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Research on the population biology of harp seals in 1979

by

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Introduction

Canadian research on harp seals was decentralized in October 1978. Work in the Gulf of St. Lawrence and in the Arctic remains at the Arctic Biological Station, Ste. Anne-de-Bellevue, Quebec. Work around Newfoundland and Labrador was transferred to the Northwest Atlantic Fisheries Center in St. John's. This regionalization approximates the winter separation of harp seals into the Gulf and Front herds. Here we report on the collaborative research and analyses conducted on harp seals in 1979.

Estimates of Pup Production

(a) 1978 Pup Production:

(i) From short-term recoveries. Mohn, Lett and Beck (unpubl. MS, 1978) estimated production in 1978 from tag recoveries and catches of beaters by landsmen in selected ICNAF Subareas in spring 1978. At the time these estimates were produced, official catch statistics in these areas were unavailable. Also, it was decided in November 1978 to increase the reward for harp seal tags from $4.00 to $10.00. This action was expected to bring in many previously unreported tags and to speed up the reporting of recently discovered tags by fishermen. In light of the above we have reanalyzed the mark-recapture data for 1978.

In March 1978, a large-scale tagging experiment took place in both the Gulf of St. Lawrence and on the Front. Unfortunately, tag returns from the landsmen hunt of beaters were low. In the Gulf this appeared to have been caused by the concentration of hunting by landsmen on the Meccatina patch in the northern Gulf (Lett et al., 1978). This patch was not tagged so that few tagged seals from the Gulf whelping patch were taken. To overcome this problem, Mohn et al. (unpubl. MS, 1978) used only recoveries and catch data from ICNAF Subareas 4Vn and 3P. A major assumption made, but not tested by Mohn et al., was that tagged pups would be randomly distributed in the population at the time of the second sample. Unfortunately, this assumption cannot be readily tested with the catch statistics in 4Vn that are currently available. We can, however, compare the ratio of tagged to untagged seals in areas 4Vn and 3P to get some idea of the degree of mixing. In area 4Vn 12 tags were recovered in a catch of 517 seals, whereas in 3P 15 tags were recovered in a catch of only 58 pups (catch statistics provided by Economics and Intelligence

Branch, Halifax and St. John's). Clearly tagged seals were not uniformly mixed in the population. We conclude that without more information, which is apparently not forthcoming for this experiment, we cannot use these data to estimate pup production in the Gulf. We suggest that the Gulf estimate of Mohn et al. (unpubl. MS, 1978) is invalid. It must be emphasized that in future catch statistics for the Gulf must be recorded on a weekly basis by area in order that the assumption of random mixing of tags may be better tested.

On the Front also, few tagged pups were recaptured in 1978, although 5,000 tags were applied. In 1978, tagging effort was concentrated on a large group of seals that whelped on fast ice in the Gannet Island area, with the result that this marked population of pups did not become available to landsmen until late April and May. The problem is to determine to what extent these marked seals were mixed in the beater population. Given the available information, this is not easily resolved. Table 1 shows the ratio of tagged to untagged beaters in the 1978 landsmen catch by month and ICNAF Subarea. Notice that in Div. 3L, 15 tags were reported in May, but no catch is reported. Most likely these tags were recovered from seals taken in Div. 3K or at least near the boundary of Div. 3L-3K. If this is taken to be the case, the ratio of tagged to untagged pups in Div. 3K varies from 1:99 to 1:365. Notice also that the tag density appears to increase with time. In Div. 3L few tagged seals were recovered. During the period April 16-29 the ratio of tagged to untagged pups was 1:944, further suggesting that tagged pups were not randomly distributed in the population. We conclude that there is strong evidence that the estimate of Mohn et al. (unpubl. MS, 1978) should be regarded as unreliable.

(ii) From long-term recoveries. Estimation of 1978 pup production is also possible using tag recaptures of age 1 seals in 1979. Let K be total pup kill in the Gulf and Front herds in 1978. Further, let N_f and N_g be the number of tagged animals surviving the whitecoat kill on the Front and Gulf, respectively, and let C_f be the catch of one-year-olds on the Front (ICNAF Subarea 3) during a specified period in 1979, with n_f of N_f and n_g of N_g tags recovered. If P_g and P_f are the survivors of the 1978 pup kills in the Gulf and Front, respectively, then the relative proportion of P_g (Gulf origin animals) to P_f (Front origin seals) available to the ICNAF Subarea 3 landsmen hunt is estimated as

$$\hat{f} = \frac{n_g}{n_f} \times \frac{N_f}{N_g} \qquad (1)$$

Estimated escapement of Front pups ($\hat{P}_f$) is given by

$$\hat{P}_f = \left(\frac{P_f}{\hat{f} P_g + P_f}\right) \times (C_f) \frac{N_f}{n_f} \qquad (2)$$

Rearranging and letting $\hat{P} = \hat{f}P_g + \hat{P}_f$, we have

$$\hat{P} = (C_f) \frac{N_f}{n_f} \qquad (3)$$

This is the Petersen estimator of the Front survivors plus a fraction ($\hat{f}P_g$) of the Gulf survivors. Notice, if $\hat{f} = 0$ then $\hat{P}$ is an estimate of Front production only and if $\hat{f} = 1$, P is an estimate of total production. The unbiased estimator of $\hat{P}$ is given by Chapman (1951) as:

$$P^* = \frac{(C_f + 1)(N_f + 1)}{(n_f + 1)}, \qquad (4)$$

if $(C_f)(N_f) \simeq 4N$, where N is true population size and the other assumptions of the model are valid (see Bowen 1979a, Seber 1973).

Now if a rough estimator, r, is available of $P_g/(P_g + P_f)$ this can be used with $\hat{f}$ to obtain the total number of pup survivors (P^*_s) where

$$P^*_s = \frac{P^*}{r\hat{f} + (1 - r)} \qquad (5)$$

Total pup production, P^*_T, is then

$$P^*_T = K + \frac{P^*}{r\hat{f} + (1 - r)} \quad \text{or } K + P^*_s \qquad (6)$$

We assume also that the mortality rate of Gulf and Front tagged seals is the same.

Calculation. The catch of age one seals (C_f) was determined by prorating the total 1+ catch according to age samples taken from the landsmen hunt. The age distribution of seals caught in nets differs markedly from the sample shot by landsmen. Therefore, these two components of the hunt must be handled separately. The net catch consisted of approximately 2,000 seals in 1979 and its age structure was determined from a sample of 872 seals collected from St. Anthony during the period January to May 1979 (Table 2). The age structure of the shot catch was determined from a sample of 205 seals collected from March to April 1979 from Twillingate and Point Lemington (Table 2).

If we examine the ratio of tagged to untagged seals in the catch by month and unit area within Subarea 3K (Table 3), we see that this ratio is fairly stable from March to May, but is more variable outside this period. Hence, it is more likely that tagged and untagged seals were randomly mixed from March to May than during the period January to June.

The catch of one-year-olds from March to May is 10,438. The number of tagged seals surviving the large vessel kill in the Gulf (N_g) and Front (N_f) is 4378-227 = 4151 and 5000-16 = 4984, respectively. These values must be corrected for non-reporting (25%) (Bowen 1979a) of tags to yield 4094 and 4980. The number of tagged age-one seals taken in 3K from March to May is 58 and 97 in the Gulf (n_g) and Front (n_f), respectively. Again these values must be corrected for non-reporting to yield 73 and 121.

Thus P* is

$$P^* = \frac{(10{,}438 + 1)\ (4980 + 1)}{(97 + 25\%) + 1} = 426{,}202 \ .$$

The relative proportion of Gulf seals to Front seals available to landsmen is

$$\hat{f} = \frac{73}{121} \times \frac{4980}{4094} = .73$$

Sergeant (1977) gives the proportion of Gulf to total pup production, r, as .38. Then the total number of beater survivors is given by

$$P^*s = \frac{426{,}202}{(.73)\ (.38) + (1 - .38)} = 473{,}558.$$

Finally, total pup production in 1978 is

$$P^*_T = 115{,}837 + 437{,}558 = 589{,}395 \text{ or } 589{,}000.$$

Based on the results of the 1979 mark-recapture experiment (Bowen 1979a) this estimate 589,000 is unrealistically optimistic. One reason for this might be that the number of one-year-olds in the landsmen catch (C_f) has been overestimated. This year the age structure of the landsmen catch was based on a sample of only 205 seals. The percentage of age one seals in the sample was 55.4. In Table 4 we see that the percentage of one-year-olds in previous samples the landsmen shot-catch was varied from 27.8% in 1977 to 55.4% in 1979. However, the percentage of age one seals was about 55% in four of the six samples, so that this year's sample does not appear to be anomalous. Although the age structure of the samples from 1974 to 1979 agree with the exception of 1977, they may all fail to adequately reflect the true kill proportions. This may occur because younger seals are spatially and/or temporally segregated from older animals. We suggest that sufficient samples be taken to permit an analysis of the age specific spatial and temporal distribution of harp seals in the landsmen catch.

(b) Survival Index Method:

The survival index method of estimating pup production, as described by Sergeant (1971) and modified by Benjaminsen and Øritsland (1975), involves relating survival of successive year-classes to the number of pups killed of each year-class. The survival index calculated from each age sample was weighted approximately proportional to sample size and weighted means were calculated for individual year-classes. Ages 2 to 8 were used in the present analysis. Age-group 1 was omitted because of the segregation of these seals in the moulting season during which time the age samples are collected.

Winters (1978) used survival indices to calculate pup production for the period 1948 to 1974. Herein we update pup production estimates to incorporate most recent data. Catch-at-age data to 1976 are found in Lett and Benjaminsen (1977), whereas 1977 and 1979 age samples come from Sergeant (1977) and this report (moulting sample by Bowen), respectively.

The average pup production from 1970-77 was estimated by linear regression of weighted mean survival indices for each year-class on total pup kill in the corresponding years (Fig. 1). For the median year 1973, pup production is estimated at 342,000 (rounded to nearest thousand). The coefficient of determination of the regression (r^2) is 0.77. The 95% confidence limits on this estimate are 267,000 to 625,000 (see Ricker 1975 for method of calculation). Note this estimate will be unbiased only if (a) there is no systematic bias in age frequency samples, and (b) pup production has been reasonably constant over the period. The extent to which these assumptions are valid is unknown. Consequently, the reliability of this estimate is also uncertain.

(c) 1979 Pup Production:

(i) From short-term recoveries in the Gulf. A total of 2680 harp seals was tagged with orange Roto-tags in late February-March 1979 near the Magdalen Islands. This tagging was to have provided an estimate of Gulf pup production from the catch of beaters in ICNAF Subareas 4Vn, 3P, and 4R. Unfortunately only 19 beaters were landed from 4Vn and no catch was reported in Subarea 3P. In Subarea 4R catch statistics are confounded, since they include Gulf seals and, most likely, significant numbers of pups from the southern Front whelping patch. This southern Front patch is believed to have penetrated into the Gulf only as far as Point Riche (Bowen 1979a). Thus beater catches south of Point Riche (ie unit area 402) should be mainly Gulf seals. Only three tags were returned from unit area 402. Consequently, it is not possible to estimate Gulf pup production in 1979.

The results of this experiment serve to emphasize the importance of tagging pups in all known whelping patches. This is particularly important for an estimate of Gulf production, as catches in 4Vn and 3P are highly variable so that estimates will be based largely on tag returns and catches in 4R. In practice a reliable estimate will be achieved only if all whelping patches in the Gulf and Strait of Belle Isle are tagged.

(ii) From short-term recoveries on the Front. Pup production on the Front is estimated to be near 220,000 in 1979. This estimate has two components: a mark-recapture estimate of 203,000 with 95% confidence intervals from 174,000 to 239,000 for the main northern patch and a visual estimate of 20,000 to 25,000 for a smaller southern patch (Bowen 1979a).

(iii) Use of catch and effort data to estimate 1979 pup production. There are two rather distinct harvests of pups on the Front. Large vessels operate mainly in whelping patches and sealers working from these vessels kill mainly whitecoats. Longliners, on the other hand, preferentially kill beaters as they become available in White Bay and Notre Dame Bay in April and May. For both hunts, 1979 catch and effort statistics are rather complete and accurate. This means that it may be possible to estimate pup production from a regression of catch per unit effort (CPUE) on cumulative catch. This is the method of Leslie and Davis (1939) and is commonly known as the Leslie method.

Large vessel hunt. The Leslie method is applicable when a population is hunted until enough animals are removed to significantly reduce the catch per unit effort. If catch per unit effort is proportional to population size then an estimate of original population size (N_0) is given by the X-axis intercept when CPUE = 0. For the method to be reliable it is also important that (from Seber 1973):

1. The population is closed.
2. There is no systematic change in catchability of seals during hunting.
3. There is no systematic change in hunting efficiency.
4. Units of effort (hunting) are independent. This means that boats do not compete for seals.
5. There is random sampling of the population so that local depletion of the population does not occur.

Theoretically, the large vessel hunt is ideally suited to CPUE analysis. Whelping occurs over a very short period and natural mortality during the hunt is negligible. Thus, the population is closed after say March 13 or 14. Also, there is no systematic change in pup catchability or hunter efficiency. Although all of the large vessels generally work the same patch of seals, they operate quite independently and space themselves over the entire population. Local population depletion may be caused if ships become frozen in the ice. However, in general this population appears to meet the assumptions of the Leslie model.

Fisheries Officers stationed on board each vessel provided the daily catch of whitecoats from the beginning of the hunt on March 12 until the last vessel left the whelping area on March 21. Daily effort of each vessel was also provided by Fisheries Officers and was calculated as the number of hunters times the number of hours hunting (nearest half hour).

In 1979, 10 vessels participated in the whitecoat hunt. The ability of these vessels to negotiate the ice, which to some extent measures hunting efficiency, varied markedly (Table 5). This would not matter if the composition of the fleet was constant during the hunt. However, this year the most efficient boats reached their harp seal quotas by March 16 or 17 and subsequently left the area to hunt hooded seals, Cystophora cristata. This has the effect of reducing mean daily CPUE of the fleet spuriously. To correct for this systematic change in fleet hunting efficiency, we divided each vessel's daily CPUE, expressed as seals/100 hunter-hr, (Table 6a) by its maximum CPUE which was given a value of 1.00. Daily indexed CPUE values are given in Table 6b.

To estimate pup production in the northern whelping patch, we regressed mean daily CPUE of the fleet on cumulative catch (Kt) using Braaten's (1969) modification (Table 7). This has the effect of distributing catch throughout the time interval t rather than assuming that all catch is taken at the start of the interval. The regression was not significant ($F = 1.00$, $df = 1,8$; $P > 0.25$; $r^2 = 0.13$). This suggests that the catch of pups in 1979 was insufficient to reduce CPUE over time. Thus no estimate of N_0 can be made using this method.

We conclude that given the present large vessel quota we are unlikely to find CPUE analyses productive. Further, it is important to realize that this type of analysis can only provide an estimate of the population size (pup production) of the patch hunted. Thus an estimate of total pup production is not currently practical with this method.

Longliner hunt of beaters. The weekly catch of beaters by landsmen was obtained from Economics and Intelligence Branch, St. John's. Longliner effort was calculated as the number of man-days hunted per boat per week. These statistics were obtained from weekly reports submitted by longliner captains to Economics and Intelligence Branch, St. John's.

We found no relationship between longliner CPUE and the cumulative landsmen catch of beaters in ICNAF Subarea 3 (Fig. 2). This finding is not surprising given that the total landsmen catch of 10,110 beaters represents only about 11% of estimated 1979 beater population on the Front (Bowen 1979a). It seems most unlikely that CPUE analyses of this beater hunt will yield reliable estimates of pup production.

Differential Migrations

Table 8 shows the recoveries of 1978 tags from March 1978 to June 1979. We see that tagged pups remained about one month longer in the Gulf than on the Front in 1978. Recoveries of tagged beaters in the Gulf lasted till August with a peak in June (most of these were casual catches in fish nets). On the Front, recoveries lasted until June with a peak in May.

Many more animals reached the Arctic (Subareas 0 and 1) in their first year from the Front (48 recoveries) than from the Gulf (14 recoveries). Most of these Arctic recoveries were from Greenland (60/62 or 95%), as is usual with first year animals; the rest were from Baffin Island. One recovery was from east Greenland. This is the first record of a western North Atlantic seal on this coast, but there has been a record from the Norwegian coast (Sergeant 1973).

The rate of first winter-spring recoveries (November 1978 to May 1979) in ICNAF Subareas 2-4 was 2.6% or 131/4980 for Front-tagged pups and 2.3% or 94/4097 for Gulf-tagged pups. Also there is a distinct tendency for pups of both areas to migrate to the Front region in their first winter. Of 131 Front-tagged seals recaptured in the above period, 86.3% were taken. on the Front, while 75.5% (72/94) of Gulf-tagged seals were recaptured on the Front.

Degree of Segregation of Gulf and Front Herds

Prior to 1978, almost all Canadian tagging or branding had been done in the Gulf of St. Lawrence. Therefore, a quantitative study is possible only of the Gulf-born animals in order to study segregation, until such time as results from 1978 and later taggings in both areas can apply to their mature cohorts, i.e., in 1983 and subsequently.

Table 9 shows an analysis of returns from the 1966-78 tagging and branding experiments in the Gulf only, using recoveries in the southern areas in first and subsequent winters up to the greatest age of recovery, 9 years.

The analysis shows a gradual increase of recoveries in the home area of Gulf-born harp seals marked as pups, from 20.0% at age one year to 66.7% at age four years, and as far as the few recoveries can show, to 75.0% of ages five and up. To date, four Gulf-born seals have been recovered on the Front as adults during the breeding season. In March and April 1978, two adults (one a male) were recaptured in Notre Dame Bay at the age of 9 years. These recoveries confirm a less reliable report of two adults in the same area at 8 years, in 1977. In spite of the few recoveries as yet at older ages, there seems little doubt that homing increases to a high degree at the same ages as the animals reach sexual maturity (Bowen 1979b).

Sightings of brands on whelped females were not included in these data prior to 1978, since mainly Gulf-breeding females were viewed from ice level, prior to 1978. But all records of B brands (put on in 1972) recorded in 1977-79 apply to females, so that the correlation of a high homing rate with sexual maturity applies mainly to females. The first B brand on a female with a pup was observed in 1977, when the seal was five years old, and had therefore matured no older than four years.

The only recent taggings on the Front, prior to 1978, were in 1973 and 1976. In 1973, 934 animals were tagged of which at least 142 were taken the first spring leaving 792 or less escaping. The large strap tag used was not as efficient as the Roto-tags used since 1975. Returns therefore cannot be quantitatively analyzed year to year. However, aggregated recoveries for winters one to five are one from the Gulf, 14 from the Front, or only 6.7% from the Gulf. This is a higher percentage from the home area than Gulf-tagged returns to home area in winters one to five (Table 9), but winter catches of animals aged one to five are much higher at the Front than in the Gulf, and no correction has been made here for this difference.

In 1976, of 199 young tagged off Labrador, 43 were recovered the first spring, leaving 156 or less tagged. In 1977 there were two recoveries, both at the Front.

Totalling 1973 and 1976 Front taggings and recoveries for ages one to five years, 1/16 or 6.3% of all wintering animals were recovered away from the home area.

Age Samples from the Gulf and Front in 1979

A total of 1914 harp seals was sampled in 1979 (Table 10). A single age sample only was obtained in the Gulf, from the St. Lawrence estuary, totalling 250 animals. On the Front, samples of the 1+ net catch were collected from Port Hope Simpson, Labrador and St. Anthony. Early ice limited to 25 the number of seals from Port Hope Simpson. As with previous collections, these net samples are biased against immature seals. Samples of the landsmen-shot catch were collected from Twillingate and Point Leamington. Unfortunately, ice and weather conditions during February and March limited the sample to 205 seals. Finally, a moulting sample of 562 seals was taken from April 16 to 29 in the Tooker Bank-Belle Isle area of northern Newfoundland.

Catch Statistics

In 1979, 160,071 harp seals were killed in the commercial harvest (Table 11). Of this total, 132,458 pups and 27,613 1+ seals were killed. This represents a pup:adult ratio of 83% to 17%. Canadian Arctic and Greenland catches are not available at this time.

Summary

1. There are no reliable estimates of 1978 pup production. The lack of an estimate from short term recoveries of tagged pups was due mainly to unfavourable ice conditions on the Front resulting in low recovery of tags and incomplete mixing of tagged and untagged seals. In the Gulf this was caused by the existence of the Meccatina patch, which was unmarked, and the lack of accurate and detailed catch statistics from ICNAF Subareas 3P and 4Vn. Future mark-recapture experiments designed to estimate Gulf production must ensure that all major whelping patches in the Gulf and Southern Front (Strait of Belle Isle) are tagged.

The estimate of 1978 pup production based on the catch of one-year-olds appears to be too high in the light of 1979 findings. The reason for this is unclear at this time. The method however appears promising and should be pursued further.

2. The 1979 mark-recapture experiment estimated Front pup production at 220,000. As in 1978, the Gulf experiment failed to provide an estimate for reasons similar to those discussed above.

3. The updated average pup production for 1970 to 1977 (median year 1973) from the survival index method is 342,000 with 95% confidence limits of 267,000 to 625,000.

4. Catch per unit effort analyses of the harp seal hunt are unlikely to provide reliable estimates of pup production. CPUE analyses provided no estimates in 1979.

5. Most recent evidence from tag recoveries continue to support the view that the degree of homing to the place of birth increases with age and reaches a maximum at sexual maturity.

6. The total catch of harp seals in 1979 was 160,071 and consisted of 132,458 pups (83%) and 27,613 1+ seals (17%).

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Table 1. The catch of beaters in ICNAF Subarea 3L and 3K in 1978 and the tag returns from these areas in parentheses. The ratio of tagged to untagged pups is also given.

Date	ICNAF Subarea	
	3L	3K
March	8	(2)?
Apr. 1-15	632	436(2); 1:218
Apr. 16-30	3777(4); 1:944	1824(5); 1:365
May 1-13	(10)?[a]	2364(14+10); 1:99
May 14-27	(5)?[a]	1459(6+5); 1:132

[a] tags assumed to have been recovered in 3K and are added to 3K returns as no catch reported in 3L.

Table 2. Age structure of 1+ harp seal catch in 1979 by landsmen in ICNAF Subarea 3.

Age	Netted sample (St. Anthony) Frequency	%	Total netted Catch at-age	Shot sample (Twillingate) Frequency	%	Total shot Catch-at-Age Sample
1	142	16.3	326	113	55.4	11,550
2	168	19.3	386	43	21.1	4,399
3	112	12.8	256	18	8.8	1,835
4	83	9.5	190	10	4.9	1,022
5	84	9.6	192	7	3.4	709
6	58	6.7	134	4	2.0	417
7	31	3.6	72	2	1.0	208
8	22	2.5	50	1	0.5	104
9	21	2.4	48	1	0.5	104
10	12	1.4	28			
11	14	1.6	32			
12	14	1.6	32			
13	17	2.0	40			
14	7	0.8	16	1	0.5	104
15	9	1.0	20	1	0.5	104
16	7	0.8	16			
17	14	1.6	32			
18	12	1.4	28			
19	9	1.0	20			
20	4	0.5	10			
21	5	0.6	12			
22	8	0.9	18			
23	1	0.1	2			
24	3	0.4	8			
25+	15	1.7	34	3	1.5	313
TOTAL	872		2000	204		20,848
Total age 1 catch			326			11,592
				11,918		

Table 3. Catch of 1+ harp seals and number of 1978 tag recoveries in January to June 1979

Date	Unit area 342	341	340	339
January	243	194	136	
February	42	139;6[a] (23)	1123;1 (1123)	149;3 (50)
March	549;2 (225)	806;8 (101)	3202;19 (169)	2148;29 (74)
April	320;5 (64)	2157;6 (360)	4254;17 (250)	1740;8 (218)
May	599;3 (200)	632;4 (158)	2569;11 (234)	570;2 (285)
June	33;1 (33)			32

[a] 139;6 reads 139 seals caught; 6 tags recovered
(23) (ratio of tagged to untagged = 1:23)

Table 4. Percentage of age one seals in shot samples of the Front landsmen catch sample in Notre Dame Bay.

Year	Sample Size	One-year-olds (%)	Source
1979	205	55.4	Bowen, this study
1978	529	43.0	Sergeant (1978)
1977	424	27.8	Sergeant (1977)
1976	374	53.7	Sergeant (1976)
1975	374	54.0	Sergeant (1975a)
1974	278	55.0	Sergeant (1975b)

Table 5. Relative efficiency of Canadian (C) and Norwegian (N) large vessels operating on the Front in 1979.

Vessel	Gross tonnage (A)	Braking Horsepower (B)	Efficiency (B/A)
Arctic Explorer (C)	991	2200	2.22
Carino (C)	564	1650	2.93
Lady Johnson II (C)	591	1080	1.83
Arctic Endeavor (C)	900	2000[a]	1.11
Gulf Star (C)	544	875	1.61
Martin Karlsen (C)	1226	1200	.98
Norvarg (N)	571	2400	4.20
Polarstar (N)	424	2022	4.77
Veselmari (N)	385	1550	4.03
Lance (N)	960	3400	3.54

[a] operating on one engine only; actual B = 1000.

Table 6. Daily catch per unit effort of large vessels on the Front in 1979. CPUE expressed as number of seals per 100 man-hours hunting.

a.

Date	Vessel										$\bar{x}$ Daily
	Explorer	Endeaver	Carino	Johnson II	Martin Karlsen	Gulf Star	Norvarg	Polarstar	Veselmari	Lance	CPUE/100
Mar. 12	502.5	483.6	756.3	635.3	732.1	537.5	743.8	684.5	475.4	261.7	5.8
13	543.3	436.9	1121.3	832.3	844.4	414.2	743.8	794.2	824.0	397.2	7.0
14	714.9	265.3	938.3	529.3	808.8	415.0	909.1	880.9	792.8	307.4	6.6
15	965.2	363.0	1024.1	238.0	793.3	365.6	681.8	1061.8	926.5	483.3	6.9
16	726.7	212.3	654.3	525.7	589.4	265.7	772.7	580.0	777.3	497.9	5.6
17	585.1	321.2	850.0	488.0	930.0	772.9	1040.0	918.3		347.2	6.9
18		556.4		557.0	596.9	635.8				503.1	5.7
19		538.9		345.6	624.1	525.0					5.1
20		558.3		429.8	70.6	317.5					3.5
21		342.3		459.5	289.5	704.5					4.5

b.

											$\bar{x}$ Daily Indexed CPUE
Mar. 12	.52	.87	.67	.76	.79	.70	.71	.65	.51	.52	.67
13	.56	.78	1.00	1.00	.91	.54	.71	.75	.89	.79	.79
14	.74	.48	.84	.64	.87	.54	.87	.83	.86	.61	.73
15	1.00	.65	.91	.29	.85	.47	.66	1.00	1.00	.96	.78
16	.75	.38	.58	.63	.63	.34	.74	.55	.84	.99	.64
17	.61	.58	.76	.59	1.00	1.00	1.00	.86		.69	.79
18		1.00		.67	.64	.82				1.00	.83
19		.97		.42	.67	.68					.69
20		1.00		.52	.08	.41					.50
21		.61		.55	.31	.91					.60

Table 7. Mean daily CPUE index and cumulative catch (K_t) of harp seals by large vessels in March 1979.

Date	Mean daily CPUE Index	C_t	$C_{t/2}$	K_t
Mar. 12	.67	10,400	5,200.0	5,200.0
13	.79	10,850	5,425.0	15,825.0
14	.73	9,897	4,948.5	26,198.5
15	.78	9,955	4,977.5	36,124.5
16	.64	8,220	4,110.0	45,212.0
17	.79	7,691	3,845.5	53,167.5
18	.83	5,809	2,904.5	59,917.5
19	.69	4,179	2,089.5	64,911.5
20	.50	3,399	1,699.5	68,700.5
21	.60	2,706	1,353.0	71,753.0

Table 8. Recovery of 1978 tags in 1978 and 1979 by month and ICNAF area

ICNAF area of tagging	2 (Front)						4 (Gulf)					
recoveries	0	1	2	3	4	5	0	1	2	3	4	5
Date												
March 1978			16	3						12	227	
April			6	15						3	12	
May			2	39						4	5	
June		10		2				1		1	16	1
July		7		1				2		2	5	
August		7						1			2	
September	1	3					1	3				
October		2										
November		2		2				2		1	1	
December		5		1	2			1			1	
January 1979		4		1	2					2		
February		5		6				1		11	1	
March		2	1	46				1		37	3	
April			4	33	8					16	12	
May			1	18	6					5	4	
June				1	1			1	1		1	
Total	1	47	30	168	19		1	13	1	94	290	1
Grand total			265						400			
Recoveries from January 1979-May 1979		11	6	104	16			2		71	20	
			137						93			

Table 9. Age-specific rates of return to home area of harp seals marked in the Gulf of St. Lawrence, 1966-78.

Year of Marking	Number Marked	Age (yrs) of recovery by area[a] 1 G	1 F	2 G	2 F	3 G	3 F	4 G	4 F	5 G	5 F	6 G	6 F	7 G	7 F	8 G	8 F	9 G	9 F
1966	1450	7	12	1	1	-	-	-	-	1	-	2	-	-	-	-	-	-	-
1968	2219	3	7		1	1		-	-	-	-	-	-	-	-	-	-	-	-
1969	1600	2	12	2	2	2	-	-	1	2	-	1	-	-	-	-	2	-	2
1970	1966	2	6	1	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-
1972	525	-	1	-	-	4	1	2	-	1[b]	-	2	-	2	-				
1973	200	-	1	-	-	1	-	-	-	-	-	-	-						
1974	391	2	2	1	-	-	-	2	-	1	-								
1975	1831	1	19	2	5	5	7	6	3										
1976	497	1	4	2	6	-	2												
1977	1230	4	44	5	17														
1978	4378	23	72																
Totals		45	180	1	32	13	11	10	5	5	-	5	-	2	-	-	2	-	2
% Gulf		20.0		30.4		54.2		66.7		100.0		100.0		100.0		0.0		0.0	

[a] during month XII-VI

[b] also B brand seen on ice

Table 10. Age samples of harp seals collected in 1979.

Age	1	2	3	4	5	6	Total
1	2	142	24	89	173	18	448
2	7	168	10	33	85	48	351
3	5	112	6	12	51	45	231
4	6	83	1	9	45	44	188
5		84	3	4	41	31	163
6	3	58	3	1	27	23	115
7		31	2	1	26	15	75
8		22		1	21	4	48
9		21		1	9	4	35
10		12			10	5	27
11	2	14			15	2	33
12		14			12	4	30
13		17			8	1	26
14		7		1	4	1	13
15		9		1	5		15
16		7			5	1	13
17		14			4		18
18		12			4	1	17
19		9			6	1	16
20		4			3	1	8
21		5			3		8
22		8					8
23		1			2	1	4
24		3					3
25+		15		3			18
TOTAL	25	872	49	156	562	250	1914

1. Port Hope Simpson (net)
2. St. Anthony (net)
3. Twillingate (shot)
4. Point Lemington (shot)
5. Moulting sample, Front (shot)
6. Saquenay area, N. Shore Quebec (shot)

Table 11. 1979 Harp seal catch statistics[a].

GULF AREA	Landsmen				Vessels < 150 GRT			Vessels > 150 GRT			GULF TOTAL
	Can-M	Can-N	Can-Q	Total	Can-N	Can-Q	Total	Can-M	Can-N	Total	
Harp seals - whitecoats	2	1,172	4,830	6,004	2,663	-	2,663	10,097	9,961	20,058	28,725
- beaters	19	650	11,172	11,841	681	-	681	-	-	-	12,522
- bedlamers	-	196	2,815	3,068	350	-	350	-	-	-	3,754
- old harps	-	57			336	-	336	-	-	-	
TOTAL	21	2,075	18,817	20,913	4,030	-[b]	4,030	10,097	9,961	20,058	45,001

FRONT AREA	Landsmen	Vessels < 150 GRT	Vessels > 150 GRT				FRONT TOTAL	FRONT + GULF		
	Can-N	Can-N	Can-M	Can-N	Norway	Total		Canada	Norway	Total
Harp seals - whitecoats	2,750	1,483	19,630	36,811	19,935	76,376	80,609	89,399	19,935	109,334
- beaters	6,138	3,972		290	202	492	10,602	22,922	202	23,124
- bedlamers	10,173	7,665	1	781	151	1,011	23,859	27,462	151	27,613
- old harps	3,523	1,487	78							
TOTAL	22,584	14,607	19,709	37,882	20,288	77,879	115,070	139,783	20,288	160,071

[a] Data obtained from Department of Fisheries and Oceans, St. John's and Halifax, and the Province of Quebec.

[b] Catch included with Quebec landsmen catch.

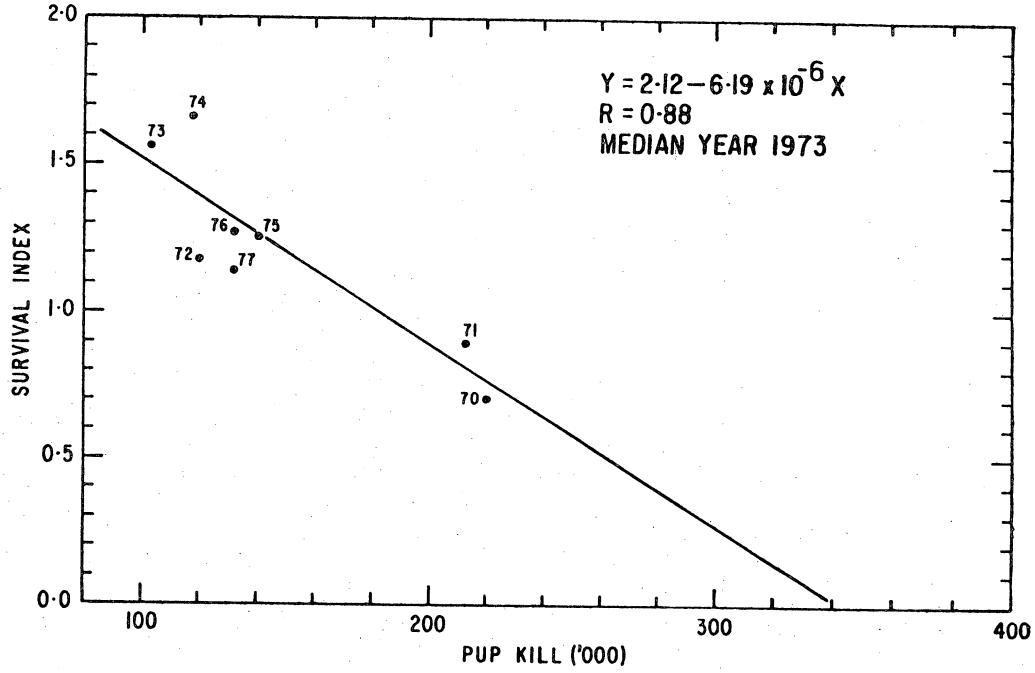

Fig. 1. Relationship between survival index and pup kill from 1970 to 1977.

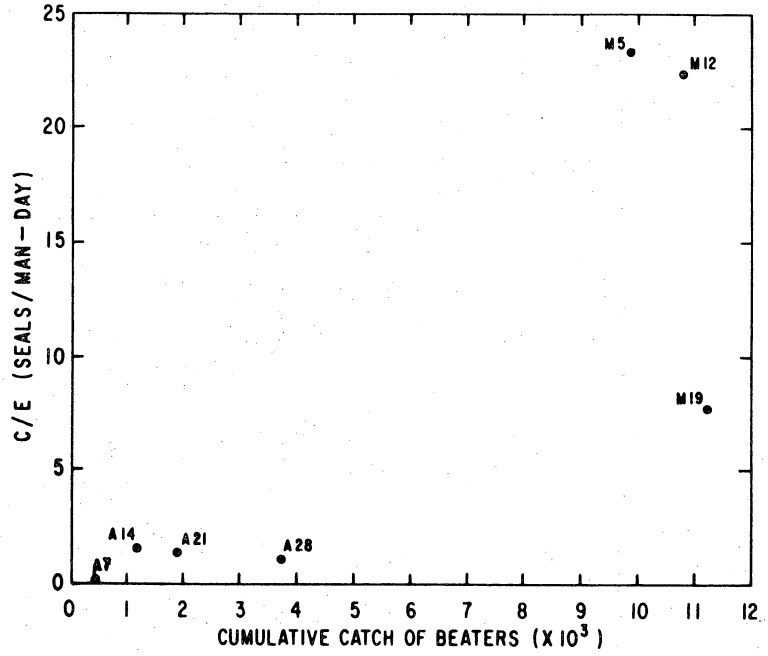

Fig. 2. The relationship between catch per unit effort (seals/man-day) of longliners and cumulative catch of beaters on the Front in April-May 1979. The alphanumeric beside each point indicates a two-week period ending, for example April 7 (A7) or May 12 (M12).