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Stock status of the American Lobster, *Homarus americanus*, in the Lobster Fishing Area 25

État du stock de homard, *Homarus americanus*, dans la zone de pêche du homard 25

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ABSTRACT

This document presents the most recent information on trends in the fishery and resource status for Lobster Fishing Area 25 (LFA 25). Landings in 2002 were 3,210 t - continuing the declining trend that began in 1985. While 2002 landings were 52% of the peak observed in 1984, they remained substantially above the low level of 1,800 t recorded from 1965 to 1975. LFA 25 is a recruitment fishery relying on animals in their first molt into the fishery. Effort continues to be extremely high. It required less than 20 days to catch > 50% of the total landings in 2002. In addition, the number of empty traps in August (when > 60% of landings were taken) has increased from 5% in 1986 to 50% in 2003. The catch per unit effort (CPUE) dropped sharply following the second week of the fishery despite many fishermen hauling traps on alternate days or less often. The at-sea sampling program and recruitment index programs both showed a continued decline in the abundance of pre-recruits and recruits into the fishery in LFA 25, suggesting the 2003 landings would be lower than those in 2002. The proportion of fertilized females that had not extruded eggs was investigated since the female lobster reproductive cycle alternates between mating and spawning on a yearly basis. In addition to being accessible to the fishery following fertilization (as occurs in all LFAs) in a given year, female lobsters in LFA 25 are exposed to the fishery a second time the following year before they can extrude eggs (egg extrusion is normally observed between mid-July and early-September). This represents the better part of two fishing seasons on fertilized females before they become ovigerous and protected from exploitation. Monitoring during the 2002 and 2003 fisheries revealed that >45% of females in their egg-extrusion year are observed in the commercial catch prior to the first week of September. This high level of exploitation on fertilized females negatively affects egg production in LFA 25. Temperature data revealed that LFA 25 operates in the warmest months of the year and that bottom temperature profiles in some years (1995 and 1997 in Escuminac, and 2001 in Shediac) were colder than average. No trend between years has been observed in the bottom temperature profiles. Distribution maps produced from a pre-fishery trawl survey conducted since 2001 indicated there were low densities of market-size lobster and negligible numbers of canner and sub-legal size lobster in the southern zone during August, and very high densities of canner and sub-legal size lobster along the N.B. coast in the northern zone of LFA 25. The highest densities of market-size lobster occurred in the central portion of LFA 25. While the location of highest lobster concentrations did not differ between years, the CPUE dropped dramatically (between 27% and >80%) between years for canner-size, market-size and sub-legal size lobsters. In the southern zone, the index of removals was high for both canner-size (57%-66%) and market-size (52%-55%) lobsters. In summary, all indices of stock status and recruitment to the fishery for 2004 indicate a continuation of the negative trend. The prospect for improvement in the status of the lobster population in LFA 25 is negligible for the short-term.

RÉSUMÉ

Nous présentons les plus récentes données sur les tendances de la pêche du homard et l'état de la ressource dans la zone de pêche du homard 25 (ZPH 25). Les prises en 2002 n'ont totalisé que 3 210 t; la tendance à la baisse qui a débuté en 1985 se poursuit donc. Bien qu'elles ne se chiffraient qu'à 52 % du pic observé en 1984, elles se situaient tout de même nettement au-dessus des faibles prises de 1 800 t enregistrées de 1965 à 1975. La pêche dans la ZPH 25 est une pêche de recrutement, car elle exploite les homards nouvellement recrutés à la pêcherie. L'effort continue d'être extrêmement élevé. Il a fallu moins de 20 jours en 2002 pour capturer plus de 50 % des prises totales. En outre, le nombre de casiers vides en août (lorsque plus de 60 % des prises sont réalisées) a augmenté de 5 % en 1986 à 50 % en 2003. Les prises par unité d'effort (PUE) ont accusé une baisse très marquée après la deuxième semaine de pêche malgré que de nombreux pêcheurs n'aient relevé leurs casiers qu'aux deux jours ou moins souvent. Les données du Programme d'échantillonnage en mer et du Programme d'indice de recrutement révèlent que l'abondance des prérecrues et des recrues continue à diminuer, ce qui donne à penser que les prises en 2003 seront moins élevées qu'en 2002. Nous avons tenté d'établir la proportion de femelles fécondes mais qui n'avaient pas encore pondu, les femelles s'accouplant une année donnée et pondant l'année suivante. Ainsi, en plus de pouvoir être capturées après s'être accouplées (comme cela est le cas dans toutes les ZPH) dans une année donnée, dans la ZPH 25, les femelles peuvent être pêchées aussi au cours de l'année suivante avant qu'elles puissent pondre (la ponte a normalement lieu entre la mi-juillet et le début de septembre). Cela signifie qu'elles peuvent être pêchées pendant presque deux saisons de pêche avant qu'elles deviennent ovigères et donc protégées de l'exploitation. Les résultats de l'étude effectuée durant les saisons de pêche de 2002 et 2003 révèlent que les prises commerciales réalisées avant la première semaine de septembre sont constituées à plus de 45 % de femelles prêtes à pondre. Ce niveau élevé d'exploitation des femelles fécondes a une incidence négative sur la production d'œufs dans la ZPH 25. Les données sur la température révèlent que la pêche dans la ZPH 25 est pratiquée pendant les mois les plus chauds de l'année et que, certaines années, les eaux de fond étaient plus froides que la moyenne (1995 et 1997 à Escuminac, et 2001 à Shédiac). Nous n'avons relevé aucune tendance dans les températures des eaux de fond d'une année à l'autre. Selon les cartes de distribution du homard des diverses catégories de taille, établies à partir des données des relevés au chalut effectués avant le début de la pêche depuis 2001, la densité du homard de marché est faible en août dans le secteur sud, le homard de conserverie et le homard de taille non réglementaire y étant rare, alors que les densités du homard de conserverie et du homard de taille non réglementaire sont très élevées le long de la côte du Nouveau-Brunswick, dans le secteur nord. Les plus fortes densités de homard de marché ont été retrouvées dans la partie centrale de la ZPH 25. Bien que l'emplacement des plus fortes concentrations n'ait pas varié d'une année à l'autre, les PUE de homards de conserverie, de homards de marché et de homards de taille non réglementaire ont connu une chute spectaculaire (soit de 27 % à plus de 80 %) d'une année à l'autre. Dans le secteur sud, l'indice de capture était élevé pour les homards de conserverie (57-66 %) et les homards de marché (52-55 %). En résumé, tous les indices de l'état du stock et du recrutement à la pêche en 2004 indiquent que la tendance à la baisse se poursuivra. Les perspectives d'amélioration de l'état de la population dans la ZPH 25 sont faibles à court terme.

1.0 INTRODUCTION

The American lobster (*Homarus americanus*) fishery in Atlantic Canada, including the southern Gulf of St. Lawrence (sGSL), began in the mid 1800s throughout the Atlantic Provinces. Over more than a century, the fishery in the sGSL essentially developed as a nearshore small-boat fishery, involving a large number of harvesters using only lobster traps as fishing gear (DeWolf 1974, Brun 1985, Landry 1994).

1.1 Fishery Management

The sGSL lobster fishery management regime (Gulf Region) is based entirely on effort control (i.e. input fishery) in five management areas (Fig. 1). Lobster Fishing Area (LFA) 25, the focus of this document, is located in the western and part of central of Northumberland Strait, and is bordered by the three Maritime Provinces. The most important measures aimed at controlling effort are the fixed number of licence holders, a trap allocation for each licence holder, a fishing season, and restriction on the gear type. In the sGSL, lobster traps can not exceed a length of 125 cm, a width of 90 cm, and a height of 50 cm. Unlike LFAs 23, 24, 26A and 26B, which are spring fisheries (May-June), LFA 25 is a summer-fall fishery operating from mid-August to mid-October. Also, the trap limit in LFA 25 is 250 compared to 300 in the other LFAs. LFA 25 has the most active licence holders with 852 in 2003. The number of licence holder has been somewhat stable since the implementation of regulations limiting fishing activities by LFA in 1934, and following the introduction of limited access to fishing licences in 1967 (DeWolf, 1974). In 2003, there were also 23 inactive licences in LFA 25.

Some clarifications are needed in terms of the number of traps per licence holder because there are two types of licences (bonafide and communal) and three subtypes. The majority of licence holders have a bonafide category A licence with 250 traps, while the others have category B or the partnership subtype with 75 and 375 traps respectively. There are also 47 communal category A licence holders that have 235 traps each. The total number of trap that could be fished in one day for the entire LFA in 2003 was 211,630. Hence, the estimated number of fishing enterprises based on the number of traps legally allocated per licence holder (250 traps based on the legislation) is 846. This number of fishing enterprises will be used hereafter as the number of licences in this assessment.

The lobster fishery also has regulations aimed at controlling the size (carapace length) and type of lobsters that fishermen can keep. The two primary management measures to protect lobsters are the minimum legal size (MLS) and the release of egg-bearing lobsters. The first measure is designed to allow some lobsters to reach sexual maturity and the latter is to protect known offspring reproducers. Numerous changes in MLS were implemented since the 1900s in LFA 25. The most prominent one was the MLS of 63.5 mm that was imposed in 1952. Afterward, the MLS was increased from 65.1 to 66.7 mm in 1990 and 1991, and to 67.5 mm in 1998. In 2003, the MLS increased to 68.5 mm and, based on the latest management plan, the MLS will increase to 69.5 mm in 2004 and 70.0 mm in 2005.

Some regulations were implemented to minimize waste or indirect fishing mortality. These regulations stipulate that each trap must be fitted with biodegradable and escape mechanisms. The biodegradable mechanism consists of a portion of the trap wall that can detach or decompose if the trap is lost at sea. The escape mechanism consists of an opening, near the base of the trap that allows sub-legal size lobsters to exit the trap when it is on the fishing ground. These mechanisms are installed in the parlor section of the traps (section with no entrance from the outside). Since 1996, traps equipped with a rectangular shape escape mechanism (width = 127.0 mm, height = 38.1 mm) are mandatory (prior to 1996, circular escape mechanisms were also allowed).

1.2 Landings

Lobster catch information for the sGSL can be traced back to the 1890s. High lobster landings reported at the turn of the 20th century were rapidly followed by an overall decline in the early part of the 1900s. Annual catches decreased from 15,000 t annually in 1895 to around 8,000 t between 1915 and 1975. Starting in the mid 1970s, lobster landings in the sGSL increase sharply (>2.5-fold) to a record landing of 22,000 t in 1990 (Fig. 2). Landings in 2002 (17,474 t) were still 60% above the long-term average (11,008 t). Although part of this latest increase in landings could be attributed to an increase in fishing power, favorable environmental factors are thought to be responsible for strong lobster recruitment success over its entire range from Labrador to North Carolina.

While landings increased in all LFAs, the timing of the peaks differed between LFAs as did the pattern of decline of landings following the peaks (Figs 3 and 4). This reflects the heterogeneity of the spatial distribution and the temporal variability of the lobster resource in the sGSL. The largest exception to the pattern is LFA 24 where the landings peak in 2002 (Fig. 3). Also, is seems that the declining trend has been less pronounced in the spring fisheries with LFAs 26A and 26B currently experiencing somewhat stable landings. This is not the case in LFA 25 where there is still in a steep declining trend (Fig. 4).

1.3 Conservation Strategy

In 1994, the Fisheries Resource Conservation Council (FRCC) was requested by the federal fisheries Minister to review the current approaches to conservation, and recommend management strategies for the lobster populations of the entire Canadian Atlantic coast. The FRCC concluded that the present fisheries, including LFA 25, were operating at excessively high exploitation rates, harvesting primarily immature animals and did not allow for adequate egg production (Anonymous, 1995). They recommended an arbitrary target of egg production per recruit (E/R) equivalent to 5% of that of an unfished population. However, despite general agreement by the fishing industry for the need to change, there was no agreement on how to implement the FRCC target. Instead, in was agreed that a doubling of the E/R value was a more acceptable and achievable goal. Hence, a four-year management plan (1998-2001) for LFA 25 was announced and to achieve the goal of that plan, the MLS was increased to 67.5 mm in 1998 and v-notching on 50% of egg bearing females caught during the fishery was implemented. Following this first multiyear management plan, another one was announced in 2003. In this latest management plan, v-notching was removed as a fishery regulation and the MLS was increased to 68.5 mm in 2003, with other increments in 2004 (69.5 mm) and 2005 (70.0 mm). Furthermore, there is a provision within the latest management plan that other measures dealing with a reduction in effort, gathering of fishery information, and habitat protection will be incorporated starting in 2004. The time period of this latest multiyear management plan is still undetermined.

1.4 Purpose

Although the MLS increments announced in the latest multiyear management plan are not completed, a Regional Advisory Process (RAP) was announced to deal specifically with the continuing decline in landings in LFA 25 (Fig. 4). The purpose of this document is to evaluate the lobster stock status of LFA 25 based on data and indicators from the fishery, a research trawl survey, and measures of female condition (growth and maturity). Data on water temperature are also presented.

2.0 COASTAL BOTTOM WATER TEMPERATURE IN NORTHUMBERLAND STRAIT

2.1 Methods

A coastal water temperature monitoring program was initiated in the sGSL by the Gulf Region lobster research group in 1995. Over the years, however, changes have been made to the methodology used for the deployment and retrieval of the temperature recorders, and the monitoring sites (Lanteigne et al., 1996; Savoie et al., 2001; Savoie and Lanteigne, 2002). This network of recorders was installed on an annual basis, for most of the ice-free season. All devices were set to record temperature every two hours.

For the purpose of this assessment, only data from sites in LFA 25 (including Escuminac adjacent to the north of LFA 25) were selected. The selected sites (Escuminac, Shediac and Pugwash; Fig. 5) were deemed representative of the general area and had multiple years of temperature monitoring. Unfortunately, some data were missing for some years in certain sites. Within these sites, weekly temperature profiles from May to November were presented with a reference to the fishing season in LFA 25 (10 Aug. to 10 Oct.). Also, the accumulated degree-days (ADD) and the daily average temperature, the temperature trend and variability for the first four weeks of the fishery were also calculated as indicators of variation in environmental conditions within LFA 25.

The ADD were calculated using the following equation (Dobson and Petrie, 1985):

$$AAD=\Sigma(T-T_{ref}) \text{ x Time},$$

where, T is the mean daily temperature, T_{ref} is the reference temperature (0 °C and 4 °C), and Time is time period in days. The ADD is calculated against 0 °C and 4 °C baselines to provide information on the level thermal energy needed for movement and feeding (starting at 0 °C) and for growth and maturation (starting at 4 °C). For each site, the ADDs were calculated from 9 June to 4 October for each of the yearly temperature profiles available.

To assess the average daily temperature, and the temperature trend and variability, only the first four weeks of the fishery were chosen. The reasons were that the temperature profile observed in LFA 25 normally increases for four weeks (until early September) followed by a declining and more stable period, and because >60% of the landings occur during that period. The average daily temperature for a given year at a given site was compared to the average temperature observed at that site for all the years, as an indicator to identify warmer or cooler years. To assess the seasonal thermal trends, the slope of the daily temperature versus day-of-the-year regression was used as the indicator. Finally, the correlation coefficient (r^2) of this relationship was used as the indicator of the temperature variability.

2.2 Results and Discussion

Coastal environmental conditions in LFA 25 are characterized by important seasonal fluctuations that dictate the life cycle of all coastal marine organisms. The Northumberland Strait is normally ice-covered during winter and bottom temperatures can drop to sub-zero temperatures (-1.5°C). The timing of the ice-melt has ranged from late March to May in recent years, at which time the coastal bottom temperatures increased until August (with daily average values above 20°C), followed by a decline until the onset of winter (Fig. 6). There are annual and spatial temperature differences within LFA 25, with lower temperatures in the northern part of the LFA, compared to a more variable but warmer temperature profile in the southern part.

Escuminac – The temperature and ADD profiles of the most northern part of LFA 25 showed the coldest temperature regime of the LFA (Fig. 6a and 7a, b). The average weekly temperature increased from near 0°C in the spring to values ranging between 12°C and 15°C. The temperature profiles in 1995 and 1997 were significantly colder than the other years. During both these years, the highest average weekly temperature did not reach 10°C, well below the range of 12°C to 15°C normally observed in more recent years (Fig. 6a). Similarly, the ADD profiles in 1995 and 1997 were well below those observed in more recent years (Fig. 7a,b). The total ADD adjusted to 0°C profiles showed that values ranging between 1300 and 1500 were observed between 1999 and 2003, compared to values of 1050 and 800 in 1997 and 1995, respectively. Values of about half of what was observed between 1999 and 2002 were also observed for the total ADD adjusted to 4°C of 1995 and 1997 (Fig. 7b). Although the total ADD adjusted to 0°C value for the 2003 profile was similar to those observed between 1999 and 2002, the trend showed that, in the early part of the year, the values were higher. However, the ADD adjusted to 4°C profile revealed that temperatures in the early part of the year were not higher than 4°C suggesting that thermal accumulation for active biological processes was low and comparable to 1997 (Fig. 7b). The total ADD adjusted to 4°C profiles showed that values of approximately 900 were observed in the warmer years compared to values of 750 in 2003, 550 in 1997, and lower than 400 in 1995. The coldest average daily temperature at the beginning of the fishing season was observed in 1995 and 1997, while 2003 was an average year, and the others were above average (Table 1). Except for 1995 and 1997 (coldest years), there was very little variability in the temperature regime. The only warming trend was observed in 1995; however, it was also identified as a colder than average year suggesting that this warming trend was not a positive sign. In terms of biological processes, 1995 followed closely by 1997 and 2003 could be classified as years with less favorable environmental conditions.

Shediac – In Shediac, the average weekly temperature increased to values between 18°C and 21°C, except in 2001 (Fig. 6b). The temperature profile in 2001 was significantly colder than the other years reaching only 15°C. Similarly, the ADD profile in 2001 was well below those observed in other years (Fig. 7c, d). The total ADD adjusted to 0°C profiles showed that values ranging between 2000 and 2200 were observed every year except in 2001. A total ADD adjusted to 4°C for 2001 was about 30% lower than those of other years (Fig. 7d). Although the total ADD adjusted to 0°C value for the 2003 profile was similar to other years (except 2001), the trend, as observed in Escuminac, showed that in the early part of the year the values were higher. However, the ADD adjusted to 4°C profile revealed that temperature in the early part of the year were not higher than 4°C and, therefore, were comparable to the other years (Fig. 7b). The total ADD adjusted to 4°C profiles showed that values of approximately 1600-1700 were observed in the warmer years compared to values of 1350 in 2003, and 1100 in 2001. The coldest average daily temperature at the beginning of the fishing season was observed in 2001, while 2003 was an average year, and the others were above average (Table 1). High weekly temperature variability has been observed in Shediac with no thermal trend evident (Table 1). In the Shediac area, 2001 had the least favorable environmental conditions.

Pugwash – In Pugwash, the average weekly temperature increased to values between 15°C and 18°C in August (Fig. 6c). The ADD profiles were fairly homogenous with the profiles in 2001 and 2002 somewhat slightly above those observed in other years (Fig. 7e, f). The total ADD adjusted to 0°C profiles show that values were at about 1700 in 2001 and 2002, and ranged between 1400 and 1500 for all the other years. Similarly, the total ADD adjusted to 4°C value for 2001 and 2002 were slightly higher than average (Fig. 7f). The average daily temperatures at the beginning of the fishing season were fairly similar throughout the years with 2002 being the warmest (Table 1). The Pugwash area has the widest temperature fluctuations in LFA 25. The temperature was highly variable in every year except in 2000 with no thermal trend (Table 1). Such temperature fluctuations could have a negative effect on the daily catch within a season (Comeau and Drinkwater, 1997).

In conclusion, the fishery in LFA 25 operates during the warmest months of the year. During the first four weeks of the fishery daily temperatures increase, followed by a stable decline. Daily temperatures can reach 16°C in the northern and colder part of the LFA, while they reach values >20°C in the southern part. This spatial difference was also observed in the ADD profiles. In warmer years, the total ADD values in the northern portion of the LFA were between 25% and 50% lower than those in the southern portion. Beside these spatial differences, annual differences were also observed. It seems that temperature regimes in Escuminac in 1995 and 1997, and in Shediac in 2001 were colder than average. Also, the daily average temperature was more variable in the southern part of the LFA, which could explain different trends in catch rate during the fishing season (Comeau and Drinkwater, 1997). More importantly, because biological processes are closely dependent on temperature (especially above 4°C), less than favorable environmental conditions observed in certain years could have some short-term and/or long-term converse effect on the stock by delaying, for example, onset of molting and egg extrusion.

3.0 INDICATORS BASED ON TRAWL SURVEYS IN LFA 25, 2001 TO 2003

3.1 Methods and Survey Stations

The trawl survey was set up to detect between-year differences in abundance using a random-block experimental design developed from a 2 X 2 nautical mile grid placed over all of Northumberland Strait. Each year, 30 to 40 stations were randomly chosen and fished within each block. We were unable to tow in water < 4 m deep. The survey net was a number 286 bottom trawl equipped with rubber "rock-hopper" footgear (Hanson 1996; Hanson and Lanteigne, 2000). For the current set of surveys, the net was towed for 15 minutes at a speed of about 4.6 km h^{-1}. The opening of the trawl for 2002 and part of 2003 was measured using SCANMAR sensors. Fishing was restricted to daylight (between 06:00 and 18:00 h). Time of day, water depth, latitude, and longitude were recorded at the beginning and end of each tow. A Vemco temperature probe was attached to the cod end and the temperature 2 minutes before the end of the tow was recorded. Contours of similar bottom temperatures were derived using ordinary Kriging.

The catch was sorted to species, each taxon weighed and numbers estimated. Carapace length (CL) and sex was recorded for all lobster, carapace width and sex for all crabs, and total length was recorded for selected fish species. Catch information was standardized to a 2000-m tow. The average wing width (± 95% CI) was 9.0 ± 0.2 m; thus, each standardized tow represented an area of 1.8 ha.

Fisheries-independent estimates of exploitation were calculated for the southern Northumberland Strait for 2001 to 2003 based on average catch-per-unit-effort (CPUE) in the pre- and post-fishery surveys. All of LFA 25 was surveyed during the July-August surveys (pre-fishery). Post fishery (October) surveys, however, were limited to the area between West Point, Prince Edward Island (P.E.I.), and just west of the Confederation Bridge. Comparisons of mean CPUE of canner and market size lobster were restricted to the area in common between the summer and October surveys. The variation in exploitation estimates was derived by means bootstrapping (a statistical resampling technique) using 1,000 iterations for each of the pre- and post-fishery surveys. We calculated exploitation for each of the 1000 pairs as follows:

$$\% E = 100 (N_s - N_o)/N_s$$

where N_s is the mean number from the summer survey and N_o is the mean number from the October survey. The median and the appropriate measures of dispersion (quartiles) were then calculated for these 1000 estimates.

Intact fish or crustaceans were retained and frozen for stomach content examination. Stomach contents were identified to the lowest practical taxonomic level, the number of individuals recorded (when possible), and the weight of all organisms in a taxon measured to the nearest mg (blotted wet weight). For the purpose of this document, the importance of the various prey diet of each fish or crustacean species was expressed as % by weight for all samples of a species combined. In the case of lobster, four size-classes were treated separately: juveniles (< 50 mm CL); sub-legals (50 mm CL - MLS); canners, and markets. The diet similarity among species and size-classes of lobster was evaluated by means of cluster analysis (Bray-Curtis similarity measure) and plotted as dendrograms and Multi-Dimensional Scaling plots (Primer software).

3.2 Temperature Distribution During Summer

The bottom water temperatures were much warmer in the southern area of Northumberland Strait than in the north-west area (Fig. 8). Bottom temperatures often exceeded 18° C in the central Northumberland Strait but were near zero in the deepest water, which was part of the cold intermediate layer, at the southern end of the Shediac Valley. There was little difference in the distribution of warm and cold water between years. Moreover, some of the inter-annual variation can be attributed to differences in the timing of the survey (i.e., the survey was done from east to west in 2002 but from west to east in 2003).

3.3 Lobster Spatial Distribution

The survey covered all of LFA 25 in the three years of this study (Fig. 9). In 2001, survey coverage was extended east of the LFA to determine whether there was a concentration of lobster continuous with, or adjacent to, the eastern boundary. In 2002, survey coverage was extended north of the LFA to determine whether there was a concentration of lobster in Inner and Outer Miramichi Bay that was continuous with, or adjacent to, the northern boundary.

While it was clear that the spatial distribution of all three size classes contracted within LFA 25 since 2001, several features were common in all three surveys (Figs 10-12).

Market-size lobsters were concentrated in the southern zone in all three years, uncommon on the P.E.I. side of the northern zone and sparse east of Cape Tormentine (Fig. 10). Substantial numbers of market-size lobster were present along the New Brunswick (N.B.) coast in 2001 and 2002; indeed, the northern-most distribution (and highest density patch) continued into Miramichi Bay of the adjacent LFA 23. In 2003, however, few market-size lobsters were present in the northern zone just prior to the opening of the 2003 summer/fall fishery. The sparse density of large lobster in the eastern-most portion of the LFA was shown to continue eastward to about Pictou Island, where densities appeared to increase.

Canner (Fig. 11) and sub-legal (Fig. 12) sized lobster had almost identical distributions. Canner-size lobster were abundant along the N.B. coast of the northern zone and in the southern zone west of the Confederation Bridge in all three years; however, densities in 2003 were much lower than in the preceding years. For sub-legal size lobster, the highest densities consistently occurred along the N.B. coast of the northern zone – centered on Kouchibouguac National Park – this may represent a discrete nursery area. The very high densities of the northern-most patch of both size classes continued into Miramichi Bay adjacent to LFA 23. Canner-size and sub-legal size lobster were almost non-existent east of Cape Tormentine in all three years and this area of very low abundance continued eastward to about Pictou Island.

3.4 Lobster Abundance Indices: Summer Surveys

Northern zone. The average CPUE of canners in the northern zone (Strata 1 and 2) has declined 80% since 2001, while the number of markets has declined by over 60% (Table 2). The number of sub-legal lobster (will molt into canners in 1 or 2 years or molted into the canner size class this year) has decreased 80% on the N.B. size and 26% on P.E.I. side – Note. the N.B. side has had higher densities than the P.E.I. side for all size-classes of lobster in all three years. Consequently, if recruitment only occurred from within LFA 25, the canner landings would be predicted to decline again in 2004.

Southern zone. The number of canners in the southern zone (Strata 3 and 4) has declined 46% since 2001, and the number of markets 27-51% (Table 2). The initial densities in stratum 3 were much higher than in stratum 4 and there was a slight increase in numbers of market lobster between 2002 and 2003 in stratum 3. The numbers of canners have continued to decline between 2002 and 2003, suggesting fewer market-size lobsters will be present in 2004. The numbers of sub-legal lobster have changed little in stratum 4 (density low in all years) and have declined each year in stratum 3. As in the northern zone, canner landings would be predicted to decline again in 2004 if recruitment only occurs from within LFA 25.

3.5 Lobster Sizes and Sex Ratio

The length-frequency distributions for the pre-fishery surveys were consistent with the abundance and distribution data (Fig. 13). There was a large spike in the sub-legal size-class in the northern zone that did not occur in the southern zone and relatively few market lobsters occurred in the northern zone.

There was a weak, but significant, difference in sex ratio (number of males/number of females) between years (increase in proportion as males) in the northern portion of LFA 25 (Table 3). There was no significant difference between years in the central Strait, where there were more females in all three years in both the pre- and post-fishery surveys. The ratio of males to females has increased in the northern survey area from 2001 to 2003 (0.91 in 2001 versus 1.12 in 2003), the opposite of what would occur if exploitation of females was less than that of males. In general, the fishery regulations only protect ovigerous females, which do not have much effect in the LFA 25 fishery because most of the landings occur before new-egg extrusion has occurred in most years.

The observed decline in the proportion of females in the LFA 25 population could occur if females were preferentially captured. An alternative explanation is that there could be a difference in timing of seasonal movements between male and female lobster. If male lobster arrived before females in the northern zone, it should, however, show up in the weekly landings (assuming they were well sampled). In contrast, the sex ratio did not differ between years in the central zone and market-size lobster comprised a larger portion of the population than in the northern zone, suggesting the two zones do not have the same movement patterns and/or there is a substantial resident population in the central zone. A comprehensive study that uses direct tracking by means of acoustic tags would be one means of distinguishing between these various hypotheses.

3.6 Fisheries-Independent Estimates of Lobster Exploitation

We estimated exploitation from pre- and post-fishery surveys for the central zone (West Point, P.E.I., to about the Confederation Bridge) in 2002 and 2003 (all of zone 3 and the area of stratum 4 covered by both surveys). The estimate for 2001 only covered part of stratum 3 (did not include Egmont Bay) and is included for illustrative purposes (Table 4). For 2002, the distribution of estimates based on re-sampling of pre- and post-fishery surveys showed a narrow distribution (Table 4 and Fig. 14).

The average exploitation rates were high (> 50%) in all three years (Table 5) and these rates are conservative because sub-legal animals molted into the fishery, and from canner to market size, during the fishery in all three years, i.e., we were catching animals that had yet to molt just before the fishery opened. The distribution of estimates was particularly narrow in all three years.

3.7 Lobster Diets

The incidence of empty stomachs was low (< 7%) for all size-classes of lobster. Lobsters are largely carnivorous - plant material was a minor component of the diet for all four size classes (Table 6). Rock crab was the principal prey of all size-classes of lobster in LFA 25, comprising 52 to 72% of total prey biomass. About 75% of the rock crab consumed by lobster represented fresh prey (muscle or gills attached) and the remainder consisted of old carapaces. Lobster represented a trace portion of the diet of the smallest lobster and increased to 10% of prey biomass of market-size lobster. Most of the lobster remains consisted of old carapaces. Lady crab and hermit crab were minor prey of lobster while shrimp occurred only in trace amounts in the diet.

Non-crustacean animals were minor prey of all four size classes of lobster. The importance of sea star in the diet declined from 10% of prey biomass for the smallest lobster to about 4% for the largest size-class. Molluscs, polychaetes, and fish did not comprise more than 7% of prey biomass for any size-class of lobster.

3.8 Diets of Potential Predators and Competitors of Lobster in LFA 25

We have been able to analyze diets of the major demersal and pelagic fishes as well as the large crustaceans in LFA 25 from May to October (Table 7). To date, 10,211 stomachs have been processed; however, those collected during summer and October 2003 have yet to be analyzed. The relatively large numbers of empty stomachs for lady crab, rock crab, and rainbow smelt were a result of sampling to confirm the daily peak in feeding activity – lady crab and rock crab essentially fed at night. We have not investigated whether the large number of empty stomachs for rainbow smelt was due to there being one or more feeding peak during the day.

The only fish species to eat lobster were shorthorn sculpin and cunner and it was a minor prey category (Fig. 15). Cluster analysis showed that herring, shad, mackerel, and alewife had very similar diets consisting primarily of planktonic crustaceans (small copepods, crab larvae, mysids) with mackerel eating a small amount of fish (Fig. 16). The diets of the four size-classes of lobster formed a clearly separate group, largely due to the high proportion of rock crab in the diet. The rock crab and lady crab diets had about 50% of the prey in common. Rainbow smelt was grouped with windowpane flounder because sand shrimp (*Crangon septemspinosa*) represented > 50% of prey biomass for both fishes. Yellowtail flounder and American plaice occurred along the deep water edge of the survey area and their diets had little in common with other species. Cunner and winter flounder had fairly diverse diets with about 50% prey similarity. The last grouping, winter skate and the two sculpins, had diets dominated by crabs, shrimp, and small fishes.

4.0 LOBSTER STOCK STATUS BASED ON FISHERY DATA

4.1 Data Sources and Analyses

Lobster size distributions, together with landings and effort, needed to calculate the CPUE, can be used as indicators to assess the stock status and possible recruitment decline. A recruitment decline should be a concern when a low proportion of first year recruits into the fishery combined with a low CPUE are observed. Numerous programs have been put in place to gather this fishery-based data. In this assessment, ovigerous females were excluded from the analyses because of the yearly fluctuation in their catchability and the possible bias that can follow. In general, fishermen tend to avoid areas where ovigerous females are abundance in order to reduce disturbance of egg bearers, but also because such areas are associated with low numbers of commercial lobsters.

The fishery-based data collected to establish the stock status of LFA 25 were taken from 1) Department of Fisheries and Oceans (DFO) official catch statistics, 2) at-sea sampling, 3) index-fishermen logbooks, and 4) recruitment-index logbooks.

4.1.1 Official Catch Statistics

Official lobster catch statistics were obtained from the Policy and Economics Branch of DFO. The database consists of a compilation of sale transactions conducted between official lobster buyers and fishermen. Although this information essentially documents monetary transactions, it is assumed that the volume sold to official lobster buyers closely tracks the quantity of lobster caught by commercial fishermen. Although the actual fishing location is not available from this data source, it was decided that landings would be separated by statistical district (SD) (Fig. 17), and assumed that the SD where lobsters were landed represents the general geographical area where lobsters were caught. There are eight SD, and for some of the analyses they were grouped into the northern (SD 75, 76, 77, 82) and the southern (SD 45, 78, 80, 83) portion of the LFA. Landings between 1948 and 1968 are only available for the entire LFA (Williamson, 1992).

4.1.2 At-Sea Sampling Program

Lobster size structure and catch rate in commercial traps was obtained from the at-sea sampling program. This program has been in place since 1982 and although the program went through numerous changes over the years, the sampling was still conducted by scientific staff onboard commercial fishing vessels during the fishing season, at several fishing ports. One sea sample was defined as one day at sea with one fisherman from a given port. Onboard the vessel, sampling technicians recorded information on lobster size (measuring all the lobster to the lowest mm), sex and condition (egg stage of ovigerous females), trap position on the line of traps (where applicable), and geographic position of the line of traps during a regular fishing day. In the early years, geographic positions were merely descriptive, but in recent years, many technicians were equipped with handheld GPS.

Because LFA 25 is heterogeneous in its lobster habitat and abundance, information collected was grouped by SD. Since almost 60% of all catches occur in the first three weeks of the fishery, only at-sea sampling data collected in August were considered. Moreover, for each SD, years with less than 400 measured lobsters were deleted from the analyses; samples considered are listed in Table 8.

Size distributions were based on 2-mm size groups. The number of lobsters per trap hauled based on 2-mm size group was obtained for each year and SD as,

$$CPUE_{id} = \frac{\text{total number of lobsters in size class } i \text{ and district } d}{\text{Number of traps sampled}} \quad .$$

Yearly proportion of traps with no commercial lobsters was also calculated for all at-sea sampling as a measure of fishing effort.

4.1.3 Recruitment-Index Program

Lobster size structure, catch and effort data were also obtained from the recruitment-index program. With the gradual implementation from 1986 to 1996 of trap escape mechanisms and the need to monitor the relative abundance of pre-recruits, a recruitment-index program was put in place in 1999. One of the objectives of the program was to gain knowledge of pre-recruit CPUE. In addition to filling a daily logbook of their catch and trap hauls, fishermen participating in this voluntary program sampled part of their catch daily throughout the season. Volunteer fishermen recorded the size and sex of all lobsters caught in six discrete traps, three of which had the escape mechanism blocked. It was thought that traps not equipped with an escape mechanism would retain more animals below the MLS. The lobster size was measured with a gauge graduated in 13 size classes (Fig. 18). Class size 1 represented lobsters of carapace length less than 20 mm from the MLS and class size 13 was for lobsters 50 mm above the MLS. Except for size classes 2, 11 and 12, which are 10-mm group size, all other size classes are in 5-mm groupings. Lobsters of group size 4 and below were sub-legal lobsters and, when the MLS was changed, the gauge was adjusted each year such that group sizes 5 and 6 represented animals from the first molting group into the fishery.

The number of participating fishermen has varied from year to year (Table 9) and was often affected by changes in fishery management plans. For the analyses, yearly information collected in the six traps was grouped according to the SD of the participating fishermen and the trap (regular or modified traps with the escape mechanism blocked). CPUE at size were calculated using the gauge's bin sizes and the equation given in the at-sea sampling program section (4.1.2).

4.1.4 Index-Fishermen Program

Catch and effort data were obtained from the lobster index-fishermen program. The effort required to capture lobsters is an indicator that is needed to assess the status of a stock managed through effort control. The index-fishermen program provides daily landings and effort information needed to calculate CPUE, that is the number of traps hauled to obtain a catch. Since there is no mandatory requirement for fishermen to inform DFO of their fishing activities, a voluntary logbook program was initiated by DFO's Science Branch. This program has been managed by the Lobster Group in Moncton since 1993 and relies on volunteer fishermen recording their fishing activities on a daily basis. Data collected included daily catches of lobster by category (i.e. canners and markets), number of traps hauled, and the number of soak days. Although the number of participants has fluctuated slightly over the years, our program provides the daily catch and effort information for approximately 2% of the fishing activity within LFA 25. Since index-fishermen are located throughout the entire LFA, it is assumed that annual changes in the catch and catch rate from our index-fishermen reflect the fishery as a whole.

For each SD, landing information was used to calculate weekly CPUE as,

$$CPUE_w = \frac{\text{total weight of commercial lobsters in week } w}{\text{Number of traps hauled in week } w} \quad .$$

The weekly number of traps hauled (Weektrap) by fishermen was also calculated for all SD as,

$$Weektrap_{wd} = \frac{\text{total number of traps hauled in week } w \text{ and district } d}{\text{Number of logbook entries in week } w \text{ and district } d} \quad ,$$

and used as a measure of fishing effort.

4.1.5 Trap Efficiency

A study on the sGSL fishing fleet showed an increase in trap sizes from 1984 to 1993 and that fishermen in LFA 25 fished with the largest average trap in the sGSL (Lanteigne, 1999). Information on traps used during the 2003 fishery based on the index-fishermen and the recruitment-index programs was compared to the 1993 study results to determine the magnitude of any possible change.

Since there has been no study conducted on trap efficiency in LFA 25, a study conducted recently in LFA 23 is presented for comparison. Fishing effort has been a concern in LFA 23, and fishermen agreed in the first multiyear management plan (1998-2001) to decrease the number of allowable traps from 375 to 300 over a period of three years (1998 to 2000). Although the purpose of this trap reduction was to reduce the fishing effort, there were indications that fishermen were increasing their trap size to compensate for the trap number reduction and were actually increasing the effective fishing effort. A trap efficiency experiment was carried out during the 2000 fishing season in the Anse-Bleue area to compare the CPUE of two trap sizes used in LFA 23.

In 2000, at-sea sampling was carried out during the regular fishing season with a fisherman using two different trap sizes in Anse-Bleue. Both traps were wood framed, semi-circle, with wire meshing. The smaller trap was 89×56×38 cm with one parlor, one kitchen, two entrances and one bait pin. The larger trap was 107×56×38 cm with one parlor but had a larger kitchen with four entrances and two bait pins (Fig. 19). The hoop size entrance and escape mechanism were not changed. Because both trap types were part of the fisherman's regular gear, there is no reason to think traps were not fished in the same manner and intensity. Information on trap catches was collected during two at-sea sampling periods during May and June. The goal was to cover the period of high and low abundance of lobster, and change in catchability associated with warming water temperatures. For more details on the at-sea sampling protocol, see section 4.1.2. The proportion of empty traps and the mid catch in grams were calculated separately for both trap types in the early and late sampling periods of the fishing season.

Lobster sizes were converted to weight in grams using the length-weight relationship from Maynard et al. (1992):

Males: $\text{weight} = 0.00140744 \times CL^{2.8675}$,
Females: $\text{weight} = 0.0031 \times CL^{2.6838}$.

For all calculations, only legal size lobsters, ovigerous females excluded, were considered for the catch. Size distributions of the catches between trap sizes were compared using the non-parametric Cramér Von Misses test.

4.2 Landings

Commercial lobster catches in LFA 25 showed a sharp increase from 1,622 t in 1973 to a record high of 6,230 t in 1985, representing an almost four-fold increase in 12 years (Fig. 4). Within the sGSL, LFA 25 was the first one to reach its record high landings (Figs 3 and 4). However, since 1985 landings in LFA 25 have been declining. In 2002, 3,210 t were landed, which represent a 52% reduction from the peak landing observed in 1985. This 17-year decline is the largest one observed in the sGSL. Furthermore, based on anecdotal information, it is expected that landings in 2003 have declined compared to 2002.

Within LFA 25, the increase in catches was observed in all SD, but they reach their peaks at different time and the declining trend that followed also differs between SDs (Fig.

20). This reflects the spatial and temporal variability of the lobster resource in LFA 25. In general, the SDs located in the southern part of the LFA peaked earlier (1985; Fig. 20e-h) than those located in the northern part (1988-1989; Fig. 20a-d). The landing trends are also very different as the southern portion of the LFA experienced a sharp increase followed by an equally sharp decline over approximately a seven year period (Fig. 20e-h). Landings observed in 2002 were similar to those observed from 1968 to 1974, prior to the sharp increase that produced the record landings. As for SDs located in the northern portion the LFA, the downward trend has not been as sharp as the declining trend observed in the southern portion (Fig. 20a-d). The landings in 2002 were higher than those observed prior to the sharp increase. Based on the historical landing patterns, the northern portion of the LFA might be expected to experience more declines in landings in the future.

The seasonal cumulative catch revealed that the landings during the fishing season were not normally distributed (Fig. 21). Based on information retrieved from sale transactions conducted between official lobster buyers and fishermen, landings were much higher at the beginning of the fishing season than at the end. It seems there is no relationship between the annual landings and the cumulative catch during that season because the same trends were observed for the cumulative catch although annual landings have been declining steadily (Fig. 21). Except for SD 45 (Fig. 21g), 25% of the annual landings were caught during the first week, while half the annual landings were caught between the second and the third week of fishing (Fig. 21) in a nine week fishing season. This extremely fast removal rate is indicative of a very high level of effort and efficiency.

Official catch statistics could be used as crude indicators of the overall status and annual fluctuations of the stock. However, compiling the catch information from sale transactions should not be considered a reliable indicator of the size or reproductive health of the lobster population. Increased fishing power and changes in social-economic situations can give the impression that landings are increasing or being maintained. Nonetheless, the extraordinary increase in lobster catches since the mid-1970s cannot be explained entirely by an increase in fishing power. This increase was observed for the entire lobster distribution range in areas with different management regimes, fishing fleet characteristics and fishing traditions. Therefore, the increase and recent decrease in lobster catches in LFA 25 have to be considered as real changes in the lobster stock biomass. However, accurately measuring the magnitude of these changes is difficult with the data presently available.

4.3 Catch Characteristics and Size Structures

4.3.1 At-Sea Sampling

In general, at-sea sampling data show a severe decline in the recruitment over time (Figs 22-25). Although the situation was more severe in the southern part of LFA 25, it was also apparent in the northern zone. Size distribution and CPUE observed for SD 45, 78, 80, and 83 showed a similar declining trend for sub-legal canner and market size lobsters to a very low abundance in the south in the recent years (Figs 22 and 23). The situation, although less severe up until 2002, showed a similar declining trend through time in SD 75, 76, and 82 (northern zone) where sub-legal size lobsters were still being caught with higher CPUE than in the southern part. Nevertheless, the abundance of sub-legal and canner size lobsters clearly showed a constant declining trend (Figs 24 and 25). The declining trend in CPUE of market size lobsters in the northern portion of the LFA seemed to be less important because they were never caught in large quantity.

Looking in more detail, the implementation of escape mechanisms in traps starting in 1986 can explain the sudden decrease of sub-legal size lobsters observed in the 1984-1985 size distributions (Figs 22a,e,i and 24a,f,g). There was also a clear pattern based on the CPUE distributions (Figs 23a,e,i and 25a,f,g). Increases in sub-legal size lobsters can be associated with years when the MLS was increased (1990-1991, 1998 and 2003) since previously exploitable lobsters became protected (Figs 22-25). For instance, in SD 75 one observes a sharp increase in sub-legal size lobsters in 1991 on the second year of the MLS increase, but this peak has disappeared by 1993. In all cases, the effect of an increase in MLS quickly vanishes within two years of implementation and more importantly, there was no change in the pattern of size distribution (no increase in abundance of large sizes). Indeed, instead of an increase in the number of larger lobsters, the size distribution was simply shifted according to the new MLS. The situation is even more severe in the most southern part of LFA 25 (SD 45 and 83) where an increase in MLS in 1998 was not followed by an increase in pre-recruit size lobsters.

The lack of change in size distributions is a sign of very low abundance of lobsters in pre-recruit sizes every year. However, the size distribution by itself is not a good abundance indicator to assess the abundance of the stock, and one has to depend on more complex reliable indices, such as the CPUE. This point is quite clearly demonstrated if we examine the size distributions for 1994-1997, where there was no change in MLS. The yearly size distributions were quite similar (Figs 22 and 24). However, based on CPUE, a declining trend can clearly be observed in the capture of both the sub-legal and canner size lobsters, indicating a likely reduction in stock abundance (Figs 23 and 25). The declining trends of the market size lobsters, although evident, were less important. The declining trends observed in the CPUE gave a better index of the lobster abundance because the size structure was standardized to effort. This is not the case for the size distribution of the catch as it is expressed in terms of percentages.

The long-term declining trend in the proportion of sub-legal size lobsters could indicate a reduction in their abundance (a decline in recruitment), or an increase in legal-size lobsters (a recruitment pulse moving through the population). To better understand the cause for a reduction in the proportion of sub-legal size lobsters, the CPUE of the catch is the proper indicator. Based on the CPUE distributions, the number of pre-recruits seen in traps has been consistently decreasing since the high catches in 1985 and 1989 in the south and north of LFA 25, respectively. In SD 75 for instance, the highest CPUE of pre-recruits with approximately 140 sub-legal size lobsters per 100 traps for lobsters 2 mm below MLS, was seen in 1988 (Fig. 25b). A peak in landings followed this high abundance in 1989 (Fig. 20a). In 2000, the CPUE of sub-legal size lobsters was down to 40 per 100 traps (Fig. 25e), a drop of 71%. Hence, it seems that the reduction in the proportion of sub-legal size lobsters observed in LFA 25 was caused by a reduction in recruitment. The severity of the decline could be viewed as a recruitment failure at the population level if it persists.

4.3.2 Recruitment-Index Program

The advantage of the recruitment-index program over the at-sea sampling program is the seasonality of the data collected. Such data give a better and more dynamic abundance indicator for the status of the stock. Information recorded from the three modified traps (escape vent blocked) allows the verification of the pre-recruit CPUE level observed in the at-sea sampling program. In the southern part, there were little differences in size distributions between the regular and the modified traps (Fig. 26). This situation was different in the northern part (Fig. 27) where modified traps caught higher numbers of sub-legal size lobsters compared to normal traps. Similar catches in both trap types in the southern part of the LFA is another sign of low abundance of pre-recruits in that area. Finally, although there was a MLS increase in 1998 and 2003, there was no sign of an increase in pre-recruits or changes in size distribution (Figs 26 and 27). Although this time series is shorter than the at-sea sampling program, the same declining trends have been observed for pre-recruit, canner and market size lobsters.

4.3.3 Index-Fishermen Program

Landing information on canner and market size lobsters collected from the index-fishermen program showed the same declining trends observed with other indicators for canner and market size lobsters. Knowing that lobsters will be in the canner size category for approximately one molt before molting into market size, the ratio of canner:market can be used as an indicator to measure the number of lobsters surviving beyond the first year in the fishery. Canner:market ratio yearly trends are declining in all SD (Fig. 28). The decline in ratio can be explained by either a recruitment pulse moving through the population (large number of canner size lobsters entering the fishery) or, conversely, by a decrease in abundance of canner size lobsters (no new canner size lobsters entering the fishery so that only market size lobsters are left). Since landings have been declining over the past 17 years, it is safe to assume that the yearly decline in the ratio is due to a decline in abundance.

4.4 Fishing Effort

Information from the index-fishermen program can also be used as a fishery effort indicator, and indicative of fishing strategies. The sharp decrease in weekly CPUE after the second week of the fishery is a sign that the stock cannot sustain the current level of fishing effort (Fig. 29). Furthermore, the effective effort, based on the actual trap haul, compared to the nominal trap haul (allowed by fishery management regulation) could also be used as an indicator of effort. In the northern part of the LFA, volunteer logbook information indicates that most fishermen haul close to their 250 allowable traps daily (Fig. 30a). In the southern portion of the LFA, however, many fishermen do not haul their entire fishing gear on a daily basis, even at the start of the fishery (Fig. 30b). Based on that information, the actual effective effort deployed to capture lobster is below the effort allowed (by the fishery management regulation) by 58% to 77% in the northern part and between 34% and 67% in the southern part of the LFA (Fig. 31). This low percentage of trap hauls, especially in the south of the LFA, is indicative of a low abundance of lobsters and, to be cost effective, fishermen have to haul their gear on alternate days or even less often. Different fishing strategies are encountered between the northern and southern portion of LFA 25. An offshore-inshore fishing pattern observed in part of SDs 75, 76 and 82 is similar to the one observed in the spring fisheries. For the remaining SD, fishermen undertake less directed movements as they cover the entire fishing grounds over the whole season. Furthermore, our data corroborate the fishing practices of fishermen in the southern portion of LFA 25 that will change their fishing practices by doing trap hauling rotations, i.e. they will either fish every two to three days or alternate from hauling half the traps one day and the other half the next day (Comeau et al. 1997). In either scenario, trap soak time will increase to compensate for low lobster abundance. Hence, one can assume that the total number of traps per fisherman could be reduced by half in some areas without any reduction in lobster landings or exploitation rate and the landings would still decline.

Another indicator of the level of fishing effort in relation to lobster abundance is the proportion of empty traps during the season. It is estimated that the number of traps not catching commercial size lobsters has increased from about 5% in 1986 (record landings) to 50% in 2003 (Fig. 32). Moreover, these estimates were only for the month of August when over 60% of the landings are observed. A much high percentage of empty traps in the fishery would be estimated if data from the months of September and October were included. As mentioned, based on information from the index-fishermen program, the lobster stock level in LFA 25 cannot sustain the current level of fishing effort.

4.5 Trap Efficiency

A study carried out in LFA 23 reveals that the trap efficiency varied between the early and late season (Figs 33 and 34). At the beginning of a spring fishing season, the proportion of traps with no commercial lobsters were quite similar with 25% and 26% for large and small traps respectively while it was 57% and 74% later in the fishing season (Fig. 33a). However, even at the beginning of the season mid-catch in the smaller traps was 505 g compare to 689 g for the larger trap, a difference of 184 g per trap. In addition, maximum catches in the smaller traps did not exceed 1,780 g while they reached over 2,750 g for the larger traps. Later in the season, catches in non-empty traps were more similar but there were 30% more empty small traps, thus considerably reducing the CPUE (Fig. 34). Also, larger traps seem to catch more weight of lobsters than the small traps based on the CPUE (Fig. 34). The ratio of CPUE of large:small traps were 1.3:1 and 2.0:1 in May and June, respectively, indicating that larger traps are twice as efficient of smaller traps at the end of the spring fishery season. The difference in catch was due primarily to the higher number of lobsters caught and not to the size of the lobsters (Fig. 35). Size distribution of lobsters caught in both type of traps were not significantly different (Carmér Von Misses test, p-value > 50%).

Based on the trap efficiency study in LFA 23, larger traps are twice as efficient as smaller traps. Hence, the trap size (length and width) could be used as an indicator of the trap efficiency in terms of fishing effort or fishing power. In 1993, Lanteigne (1999) estimated the trap fishing area (length by width), in square metres, as a measure of fishing effort for each LFA located in the sGSL and found that LFA 25 had the largest average trap size (0.71 m^2; Fig 36). Comparatively, the trap surface area for LFA 23 in 1993 was only 0.53 m^2. Based on information from our index-fishermen and recruitment-index programs, the trap size has since increased in all LFAs, with LFA 25 still having the largest average size in 2003 at 0.74 m^2, compared to 0.61 m^2 in LFA 23 (Fig. 36). An interesting fact in LFA 23 is that the 15% increase in trap size between 1995 and 2003 (from 0.53 m^2 to 0.61 m^2) almost compensates for the reduction in trap number (from 375 to 300) between 1998 and 2000. No increase of trap size occurred prior to the reduction in the permissible number of traps (Fig. 36). This corroborates the statement that fishermen in LFA 23 were increasing their trap size to compensate for the trap reduction in number, thereby increasing the effective fishing effort. Hence, a reduction in the nominal effort (effort allowed under the fishery management regulation) does not automatically translate to a reduction in the effective effort (the amount of fishing effort including efficiency in terms of fishing power actually applied in a fishery). The increasing trend observed in the trap length also reveals that fishermen have fished with larger traps in 2003 compared to 1993 (Fig. 37). Hence, this high trap efficiency in LFA 25 has no doubt contributed to the continuing decline in lobster abundance.

The fishing power in terms of trap efficiency could still increase in the future if restrictive measures are not implemented. The current fishery regulation on maximum allowable trap size (125 cm L x 90 cm W) could lead to a trap size of up to 1.13 m^2, allowing for almost a two-fold increase. Also, trap design (structural design such as the number of compartments, bait pins, etc…), as well as the way in which the trap is being fished, the amount of bait used and/or trap movement, all influence the performance of a trap and will contribute to increasing the fishing effort (Miller, 1989, 1990, 1996; Krouse, 1989). All of these parameters need to be investigated to quantify their contribution to the fishing effort. Certainly, fishery management regulations on trap size and design would curtail some increase in the fishing effort.

5.0 FEMALE LOBSTER REPRODUCTIVE STATUS

5.1 Background

In the sGSL, lobster mating and spawning occur between July and September. Recently, Comeau and Savoie (2002) reported that the majority of female lobsters follow a two-year reproductive cycle with females molting and mating during the same summer, extruding the eggs the following year, and carrying them attached on pleopods under the abdomen for nearly another year. However, up to 20% of the females in the sGSL could spawn in successive years and some could even molt and spawn in the same summer.

Comeau and Savoie (2002) also indicated that the length of the reproductive cycle is related to water temperature. Based on this information, females with a one-year reproductive cycle are fully protected in a spring season since they will spawn and be legally protected during the summer period and be ovigerous (thereby protected from the fishery) the following fishing season. However, in LFA 25 (fishing season from early August to early October) fishermen can catch females with a one-year reproductive cycle in early postmolt, but before they extrude their eggs (i.e. in the same year before they become primiparous females), and multiparous females that have the ability to spawn in successive years before they can release another clutch of eggs. Hence, nearly all of the potential egg-producing females would be vulnerable to the fishery before they have the opportunity to extrude their eggs and get "legal protection". Based on this scenario, significant numbers of mature females in their egg-extrusion year (ready to spawn) should be observed in the commercial catch during the early part of the fishing season in LFA 25. In order to verify this hypothesis, a study to investigate the reproductive condition of females was carried out.

5.2 Methods

The reproductive potential of the stock and the female maturity condition in LFA 25 was investigated in 2002 and 2003. This program studied the female reproductive condition in the northern (Loggiecroft) and the southern (Aboiteau) portion of LFA 25. A total of 100 canner size females were randomly collected every week at the beginning of the fishing season. In Loggiecroft, females were collected for the first three weeks every year, and in Aboiteau females were collected for the first four weeks in 2002 and the first five weeks in 2003. All females were transported to the laboratory to be examined according to the technique described by Comeau and Savoie (2002). Their reproductive condition (readiness to spawn) was established based on ovary condition and pleopod staging techniques. Although the ovary condition technique is very accurate, it requires dissection and is quite labor-intensive. Hence, to investigate the reproductive condition of females for the entire fishing season, the fast and nondestructive pleopod staging technique was used. Pleopods were sampled using a stratified sampling technique that consists of collecting five pleopods per 2-mm size group starting at the MLS for the canner size females. The ovary condition technique was used to validate the fast and nondestructive pleopod staging technique.

5.3 Results and Discussion

Females in their egg-extrusion year were observed in the commercial catch in both areas. The weekly level of females in their egg-extrusion year in the catch was different between the northern and southern portion of the LFA, being higher in the south (Fig. 38). However, the absence in the catch of females in their egg-extrusion year was observed simultaneously in both areas (Fig. 38).

Loggiecroft – The weekly percentage of females in their egg-extrusion year was higher in 2003 compared to 2002 (Fig. 38). Based on the ovary condition, the weekly percentage of females in their egg-extrusion year in Loggiecroft was high during the first week of the fishery at 19% and 26% in 2002 and 2003 (Fig. 38). The weekly percentage then dropped to 6% and 9% by the third week in 2002 and 2003 (Fig. 38). The weekly percentage of primiparous (0%-2%) and multiparous (0%-13%) females with a one-year reproductive cycle, that are fully protected in a spring fishery, was observed between 1% and 2% in 2002 and between 1% and 13% in 2003 on a weekly basis during the first three weeks of the fishery in August. Both primiparous (1%-5%) and multiparous (1%-17%) females with a two-year reproductive cycle were observed in the catch in 2002 (4%-17%) and 2003 (6%-19%). These females were already exposed to the fishery the previous year. This "double-dipping" of mature females by the fishery is not observed in a spring fishery. The weekly percentage of females in their egg-extrusion year estimated from the stratified pleopod sampling followed the same level and the same trend as the ovary condition, except for the very low level (3%) observed during the first week of sampling in 2003 (Fig. 38). The weekly percentage of females in their egg-extrusion year reached 0% (absence in the catch) later in 2003 compared to 2002 (Fig. 38). Absence of females in their egg-extrusion year was observed between 27 August and 4 September in 2002, and between 9 and 15 September in 2003.

Aboiteau – As observed in Loggiecroft, but at higher levels, the weekly percentage of females in their egg-extrusion year was higher in 2003 compared to 2002 (Fig. 38). Based on the ovary condition, the weekly percentage of females in their egg-extrusion year in Aboiteau was high during the first week of the fishery at 33% and 47% in 2002 and 2003 (Fig. 38). The weekly percentage then dropped to 1% and 6% by 29 August 2002 and 3 September 2003 (Fig. 38). The weekly percentage of primiparous and multiparous females with a one-year reproductive cycle was observed between 1% and 4% in 2002 and between 0% and 1% in 2003 during the first part of the fishery in August-September. Both primiparous (0%-23%) and multiparous (0%-29%) females with a two-year reproductive cycle were observed in the catch in 2002 (0%-34%) and 2003 (6%-47%). Once again, this "double-dipping" of mature females by the fishery is not observed in a spring fishery. The weekly percentage of females in their egg-extrusion year estimated from the stratified pleopod sampling followed the same level and the same trend as the ovary condition, except for the first four early samples in 2003. During that time, the percentage of females in their egg-extrusion year peaked at 63% (Fig. 38). The reason for this discrepancy between the two techniques is not clear, but since the ovary condition technique is more accurate, these levels will be used. Fortunately, the estimates on 2 September 2003 from both techniques are quite similar (Fig. 38). The weekly percentage of females in their egg-extrusion year reached 0% (absence in the catch) later in 2003 compared to 2002 (Fig. 38). Absence of females in their egg-extrusion year was observed during the same period as for Loggiecroft, between 28 August and 5 September in 2002, and between 10 and 17 September in 2003.

Under a high exploitation level, it is imperative that the reproductive potential of the lobster stock be fully protected (females ready to spawn should be totally absent from the commercial catch). For lobster fisheries operating during the critical period of the life cycle (summer season), the reproductive potential is not fully protected even if the landing of ovigerous females is prohibited. This contradicts the FRCC's (1995) recommendations for lobster conservation. In LFA 25 (summer fishery), the fishing season should not operate in August to protect the reproduction potential of the stock and avoid an increased exploitation rate of the mature females that have not yet spawned (avoid the double-dipping of mature females).

6.0 CONCLUSION

The stock status of LFA 25 has been assessed using a suite of indicators from trawl data, DFO official catch statistics, at-sea sampling, index-fishermen logbooks, recruitment-index logbooks, and biological sampling. Table 10 summarizes the impact on the stock (🡅 positive, ➔ no impact or not detectable, 🡇 negative) of the trends observed from the indicators. Based on the trawl survey, the trends for the abundance indicators (*spatial distribution* and the *abundance index*) of pre-recruit, canner and market size lobsters were all declining, indicating an annual reduction of the abundance of lobsters on the fishing ground. The *exploitation rate* calculated within the trawlable area in the southern part of the LFA was high, indicating that the stock is negatively impacted. Information on the *ecosystem* has not revealed any negative impact on the stock – largely because lobster is a top predator with few natural predators other than humans. We could not evaluate potential competitive interactions because we do not have a time-series that represents food availability per individual lobster. Similarly, there is little change in the environment quality indicators based on the coastal bottom temperature program. From fishery-based data, the *landings* revealed different trends for different SD. First, the 2002 landing for the entire LFA was comparable to the 55-year average, which could be viewed as a positive sign. Secondly, only two (most northern SD of the LFA) out of the eight SD had higher than average landings in 2002 compared to the 35-year average that include landings prior to the larger increase in landings observed in the late 1980s and early 1990s. Thirdly, landings in all SD were lower in 2002 compared to the 20- and 10-year averages. Also, no increase has been observed in the short-term (2001 landings compared to the ones in 2002). Finally, the trend in the cumulative catch revealed that the majority of the landings are caught within the first three to four weeks of the fishery, which is not a positive sign. The long-term trends from the fishery-based data (*at-sea, recruitment-index and index-fishermen catch rate*) of pre-recruit, canner, and market size lobsters were all declining indicating a long-term annual reduction of the abundance of lobsters on the fishing ground. The *female reproductive condition* indicator reveals that a high percentage (up to 47%) of mature females in their egg-extrusion year (exposed to the fishery a second time) is observed in the commercial catch indicating that the reproduction of the stock is not fully protected in LFA 25 (due to the timing of the fishery), which is a negative sign. All the *fishing effort* indicators suggest that the stock is negatively impacted by a high fishing effort. The *percentage of first molt group in the landings* has remained high since 1984 and coupled with a low percentage of market size lobster, reveals that the fishing effort in LFA 25 is very high. The seasonal trend of the *cumulative trap haul* is low, indicating that lobster abundance is too low to support the current level of fishing effort. The number of *empty traps* is high, which is also indicative of a low abundance. Finally, LFA 25 has the larger trap surface in the sGSL which is indicative of a high *trap efficiency* that could significantly increase the fishing effort.

The landings in LFA 25 have shown wide fluctuations since 1948. The landing trend in LFA 25 is typical of a boom and bust fishery (Acheson and Steneck, 1997). All indicators suggest that we are presently in or moving into a "bust" situation and that, based on historical landing information, at least part of the LFA might still experience further declines in the future. To achieve a sustainable fishery in LFA 25, some fishery management regulations have to be changed drastically and immediately.

The declining trends in landings observed in every SD within LFA 25 for the past 13 years are caused by a severe reduction in annual recruitment and very high fishing capacity. Indicators from both trawl survey data and CPUE calculated from volunteer index programs indicate that lobster abundance on the bottom is low and has been declining over the years. Based on these same indicators for pre-recruiting sizes, there is no short-term recovery from this situation. Furthermore, the benefit to the stock of any corrective measures (to reduce the fishing effort and enhance the egg production) that would be put in place would take at least seven years, simply due to the time it takes a lobster to develop from egg to canner size. Although the exact cause for this recruitment decline is unknown, there is no doubt that the high level of effort and an insufficient supply of offspring are responsible for part of the decline.

The high portion of canners in the catch and the low abundance of market size lobsters that have not changed throughout the years provide further support to the statement brought forward by FRCC (Anonymous, 1995) and previous assessments in the sGSL (Lanteigne et al., 1998, 2004) that the lobster fishery is defined as a recruitment fishery. This situation arises from the high level of fishing effort and an exploitation rate that results in very few lobsters surviving more than one year into the fishery. Although changes in management measures were implemented in terms of increasing the MLS in the last two management plans, no actual progress was made on reducing the fishing effort and the exploitation rate. The increases in MLS started in the 1980s, and as part of the last two management plans, were primarily engineered to increase the egg production of the lobster population and not to tackle the issue of the fishery depending heavily on the annual recruitment. Indicators from both fishery-based and trawl survey data still corroborate this situation for the 2003. A sustainable lobster fishery cannot be achieved in LFA 25, or other LFAs, when the overall commercial catch relies heavily on the annual contribution of new recruits into the fishery. Reduction in the effective effort is needed to change this situation as recruitment fisheries are seldom stable.

As mentioned earlier, the increase of the MLS was implemented to increase egg production. However, the reproductive potential of the stock is not fully protected in a summer fishery. Undoubtedly, by increasing the MLS a larger number of primiparous females will have the opportunity to spawn at least once and a larger number of multiparous females will also be protected. This will increase the number of eggs produced. Under the present management plan, the MLS will be increased to 70 mm by 2005 allowing 35% of primiparous females to be legally protected. To protect 50% or 100% of the primiparous females, the MLS would have to be set at 73 mm or 84 mm, respectively. However, in order to produce eggs, a mature female larger than the MLS has to go through a fishery once before spawning based on the two-year reproductive cycle.

This is true for spring fisheries, but not for a fishery operating in August. In such a fishery, mature females larger than the MLS are still vulnerable to the fishery for a second time before extruding a batch of eggs and being legally protected. It is estimated that during the first three weeks of the fishery in LFA 25 up to 47% of the females that are ready to spawn are removed by the fishery. Under the current fishery management regulation in LFA 25 (season operating between 10 August and 10 October), this "double-dipping" by the fishery of mature females larger than the MLS severely reduces the egg production compared to a spring fishery.

The total lack of reliable catch, effort and effort location information from fishermen is making it difficult to understand and analyze landing fluctuations. This situation is symptomatic for most of the Canadian lobster fishery, and has been raised by every biologist assessing lobster stocks in eastern Canada (see research documents and the stock status reports at www.dfo-mpo.gc.ca/CSAS/CSAS/Engligh/Status/Invert). Although fishermen in communities within LFA 25 are indicating important changes in their catches, it is impossible to clearly determine where they are occurring, to quantify these changes and to determine if they are the result of shift in effort. These issues can only be fully understood with timely accurate temporal and spatial data supplied directly from the users, i.e. fishermen.

7.0 MANAGEMENT RECOMMENDATIONS

- Based on fishery-based and trawl survey indicators, lobster abundance and annual recruitment in LFA 25 is low and has been declining for years. Furthermore, the fishery still relies too heavily on the annual recruitment. To change this severe situation, a substantial reduction in effort to lower the exploitation rate is needed. The reduction of the effective effort should be in the order of 40%. This reduction could be achieved by diminishing the number of participants, the number of traps per participant or the number of days in the season. Any reduction in the number of traps should be coupled with restrictive measures to limit the efficiency of the trap (fishing power) to actually reduce the effective effort. These restrictive measures include reducing the trap size, the number of compartments and entrances.

- At present there is no direct data on the spatial distribution of landings and effort. This information is needed to monitor the extent and changes in the distribution of fishing effort and to map the overlap of fishing gear. Information on catch, effort and fishing location from all the users is imperative to properly assess lobster stocks. The lobster fishery is the only one with such an economical important without any accountability from the users. The Oceans and Science Branch can not rely solely on volunteer programs to assess the stock status of this economically valuable resource. There is a need for information supplied directly by fishermen (not available at the present time) that is timely, accurate and available via a structured database.

- To enhance the egg production and truly protect mature females, the fishery in LFA 25 should not operate in August during the spawning period. Presently, the timing of the summer-fall fishery in LFA 25 is detrimental to the reproductive potential of the stock.

- Egg production could also be enhanced by further increasing the MLS. An increase of the MLS will allow more females to spawn at least once and protect a larger number of multiparous females, thus increasing egg production. In turn, that could reduce the risk of further recruitment decline, as presently observed for years in LFA 25, and would ensure a higher production of offspring.

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Table 1. Average coastal bottom temperature and yearly average temperature for the first four weeks (early August to early September) of the fishing season in selected areas within or adjacent to Lobster Fishing Area 25. The slope is an indicator of the thermal trend, and the r^2 is an indicator of the yearly variability.

Year	Average	Yearly Average	Slope	r^2
Escuminac				
1995	12.2	10.3	0.22	0.43
1997	12.2	9.7	-0.07	0.51
1999	12.2	13.5	0.08	0.15
2001	12.2	13.7	0.00	0.00
2002	12.2	13.7	0.05	0.11
2003	12.2	12.2	0.01	0.00
Shediac				
1997	16.9	16.6	0.08	0.65
1998	16.9	18.6	0.06	0.78
1999	16.9	17.6	0.10	0.82
2001	16.9	13.5	-0.04	0.03
2002	16.9	17.7	-0.03	0.24
2003	16.9	17.0	0.00	0.00
Pugwash				
1995	15.6	15.3	0.14	0.50
1996	15.6	14.8	0.26	0.88
1997	15.6	15.2	0.09	0.51
1998	15.6	15.5	0.12	0.39
1999	15.6	15.5	0.04	0.62
2000	15.6	15.9	-0.01	0.00
2001	15.6	16.1	0.13	0.65
2002	15.6	16.8	0.12	0.61
2003	15.6	15.0	0.06	0.37

Table 2. Summer trawl surveys in Northumberland Strait. Number per standard (2000 m = 1.8 ha tow) and standard error. % change = (1-(2003/2001))*100. LFA= Lobster Fishing Area

Canners

LFA	Stratum	2001 Average	2002 Average	2003 Average	% change
25	1	80.6 ± 28.5 (28)	31.5 ± 6.8 (37)*	8.9 ± 2.3 (30)	- 89
25	2	15.3 ± 4.7 (24)	7.9 ± 3.3 (25)	2.9 ± 1.4 (28)	- 81
25	3	13.6 ± 1.6(45)	9.2 ± 1.1 (44)	7.4 ± 1.2 (41)	- 46
25	4	3.9 ± 0.9 (43)	1.8 ± 0.7 (33)	2.1 ± 0.6 (40)	- 46

Markets

LFA	Stratum	2001 Average	2002 Average	2003 Average	% change
25	1	7.9 ± 2.2 (28)	4.5 ± 0.8 (37)*	2.6 ± 0.7 (30)	- 67
25	2	3.5 ± 1.2 (24)	1.8 ± 0.9 (25)	1.4 ± 0.5 (28)	- 60
25	3	11.2 ± 1.3 (45)	5.7 ± .07 (44)	8.2 ± 1.1 (41)	- 27
25	4	6.8 ± 1.2 (43)	3.7 ± 0.9 (33)	3.3 ± 0.6 (40)	- 51

Sub-legal

LFA	Stratum	2001 Average	2002 Average	2003 Average	% change
25	1	102.0 ± 33.1 (28)	26.3 ± 5.9 (37)*	19.1 ± 4.3 (30)	- 81
25	2	7.1 ± 2.5 (24)	4.2 ± 1.5 (25)	5.3 ± 2.4 (28)	- 26
25	3	8.6 ± 1.5 (45)	5.9 ± 0.9 (44)	4.7 ± 1.5 (41)	- 45
25	4	1.5 ± 0.8 (43)	1.2 ± 0.6 (33)	1.4 ± 0.5 (40)	- 7

Table 3. Pre- and post-fishery (in parenthesis) sex ratio for lobster in the Lobster Fishing Area 25. NS = not significant.

Zone North	Males	Females	M:F
2001	1734	1898	0.914
2002	808	778	1.039
2003	368	330	1.115
	Between year χ^2 = 8.490, df = 2, P = 0.014		

Zone South	Males	Females	M:F
2001	551	672	0.820 (0.883)
2002	316	384	0.823 (0.800)
2003	298	354	0.841 (0786)
	Between year χ^2 = 0.080, df = 2, NS (also NS)		

Table 4. Average (SE in parentheses) standardized (number per 2000 m tow = 1.8 ha) catches of canner and market size lobster in pre-and post-fishery surveys in central Northumberland Strait, 2001 – 2003.

Year	Survey	Canner	Market	Number of tows
2001	Pre-fishery	13.60 (1.604)	11.20 (1.296)	45
2001	Post fishery	2.03 (0.559)	2.65 (0.443)	30
2002	Pre-fishery	9.20 (1.116)	5.70 (0.709)	44
2002	Post fishery	3.06 (0.563)	2.575 (0.456)	66
2003	Pre-fishery	7.29 (1.044)	7.49 (0.978)	49
2003	Post fishery	3.44 (0.579)	3.83 (0.502)	60

Table 5. Fisheries-independent estimates of exploitation rate (as a percentage) of lobster in central Northumberland Strait, 2001-2003. Medians and quartiles were derived from 1,000 iterations randomly re-sampling (bootstrapping) for both the pre- and post fishery surveys.

Year	Size	Median	Lower 25%	Upper 25%
2001	Canner	75.8	72.2	79.1
2001	Market	68.4	63.8	72.4
2002	Canner	66.2	58.9	65.7
2002	Market	52.0	46.2	56.5
2003	Canner	57.8	51.2	63.5
2003	Market	51.8	45.3	56.9

Table 6. Diets (as % biomass) of lobster in the Lobster Fishing Area 25, 2001 – 2003. CL=carapace length in mm.

	Size-classes (CL)			
Prey taxon	**< 50**	**50 - 67.5**	**68 - 80**	**> 80**
Shrimp	0.177	0.655	0.793	0.083
Hermit crab	2.360	0.650	1.941	0.422
Rock crab remains	41.798	43.081	44.425	61.295
Rock crab old carapace	9.773	15.906	16.861	10.911
Lady crab	3.211	1.933	2.079	4.138
Lobster old carapace	0.128	2.184	3.264	7.356
Lobster remains	0.000	3.852	4.670	2.869
Polychaete	5.623	4.646	2.268	1.437
Bivalves	3.829	2.956	3.835	2.098
Gastropods	2.517	2.020	0.802	0.349
Sea star	10.749	8.398	8.498	3.890
Sand dollar	0.000	0.197	0.180	0.000
Sea urchin	0.020	0.171	0.001	0.000
Tunicates	2.866	2.151	1.341	0.000
Sponges	3.612	0.291	0.396	0.258
Fish remains	5.876	4.239	4.657	3.228
Other animal prey	0.048	0.891	0.192	0.109
Detritus	6.125	3.780	1.347	0.343
Plant material	1.288	2.001	2.127	1.205
Number of stomachs	88	724	549	231
% empty	4.54	6.63	5.46	6.5

Table 7. Numbers of fish and large crustacean stomachs analyzed for diet in the Lobster Fishing Area 25 or adjacent waters.

Species	**Number examined**	**Number empty**
Longhorn sculpin	750	129
Shorthorn sculpin*	70	11
Cunner	752	23
Winter skate*	183	5
American plaice	262	74
Windowpane flounder*	114	8
Yellowtail flounder	238	37
Winter flounder	829	63
Rainbow smelt	2339	709
Atlantic herring	628	27
Alewife	504	14
American shad	378	2
Atlantic mackerel	360	15
Lady crab	986	350
Rock crab	226	77
American lobster*	1592	97

* samples from 2003 remain to be processed

Table 8. Number of lobsters measured per Statistical District during the August at-sea sampling.

Year	Statistical Districts						
	45	75	76	78	80	82	83
1982		945			1566	1796	1358
1983	2893	480			1414	569	1044
1984	9332	3149	2676	1401		2713	1741
1985	646		3302	5660		6537	4456
1986	843	838	551	879			
1987	1481	437			522		1009
1988	1431	835			474		1217
1989	1618	1359			512		578
1990	1254	1729	1338		2046	7399	2346
1991	550	1537	806		1357	4648	2742
1992	556	1085			1286	7285	4313
1993		1167	592		1349	2803	1344
1994		682					
1995		835			828	1493	1521
1996		571				997	467
1997	578	700			421	514	764
1998	648	747				4898	2873
1999	1443	1856			1358	5567	2923
2000	750	1741			618	8041	2699
2001				2546			
2002						3516	640
2003						5296	975

Table 9. Number of fishermen per Statistical District participating in the recruitment-index program in the Lobster Fishing Area 25 from 1999 to 2003.

Statistical District	1999		2000		2001		2002		2003	
	No Fishermen	No. Lobsters measured	No Fishermen	No. Lobsters measured	No Fishermen	No. Lobsters measured	No Fishermen	No. Lobsters measured	No Fishermen	No. Lobsters measured
45	4	563	3	480						
75	3	3452	3	3052						
76	2	1022		1587						
77	2	1358	4	1874						
78	3	499	2	521	6	1324	4	762	4	564
80	2	302	2	562	4	961	4	786	4	522
82	3	1660	8	4792	14	10189	15	8756	14	7310
83	5	708	2	528	3	691	3	729	4	737
Total	24	9564	24	13396	27	13165	26	11033	26	9133

Table 10. Summary of trends for different indicators used to assess the lobster stock status in LFA 25, sub-area 25 North (statistical district [SD] 75, 76, 77, 82) and sub-area 25 South (SD 45, 78, 80, 83). ↑ the trend observed indicates that the stock is impacted positively; → indicates that there is no trend (variable) or the impact on the stock is not detected (uncertainty); ↓ the trend observed indicates that the stock is impacted negatively.

Indicator	**25 All**	**25 N**	**25 S**	**SD 75**	**SD 76**	**SD 77**	**SD 82**	**SD 78**	**SD 80**	**SD 45**	**SD 83**
Trawl Survey											
Spatial distribution											
Pre-recruit	↓										
Canner	↓										
Market	↓										
Abundance index											
Pre-recruit	↓										
Canner	↓										
Market	↓										
Fishery parameter											
Exploitation rate			↓								
Ecosystem											
Predator-prey	→										
Bottom temperature	→										
Fishery-based data											
Landings											
55-yr average vs. 2002	→										
35-yr average vs. 2002	↓			↑	→	↓	↑	↓	↓	↓	↓
20-yr average vs. 2002	↓			↓	↓	↓	↓	↓	↓	↓	↓
10-yr average vs. 2002	↓			→	↓	↓	↓	↓	↓	↓	→
2001 vs. 2002	↓			→	↓	→	→	↓	↓	↓	→
Cumulative catch	↓			↓	↓	↓	↓	↓	↓	↓	↓
Pre-recruit											
At-sea catch rate	↓			↓	↓	↓	↓	↓	↓	↓	↓
Recruit-index catch rate	↓			↓	↓	↓	↓	↓	↓	↓	↓
Canner											
At-sea catch rate	↓			↓	↓	↓	↓	↓	↓	↓	↓
Recruit-index catch rate	↓			↓	↓	↓	↓	↓	↓	↓	↓
Index-fisher catch rate	↓			↓	↓	↓	↓	↓	↓	↓	↓
Market											
At-sea catch rate	↓			↓	↓	↓	↓	↓	↓	↓	↓
Recruit-index catch rate	↓			↓	↓	↓	↓	↓	↓	↓	↓
Index-fisher catch rate	↓			↓	↓	↓	↓	↓	↓	↓	↓
Biological											
Female reproductive condition	↓	↓	↓								
Fishing effort											
% of 1st molt group in landings	↓			↓	↓	↓	↓	↓	↓	↓	↓
Cumulative trap haul	↓			↓	↓	↓	↓	↓	↓	↓	↓
Empty traps	↓			↓	↓	↓	↓	↓	↓	↓	↓
Trap efficiency-Trap size	↓										
Ecosystem											
Bottom temperature	→	→	→								
Accumulated degree-day	→	→	→								

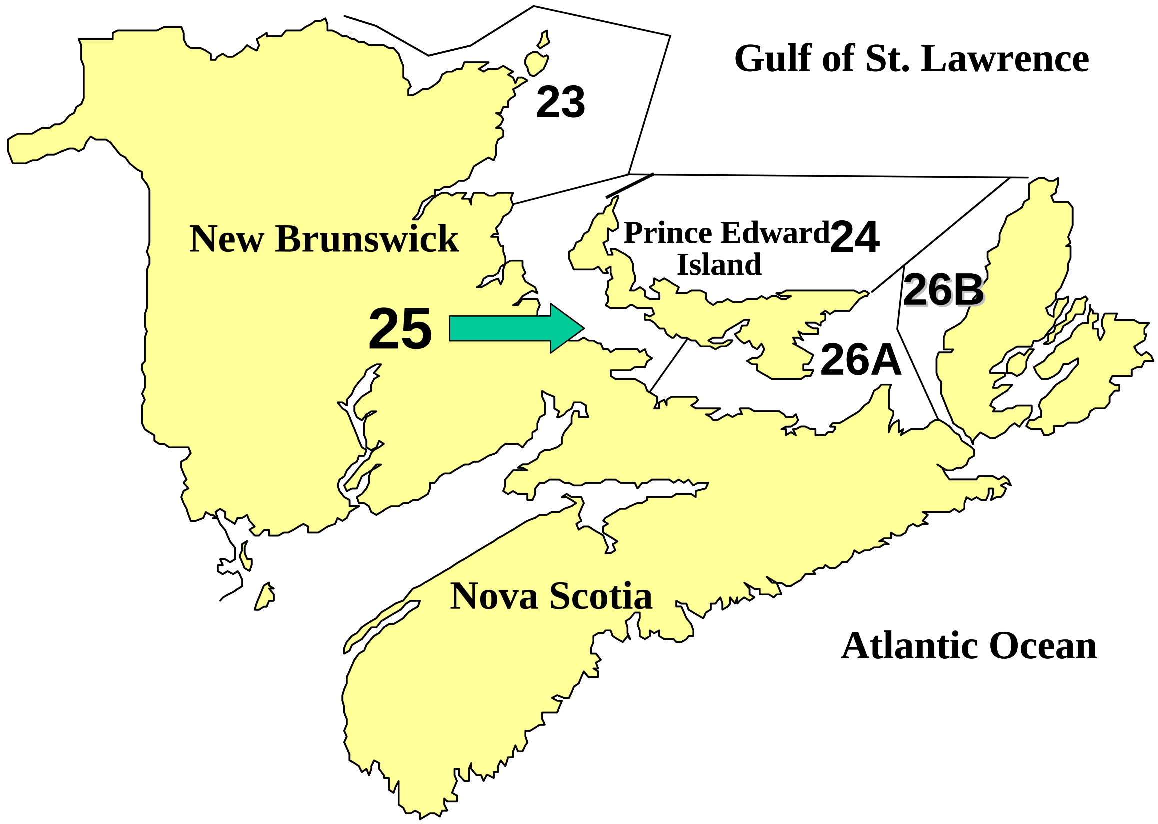


Figure 1. Lobster Fishing Areas in the southern Gulf of St. Lawrence (DFO, Gulf Region).

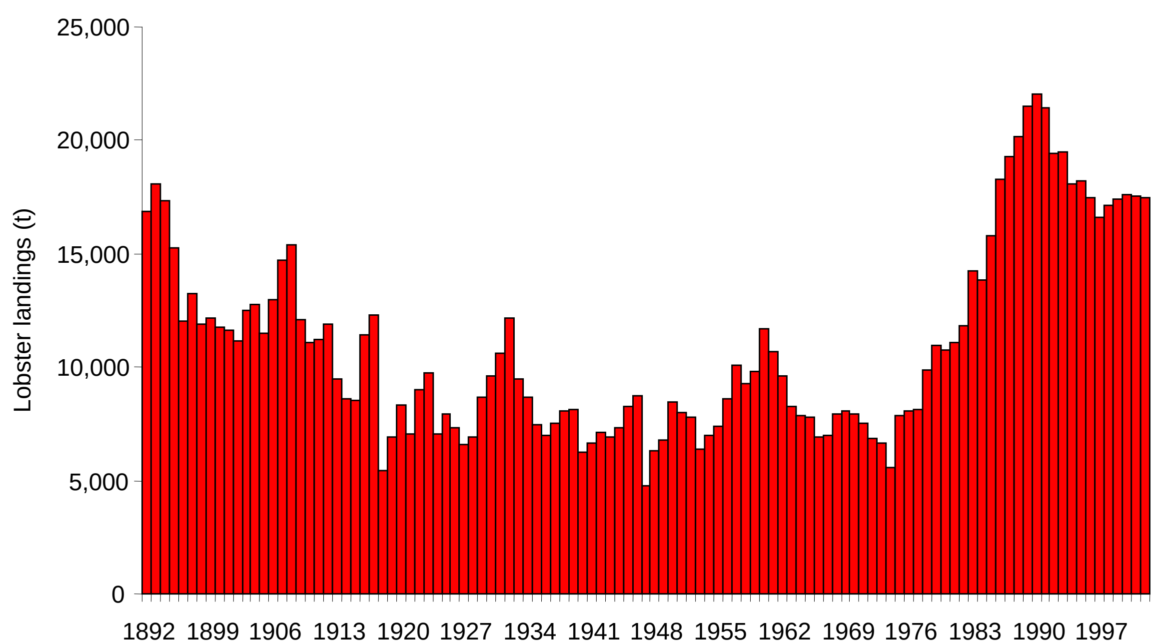


Figure 2. Historical lobster landings in the southern Gulf of St. Lawrence (DFO, Gulf Region) from 1892 to 2002.

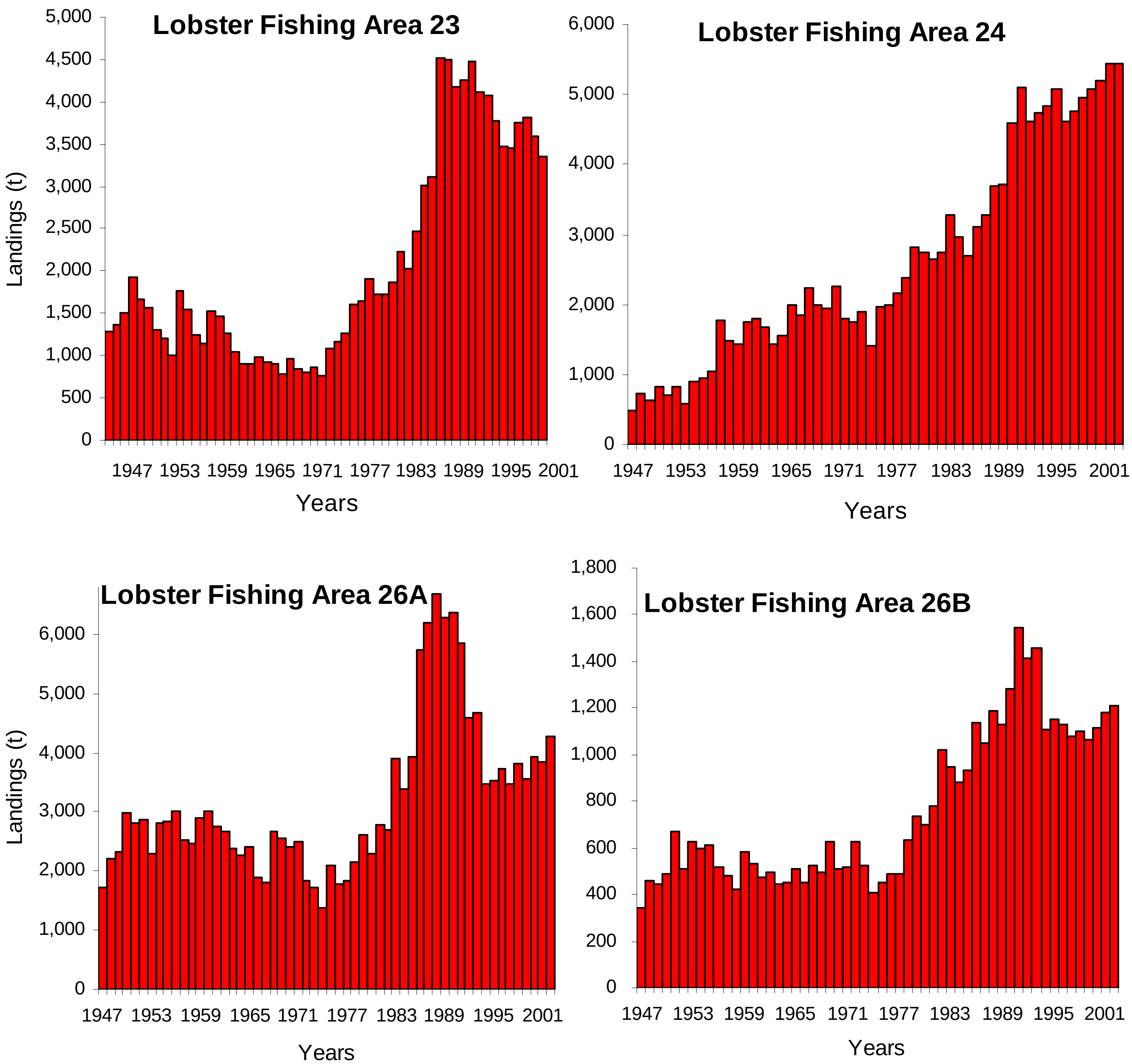


Figure 3. Historical lobster landings in Lobster Fishing Areas 23, 24, 26A and 26B between 1947 and 2002.

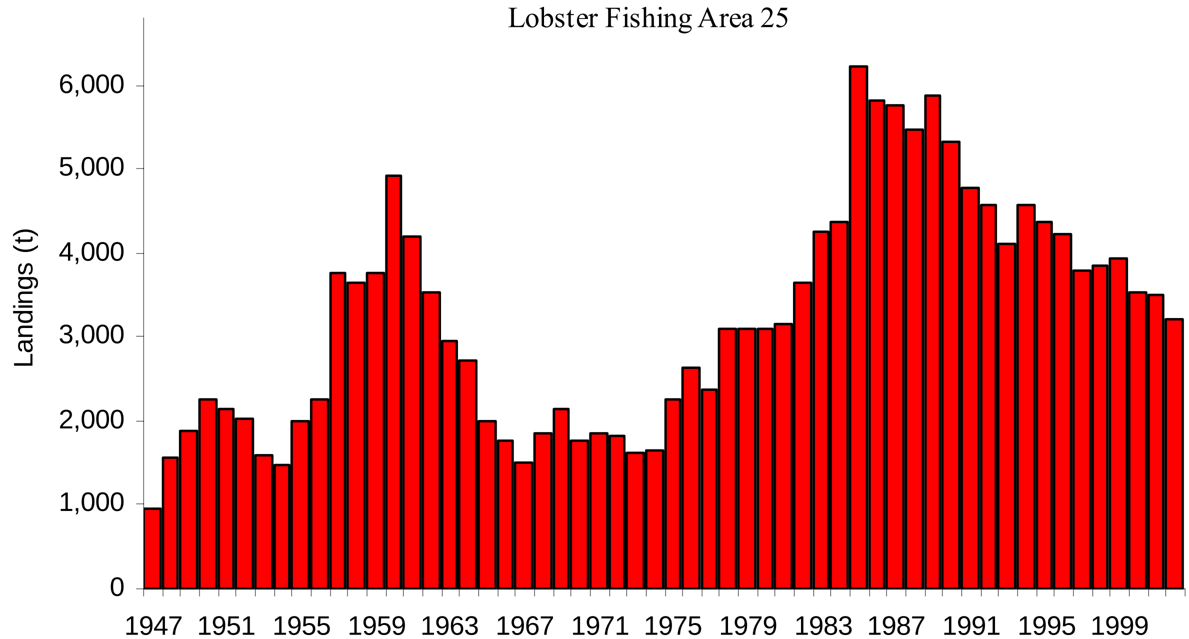


Figure 4. Lobster landings in the Lobster Fishing Area 25 from 1947 to 2002.

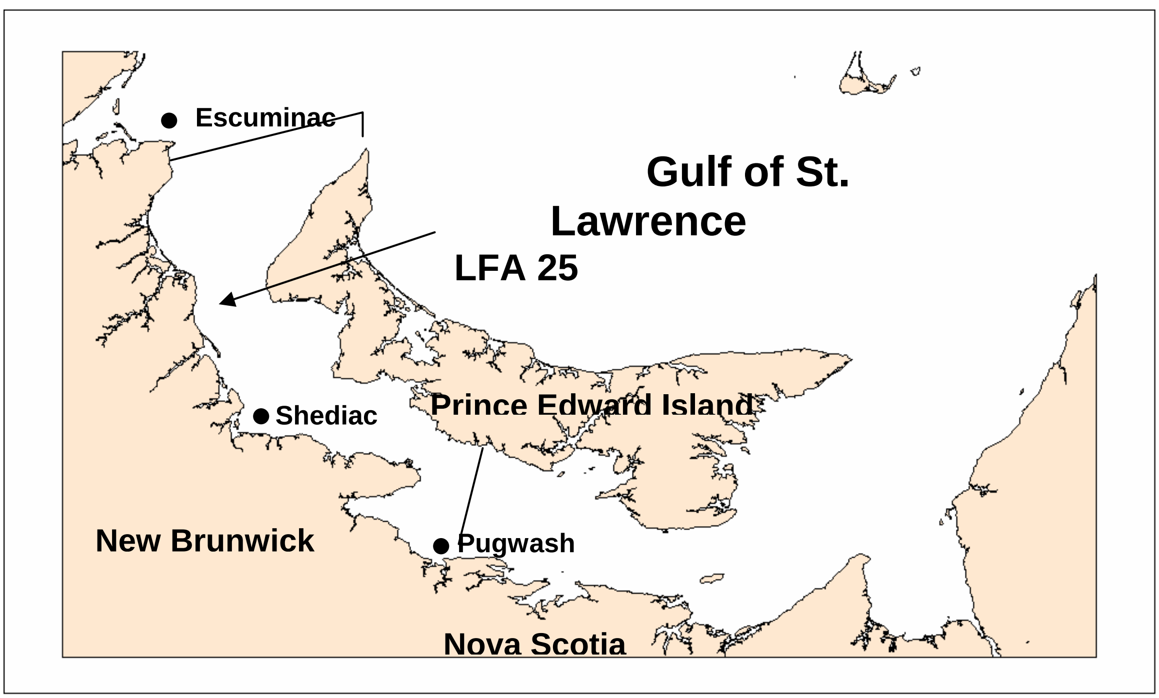


Figure 5. Locations of the bottom temperature monitoring sites within and adjacent to the Lobster Fishing Area 25.

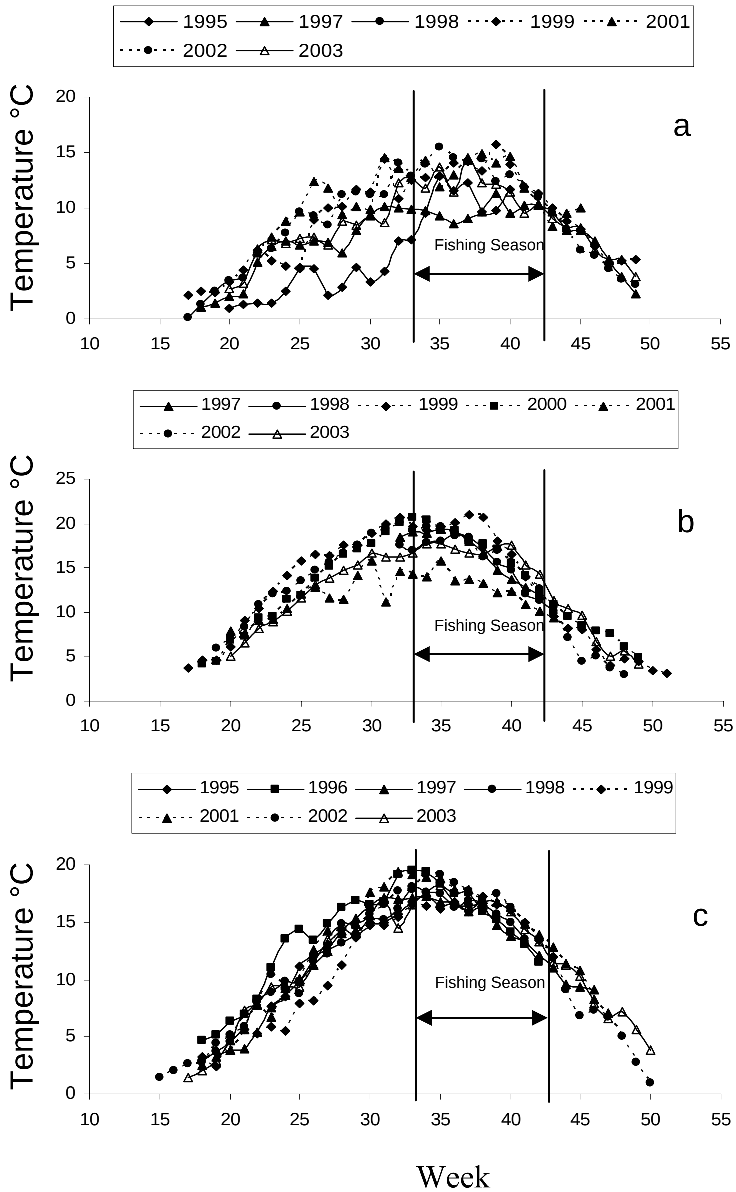


Figure 6. Weekly bottom temperature profiles for a) Escuminac, b) Shediac, and c) Pugwash.

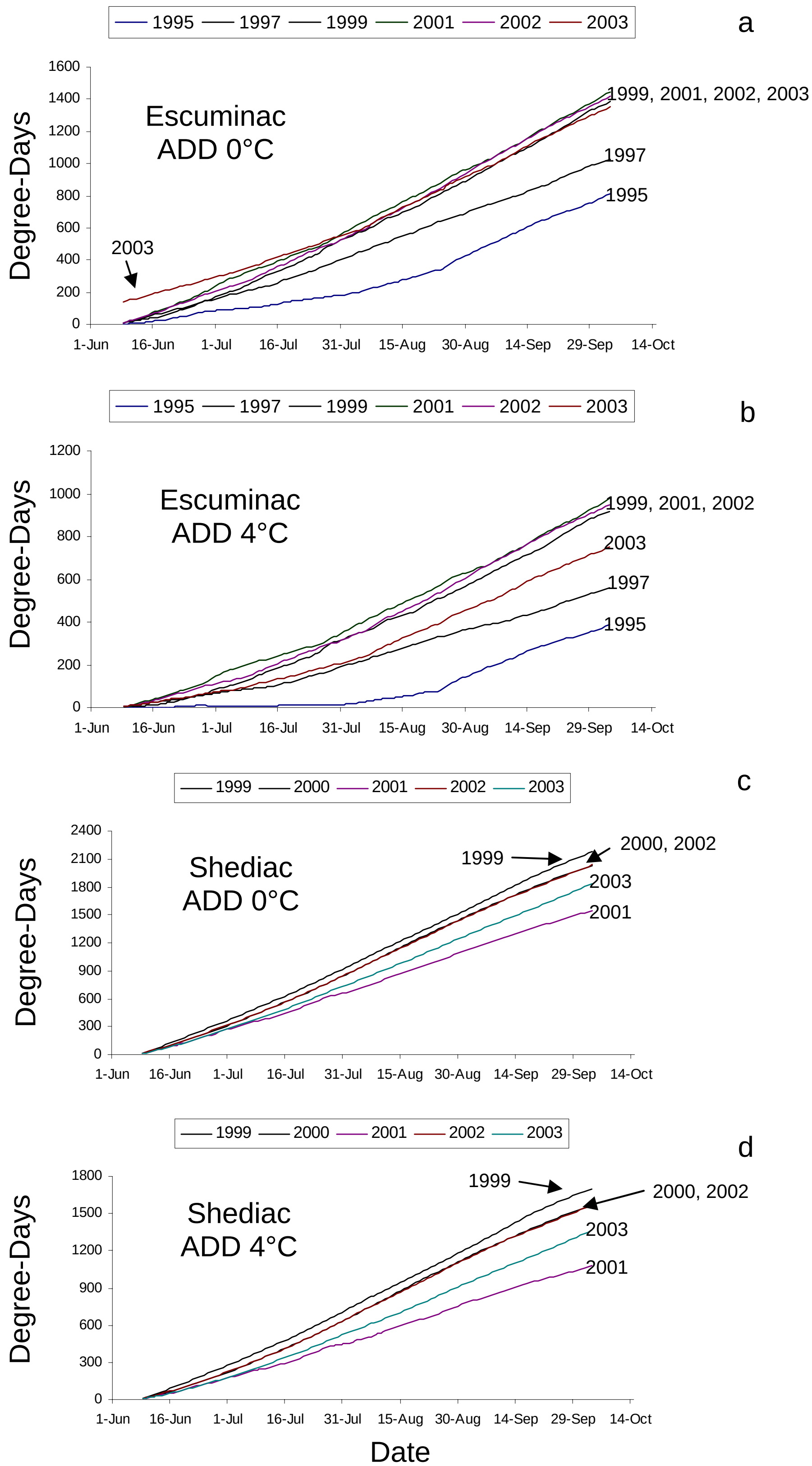


Figure 7. Accumulated degree days (ADD) at 0°C and 4°C for Escuminac (a,b), Shediac (c,d), and Pugwash (e,f).

e

f

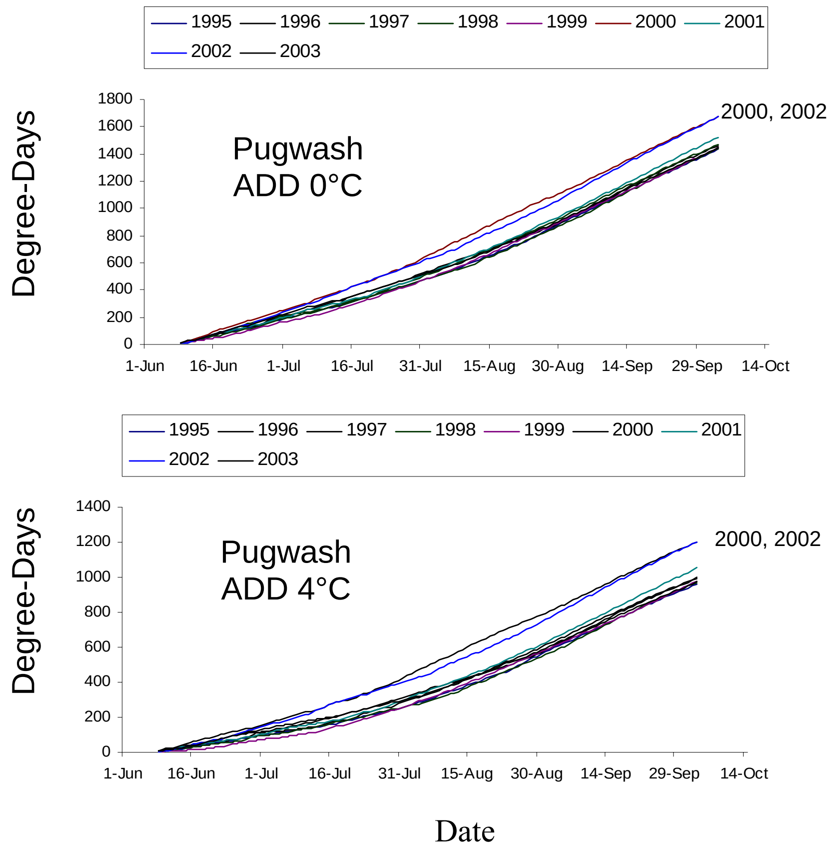


Figure 7. cont.

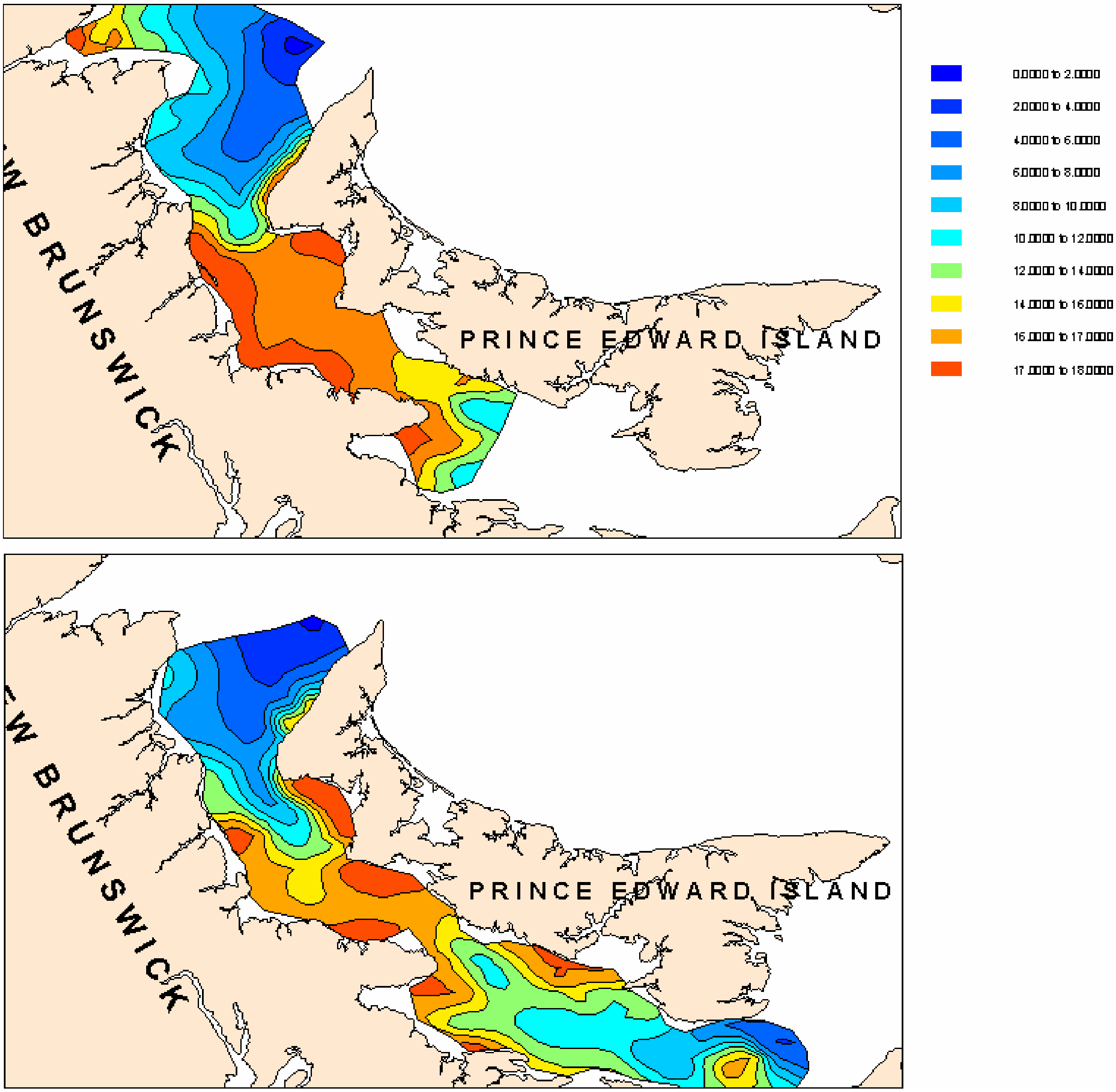


Figure 8. Bottom temperature (°C) contours of Northumberland Strait during pre-fishery surveys in 2002 (upper panel) and 2003 (lower panel).

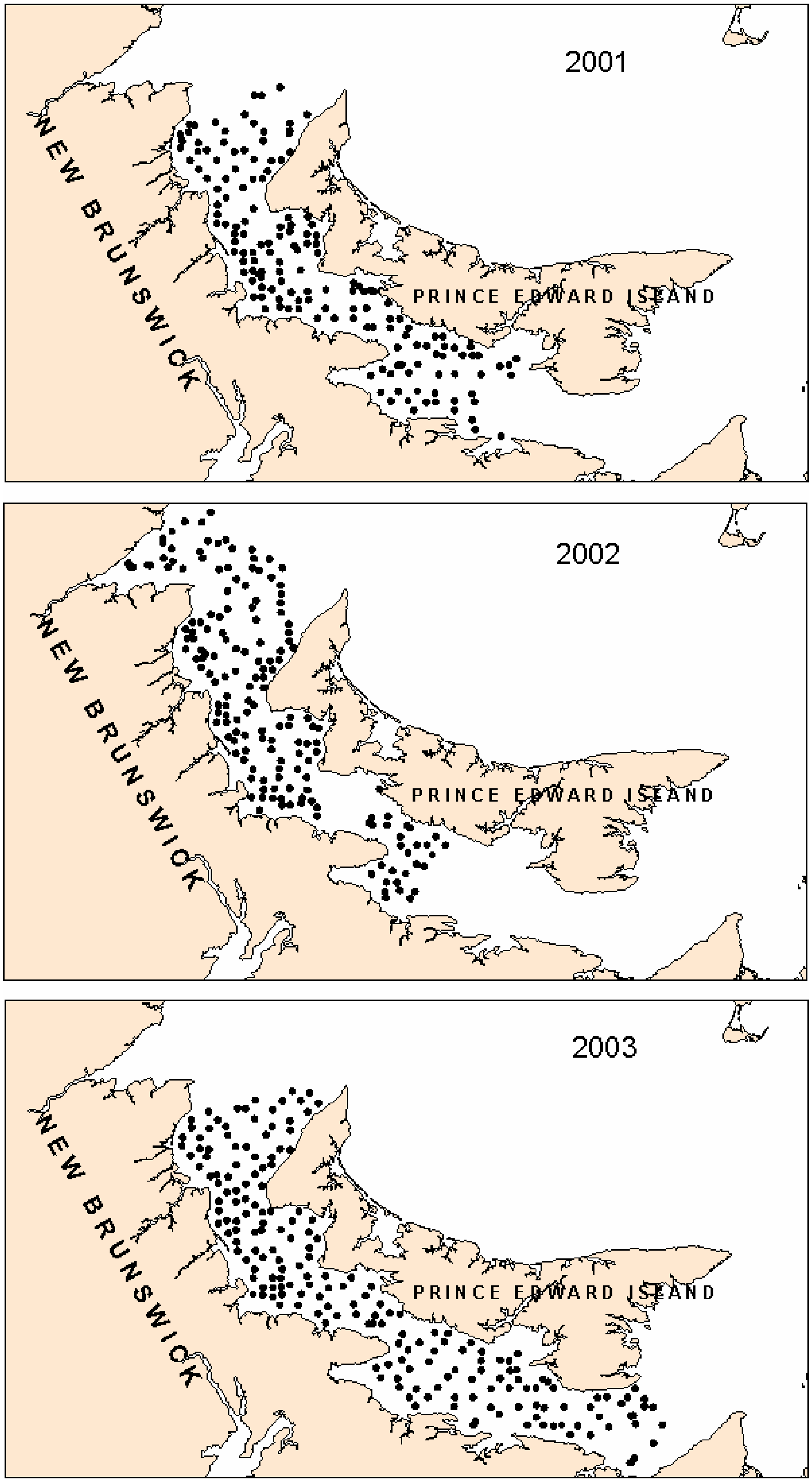


Figure 9. Stations fished during pre-fishery surveys of the Lobster Fishing Area 25, and adjacent waters, 2001-2003.

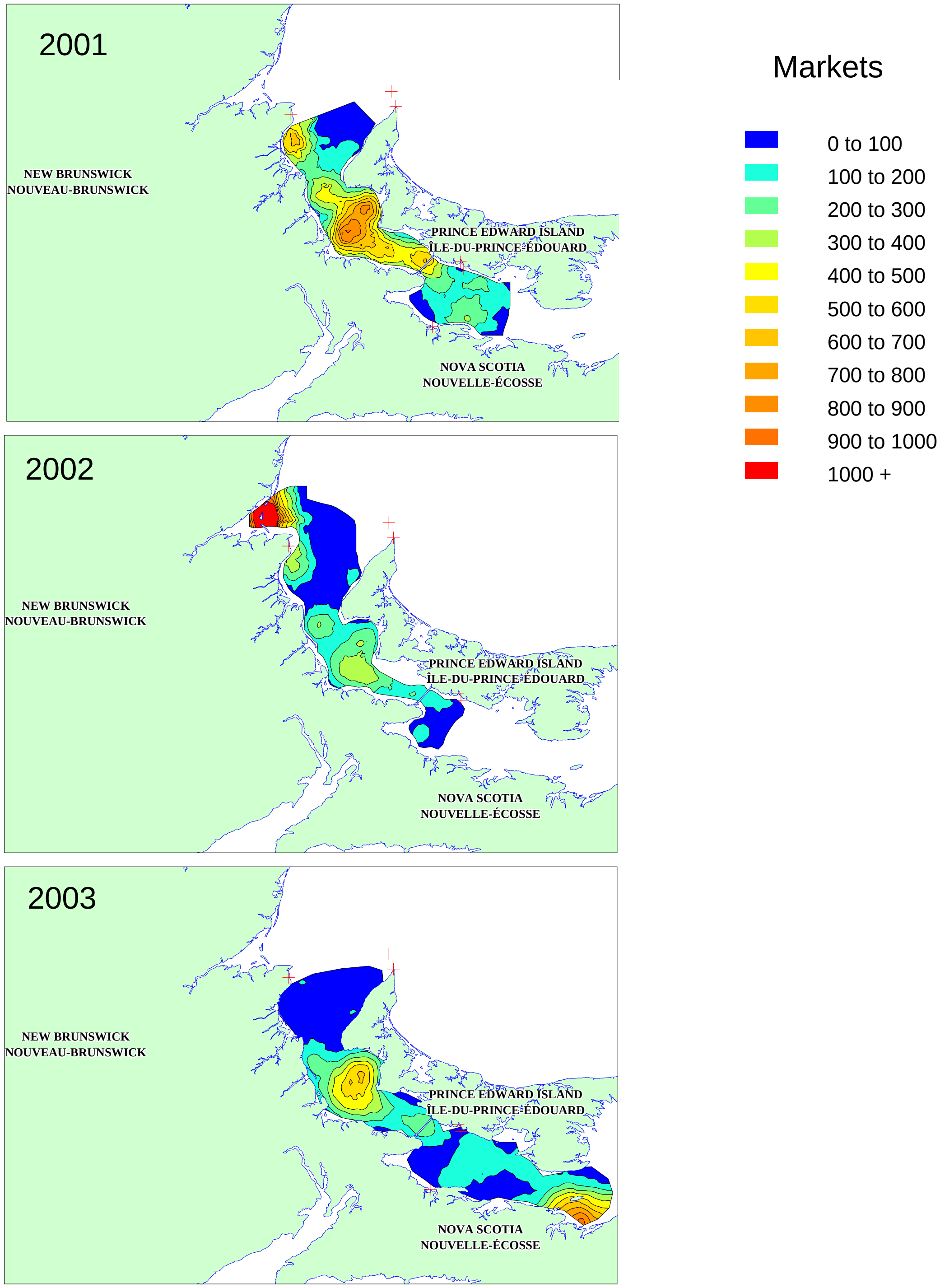


Figure 10. Distribution of market (> 80 mm CL) size lobster during pre-fishery surveys of the Lobster Fishing Area 25 and adjacent waters, 2001-2003.

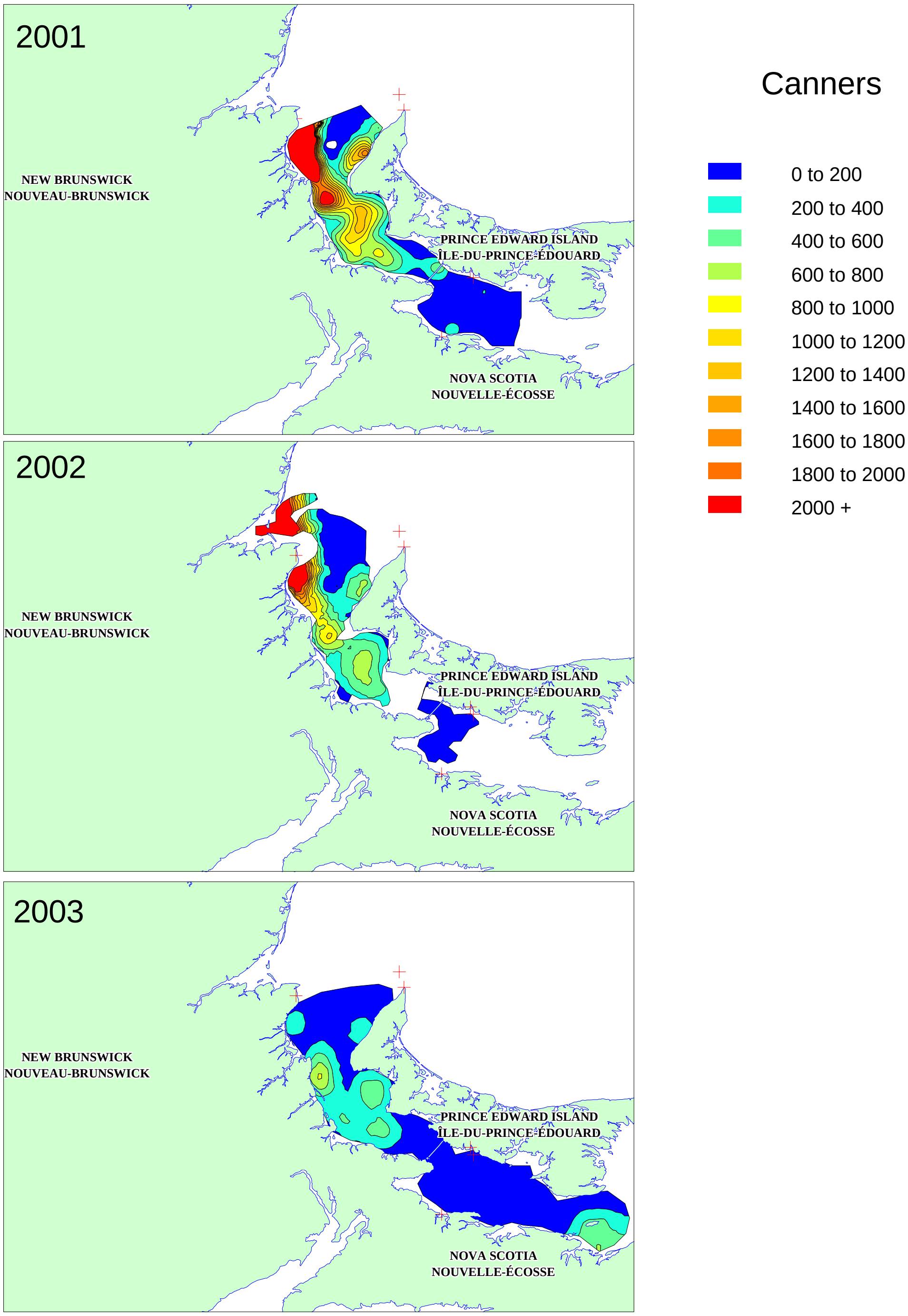


Figure 11. Distribution of canner (> 67.5 mm CL in 2001, 2002; >68.5 mm CL in 2003) size lobster during pre-fishery surveys of the Lobster Fishing Area 25 and adjacent waters, 2001-2003.

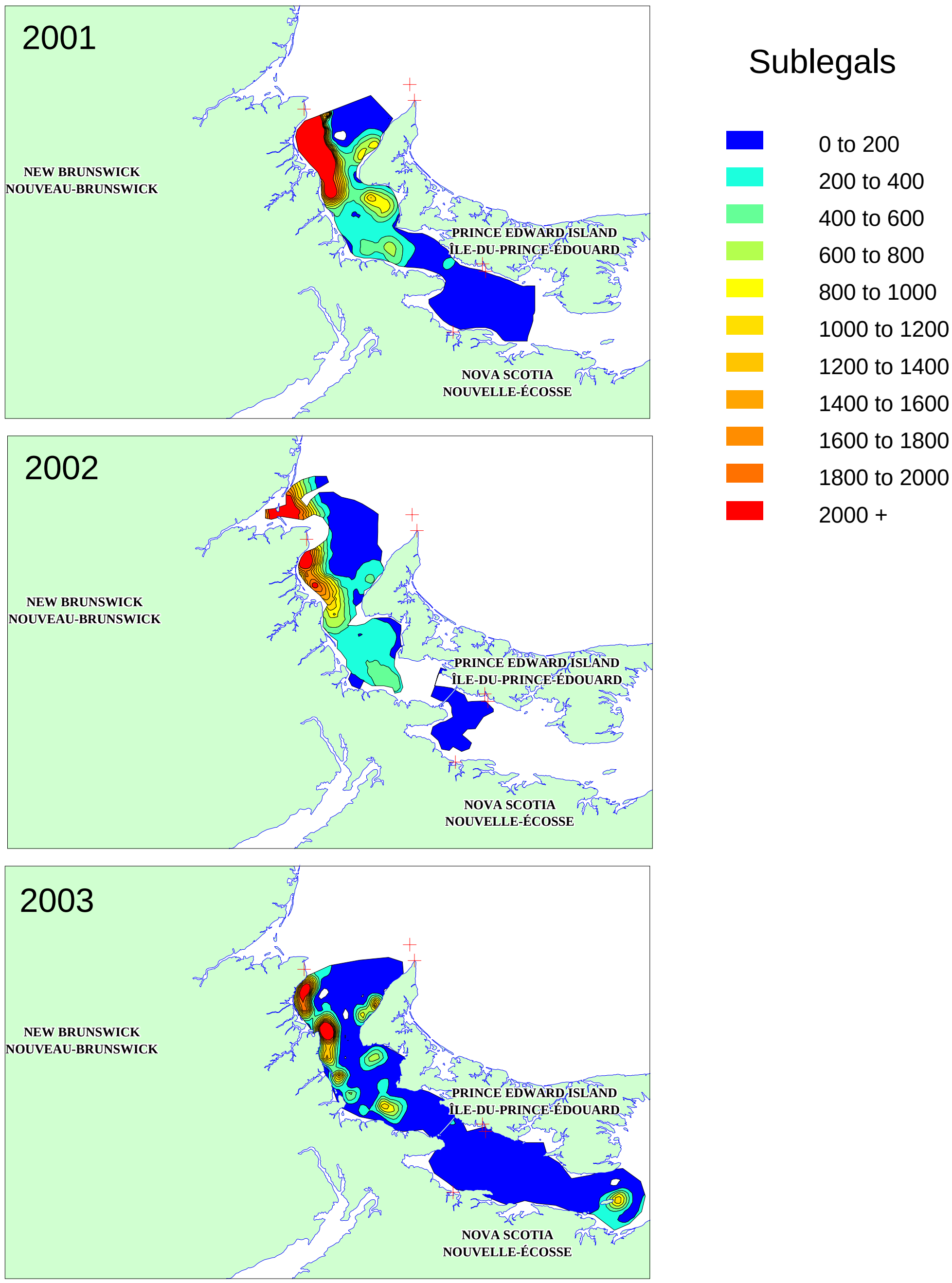


Figure 12. Distribution of sub-legal (< 67.5 mm CL) size lobster during pre-fishery surveys of the Lobster Fishing Area 25 and adjacent waters, 2001-2003.

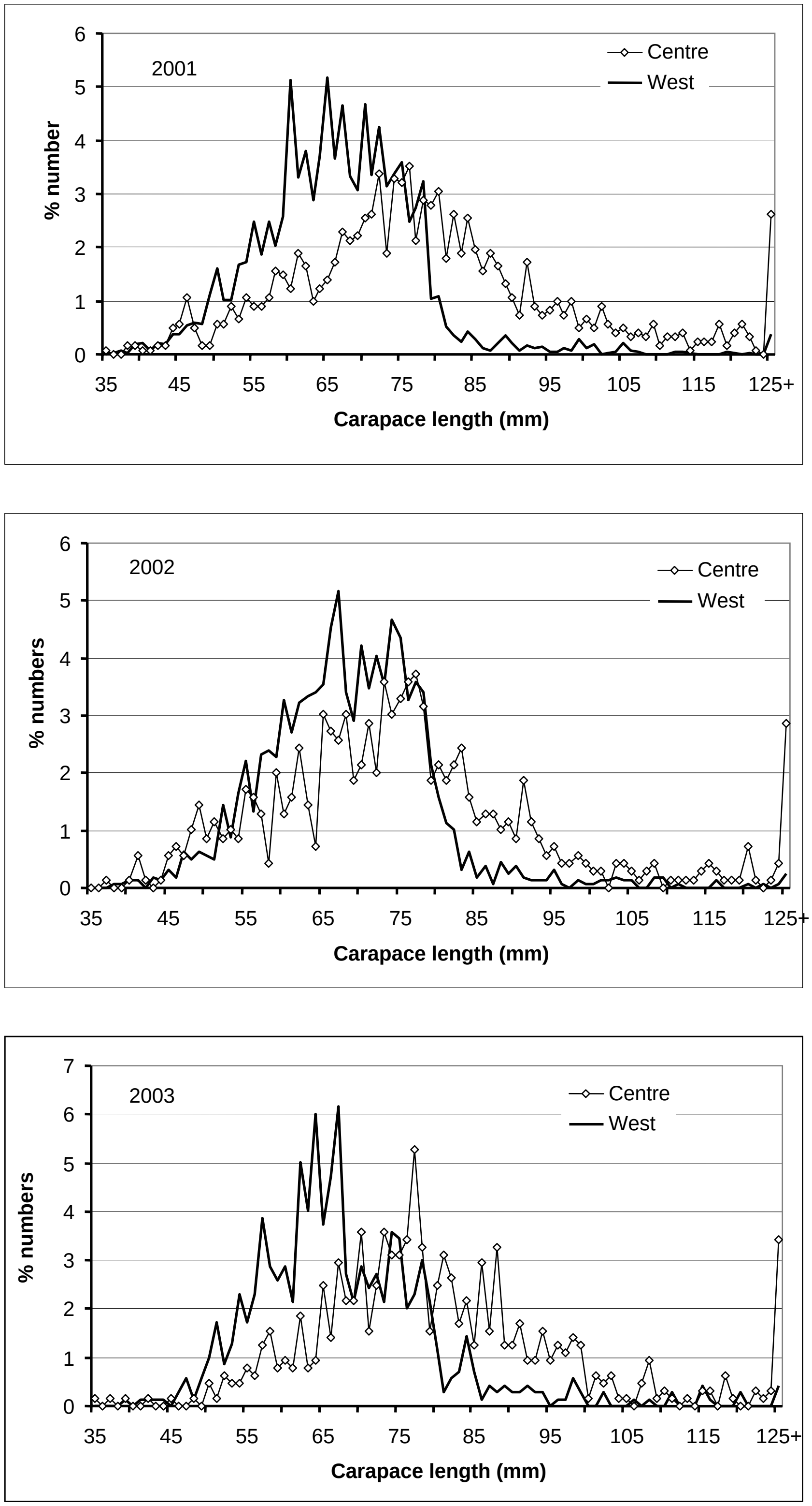


Figure 13. Size frequency distributions of lobster during summer surveys in the Lobster Fishing Area 25.

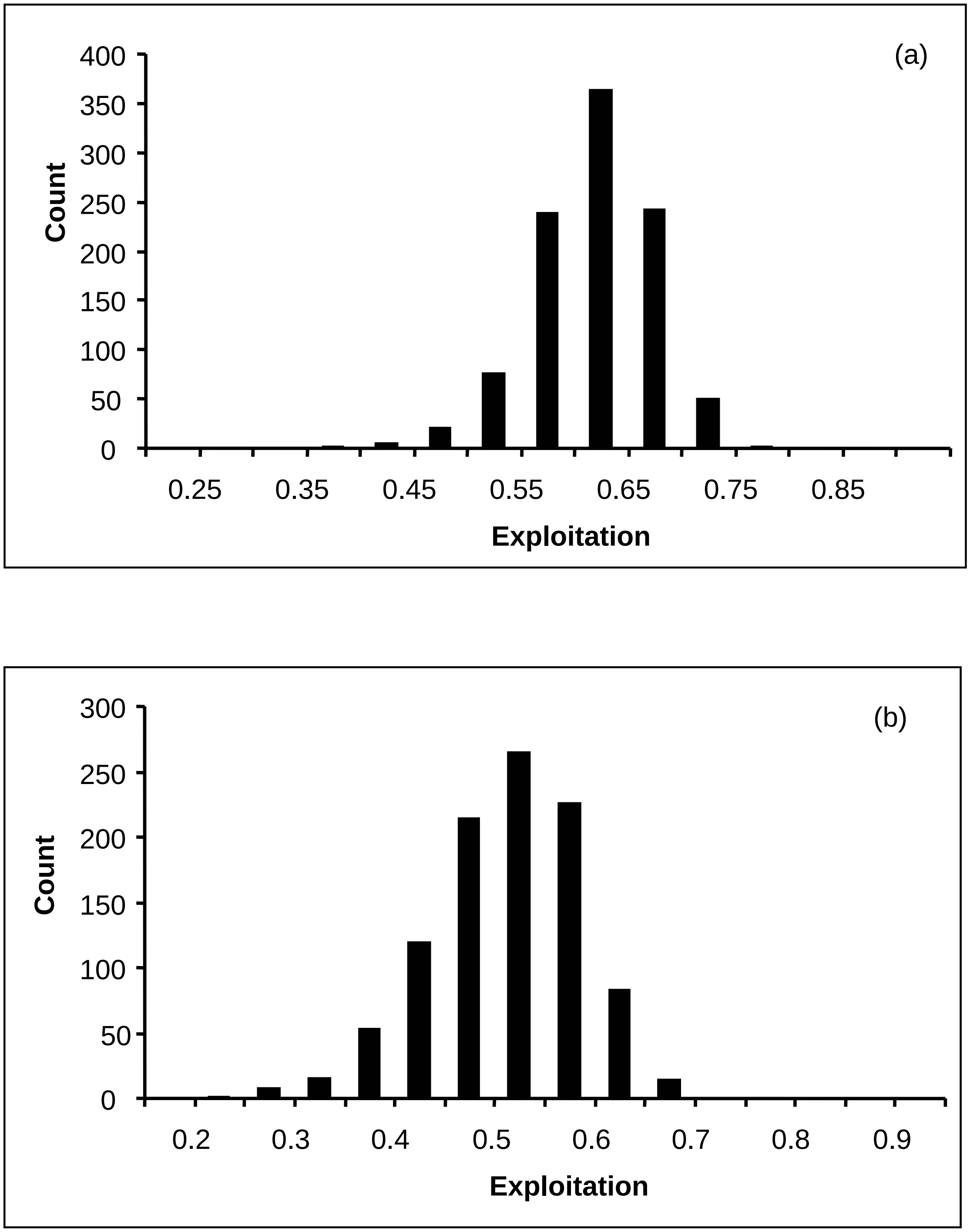


Figure 14. Distribution of 1,000 estimates of exploitation of (a) canner- and (b) market-size lobster in central Northumberland Strait in 2002.

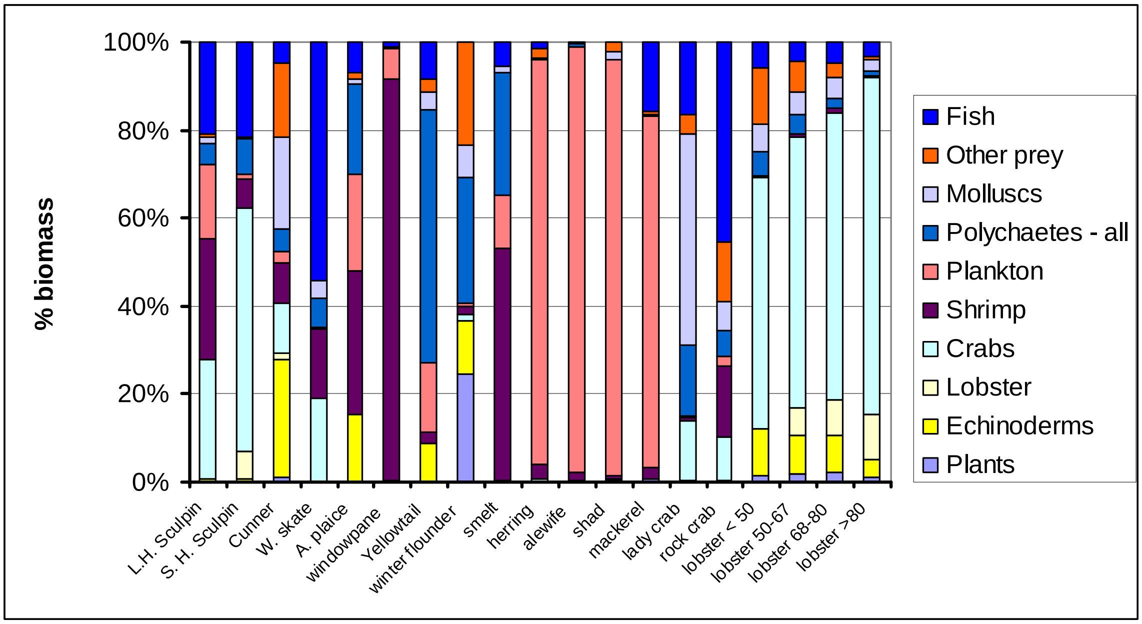
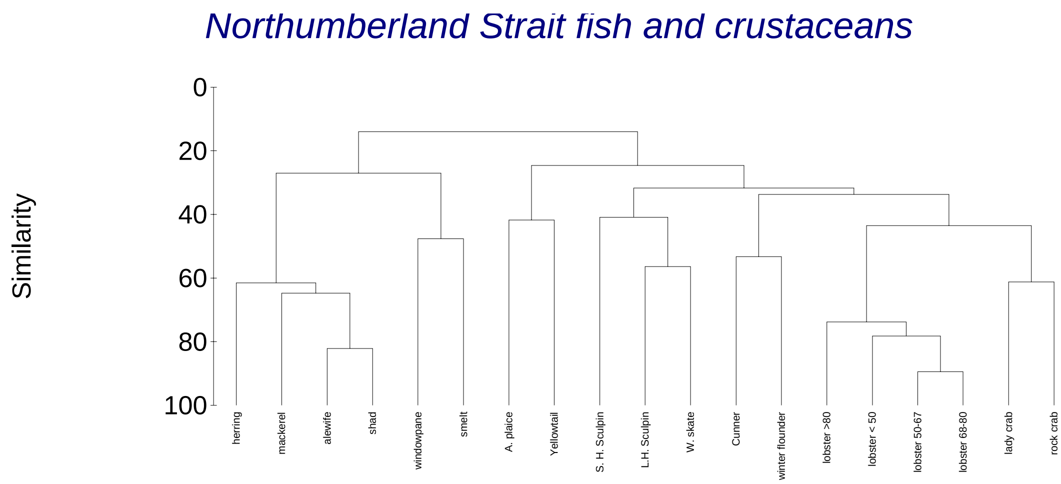


Figure 15. Diets of principal pelagic and demersal fishes, and large crustaceans, in the Lobster Fishing Area 25, 2000-2003.



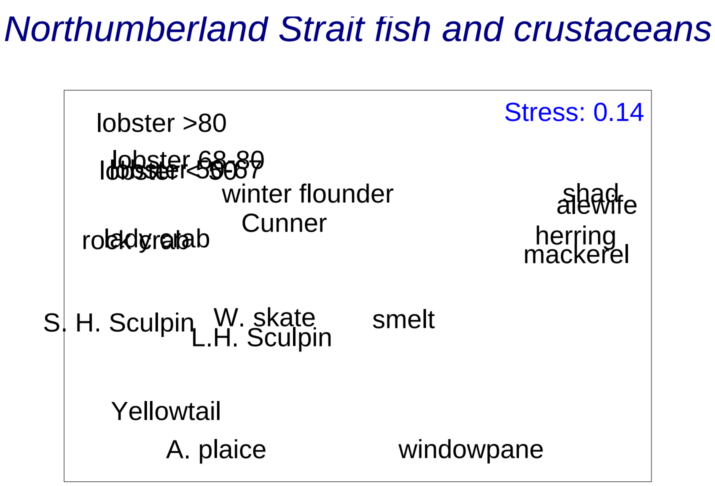


Figure 16. Cluster-analysis of diets of fishes and large crustaceans from the Lobster Fishing Area 25. The upper panel is a dendrogram derived using the Bray-Curtis Similarity measure. The lower panel shows the same information using Multi-Dimensional Scaling.

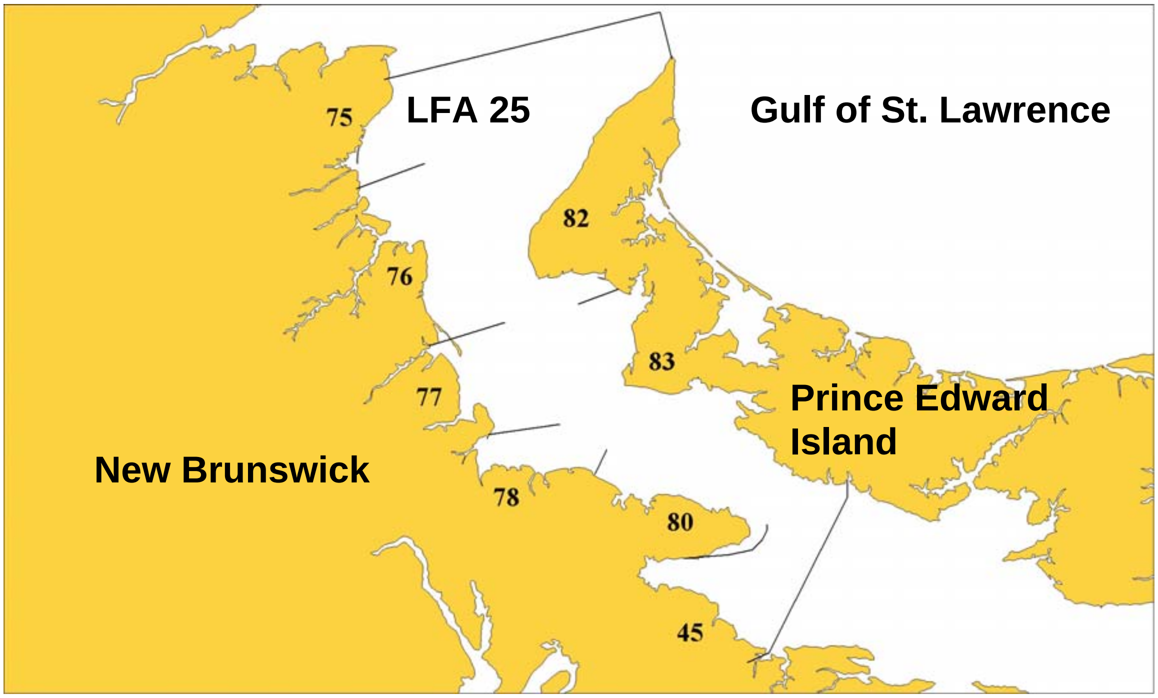


Figure 17. Statistical Districts located in the Lobster Fishing Area (LFA) 25.

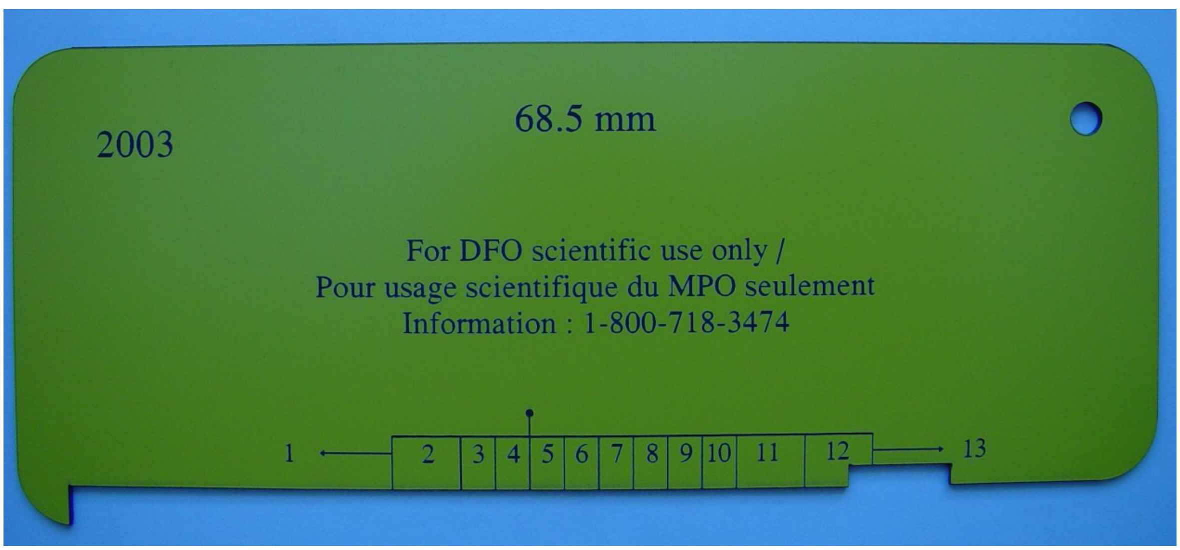


Figure 18. Gauge used by fishermen participating in the recruitment-index program. Size class 5 was adjusted to the minimum legal size each year. Size classes 3 to 10 are 5-mm size classes while size classes 2, 11 and 12 are 10-mm wide.

Figure 19. One of the two trap types used in the trap efficiency study carried out in Anse-Bleue in 2000. The trap presented is the large trap (107 cm L x 56 cm W x 38 cm H) with one parlor, four entrances and two bait pins. The smaller traps (89 cm L x 56 cm W x 38 cm H) were shorter and had two entrances and one bait pin.

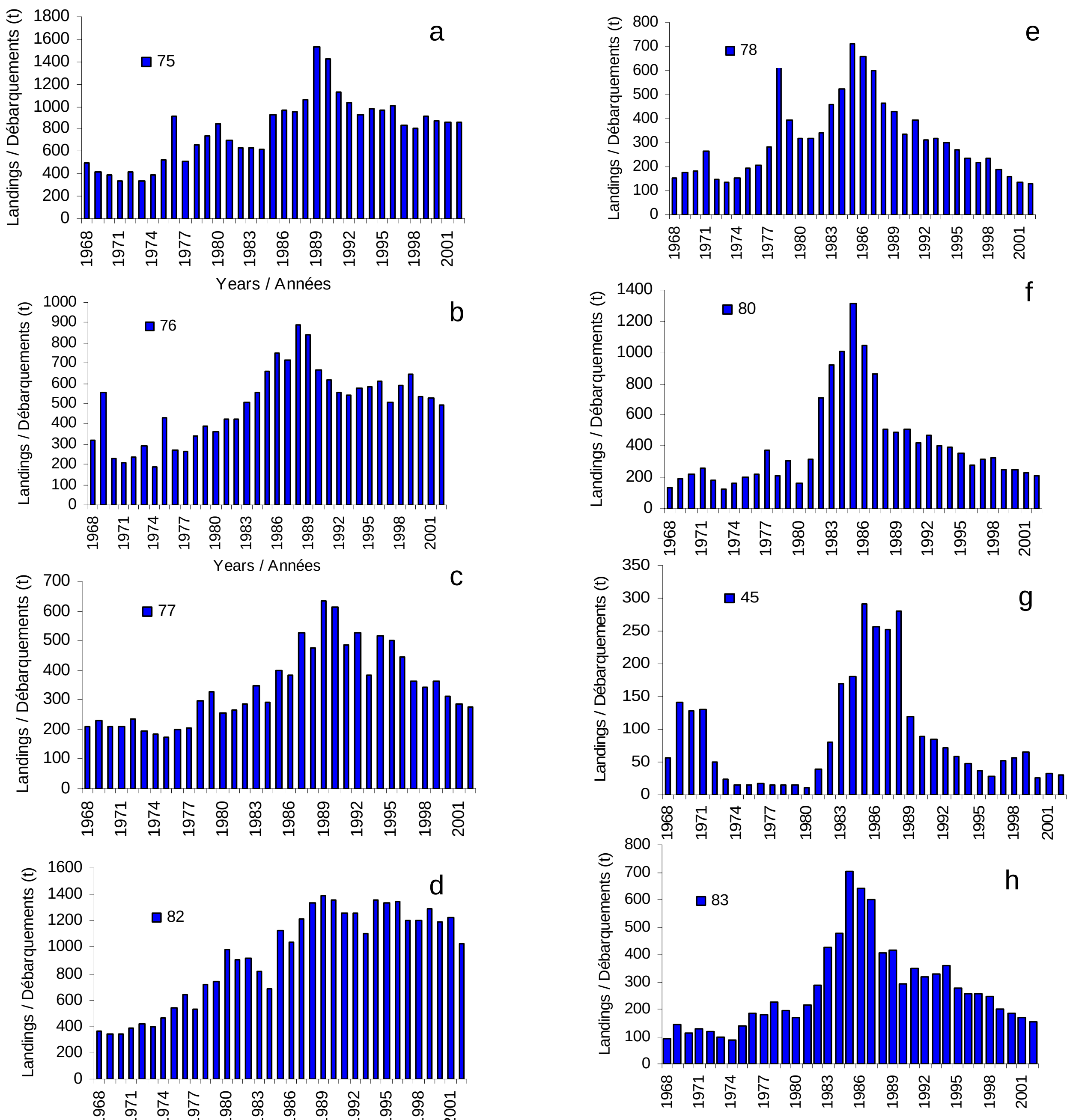


Figure 20. Lobster commercial catches in each Statistical District (SD) of Lobster Fishing Area (LFA) 25 between 1968 and 2002. SD 75 (a), 76 (b), 77 (c), and 82 (d) represent the northern portion, and SD 78 (e), 80 (f), 45 (g), and 83 (h) represent the southern portion of the LFA.

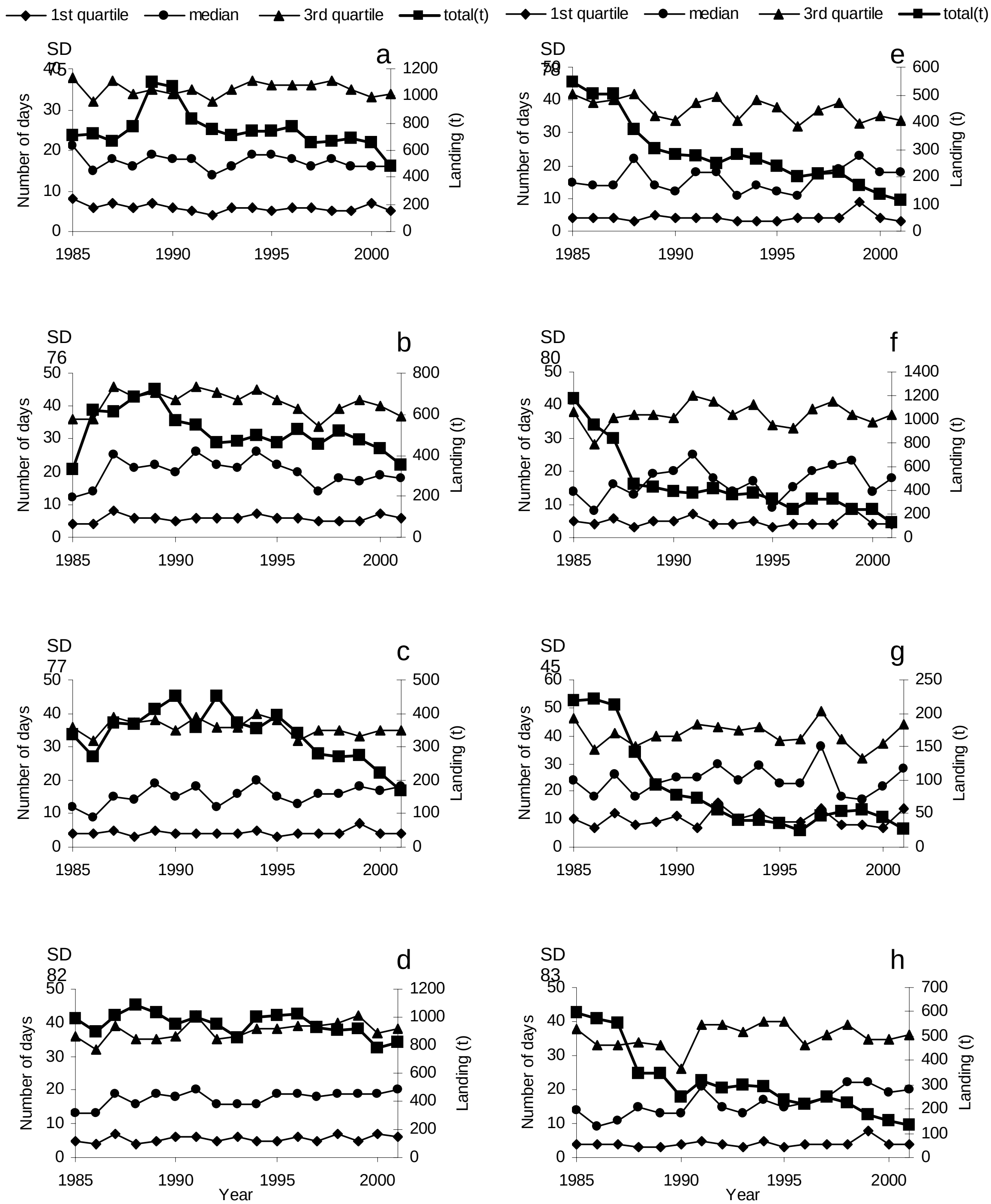


Figure 21. The number of fishing days required to reach 25% (1st quartile), 50% (median) and 75% (3rd quartile) of the cumulative catch in each Statistical District (SD) of Lobster Fishing Area (LFA) 25 between 1985 and 2001. SD 75 (a), 76 (b), 77 (c), and 82 (d) represent the northern portion, and SD 78 (e), 80 (f), 45 (g) and 83 (h) represent the southern portion of the LFA. The total landing of the SD is also represented (bold line with squares). Catch data were taken from DFO Statistical Branch.

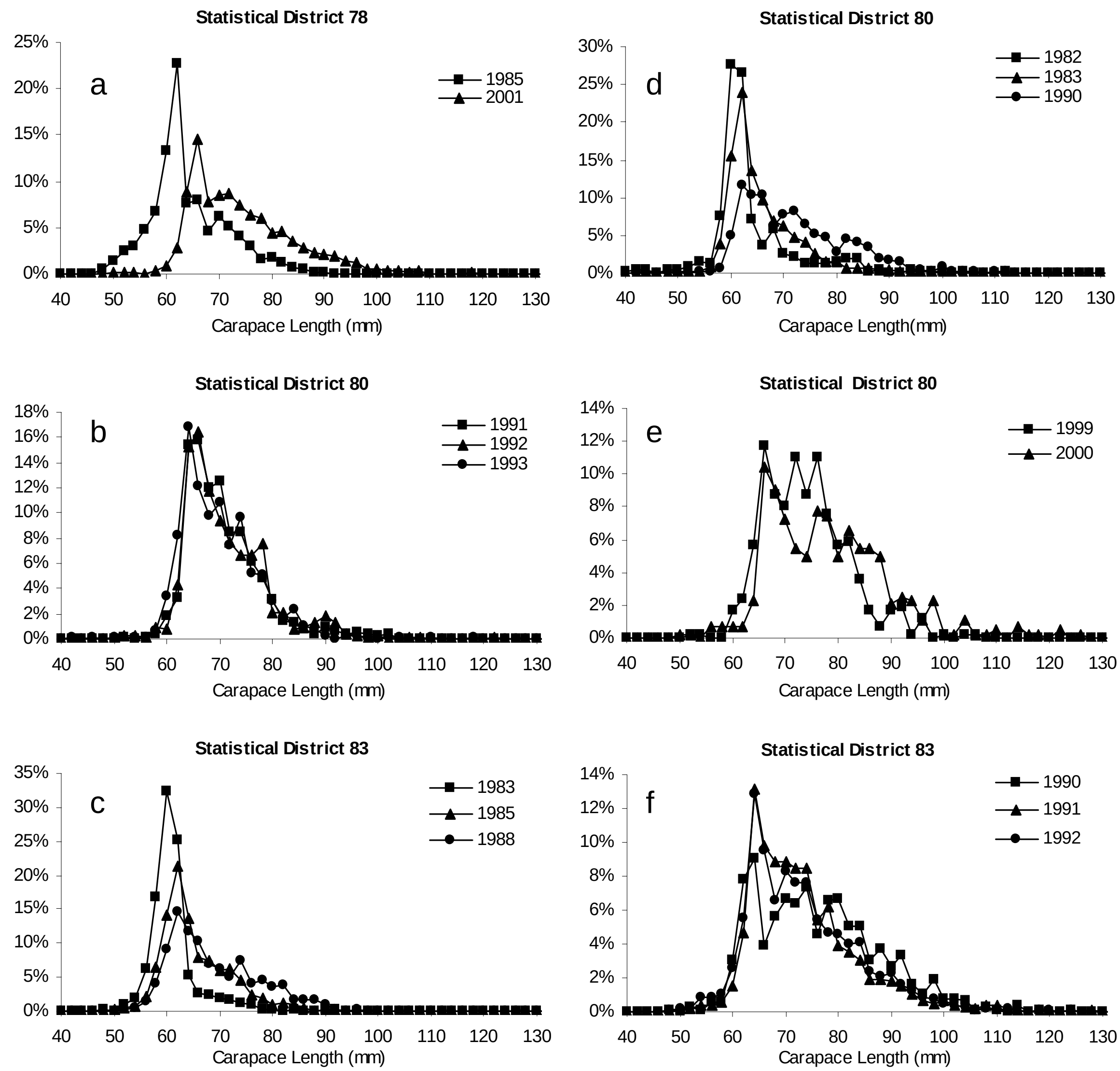


Figure 22. Yearly size distributions (in percentages) of catches from the at-sea sampling program in the southern portion of the Lobster Fishing Area 25 by Statistical District.

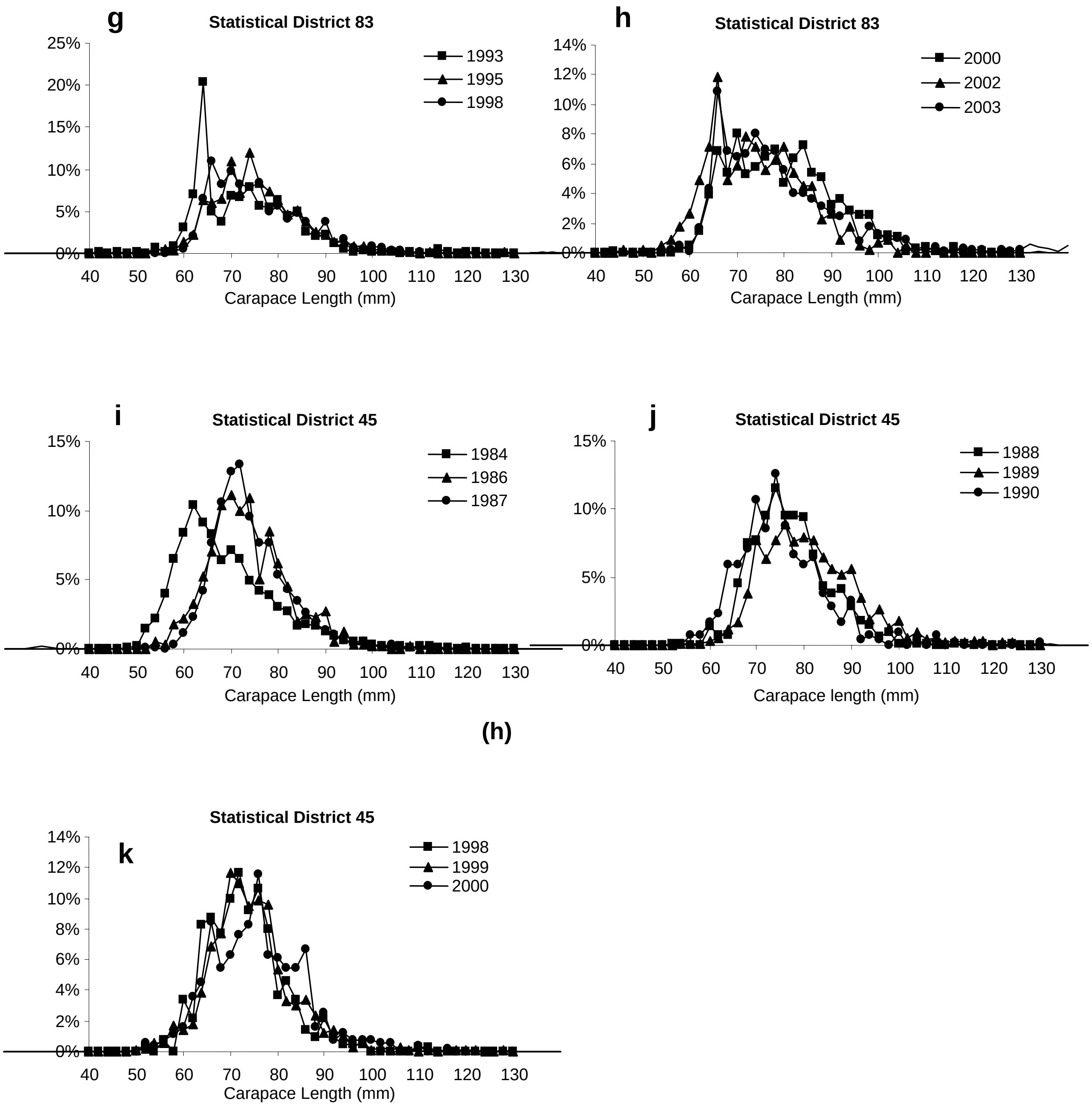


Figure 22. cont

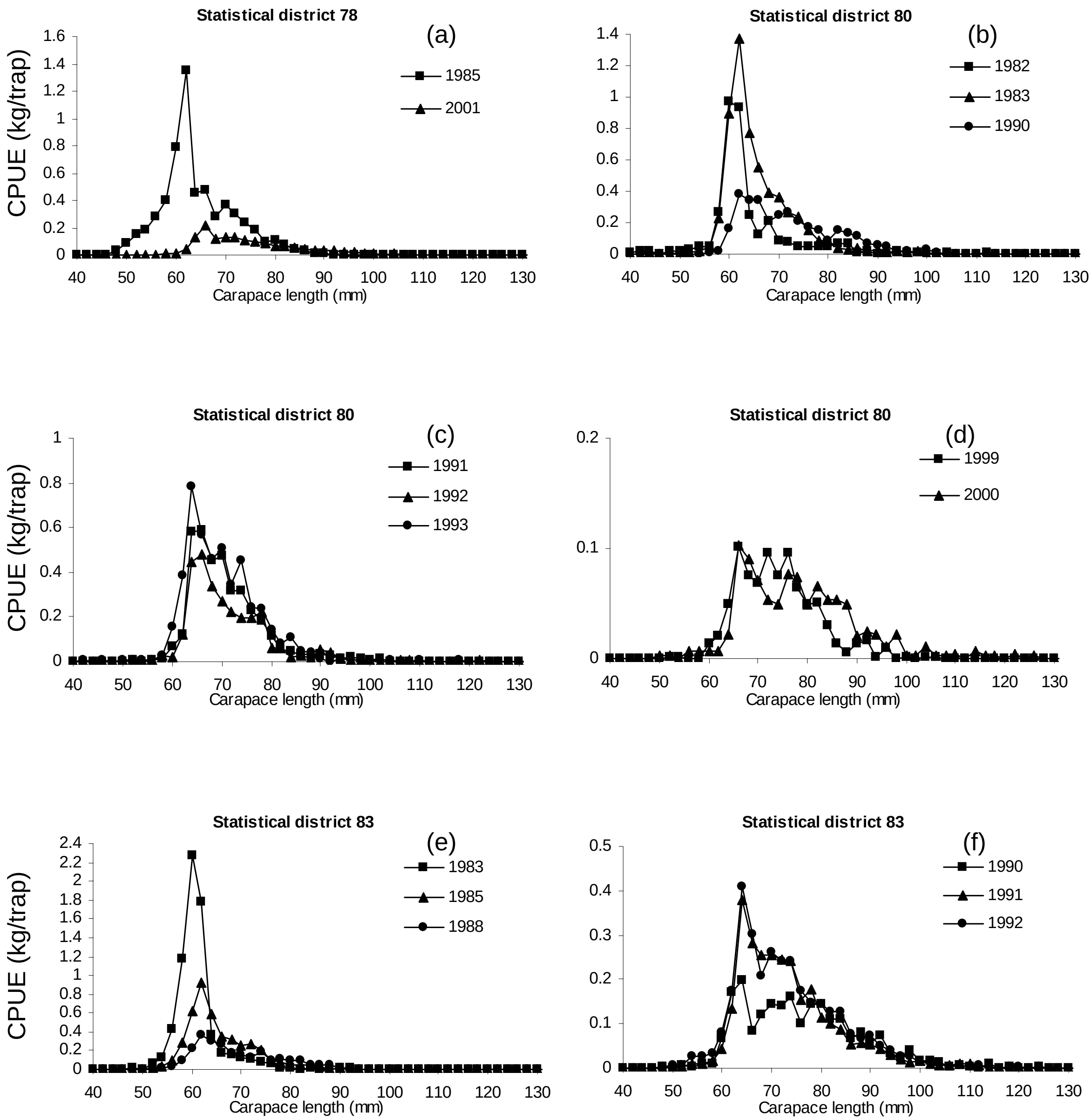


Figure 23. Yearly catch per unit effort (CPUE) of catches from the at-sea sampling program in the southern portion of the Lobster Fishing Area 25 by Statistical District.

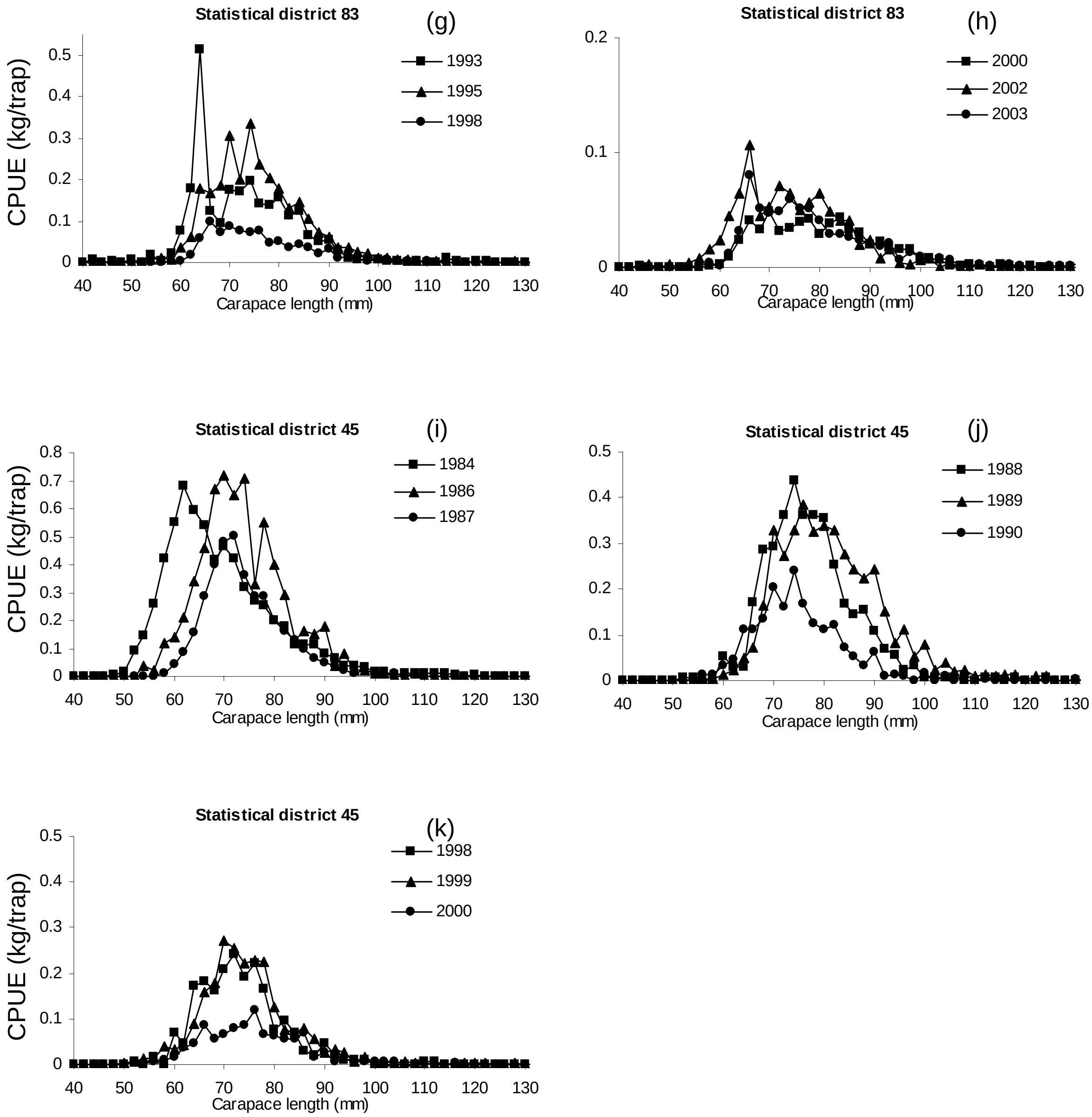


Figure 23. cont.

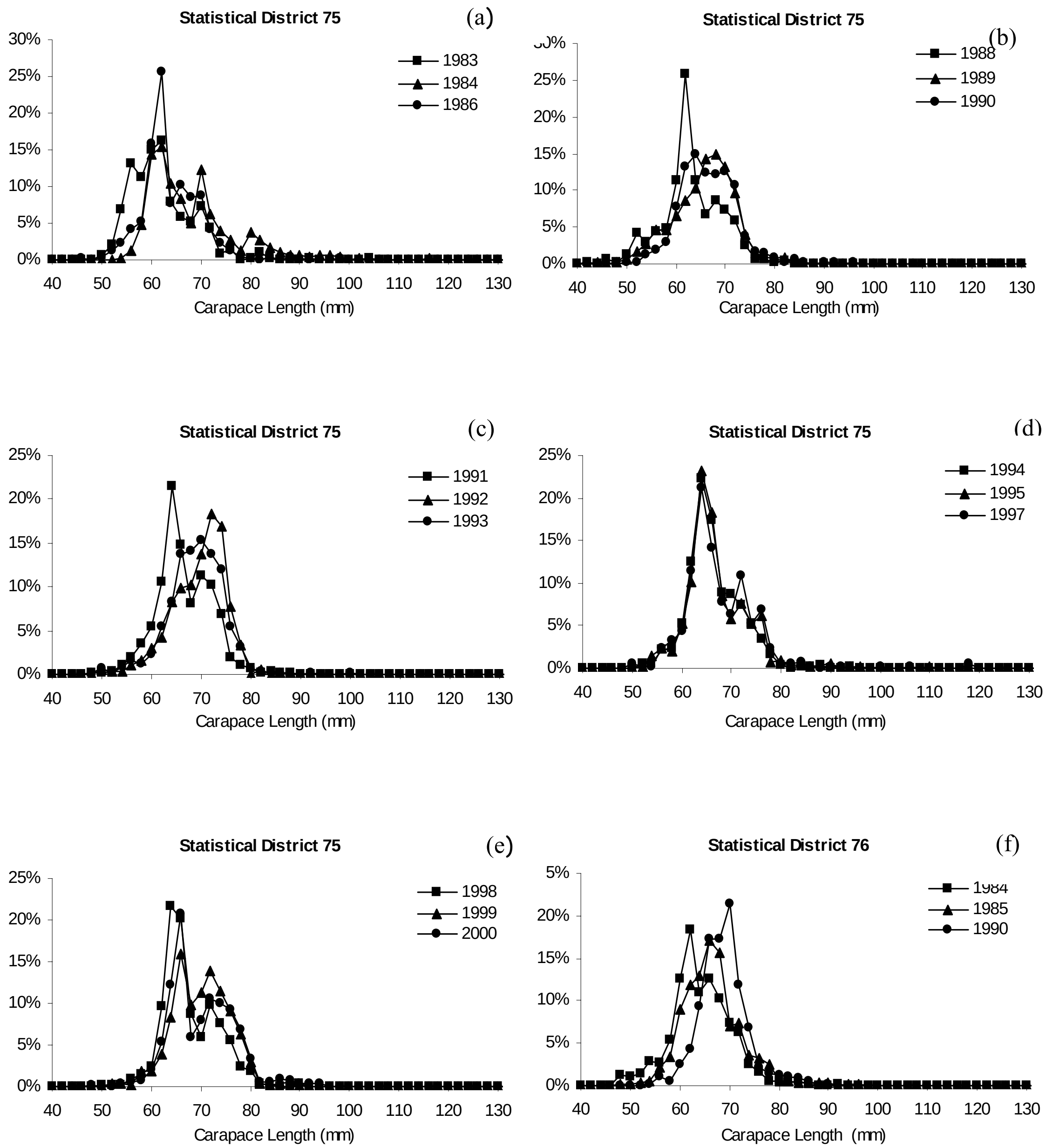


Figure 24. Yearly size distributions (in percentages) of catches from the at-sea sampling program in the northern portion of the Lobster Fishing Area 25 by Statistical District.

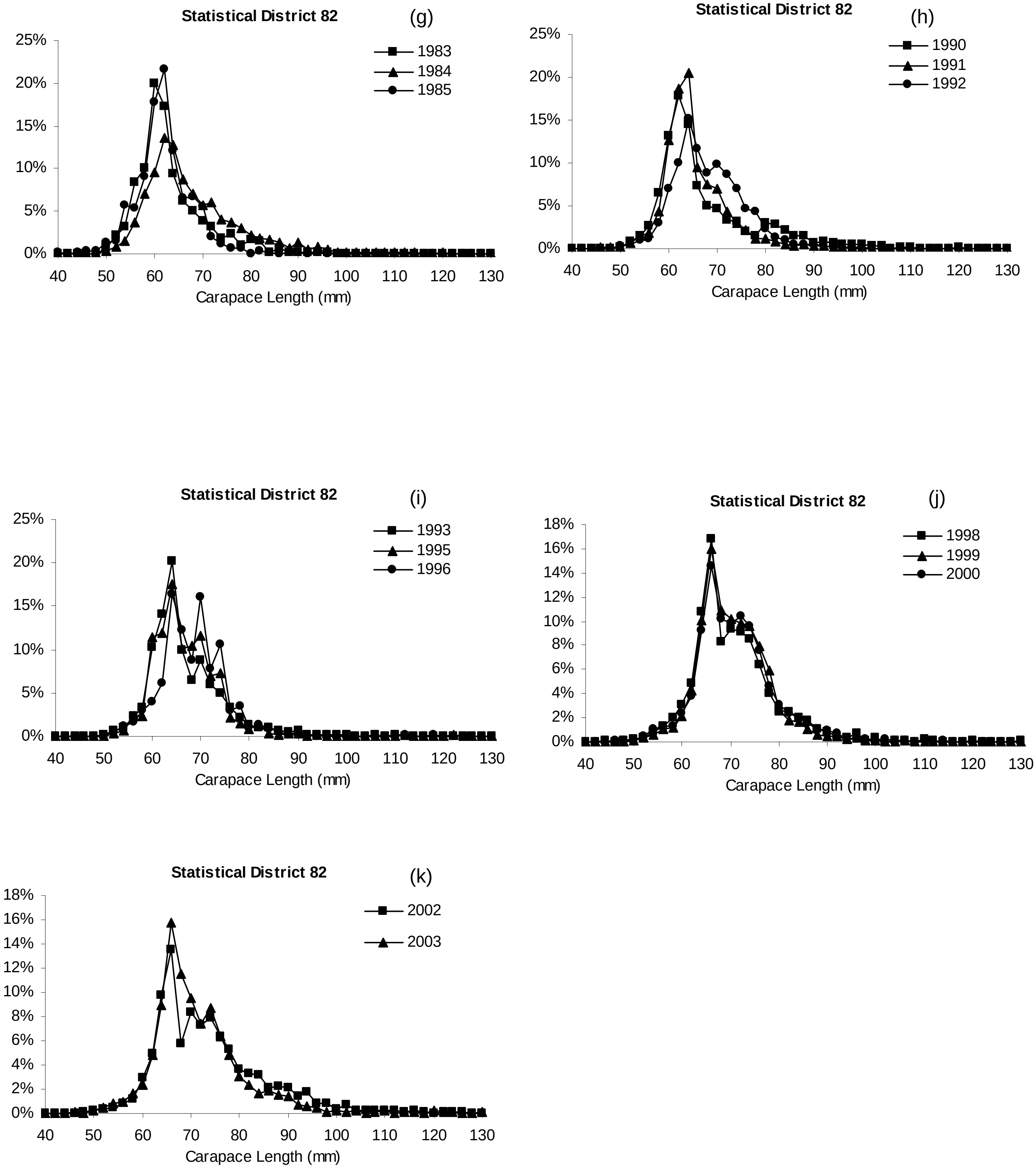


Figure 24. cont.

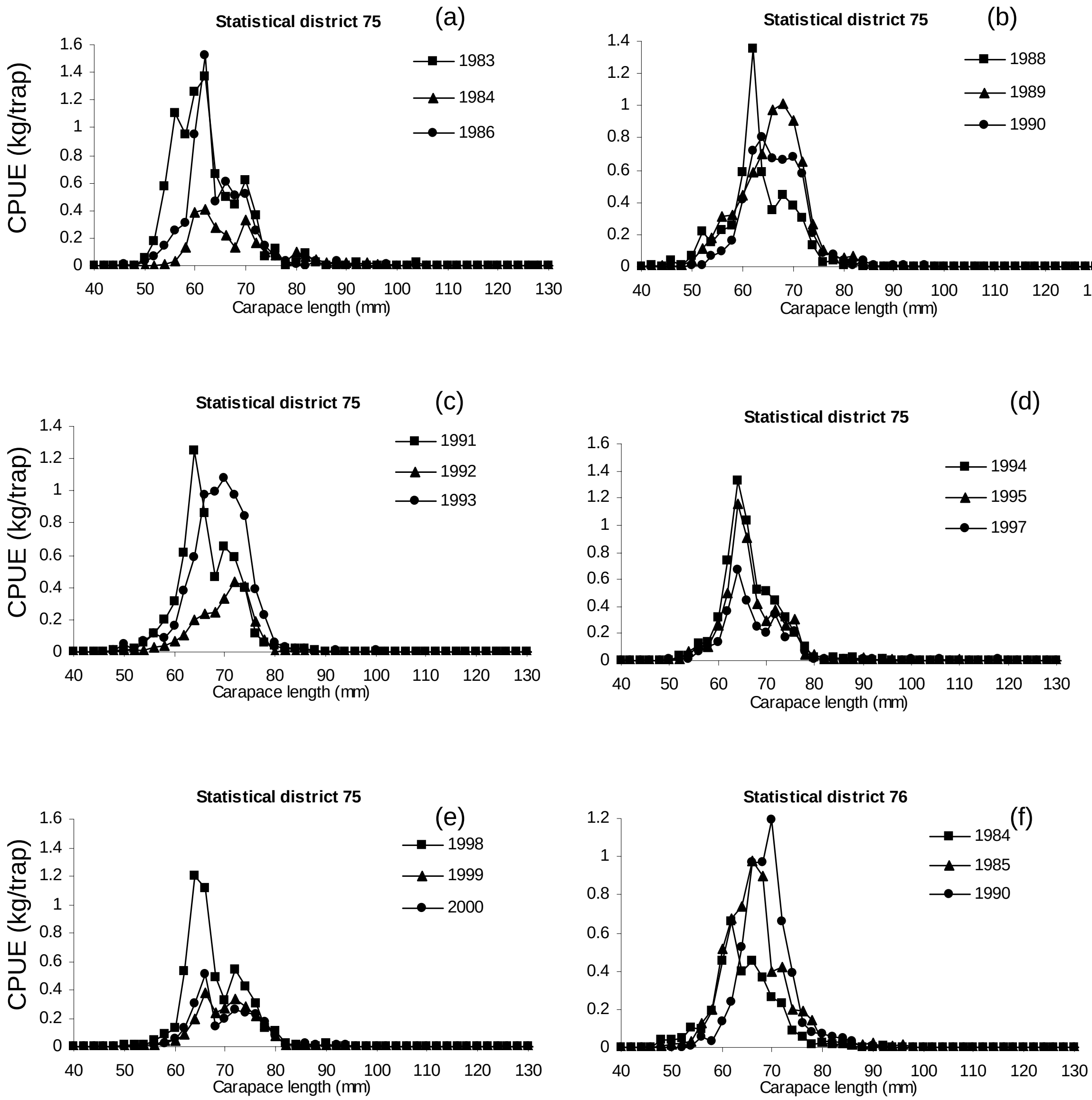


Figure 25. Yearly catch per unit effort (CPUE) of catches from the at-sea sampling program in the northern portion of the Lobster Fishing Area 25 by Statistical District.

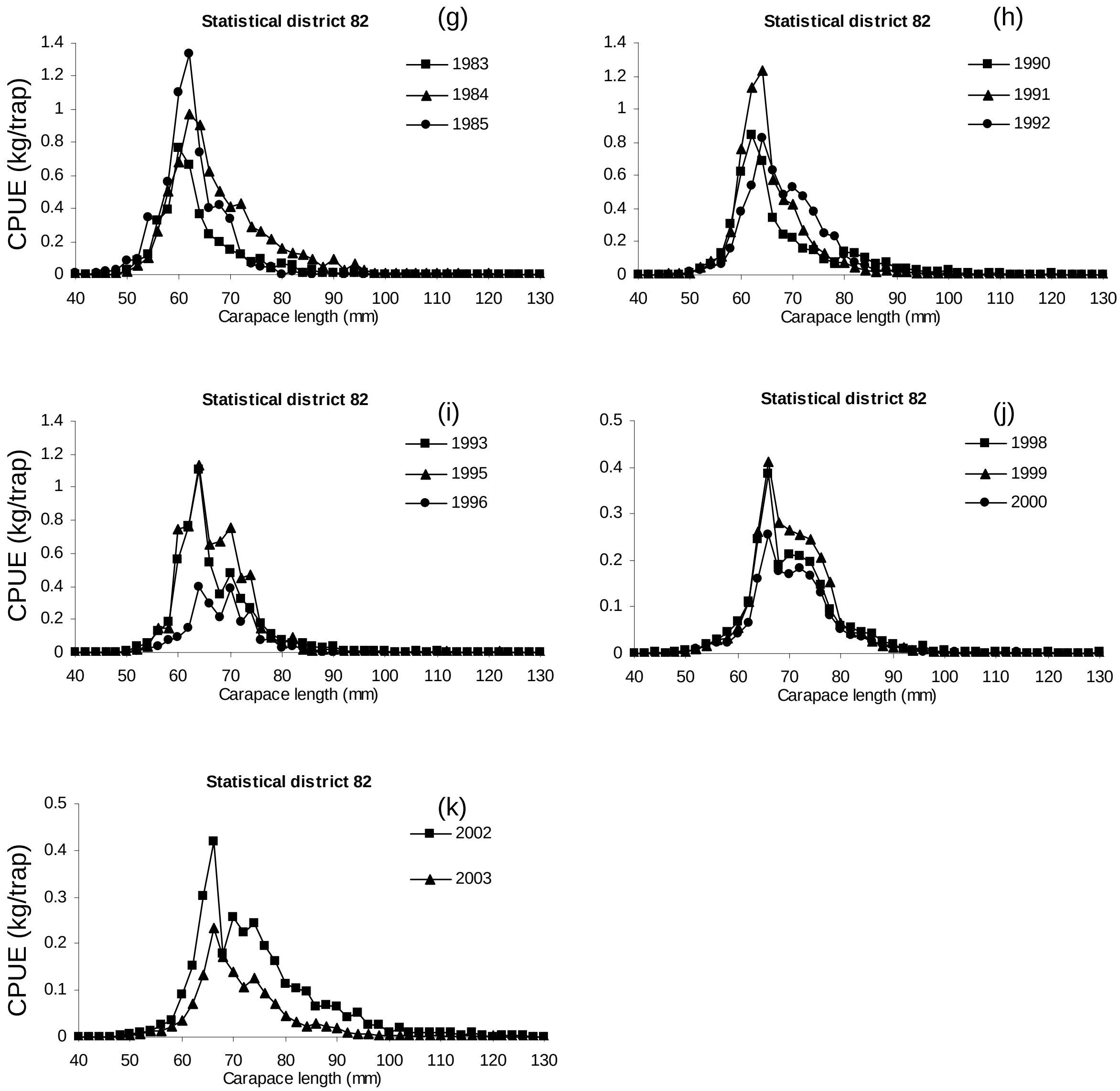


Figure 25. cont.

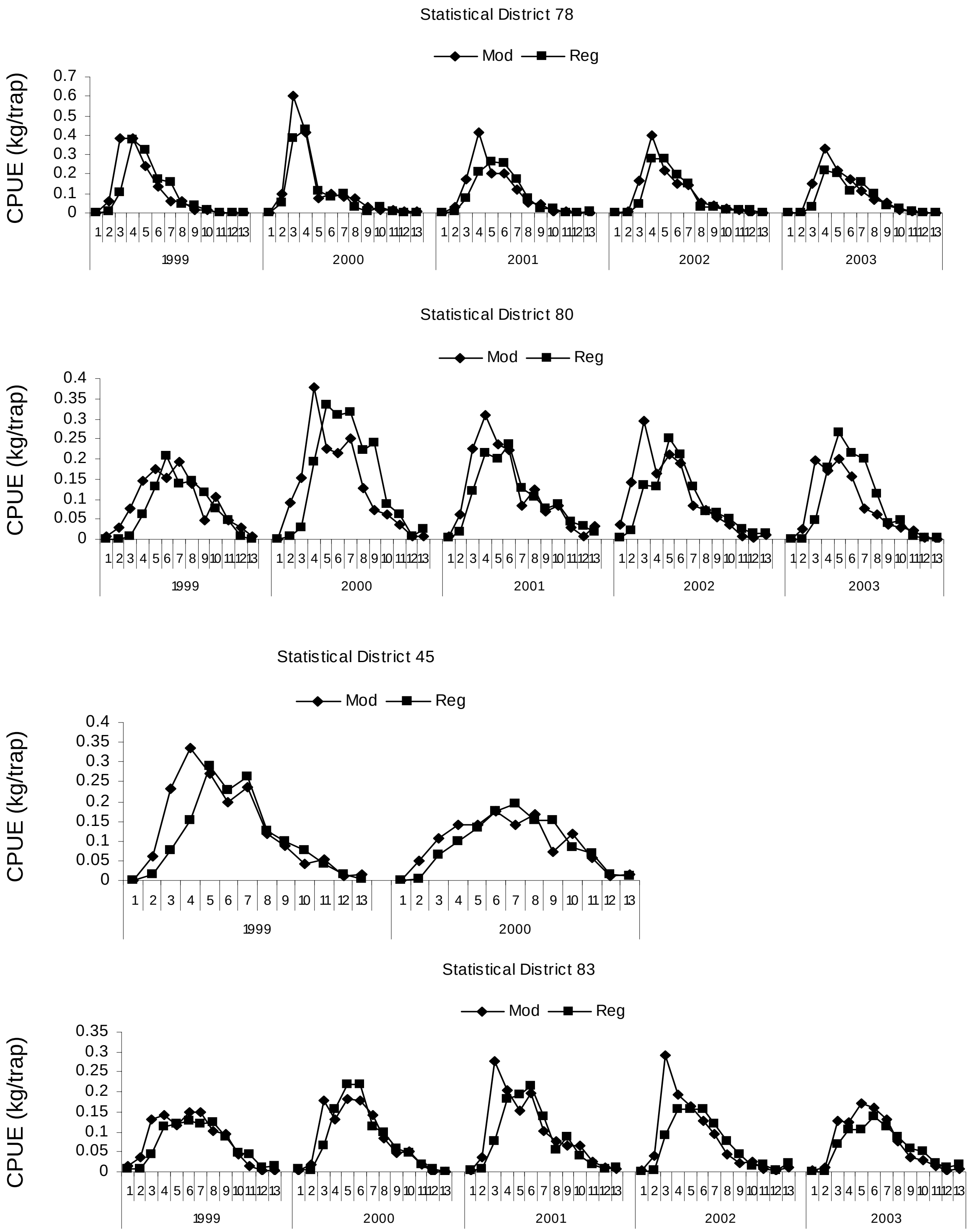


Figure 26. Annual catch per unit effort (CPUE) at size in the reported catches in regular (Reg) and modified (Mod) traps by year from the recruitment-index program for the southern portion of the Lobster Fishing Area 25.

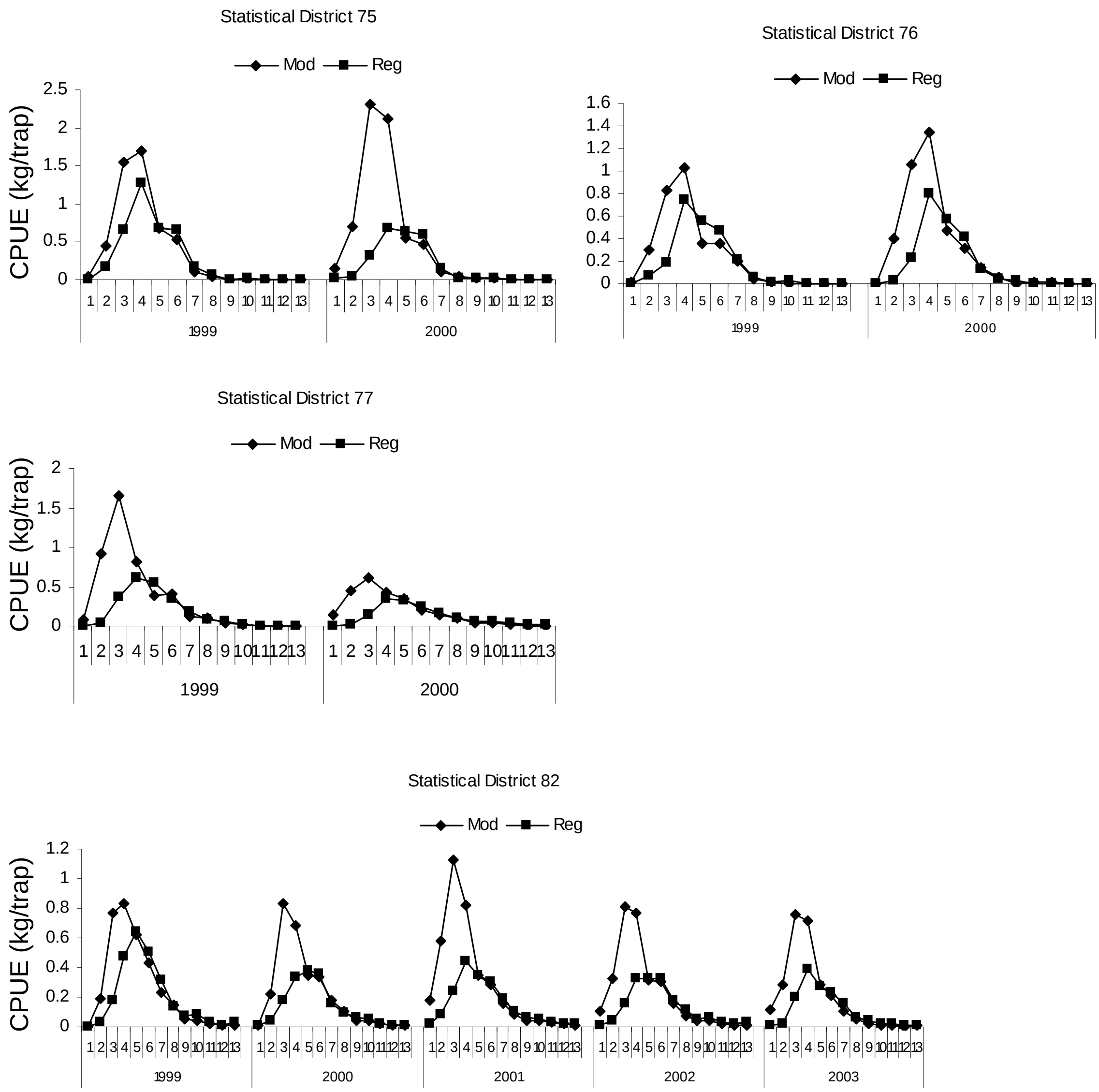


Figure 27. Annual catch per unit effort (CPUE) at size in the reported catches in regular (Reg) and modified (Mod) traps by year from the recruitment-index program for the northern portion of the Lobster Fishing Area 25.

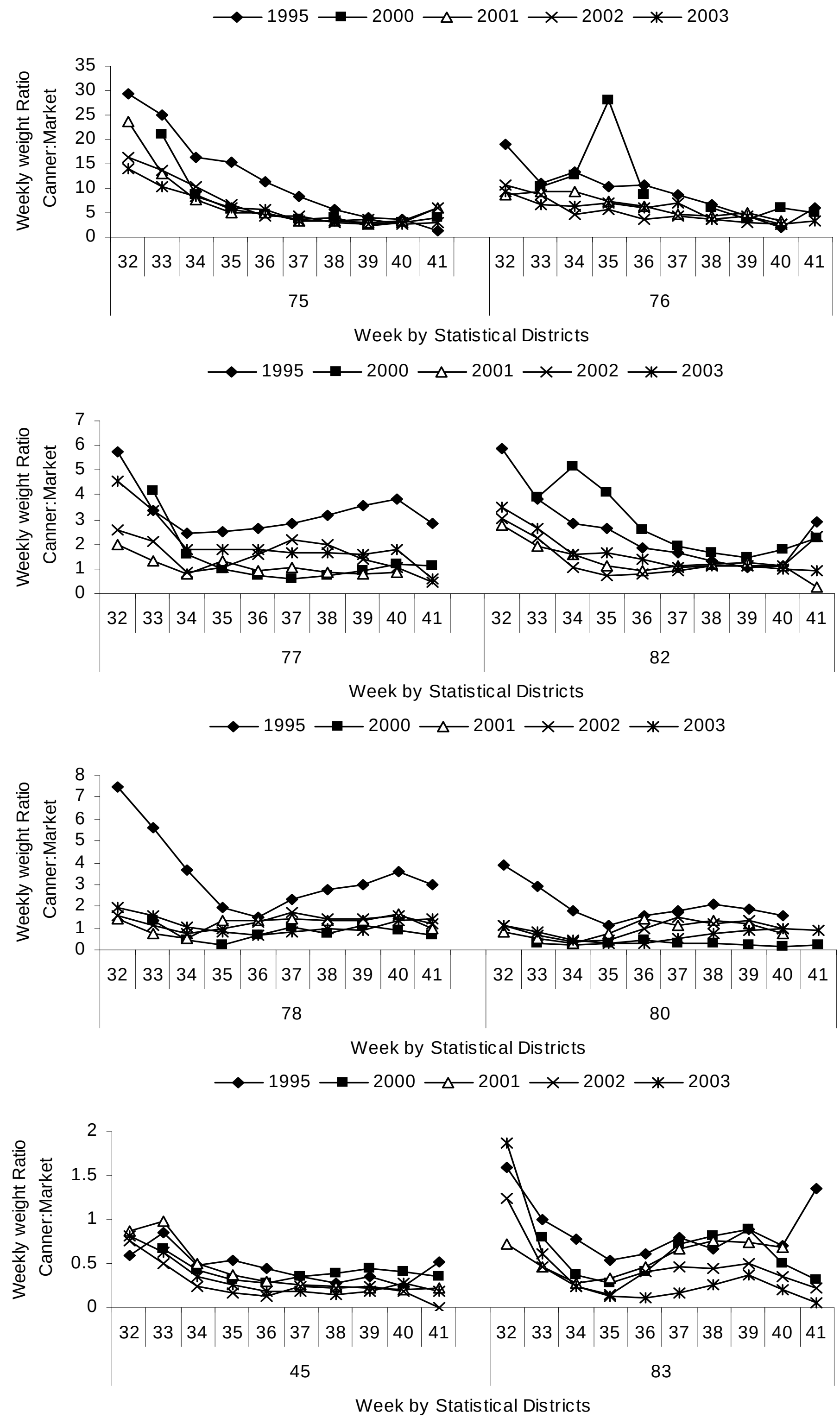
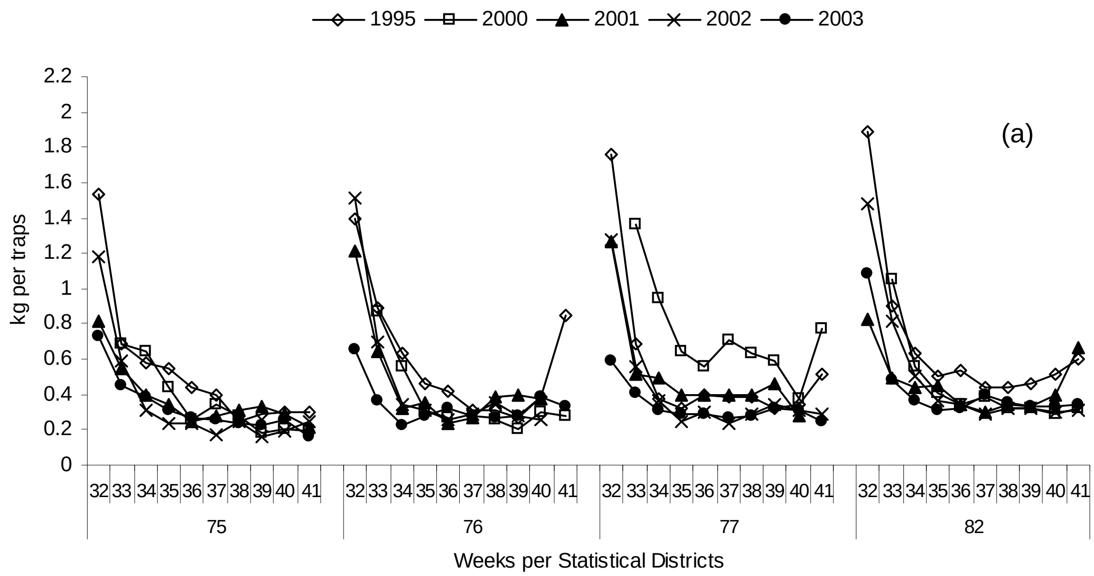


Figure 28. Weekly ratio of canner:market in the reported catches from the index-fishermen logbook program.



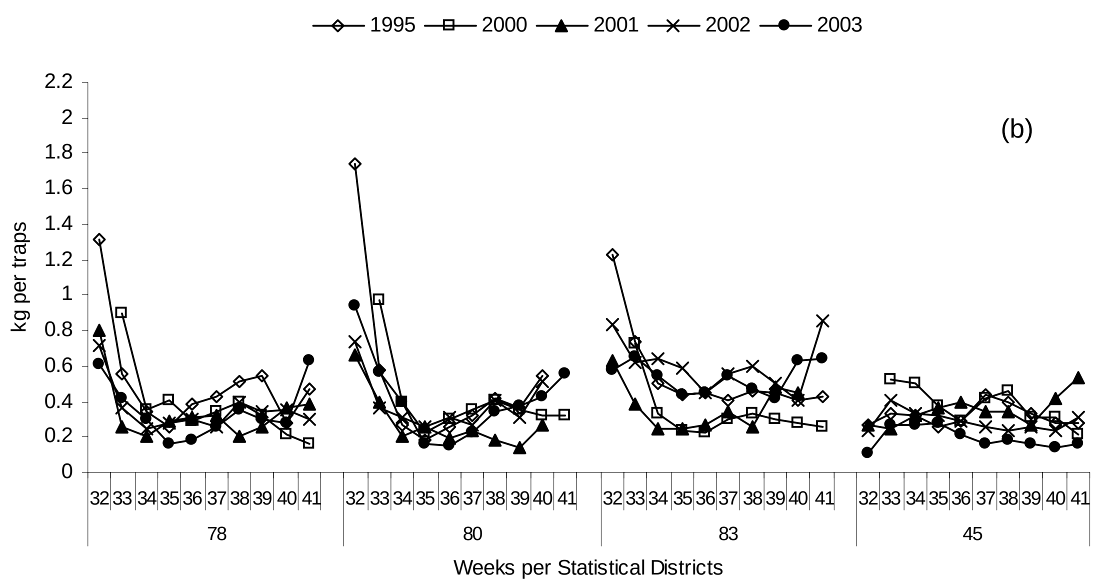


Figure 29. Weekly catch per unit effort (kg per trap) in the Lobster Fishing Area (LFA) 25 based on the index-fishermen logbook program for the (a) northern and (b) southern portion of LFA.

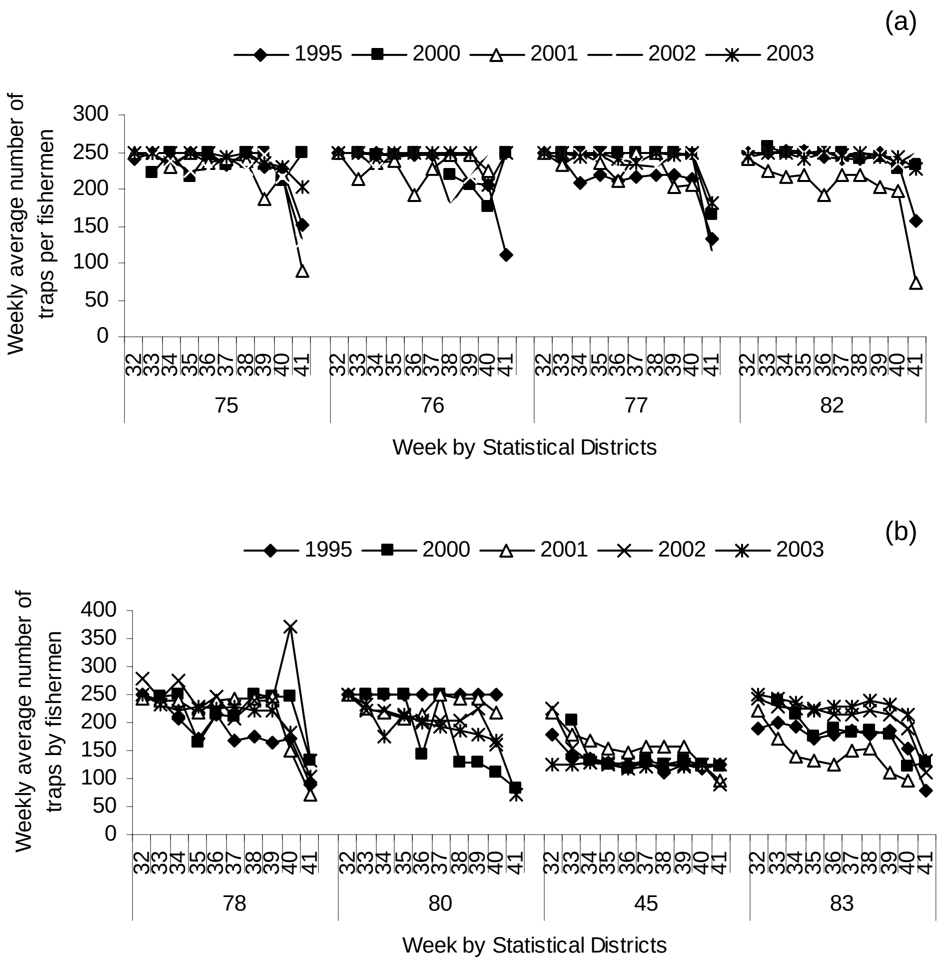


Figure 30. Average daily number of traps hauled during the summer-fall season in the (a) northern and (b) southern portion of the Lobster Fishing Area 25.

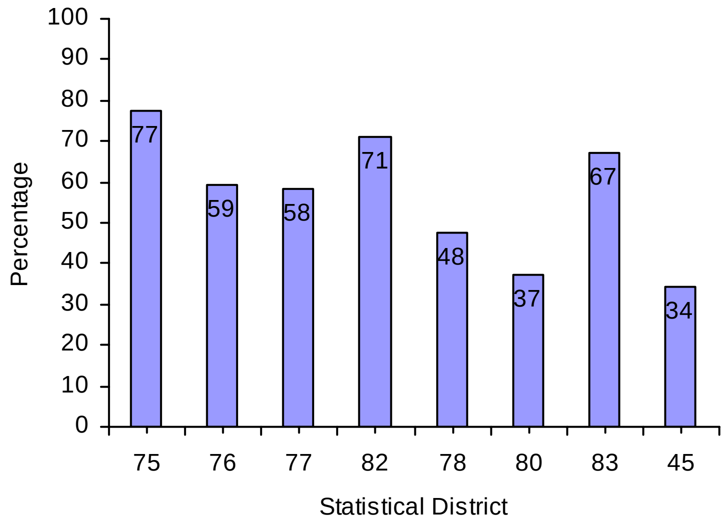


Figure 31. Percentage (%) of effective trap hauls taken from the 2003 index-fishermen program compared to maximal number of trap hauls allowed in the management plan in the Lobster Fishing Area (LFA) 25. The data have been divided for the northern and southern portion of the LFA by statistical district.

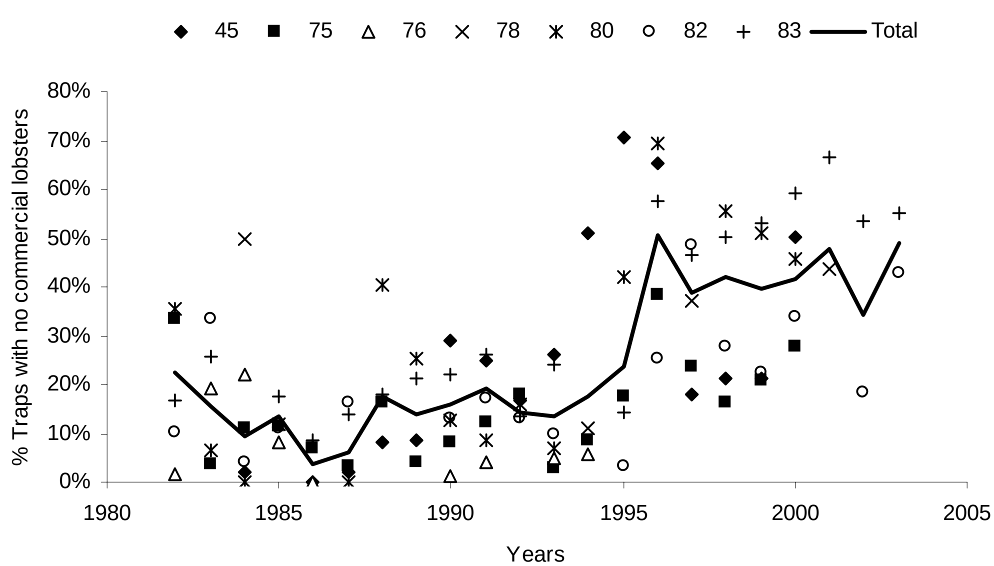


Figure 32. Yearly proportion of traps with no commercial lobsters in the at-sea sampling program in August by Statistical District.

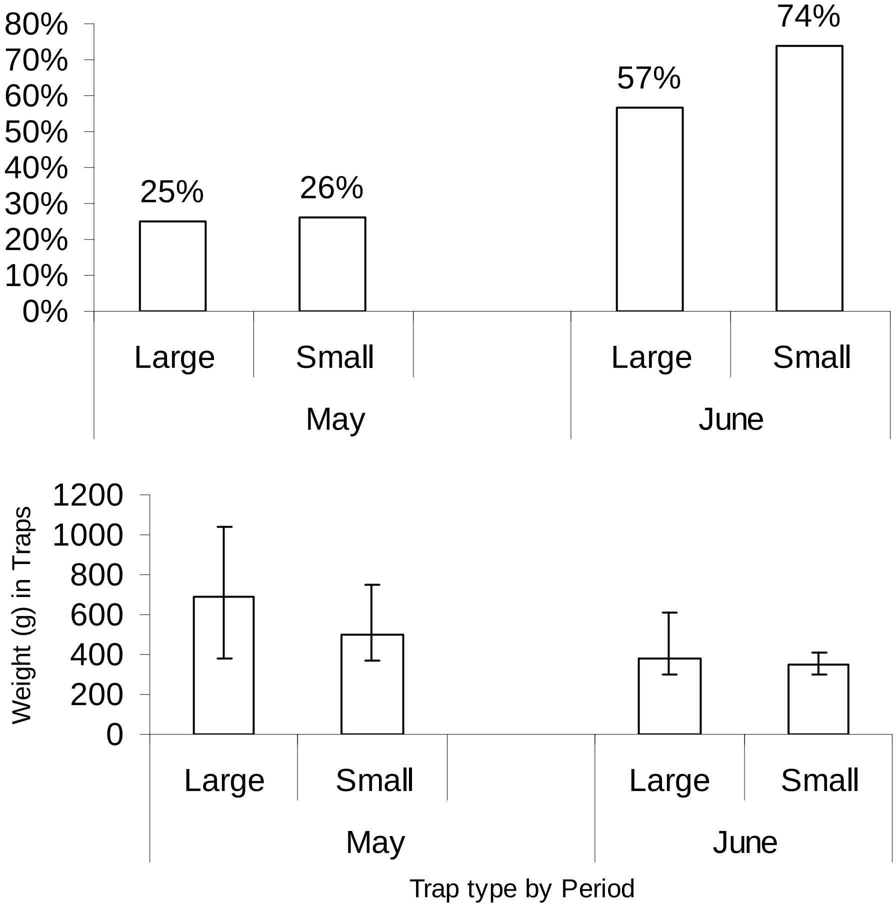


Figure 33. Comparison of catch between large and small traps in Anse-Bleue, 2000; (a) proportion of traps with no commercial catch in the sample; (b) mid-catch in grams and interquartile range.

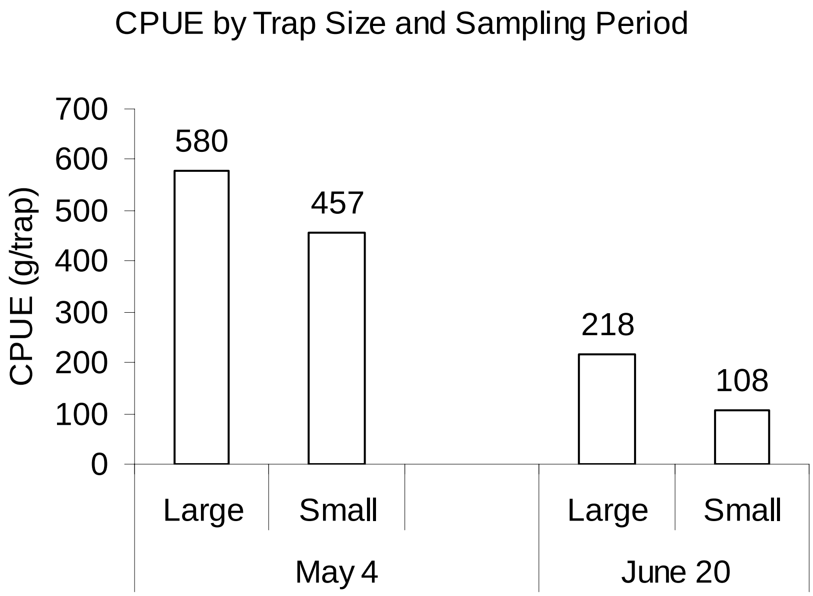
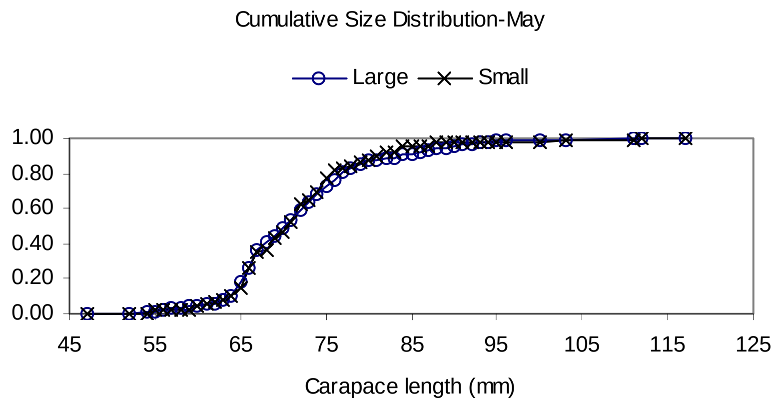


Figure 34. Catch per unit effort (CPUE) between large and small traps in Anse-Bleue, 2000.



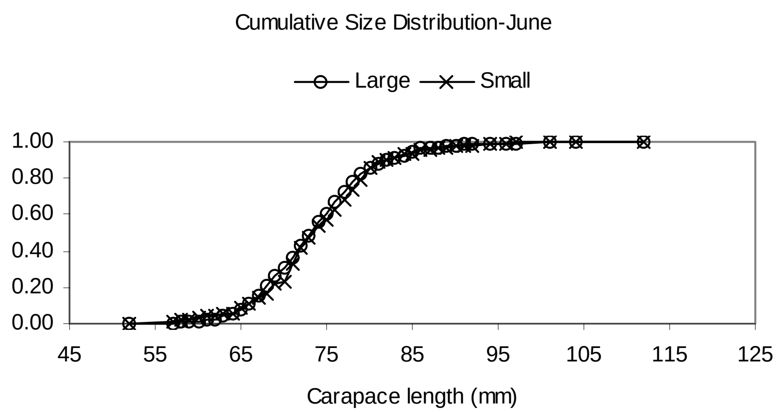


Figure 35. Comparison of the cumulative size distribution between large and small traps in Anse-Bleue, 2000.

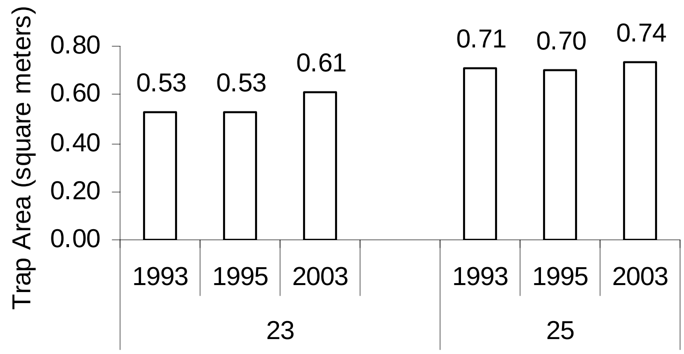


Figure 36. The area covered (estimated based on trap length and width) by traps in 1993, 1995 and 2003 in the Lobster Fishing Areas 23 and 25. Data for 1993 were taken from Lanteigne (1999), and data for 1995 and 2003 were taken from both the index-fishermen and the recruitment-index programs.

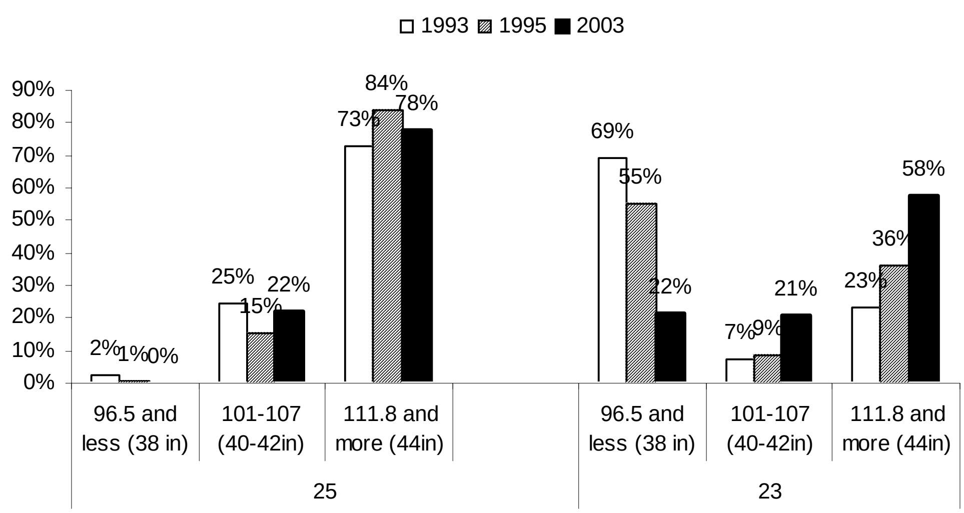
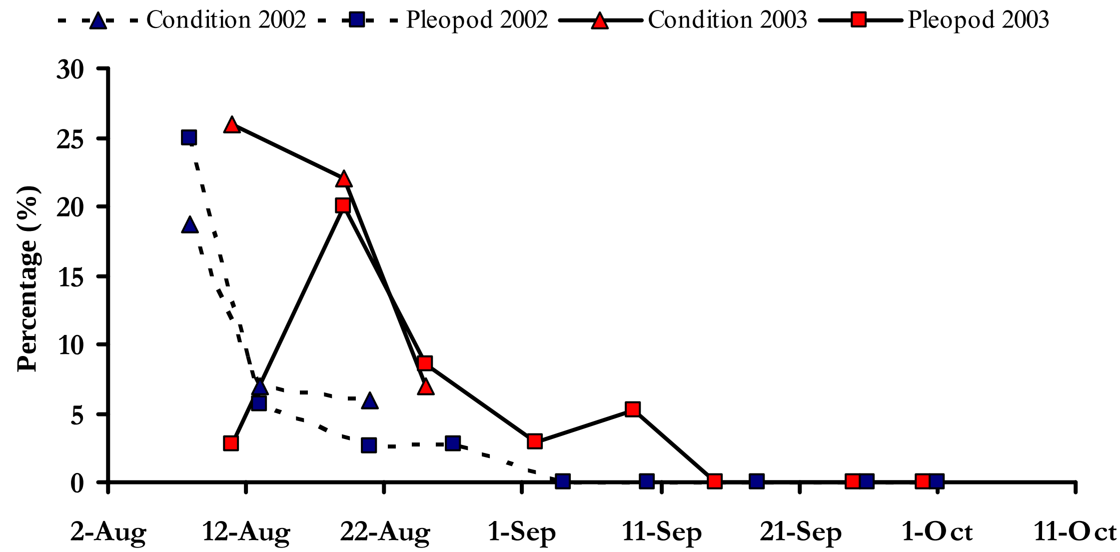


Figure 37. Proportion of traps in different size categories between 1993, 1995 and 2003 in the Lobster Fishing Areas 23 and 25. Data for 1993 were taken from Lanteigne (1999), and data for 1995 and 2003 were taken from both the index-fishermen and the recruitment-index programs.



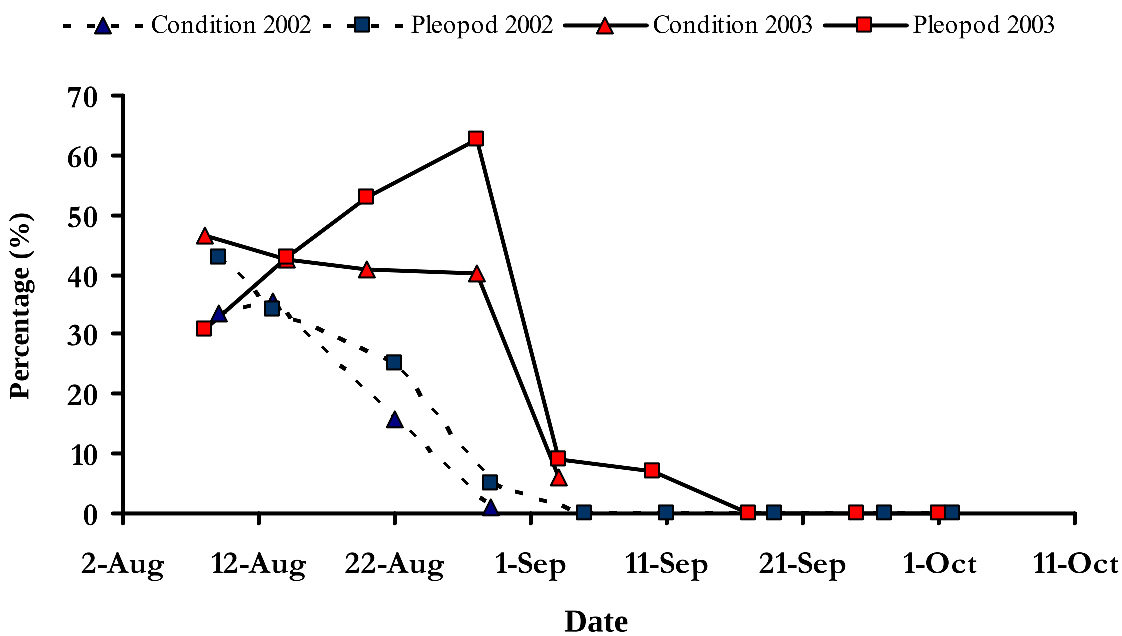


Figure 38. Percentages of mature females in their egg-extrusion year in the commercial catch of Lobster Fishing Area (LFA) 25 in 2002 and 2003; the upper graph represents the northern portion of the LFA (Loggiecroft) and the lower graph represents the southern portion of the LFA (Aboiteau). The ovaries' condition (triangles) was established for the first weeks of the fishing season using a random sample of 100 canner size females, and stratified samples of pleopods (five per 2-mm size class) from canner size females were done throughout the fishing season (squares).