Northwest Atlantic Fisheries Organization

Serial No. N2550 NAFO SCR Doc. 95/41

SCIENTIFIC COUNCIL MEETING - JUNE 1995

JOINT ICES/NAFO WORKING GROUP ON HARP AND HOODED SEALS, 5-9 JUNE 1995
(SEA-72)

Seasonal Variation in Body Condition of Adult Barents Sea Harp Seals *Phoca groenlandica*

by

K. T. Nilssen[1], P. E. Grotnes[2], T. Haug[1] and V. Potelov [3]

[1] Norwegian Institute of Fisheries and Aquaculture,
N-9002 Tromsø, Norway

[2] Norwegian College of Fisheries Science, University of Tromsø,
N-9037 Tromsø, Norway

[3] Polar Research Institute of Marine Fisheries and Oceanography (PINRO),
6 Knipovich Street, 183763 Murmansk, Russia

ABSTRACT

In the period 1990-1994, harp seals *Phoca groenlandica* were sampled for ecological studies in various areas and seasons in the Barents Sea. Data on total body weight, standard body length, axillary and maximum girth, dorsal and ventral blubber thickness were selected from all adult seals (defined as seals with standard body length 150 cm or more) in order to evaluate the seasonal dynamics in condition of the animals. Blubber thickness measurements and a condition index (one including length, weight and dorsal blubber thickness and the other including maximum girth and length) showed the same seasonal patterns. The seals were in poor condition in spring and early summer (May-June), condition improved during the course of summer, and the animals were in good condition in September and in October when the mean dorsal blubber thickness was approximately 88 mm. The energy stores built up during the summer and autumn were maintained until February, whereafter the seals became thinner as the stores of blubber decreased rapidly during the breeding season (February/March). A slight increase in dorsal blubber thickness was observed in the short period between lactation and moult (late March-early April), but the stores of blubber decreased further during moult (late April-May) to a mean dorsal blubber thickness of less than 20 mm in mid-June. No significant differences were observed in blubber thickness or condition indices between the sexes in the various periods, except during April when the females were in significantly poorer condition than the males. Harp seals sampled during the seal invasions to North Norwegian coastal waters in February 1988 were in poorer condition than seals captured in the Barents Sea in February 1993.

Introduction

In phocid seals and cetaceans, the subdermal fat tissue, the blubber layer, is important for thermal insulation, serves as buoyancy, streamline the body, and also serves as an energy source (Scholander *et al.* 1950; Pond 1978; Worthy and Lavigne 1987; Ryg *et al.* 1988). The relative amount of fat stored in the blubber layer and in the core of the animals (muscle, skeleton and viscera) varies between marine mammal species (Worthy and Lavigne 1987). The energy reserves also varies in conjunction with the reproductive cycle, migrations and food availability (Sergeant 1973, 1991; Pitcher 1986; Fedak and Andersen 1987; Ryg *et al.* 1990). In marine mammals the level of fat reserves, which is mainly the blubber layer, has been considered the best indication of body condition and energetic status(Lockyer 1986; Read 1990; Ryg *et al.* 1990).

In harp seals *Phoca groenlandica* most effort in body condition studies has been carried out during the reproduction period (Worthy and Lavigne 1983a, 1983b, 1987; Stewart

and Lavigne 1984; Worthy 1987; Kovacs *et al.* 1991), although some studies have been carried out in the northwest Atlantic in other periods (Sergeant 1973, 1991; Beck *et al.* 1993) and on captive animals (Renouf *et al.* 1993). In the Barents Sea area earlier studies of harp seal condition have been carried out only during spring, including both breeding, between breeding and moult, and moult (Sivertsen 1941).

In 1978 the population of Barents Sea harp seals was estimated to comprise approximately 800000 animals, with 170000 pups born annually and increasing in size (Benjaminsen 1979). During the 1980ies, however, some decrease in rates of recruitment to the population may have occurred (Anon. 1992, 1994; Kjellqwist *et al.* 1995). Nevertheless, the harp seal is the most abundant seal species and an important predator in the Barents Sea. The species is now included in a multispecies model (MULTSPEC), which may provide the basis for future management of marine resources in the Barents Sea (Bogstad *et al.* 1995). The annual migration pattern of Barents Sea harp seals is usually characterized by a north-bound feeding migration in spring and summer and a south-bound breeding migration during winter (Haug *et al.* 1994). Summer and autumn, and probably also early winter seem to be the most intensive feeding periods for this population(Lydersen *et al.* 1991; Nilssen *et al.* 1994, 1995a, 1995b).Data describing the variations in condition of the harp seals through the year are necessary prerequisites when the annual consumption of various prey species by the seal stock is to be estimated. In the period 1990-1994, harp seals were sampled for ecological studies in various areas and seasons in the Barents Sea (Nilssen *et al.* 1994, 1995a,b). Data from all adult seals (defined as seals with standard body length 150 cm or more; see Kjellqwist *et al.* 1995) were selected for evaluations of seasonal variation in condition. Condition parameters from these animals were also compared with equal parameters selected from harp seals sampled during the seal invasions to North Norwegian coastal waters in 1988 (Haug *et al.* 1991; Nilssen *et al.* 1992).

Materials and methods

Sampling areas and periods

Data were obtained from harp seals taken as by-catches in gill net cod-fisheries at the coast of North Norway in February and June 1988. (Table 1; Fig. 1).

In winter and spring, data were collected in the southern parts of the Barents Sea, in the White Sea and at the northeastern coast of North Norway. A survey designed to collect biological material from harp seals in the areas between Cape Kanin and Novaya Zemlya was conducted in February 1993 (Nilssen *et al.* 1994). Between breeding and moult, in the last week of March and the first week of April, in 1992, harp seals were either shot or collected from by-catches in gill net cod-fisheries in Varangerfjord, North Norway (Nilssen *et al.* 1995a). In the moulting period, data were collected from seals taken during Norwegian commercial sealing in the southern parts of the Barents Sea (the «East Ice») in April 1992 (Nilssen *et al.* 1995a), and from seals taken during Russian scientific sealing in the White Sea in May 1994 (Table 1; Fig. 1).

During the summer period, a harp seal survey was carried out along the edge of the drifting pack-ice between Novaya Zemlya and Hopen in June 1991, and seals were sampled southeast of Hopen (Table 1; Fig. 1). Some of these seals were in their latest stages of moult as late as mid-June (Nilssen *et al.* 1995b).

During autumn, surveys were conducted in the harp seal feeding areas in the northernmost parts of the Barents Sea in September 1990 and 1991, and in October 1992 (Nilssen *et al.* 1995b)(Table 1; Fig. 1).

Condition measurements

Seals were weighed to the nearest kg in all sampling periods except in June 1988 and in May 1994 (Table 1). No corrections were made for the weight of stomach contents or foetus, or for the weight of lost blood following the killing by shooting and subsequent bleeding of the seals.

Standard body length (L) of all seals were measured to the nearest cm in a straight line from the tip of snout to the tip of tail, with the animal lying on its back. Axillary and maximal girth was measured to the nearest cm. Ventral blubber thickness between the front flippers (in a knife-cut on the sternum) and dorsal blubber thickness (in a knife-cut at the mid-line between the front flippers) were measured (excluding the thickness of the skin) to the nearest mm.

During the commercial sealing in the East Ice in April 1992, all measurements were recorded after draining out the blood by first cutting ventrally along a mid-line from the lower jaw to behind the front flippers and then cutting over the bloodvessels to these flippers. The girth measurements may have been slightly biased due to this operation. During these commercial catch samplings, and also during the research cruise in June 1991, the dorsal blubber thickness were measured, after skinning the animals, in a knife-cut through the blubber layer against the inside of the skin, which may have introduced errors in these measurements compared with other periods.

Data analyses

The mean dorsal and ventral blubber thicknesses were compared among different seasons for all seals collected in the period 1990-1994. Blubber thickness data from the seals taken in February and June 1988 were compared with similar data from animals collected in February 1993 and June 1991.

A condition index (C) expressed as $C = \sqrt{L/M} * d$, where L is standard body length in cm, M is total body mass in kg and d is dorsal blubber thickness in cm (Ryg *et al.*1990), was used to evaluate the seasonal variation in the condition of the animals. In order to include the condition data sampled in May 1994 (Table 1), where total body weights were lacking, the correlation between a volume index and body weight was calculated on the basis of data from April 1992 and June 1991. Data from these periods were chosen because the condition of the seals were supposed to be most equal to the condition of animals taken in May 1994. The measurements from May 1994 were used to calculate the volume index (V), expressed as $V = (L^2 * G)/100\ 000$, where L is as above and G is the girth measured in cm right behind the front flippers (axillary girth).

The condition index was tested for possible differences between the sexes for all periods.

The correlation between the condition index (C) and the relation girth/length was tested, and also possible relationship between blubber thickness and length. The relationship between length and weight was tested and compared between June 1991, when the animals were leanest, and October 1992, when the seals were observed to be fattest. Least squares linear regression analyses was used to find the relationship between various parameters. Various differences were tested using student`s t-test. All tests and calculations were carried out in Quattro Pro (Borland & Osborne 1990).

Results

No correlation were observed between dorsal/ventral blubber thickness and body length in the seals in any of the sampling periods.

The variation in dorsal and ventral blubber thickness (both sexes pooled) within the various seasons in the period 1990-1994 are shown in Fig. 2. The dorsal blubber vary more than the ventral blubber in thickness, however, with both parameters being lowest in spring, with mean values less than 20 mm in June 1991. The blubber increased during the course of summer, and the seals were very fat in September and October, with mean dorsal blubber thickness of approximately 88 mm in October 1992. In this period maximal dorsal blubber thickness was 116 mm for a 14 years old male with standard body length 183 cm and weighing 189 kg. The energy stored as blubber during the summer and autumn was maintained until February, whereafter the seals became rapidly thinner during the breeding period (late February to mid-March). The blubber thickness seemed to be relatively constant in the period between lactation and moult, since no significant differences in blubber thickness were observed between March and April, but the stores of blubber decreased during moult (April-May) to the very low levels observed

in June 1991.

Ventral mean blubber thickness were significantly lower ($p<0.001$) in harp seals invading the North Norwegian coast in February 1988, compared with similar data from seals captured in the East Ice in February 1993 (Fig. 3). No significant differences in blubber thickness were observed, however, between seals taken during the invasions in June 1988 as compared with seals sampled in the Barents Sea in June 1991 (Fig. 4).

The regression between the volume index (V) and the body weight (W) in the April 1992 and June 1991 materials was:

$$W = 4.5 + 3 * V$$

The body weight was significantly correlated ($p<0.001$) to the volum index (Fig. 5).

The regression between girth/length and the condition index (C) in the the April 1992 and June 1991 materials was:

$$C = -0.097 + 0.225 * \text{girth/length}$$

The condition index was significantly correlated ($p<0.001$) to girth/length (Fig. 6).

No significant differences were observed between sexes in the condition index in the various periods in 1990-1994, except for April 1992, where the condition of the females was significantly lower than for the males ($p<0.001$).

The seasonal variation in the condition index ($C = \sqrt{L/M} * d$) of the harp seals taken in the period 1990-1994 is shown in Fig. 7, where data from both sexes are pooled. The seasonal variation in the condition index was comparable with the variation in blubber thickness (Fig. 4). In the spring period, March-June, the condition index was significantly lower than in the autumn and winter period (September-February). Within the spring season, all recorded indices were significantly different from the mean for this period ($P<0.001$), except for March 1992. During the autumn-winter season, however, none of the recorded indices differs significantly from the mean for this period. The relationship between the condition index (C) and the index described as maximum girth*100/standard body length (Sergeant 1973) in the various seasons during 1990 to 1993 is given in Fig. 8.

To evaluate the increase in body mass between the extremes in spring and fall, the correlation between length and weight was calculated for June 1991 and October 1992 (Fig. 9). In order to obtain comparable data, only animals longer than 157 cm were used in this calculation. The regressions were:

June 1991: $\ln(W) = -6.24 + 2.08 * \ln(L)$

October 1992: $\ln(W) = -5.9 + 2.13 * \ln(L)$

No significant difference was found between June and October for the coefficient giving the relationship between ln(L) and ln(W), which indicate that the increase in weight during the summer-autumn period were relatively similar for all animals longer than 157 cm.

Discussion

The analyses of body condition, using both condition indices and blubber thickness measurements, in this study suggest that harp seals are generally in poor condition in spring and early summer (May-June), condition improves during the course of summer, and seals are in good condition in September-October (Fig. 2, 7). The energy stores built up during the summer and autumn are maintained until February, but then the seals become thinner as the stores of blubber decrease rapidly during the breeding period (late February - early March). There may be a slight, but not significant, increase in condition (Fig. 7) in the short period between lactation and moult (late March - early April), but the stores of blubber again decrease during moult, which occurs from late April to June (Fig. 2, 7).

The observed increase in condition between mid-June and September, and a further increase to October (Fig. 8), indicate that summer and autumn must be very intensive feeding periods. The apparent stability in condition during late autumn and early winter suggests that the seals are able to consume sufficient prey to meet energy requirements during this period. The very poor condition observed in both sexes in March and June provide clear indications that feeding by the adult seals must be restricted during breeding and moult.

The results in this study confirm observations made in Northwest Atlantic harp seals where the stores of blubber decreased rapidly during the breeding period (Sergeant 1973, 1991; Stewart and Lavigne 1984; Kovacs *et al.* 1991). Variations in condition and blubber thickness through the year have also been observed in the Northwest Atlantic harp seals. Fatness increased in late winter, falled during whelping and again during moult, and the seals were still in very lean condition during the summer. The animals increased in condition during late summer and by December they were fat. Adult females showed a steady fatness from December to late February, while adult males appeared still to increase in condition until late February. The fall in condition of adult females during lactation, was followed by a short period of intensive feeding in early April before the loss in fatness due to the moult (Sergeant 1973, 1991). The increase in conditition during the course of summer seemed to be lower in harp seals in the Northwest Atlantic than in the Barents Sea. Observations in this study also suggest that adult Barents Sea harp seals reached their maximal condition level earlier in the autumn (October) than in Northwest Atlantic (December-February).

The results in this study during spring also confirm earlier studies of Barents Sea harp seal condition, which suggest that the adult females had a short feeding period between lactation and moult (March-April), due to observed increase in blubber thickness (Sivertsen 1941).

Seasonal variations in mass, blubber thickness, condition index and energy consumption were observed in captive, both subadult and adult, harp seals, but with substantial variations among individual animals (Renouf *et al.* 1992). Lager *et al.* (1994) also reported that food intake in captive subadult harp seals was generally low during moult (May-June), to be followed by a pronounced increase in feeding in the period July-October. During the period October-April the food intake of captive seals was observed to be relatively stable.

During the extensive harp seal invasions in 1986-1987 to the coast of North Norway the invading harp seals, particularly the subadults, were said to be thin and in poor condition (Wiig 1988; Øritsland 1990). Adult seals taken as bycatches in gill nets at the North Norwegian coast in February 1988 confirm this by having sacrificed parts of their storage blubber and being significantly thinner than animals taken in the southeastern Barents Sea in February 1993. By the end of the annual starvation period, however, no significant differences were observed in blubber thickness between adult seals taken in June 1988 at the coast of North Norway compared with seals taken southeast of Hopen in June 1991.

Acknowledgements

Thanks are due to the crews and field assistants on board the vessels "Johan Ruud", "Polarfangst", Michael Sars", "Selis", "Meridian", "Melshorn", "Jan Mayen" and "Varzuga". The following field assistants participated during the sampling in Varangerfjord and in the White Sea: A. Ørjebu, T.O. Rudi, S.A. Kjellqwist, G. Henriksen, Y. Nazarenko and V. Adrianov. Thanks are also due to B. Bergflødt, K.A. Fagerheim, N.E. Skavberg, F. Strand and L. Olsen for technical assistance. The ecological studies of harp seals were supported by funding from the Norwegian Council of Research, project no. 4001-701.260.

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Table 1. Summary of the Barents Sea harp seals collected for studies of body condition in the period 1988-1994. CS = commercial sealing; SE = scientific expeditition; GN = gill net bycatches. The numbers in parenthesis indicate the sampling areas shown in Fig. 1.

YEAR	SEASON	AREA	SAMPLING TYPE	NUMBER OF SEALS
1988	Feb/Jun	Coast of North Norway (8)	GN	14/60
1990	Sep	East of Svalbard (5)	SE	18
1991	Jun	East of Hopen (4)	SE	61
1991	Sep	East of Svalbard (6)	SE	23
1992	Mar-Apr	Varangerfjord (8)	SE/GN	28
1992	Apr	East Ice (2)	CS	232
1992	Oct	East of Svalbard (7)	SE	34
1993	Feb	Southeastern Barents Sea (3)	SE	24
1994	May	White Sea (1)	SE	42
Total				536

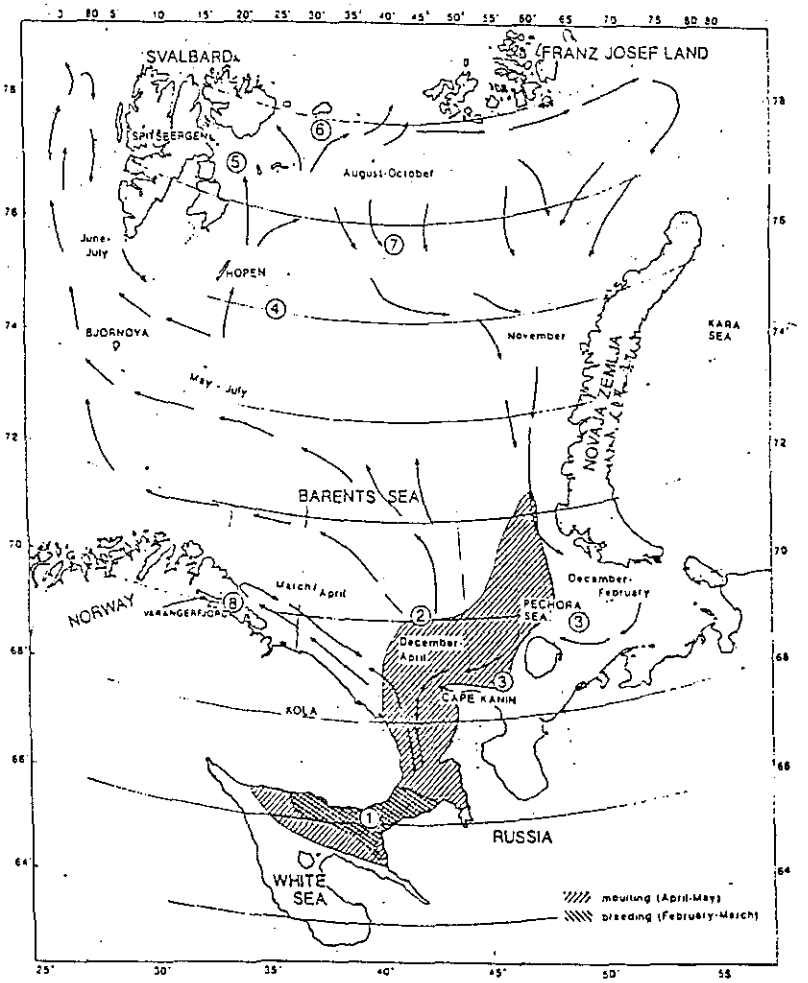

Fig. 1. Map showing the annual migration pattern of Barents Sea harp seals, and indicating the sampling areas of harp seals in the period 1988-1994.

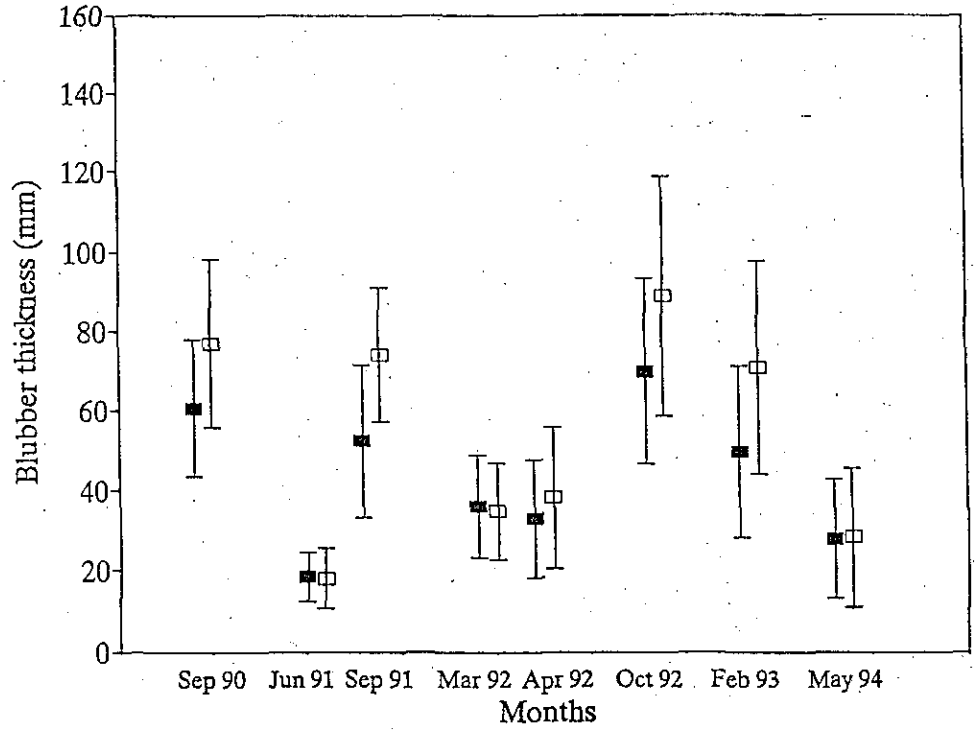

Fig. 2. Seasonal variation in ventral (black squares) and dorsal (white squares) blubber thickness in adult Barents Sea harp seals (both sexes pooled).

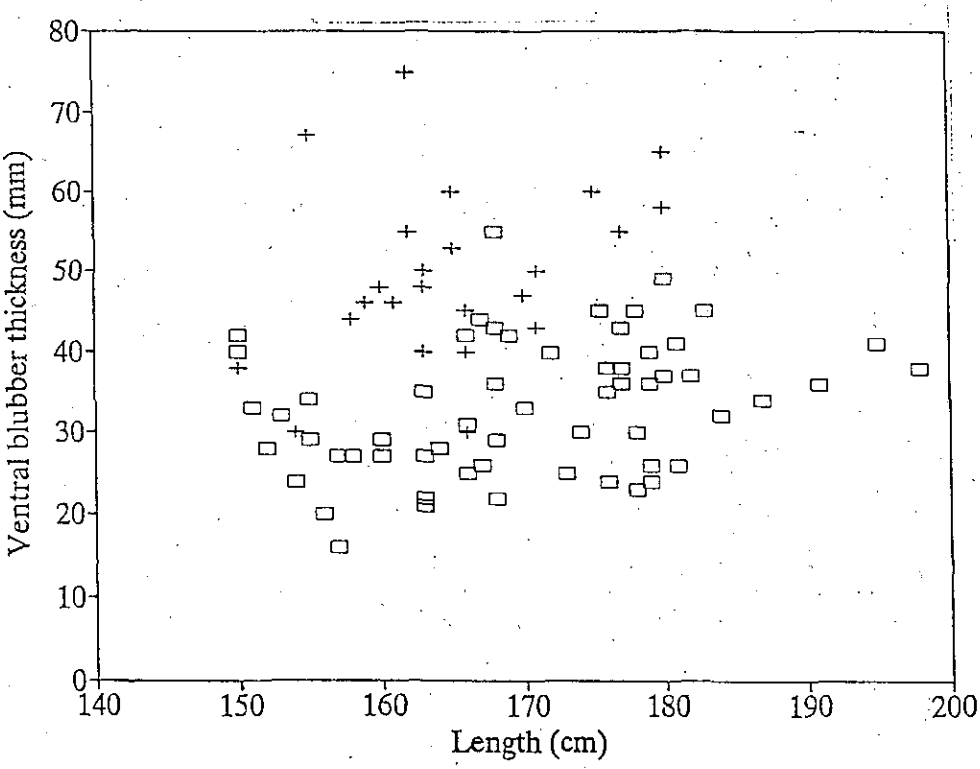

Fig. 3. Ventral blubber thickness in adult harp seals (both sexes pooled) collected in February 1988 (white squares) at the coast of North Norway and in February 1993 (+) in the southeastern Barents Sea.

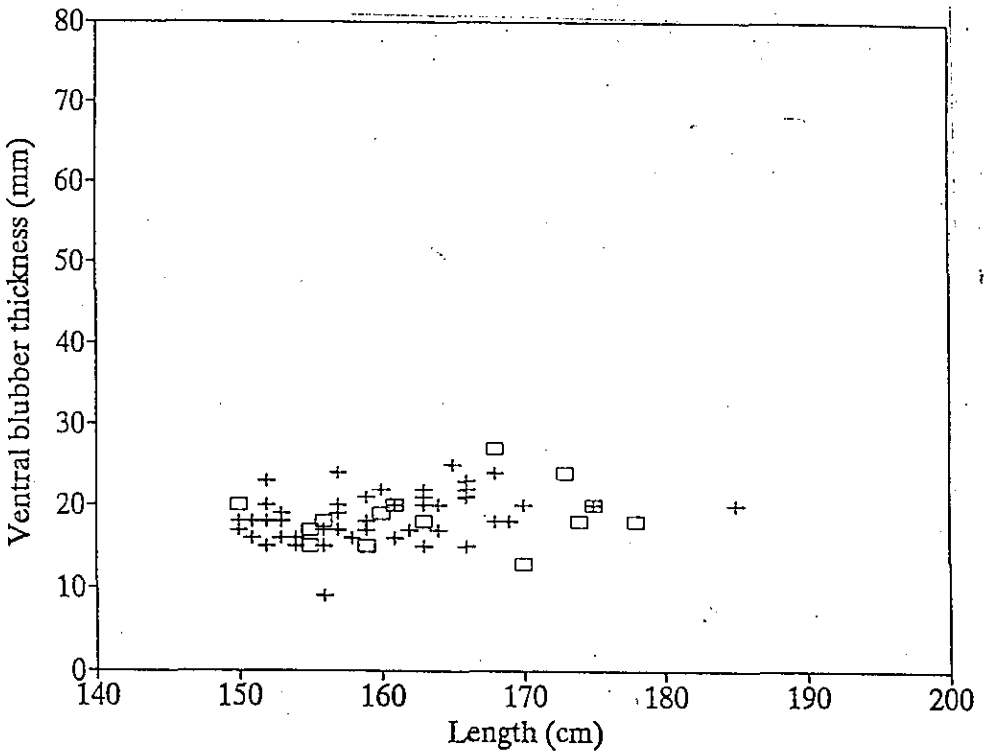

Fig. 4. Ventral blubber thickness in adult harp seals (both sexes pooled) collected in June 1988 (white squares) at the coast of North Norway and in June 1991 (+) southeast of Hopen.

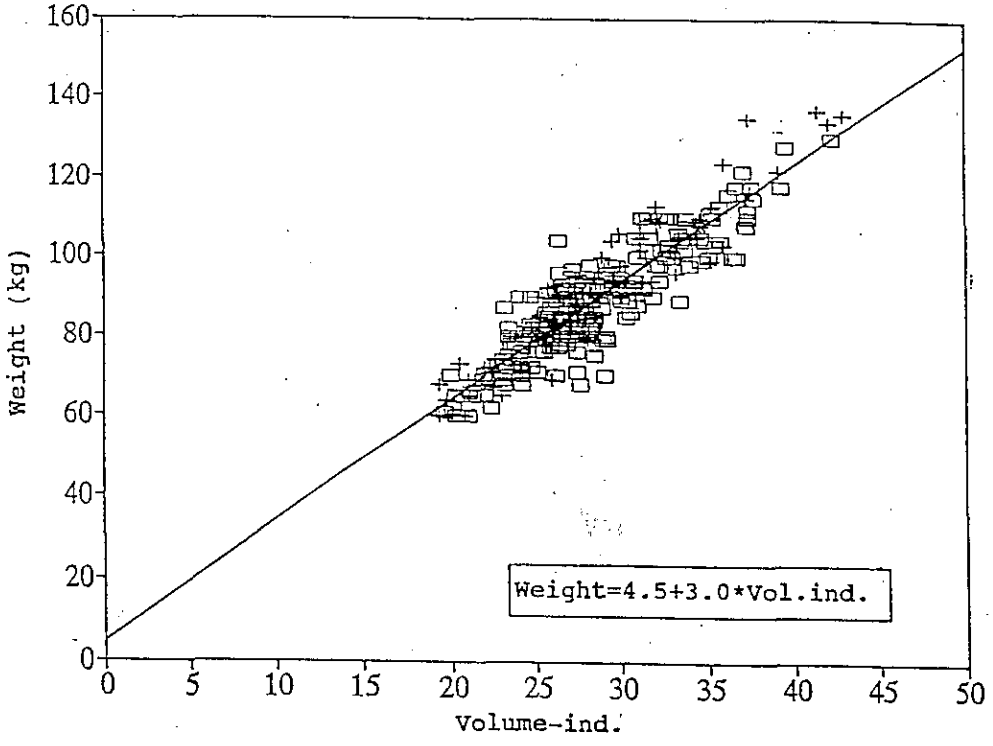

Fig. 5. Correlation between total body weight and the volume-index (V) in adult harp seals (both sexes pooled) collected in the East Ice area in April 1992 (+) and southeast of Hopen in June 1991 (white squares). V = L^2 * G / 100000, where L is standard body length (cm) and G is axillary girth (cm).

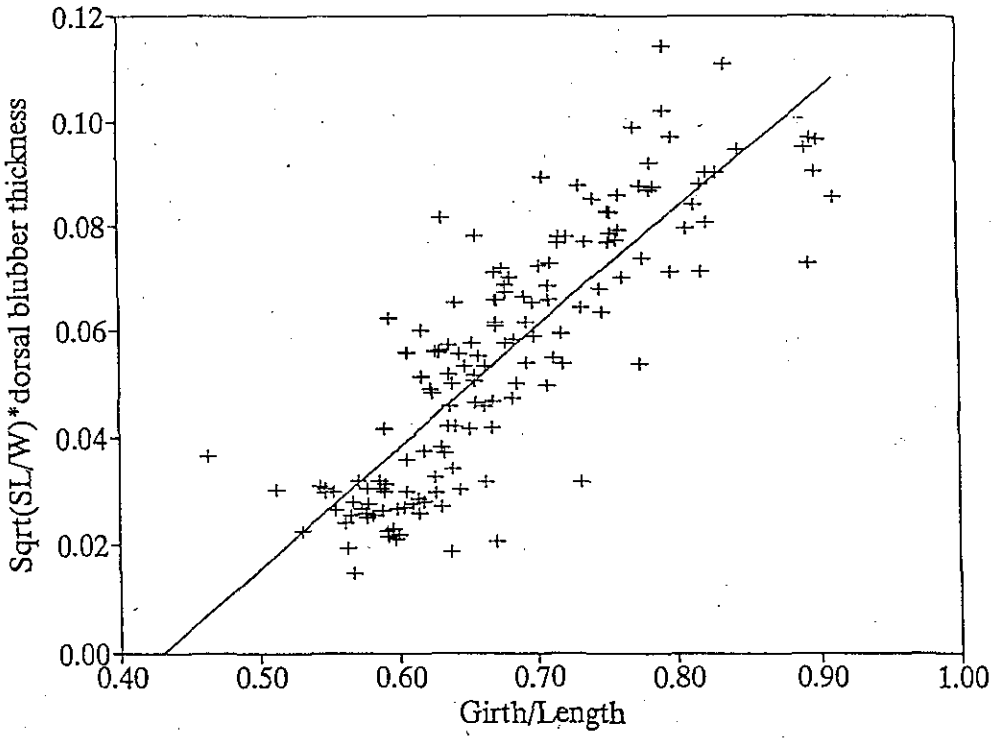

Fig. 6. Correlation between axillary girth/standard body length and the condition index (c) in adult harp seals (both sexes pooled) collected in the East Ice area in April 1992 and southeast of Hopen in June 1991. C = sqrt(SL/W) * dorsal blubber thickness, where SL is standard body length (m) and W is total body weight (kg).

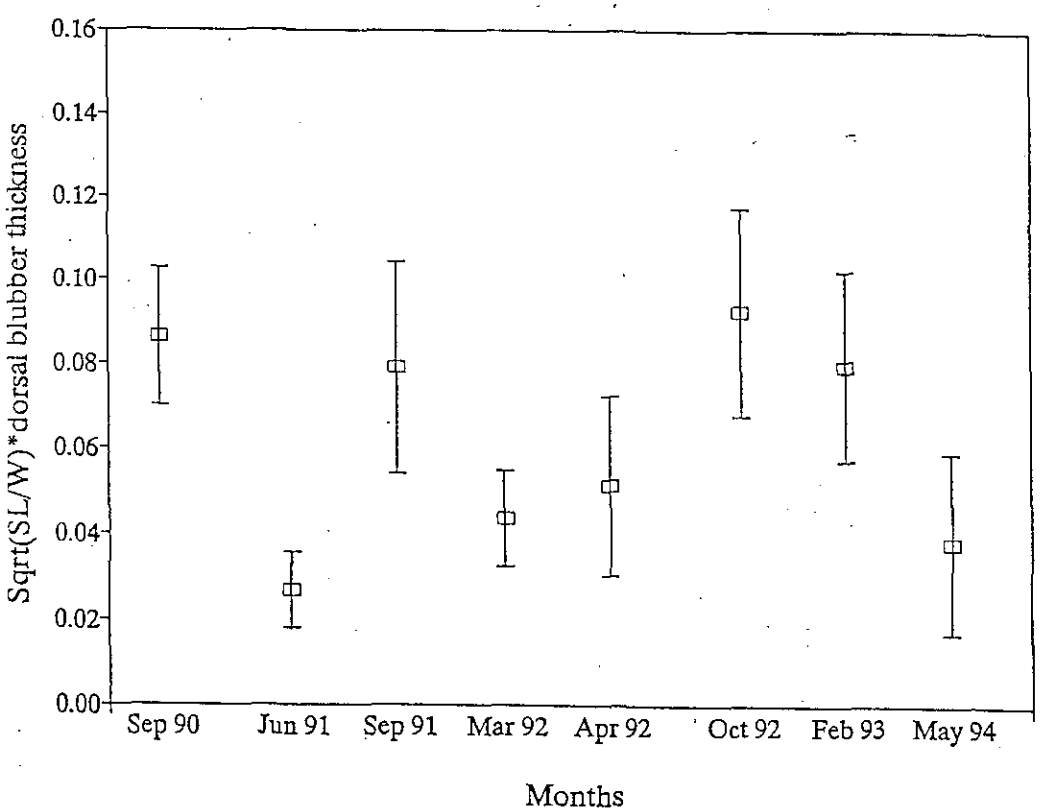

Fig. 7. Seasonal variation in the codition index (C) in adult harp seals (both sexes pooled) collected in the Barents Sea area in 1990-1994. C = sqrt(SL/W) * dorsal blubber thickness, where SL is standard body length (m) and W is total body weight (kg).

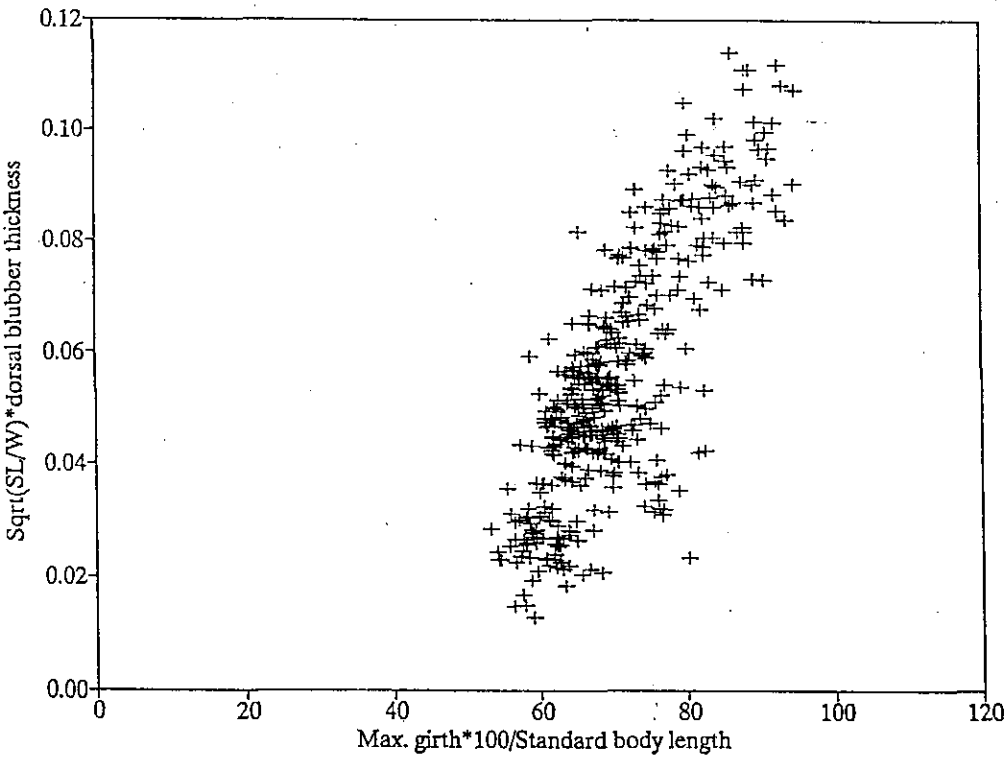

Fig. 8. Relationship between two condition indices in adult harp seals (both sexes pooled) sampled in various seasons during 1990-1993. Maximum girth (cm) * 100/ SL (Sergeant 1973) and C = sqrt(SL/W) * dorsal blubber thickness, where SL is standard body length (m) and W is total body weight (kg) (Ryg *et al.* 1990).

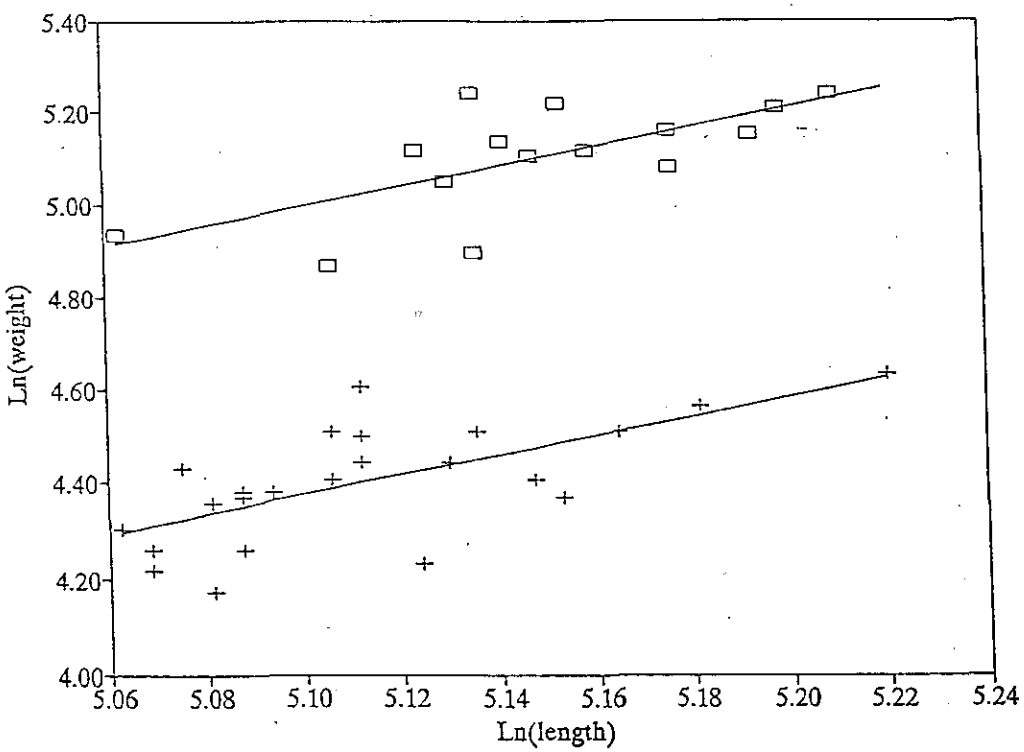

Fig. 9. Variation in total body weight (kg) in adult harp seals (157 cm and longer and both sexes pooled) between June 1991 (+) and October 1992 (white squares).