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CATCH AND EFFORT TRENDS OF THE IRISH MOSS (*CHONDRUS CRISPUS* STACKHOUSE) FISHERY IN SOUTHWESTERN NOVA SCOTIA, 1978 TO 1980

by

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Chondrus crispus Stackhouse has been handraked for about 35 years in southwestern Nova Scotia. There was a 48% decline in annual landings between 1978 and 1980. Individual daily landings from a cross section of harvesters declined by only 2.6%; however, the number of deliveries declined by 27%. The total number of potential harvesters (licensees) declined by 13%.

Biomass was down 25% and accessibility to the resource was lower in 1980 due to fewer low daylight tides (28%) and poor weather conditions. The price paid per kg to fishermen for labour-competitive fisheries such as groundfish, herring, and scallops has increased, while Chondrus has declined due to static price.

A core group of harvesters (28% to 35% of the total - 1980 n = 788) land 72% to 78% of the assumed crop. They harvest more frequently (four times) with a 35% higher CPUE than other harvesters. This group is least affected by fluctuations in resource abundance and accessibility.

Analyses suggest the resource will likely remain underutilized if the minimum economic CPUE continues to increase. Options for increasing the utilization of this resource are discussed.

Key words: Chondrus, Irish moss, handrake, harvesting, landings, effort, CPUE, standing crop, competitive fisheries.

RÉSUMÉ

Sharp, G.J. and D.L. Roddick. 1982. Catch and effort trends of the Irish moss (Chondrus crispus Stackhouse) fishery in southwestern Nova Scotia, 1978 to 1980. Can. Tech. Rep. Fish. Aquat. Sci. 1118: vii + 43 p.

Dans le sud-ouest de la Nouvelle-Écosse, on moissonne la mousse d'Irlande (Chondrus crispus - Stackhouse) à l'aide d'un râteau à main depuis environ 35 ans. Entre 1978 et 1980, le nombre des débarquements annuels a diminué de 48%. Chez une population-type de moissonneurs, les débarquements individuels quotidiens n'ont diminué que de 2.6%; le nombre des livraisons a toutefois baissé de 27%. Quant au nombre total de moissonneurs possibles (détenteurs de permis), il a chuté de 13%.

La biomasse a connu une réduction de 25% et il a été plus difficile d'exploiter la ressource en 1980 à cause de la diminution du nombre des basses mers diurnes (28%) et des conditions météorologiques mauvaises. Le prix offert aux pêcheurs pour un kilogramme de poisson de fond, de hareng, de pétoncles et d'autres espèces pour lesquelles les pêcheurs sont en conditions de concurrence, a augmenté; la production de mousses d'Irlande a baissé étant donné que le prix offert aux moissonneurs est demeuré fixe.

Une minorité de moissonneurs (de 28 à 35% du total - nombre en 1980: 788) ont débarqué de 72 à 78% de la moisson connue. Ils ont moissonné plus fréquemment (quatre fois) et ils ont obtenu des prises par unité d'effort supérieures de 35% à celles d'autres moissonneurs. Cette minorité de moissonneurs sont moins touchés que les autres par le fait que la quantité de mousses varie et qu'il est plus ou moins facile de moissonner celles-ci selon les années.

Des analyses laissent croire que la ressource continuera d'être sous-utilisée si le nombre de prises par unité d'effort qu'il est nécessaire de faire pour que les moissons soient rentables ne cesse pas d'augmenter. On discute de mesures que l'on pourrait prendre pour accroître l'utilisation de la ressource.

INTRODUCTION

The Irish moss (Chondrus crispus Stackhouse) harvest in southwestern Nova Scotia (Marine Plants District 12) has been active for 35 years (Fig. 1a). During the last 20 years, the collection and sale of Chondrus has developed into an important source of supplementary income for bona fide inshore fishermen and others, mainly between Cape Sable Island and Yarmouth (Fisheries and Oceans Statistical Districts 32, 33, and 34). Harvesting technology has not developed beyond the use of the original handrake design (MacFarlane, 1966; Pringle, 1979) (Fig. 1b). Dragraking was made possible by the introduction of outboard motor-powered skiffs, but substrate limits its use to 10% of the effort (Sharp and Roddick, 1979). Commercial Chondrus beds occur between -5 m and +1 m depths (chart datum) (Pringle and Semple, 1980). As a result, accessibility by handraking is limited in this area of a 5 m mean tidal amplitude to two hours before and after a low tide. A total of 61 commercial Chondrus beds occur between Cape Sable Island, Shelburne County, and Pinkney's Point, Yarmouth County, in a wide variety of wave and wind exposures (Pringle and Semple, op. cit.). Daily variations in wind speed and direction can affect the accessibility of these beds to handraking (Sharp and Roddick, 1979).

Irish moss harvesting in District 12 is an open fishery. The capital investment ranges from $1,700 to $2,500 and operating costs from $250 to $600 per year. Harvesters fall into the following groups: 1) school children who gather moss on the shore or periodically accompany their fathers; 2) school children having their own manually powered or outboard-motor skiff who harvest on weekends or evening tides and full time when school ends; 3) retired or semi-retired individuals; 4) part-time workers from a range of primary occupations who usually harvest only on weekends or holidays; 5) full-time fishermen with boats and gear for other fisheries; and 6) full-time fishermen without this equipment (deckhands).

Those in Categories 1 and 2 do not require licences (up to 16 years old), and thus their numbers can only be estimated. The remaining groups are accounted for in the personal license statistics, which provides an estimate of the potential effort only for a given season. The percentage of licensed individuals actively harvesting must be determined through direct observation or buyers' records.

A 48% decrease in annual landings since 1978 has emphasized the need to better determine the main factors contributing to yearly fluctuations. Annual landings are affected by a complex of factors which are expressed as effort and catch per unit

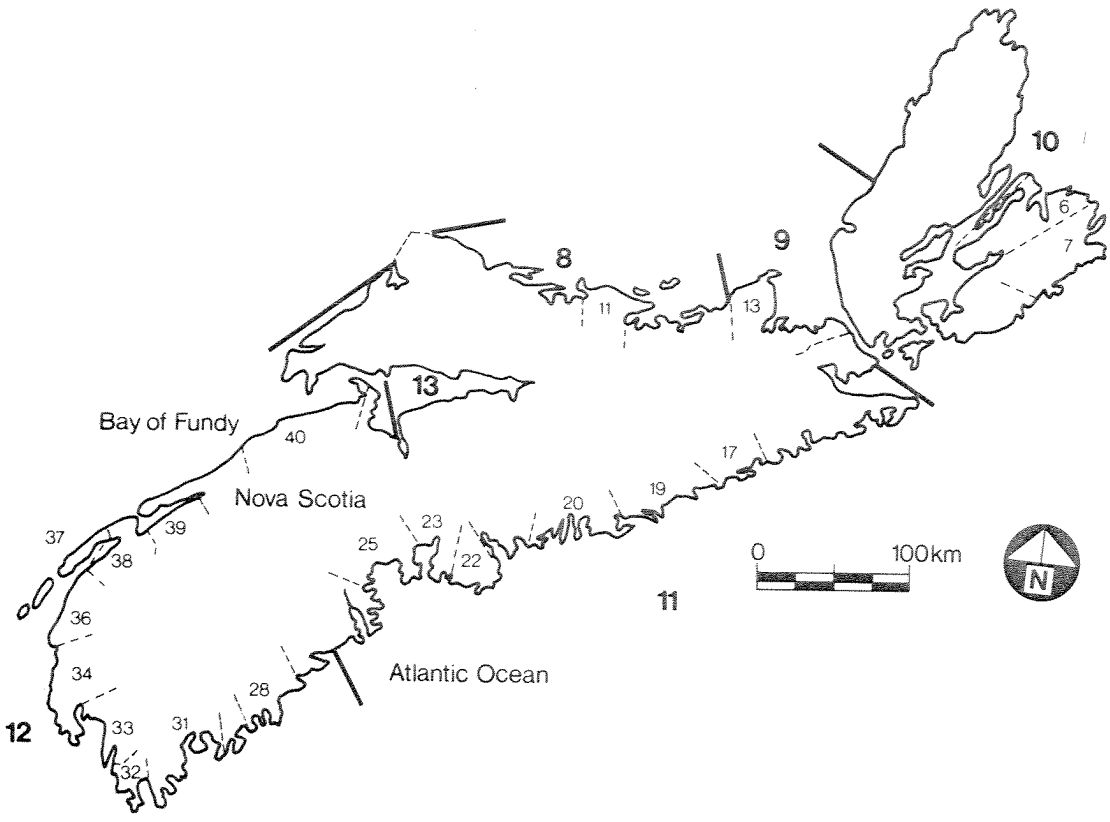

Figure 1a. Nova Scotia Fisheries Statistical Districts delineated by broken lines; Marine Plants Districts delineated by solid lines.

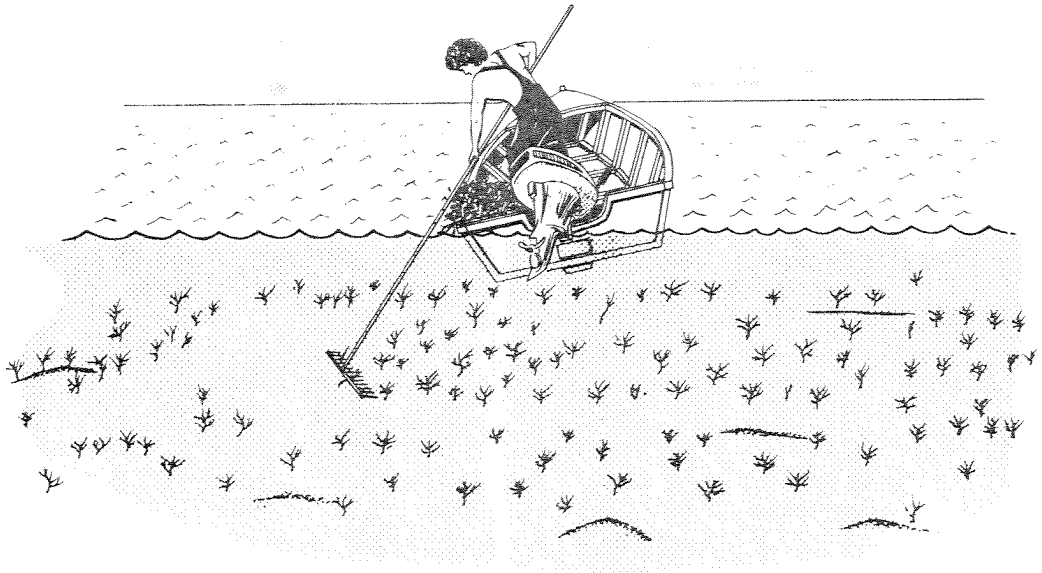

Figure 1b. Chondrus harvesters using handrakes from "mossing" skiffs in southwestern Nova Scotia.

effort. Effort may be altered by both the buyers' prices and buying strategy, the success of competitive fisheries, weather, tides, and catch per unit effort. Catch per unit effort varies with harvestable standing crop (abundance), bed accessibility (weather, tides, distance), and the harvesters' physical abilities. Harvestable standing crop is affected by ocean climate, nutrients, incidental light, ice scouring, and past harvesting activity. This paper attempts to identify those variables which affected annual yields between 1978 and 1980.

METHODS

CATCH AND EFFORT

Landings are required by law to be reported to Fisheries and Oceans Canada monthly, by each company for every buying site. The data base used in this analysis consisted of daily individual landing records as noted for each buying station of Acadian Seaplants Limited. (A.S.L.) (formerly Marine Colloids Limited) which purchased a major proportion (%) of the landings for 1978 to 1980. Buyers place shipping containers on the principal wharfs and purchase directly from each harvester. The limited carrying capacity of the mossing skiff and possible dehydration of the harvest dictates that the harvest be sold after each tide. Therefore, effort is defined as one man, tide, delivery. The exceptions to this situation might be double tides (two daylight tides per day) if only a small harvest were obtained on the first tide. Complete company records were used to define the overall average annually, the mean daily effort, CPUE, and the proportion of harvesters that attain better than average harvests. All confidential values are reported on a relative scale for protection of A.S.L.'s business privacy. A.S.L. bought at eight sites throughout Statistical Districts 32, 33, and 34 in 1978 and 1979. Due to a reduction in buying sites in 1980 only these sites were used in yearly comparisons.

Dried Chondrus and Island moss (that harvested from Mud and Seal Islands) was not included in the analysis. The harvesting date of the former cannot be established, and frequently several harvests were dried and sold as a unit. The latter is harvested over a number of tides and sold as a single weight.

To examine CPUE and effort during 1980, we defined a core group of harvesters whose landing records were consistent from A.S.L.'s records. To establish this group, we examined total landings during June and July. This period was chosen to reduce the confusion created by late-season low CPUE, high dropout rates, and increased dry moss landings.

Analysis of total individual landings for June and July of 1978 and 1980 found a minority of harvesters landed the majority of the harvest. Two harvester groups were established by criteria of total landings to July 31. Those with less than 6818 kg (15,000 lb) were placed in Group 1, and those with over 6818 kg were placed in Group 2 (Table 1; Fig. 2). Group 3 harvesters consisted of those individuals not recording a landing until August 1. In both 1978 and 1980, the major factor causing the large differences in total landings between groups was number of harvest days. Group 2 individuals were out an average four times more than Group 1 harvests (Table 1). The average weight per landing by Group 2 harvester was greater for both years by 33% to 35%.

It was concluded that Group 1 was likely a mixture of students and part-time harvesters, or harvesters who did not have buyer loyalty. The third group were those individuals who did not record landings at A.S.L. in June or July. They may have sold to other buyers in June and July, or near the end of the season, for various economic reasons, landings were sold in another person's name. These landings accounted for only 0.7% of the total harvest.

Data provided by Genu Products Canada Limited consisted of weekly summaries for total landings and number of deliveries by a selected group of harvesters. These individuals were identified by the buyer as loyal, consistently strong harvesters who participated in the harvest from June to August. Due to the subjective character of these data, they were treated separately when examining CPUE and effort.

PHYSICAL MEASUREMENTS

Wind direction and velocity, precipitation, and obstructions to vision were obtained from Yarmouth airport's hourly meterological observations. Wind direction and velocity measurements were averaged for each 4 h daylight low tide period based on the Yarmouth reference port.

Yearly comparison of low tide heights and frequencies were based on Atlantic Coast and Bay of Fundy Canadian Tide and Current Tables, 1978-80, using Yarmouth as the reference port.

COMPETITIVE/ALTERNATIVE FISHERIES

The degree of competition for fisheries labor or impact on total earnings was based upon the number of licences and yearly landings and landed value for the competitive fishery. Those fisheries considered to be open to participation for a

Table 1. Landings, participation, and CPUE of two major subdivisions of harvesters selling to Acadian Seaplants Ltd. during June and July, 1978 and 1980.

Year	Group 1				Group 2			
	Percent of harvest force	Percent of June/July landings	Mean days out	Mean weight per delivery (kg)	Percent of harvest force	Percent of June/July landings	Mean days out	Mean weight per delivery (kg)
1978	65	22	7.3 ± 7.2	305	35	78	31.3 ± 11.1	455
1980	72	27	6.8 ± 6.9	293	28	73	29.0 ± 9.4	448

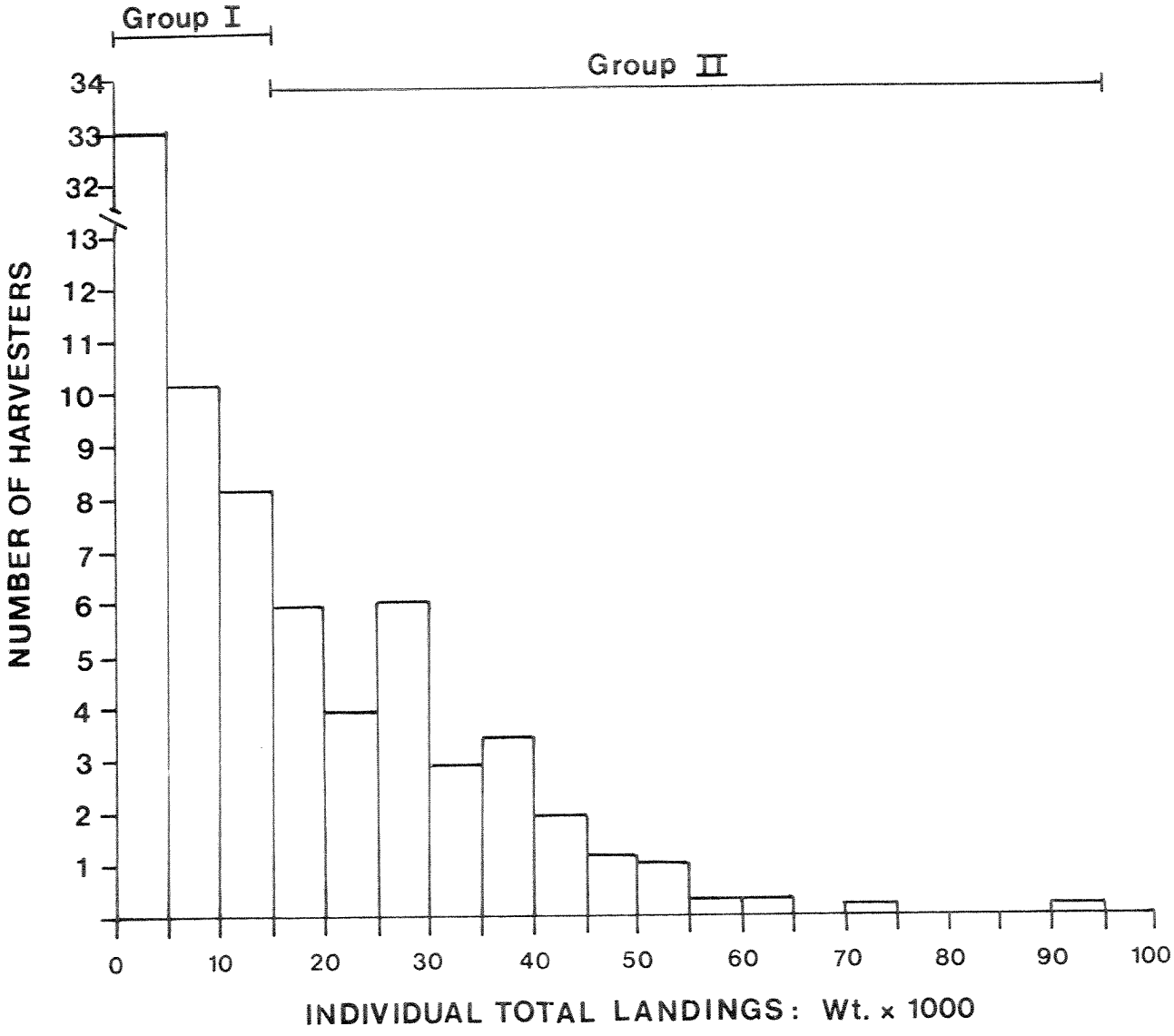

Fig. 2. Distribution of individual total landings for June and July, 1978, purchased by Acadian Seaplants Limited.

significant portion of Chondrus licence holders were examined. This information was compiled from existing documents or from the data files of the Statistics Section of the Department of Fisheries and Oceans.

Potential effort was derived from the total number of licences purchased for Chondrus harvesting in Districts 32, 33, and 34. The majority of these licences are purchased prior to June 7 and provide an indication of the total harvesting force available (except those individuals under 16 years of age).

CALCULATIONS

Data were treated with various statistical tests (Nie et al., 1975). Comparisons of mean values were made with Tukey's test. Single regressions were calculated with the subprogram Scattergram. A mutliple stepwise regression was used to examine the contribution of the variables, day of season, wind velocity, tide levels, and individual to variation in daily level of effort and CPUE (Nie, et al., 1975).

RESULTS

ANNUAL CATCH

Annual mean landings for District 12 were 10928 t (24,041,943 lb) from 1974 to 1978. Prior to this they fluctuated between 7000 and 12000 t (15,400,000 to 25,400,000 lb), reaching a maximum of 16238 t in 1969 (Fig. 3a). Landings in 1979 dropped to 1972 to 1973 and 1964 to 1965 values. However, 1980 landings of 5769.4 t (21,692,680 lb) were the lowest in 20 years.

The decline in landings since 1978 was not attributable to any one of the three statistical districts (Fig. 3b). However, a significant change was found in the total monthly landings through the season. Normally, total July landings exceed June totals (Fig. 4). However, in 1980, June landings were the largest proportion of the total landings in spite of fewer harvest days due to the June 7 season opening.

The total wet moss landings for A.S.L. in June 1980 were 27% lower than June 1978 (Table 2). Total deliveries during the same period dropped by 25%. In July 1980 the landings were 29% lower than 1978 and deliveries were down by 22% (Table 2). The company's wet moss landings were down by 26% overall and effort by 24%. The differential between the decline in A.S.L.'s landings and total season landings may relate to landings of dry

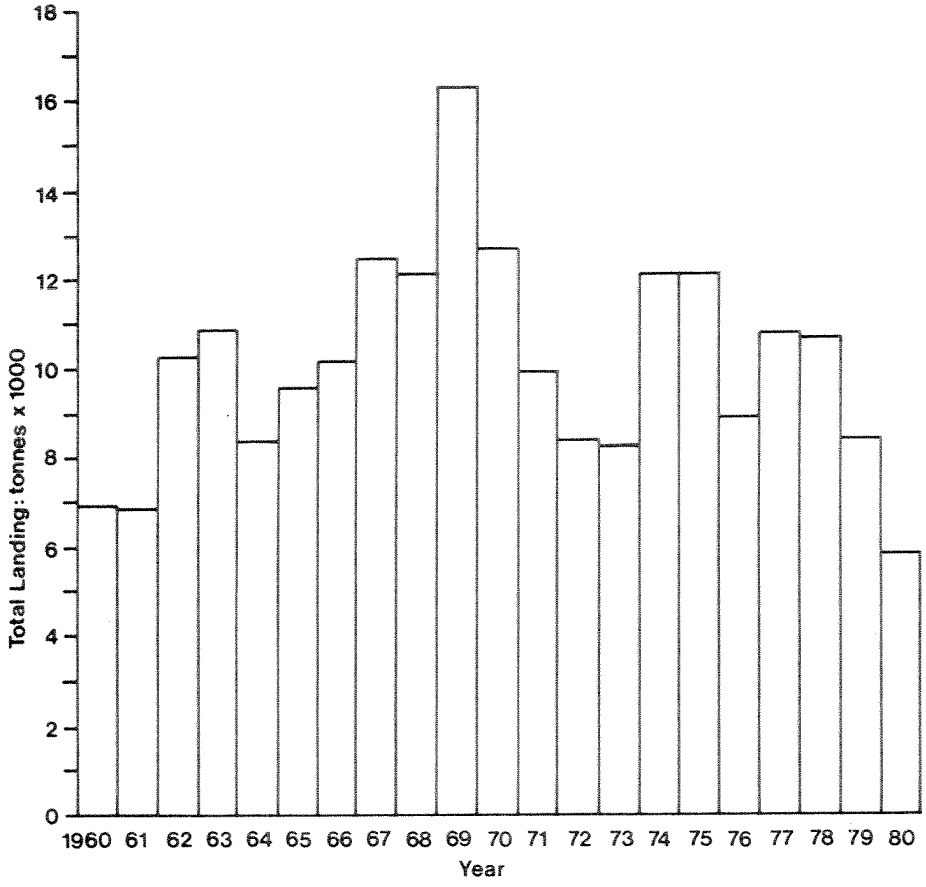

Fig. 3a. Yearly Chondrus landings (wet weight) in Marine Plants District 12, 1960 to 1980.

Fig. 3b. The relative proportions of yearly Chondrus landings in Marine Plants District 12 from the Statistical Districts 32, 33, and 34, 1978 to 1980. Total landings were 11,088.6, 8,282.7, and 5,769.4 t in the respective years.

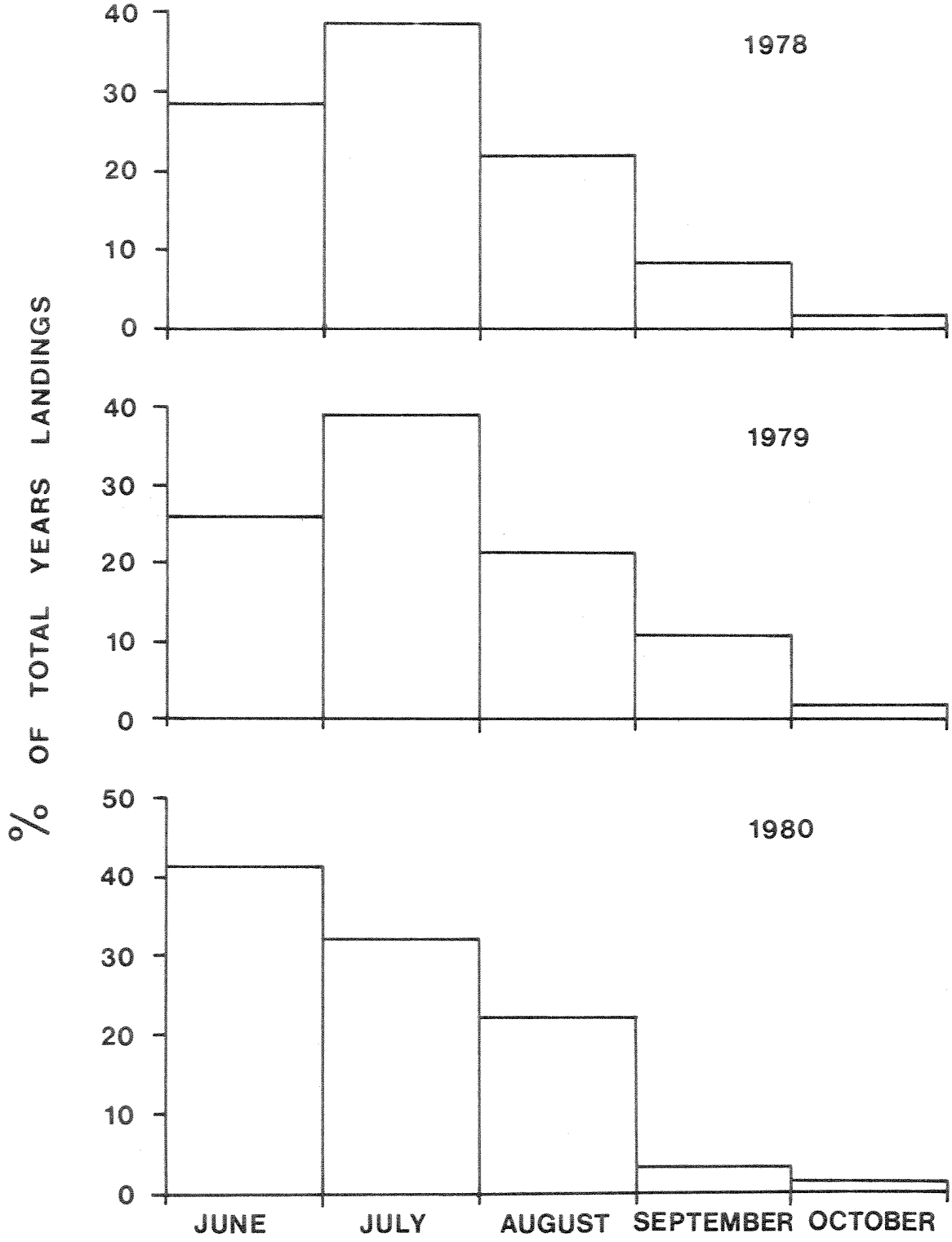

Fig. 4: The monthly proportions of yearly Chondrus landings, Marine Plants District 12, 1978 - 1980. Total landings in the respective years were 11088.6, 8282.7, and 5769.4 t.

Table 2. Monthly landings (TL)*, number of harvester deliveries (NOHD), days of recorded landings (DO), and average catch per unit effort (CPUE) for 1978 to 1980 are indexed on 1978 for between-year comparisons; within-year comparisons are indexed on June of each year - Statistical Districts 32, 33, and 34. (Purchase of wet moss ceased mid-September, 1980.)

Year	June				July				August				September			
	TL	NOHD	DO	CPUE (kg)	TL	NOHD	DO	CPUE (kg)	TL	NOHD	DO	CPUE (kg)	TL	NOHD	DO	CPUE (kg)
1978	1.00 (1.00)	1.00 (1.00)	21	438.5	1.00 (0.93)	1.00 (1.15)	26	357.2	1.00 (0.52)	1.00 (0.73)	27	312.2	1.00 (0.11)	1.00 (0.16)	26	303.3
1979	0.87 (1.00)	0.87 (1.00)	21	436.5	0.71 (0.77)	0.69 (0.92)	26	366.4	0.62 (0.37)	0.60 (0.50)	29	320.5	1.96 (0.26)	1.47 (0.28)	25	402.8
1980	0.73 (1.00)	0.75 (1.00)	21	422.7	0.71 (0.91)	0.78 (1.20)	27	325.5	0.93 (0.67)	0.87 (0.86)	26	327.1	0.41 (0.06)	0.36 (0.08)	13	341.5

*Records corrected for differences in buying strategy.

moss, Mud Island moss, and buying strategy. As well, purchase of wet Chondrus ceased on September 15, 1980, versus mid October in 1978 and 1979. Between 1979 and 1980, landings dropped 8%, with a 1% drop in total effort.

By the fiftieth day of the 147-day season, 72% to 74% of the landings were completed in all years (Fig. 5). The relationship between cumulative catch and cumulative effort was closely linear for all three years. The slope of the line in 1980 after the first 1,000 units of effort dropped below the 1979 and 1978 plot lines, indicating a lower catch rate (CPUE). Total weekly landings had clear minimums and maximums in 1978 and 1980, which closely followed peaks and troughs of effort deliveries (Fig. 6a and b). The correlation coefficient between number of daily deliveries and landings was $R = 0.93$.

EFFORT

There were large daily fluctuations in effort (harvester, deliveries per day) (Fig. 7). However, there was a core of 150 harvesters available to respond to the best harvesting conditions for the first 50 days of each season. Harvesting effort declined through the season in all three years (Fig. 7). In 1980, purchase of wet Chondrus ceased on the one-hundredth day of the season. The maximum effort during any season was reached within Week 1 and declined thereafter. Although there was a large degree of daily variability in effort during the first 50 days of 1978, 17 days had greater than 150 deliveries versus six days in 1979 and four in 1980. Mean daily effort in 1978 did not drop significantly between June and July. In general, effort in 1978 was higher and sustained longer than in 1979 or 1980.

CATCH PER UNIT EFFORT

Mean daily CPUE mo^{-1} (landing/delivery) declined between June and July significantly in each year (Table 3). A further decline was observed between July and August of 1979 and 1978, while in 1980 it remained constant after June. The significant ($P < 0.05$) increase of monthly CPUE of September 1979 may relate to that year's high bycatch of algae. There was a significant difference ($P < 0.05$) in mean CPUE mo^{-1} between June of 1978 and 1980.

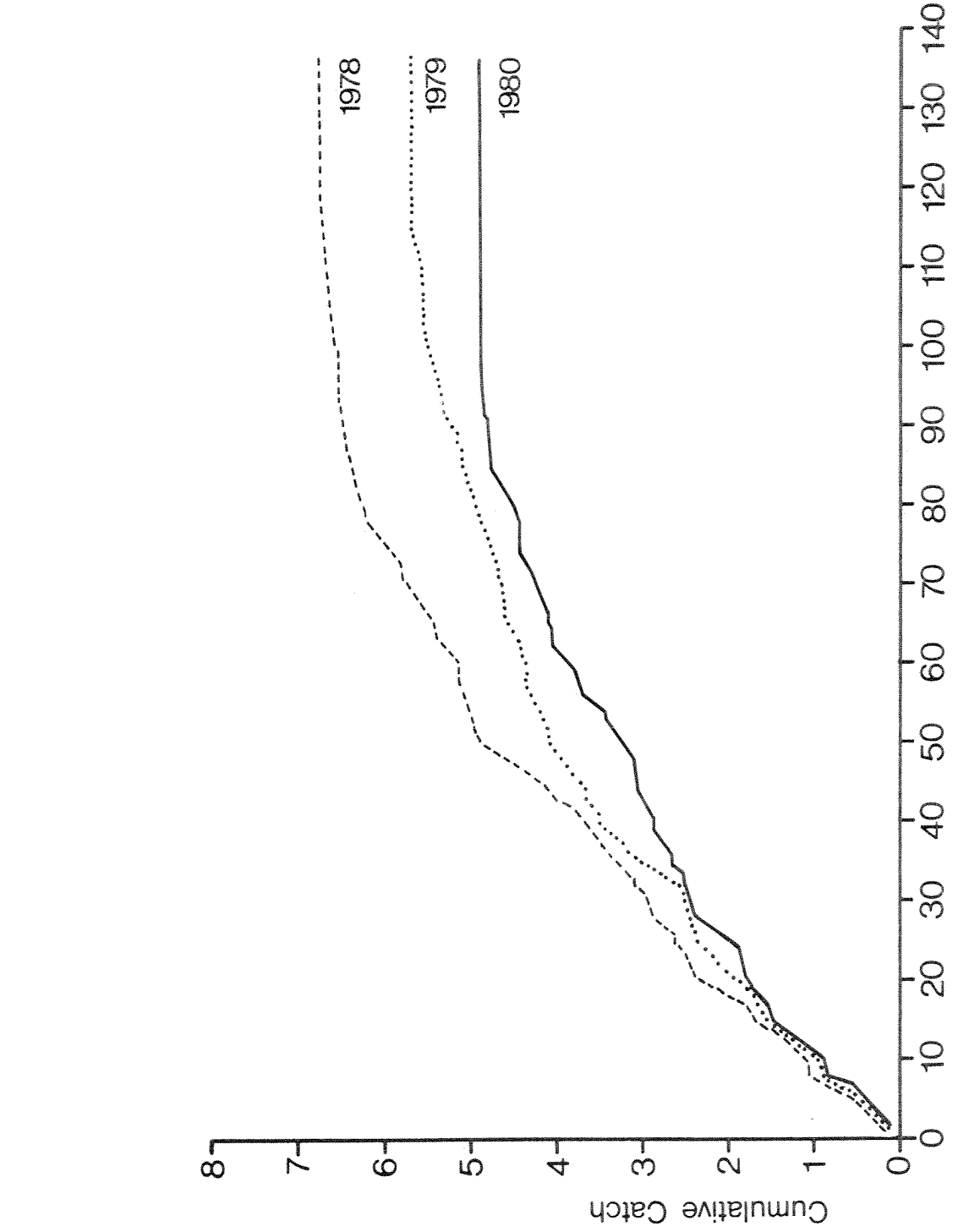

Fig. 5. Indexed cumulative landings of wet Chondrus (Acadian Seaplants Ltd.) during the 1978-80 harvesting seasons (June 7 to October 30).

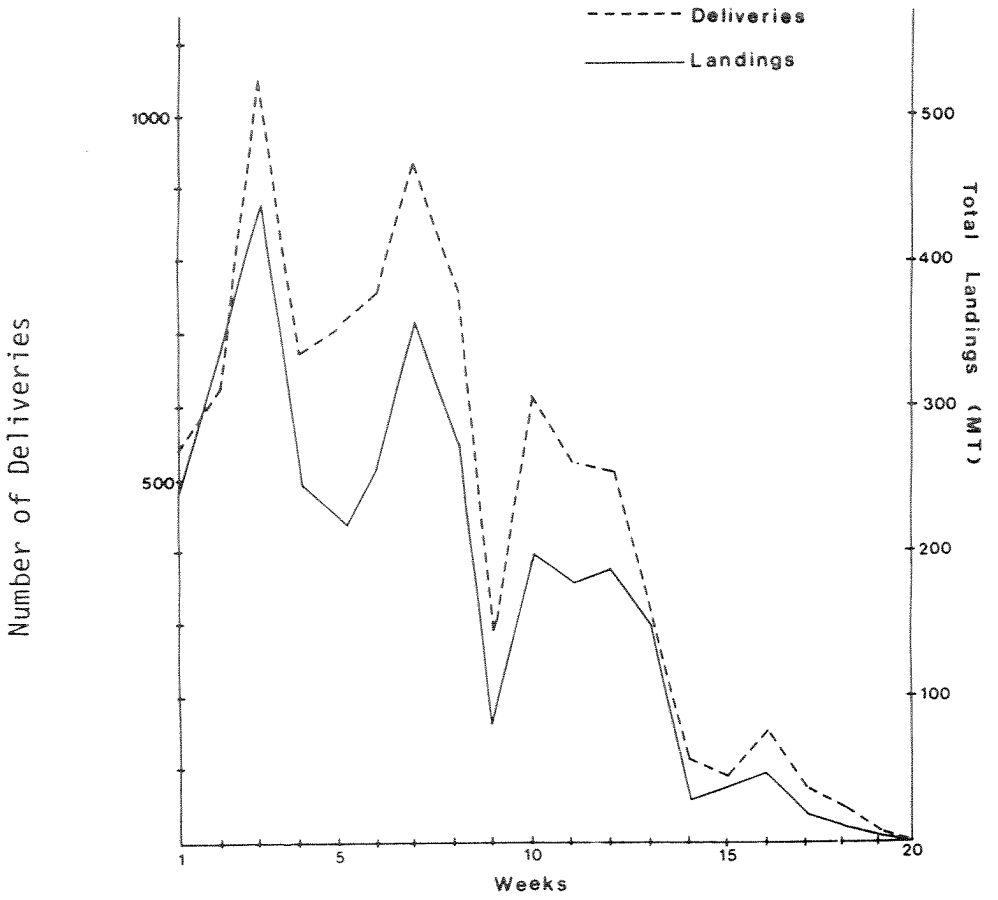

Fig. 6a. Weekly wet Chondrus landings and deliveries (A.S.L.) from Marine Plants District 12, 1978.

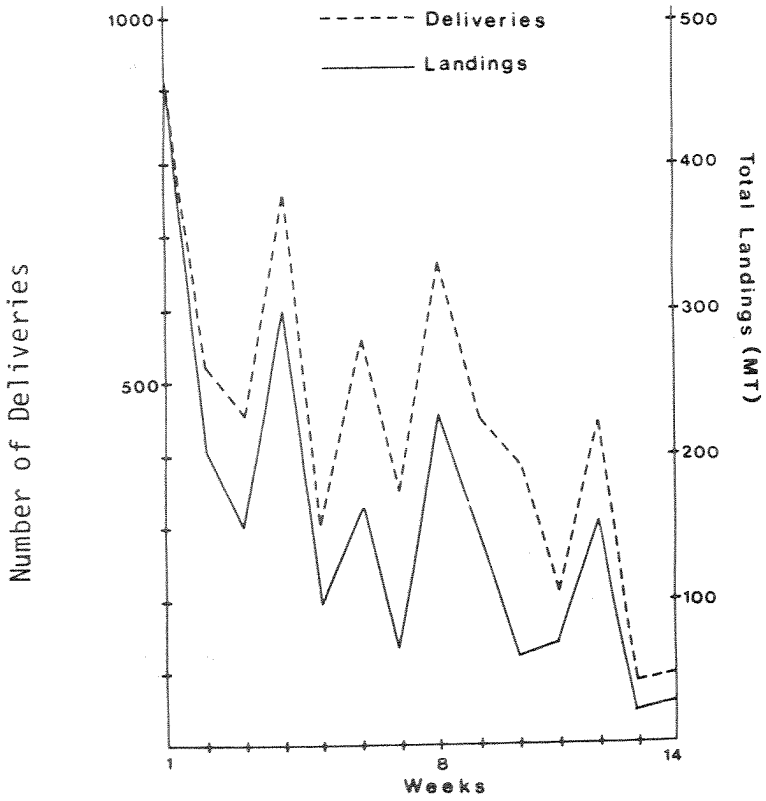

Fig. 6b. Weekly wet Chondrus landings and deliveries (A.S.L.) from Marine Plants District 12, 1980.

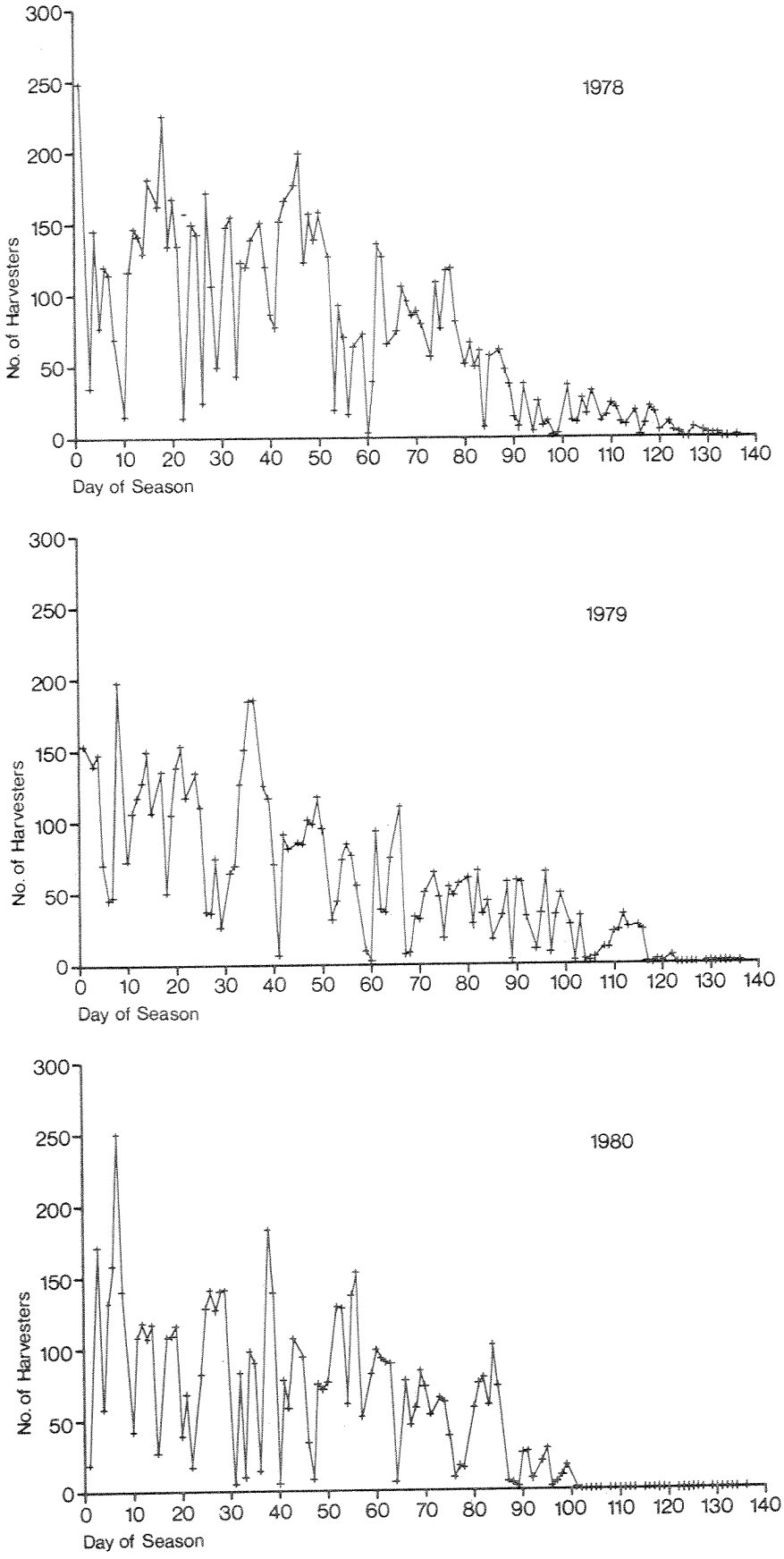

Fig. 7. Daily harvesting effort (number of individual deliveries to Acadian Seaplants Ltd.) in Marine Plants District 12, 1978-80 (excluding Sundays), June 7 to October 31.

Table 3. Monthly mean CPUE (kg/delivery) for all harvesters sampled in Statistical Districts 32, 33, and 34.

Year	Mean kg/delivery ± standard deviation			
	June	July	August	September
1978	a,† 1*	b, 3	c, 5	c, 6
	437.4 ± 217.9	358.4 ± 195.8	311.6 ± 170.9	308.0 ± 173.9
1979	a	b	c	d
	442.1 ± 275.3	382.2 ± 302.8	328.0 ± 240.1	405.4 ± 257.3
1980	a, 2	b, 4	b, 5	b, 3
	426.2 ± 249.4	328.9 ± 208.3	329.1 ± 195.4	325.0 ± 197.4

†Within each year, values not significantly different have common letters.
*Between 1978 and 1980, values not significantly different have common numbers.

WEATHER AND TIDES

Catch

The peak of landings at Week 3 in 1978 corresponded to a period of extreme low tides (< 0.5 m) and predominantly light winds (< 7 kn) (Fig. 6a). The low values of Weeks 4 to 5 occurred when tides exceeded 0.5 m and winds were predominantly over 7 kn. The peak values at Week 7 again correspond to extreme low tides, light winds, and no obstructions to visibility.

Similarly, the pattern of weekly landings in 1980 (Fig. 6b) could be related to tide levels, wind, and weather conditions. During the minimum landing period of Weeks 2 and 3, low tides were over 0.8 m and average winds were over 7 kn. The peak at Week 4 coincided with tides $\leq$ 0.5 m and winds < 5 kn or winds from a northerly direction.

Effort

The number of deliveries was inversely related to tide height and wind speed (Table 4). A lack of response by harvesters to poor low tides may have contributed to the lower overall effort in 1980 when extreme low (< 0.3 m) tides were scarce (Table 5). Wind velocity may also have contributed to low effort, as there were nine (40%) fewer calm tides in 1980 and seven more tides with 5-10 kn winds than in 1978 (Table 6).

Catch per unit effort

On July 25, 1980, coinciding with low velocity winds, clear weather, and a 0.4 m tide, the CPUE was 97% of the opening-day value of 494.4 kg/delivery (1,092.1 lb). Adding the variables wind direction, wind speed, day of season, number of harvesters, and tide height in a stepwise multiple regression found after day of season and the number of harvesters, tide height was the third most important factor affecting in level of CPUE (Table 7). The sum of these variables resulted in a multiple R of 0.58. Between harvester variability due to a range of ages, skills and physical ability masked the effects of wind and tide. Although there were some definite differences in available numbers and excellence of low tides between 1978 and 1980 (Table 5), the overall mean CPUE was not significantly affected (Table 3).

Table 4. Multiple regression, stepwise addition of variables affecting number of harvesters (effort) landing on tides in 1980.

	Individual R	Multiple R	Significance
Wind direction	0.16	0.16	0.167
Wind speed	-0.20	0.26	0.074
Day of season	-0.31	0.45	0.001
CPUE	0.30	0.46	0.002
Tide height	-0.27	0.52	0.002

Table 5. Daylight tides: (5:30 a.m. to 8:30 p.m., excluding Sundays) based on Yarmouth reference port - 1978-80 - Canadian Atlantic Coast tide tables - Fisheries and Marine Service.

Tides	Year	June	July	August	Total
Total daylight tides	1978	27	32	32	91
	1979	29	36	35	100
	1980	23	32	34	89
Tides $\leq$ 0.8 m (2.5 ft)	1978	18	18	21	57
	1979	23	18	18	59
	1980	15	23	17	55
Tides $\leq$ 0.3 m (1.0 ft)	1978	6	5	7	18
	1979	4	6	8	18
	1980	2	3	8	13
Tides $\leq$ 0 m	1978	1	2	0	3
	1979	0	0	2	2
	1980	0	0	1	1
Tides unuseable due to wind and/ or rain	1978	15	9	8	32
	1980	12	13	10	35

Table 6. Weather conditions on low tide periods - June to August, 1978 and 1980 - Yarmouth Weather Station.

Month	No. of daylight tides	Average wind velocity (km)			Prevailing wind direction						W & O.V.†	
		5	5-10	≥ 10	NW	NE	SW	SE	S	W	Rain*	Fog
Year 1980:												
June	23	1	12	10	4	0	11	5	0	3	4	2
July	32	6	22	6	9	3	14	8	0	0	4	11
August	34	6	22	6	9	3	14	8	0	0	4	11
TOTALS:	89	13	56	22	22	6	39	21	0	3	12	24
Year 1978:												
June	27	3	14	10	5	0	13	6	2	1	8	5
July	32	6	19	7	8	3	17	3	1	0	2	8
August	32	13	16	3	9	5	12	5	0	1	6	10
TOTALS:	91	22	49	20	22	8	42	14	3	2	16	23

† Weather and obstructions to vision.
* Rain = measurable precipitation.

Table 7. Stepwise multiple regression, addition of variables affecting mean daily CPUE in 1980.

	Individual R	Multiple R	Overall significance
Wind direction	0.11	0.11	0.348
Wind speed	-0.02	0.12	0.628
Day of season	-0.44	0.47	0.001
Number of harvesters	0.25	0.47	0.002
Tide height	0.32	0.58	0.000

SELECTED HARVESTERS

Acadian Seaplants Limited

Landings: Total daily landings were negatively correlated with day of season (Group 1, R = 0.54; Group 2, R = 0.47) (Fig. 8a). Cumulative catch plotted against cumulative effort found the rate of catch was lower for Group 1 than Group 2 (Fig. 8a). Group 2 harvesters had a decline in mean total monthly landing per individual over the season (Table 8). In 1980, the mean monthly landings were lower than in the previous two years except in August. Overall, Group 2 harvesters' landings for the season declined on average by 3881 kg per individual between 1978 and 1980.

Effort: Daily effort was defined as the number of deliveries per day excluding Sundays. Daily effort for Groups 1 and 2 varied by factors of ten within months and declined overall with day of season in 1980 (Fig 8b).

Catch per unit effort: The average daily CPUE of Groups 1 and 2 showed parallel trends of highs and lows throughout the 1980 harvesting season. The day-to-day variability was greater than seasonal trends. Both Groups 1 and 2 had a sharp drop in CPUE over the first ten days of the 1980 season. No correlation with season was found in Group 1, R = 0.05; a -0.41 R value was calculated for Group 2 (Fig. 8c).

Genu Products Canada Limited

Maximum landings for selected harvesters from Genu Products Canada Limited occurred in 1979, which was also the year of maximum deliveries (Table 9). The mean CPUE per month declined significantly each year after June, except in 1979 (Table 10). There was no significant difference between CPUE in June of the three years.

Marine plant harvesting licences

There was a 13% drop in licensed individuals from 1978 to 1980, mainly as a result of declines in Statistical District 32 and 33 (Table 11). Annually, approximately one-third of the previous year's licenses are not renewed and one-quarter of the year's licensees are new. A core group of 521 licensees (44%) were found in both 1978 and 1980 (Table 11).

The average age of Irish moss license holders in 1980 was 36 (Fisheries and Oceans license records) in Statistical Districts 32, 33, and 34. The mode was at ages 30 to 35 (Fig. 9). Attrition was rapid after this age group, although

Table 8. Mean total landing of wet Chondrus crispus per month per harvester in Group 2 (> 15,000 lb by August 1) - 1978 to 1980.

Year	Month												Totals	
	June			July			August			September				
	Landing (kg)	Landing (lb)	No. of harvesters	Landing (kg)	Landing (lb)	No. of harvesters	Landing (kg)	Landing (lb)	No. of harvesters	Landing (kg)	Landing (lb)	No. of harvesters	(kg)	(lb)
1978	8099	17,817	126	7574	16,663	124	5216	11,475	100	1952	4,294	56	22840	50,249
1979	8320	18,304	97	7139	15,706	97	3713	8,169	77	3387	7,451	60	22559	49,630
1980	6547	14,403	101	6245	13,740	100	5018	11,039	88	1149	2,528	44	18959	41,710

Table 9. Genu Products Canada Ltd. landing data - selected harvesters.

Year	Total landings (t)	No. of deliveries	Mean weight per delivery (kg)	(lb)
1980	586.2	937	253.2	547.7
1979	659.6	1,217	285.0	508.6
1978	645.3	1,181	141.0	486.4

Table 10. Monthly mean CPUE for selected harvesters selling to Genu Products Canada Ltd., 1978 to 1980.

Year	Month			
	June	July	August	September
1980	1, a†	2, bc*	3, ab	4, c
	643.2	492.3	566.4	422.3
1979	1, a	2, a	4, b	4, ab
	556.8	555.0	419.5	457.7
1978	1, a	2, b	3, b	4, c
	575.0	500.0	456.0	364.0

†Within-years' values indexed by common letters are not significantly different.
*Between-years' values the index is a number.

Table 11. Numbers of licensed marine plant harvesters in Statistical Districts 32, 33, and 34, 1978 to 1980.

Statistical Districts	1978	1979				1980			
	Total	Renewal	Non-renewal	New	Total	Renewal	Non-renewal	New	Total
32	314	207	108	99	306	196	110	77	272
33	439	290	149	100	390	268	123	103	371
34	155	103	51	43	146	85	60	59	145
Totals:	908	600	308	242	842	549	293	239	788

1978 versus 1980			
Statistical Districts	Renewal	Non-renewal	New
32	178	137	95
33	256	183	114
34	87	67	58
Totals:	521	387	267

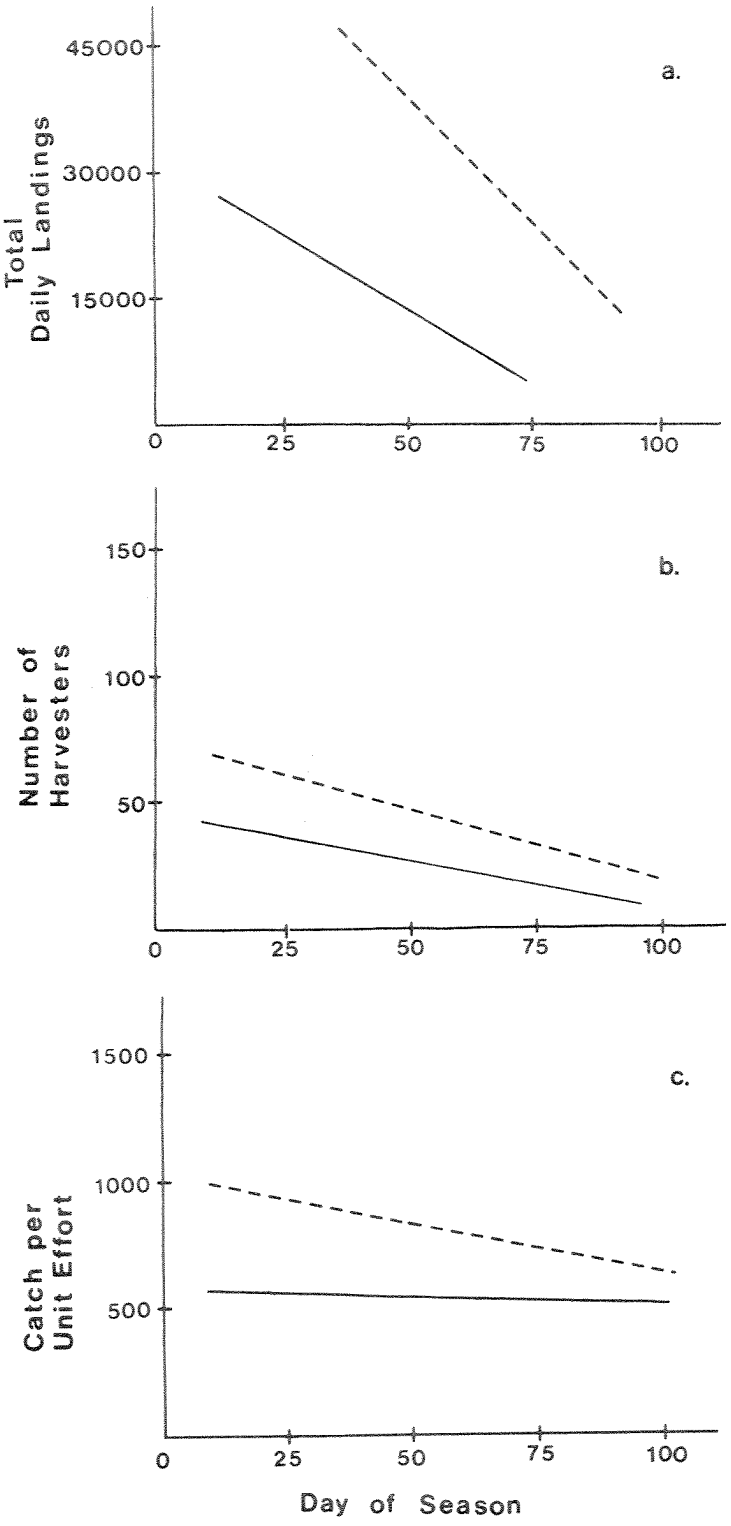

Fig. 8. a) Regression lines for total daily landings against day of season - Group 1 (——) and Group 2 (----), 1980.

b) Regression lines for effort against day of season - Goup 1 (——) and Group 2 (----), 1980.

c) Regression lines for CPUE against day of season - Group 1 (——) and Group 2 (----), 1980.

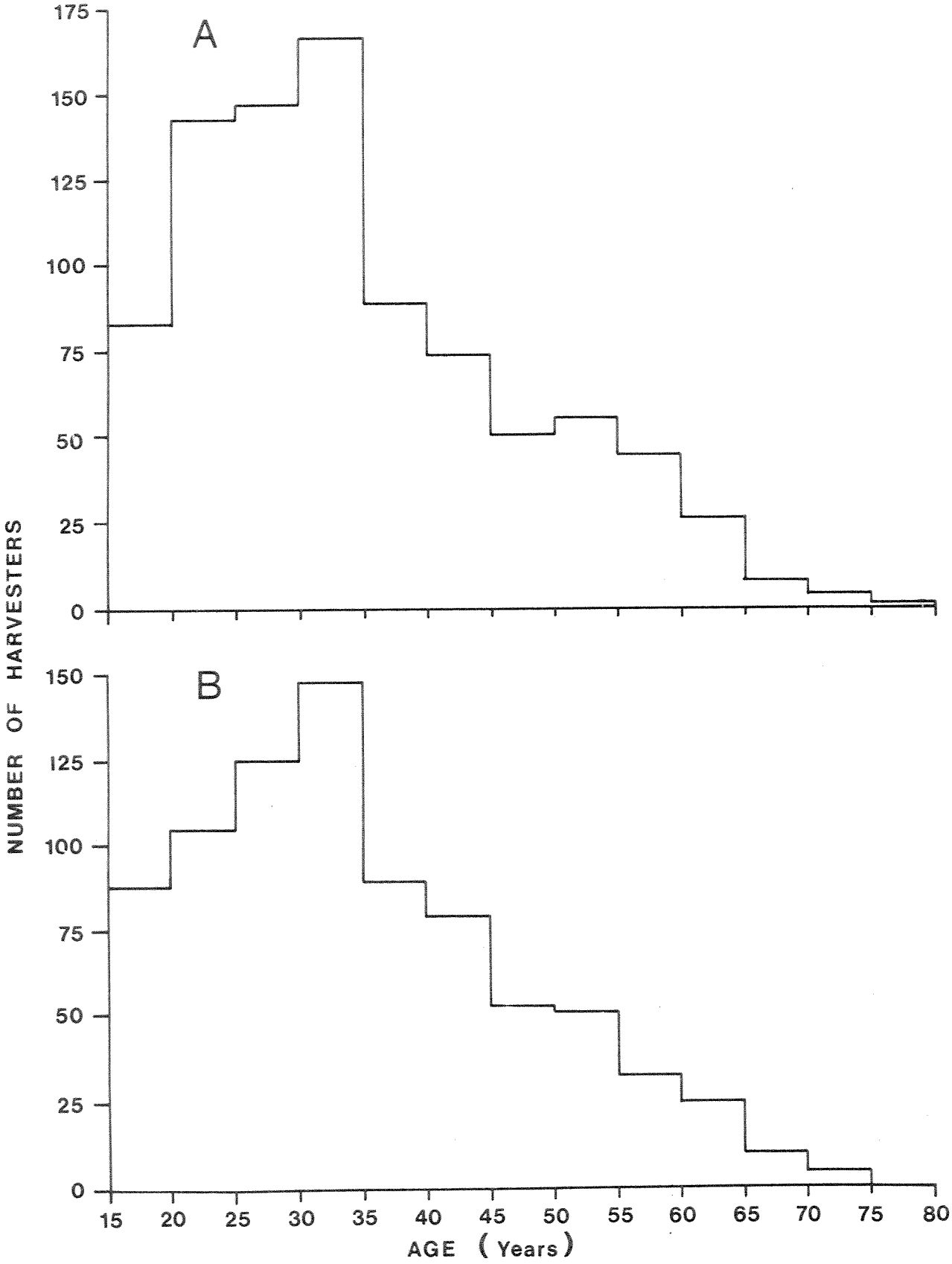

Fig. 9. The distribution of ages for the holders of Marine Plant licenses in District 12.
A. 1978
B. 1980

there were 42 licensed individuals over the age of 60 in 1980 (Fig. 9). New license holders in 1980 were primarily in the 20 to 35 year age group (Fig. 10a). Persons not renewing their licenses in 1980 were mainly in the 15 to 30 year age group (Fig. 10b).

Interviews of 104 active harvesters in 1975 found the average number of years of participation in the industry was 11 years. Examination of the distribution of participation found the largest mode (36) in the 0 to 5 year age group, with a 34.6% drop to a second mode (19) in the 15 to 20 year age group (Fig. 11). In 1975, there appeared to be a core group of experienced harvesters with a good influx of beginners. From these data, we would expect the majority of individuals with 15 or more years in the industry to have dropped out by 1980. The large influx of 0 to 5 year harvesters should be in the 20 to 25 year age group. This was not apparent in our data.

Although these data do not account directly for all the school-age harvesters, we are unlikely to find a larger group of 14 year olds ready to enter the fishery than in any previous years. Population projections for Yarmouth County based on the 1976 census show a slight net decrease in 15 to 35 year old males to the year 1986 (Coffey, 1979). These projections also predict an overall decrease in the labor force of Shelburne and Yarmouth Counties.

Possible factors affecting the degree of participation by full-time fishermen (boat owners and deckhands) are:

a) their success in the preceding lobster season;
b) the returns of inshore groundfishing (boats up to 25.5 t - longliners and draggers);
c) the initiation date and success of the summer/fall herring fishery;
d) offshore fishing activity; and
e) onshore job opportunities (mainly fish processing).

Each of these competitive fisheries was examined from 1978-80 and their impact on the Irish moss industry evaluated.

ALTERNATE FISHERIES

Lobster Fishery

Lobstering in Statistical Districts 32, 33, and 34 does not compete directly with the Chondrus harvest, as the fishing seasons are complementary. However, a successful lobster season will reduce the need to supplement the fishermen's income. A

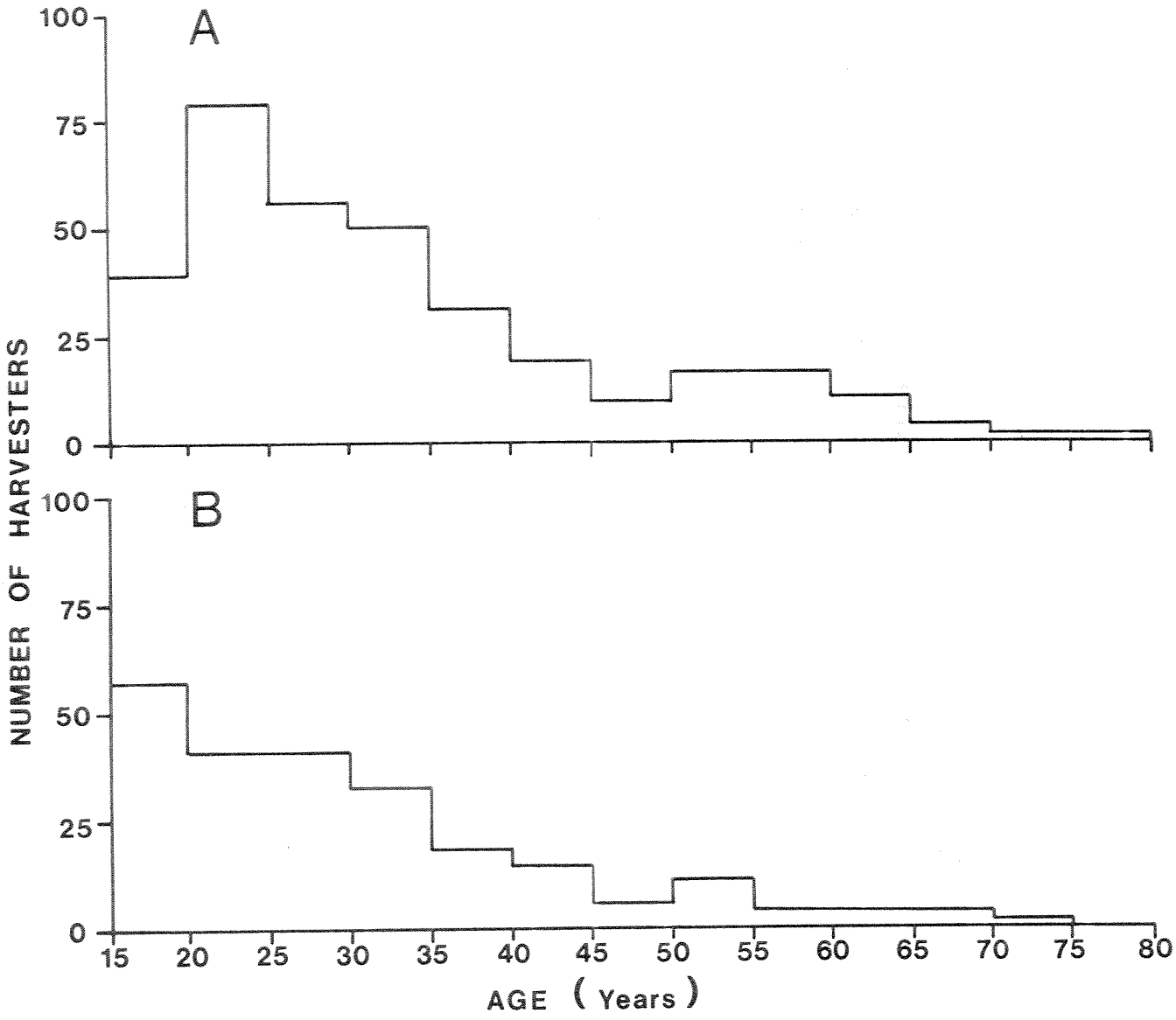

Fig. 10. A. Age distribution of new licensees in 1980.

B. Age distribution of licensees in 1978 who did not register in 1980.

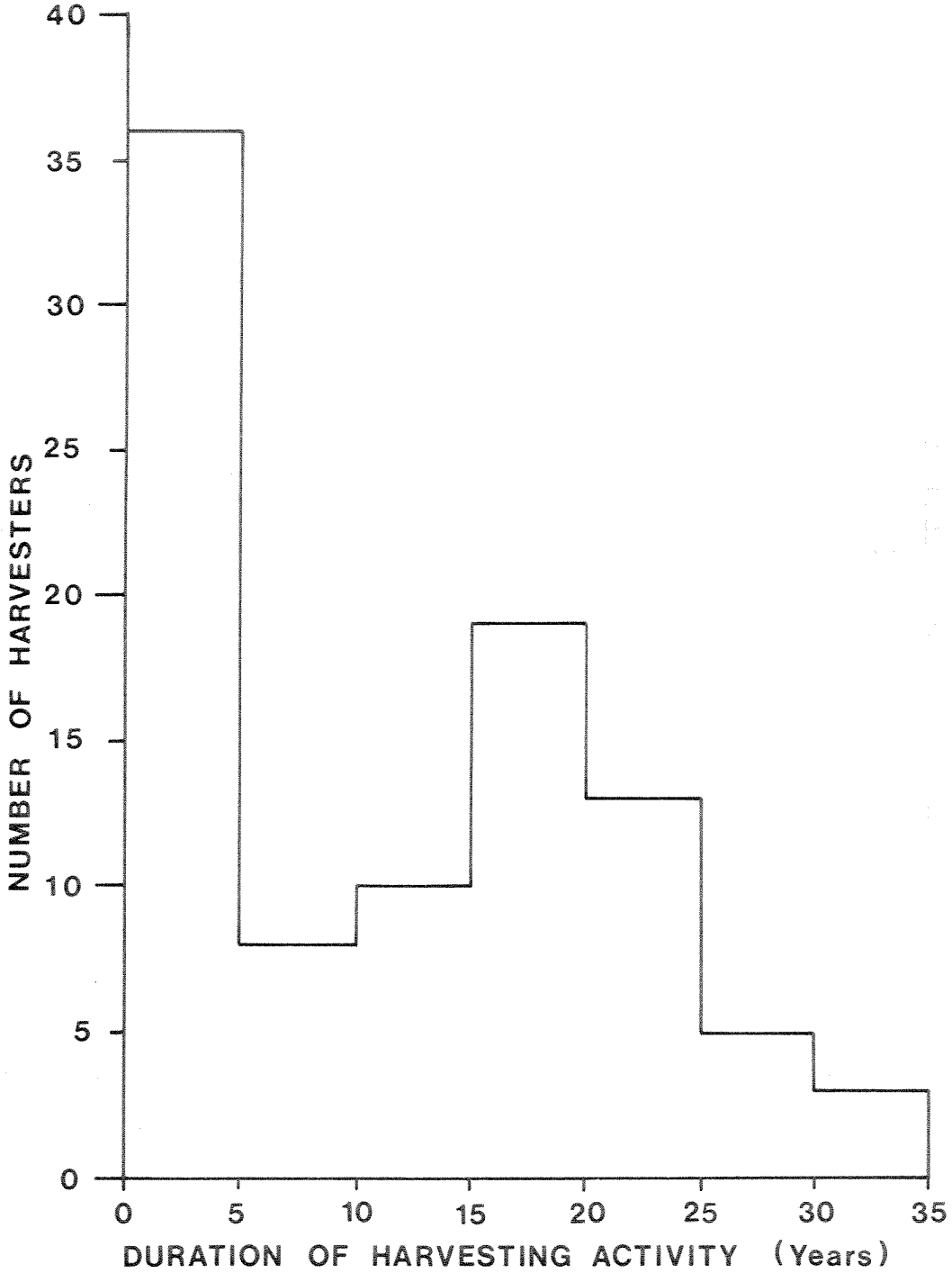

Fig. 11. Duration of participation in the Chondrus harvest by polled harvesters, 1975.

premature departure from the Chondrus harvest may occur if most of this additional income is lost due to taxation or if the amount of harvest becomes too low to allow maximum unemployment insurance benefits.

Lobstering is a limited-entry fishery. However, inshore catches within Districts 32, 33, and 34 have increased during 1978 to 1980 by 23%, while landed value has increased by 28%. District 32 landings increased by 52% between 1978 and 1980 (Table 12). The spring landings were better than the fall in Statistical Districts 32 and 33, which is the reverse of the pattern since 1968 in southwestern Nova Scotia (Stasko and Campbell, 1980). In summary, over the past three years the negative effects successful lobstering has on Chondrus harvesting effort have increased.

Inshore groundfish (draggers and longliners)

The number of inshore draggers and longliners (boats 25.5 t or less and less than 13.7 m long) has increased in recent years. Groundfishing is the next upward step in the fishing industry for individuals with significant assets in the lobster industry. Many of these individuals were Irish moss harvesters previously.

The number of small draggers has been limited since the removal of back-pocket licenses in the fall of 1979 (approximately 300) and a freeze on the issuance of new licenses in 1980. A total of 112 otter trawl licenses existed in Statistical Districts 32, 33, and 34 during 1980. Longline licenses have not undergone any restrictions but have declined from 535 in 1979 to 426 in 1980.

Between 1978 and 1980, there was an 18% increase in inshore groundfish landings and a 54% increase in landed value (Table 13). The price per kilogram of all major groundfish species has risen between 30% and 40% over these three years. Total groundfish landings (inshore and offshore) have increased each year and in 1980 were up by 6400 t over 1978; landed value was up by 54% (Table 14). The 1981 groundfish plan at present provides a strong provision in the quotas for inshore vessels.

Although there was an increase in both groundfish landings and value, a pertinent question in an inflationary economy is whether the real income of groundfishermen has increased in recent years. An analysis of average earnings for 12 m longliners found 1979 skipper and net boat earnings were up by 122% over 1977; crewmembers' earnings were up by 74% (Table 15). Peak inshore groundfish fishing activity occurs in the summer months; its competitive impact on Chondrus effort is direct and has increased in recent years.

Table 12. Seasonal inshore lobster landings (t) - Statistical Districts 32, 33, and 34, 1977 to 1980.

Years	Statistical Districts 32		33		34		Seasonal total - all districts		Yearly total	Value ($,000)
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring		
1977-78	345	453	244	408	490	375	1079	1236	2315	12,953
1978-79	451	655	293	476	362	384	1106	1515	2621	16,150
1979-80	575	642	313	440	548	332	1436	1414	2850	16,576

Table 13. Inshore vessels (< 25.5 t). Groundfish landings and value - Statistical Districts 32, 33, and 34 - 1978 to 1980.

Species*	Year					
	1978		1979		1980	
	t	Value ($,000)	t	Value ($,000)	t	Value ($,000)
Cod	5151	2,215	5886	4,019	7013	3,682
Haddock	3096	1,393	2230	1,067	3770	2,144
Halibut	171	460	166	544	183	500
Yellowtail	126	38	56	26	81	33
Pollock	505	141	1303	482	1307	455
Common Hake	328	102	552	193	510	188
Cusk	2049	594	1838	688	1892	714
Totals:	11426	4,933	12031	7,580	14756	7,716
All groundfish:	12615	5,313.5	13623	7,580	16205	8,559

*Exceeding 100 t.

Table 14. Offshore landings (excluding herring and lobsters) - Statistical Districts 32, 33, and 34.

Species	Year					
	1978		1979		1980	
	t	Value ($,000)	t	Value ($,000)	t	Value ($,000)
Scallops	8323	4,748	4829	4,013	4969	4,749
Offshore groundfish	9888	3,941	12988	5,638		
Combined inshore and offshore groundfish	22503	9,254	26611	13,218	28936	14,259

Table 15. The average earnings (income) for skipper, boat, and crewmember for the average 40 ft. longliner operating in Southwestern Nova Scotia.

	Year						
	1977	1978		1979		1980[2]	
	actual	actual	estimated	actual	estimated	actual	estimated
Skipper/owner earnings	$10,421	$10,216	$11,463 [1]	$10,668	$12,609	$18,491	$13,870
Net boat earnings	6,577	5,586	7,235	15,600	7,959	19,296	8,754
Subtotal:	$16,998	$15,802	$18,698	$26,268	$20,568	$37,789	$22,624
Crewmember earnings	8,459	6,909	9,305	11,668	10,235	14,749	11,259

[1]Earnings adjusted upwards by 10% annual inflation rate.
[2]1980 sample had five vessels as opposed to three in 1979.

Scallop landings are reported mainly from District 34. However, this lucrative fishery can attract individuals from surrounding areas. Landings in 1980 were down by one-third over 1978; however, strong price increases have kept the landed value stable (Table 14). Although the scallop fishery has a high value and peaks in the summer months, its proportion of the labour pool is small. A total of 15 offshore scallop vessels were based in Yarmouth and four were based in Pubnico.

Herring

The herring set and drift gill net fishery can be entered by any lobster boat owner willing to make minor modifications and a relatively small capital investment. The season varies with the occurrence of the fish but usually peaks in the late summer months. When fish are plentiful and the price stable, gross returns can be in the thousands of dollars per night. Each boat utilizes three to four crewmembers. As a result, this fishery can have a significant impact on moss harvesting effort in July and August. Preparation and participation dates depend on the pattern of early-season landings. The use of herring as human food rather than animal meal has increased the price from $20/ton to $200/ton. Gill net landings in 1978 were 3320 t, valued at $631,000; they quadrupled to 13983.5 t in 1980, for a value of $2.5 million. The onset of the drift net fishery is of more importance than the set net fishery as this gear type requires full-time participation. The set net fishery accounted for a small peak in landings between May and June 1978 and 1979 (Fig. 12). The drift net fishery contributed 75% to 80% of the landings between July and September. In 1980, drift net landings were 71% (9890 t) of the total gill net landings and peaked in Weeks 35 to 37 (Fig. 12). In 1978, significant drift net catches (> 10 t) occurred in Week 27 onward. Significant drift net catches did not occur in 1979 until Week 33 but rapidly rose above the 1978 levels. By Week 25 (mid June) in 1980, significant drift net landings were recorded (Fig. 12). Drift net effort, as measured by the number of deliveries per week, peaked at 387 in Week 34 of 1978, 257 in Week 37 of 1979, and 608 deliveries in Week 33 of 1980. Total drift net deliveries in 1978 were 1,361 for 2526.6 t (1.86 t/delivery); in 1979, 2904.15 t were landed in 1,043 deliveries (2.78 t/delivery); and in 1980, 11448 t were landed in 3,552 deliveries (3.2 t/delivery).

The 1979 4WX herring assessment predicted a strong 1976 year class of fish which should give increased catches through to 1982 (Sinclair and Iles, 1979).

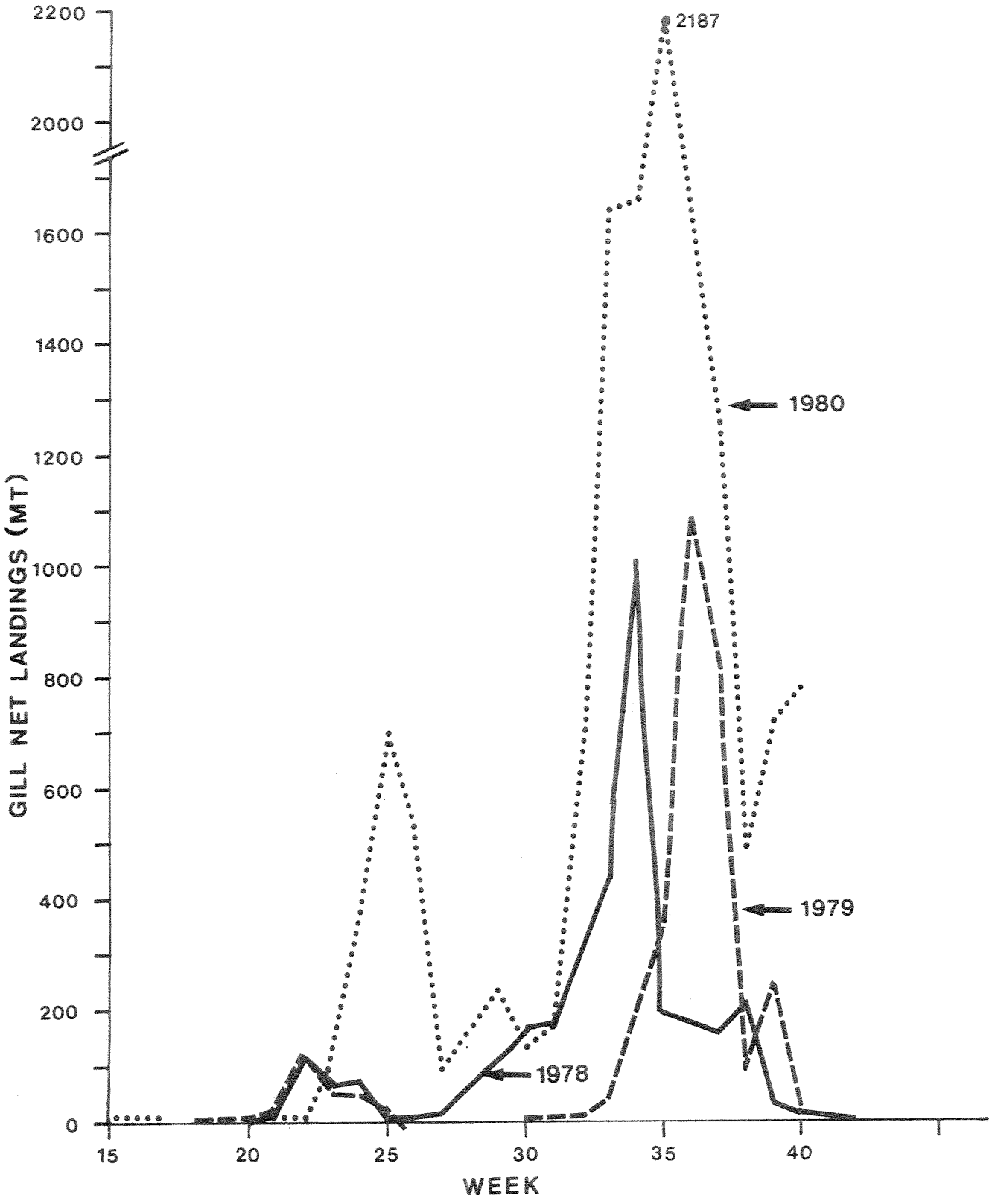

Fig. 12. Weekly landings and deliveries of gill net herring from Statistical districts 32, 33, and 34. 1978-1980.

Fish processing

Increased groundfish landings and the more labour-intensive processing of herring for human consumption has led to a boom in fish plant development. The majority of plant workers are non or semi-skilled. Due to the seasonality of the fishery, jobs are open to school children as well as persons working in the lobster fishery. In 1979 to 1980, there were a total of 46 plants in Statistical Districts 32, 33, and 34, employing 1,607 individuals (Anonymous, 1980). In 1975, there were 33 plants employing 663 workers (Anonymous, 1975). A high percentage of these workers are females who have not traditionally been involved in harvesting Chondrus. However, males in the 15 to 20 year age group are recruited, which could affect effort in the Chondrus fishery.

DISCUSSION

The 48% drop in annual landings between 1978 and 1980 to a pre-1960 level cannot be attributed to any one factor. The decline in landings was not isolated geographically, as all three statistical districts had a similar proportion of the landings (Fig. 3). Environmental factors, stock abundance, and effort were widely different between 1978 and 1980. Solar radiation both prior to and during the harvest season was below average in 1980 and above average in 1978 (unpublished Charlesville aquaculture site data). This may have contributed to the 25% lower standing crop in June 1980 and lack of recovery to 1978 levels by July (Sharp, unpublished data). During the 1978 harvest season, favorable tides, winds, and precipitation provided better harvesting conditions than in 1980. These factors resulted in a 1978 resource base that was both larger and more accessible than in 1980.

Irish moss harvesting is one of the few fisheries left which involves solely manual labour and extremely irregular work hours. The harvest requires individuals to crop with rakes for 3 to 4 hours, as regulated by tidal cycles. Most other fisheries have adopted mechanization. The number of work days and productivity are greatly affected by changes in weather and sea state (see section on effort and CPUE). However, there has in the past been a strong tradition of entry into "mossing" as a supplementary income between other fisheries. Prior to the 1980 season, there was a 13% reduction in the number of licensed harvesters, largely in the highly productive 20 to 30 year age group. Total season effort (number of deliveries) was 20% lower in 1980 than 1978. The active harvest force June-July (individuals) based on our sample and total landings was down by 25% overall and by 30% in the Group 2 high-output harvesters.

The magnitude of the first week's effort in 1980 was misleading due to a Saturday opening day. This allowed a larger number of part-time harvesters to participate than usual. The rapid drop-off in effort following the first week in 1980 can be partially attributed to the value and activity of competitive fisheries. The most important competitor was the herring fishery due to its early start in 1980 and level of landings. Significant gill net landings (> 100 t) occurred by mid June when generally only small landings occur. Harvesters encountering both poor weather and tides at this time were thus encouraged to begin herring fishing earlier.

There was a small but significant ($P < 0.05$) 4% decrease (19.3 kg) in average CPUE between June 1978 and 1980. If abundance were down by 25% from 1978, we would expect a much larger drop in CPUE. However, these data reflect only daily landings and do not account for an increased harvesting time per day or harvesters choice to eliminate low or moderate yielding beds for harder-to-reach but more-productive areas. The Genu Products Canada Limited data illustrated the ability of highly productive harvesters to compensate for any changes in resource abundance or accessibility through the season or between years.

Other factors may have affected the acceptable level of daily individual landings. First, the price per pound did not change between 1978 to 1980 (6.5¢/lb, 14.3¢/kg). Due to inflation (10%/yr), a CPUE of 441.0 kg day^{-1} ($62.71) in 1978 must increase by 20% to 529.4 kg day^{-1} to provide equivalent earnings. In 1980, average daily CPUE did drop after the first week until early July, further encouraging a departure to other more lucrative fisheries.

Effort in the Irish moss fishery is sensitive to weather conditions due to the size of the harvesting boat ($\leq$ 5 m) and the shallow-water operation. The decrease in average monthly CPUE for all harvesters following June in 1978 to 1980 suggests the accessible portions of easily reached beds were harvested within the first four weeks of the season. Periodic high daily average CPUE during the rest of the season corresponded to extreme low tides and excellent weather conditions. This suggests there were unharvested portions of the resource as late as September. As a result, accessibility of the resource becomes more important than absolute year-to-year variation in abundance after June. The differences in weather and tide between 1978 and 1980 were greatest in July and August. During July and August 1978 there were 19 tides with calm (< 5 kn) winds versus 12 in 1980. Therefore, a larger proportion of the bed areas were available to the harvester in 1978. This decrease in resource accessibility would likely discount any increase in resource abundance due to the 25% decrease in effort for June 1980 over 1978.

If competitive fisheries, particularly the herring fishery, are the principal reason for declining effort both during the season and between years, landings during the first 50 days of the season are most crucial. To enhance these landings there are two options. Option 1 is to increase the number of available tides prior to the herring season by opening the Irish moss season on June 1. If the total harvesting force was 800 with an average CPUE of 409 kg (900 lb) over seven tides, 2290 t would result. This strategy assumes that effort would not decline earlier due to a self-imposed landing limit in response to economic factors or entry into competitive fisheries. A second option for maximizing the first two months' landings is to increase the biomass by delaying the season start to July 1. A 20% increase in CPUE would result in a 6% landing increase if subsequent effort in September compensates for the loss of June tides. However, a 25% measured difference in abundance between June 1978 and 1980 resulted in only a 4% gain in CPUE. It is also unlikely that a 20% increase in CPUE would be sufficient to counteract the competitive value of the herring fishery.

At present, the industry depends on a large pulse of harvesters over the first 50 days of the season. This accentuates the importance of weather and tides in the initial 35% of the season. If a constant harvest force were maintained through all harvestable tides in a season, large fluctuations in total landings are unlikely to occur beyond yearly fluctuations in abundance and accessibility. However, the minimum level of effort cannot be directly estimated by the man-by-tide-by-catch-per-tide formula. We cannot predict weather in advance or the portion of any harvest force that will be active.

Developing a harvest technology more independent of tide and weather could increase harvester efficiency and allow a delay of the season opening to allow the crop to reach a peak. The cost of equipment and operation will require a highly efficient harvester and change the industry from one producing supplementary income to at least a secondary income base. The number of harvesters would be significantly less than the present 800 licensed. At the present time, no such technology is available for introduction.

SUMMARY

1. Annual Irish moss landings (5769.9 t) in 1980 were 48% below those of 1978 (11088 t).

2. The number of licensed harvesters (pre-season) in 1980 was 13% lower than that of 1978. The bulk of this reduction was in the 20 to 30 year age class.

3. The resource was approximately 25% less abundant (harvestable crop) through the 1980 season than in 1978 on the Lear Island bed.

4. The resource was less accessible in 1980 due to fewer harvestable low tides (10%) and fewer extreme low tides (28%) $\leq$ 0.3 m ($\leq$ 1 ft) than 1978.

5. Average monthly catch per unit effort (daily delivery) declined significantly in each year 1978 to 1980 after June. CPUE was 441 kg per day in June 1978 and 422 kg per day in June 1980. Average daily CPUE in 1980 dropped more rapidly than in 1979 and 1978.

6. CPUE was highly correlated with the following factors listed in order of correlation: a) individual harvester; b) day of season; c) tide level; and d) wind.

7. Highly skilled and productive harvesters are able to compensate for year-to-year fluctuations in resource abundance or accessibility to maintain a relatively constant CPUE.

8. The real price of Irish moss to the harvester was reduced by 20% in 1980 due to inflation and a static price during 1978-80.

9. The price paid for groundfish rose by 30% to 40% between 1978 and 1980; the price for herring rose dramatically between 1978 and 1980; the landings for both these inshore fisheries are up substantially. There is competition for labour between these inshore fisheries and the Irish moss fishery.

10. Total effort in certain ports in 1980, as determined by number of deliveries, was 75% of that in 1978.

11. Seventy percent to 74% of the total wet Irish moss landings are obtained in the first 50 days of a season.

12. Peak weekly landings corresponded to periods of clear, calm weather and maximum low tides.

13. In the 1978 and 1980 seasons, there was a core group of harvesters, 28% to 35%, who cropped 72% to 78% of the total June-July landings.

14. The core group of harvesters on average harvested four times the number of days and had a 35% higher average CPUE than the majority of harvesters.

SYNOPSIS

Landings in 1980 were 48% below 1978 levels primarily due to a reduction in effort. Poor resource accessibility and lowered abundance combined with the decrease in real value of Chondrus and increasing real value of competitive fisheries lead to the decreased level of effort.

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