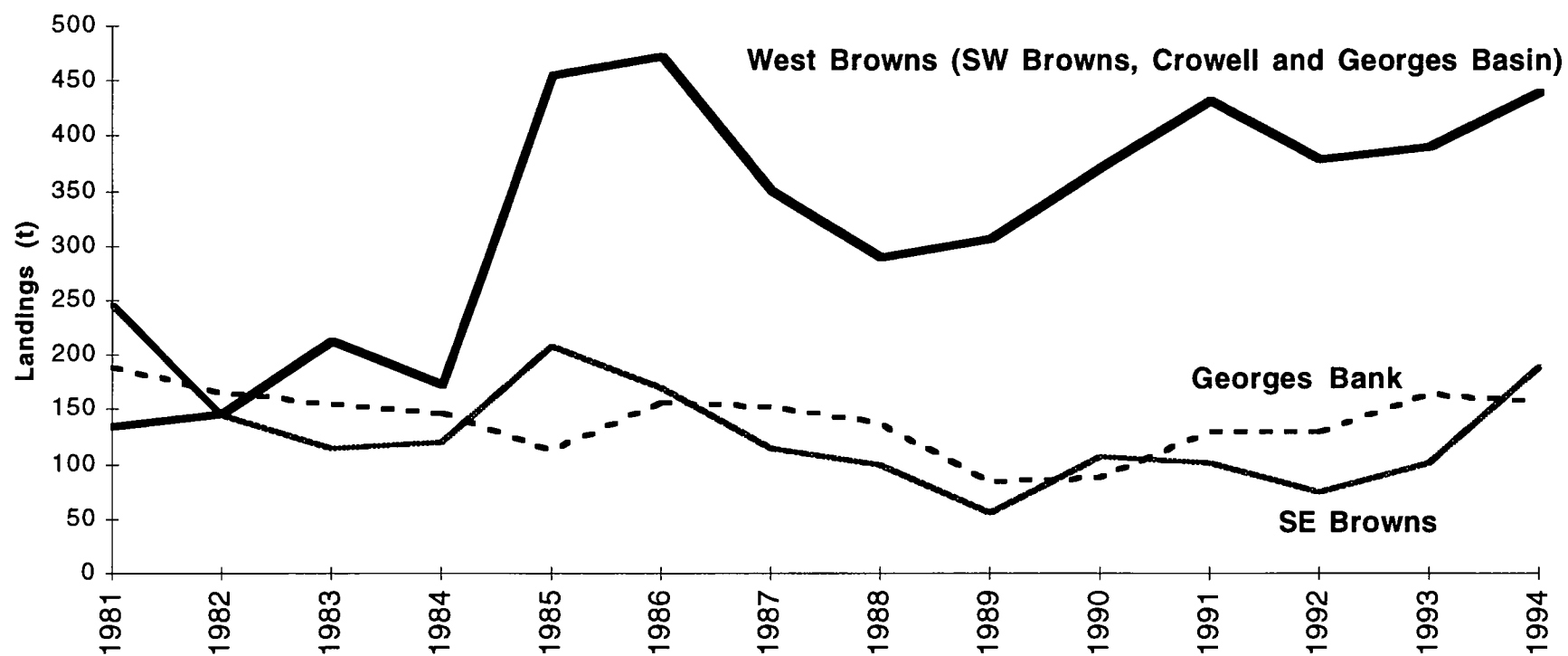


Figure 12: Annual landings (metric tons) 1981-1994, West Browns (Southwest Browns, Crowell Basin, Georges Basin), Southeast Browns and Georges Bank.

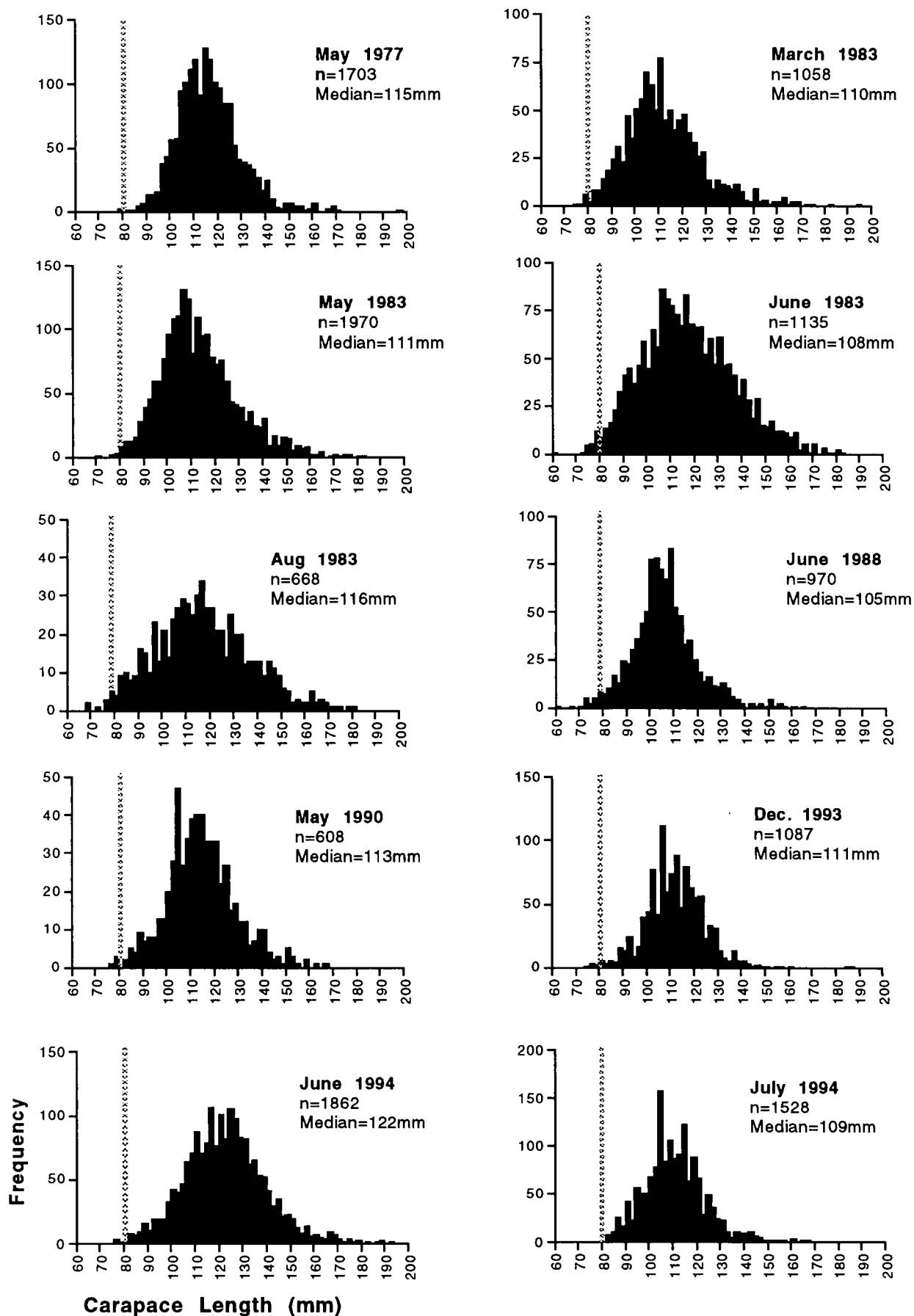


Figure 13: Southwest Browns Bank size frequencies (2mm CL size groups) from at-sea samples 1977-1994

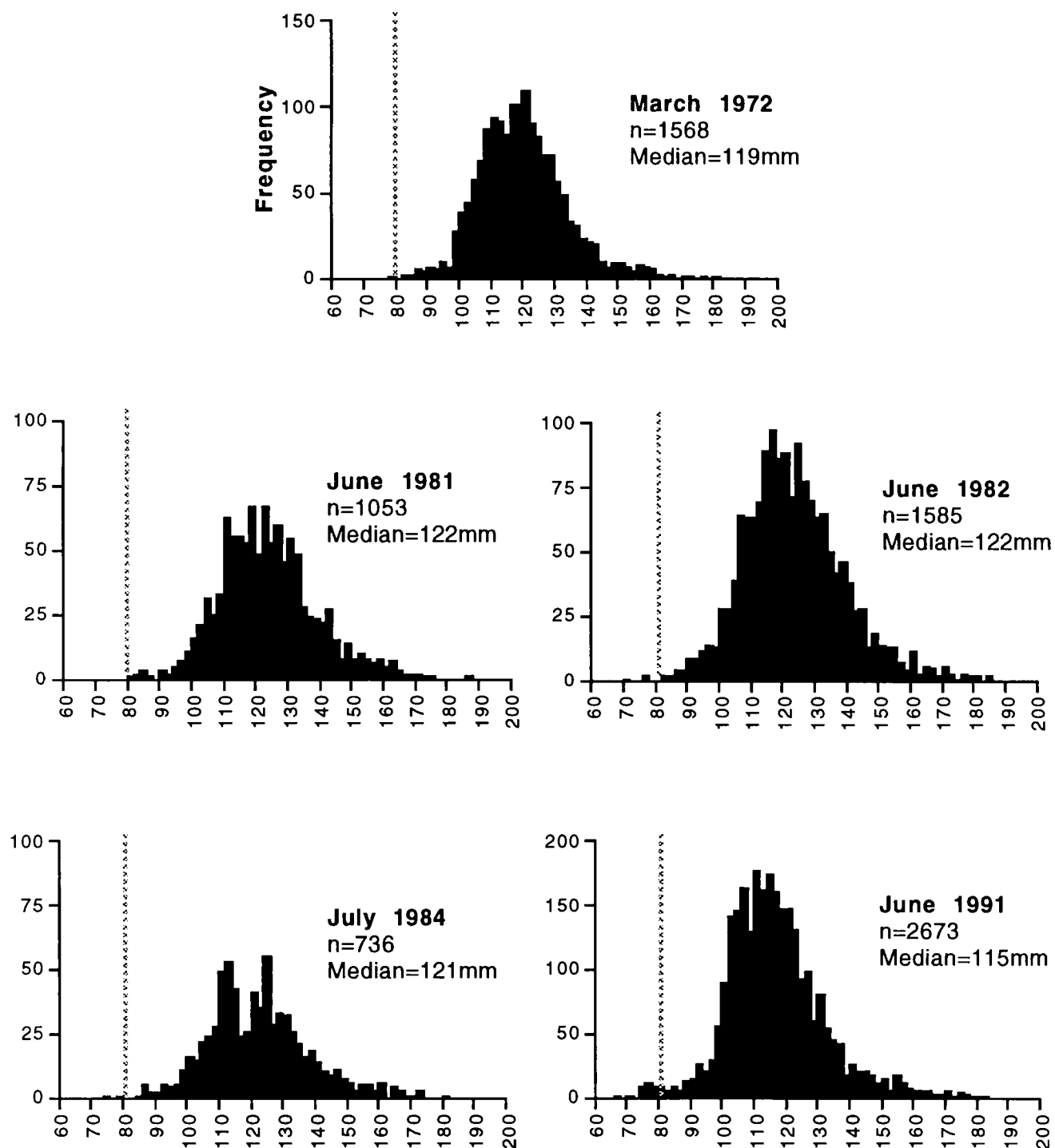


Figure 14: Southeast Browns Bank size frequencies (2mm CL size groups) from at-sea samples 1972-1991

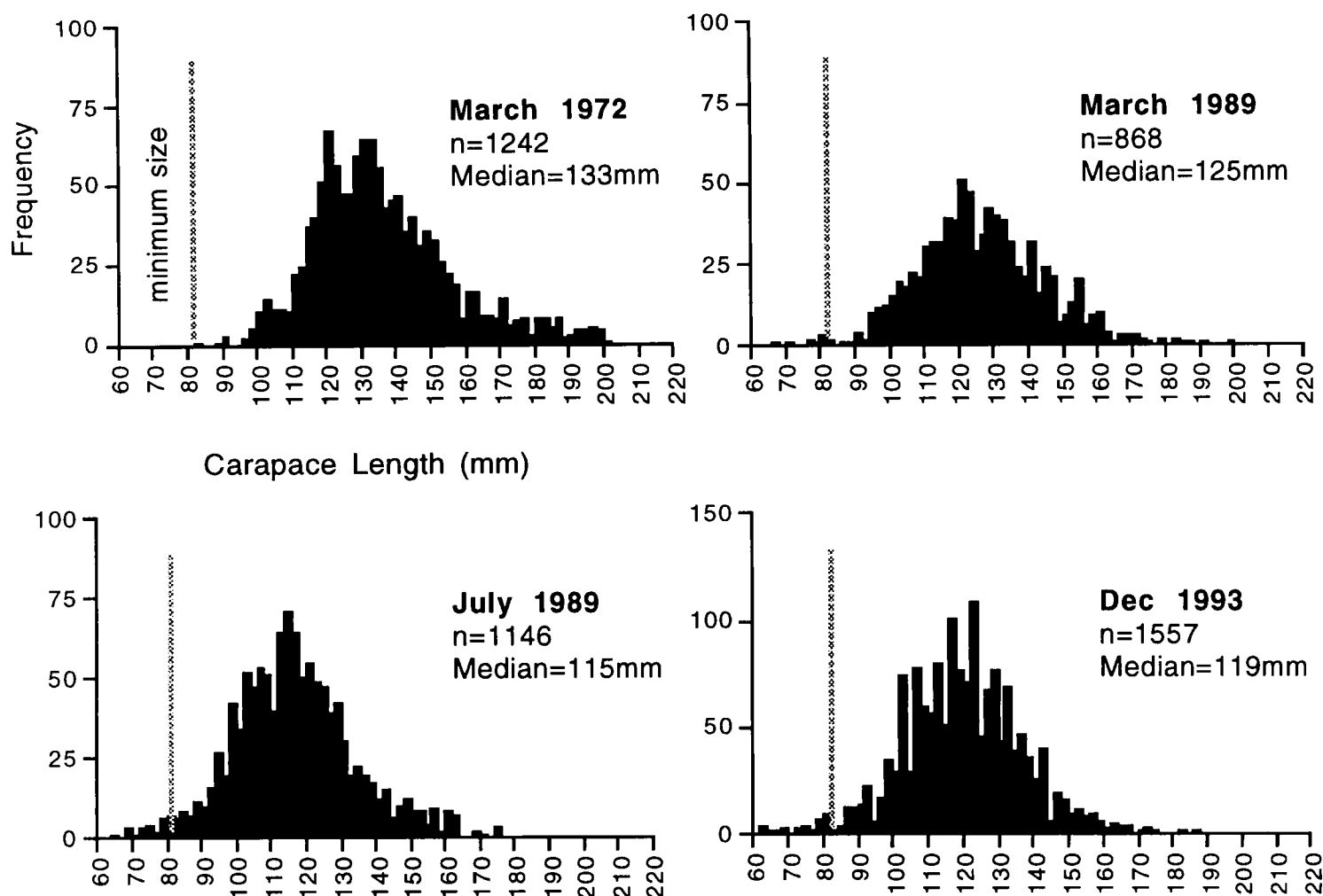


Figure 15: Corsair Canyon (Georges Bank) size frequencies (2mm CL size groups) from at-sea samples 1972-1993

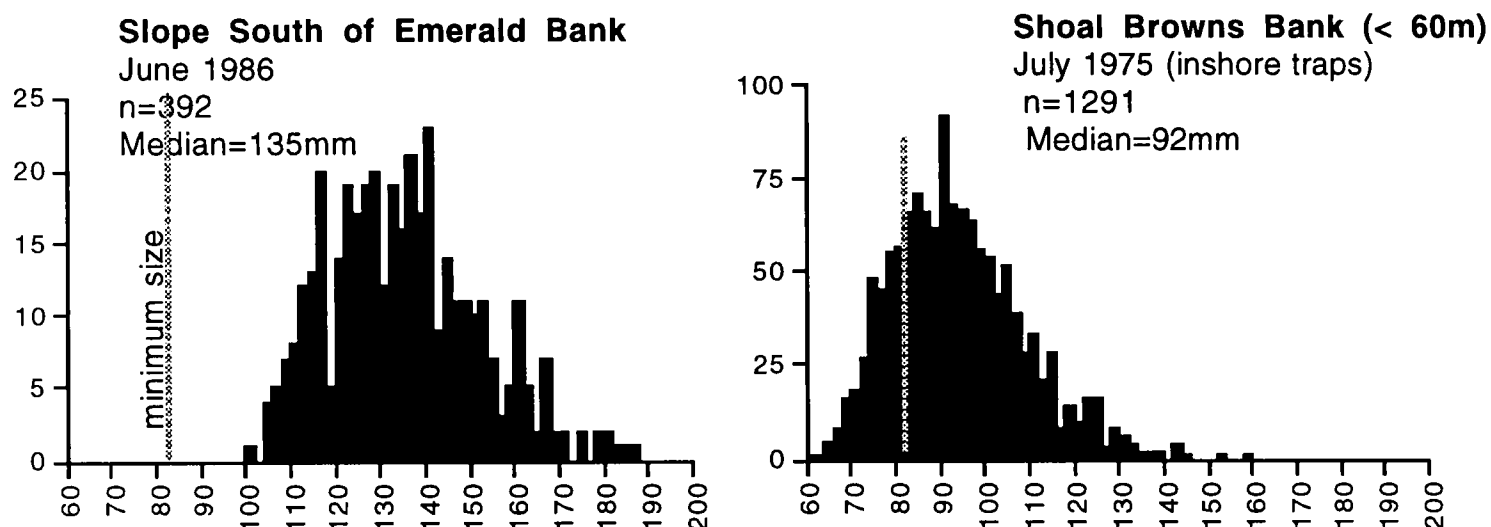


Figure 16: Size frequencies (2mm CL size groups) from at-sea samples along slope south of Emerald Bank (1986), and shoal water on the northern edge of Browns Bank using inshore traps (1975)

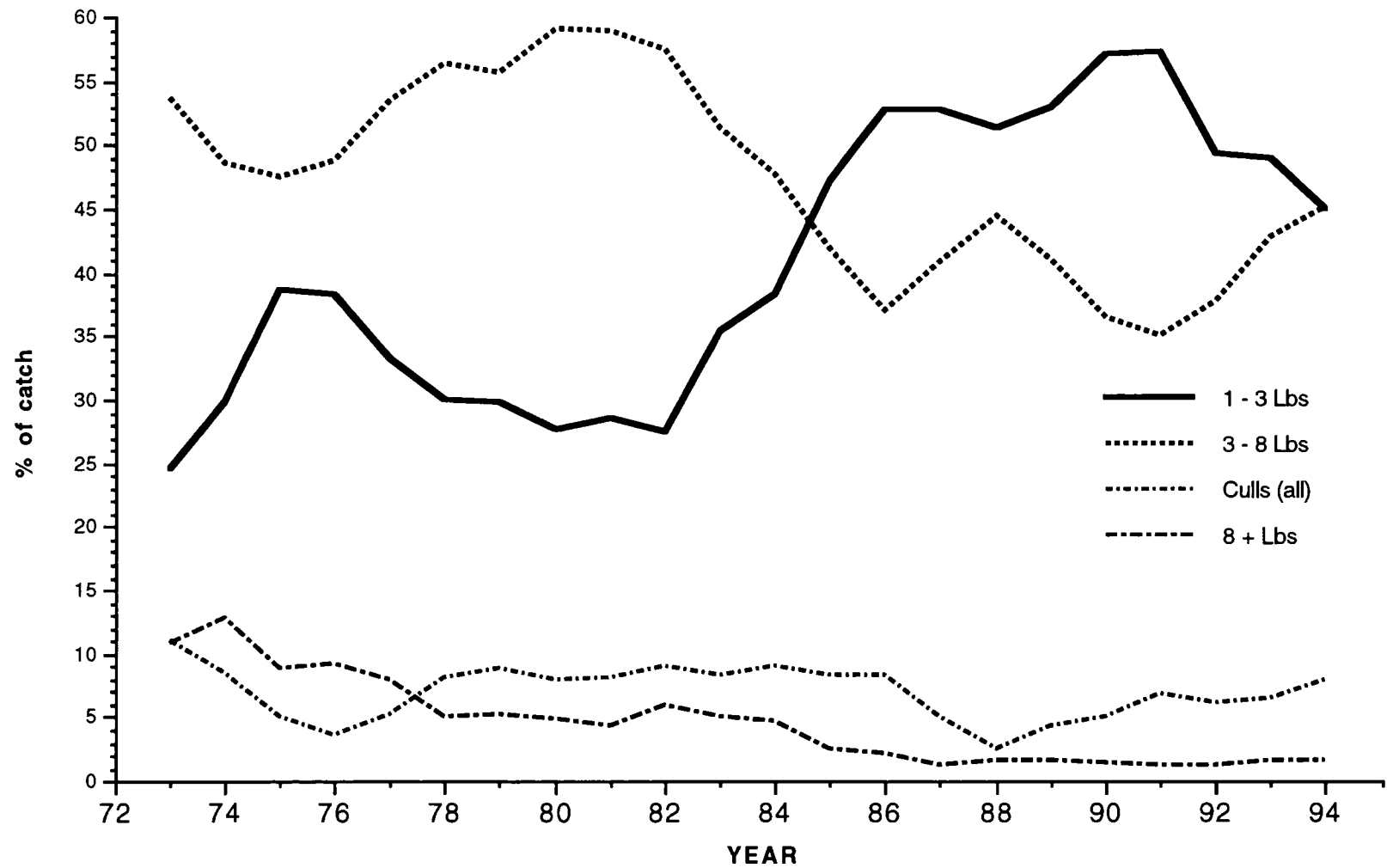


Figure 17: Percentage of landings in each market group as recorded on trip sales slips

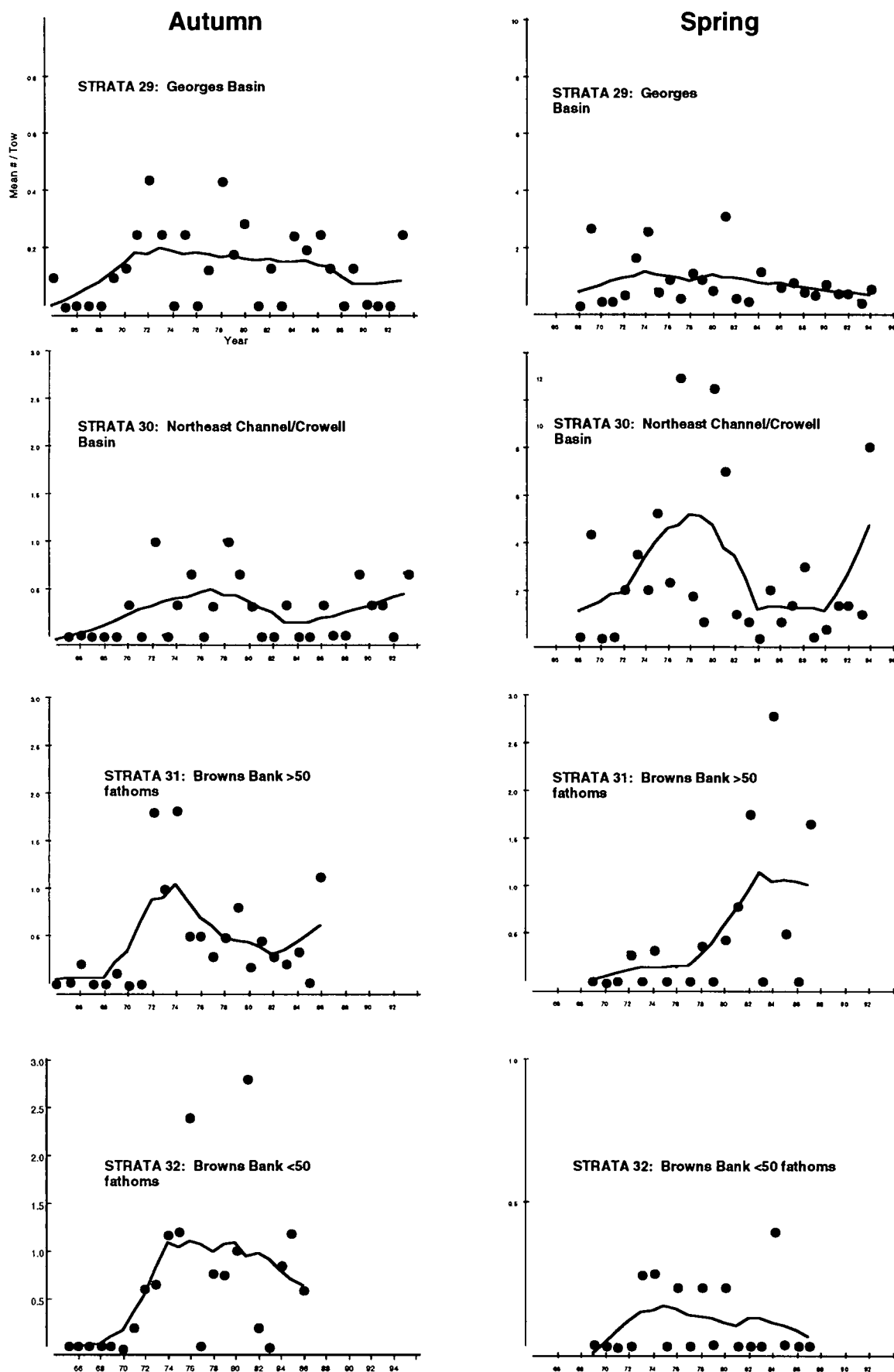


Figure 18: Delta Mean lobster number per tow from NMFS autumn and spring groundfish trawl surveys - 1968-1994. Solid line indicates smoothed fit using Lowess method (Cleveland 1979)

Autumn

Spring

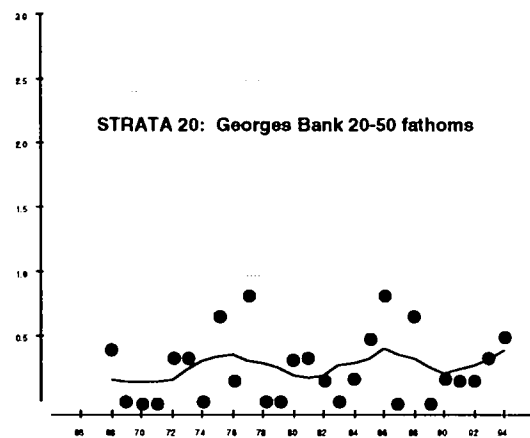
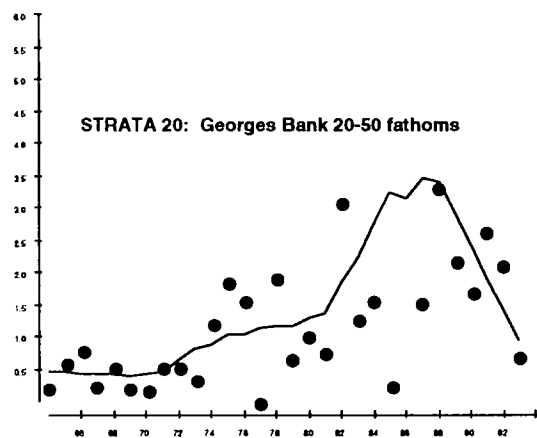
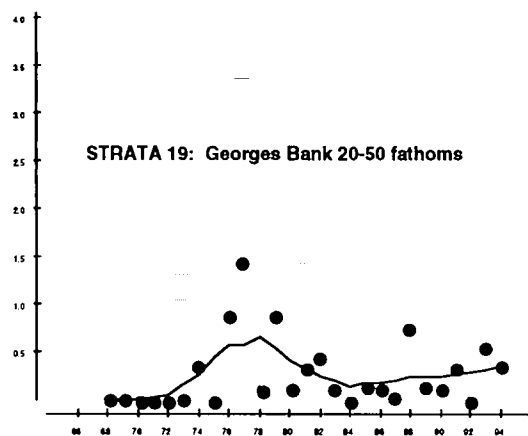
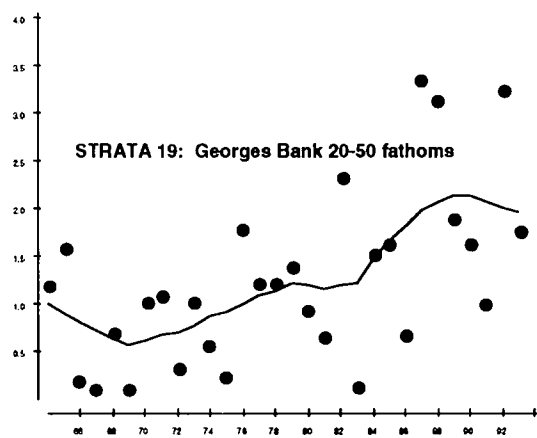
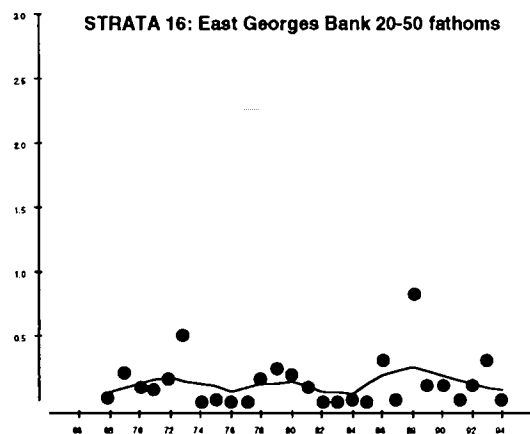
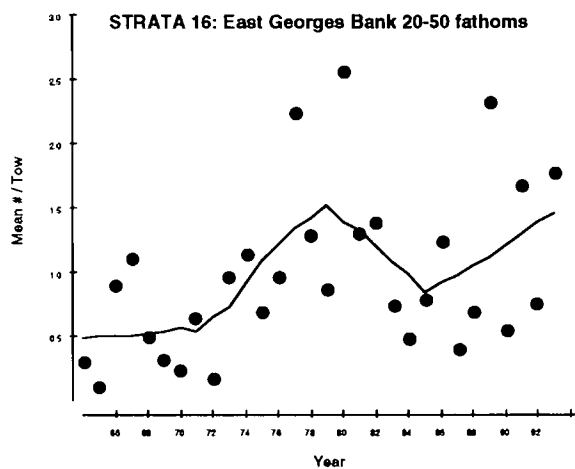


Figure 19: Delta Mean lobster number per tow from NMFS autumn and spring groundfish trawl surveys - 1968-1994. Solid line indicates smoothed fit using Lowess method (Cleveland 1979)

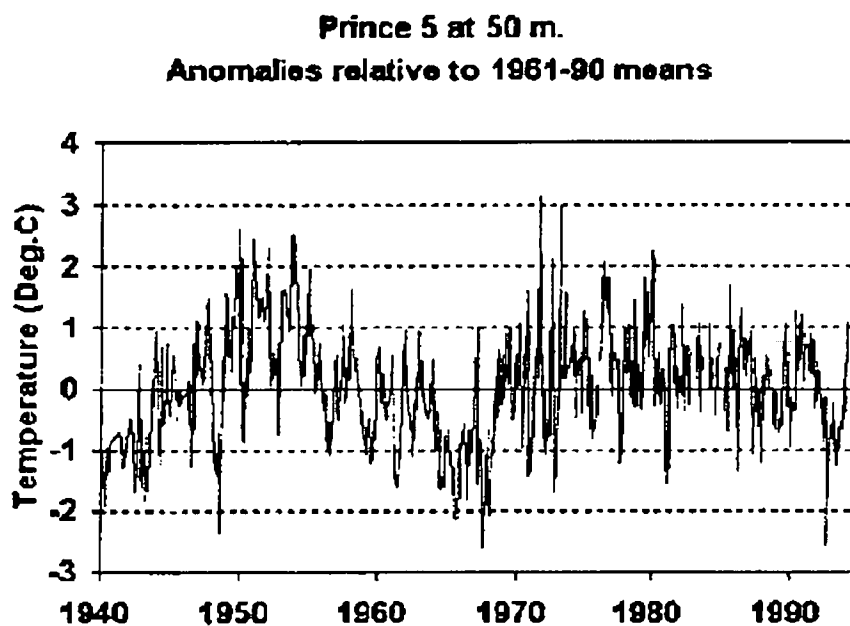


Figure 20: Prince Station 5 temperature anomalies at 50 m relative to 1961-90 means. (From Report of Scotia Fundy Regional Advisory Process (RAP) 1984. Ed. O'Boyle, R.N. and K.C.T Zwananburg. Can. Man. Rept. Fish. Aquatic Sci. 2252)