Netherlands Journal of Sea Research
10 (2) : 223–235 (1976)

THE HARBOUR SEAL (PHOCA VITULINA) POPULATION IN THE DUTCH WADDEN SEA: SIZE AND COMPOSITION

by

P. J. H. REIJNDERS
(Netherlands Institute for Sea Research, Texel, The Netherlands)

CONTENTS

I. INTRODUCTION

As there were signs that the seal stock in the Dutch coastal waters declined, seals were partially protected by law in 1954 (*cf.* VAN BEMMEL, 1956a, 1956b).

Nevertheless the decrease held on, and hunting was completely banned in 1962. Probably due to total protection there was a slight increase, but since 1965 a new decline set in, which lasts up to the present. This continuing decrease was the motive to start a study of its causes.

The size of a population is determined by reproduction, mortality and migration. Each of these parameters may vary with age and sex. As seals in the Wadden Sea do no longer have any predators since man decided to abstain from hunting, the population size is determined by such factors as food quality and quantity, parasites, diseases, pollution and rate of disturbance.

This study discusses the size and composition of the seal population. Further study is in progress to obtain information about reproduction, mortality and migration.

Acknowledgements.—This study was undertaken at the initiative of Dr J. L. van Haaften (State Institute for Nature Management, Arnhem, The Netherlands) and Prof. Dr M. F. Mörzer Bruyns (Agricultural University, Department of Nature Conservation, Wageningen, The Netherlands).

The author is much indebted to Dr J. L. van Haaften who since 1958 studied seals in The Netherlands. His field observations and many suggestions are incorporated in this study. Thanks are also due to Dr J. J. Zijlstra, director of the Netherlands Institute for Sea Research, for his hospitality, reading of the manuscript and valuable comments. The advice of Dr H. G. Fransz and Mr W. G. van Arkel in statistics has been greatly appreciated.

The author also acknowledges Mr G. J. de Haan, director of the Texel Museum and Dr D. Dekker, Artis Zoo, Amsterdam, for the opportunity given to experiment with captive seals, the aviator Mr A. Droog, and the crews of M.S. "Eider" of the Institute and M.S. "R.P. 19" of the water police, district Delfzijl.

Financial support from the Netherlands Organization for the Advancement of Pure Research (ZWO) and World Wildlife Fund Holland made this study possible.

II. TRACK WIDTH MEASUREMENTS AS A METHOD FOR AGE DETERMINATION

In comparable studies of BIGG (1969), SMITH (1973) and BOULVA (1974) information on the size-, age-, and sex-composition of seals was obtained from random samples of animals shot.

Because of the low numbers of seals in the Dutch Wadden Sea this method could not be used, instead another more indirect method was applied. Already VAN HAAFTEN (1959) in his censuses, used the tracks the seals leave on the flats when they move from their resting places to the water edge. These tracks may be a mean to determine their size. The seal uses the nails of its fore-flippers to crawl over the sand. The width of the track now may indicate the size of the seal and, by a size-age relationship, also roughly the age class (juvenile, subadult and adult animals).

To test the possible use of the track for age group determination the smallest distance between the imprints of left and right fore-flipper nails was measured and is referred to as "track width" (Fig. 1). Seals kept in captivity at the Texel Museum and the Artis Zoo, Amsterdam, provided basic measurements which were carried out in mid-July. The animals were sent one by one through a rather narrow lock with a moist sandy bottom. The track each animal left behind was measured and compared with its age. In addition track widths of seals in representative areas of the Wadden Sea were measured during 4 boat trips, respectively in June 1974 (whelping time), in late August 1974 (mating time), at the end of May 1975 (pre-whelping time) and in

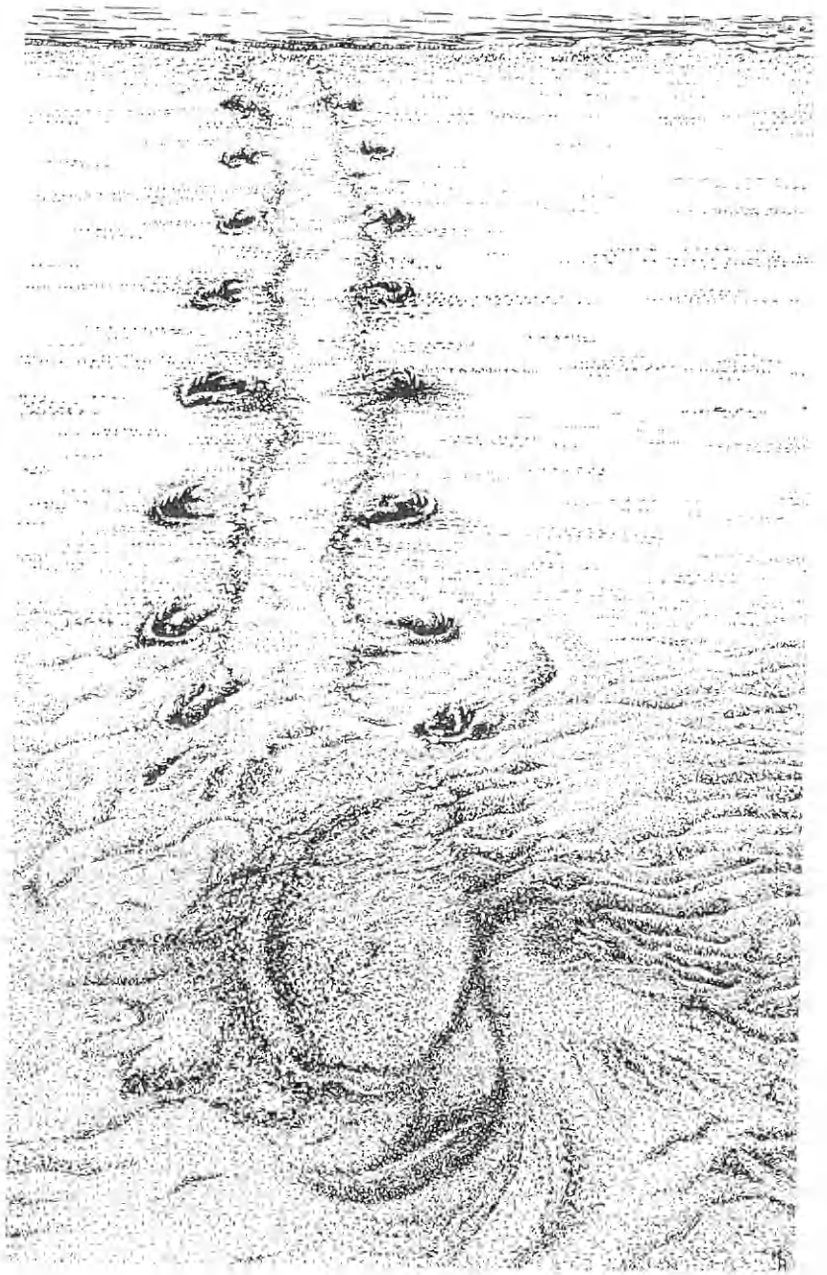

Fig. 1. Resting place and seal track on sand bank.

early August 1975 (post-whelping time).

The relation between age and track width for captive seals is shown in Fig. 2 in which the limits between juveniles, subadults and adults are

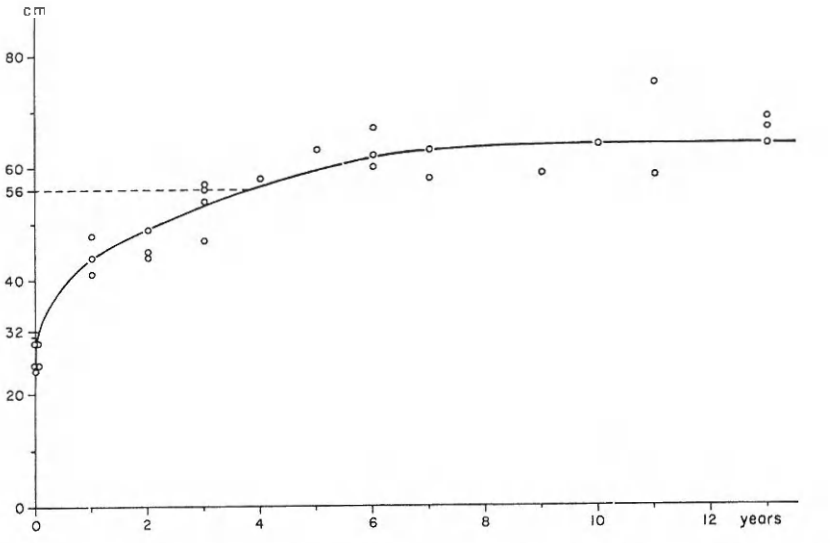

Fig. 2. Relationship between track width (cm) and age (years) of harbour seals based on captive animals measured in July; eye-fitted curve.

indicated. These limits are based on a trinomial fit of the data (REIJNDERS, 1975).

To make sure that the captive seals are representative for seals living in the Wadden Sea—*i.e.* have the same skeletal growth rate—the results were compared with the field observations made in the same period (June-July) as the tracks of the captive seals were measured. When a mother and young were observed, and also single juveniles, the corresponding track widths were measured (Table I).

The mean value for mature captive seals is somewhat higher than that for wild seals. However, in the captive group the mature seals were mainly males (10 out of 15) and full-grown males are about 3% longer (WIPPER, 1974). Thus the mean value for the captive group has to be regarded somewhat too high, the mean value for the wild seals (just females) somewhat too low.

In the captive group, due to low numbers of individuals, no attention could be given to the possibility whether the sexes showed different track widths at certain ages. BISHOP (1968), BIGG (1969) and FISHER (1952) stated that there appears to be no significant difference in length and weight between sexes till the age of 6 years. For seals in the

TABLE I

Comparison between track widths measured for captive harbour seals and for wild ones at ages of less than one month (pups) and of 4 years and older (adults).

	Group	*Mean (cm)*	*SD (cm)*	*Numbers*
pups	captive	26.4	2.4	5
	wild	26.3	3.0	111
adults	captive	63.3	4.7	15
	wild	61.7	4.9	62

Texel Museum a linear regression was established between girth and track width ($r = 0.98$; $p < 0.001$; $n = 22$). FISHER (1952: 6) also reports data on girth behind fore-flippers and age, he found no difference between sexes. Thus FISHER's data offer circumstantial evidence that the sexes, till the age of 6, do not vary in track width.

Fig. 2 shows that 3 age groups have clearly distinguishable ranges in track width; shortly after whelping time juveniles (0.01 year) measured 26 to 32 cm, subadults (1, 2 and 3 year) 36 to 55 cm, adults (4 year and older) above 56 cm.

III. POPULATION SIZE AND COMPOSITION

1. METHODS

The harbour seals in the Wadden Sea do not constitute one continuous population, but are distributed in several small groups, apparently isolated from one another, at least during summer time when they stay in the Wadden Sea. Fig. 3 shows the subareas between which little or no exchange takes place. It was found that the same animals returned every low tide to one specific sand bank. It could not be determined whether the same animals returned to that specific sand bank the next year after having left the Wadden Sea during winter time (REIJNDERS, 1973).

Estimates of the population size were made by regular aerial surveys from May till September 1974 and 1975 during low tide, when the seals are resting on the edges of the tidal flats. All counts were made at heights of about 150 m and each survey lasted about 2½ hours.

Size and composition of the population were established during the 4 boat trips made in 1974 and 1975, both years about whelping time (June) and about mating time (August). Juveniles, subadults and adults were distinguished by measuring the track widths of the animals.

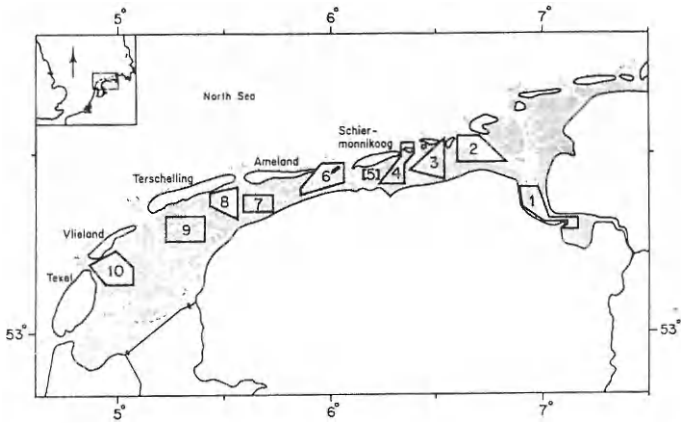

Fig. 3. Studied area of the Dutch Wadden Sea with localities occupied by harbour seal.

2. RESULTS

a. POPULATION SIZE

Since 1959 estimates of the size of the seal population are available from regular aerial surveys, they are given in Fig. 4. Such aerial censuses are thought to be fairly reliable because in restricted areas counts by plane gave nearly the same results as counts by boat (Table II). Moreover, the whole Dutch Wadden Sea can be covered during one low tide, thus avoiding double counts.

b. POPULATION COMPOSITION

The track width measurements provide the information for an estimation of the age group composition of the total wild population established in the aerial surveys. The age group distribution was estimated per area (Table II) which needed some calculation.

Not all seals in each area left a well defined track behind because the substrate was unsuitable (*e.g.* too soft) or because seals moved by lateral undulation rather than by the usual dorso-ventral way or because seals did not haul out at the moment their hauling area was visited. The assumption is made (based on Table II, post-whelping time 1975) that the animals measured represent a fair sample of the animals present in the area. In some areas no measurements were made, in that cases age group splits were made on basis of the total of the areas where measurements were carried out. A better estimate was possible during whelping time (1974) and the post-whelping time

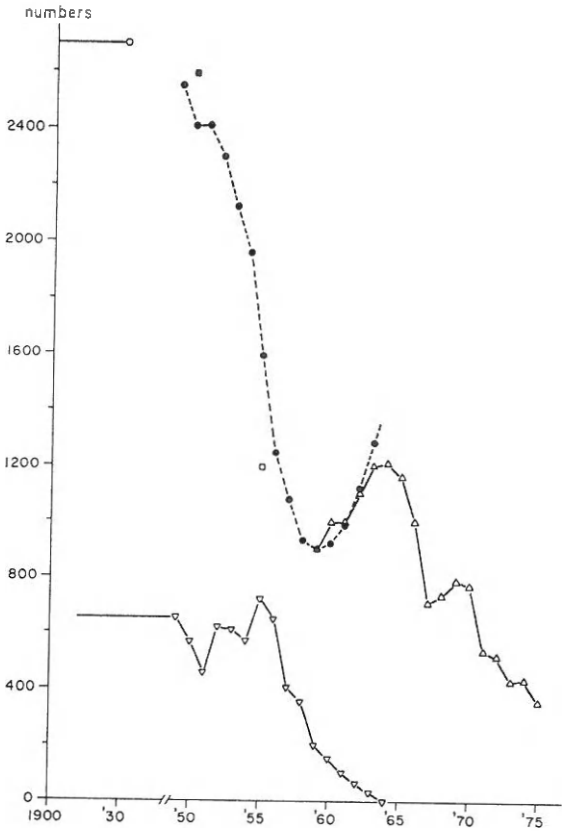

Fig. 4. Population sizes of harbour seals present in the Dutch Wadden Sea in September, according to the aerial surveys (△), estimates of HAVINGA (1933) (○), MOHR (1952) (■) and VAN BEMMEL (1956b) (□), and to own calculations backward and forward from 1959 (●). Also indicated are numbers killed by hunting according to MEYER (1964) (▽).

(1975), as it could be demonstrated (REIJNDERS, 1973; VAN HAAFTEN, personal communication) that, due to suckling and their apparently higher need for rest, all pups are detected during the aerial counts in these periods. Therefore, the ratio achieved between subadults and adults for the areas with measurements was applied to the numbers counted by the aerial survey at the nearest date in the other areas, after subtraction of the known number of juveniles.

The data treated in this way, resulted in estimates for the whole Dutch Wadden Sea population as shown in Table II (last column).

TABLE II

Calculation of the population composition of seals in the Dutch Wadden Sea based on track width measurements in part of the subareas, and on aerial census. In 1974 for whelping time (end of June) and mating time (early September); in 1975 for pre-whelping time (end of May) and post-whelping time (early August). Data between brackets are estimates obtained from ratios in the subareas sampled (for location of subareas see Fig. 3). Resulting total numbers of juveniles, subadults and adults are given with 95% confidence limits.

Group	*Subarea*										
	I	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*Total*
1974, whelping time											
Juveniles	0	12	9	2	1	0	0	0	0	2	26 ± 13
Subadults	(7)	31	24	27	12	21	18	13	(10)	17	180 ± 24
Adults	(5)	20	26	21	9	4	0	0	(7)	22	114 ± 23
Measured	0	34	34	32	15	18	7	8	0	22	170
Boat census		34	47	43	15	18	10	8		22	197
Aerial census	12	63	59	50	22	25	18	13	17	41	320
1974, mating time											
Juveniles	(4)	(7)	5	5	4	6	(3)	(1)	(2)	(3)	40 ± 27
Subadults	(24)	(40)	38	42	9	25	(16)	(4)	(13)	(22)	233 ± 49
Adults	(24)	(40)	54	21	20	13	(15)	(3)	(12)	(21)	223 ± 49
Measured	0	0	38	29	18	14	0	0	0	0	99
Boat census			45	45	22	15					127
Aerial census	52	87	97	68	33	44	34	8	27	46	496
1975, pre-whelping time											
Juveniles	0	0	0	0	0	0	0	0	0	0	0
Subadults	(3)	26	16	5	9	19	(2)	(2)	4	7	93 ± 18
Adults	(4)	14	40	15	3	5	(3)	(3)	5	14	106 ± 18
Measured	0	25	35	19	4	18	0	0	5	14	120
Boat census		40	56	20	7	24			5	15	167
Aerial census	7	40	56	20	12	24	5	5	9	21	199
1975, post-whelping time											
Juveniles	2	12	22	9	2	2	4	4	6	1	64 ± 17
Subadults	20	30	34	12	15	28	10	14	16	9	188 ± 23
Adults	11	39	62	33	11	5	22	19	16	19	237 ± 23
Measured	32	69	114	39	23	34	30	34	34	20	429
Boat census	33	81	117	47	23	34	32	36	40	20	463
Aerial census	33	81	118	54	28	35	36	37	38	29	489

About the sex ratio no data could be obtained with the present method but juvenile harbour seals caught in the Dutch Wadden Sea in the period 1965 to 1975 had a sex ratio of 1, 100 females against 102 males (Table III).

For subadults, data collected from stranded seals by VAN HAAFTEN (personal communication), a sex ratio of nearly 1 was found (25 females out of 47 animals).

TABLE III

Sex ratio (females : males) of harbour seals estimated by various authors (numbers sampled between parentheses).

Author	*Area*	*Sex ratio*		
		Juv.	*Subad.*	*Adult*
Present study	Dutch Wadden Sea	1(202)	1.1(47)	
WIPPER (1974)	West German Wadden Sea	1.1(180)		0.9(42)
HAVINGA (1933)	Dutch Coast	1(37)	1(38)	
BONNER & VAUGHAN (1972)	England	1(308)		
BOULVA (1971,1974)	Eastern Canada	0.9(188)	1.1(246)	
BIGG 1969	British Columbia	1(64)	1.1(245)	
BISHOP (1968)	Alaska	1(197)	0.9(50)	

IV. DISCUSSION

Before 1959, the year VAN HAAFTEN (1974) started his aerial censuses (Fig. 4), data on the population size of *Phoca vitulina* in the Dutch Wadden Sea are sarce. BROUWER (1928) estimated the total numbers at 1500, HAVINGA (1933) at 2700 and VAN BEMMEL (1956b) at 1200 specimens. None of these authors explains exactly how and when the estimates were obtained. From data available on annual numbers killed (MEYER, 1964), and by using rates known from stable populations of harbour seals, it is tried to calculate population sizes earlier than 1959.

Since the population size varies with the season, and the counts of VAN HAAFTEN (1974) were done in September, calculations for earlier years have been made for the same time of the year.

Assuming pups to constitute, on an average, about 30% of the September population (VAN BEMMEL, 1956b; VAN HAAFTEN, personal communication) and an annual mortality of 17% (BOULVA, 1974), the annual hunting data (K_{t+1}) can be used to obtain the September size of the population (N_t) out of the September size of the population in the next year (N_{t+1}), following the equation:

$$N_{t+1} = \frac{100}{70}(1 - 0.17)\, N_t - K_{t+1}$$

Starting with the value of 900 seals for 1959 of VAN HAAFTEN (1974) and using the annual kills according to MEYER (1964) (Fig. 4), the September population sizes (N_t) are calculated backwards from year to year (Fig. 4). In this way a population size of 2550 specimens is obtained for 1949.

HAVINGA (1933) estimated the harbour seal population in the Dutch Wadden Sea from 1900 till 1930 on about 2700 specimens. For his estimate he assumed the percentage of subadults to be 15% of the total population which is certainly too low as BOULVA (1974), BIGG (1969) and WIPPER (1974) arrive at percentages of 30%. At the other side he added a certain number of seals to his estimate (based on bounty data) without further explanation.

Also on bounty data MOHR (1952) estimated the population size in the Dutch Wadden Sea on about 2600 specimens for 1950.

Though based on several implicit assumptions, the calculation over the period from 1949 to 1959 seems useful to bridge the gap between the time of the stable population and the period of registered decline. It may imply that between 1900 and 1950 the population in the Dutch Wadden Sea fluctuated around 2600 specimens and that from that time on a steady decrease set in. The start of this decrease may be caused by the fact that from 1949 bounties were not paid any longer. The result will have been that nearly only pups were killed for the fur industry. The interest for adults was diminished not only because the payment of bounty was stopped but also because the demand for train-oil had ended (MEYER, 1964; 'T HART, personal communication).

It should be mentioned that in the foregoing calculation no attention was paid to migration. A considerable migration to or from especially other parts of the Wadden Sea (Denmark, Germany) may have had its influence on the population under consideration. Also in these areas bounty killing occurred.

From 1959 on the aerial surveys provided more reliable data (Fig. 4), though they are quite probably underestimates as some animals did not haul out. The seals still decreased in numbers, with only slight peaks in 1963–1964 and 1969–1970. The first increase, setting in with the count of 1959, probably resulted from the fast decrease in kills up to the year 1962 when hunting was forbidden and the seals got totally protected; compare the continuation after 1959 of the calculated population size estimate (Fig. 4). This extra quantity of pups not shot in this way may not only explain the first increase in numbers but perhaps also the slight second increase beginning in 1968, as these pups started a new wave of births when they became mature 4 to 5 years later.

When the calculated curve for the population, with its decrease before 1959 and its initial increase after that year, is of real importance this would also imply (Fig. 4) that after 1963 another factor than hunting has to be responsible for the further decrease in numbers.

The frequency distribution (Fig.5) of the track widths measured is fairly different for the 4 measuring series. The first boat trip was made

during whelping time, whilst the third trip was made before the whelping began. The second trip was carried out late in the mating time, so some seals might already had left the Wadden Sea (VAN HAAFTEN, 1974), whilst the fourth trip was made just when whelping

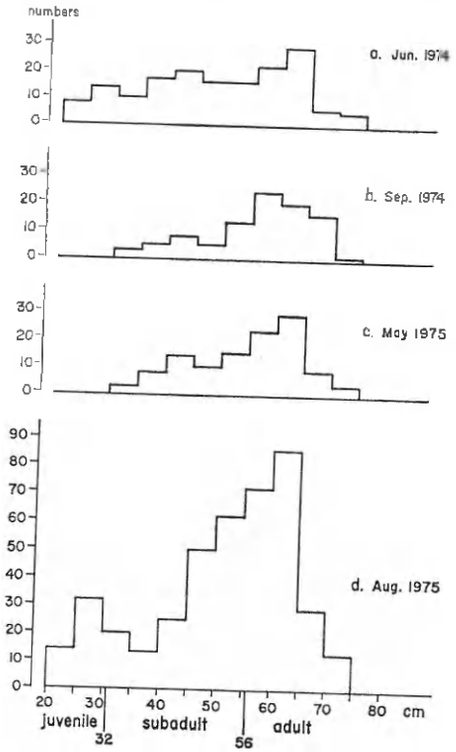

Fig. 5. Track width frequency distributions of harbour seals in the Dutch Wadden Sea: a. at whelping time (end June 1974); b. at mating time (September 1974); c. at pre-whelping time (end May 1975); d. at post-whelping time (early August 1975).

was finished and the mating time started. The estimates during the post-whelping time of 1975 are obviously the best ones as 88% of the population present was measured. The distribution of these 1975 measurements is clearly bimodal. One peak, at 25 to 30 cm, reflects the pronounced age group of the newborn pups. The second peak, at 55 to 65 cm, demonstrates the decreasing length growth from their fourth year forward (Fig. 2) of the adults.

Table II gives more details on the population composition of the seals. Due to the high variance in the age composition between subareas it was necessary to sample as many subareas as possible to obtain

by extrapolation a more or less reliable picture of the total composition during the 4 measuring series. The results of 1974 should be considered with caution.

The results indicate that all three groups distinguished increased between June and August. The largest increase is found for the adults, in both years about 120. This may signify migration of males into the Wadden Sea for the mating season (VAN BEMMEL, 1956a; VAN HAAFTEN, 1974). Also the increase of subadults in 1975 is remarkable. Information about migration is not available but the general impression is that first the pregnant females migrate to the Wadden Sea and soon afterwards the subadults and other adults.

Data on population composition from other Wadden Sea areas are not available, only maximum numbers of pups counted and maximum population sizes. WIPPER (1974) found for the western German Wadden Sea the pups to constitute about 27% of the total population. In the Dutch Wadden Sea only 11% pups were found in 1974, and 16% in 1975. As the East-Frisian population is considered to be fairly stable, it is clear that in the Dutch Wadden Sea population either reproduction is abnormally low or juvenile mortality is abnormally high, or both. This low recruitment in the Dutch Wadden Sea will be the main cause for the decline of the population.

Table III shows that the sex ratio for juvenile and older harbour seals in the Dutch Wadden Sea agrees well with that of other regions.

V. SUMMARY

The numbers of harbour seals (*Phoca vitulina*) in the Dutch Wadden Sea decreased from about 2700 in 1950 to 350 in 1975. The age groups juveniles, subadults and adults in the population were estimated by measuring the width of the tracks the animals leave when they move to the edge of the tidal flat. It appeared that the recruitment of the population was much lower than in the adjoining German part of the Wadden Sea. This will be the main reason for the drastic decrease in numbers of the population.

VI. REFERENCES

BEMMEL, A. C. V. VAN, 1956a. Zeehonden in Nederland.—Levende Nat. **59** (1): 1–12.

——, 1956b. Planning a census of the harbour seal (*Phoca vitulina* L.) on the coasts of the Netherlands.—Beaufortia **5** (54): 121–132.

BIGG, M. A., 1969. The harbour seal in British Columbia.—Bull. Fish. Res. Bd Can. **172:** 1–33.

BISHOP, R. H., 1968. Reproduction, age determination, and behaviour of the harbour seal, *Phoca vitulina* L. in the Gulf of Alaska. University of Alaska (thesis).

BONNER, W. M. & R. W. VAUGHAN, 1972. Sealing and common seals *(Phoca vitulina)* in the Wash, England. ICES C.M. 1972/N: 10 (mimeo).

BOULVA, J., 1971. Observations on a colony of whelping harbour seals, *Phoca vitulina concolor*, on Sable Island, Nova Scotia.—J. Fish. Res. Bd Can. **28:** 755–759.

——, 1974. The harbour seal, *Phoca vitulina concolor*, in eastern Canada. Dalhousie University, National Library Ottawa, Canada (thesis).

BROUWER, G. A., 1928. De levensomstandigheden van den zeehond (*Phoca vitulina* L.) in Nederland, I–IV.—Levende Nat. **33:** 115–119; 149–153; 185–191; 213–218.

FISHER, H. D., 1952. The status of the harbour seal in British Columbia, with particular reference to the Skeena River.—Bull. Fish. Res. Bd Can. **93:** 1–58.

HAAFTEN, J. L. VAN, 1959. Harbour seals and grey seals in the Dutch coastal waters. 4th Congress of the International Union of Game Biologists, Arnhem.

——, 1974. Zeehonden langs de Nederlandse kust. R.I.N. Mededeling **104**.

HAVINGA, B., 1933. Der Seehund in den Holländischen Gewässern.—Tijdschr. ned. dierk. Vereen. **3:** 79–111.

MEYER, F. W., 1964. De zeehond aan onze kust.—Ned. Jager **69** (22): 626–627.

MOHR, E., 1952. Die Robben der Europäischen Gewässer. P. Schopps, Frankfurt/Main.

REIJNDERS, P. J. H., 1973. Levensomstandigheden en gedrag van de zeehond (*Phoca vitulina* L.) in het reservaat Eierlandse Gat. Scriptie Natuurbeheer, Landbouw Hogeschool, Wageningen.

——, 1975. A simple field method for age-class determination in the harbour seal (*Phoca vitulina* L.). 12th Congress of the International Union of Game Biologists, Lisboa.

SMITH, TH. G., 1973. Population dynamics of the ringed seal in the Canadian eastern Arctic.—Bull. Fish. Res. Bd Can. **181:** 1–55.

WIPPER, E., 1974. Die ökologischen und pathologischen Probleme beim Europäischen Seehund (*Phoca vitulina* Linné 1758) an der niedersächsischen Nordseeküste. Ludwig-Maximillians Universität, München (thesis).