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# CALCULATION OF PRODUCTION OF HARP SEALS IN THE WESTERN NORTH ATLANTIC

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CONTENTS

1. Introduction

Experience has shown that some differences in the biological features of harp seals and fish need to be stressed to fisheries biologists. First, Pagophilus groenlandicus Erxleben is a long-lived mammal in which mortality rates are low and rather constant. Consequently a large number of age-classes of approximately similar strength contribute to annual production, which therefore fluctuates little. The population dynamics of the species are in fact more like those of human beings than fish. Secondly, the yield is taken as newborn or a few weeks old young before virtually any mortality has taken place, for mortality in the first week or so has been measured at 0.01 or less (unpublished data of the author). Therefore, yield to the fishery is a simple fraction of production. Third, the species is aggregated at more or less constant density when the young are fished, regardless of the size of the aggregation or whelping group. (This density is ideally set by an individual distance which exists between adult females with pups, i.e. they are over-dispersed, but the density is further reduced by the inaccessibility to seals of the centres of large ice floes.) Therefore, catch per unit of effort will not change with increasing catch of young until this catch is well above sustainable yield, and such data will not be of much practical value.

Four general methods developed for estimation of production will be discussed here. They are: photographic aerial survey, capture-recapture tagging, study of escapement of year-classes after large and small catches of young, and study of total catch of young when there are grounds, from the first three methods, for believing that the catches of young are a high proportion of production.

Definitions used are as follows: 0-group seals are termed juveniles, approximately 1-5 year old harp seals are sexually immature, and adults are aged some 6 years and up. The Front ice is off the Labrador coast in Subareas 2 and 3, the Gulf of St. Lawrence ice is in Subarea 4.

2. Reproductive Rates

The maximum sustainable yield of young has been calculated (Sergeant, MS, 1969) at between 0.24 and 0.38 of production for observed extremes of reproductive rate. The reproductive rate recently measured in the Gulf (Table 1) would favour the lower yield but may not apply to the Front population, where it has not been possible recently to measure the reproductive rate accurately. In 1962 the reproductive rate at the Front was optimal (Sergeant, 1966), as it was in the White Sea under heavy exploitation of both young and adult seals (Yakovenko and Nazarenko, 1967). The suboptimal reproductive rate in recent years in the Gulf can be associated with an observed interaction between adults and young immatures at winter feeding grounds (Sergeant, MS, 1969). Segregation occurred and the adults appeared to be using the better feeding areas. Competition for food could affect rates of growth and reproduction. If the same lowered reproductive rate now exists at the Front, as seems likely from small data, then doubt is thrown on the assumption that the optimal yield is obtained from fishing the young animals only. However, it is difficult to reconcile the thesis, developed below, that total population has declined with postulated competition between age-classes. The question has not yet been resolved.

3. Aerial Surveys

The main apparent advantage of aerial surveys is that they give the only direct count or estimate, either of production, when applied to young seals or the adult females producing them, or of standing crop when applied to moulting groups of adults and immatures (Dorofeev and Freiman, 1928, and subsequent Soviet authors).

The main disadvantages are high costs of surveys and the need for completeness of each survey. Particularly, surveys of moulting groups must be simultaneous, since the groups may change position daily, and must be repeated to demonstrate patterns of aggregation. 'Ground' control is necessary to measure age and sex composition. Pilots must know how to find seals and at the same time the photography must be competent. No repeat is usually possible in the same year.

Surveys of whelping groups show that many young are invisible and few controls are possible. One control was achieved in Canada in 1967 when the industry decimated a group of seals just previously surveyed and detailed catch figures were available. Twenty thousand whelping adults had been estimated by aerial survey on March 10. Thirty-five thousand young were taken on March 13 and 14. Clearly, many adult females were in the water, either because they had not yet pupped, or had left the pup between episodes of suckling. This correction (0.57 of adults present in a group) might be applied to all counts made at the same stage of the reproductive cycle, but other variables, e.g. whether the seals are whelping on open pack ice with many leads, or on frozen-together shore ice affect their ability to enter the water. The sex ratio of whelping adults also is not accurately known, since on disturbance the males, present in some numbers ahead of mating time, enter the water more freely than the females attached to pups. Presumably, unwhelped females also enter the water readily. All these corrections might be entered into surveys, given repeated facilities of fixed-wing aircraft and helicopters, but total costs would be high.

Aerial survey was made of whelping groups in the Gulf and on the Front in 1970. The search was highly successful in that all whelping groups of seals were believed located, except that one Gulf group was located by another Government charter plane but not by the photographic plane, and its size was not precisely estimated.

However, the photography was poor. A 70-mm camera, used for the first time in place of the usual 9 X 9" aerographic camera, proved to have film lengths too short for continuous overlapping coverage of the long axis of most seal patches. It was therefore necessary to load the film magazine in mid-survey and the long lines could not be matched afterwards when the mosaics of prints were mounted.

Results are shown in Table 2 with estimated major uncertainties in accuracy. Catches in a fourth Gulf group which was not surveyed were 10,000 seals, bringing the Gulf estimate to at least 75,000 whelping adults or young seals. Previous successful aerial surveys (Sergeant, MS, 1969) gave estimates or indices of 100,000 young seals produced in the Gulf in 1964, and 215,000 produced on the Front in 1960.

The main value of the 1970 survey was that the relative sizes of sets of whelping groups on the Front on the one hand, and in the southern Gulf of St. Lawrence on the other, were compared visually within a short space of time. They were approximately 5 to 3 or 2 to 1, the Front having the larger set of groups. This estimate is confirmed from the counts (Table 2) and is important in relation to the unsolved problem of mixing of Front and Gulf groups, as follows:

In 1969, lack of ice in the southern Gulf had forced many Gulf animals to whelp on the Front (Section 8). By 1970, the usual numbers of animals had returned to the Gulf. Moreover, the Front has for many years taken a heavier fishery than the Gulf, a trend which has been continued since 1965 when the catch of young in the Gulf was regulated. In spite of this long-continued difference in intensity of catch, the Front whelping groups in 1970 were larger. Therefore, either the Front has not been heavily exploited, which from the evidence presented below is unlikely, or else the population of seals re-sorts itself annually between Gulf and Front.

4. Capture-recapture Tagging

This method has been made possible mainly by a latening of the starting dates for hunting young seals from March 7 to March 12 or later.

Tagging between 2000 and 3500 young seals has usually been possible from an icebreaker or helicopter. The first figure represents, it is calculated, about 2% of Gulf production, the second, 2% of Front production. The interval between tagging and start of the fishery for young seals has varied from no time to up to 2 weeks. The longer the interval, the greater the chance of randomisation of the tagged seals through ice movement. Mortality of young at or immediately after birth, as already stated, is low and not likely much increased in the first few weeks (Popov, 1966). Greatest errors come from a concentration of tagging and recoveries in the same group of seals when other groups are not found or are inaccessible to either tagging or recapture effort. I have determined also that considerable variation occurs in catch returns of tagged seals from ship to ship within one tagged group, apparently because of failure to achieve randomisation of tagging. With such errors, sophisticated treatment seems as unprofitable as for aerial survey, and the best validation has come from three successive experiments in the Gulf, carried out in 1964, 1968 and 1970, which have given comparable estimates (Table 3). One experiment has been performed on the Front. Resulting estimates of Gulf and Front production, when compared, are in line with the 5/3 ratio between Front and Gulf production observed in 1970, and absolute figures are also broadly comparable when allowance is made for the incompleteness of aerial counts.

5. Study of Escapement After Varying Catch

Use of this method started from the observation from a number of age samples (one Danish, several Canadian) collected and analysed in 1953, that after an unusually heavy catch of young seals in 1951, the size of this year-class was consistently reduced. The same result was found after the next unusually heavy catch of young in 1956 and has been observed repeatedly thereafter, particularly following heavy kills of young in 1962 and 1963 (Figs. 1 and 2). The results should be particularly clear since 1961, when closing dates lowered the kill of age-groups older than the young (0-group), making the kill of older age-groups steady at about 35,000 annually as opposed to variable and up to 100,000 prior to 1961. Previously it was possible for a year-class of young, which had received light exploitation and consequently had survived well, to be exploited heavily at a later age, especially as the somewhat segregated 1-year-old moulting animals.

The problem is to quantify the strength of each year-class as a measure of the degree of its survival.

a. Using all age samples

A first, semi-quantitative method has been to sum the results of all age samples, allowing for various sorts of bias in these age samples which are known from long sampling to be steady, and the biological reasons for which are known. Thus, southward migrant seals lack younger age-classes, the number of immatures progressively increasing with increasing age (Fig. 1). In a real life table, they should of course decrease due to mortality. It is however known, from tagging results and from collection of age samples in West Greenland in winter, that the younger age-classes remain north in the winter up to 2 or 3 months longer than the main groups (Sergeant, 1965). The opposite bias occurs with samples from moulting groups at the icefields in April (Fig. 2, left). One and two year-olds are then over-represented. The reasons may be threefold: concentration and segregation of such immatures in the southern edges of the icefields most easily reached by ships, tameness of the young year-classes, and a movement (demonstrated by tagging) of young year-classes of Gulf seals to the Front at 1-3 years of age.

Few samples, chosen eclectically, have been "ideal", that is, corresponding to the expected age frequency distribution. Best were a West Greenland sample collected from many points by Danish scientists in 1953, and a unique sample of moulting seals collected in the northern Gulf in 1966. These samples were used to estimate mortality rates. No apology is made for the slight circularity in this argument, since much other unquoted evidence on the expected mortality rates of seals was used in regarding these samples as ideal. An ideal distribution, for example, reasonably gives higher mortality rates to the inexperienced immatures than to the adults. Table 4 shows sources of age samples used and their probable biases. Detailed age frequencies are shown in Appendix Table 1. Table 5 shows the result of combining all samples in order to estimate the escapement or index of survival of each year-class from 1960 to 1969. Clearly there is more accumulated evidence for earlier year-classes. The index of survival is expressed in four categories: very good rates as 3, good as 2, poor as 1 and very poor as 0. These values are summed and then expressed as a proportion of the maximum possible score (always 3). By this means a year-class which always showed an index of 'very good' would score 1.00, one which always showed an index of 'very poor' would score 0.00. Results of the analysis are plotted in Figure 3. From the least squares fit, extrapolation down to survival index 0.00 would occur at an estimated catch of 365,000 young seals, which therefore represents an estimate of present production. Survival to index 1.00 would occur at a catch of 115,000 young harp seals. The precise biological significance of this figure is obscure but since it measures "consistently good escapement of a particular year-class in all age samples, as compared with other year-classes," it may represent approximately the present sustainable yield. The ratio 115/365 = 0.32 whereas the sustainable yield of young seals has been calculated from known mortality and fecundity rates at between 0.24 and 0.38 (mean, 0.31). Presumably, below catches of 115,000 natural mortality increases in a density-dependent manner, while above this value, an irreducible minimal mortality of juveniles occurs. This mortality is believed, by extrapolation back from mortality rates of immatures, to be about 0.20 on an annual basis (Sergeant and Fisher, MS, 1960).

b. Using single sets of age samples

This method is the same as above but confined to one set of age samples at a time, so that variations in selectivity or bias between sets of samples is eliminated. Within one set of samples, bias is seen to be much the same each year (Fig. 2), so that by expressing catch and escapement as proportions between one year and the next, this bias can be eliminated. Thus true quantitative results can be achieved. For proper formulation of the method I am much indebted to Dr. W. E. Ricker.

Consider for example the two sets of samples seen in Figure 2. One is of seals sampled by net from a shore fishery at or near St. Anthony, northeast Newfoundland, in January to March 1967, 1968, 1969 and 1970. The second set comes from the ship fishery a few miles off this coast and two months later, in April. The animals are then shedding their hair on their annual moult and are shot. In the second set, a bias towards one and two year-old animals is seen as compared with the first set.

Let us consider the shore fishery only. In the first two samples, year-classes 1966 and 1967 show up poorly as one year-old animals but, in the third sample, collected in 1969, year-class 1968 appears in great strength. Now the catch of young seals in 1968 was reduced to half the catch in 1967 or 1966, as the result of a late starting date and temporary reductions in catching effort. The association between low catch and enhanced escapement is seen also in the moulting samples.

We will assume that in successive adjacent years neither stock nor production have changed by an appreciable amount, and that natural mortality during age 0 is constant over this period (i.e. that not even in 1968 was maximal sustainable yield taken).

Let $S$ = stock excluding young (same in both years)

$B$ = number of young just before harvesting (same in both years)

$C$ = catch (known)

$v$ = natural mortality rate after kill and before sample taken at age 1 (same in both years)

$K$ = ratio of age 1 seals to $S$ (known for each year).

We wish to estimate B. From the above we can write:

Survivors after catch = B - C

Survivors at age 1 = (B - C) (1 - v)

Age 1 divided by stock = $\frac{(B - C)(1 - v)}{S} = K$

$$\frac{K_1}{K_2} = \frac{B - C_1}{B - C_2} \qquad B = \frac{K_1 C_2 - K_2 C_1}{K_1 - K_2}$$

Table 6 shows the data and Table 7 the calculations using St. Anthony samples on the left side and icefield samples on the right, the mean of 1966 and 1967 catches and escapements compared with 1968, above, and 1968 compared with 1969, below.

For the 1966-1967/1968 comparison, from both areas, results are in good agreement. Using the Front catch figures, production is calculated at close to 200,000, while using total catch figures, production is close to 300,000. These figures represent estimates respectively of Front production and total production.

For the 1968/1969 comparison, the Front figure increases and the total figure decreases. This result may be associated with an apparent move to the Front in 1969 of some seals which would normally have whelped in the Gulf (see below, Section 8). With this known abnormal year, it is probably better to use the 1966-1967/1968 comparison as more normal. This is shown graphically in Figure 4, where values of K are plotted against catch C. The least squares line is fitted to data for the first three years only. For K equal to 0, estimates of catch = production are: for the Front - 192,000, for the total production - 283,000. Expected further samples will allow refinement of these estimates.

6. Use of Catch Statistics

a. Total catch

Table 8 shows recent catches of young, uncontrolled at the Front save by season and partial abstention (1968) but controlled in the Gulf by Canadian regulation and Norwegian abstention since 1965.

Inspection of Front catches of young from 1960 to 1970 shows that in no year have catches exceeded 187,000 in spite of heavy catching effort and uncontrolled (unregulated) catch. This is itself strong evidence that production on the Front does not exceed, and may be less than, 200,000.

Figure 2 and Table 5 showed that, after years of highest catch (e.g. 1963, 1964, 1967) escapement of young was very low. Very low and maintained low escapement after high total catches in 1963, higher than normal in the Gulf, slightly lower than normal at the Front, suggest the importance of mixing between stocks.

b. Whitecoats and beaters

Mr. T. Øritsland (MS, 1967) demonstrated a variant of this method. If all the young are taken as whitecoats, none will escape to be taken at one month of age as "beaters," hence the beater catch will decline. He demonstrated a progressive decline in beater catches by the Norwegian fleet, indicating that a progressively increased proportion of production was being taken.

In order to convert to absolute production, the Canadian (and other) catches of young must be added. Unfortunately Canadian catch statistics did not separate whitecoats and beaters till 1966. In 1966 catches of young at the Front were not maximal (168,000), 1968 was a beater season, and in 1969 the Gulf ice was abnormal so that some whelping females from the Gulf probably moved to the Front. This leaves us 1967, a year of maximal catch of young at the Front (187,000). Indeed in this year beater catches were exceedingly low (1700 only) and whitecoat catches 181,000. (An intermediate category of 'ragged jacket' accounts for the rest.) The combined catch of 187,000 young seals at the Front was therefore very likely close to total production.

7. Discussion

If the two populations mix, as now seems very probable, then removal annually of a high proportion of Front production plus a substantial amount of Gulf production will cause the population to decline. In quantitative terms, if production now equals 300,000 and actual removal averages 218,000 (Table 8) while sustainable yield is 125,000, the population as a whole must be declining. Is there any direct evidence that this is so?

First, to revert to Table 8 and the method of Section 5a. Larger maximal catches of young were taken at the Front in the 1950's (up to 248,000) than in the 1960's (up to 188,000). This suggests a decline in production since if anything, catching effort has increased, due to experience of skippers and use of more powerful ships. Decline was probably faster in the 1950's since large numbers of adult and immature as well as young seals were then taken, until imposition of a closing date in 1961. Perhaps also the Gulf population, managed since 1965, has contributed part of its production to the overexploited Front. I do not think that the constant mean catches of young (Table 8) are an objection to my thesis, as has been suggested by the sealing industry. On the contrary, I think that they only mean that an increasing proportion of young is being killed.

A second line of evidence comes from a long series of samples, now extending over 20 years, from the net fishery on the North Shore of the Gulf of St. Lawrence at La Tabatiere (Age reading of this series was begun by Dr. H. D. Fisher and continued, with cross-checking of ages, by the author.). In the early 1950's this sample contained a lot of older immatures or young mature adults, aged 4-6 years. In recent years this proportion has declined (Fig. 1). This can only mean, either that we are underfishing the adults so that they are accumulating, or that we are overfishing the young seals, so that recruitment steadily declines to the population as a whole. All the other evidence cited in this paper favours the second hypothesis. Again, this evidence, so interpreted, favours a high degree of mixing between populations, since it is unlikely that the Gulf, from where these samples come, has itself been overexploited under a controlled fishery.

8. Mixing of Stocks

Some evidence has been discussed above. Further evidence is as follows:

In 1969, abnormally restricted pack ice in the southern Gulf interfered with whelping of harp seals. After 32,000 young had been killed, the hunt was called off by Government order. Careful Governmental survey found only 6600 more young. There was no ice elsewhere in the Gulf. Therefore an estimate of production in the Gulf in 1969 was less than 40,000. This is below the normal production estimated at some 100,000. The other whelping seals must either have aborted at sea, or looked for and whelped on ice elsewhere. There was no evidence for large numbers of washed-up corpses of neonates, and the second alternative seems logical. The nearest suitable ice was in Hamilton Inlet, Labrador, where a large, compact herd whelped. Here, although the herd was in Canadian territorial limits for the most part so that few Norwegian ships took part in the whitecoat fishery, the total catch of young at the Front was 187,000 young animals, equal to any other maximum (Table 8). Is there any evidence that Gulf animals were involved? I think so, extending the method of Section 5b above.

If many seals moved to the Front to whelp, escapement of the 1969 year-class will not be much below the expected level after a total catch of 220,000 young (Fig. 3), i.e. fair to poor (index 1 or 2) survival. But if they stayed in the Gulf and failed to whelp successfully, then the total Front production was taken, as well as the reduced production in the Gulf, so that escapement would have been very poor (index 0).

In fact, Front samples for 1970 (Tables 5d, e and 6) show that escapement of the 1969 year-class was about one third higher than for 1966 and 1967. If K, the ratio of one year-olds to total animals in age samples (method of Section 5b) is plotted against Front catch for the 4 years of available data from 1967 to 1970 (Fig. 4), in 1970 it falls above the least squares line of fit of the other 3 years, giving an increased value for production at the Front. But if plotted against total catch in 1970, it falls somewhat below the line, giving a lowered value for total production. This suggests to me that most animals which did not whelp in the Gulf whelped on the Front.

During 1969 the ratio of whelping animals was more than 187,000 on the Front to 40,000 in the Gulf, or higher than 4.5 to 1. In 1970, aerial survey showed the ratio to be nearer 3:2. Therefore, animals had returned to the Gulf. The effect of delayed whelping in the Gulf (and on the Front too for animals that moved) due to poor ice was apparently reflected in abnormally late whelping in the Gulf in 1970. One large patch was actively whelping between about March 8 and 16, as compared with normal dates of about March 1 to 7. (This observation also suggests that the date of whelping in March is fixed by the date of mating in April of the previous year, and not by the date of implantation, which occurs in the arctic about the end of July.)

The simplest hypothesis available at the present time from all the above evidence is that the seals mix freely on the southward migration in January when they feed for some 2 months in ice-free waters before whelping. They then whelp on the nearest available ice, beginning in late February. While this hypothesis does not rule out the possibility of some homing to, for instance, Gulf waters by the same animals yearly, its truth would rule out the possibility that sharp morphological or biochemical differences might be detectable between the populations except for phenotypic influences on the young (e.g. differences in weather which could affect hair quality). A more serious consequence would be that if, as demonstrated above, the Front population is being heavily overfished, and, if the populations mix, this effect will spread to the Gulf population which will also decline. Probably this is happening now. Capture-recapture estimates in the Gulf show a progressive decline (Table 3), and an increase in percentage of recaptured young, and production in the southern Gulf has almost certainly now sunk below 100,000 young.

9. Are Any Seals Being Missed?

The possibility of far northern harp seals was explored by flights along the Labrador coast in 1960 (Sergeant and Fisher, MS, 1960). None were found in March north of Hamilton Inlet, the ice being unsuitable due to lack of open water leads until too far out to sea. If such seals exist, they must whelp in April, and may contribute to small numbers of whitecoats seen at the Front late in the season in some years. Catches from these would enter catch figures so that the methods of Section 5 have allowed for them.

More important are a variably sized herd in the northern Gulf, whelping on the rather small and variable amount of ice entering through the Strait of Belle Isle. From catch figures they were known to reach a maximum of perhaps 50,000 in 1965 and 35,000 in 1967. The minimum may be a few hundred seen, for instance, by survey in March 1970. Again such catches enter catch figures, since the seals are taken sometimes by the larger ships and regularly by longliners active in the northern Gulf in April. Thus this production has also been taken into account in the methods of Section 5.

If the method of Section 6a is applied to total catches it is seen that total catches in the 1960's did not exceed 280,000 (Table 8) less than our postulated 300,000 total production. Big production in the north, occasionally entering the catches, would surely raise catch levels occasionally to a higher figure. Therefore I think that such added northern production is negligible. Higher total catches in the 1950's, up to 350,000 young seals, can be attributed to a higher production at that time.

10. Management

The 1971 quota of 200,000 seals of all species assigned to ships is divided 50,000 to the Gulf and 150,000 to the Front. These could all be taken as young harp seals, since the estimated production in each area will allow such catches, and because the fishery for young seals, (beginning about March 12) comes before the fishery for hood seals on the Front (beginning about March 20) and the fishery for moulting adult and immature harp seals (beginning about March 30). If this quota is fully taken as young harp seals some 50,000 young will be left available in each area, according to the present thesis, to be taken by smaller craft if these are not subject to the 200,000 quota. The numbers of these smaller vessels are known to be increasing rapidly as prices of harp seal furs remain firm.

In this way the proposed 1971 quota, as presently understood, would allow almost total destruction of the 1971 year-class of harp seals. If the population of western harp seals is to remain even at its present, reduced level, the quota must be cut to no more than 125,000 young harp seals taken by all agencies, or else the starting date for sealing must be made so late that the catch of the more highly dispersed "beaters" is no more than this figure. As with the International Whaling Commission a decade ago a major difficulty towards effective regulation is that there exists an excessive and growing catching fleet, the costs of construction of which must be amortized. I have previously suggested (Sergeant, MS, 1966) that the catching fleet should be halved, from some 24 to 12 large vessels, to maintain present sustainable yield and take it efficiently. Now in 1971, this measure would be inadequate. I now suggest that as many sealing ships as possible, most of which constitute a long-distance fleet, be diverted to fishing the stocks of crabeater seals <u>Lobodon carcinophagus</u> and other species in the Antarctic. Their biology, as seen from a pioneering Norwegian voyage, has been described by Øritsland (1970). The sustainable yield of harp seals could then be taken, and the stock possibly allowed to increase, by leaving such ships as are fit only for nearshore waters, together with the increasing fleet of longliners. While such a proposal is outside the scope of formal consideration by a regional organization such as ICNAF, possibly ICNAF should consider an approach to the Antarctic Treaty organization if a diversion of the kind suggested is recommended.

11. Summary

Present production of young harp seals in the western North Atlantic is calculated by four independent methods to be about 300,000 and declining. Under normal ice conditions some 200,000 are believed produced on the Front ice in Subareas 2 and 3, and 100,000 in the Gulf of St. Lawrence, Subarea 4. Shifts of population under abnormal ice conditions, and other evidence, suggest intermixing of stocks between the two subareas. The combined sustainable yield at present is estimated to be no more than 125,000 young harp seals. Present annual catches average 218,000 young and effort is increasing. Diversion of the more mobile part of the fleets to sub-Antarctic seal stocks is suggested as an alternative to continued overexploitation.

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Table 1. Reproductive rates of female harp seals collected in the Gulf of St. Lawrence, 1965-1969.

| Age at parturition (yrs) | Number: Immature | With regressed corpus luteum | Pregnant | Total | Percent pregnant |
|---|---|---|---|---|---|
| 1 | 25 | | | 25 | |
| 2 | 35 | | | 35 | |
| 3 | 69 | | | 69 | |
| 4 | 77 | | 2 | 79 | 2.5 |
| 5 | 74 | 1 | 21 | 96 | 21.9 |
| 6 | 35 | 4 | 65 | 104 | 62.5 |
| 7 | 14 | 1 | 81 | 96 | 84.4 |
| 8 | 7 | 5 | 66 | 78 | 84.6 |
| 9 | 3 | 2 | 51 | 56 | 91.1 |
| 10 | 4 | | 50 | 54 | 92.6 |
| 11 | | 5 | 43 | 48 | 89.6 |
| 12 | 1 | 2 | 31 | 34 | 88.1 (ages 12-27) |
| 13 | 2 | 4 | 23 | 29 | |
| 14 | 1 | 1 | 39 | 41 | |
| 15 | | 2 | 31 | 33 | |
| 16 | | 1 | 23 | 24 | |
| 17 | | 4 | 15 | 19 | |
| 18 | 2 | 1 | 11 | 14 | |
| 19 | 1 | 1 | 12 | 14 | |
| 20 | | 2 | 4 | 6 | |
| 21 | | | 4 | 4 | |
| 22 | | | 7 | 7 | |
| 23 | | | 2 | 2 | |
| 24 | | | 2 | 2 | |
| 25 | | 3 | 1 | 4 | |
| 26 | | | 1 | 1 | |
| 27 | | | 1 | 1 | |
| | 350 | 39 | 586 | 975 | |

Table 2. Aerial photographic survey of whelping seals, 1970.

A. Gulf (March 8, 10)

| March | Area (sq. miles) 8 | Area (sq. miles) 10 | Density (seals/sq. mile) 8 | Density (seals/sq. mile) 10 | Total number 8 | Total number 10 |
|---|---|---|---|---|---|---|
| Group I | 13 | 29 | 828 | 890 | 11,856 | 26,665 |
| II | very small | | - | - | (1,000) | (1,000) |
| III | 25 | 60 | 667 | 600 | 18,377 | 36,500* |
| | | | | | | 64,165 |

* Whelping not completed till ca March 16.

B. Front (March 14)

| | Area | Density | Total number |
|---|---|---|---|
| Group I | - | - | (5,000)* |
| II | 2 | 3,619 | 7,200 |
| III | 6 | 2,798 | 16,788 |
| IV | 95° | 963.3 | 91,515 |
| | | | 120,503 |

* Cloud prevented photography.
° Area estimated from timed lines only.

Table 3. Results of capture-recapture tagging 1964 to 1970.

A. Gulf

| Year | Tagged | Recaptured | | | Catches | | | Estimate of production from: | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ships | Planes | Total | Ships | Planes | Total | Ships | Planes |
| 1964 | 2,971 | 782 | 876 | 1,658 (58.3%) | 42,256 | 39,252 | 81,508 | 154,072 | 127,432 |
| 1968 | 2,219 | 1,055 (47.5%) | | | 59,735 | | | 127,209 | |
| 1970 | 1,966 | 1,546 (78.4%) | | | (50,000) | | | 63,000 + at least 10,000 from untagged patch<br>73,580 + | |

B. Front

| Year | Tagged | Recaptured | | | Catches | | | Estimate of production from Canadian ships* |
|---|---|---|---|---|---|---|---|---|
| | | Canadian ships | Norwegian ships | Total | Canadian ships | Norwegian ships | Total | |
| 1966 | 3,581 | 1,042 | 620 | 1,662 | 54,955 | 107,213 | 162,168 | 188,913 |

* Norwegian ships' recoveries believed incompletely reported.

Table 4. Sources of age samples analysed in Table 5. Samples arranged in seasonal sequence.

| Number | Location | Behaviour of animals | Season | Known biases |
|---|---|---|---|---|
| a. | Labrador | Migrating south | Nov.-Dec. | Few 1-4 year animals |
| b. | Northern Gulf | Migrating south | January | Few 1-4 and >10 year animals |
| c. | Western Gulf | Wintering | Jan.-April | Few >5 year animals |
| d. | Front shore catch | Wintering | Jan.-April | Good |
| e. | Front ship catch | Spring moult | April | Excess 1-2 year animals |
| f. | Arctic | Summering | July-Oct. | Excess 1-2 yrs (Greenland) or too few 1-2 yrs (Baffin I.) |

Table 5. Index of survival (escapement) of year-classes of harp seals 1960-69, assessed subjectively from the series of age samples identified in Table 4, as very good = 3, good = 2, poor = 1, very poor = 0. Data in Appendix Table 1. No data shown, where they exist, indicates an expected bias or inadequate data.

| Year class | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample | | | | | | | | | | |
| 1970 | | | | | | | | | | |
| e | ---- | ---- | ---- | ---- | ---- | 2 | 2 | 0 | 3 | 2 |
| d | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 0 | 3 | 2 |
| c | ---- | ---- | ---- | ---- | ---- | ---- | 2 | 3 | 2 | 1 |
| b | 3 | 2 | 2 | 1 | 1 | 3 | ---- | ---- | ---- | ---- |
| a | 1 | 2 | 1 | 1 | 2 | 3 | ---- | ---- | ---- | ---- |
| 1969 | | | | | | | | | | |
| f | 2 | 0 | 1 | 2 | 1 | 3 | 2 | 1 | 3 | ---- |
| e | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 2 | |
| d | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 1 | 2 | |
| c | ---- | ---- | ---- | ---- | ---- | ---- | 2 | 1 | 3 | |
| b | 1 | 2 | 2 | 1 | 2 | 3 | ---- | ---- | ---- | |
| a | 2 | 2 | 2 | 0 | 1 | 2 | 1 | 1 | 2 | |
| 1968 | | | | | | | | | | |
| e | 3 | 2 | 1 | 1 | 1 | 3 | ---- | ---- | | |
| d | 3 | 2 | 1 | 0 | 1 | 1 | 1 | 1 | | |
| b | 2 | 2 | 2 | 1 | 2 | 3 | ---- | ---- | | |
| 1967 | | | | | | | | | | |
| f | 2 | 2 | 2 | 1 | 2 | 2 | ---- | ---- | | |
| e | 3 | 3 | 2 | 1 | 0 | ---- | ---- | | | |
| d | 3 | 2 | 1 | 1 | 0 | 1 | 1 | | | |
| b | 2 | 3 | 2 | 1 | ---- | ---- | ---- | | | |
| a | 2 | 2 | 2 | 2 | ---- | ---- | ---- | | | |
| 1966 | | | | | | | | | | |
| e | 2 | 1 | 1 | 1 | ---- | ---- | | | | |
| b | 3 | 2 | 2 | ---- | ---- | ---- | | | | |
| 1965 | | | | | | | | | | |
| e | 2 | 1 | 1 | 1 | ---- | | | | | |
| b | 3 | 3 | ---- | ---- | ---- | | | | | |
| a | 2 | 2 | ---- | ---- | ---- | | | | | |
| 1964 | | | | | | | | | | |
| b | 3 | 2 | ---- | ---- | | | | | | |
| a | 3 | 3 | 1 | 2 | | | | | | |
| 1963 | | | | | | | | | | |
| e | 3 | 3 | 1 | | | | | | | |
| b | 2 | 2 | 1 | | | | | | | |
| a | 2 | 3 | 1 | | | | | | | |
| 1962 | | | | | | | | | | |
| f | 2 | 2 | ---- | | | | | | | |
| e | 3 | 2 | | | | | | | | |
| b | ---- | ---- | | | | | | | | |
| a | ---- | ---- | | | | | | | | |
| 1961 | | | | | | | | | | |
| e | ---- | | | | | | | | | |
| b | ---- | | | | | | | | | |
| Total | 62 | 56 | 32 | 18 | 15 | 28 | 13 | 8 | 20 | 5 |
| Maximal | 72 | 72 | 63 | 51 | 36 | 36 | 24 | 24 | 24 | 9 |
| Ratio = Index | 0.86 | 0.78 | 0.51 | 0.35 | 0.41 | 0.78 | 0.54 | 0.33 | 0.83 | 0.56 |
| Catch ($X10^3$) | 156 | [illegible] | 207 | 270 | 266 | 183 | 252 | 280 | 156 | 220 |

Table 6. Escapement at one year of age, correlated with catch of young and expressed as percentage of total sample, for samples from (a) St. Anthony and (b) the Front icefields.

| Year class | Catch of young (C) $\times 10^{-3}$ Front | Total | Number & percent of juveniles in samples from St. Anthony 1 yr | Total | Ratio (K) | Front icefields 1 yr | Total | Ratio (K) |
|---|---|---|---|---|---|---|---|---|
| 1966 | 180 | 264 | 18 | 315 | .057 | 77 | 405 | .190 |
| 1967 | 184 | 276 | 7 | 201 | .035 | 84 | 576 | .145 |
| Mean | 182 | 270 | | | .046 | | | .168 |
| 1968 | 98 | 155 | 87 | 205 | .424 | 62 | 107 | .579 |
| 1969 | 187 | 220 | 41 | 571 | .072 | 105 | 431 | .244 |

Table 7. Calculation of Front and total production comparing mean figures of catch and escapement for 1966-67 with 1968 and 1968 with 1969.

| Catch | Front | | Total | |
|---|---|---|---|---|
| Age sample | St. Anthony | Front icefields | St. Anthony | Front icefields |
| Years compared | | 1966-67/68 | | |
| Estimated production | 192,704 | 216,336 | 283,994 | 317,007 |
| | (204,520) | | (300,500) | |
| Years compared | | 1968/69 | | |
| Estimated production | 205,205 | 251,824 | 233,295 | 267,343 |
| | (228,514) | | (250,319) | |

Table 8. Catches of young harp seals $\times 10^{-3}$.

| Year | Gulf of St. Lawrence | Front | Total | 5-yr mean |
|---|---|---|---|---|
| 1950 | 31 | 195 | 226 | |
| 1951 | 90 | 229 | 319 | |
| 1952 | 63 | 135 | 198 | 223 |
| 1953 | 32 | 166 | 198 | 228 |
| 1954 | 74 | 101 | 175 | 233 |
| 1955 | 94 | 158 | 252 | 226 |
| 1956 | 93 | 248 | 341 | 215 |
| 1957 | 74 | 91 | 165 | 228 |
| 1958 | 90 | 51 | 141 | 208 |
| 1959 | 62 | 177 | 239 | 174 |
| 1960 | 85 | 71 | 156 | 182 |
| 1961 | 41 | 128 | 169 | 208 |
| 1962 | 89 | 118 | 207 | 214 |
| 1963 | 110 | 160 | 270 | 219 |
| 1964 | 84 | 182 | 266 | 236 |
| 1965 | 90 | 93 | 183 | 250 |
| 1966 | 84 | 180 | 264 | 227 |
| 1967 | 92 | 184 | 276 | 218 |
| 1968 | 57 | 98 | 155 | |
| 1969 | 33 | 187 | 220 | |
| (1970 preliminary | 57 | 150 | 207) | |

Appendix Table 1. Age samples.

(a) Labrador (November of previous year to January of current year).

| Age (yrs) nearly | 1970 | 1969 | 1968 | 1967 | 1966 | 1965 | 1964 | 1963 | 1962 | 1961 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21 | 5 | | 6 | 1 | 4 | 43 | 26 | 6 | |
| 2 | 60 | 4 | | 11 | 2 | 10 | 42 | 83 | 15 | |
| 3 | 67 | 29 | | 17 | 3 | 24 | 50 | 54 | 16 | |
| 4 | 63 | 18 | | 24 | 5 | 34 | 32 | 33 | 30 | |
| 5 | 68 | 11 | | 30 | 7 | 24 | 32 | 26 | 21 | |
| 6 | 44 | 6 | | 25 | 5 | 18 | 42 | 21 | 7 | |
| 7 | 24 | 11 | | 27 | 4 | 15 | 29 | 8 | 14 | |
| 8 | 22 | 10 | | 14 | | 16 | 35 | 10 | 16 | |
| 9 | 25 | 11 | | 10 | 4 | 4 | 23 | 12 | 13 | |
| 10 | 24 | 2 | | 9 | 2 | 5 | 27 | 15 | 16 | |
| 11 | 13 | 3 | | 11 | 1 | 5 | 18 | 14 | 10 | |
| 12 | 8 | 6 | | 5 | | 6 | 21 | 10 | 3 | |
| 13 | 8 | 1 | | 6 | | 7 | 20 | 9 | 11 | |
| 14 | 5 | 1 | | 7 | | 7 | 21 | 14 | 8 | |
| 15 | 10 | | | 7 | | 10 | 7 | 11 | 23 | |
| 16 | 2 | 1 | | 6 | 1 | 6 | 11 | 9 | 10 | |
| 17 | 9 | | | 3 | 2 | 5 | 12 | 11 | 4 | |
| 18 | 6 | 1 | | 4 | | 4 | 6 | 4 | 4 | |
| 19 | 6 | | | 6 | 2 | 4 | 14 | 12 | 6 | |
| 20 | 6 | 1 | | 4 | | 1 | 6 | 10 | 12 | |
| 21 | 1 | 1 | | 4 | | 2 | 6 | 6 | 2 | |
| 22 | 1 | | | | 1 | 1 | 3 | 8 | 5 | |
| 23 | 3 | | | 1 | | | 5 | 10 | 3 | |
| 24 | 1 | | | 2 | | 2 | 2 | 6 | 2 | |
| 25 | | | | 1 | 2 | 2 | 6 | 2 | 3 | |
| 26 | | | | | | 1 | 3 | 2 | | |
| 27 | | | | | | 1 | | 1 | 3 | |
| 28 | | | | 1 | | | 1 | 2 | 2 | |
| 29 | | | | | | | | 3 | | |
| 30 | | | | 2 | | | | 4 | | |
| 30+ | | | | | | | 2 | | 3 | |
| N | 497 | 122 | | 243 | 42 | 218 | 519 | 439 | 266 | |

Appendix Table 1 (Continued). Age samples.

(b) Northern Gulf (January).

| Age (yrs) nearly | 1970 | 1969 | 1968 | 1967 | 1966 | 1965 | 1964 | 1963 | 1962 | 1961 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 9 | 11 | 12 | 10 | 4 | 10 | 18 | 20 | 16 |
| 2 | 12 | 20 | 48 | 42 | 29 | 17 | 31 | 52 | 50 | 65 |
| 3 | 32 | 49 | 68 | 46 | 42 | 45 | 74 | 86 | 74 | 100 |
| 4 | 55 | 69 | 56 | 37 | 44 | 72 | 64 | 90 | 95 | 126 |
| 5 | 77 | 71 | 39 | 58 | 42 | 71 | 65 | 80 | 95 | 39 |
| 6 | 38 | 49 | 54 | 72 | 50 | 66 | 40 | 56 | 33 | 52 |
| 7 | 35 | 60 | 41 | 64 | 33 | 39 | 27 | 32 | 46 | 43 |
| 8 | 64 | 59 | 39 | 43 | 19 | 32 | 11 | 36 | 42 | 27 |
| 9 | 66 | 43 | 17 | 31 | 14 | 18 | 10 | 22 | 29 | 28 |
| 10 | 82 | 40 | 18 | 27 | 8 | 9 | 6 | 25 | 18 | 24 |
| 11 | 61 | 38 | 14 | 14 | 10 | 10 | 11 | 24 | 14 | 15 |
| 12 | 42 | 22 | 14 | 15 | 5 | 12 | 5 | 20 | 17 | 20 |
| 13 | 37 | 20 | 7 | 10 | 7 | 16 | 6 | 11 | 11 | 16 |
| 14 | 30 | 16 | 9 | 16 | 7 | 8 | 3 | 17 | 13 | 7 |
| 15 | 32 | 24 | 10 | 12 | 7 | 8 | 4 | 22 | 21 | 12 |
| 16 | 27 | 18 | 6 | 4 | 7 | 6 | 2 | 15 | 7 | 5 |
| 17 | 30 | 11 | 9 | 9 | 3 | 5 | 4 | 13 | 9 | 3 |
| 18 | 21 | 11 | 4 | 7 | 1 | 2 | 1 | 9 | 11 | 2 |
| 19 | 17 | 5 | 5 | 4 | 1 | 6 | | 4 | 1 | |
| 20 | 16 | 4 | 2 | 5 | 2 | 3 | 2 | 10 | 4 | 7 |
| 21 | 10 | 5 | 1 | 3 | 1 | 3 | | 5 | 1 | |
| 22 | 9 | 2 | 3 | 4 | 1 | 1 | 2 | 5 | 6 | |
| 23 | 4 | | | | 1 | 2 | | 4 | 1 | 2 |
| 24 | 5 | 1 | | 2 | | 1 | | 2 | 1 | 1 |
| 25 | 6 | | 1 | 3 | | 1 | 1 | 1 | 2 | 4 |
| 26 | 3 | | 1 | | 1 | 1 | | 3 | | 1 |
| 27 | 3 | | 2 | | | | | 2 | | |
| 28 | 4 | | | | 2 | | | 3 | | 2 |
| 29 | | | | | | | | | | |
| 30 | 2 | | | | | 1 | 1 | 5 | | 2 |
| N | 824 | 646 | 479 | 540 | 347 | 459 | 380 | 672 | 621 | 619 |

Appendix Table 1 (Continued). Age samples.

| Age (yrs) | (c) Western Gulf January-April | | (d) Front shore catch January-April | | | |
|---|---|---|---|---|---|---|
| | 1970 | 1969 | 1970 | 1969 | 1968 | 1967 |
| 1 | 31 | 37 | 41 | 87 | 7 | 17 |
| 2 | 69 | 14 | 41 | 13 | 8 | 14 |
| 3 | 89 | 21 | 15 | 13 | 8 | 1 |
| 4 | 45 | 10 | 25 | 13 | 8 | 9 |
| 5 | 40 | 11 | 23 | 11 | 5 | 11 |
| 6 | 16 | 2 | 19 | 10 | 9 | 21 |
| 7 | 8 | 5 | 14 | 5 | 12 | 26 |
| 8 | 12 | 4 | 43 | 7 | 15 | 21 |
| 9 | 8 | 2 | 49 | 1 | 16 | 26 |
| 10 | 8 | 11 | 39 | 6 | 15 | 16 |
| 11 | 4 | 6 | 24 | 4 | 10 | 21 |
| 12 | 4 | 2 | 28 | 4 | 13 | 14 |
| 13 | 1 | 5 | 26 | 5 | 9 | 16 |
| 14 | | 2 | 19 | 3 | 7 | 15 |
| 15 | 2 | 1 | 29 | 3 | 9 | 13 |
| 16 | 1 | 1 | 30 | 2 | 11 | 17 |
| 17 | | 5 | 20 | 6 | 10 | 12 |
| 18 | 1 | | 12 | 2 | 7 | 9 |
| 19 | 1 | 2 | 18 | 3 | 5 | 8 |
| 20 | 3 | | 22 | 2 | 3 | 11 |
| 21 | 1 | | 10 | 2 | 4 | 3 |
| 22 | | 1 | 5 | 1 | 4 | 2 |
| 23 | | | 7 | 2 | 2 | 3 |
| 24 | | 1 | 5 | | 1 | 5 |
| 25 | | | 3 | | | 1 |
| 26 | | | 1 | | | 1 |
| 27 | | | | | 1 | |
| 28 | | | | | | 1 |
| 29 | | | | | | |
| 30 | | | 1 | | 1 | |
| 30+ | | | | | 1 | 1 |
| N | 359 | 144 | 571 | 205 | 201 | 315 |

Appendix Table 1 (Continued). Age samples.

(e) Ships' catch of moulters. All or mostly from Front except 1966 when from Gulf.

| Age (yrs) | 1970 | 1969 | 1968 | 1967 | 1966 | 1965 | 1964 | 1963 | 1962 | 1961 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 105 | 62 | 84 | 176 | 120 | 32 | | 111 | 201 | 122 |
| 2 | 98 | 2 | 77 | 61 | 100 | 13 | | 121 | 245 | 34 |
| 3 | 11 | 6 | 48 | 18 | 39 | 13 | | 106 | 61 | 25 |
| 4 | 17 | 1 | 20 | 18 | 40 | 15 | | 55 | 56 | 30 |
| 5 | 18 | 2 | 17 | 29 | 45 | 23 | | 46 | 39 | 11 |
| 6 | 12 | 4 | 23 | 46 | 45 | 22 | | 61 | 17 | 13 |
| 7 | 15 | 1 | 27 | 40 | 44 | 7 | | 67 | 15 | 15 |
| 8 | 8 | 6 | 39 | 30 | 31 | 2 | | 66 | 16 | 9 |
| 9 | 13 | 2 | 23 | 23 | 15 | 2 | | 63 | 17 | 8 |
| 10 | 18 | | 26 | 16 | 17 | 5 | | 72 | 6 | 17 |
| 11 | 13 | 3 | 19 | 23 | 23 | 1 | | 70 | 8 | 10 |
| 12 | 20 | 1 | 18 | 18 | 17 | 7 | | 51 | 13 | 3 |
| 13 | 12 | 2 | 16 | 14 | 15 | | | 57 | 6 | 4 |
| 14 | 6 | 2 | 24 | 19 | 17 | 5 | | 56 | 9 | 6 |
| 15 | 11 | 2 | 20 | 20 | 14 | 4 | | 42 | 12 | 1 |
| 16 | 13 | 2 | 20 | 14 | 14 | 2 | | 54 | 4 | 5 |
| 17 | 7 | | 11 | 18 | 10 | 1 | | 36 | 12 | 4 |
| 18 | 7 | | 17 | 20 | 17 | 3 | | 24 | 5 | 2 |
| 19 | 7 | | 16 | 21 | 10 | 3 | | 18 | 4 | 3 |
| 20 | 6 | | 11 | 15 | 11 | 1 | | 18 | 9 | 2 |
| 21 | 4 | 1 | 6 | 8 | 8 | 2 | | 17 | 1 | |
| 22 | 5 | 2 | 5 | 8 | 3 | 1 | | 12 | 4 | 2 |
| 23 | 3 | 2 | 4 | 8 | 7 | | | 9 | | 1 |
| 24 | 3 | 1 | 2 | 4 | 4 | | | 8 | 1 | |
| 25 | | | 1 | 4 | 2 | | | 4 | 1 | 1 |
| 26 | 1 | 1 | 1 | 1 | 4 | 3 | | 4 | 1 | 1 |
| 27 | | | 2 | 3 | 1 | | | 1 | 1 | |
| 28 | 2 | | | | 1 | | | 1 | 1 | |
| 29 | | 1 | 1 | | | | | | | |
| 30 | | | | 4 | | | | | | |
| 30+ | | | | | 3 | | | | | |
| N | 431 | 107 | 578 | 679 | 677 | 167 | | 1247 | 767 | 330 |
| No. of ships | 2 | 1 | 4 | 4[x] | 1 | 7 | | 1* | | 1+ |

*USSR (Khuzin, 1963)

[x]including 1 Norwegian

+USSR (from Popov and Timoshenko, 1965)

Appendix Table 1 (Continued). Age samples.
(f) Arctic, July-September.

| Age (yrs) | Baffin Island 1969 | Baffin Island 1967 | West Greenland 1962 |
|---|---|---|---|
| 0 | 9 | 5 | 275 |
| 1 | 23 | 11 | 37 |
| 2 | 11 | 25 | 19 |
| 3 | 19 | 13 | 3 |
| 4 | 23 | 9 | 1 |
| 5 | 12 | 17 | 3 |
| 6 | 17 | 20 | 2 |
| 7 | 9 | 14 | 3 |
| 8 | 9 | 10 | 1 |
| 9 | 19 | 14 | 2 |
| 10 | 14 | 9 | 1 |
| 11 | 11 | 14 | |
| 12 | 9 | 8 | |
| 13 | 8 | 10 | 2 |
| 14 | 17 | 12 | |
| 15 | 5 | 7 | 9 |
| 16 | 6 | 7 | |
| 17 | 5 | 6 | |
| 18 | 5 | 2 | |
| 19 | 10 | 5 | |
| 20 | 3 | 4 | |
| 21 | 1 | 3 | |
| 22 | 3 | 2 | |
| 23 | 6 | 1 | |
| 24 | 2 | 2 | |
| 25 | 1 | | |
| 26 | | | |
| 27 | 1 | | |
| 28 | | | |
| 29 | | | |
| 30 | | | |
| 30+ | | | |
| N | 264 | 232 | 358 |

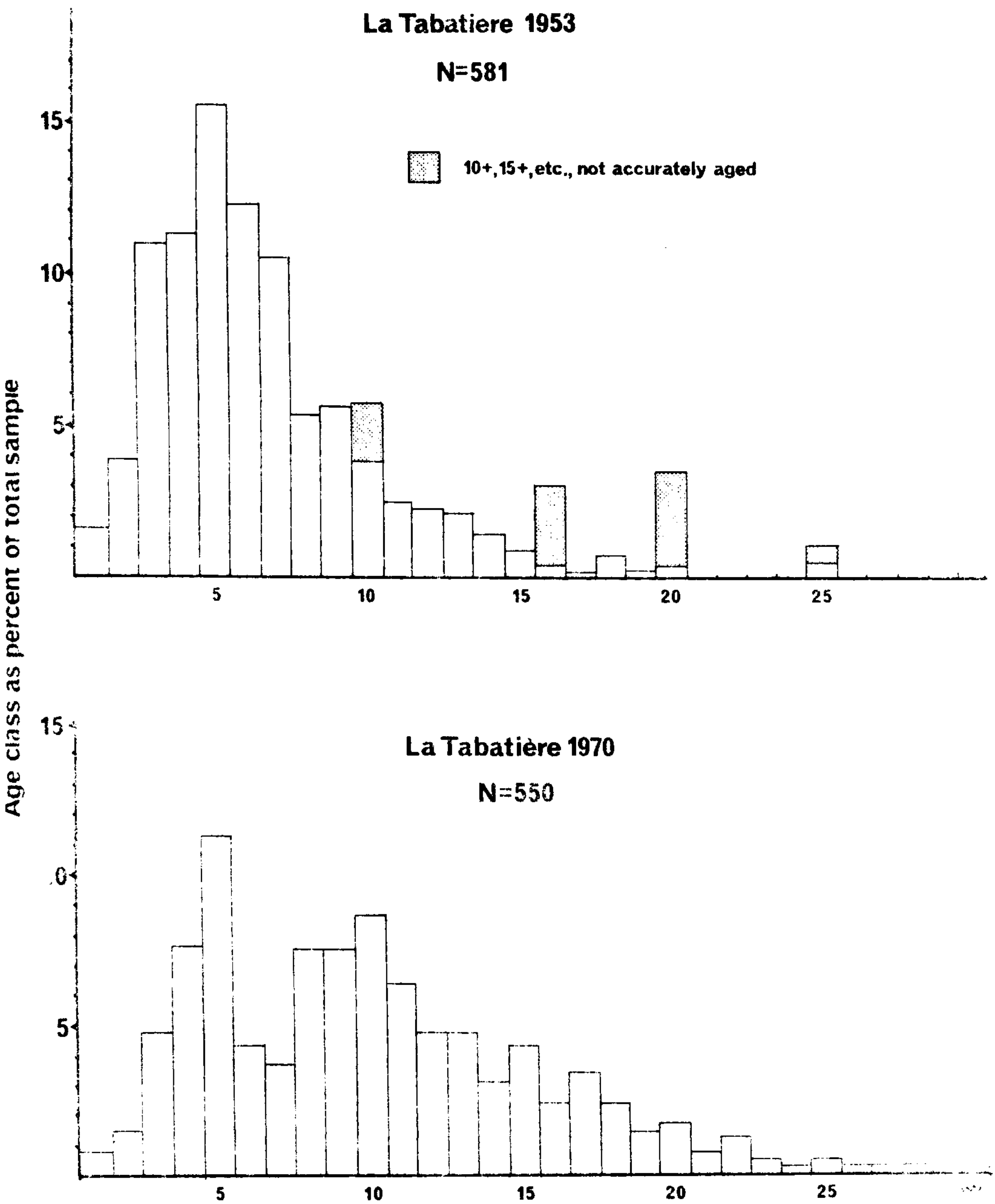


Figure 1. Age samples of southward migrant seals from the same site, La Tabatière, in 1953 and 1970.

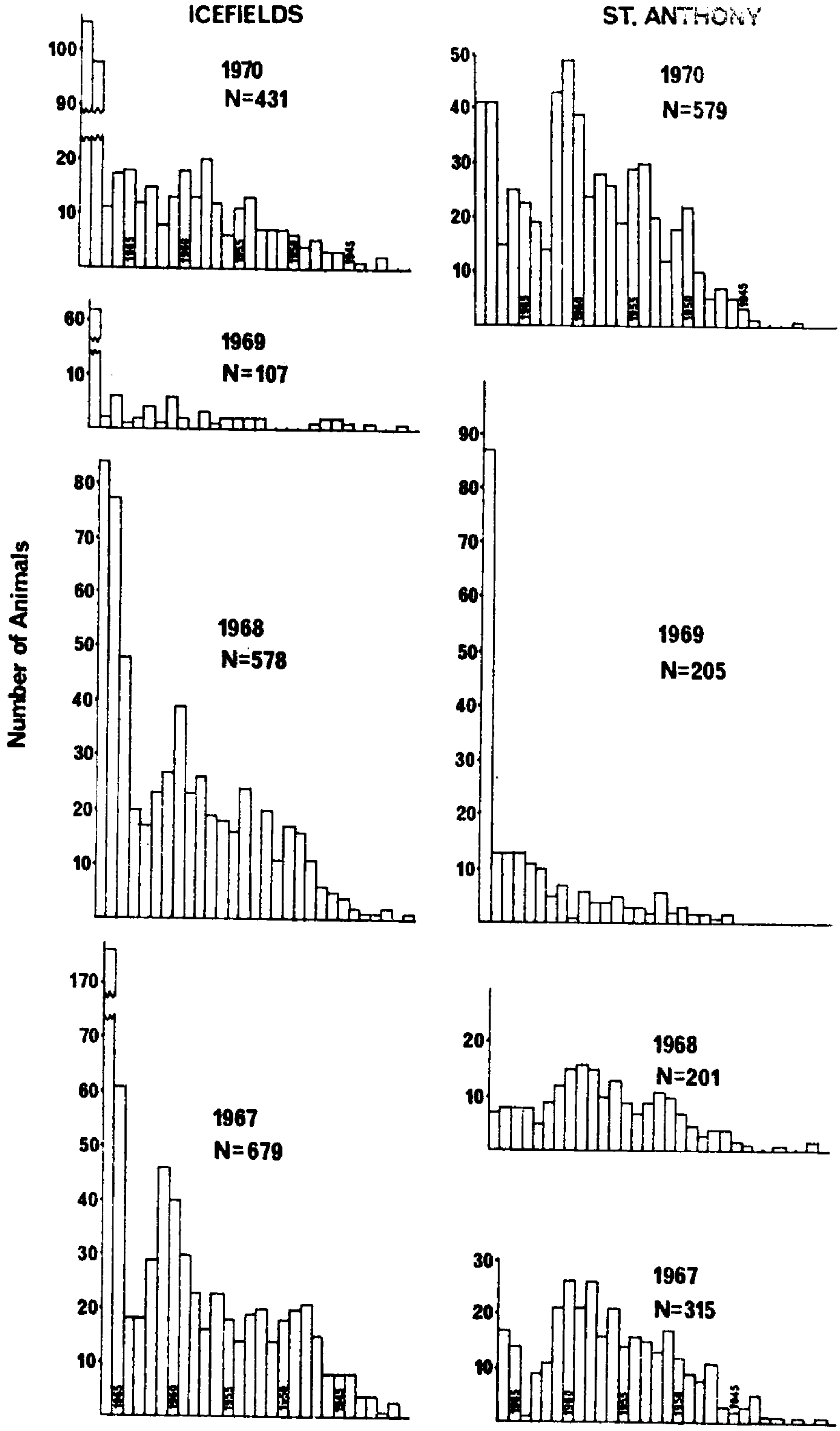


Figure 2. Age samples from St. Anthony, Newfoundland, and the Front icefields, 1967-1970.

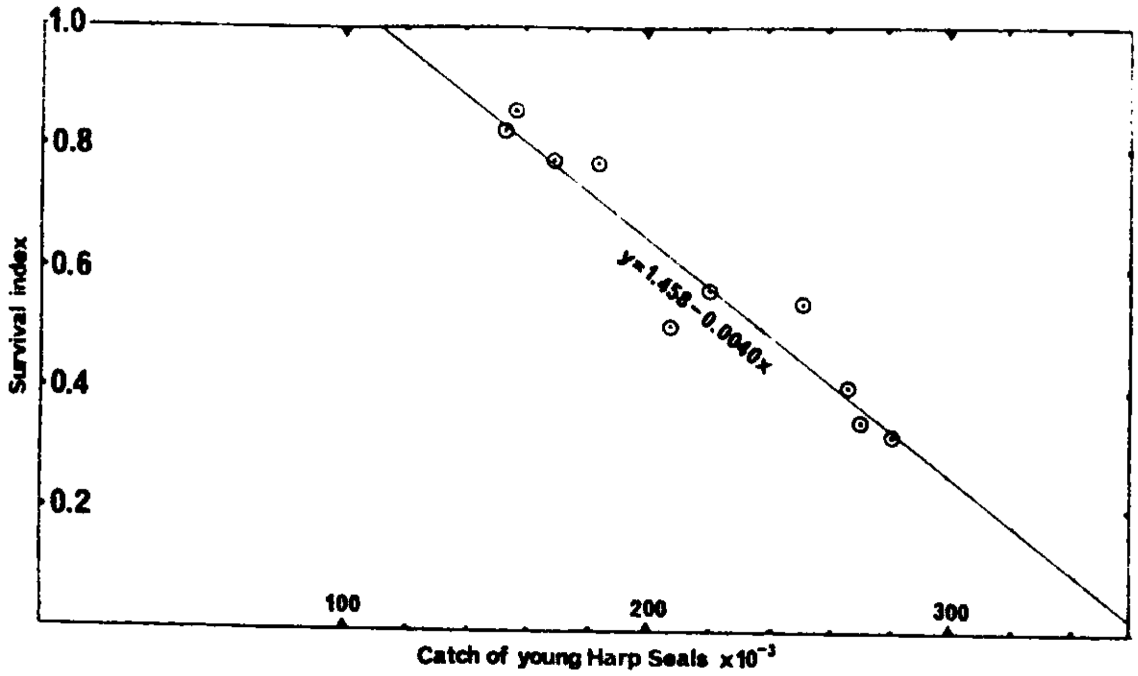


Figure 3. Index of survival plotted against total catch for year-classes 1960 to 1969. See text.

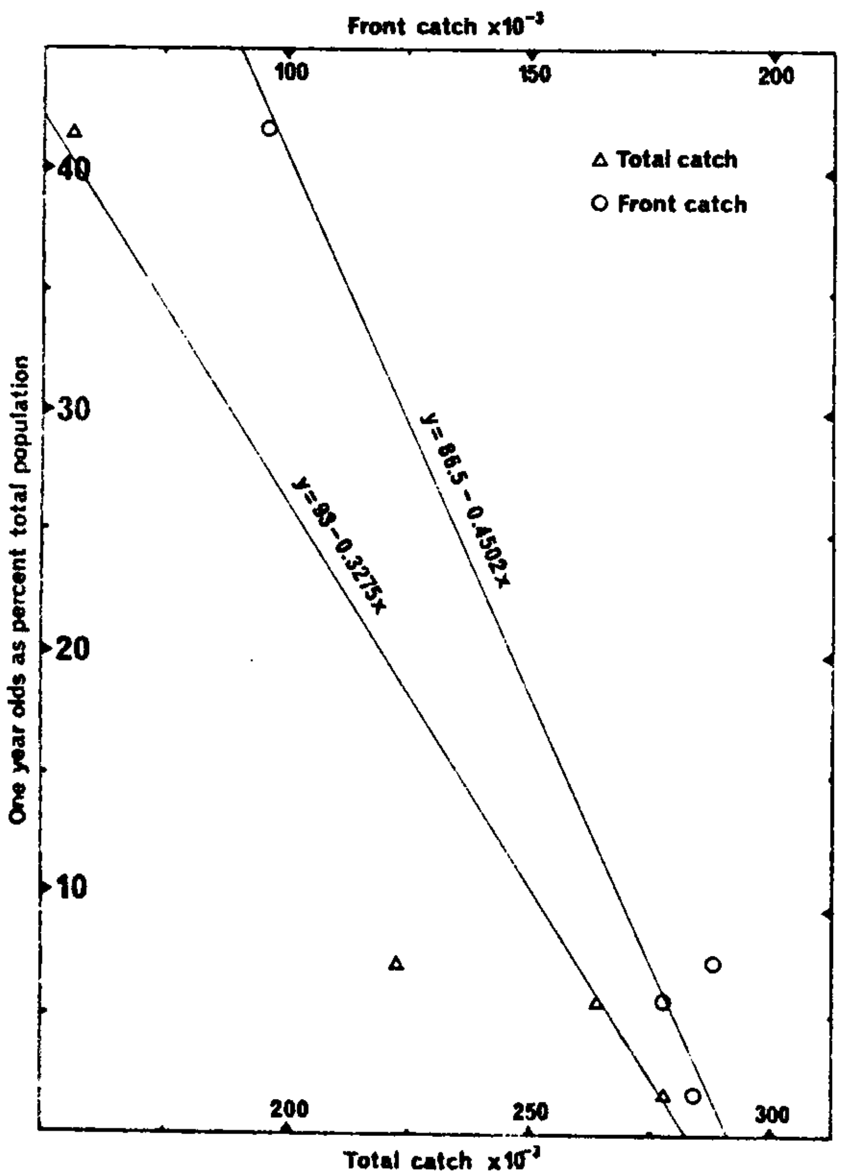


Figure 4. Index K, the ratio of young to total seals in four annual age samples (1967-1970) from St. Anthony, Newfoundland, plotted against total catch of young of the same year-class, and catch of young at the Front, to show the aberrant year, 1969. See text.