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STATUS of the RINGED SEAL POPULATION

of

THESIGER BAY, N.W.T., 1987-1988

by

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SUMMARY

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One hundred and twenty-three Ringed Seals (59 males, 64 females) were collected from Thesiger Bay off the south coast of Banks Island, N.W.T. from June 4 to August 23, 1988. Almost a third of this sample (35) were pups, a substantial increase over 1987 when less than 3% (2) of that summer's catch were pups. Measurements, age samples, and organ and tissue samples were taken. The seals collected were as fat and heavy as usual at that time of year. Condition values were significantly higher for 1988 seals than 1987. No pathological conditions were noted in the sample population except for an emaciated yearling shot June 29 and an emaciated female shot August 17 with a 4 lb. pup in the abdominal cavity, resulting either from an extrauterine pregnancy or an abnormality in parturition. Of 22 females age 6 years and older, all but 1 (95.4%) had ovulated and 16 (72.7%) had uterine evidence of previous pregnancy.

Comparison of 1988 with 1987 data on age structure and reproductive status indicates that there was a substantial failure of recruitment from 1984 to 1987, but that it was temporary and that reproductive activity returned to normal levels in 1988.

Seal densities on the ice off the west coast of Banks Island (Thesiger Bay/eastern Beaufort Sea) were much lower (1.3/sq. km.) than for Amundsen Gulf (4.6) and Prince Albert Sound (6.9). The estimated population of Amundsen Gulf was lower than in previous years, possibly owing to low ice cover at survey time; the estimated population of Prince Albert Sound was

higher than in previous years.

Organochlorine residues in seal blubber were lower in 1988 than 1987, except dieldrin which was found in greater concentrations in 1988. In comparison to other Arctic and northern European populations our seals had low to normal organochlorine loads. High concentrations of mercury and selenium in the seal livers are similar to levels recorded in Amundsen Gulf ringed seals in 1972 and 1978.

INTRODUCTION

From 1984 to 1987 Sachs Harbour seal hunters had only brought in a handful of pups each year, and feared a permanent drop in seal productivity. The Sachs Harbour Hunters and Trappers Committee presented this concern to the Fisheries Joint Management Committee, set up under the Western Arctic Land Claims Agreement to advise the Minister of Fisheries and Oceans on management concerns and research priorities. In 1987 the F.J.M.C. asked for, and accepted, a proposal from the Department of Fisheries and Oceans to investigate the condition of the population and to determine whether any abnormal factors exist to explain the recent scarcity of pups in the open water harvest by the Sachs Harbour Inuvialuit. Two additions were later made to the scope of the project. These were an analysis of heavy metal levels, as baseline data in case of ocean dumping of scrap, and an extension of the population structure study, in 1988, to the community of Holman Island, N.W.T. This report presents the findings of the study.

The Ringed Seal is an important species. It is the main prey of the polar bear (Stirling 1977; Stirling and McEwan 1975; Stirling and Archibald 1977; Smith 1980). Feeding on fish and crustaceans, the Ringed Seal is an important link in Arctic seas between primary production and the top predators, polar bear and man. As well, the Ringed Seal may be a useful indicator of ecological health, being a large marine vertebrate distributed widely and evenly all over the Arctic, and actively collected almost year-round by northern people.

The Ringed Seal is not now a staple in the diet of the Sachs Harbour

Inuvialuit. Muskox and caribou are plentiful on Banks Island and southern foods are accepted and available, although expensive. Adult and subadult seals are now hunted solely for dog food. Seal pups are still eaten, a delicacy prized by the local people. There is no longer a market for seal pelts in the general fur trade, but a few families still use seal skins for clothing and handicrafts to supplement their income.

Nevertheless, one must not depreciate the role of the Ringed Seal in the economy of Sachs Harbour. Although skidoos are the preferred mode of winter transportation, dogteams are still required by guides for polar bear sport hunts in early spring, which bring tens of thousands of dollars to Sachs Harbour every year. During the 2 to 4 week spring period of the hunt the dogs must be in prime, vigorous condition. To this end, seal meat and blubber form the necessary basis of the canine diet throughout the year.

Previous Studies:

The biology of the Ringed Seal in the western Canadian Arctic has been studied intensively for two decades, most notably by Dr. T.G. Smith (1973, 1976, 1987; Smith and Stirling 1975, 1978), Dr. I. Stirling (1973; Stirling et al. 1977, 1982) and M.C.S. Kingsley (1984, 1986; Kingsley and Lunn 1983; Kingsley et al. 1982). These years of research have suggested that annual reproductive success and recruitment may fluctuate significantly from year to year. Ice conditions, female physical condition and fox predation may be limiting factors (Stirling et al. 1977, 1982; Smith and Stirling 1978; Smith 1987).

There is little baseline data for the waters off southwest Banks Island. Cumulative results of aerial surveys from 1974 to 1979 (Stirling et al. 1982) show that the area from Cape Parry north to and including Thesiger Bay had the highest concentration of Ringed Seals in the eastern Beaufort Sea. In the Beaufort Sea, the area north and east of Cape Dalhousie, south of Cape Kellet, and west of Nelson Head had the highest densities of Ringed Seals (mean rank of this area from 1974 through 1979 was 1.67 of 4). Mean densities in Thesiger Bay, south of Cape Kellet and west of Nelson Head, ranged from 0.161 to 0.6 /sq. km. (Stirling 1982, aerial survey detailed data). Amundsen Gulf had high densities of Ringed Seals, up to 3 /sq. km., in four years of aerial survey from 1981 through 1984 (Kingsley 1986).

METHODS

Study Design and Study Area:

It was determined that the first step in investigating the status of the Ringed Seal population of the Thesiger Bay area would be to examine the seals taken by the Sachs Harbour hunters. It was proposed that the physical condition of the seals, the age and sex structure of the population, the reproductive history of the females, and contaminant levels in body tissues should be investigated.

All seals were collected by Inuk hunters of Sachs Harbour from Thesiger Bay off the southwest coast of Banks Island. Thesiger Bay lies between the Beaufort Sea to the west and Amundsen Gulf to the south and east.

An aerial survey was conducted on June 9-11, 1988 to count Ringed and Bearded seals on the sea ice of the eastern Beaufort/Thesiger Bay/Amundsen

Gulf area (Fig. 1). The survey was a strip transect design, and data was collected and analysed as in Kingsley (1986). A Britten-Norman BN2A-27 "Islander" was used instead of the Cessna 337 "Skymaster" of the previous surveys; it is about as fast but has no strut. A single survey strip of a quarter-mile on each side was delimited by marks on the windows.

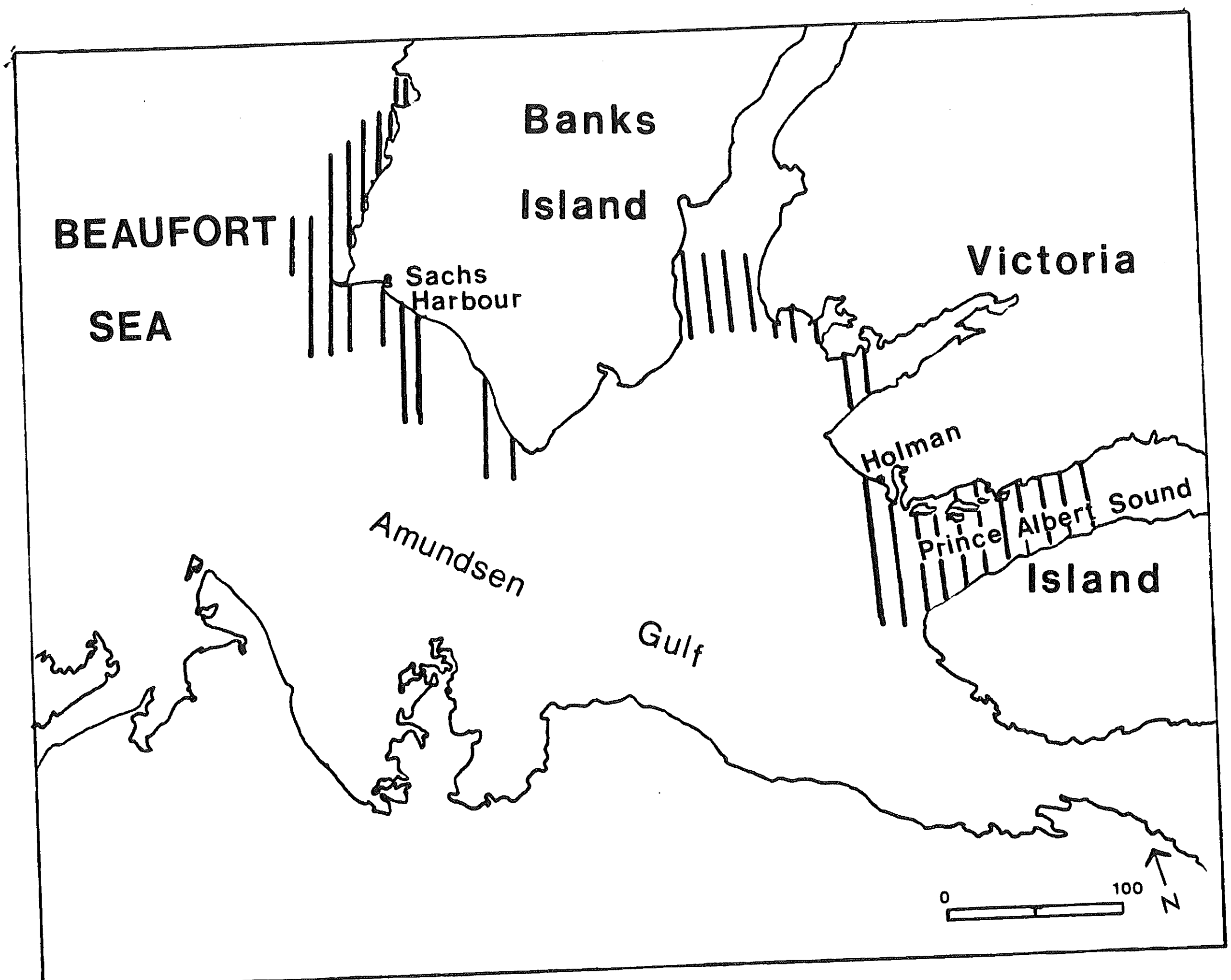

Fig. 1. Study area, with aerial survey transect lines, 1988.

Field Sampling and Lab Analysis of Samples:

All seals brought into Sachs Harbour by the Inuk hunters were processed according to standard necropsy procedures for pinnipeds (Fay et al. 1979). For each seal these data were recorded:

1. Date, habitat and location of kill; whenever possible, approximate time and distance from shore; on ice, accompanying seals at holes or cracks;

2. Hair slip and general coat condition;

3. Ridge counts on foreclaws;

4. Total length and axillary girth to nearest cm;

5. Total body weight (this as well as sculp weight to nearest pound, later converted to kilograms);

6. Blubber thickness between sternum and skin to nearest mm;

7. Sculp weight (ears to hips);

and these samples obtained:

1. Brain and lung samples extracted from a subsample of seals and preserved;

2. Reproductive organs, stomach contents, and samples of blubber, muscle (from flank or back over ribcage), liver, and kidney were extracted and preserved, reproductive organs in formalin, others by freezing;

3. Lower jaw skinned out and saved for later aging by sectioning and reading of canines.

Seals were aged by the methods of Smith (1973). The jaws were boiled to loosen the teeth, and a canine was pulled out. Cross sections about 0.1 mm thick were sawn, fixed in an alcohol/glycerine mixture, and examined under transmitted light. Layers in the dentine of each section were counted three to five times in blind replicate readings, but not by different observers.

In all age-based analyses the tooth age was used rather than the claw age. Claw age determinations were found to be unreliable, especially for adults. Subadult ages from claw rings were often underestimated by 1 to 2 years in comparison with the tooth age determinations of the same individuals. For adults, differences in ages between the two methods were 2 to 4 times greater than this.

Past reproduction of females was determined from the condition of the uterus. Multiparous females, that is those that had borne more than one pup, were identified by both uterine horns being stretched or swollen; primiparous females, that had only given birth once, by stretching of only one horn.

Two indices of body condition, i.e. fatness, were calculated for each seal. The first was defined by:

Cond1 = (Girth / Total Length) x 100;

the second by:

Cond2 = (Total Weight / Total Length) x 100 (Smith 1987).

Emaciated seals were excluded from all analyses of condition data.

RESULTS and DISCUSSION

Ice Chronology:

In 1987, Thesiger Bay was clear of all consolidated ice by July 9, there being only a 2/10 cover of floating pan ice. By July 30, Amundsen Gulf was relatively ice-free except for a wide belt of fast ice along the coast of Victoria Island and 2-6/10 ice cover at the western mouth of the Gulf. In 1988, the west coast of Banks Island to about 70 - 100 km. offshore, Thesiger Bay, and Amundsen Gulf were clear of all ice save for a few large floes of thick first-year ice. Fast ice remained on the west coast of Banks Island until the third week of June, and in the large inlets of Victoria Island until the third week of July. Freeze-up, with 9/10 ice cover, commenced in both years at the end of October.

Sex and Age Structure:

The sex ratio is close to unity (1:1) for the 1987 and 1988 Thesiger Bay populations, as well as for 1988 pups. Female:male ratios for 1987, 1988 and 1988 pups are 36:39; 64:59 and 20:21 respectively.

Collections from the ice are usually biased towards breeding adults, but open water collections should be less biased (Smith 1987). In 1987, 86.7% of the Sachs Harbour ringed seal summer collection was from open water, 91.9% in 1988. The 1987 sample showed the year classes 0+ - 3+ accounting for only 5% of the total population (Fig. 2a), and there appeared to be a discontinuity between the 3+ age class and the much more numerous 4+ class. Young of the year rebounded in 1988, with 28.4% of the population in the 0+ class (Figs. 2b,3). The earlier gap in the production of young seals was still evident in the age profile, but was shifted up one year to the 1+ to 4+ age classes. This was consistent with reduced reproductive success of female seals in the years 1984-1987, but a return to more normal levels in 1988. The persistence of the gap in the age profile agreed with a similar observation for the 1973-1975 cohorts in Holman collections, which persisted for up to 4 years (Smith 1987 Table 23),

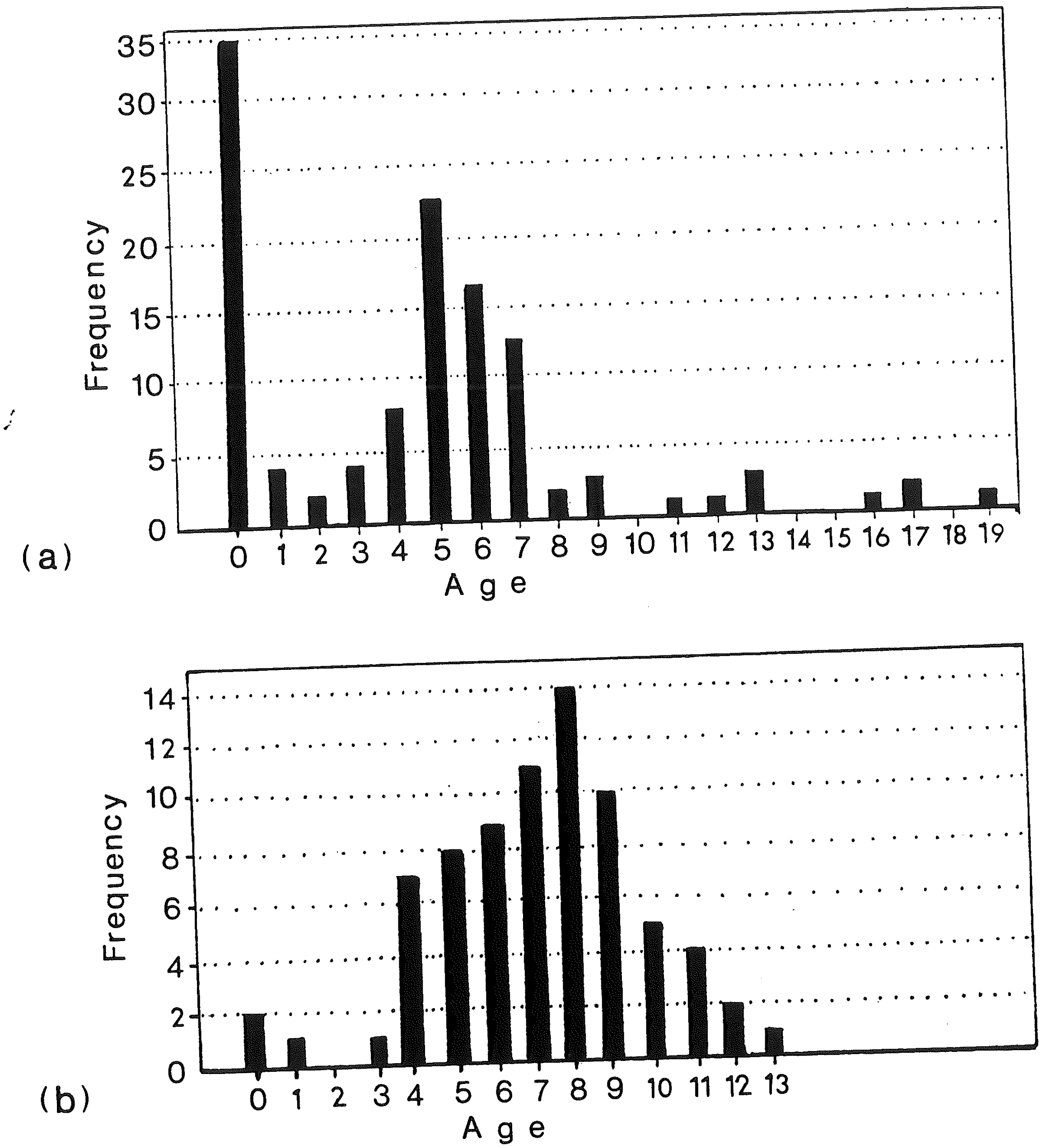

Fig. 2. Age frequency distribution of Thesiger Bay ringed seals in (a) 1988 and (b) 1987.

and indicated either a reproductive failure spread over a wide area, or else little mixing of seal populations to replace the missing cohorts. Smith's samples from open-water hunts out of Holman and in Prince Albert Sound had between 14 and 42% young-of-the-year in good seal production years: 1971-72 and 1976-81. His collections were made in waters surrounded by annually dependable fast ice and good breeding habitat. The southwest coast of Banks Island is close to the Cape Bathurst polynya, which opens up by early summer in most years and may affect the dependability of the fast ice breeding habitat of Thesiger Bay. There is no good accumulation of baseline data for Thesiger Bay to indicate the long-term catch composition.

Figure 3 shows a substantial difference in the age composition from 1987 to 1988. Whereas the population was represented mostly by adults in

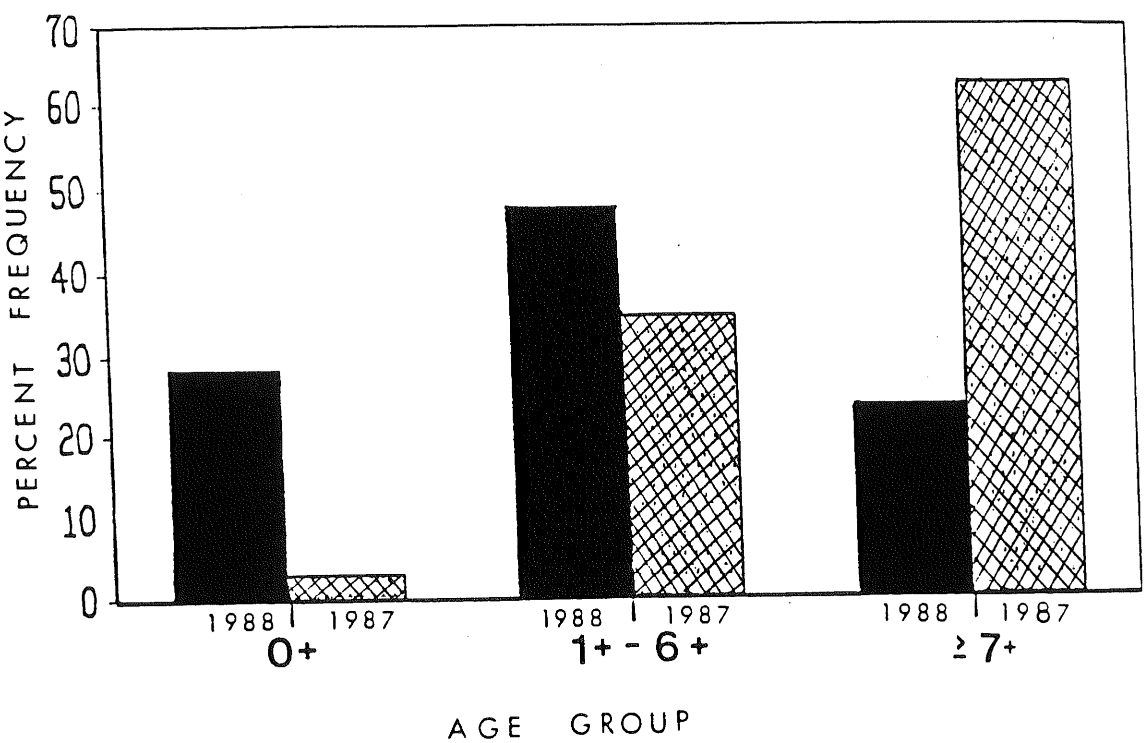

Fig. 3. Percent frequency of pups, juvenile and adult Ringed Seals in Thesiger Bay in 1988 and 1987.

1987, a higher percentage of pups (28.4%) than adults (23.6%) was found in the 1988 data. Subadults make up almost half the '88 population, although the number of 1 - 3 year-olds remained low (8.2% of the population; 17.2% of the subadults).

The low recruitment of 1984-87 cohorts cannot be explained at this time. Possible reasons are: high pup losses due to exposure or predation; reduced conception rates associated with poor condition; physiological dysfunction in reproductive processes due to contamination by chlorinated hydrocarbon residues; and poor ice conditions over the breeding habitat. Pups are heavily preyed on by Arctic foxes and polar bears, from which they are hidden and partly protected by the birth lair (Smith 1976, 1987; Stirling 1977; Burns and Kelly 1982; Lydersen and Gjertz 1986). Low snow cover may be an important factor in pup mortality: lack of sufficient snow accumulation may cause higher predation rates on the then more accessible pups, or perhaps expose pups to the elements (Smith and Hammill 1980). Very low snowfall in 1985 (Fig. 4) may have had an effect on pup survival in that year (no 2-year-olds in our 1987 sample). This would not, however, explain the low percentage of 3-year-olds in 1987 and 4-year-olds in 1988 as 1984 was a very high snowfall year.

Heavy ice cover in the Beaufort Sea in the winter of 1974/75, lingering through much of the following summer, was associated with a crash in Ringed Seal condition and pregnancy rates (Stirling et al. 1977), a drop in densities found in aerial survey, and a reduction in polar bear reproduction rates and condition (Kingsley 1979). In the summer of 1985, the Beaufort Sea cleared of ice slowly and late (Lawrence, pers. comm.),

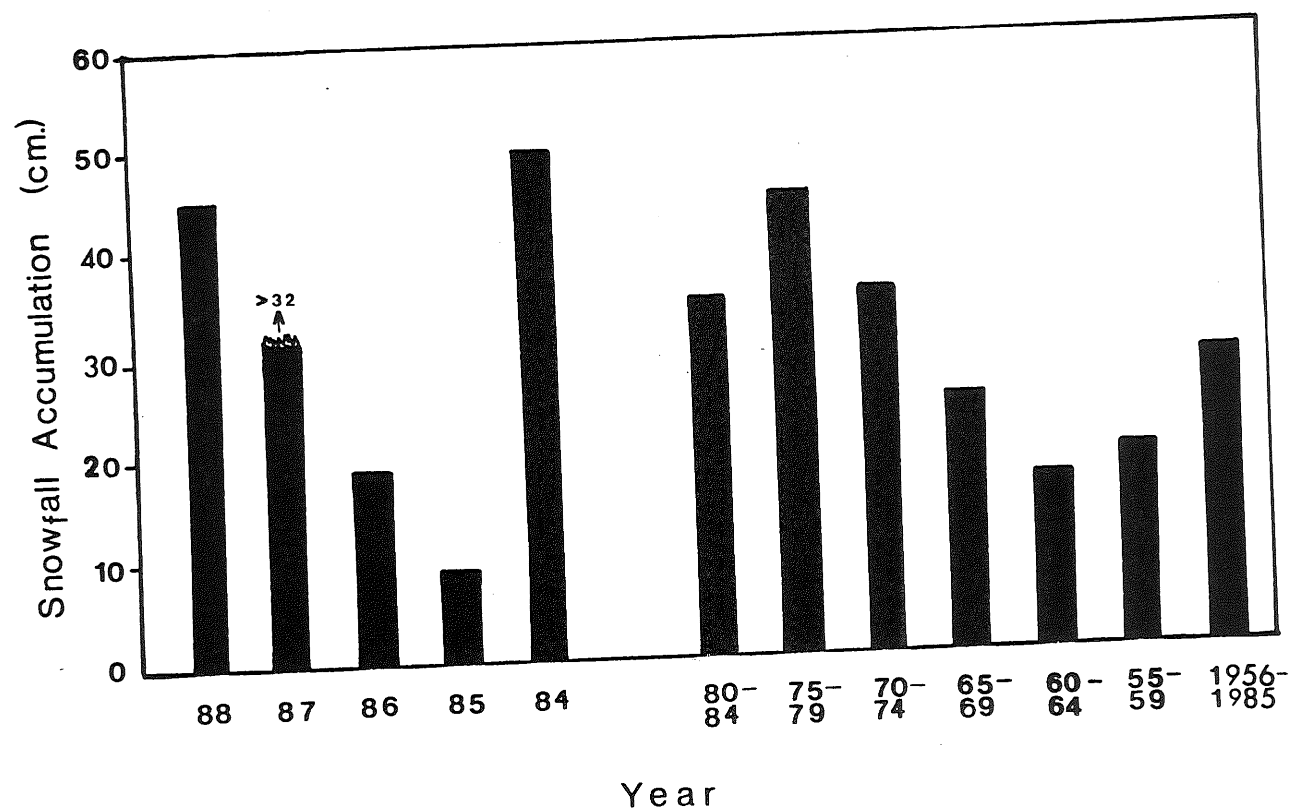

Fig. 4. Snowfall accumulation for Sachs Harbour for the winter months November through February (Nov. and Dec. data missing for the Nov. to Feb. period ending in 1987); 5-year means for 1956-1984; mean for 1956-1985.

and multi-year ice was further south in the winter of 1985-1986 than in winter 84-85 or 86-87 (Stirling et al. 1988). The polar bear lives on ringed seals, and its population parameters have previously been found to alter when availability and condition of ringed seals is lowered (Kingsley 1979). The litter-produced rate of 6-year-old female bears, i.e. novice reproducers, in 1986 and 1987 was less than a quarter of the 1985 value, and the weights of cubs borne to females of all ages was also lower (Stirling et al. 1988). There has also been recent evidence from radio-tagging that polar bears of the Beaufort Sea population have made unusual movements into the Chuckchi Sea (Stirling pers. comm.). These other ecological indicators confirm the direct evidence from the Sachs Harbour seal data of low seal recruitment in recent years.

Reproductive Status:

Female ringed seals normally mature sexually between 6 and 8 years of age (Smith 1973, Table 8; 1987, Table 11). For our Sachs Harbour samples, the female fecundity profile differs substantially between 1987 and 1988. Fecundities (ovulation rates) improved from 60% of females 6 or more years old in 1987 to 95.4% in 1988.

In 1987, 13 of 25 sexually mature females (52%) had previously borne pups, and 8% more (2/25), although they had not, had ovarian bodies (corpora) or developing follicles (i.e. only 60% had started reproductive life). Similarly, in 1974 and 1975, years of low production in Amundsen Gulf, only 61% and 54% of females had reproduced (Smith 1987); and Stirling et al. (1977, 1982) found an ovulation rate of only 51% in the eastern Beaufort Sea and Thesiger Bay in 1975, a year of pup scarcity (2% of 186 seals).

In 1988 reproductive activity was higher. Of 22 females 6+ and older, 16 (72.7%) had previously borne pups, and 5 more, which had not, had corpora in their ovaries (total 95.4%). All 5 year-olds, 3 of 4 four-year-olds and 1 of 3 three-year-olds had also ovulated, and one of 12 five-year-olds had borne more than one pup. The only inactive mature female in the 1988 sample was a 6-year-old in below-average condition (cond1: 74.52; cond2: 30.46).

In our 1987 data, 10 of 16 females (62.5%) of year classes 7+ through 9+ had no signs of any previous pregnancy (Fig. 5). I.e., of the female seals that had become 6 years old in 1984-1987, fewer than normal had started to reproduce, but seals 10+ and older in 1987, which had become 6+ in 1983 or before, had all reproduced. In 1988, only 55.5% (5 of 9) of females of the 7+ through 9+ (no 10-year-old females in sample) classes were parous. All females older than 10 years old had reproduced.

It is clear from the reports of the Sachs Harbour hunters and from these data that the ringed seals of the western Arctic had lower reproductive rates than usual in 1986 and 1987. The age profiles in our data may indicate that the gap in reproduction had extended since 1984, and this is supported by the numbers of relatively old seals in the 1987 sample with no reproductive history. But we have not found any climatic events in the early 80s to cause it, and polar bear reproduction and condition were still normal up to 1985 (Stirling et al. 1988). The age gap in our data in 1987 may then have been caused by poor survival of the 1984-85 cohorts.

Pathological conditions were noted in the reproductive tracts of 2

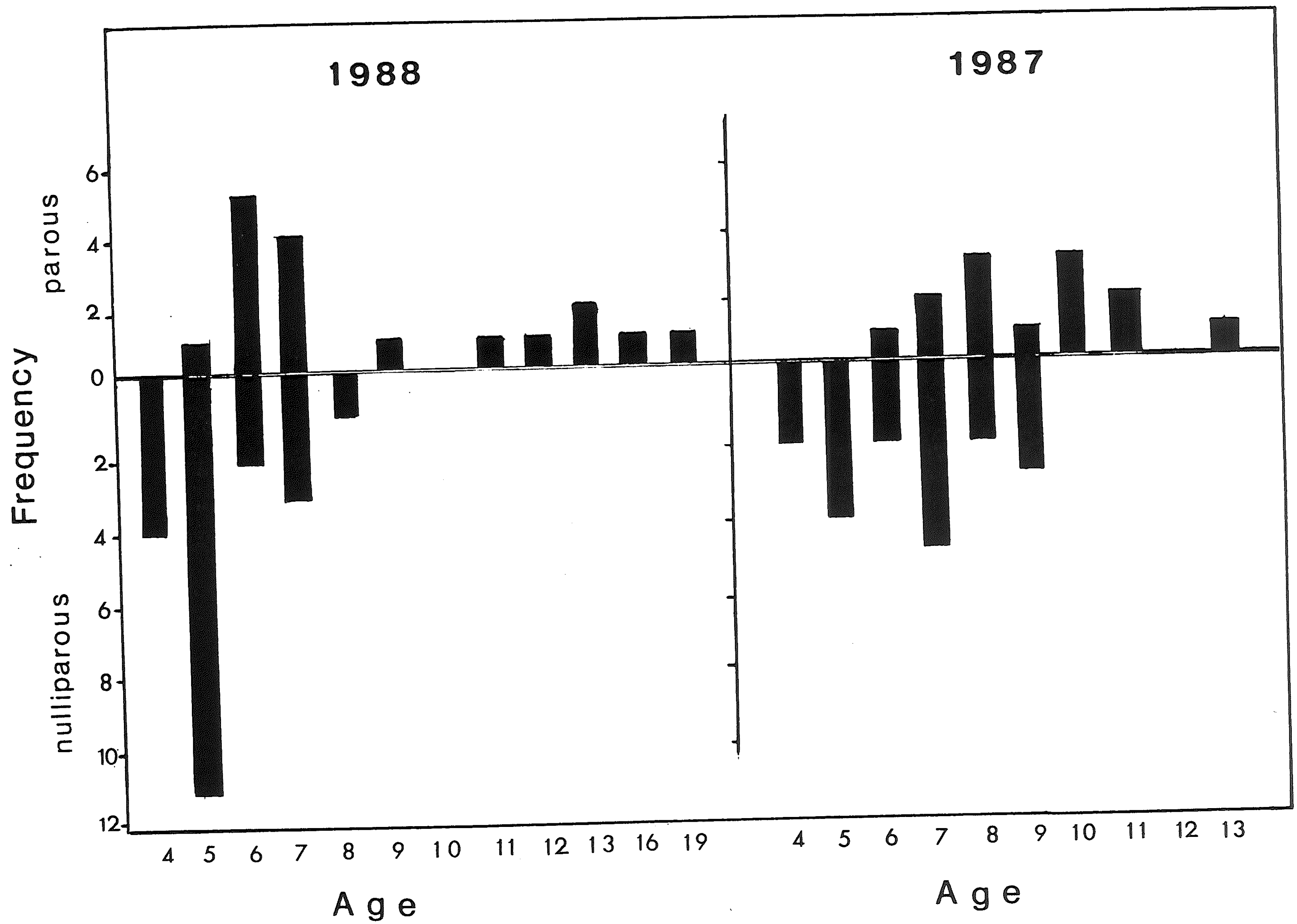

Fig. 5. Frequency histograms of nulliparous and parous females from all age classes in 1988 and 1987.

seals. One female, a 7-year-old collected on June 10, 1987, had an ovarian cyst 2.5 cm in diameter. Another seven-year-old, shot on August 17,1988, showed evidence of an extrauterine pregnancy or of an abnormal parturition, and had a 4-lb. pup remaining in her abdominal cavity.

All five females collected from Amundsen Gulf in 1988 (4, 5, 5, 7 and 10 years old) had corpora in their ovaries. The four-year-old and the oldest two were multiparous.

Physical Condition:

Indices of physical condition in both years decreased from June to July, and rose again through August (Fig. 6). This agrees with known cycles of condition in Ringed Seals (McLaren 1958; Smith 1987), which lose a lot of their fat reserves in the moulting fast starting in May and continuing through the summer. Condition (condl) of adult Ringed Seals at Holman declined from the beginning of June through July to a mean low of between 70 and 75, then returned to values over 80 by the first half of August (Smith 1987). The mean condition of the Holman subadult samples followed much the same pattern, but didn't start increasing again until the second half of August.

Seals were in better condition in 1988 than in 1987. The mean values of the condition indices were higher for the entire summer, and sternum blubber was thicker for the month July 16 through August 15 (Table 1). A small collection of seals at Holman in 1988 (Table 2) were in better condition than Thesiger Bay seals.

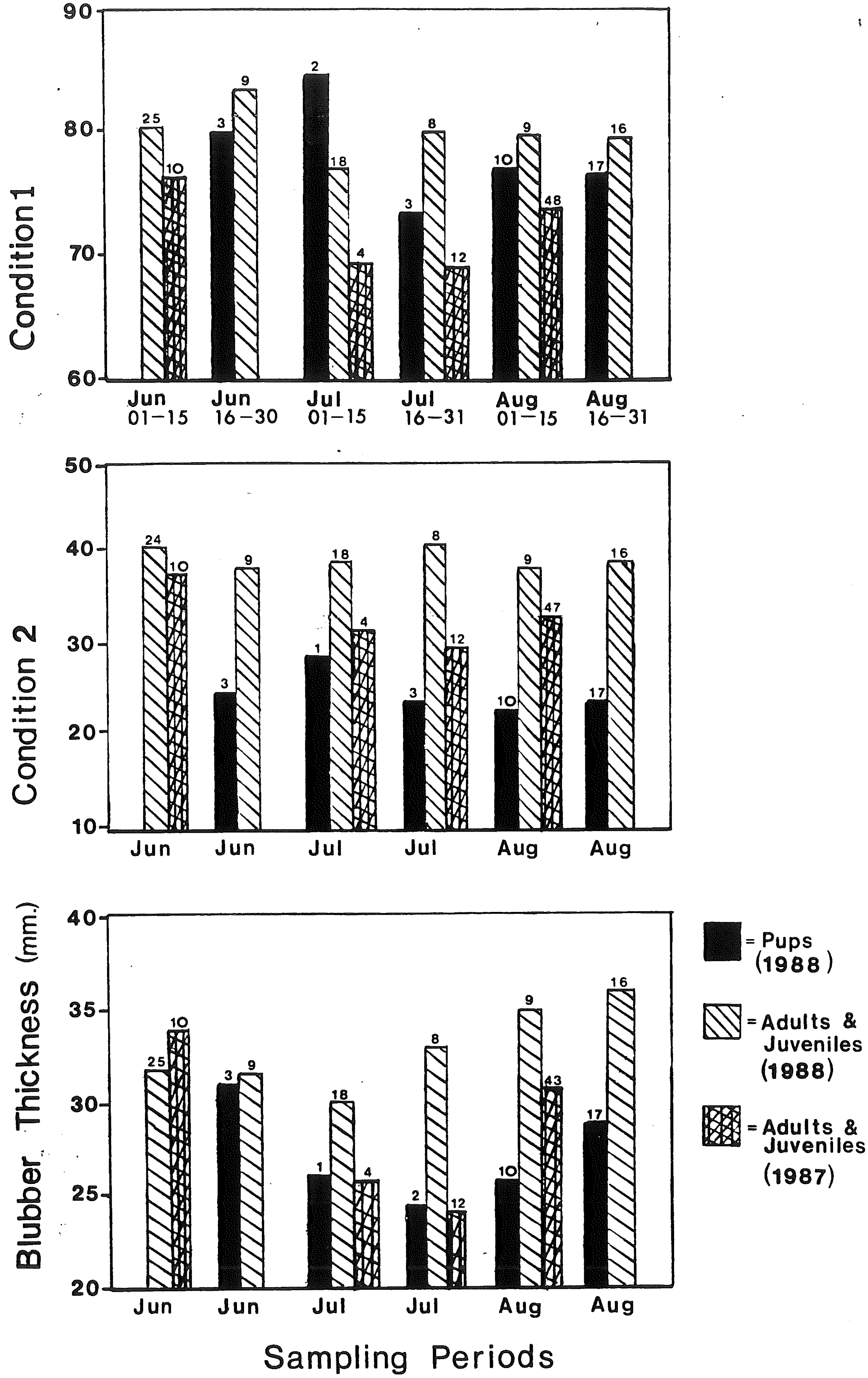

Fig. 6. Condition indices and blubber thickness, with sample sizes, of Ringed Seals in the summer months of 1987 and 1988.

Table 1. Comparison of condition of Thesiger Bay ringed seals between 1987 (in brackets) and 1988.

Sample Period	Cond1	Cond2	Blubber Thickness (mm.)
June 01-15	80.31 (76.26)	40.19 (37.43)	31.8 (33.6)
N	25 (10)	24 (10)	25 (10)
t-test	2.422	1.356	1.324
July 01-15	77.24 (69.76)	39.07 (31.39)	29.9 (25.5)
N	18 (4)	18 (4)	18 (4)
t-test	2.096	3.049	1.284
July 16-31	80.21 (69.40)	41.12 (29.87)	33.0 (24.0)
N	8 (11)	8 (11)	8 (12)
t-test	4.794	2.824	4.472
Aug. 01-15	79.97 (74.04)	38.48 (33.43)	35.0 (30.7)
N	9 (44)	9 (43)	9 (44)
t-test	3.217	2.319	1.656

Table 2. Comparison of mean condition values and blubber thickness between Thesiger Bay and Amundsen Gulf ringed seals (August, 1988).

Sample Period		Thesiger Bay	Amundsen Gulf
August 01 - 15	Cond1	80.0 ± 5.2 (9)	85.1 ± 3.3 (6)
	Cond2	38.5 6.8 (9)	45.4 6.9 (6)
	Blubber (mm)	35.0 7.5 (9)	39.2 8.6 (6)
August 16 - 31	Cond1	79.6 ± 6.0 (16)	87.8 ± 1.8 (2)
	Cond2	39.5 8.9 (16)	46.3 1.6 (2)
	Blubber (mm)	36.1 6.2 (16)	45.0 7.1 (2)

N = number in parentheses.

Pups collected for this study in Thesiger Bay in open water had similar standard lengths to Smith's (1987) from Amundsen Gulf (Table 3). A single pup collected August 26, 1988 from Holman Island matches Smith's (1987) Brown's Harbour mean length perfectly at 89.5 cm. Assuming no disparities in seasonal timing of parturition, there thus appears to be no great difference in growth rate of Thesiger Bay/ Amundsen Gulf ringed seal pups in 1988 from previous years, although our data is inconclusive.

Table 3. Comparison of mean pup lengths for 1988 Thesiger Bay seals with Amundsen Gulf/Brown's Harbour mean pup lengths (1972-1977).

Sample Date	Sachs Harbour		Amundsen Gulf*		Brown's Harbour*	
June 16-31	90.9	(3)	91	(20)		
July 16-31	91.9	(3)	95	(12)		
Aug. 16-31	88.5	(17)			90	(10)

N = numbers in parentheses.
* = from Smith 1987.

On the basis of Smith's (1987) criteria for stunted seals (two standard deviations below the mean standard length for that age group) our 1987-88 sample population contained only one dwarf, although 10 (3 adult and 2 subadult females, 1 adult and 2 subadult males and a male and female pup) were at least 1.5 st. dev. below their means. A yearling shot on June 30, 1988 was over 4 standard deviation units below the mean length for its age class. It was in poor condition with only 8 mm. of blubber, its body condition values (Cond1=65.6; Cond2=8.2) significantly below the sample means (t[Cond1]=2.288, p<.05; t[Cond2]=4.260, p<.01). It was not retained for later examination in the lab, being mistaken in the field for a skinny young-of-the-year and processed accordingly.

In 1987, the condition of non-ovulating mature females (Table 4) was worse than that of females that had borne pups. There is some basis for argument that body condition has an effect on ovulation (Stirling et al. 1982). Three of the 8 non-ovulating mature females appeared to have somewhat retarded growth (at least 1.5 standard deviations below the means for their ages).

Table 4. Condition indices of ovulating vs. non-ovulating ringed seals of Thesiger Bay.

Collection period		Ovulation Status: ovulating	non-ovulating	t-test
June 01-15	Cond1	76.34 ± 2.33	78.36 ± 0.69	
	Cond2	34.53 ± 3.20	34.08 ± 0.11	
	n	4	2	
July 01-15	Cond1	73.57 ± 3.12	66.02 ± 1.10	
	Cond2	30.66 ± 0.75	23.42 ± 0.81	
	n	2	2	
Aug. 01-15	Cond1	75.59 ± 5.74	69.28 ± 5.89	4.437
	Cond2	39.01 ± 6.14	28.56 ± 1.44	7.925
	n	10	4	
Total (June-Aug)	Cond1	75.52 ± 4.71	70.74 ± 6.27	4.838
	Cond2	36.84 ± 5.86	28.66 ± 4.15	8.193
	n	16	8	

Pathology:

On superficial examination, 2 seals were found to have lung cysts (a 10-year-old female and a 9-year-old male). However, the male had above average condition indices (cond1 = 70, cond2 = 34), and the female's were only slightly below average (69, 33.5).

Three mature seals (a 9 year-old female and two 8 year-old males) in the 1987 sample were found to be emaciated. The female had body condition indices of 62.97 and 28.21. The males had condition indices of 58.08 and 22.92, and 63.64 and 28.63. These thin seals had obviously enlarged gall bladders (8.2 to 9.1 cm. long); the mammalian gall bladder becomes distended with backed-up bile during fasting or starvation (Hightower and Janowitz 1979). There were no pathological conditions to explain these emaciations. Two 1988 seals were emaciated, one the previously mentioned dwarf yearling, the other a 7-year-old female. The female had suffered an abnormal parturition, and had not been able to deliver her pup. The 4-pound pup was found in the abdominal cavity, and shed lanugo covered the mother's abdominal organs. A small (4-5 mm.) hole was noticed in the wall of the regressing uterus, which may have indicated a rupture due to an abnormal presentation.

No pathological parasite infections were found in these seals. One seal in our 1987 sample, an eight-year-old female, had a heavy load of gastric roundworms, and several 1988 seals had light infestations.

Population Density:

Ice conditions at survey time in 1988 were similar to those of 1981. In both these years, Amundsen Gulf cleared of ice early, and seals crowded

Table 5. Ringed seal densities over 6/8 or greater ice cover for 3 aerial survey areas from 1981-1988.

Year	Ringed Seal Density #/sq. km. (st. error)	Estimated Population Number (x 1000)
	Prince Albert Sound	
1981 *	3.46 (0.67)	16.9
1982 *	2.03 (0.21)	15.0
1983 *	2.34 (0.13)	17.8
1984 *	2.37 (0.26)	18.3
1988	6.94 (0.85)	48.9
	Amundsen Gulf	
1981	3.08 (0.66)	14.0
1982	2.61 (0.26)	54.9
1983	3.02 (0.15)	56.5
1984	1.60 (0.16)	31.2
1988	4.63 (1.18)	12.5
	Thesiger Bay/Beaufort coast of Banks Is.	
1988	1.30 (0.23)	2.2

* from Kingsley 1985.

onto the remaining ice at the southern end of Prince of Wales Strait and in Amundsen Gulf. In the summer of 1988, Prince Albert Sound held the highest density of Ringed Seals, Thesiger Bay/west Banks Island coast held the lowest (Table 5). Ringed Seal density over the ice of Prince Albert Sound is twice the previous highest density year of 1981 for that area and the estimated population of 48,900 is about 3 times the estimated populations in 1981-1984. Densities over the ice of Amundsen Gulf were greater in 1988 than the previous highest density years of 1981 and 1983. However, Amundsen Gulf's estimated 1988 population of 12,500 is less than the previous lowest estimated population of 14,000 for the area. The estimated population for the whole Amundsen Gulf/Prince Albert Sound area (61,400) is down from the 1982-83 figures, but substantially increased over 1981 (30,900) and 1984 (49,500). The 1988 data confirm the 1981 findings (Kingsley et.al. 1982) that in an early ice year, seals crowd more heavily into the mouth of Prince Albert Sound.

Feeding:

The diet of the Ringed Seals in our study area consists almost exclusively of crustaceans and fish (Table 6), agreeing with previous work on this topic (McLaren 1958, Lowry et.al. 1980, Smith 1987). The dominant crustacean prey are Lyssianassid and Hyperiid amphipods, mostly _Parethemisto_ sp. As Ringed Seals get older they feed more on fish, less on amphipods (occurrence data) (Table 7; Smith 1987). However, the data are not statistically significant (chi-square ranges from 0.254-1.092 between age groups, $p<.5$).

Contaminants:

Organochlorine analysis of 21 Ringed Seal blubber samples from 1988 showed residues were lower than in the 1987 samples for all organochlorines except dieldrin (Table 8). The reasons for these decreased levels are unknown, but may have something to do with the younger mean age of the 1988

Table 6. Percent occurrence of 74 seals having food type in stomachs.

Food Taxa	Percent Occurrence	N
Amphipods	78.4	58
Mysids	35.1	26
Decapods/Euphausiids (shrimp) (krill)	33.8	25
Cumaceans	14.9	11
Copepods	5.4	4
All Crustaceans	91.9	68
Fish	64.9	48
Bivalves	2.7	2
Polychaetes (tubes)	2.7	2
Cephalopods (mandibles)	1.4	1

Table 7. Percent occurrence of 73 Ringed Seals by age group having food in stomachs.

Food Taxa	Pups (n=14)		Adolescents (1+ - 6+) (n=43)		Adults (>=7+) (n=16)	
Amphipods	100.0	(14)	72.1	(31)	68.8	(11)
All Crustaceans	100.0	(14)	88.4	(38)	81.2	(13)
Fish	57.1	(8)	62.8	(27)	75.0	(12)

Numbers in parentheses are number of observations.

sample. The 1988 samples were at normal to low residue levels compared to other Canadian Arctic seal populations, and hundreds of times lower than northern European seals. Mean levels of all organochlorines except dieldrin are higher in the six 1987 Thesiger Bay ringed seals than recorded in ringed seals elsewhere in the Canadian Arctic in the past 15 years, although Harp Seals from 1976-78 in Grise Fjord, Pangnirtung, and northwest Greenland (Ronald et al. 1984) had greater DDT (both sexes) and PCB (adult males) levels.

Of the two female samples analyzed in 1987, a non-ovulating 7-year-old had less PCB, total DDT and toxaphene residues than a multiparous 10-year-old. However, the nullipara had twice the HCH levels and 3 times the CBz of the multipara, as well as greater dieldrin levels (Table 9).

Mercury and selenium concentrations in the livers of 13 seals (Table 10) were positively correlated with age (Hg: $p<.005$; Se: $p=.001$). This agrees with the literature (Sergeant 1980, Smith and Armstrong 1978, Drescher et. al. 1977, Heppleston and French 1973). There was also a significant correlation ($r=.8516$, $p<.001$) between Hg and Se concentrations. Smith and Armstrong (1978) also report this correlation. This finding may be due more to these metals' comparable accumulation rates with age in pinnipeds, rather than any significant interactions between the two contaminants (Perttila et. al. 1986).

Mean mercury and selenium concentrations in the livers of 13 seals (1988 samples) are relatively high in comparison to other Arctic locations (Wagemann and Muir 1984), and are well above the federally accepted tolerance levels of 0.5 ppm. in food, but are similar to concentrations

Table 8. Mean concentrations (mg/100 g) of organochlorine in blubber of Phoca hispida.

Location	Sex	Age	n	HCH	CBz	Chlor	DDT	PCB	Txph	Diel	Source
Sachs H.											
(1988)	M	4	11	2.67	0.61	4.23	3.8	5.8	1.9	0.50	this report
	F	5-6	10	2.34	0.51	3.44	3.6	5.2	1.3	0.41	
(1987)	M	8	4	6.00	1.32	8.19	10.5	11.8	5.0	0.43	this report
	F	8	2	5.63	1.08	8.35	6.8	7.8	12.2	0.35	
(1972)	M	-	3				9.3	7.2			Bowes & Jonkel
	F	-	2				19.1	12.2			(1975)
Tuktoyaktuk (1986-87)		-	7	2.90		4.05	2.9	6.3	3.4		Muir (pers. comm.)
Cambridge B.	M	-	10	3.02		5.57	4.7	8.8	3.8		"
(1986)	F	-	6	2.98		4.93	3.0	6.7	3.1		
Grise Fd											Muir et al.
(1972)	F	-	3	1.32	0.32	2.23	8.1	6.4	<0.1	0.54	(in prep.)
Admiralty Inlet											" "
(1975-76)	F	3	5	2.41	0.30	3.62	6.3	6.0	<0.1	0.68	
(1983)	M	6	10	2.27	0.32	4.62	13.3	7.9	<0.1	0.74	
	F	6	16	2.04	0.24	2.84	4.8	3.1	<0.1	0.77	
Barrow Str.											" "
(1984)	M	10	19	2.74	0.25	4.57	7.1	5.7	<0.1	0.96	
	F	9	14	3.08	0.27	3.53	4.8	3.8	<0.1	0.73	
West Greenland											Johansen et al. (1980)
(1974-76)		-	57				10.2	9.6			
East Greenland											" "
(1974)		-	7				31.0	32.0			
EUROPE											
Bothnian B.	M	-	24				1300.0	1000.0			Helle et al.
(1973)	F	-	29	(uter. abn)			1300.0	1100.0			(1976)
	F	-	8	(uter. norm)			620.0	890.0			
Gulf of Finland											Perttila et al. (1986)
(1976-82)		7	19				759.0	758.0			
	F	>7	1	(uter. norm)				>2500.			
	* F	>7	1	(uter. abn)				680.0			
	* F	>7	1	(uter. abn)				790.0			

Age is mean age in most studies.
* It is unclear whether these females were ringed or grey seals.
n.d. Non-detectable levels. uter. norm. = normal uterus
HCH = hexachlorocyclohexanes uter. abn. = abnormal "
CBz = chlorobenzenes
Chlor = chlordane Txph = toxaphene Diel = dieldrin

Table 9. Organochlorine levels in an ovulating (#8705) and a non-ovulating (#8704) female.

Sample #	Age	CBz	HCH	Chlor.	DDT	PCB	Toxaph.	Dield.
SH8704	7	158.06	766.98	598.15	666.02	1172.50	368.76	39.03
SH8705	10	57.70	358.54	1071.49	702.22	2252.65	2074.42	30.81

CBz = chlorobenzenes; HCH = hexachlorocyclohexanes; Chlor. = chlordane; DDT = sum of DDT isomers & metabolites; Dield. = dieldrin; Toxaph. = toxaphene (results subject to further study).

Table 10. Heavy metal concentrations in livers of 13 Thesiger Bay ringed seals. (ug./gm. wet wt.)

Sex	Age	Cu	Cd	Hg	Se	Zn
M	0+	7.37	0.10	0.66	0.87	32.3
M	2	4.72	2.81	3.64	3.79	39.8
M	4	6.90	7.77	42.20	18.90	43.5
M	6	4.45	7.45	18.0	10.50	40.0
M	9	3.87	2.62	48.3	20.30	24.4
M	9	8.09	3.67	63.8	31.2	35.6
$\bar{X}$	5.0	5.9	4.07	29.43	14.26	35.9
F	1	8.55	0.45	0.64	1.37	34.6
F	3	17.10	2.05	1.88	2.47	42.5
F	4	3.10	4.34	2.81	4.22	32.7
F	6	13.50	4.86	35.10	22.80	47.0
F	6	14.90	5.55	21.9	29.8	48.4
F	7	4.77	9.45	91.1	31.0	48.1
F	7	3.52	5.27	36.0	12.8	49.3
$\bar{X}$	4.8	9.35	4.57	27.06	14.92	43.2

found in Ringed Seals from the eastern end of Amundsen Gulf in 1972 and 1977 (Smith and Armstrong, 1978). However, the concentrations of Hg in our seals are significantly higher than for 1972 Cape Parry seals, which can be explained by the mean age difference. The Cape Parry sample was composed of younger seals than our Thesiger Bay sample.

Zinc mean concentrations are within the range of means (34.3 - 44.0 ug./gm.) for the highest recorded levels in Canada (Wagemann and Muir 1984). Cadmium levels are low, and residues of lead, arsenic, vanadium and copper are negligible (< 0.1 ug./gm.).

There is evidence associating reproductive dysfunction and population declines among ringed and common seals in Europe with chronic contamination with chlorinated residues (Helle 1983; Reijnders 1980). Narrowing or blocking of the uterine tubes has been associated with DDT and PCB contamination in ringed seals in the Baltic Sea (Helle 1976). Common seals have declined in the western Waddensee where levels of DDT and PCBs are high, and interference with reproductive processes was indicated by feeding captive seals on Waddensee fish (Reijnders 1986). DeLong et al. (1973) found high organochlorine levels in female California sea lions bearing prematurely or aborting.

It isn't clear, however, what is cause and what is effect. Cow seals unload organochlorines into milk during lactation, and reproductive failure blocks this faculty for depuration. So reproductive failure may be the cause, not the effect, of high individual organochlorine levels. The Baltic seals' uterine stenosis (Helle et. al. 1976) may have been due to a viral infection. The California sea lions had abnormal concentrations of heavy metals and had bacterial and viral infections, complicating the direct cause-effect relationship (Reijnders 1986). Organochlorines, being immunosuppression agents (Reijnders 1984), may have heightened the California and Baltic pinnipeds' susceptibility to these infections. Contaminant levels in our sample were not at levels expected to cause reproductive failure, and we saw no indication of any pathological conditions in the female reproductive tracts that could be attributable to contaminant effects.

CONCLUSIONS

We conclude that reproductive success has been low among the Ringed Seals of the eastern Beaufort Sea in 1986 and 1987 and possibly also in 1984-85, results from our sample being confirmed by the state of polar bears during that period. Poor reproductive success in 1974 and 75 was apparently associated with a winter of heavy ice in the Beaufort Sea, and a similar occurrence may have been responsible this time. Pupping success returned to normal in 1988. These indications that reproductive failures lasting for more than one year may be recurring phenomena are of ecological interest for the effect they may have on the predator-prey relationship between ringed seals and polar bears. They also have implications for the conduct and interpretation of impact assessment evaluations of ringed seal populations. There is now no evidence of poor body condition, widespread disease or heavy parasite infestation, or high pollution contamination in the area.

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