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by H.E. Drescher

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Contributions to game biology

Issue 1

Biologie, Oekologie und Schutz der Seehunde im schleswig-holsteinischen Wattenmeer

Biology, ecology, and conservation of Harbour Seals in the tidelands of Schleswig-Holstein

by H. EBERHARD DRESCHER, Institute for the Zoology of Domesticated Animals (Institut fuer Haustierkunde), Kiel University

Report prepared for the Supreme Hunting and Conservation Board (Oberste Jagd- und Naturschutzbehoerde) of the State of Schleswig-Holstein

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All illustrations except Figure 20 are by the author

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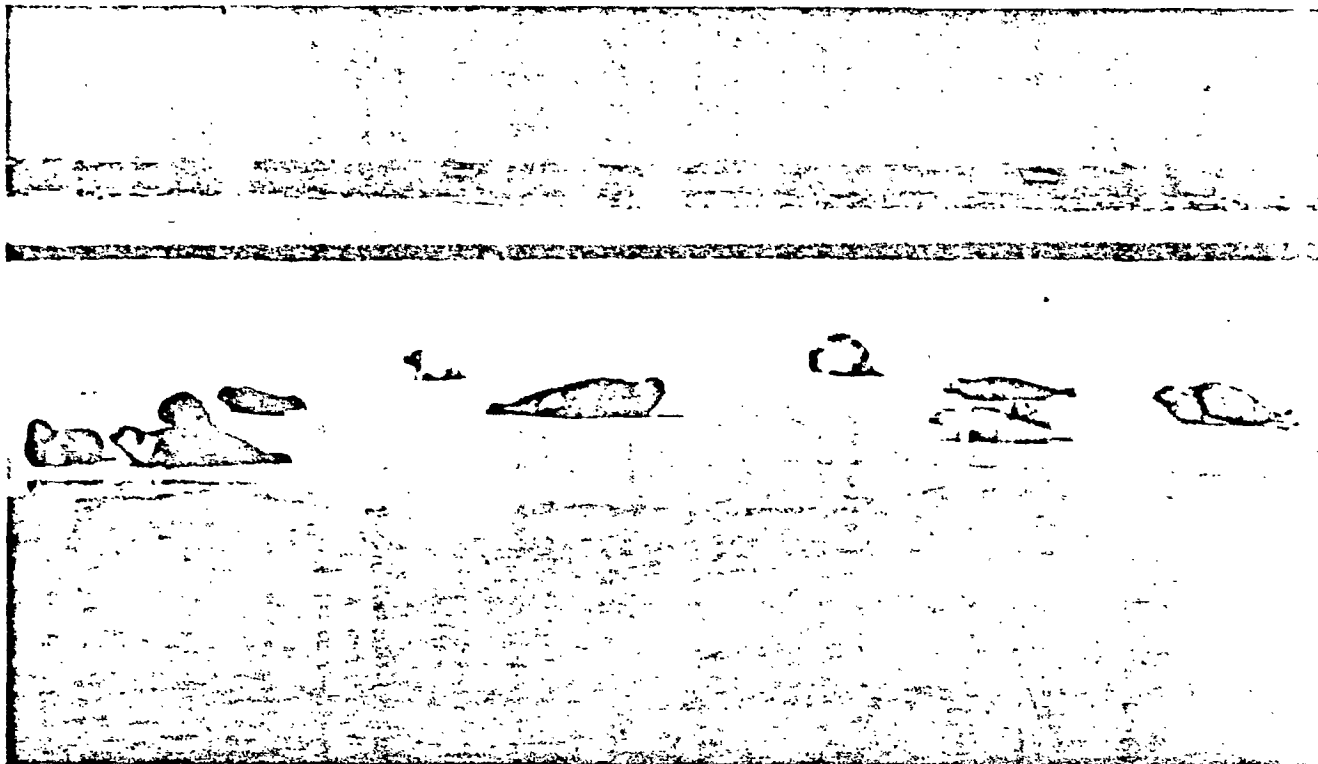


Figure 1. Herd of harbour seals in the North Frisian tidelands.

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## 1. Introduction

p.8

The Harbour Seal, Phoca vitulina, has four subspecies, together making up a circumpolar distribution. The populations occurring in the eastern Atlantic near Iceland, the British Isles, the tidelands along the coast of the European continent, and the Norwegian coast up to North Cape belong to the subspecies P. v. vitulina. The animals of this subspecies living in the North Sea and the Baltic are considered an endangered species (BLAB and NOWAK 1976). This was recognized chiefly because of the sharp decline of harbour seals in the Dutch Wadden Sea from an estimated 3000 in the 1930's to 500 today (HAAFTEN 1974; REIJNDERS 1978). There was a very distinct decline also in the tidelands of Lower Saxony (WIPPER 1974). Research on the biology of the Harbour Seal with the purpose of discovering the causes of this decline began already in 1959 in the Netherlands. In 1970, a research project was launched in Lower Saxony which lasted until 1975 (KRAFT 1976). From 1.11.1974 to 31.12.1978 a biological research project on the Harbour Seal was carried out on the North Sea coast of Schleswig-Holstein. This project was supported by the state hunters' association.

The goal of our investigations in this project was to collect data on the general biology and ecology of the Harbour Seal, in order to gain a better understanding of the seasonal rhythm of this species, its demands on the tidelands, and the nature and extent of the limiting factors. We also focussed on the question of the situation of the Harbour Seal in the tidelands of Schleswig-Holstein compared to other tideland areas on the German Bight. The data obtained formed the basis of recommendations for the conservation and management of the Harbour Seal.

In addition, research on harbour seals is relevant now for the following reasons:

(1) the increasing scientific interest in marine mammals as indicators of the degree of pollution and interference with marine systems (DRESCHER 1978; GERLACH 1978);

(2) increasing international efforts to intensify research on harbour seals and see the problems of this species without reference to national and international boundaries (INTERNATIONALE SEEHUNDARBEITSGRUPPE, "International Study Group on Harbour Seals", 1978);

(3) the growing public interest in questions of conservation and the protection of species in the tidelands; and

(4) the needs of hunters for biological studies on game.

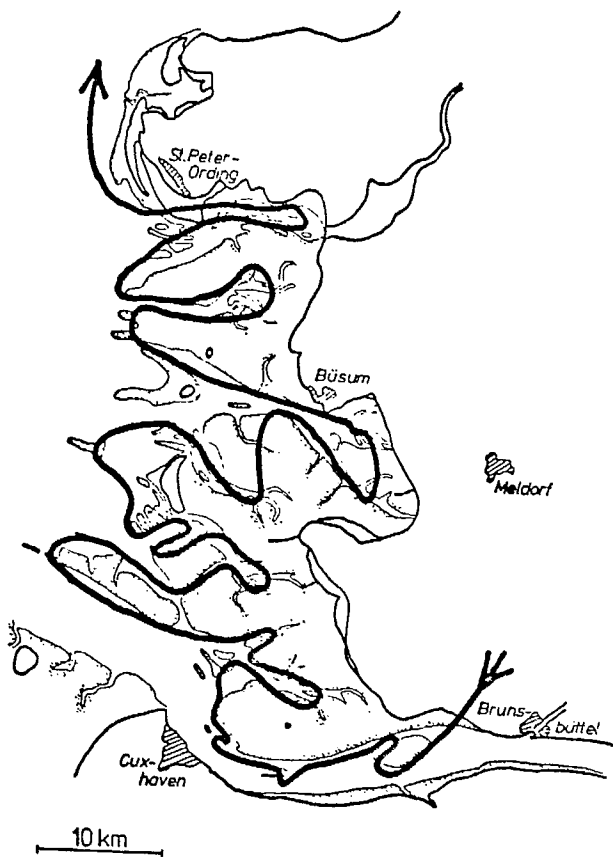
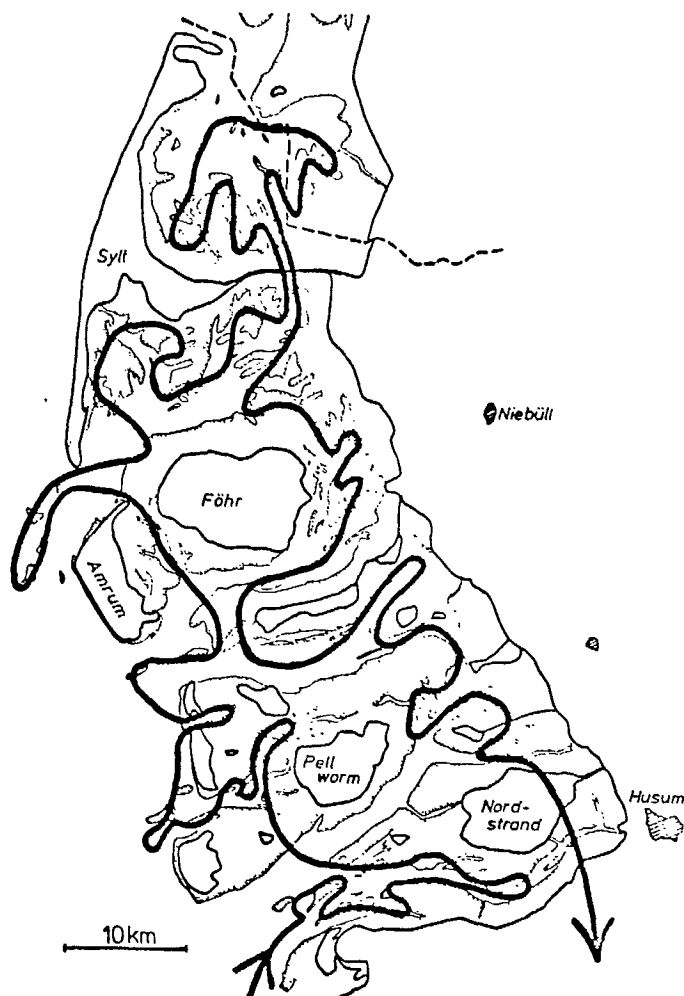


Figure 2. Area investigated, with the regular flight path for counting the seals.

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#### Acknowledgement

This project would not have been possible without the assistance of many who supported me in my work. I am especially indebted for their kind cooperation to those who helped me make the flights to count the seals, and to the Hunters' Association of the State of Schleswig-Holstein, and the sealing captains.



(This map is also part of Fig. 2)

## 2. Method and material

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The area investigated comprised the tidelands of Schleswig-Holstein from the mouth of the Elbe to the Danish border and the Danish part of the tidelands south of the List - Jordsand line (Figure 2). We always flew over the Danish part also in counting the seals, because of the unnatural location of the border. These values were always recorded under partial values for the "tidelands between Hindenburgdamm and List - Jordsand", and under the total values. The average maximum number of seals in this Danish subregion was 80,

including 20 pups. The flight path for counting the seals was always the same (Figure 2). All creeks and sandbanks were surveyed systematically at low tide. Because of the large size of the area (ca. 2500 km<sup>2</sup>), the counting had to be performed on two successive days during the summer. The previous experience of the Schleswig-Holstein hunters' association in counting harbour seals was very helpful in planning our flights. The flights were scheduled according to the tides: Counting began in the south, at the mouth of the Elbe, approximately one hour before low tide at Buesum, and in the North Frisian tidelands in the Hever region approximately two hours before low tide at Husum. As a rule, in addition to the pilot, the crew consisted of three persons, two of whom were present on all 35 enumerations from 1975 to 1978. In addition to recording the total number of seals and the proportion of pups, the herds were charted and photographed (Figures 4 and 5). The final values were obtained by evaluating the aerial photographs.

We started tagging free-living harbour-seal pups at the beginning of August each year. The seals were lured and seized, as in the hunt. In addition to fastening the tag in the web-membrane of the hind flippers, we recorded the following data: weight, length, girth behind the fore flippers, sex, and any injuries, such as umbilical inflammations. Also, the seals reared by hand in Buesum ("howlers") were measured and tagged when they were liberated. In 1975 and 1976, the



Figure 3. North Frisian tidelands at low tide (Hever).



Figure 4. Herd of harbour seals in the outer part of the North Frisian tidelands (Knob).

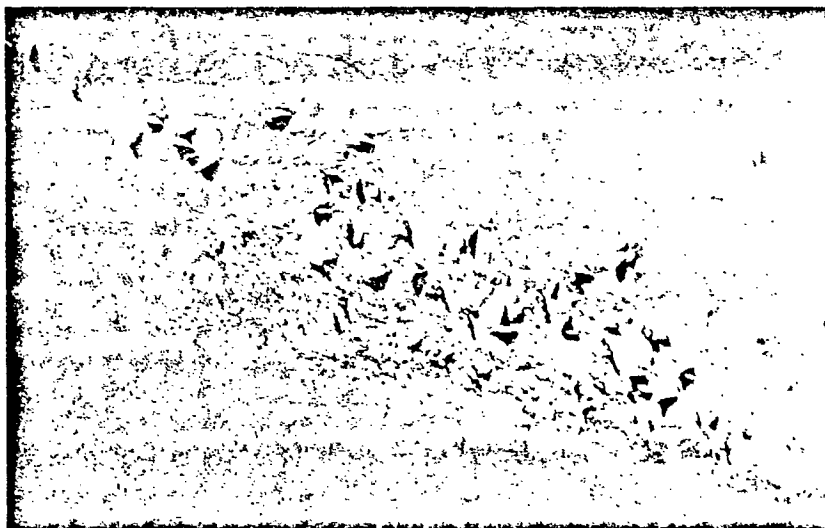


Figure 5. Rookery north of Hindenburgdamm.

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howlers were weighed every week from their arrival to early September, to obtain a record of their growth. Altogether, 101 harbour seals were tagged from 1974 to 1978 (39 free-living, 62 reared by hand).

Harbour seals found dead, or killed for research purposes were dissected at the Institute for the Zoology of Domesticated Animals. This procedure included a protocol recording data on size, weight, sex, age, condition, diseases, parasites, etc. The following criteria were employed to determine the age of the seals: body size, ossification of skull and pelvis, dental ridges, and the level of development of the reproductive organs. Altogether, 275 seals were investigated.

An analysis of harmful residues in the organs of a total of 70 seals was performed at the Federal Fisheries Research Institute (Bundesforschungsanstalt fuer Fischerei)

in Hamburg. Brains, fat, liver, kidneys, and muscles were partially investigated for the following heavy metals and chlorinated hydrocarbons: mercury, cadmium, lead, zinc, and copper; PCB's, DDT and its metabolites, dieldrin and lindane. For the methods of analysis, see DRESCHER et al. 1977.

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### 3. Biological investigations

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#### 3.1. Population

The results of our enumerations of the harbour seals from 1975 to 1978 are presented in Table 1.

##### 3.1.1. Seasonal fluctuations and population size

Several enumerations of the harbour seals were taken in 1975 and 1976 in order to ascertain at what time of year the maximum number of these seals can be observed in the tidelands. Figure 6 is a graphic representation of the variation of the population size, as exemplified by the area of the North Frisian tidelands, including the area north of Hindenburgdamm.

The largest number of seals was found in the tidelands in both years almost at the same time, viz., around the middle of July. A considerable rise in the number of seals took place during the period from the middle of June to mid-July. This increase was caused by the actual immigration of other age groups as well as the birth of the pups. A few days after the

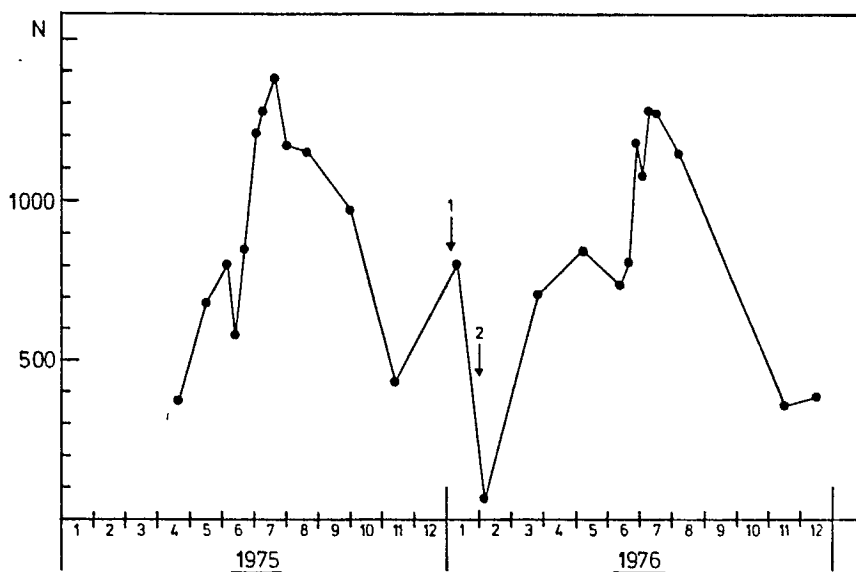


Figure 6. Seasonal fluctuations in the number of harbour seals in the North Frisian tidelands, including the area within the List - Jordsand line. Arrow 1 = high tide raised by a storm on 3 January 1976; Arrow 2 = tidal flats frozen over.

maximum, the number of seals lying on the tidal sandbanks declined again. As a rule, few seals were found in the tidelands during the winter. From spring into summer, a distinct increase occurred once again. In the next two years, 1977 and 1978, far fewer enumerations were taken, yet the results fit exactly into the above pattern. Also in these years, the maximum number was found approximately at the middle of July. Thus it was shown that the number of harbour seals staying in the tidelands is subject to distinct seasonal fluctuations. WIPPER (1974) found a nearly identical pattern for Lower Saxony.

Datum	2		4		5		6			7
	Dithm. Watt: (Elbe bis Eider)		Nordfries. Wattenmeer		Watt nördl. Hilf.-Barr		gesamtes schl.-holst. Wattenmeer			
	N (davon)	Juv.	N	Juv.	N	Juv.	N	Juv.	ges. Juv.	
1	2	3	4	5	6	7	8	9	10	11
<u>1975</u>										
18.3.75	39	-	n.e.	-	n.e.	-	n.e.	-	-	Tz
17./18.4.75	144	-	328	-	46	-	518	-	-	--
14./15.5.75	174	-	595	-	85	-	854	-	-	--
5./6.6.75	225	-	711	3	91	-	1027	3	3	--
12./13.6.75	185	1	476	4	101	2	762	7	7	--
19./20.6.75	204	2	714	11	137	11	1055	24	24	--
1./2.7.75	245	40	996	230	212	51	1453	321	321	--
7./8.7.75	349	89	1109	266	169	40	1627	395	389	--
15./21.7.75	349	78	1184	275	196	50	1725	403	313	--
31.7./1.8.75	323	60	1005	173	165	34	1493	267	40	--
18./19.8.75	382	73	1000	159	153	27	1535	259	3	--
29./30.9.75	156	-	898	-	75	-	1128	-	-	--
11./12.11.75	205	-	373	-	59	-	637	-	-	--
<u>1976</u>										
9.1.76	n.e.	-	716	-	88	-	n.e.	-	-	-
6.2.76	1	-	67	-	-	-	68	-	-	--
24.3.76	n.e.	-	640	-	68	-	n.e.	-	-	Tz
7./9.5.76	215	-	723	-	123	1	1061	1	1	--
9./10.6.76	227	-	647	-	95	-	969	-	-	--
16./18.6.76	128	-	750	14	57	2	935	16	16	--
23./24.6.76	310	14	1005	86	173	24	1495	124	124	--
1./2.7.76	352	50	859	175	219	57	1430	282	282	--
7./8.7.76	352	65	1131	311	211	60	1624	436	400	--
15./16.7.76	376	69	1079	273	198	47	1653	389	327	--
5./6.8.76	276	33	990	116	150	27	1422	176	6	--
15.11.76	100	-	294	-	65	-	459	-	-	--
15.12.76	119	-	353	-	32	-	504	-	-	--
<u>1977</u>										
28.2.77	126	-	209	-	33	-	368	-	-	--
25.5.77	217	-	680	-	103	-	1002	-	-	--
20./21.6.77	144	4	797	21	166	11	1107	36	n.e.	--
6./7.7.77	329	78	1031	240	200	43	1560	361	n.e.	--
13./14.7.77	353	95	1234	327	219	60	1806	469	r.r.	--
<u>1978</u>										
17.5.78	254	-	n.e.	-	116	-	n.e.	-	-	Tz
1.7.78	n.e.	-	n.e.	-	132	33	n.e.	n.e.	n.e.	Tz
10./11.7.78	336	67	1217	328	242	74	1725	462	n.e.	--
17./18.7.78	358	67	1075	282	258	76	1651	425	n.e.	--

Table 1. Results of enumerations (aerial) of harbour seals in the Schleswig-Holstein tidelands in 1975-1978, showing the total number (N) and the number of new-born pups (juv.); Tz= partial enumeration, n.e.= not counted, ges. juv.= sucking pups; (N= total number including juv.).

Key: 1- date 2- Dithmarsch flats (Elbe to Eider) 3- "N (of which) juv." 4- North Frisian tidelands 5- flats north of Hindenburgdamm 6- total for Schleswig-Holstein tidelands 7- remarks

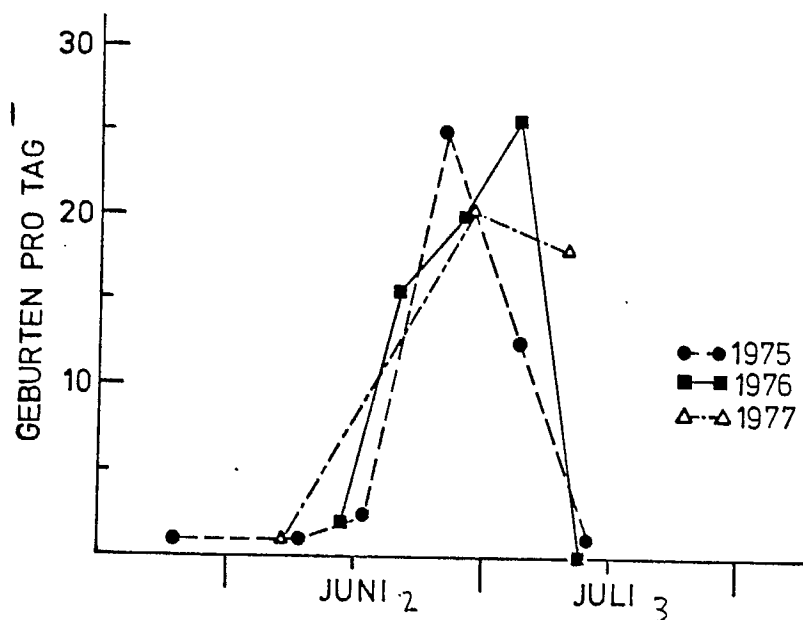


Figure 7. Average daily birth rates of harbour seals in the Schleswig-Holstein tidelands for 1975, 1976, and 1977.  
 Key: 1- births per day 2- June 3- July

Some peculiar features are shown by the population chart. In both years, the number of seals in the tidelands receded for a brief period early in June. The same phenomenon has been observed also in the Dutch Wadden Sea (REIJNDERS, personal communication). There is no explanation yet for this phenomenon, but the tourism beginning at this time may be involved.

The number of seals in the tidelands during the winter is very dependent on meteorological factors. Thus, on 9.1.1976, a few days after the tide was raised by a severe storm on 3.1.1976, we counted the seals on the flats north of the Eiderstedt Peninsula, and found an unusually large number for

this season (804, see Table 1). A month later, these flats were frozen over, and only 67 seals were counted in the same area.

The maximum number of seals in the Schleswig-Holstein tidelands was ca. 1700 in 1975 and 1976, and ca. 1800 in 1977 and 1978 (Table 1). Whether this represents an increasing trend must be determined by long-term observations. However, it is not correct to treat these values as representative of "the Schleswig-Holstein stock", since by the next summer, they would have fallen to ca. 1300-1400 as a result of natural mortality. It is more realistic to assume an average population of 1500 - 1600 seals.

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### 3.1.2. Birth rate

The number of new-born pups counted increased from 403 in 1975 to 436 in 1976, and 488 in 1977. In 1978, 469 pups were counted (Table 1). Overall, the percentage of pups in the total population (mid-July) averaged 25.5% over the four years. More than two-thirds of the pups (69%) were born on the North Frisian tidal flats, 18% in the tidelands between the Elbe and Eider, and 13% in the area between Hindenburgdamm and List-Jordsand.

Only pups sighted alive were counted in these enumerations. The number of pups obtained by this direct counting method is less than the number actually born. At the end of the whelping period, around the middle of July, when the most

pups are counted, some of those born have already died (or emigrated). REIJNDERS (1978) made a statistical evaluation of my data with computer programs using population models, and found that the maximum numbers of pups obtained in my enumerations in Schleswig-Holstein represented 86% of the numbers actually born.

### 3.1.3. Whelping time

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From the data of the pups counted each year from 1975 to 1977 (Table 1) we can calculate the average number of seals born daily (DRESCHER 1978b). This yields Figure 7, which shows the concentrated time span of the whelping period. The whelping time showed approximately the same pattern in all three years, and also the values for 1978 imply this same pattern. The first pups may be born in May. Half of the pups are born by around June 27. 95% are born in the period from June 16 to July 8, i.e., within 23 days. Thus, the main whelping period can be defined very precisely. There may be shifts in the dates on which the most pups are born, but overall, the whelping time falls in the same period every year.

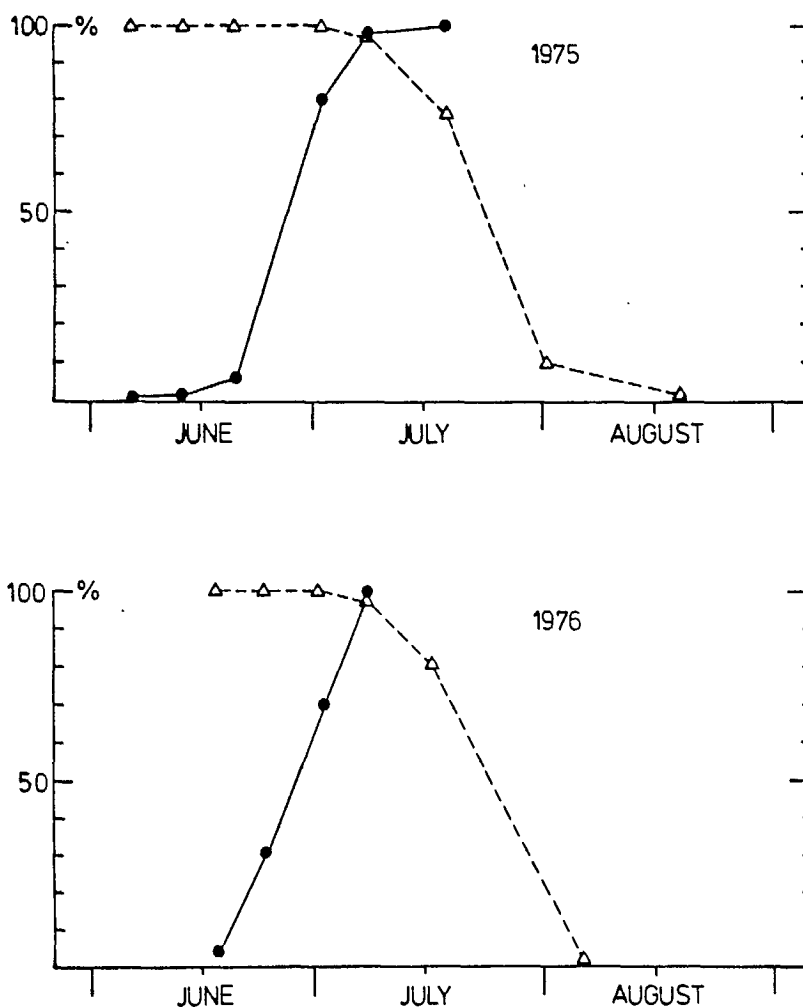


Figure 8. Increasing percentage of pups born during the whelping period in 1975 and 1976 (solid line), and the percentage suckled (broken line).

#### 3.1.4. Suckling period

On each enumeration, in addition to the new-born pups sighted, the photographic evidence made it possible also to determine how many pups were still dependent on their mother, and still being suckled (Table 1, column 10). This was always clearly discernible from the position of the pup in relation to the mother. These findings are summarized for 1975 and 1976 in Figure 8.

First, the cumulative increase in the percentage of pups born is shown (solid line). The percentage of the pups being suckled is represented by the broken line. At the beginning of the whelping period, naturally all pups sighted were being suckled. The number of pups being nursed decreases during July and August, and this decrease proceeds at the same rate as the June-July increase in the number born. Pups were observed being suckled until approximately the middle of August. On July 16, ca. 80% of all pups were still being suckled; on August 1, ca. 10-20% were being nursed.

By comparing the curves for the increasing number of pups and the decreasing number of those being suckled, we can obtain the mean individual suckling period. On the average, the pups in the Schleswig-Holstein tidelands are suckled for 26 days, or approximately 4 weeks.

#### 3.1.5. Death rate

The death rate generally can be determined only indirectly for mammals, since various factors always have to be assumed as given. To arrive at an estimate of the natural death rate, we determined the age composition of the dead seals reported and investigated, and compared it with the numerical findings for the different years.

	♂♂:♀♀	<sup>4</sup> Juli	Aug.	Sept.	<sup>5</sup> Okt.	Nov.	<sup>6</sup> Dez.	Jan.	Feb.	<sup>7</sup> März	April	<sup>8</sup> Mai	<sup>9</sup> Juni	<sup>10</sup> gesamt
Jungtiere <sup>1</sup>	1.2:1	27	11	6	7	10	5	3	3	-	1	2	1	76
Subadulte <sup>2</sup> (1-3 J.)	1:1	4	5	2	2	2	-	-	1	-	1	-	1	18
Adulte <sup>3</sup>	♂♂ ♀♀	- 1	- 3	- 6	2 4	- 1	- -	- -	- -	- -	- -	- 2	1 4	3 21

Table 2. Number of dead seals in each of three age groups reported and investigated during the years 1974-1978 in the Schleswig-Holstein tidelands.

Key: 1- pups 2- subadults (1-3 years) 3- adults 4- July  
5- October 6- December 7- March 8- May 9- June 10- total

The mortality of pups in the first year of life is especially interesting. The method described above yielded the following death rates: 65% of the pups do not survive the first year of life. For the subadults (1-3 years) we found an annual death rate of 18%, and for the adults 9%.

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REIJNDERS (1978) obtained similar results by another method. By statistical treatment of population models, he produced a longevity table, based on my enumerations, for the seals in the Schleswig-Holstein tidelands. He found the following death rates: First year--60%, subadults (1-3 years)--13%, and adults--13%.

The high natural mortality found in the first year of life-- 60-65% --should be emphasized. It is considerably higher than was generally assumed hitherto. Similar values have been found also for other seal species, such as the Gray Seal in England (60%; HEWER 1964). The dead animals may also be classified, under the three age groups, according to seasonal occurrence or sex ratio (Table 2). The values then are

relatively small, but focal points are still discernible. In the case of the pups, the highest mortality was recorded in July and August, amounting to half of the total mortality during the first year of life. It then declined, to rise again in October and November. Also among the subadults, the most animals were found dead in July and August, although the absolute numbers were much smaller. The sex ratio of the dead animals of both age groups was about evenly balanced.

In the adult age group, 3 males and 21 females were found dead (1:7). The greatest number of adult females died in the months from August to October (Table 2). An extremely uneven sex ratio for this age group was shown also by the adult seals killed during the hunting season in September and October from 1974 to 1978: 5 males and 14 females were shot. Similar sex ratios have been found, among seals shot as well as those found dead, in the Netherlands (REIJNDERS 1978) and in Lower Saxony (WIPPER 1974).

Why the ratio of adult seals found in this period is weighted so heavily in favour of the females, must remain largely an open question. However, there are some possible explanations:

First hypothesis: The proportion of females among adult harbour seals is actually higher than that of the males. This hypothesis is supported by findings of BIGG 1969, BOULVA 1973, and REIJNDERS 1978, albeit not in such high ratios.

Second hypothesis: The probability of adult females dying between August and October is greater than in the case of males of the same age group. This hypothesis is very obvious for the following reasons. During the suckling period, the blubber layer of the nursing females diminishes sharply. The thickness of this layer of blubber beneath the skin represents an indicator of the general physical condition of the seal. The reason for the thinning of this layer in nursing females is the degradation of their fat in favour of the very fatty milk, which has a fat content of 45% (HARRISON 1960). After the suckling period, the blubber is often only a few millimeters thick. With such a thin layer of fat under the skin, the risk of death for these seals is high (see Chapter 3.3). This would explain the relatively large number of adult females found dead after the suckling period. Also, at this time the females must stop to rest on the sandbanks more frequently, and therefore are found by the hunters more often, especially since, because of their general weakness, probably their flight distance is smaller.

Datum <sup>1</sup>	Wesselbu- rener Loch		Ubriges <sup>2</sup> Dithm. Watt		Hever		Rummel- loch		Hooger Loch		Knobsände <sup>3</sup> W. Amrum	
	N	Juv.	N	Juv.	N	Juv.	N	Juv.	N	Juv.	N	Juv.
	2	3	4	5	6	7	8	9	10	11	12	13
15./21.7.75	151	38	198	40	159	52	219	56	193	51	114	--
7./8.7.76	171	46	181	19	163	55	208	72	197	47	101	--
13./14.7.77	182	57	171	38	216	78	208	69	273	60	93	1
10./11.7.78	179	46	157	21	217	84	199	69	247	62	109	2

Fortsetzung der Tabelle 3:<sup>4</sup>

Datum <sup>1</sup>	Watt zw. 5 Föhr u. Sylt		Föhrer Lev		Ubriges <sup>6</sup> nordfr. Watt "innerwatt"		Watt nördl. 7 Hi.-P.-L.-L. (bis List/Jords.)		schl.-holst. <sup>8</sup> Watt (bis List/Jords.)	
	N	Juv.	N	Juv.	N	Juv.	N	Juv.	N	Juv.
	14	15	16	17	18	19	20	21	22	23
15./21.7.75	215	52	98	24	186	40	196	50	1729	400
7./8.7.76	235	68	94	33	133	36	211	60	1600	200
13./14.7.77	199	59	114	32	131	28	219	66	1806	100
10./11.7.78	174	51	116	33	126	27	242	74	1755	400

Table 3. Regional breakdown of the maximum numbers of harbour seals counted (from air) in the Schleswig-Holstein tidelands from 1975 to 1978; N= total number (including juv.); juv.= number of new-born pups.

Key: 1- date 2- remainder of Dithmarsch flats 3- Knobsaende west of Amrum 4- continuation of Table 3 5- flats between Foehr and Sylt 6- remainder of the North Frisian flats; "inner flats" 7- flats north of Hindenburgdamm to List - Jordsand line 8- Schleswig-Holstein tidelands (total)

### 3.1.6. Geographic distribution of the harbour seals in the Schleswig-Holstein tidelands

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In the summer, at low tide, the harbour seals in the Schleswig-Holstein tidelands are scattered on sandbanks throughout the area (Figure 9). Large herds occur even close to the land. It is well known that there are certain areas which the seals seek out preferentially and where high concentrations form with large herds (Figure 9). As a rule, in these areas harbour seals may be found even during the winter.

Several areas are sought out preferentially by pregnant females or those nursing pups. Hence, on these "nursing banks" ("Mutterbaenken") the proportion of pups in the herds during the whelping and suckling periods is uncommonly high (Figure 5). In the list below, the Schleswig-Holstein tidelands are divided into arbitrary subregions (without exact boundaries) to display the importance of different areas for breeding (see also Table 3). The percentage of pups in the herds of each area, and the absolute number of pups are shown, expressed as average values for the period 1975-1978. The percentage of pups in the total population of the Schleswig-Holstein tidelands is used as a standard value. For the four years from 1975 to 1978, the average percentage of pups in the total population of the Schleswig-Holstein tidelands was 25.5% ( $\bar{N}$ =449 pups).

	Percentage of pups in the herds	Absolute number of pups
Average value for 1975-1978		
Dithmarsch tidal flats		
1. Wesselburener Loch	27.7%	47
2. All remaining tidelands from Elbe to Eider	16.6%	30
North Frisian tidelands		
1. Hever area north of Eiderstedt (expanded "Quiet Zone 1")	34.1%	67
2. Rummelloch ("Quiet Zone 2")	32.0%	67
3. Hooger Loch ("Quiet Zone 2")	24.3%	55
4. Foehrer Ley and Dagebuell Channel ("Quiet Zone 3")	29.0%	31
5. Flats between Sylt and Foehr ("Quiet Zone 4")	28.0%	58

6. Remaining North Frisian tidelands other than the above areas and Knobsaende ("inner flats")	23.1%	33
Tidelands north of Hindenburgdamm to the List - Jordsand line	28.7%	63

In the following areas, the number of pups in the herds was above the average for the entire population: Wesselburener Loch, Hever area, Rummelloch, Foehrer Ley, the tidal flats between Sylt and Foehr, and the flats north of Hindenburgdamm. Hence the "quiet zones" certified for the North Frisian Tidelands Wildlife Sanctuary by the regulation of 22.1.1974 are a good reflection of the breeding areas in this part of the tidelands.

There are also areas in which practically no pups are found in the herds (Table 3). The most important such area in the North Frisian tidelands is the "Knobsaende" west of Amrum Island, with herds of approximately 100 seals (Figure 4). As revealed by measurements of seal trails during June, a large portion of sexually immature seals stay in this area. Another such resting site with herds of regular size (ca. 100 seals) without pups during the whelping and suckling period is in the outer part of the Danish tidelands north of Sylt. Other resting sites in the Schleswig-Holstein tidelands with herds without pups (but much smaller herds) are Liinsand, northwest of Foehr Island (herds of ca. 10 seals) and D-Steert near Trischen (herds of ca. 20 seals). The different composition of the herds and their distinct geographical zoning

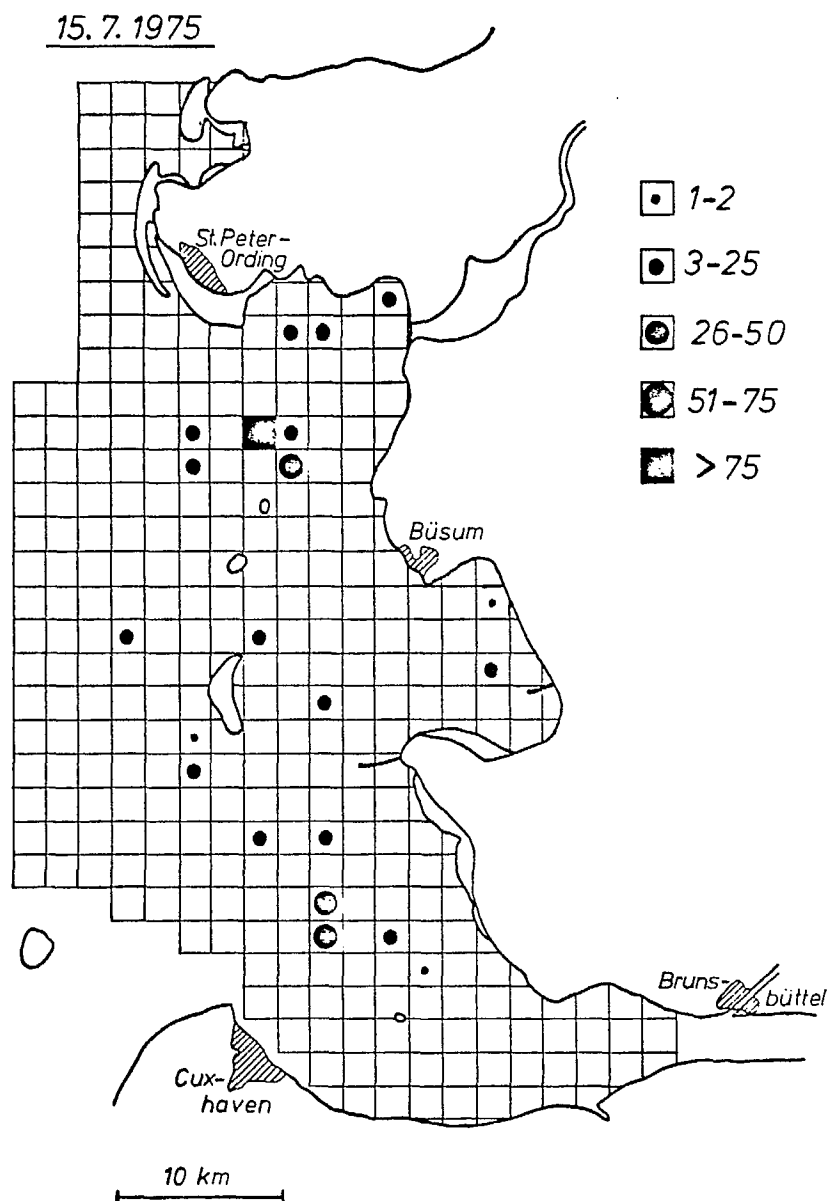


Figure 9a. Distribution and frequency of harbour seals in the Dithmarsch tidelands in July.

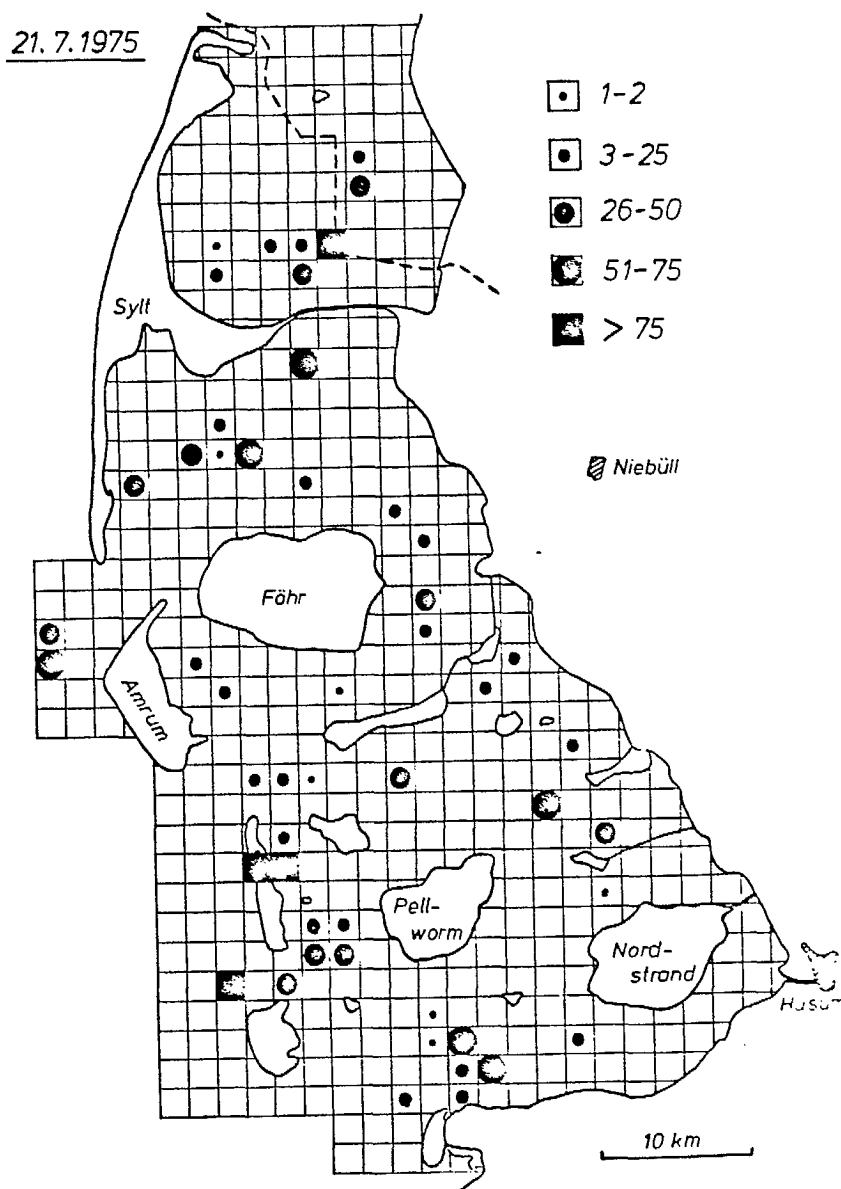


Figure 9b. Distribution and frequency of harbour seals in the North Frisian tidalands in July.

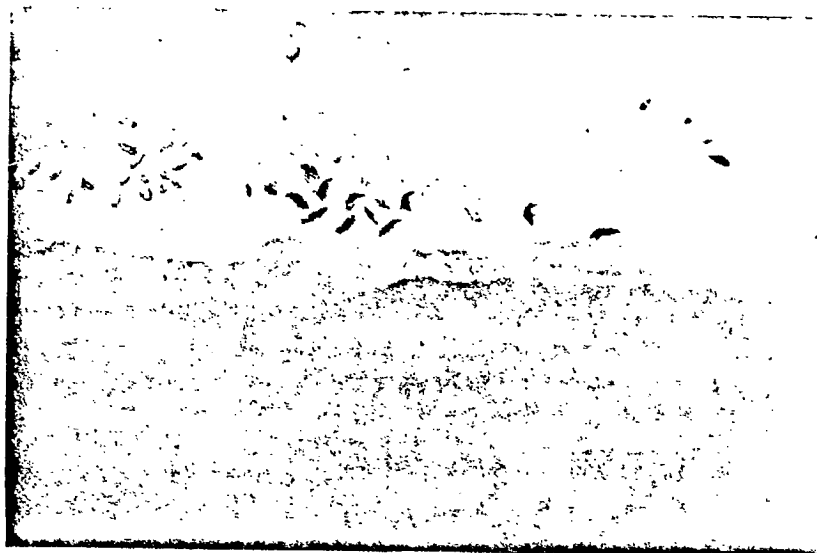


Figure 10. Gray seals (center) and harbour seals at Knobsaende near Amrum.

indicate peculiarities of the social behaviour of these seals, but at present there are absolutely no data available in this connection.

At Knobsaende, west of Amrum Island, there is also the only regular occurrence of the Gray Seal, Halichoerus grypus, on the entire continental North Sea coast (Figures 10 and 11). We counted a maximum of 34 gray seals. For biological reasons, this species can not reproduce successfully on the tidal sandbanks.\*

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\*At this time, I should like to point out that the "gray-seal pups" reportedly found in the Schleswig-Holstein tidelands are actually harbour seals born prematurely. Harbour seals normally shed their long-haired, silky, embryonic skin in the uterus and are born with a normal coat. In premature births, they emerge with the embryonic skin, and, if they survive, shed it later. Moreover, the pupping time for gray seals is in a different season.

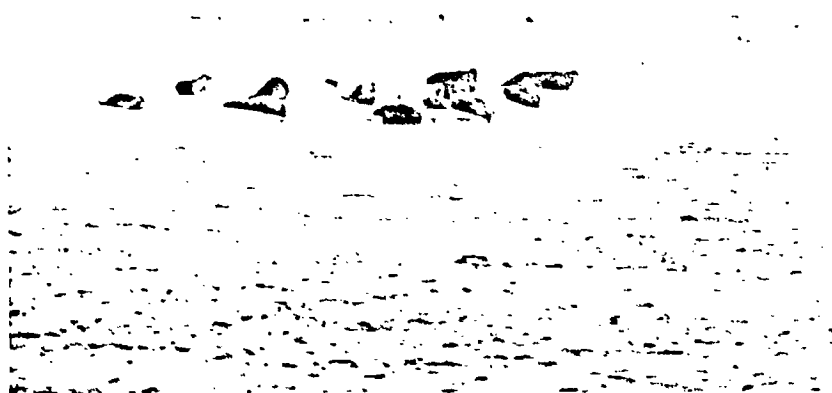


Figure 11. Gray seals near Amrum (a harbour seal on the extreme left).

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3.1.7. Migrations of tagged pups; population unit

27

Of the 101 pups tagged from 1974 to 1978, so far 20 (20%) have been found again. Figure 15 shows their recovery sites.

Findings of tagged, hand-reared "howlers"

1974: 6 "howlers" were liberated; 5 were found again, 4 of them shot (3 in Denmark, 1 in Schleswig-Holstein), 1 found dead in Lower Saxony 1 year and 8 months after tagging.

1975: 10 "howlers" released; 2 recovered, 1 shot in Schleswig-Holstein and 1 found dead at Scharhoern 1 year and 10 months after tagging.

1976: 17 "howlers" released; 3 found again: 1 sighted several times in the Elbe near Geesthacht, 2 drowned in fishing traps or nets (1 in Denmark, 1 in Lower Saxony) 8 months after tagging.



Figure 12. Feeding "howlers" at the seal-rearing station in Buesum.



Figure 13. Pup at the rearing station.

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1977: 13 "howlers" released; 3 found again, all drowned in fishing traps (1 in Lower Saxony, 1 in the Elbe, 1 in Denmark), 1, 2, and 8 months after tagging.

1978: 16 "howlers" liberated; 1 found again, 3 months after its release, living on Schiermannikoog (Netherlands).

Findings of seals tagged in the open

1975: 12 seals were tagged; 1 sighted near Amrum.

1976: 13 seals tagged; 1 shot at the tagging site 2 months later because of illness.

1977: 14 seals tagged: 4 found dead, all gone astray or infected with skin disease; 1 at the tagging site (1½ months), 1 at Sylt (6 months), and 2 in Denmark (5 and 12 months).



Figure 14. Hand-reared seals being liberated on the tidal flats.

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The pups reared by hand showed a distinct tendency to disperse through the tidelands. Their recovery rate was higher than that of the other group, evidently because they are accustomed to Man and his devices - a familiarity which often proves fateful for them.

Without wishing to overvalue the evidence of the small number of seals found again which were tagged in the open, we can discern also in these a tendency to disperse. This confirms the results of WIPPER's (1974, 1975a) extensive tagging. In 1971 and 1972, WIPPER tagged a total of 146 free-living pups in the tidelands of Lower Saxony. The reports obtained from this large series allow definite conclusions concerning the migrating behaviour of the pups. These reports indicated that the pups, which were tagged mainly in the Weser Estuary,

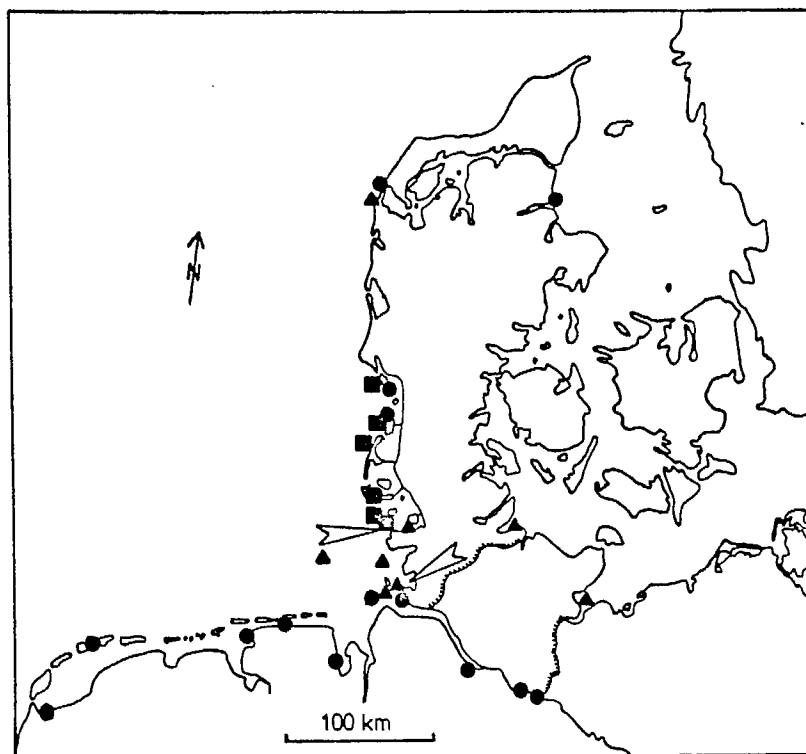


Figure 15. Sites of recovery of harbour-seal pups tagged in Schleswig-Holstein. Arrows= tagging areas. Triangles= Seal pups reared by hand, and tagged by the Schleswig-Holstein state hunters' association, up to 1973 ("howlers"). Circles= Seal pups reared in the station at Buesum, tagged since 1974 ("howlers"). Triangles= Seal pups tagged in the open in 1975-1977.

at first remained in the tidelands of Lower Saxony, drifting towards the west. However, three months after the rearing period they began to be found in all parts of the tidelands (WIPPER 1975a).

The major conclusion to be drawn from these results is that the harbour seals in the tidelands and in the German Bight should be considered as a single population. A general exchange of young seals takes place, as is reasonable also in terms of population genetics. The possibility that adult harbour

seals are more bound to particular places would not be inconsistent with this, but it remains essentially unconfirmed.

The discovery that the harbour seals of the German Bight, which are bound to the tidelands, represent a single population is one of the most important findings of recent research on harbour seals. All regional and local measures for conservation and management must be oriented towards this fact.

#### 3.1.8. Selection of resting site

30

It is a well known fact that it is always the same sandbanks that are sought out at low tide in the tidelands by seals. However, it is not at all clear whether the same seals also always return to the same sandbank. Yet it can be said that there are traditional "seal banks", the existence of which is dependent only upon natural changes and construction projects in the tidelands. The question arises why precisely these sandbanks, and not others, are acceptable to the seals. To resolve this question, we charted all of the resting sites where seals had been observed in our enumerations. These flights and the aerial photographs taken, together with an evaluation of the latest vertical photographs of the tidelands at low tide, which the German Federal Armed Forces allowed me to examine, revealed certain criteria for the selection of resting sites by the harbour seals.

Harbour seals were sighted at low tide more than once at a total of 87 sites in the Schleswig-Holstein tidelands. These resting sites exhibited the following characteristics:

1. The resting site must be located on a deep creek, and have a relatively steep bank.
2. The sandbank should be as high as possible. Evidently, however, this characteristic is less critical, especially if the first criterion is fulfilled. For example, south and north of Hindenburgdamm there are some resting sites on low flats, but with a steep edge into deep water.
3. The resting site must be located in a system of creeks or sandbanks with calm waters, i.e., without surf along the edge of the resting site. Obviously, the place must be undisturbed by Man.
4. The wind direction plays a role. As a rule, the seals choose a site where the wind blows off the sandbank. This is useful for security reasons, since they have to expect danger mainly from the land, but it may also be connected with the avoidance of surf at the resting site. The wind direction is an important criterion for the selection of a resting site by harbour seals. In the Hever area north of the Eiderstedt Peninsula, for example, there are several sandbanks suitable as resting places, but they are oriented differently with respect to the water. Here the choice clearly is made according to the direction of the prevailing winds.

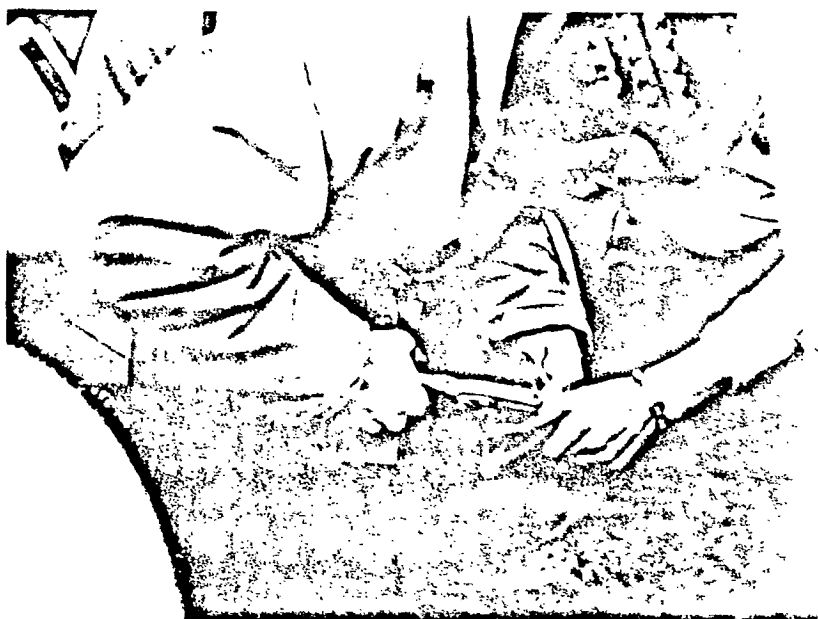


Figure 16. Tagging a harbour seal.

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5. The orientation of the resting site in relation to the water is important. More than half of the resting sites in the Schleswig-Holstein tidelands are located on the east and southeast sides of the sandbanks (Figure 18). The lowest number of resting sites are towards the west and southwest. Of course, there are probably also , in general, fewer sandbanks with resting sites having these orientations which satisfy the first three criteria; for, often they have gently sloping banks towards the west or are too close to shore. If at least the first three criteria are fulfilled, the orientation need not necessarily be decisive for the choice of a resting site, as has been shown often by the example of the northern tip of Norderoog Sand in the Hooger Loch.

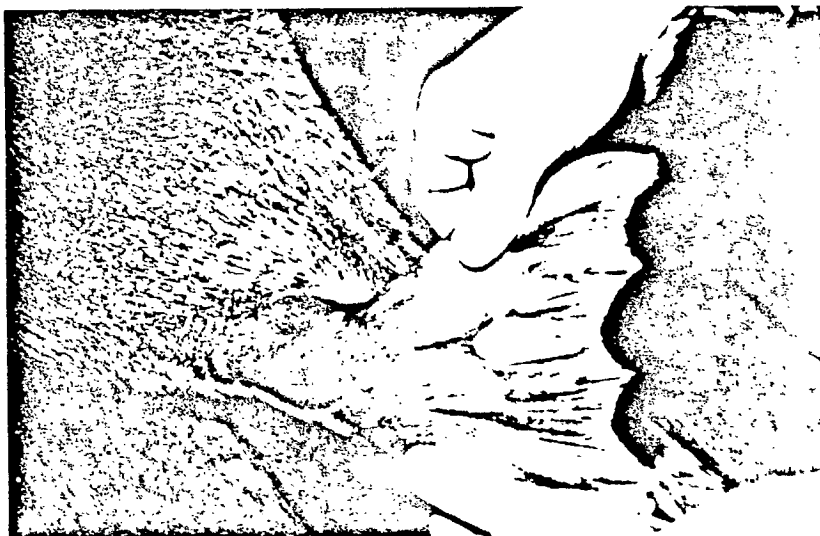


Figure 17. Tag on the hind flipper of a seal.

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Also VAUGHAN (1978) found similar characteristics for harbour-seal resting sites in investigations of the English tidal flats in The Wash.

Certainly also the social behaviour of the seals plays a decisive role in the choice of a resting site. This involves especially sex- and age-specific factors, as shown by the different composition of the herds (see above), which also result in spatial differentiation. However, it is clear from the criteria that have been mentioned that the number of suitable resting sites in the Schleswig-Holstein tidelands can not be augmented indefinitely. Since the seals must resort to these sites in the tidelands during the summer months, the presence of suitable sites and their size represent a limiting factor for the population of harbour seals.

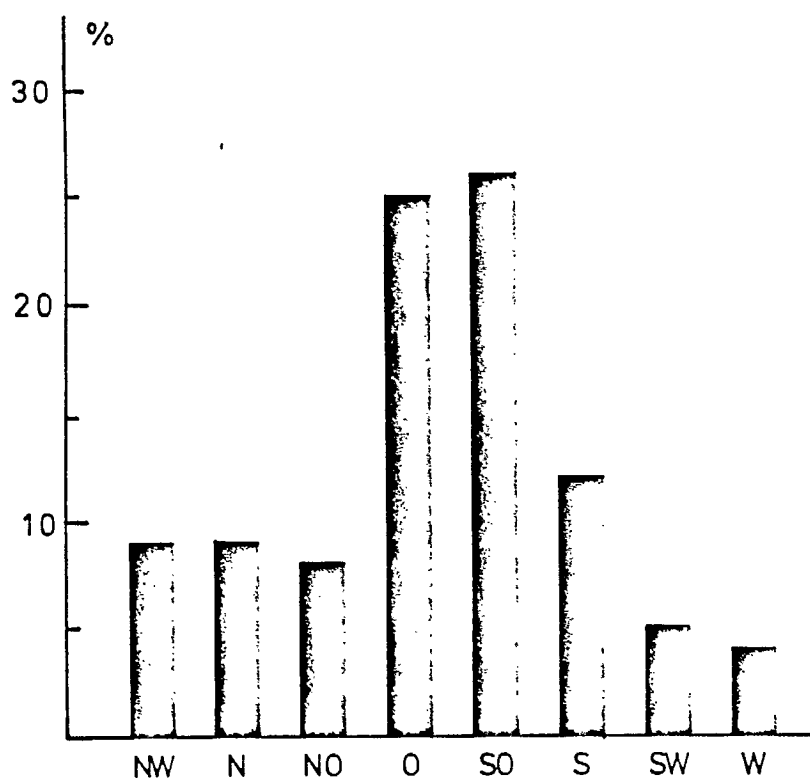


Figure 18. Frequency distribution of the orientations of seal resting sites in the Schleswig-Holstein tidelands in relation to the water.

Key: NO=NE O=E SO=SE

In the event of population growth, there could be some more sandbanks which may be suitable for harbour seals. It is also possible that more seals could come to the traditional resting sites. However, since certain individual distances must be maintained, apart from the still unknown social factors, this possibility is also spatially limited.

In summer, the greatest number of harbour seals per unit area occurs in the North Frisian tidelands, as opposed to all other regions. If, with growth, the upper limit of

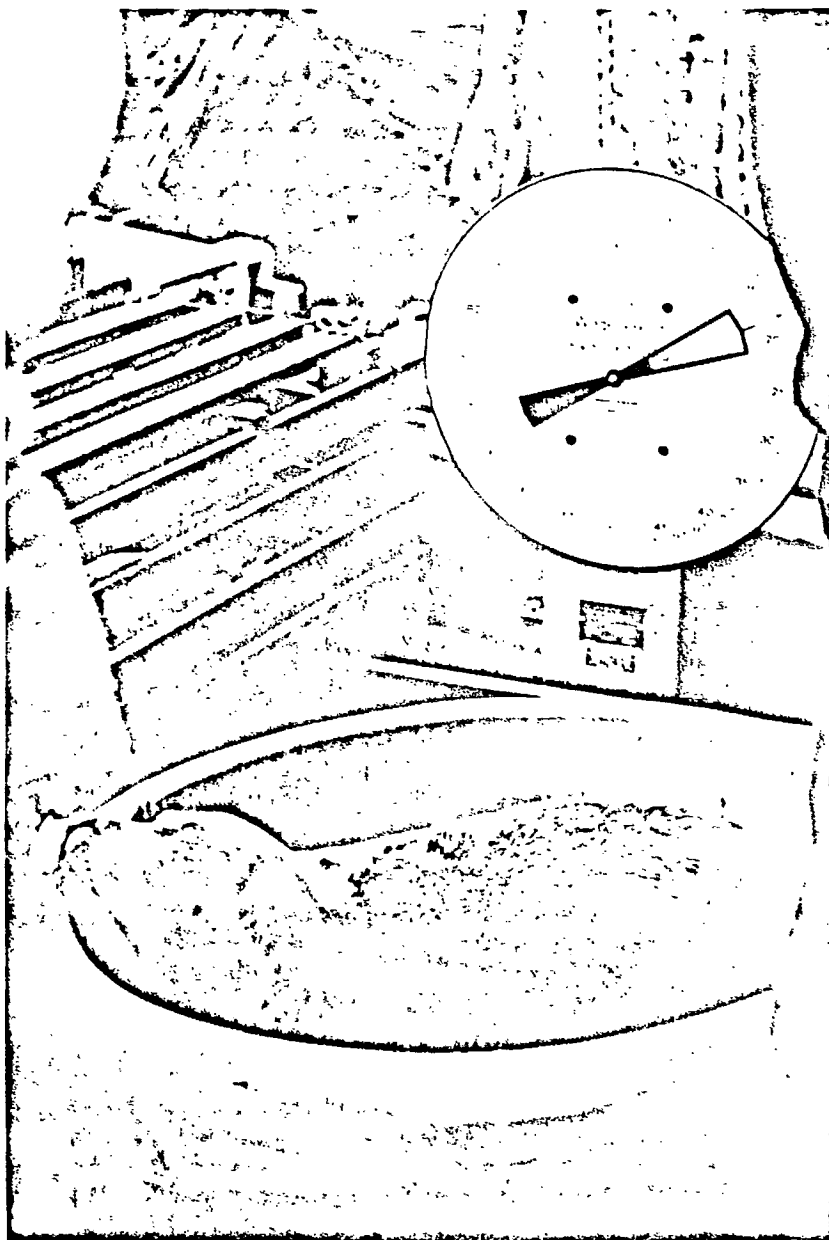


Figure 19. A hand-reared seal is weighed before being liberated.



Figure 20. Weighing a free-living seal on the tidal flats  
(photo by P. BORKENHAGEN).

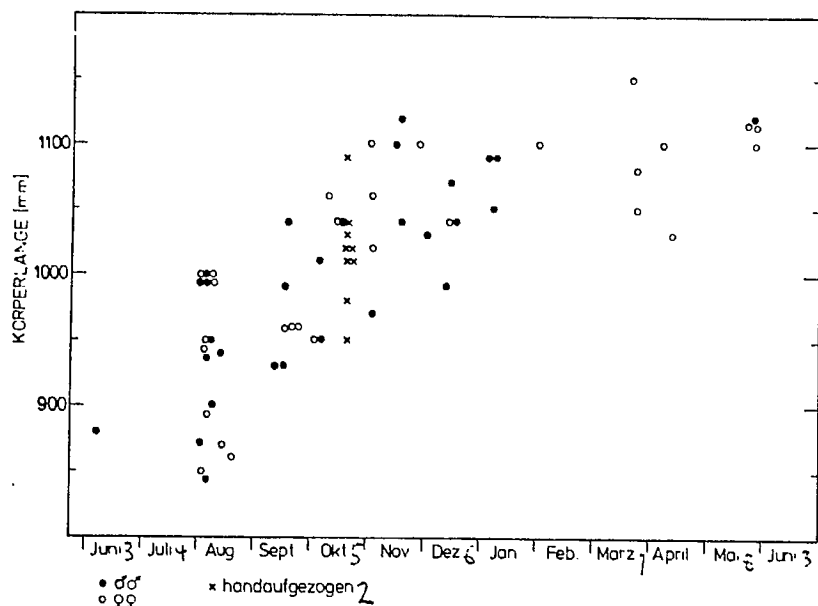


Figure 21. Increase in body length of harbour seals during the first year of life.  
 Key: 1- body length (mm) 2- reared by hand 3- June 4- July  
 5- October 6- December 7- March 8- May

the population density, or the capacity of the resting sites, is attained, it is likely that portions of the population will move to other areas. This would affect, first of all, the subadults, and there are already concrete indications of this: In the Dutch Wadden Sea in 1978, REIJNDERS found a higher than average percentage of subadult seals. This point demonstrates once again that it is essential to approach the problems of the Harbour Seal on an overall regional basis.

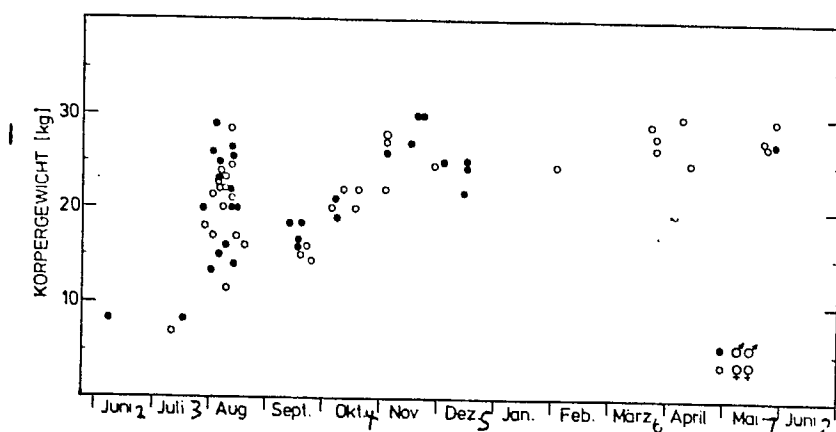


Figure 22. Increase in body weight of harbour seals during the first year of life.

Key: 1- body weight (kg) 2- June 3- July 4- October 5- December 6- March 7- May

### 3.2. Body growth of pups

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A knowledge of the growth of the pup body, considered in connection with the development of the blubber layer (see 3.3), is important for evaluating the high juvenile mortality, estimated at 60-65% (see 3.1.5) in the first year of life.

#### 3.2.1. Body length

The lengths of seal pups are plotted in Figure 21 according to the date of measurement. The length of the body at birth is approximately 85 cm. The increase in length of free-living seals during the first year of life, allowing for all variations, shows the normal pattern for a continuous growth curve. The values for the length of hand-reared "howlers" at the time of their liberation fall completely within the range of variation of the length of free-living seals.

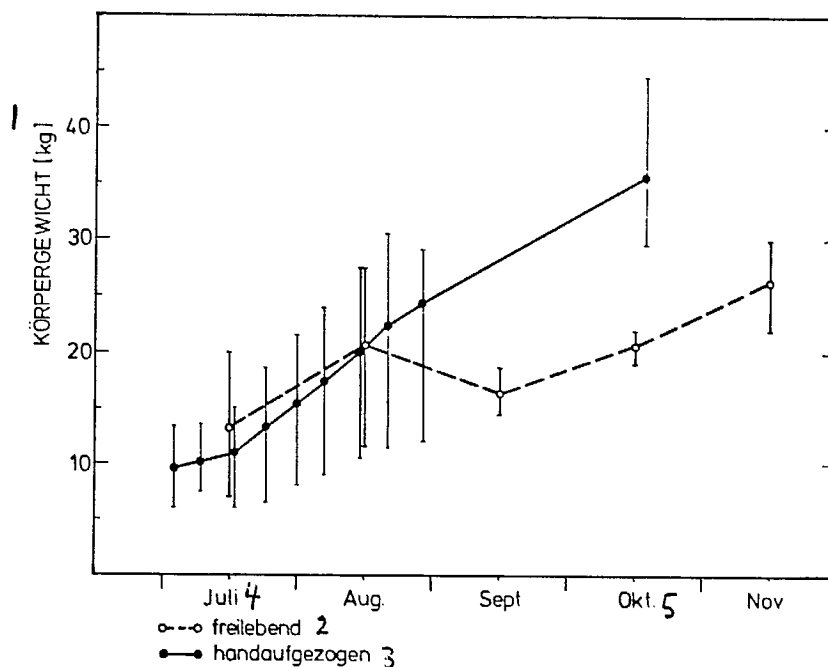


Figure 23. Body weight of hand-reared seals ("howlers") up to the time of their release, compared with free-living seals of the same age (monthly averages). Vertical lines show the range of variation.

Key: 1- body weight (kg) 2- free-living 3- reared by hand  
4- July 5- October

### 3.2.2. Body weight

38

Figure 22 shows the weight values for free-living seals which were shot or captured for tagging. The weight of harbour seals at birth is 7 to 9 kilograms. During the suckling period of approximately 26 days (see 3.1.4), there is a massive increase in the weight of free-living seals, up to  $2\frac{1}{2}$  -  $3\frac{1}{2}$  times their weight at birth. At the beginning of August, we found pups weighing up to 29 kg. In September, however, the weight

of the free-living pups was much lower, less than 20 kg. In October, their weight rose again, but it recovered the average level for the month of August only in November. After one year of life, the average weight was still less than 30 kg. Thus, after a rapid increase in weight during the suckling period, a phase of weight loss begins. The loss may amount to 20 to 40% of the weight at the end of the suckling period. With these values, this "transitional stage" would have a duration of approximately 4 weeks. It is connected with the pup's changeover to obtaining its own food. Such a pattern is known also for other seal species (e.g., LAWS 1953).

The body weight of seals reared by hand follows a different pattern (Figure 23). The howlers increase in weight steadily from the time of their capture, and when they are liberated, weigh nearly twice as much as seals of the same age in nature. Since they correspond exactly with the free-living seals with respect to their body length (see above), the difference in weight is caused exclusively by a much thicker blubber layer.

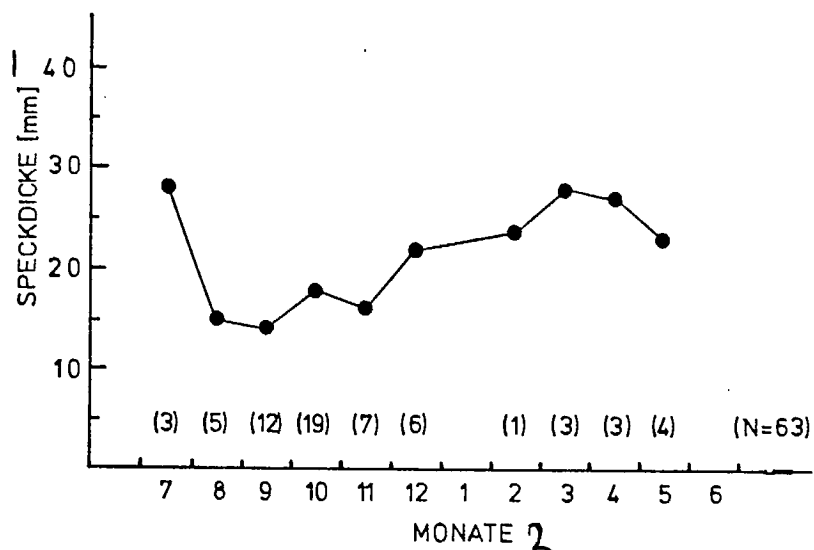


Figure 24. Thickness of the blubber layer of harbour-seal pups during the first year of life, after the suckling period. (Numbers in parentheses refer to the number of seals investigated.)

Key: 1- thickness of blubber layer (mm) 2- months

### 3.3. The blubber layer

The blubber layer under the skin represents the only part of the body of harbour seals where fat accumulates in large quantities. The entire body, excepting only the extremities and the head, is surrounded by this layer of fat. The most important functions of the blubber are (1) insulation, since the protection offered by the fur is hardly adequate, and (2) storage. These functions are closely related, and they affect the general resistance of the organism to disease and parasites.

### 3.3.1. The blubber layer of pups

The rapid increase in the weight of wild pups during the suckling period is effected not only by the growth of bones, muscles, and organs, but especially by the build-up of the blubber layer. During the short suckling period of approximately four weeks, the pup must build up a sufficiently thick blubber layer. At the end of the suckling period, we obtained values of ca. 30 mm for the thickness of the blubber (measured above the sternum) (Figure 24). In the "transitional phase" which follows, the blubber is degraded. Hence the weight loss during this phase is exclusively due to a considerable diminution of the blubber layer, to an average thickness of ca. 15 mm (Figure 24). The thickness of the blubber increases again beginning in October, but it does not regain the thickness of the end of the suckling period until March of the following year.

Evidently it often happens that the blubber layer is not sufficiently thick at the end of the suckling period, and falls below a critical thickness in the transitional phase. This threshold value is approximately 11 to 15 mm (see below). In pups below the critical value, the resistance to disease and parasites recedes sharply. As a rule, then, in early September, emaciated pups are sighted, in most cases with skin disease and the external symptoms of lungworm disease (arching of the back) . The increase in juvenile mortality at this time (see 3.1.4) must be connected with this phenomenon.

### 3.3.2. The blubber layer of older seals

The changes in the average thickness of the blubber of older seals (more than 9 months old) over the course of a year exhibit a characteristic cyclical pattern (Figure 25). In the spring, we find values of ca. 30 mm. The blubber layer decreases distinctly towards summer, averaging between 15 and 20 mm. It expands again relatively quickly starting in October. The highest values are found in the winter and spring. The maximum values obtained were 45 and 50 mm in two full-grown female seals (both pregnant) in December.

The distribution of the fat reserves in the body of harbour seals exhibits a regular pattern. The reserves are initially deposited exclusively in the layer under the skin. Only after the blubber layer has attained a certain thickness, is fat deposited in other parts of the body: on the pericardium, the renules, and the peritoneum. According to our findings from dissections, the threshold value is a blubber thickness of ca. 40 mm.

From the annual variation in the thickness of the blubber, it is clear that the most important feeding time for harbour seals occurs in the winter and spring, in the open waters of the North Sea. The sojourn in the tidelands during the summer, for various reasons, represents a period of great stress for these animals, so that the decrease in the thickness of the blubber in this season is understandable (see discussion).

### 3.3.3. Thickness of the blubber of seals found dead

The average values obtained for the thickness of the blubber of seals found dead also are reproduced in Figure 25. With the exception of the two values for May, they are distinctly below the "normal values". The annual variation of the thickness of the blubber of pups (Figure 24) and of older seals shows that the lowest normal values are around 15 mm. This is evidently the average minimum level for the blubber of harbour seals. Below this critical value, the chances of survival for a seal decline rapidly. The average thickness for seals found dead was approximately 11 mm. However, the individual measurements were generally below this level. In almost all of the carcasses, we found diseases and parasites as well as a thin blubber layer.

### 3.3.4. Nutritive condition, feeding, and food base

A blubber layer about 15 mm thick seems just adequate to satisfy all the demands made on the blubber by the body of a seal in the summer, such as insulation and sufficient reserves of energy to resist disease and parasitic infestation. It is important in this connection to build up a sufficiently thick blubber layer during the winter and spring "feeding season" to survive the summer without injury. The question arises whether the seals have a quantitatively and qualitatively adequate food base for this purpose in the North Sea during the winter months. Changes in the ichthyofauna of the North Sea due to fishing, such as the overfishing

of the herring, and to climatic and hydrographic changes are a familiar phenomenon (HEMPEL 1977). However, it is impossible to establish any connection between the reduction of fish species and the nutritive condition of the Harbour Seal. As various food analyses have shown, harbour seals are opportunists as far as their food species are concerned. The quality of the food taken up--i.e., the fat content of the fish--plays an essential role in the nutrition of the seals and the build-up of their blubber layer (GERACI 1975). The entire question of the nutrition of harbour seals still represents a completely open field for eco-physiology and bioenergetics.

#### 3.4. Skin disease in harbour seals

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Diseases and injuries of the skin are the most frequently occurring pathological phenomena in seals. In the harbour seals of the tidelands, striking alterations of the skin are observed, especially in the umbilical region (Figure 26). The causes and course of this skin disease were clarified extensively during our research project (DRESCHER 1978c).

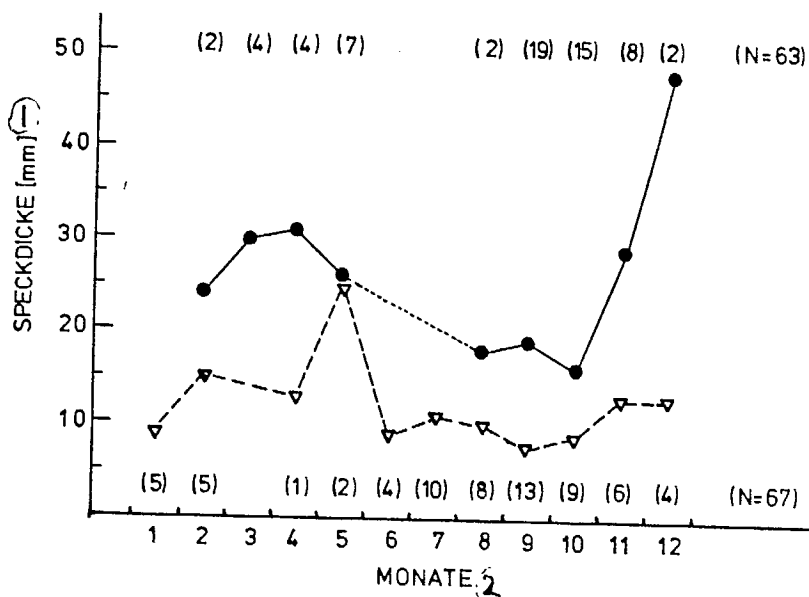


Figure 25. Thickness of the blubber of harbour seals: (a) annual variation of the average thickness of the blubber of older seals (from the age of 9 months; solid line); (b) average thickness of the blubber of seals of all ages found dead (broken line). The number of seals investigated is shown in parentheses. Key: 1- thickness of blubber (mm) 2- months

### 3.4.1. On the history of the occurrence of skin disease

Information on the historical occurrence of the characteristic skin disease can be obtained from the files of the Ministry for food, Agriculture and Forestry in Kiel. As evidenced by a letter written by the sealing captain and fisherman Boje SEVERIN on 26.9.1950, this definitely is not a new phenomenon:

"...Added to this is the fact that a terrible disease has raged among the seals since 1938. The center of infection extended from the Hever current far to the north. I have encountered a large number of animals with this disease on the Hever as well as on the tidal flats around Sylt. There



Figure 26. Pup with a skin ulcer in the umbilical region (age ca. 11 months; photographed on 19.5.1976 in Rummelloch).

were severe inflammations up to the size of a plate, where the entire skin and even the blubber were eaten away and suppurated. These animals could no longer lie properly on the sandbank, and thus a large part of the stock perished. When I questioned other captains, they had made similar observations."

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On 16.7.1943, Captain W. ROHWEDDER of Friedrichskoog reported that he had taken a seal with such ulcers. The dissection of a seal sent to the Veterinary Research Bureau (Veterinaeruntersuchungsamt) in Neumuenster resulted in the following findings:

"On the lower side of the animal, there were large ulcerous spots approximately the size of a 5-DM coin (~2.6 cm). sharply bounded on the inside by connective tissue. No cause was found for these injuries."

A memorandum dated 18.10.1960 reads: "We have known since 1951 that lichenoid diseases are observed in harbour seals."

Again, on 7.2.1961, the Hoernum-Sylt Water Police referred to seals with "diseased patches in the abdominal region, as large as a hand". The police station held consultations with Captain P. RAFFELHUESCHEN of Westerland, and afterwards noted: "This disease affects mainly the pups. They have purulent spots as large as a hand in the abdominal region, resembling ulcers. RAFFELHUESCHEN estimated that ca. 30% of the seals were infected with the disease. He also reported that the diseased individuals were exceedingly emaciated and had lost their fear of Man." 43

On 13.10.1969, Captain W. HAARMANN of Toening reported in a letter: "On the average, the seals taken recently have been very lean. They had at best 1-1½ cm of blubber... Moreover, almost all of these seals were suffering from a peculiar skin disease, especially on the abdomen, and from very severe filarial infection of the stomach, gut, and lungs."

Starting in 1973, more seals and samples were sent in for investigation, but the cause of the ulcerous skin lesions remained obscure.

These documents show that the skin disease, which is very striking and readily noticed, has been known already for 40 years, and infected seals have sometimes been found in large numbers.



Figure 27. Skin ulcer on a 16-month-old seal. Scar tissue has already been formed at an earlier stage (dark circle); subsequently renewed inflammation and enlargement.

#### 3.4.2. Course of disease, and causes

44

A systematic study of skin disease in seals was undertaken in 1975 and 1976 (DRESCHER 1978c). In these years, 104 infected seals were investigated which had been shot or found dead. 78 of these exhibited skin lesions in different parts of the body. In 71 cases (91%), the umbilical region was affected, in the form of inflammations of the umbilicus in pups, or extensive ulcers (Figure 26). Injuries occurred also on other parts of the skin, usually in addition to the umbilical lesions.

The age distribution was as follows: 60 of the 78 seals with skin injuries were in the first year of life, 11 in the second year, and 4 in the third, fourth, or sixth. Three old females had skin injuries on the neck.

On the basis of the age-distribution pattern of the disease, and the size, location, and nature of the injuries, we can describe the typical course of the disease. As a rule, it begins in the pup, at the age of a few days or weeks, with an inflammation of the umbilicus. This inflammation may erupt, so that the seal dies from an inflammation of the peritoneum. In most cases, it forms an expanding ulcer with sanious suppuration around the umbilicus. After six months, this skin ulcer may already measure 20 cm in diameter. Secondary abscesses may develop in the blubber layer in other parts of the body, which erupt and give rise to further ulcers.

In the winter and spring, the seals are no longer closely bound to the tidelands (see 3.1.1); they stay mostly in the open waters of the North Sea. Consequently, the mechanical stimulation of the wound through crawling on the sandbank is eliminated, and the wound may heal. Initially light scar tissue, later turning black, develops from the edge of the wound. In this condition, the bottom of the ulcer is red from the proliferation of blood vessels.

In most cases, the cicatrization remains incomplete. Only one case of complete healing of a former ulcer was recorded. As the seals stay on the sandbanks increasingly in the following months, a renewed inflammation develops on the edge of the partially cicatrized ulcer and in the parts not



Figure 28. Parasites of the Harbour Seal: Nematodes in the lung of a pup.

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yet healed. Inevitably, with this new inflammation around the edge, the diseased area becomes larger (Figure 27). Subsequently, during the second and third moult, the fur completely re-covers the older scar tissue formed in the first spring and winter. In a relatively small number of infected seals, this repeated partial healing and re-inflammation may recur several times. Meanwhile, the affected area constantly expands. However, complete healing of the skin after several years is conceivable.

Skin ulcers of the kind which I have just described can develop also on other parts of the body. They probably begin with a superficial skin injury, which expands to form an ulcer. The course of the disease is the same.



Figure 29. Filariae in the heart of a harbour-seal pup.

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When we examined the trails of seals crawling on the tidal flats, traces of blood and pus were found in 81 of the 561 trails examined; i.e., ca. 14% of the seals had the skin disease. Since the seals affected were mainly pups and yearlings, the percentage would be much higher for these age groups. Based on the numbers of seals found dead and the overall mortality of the respective age groups, it is estimated that in the two years of our investigations, approximately 40% of the pups suffered from umbilical inflammations which later developed into skin ulcers.

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This skin disease represents a bacterial infection. It is probable that the delicate epidermis of the umbilical stump at the site where the umbilical cord was detached becomes injured through the mechanical stimulation of crawling

on the sand, and can not heal. This wound becomes the place of entry for the bacteria. Crawling on the sand also prevents the wounds from healing and leads to their renewed inflammation and enlargement.

Apart from those cases with inflammation of the peritoneum or septicemia, the umbilical injuries and skin disease were not the only cause of death in the carcasses found with such diseases. In most cases--more than 70% of seals found dead in the first and second year of life--death was caused by the simultaneous occurrence of skin disease, parasitic infection of the lungs (by nematodes, Figure 28) and/or heart (filariae, Figure 29), and a low blubber layer (less than 15 mm). All of these factors have a cumulative unfavourable effect on the seal.

Disturbances of any kind during the suckling period must be viewed as one of the major causes of the occurrence and expansion of skin ulcers in the umbilical region in pups. The disturbances oblige the pups to move frequently and change their position, which may result in inflammation of the navel. In various parts of the tidelands, such disturbances during the suckling period are so frequent that the females and their pups must remain in the water exceedingly long during low tide. This time is lost for suckling and rest, giving rise to the possibility that the pups will not be able to store sufficient fat reserves during the suckling time, i.e., the blubber layer will not be built up adequately. The

transition to independent feeding is accompanied by a considerable loss of weight, based on a reduction in thickness of the blubber (see 3.3.1). Also, if a pup has not stored adequate reserves, its resistance is reduced during the subsequent transitional phase. Hence, human disturbance of the seals at their resting sites must be held partially responsible for the occurrence of umbilical skin disease.

### 3.5. Accumulation of harmful substances in harbour seals

47

Organs from a total of 74 seals were investigated with respect to their content of heavy metals and chlorinated hydrocarbons. The analyses were performed in collaboration with the Federal Fisheries Research Institute (Bundesforschungs-Anstalt fuer Fischerei) in Hamburg (DRESCHER et al. 1977; HARMS et al. 1978).

#### 3.5.1. Heavy metals

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The results of our analyses of residual copper, zinc, cadmium, lead and mercury in the different organs of seals are presented in Table 4. The highest values for all of these metals, with the exception of cadmium, were found in the liver. Cadmium accumulates chiefly in the kidneys. The contents of mercury and cadmium in the organs rose progressively with increasing age.

An interesting aspect is the accumulation of heavy metals in the food chain. The level of the concentrations of

	Unters. Organ 1	2 Anzahl	Durchschn. ppm 3	Var.-Breite ppm 4
<u>Kupfer</u> 5	Leber 9	58	6.8	2.6 - 17.0
	Niere 10	16	3.1	2.3 - 4.0
	Gehirn 11	16	3.1	2.4 - 4.0
<u>Zink</u> 6	Leber	57	39.4	27.0 - 60.0
	Niere	16	22.6	15.5 - 34.0
	Gehirn	16	13.2	10.8 - 15.0
<u>Cadmium</u>	Leber	58		0.01 - 0.21
	Niere	16		0.06 - 1.0
	Gehirn	17		0.002 - 0.014
<u>Blei</u> 7	Leber	58	0.24	0.09 - 0.74
	Niere	16	0.36	0.08 - 0.6
	Gehirn	17	0.11	0.04 - 0.2
<u>Quecksilber</u> 8	Leber	58		1.5 - 160
	Niere	16		1.6 - 12.5
	Gehirn	17		0.11 - 0.04

Table 4. Heavy metals in the bodies of harbour seals from the North Sea coast of Schleswig-Holstein. (No average values are shown for cadmium and mercury, since these metals show an age-dependent pattern of accumulation.) (mg/kg fresh weight)  
Key: 1- organ investigated 2- number 3- average ppm 4- range of variation (ppm) 5- copper 6- zinc 7- lead 8- mercury 9- liver 10- kidney 11- brain

copper, zinc, cadmium and lead is not essentially different in the liver of fish and seals. However, we find up to 1000 times as much mercury in the liver of seals than in the fish. In the liver of an adult seal, we found a maximum value of 160 ppm mercury.

	Unters. Organ	Anzahl 2	Mittlerer Fettgehalt % 3	Durchschn. ppm 4	Var.-Breite ppm 5
PCB	Fett <sup>8</sup>	59	85.5	151.5	27 - 564
	Leber <sup>9</sup>	20	2.28	3.08	0.4 - 8.2
	Gehirn <sup>10</sup>	8	7.18	1.18	0.48 - 2.96
	Niere <sup>11</sup>	4	1.78	0.54	0.18 - 1.22
Gesamt-DDT 6	Fett	59	85.5	8.7	1.8 - 27.2
	Leber	20	2.28	0.24	0.04 - 0.43
	Gehirn	8	7.18	0.09	0.04 - 0.16
	Niere	4	1.78	0.15	0.01 - 0.4
Lindan 7	Fett	59	85.5	0.31	0.04 - 1.0
	Leber	20	2.28	0.007	0.003 - 0.006
	Gehirn	8	7.18	+	---
	Niere	4	1.78	+	---
Dieldrin	Fett	59	85.5	0.24	0.04 - 1.0
	Leber	20	2.28	0.023	0.006 - 0.054
	Gehirn	8	7.18	+	---
	Niere	4	1.78	+	---

Table 5. Residues of chlorinated hydrocarbons in the bodies of harbour seals from the North Sea coast of Schleswig-Holstein. (+ = present, but below the threshold of detection) (mg/kg fresh weight)

Key: 1- organ investigated 2- number 3- average fat content (%)  
 4- average ppm 5- range of variation (ppm) 6- total DDT  
 7- lindane 8- blubber 9- liver 10- brain 11- kidney

### 3.5.2. Chlorinated hydrocarbons

The average values and range of variation for the residues of the insecticides DDT, lindane, and dieldrin, and also for polychlorinated biphenyls (PCB's) are reproduced in Table 5. We detected a maximum of 27.2 ppm total DDT in the Harbour Seal, and 564 ppm PCB's. The values for dieldrin and lindane averaged 1 to 2 powers of ten lower than the values for total DDT.

The order of magnitude of the PCB residues in organisms representing different levels of organization in the North Sea is shown in Figure 30, to illustrate the accumulation of this substance in the food chain. From the water of the North Sea to the fat of gulls, seals, and porpoises, the PCB concentration rises by 8 powers of ten (a factor of 100 million). It should be mentioned that PCB's--as well as DDT and other chlorinated hydrocarbons--are fat-soluble, and remain in the water only in very small concentrations, since they have a tendency to migrate directly into organisms. Hence it is clear that water analyses are only partially conclusive with respect to the environmental residues of harmful substances, unless they are accompanied also by studies of the behaviour of these various substances in the food chain. Similar tables could be elaborated also for DDT and mercury.

#### 4. Disturbance of seals resting at low tide

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During our counting flights and at every stop made on the flats, we recorded the sources of disturbance and their effects on the seals. The behaviour of the seals when disturbed was observed during the suckling period, using some excursion trips in the North Frisian tidelands--especially the Hever area--as an example (DRESCHER 1976a).

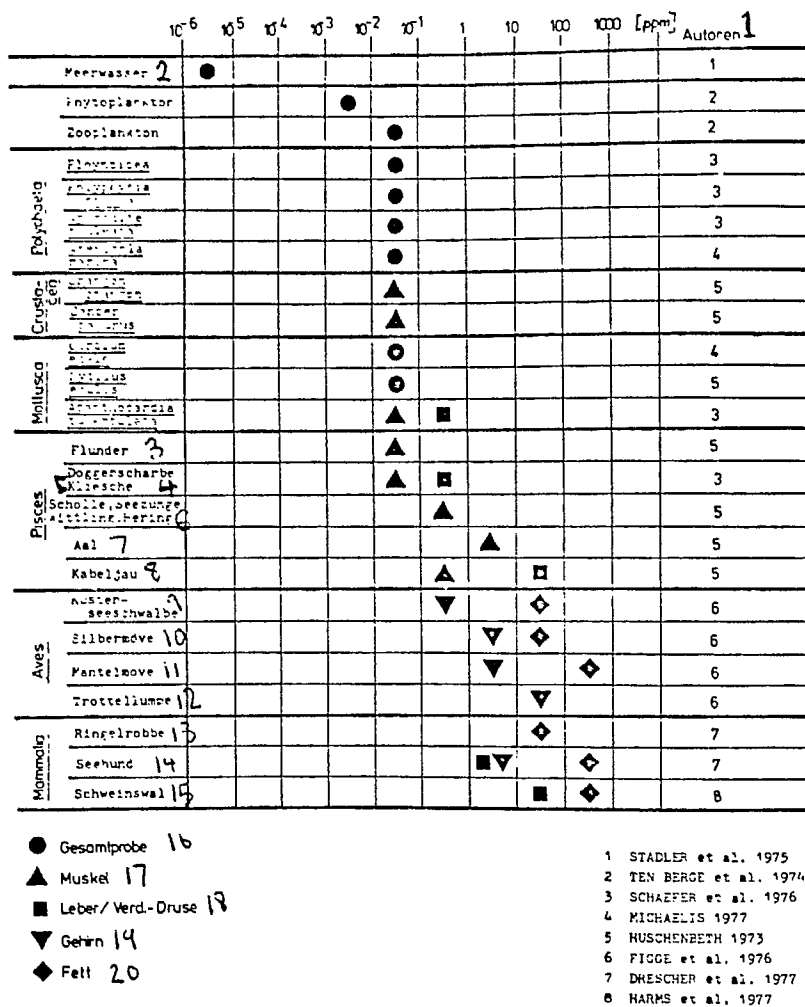


Figure 30. Polychlorinated biphenyls (PCB's) in the water and organisms of the North Sea (according to various authors). Key: 1- author 2- sea water 3- flounder 4- long rough dab 5- halibut 6- plaice, sole, whiting and herring 7- eel 8- cod 9- tern 10- herring gull 11- great black-backed gull 12- common murre 13- ringed seal 14- harbour seal 15- porpoise 16- whole body 17- muscle 18- liver/digestive gland 19- brain 20- fat

#### 4.1. Sources of disturbance

##### A. Excursion trips "to the seal banks" (Figure 31)

As far as I know, excursion trips are made to the following areas in the tidelands: Hever area north of the Eiderstedt Peninsula; Nordstrand Moor; Rummelloch; Suederaue; Amrum Deep; Knobsaende west of Amrum; and the flats near List-Sylt. I do not know the destination of excursions in the Dithmarsch tidal flats (departing from Buesum). In this area, private ships play a greater role as sources of disturbance.

The most severely affected area is the Hever area north of the Eiderstedt Peninsula ("Quiet Zone 1" of the North Frisian Tidelands Wildlife Sanctuary). Frequently several ships traverse this region at the same time. In June and July of 1976, a total of 121 registered passages were made in the Hever area by four ships (three from Nordstrand and one from Husum). In addition to these, there were a number of unregistered passages, e.g., from Pellworm. During the next two years, the number of passages was even higher in the two summer months, due to an increase in excursion vessels.

The Hever area represents one of the most important breeding grounds in the North Frisian tidelands. An average of 22% of the pups for the entire North Frisian Tidelands Wildlife Sanctuary were counted in this area alone (cf. Tables 1 and 2).

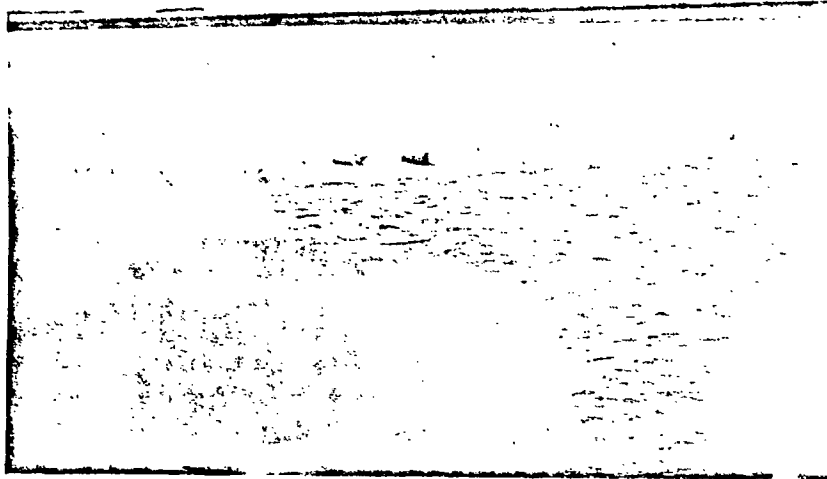


Figure 31. Sources of disturbance: Excursion trips "to the seal banks".

It should be emphasized that those captains of excursion vessels who are also sealing captains are attempting to enlighten their comrades to the need to divert the excursions to less problematical areas than, e.g., the Hever area, and, at the same time, to approach the resting sites of the seals cautiously.

B. Private shipping traffic (sailboats, motorboats and speedboats)  
(Figure 32)

Even private ships often approach the seal banks. Since, as a rule, the resting sites of the seals are on high sandbanks with steep shores, private ships frequently anchor directly next to the resting site. These places then are lost for the seals as resting sites for the duration of the low tide. Because of the high growth rate of this branch of tourism, disturbances due to private ships in the tidelands are becoming increasingly serious, not only for seals.

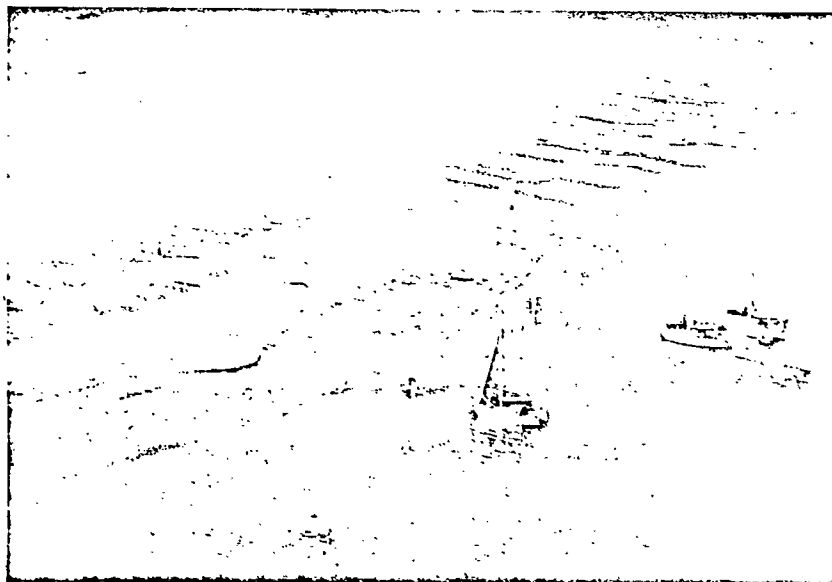


Figure 32. Sources of disturbance: Sport boats anchored at a resting site (note the trails left by crawling seals).

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C. Sight-seers: Individuals and groups

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Sight-seers often seek out the seal banks (e.g., Liinsand, northwest of Foehr; Hooger Loch, west of Hooge; Rummelloch, west of Pellworm). The practise of excursion boats letting their passengers disembark at Norderoogsand in the Rummelloch to walk freely to the Hooger Loch is regrettable. ("Quiet Zone 2" of the North Frisian Tidelands Wildlife Sanctuary.)

D. Low-flying military and civilian aircraft: Supersonic boom.

#### 4.2. Reaction of seals when disturbed by excursion boats

The seal banks are generally approached by throttling the motor and drifting up close to the seals, frequently to within 30 or 40 meters. It was observed that during the suckling period, the seals, triggered by the alarm reaction of one or two members of the herd, already fled into the water at a distance of approximately 200 meters. It was further observed that even if ships approached slowly, the seals gradually went into the water. Frequently the ships approach so close to the sandbank that they come within the flight distance even of the last of the seals. Old animals and mothers with pups have the greatest flight distance. If a pup is being suckled when the ship arrives, the suckling is always interrupted, then the seals take flight into the water. When the ship moved away from the sandbank, in isolated cases, after a distance of ca. 100 to 150 meters, we saw individual seals--exclusively subadults--crawl back cautiously onto the sandbank. However, as long as the sandbank was visible from the ship, it was never observed that a mother and pup, or the entire rookery, went back on land. Thus the duration of the disturbance is considerably longer than the approach of a ship to the sandbank and its actual passage. The practise of this type of excursion represents a considerable encroachment upon the life style of all the seals lying on the sandbank, except a few isolated subadults. Pups still being nursed are especially affected by such a disturbance. The

suckling can take place only on the sandbank. Because of the frequent disturbances, the mother and pup must spend in the water too much of the time available at low tide for suckling and rest.

## 5. Hunting

54

In the following pages, the hunting regulations and the seal hunt in the Schleswig-Holstein tidelands are described according to official data.

### 5.1. Hunting regulations

The seal hunt was regulated by law for the first time in the Imperial Hunting Law of 3 July 1934. The Harbour Seal was declared legal game (§ 2), with a closed season from March 1 to July 15. Previously the seals had no legal protection. The legal regulation of the hunt obviously arose under the impression that the stocks were reduced. The harbour seals must have been much more numerous around the turn of the century, since the hunting journals reveal that for some sealers, an annual bag of 150 seals was possible (MEYER-BRENKEN 1974).

Detailed regulations for the seal hunt were determined by an ordinance of 24.7.1935, which regulated the display of hunting licences, prohibited hunting with nets, dogs, or shot, and prescribed an arrangement with the fisheries administration and the conservation authorities. Also, seal reserves were established for the first time. The copy of this decree sent to local controllers of the hunt, dated 7.8.1935, reads, in part, as follows:

"In the region of the North Sea adjacent to the coast of Schleswig-Holstein, the following areas are specified for the protection and conservation of seals:

(a) In the section from the mouth of the Elbe to Buesum, the islands of Trischen (Buschsand) and Helmsand;

(b) in the section from Buesum to Husum, the island of Blauort;

(c) in the section from Husum up to the level of Fahretoft, the islands Suedfall, Suederoog, Hamburg-Hallig, Hooge, Seesand, and Apelland - Habel; and

(d) in the section from Fahretoft up to the Danish border, the island of Foehr.

The reserves extend around the said islands, from 100 meters out to sea in to the point of the normal height of the tide. In these areas, the shooting and capture of seals of all species is prohibited."

However, with the exception of the "Seesand" area-- which probably refers to the Outer Sands--this decree does not seem very sensible, since even at that time, there would have been hardly any seals staying within a zone of 100 meters around islands and the Halligen.

New regulations for the allotment of hunting licences for the seal hunt were decreed on 2.8.1949. The specifications concerning the reserves continued to remain in force.

<u>Jahr</u> <sup>1</sup>	<u>Geschätzter Bestand</u> <sup>2</sup>	<u>Zum Abschuf freigegeben</u> <sup>3</sup>	<u>Anzahl der erlegten Seehunde</u> <sup>4</sup>
1951	1200	240	88
1952	1200	240	?
1953	?	?	94
1954	1350	250	109
1955	1700	340	172
1956	1200	240	166
1957	1650	240	194
1958	1700	310	252
1959	1420	290	270
1960	1410	290	261
1961	1720	300	272
1962	1400	310	256
1963	1210	230	206
1964	1420	310	276
1965	1620	345	273
1966	1660	345	277
1967	1605	320	226
1968	1560	330	265
1969	1710	330	261
1970	1647	306	230
1971	1490	215	178
1972	1500	299	195
1973	1600	153	93
1974	1544*	-	-

\* Flugzählung am 8./11.7.74 (377 juv.). 5

Table 6. Estimated stock, numbers of game permitted, and actual numbers taken, for harbour seals in the Schleswig-Holstein tidelands (according to official data) from 1951 to 1974.

Key: 1- year 2- estimated stock 3- number of game permitted  
4- number of seals taken 5- aerial enumeration on 8-11.7.74 (377 juv.).

After the war, serious concern for the size of the seal stock arose for the first time in 1950. The figures submitted were very different and biased. They ranged from 400 to 4000 (DRESCHER 1975). The sealer and fisherman Boje SEVERIN of Buesum reported that since 1935 (2000 seals) the number of seals had been reduced to 1200-1400 (MARRE 1950).

55

A regulated seal hunt by authorized sealers reportedly took place for the first time in 1951. According to a memorandum of 12.7.1951, in the conference on 4.7.1951 regarding the hunt it was stressed that "after years of indiscriminate killing, the hunting of harbour seals must be restored to planned control through suitable quotas, in order to preserve the stock of this game in the interests of the fishermen". On the other hand, there was also awareness of a responsibility "to protect this interesting species occurring only in limited numbers on the west coast of Schleswig-Holstein from irresponsible decimation".

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After that time, the sealing captains were summoned for a consultation by the Supreme Hunting Board (Oberste Jagdbehoerde) once a year, before the start of the hunt. The general situation of the seal stocks was discussed, an estimate of the stock was made, and the quota was fixed. The hunting season extended from July 16 to February 28.

The Imperial Hunting Law was repealed on 31.3.1953 and replaced by the State Hunting Law on 11.7.1953. Starting in 1956, the end of the hunting season was December 31. On 15.6.1970,

the beginning of the open season for harbour seals was moved to August 1. (GVOBL\* p.151, 26.6.1970)

The report of December 1976 on research on the Harbour Seal recommended that the beginning of the open season be moved to September 15 for biological reasons (DRESCHER 1976b). This proposal was taken into account in the state ordinance of 22.4.1977 changing the hunting season (GVOBL Schleswig-Holstein p.94, 29.4.1977). In addition, in accordance with the federal regulations, the hunting season was limited to before October 31. Detailed regulations of the seal hunt may be found in § 4 of the said state ordinance.

## 5.2. The hunt

From the very start, the Hunting Board and the State Hunters' Association have strived to establish planning for the seal hunt in the Schleswig-Holstein tidelands (BEHNKE 1969; BRUELL 1967). It was the Schleswig-Holstein Hunters' Association that introduced aerial enumeration of the seals. Since 1956, such flights have been made (BEHNKE 1977a, b), and the results compared with the counts made by sealing captains from cutters. In this way the stock was estimated and the annual quota determined (Table 6).

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\*Gesetz- und Verordnungsblatt ("Law gazette and statute roll")

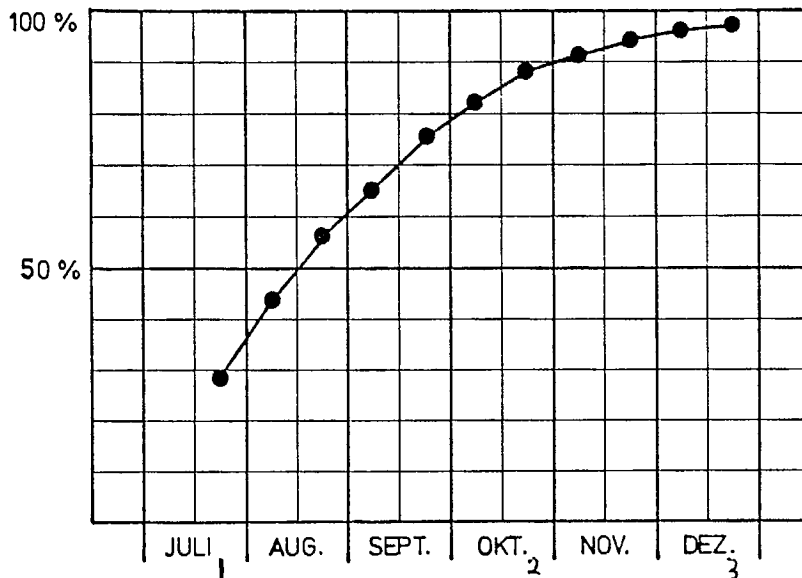


Figure 33. Average pattern in time of the seal hunt in Schleswig-Holstein for the hunting seasons of 1962-1967: Percentage of the kill taken (according to official data).  
 Key: 1- July 2- October 3- December

However, an evaluation of the results revealed that the values reported for the size of the stock up to 1973 are not comparable with the results obtained from 1975 to 1978. The former values were made up of partial enumerations made at different times--often as early as May and June-- supplemented by the counts taken from cutters (DRESCHER 1975). But as I 57 have explained above, an accurate count of the maximum number and of the new-born pups can be obtained only by taking several systematic enumerations of all the seals in the first two-thirds of July.

In Schleswig-Holstein, the quotas were suitably based on the assumption that the new generation--i.e., the proportion of pups in the total population--represents approximately 20% (BEHNKE 1969). As a rule, the quota was set at this level (Table 6). From 1951 to 1953, an average of 210 seals per year were killed, corresponding to an average of 73% of the quota. The most seals were taken in 1958 to 1970, averaging 256 per year. This number represented 83% of the estimated size of the new generation.

From 1962 to 1967, following HOFFMEYER's (1962) proposal, data were compiled on the age, sex, and date of capture of all animals bagged. The season began on July 16. These data reveal that during these years, 28% of the kill was effected between July 16 and July 31 (Figure 33) and 15% between August 1 and August 15. Thus the majority of the seals were taken at a time when pups are still being suckled (cf. 3.1.4, Figure 4). (On July 16, approximately 80% of the pups are being suckled, and on August 1, 10-20% are still being nursed.) The seals bagged from July 16 to August 15 in 1962 to 1967 were 86% pups and 14% adults.\*

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\*In 1965-1966, there was heated public controversy concerning the opening date of the hunting season. However, the focus of this debate was not the hunt as a source of disturbance during the suckling period, but the possibility that nursing mothers might be killed. This definitely was not the case. (Cf. also FRANK 1940, p. 43.)

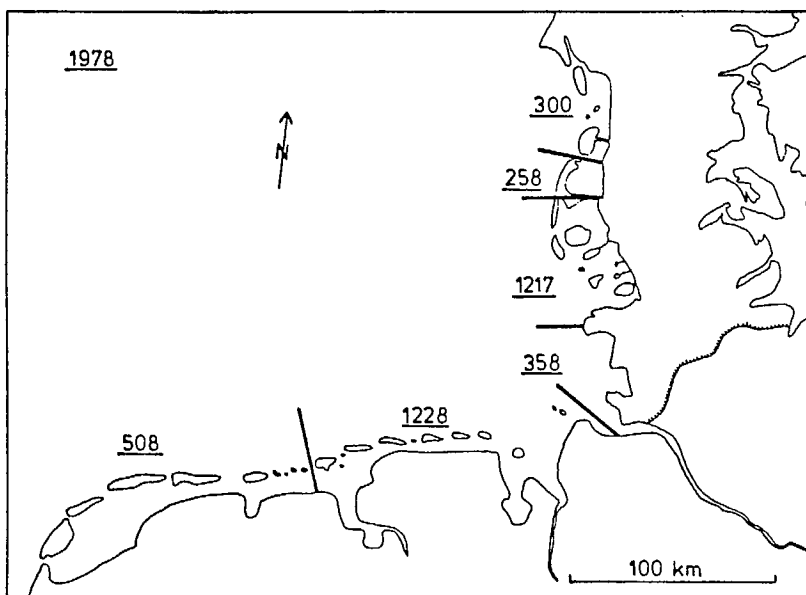


Figure 34. Maximum numbers of seals (including pups) counted in the different parts of the tidelands in 1978.

In 1970, the beginning of the hunting season was moved to August 1. The reason was that a diminution of the stock had been observed. Furthermore, apparently the number of infected seals with open wounds or other disease symptoms had increased sharply. The captains were encouraged to shoot mainly the infected seals. In 1973, 80% of the animals taken were ill.

Since 1974, the seal hunt has been restricted. The seals killed were<sup>made</sup> available to our research project. From 1974 to 1976, 51 seals were allowed to be taken within the hunting season (1.8 to 31.12) each year. In 1977 and 1978 (hunting season: 15.9 to 31.10) 15 seals were killed each year for research purposes. Moreover, unrestricted hunting of infected seals has been allowed every year since 1974.

6. Discussion

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## I

Based on the tagging results, it must be assumed that the harbour seals of the German Bight represent a single population unit. Furthermore, as shown by isolated recoveries of the tagged seals in England and northern Denmark, this population is not isolated (WIPPER 1975a). Given the recognition of this fact, the reduction of this species in the western tidelands must be viewed on a supra-regional basis. The decrease in the number of seals in the Dutch Wadden Sea from approximately 3000 in the 1930's to 500 today (HAAFTEN 1974) can no longer be viewed as a matter of concern only to The Netherlands. Certainly the most far-reaching environmental changes have been in the Dutch part of the tidelands: Considerable tidal areas have been lost through extensive land-reclamation projects; as in all other tideland areas, the pressure of tourism on the remaining flats has greatly intensified; and due to the Rhine, which transports the waste water of five highly industrialized countries into the North Sea, the water pollution is very heavy. Hitherto in the German Bight, in spite of the considerable concentrations of harmful substances in the bodies of harbour seals (KOEMAN et al. 1975; DRESCHER et al. 1977; HARMS et al. 1978), we have not observed any direct effects of a pathological nature in seals. There has been a dramatic manifestation of such effects in the Baltic, where a high percentage of the adult females of all three seal species

present are sterile due to pathological symptoms in the uterus caused by chlorinated hydrocarbons (DDT, PCB's) (HELLE et al. 1976).

The distribution of the seals in the tidelands reveals a distinct concentration. The number of seals per unit area increases in the different subregions from west to east (Figure 34). Also the relative proportion of pups in the total population of each region shows the same pattern (Figure 35). This makes it very clear that the Schleswig-Holstein tidelands, and especially the North Frisian tidelands, have considerable importance for the harbour seals throughout the German Bight. Actually these northern shoals represent an "optimal habitat" for the Harbour Seal during the summer, which is most important for reproduction and rearing. When a population undergoes an overall reduction, this is noticeable mainly in the marginal portions of its area of distribution, i.e., in the suboptimal regions. This is the case even when there is interference in the area classified as optimal. This may explain why no decline was observed in the Schleswig-Holstein tidelands.

The Harbour Seal was hunted relatively intensively in Lower Saxony until 1970 and in Schleswig-Holstein until 1973. It is debat<sup>able</sup> whether the hunting should be inculcated as another possible factor in the reduction of this species. A sober analysis of the facts regarding the hunt as actually practised up to 1970 shows that in addition to the removal of seals (mostly pups), the hunt represented an important source

of disturbance during the suckling period, when the most intensive hunting occurred (the opening date of the season, up to 1970, was July 16). This had the consequences which have been described for the possible inadequate condition of the pups at the end of suckling (see 3.5.). It remains an open question whether hunting pups had an additive or compensatory effect on the overall mortality, apart from the high natural mortality of the pups (cf. 3.1.5).

## II

The method of counting the stock of harbour seals in the Schleswig-Holstein tidelands was standardized using the results of numerous aerial enumerations. Population size and the proportion comprised by the new generation can be determined only by taking several enumerations from the air within a brief period of a few days in the first two-thirds of July (from July 6 to July 20).

The harbour seals carry out seasonal migrations between the open sea and the tidelands. The majority of the seals seek out the tidelands for a certain time in summer for specific biological reasons, viz., for whelping and rearing, and probably also for mating and moulting. During this time they are bound to the tidelands (WIPPER 1975b). At present it is still unknown whether only certain individuals are bound to the tidelands in winter, or whether the seals

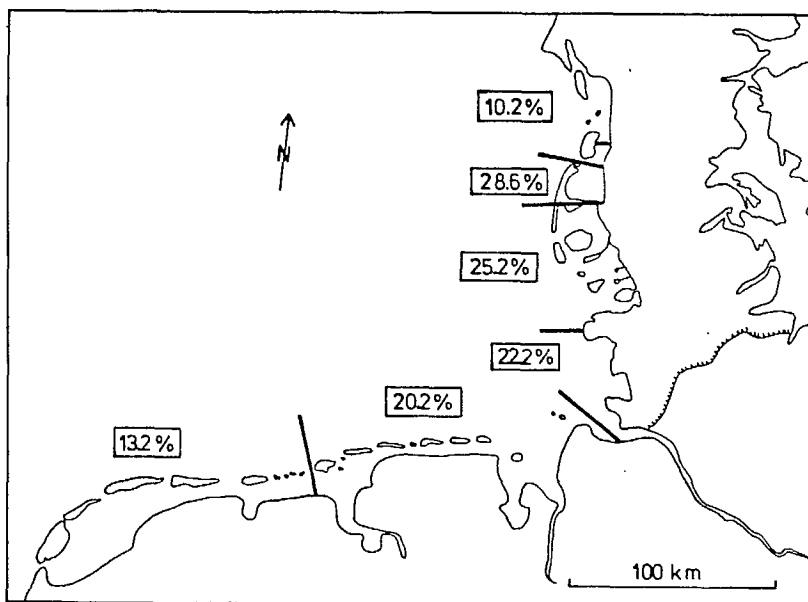


Figure 35. The percentages of new-born pups in the total populations of the respective subregions manifest the importance of the Schleswig-Holstein tidelands for the reproduction of the Harbour Seal in the German Bight. (Netherlands and Lower Saxony: Average values for 1975-1977. Schleswig-Holstein: Average values for 1975-1977. Denmark: Value for 1978.)

in general enter the shallows much more rarely. The results of the enumeration after the storm tide in 1976 (see 3.1.1) permit a provisional conclusion that the seals remain in the open sea not too far from the tidelands.

However, it is definitely not the case that the seals seek out the tidelands in summer in order to accumulate fat reserves for the coming winter. This conception has often been transferred to the Harbour Seal from the game of the mainland. The opposite is the case. The summer sojourn on the tidal flats is physiologically necessary and exhausting for the seals. During this period, they are exposed to extraordinary (biological) stress factors: whelping and

rearing the pups, the low individual distance at this time due to their concentration on the tidal flat and at the resting sites, moulting, mating, and the limited time available for food uptake because they must stay on the sandbanks at low tide. This is shown distinctly by the reduction of the blubber layer (see 3.3.2). The thickness of the blubber of the seals in the winter and spring makes it clear that this is / <sup>when they</sup> deposit the reserves which they require for the summer months. Their biologically necessary sojourn in the tidelands in summer represents a bottleneck situation for the seals, during which they need increased protection against additional disturbance by Man.

### III

Protective measures for the Harbour Seal are necessary in all tideland areas. They are most effective in those regions which currently represent the most important summer habitat with the highest production of pups (North Frisian tidelands). It is important to guarantee that the pups are reared without disturbance during the months of June to August, so that the natural mortality of the pups declines (cf. 3.1.5, 3.4). This can be done by establishing "seal reserves". Furthermore, efforts to protect the seals in those regions now seen as suboptimal summer habitats should focus more intensively on conservation of the biotope (DRESCHER 1978-1979). In the

long run, such measures could result in renewed growth of the population in the German Bight. The number of sandbanks in the northern tidelands acceptable to the seals as resting sites is limited, because these sites must fulfill certain requirements (see 3.1.8). For spatial and social reasons, a rising population density in the northern tideland areas could produce a population pressure which would cause an increase in the number of seals and percentage of new-born pups in the western areas as well.

## 7. Recommendations

Based on the results of our research project, the following recommendations may be proposed for the protection and management of the Harbour Seal in Schleswig-Holstein:

### Short-term measures

The immediate steps for the protection of the Harbour Seal involve measures to reduce human disturbance during the whelping and suckling period.

Definition: A "seal reserve" is a bounded tideland area representing important breeding grounds of the Harbour Seal, and where, at least during the whelping and suckling period from June 1 to August 15, shipping and pedestrian traffic are prohibited on the sandbanks. Restrictions on the use of federal waterways in wildlife sanctuaries and

national parks can be imposed by a regulation of the Federal Ministry of Transport \* (Federal Conservation Law <sup>↓</sup> § 36 ).

1. Expansion of "Quiet Zone 1" in the North Frisian Tidelands Wildlife Sanctuary to the east and to the north (Appendix 1). The channel passage should be excepted.

2. Certification of "Quiet Zones 1-4" in the North Frisian Tidelands Wildlife Sanctuary as "seal reserves".

3. Certification of the "Wesselburener Loch" in the Dithmarsch tidal flats as a "seal reserve". (Simultaneously, the Dithmarsch tidal flats should be secured as a wildlife sanctuary.) (Appendix 2.)

4. Certification of the southeastern portion of the "Bird Sanctuary of the Tidelands east of Sylt" as a "seal reserve" (Appendix 3).

5. Incorporation of the "Knobsaende" west of the island of Amrum into the North Frisian Tidelands Wildlife Sanctuary, in order to protect the harbour seals and gray seals resting in this area (Appendix 4). 63

6. Until further notice, hunting should remain restricted to the removal of diseased seals, and to management and research purposes.

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\*In the "quiet zones" of the North Frisian Tidelands Wildlife Sanctuary, pedestrian traffic on the sandbanks at low tide is prohibited, but shipping traffic through the "quiet zones" at low tide is not subject to any explicit restrictions (GVOBL Schleswig-Holstein 1.2.1974, p. 44 ff., § 4 and 5).

\* In German this symbol denotes a particular Section in a law (TRANSLATOR)

Long-term measures

1. Regular yearly enumerations for purposes of supervision, and for determining the population size and percentage of new-born pups. During the first two-thirds of July, there should be three complete enumerations made <sup>from</sup> (the air), because reliable figures are attainable only in this way.

2. Continued close cooperation with Denmark and The Netherlands as well as Lower Saxony in the "International Study Group on Harbour Seals" to monitor the overall development of the Harbour-Seal population in the German Bight.

3. Long-term investigations of residues of harmful substances in the bodies of harbour seals; the seals, as the last link in the food chain, represent an important biological indicator in the North Sea.

4. Eventual curtailment of the introduction of harmful substances of all kinds into the North Sea and the oceans of the world, through negotiations and measures at every political level--regional, national, and international.

5. Material support and personnel for continued research on harbour seals. In addition to the supervisory activities (Recommendations 1-3), the meeting of the "International Study Group on Harbour Seals" on 30.11.1978 in Kiel emphasized the need for research focussing on the following areas:

(a) Investigations regarding the population dynamics of harbour seals: Age structure, sex ratio, mortality after

the first year of life, and migrations, particularly in relation to the question whether the same seals tend to return to the same location.

(b) Behavioural studies, especially on groups of mothers and pups disturbed on the tidal flats.

(c) Experiments concerning the effects of harmful substances on the seal organism.

(d) Further veterinary medical investigations with respect to the origin, course, and treatment of diseases of harbour seals.

(e) Qualitative and quantitative investigations regarding the feeding ecology of the Harbour Seal; investigations concerning the availability of food species.

6. There should be institutional guarantees--especially in the North Frisian Tidelands Wildlife Sanctuary, which is important for the entire region--for the scientific surveillance of the Harbour Seal and the enforcement of the legal regulations for the protection of this species.

## 9. Summary

### Biology, ecology, and conservation of the harbour seal in the Wadden Sea of Schleswig-Holstein.

1. A research project on the harbour seal, *Phoca vitulina*, has been carried out on the North Sea coast of Schleswig-Holstein, from 1.11.1974 to 31.12.1978. It is the aim of the investigations to collect data concerning the biology and ecology of the harbour seal for a better understanding of the seasonal rhythm of the species, its demands of the Wadden Sea habitat, and type and range of the limiting factors. The investigation of the status of the harbour seal in the Wadden Sea of Schleswig-Holstein compared to the other Wadden Sea areas in the German Bight is also of great importance. The collected data are the background for recommendations for conservation and management of the harbour seals.
2. The number of harbour seals in the Wadden Sea fluctuates throughout the year, i.e. the seals are dependant on the Wadden Sea to a seasonally varying extent. The maximum number is reached from the beginning to the middle of July.
3. The progressing of the whelping and nursing season is clearly determined: 95 % of the pups are normally born between 16 June and 8 July. The individual nursing period amounts to about four weeks. Nursed pups can still be found up to the middle of August. The mortality of the harbour seal within the first year of life amounts approximately to 60-65%.
4. Young tagged harbour seals disperse in all parts of the Wadden Sea. This fact supports the view that the harbour seals in the German Bight have to be looked upon as a single population.
5. During the summer months, the Northfrisian Wadden Sea is the most important area for the seal population in the German Bight. The highest density of seals are encountered here. It is the most important whelping and nursing area, because, having the highest percentage of pups in the total numbers, approximately half of the young harbour seals in the German Bight are born here.
6. The resting places of the harbour seals have to exhibit certain typical features. They may therefore be a spatial limiting factor.

7. The survival chance of the pups depends largely on an undisturbed nursing period, and/or the nutritional status at the end of that time. The blubber layer is of great importance for the energy budget and metabolism of the seal. It is a distinct indicator of the physical condition. Should the blubber layer become thinner than a specific threshold thickness during the transition period to self-reliant feeding, the pups would become weakened and susceptible to parasitic invasion and an infection of the umbilicus, which would be followed by characteristic skin lesions.
8. The blubber thickness in older seals shows seasonal variations: in the average, it is lowest during the summer months. During the months of winter and spring, it is rebuilt again. This makes clear that the necessity to stay in the Wadden Sea during the summer months is a „bottle-neck situation“ for the harbour seal, for several biological reasons. During this time, the seals require an intensified protection against additional human disturbances.
9. The harbour seal, being the final link of the marine food chain, accumulates considerable amounts of pesticides in its organism. The following maximum values have been recorded: 160 ppm mercury in the liver, 27 ppm DDT and 564 ppm PCB in the blubber fat (all wet weight basis).
10. As a short term measure for the conservation of the seals, it is recommended that during the time from 1 June to 15 August seal reserves should be established for the prevention of disturbances in the most important whelping and nursing areas. In the long run, surveying of the population by standardized counting methods is necessary, as well as the continuation of the international cooperation to monitor the development of the population in the total German Bight. Furthermore, the long-term control of pesticide residues in the seal organism, and measurements to reduce the introduction of pesticides into the seas are essential. It should also be made possible, by financial support, to continue and extend the research on the biology and ecology of the harbour seals.

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Translation of non-English titles

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1. Seal management
2. Counting seals, from the air and from cutters
3. Seal management; 20 years of constructive work in vain?
4. Red list of endangered animal species in the (German) Federal Republic. Part 1: Vertebrates except Birds (First edition)
5. Basic introduction to the "seal hunt"
6. Report on the research project on Harbour Seals. 16 pp. March 1975 (unpublished)
7. Report on the detriment to the seals caused by excursions "to the seal banks" in the North Frisian Tidelands. 4 pp. (unpublished)
8. Final report on the harbour-seal research project from 1.11.1974 to 31.12.1976. 14 pp. December 1976 (unpublished)
9. Marine mammals as biological indicators... (at the press)
10. Skin disease in the Harbour Seal, Phoca vitulina, in the North Sea
11. Harbour Seals in the North Sea
12. Mercury in fish used for human consumption and in marine mammals
13. Seals on the Dutch coast
14. Biological problems of fishing marine ecosystems
15. Harbour seals and the seal hunt on the German North Sea coast
16. International Study Group on Harbour Seals... Report of the meeting on 30.11.1978 in Kiel
17. Investigation of the European Harbour Seal on the North Sea coast with respect to its biology. Report concerning the research plans of the Minister for Nutrition, Agriculture, and Forestry of Lower Saxony (unpublished)
18. Fishing and sealing in Schleswig-Holstein

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19. Seal stock endangered?

20. The ecological and pathological problems of the Harbour Seal (Phoca vitulina LINNE 1758) on the North Sea coast of Lower Saxony. Dissertation, Munich 1974

21. Seasonal migrations of harbour seals

22. Ecology of the Harbour Seal, Phoca vitulina (LINNE 1758) on the North Sea coast of Lower Saxony

## 11. Appendices

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Based on the following maps:

DHI (Deutsches Hydrographisches Institut, "German Hydrographic Institute") nautical chart no. 103; 1:100,000 (appendices 1-3)

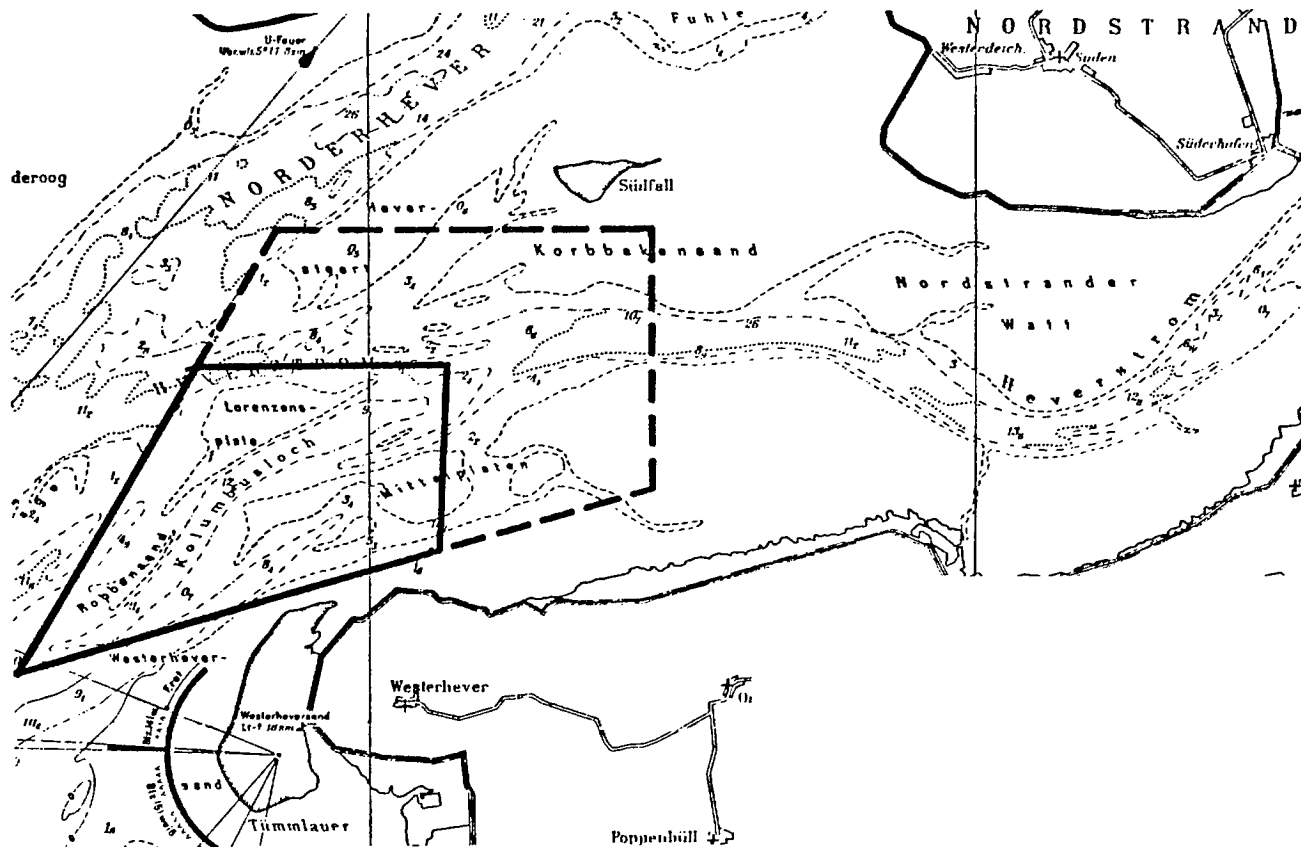
Topogr. map, no. L 1314; 1:50,000 (appendix 4)

Appendix 1: Proposed expansion of "Quiet Zone 1" in the North Frisian Tidelands Wildlife Sanctuary for a "seal reserve".

Appendix 2: "Wesselburener Loch"--proposed "seal reserve" area in the Dithmarsch tidal flats.

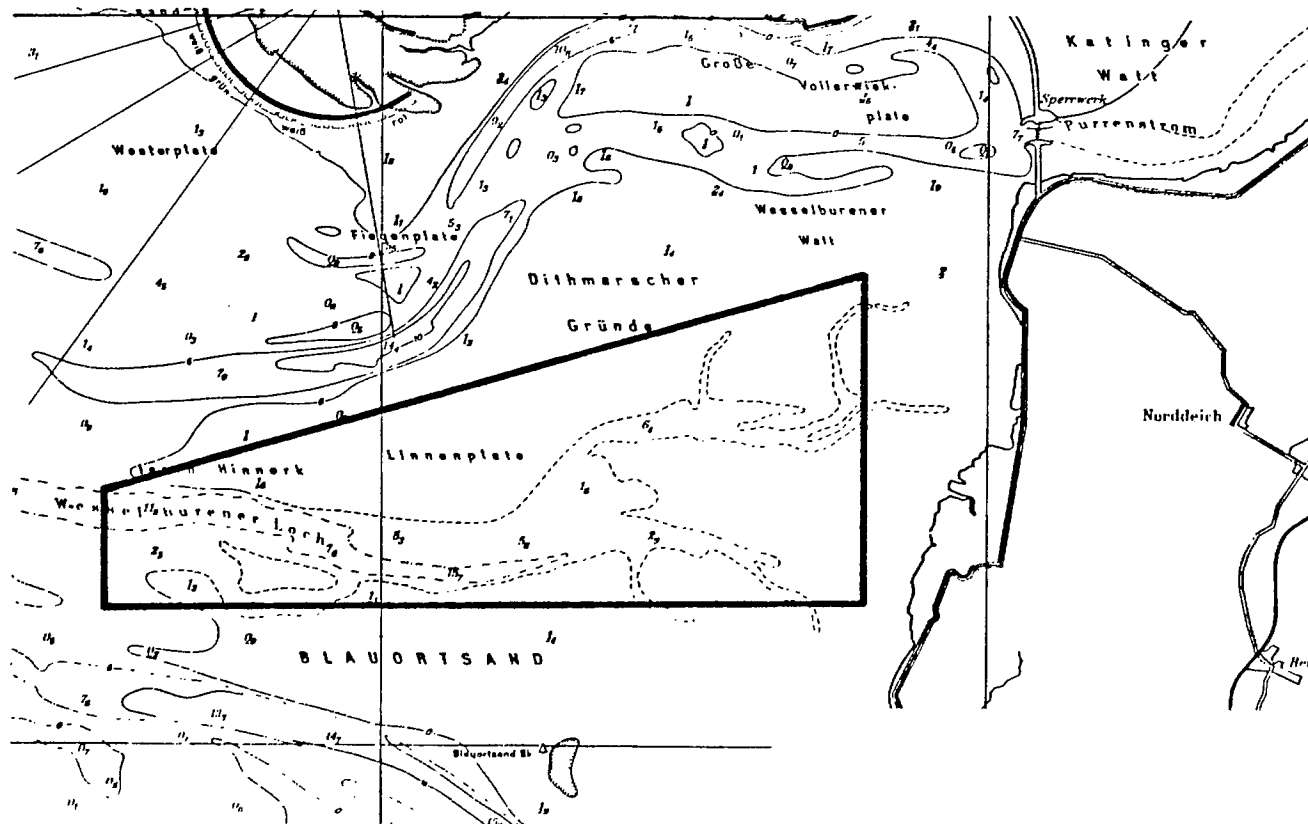
Appendix 3: Proposed "seal reserve" area in the "Bird Sanctuary of the Tidelands east of Sylt".

Appendix 4: Area of the "Knobsaende" west of the island Amrum proposed for annexation into the North Frisian Tidelands Wildlife Sanctuary

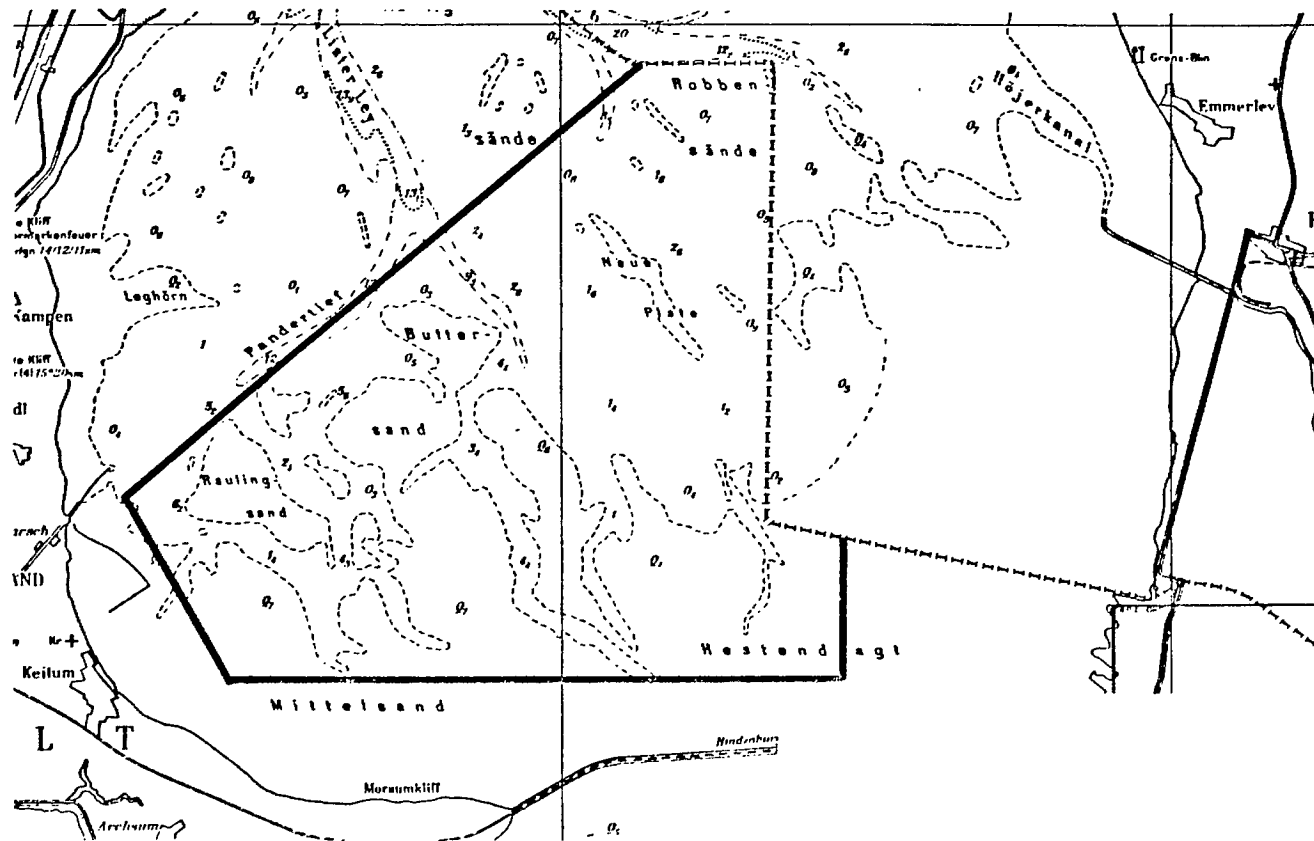


Appendix 1: Proposed expansion of "Quiet Zone 1" in the North Frisian Tidelands Wildlife Sanctuary for a "seal reserve" (channel passage excepted).

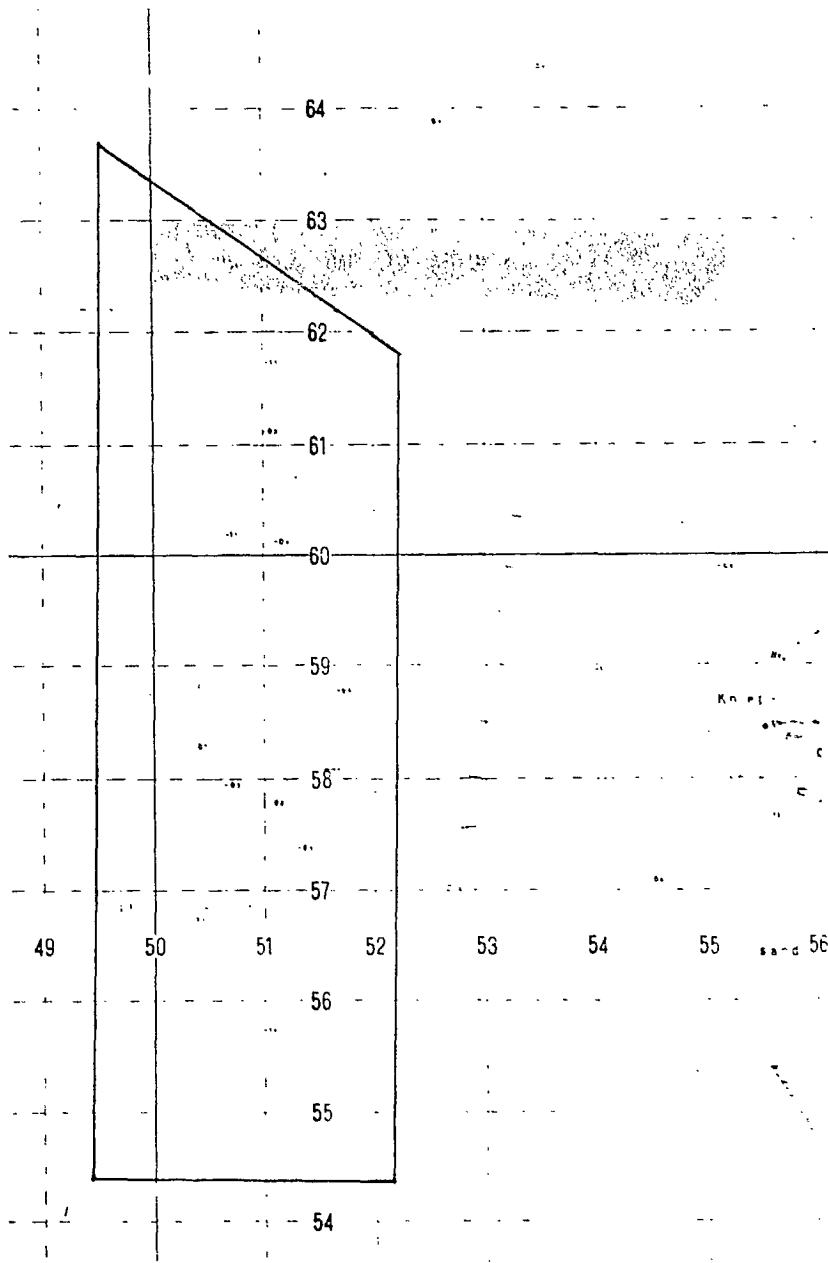
- previous boundary
- proposed new boundary



Appendix 2: "Wesselburener Loch"--proposed "seal reserve" area in the Dithmarsch tidal flats.



Appendix 3: Proposed "seal reserve" area in the "Bird Sanctuary of the Tidelands east of Sylt".



Appendix 4: Area of the "Knobsaende" west of the island of Amrum proposed for annexation into the North Frisian Tidelands Wildlife Sanctuary.