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# Harbour Porpoise *Phocoena phocoena* in Norwegian waters

by

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## ABSTRACT

Recordings made on the Norwegian Sighting Survey 1988 and the North Atlantic Sighting Survey 1988 (NASS-89) indicate a divided off shore distribution during summer for harbour porpoises in Norwegian waters, with a southern component in the North Sea area and a northern component from Lofoten and into the Barents Sea. Incidental sightings during the period 1964 - 1988, and distribution of by-catches in the drift net salmon fishery 1988, support these findings.

Estimates of pod size and abundance of harbour porpoise in the North and Barents Seas are given. The abundance estimates were about 82 600 porpoises (c.v. 0.24) for the southern component (the North Sea area) and about 11 000 porpoises (c.v. 0.44) for the northern component (Lofoten - Barents Sea). These estimates were based on NASS-89.

Incidentally caught porpoises were used to establish growth curves, age at sexual maturity, and to study the composition of prey species in the stomach content as well as contamination of organochlorines in the blubber. The testicular weight increment was used as an indicator of sexual maturition in males, and the age of first time ovulation was used as age of sexual maturity in females. Using the von Bertalanffy growth model, asymtotic values for body length were 142.3 cm for males and 155.9 cm for females, and asymtotic values for body weight of males and females were 52.7 kg and 49.4 kg, respectively. In a total of 23 females, 18 were three years old or younger, and these were all immature. Two out of three were sexually mature at the age of four years, and from the fifth year and onwards all were mature. Although the sample size is too small to be conclusive, these preliminary results indicate that sexual maturity is attained from age three in males, and about one year later in females.

Stomachs from 176 porpoises from Kattegat, the northern North Sea and the Barents Sea were examined. A minimum number of 2979 specimen of fish from 27 different species were identified based on otoliths recorded in the stomach contents. Remains of hagfish, squids and polychaetes were recorded in a few stomachs. Geographical variation of species distribution in the stomach content was noted, reflecting geographical variation in availability of prey species.

Contamination levels of 16 different organochlorines in blubber of male porpoises from Kattegat were compared with porpoises from the northern North Sea and the Barents Sea. Geographical differences in concentrations were recorded for eight of the compounds.

# INTRODUCTION

When the IWC Scientific Committee reviewed the status of stocks of harbour porpoise *Phocoena phocoena* in 1983, both Andersen and Clausen (1983) and Gaskin (1984) reported that a significant population decline had occurred in the Baltic and North Sea region, and stock declines were assumed to be a consequence of pollution, disease or by-catches. The IWC Small Cetacean sub-committee noted that very little information was available on stocks of harbour porpoises, but expressed grave concern for the status of the species in these two areas. The sub-committee further noted that the coast of Norway could be of great importance as the eastern North Sea habitat of this species. The Scientific Committee advised an augmentation in harbour porpoise research by member countries, including increasing effort on stock identification, assessment and reporting of by-catches (IWC 1984).

The status of stocks of harbour porpoises in the southern North Sea was also summarized by Kayes (1985). Further evidence on the decline in stocks of harbour porpoise in the North Sea region was substantiated through recent studies in Dutch waters (Smeenk 1987), in Danish waters (Kinze 1986) and in Swedish waters, although there were some indications on increasing occurrence of porpoises in Swedish waters during the 1980-ies (Lindstedt and Lindstedt 1988). A further recent decline (during the 1980-ies) was indicated for porpoises in UK waters of the northern North Sea (Evans 1987). Corresponding information based on systematic recorded data from Norwegian waters has not yet been published.

Although harbour porpoises are a common inhabitant in Norwegian coastal waters, there are no previous data available on growth and reproduction of harbour porpoises from these areas. Møhl-Hansen (1954) examined growth and reproduction in harbour porpoises from the Baltic, caught during World War II. Growth in by-caught porpoises from the southern North Sea area was studied by van Utrecht (1978). Recently, Buus-Sørensen and Kinze (1990) reported that male porpoises became sexually mature at lengths of 135 cm and three years of age, and females at lengths 140 cm and 4 years of age.

Little is known about the feeding habits and contamination of pollutants in porpoises in Norwegian waters. The accumulation of organochlorines in mammals is essentially related to feeding. The lipophilic nature and persistence of the organochlorines contributes to their high bioaccumulation potential and their biomagnification in higher trophic levels in the marine ecosystem. Ecological effects of these chemicals are poorly understood, but impact on top predators and specially on their reproductive successes are observed (Delong et al. 1973, Helle et al. 1976a,b, Reijnders 1986). Pollutant levels in tissues of porpoises in the North Atlantic were recently reviewed by Aguilar and Borrell (1990).

A research project on harbour porpoise was initiated in Norway in 1988. The aims of this project were to assess the incidental by-catches of porpoises, and to collect samples from incidentally caught porpoises for further analysis of i.a. growth and reproduction, stomach contents, and contamination of organochlorines. Project Porpoise was in 1988 funded by World Wide Fund for nature (WWF). From 1989 to 1990 the project was co-sponsored by WWF and the Norwegian Fisheries Research Council and it was co-ordinated with the Norwegian Marine Mammal Research Programme 1989-1993.

This paper summarises the present results of Project Porpoise for discussion in the ICES Marine Mammals Committee. Analysis of the material will be finalised shortly, and the results prepared for publication.

## MATERIAL AND METHODS

### Information from sightings and by-catches

The distribution of porpoises is based on information from three different sources; incidental by-catches in drift nets set for salmon in 1988, incidental sightings in the period 1964 -1988, and systematic records of sightings and effort made at the Norwegian Sighting Survey 1988 and at the international North Atlantic Sighting Survey 1989 (NASS -89).

The salmon fishery in Norway is organized in 34 salmon districts. Drift net fishery was until 1988 allowed in 18 of these districts on the west and north coast. The salmon districts are shown and compared with marine fisheries statistics areas in Fig. 1. A total of 580 fishermen were licenced for salmon fishery with drift nets, and all licenced fishermen were requested to report on incidental catches of harbour porpoises from late May to early July 1988.

Incidental sightings recorded at the Institute of Marine Research in Bergen (IMR) were reported by letter or telephone from the public, IMR research vessels, coast guard, whaling, and fishing vessels. There was no quantitative information on the effort involved, implying that it is not possible to infer trends in abundance from these recordings of incidental sightings. However, the information is here used to support the other findings on distribution of porpoises in Norwegian waters.

In 1988 a sighting survey covering the Norwegian and Barents Seas was conducted by Norway. The following year, Norway, as its contribution to NASS -89, covered the stock area of the Northeast Atlantic minke whales as defined by IWC. That is the area east of longitude 6° W and north of latitude 56° N. Nine vessels were used to cover this area. The main objective of these surveys was to assess the abundance of minke whales and other large whales in the Northeast Atlantic. The surveys did therefore not have the optimum stratification with regard to harbour porpoises. Both surveys were conducted in July, and narratives of the surveys, including survey block boundaries and design are described by Øien (1989 and 1990).

### Analysis of incidentally caught porpoises

*Material*
A total of 139 porpoises were collected from Norwegian coastal fisheries in 1988 -1990 (80 males and 59 females). They were all incidentally caught in gillnets, and the salmon drift net fishery in 1988 counted for most of the catches with 76 porpoises (collected from a total of 96 porpoises by-caught in that fishery that season). The incidentally caught porpoises were used to establish growth curves, age at sexual maturity, and to study the composition of prey species in the stomach contents as well as contamination of organochlorines in the blubber.

In addition, blubber samples from 12 porpoises were provided by WWF-projects in Denmark for organochlorine analysis, and stomachs from 81 porpoises were provided by WWF-projects in Sweden.

*Age determination*
Age determination was based on counts of dentinal growth layers. The teeth were decalcified in 5% $HNO_3$ for five hours, cut in 20 micrometers tick sections using a freeze microtome. The thin sections were stained in Mayers haemalun for 45 minutes before mounting. The dentinal layers were counted from the neonatal line to the pulp

cavity. One dark zone (or group of zones) and one light zone (or group of zones) were counted as one annual growth layer group.

As a part of this project, a workshop on age determination in harbour porpoises was held in Oslo, Norway, 21 - 23 May 1990. An experiment was conducted to test for within- and between-reader variability in age estimates in a sample of teeth provided at the workshop. The teeth were read by three people with experience and four people with little or no experience in age estimation in harbour porpoise. An analysis of variance of the experimental results showed more variation for inexperienced readers than for experienced, and more for older animals than younger. For the experienced readers, the reliability of age reading for animals less than five years of age was high. The pooled standard deviation was in this case 0.32 years, which was made up of contributions from pure error, between section (multiple sections from same animal), and between reader variability, in increasing order of importance.

*Estimating growth and age at sexual maturity*
A total of 41 males and 35 females by-caught in 1988 and 1989 were included in this examination. Total length was measured to the nearest 0.5 cm along a straight line from the tip of the snout to the notch in the tail fluke. Total body weight was determined to the nearest 0.1 kg. Growth curves for body length and weight were established using a least squares approximation of the von Bertalanffy growth model.

The testicular weight increment was used as an indicator of sexual maturition in males, and the age of first time ovulation was used as age of sexual maturity in females.Testes weight is given as the total weight (g) of both testes divided by two. The ovaries were first examined externally for active ovulation bodies, *corpora lutea*, or scars from old ovulations, *corpora albicantia*, at the surface of the ovary. The ovaries were then sectioned and examined for subsurface *corpora*.

*Analysis of stomach contents*
The stomachs were kept frozen until examined. The stomachs were then thawed and rinsed over three nested sives ( 2.0, 1.0 and 0.25 mm mesh) and otoliths and other hard parts retrived by hand. The otoliths were identified using a guide to otoliths from the Northeast Atlantic bony fishes (Härkönen 1986). The number of each fishs species in a stomach were estimated as the highest number of either left or right sided otoliths depending on which gave the highest number of individuals. If otoliths were severely eroded and difficult to determine as left or right sided, the total number were divided by two to rely the number of individuals.

*Analysis of organochlorines*
The organochlorine analysis were done at the Research Institute for Nature Management (R.I.N.) in Holland. A modified clean-up procedure as described by Holden and Marsden (1969) was used, combined with a high resolution gas-liquid chromatography with electron capture detector (GLC-ECD). Selection of animals tab.6.

## RESULTS

### Distribution

A total of 149 pods of harbour porpoises comprising 429 individuals were recorded by Norwegian vessels during NASS -89. The observations grouped into two geographical components (Fig. 2); a southern component mainly in the North Sea area, and a northern component from Lofoten and northwards.

A total of 90 incidental sightings of harbour porpoises are recorded in the period from 1964 to 1988. The incidental sightings are recorded in marine fisheries statistics areas as shown in Fig. 1a. One plot in Fig. 1a may represent more than one observation recorded at the same position, and the sightings are given for each area in Table 1.

By request, the salmon fishermen reported a total of 96 incidentally caught porpoises from the drift net fishery in a six weeks period from late May to early July 1988. The incidental catches and the effort of the salmon fishery are given in Table 1 and the geographical distribution of incidental catches is also shown in Fig. 1b.

A total of 96 porpoises were reported incidentally caught in this period. The incidental catches were recorded by licence-holder, day and salmon district (Fig. 1b). Good information on effort was available for this fishery, and effort given as drift-net-meter-hours per week and salmon district, is used in this paper to compare the incidental catch per unit fishing effort in different areas (Table 1). The highest catches per unit effort were calculated from the northern North Sea and the Lofoten area. (The incidental mortality of porpoises in Norwegian fisheries is further discussed on page 8)

Both the distribution of incidental sightings and the incidental catches support the findings made by NASS-89 of an off shore distribution divided into a southern component in the North Sea and a northern component in the Lofoten-Barents Sea area.

## Pod Sizes and Abundance Estimates

*Pod sizes*

Information on pod sizes was recorded for 58 of the 90 incidental sightings of harbour porpoises. The estimated mean pod size for all 58 quantitative incidental sightings was 5.02 (c.v. 0.35). The recorded number for one of these sightings were 100 porpoises. Excluding this observation, the mean pod size for incidental sightings was 3.35 (c.v. 0.16). Information on pod sizes is given in Table 2.

The estimated mean pod size was 2.15 individuals (c.v. 0.19) for all observations made during the Sighting Survey in 1988. However, 47.4 % of the porpoises were recorded as solitary at the survey. One observation was made of a school numbering 14 individuals (Table 2). Excluding this single observation, the mean pod size was 1.76 (c.v. 0.09). This observation has also been excluded when estimating the abundance for that particular block.

*Abundance Estimates, Norwegian Sighting Survey 1988*

A total of 38 observations (79 individuals) of harbour porpoises were made during the Norwegian Sighting Survey 1988. Abundance estimates have been calculated by block using standard line transect theory, and a hazard-rate detection function as described in Øien (1989). The fitted detection function has the form:

$$g(y) = 1 - \mathrm{EXP}\,[(-y / 0.081)^{(1-3.691)}]$$

Estimates of density and abundance of harbour porpoises in each survey block are given in Table 3. The estimated total abundance in the surveyed area was 10 077 individuals (c.v. 0.45).

*Abundance Estimates, NASS-89*

Of the 149 recorded pods were 123 primary sightings and thus used for abundance calculations. For this purpose a hazard-rate detection function was fitted to the perpendicular distance data grouped by 0.05 nautical miles to estimate the effective search width. (Goodness of fit test: $X^2= 6.3$, df = 3, P>0.05). The fitted detection function then has the form :

$$g(y)1\text{-EXP}[-(y / 0.070)^{(1-3818)}]$$

The effective search half-width is then 0.095 nmi (c.v. 0.10). Total abundance in the total surveyed area (Table 4) is 93 600 (C.V. 0.22), composed of 82 600 porpoises (c.v. 0.24) in the southern component , and 11 000 porpoises (c.v. 0.44) in the northern component (see Fig. 2). For comparison between blocks surveyed both years, see Tables 3 and 4.

The effective search widths varied little between blocks, and thus the pooled data have been used in these estimations. Information on pod size is given in Table 2. The maximum pod size recorded was 30 individuals. The large pod observations have not been included in the analysis although they have been recorded as primary sightings. This is because of the difficulties involved in recording distance and angle to a large pod.

## Growth

Both males and females show a rapid increase in both length and weight during the first three years of life, after which the growth rate decreases. Fig. 3 shows the age-length relation using the von Bertalanffy growth model. The asymtotic values were 142.3 cm for males and 155.9 cm for females. The age - weight relationships in males and females are shown in Fig. 4. The asymtotic value for adult weight in males was 52.7 kg and the corresponding value for females was 49.4 kg. The maximum lengths and weights recorded were 147.0 cm and 66.0 kg for males, and for females 168.0 cm and 58.8 kg respectively.

## Reproduction

No *corpora* were recorded in ovaries of animals younger than four years of age (Table 5). At the age of four years, two out of three females had ovulated, and ovulating for the first time. *Corpora* were found in all females five years old and older.

The mean weight of testes (Fig. 5) in newborn porpoises was 3.7 g (range 2.9 g - 4.8 g) and in one year old porpoises 13.3 g (range 9.5 g - 18.7 g) At the age of three years, the testes weight ranged from 63.9 g to 815.0 g with a mean of 586.5 g. The mean testes weight in all males four years old and older was 776.5 g (range 335.0 g - 1490.0 g).

## Stomach contents

Of the 176 examined stomachs 25 % were empty or contained only fluid. The remaining stomachs contained whole fish, otoliths or squid remains. Remains of hagfish, squid and polychaetes were recorded in a few stomachs.The total number of fish individuals were estimated to 2979, based on the otoliths. These individuals belonged to 27 different species in 13 families (Fig.6).

The family Sternoptychidae represented by one species, pearlsides (*Mauroliucus muelleri* ) accounted for 35.7 % of the total number of individuals. One stomach contained otoliths from 657 pearlsides. The family Osmeridae accounted for 19.5 % ; Gadidae 19.2 % ; Clupeidae for 11.78 % and Gobiidae for 11.58 % of the individuals. Herring (*Clupea harengus*), seith (*Pollachius virens*), gobiidae sp. and capelin (*Mallotus villosus)* were the most frequently occurring species (Fig.7) .
A geographical shifting in occurrence of prey species was noted.

## Contamination of organochlorines in the blubber of male porpoises

Pesticides and industrial chemicals extracted from blubber of male porpoises for analysis, included the heptachlorocyclohexane lindane (g-HCH) and two of its isomers (α-HCH and ß-HCH), heptachlor epoxide, oxychlordane, trans-nonachlor, dieldrin, endrin, dichlorodiphenyltrichloroethane (DDT) and its metabolites (op-DDT, pp-DDT, pp-DDE, op-DDD and pp-DDD), the polychlorinated biphenyls (PCBs) and hexachlorbenzene (HCB). These 16 organochlorines were determined and quantified against specific standards of the same compounds. Concentrations ranged from 0 to 65 ppm by lipid weight.

*Organochlorine contamination and age*
Higher concentrations in older animals were observed for most of the studied organochlorines, including total PCB, total DDT, op-DDT,op-DDD and pp-DDE, dieldrin, endrin, heptachlor epoxide, trans-nonachlor and oxychlordane. There was no significant accumulation of HCB, α-, ß- and γ-HCH with age.

*Organochlorine concentration related to latitude*
Blubber concentrations of the organochlorines were examined to evaluate possible differences in their geographical distribution (Fig. 8). Levels of oxychlordane, endrin, op-DDT, α-HCH and ß-HCH were significantly different ($p<0.05$) at the three locations. Although not statistically significant, the PCBs, γ-HCH and trans-nonachlor, also displayed a clear tendency of geographical variation.

For oxychlordane (Fig.9), trans -nonachlor and endrin, the highest concentrations were recorded in porpoises from the Barents Sea. For all other organochlorines, where geographical differences were recorded, the concentrations were highest in porpoises from Kattegat. This includes the PCBs shown in Fig.10.

# DISCUSSION

## Distribution and topography

Porpoises are recorded in all Norwegian waters from the fjords to deep oceanic waters. The northernmost sighting was made at almost 77° N off the west coast of Spitsbergen, Svalbard. The porpoises, however, seem to be relatively more abundant in the northern North Sea area and in the Lofoten - Barents Sea are, while being relatively less abundant in the intermediate Helgeland area. If porpoises are dependent on shallow waters (for feeding or for other reasons), this divided distribution can be related to the extensive shallow shelf waters in the North Sea and the Barents Sea.

The sighting surveys were designed to cover the distribution of minke whales, and therefore not suitable to detect any porpoises in fjords and in shore coastal waters.

## Feeding ecology and contamination

Examinations of porpoises incidentally caught in gill nets indicate that they may have been feeding in a coastal environment. Two of the fish species found in the stomachs, smelt (*Osmerus eperlanus*) and houting (*Coregonus lavaretus*), are fresh- or brackish water species. A high proportion of the diet recorded was constituted by demersal species. These findings may imply that coastal and shallow shelf water are important feeding habitats for porpoises.

A geographical shift in composition of the stomach content was noted. This probably reflects the geographical differences in the availability of prey species. Geographical variation and a high number of different prey species indicate that the porpoises are opportunistic feeders on several fish species in this area, although herring was a frequently recurring species in the diet.

Bioaccumulated organochlorines are transferred to porpoises through the food webs, and geographical variations in the food webs and in the composition of the diet may account for the geographical differences in contamination levels recorded in porpoises. The recorded variation of contaminats in porpoises may also reflect differentiated pollution from local sources. The observed variations in contamination levels and particularly the distribution of different PCB congeners, may also indicate separate populations or sub-populations of porpoises in these waters. These questions call for further studies on distribution of organochlorines in the ecosystem and on the transfer of these compounds in the food webs. Samples collected for genetic stock identification may provide further information on possible sub-population structures of porpoises in Norwegian waters.

The highest levels of sum PCB and of sum DDT in porpoise recorded in this study are below levels reported from Canadian waters (Gaskin *et al.* 1983), in Danish waters (Andersen *et al.* 1976), the North Sea (Koeman *et al.* 1972 ) and in the Baltic (Huschenbeeth 1977). Although the levels of total PCB and total DDT recorded at the west coast of Norway and in the Barents Sea are lower than levls recorded in some other areas, there is still a need to monitor this potential threat to the porpoises in these waters.

## Abundance estimates

The Norwegian Sightings Survey 1988 was designed and conducted primarily to obtain information on the abundance of minke whales and other large whales. The stratification chosen for the survey, may therefore not be suitable for observation of porpoises. An additional problem is related to the rather small perpendicular distances observed, resulting in a very narrow effective strip width. An alternative fitting of the perpendicular distances to a negative exponential model gives an effective search half-width of 0.0574 (c.v. 0.28), which illustrates the problems involved. The large coefficients of variation, further emphasize the associated uncertainty.

However, the estimates for blocks surveyed both years were not very different between the two years, exept for Lofoten, were the estimate was 3 033 porpoises in 1988 compared with 603 porpoises in 1989.

The estimate of 82 600 porpoises for the North Sea indicates a "stock" size not very different from the number of grey seals in the same area. Due to uncertainties related to the estimate and the lack of comparative historical data, this estimate does not provide new information that repeal the previous information on a stock decline of porpoises in the North Sea area.

## Incidental catches and mortality of porpoises in Norwegian fisheries

In 1988 we made contact (personal letter) to all 580 fishermen licenced to catch salmon with drift nets, to examine the number of porpoises incidentally caught in that particular fishery. A total of 96 porpoises were reported caught during a six weeks period (about half the season for this fishery) from late May to early July 1988. A figure we believe was very close to the true number of porpoises caught in this fishery during that period. After the 1988 fishing season the government imposed a ban on the use of drift nets for salmon fisheries in Norwegian waters.

In 1989 and 1990 we have looked into other Norwegian gill net fisheries to assess the incidental catches of porpoises. Preliminary results of these studies indicate that the incidental catch of porpoises per unit fishing effort (net-meter-hour) in other net fisheries (set nets) are far less than in the former salmon drift net fishery. We therefore believe that porpoises were particularly vulnerable to those drift nets, and that the ban on use of drift nets in salmon fisheries led to an improvement with regard to incidental mortality of porpoises in Norwegian fisheries. The data are so far, insufficient for assessing the total mortality in Norwegian fisheries, and therefore also for assessing the impact on stocks.

## Growth and Reproduction

The number of animals analysed so far is insufficient to be conclusive about growth and reproduction of porpoises in Norwegian waters. However, the preliminary growth curves support the findings of other authors (Fisher and Harrison 1970, Gaskin and Blair 1977, von Utrecht 1978, and Kinze 1989) that female porpoise attain a larger body length, and preliminary analysis of ovaries and testes indicate that females mature one year later than males. All animals were incidentally caught in the delivery or lactation period. The smaller weight/length ratio in adult females compared with adult males, might possibly be caused by female weight loss during lactation.

The porpoises examined in Norway indicate sexual maturity at a lower age compared with the animals from the southern North Sea (von Utrecht 1978) The ages of sexual maturition recorded in our study are, however, well in accordance with the observations made by Buus Sørensen and Kinze (1990) from Danish coastal waters, and by Kinze (1989) on porpoises from West Greenland.

The number of *corpora* in five years old and older females indicate that these females had ovulated every year after their first ovulation. However, ovulation and pregnancy rates remain to be investigated when more females are examined.

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Table 1.

Incidental sightings and incidental by-catches of porpoises in drift nets set for salmon. The incidental sightings are recorded in Norwegian Marine Fisheries Statistics Areas. No effort data is available for these sightings. The incidental catches are recorded on Salmon Fisheries Districts. Salmon districts are grouped to approximate the marine fisheries areas. Effort in the salmon fishery is given as 1000 net meter hours. ICPNMH is Incidental Catch Per Net Meter Hour.

| | Incidental sightings of porpoises, 1964 - 1988 | | By-catches of porpoises in salmon nets, May - July 1988 | | | |
|---|---|---|---|---|---|---|
| Marine fisheries statistics area code | May-July | Total all months | Salmon districts, grouped to approx marine fish. areas | No. | Effort, $10^3$net m hrs | ICPNMH$10^6$ |
| 08 Egersundbanken | 11 | 13 | 11-12-14 | 5 | 6 927 | 0.72 |
| 28 Vikingbanken | 11 | 22 | 15-16-17 | 18 | 14 958 | 1.20 |
| 07 Møre | 0 | 2 | 18-19-20-22 | 19 | 23 916 | 0.79 |
| 06 Helgeland | 0 | 0 | 24-25 | 16 | 33 550 | 0.48 |
| 00+05 Vestfjorden-Malangsgr. | 4 | 10 | 26-27-28 | 20 | 13 620 | 1.47 |
| 04 Vest-Finnmark | 5 | 8 | 29-30-31 | 18 | 27 710 | 0.65 |
| - - - - - - - - - - - - | | | | | | |
| 01-02-03-10-11-12-13-14 Southeastern Barents Sea incl eastern Finnmark and Kola | 25 | 32 | - | - | - | - |
| 20-21 Bear Island and West Spitsbergen | 0 | 3 | - | - | - | - |
| Totals | 56 | 90 | - | 96 | 120 681 | 0.80 |

Table 2.
Pod sizes recorded at the Norwegian Sighting Survey July 1988, the North Atlantic Sighting Survey 1989 (NASS-89) and recorded from incidental sightings. Numbers in brackets are coefficients of variation.

| Pod size | Incidental sightings | | Sighting survey 88 | | NASS -89 | |
|---|---|---|---|---|---|---|
| | Frequency | % | Frequency | % | Frequency | % |
| 1 | 25 | 43.1 | 18 | 47.4 | 67 | 45.0 |
| 2 | 9 | 15.5 | 13 | 34.2 | 33 | 22.1 |
| 3 | 8 | 13.8 | 4 | 10.5 | 20 | 13.4 |
| 4 | 2 | 3.4 | 1 | 2.6 | 12 | 8.1 |
| 5 | 5 | 8.6 | 1 | 2.6 | 5 | 3.4 |
| 6 | 1 | 1.7 | 0 | - | 1 | 0.7 |
| 7-10 | 3 | 5.2 | 0 | - | 5 | 3.4 |
| 11-15 | 3 | 5.2 | 1 | 2.6 | 4 | 2.7 |
| 16-20 | 0 | - | 0 | - | 0 | - |
| 21-50 | 1 | 1.7 | 0 | - | 2 | 1.3 |
| 51-100 | 1 | 1.7 | 0 | - | 0 | - |
| Total sightings | 58 | | 38 | | 149 | |
| Mean pod size | 5.02 (0.3493) | | 2.15 (0.1888) | | 2.92 (0.1155) | |

Table 3.
Abundance estimates of harbour porpoises based on records from the Norwegian Sighting Survey in July 1988, by blocks as defined in Øien 1989. Effective half search width is estimated by fitting a hazard-rate detection function to perpendicular distances pooled over blocks. Numbers in brackets are coefficients of variation.

| Block: | NV | NØ | LO | FI | KO |
|---|---|---|---|---|---|
| Search effort, L, aut.m. | 487.7 | 2 010.9 | 1 089.3 | 548.5 | 904.0 |
| Area: A, sq naut. m. | 52 719 | 101 339 | 37 944 | 28 129 | 28 315 |
| No of pods, n | 5 | 2 | 10 | 2 | 3 |
| Sighting rate, n/L | 0.0103 | 0.0010 | 0.0092 | 0.0036 | 0.0033 |
| | (0.5715) | (0.4400) | (0.3780) | (0.6996) | (0.8784) |
| Effective search, half width, w, naut mile | | 0.1105 | (0.4470) | | |
| Mean pod size, s | 2.00 | 1.67 | 1.92 | 1.40 | 1.71 |
| | (0.3536) | (0.2000) | (0.1713) | (0.1750) | (0.1667) |
| Porpoise density, ind/sq naut. m. | 0.0932 | 0.0076 | 0.0799 | 0.0228 | 0.0255 |
| | (0.8071) | (0.6583) | (0.6099) | (0.8485) | (0.9996) |
| Abundance | 4 914 | 766 | 3 033 | 641 | 723 |
| | (0.8071) | (0.6583) | (0.6099) | (0.8485) | (0.9996) |
| Abundance all blocks | | 10 077 | (0.4463) | | |

Table 4.

Abundance estimates of harbour porpoises based on records from Norwegian vessels in the North Atlantic Sighting Survey July 1989 (NASS-89), by blocks as defined in Øien 1990. Effective half search width is estimated by fitting a hazard-rate detection function to perpendicular distances pooled over blocks. Numbers in brackets are coefficients of variation.

| Block: | BA | CA | KO | FI | LO | NØ | SN | NS |
|---|---|---|---|---|---|---|---|---|
| Search effort, L, aut.m. | 1955.8 | 923.8 | 1299.5 | 582.6 | 1231.7 | 1858.4 | 1508.6 | 1751.1 |
| Area: A, sq naut. m. | 146 909 | 46 380 | 26 840 | 26 221 | 35 784 | 101 823 | 135 953 | 73 484 |
| No of pods, n | 7 | 2 | 7 | 1 | 2 | 1 | 25 | 78 |
| Sighting rate, n/L | 0.0036 | 0.0022 | 0.0054 | 0.0017 | 0.0016 | 0.0005 | 0.0166 | 0.0445 |
| | (0.3579) | (0.7164) | (1.0547) | (1.0162) | (1.2597) | (1.2296) | (0.3497) | (0.2356) |
| Effective search, half width, w, naut mile | | | | 0.1105 | (0.4470) | | | |
| Mean pod size, s | 2.86 | 1.0 | 1.5 | 2.0 | 2.0 | 1.0 | 1.79 | 3.56 |
| | (0.4416) | (0) | (0.1782) | (0) | (0.5) | (0) | (0.1249) | (0.1433) |
| Porpoise density, ind/sq naut. m. | 0.0542 | 0.0116 | 0.0427 | 0.0179 | 0.0169 | 0.0026 | 0.1566 | 0.8347 |
| | (0.5764) | (0.7227) | (1.0739) | (1.0207) | (1.3586) | (1.2333) | (0.3834) | (0.2918) |
| Abundance | 7 969 | 583 | 1 145 | 470 | 603 | 268 | 21 284 | 61 335 |
| | (0.5764) | (0.7227) | (1.0739) | (1.0207) | (1.3586) | (1.2333) | (0.3834) | (0.2918) |

| | | |
|---|---|---|
| Abundance all blocks | 93 612 | (0.2165) |
| Abundance southern component (North Sea area) | 82 619 | (0.2381) |
| Abundance northern component (Lofoten - Barent Sea area) | 10 994 | (0.4435) |

Table 5.
The age-specific frequency of sexually immature and mature female harbour porpoises from Norwegian coastal waters.

| Age | No. of animals examined | Immature | Mature |
|---|---|---|---|
| 0 | 1 | 1 | 0 |
| 1 | 8 | 8 | 0 |
| 2 | 6 | 6 | 0 |
| 3 | 3 | 3 | 0 |
| 4 | 3 | 1 | 2 |
| 5 | 1 | 0 | 1 |
| 6 | 0 | - | - |
| 7 | 0 | - | - |
| $8^+$ | 1 | 0 | 1 |

Table 6.
Number of porpoises and age distribution from the three locations, Kattegat, northern North Sea and Barents Sea, selected for organochlorine analysis.

| | Age | Kattegat | northern North Sea | Barents Sea |
|---|---|---|---|---|
| | 0 | - | 3 | - |
| | 1 | 5 | 1 | - |
| | 2 | 4 | 1 | 1 |
| | 3 | 1 | 4 | - |
| | 4 | 1 | 2 | - |
| | 5 | - | 1 | 2 |
| | 6 | - | - | 1 |
| | 7 | - | 1 | - |
| | $8^+$ | 1 | 2 | 3 |
| Number of animals | | 12 | 15 | 7 |

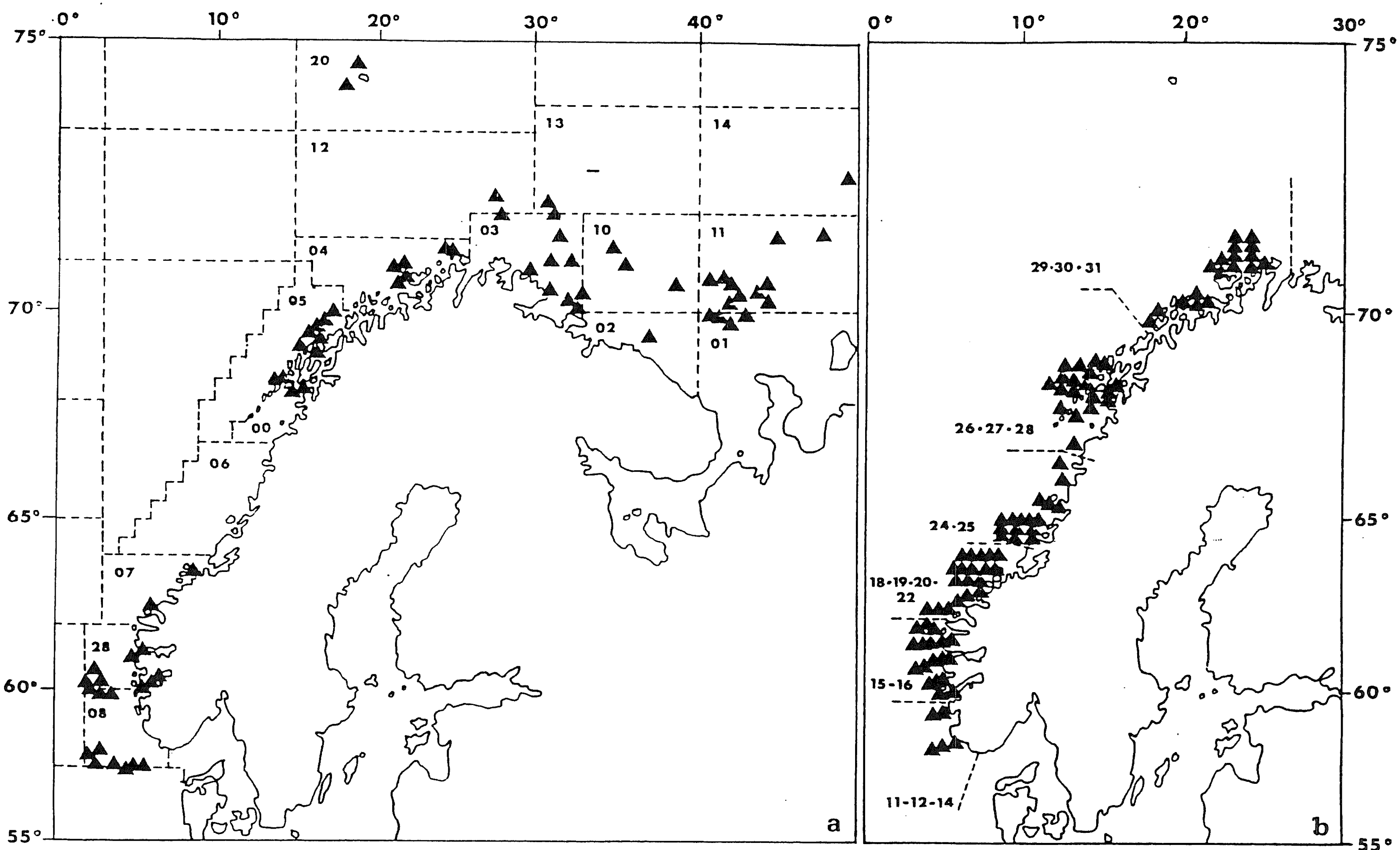


Fig. 1. Fig 1a shows the geographical distribution of incidental sightings of harbour porpoises recorded in Norwegian coastal and adjacent waters in the period 1964 - 1988, and the Marine Fisheries Statistics Areas. There is an additional incidental sighting at 77° N off the southwest coast of Spitsbergen, Svalbard. Each plot may represent more than one sighting recorded at the same position. Fig 1b shows the incidental by-catches of harbour porpoises in drift- nets set for salmon in June and July 1988, and the Salmon Districts grouped to approximate the Marine Fishery Statistics Areas.

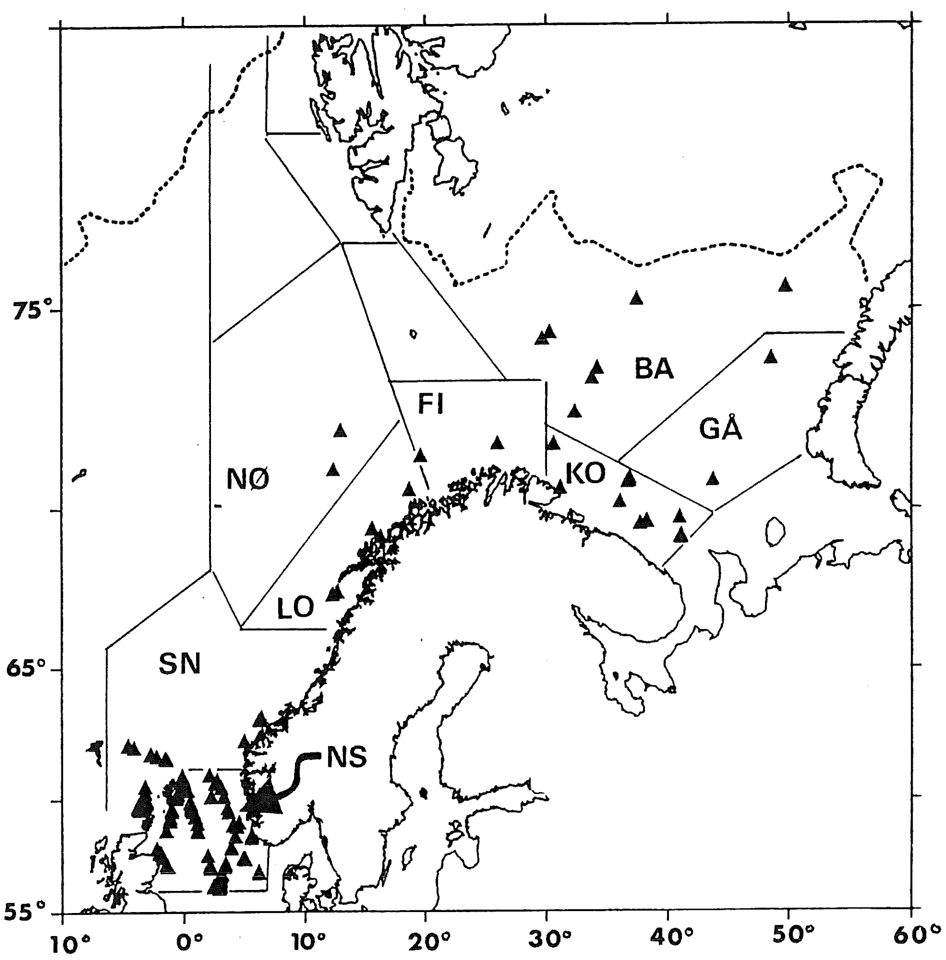


Fig. 2. Sightings of harbour porpoise and surveyed blocks by Norwegian vessels in NASS-89. The dotted line is the approximate iceedge

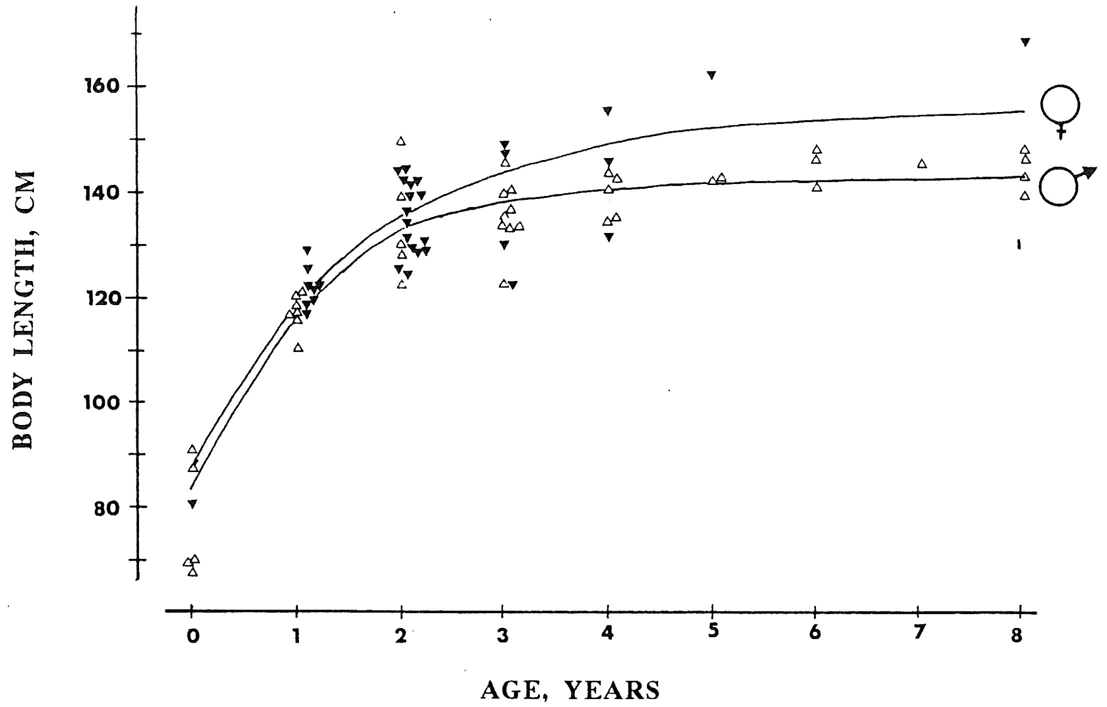


Fig. 3 The estimated age-length relationship of male and female harbour porpoises using the von Bertalanffy growth model (solid lines). Observed data are indicated with triangles, △ = males, and ▼ = females.

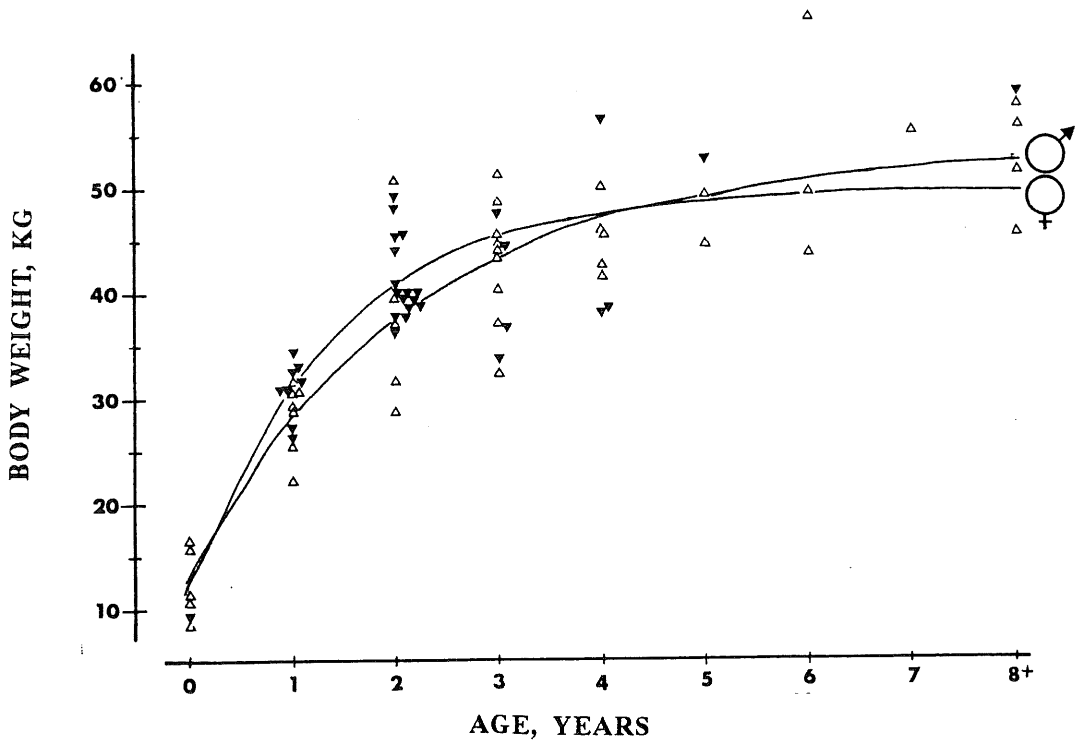


Fig. 4 The estimated age-weight relationship of male and female harbour porpoises using the von Bertalanffy growth model (solid lines). Observed data are indicated with triangles, △ = males, and ▼ = females.

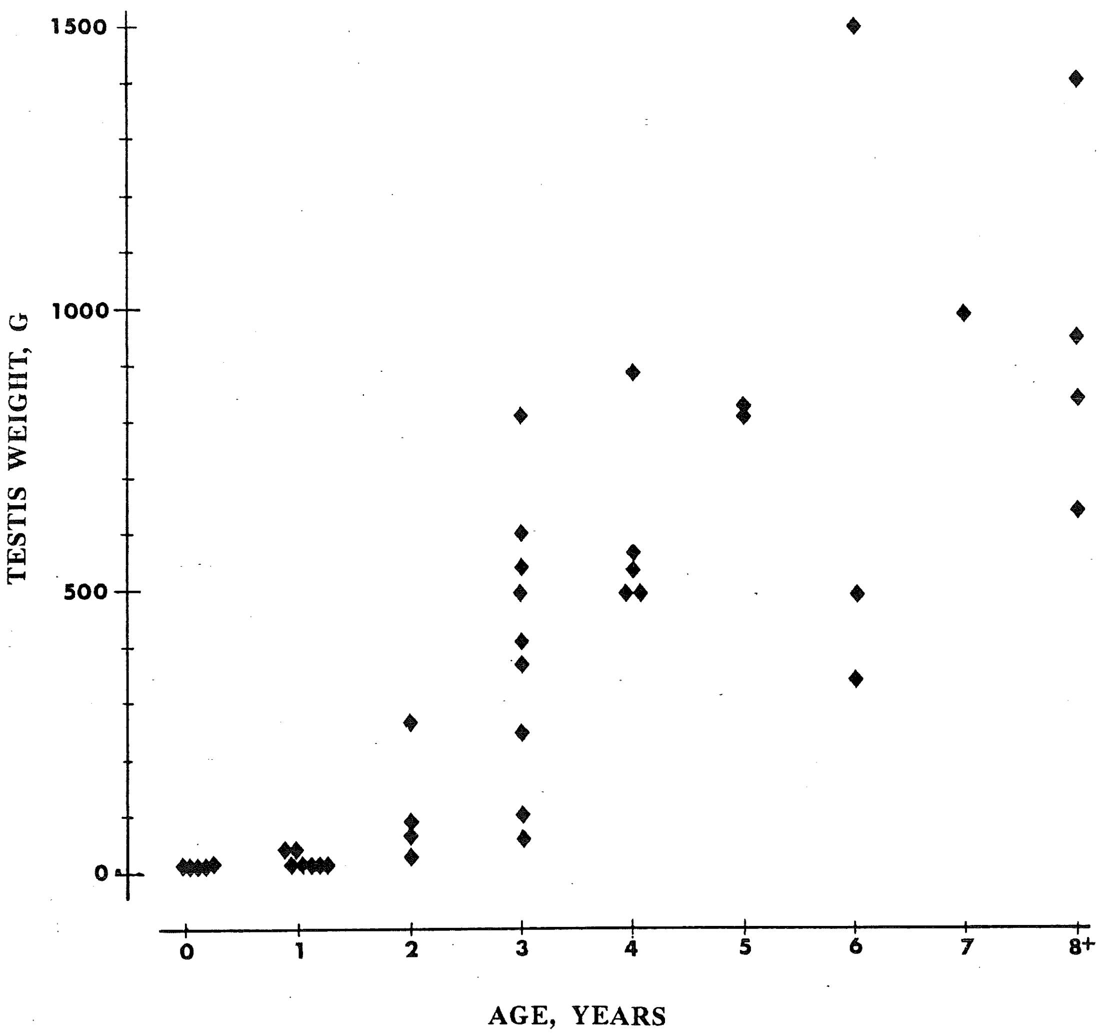


Fig. 5 The age specific weight of testes from harbour porpoises incidentally caught in Norwegian coastal waters.

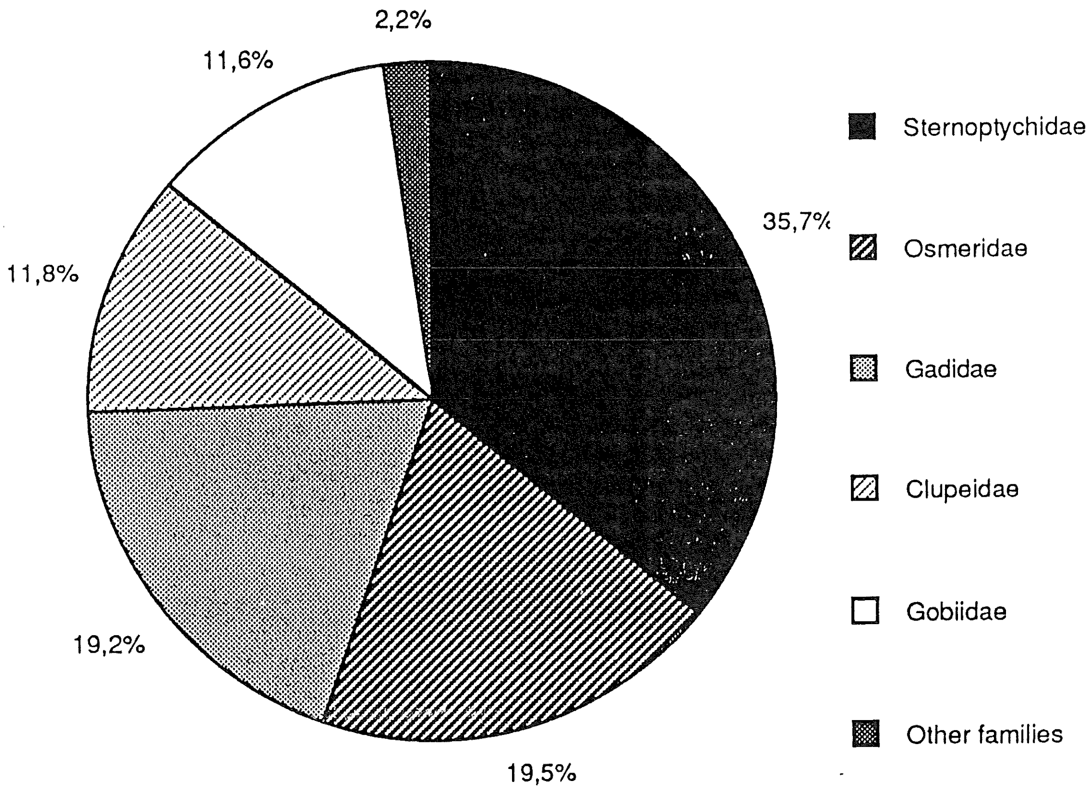


Fig. 6. The percent occurrence (by individual fish) of fish families recorded in stomach contents of harbour porpoises incidentally caught in Scandinavian waters, 1988 - 1990.

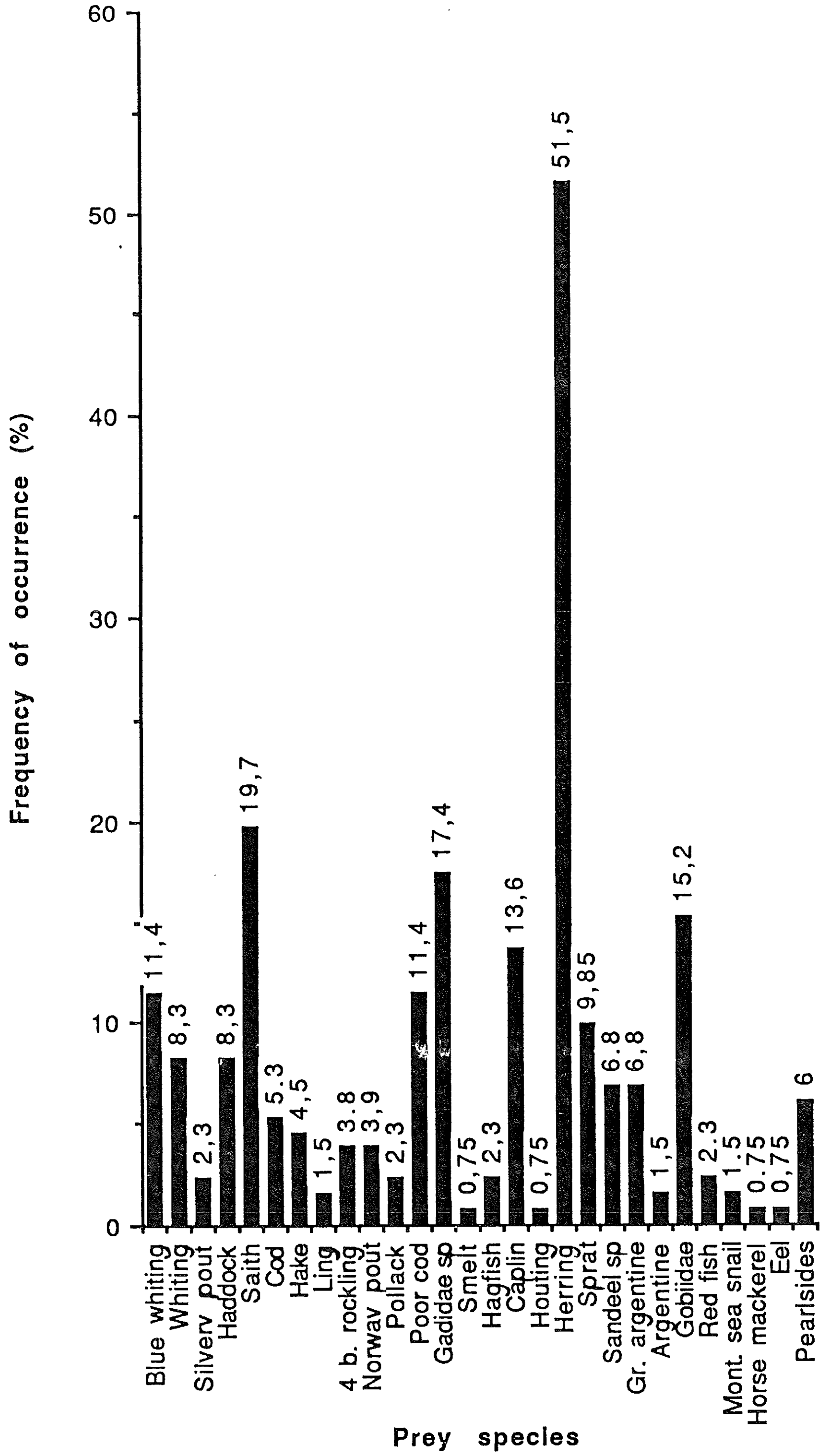


Fig.7. Frequency of occurrence of prey species recorded in stomach contents of harbour porpoises incidentally caught in Scandinavian waters, 1988 - 1990.

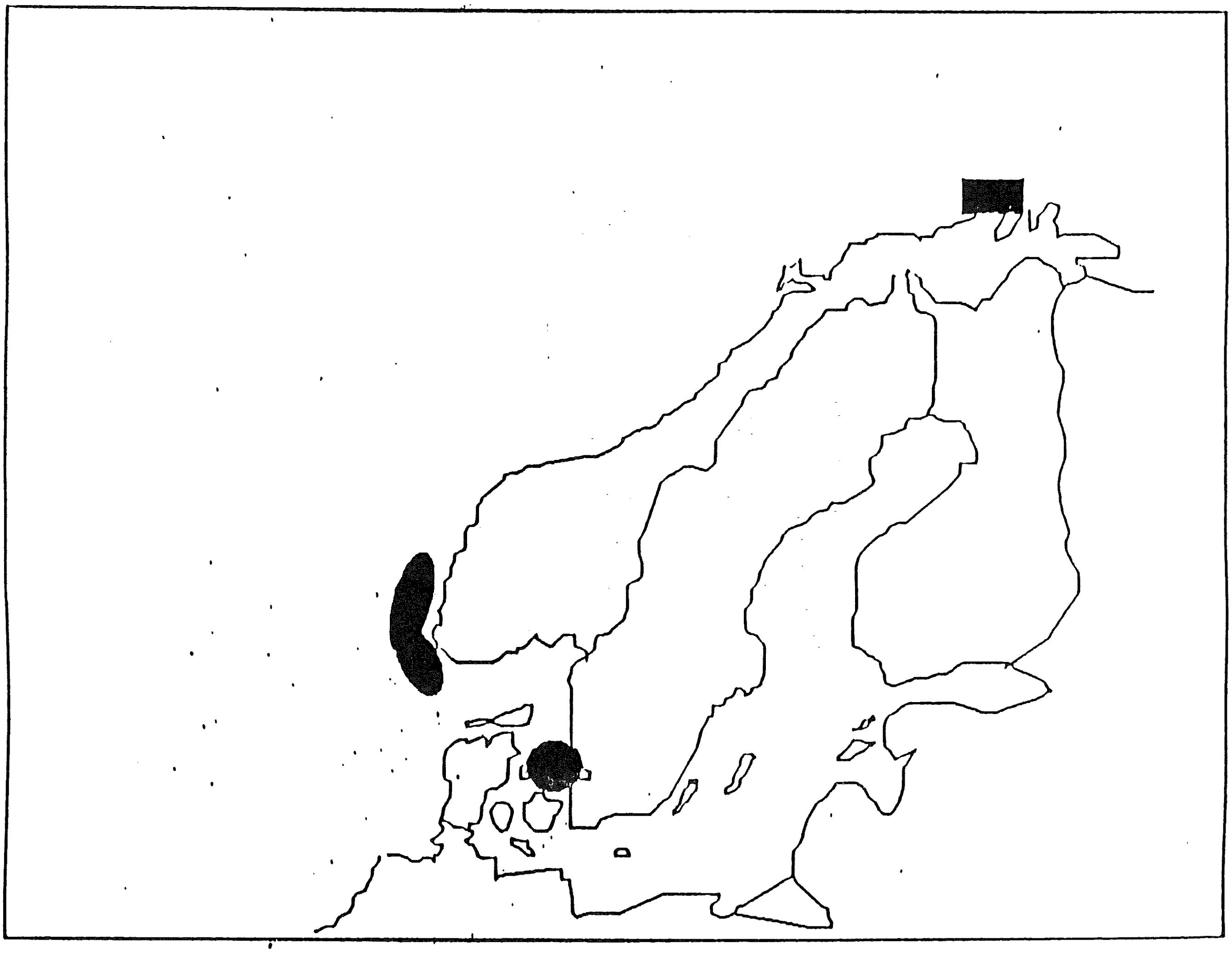

Fig. 8. Sampling areas for porpoises collected for analysing organochlorine contamination in the blubber. Porpoises from the Kattegat, were compared with porpoises from northern North Sea and the Barents Sea. All porpoises were incidentally caught in fish nets.

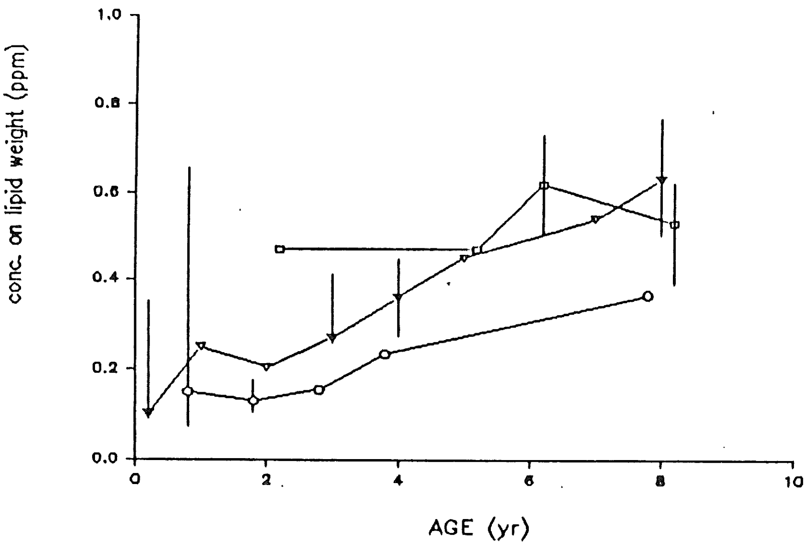


Fig. 9. Contamination of oxychlordane in blubber of male porpoises from Kattegat (O), northern North Sea (Δ) and the Barent Sea (□).

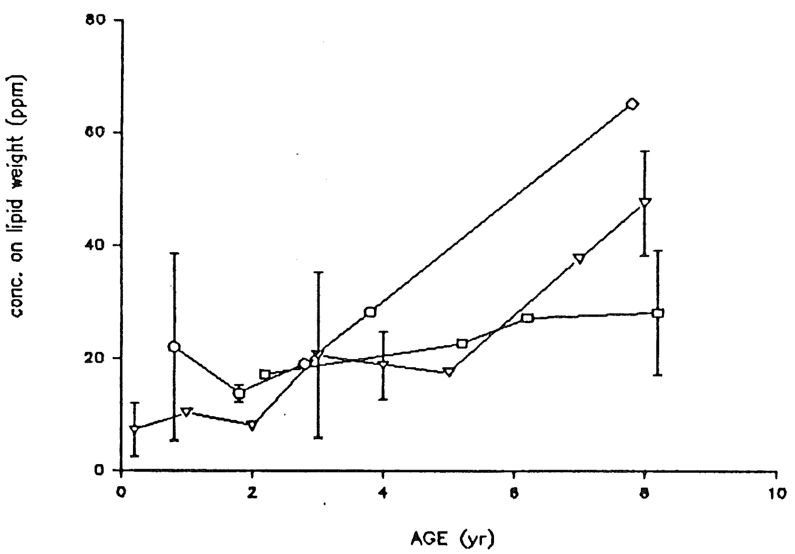


Fig. 10. Concentraton of total PCB in blubber of male porpoises from Kattegat (O), northern North Sea (Δ) and the Barent Sea (□).