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Stock and fishery status of the American Lobster, *Homarus americanus*, in the southern Gulf of St. Lawrence, for 2001 (Lobster Fishing Areas 23, 24, 25, 26A and 26B)

État des stocks et de la pêche du homard (*Homarus americanus),* du sud du golfe du Saint-Laurent en 2001 (zones de pêche du homard 23, 24, 25, 26A et 26B)

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Abstract

Annual lobster commercial catches are highly variable within the southern Gulf of St. Lawrence. Depending on the lobster fishing area, yields on fishing grounds were ranging from 0.8 to 2.3 t/km^2 in 2000. However, the overall lobster catches in the southern Gulf have been slowly declining since the 1990 record landing of 22,063 t, to 17,564t in 2001.

In 2001, the management objective was to have management measures in place to allow for the doubling of the egg per recruit (E/R) from the 1998 values. Although this initial objective was not achieved, there were important progresses made in increasing the overall relative egg production in five fishing areas.

In general, the results presented indicate that the exploitation rate on the resource is still high and the fishery relies heavily on the success and strength of annual recruitment. Overall fishing effort level has shown little changes over the last 15 years.

Résumé

Les captures commerciales de homard présentent d'importantes variabilités annuelles à l'intérieur du sud du Golfe du Saint Laurent. Selon la zone de pêche du homard, les rendements des gisements ont fluctués entre 0.8 et 2.3 t/km^2 en 2000. Cependant, les captures totales de homard pour le sud du Golfe ont tranquillement diminuées depuis le niveau de capture record de 22 063t en 1990, pour atteindre 17 564t en 2001.

En 2001, l'objectif de gestion était d'avoir des mesures de gestion en place permettant de doubler le niveau d'œuf par recrut (O/R) par rapport au niveau de 1998. Bien que cet objectif initial n'ai pas été atteint, il y a eu des progrès importants dans l'augmentation globale du niveau d'œuf par recrut dans chacune des cinq zones de pèche du homard.

En général, les résultats présentés indiquent que le taux d'exploitation sur cette ressource est toujours élevé et que la pêcherie dépend beaucoup sur le succès et la magnitude du recrutement annuel. Dans l'ensemble, le niveau d'effort de pêche a peut changé au cours des dernières 15 années.

1.0 Introduction

1.1 Fishery

The Canadian lobster (*Homarus americanus*) fishery began in the mid 1800's in numerous locations of the Atlantic Provinces, including the southern Gulf of St. Lawrence (sGSL). Over more than a century, the fishery essentially developed as a nearshore small-boat fishery, involving a large number of harvesters and using only passive fishing gear (i.e. lobster traps). General overviews and historical facts about the lobster fishery in Atlantic Canada can be found in DeWolf (1974), Brun (1985) and Landry (1994).

Lobster catch information for the sGSL can be traced back to the 1890's. During a short period corresponding to the transition between the 19th and 20th century, high lobster catches were reported in the sGSL. These years of good catches were rapidly followed by an overall decline in landings in the early part of the 1900's, which are often link with technological improvements in the fishing sector, and the resulting expanding fishing effort. Annual catches decreased from 15,000 t annually in 1895 to landings fluctuating around 8,000 t between 1915 and 1975. It is only in the mid 1970's that lobster landings in the sGSL regained in strength, reaching record high landings of 22,000 t in 1990 (Fig. 1).

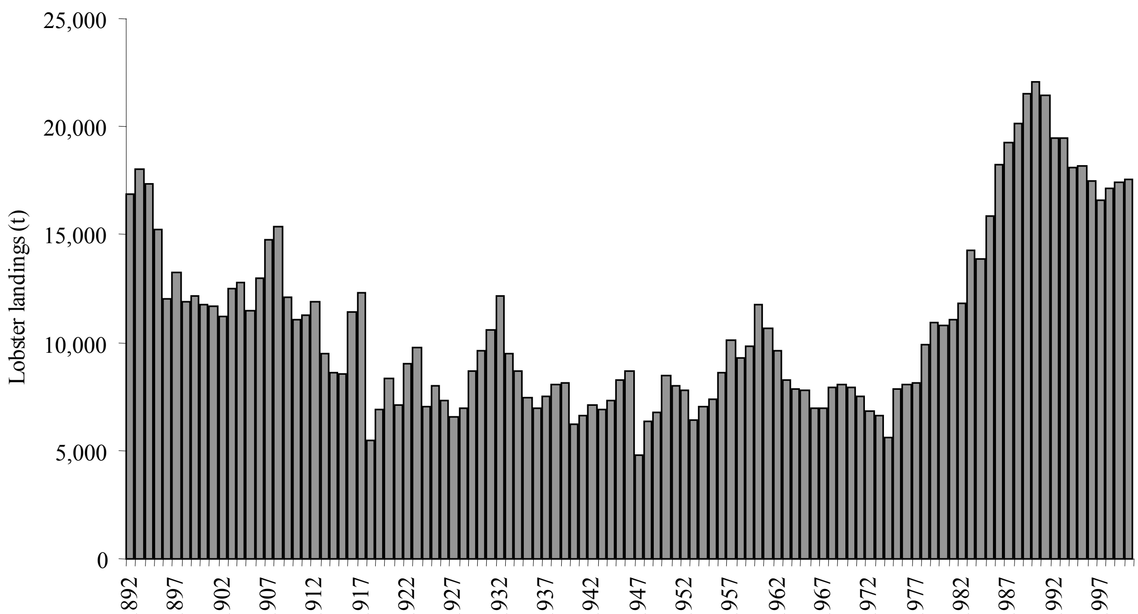

Figure 1. Historical lobster catches in the southern Gulf of St. Lawrence (DFO, Gulf Region) from 1892 to 2001.

The causes for the extraordinary catch increase in the last 25 years are not well known. It is believed that the overall fishing power has substantially increased when economic and technological developments took an accelerated pace after the Second World War. However, this alone cannot explain the magnitude of the increase that was seen all over the geographical range of the American lobster, from North Carolina to Labrador. Favorable environmental factors are believed to have favored the survival of lobster recruitment over its entire distribution range.

Over the years, the lobster fishery has become and still plays a major role in the social and economic development of communities along the Atlantic coast, and especially to communities in the sGSL. In 2001, the 3,180 license holders in Lobster Fishing Areas (LFA) 23, 24, 25, 26A and 26B have caught more than 17,000 t of lobster for a landed value of approximately $200 million.

Table 1. Management measures to control lobster fishing effort in the southern Gulf of St. Lawrence (2001).

Management measures	**Descriptions/Explanation**				
Division of the coastal area in Lobster Fishing Areas (LFA)	LFA 23	LFA 24	LFA 25	LFA 26A	LFA 26B
Fishing season	May - June	May - June	Early Aug. to early Oct.	May - June	May - June
Number of license holders	722	614	793	749	251
Number of traps/license holder	300	300	250	300	300
Restriction of gear type	Traps (no restriction on internal design)				
Trap overall dimension	Length = 125 cm, Width = 90 cm, Height = 50 cm				

1.2 Management

The lobster fishery is certainly one of the most regulated fisheries on the Canadian Atlantic coast. Throughout the last century, numerous management measures were implemented and some are still in place today. The sGSL lobster fishery management regime is based entirely on effort control (i.e. input fishery) in five management areas (Fig. 2). This regime is characterized by a combination of different and common management measures in each LFA (Table 1). The most important measures aimed at controlling effort are the fixed number of license holders, a trap allocation for each license holder and fishing seasons. Since the implementation of regulations limiting fishing activities by LFA in 1934 and especially following the introduction of limited access to fishing licenses in 1967

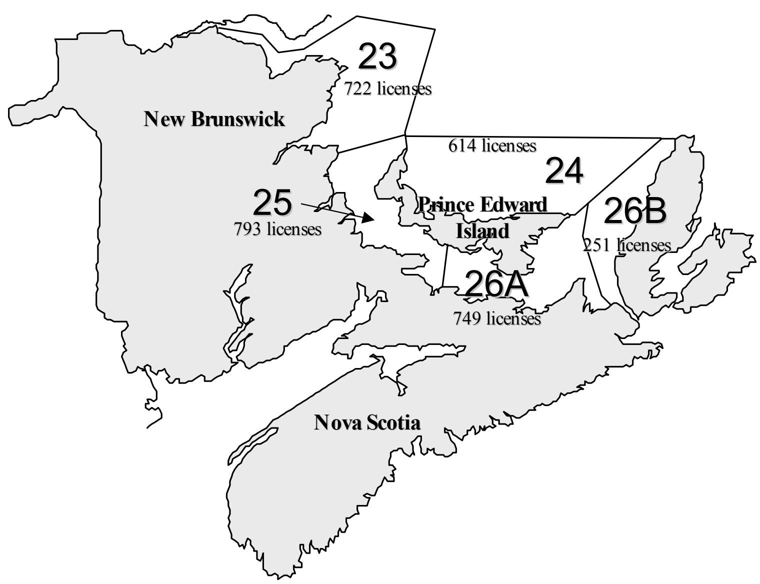

Figure 2. Lobster Fishing Areas and number of lobster fishing license holders.

(DeWolf, 1974), the number of license holders has been somewhat stabled to approximately 3,200. The geographical location of each LFA and the distribution of license holders are presented in Fig. 2.

The lobster fishery also has numerous regulations aimed at controlling the size and type of lobsters that fishermen can keep. The two primarily management measures to protect lobsters are the minimum legal size (MLS) and a prohibition for fishermen to keep and land egg-bearing lobsters. The first measure is to allow lobsters to reach sizes where they

Table 2. Management measures to control the size and type of lobsters kept by fishermen, and to minimize indirect fishing mortality in the southern Gulf of St. Lawrence (2001).

	Lobster Fishing Area (LFAs)				
Management measures	**LFA 23**	**LFA 24**	**LFA 25**	**LFA 26A**	**LFA 26B**
Minimum legal carapace size[1]	67.5 mm	67.5 mm	67.5 mm	67.5 mm	70.0 mm
Landing of egg-bearing females is prohibited[2]	Common to all LFAs				
Rectangular escape mechanism in the parlor section of the trap[3]	Common to all LFAs Dimensions: width = 127 mm, height = 38.1 mm				
Biodegradable mechanism in the parlor section of the trap[4]	Common to all LFAs Dimensions of unobstructed opening not less than 89 mm in height and 152 mm in width				

1 – To maximize yield and allow a portion of the lobster population to reach sexual maturity before being harvested.
2 – To protect the reproductive potential.
3 – To minimize waste by reducing the capture of lobsters under the minimum legal size and potential indirect fishing mortality.
4 – To minimize indirect fishing mortality (ghost fishing) when traps are lost at sea.

become sexually mature and the later is to protect known offspring reproducers (broodstock). As for the effort control, management measures may differ between LFA and some are common throughout the sGSL. These measures are summarized in Table 2.

Numerous changes in MLS were implemented since the 1900's. The most prominent one is certainly the MLS of 63.5 mm that was imposed in 1952 for the entire sGSL. However, by the end of the 1980's, representatives from the fishing and processing sectors were requesting actions to improve the conservation aspects and the economic benefits of the resource. Consequently, MLS were increased in all LFAs, except LFA 24, between 1987 and 1991. Although the initial plan was for all LFAs to increase the MLS, not all areas went through the full process of size increases, and by 1991 there was four (4) different regulated MLS in the sGSL. Further increases occurred from 1998 to 2001. At the end of 2001, the number of regulated MLS in the sGSL was reduced to two (2); 70 mm in LFA 26B and 67.5 mm in all other LFAs. A summary of the regulatory changes in MLS that occurred in the sGSL is presented in Appendix I.

Some regulations are also implemented to minimize waste or indirect fishing mortality. These regulations stipulate that each trap must be fitted with both escape and biodegradable mechanisms. The escape mechanism consists of a regulated opening, near the base of the trap, allowing sub-legal size lobsters to exit the trap when it is on the fishing ground. The objective of the escape mechanism is to minimize handling and potential mortality of sub-legal size lobsters. These mechanisms are installed in the parlor section of the traps (section with no entrance from the outside). Prior to 1996, rectangular (width = 127 mm, height = 38.1 mm) and circular (44.24 mm or 50.8 mm in diameter depending on the LFA) escape mechanisms were allowed. In 1996, the rectangular shape mechanism became the only one accepted in the entire sGSL (Table 2).

The biodegradable mechanism consists of a portion of the trap wall that can detach or decompose if the trap is lost at sea. The regulation requires that each trap be fitted with a biodegradable mechanism allowing a minimum opening of 152 mm in width and 89 mm in height. Since 3% to 4% of the traps in use in the sGSL are lost at sea each year (Lanteigne, 1999), the objective of this regulation is to minimize the impact of these traps as they continue trapping marine animals, including lobsters. The regulation requires the use of organic material (cotton and wood) or steel to construct or attach the biodegradable mechanism. These materials are assumed to disintegrate after a certain period in the water.

1.3 Conservation strategy

In 1994, the Fisheries Resource Conservation Council (FRCC) was requested by the federal fisheries Minister to review the current approaches to conservation, and recommend strategies for the lobster populations of the entire Canadian Atlantic coast. In November 1995, the FRCC presented their report titled "A Conservation Framework for Atlantic Lobster" (Anonymous, 1995). The FRCC concluded that the present fisheries were operating at high exploitation rates, harvesting primarily immature animals and did not allow for adequate egg production. It was recommended to implement a new conservation framework, to establish seven conservation units (Lobster Production Areas) and increase egg production. A precautionary biological reference point was adopted in the form of a target level of egg production per recruits (*E/R*). A level equivalent to 5% of that of an unfished population was recommended.

The FRCC report has presented an extensive overview of *E/R* values for the entire lobster fisheries on the Canadian Atlantic coast. These values were obtained with a model designed in the United States and adapted to the Canadian lobster fisheries. However, some biases in the parameters required by the model were raised by Canadian biologists, especially on the parameters relating to growth, natural and molting mortality, and exploitation rates. This situation of uncertainty for some parameters was creating difficulties in assessing adequately the status of each LFA in relation with the target of 5% *E/R* and resulted in further research work and refinement of the model used to calculate the E/R values. In addition, more time was given to the fishing industry to discuss the issues and to work on conservation and harvesting plans.

The official announcement from the Department of Fisheries and Oceans (DFO) on the sGSL lobster conservation measures was presented on 22 April, 1998. However, despite general agreement by the fishing industry for the need to change, there was no agreement on the FRCC target. As a result, doubling E/R was selected. This target resulted in conservation measures adapted for each LFA in the sGSL. The objective was to make changes over four years (1998-2001) and be in a position to at least double E/R (often incorrectly referred as egg production) of the lobster population prior to 1998. A detail description of the four-year management plan is presented in Appendix II.

In addition to the management measures indicated in the four-year plan, fishermen in some LFAs and portion of LFAs initiated additional measures that favored further increase in egg production. In LFA 23, fishermen agreed to reduce the trap allocation from 375 traps to 300 traps per fisherman over three years (1998 to 2000) at a rate of 25 traps per year. In LFA 26A, fishermen from the province of Nova Scotia (NS) initiated a MLS increase in 1996. By 2001, most of the fishermen in LFA 26A NS were fishing at a MLS of 70mm. Fishermen from Prince Edward Island (PEI) sharing the same LFA continued fishing at a MLS of 67.5 mm, as per the management plan.

2.0 Biological Background

2.1 Movement

Based on tagging studies, the average distance traveled by lobsters is generally less than 15 km in the Gulf of St. Lawrence (GSL), (for review see; Stasko, 1980; Lawton and Lavalli, 1995; Comeau et al., 1998, Comeau and Savoie, 2002a). Similar studies on lobster movements have been carried out in inshore waters outside the GSL with, however, a important difference concerning long distance movements of more than 90 km for up to 20% of the animals (Dow, 1974; Fogarty et al., 1980; Campbell and Stasko, 1985, 1986; Campbell, 1989; Robichaud and Lawton, 1997). Lobster movements of more than 40 km are rare in the GSL and movements exceeding 70 km have never been observed. To explain this lack of long range movements in the GSL, Comeau and Savoie (2002) indicated that the extensive cold (<1.5°C) intermediate layer (CIL) appeared to be an effective barrier to lobster movements across the GSL, and suggested that the lobster movement in the GSL is temperature-dependent.

Two types of movements have been described for lobsters in the sGSL; 1) seasonal movement perpendicular to the coast and 2) movement along the coast near shore. Seasonal movements to inshore waters in the spring and back to deeper waters during the cold season have been documented (Templeman, 1936; Corrivault, 1948; Bergeron, 1967; Munro and Therriault, 1983; Ennis, 1984) and are well known by fishermen. This type of movement refers strictly to perpendicular movement from the coast to depths close to the CIL. Comeau and Savoie (2002a) reported that lobster movements oriented along the coast are mostly in inshore waters (<20 m), and the distances are related to the local topography and are depth-dependent. They observed that lobsters traveled longer distances in areas characterized by a gradually sloping bottom where the distance between the shore and the 20 m contour line is extensive (e.g.: central Northumberland Strait, Caraquet Bay, Malpeque Bay), then in areas characterized by rapidly changing depths and relatively small amount of habitat shallower than 20 m (e.g.: west coast of Cape Breton). Comeau and Savoie (2002a) further indicated that the distance traveled by lobsters in the sGSL is not sex- or size-dependent, except for berried females. They observed that on average berried females traveled shorter distances than males and non-berried females, and indicated that the distance traveled by berried females could be related to their physiological state (carrying eggs).

In terms of fishery management, the main concern of fishermen in the sGSL is lobster movements in relation to time, i.e. if lobsters released in a given area in one season will be recaptured in the same area in future seasons. Recently, Comeau and Savoie (2002a) indicated that distances traveled by lobsters are not time-dependent, i.e. lobsters do not move farther if they are at large for a longer period. Hence, since lobsters in their benthic stages have little long distance interaction, movements in the sGSL should have minimal consequences in terms of lobster management.

2.2 Growth

Lobsters grow by replacing their rigid carapace by a new and larger one during a process called molting. The main molting period for lobster in the sGSL is from early July to early September. Based on tagging studies conducted in Baie des Chaleurs, Comeau and Savoie (2001) indicated that male lobsters had significantly larger molt increments than females, and estimated them at 16.8% and 15.2% respectively. These tagging results are based solely on lobsters tagged in postmolt and intermolt stages, since lobsters tagged in premolt stages are showing significantly lower molt increments. The difference in molt increment is believed to be related to tagging trauma which is likely greater for lobsters actively developing a new carapace prior to molting (Comeau and Savoie, 2001). Other authors have also reported a higher molt increment for male compare to females (Templeman, 1933, 1936; Wilder, 1953, 1963; Squires, 1970; Ennis, 1972; Conan et al., 1982; Maynard et al., 1992). Female lower growth rate is believed to be related to the egg production (female maturity), which has a greater stunting effect than sperm production, and can also be observed by the lowest average percentage of molt increment for berried females, i.e. mature females (Comeau and Savoie, 2001). Furthermore, Comeau and Savoie (2001) also reported that the molt increment rate is not size-dependent for lobsters from the sGSL ranging in size from 50 to 90 mm of carapace length (CL).

Molting frequency, one important parameter related to growth and required in the E/R model, can be influenced by many factors (Waddy et al., 1995). Temperature, or the seasonal temperature regime, is the most important factor and has been directly related to influence the number of molt in a year and the period of the annual molting (Templeman, 1936; Munro and Therriault, 1983; Tremblay and Eagles, 1997; Comeau and Savoie, 2001). Size is also important as the molting probability declines with increasing size (Ennis et al., 1982; Campbell, 1983; Tremblay and Eagles, 1997). Conversely to Templeman (1936) and Munro and Therriault (1983) that reported double molting in specific areas of the sGSL, Comeau and Savoie (2001) showed that there is little evidence of a widespread double molting (<0.2%). Based on tagging and trap studies, and as reported by Moriyasu et al. (1999), Comeau and Savoie (2001) showed evidence of two molting seasons for male lobsters. Further, they reported evidence of animal skipping their annual molt in the sGSL. The major difference between areas with double molting compared to areas where it is not detected is the high temperature observed in May and early June. Hence, Comeau and Savoie (2001) concluded that the accumulation of degree-days (the cumulative daily mean temperature recorded above $0^{o}C$) in the early part of the season seems to be the most important factor influencing the timing of the molting period and, perhaps, the number of molt per year for lobsters.

With a better knowledge of lobster growth, it would be worthwhile to investigate the sensitivity the *E/R* model proposed by the FRCC (Anonymous, 1995), to growth variations. It would be imperative to insure that the E/R model could incorporate different molt increments as observed for females (berried and non-berried), and molt frequencies, as well as occasionally skip molting or double molting.

2.3 Maturity

Lobster maturity can generally be defined by either the ability to produce mature gametes (gonadal maturity), or to mate and spawn efficiently (functional maturity). Gonadal maturity for male lobster can be determined by the presence of spermatozoa from vasa deferentia smear (Krouse, 1973). Based on that technique, the size at 50% of the onset of sexual maturity (SOM_{50}) is estimated at 49.8 mm CL for males from the sGSL (Conan et al., 2001). Male gonadal maturity is a prerequisite to fertilize oocytes, but it does not correspond to the size at which the male lobster can copulate (functional maturity). For males, the size at gonadal maturity only provides the minimum or a conservative estimate of the SOM_{50}. The problem for establishing the functional maturity of male lobsters is the lack of an accurate and practical technique. Although many authors have used morphometric techniques to establish functional maturity (for review see; Waddy et al., 1995), Conan et al. (1985, 2001) showed that these approaches cannot be used to detect maturity for male lobsters because the secondary character (claws) gradually changes from early juvenile stages. As an alternative, Conan et al. (2001) suggested to indirectly estimate the male SOM_{50} using the easier to estimate female SOM_{50}, since female lobsters make the initial mate choice and will seek dominant males comparable to their postmolt size (Atema et al., 1979; Cowan and Atema, 1985, 1990; Atema, 1986).

Size at the onset of sexual maturity for female lobsters can easily be established by the observations of the ovarian condition, either color or weight, and cement glands staging. However, it cannot be detected by the morphometry of their abdomen (Conan et al. 1985; Comeau and Savoie, 2002b). Conversely to male lobster maturity, there is a direct relation between the maturity of the ovaries and mating or egg laying for female lobsters (Aiken and Waddy, 1982; Waddy et al., 1995). Recently in the sGSL, Comeau and Savoie (2002b) estimated female SOM_{50} at 70.5 mm CL. Their estimated SOM_{50} is similar to the one reported by Conan et al. (1985), but smaller than the one reported by Campbell and Robinson (1983). Comeau and Savoie (2002b) explain that difference on the techniques and criteria used. They demonstrated that conversely to Campbell and Robinson (1983) that used stage 3, mature ovaries correspond to stage 2 of the glands staging technique during the period of the year they did their observations. It is clear that using the stage 3 will underestimate the number of mature females observed, thus giving a larger SOM_{50}.

One important parameter related to maturity that is also needed for the E/R model is the female reproductive cycle. Small mature female lobsters (CL <120 mm) are thought to follow a 2-year reproductive cycle (Aiken and Waddy, 1982). In a typical cycle, females are molting and mating during the same summer, extruding the eggs the following year, and carrying them attached on pleopods under the abdomen for nearly another year. This 2-year reproductive cycle may be shortened to one year for primiparous (first spawners) females by fluctuation of environment factors, mainly temperature (Templeman, 1934, 1936; Waddy and Aiken, 1992; Waddy et al., 1995; Comeau and Savoie, 2002b). The reproductive cycle is also influenced by the female size, as larger females can spawn in successive years before molting (Waddy and Aiken, 1986). Recently, Comeau and Savoie (2002b) have challenged these believed as they demonstrated that molting and spawning in the same year is not restricted to small primiparous females nor is the 1-year reproductive cycle limited to larger females (CL >120 mm) in the sGSL. Although they found that the majority (80%) of small mature females had a typical 2-year reproductive cycle, they also found that up to 20% of small multiparous (multiple spawners) females could spawn in successive years instead of the generally accepted 2-year cycle, and some could even molt and spawn during the same summer. Similarly, up to 20% of primiparous females, as it was also reported by Aiken and Waddy (1982), could molt and spawn (for the first time) in the same year instead of spawning the following year. Furthermore, Comeau and Savoie (2002b) reported that a low percentage (5%) of small mature females could also skip molting or spawning for a year. These recent findings suggest that females from the sGSL have the opportunity to produce over the years a larger quantity of eggs than previously believed.

One of the most important regulations of a lobster fishery is the MLS that is often set based on female SOM_{50} (Campbell, 1985). For conservation purposes, this MLS should be set to allow an acceptable number of females to mate, and produce eggs at least once before being captured. In order to achieve a healthy fishery, the MLS should be set at 70.5 mm CL to allow 50% (Comeau and Savoie, 2002b) of primiparous females to spawn at least once before entering into the fishery. This would be considered a minimal precautionary measure. Ideally, the full reproductive potential of the stock in term of primiparous female could be protected and the MSL set at 79 mm CL. Sensitivity of the *E/R* model to variability of the female reproductive cycle should be investigated. Moreover, it would be imperative to modify the E/R model in order to incorporate the 1- and 2-year reproductive cycles with or without molting for small mature females which is currently absent from the model.

3.0 Material and methods

3.1 Data sources

3.1.1 Official catch statistics

Official lobster catch statistics for each LFA were obtained from the Policy and Economics Branch of DFO. The database consists of a compilation of sale transactions conducted between official lobster buyers and fishermen for the entire sGSL. Although this information is essentially documenting monetary transactions, it is assumed that the volume sold to official lobster buyers closely represents quantity of lobster caught by commercial fishermen.

3.1.2 At-sea sampling program

Lobster size structure in commercial traps was obtained from at-sea sampling program. The program has been in place for more than 20 years. Although the program went through numerous changes over the years, the sampling is still conducted by scientific staff onboard commercial fishing vessels during the fishing season, at several fishing ports. One sea sample is defined as one day at sea with one fishermen of a given port. Onboard the vessel, sampling technicians are requested to measure all the lobsters (to the lowest mm) from as many traps as possible. The sex, condition, and egg stage of berried females are also recorded.

Table 3. Number of index-fishermen that provided daily catch and effort information (percentage of all the license holders in the sGSL participating in the logbook program in parenthesis).

	Lobster Fishing Areas (LFAs)					**Total**
Years	**23**	**24**	**25**	**26A**	**26B**	**sGSL**
1993[1]	15	3	11	9	1	39 (1.2%)
1994	27	6	37	15	7	81 (2.6%)
1995	32	26	34	26	13	102 (3.3%)
1996	39	29	32	27	11	135 (4.3%)
1997	36	28	33	32	11	132 (4.2%)
1998[2]	27	14	29	29	7	98 (3.1%)
1999	34	28	36	42	21	122 (3.9%)
2000	27	24	34	48	21	154 (4.9%)
2001	30	67	41	58	18	214 (6.8%)

1 - Data from the first year of the program were not considered in the analyses.
2 - Numerous volunteer fishermen refused to participate into the program after the implementation of the 4-year management plan, especially in LFA 24.

The number of fishing days sampled during the at-sea sampling program represents a small fraction of the total number of fishing days conducted by the entire sGSL lobster fishing fleet. From 1983 to 2001, an average of 54 at-sea samples was conducted annually. This represents approximately 0.03% of the total annual fishermen's sea days in the sGSL.

3.1.3 Index-fishermen program

Catch and effort data are obtained from the lobster index-fishermen program. The program, initiated in 1993, relies on fishermen recording their fishing activities on a daily basis. Since it is not a mandatory requirement of their license, and fishermen are participating on a voluntary basis, the number of participants has fluctuated over the years (Table 3). The first year of the program was considered the initiation and training year, and was not considered in the analyses. Data collected include daily catches of lobster by category (i.e.: canners and markets), number of trap hauls and weather condition. In 2001, the number of participants to the logbook program represented 6.8% of the sGSL fishermen.

3.1.4 Bottom water temperature

A coastal water temperature monitoring program was initiated in the sGSL in 1995. Over the years, changes were made to the methodology used for the deployment and retrieval of the temperature recorders, and the monitoring sites. A description of the methodology and location of the sites can be found in Lanteigne et al. (1996) and Savoie et al. (2002). This network of recorders is installed on an annual basis, for most of the ice-free season. All devices are set to record temperature every two hours.

For the purpose of this assessment, a limited number of sites were selected. The sites selected were deemed representative of the general area and had multiple years of temperature monitoring. The selected sites are presented in Fig. 3.

3.2 Data analyses

3.2.1 Estimations of fishing effort

Based on present fishing regulation on effort control, a trap haul was considered as the unit of fishing effort. Three (3) methods were used to estimate fishing effort in each LFA; 1) the maximum potential trap hauls, 2) the estimated reported trap hauls from sale transactions, and 3) the estimated reported trap hauls from index-fishermen. The parameters and data used to calculate fishing effort are presented in appendix III.

The maximum potential trap hauls (*MP*) was defined as the total number of trap hauls permitted by regulations, in a given LFA and for an entire fishing season. For a particular LFA, the *MP* is defined as:

$$MP_{LFA} = NF_{LFA} \text{ x } TA_{LFA} \text{ x } ND_{LFA} ,$$

where, for each LFA;
NF = number of licensed fishermen, *TA* = trap allocation per fisherman, and *ND* = number of potential fishing days in the season.

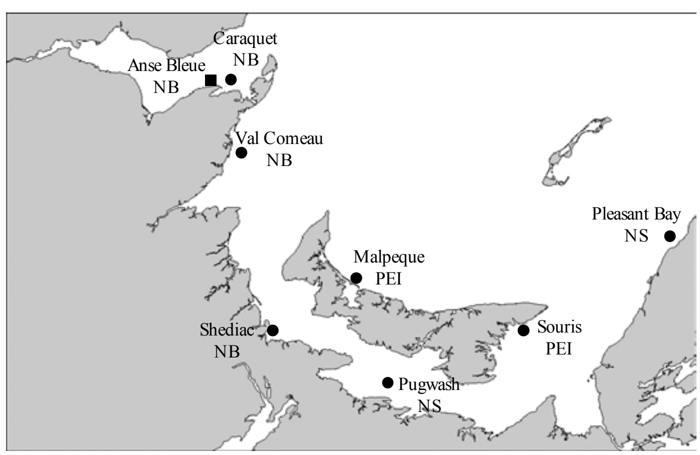

Figure 3. Locations of the bottom temperature monitoring sites selected to represent the different coastal areas of the southern Gulf of St. Lawrence. Temperature information are presented for the duration of the lobster season at sites identified by circles. Full year information is presented for the site identified by a square.

The estimated reported trap hauls (*ERST*) was defined as the number of trap hauls estimated from the official sale transactions. Since most lobster fishermen in the sGSL are landing and selling their catch daily, each sale transaction was assumed to represent one fishing day, by one license holder with full trap allocation:

$$ERST_{LFA} \quad = \quad NT_{LFA} \times TA_{LFA} \, ,$$

where, for each LFA, NT = number of sale transactions.

For a given LFA, the estimated reported trap hauls from index-fishermen (*ERIF*) was obtained by extrapolating the number of participating fishermen and their total effort in trap hauls to the number of license holders for that LFA. The assumption was that all participating fishermen were providing effort information for the entire season and were a representative sample of the entire fishing fleet.

$$ERIF_{LFA} \quad = \quad \frac{NF_{LFA} \times EIF_{LFA}}{NIF_{LFA}} \, ,$$

where, for each LFA, EIF = effort in trap hauls of index-fishermen, and NIF = number of index-fishermen.

3.2.2 Catch characteristics

Lobster landings in the sGSL have the unique particularity of being recorded in canner and market size categories. This can allow further analyses of the official catch statistics to obtain general information on catch composition. These categories are set for commercial purposes only and have been recorded in the official catch database since 1984. Canners are lobsters ranging from the MLS to 80mm, where markets are lobsters of 81mm and above. The proportion of canners (in weight) in the commercial catch can provide a general overview of the temporal and spatial changes in the relative catch size structure.

Similarly, the annual changes in the proportion of canner size lobsters were also calculated for each LFA using the at-sea sampling data. Although MLS increased over the years, no adjustments or standardization of the proportion of canners were attempted for the official catch statistics and at-sea sampling data.

3.2.3 Size structure

The at-sea-sampling program is presently the only sampling program that can provide information on size structure. The data collected from 1983 to 2001 were pooled by LFAs and years. Lobsters were grouped by size in four (4) molt classes; one pre-recruited (M-1) and three recruited into the fishery (M+1, M+2, M+3). The molts classes were fixed at every 10mm from the MLS. When the MLS was increased, the molt groups were adjusted accordingly (appendix IV).

3.2.4 Exploitation rate calculation based on a catch-effort model

Catch-effort models are based on the assumption that the size of a sample captured from a population is proportional to the effort in retrieving the sample. Hence, one unit of sampling effort is assumed to catch a fixed proportion of the population. Therefore, if samples are permanently removed, the decline in population size will produce a decline in catch-per-unit-effort (CPUE). One of the most commonly used catch-effort models for closed population in crustacean fisheries in eastern Canada is the Leslie model (Leslie and Davis, 1939). Braaten (1969) suggested enhancements to the Leslie model, and a full description is presented in Ricker (1975). Recently, Gould and Pollock (1997) have shown that maximum likelihood estimation for catchability (q) and exploitation rate ($\hat{u}$) is more accurate and flexible. We used this method which consists of maximizing a multinomial likelihood function subject to the constraint $P_j = 1 - \exp(-qf_j)$, where f_j is the number of trap hauls for the period j. The variance of $\hat{u}$ is estimated via bootstrapping (see Gould and Pollock (1997) for further details). Logbook data containing daily catches and the number of trap hauls were used for the model. A visual assessment of the model validity is done by plotting the weekly values of CPUE against cumulative catches. The result should show a downward straight line, however a downward line does not assure the validity of the model.

3.2.5 Exploitation rate calculation based on the change-in–ratio model

In general, the change-in-ratio (CIR) technique is the comparisons of relative abundance of two identifiable components from a population over time. There are several variants to this technique (Paulik and Robson, 1969). For this assessment, the two components of the population are the legal size and sub-legal size lobsters. Sea sampling data collected at the beginning and the end of each fishery were used to calculate $\hat{u}$. Estimated $\hat{u}$ is defined as:

$$\hat{u} = \frac{(p_1 - p_2)}{p_1\,(1 - p_2)},$$

where p_1 is the proportion of legal size animals in the first sample (beginning of the fishery), and p_2 is the proportion of legal size animals in the second sample (end). Berried females and lobsters below 57 mm were not considered in the model. The variance of $\hat{u}$ was estimated by bootstrapping as described by Frusher et al. (1997).

3.2.6 Egg-per-recruit

In the 1998 lobster stock status assessment for the sGSL (Lanteigne et al., 1998), calculations of the lobster population *E/R* were presented for each LFA. These calculations were conducted with a model developed by Josef Idoine and Paul Rago (National Marine Fisheries Service, USA) and used in the NEFSC SAW 22 (North East Fisheries Science Center Stock Assessment Workshop) assessment (Anonymous, 1996). The model is a modification of earlier work by Fogarty and Idoine (1988). The parameters used for the calculations in the sGSL are presented in appendix V.

The intent of the present assessment was not to conduct new E/R calculations. It was to verify if the initial objective of having the fishery in a position to double the initial E/R value in each LFA was achieved and comment on the E/R situation following the completion of the four-year management plan.

4.0 Results and Discussion

4.1 General landing trends

Commercial lobster catches in the sGSL have shown a sharp increase since 1974 from 5,594 t to a record high of 22,063 t in 1990. This represents a four folds increase over a 16-year period. Current catches are considered at all time highs compared to historical landings from the last century of lobster fishing (appendix VI). However since 1990, landings in the sGSL have shown a steady declining trend. In 2000, 17,580 t were landed which represent a 20% reduction from the peak landing observed in 1990.

The increase in catches has been observed in all LFAs. However, LFAs had their peak landing at different time and the declining trend of recent years is not similar in all LFAs (Fig. 4, Table 4). This reflects the spatial and temporal variability of the lobster resource in the sGSL. Calculation of yield (t) per km^2 of fishing ground can further illustrate this situation. For each LFA, the total annual landing was divided by the total surface of fishing ground for 1970, 1980, 1990 and 2000. The fishing ground was defined as the area comprised between depths of 3 and 40 m (Lanteigne, 1999).

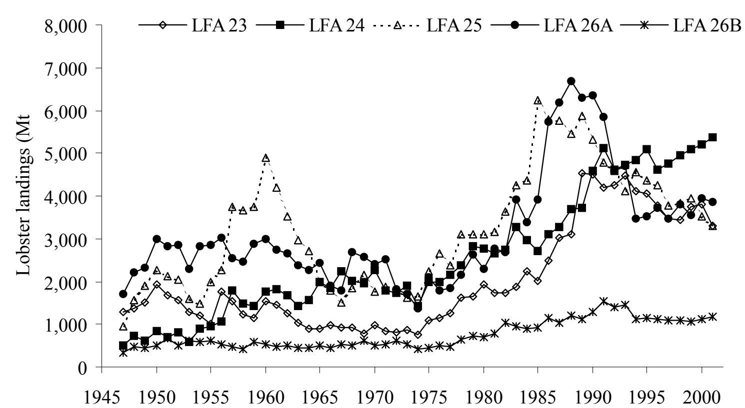

Figure 4. Lobster commercial catches in each Lobster Fishing Areas (LFA) from 1946 to 2001.

Fishing ground yields varied between LFAs and over the years (Table 5). In most LFAs, yields have increased approximately two folds every 10 years. Maximum yields were observed in the early 1990's, with the exception of LFA 24, which presented another increase for 2000. The decade that followed the peak of 1990 was characterized by a slow decrease in yield. In 2000, most LFAs were still above the yields observed in 1980. However, LFA 25 is rapidly approaching the yield of 1980.

Table 4. Lobster landings (t) by Lobster Fishing Area (LFA) and for the entire southern Gulf of St. Lawrence (sGSL).

	Lobster Fishing Areas					Total
Years	**23**	**24**	**25**	**26A**	**26B**	**SGSL**
1950-59 avg.	*1,437*	*1,057*	*2,494*	*2,751*	*552*	*8,290*
1960-69 avg.	*1,069*	*1,826*	*2,755*	*2,440*	*500*	*8,592*
1970-79 avg.	*1,099*	*2,044*	*2,217*	*2,037*	*539*	*7,939*
1980-89 avg.	*2,463*	*3,090*	*4,764*	*4,389*	*977*	*15,685*
1990-99 avg.	*4,007*	*4,835*	*4,351*	*4,306*	*1,232*	*18,732*
1995	4,069	5,083	4,360	3,536	1,152	18,200
1996	3,784	4,604	4,239	3,720	1,126	17,472
1997	3,467	4,757	3,784	3,481	1,079	16,568
1998	3,453	4,959	3,844	3,804	1,098	17,158
1999	3,752	5,079	3,946	3,554	1,068	17,398
2000	3,808	5,198	3,526	3,934	1,114	17,580
2001	3,594	5,436	3,499	3,856	1,180	17,564

Table 5. Yield of commercial catches per surface of fishing ground (t/km^2) for each Lobster Fishing Area (LFA) in 1970, 1980, 1990 and 2000.

LFA	**Surface of fishing ground (km^2)**	**1970**		**1980**		**1990**		**2000**	
		Landings (t)	**Yield (t/km^2)**	**Landings (t)**	**Yield (t/km^2)**	**Landings (t)**	**Yield (t/ km^2)**	**Landings (t)**	**Yield (t/ km^2)**
23	4,625	974	0.2	1,917	0.4	4,508	1.0	3,808	0.8
24	2,249	2,266	1.0	2,755	1.2	4,591	2.0	5,198	2.3
25	4,394	1,754	0.4	3,103	0.7	5,320	1.2	3,526	0.8
26A	4,530	2,416	0.5	2,302	0.5	6,363	1.4	3,934	0.9
26B	613	514	0.8	700	1.1	1,281	2.1	1,114	1.8

Note: The fishing ground area for a particular LFA is defined as the total surface between the depth of 3 and 40 m within the boundary of that LFA.

Official catch statistics could be used as crude indicators of the overall status and annual fluctuations of the stock. However, compiling the catch information from sale transactions should not be considered reliable indicators of the size or reproductive health of the lobster population. Increases in fishing effort, improved efficiency, changes in social-economic situations can maintain or give the impression that landings are increasing or being maintained. Nonetheless, the extraordinary increase in lobster catches since the mid-1970's cannot be explained entirely by an increase in fishing power. This period of increase was observed for the entire range of the lobster distribution (Fig. 5), from southern Labrador to Maryland (USA), in areas with different management regimes, fishing fleet characteristics and fishing traditions. Therefore, the increase and recent decrease in lobster catches in the sGSL have to be considered as real changes in the overall lobster biomass. However, accurately measuring the magnitude of these changes is difficult with the data presently available.

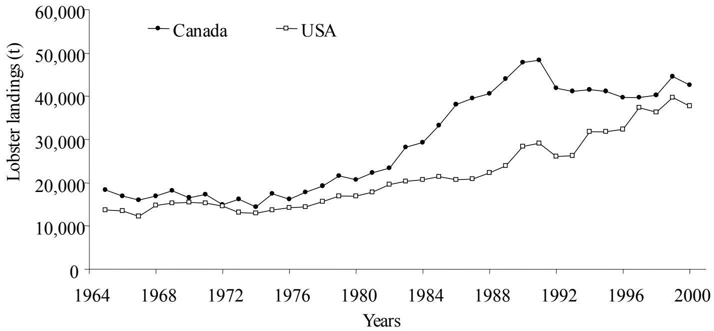

Figure 5. Commercial lobster landings in Canada and the United States, from 1965 to 2000.

The lack of mechanisms to obtain reliable catch, effort and effort location information from fishermen is creating difficulties in understanding and analyzing landing fluctuations. This situation is symptomatic for most of the Canadian lobster fishery, and has been raised by Lawton et al. (1999) and Pezzack et al. (1999). Although fishermen in communities within LFAs are indicating important changes in their catches, it is impossible to determine clearly where they are occurring, to quantify these changes and to determine if they are the result of shift in effort. These issues can only be fully understood with adequate temporal and spatial data supplied through the co-operation of fishermen.

4.2 *Environmental conditions*

The coastal environmental conditions in the sGSL are characterized by important seasonal fluctuations that dictate the life cycle of all coastal marine organisms. The southern Gulf is covered with a layer of ice during the winter season and bottom temperatures on lobster fishing grounds reaches sub-zero temperatures. In the summer, bottom temperature of 15 ^{o}C can be reached at depths of 15 to 20 m in most areas of the sGSL. An example is presented in Fig. 6 for Anse Bleue (NB), where a temperature recording device was set for approximately 1.5 year. The annual temperature at 20m fluctuated between –1.5 ^{o}C and 17 ^{o}C.

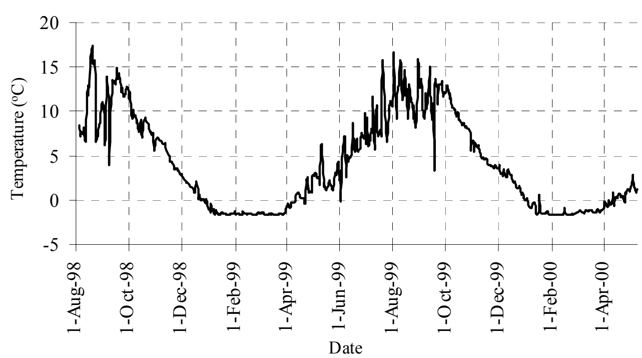

Figure 6. Average daily bottom temperature recorded at 20 m depth, in Anse Bleue, located in northern New Brunswick (August 1998 to May 2000).

The spring lobster fishery starts immediately following the ice departure in coastal waters. Therefore, the entire spring season occurs during the period of water warm-up. At the beginning of the fishing season, in May, temperature will increase from 0 ^{o}C to reach temperatures between 10 and 15 ^{o}C by the end of June (appendix VII, A to F). The numerous storms and influx of cold water from the deep layers can create important temperature fluctuations within short periods. Although the effect of these fluctuations cannot be quantified, they will have a short-term (2 to 3 days) adverse effect on lobster catchability (Comeau and Drinkwater, 1997). These seasonal fluctuations are also highly variable from year to year and between areas within the sGSL.

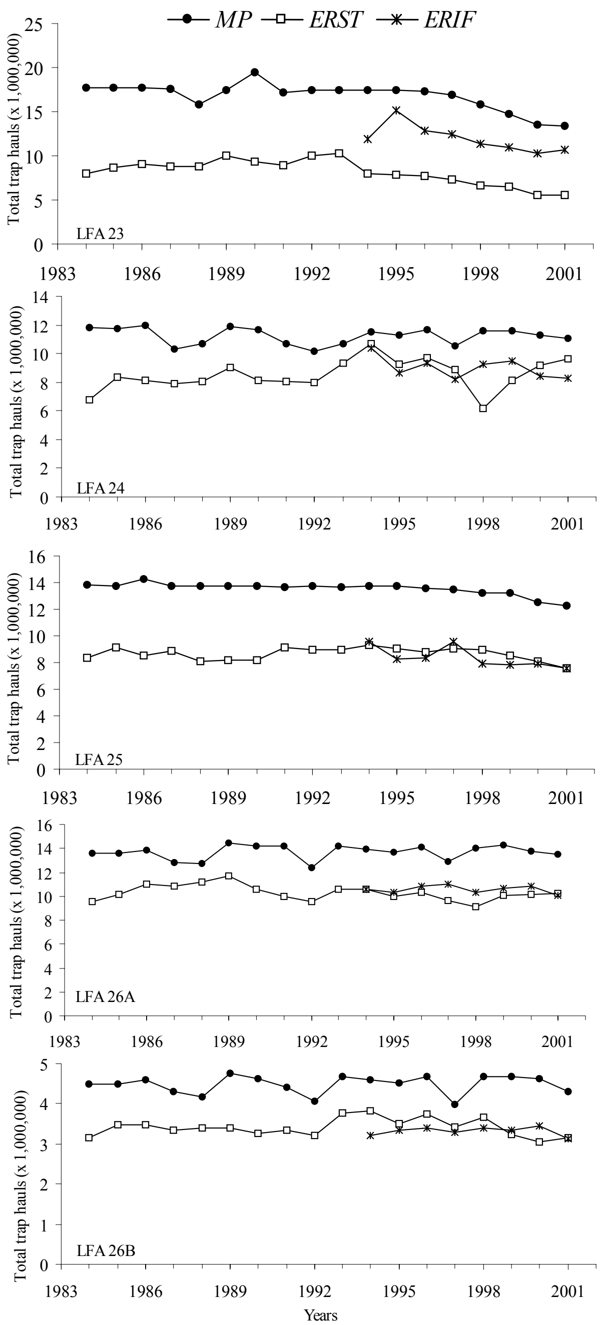

Figure 7. Lobster fishing effort (trap hauls) from 1983 to 2001, for each Lobster Fishing Area (LFA). Results of three methods of calculations are presented; MP: maximum potential trap hauls based on regulations, ERST: estimated reported trap hauls from sale transactions and ERIF: estimated reported trap hauls

Lesser fluctuations and a more stable temperature profile characterize the summer-fall fishery in LFA 25, from the beginning of August to the beginning of October. The temperature ranges between 10 and 20 ^{o}C at a depth of 15 m, throughout the season (appendix VII, G and H). As for the spring fishing season, annual and spatial differences are sometimes important. The year 2001 was noticeably different for the Shediac area (appendix VII, G). Bottom temperatures are typically above 15 ^{o}C for most of the season in this section of LFA 25, but it stayed below 15 ^{o}C for most of the 2001 fishing season. The season was also characterized by numerous fluctuations of approximately 5^{o}C within 4-5 days. This temperature profile was not observed to the same intensity in Pugwash (appendix VII, H), which is located in the same LFA.

4.3 Fishing effort

The fixed number of license holders, fishing seasons, and trap allocations are often seen as the effort unit for the lobster fishery. However, these elements of effort are only tools to control the number of trap hauls which are the basic unit of effort for this input fishery.

Calculation of *MP* is based strictly on fishing regulations and represents the maximum level of effort that fishermen can exert on the resource (appendix VIII). The calculation is based on the assumption that fishermen haul their entire trap allocation once a day, for the entire fishing season. Although trap designs, fishing strategy and intensity are known to vary throughout the sGSL (Lanteigne, 1999; Lanteigne and Paulin, 2001), these elements and activities are well within the fishing regulations (Fig. 7). Any annual fluctuations in *MP* values are the result of changes in the fishing regulations. Variations in the length of the fishing season are the predominant factor of *MP* value fluctuations.

The *ERST* and *ERIF* are believed to better reflect the actual level of fishing activities, and are giving values lower than the *MP* (Fig. 7). The calculations are based on information collected and compiled when fishermen are landing their catch. Therefore, the *ERST* and *ERIF* calculations will provide some adjustments to the fact that not all fishermen are hauling traps every day of the season, because of the within season decreasing catches or bad weather for example. The *ERIF* will further take into account that not the full trap allocation is hauled everyday.

With the exception of LFA 23, both *ERST* and *ERIF* are presenting similar values and fluctuations over the years (Fig. 7), ranging between 63% and 79% (Table. 6). In LFA 23, the *ERIF* values from 1994 to 2001 are approximately 50% higher than the *ERST* values, but still lower than the *MP* values. The *ERIF* values were assumed to better reflect the fishing effort, since volunteer fishermen provided the information. The *ERIF* represents on average, 64% of *MP* values, which is within the range of effort level observed in the other LFAs (Table 6).

Table 6. Average proportion (%) of trap hauls reported in the sale transactions (ERST) and the index-fishermen (ERIF) in relation to the maximum potential trap hauls (MP). The standard deviations are in parenthesis.

	Lobster Fishing Area (LFA)				
	LFA 23	**LFA 24**	**LFA 25**	**LFA 26A**	**LFA 26B**
Calculated from catch statistics, 1984 to 2001	48% (6.0%)	76% (9.9%)	63% (3.5%)	75% (5.4%)	75% (5.6%)
Calculated from index-fishermen data, 1994 to 2001	64% (4.8%)	79% (5.1%)	63% (4.6%)	77% (3.8%)	74% (4.0%)

The differences between *ERST* and *ERIF*, and *MP* are believed to reflect the reality of the lobster fishing in the sGSL. The fluctuations in *ERST* and *ERIF* values over the years (Fig. 7), may be the result of changes in reporting practices for sale transaction and index fishermen information. This situation is more evident in the difference between *ERST* and *ERIF* values in LFA 23, where fishermen indicated the common practice of selling the catch of multiple days of fishing under a single sale transaction. Reporting more than one fishing day onto a single sale transaction would underestimate the *ERST* calculations. The extent of this practice, although more apparent in LFA 23, cannot be quantify in any LFA.

The effort levels obtained with *ERST* and *ERIF* suggest that fishing effort in every LFA is not reaching the maximum potential fishing effort permitted under the regulations. If the conditions would allow (i.e.: fishermen able to fish every day of the season with full trap allocation), the present fishing fleet could further increase the level of trap hauls by approximately 25%, and still be within the limits of the fishing regulations. Although the fishing industry may say that it is presently impossible to apply maximum effort because of uncontrollable factors like bad weather or low trap yields at the end of the season, they may found ways around these difficulties. Fishermen are innovative by nature and stimulated by competition. In adverse situations, they will adapt and adjust to maintain their fishing activities and ensure good returns for their efforts. In the last 30 years, fishing fleets for most species all over the world have increased their fishing efficiency. The lobster fishery is not an exception and it is believed that fishing efficiency is still increasing.

To allow comparison between LFAs having different number of license holders, the average fishing effort by fisherman (trap hauls/fisherman) was calculated for 2001 (Fig. 8). Based on *MP* calculations, the *MP* that each fisherman could exert ranged from 15,000 trap hauls/fisherman in LFA 25 to 18,000 trap hauls/fisherman in LFA 23. However, *ERST* and *ERIF* are lower in all LFAs. Aside from LFA 23 where discrepancies were detected between *ERST* and *ERIF*, the lowest and highest effort values are observed in LFA 25 and 24 with 8,000 and 15,000 trap hauls/fisherman respectively. These two LFAs are also characterized by fishing ground with the lowest and highest yields (t/km^2, see Table 5) in recent years. It is difficult to determine if the effort variation is the result of different yields or the different practices of reporting information. However, it may suggest that when catches are good, fisherman could either apply or report more fishing effort, and approach the maximum potential effort allowed by fishing regulations.

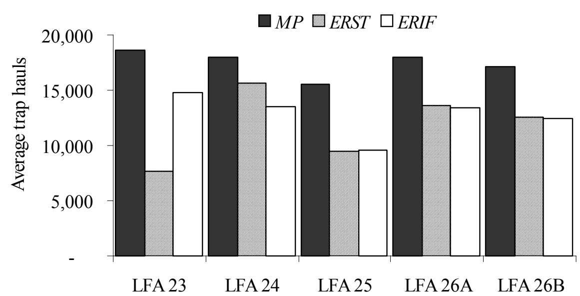

Figure 8. Fishing effort by license holder (trap hauls/fisherman) and Lobster Fishing Area (LFA) in 2001. Results of three methods of calculations are presented; MP: maximum potential trap hauls based on regulations, ERST: estimated reported trap hauls from sale transactions and ERIF: estimated reported trap hauls from index-fishermen.

4.4 Catch characteristics and size structure

Data on catch size structure can provide valuable information on the status of the lobster population and the fishery. Knowledge of the overall size structure is essential to conduct length based assessment. Unfortunately, this information is lacking or is considered biased for the lobster population in the sGSL. Catches and size structures vary geographically and yearly. Although there are different sources of information that can provide catch characteristics and size structure, no single source can adequately quantify spatial and temporal variability.

An alternative to the lack of proper quantitative sampling programs or techniques to obtain reliable catch size structure is to look at trends from different sources of information. For this assessment, official catch statistics, catch and effort data collected by fishermen participating in the index fishermen program, and information gathered during the at-sea sampling program were analyzed. The objective was to identify general indicators that would provide some qualitative or semi-quantitative data on the status of the resource and the fishery.

4.4.1 *Proportion of canner size lobster in the commercial catch*

In the sGSL, all legal size lobster less than 81 mm CL are considered canner size lobsters. Canners represent a size class of approximately 11 to 17.5 mm, depending on the MLS in place for the LFA and the year. They can be considered as lobsters in the first molt group recruited to the fishery and approximately half of the second molt group. Although the information on canners is in weight and not number, looking at the proportion of the canner size category in the total commercial catch can still provide general information on the recruitment level of commercial size lobsters into the fishery.

Spatial and temporal fluctuations of the proportion of canners need to be interpreted with caution. Numerous factors can affect the proportion of canners in the total annual catch. Increases in MLS are one of the most important factors. By reducing the size range of the canner category, the result would be a reduction in the proportion of canners. However, a strong pulse of recruitment into the fishery can easily mask the impact of size increases, especially when these size increases are relatively small. In the sGSL, all MLS increases were 0.7 mm at a time, with a few at 1.5 mm. Consequently, fluctuations in percentages of canners and the annual fluctuations of the commercial catches need to be interpreted together.

To conduct the analyzes, the following conditions were assumed constant in each LFA; 1) level of fishing effort, 2) trap catchability, 3) level and quality of catch reporting, and 4) high exploitation rate. Movement of juvenile and adult lobsters between LFAs was considered negligible (Comeau and Savoie, 2002b). To simplify the interpretation, three (3) combinations of fluctuations for canners and catches were identified and classified. These scenarios are presented and explained in Table 7. In the event of MLS increases, the

Table 7. Classification of trends based on the combination of percentages of canner size lobsters and commercial catches.

Classification	Scenario	Possible explanation - interpretation
Period of strong recruitment	Increase/stable percentages of canners Increase commercial catches	Strong recruitment pulse entering the fishery maintains or increases the percentage of canners (recruits). Commercial catches increase.
Period of stability/transition	Stable/decrease percentages of canners Stable commercial catches	Period of equilibrium between availability of the resource and exploitation rate. May be a transition before a change in recruitment level.
Period of weak/declining recruitment	Stable/decrease percentages of canners Decrease commercial catches	Recruitment level is decreasing and is rapidly followed by a decline in commercial catches since a large portion of the total catch consist of canners (recruits).

interpretation was more complex. If the size increases were conducted on subsequent years, the impact on the proportion of canners was more acute than when the increases were sporadic or separated by multiple years.

This approach for analyzing catch statistics shows a strong recruitment pulse in the sGSL in the 1980's (Fig. 9). Following this pulse, recruitment fluctuations appeared in each LFA.

- In LFA 23, the recruitment level is slowly declining since 1994. At present exploitation rate, the declining recruitment cannot maintain the high catches of the early 1990's. Although there was a trap allocation reduction from 375 to 300 traps/fishermen from 1998 to 2000, there was no visible impact on the percentage of canners or reduction in commercial catches.
- In LFA 24, the strong recruitment may be over but the overall situation is very good. The regulation on rectangular escape mechanisms imposed in 1996 and the four MLS increases from 1998 to 2001 had little impact on the percentage of canners. A good recruitment into the fishery, in addition with the weight gain from the growth of all the lobsters returned at sea with the new MLS, may in part be responsible for the catch increases in recent years.
- The worst scenario is observed in LFA 25. The declining recruitment since 1985 is impacting heavily on commercial catches.
- In LFAs 26A and 26B, following a period of declining recruitment and catches in the early 1990's, the situation seems to have stabilized. Annual catches are stable although there is a slow, but steady decline in the percentage of canners since the mid-1995.

In most LFAs, size increases were conducted from 1987 to 1991, and from 1998 to 2001. These size increases have reduced the size range of canners and would theoretically reduce the proportion of

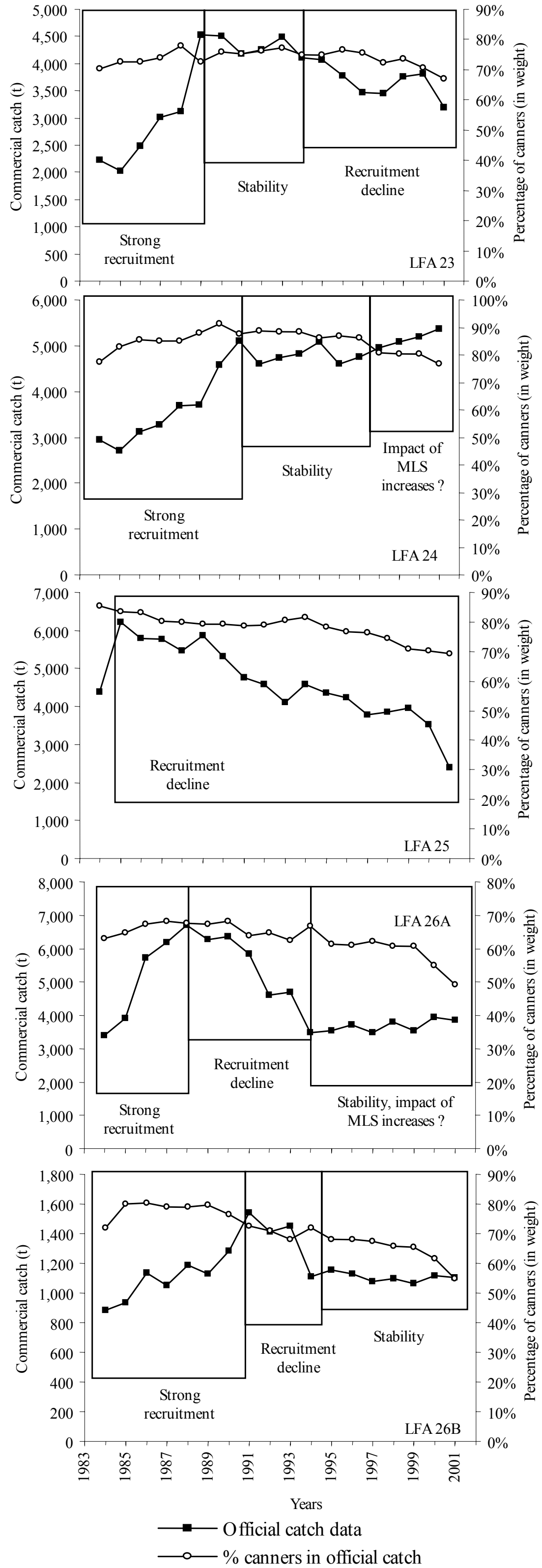

Figure 9. Official landings and percentage (in weight) of canner size lobster in the commercial catch in each Lobster Fishing Area (LFA) from 1984 to 2001.

canners in the catches. This situation is considered as a source of uncertainty when percentage of canners is to be used as first year recruitment indices. Therefore, the analysis and interpretation of the proportions of canners must be conducted with care and in combination with other indices.

Average contributions, by weight, of canners in commercial catches are highly variable between LFAs, but somewhat consistent within LFAs over time (Table 8). The highest values were observed in LFA 24, with percentages ranging between 80% and 87%. The lowest values were ranging between 56% and 67% in LFA 26A. All other LFAs had values ranging from 69% to 84%.

The high portion of canners in the catch provide further support to the statement brought forward by FRCC (Anonymous, 1995) and previous assessment (Lanteigne et al., 1998) that the lobster fishery is defined as a recruitment fishery. This situation arises from the high level of fishing effort and exploitation rate. Although changes in management measures were implemented in terms of increasing the MLS, no actual progress was made on reducing the fishing effort and the exploitation rate. The overall commercial catch relies heavily on the annual contribution of new recruits to the fishery.

Table 8. Average percentages (in weight) of canner size lobsters in commercial catches, by time periods and Lobster Fishing Area (LFA). Calculations conducted on sale slip information.

LFA	1984 to 1986 no size increases	1987 to 1991 size increases	1992 to 1997 no size increases	1998 to 2001 size increases
LFA 23	72%	75%	76%	71%
LFA 24	82%	87%*	87%	80%
LFA 25	84%	80%	79%	71%
LFA 26A	65%	67%	63%	56%
LFA 26B	77%	77%	69%	62%*

** There were no minimum legal size increases during that time period, for that LFA.*

4.4.2 Catch size structure obtained from at-sea samples

For each LFA and year, the at-sea samples were pooled and lobster size measurements divided in molt groups recruiting into the fishery (appendix IX). Analyses of the temporal fluctuations of each molt group were conducted in an attempt to identify general indicators of the state of the resource.

Size frequency analyses of at-sea sampling data collected from 1984 to 2001 indicate that a high proportion of the overall catch was in the first recruited molt group for all LFAs (Fig. 10). The percentages of first recruited molt groups exhibit the same patterns between LFAs as the percentage of canners.

Molt group data from 1984-2001 were divided into four time periods, of which two experienced increase in MLS (1987-1991, 1998-2001)and two experienced no changes (1984-1986, 1992-1997). Average percentages of first recruits calculated for the four (4) time periods, have shown the highest percentages in LFA 24 , with relatively consistent

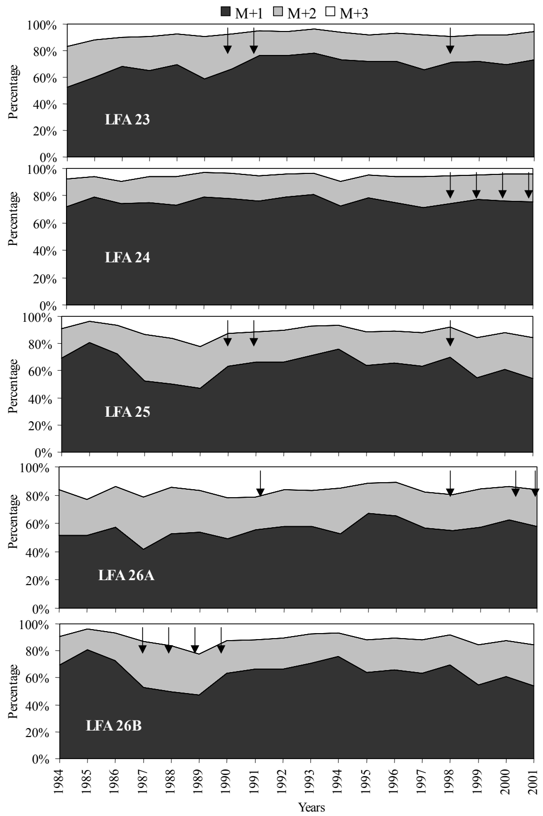

Figure 10. Proportion (%) of molt classes recruited into the fishery estimated from at-sea sampling data. Proportions were calculated from lobster counts. Arrows are indicating minimum legal size increases.

values of 75% - 76%. The lowest percentages were in LFA 26A with values ranging from 51% to 59%. All other LFAs had values ranging from 56% to 78% (Table 9).

The increase in MLS in each LFAs over the years did not result in noticeable changes in the proportion of first recruited molt group in the commercial catches (Table 9). As indicated in the FRCC report (Anonymous 1995), the lobster fishery is define as a recruitment fishery. The increases in MLS since the mid 1980's and as part of the 4-years management plan (1998-2001), were primarily engineered to increase the relative egg production (*E/R*) of the lobster population and not to tackle the issue of the fishery depending heavily on annual recruitment. At-sea sampling observations corroborate this situation. After completing the 4-year management plan, the lobster fishery in the sGSL is still defined as a recruitment fishery.

4.5 Exploitation rate

Catch-effort estimates were calculated by combining the catch and effort data of all index-fishermen within a LFA. In comparison, CIR estimates were calculated using data from selected ports representing landings sites for a small area within a LFA. Combining data from various ports was not possible since at-sea samplings were carried out at different time of the season. Hence, for the exploitation rate estimations, LFA's were divided into areas and a representative port was chosen for each area. It should be noted that except for 2001, at-sea sampling was not originally designed to collect data for the CIR estimator and thus in some cases, data at the beginning and end of the fishery, as required by the method, was not available. Catch-effort assumes a direct and strong relationship between the landings and the number of traps hauled. In some areas or years, other parameters,

Table 9. Average percentages (in number) of the first recruited molt group (adjusted to minimum legal size) in commercial catches, by time periods and Lobster Fishing Area (LFA). Calculations performed on at-sea sampling information.

LFA	1984 to 1986 no size increases	1987 to 1991 size increases	1992 to 1997 no size increases	1998 to 2001 size increases
LFA 23	60%	67%	73%	71%
LFA 24	75%	76%*	76%	76%
LFA 25	74%	56%	68%	60%
LFA 26A	53%	51%	59%	58%
LFA 26B	72%	79%	74%	66%*

** There were no minimum legal size increases during that time period, for that LFA.*

temperature for example, have influenced the landings more importantly than the effort thus invalidating the application of the catch and effort method.

Estimates of exploitation rate varied between 35% and 90% depending on the method. Although there were differences in exploitation rates between LFAs, the estimates were fairly stable within each LFA (Fig. 11). Both the CIR and catch-effort estimates gave comparable results except for LFA 26A. Variable legal size within LFA 26A could explain part of the discrepancy with the PEI side of LFA 26A fishing at the regulated 67.5 mm MLS and fishermen of the NS side of LFA 26A using a MLS of 70 mm. The CIR estimate is based on at-sea sampling from PEI while most index-fishermen were from NS. Furthermore, low exploitation rate estimates based on the CIR method had wide 95% confidence interval.

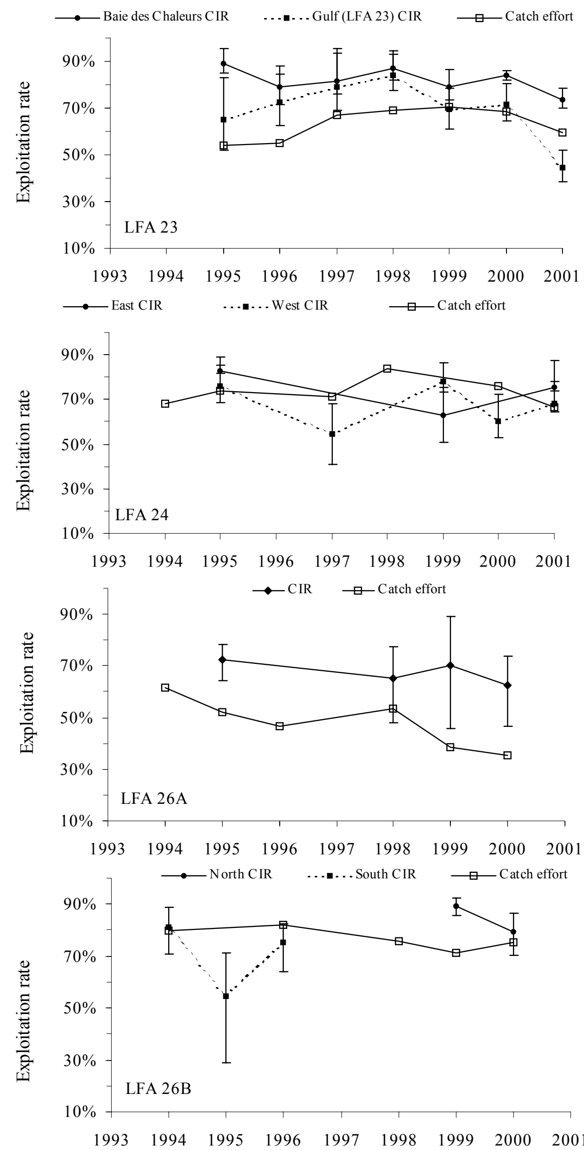

Figure 11. Annual exploitation rate calculated for each Lobster Fishing Area (LFA) with the change-in-ratio (CIR) and catch-effort methods. The 95% boostrap confidence intervals are presented for CIR estimates.

Considering the more general trend, the high values of exploitation rates obtained using both models coincided with the high percentage of canners in the landings (Fig. 9) and the large proportion of the first recruited molt sizes observed in the at-sea sampling data (M+1, Fig. 10). Sub-areas were defined within LFA 23, 24 and 26B because differences observed in the landings and the environmental conditions were thought to influence the exploitation rate. The sub-areas within each LFAs exhibited similar trends in their exploitation rate but with a different magnitude. Overall, exploitation rates in LFA 26A were the lowest, which also coincided with the lower percentage of canners and first recruited molt sizes.

In the sGSL, the lobster fishery lasts at most 9 weeks and it is assumed that natural mortality occurring during the fishery is negligible compared to the mortality induced by the fishery. This type of fishery is referred by Ricker (1975) as a Type I fishery, and the lobster annual exploitation rate refers to a 9 week fishing season. Several methods are available to estimate exploitation rate but very few are applicable to the lobster fishery because of the nature of the fishery itself: with a passive gear, the traps may be empty (null catch) and yet, there is lobster available. The two chosen methods required different underlying assumptions and data set. However, neither method could estimate exploitation rate in LFA 25 since most assumptions were violated, mainly because of the molting occurring during the fishery.

4.6 Egg-per-recruit (E/R)

The *E/R* is a measure of reproductive potential. By taking in consideration all the numerous parameters of the life cycle and the fishery, the *E/R* value represents the ratio of the number of eggs that a female will produce during its entire lifetime in a fishery, over the number of eggs for a female in a non-exploited population. This concept of *E/R* is currently used for the American lobster in the United States.

To be useful for fishery management, a minimum level of *E/R* needs to be set in accordance to basic biological and ecological parameters for the species. Based on observations made by Mace and Sissenwine (1993) on groundfish species, *E/R* values of 20% to 35% were necessary to renew the stock and avoid recruitment overfishing. Based on this principle, the United-States have set a level of *E/R* for the lobster population of 10%, under which the stock is regarded as overexploited.

Calculations for most of the Canadian lobster fisheries by Pezzack and Maguire (1995) and the FRCC (Anonymous, 1995), have resulted in E/R values of less than 2%. Following these results, although a value defining overfishing was not set for Canadian fisheries, a *E/R* of 5% was proposed as a target for conservation purposes (Anonymous, 1995).

E/R values calculated for the sGSL in 1997 ranged from 0.3% to 1.0% (Table 10, Lanteigne et al., 1998), well below the target of 5% recommended by FRCC (Anonymous, 1995). With the introduction of the four-year management plan (1998-2001, appendix II), the objective was to have new measures in place for 2001 so that the lobster population in the sGSL would be in a position to at least double the E/R levels previous to 1998. Now that the management plan has been completed, was the objective achieved?

Following discussion with fishermen and from observations at sea, it was concluded that most fishermen did not comply with the requirement to V-notch 50% of the egg bearing females in the catches. The V-notching was announced as an element of the four-year management plan in addition to carapace size increases and was required in all LFAs, except LFA 24. Although it was discussed, the fishing industry indicated that the notching activity was never part of their proposed management plan and fishermen of the sGSL have raised concerns on the potential induced mortality and enforcement problem of a V-notching program. Field studies conducted in 1999 and 2000 have shown that V-notching was not increasing mortality on lobsters (Anonymous, 1999, 2001). However, fishermen indicated that they did not comply with this element of the management plan. Since V-notching was not conducted, it must be concluded that the initial objective of the management plan was not fully achieved. A summary of the E/R values with and without V-notching is presented in Table 10.

Table 10. Egg-per-recruit (E/R) values calculated for each Lobster Fishing Area (LFA) prior (1997) and as a result of the four-year management plan (1998-2001), with two scenarios of compliance to the V-notching requirement. The weighted average E/R is presented for the southern Gulf of St. Lawrence (sGSL).

	LFA 23	**LFA 24** [1]	**LFA 25**	**LFA 26A**	**LFA 26B**	**sGSL** [2]
1997 E/R	0.6%	0.3%	0.6%	0.6%	1.0%	0.6%
2001 E/R with full compliance to V-notching requirement	1.3%	1.0%	1.3%	1.3%	1.9%	1.3%
2001 E/R without compliance to V-notching requirement	0.9%	1.0%	0.9%	1.1%	1.0%	1.0%
Weighing factors [3]	0.19	0.22	0.26	0.26	0.06	

1 - Fishermen in LFA 24 were not required to conduct V-notching.
2 - Weighted average E/R for the sGSL.
3 - Weighing factors by LFA calculated from their average contribution to the total catch of the sGSL from 1985 to 1997 (ex: on average, LFA 26B is providing 6% of the sGSL landings).

Although the initial objective of doubling *E/R* was not achieved, there was progress made in increasing egg production. Assessing the success of the implemented measures and the expected changes to the lobster population is not an easy task. Any benefit in relative egg production from a MLS increase requires years to reach full effect. However, field observations can give some early indications on the expected changes in the lobster population as a result of changes in management measures.

Using at-sea-sampling data from each LFA, the percentage of egg berried females in the total group of females were calculated for lobsters ≥70 mm and <75 mm. This size range was selected to represent a common size class for all LFAs that were not affected by the size increases that took place since 1987, including the four-year management plan (appendix I). It is also considered as a size range characterized with rapid changes in SOM on the sexual maturity ogive, and includes the SOM_{50} of 70.5 mm (Comeau and Savoie, 2002b). Over the years, the percentages of egg bearing females have increased in each LFA (Fig. 12). The increase seems to corroborate with MLS increases. The implementation of the rectangular escape mechanism may also have contributed to some increase in the percentage of berried females. The mechanism that reduces indirect fishing mortality on sub-legal size lobsters was introduced in the mid-1980s and became a standard feature on traps for fishermen in the sGSL within 1985 to 1995.

With the exception of LFA 25 which shows more variability, all LFAs had percentages of berried females around 10% or less for most of the 1980s. After the MLS increases, the percentage increased to approximately 26 to 30% for the ≥70 mm - <75 mm size class. These at-sea observations corroborate with the expected changes in the lobster population and commercial catches.

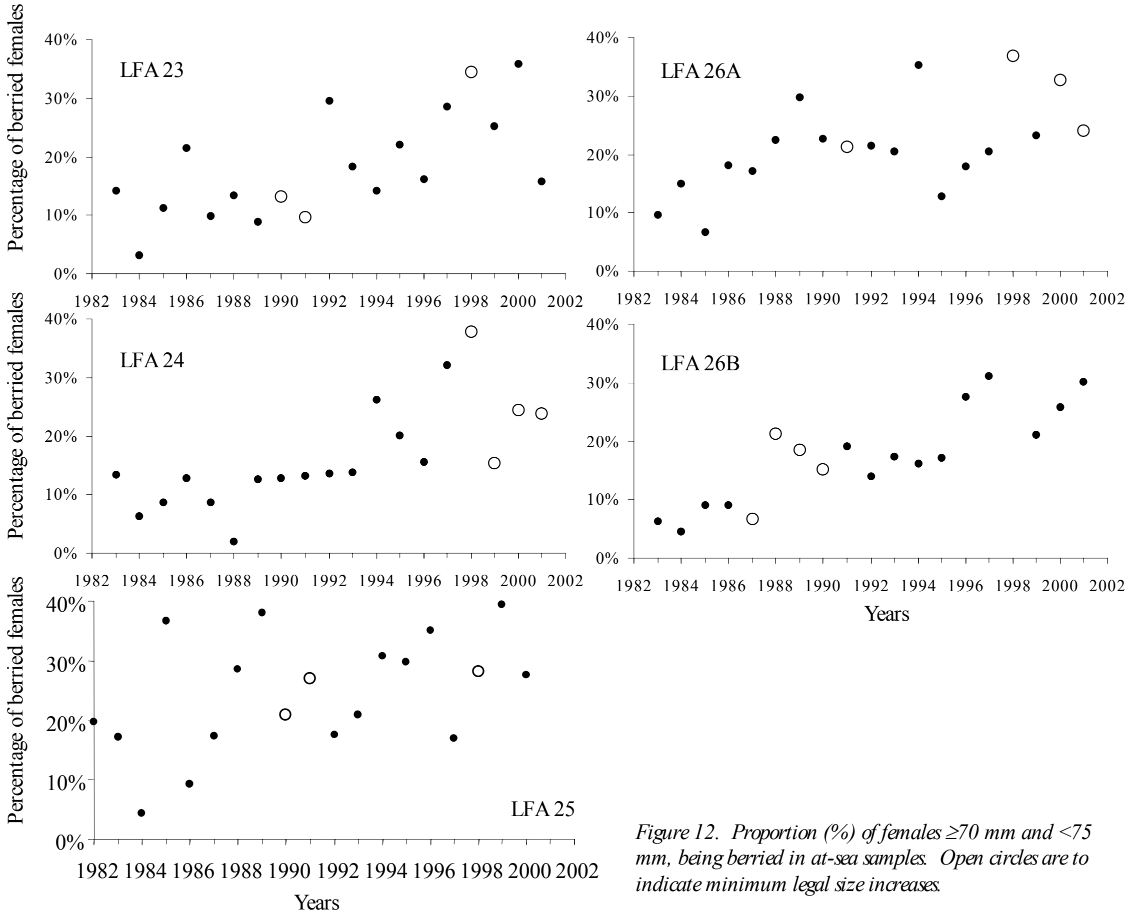

Figure 12. Proportion (%) of females ≥70 mm and <75 mm, being berried in at-sea samples. Open circles are to indicate minimum legal size increases.

5.0 Conclusion

5.1 Management considerations

The four year lobster management plan was completed in 2001. After four years, the objective of having the management measures in place, which would allow doubling the E/R, was partially achieved. New information are confirming past conclusions that most MLS are set bellow the SOM_{50} (Comeau and Savoie, 2002b) and that the exploitation rates are still high (above 75% in some LFAs). The fishery is still characterized by high exploitation rates, rely on annual recruitment and still harvest a large portion of the females before they can produce eggs. This combination of factors poses a high risk to the economic viability of the fishery. Any major or sustained decline in recruitment will quickly be felt by a reduction of commercial catches. Although scientific data are not able to ascertain and quantify the relationship between the quantity of eggs produced and the recruitment level into the fishery, maximizing egg production is a logical approach to consider for a fishery characterized by a high exploitation rate and the harvesting of a portion of sexually immature animals.

Increases in MLS and any other measures applied on the animal to improve egg production and yield must not be considered as mechanisms to maintain the exceptionally high catches experienced in the early 1990's. These management measures are in place to provide certain level of safeguard in case of recruitment failure, and to allow the resource to rebound faster after a period of low production. By increasing E/R, the objective is to avoid having egg production as a limiting factor. Although we cannot avoid natural lobster population fluctuations, maximizing egg production could result in good recruitment when environmental conditions are favorable.

Since fishing effort and not the exploitation rate, is at the basis of the management regime (i.e.: input fishery), allowing high effort level and exploitation rate can be considered a high risk for the fishery. The resource level may decline below some social-economic threshold, below which the economic viability of individual harvesters is jeopardized. In a situation of financial crisis, adding more restrictions on the type and size of lobster that fishermen can keep is not an insurance that the lobster resource will quickly rebound to higher catches. On the contrary, this will further increase the economic burden on individual fisherman. If the quantity and economic viability of individual harvesters are to be considered, removing effective fishing effort is often the only solution to maintain an economically viable fishery. Unfortunately, there are no short term commitments from the fishing industry to reduce fishing effort or exploitation rate.

The scientific community is continuously gaining new knowledge on the biology, the ecology and the impact of the fishery on the lobster populations. Although accurate information is always sought to improve our capability to managing a fishery, we already have a wealth of knowledge on that species, and even more on the fishermen harvesting this resource. The question is now; "Do we have the level of knowledge to make sound assessments and judgments, which would eventually translate into efficient management decisions?" The basic principles of fishery's management are to take decisions and implement conservation measures that would provide an acceptable risk for the resource and the economic survival of the fishery (i.e.: sustainable fishery). The degree of risk will vary greatly between harvested species and management regimes. Since the fishery is conducted with passive fishing gears (i.e.: traps), the lobster population is not in danger of extinction. However, under the present management regime, it is believed that the sGSL lobster fishery is operating under a high risk of economic failure. Risk assessments involving biological and financial parameters (i.e.: bio-economic model) would be the next logical field of activity to improve our knowledge on this fishery.

5.2 Outlook

There are presently no efficient methods or tools to predict recruitment levels and landings in the lobster fishery. The short-term outlook for the sGSL is for sustained catches well above the landings reported prior to 1975. However, landings are slowly declining from the peak catches of the early 1990's, and this trend may continue.

Observations and indices calculated in every LFAs of the sGSL indicate high exploitation rates and effort, MLS set below SOM_{50}, low E/R, and lack of accurate data on catch, effort and effort location. Although MLS increases were conducted from 1987 to 2001 (Appendix I), there were little changes in the lobster fishery to reduce exploitation rate and fishing effort, and increase fishermen's accountability in providing data. These issues are major concerns and will need to be addressed.

Based on comments from numerous fishermen's groups, some small areas within each LFA are showing major reductions in commercial catches in the last 5 to 10 years. Since the lobster habitat is not homogeneous and the population is not distributed evenly throughout the sGSL, these situations are to be expected. These localized regions of catch reductions seem to be more numerous over the years, as more fishermen have expressed their concerns on the economic-viability of the fishery. These observations may confirm the overall slow declining trend for the sGSL. If the declining trend is to continue, more fishermen will raise the issue of economic survival.

6.0 Acknowledgements

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7.0 References

Aiken, D. E., and S. L. Waddy. 1982. Cement gland development, ovary maturation and reproductive cycle in the American lobster *Homarus americanus*. Journal of Crustacean Biology 2:315-327.

Anonymous. 1995. A conservation framework for Atlantic lobster. Fishery Resource Conservation Council, Report to the Minister of Fisheries and Oceans, FRCC 95.R.1, Nov. 1995. 49 pp.

Anonymous. 1996. 22nd Northeast Regional Assessment Workshop (22nd SAW). Northeast Fisheries Science Center Reference Document 96-13.

Anonymous. 1999. An investigation of the effects of v-notching on ovigerous ("berried" female) American lobster (*Homarus americanus*). Atlantic Veterinary College: AFH-99-067. 28p.

Anonymous. 2001. A field investigation of the effects of v-notching on the health and susceptibility to infection of berried female lobster (*Homarus americanus*). Atlantic Veterinary College: AFH-99-084. 30p.

Atema, J. 1986. Review of sexual selection and chemical communication in the lobster, *Homarus americanus*. Can. J. Fish. Aqua. Sci. 43: 2283-2390.

Atema, J., S. Jacobson, E. Karnofsky, S. Oleszko-Szuts, and L. S. Stein. 1979. Pair formation in the lobster, *Homarus americanus*: behavioral development, pheromones and mating. Marine Behavior and Physiology 6: 277-296.

Bergeron, T. 1967. Contribution à la biologie du homard (*Homarus americanus* M. Edw.) des Îles-de-la-Madeleine. Naturaliste Can. 94: 169-207.

Braaten, D. O. 1969. Robustness of the DeLury population estimator. J. Fish. Res. Board Can. 26: 339-355.

Brun, R. 1985. L'industrie du homard dans le Sud-Est acadien du Nouveau-Brunswick, 1850-1900. p 17-33, *dans* Égalité, Revue acadienne d'analyse politique. Num. 16.

Campbell, A. 1983. Growth of tagged American lobsters, *Homarus americanus*, in the Bay of Fundy. Can. J. Fish. Aqua. Sci. 40: 1667-1675.

Campbell, A. 1985. Application of a yield and egg-per-recruit model to the lobster fishery in the Bay of Fundy. North American Journal of Fisheries Management 5: 91-104.

Campbell, A. 1989. Dispersal of American lobsters, *Homarus americanus*, tagged off southern Nova Scotia. Can. J. Fish. Aquat. Sci. 46: 1842-1844.

Campbell, A., and D. G. Robinson. 1983. Reproductive potential of three American lobster (*Homarus americanus*) stocks in the Canadian Maritimes. Can. J. Fish. Aquat. Sci. 40: 1958--1967.

Campbell, A., and A. B. Stasko. 1985. Movements of tagged American lobsters, *Homarus americanus*, off southwestern Nova Scotia. Can. J. Fish. Aquat. Sci. 42: 229-238.

Campbell, A., and A. B. Stasko. 1986. Movements of lobsters (*Homarus americanus*) tagged in the Bay of Fundy, Canada. Mar. Biol.. 92: 393-404.

Chen, C. L., K. Pollock, and J. Hoening. 1998. Combining change-in-ratio, index-removal, and removal models for estimating population size. Biometrics 54: 815-827.

Comeau, M., and F. Savoie. 2001. Growth increment and molt frequency of the American lobster (*Homarus americanus*) in the southwestern Gulf of St. Lawrence. J. Crust. Biol. 21(4): 923-936.

Comeau, M., and F. Savoie. 2002a. Movement of the American lobster, *Homarus americanus*, in the southwestern Gulf of St. Lawrence. Fish. Bull. 100(2): 181-192.

Comeau, M., and F. Savoie. 2002b. Maturity and reproduction cycle of the female American lobster, *Homarus americanus* (Milne Edwards, 1837), in the southwestern Gulf of St. Lawrence, Canada. J. Crust. Biol. 22(4): 762-774.

Comeau, M. and K. Drinkwater 1997. The interaction of wind, temperature, and catch rate of lobster *Homarus americanus* on the Acadian peninsula. Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 97/97: 18p.

Comeau, M., W. Landsburg, M. Lanteigne, M. Mallet, P. Mallet, G. Robichaud, and F. Savoie. 1998. Lobster (*Homarus americanus*) tagging project in Caraquet (1993) - Tag return from 1994 to 1997. Can. Tech. Rep. Fish. Aquat. Sci. 2216, 35 p.

Conan, G. Y., M. Comeau, and M. Moriyasu. 1985. Functional maturity of the American lobster *Homarus americanus*. International Commission for the Exploration of the Sea C.M. 1985/K:29. 56 pp.

Conan, G. Y., M. Comeau, and M. Moriyasu. 2001. Are morphometric approaches appropriate to establish size at maturity for male American lobster, *Homarus americanus*? J. Crust. Biol. 21(4): 937-947.

Conan, G. Y., D. G. Robinson, and D. R. Maynard. 1982. Growth at molt of lobsters in two areas of Northumberland Strait, Canada. International Council for the Exploration of the Sea Shellfish Committee C.M. 1982/K: 35: 1-10

Corrivault, G. W. 1948. Contribution à l'étude de la biologie du homard (*Homarus americanus*) des eaux de la province de Québec. Ph.D. thesis, Université Laval, Québec. 283 p.

Cowan, D., and J. Atema. 1985. Serial monogamy, mate choice, and pre- and post-copulatory guarding in lobsters. Biological Bulletin 169: 1-550.

Cowan, D., and J. Atema. 1990. Moult staggering and serial monogamy in American lobsters, *Homarus americanus*. Animal Behavior 39: 1199-1206.

DeWolf, A.G. 1974. The lobster fishery of the Maritime Provinces: economic effects of regulations. Bull. Fish. Res. Board Can. 187: 59 p.

Dow, R. L. 1974. American lobsters tagged by Maine commercial fishermen, 1957-59. Fish. Bull. 72: 622-623.

Ennis, G. P. 1972. Growth per moult of tagged lobsters (*Homarus americanus*) in Bonavista Bay, Newfoundland. J. Fish. Res. Board Can. 29: 143-148.

Ennis, G. P. 1984. Small-scale seasonal movements of the American lobster, *Homarus americanus*. Trans. Am. Fish. Soc. 113: 336-338.

Ennis, G. P., P. W. Collins, and G. Dawe. 1982. Fisheries and population biology of lobsters (*Homarus americanus*) at Comfort Cove, Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. 1116: 1-45.

Fogarty, M. J., and J. S. Idoine. 1988. Application of a yield and egg per recruit model based on size to an offshore American lobster population. Trans. Amer. Fish. Soc. 117: 350-362.

Fogarty, M. J., D. V. D. Borden, and H. J. Russell. 1980. Movements of tagged American lobster, *Homarus americanus*, off Rhode Island. Fish. Bull. 78: 771-780.

Frusher S. D., R. B. Kennedy, and I. D. Gibson. 1997. Precision of exploitation-rate in the Tasmanian rock-lobster fishery based on change-in-ratio techniques. Mar. Freshwater Res. 48: 1069-1074.

Gould, W. R., and K. H. Pollock. 1997. Catch-effort maximum likelihood estimation of important population parameters. Can. J. of Fish. Aquat. Sci. 54: 890-897.

Krouse, J. S. 1973. Maturity, sex-ratio, and size composition of the natural population of American lobster, *Homarus americanus*, along the Maine Coast. Fisheries Bulletin 71: 165--173.

Landry, N. 1994. Les pêches dans la péninsule acadienne, 1850-1900. Les Édition d'Acadie, Moncton, 192p.

Lanteigne, M. 1999. Description of the 1993 lobster fishery and fishing fleet of the southern Gulf of St. Lawrence and a retrospective look of the changes that took place from 1984 to 1993. Can. Ind. Rep. Fish. Aquat. Sci. 250.

Lanteigne, M. and G. Paulin. 2001. Description of the 1999 lobster fishing effort along the western coast of Cape Breton (Lobster Fishing Area 26B). Can. Ind. Rep. Fish. Aquat. Sci. 259.

Lanteigne, M., F. Savoie, G. Robichaud and W. Landsburg. 1996. Coastal Temperature monitoring program for 1995 : Southern Gulf of St. Lawrence. Can. Data Rep. Fish. Aquat. Sci. 997 : 58p.

Lanteigne, M. M. Comeau, M. Mallet, G. Robichaud and F. Savoie. 1998. The American Lobster, *Homarus americanus*, in the southern Gulf of St. Lawrence (Lobster Fishing Areas 23, 24, 25, 26A and 26B). Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 98/123: 29p.

Lawton, P., and K. L. Lavalli. 1995. Postlarval, juvenile, adolescent, and adult ecology. *In* J. R. Factor (ed.), Biology of lobster, *Homarus americanus*, p. 47-81. Academic Press, New York, New York, 528 p.

Lawton, P., D.A. Robichaud, D.S. Pezzack, M.B. Strong and D.R. Duggan. 1999. The American Lobster, *Homarus americanus*, fishery in the Bay of Fundy (Lobster Fishing Areas 35, 36 and 38. Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 99/31: 59p.

Leslie, P. H., and D. H. S. Davis. 1939. An attempt to determine the absolute number of rats on a given area. J. Anim. Ecol. 8: 94-113.

Mace, P.M. and M.P Sissenwine. 1993. How much spawning per recruit is enough. Can. Spec. Publ. Fish. Aquat. Sci. 120: 101-118.

Maynard, D. R., F. Savoie, W. Landsburg, G. Roach, and E. Wade. 1992. The Cape Breton experiment on legal minimum lobster size increase: an intermediate report. Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 92/64: 1-47.

Moriyasu, M., W. Landsburg, E. Wade, and D. R. Maynard. 1999. The role of an estuary environment for regeneration of claws in the American lobster, *Homarus americanus* H. Milne Edwards, 1837 (Decapoda). Crustaceana 72: 415-433.

Munro, J., and J.-C. Therriault. 1983. Migrations saisonnières du homard (*Homarus americanus*) entre la côte et les lagunes des Îles-de-la-Madeleine. Can. J. Fish. Aquat. Sci. 40: 905-918.

Paulik, G. J., and D. S. Robson. 1969. Statistical calculations for change-in-ratio estimators of population parameters. J. Wild. Manag. 33: 1-27.

Pezzack, D.S, and J.J. Maguire. 1995. Preliminary examination of egg per recruit estimates in the Canadian lobster fishery. DFO Atl. Fish. Res. Doc. 95/92. 23p.

Pezzack, D.S, P. Lawton, I.M. Gutt, D.R. Duggan, D.A. Robichaud and M.B. Strong. 1999. The American Lobster, *Homarus americanus*, fishery off of South-western Nova

Scotia (Lobster Fishing Area 34). Can. Atl. Fish. Sci. Advis. Comm. Res. Doc. 99/31: 59p.
Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191. 382 p.
Robichaud, D. A., and P. Lawton. 1997. Seasonal movement and dispersal of American lobsters, *Homarus americanus*, released in the upper Bay of Fundy. Can Tech. Rep. Fish. Aquat. Sci. 2153, 21 p.
Savoie, F., S. Comeau, and M. Lanteigne. 2002. Coastal Temperature Monitoring Program from 1996 to 2000 : Southern Gulf of St. Lawrence. Can. Data. Rep. Fish. Aquat. Sci., 1087.
Squires, H. J. 1970. Lobster (*Homarus americanus*) fishery and ecology in Port-au-Port Bay, Newfoundland 1960-65. Proceedings of the National Shellfisheries Association 60: 22-39.
Stasko, A. B. 1980. Tagging and lobster movements. Can. Tech. Rep. Fish. Aquat. Sci. 932: 141-150.
Templeman, W. 1933. Female lobsters handicapped in growth by spawning. Fisheries Research Board of Canada Atlantic Progress Report 6: 5-6.
Templeman, W. 1934. Mating in the American lobster. Contribution Canadian Biological Fishery 8: 423-432.
Templeman, W. 1936. Local differences in the life history of lobster on the coast of the maritime provinces of Canada. J. Biol. Board Can. 2: 41-88.
Tremblay, M. J., and M. D. Eagles. 1997. Molt timing and growth of the lobster, *Homarus americanus*, off northeastern Cape Breton Island, Nova Scotia. J. Shell. Res. 16: 383-394.
Udevitz, M. S., and K. Pollack. 1995. Using effort information with change-in-ratio data for population estimator. Biometrics 51: 471-481.
Waddy, S. L., and D. E. Aiken. 1986. Multiple fertilization and consecutive spawning in large American lobster, *Homarus americanus*. Can. J. Fish. Aquat. Sci. 43: 2291-2294.
Waddy, S. L., and D. E. Aiken. 1992. Seasonal variation in spawning by preovigerous American lobster (Homarus americanus) in response to temperature and photoperiod manipulation. Can. J. Fish. Aquat. Sci. 49: 1114-1117.
Waddy, S. L., D. E. Aiken, and D. P. V. De Kleijn. 1995. Control of growth and reproduction. Pp. 217-266 *in* J. R. Factor, ed. Biology of the lobster, *Homarus americanus*. Academic Press, New York.
Wilder, D.G. 1953. The growth of the American lobster (*Homarus americanus*). J. Fish. Res. Board Can. 10: 371-412
Wilder, D.G. 1963. Movement, growth and survival of marked and tagged lobsters liberated in Egmont Bay, Prince Edward Island. Journal of the Fisheries Research Board of Canada 20: 305-318.

8.0 Acronyms used in this document

CIL	cold intermediate layer	NB	New Brunswick
CIR	change-in-ratio	*ND*	number of days in the fishing season
CL	carapace length	NEFSC SAW	North East Fisheries Science Center Stock Assessment Workshop
CPUE	catch-per-unit-of-effort (kg/trap haul per day)	*NF*	number of licensed fishermen
DFO	Department of Fisheries and Oceans	*NIF*	number of index-fishermen
E/R	egg-per-recruit	NS	Nova Scotia
EIF	effort in trap hauls of index-fishermen	*NT*	number of sale transactions
ERIF	estimated reported trap hauls from index-fishermen	PEI	Prince Edward Island
ERST	estimated reported trap from sale transactions	q	catchability
f	fishing effort (number of trap hauls)	GSL	Gulf of St. Lawrence
F	Fishing mortality	sGSL	southern Gulf of St. Lawrence
FRCC	Fisheries Resource Conservation Council	*SOM*	size at the onset of sexual maturity
LFA	Lobster Fishing Area	SOM_{50}	size at 50% sexual maturity
MLS	minimum legal size	*TA*	trap allocation per fisherman
MP	maximum potential trap hauls	$\hat{u}$	exploitation rate

9.0 Appendices

Appendix I. Historical overview of the increase in minimum legal size (MLS) in each Lobster Fishing Area (LFA).

LFA 23	LFA 24	LFA 25	LFA 26A[2]	LFA 26B
1952 – 63.5mm	1952 - 63.5 mm	1952 – 63.5mm	1952 – 63.5mm	1952 – 63.5mm
1990 – 65.1mm	1998 – 65.1mm[1]	1990 – 65.1mm	1991 – 65.1mm	1987 – 65.1mm
1991 – 66.7mm	1999 – 65.9mm[1]	1991 – 66.7mm	1998 – 65.9mm[1]	1988 – 66.7mm
1998 – 67.5mm[1]	2000 – 66.7mm[1]	1998 – 67.5mm[1]	2000 – 66.7mm[1]	1989 – 68.3mm
	2001 – 67.5mm[1]		2001 – 67.5mm[1]	1990 – 70.0mm

1 = Management measures implemented as part of the 4-year management plan aimed at increasing the egg/recruit (1998-2001).

2 = Since 1998, approximately 50% of the fishermen in LFA 26A (fishermen from the province of Nova Scotia) have agreed to gradually increase the MLS to 70mm in 2000.

Appendix II. Lobster conservation measures in the four-year management plan, by Lobster Fishing Area (LFA) in the southern Gulf of St. Lawrence (MLS: minimum legal size).

	1998	1999	2000	2001
LFA 23	Increase MLS to 67.5mm 50% V-notching on egg bearing females* Trap allocation reduction from 375 to 350 traps**	Trap allocation reduction from 350 to 325 traps**	Trap allocation reduction from 325 to 300 traps**	
LFA 24	Increase MLS to 65.1mm	Increase MLS to 65.9mm	Increase MLS to 66.7mm	Increase MLS to 67.5mm
LFA 25	Increase MLS to 67.5mm 50% V-notching on egg bearing females*			
LFA 26A	Increase MLS to 65.9mm 50% V-notching on egg bearing females*		Increase MLS to 66.7mm	Increase MLS to 67.5mm
LFA 26B	50% V-notching on egg bearing females*			

* *V-notching on 50% of egg bearing females caught by trap.*

** *This effort reduction was requested and conducted by fishermen in LFA 23 and was not part of the initial 4-years management plan.*

Appendix III. Parameters used to calculate lobster fishing effort (trap hauls). Underlined values are estimations.

Lobster Fishing Area 23						
Year	Season duration in days (*ND*)	Trap allocation per fishermen (*TA*)	Number of licensed fishermen (*NF*)	Number of sale transactions (*NT*)	Number of index-fishermen (*NIF*)	Trap hauls from index-fishermen (*EIF*)
1984	<u>61</u>	375	786	21,219		
1985	<u>57</u>	375	786	23,126		
1986	61	375	773	24,314		
1987	61	375	766	23,517		
1988	<u>55</u>	375	768	23,582		
1989	61	375	765	26,749		
1990	68	375	764	24,761		
1991	60	375	761	23,647		
1992	61	375	765	26,835		
1993	61	375	765	27,546		
1994	61	375	764	21,186	27	402,715
1995	61	375	765	20,883	32	605,555
1996	61	375	757	20,423	39	625,531
1997	60	375	749	19,562	36	563,967
1998	61	350	743	18,945	27	396,033
1999	61	325	743	20,138	33	462,223
2000	61	300	735	18,596	27	362,533
2001	62	300	722	18,321	30	437,722

Lobster Fishing Area 24						
Year	Season duration in days (*ND*)	Trap allocation per fishermen (*TA*)	Number of licensed fishermen (*NF*)	Number of sale transactions (*NT*)	Number of index-fishermen (*NIF*)	Trap hauls from index-fishermen (*EIF*)
1984	<u>60</u>	300	656	22,674		
1985	<u>60</u>	300	653	27,932		
1986	61	300	654	27,180		
1987	53	300	649	26,395		
1988	55	300	646	26,952		
1989	62	300	639	30,230		
1990	61	300	639	26,987		
1991	56	300	638	26,811		
1992	53	300	637	26,633		
1993	56	300	638	31,086		
1994	60	300	638	35,562	6	90,499
1995	59	300	639	30,895	26	332,389
1996	61	300	639	32,391	29	406,640
1997	55	300	637	29,535	27	315,056
1998	61	300	635	20,524	14	188,514
1999	61	300	635	27,222	25	333,452
2000	61	300	619	30,679	24	296,294
2001	60	300	614	31,991	67	888,811

Appendix III. Continued.

Lobster Fishing Area 25

Year	Season duration in days (*ND*)	Trap allocation per fishermen (*TA*)	Number of licensed fishermen (*NF*)	Number of sale transactions (*NT*)	Number of index-fishermen (*NIF*)	Trap hauls from index-fishermen (*EIF*)
1984	*62*	250	891	33,233		
1985	*62*	250	887	36,577		
1986	64	250	889	34,079		
1987	62	250	888	35,434		
1988	62	250	888	32,407		
1989	62	250	887	32,771		
1990	62	250	885	32,861		
1991	62	250	882	36,534		
1992	62	250	884	35,659		
1993	62	250	879	35,662		
1994	62	250	887	37,318	36	354,848
1995	62	250	887	36,038	34	297,420
1996	62	250	876	35,059	32	294,402
1997	62	250	867	36,033	33	312,619
1998	62	250	855	35,786	29	259,580
1999	62	250	852	34,218	34	595,105
2000	61	250	823	32,505	34	295,335
2001	62	250	793	30,124	41	374,929

Lobster Fishing Area 26A

Year	Season duration in days (*ND*)	Trap allocation per fishermen (*TA*)	Number of licensed fishermen (*NF*)	Number of sale transactions (*NT*)	Number of index-fishermen (*NIF*)	Trap hauls from index-fishermen (*EIF*)
1984	*60*	300	*754*	31,800		
1985	*60*	300	*754*	33,758		
1986	61	300	*758*	36,756		
1987	56	300	765	36,119		
1988	*55*	300	772	37,252		
1989	62	300	776	39,131		
1990	61	300	775	35,134		
1991	61	300	775	33,200		
1992	53	300	777	31,727		
1993	61	300	776	35,151		
1994	60	300	774	35,156	15	176,373
1995	59	300	772	33,191	26	317,066
1996	61	300	771	34,427	27	352,881
1997	56	300	767	32,099	32	426,558
1998	61	300	767	30,387	29	375,237
1999	62	300	767	33,505	40	506,088
2000	61	300	753	33,976	47	616,602
2001	60	300	749	34,022	60	769,650

Appendix III. Continued.

Lobster Fishing Area 26B						
Year	Season duration in days (*ND*)	Trap allocation per fishermen (*TA*)	Number of licensed fishermen (*NF*)	Number of sale transactions (*NT*)	Number of index-fishermen (*NIF*)	Trap hauls from index-fishermen (*EIF*)
1984	*60*	300	*250*	10,514		
1985	*60*	300	*249*	11,550		
1986	61	300	*251*	11,592		
1987	56	300	257	11,160		
1988	*55*	300	253	11,330		
1989	62	300	256	11,280		
1990	61	300	253	10,896		
1991	58	300	253	11,126		
1992	53	300	256	10,709		
1993	61	300	255	12,584		
1994	60	300	255	12,731	7	82,169
1995	59	300	255	11,683	13	157,600
1996	61	300	256	12,441	11	142,275
1997	52	300	256	11,396	32	384,738
1998	61	300	255	12,200	7	79,732
1999	61	300	255	10,784	21	260,883
2000	61	300	253	10,192	21	259,082
2001	57	300	251	10,477	18	201,398

Appendix IV. Size groupings of sea sampling data to represent molt classes. The molt classes were adjusted to the increase in minimum legal size in each Lobster Fishing Area (LFA) and year.

Years	LFAs	Pre-recruit molt class	Molt classes recruited into the fishery		
		M-1	M+1	M+2	M+3
1983-1986	23, 24, 25, 26A, 26B	54-63.9	64-73.9	74-83.9	>83.9
1987	23, 24, 25, 26A	54-63.9	64-73.9	74-83.9	>83.9
	26B	55-64.9	65-74.9	75-84.9	>84.9
1988	23, 24, 25, 26A	54-63.9	64-73.9	74-83.9	>83.9
	26B	57-66.9	67-76.9	77-86.9	>86.9
1989	26B	58-67.9	68-77.9	78-87.9	>87.9
	23, 24, 25, 26A	54-63.9	64-73.9	74-83.9	>83.9
1990	23, 25	55-64.9	65-74.9	75-84.9	>84.9
	24, 26A	54-63.9	64-73.9	74-83.9	>83.9
	26B	60-69.9	70-79.9	80-89.9	>89.9
1991-1997	23, 25	57-66.9	67-76.9	77-86.9	>86.9
	24, 26A	54-63.9	64-73.9	74-83.9	>83.9
	26B	60-69.9	70-79.9	80-89.9	>89.9
1998	23, 25	58-67.9	68-77.9	78-87.9	>87.9
	24	55-64.9	65-74.9	75-84.9	>84.9
	26A	56-65.9	66-75.9	76-85.9	>85.9
	26B	60-69.9	70-79.9	80-89.9	>89.9
1999	23, 25	58-67.9	68-77.9	78-87.9	>87.9
	24, 26A	56-65.9	66-75.9	76-85.9	>85.9
	26B	60-69.9	70-79.9	80-89.9	>89.9
2000	23, 25	58-67.9	68-77.9	78-87.9	>87.9
	24, 26A	57-66.9	67-76.9	77-86.9	>86.9
	26B	60-69.9	70-79.9	80-89.9	>89.9
2001	23, 24, 25, 26A	58-67.9	68-77.9	78-87.9	>87.9
	26B	60-69.9	70-79.9	80-89.9	>89.9

Appendix V. Parameters used in the 1997 mathematical model to calculate the egg per recruit values for the different Lobster Fishing Areas (LFA).

LFA specific Parameters		LFA 23	LFA 24	LFA 25	LFA 26A	LFA 26B
Fishing mortality (*F*)		1.39	1.39	1.39	1.2	1.39
Fishing mortality in percentage		75%	75%	75%	70%	75%

Parameters common to all LFAs		
Natural mortality (at molt)		10%
Natural mortality (other than at molt)		5%
Female sexual maturity (%) at size (*Pm*)		*Pm = 1/(1+exp(20.9545-0.2941CL))*
Double molt probability (%)	55-57 mm	10%
	58-60 mm	8%
	61-65 mm	5%
Annual molting probability (%)	Immature	100%
Sexually mature	<= 110 mm	50%
Sexually mature	111-150 mm	33.3%
Sexually mature	>= 150 mm	25%
Fecundity (number of eggs at size), (*Fec*)		$Fec = 0.00265\ CL^{3.409}$
Growth (minimal growth, average and *stdev*)		
	<= 95 mm	Min.=7mm, Avg.=10mm, *stdev* =1.49mm
	96-119 mm	Min.=6mm, Avg.=11mm, *stdev* =2.78mm
	>= 120 mm	Min.=6mm, Avg.=11mm, *stdev* =2.78mm

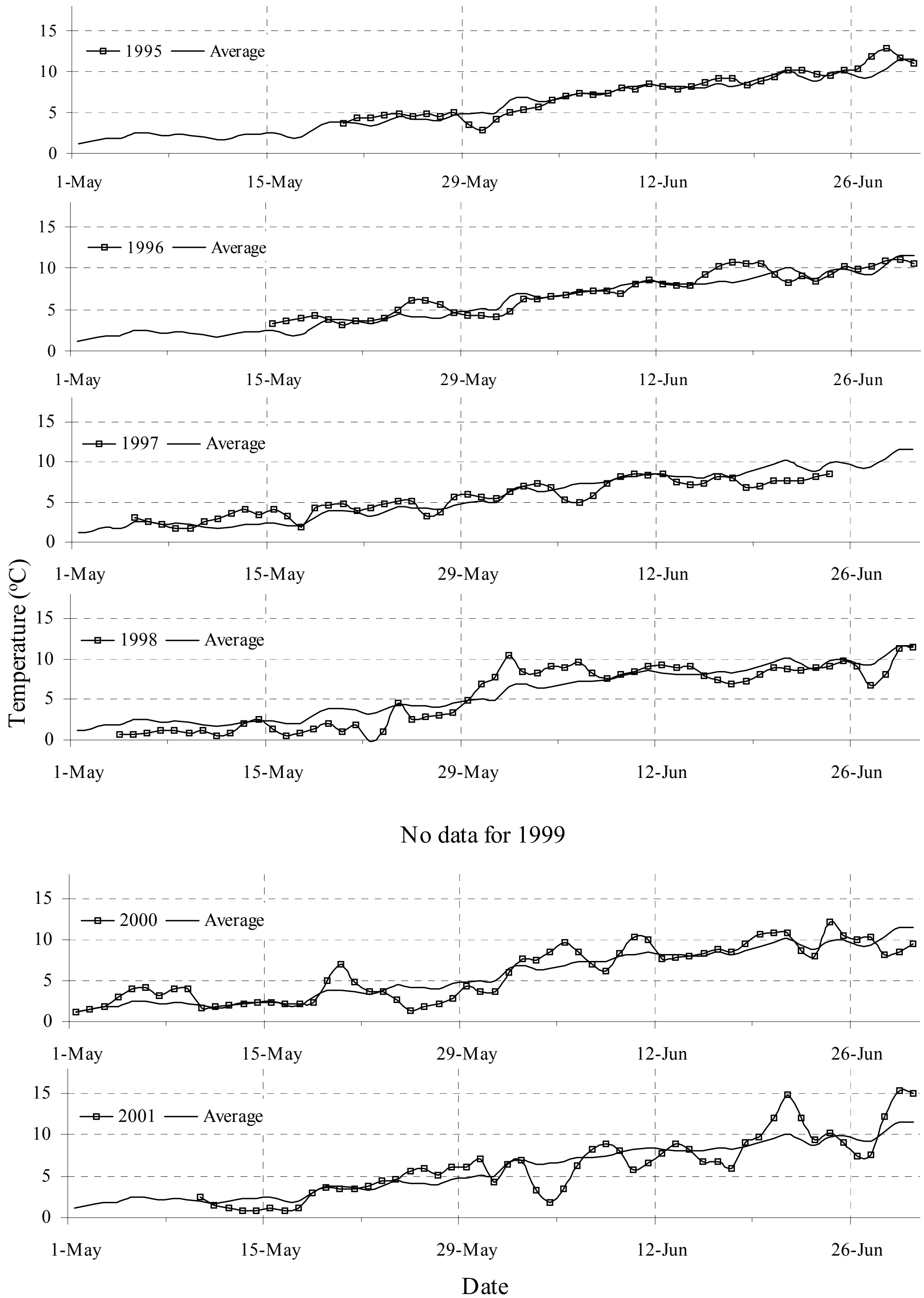
Appendix VI. Lobster landings (t) in the southern Gulf of St. Lawrence, by Lobster Fishing Area (LFA), from 1892 to 2001).

Year	LFA 23	LFA 24	LFA 25	LFA 26A	LFA 26B	TOTAL
1892	2,649				541	16,876
1893	2,987	Information not available for these LFA but included in the total for the southern Gulf of St. Lawrence			645	18,059
1894	2,756				617	17,369
1895	2,727				609	15,260
1896	2,630				670	12,026
1897	3,444				679	13,245
1898	2,415				588	11,884
1899	1,908				585	12,173
1900	1,718				600	11,735
1901	1,599				611	11,656
1902	1,991				538	11,170
1903	2,298				770	12,495
1904	2,506				660	12,764
1905	2,560				739	11,463
1906	2,414				911	12,988
1907	2,765				647	14,720
1908	2,788				533	15,373
1909	2,315				405	12,067
1910	1,893				464	11,076
1911	1,877				677	11,249
1912	1,664				819	11,916
1913	1,223				714	9,504
1914	1,146				579	8,611
1915	1,416				633	8,560
1916	2,146				657	11,395
1917	2,627				557	12,296
1918	935				510	5,470
1919	1,326				617	6,901
1920	1,286				734	8,355
1921	1,213				508	7,085
1922	1,391				780	9,021
1923	1,520				788	9,762
1924	1,473				393	7,055
1925	1,511				506	7,958
1926	1,413				662	7,324
1927	1,100				662	6,570
1928	1,041				590	6,944
1929	1,366				572	8,686
1930	1,359				651	9,634
1931	1,492				639	10,610
1932	1,598				687	12,153
1933	1,349				563	9,497
1934	1,244				599	8,676
1935	1,006				598	7,474
1936	1,041				545	6,963
1937	1,131				536	7,524
1938	936				596	8,094
1939	1,027				443	8,125
1940	1,007				303	6,241
1941	926				459	6,647
1942	1,113				411	7,126
1943	1,070				438	6,890
1944	1,292				390	7,302
1945	1,557				490	8,282

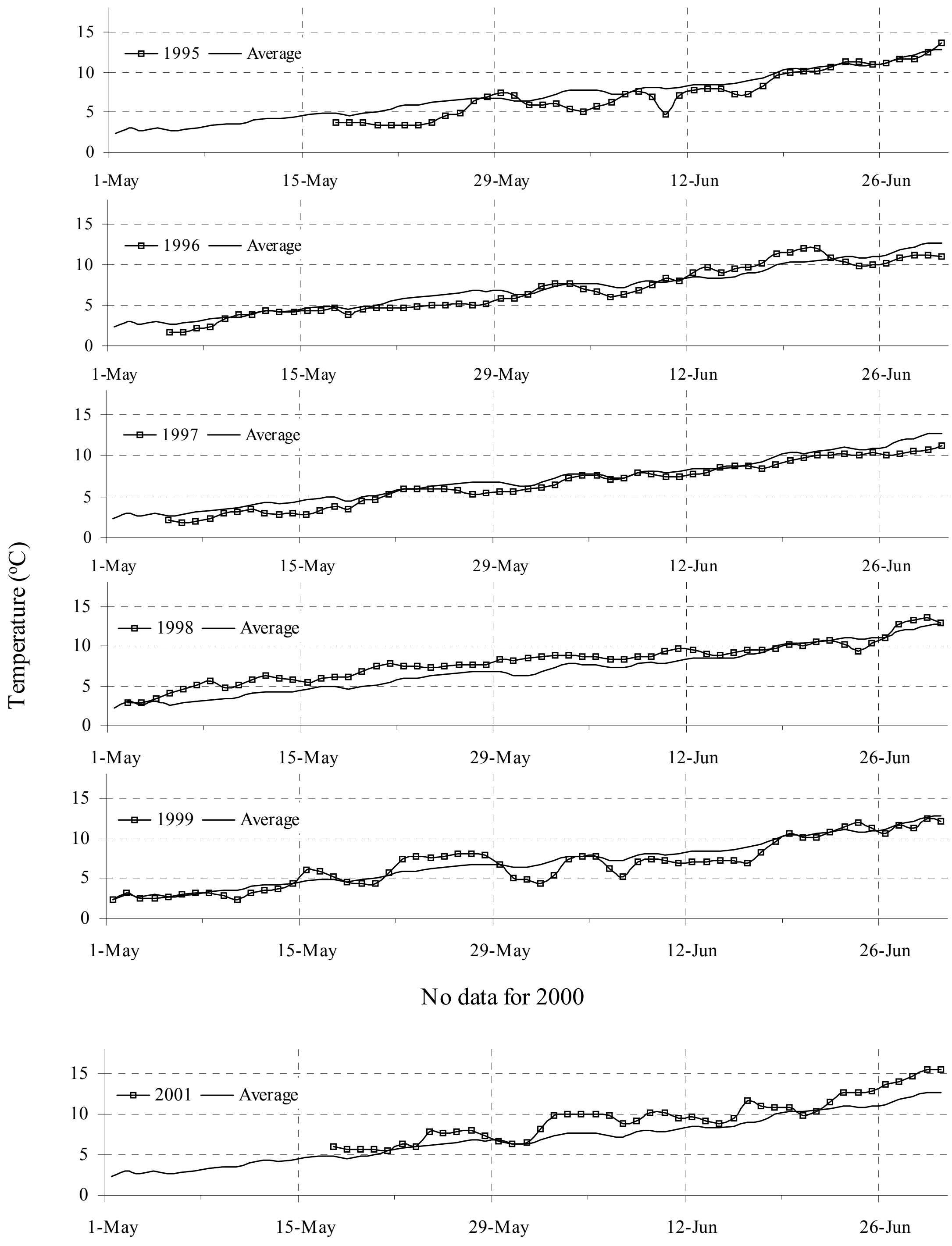
Year	LFA 23	LFA 24	LFA 25	LFA 26A	LFA 26B	TOTAL
1946	1,854				414	8,705
1947	1,285	497	941	1,720	345	4,788
1948	1,375	738	1,565	2,206	462	6,346
1949	1,508	621	1,891	2,311	445	6,776
1950	1,919	836	2,257	2,989	491	8,492
1951	1,665	712	2,131	2,813	672	7,993
1952	1,568	824	2,039	2,855	512	7,798
1953	1,298	591	1,592	2,282	628	6,391
1954	1,202	905	1,489	2,819	594	7,009
1955	1,009	942	1,988	2,853	611	7,403
1956	1,765	1,055	2,268	3,011	520	8,619
1957	1,550	1,783	3,756	2,533	482	10,104
1958	1,241	1,492	3,655	2,461	426	9,275
1959	1,148	1,426	3,760	2,893	585	9,812
1960	1,529	1,758	4,909	2,999	530	11,725
1961	1,464	1,807	4,186	2,753	475	10,685
1962	1,265	1,685	3,520	2,658	495	9,623
1963	1,038	1,425	2,954	2,377	441	8,235
1964	898	1,562	2,711	2,257	450	7,878
1965	901	1,983	1,997	2,423	511	7,815
1966	977	1,848	1,777	1,901	451	6,954
1967	914	2,232	1,515	1,795	524	6,980
1968	913	2,001	1,839	2,676	495	7,936
1969	791	1,955	2,143	2,562	629	8,087
1970	974	2,266	1,754	2,416	514	7,926
1971	836	1,797	1,866	2,507	519	7,530
1972	811	1,744	1,825	1,827	629	6,844
1973	868	1,890	1,622	1,719	526	6,633

Year	LFA 23	LFA 24	LFA 25	LFA 26A	LFA 26B	TOTAL
1974	759	1,419	1,638	1,372	406	5,594
1975	1,077	1,979	2,247	2,105	453	7,868
1976	1,157	1,984	2,645	1,785	491	8,062
1977	1,256	2,157	2,365	1,847	487	8,112
1978	1,612	2,382	3,096	2,166	632	9,889
1979	1,640	2,825	3,110	2,622	733	10,933
1980	1,917	2,755	3,103	2,302	700	10,780
1981	1,732	2,657	3,155	2,771	780	11,096
1982	1,730	2,754	3,643	2,693	1,023	11,845
1983	1,864	3,281	4,241	3,902	948	14,249
1984	2,230	2,955	4,369	3,396	883	13,834
1985	2,026	2,701	6,230	3,927	935	15,819
1986	2,478	3,114	5,803	5,726	1,134	18,255
1987	3,009	3,278	5,758	6,194	1,048	19,288
1988	3,114	3,698	5,463	6,691	1,190	20,156
1989	4,528	3,710	5,877	6,284	1,130	21,529
1990	4,508	4,591	5,320	6,363	1,281	22,063
1991	4,186	5,109	4,770	5,844	1,543	21,451
1992	4,257	4,605	4,578	4,594	1,411	19,444
1993	4,486	4,732	4,100	4,686	1,455	19,459
1994	4,111	4,830	4,572	3,480	1,110	18,103
1995	4,069	5,083	4,360	3,536	1,152	18,200
1996	3,784	4,604	4,239	3,720	1,126	17,473
1997	3,467	4,757	3,784	3,480	1,079	16,568
1998	3,453	4,959	3,844	3,804	1,098	17,158
1999	3,752	5,079	3,946	3,554	1,068	17,399
2000	3,808	5,198	3,526	3,934	1,114	17,580
2001	3,594	5,436	3,499	3,856	1,180	17,564

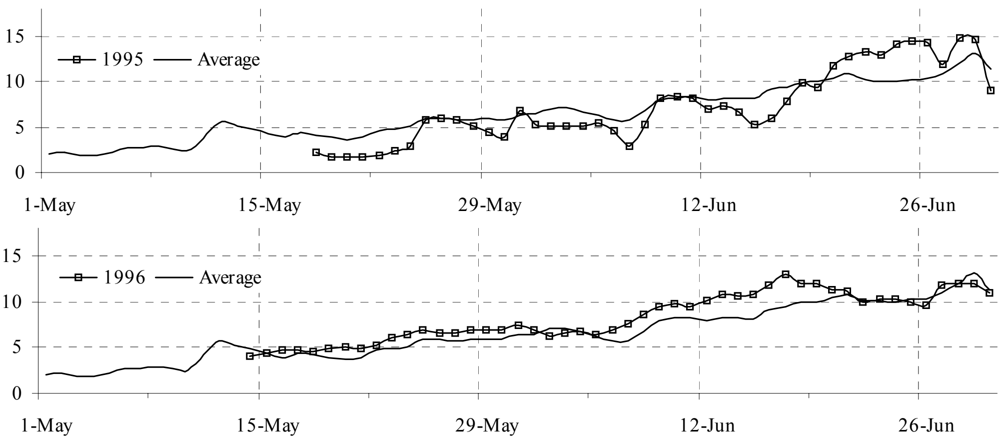
Appendix VII, (A). Average daily bottom temperature recorded in Caraquet (LFA 23, depth = 15m). The continuous line represents the daily average temperature from 1995 to 2001.



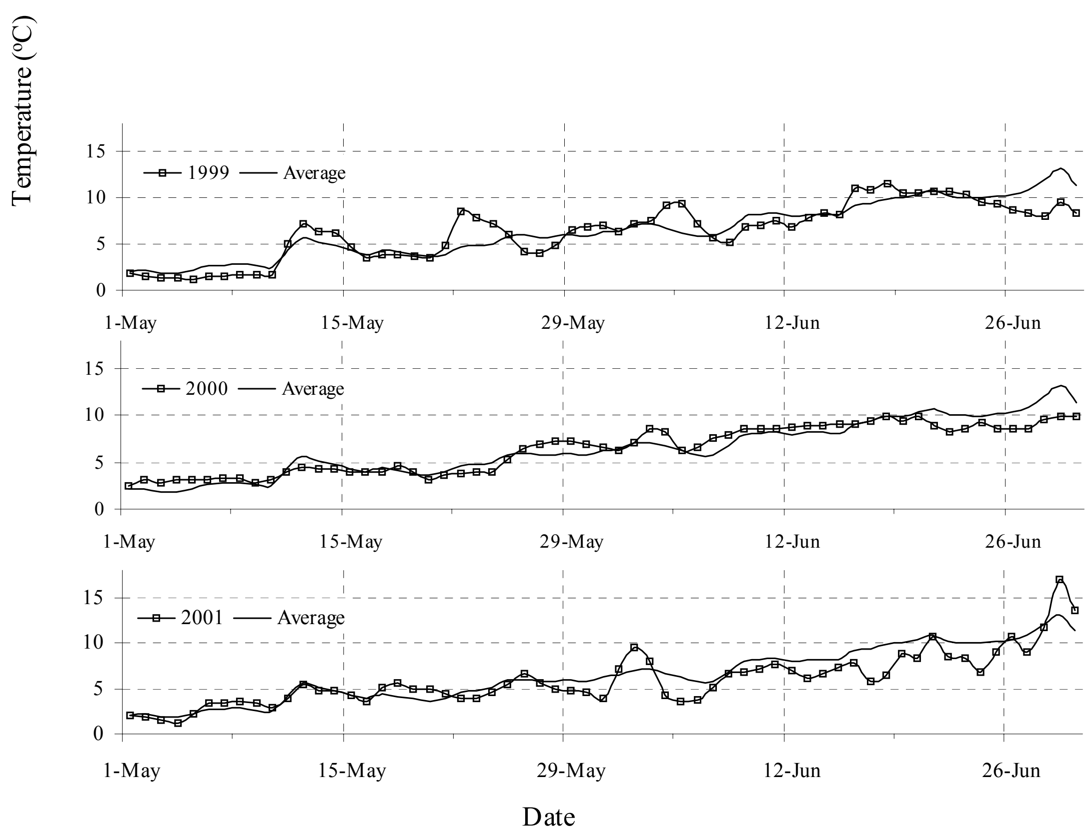
Appendix VII, (B). Average daily bottom temperature recorded in Val Comeau (LFA 23, depth = 10m). The continuous line represents the daily average temperature from 1995 to 2001.



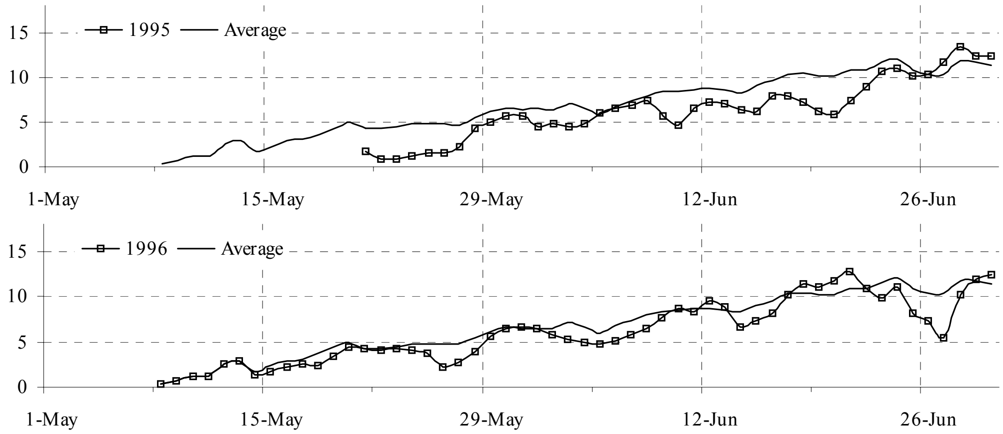
Appendix VII, (C). Average daily bottom temperature recorded in Malpeque (LFA 24, depth = 15m). The continuous line represents the daily average temperature from 1995 to 2001.



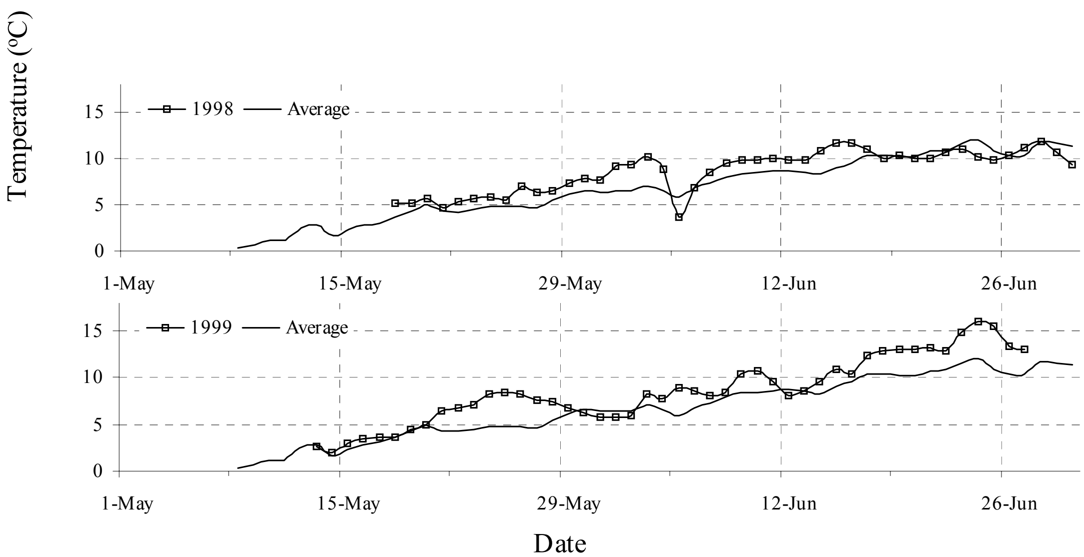
No data for 1997, 1998



Appendix VII, (D). Average daily bottom temperature recorded in Souris (LFA 26A, depth = 20m). The continuous line represents the daily average temperature from 1995 to 1999.

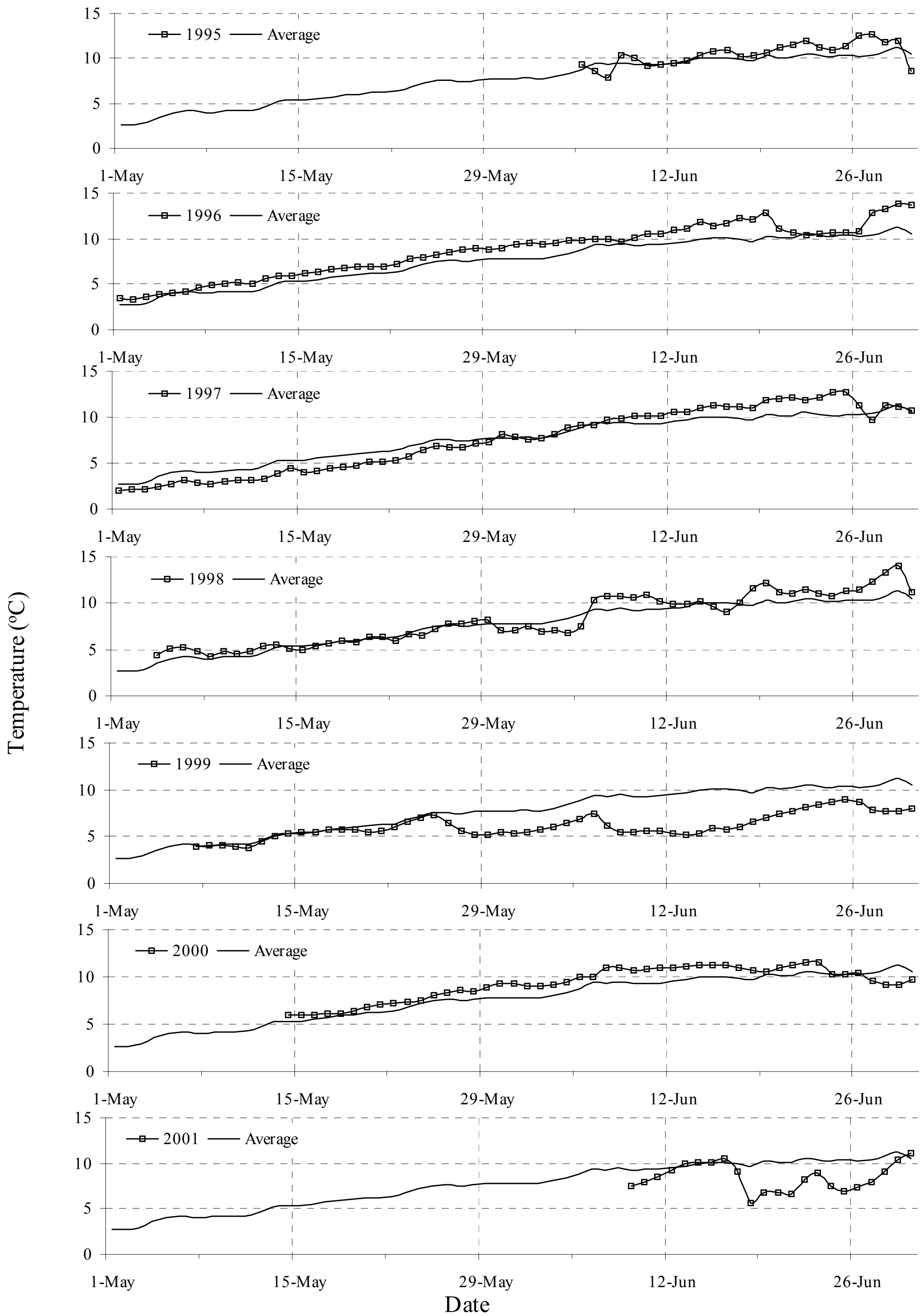


No data for 1997

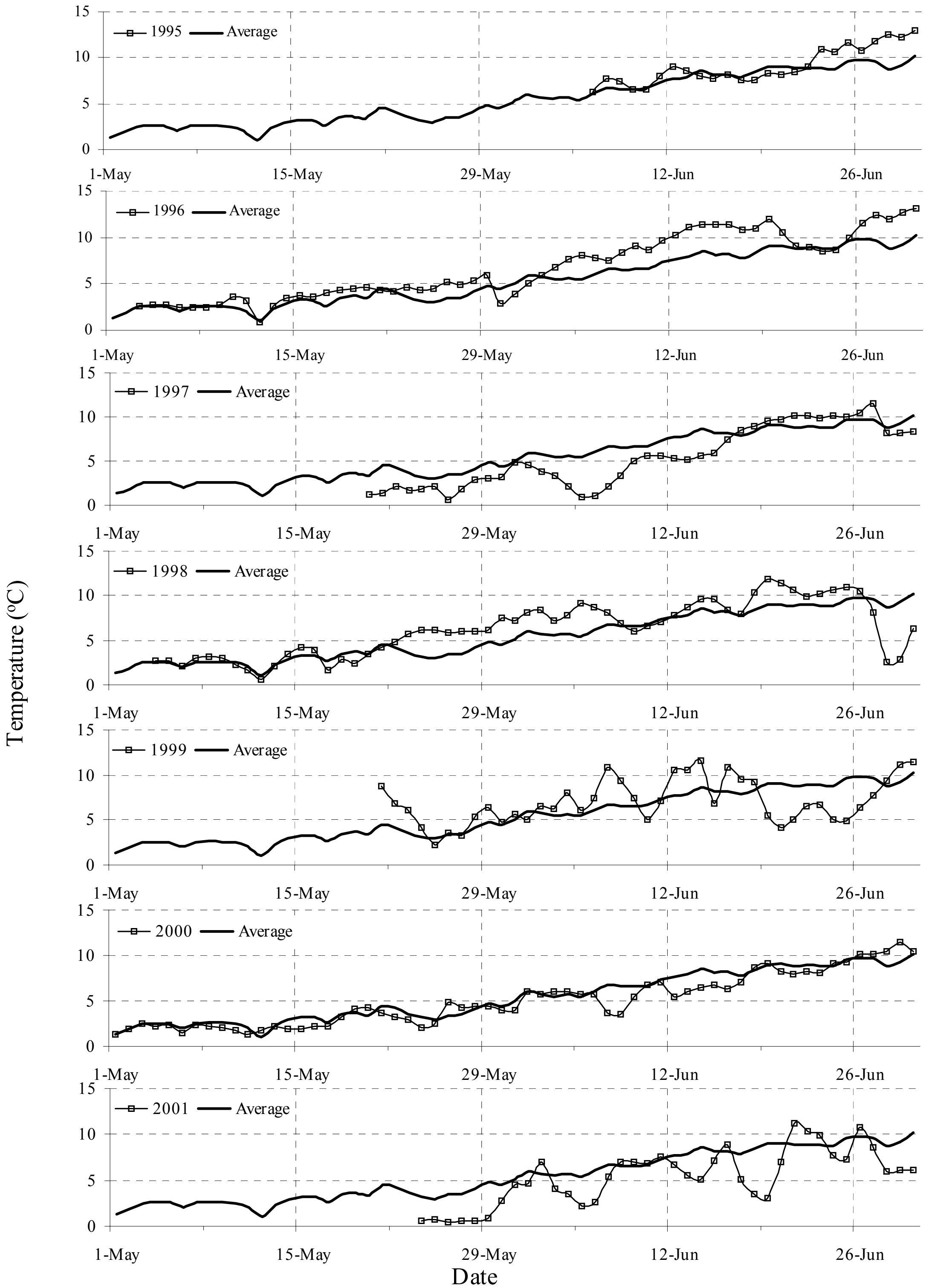


No data for 2000, 2001

Appendix VII, (E). Average daily bottom temperature recorded in Pugwash (LFA 26A, depth = 15m). The continuous line represents the daily average temperature from 1995 to 2001.

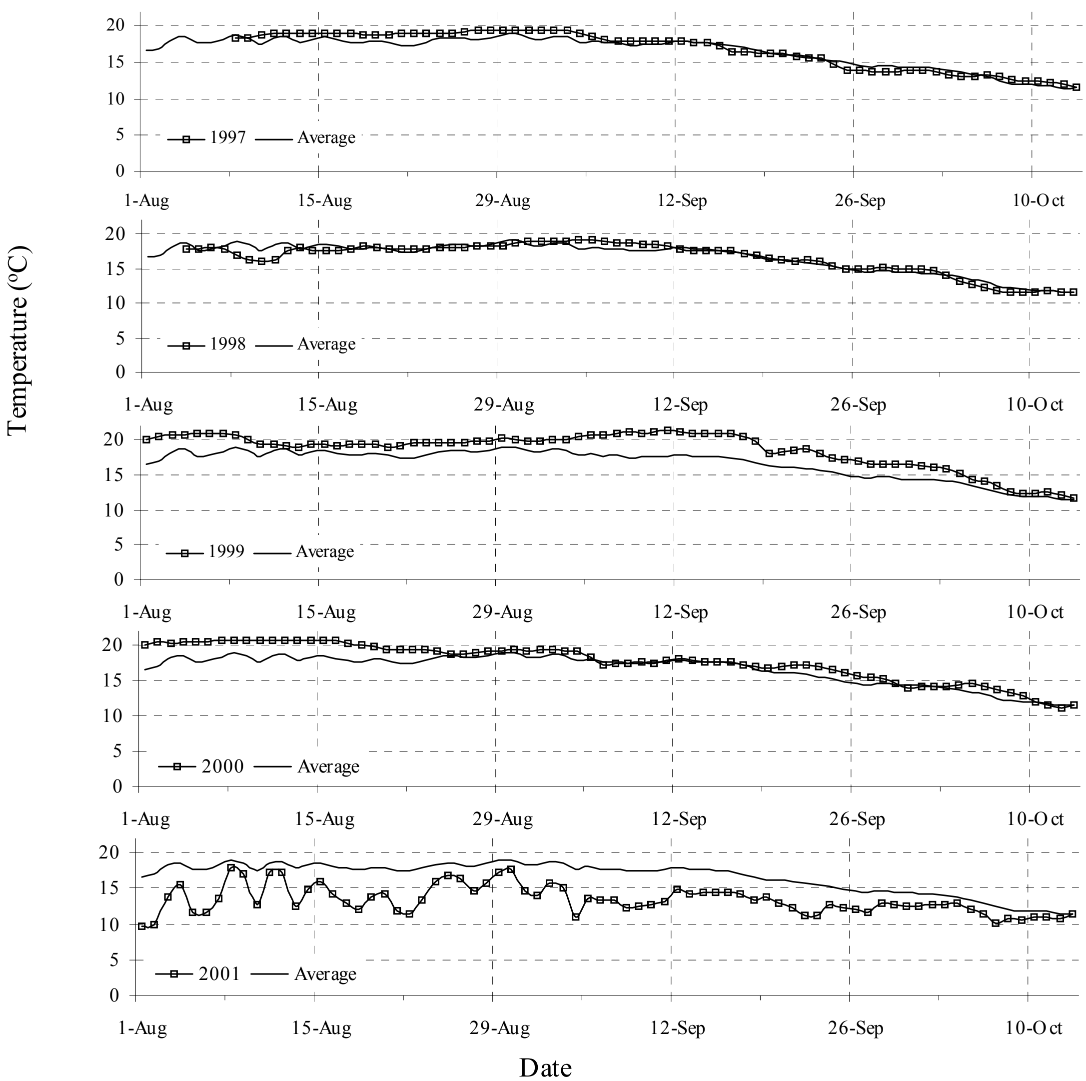


Appendix VII, (F). Average daily bottom temperature recorded in Pleasant Bay (LFA 26B, depth = 20m). The continuous line represents the daily average temperature from 1995 to 2001.

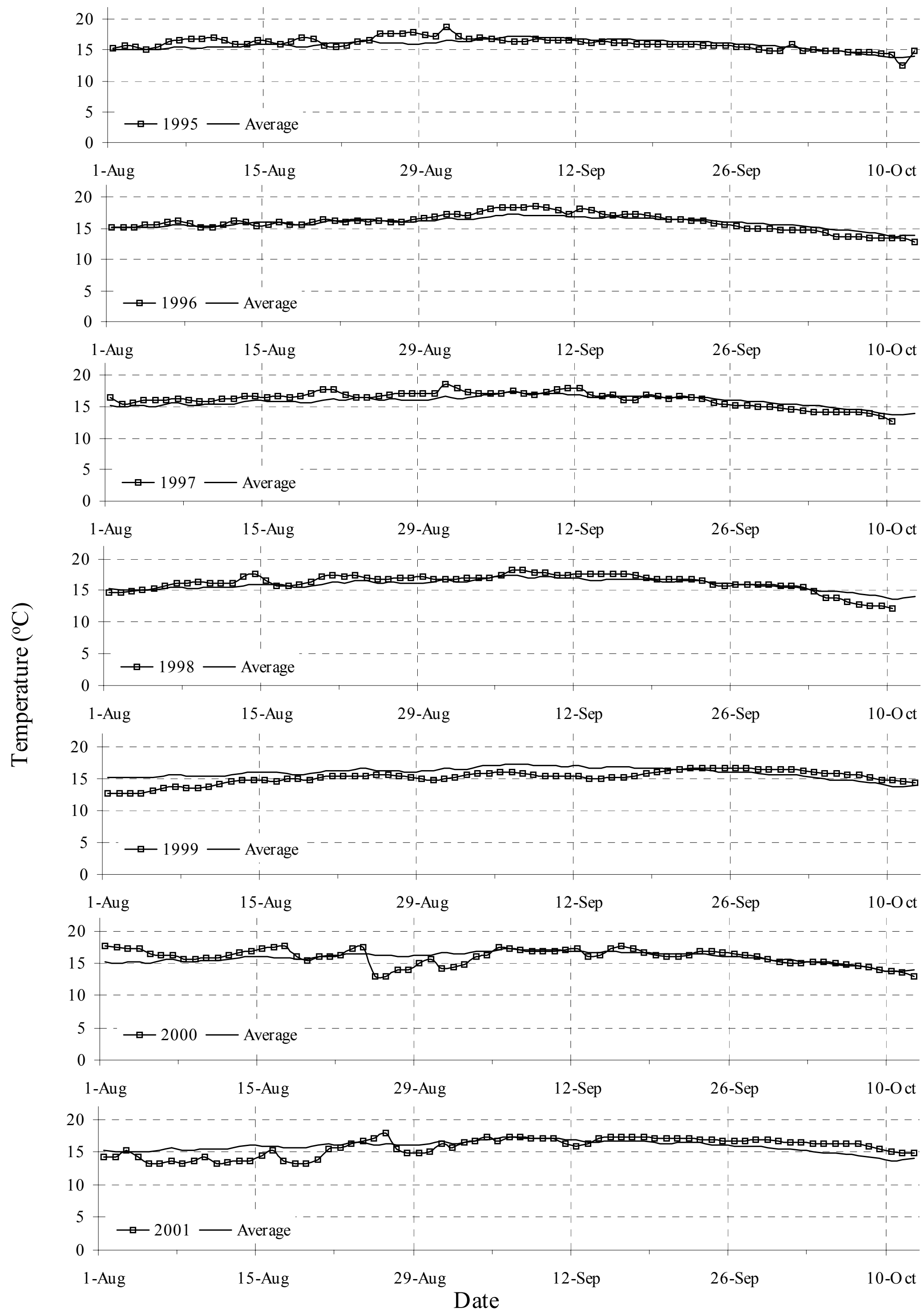


Appendix VII, (G). Average daily bottom temperature recorded in Shediac (LFA 25, Summer-Fall fishery, depth = 10m). The continuous line represents the daily average temperature from 1997 to 2001.

No data for 1995, 1996



Appendix VII, (H). Average daily bottom temperature recorded in Pugwash (LFA 25, Summer-Fall fishery, depth = 15m). The continuous line represents the daily average temperature from 1995 to 2001.



Appendix VIII. Lobster fishing effort in total trap hauls (x 1,000,000) by Lobster Fishing Area (LFA) calculated with three methods; MP: maximum potential trap hauls from regulations, ERST: estimated reported trap hauls from sale transactions and ERIF: estimated reported trap hauls from index-fishermen.

	LFA 23			LFA 24			LFA 25			LFA 26A			LFA 26B		
	MP	*ERST*	*ERIF*	*MP*	*ERST*	*ERIF*	*MP*	*ERST*	*ERIF*	*MP*	*ERST*	*ERIF*	*MP*	*ERST*	*ERIF*
1984	17.7	8.0		11.8	6.8		13.8	8.3		13.8	9.5		4.7	3.2	
1985	17.8	8.7		11.8	8.4		13.8	9.1		13.8	10.1		4.7	3.5	
1986	17.8	9.1		11.9	8.2		14.2	8.5		14.0	11.0		4.7	3.5	
1987	17.7	8.8		10.3	7.9		13.8	8.9		12.9	10.8		4.4	3.3	
1988	15.9	8.8		10.7	8.1		13.8	8.1		12.8	11.2		4.2	3.4	
1989	17.6	10.0		11.9	9.1		13.8	8.2		14.5	11.7		4.8	3.4	
1990	19.6	9.3		11.7	8.1		13.7	8.2		14.2	10.5		4.7	3.3	
1991	17.3	8.9		10.7	8.0		13.7	9.1		14.2	10.0		4.5	3.3	
1992	17.5	10.1		10.1	8.0		13.7	8.9		12.4	9.5		4.1	3.2	
1993	17.5	10.3		10.7	9.3		13.6	8.9		14.2	10.5		4.7	3.8	
1994	17.5	7.9	10.0	11.5	10.7	10.4	13.7	9.3	9.4	13.9	10.5	10.6	4.6	3.8	3.2
1995	17.5	7.8	12.8	11.3	9.3	8.7	13.7	9.0	8.1	13.7	10.0	10.3	4.5	3.5	3.3
1996	17.3	7.7	10.9	11.7	9.7	9.3	13.6	8.8	8.3	14.1	10.3	10.9	4.7	3.7	3.4
1997	16.8	7.3	10.6	10.5	8.9	8.2	13.4	9.0	9.5	12.8	9.6	11.0	4.0	3.4	3.3
1998	15.9	6.6	9.9	11.6	6.2	9.3	13.3	8.9	8.0	14.0	9.1	10.3	4.6	3.7	3.4
1999	14.7	6.5	9.1	11.6	8.2	9.5	13.2	8.6	7.8	14.2	10.1	10.6	4.6	3.2	3.3
2000	13.6	5.6	8.5	11.6	9.2	8.6	12.8	8.1	8.3	13.9	10.2	10.9	4.6	3.1	3.5
2001*	13.9	5.5	9.6	11.5	9.6	8.6	13.4	7.5	8.3	13.8	10.2	10.3	4.4	3.1	3.2

** ERST calculations are conducted on preliminary sale transactions data*

Appendix IX. Percentage of lobster (in number) in the first (M+1), second (M+2) and third (M+3) molt groups recruited into the fishery (males and females combined, egg bearing females excluded), for each Lobster Fishing Area (LFA), from 1983 to 2001 taken from at-sea samples. Years when minimum legal sizes were increased are underlined.

	LFA 23			LFA 24			LFA 25			LFA 26A			LFA 26B		
Years	M+1	M+2	M+3	M+1	M+2	M+3	M+1	M+2	M+3	M+1	M+2	M+3	M+1	M+2	M+3
1983	62%	23%	15%	57%	28%	15%	65%	23%	11%	52%	28%	21%	57%	25%	17%
1984	53%	30%	17%	72%	20%	8%	70%	21%	9%	52%	32%	16%	69%	26%	5%
1985	60%	28%	12%	79%	15%	6%	81%	16%	4%	51%	26%	23%	75%	19%	6%
1986	68%	22%	10%	74%	16%	9%	72%	21%	7%	57%	29%	14%	73%	20%	7%
1987	65%	25%	10%	75%	19%	6%	53%	34%	13%	42%	37%	22%	<u>79%</u>	<u>15%</u>	<u>6%</u>
1988	70%	23%	8%	73%	21%	6%	50%	34%	16%	53%	33%	15%	<u>80%</u>	<u>16%</u>	<u>4%</u>
1989	59%	32%	10%	79%	18%	3%	47%	31%	22%	54%	30%	17%	<u>81%</u>	<u>13%</u>	<u>6%</u>
1990	<u>66%</u>	<u>26%</u>	<u>8%</u>	78%	18%	4%	<u>63%</u>	<u>24%</u>	<u>13%</u>	49%	29%	22%	<u>80%</u>	<u>17%</u>	<u>4%</u>
1991	<u>76%</u>	<u>19%</u>	<u>5%</u>	76%	19%	5%	<u>66%</u>	<u>22%</u>	<u>12%</u>	<u>56%</u>	<u>23%</u>	<u>22%</u>	75%	20%	5%
1992	76%	18%	6%	79%	17%	4%	66%	23%	10%	58%	26%	16%	76%	20%	4%
1993	78%	18%	4%	81%	15%	4%	71%	22%	7%	58%	26%	17%	74%	20%	6%
1994	73%	21%	6%	72%	18%	9%	76%	17%	7%	52%	32%	15%	75%	20%	5%
1995	72%	20%	8%	78%	17%	5%	64%	25%	12%	67%	22%	11%	75%	21%	4%
1996	72%	21%	7%	75%	19%	6%	66%	23%	11%	65%	24%	11%	70%	22%	7%
1997	65%	26%	8%	71%	23%	6%	63%	25%	12%	57%	26%	18%	75%	19%	6%
1998	<u>71%</u>	<u>20%</u>	<u>9%</u>	<u>74%</u>	<u>20%</u>	<u>5%</u>	<u>70%</u>	<u>22%</u>	<u>8%</u>	<u>55%</u>	<u>25%</u>	<u>20%</u>	75%	18%	6%
1999	72%	20%	8%	<u>77%</u>	<u>18%</u>	<u>5%</u>	55%	29%	16%	57%	27%	16%	65%	21%	14%
2000	69%	23%	8%	<u>76%</u>	<u>20%</u>	<u>4%</u>	61%	27%	12%	<u>63%</u>	<u>24%</u>	<u>14%</u>	56%	27%	17%
2001	73%	21%	6%	<u>75%</u>	<u>20%</u>	<u>4%</u>	54%	30%	16%	<u>58%</u>	<u>26%</u>	<u>16%</u>	68%	27%	5%
Average	*68%*	*23%*	*9%*	*75%*	*19%*	*6%*	*64%*	*25%*	*11%*	*55%*	*28%*	*17%*	*72%*	*20%*	*7%*
Maximum	*78%*	*32%*	*17%*	*81%*	*28%*	*15%*	*81%*	*34%*	*22%*	*67%*	*37%*	*23%*	*81%*	*27%*	*17%*
Minimum	*53%*	*18%*	*4%*	*57%*	*15%*	*3%*	*47%*	*16%*	*4%*	*42%*	*22%*	*11%*	*56%*	*13%*	*4%*