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Lobster stock status in the coastal waters of Québec (LFAs 15 to 22) in 2011 and determination of reference points for the implementation of a precautionary approach in the Magdalen Islands (LFA 22)

État des stocks de homard des eaux côtières du Québec (ZPH 15 à 22) en 2011 et détermination de points de référence pour la mise en œuvre d'une approche de précaution aux Îles-de-la-Madeleine (ZPH 22)

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ABSTRACT

Since 2005, the assessment of lobster stocks in the Quebec waters (Lobster Fishing Areas, LFAs 15 to 22) is performed every three years. The last assessment was performed in 2008. The present document describes the data and analyses that served to determine stock status and provide recommendations for the 2012-2014 fishing seasons. There is no direct measurements of lobster biomass (empirical or analytical) and stock status assessments are based on an examination of four groups of indicators that describe the abundance, demography, fishing pressure and productivity of the stocks in terms of reproduction and recruitment. Stock status assessment is done by examining indicator trends versus the time series of the various data groups. Stock status assessment is done for the three main Quebec regions, i.e., the Magdalen islands (LFA 22), the Gaspé area (LFAs 19, 20 and 21), and for the North Shore (LFAs 15, 16 and 18) – Anticosti Island (LFA 17) area, which accounted, respectively, in 2011, for 71%, 23% and 6% of total Quebec landings. The lobster fishery is an input-control fishery (effort, sizes and protection of berried females). The minimum catch size (MCS) was increased by 6-7 mm in the last 15 years, which contributed to better protect immature lobsters and reach the objective of increasing egg production.

The abundance indicators were quite high in 2011 in the Magdalen Islands: the landings, the catches per unit effort (CPUEs) of commercial lobsters and the commercial density and biomass from the trawl survey were higher than they were in 2008 and above the series average. The average size of commercial lobsters has remained rather stable since 2008 and since the end of the MCS increase in 2003. Exploitation rates of the harvestable male fraction of the population are still high. However, since 2003, fishing mortality for the whole population dropped as a result of the increase in the MCS. The productivity indicators remained high and recruitment indices suggest still high landings in the short term and show excellent potential for maintaining good recruitment to the fishery in the longer term. According to the precautionary approach the lobster stock of the Magdalen Islands is currently in the healthy zone.

The abundance indicators have increased since 2008 in the Gaspé, after a period of marked decrease at the beginning of the 2000s. The 2011 landings were higher compared to 2008, and above the average of the past 25 years. (CPUE) were higher than in 2008 and above the data series average. The average size of commercial lobster has remained stable. Exploitation rates remained high in general in LFA 20, but dropped in areas where there was a noticeable decrease in fishing effort. Fishing mortality for the whole population dropped as a result of the increase in the MCS. Productivity indicators were high in LFA 20 suggesting that recent landing levels could be maintained at least in the short term.

At Anticosti Island, landings have risen since 2008 and in 2011, they were well above the average of the past 25 years. CPUEs were also greater in 2011. However, lobster size structures have changed in recent years and the average size has dropped, which could

be explained by the arrival of recruitment. However, the drop in the number of large lobsters suggests exploitation has increased. This could translate into weaker egg production. Lobster landings along the Lower North Shore dropped below the average for the last 25 years. The landings information may have been incomplete or this decrease may reflect a long-term decline in fishing effort. Catches per unit effort remained relatively stable from 2008 to 2011. Few lobsters were measured over the past few years in LFAs 15 and 16, which makes it difficult to assess demographic indicators.

On the whole, the situation is positive for most LFAs, Programs of fishing effort reduction are in progress in a number of LFAs which should contribute to further increase the robustness of the populations. A precautionary approach (PA) based on an empirical method was developed for the lobster fishery in the Magdalen Islands. The limit and upper stock reference points (LRP and USR) and the stock status zones (healthy, cautious and critical) were defined from a stock biomass indicator and in compliance with the DFO operational policy framework. The approach will eventually be improved and developed also for other LFAs.

RÉSUMÉ

Depuis 2005, l'évaluation des stocks de homard du Québec (Zones de pêche, ZPH, 15 à 22) se fait à tous les trois ans. La dernière évaluation remonte à 2008. Le présent document décrit les données et analyses qui ont servi à produire les avis sur l'état des stocks et à élaborer les recommandations pour les saisons de pêche 2012 à 2014. Il n'existe pas pour le homard de mesures directes de la biomasse (empiriques ou analytiques) et l'évaluation de l'état du stock est basée sur l'examen de quatre groupes d'indicateurs qui décrivent l'abondance, la démographie, la pression de pêche et la productivité des stocks, en termes de reproduction et de recrutement. L'évaluation se fait par l'examen de la tendance des indicateurs par rapport à la série chronologique des différents groupes de données. La revue de l'état des stocks est faite pour les trois grandes régions du Québec, soit les Îles-de-la-Madeleine (ZPH 22), la Gaspésie (ZPH 19, 20 et 21) et la Côte-Nord (ZPH 15, 16 et 18) - île d'Anticosti (ZPH 17), et qui comptaient, en 2011, respectivement pour 71 %, 23 % et 6 % des débarquements totaux du Québec. La pêche au homard est gérée par un contrôle des intrants (effort, limites de tailles et protection des femelles œuvées). La taille minimale de capture (TMC) a été augmentée de 6-7 mm au cours des dernières 15 années, ce qui a permis de mieux protéger les immatures et atteindre l'objectif d'augmenter la production d'œufs.

Les indicateurs d'abondance étaient très élevés en 2011 aux Îles-de-la-Madeleine : les débarquements, les prises par unité d'effort (PUE) des homards commerciaux ainsi que la densité et la biomasse commerciales du relevé au chalut étaient supérieurs à ceux de 2008 ainsi qu'à la moyenne des séries. La taille moyenne des homards commerciaux est demeurée plutôt stable depuis 2008 ainsi que depuis la fin de l'augmentation de la TMC en 2003. Les taux d'exploitation de la fraction exploitable mâle de la population sont demeurés élevés, mais la mortalité par pêche de l'ensemble de la population a diminué avec l'augmentation de la TMC. Les indicateurs de la productivité sont demeurés élevés et les indices de recrutement à la pêche suggèrent des débarquements encore élevés à court terme ainsi qu'un un excellent potentiel pour le maintien d'un bon recrutement à la pêche à long terme. Selon l'approche de précaution le stock de homard des Îles se situe présentement dans la zone saine.

Les indicateurs d'abondance ont été à la hausse en Gaspésie depuis 2008, après une période de baisse marquée au début des années 2000. Les débarquements ont été plus élevés en 2011 qu'en 2008 et supérieurs à la moyenne des 25 dernières années. Les PUE étaient en général supérieures à celles de 2008 et à la moyenne des séries. Les tailles moyennes sont demeurées stables. Les taux d'exploitation sont demeurés élevés en général dans la ZPH20, mais ont diminué là où il y a eu une baisse marquée de l'effort de pêche. La mortalité par pêche de l'ensemble des la population a diminué avec l'augmentation de la TMC. Dans la ZPH 20, les indicateurs de la productivité étaient élevés suggérant le maintien d'un bon recrutement à la pêche du moins à court terme.

À l'île d'Anticosti, les débarquements ont été à la hausse depuis 2008 et en 2011, ils étaient de beaucoup supérieurs à la moyenne des 25 dernières années. Les PUE étaient également élevées en 2011. Par contre, les structures de taille ont changé récemment et la taille moyenne a diminué, ce qui peut s'expliquer par l'arrivée de recrutement. Par contre, la diminution du nombre de gros homards suggère que le taux d'exploitation a augmenté, ce qui pourrait se traduire chez les femelles par une production d'œufs moins forte. Les débarquements de homard en Basse-Côte-Nord ont été à la baisse dernièrement, ce qui peut être dû à de l'information incomplète ou à une réduction de

l’effort de pêche. Par contre, les PUE sont demeurées assez stables depuis 2008. Peu de homards ont été mesurés au cours des dernières années dans les ZPH 15 et 16, ce qui rend l’évaluation des indicateurs démographiques difficile.

Dans l’ensemble, la situation est positive dans la plupart des ZPH. Des programmes de réduction d’effort sont en cours dans plusieurs ZPH, ce qui devrait contribuer à augmenter davantage la robustesse des populations. Une approche de précaution a été développée pour les Îles-de-la-Madeleine selon une méthode empirique. Les points de référence limite (PRL) et supérieur (PRS) ainsi que les zones d’état du stock (saine, de prudence et critique) ont été définis à partir d’un indicateur de la biomasse du stock et en conformité avec la politique-cadre du MPO. L’approche sera éventuellement améliorée et développée également pour d’autres ZPH.

1. INTRODUCTION

This document presents an assessment of lobster stock status in Quebec. The assessment has been performed every three years since 2005. The last assessment was performed in 2008 and this document describes the situation in 2011 and the changes observed since 2008. It stems from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Regional Advisory Meeting of February 1 and 2, 2012 on “Assessment of Lobster Stock Status in the Coastal Waters of Quebec.” Three Science Advisory Reports and proceedings have been produced and are posted on the DFO Canadian Science Advisory Secretariat website: http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Stock status assessments are based on the examination of a series of indicators developed using data primarily from the commercial fishery (statistics, logbooks and sampling at sea on fishing vessels and dockside). Other indicators are based on independent data from the fishery, i.e. trawl surveys and SCUBA surveys conducted in the Magdalen Islands (Lobster Fishing Area, LFA 22) or with traps (standard and modified by closing the escape vents) in LFA 20. The various indicators provide information on the abundance, population, productivity (reproduction and recruitment) of the stock and on fishing pressure. Environmental data (temperature) are also used to interpret the data. Stock status assessments are performed by examining the trends of the various indicators relative to a reference period, and for some indicators, based on conservation objectives or a precautionary approach (PA).

1.1 BIOLOGY

American lobster (*Homarus americanus*) occurs along the west coast of the Atlantic Ocean, from Labrador to Cape Hatteras. Adult lobsters prefer rocky substrates where they can find shelter, but can also live on sandy and even muddy bottoms. Commercial concentrations are generally found at depths of less than 35 m. In the Magdalen Islands, females reach sexual maturity at around 79 mm carapace length, CL on the south side and around 84 mm CL on the north side (Dubé and Grondin 1985, Gendron 2003). The size at sexual maturity is reached around 82 mm in the Gaspé (L. Gendron, unpublished data) and over 90 mm on the North shore (Gauthier 1988, Gendron et al. 2004) and Anticosti Island (L. Gendron, unpublished data). Males reach sexual maturity at a smaller size. Size at sexual maturity is often established based on functional sexual maturity which is determined from the degree of development of the cement glands (Aiken and Waddy 1982). Functional maturity is well correlated to the physiological maturity, determined from the gonado-somatic index. Secondary sexual characters are visible in the morphology of lobsters (Émond et al. 2010) which are sometimes used to approximate the size at sexual maturity. Mating occurs when females molt. The amount of sperm transferred by the male to the female is function of male size (Gosselin et al. 2003). Male size also plays a role in the amount of time spent with the female following mating. Larger males will spend more time, providing longer protection during the period of vulnerability to predation following moulting. This behaviour also allows the male to protect its progeny and genome from female’s mortality or from competition with another male’s sperm that could mate with the same female (Gosselin et al. 2003). Females generally have a two-year reproductive cycle, spawning one year and moulting the next. Females spawning for the first time can produce nearly 8 000 eggs while large females measuring 127 mm CL (jumbo size) can lay up to 35 000 eggs (Campbell and Robinson 1983). In addition to being more fertile, certain large females could spawn for two consecutive years before moulting (Waddy and Aiken 1986). Once released, the eggs remain attached to the females' swimmerets for 9 to 12 months, until the planktonic larvae hatch the following summer. Spawning and hatching can occur earlier in the season for multiparous females (females spawning for the second time at least) than for primiparous females (Gendron and Ouellet 2009). It was also noticed that larvae at the time of release could be larger for multiparous females than for primiparous females (Plante et al. 2001, Ouellet et al. 2003). The larvae's planktonic phase lasts from 3 to 10 weeks, depending on the temperature of the water. Following metamorphosis, postlarval lobsters (stage IV), which now resemble adult lobsters, drift down from the surface layer to settle on the sea floor. The survival of lobster from their larval stage to their initial benthic stages is impacted by predation as well as by hydrodynamic factors that cause advection or retain the larvae near the areas that are favourable for benthic settlement (see review by Butler et al. 2006). During the first few years of benthic life, until they reach approximately 40 mm, lobsters lead a cryptic existence; i.e. they live hidden in habitat providing many shelters. In the Magdalen Islands and in the Gaspé, lobsters are estimated to reach the minimum catch size (MCS) (82-83 mm) at around eight or nine years of age after having moulted approximately 16 times since their benthic settlement (Gendron and Sainte-Marie 2006). Recruitment to the fishery could be delayed in more northern areas because of slower growth, i.e., smaller moult increment and lower moulting frequency.

1.2 LOBSTER FISHERY MANAGEMENT

In Quebec, the lobster fishery takes place in spring. It usually begins after the ice break and lasts from 9 to 12 weeks. The lobster fishery is an input-control fishery. Fishing effort is controlled by limits on the number of licences, the number and size of traps, on the duration of the fishing season as well as on the daily fishing hours as well as on the organization of traps on fishing lines. Fishery management also includes escapement measures including minimum and maximum catch sizes, the release of berried females as well as females with a v-notch on their uropods. Management measures in effect in 2011 in the different LFAs are presented in Table 1.

1.2.1 Lobster fishing areas (LFA) and number of licences

Lobster fishers in Quebec operate in 8 major lobster fishing areas (LFAs 15 to 22) (Figure 1) and in 2011 there were a total of 564 active licences. Each fishing licence belongs to a fishing enterprise composed of a captain-owner and one or more fishers' helpers. In 2011, 325 licences were issued in the Magdalen Islands (LFA 22), which accounted for 57.6% of all Quebec licences. Although there is only one fishing area in the Magdalen Islands, it has traditionally been divided into two parts: the north (from Grosse Île to Millerand) and the south (Old Harry to Havre-Aubert) (Figure 2A). About one-third of all Islands lobster fishers operate in the northern area versus two-thirds in the southern area. Fishers are not assigned to a particular area and can change areas from one year to the next, but not during the year. In 2011, 180 fishing licences were issued in three fishing areas in the Gaspé (LFAs 19, 20 and 21) (Figure 1), which are subdivided into 27 sub-areas (Figure 3). The greatest number of licences (160) is issued in LFA 20, which accounts for 89% of the total number of licences in the Gaspé. A small fleet (8 licences) fishes along the north shore of the Gaspé Peninsula (LFA 19) from the Forillon Peninsula to Grande-Vallée. In LFA 21, there are 12 commercial licences (including 8 community licences). In Area 21B, the Listuguj Mi'kmaq community operates a fall subsistence fishery since 2001. The number of fishing licences has declined significantly since 2003 in the Gaspé while 38 licences were withdrawn (buy-back program), which represents a 17% decrease. The licences were bought back mainly in sub-areas where yields were lower.

The lobster fishery along Quebec's North Shore is operated by some 40 fishers in 3 lobster fishing areas (LFA 15, 16 and 18) (Figure 1). Most of the North Shore fishers are in LFA 15 and in 2011 there were 38 active fishers in this area (Figure 4A). In 2011, there were 4 fishers in LFA 16 and 3 in LFA 18, most of whom operated in sub-area 18H (Figure 1). In 2011, the lobster fishery off Anticosti Island was operated by 14 fishers originating from the Middle North Shore, the Gaspé and the Magdalen Islands. They fish primarily around the easternmost tip of the Island in sub-area 17B (Figure 4B). The lobster harvested off Anticosti Island is landed at the fishers' home ports. One exploratory licence was also issued in LFA 17A.

1.2.2 Number and size of traps

Until 2005 inclusive, 300 traps were allowed per licence in LFAs 17 and 22, and 250 elsewhere. In 2006, a fishing effort reduction program was implemented in LFA 22 to reduce the effort by a total of 27 traps per fisher by withdrawing 3 traps per year for 9 years (2006 to 2014). In 2011, 282 traps were allowed in the LFA. The number of traps also decreased in the Gaspé in LFAs 20 and 21 and starting in 2006 the number of traps allowed was 235 instead of 250. There are also trap size limits. Sizes vary a little in the various LFAs (Table 1). The use of larger than standard traps was prohibited except off Anticosti Island and along the North Shore. However, the number of oversize traps authorized is lower than that of standard traps. Since 1994, all traps have to be equipped with escape vents to let out small lobsters. The size of the vents increased in recent years to adjust to the new minimum catch size (see point 1.2.3). Thus, when the minimum catch size (MCS) was 76 mm (until 1996), the height of the escape vent was 43 mm. It was increased to 46 mm when the MCS reached 82 mm in LFAs 15, 16, 18, 20 and 21, and to 47 mm when MCS reached 83 mm in LFAs17, 19 and 22.These adjustments were made based on trap selectivity data from Gauthier and Hazel (1986).

1.2.3 Escapement measures (size and berried females)

The mandatory release of berried females and the minimum catch size (MCS) are the main escapement measures. The MCS has remained at 76 mm for 40 years (1957 to 1996) in all Québec LFAs. Starting in 1997, the MCS was increased by 6 or 7 mm depending on the LFA over a 7- to 10-year period. It is currently 82 mm in LFAs 15, 16, 20 and 21, and 83 mm in LFAs 17, 18, 19 and 22 (Table 1). The MCS was increased in order to double egg production per recruit compared to 1996 levels (Gendron and Gagnon 2001, Gendron 2005).

In the Gaspé, mainly in LFA 20, fishers cut a V-shaped notch into the uropods of berried females. This operation is optional, but releasing the marked lobster is mandatory. The number of notched females varies and is not recorded. In 2008, a maximum catch size of 155 mm CL (carapace length) was implemented in LFA 20. It has been 150 mm CL since 2010.

1.2.4 Other management measures

Hauling traps more than once a day is forbidden in the Magdalen Islands and Gaspé. In 2007, fishing hours (5:00 a.m. to 9:30 p.m.) in LFA 22 were regulated under the ban. The minimum number of traps per fishing line was set at 7 in the Magdalen Islands and 6 in the Gaspé. Moreover, the maximum line-length was set at 56 fathoms in the Magdalen Islands and 60 in the Gaspé. These measures have an impact on fishing efficiency.

1.3 CONSERVATION APPROACH

The conservation objective, as stated by the Fisheries Resource Conservation Council (FRCC) (1995) is to maintain robust stocks by maintaining a spawner biomass to ensure strong and continuous production of juveniles under the entire range of environmental conditions likely to be encountered. Populations are described as robust if they are abundant and have a broad size range and a balanced sex ratio. During the last stock assessment in 2008, it was noted that despite conservation efforts (increases in MCS) and positive trends in most LFAs, the size structure of stocks still needed to be improved. The report indicated that such improvements could help reduce the fishery's dependence on annual recruitment. They would also help increase the percentage of multiparous females in the population and keep sex ratios balanced to ensure reproductive success for females of all sizes. These recommendations were consistent with those stated by the FRCC (2007) and appropriate action was taken.

Canada is committed to implementing the Precautionary Approach (PA) to fisheries management. The implement of a PA is also requested by independent bodies to obtain eco-certification. A PA has been proposed for the lobster fishery in the Magdalen Islands (LFA 22) based on an empirical method (see Section 4.0). A limit and upper stock reference points (LRP and USR) and the stock status zones (healthy, cautious and critical) were defined from a stock biomass indicator in accordance with the DFO operational policy framework (DFO 2009). In the coming years, a PA will be developed for the Gaspé.

1.4 LOBSTER LANDINGS IN QUEBEC (LFAS 15 TO 22)

Lobster landings in Quebec were 3,716 t in 2011 (Table 2, Figure 5A). In 2011, 71% of landings came from the Magdalen Islands (LFA 22), 23% from the Gaspé (LFAs 19, 20 and 21), 5% from Anticosti Island (LFA 17) and 1% from the North Shore (LFAs 15, 16 and 18) (Figure 5B). Landings for all of Quebec in 2011 were 15% higher than the average for the last 25 years (1986 to 2010) at 3,245 t. Record lobster landings of 4,156 t were achieved in 2010. Lobster landings in Quebec have remained high for the last two decades.

2. MATERIAL AND METHODS

2.1 DATA SOURCES

2.1.1 Landing statistics and logbooks

Landing statistics are largely derived from processing plant purchase slips. The plants produce weekly reports of purchases from every fisher, which they then forward to DFO. Landing statistics have been compiled by DFO since 1984. They are presented based on the areas where the catches are made, not where they are landed.

Landings from logbooks are provided on a daily basis and estimated values are corrected with the weighed values on the purchase slips. The number of traps hauled associated with each landing is indicated, as well as a (LAT LONG) position. Logbooks became mandatory in LFA 17B in 2004 and in LFAs 15 and 16 in 2007. Electronic logbooks (ELBs) were introduced in 2010 in the Gaspé and in 2011, 63 fishers (more than a third of the fleet) took part in this pilot project; the target for 2012 is 100% coverage. The ELB data will be included in the next stock assessment. For now, some data from the 2011 ELBs will be presented for information purposes only. An ELB project is being developed for LFA 22.

The data shown as of 2001 does not include unreported catches (personal consumption and poaching). It had already been determined that these catches accounted for 3% on average (1984 to 2001) in the Magdalen Islands and could range from 1 to 10% (4% average) in the Gaspé for the same period.

From 1956 to 1983, lobster landings data were compiled by the Bureau de la statistique du Québec (BSQ). Landing statistics prior to 1956 are listed in Bergeron's work (1967). Landings from 1871 to 1917 were estimated from canned lobster production, using a conversion factor: one pound of lobster meat equaled 4 pounds of whole lobster (COSTACA code, Bergeron 1967).

2.1.2 Commercial sampling at sea

Commercial sampling at sea has been performed every year in the Magdalen Islands since 1985 and since 1986 in the Gaspé. Two areas are sampled in the south section of the Magdalen Islands, one off Grande-Entrée and the other near Île d'Entrée (Figure 2A). Two areas are also sampled in the north: the Étang-du-Nord and Pointe-aux-Loups area and the Grosse-Île and Île Brion area (Figure 2A). In the Gaspé, sampling at sea is done in the Anse-à-Brillant and Pointe Saint-Pierre (east of Saint-Georges-de-la-Malbaie) area (20A2), the Sainte-Thérèse-de-Gaspé and Grande-Rivière area (20A8-A9) and the Shigawake and Saint-Godefroi area (20B5-B6) (Figure 3).

Sampling at sea was also done in LFA 19C from 2001 to 2004 and in 2011. Parks Canada collected data at sea in the Forillon Park area (19C and 20A1) from 2008 to 2010 in accordance with the DFO protocol. Sampling at sea was also done in LFA 21B from 1997 to 2004, and in LFAs 15 and 16 in Tête-à-la-Baleine, La Tabatière and La Romaine from 1993 to 2004. Starting in 2005, dockside sampling replaced sampling at sea in LFAs 19C, 21B, 15 and 16. The total number of lobsters measured since 1985 in the various LFAs is indicated in Table 3.

Samples are taken at sea 3 times during the fishing season: at the start of the season (S: 1st and 2nd week of fishing), in the middle of the fishing season (M: 4th and 5th weeks of fishing) and at the end of the season (E: the penultimate and final weeks of fishing). For each period and in each area, sampling is conducted on two complete catches (all traps) from two different fishers, selected to provide optimal coverage of the target area. The fishers selected use standard traps and the trips are planned to coincide with the 24-hour soak time. For example, since there is no fishing on Sundays off the Magdalen Islands, sampling is never done on Mondays. On each trip to sea, the carapace length (CL) (eye orbit to the carapace margin) is measured on all individuals caught (1.0 mm accuracy). All lobsters are sexed (males and females) and the presence of eggs in females is recorded. Egg development is also classified into one of three phases (1: newly laid black eggs, 2: green eggs in development and 3: orange eggs with visible larvae). Data are collected for all traps during a fishing trip and recorded separately for each trap. For each sampling period (S, M and E), all lobsters from all traps in a given sub-area or area are grouped together for the analyses. This represents two fishing trips for each of the three sub-areas of the Gaspé (20A2, 20A8-A9 and 20B5-B6) and four trips to both parts of the Magdalen Islands (north and south). For each fishing period and area, the number of male, female and berried female lobsters and the number of traps are calculated. A CPUE (catch per unit effort) is calculated for each period ($CPUE_{period}$), and by area, by dividing the total number of lobster by the total number of traps (see Section 2.2.1.1).

A CPUE in weight (commercial lobsters only) is also calculated the same way. The weight of each commercial size lobster is estimated from its size using the usual length (L) – weight (W) relationship taken from Gendron et al. (1994):

$$Male: W=0.000288 \times L^{3.24}$$

$$Female: W=0.001778 \times L^{2.82}$$

2.1.3 Dockside commercial sampling

The dockside (or plant) sampling protocol involves randomly selecting at least 250 lobsters from one or more complete catches. The entire landing of one or two fishers can also be sampled. The number of traps associated with the measured landing is recorded for purposes of calculating the CPUE. Lobsters are measured as indicated in the previous section. Dockside sampling targets only the commercial portion and no information is obtained on berried females which are not landed. Dockside sampling has replaced sampling at sea in areas 15, 16, 19C and 21B since 2005. It has also been conducted in LFA 17 since 1998 in Rivière-au-Renard and Havre St-Pierre. In this case, landings are comprised of a mixture of weekly catches from several fishers who get together to deliver their catch at landing ports using a shuttle boat that makes the trip about once a week. Sampling is done at the plant before the catch is sorted by size. The number of lobsters measured since 1998 in the various LFAs is shown in Table 4.

2.1.4 Trawl survey (LFA 22)

Since 1995, a trawl survey is conducted in the southeastern part of the Magdalen Islands (LFA 22) at depths ranging from 7 to 35 m (Figure 2B). The survey is performed using a *Nephrops* bottom trawl with doors with a 20-metre headline. The trawl mesh is 80 mm, 60 mm and 50 mm at the wings, body and codend respectively. The trawl sets are made at a speed of 2.5 to 3 knots for 11 to 12 minutes so as to cover 1,000 m during each set. A Scanmar probe installed on the wings of the trawl is used to determine the horizontal opening of the trawl. The average opening is about 8 metres, so that an area of approximately 8,000 m^2 is swept during each set. The location of trawl stations was initially determined using a systematic sampling plan. However, stations located on untrawlable reefs were moved to adjacent soft bottoms.

The survey covers 50 fixed stations, 6 of which are located in Plaisance Bay. Two sets approximately 100 to 200 metres apart are made on 20 stations (including three in Plaisance Bay) to obtain data on the variability of lobster abundance over short distances to calculate variograms (see Section 2.2.1.4). From 1995 to 1998, two trawl sets were done at each station. Starting in 1999, the second set was eliminated at most stations because it was not needed to calculate the variograms.

All lobsters caught are measured and sexed and the shell condition is recorded to identify the molt stage (premolt, molting, intermolt and postmolt). The eggs of berried females are taken to determine the degree of embryonic development. Since 2004, recently molted females ≥ 80 mm CL are examined to determine whether they have a sperm plug in the entrance of the seminal receptacle. A sperm plug indicates that the female has mated and that there is sperm in the seminal receptacle, which provides an indication of mating success.

The survey is conducted in September after the lobster's molting period and when the lobster is located near the coast. The sample population therefore represents the population that will be available to the fishery the following spring. The main characteristics of the trawl survey are presented in Table 5.

The study area was divided into four depth strata (1: <15 m, 2: 15 m to <20 m, 3: 20 m to <25 m and 4: ≥ 25 m) with respective areas of 69.3, 144.1, 200.3 and 49.8 km^2 (Figure 2B). Plaisance Bay (104 km^2) was processed separately. In addition to the geostatistical analysis of the commercial portion (see Section 2.1.1.4), a statistical average of the lobster density is also calculated for other lobster classes (berried females, mature females and prerecruits) for the area trawled by adding the averages of the four depth strata, each weighted by the area of the stratum. The weighting factors are 0.15, 0.31, 0.43 and 0.11, for strata 1, 2, 3 and 4, respectively.

2.1.5 SCUBA survey (LFA 22)

A SCUBA survey is been conducted in the Magdalen Islands since 1995 (except 2002) in the Demoiselles area of Plaisance Bay (Figure 2A). It is conducted in September, after the benthic settlement of the lobsters. Lobsters are caught by hand in a 1-metre wide strip along 4 to 6 transects ≈ 50 m in length (Table 6). The lobsters are caught by searching under stones and around rocks. All lobsters that are caught are brought to the surface and measured (carapace length, 0.01 mm accuracy) and sexed. The main characteristics of the SCUBA survey are presented in Table 6.

2.1.6 Survey with experimental traps (LFA 20)

Since 2006, 25 to 37 fishers have participated in a fishery recruitment index project (Table 7). Sampling was done using four traps (experimental traps) two of which had closed escape vents (modified) to retain a greater number of small lobsters while the other two were unmodified (regular). The traps were set in alternate positions (regular and modified) at the beginning of a fishing line. They were surveyed as often as the other traps throughout the season. As a rule, the line of experimental traps was distributed randomly among the other trap lines. The fishers measured the lobsters themselves on a daily basis and entered the data in a logbook (Figure 6). Lobsters were measured with a gauge divided into 12 (2006 and 2007) and 14 (2008 to 2011) size classes (Figure 7). The gauge was graduated in order to identify prerecruits, commercial lobsters, jumbo lobsters and lobsters over legal size (155 mm in 2008 and 2009 and 150 mm since 2010). For each of the four traps, the size class of each lobster caught was entered in the appropriate lobster class column (male, female and berried female). The fishers were also asked to record their daily catch and effort (number of traps) in the section of the form entitled Daily Logbook (Figure 6). Depending on the year, between 72% and 85% of the fishers who participated entered data for at least 85% of fishing days in this section of the form. Data from 2006 are not included in this document.

2.1.7 Post-season trap survey (LFA 20)

From September 12 to 17, 2011, a post-season survey was conducted with modified traps (closed escape vents) in five LFAs in the Gaspé (20A2, 20A5, 20A8, 20B1 and 20B5) (Figure 8). The purpose of the survey is to develop another tool for predicting recruitment to the fishery one or two years in advance. The survey was conducted in September after the lobster's molting period and when the lobster was near the coast. The sample population represents the population that will be available to the fishery the following spring. In each LFA, 49 stations were set up along 7 transects (7 stations per transect) in three depth strata ranging from 5 to 40 metres: 2 stations were set at depths ranging from 5 to 10 m, 2 stations at depths ranging from 10 to 20 m and 3 stations from 20 to 40 m, along each transect. For each LFA, transects were positioned along roughly 7 km of coast. At each station, a line of 6 traps with closed vents, 6 fathoms apart was soaked for 24 hours. All lobsters caught were measured (1 mm accuracy) and sexed and the carapace was classified as hard or not (soft, papershell or crackable). The development stage of berried females' eggs was recorded using the same three classes described in Section 2.1.2. Data collection was done by fishers' helpers who had received training from a professional sampling technician.

2.1.8 Ecosystem

Data from thermographs located off Shag Island in the Magdalen Islands and Grande-Rivière in the Gaspé, at a depth of 10 metres were used as indicators of environmental conditions during the fishing season. These two thermographs are installed and removed, and the data are extracted and validated by the DFO coastal zone monitoring program's data management team since the mid-1990s. Temperature data measured directly in the fishing grounds were also obtained from the fishers themselves, who were provided with a thermograph, which they placed on one of their traps throughout the entire fishing season. The thermographs were returned to us for data extraction and analysis.

A by-catch inventory was taken during the 2011 lobster season in the Magdalen Islands (LFA 22) and the Gaspé (LFAs 19 and 20). Results will be presented in a separate document.

The list of available data by LFA is presented in Table 8.

2.2 DETERMINATION AND INTERPRETATION OF INDICATORS

There is no direct measurements of lobster biomass (empirical or analytical) and stock status assessments are based on an examination of four groups of indicators that describe the abundance, demography, fishing pressure and productivity of the stocks in terms of reproduction and recruitment. Abundance indicators include landings recorded on processing plant purchase slips and catch rates of commercial size lobsters from sampling campaigns and logbooks, and densities from trawl surveys. The demographic indicators are taken from lobster size structure analysis (commercial sampling and surveys) and include average size and weight, jumbo abundance (≥ 127 mm) and sex ratio. The fishing pressure index (exploitation rate) is obtained by calculating the ratio between the number of individuals (males) from the first molt class recruited to the fishery in a given year and number of individuals from the second molt class recruited to the fishery one year later. Productivity indicators (reproduction and recruitment) are based on abundance of berried females and egg production, abundance of prerecruits, one year before the fishery (trawl and trap surveys), and cohort strength at the time of benthic settlement (SCUBA survey). An overview of how the fishing season took place is obtained by examining fishing effort and temperature data. The list of indicators compiled for each LFA is presented in Table 9.

Stock status assessment is done by examining indicator trends versus a reference period corresponding to the time series of the various data groups. Recommendations are developed on the measures to be taken if the level of certain indicators drops significantly. The extent of the decreases is determined relative to the average of the time series. For example, we consider that the mean CPUE for a given year is not different from the mean of the series if the latter is included in the 95 % confidence interval on the annual mean. For other variables, we consider that an annual mean does not differ from the mean of the series if it is in its ± 0.5 standard deviation interval.

However, no reference points are defined for the various indicators, at this time, except for landings in LFA 22 (see point 4.0). However, in the recent history of lobster fishery management, target reference points (TRPs) have already been used. In 1995, a TRP was defined for a productivity indicator, i.e. egg production per recruit (EPR). The TRP for EPR was defined as its doubling with respect to the 1995 level. In Quebec, the target was reached by increasing the minimum catch size (Gendron and Gagnon 2001, Gendron 2005). This TRP was chosen in order to avoid entering a stock status zone in which there would have been a high risk of recruitment overfishing. A limit reference point (LRP) equal to a percentage (5%) of egg production of an unfished stock had been temporarily defined but was abandoned because it could not be adequately quantified. However, implementing a TRP implicitly enabled a move away from the LRP.

2.2.1 Abundance indicators (commercial portion)

2.2.1.1 CPUE – Sampling at sea

An annual CPUE ($CPUE_{annual}$) in number and weight is calculated by fitting a (linear, logarithmic or polynomial) model to the three values of CPUEs obtained from sampling at sea (start S, middle M, and end E, of season) ($CPUE_{period}$) and to a minimum value, representing the minimum generally observed by the index fishers (i.e. fishers who kept daily logbooks on a voluntary basis, especially during the 1990s). The model is used to represent CPUE trends as a function of the season and to calculate a CPUE value for each of the 9 or 10 weeks of fishing ($CPUE_{week}$) from which an average is calculated to represent the annual CPUE. In summary, calculation is done the following way:

$$CPUE_{annual} = \frac{\sum CPUE_{week}}{Nb\ weeks}$$

$CPUE_{weekly}$ is obtained from the model adjusted to the three $CPUE_{period}$ from sampling at sea (S, M, E) and a minimum CPUE value. The $CPUE_{period}$ is calculated for each area of interest the following way:

$$CPUE_{period} = \frac{\sum lobsters_{period}}{\sum traps_{period}}$$

An annual CPUE was calculated for each year for the south and north sections of the Magdalen Islands (LFA 22) and for LFAs 20A2, 20A8-A9 and 20B5-B6 in the Gaspé.

A single annual CPUE for all the Islands was also compiled by weighting the data from the south and north in proportion to the landings in each section for the year in question. In general, the proportions are 0.7 for the south and 0.3 for the north. Similarly, an annual CPUE for the entire LFA 20 in the Gaspé is compiled by weighting the data from the three sub-areas sampled in proportion to the landings in each section for the year in question. In general, proportions for LFAs 20A2, 20A8-A9 and 20B5-B6 are around 0.2, 0.5, and 0.3, respectively.

The four CPUE values (in number and weight per trap) and the fitting model are presented for the south (Figures 9A and 9B) and north sections (Figures 10A and 10B) of the Magdalen Islands (LFA 22) from 1985 to 2011 and for LFAs 20A2 (Figures 11A and 11B), 20A8-A9 (Figures 12A and 12B) and 20B5-B6 (Figures 13A and 13B) from 1986 to 2011. The model equations appear in the figures. Each model is an approximation of the lobster abundance depletion pattern based on the season. Depletion is rather linear in LFA 22, but more variable in LFA 20 where CPUE at the beginning of the season can be very low if weather conditions are unfavourable.

2.2.1.2 CPUE – Logbooks

An annual CPUE is calculated for each LFA where completing logbooks is mandatory, i.e., LFAs 15, 16 and 17. The calculation is also based on data obtained during the recruitment project in LFA 20 where fishers also completed a logbook, but on a voluntary basis. In this case, data from all the fishers in the 12 sub-areas covered by the project was consolidated to obtain a single CPUE value for all of LFA 20. Between 2007 and 2011, 21 to 26 fishers provided data (Table 7). The 2006 data was not used because it did not cover the entire fishing season.

A daily CPUE ($CPUE_i$) is first calculated by dividing the sum of the daily catches (*catch*) by the sum of traps (*eff*) hauled that day by all fishers in the area in question.

$$CPUE_i = \frac{\sum catch_i}{\sum eff_i}$$

where index i is the time window, *i.e.* the day.

An annual CPUE is also calculated by dividing the sum of the catches by the number of traps for the entire fishing season. The following equation is used to estimate the variance of the annual CPUE based on the daily CPUE data:

$$\sigma^2_{cpue} = \left(\frac{mean_{catch}}{mean_{eff}}\right)^2 * \frac{\sigma^2_{catch}}{mean^2_{catch}} + \frac{\sigma^2_{eff}}{mean^2_{eff}} - \left(2 * \frac{COV_{[catch,eff]}}{mean_{catch} * mean_{eff}}\right)$$

The equation calculates the variance of a quotient of two random variables, taking into account the mean (*mean*) and the variance (σ^2) of the two variables, i.e. the catches (*catch*) and effort (*eff*) and the covariance (*COV*) between the two variables (Mood et al. 1974).

Annual CPUEs are not standardized. The effect of factors other than abundance on CPUEs is assumed to be negligible. It is known that CPUEs vary during the fishing season (higher CPUEs at the beginning and end of the season), but every year the entire season is covered as fishers always fish throughout the entire season. There are also differences between fishers in the same LFA generally linked to spatial differences in the abundance of lobster within the LFAs. However, every year, all fishers in an area are active and furthermore, they are the same ones from one year to the next. These fishers also operate within a spatial fishing pattern, so the same fishing grounds, and generally all the fishing grounds are fished each year. We recognize however that the unit of effort (the trap) has changed from the middle 1970's to the beginning of the 1990's and that part of CPUE increase during that period can reflect an increase in trap efficiency (see Gendron and Archambault 1997). The data are not corrected for soak time. Most of the traps in LFAs 17 and 20 are hauled every day. The soak time is longer in LFAs 15 and 16 (2 to 4 days) because of the low abundance of lobster and the importance of other activities. However, we assume the situation did not change much from year to year.

2.2.1.3. CPUE – Experimental traps

An annual CPUE was calculated from 2007 to 2011 with data from the two standard traps used in the recruitment project conducted in LFA 20 (see Section 2.1.6). Males and females (non-berried only) from size classes 5 to 12 of the gauge (Figure 7) were selected for the calculation. The annual CPUEs were the average of the CPUEs for the 12 sub-areas.

2.2.1.4 Density and biomass – Trawl survey

The density of commercial size lobster (≥ MCS) (number/1,000 m^2) is calculated for each trawl set. Sizes are converted to weight using the standard equations (see section 2.1.2) and the biomass of commercial lobster (kg/1,000 m^2) is also calculated. From 1995 to

2011, the estimated annual average density and biomass of all commercial lobster (CL ≥ MCS, berried females excluded) were calculated using kriging. A variogram model was defined and its parameters (nugget, sill and range) were estimated using GS+ software (Figure 14 and Table 10) (for computation details, see Isaaks and Srivastava 1989). The kriged average and estimate variance were calculated with EVA2 software. The anisotropy of the variogram models was confirmed visually using maps generated with GS+ software. GS+ software was used to cross-validate kriged values with actual values (Figure 15 and Table 10). Figure 15 shows cross-validation for the density and Table 10 presents the determination coefficients of cross-validation for density as well as for biomass. The cross-validation results were used to validate the choice of variogram model.

Maps of the commercial lobster biomass were produced using kriging. Point kriging was performed with GS+ software using the parameters of the variogram model that was selected, on a regular 321 x 211 grid of 0.1 km^2 cells. The estimate was calculated using a search ellipse consisting of the 26 closest observations. Kriging maps of the commercial lobster biomass were produced with R software.

2.2.2 Demographic indicators (commercial portion)

The size frequency distributions of all lobsters caught during sampling at sea are compiled annually for each sub-area or area and each fishing period (S, M, E), and by class (males, females and berried females). For LFAs 15, 16 and 21B, size distributions are expressed as percentages. For LFAs 17, 19, 20 and 22, size frequency distributions of commercial size lobsters (males and non-berried female ≥ MCS) are weighted by landings in the fishing period (S, M, E) in order to estimate the total number of lobsters and the number of lobsters by size class landed in a fishing season. The weight of lobsters by size class for each sample is calculated by multiplying the number of lobsters in the class by the average weight of a lobster in this size class, based on standard length-weight relationships (see section 2.1.2). Thereafter, the weight proportion of each class is measured and multiplied by the landings for the period. Weights are converted to numbers by dividing by the average weight of the class.

For the Magdalen Islands, landings for the 9 weeks of fishing are divided into 3 periods: 3 weeks for the beginning, 4 weeks for middle and 2 weeks for the end. For the Gaspé, the period is divided into 3, 4 and 3 weeks. Size frequency distributions are calculated for 1 mm classes and then smoothed over 3 classes. Sizes and weights of landed lobsters are estimated based on these weighted distributions. The percentage of landings (in number and weight) consisting of jumbo lobsters ≥ 127 mm CL is calculated. Sex ratios are calculated for all commercial lobsters and for the largest lobsters (≥ 90 mm).

2.2.3 Fishing pressure indicator

The exploitation rate is calculated for commercial size males only, by measuring the change in abundance of the first molt class recruited to the fishery, compared to that of the second molt class a year later. The abundance of a cohort is monitored over two years. The calculation is based on weighted size frequency distributions from commercial catch sampling. The calculation is also performed using trawl survey data. The calculation method is taken from Miller et al. (1987). The following equation is used to estimate an instantaneous mortality rate for the first molt class recruited to the fishery:

$$Z = -\log_e (N_2 / N_1)$$

where $N_1 = N_1' / t_{N1}$, and $N_2 = N_2' / t_{N2}$. N_1' is the number of lobsters in the first molt class and N_2' is the number of lobsters in the second molt class. t_{N1} and t_{N2} represent the time elapsed in years, in the molt classes (intermolt time). Molt classes are estimated using lobster growth data from the Magdalen Islands reported by Dubé (1985). Until 1996, the first molt class of recruits included individuals between 76 mm and 86 mm, and the second molt class included individuals between 87 m and 99 mm. From 1997 to 2003 (Magdalen Islands) and to 2004 (Gaspé), the classes were adjusted to take into account every increase in MCS (Table 11). Intermolt time is estimated using molt probability data calculated by Dubé (1985).

To avoid biases that would be due to changes in recruitment, N_1 for a given year is compared with N_2 for the following year so as to monitor the same cohort over time. It is assumed that the catchability of lobsters of different sizes is comparable, which is realistic according to Tremblay et al. (1998) and is also comparable from year to year. The following equation is then used to calculate the exploitation rate (U):

$$U = F/Z \ (1-e^{-z}) \text{ (Ricker 1980)}$$

assuming that natural mortality M = 0.15, so that $F = Z - 0.15$.

2.4.4 Productivity indicator – Reproduction

2.2.4.1 Berried females (BF)

An annual CPUE ($CPUE\ BF_{annual}$) in numbers is calculated for berried females (BF) by weighting each sampling at sea value ($CPUE_{beginning}$, $CPUE_{middle}$ and $CPUE_{end}$) by the duration of the period, i.e., 3, 4 and 2 weeks for the Islands and 3, 4, 3 weeks for the Gaspé. No model was fitted to the CPUEs of berried female as was the case with the CPUEs of commercial lobsters.

$$CPUE\ BF_{annual} = 0.33\ CPUE_{beginning} + 0.44\ CPUE_{middle} + 0.22\ CPUE_{end} \text{ (Magdalen Islands)}$$

$$CPUE\ BF_{annual} = 0.3\ CPUE_{beginning} + 0.4\ CPUE_{middle} + 0.2\ CPUE_{end} \text{ (Gaspé)}$$

$CPUEs_{beginning,\ middle\ and\ end}$ correspond to the samples collected at three periods ($period$) of the fishing season: beginning, middle and end. They are calculated for each area of interest (see point 2.1.2) the following way:

$$CPUE_{period} = \frac{\Sigma\ lobsters_{period}}{\Sigma\ traps_{period}}$$

Berried females appeared difficult to catch with the trawl. Nevertheless, for the Magdalen Islands, an average density of berried females ($D\text{-}BF$) was calculated each year, for the area trawled, by adding the weighted averages for each of the four depth strata (str) (see Section 2.1.4). The averages were weighted by the area of each stratum.

$$D\text{-}BF = 0.15\ D\text{-}BF_{str\ 1} + 0.31\ D\text{-}BF_{str\ 2} + 0.43\ D\text{-}BF_{str\ 3} + 0.11\ D\text{-}BF_{str\ 4}$$

In addition, an abundance index of mature females (CL ≥ 79 mm) ($D\text{-}MF$) was calculated in a similar manner.

$$D\text{-}MF = 0.15\ D\text{-}MF_{str\ 1} + 0.31\ D\text{-}MF_{str\ 2} + 0.43\ D\text{-}MF_{str\ 3} + 0.11\ D\text{-}MF_{str\ 4}$$

2.2.4.2 Egg production

Size frequency distributions of berried females from sampling at sea data are compiled each year by combining data from the three fishing periods and integrating all sizes

≥ 67 mm CL for the Islands and ≥ 64 mm CL for the Gaspé. The size frequency distributions are calculated for 1 mm classes, and then smoothed over 3 classes. The average size of berried females is estimated based on all females collected in a given year, without weighting depending on the period.

An egg production index is calculated annually ($EGG\ PROD_{annual}$) based on the size frequency distribution of berried females and fecundity at size. Size frequencies are converted to percentages ($\%_{size\ class}$) and then multiplied by the abundance index of the berried females, i.e. the value of the weighted annual CPUE ($CPUE\ BF_{annual}$) (see Section 2.2.4.1). Egg production is estimated for each size class ($EGG\ PROD_{size\ class}$) by multiplying the abundance index with the fecundity associated to the size class ($FEC_{size\ class}$). The total egg production for a given year is calculated by adding the number of eggs in each size class.

$$EGG\ PROD_{annual} = \Sigma\ EGG\ PROD_{size\ class}$$

$$EGG\ PROD_{size\ class} = CPUE\ BF_{annual} \times \%_{size\ class} \times FEC_{size\ class}$$

Fecundity is obtained from Campbell and Robinson's (1983) equation relating fecundity (FEC) to carapace length (CL).

$$FEC = 0{,}00256 \times CL^{3{,}409}$$

The number of eggs calculated in this manner for a given year was divided by the estimated average egg production for the three years (1994, 1995 and 1996) preceding the increase in the MCS, in order to calculate an egg production increase factor related to the increase in MCS.

2.2.4.3 Multiparous females

The percentage of multiparous females (females that have produced eggs more than once) is also assessed. It is assumed that the percentage of multiparous females based on size follows the same curve as the percentage of mature females based on size (maturity ogive) (Figure 16), but the curve is shifted 10 mm to the right, which reflects an increase in molting (Dubé 1985, L. Gendron, unpublished data). Females that reach maturity and spawn for the first time are considered primiparous. They will become multiparous after they have released their first batch of eggs and molted.

The values of parameters a and b of the maturity ogives logistic equations:

$$Percentage\ mature = 1/1 + e^{-a\ CL + b}$$

are 0.314 and 24.8 for the south part of the Islands, 0.314 and 26.37 for the north part of the Islands and 0.169 and 14.15 for the Gaspé (Gendron and Gagnon 2001, Gendron 2003 and L. Gendron, unpublished data).

The contribution of egg production by each category (CAT) of females: primiparous ($PRIMI$) and multiparous ($MULTI$) ($EGG\ PROD\ CAT_{annual}$) was assessed as described above for total egg production (section 2.2.4.2). First, egg production by multiparous females ($EGG\ PROD\ MULTI_{size\ class}$) was calculated by multiplying the total egg production ($EGG\ PROD_{size\ class}$) by the percentage of multiparous females ($\%\ multiparous$) in the corresponding size class, which was derived from the maturity ogive. Secondly, egg production by primiparous females ($EGG\ PROD\ PRIMI\ size\ class$) was obtained by subtracting egg production by multiparous females from the total egg production, for each size class. Total egg production of each category of females (primiparous and multiparous) was obtained by adding for all size classes.

$$EGG\ PROD\ CAT_{annual} = \Sigma\ EGG\ PROD\ CAT_{size\ class}$$

where $CAT = PRIMI$ and $MULTI$

$$EGG\ PROD\ MULTI_{size\ class} = EGG\ PROD_{size\ class} \times \%\ multiparous$$

$$EGG\ PROD\ PRIMI_{size\ class} = EGG\ PROD_{size\ class} - EGG\ PROD\ MULTI_{size\ class}$$

2.2.5 Productivity indicator – Recruitment

2.2.5.1 Prerecruit density – Trawl survey

The average density of prerecruits (*D-PR1, D-PR2,* and *D-JUV*) is calculated for the area trawled in the Magdalen islands by adding the weighted averages for each of the four depth strata (see Section 2.1.4). Averages are weighted by the area of each stratum. Three classes of prerecruits were defined: 1) prerecruits who are one molt below commercial size (PR1). The lower size limit for this class is about 10 mm below the MCS. Individuals in the PR1 class will reach commercial size at their next molt, assuming a 15% growth rate at the molt (Dubé 1985, L. Gendron, unpublished data). 2) Individuals in prerecruit class 2 (PR2) will have to undergo two or three molts before reaching the MCS. The size limits for PRE1 and PRE2 classes were modified over the years to reflect changes in the MCS (Table 12). 3) All lobsters smaller than 55 mm caught by the trawl were included in the juvenile class (JUV). These young lobsters (aged about 3 to 4 years) are beginning their vagile phase and emerging from nurseries. They will reach commercial size only 5 to 6 years later (see Gendron and Sainte-Marie 2006).

$$D\text{-}PR1 = 0{,}15\ D\text{-}PR1_{str\ 1} + 0{,}31\ D\text{-}PR1_{str\ 2} + 0{,}43\ D\text{-}PR1_{str\ 3} + 0{,}11\ D\text{-}PR1_{str\ 4}$$

$$D\text{-}PR2 = 0{,}15\ D\text{-}PR2_{str\ 1} + 0{,}31\ D\text{-}PR2_{str\ 2} + 0{,}43\ D\text{-}PR2_{str\ 3} + 0{,}11\ D\text{-}PR2_{str\ 4}$$

$$D\text{-}JUV = 0{,}15\ D\text{-}JUV_{str\ 1} + 0{,}31\ D\text{-}JUV_{str\ 2} + 0{,}43\ D\text{-}JUV_{str\ 3} + 0{,}11\ D\text{-}JUV_{str\ 4}$$

2.2.5.2 Prerecruit CPUE – Experimental traps

An annual average CPUE was calculated for each sub-area of the Gaspé and for each year of the program (2007 to 2011). Data from 2006 were not retained. All fishers operating in a sub-area were grouped together. Annual averages were calculated for all of LFA 20, as well as for 20A and 20B separately (unweighted averages of the sub-areas). Only lobsters in size class 4 of the gauge (see Figure 7), corresponding to prerecruits one molt below commercial size (PRE1) were used for this index. The relationship between prerecruits (size class 4) from one year and commercial lobster (size classes 5 and 6 of the gauge) the following year was explored, for males only. The details of the computations will be available in a separate document (B. Bruneau and L. Gendron, Canadian Technical Report on Aquatic and Fisheries Science, in preparation).

2.2.5.3 Prerecruit CPUE – Post-season survey

CPUEs obtained in 2011 in the Gaspé were compiled by station (sum of catches in the 6 traps/6) and analyzed by depth strata and fishing area. Lobsters were divided into three size classes, 1) commercial lobster (COM) that would make up the catch the following year (CL ≥ 82 mm, males and females, excluding berried females), 2) prerecruit 1 (PRE1) i.e. lobsters one molt below the commercial size that will make up the catch two years later (70 ≤ CL <82 mm, males and females, excluding berried females) and 3) prerecruit 2 (PRE2) i.e. lobsters that are two or three molts below commercial size and will make up the catches at least three years later (CL <70 mm).

The effect of depth stratum and fishing area on the CPUE of the various size classes was examined by means of two-way variance analysis (ANOVA) (area and stratum). Multiple comparisons were performed to examine differences between strata within the same area, as well as differences between areas for the same depth stratum. Comparisons were made using a Student *t* test. The assumptions of the ANOVA were tested using the D'Agostino normality test and the Browne-Forsythe homogeneity of variance test (Zar, 2010).

3. STOCK STATUS

3.1 MAGDALEN ISLANDS (LFA 22)

3.1.1 <u>Fishing effort</u>

The total number of purchase slips compiled for a lobster fisher in a given year is equal to the total number of fishing trips (or fishing days) the fisher has completed. For each year, from 1990 to 2011, the total number of fishing trips (for all fishers) made to the Magdalen Islands was recorded. To get a measurement of nominal fishing effort in a given year, the number of trips was multiplied by the number of traps allowed per fisher (300 until 2005 with a decrease of 3 traps per year since 2006, for a total of 282 in 2011). It was assumed that fishers haul all of their traps on each trip. Sometimes there are a few exceptions, for example during storms when only some traps are hauled. This accounts for only a few days in the season and does not affect all fishers. From 1990 to 2011, an average of 16,030 ± 399 (average ± standard deviation) trips were completed annually (Figure 17A). This number has changed little in the last 22 years. It was somewhat lower from 1990 to 1994 (around 15,600 trips). In 2011, 16,357 trips were recorded. In general, the number of trips is 93% of the maximum (number of fishing days x number of fishers) which has been 17,755 since the number of licences and the number of traps per licence was limited (in 1973).

The effort in 2011 was 4.61 million traps or 93% of the maximum allowed, which is 4.95 million traps (Figure 17B). The nominal effort decreased by 6% since 2006, the year when the trap reduction program was introduced. The previous authorized maximum was 5.27 million traps. An average of 4.77 ± 0.13 million traps (average ± standard deviation) was set from 1990 to 2011. This number has changed little in the last 22 years.

3.1.2 <u>Temperature</u>

When the fishery opened on May 7, 2011, the water temperature at a depth of 10 m on the south side of the Islands (Shag Island) was 4.7°C, which was the same temperature recorded on the same date in 2010 (Figure 18A). These temperatures are much higher than those usually observed in the past. The average temperature for May 7 from 1994 to 2008 was 2.8°C. The water temperature rose steadily during the 2011 fishing season, but more slowly than in 2010. The temperature dropped several degrees in early July, which is probably attributable to a wind event causing upwelling of cold water. At the end of the season, the number of accumulated degree-days (DD) between May 1 and July 10 was

545, which was above the average for the period from 1994 to 2010 (520 DD), but lower than the numbers recorded in 2010 (603 DD) and 2006 (640 DD), the warmest year of the series ((Figure 18B). Overall, the 2011 fishing season was relatively warm and favoured lobster catchability.

3.1.3 Abundance indicators (commercial portion)

3.1.3.1 Landings

Landings for the Magdalen Islands reached 2,648 t in 2011 (Figure 19A, Table 2). Although these are preliminary data, they represent more than 95 % of the total. They increased by 6.5% compared to 2008 (2,487 t). In 2011, they were more than 17.6% of the average of the past 25 years (1986–2010) (2,252 t). In 2010, they reached a historic high of 3 033 t, breaking the record observed in 1992. In 2011, landings were higher than in 2008 both in the south and north (Figure 19B). They were also 17% above the average for the last 25 years (1986 to 2010) which was 1,550 t in the south and 702 t in the north. In 2010, landings reached a record 2,137 t in the south and 896 t in the north, which was the highest figure since 1992 (936 t). In 2011, the south accounted for 69% of total landings in the archipelago (1,804 t); the north accounted for the other 31% (818 t), which is in line with normal values.

3.1.3.2 Commercial lobster CPUE

Catch rates correspond to the catches per unit of effort (CPUEs) expressed in number or weight of lobster per trap. In 2011, for all of the Islands, the CPUE for commercial-size lobsters was 0.84 lobster per trap (l/t) (Figure 20A). The CPUE in number in 2011 was 6.3% higher than that in 2008 and 10.5% above the series average (1985 to 2010) (0.73 l/t). CPUE in the south was 0.9 l/t in 2011, an 11% increase over 2008 and 15% above the series average (0.78 l/t) (Figure 20B). However, the CPUE in the north was 4% lower than in 2008 (0.73 l/t), but equal to the series average (0.7 l/t). The CPUE was very high in 2010, reaching 0.98 l/t, the highest value of the series (the same as in 1992). At the beginning of the 2010 season, CPUEs were 1.65 l/t in the south and 1.6 l/t in the north, which was very high (Figures 9A and 10A). At the beginning of the 2011 fishing season, the CPUE was also very high in the south at 1.55 l/t (Figure 9A).

In 2011, CPUE in weight for all of the Islands was 0.56 kg/trap (kg/t), which is 27% higher than that in 2008 and 33% above the series average (0.42 kg/t) (Figure 20C). In the south, the CPUE was 0.6 kg/t in 2011 (Figure 20D). This was higher than the 2008 CPUE and the series average, which were both at 0.42 kg/t. In the north, the 2011 CPUE in weight was 0.48 kg/t, the same as in 2008 but 15% above the series average (0.41 kg/t (Figure 20D). The 2010 CPUEs in weight were the highest in the series, both in the south (0.6 kg/t) and north (0.66 kg/t).

The CPUE values for LFA 22 (south, north and total) are presented in Appendix 1.

3.1.3.3 Density and biomass – Trawl survey

The lobster population sampled in the fall of one year during the trawl survey represents the population to be available to the fishery in the spring of the following year. The commercial lobster density observed in the 2010 trawl survey was 8.9 lobster/1 000 m^2 (Figure 21A). The corresponding biomass was 6.1 kg/1 000 m^2 (Figure 21B). The values observed in 2010 were respectively 33.7% and 25.3% higher than those observed during the 2007 trawl survey. The 2010 values were above the 1995–2009 series average.

The lobster biomass distribution obtained by kriging is shown in Figure 22 for 1995 to 2011 for the area covered by the trawl survey (excluding baie de Plaisance). The values for 2011 represent what will be available to the fishery in 2012.

All of the abundance indicators have increased since 2008. Landings and CPUEs in weight from commercial sampling are significantly correlated ($p < 0.01$) to the biomass from the previous year's trawl survey, for 1995 to 2010 ($r = 0.85$ and 0.8, respectively) (Figures 23A and 23B).

3.1.4 Demographic Indicators

There was no notable change in commercial-size lobster size structures (≥ 83 mm) since 2008 (Figures 24 to 26) or since the end of MCS increase in 2003. The size structures have a truncated appearance and are dominated by a moult class of 83–94 mm for males and 83–90 mm for females corresponding to the year's recruits. Female size distributions are more truncated toward small sizes than male size distributions are. This reflects a decrease in female growth as they reach sexual maturity. The data from the trawl survey in the south part of the Islands (Figure 25) shows the same trends as the commercial sampling data (Figure 24). The increase in the MCS extended the size structure (Figures 27A, 27B and 27C), however, there has been no change in the size structures since 2008 (Figures 28A, B and C).

The mean size and weight of landed lobsters has remained stable since 2008, around 91 mm CL and 640 g in the south (Figure 28A) and around 92 mm and 660 g in the north (Figure 28C). The stability in the mean size and weight of commercial-size lobsters was also observed in the trawl survey (Figure 28B). Changes in mean size of commercial-size lobsters between 1985 and 2011 for all of the Magdalen Islands (north, south, males and females combined) are shown in Figure 28D. In general, trawl sizes are slightly higher by about 2 to 3 mm, which is attributable to changes in catchability related to the season and the sampling gear.

The boxplots illustrate the changes (1996 to 2002) and stability (since 2003) in the average, median and large sizes in the south (Figures 29 and 30) and north (Figure 31). There was very little change since 2008 and if so, differences were minimal (± 1 mm). However, in the south, there were more large females in 2010 and 2011 than in 2008. The maximum size of the boxplots increased from 97 mm in 2008 to 100 mm in 2011. In the north, sizes were stable and similar to those in the south for males, but 2 to 3 mm larger in females.

The proportion of jumbo lobsters (≥ 127 mm) observed during at-sea sampling is generally less than 1%. It was 0.4% in 2011 on the south side of the Islands compared to 0.7% in 2008 (Figure 32A). In the trawl survey conducted in the fall of 2010, the proportion of jumbos was 1.1% compared to 0.6% in the fall of 2007. There has been a steady increase in the number of jumbo lobsters caught in the trawl since the early 2000s. Their percentage increased by a factor of 7 between 2001 and 2011. The proportion on the north side reached 0.7% in 2011 compared to 0.3% in 2008. Most jumbo lobsters are males (Figure 32B). There are a few more jumbo females in the north, but the percentage remains under 0.3% (Figure 32C).

A sex ratio was calculated taking into account only non-berried females (number of males / number of non-berried females). This operational sex ratio reflects the number of males available for mating with each female. In the south, the ratio generally favours males. It is slightly > 1 for all commercial lobster, but increases for larger sizes (Figure 33A). The sex ratio for lobsters ≥ 90 mm clearly favours males. It was slightly higher in commercial catches (2.3) than in the trawl (1.8) (Figure 33B). The larger females could be relatively more catchable than males in the autumn trawl because they have molted more recently than the males.

On the north side of the Islands, the sex ratio is close to 1 for all commercial lobster (Figure 33C). It is higher for lobsters ≥ 90 mm but less than in the south. There are more large females in the north than in the south. This is related to greater growth associated with reaching sexual maturity later. In all cases, the sex ratios appear adequate to ensure mating (≥ 1).

3.1.5 Fishing pressure indicators

The exploitation rates calculated for commercial size males in 2010 were 75% in the south and 68% in the north. (Table 13, Figure 34A). These values have varied little since 2003 but are above the 1985 to 2009 series average: 68% in the south and 60% in the north. The exploitation rate calculated from the trawl survey data has also been fairly stable since 2003 (66.3 ± 1.7%) (average ± standard error). In general, the rates calculated from trawl data are slightly lower, which is consistent with the actual differences in average sizes (previous section). However, they are highly correlated with the rate calculated from commercial sampling data ($r = 0.73$, $p < 0.01$, $n = 15$).

Changes in the exploitation rate is partially attributable (53%, excluding 2006) to the temperature during the fishing season (Figure 34B). Colder temperatures (anomalies <0) seem to have a negative impact on the exploitation rate. However, exploitation rates are not necessarily higher when the temperature is warmer (anomalies > 0).

The exploitation rates calculated here only involve the exploitable population (> MCS). With the increase in MCS, it is obvious that fishing mortality for the entire population decreased, which is not apparent in the results presented here. We had previously used the change-in-ratio method (see Gendron and Savard 2003a) to calculate an exploitation rate index for males ≥ 76 mm. We showed that for this class size, the exploitation rate decreased to approximately 50% when the MCS was at 82 mm in 2002. Also, female mortality is lower because they are protected when berried. Female fishing mortality decreased as a result of the increase in MCS as a larger percentage of them became mature before reaching commercial size.

3.1.6 Productivity indicators – Reproduction

In 2011, for all of the Islands, the CPUE of female lobsters was 0.23 l/t (Figure 35A). The average CPUE since the MLS was increased to 83 mm (2003 to 2010) was 0.18 l/t compared to 0.09 l/t for 1985 to 1996 when the MLS was 76 mm CL. The 2011 CPUE was higher than in 2008 (0.13 l/t). This high value reflects the situation in the south where the abundance of berried females was particularly high in 2011 as in 2009 and 2010 (Figure 35B). Although berried females were not as abundant north of the Islands in 2011, overall, abundance still rose significantly as a result of the increase in MCS (Figure 35C). Changes in the north were less pronounced than in the south because sexual maturity is reached at a larger size.

The density of berried females in the trawl survey is rather low (Figure 36A). Catchability of berried females in the trawl is lower, probably because these females are not in postmolt. They are less mobile and eat less than the other lobsters. It is difficult to see a trend in the series although the highest values occurred after the increase in MCS. The percentage of berried females in the trawl could be influenced by the temperature on the grounds at the time of the survey. This hypothesis should be explored. A mature female

(CL ≥ 79 mm) abundance index was calculated from the trawl survey data (Figure 36B). The data show an increase from 1995 to 2010. The density of mature females was less than 3.0 lobsters / 1,000 m^2 before 1997 but reached 5.0 l and 5.3 l / 1,000 m^2 in 2010 and 2011 respectively. The density of mature females in the trawl is significantly correlated with the commercial sampling BF CPUE ($r = 0.76$, $p < 0.01$, $n = 16$) (Figure 36C).

The examination of the size structure of berried females shows a strong mode under the MCS on the south and north sides (Figures 37 and 38). On the south side, 62% of berried females are under the MCS whereas on the north side, 30% are below it. Before the MCS was increased, most of these females did not contribute to egg production. In 2011, the average size of berried females was 81.5 mm in the south and 87.1 mm in the north. The largest size of berried females on the north side is mainly explained by a larger size at sexual maturity. Berried female size structures from the trawl survey are similar to those from at-sea sampling on the south side of the Islands.

In 2011, multiparous females (those that spawn for the second time at least) represented 21% and 27% of berried females in the south and the north, respectively, compared to 17% and 23% in 2008. Multiparous females were more numerous than in 1996 (Figures 37 and 38). Berried female size structures from the trawl survey are presented in Figure 39. Overall, they were similar to those from sampling at sea south of the Islands.

An egg production index was obtained by multiplying the abundance index of berried females for each 1-mm size class by the size-specific fecundity. Egg production for 2003 to 2011, after the increase in MCS was divided by the mean egg production for 1994 to 1996, just before the start of the increase in MCS, to highlight the changes related tot this management measure. In 2011, the egg production index for the Magdalen Islands was 3.4 times higher than that calculated for 1994 to 1996, before the MCS was increased. It has been at least twice as high since 2003 (Figure 40A).

Multiparous female egg production also increased. It has always been at least twice as high since 2003 compared to the 1994-1996 average, but between four to five times higher in the last three years. In 2011, multiparous females accounted for 32% of total egg production. They accounted for 22% on average from 1994 to 1996 (Figure 40B).

Since 2004, at the time of the trawl survey, females ≥ 80 mm and in recent postmolt have been examined to see if they have a sperm plug in the entrance of the seminal receptacle. The presence of a sperm plug indicates that the female has mated and that there is sperm in the seminal receptacle. The purpose of this type of observation is to detect any anomalies in mating success that could be consistent with too strong fishing pressure on males and with a sex ratio imbalance. In 2011, about 69% of females had a plug compared to 81% in 2008 (Figure 41). Percentages were lower over the past three years (67 to 69%). Between 2004 and 2007, rates fluctuated between 70 and 79% without showing a trend. The recent decrease in rates is still no cause for concern, but the situation must be monitored. A partial explanation for these low rates is that sampling could have been done before the end of the reproduction season. Rates were higher for females ≥ 95 mm; at that size, they have reached full maturity.

3.1.7 <u>Productivity indicators – Recruitment</u>

A broader range of lobster sizes is caught in the trawl survey than in traps (Figure 42). Lobsters under commercial size can provide an index of recruitment to the fishery a few years in advance. Juvenile lobsters (<55 mm) are also caught in the trawl, but to a lesser extent because they are small and still spending most of their time living in shelters, which makes them far less vulnerable to trawling. The fact that the survey is conducted in the fall after molting provides a good picture of the population available to the fishery the following spring.

Lobster biomass and density increased throughout the years (Figures 43A and 43B).The density and biomass indices from the 2011 trawl survey were 8.0 l and 5.4 kg/1,000 m^2. These values are was lower than that of the past two years (9.1 and 8.9 l and 6.2 and 6.1 kg/1,000 m^2 in 2009 and 2010, respectively). The relationship between the biomass of commercial size lobster estimated during the trawl survey in a given year and the total landings from the Islands the following year is positive and significant (Figure 44A). In fact, 78% of the variance in landings can be attributed to variations in biomass observed the preceding fall. The predicted value of landings for 2012 based on the calculated regression model would be approximately 2,572 t, which remains fairly high and comparable to those for the last 5 years (excluding the very high ones in 2010).

The abundance of prerecruits (PR1, one molt below commercial size) in recent years was higher than in the late 1990s and early 2000s (Figure 45A). It was approximately 5 l/1,000 m^2, compared to 3 to 4 l/1,000 m^2. Two-year landing forecasts based on the PR1 index is less reliable. There is greater uncertainty in the predicted value. The abundance of PR1 accounted for 57% of variations in the landings. The 2011 PR1 abundance index suggests that 2013 landings will still be quite high (Figure 44B), at approximately 2,667 t. The abundance of PR1 in a given year provides a fairly accurate prediction of the commercial lobster abundance the following year (Figure 44C). There were no particular trends in PR2 (at least two molts below commercial size) and juvenile (<55 mm) densities (Figures 45B and 45C). It is interesting to note that juvenile density in Plaisance Bay reached 11 l/1,000 m^2 in 2011. It was up to 25 l/1,000 m^2 at a station near the nursery. This could correspond to lobsters from the strong 2008 cohort (see below).

The benthic settlement on the Les Demoiselles site (Figure 46) has been higher on average since 2002 compared to what was observed between 1996 and 2001. The high values in recent years coincide with the increase in egg production. However, benthic settlement is also influenced by wind strength and direction during the larval period. Benthic settlement observed in 2010 and 2011 was exceptional, with a density of young-of-the-year reaching 5 and 3 l/m^2, respectively. These values are two to three times higher than that observed in 2008, yet described as excellent. The survival of these young lobsters until they reach commercial size is still uncertain. For example, the abundance of the 2010 cohort decreased by 50% the first year. However, it was still very high for one-year-olds. Moreover, it is possible that the high landings in 2010 are related to the strong settlement observed in 2002 (1 l/m^2). The 2002 cohort was the strongest observed between 1995 and 2007.

3.1.8 Summary and Synoptic table

The abundance indicators were quite high in 2011. The landings were higher than in 2008 and 18% above the average of the past 25 years. Landings reached a historic high of 3,033 t in 2010. Catches per unit effort (CPUEs) in number and weight of commercial lobsters and the commercial density and biomass from the trawl survey were also higher than they were in 2008 and above the series average. All abundance indices are strongly correlated and show the same trends. With regard to the demographic indicators, the average size of commercial lobsters has remained rather stable since 2008 and since the end of the MCS increase in 2003. The sex ratio is still stable and balanced. The size structures are still truncated, but the proportion of jumbo lobsters (≥ 127 mm CL) has increased slightly since 2008. The fishing pressure indicators show that exploitation rates are still high. However, since 2003, fishing mortality for the portion of the population ≥ 76 mm CL dropped as a result of the increase in the MCS. The productivity indicators remained high. With regard to reproduction, the abundance of berried females and egg production were higher in 2011 than in 2008. The contribution of multiparous females to this production also increased. Recruitment indices suggest that landings in 2012 and 2013 will remain high. Juvenile abundance indices show excellent potential for maintaining good recruitment to the fishery in the longer term (8–10 years). It can be concluded that with its high abundance and productivity, the lobster stock in the Magdalen Islands is in good shape and that under the present environmental conditions, current exploitation levels do not compromise its sustainability. According to the precautionary approach developed for LFA 22 (see section 4.0), the lobster stock of the Magdalen Islands is currently in the healthy zone.

A summary table was prepared (Figure 47) to highlight the trends in the various indicators during the reference period from 1985 to 2011 for sampling at sea data and, from 1995 to 2011, for trawl survey data. For each year, a standardized score (anomaly) is assigned to each indicator, which is the difference between its value and the average value for the reference period, divided by the standard deviation of the average. A colour score card highlighting positive (red) and negative (blue) trends is then prepared. Indicators were grouped into the four standard classes: abundance, demography, fishing pressure and productivity (reproduction and recruitment). Trends are for all of the Magdalen Islands, except for the trawl and SCUBA survey data, which are for the south only.

3.2 GASPÉ (LFA 19, 20 and 21)

3.2.1 Fishing effort

Fleet rationalization efforts caused a significant decrease in fishing effort in the Gaspé. There were 9,626 fishing trips (day trips) in 2011, which was 5% lower than in 2008 (10,137 trips) and 24.5% below the average from 1994 to 2005 (12,270 trips) (Figure 48). This drop is due to a decrease in the number of licences and licence fusion. In 2011, 2.26 million traps were hauled, which is 5% lower than in 2008 and 26% below the average from 1994 to 2005, before the number of traps decreased from 250 to 235 per licence. The effort in 2011 was about 80% of the total effort allowed.

3.2.2 Temperature

The water temperature was normal at the beginning of the 2011 fishing season. It was approximately 3°C, which is the average temperature from 1997 to 2010 (Figure 49A). The situation in the early season was the same in 2009. However, the 2010 fishing season started with temperatures running 1 to 1.5°C above average. The water temperature rose steadily during the 2011 fishing season, similar to 2009, but remained colder than in 2010. There were episodes of cooling water, often brought on by winds that caused cold water upwelling. This phenomenon is common in the Gaspé. However, these upwellings were not observed until the very end of the fishing season in 2010. The number of accumulated degree-days between May 17 and June 30, 2011 (45 days) was 323, which is average for the period from 1996 to 2010 (316 DD) (Figure 49B). It was particularly warm in 2010 with 364 DD, as in 2008 (358 DD) and 2001 (352 DD), the three warmest years in the series (1996 to 2011). Overall, fishing seasons from 2009 to 2011 were relatively warm and favoured lobster catchability. There was no obvious relationship between temperature (cumulative DD during a fishing season) and landings (R^2 = 0.04) (Figure 49C).

3.2.3 Abundance indicators (commercial portion)

3.2.3.1 Landings

Landings for the whole of the Gaspé Peninsula reached 872 t in 2011 (Figure 50A). They increased by 14.8% compared to 2008 (786 t). In 2011, they were 6% above the average of the past 25 years (1986–2010) (823 t). Also that year, 92% of the Gaspé landings were from LFA 20, 3% from LFA 19 and 5% from LFA 21 (Figure 50B).

In LFA 20, more particularly, landings in 2011 reached 805 t (Figure 50C, Table 2). This represents an increase of 8% compared to 2008 (739 t) and 6% compared to the average of the past 25 years (761 t). The upward trend observed since 2008 was noted in most of the sub-areas in LFA 20 (Figure 51). Note that landings from LFA 20 dropped significantly between 1999 and 2005 and did not increase between 2005 and 2008.

Landings in LFA 19 reached 28 t in 2011, just as they did in 2008 (Figure 50B, Table 2). The average of the past 25 years in LFA 19 is 26 t. Landings in LFA 21A more than doubled between 2008 (16 t) and 2011 (36 t) (Figure 50D). In Area 21B, combined landings from the fall fishery and the spring fishery of the following year increased from 5 to 12 t between 2006 and 2011 (Figure 50E). The drop in spring landings since 2004 is related to a drop in fishing effort. Fall landings have increased since 2006.

3.2.3.2 Commercial lobsters - CPUE

Catch rates correspond to the catches per unit of effort (CPUEs) expressed in number or weight of lobster per trap. In 2011, the CPUE for commercial-size lobsters in LFA 20 was 0.58 lobster per trap (l/trap), which corresponds to a weight of 0.35 kg/trap (Figures 52A and 52B). The CPUE in number in 2011 was 32% higher than that in 2008 and 9.4% above the series average (1986 to 2010) (0.53 l/trap). The CPUE in weight was 34.6% higher than that in 2008 and 39.6% above the series average (0.27 kg/trap). CPUEs in numbers decreased starting in 1999, but the decrease in weight was less significant because of the benefits of increasing the MCS and the fact that the lobsters caught were larger (see Section 3.2.4). CPUE values obtained from the recruitment project also showed an upward trend between 2006 and 2011 (Figures 52A and 52B). The values presented are those obtained with regular traps; modified traps generally contained slightly fewer commercial lobsters. The values of CPUEs in weight are those reported in the Daily Logbook section. The three abundance indicators (by weight) under study all show the same upward trend since 2008 and are correlated. Commercial sampling CPUEs in weight are significantly correlated with landings from 1989 to 2011 ($r = 0.69$, $p < 0.01$) and CPUEs from the recruitment project logbooks for the period 2007 to 2011 are highly (but not significantly) correlated with landings ($r = 0.85$, $p = 0.068$) (Figure 52C).

The increase in CPUEs in recent years was observed in the three groups of sub-areas sampled (Figure 53). In LFA 20A2, in 2011, the CPUEs reached 0.73 l and 0.43 kg/trap. These figures were 14% and 48% higher than the 1986 to 2010 average (0.54 l and 0.29 kg/trap). The CPUEs for area 20A2 vary a great deal from year to year. They were lower for much of the 2000s, but have increased over the last four years. In 20A8-A9, the CPUEs reached 0.64 l and 0.37 kg/trap in 2011. These figures are 6.7% and 19.3% higher than the 1986 to 2010 average (0.6 l and 0.31 kg/trap). The CPUEs also decreased in the early 2000s, but rose in recent years. In 20B5-B6, in 2011, the CPUEs reached 0.4 l and 0.26 kg/trap. The number of lobsters was the same but the weight was 30% above the 1986 to 2010 average (0.4 l and 0.2 kg/trap). CPUEs have been stable and low for nearly 10 years. Increasing the MCS partially offset what appeared to have been a decrease in recruitment. However, CPUEs increased significantly in recent years. This increase is partly attributable to the fact that fishing effort declined significantly in these LFAs. Buyback programs have targeted this area because of low catch rates; between 2006 and 2011, the number of licences decreased by 35% from 26 to 17.

CPUEs in Area 19 were 0.59 l/trap and 0.48 kg/trap in 2011, which is, respectively, 8% and 6% lower than in 2008 (Figures 54A and 54B). However, the values fluctuate considerably from one year to the next. The CPUEs in numbers are comparable to those in LFA 20, but CPUEs in weight are much higher because the lobsters are larger (see Section 3.2.4).

The CPUE values for LFA 20 are presented in Appendix 1.

The average CPUE measured during the fall fishery in LFA 21B was 2.1 kg/trap (Figure 54C). This is the highest value observed since the start of the fall fishery in 2001. The 2001–2011 average is 1.2 kg/trap and these high values reflect the highest catchability of lobster in the fall. Traditionally, average CPUEs observed during the spring fishery are about 0.2 kg/trap.

3.2.4 Demographic indicators

Lobster size structures in the Gaspé, in LFA 20 have a truncated appearance and are dominated by a moult class of 82–93 mm for males and 82–89 mm for females corresponding to the year's recruits (Figure 55). Female size distributions are more truncated toward small sizes than male size distributions are. This reflects a decrease in the growth of females as they reach sexual maturity. The size structures have changed markedly since with the increase in MCS. They are more extended to the right (Figure 56A). However, there has been no significant changes in size structures of commercial-size lobsters (> 82 mm) since 2008 in LFA 20 (Figure 56B), or since the end of the increase in MCS in 2004. The mean size and weight of landed lobsters has remained stable since 2008 at around 88 mm and 580 g (Figure 56B and 57A). The boxplots illustrate the changes (1996 to 2003) and stability (since 2004) in the mean, median and large sizes in LFA 20 (Figure 57B and 57C).

Changes in the size structures (Figures 58, 60 and 62) and in the various size statistics (Figures 59, 61 and 63) since 1996 are presented for the three groups of sub-areas sampled, 20A2, 20A8-A9 and 20B5-B6. In LFA 20A2, there was a small decrease in large sizes among females in 2010 and in males in 2011. However, these changes are minor—on the order of 1 mm. In LFAs 20A8-A9, the situation has changed little in recent years and the average and median values were stable. The changes are on the order of 1 mm. In LFA 20B5-B6, median values are quite stable. However, there was a slight increase in larger sizes over the last year on the order of 2 to 3 mm, compared to 2004. This increase could be associated with a decrease in fishing pressure (see Section 3.2.5).

The proportion of jumbo lobsters observed in at-sea sampling is quite low. In 2011, the proportion reached 0.28%. It was 0.34% in 2008. No jumbos were observed in LFA 20A2 in 2011, unlike other years, such as in 2008, for example, when the proportion was 0.78%. In LFAs 20A8-A9, the proportion was 0.41% in 2011, which was higher than in 2008 (0.31%) and 2009 and 2010 (0.15%). The percentage of jumbos was higher in 20B5-B6 in 2010 (0.35%) and in 2011 (0.22%). In fact, no jumbos were recorded in 20B5-B6 in 2008 or 2009.

A sex ratio was calculated taking into account only non-berried females (number of males / number of non-berried females). This operational sex ratio reflects the number of males available for mating with each female. For all of LFA 20, the ratio generally favours males

(Figure 64A). It is slightly > 1 for all commercial lobster, but increases for larger sizes (Figure 64A). The sex ratio for lobsters ≥ 90 mm clearly favours males (≈ 2). Overall, the sex ratios appear adequate to ensure mating (≥ 1).

However, there are differences between sub-areas. In 20A2, the sex ratio hovers around 1.0 and 2.0 for all commercial lobsters and lobsters ≥ 90 mm respectively (Figure 64B). In LFAs 20A8-A9, the sex ratio is about 0.5, which is significantly lower than the 1.0 recorded in 2002, 2004 and 2005 (Figure 64C). It is less than 2 for large sizes. This situation, which should be monitored, could be attributable to excessively high fishing pressure on males relative to females since the increase in MCS. The situation was different prior to 2004 when there were far more males ≥ 90 mm than females (sex ratio ≈ 2.0). The situation is different in LFAs 20B5-B6 where sex ratios for sizes ≥ 90 mm are still > 2 (Figure 64D).

Size structures are more spread out in LFA 19C compared to LFA 20 (Figure 65). Several moult classes are recognized there. The mean size and weight of landed lobsters has remained stable since 2008, around 98 mm and 850 g, and are higher than in LFA 20 (Figure 66A to 66C). The proportion of jumbo lobsters observed is also much higher there. It was 6% in 2011 and has fluctuated between 5% and 6% since 2008. There are also some jumbos among females; the proportion ranged from 2.6% to 5.5% between 2008 and 2011. In males, the proportion varied between 5.2% and 8.6% for the same period. Sex ratios generally favour males (> 1), except in 2004 and 2005 where values were around 0.7 to 0.8 (Figure 64 E). The sex ratio seems favourable to mating.

The mean size of landed lobsters in LFA 21B (dockside sampling) in 2011 was 91 mm in spring and fall (Figures 67A and 67B). Size structures are slightly less truncated than those observed in LFA 20. From 2008 to 2011, no jumbo lobsters were observed in the samples. Sex ratio is generally largely in favour of males (around 2) and even more for larger sizes (Figure 64F).

3.2.5 <u>Fishing pressure indicators</u>

Truncated size structures are indicative of high exploitation rates. Exploitation rates calculated for the commercial-size males in LFA 20 (cohort monitoring) were 83% in 2010 (Figure 68A). They were 86% in 2008. These values are above the 1986–2009 series average of 76%. The exploitation rate index for males ≥ 76 mm CL has decreased to about 50–60% since the minimum legal size of 82 mm was reached.

The situation varies from one sub-area to the next (Figure 68B). It is interesting to note that in LFAs 20B5-B6, where fishing effort was reduced by 35% between 2006 and 2011, the exploitation rate decreased by 6 points, from 85.9% to 79.8%. During this short period, there was a high but not significant correlation ($r = 0.78$, $p = 0.12$) between fishing effort and the exploitation rate. By comparison, in LFAs 20A8-A9, where fishing effort was not reduced, the exploitation rate remained at about 89% to 91% during this period.

Exploitation rates calculated here only involve the exploitable population (> MCS). With the increase in MCS, it is clear that fishing mortality for the entire population decreased, which is not apparent in the results presented here. We had previously used the change-in-ratio method (see Gendron and Savard 2003b) to calculate an exploitation rate index for males ≥ 76 mm. We showed that for this class size, the exploitation rate decreased to approximately 50% when the MCS was at 81 mm in 2002. Also, female mortality is lower because they are protected when berried. Female fishing mortality decreased as a result of the increase in MCS as a larger percentage of them became mature before reaching commercial size.

The situation is different in LFA 19C, where spread-out size structures indicate that exploitation rates are lower (around 30%). Since 2008, sex ratios have always been over one and seem suitable for mating. In LFA 21B, size structures indicate that exploitation rates are somewhat high (not estimated). The sex ratios observed over the past few years were quite often widely in favour of males (> 2.0).

3.2.6 Productivity indicators – Reproduction

In 2011 in LFA 20, the CPUE for berried females reached 0.25 l/trap compared to 0.2 l/trap in 2008. Since then, the abundance of berried females has been at least three times higher than it was when the MLS was 76 mm (Figure 69A). The average CPUE from 1986 to 1996 was 0.06 l/trap. CPUE values obtained in the recruitment project where experimental traps were used have also shown an upward trend since 2007 (Figure 69A). The values are from modified traps (without escape vents), which explains why they are higher than the values from at-sea sampling.

The increased abundance of berried females is visible in the three sub-areas sampled (Figures 69B, 69C and 69D), especially in 20A8-A9 and 20B5-B6 where the abundance of berried females in 2011 was 4.8 and 6.6 times higher respectively than from 1986 to 1996, before the MCS was increased. In 20A2, abundance was 1.5 times greater. In all three cases, the CPUE was higher in 2011 than in 2008.

The examination of size structures of berried females in LFA 20 shows a strong mode under the MLS (Figure 70). A total of 66% of berried females are sublegal. Before the MLS was increased, most of these females did not contribute to egg production. In 2011, the average size of berried females was 81.3 mm CL. It is generally around 82 mm. The size decrease could be associated with the arrival of recruits, as revealed by the increase in CPUE.

An egg production index was obtained by multiplying the abundance index of berried females for each 1-mm size class by the size-specific fecundity. In 2011, the egg production index for all of LFA 20 was 3.1 times higher than that calculated for 1994 to 1996, before the increase in the MCS (Figure 71A). Also that year, multiparous females (those that spawn for at least a second time) represented 13% of berried females and contributed to 21% of total egg production (Figure 71B). Their contribution has also increased since the MCS was raised. Their relative contribution (in %) is a result of the recruitment of small females and fishing pressure. The lower value recorded in 2011 could be attributable to recruitment.

In LFA 19C, the abundance of berried females has fluctuated over the years without showing any clear trend (Figure 72A). The increase in the MLS had less of an impact on berried females than it did in LFA 20 because of a higher size at sexual maturity. The size structures of berried females in LFA 19C clearly differ from those in LFA 20 (Figure 72B). Because of lower exploitation rates, a wider range of sizes is observed. The percentage of sublegal berried females (10%) is much lower than it is in LFA 20. The average size of berried females measured in 2011 was 96.6 mm. There is also a non-negligible portion of jumbo females (4%).

3.2.7 Productivity indicators – Recruitment

Abundance indices of prerecruits (70–81 mm, one moult below commercial size) from modified traps (closed escape vents) from the recruitment project have increased since 2007 in LFA 20 (Figure 73A). There is considerable spatial heterogeneity in the abundance of prerecruits in the Gaspé, but the upward trend was observed in most of the

12 sub-areas covered by the study. Generally, there is a positive relationship between the abundance of prerecruits in one year and commercial-size lobsters in the following year for LFA 20 (Figure 73B) and for 20A and 20B (Figure 73C). On the whole, the abundance of prerecruits observed in 2011 suggests that landings observed over the past two years could be maintained in 2012. Prerecruit abundance observed in 2011 for LFA 20 (0.59 l/trap) and for 20A (0.62 l/trap) and 20B (0.79 l/trap) were relatively high. The medium-term outlook (two years) is still inaccurate because of the short data series (only 3 points).

Another index of recruitment to the fishery is currently being developed and is based on a postseason survey. The survey is conducted in the fall after moulting and the population sampled represents that which is available to the fishery in the following year. In 2011, traps with closed vents were used to collect data on the abundance of prerecruits at 245 stations in five sub-areas of LFA 20. A total of 10,973 lobsters were caught and measured during the survey. The number of lobsters per station ranged from approximately 1,800 to 2,100, except for 20B6 where 2,980 lobsters were caught. The commercial lobster CPUEs (2012 recruits) were high at the five stations, averaging 3.4 l/t (Figure 74A). These high catch rates were the result of lobsters being caught during a period of high catchability, related to the molting cycle. The ANOVA showed that sub-areas and strata had a significant effect ($p = 0.0004$ and 0.0077 respectively) on the abundance of commercial lobsters. The interaction between the two main factors was not significant ($p = 0.234$). There were no differences between the three depth strata at stations 20A2, 20A5 and 20B6. However, there were fewer lobsters in shallow water in 20A8 and in the middle stratum in 20B1. There were no differences between stations 20A2, 20A5 and 20A8, but they differed from 20B1 in terms of stratum 1 (5-10 m). In 20B1, the CPUE in stratum 1 was 4 l/t compared to 2.1 to 2.8 l/t for sub-areas in 20A. The highest abundances were recorded in area 20B6 in the deepest strata (2, 10-20 m and 3, 20-40 m) at 4.3 l/t. This was significantly higher than the values recorded in 20A5, 20A8 (stratum 3) and 20B1 (stratum 2): about 3 l/t.

Somewhat fewer lobsters in the prerecruit 1 class (PRE1, 70 to 82 mm) were caught: 2.7 l/t on average (Figure 74B). These lobsters will enter the fishery in 2013. The ANOVA showed significant interaction ($p = 0.0003$) between the two factors (sub-areas and stratum). There were no differences between the strata within 20A2, 20A5 and 20A8 unlike 20B1 and 20B6. In 20B6, PRE1 were significantly more abundant in stratum 3 (20-40 m) (4.5 l/t) while in 20B1, abundance was greater in shallow waters (5-10 m) (3.2 l/t). There were no differences between 20A2, 20A5 and 20A8. However, there were differences between 20A5, 20A8 and 20B1 (between 2 to 3 l/t) and 20B6 in terms of stratum 3, where lobsters were significantly more abundant (4.5 l/t).

Prerecruit 2 class lobsters (PRE2, <70 mm) were caught at an average rate of 1.2 l/t (Figure 74C). These lobsters will start to enter the fishery in 2014. The ANOVA showed significant interaction ($p = 0.015$) between the two factors (sub-areas and stratum). There were differences between the depth strata in 20A2, 20A8 and 20B1. Lobsters were significantly more abundant in shallow water. In 20A5 and 20B6, abundance was homogeneous as a function of depth. Abundance was significantly higher than elsewhere in 20B6, regardless of the stratum (1.7 to 2.6 l/t) (except in stratum 2 in 20A5). Regardless of the stratum, PRE2 values were lowest in 20A2. They were also low in 20A8, but to a lesser extent.

Very few berried females were seen in the survey (average of 0.07 l/t); those seen were in shallow water (stratum 1) (Figure 74C). Berried females are much less catchable than recent postmolt lobsters, which could explain why there were so few of them. Their distribution may also have been shallower than that of the survey. The size frequency distributions of all lobsters caught in each LFA are presented in Figure 75.

The development of a time series (5–10 years) should, in the medium term (five years), establish a connection between the abundance of prerecruits one year and landings one or two years later. It is important that the same sampling plan be used every year. The differences observed between stations and depth strata show that it is important to provide broad and constant spatial and bathymetric coverage to be able to compare years and minimize noise to highlight differences between years. In the fall, lobsters move from inshore to offshore and these movements can occur at different times from year to year, which is why it is important to maintain bathymetric coverage.

Benthic settlement of lobster is currently monitored in the Magdalen Islands, but not in the Gaspé. However, since 2008, SCUBA diving surveys have been conducted to locate lobster nurseries. About 70 km of coastline were explored between St-Godefroi and Douglastown. Several nurseries were found in this area. Monitoring of the abundance of lobster in some of those nurseries could help in the development of an index of recruitment to the fishery in the longer term.

3.2.8 Summary and Synoptic table

The abundance indicators have increased since 2008. The 2011 landings were 15% higher compared to 2008, and 6% above the average of the past 25 years. Catches per unit effort (CPUE) in number and weight were higher than in 2008 and above the data series average. In LFA 20, the demographic indicators show that the average size of commercial lobster has changed little since 2008. The sex ratio is generally stable and balanced. Size structures are highly truncated and characterized by very few (< 1%) jumbo lobsters (≥ 127 mm CL). In LFA 19C, the size structures are much broader, the mean size is larger and the proportion of jumbos is higher. The fishing pressure indicators show that exploitation rates generally remained high in LFA 20. However, a drop in these rates was noted in some sub-areas where there was a noticeable decrease in fishing effort. Since 2004, fishing mortality for the portion of the population ≥ 76 mm CL has dropped as a result of the increase in the minimum legal size. The exploitation rate is much lower in LFA 19C. Productivity indicators are high in LFA 20. The abundance of berried females, egg production and recruitment were higher in 2011 than in 2008. Prerecruit abundance was high in 2011, suggesting that recent landing levels could be maintained in 2012. The situation was also positive in LFA 21 in terms of abundance and demography.

A synoptic table was prepared (Figure 76) to highlight the trends in the various indicators during the reference period from 1986 to 2011. For each year, a standardized score (anomaly) was assigned to each indicator, which was the difference between its value and the average value for the reference period, divided by the standard deviation of the average. A colour score card highlighting positive (red) and negative (blue) trends was then prepared. Indicators were grouped into the four standard classes: abundance, demography, fishing pressure and productivity (reproduction and recruitment). Trends are for all of LFA 20.

3.3 NORTH SHORE AND ANTICOSTI ISLAND (LFAs 15, 16, 17 and 18)

3.3.1 Fishing effort

The introduction of mandatory logbooks on Anticosti Island in 2004 and the North Shore in 2007 has provided the opportunity to have a better idea on fishing effort distribution. In

LFAs 15 and 16, 40 to 46 fishers completed logbooks between 2008 and 2011 (2007 was a breaking in period). In 2011, the 44 fishers reported a total of 89,422 trap hauls. In 2008, the 40 fishers reported 107,773 traps. Overall, the number of trap hauls is low compared to the potential number (number of licences x number of traps per licence x number of days fished). From 2008 to 2011, the estimated average number of traps hauled per fisher based on logbook data was only 13% of the authorized effort. The traps are not hauled as frequently as in the Magdalen Islands and the Gaspé. In 2011, only 19% of traps were hauled after a 24-hour soak time. Most traps (67%) are hauled after 2 or 3 days and 15% are hauled after 4 days or more. Over the last 4 years, the effort was relatively low but constant.

The situation is different off Anticosti Island where fishing is more intensive. In 2011, 73% of traps were hauled after 24 hours of soak time and the percentage of traps hauled after 2, 3 and 4 days was 18, 7 and 2% respectively. In 2011, about 150,000 traps were hauled. In 2011, 14 of 15 fishers were active. In 2007 and 2009, nearly 190,000 traps were hauled by 15 fishers, which is about 60% of the maximum allowable effort (15 fishers x 300 traps x 70 fishing days). These estimates are based on the assumption that all fishers enter all traps hauled in their logbooks. Failure to achieve the maximum allowable effort is most of the time attributable to harsh weather conditions.

3.3.2 Temperature

In Tête-à-la-Baleine (LFA 15), the 2009 and 2011 fishing seasons appeared to have been warmer than the average from 1997 to 2010, while the 2010 season was within the average range (Figure 77A). At the beginning of the fishing season, the temperature stayed around 3°C. The water warmed up slowly and reached 10°C around the third week of July on average, but sometimes in the third week of June, in the warmest years. The data presented here come from thermographs installed on a trap of one or more fishers. Variations in temperature reflect seasonal changes, but perhaps also changes in fishing grounds, if the fisher moves during the season. It may eventually be possible to associate the temperature data at the locations entered in the logbooks to better understand the causes for variations. Yearly variations may be due to spatial variations as it was not always the same fishers who provide the temperature data. For the time being, interpretations drawn from these patterns are limited.

Off Anticosti Island (LFA 17B), the 2011 season was quite similar to the average from 2005 to 2010 (Figure 77B). In general, the water temperature at the opening of the season is about 2°C. The water warms up slowly and reaches 10°C around the third week of June. The season ends around mid-July while the temperature is around 12 to 14°C. Temperature drops, generally associated with the arrival of deeper cold waters, were common in June 2010. These temperature changes can affect lobster catchability and cause catch rates to vary. The beginning of the 2009 fishing season was colder than average and warmed up more slowly, but from mid-June, the temperature rose more quickly and reached 15°C in early July, about 5°C above average. For Anticosti Island, as for the North Shore, the data come from thermographs installed on fishers' traps. They could also reflect spatial changes.

3.3.3 Abundance indicators (commercial portion)

3.3.3.1 Landings

Lobster landings in LFA 15 were 14 t in 2011, which represents a drop of 22% compared to 2008 and 44% compared to the average of the past 25 years, or 25 t (Figure 78A, Table 2). In LFA 16, landings have been stable since 2008 at about 6 t, which is less than 46%

of the average for the past 25 years (11 t) (Figure 78B, Table 2). However, landing data may be incomplete. Landings at Anticosti Island (LFA 17B) have increased since 2008, peaking at 205 tons in 2010 (Figure 78C, Table 2). They were 174 t in 2011, which is 11% higher than in 2008 and 48% above the average of the past 25 years (125 t). It should be noted that data for LFA 18 may be incomplete and since 2006, landings total around 1 t (Figure 78D)

3.3.3.2 Commercial lobster CPUE

Catch rates correspond to the catches per unit of effort (CPUE) expressed in number or weight of lobster per trap. In 2011, catches per unit effort (CPUE) from at-sea sampling data in LFAs 15 and 16 combined were 0.27 lobsters per trap (l/trap) and 0.2 kg/trap (Figures 79A and 79B). These values are very similar to what was observed in 2008. In 2011, catch rates were lower in number (16%) but higher in weight (11%) than the average for the 1993-2010 period (0.32 l/trap and 0.18 kg/trap). The CPUE increase in weight (despite a decline in CPUE in number) is in all likelihood a positive effect of increasing the minimum legal size (6 mm increase between 1998 and 2005). In 2011, the average CPUE (in weight) estimated from data in logbooks completed by 42 fishers in LFAs 15 and 16 was 0.22 kg/trap. It has varied between 0.19 and 0.22 kg/rap since 2008. CPUE values from both data sources are similar (Figure 79B), except for the peak observed in 2010 using sampling data but not shown with the logbooks. This may be due to an artifact of the commercial sampling since it is only conducted on a few occasions and covers less than 1% of fishing trips. Sampling in 2010 was particularly low. Catch rates were better in 2011 than in 2008 throughout the entire fishing season (Figure 79C).

In LFA 17B, CPUEs reached 1.1 kg/trap in 2011, which was the highest value (as in 2010) since 2006. The 2011 CPUE was 32% higher than in 2008 (0.82 kg/trap) (Figure 80A). As on the North Shore, catch rates were better in 2011 than in 2008 throughout the entire fishing season (Figure 80B). The decrease in CPUEs during the 2011 fishing season was slow and CPUEs were still high late in the season, around 0.6 kg/trap.

3.3.4 Demographic indicators

The size structures of commercial-size lobsters in LFAs 15 and 16 show at least three modes (Figure 81), suggesting a lower exploitation rate than what is observed in the Gaspé Peninsula for example. In recent years, the average size has remained around 92-94 mm CL (2010 excluded). It is important to note that prior to the increase of the minimum legal size, average size was around 83-84 mm (Figure 82). Jumbo lobsters would previously show up in samples (1-2%) but in 2010 and 2011 none of these were observed. In 2011 as in 2008, the sex ratio was slightly in favour of females (ratio M:F = 0.7-0.8). In general, it is difficult to interpret with confidence the demographic indicators from LFAs 15 and 16 due to the few lobsters measured in recent years. It is uncertain whether samples collected, especially those in 2010, are representative of the population.

In LFA 17B, size structures have always been characterized by the presence of several modes (Figure 83). However, they have become more truncated in recent years. The mean size for all commercial lobster decreased by 3 mm since 2008, from 96.6 mm to 93.7 mm in 2011. The decrease in the mean size and the truncated appearance can be partly explained by the arrival in high abundance of new recruits to the fishery, which is consistent with the recent increase in CPUE. However, the average size of lobster larger than the new recruits (> 95 mm CL) has also dropped since 2008, by around 3 mm, and the number of jumbos was two times lower in 2011 than in 2008 (Figure 84). This could indicate an increased exploitation rate. In this context, the decline in large females could have negative impacts on egg production for the population. For the moment, the sex-ratio is above one, which seems suitable for mating.

3.3.5 Summary

Lobster landings along the Lower North Shore in LFAs 15 and 16 dropped below the average for the last 25 years. The landings information may have been incomplete or this decrease may reflect a long-term decline in fishing effort. The fishing effort deployed was low and corresponds to only 13% of the effort permitted. Catches per unit effort remained relatively stable from 2008 to 2011. Few lobsters were measured over the past few years in LFAs 15 and 16, which makes it difficult to assess demographic indicators. .At Anticosti Island, in LFA 17B, landings have risen since 2008 and in 2011, they were 48% above the average of the past 25 years. In 2011, catches per unit effort (CPUE) from logbooks were 32% greater than those in 2008. In LFA 17B, lobster size structures have changed considerably in recent years, becoming more truncated. The smaller mean size suggests the arrival of recruitment. However, the sharp drop in the proportion of large lobsters suggests exploitation has increased. This could translate into weaker egg production.

Although abundance is currently high in LFA 17B, the demographic changes are not negligible. If these changes intensify in the future, the fishery will likely become increasingly dependent on annual recruitment. In addition, fishing pressure will increase on immature lobster, affecting the population's reproductive potential. Lobster abundance on the Lower North Shore is low but has remained stable over the years. Additional information would be necessary to better assess stock status in this area. It is essential that these stocks be managed very carefully to prevent overfishing.

4. PRECAUTIONARY APPROACH (LFA 22)

Canada is committed to applying the Precautionary Approach (PA) in managing its fisheries. In 2009, Fisheries and Oceans Canada (DFO) developed the Sustainable Fisheries Framework (SFF), which establishes the framework for the application of the PA (DFO 2009). The framework has three main components: (1) reference points and stock status zones, (2) a strategy and decision rules for fisheries, and (3) an uncertainty and risk assessment.

In April 2010, there was a workshop on implementing the PA in the lobster fishery. The goals of the workshop were to address the first component and to determine potential indicators that could serve to define the stock status zones for all lobster fishing areas (LFAs) in the Quebec and Atlantic regions (DFO 2010a). After the workshop, a study was conducted in 2010–2011 by an external consultant on behalf of DFO (DFO 2011), which featured a series of recommendations and specific measures for implementing the PA in the LFAs.

A PA has been developed for the Magdalen Islands lobster fishery based on this information. It is the result of collaboration between DFO (Science and Fisheries Management Branch) and the Association des pêcheurs propriétaires des Îles-de-la-Madeleine, an organization representing most of the 325 fishers. This first PA is based on an empirical method. In an understandable and accessible manner, it sets out the first two components of the PA: (1) determination of reference points and stock status zones and (2) development of a strategy and decision rules for the fishery. The third component, the uncertainty and risk assessment, has not yet been prepared (risk and uncertainty pertaining to capacity of management decision rules to meet the desired goals). It is difficult to assess uncertainty and risk without a lobster population model.

4.1 DEVELOPEMNT OF THE PA

As a first step, some of the indicators used in assessing stock status were examined in order to determine their potential as possible reference points. This took place at a national workshop in April 2010 (DFO 2010a). The indicators examined were landings, catch per unit effort (CPUE) taken from the at-sea sampling, mean size, sex ratio and CPUE of berried females. Discussion on how well each indicator reflects the abundance or status of the stock was presented in the context of changing management. Over the past ten years, minimum legal size was increased by 7 mm, nominal fishing effort was reduced by nearly 10% and measures to limit increases in fishing efficiency were implemented. All these management changes have introduced uncertainty in the interpretation of trends in the indicators. We also examined the monitoring capacity for each potential indicator. It came out from the exercise that landings could serve as a desirable indicator in the beginning stages of the PA process.

For the first component of the PA, i.e. the definition of reference points and stock status zones, we therefore chose to use landings as an indicator. This decision was based on Recommendation #6 in the consultant's report (DFO 2011). Recommendation #6 also led us to consider certain factors that would aid in interpreting the time series of the landings. For the primary indicator chosen (i.e. landings), a limit reference point (LRP) and an upper stock reference (USR) were established, delimiting three stock status zones: a Healthy zone (above the USR), a Cautious zone (between the USR and the LRP) and a Critical zone (below the LRP).

Although useful as an indicator, landings represent only one facet of stock status. There are a number of other important indicators such as those related to abundance, demography, productivity (reproductive potential and recruitment) and fishing pressure (e.g., exploitation rate); these indicators make it possible to interpret fluctuations in landings and, in some cases, predict them (e.g. recruitment indicators). In the Gulf of Maine, secondary indicators (reproductive biomass and recruitment index) were considered in addition to the primary indicator (biomass, calculated from a model) in establishing decision rules (see workshop presentation, DFO 2010a). We opted not to include these secondary indicators in the formal PA framework developed here. The Magdalen Islands stock status indicators will continue to be compiled and analysed in stock assessments (every three years) and will also be used in the preparation of scientific advices. Examination of all the indicators will help determine the nature and makeup of the stock, which can account for fluctuations observed in landings, and consequently help stakeholders develop informed, appropriate solutions. Assessment of secondary indicators could lead to new analyses, research projects or monitoring projects and, if needed, expedite the application of certain management measures. The indicators assessed could also be of use in establishing target reference points (TRP). For the moment, the PA developed here, accompanied by the stock status assessment, will provide a more complete perspective of the population status, until a model that includes population dynamics can be developed.

4.2 INDICATOR AND REFERENCE POINTS

4.2.1 Selection of the primary indicator: landings

Landings were selected as the primary indicator. We assume that, even though landings are acted upon by a number of factors (e.g. nominal effort, effective effort, and the precision with which they are reported), they are still representative of the true lobster biomass.

4.2.1.1 Nominal effort

It is known that landings can be influenced by the level of effort in a given year. However, nominal effort varies little from one year to the next. The number of permits, the number of traps, and the length of the fishing season have remained virtually unchanged since 1973. Records of the number of fishing trips (daily trips out to sea made by each fisher) have been kept from 1990 to 2011 (see section 3.1.1). From 1990 to 2010, the mean effort was 4.76 ± 0.12 million traps (mean ± standard deviation). Fishing effort being relatively constant, it is reasonable to assume that variation in landings is not attributable to variation in nominal fishing effort. There is a strong relationship (r^2=0.97) between 1990–2011 landings weighted by fishing effort and those not weighted by fishing effort.

4.2.1.2 Effective effort

Although nominal effort has remained relatively stable over several decades, effective effort increased from the mid-1970s to the early 1990s (see Gendron and Archambault 1997). The increase in landings observed between 1975 and 1995 can in part be attributed to greater fishing efficiency. The increases observed in the 2000s, unlike those that came before, are reflective of increased lobster biomass. The effective effort has not shown much of an increase in the last decade, during which time a number of management measures have been implemented to slow the increase in fishing efficiency (daily fishing hours, hauls limited to one per day, trap size limits, maximum line length, minimum number of traps per line) (DFO 2010b).

4.2.1.3 Catch reporting

Since the lobster fishery is not managed by quota, monitoring of catches is not mandatory; there are no figures from mandatory dockside weighing. Catch data are instead based on purchase slips from plants. Although a certain proportion of catches will be kept for the fishers' personal use or sold directly on the local market, we believe that most of the catch is sold to plants and that the data reported by plants are therefore reliable and representative of the true landings. Fishers have a number of incentives to sell to plants, including pricing and volume discount mechanisms, which are managed by the marketing corporation in LFA 22, as well as eligibility for employment insurance. Also, past actions have been taken against certain marginal buyers who encouraged sale on the black market, and these were applauded by both buyers and producers in the sector. For these reasons, it is reasonable to assume that producers declare their catches accurately. Fishery officers (Conservation and Protection) agree that only a small amount of landings go towards personal use.

4.2.1.4 Other factors

Landings can also be influenced by climatic conditions. Landings could be slightly higher or lower depending on temperature because of its influence on lobster catchability (see section 3.1.5). However, this factor is unlikely to overshadow the effect of changes in biomass, at least over the medium term. Temperature monitoring is still recommended so that this factor can be interpreted and compared to fluctuations in landings over time.

4.2.1.5 Validation

The annual trawl survey conducted in the Magdalen Islands since 1995 provides an independent assessment of lobster abundance. Increased lobster density has been observed in trawl survey results over the last few years, which is consistent with the idea that the recent increase in landings is in fact attributable to greater lobster biomass (see section 3.1.3.3).

4.2.2 Definition of the limit reference point (LRP) and upper stock reference (USR)

These reference points were based on the DFO's A Fishery Decision-Making Framework Incorporating the Precautionary Approach (DFO 2009).

In a PA, the LRP represents a threshold below which stock productivity is severely compromised; this is called the Critical zone. According to the definition in the decision-making framework, a stock is considered to be in the Critical zone if the biomass, or its index, is less than or equal to 40% of maximum sustainable yield (B_{MSY}). In other words, 40% of the B_{MSY} corresponds to the LRP. Similarly, a stock is considered to be in the Healthy zone if the biomass, or its index, is greater than 80% of B_{MSY}; 80% of the B_{MSY} corresponds to the USR. The stock is considered to be in the Cautious zone if the biomass, or its index, is between the LRP and the USR, i.e. higher than 40% of B_{MSY} but lower than 80% of B_{MSY}. The document also specifies that if no stock status estimates are available from a formal model (e.g. the U.S. model currently under development), tentative estimates of the B_{MSY} may be used. The mean biomass (or index of biomass) during a productive period is one potential substitute; 50% of the maximum historical biomass is another.

Since there are no biomass estimates for lobster stocks in the Magdalen Islands, a provisional estimate of B_{MSY} was taken by using landings from a productive period. In the case of the Islands, landings are considered as an indicator that is reasonably representative of the biomass. Average landings from 1985 to 2009 were used as an approximation of B_{MSY}. These 25 years correspond to a productive period for lobster during which at least two generations of them were produced in large numbers. Average landings from 1985 to 2009 were 2,188 t (Figure 85). The LRP (40% x average) is 875 t and the URP (80% x average) is 1,750 t. For practical reasons, these values can be rounded to 2 and 4 millions pounds, respectively. The LRP of 875 t corresponds to the landings observed in the early 1970s, which were among the lowest recorded in 60 years. At that time, the stock was considered overexploited. We cannot state with certainty that it is a limit, but it is nevertheless used here as a proxy of a limit point below which stock productivity would be compromised. However, we know that it is a point from which the stock was able to rebound, following favourable environmental conditions. Landings have more than doubled between the mid-1970s and the beginning of the 1990s. Although the LRP was established more or less arbitrarily, it does correspond to a point above which the stock would presumably be able to recover, provided that environmental conditions remain favourable for the lobster. It is important to note also that landings of 875 t in 2010 are not equivalent to landings 875 t in 1970. The stock is considered stronger today than it was in 1970 because the spawning biomass is now higher following the increase in the MLS.

4.3 DECISION RULES

The purpose of the PA is essentially to guide management actions (predetermined decision rules) depending on the stock status zone (Figure 86). In principle, decision rules or management measures should ensure that the desired results are attained by adjustments made to the removal rate (DFO 2009). The decision rules are made in response to a management strategy whose goal, in the case of lobsters, is to maintain stock productivity (DFO 2010b), by strong, continued egg production.

Three categories of management measures apply in the lobster fishery: escapement measures, input control measures and output control measures. For each of the three categories, there is a set of tools described in the "tool box" in FRCC (1995). Escapement measures include size limits (minimum, maximum or a closed window of sizes), V-notching and systematically discarding certain categories of lobster such as pre-recruits and berried females. Input control measures include those designed to limit the various components of the fishing effort (number of fishing days allowed, number of traps, trap dimensions) and those limiting fishing operations (daily hours of fishing operation, number of hauls, length of trap lines, number of traps per line), as well as the implementation of fishing exclusion zones. Output control measures are intended to control the amount of landings; these measures rely on quotas.

In the lobster fishery PA, we favour the successive and additive use of escapement measures, input control measures (when the stock is in the Cautious zone) and, as a last resort, output control measures when the stock is in the Critical zone (Figure 87).

4.3.1 Description of zones and actions

4.3.1.1 Healthy zone

When the stock is in the Healthy zone, no new management measures are needed. Under current conditions, the removal rate is not considered a danger to the health of the stock, and need not be changed as long as the stock remains in the Healthy zone. As a general rule, the exploitation rate for lobsters has always been quite high (FRCC 1995, 2007), but monitoring in the Magdalen Islands indicates that the stock is resilient and that under current conditions (DFO 2012, and this document) a high exploitation rate can be supported without posing a threat to the stock. When the stock is in the Healthy zone, it is possible to apply TRPs that are not necessarily biological in nature, e.g. socio-economic targets. Targets could be defined on the basis of stock status assessment results or specific studies (e.g. the study on round vs. square traps, Gendron and Grégoire 2009), or they could be taken directly from the IFMP (DFO 2010b).

4.3.1.2 Cautious zone:

In theory, when the stock is in the Cautious zone, the removal rate is adjusted in proportion to how much the indicator has decreased (Figure 86). Since it is impossible at this time to predict what effect management measures will have on the stock trajectory, the preferred approach is to introduce successive and additive conservation measures until the stock returns to the Healthy zone (Figure 87). A first conservation measure is to be applied in Year 3 if the stock has remained in the Cautious zone for two consecutive years. The year following the implementation of the measure, Year 4, would be a year of observation; no action would be taken. If the stock is still in the Cautious zone the following year (Year 5), a second management measure would be applied in Year 6, and so on. The following measures are to be applied one after the other as long as the stock is in the Cautious zone: increasing the minimum catch size, and reducing fishing effort by 10% (two rounds). The conservation action taken may be taken sooner if the stock is in the lower part of the Cautious zone, close to the LRP (e.g. implemented after one year instead of two). Approaching the Cautious zone might also require development of a new stock biomass indicator for monitoring. When the stock returns to the Healthy zone, a higher exploitation rate may be used. This could take the form of lowering the minimum catch size again or increasing fishing effort. The actions in this approach bear discussion, as they are not yet part of the lobster stock management culture, in which management measures are always irreversible.

4.3.1.3 Critical zone

This zone is obviously to be avoided. Despite appropriate management measures, it could still be reached if, for example, a disease were to affect the lobster stock or if environmental conditions (physical, chemical, biological) were to change considerably. In this case, more serious measures would have to be applied to reduce catches significantly and to increase the likelihood of the stock recovering. A partial closure of the fisheries would be imposed. In extreme cases, only an index fishery would be retained, one whose effort or catches would be limited. The decision would be made by a recovery committee that would also study the underlying causes of the reduction in stock abundance (Figure 87).

4.4 UNCERTAINTIES

The third component of the PA deals with identifying scientific uncertainty in order to determine the likelihood that a given management measure will allow the desired objectives to be met.

It is not currently possible to assess the uncertainty. At the workshop (DFO 2010), participants pointed out that it would be difficult to begin assessing it without first having a model of the lobster population. We do not at this time possess any analytical tools to quantify the exact removal rate associated with a given management measure (escapement or input), nor are we able to precisely determine the stock's trajectory as a function of different removal rates. The analytical model currently used in the United States is in the process of being applied to the lobster fishery in LFA 22. A workshop on adapting the American model to the situation in the Magdalen Islands was held in March of 2011 (Tremblay 2011). When the model is finally applied in 2012–2013, it will be possible to quantify the uncertainty and to evaluate management risks. For the moment, the stock's response to a given management measure can only be described in empirical terms, after the fact, by monitoring the different indicators.

Also, in cases when the stock is approaching the Cautious zone (or before), it will be necessary to develop a new indicator for biomass other than landings. It is true that landings can serve as a very useful indicator as a starting point in developing a PA framework and in defining the stock status zones. However, if the proposed management measures for the Cautious zone are applied, the strong relationship between landings and biomass will change. The existing relationship assumes that the exploitation rate is constant. So, as the exploitation rate decreases in the Cautious zone, the trajectory of landings will deviate from that of the biomass, making it impossible to interpret changes in landings as equivalent to changes in biomass. Therefore, a biomass indicator that remains unaffected by management measures (e.g. biomass of the trawl survey for the Magdalen Islands, or CPUE of a trap survey for some other LFAs) should be developed and included in the PA. As a general rule, the new biomass indicators should be developed as soon as the stock approaches the Cautious zone. In the Magdalen Islands, as the time series of the data gets longer, the biomass indicators taken from the trawl survey will become more and more useful in refining the PA.

Canada would like to implement a PA for all stocks fished. The PA framework was defined for stocks for which management is accomplished by means of quota, for which the removal rate and biomass can be readily assessed, and for which there are indications (empirical or analytical) of the biomass below which stock productivity is compromised. Development of the PA for the lobster is complicated by lack of information on the key elements of the PA framework. The PA developed here for lobsters in the Magdalen Islands should be seen as a first step and could prove useful for other stocks in the

Atlantic. To this end, the approach developed here is connected with that in development in the Maritimes Region (Tremblay et al. 2011). This lobster PA can fall into compliance with the DFO's formal PA if certain tools are developed or maintained, including monitoring programs for developing reliable stock status indicators, as well as integrated analytical models based on probability (stock dynamics, management measures). Presently, the PA developed here is not intended to replace the management approach currently in use, which up until now has met with success

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Table 1. Summary of management measures in force in 2011 in the various lobster fishing areas (LFA) in Quebec.

LFA	Number of active licences	Duration of 2011 fishing season	Number and size of traps	Minimum catch size	Other conservation measures	Mandatory logbooks
15	38	12 weeks	92 cm X 71 cm X 50 cm n=250 or 124 cm X 92 cm X 50 cm n=175	82 mm		√ since 2007
16	4	12 weeks	92 cm X 71 cm X 50 cm n=250 or 124 cm X 92 cm X 50 cm n=175	82 mm		√ since 2007
17	14	11 weeks	92 cm X 71 cm X 50 cm n=300 or 124 cm X 92 cm X 50 cm n=210	83 mm		√ since 2004
18	3	11 weeks	92 cm X 71 cm X 50 cm n=250 or 124 cm X 92 cm X 50 cm n=175	83 mm		
19	8	71 days	92 X 61x X 50 cm n=250	83 mm	V-notch[1]	
20	160	69 days	92 X 61 X 50 cm n=235	82 mm	V-notch[1] Maximum size at 150 mm Minimum of 6 traps per line Maximum line length: 60 fathoms	
21 *Spring*	12	69 days	92 X 61 X 50 cm n=235	82 mm	V-notch[1]	
21B *Fall*	1 *community*	21 days	92 X 61 X 50 cm n=500	82 mm		
22	325	9 weeks excluding Sundays	81 X 61 X 50 cm n=282	83 mm	Minimum of 7 traps per line Maximum line length: 56 fathoms Fishing hours (5 a.m.-9 p.m.)	

1: Mandatory release of females with a V-notch on each uropod located immediately on either side of the telson. Marking is on a voluntary basis.

Table 2. *Lobster landings (t) in the 8 Lobster Fishing Areas (LFA) of Quebec, from 1984 to 2011.*

	North Shore - Anticosti				Gaspé			Magdalen Islands	Total
	15	16	17	18	19	20	21	22	
1984	41	10	10	-	8	573	40	1193	1875
1985	30	14	38	-	26	510	33	1458	2109
1986	51	5	51	-	9	513	28	1581	2238
1987	34	5	117	-	9	553	27	1878	2623
1988	42	6	68	-	21	530	44	1798	2509
1989	32	19	91	-	21	592	38	2375	3168
1990	31	20	51	-	26	709	70	2380	3287
1991	29	11	75	-	22	626	64	2646	3473
1992	37	16	98	5	18	797	58	2806	3835
1993	26	14	108	12	25	751	59	2593	3588
1994	8	10	143	8	25	730	51	2007	2982
1995	12	12	137	17	40	985	46	2142	3393
1996	14	18	155	6	36	1016	39	2219	3503
1997	19	12	184	19	23	648	37	1883	2825
1998	18	15	130	7	32	889	42	1915	3049
1999	18	22	178	8	40	981	30	1936	3214
2000	38	11	148	21	36	1053	26	2080	3413
2001	26	17	139	3	30	974	23	2270	3527
2002	30	9	135	2	28	779	29	2160	3162
2003	24	8	114	2	29	844	31	2087	3128
2004	20	7	97	7	28	794	26	2372	3323
2005	15	9	125	2	29	648	21	2341	3186
2006	10	6	112	1	24	735	13	2346	3247
2007	17	8	131	1	20	670	14	2372	3233
2008	18	6	157	1	28	739	19	2487	3455
2009	19	4	174	1	24	696	21	2566	3505
2010	23	6	205	2	25	833	30	3033	4156
2011*	14	6	174	2	28	805	39	2648	3716

since 2001 : reported landings only
** preminimary data*

Table 3. Commercial sampling at sea. Number of lobsters measured per LFA and per year.

	22S	22N	20A2	20A8-A9	20B5-B6	21B Spring (Fall)	19C	15-16
1985	6195	4952						
1986	5550	3486	74	2246	2024			
1987	8448	4442	1727	1203	2388			
1988	5358	4210	1572	1596	4634			
1989	6738	4358	1827	1983	2557			
1990	7627	5369	2095	1895	2135			
1991	7367	5552	2862	2481	3021			
1992	7846	5556	2286	2312	3014			
1993	4776	5206	2755	2185	3267			1763
1994	6036	5431	2237	1708	1870			886
1995	6089	5438	3122	2470	2514			806
1996	6111	5200	2482	3685	3010			746
1997	6239	5047	2276	2499	1779	1404		746
1998	5179	4273	2159	3501	2338	1397		908
1999	6489	4750	2053	4069	3478	1530		875
2000	7467	4705	2231	4411	3448	1073		1072
2001	7391	5271	1968	4464	2578	1762	1373	901
2002	6396	4864	1408	2647	1961	1913 (1026)	1191	501
2003	5767	4635	1641	2333	1810	1922 (1075)	1808	628
2004	6740	3821	1584	2108	1772	525 (836)	1448	655
2005	6458	5187	1652	2345	1688			
2006	5758	4607	1473	2266	1850			
2007	5932	4236	1248	1973	1982			
2008	5504	4409	2097	2596	1768		989 PC	
2009	6284	4412	1514	3104	2348			
2010	6967	5437	2323	2730	2504			
2011	6281	4246	2201	2927	3152		1184	

PC=Parks Canada

Table 4. Dockside commercial sampling. Number of lobsters measured per LFA and per year.

	15 & 16	17B	19C	21-Spring (Fall)
1998		1704		
1999		1541		
2000		358		
2001		1279		
2002		1244		
2003		360		
2004		1273		
2005	544	2050	1177	556 (746)
2006	406	2240	948	545 (724)
2007	528	2053	757	509 (684)
2008	403	2654	1211	461 (866)
2009	285	2634	1014	582 (1029)
2010	155	3398	1455	814 (982)
2011	112	2929		571 (882)

Table 5. Characteristics of the trawl survey conducted off the Magdalen Islands since 1995.

Year	Sampling period	Nb of stations	Nb trawl sets	Nb of lobster caught
1995	8-22 Sept	39	84	7 956
1996	5-13 Sept	44 (addition #41-46)	88	6 123
1997	4-13 Sept	(addition Plaisance Bay)	99	8 431
1998	3-13 Sept	50 (addition #47-48)	94	8 176
1999	2-10 Sept	50	76	6 958
2000	5-11 Sept	46	59	6 010
2001	3-10 Sept	50	72	7 444
2002	3-10 Sept	50	65	6 751
2003	11-18 Sept	50	70	5 968
2004	1-6 Sept	47	63	7 302
2005	2-13 Sept	50	77	7 190
2006	7-13 Sept	46	61	6 446
2007	6-13 Sept	50	68	7 837
2008	6-13 Sept	50	67	9 267
2009	5-13 Sept	49	69	9 145
2010	5-14 Sept	42	57	8 818
2011	7-13 Sept	50	68	12 246

Table 6. Characteristics of the SCUBA survey performed off the Magdalen Islands in the Demoiselles area in Plaisance Bay since 1995.

	Sampling period	Nb transects	Total surface sampled (m^2)	Nb of lobster caught
1995	21-25 Sept	Qualitative sampling		241
1996	28 Aug-31 Oct	6	497	388
1997	24 Aug-13 Sept	6	501	293
1998	18 Aug-3 Sept	6	309	389
1999	10-21 Sept	5	234	326
2000	8-16 Sept	6	283	366
2001	8-17 Sept	6	265	224
2002	—	—	—	—
2003	17-23 Sept	5	250	485
2004	9-17 Sept	4	200	377
2005	8-16 Sept	5	240	314
2006	6-17 Sept	6	254	386
2007	10-17 Sept	6	245	464
2008	12-17 Sept	5	240	655
2009	11-17 Sept	6	286	523
2010	13-17 Sept	5	200	1312
2011	8-15 Sept	4	156	876

Table 7. Number of fishers by sub-area involved in the recruitment project in the Gaspé and collecting data with experimental traps from 2006 to 2011.

Fishing sub-areas	2006	2007	2008	2009	2010	2011
19A2	1	0	0	0	0	0
19C1	1	1	1	1	1	1
20A1	1	0	0	2	1	2
20A2	2	2	1	1	1	1
20A3	1	0	0	0	0	0
20A3A	1	1	1	1	0	0
20A4	2	2	2	1	1	2
20A5	2	2	2	2	2	2
20A6	2	2	2	1	1	1
20A7	2	1	1	1	1	1
20A8	2	2	2	2	2	2
20A9	2	3	3	2	2	3
20A9A	2	2	2	2	1	2
20A10	2	2	0	1	0	1
20B1	2	2	2	2	2	2
20B2	2	2	2	1	1	1
20B3	2	1	1	2	2	2
20B4	2	1	2	2	2	2
20B5	2	1	1	1	1	1
20B6	1	0	0	2	1	1
20B7	1	0	0	0	0	0
20B8	1	0	0	0	0	0
21A	1	0	0	0	0	0
Total	37	27	25	27	22	27

Table 8. Summary table of available data by LFA.

	Statistics Purchase slips	Logbook mandatory	Logbook volontary	Sampling at-sea	Sampling dockside	Trawl survey	SCUBA diving	Modified traps (prerecruit)	Post-season survey	Tempe-rature	By-catch
22	√	ELB 2014		√ 1985-2011		√ 1995-2011	√ 1999-2011			√	√ 2011
20	√	ELB 2012	√ 2007-2011	√ 1986-2011				√ 2006-2011	√ 2011	√	√ 2011
19	√			√ 2001-2004 and 2011	√ 2005-2010						√ 2011
19c & 20A1 Forillon	√			√ 2008-2010 Parks Canada							
21 Spring	√			√ 1997-2004	√ 2005-2011						
21 Autumn	Report				√						
17	√	√ 2004-2011		√ 1997	√ 1998-2011					√	
15	√	√ 2007-2011		√ 1993-2004	√ 2005-2011					√	
16	√	√ 2007-2011		√ 1993-2004	√ 2005-2008						
18	√										

ELB: Electronic logbook

Table 9. List of indicators compiled for each LFA.

		22	20	19	21B Spr	21B Fall	15-16	17	18
Fishing effort	Number of trips and traps	√							
Commercial abundance	Landings	√	√	√	√	√	√	√	√
	Catch rates (CPUE) (*com sampling*)	√s	√s	√d	√d	√d	√d		
	Catch rates – logbooks		√ET				√	√	
	Density and biomass (fishery-ind,)	√ Tr							
Demography	Size structures	√w	√w	√w	√w	√r	√r	√w	
	Mean size and weight – commercial lobsters	√	√	√	√	√	√	√	
	Jumbos (> 127 mm CL)	√	√	√	√	√	√	√	
	Sex-ratio (*M:F*)	√	√	√	√	√	√	√	
Fishing pressure	Exploitation rate	√	√	√					
Productivity Reproduction	Berried female abundance	√	√	√					
	Egg production (C*PUE x fecundity x size)*	√	√						
	Multiparous females	√	√						
	Mating success	√							
Productivity Recruitment	Prerecruit abundance	√ Tr	√ ET+PS						
	Benthic settlement index	√ Sc							
Environment	Temperature (*degree-days*)	√	√				√	√	
	By-catch	√	√	√					

Sampling at sea (s) and dockside (d); Tr = trawl survey; ET = experimental trap project; PS = post-season trap survey; Sc = SCUBA survey; w = frequencies weighted by landings, r = relative. By-catch : separate document.

Table 10. Parameters (nugget, sill, range and coefficient of determination, r^2) of the variogram models for lobster density and biomass (commercial portion) calculated from 1995 to 2011 trawl survey data and values of the coefficient of determination (r^2) of the linear relationship between the kriged density and biomass values and actual values (cross-validation).

Commercial density

	Model	Nugget	Sill	Range (km)	r2	cross validation r2
1995	Spherical	0.01	26.58	1.18	0.51	0.794
1996	Exponential	1.68	7.78	1.19	0.476	0.702
1997	Spherical	2.63	23.05	5.74	0.176	0.79
1998	Spherical	2.31	16.92	6.48	0.381	0.829
1999	Spherical	2.99	12.43	6.09	0.583	0.565
2000	Spherical	0.01	28.59	4.63	0.678	0.364
2001	Spherical	1.26	18.25	9.54	0.99	0.547
2002	Spherical	0.87	20.21	4.99	0.803	0.531
2003	Spherical	2.94	13.81	9.19	0.846	0.39
2004	Spherical	0.01	30.66	5.94	0.526	0.753
2005	Spherical	3.24	22.6	7.03	0.824	0.388
2006	Spherical	0.21	13.15	7.07	0.956	0.507
2007	Spherical	1.25	19.12	9.79	0.867	0.743
2008	Spherical	8.8	41.25	11	0.649	0.546
2009	Spherical	12.3	50.73	7.65	0.657	0.52
2010	Spherical	0.7	30.85	9.5	0.559	0.265
2011	Spherical	1.55	18.66	8.58	0.915	0.516

Commercial Biomass

	Model	Nugget	Sill	Range (km)	r2	cross validation r2
1995	Spherical	0.01	7.2	1.14	0.046	0.775
1996	Exponential	0.312	2.44	2.67	0.501	0.697
1997	Spherical	0.7	7.39	5.77	0.185	0.789
1998	Spherical	0.81	5.42	6.48	0.349	0.823
1999	Spherical	1.02	4.37	6.07	0.605	0.577
2000	Spherical	0.01	10.45	4.77	0.751	0.391
2001	Spherical	0.44	7.123	9.34	0.983	0.555
2002	Spherical	0.7	10.7	6.34	0.797	0.584
2003	Spherical	1.37	7.369	10.13	0.815	0.431
2004	Spherical	0.01	14.69	5.99	0.552	0.802
2005	Spherical	2.13	10.46	7.47	0.803	0.372
2006	Spherical	0.17	7.546	8.02	0.969	0.537
2007	Spherical	0.07	9.1	8.76	0.954	0.702
2008	Spherical	3.77	20.57	10.29	0.627	0.576
2009	Spherical	6.02	27.25	7.72	0.686	0.551
2010	Spherical	0.09	17.17	8.19	0.48	0.397
2011	Spherical	0.71	11.07	8.52	0.916	0.564

Table 11. Lobster size in the two molt classes based on the minimum catch size (MCS) in force, used to calculate the exploitation rate. Duration of intermolt (in years) is indicated in parentheses.

MLS	**First molt class (intermolt period)**	**Second molt class (intermolt period)**
76 mm until 1996	76-86 m (1.13)	87-99 mm (1.52)
77 mm	77-87 m (1.14)	88-100 mm (1.58)
78 mm	78-89 mm (1.17)	90-103 mm (1.77)
79 mm	79-90 mm (1.19)	91-104 mm (1.905)
80 mm	80-91 mm (1.218)	92-104 mm (2.064)
81 mm	81-92 mm (1.245)	93-106 mm (2.247)
82 mm (since 2004 in the Gaspé)	82-93 mm (1.275)	94-107 mm (2.247)
83 mm (since 2003 in the Magdalen Islands)	83-94 mm (1.309)	95-108 mm (2.319)

Table 12. Sizes of the various classes of prerecruits (PR1, prerecruits one molt below commercial size, PR2, prerecruits at least two molts below commercial size) from 1995 to 2011. Sizes vary with the increase in minimum catch size (MCS).

Year of survey (t) MLS (t+1)	PR1	PR 2
1995 (76 mm)	67- <76 mm	55- <67 mm
1996 (77 mm)	68- <77 mm	55- <67 mm
1997 (78 mm)	69- <78 mm	55- <67 mm
1998 (79 mm)	70- <79 mm	55- <67 mm
1999 (80 mm)	71- <80 mm	55- <67 mm
2000 (81 mm)	72- <81 mm	55- <67 mm
2001 (82 mm)	72- <82 mm	55- <67 mm
2002-2011 (83 mm)	73- <83 mm	55- <67 mm

Table 13. Exploitation rate calculated for the exploitable portion (≥ MCS) of the male population using commercial sampling data for the areas north and south of the Magdalen Islands from 1985 to 2010 and 1996 to 2011 south trawl survey data.

SOUTH	1	2	3	4	5	6	7	8	
	class 1	col 1 /moult freq	classe 2	col 3 /fmoult freq	survival	Z	F, M=0.15	F/Z	u=expl rate
					col4/col2	ln(col5)	col6-0,15	col7/col6	M=0.15
1985	641448	567653	339935	223641	0.394	0.931	0.781	0.839	**50.8**
1986	618560	547398	357792	235389	0.430	0.844	0.694	0.822	**46.9**
1987	875359	774654	316905	208490	0.269	1.313	1.163	0.886	**64.7**
1988	975540	863310	416967	274320	0.318	1.146	0.996	0.869	**59.3**
1989	1292228	1143565	423691	278744	0.244	1.412	1.262	0.894	**67.6**
1990	1210414	1071163	492974	324325	0.303	1.195	1.045	0.874	**61.0**
1991	1331058	1177927	485022	319093	0.271	1.306	1.156	0.885	**64.5**
1992	1170690	1036009	464103	305331	0.295	1.222	1.072	0.877	**61.9**
1993	1247618	1104087	370706	243886	0.221	1.510	1.360	0.901	**70.2**
1994	1119912	991073	411205	270530	0.273	1.298	1.148	0.884	**64.3**
1995	1297618	1148335	411692	270850	0.236	1.445	1.295	0.896	**68.5**
1996	1116448	988007	330314	217312	0.220	1.514	1.364	0.901	**70.3**
1997	974336	854681	357557	226302	0.265	1.329	1.179	0.887	**65.2**
1998	1066797	911792	303627	171541	0.188	1.671	1.521	0.910	**73.9**
1999	1083243	910288	338321	181893	0.200	1.610	1.460	0.907	**72.6**
2000	1091174	895874	337042	176925	0.197	1.622	1.472	0.908	**72.8**
2001	976158	784063	229635	111257	0.142	1.953	1.803	0.923	**79.2**
2002	990738	776745	291957	129920	0.167	1.788	1.638	0.916	**76.3**
2003	949402	725288	380180	163941	0.226	1.487	1.337	0.899	**69.6**
2004	1006370	768808	339048	146204	0.190	1.660	1.510	0.910	**73.7**
2005	1102420	842185	307853	132752	0.158	1.848	1.698	0.919	**77.4**
2006	1058110	808335	385217	166113	0.206	1.582	1.432	0.905	**71.9**
2007	956741	730895	381874	164672	0.225	1.490	1.340	0.899	**69.7**
2008	1014576	775077	381875	164672	0.212	1.549	1.399	0.903	**71.1**
2009	1064876	813503	381876	164673	0.202	1.597	1.447	0.906	**72.3**
2010	1193490	911757	378035	163016	0.179	1.722	1.572	0.913	**75.0**

	1	2	3	4	5	6	7	8	
SOUTH (trawl)	class 1	col 1 /moult freq	classe 2	col 3 /fmoult freq	survival	Z	F, M=0.15	F/Z	u=expl rate
					col4/col2	ln(col5)	col6-0,15	col7/col6	M=0.15
1996	2.514	2.225	0.879	0.578	0.260	1.347	1.197	0.889	**65.8**
1997	1.866	1.637	1.023	0.648	0.396	0.927	0.777	0.838	**50.7**
1998	2.343	2.002	0.640	0.362	0.181	1.712	1.562	0.912	**74.8**
1999	2.004	1.684	0.909	0.489	0.290	1.237	1.087	0.879	**62.4**
2000	2.677	2.198	1.085	0.569	0.259	1.351	1.201	0.889	**65.9**
2001	2.949	2.369	1.234	0.598	0.252	1.376	1.226	0.891	**66.6**
2002	2.975	2.332	1.262	0.562	0.241	1.423	1.273	0.895	**67.9**
2003	2.577	1.969	1.316	0.567	0.288	1.244	1.094	0.879	**62.6**
2004	2.654	2.027	1.173	0.506	0.249	1.388	1.238	0.892	**66.9**
2005	2.823	2.156	1.022	0.441	0.204	1.588	1.438	0.906	**72.0**
2006	2.647	2.022	1.058	0.456	0.226	1.489	1.339	0.899	**69.6**
2007	2.343	1.790	1.253	0.540	0.302	1.197	1.047	0.875	**61.1**
2008	2.739	2.092	1.490	0.642	0.307	1.181	1.031	0.873	**60.5**
2009	3.475	2.655	1.461	0.630	0.237	1.439	1.289	0.896	**68.3**
2010	3.236	2.472	1.299	0.560	0.226	1.485	1.335	0.899	**69.5**
2011	2.758	2.107	1.079	0.465	0.221	1.511	1.361	0.901	**70.2**

Table 13. Suite

NORTH	1	2	3	4	5	6	7	8	
	class 1	col 1 /moult freq	classe 2	col 3 /fmoult freq	survival	Z	F, M=0.15	F/Z	u=expl rate
					col4/col2	ln(col5)	col6-0,15	col7/col6	M=0.15
1985	274041	242514	134104	88226	0.364	1.011	0.861	0.852	**54.2**
1986	237130	209850	161973	106561	0.508	0.678	0.528	0.779	**38.3**
1987	298587	264236	159646	105030	0.397	0.923	0.773	0.837	**50.5**
1988	374274	331216	265000	174342	0.526	0.642	0.492	0.766	**36.3**
1989	563033	498259	217289	142953	0.287	1.249	1.099	0.880	**62.7**
1990	546188	483352	261663	172147	0.356	1.032	0.882	0.855	**55.0**
1991	537413	475587	294700	193882	0.408	0.897	0.747	0.833	**49.3**
1992	522759	462619	259713	170864	0.369	0.996	0.846	0.849	**53.6**
1993	446240	394903	295886	194662	0.493	0.707	0.557	0.788	**40.0**
1994	447121	395682	267507	175991	0.445	0.810	0.660	0.815	**45.2**
1995	641138	567379	326089	214532	0.378	0.973	0.823	0.846	**52.6**
1996	435342	385258	181535	119431	0.310	1.171	1.021	0.872	**60.2**
1997	338536	296961	172572	109223	0.368	1.000	0.850	0.850	**53.7**
1998	397015	339329	116341	65729	0.194	1.641	1.491	0.909	**73.3**
1999	339409	285218	144315	77589	0.272	1.302	1.152	0.885	**64.4**
2000	370048	303816	154553	81130	0.267	1.320	1.170	0.886	**65.0**
2001	373991	300394	115677	56045	0.187	1.679	1.529	0.911	**74.1**
2002	333951	261820	115644	51461	0.197	1.627	1.477	0.908	**72.9**
2003	351497	268523	125568	54147	0.202	1.601	1.451	0.906	**72.4**
2004	385107	294199	129553	55866	0.190	1.661	1.511	0.910	**73.7**
2005	421822	322248	159566	68808	0.214	1.544	1.394	0.903	**71.0**
2006	389175	297307	161870	69802	0.235	1.449	1.299	0.896	**68.6**
2007	398705	304587	149673	64542	0.212	1.552	1.402	0.903	**71.2**
2008	385704	294655	155740	67158	0.228	1.479	1.329	0.899	**69.4**
2009	441000	336898	165978	71573	0.212	1.549	1.399	0.903	**71.1**
2010	399087	304879	168218	72539	0.238	1.436	1.286	0.896	**68.2**

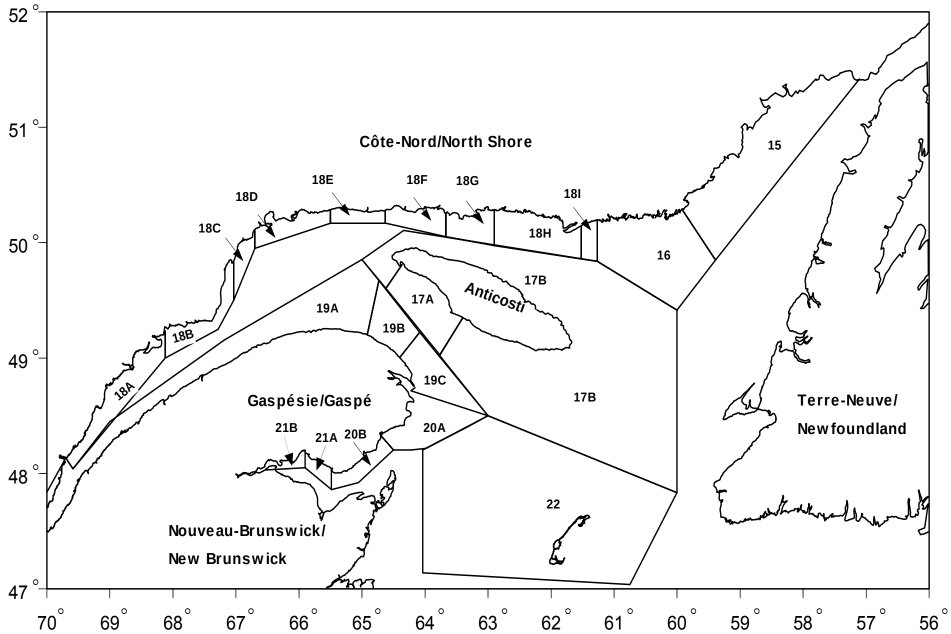


Figure 1. Map showing the lobster fishing areas (LFAs) in Quebec (LFAs 15 to 18: North Shore and Anticosti, LFAs 19 to 21: Gaspé Peninsula and LFA 22: Magdalen Islands).

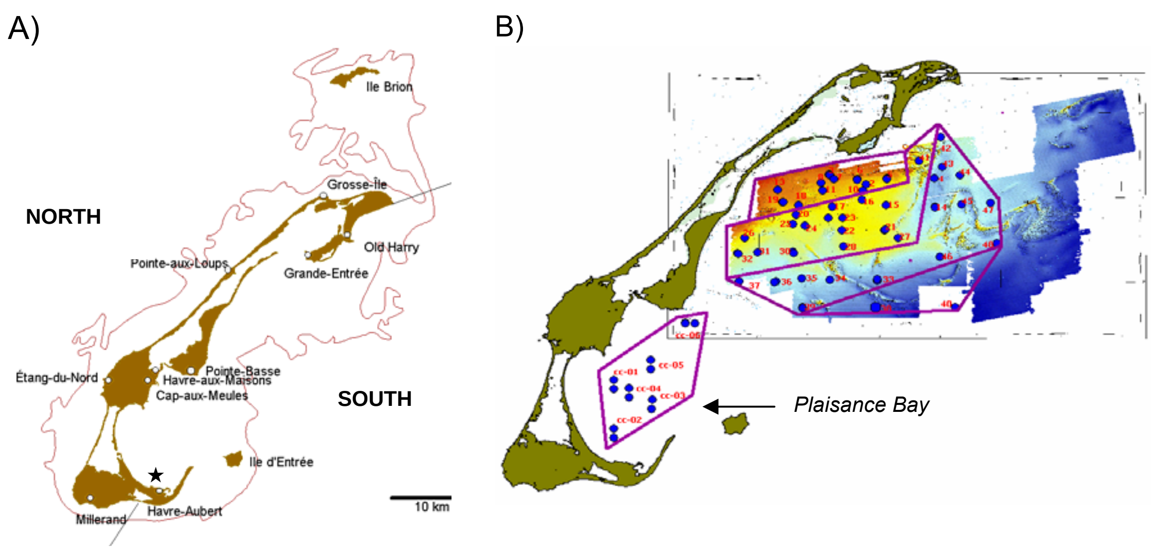
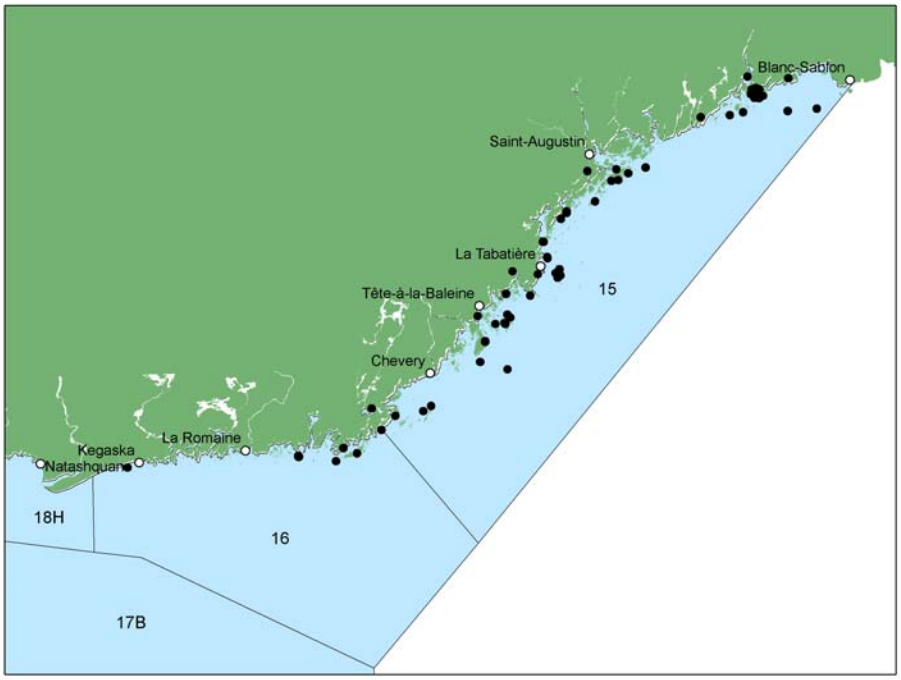


Figure 2. Map of the Magdalen Islands showing A) the boundaries of the south and north areas and the main lobster landing ports and B) the location of the trawl stations (Nephrops trawl) inside the strata with the EM-1000 multibeam bathymetric map in background. The star on A indicates the area in the Demoiselles where the SCUBA survey was conducted.

Figure 3. Map of the Gaspé Peninsula showing the different sub-areas of LFA 19 (19A1 to 19C), LFA 20 (20A1 to 20A10 and 20B1 to 20B8) and LFA 21 (21A and 21B).

A)



B)

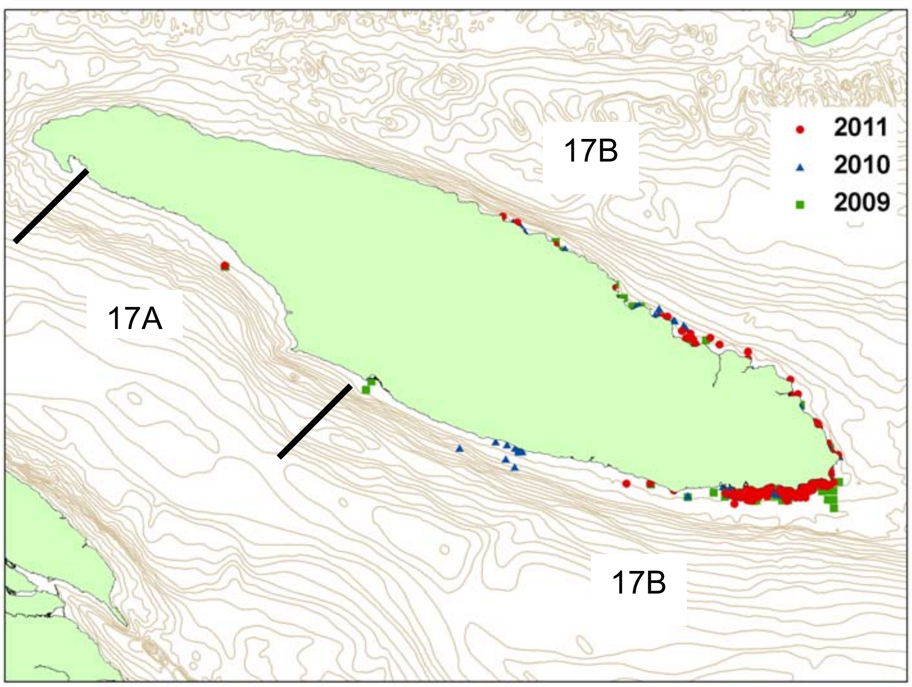
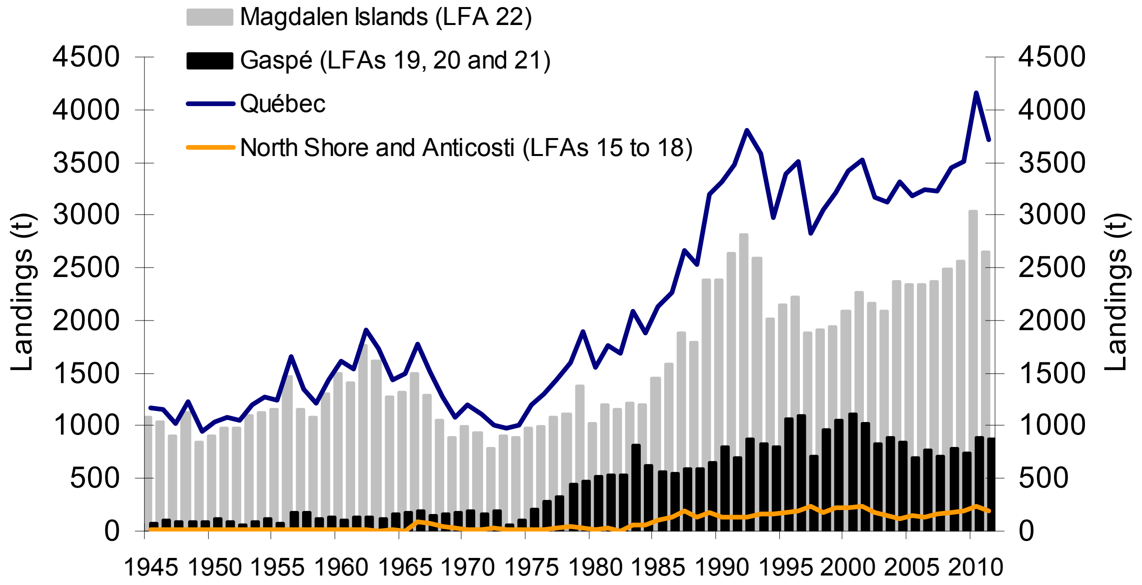


Figure 4. Maps showing the distribution of fishing effort A) on the Lower North Shore, LFAs 15 and 16 in 2011 and B) at Anticosti Island LFA 17 between 2009 and 2011.

A)



B)

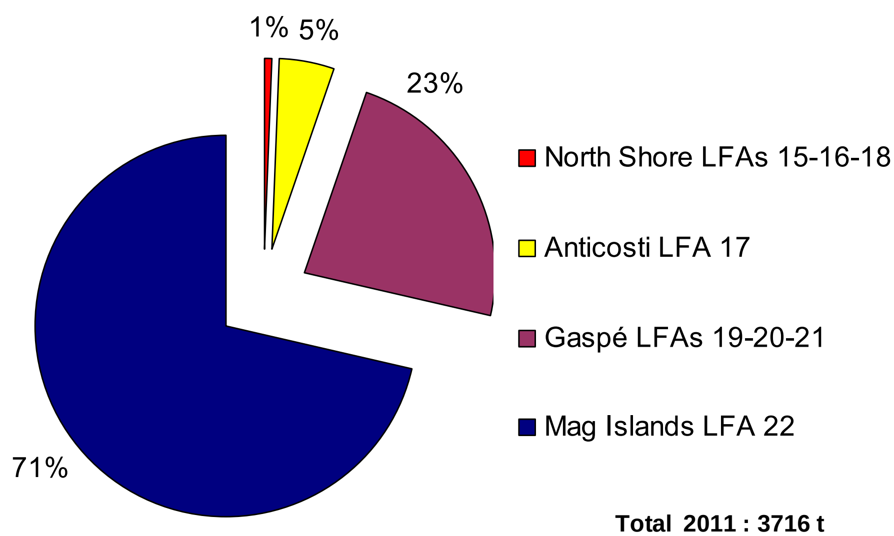


Figure 5. A) Lobster landings (t) in Quebec from 1945 to 2011 and B) 2011 landings by area.

Pêches et Océans Canada Fisheries and Oceans Canada

Formulaire HOMARD Casiers expérimentaux –*Form LOBSTER (experimental traps)*

IDENTIFICATION		**MÉTÉO**
Bateau / *Vessel* ____________ Capitaine / *Captain* ____________ NEB /*VRN* ______ Zone de pêche/Fishing area __________	Acheteur / *buyer* ________ Code __ __ __ __ __ __ __ __ __ __ Formulaire No	N NE E SE S SW W NW *vitesse (nœuds) / speed(knots)* 0 5 10 15 20 25 30 35+

Protégé **JOURNAL DE BORD QUOTIDIEN / *DAILY LOGBOOK*** ***Protected***

Date	Nombre de casiers *Number of traps* ______	Temps d'immersion (jours) *Soak time (days)* ______	Capture (lbs) *Catch (pounds)* ________
________			

CASIERS EXPÉRIMENTAUX / *EXPERIMENTAL TRAPS*

Temps d'immersion (jours) *Soak time (days)*	Position LATITUDE Deg____°Min____'Sec____''N	Position LONGITUDE Deg____°Min____' Sec____''W

RÉGULIER /*REGULAR*			**MODIFIÉ/*MODIFIED***			**RÉGULIER/*REGULAR***			**MODIFIÉ/*MODIFIED***		
M	**F**	**FO/*BF***	**M**	**F**	**FO/*BF***	**M**	**F**	**FO/*BF***	**M**	**F**	**FO/*BF***

Signature de l'exploitant (détenteur du permis ou de son représentant autorisé) *Operator's signature (license holder or his authorized representative)* --	Original (bleu) pour le Ministère. Copie blanche pour le pêcheur. Copie jaune pour les Sciences / *Original (blue) for DFO.White copy for fisherman. Yellow copy for Sciences.*

Figure 6. Logbook used by fishers involved in the recruitment project in the Gaspé from 2006 to 2011.

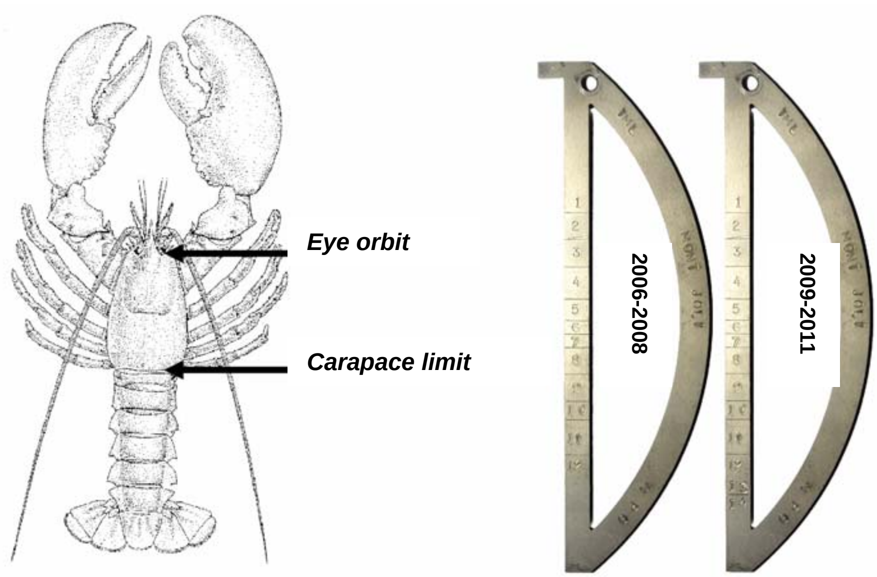


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Figure 7. Gauge used by fishers to measure lobsters based on the various size classes (12 in 2006 and 2007 and 14 from 2009 to 2011) for the recruitment project in the Gaspé.

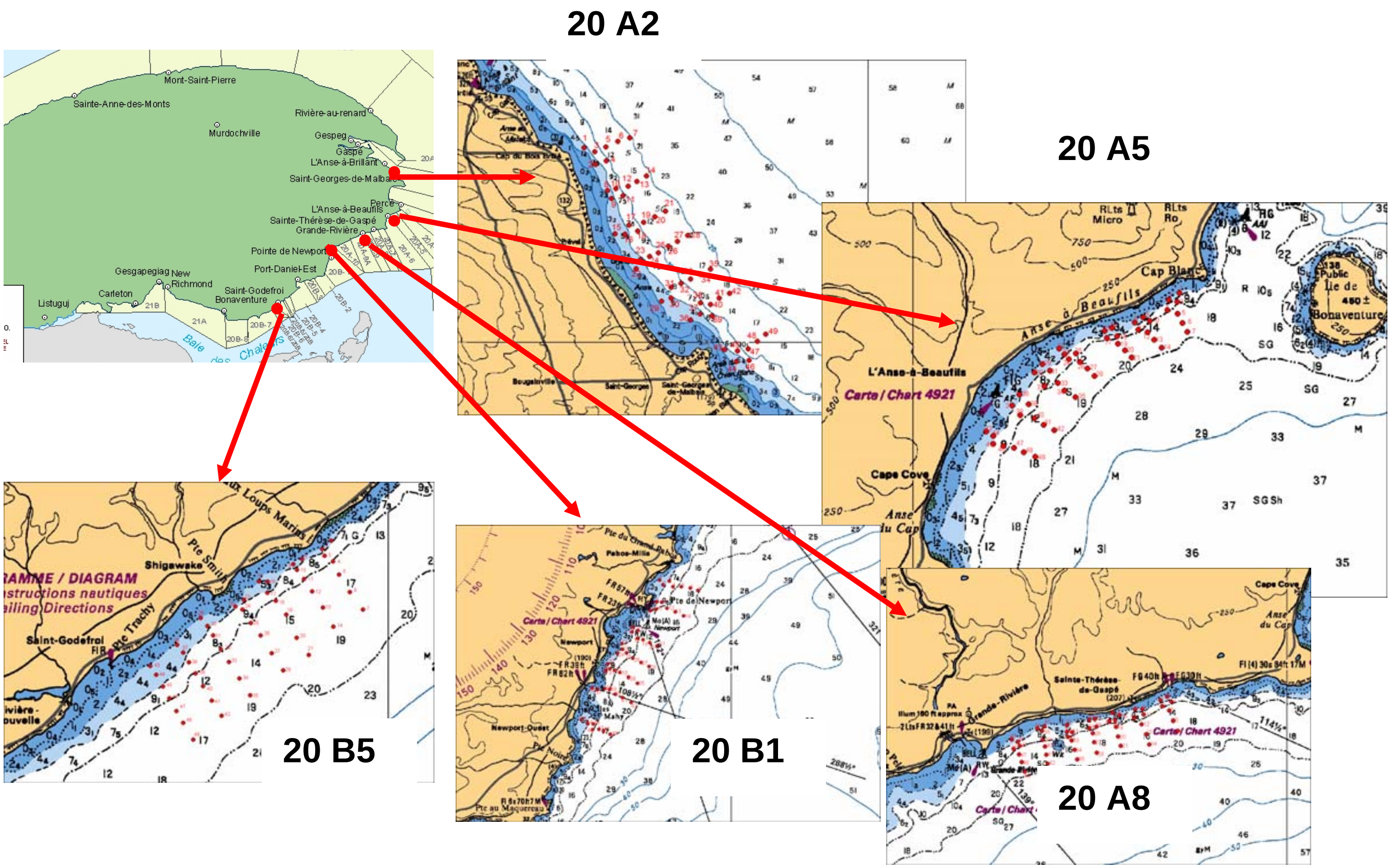


Figure 8. Location of stations (49 stations: 7 stations along 7 transects) in the post-season survey conducted in the Gaspé in 2011 in LFAs 20A2, 20A5, 20A8, 20B1 and 20B5.

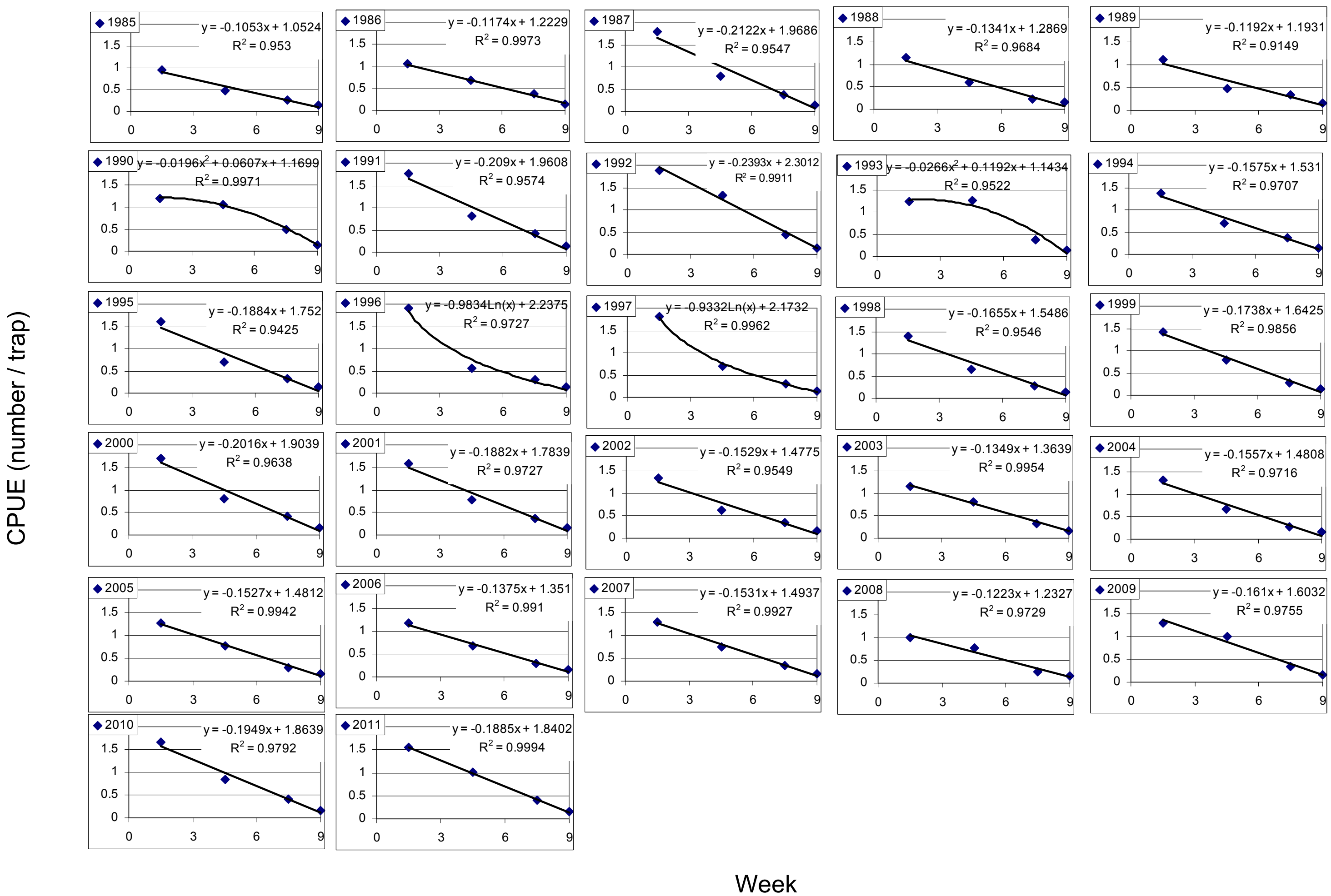


Figure 9A. Catch per unit effort (CPUE) in number of lobsters per trap (l/t) based on the fishing week for the south side of the Magdalen Islands (LFA 22) from 1985 to 2011. Sampling at sea data for weeks 1.5, 4.5 and 7.5 and the lowest value (0.15 l/t) for week 9. The fit model equations are presented.

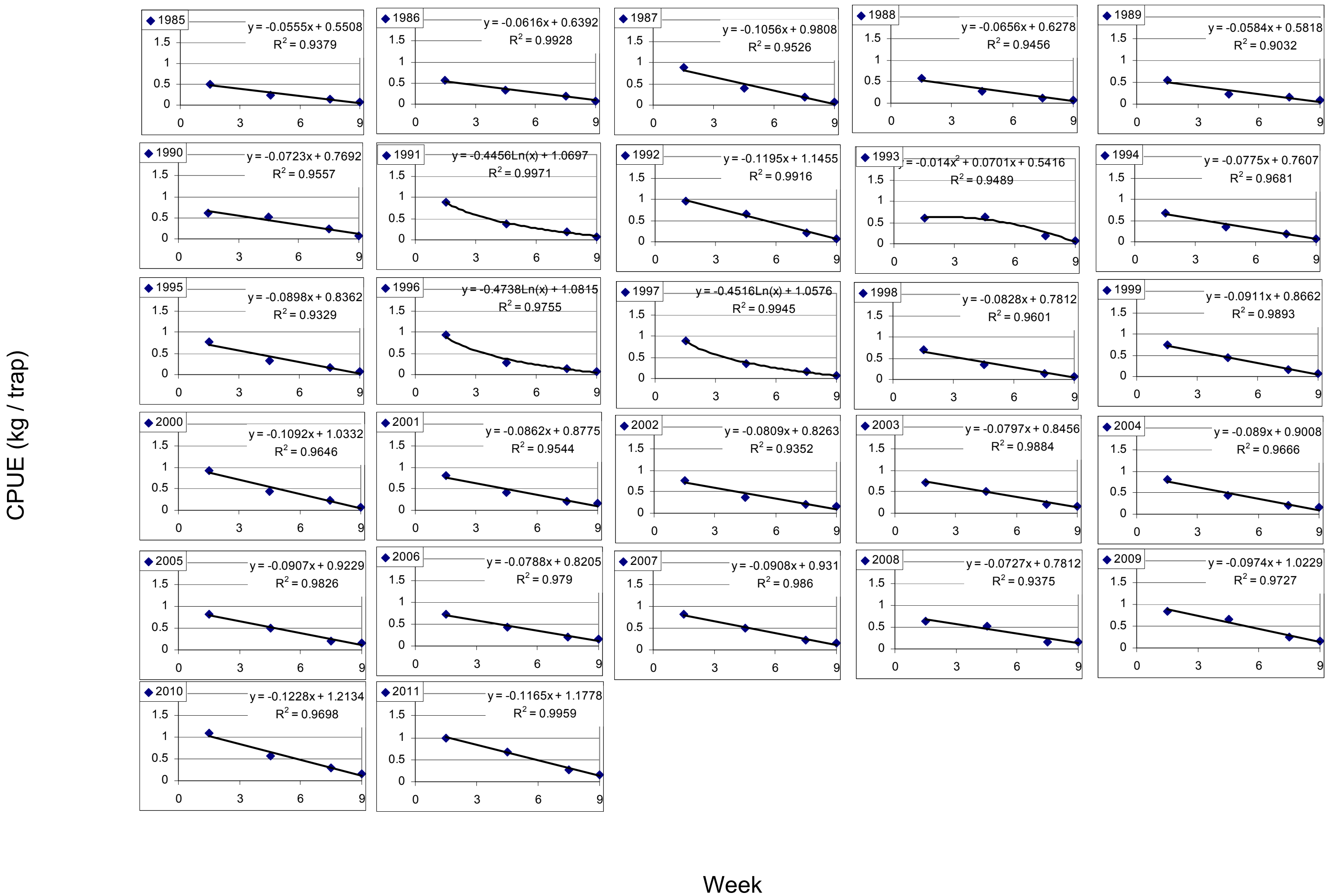


Figure 9B. Catch per unit effort (CPUE) in kg of lobster per trap (kg/t) based on the fishing week for the south side of the Magdalen Islands (LFA 22) from 1985 to 2011. Sampling at sea data for weeks 1.5, 4.5 and 7.5 and the lowest value (0.08 kg/t) for week 9. The fit model equations are presented.

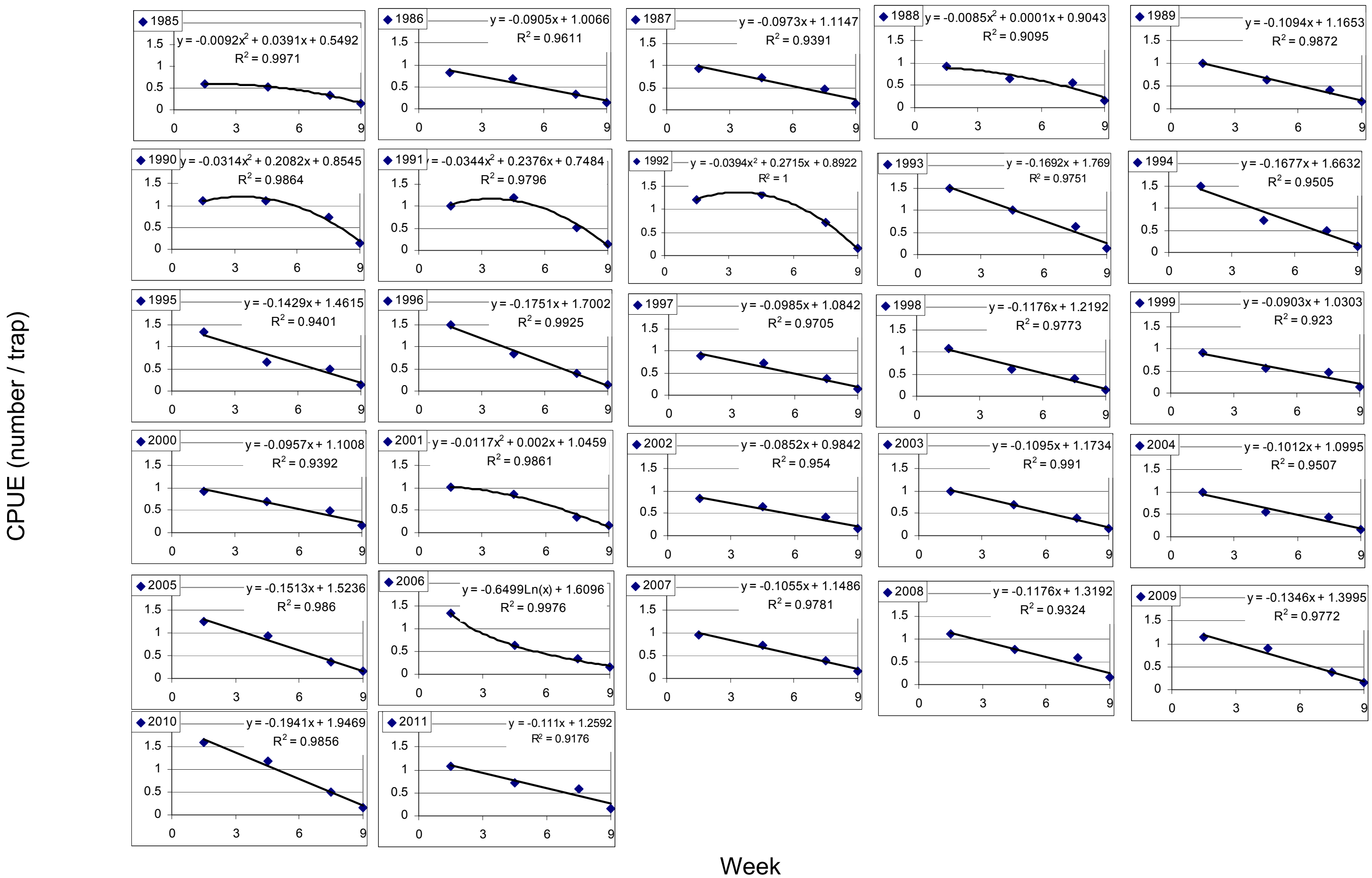


Figure 10A. Catch per unit effort (CPUE) in number of lobsters per trap (l/t) based on the fishing week for the north side of the Magdalen Islands (LFA 22) from 1985 to 2011. Sampling at sea data for weeks 1.5, 4.5 and 7.5 and the lowest value (0.15 l/t) for week 9. The fit model equations are presented.

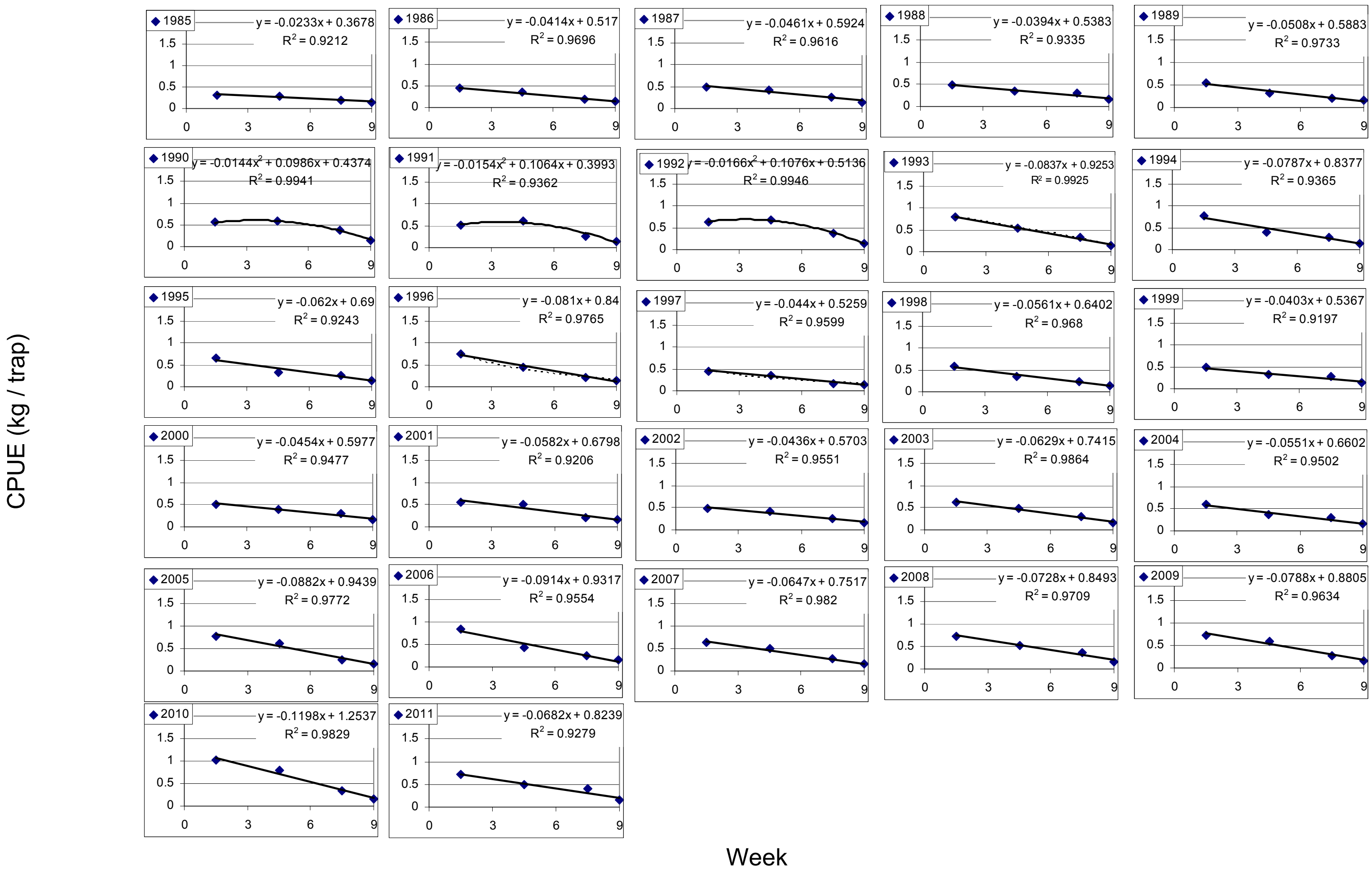


Figure 10B. Catch per unit effort (CPUE) in kg of lobster per trap (kg/t) based on the fishing week for the north side of the Magdalen Islands (LFA 22) from 1985 to 2011. Sampling at sea data for weeks 1.5, 4.5 and 7.5 and the lowest value (0.15 kg/t) for week 9. The fit model equations are presented.

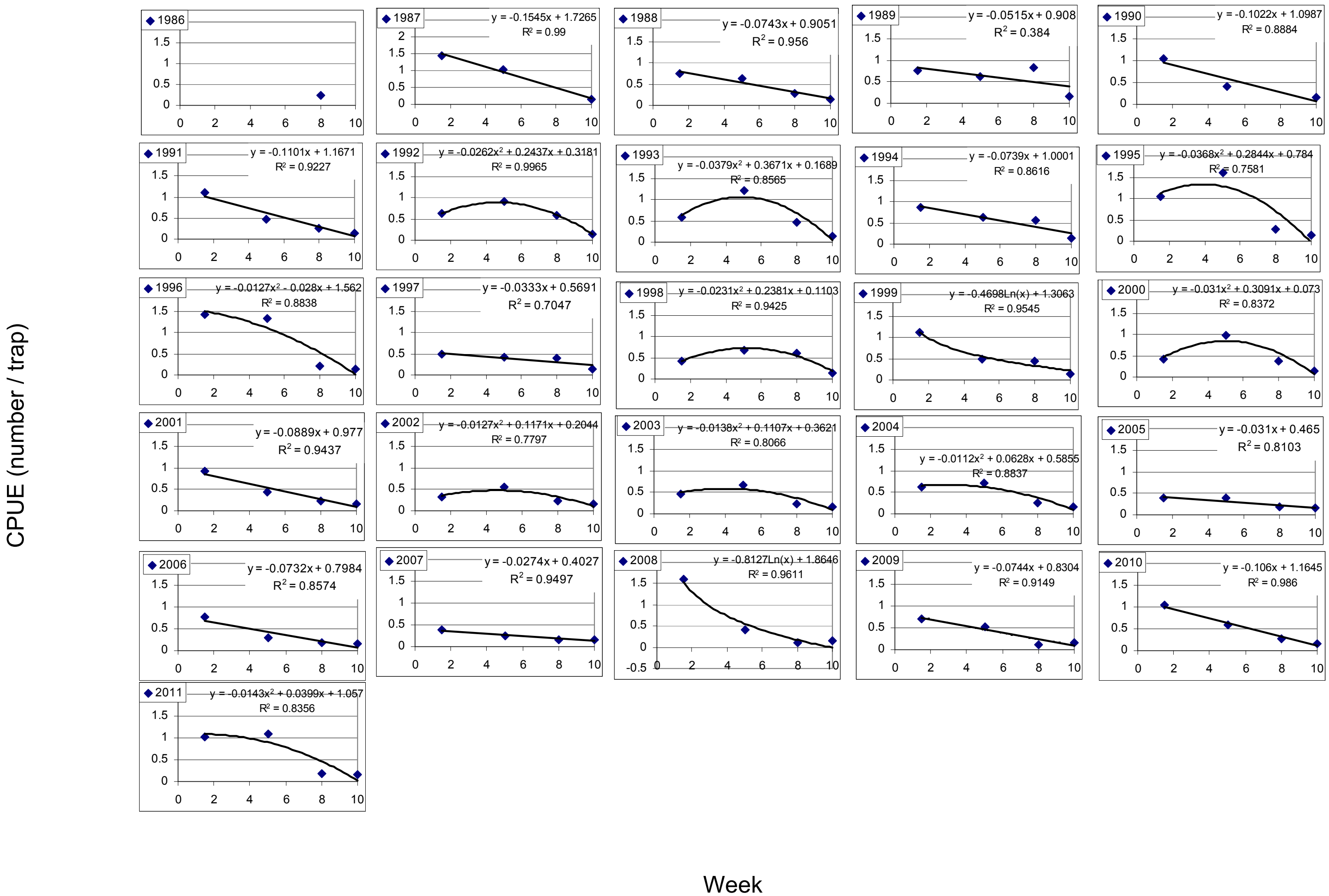


Figure 11A. Catch per unit effort (CPUE) in number of lobsters per trap (l/t) based on the fishing week for LFA 20A2 in the Gaspé from 1986 to 2011. Sampling at sea data for weeks 1.5, 5 and 8 and the lowest value (0.15 l/t) for week 10. The fit model equations are presented.

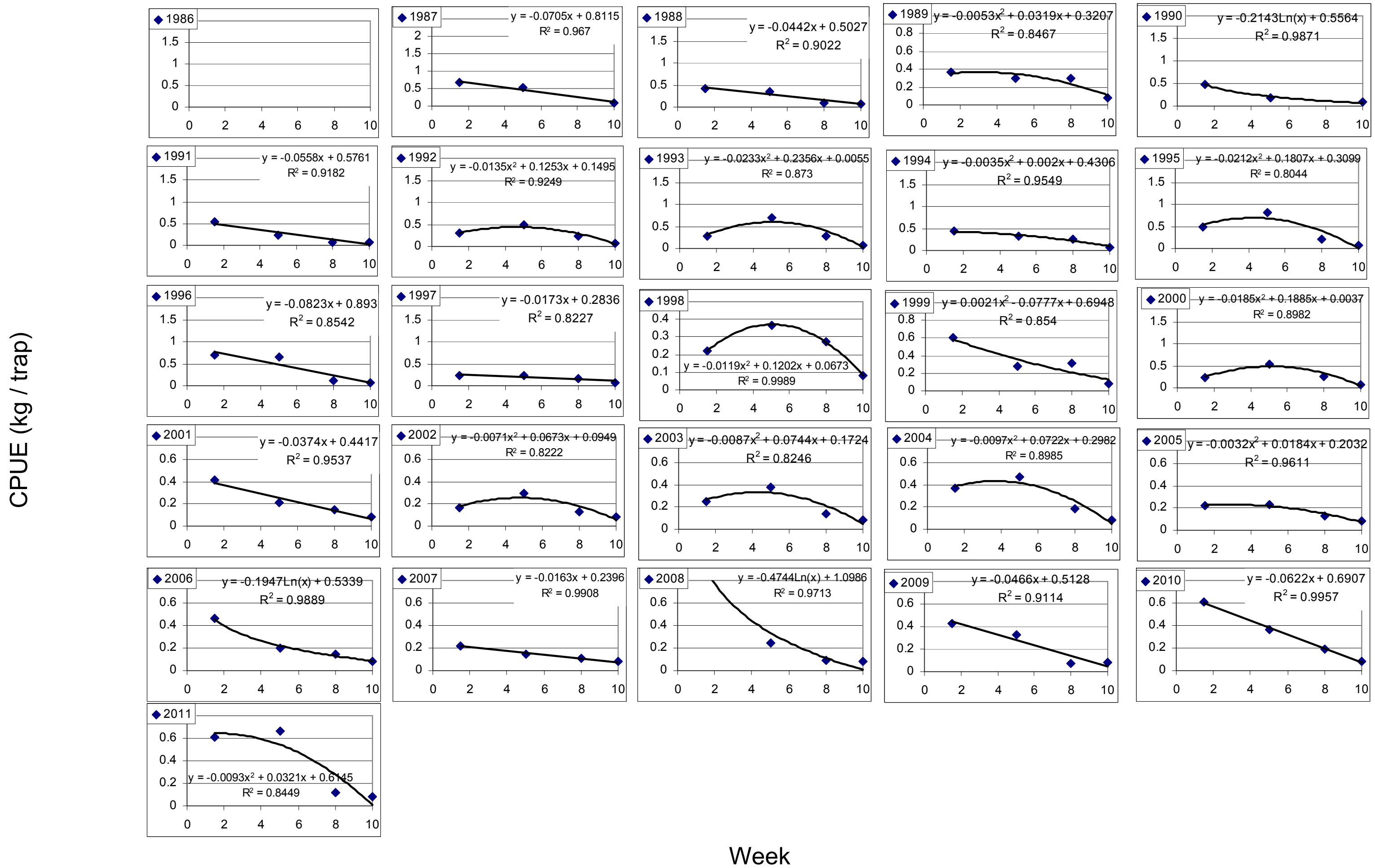


Figure 11B. Catch per unit effort (CPUE) in kg of lobster per trap (kg/t) based on the fishing week for LFA 20A2 in the Gaspé from 1986 to 2011. Sampling at sea data for weeks 1.5, 5 and 8 and the lowest value (0.08 kg/t) for week 10. The fit model equations are presented.

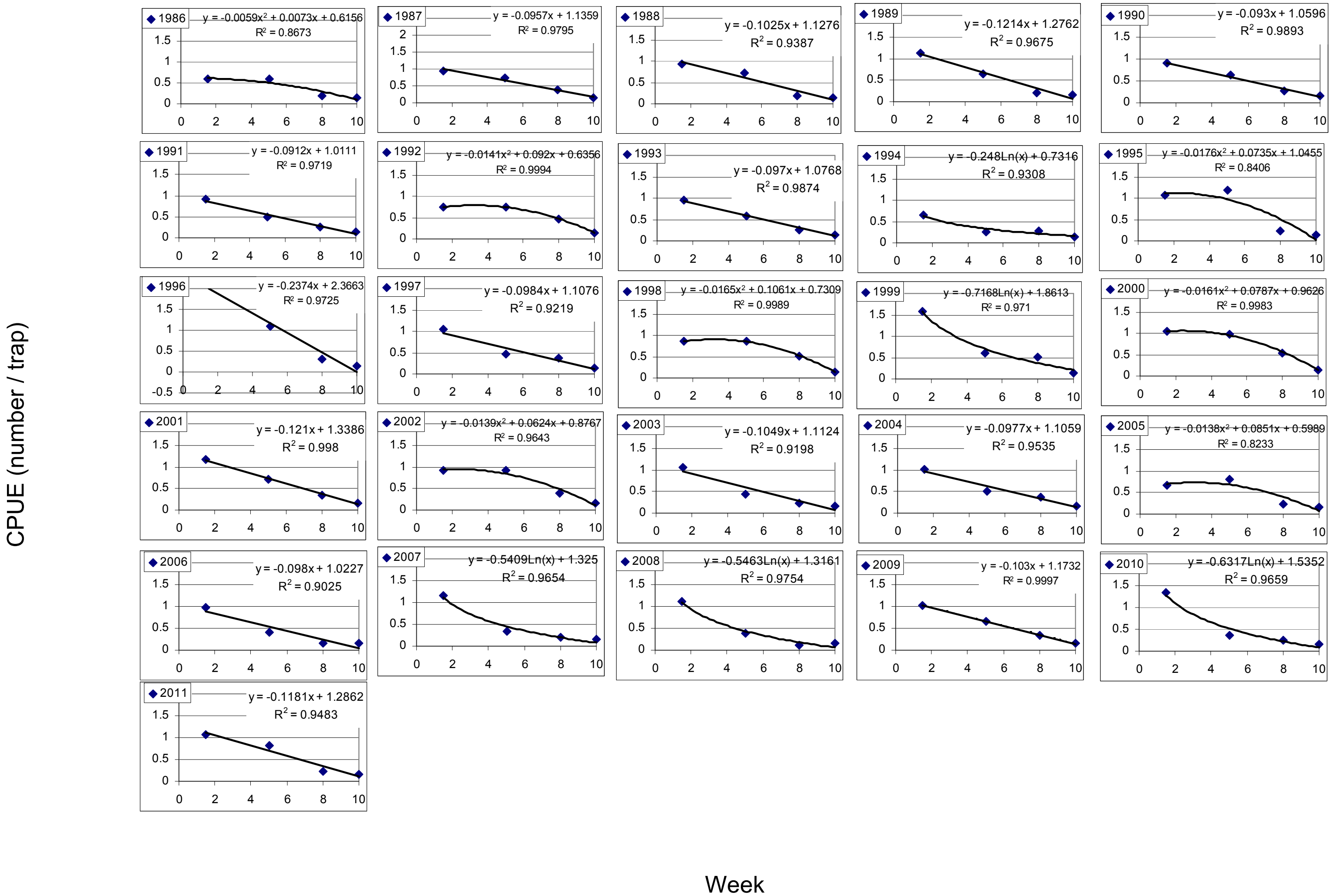


Figure 12A. Catch per unit effort (CPUE) in number of lobsters per trap (l/t) based on the fishing week for LFA 20A8-A9 in the Gaspé from 1986 to 2011. Sampling at sea data for weeks 1.5, 5 and 8 and the lowest value (0.15 l/t) for week 10. The fit model equations are presented.

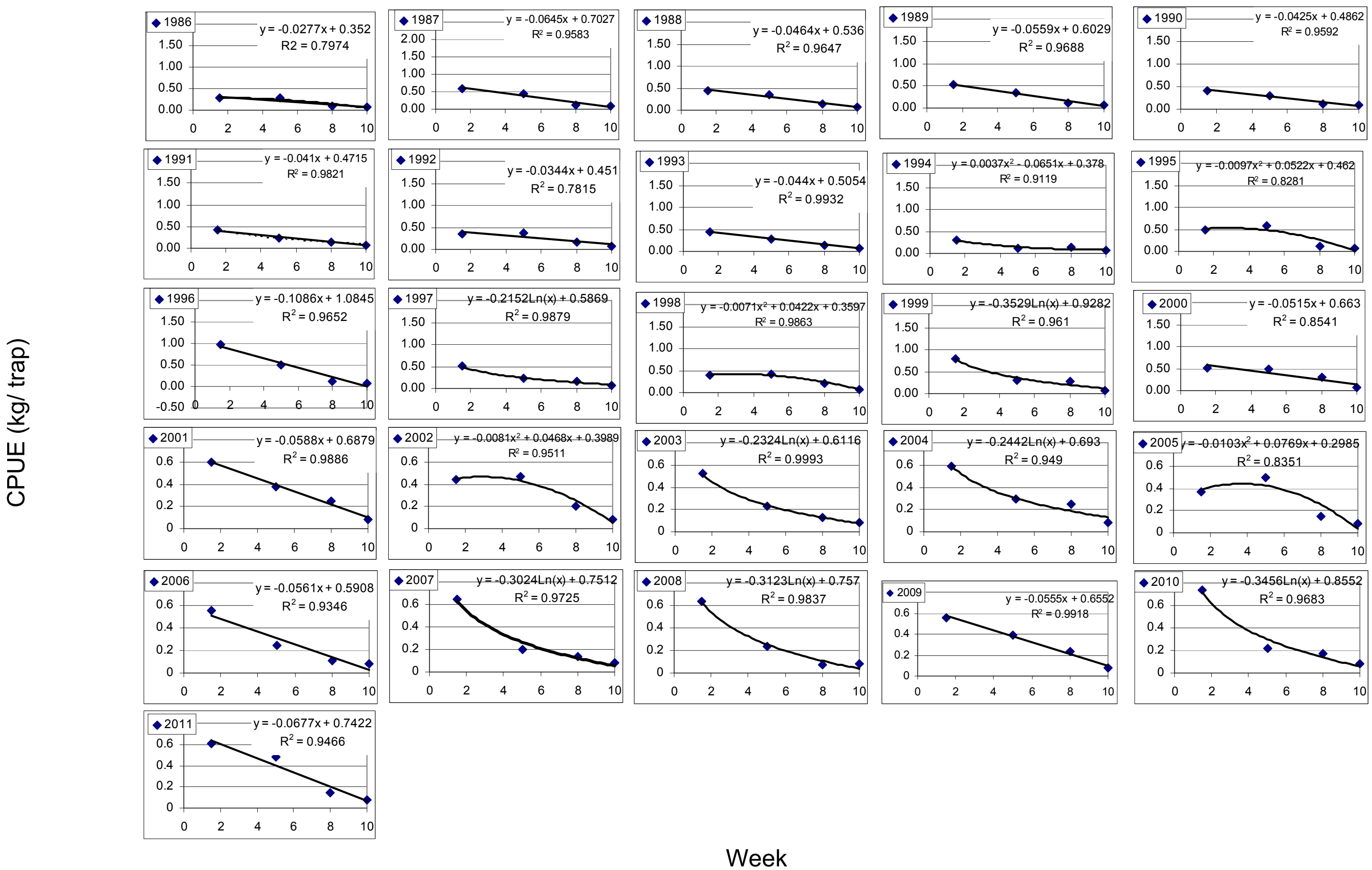


Figure 12B. Catch per unit effort (CPUE) in kg of lobster per trap (kg/t) based on the fishing week for LFA 20A8-A9 in the Gaspé from 1986 to 2011. Sampling at sea data for weeks 1.5, 5 and 8 and the lowest value (0.08 kg/t) for week 10. The fit model equations are presented.

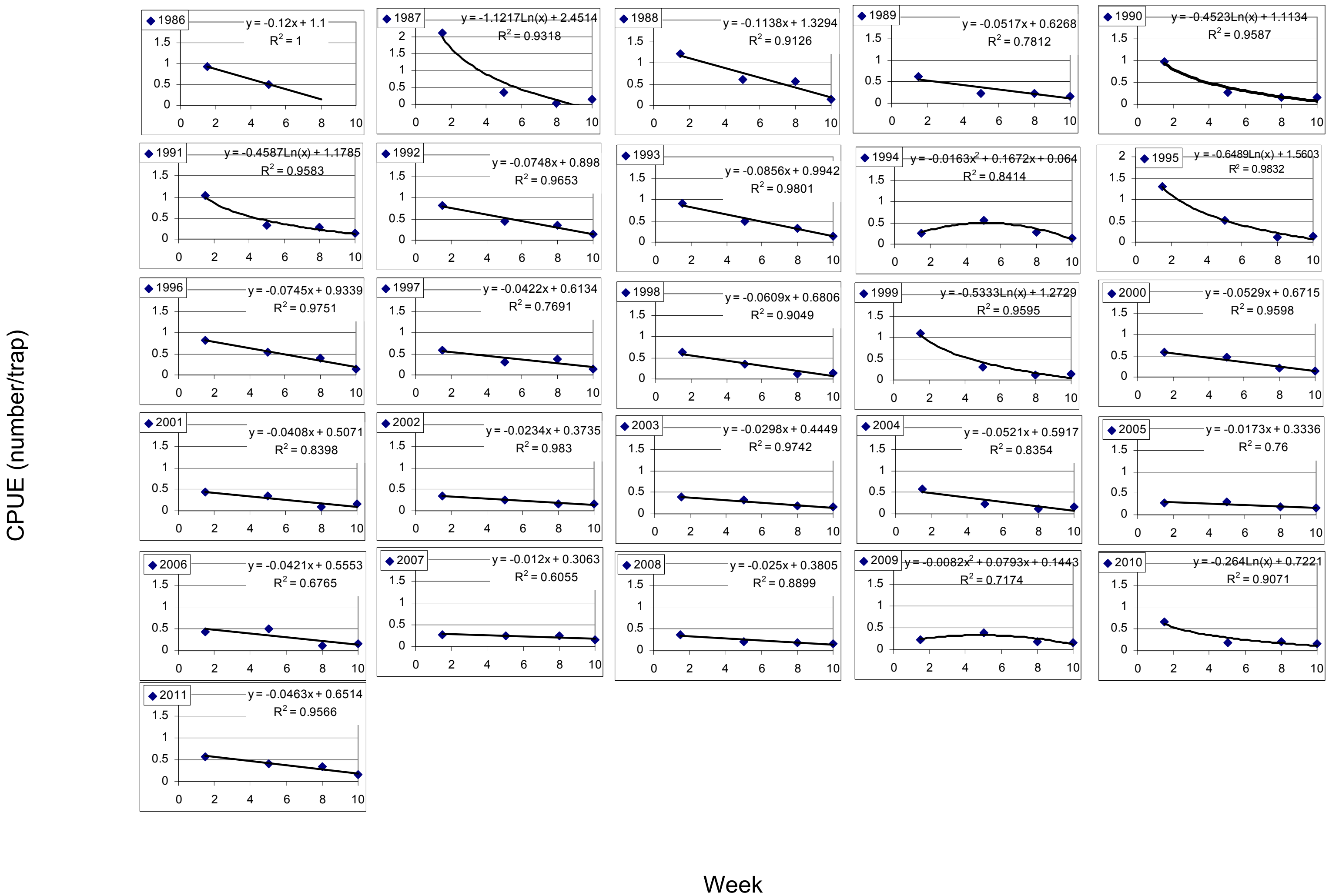


Figure 13A. Catch per unit effort (CPUE) in number of lobsters per trap (l/t) based on the fishing week for 20B5-B6 in the Gaspé from 1986 to 2011. Sampling at sea data for weeks 1.5, 5 and 8 and the lowest value (0.15 l/t) for week 10. The fit model equations are presented.

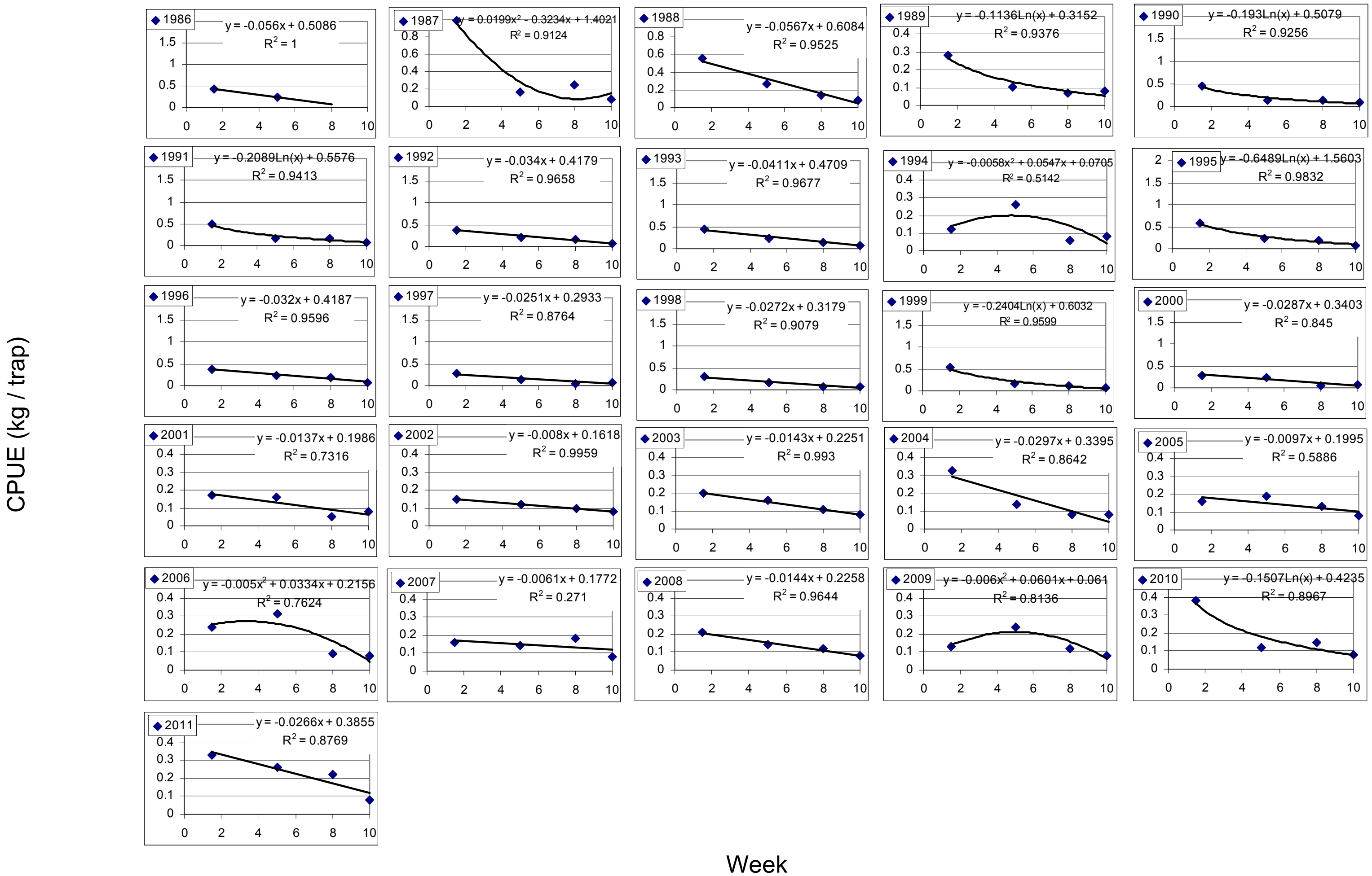


Figure 13B. Catch per unit effort (CPUE) in kg of lobster per trap (kg/t) based on the fishing week for LFA 20B5-B6 in the Gaspé from 1986 to 2011. Sampling at sea data for weeks 1.5, 5 and 8 and the lowest value (0.15 l/t) for week 10. The fit model equations are presented.

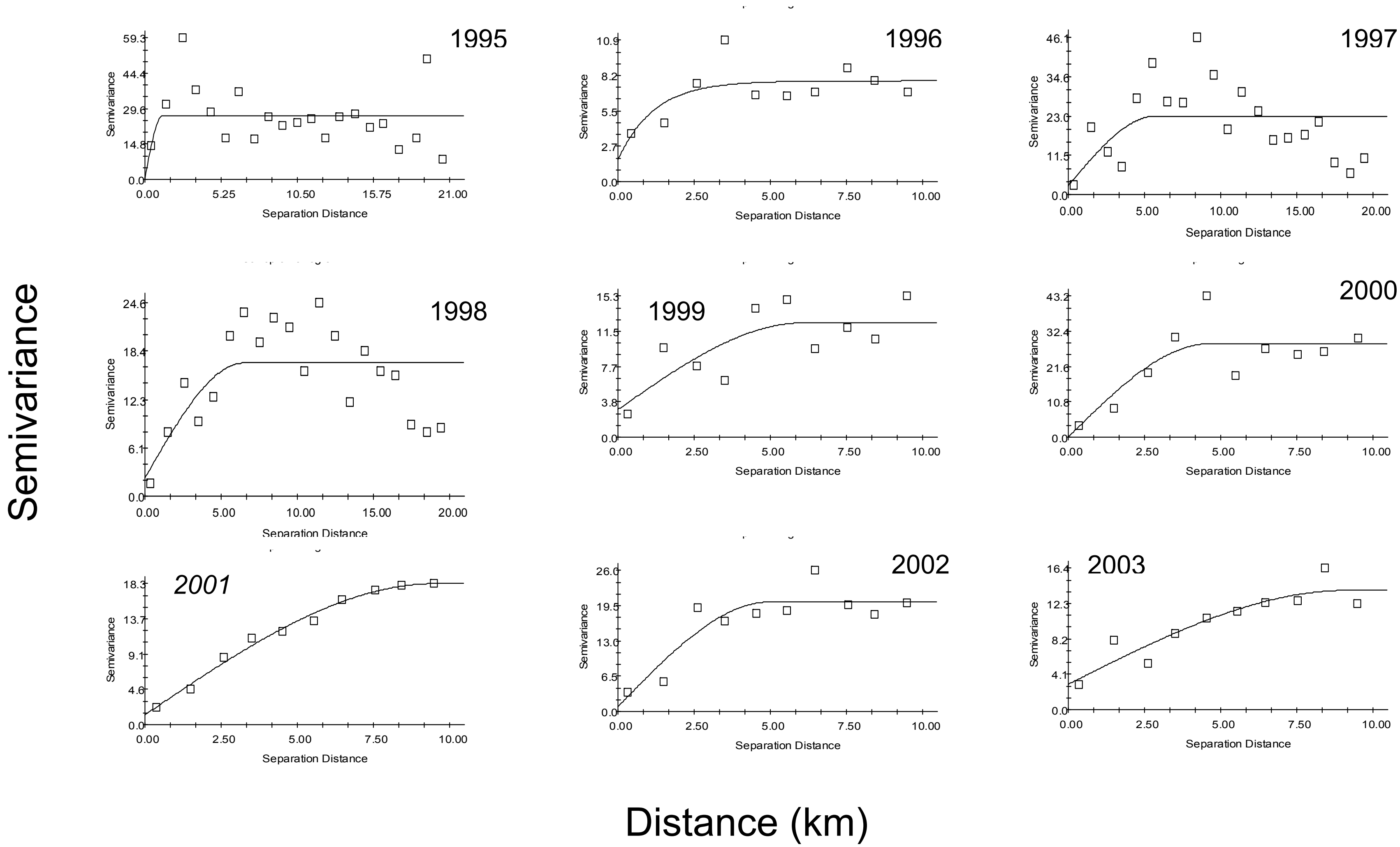


Figure 14. Omnidirectional (isotropic) variograms of lobster density from the 1995 to 2011 trawl survey calculated with GS+ software. Model parameters are presented in Table 10.

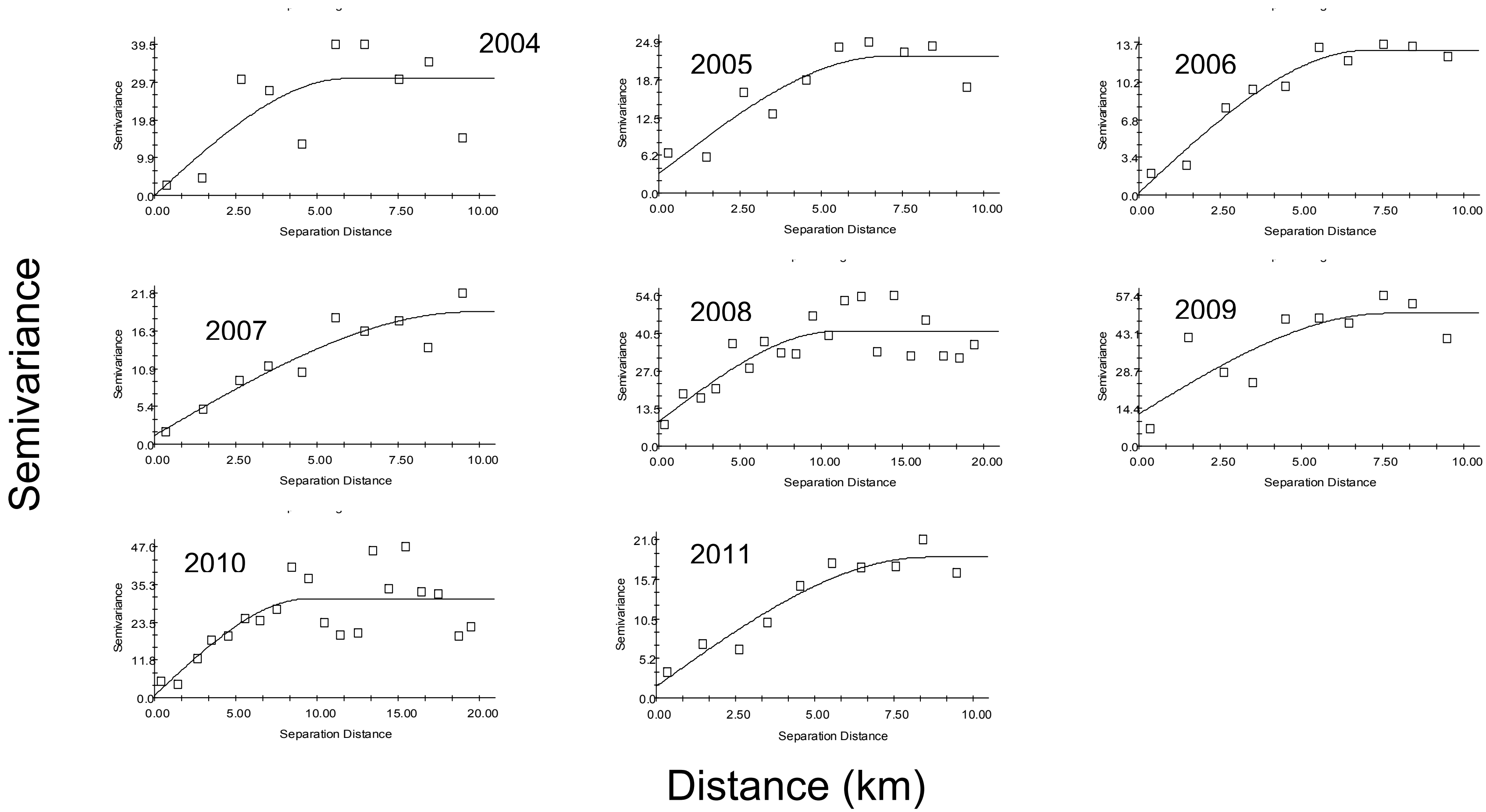


Figure 14. Cont'd.

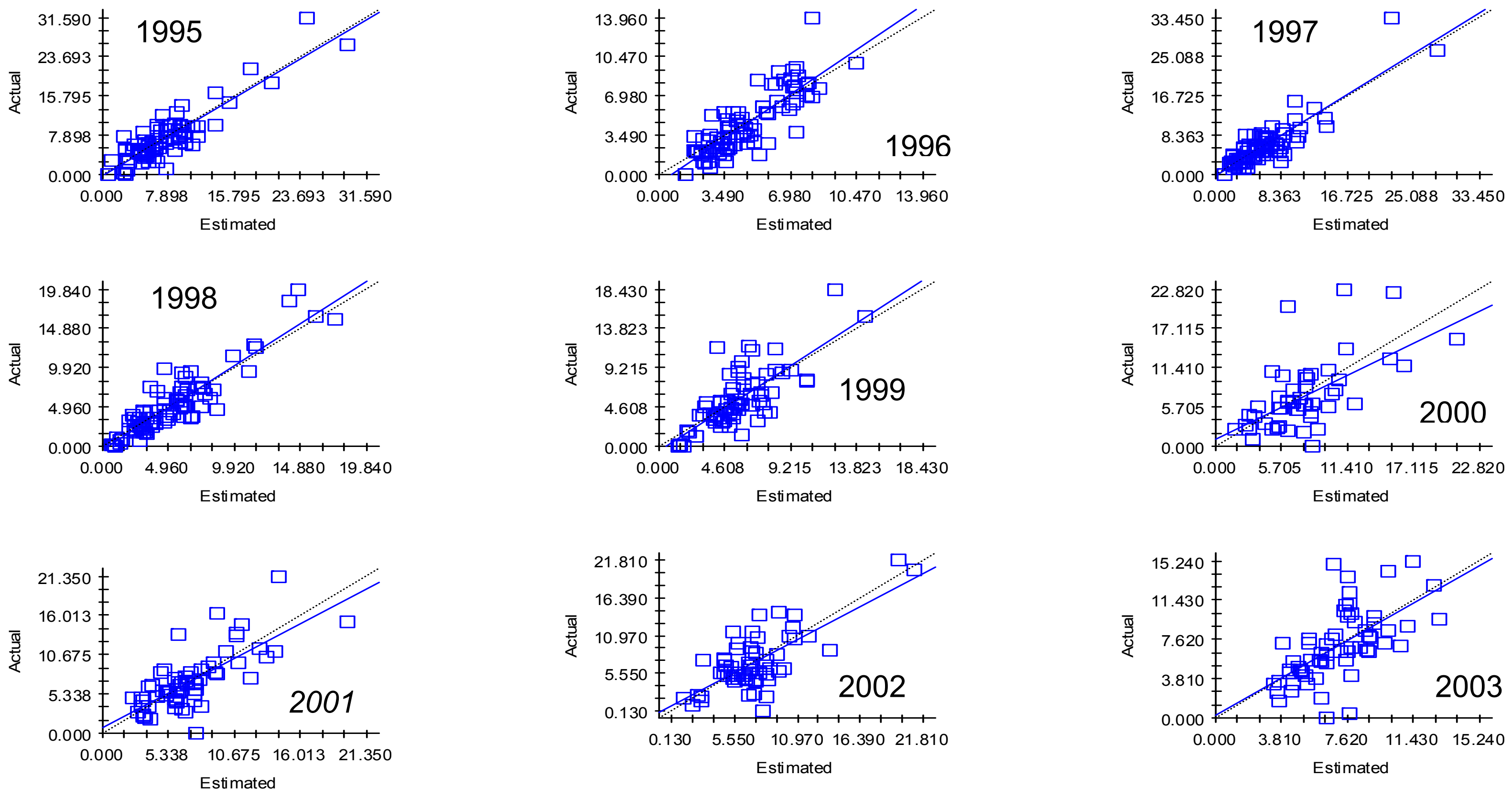


Figure 15. Cross-validation showing the density values (number/1,000 m^2) of commercial sized lobster estimated by kriging and actual values from the 1995 to 2011 trawl surveys. The solid line represents the linear relationship between the two datasets. The r^2 values for the linear model are provided in Table 10. The dotted line has a slope = 1.

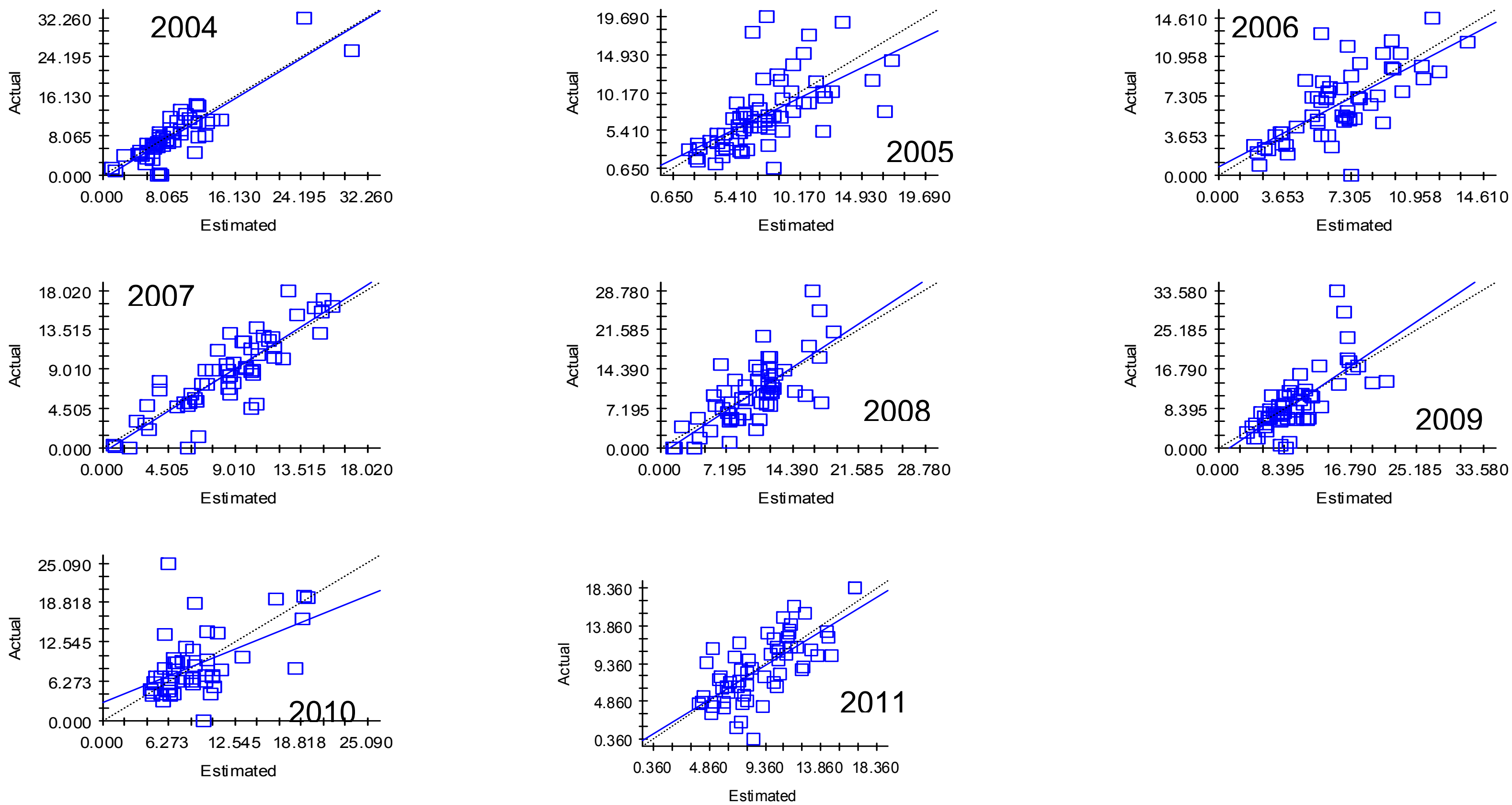


Figure 15. Cont'd.

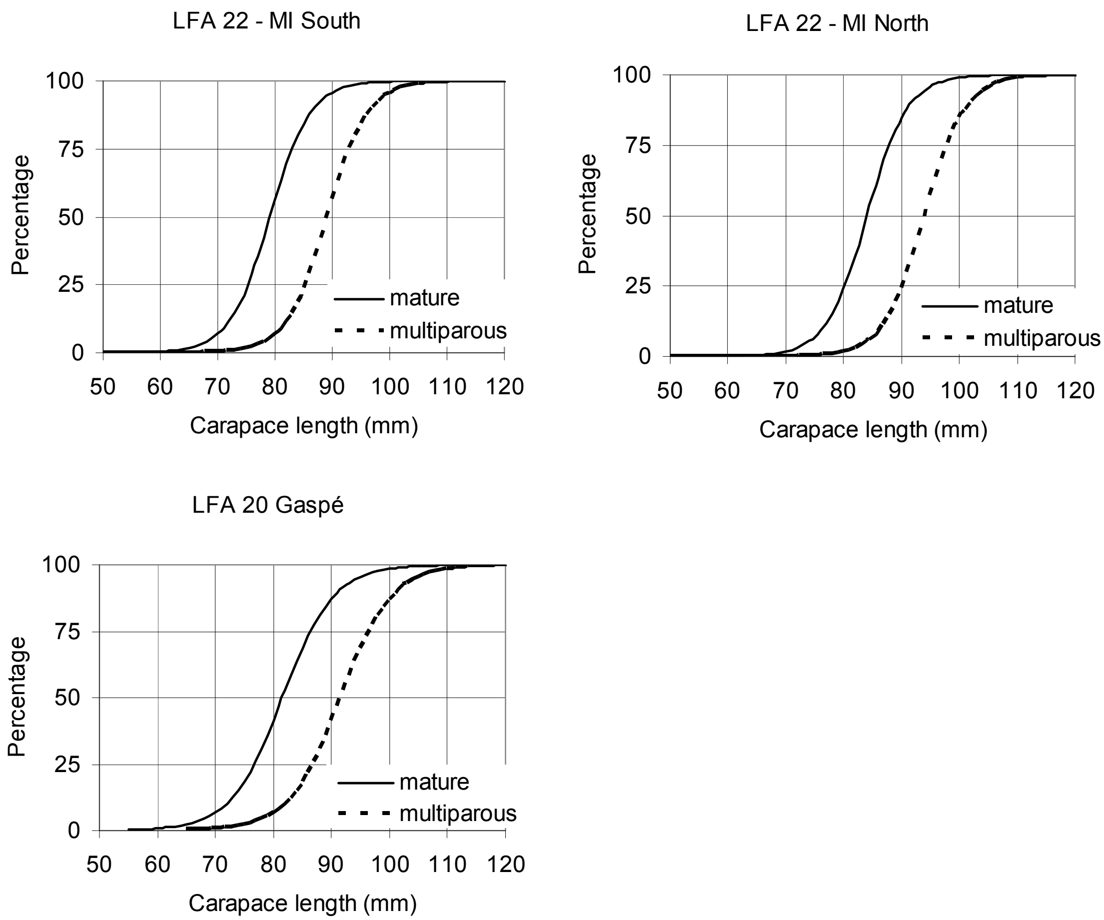
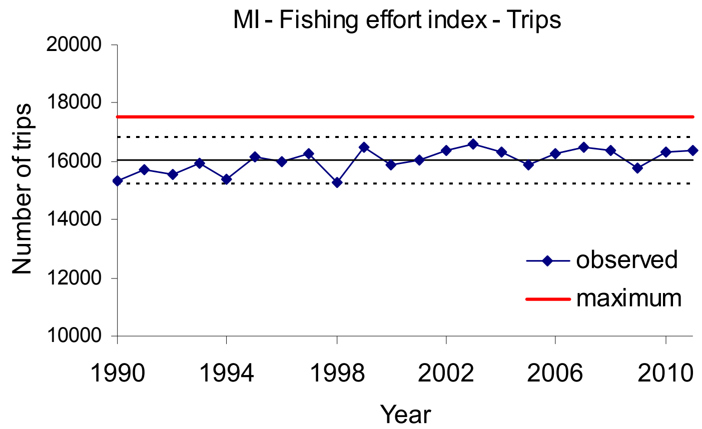


Figure 16. Maturity ogives showing the percentage of mature (solid line) and multiparous (dotted line) females as a function of size for the south and north sides of Magdalen Islands and the Gaspé.

A)



B)

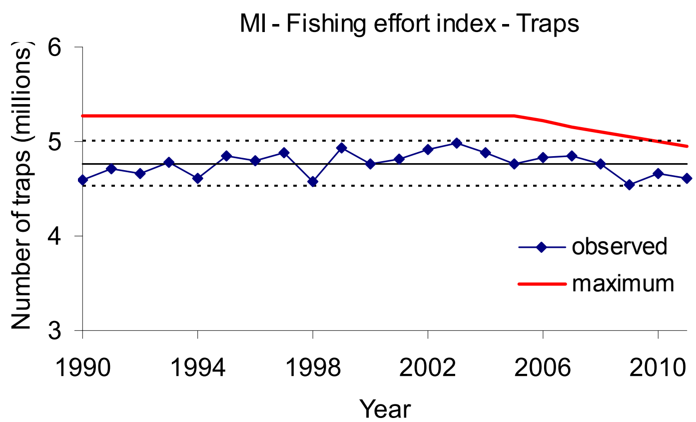
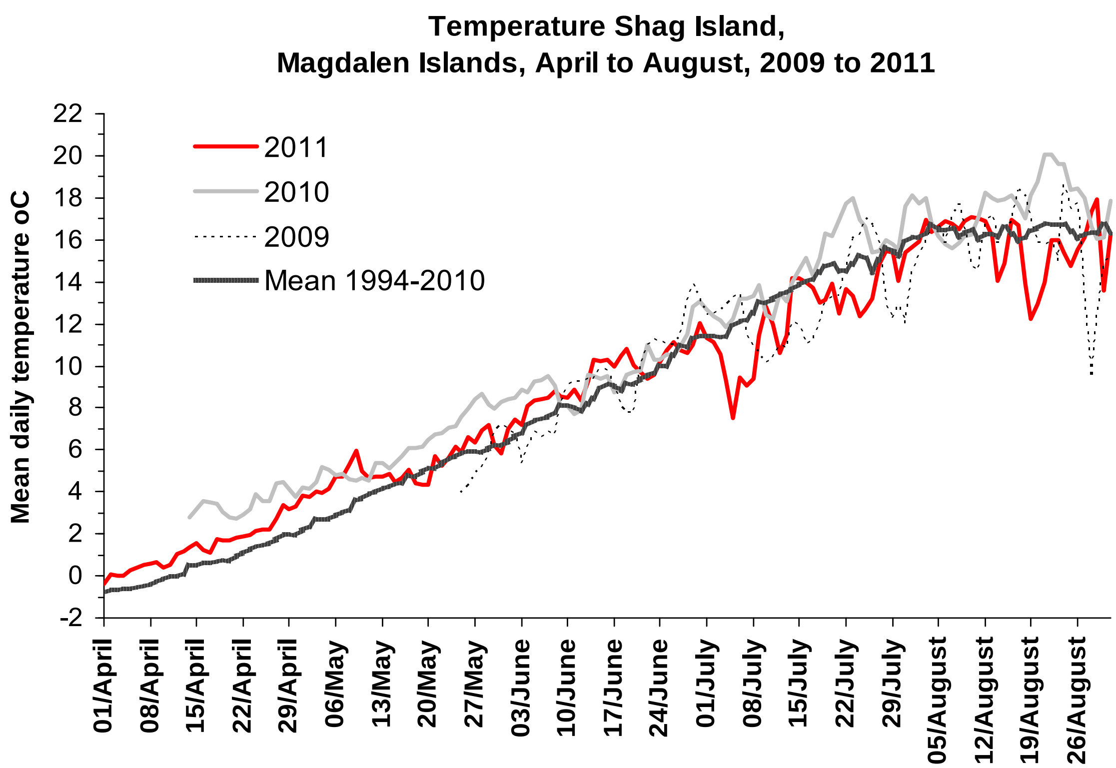


Figure 17. Index of fishing effort in the Magdalen Islands from 1990 to 2011 A) in number of daily fishing trips and B) in trap hauls. Average for the period from 1990 to 2011 (solid line) ±5% (dotted lines). The maximums are the regulatory limits.

A)



B)

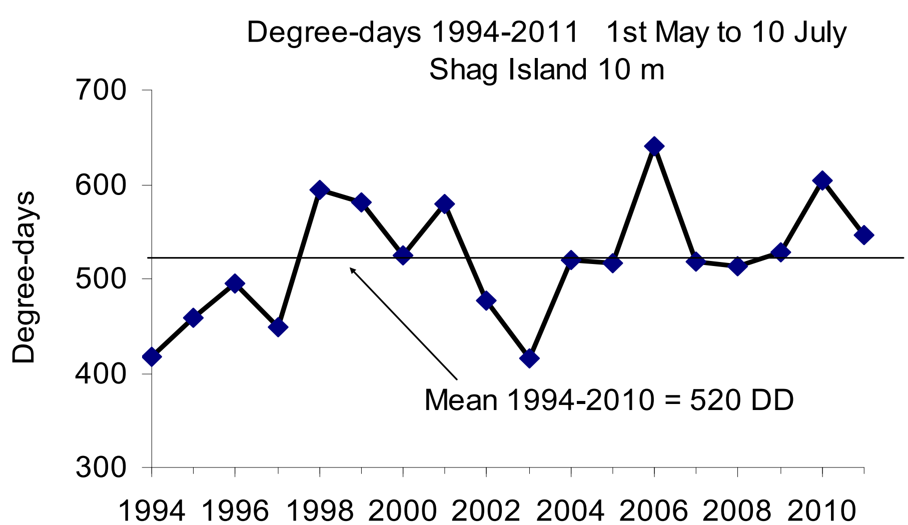
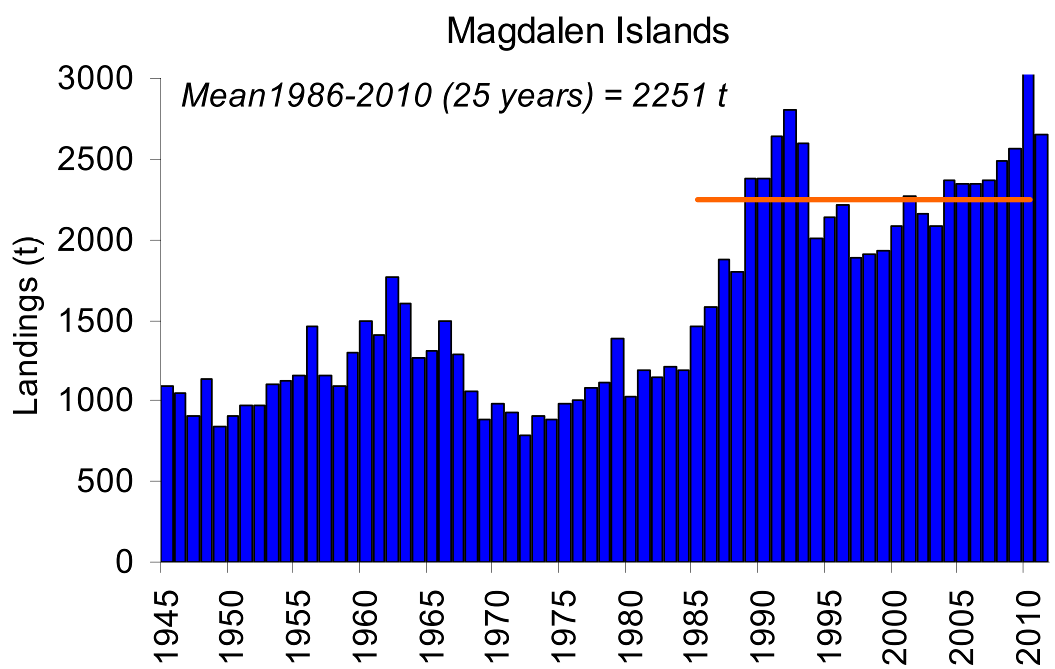


Figure 18. A) Temperature recorded at sea off Shag Island (Magdalen Islands) at a depth of ten metres from April 1 to August 30, 2009, 2010 and 2011 and B) number of cumulative degree-days from May 1 to July 10, 1994 to 2011.

A)



B)

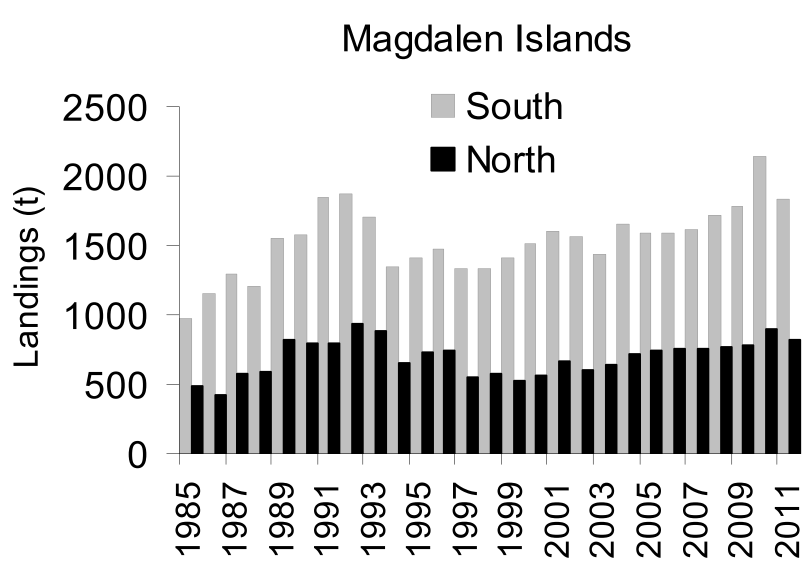


Figure 19. Landings (t) of lobster in the Magdalen Islands for A) all the Islands from 1945 to 2011 and B) for the south and north areas from 1985 to 2011.

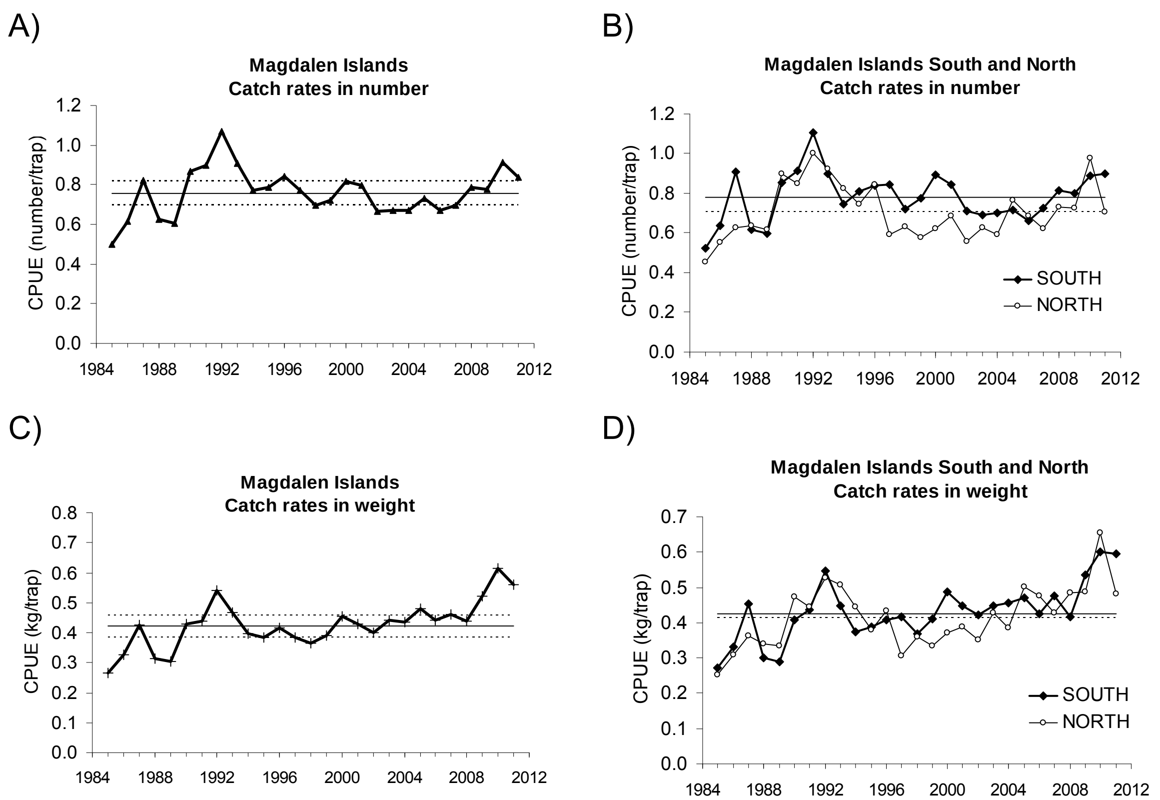


Figure 20. A) CPUE in number (number / trap) for all the Magdalen Islands and B) for the south and north areas, C) CPUE in weight (kg / trap) for all the Magdalen Islands and D) for the south and north areas from 1985 to 2011. For A) and C), the solid line represents the series average (1985 to 2010) ± 0.5 standard deviation (dotted lines). For B) and D), the solid line represents the series average for the south and the dotted line represents the series average for the north.

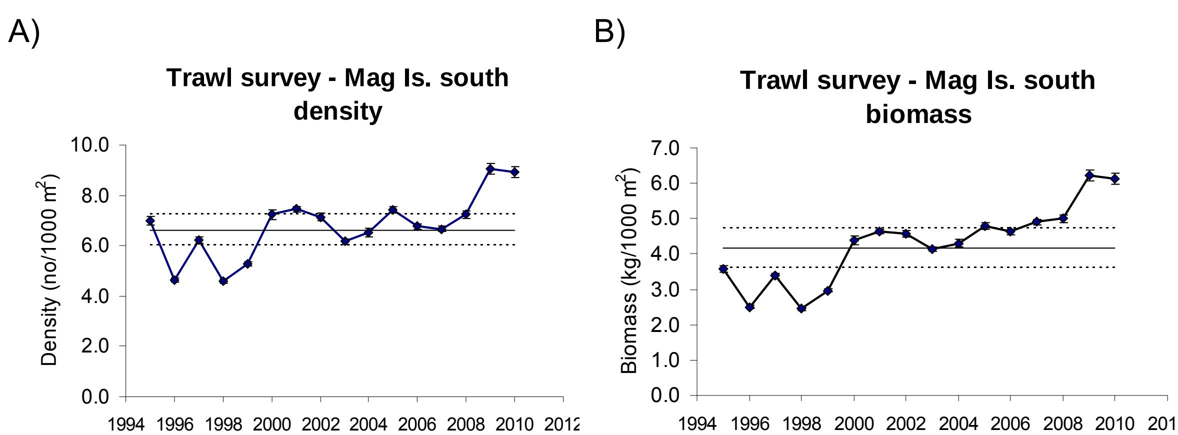


Figure 21. A) Density and B) biomass (kg) per 1,000 m^2 (average ± 95% CI) observed during the September trawl survey conducted in the south part of the Magdalen Islands between 1995 and 2010. 1995 to 2009 average (solid line) ± 0.5 standard deviation (dotted lines).

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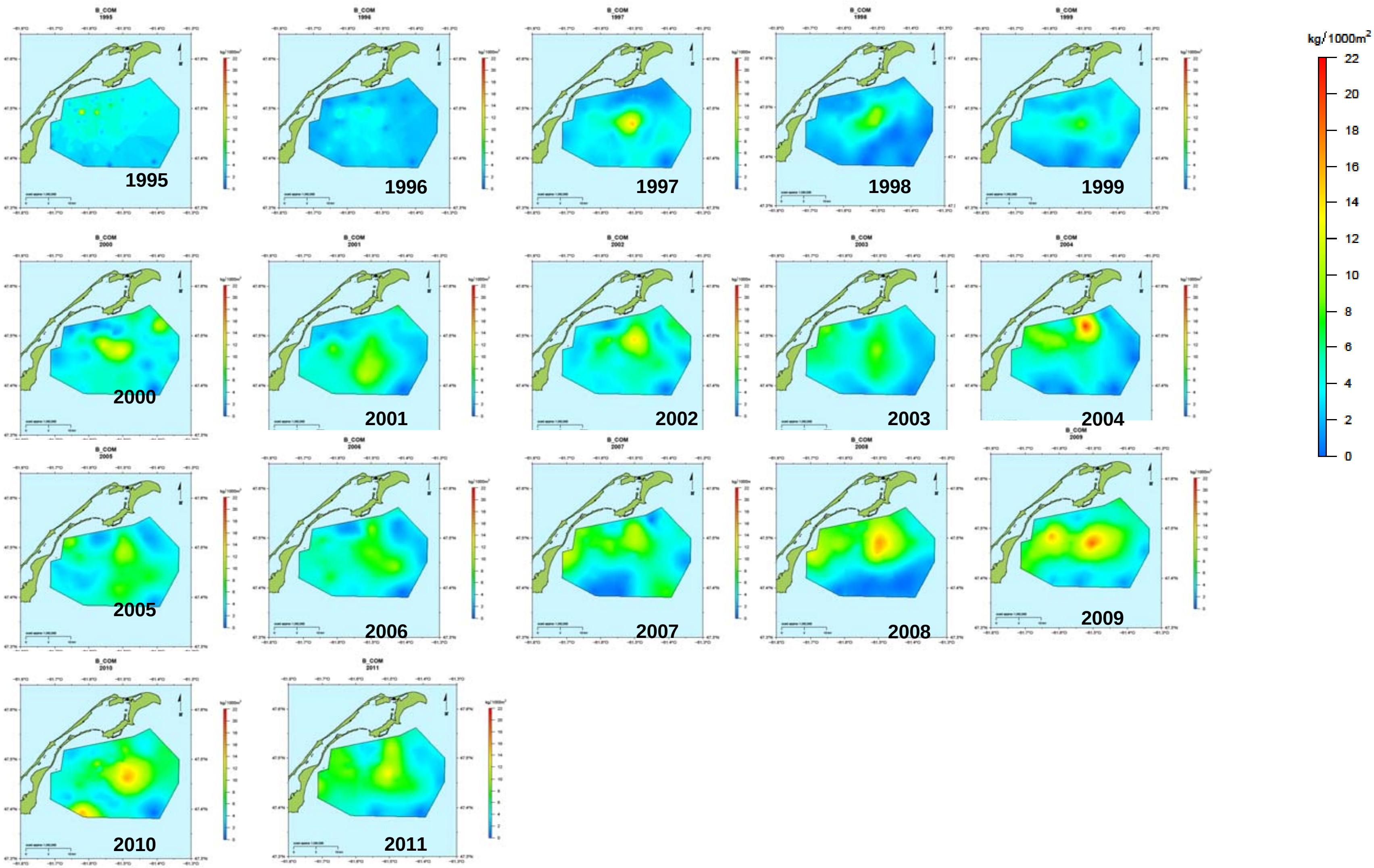


Figure 22. Biomass kriging maps (kg/1,000 m^2) of commercial size lobster from 1995 to 2011 produced from trawl survey data.

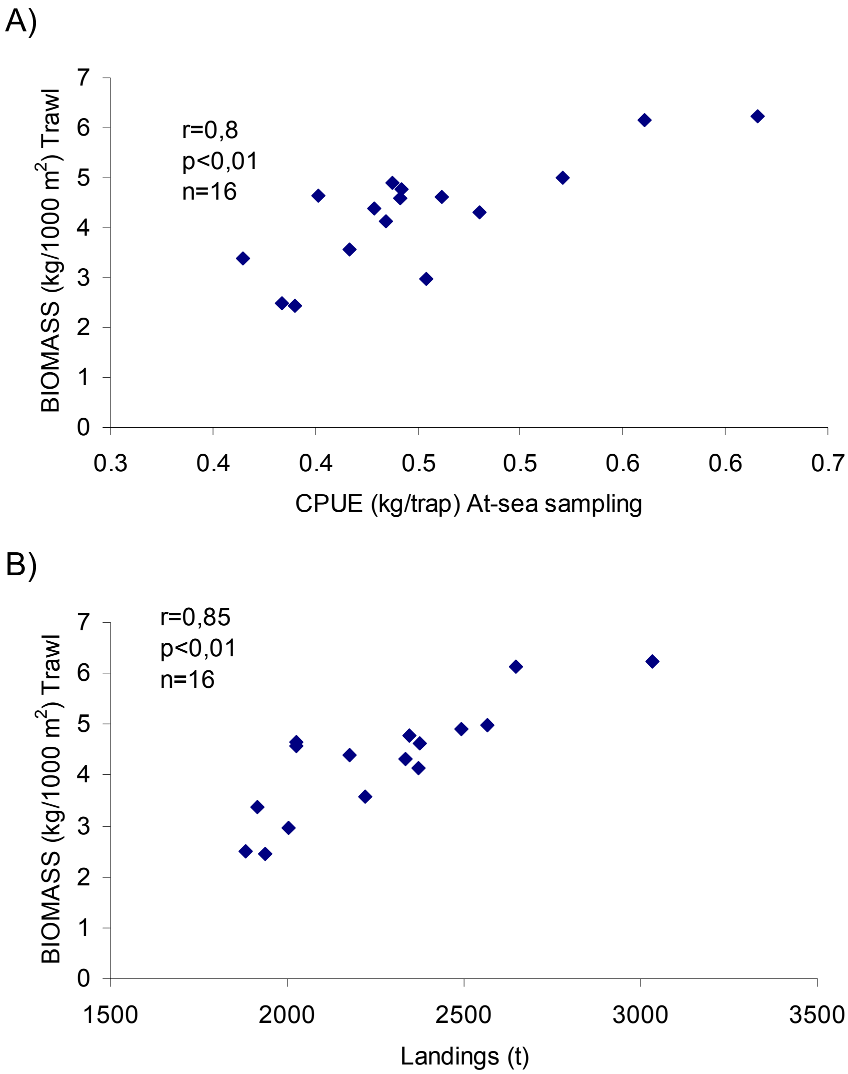


Figure 23. Correlation between the various abundance indicators. A) Biomass from the trawl survey at time t (1995 to 2010) and CPUE in weight from commercial sampling at time t+1 (1996 to 2011) and B) biomass from the trawl survey at time t (1995 to 2010) and landings at time t+1 (1996 to 2011).

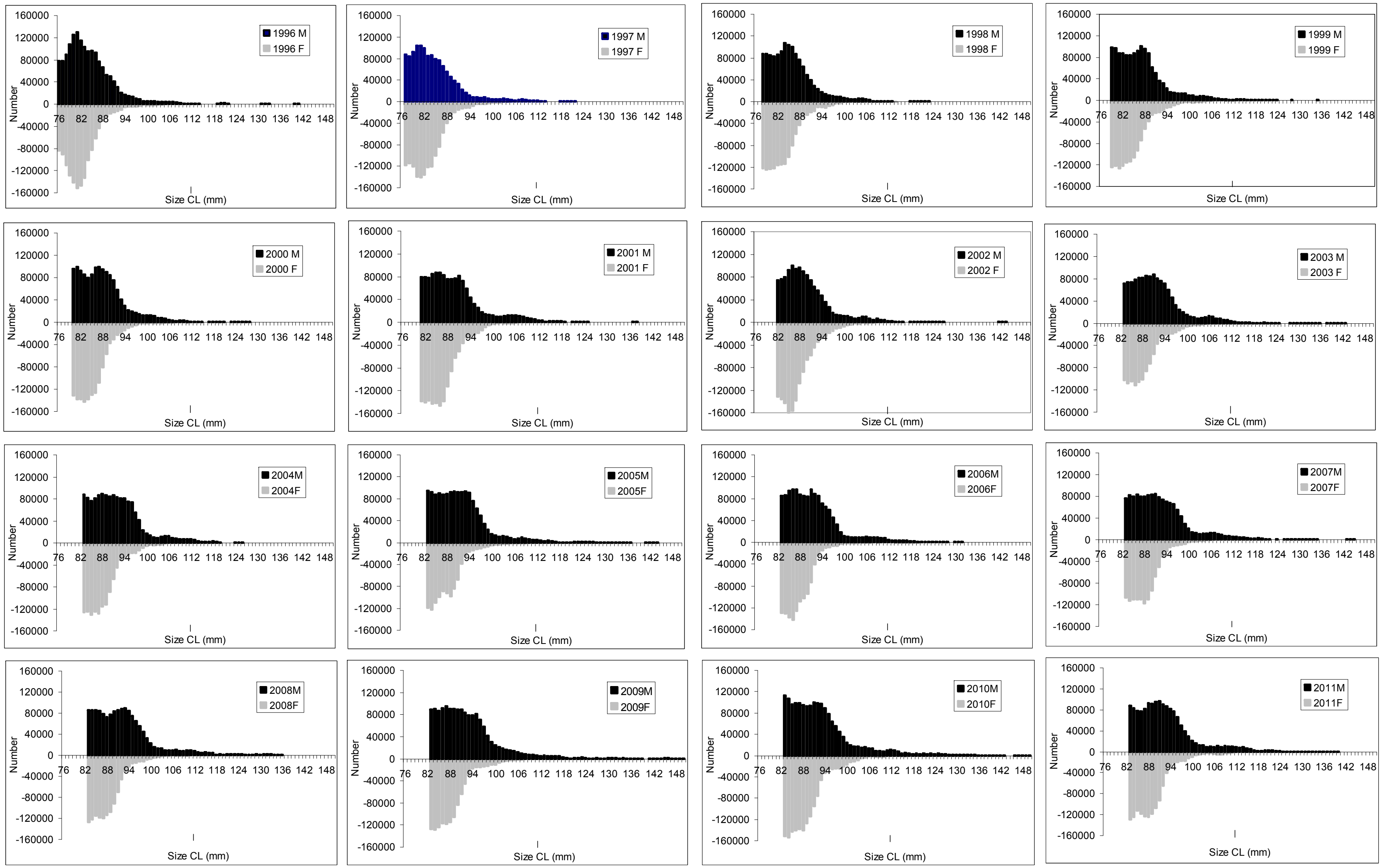


Figure 24. Size frequency distribution of male lobsters (black) and female lobsters (grey) (commercial portion) from 1996 to 2011 for the south side of the Magdalen Islands. Sampling at sea data. The frequencies are weighted by landings.

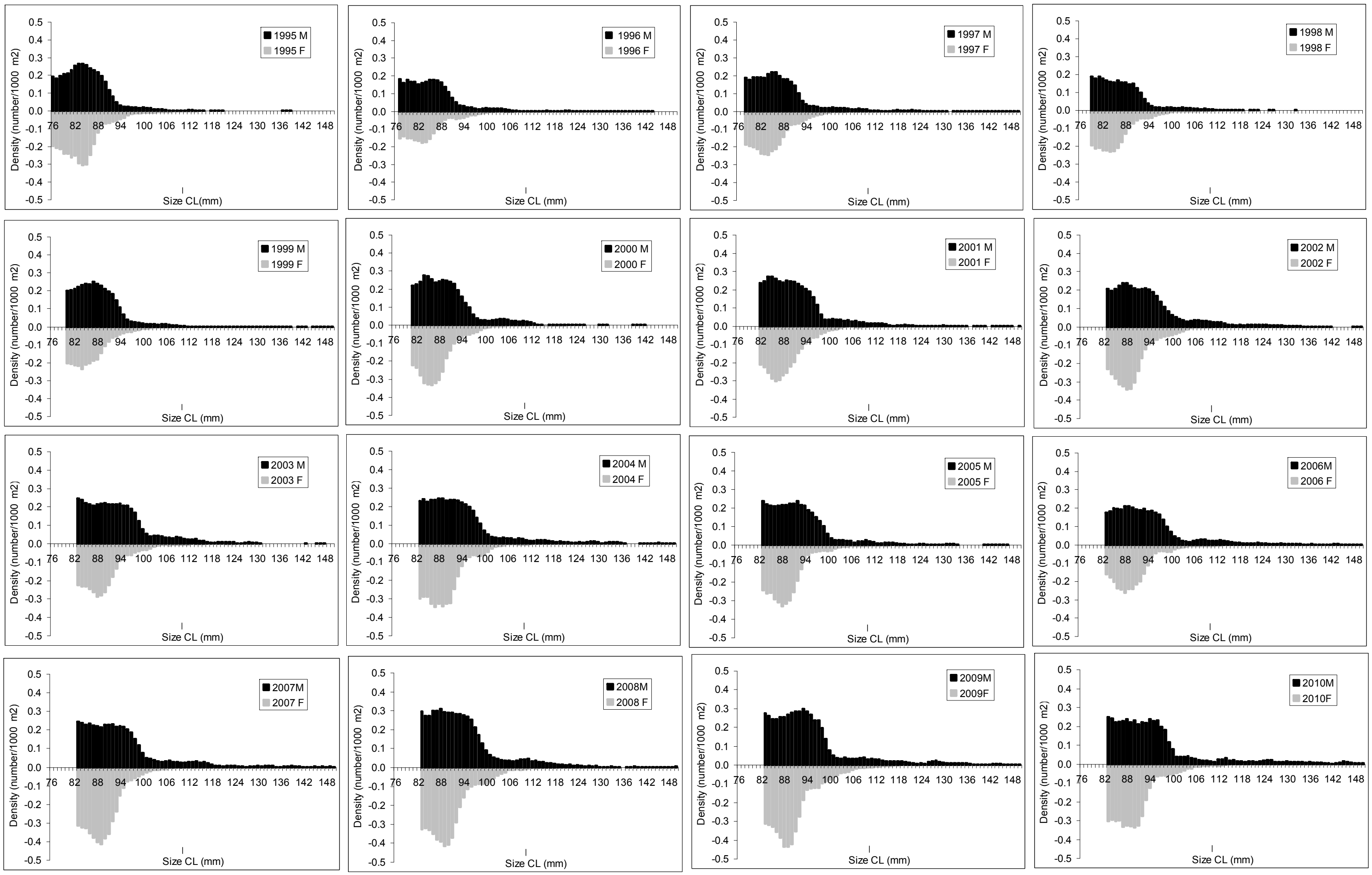


Figure 25. Size frequency distribution of male lobsters (black) and female lobsters (grey) (commercial portion) from 1995 to 2011 for the south side of the Magdalen Islands. Trawl survey data. Frequencies are in number per 1,000 m^2.

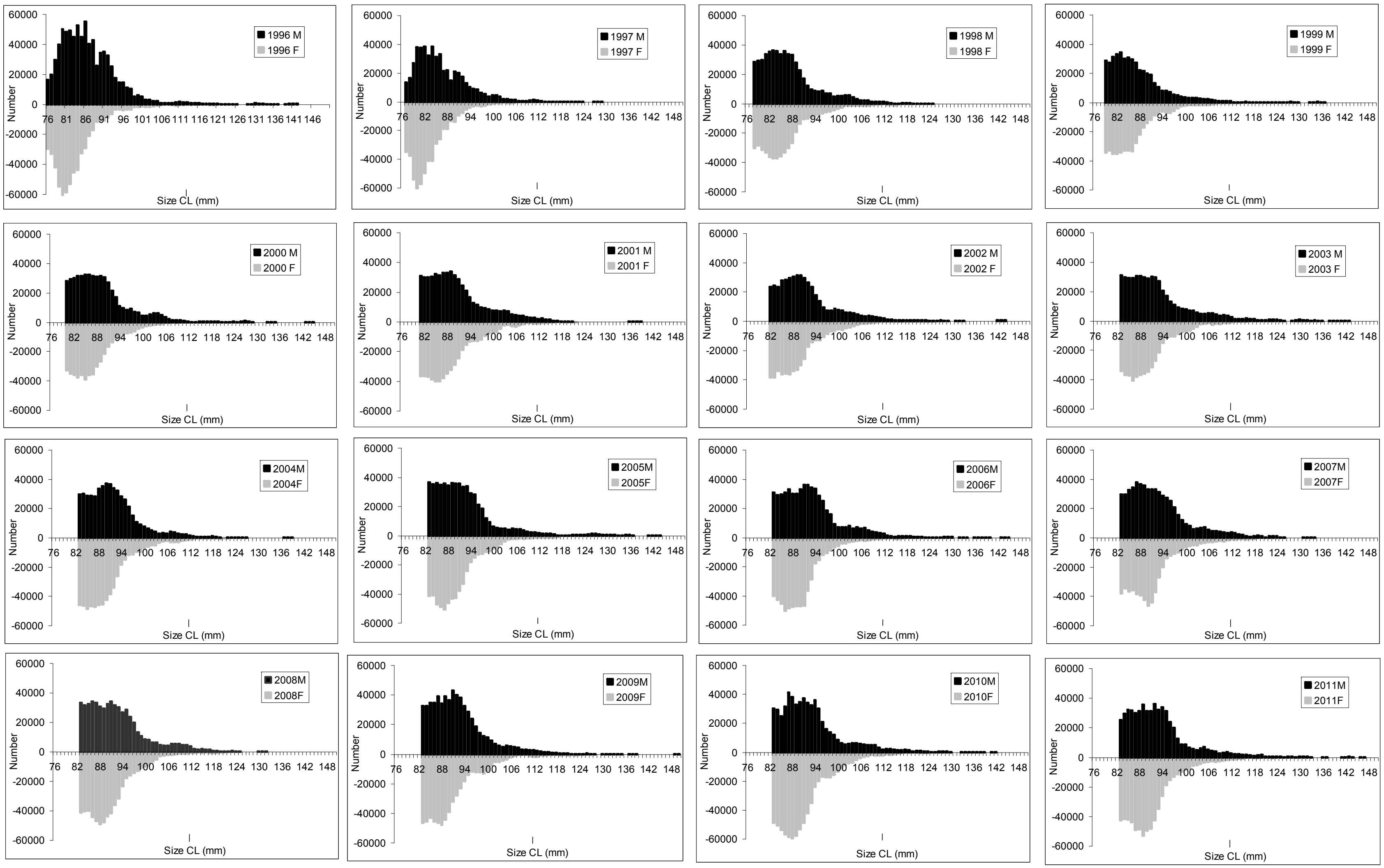


Figure 26. Size frequency distribution of male lobsters (black) and female lobsters (grey) (commercial portion) from 1995 to 2011 for the north side of the Magdalen Islands. Sampling at sea data. The frequencies are weighted by landings.

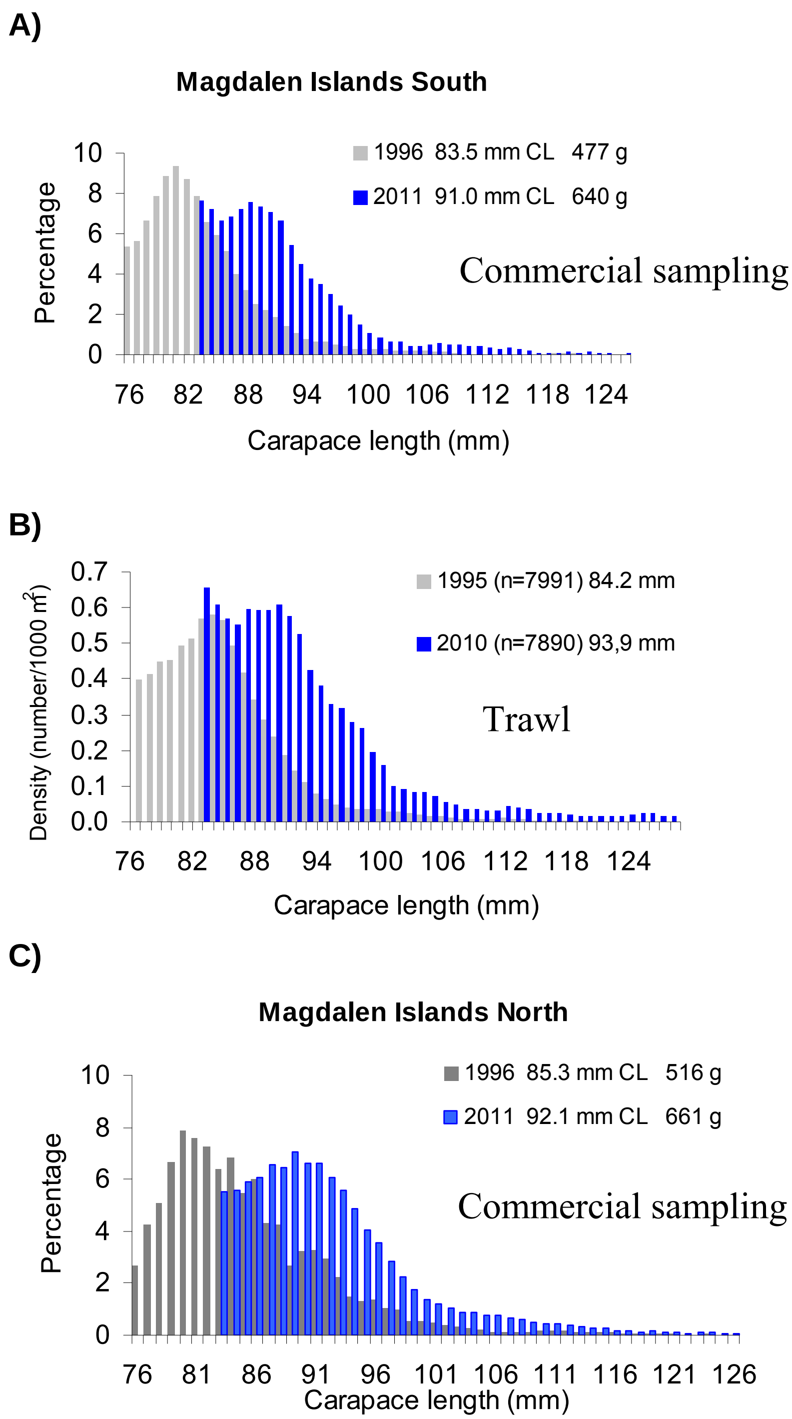


Figure 27. Size frequency distribution of lobster (males and females combined) (commercial portion) in 1996 and 2011 for the south side of the Magdalen Islands, A) based on sampling at sea data, B) in 1995 and 2010 based on trawl survey data and C) in 1996 and 2011 for the north side of the Magdalen Islands based on sampling at sea. Data for A) and C) are relative frequencies (%) and data for B) are densities (number/1,000 m^2).

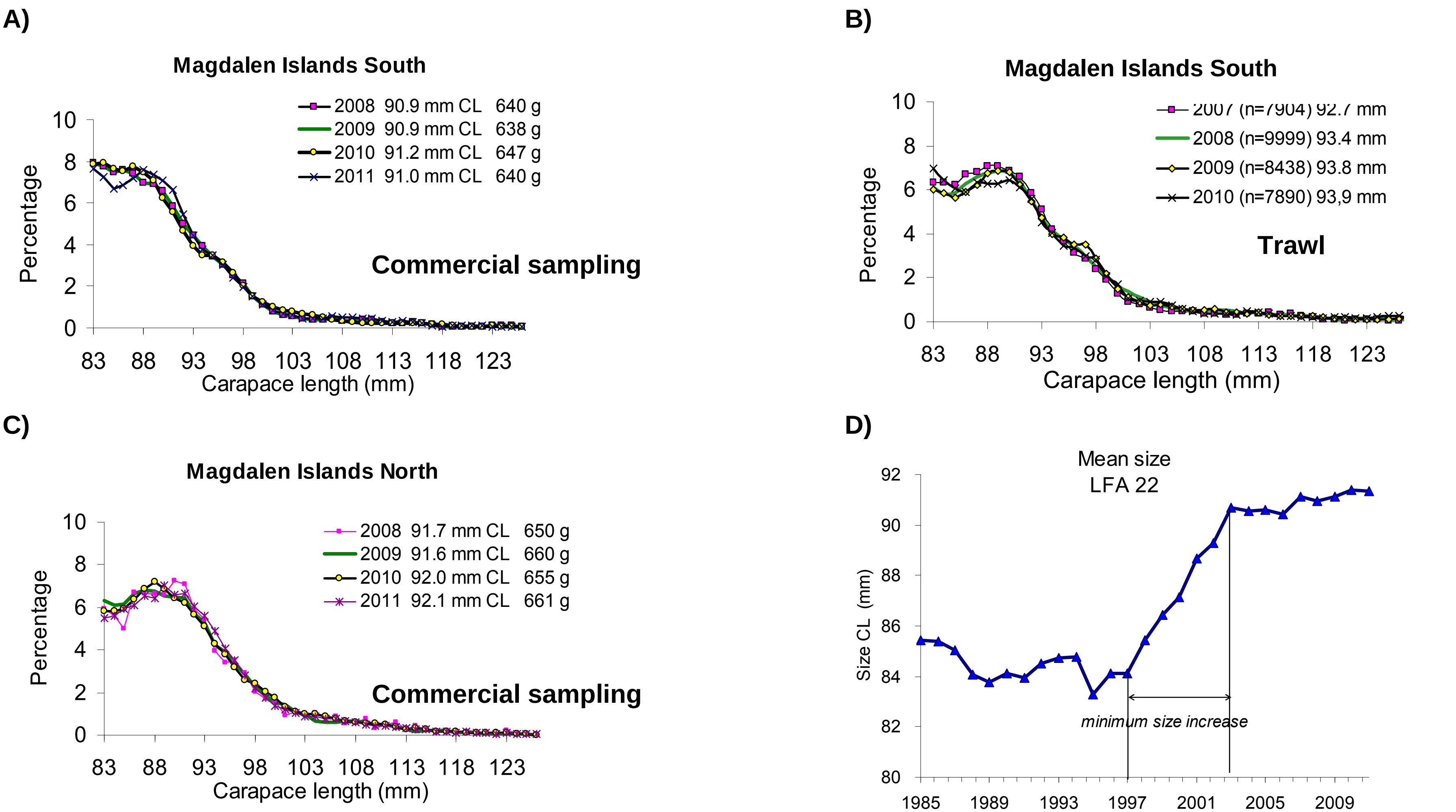
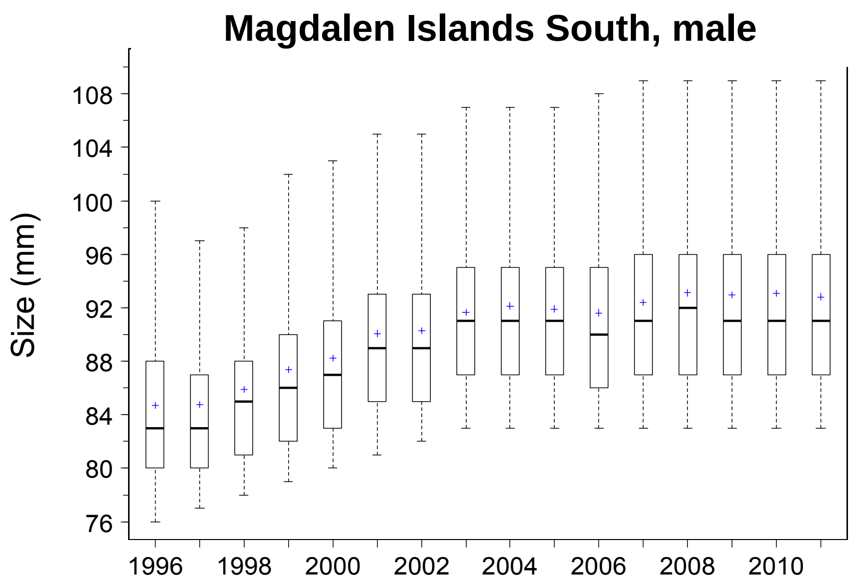


Figure 28. Size frequency distribution of lobster (males and females combined) (commercial portion) south of the Magdalen Islands, A) based on sampling at sea data from 2008 to 2011, B) based on trawl survey data from 2007 to 2010 and C) north of the Magdalen Islands based on sampling at sea from 2008 to 2011. The data are relative frequencies (%). D) Average size of commercial lobster for all the Magdalen Islands (north and south, males and females combined) from 1985 to 2011 based on commercial sampling.



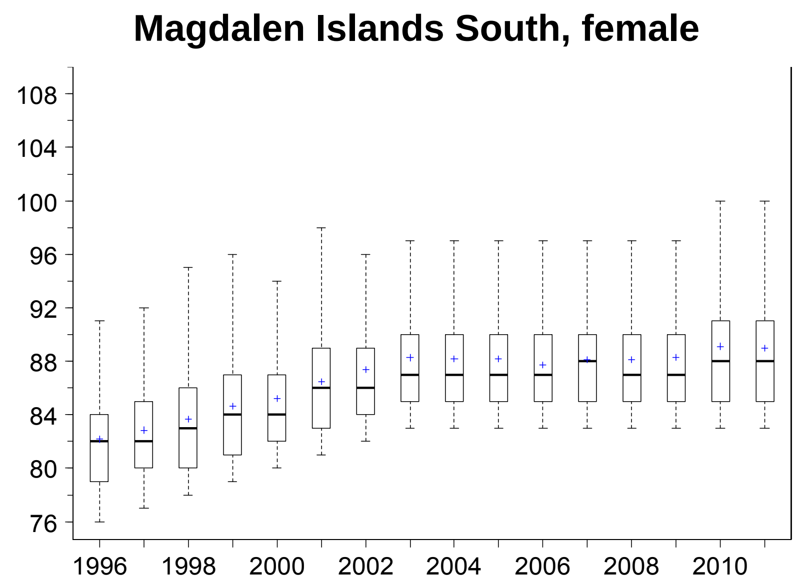


Figure 29. Boxplots of the size of male and female lobsters from commercial sampling conducted on the south side of the Magdalen Islands from 1996 to 2011. The rectangle ranges from the 25th to the 75th percentile and includes the median (horizontal line). The boxplots are up to a maximum of 1.5 times the height of the box provided there are values. The average is indicated by a cross.

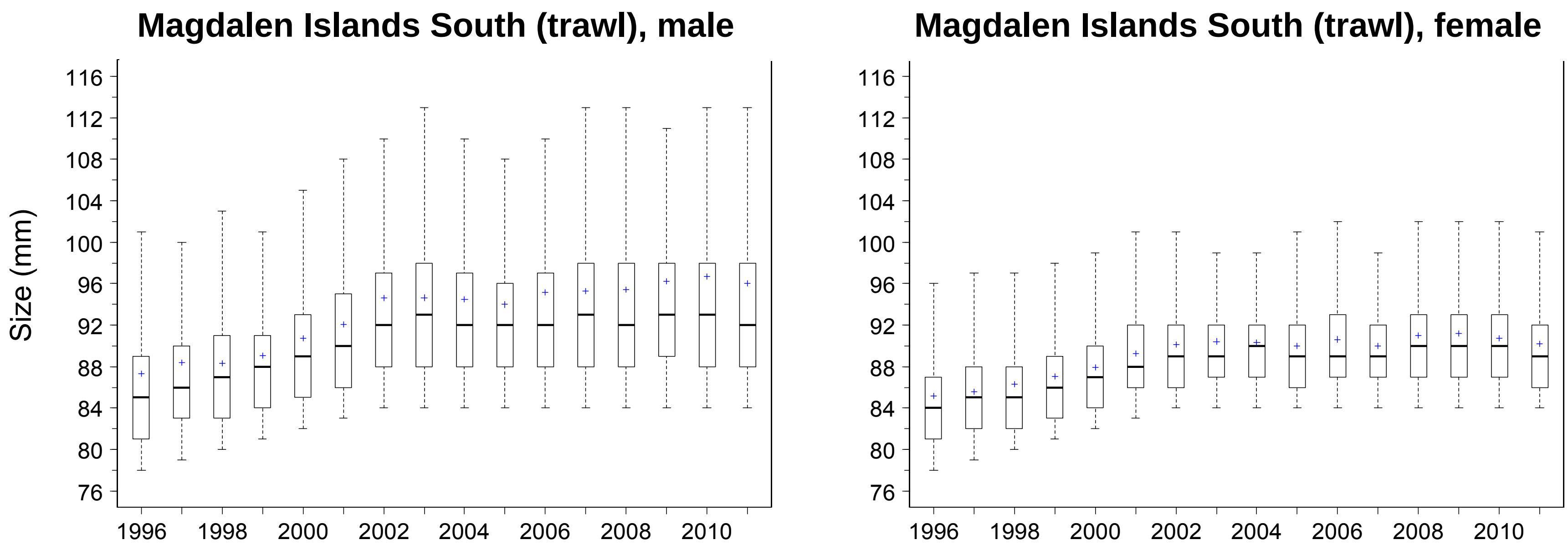


Figure 30. Boxplots of the size of male and female lobsters from the trawl survey conducted on the south side of the Magdalen Islands from 1996 to 2011. The rectangle ranges from the 25th to the 75th percentile and includes the median (horizontal line). The boxplots are up to a maximum 1.5 times the height of the box provided there are values. The average is indicated by a cross.

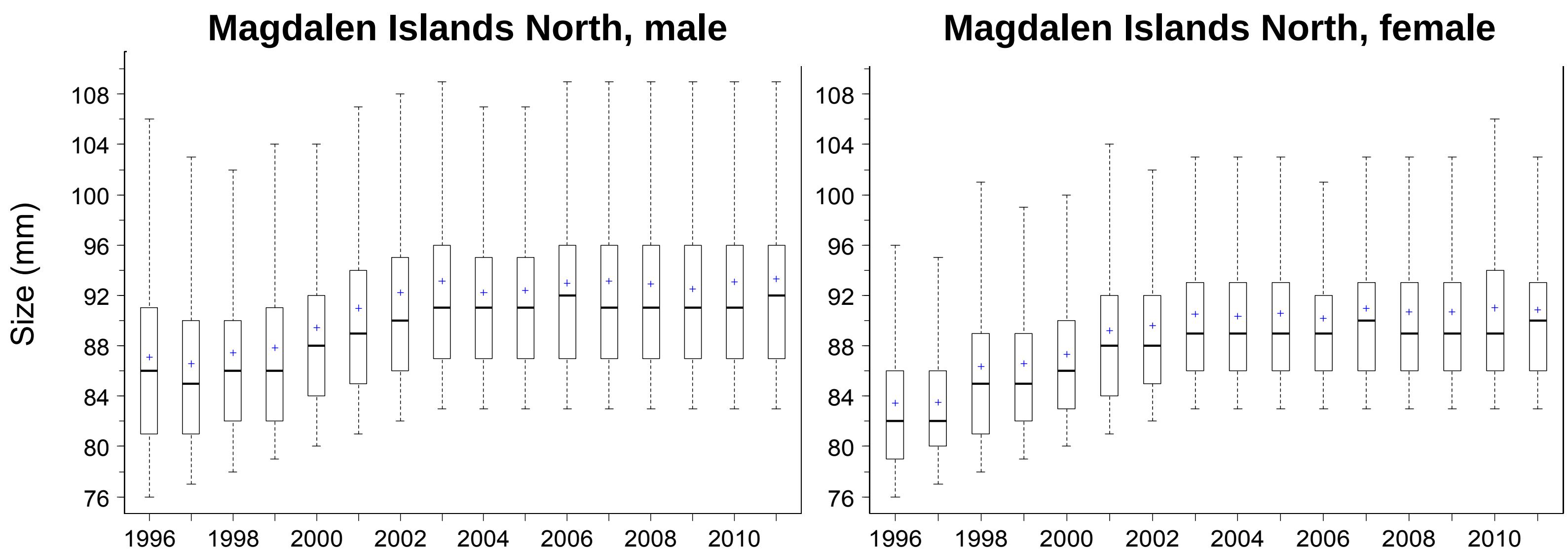


Figure 31. Boxplots of the size of male and female lobsters from commercial sampling conducted on the north side of the Magdalen Islands from 1996 to 2011. The rectangle ranges from the 25th to the 75th percentile and includes the median (horizontal line). The boxplots are up to a maximum 1.5 times the height of the box provided there are values. The average is indicated by a cross.

A)

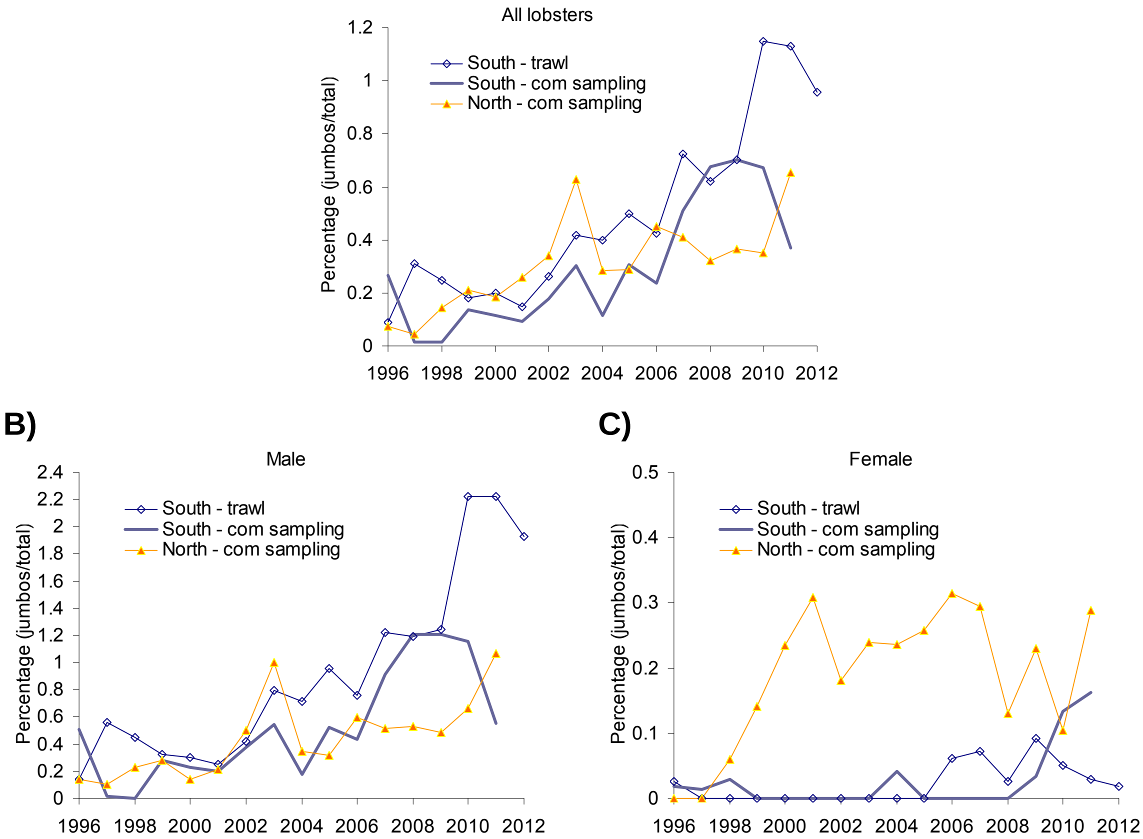


Figure 32. Actual percentage of jumbo lobsters (≥ 127 mm) from sampling at sea and the trawl survey, A) all lobsters, B) males and C) females.

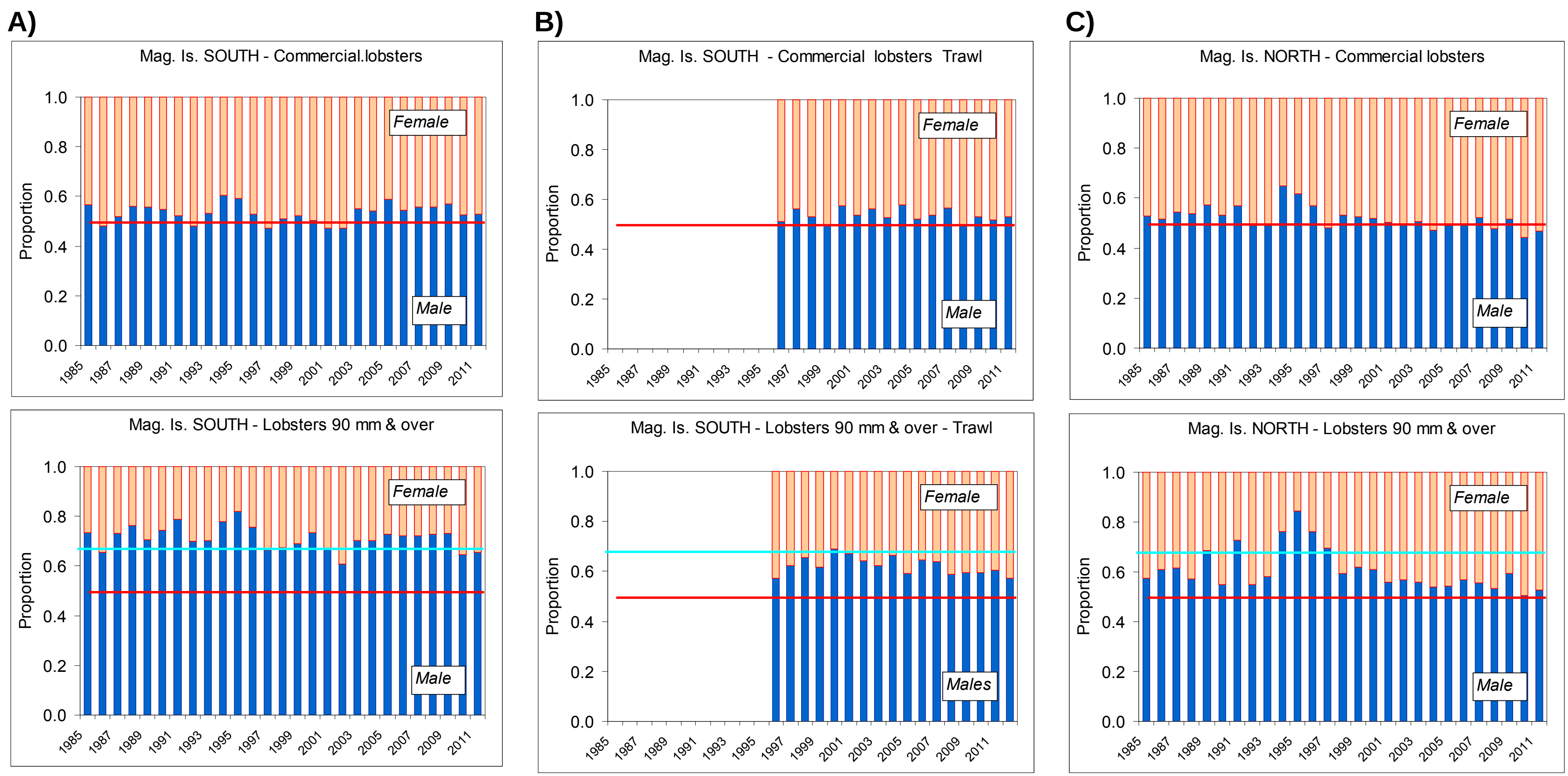


Figure 33. Actual sex ratio (males / non-berried females) south of the Magdalen Islands A) from sampling at sea and B) from the trawl survey and C) north of the Magdalen Islands from sampling at sea. The red line indicates a 1:1 M:F ratio and the turquoise line a 2:1 ratio

A)

B)

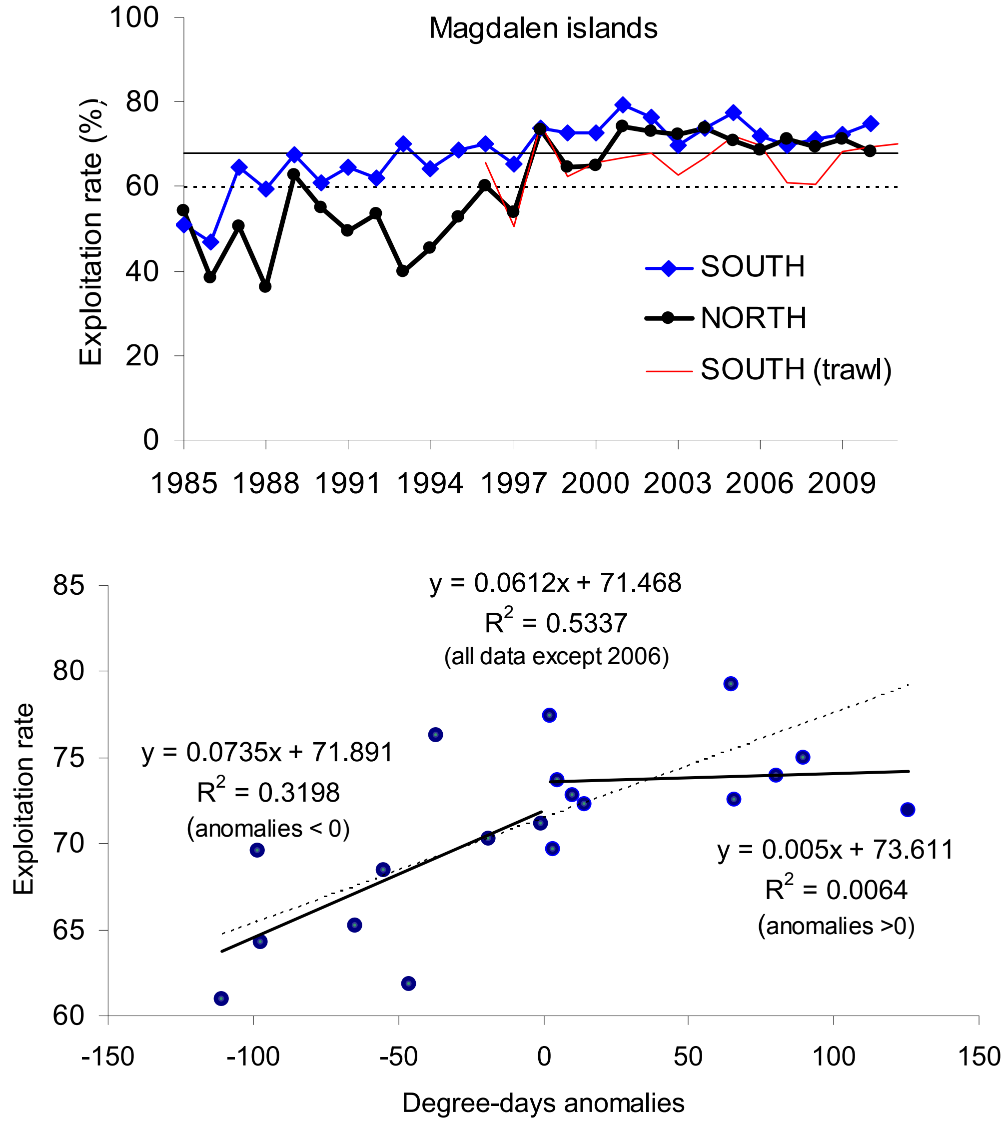
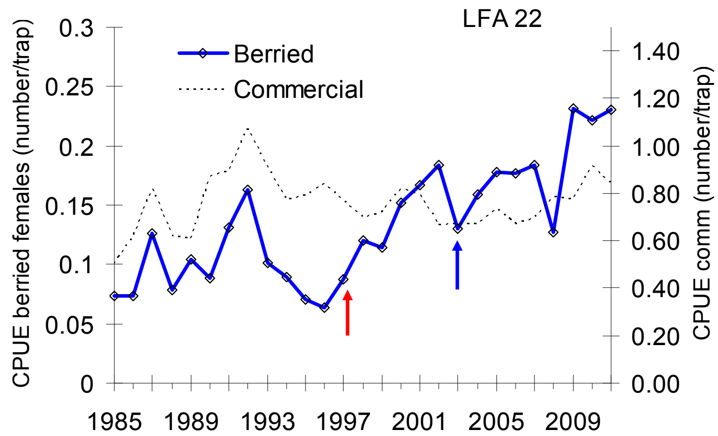
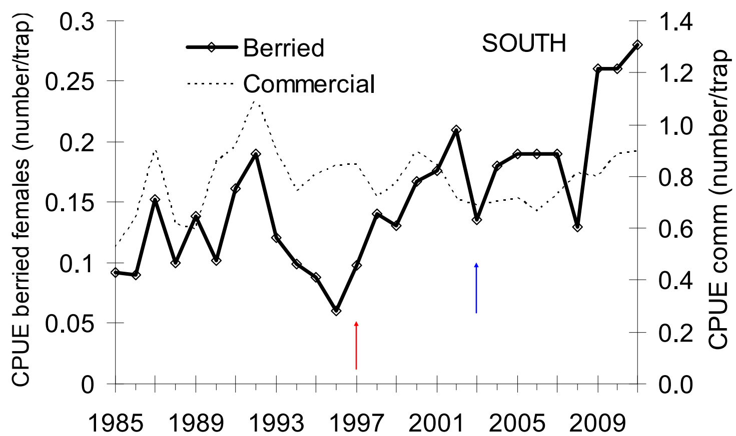


Figure 34. A) Exploitation rate calculated for the exploitable portion (≥ MCS) of the male population using commercial sampling data for the areas north and south of the Magdalen Islands from 1985 to 2010 and south trawl survey data from 1996 to 2011. The solid line represents the series average (1985 to 2009) for the south and the dotted line the series average for the north. B) Relationship between the exploitation rate in the south (commercial sampling data) and temperature (degree-day anomalies: degree-days in a year – average degree-days from 1985 to 2010). Regressions for all data (except 2006) and for years with degree-day anomalies greater and less than zero.

A)



B)



C)

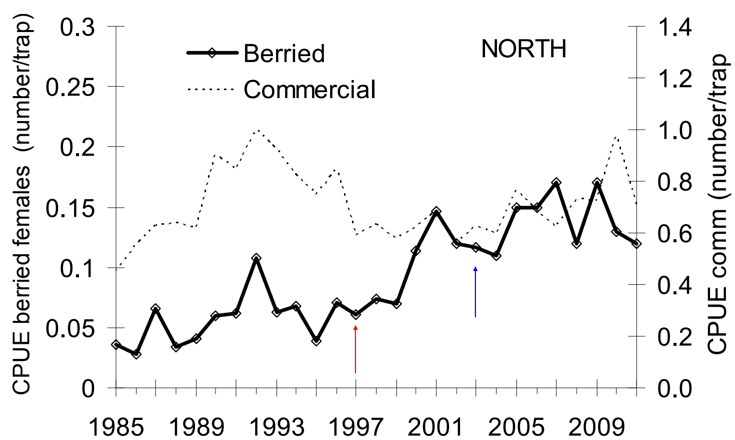
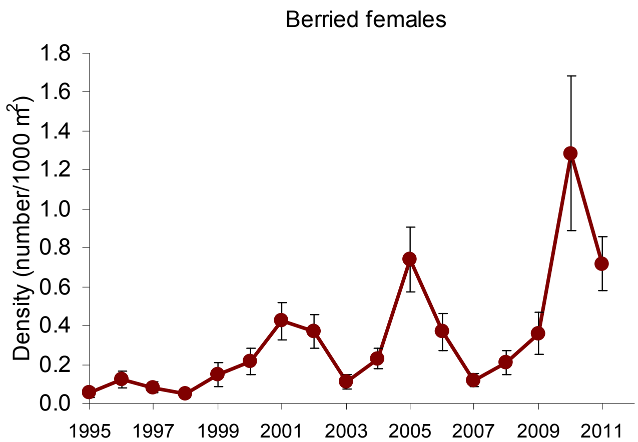
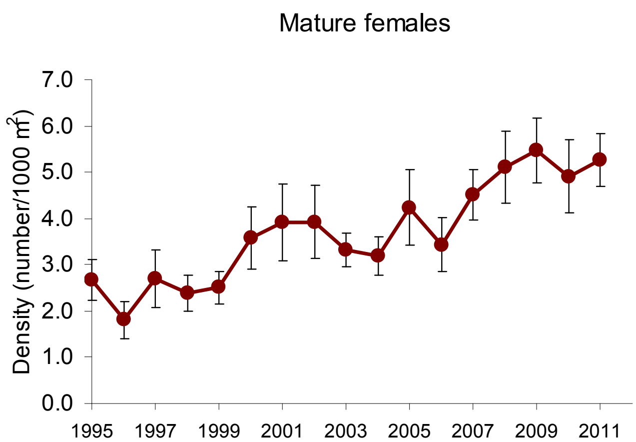


Figure 35. Catch rates (CPUE) of berried females for A) all, B) south and C) north of Magdalen Islands from 1985 to 2011. The first arrow indicates the start of the increases in MCS and the second arrow indicates the year when the height of the escape vents was increased from 43 mm to 47 mm. The dotted line indicates CPUEs of commercial size lobsters during the same period.

A)



B)



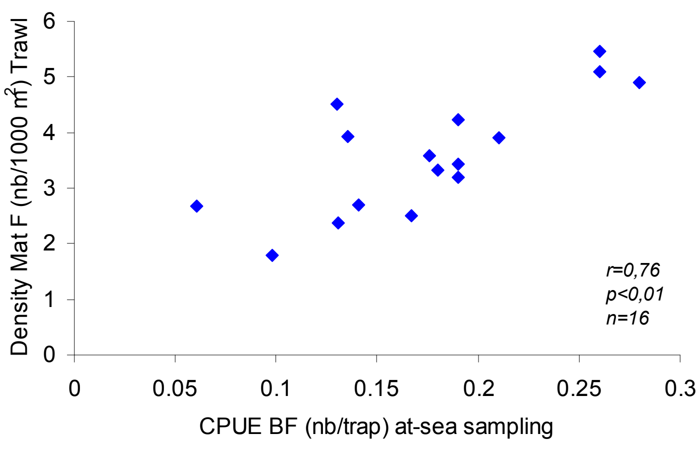


Figure 36. Densities of A) berried females and B) mature females (≥ 79 mm) per 1,000 m^2 (average ± 95% CI) observed during the trawl survey conducted in September on the south side of Magdalen Islands from 1995 to 2011 and C) correlation between the density of mature females observed at time t during the trawl survey and berried female CPUE from commercial sampling in the south at time t +1.

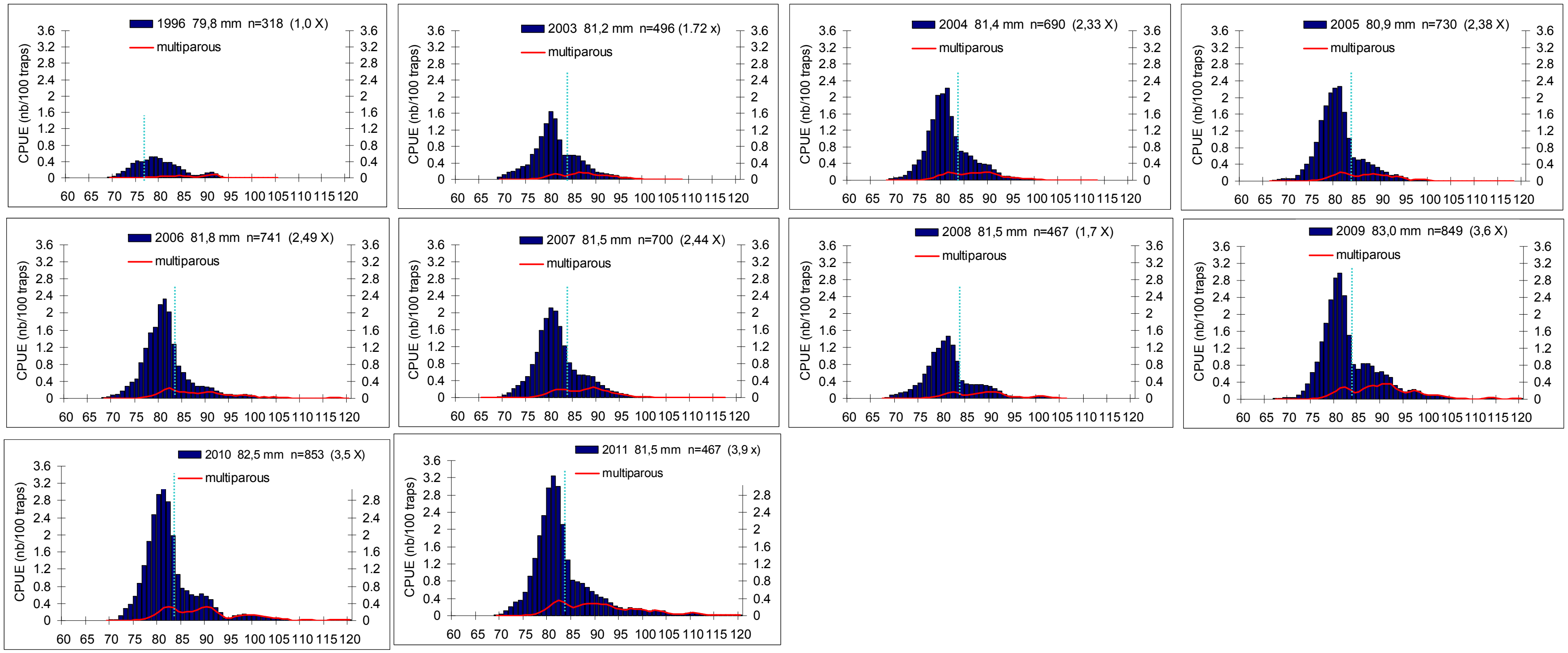


Figure 37. Size frequency distribution of berried females on the south side of the Magdalen Islands in 1996 and from 2003 to 2011. The red line represents multiparous females. The distributions are weighted by abundance indices (annual CPUE). The average size and total number of berried females and the increase in egg production compared to the 1994-1996 mean are indicated. The vertical dotted line indicates the MCS.

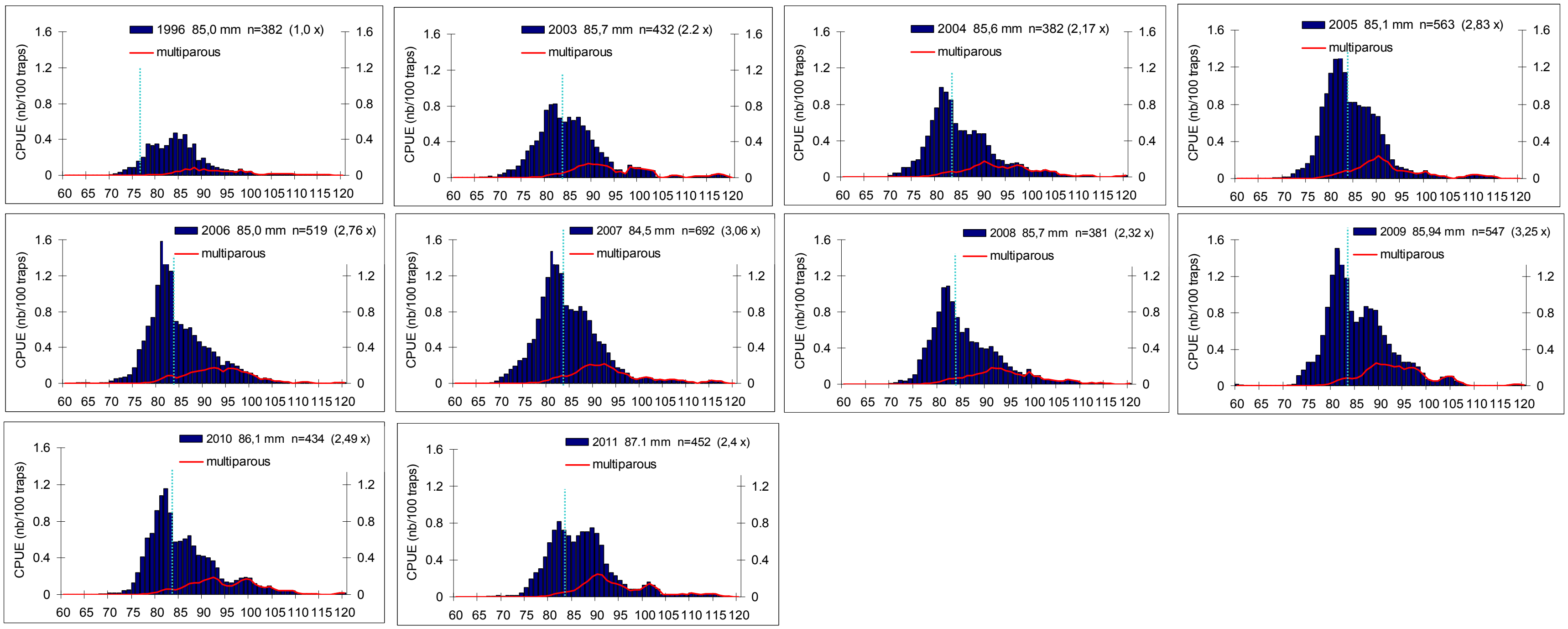


Figure 38. Size frequency distribution of berried females on the north side of the Magdalen Islands in 1996 and from 2003 to 2011. The red line represents multiparous females. The distributions are weighted by abundance indices (annual CPUE). The average size and total number of berried females and the increase in egg production compared to the 1994-1996 mean are indicated. The vertical dotted line indicates the MCS.

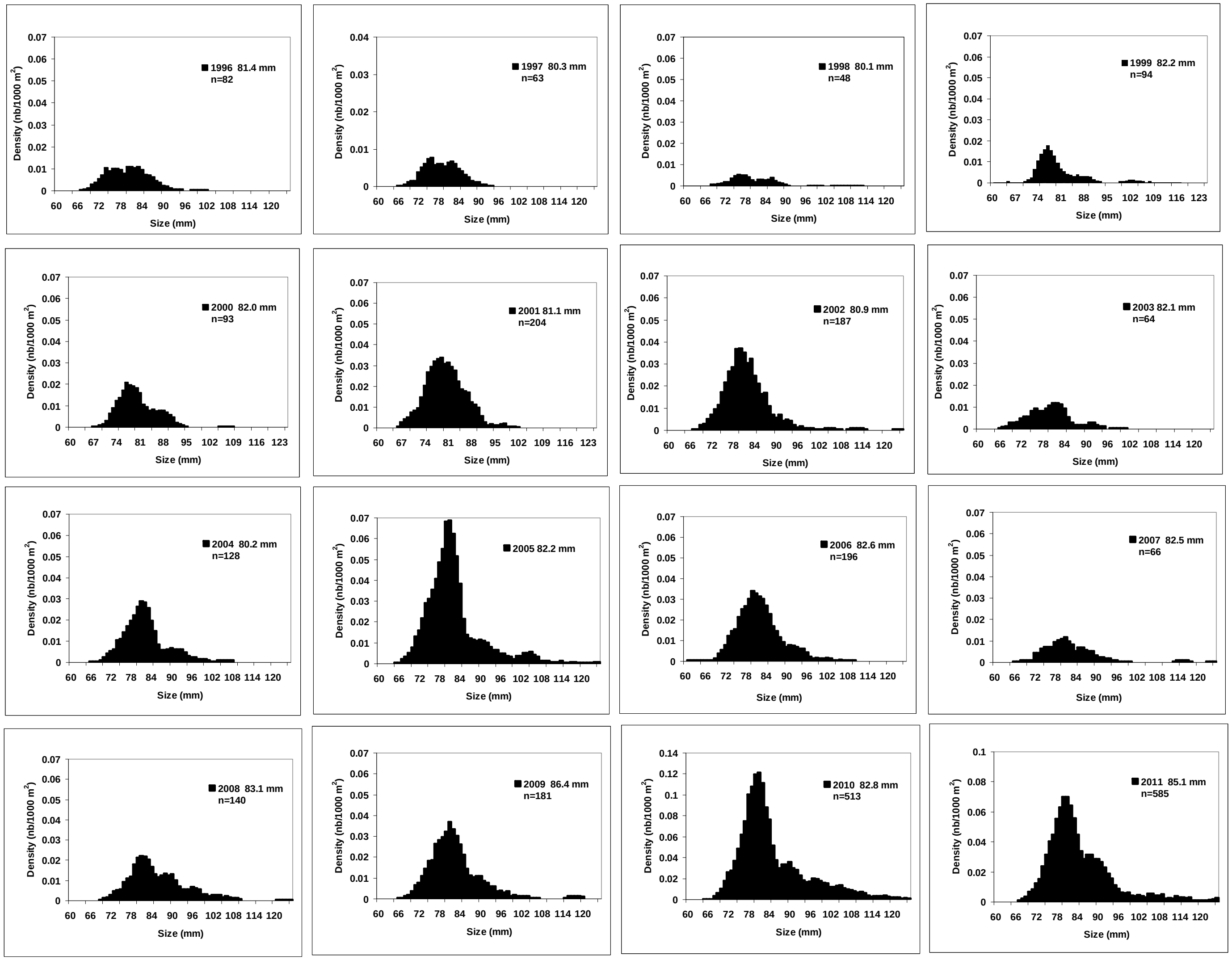
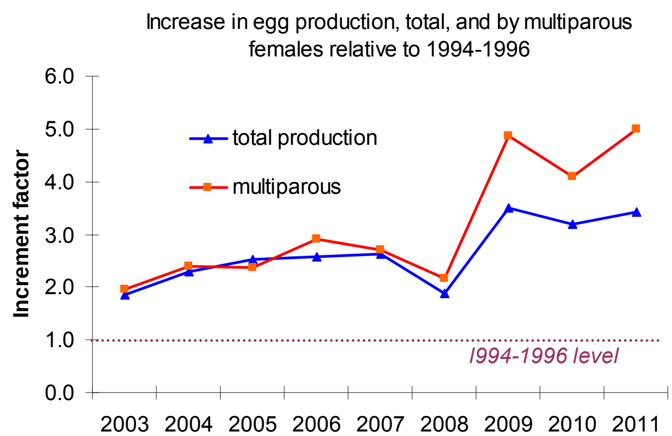


Figure 39. Size frequency distribution (in number/1,000 m^2) of berried females on the south side of the Magdalen Islands from 1996 to 2011 from trawl survey data. The average size and total number of berried females measured are indicated.

A)



B)

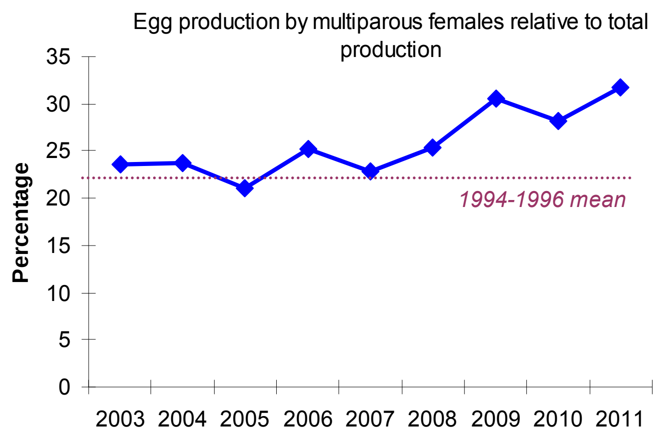


Figure 40. A) Increase in egg production, total and by multiparous females in LFA 22 from 2003 to 2011 versus average production from 1994 to 1996, before the MCS was increased. B) Contribution (percentage) of multiparous females to total egg production for all of the Magdalen Islands from 2003 to 2011 and from 1994 to 1996.

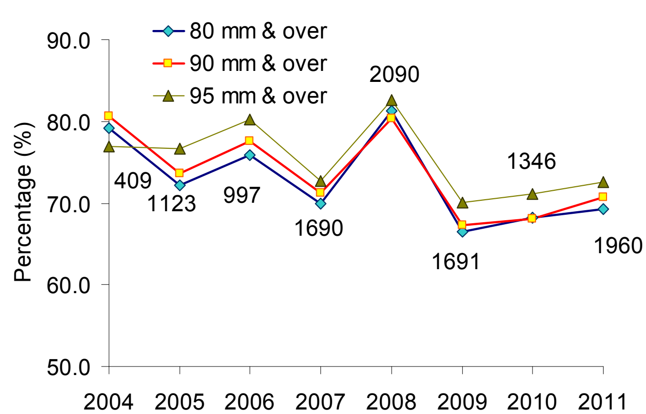


Figure 41. Percentage of females in recent postmolt with sperm plugs. Trawl survey data. The number of females observed every year is indicated.

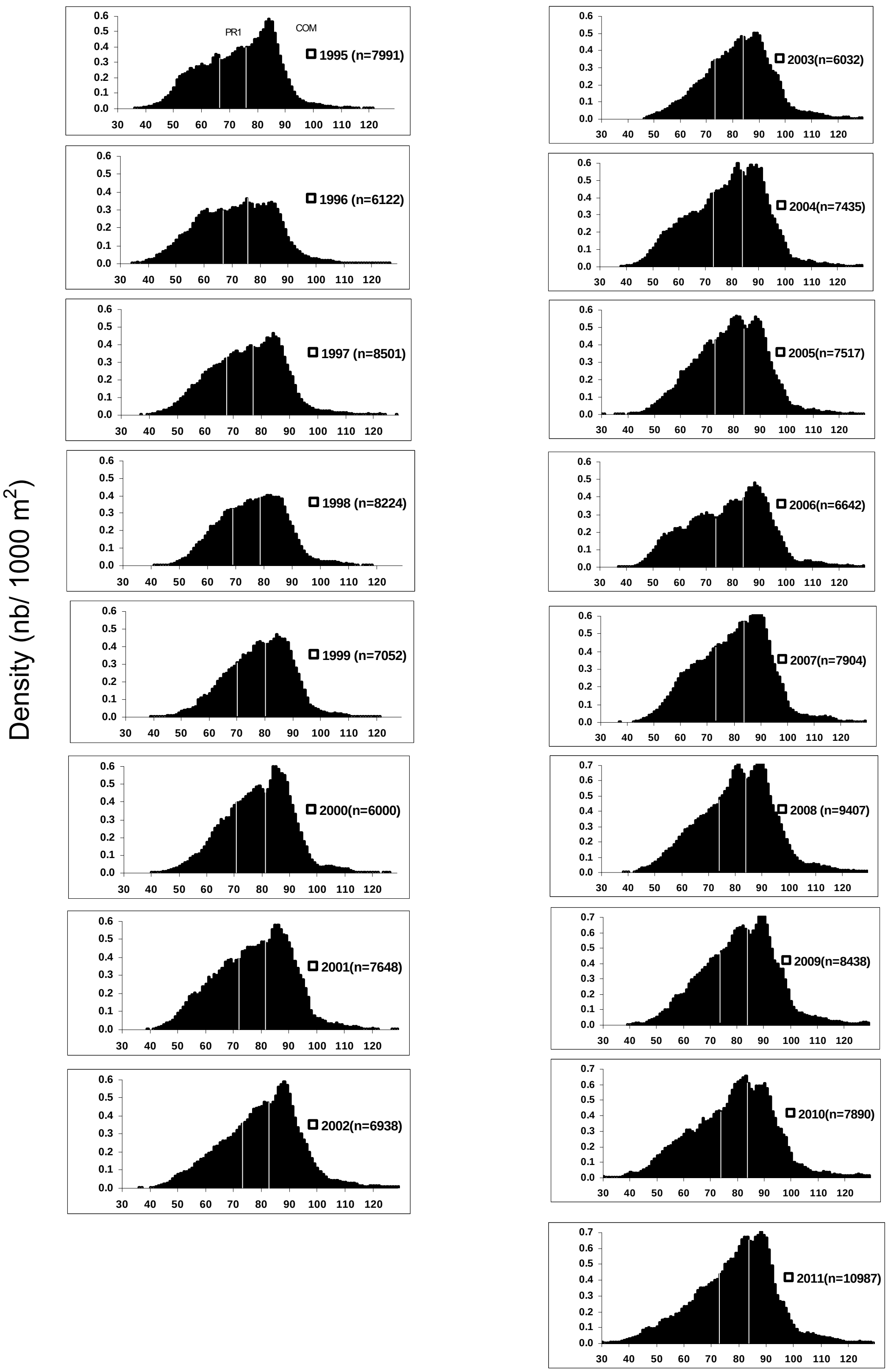
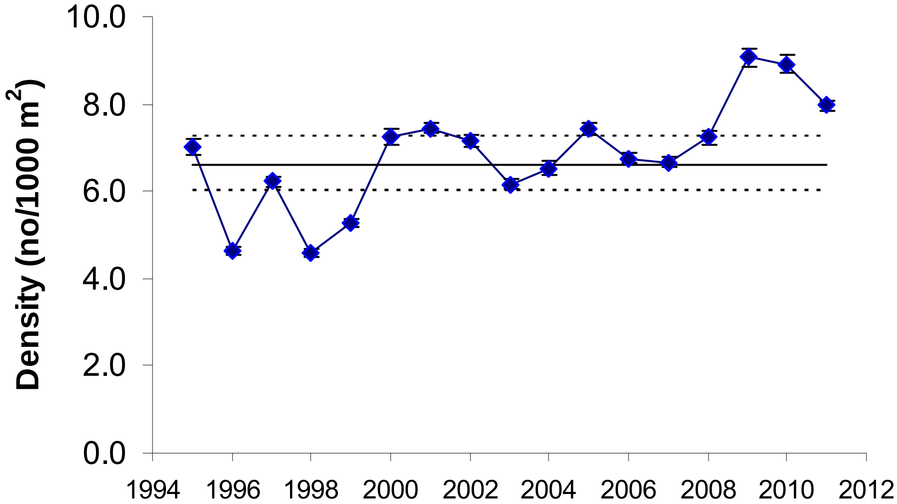


Figure 42. Size frequency distribution of lobsters caught during the trawl survey south of the Magdalen Islands from 1996 to 2011. Frequencies are in number/1,000 m^2. The number of lobsters measured is indicated. Limits for the commercial portion (COM) and prerecruits one molt below commercial size (PR1) are indicated (see Table 12).

A)



B)

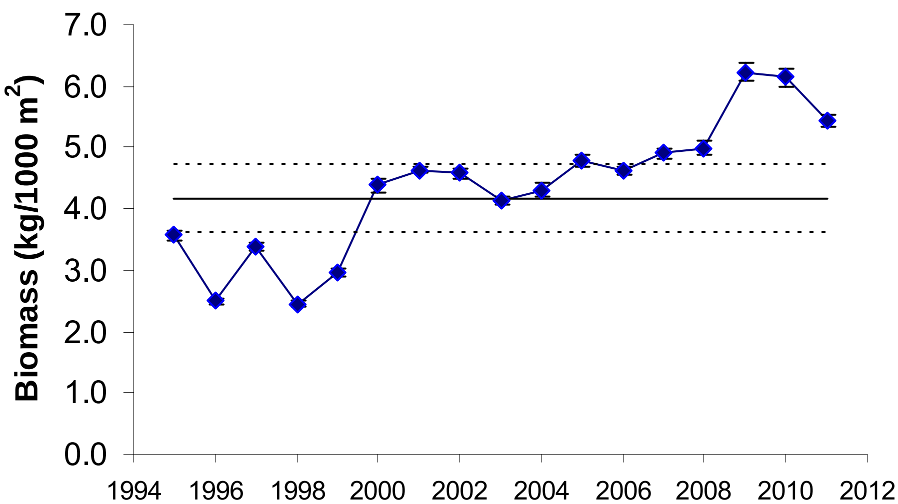
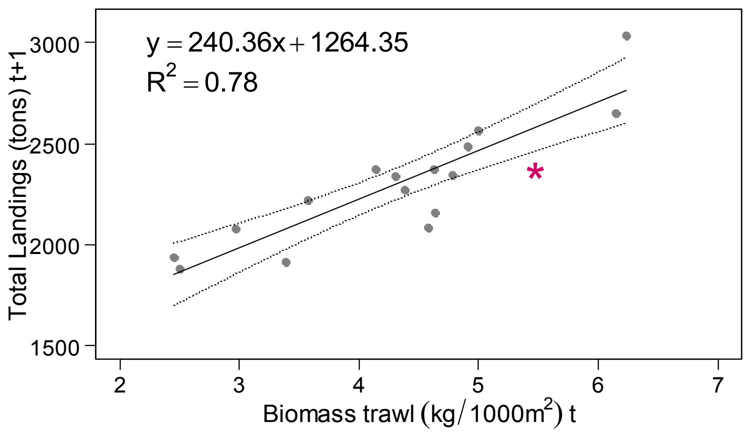
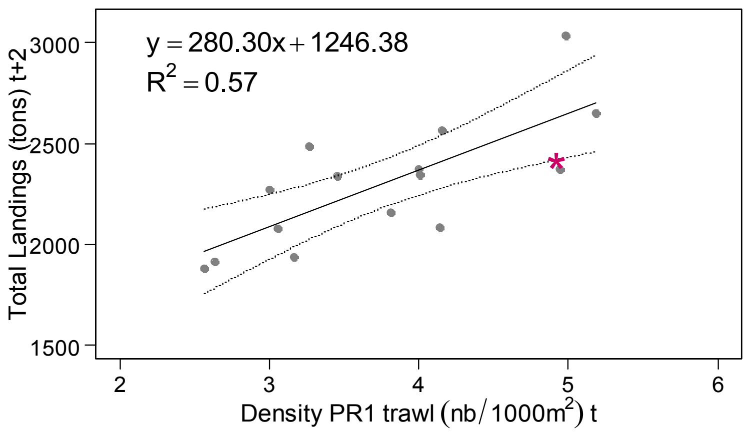


Figure 43. A) Density and B) biomass (kg) of commercial size lobster per 1,000 m^2 (average ± 95% CI) observed during the trawl survey conducted south of the Magdalen Islands from 1995 to 2011. 1995 to 2010 average (solid line) ± 0.5 standard deviation (dotted lines). Annual means calculated using geostatistics.

A)



B)



C)

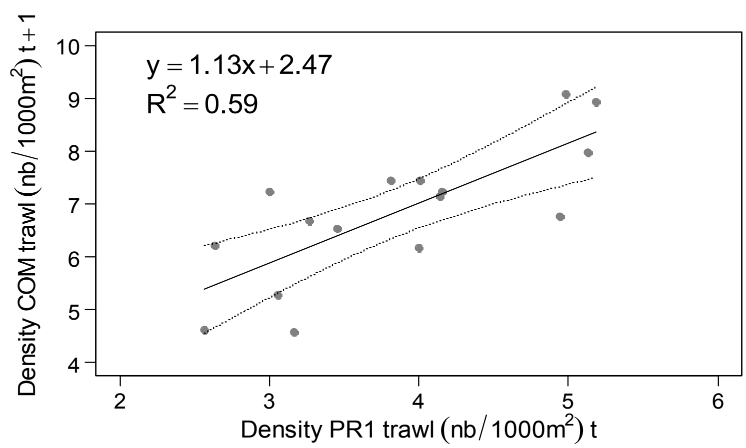


Figure 44. Relationship between A) the biomass of commercial lobster and B) the density of PR1s and lobster landings in the Magdalen Islands, one and two years later respectively. C) Relationship between the density of PR1s and the commercial lobsters the following year. The dotted lines indicate the confidence interval ± 95%. For A and B, the red stars indicate the actual values from the 2011 survey.

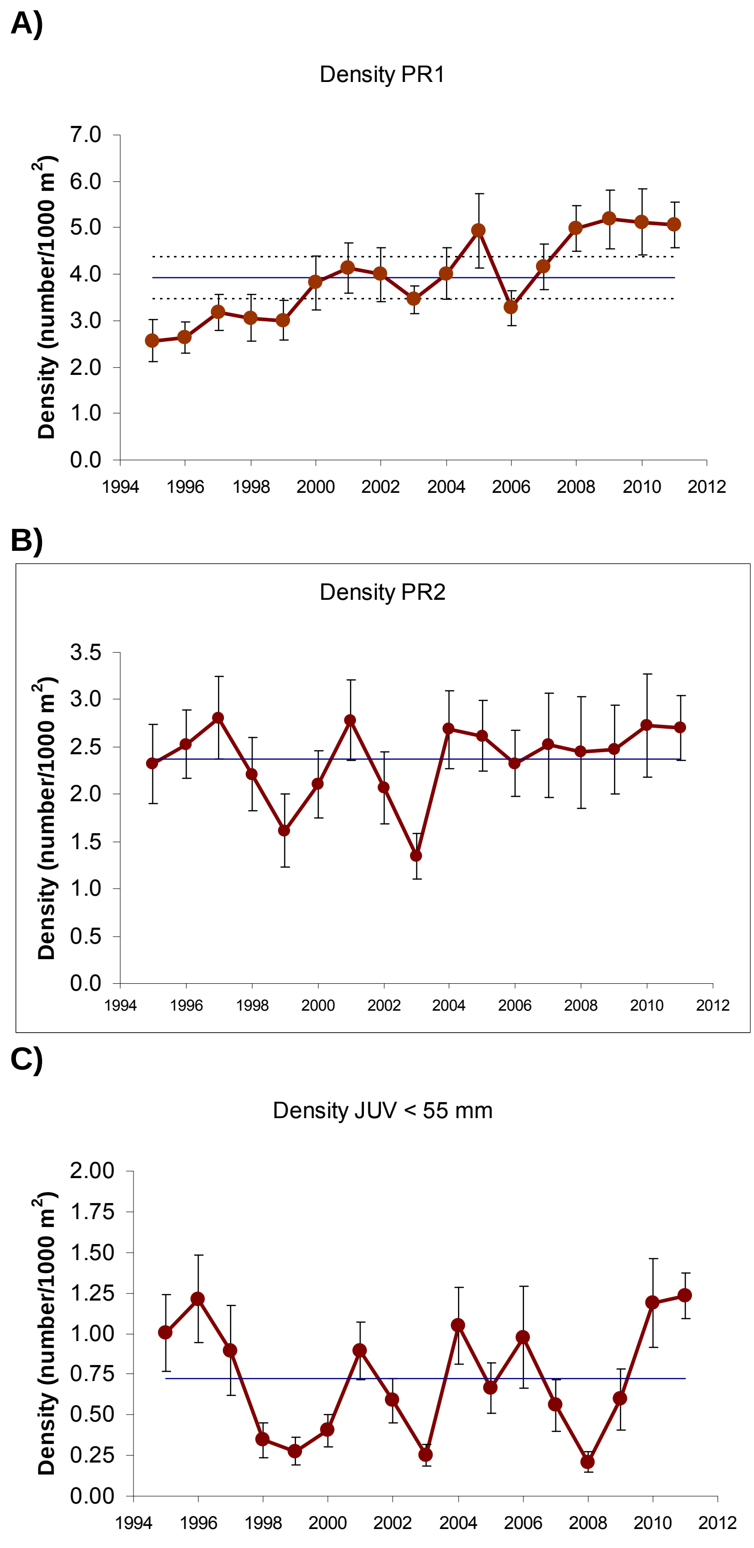


Figure 45. Densities of A) PR1 lobsters, B) PR2 lobsters and C) juvenile lobsters per 1,000 m^2 (average ± 95% CI) observed during the trawl survey conducted south of the Magdalen Islands from 1995 to 2011. 1995 to 2010 average (solid line) ± 0.5 standard deviation (dotted lines). Size class details are presented in Table 12.

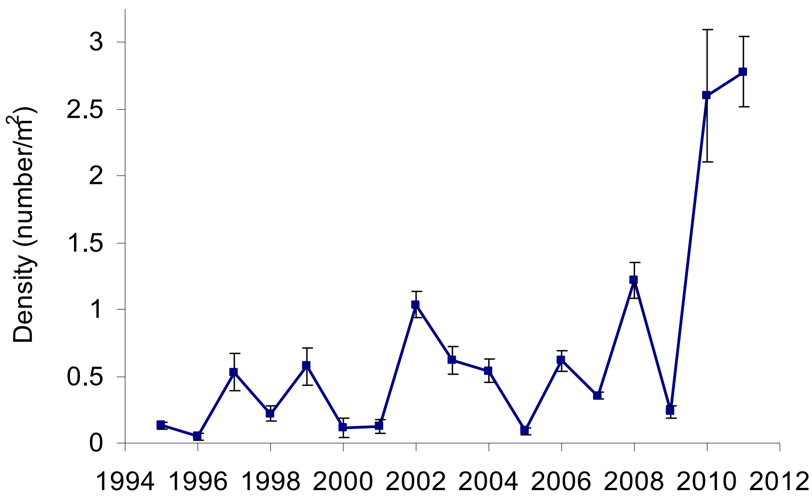


Figure 46. Cohort strength (number/m^2) observed in the Demoiselles area from 1995 to 2011. Cohort strength is determined one year after their settlement (age 1+), except for 2011 (age 0+).

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
COM ABUNDANCE																											
Landings	-2.1	-1.8	-1.0	-1.2	0.4	0.4	1.1	1.6	1.0	-0.6	-0.3	0.0	-1.0	-0.9	-0.8	-0.4	0.1	-0.2	-0.4	0.4	0.3	0.3	0.4	0.7	0.9	2.2	1.1
CPUE number	-2.2	-1.2	0.5	-1.2	-1.3	0.9	1.1	2.6	1.2	0.1	0.2	0.7	0.1	-0.6	-0.3	0.5	0.3	-0.8	-0.8	-0.8	-0.2	-0.8	-0.6	0.2	0.1	1.3	0.7
CPUE weight	-2.1	-1.3	0.0	-1.5	-1.6	0.0	0.1	1.5	0.5	-0.4	-0.5	-0.1	-0.6	-0.8	-0.5	0.3	0.0	-0.3	0.2	0.1	0.7	0.2	0.4	0.1	1.2	2.4	1.7
Density -Trawl												0.2	-1.7	-0.4	-1.7	-1.2	0.4	0.5	0.3	-0.5	-0.2	0.5	0.0	-0.1	0.4	1.8	1.7
Biomass -Trawl												-0.6	-1.6	-0.8	-1.7	-1.2	0.1	0.3	0.3	-0.1	0.0	0.4	0.3	0.6	0.6	1.8	1.7
DEMOGRAPHY																											
Mean size	-0.6	-0.6	-0.7	-1.0	-1.1	-1.0	-1.0	-0.9	-0.8	-0.8	-1.3	-1.0	-1.0	-0.6	-0.2	0.0	0.5	0.7	1.2	1.1	1.1	1.1	1.3	1.3	1.3	1.4	1.4
Mean size (>2002)																			-0.6	-1.0	-0.9	-1.3	0.6	0.1	0.5	1.4	1.2
Sex-ratio	0.6	-1.0	-0.2	0.6	0.9	0.3	0.2	-1.2	-0.4	2.9	2.2	0.3	-1.4	-0.5	-0.3	-0.6	-1.3	-1.3	0.2	-0.3	0.9	-0.1	0.4	0.1	0.6	-0.8	-0.5
FISHING PRESSURE																											
Expl rate	2.3	2.8	0.4	1.1	0.1	0.9	0.5	0.8	-0.3	0.5	-0.1	-0.3	0.4	-0.8	-0.6	-0.6	-1.5	-1.1	-0.2	-0.7	-1.2	-0.5	-0.2	-0.4	-0.5	-0.9	
PRODUCTIVITY REPRODUCTION																											
Berried Females	-1.2	-1.2	-0.2	-1.1	-0.6	-0.9	-0.1	0.6	-0.7	-0.9	-1.3	-1.4	-0.9	-0.3	-0.4	0.3	0.6	1.0	-0.1	0.5	0.9	0.8	1.0	-0.1	1.9	1.7	1.9
Mature F -Trawl												-0.9	-1.7	-0.9	-1.2	-1.0	0.0	0.3	0.3	-0.3	-0.4	0.6	-0.2	0.9	1.4	1.8	1.2
PRODUCTIVITY RECRUITMENT																											
PR1 density -Trawl												-1.5	-1.4	-0.8	-0.9	-1.0	0.0	0.3	0.2	-0.4	0.2	1.3	-0.7	0.4	1.3	1.5	1.5
JUV density -SCUBA											-0.7	-0.8	-0.2	-0.6	-0.1	-0.7	-0.7	0.4	-0.1	-0.2	-0.7	-0.1	-0.4	0.6	-0.6	2.3	2.5

Figure 47. Table summarizing the trend of stock status indicators for the periods covered by the data sources (sampling at sea from 1985 to 2011 and trawl survey from 1995 to 2011). The sampling at sea data are for all the islands and trawl data are for the southern area. The commercial abundance data from the trawl survey in a given year are associated to other data (landings and sampling data) from the year following the survey for comparison purposes. Red = positive trend and blue = negative trend (see text, Section 3.1.8). For comparison purposes, the inverse of fishing pressure (survival) is shown here.

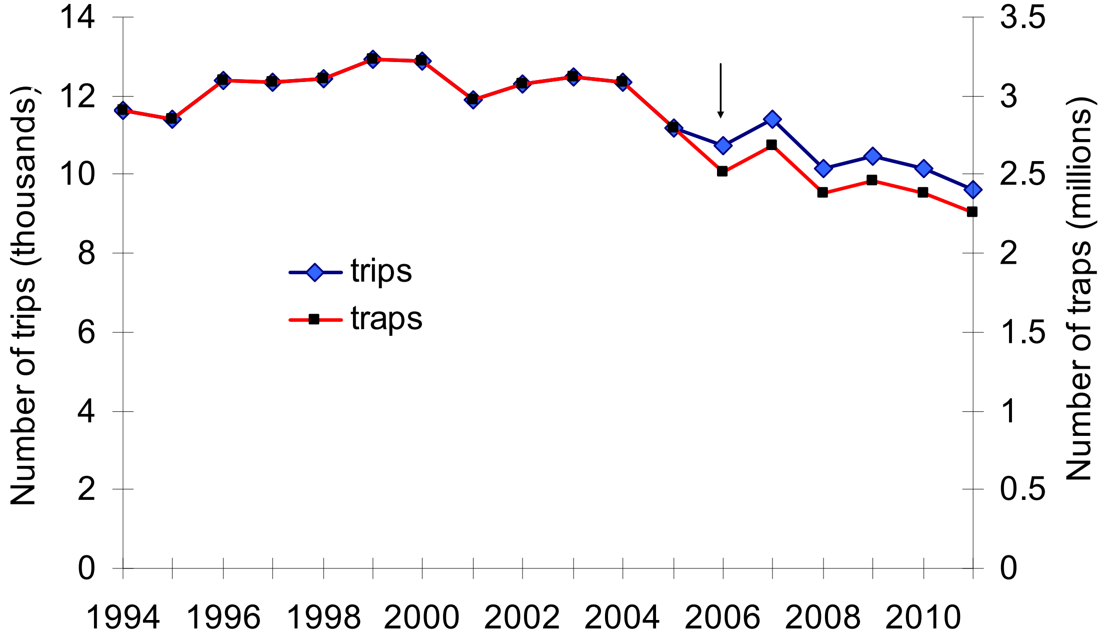
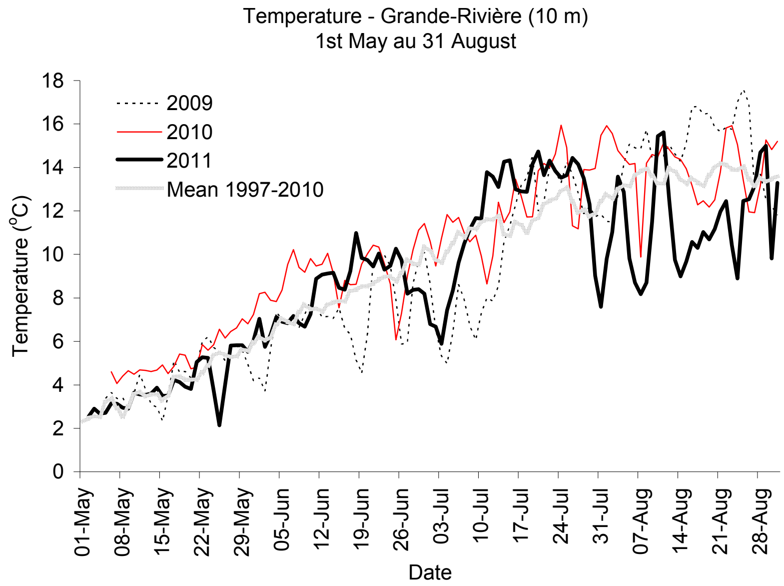
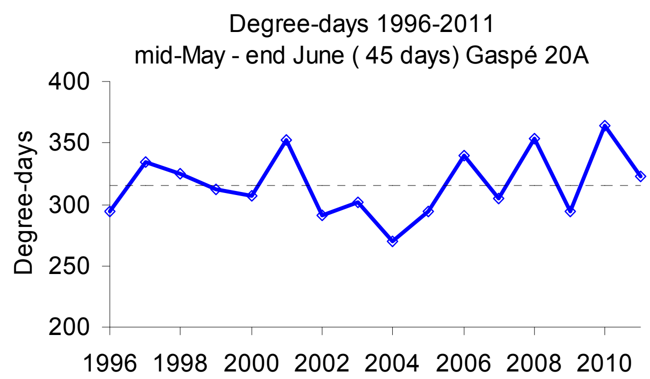


Figure 48. Number of fishing trips and trap hauls in the Gaspé from 1994 to 2011. The arrow indicates the time (2006) where the number of traps per licence decreased from 250 to 235 in LFAs 20 and 21.

A)



B)



C)

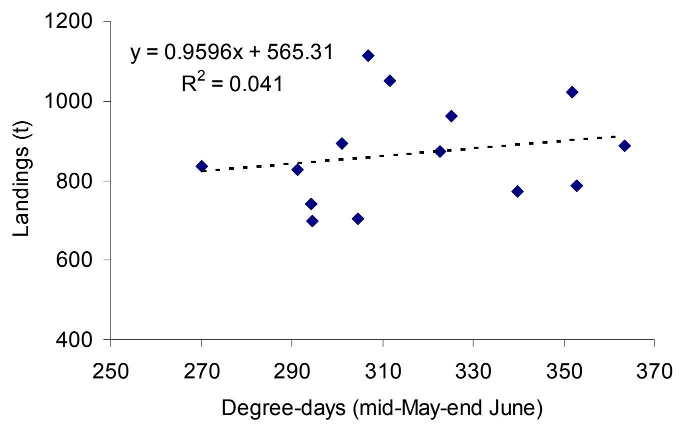


Figure 49. A) Temperature recorded in Grande-Rivière at a 10 m depth from May 1 to August 30, 2009, 2010 and 2011 and on average from 1997 to 2010. B) Number of cumulative degree-days from May 17 to June 30 for 1996 to 2011 (doted line: 1996-2010 mean). C) Linear regression between landings and the number of degree-days from 1996 to 2011.

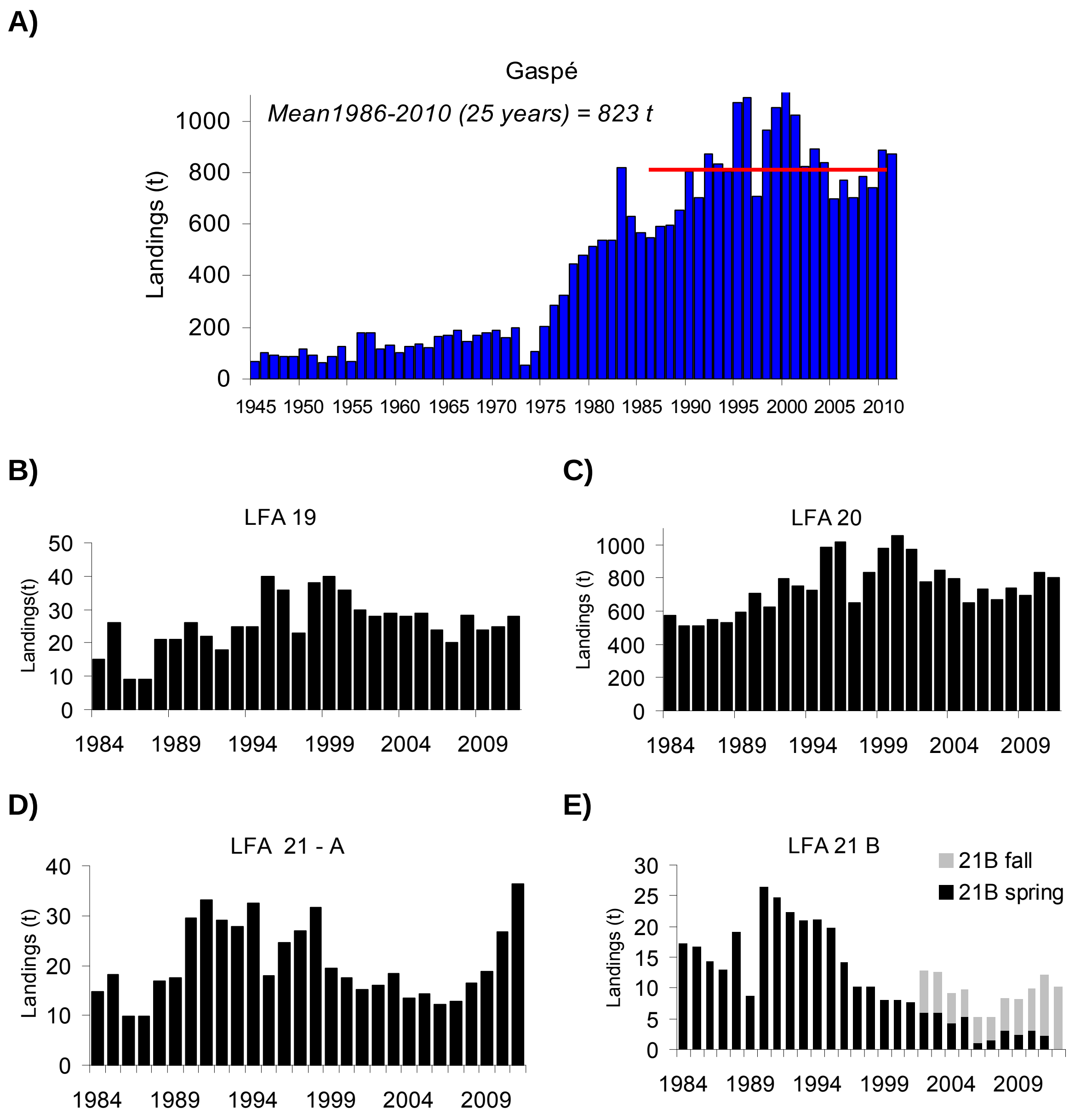
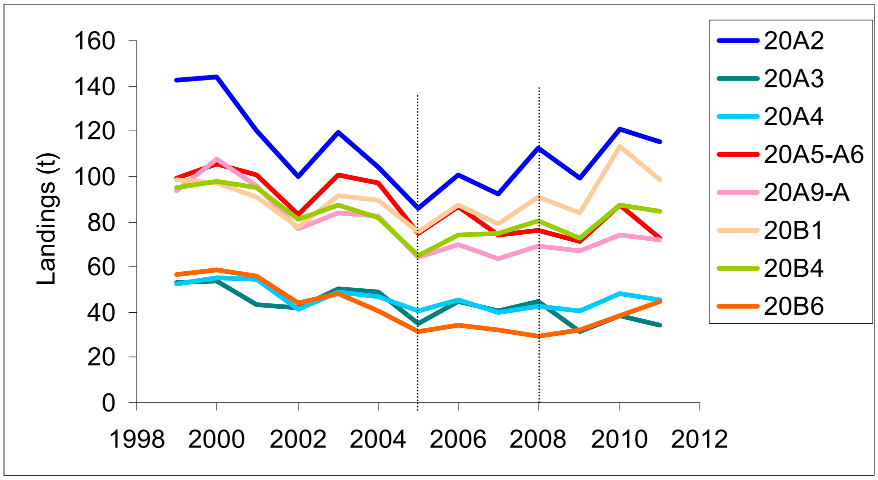


Figure 50. Lobster landings A) in the Gaspé from 1945 to 2011 and from 1984 to 2011 for B) LFA 19, C) LFA 20, D) LFA 21A and E) LFA 21B.



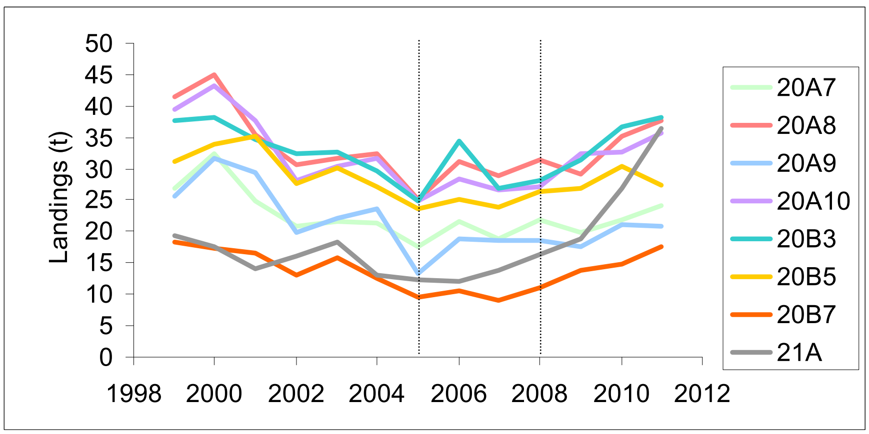


Figure 51. Lobster landings for different sub-areas of the Gaspé from 1999 to 2011. The vertical dotted lines separate periods of decrease (1999 to 2005), relative stability (2005 to 2008) and increase (2008 to 2011).

A)

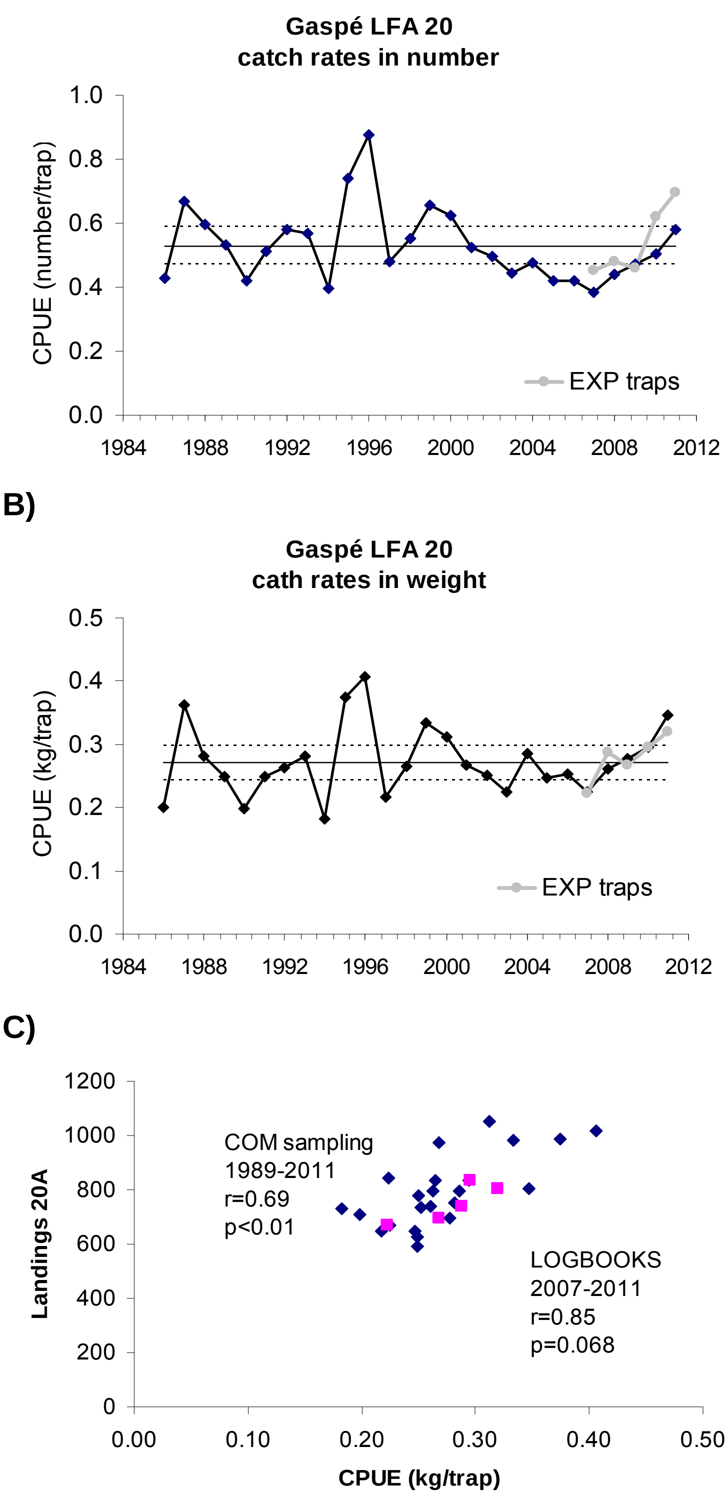


Figure 52. Catch rates (CPUE) of commercial-size lobsters for LFA 20 in the Gaspé from 1986 to 2011 A) in number and B) in weight per trap. Mean (solid line) ± 0.5 standard deviation (dotted lines). The grey lines represent CPUEs reported by fishers in LFA 20 who participated in the 2007–2011 recruitment project with experimental traps. C) Relationship between CPUE in weight (commercial sampling and logbooks) and landings.

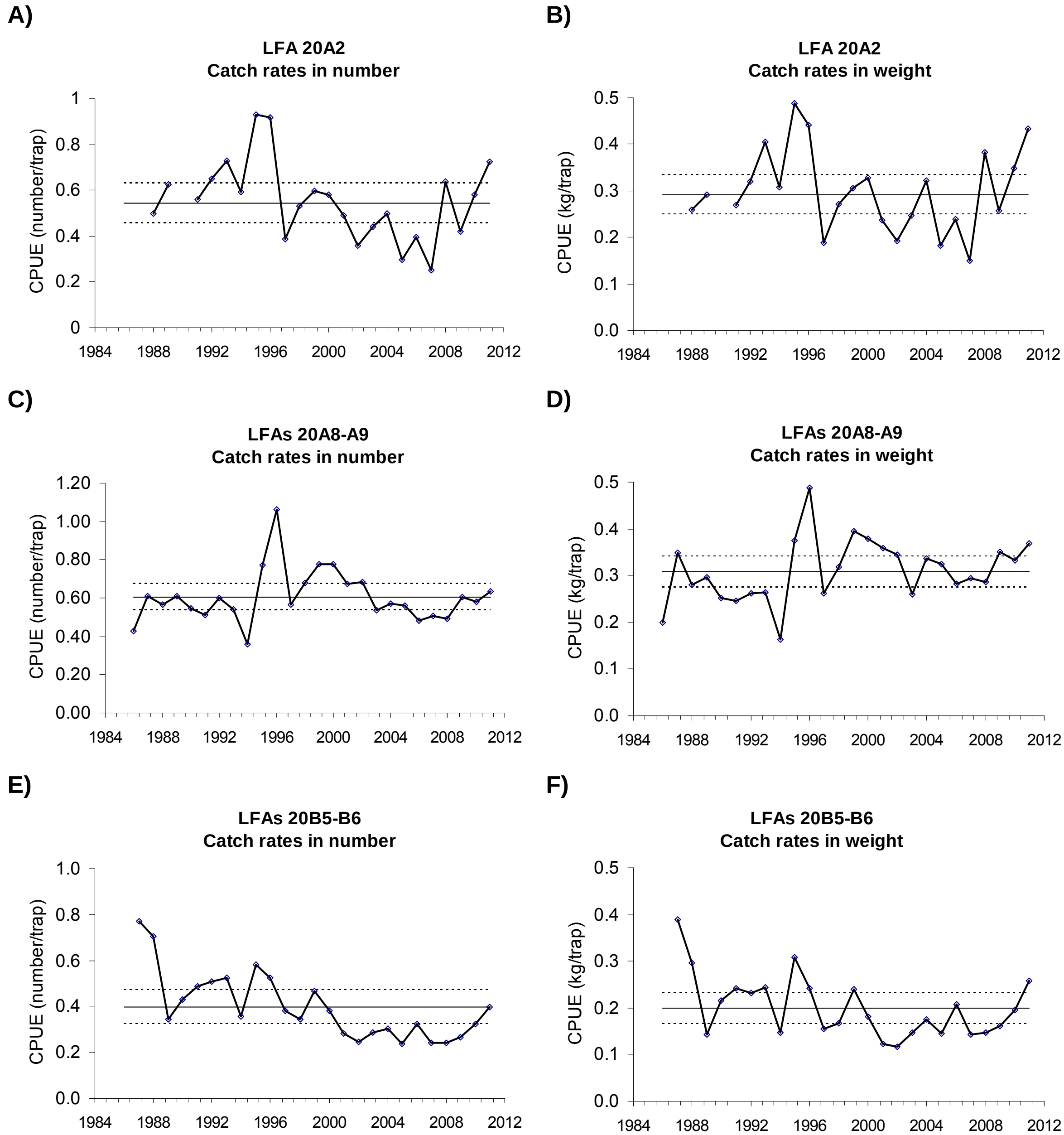


Figure 53. Catch rates (CPUE) of commercial-size lobsters for the three sampling areas in LFA 20 in the Gaspé from 1986 to 2011 in number and weight per trap for A) and B) LFA 20A2, C) and D) 20A8-A9, and E) and F) 20B5-B6. Mean 1986-2010 (solid line) ± 0.5 standard deviation (dotted lines).

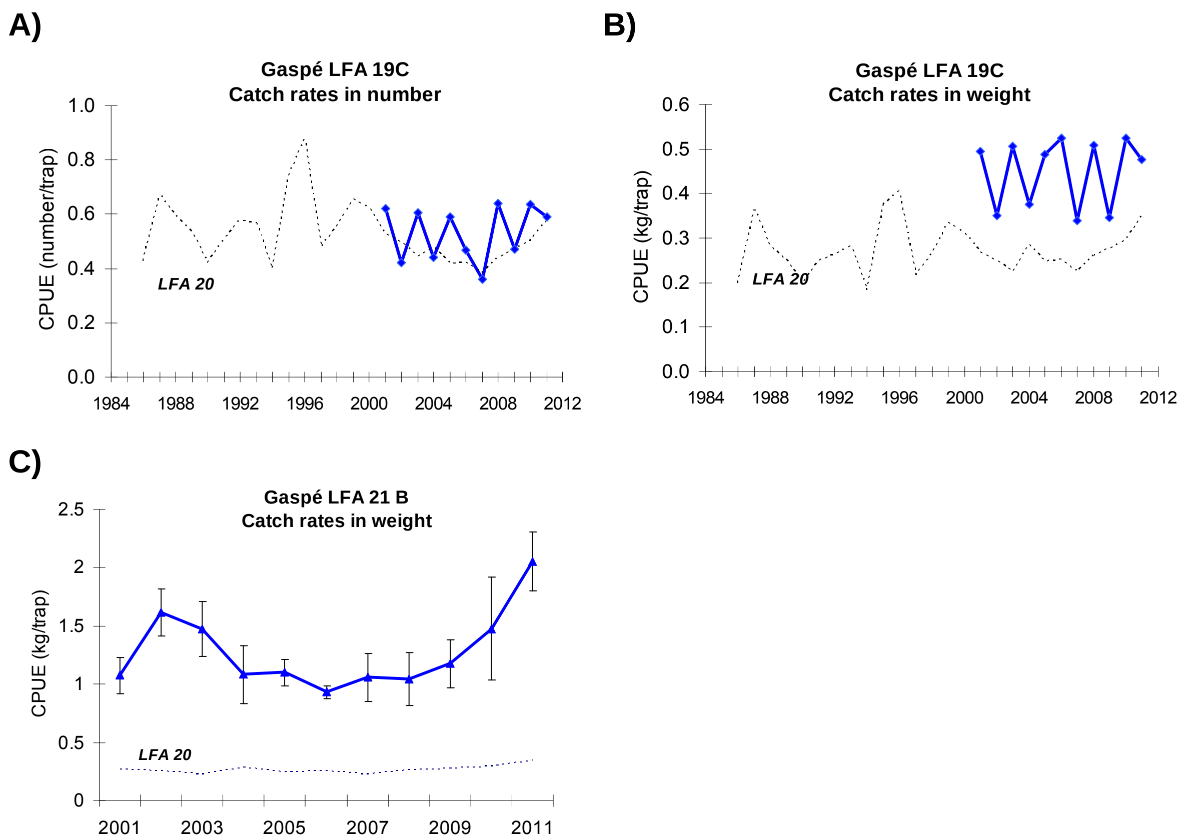


Figure 54. Catch rates (CPUE) of commercial-size lobsters for LFA 19 in the Gaspé from 2001 to 2011 A) in number and B) in weight per trap, and C) for LFA 21B in the fall in kg/trap ± 95% confidence interval. The dotted line represents CPUEs in LFA 20.

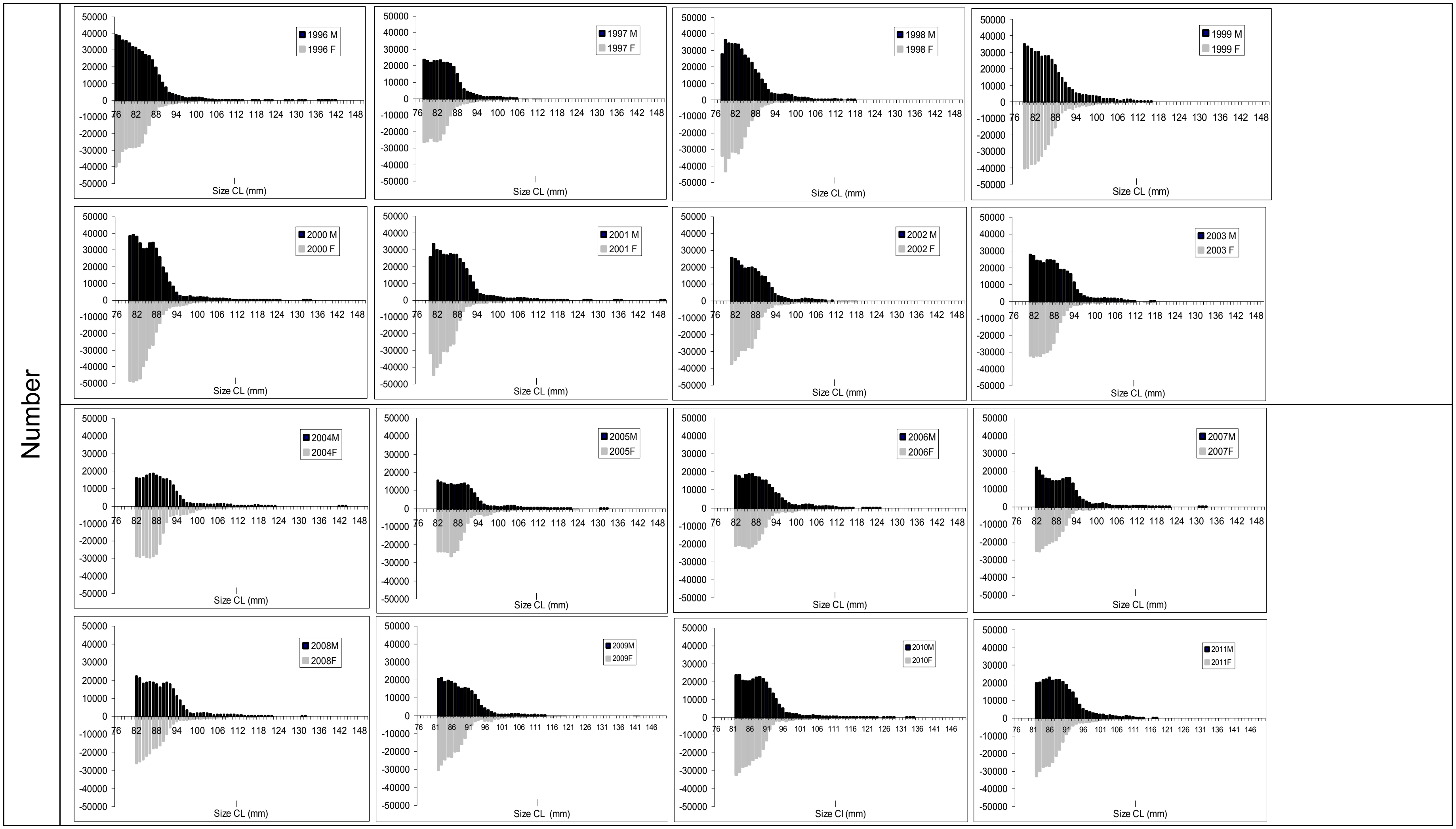
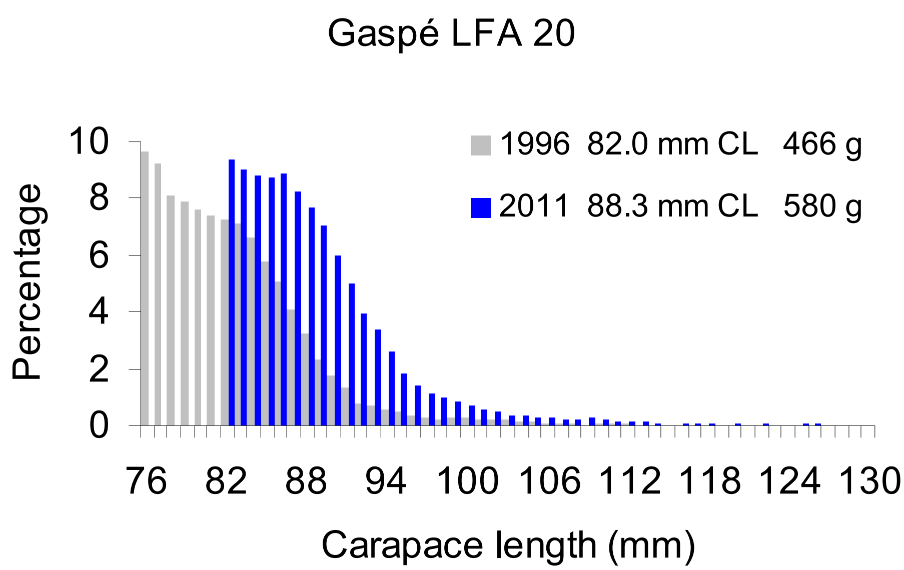


Figure 55. Size frequency distribution of male lobsters (black) and female lobsters (grey) (commercial portion) from 1996 to 2011 for all of LFA 20 in the Gaspé. Sampling at sea data. The frequencies are weighted by landings.

A)



B)

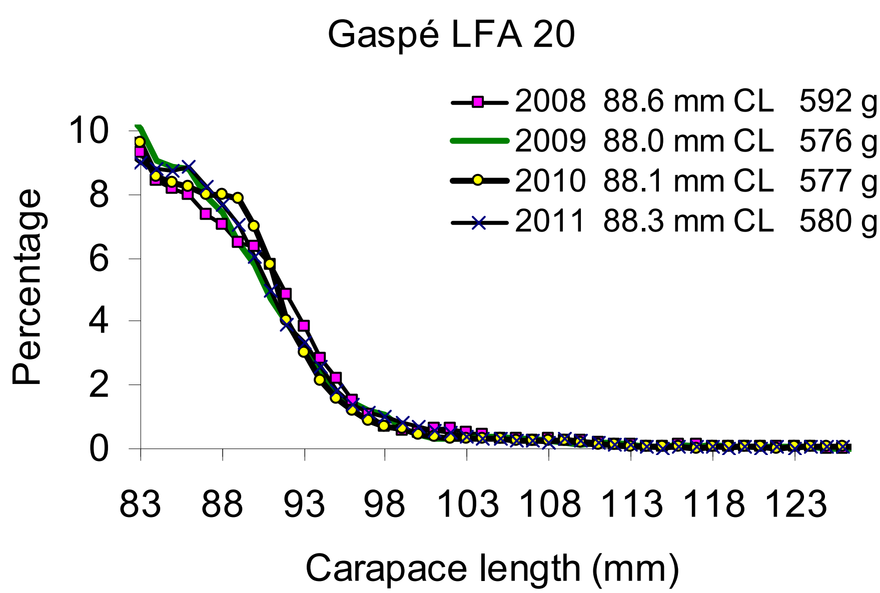


Figure 56. A) Size frequency distribution of lobsters (males and females combined) (commercial portion) in 1996 and 2011 and B) from 2008 to 2011 for all of LFA 20 based on sampling at sea data. The data are relative frequencies (%).

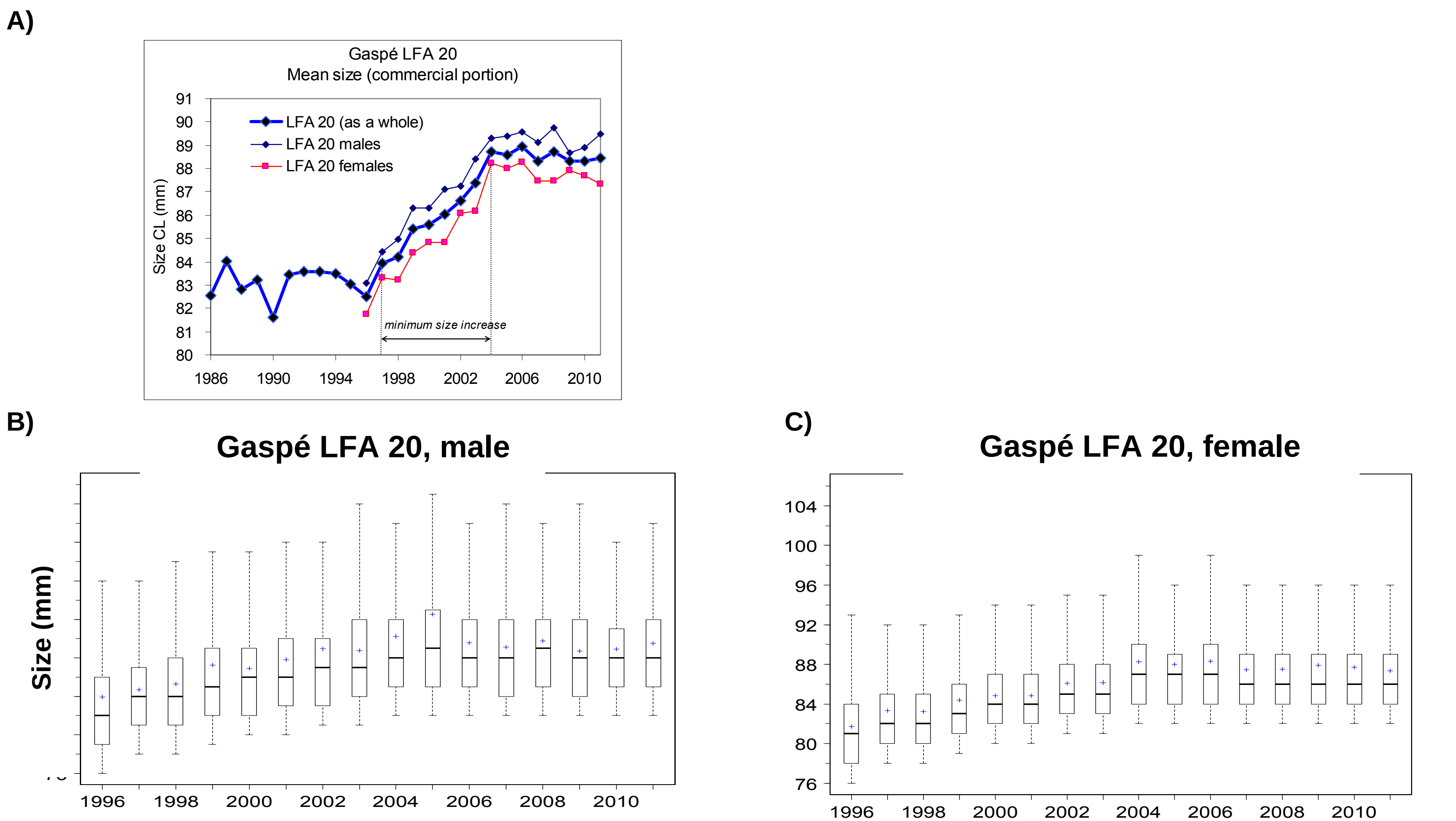


Figure 57. A) Average size of commercial lobster in LFA 20. Boxplots of the size of B) male and C) female lobsters from sampling at sea from 1996 to 2011. The rectangle ranges from the 25th to the 75th percentile and includes the median (horizontal line). The boxplots are up to a maximum 1.5 times the height of the box provided there are values. The average is indicated by a cross.

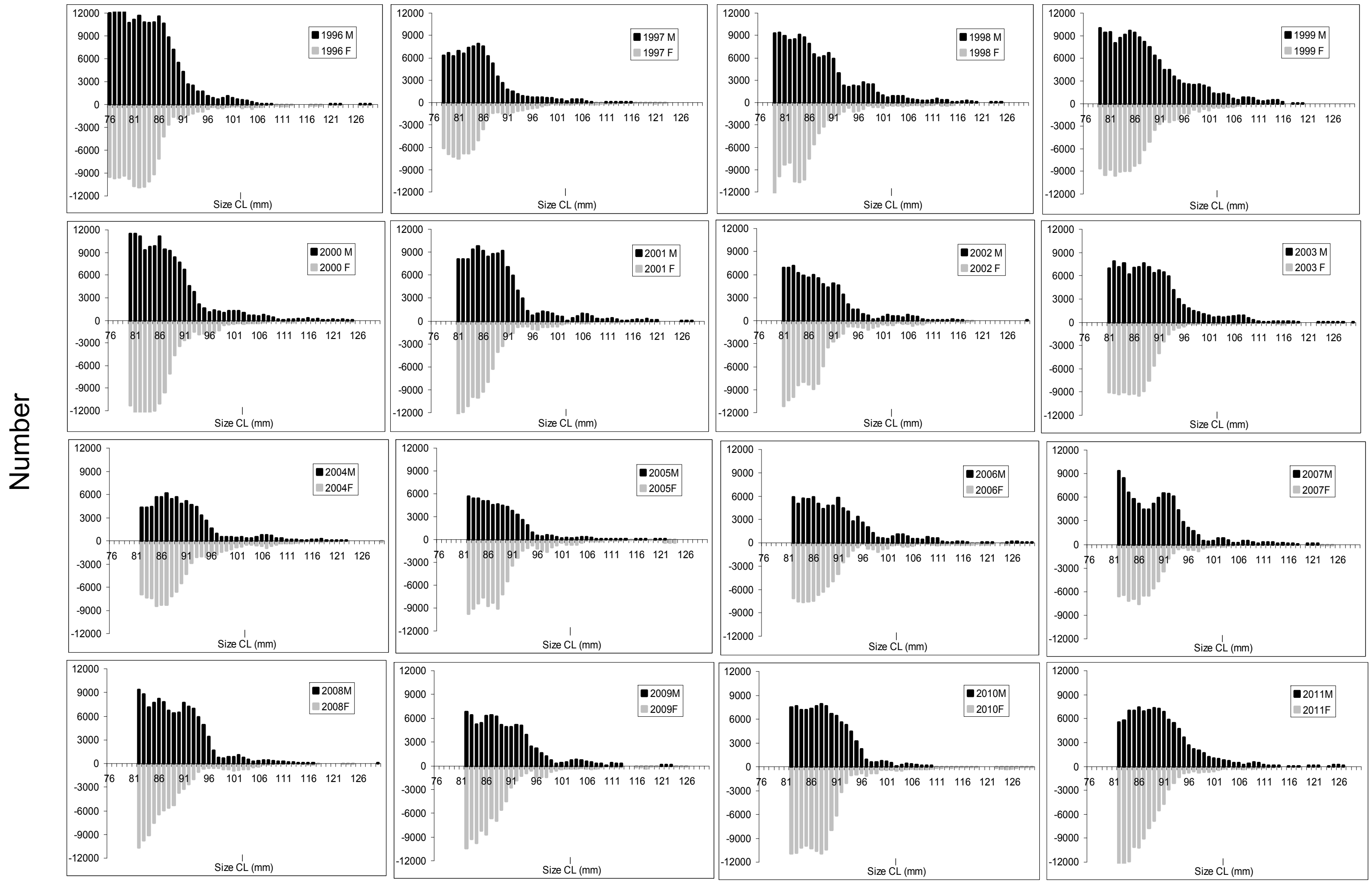


Figure 58. Size frequency distribution of male lobsters (black) and female lobsters (grey) (commercial portion) from 1996 to 2011 for LFA 20A2 in the Gaspé. Sampling at sea data. The frequencies are weighted by landings

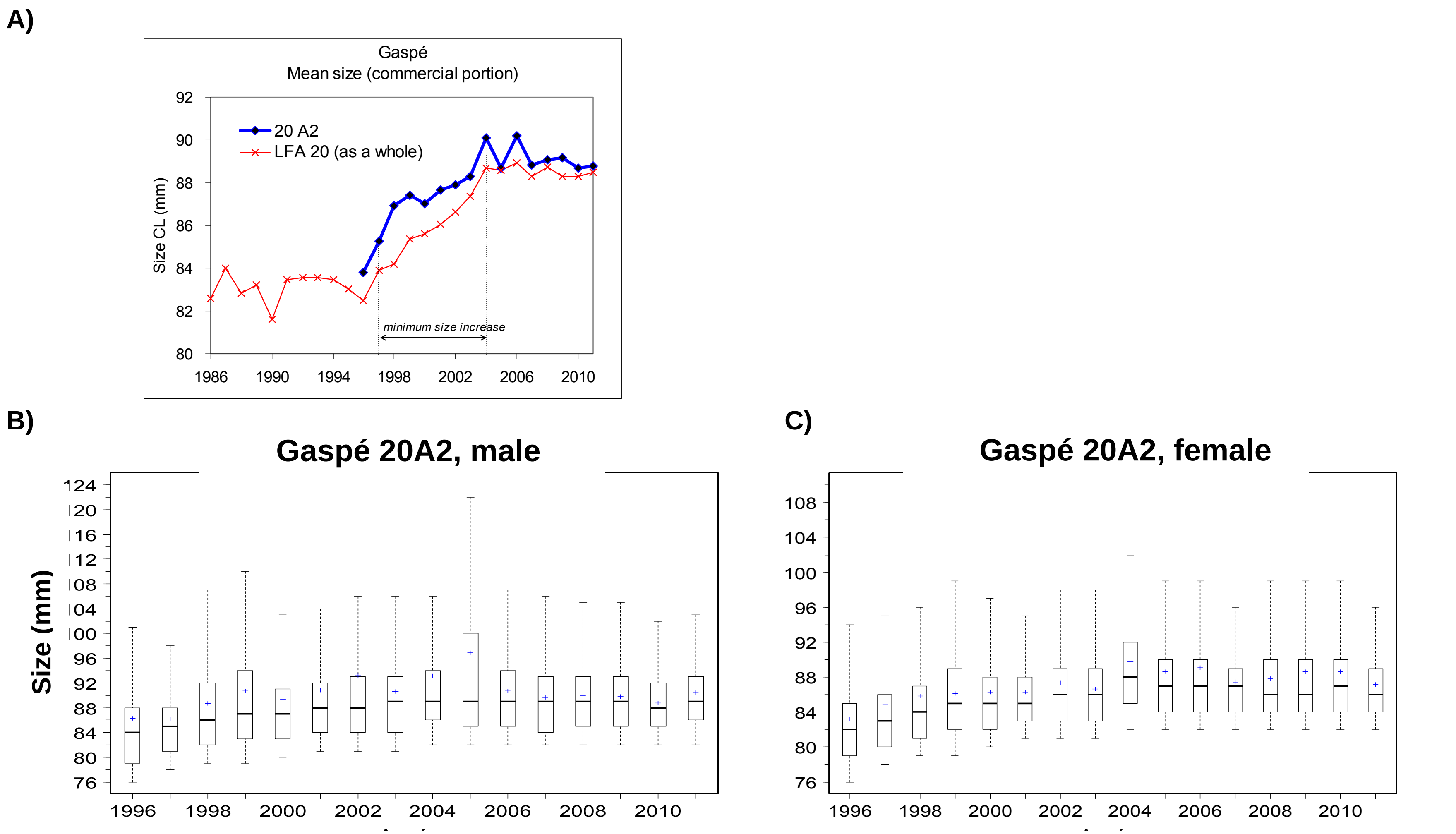


Figure 59. A) Average size of commercial lobster in LFA 20A2 and all of LFA 20. Boxplots of the size of B) male and C) female lobsters from sampling at sea from 1996 to 2011. The rectangle ranges from the 25th to the 75th percentile and includes the median (horizontal line). The boxplots are up to a maximum 1.5 times the height of the box provided there are values. The average is indicated by a cross.

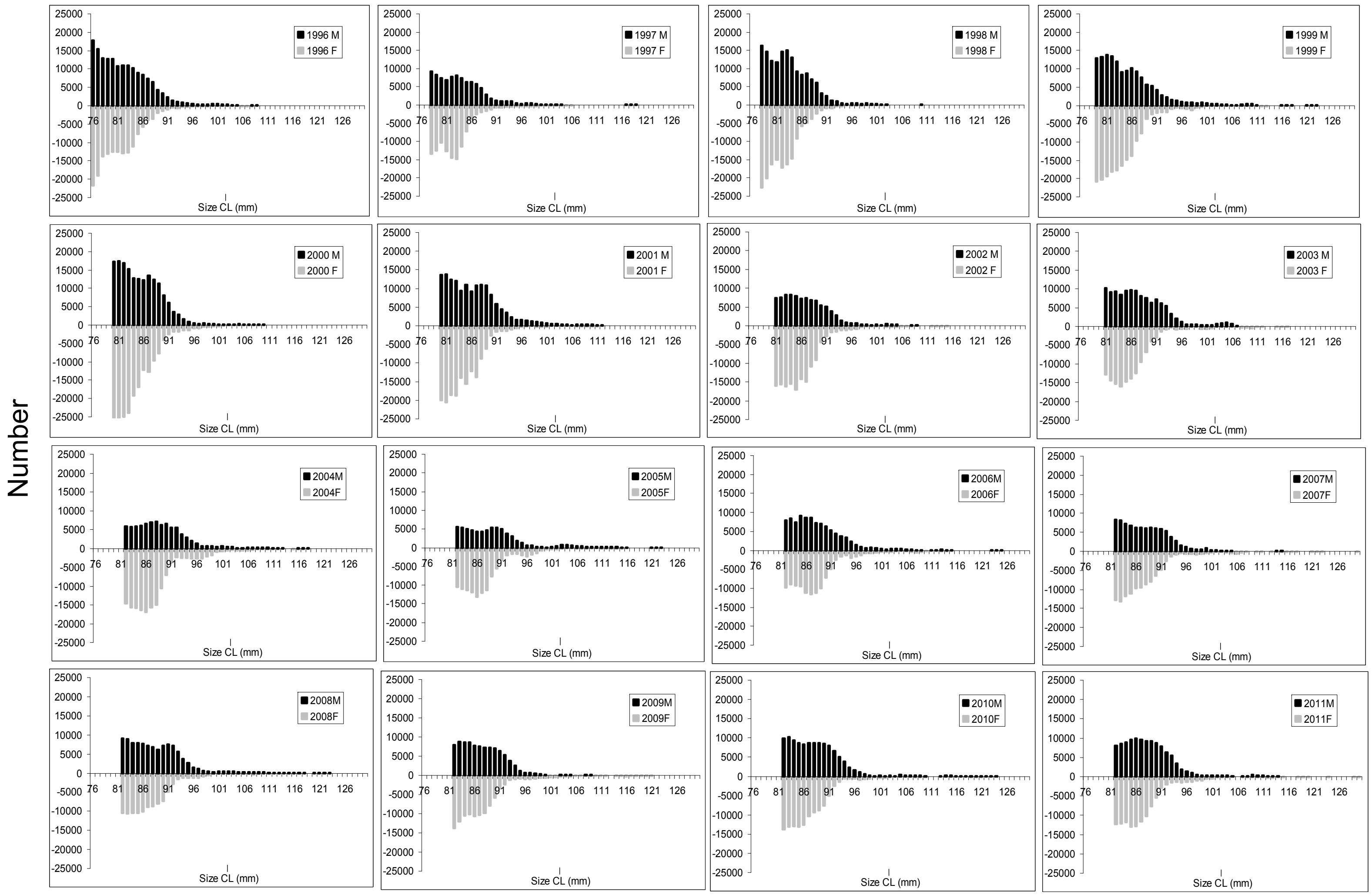


Figure 60. Size frequency distribution of male lobsters (black) and female lobsters (grey) (commercial portion) from 1996 to 2011 for LFAs 20A8-A9 in the Gaspé. Sampling at sea data. The frequencies are weighted by landings.

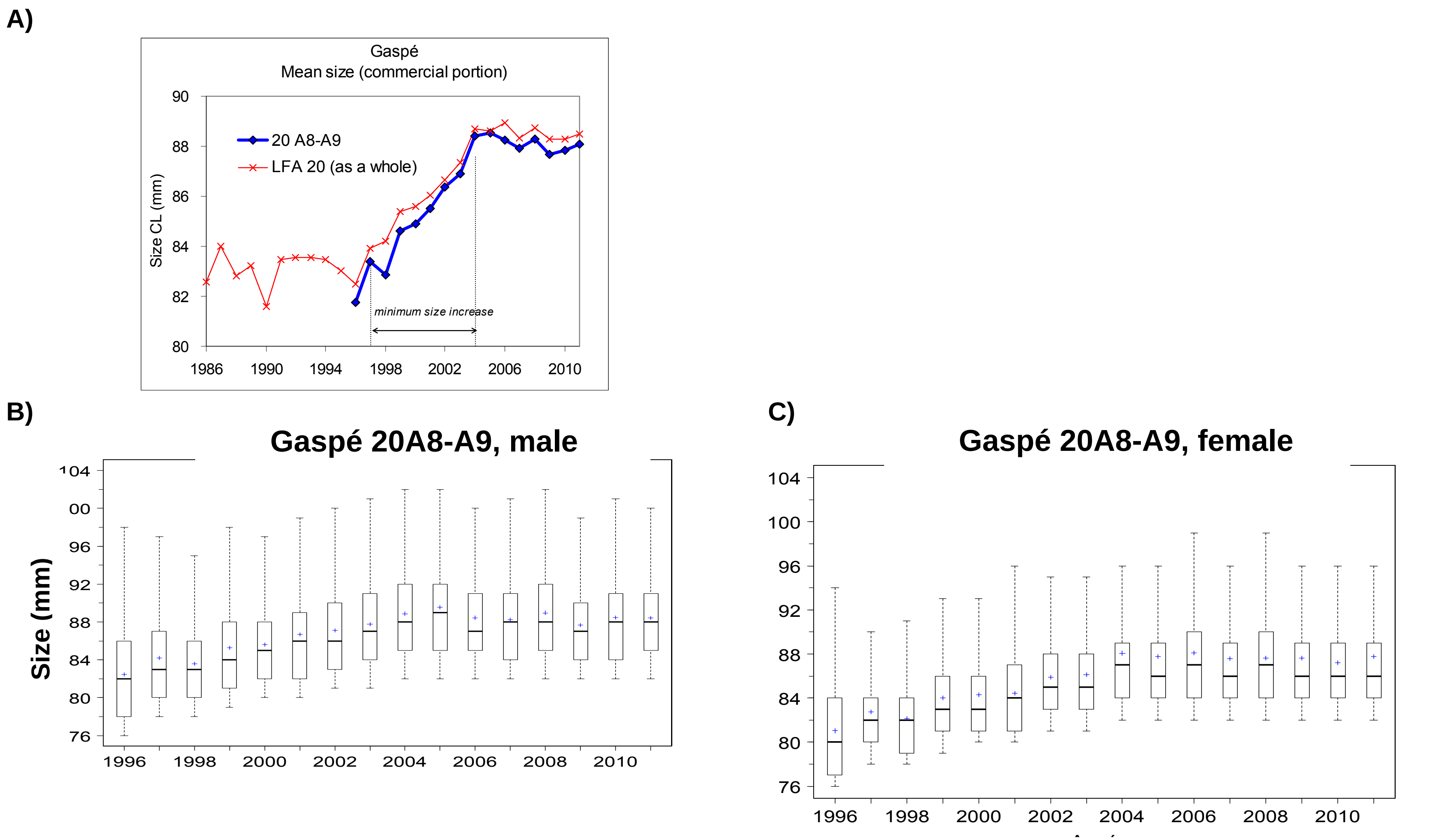


Figure 61. A) Average size of commercial lobster in LFAs 20A8-A9 and all of LFA 20. Boxplots of the size of B) male and C) female lobsters from sampling at sea from 1996 to 2011. The rectangle ranges from the 25th to the 75th percentile and includes the median (horizontal line). The boxplots are up to a maximum 1.5 times the height of the box provided there are values. The average is indicated by a cross.

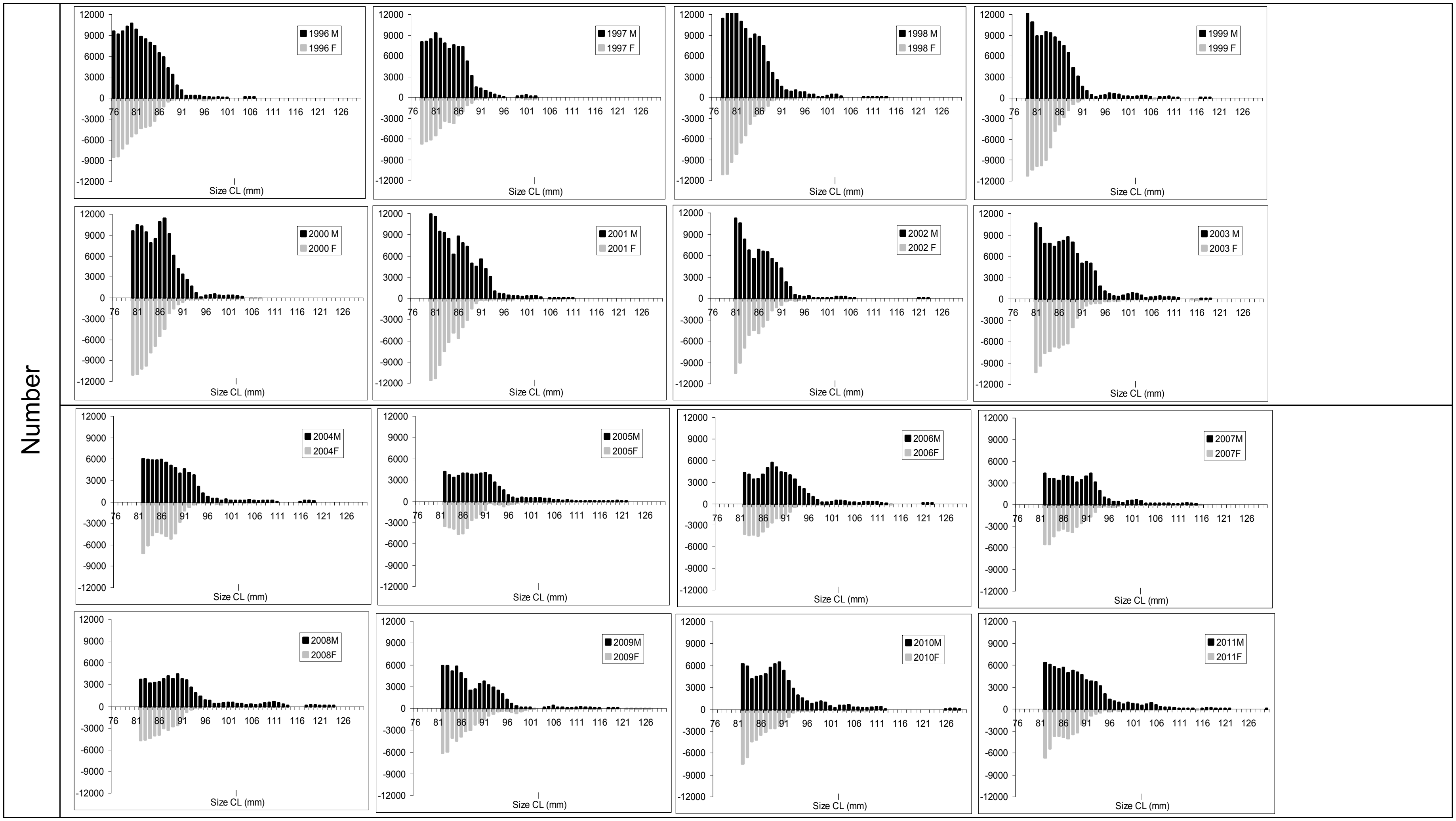


Figure 62. Size frequency distribution of male lobsters (black) and female lobsters (grey) (commercial portion) from 1996 to 2011 for LFAs 20B5-B6 in the Gaspé. Sampling at sea data. The frequencies are weighted by landings.

A)

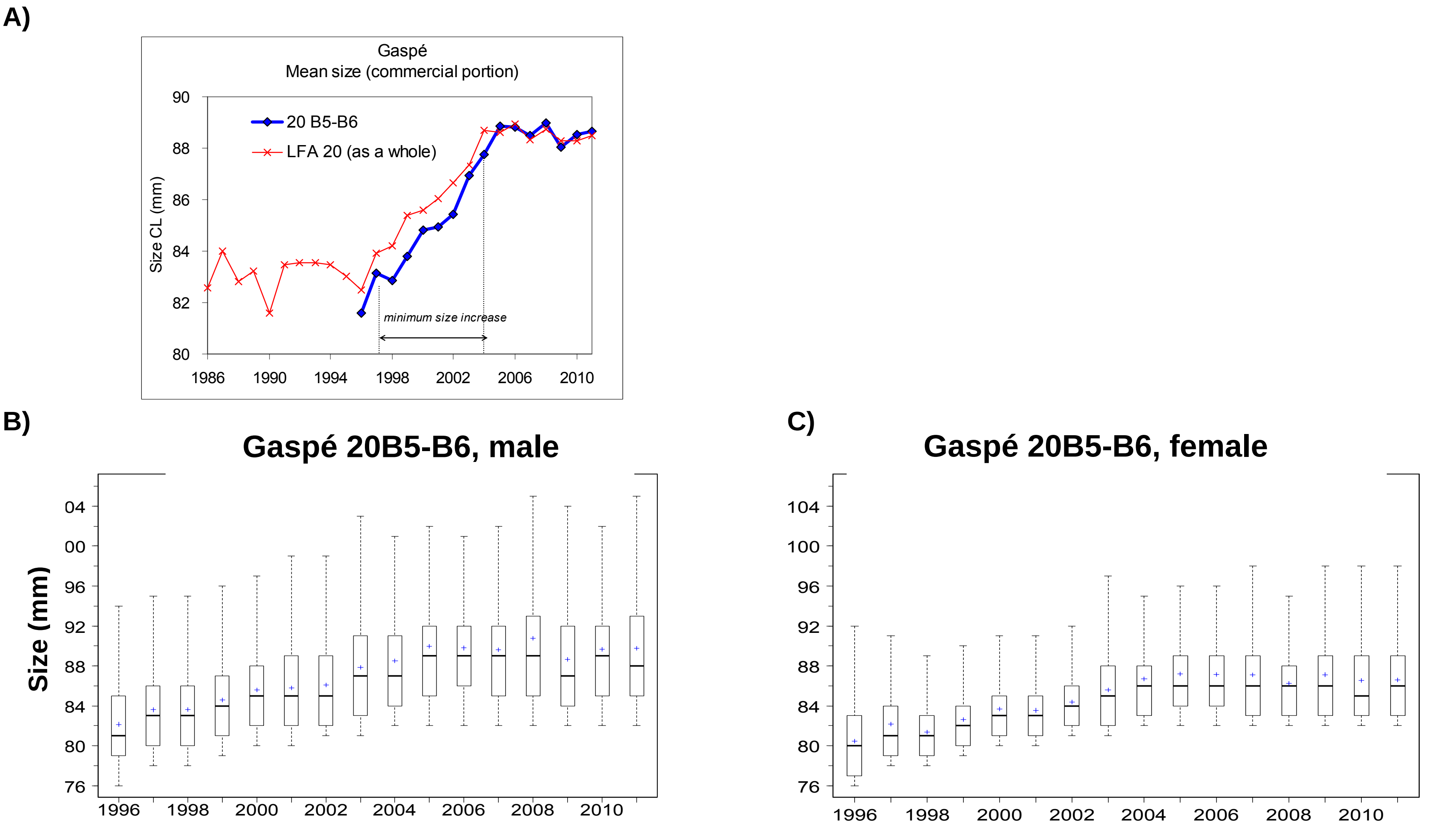


Figure 63. A) Average size of commercial lobster in LFAs 20B5-B6 and all of LFA 20. Boxplots of the size of B) male and C) female lobsters from sampling at sea from 1996 to 2011. The rectangle ranges from the 25th to the 75th percentile and includes the median (horizontal line). The boxplots are up to a maximum 1.5 times the height of the box provided there are values. The average is indicated by a cross.

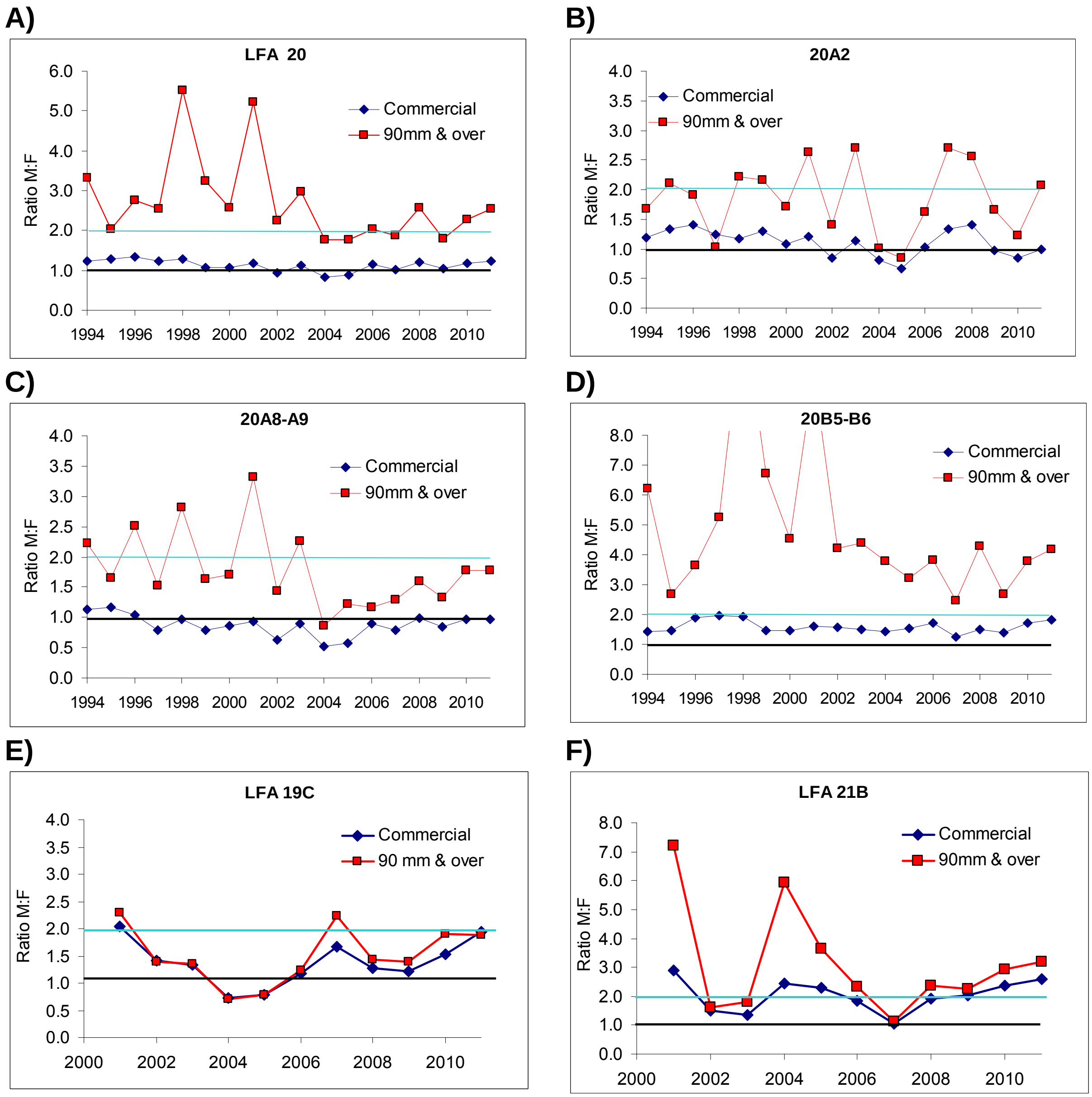


Figure 64. Actual sex ratio (males / non-berried females) A) for all of LFA20, B) for 20A2, C) 20A8-A9, D) 20B5-B6 from 1994 to 2011, E) 19C and F) 21B from 2001 to 2011. The grey line indicates a 1:1 M:F ratio and the turquoise line a 2:1 ratio.

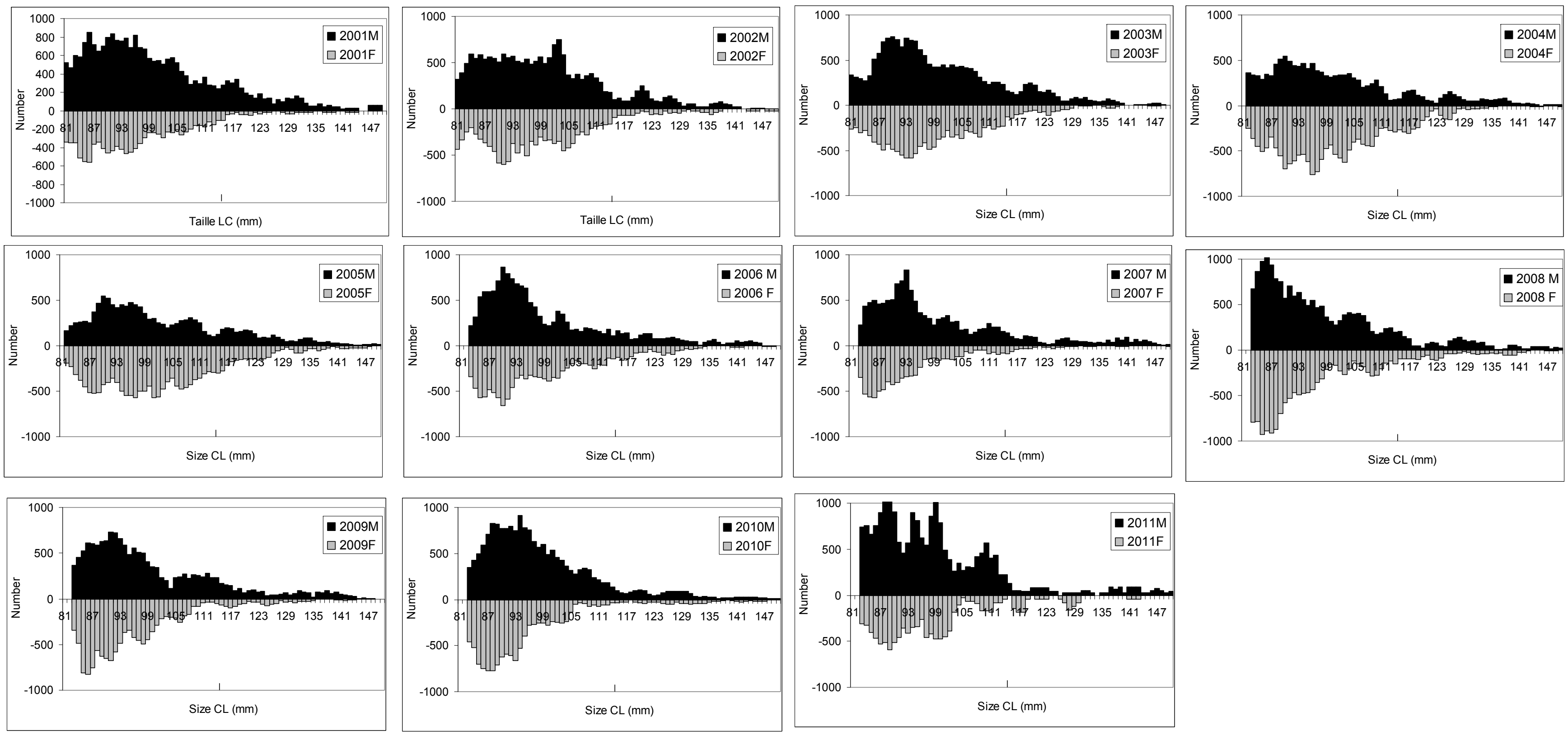


Figure 65. Size frequency distribution of male lobsters (black) and female lobsters (grey) (commercial portion) from 2001 to 2011 for LFA 19C in the Gaspé. Sampling at sea data. The frequencies are weighted by landings.

A)

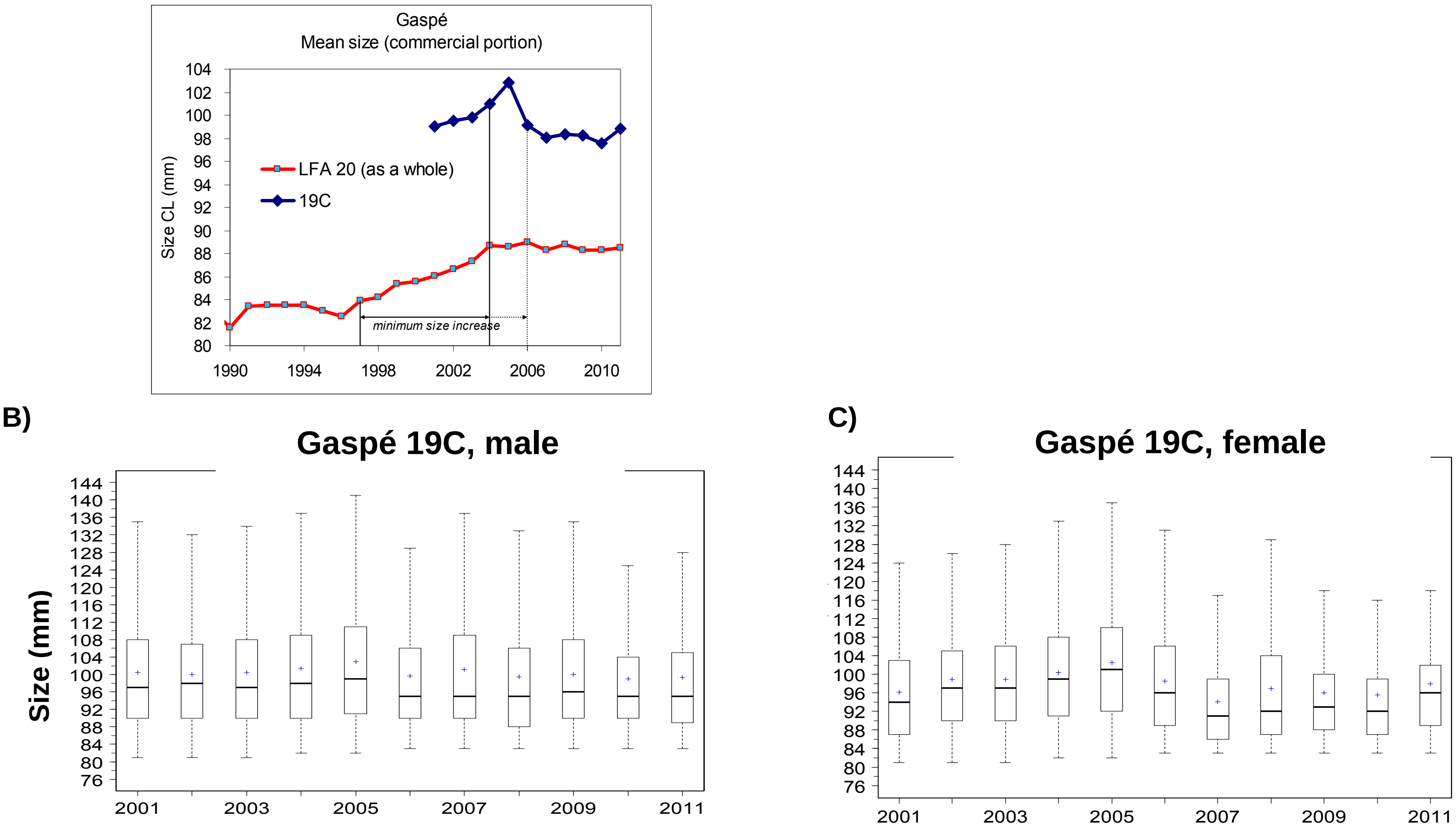


Figure 66. A) Average size of commercial lobster in LFA 19C and all of LFA 20. Boxplots of the size of B) male and C) female lobsters from sampling at sea from 1996 to 2011. The rectangle ranges from the 25th to the 75th percentile and includes the median (horizontal line). The boxplots are up to a maximum 1.5 times the height of the box provided there are values. The average is indicated by a cross. For A, the grey vertical line indicates when the MCS was increased from 82 to 83 mm CL.

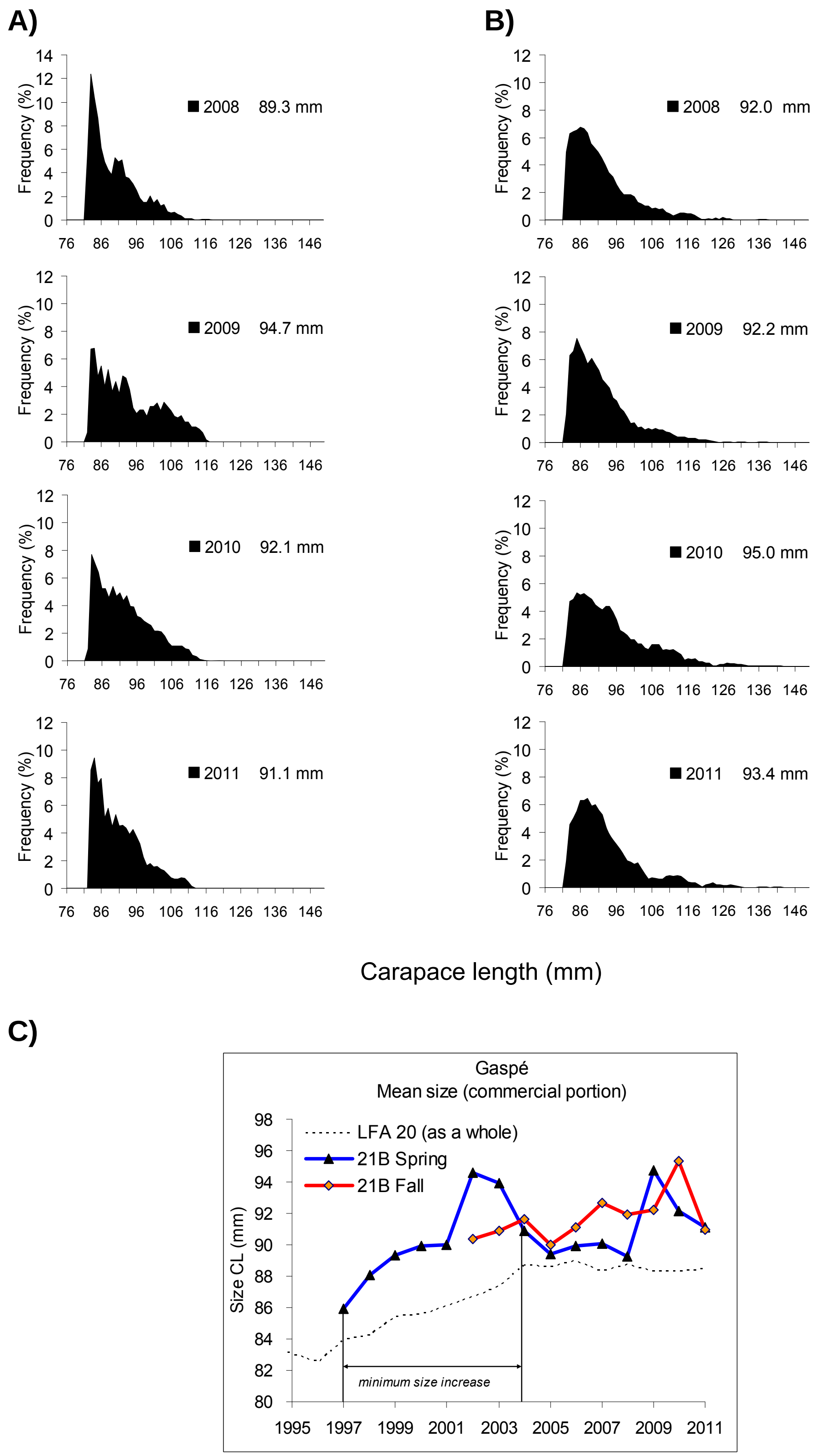
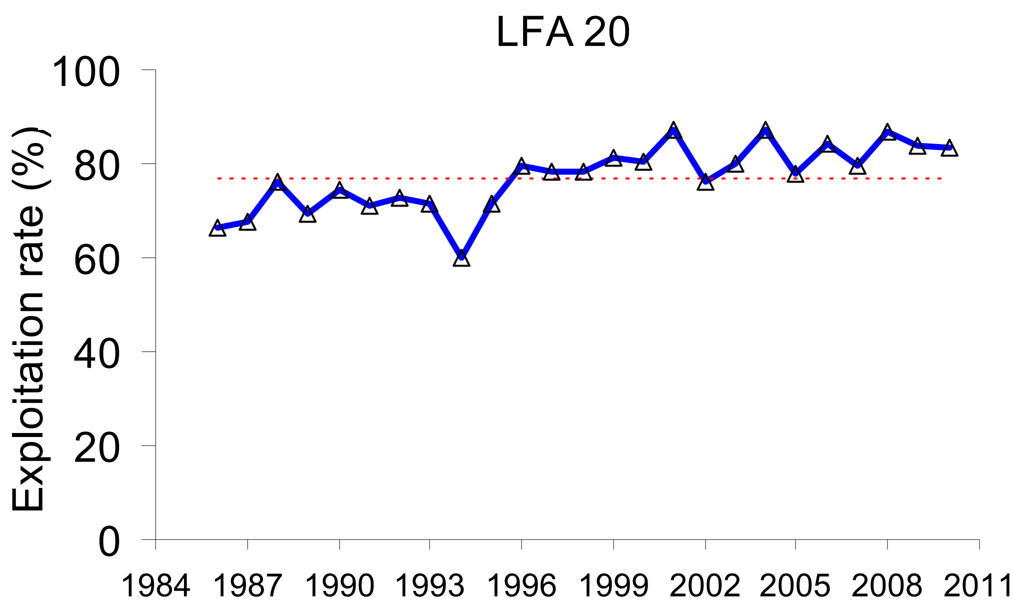


Figure 67. A) Size frequency distribution (relative frequency in %) of lobsters caught A) in spring and B) in the fall in LFA 21B from 2008 to 2011 and C) average sizes. Data from commercial sampling at sea (1997 to 2004) and dockside (2005 to 2011). The dotted line shows the average size of lobster in LFA 20.

A)



B)

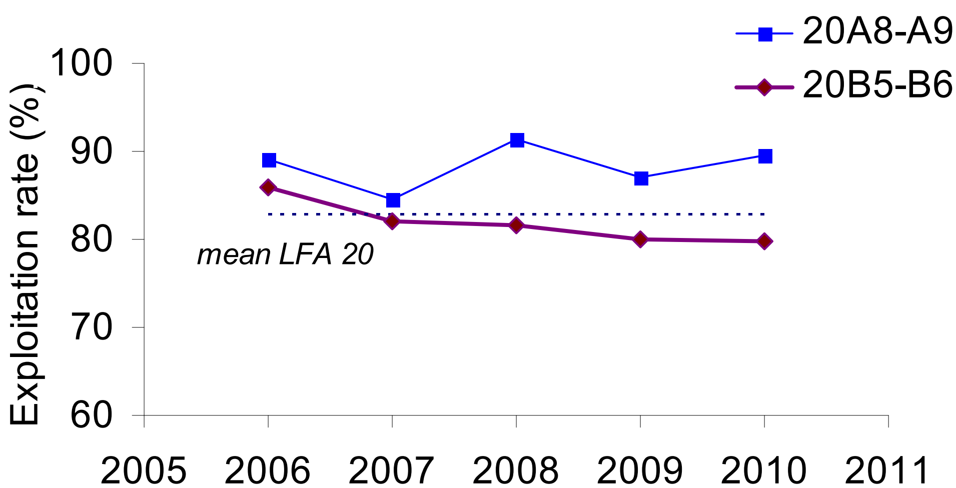


Figure 68. Exploitation rates of commercial size males A) for LFA 20 in the Gaspé from 1986 to 2010; the dotted line represents the series average (1986 to 2009) and B) for LFA 20A8-A9 and 20B5-B6 from 2006 to 2010; the dotted line represents the average for LFA 20 from 2006 to 2010.

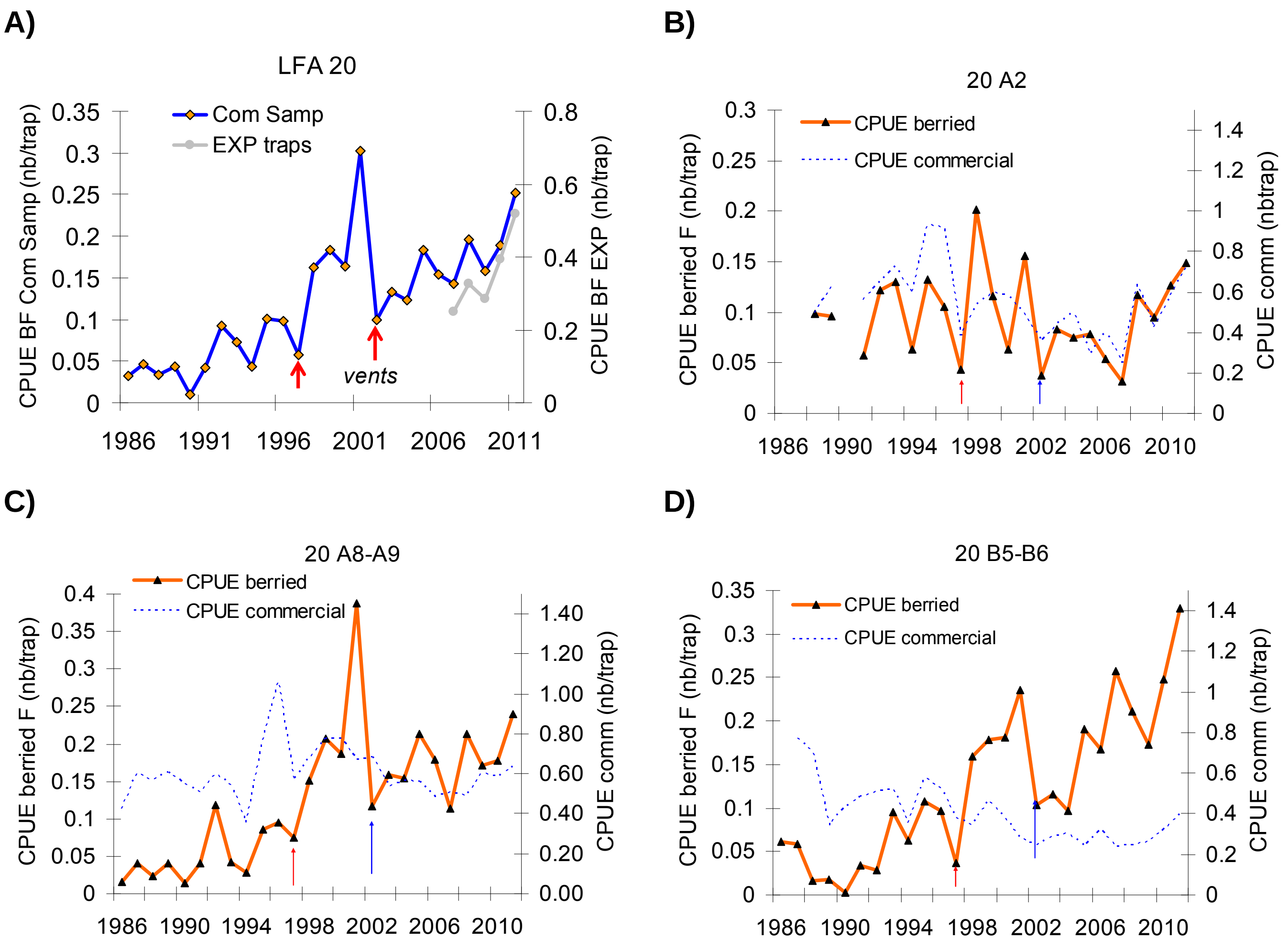


Figure 69. Catch rates (CPUEs) of berried females A) in LFA 20, B) in 20A2, C) in 20A8-A9 and D) in 20B5-B6, from 1986 to 2011. The first arrow indicates the start of the increase in minimum catch size and the second arrow indicates the year when the height of the escape vents was increased from 43 mm to 46 mm. For A, the grey line represents CPUEs reported by fishers in LFA 20 who participated in the 2007-2011 recruitment project with experimental traps. For B, C and D, the dotted line represents the commercial CPUE.

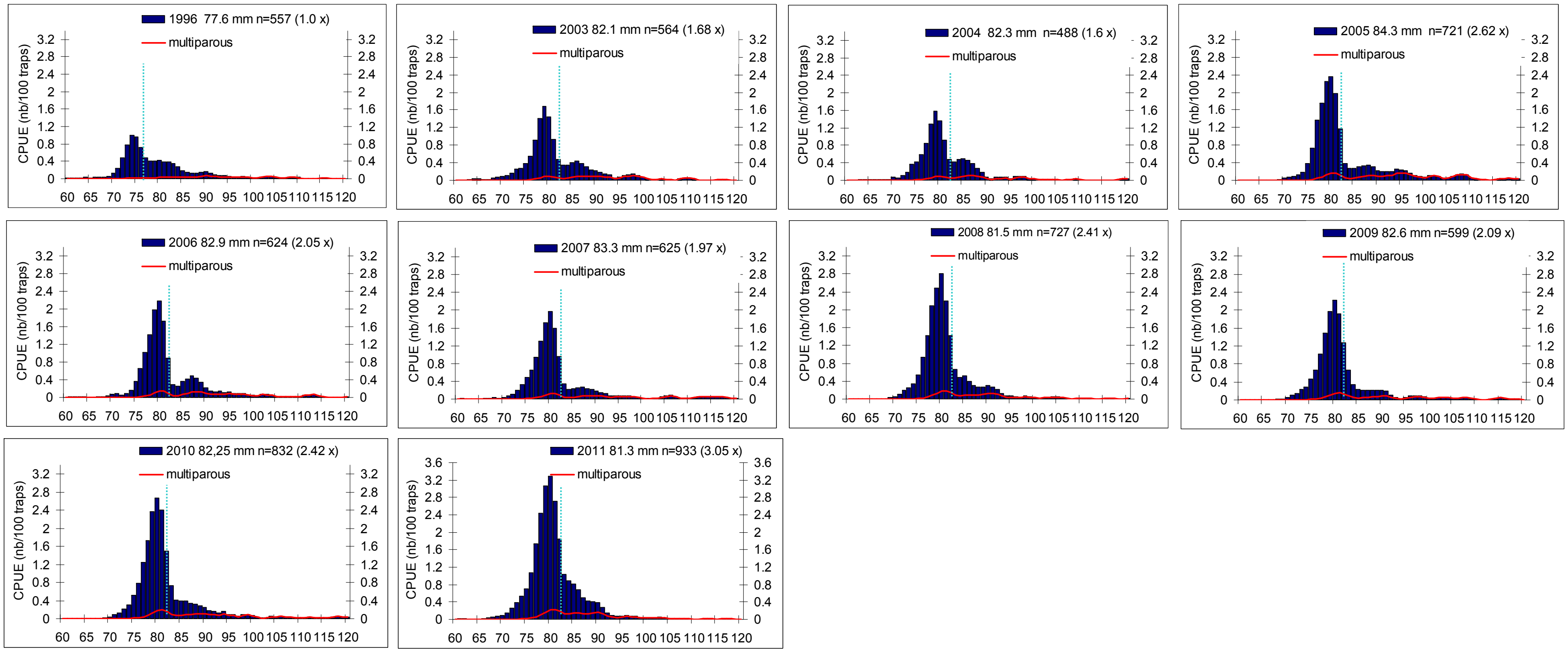
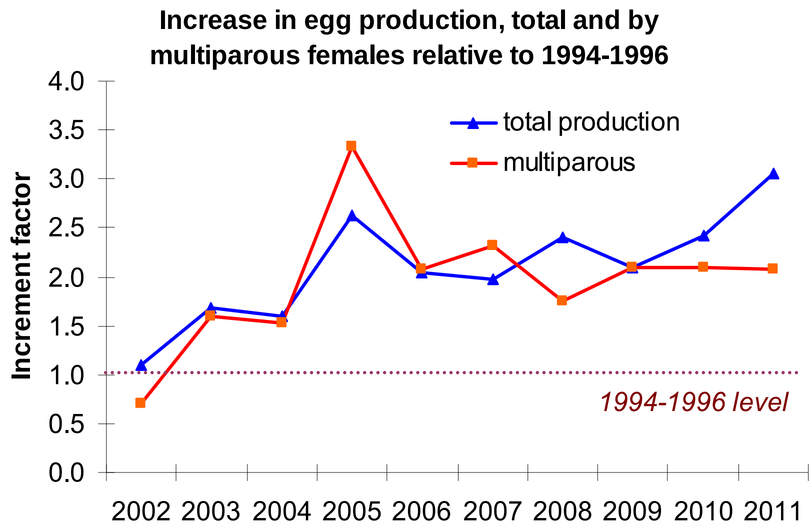


Figure 70. Size frequency distribution of berried females in LFA 20 in 1996 and from 2003 to 2011. The red line represents multiparous females. The distributions are weighted by abundance indices (annual CPUE). The average size and total number of berried females and the increase in egg production compared to the 1994-1996 mean are indicated. The vertical dotted line indicates the MCS.

.

A)



B)

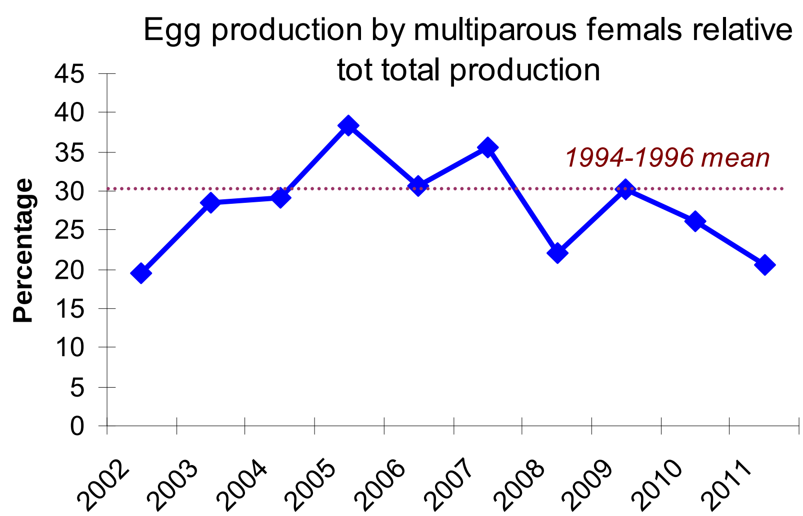
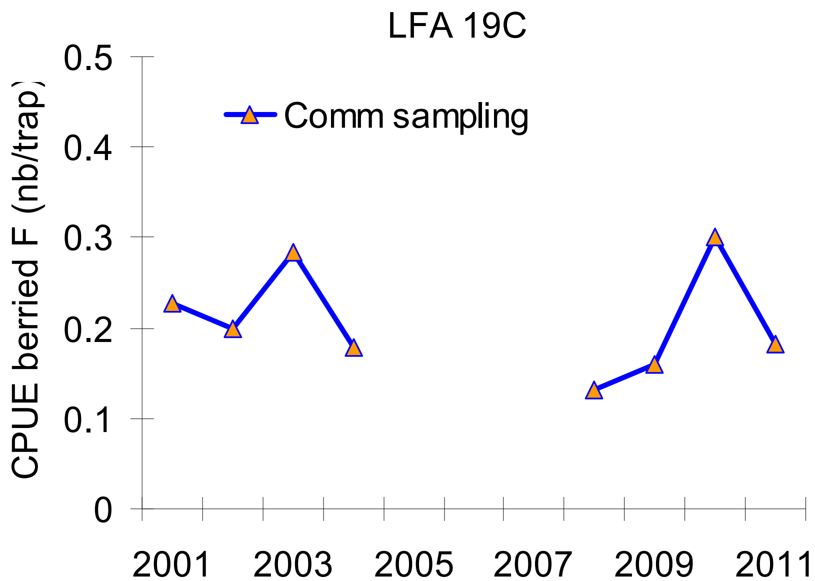


Figure 71.A) Increase in egg production, total and by multiparous females in LFA 20 from 2002 to 2011 versus average production from 1994 to 1996, before the MCS was increased. B) Contribution (percentage) of multiparous females to total egg production for all of LFA 20 from 2002 to 2011 and from 1994 to 1996.

A)



B)

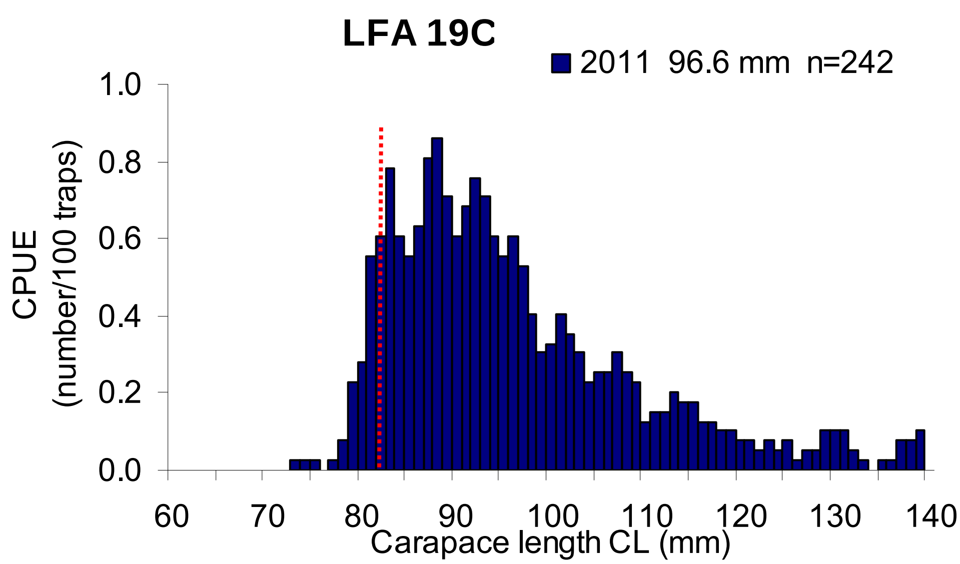
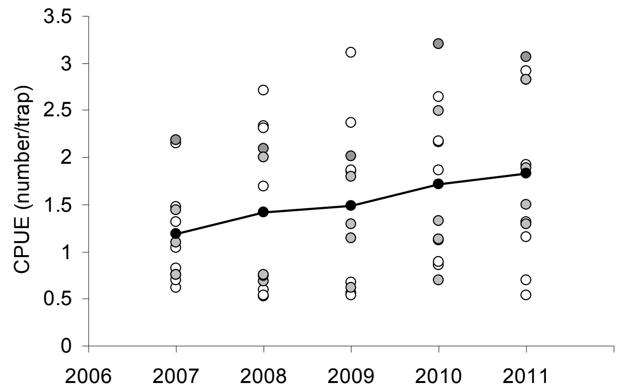
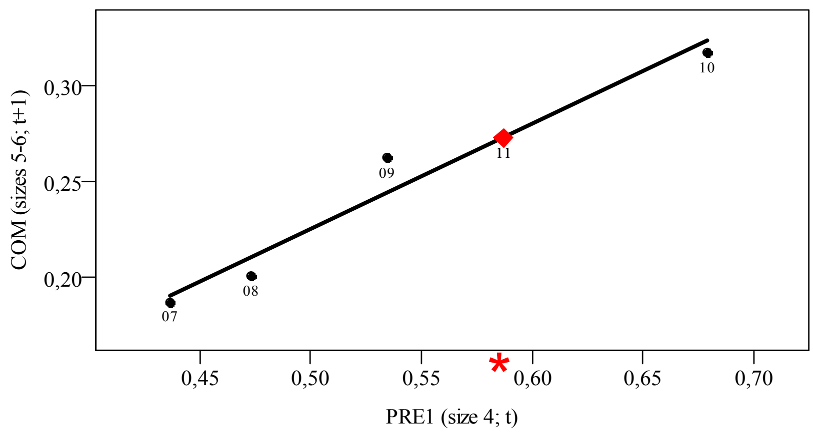


Figure 72. A) Catch rate (CPUE) of berried females in LFA 19C and B) Size frequency distribution of berried females in LFA 19C in 2011. The average size and number of females measured are indicated. The red line indicates the MCS. Sampling at sea data.

A)



B)



C)

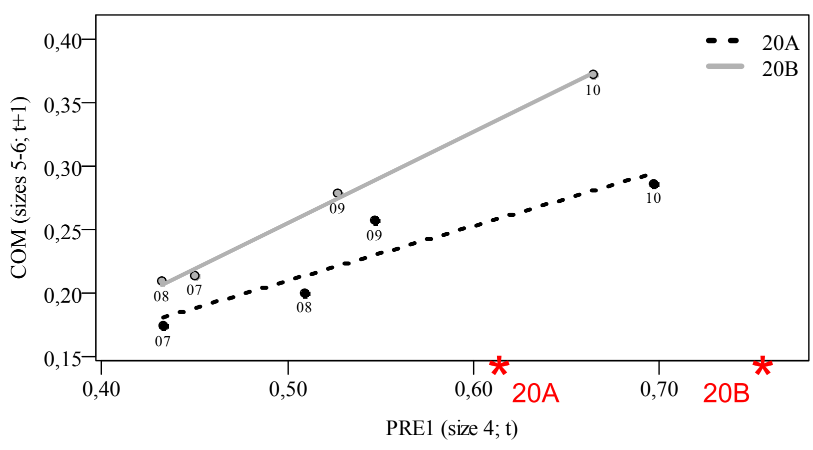


Figure 73. A) Catch rates (CPUEs) of prerecruits (70 to 81 mm one molt below commercial size) from 2007 to 2011 for sub-areas 20A (blank circles), 20B (grey circles) and all of LFA 20 (black circles and black line). Data from experimental traps (closed vents). B) Relationship between the number of prerecruits in a given year and the number of commercial lobsters the following year (male new recruits only) for LFA 20 and C) for 20A and 20B. The red stars indicate the 2011 PRE1 values.

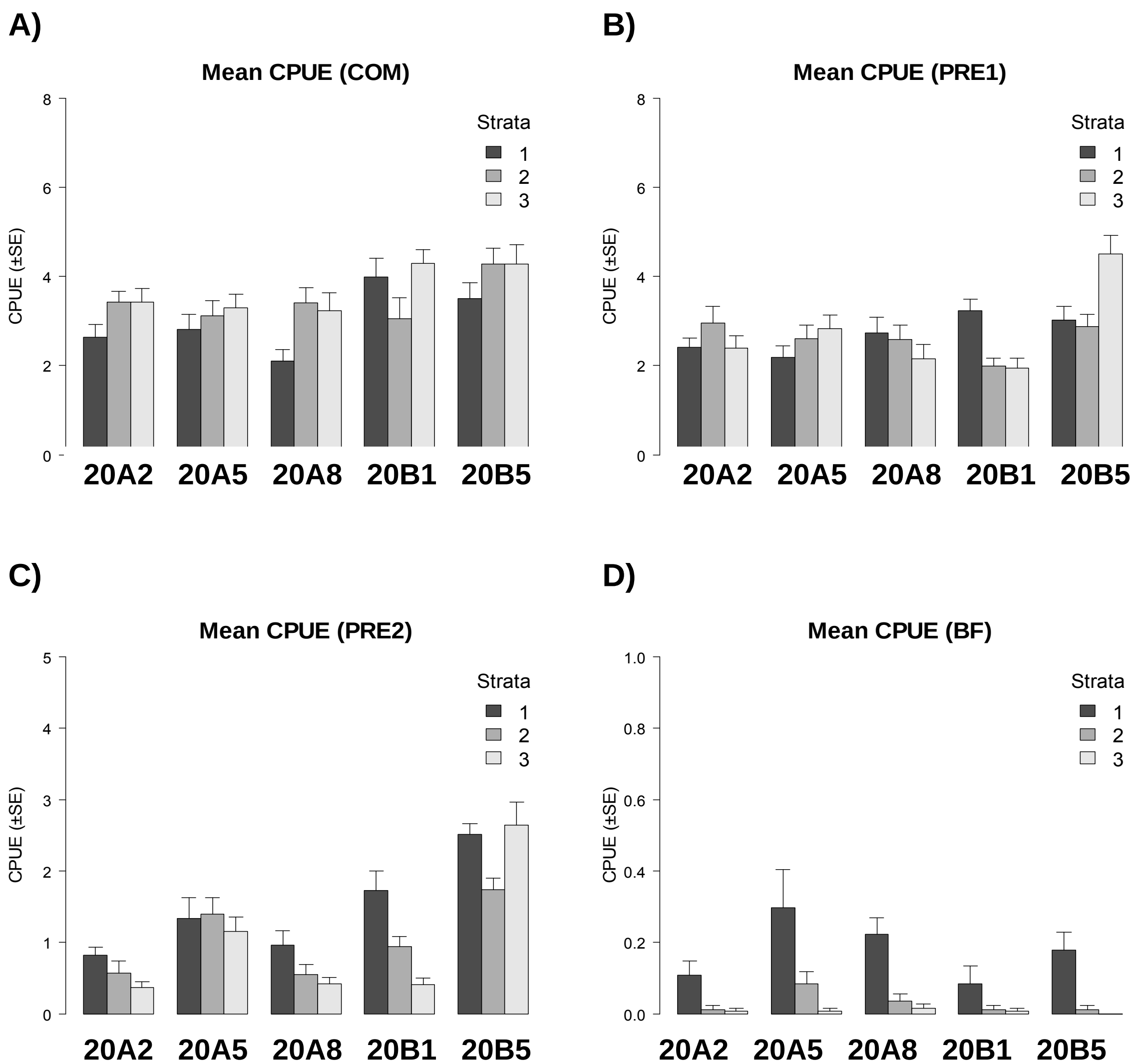


Figure 74. CPUEs (average ± standard error) in actual number of lobsters per trap by depth strata (1: 5 m to 10 m, 2: 10 m to 20 m and 3: 20 m to 40 m) in the five sub-areas of LFA 20 sampled during the post-season survey in the Gaspé in September 2011.

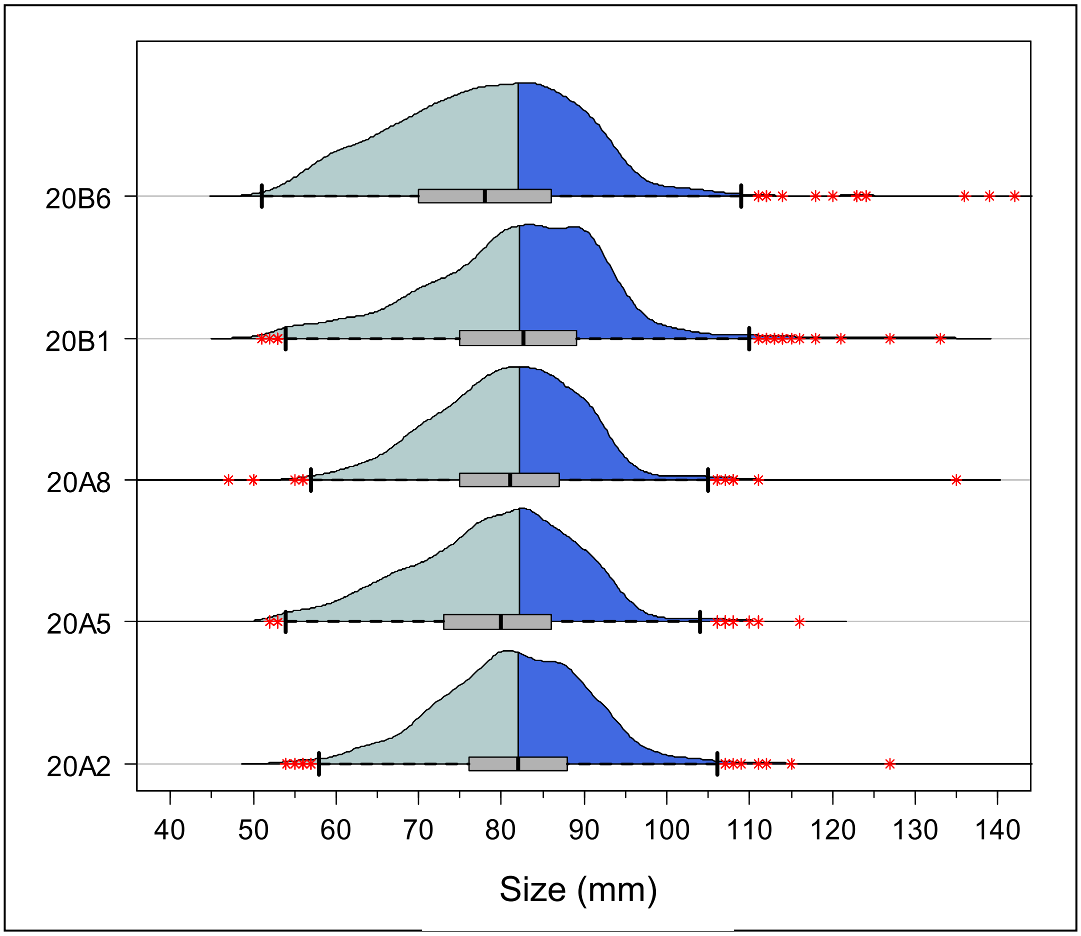
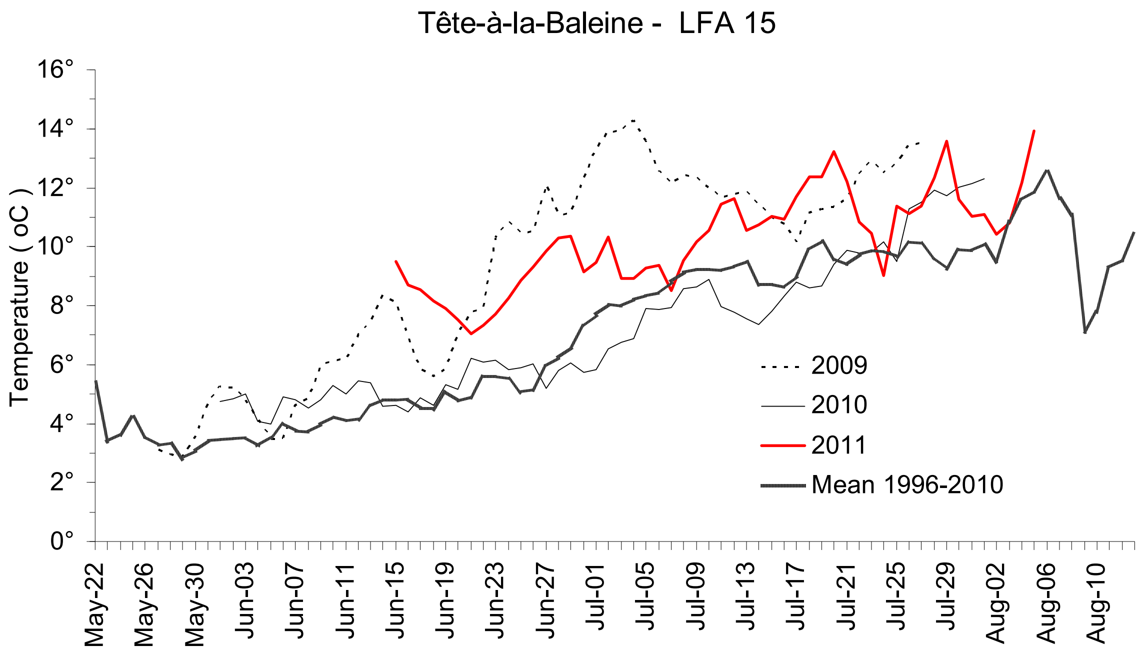


Figure 75. Size frequency distribution of lobsters caught during the September 2011 post-season survey conducted in LFA 20. Commercial lobsters (≥ 82 mm) are in blue. A boxplot is shown at the base of each figure. The dotted line shows the boundary between PRE1s and PRE2s.

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
COM ABUNDANCE																										
Landings	-1.7	-1.5	-1.5	-1.1	-0.1	-0.8	0.3	0.1	-0.1	1.6	1.7	-0.7	0.9	1.4	1.8	1.3	0.0	0.4	0.1	-0.8	-0.3	-0.8	-0.2	-0.5	0.4	0.3
CPUE number	-0.9	1.2	0.6	0.0	-1.0	-0.2	0.4	0.3	-1.2	1.8	3.0	-0.4	0.2	1.1	0.8	-0.1	-0.3	-0.8	-0.5	-1.0	-1.0	-1.3	-0.8	-0.5	-0.2	0.4
CPUE weight	-1.3	1.6	0.2	-0.4	-1.3	-0.4	-0.2	0.2	-1.6	1.8	2.4	-1.0	-0.1	1.1	0.7	-0.1	-0.4	-0.9	0.2	-0.5	-0.4	-0.9	-0.2	0.1	0.4	1.3
DEMOGRAPHY																										
Mean size	-1.2	-0.6	-1.1	-0.9	-1.6	-0.8	-0.8	-0.8	-0.8	-1.0	-1.2	-0.6	-0.5	0.0	0.1	0.2	0.5	0.8	1.3	1.3	1.4	1.2	1.3	1.2	1.2	1.2
Mean size (>2003)																			0.7	0.2	1.7	-1.0	0.8	-1.0	-1.0	-0.3
Sex-ratio									0.7	1.0	1.5	0.6	1.0	-0.3	-0.3	0.4	-1.2	-0.1	-1.9	-1.7	0.2	-0.7	0.6	-0.6	0.2	0.7
FISHING PRESSURE																										
Expl rate	1.6	1.3		1.1		0.9	0.6	0.8	2.5	0.8	-0.4	-0.2	-0.2	-0.7	-0.5	-1.5	0.1	-0.5	-1.4	0.0	-1.0	-0.3	-1.4	-0.9	-0.9	
PRODUCTIVITY REPRODUCTION																										
Berried F	-1.2	-1.0	-1.2	-1.0	-1.5	-1.1	-0.4	-0.6	-1.0	-0.3	-0.3	-0.8	0.6	0.9	0.6	2.5	-0.3	0.2	0.0	0.9	0.5	0.3	1.0	0.5	0.9	1.8
PRODUCTIVITY RECRUITMENT																										
PRE1 abundance EXP-traps																						-1.3	-0.4	-0.2	0.7	1.2

Figure 76. Table summarizing the trend of stock status indicators for LFA 20 from 1986 to 2011. Red = positive trend and blue = negative trend (see text, Section 3.2.8) For comparison purposes, the inverse of fishing pressure (survival) is shown here.

A)



B)

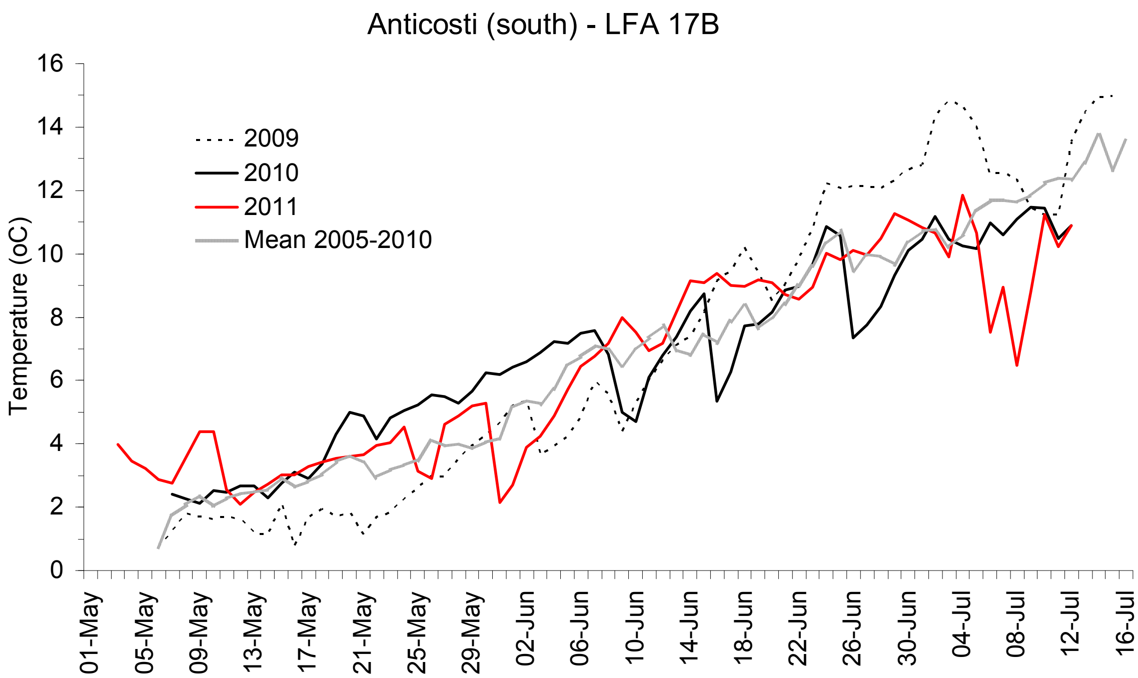


Figure 77. Water temperature on the fishing grounds A) in Tête-à-la-Baleine (LFA 15) and B) Anticosti Island (LFA 17) from 2009 to 2011. The data are from thermographs installed on fishers' traps.

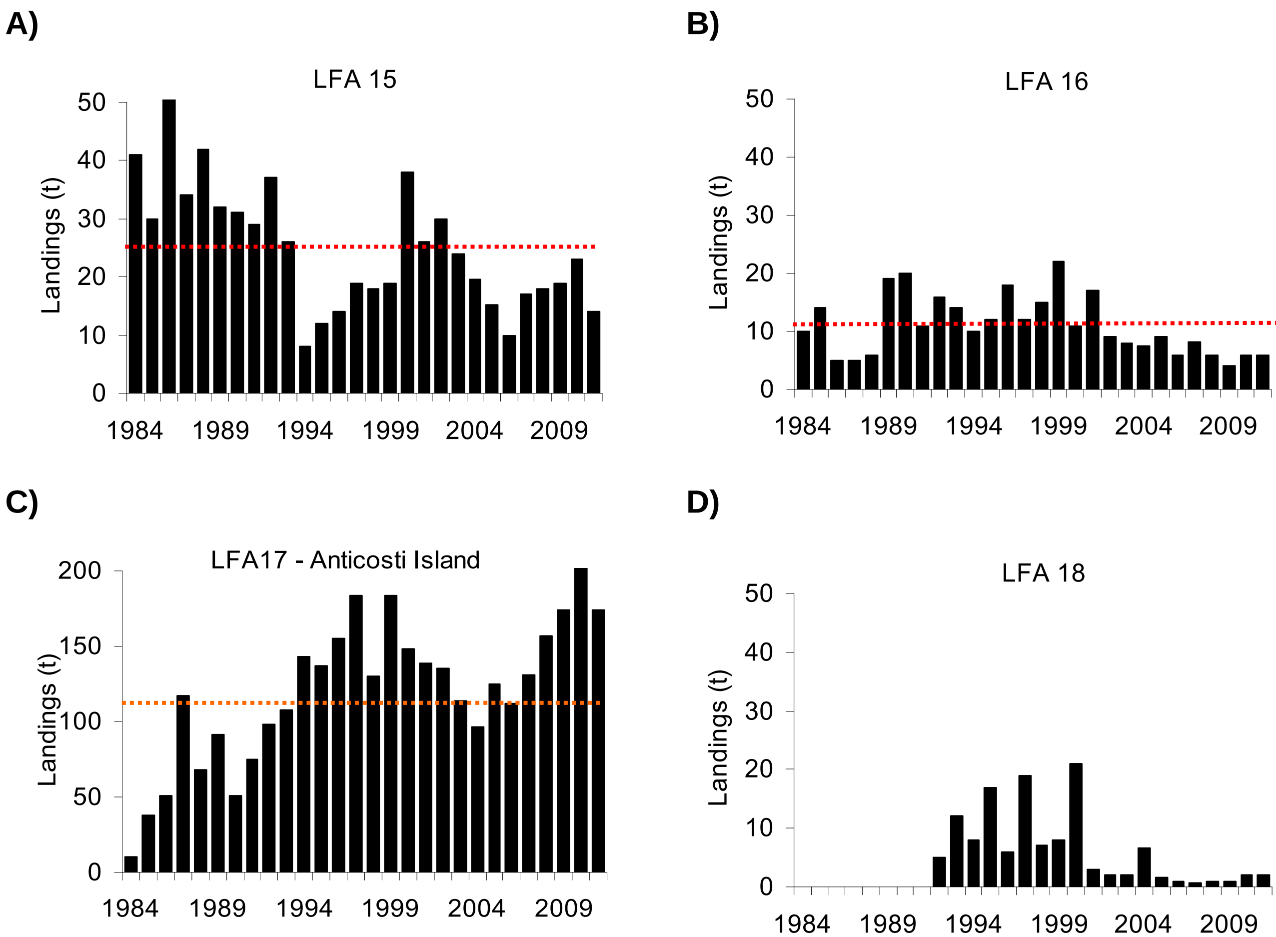


Figure 78. Lobster landings on the North Shore and Anticosti Island from 1984 to 2011. A) LFA 15, B) LFA 16, C) LFA 17 and D) LFA 18. The dotted lines represent the average value for the 1984-2010 period.

A)

B)

C)

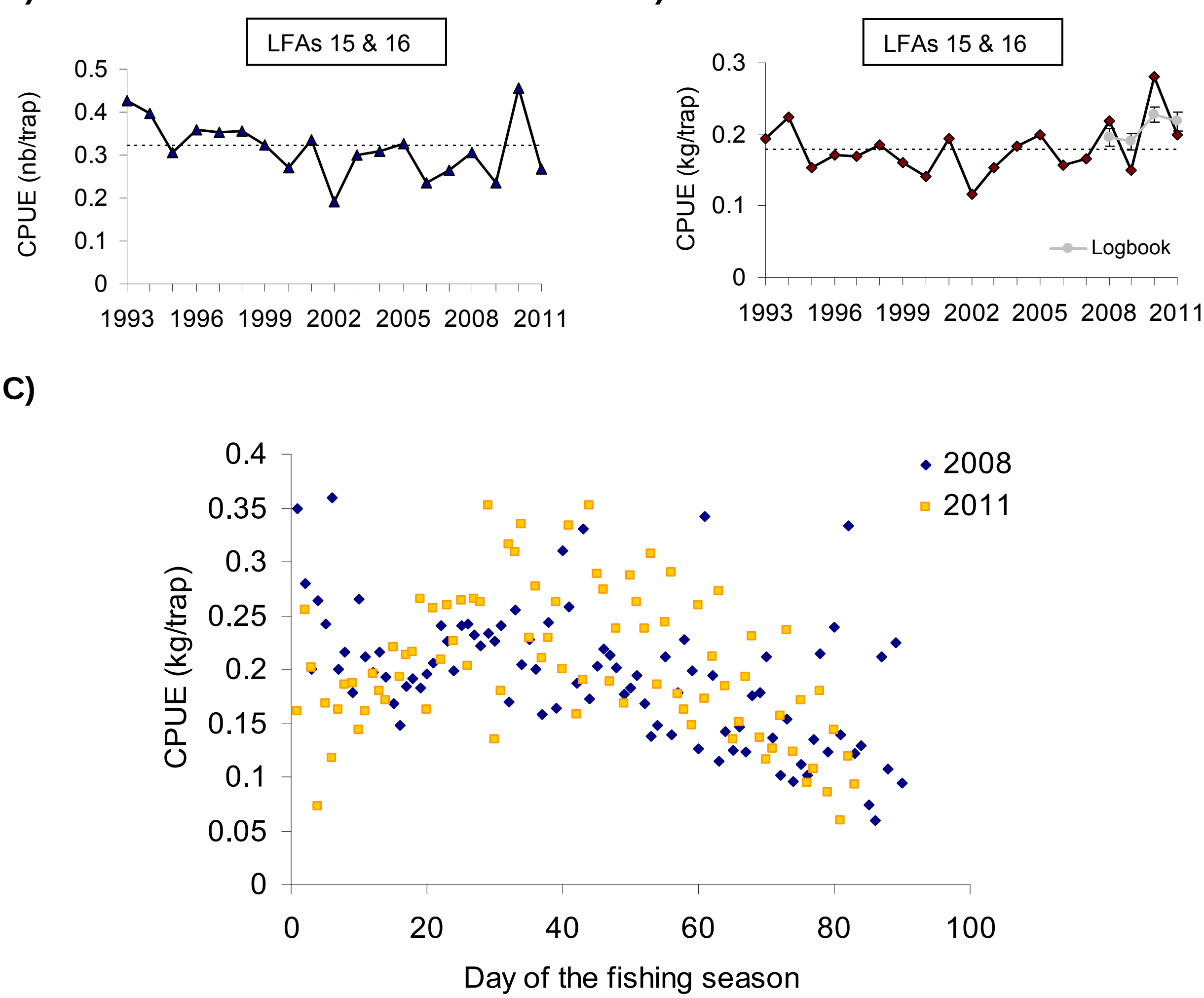
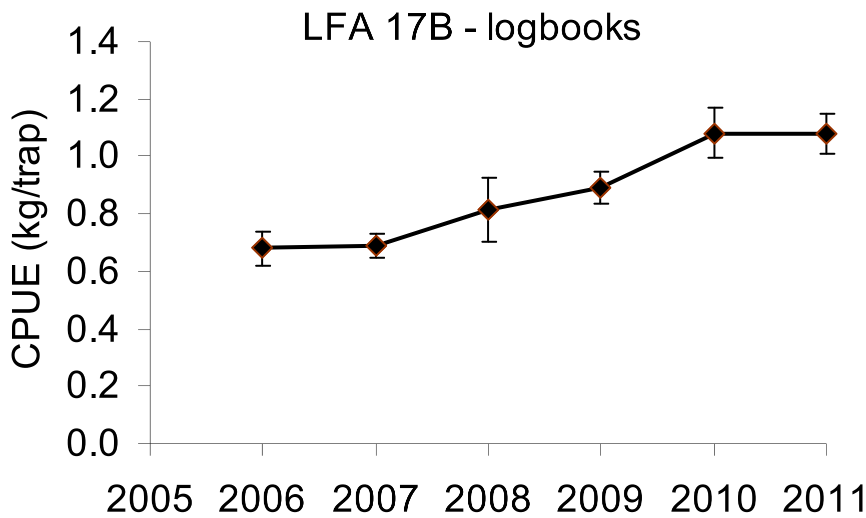


Figure 79. Catch rates (CPUEs) of commercial-size lobster in LFAs 15 and 16 on the Lower North Shore from 1993 to 2011 A) in number and B) in weight per trap and from commercial sampling (at-sea and dockside). For B, the grey line represents data from logbooks, mean ± 95% confidence interval. C) Mean daily CPUE in weight for 2008 (40 fishers) and 2011 (42 fishers). Logbook data.

A)



B)

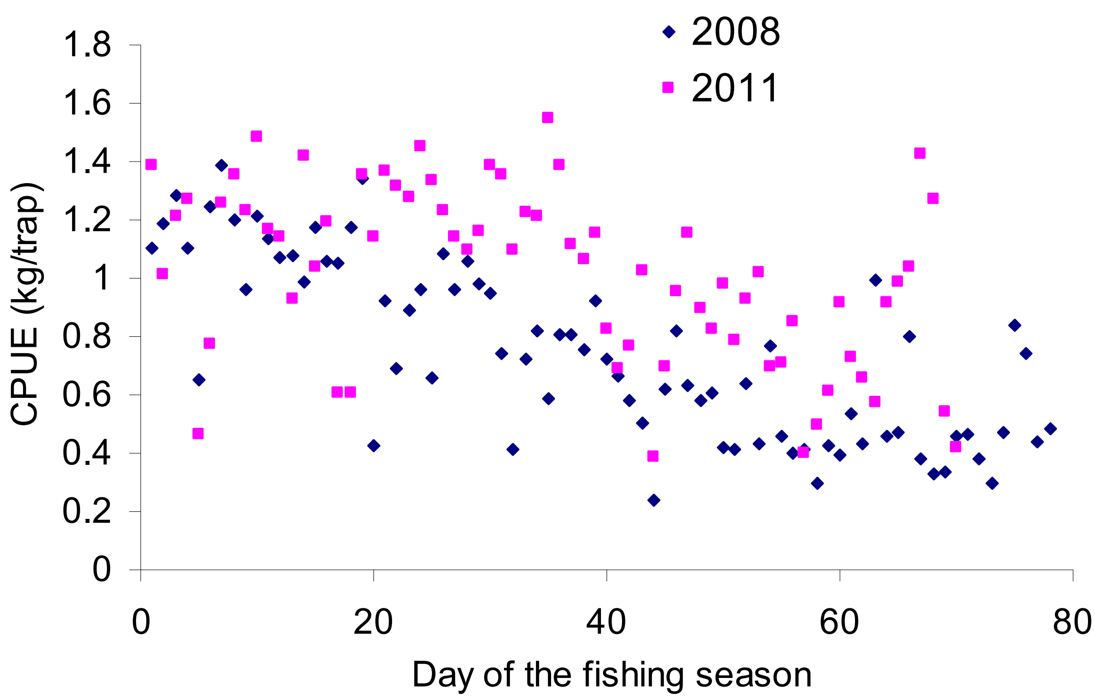


Figure 80. A) Catch rates (CPUEs) of commercial size lobsters in LFA 17B in weight per trap. Logbook data from 2006 to 2011, average ± 95% confidence interval. B) Daily average CPUE in weight for 2008 (15 fishers) and 2011 (14 fishers). Logbook data.

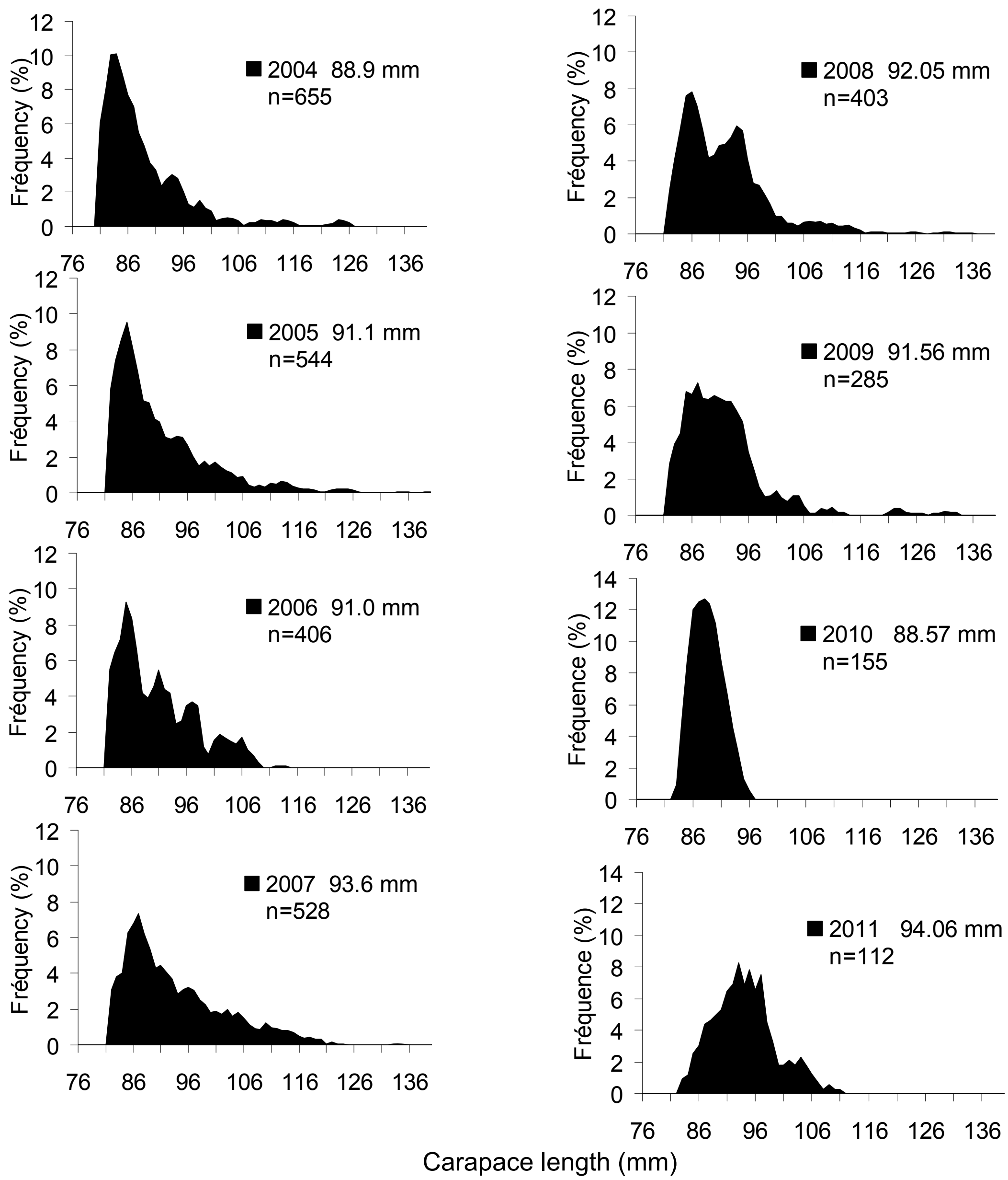


Figure 81. Size frequency distribution for lobster (commercial-size) on the Lower North Shore (LFAs 15 and 16) from 2004 to 2011. Frequencies are in percentage. The mean size and number of lobster measured are indicated.

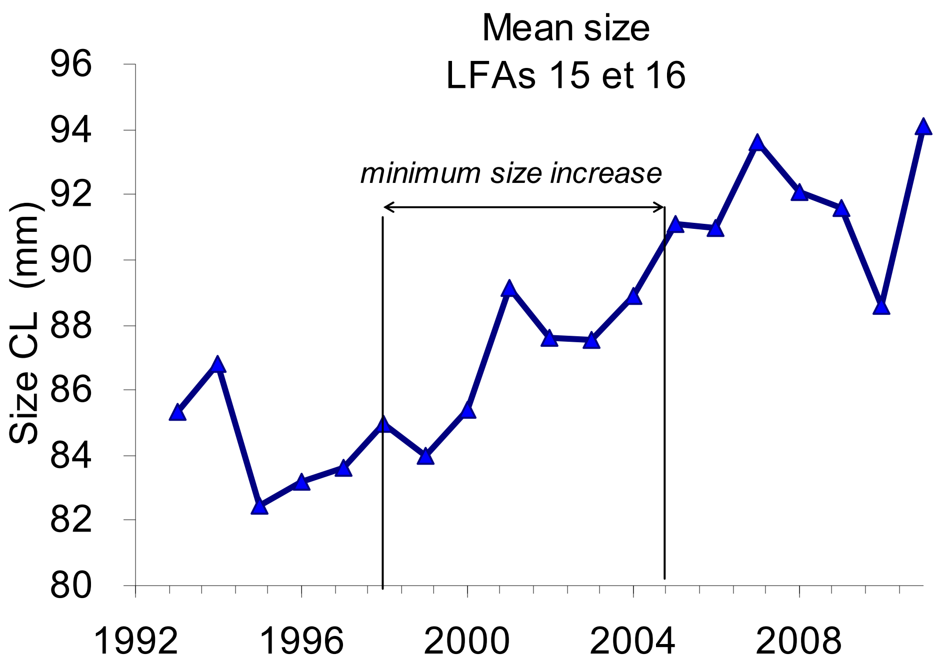


Figure 82. Average size of commercial lobsters in LFAs 15 and 16 from 1993 to 2011. The data are from commercial sampling at sea (1993 to 2004) and dockside (2005 to 2011). No samples were taken in LFA 16 in 2009, 2010 and 2011.

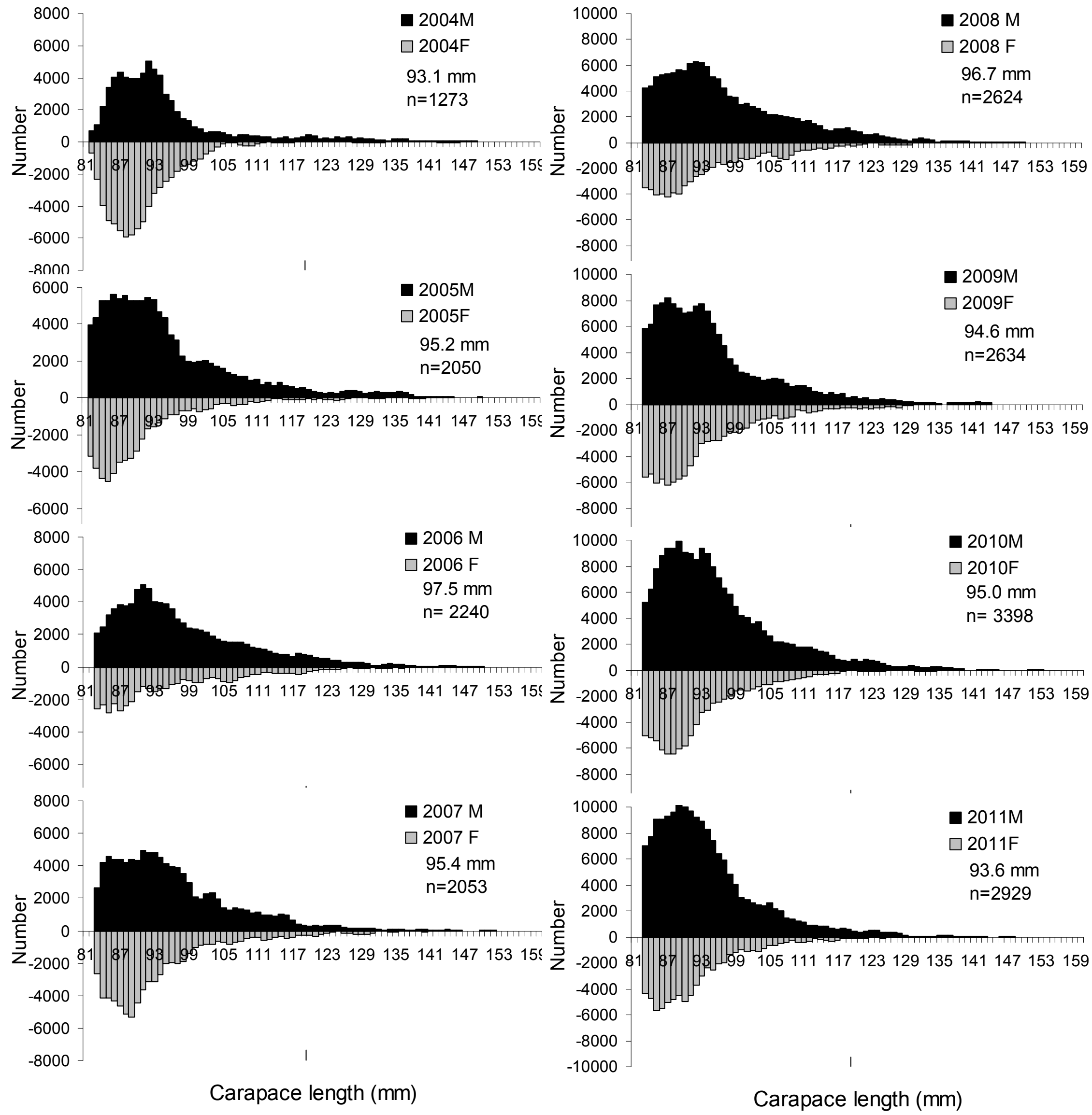
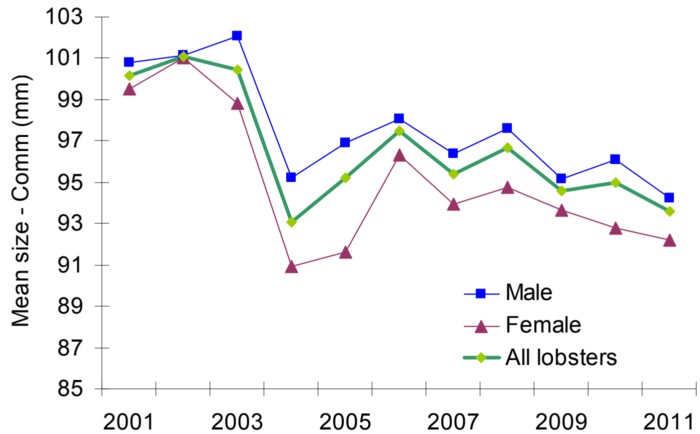
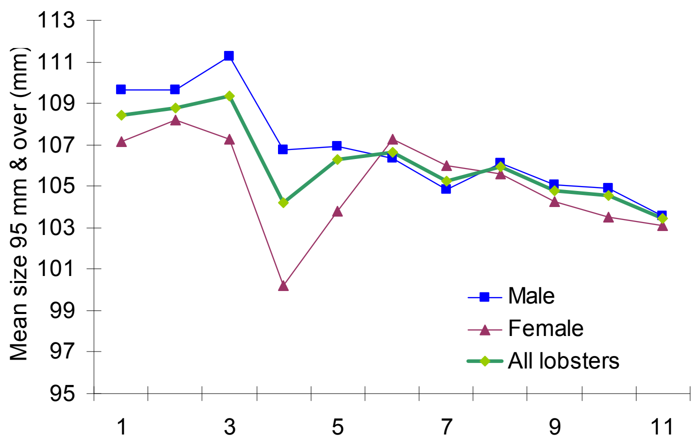


Figure 83. Size frequency distribution for lobster (commercial-size) at Anticosti Island (LFA 17B) from 2004 to 2011. Frequencies are in weighted numbers per landings for males (black) and females (grey). The average size and number of lobster measured are indicated

A)



B)



C)

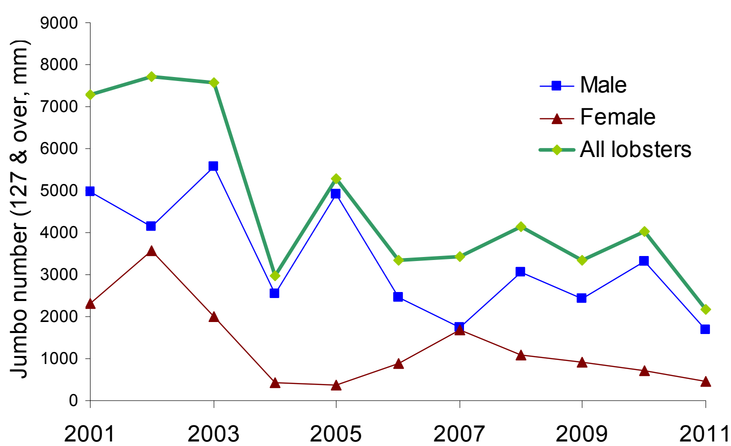


Figure 84. Mean size of A) commercial lobsters (≥ 83 mm), B) lobsters ≥ 95 mm and C) abundance of jumbo lobsters ≥ 127 mm in LFA 17 from 2001 to 2011. Numbers extracted from size frequency distributions weighted by landings from dockside sampling.

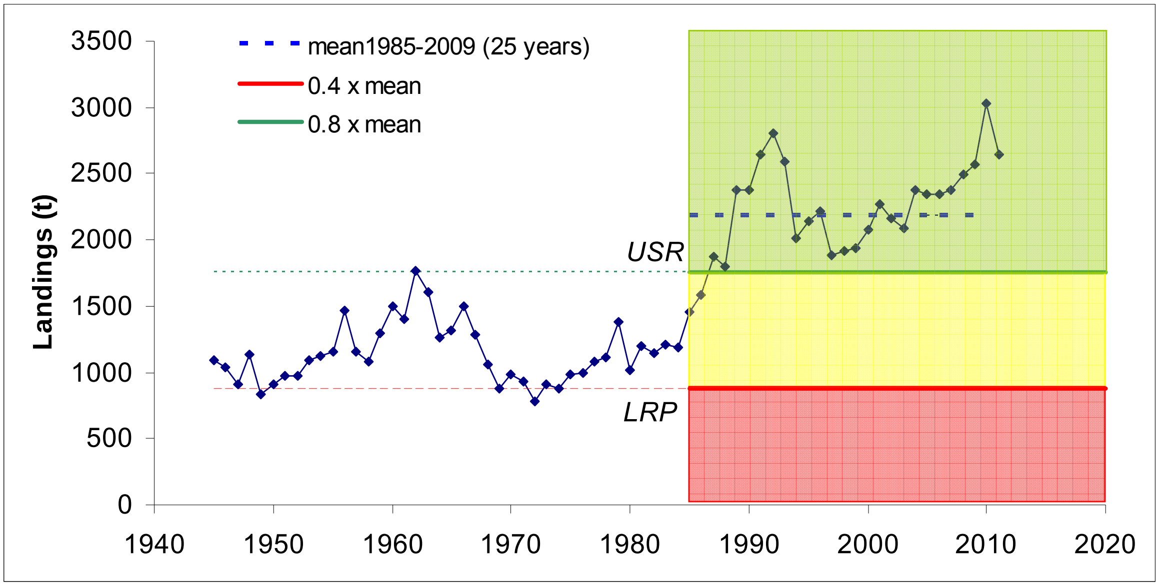


Figure 85. Lobster landings from 1945 to 2011 in the Magdalen Islands and stock status zones (Healthy zone in green, Cautious zone in yellow, Critical zone in red) as defined by the upper stock reference point (USR) and the limit reference point (LRP), which correspond to 80% and 40%, respectively, of the mean landings from 1985 to 2009 (dotted line).

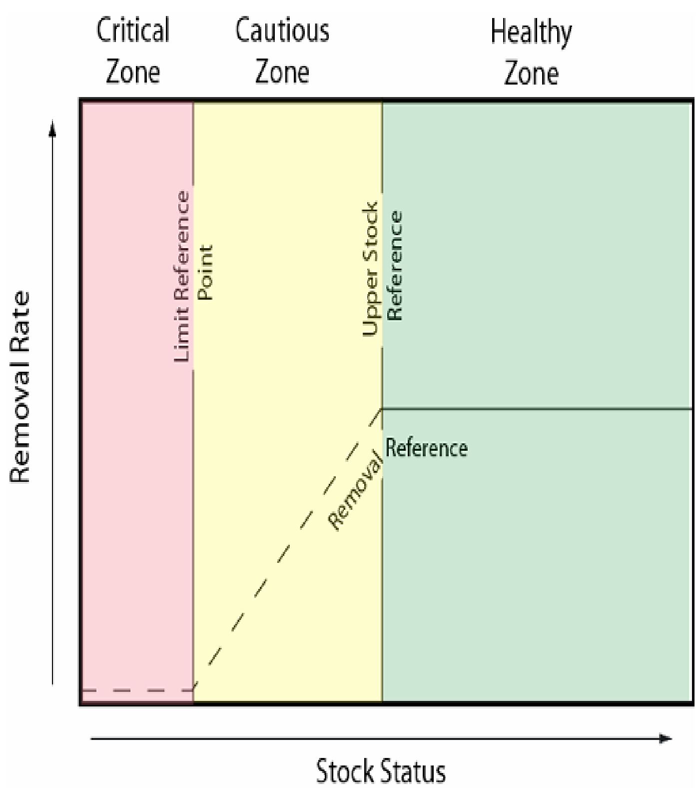


Figure 86. Association between removal rate and stock status in fisheries management framework consistent with a precautionary approach (from Fisheries and Oceans Canada, 20010a).

Indicator : Landings		**Predetermined Action**
HEALTHY ZONE **Above USR**		**HEALTHY ZONE** **No action** **Addition if required Target-RP** **(biological, socio-economic)**
CAUTIOUS ZONE Between USR and LRP		**CAUTIOUS ZONE** **Year 1 : Indicator < URP – No action** **Year 2 : Indicator < URP – Action planned for the following year** **Year 3 : Increase of MLS by 1 mm (83 à 84 mm CL)** **Year 4 : Indicator * < URP – No action** **Year 5 : Indicator < URP – Action planned for the following year** **Year 6 : Reduction of fishing effort by 10 %** **Year 7 : Indicator < URP – No action** **Year 8 : Indicator < URP – Action planned for the following year** **Year 9 : Reduction of fishing effort by 10 %** **monitoring of a new biomass indicator*
CRITICAL ZONE **Below LRP**		**CRITICAL ZONE** **Urgent Action** Partial closure of the fishery sentinel fishery ▪ Managed by a control of the fiishing effort ▪ Managed by quota in case of extreme necessity **Rehabilitation Plan**

Figure 87. Decision rules (predetermined actions) for each stock status zone (Healthy, Cautious and Critical), The rules were determined jointly by DFO – Science and Management – and the industry (Association des pêcheurs propriétaires des Îles-de-la-Madeleine, APPIM).

APPENDIX 1.:
CPUEs (commercial lobsters) in number and weight for the Magdalen Islands and the Gaspé. Annual averages calculated using the method described in Section 2.2.1.1.

CPUE Commercial lobsters
MAGDALEN ISLANDS LFA 22

	CPUE number			CPUE weight (kg)		
	SOUTH	NORTH	TOTAL	SOUTH	NORTH	TOTAL
1985	0.53	0.45	0.50	0.27	0.25	0.27
1986	0.64	0.55	0.61	0.33	0.31	0.33
1987	0.91	0.63	0.82	0.45	0.36	0.42
1988	0.62	0.64	0.62	0.30	0.34	0.31
1989	0.60	0.62	0.60	0.29	0.33	0.31
1990	0.85	0.90	0.87	0.41	0.47	0.43
1991	0.92	0.85	0.90	0.44	0.44	0.44
1992	1.10	1.00	1.07	0.55	0.53	0.54
1993	0.90	0.92	0.91	0.45	0.51	0.47
1994	0.74	0.82	0.77	0.37	0.44	0.40
1995	0.81	0.75	0.79	0.39	0.38	0.38
1996	0.84	0.84	0.84	0.41	0.44	0.42
1997	0.85	0.59	0.77	0.42	0.31	0.38
1998	0.72	0.63	0.69	0.37	0.36	0.36
1999	0.77	0.58	0.72	0.41	0.34	0.39
2000	0.90	0.62	0.82	0.49	0.37	0.45
2001	0.84	0.69	0.79	0.45	0.39	0.43
2002	0.71	0.56	0.67	0.42	0.35	0.40
2003	0.69	0.63	0.67	0.45	0.43	0.44
2004	0.70	0.59	0.67	0.46	0.38	0.43
2005	0.72	0.77	0.73	0.47	0.50	0.48
2006	0.66	0.69	0.67	0.43	0.47	0.44
2007	0.73	0.62	0.69	0.48	0.43	0.46
2008	0.81	0.73	0.79	0.42	0.49	0.44
2009	0.80	0.73	0.78	0.54	0.49	0.52
2010	0.89	0.98	0.92	0.60	0.65	0.62
2011	0.90	0.70	0.84	0.60	0.48	0.56

CPUE Commercial lobsters
GASPÉ LFA 20

	CPUE number				CPUE weight (kg)			
	20A2	**20A8-A9**	**20B5-B6**	**TOTAL**	**20A2**	**20A8-A9**	**20B5-B6**	**TOTAL**
1986		0.43		0.43		0.20		0.20
1987		0.61	0.77	0.67		0.35	0.39	0.36
1988	0.50	0.56	0.70	0.59	0.26	0.28	0.30	0.28
1989	0.62	0.61	0.34	0.53	0.29	0.30	0.14	0.25
1990		0.55	0.43	0.42		0.25	0.22	0.20
1991	0.56	0.51	0.49	0.51	0.27	0.25	0.24	0.25
1992	0.65	0.60	0.51	0.58	0.32	0.26	0.23	0.26
1993	0.73	0.54	0.52	0.57	0.40	0.26	0.24	0.28
1994	0.59	0.36	0.36	0.40	0.31	0.16	0.15	0.18
1995	0.93	0.77	0.58	0.74	0.49	0.38	0.31	0.37
1996	0.92	1.06	0.52	0.88	0.44	0.49	0.24	0.41
1997	0.39	0.57	0.38	0.48	0.19	0.26	0.16	0.22
1998	0.53	0.68	0.35	0.55	0.27	0.32	0.17	0.27
1999	0.60	0.78	0.47	0.65	0.31	0.40	0.24	0.33
2000	0.58	0.78	0.38	0.62	0.33	0.38	0.18	0.31
2001	0.49	0.67	0.28	0.52	0.24	0.36	0.12	0.27
2002	0.36	0.68	0.24	0.50	0.19	0.34	0.12	0.25
2003	0.44	0.54	0.29	0.44	0.25	0.26	0.15	0.22
2004	0.50	0.57	0.31	0.48	0.32	0.34	0.18	0.29
2005	0.29	0.56	0.24	0.42	0.18	0.32	0.15	0.25
2006	0.40	0.48	0.32	0.42	0.24	0.28	0.21	0.25
2007	0.25	0.51	0.24	0.38	0.15	0.29	0.14	0.22
2008	0.64	0.49	0.24	0.44	0.38	0.29	0.15	0.26
2009	0.42	0.61	0.26	0.47	0.26	0.35	0.16	0.28
2010	0.58	0.58	0.32	0.50	0.35	0.33	0.20	0.29
2011	0.73	0.64	0.40	0.58	0.43	0.37	0.26	0.35