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Lobster Stock Monitoring by the Guysborough County Inshore Fishermen's Association

Surveillance d'un stock de homard par la Guysborough County Inshore Fishermen's Association

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Abstract

In 2002 and 2003 the Guysborough County Inshore Fishermen's Association measured abundance of six life history stages. This paper describes survey methods, presents results, and reviews successes and failures. Petersen tag-recapture studies during the fishing season estimated absolute abundance of ovigerous females and "window" females (non-ovigerous 114-123 mm CL). Size distributions of ovigerous females from at-sea sampling were combined with abundance estimates to calculate annual egg production for several fishing ports. At-sea samples also provided locations of ovigerous females near the time of hatching. If larval drift modeling is initiated these data will provide the starting locations for the drift. Plankton tows provided indices of early and late larval stages. Larval survival was higher in 2002 than 2003. Out-of-season trapping surveys provided indices of abundance of a first year and two pre-recruit year classes. These are tools for implementing an empirical "probable good" approach to lobster stock management.

Résumé

En 2002 et en 2003, la Guysborough County Inshore Fishermen's Association a déterminé l'abondance de six stades biologiques du homard. Ce document décrit les méthodes de relevé utilisées, présente les résultats et examine les succès et les échecs. Des études de marquage-recapture réalisées par la méthode de Petersen durant la saison de pêche ont permis d'estimer l'abondance absolue des femelles oeuvées et des femelles non oeuvées protégées (longueur de carapace allant de 114 à 123 mm). Les répartitions par taille des femelles oeuvées obtenues par échantillonnage en mer ont été combinées avec des estimations de leur abondance pour calculer la ponte annuelle pour plusieurs ports de pêche. L'échantillonnage en mer a aussi permis de déterminer les endroits où se trouvent les femelles oeuvées près du moment de l'éclosion. Si l'on décide de modéliser la dérive des larves, ces données fourniront les points de départ de la dérive. Des traits de filet à plancton ont permis d'obtenir des indices de l'abondance des premiers et des derniers stades larvaires. La survie des larves était plus élevée en 2002 qu'en 2003. Des relevés aux casiers effectués hors saison ont donné des indices de l'abondance de la classe d'âge de la première année et de deux classes d'âge de pré-recrues. Ces données constituent des outils de mise en œuvre d'une méthode empirique « probablement bonne » de gestion du stock de homard.

Introduction

A successful fishery management plan should be flexible enough to respond to changes in the environment and changes in fishing pressure. The environment can have a strong influence on survival of early life history stages. Annual trap hauls, trap design, or fishing location can affect egg production and the average weight yield per fishery recruit.

During 2002 and 2003 the Guysborough County Inshore Fishermen's Association (GCIFA) assumed a large measure of the responsibility for monitoring their lobster population. It is appropriate that fishermen do this as well as write their fishery management plans because they and their communities have so much at stake in the fishery.

Abundance measurements from surveys are a powerful addition to model predictions from yield or egg per recruit or cohort analysis. Models predict changes to stock structure and yields in weight and eggs that will result from specified management changes, if fishing and the environment remain constant. Surveys measure a net response of a stock to changes in all of management, fishing pressure, and the environment. We could view the model as hypothesis formulation and the survey as hypothesis testing.

Surveys also have weaknesses. Because factors other than regulation change affect the stock response we cannot be sure of the cause of the response. We almost never have an experimental control in fishery management. Also, surveys can be biased if we are not measuring what we think we are measuring. Surveys have the advantages of being more transparent than models, they require less mathematical skill, and they do integrate all influences on the stock, if the measurements are unbiased. An example of integration is an increase in egg production from a larger minimum legal size but a decrease from lower recruitment. If we wish to manage a stock for a target egg production the integrated response is desirable.

Thus far GCIFA fishermen have measured six life history stages in some of their ports: ovigerous female abundance, annual egg production, larval stages I and IV, late pre-recruits, and "window females" (mature non-ovigerous females 114-123 mm CL). In addition, DFO collates their landings records for annual landings by statistical area and lobster fishing area.

Figure 1 is a time line of lobster life history showing the stages monitored. Egg production is influenced by regulations such as minimum and maximum legal size and controls on fishing effort. However, survival through larval and pre-recruit stages are largely subject to a capricious environment. Larvae spend about 1-month in the water column before settling to the bottom. Pre-recruits and first-year recruits are mostly within 3-years of entering the fishery. Window females are returned to the fishing ground to increase egg production and they typically spend two fishing seasons in the window size. They are non-ovigerous the first season, ovigerous the second, and molt out of the window to legal size before the third. Because the size of 50% maturity is about 84 mm CL (Watson 1988), these females should all be repeat spawners. The legal catch is a report card for the success of fishery management. This is reported monthly to DFO by individual license holders. The number of year classes in the fishery depends on how hard the stock is fished.

Most participants were members of the GCIFA, however, in 2003 several from the Eastern Shore Fishermans Protective Association participated in tagging ovigerous females. Most place names are shown in Figure 2.

The purpose of this paper is to describe the survey methods, present initial results, and review reasons for successes and failures of surveys to date.

Methods

Tagging

Any population component that is trapped by the fishery but returned to the fishing ground is a candidate for measuring population size by this method. Possible components are ovigerous females, late pre-recruits, tail-notched, window females, culls (missing one or both claws), and lobsters greater than a maximum legal size. During the fishing season participating fishermen were expected to tag all ovigerous or window females and record all recaptures. Lobsters were tagged with cable ties secured tightly around the long leg segment (merus) proximal to the claw. The GCIFA tags were numbered and fishermen were asked to record the tag number and date for each release and recapture. Recording locations was optional. ESFPA tags were not numbered. These fishermen were instructed to record daily how many tags were released and how many recaptured. After the 5th week of the season when a substantial number of tagged lobsters had accumulated on the fishing grounds, releases and recaptures were summed within weeks for the final 4 weeks.

Abundance of ovigerous or window females was calculated for each of 4-weeks using the Peterson method (modified from Ricker 1975). P_i is population size in week i, t_i and r_i are number of untagged and tagged lobsters captured in week i, and T is the total number of tags released

$$P_i = \frac{t_i + r_i + 1}{r_i + 1}\, T$$

from the beginning of the season to the midpoint of week i. The number of untagged captured (t_i) was usually the same as the number of new tags released, so was added to T. However, if a fisherman ran out of tags or was working near shore in a heavy sea and felt it unsafe to take time to tag, he was asked to record that an untagged lobster was seen but not tagged. Several fishermen recorded releases but not recaptures; these were included in T only.

The annual egg production on a fishing ground was calculated from each of the four weekly estimates of population size of ovigerous females (P_i), the mean size of ovigerous females (CL) on the fishing ground as obtained from at-sea samples, and the fecundity-carapace length relationship from Campbell and Robinson (1983).

$$\text{population egg production} = (0.00256\ CL^{3.409})\ P_i$$

This represents the annual egg production because females produce no more than one clutch of eggs annually and these hatch after the fishing season. Campbell and Robinson measured fecundity within 1-2 months of hatching and after most egg loss during the 12 month ovigerous stage.

Population sizes of window females (P_W) were estimated in June, 1-2 months before egg extrusion (Campbell 1986; Ugarte 1994); therefore, the portion not extruding and the mortality during the year before hatching need to be considered when calculating egg production from this group. Fecundity (F) of an average sized window lobster is 29,000 (Campbell and Robinson 1983). Waddy et al. (1995) state that most females of window size molt and extrude in alternate years. From windows tagged in 2002 and recovered in 2003 in this project, 155 of 159 were ovigerous. Others may have molted and lost their tag. We assumed 3% for each of these possibilities giving a probability of extrusion (E) of 0.94.

Natural mortality estimates are sparse. Ennis (1979) estimates 2% and Thomas (1973) 2-30%. We set the probability of annual survival (S) at 0.90. Substituting in the following equation we obtain annual egg production from window lobsters as 24,500 P_W.

$$\text{window egg production} = F \cdot E \cdot S \cdot P_W$$

Larval abundance

Larvae were sampled on the fishing grounds of four adjacent communities, Canso, Dover, White Head, and Port Felix, in 2002 and 2003 (Fig. 3). In 2002 we intended to sample 48 stations 5 times each at 2-week intervals, but sampled only 50% of the stations because boats were not available. In 2003 we intended to sample 56 stations 6 times each at 2-week intervals and sampled 96% of these, but some intervals were longer than 2-weeks. Usually one boat-day was required to sample the stations in each of areas A, B, C, and D (Fig. 3). Sampling occurred between 0600 and 1500 h Atlantic Standard Time.

A push net previously mounted on the bow of an outboard skiff (Miller 1997) was modified to be towed by a lobster boat (Fig. 4). A deflector kept most of the net outside the boat's wake. The net opening was 0.6 x 2.35 m with 1.3 x 1.3 mm mesh and fitted with a flow meter. Tows lasted 10 min and sampled about 2100 m^2 of the top 0.5 m of the water column. Larval densities are expressed per 1000 m^2.

Seaweed and jellyfish were rinsed and removed at sea, the remaining sample was concentrated in 1.0 l jars and preserved in 4% formalin. The four larval stages were sorted in the laboratory.

Larval drift

During the larval period in 2002 surface drifters equipped with hand-held GPS recorders were deployed to record drift tracks. Location of ovigerous females caught in at-sea samples during the May-June fishing season was presumed to approximate the hatching location of larvae. If funding was obtained, staff of BIO Ocean Sciences Division planned to model larval drift.

Pre-recruits and first year recruits

Pre-recruits and first year recruits (~86-98mm CL) and pre-recruit trapping was carried out by one fisherman in each of Cooks Cove and Queensport in Chedabucto Bay, and Dover and Whitehead on the open coast. They fished 30 traps three times in each of August, September, and October for a total of 1080 trap hauls. While at sea, fishermen recorded sex and carapace length, rounded down to the nearest mm, for each lobster caught.

Fishermen chose trapping locations they thought represented the small lobster distribution on their fishing grounds and recorded the latitude and longitude of each location. Over the 3-days fishing within a month they moved each trap, but within 100m distance and within 2 m depth. Overall, depths were <10 m and distance from shore was <1 km.

Traps were of the type used in the Fishermens Scientist Research Society juvenile surveys (Claytor and Allard 2003), 102 x 53 x 36 cm high made of 2.5 x 2.5 cm wire mesh with 12.7 or 15.4 cm diameter entrance hoops. The entrances were partly blocked with wire mesh to exclude large lobsters. Frozen mackerel was always the bait and soak time was usually 1-day but occasionally 2-days.

Results

Assumptions of mark-recapture (Ricker 1975)

The marked fish suffer the same natural mortality as the unmarked and do not lose their marks. Lobsters are nearly always vigorous when removed from traps and were tagged and returned to the water within a few minutes. Also, 34 lobsters, equally divided between sizes of 0.5 kg and 1.3 kg, were tagged with two cable ties each and held communally in laboratory tanks for 12 months. None died and no tags became unfastened. Tagging studies reported here lasted only 9 weeks, the duration of the fishing season. We believe this assumption was met.

The marked fish are as vulnerable to fishing as the unmarked. In some ports the ratio of tagged to untagged captured didn't increase in the final 1-3 weeks of the season as one would expect from an increasing number of tagged lobsters in the population. An increasing catch rate of ovigerous lobsters through the season (Fig. 5) could explain this result and would bias low the mean of weekly estimates of stock size. Unequal catchability of males and females and of different sized individuals are the usual concern (Miller 1990). The window females are all similar sized and non-ovigerous. The ovigerous females span a range of sizes, but Campbell (1990) found similar catchabilities among ovigerous lobsters 100-160 mm CL.

The marked fish become randomly mixed with the unmarked. We hoped the distribution of fishing effort by the participating fishermen spanned the distribution of lobsters. Some fishermen move their traps from deep to shallow water as the season progresses. Although their intent is to follow a migration of lobsters inshore, a component of the ovigerous or window populations may either remain inshore or arrive before the fishermen so that fishermen are sampling a new component. If part of the population is fished only late in the season, early estimates will be below true population size.

All marks are recognized and reported on recovery. If a fisherman's ratio of recaptures to releases were significantly lower than others his recovery data were not used. All tag releases were used for a correct count of total tags in the population. If recoveries were not recorded and this went undetected, then population size would have been overestimated.

There is only a negligible amount of recruitment to the catchable population during the time the recoveries are being made. Recruitment by growth is not a problem here because all releases and recaptures are within a 9-week Spring fishery before molting occurs in July-October (Ugarte 1994). However, late season movement of traps inshore or increased catchability, as noted above, could be considered recruitment to the catchable population. Tagging studies have shown very little long-shore movement in eastern Nova Scotia (Miller et al. 1989).

Most mark-recapture studies identify repeat recaptures from numbers on tags. In this study we did not have tag numbers or ignored them where we did. Untagged lobsters could only be captured once in a week because they would be tagged at first capture, however, tagged lobsters could be captured more than once. This could result in an overestimate of recaptures and underestimate of population size. However, recaptures within 1-week were usually in the range of 2-7% of the tags at large (Tables 1 and 2). The Eastern Shore Fishermans Protective Association sponsors a program in which large females are tagged with a tag retained through the molt. In 2003 they reported 1489 recaptures of lobsters released in 2001. Over the 9-week season each lobster was captured an average of 1.26 times (N. Baker-Stevens, pers. comm.). The probability of capturing the same lobster more than once in one week is expected to be small.

<u>Window female tagging</u>

The window population and resulting annual egg production are available for four fishing grounds (Table. 1). In 2002 licensees providing both release and recapture data throughout most of the season were 5 of 9 in Whitehead, 4 of 22 in Dover, 3 of 19 in Canso and 3 of 7 in Queensport. Several other license holders released tagged lobsters for at least part of the season. In 2003, recapture data from 4 of 19 in Canso and 3 of 7 in Queensport were useable. Given the low level of participation, variation among weeks within ports for calculated size of the window population was less than anticipated. The 20% increase from 2002 to 2003 in size of the window population for Canso is also not unreasonable. Egg production from releases were calculated as a function of fecundity, the probability of extruding eggs the summer after release, and the probability of surviving until the eggs hatched, as detailed in the methods section. Window females which survive the fishery to produce a second batch of eggs 2-years later would increase this total. However, we have yet to measure this contribution.

Using the data collected from Whitehead in 2002, we calculated the cost to each fisherman of putting back window lobsters. Because many windows captured would have been caught earlier in the season by the same or another fisherman, we needed to calculate the number caught for the first time if all 9 fishermen had been tagging. If all nine had participated then the number of windows caught without a tag would have equaled the number caught the first time. Because only five fishermen tagged, the von Bertlanffy equation was used to estimate the total catch by nine fishermen. This equation was chosen because included parameters for a rate of increase and asymptote. L_{inf} was the estimated population size (902), L_t the total recaptures by the participating fishermen (432 including weeks 1-5 not shown in Table 1), and t is the number of participants (5).

$$L_t = L_{inf}\ (1-e^{-kt})$$

The equation was solved for k (0.130) then solved again for L_t when t=9 fishermen. The new L_t was 622, or 69 lobsters caught the first time by each of nine fishermen, considerably less than the 130 window females caught per fisherman including recaptures. The wharf price for 69 window lobsters in 2002 was about $1290. Of course, this cost will be recovered 2-years later after the females extrude eggs, molt, and re-enter the fishery above the window size.

<u>Ovigerous female tagging</u>

Problems in data quality were greater than for window tagging because many fishermen had not previously participated, ovigerous females were much more numerous, and objectives were too ambitious. Fishermen stopped tagging during the season, no dates were given, and not all tag recoveries were recorded. Recovery data were excluded when data problems were suspected. All tags released from a port had to be included if any of the data for that port were to be used because these tags were on the fishing ground for anyone to catch. 9351 ovigerous females were tagged, 1534 of these from ports where insufficient data on recoveries were obtained for analysis.

The variation in population estimates among weeks within a port were reasonably close except for a large value in week 9 in Port Felix-Cole Harbour. This week-to-week similarity does not exclude the possibility of a systematic bias over all weeks. The week-to-week increases in population size in E. Halifax County and Musquodoboit Harbour (Table 2) may be examples of new population components being fished at the end of the season or increased catchability, as discussed above.

Egg production from window females and total egg production were estimated at 22 $x10^6$ and 91×10^6 respectively for Whitehead. These numbers provide a basis for deciding whether the window contribution is a large enough component of total egg production to justify the effort.

Larval abundance

Lobster larval densities for 2-years suggest a few generalizations. Stage I density was higher in areas A-B than areas C-D in both years (Fig. 6). For dates in 2002 and 2003 when sampling overlapped, stage I density was similar. Catch rates and total catch of stage IV larvae were higher in 2002, even with the fewer sampling dates. If juvenile trapping continues, we can look for a corresponding decrease in catch rates a few years hence.

Larval drift

Surface temperatures suggest a reason for the fewer stage IVs in 2003. Note in Fig. 7 that the temperature dipped in late July and early August in areas B and C-D. (Area A, located in the more sheltered waters of Chedabucto Bay, did not dip.) There was no evidence for this dip in 2002 (Fig. 7). The temperature decrease in 2003 suggests the surface water containing early larval stages may have been advected offshore, and the surface water that returned several days later did not replace the larvae lost. The approximately 1-month later appearance of stage IVs in 2003 also suggests the early hatch failed to survive, and that the stage IV that appeared in September developed from the smaller August hatch rather than larger July hatch.

Based on at-sea samples, ovigerous females were concentrated in shallow water in both 2002 and 2003 (Table 3).

In the absence of wind surface drift from six drifter deployments in southeast Chedabucto Bay was slight. Of seven successful deployments off Dover Head, five went west and two east.

Trapping pre-recruits and first-year recruits

Catch rates of pre-recruits and first-year recruits for two of the four sampling ports show sex ratios and size distributions for 3-months (Fig. 8). Catches were predominantly males. In both ports the highest catches were in October. At least 3-years of data are needed to decide which month's results, if any, are best correlated with subsequent commercial catches. Given growth expectations (Campbell 1985, Miller et al. 1989), lobsters 86-98 mm CL will recruit to the fishery in 2004, 74-85 mm CL will recruit in 2005, and 63-73 mm CL will recruit in 200, assuming the 2003 molt occurred before the sampling.

Discussion

Improved data collection

A new tagging sheet (Table 4) will hopefully reduce recording errors. First, columns for tag numbers and tagging locations have been omitted to reduce errors and fatigue among fishermen. Each day of the season is pre-entered on the data sheet and only one line of data entry is required per day. For the first few weeks the number of tags recovered will not be recorded because recoveries are too few to be used for population calculations. Later in the season separate columns are added for the number of target lobsters caught without tags and the number tagged. Thus, if the sea is too rough for tagging or the fishermen has no tags he can continue to provide useful data on the numbers of tagged and untagged lobsters caught. New columns for number of traps hauled daily will allow calculation of catch per unit effort and, by comparison with other fishermen's records, help to determine if tagging is complete. Tagging will not continue into the final week of the season because these lobsters will have little opportunity to be recaptured.

Clearly better communication is needed, including more one-on-one contacts before and during the season. Participants need to understand the purpose of the study and consequences of departures from correct execution. Fewer but more committed participants should improve the outcome.

Before continuing drifter deployment a new drifter design is needed, one that is less influenced by wind and continues to drift if it touches bottom. Furthermore drifter deployment and drift modeling will require substantial funding for drifter components, boat time, local wind recording, and modeling expertise.

Approach for management

We propose more effort on an empirical approach to lobster fishery management that involves fishermen in data collection and interpretation. Rather than relying on model predictions of egg production or mortality rates, we propose to measure them. We can not satisfy well the data requirements of complex models such as eggs per recruit (Caddy 2001). We lack an empirical basis for choosing a reference point that will avoid a downturn in landing or attain a target level of sustainable yield. If it were possible to find such a reference point for one place or time, we have no reason to expect it could be extrapolated spatially or temporally. Without a quantitative relationship between reference points and fishery yield we are left to manage by "probable good". For example, high egg production or several spawner year classes in the population will not hurt fishery yield and may help (Campbell 1985; Miller 2003).

If surveys of different life history stages reflect true abundance, then we need not wait for fishery yields to tell us whether changes in regulations, fishing effort, or the environment are affecting the population. We can have measurements of population response sooner and in terms stakeholders can understand. Several interesting questions can be addressed.

- How does the window regulation affect egg production? In Whitehead this regulation provided 22 million of the 88 million total egg production (if estimates are correct).
- Are suspected changes in fishing activity, such as targeting large lobsters or increasing exploitation rate, changing the number and size of ovigerous females?
- Do temporal changes in egg production or stage I larvae predict changes in stage IV larvae. Do changes in stage IVs predict changes in pre-recruits?
- Can year-to-year changes in catches of pre-recruits be tracked from 50 mm CL to >86 mm CL?
- Using measures of absolute egg production, what is the survival rate from eggs to fishery recruits?

The advantages of the tagging method described are several. Any population component captured but not retained can be measured. Fishermen can tag, release, and record recaptures during normal fishing operations without dedicated personnel. A tagging project is completed within a 9-week fishing season so that results can be available the same year. Because fishermen range over their fishing grounds releases are widely distributed. There is no complication of lobster growth and migration is less than in longer term studies. If the assumptions of tag-recapture studies are met, absolute annual egg production is obtained. However, increasing catchability of ovigerous females through a Spring fishing season may bias the estimates low. One-on-one instruction of participants may be required. This is a useful baseline number against which to measure change and is preferable to the per female measure of egg/recruit or an index from ovigerous females per trap haul. The tag is inexpensive (4 cents without numbers and 18 cents with numbers), robust, and easy to apply. Other than instruction and tags, there are no costs to collecting the data. However, several participants from each port are needed for adequate numbers of releases and recaptures and adequate spatial distribution of releases and recaptures.

Ennis et al. (1982) also used Petersen tag-recapture to estimate population size in a Newfoundland Cove. They applied carapace tags in the autumn after the annual molt and they were recaptured in the Spring fishery.

Larval sampling can be carried out from lobster boats without boat modification. However, 24 dedicated boat-days, at least one trained person, and about $6000 in equipment are required. The annual larval production is underestimated (Scarratt 1964; 1973), so the result is an index rather than an absolute measure. A time series is necessary to determine if data are precise enough to predict abundance of later stages.

Pre-recruit trapping and data analysis can be carried out by participating fishermen. No other personnel are needed. As conducted in 2003, each participant fished from his boat for a few hours on each of 12 days over 3-months. Costs were boat, captain, bait, and traps. GCIFA is planning to purchase traps for the survey at a cost of $2200. Whether the survey results can predict fishery yields will have to wait a few years data accumulation.

The following are recommendations for the GCIFA to continue their initiatives in stock monitoring and fishery management.

1. Continue larval and pre-recruit surveys for long enough to decide which is most useful for predicting future catches.
2. Every few years monitor stock egg production because of its likely importance to long-term stock productivity. Tagging ovigerous females appears to be an effective method.
3. Promote expertise and leadership among members for conducting each type of survey.
4. Set high standards for data quality. Bad data are worse than no data because they support incorrect decisions.
5. Look for inexpensive ways to improve the fishery, e.g. reduce ghost fishing and handling mortality and improve compliance with regulations.
6. Promote the enjoyment of discovery of new knowledge. An occasional study only to satisfy members’ curiosity, such as growth of juveniles, small scale movement, or how often the same lobster will enter a trap, could encourage this attitude.
7. Invite DFO enforcement officers to participate in joint enforcement initiatives with members.
8. Invite DFO scientists to participate as co-investigators and advisors. They can provide expertise in designing studies and analyzing data. Members should in turn provide scientists with quality data they can publish.
9. Develop a multi-year management plan. Be flexible in the choice of management tools while looking for what produces the best results.

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Table 1. Window population and window egg production in 2002 and 2003.

Port/year	Week	Total tagged	Untagged	Recap	Window population	Egg prod. x 10^6
Whitehead	6	330	72	49	805	
2002	7	409	66	60	852	
	8	467	44	39	981	
	9	498	18	18	969	
				mean	902	22
Dover	6	357	23	10	1106	
2002	7	414	17	13	917	
	8	471	32	14	1478	
	9	a	a	a		
				mean	1167	30
Canso	6	273	53	13	1306	
2002	7	343	37	17	1049	
	8	408	58	17	1722	
	9	461	23	10	1424	
				mean	1375	34
Canso	6	438	69	32	1353	
2003	7	552	80	34	1814	
	8	654	76	43	1786	
	9	743	63	53	1614	
				mean	1641	40
Queensport	5-6	64	19	10	174	
2003	7-8	96	13	19	162	
	9	118	11	13	211	
				mean	182	4

[a]insufficient recaptures

Table 2. Ovigerous female population and egg production from 2003 tagging.

Port	Week	Total tagged	Untagged	Recap.	Ovigerous population	95% CI[a]	Egg prod. x 10^6
Whitehead	6	747	103	16	5276	3418-9662	
	7	884	98	19	5216	3494-8993	
	8	1026	119	31	4841	3498-7328	
	9	1246	221	40	7969	5967-11370	
				mean	5825		88
Port Felix-Cole Hbr.	6	1322	229	91	4612	3787-5709	
	7	1599	118	60	4695	3687-6108	
	8	1835	272	149	5182	4417-6088	
	9	2098	230	42	13326	9738-18834	
				mean	6954		125
Larrys River-Torbay	6	1115	153	56	4101		
	7	1376	63	66	2669		
	8	1545	76	85	2912		
	9	1657	37	30	3637		
				mean	3330		67
New Hbr.	6	779	99	38	2727	2002-3923	
	7	878	49	16	3413	2195-6203	
	8	999	45	10	5090	2986-11690	
	9	b	b	b			
				mean	3743		71
Isaacs Hbr.-Fishermens Hbr.	6	625	78	54	1512		
	7	b	b	b			
	8	713	46	40	1513		
	9	b	b	b			
				mean	1513		27
E. Halifax County	6	931	278	123	3018	2543-3621	
	7	1326	142	69	4019	3205-5133	
	8	1622	188	96	4766	3930-5861	
	9	1895	203	101	5669	4695-6932	
				mean	4368		84
Musquodoboit Hbr.	6	323	181	52	1426		
	7	486	86	41	1481		
	8	606	126	53	2020		
	9	743	210	77	2747		
				mean	1919		32
Petpeswick	6	349	145	40	1588		
	7	446	48	27	1213		
	8	501	62	24	1743		
	9	583	103	43	1954		
				mean	1625		24

[a]95% confidence intervals are conservative estimates recommended by Ricker (1975), p78
Samples are large enough to avoid statistical bias (Robson and Regier 1964).
[b]insufficient tag recoveries

Table 3. Catches of ovigerous females per 1000 trap hauls (TH) by depth, from at-sea samples in LFAs 31A and 31B combined.

	2002		2003	
Depth (fms.)	No. traps	Catch/1000 TH	No. Traps	Catch/1000 TH
0-4	666	83	1069	115
5-8	1065	63	1227	80
9-12	607	21	340	18
>12	75	0	27	0
totals	2413	167	2663	213

Table 4. Proposed tagging data sheet.

2004 Berried Female Tagging

Date	**Number new tags released**	**Number traps hauled**	**Date**	**Number new tags released**	**Number berrieds without tags**	**Number berrieds with tags**	**Number traps hauled**
April 20			May 17				
April 21			May 18				
April 22			May 19				
April 23			May 20				
			June 18	OMIT			
			June 19	OMIT			
			June 20	OMIT			

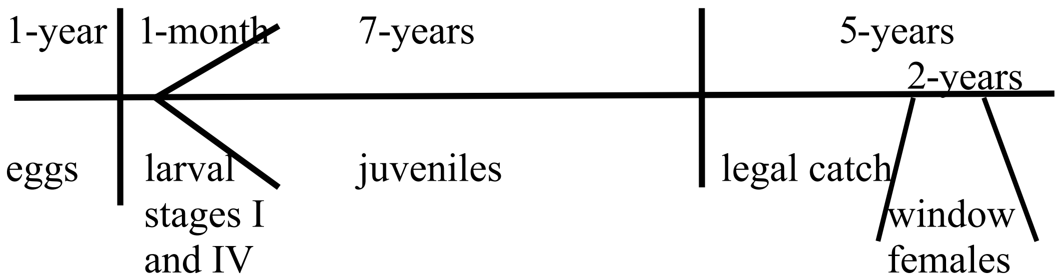

Fig. 1. Lobster life history stages surveyed.

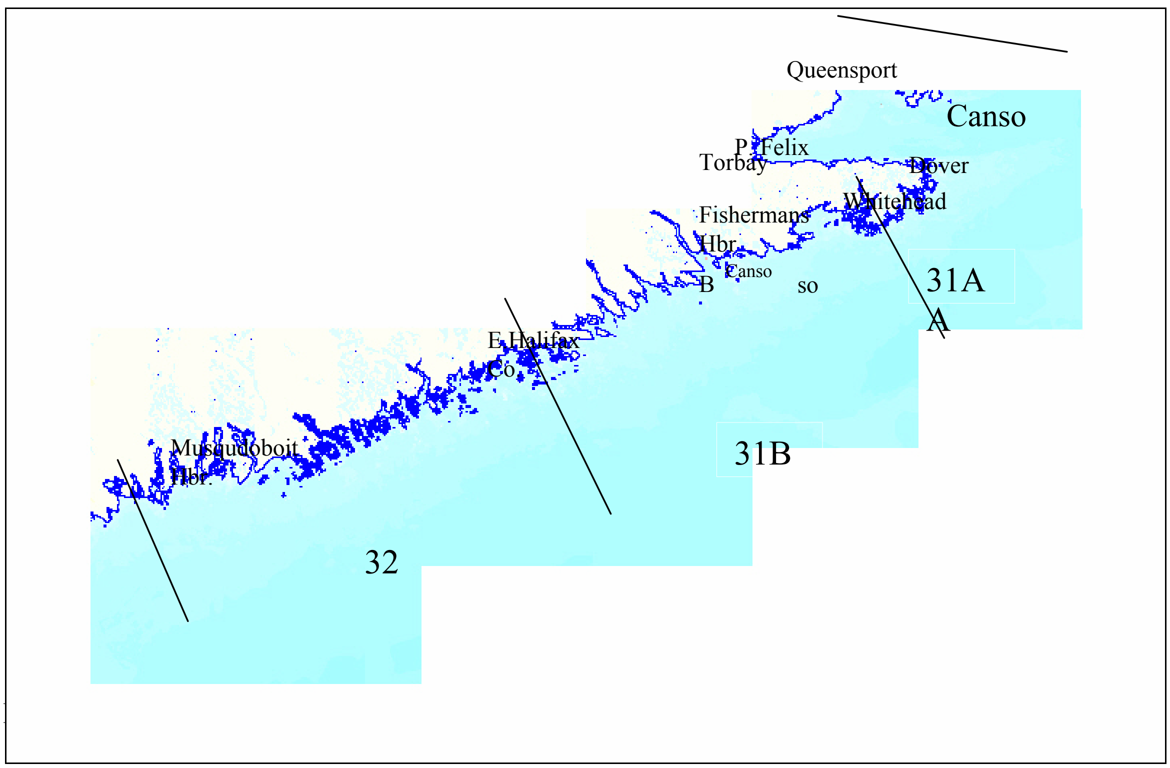

Fig. 2. Study area with place names.

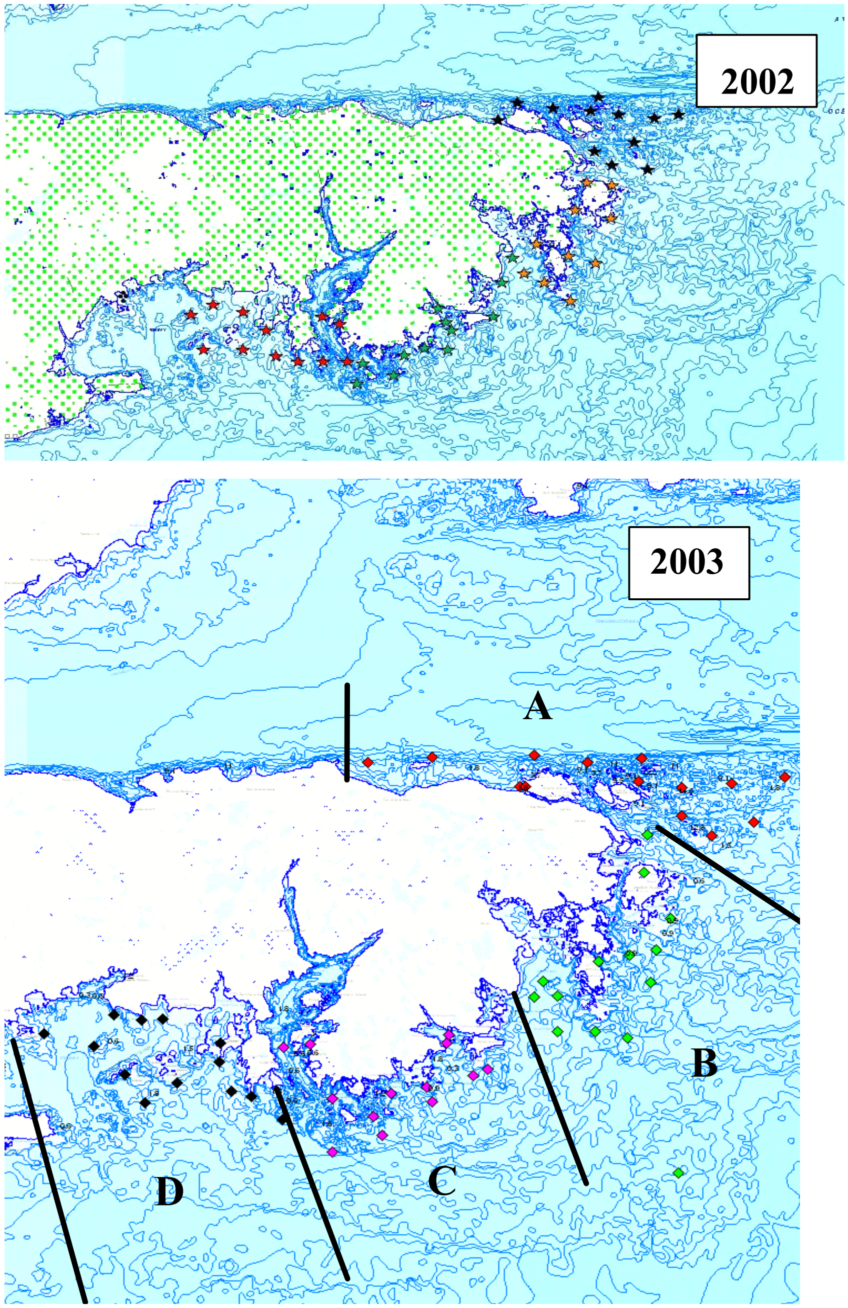

Fig. 3. Larval sampling stations in 2002 and 2003. Areas A, B, C, and D represent 1-days sampling.

Fig. 4. Larval sampling net on the stern of lobster boat with intern (top); net fishing (bottom).

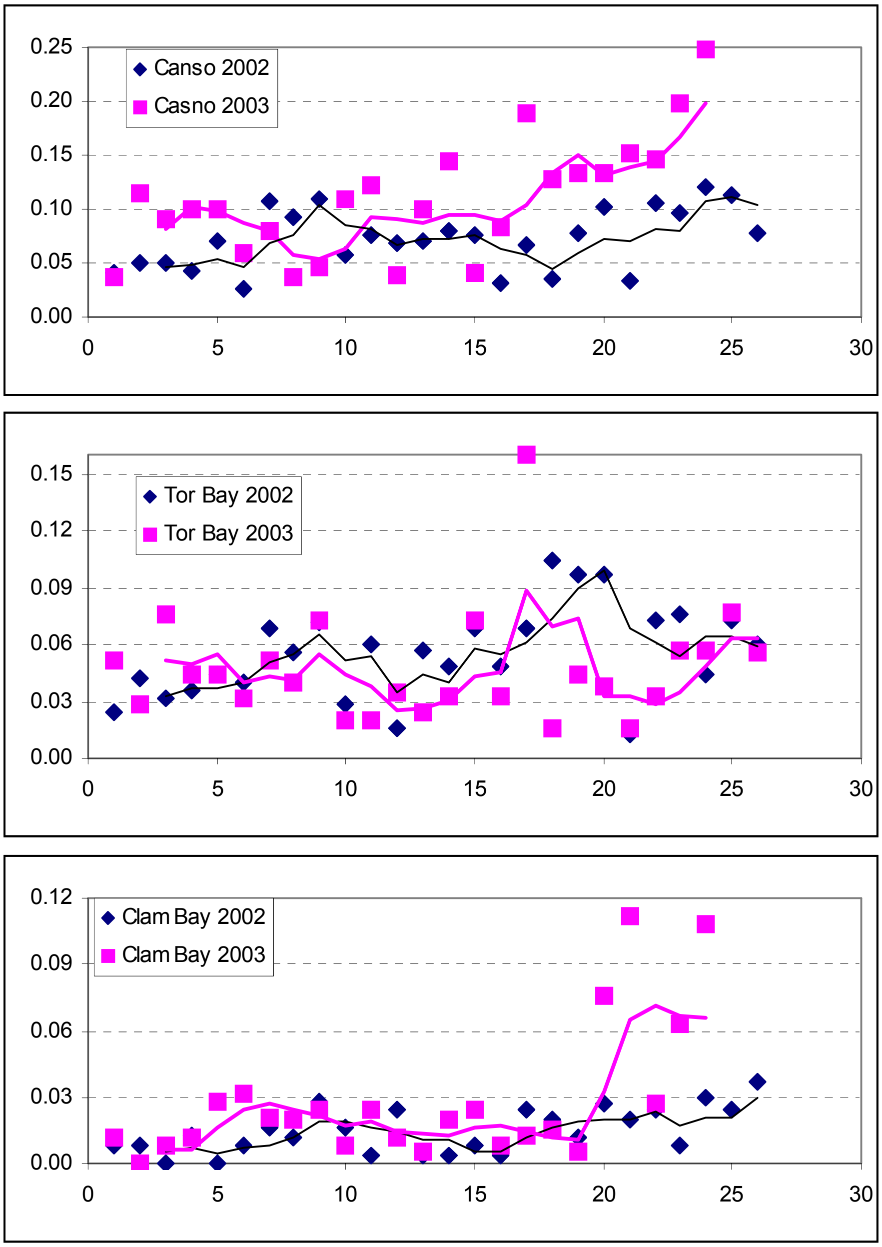

Fig. 5. Catch per trap haul of ovigerous females for the last half of season for one fisherman in each of three ports. Lines are 3-day running averages.

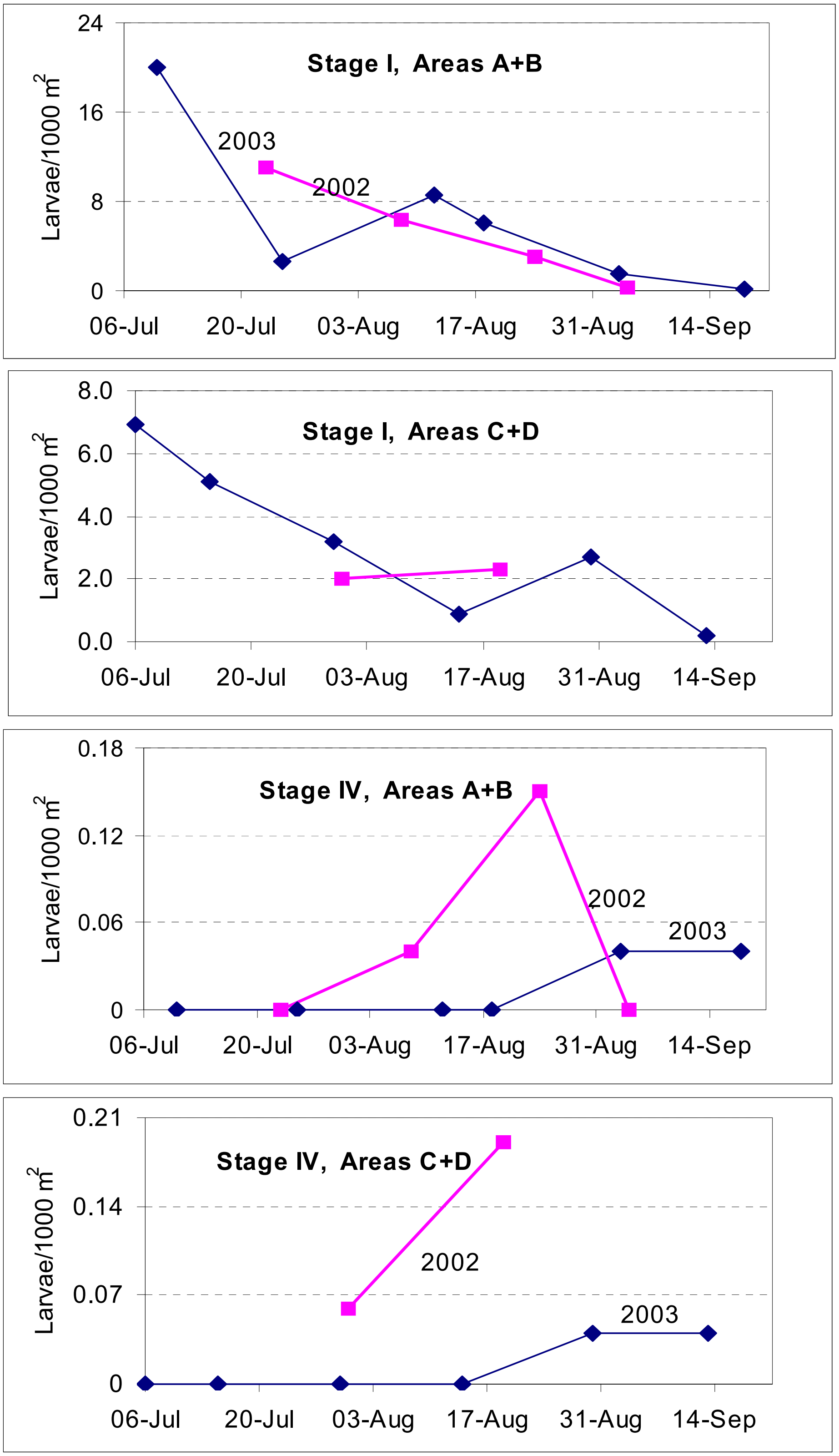

Fig. 6. Larval densities in 2002 and 2003. Area B missing for August 8 and 18, 2002, and August 18, 2003. Area A missing for September 4, 2002.

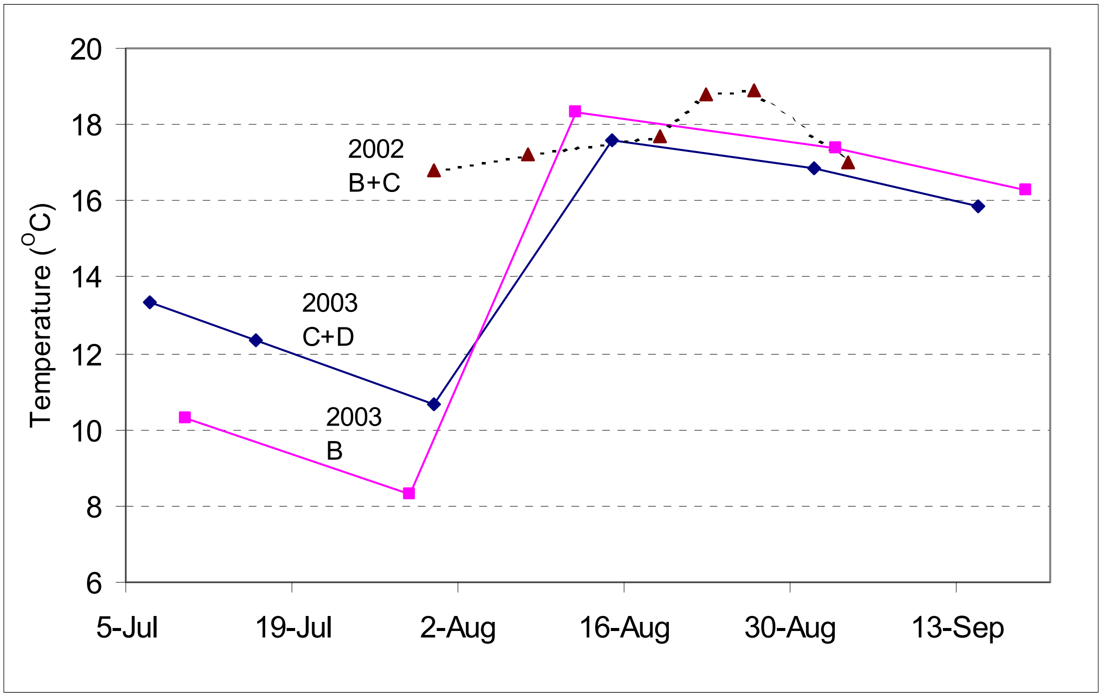

Fig. 7. Mean surface temperatures during larval sampling. Letters (B,C, D) denote sampling areas.

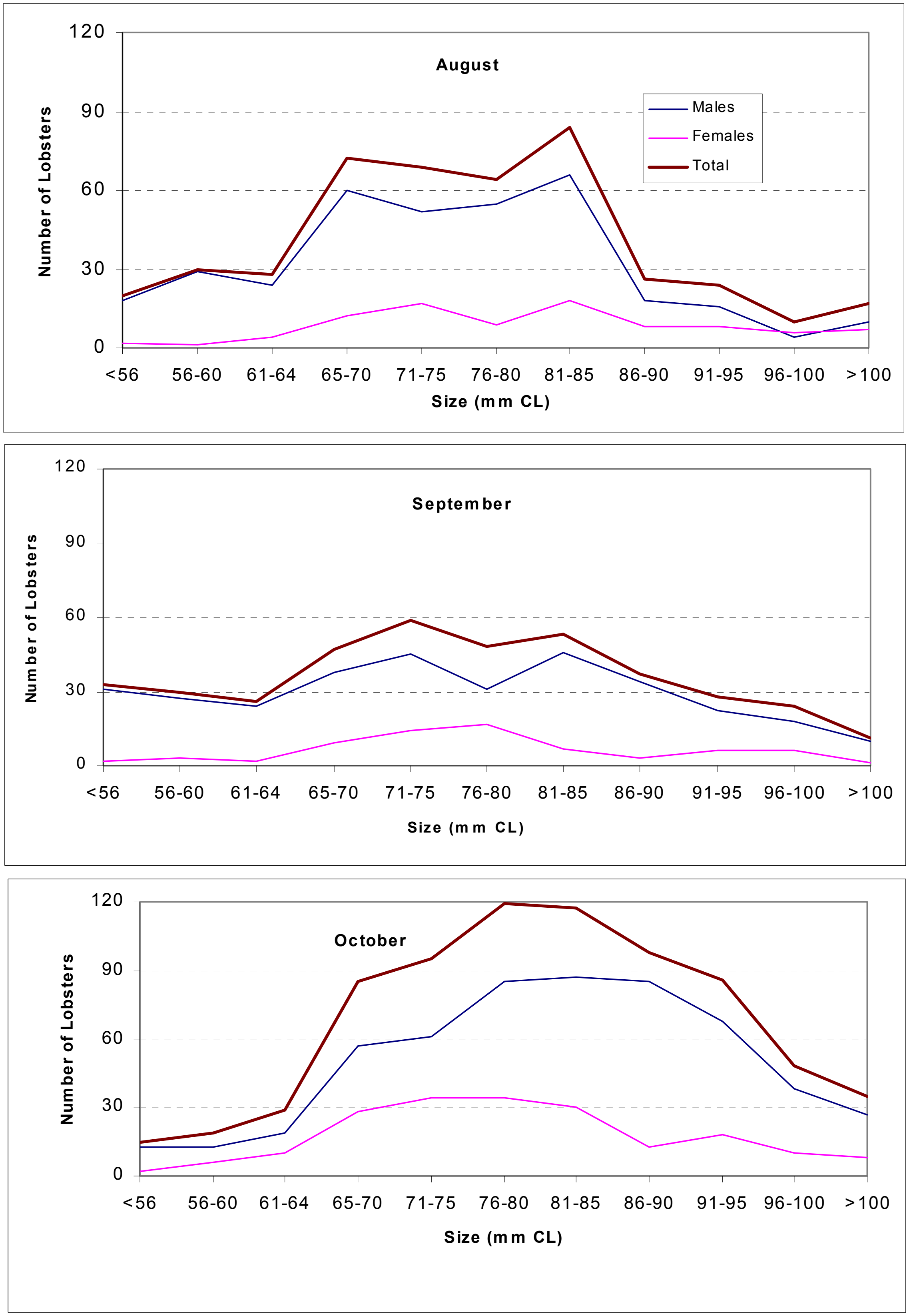

Fig. 8A. Size frequencies of pre-recruits and first year recruits (86-98 mm) trapped in Whitehead in 2003; catches from 90 trap hauls each month.

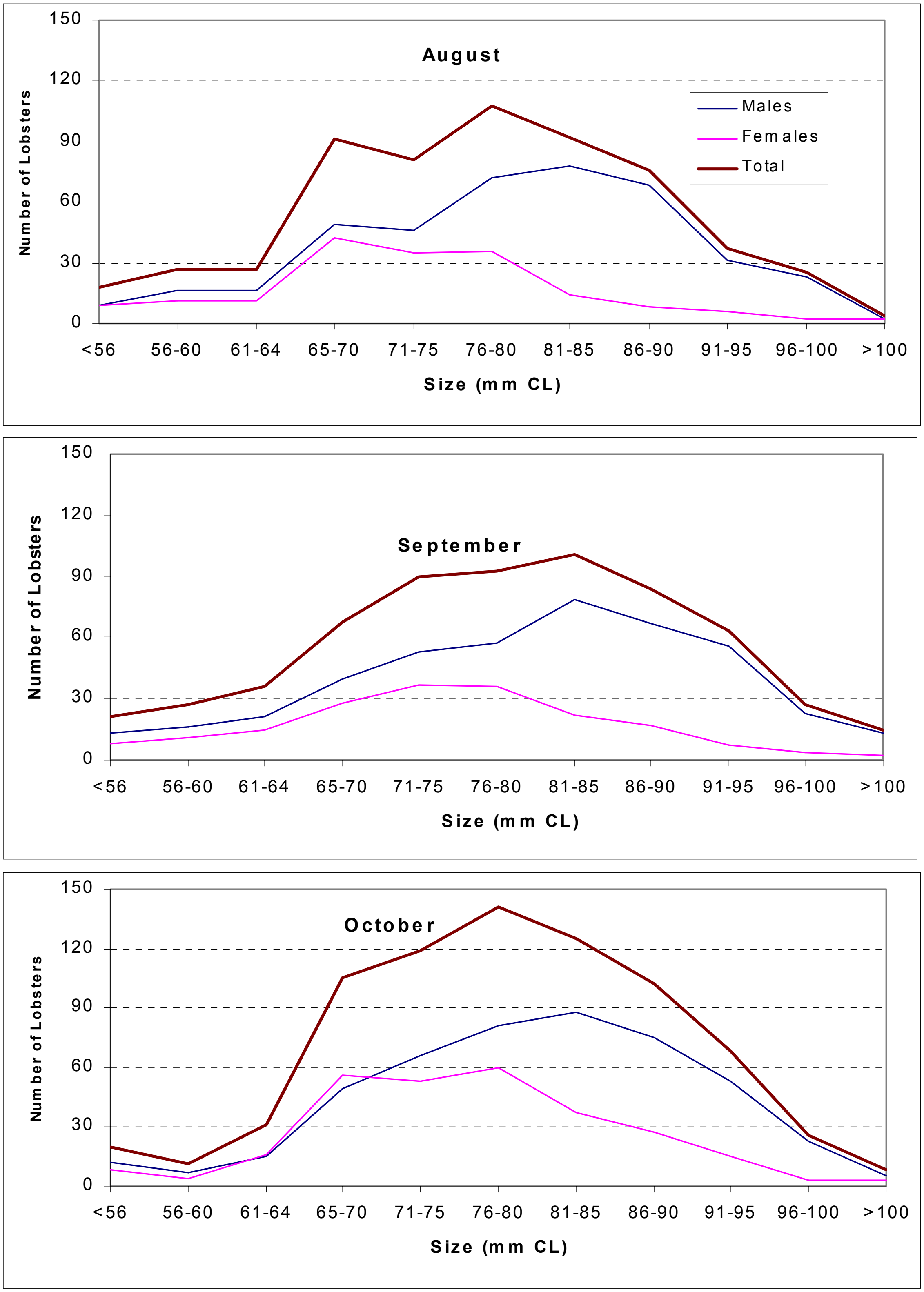

Fig. 8B. Size frequencies of pre-recruits and first year recruits (86-98 mm) trapped in Queensport in 2003; catches from 90 trap hauls each month.