VARIABILITY IN LOBSTER, *HOMARUS AMERICANUS*, TRAP CATCHES

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ABSTRACT

Although at-sea sampling is the main approach used by the Department of Fisheries and Oceans Canada to assess changes in the American lobster (*Homarus americanus*) populations, no previous study has directly estimated the inherent variability of the information collected. This report assessed the variation components of the at-sea sampling and compared catch per unit effort (CPUE) from traps built from different construction material. The sampling variance estimation for the mean CPUE was based on a three stage sampling design with days as the primary unit, buoy and trap as secondary and third stage unit, respectively. Using the estimated variance components to predict and compare the variance of the mean CPUE for various at-sea sampling designs, we show that it would be more efficient to sample a few traps (at least 3) every day for the entire fishing season than the traditional at-sea sampling of the entire fishing gear twice or three times in a season by trained technicians. It was also found that building material, in this case wood and wire, did not affect the commercial yield of lobster traps. Designing a fishermen-based at-sea sampling program in all lobster fishing areas could be an efficient approach for gathering essential fishery data, increasing fishermen participation in managing the resource, and rationalizing monitoring.

RÉSUMÉ

Bien que l’échantillonnage en mer constitue la méthode principale de récolte de données au Ministère des Pêches et Océans afin d’étudier les changements dans la population de homards (*Homarus americanus*), aucune étude quantitative n’a jusqu’à présent été menée pour étudier spécifiquement la variation d’une telle méthode d’échantillonnage. Ce rapport présente des estimations des composantes de la variance lors d’une étude d’échantillonnage en mer et compare également la prise par unité d’effort (PUE) commerciale de deux types de casiers. L’estimation de la variance d’échantillonnage pour la moyenne des PUE est basé sur un échantillonnage à trois degrés où les jours représentent les unités primaires, les bouées les unités secondaires et les casiers les unités tertiaires. En utilisant les estimations des composantes de la variance afin de prédire la variance associée à différents protocoles d'échantillonnage, il est démontré qu'il est plus efficace d'échantillonner quotidiennement quelques casiers (au moins trois) durant toute la saison de pêche plutôt que de faire trois échantillonnages en mer traditionnel avec un technicien à bord d'un bateau pour mesurer le contenu de tous les casiers d'un pêcheur. Il semblerait également que les matériaux de construction, i.e. le bois et la broche, n'influence pas les captures des casiers dans la mesure où le design du casier soit le même. Ainsi un protocole d'échantillonnage en mer du type pêcheur-échantillonneur pourrait être une option efficace afin de récolter des données essentielles à la pêcherie et de rationaliser les coûts tout en permettant la participation des pêcheurs.

1.0 INTRODUCTION

The American lobster (*Homarus americanus*) fishery is the most valuable coastal fishery in eastern Canada and, as for many other invertebrate fisheries (Starr and Vignaux 1997), information on the abundance and size composition of the population is mostly gathered using the commercial trap catches. Although trawling is one of the most effective method used by fisheries research scientists to study fish stocks, the nature of the lobster's habitat makes trawling both impractical and inefficient in many places. Another method that is independent from the fishery and allows for a greater accessibility to the lobster habitat is SCUBA, however, it is time consuming and restricted to small survey area. Therefore, using commercial catch data to establish the size composition of the population and the catch per unit effort (CPUE) for assessment purposes is, by default, the most common approach for lobster.

Various at-sea sampling protocols have been developed throughout the years to monitor the lobster population and the fishery in the southern Gulf of St. Lawrence (sGSL) (Mallet et al. 2006). These different protocols have been carried out almost exclusively by trained government technicians opportunistically boarding commercial lobster boats. Between 1976 and the mid 1980s, commercial size lobsters were measured during port sampling, while ovigerous females and lobsters smaller than the minimal legal size (MLS) were measured during at-sea sampling. At that time, the objective of the at-sea sampling was to record information on lobsters that could not be legally landed. By 1984, the at-sea sampling was modified and all lobsters caught in traps were measured. However, biases were introduced by inadvertently modifying the sampling protocol, mainly by unclear trap selection processes or ignoring empty traps (Mallet et al. 2006). At that time, the frequency of sampling and the number of wharfs sampled often varied according to the ever changing management concerns (Mallet et al. 2006). By 2001, a more standardized at-sea sampling protocol was put in place targeting 100% coverage (i.e., measuring all lobsters captured). In this standard protocol, a technician has the option (pre-established protocol) to ignore entire trap lines rather than sampling a few traps within a trap line if 100% coverage would interfere with the normal lobster fishing activity. A trap line is defined as individual traps attached one after the other (from 2 to 10 traps per line in the sGSL) to a buoy line. Hence, the goal is to maximize the number of trap line sampled. Ordinarily, at-sea sampling would be carried out twice during the lobster fishing season at predetermined wharves within LFAs.

Starting in 1999, the Department of Fisheries and Oceans Canada (DFO) established some index programs in collaboration with the fishing industry in the sGSL to gather information on the lobster distribution (Comeau et al. 2004, Lanteigne et al. 2004). Essentially, fishermen were asked to record the size and sex of all lobsters caught in 6 predetermined traps. The lobster carapace length (CL) was measured with a gauge graduated in 13 size classes, where lobsters in group size 4 and below were sub-legal lobsters. This index program is collecting information on lobster size and CPUE throughout the fishing season in contrast with the pulse information gathered during the tradition at-sea sampling. Furthermore, the index program allowed fishermen to be more involved with the stock assessment process. However, these two methods of collecting information are operating simultaneously and little is known of advantages and disadvantages of these approaches in terms of data precision or variability of the information collected.

Sampling survey designs have been proposed for sampling traps (Bergh and Johnston 1992; Punt and Kennedy 1997; McGarvey and Pennington 2001). Based on the McGarvey and Pennington (2001) approach, a three stage sampling design was used to provide estimates of the variability of data collected during at-sea sampling. The purpose of this study was to assess and compare four at-sea sampling scenarios, including the traditional at-sea sampling and three others with fishermen involvement, based on estimated variance components to suggest a more efficient at-sea sampling protocol with higher precision. This study also compares fishing efficiency of two trap types for the possibility of increasing effort through trap design.

2.0 MATERIALS AND METHODS

2.1 DATA COLLECTION

The study area was located in Graham's Pond in eastern Prince Edward Island (PEI) (Fig. 1) at water depths ranging between 3 and 18 m. Fishermen in the study area obey a gentleman's agreement on no Sunday fishing; thus, Monday's traps were always hauled after two soak days. Data were collected by the same trained technician during the regular commercial fishing activity in 2001 and 2002. In 2001, sampling was carried out from 14 May to 9 June for a total of four weeks and little over three weeks in 2002 from 6 May to 27 May. To control possible variation associated with human factor (e.g., fisherman's knowledge and experience), the same traps were sampled with the same captain and boat for the duration of both experiments.

Two types of traps commonly used in eastern PEI (i.e., wire trap and a wood trap) were considered for this study (Fig. 2). Wire traps were 118 × 56 × 32 cm with two parlours and one kitchen housing two bait pins. They were covered with a 2.5 cm plastic coated wire mesh. A pair of knitted heads led to side entrance rings with a diameter of 14 cm. For the wood traps, nylon mesh covers a wood frame measuring 117 × 58 × 36 cm (modelled after the wire traps). The diameter entrance is the same as the wire traps. Both traps had horizontal escape vents measuring 2.7 × 7.5 cm. Traps were set in lines of five traps with a buoy on each end of the line. A line consisted of five traps of the same type. In 2001 and 2002, 10 lines of wood traps were sampled, while 50 lines were sampled in 2001 and 40 lines in 2002 for the wire traps.

The CL, defined as the length from the posterior part of the eye socket to the back of the carapace parallel to the medio-dorsal line, was measured to the lowest mm using a caliper for each lobster captured. All lobsters in the 67.0-68.0 mm size class were measured to the nearest tenth of a mm to assign the lobster to the commercial or sub-legal category since the MLS at that time was 67.5 mm. The sex of each lobster, the female condition (i.e., ovigerous or non ovigerous), the buoy number, location (lat-long), the trap position on the line, and the trap type were also recorded.

Lobster weight (g) was estimated using the following length-weight relationship (M. Comeau, unpublished data):

Male: weight = 0.0015 ×CL$^{2.8570}$;

Females: weight = 0.0010 ×CL$^{2.9504}$.

2.2 ANALYSIS

Sampling variance estimation was based on a three stage sampling design with days as primary unit, buoy as secondary unit, and trap as the third stage unit (Cochran 1977; McGarvey and Pennington 2001). If *n* days are chosen at random from *N* possible days, and within in each day, *m* buoys from the *M* available are selected from which *k* traps out of *K* are sampled, then variance of the average number of lobsters per trap ($\overline{Y}_{...}$) is given by:

$$V(\overline{y}_{...}) = (1 - f_1)\frac{\sigma_D^2}{n} + (1 - f_2)\frac{\sigma_B^2}{nm} + (1 - f_3)\frac{\sigma_T^2}{nmk} \quad , \quad (1)$$

where σ_D^2, σ_B^2 and σ_T^2 represent the variance components for day, buoy and trap, and $f_1=n/N$, $f_2=m/M$ and $f_3=k/K$ are the proportion of days, buoys and traps sampled in the population.

More specifically, $\overline{Y}_{...}$ is calculated as:

$$\overline{Y}_{...} = \sum_{i=1}^{N} \frac{\overline{Y}_{i..}}{N} \quad \text{where} \quad \overline{Y}_{i..} = \sum_{j=1}^{M} \frac{\overline{Y}_{ij.}}{M} \quad \text{and} \quad \overline{Y}_{ij.} = \sum_{u=1}^{K} \frac{Y_{iju}}{K} \quad ,$$

and

$$\sigma_D^2 = \frac{\sum_{i=1}^{N}\left(\overline{Y}_{i..} - \overline{Y}_{...}\right)^2}{N-1} \quad , \quad \sigma_B^2 = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M}\left(\overline{Y}_{ij.} - \overline{Y}_{i..}\right)^2}{N(M-1)} \quad \text{and} \quad \sigma_T^2 = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M}\sum_{u=1}^{K}\left(Y_{iju} - \overline{Y}_{ij.}\right)^2}{NM(K-1)} \quad . \quad (2)$$

Estimators for the above variance components σ^2_{D}, σ^2_{B} and σ^2_{T} and mean terms are their sampling equivalent where *N*, *M* and *K* are replaced by *n*, *m* and *k* and the population values Y_{ijk} are replaced by the sampled values y_{ijk} . Estimation was carried out separately for each year, trap type and lobster groups (ovigerous female, sub-legal and commercial).

Trap yield in weight of commercial lobsters only was used to compare trap type efficiency. Statistical comparison was based on a permutation test (Good, 2000). For each sampled year, trap type labels were permuted between set of traps within a given day. Permutation was not made on trap basis because of possible inherent catch pattern between traps within a line depending on the trap position on the line (Smith and Tremblay 2003). For a given year, the total commercial catch of the wood traps, in kg, was obtained by adding up the daily catches estimated using the length-weight relationship on commercial catch. Trap type's labels were then permuted between the wood and wire lines of traps and a permuted total commercial catch for wood traps was obtained. A total of 1000 permutations were performed resulting in 1000 permuted wood traps' total commercial catch. The permutation test consists of comparing the observed wood trap catch to the distribution of the permuted wood trap catches. Observed catches not falling in one of the tail ends of the permuted catches distribution would mean that switching the trap type labels did not modify greatly the catches of the wood traps, thus indicating that wood and wire traps have similar catches. Note that since there are only two trap types being compared, the results are symmetrical for the wood and wire traps since the permuted wire trap's catches can be simply obtained by subtracting the total wood trap catch from the total catch.

3.0 RESULTS

In 2001, two storms and technical problems prevented sampling on three occasions resulting in 21 sampled days. A total of 5,822 lobsters were measured from 1,003 lines of traps, that is 209 lines of wood traps and 794 lines of wire traps (Table 1). In 2002, two storms prevented sampling and at-sea sampling was carried out over 17 days; 3,850 lobsters were measured and 798 lines of traps were sampled consisting of 168 wood traps lines and 630 wire traps lines (Table 1). Size distributions of all lobsters measured during the two sampling periods are given in Figure 3.

3.1 VARIANCE ESTIMATION

Estimation of the variance components for the number of ovigerous females, undersize and commercial lobsters, and the weight (kg) of commercial lobsters per traps were calculated as in equation (2) but using the sampling version (Tables 2 and 3). The highest source of variation comes from the between trap component within line and day $\hat{\sigma}_T^2$. Interestingly, lowers variances were observed in the daily variance component (σ_D^2) between 2001 and 2002 for both sub-legal and commercial lobsters (Table 2). Also, lower values for all three variance components were observed for ovigerous females (Table 2). Slightly higher values were observed for the daily variance component of ovigerous females and for the buoy line variance component of commercial size animals between 2001 and 2002 (Table 2). A lower value of the daily component of the variance was also observed for the weight of commercial lobsters per traps (Table 3). Finally, the daily variance component of the commercial lobsters is much higher compared to sub-legal (about 8-fold) and ovigerous lobsters (between 19- to 43-fold) (Table 2).

Based on this intensive sampling study, there was not a significant effect of the year (P = 0.55) or trap (P = 0.20) component for the mean number of ovigerous females per trap ($\bar{y}_{...}$) (Table 2). Similarly, year (P = 0.09) and trap (P = 0.70) effects were not significant for the mean number of commercial lobster per trap. However, a significant difference in the mean number of sub-legal lobsters per trap was observed between 2001 and 2002 (P < 0.0001), but the trap effect was not significantly different (P = 0.53).

The estimates of variance components from Tables 2 and 3 can be substituted into equation (1) to assess the effect of various sampling designs on the precision of the estimators of catch. Hence, the difference in variance can be assessed between a more traditional at-sea sampling protocol where the content of all traps hauled in a given day is measured by a technician (protocol 1) versus different protocols where a fisherman measures the content of one (protocol 2), three (protocol 3) or five (protocol 4) pre-identified traps daily. These protocols based on a variation of the number of trap sampled on a given buoy line were chosen because they were more realistic and practical than sampling traps from various buoy lines. From past experiences, the latter will increase the sampling bias by deviating from a pre-determined protocol (Mallet et al. 2006). For the computations, we assumed a possible total of N = 55 fishing days and M = 60 lines of K = 5 traps, and use the wire trap variance component estimates.

There was very little difference in the standard error estimates between years for each of our lobster groups (Table 4). The total number of trap sampled during a season will be the highest with protocol 1 at 590 and the lowest with protocol 2 at 53. As expected, the standard error for both the ovigerous females and the sub-legal lobsters was the highest for protocol 2 (Table 4) since the trap variance component represents 80% of the variability (Table 2). Protocols 3 and 4 yield the lowest standard error values (Table 4). Hence, it was more efficient to increase or maximize the number of trap sampled every day (protocols 3 and 4) than reducing the number of sampling days and increasing the number of lines and traps (protocol 1). Results for commercial size lobsters by number or weight were similar and slightly different compared to the ovigerous females and the sub-legal lobsters. Protocols involving the participation of a fisherman throughout the fishing season (protocols 2-4) yielded lower standard error estimates than the more traditional at-sea sampling (protocol 1). This difference in protocol efficiency was due to the higher variability of the daily variance component (Table 2) for commercial animals (up to 7%) compared to the other two groups (2%). Both protocols 3 and 4 have quite similar standard error estimates (Table 4). Of the four protocols, either 3 or 4 were the most efficient. Hence, it is better to sample at least three traps for as many days as possible

3.2 COMPARISON OF COMMERCIAL YIELD

Sampling estimated yields for wood and wire traps in 2001 and 2002 were 328 kg (0.314 kg/trap), 1,196 kg (0.301 kg/trap), 215 kg (0.256 kg/trap) and 807 kg (0.256 kg/trap) respectively (Tables 1 and 3). Out of the 1000 permuted wood trap yields, the observed yield felt in the 32nd

percentile in 2001 and the 50th percentile in 2002, indicating no significant difference between yields from wood and wire traps (Fig. 4).

4.0 DISCUSSION

An alterative to traditional at-sea sampling carried out by trained technicians on board a fishing vessel would be to relying on fishermen to measure lobsters from a few selected traps during their daily fishing activity throughout the season. Our results showed that such an option could be efficient in terms of reducing data variability because the highest source of variation came from the between trap component. Hence, by increasing the number of sampled days n, the trap variation is reduced by a factor of $1/nmk$ (equations (1) and (2)) while increasing only the number of traps sampled reduced the trap variance component by $1/k$. McGarvey and Pennington (2001) reached a similar conclusion for gathering information on the southern rock lobster (*Jasus edwardsii*) trap fisheries in South Australia.

The degree of precision needed should be clearly stated in the objectives of an at-sea sampling program. It is clear from our results that the sampling protocol would be different if the goal is to assess the number of lobster from the unexploited population (with replacement, i.e. sub-legal and ovigerous female lobsters), or the number from the exploited population (without replacement, i.e. legal lobsters) simply because their variance differ. The commercial component of the population will require a more intense sampling to reach a variance level as low as the sub-legal or ovigerous female lobsters.

In addition to data variability, cost should be taken into consideration when planning or assessing a data collection program. Traditional at-sea sampling requires a trained technician one day at sea to collect the data and another day to have the data entered on the computer. Realistically for the lobster fisheries in the sGSL, two at-sea samples could be done per week, weather permitting, for a maximum of 18 per fishing season. For a fisherman-based at-sea sampling program, although no technician is going at sea, the program still needs to be coordinated and monitored. The logistics involved include the preparation and delivery of the data logbook before the fishing season, frequent calls or visits to fishermen during the fishing season, and collection of logbooks at the end of the fishing season. A quick recovery of logbooks at the end of the fishing season is critical to allow the coordinator to verify the recorded information and insure that any missing or unclear information are properly collected. Although fewer traps were sampled during different index programs in collaboration with the fishing industry in the sGSL, the time required to enter the data was equivalent to a traditional at-sea sampling (M Comeau, personnel communication). Hence, fishery biologists have to assess which option will yield the most efficient data collection for the resource available (both human and funding).

Fishermen’s participation is also a key element to elaborate a fisherman-based at-sea program. Hence, the amount of work involved in sampling should not only take into consideration the type of information needed for scientific purposes, but also fishermen’s limits in terms of both data precision and the disruption in their daily fishing activity. A clear advantage of a fisherman-based program over the traditional at-sea sampling program is the seasonality of the data collected, giving a dynamic abundance indicator for the status of the stock instead of the two or three snapshots during the fishing season. However, it is not possible to demand that fishermen measure the lobster CL using a caliper similar to the one used by a trained technician because, in many cases, it will slow their fishing activity. An acceptable solution for volunteer fishermen participating in data collection programs was to use a pre-determined graduated gauge (Fig. 5) similar to their legal gauge. Although the size information is slightly less precise (recording bins instead of actual CL), it could still be used to gain information on the lobster population size structure. The real disadvantage is that bin-size CL cannot be converted very precisely into weight. Furthermore, in cases where accurate and precise information are needed (e.g., trap selection studies, efficiency of escape mechanisms), the tradition at-sea sampling is still the best option. Other circumstances that could limit fishermen participation as volunteer would be poor landings and dissatisfaction with changes imposed with new fishery management plans.

At-sea sampling is currently an easy technique for obtaining information on sub-legal and ovigerous female lobsters and further studies would be required on variation of at-sea sampling data if fishery indicators such as population structure and abundance are determined from this type of data. Most importantly, catchability in relation to different fishing strategies should also be addressed as fishermen in some areas could avoid high concentrations of ovigerous females, and sub-legal lobster to some instances, since these lobsters do not contribute to their fishing income. Benefits (either scientific or economic) of port sampling to gather information on the size distribution of the population commercially exploitable should also be considered.

Yields of commercial catches from wood and wire traps were not significantly different; in this particular case only the building material differ, the design being the same. The result came as a surprise based on the fisherman's interview (M. Mallet, unpublished data) indicating that the two trap types were not fished in the same manner. The less sturdy wood traps were not set in areas where they could be damaged, i.e. they were mostly left in deeper and calmer waters, while wire traps were set at different depths (very close to shore where strong current and wave action are observed) and were moved more frequently. Perhaps the lobster population distribution was fairly homogenous in the study area.

Information gathered in this paper was related to a single source (i.e., a fisherman or a single license) to reflect the at-sea sample protocol presently in place in the sGSL. However, McGarvey and Pennington (2001) suggested that the most efficient way to increase the precision of trap-based data gathered by fishermen is to increase the number of participants. Hence, before establishing a large scale fisherman-based at-sea sampling program in the sGSL information on the license variance component is needed. This would permit estimation of the optimal number of participant required to significantly increase the precision. Finally, further studies are also needed to compare yield of different trap designs as they greatly affect lobster catchability (Krouse 1989, Miller 1989 1990). Trap designs currently in use include one or two parlours, one or two kitchens, parallel or offset entrances with a varying number and size of heads (entrance rings), and one to several bait bins.

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Table 1. Summary of the American lobster (*Homarus americanus*) at-sea sampling observations carried out in 2001 and 2002. In 2001, two lines of wire traps only had 4 traps sampled out of the 5; in 2002, one line of both wood and wire traps had 4 traps sampled out of the 5.

Year	Data		trap type wire	trap type wood	Total
2001	Number of lobsters	ovigerous females	404	100	504
		commercial	3022	865	3887
		undersize	1154	277	1431
		total	4580	1242	5822
	Weight of commercial lobsters (kg)		1196	328	1523
	Total traps sampled		3968	1045	5013
	Total line of traps sampled		794	209	1003
2002	Number of lobsters	ovigerous females	279	82	361
		commercial	2152	573	2725
		undersize	623	141	764
		total	3054	796	3850
	Weight of commercial lobsters (kg)		807	215	1034
	Total traps sampled		3149	839	4020
	Total line of traps sampled		630	168	798

Table 2. Estimates of the three variance components for the number of ovigerous females, undersize and commercial lobsters caught per wood and wire traps in 2001 and 2002; $\bar{y}_{...}$ is the estimated catch per unit of effort, and $\hat{\sigma}_D^2$, $\hat{\sigma}_B^2$, $\hat{\sigma}_T^2$ represent the estimated variance components for day, buoy and trap, respectively.

Population component	Year	Trap Type	$\hat{\sigma}_D^2$	$\hat{\sigma}_B^2$	$\hat{\sigma}_T^2$	$\bar{y}_{...}$	Standard error
ovigerous	2001	wood	0.0049	0.0199	0.0990	0.0957	0.0120
		wire	0.0017	0.0224	0.0994	0.1020	0.0139
	2002	wood	0.0018	0.0231	0.1000	0.0977	0.0076
		wire	0.0019	0.0203	0.0907	0.0877	0.0099
undersize	2001	wood	0.0175	0.0601	0.2770	0.2650	0.0227
		wire	0.0095	0.0739	0.3250	0.2910	0.0273
	2002	wood	0.0049	0.0348	0.1660	0.1680	0.0127
		wire	0.0043	0.0466	0.2140	0.1960	0.0149
commercial	2001	wood	0.1200	0.2110	0.8220	0.8280	0.0594
		wire	0.0736	0.2420	0.7500	0.7620	0.0608
	2002	wood	0.0502	0.2130	0.6840	0.6830	0.0406
		wire	0.0369	0.2590	0.7050	0.6770	0.0401

Table 3. Estimates of the three variance components for the weight (in kg) of commercial American lobsters (*Homarus americanus*) caught in 2001 and 2002; $\bar{y}_{...}$ is the estimated catch per unit of effort, and $\hat{\sigma}^2_D$, $\hat{\sigma}^2_B$, $\hat{\sigma}^2_T$ represent the estimated variance components for day, buoy and trap, respectively.

Year	Trap Type	$\hat{\sigma}^2_D$	$\hat{\sigma}^2_B$	$\hat{\sigma}^2_T$	$\bar{y}_{...}$	Standard error
2001	wood	0.0172	0.0344	0.134	0.314	0.0225
	wire	0.0120	0.0430	0.138	0.301	0.0250
2002	wood	0.00849	0.0320	0.105	0.256	0.0158
	wire	0.00531	0.0394	0.113	0.256	0.0154

Table 4. Assessment of various sampling designs for estimating the number and weight for different type of American lobster (*Homarus americanus*) per trap in the southern Gulf of St. Laurent. Protocol 1 is the traditional at-sea sampling where almost all of the entire gear is sampled by a trained scientific technician twice in the season. Protocols 2, 3 and 4 are where a fisherman will sample 1, 3 and 5 traps, respectively on one line almost every day. Calculations based on wire trap variance estimates.

Lobster Group	Year	Sampling Protocol	Number of Days	Lines Sampled	Traps Sampled	Traps Total	SE (% of mean)
Ovigerous	2001	1	2	59	5	590	28%
		2	53	1	1	53	43%
		3	53	1	3	159	25%
		4	53	1	5	265	20%
	2002	1	2	59	5	590	35%
		2	53	1	1	53	48%
		3	53	1	3	159	28%
		4	53	1	5	265	22%
Sub-Legal	2001	1	2	59	5	590	23%
		2	53	1	1	53	27%
		3	53	1	3	159	16%
		4	53	1	5	265	13%
	2002	1	2	59	5	590	23%
		2	53	1	1	53	33%
		3	53	1	3	159	19%
		4	53	1	5	265	15%

Table 4. continued

Lobster Group	Year	Sampling Protocol	Number of Days	Lines Sampled	Traps		SE (% of mean)
					Sampled	Total	
Commercial (weight)	2001	1	2	59	5	590	25%
		2	53	1	1	53	18%
		3	53	1	3	159	11%
		4	53	1	5	265	9%
	2002	1	2	59	5	590	20%
		2	53	1	1	53	19%
		3	53	1	3	159	12%
		4	53	1	5	265	11%

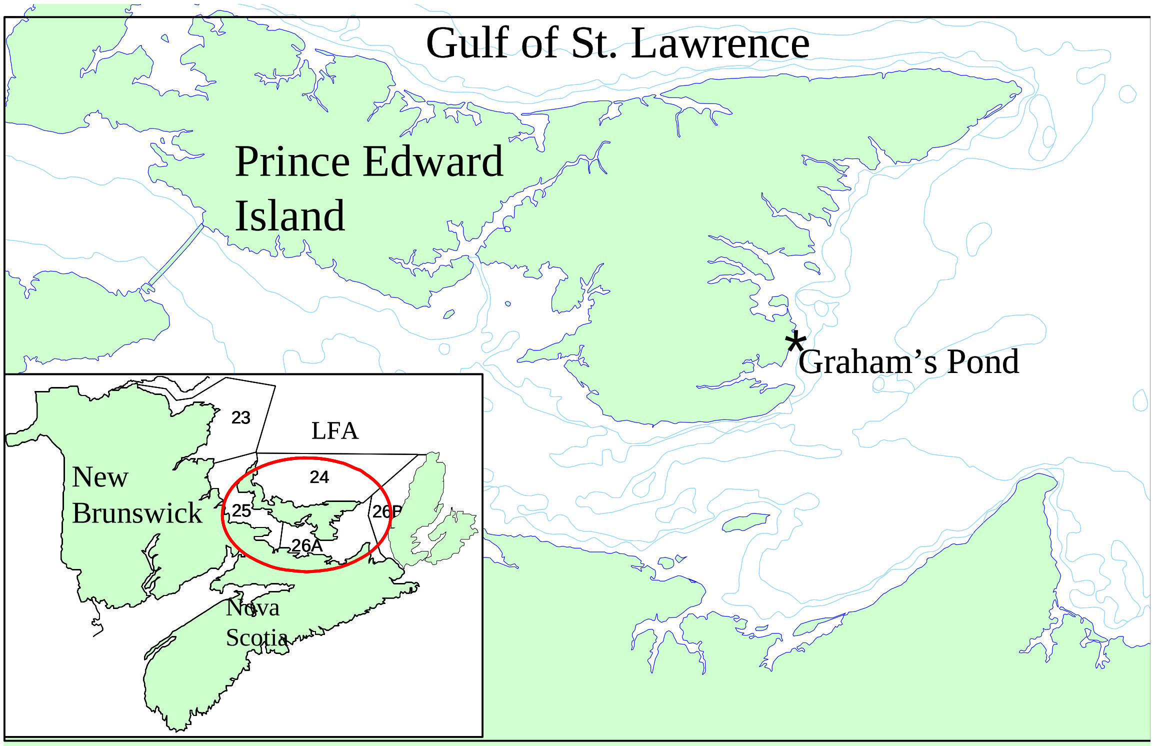

Figure 1. Map of the study site in Graham's Pond (eastern Prince Edward Island) and the five Lobster (*Homarus americanus*) Fishing Areas (LFA) located in the southern Gulf of St. Lawrence in insert.

Figure 2. Wire (top) and wood traps (bottom) used by the fisherman and the study.

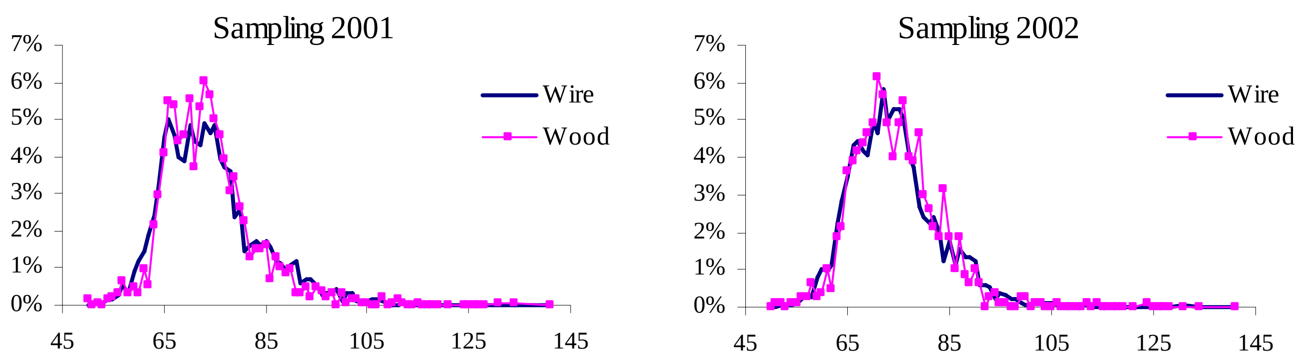

Figure 3. Size distribution of all lobsters (*Homarus americanus*) caught in wire and wood traps.

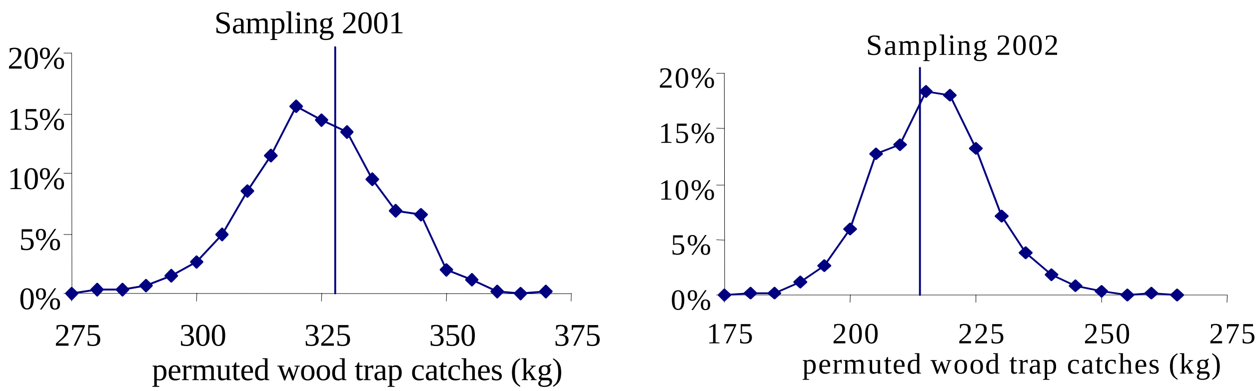

Figure 4. Distribution of 1000 permutations on trap type yield for lobster (*Homarus americanus* observed during the at-sea sampling in 2001 and 2002. The vertical line represents the observed yield.

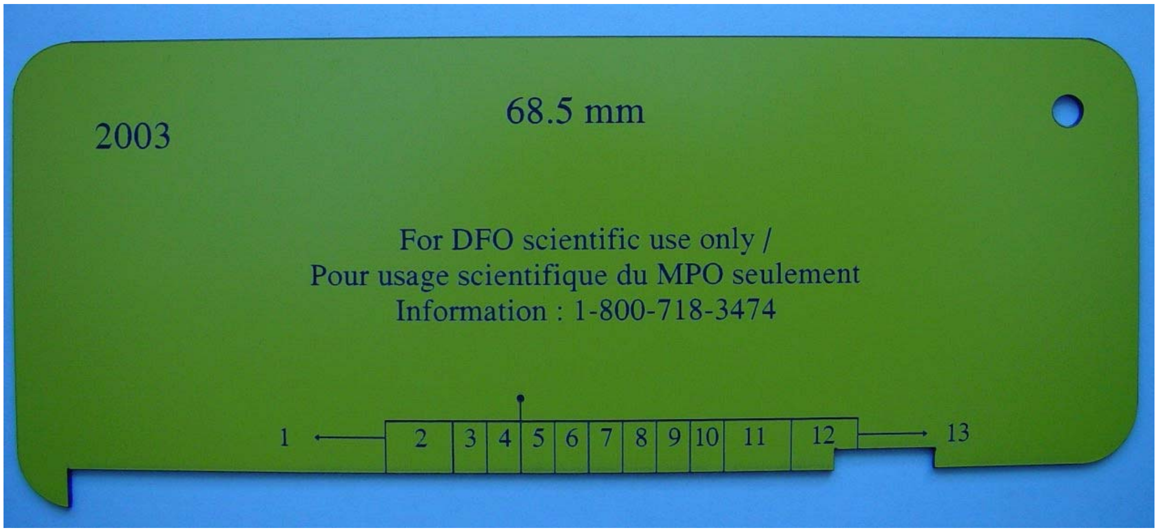

Figure 5. Plastic measuring gauge used by volunteer fishermen during index programs. The minimum legal size and starting point for size bin 5 is 68.5 mm. The dent within size bin 12 and part of 13 represent the protected female window size implemented in 2003.