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Effects of a by-catch of young redfish in the Port au Choix shrimp fishery--first implications

by

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Introduction

Shrimp fisheries in the Gulf of St. Lawrence are well-known to produce a visually impressive by-catch of young, unmarketable redfish. These fish are discarded and die. Consequently, each year millions of small/young redfish are removed through the Gulf fisheries. This paper attempts to assess the immediate and project the long-term effects of such removals and help place the problem in perspective. Data are minimal and the preliminary, one-point estimates should be viewed with caution.

Materials and Methods

In 1976 a two-pronged attach was initiated to assess the by-catch problem. The shrimp fishery at Port au Choix on Newfoundland's north-west coast was closely monitored to obtain reliable estimates of the by-catch. This practice was continued in 1977. Secondly, data were collected to obtain minimum biomass estimates of the stock of small redfish throughout the Gulf. In this analysis small redfish refers to fish $\leq$25 cm, a value selected between the two modes of redfish distribution presently evident in the area (Fig. 1). With estimates of the relative numbers of small fish and removals in the fishery, it was hoped to approach the percentage effect of these removals. Assessment of the long-term effects was accomplished using estimates of natural mortality (M) for small fish from two years of commercial sampling data.

Commercial Sampling

Sampling teams from the biological station is St. John's carried on monthly investigations into the shrimp fishery at Port au Choix for the 1976 and 1977 seasons (May through December). Data collected were: the catch weight ratio of shrimp to small redfish, the number of small redfish per kilogram, length distribution and the number of hours fished. At the end of each sampling year the shrimp catch for ICNAF Division 4R (Newfoundland) was obtained and was assumed to represent the Port au Choix fishery. Using the average ratios of shrimp to small redfish, the total by-catch of small redfish for each year was estimated in kilograms. Weights were converted to numbers and applied to the length frequency distribution for the year. The length compositions of the total by-catch were applied to mid-season age/length keys to arrive at the age distributions of the by-catch for 1976 and 1977.

Estimates of instantaneous mortality were also calculated comparing the numbers caught per hour at age in 1976 and 1977. The instantaneous rate (Z) was calculated using the absolute value of the natural log of the survival rate (Ricker, 1975). No mortality was calculated from age 1 to age 2. It is assumed that the availability at such age/size is incomplete,usually resulting in an increase from one year to the next instead of a decrease. To project the by-catch of 1-year-olds, a mortality equal to that from age 2 to age 3 was assumed. This is considered a minimum.

Biomass Estimates

The M.V. Beothic Venture was chartered during the summer of 1976 to undertake a survey of the biomass of small redfish and shrimp in the Gulf of St. Lawrence (Fig. 2). A number 36 shrimp trawl with a wing spread of 35 ft (Carrothers and Foulkes, 1972) was towed for thrity minutes at 2.5 knots at randomly selected stations within the stratification area (Sandeman, personal communication). This gear is compatible to that used by the commercial shrimp trawlers with the exception that the codend was lined with a 1/2" liner. Figure 3 shows the four general stratification zones used in the survey. For the purposes of this paper Zone 1, the Esquiman Channel, will be considered. Details of the stratification are evident in Figure 4. Biomass at age was calculated from age/length data.

Results

Information from both sources of data are compared in Table 1. Upper limits of 3.5% by numbers and 2.5% by weight of the biomass estimated for the Esquiman Channel were removed in the 1976 by-catch. For most year-classes representing the small fish, removals represented less than

3% of the biomass (expressed in numbers) at age. The indicated 7.5% removal at age 1 is the only exception.

Estimates of mortality (Z≃M) are shown in Table 2. These figures were rounded up to age 6 and the assumed natural mortality of 0.10 for redfish was applied from age 8 onward. Initial rounding to tenths was changed to hundredths for latter ages reflecting the exponential decline in mortality at age. Final figures were used in Tables 3 and 4 to project the discarded fish 10 years hence. If the by-catch in 1976 were replaced in the environment and allowed to live for 10 years experiencing only natural mortality, they would represent a potential yield of 877 metric tons (Table 3). Similarly, the 1977 by-catch would represent a yield of approximately 1400 tons in 1987 (Table 4).

Discussion

Cursory observations indicate percent removals of small redfish by the shrimp fishery in Port au Choix are low. A median 2% of the biomass (numbers) of small redfish in the Esquiman Channel in 1976 was lost due to by-catch (1% by weight). No year-class is considered prosecuted to a point of concern compared with any others. The 7.5% removals of 1-year-olds is considered anomalous as the biomass estimates were obtained in mid-season (July and August) when relatively few 1-year-olds were present in the catch. By the end of the calendar year these fish were being caught in the commercial net--growth and/or migration to slightly deeper water making them more available to the gear. It is assumed, therefore, that the biomass of age 1 fish is underestimated and that percent removal by the fishery is probably nearer the level of the 2- and 3-year-olds if not lower.

Estimates of the total mortality (Z) were considered approximate to natural mortality (M). Very low percent removals facilitate this assumption, i.e. fishing mortality is negligible. It should be noted here that the high Z values obtained may be, to some degree, a function of density-dependent factors. The possibility exists that an unusually high production of offspring occurred in the early mid-1970's, especially 1974. Mortalities evident from 1976 to 1977 may reflect increases in predation, competition and disease aberrant to those encountered over the norm. Although this cannot be proven with only two years of data, the possibility should be appreciated when considering these results.

The by-catch in 1976 of over 100 million small redfish represents only 877 tons under ideal conditions ten years hence, i.e. 1986. In reality, fishing mortalities of varying values would be expected anytime

after age 10 further reducing this yield. High mortality for the young fish is to be expected since at least predation at these ages (0 to 5) must be very high. Figures 5, 6 and 7 from commercial data show a tremendous reduction in number caught per hour fished over a similar size range from 1976 to 1977. The monthly catches per unit effort for 1977 are represented on a vertical scale which is one-tenth that for the 1976 data (Fig. 5 and 6). Figure 7 shows the strong 1974 and perhaps 1973 year-classes approaching decimation from one year to the next. These results suggest that the high natural mortality for fish at these ages places the magnitude of a by-catch in the shrimp fishery as incidental.

The removal for 1977, roughly one-quarter the numbers for 1976, nevertheless results in a potential catch 10 years hence which is appreciably higher than that of the previous year's by-catch. Figure 6 shows the catch for July, 1977, with a substantial catch of slightly larger fish possibly representing the 1971 year-class. The trend is also evident in October but on a much smaller scale. Figure 8 clearly exemplifies inconsistency as catch weights for all months in 1977 are well below the weights per hour in 1976 except for July. The fact that this is due to larger fish is reflected in Figure 9 with lower numbers per hour caught in July, 1977, than in July, 1976. Figure 5 for 1976 may indicate this phenomenon to be recurrent from year to year as the proportion of slightly larger fish is greater in July, 1976, also. Fish at ages 6 to 8 have already undergone their heaviest natural mortality rates. The extra tonnage attained by projecting the 1977 by-catch is the direct result of the July catch (Table 4) and may be some cause for concern if the situation continues.

Review of sampling details for July 1977 show no inconsistencies in either area or depths fished. However, for that month only two trips were made onboard one vessel and the data may not be representative of the total fleet. Catches of commercial size redfish usually occur as a substantial by-catch in July, August and September. If the fish of the 1971 year-class have adapted the habits of the older, larger fish, then they would be expected to occur frequently in catches of these later months as well. If there is a trend shown in July 1976 and 1977, it may indicate a behavioural characteristic of fish of intermediate sizes, different from larger and smaller fish. Only continued observation will bear this out.

Conclusions

The removals of small redfish as a percentage of biomass in a given year appear to be negligible. However,this may be a somewhat hasty conclusion considering only one biomass estimate is available to

which commercial data can be applied. The potential of the by-catch to represent a meaningful catch over the long term is also doubtful. Aberrant catches of slightly older fish in July may be a point of concern and if the situation continues over time, significant removals may be attained and year-class survival may be threatened. The uncertainty of the situation suggests that a continued monitoring of the fishery is imperative as is the need for new biomass estimates.

These implications must be considered in perspective. Estimates of biomass and mortalities are one-point estimates. Confidence limits on the biomass in numbers at age are in some cases represented by negative numbers at the lower end. Age/length keys are mid-season data and when applied to yearly data have inherent errors involving the growth and availability of small fish. If present sampling practices are continued and estimates of biomass are forthcoming, the situation may be realized in two or three years with considerable reduction in error. In the meantime,there is no tangible evidence to restrict the shrimp fishery based on concern for the future of the redfish stocks.

References

Carrothers, P.J.G. and T. J. Foulkes. 1972. Measured towing characteristics of Canadian east coast trawls. Intern. Comm. Northw. Atlant. Fish. Res. Bull. 9: 11-20.

Ricker, W. E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Fish. Res. Bd. Canada Bull. 191.

Table 1. 1976 Biomass at age, by-catch at age and catch per biomass from commercial and research data

Biomass (millions of fish) Esquiman Channel (Zone 1)

	AGE									
	1	2	3	4	5	6	7	8	9	10
No Sex	8.0	2304.0	1578.1	692.3	431.9	75.9	19.4			
Males				12.1	292.2	132.9	64.2	13.5	4.1	1.1
Females				16.0	404.5	128.2	104.0	24.1	2.1	0.1
Total	8.0	2304.0	1578.1	720.4	1128.6	337.0	187.6	37.6	6.2	1.2
1976 Catch At Age	0.6	57.7	33.6	8.9	5.9	1.3	0.6	0.1	<0.1	<0.1
Catch/ Total Biom.	0.075	0.025	0.021	0.012	0.005	0.004	0.003	0.003	-	-
%	7.5	2.5	2.1	1.2	0.5	0.4	0.3	0.3	-	-

1976 Estimated percent total loss due to by-catch.

Numbers

Biomass Esquiman Channel 1976 = 6,306 million small redfish

Total Catch P.A.C. 1976 = 109 million

Catch/Biomass = 0.0173 $\sim$ 2%

95% Confidence Limits 1% to 3.5%

Weight

Biomass (tons) Esquiman Channel 1976 = 195,000

Catch (tons) P.A.C. 1976 = 2,050

Catch/Biomass = 0.0105 = 1%

95% Confidence Limits 0.7% to 2.5%

Table 2. Mortality estimates from number caught per hour (commercial) -- 1976 vs 1977.

Age	CATCH 1976	CATCH 1977	Z ≃ M	Rounded Estimates
1	27			
2	2834	32	?	2.00*
3	1653	349	2.09	2.00
4	439	278	1.78	1.75
5	289	132	1.20	1.25
6	62	119	0.89	0.90
7	31	43	0.37	0.40
8		28	0.10	0.10

*Estimated Minimum

Table 3. Small redfish by-catch in 1976 replaced and projected under estimated M for 10 years ('000s fish)

AGE	No. caught 1976	Z=M	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	Wt. at Age (KG) X ♂ & ♀	Wt. of discarded fish in tons 10 years hence
0														
1	600	2.00												
2	57,700	2.00	81											
3	33,600	1.75	7,809	11										
4	8,900	1.25	5,839	1,357	2									
5	5,900	0.90	2,550	1,673	389	0.6								
6	1,300	0.40	2,399	1,037	680	158	0.2							
7	600	0.10	871	1,608	695	456	106	0.1						
8	100	0.10	543	788	1,455	629	413	96	0.1					
9		0.10	90	491	713	1,317	569	374	87	0.1				
10		0.10		81	444	645	1,192	515	338	79	0.1			
11		0.10			73	402	584	1,079	466	306	71	0.1		
12		0.10				66	364	528	976	422	277	64	.322	21
13		0.10					60	329	478	883	382	251	.362	91
14		0.10						54	298	433	799	346	.403	139
15		0.10							49	270	392	723	.443	320
16		0.10								44	244	355	.482	171
17		0.10									40	221	.521	115
18		0.10										36	.559	20
19		0.10												
20		0.10												
													TOTAL	877

Table 4. Small redfish by-catch in 1977 replaced and projected under estimated M for 10 years ('000s fish).

	No. caught												
AGE	1977	Z≃M	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	Wt. at Age (KG) ♂ & ♀	Wt. of discarded fish in tons 10 years hence
0														
1	1	2.00												
2	948	2.00	0.1											
3	10,401	1.75	128	0.1										
4	8,288	1.25	1,807	22										
5	3,957	0.90	2,375	518	6									
6	3,576	0.40	1,609	966	211	2								
7	1,290	0.10	2,397	1,079	648	141	1							
8	873	0.10	1,167	2,169	976	586	128	0.9						
9	342	0.10	790	1,056	1,963	883	530	116	0.8					
10	145	0.10	309	715	956	1,776	799	480	105	0.7				
11	25	0.10	131	280	647	865	1,607	723	434	95	0.6			
12		0.10	23	119	253	585	783	1,454	654	393	86	0.5	.322	
13		0.10		21	108	229	529	708	1,316	592	356	78	.362	28
14		0.10			19	98	207	479	641	1,191	536	322	.403	130
15		0.10				17	89	187	433	580	1,078	485	.443	215
16		0.10					15	81	169	392	525	975	.482	470
17		0.10						14	73	153	355	475	.521	247
18		0.10							13	66	138	321	.559	179
19		0.10								12	60	125	.596	75
20		0.10									11	54	.631	34
21		0.10										10	.665	7
													TOTAL	1,385

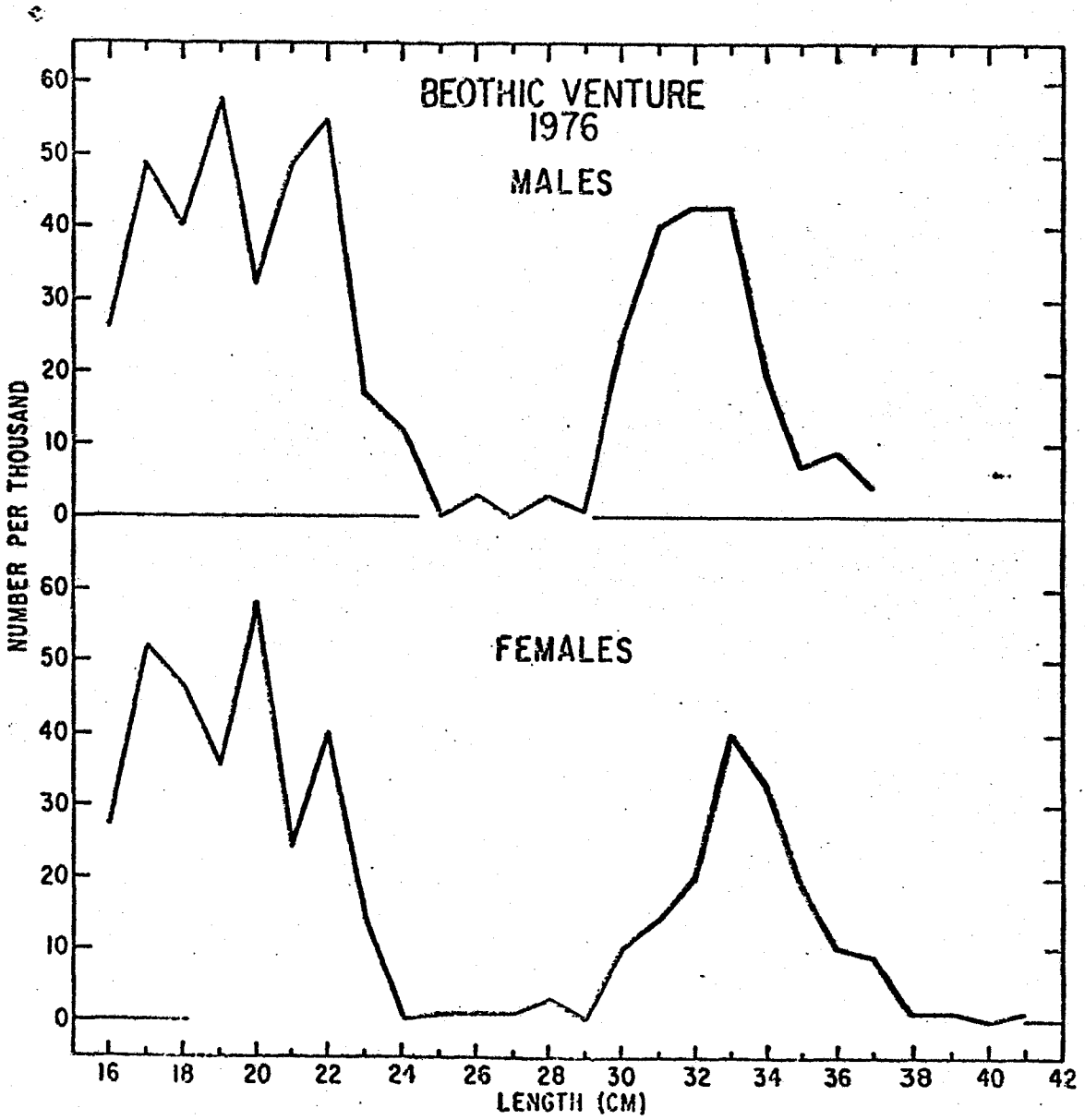

Fig. 1. Typical length distribution -- Gulf of St. Lawrence.

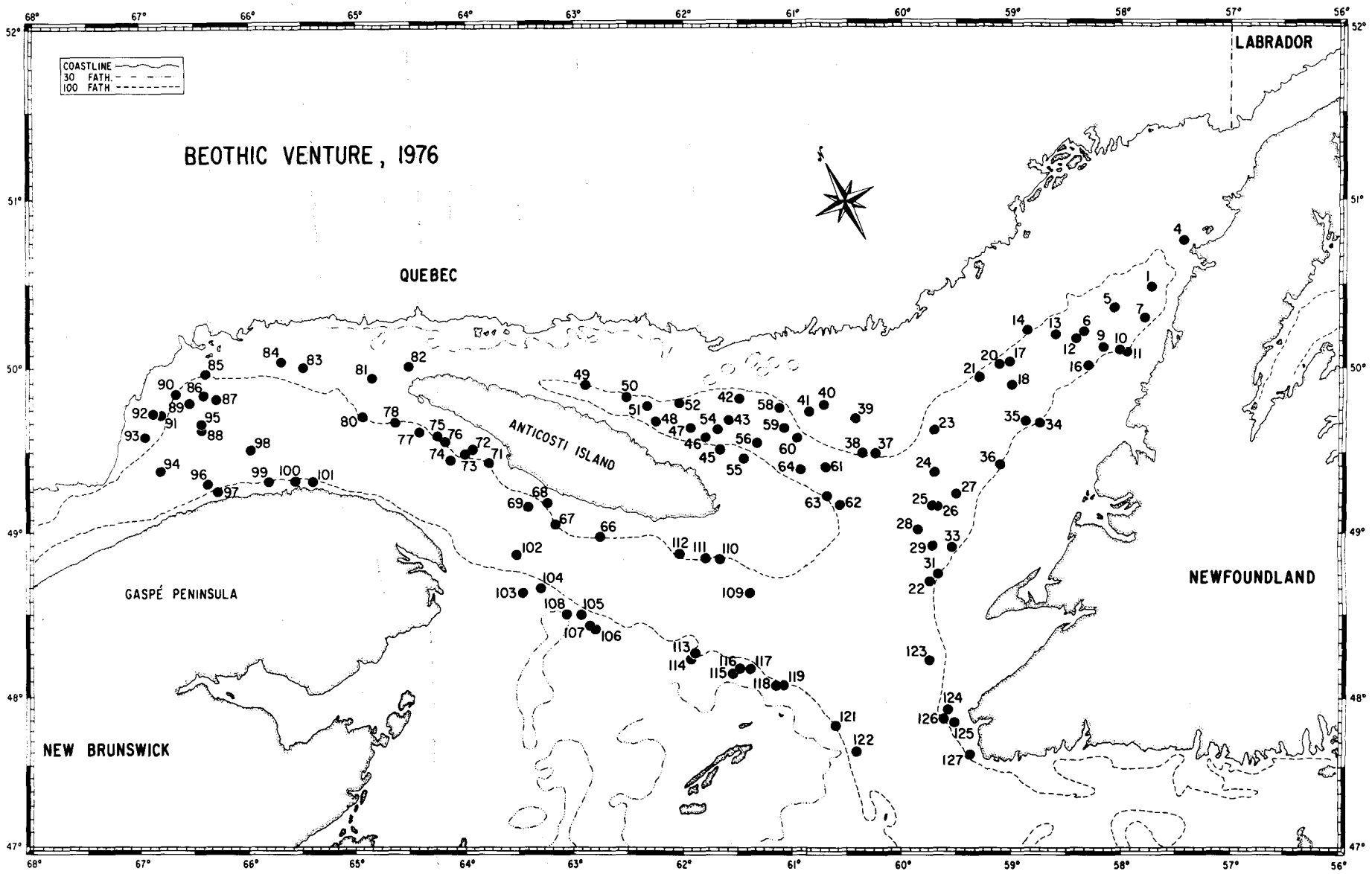

Fig. 2. Random-stratified survey sets -- Redfish and Shrimp-

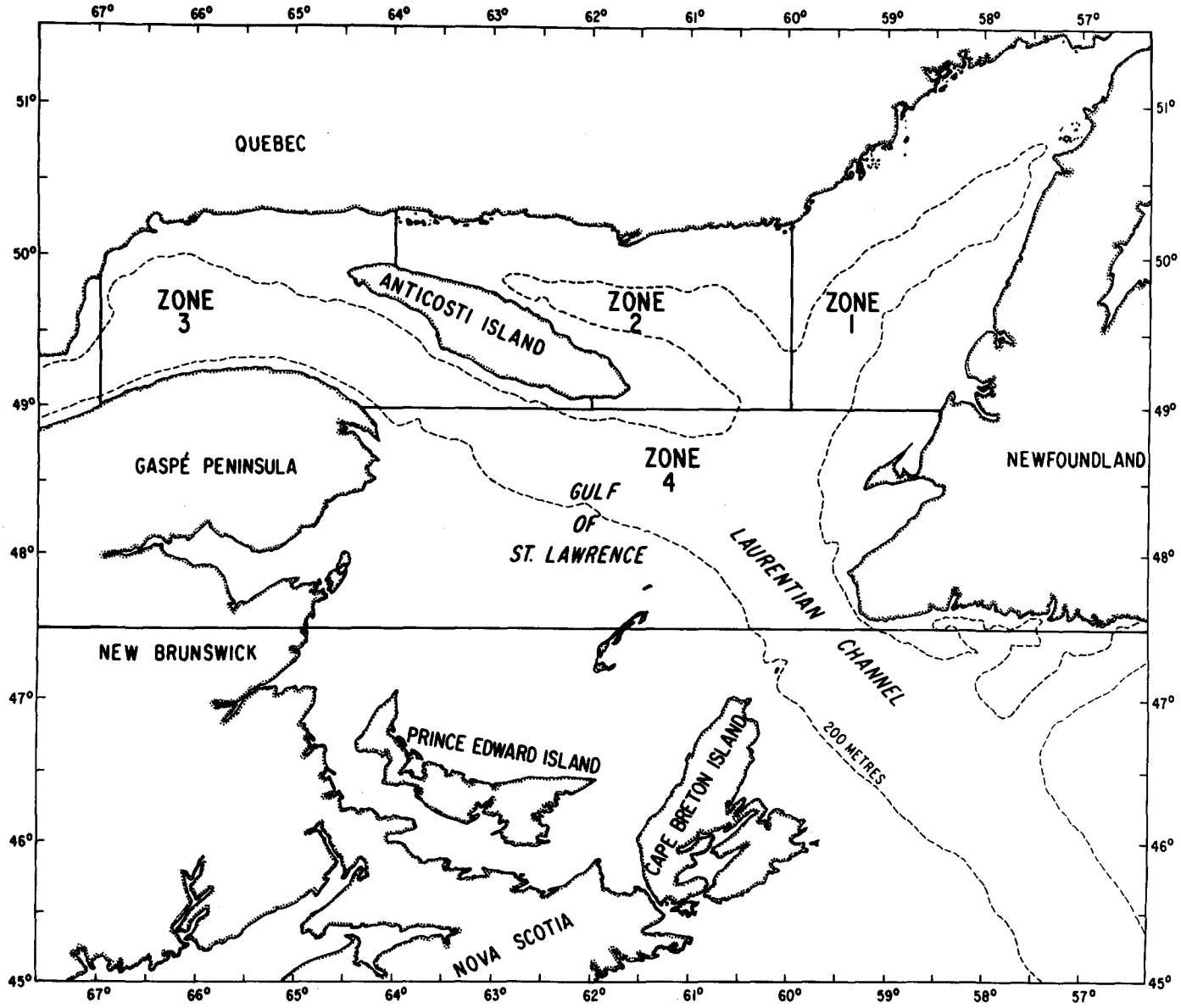

Fig. 3. General Stratified Zones (Sandeman, 1976, personal communication).

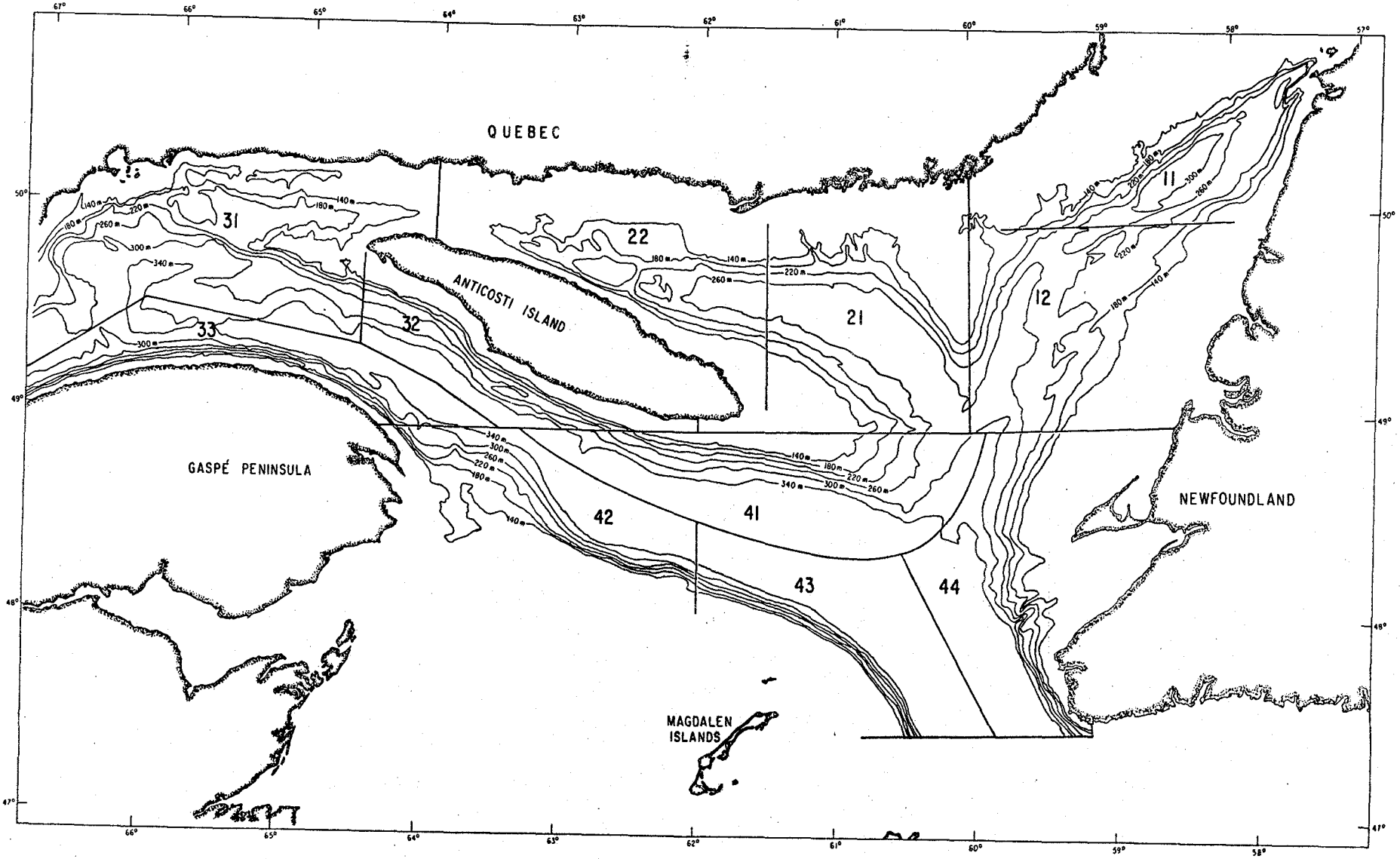

Fig. 4. Details of Stratification (Sandeman, 1976, personal communication).

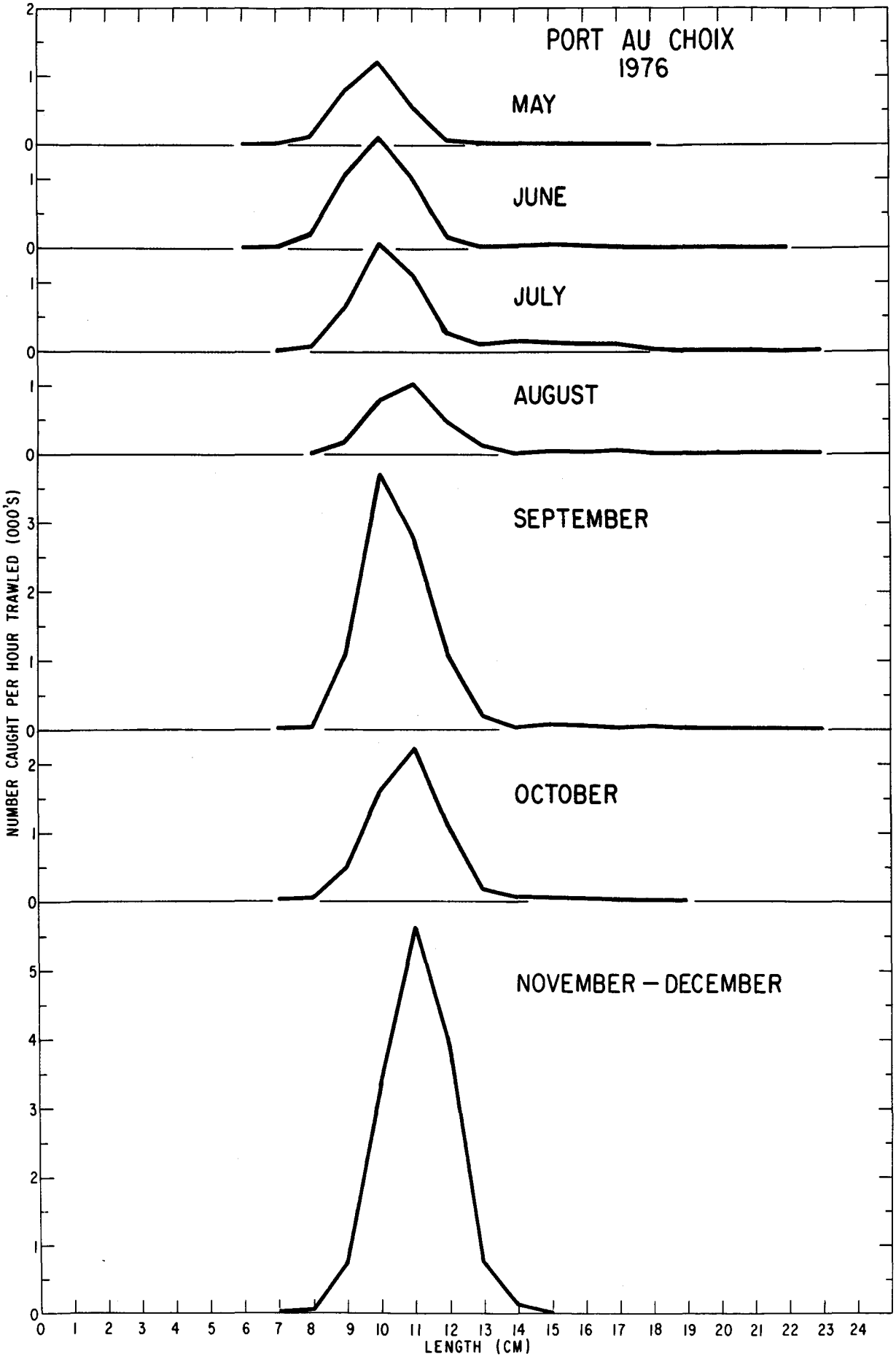

Fig. 5. Monthly commercial catch per effort, 1976.

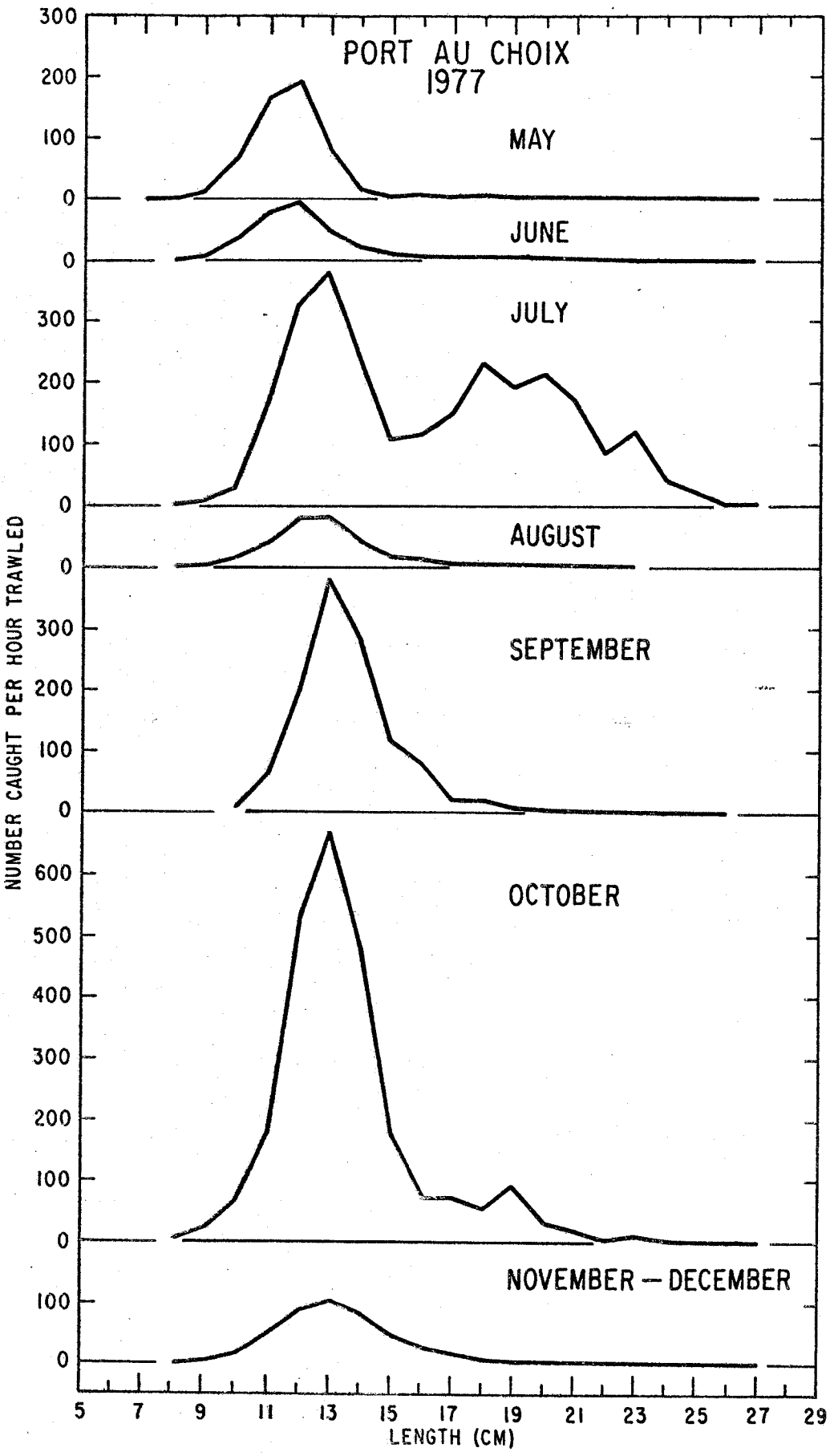

Fig. 6. Monthly commercial catch per effort, 1977.

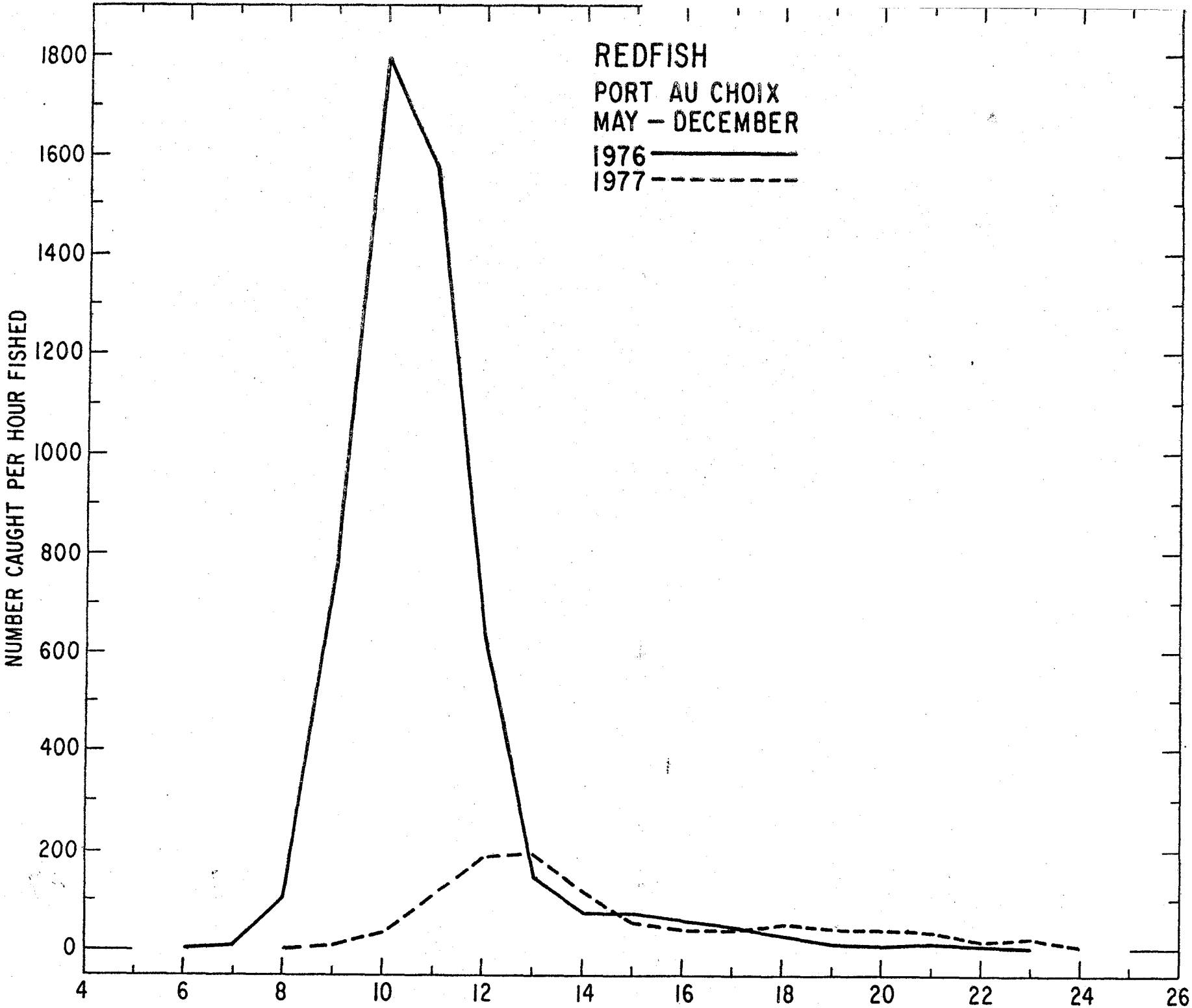

Fig. 7. Yearly catch per effort, 1976 vs 1977.

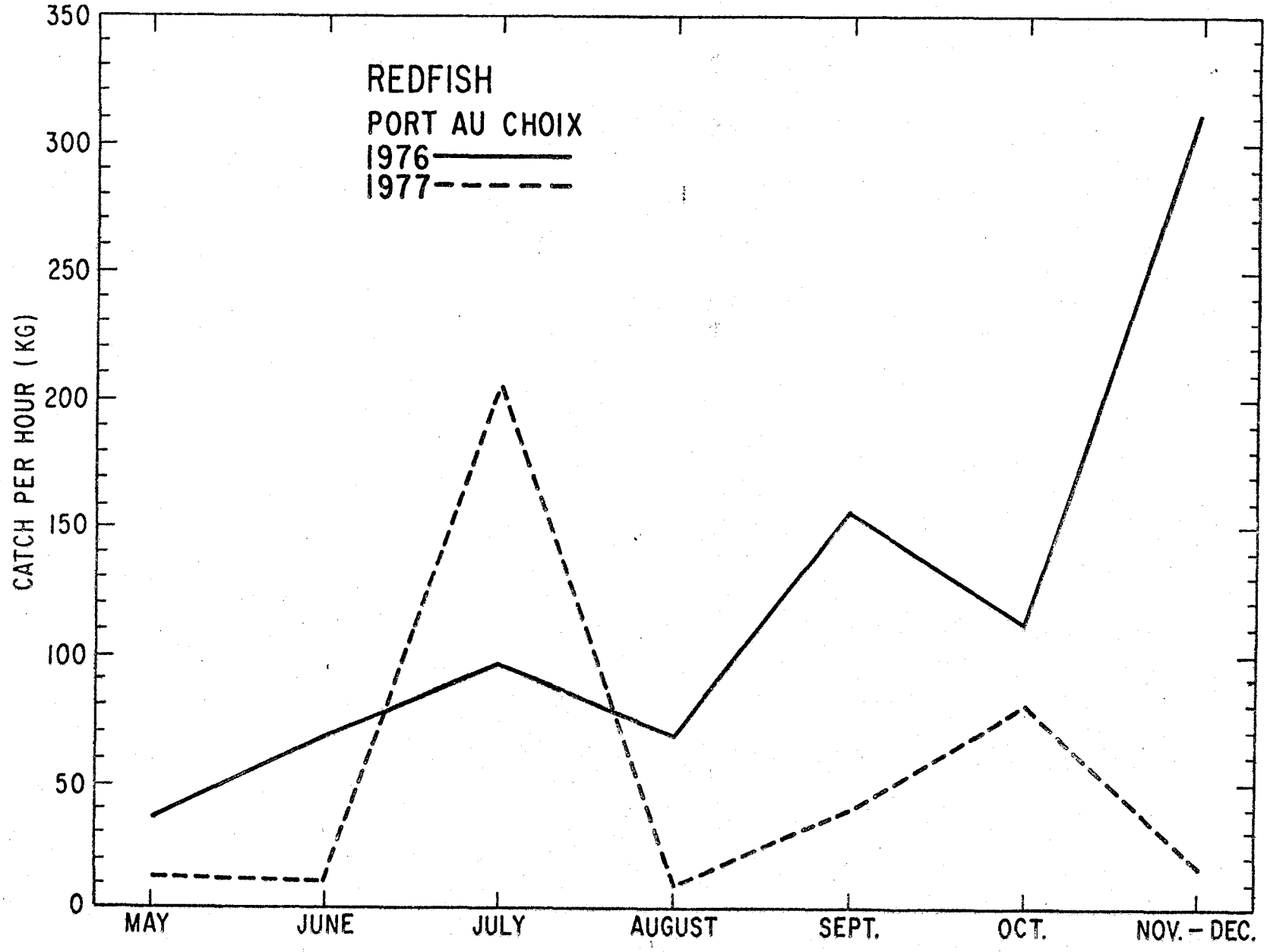

Fig. 8. Monthly catch (kg) per effort -- 1976 vs 1977.

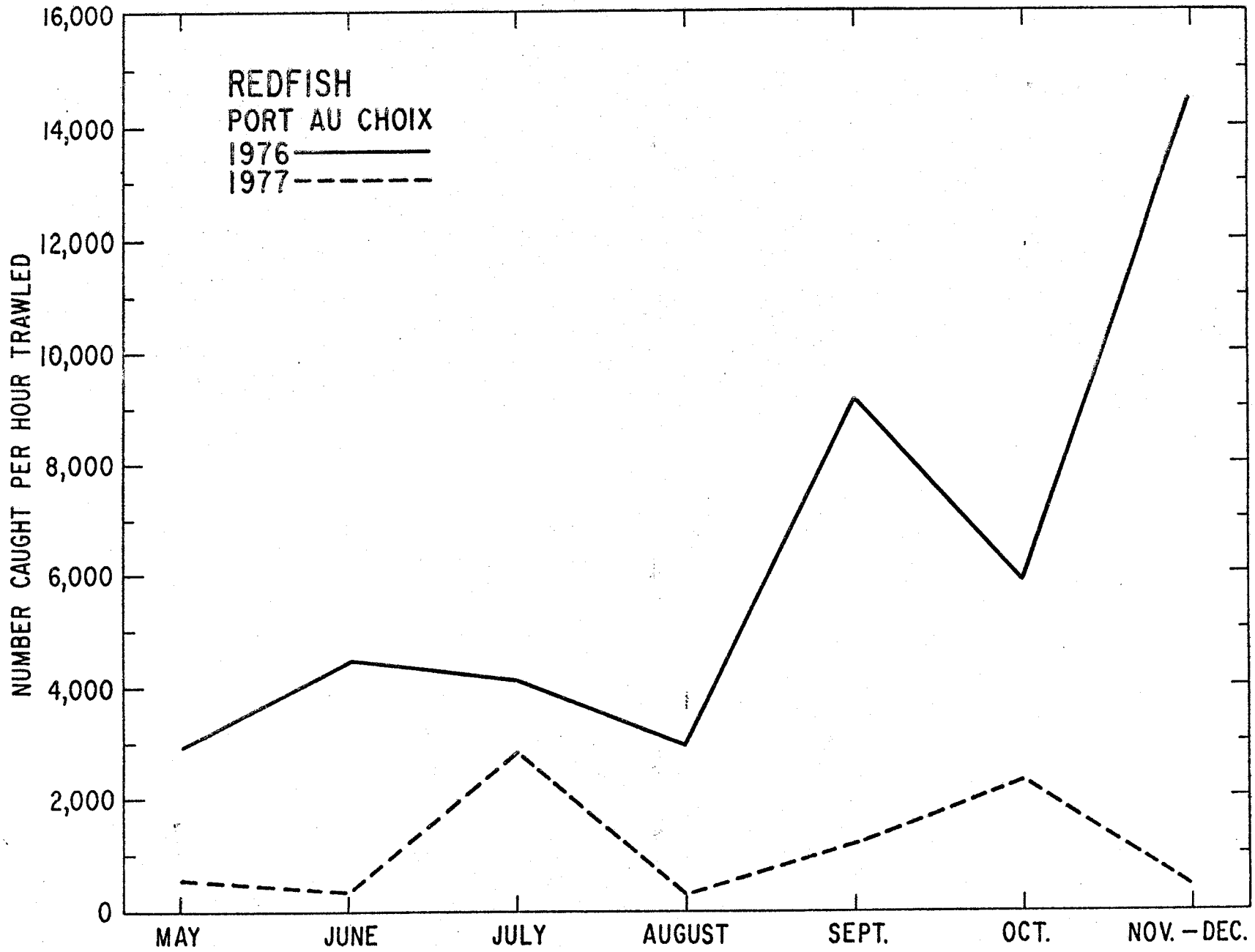

Fig. 9. Monthly catch (numbers) per effort -- 1976 vs 1977.