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REVIEW OF THE GRAND MANAN LOBSTER FISHERY WITH AN ANALYSIS OF RECENT CATCH AND EFFORT TRENDS

by

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ABSTRACT

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Historical (1877-1980) annual landings, values, effort and regulations are presented for the Grand Manan lobster fishery. Lobster landings have been relatively stable at 322 000 kg although the value of lobsters has increased from < $1.0 to ≥ $6.0/kg from 1948 to 1979. Over 80% (by weight) of all commercial lobsters trapped each fishing season are caught in the shallow (<40 fath, 73 m) waters off southern Grand Manan. Fishermen from North Head, however, have increased their catch from 9% of the total Grand Manan landings during the 1974-75 season, to 13% in the 1979-80 season by directing their efforts in searching for large, mature lobsters in deep (41-110 fath, 75-201 m) waters east and south of Grand Manan. The percentage of 'jumbo' lobsters (≥127 mm carapace length) of total landed catch at North Head has increased from 27% in 1975-76 to 52% in 1979-80.

Initial population biomass estimates of commercial-sized lobsters by using Leslie regression analysis of catch-per-unit-effort data for 7 yr ranged from 346 432 to 569 320 kg for the 1978-79 and 1952-53 fishing seasons, respectively, off southern Grand Manan. Exploitation rates have generally increased from 56.4% during 1948-49 to 84.9% during 1979-80 in southern Grand Manan.

Keywords: Lobster, *Homarus americanus*, catch-per-unit-effort, exploitation rates, population size estimates

RÉSUMÉ

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Des données sur les débarquements, la valeur, l'effort et la réglementation de la pêche du homard dans la région de Grand-Manan sont présentées pour les années 1877 à 1980. Les débarquements de homard ont été relativement stables, totalisant 322 000 kg, bien que la valeur de homard soit passée de moins de $1 à plus de $6 le kilogramme de 1948 à 1979. Plus de 80 pour cent (du poids) de tous les homards capturés au casier au cours de chaque saison de pêche commerciale proviennent des eaux peu profondes (moins de 40 brasses, 73 m) au sud de l'île Grand-Manan. Les prises des pêcheurs de North Head, qui représentaient 9 pour cent du total des débarquements de Grand-Manan, pour la saison de pêche 1974-1975, ont cependant augmenté, représentant 13 pour cent des débarquements de la saison de 1979-1980. Cette hausse est attribuable à un déplacement de l'effort de pêche; les pêcheurs ont, en effet, cherché des homards plus gros dans les eaux profondes (41 à 110 brasses, 75 à 201 m) à l'est et au sud de l'île Grand-Manan. Du total des prises débarquées, la proportion de homards très gros (carapace d'au moins 127 mm de longueur) est passée de 27 pour cent en 1975-1976 à 52 pour cent en 1979-1980.

D'après les évaluations initiales établies au moyen de l'analyse de régression des prises par unité d'effort de Leslie, pour une période de sept ans, la biomasse de la population de homards de taille commercialement exploitable varie entre 346 432 et 569 320 kg pour les saisons de pêche respectives de 1978-1979 et 1952-1953, dans les eaux situées au sud de l'île Grand-Manan. Les taux d'exploitation au sud de l'île Grand-Manan ont généralement augmenté, passant de 56,4 pour cent en 1948-1949 à 84,9 pour cent en 1979-1980.

INTRODUCTION

As early as 1877, fishermen caught lobsters near Grand Manan, New Brunswick (Fig. 1, 2). Few publications concerning the catch and effort trends of the Grand Manan lobster fishery are available (Wilder 1960; Wilder et al. 1974; Campbell 1979). During 1979 the value of the lobsters landed on Grand Manan was over $1.7 million (Fig. 3). Historically, the majority of fishermen have trapped lobsters in shallow (≤40 fa, 73 m) waters of southern Grand Manan (Fig. 1B). The southern area may be a nursery ground for juvenile lobsters (<95 mm carapace length, CL) (Campbell, unpublished data) because of the productive shoals and possible eddy, caused by water flowing out of the Bay of Fundy past Grand Manan (Bumpus and Lauzier 1965), helping to concentrate lobster larvae. Since 1974, a few fishermen from North Head have fished in water deeper than 40 fath (73 m), trapping lobsters that are mostly mature and larger (≥95 mm CL) (Aiken and Waddy 1980) than those caught in waters south of Grand Manan. Fishermen and biologists have expressed concern that increasing effort in fishing for these large, mature lobsters would reduce the reproductive potential of the population. Consequently, a number of studies during 1977-80 to determine the biological characteristics of lobsters and future prospects of the lobster fishery in the Grand Manan area have resulted (Groom 1978; Stasko et al. 1980).

Accurate and consistent catch and effort data are invaluable in understanding the dynamics of a fishery. Although the majority of lobster landings are reported on sales slips (when fishermen sell lobsters to wholesale buyers), few data on effort have been recorded. Attempts to introduce voluntary log sheets to Grand Manan fishermen during 1978 were unsuccessful as few fishermen kept consistent data. There are, however, records of effort (numbers of traps hauled) and catch (weight) of lobsters caught for seven fishing seasons during 1948-53 and 1978-80. This paper puts recent catch and effort trends into perspective with a description of historical lobster landings, price changes, fishing methods and regulation changes, and makes preliminary estimates of population sizes and exploitation rates of legal-sized lobsters.

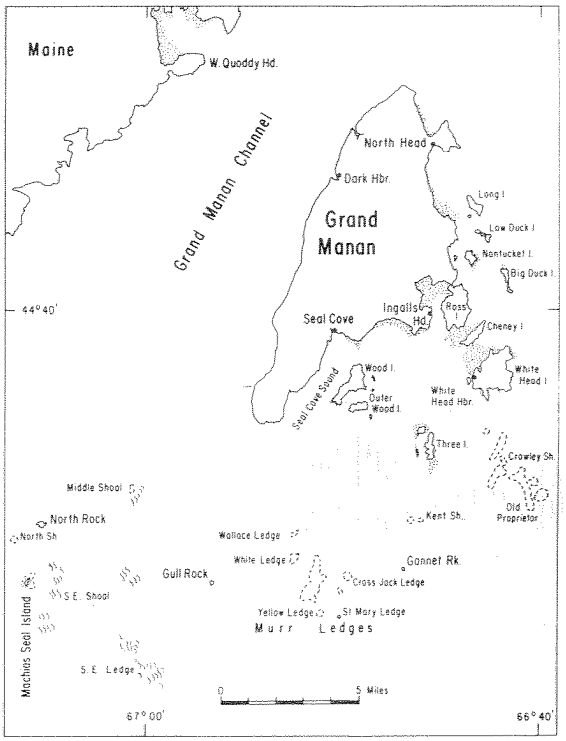

Fig. 1A. Map of Grand Manan showing ports, shoals and smaller islands.

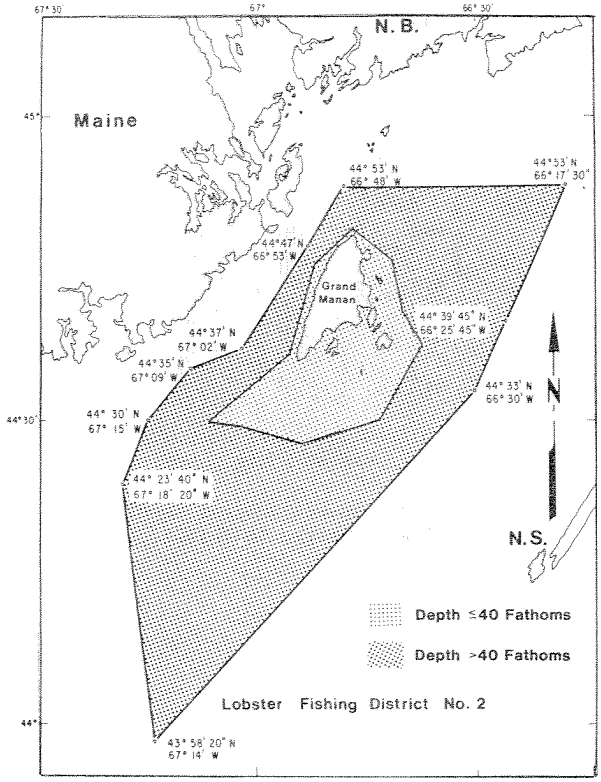

Fig. 1B. Map of Grand Manan with Lobster District 2 boundary. Light-shaded area consists of 274 naut mi^2 of water ≤ 40 fath (73 m) deep in which most of the lobsters, especially in southern Grand Manan, are caught. The dark-shaded area consists of 659 naut mi^2 of water 41-110 fath (75-201 m) deep of which east and south of North Head are fished for the large, mature lobsters.

DESCRIPTION OF THE FISHERY

Lobster fishing in the Grand Manan area has been regulated in a number of ways. Although in recent years the number of licenses and maximum traps per fisherman have been limited to about 120 and 375, respectively, egg-bearing females have been protected and size limits and fishing season restrictions have been imposed since 1873 (Table 1). The fishing season has basically remained fall-spring since the turn of the century with few modifications. These fishing seasons were intended, in part, to protect lobsters while molting, mating and extruding eggs, to reduce exploitation rates, and to adjust for seasonal marketing problems.

Fig. 2. Annual lobster landings, number of licenses and traps in the Grand Manan lobster fishery, 1877-1979.

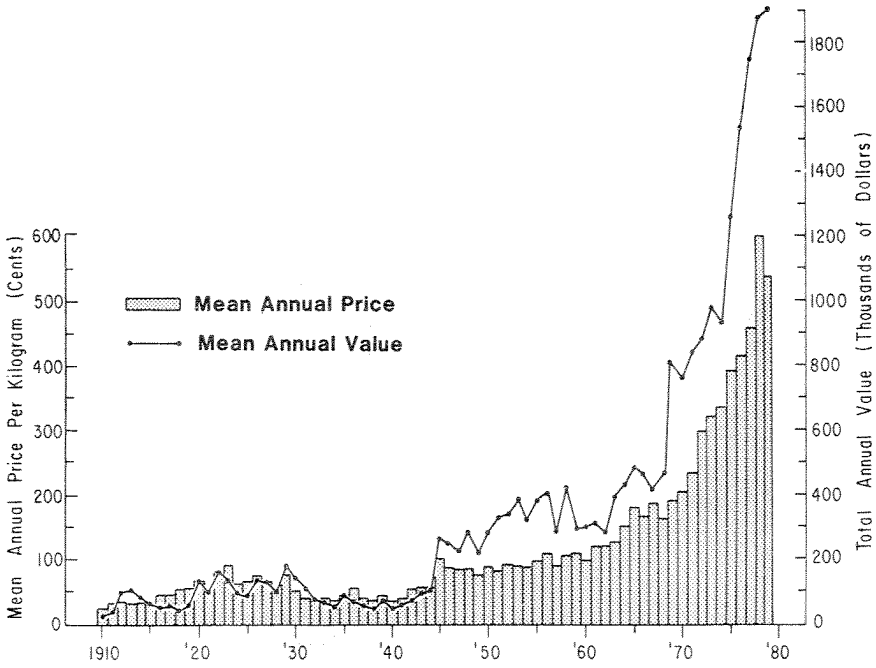

Fig. 3. Total annual value and mean price/kg of lobsters landed at Grand Manan, 1910-1979.

The minimum size limit was 4 3/4 in. (120.6 mm) CL during 1910-33 and was changed slightly to about 3 1/4 in. (82.5 mm) CL in 1934. From 1951 to the present, the legal minimum size has been 3 3/16 in. (81 mm) CL. A maximum size limit of 4 3/4-5 in. (120.6-127.0 mm) CL was imposed only during 1934-41 to protect large reproducing lobsters.

During 1946-47, a lath space experiment concluded that larger lath spaces would benefit the fishermen by reducing the number of sublegal-sized lobsters retained by the lobster traps and consequently damage to lobsters by handling (Wilder, unpublished data). Subsequently, a lath space (of 1 5/8 in., 4.1 cm) regulation was enforced during spring 1952. The fishermen strongly opposed this regulation, claiming that smaller legal lobsters were able to escape. By fall, 1952, the lath space regulation was no longer enforced and lobster fisheries research personnel were strongly discouraged by the fishermen from monitoring the Grand Manan lobster fishery. Indeed, only during the last few years have fisheries research personnel returned to Grand Manan to monitor the lobster fishery.

The fishing vessels now used are generally Cape Island type boats of 10-14 m length. The average boat size has gradually increased over the years and with the introduction of hydraulic trap haulers, depth sounders and radar, many fishermen are able to travel further and fish more efficiently than fishermen prior to a decade ago. Almost all commercial lobster traps are wooden, either half-cylindrical or box-like in shape with the base wider than the top, with 3 or 4 bows, 80-122 cm long, with a variety of entrance rings (hoop size) 12-23 cm in diameter (some trap entrances are made only of knitted twine instead of wood or plastic entrance rings) (Table 2). Increasingly, more fishermen are starting to use traps made with plastic-coated wire rather than with wooden parts. The bait used depends on whatever is locally available at low cost, but normally consists of salted, fresh or frozen herring, fish heads, or frozen mackerel. In shallow waters traps are generally set singly with a buoy for each trap. In deeper waters traps are usually set in a string of 10-15 traps.

METHODOLOGY

DATA COLLECTION

Nearly all commercial lobster landings by weight (in lb), dollar value and port recorded on sales slips were collected by Fishery Officers and sent to Statistics Canada, Halifax. We estimated that less than 1% of lobsters trapped in the Grand Manan lobster fishery are sold privately and thus not recorded on sales slips. Landings from Seal Cove, Ingalls Head, White Head and Dark Harbour were combined and called 'south' Grand Manan landings and kept separate from North Head landings because catch curve data indicated that trapped lobsters were of a similar size for the 'southern' group (or shallow water fishery) but much larger for the North Head landings (or deep water fishery) (Groom 1978; Wilder 1960). All landings were converted to kg.

Commercial lobster fishermen were usually interviewed as they were unloading the day's catch at the dock. Interviews were conducted by fisheries personnel and/or seasonal aids during seven fishing seasons 1948-53 and 1978-80. Information recorded during each interview included the number of traps hauled that day, date, location and depth of traps fished, and weight in pounds of lobsters landed; soak-over-days (number of days between traps being set with bait and hauled) were recorded for 1978-80 only. Catch-per-unit-effort (CPUE) was calculated by dividing the number of kilograms landed by the number of trap hauls. Additional estimates of effort defined as the number of days fished were obtained from the number of times lobsters were sold and recorded on the sales slips; the majority of fishermen sell their catch on the same day fished. We reanalyzed all available sales slips from the last six fishing seasons (1974-80) to obtain detailed information on when the total pounds of lobsters were landed by each fisherman. One fisherman was considered as equal to one fishing boat, including crew for the purpose of this paper.

The average lobster weight was determined by dividing known weight of a commercial crate containing approximately 100 lb (45.5 kg) of lobsters by the number of lobsters in the crate. The total number of lobsters landed for approximately a 2-wk period was estimated by dividing the total weight of lobsters trapped by the average weight of a lobster for the similar period and appropriate port.

The total number of trap hauls per week during the 1978-79, 1979-80 seasons was estimated by dividing the total weight landed by the CPUE (kg/trap haul) determined from interviews with fishermen.

POPULATION ESTIMATES

Preliminary estimates of population size, in terms of biomass (kg), of legal-sized lobsters at the start of each of seven fishing seasons (1948-53 and 1978-80) were calculated from the combined 'southern' Grand Manan CPUE and cumulative weight landed data on biweekly periods of fishing (Table 3); weekly periods in Tables 4 and 5 were converted to 2-wk periods. During fall 1950, poor weather conditions resulted in heavy gear loss and low fishing effort, thus only data from spring 1951 were used for that season in the analysis. In the last 2 wk of each fishing season few fishermen fished, causing potentially deviant CPUE data; data were excluded from analysis if less than 1000 trap hauls were recorded. The following equations were used, based on Leslie's least squares method (Leslie and Davis 1939; Paloheimo 1963; Ricker 1975):

$$(C/f)_t = qN_o - qK_t \qquad (1)$$

or equivalent to the straight line regression of the general form:

$$Y = a + bX \qquad (2)$$

where, C_t = total catch (kg) of legal-sized lobsters landed during the tth period,

f_t = fishing effort (number of trap hauls) during the tth period,

q = catchability, represents slope (b) of the straight line regression, $Y = (C/f)_t$,

K_t = cumulative catch (or X) during the tth period,

N_o = estimated population of legal-sized lobsters at start of the fishing season which is = a/b, where a = y-axis intercept which is the product of N_o and q.

Equation (1) assumes constant catchability. A lobster fishery that has a fall, winter and spring open fishing season presents problems with this assumption because of changes in temperature (Fig. 4) and consequently lobster catchability (McLeese and Wilder 1958; Paloheimo 1963). We used only CPUE data from the beginning and end of the fishing season when lobsters are exposed to the same temperature range of 5.0-9.5°C and to approximately equal trap densities. Confidence limits for N_o were calculated by using the lengthy formula quoted by Ricker (1975, p. 150).

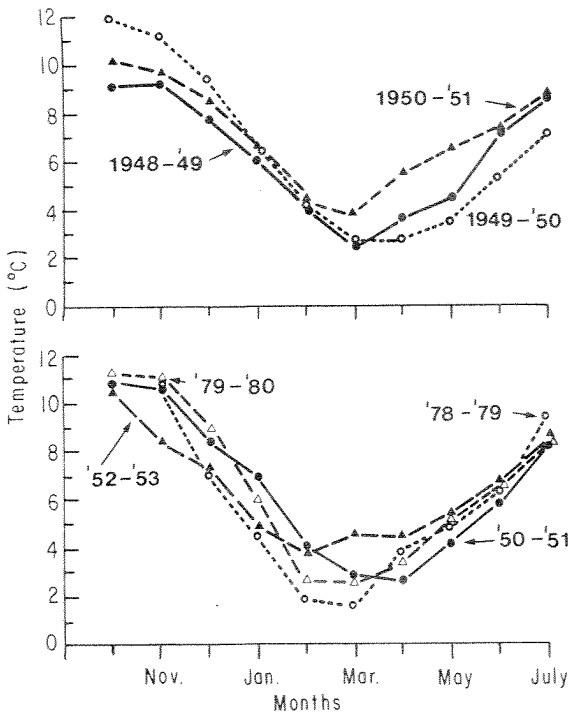

Fig. 4. Bottom water temperatures (50 fath) (Prince Station 5) during the October-July period for years 1948-53 and 1978-79. Lines are eye fitted.

Exploitation rates, μ, were calculated, using the formula:

$$\mu = \frac{K_k}{N_o} \qquad (3)$$

where, K_k = accumulated catch (kg) of legal-sized lobsters landed for the whole fishing period where k = number of t periods.

We were unable to use the Leslie regression analysis to estimate initial population biomass on the North Head CPUE data (Tables 6, 7) because fishermen changed the areas fished and lobsters moved into these areas from other areas, resulting in an increased rather than decreased kg/trap haul as the season progressed.

HISTORICAL LOBSTER LANDINGS

ANNUAL TRENDS

Catch statistics for the Grand Manan lobster fishery dating back to 1877 show annual landings (total landings per calendar year) ranging from a high of 813 metric tons (MT) in 1885 to a low of 76 MT in 1918 (Fig. 2). Prior to 1900, annual landings were equal to or higher than those of the 1950-79 period. Landings have fluctuated with peaks occurring every 9-16 yr. The causes of these fluctuations may be numerous: possible factors are water temperature fluctuations (Dow 1977), changes in effort and markets, recruitment pulses, and/or minimum and maximum size regulations.

SEASONAL TRENDS

Statistics on the monthly lobster landings for the last 29 fishing seasons indicate that about 60% of the total landings normally occur during November and December (Fig. 5). There are few lobsters landed during February-April when winter weather prevails and water temperatures are usually lower than 4°C (Fig. 4). Landings increase again during the May and June period.

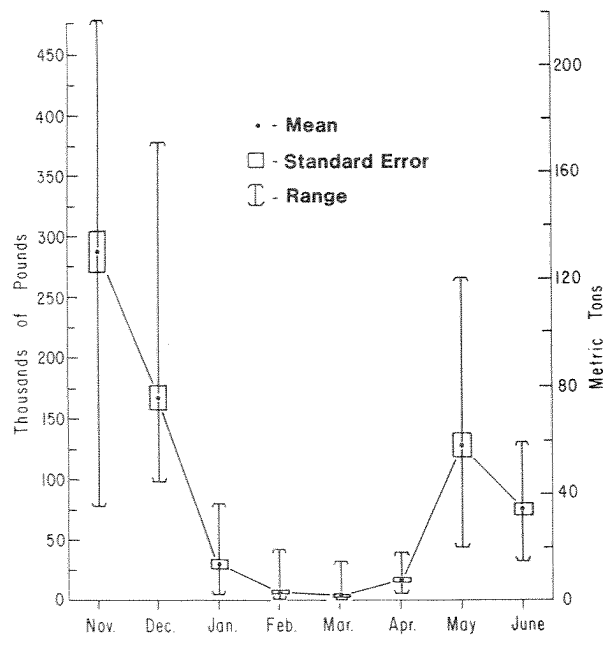

Fig. 5. Mean monthly lobster landings at Grand Manan for 29 yr, 1948-79.

Total landings for each fishing season after World War II have been relatively stable at a mean 322 (range 220-423) MT for the 1948-80 period (Fig. 6). The value of lobsters in the last decade has increased dramatically (Fig. 3), giving the fishermen increased incomes (not adjusted for inflation) although the landed weight of lobsters has remained relatively constant in the same period. Since the deep-water fishery, based mainly in North Head, tends to land 'jumbo' lobsters (≥127 mm CL), the prices of the 'jumbo' (which is slightly lower than that of the markets) and the 'market' lobsters are

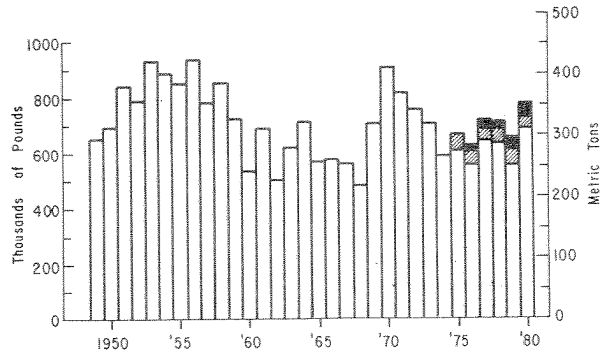

Fig. 6. Seasonal (November-June) lobster landings for Grand Manan, 1949-80. The column 1950 = 1949-50 season landings. The total North Head landings are separated from other ports of the last 5 yr only and are indicated by the hatched part of the histogram; the darker area shows the large lobster (≥127 mm CL) part of the landings.

recorded separately on the sales slips, making possible the separation of the total 'jumbo' and 'market' landings (Fig. 6).

CATCH AND EFFORT TRENDS

SEASONAL DIFFERENCES

During 1978-80, there were almost twice as many fishermen fishing during the fall than during the spring with few, if any, fishing during February-March, resulting in a maximum total number of fishing days and traps hauled per week in the first 2 wk of each of the two fishing seasons (Fig. 5, Tables 4-7). However, there was a greater total effort by fewer fishermen in the spring season (e.g. 1614 fishing days in the first 10 wk versus 1708 d in weeks 18-30, Table 4). The average number of days fished per fisherman was higher and the catch per fishermen was lower during the spring than during the fall for most fishermen (in 'southern' ports) (Fig. 7, 8).

In contrast, although more fishermen from North Head fished and caught more lobsters in the fall, the mean weight landed per fisherman was generally higher during the spring months than during November-December (Fig. 7, 8). Most fishermen from North Head trap in the shallow waters during the early part of the season and only about a third of the fishermen move to deeper waters to catch fewer but heavier, larger, and mature lobsters in the spring (Fig. 8, 9; Tables 8, 9).

The CPUE generally declined on a biweekly basis during 1948-53 (Table 3) and on a weekly basis during fall and spring 1978-80 for all Grand Manan ports excluding North Head (Tables 4, 5). The CPUE for North Head, however, generally increased over the fishing season (Tables 6, 7) which could be due to fishermen attempting to maximize their CPUE by moving to deeper areas for larger lobsters, and to lobsters probably moving into the deeper waters from other areas such as the inner Bay of Fundy.

ANNUAL DIFFERENCES

Detailed analysis of the sales slips for five fishing seasons (1974-80) gave an accurate indication of the number of active lobster fishermen, total and average days fished and kilograms lobsters landed for each of the five Grand Manan ports (Tables 10-18). The majority (90%) of the fishing effort, in terms of days fished, occurred from three southern ports, Ingalls Head, Seal Cove and White Head (Table 17) with an average of 2516 kg lobsters landed per fisherman per fishing season (Table 14). Landings and fishing effort have been relatively stable. Dark Harbour in northern Grand Manan has only 3-4 fishermen and contributes less than 1% to the total lobster landings of Grand Manan.

Although the number of active fishermen at North Head has remained stable at 11-15 (Table 10) and the number of fishing days increased slightly (Tables 12, 13, 17), the lobster landings have almost doubled from 26 773 kg in the 1974-75 season to 45 568 kg in the 1979-80 season (Tables 11, 14, 16). During the 1978-79 fishing season, North Head fishermen landed 15.25% by weight, but only 4.72% by number, of the total lobster landings in Grand Manan (Table 8). Obviously, some of the lobster fishermen at North Head have become more efficient at finding large lobsters in deeper waters, thereby increasing the percentage of large 'jumbo' lobsters to the total landed catch from 27-44% over the last 5 yr (Table 18).

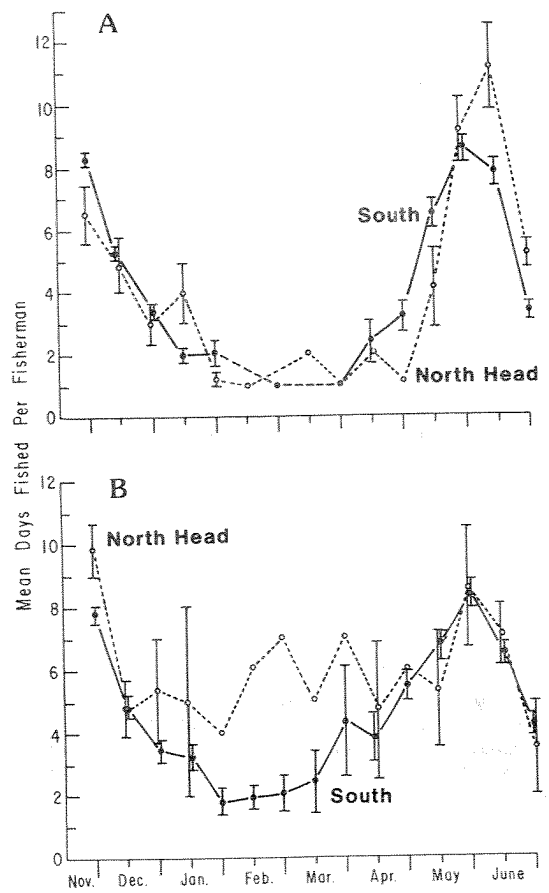

Fig. 7. Mean number of days fished/fisherman/week by lobster fishermen at North Head and the rest of the Grand Manan ports ('south') during (A) 1978-79, and (B) 1979-80, fishing seasons. Dots and crosses are means and vertical line ±1 SE.

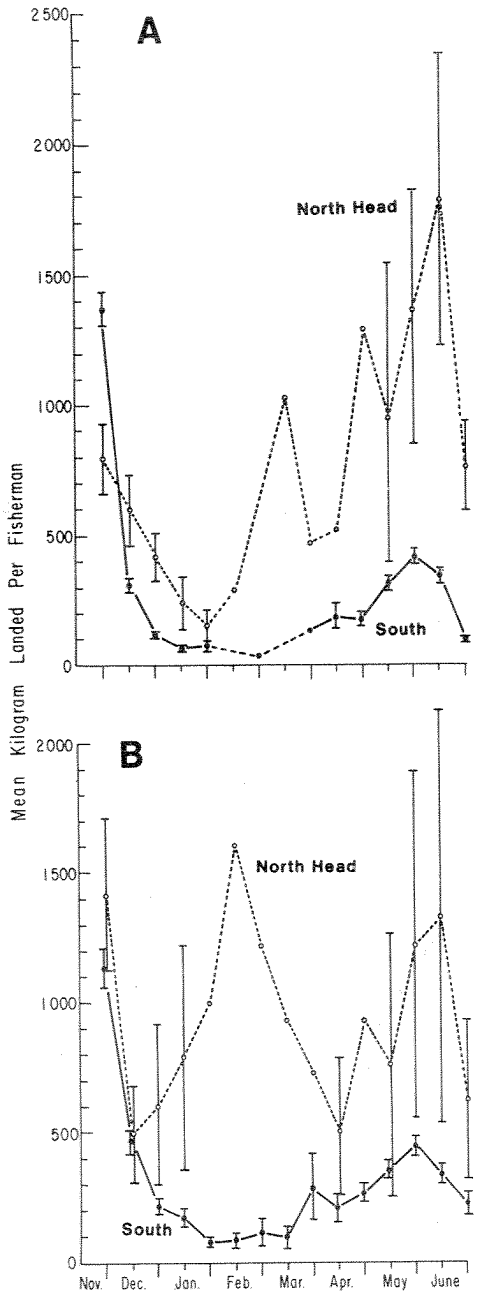

Fig. 8. Mean kilograms landed/fisherman/week by lobster fishermen at North Head and the rest of the Grand Manan ports ('south') during (A) 1978-79, and (B) 1979-80, fishing seasons. Dots and crosses are means, vertical lines are ±1 SE.

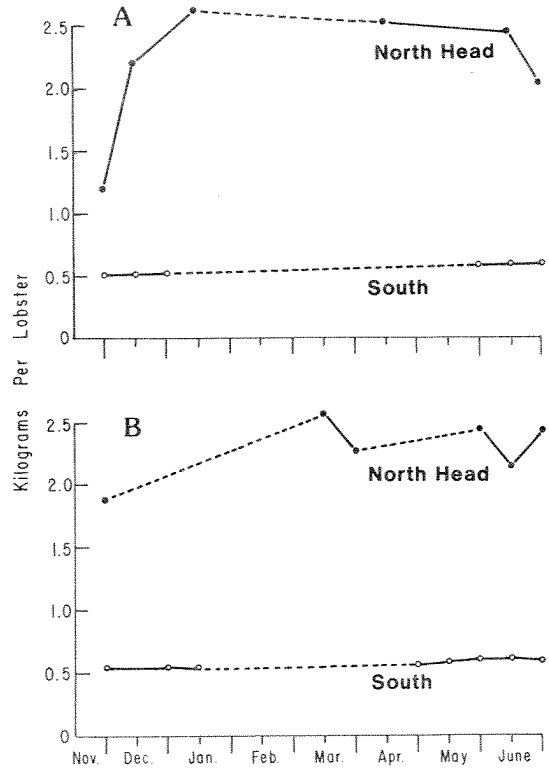

Fig. 9. Mean kilograms/lobster on a biweekly basis for North Head and all other ports ('south') in Grand Manan during the (A) 1978-79 and (B) 1979-80, fishing seasons. Dashed lines are extrapolated.

POPULATION ESTIMATES

Table 19 shows the results of the Leslie analysis on the biweekly catch/effort data (Tables 1-3). The initial population biomass estimates at the beginning of the season in southern Grand Manan ranged from 460 074-569 320 kg during 1948-53 which were higher than 363 947 kg calculated for the 1979-80 season. Rates of exploitation increased from 56.4-78% from 1948-52 but declined to 74.3% in the 1952-53 season, and ranged from 72.8-84.9% in the 1978-80 period (Table 19).

The Leslie population estimates rely on three assumptions:

1) the whole population in an area is available for capture,

2) there should not be an excess of emigration and natural mortality over recruitment and immigration and vice versa,

3) the catchability of the population is constant.

The lobster population estimates for southern Grand Manan were for only the commercial legal-sized individuals which were mostly (>80%) juveniles in the 81-95 mm CL (Campbell, unpublished data); thus the first assumption was met. The second assumption was probably also met as most legal-sized lobsters caught in southern Grand Manan in this area molt from July-October (i.e. during the closed season) of each year (Wilder 1953) and probably most lobsters do not move out of or into the area during the fishing season in southern Grand Manan (Stasko et al. 1980). The third assumption was generally met by considering only the CPUE data when lobsters were exposed to a similar temperature range 5.0-9.5°C.

During November 1978, most fishermen in the Seal Cove area hauled their traps once a day (Fig. 10) to keep abreast of the large number of lobsters per trap haul. Most traps were hauled within 4 d of setting during the rest of the fishing season and rarely were traps left for more than a week before being hauled. Trap retention of lobsters seemed to increase for at least the first 4 d during May and June; we have insufficient data to determine trap retention for ≥5 soak-over-days. The CPUE data were not adjusted for lower trap retention of lobsters during longer soak periods because there were insufficient soak-days' data for the 7 yr we analyzed by using the Leslie regression method. We assumed that the majority of the traps were hauled within a range of 1-5 soak-over-days when trap retention was generally constant.

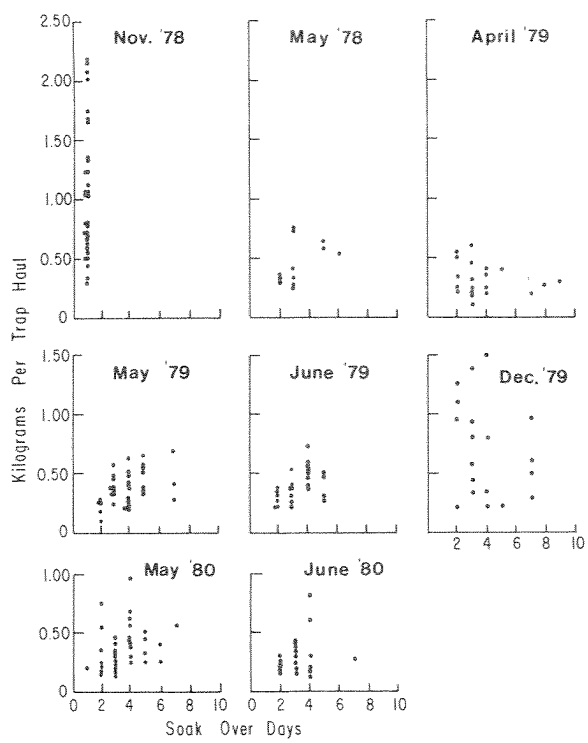

Fig. 10. Relationship between CPUE and trap soak time (number of days between the time trap is baited and hauled for lobsters) in Seal Cove area during several months, 1978-80.

Although fishermen have annually removed 70-85% of the commercial-sized lobsters from southern Grand Manan since the 1950's, this lobster fishery has remained relatively stable and productive. However, the fact that less than 0.2% of the lobsters (N=41 000) measured at sea from the shallow waters of southern Grand Manan during the 1945-80 fishing seasons were egg-bearing suggests that the majority of recruitment into the fishery comes from elsewhere (Campbell, unpublished data). Larval recruitment patterns in this area are a matter of conjecture (Stasko and Campbell 1980). As much as 20% of 919 female lobsters sampled off North Head in ≥41 fath (73 m) during the 1979-80 fishing season were egg-bearing. Possibly such mature lobsters in deep-water areas adjacent to Grand Manan contribute the majority of recruitment to the shallow areas off southern Grand Manan. This reservoir of mature lobsters has only recently (5-7 yr) been exploited. To what extent this reservoir can continue to be exploited without adversely affecting recruitment into the southern Grand Manan lobster fishery is unknown.

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Table 1. Lobster size limit and fishing season regulations governing the Grand Manan lobster fishery, 1873-1980; CL = carapace length.

Year	Size limit	Season
1873	1½ lb (0.68 kg)	No season restriction
1874	9 in. total length (approx. 79 mm CL)	July & August closed season
1910	4¾ in. (120.6 mm) CL	Jan. 6-June 29
1914		Nov. 15-June 15
1918		Nov. 15-June 8
1932		Nov. 15-Jan. 15 and Apr. 25-June 24
1934	3½ in. minimum : 4¾ in. (120.6 mm) maximum CL	Nov. 15-May 31, 1935, changed later in year to Nov. 15 to last day of Feb.
1938	3¼ in. (82.5 mm) minimum : 5 in. (127 mm) maximum CL	Nov. 15-Dec. 31 and Apr. 15-May 31
1941	3 1/8 in. minimum : 4¾ in. (120.6 mm) maximum CL	
1942	3 1/8 in. minimum : no max. CL	Nov. 15-Jan. 15 and Apr. 14-June 24
Spring 1948	3¼ in. minimum : no max. CL	
Fall 1948	3 1/8 in. minimum : no max. CL	
1951	3 3/16 in. (81 mm) minimum : no maximum CL	
1956		Nov. 15-June 24
1978		2nd Wednesday Nov.-3rd Thursday June
1979		2nd Wednesday Nov.-June 23

In 1969 the license policy was changed whereby only the owner of the lobster boat could purchase a lobster fishing license, eliminating the 'helper' lobster licenses.

Table 2. Dimensions of 20 lobster traps examined at three ports in Grand Manan, March 30, 1979 (SD = standard deviation).

Port		Length cm	Length (in.)	Width cm	Width (in.)	Height cm	Height (in.)	Hoop size cm	Hoop size (in.)	Lath space cm	Lath space (in.)
Seal Cove											
	Mean	89.79	(35.35)	65.61	(25.83)	38.54	(15.18)	14.78[a]	(5.82)[a]	3.19[b]	(1.26)[b]
	SD	3.22	(1.27)	4.86	(1.91)	2.38	(0.94)	1.17	(0.46)	0.27	(0.11)
	Min.	81.28	(32.0)	45.72	(18.0)	30.48	(12.0)	13.97	(5.5)	2.86	(1.125)
	Max.	93.98	(37.0)	71.12	(28.0)	40.64	(16.0)	16.51	(6.5)	3.81	(1.50)
North Head											
	Mean	99.50	(39.18)	67.44	(26.55)	42.29	(16.65)	17.40[c]	(6.85)	3.14[d]	(1.24)
	SD	12.44	(4.90)	3.64	(1.43)	4.16	(1.64)	2.61	(1.03)	0.21	(0.08)
	Min.	88.90	(35.0)	66.04	(26.0)	38.10	(15.0)	13.97	(5.5)	2.86	(1.125)
	Max.	121.92	(48.0)	81.28	(32.0)	50.80	(20.0)	22.86	(9.0)	3.81	(1.50)
Ingalls Head											
	Mean	87.50	(34.45)	64.90	(25.55)	39.73	(15.64)	15.67[e]	(6.17)	3.02	(1.19)
	SD	17.45	(6.87)	1.75	(0.69)	2.87	(1.13)	1.80	(0.71)	0.20	(0.08)
	Min.	86.36	(34.0)	60.96	(24.0)	36.83	(14.5)	12.70	(5.0)	2.86	(1.125)
	Max.	106.68	(42.0)	66.04	(26.0)	50.80	(20.0)	17.78	(7.0)	3.49	(1.375)

[a]Of the 20 traps sampled, 55% had hoops, the other 45% had entrances made only of knitted twine and are expandable to approximately 23-26 cm (9-10 in.).
[b]95% of traps sampled had wooden laths, the other 5% had 2.5-cm (1-in.) square plastic-coated wire.
[c]50% of traps sampled had hoops, the other 50% had entrances made only of knitted twine.
[d]95% of traps sampled had wooden laths, the other 5% had 5.08-cm (2-in.) square plastic-coated wire.
[e]55% of traps sampled had hoops, the other 45% had entrances made only of knitted twine.

Table 3. Cumulative catch (kg) and catch/effort (kg/trap haul) by 2-wk periods of lobsters from southern Grand Manan, 1948-49 to 1952-53 seasons. I = first 2 wk, and II = last 2 wk of a month.

	1948-49		1949-50		1950-51		1951-52		1952-53	
Period	Cumulative catch	Catch/ effort	Cumulative catch	Catch/ effort	Cumulative catch	Catch/ effort	Cumulative catch	Catch/ effort	Cumulative catch	Catch/ effort
Nov. II	123 039	0.832	123 311	0.928	112 608[a]	0.998	165 079	1.084	166 893	0.921
Dec. I	156 413	0.713	163 239	0.898	174 212[a]	0.986	225 571	0.794	231 986	0.762
Dec. II	174 921	0.752	182 359	0.771	207 529[a]	1.275	243 174	0.885	262 675	0.706
Jan. I	187 880	0.775	208 255	0.682	229 615	1.031	258 548	0.740	282 210	0.628
May I	222 586	0.541	233 284	0.578	297 399	0.790	306 147	0.447	351 468	0.487
May II	264 218	0.489	280 364	0.624	349 842	0.639	338 911	0.376	395 645	0.388
June I	288 270	0.482	305 941	0.431	376 663	0.482	356 010	0.301	420 556	0.322
June II	294 830	0.420	313 607	0.349	380 046	0.554	359 002	0.439	422 811	0.402
Total/Mean	294 830	0.626	313 607	0.658	380 046	0.844	359 002	0.633	422 811	0.577

[a]Bad weather caused heavy gear loss during fall fishing season.

Table 4. Catch and effort data for the 'southern' Grand Manan lobster fishery during fishing season 1978-79, on weekly basis, based upon sales slips and interviews with fishermen.

Week no.	Period	No. of fishermen	Effort: No. of fishing days	Effort: Estimated trap hauls[b]	Catch (kg)	CPUE: kg/trap haul[a]	CPUE: kg/d fished
1	Nov. 15-22	95	445	103 980	100 965	0.971	226.9
2	" 23-30	93	348	64 291	30 924	0.481	88.9
3	Dec. 1-7	94	297	27 784	18 393	0.662	61.9
4	" 8-15	92	203	12 673	11 089	0.875	54.6
5	" 16-22	58	105	5 329	3 336	0.626	31.8
6	" 23-31	53	121	8 392	4 565	0.544	37.7
7	Jan. 1-7	28	41	-	1 204	-	29.4
8	" 8-15	15	21	-	807	-	38.4
9	" 16-22	10	13	-	282	-	21.7
10	" 23-31	9	20	-	968	-	48.4
11	Feb. 1-7	-	-	-	-	-	-
12	" 8-15	-	-	-	-	-	-
13	" 16-22	-	-	-	-	-	-
14	" 23-28	1	1	-	31	-	31.0
15	March 1-7	-	-	-	-	-	-
16	" 8-15	-	-	-	-	-	-
17	" 16-22	-	-	-	-	-	-
18	" 23-31	1	1	-	141	-	141.0
19	April 1-7	4	8	1 670	561	0.336	70.1
20	" 8-15	9	16	3 900	1 326	0.340	82.9
21	" 16-22	19	35	6 543	2 460	0.376	70.3
22	" 23-30	32	72	11 259	3 569	0.317	49.6
23	May 1-7	44	146	20 676	7 774	0.376	53.2
24	" 8-15	53	205	27 588	9 380	0.340	45.8
25	" 16-22	58	243	37 071	11 937	0.322	49.1
26	" 23-31	63	304	45 413	14 623	0.322	48.1
27	June 1-7	64	262	31 957	13 326	0.417	50.9
28	" 8-15	59	240	22 554	9 112	0.404	38.0
29	" 16-22	54	169	14 755	5 356	0.363	31.7
30	" 23-24	7	7	250	128	0.512	18.3
Total/Mean		101	3 323	446 085	252 257	0.477	60.3

[a]From interviews.
[b]Estimated from total catch (kg) ÷ CPUE (kg/trap haul) measured from interviews.

Table 5. Catch and effort data for the 'southern' Grand Manan lobster fishery during fishing season 1979-80, on weekly basis, based upon sale slips and interviews with fishermen.

Week no.	Period	No. of fishermen	Effort: No. of fishing days	Effort: Estimated trap hauls[b]	Catch (kg)	CPUE: kg/trap haul[a]	CPUE: kg/d fished
1	Nov. 14-22	86	549	72 130	126 877	1.759	231.1
2	" 23-30	83	291	31 980	33 579	1.050	115.4
3	Dec. 1-7	78	236	30 989	22 715	0.733	96.3
4	" 8-15	71	185	26 190	17 966	0.686	97.1
5	" 17-22	47	98	9 235	5 661	0.613	57.8
6	" 24-31	32	74	7 041	5 119	0.727	69.2
7	Jan. 1-7	28	51	3 463	2 774	0.801	54.4
8	" 8-15	28	58	4 877	3 126	0.641	53.9
9	" 16-22	20	28	2 940	1 376	0.468	49.1
10	" 23-31	03	09	645	258	0.400	28.7
11	Feb. 2-8	04	08	578	268	0.435	33.5
12	" 9-15	08	11	1 214	562	0.463	51.1
13	" 16-22	03	05	-	182	-	36.4
14	" 23-29	02	04	-	286	-	71.5
15	March 1-7	04	08	-	273	-	34.1
16	" 8-14	03	03	-	186	-	62.0
17	" 15-21	01	02	-	123	-	61.5
18	" 22-31	03	11	1 945	741	0.381	67.4
19	April 1-7	09	22	3 843	1 276	0.332	58.0
20	" 8-15	16	42	9 016	2 254	0.250	53.7
21	" 16-22	24	65	9 114	3 436	0.377	52.9
22	" 23-30	37	136	26 570	6 483	0.244	47.7
23	May 1-7	39	136	25 753	7 288	0.283	53.6
24	" 8-15	49	199	30 155	10 343	0.343	52.0
25	" 16-22	56	182	23 457	9 594	0.406	52.7
26	" 23-31	58	309	50 905	16 697	0.328	54.0
27	June 2-7	55	203	32 006	11 522	0.360	56.8
28	" 9-15	48	156	26 549	7 248	0.273	46.5
29	" 16-21	40	147	25 663	7 006	0.273	47.7
30	" 23-27	26	61	15 977	4 106	0.257	67.3
Total/Mean		106	3 289	472 235	309 328	0.653	94.0

[a]From interviews.
[b]Estimated from total catch (kg) ÷ CPUE (kg/trap haul) measured from interviews.

Table 6. Catch and effort data for the North Head area of the Grand Manan lobster fishery during fishing season 1978-79, on weekly basis, based upon sales slips and interviews with fishermen.

Week no.	Period	No. of days fished per week	No. of fishermen	Effort: No. of fishing days	Catch (kg)	CPUE: kg/trap haul[a]	CPUE: kg per days fished
1	Nov. 15-22	7	13	53	6 054	0.668	114.2
2	" 23-30	6	12	32	3 871	0.691	120.9
3	Dec. 1-7	5	13	31	4 100	1.101	132.3
4	" 8-15	6	11	33	3 584	1.127	108.6
5	" 16-22	4	9	14	1 716	1.077	122.6
6	" 23-31	5	7	13	1 996	1.243	153.6
7	Jan. 1-7	2	5	9	757	1.355	84.2
8	" 8-15	4	6	15	665	0.817	44.3
9	" 16-22	3	3	3	436	1.260	145.4
10	" 23-31	1	3	3	301	1.573	100.2
11	Feb. 1-7	-	-	-	-	-	-
12	" 8-15	1	1	1	287	1.513	286.6
13	" 16-22	-	-	-	-	-	-
14	" 23-28	-	-	-	-	-	-
15	Mar. 1-7	1	1	1	483	1.787	483.0
16	" 8-15	1	1	1	545	1.512	545.1
17	" 16-22	-	-	-	-	-	-
18	" 23-31	1	1	1	471	2.390	470.8
19	Apr. 1-7	1	1	1	295	1,487	295.2
20	" 8-15	1	1	1	213	1.652	213.2
21	" 16-22	1	1	1	712	2.388	712.5
22	" 23-30	1	1	1	577	2.967	577.3
23	May 1-7	2	3	3	2 093	-	697.8
24	" 8-15	7	3	13	1 687	2.028	129.8
25	" 16-22	6	3	16	1 973	-	123.3
26	" 23-31	5	3	12	2 046	-	170.5
27	June 1-7	6	4	20	3 120	-	156.0
28	" 8-15	7	4	24	4 008	-	167.0
29	" 16-22	6	4	19	2 992	-	157.5
30	" 23-24	1	1	1	50	-	49.9
Total/Mean		3.5	13	322	45 032	1.506	243.4

[a]From interviews.

Table 7. Catch and effort data for the North Head area of the Grand Manan lobster fishery during fishing season 1979-80, on weekly basis, based upon sales slips and interviews with fishermen.

Week no.	Period	No. of days fished per week	No. of fishermen	Effort: No. of fishing days	Catch (kg)	CPUE: kg/trap haul[a]	CPUE: kg per days fished
1	Nov. 14-22	8	10	63	10 425	1.859	165.48
2	" 23-30	7	10	47	5 859	1.859	124.65
3	Dec. 1-7	6	9	35	3 048	-	87.07
4	" 8-15	3	4	08	1 366	-	170.69
5	" 17-22	4	3	09	995	-	110.56
6	" 24-31	3	3	07	818	-	116.81
7	Jan. 1-7	2	2	03	478	-	159.49
8	" 8-15	6	2	07	1 097	-	156.72
9	" 16-22	3	1	03	521	-	173.70
10	" 23-31	1	1	01	377	-	376.87
11	Feb. 2-8	3	1	03	722	-	240.82
12	" 9-15	3	1	03	884	-	294.78
13	" 16-22	5	1	05	830	-	165.99
14	" 23-29	2	1	02	385	-	192.74
15	March 1-7	2	1	02	567	2.578	283.45
16	" 8-14	3	1	03	363	-	120.94
17	" 15-21	3	1	03	317	-	105.82
18	" 22-31	4	1	04	413	-	103.17
19	April 1-7	5	2	07	603	-	86.10
20	" 8-15	5	2	07	878	2.268	125.43
21	" 16-22	2	1	02	295	2.268	147.39
22	" 23-30	4	1	04	635	-	158.73
23	May 1-7	4	3	06	1 214	-	202.27
24	" 8-15	7	4	15	1 814	-	120.91
25	" 16-22	6	3	13	1 983	-	152.52
26	" 23-31	8	4	21	2 908	2.471	138.49
27	June 2-7	4	2	04	1 331	-	332.77
28	" 9-15	5	2	10	1 326	2.171	132.61
29	" 16-21	6	3	12	1 813	2.451	151.10
30	" 23-27	3	4	05	1 304	-	260.77
Total/Mean		4.23	11	314	45 568	2.241	145.12

[a]From interviews.

Table 8. Lobsters landed at North Head and at other ('south') ports in Grand Manan during fishing season 1978-79, expressed as a percentage of total weight (total = 297 632 kg) and estimated number (475 283).

Period	Percentage of total landings			
	by weight		by estimated numbers	
	'south'	North Head	'south'	North Head
November 15-30	44.31	3.45	51.19	1.72
December 1-15	9.91	2.58	11.47	0.70
" 16.31	2.65	1.25	3.05	0.30
January 1.15	0.68	0.48	0.77	0.11
" 16-31	0.42	0.25	0.48	0.06
February 1-15	-	0.10	-	0.02
" 16-28	0.01	-	0.01	-
March 1-15	-	0.35	-	0.08
" 16-31	0.05	0.16	0.05	0.04
April 1-15	0.63	0.17	0.71	0.04
" 16-30	2.03	0.43	2.28	0.10
May 1-15	5.76	1.27	6.14	0.32
" 16-31	8.92	1.35	9.27	0.34
June 1-15	7.54	2.39	7.96	0.59
" 16-30	1.84	1.02	1.90	0.30
Total	84.75	15.25	95.28	4.72

Table 9. Lobsters landed at North Head and at other ('south') ports in Grand Manan during fishing season 1979-80, expressed as a percentage of total weight (total = 354 896 kg) and estimated number (563 062).

Period	Percentage of total landings			
	by weight		by estimated numbers	
	'south'	North Head	'south'	North Head
November 15-30	45.21	4.59	52.80	1.65
December 1-15	11.46	1.24	13.22	0.45
" 16.31	3.04	0.51	3.43	0.18
January 1.15	1.66	0.44	1.88	0.16
" 16-31	0.46	0.25	0.52	0.09
February 1-15	0.23	0.45	0.27	0.16
" 16-28	0.13	0.34	0.15	0.12
March 1-15	0.13	0.26	0.15	0.09
" 16-31	0.24	0.21	0.28	0.07
April 1-15	0.99	0.42	1.10	0.15
" 16-30	2.80	0.26	3.01	0.09
May 1-15	4.97	0.85	5.19	0.31
" 16-31	7.41	1.38	7.77	0.49
June 1-15	5.29	0.75	3.68	0.15
" 16-30	3.13	0.88	2.18	0.18
Total	87.15	12.83	95.63	4.34

Table 10. Number of lobster fishermen, by port, Grand Manan, 1974-80.

Port	Fishing season 1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Dark Harbour	04	04	03	03	03	02
Ingalls Head	44	52	58	57	46	51
Seal Cove	39	37	32	36	33	35
White Head	27	27	25	22	19	18
S. Grand Manan Total	114	120	118	118	101	106
North Head	15	14	13	11	13	11
Total Grand Manan	129	134	131	129	114	117

Table 11. Lobster landings (kg) by port, Grand Manan, 1974-80.

Port	Fishing season 1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Dark Harbour	1 529	931	565	339	1 107	789
Ingalls Head	81 414	78 337	103 261	111 662	98 496	117 813
Seal Cove	127 335	114 450	128 553	104 220	106 086	136 522
White Head	64 809	57 785	59 633	68 925	46 567	54 204
S. Gr. Manan Total	275 087	251 503	292 012	285 146	252 256	309 328
North Head	26 773	31 504	32 661	38 005	45 376	45 568
Total Grand Manan	301 860	283 007	324 673	323 151	297 632	354 896

Table 12. Number of days fished, by port, Grand Manan, 1974-80.

Port	Fishing season 1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Dark Harbour	35	23	09	19	29	18
Ingalls Head	1 199	1 108	1 410	1 470	1 200	1 157
Seal Cove	1 558	1 341	1 376	1 133	1 492	1 560
White Head	959	719	724	786	646	554
S. Grand Manan Total	3 751	3 191	3 519	3 408	3 367	3 289
North Head	279	273	277	287	328	314
Total Grand Manan	4 030	3 464	3 796	3 695	3 695	3 603

Table 13. Mean number of days fished per fisherman, by port, Grand Manan, 1974-80.

Port	Fishing season 1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Dark Harbour	8.75	5.75	4.50	6.33	9.67	9.00
Ingalls Head	27.25	21.65	24.31	25.79	26.22	22.69
Seal Cove	39.95	36.22	43.00	31.47	43.67	44.57
White Head	35.52	26.63	28.96	35.73	34.05	30.78
S. Grand Manan Total	32.90	26.68	30.08	28.88	32.86	31.03
North Head	18.60	19.50	21.31	26.09	24.69	28.55
Total Grand Manan	31.24	25.93	29.20	28.64	31.97	30.79

Table 14. Mean number of kg of lobsters landed per fisherman, by port, Grand Manan, 1974-80.

Port	Fishing season 1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Dark Harbour	382.3	233.0	283.0	113.0	368.9	394.5
Ingalls Head	1850.3	2140.2	1780.4	1959.0	2141.2	2310.1
Seal Cove	3265.0	3093.2	4017.3	2895.0	3214.7	3900.6
White Head	2400.3	1506.5	2385.3	3133.0	2450.8	3011.3
S. Grand Manan Total	2413.0	2095.9	2495.8	2416.5	2467.1	2918.2
North Head	1785.0	2250.3	2512.3	3455.0	3489.1	4142.5
Total Grand Manan	2340.0	2112.0	2497.5	2505.1	2610.8	3033.3

Table 15. Lobster fishermen, by port, expressed as a percentage of total Grand Manan fishermen, 1974-80.

Port	Fishing season 1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Dark Harbour	3.10	2.99	2.29	2.33	2.63	1.71
Ingalls Head	34.11	38.81	44.27	44.19	40.35	43.59
Seal Cove	30.23	27.61	24.43	27.91	28.95	29.91
White Head	20.93	20.15	19.08	17.05	16.67	15.38
S. Grand Manan Total	88.37	89.55	90.08	91.47	88.60	90.60
North Head	11.63	10.45	9.92	8.53	11.40	9.40
Total Grand Manan	129	134	131	129	114	117

Table 16. Lobster landings, by port, expressed as a percentage of Grand Manan total landed weight (kg), 1974-80.

Port	Fishing season 1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Dark Harbour	0.51	0.33	0.17	0.10	0.37	0.22
Ingalls Head	29.97	27.68	31.80	34.55	33.09	33.20
Seal Cove	42.18	40.44	39.59	32.25	35.64	38.47
White Head	20.85	20.42	18.37	21.33	15.65	15.27
S. Grand Manan Total	91.13	88.87	89.94	88.24	84.75	87.16
North Head	8.87	11.13	10.06	11.76	15.25	12.84
Total Grand Manan	301 860	283 007	324 673	323 151	297 632	354 896

Table 17. Days fished, by port, expressed as a percentage of total days fished at Grand Manan, 1947-80.

Port	Fishing season 1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Dark Harbour	0.87	0.66	0.24	0.51	0.78	0.50
Ingalls Head	29.75	31.99	37.14	39.78	32.48	32.11
Seal Cove	38.66	38.71	36.25	30.66	40.38	43.30
White Head	23.80	20.76	19.07	21.27	17.48	15.38
S. Grand Manan Total	93.08	92.12	92.70	92.23	91.12	91.29
North Head	6.92	7.88	7.30	7.77	8.88	8.71
Total Grand Manan	4030	3464	3796	3695	3695	3603

Table 18. Large lobsters (≥127 mm CL) landed at North Head, expressed as kg total weight, and as percentage of local and Grand Manan catches, 1975-80.

	Fishing season 1975-76	1976-77	1977-78	1978-79	1979-80
Total Grand Manan landings (kg)	283 007	324 673	323 151	297 632	354 896
Total North Head landings (kg)	31 504	32 661	38 005	45 376	45 568
Landings (kg) large lobsters at North Head	8 495	12 908	11 449	20 079	23 800
% large lobsters at North Head of total Grand Manan landings	3.00	3.98	3.54	6.75	6.71
% large lobsters of total North Head landings	26.96	39.52	30.12	44.25	52.23

N.B. The deep water fishery began in 1974-75; however, large and small lobsters were not recorded separately until 1975-76.

Table 19. Estimated population sizes, in terms of biomass (kg), at start of fishing season with confidence limits for the population size estimates and rates of exploitation for southern Grand Manan lobsters (N = number in sample, a and b = regression constants, q = catchability).

Season Nov.-June	Intercept a	Slope b	Slope q	Correlation coefficient	N	Initial population biomass (kg) Population size	95% Confidence limits Lower	95% Confidence limits Upper	Total catch(kg)	Exploitation rate μ (%)
1948-49	1.000	-0.00000191		0.913	8	522 329	417 934	790 167	294 830	56.4
1949-50	1.152	-0.00000239		0.951	8	481 588	410 719	617 432	313 607	65.1
1950-51[ab]	1.600	-0.00000304		0.983	3	526 264	389 054	-	380 046	72.2
1951-52[b]	1.414	-0.00000307		0.933	7	460 074	387 163	638 928	359 002	78.0
1952-53[b]	1.138	-0.00000200		0.981	7	569 320	510 355	660 706	422 811	74.3
1978-79	1.010	-0.00000291		0.784	9	346 432	271 499	760 758	252 256	72.8
1979-80	1.381	-0.00000379		0.927	6	363 947	320 308	492 919	309 328	84.9

[a]Only spring season (May-June) data used in analysis as poor weather conditions resulted in heavy gear loss and low fishing effort in the fall season (Nov.-Dec.).
[b]Second period in June excluded in analysis as $<$ 1000 trap hauls recorded for catch-effort samples.