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On the change in fishing season in Lobster District 1 (36)

by

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Abstract

Information on the fishery and biology of lobsters in the Bay of Fundy is reviewed. In particular, data on landings, size-frequency distributions, movement patterns, and mortality are assessed to ascertain the effect of fishing season extensions into July and/or October. The concensus is that such extensions would adversely impact the fishery by exacerbating the already excessive exploitation rate, increasing the incidence of soft-shelled lobsters in catches, and reducing brood stock abundance. The potential for various alternative management strategies [1) increase in minimum legal size; 2) introduction of maximum legal size; and 3) effort reduction] to improve future yields is discussed.

Résumé

Les données sur la pêche et la biologie du homard dans la baie de Fundy sont analysées. On évalue plus particulièrement les données sur les débarquements, les répartitions de la fréquence par taille, les mouvements migratoires et les taux de mortalité afin de déterminer les répercussions du prolongement de la saison de pêche jusqu'en juillet et en octobre. Il est reconnu que de tels prolongements ont des effets nocifs sur la pêche du fait qu'ils accentuent le taux d'exploitation déjà excessif, augmentent la proportion de homards à carapace molle dans les prises et réduit les stocks de reproducteurs. Les diverses possibilités d'exploitation rationnelle [1) augmenter la taille minimale légale; 2) adopter une taille maximale légale; et 3) réduire l'effort] visant à améliorer les prises futures sont également analysées.

Introduction

Since the late 1970's, lobster fishermen from Lobster District 1 (LD1, or 36 new numbering system) (Fig. 1, 2) have been refused their repeated requests to extend their fishing season (2nd Wed. Nov. to 14 Jan. and 1 Apr. to 29 June) to that of LD3 (15 Oct.-31 Dec. and 1 Mar.-31 July) on the basis that increased fishing seasons would increase exploitation and would have a long-term detrimental effect on local lobster populations. LD2 has a similar fishing season (2nd Wed. Nov. to 4th Thurs. June) to that of LD1. Recently, however, for various nonbiological reasons, season extensions were granted on a trial basis to LD1 fishermen for 8 d (29 June-6 July) at the end of the 1984-85 season and 8 d (5-12 November) at the beginning of the 1985-86 season.

Although LD1 has 48% of the lobster licenses, yields average only 35% for the whole of the Bay of Fundy (Table 1). An alternative management strategy to the present strategy is clearly required to improve the average yield per license for LD1 fishermen.

This paper provides a brief summary of some information on the lobster fishery and biology in the Bay of Fundy, especially for lobster District 1. Geographic and seasonal changes in lobster size composition are provided from size frequency at-sea samples of lobster traps. An attempt is made to assess the effect of the season extension during 29 June-6 July 1985. Possible effects of several management measures: (1) change in fishing season, (2) increasing minimum legal carapace length, (3) introducing a maximum size, (4) and reducing effort on this fishery are presented in an attempt to improve future yields for LD1.

Landings

In recent years (1981-85), the yield of legal-sized lobsters in the Bay of Fundy have generally increased as a result of increased recruitment (Fig. 3). For Lobster District 1 (LD1), lobster landings during the 1984-85 fishing season were 17.9% higher (13.2 t excluding the 8-d fishing season extension June-July 1985) than the average annual landings (Fig. 3, Table 1). LD1, on average, contributes about 35% to the total average lobster landings in the Bay of Fundy (Table 1).

More lobsters were caught (60%) during the fall 1984 than during spring (40%) in LD1 (Table 2). The majority of the lobsters is caught in the lower half of LD1 (Stat. Dist. 51, 52, 53) during the fall. During the 1984-85 fishing season, however, the upper half of LD1 (Stat. Dist. 49 + 48) caught 54.7% of the landings, especially during spring 1985 (Table 3).

Size Frequencies

Geographic Differences

Size frequencies vary considerably from area to area in the Bay of Fundy (Fig. 4). Although trap selectivity may have some effect on the sizes of lobsters trapped, measurements of hoop size and lathe spacing of traps throughout the Bay of Fundy (Table 4) probably did not have a major effect on the general differences in size frequencies observed (Fig. 4). In general, the mean size of lobsters increases further up the Bay of Fundy (e.g. St. Martins, Alma and Halls Harbour). In shallow water areas near southern Grand Manan and Statistical Districts 53 and 49, the main productive fishery consists of recently recruited lobsters (1-2 molt into the legal size).

Seasonal Changes

The effects of fishing (Fig. 5A, B), molting and large lobsters moving into shallow waters during summer (Fig. 5C, D, E) effect the seasonal size frequencies in the Chance Harbour area (Fig. 5, 6, 7).

The size frequencies are predominantly influenced by the high proportion of first molt into legal size (immature $\leq$ 95 mm CL) lobsters (Fig. 5). However, some mature lobsters appear in the traps from mid-June to October (Fig. 5, 6B). The increase of and peak carapace length (Fig. 6A) is due mainly to removal of many small lobsters by the fishery and the first appearance of large lobsters; the decline in mean CL during August-September is due to the molting of prerecruits into recruit sizes (Fig. 5) with a corresponding increase in number of recruits per trap haul starting in August (Fig. 7A). The decline in CL was probably due to reduction in the number of mature lobsters being caught in the traps Oct.-Dec. (Fig. 5, 6B). The reduction in the number of recruits/trap haul during Nov.-Dec. was, in part, due to the heavy fishing pressure which continued May and June (Fig. 7A); the increase in recruits/trap haul was due to lobsters molting (Campbell 1983) or recruiting into the recruit size during Aug.-Sept.

Equivalent size frequencies for Alma are provided (Fig. 8, 9, 10) to indicate the seasonal changes to be expected in the northeastern border of LD1. There was a higher percentage of mature lobsters from Alma than from Chance Harbour.

Sex ratio of immature lobsters (60-94 mm CL) caught in traps was generally 1:1, fluctuating between 40-80% for both Alma and Chance Harbour (Fig. 7, 10). Physiological maturity (50%) for male and female lobsters was estimated at ca. 95 mm CL using the gonad examination technique of Aiken and Waddy (1980). When examining the incidence of mature lobsters from Alma, there was a preponderance of male lobsters during the November-December and May-July fishing periods (Fig. 8, 9). In contrast, during August 1979-80, more females, especially berried females, were found in traps than males (Fig. 8, 9).

The mean CL of mature males from Alma fluctuated between 105 and 118 mm throughout 1979-80, whereas the mean CL of mature females showed definite trends from a low of 95 mm during winter to early summer increasing steadily to over 110 mm in August-September before declining again (Fig. 9).

Increases in male and female lobsters per trap haul during the summer months were probably caused by a number of factors, such as (1) increases in the number of mature male losbters due to movement into the area and (2) increased water temperature which increased the catchability of lobsters (McLeese and Wilder 1958) during the summer. Also, there was an apparent increase in berried females because of the overlap of females carrying old and new eggs (Fig. 6D, 9D). Lobster females incubate eggs on their pleopods for about 9-12 mo (Perkins 1972). During July and August, pelagic larvae hatch from the eggs while different females with mature ovaries will have extruded new eggs by late August (Fig. 6D, 9D). Mature females normally undergo a 2-yr maturation cycle, i.e. a female can extrude eggs in alternate years (Aiken and Waddy 1980). Berried females hatch their eggs 2-4 wk earlier at Alma than at Chance Harbour (Fig. 6D, 9D) due to summer temperatures being 2-4°C higher at Alma than at Chance Harbour (Campbell and Stasko 1986, unpublished).

Movement

Tagging studies (Campbell and Stasko 1985, 1986 unpublished data; Campbell 1986, unpublished data) reveal that mature lobsters are capable of moving considerable distances (>50 km), and that there is some interchange of lobsters throughout the Bay of Fundy, Gulf of Maine and adjoining Continental Shelf. Interpretation of patterns of lobster movements must be tempered by the fact that tag recovery locations and frequencies are biased by the distribution and amount of fishing effort. Notwithstanding this caveat, available evidence indicates mature lobsters do move sufficient distances to allow mixing of lobsters in the Gulf of Maine.

In some areas (Bay of Fundy, Browns Bank, Continental Shelf), many mature lobsters move seasonally into shallow, warm waters during summer-fall and into deeper waters during winter-spring. The deep waters in the Gulf of Maine tend to remain about 6-8°C throughout the year, allowing lobsters to continue to feed, grow and mature their ovaries and eggs during the winter when surface or shallow waters are near 0°C.

Recent results from tagging studies in the Bay of Fundy are as follows. A total of 18,359 lobsters were tagged near Alma, Chance Harbour and Grand Manan during 1977-80. Within 6 years of release, 5375 lobsters (29.3%) were recaptured. The following conclusions are summarized:

1) Immature lobster (less than 95 mm (3.74 in.) carapace length (CL) or about 1.53 lb) on average moved less than 7.3 km; 88% were recaptured less than 18 km (10 naut mi) from the release sites.

2) Mature lobsters (more than 95 mm CL) moved greater distances than immature lobster. As much as 46% mature lobsters moved greater than 18 km with 16.2% moving greater than 92.6 km (100 naut mi).

3) Many mature lobsters make seasonal deep-shallow migrations which seem to be associated with the seasonal temperature changes in the Bay of Fundy. Mature lobsters tended to be in shallow, warm waters during July-November and in deeper waters during January-May. Depending on the local temperature conditions, the seasonal lobster movements were highest during October-December into deep waters and May-July to shallow waters. These migrations help the mature lobsters maintain optimum temperatures required for molting, reproduction and egg hatching.

4) The distances moved for mature lobsters released in the upper half of the Bay of Fundy were greater than for those in the lower half of the Bay. This is probably due to mature lobsters having to move greater distances to reach deep water; the sea bed gradient is steep near Grand Manan but gentle near Alma.

5) Some mature lobsters returned to the original area of release after making the seasonal deep-shallow migration. Other lobsters moved to different areas after making the migration. There was a general mixing of mature lobsters in the Bay of Fundy. For example, LD1 caught about 27% of the mature lobsters tagged in Alma that moved more than 30 km. This confirms that mature lobsters tagged in other areas of the Bay of Fundy are caught in LD1. Also, mature lobsters can seasonally move through LD1 in transit from the upper part to the mouth of the Bay of Fundy.

6) In some areas, mature females moved earlier than mature males. Consequently, the males were more vulnerable to removal by the local fishery. The timing of the local fishing season with the timing of seasonal movement of mature lobsters has an important effect on the proportion of mature lobsters removed in an area.

Source of Larval Recruitment

The relationship between seasonal movements of adult lobsters, larval recruitment patterns and oceanographic features is still unclear. Major concentrations of brood stocks (berried females with eggs about to hatch) have to date been found on the N.B. side of the Bay of Fundy, top of Browns Bank and Georges Bank during summer months (Campbell and Pezzack 1986). To a lesser extent some berried females were found on coastal areas of SW N.S. Consequently, all these areas are capable of producing lobster larvae. Whether or not recruitment comes from outside or within the Bay of Fundy is uncertain (Campbell 1985). There are many large mature females found in shallow waters during the summer months, especially on the N.B. side of the Bay of Fundy. This area may be important for larval recruitment downstream. Water currents tend to flow into the Bay of Fundy on the N.S. side, whereas currents on the N.B. side tend to flow out of the Bay of Fundy. Where the free-swimming pelagic larvae eventually settle as benthic juveniles is a matter of speculation at present because few larvae have been found in plankton tows in the Bay of Fundy. The larvae may be swept along the Gulf of Maine coastline by the surface currents, caught in eddies in bays on the mainland N.B. coast or the southern coast of Grand Manan. Previously larvae were assumed to be passive surface drifters. However, recent studies suggest that some lobster larval stages may undergo vertical migration which would influence the interpretation of the larval transport patterns in relation to various current patterns.

Mortality Estimates and Changes

The size frequencies were weighted according to the local landings obtained at the beginning and end of each fishing season and statistical district 49 and 52 to represent LD1 for 1983-84 and 1984-85 (Fig. 11). The proportion of recruits (% first molt into legal size) was as much as 76-79%. Overall mortality Z (Campbell 1980) was calculated as 1.94 and 1.81 (Fig. 11); assuming M = 0.1, exploitation rates were about 84 and 82%, respectively. These values are probably too high (by 5-10%) since equivalent size frequency data for Stat. Dist. 48, 51 and 53 were not available for 1983-85.

Exploitation rates have increased in the Bay of Fundy, e.g. Grand Manan (Campbell and Duggan 1980). Exploitation is influenced mainly by the number of licenses, number of traps hauled and seasonal timing and length of the fishing season. Increased efficiency of lobster boats in recent years in hauling traps and traveling further afield have made the lobster fishing fleet increasingly responsive to changes in lobster abundance. Biological assessments suggest that increases in exploitation, through increases in fishing season, trap numbers or licenses, are not biologically advisable. Increases in exploitation would reduce yield per recruit slightly, but substantially reduce the number of eggs per recruit (Table 5, 6) by removing potentially reproductive females.

Reducing the number of licenses in LD1 would increase the yield per license and bring the average yield per license closer to that of LD3 or LD2 (Table 1). LD1 has a 300 trap/license limit at present.

Since the fishery is dependent on recruitment, fluctuations in annual landings are unavoidable. However, increasing exploitation rates may in the future increase the magnitude of these fluctuations. Further stability and higher landings might be accomplished by maintaining lower levels of exploitation.

The exact number of mature lobsters required to maintain a healthy productive fishery is unknown and difficult to determine. Consequently, any conservative management measures used, such as reducing exploitation, increasing recruit size and/or adding a maximum size limit, that increases egg production substantially would assist in ensuring optimal recruitment into an area.

Fishing Season Changes

The closed lobster fishing season is intended, in part, to protect lobsters while molting, mating, extruding and hatching eggs and to reduce exploitation rates. The lobster fishing season in LD1 has basically remained fall-spring since the turn of the century, with few modifications. This fishing season ensures that lobsters are landed hard-shelled, full-meated and better able to withstand storage and shipment to distant markets during cooler weather than during summer months. Also, fishermen receive much better prices during winter when lobsters are scarce than in spring-summer when the lobster supply is greatest.

Since temperatures are warmer in shallow waters during the summer months, lobster catchability becomes substantially higher compared to the low winter temperatures (McLeese and Wilder 1958). Water temperature becomes warmer more rapidly making lobsters more catchable at the eastern end than at the western end of LD1 during May-July. Consequently, seasonal timing (period) and length of the fishing season has an important effect on exploitation rates.

Extending the fishing season into July and/or early November has to increase exploitation by removing more lobsters from the fishing grounds. More immature legal lobsters will be removed thereby reducing the number of lobsters reaching maturity, and consequently the number of eggs per recruit (Table 5) and possibly the eventual reduction in recruitment into the fishery many years later. In addition, more large mature lobsters become vulnerable to removal since mature lobsters move seasonally from deep waters in winter to shallow waters in the summer months. The closed summer fishing season helps protect large lobsters moving into shallow waters to reproduce (mate, extrude and hatch eggs) and molt. Increasing exploitation of large mature lobsters, especially in Stat. Dist. 48, may reduce the quantity of larvae recruiting to downstream areas, e.g. the rest of LD1.

Although the effect of increasing the fishing season can have an immediate short-term gain to fishermen, a long-term reduction in landings can be expected. An example is provided from the following crude calculations for the 8-day extension in fishing season from 29 June to 6 July 1985 for LD1. An estimated 5.4% increase in landings (14.5 t) from 254 t to 268.5 t was realized with the 8-day extension (Table 1). Assuming 82% exploitation, then the estimated total lobster biomass available in the water was approximately 254 ÷ 0.82 = 309.8 t during the regular 1984-85 fishing season. The season extension resulted in a total exploitation of (268.5 ÷ 309.8) x 100 = 86.7%; an increase in exploitation of about 4.6%. In the long term, an increase in exploitation rate from 83 to 86%, for example, could result in 41.7% reduction in eggs per recruit (Table 5). The period for development from egg to molt into the legal size takes about 6-8 years and an additional 1-2 years to reach maturity. Assuming recruitment results from local mature females hatching eggs, a reduction in recruitment in LD1 could be expected in 1992-95 as a result of the summer 1985 fishing extension.

Catchability was assumed to linearly increase with temperature increases up to 10°C with a lower threshold of 3°C (McLeese and Wilder 1958). The number of degree days above 3°C was estimated from temperature profiles (e.g. Fig. 12) for periods of the regular fishing season and proposed 8-d extensions (Table 9). Assuming a 8-d extension, an equivalent number of days during the regular fishing season for reduction was estimated with the same number of degree days. This equivalent degree-day closure period does not guarantee maintaining the same or reducing the present exploitation rate since the latent fishing effort could increase (by increasing trap hauls) and seasonal temperatures could vary from one year to another.

To conduct a more sophisticated analysis to estimate seasonal weekly changes in exploitation would require detailed information, which is not available, on the effect of effort changes, temperature changes, and the interaction of trap-lobster densities on lobster catchability.

Carapace Length Changes

Since smaller lobsters generally bring lower prices, the present minimum size limit (81 mm or 3 3/16 in. CL) is effective in providing a product of relatively high unit value. The fact that rates of exploitation are about 70% and higher in the Bay of Fundy shows that the minimum legal size limit has undoubtedly performed an important conservation function in helping to maintain a viable lobster fishery. The present legal size limit, however, is below the lobster size providing maximum yield in weight per recruit for this area. In addition, since the legal size is 1 to 2 molts below that which most lobsters mature in this area, the theoretical maximum number of eggs per recruit is not achieved.

Despite the present legal minimum size being below the theoretical optimum, the fact remains that the lobster fishery in the Bay of Fundy remains reasonably viable at present. This suggests that other conservation regulations may be important adjuncts to the present legal minimum size regulation such as: (1) berried female protection; (2) restricted number of licenses and traps per fisherman; and (3) restricted fishing seasons.

However, a longer minimum legal size may be appropriate in the future. The effects of increasing the minimum legal size to yield per recruit and eggs per recruit under different exploitation rates are shown in Table 6. Loss in catch in first year by increasing the minimum legal size will depend on the sizes of legal lobsters caught in a particular area. For Lobster District 1, annual small increment increases of 1 mm (e.g. 81 to 82 mm) CL would result in a yield loss about 6% in the first year. Thereafter, the losses would be smaller since the benefit of increased yield per recruit from a larger legal minimum size would start being realized. The percentage increases and losses associated with small increases in minimum size would probably not be readily observed due to various environmental effects on the natural fluctuations of the lobster populations.

Maximum Size

Adding a maximum size of 127 mm carapace length (CL) to the existing minimum legal size of 81 mm CL would protect large mature lobsters above the 127-mm (5-in.) CL size (about 3.6 lb). Although there would be a slight loss in yield per recruit, there would be a substantial increase in eggs per recruit (Table 7). Increasing the legal minimum size while maintaining a maximum size would result in similar percentage increases in yield and eggs per recruit as without a maximum size (Table 7, 8). However, the starting point in eggs per recruit at an existing 127-mm CL maximum size would be higher and more eggs per recruit would be produced than if a maximum size were not in place. Maintaining a maximum size while increasing recruit size would be advantageous, especially if increase in egg production is a primary management goal.

A maximum size acts as a refugium or protection for the large mature lobsters that produce large amounts of eggs and can be an interim management strategy if there are high exploitation rates and the prospect of increase in minimum legal size is low in the immediate future.

The overall loss in yield to the fishery would be about 4% of total landings in the first year if a 127-mm CL maximum is applied. The few fishermen fishing for only large lobsters could lose between 4 and 20% (median about 10%) based on current catches in Lobster District 1.

Summary

The Lobster District 1 (36) fishery is yield-overfished at present size limit, effort levels and season restrictions. A fishing season extension for Lobster District 1 (36) into July and/or October from the present season (2nd Wed. Nov. to 14 Jan. and 1 Apr. to 29 June) would result in:

(1) Increased effort and exploitation of the lobster stock. Since water temperatures are warmer, lobster catchability would be higher. Current biological advice to management is that exploitation rates of lobsters for most areas are too high and that, wherever possible, exploitation and effort should be reduced. Lobster District 1 has almost twice the number of licenses compared to either LD2 or LD3. Increasing fishing effort in LD1 would have a major effect on the lobster stock in the Bay of Fundy, especially where most lobsters are removed before they reach maturity and have a chance to reproduce.

(2) Fishing closer to the molting period. Many soft-shell lobsters could be caught, resulting in lower value (price) per lobster catch for fishermen. The percentage of soft shell caught would depend on the local water temperatures each year.

(3) Removal of more large mature lobsters which are part of the brood stock, thus providing short-term increases in landings (about 5-10%), but causing long-term reduction in recruitment and landings. Recent studies show that mature lobsters move seasonally from deep waters in winter to shallow waters in summer months. The closed summer fishing season helps protect large lobsters moving into shallow waters to reproduce (mate, extrude and hatch eggs) and molt in LD1. Increasing exploitation of large mature lobsters, especially in Statistical District 48, may reduce the quantity of larvae recruiting to downstream areas, e.g. rest of LD1.

Alternative management strategies to improve the yield and economic benefits to fishermen in LD1 could include the following possible solutions:

(1) As an interim measure for LD1, the fishing season could be shifted slightly without increasing the exploitation potential, e.g. an 8-d extension to first Tuesday of November would require an equivalent degree-day reduction in season such as a 20 Dec. to 14 Jan. closure.

Only one season shift should be recommended?

(2) Fishing seasons in LD1, 2, 3 of the Bay of Fundy be made similar after negotiations with fishermen representatives of each district.

(3) Effort reduction in LD1:

(a) reduce number of licenses to increase yield per license
(b) reduce season length

(4) Increase recruit (minimum carapace length) size to increase yield per recruit and eggs per recruit.

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Table 1. Summary of seasonal landings and licenses for Lobster Districts 1, 2 and 3 during the 1984-85 season. Values in brackets are percentages of total.

	Lobster District			
	1	2	3	Total
Landings (tonnes)	268.5[a] (34.5)	334 (42.9)	176 (22.6)	778.5
Mean landings 1944-84	220.5 (34.9)	319.4 (50.5)	92.7 (14.6)	632.6
Licenses	185 (48.1)	109 (28.3)	91 (23.6)	385
Landings/license	1.4	3.1	1.9	2.0

[a]Estimated 5.4% (14.5 t) due to an 8-day extension of season (29 June-6 July).

Table 2. Percent of lobster landings by season total for the various statistical districts in Lobster District 1 during the 1983-84 and 1984-85 fishing seasons. Values in brackets are tonnes.

	Statistical District					
Season	51	52	53	49	48	Total
Fall '83	84.0	78.2	82.4	72.4	33.9	67.8
Spring '84	16.0	21.8	17.6	27.6	66.1	32.2
Total (tonnes)	(50.0)	(27.5)	(37.0)	(43.5)	(54.5)	(212.5)
Fall '84	82.2	86.8	79.8	64.9	31.0	60.3
Spring '85	17.8	13.2	20.2	35.1	69.0	39.7
Total (tonnes)	(50.5)	(26.5)	(44.5)	(48.5)	(98.5)	(268.5)

Table 3. Percent of lobster landings by statistical area total for Lobster District 1 during 1983-84 and 1984-85 fishing seasons. Values in brackets are tonnes.

	Statistical District					
Season	51	52	53	49	48	Total
Fall '83	29.2	14.9	21.2	21.9	12.8	(144.0)
Spring '84	11.7	8.8	9.5	17.5	52.5	(68.5)
Total (tonnes)	23.5	12.9	17.4	20.5	25.7	(212.5)
Fall '84	25.6	14.2	21.9	19.5	18.8	(162.0)
Spring '85	8.4	3.3	8.5	15.9	63.9	(106.5)
Total (tonnes)	18.8	9.9	16.6	18.0	36.7	(268.5)

Table 4. Entrance hoop diameters and lath spaces (cm) of commercial lobster traps sampled in the Bay of Fundy, 1979-80.

Area	Entrance diameter				Lath space				N
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	
North Head	17.4[a]	2.6	13.9	22.9	3.1	0.2	2.9	3.8	20
Seal Cove	14.8[a]	1.2	13.9	16.5	3.2	0.3	2.9	3.8	20
Chance Harbour	16.4[b]	1.3	14.2	19.6	3.4	0.5	1.9	4.6	66
Alma	17.8[c]	1.7	14.6	21.9	3.3	0.2	2.8	4.0	64
Delap Cove	17.0[d]	1.8	12.6	22.7	3.4	0.3	2.0	4.6	63

[a]About 50% of traps sampled with hoops, rest had entrances made of knitted twine only which were expandable to 23-26 cm.

[b]About 7% traps had entrances made of knitted twine only.

[c]About 15% traps had entrances made of knitted twine only.

[d]About 3% traps had entrances made of knitted twine only.

Table 5. Effect of different exploitation rates on lobster yield per recruit and eggs per recruit at current recruit size (81 mm or 3 3/16 in. CL). Values in brackets are actual yield/recruit (average for males and females) and eggs/recruit values. (After Campbell 1985).

Exploitation rates (%)	Percent change assuming average exploitation of 70%	
	Yield per recruit	Eggs per recruit
55	9.2 (555)	321.9 (2844)
63	3.7 (527)	99.9 (1347)
70	0 (508)	0 (674)
75	-2.5 (496)	-47.8 (352)
80	-4.2 (487)	-71.5 (192)
83	-5.4 (481)	-83.9 (108)
86	-6.2 (476)	-90.7 (63)

Table 6. Percentage change in yield and eggs per recruit at different exploitation levels, from the current legal minimum size of 81 mm CL to various increases in minimum size. Sexes combined. Values in brackets are actual values of yield and eggs per recruit. (After Campbell 1985).

Legal minimum size			Exploitation rate							
CL		Weight	63%		70%		75%		86%	
mm	in.	lb	Yield	Eggs	Yield	Eggs	Yield	Eggs	Yield	Eggs
81	3.19	0.95	(527)	(1347)	(508)	(674)	(496)	(352)	(476)	(63)
83	3.27	1.02	4.6	33.7	4.9	46.7	5.0	63.2	5.2	143.2
85	3.35	1.10	9.2	66.6	6.7	92.4	10.0	125.1	10.5	286.5
87	3.43	1.18	13.8	100.0	14.5	138.6	14.9	187.7	15.7	429.7
90	3.54	1.30	20.7	150.0	21.7	207.9	22.4	281.6	23.5	644.6
94	3.70	1.48	30.6	221.7	32.1	307.3	33.0	416.0	34.7	952.4

Table 7. Percentage change in yield and eggs per recruit with the addition of a 127-mm (5-in.) CL (about 3.6 lb) maximum size to current recruit size of 81 mm CL at different exploitation rates. Sexes combined for yield per recruit. Values for yield and eggs per recruit without a maximum size and with a 81-mm CL recruit size are shown in Table 5. (After Campbell 1985).

Exploitation rates (%)	Percent change when a maximum size of 127 mm CL is added to 81 mm CL recruit size	
	Yield (g)/recruit	Eggs per recruit
55	-8.3	269.6
63	-4.2	297.9
70	-2.9	310.1
75	-1.0	308.9
80	-0.5	296.6
83	-0.3	275.4
86	-0.1	248.4

Table 8. Percentage change in yield and egg per recruit with increases in minimum legal (recruit) size from 81 to 94 mm CL with a maximum size of 127 mm CL already in place. Exploitation rate = 70%. Actual values of yield and eggs per recruit are shown in brackets. (After Campbell 1985).

Legal minimum size			Percentage change	
CL		Weight		
mm	in.	lb	Yield/recruit	Eggs/recruit
81	3.19	0.95	(493)	(2762)
83	3.27	1.02	4.9	47.0
85	3.35	1.10	8.9	93.1
87	3.43	1.18	12.9	139.6
90	3.54	1.30	19.0	209.4
94	3.70	1.48	27.3	309.5

Table 9. Equivalent degree-days above the threshold temperature (3°C) of lobster catchability for fishing season extensions.

Extension period	Degree days > 3°C	Equivalent period for season closure
Second Tuesday November	Prince St. 5 temperatures (10 m)	
1- 8 Nov. 1983	54	29 Dec. '83 - 14 Jan. '84
6-13 Nov. 1984	56	24 Dec. '84 - 14 Jan. '85
5-12 Nov. 1985	56	20 Dec. '85 - 14 Jan. '86
	Alma temperatures	
5-12 Nov. 1979	67	21 Dec. '79 - 14 Jan. '80
	Prince St. 5 temperatures (10 m)	
29 June-6 July 1984	41	1-25 Apr. '84
29 June-6 July 1985	43	1 Apr.-19 May '85
	Alma	
29 June-6 July 1980	63	1 Apr.-25 May '80

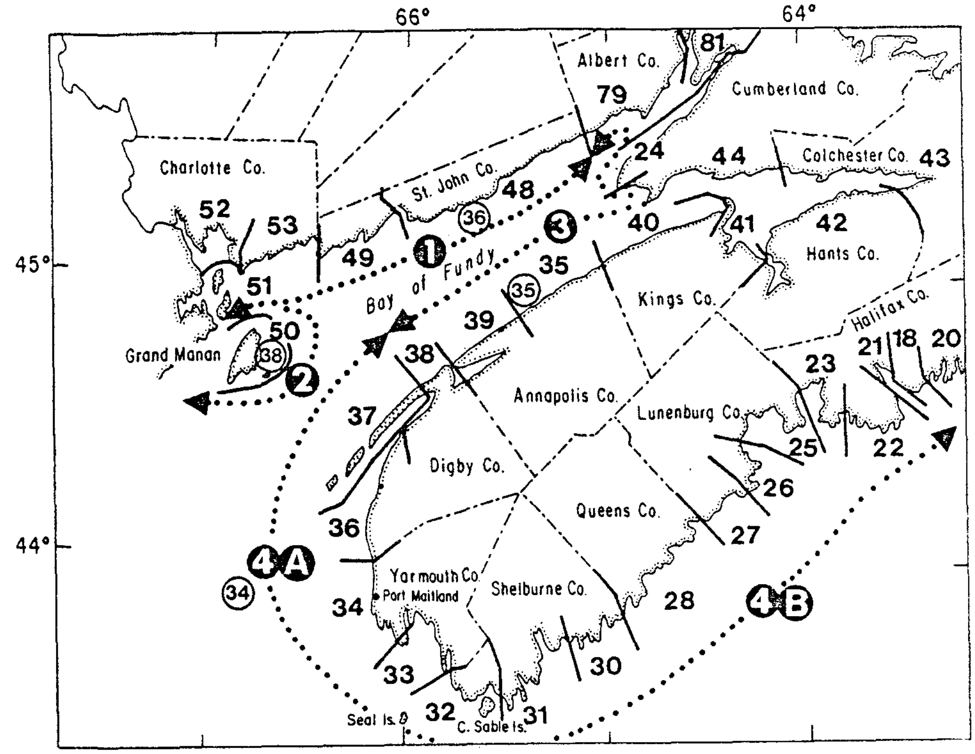

Fig. 1. Counties, statistical and lobster districts (dotted line). New lobster district numbers in open circles.

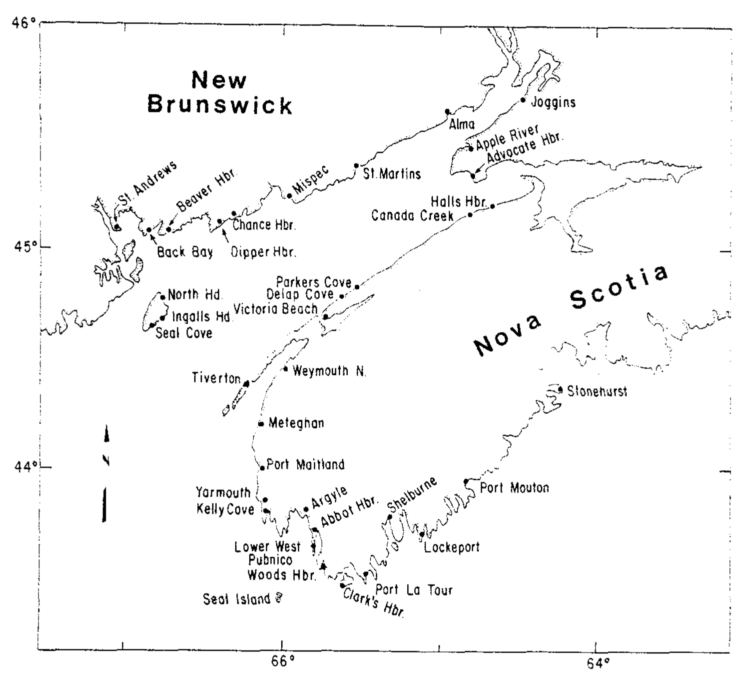

Fig 2. Sample ports.

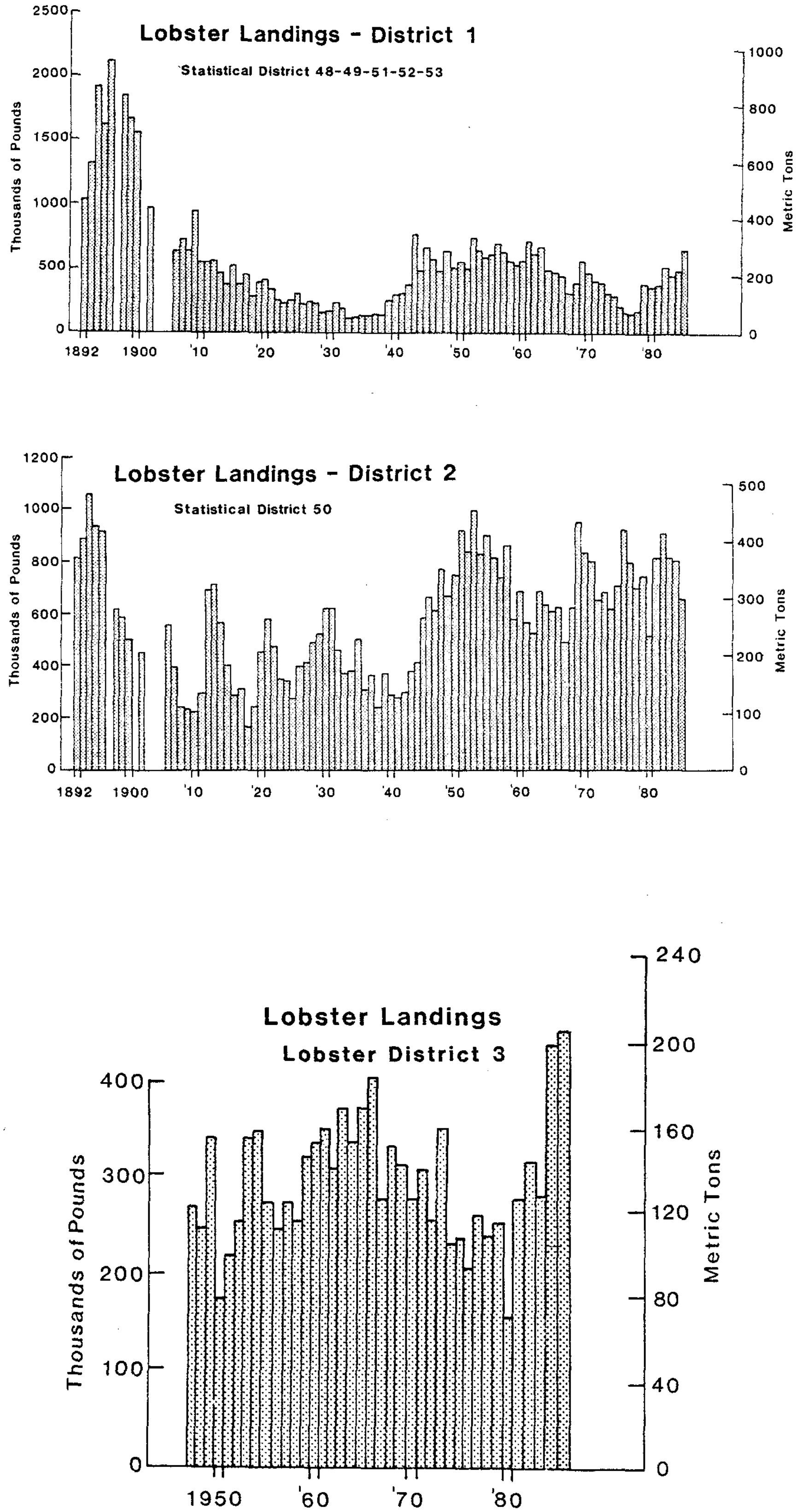

Fig. 3. Annual lobster landings for Lobster Districts 1, 2, 3. 1985 landings are only preliminary.

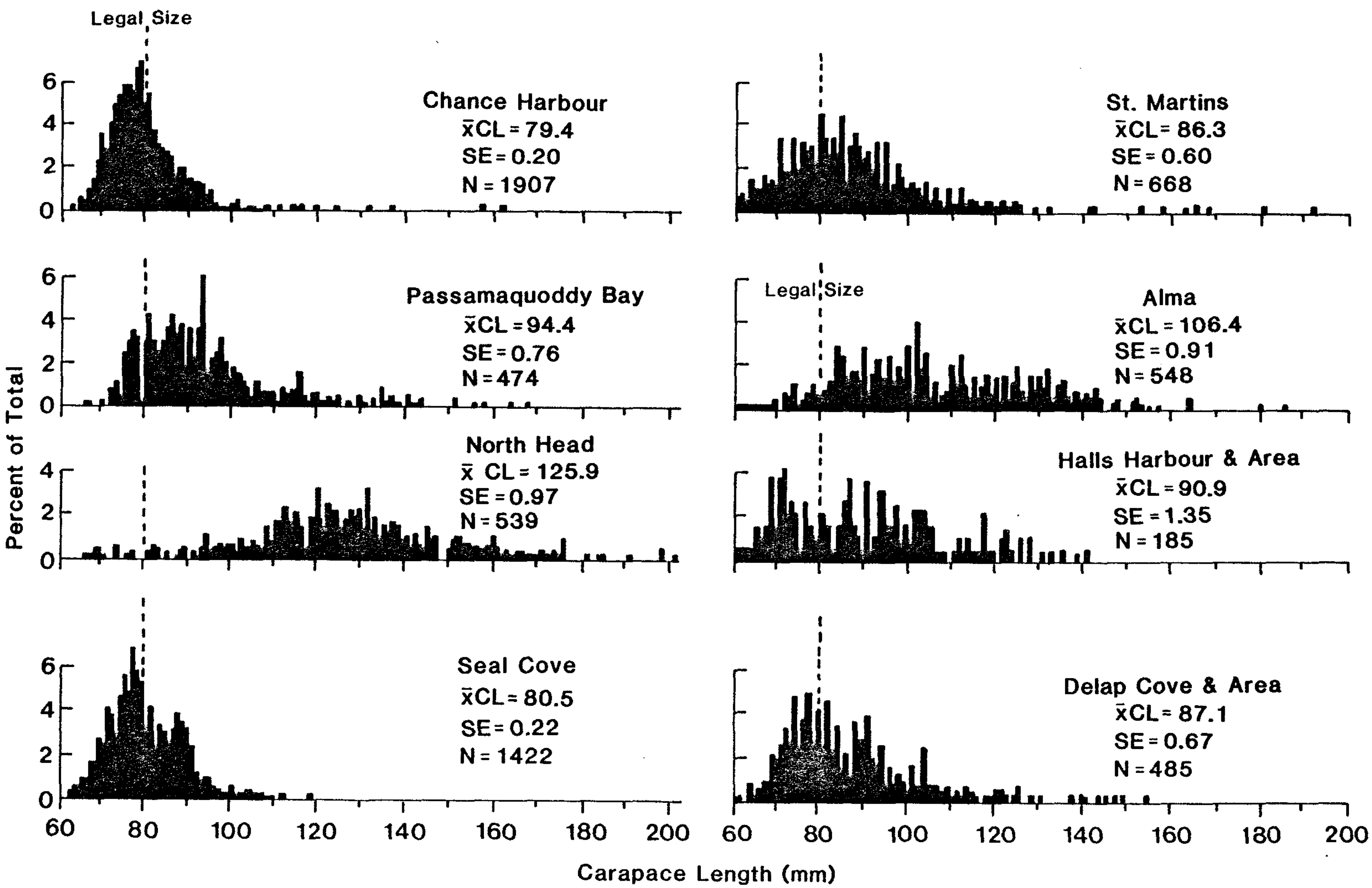

Fig. 4. Size frequencies from at-sea trap data obtained in the Bay of Fundy during October-December 1979.

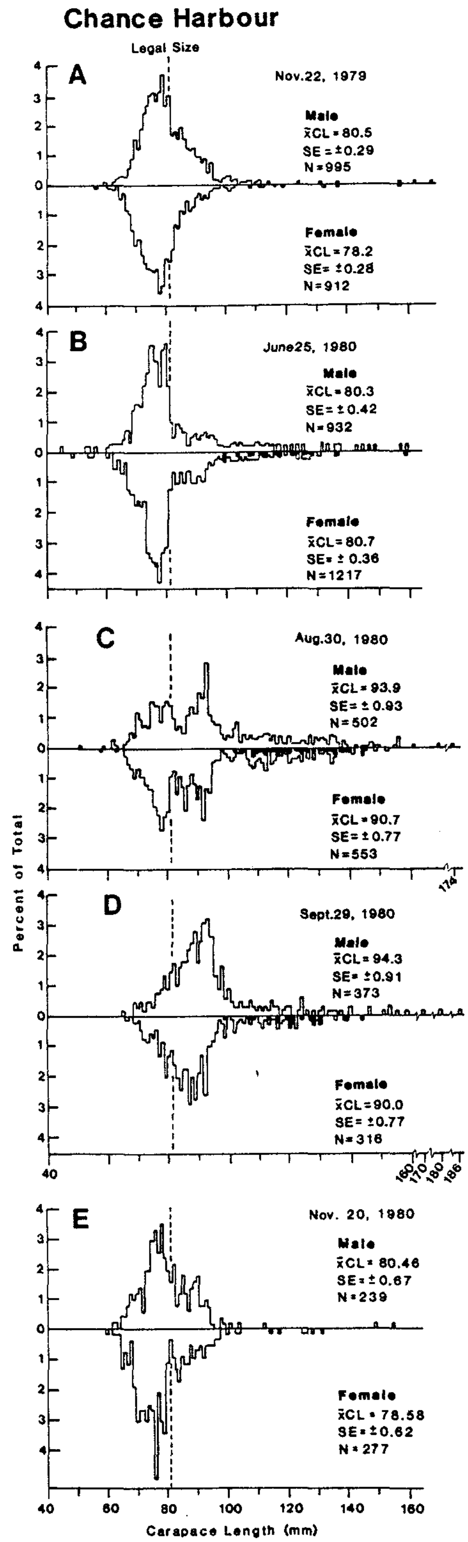

Fig. 5. Seasonal changes in size frequencies of male, non-berried female (light histograms) and berried female (dark histograms) lobsters obtained from at-sea samples of traps near Chance Harbour, 1979-80. X_{CL} = mean CL; SE = standard error; N = total number of each sex.

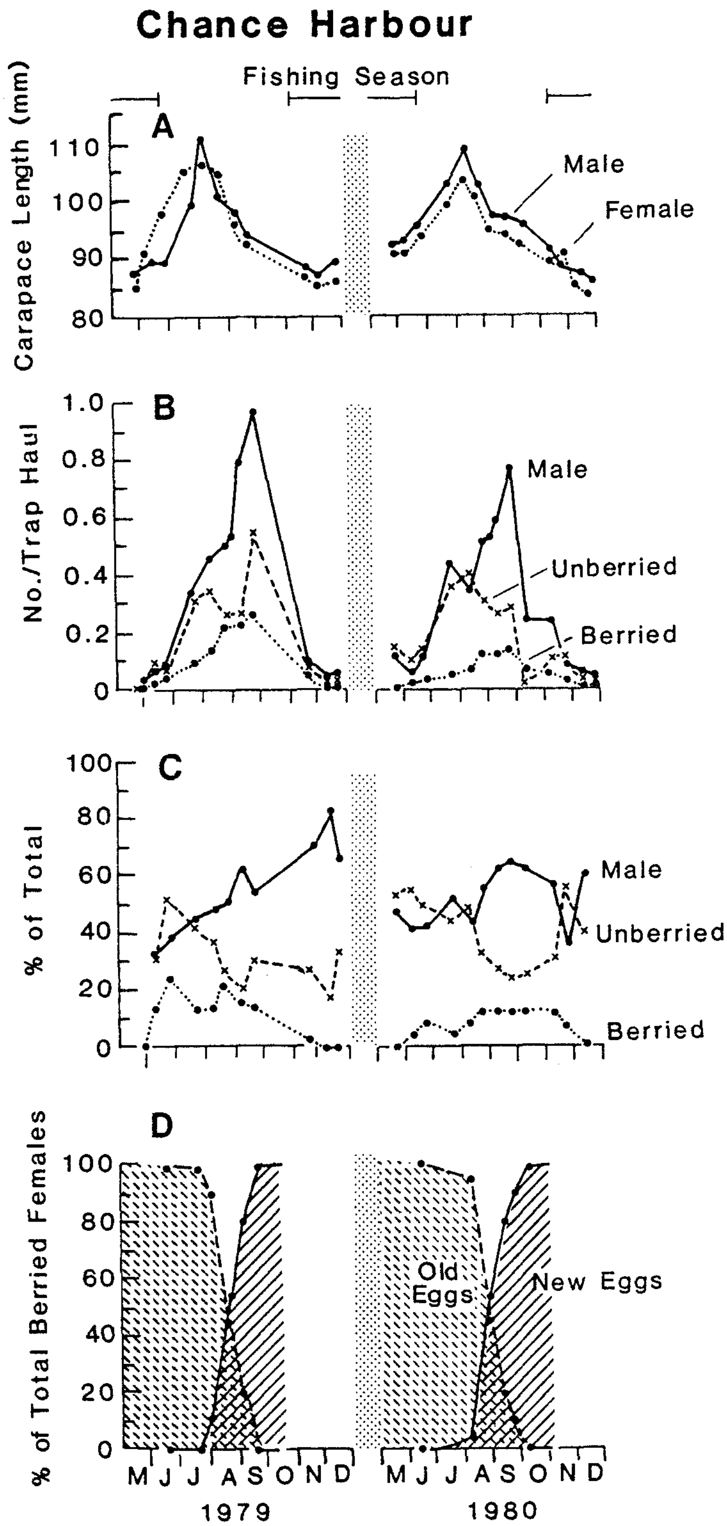

Fig. 6. Two-week means for (A) carapace length of legal-sized lobsters, (B) number of lobsters ≥ 95 mm CL per trap haul, (C) percent of total lobsters ≥ 95 mm CL, and (D) percent new and old eggs (with eye spots) on berried females obtained from at-sea samples of traps near Chance Harbour, 1979-80.

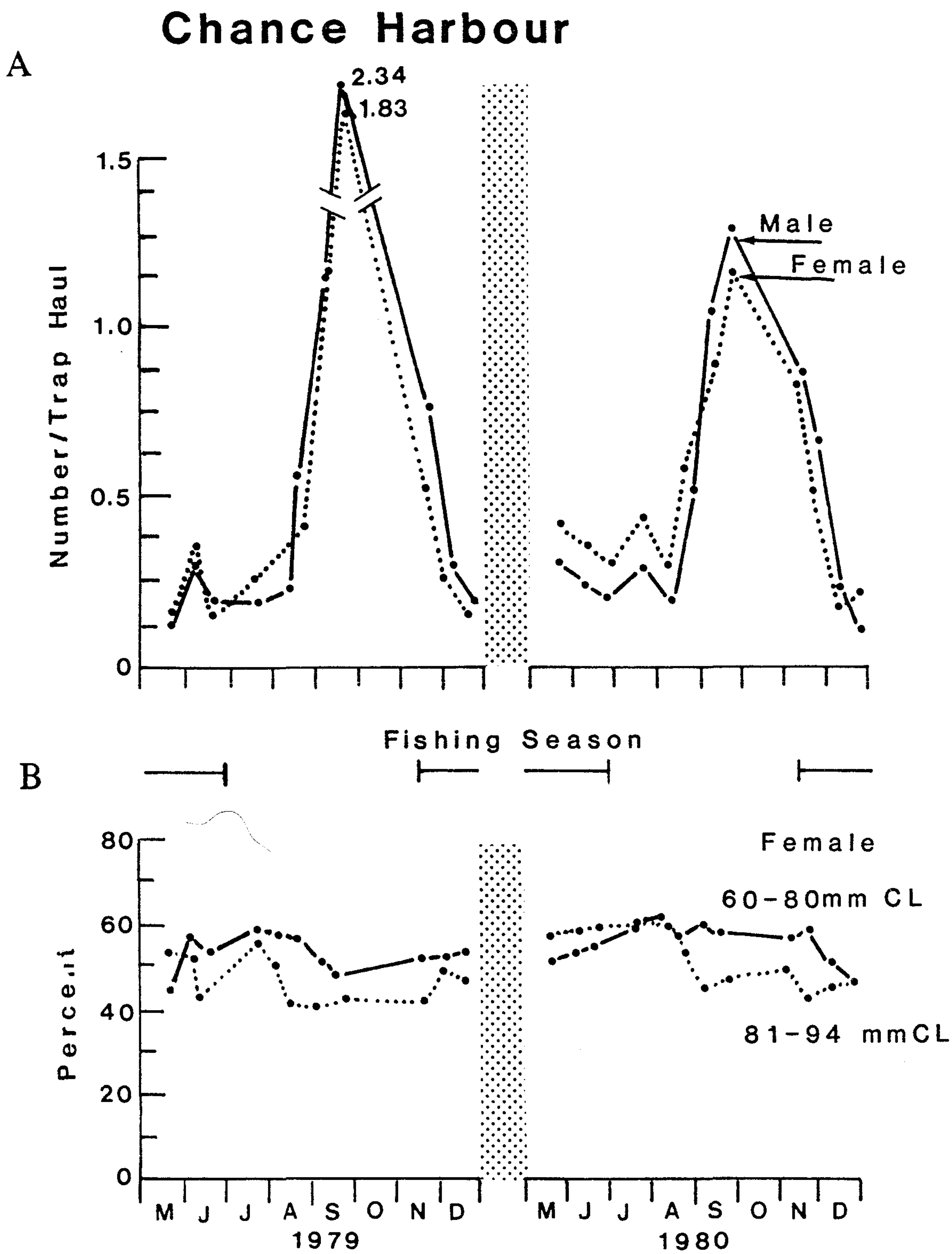

Fig. 7. Two-week means for (A) number of lobsters 81-94 mm CL per trap haul, (B) percent females per total in the 60-80 mm CL and 81-94 mm CL group, obtained from at-sea samples of traps near Chance Harbour, 1979-80.

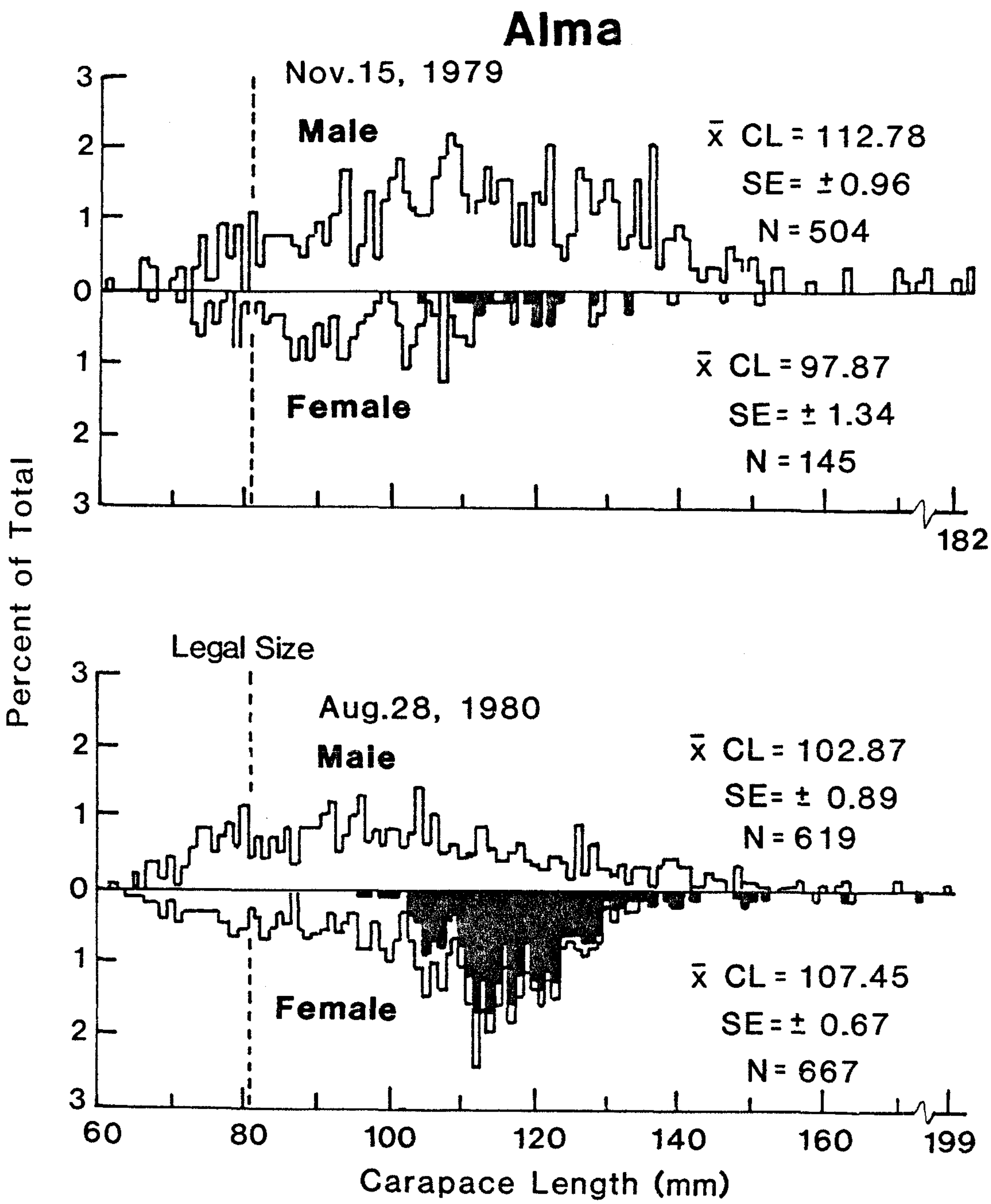

Fig. 8. Size frequency distribution expressed as percentage of total numbers of trap-caught male and female lobsters in Alma study area during November 1979 and August 1980. Black histograms are berried females. X_{CL} mean carapace length; SE = standard error; N = total number of each sex.

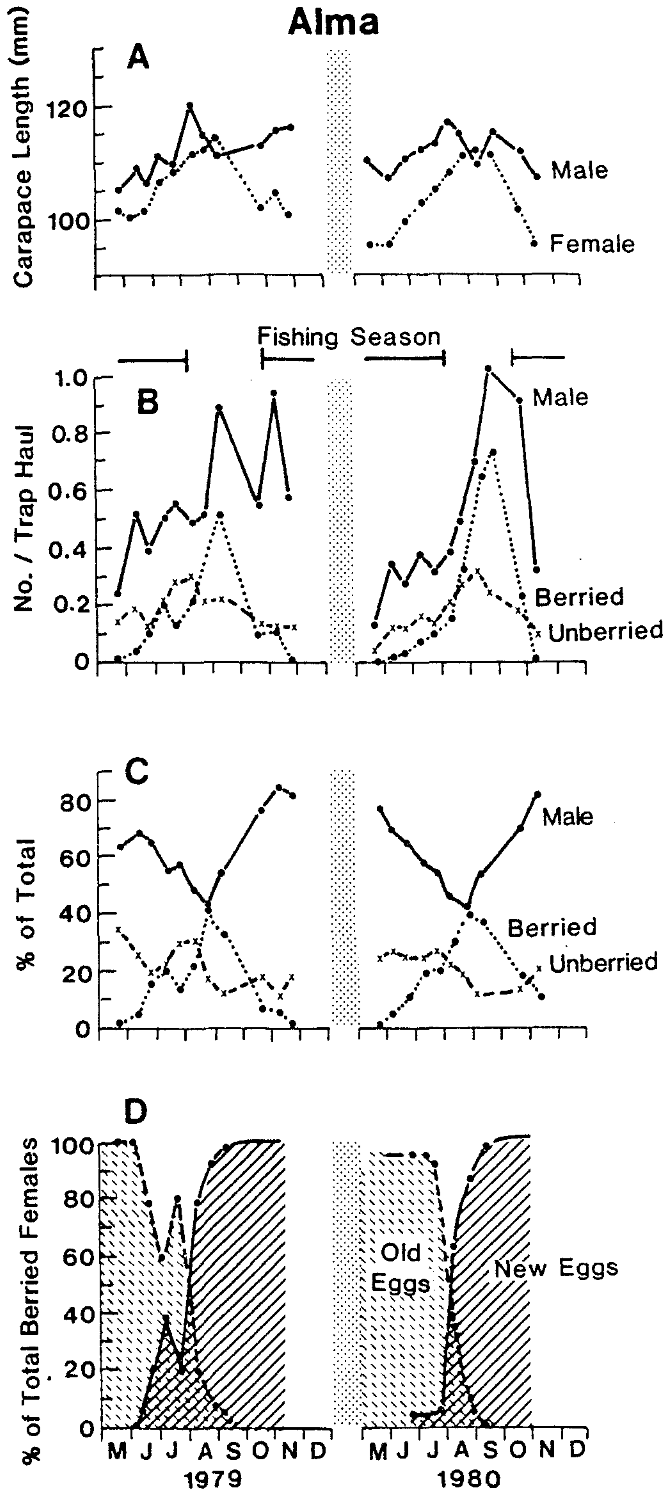

Fig. 9. Two-week means for (A) carapace length of legal-sized lobsters, (B) number of lobsters ≳ 95 mm CL per trap haul, (C) percent of total lobsters ≳ 95 mm CL, and (D) percent new and old eggs (with eye spots) on berried females obtained from at-sea samples of traps near Alma, 1979-80.

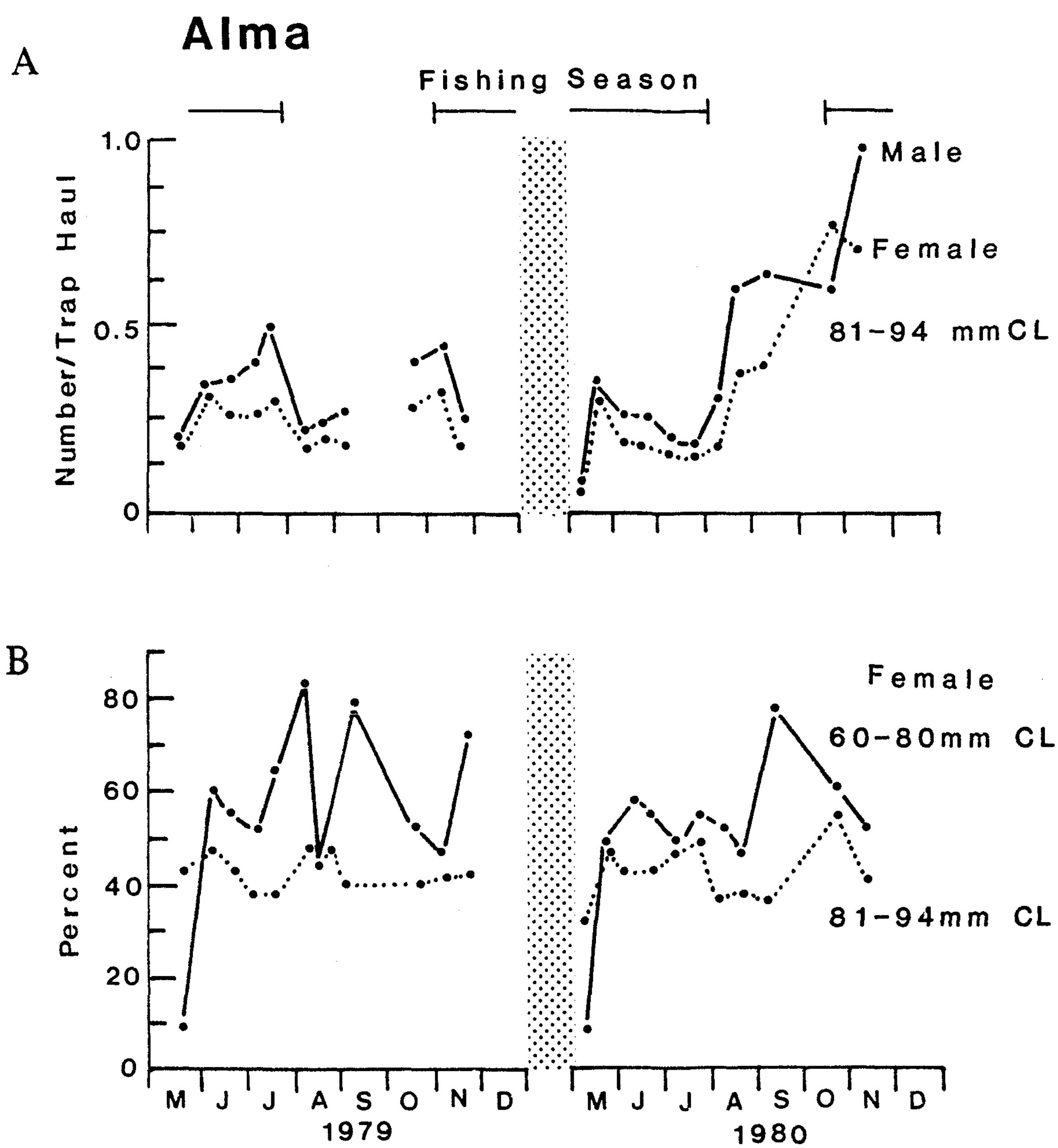

Fig. 10. Two-week means for (A) number of lobsters 81-94 mm CL per trap haul, (B) percent females per total in the 60-80 mm CL and 81-94 mm CL group, obtained from at-sea samples of traps near Alma, 1979-80. Sample sizes for 60-80 mm CL lobsters are small causing high values in B.

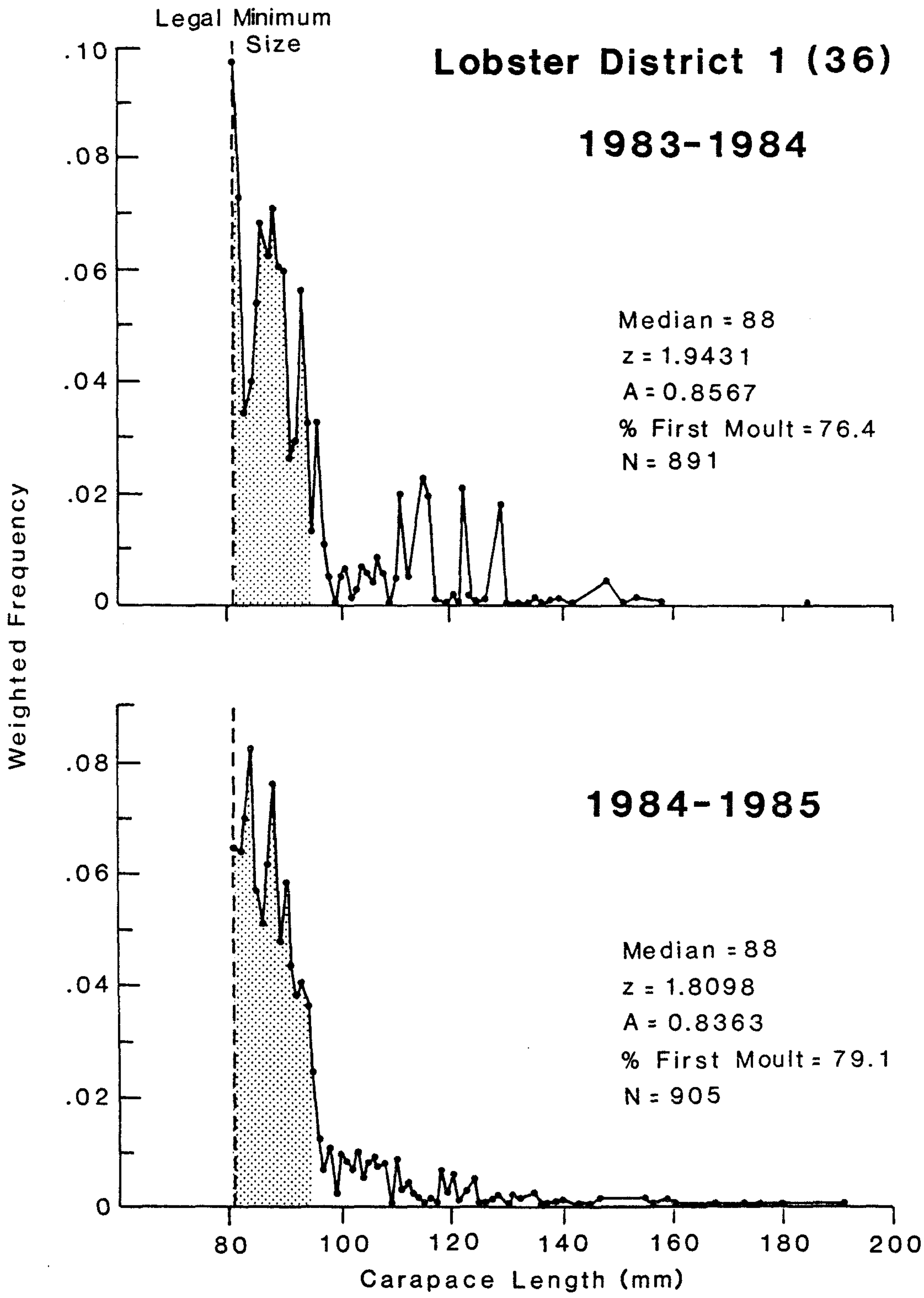

Fig. 11. Size frequencies from at-sea samples for LD1 weighted according to seasonal and geographic distribution (Stat. Dist. 49 and 52) of lobster landings for 1983-84 and 1984-85 fishing season.

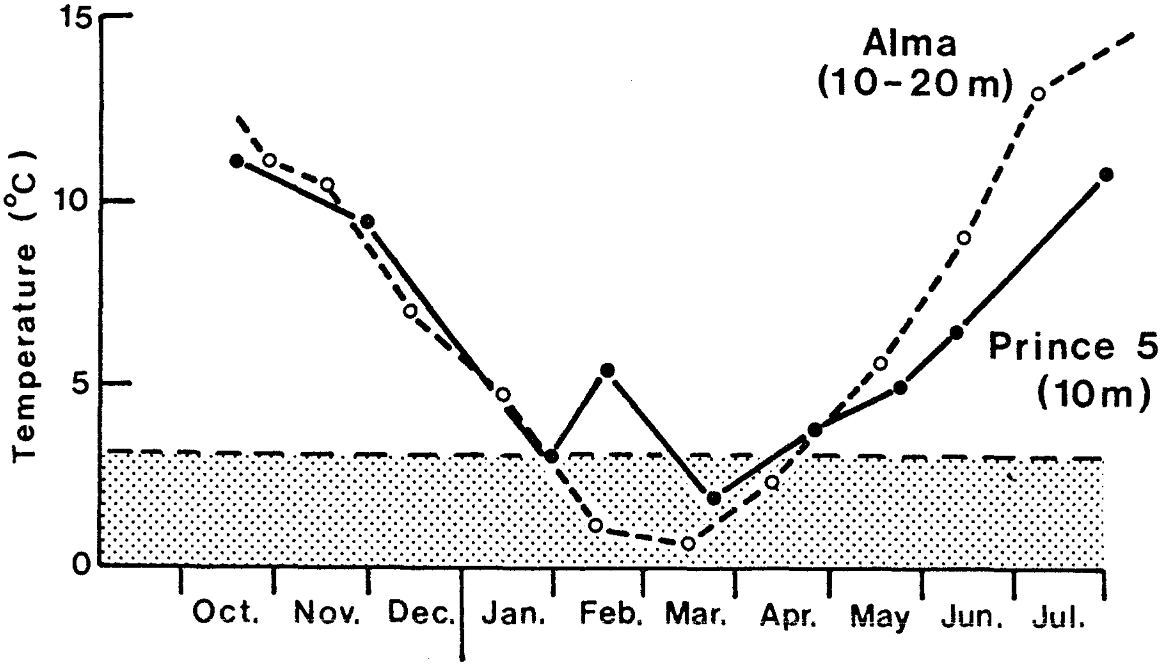

Fig. 12. Temperatures for the western end (Prince 5, 1984-85) and approximate eastern end (Alma, 1979-80) of Lobster District 1. Stipuled area is for temperatures below 3°C for which lobsters are least catchable (after McLeese and Wilder 1958).