

The effects of raking Irish moss (*Chondrus crispus*) on lobsters in Prince Edward Island

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EXTRAIT: Effets, de la récolte de «mousse d'Irlande» (*Chondrus crispus*) sur les homards, dans l'île du Prince-Edouard. Quatre méthodes principales furent utilisées pour évaluer le dommage causé aux stocks de homards par la récolte de *Chondrus crispus*: l'observation depuis les bateaux équipés à cette fin; l'examen, par des plongeurs, des secteurs prospectés et de la densité des peuplements de homards; l'observation sousmarine des rateaux en mouvement et des réactions provoquées sur les homards (*Homarus americanus*); l'examen des traces creusées par les rateaux et des homards qui s'y trouvaient. Sur les fonds de mousse lisses les peuplements de homards étaient peu denses et les dommages causés par récolte de mousse étaient sans importance. Sur les fonds modérément raboteux l'abondance des homards est estimée à 600 par hectare; approximativement 2 % des homards récoltés sur les traces des rateaux étaient tués à chaque passage. Sur les fonds très raboteux, l'abondance des homards dépassait 1000 par hectare; 5,2 % des homards récoltés sur les traces des rateaux étaient tués. Une récolte intensive de mousse est estimée entraîner la perte de 280 homards par bateau et par jour; il s'y ajoute d'autres dommages, tels que la perte des pinces ou les blessures qui abaissent le taux de croissance et la valeur commerciale. La taille moyenne des homards tués était de 35 mm pour la longueur de la carapace (environ 100 mm de longueur totale); ces homards auraient été commercialement exploitables dans un délai de deux ans, et auraient alors la valeur d'environ 8 «cents» canadiens pièce. La perte totale causée à ces fonds raboteux fut évalué à 36.000 \$, somme correspondant à 16–20 % de la valeur de la récolte de mousse, ou à 7 % de la valeur annuelle de la récolte de homards dans ce secteur. Ces chiffres sont suffisamment élevés pour justifier un examen critique des efforts consacrés à la récolte de mousse.

INTRODUCTION

The seaweed harvest from the Canadian Atlantic Ocean has increased in value from \$ 50,000 in the 1940's to about \$ 3 million in 1970. The principal species is Irish moss (*Chondrus crispus*) which grows from LWM to 6–8 m in a number of rocky areas. Approximately half the harvest is from Prince Edward Island (P.E.I.) where, originally, moss dislodged by wave action was gathered off the beach or in the surf. Alternatively, a hand rake was used to "comb" moss off the rocks. Since the early 1960's the hand rake has been modified and mechanized. Rakes are now up to 3 m wide, weighing up to 100 kg, and are towed on steel cables by power boats at speeds to 2 knots (1 m/sec). In western P.E.I. (Fig. 1), this rake is now the principal harvesting method. In eastern P.E.I., the presence of the more delicate commercially valuable

weed *Furcellaria fastigiata* among the moss, has inhibited the development of drag raking as a harvesting method.

All areas where *Chondrus crispus* grows are also fished for lobsters. Thus it was inevitable that the spread of drag raking for Irish moss would be opposed by conservation-minded lobster fishermen. The question of damage to lobsters (*Homarus americanus*) by moss raking first arose in eastern Prince County, P.E.I., where rakers observed that crushed lobsters or parts of lobsters were being found in the rakes and

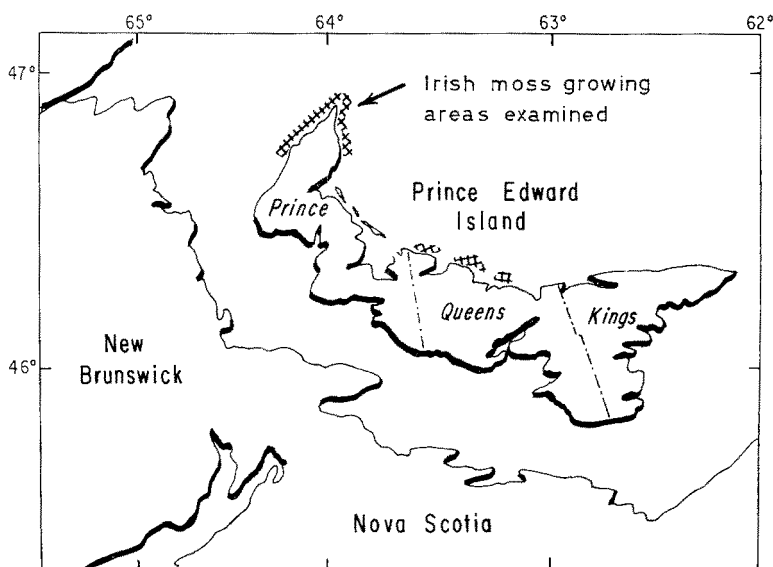


Fig. 1: Irish moss growing areas of Prince Edward Island (Canada) examined in 1970 and 1971

speculated that more damage was being caused than was actually seen. Observations aboard commercial boats, and under water, suggested the total damage was inconsequential and raking was permitted to continue.

The spread of raking into the north shore of Queens County, P.E.I., in 1969 was vigorously opposed by local lobster fishermen. More lobsters were seen in moss rakes here than in areas further west and fishermen believed that serious damage would result if raking were allowed to continue. An investigation was initiated in May, 1970. It sought to compare the damage observed aboard commercial moss rakers on different grounds, and using diving techniques, to investigate the numbers of lobsters on moss beds, their reactions to raking, and the numbers killed or damaged. This would enable the effects of moss raking to be explained and predicted, and the probable costs (in dollars) compared with profits to fishermen.

This paper summarizes results of the 1970 and 1971 investigations. A more detailed report will be published elsewhere.

METHODS

Observations aboard commercial moss raking vessels

An observer accompanied moss boats selected at random from a number of ports in Prince and Queens Counties. A full count was kept of all tows made each day. Moss landings were estimated or the weight obtained from buyers' records. In 1970, a few tows were timed by stop-watch and crude estimates of towing speed made by stop-watch timing chips of wood past measured distances along the boat's side. Lobsters, or parts of lobsters recovered from the moss, were measured with a vernier caliper.

In 1971, following repeated lobbying by lobstermen's associations, a temporary ban was imposed on moss raking in Queens County which restricted observations to Prince County boats. Similar records were kept, except that each day ten tows were timed and ten estimates of towing speed were made using a modified ship's log. It was assumed that boat speed would give a reasonable estimate of rake speed, hence distance travelled and area raked could be calculated.

Lobster abundance estimates

Selection of sampling sites in 1970 was made following survey of the moss beds from a manned, towed underwater sled (FOULKES & SCARRATT 1972). A section of moss bed, 300 m long, was selected and marked off as an experimental zone from which commercial rakers were excluded.

Initial lobster abundance estimates were made by divers counting and collecting all lobsters found within a 20.8 m² area enclosed within a square folding metal frame, which was set four times at each station (SCARRATT 1968). Later, an improved method was developed using two 50 m long lead-cored lines laid individually at each station. Divers, carrying a metal rod, 1 m long, collected all lobsters within a metre of one side of each line. Each station was thus 100 m². Notes were made of depth, bottom type, identity and abundance of seaweeds and major fauna.

Reaction of lobsters to moving rakes

Initially, two standard 3 ft (0.9 m) rake units were rigged together with a polypropylene rope bridle. Later this bridle was replaced by chain slings and a steel-pipe spreader bar to which the rake units were shackled, thus duplicating commercial practice. A 12 mm diameter polypropylene line, 5 m long, knotted at intervals, was fastened to the end of the tow rope. A diver entered the water holding this rope with the boat moving. The rakes were pushed overboard and the tow rope paid out. Once the rake started moving, the diver noted lobsters seen in, or escaping from, the path of the rake. Count was kept of those that: (a) avoided the rake completely; (b) touched or were hit by the rake but were uninjured; (c) lost legs or claws or suffered minor injuries; (d) were killed outright or so seriously wounded that survival was unlikely.

Each tow was 3 minutes long. After each tow, the diver reported lobsters seen to an assistant on deck. Usually 12 tows were observed in sequence.

Rake track examination

To determine whether more lobsters were killed or injured than were seen by observers, sections of rake track approximately 100 m² in area were examined. Lead-cored, braided nylon lines, 50 m long, weighted and buoyed at one end, were threaded through guides welded on each side of the rake. Buoys, weights, and rake were pushed off the stern of the boat in sequence and the lines paid out to mark each side of the track which was about 2 m wide. Divers began to examine the track immediately the lines had cleared the guides. Lobsters observed between the lines were collected and examined.

Towing speed calibration

Survey boat towing speed was adjusted by experience to match commercial practice. In 1970, a number of tows were timed past marks set 50 m apart to give a more accurate estimation of raking speed, and in 1971 a number of timed tows were made with an odometer wheel fastened to the rake and connected to an event recorder on deck. Raking speeds so estimated were compared with boat speeds estimated with the ship's log.

RESULTS AND ANALYSIS

Observations aboard moss raking boats

Rake sets are normally rigged with two or three standard 3 ft (0.9 m) units on a spreader bar. Boats with two sets of rakes normally work them alternately so that one

Table 1

Summarized observations aboard moss raking boats in 1970 and 1971.
Tow speed and duration are based on 10 observations per day's raking

Year	County	Days observed	Mean tows (per day)	Mean tow time (sec)	Speed (cm/sec)	Mean wt moss landed (kg)	Total no. lobsters seen
1970	W. Prince	8	136	—	70*	745	2
	E. Prince	2	167	128*	85*	1410	2
	Queens	11	166	130**	88***	1680	25+
1971	W. Prince	12	128	218	85	795	4
	E. Prince	7	166	224	91	805	7

* 1 boat; ** 6 boats; *** 3 boats; + plus 44 lobsters taken unharmed in baskets fitted to rakes in 2 days' raking.

Table 2
Mean number of lobsters seen per day in commercial moss rakes

County	1970	1971
W. Prince	0.25	0.33
E. Prince	1.0	1.0
Queens	2.5*	no raking

* Excludes those taken uninjured in baskets.

is being set for raking while the other is being hauled back for the moss to be removed. On good moss grounds, rakes fill rapidly and tow duration is determined by the time taken to clean rakes. On poor or marginal grounds, tow duration increases. Some boats fit wire mesh baskets to the rakes to catch dislodged moss.

Twenty-one days' observations were made in 1970 and 19 days' observations in 1971 (Table 1). Mean boat speed was about 85–90 cm/sec. Mean tow duration in 1970 was 2 minutes 10 seconds, and in 1971 3 minutes 40 seconds. Boats made on average about 150 tows per day. Most lobsters were seen per day in Queens County and fewest in W. Prince County (Table 2). The mean estimated size of 44 lobsters found in rakes in 1970 was 44.4 ± 8.8 mm carapace length. All were below the minimum legal size limit of 63.5 mm carapace length (c.l.).

Lobster abundance

Lobster abundance was lowest on the smooth, flat bedrock ledges off W. Prince County, higher on the medium rough moss beds off E. Prince County, and highest on the heavily boulder strewn Queens County beds (Table 3). The Queens County beds

Table 3
Lobster abundance estimates and mean carapace length at sample stations in 1970 and 1971

County	Dates	Stations worked	Lobsters (no./100 m ²)	Mean carapace length (mm)
Queens	1970			
	May/June	6	4.2*	37.7
	June	14	10.9	39.4
	July	15	9.4	39.2
W. Prince E. Prince Queens	1971			
	June	29	0.7	39.5
	July	9	5.8	42.4
	June	12	6.3	39.0
	July	8	8.5	40.0
	August	8	10.3	38.6

* Based on 100 yd² samples.

also showed increase in lobster abundance on moss beds from spring to summer. At the time of year when moss raking was, or would have been, at its peak, lobster abundance on Queens County beds averaged 9.4/100 m². There were no differences in lobster abundance between stations sampled in 1970 inside the zone closed to commercial raking and those sampled outside (SCARRATT MS 1971). Mean size of lobsters on moss beds was between 38 and 42 mm c.l.

Damage observed from moving rakes

One hundred and eighty-nine 3-min tows were observed by divers riding the rope-bridled rake (Table 4). Damage observed was less than that seen in 165 diver-observed tows with the chain-bridled rake, suggesting that the heavier, noisier chain-bridled rake with its heavy spreader bar is more lethal to lobsters. A series of tows

Table 4
Lobsters observed by divers during 3-minute rake tows in 1970 and 1971

Year and series	Tows number	Avoid rake	Numbers of lobsters			Total
			Hit un-damaged	Light wound	Killed crushed	
(a) Rope-bridled rake:						
1970 Queens County	189	496	472	24	13	1005
(b) Chain-bridled rake:						
1970 Queens County						
slow tows	24	102	82	6	2	192
fast tows	24	79	78	6	8	171
Queens County	48	84	120	23	4	231
1971 E. Prince County*	9	35	27	7	2	71
1971 Queens County	60	177	398	37	7	619
Sub-total	165	477	705	79	23	1284

* Made by a commercial boat: mean rake speed 73 cm/sec; mean tow duration 130 sec.

with alternating slow and fast haul-back showed that higher rake speeds caused significantly more observable damage. The majority of lobsters seen avoided the rake or escaped injury but subsequent calculation showed that only a fraction (19–72 %) of those estimated to be in the path of the rake had been seen to respond (Table 5). The fate of lobsters not seen could not be determined by this method. Many boulders were rolled or displaced by the rakes and a high proportion of the moss cut was not collected.

Examination of rake tracks

Twenty-five fresh, 50 m long, rake tracks were examined in August and September, 1970 (Table 6). Twelve were on commercially raked grounds and 13 were on the closed zone. A total of 13 freshly killed lobsters was found out of 225 examined. Many

Table 5

Lobster population density, no./100 m² estimate of lobsters in the path of rake, mean numbers observed during 3-minute tow, and mean numbers recovered from 100 m² rake tracks

Date	County	No./100 m ² lobster population	Estimated number in path	Mean number observed per tow	Mean number in rake track 100 m ²
1970					
July	Queens	9.4	29.6*	5.5	
August	Queens			5.3 rope bridle 7.5 chain bridle	9.0
September	Queens			4.8	9.0
1971					
July	E. Prince	5.8	11.0**	7.9	6.2
July	Queens	8.5	24.3***	8.6	6.6
August	Queens	10.3	29.4***	12.9	8.0
					4.8+
September	Queens				5.6
					10.0+

* Towing speed = 88 cm/sec; ** Tow duration = 2 min 10 sec tows at 73 cm/sec;
*** Towing speed = 79 cm/sec; + Rake tracks examined after previous intensive raking.

Table 6

Lobsters observed in fresh 50 m long rake tracks

Year	County	Number of tracks	Not exam- ined	Numbers of lobsters				Dead	Total*
				Undam- aged	Missing claws	Old wounds	New wounds		
1970	Queens	13**	2	68	21	3	4	6	102
		12***	1	74	32	3	5	8+	123
1971	E. Prince	17	8	80	12	6	1	2	106
	Queens	50	17	218	61	27	28	7	350
	(July)								
	Queens	17++	4	77	26	11	7	0	119
	Queens	9+++	0	44	8	3	4	2	59

* Total is of number of lobsters in tracks. It may include lobsters with more than one type of wound; ** Within area closed to fishermen; *** On commercially raked beds; + One lobster partly consumed by amphipods; ++ Tows made before intensive raking; +++ Tows made after intensive raking.

had been crushed between boulders rather than hit by the rake. There were no differences between the areas open and closed to commercial raking. Lobster abundance on Queens County moss beds at this time of year is about 10/100 m², therefore 13 lobsters killed represent 5.2 % of the exposed population.

In 1971 in E. Prince County in 17 tracks, two dead lobsters were found, which represent about 2 % of the 99 estimated to be in the rake path. In 50 tracks examined in Queens County in July, 1971, after the ban on raking had been imposed, only seven

dead lobsters were found out of 350 examined. From lobster abundance estimates, the number expected in 50 tracks is 425. The seven dead lobsters represent 1.6 % of the theoretical population in the rake path. This is significantly lower than the 5.2 % observed in 1970 when commercial raking was in progress.

To explore the effect of intensive raking on Queens County beds, a number of tracks were examined in a small area, the area was then raked for 2–3 hours and then more tracks were examined (Table 6). The numbers are small but observed mortality (2/59) after intensive raking was higher than before (0/119) ($Z = 2.4$, $p = 0.016$). This suggests that raking mortality in undisturbed populations is lower than in heavily raked populations and confirms the higher mortality estimate for Queens County in 1970.

The mean carapace length of lobsters found killed in rake tracks was 35 mm. The high incidence of claw loss (up to 25 %) and wounding in these small lobsters is possibly due to raking but also partly to winter ice conditions.

Natural mortality and value of lobsters

The value of legal-sized lobsters before capture is the product of market price and lobster weight. Sub-legal lobsters, having no legitimate market, only have a potential value based on the probability of their survival to legal size. From WILDER (1953) it is possible to estimate that 35 mm lobsters in this area are two years from entering the

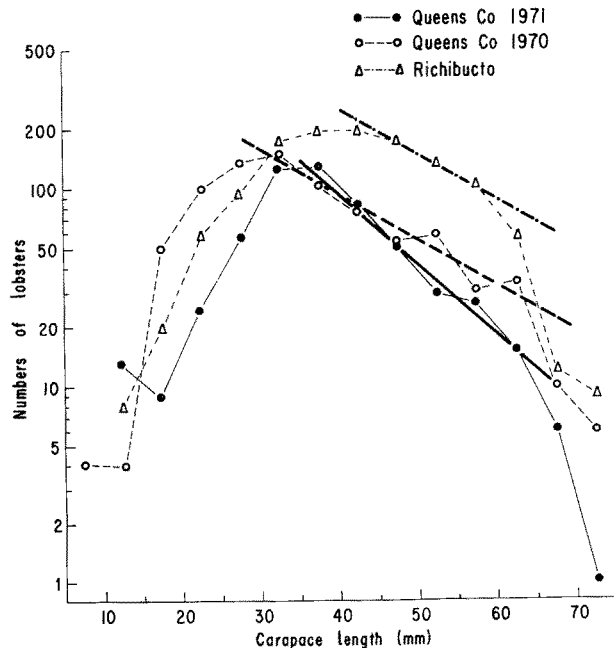


Fig. 2: Size frequency curves of hand caught lobsters

fishery. D. E. AIKEN (personal communication) corroborates this with data showing that 50–55 mm c.l. lobsters moult twice per year with an average annual increment of 15 mm.

Semi-log size frequency plots of 1238 lobsters hand collected at Richibucto, N.B., 818 lobsters collected off Queens County moss beds in 1970 and 861 collected in 1971 gave mortality estimates over 15 mm increments of 54 %, 56 % and 70 %, respectively (Fig. 2). The 1971 annual mortality value of 70 % followed extremely heavy raking the year before; therefore, it is reasonable to deduce that normal annual mortality is about 55 %. The average value of commercial Queens County lobsters is about 40 c each, therefore the value of 35 mm lobsters is about 8 c each.

Estimate of damage attributable to raking in Queens County

According to FFRENCH (1971), 25 boats worked the Queens County beds in 1970 for an average season of 65 working days each. From data in Table 1, each boat would rake between 3.8 to 5.7 hectares (double or triple rakes) at 130 sec mean tow duration or 6.4 to 9.6 ha per day at 220 sec tow duration.

The number of lobsters in 5.7 ha is about 5,360 of which 5.2 % or 280 might be killed. If each lobster has an average value of 8 c, damage by each raker per day can be estimated at \$ 22.36 with a fleet season total of \$ 36,000.

Analysis of buyer's records shows 74 % of moss harvested in 1970 was landed by rakers. The season's total was worth \$ 268,250 of which \$ 198,000 can be attributed to raking. Lobster landings in 1970 were \$ 514,000 (official statistics). Thus a damage estimate of \$ 36,000 is equivalent to 18 % of the moss raked or 7 % of the lobsters landed.

CONCLUSIONS

Damage to lobsters by moss raking is related to the roughness of the beds and lobster abundance on them, the type of rake used, and the speed of towing. On smooth beds, lobster populations are low and mortality negligible. On rough grounds, lobster populations are high and damage to them justifies some control of raking activities.

SUMMARY

1. The number of damaged lobsters (*Homarus americanus*) seen aboard commercial moss raking boats varies with the abundance of lobsters on the grounds, but is low in comparison with the numbers known to be damaged.
2. Lobster abundance is highest on rough, boulder strewn moss beds, and lowest where beds are smooth.
3. Some lobsters are seen to escape from the path of the rake unharmed. The proportion avoiding the rake is lowest on rough grounds, and highest on smooth grounds.

4. Examination of rake tracks in heavily raked areas shows that up to 5.2 % of lobsters in the path may be killed by each passage of the rakes.
5. Up to 280 lobsters, average size 35 mm carapace length, average value 8 c each, may be killed by one moss raking boat in one day. More lose claws or are wounded.
6. Total value of lobsters killed by all rakers in one area is \$ 36,000 which is 18 % of landed value of moss or 7 % of lobster landings.
7. Some control of moss raking is justified.

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