Fisheries and Oceans Science | Pêches et Océans Sciences

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Research Document 2001/156

Document de recherche 2001/156

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Update on Stock Status of American Lobster, *Homarus americanus*, Lobster Fishing Area 34

Le point sur l'état du stock de homard d'Amérique, *Homarus americanus*, de la zone de pêche du homard 34

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Ce document est disponible sur l'Internet à:

http://www.dfo-mpo.gc.ca/csas/

ISSN 1480-4883
Ottawa, 2001

Canada

Abstract

Temporal trends in landings for Lobster Fishing Area (LFA) 34 with addition data from LFA 41 are reviewed, as are data from key fisheries sampling programs and logbooks.

During the 1980's LFA 34 landings increased steadily and peaked in 1990-91 at 11,071t. Landings were down in 1991-92 and 1992-93 at 8876 and 8916 t respectively. Landings remained between 10,314 and 11,890 between 1993-94 and 1997-98, then rose to 13,004 in 1998-99 and 12,958 in 1999-00. The 1990-2000 landings were 3.6 times the average for the 1947-80 period.

The spatial distribution of the lobster fishery was modelled for the 1998/99 and 1999/2000 fishing seasons using new logbook data based on a 10-min grid system, and expansion of landings to catch at size, using an expanded at-sea sampling program. For the 1999/2000 fishing season, 84% of lobsters estimated to have been landed were in the first molt group (81-94 mm CL). Only 4% of LFA 34 landings were in the third molt group (110+).

LFA 34 exploitation rates estimated at 68%. Including data from LFA 41 gives estimates of 59-63%. These values are higher than the last assessment (50-66%) but based on a more accurate picture of the landings and size frequencies.

The majority of the LFA 34 catch is immature and have never reproduced. The majority of mature females removed in the LFAs 34 / 41(4X) area are taken in the first two molt groups (81-104 mm CL) in nearshore LFA 34. The majority of these are newly mature and have not reproduced before. LFA 34 accounts for 80% of the removed potential egg production, with 50% of the total accounted for by the nearshore fishery.

The logbook data provides the number of lobsters v-notch as reported by fishermen. In the initial year, 117,727 notches were reported. Second year participation rates declined, with 41,209 notches reported.

Résumé

Ce document examine l'évolution des débarquements de homard de la zone de pêche du homard (ZPH) 34, des données supplémentaires pour la ZPH 41 ainsi que des données provenant de journaux de bord et des principaux programmes d'échantillonnage des pêches.

Au cours des années 1980, les débarquements de la ZPH 34 ont constamment augmenté pour atteindre un sommet en 1990-1991, à 11 071 t. En 1991-1992 et en 1992-1993, les débarquements ont baissé respectivement à 8876 t et à 8916 t. De 1993-1994 à 1997-1998, ils se sont maintenus entre 10 314 t et 11 890 t, puis ont augmenté à 13 004 t en 1998-1999 et à 12 958 t en 1999-2000. Durant la période 1990-2000, les débarquements moyens étaient 3,6 fois plus élevés que la moyenne pour la période allant de 1947 à 1980.

Nous avons modélisé la répartition spatiale de la pêche du homard pour les saisons 1998-1999 et 1999-2000, à partir de nouvelles données de journaux de bord fondées sur un système de quadrillage à intervalles de 10 minutes et de données de captures selon la taille obtenues en extrapolant à partir des débarquements grâce à un programme élargi d'échantillonnage en mer. Pour la saison de pêche 1999-2000, 84 % des homards qui auraient été débarqués étaient dans la première classe de mue (LC : 81-94 mm), tandis que seulement 4 % des débarquements de la ZPH 34 étaient dans la troisième classe de mue (LC µ 110 mm).

Nous avons estimé à 68 % les taux d'exploitation dans la ZPH 34. Le taux est de 59-63 % lorsqu'on inclut les données pour la ZPH 41. Ces valeurs sont plus élevées que celles de la dernière évaluation (50-66 %) et elles sont fondées sur une évaluation plus exacte des débarquements et des fréquences de taille.

La plupart des prises dans la ZPH 34 sont immatures, ces homards ne s'étant jamais reproduits. La majorité des femelles capturées dans le secteur des ZPH 34 / 41(4X) étaient des individus dans les deux premières classes de mue (LC : 81-104 mm) et ont été prises dans les eaux côtières dans la ZPH 34; la plupart venaient d'atteindre leur maturité et ne s'étaient pas reproduites auparavant. La récolte dans la ZPH 34 représente 80 % de la production d'œufs potentielle supprimée; la pêche côtière était responsable de 50 % du total.

Les données de journaux de bord donnent le nombre de homards marqués d'un V déclarés par les pêcheurs. La première année, les pêcheurs ont signalé la capture de 117 727 homards ainsi marqués contre 41 209 la deuxième année, qui a connu une baisse des taux de participation.

INTRODUCTION

Lobster Fishing Area (LFA) 34, off Southwest Nova Scotia (Figure 1) is a diverse region between Digby Neck and Barrington Bay encompassing 21,000 km2. Fishing takes place in shallow near-shore areas extending to deep water areas just inside the 92 km (50 nautical mile) offshore lobster line. The lobster grounds are amongst the most productive in the world with landings in recent years exceeding 13,000mt (Table 1) and accounting for over 25% of Canada's lobster landings.

The fishery is undertaken by 971 Category A Vessel Based licenses, 7 Communal Based licences (First nations) and 1 Category B license (part-time). It is managed by input controls including a minimum size carapace length (CL), prohibition on landing egg-bearing female, limited entry, a season between the last Tuesday in November through to May 31, and a trap limit of 375 from November to March and 400 in March to May. The history of regulations in LFA 34 is summarised in Appendix 1.

The status of the lobster stocks in LFA 34 was last assessed in 1998 by Pezzack et al, (1999). The adjacent LFA 35-38 fishery was also assessed at that time by Lawton et al (1999). Reference is made to these earlier reports for background information on historical aspects of the fisheries, earlier biological studies, and assessment methodologies where these have not changed substantially since the last assessment.

This document updates stock status of LFA 34 as of the end of the 1999/2000 season. The paper also presents updates of information on LFA 41 in line with suggestions in the last assessment that it needs to be taken into account in any assessment as LFA 34 and 41 share access to the Gulf of Maine lobsters.

The general conclusion from the available scientific studies is that the Southwest Nova Scotia fisheries should be considered to be components of a Gulf of Maine lobster metapopulation. The degree to which they represent a source of larval production for adjacent areas or a sink is not known. There is a need to increase the capability of physical and biological oceanographic models of the Gulf of Maine system to model the components of the system.

Where LFA 41 is compared to LFA 34 it is the NAFO 4x portion (Gulf of Maine/ Browns bank/Scotian Shelf) which is used. Georges Bank is considered very likely a separate unit with less directly links to LFA 34. This is based on population trends (ASMFC assessment 2000; 22nd SAW 1996), modelled larval drift and movement of tagged lobsters (Pezzack and Duggan 1985; Pezzack 1987).

Recent Management Issues

A major conservation management program was initiated in Atlantic Canada in light of the October 1995 review of the Atlantic lobster fishery by the Fisheries Resource Conservation Council (FRCC, 1995). In their report, the FRCC concluded that under the current management regimes, lobster fishers generally were "taking too much, and leaving too little". Based on the scientific data available to the Council, they concluded that Atlantic lobster fisheries are designed towards high exploitation rates, harvest primarily immature animals, and result in very low levels of egg production (estimated to be as low as 1-2% of what might be expected in an unfished population). While they accepted that lobster stocks have traditionally been quite resilient, they concluded that the risk of recruitment failure is unacceptably high.

Inshore lobster fishers which prosecute the "winter fisheries" (LFA's 33-38) developed responses to a directive issued by the Minister of Fisheries and Oceans in December 1997, for Atlantic lobster fishers to set in place new management measures which, over a four year period, would introduce measures to achieve a doubling in egg production per recruit.

ASSESSMENT METHODOLOGY

Commencing in 1997, all new lobster research and assessment data sets are fully georeferenced. Regular GPS and DGPS receivers are used to collect positional data during all field operations. For commercial sea sampling, waypoints are logged on GPS receivers for as many traps as possible (waypoint numbers are recorded on paper forms), and later uploaded for entry using the newly developed Crustacean Research Information System (CRIS). This ensures that some editorial range checks are performed.

Landings

Lobster landings data is accessed from Oracle database tables created by DFO's Marine Fisheries Division from data compiled by DFO Statistics Branch into the ZIFF (Zonal Interchange File Format) database. The ZIFF database includes lobster landings by Statistical District, (S.D.) (Figure 2) port and date in a series of tables aggregated by year since 1989 (called Identified_catches_YYYY).

The mandatory catch reporting system changed in 1995 from a system based on dealer sales slips to one based on individual fishermen sending in monthly catch settlement reports. This system came into effect in November 1995. For all LFA's, the catch settlement report only provided information on daily catch by port and date of landing. Thus landings data were reported by LFA, or Statistical District, (S.D.) (Figure 2). In November 1998, as part of their lobster conservation plan, LFA 34 fishermen adopted an expanded catch settlement reporting system, which required them to provide information on daily catch and effort by reference to a 10 min x 10 min grid system. (Figure 3, 4). This provided the first picture of landings and effort distribution in LFA 34. Similar grids were also used to group LFA 41 data which has since 1972 been recorded by latitude and longitude (Figure 4b).

To show larger scale patterns in effort and landings, grids are grouped into 8 groups (Figure 4a) based on depth and adjacent S.D. These groupings were also used for summarising size frequency data. Groups used in LFA 41 correspond to the five assessment areas used in previous assessments (Figure 4b).

Four transects of grid squares (Figure 5) were looked at examine trends in landings, effort and CPUE with depth and distance from shore.

The present report presents the initial look the spatial patterns of landings and sizes within LFA 34 and 41. It may be premature to make detailed interpretations of the results and detecting temporal trends will require many more years of data, however the general patterns are useful in understanding and interpreting other fishery trends and indices.

At-Sea Sampling

At-sea samples collect information from fishermen's catch during normal commercial fishing operation. The data collected includes: carapace length measured to the nearest millimetre (from the back of eye socket to the end of the carapace), sex, egg presence and stage, number, location and depth of traps.

At-sea sampling provides detailed information on lobster size-structure in the traps (including sub-legal, berried, and soft-shelled lobsters). As all lobsters retained in each trap haul are measured , biologists are able to convert the numbers caught into estimates of the catch rate of legal-sized animals by weight.

In the 1998 stock assessment it was acknowledged that the existing scale of catch sampling undertaken in the lobster fishery was grossly inadequate for the derivation of general estimates of the catch size structure. Substantial effort has been undertaken since the last assessment to expand the capability to obtain, access, and interpret at-sea sampling data.

Data was obtained through at-sea sampling conducted during the second to fourth weeks of the fall season, and the last 3 weeks of spring season. Although, the time of sampling has remained relatively consistent, the number of areas and level of sampling has varied considerably over time (Figure 6a-c). The sampling effort was high in 1985-86 with 21 samples, and between 11-15 samples per season from 1987 to 1993. The sample number was further reduced between 1993-1995, as a result of budget constraints, to 6-7 samples seasonally with greater emphasis placed on the springtime. During 1995-1997, the lowest level of sampling was reached with only 3 spring samples achieved.

Sampling of the midshore fishery, deeper than 30 fathoms, has historically been sporadic. This is in part due to the higher cost associated with the longer midshore trips, fishing effort taking place outside of the traditional sampling periods and in mid winter, the variability of times when vessels fish specific areas and the difficulty caused by short notice of sailing in the mid-winter period.

Faced with these short falls in the sampling program, biologists designed a more frequent and intensive at-sea sampling program for 1998/99 meant to supply information on both the temporal and spatial variation of size frequencies. The sampling strategy focused on a "corridor" approach (Figure 6c, 7a) with efforts concentrated on an area running from the coast off Lobster Bay, Nova Scotia out to Crowell Basin in Lobster Fishing Area 41. Samples were taken from four sub-areas: inside Lobster Bay, outside Lobster Bay, German Bank and outside German Bank to the 92 km offshore line, at least 4 times during the season beginning in December and ending in May. This transact was chosen as a number of index fishers hold historical fishing and temperature records for these sub-areas, the lobster rich nearshore grounds of Lobster Bay are included, and it is contiguous with the offshore grounds in Crowell Basin. Such a zone is also advantageous as it encompasses contrasting types of grounds and provides a cross section of the shelf.

Areas outside the corridor, such as Port Maitland and Cape Sable Island, were only sampled once during the fall and spring season.

In 1999/2000 sea-sampling effort was expanded to cover the all of LFA 34 and over 90 samples were collected during the season (Figure 7b Table 2). The spatial and temporal distribution of the samples were based on the results of the new logbook introduced in 1998/99 which provided daily information on catch and effort by 10 min squares (Figure 3). The LFA was divided into sampling areas based on location and depth and sample numbers per month assigned based on the landings from those areas the previous year. This gives more emphasis to the areas with higher landings where variation may be greater. It was however recognised that the deepwater areas of the midshore are a region of special interest and importance, so additional samples were assigned to these areas.

Molt Groups

Size frequency data from at sea samples was summarised by molt groups determined from the mean growth rates. The first molt group (81-94 mm CL) represents the newly recruited animals that molted into legal size the previous summer. Molt Group 2 is 95-109m CL and molt group 3+ is 110 mm CL +. The median size of maturity (size at which 50% of females are mature) is approximately 97 mm CL in LFA 34 and 41.

Calculation of Number of Lobsters Landed At Size

To better understand removals and allow comparisons between areas the sample size frequency data was expanded by the landings to give an estimate of numbers at size landed by the fishery. To do this the following steps were taken:

1. Frequency distribution of lobsters was defined by 1mm increments for each sex for all of the lobsters sampled (including shorts and berried lobsters) per month or groups of months calculated for each of the grid groupings. (Nov-Dec, Jan-March, April, May).
2. Where size frequencies were not available for a given month, samples from adjacent months were applied. Where this was not available samples for the same period the previous year were used. For the deepwater regions of LFA 34 near the offshore line, samples from the LFA 41 fishery were used.
3. Numbers at size for each sex were converted to total weight at size using separate length-weight relationships for males and females.
4. Percent distribution of sample weight by 1 mm increments was calculated for the legal portion of the sample.
5. Landings for each group and month period were determined from logbook grid data.
6. Ratios of landings to sample were calculated to provide an expansion factor.
7. Numbers at size in the samples were expanded by the expansion factor to give numbers landed at size.

Calculating Removal Levels of Mature Females and Potential Egg Production

Alternative measurements of the impact of the fisheries and conservation measures on the stock have been suggested due to the lack of biomass estimates or independent estimates of F. Such measurements could serve as part of new Biological reference points.

A comparison of removals and lost egg production by area allows for comparison between areas and their relative impacts on the overall egg production.

Using the estimates of numbers landed at size the numbers of mature females removed were obtained by applying the maturity relationship to the size frequency. Using this data it is possible to apply the egg at size relationship to estimate the number of eggs that would have been produced that summer had they not been removed by the fishery.

Fishing Mortality and Exploitation Rate

The 1996 Invertebrate Fisheries RAP recommended that a common method of determining Fishing Mortality (F) be used in future assessments. At that time, there were four methods in use the Length Cohort Analysis (Cadrin and Estrella 1996), a length-based method based on work by John Caddy (Caddy 1977), mark recapture methods, and the Leslie -Delury regression method (Miller and Mohn 1989). The latter two methods are not applicable to all areas but can be useful as a secondary method to verify results. The LCA was chosen as the common method of assessment because it uses all sizes and incorporates more information on growth and time at-size than the previously used length based methods, and has been routinely used in U.S. lobster fisheries assessments (Cadrin and Estrella 1996).

LCA was used in the 1998 stock assessment (Lawton *et al.* 1999; Pezzack *et al.* 1999)which provides references to the methodology. As noted in that document the LCA method assumes an equilibrium condition with constant recruitment.

E/R Analyses

Female lobsters have a complex reproductive pattern and non-continuous growth, factors that are not easily accommodated by traditional dynamic pool models (Beverton and Holt 1957). The egg per recruit analysis is based on the size-structured egg and yield per recruit model developed by Josef Idoine and Paul Rago (NMFS) and used in the SAW 22 assessment (ASMFC assessment 2000; 22nd SAW 1996). The model is based on earlier work by (Fogarty and Idoine 1988) and is described in detail in the 22nd SAW report and (Pezzack *et al.* 1999).

RESULTS AND DISCUSSION

Trends in Landings

1890-1980

Commercial lobster fishing began in the mid-1800s and annual lobster landings in the Gulf of Maine were first recorded in 1893. Landings peaked in 1898 at 12,995 metric tons (t) and were followed by a decline in landings, dropping to 1,600t in the early 1930s (Figure 8). Concerns were raised as early as 1872, when a decline in the average size in the catch was first observed in nearshore catches. Over the next 50 years, numerous Government Commissions reviewed the decline and recommended changes in regulations in an attempt to stop further declines. The landings remained low (1600-3000t) during the 1930s and early 1940s. Landings rose following WW II, varying between 2200 and 4500t (averaging 3334t) until the 1980s. Landings increased throughout the 1980s as part of a western Atlantic wide pattern that saw landings increase over the entire lobster's range. LFA 34 landings peaked at 11,000t during the 1990-91 season.

Other regions followed a similar trend in the early part of the century with major declines during the late 1890s to mid 1920s followed by fluctuations through to the 1970s (Figure 8).

1980-2000

Landing data since the 1980's are expressed on seasonal rather than annual bases to better reflect the biology and true nature of the fishery. During the 1980's LFA 34 landings increased steadily and peaked in 1990-91 at 11,071t. (Figure 9) Landings were down in 1991-92 and 1992-93 at 8876 and 8916 t respectively. Landings remained between 10,314 and 11,890 between 1993-94 and 1997-98, then rose to 13,004 in 1998-99 and 12,958 in 1999-00. The 1990-2000 landings were 3.6 times the average for the 1947-80 period.

The increase in landings observed in LFA 34 during the 1980s was part of a wide scale increase observed over most of the range of lobsters in the western Atlantic. Figure 10-12 and Table 3-4 shows the recent trends in the major fishing areas. The overall trends were for increased landings during the late 1970-80's peaking in most areas in the 1990-91 period. Many areas have since declined including parts the large Southern Gulf of St Lawrence fishery, Quebec, Newfoundland, Cape Breton and South Shore of Nova Scotia. Southern New England and the Eastern Shore of Nova Scotia have reached a plateau and the Canadian and American Gulf of Maine portions have continued to increase. The latter is due in part to the recent increases observed in Maine and the Bay of Fundy areas which were not as affected by the increase in the 1980's.

Most areas approached or exceeded the historic highs of the 1890s though it was done with greater effort and over larger fishing grounds. The exception is the Atlantic coast of Nova Scotia that peaked at levels lower *then* the last upswing in the 1950's (Figure 8, 11).

The cause of the wide spread increase is not known but its wide scale affect suggests an environmental and or ecological component (Campbell *et al.* 1991; Elner and Campbell 1991; Pezzack 1993; Drinkwater *et al.* 1996). If the abundance trends are related to large-scale events then the reversal of the landing trends in many areas is one of concern for those areas that are still high. Increases were observed earliest in the warmer water areas of the southern Gulf and Massachusetts and these have show recent declines. Marginal areas such as Newfoundland and the Eastern Shore of Nova Scotia have also declined. In a general decline it would be such areas that would likely show downturns before the most productive areas.

Recent predictions for the US fishery from a group of Maine scientist of a potentially large-scale recruitment signal in the early benthic recruitment period (Appendix 3) suggest the first signs of a decrease in recruitment in the Gulf of Maine. Limited benthic recruitment sampling in the lower Bay of Fundy shows a reduction in settlement strength in the mid-1990's consistent with the pattern in lower Maine. However, benthic sampling in the late 1990's suggested that this might have a short term effect in the Bay of Fundy. No data exist for the SW Nova Scotia region.

Seasonal trends

The fishery is dominated by the fall landings with up to 50% of the seasons landings occurring in Nov/Dec., (Figure 13) January represents between 10-20%, February generally less than 5%, March 5-10%, April 10-20% and May 20-30%. No strong trends exist over the 19 years of data present, but there are indications of a trend to higher Dec, Jan and Feb landings over the last 10 years and lower April, May percentages.

Spatial Distribution of Landings

Statistical districts

On a sub-LFA scale landings can be examined by Statistical Districts (S.D.). These landings are based on data from port of landing and thus do not provide information on where the lobsters are caught.

Landings by Statistical district reflect the strong landings during the 1980's across the entire LFA with the largest absolute increases in S.D. 32-34 (Figure 14 Table 5)). On a relative scale comparing landings to their 1981-82 levels, S.D. 32-34 and 37/38 increase between 3-4 times. Landings in S.D. 36 (Digby County -St Mary's Bay - Digby Neck) followed a similar pattern to other S.D. up to 1995-96. Since then it has increase more rapidly than other areas with 1998-99 landings 7x those of 1981-82 (Figure 15). The timing of this increase is consistent with the timing of the recent increases in the adjacent Bay of Fundy landings and those of Maine (Lawton *et al.* 2001).

Midshore

Based on fishermen interviews, prior to the mid 1970s lobster fishing grounds were generally limited to depths less than 30 fathoms. Inshore vessels began exploring further from shore and by the mid 1970s were fishing Browns Bank and German Bank, which has become known as the midshore. This fishery continued to expand with some fishermen fishing the midshore all season, and others fishing it for only part of the season, and moving nearshore when catch rates are higher there. The midshore fishing effort expanded during the 1980s and in 1994 represented approximately 100 fishermen and 10% of the LFA 34 landings. Based on subsequent comments by fishermen it was estimated that during the late 1990s this had increased to 100-200 fishermen and landings represented 20-30% of the LFA's landings.

In the 1998 assessment (Pezzack *et al.* 1999) attempts were made to assign landings to nearshore and midshore areas to allow the size frequencies to be expanded to estimate numbers landed at size. This was done using the S.D. landings (Figure 16) and the information on the distribution and size of the midshore fishery based on fishermen interviews in 1995 (Duggan and Pezzack 1995) and subsequent comments from fishermen (Figure 17).

Data from the logbooks introduced in 1998-99 shows that though the number of fishermen fishing the midshore area was correctly estimated in the interviews, but that they over estimated landings (Table 6). In 1998-99 and 1999-2000 midshore landings represented only 6.7 and 9.4% of the total respectively. The failure of the interviews to correctly capture the level of landings may be due to highly mobile nature of the fishermen many of whom would fish the midshore for only part of the season or fish only part of their gear there. The new estimates of the size of the midshore fishery will affect estimates of exploitation rates and the predicted impact of various conservation measures on the fishery and conservation.

Logbook Grid Data

With only 2 years of logbook data, detailed determination of how fishing patterns change over time is not possible. Table 7 summarises landings, effort and season CPUE (landings/trap hauls) by the grid groupings and maps (Figure 18-22) give a picture of the importance of the various parts of the LFA.

Landings in figure 18-19 show a consistent pattern over the two seasons with landings highest in nearshore areas and low in waters deeper than 100m. The seasonal pattern shows again the importance of the fall and spring with lower values during the winter months. At the resolution presented monthly, movement of effort between areas is not available but future analysis of this question is possible.

Trap hauls in Figure 20-21 show a similar overall pattern as landings and like landings a similar pattern over the two seasons. Unlike landings, the level of trap hauls is more constant over the fall, winter and spring season with the highest effort during the spring season. Higher spring effort is due to a high trap limit in the spring (400 vs. 375 for the fall and winter) an better weather allowing more fishing days.

CPUE is not presented by individual grids but by grid groups (Figure 22, Table 7). CPUE is more uniformly distributed than landings or effort levels. This suggests that the level of effort in the various areas has developed over time to match availability and thus provide a more consistent CPUE. Areas of higher abundance nearshore can support more fishermen while deeper midshore areas with lower abundance supports fewer fishermen. The soak time for the traps may also be a factor with longer soak times being used in the more distant deeper water regions which have lower lobster densities.

The four transect lines based on the grid data show the nearshore to offshore patterns. Landings and effort are highest in the nearshore grids and drop off sharply away from the coast. CPUE levels remain more constant and increase in the LFA 41 portion of the transects in Crowell and Georges Basin (Figure 23).

Issues and uncertainty

Landing levels are a function of abundance, level of fishing effort (trap hauls, SOD, timing of effort and fishing strategy), catchability (environmental, gear efficiency, density, and migrations) and distribution of animals and effort. Changes in any of these can affect landings. Thus landings are not an exact reflection of abundance. Caution must be observed as increasing effective effort or serial depletion of grounds can maintain landings at a high level for a period of time while absolute abundance is declining.

The results of NMFS Groundfish trawl surveys in the Gulf of Main (American Lobster Stock Assessment Report 2000) show the pulse in recruitment observed in the fishery and a higher abundance in the deepwater basins than 20 years ago. There are increased numbers of new recruits with peaks in late 1980’s, 1994 and 1996. Massachusetts Bay region does not follow this trend. Fully recruited females declined between 1984-88 increased until 1994 have since decreased with 1997 being the lowest in the 15 year time series. Recent trends in survey data show a levelling off or decline in numbers with particular areas experiencing large downturns.

Changes in reporting systems in 1996 and 1998 may influence accuracy and completeness of landings. Prior to 1996 landings were based on sales slips which may have missed a portion of the catch sold directly to consumers or sold directly in the USA. The size of the underestimation is not known. Post 1996 landings have been reported by fishermen directly and should be more complete however no analysis has been done to determine completeness or accuracy of reports. Thus increases observed since 1996 must be viewed in light of the change in reporting methods.

Size Structure

Historical Sizes

Size information does not exist for most of the history of the fishery, so information on historic size structures is based on market reports, opportunistic observation and comments by fishermen and scientists. Early records within the Gulf of Maine indicated that the average size of lobster marketed in 1890s was greater than 2.5 lb. (approx. 113mm CL). The average size of lobster in these areas today is 1.1 lb. (87mm CL). Concerns were raised as early as 1872, when a decline in the average size in the catch was first observed in nearshore catches.(Venning 1873; Rathbun 1884)

Landings Size Structure and Molt Groups

Previous analysis indicated 70% of the catch was in the first molt group and that that had been relatively constant over the 1982-1996 period. These were based on a smaller number of at sea samples with poor spatial coverage, and landings from Statistical Districts with estimates from interviews as to the proportion in nearshore and midshore areas (Figure 26).

The catch in LFA 34 is predominated by the first molt group (18,064,779; 84.0% of catch in 1998/99; 19,935,312; 83.8% of catch in 1999/00). (Table 8, Figure 24) While catches in LFA 41 is dominated by lobsters in the 3+ molt group (>110 mm) (277,168, 56% of catch in 1998-99; 325,580, 51.2% of catch in 1999-2000). (Table 8, Figure 25) Catches in combined LFA 34-41 landings are dominated by lobsters in the first molt group (82.4% and 82.1% in 1998-99 and 1999-2000 respectively). In LFA 34 only 4.0% of the catch in 1998/99 (3.9% in 1999/00) was represented by lobsters that had survived through 2 molts since their entry into the catchable size. The 110+ molt group is fully mature and contains many females that have already bred once.

Logbook data showed that the estimates of landings used in the 1998 assessment overestimated the size of the midshore landings. The lower, but more accurate estimates of landings from the midshore region that contains a higher proportion of larger animals than the nearshore areas, resulted in an overall higher estimate of the proportion of the catch in the first molt group (1998 estimate 70%; 2001 estimate 84%).

The majority of the LFA 34 landings at all sizes occurs in the fall (Nov-Dec), but during the winter period (Jan-March) there is a higher proportion in the larger sizes. This may be due to greater effort in deeper water during the winter where larger sizes are more common.

The long-term time series of size frequencies from Port Maitland shows trends in the percentage of the catch in the first 3 molt groups (Figure 27). During the 1944-45 season the first molt group made up 82% and 73% of the catch in December and May respectively. This percentage increased over the time series and reached 96% and 90% in 1968-69. The fishery at this time was more restricted to shallower nearshore, and used fewer traps than the fishery of the later time period 1981-2000. At the start of this second time series the percentage in the first molt group was 79% and 61% for the December and May samples. The lower values than 1968-69 may reflect a different portion of the population being fished as fishing grounds expanded outward with new vessels and gear. The proportion in the first molt group increased over the 1981-2000 period to 89% and 90% in the December and May period in 1998-99. The values are more variable during this second time period possible reflecting the wide grounds being sampled with more variations in the sizes available in the different areas.

The historical size sampling data suggest that the traditional nearshore have been heavily exploited for at least 50 years and likely since the early 1900s.

Distribution of Molt Groups

Figure 28-30 shows the distribution of lobsters landed in each of the 3 molt groups. The maps show that the first molt group (81-94 mm) dominates the landings and is concentrate in the nearshore regions. Numbers in the second molt group (95-109 mm) are much lower and show a similar distribution but are also found in significant numbers further from shore and LFA 41 west of the Browns Closed area. Numbers landed in the third molt group (110+ mm) are at very low numbers with the highest landings in the deepwater portion of LFA 34 inside of Jordan Basin and the Lobster Bay-Seal Island area. In LFA 41 the highest landings of Molt group 3+ animals are in the Corsair Canyon area of Georges Bank and the area west of Browns bank. The presence of mature animals in nearshore areas indicates that spawning likely occurs in all areas and is not concentrated in the offshore regions as some have previous suggested.

Issues and uncertainty

Recent improvements in allocation of sampling effort based on previous years log book data and special funding for increased sampling has allowed for the first truly LFA wide picture of size structure. Even so there are still gaps and weaknesses in the coverage particularly in the deepwater areas further from the coast. The present level of sampling though low as a percentage of the actual catch is still expensive to operate. New methods are needed to help supplement the at-sea sampling and allow for greater spatial and temporal coverage.

The grouping of at-sea samples is based on depth with additional breakdowns along the coast to correspond with past assessments based on Stat Districts. Different groupings of the grids may yield slightly different results. To test this however greater coverage of the sea samplings may be needed.

Fishing Mortality and Exploitation Rate

Length-based cohort analysis (LCA)

Application of the LCA approach for LFA34 in the 1998 assessment generated substantially lower estimates of Fishing Mortality (F) and Exploitation Rate (A) than were provided in earlier fishery assessments and used by the FRCC in their review of the Atlantic lobster fishery (FRCC, 1995). The molt group comparison techniques used in those assessments provided exploitation rate estimates in the range 60-85%. Estimates provided by Pezzack *et al.* (1999) from LCA range from between 50-66%.

LCA of the LFA 34 1998-99 and 1999-2000 data gives F=1.14 or an exploitation rate of 68% (Table 9). Including data from LFA 41 gives estimates of F=0.89 – 0.98 or 59-63%. These values are higher than the last assessment but based on a more accurate picture of the landings and size frequencies.

The last assessment indicated that nearshore exploitation rates remained relatively constant through the 1980s and 90s in spite of increased abundance and a shift of part of the effort to the midshore area. Thus the fishery has been able to respond to increased abundance and maintain the exploitation rate at a high level.

In contrast to the nearshore, which has been exploited for over 100 years, the deeper water midshore was first fished extensively in the early 1980s (based on fishermen and fishery officer interviews). Thus exploitation on this portion of the population has increased significantly from the pre 1980s level. The additional pressure on these previously lightly fished areas needs to be considered when viewing the overall estimates of exploitation rates.

Issues and uncertainty

While LCA had been used routinely in US lobster assessments, the 1998 assessment cycle represented its first widespread application in Canadian lobster fisheries. The model assumes an equilibrium condition and is there for affected by changing recruitment levels. To reduce this problem single year estimates are not made but values are based on multi year averages.

However, comparison of the LCA results with those from other F estimation approaches (Leslie analysis, molt group comparison, mark-recapture studies) in other LFA's has indicated some robustness and comparability in the estimates. The F and A estimates for the LFA 34 are consistent with general results from the first application of the LCA approach in other lobster fishing areas.

Caution must be used in applying this method to the combined nearshore, midshore LFA 34 and offshore LFA 41. These fisheries have different management and fishing patterns and histories of exploitation. While it is clear the nearshore has been heavily exploited for over a century it is not clear at what stage or level of exploitation the midshore or offshore are at. The analysis done here does not take into account stock relationships or size and has simply pooled the landings. A simple example of the problem is that prior to 1980 with no midshore fishery, calculated exploitation rates would have been very high based only on the nearshore landings but as the fishery expanded outward exploiting larger animals in previously unfished areas the apparent exploitation rate would decline.

Considerable work has been undertaken since 1998 to determine the appropriate spatial and temporal resolution of catch size structure needed to accurately translate landings to estimates of removals from the fishable stock. The recent ability to access the landings database at a finer scale of resolution has been an important tool in refining fishery-sampling strategies, though uncertainties in landings data quality are still being investigated. Additionally, the requirement to be able to sample catches in a cost-effective manner over the longer-term needs to be addressed.

Removal levels of mature females and potential egg production

Estimates of the mature females removed and the egg production they would have produced the following summer can be used to estimate the relative impacts that the fishery in these areas could have on the overall egg production. Areas removing more females would have a larger impact than those removing smaller numbers. In addition, the females can be looked at as immature sizes that have never reproduced and thus contributed nothing to the stock, mature lobsters which at the smaller sizes have, like the immature lobsters, contributed nothing, and at larger sizes have, depending upon size, reproduced one or more times.

This is a measure of the potential impact but does not account for the long term loss or previous egg production. In reality the removal of immature sizes that have never reproduced, and have contributed nothing to the stock would have a much greater long term impact than removal of a larger mature lobsters that had, depending upon size, previously reproduced one or more times.

Removal of females at size for LFA 34 and 41 are given in Figure 31. The level of the LFA 41 catch is difficult to see due to its small size relative to LFA 34. The majority of the LFA 34 catch are immature and thus have never reproduced (Figure 32). In addition large percent of the mature lobsters in the 81-104 mm size range are newly mature and have not reproduced before.

The majority of mature females removed in the LFA 34 / 41(4X) area (Figure 33) are taken in the first two molt groups (81-104 mm CL) in nearshore LFA 34. The majority of these are newly mature and have not reproduced before. Landings were low in LFA 41 during the 1998-99 season and at all sizes more females were removed from LFA 34. However as landings rebounded in 1999-2000 the removals from LFA 41 increased and at sizes > 112mm CL exceed slightly the removals from LFA 34 in these sizes.

Translating removals to removed egg production that year are given in Figure 34 and 35. In the combined LFA 34/LFA 41 (4X) area, LFA 34 accounts for close to 80% of the removed potential egg production, with 50% of the total accounted for by the nearshore fishery. The longer term impact of the nearshore removals is even greater as most of these have not reproduced while the majority of females removed from the midshore and offshore are larger and have reproduced at least once.

Issues and uncertainty

Differences in the size at maturity may vary over the LFA and with depth. The present estimates of the median size is 95-97 mm CL based on work in Lobster Bay and Browns Bank.

The value of eggs may differ with the size of the female or number of previous breeding. In some marine species it has been demonstrated that egg size is smaller and survival is lower in first time breeders.

Simply looking at removal of egg production in that year ignores the longer term potential and past breeding. First time breeders have contributed nothing to the stock but have potential to breed 8-12 times more. In contrast a 150mm lobster has breed 4-6 times making a large contribution to the stock.

V-notching

The logbook data provides the number of lobsters v-notch, as reported by fishermen. In the initial year, 117,727 notches were reported (Table 10). Second year participation rates declined, with 41,209 notches reported. V-notching levels in 1999-2000 were significantly lower than in the previous year and concentrated in a few areas. There were fewer participants but with similar levels of v-notching for those who continued to notch.

The logbooks allowed determination of v-notch patterns and numbers. Figure 36-37 shows reported number of v-notches done by grid by season. In both years the majority of the v-notching occurred in the spring and in nearshore areas where the bulk of lobsters are landed. Two possible reasons for the higher spring v-notching rate are a higher catch rate of berried females in the spring and more time to notch in the spring due to a lower overall catch rates and more favourable weather. The eggs per recruit model assumes a constant catch rate of berried females and v-notching rates over the season. Adjustments will be needed for future assessments to account for the observed seasonal pattern in v-notching.

Observations during the at sea sampling should provide an independent indication of v-notching levels, however there was difficulty in identifying and classifying v-notches during the first year making the data unreliable. However there was a very low number of v-notches reported rate in the at sea samples.

While there is no way of estimating directly what percentages of the berried females caught were notched, it is possible to determine if the estimate used in the model is in the correct range. Based on the expanded landings data fishermen v-notched 1.1% and 0.3% of the total legal size females seen by fishermen in their traps in 1998-99 and 1999-2000 respectively (Table 11). Expressed as a percentage of mature sizes only, it would be 4.8% and 1.4%. As a percentage of the berried females seen in the catch as estimated from the at sea samples, 36.4% and 14.3% were notched in the two seasons. Estimates of berried females should be used with caution, as numbers per sample are generally low thus subject to greater error when extrapolated to the entire fishery. Also berried females unlike landed catch may also be recaptured and thus counted more than once.

E/R Analyses

In November 1995, the Fisheries Resource Conservation Council (FRCC) presented a review of the conservation status of the Atlantic lobster fishery (FRCC, 1995). They observed that the present fisheries were operating at high exploitation rates, harvesting primarily immature animals and concluded that this did not allow for adequate eggs per recruit.

In December 1997, the Minister of Fisheries and Oceans issued a directive to Atlantic lobster fishers to implement new conservation measures, over a period of 4 years, which would achieve a doubling of eggs per recruit from current levels.

Regulation change	LFA 34	LFA 41
V-notching program & prohibition on possession of V-notched lobsters	Fall 1998	Fall 1998*
Minimum size increase from 81 to 82.5 mm	Fall 1999	Fall 1999

(* LFA 41 vessels not actively engaged in v-notching of lobsters)

The eggs per recruit values are estimated to be 1-2% of the unfished condition. Low values of eggs per recruit results in a higher risk of recruitment failure over the long term under varied environmental and ecological conditions.

Subsequent to the last assessment, a default conservation management plan for LFA 34 proposed to introduce a maximum size on female lobsters. Industry challenged the science assessment of this conservation approach, listing as major concerns the differential impacts it would have on fleet segments, and the potential for relocation of fishing effort in some LFAs, that would reduce its overall effectiveness.

Given the recent catch history in LFA 34, and uncertainty over the final realised benefits of default measures, Industry has been reluctant to adopt additional conservation measures.

The midshore has been an area of concern because it represents an expansion of the fishery into a portion of the stock previously not fished extensively. This unfished portion of the population has a higher percentage of mature animals and may have served as a source of recruitment and acted as a buffer to the low eggs per recruit in the nearshore areas and during past periods of poor recruitment. This may be part of the reason for the higher stability of landings in the Gulf of Maine relative to other lobster areas.

Population simulation models indicate that the contributions of a small portion of the population with a low exploitation rate that provides recruitment to a larger portion of the population can maintain the larger portion even when it in exposed to very high exploitation rate. However if high exploitation is applied to both portions of the model populations, a collapse of both may result. The greatest benefit and stability is obtained with a balanced approach in each area.

No new e/r analyses have been undertaken for this assessment because there has been no significant changes in the estimate of exploitation rates. In the previous assessment, e/r analyses were produced using two estimates of exploitation rate, which provided a broad range of projected benefits. Significant increases in minimum size (if this were adopted as the sole approach) were estimated to be required, beyond 86 mm CL, which by itself provided only an approximate 55-75% increase at an exploitation rate of 50 and 64% (Pezzack et al, 1999). Management measures that included a move to then US minimum size, 83 mm CL, were projected to require additional measures (e.g. maximum size regulations; v-notching) to achieve the target doubling (discussed by Pezzack et al, 1999).

With the current minimum size of 82.5 mm CL and an assumed 50% rate of v-notching, 35-45% of the required doubling of eggs per recruit would be obtained. An increase in minimum size to 82.5 mm CL by itself is estimated to provide a 20-25% increase. With 50%, v-notching a significant increase in minimum size only to 87 mm CL or inclusion of a maximum size of 127 mm CL or a combination of measures such as 85 mm CL and a maximum size of 133 mm CL would be required to reach the doubling of eggs per recruit. If the 50% v-notching level is not reached and maintained, additional measures would be required. Given the lower observed v-notching rate the actual percentages obtained to date would be in the range of 25- 35%.

Issues and uncertainty

One of the management measures included in the DFO default conservation plan was the imposition of a maximum size regulation on female lobsters, scheduled for the final year of the conservation plan. During the period since the last stock assessment lobster fishers, particularly those in LFA 38 and LFA 34, have raised significant questions on realised benefits from adopting this conservation management approach. Projected benefits of a maximum size measure, as developed through e/r modelling of the fishery as a whole, does not recognise the potential differential effects on segments of the fishing fleet that have directed fisheries for large lobsters, nor potential for redistribution of fishing effort to inshore grounds by fishers displaced by such a management measure.

General issues and uncertainty

Resource management of lobsters in the Gulf of Maine is complicated by structural complexity inherent in the lobster population itself, and that imposed by multiple management jurisdictions (2 Canadian Provinces; Federal inshore and offshore management areas; state and federal jurisdiction in the US portion of the Gulf of Maine). The relative importance of intrinsic and extrinsic larval production is not known, though model results suggest local nearshore production may be critical to nearshore recruitment.

Given the recent catch history, and uncertainty over the final realised benefits of default measures in the e/r doubling plan, Industry has been reluctant to adopt additional measures within the current 4-year plan beyond the initial minimum size increase, and v-notching. The proposed maximum size regulation, in particular, is very controversial with Industry due to the differential impacts it would have on fleet segments, and the potential for relocation of fishing effort in some LFA’s, which would reduce its overall effectiveness.

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Tables

Season*	1990 - 1991	1991 - 1992	1992 - 1993	1993 - 1994	1994 - 1995	1995 - 1996	1996 - 1997	1997 - 1998	1998 - 1999	1999 - 2000
LFA 34	11,071	8,876	8,916	10,326	9,692	10,314	10,604	11,890	13,004	12,958
LFA 41	713	609	544	700	717	721	670	622	548	718
Total	11,784	9,485	9,460	11,026	10,409	11,035	11,274	12,512	13,552	13,676

Table 1. Seasonal landings (mt) for LFA 34 and 41, 1990/1991 to 1999/2000

SEASON	Total Samples Taken	# of Males	# of Non-Berried Females	# of Berried Females	# of Lobsters
1998-1999	36	11,874	13,040	176	25,090
1999-2000	94	20,482	23,533	342	44,357

Table 2. Summary of at Sea samples 1998-2000

SEASON	LFA 34	LFA 35	LFA 36	LFA 38	LFA 41	LFA 33	LFA 31	LFA 32	LFA 30	LFA 27	LFA 28-29	Southern Gulf	Quebec	Nfld.	US GOM	S New England
1990-1991	11,071	233	267	498	713	2,602	401	298	151	3,526	168	21,451	3,481	3,080	22,280	6,809
1991-1992	8,876	268	259	512	609	1,921	358	304	167	2,778	150	19,444	3,835	3,232	20,041	5,940
1992-1993	8,916	238	256	471	544	1,699	284	279	132	2,458	104	19,459	3,588	2,623	20,846	5,445
1993-1994	10,326	240	278	522	700	2,007	240	262	130	2,190	104	18,103	2,982	2,639	25,719	6,002
1994-1995	9,692	335	318	659	717	1,439	229	219	126	2,142	107	18,200	3,391	2,545	24,864	6,877
1995-1996	10,314	556	418	600	721	1,812	174	223	90	1,616	74	17,472	3,503	2,380	24,062	8,271
1996-1997	10,604	751	662	546	670	1,771	148	247	80	1,293	52	16,568	2,825	2,185	28,817	8,621
1997-1998	11,890	851	753	695	622	2,100	200	309	70	1,259	64	17,158	3,048	2,017	27,901	8,428
1998-1999	13,004	964	813	806	548	2,112	217	303	70	1,307	55	16,835	2,921	1,909	31,937	7,713
1999-2000	12,958	889	776	741	718	2,053	285	376	48	1,250	46	16,662	N/A	1,786	N/A	N/A

Table 3. Recent seasonal landings (Oct-Sept) by LFA and Region

SEASON	Bay of Fundy (LFA 35, 36, 38)	SW Nova Scotia (LFA 34)	South Shore (LFA 33)	Eastern Shore (LFA 31-32)	Cape Breton (LFA 27-30)	Southern Gulf	Newfoundland	Quebec	US Gulf of Maine	Southern New England
1990-1991	998	11,071	2,602	699	3,845	21,451	3,080	3,481	22,280	6,809
1991-1992	1,039	8,876	1,921	662	3,095	19,444	3,232	3,835	20,041	5,940
1992-1993	965	8,916	1,699	563	2,694	19,459	2,623	3,588	20,846	5,445
1993-1994	1,040	10,326	2,007	502	2,424	18,103	2,639	2,982	25,719	6,002
1994-1995	1,312	9,692	1,439	448	2,375	18,200	2,545	3,391	24,864	6,877
1995-1996	1,574	10,314	1,812	397	1,780	17,472	2,380	3,503	24,062	8,271
1996-1997	1,959	10,604	1,771	395	1,425	16,568	2,185	2,825	28,817	8,621
1997-1998	2,299	11,890	2,100	509	1,393	17,158	2,017	3,048	27,901	8,428
1998-1999	2,583	13,004	2,112	520	1,432	16,835	1,909	2,921	31,937	7,713
1999-2000	2,406	12,958	2,053	661	1,344	16,662	1,786	N/A	N/A	N/A

Table 4. Recent seasonal landings (Oct-Sept) by LFA groupings and Region

STAT DISTRICT	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	TOTAL
32	1,261	1,475	1,636	2,249	2,580	2,951	3,185	2,421	3,297	4,032	2,839	2,724	3,776	3,456	3,728	3,989	4,357	4,211	4,270	58,437
33	929	1,365	1,525	1,772	2,000	2,127	2,109	2,516	2,748	3,291	2,746	2,902	2,795	2,689	3,002	2,748	3,171	3,737	3,844	48,015
34	1,044	1,167	1,421	1,305	1,515	1,707	1,960	2,231	2,403	2,503	2,132	2,108	2,512	2,394	2,039	2,164	2,520	2,966	2,865	38,955
36	148	186	200	187	292	317	399	425	458	501	506	497	515	445	698	868	1,005	1,101	1,006	9,755
37	265	346	351	421	496	561	581	626	546	738	644	683	729	708	831	813	828	973	956	12,097
38	16	20	22	17	16	18	13	8	2	5	8	3	0		16	22	9	16	17	230

Table 5. Recent seasonal landings (Oct-Sept) by Statistical District

SEASON	Old Interview Estimate		1998-99			1999-2000		
	%	value	LFA 34	Midshore	% Midshore	LFA 34	Midshore	% Midshore
Fishermen		100-200	930	177	19%	942	197	21%
Landings (lb.)	20-25% (1999-2000)	5,816,926 – 7,271,157	27,583,426	1,844,307	6.7%	29,084,628	2,723,700	9.4%
Trap Hauls			19,661,015	1,231,163	6.3%	17,981,942	1,303,287	7.2%

Table 6. Comparison of Interview and Logbook estimates of the midshore fishery effort and landings

		Group								
		1	2	3	4	5	6	7	8	Total
98/99	CATCH (KGS)	2,365,181	3,691,212	2,874,683	1,534,654	452,488	96,391	301,697	72,817	**11,389,124**
	HAULS	3,946,106	6,210,196	5,088,983	1,956,836	696,137	181,692	400,305	97,785	**18,578,040**
	CATCH/THAUL	0.60	0.59	0.56	0.78	0.65	0.53	0.75	0.74	**0.61**
99/00	CATCH (KGS)	2,310,191	3,501,544	3,027,851	1,511,673	744,248	86,921	356,687	193,179	**11,732,294**
	HAULS	3,661,603	5,347,106	4,645,020	1,675,703	732,820	152,084	391,778	172,792	**16,778,906**
	CATCH/THAUL	0.63	0.65	0.65	0.90	1.02	0.57	0.91	1.12	**0.70**

Table 7. Summary of catch and effort by grid groupings

(a)

 # Landed per Molt Group for LFA 34

Season	**81 - 94**	**95 - 109**	**110 +**	**Total**
98/99	18,064,779	2,575,720	867,048	21,507,547
99/00	19,935,312	2,925,079	921,074	23,781,466

Percent of Total for LFA 34

Season	**81-94**	**95-109**	**110+**
98/99	84.0%	12.0%	4.0%
99/00	83.8%	12.3%	3.9%

(b)

 # Landed per Molt Group for LFA 41

Season	**81-94**	**95-109**	**110+**	**Total**
98/99	70,634	147,292	277,168	495,094
99/00	104,368	206,212	325,580	636,161

Percent of Total for LFA 41

Season	**81 - 94**	**95 - 109**	**110 +**
98/99	14.3%	29.7%	56.0%
99/00	16.4%	32.4%	51.2%

(c)

 # Landed per Molt Group for LFA 34+41

Season	**81-94**	**95-109**	**110+**	**Total**
98/99	18,135,413	2,723,012	1,144,216	22,002,641
99/00	20,039,680	3,131,291	1,246,654	24,417,627

Percent of Total for LFA 34+41

Season	**81 - 94**	**95 - 109**	**110 +**
98/99	82.4%	12.4%	5.2%
99/00	82.1%	12.8%	5.1%

Table 8. Estimated numbers landed by molt group for LFA 34 and 41 for 1998-99 and 1999-2000 seasons

LFA34 females, 1998-99 fishing season

Terminal F =	0.2
Natural Mortality (m)=	0.125
Tc =	0.45

27/03/01

Length (mm)	Catch (numbers)	Delta-t (y)	Stock Numbers	Mean Number	F/Z	Z	F	F*C
191 - 195	100	1.07	163					
186 - 190	471	1.07	686	419	0.900	1.249	1.124	529
181 - 185	46	1.07	833	807	0.314	0.182	0.057	3
176 - 180	250	1.07	1218	1075	0.651	0.358	0.233	58
171 - 175	563	1.07	1990	1668	0.730	0.463	0.338	190
166 - 170	1367	1.07	3725	2945	0.788	0.589	0.464	635
161 - 165	1321	1.06	5657	4892	0.684	0.395	0.270	357
156 - 160	1304	1.06	7844	7064	0.596	0.310	0.185	241
151 - 155	610	1.06	9600	9169	0.347	0.191	0.066	41
146 - 150	1266	1.05	12291	11410	0.470	0.236	0.111	140
141 - 145	1266	1.04	15348	14327	0.414	0.213	0.088	112
136 - 140	3378	1.03	21046	18559	0.593	0.307	0.182	615
131 - 135	7399	1.02	31745	26407	0.691	0.405	0.280	2073
126 - 130	13467	1.00	50233	40163	0.728	0.460	0.335	4516
121 - 125	17978	0.98	75777	60527	0.704	0.422	0.297	5340
116 - 120	41696	0.95	129304	94648	0.779	0.566	0.441	18368
111 - 115	63132	0.89	210876	147522	0.774	0.553	0.428	27017
106 - 110	137199	0.82	377449	234997	0.824	0.709	0.584	80101
101 - 105	242303	0.77	668569	390531	0.832	0.745	0.620	150336
96 - 100	473714	0.69	1221680	635181	0.856	0.871	0.746	353292
91 - 95	1905060	0.60	3287672	1287456	0.922	1.605	1.480	2818934
86 - 90	3026820	0.52	6627124	2501053	0.906	1.335	1.210	3663114
81 - 85	4454183	0.47	11604086	4182232	0.895	1.190	1.065	4743819
Total	10,394,893			9,673,049	**Wtd.Ave.F =**		**1.142**	11869831
					A=		**0.681**	

Table 9a. Length Based Cohort Analysis Output

LFA34 females, 1999-2000 fishing season

Terminal F =	0.2	27/03/01
Natural Mortality (m)=	0.125	
Tc =	0.45	

Length (mm)	Catch (numbers)	Delta-t (y)	Stock Numbers	Mean Number	F/Z	Z	F	F*C
191 - 195	55	1.068	89					
186 - 190	142	1.068	253	173	0.868	0.950	0.825	117
181 - 185	300	1.067	608	438	0.846	0.810	0.685	206
176 - 180	700	1.067	1438	1040	0.843	0.798	0.673	471
171 - 175	1102	1.067	2813	2186	0.801	0.629	0.504	556
166 - 170	1475	1.066	4780	3937	0.750	0.500	0.375	553
161 - 165	960	1.064	6479	5915	0.565	0.287	0.162	156
156 - 160	2625	1.062	10185	8648	0.708	0.429	0.304	797
151 - 155	800	1.058	12474	11910	0.350	0.192	0.067	54
146 - 150	1156	1.052	15453	14587	0.388	0.204	0.079	92
141 - 145	2790	1.044	20567	18592	0.546	0.275	0.150	419
136 - 140	2958	1.034	26540	24119	0.495	0.248	0.123	363
131 - 135	9508	1.021	40220	33385	0.695	0.410	0.285	2708
126 - 130	17790	1.003	64413	51223	0.735	0.472	0.347	6179
121 - 125	23845	0.980	98004	77971	0.710	0.431	0.306	7292
116 - 120	51365	0.949	164530	121287	0.772	0.549	0.424	21753
111 - 115	75738	0.889	263496	185827	0.765	0.533	0.408	30869
106 - 110	175364	0.824	475752	295128	0.826	0.719	0.594	104201
101 - 105	284173	0.769	820516	484727	0.824	0.711	0.586	166597
96 - 100	597854	0.694	1516467	784785	0.859	0.887	0.762	455449
91 - 95	2420835	0.601	4138996	1613554	0.923	1.625	1.500	3632008
86 - 90	3200338	0.523	7714692	3002858	0.895	1.191	1.066	3410805
81 - 85	5628549	0.472	13963746	4964041	0.901	1.259	1.134	6382011
Total	12,500,421			11,706,329	Wtd.Ave.F =		1.138	14223653
					A=		0.679	

Table 9b. Length Based Cohort Analysis Output

LFA34-41 females, 98-99 fishing season

Terminal F =	0.2
Natural Mortality (m)=	0.125
Tc =	0.45

27/03/01

Length (mm)		Catch (numbers)	Delta-t (y)	Stock Numbers	Mean Number	F/Z	Z	F	F*C
191 -	195	164	1.068	267					
186 -	190	547	1.068	886	576	0.884	1.075	0.950	520
181 -	185	346	1.067	1380	1183	0.701	0.418	0.293	101
176 -	180	547	1.067	2158	1846	0.703	0.421	0.296	162
171 -	175	1509	1.067	4068	3208	0.790	0.595	0.470	710
166 -	170	2818	1.066	7640	6031	0.789	0.592	0.467	1317
161 -	165	4125	1.064	13106	10733	0.755	0.509	0.384	1585
156 -	160	4929	1.062	20199	17306	0.695	0.410	0.285	1404
151 -	155	5127	1.058	28495	25355	0.618	0.327	0.202	1037
146 -	150	8581	1.052	41603	36221	0.655	0.362	0.237	2033
141 -	145	11693	1.044	59806	52079	0.642	0.350	0.225	2625
136 -	140	16959	1.034	86033	74140	0.647	0.354	0.229	3879
131 -	135	22844	1.021	121933	104451	0.636	0.344	0.219	4996
126 -	130	33063	1.003	173197	145603	0.645	0.352	0.227	7508
121 -	125	42601	0.980	240786	199898	0.630	0.338	0.213	9079
116 -	120	75605	0.949	350865	275795	0.687	0.399	0.274	20726
111 -	115	100628	0.889	497906	371297	0.684	0.396	0.271	27272
106 -	110	182401	0.824	742952	501162	0.744	0.489	0.364	66386
101 -	105	290489	0.769	1121282	702735	0.768	0.538	0.413	120079
96 -	100	499764	0.694	1742482	971483	0.805	0.639	0.514	257096
91 -	95	1926530	0.601	3871344	1618657	0.905	1.315	1.190	2292961
86 -	90	3043927	0.523	7267865	2820753	0.896	1.204	1.079	3284757
81 -	85	4464872	0.472	12294757.366	4496164.807	0.888	1.118	0.993	4433797
Total		10,740,070			12,436,677	**Wtd.Ave.F =**		**0.981**	10540031
						A=		**0.625**	

Table 9c. Length Based Cohort Analysis Output

LFA34-41 females, 1999-00 fishing season

Terminal F =	0.2
Natural Mortality (m)=	0.125
Tc =	0.45

27/03/01

Length (mm)	Catch (numbers)	Delta-t (y)	Stock Numbers	Mean Number	F/Z	Z	F	F*C
191 - 195	62	1.07	101					
186 - 190	212	1.07	340	220	0.885	1.088	0.963	204
181 - 185	426	1.07	841	599	0.851	0.836	0.711	303
176 - 180	551	1.07	1546	1232	0.781	0.572	0.447	246
171 - 175	2680	1.07	4612	3089	0.874	0.993	0.868	2325
166 - 170	3907	1.07	9418	7191	0.813	0.668	0.543	2123
161 - 165	5019	1.06	16086	13198	0.753	0.505	0.380	1908
156 - 160	8159	1.06	27030	22279	0.746	0.491	0.366	2988
151 - 155	9056	1.06	40462	35007	0.674	0.384	0.259	2343
146 - 150	14727	1.05	61773	52672	0.691	0.405	0.280	4117
141 - 145	21937	1.04	93652	79542	0.688	0.401	0.276	6050
136 - 140	26711	1.03	134885	116172	0.648	0.355	0.230	6142
131 - 135	40115	1.02	195724	165794	0.659	0.367	0.242	9706
126 - 130	58346	1.00	283590	236165	0.664	0.372	0.247	14415
121 - 125	75985	0.98	400842	330135	0.648	0.355	0.230	17489
116 - 120	128776	0.95	587167	460400	0.691	0.405	0.280	36019
111 - 115	165438	0.89	830124	620145	0.681	0.392	0.267	44135
106 - 110	285160	0.82	1218830	828366	0.734	0.469	0.344	98165
101 - 105	403420	0.77	1763122	1126979	0.741	0.483	0.358	144410
96 - 100	660313	0.69	2609388	1487623	0.780	0.569	0.444	293094
91 - 95	2475930	0.60	5374238	2311355	0.896	1.196	1.071	2652224
86 - 90	3243383	0.52	9077757	3681084	0.876	1.006	0.881	2857727
81 - 85	5655161	0.47	15437007	5632714	0.889	1.129	1.004	5677697
Total	13,285,473			17,211,963	**Wtd.Ave.F =**		**0.894**	11873830
					A=		**0.591**	

Table 9d. Length Based Cohort Analysis Output

	Grid Group								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
1998/99	30,352	42,702	20,592	15,914	1,952	465	4,981	769	**117,727**
1999/00	13,360	8,745	9,466	7,171	836	159	1,314	158	**41,209**

Table 10. Number of lobster v-notched per assessment group as reported from the LFA 34 Catch and Settlement Reports in 1998/1999 and 1999/2000 fishing season

			Reported v-notch as a % of		
	Number v-notched	**# of v-notch /100 Trap haul**	**Total females in traps (landed + berried)**	**Mature Females in traps (mature + berried)**	**Berried females in traps**
1998/99	117,727	0.63	1.1%	4.8%	36.4%
1999/00	41,209	0.25	0.3%	1.4%	14.3%

Table 11. Number of lobster v-notched as reported from the LFA 34 Catch and Settlement Reports in 1998/1999 and 1999/2000 fishing season and notched as a percentage of females caught

Figures

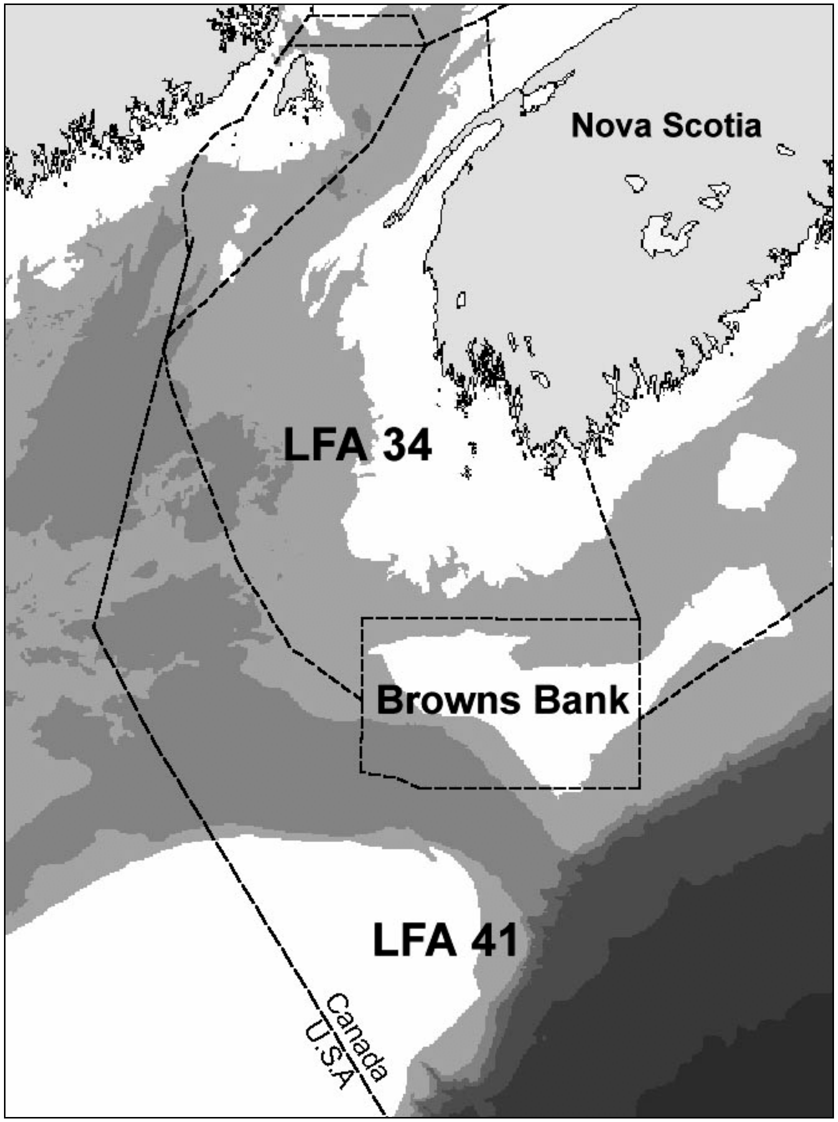


Figure 1. Gulf of Maine/Bay of Fundy map showing LFA 34/41

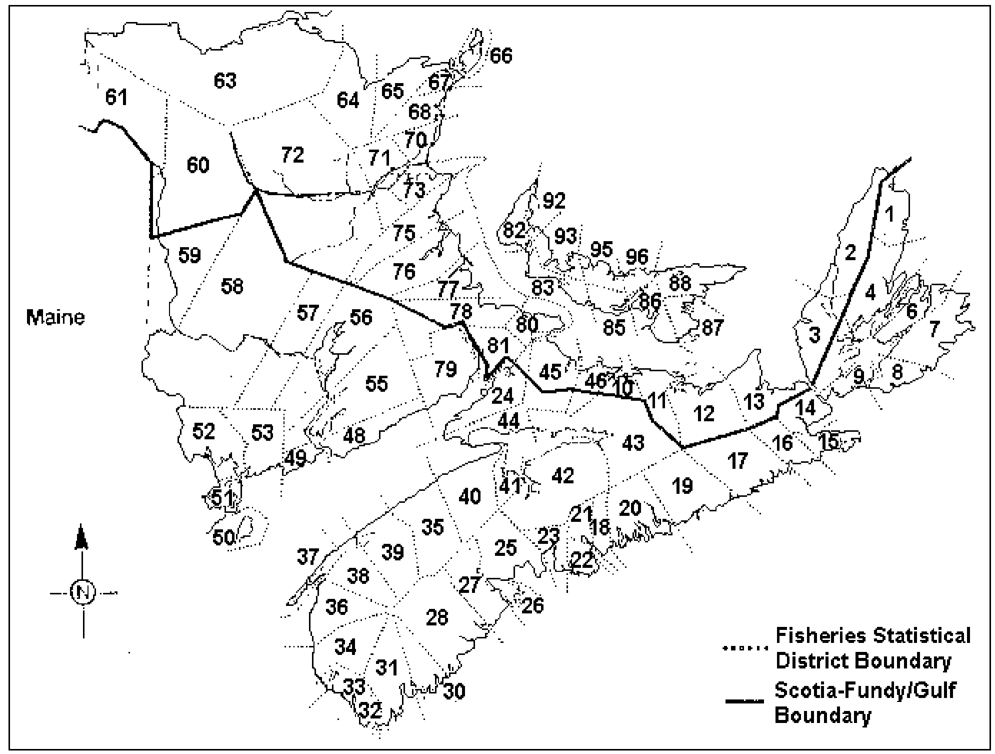


Figure 2. Statistical Districts (S.D.)

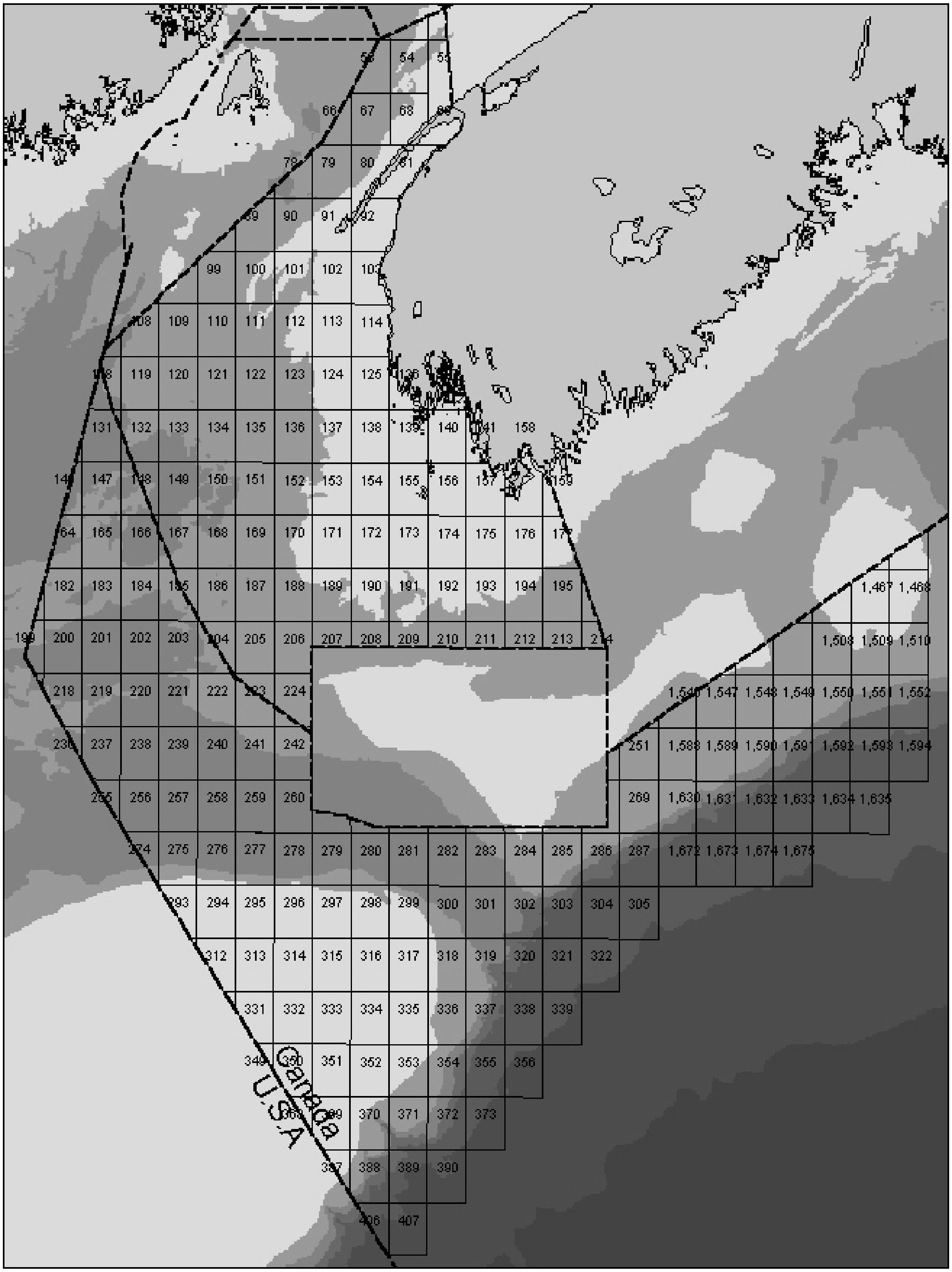


Figure 3. LFA 34 Log Book Grids and LFA 41 data analysis grids

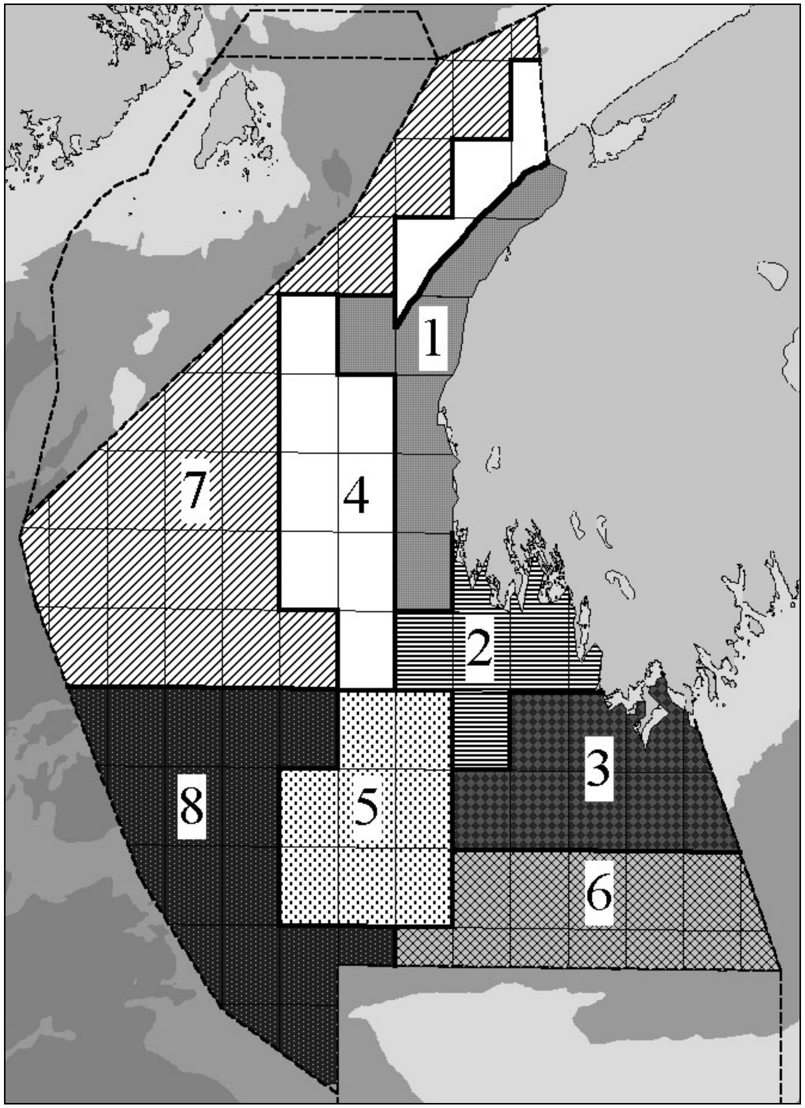


Figure 4a. LFA 34 Grid Groupings

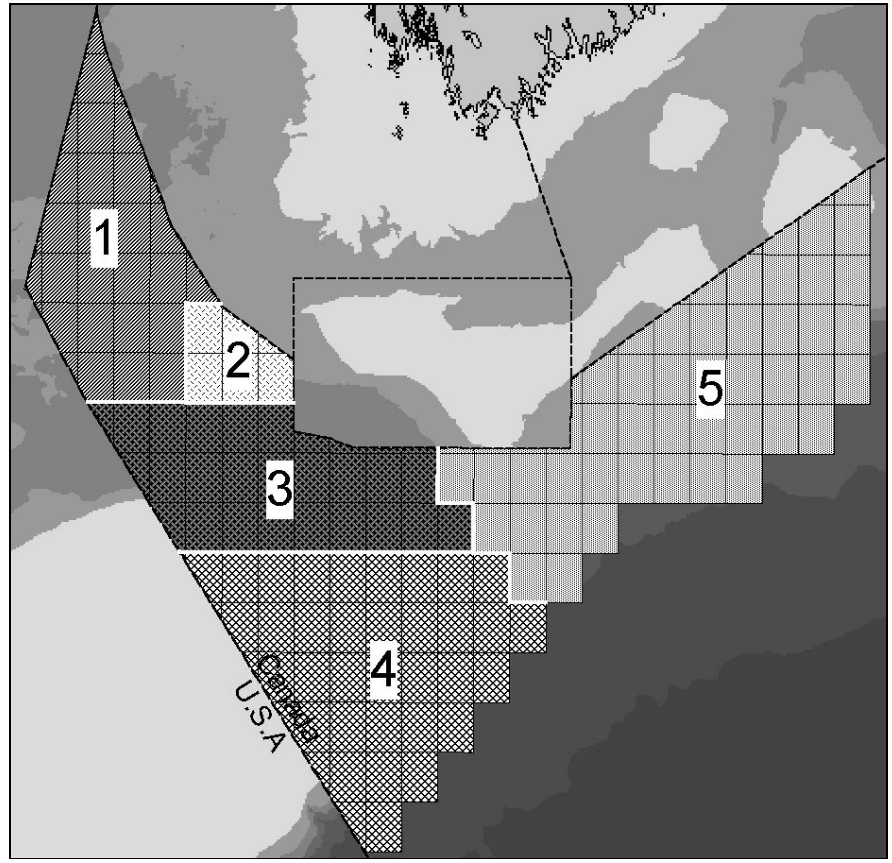


Figure 4b. LFA 41 Grid Groupings (Data reported by lat/long but grouped by grid for analysis)

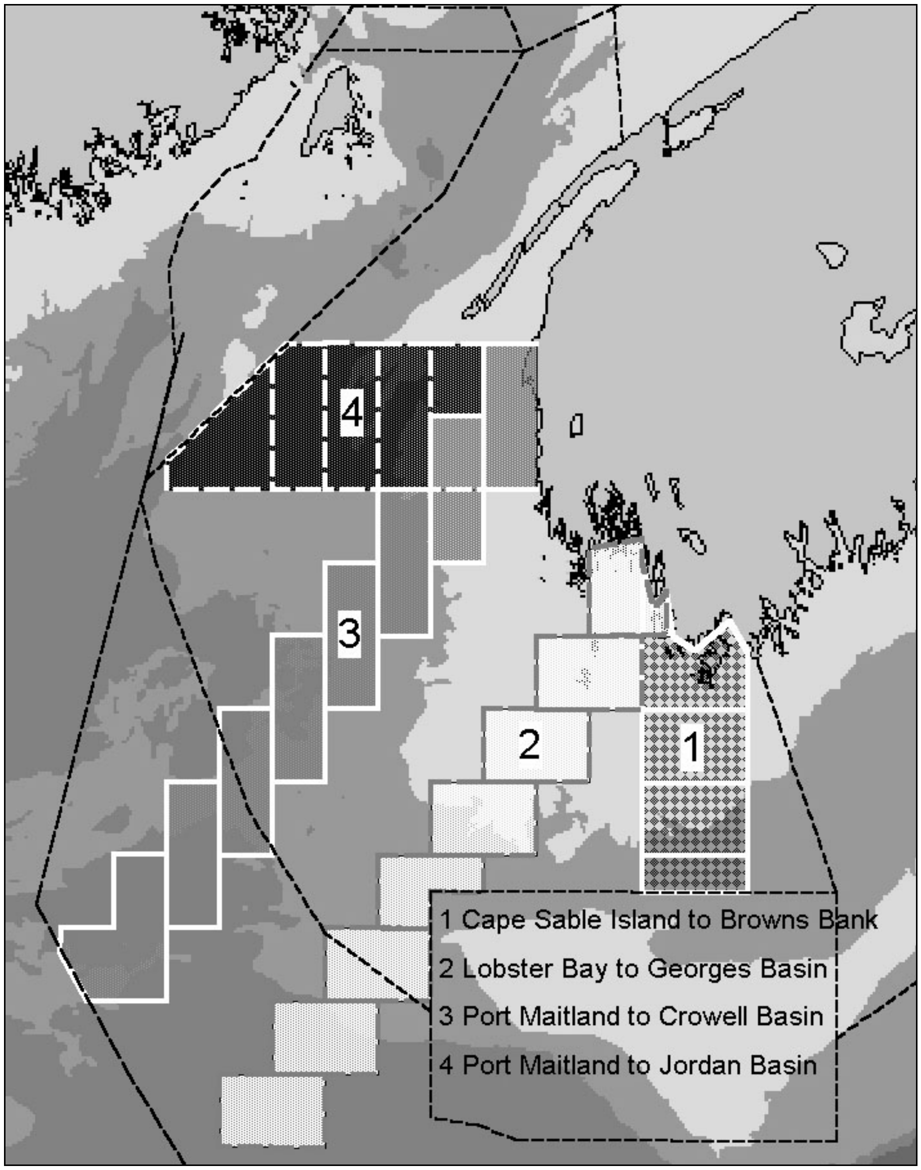


Figure 5. LFA 34/ 41 Grid transects 1 to 4

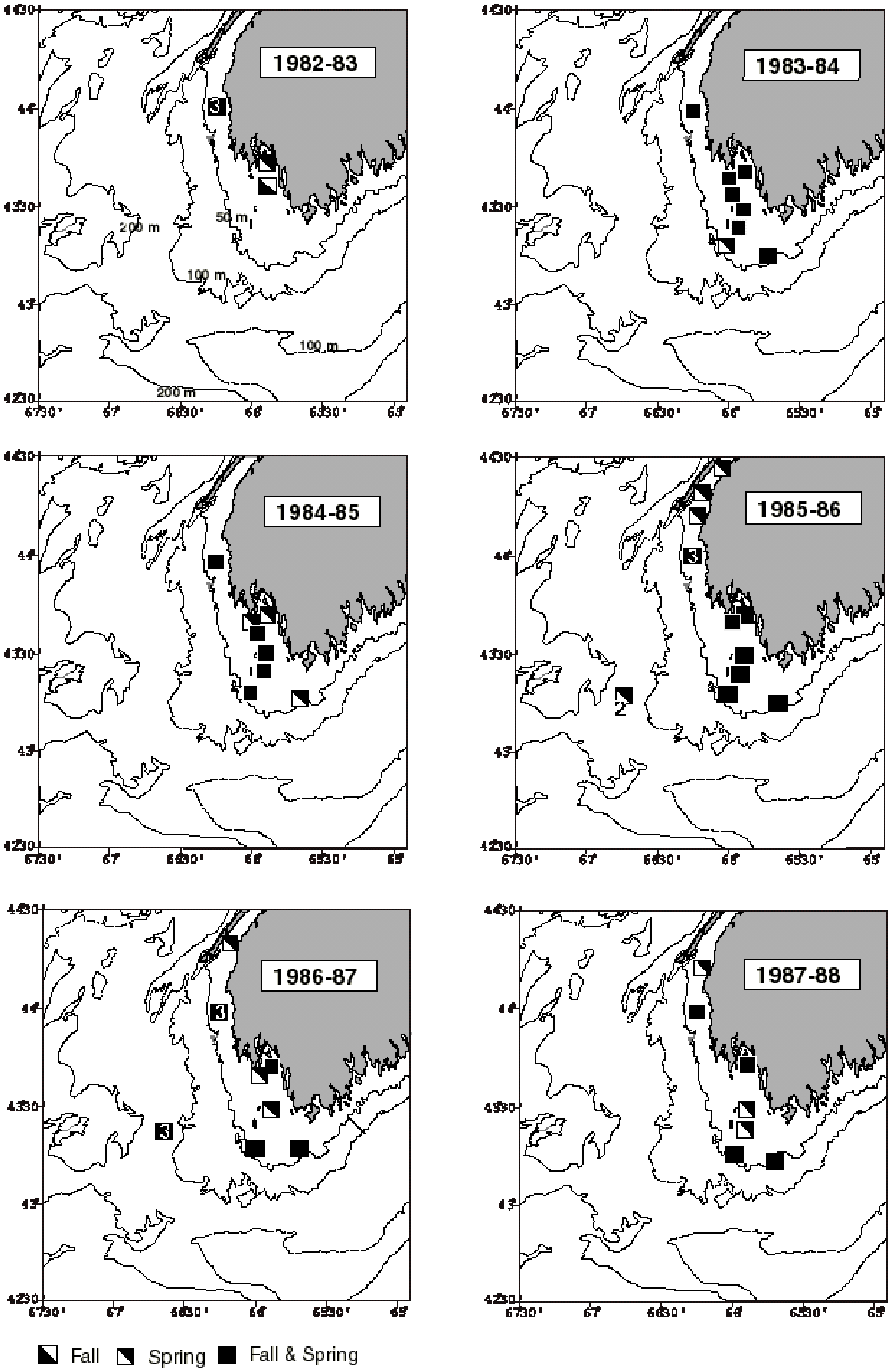


Figure 6a. Locations of lobster at sea samples in LFA 34 from the 1982/83 until 1987/88 season.

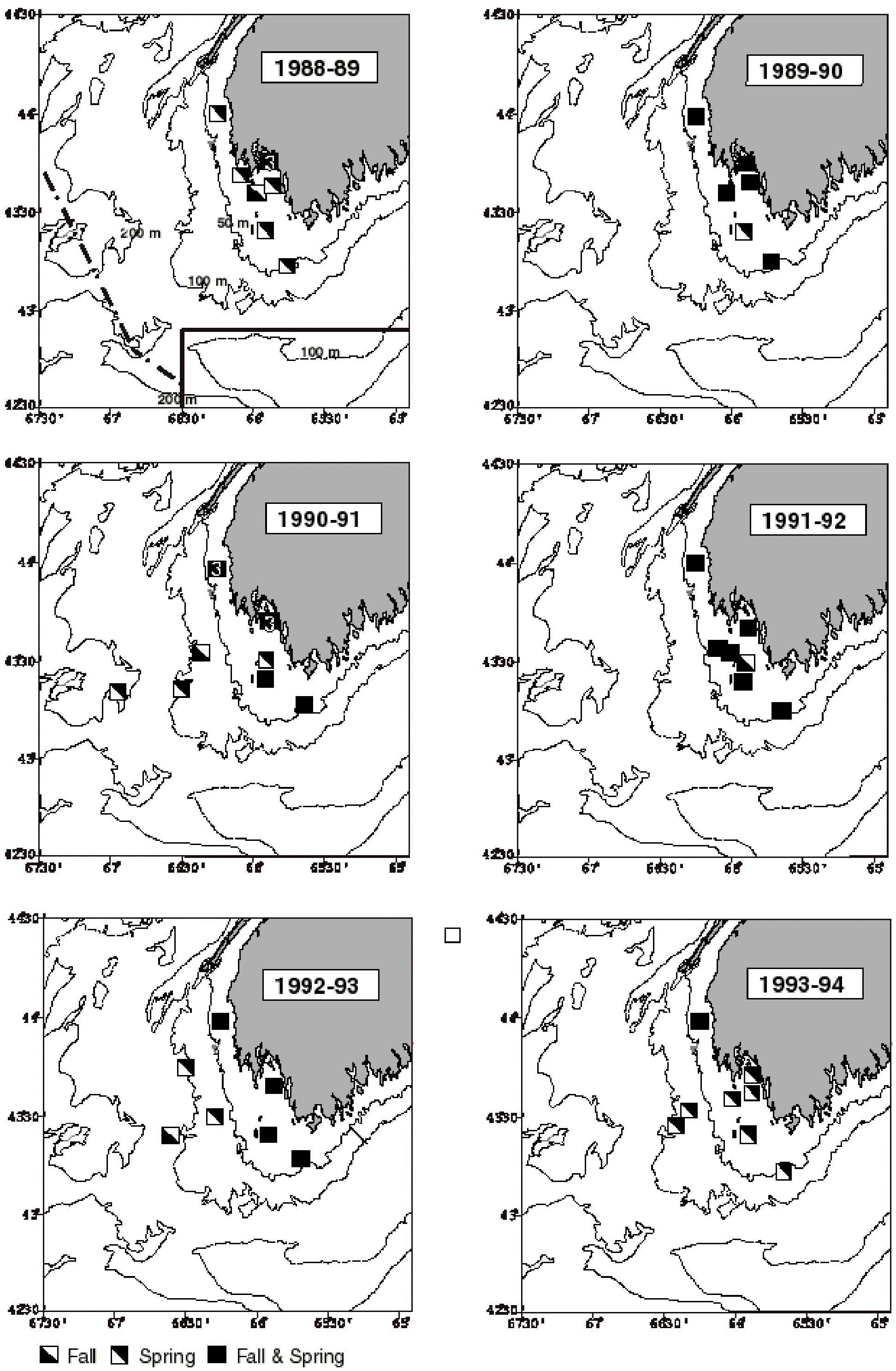


Figure 6b. Locations of lobster at sea samples in LFA 34 from the 1988/98 until the 1993/94 season.

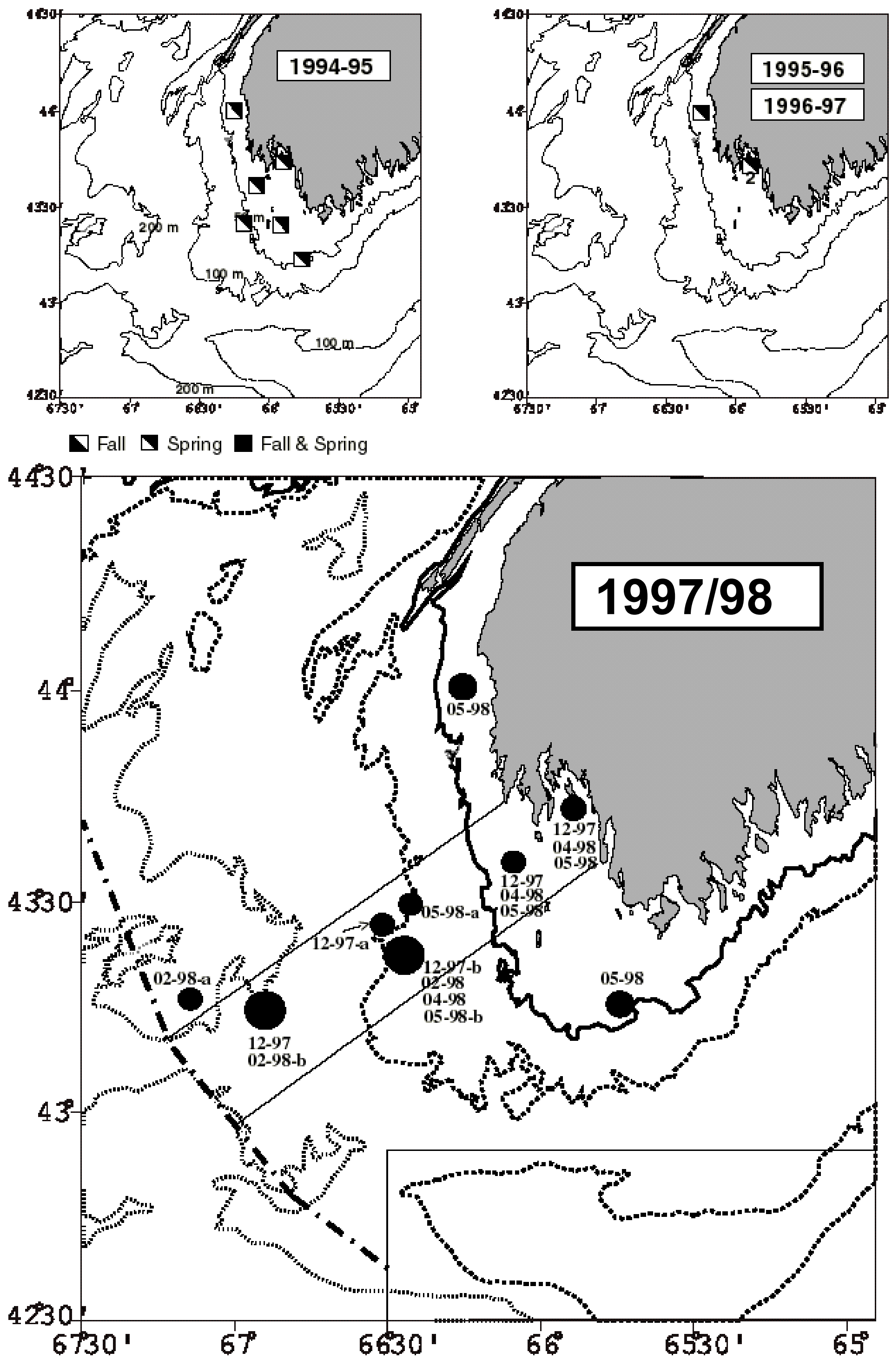


Figure 6c. Locations of lobster at sea samples in LFA 34 from the 1995/96 until 1997/98 season and the corridor sampling strategy implemented in 1997.

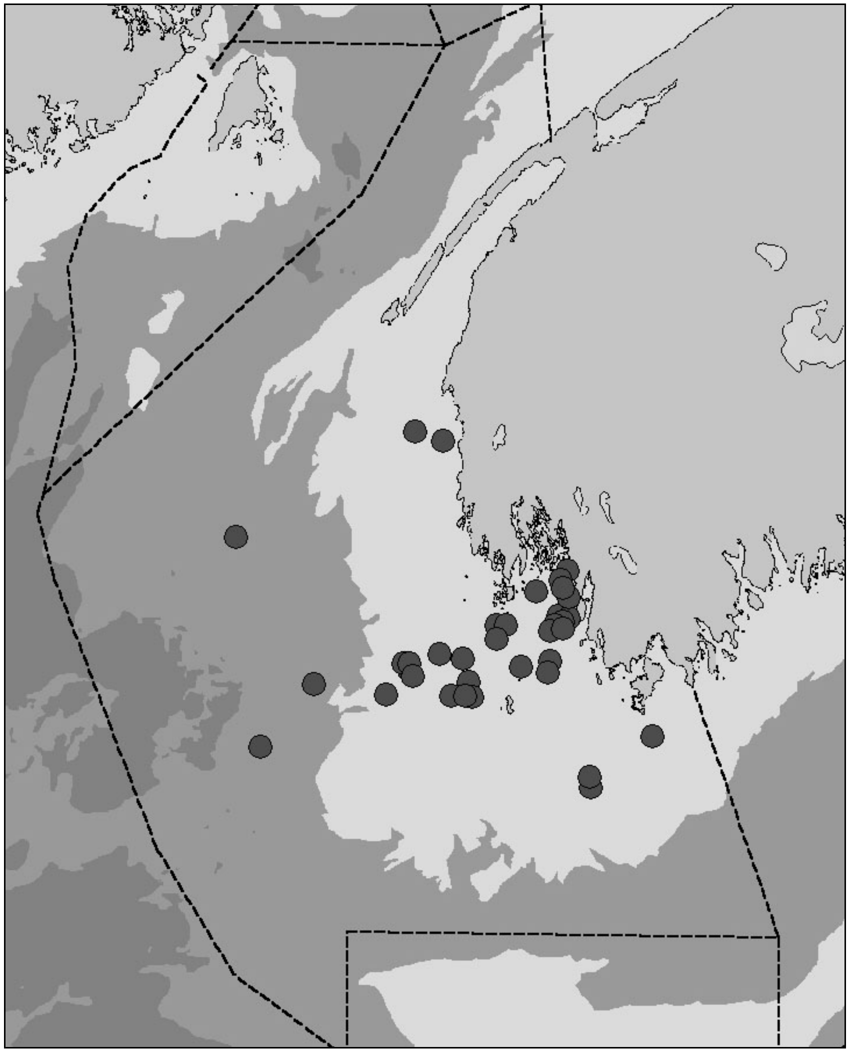


Figure 7a. LFA 34 at sea sampling approximate locations 1998/1999

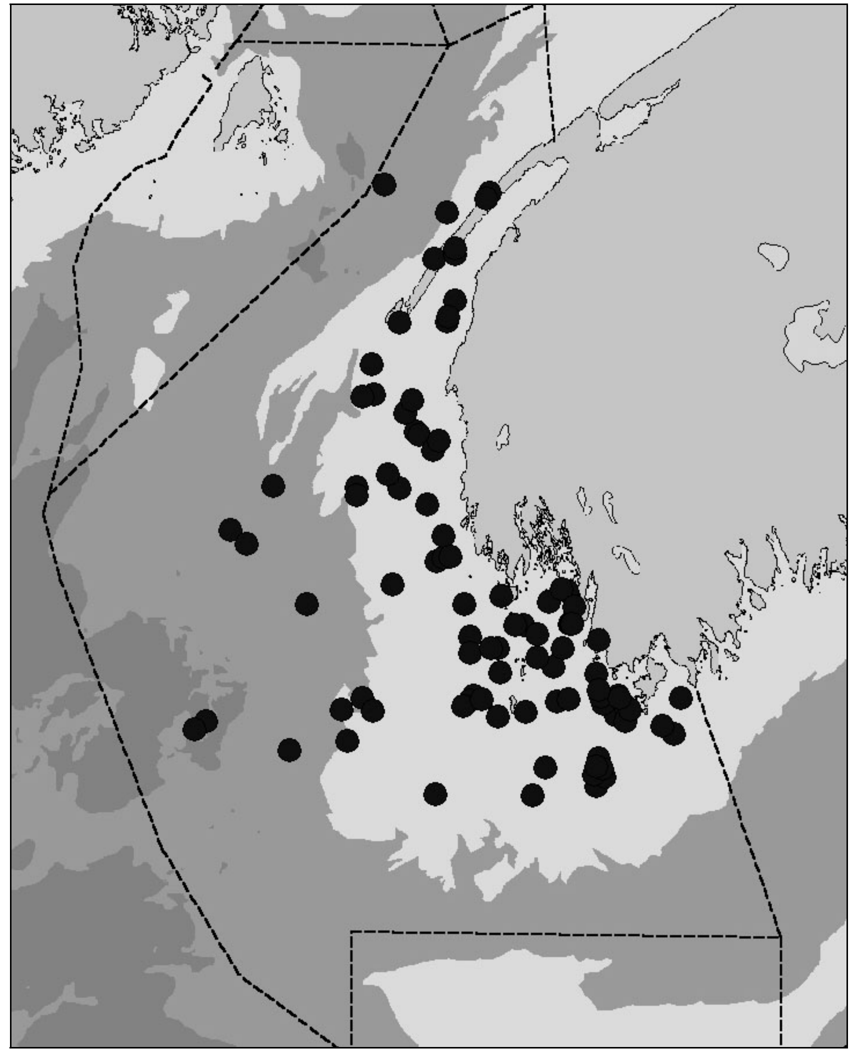


Figure 7b. LFA 34 at sea sampling approximate locations 1999/2000

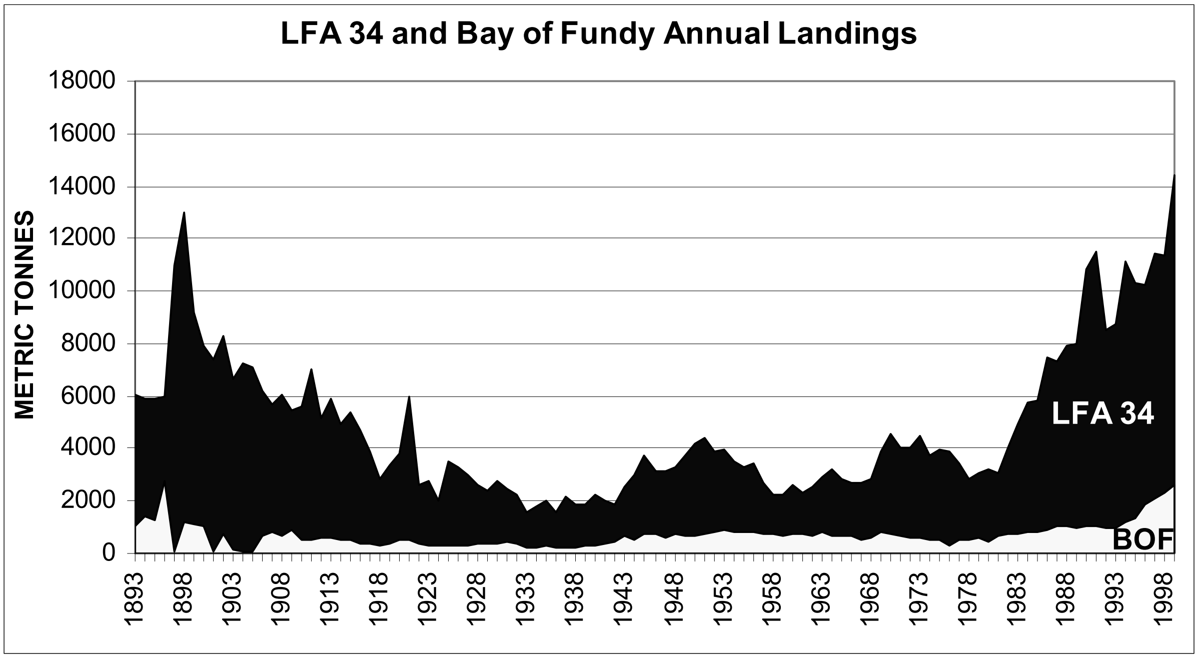


Figure 8a. Historic landings 1893-1999 LFA 34 and Bay of Fundy (LFA 35,36,38)

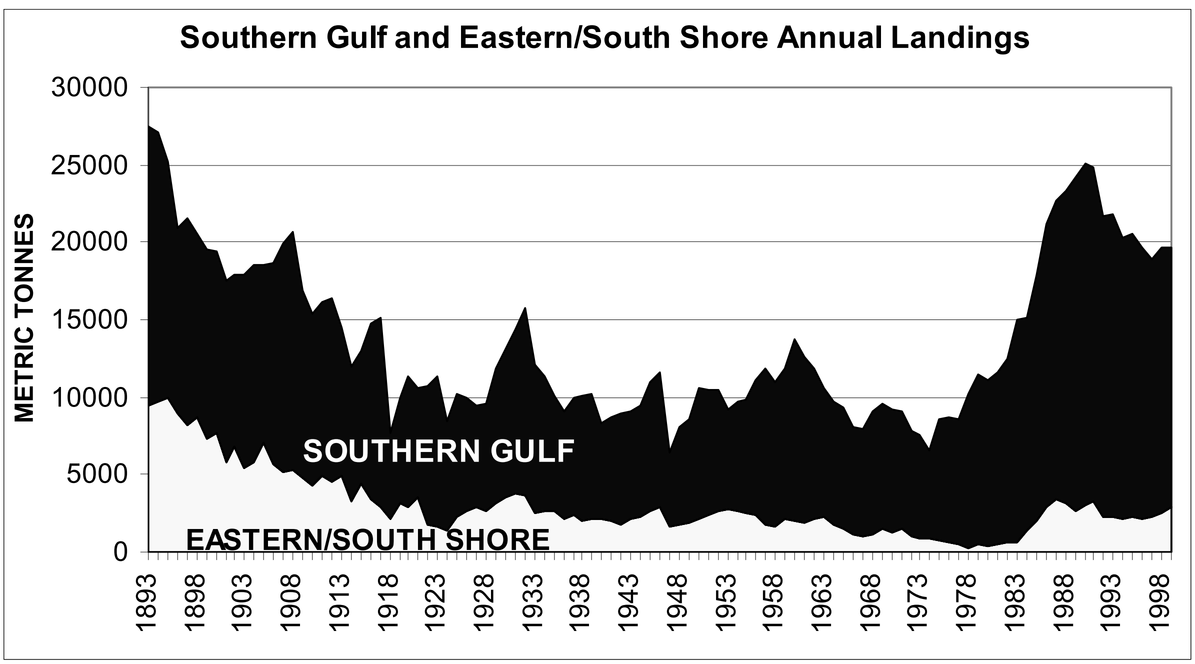


Figure 8b. Historic Landings 1893-1999 Southern Gulf (LFA 23,24,25,26A, 26B) and Eastern/South Shore (LFA 31,32,33)

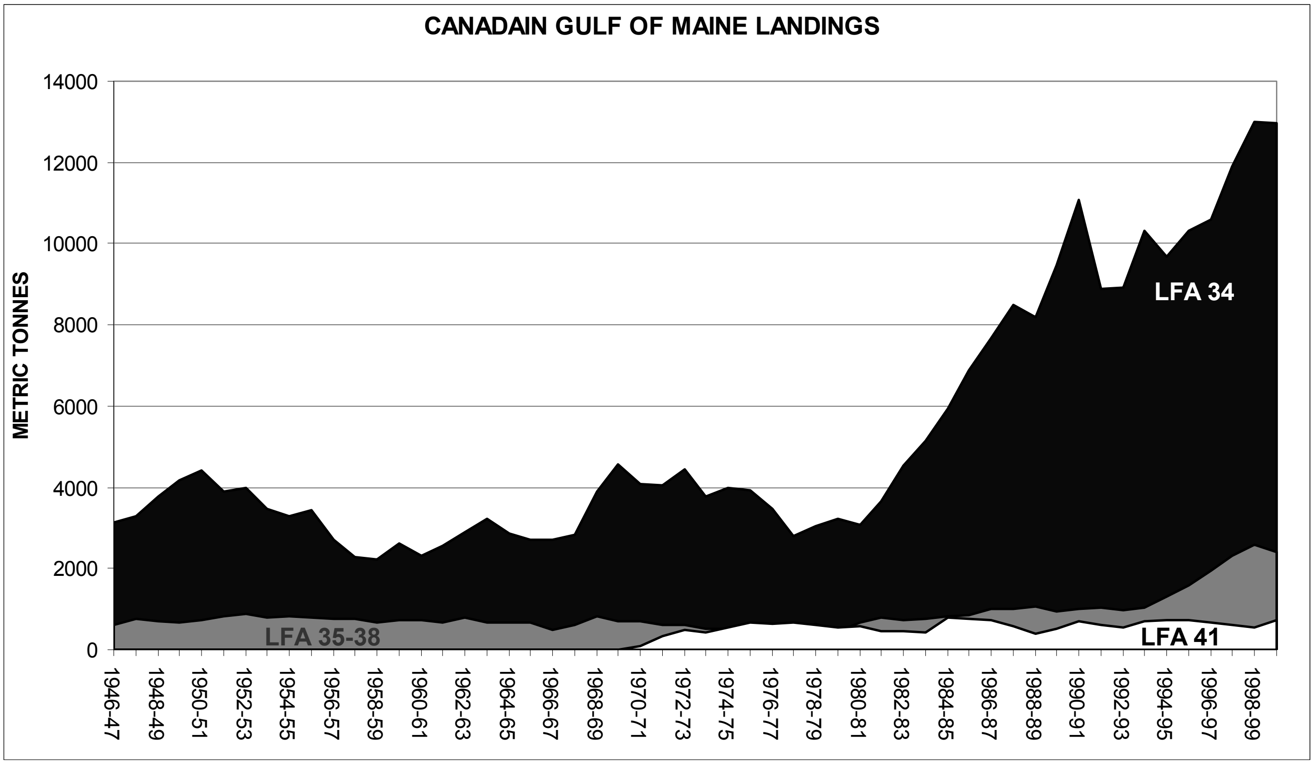


Figure 9: **Seasonal landings LFA 34, 41 and Bay of Fundy**

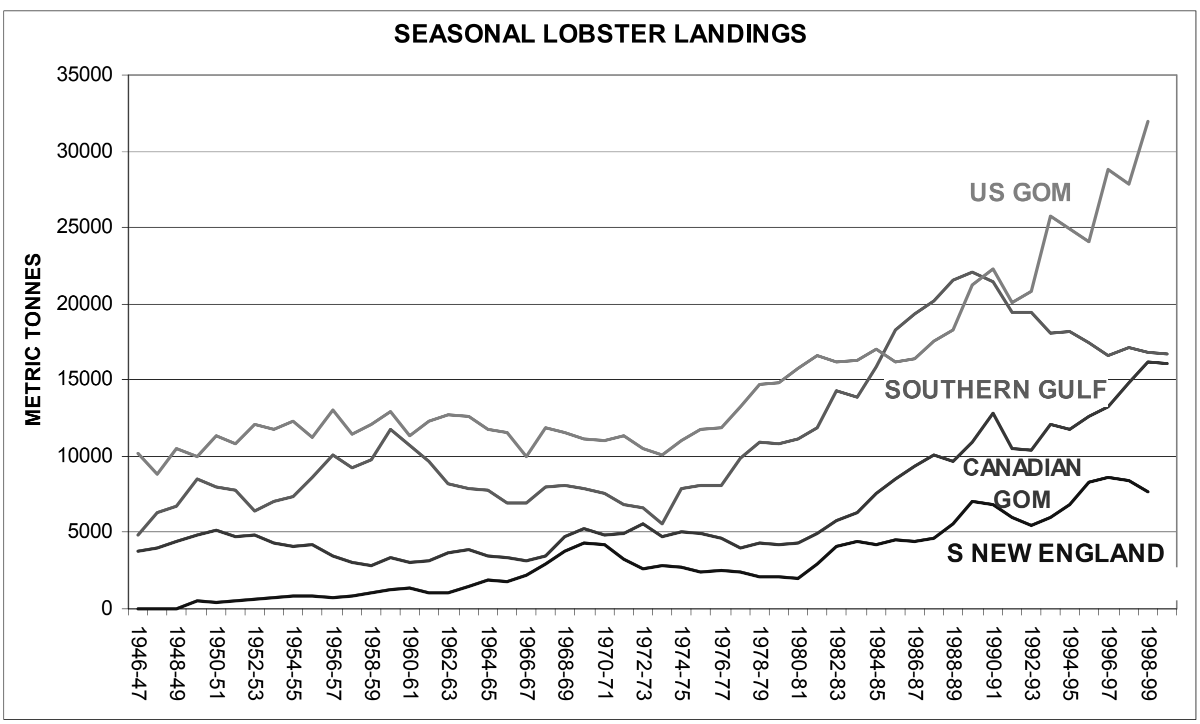


Figure 10. Seasonal landings (mt) United States Gulf of Maine (Annual), Southern Gulf, Canadian Gulf of Maine and Southern New England (Annual)

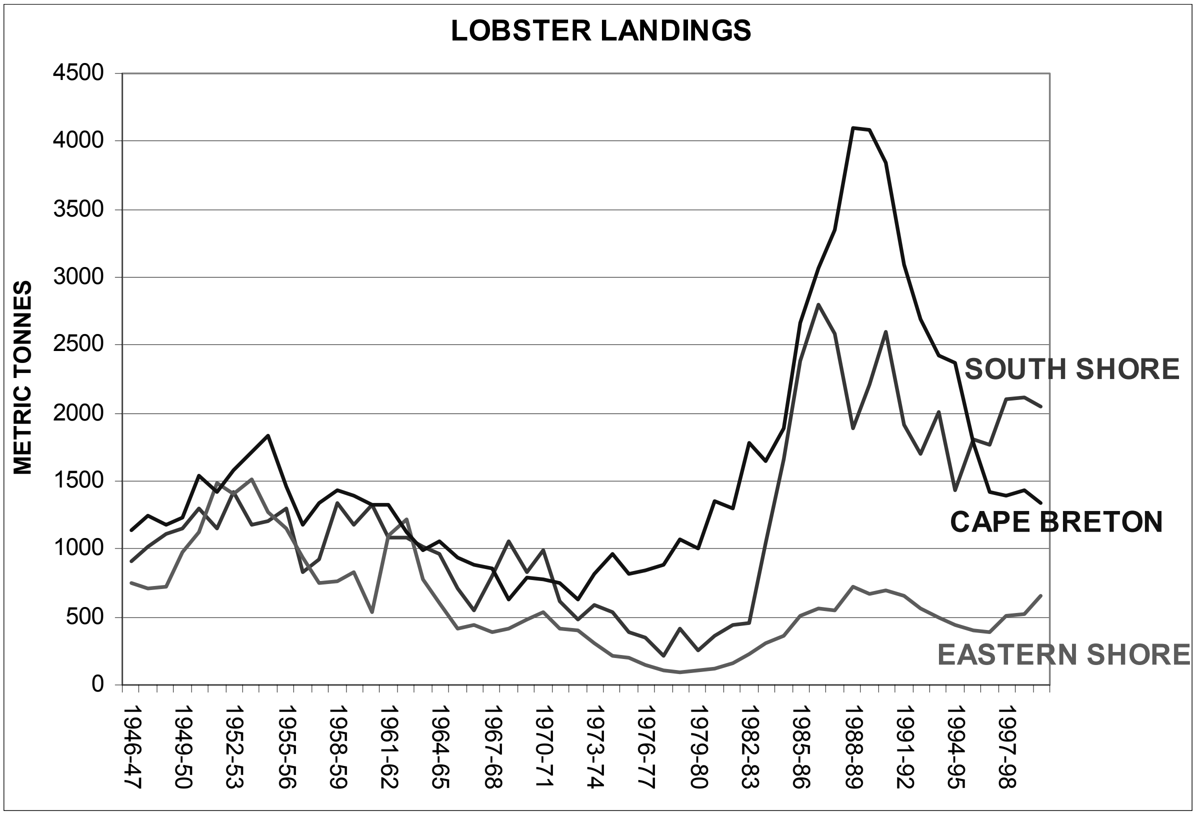


Figure 11. Seasonal landings (mt) South Shore, Cape Breton, and Eastern Shore Nova Scotia.

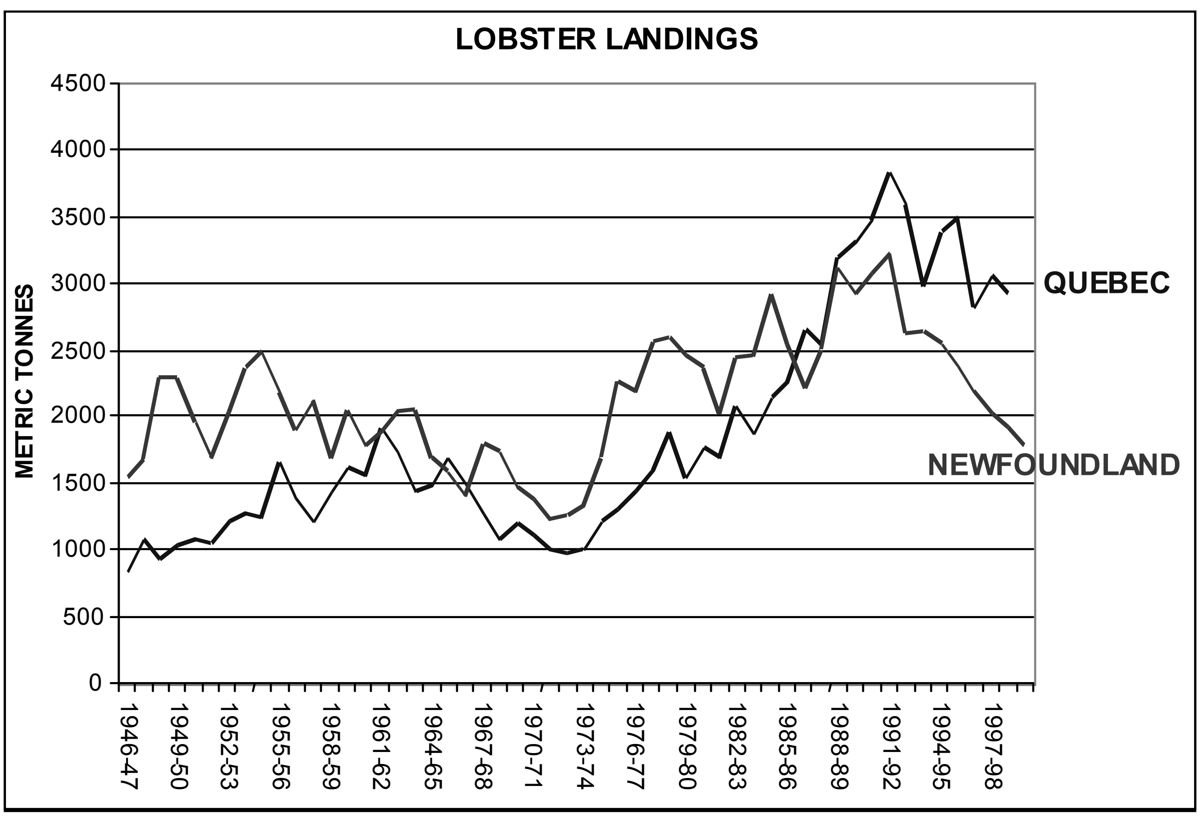


Figure 12. Seasonal landings (mt) Quebec and Newfoundland.

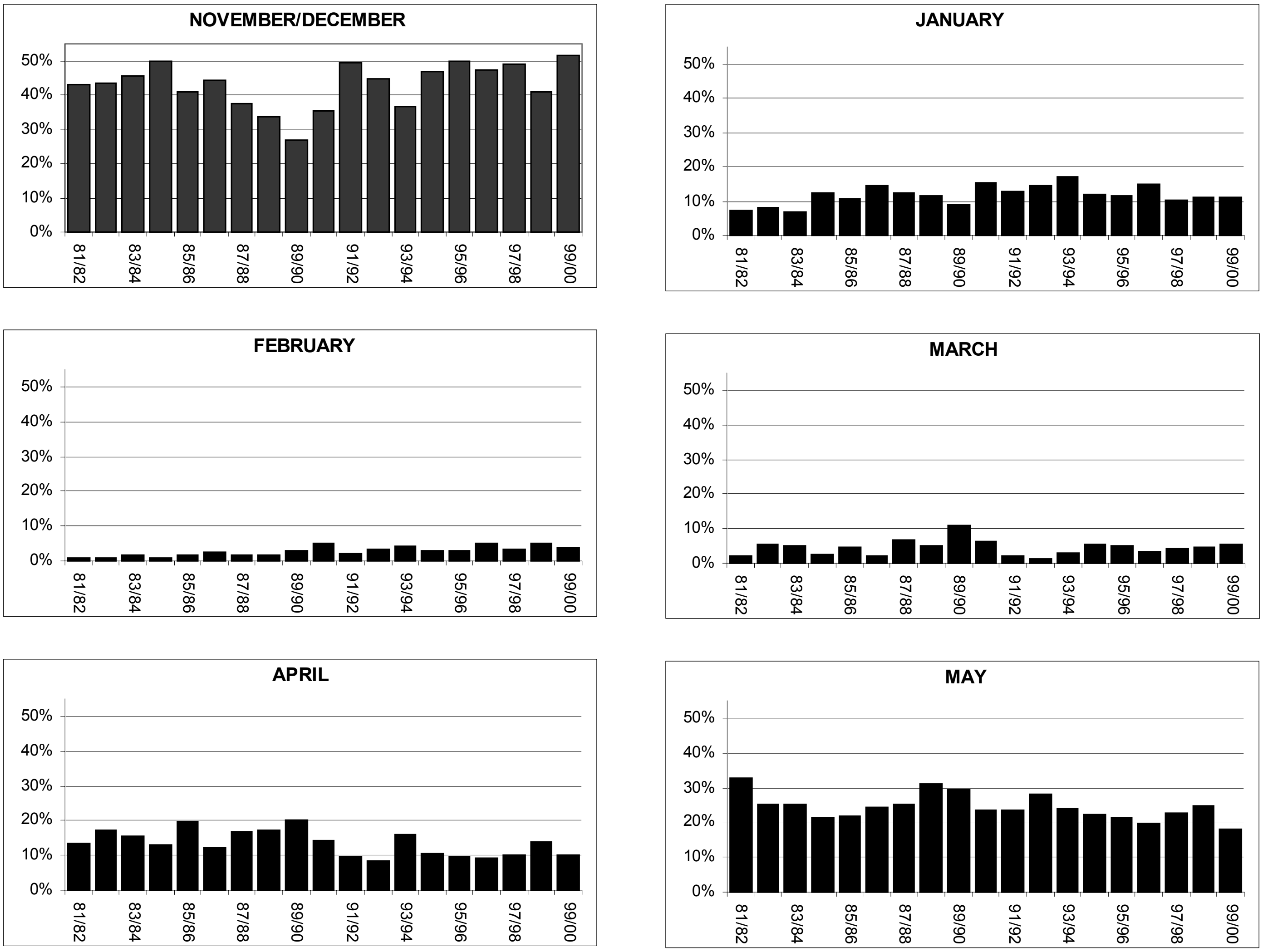


Figure 13. Monthly percentage of total seasonal landings from LFA 34 from 1981-82 to the 1999-00 fishing season.

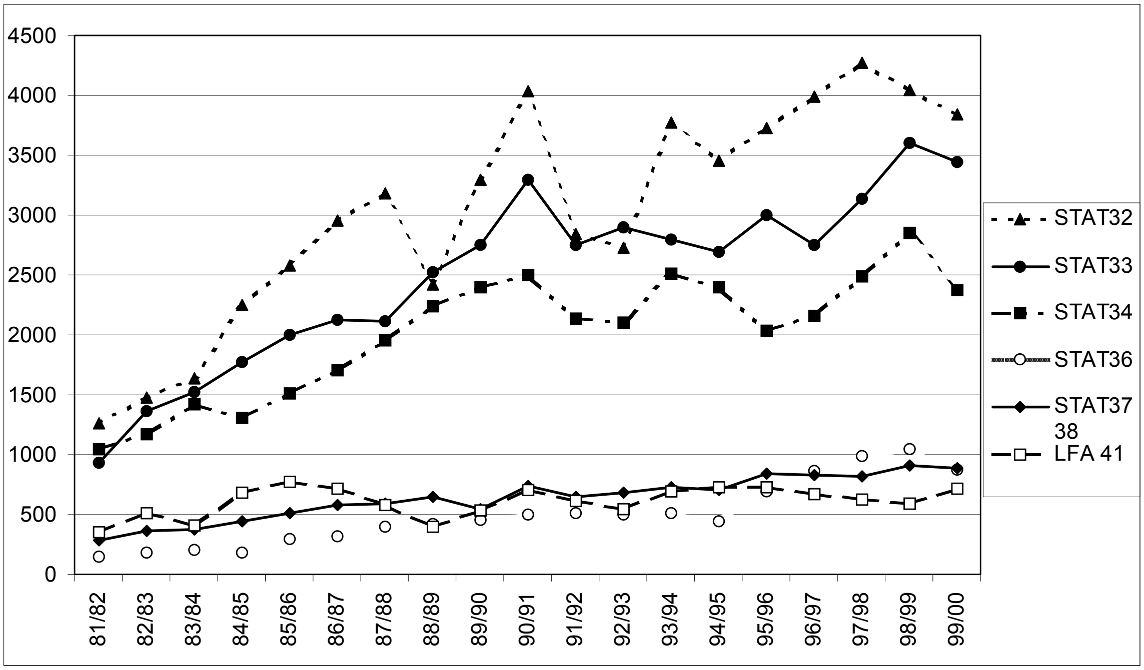


Figure 14. Seasonal landings (mt) by statistical district 1981-82 to 1999-2000.

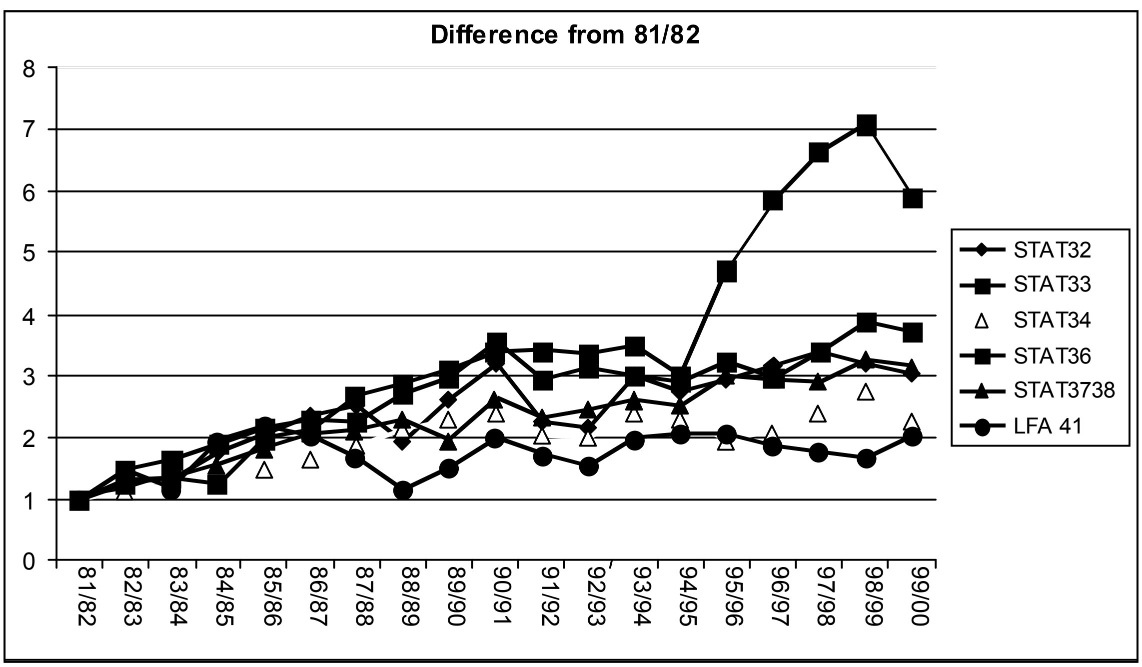


Figure 15. Seasonal landings (mt) relative to 1981-82 landings (1981-82 landings =1) by statistical district.

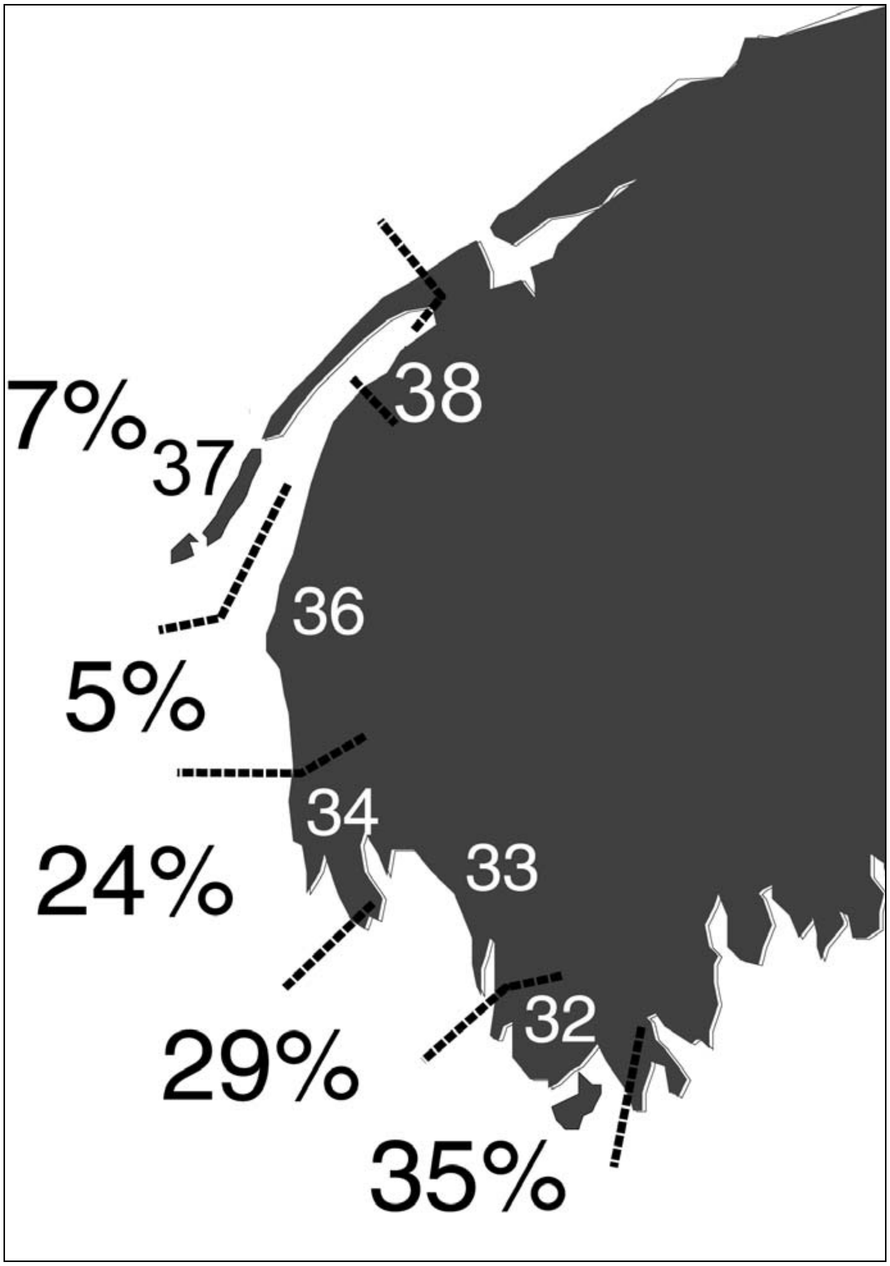


Figure 16. LFA 34 percent landings by statistical district used in 1998 assessment

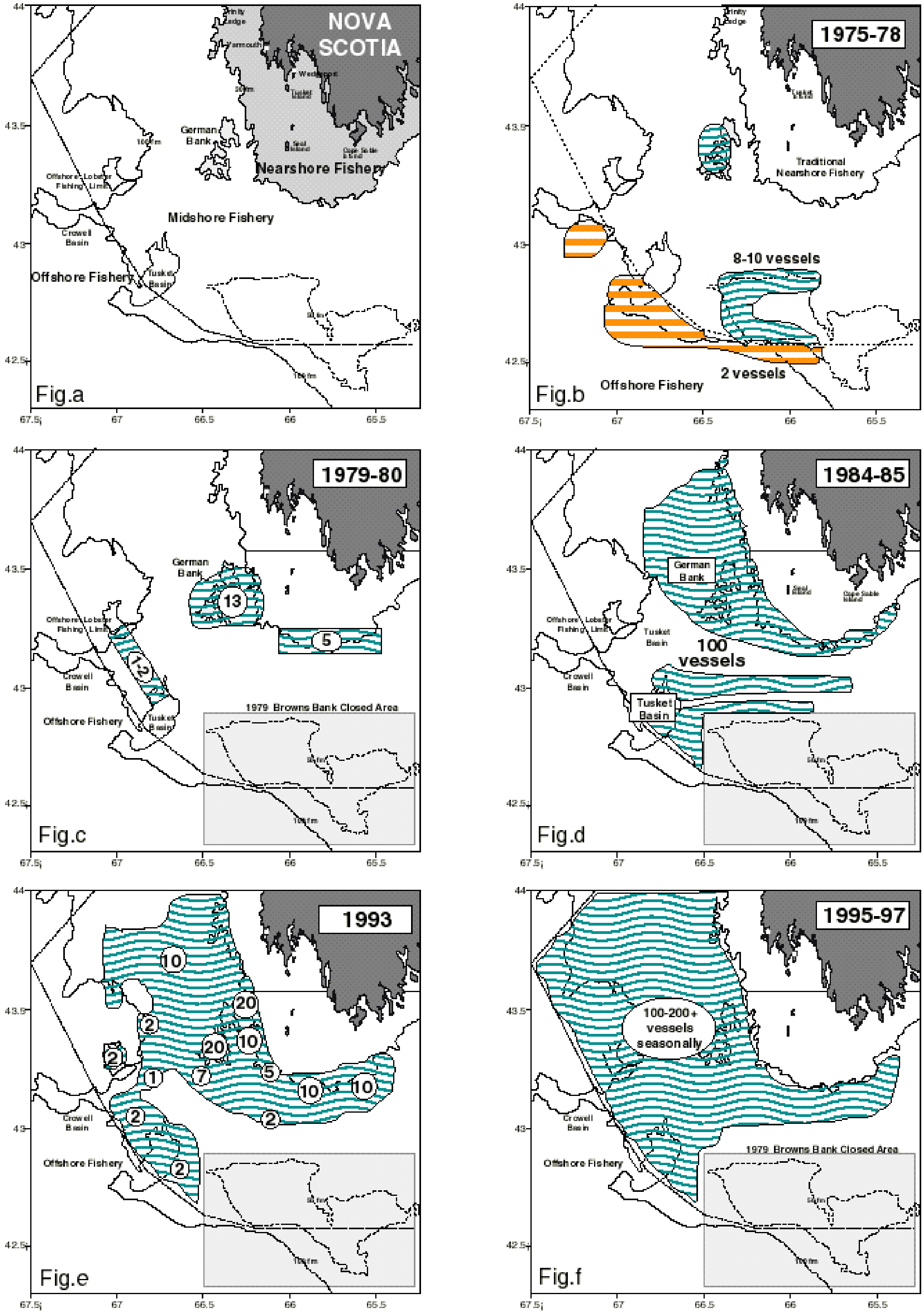
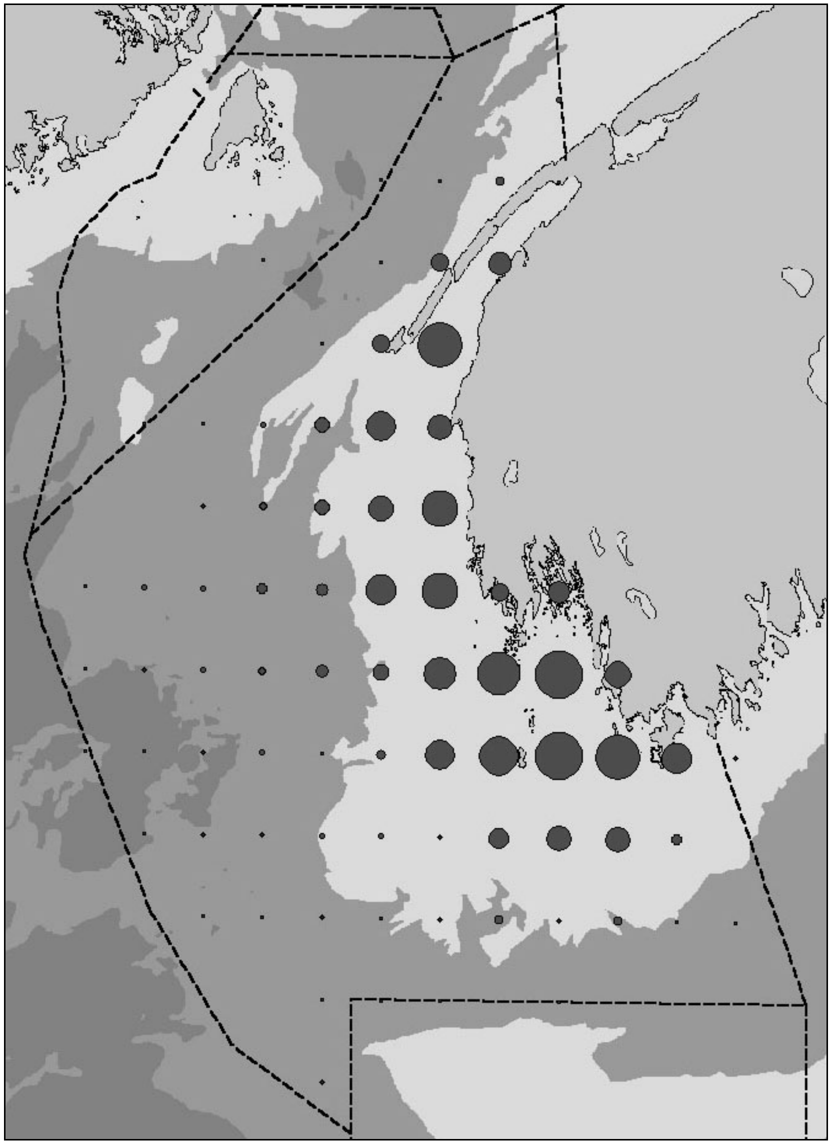
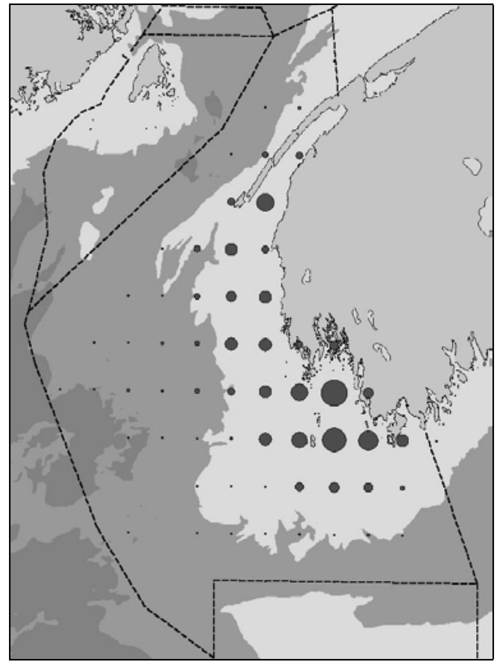


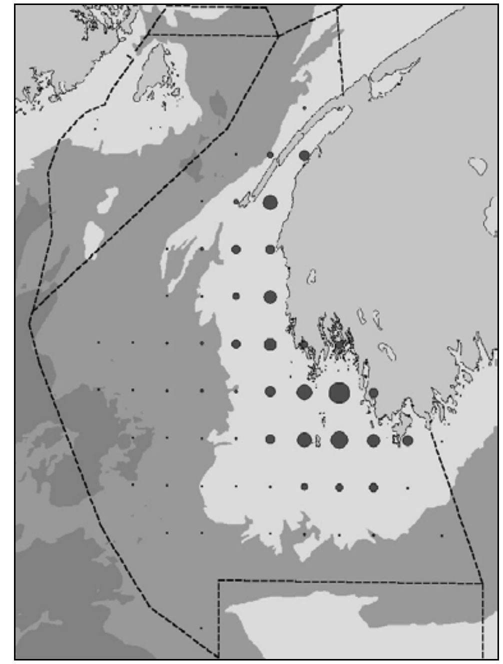
Figure 17. Development of midshore fishery based on fishermen interviews



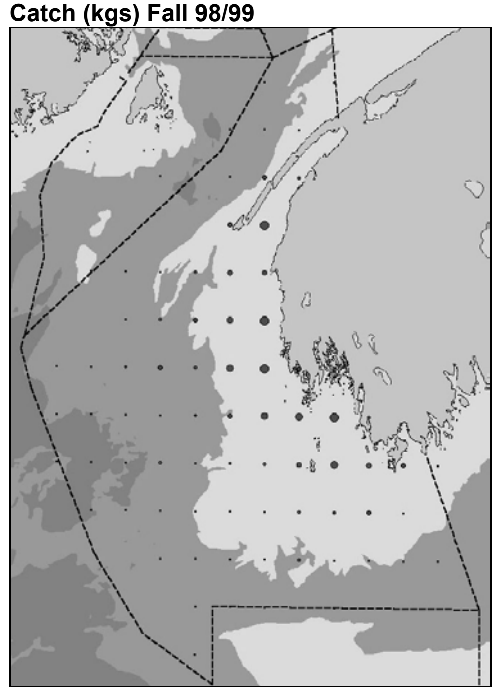
Catch (kgs) 98/99



Catch (kgs) Fall 98/99



Catch (kgs) Spring 98/99



Catch (kgs) Winter 98/99

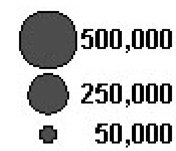
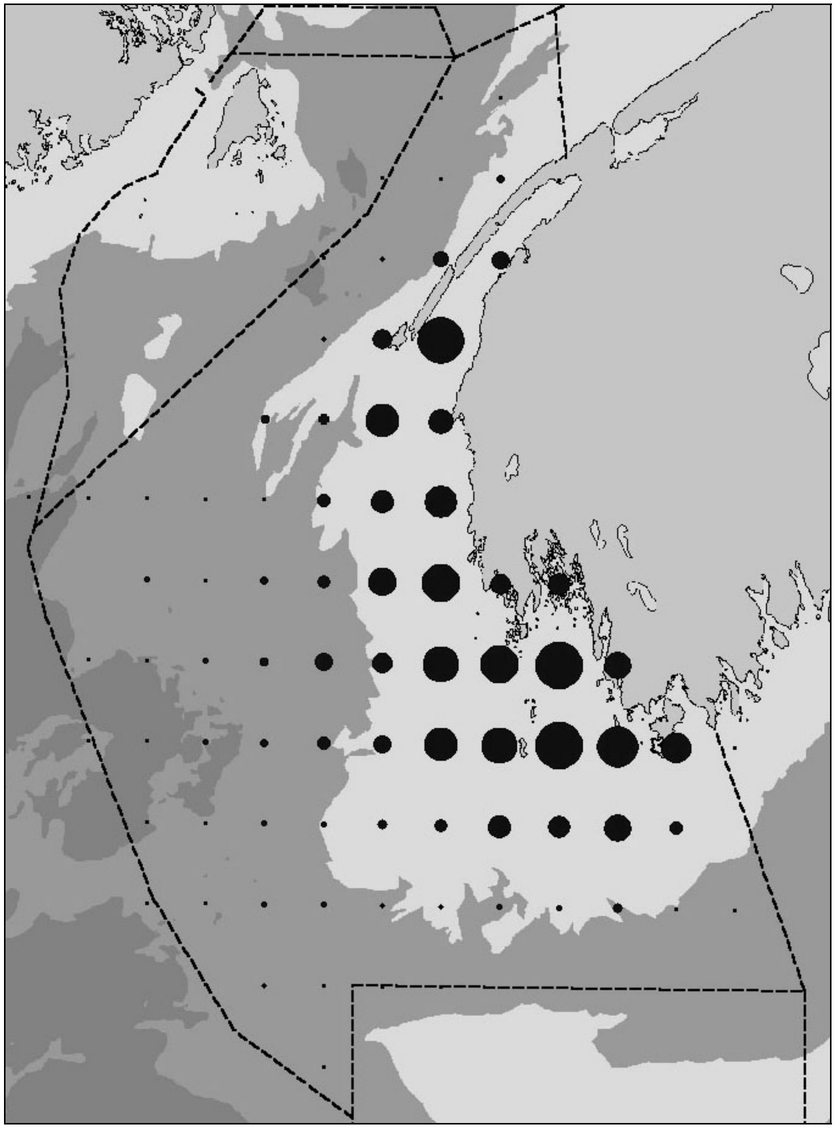
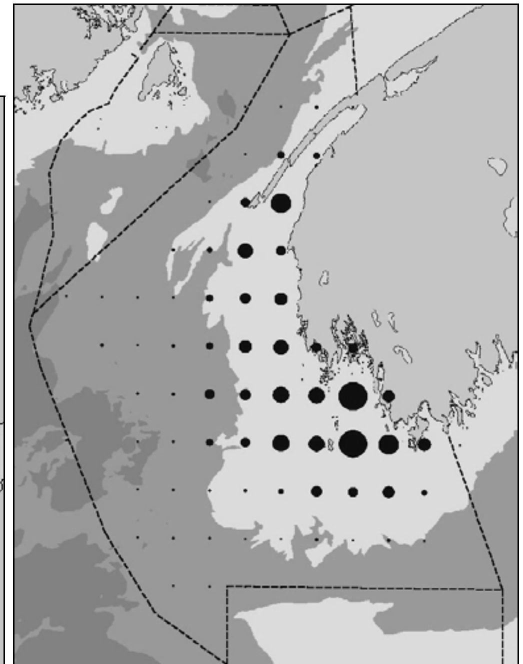


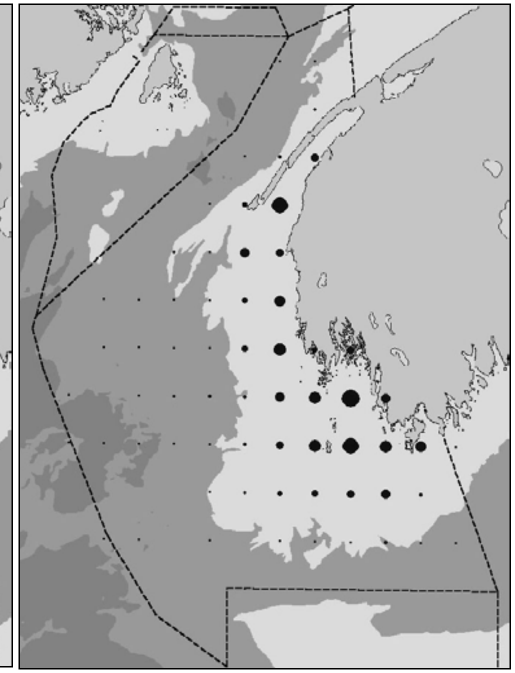
Figure 18. LFA 34 catch (kgs) by fishing season (98/99) and by fall 1998, winter 1999 and spring 1999



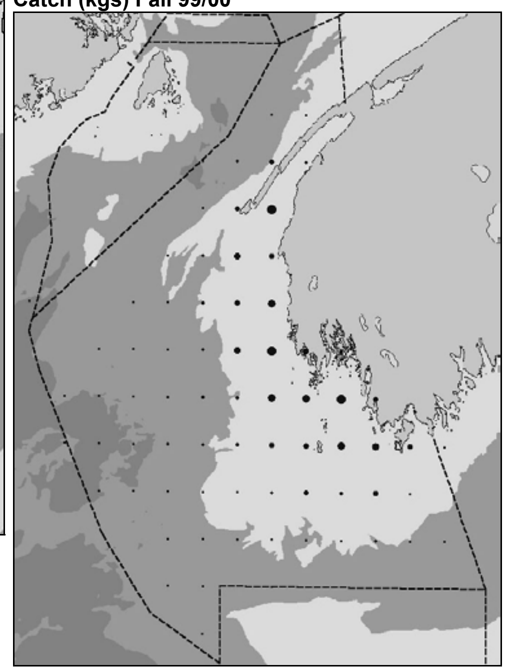
Catch (kgs) 99/00



Catch (kgs) Fall 99/00



Catch (kgs) Spring 99/00



Catch (kgs) Winter 99/00

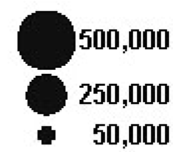


Figure 19. LFA 34 catch (kgs) by fishing season (99/00) and by fall 1999, winter 2000 and spring 2000

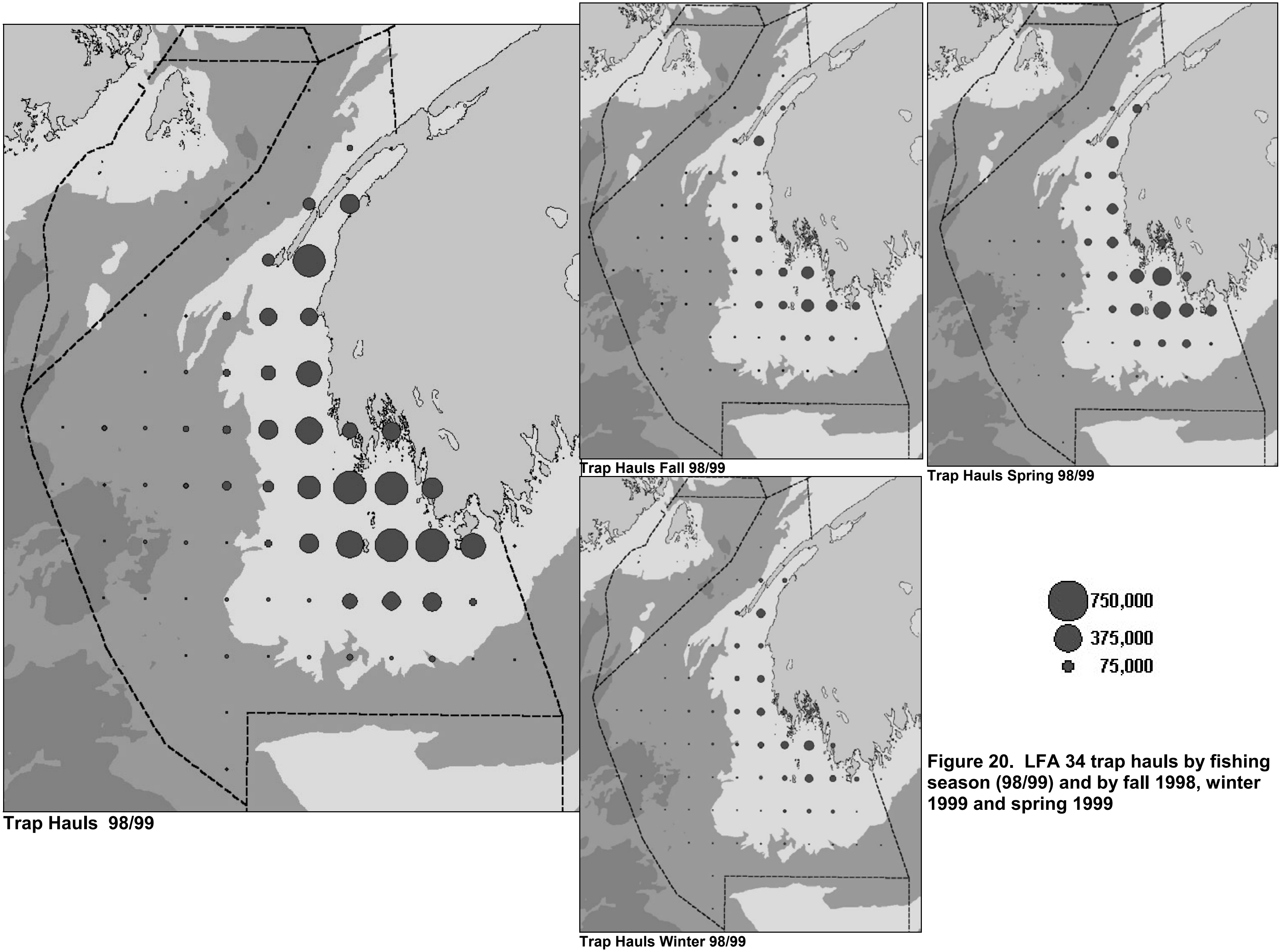
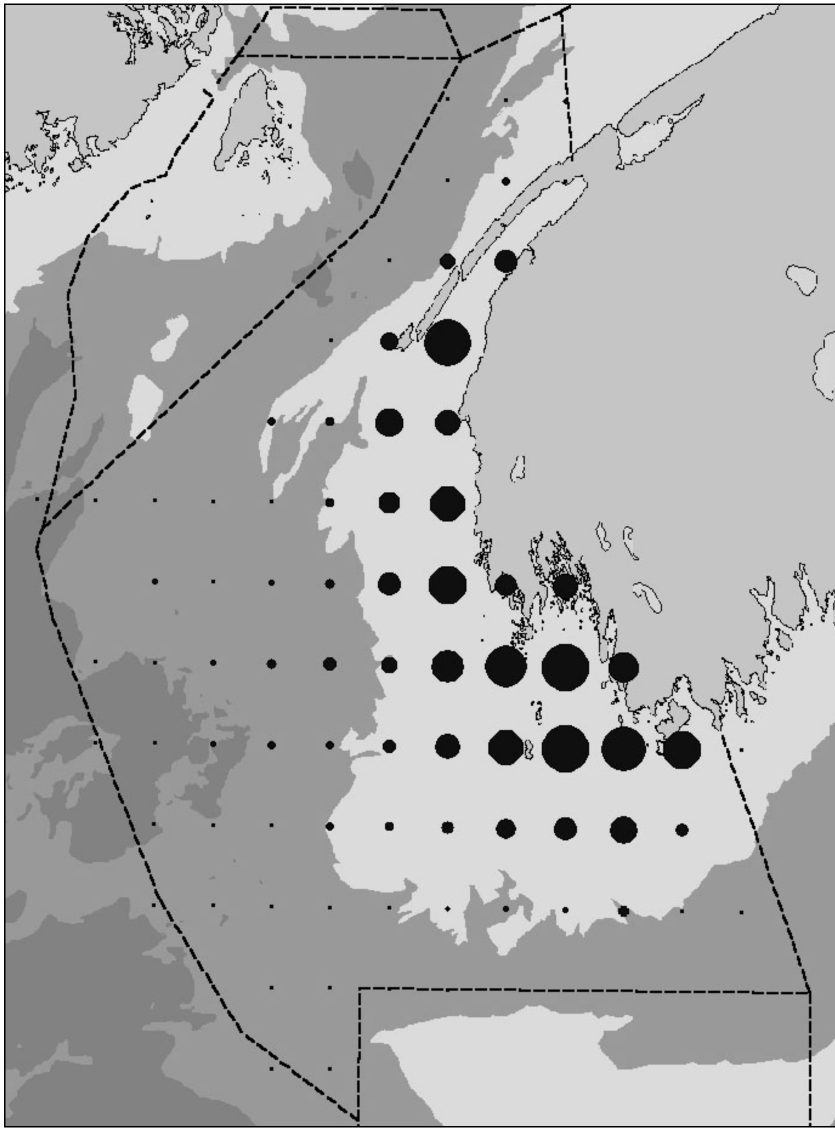
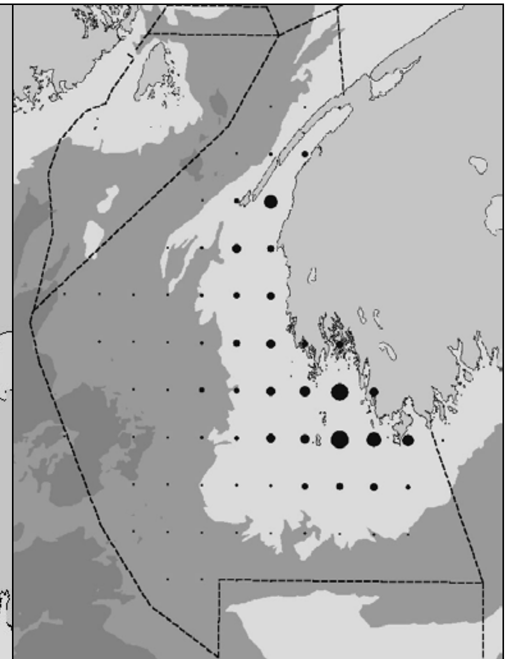


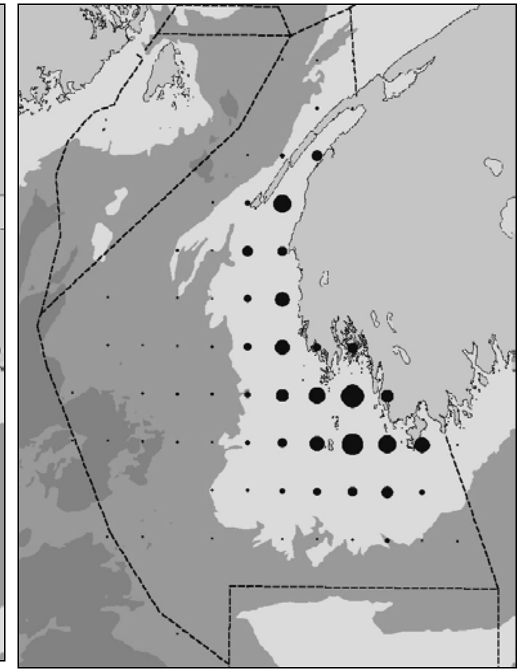
Figure 20. LFA 34 trap hauls by fishing season (98/99) and by fall 1998, winter 1999 and spring 1999



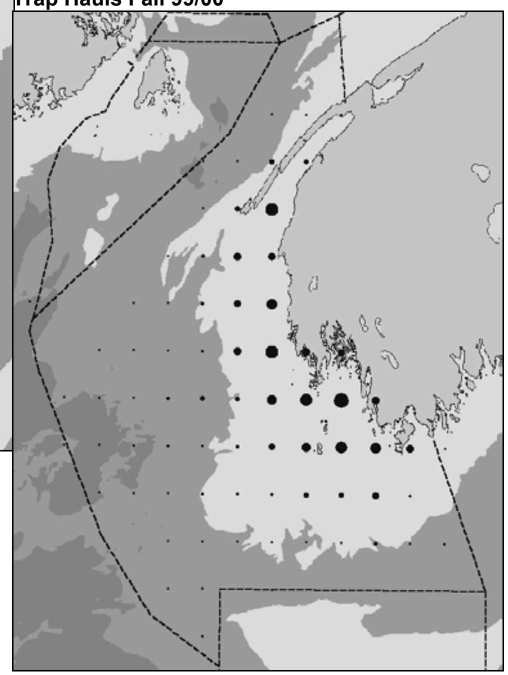
Trap Hauls 99/00



Trap Hauls Fall 99/00



Trap Hauls Spring 99/00



Trap Hauls Winter 99/00

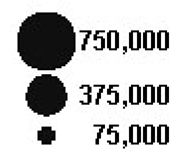


Figure 21. LFA 34 trap hauls by fishing season (99/00) and by fall 1999, winter 2000 and spring 2000

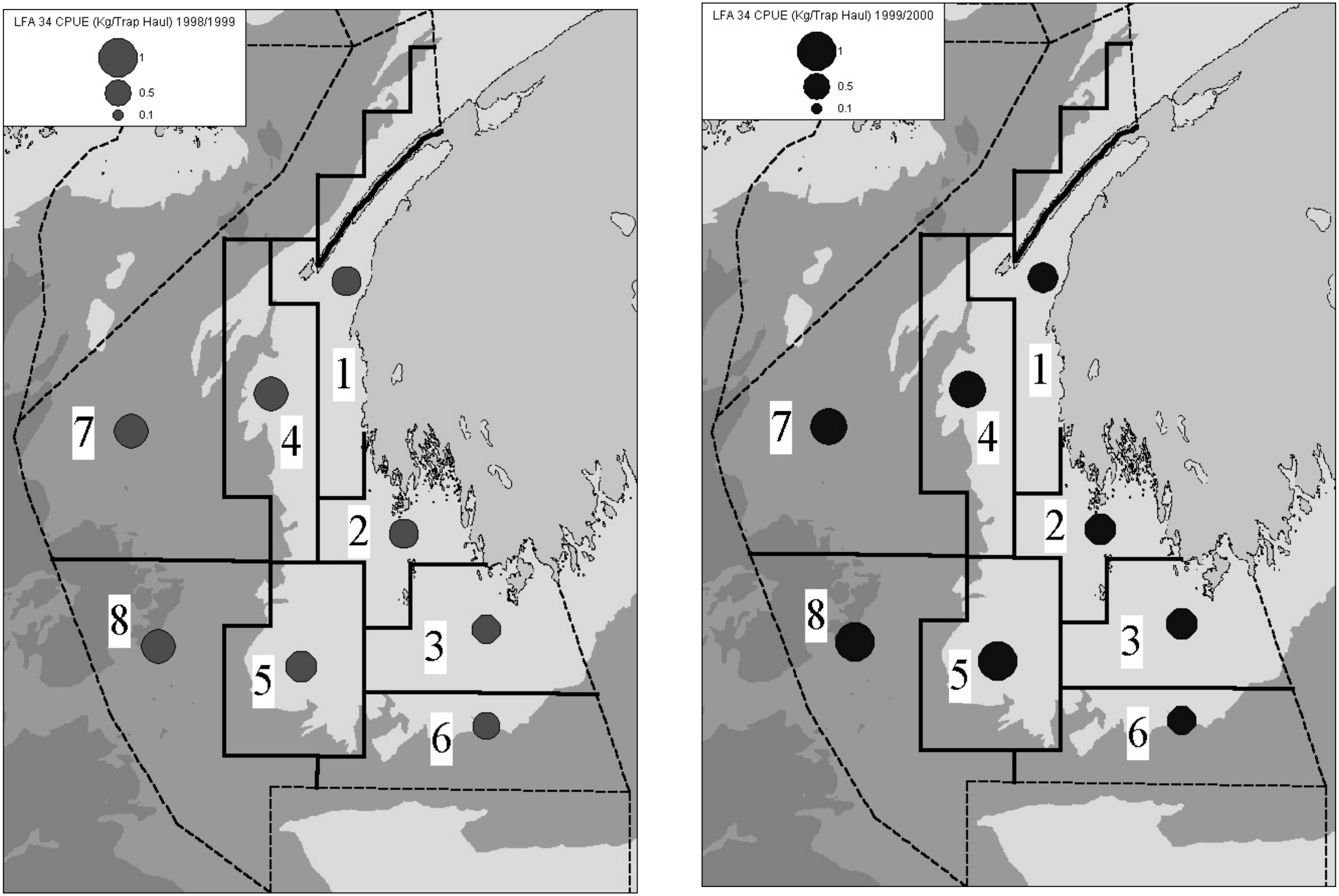
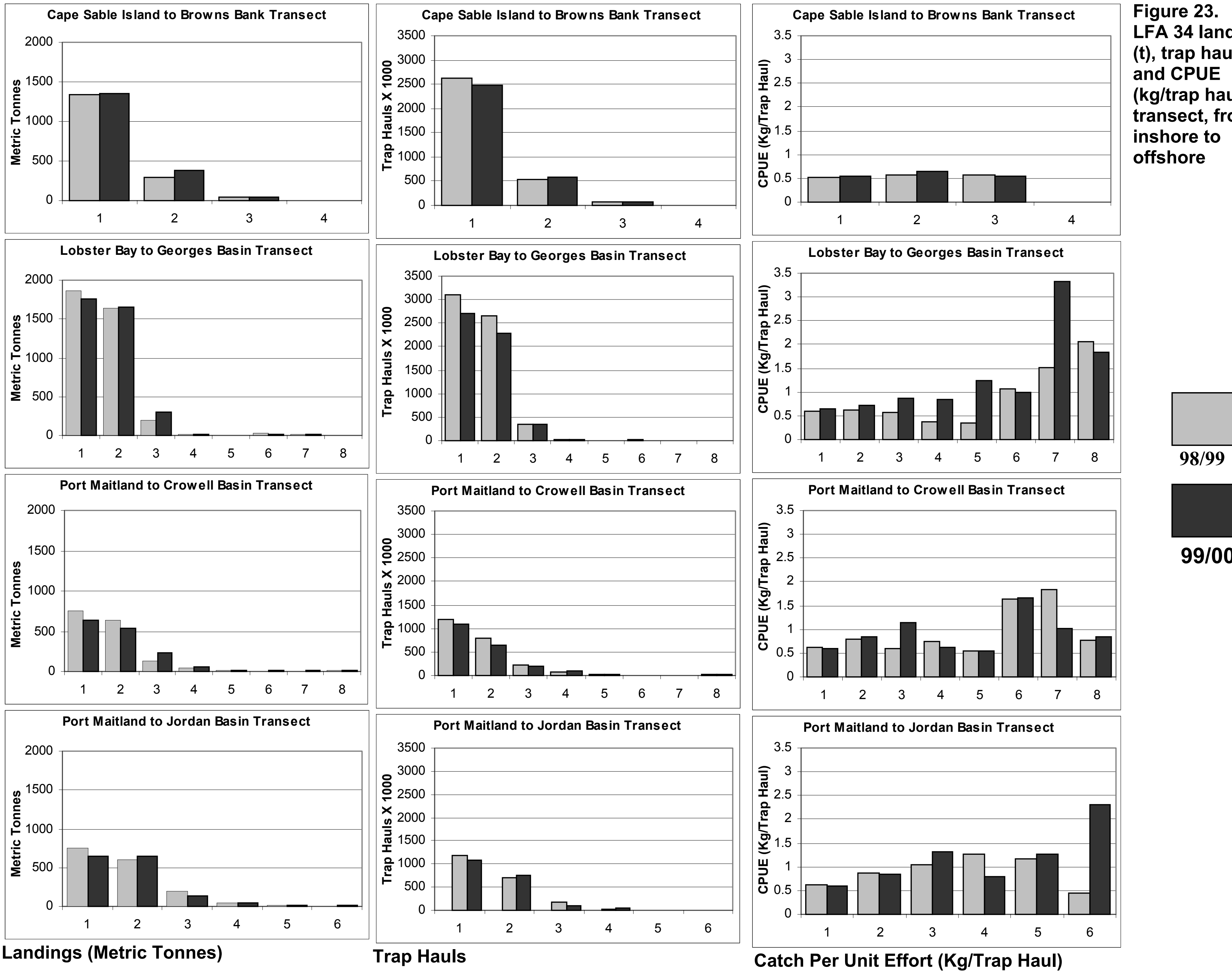


Figure 22. LFA 34 catch per unit effort (kg/trap haul) for 1998/1999 and 1999/2000 by grid grouping

Figure 23. LFA 34 landings (t), trap hauls, and CPUE (kg/trap haul) by transect, from inshore to offshore



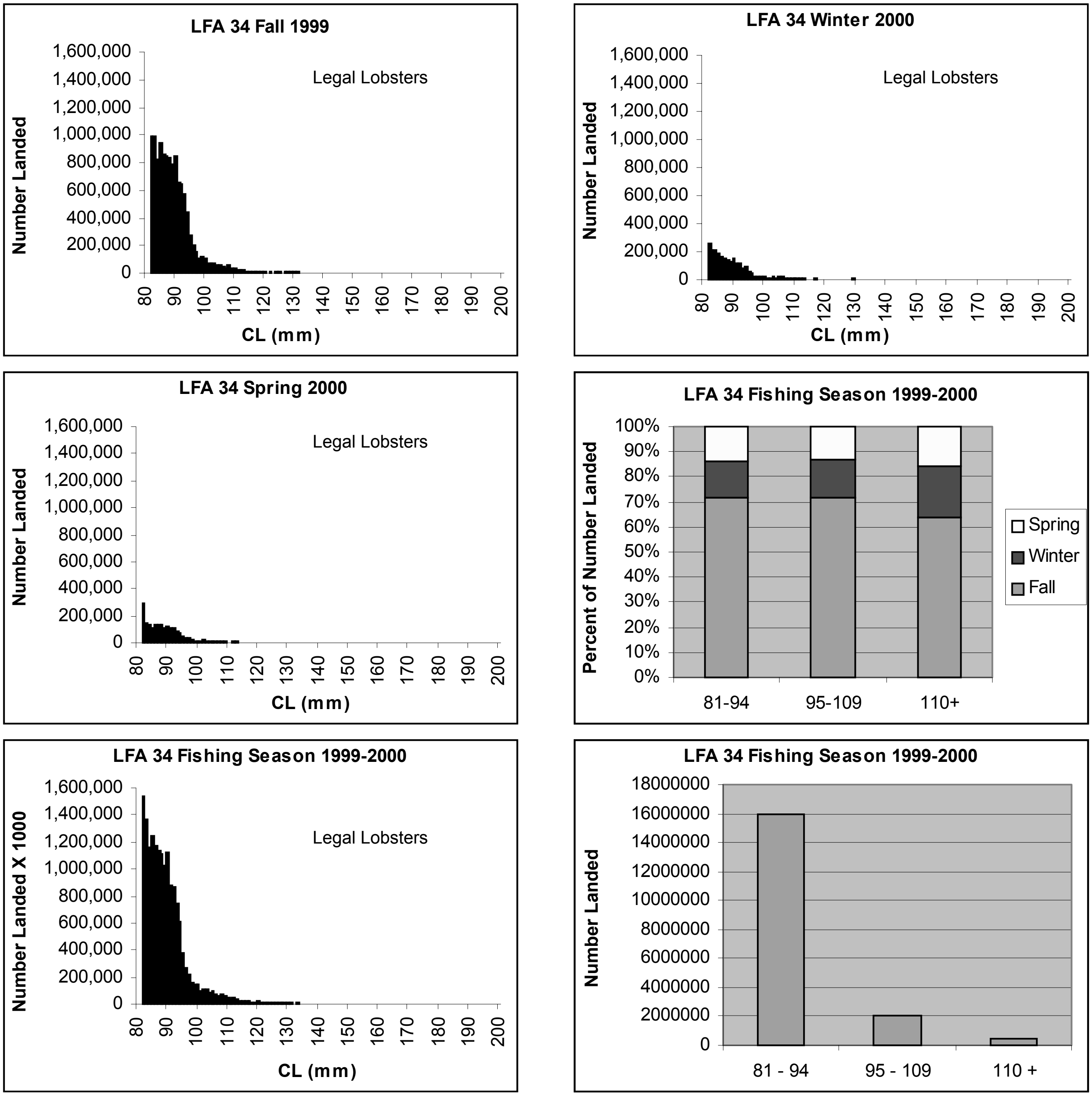


Figure 24. LFA 34 Catch composition 1999-2000

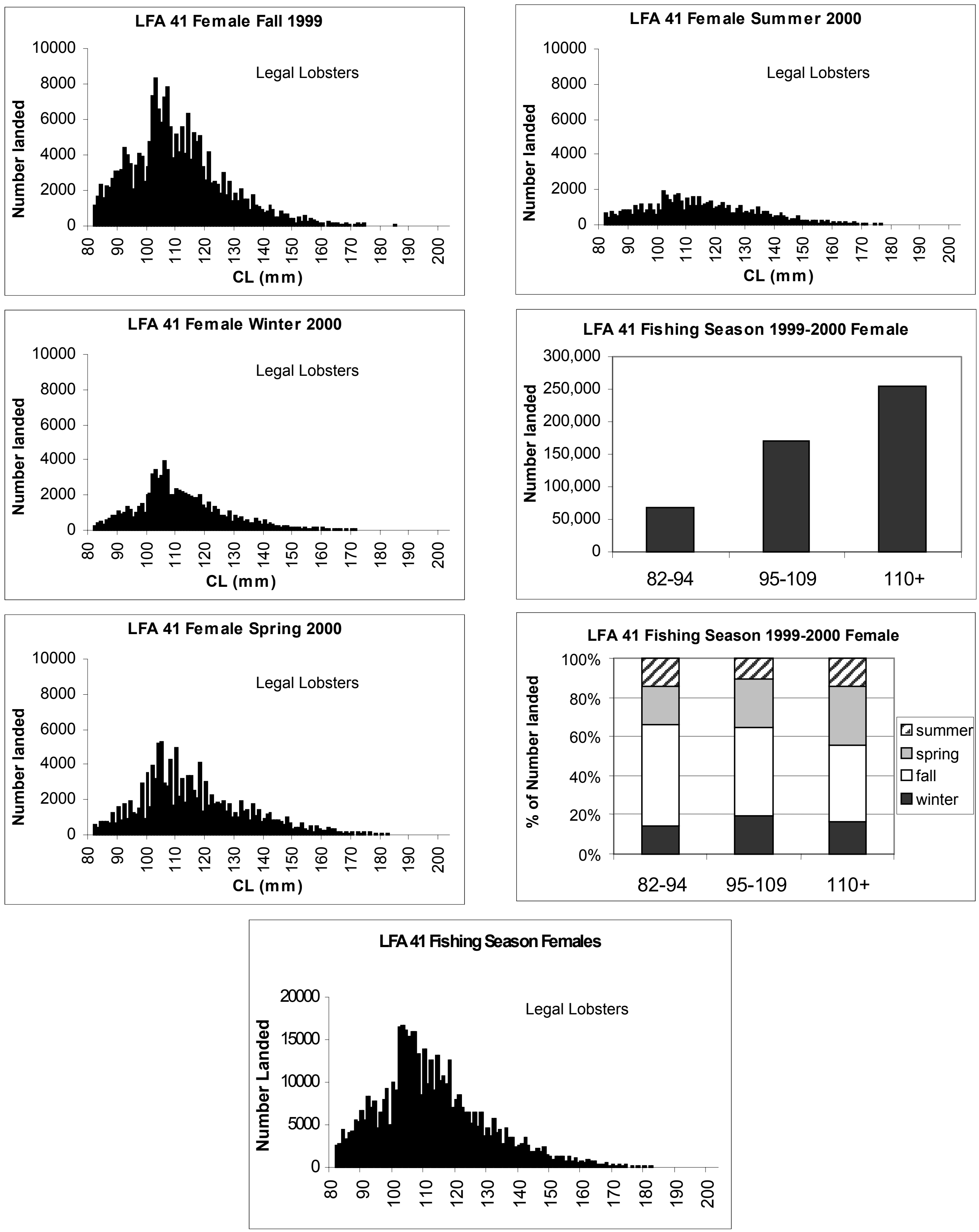


Figure 25. LFA 41 Female Catch Composition 1999/2000

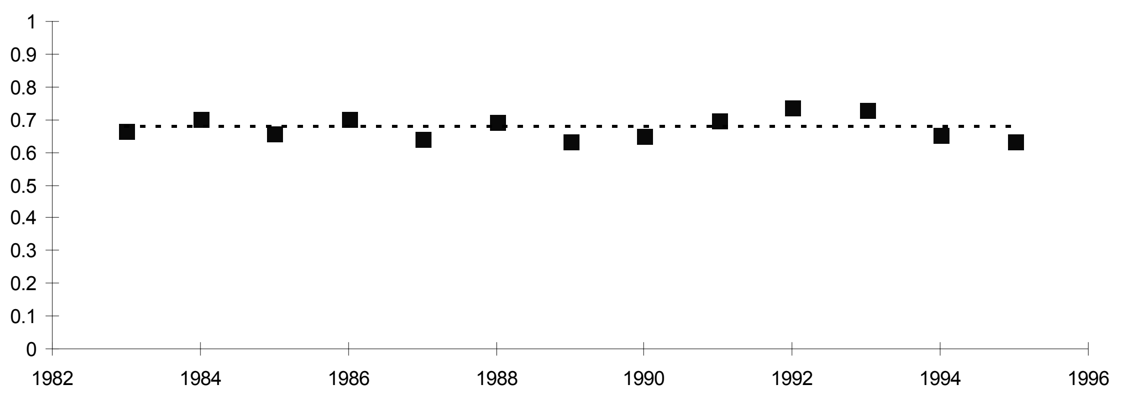
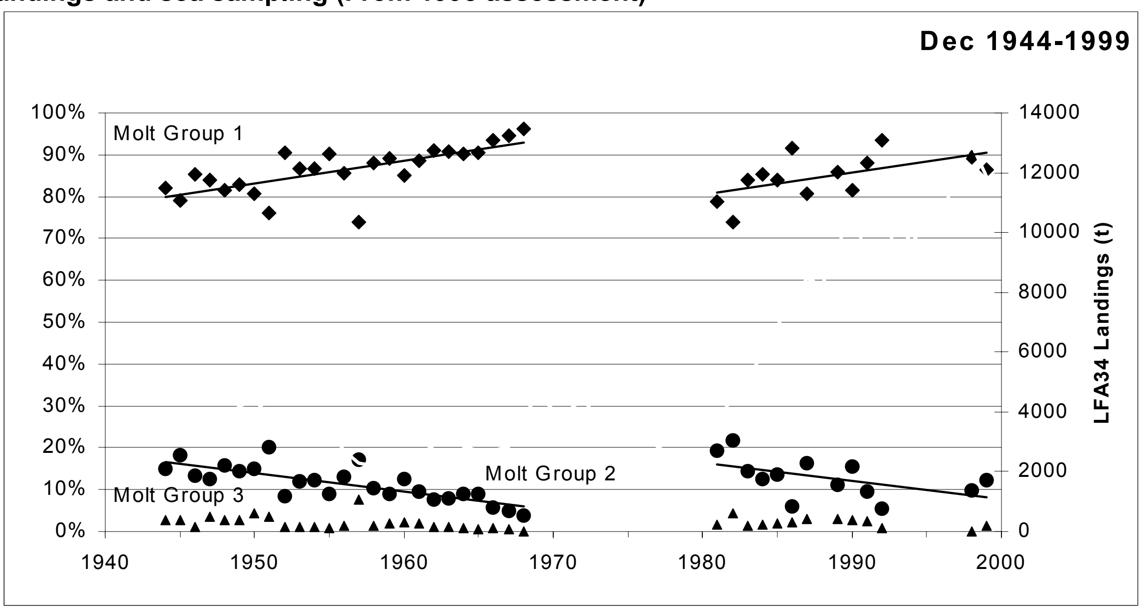


Figure 26. Proportion of the LFA 34 landings in Molt Group 1 (81-94mm CL) as calculated using Statistical District landings and sea sampling (From 1998 assessment)



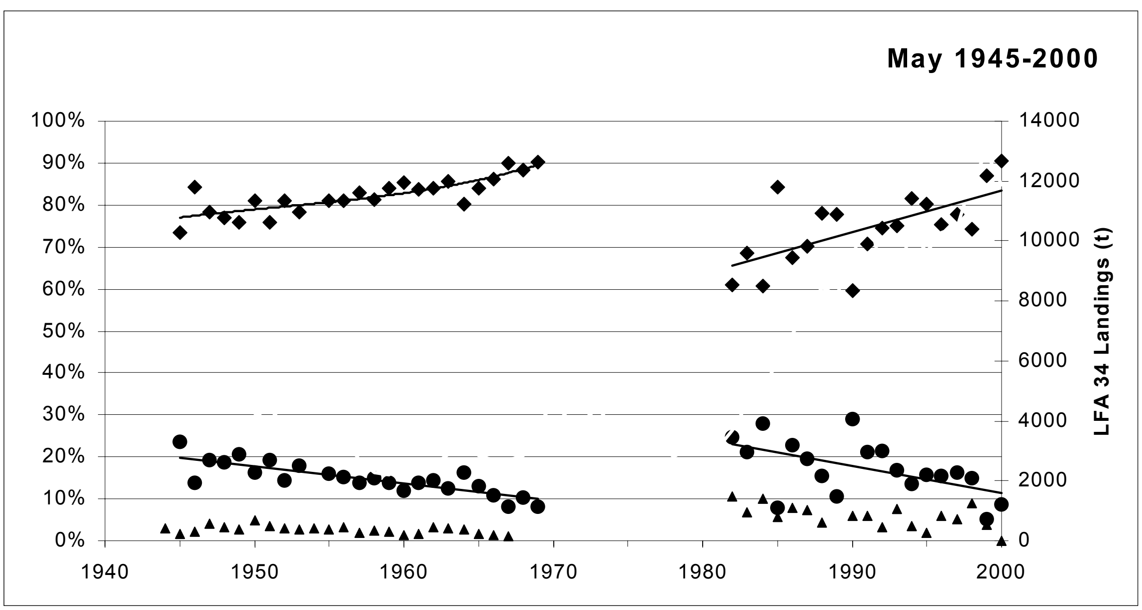


Figure 27. Proportion of animals in Molt Group 1 in Port Maitland at-sea samples 1944-2000 for Dec and May periods, and total LFA 34 landing

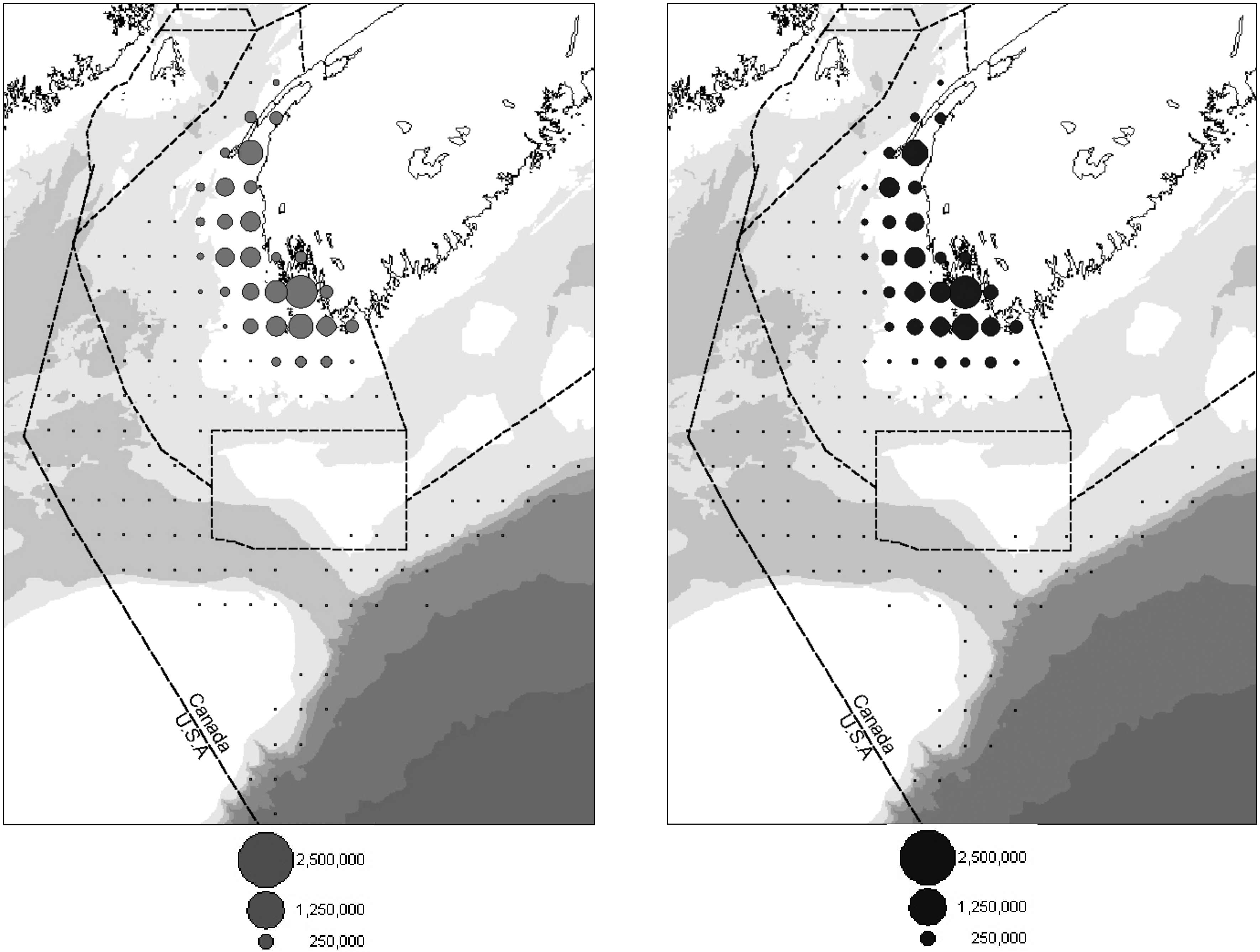


Figure 28. LFA 34 numbers landed per molt group 1 (81mm to 94 mm) by graduated symbols 1998/1999 and 1999/2000

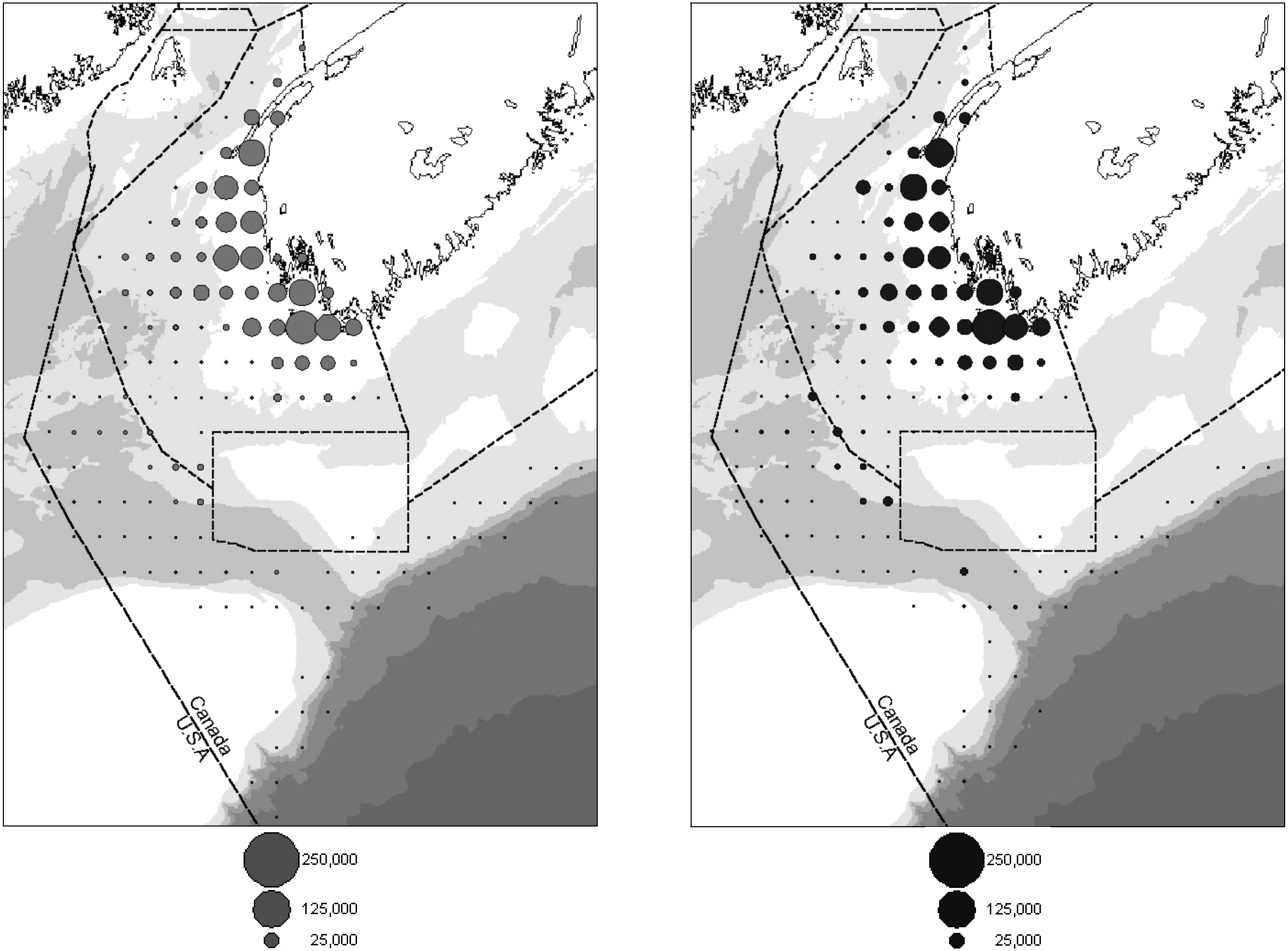


Figure 29. LFA 34 numbers landed per molt group 2 (95mm to 109 mm) by graduated symbols 1998/1999 and 1999/2000

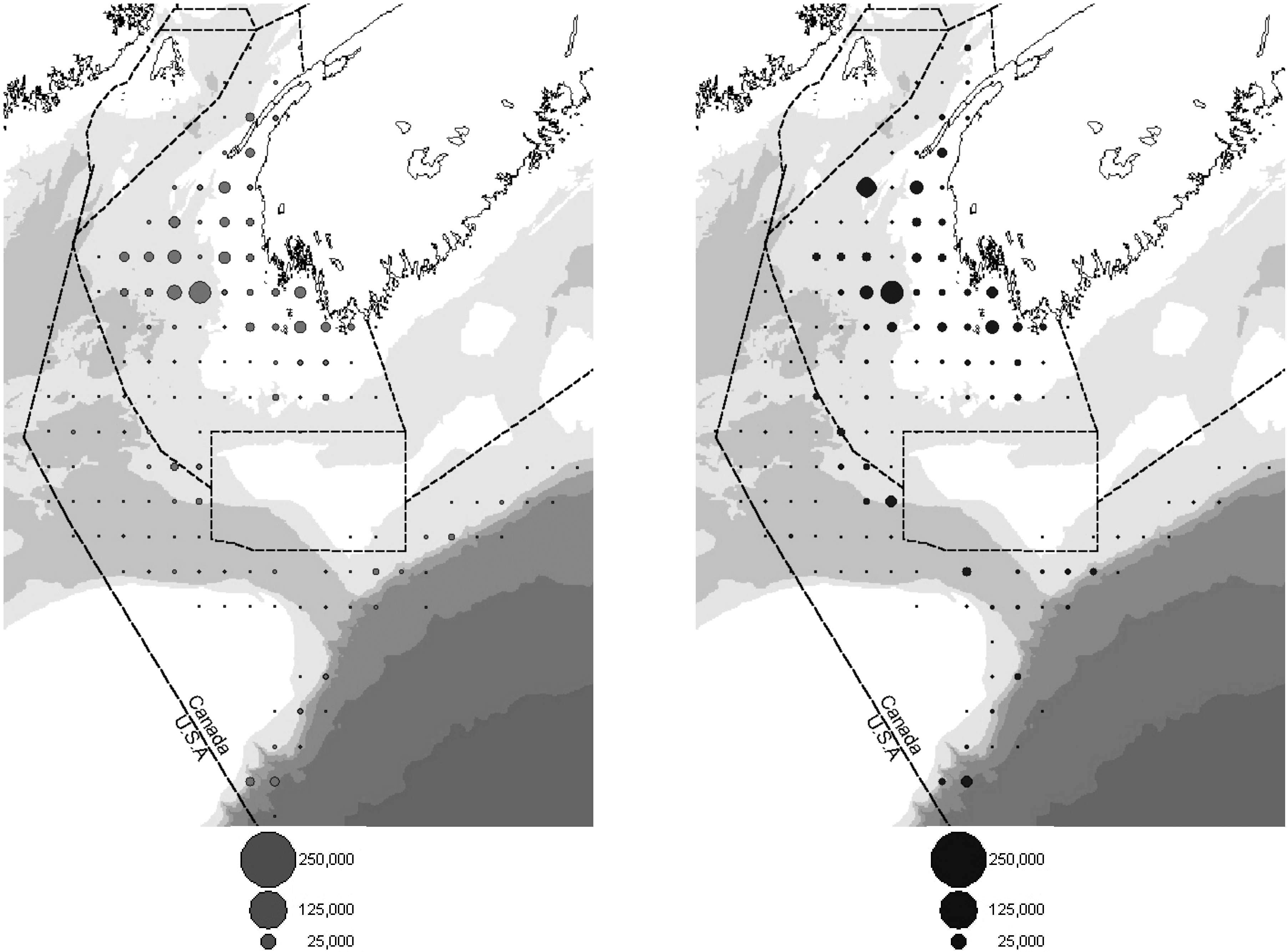
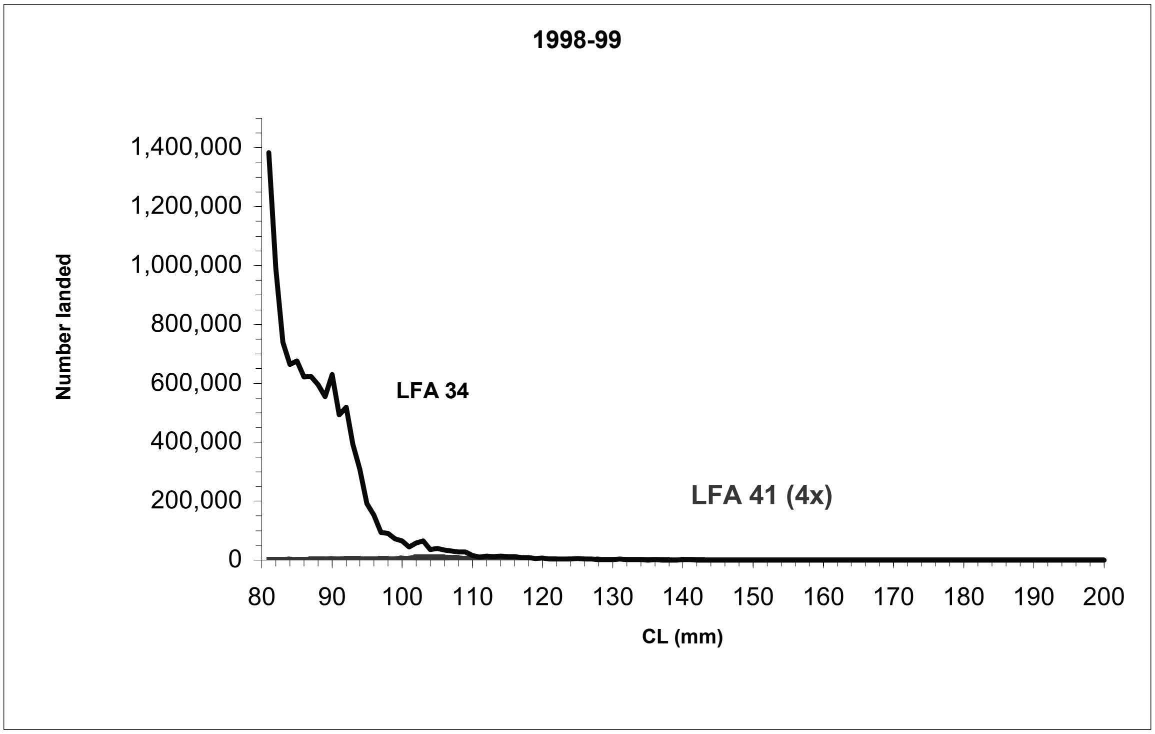


Figure 30. LFA 34 numbers landed per molt group 3 (110+ mm) by graduated symbols 1998/1999 and 1999/2000 scaled at 250,000



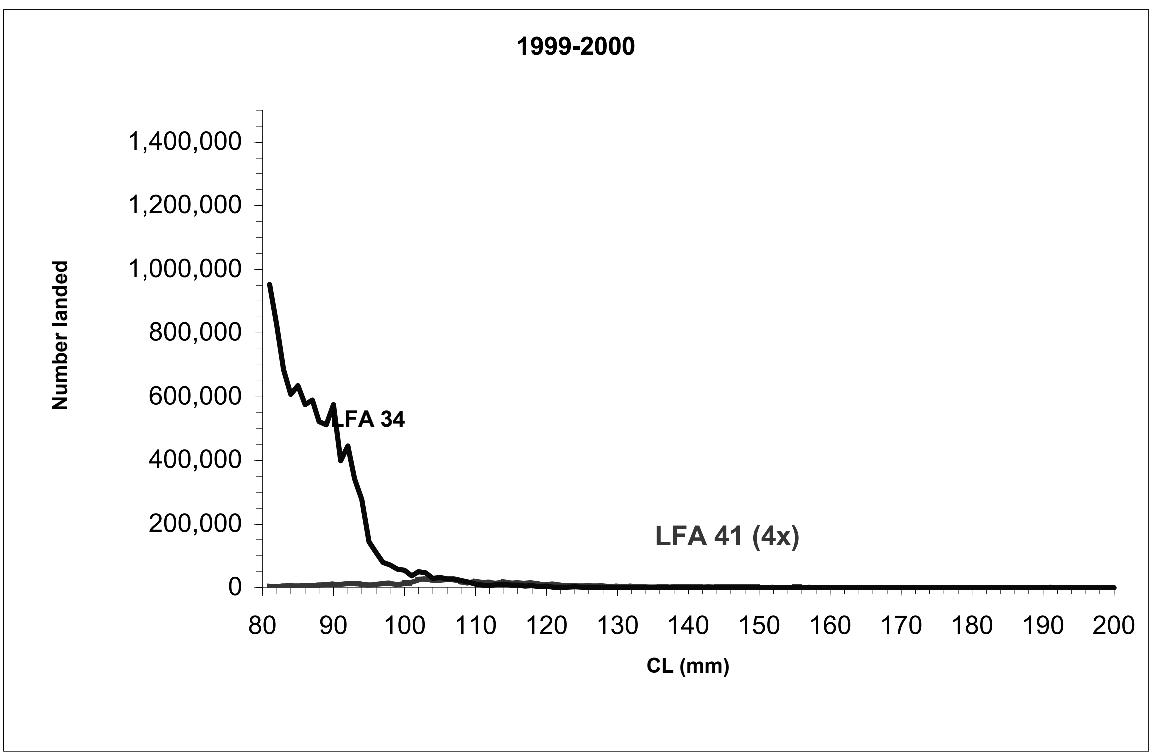
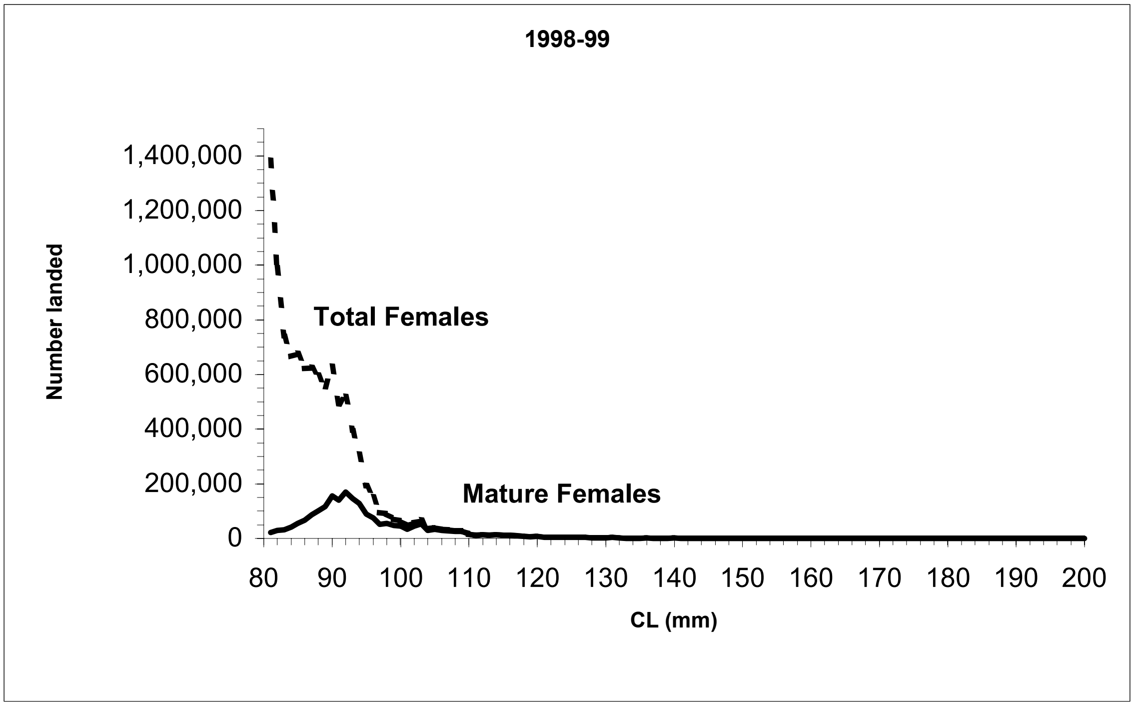


Figure 31. Numbers of female lobsters landed at size LFA 34 and 41 (4x)



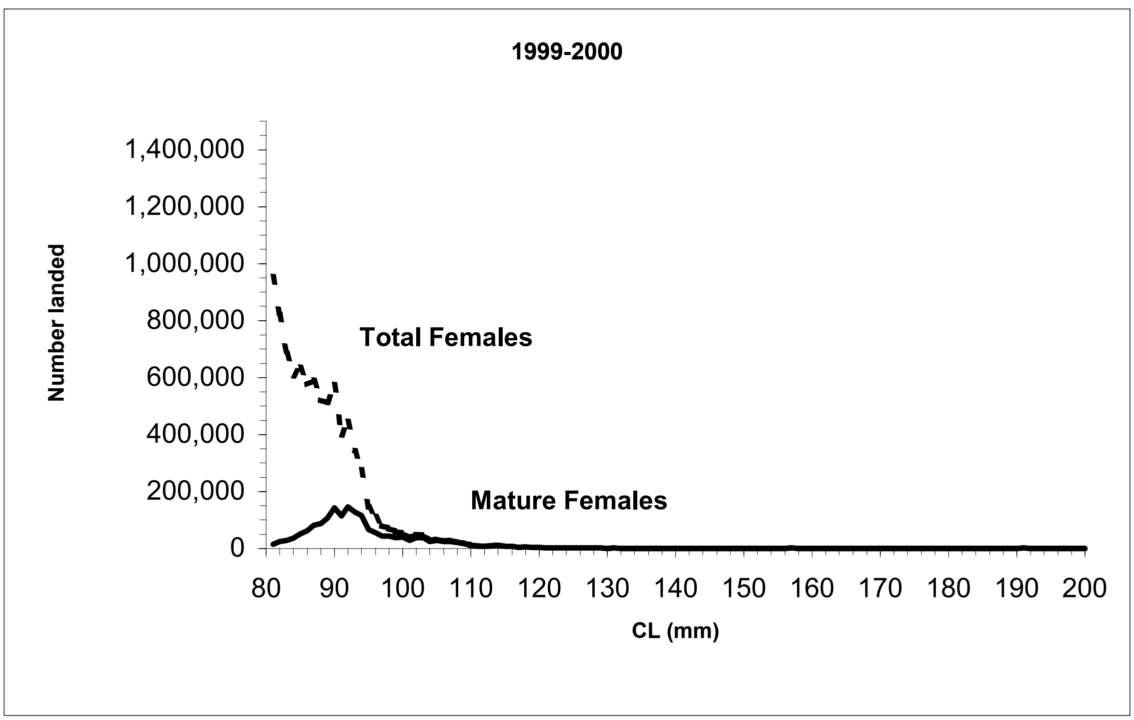
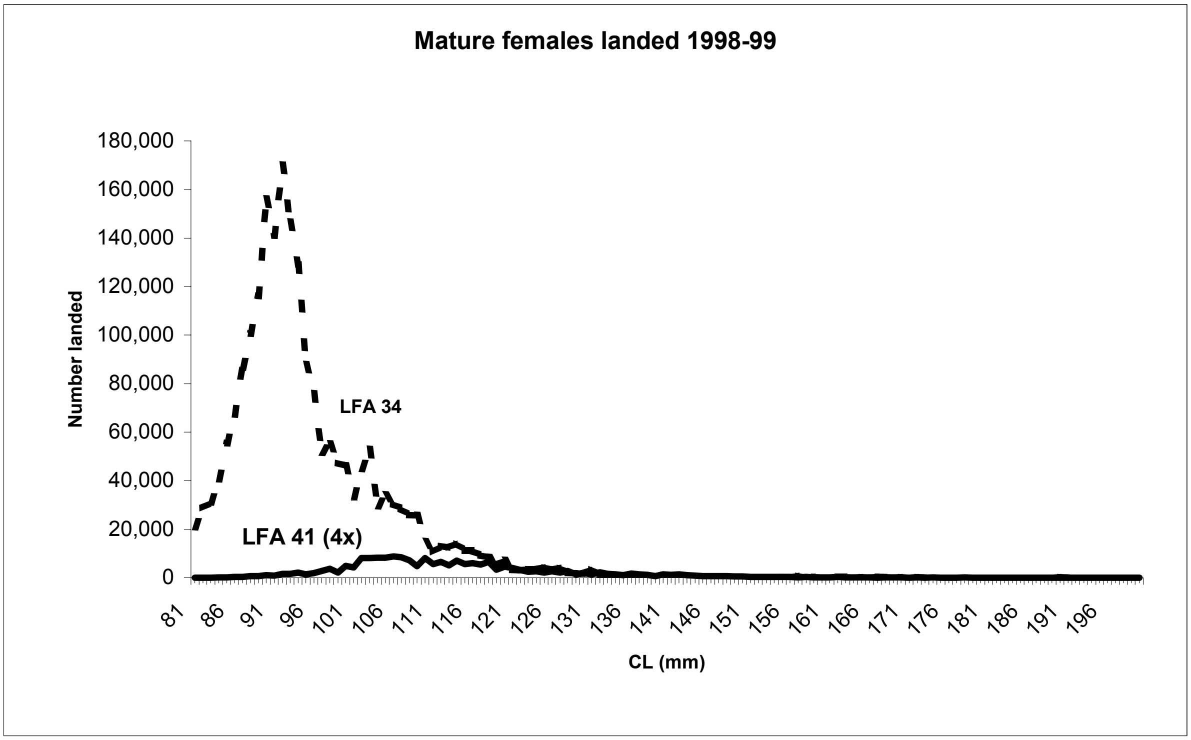


Figure 32. Number of females and mature female lobsters landed at size in LFA 34



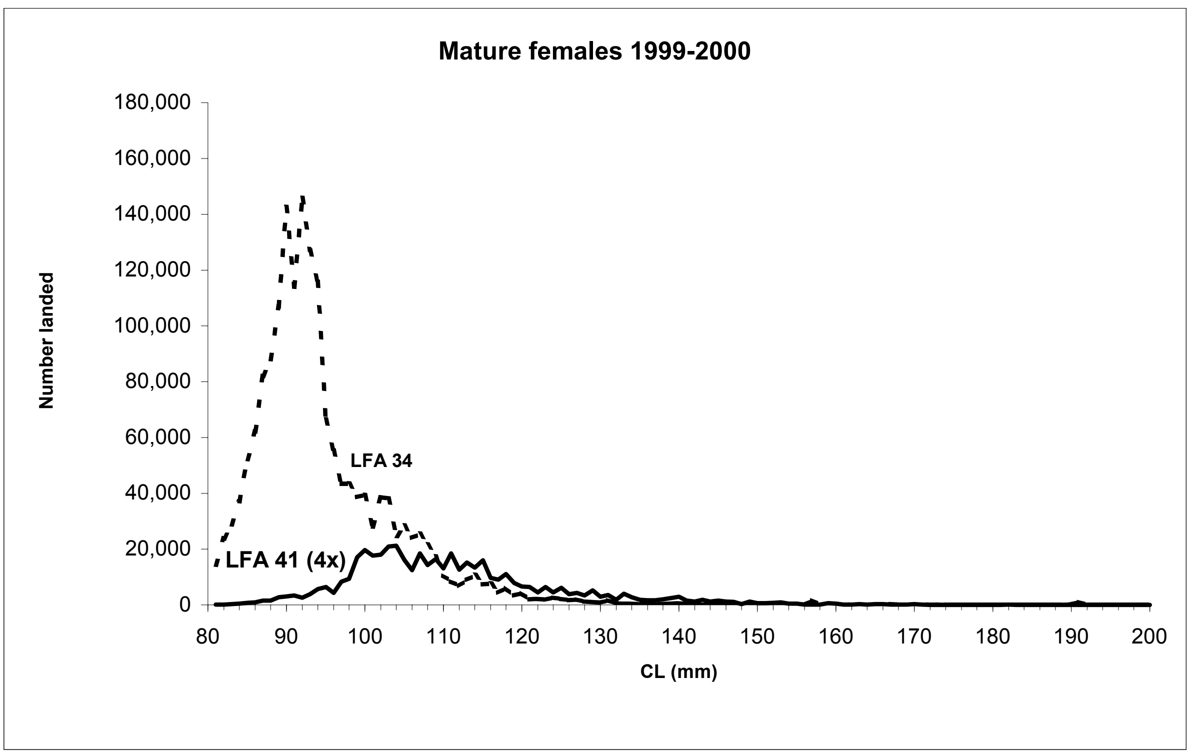
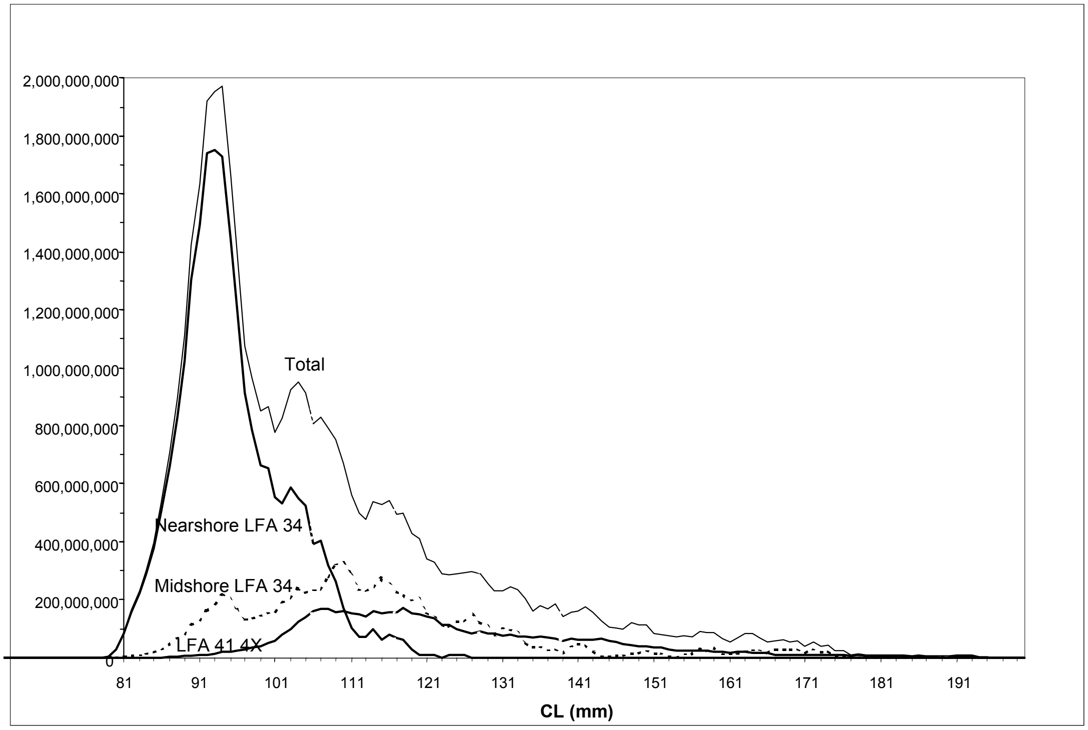


Figure 33. Number of mature female lobsters landed at size



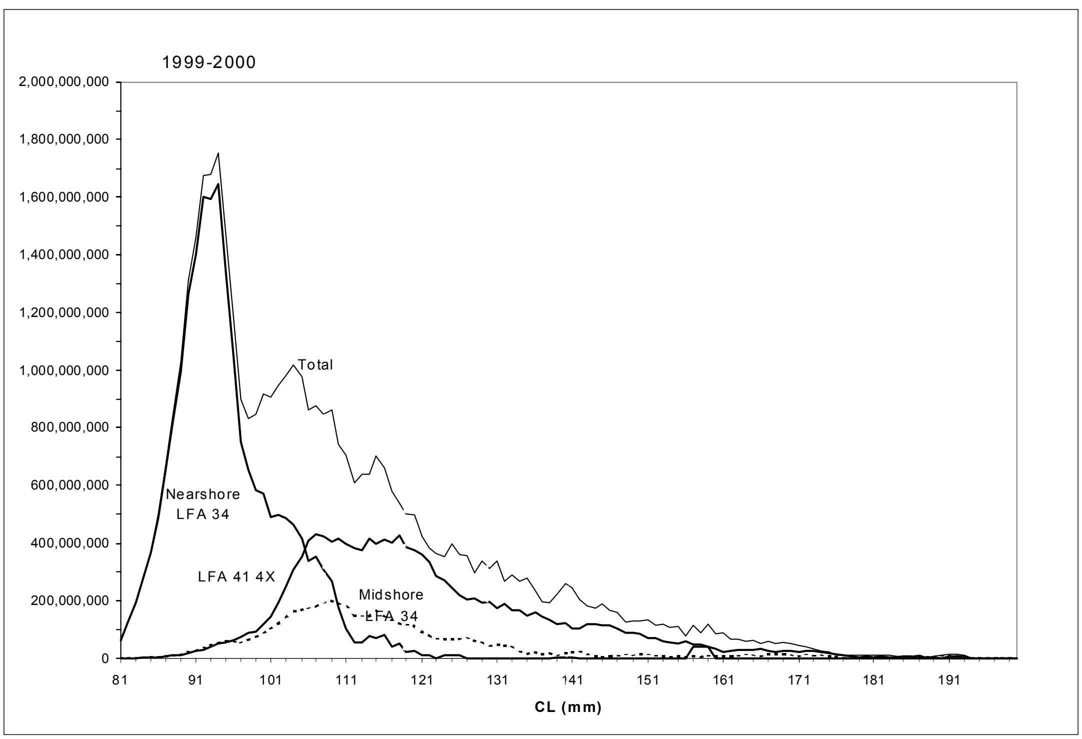


Figure 34. Number of eggs that females could have produced the next season if not captured (1998-99 and 1999-2000)

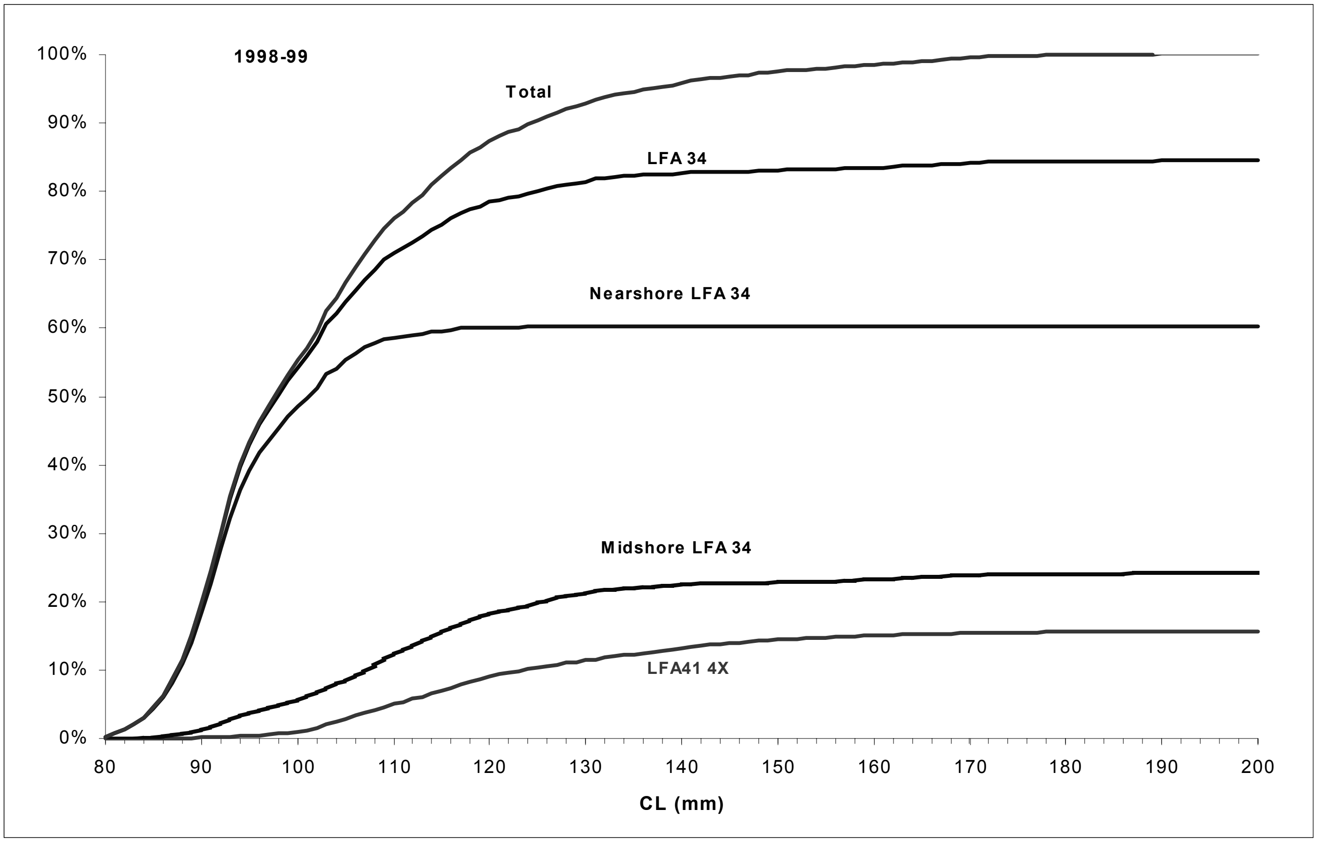


Figure 35. Cumulative % of total egg production that was removed in each area (Note only percentage of that removed and gives no indication of level which remained)

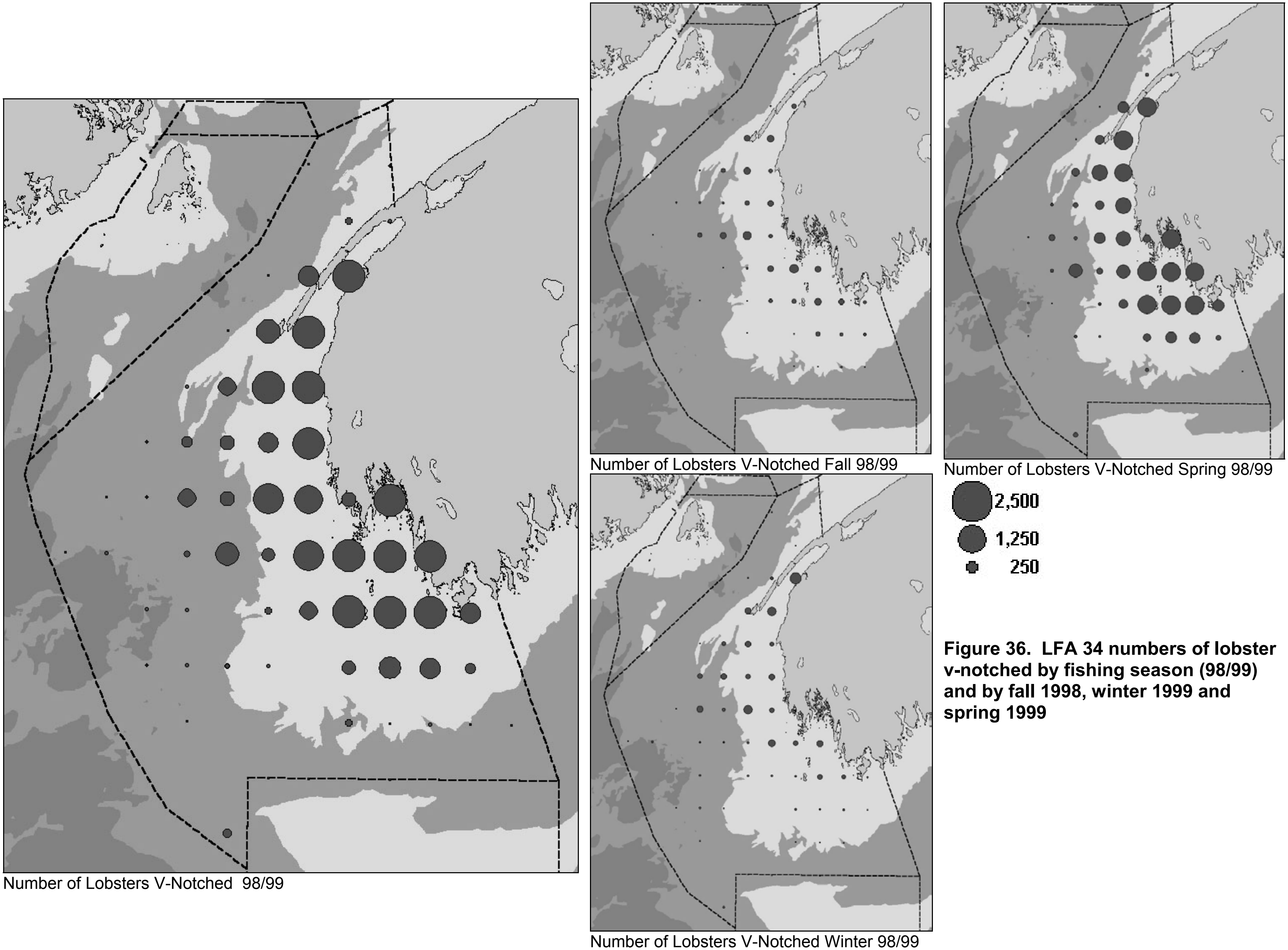
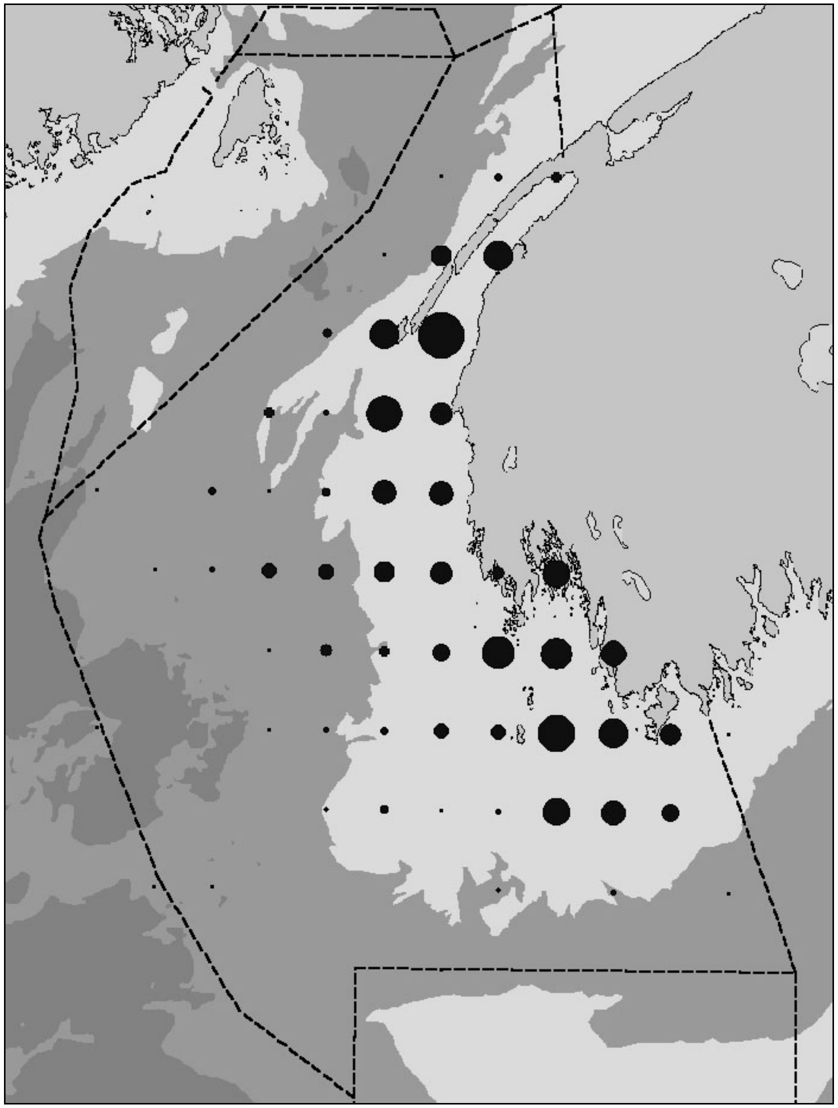
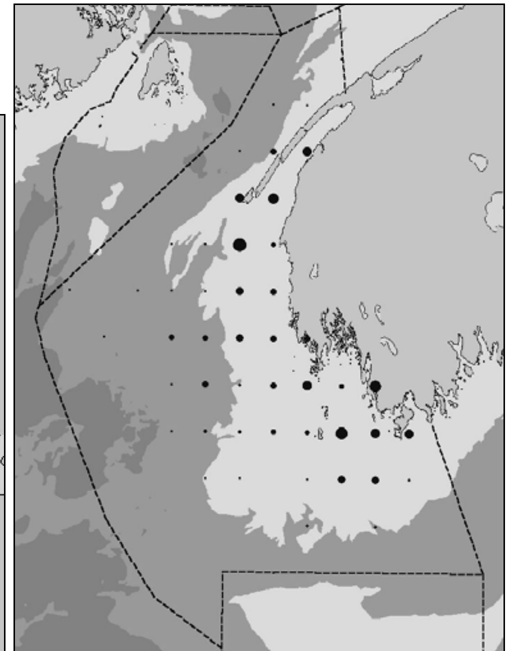


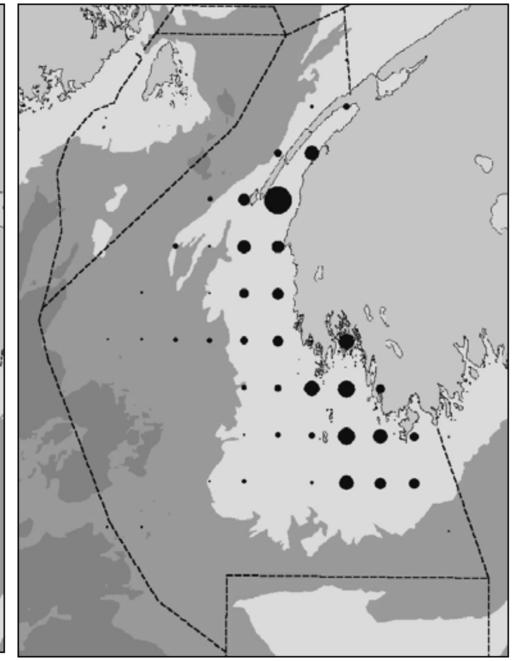
Figure 36. LFA 34 numbers of lobster v-notched by fishing season (98/99) and by fall 1998, winter 1999 and spring 1999



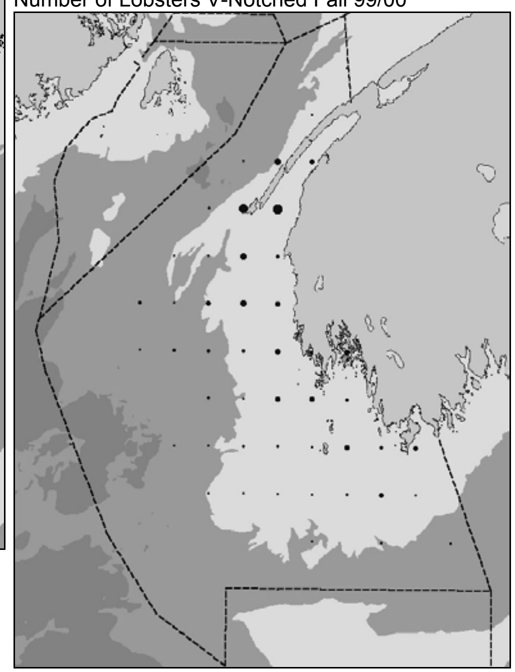
Number of Lobsters V-Notched Fall 99/00



Number of Lobsters V-Notched Fall 99/00



Number of Lobsters V-Notched Fall 99/00



Number of Lobsters V-Notched Fall 99/00

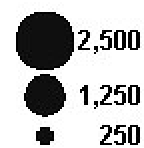


Figure 37. LFA 34 numbers of lobster v-notched by fishing season (99/00) and by fall 1999, winter 2000 and spring 2000

Appendix 1

History of regulations LFA 34

LFA 34 Fishery Regulations and Methods					
Year	**Events in Fishery**	**Minimum Size/V-Notch**	**Seasons**	**Licenses**	**Gear**
1870's	Decreasing average size, first signs of over fishing (Venning 1973) **1878** -Development of live lobster trade in SW Nova Scotia	**1873** - no landing of soft shell or berried females minimum size 1.5 lbs. **1874** - 9" total (79mm CL) replaced 1.5lb minimum (approx. 94mm CL)	**1874 - 1879**: September - July (replaced prohibtion on soft shelled lobsters)		Hoop Trap and shore gathering method
1880's	Poor enforcement and canning of short and berried lobsters common Decline began 1887-1918	**1887** - 79 mm CL	**1879 - 1887**: April - July (first attempt to reduce exploitation rates)		First box traps. ..Aprrox. 75 - 90 traps/fisher
1890's	1887-1913- 8 Commissions to study fishery Hatcheries established	**1899** - 79 mm CL for Yarmouth/Shelburne County **1899** - 92 mm CL for Digby County	**1887 - 1900**: January - June		
1900's	Gasoline powered moterboats began replacing sail and row boats		November 30 - May 31 with small variations. Currently last Monday in November - May 31		
1910's	1919- Hatcheries closed	**1910** - No size limit for Yarmouth/Shelburne County **1910** - 79 mm CL for Digby County		**1918** - license required, area unrestricted	**1910 - 1914**: 32 mm lath spacing. **1918** approx. 250 - 300 traps/fisher
1920's	Enforcement poor with large % of catch in some districts taken during closed season.				
1930's		**1934** - 78 mm CL		**1933** - fisher confined to one district in a given year	
1940's	Effort made to enforce size and seasons	**1941** - 79 mm CL		**1945**- use of vessel and gear resticted to one district in a given year	
1950's	Mass. increases minimum size and Canadian sizes adjusted to conform	**1952** - 81 mm CL			**1950 - 1955**: 41 mm lath spacing (resinded in 1955 due to fishermen opposition and difficulty of enforcement)
1960's				**1968** - no new licenses, A & B licenses	**1968** - 375 trap limit, each trap tagged
1970's	**1972**- offfshore lobster district opened			**1973** - licenses confined to one district, **1976** - A, B & C licenses, **1978** - buyback	
1980's	**1988** USA size increased to 82.5mm CL Lobsters less than 82.5 mm CL restricted from USA live market				split trap limit , 375 Nov-march/ 400 April-May
1990's	FRCC report recommenting increased conservation	**1998/99** - V-Notching introduced			**1993** - 41 mm escape gaps and ghost panels 1999- issuing of 25 replacemnt tags to all fishers in spring
2000's		**1999 (Dec)** - 82.5 mm CL			

Appendix 2

Midcoast Maine Lobster Decline Coming.

In a joint statement, three of Maine's top lobster scientists warn that Maine & Rhode Island lobster landings are about to drop.
"Signals of a widespread decline in landings are now evident."
==

JANUARY 22, 2001

JOINT STATEMENT BY
* Robert S. Steneck, Ph.D. Professor, University of Maine School of Marine Sciences
* Richard A. Wahle, Ph.D. Research Scientist, Bigelow Laboratory for Ocean Sciences
* Lewis S. Incze, Ph. D. Research Scientist, Bigelow Laboratory for Ocean Sciences

Potential Slowdown in Lobster Landings

The abundance of juvenile lobsters in key lobster producing regions of mid-coast Maine appears to be declining. We expect landings in those regions and possibly elsewhere to decline sometime during the next two to four years. Given that lobsters are the single most valuable species to Maine's fisheries, we think it is important to alert the lobstering industry, state managers, policy makers and the general public to our findings.

For more than a decade, scientists from the University of Maine and Bigelow Laboratory for Ocean Sciences have been working to develop means of predicting lobster abundance and landings. Our approach differs from those traditionally used in Maine and New England by independently monitoring three different life stages:

1) larvae in the water,
2) newly settled individuals on the bottom and
3) older juvenile lobsters.

Our research measured linkages between each of these three successive stages. Larval lobsters in coastal zones dive down to become the new year-class of lobsters on the bottom, and if these lobsters survive, they will become juvenile lobsters, and eventually comprise our future landings. In concept it's similar to counting the number of seeds you sow in your garden and finding that they correspond to some reduced number of seedlings and eventually the plants you harvest.

Predicting lobster abundances or landings is no easier than predicting the economy or the weather. While local lobster landings may generally reflect local lobster abundance, measuring abundance is fraught with uncertainty. We can never be sure that we "know" the abundance of any phase in a lobster's life.

However, by going to the same locations and using the same methods over many years, we can detect trends. Since any single measure of abundance may be flawed, we monitored abundance of three distinct stages, each requiring a different means of detection.

Censusing different developmental stages in juvenile lobster populations over time is similar to monitoring the total number of students in elementary schools as an indicator of future high school class sizes. If significant changes occur in the abundance of lobster larvae they should immediately translate to changes in that year-class on the bottom. A couple of years later, changes should be evident in the older juvenile lobsters.

Since 1995 newly settled lobsters on the bottom have been declining in the Boothbay monitoring region. Similar trends were detected in larvae in New Hampshire and new settlers in Rhode Island.

The larvae and settlement studies suggest widespread declines at least west of Penobscot Bay (no larval monitoring has been done east of there). Censuses of juvenile lobsters that are 2 to 4 years old (2 to 5 years prior to harvest) have been conducted statewide at nearly 40 sites distributed from York to Jonesport. Most troubling is the consistent decline since 1997 of juvenile lobsters from eastern Muscongus Bay, throughout Penobscot Bay and Hancock County.

This broad swath includes Maine's most-productive lobster-producing regions. While not all of our indicators at all of our study regions are consistent, enough are for us to announce that signals of a widespread decline in landings are now evident.

Many lobstermen will quickly point out that they have seen more egg-bearing lobsters over the past decade than ever before, and we agree. In fact, in the most recent lobster stock assessment there is evidence that the reproductive potential of lobster stocks is currently high. The decrease in larval lobsters and year-classes on the bottom must be the result of other factors, possibly changes in the ocean environment itself which could affect survival or delivery of the larval stages.

However, just as we cannot explain the dramatic increase in lobster abundances and landings over the past two decades throughout the northeast, from Delaware to Newfoundland Canada, we cannot explain the pending decline. Further, larvae and young of the year lobsters in Rhode Island and Maine are showing similar patterns of change despite being two oceanographically and reproductively distinct systems separated by Cape Cod. Thus the environmental factor(s) responsible appear to be very wide-spread.

What should be done? This question is best addressed by the lobstering community and state managers. As scientists we feel it's important to alert the public and stakeholders. No one has prior experience with the type of data we have. So we can't be sure how closely the harvest will follow our findings.

However, if the patterns we see turn out to be accurate predictors of declining harvest and are primarily controlled by the environment, *than* some traditional management actions such as increasing egg production may do little or nothing to reverse the situation. Nevertheless, steps should be taken to preserve existing broodstock. Certainly, a decline in lobster stocks given the large fishing capacity that exists could threaten the reproductive potential of the stock and reduce chances of recovery.

If lobster landings are to decline, it might be a good idea to wait before making large new financial commitments. Nature may still have more surprises for us and this trend could turn around. However, this is an excellent time for industry and managers to discuss the most appropriate actions so that the stocks and the fishermen both survive the fluctuations inherent in nature.

Robert S. Steneck
Richard A. Wahle
Lewis S. Incze

Appendix 3.

Biological Background

The American lobster, *Homarus americanus*, inhabits coastal waters from southern Labrador to Maryland, with major fisheries in the Gulf of St. Lawrence and the Gulf of Maine. Although lobsters are most common in coastal waters, they are also found in areas of warm deep water in the Gulf of Maine and along the outer edge of the continental shelf from Sable Island to North Carolina (Figure 4) to depths of 750m. In other areas lobsters are restricted to a band along the coast by cold bottom waters found at depth. In the Gulf of Maine, warm slope waters with year round temperatures of 6 to 9 degrees Celsius fill deep basins offering habitat for lobsters and allowing movement over long distances.

Lobsters make seasonal migrations moving to shallower waters in summer and deeper waters in winter. Tagging studies indicate that these movements often amount to a few kilometres in most regions, however, in the Gulf of Maine lobsters undertake long distance migrations of tens to hundreds of kilometres. Similar work has also shown site fidelity with some of these lobsters return to the same areas each year (Saila and Flowers 1968; Pezzack and Duggan 1986; Campbell 1987).

Current thinking is that the Gulf of Maine lobster population can be viewed as a metapopulation, meaning that a number of sub-populations are linked in various ways by movements of larvae via water currents and motion of adults. Exchange of genetic information occurs through the dispersal of larvae and adults. The dynamics of this relationship have not been fully evaluated with the number and distribution of these subpopulations remaining unknown.

To grow, lobsters must shed their exoskeleton through a process called molting. Lobsters exhibit continuous growth such that they continue to grow even after reaching morphometric maturity. In the region off SW Nova Scotia the size at 50% maturity is between 95 and 100mm carapace length (CL), at an average weight of 0.7 kg (1.5 lb.).

Mating occurs in midsummer, after mature females molt. The following summer she produces eggs that attach to the underside of the tail and are carried for 10-12 months, hatching in July or August. The larvae spend 30-60 days feeding and growing near the surface before settling to the bottom and seeking shelter. For the first 4-5 years lobsters remain in or near sheltered areas to avoid predation by small fish. Very young lobsters can molt 3-4 times a year, increasing 50% in weight and 15% in length with each molt. As they grow and have less chance of being eaten, they spend more time foraging in open areas and become more catchable in lobster traps.

In the waters off south-western Nova Scotia lobsters take 7-8 years to reach the legal size of 81 mm carapace length when they can be captured by the fishery. At this size they weigh 0.45 kg (1 lb.) and molt once a year. Larger lobsters molt less often, with a 1.4–2.8kg (3-6 lb.) lobster molting every 2-3 years.

Appendix 4
LFA 41 landings

Year	No. of Vessels	Browns Bank (4X)	Georges Bank (5Ze)	Total (Jan.-Dec.)	TAC
1971	5	8	92	100	
1972	6	180	154	334	
1973	7	317	176	493	
1974	6	281	135	416	
1975	8	372	173	545	
1976	7	496	182	678	
1977	8	358	277	635	408 (4X)
1978	8	381	303	684	408 (4X)
1979	8	373	236	609	408 (4X)
1980	8	357	192	549	408 (4X)
1981	7	382	190	572	408 (4X)
1982	8	303	166	469	408 (4X)
1983	8	324	154	478	408 (4X)
1984	7	300	140	440	408 (4X)
1985	8	664	114	777	720*
1986	8	648	162	809	720*
1987	7	463	145	608	720*
1988	6	387	139	526	720*
1989	6	364	85	449	720*
1990	5	480	85	565	720*
1991	5	536	129	665	720*
1992	5	456	130	585	720*
1993	7	493	164	656	720*
1994	6	606	172	778	720*
1995	7	557	121	677	720*
1996	7	574	76	650	720*
1997	8	497	177	675	720*
1998	8	416	132	548	720*
1999	8	547	173	720	720*
2000	8	595	182	777	720*

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

Table A4-1. Annual offshore lobster landings by NAFO area 1971 to 2000

Season	No. of Vessels	Crowell Basin	SW Browns	Georges Basin	SE Browns	Georges Bank	Total	TAC mt
85-86*	8	71	180	261	201	137	850	870*
86-87	8	74	136	179	143	185	717	720
87-88	7	78	133	150	99	118	578	720
88-89	6	80	114	37	57	114	402	720
89-90	6	94	180	62	101	95	532	720
90-91	5	79	222	188	105	120	714	720
91-92	5	81	193	128	75	133	610	720
92-93	5	101	130	104	75	134	544	720
93-94	7	104	166	110	152	169	701	720
94-95	6	126	214	83	178	118	719	720
95-96	7	124	190	112	186	110	722	720
96-97	7	84	141	112	188	145	670	720
97-98	8	79	160	94	145	145	623	720
98-99	8	70	120	102	132	161	585	720
99-00	8	114	153	137	131	176	711	720

Table A4-2. Seasonal offshore lobster landings by offshore assessment area 1985/1986 to 1999/2000

Season	No. of Vessels	Browns Bank (4X)	Georges Bank (5Ze)	Total	TAC mt
85-86*	8	714	137	851	870*
86-87	8	533	185	718	720
87-88	7	460	118	578	720
88-89	6	289	114	403	720
89-90	6	437	95	532	720
90-91	5	593	120	713	720
91-92	5	477	133	610	720
92-93	5	409	134	543	720
93-94	7	532	169	701	720
94-95	6	600	118	718	720
95-96	7	612	110	722	720
96-97	7	525	145	670	720
97-98	8	477	145	622	720
98-99	8	424	161	585	720
99-00	8	535	176	711	720

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

Table A4-3. Seasonal offshore lobster landings by NAFO area 1985-1986 to 1999/2000