Apsects of Lobster Biology and Fishery in the Upper Reaches of the Bay of Fundy

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ABSTRACT

The lobster fishery in the upper reaches of the Bay of Fundy is low in productivity and consists of less then 10% of the total lobster landings and fishermen of the whole Bay of Fundy. The majority of commercial size lobsters caught are large (95 mm carapace length) and mature. Evidence from size frequency distributions and tag release-recapture experiments indicated that immature lobsters (60-94 mm carapace length) had a 1:1 sex ratio and the majority did not generally move greater than 18.5 km. In contrast, sex ratios changed seasonally for mature lobsters. There was a preponderance of males in traps during the winter, while more females, especially ovigerous ones, were caught during summer (August). The tagging data indicated that mature females moved a greater mean distance (87.9 km) than males (43.2 km) and suggested a seasonal inshore shallow and offshore deep water movement. Chignecto Bay is occupied by many large mature female lobsters during summer months that molt, extrude new eggs, or hatch their old eggs as pelagic larvae. The proposed tidal dam, if placed in either Cobequid Bay or Cumberland Basin, would probably have an insignificant effect on the local lobster fishery and biology.

Key words: lobster, Homarus americanus, tagging, movements, fishery, landings, tidal barrage effects.

RÉSUMÉ

Dans la partie amont de la baie de Fundy, la pêche du homard est caractérisée par une faible productivité, avec moins de 10% du total des captures; d'autre part, les pêcheurs représentent moins de 10% du contingent de l'ensemble de la baie de Fundy. La majorité des homards de taille convenant à la vente sont grands (longeur de la carapace $\geq$ 95 mm) et parvenus à maturité. La distribution de fréquence des tailles, et les expériences consistant à libérer et recatturer des animaux marqués, ont indiqué que les populations de homards juvéniles (longueur de la carapace 60-94 mm) comportaient un nombre égal de mâles et de femelles, et ne se déplaçaient généralement pas de plus de 18,5 km. Par contre, dans le cas des homards adultes, le rapport mâles/Femelles varie de façon saisonnière. On a observé une prépondérance des mâles dans les pièges pendant l'hiver, et de femelles, en majorité gravides, pendant l'été (août). Les données fournies par le marquage ont indiqué que les femelles "matures" se déplaçaient sur

une distance moyenne plus grande (87,9 km) que les mâles (43,2 km), et suggèrent qu'ont lieu des mouvements saisonniers de l'eau à faible profondeur près du rivage, et à grande profondeur au large. La baie Chignecto contient de vastes populations de femelles matures de grande taille pendant l'été, époque à laquelle ont lieu la mue, la production de nouvelles pontes, ou l'éclosion des oeufs avec apparition de larves pélagiques.

Si l'on construit l'usine marémotrice proposée dans la baie Cobequid ou le bassin Cumberland, on n'observera probablement que des effets minimes sur la pêche et la biologie des populations locales de homards.

INTRODUCTION

Apart from some general fisheries statistics (Campbell 1979, Scarratt 1977, Wilder et al. 1974), little published information is available on the fishery and biology of the lobster Homarus americanus H. Milne-Edwards (Decapoda:Nephropidae) in the upper reaches of the Bay of Fundy. The purpose of this paper is to present and discuss data on the lobster fishery for part of Lobster District 3 (from Statistical Districts 24, 40-79) (Fig. 1) and on lobster population size and sex structures and movements of tagged lobsters obtained from a study area off Alma in Chignecto Bay (Fig. 2). Although this study was not specifically designed to determine the impact of tidal power structures on lobsters, the results are used to consider the possible effects on the lobster fishery should a tidal dam be placed in either Cobequid Bay or Cumberland Basin (Daborn 1977).

The study is limited to lobsters of a size range vulnerable to commercial fishing gear, which includes subadult and adult lobsters. Little information is available on the ecology of juvenile benthic and larval pelagic stages of H. americanus in this area.

MATERIALS AND METHODS

Statistical information on annual lobster landings and the number of licenced lobster fishing boats were obtained from Statistics Canada, Halifax, and from local fisheries officers. About 60 lobster traps were randomly chosen from Alma during September 1980 and measured for size (length, width, and height), lath spacing and entrance ring diameter (hoop size).

At-sea sampling of lobsters caught in commercial lobster fishing boats was conducted from representative ports (Alma, Halls Harbour and Canada Creek) in Lobster District 3 during May 1979-November 1980 (Fig. 2). A lobster fishing boat from Alma was also chartered to tag lobsters August-September 1979 and 1980. At-sea sampling included recording the number of trap hauls, carapace length in millimeters, and sex of sublegal ("shorts") ovigerous females and commercial size lobsters. The carapace length (CL) was measured from the inner base of the eye socket to the dorsal posterior margin of the carapace along the mid-line with vernier calipers. The

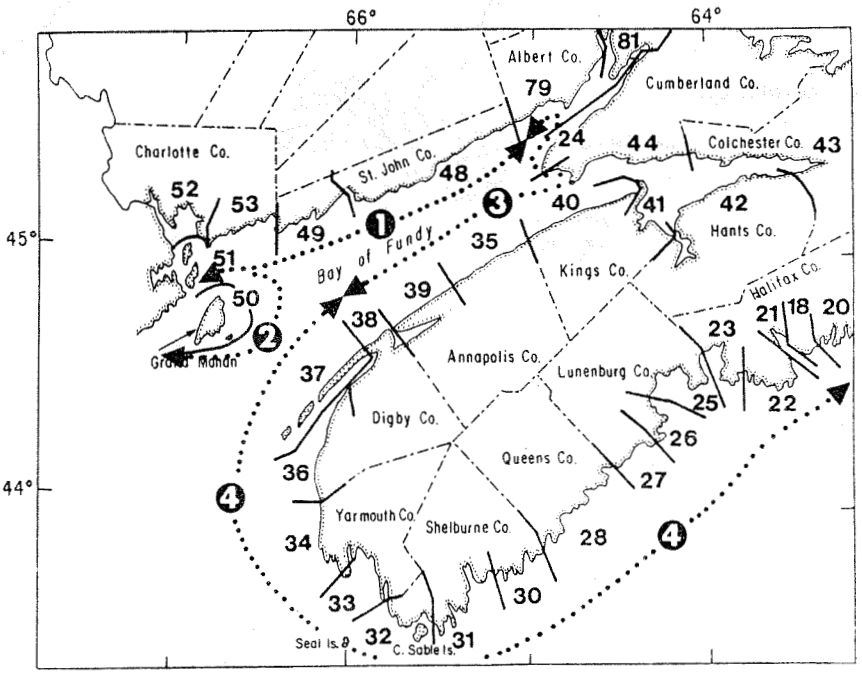

Fig. 1. Counties, statistical districts and lobster districts (dotted lines) for southern New Brunswaick and Nova Scotia.

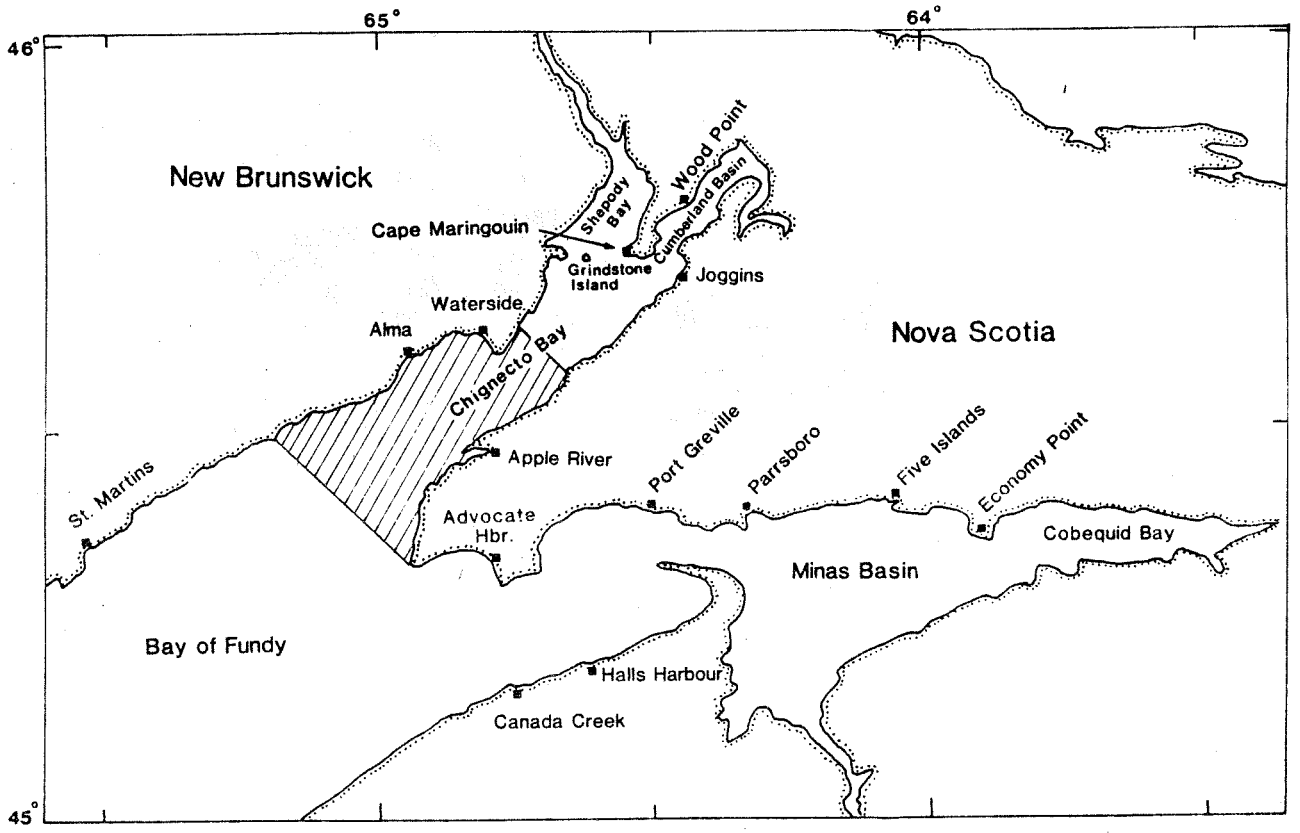

Fig. 2. Upper reaches of the Bay of Fundy. Shaded area shows the Alma study area.

developmental stage of lobster eggs, classed as new eggs (no embryo visible) and old eggs (well developed embryo visible), were recorded for each ovigerous ("berried") female.

During August-September 1979 and 1980, 2831 and 1970, respectively, lobsters were tagged with sphyrion spaghetti tags (Scarratt and Elson 1965) in the Alma area to determine growth and movement. A reward of $3.00 was offered for tags returned with accurate recapture location and depth information. An additional $2.00 was offered to fishermen for allowing each tagged lobster to be measured. Data on tag returns collected up to September 30, 1982 are used in this study. An analysis of variance program (Kim and Kohout 1975) was used to compare the distance travelled by immature, mature male, and female tagged lobsters after $\log_{10}(x + 1)$ transformation to normalize the data. Water temperatures at 10-20 m depth were obtained with continuous recording submersible thermographs (Model J180, Peabody Ryan, Kirkland, WA, U.S.A.).

RESULTS AND DISCUSSION

LOBSTER FISHERY

Regulations

Lobster fishing in Lobster District 3 is regulated in a number of ways. The fishing season is split into two periods, October 15-December 31 of one year and March 1- July 31 of the next year. Fishing seasons were designed, in part, to protect lobsters while mating, extruding eggs and molting, to assist in marketing, and to reduce exploitation rates. The number of licences issued are restricted and the number of traps (300 traps per class A fishermen and 90 traps per class B fishermen) are limited. Egg bearing ('berried') females are protected and a minimum size limit of 3 3/16 in. (81 mm) CL is in effect.

Fishing methods and gear

The fishing vessels now used are generally Cape Island style boats of 10-14 m length constructed of wood or fiberglass. Some class B fishermen use skiffs or dories 4.6-6.1 m long. Hydraulic trap haulers, depth sounders, radar, and improved boat design have allowed fishermen to travel faster, further and fish more efficiently than fishermen prior to ten years ago. Practically all commercial traps are made of oak and laminated plywood or spruce. Some fishermen are experimenting with vinyl-coated wire traps. Traps from Alma are usually half-cylindrical in shape with three bows, 92-216 cm long, about 71 cm wide, and 38 cm high, each with an entrance ring (wire or wood) 15-22 cm in diameter (about 10-15% have entrances made only of knitted twine) and laths spaced about 3.3 cm apart. Lobster traps are set singly, each with a buoy. Trap ballast is made of cement or flat rocks. Bait depends on whatever is locally available at low cost, but usually consists of salted fresh or frozen herring or mackerel. The boats dock in high-water harbours and usually have 1.5 h before and after each high tide to go in and out of ports. The extreme tidal amplitude in this area allows the traps to be hauled only during slack water

periods; the strong tidal currents usually submerge the buoys from sight of the fishermen. Recently caught lobsters are usually kept alive in floating wooden crates up to a week by the fishermen prior to selling the lobsters to travelling commercial dealer-buyers. About a third of the lobster catch is sold privately to tourists and local residents.

Catch and effort

The upper reaches of the Bay of Fundy constituted less than 10% of the total lobster vessel licences and lobster landings in the Bay of Fundy. The value of the catch at \$5.50 kg^{-1} was ca. \$0.24 million compared to ca.\$3.75 million for the whole of the Bay of Fundy. The area has traditionally been a low production lobster fishery compared to the rest of the Bay of Fundy (Fig. 3).

The number of licenced lobster fishermen residing in or near towns close to the proposed tidal power dams are six for Alma, two for Waterside, three for Woodpoint, four for Joggins, three for Apple River, seven for Advocate Harbour, one for Port Greville, four for Parrsboro, and four for Five Islands (Fig. 2). Three licenced lobster fishermen at Wood Point would be affected above the proposed tidal barrages in either Cobequid Bay or Cumberland Basin. As few lobsters are caught, lobster fishermen do not consider it economical to set traps beyond Economy Point into Cobequid Bay, beyond Grindstone Island into Shepody Bay and Cape Maringouin (Ward Point) into Cumberland Basin. Most of these fishermen set lobster traps in Minas Basin (and Greville Bay) and Chignicto Bay.

Size Composition

Typically there is a high proportion of large lobsters caught (60% over 100 mm CL for Alma area) in the upper reaches of the Bay of Fundy (Fig. 4, 5). In the more productive areas of the Bay of Fundy (e.g. in Lobster District 2 at Seal cove, Grand Manan) 95% of the commercial sized lobsters caught are within the 80-100 mm CL range (A. Campbell, unpubl. data, Wilder 1960).

LOBSTER BIOLOGY

Most of the following discussion on lobster biology is based on a study of lobsters in the Alma area of Chignecto Bay conducted during 1979-80. Similar phenomena concerning lobsters probably occur in the Advocate Harbour to Parrsboro area. This paper does not discuss every aspect of lobster biology; detailed reviews of lobster biology can be found in Cobb and Phillips (1980).

Seasonal Changes

During July-October of 1979-80 water temperatures at 10-20m depth were in the 13-15 C range, whereas during the winter months (January-April) temperatures were in the 0.5-4.5 C range.

TABLE 1. Lobster landings and total lobster licences in the upper and lower reaches of the Bay of Fundy during 1980. N.B. = New Brunswick and N.S. = Nova Scotia.

Bay of Fundy		Landings		Lobster vessel licences	
		kg x 1000	% of Total	Number	% of Total
Upper reaches					
Stat. District	40	8.7	1.3	10	2.0
	41	2.4	0.3	3	0.6
	42	0.0	0.0	0	0.0
	43	6.2	0.9	4	0.8
	44	6.6	1.0	11	2.2
	24	7.5	1.1	8	1.6
	79	13.0	1.9	11	2.2
	81	0.0	0.0	0	0.0
Total		44.4	6.5	47	9.4
Lower reaches					
N.B. side[1]		392.7	57.6	334	66.7
N.S. side[2]		245.0	35.9	120	23.9
Total Bay of Fundy		682.1	100.1	501	100.0

[1] Statistical Districts 48, 49, 50, 51, 52, 53.
[2] Statistical Districts 35, 37, 38, 39.

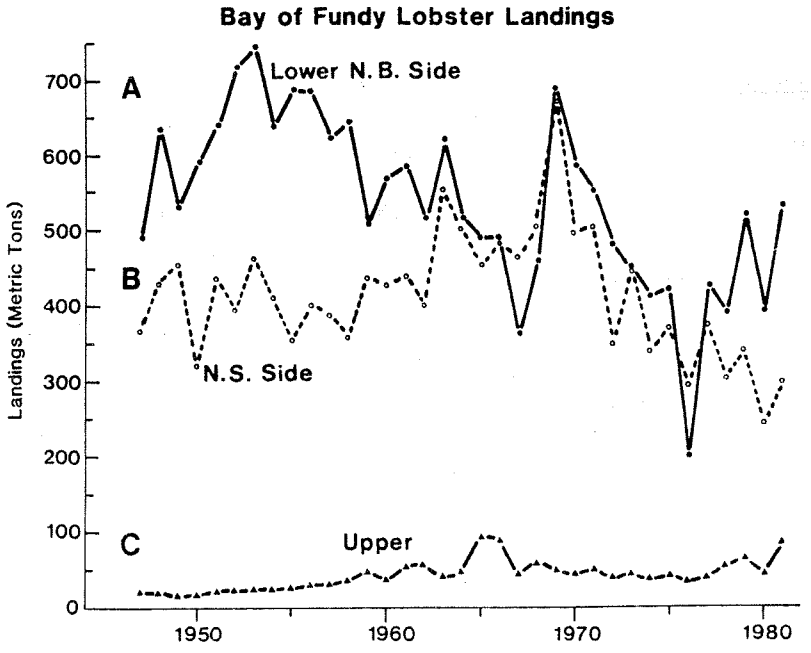

Fig. 3. Annual lobster landings for the Bay of Fundy, 1947-81. A = lower reaches, New Brunswick side (Statistical Districts 48, 49, 50, 51, 52, 53); B=lower reaches, Nova Scotia side (Statistical Districts 35, 37, 38, 39); C=upper reaches (Statistical Districts 40, 41, 43, 44, 24, 79).

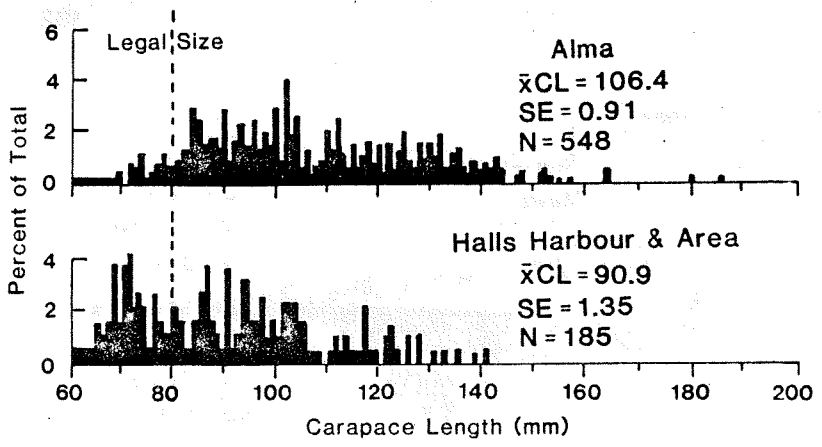

Fig. 4. Size frequency distributions expressed as percentage of total numbers of at-sea trap-caught lobsters at beginning of fishing season October 1979 for Alma area and Halls Harbour area. $\overline{X}_{CL}$ = mean carapace length: SE = standard error of mean; N = total number of lobsters measured.

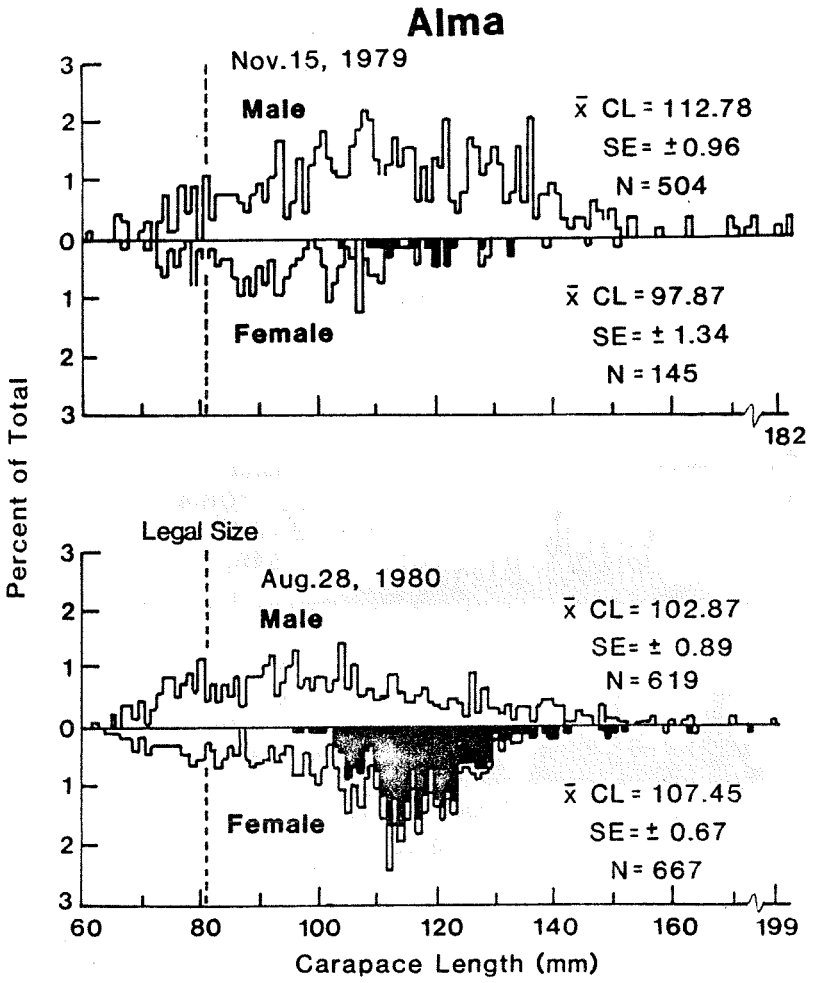

Fig. 5. Size frequency distribution expressed as percentage of total numbers of trap-caught male and female lobsters in Alma study area during November 1979 and August 1980. Black histograms are berried females. $\bar{X}_{CL}$ mean carapace length; SE = standard error of mean; N = total number of each sex of lobsters.

Sex ratio of immature lobsters (60-94 mm CL) caught in traps was generally 1:1, fluctuating between 40-60%. 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 (95 mm CL) there was a preponderance of male lobsters during the November-December and May-July fishing periods (Fig.5 , 6). In contrast, during August 1989-80, more females, especially berried females, were found in traps than males (Fig. 5,6).

The mean CL mature males 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. 6).

Increases in male and female lobsters per trap haul during the summer months (Fig. 6) were probably caused by a number of factors, such as increased density of mature male lobsters which due to movement into the area and 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). Lobster females incubate eggs on their pleopods for about 9-12 mo (Perkins 1971). 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). Mature females normally undergo a 2 yr maturation cycle, i.e. a female can extrude eggs in alternate years (Aiken and Waddy 1980).

Movement

Between 75 and 80% of immature tagged lobsters were recaptured within 18.5 km of release, wheras 17.7% of mature males and 44.7% of mature females were recaptured greater than 92.6 km from the release site (Table 2). Immature male and female tagged lobsters (60-94 mm CL) moved a mean of 19.3 km and 13.5km respectively (no difference between means, $p>0.05$) (Table 2). In contrast, there were significant ($p<0.001$) differences in mean distance moved between mature and immature tagged lobsters, with mature females moving further (87.9 km) than mature males (43.2 km) (Table 2).

Tagged lobsters that moved <50 km were recaptured in the direction of St. Martins, Advocate Harbour, and up Chignecto Bay as far as Joggins (Fig. 7). No lobsters were recaptured in Cumberland Basin.

Tagged lobsters moving > 50 km were recaptured along the coastlines of Nova Scotia, New Brunswick, Maine, and as far as Cape Cod (Fig.8). The direction of travel was generally west and south for those lobsters moving long distances. The furthest distance moved was 590 km for a 131 mm CL male (at release) and 578 km for a 113 mm CL female (at release) both of which were recaptured in the Cape Cod area about 2 yr after release.

Evidence for lobsters moving long distances (>100 km) and seasonally inshore-offshore (shallow and deep waters) in the Gulf of Maine and on Georges Bank has been shown (cf. reviews by Krouse 1980, Stasko 1980).

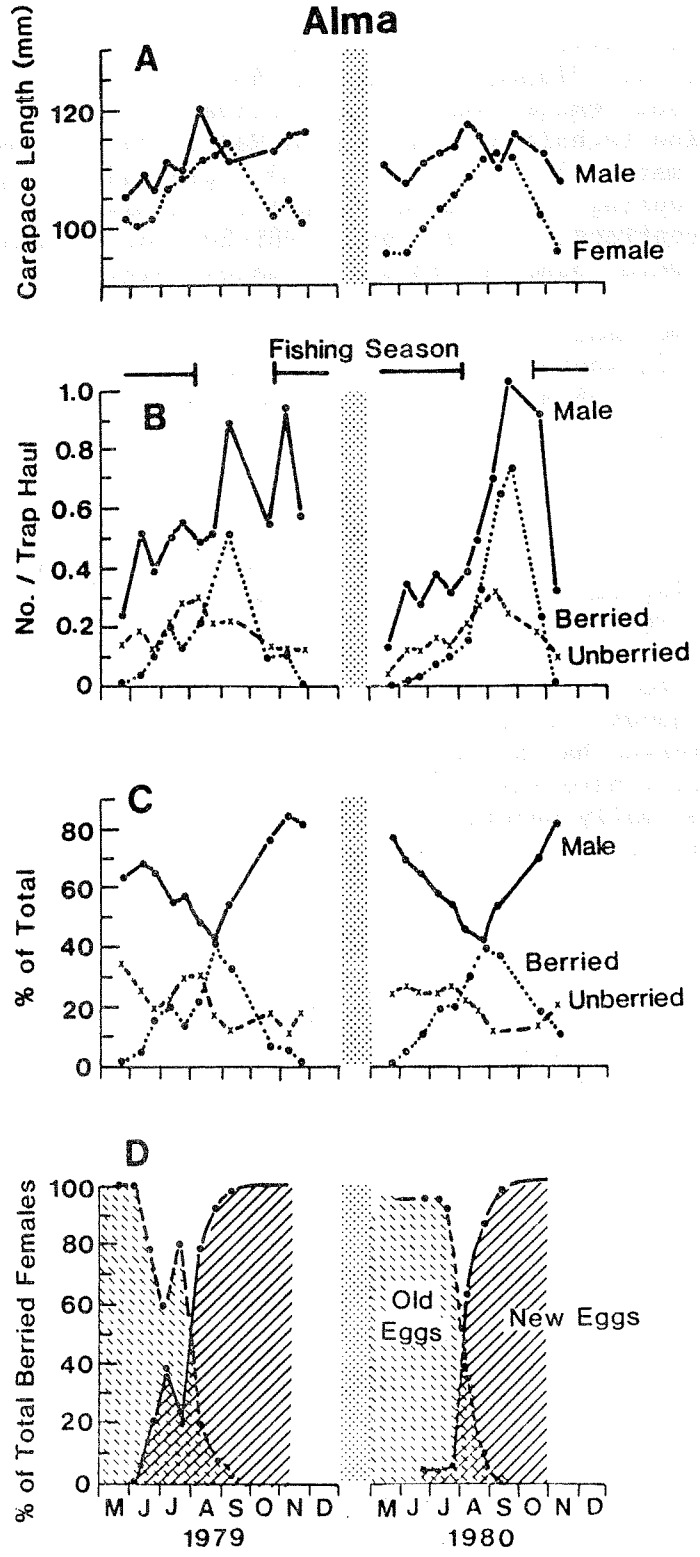

Fig. 6. Two-week means for mature (95 mm CL) lobsters (A) carapace length means, (B) number per trap haul, (C) sex ratio or percentage of total mature lobsters, (D) percentage egg stage of total berried females sampled from the Alma area, 1979-80.

TABLE 2. Summary of movements of tagged lobsters released off Alma. New Brunswick, during August-September 1979-80, including recaptures up to September 30, 1981. Lobsters grouped into physiologically immature (60-94 mm CL) and mature (>95 mm CL) at release.

Details	Percent of total lobster recaptures			
	Male		Female	
	Immature	Mature	Immature	Mature
Distance moved from (km)				
18.5	75.0	56.7	81.2	35.1
18.5-36.9	13.1	22.1	14.5	12.3
37.0-92.6	6.0	3.5	2.9	7.9
92.6	5.9	17.7	1.4	44.7
Total % Recaptured	14.6	14.6	16.9	11.0
Total Number released	577	1737	409	2078
Mean distance(km) travelled	19.3[1]	43.2	13.5[1]	87.9
Max. distance (km) travelled	168.8	590.1	171.1	577.6

[1] Means followd by the same letter in row are similar ($p > 0.05$) other means nor followed by same letter in same row are significantly different from each other ($p < 0.001$).

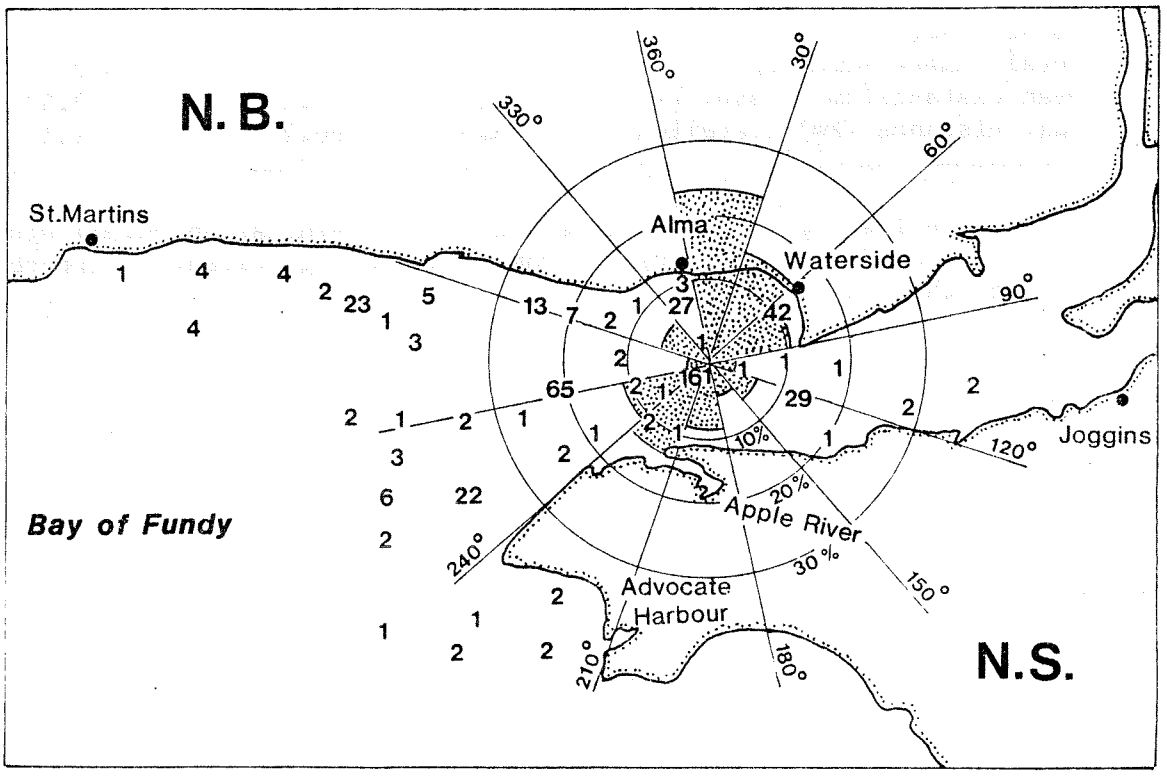

Fig. 7. Map showing number of recaptured tagged lobsters moving <50 km from release. Circles and shading indicate direction moved in 30 degree units (of true north) expressed as percentages of total recaptures.

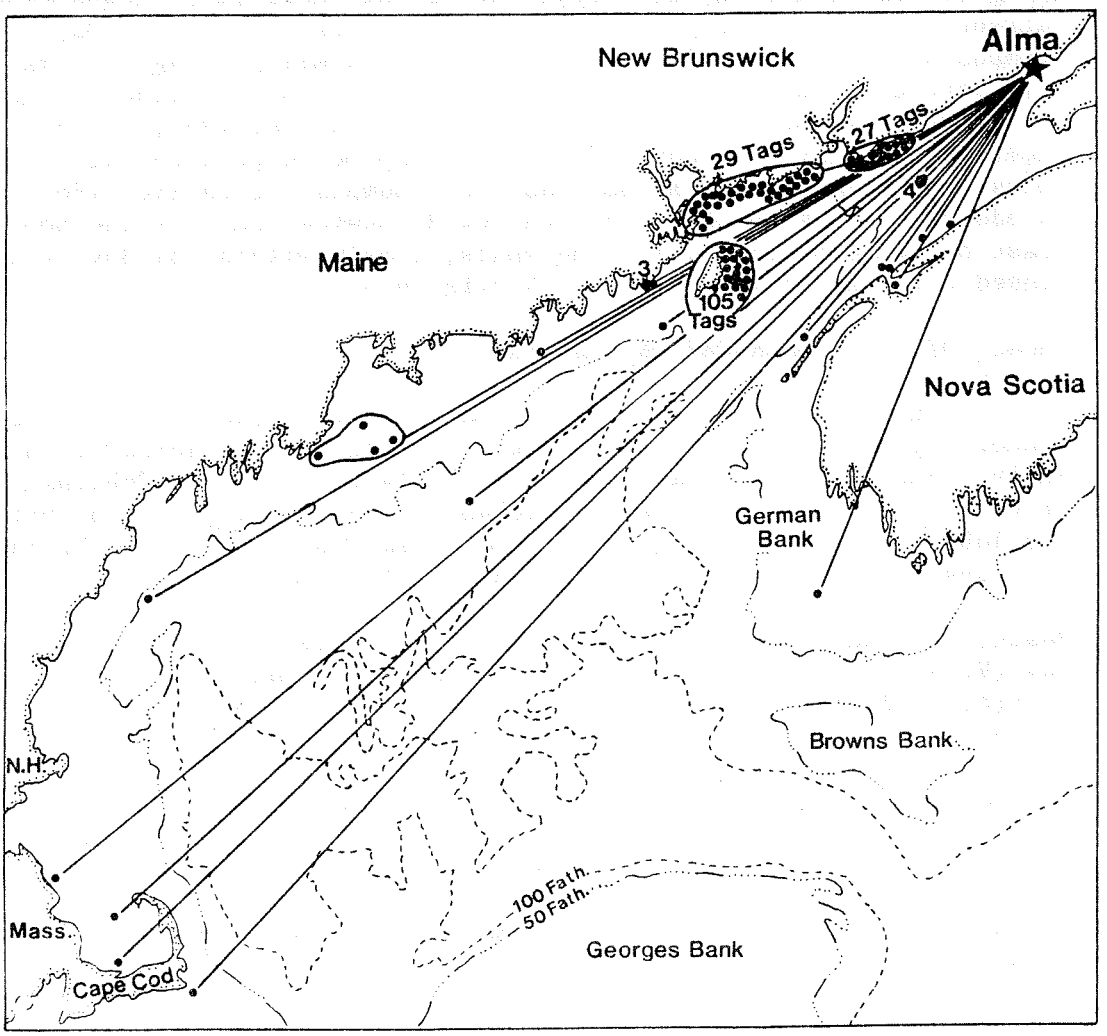

Fig. 8. Map of release and recapture points with straight-line distances travelled for all tagged lobsters recaptured >50 km from the Alma study area, 1979-81.

Additional evidence of tagged lobsters moving up the Bay of Fundy is shown from a similar tagging study conducted at Chance Harbour and St. Martins during 1979-80 (Fig. 9) (A. Campbell, unpubl. data).

Mature lobsters in the Bay of Fundy probably move from deep waters (<60 m) to shallow water during summer months to take advantage of the warm shallow water (up to 15 C) for molting and reproduction. Indeed the Alma area seems to be an important area amongst other shallow waters in the Bay of Fundy (A. Campbell, unpubl data) for large, mature females to come to during the summer months to hatch well developed eggs, molt (Wilder 1953), mate, and extrude new eggs. Thus Chignecto Bay may be an important area, among others in the Bay of Fundy, for larval recruitment downstream. Water currents on the New Brunswick side tend to flush out of the Bay of Fundy (Bumpus and Lauzier 1965). Where the free-swimming pelagic larvae eventually settle as benthic juveniles is a matter of speculation at present as few larvae have been found in plankton tows (Wilder 1960, Stasko, pers. comm.) in the Bay of Fundy. The larvae may be swept with the surface currents along the Gulf of Maine coastline (Bumpus and Lauzier 1965) or caught in eddies in bays on the Maine and New Brunswick coast or the southern coast of Grand Manan or, in some years, remain within the Bay of Fundy in a closed circulating water system (Dickie 1955).

IMPACT OF TIDAL BARRAGES ON LOBSTERS

From results of this paper the following deductions can be made concerning tidal barrages and lobsters in the upper reaches of the Bay of Fundy. The proposed tidal barrages, if placed in either Cobequid Bay (B9) or Cumberland Basin (A8), would probably have an insignificant effect on the lobster fishery in the local area. Few lobsters are caught in these two bays; only three lobster fishermen (only recently licenced) are stationed at Wood Point above the proposed barrage location in Cumberland Basin, and there are no lobster fishermen stationed in towns in Cobequid Bay (V. Nuttall, pers. comm.). There were no fishermen in Statistical Districts 42 and 81 during 1980 (Table 1, Fig. 1). The majority of lobsters caught in Statistical District 43 are from the Minas Basin to Advocate Harbour with the four licenced fishermen from Five Islands fishing well outside Cobequid Bay. Details of lobster landings by towns with these lobster districts are not available. The probable reason for the low number of lobsters is the low salinity and the extreme siltation and muddy subtrate in Cobequid Bay and Cumberland Basin (Daborn 1977) which the lobsters may avoid (Cobb 1968, Cooper and Uzmann 1980, Pottle and Elner 1982). Ice scouring during winter in these areas (Gordon and Desplanque 1983) may also be a factor causing severe lobster mortality reducing lobster densities. Whether the tidal barrage would affect water temperatures, siltation, and salinity sufficiently below the barrage in the open Bay of Fundy to affect lobsters is at present unknown.

Although the upper reaches of the Bay of Fundy are lower lobster productivity areas compared to the rest of the Bay of Fundy, the Chignecto Bay area, as are other areas in the Bay of Fundy, may be important biologically as a source of larval recruitment for other areas downstream.

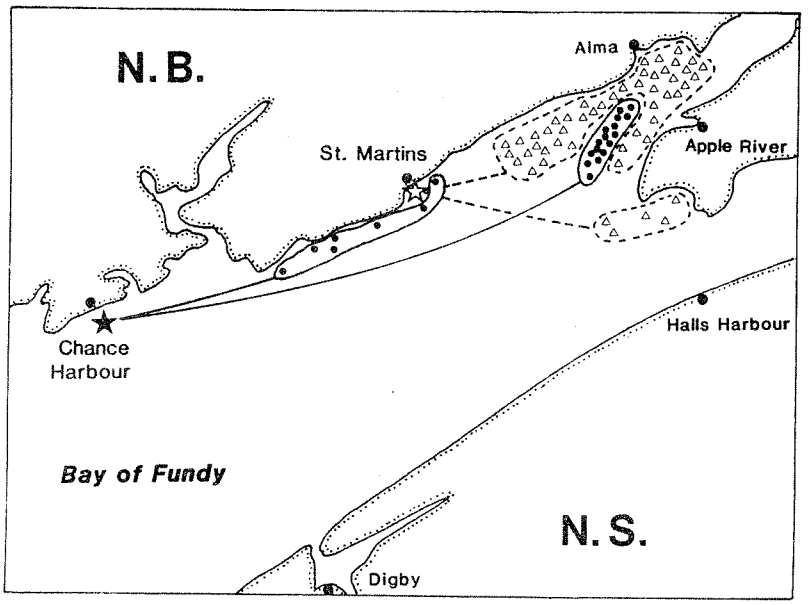

Fig. 9. Map of release and recapture points with straight-line distances travelled for tagged lobsters moving up the Bay of Fundy from Chance Harbour and St. Martins, 1979-81 (after A. Campbell, unpubl. data).

A tidal barrage would probably not have a major effect on the local lobster fisheries in the upper reaches of the Bay of Fundy. One can only speculate on the effect of a tidal barrage on lobsters further downstream on a large scale. Analysis of lobster landing trends and lobster movements indicate that there is probably one lobster stock in the Bay of Fundy including the Gulf of Maine (Campbell and Mohn 1982). If water temperatures and velocities or tidal amplitudes do change as a result of a tidal barrage, as suggested by Greenberg (1984), then lobster populations could be affected. Changes in current velocity or patterns may change larval recruitment patterns which are at present poorly known. Water temperature change would affect lobster development at all stages (Aiken 1980), catchability (McLeese and Wilder 1958), and landings (Dow 1978, Flowers and Saila 1972). The degree to which the tidal barrage induced perturbations would have over seasonal and long term temperature trends affecting lobsters is unknown.

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QUESTIONS AND COMMENTS

K. Mann: Looking at the slide with respects to temperature and onshore-offshore movements I wonder how the Halifax lobster fishermen catch anything at all if the lobsters move to deeper water during their winter lobster season or does this not apply to other areas?

A. Campbell: Lobster movements along the eastern shore of Nova Scotia are poorly studied. Work by Wilder in this region during the 1960's showed no large scale movements. However it depends on where you are. To reach deep water in the Alma area of the Bay of Fundy a lobster would have to move a large distance but along the east coast of Nova Scotia only a few km of movement would allow the lobster to change the environment.

K. Mann: What about downstream effects of the tidal barrages. Since there is good evidence the Canso Causeway caused recruitment failure do you think a tidal dam at the head of the Bay of Fundy could cause a similar effect.

A. Campbell: I do not think the situation is analogous. The eastern Nova Scotia system is quite different. In terms of Cumberland Basin not that many lobsters seem to go in there or into Cobequid Bay. The majority of

the large lobsters only need to go into shallow water in the Alma area to obtain warm temperatures for development of their eggs or to moult. There do not seem to be any similar problems with the tidal barrages unless they change the environment or the ecology in areas outside of them.