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Exploration of the Sea

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REPORT OF THE STUDY GROUP ON SEALS AND SMALL CETACEANS IN EUROPEAN SEAS

Cambridge, England, 14–18 March 1994

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1 INTRODUCTION

The Study Group on Seals and Small Cetaceans in European Seas (SGSSC) met from 14–18 March 1994 at the headquarters of the British Antarctic Survey in Cambridge under the chairmanship of Dr J. Harwood. A Workshop on Factors Affecting the Survival and Reproduction of Marine Mammals, which involved members of the Study Group and a number of other scientists, was held at the same location on 14 March 1994. The report of the workshop (WP1) was considered at the meeting.

The agreed agenda for the meeting is attached as Annex 1. Annex 2 contains a list of Study Group members. Working Papers for the meeting are listed in Annex 3.

2 TERMS OF REFERENCE

The terms of reference (C.Res.1993/2:65) for this meeting of the Study Group on Seals and Small Cetaceans in European Seas were to:

a) carry out a comprehensive review of the current and historical size of the marine mammal populations within its area of responsibility and the methods used to estimate them, and develop a standardized format for presenting this information; the area of responsibility of the Study Group will be extended to include Division VIb, VIIc and k, VIIIc,d,e, IXa and b, and the coasts of the Azores archipelago in Sub-area X, in addition to the areas already covered;

b) assess the relative importance of factors (such as disturbance, pollution, disease, food availability, by-catches, and strandings) which are believed to have an effect upon survival and reproduction in marine mammal populations, and to identify the research that will be necessary to clarify and quantify these effects;

c) evaluate the size of seal populations in the Baltic Sea and assess their condition in relation to contamination and by-catch.

3 COMPREHENSIVE REVIEW OF CURRENT AND HISTORICAL POPULATION SIZES

3.1 Estimation Methods

The SGSSC reviewed the methods which have been used to estimate the current and historical sizes of marine mammal populations. Seal numbers are estimated from counts of animals on land, usually during the pupping or moulting season. Estimates of small cetacean numbers are usually based on line transect surveys, conducted from a ship or airplane, or on photoidentification studies where individual animals are identified by their unique marks or scars.

3.1.1 Seals: counts during the pupping season

This method has been used extensively to estimate the size of grey seal populations. Grey seals breed colonially on a relatively small number of remote islands, caves, or beaches. They can be counted from aerial photographs of the colony or directly on the ground. Pups are born over a period of weeks or months; they are fed by their mothers for approximately 20 days and then abandoned. They may leave the colony soon after this. As a result, it is unusual for all the pups born at a particular colony to be present at any one time. Two approaches have been used to compensate for this.

1. A number of counts are made at each colony during the pupping season. The total number of pups born in the season is estimated either by fitting an equation describing the way births are distributed through the season to these counts (Ward *et al.*, 1987) or by marking all pups on each count so that pups born between counts can be identified (Coulson and Hickling, 1964).

2. The count from a single survey is multiplied by a correction factor to account for pups which had left before the survey was conducted, or which will be born after the survey. This correction factor may be based on the results of detailed studies at individual colonies (Summers, 1978), or it may be arbitrary.

The relationship between the number of pups born each year and the size of the total population depends on the fecundity rate, and adult and juvenile survival rates. Population size may be estimated by fitting some underlying demographic model to a time series of pup production estimates (Hiby *et al.*, in prep.), or by multiplying the estimate of pup production by a correction factor which may be based on information about the age structure of the population (see Harwood and Prime, 1978). As a result of this process, the estimation of total population size will usually have confidence limits which are much wider than those for the estimates of pup production alone.

3.1.2 Seals: counts during the moult

Harbour seals spend much of their time out of the water during the moult, thus a large proportion (probably around 60%–Thompson and Harwood, 1990; Härkönen and Heide-Jørgensen, 1990) of the population can be counted in surveys conducted at this time. Throughout the area covered by the Study Group, counts of moulting harbour seals are usually carried out from the air using vertical or oblique photography. Aggregations of seals occur at well defined localities and it is usually possible to survey all of these aggregations within a short period. In many areas these aggregations are on sandbanks and they are easy to identify. However, in the UK many aggregations are on rocky skerries and it is difficult to identify them. In this case, a thermal-imaging camera mounted in a helicopter is used to locate aggregations, which are then photographed using a conventional camera.

Ringed seals also spend a significant proportion of their time out of the water on ice during the moult. However, they do not form large aggregations and it is not, therefore, possible to count all the seals in a particular area. Instead, randomly-chosen, low level aerial transects are flown over part of the distribution of the species, and the number of seals in a strip on either side of the aircraft is counted (Härkönen and Lunneryd, 1992).

3.1.3 Seals: counts at other times of the year

In some areas, the number of seals present on rocks, sandbanks, and skerries have been counted at times of the year other than the moulting season. Such counts are carried out from the shore, from small boats or from the air. The proportion of time that seals spend out of the water at these times of the year is known to be highly variable (Thompson and Harwood, 1990) and seals are known to move substantial distances between sites over short periods (McConnell *et al.*, 1992). Studies of harbour seals in the UK have indicated that estimates of the numbers of seals in an area based on counts made from boats are usually only half the size of counts made from the air. As a result, such counts provide a poor measure of population size.

3.1.4 Cetaceans: line transect surveys

The Scientific Committee of the International Whaling Commission has developed a standard methodology for designing, conducting and analyzing the results of line transect surveys of cetaceans (Anon., 1994). The SGSSC recommended that this methodology should be used to ensure comparability of results. It has already been adopted on a number of past and planned surveys conducted within the area covered by the Study Group (Buckland *et al.*, 1993; Øien, 1990). In particular, it will be used by the integrated survey of Small Cetacean Abundance in the North Sea (SCANS) which will take place during the summer of 1994 (see ICES, 1993).

3.1.5 Cetaceans: photoidentification studies

A number of cetacean species show sufficient variability in colour pattern and scarring that individual animals can be distinguished reliably. The number of individuals which can be identified in a particular area provides an estimate of the minimum size of the population. However, such estimates must be interpreted with caution. Catalogues of recognizable individuals are often built up over a number of years. Some individuals are only ever seen once and may be transient animals, marks may change with time resulting in the same animal being catalogued twice, and recognized animals may die. Systematic resightings of individuals can form the basis for estimates of population size and other demographic parameters using capture/recapture analysis.

3.1.6 Cetaceans: methods for determining geographical, seasonal, or long-term variations in density

Some indication of geographical, seasonal, and long-term variations in the density of cetaceans can be obtained from land-based observations, observations collected opportunistically as part of surveys directed at other species (e.g., seabirds), and from surveys directed at cetaceans which do not use standard line transect methodology but which do quantify observer effort. Information on geographic variation in density of certain small cetaceans over the North Sea and Northeast Atlantic is available from sightings made by the various national "seabirds at sea" teams (e.g., Northridge *et al.*, in press). Such density estimates may not be strictly comparable with those obtained from dedicated line transect surveys, but attempts to intercalibrate the two methods will be made during the 1994 SCANS surveys. Sightings of cetaceans at sea are also reported by coastguards, fishermen, and yachtsmen but in these cases the measures of effort are usually rather crude (number of days at sea, number of kilometres steamed in particular ICES rectangles). Nevertheless, such information can provide a useful indication of seasonal and regional variations in abundance, and can be used to improve the efficiency of dedicated surveys. Other examples are trial surveys of harbour porpoise abundance using passive acoustic detection currently being carried out on the west coast of Scotland. The effectiveness of this method will also be investigated during the SCANS survey.

The SGSSC suggested that valuable information on the distribution of small cetaceans could be obtained if fishermen were required to record the location, species, and length of all by-catches of these animals in their logbooks.

Sightings made by land-based observers can also provide information on trends in local density if observer effort is quantified (e.g., Evans, 1992). Such sightings only provide information on trends in density in the immediate vicinity of the observation point, but their usefulness is enhanced if time series from adjacent observation points show similar patterns of variation (e.g., Camphuysen and Leopold, 1993).

The SGSSC noted that the International Bottom Trawl Surveys will cover the entire North Sea and the

Kattegat/Skagerrak in each quarter of the year in 1995, and that a coordinated survey for mackerel eggs will cover the eastern North Atlantic from the Hebrides to Gibraltar from the beginning of February to the end of July in 1995. Vessels involved in these surveys could provide good platforms of opportunity for cetacean surveys.

3.1.7 Calculation of historical population size from catch information

In a number of cases described later in this section, the historical size of a marine mammal population had been calculated from an estimate of current population size and data on annual removals. The Study Group noted that the reliability of estimates made in this way depends critically on the quality of the data on removals which are available, on the nature of the hunting process, and on the changes in demographic parameters which may have occurred during the population's history. In general, detailed data on the age structure of the catch are not available and removals have been relatively small. As a result, errors in parameter values will have a multiplicative effect on the estimate of historical population size and this is likely to have very wide confidence limits.

3.2 Population Identity

There are many definitions of what constitutes a population. The fisheries literature distinguishes between biological stocks (groups of animals which only rarely interbreed, usually identified by the use they make of different spawning grounds) and management stocks (the fish which are exploited within a particular geographical area).

In the case of seals, most estimates of abundance are based on counts of animals at well-defined localities; these can be conveniently assigned to a number of distinct geographical areas. The areas used for each species are defined in Section 3.4.

In the case of cetaceans, most estimates of abundance are derived from estimates of density within certain, often arbitrarily defined, geographical areas. Each of these areas may include the range of a number of biological stocks, or the entire area surveyed may be only a part of the range of a single biological stock. In theory, it is possible to identify the different biological stocks which occur in a particular area using a combination of genetic, toxicological, morphometric, and parasitological information. However, some of these analyses require material from dead animals which is not available for most marine mammal populations. The Study Group therefore decided to take a pragmatic approach: abundance estimates are simply associated with the area that was surveyed to produce them. In many cases, this means that abundance estimates are only available for a small part of the known range of the species.

3.3 Presentation of Information

The data which were available to the SGSSC on the abundance of seals and small cetaceans within its area are shown in Appendix Tables 1–5. Data on harp and hooded seals, and on pilot whales are not included because these species are covered by separate study groups. **For grey seals, estimates of the number of pups born and not total population size in particular areas are presented,** because the Study Group believed that these provided the most reliable measure of local population size. **For harbour seals and ringed seals, the estimates are based on counts of all age classes.** Most of these were made during the moult, but numbers for Norway come from counts made at the end of the pupping season.

Table 1 summarizes the most recently published estimates of the size of seal and small cetacean populations in the area covered by the SGSSC. It should be noted that the quality of these estimates is highly variable and that the values given for grey seals are for total population size, not numbers of pups.

3.4 Species Reviews: Seals

3.4.1 Harbour seal *Phoca vitulina* (Appendix Table 1)

Barents Sea coast
Up to 195 seals have been counted on the Barents Sea coast of Norway. There is also a small population on the Russian coast, but no counts were available to the Study Group.

West coast of Norway
The estimate of harbour seal numbers in this area is the sum of the maximum count recorded in each of nine counties during the period 1977–1989. Most counts were made outside the moulting season and are therefore subject to the problems associated with this method which are described in Section 2.1. Data from 1964–1966 are based primarily on reports from fishermen, seal hunters, and lighthouse keepers.

Oslofjord
It is estimated that this population suffered 70% mortality during the 1988 phocine distemper virus epizootic. No information on the subsequent recovery (if any) of this population was available to the Study Group.

Baltic
There appear to be two harbour seal populations in the Baltic which are genetically distinct (Goodman, pers.

comm.; Stanley, pers. comm.). The population in ICES Areas IIIb and IIIc is sometimes referred to as the "west Baltic population". This suffered 60% mortality during the 1988 epizootic and has shown no signs of recovery (Helander and Bignert, 1992). Pup mortality appears to be close to 100% in some years. The population on the east coast of Sweden, in ICES Area IIId, is sometimes referred to as the "east Baltic population". It was not affected by the 1988 epizootic and appears to be increasing in size, although it is still small and only a fraction of its size at the beginning of this century. The Study Group expressed concern about the status of both populations; this is discussed in more detail in Section 5.

Kattegat/Skagerrak
This population has been surveyed annually since 1976. It has shown a rapid recovery from the effects of the 1988 epizootic and is expected to return to its pre-epizootic level by 1995/96 (Heide-Jørgensen *et al.*, 1992). The results of Swedish surveys carried out in 1992 and 1993 were not available to the Study Group.

Limfjorden
This population suffered substantial mortality in the 1988 epizootic but has now returned to close to its pre-epizootic level.

Wadden Sea
All of the Wadden Sea populations appear to have returned to levels close to those that were observed before 1988.

Netherlands–Delta area
The harbour seal population in this area was drastically reduced by over-hunting and habitat loss during the first half of this century. Only a few seals now remain, although there seems to be potential for recolonization (Reijnders, 1985).

France
There is a small population of harbour seals in the Baie de la Somme which is monitored regularly. However, there are, as yet, very few reports of successful breeding.

Wash and east coast of England
This population suffered 50% mortality during the 1988 epizootic and showed little sign of recovery until 1992. However, this was expected because adult females were disproportionately affected by the epizootic.

North and east coasts of Scotland
This population appears to have recovered from the limited effects of the 1988 epizootic. However, there has been a directed take (probably >100) in the last year.

Orkney
Although counts made in 1993 were higher than those made in 1989, there were differences in methodology between the two surveys (the 1989 survey was based on visual counts from a helicopter, whereas a thermal-imaging camera and conventional photography were used in 1993).

Shetland
There was some concern about the potential impact of the wreck of the oil tanker MV *Braer* in January 1993 on this population. However, more harbour seals were counted during a survey in 1993 than had been counted before the oil spill. Nevertheless, there may be longer term effects on fecundity and juvenile survival if seals are consuming contaminated fish.

West coast of Scotland
Annual monitoring of local populations along the west coast of Scotland has revealed no significant changes in overall abundance over the last five years.

Outer Hebrides
There is no information on trends in this population. It is known that there is some directed take (mostly around fish farms).

Northern Ireland
The largest harbour seal population in Northern Ireland is found in Strangford Lough. The seals there have been counted annually since 1988 and numbers have declined steadily. The Study Group expressed some concern about this, given the high levels of contaminants which have been recorded in harbour seals and other marine mammals from the Irish Sea.

Republic of Ireland
No new information on harbour seal numbers in the Republic of Ireland was available to the Study Group.

3.4.2 Ringed seal *Phoca hispida* (Appendix Table 2)

Aerial surveys of ringed seal numbers in the Bothnian Bay have been conducted since 1975. These show a decline to the mid-1980s, with some evidence of an increase in numbers since that time. The status of the ringed seal in the Baltic is discussed in more detail in Section 5.

3.4.3 Grey seal *Halichoerus grypus* (Appendix Table 3)

Barents Sea coast
The values in Appendix Table 3 are the numbers of pups actually counted on individual visits to pupping sites, as reported in Haug *et al.* (in press). The maximum number counted in any one year was 328. However, the Russian authors of these figures estimate that a total of

850 pups are born each year and that this represents a population of 3400 seals. The basis for this calculation is not provided.

Finnmark, Tromsø, and Nordland

No reliable pup production figures are available for Finnmark and Tromsø. Haug *et al.* (in press) suggest that the maximum count of 171 pups for Nordland is produced by a population of 700 seals. There have been large kills of seals (324 in 1987) from this population. The available data are not adequate to determine whether numbers are increasing or decreasing.

Sør-Trøndelag

The other major pupping area for grey seals in Norway is in Froan. There are few complete counts of all the colonies within the same year. The values shown in Appendix Table 3 are the "comparable counts" from Table 1 of Wiig *et al.* (1990). The total population in Sør-Trøndelag was estimated to be 1400 animals by Øritsland and Bjørge (1982) using a factor of 4.7 to convert pup production to total population size. This factor is based on data from grey seals in the eastern Canadian Arctic. In total, about 310 seals (including 100 adult females) were killed in Froan between 1977 and 1985 (Wiig, 1987).

Baltic

In normal years, grey seals in the Baltic breed on ice and it is difficult to determine pup production. However, between 1989 and 1993 the distribution of sea ice was restricted and many grey seal pups were born on islands off the coast of Estonia. 1300 pups were counted in 1992. Counts of grey seals hauled out on skerries off the coasts of Sweden, Finland, Estonia, and Russia provide an index of abundance for this population. The counts for Finland and northern Sweden show an increasing trend whereas those for Estonia and southern Sweden do not. Together they suggest that there are at least 5000 grey seals in the Baltic (see WP2). This is consistent with the reported pup production. The status of the Baltic grey seal population is discussed in more detail in Section 5.

Kattegat/Skagerrak

Two grey seal pups have been reported from the Kattegat/Skagerrak in the last 50 years.

Wadden Sea

There are three grey seal colonies in the Wadden Sea, the maximum number of pups observed in 1993 was 32. The colony in the Netherlands has grown steadily in size since 1985. The Study Group noted that this increase exactly parallels the increase in the number of rehabilitated grey seal pups released from two Dutch rescue stations (Reijnders *et al.*, 1992), suggesting that the situation is somewhat artificial.

Northeast coast of Britain

The number of pups born at the Farne Islands, the largest colony in this area, has remained virtually constant since 1980 as a result of small directed take and disturbance, but the total number of pups born in the area has risen steadily since 1983.

Orkney

The number of pups born in this area increased throughout the 1970s, despite a directed take of up to 1200 pups each year. Since pup hunting ceased in 1983, pup production has increased at an annual rate of 10%.

Shetland

Most grey seal pups are born in small colonies in caves or on beaches under steep cliffs. This makes them difficult to survey. The last comprehensive survey of pupping sites was in 1977, but an experimental aerial survey was carried out in 1993.

Inner and Outer Hebrides

This area contains the largest grey seal colony in Europe, at the Monach Isles where more than 7000 pups were born in 1992. Pup production in this area has increased by approximately 10% annually for the last decade.

Wales

Recent surveys in this area have indicated a substantial increase in the number of pups born since the last survey in 1977.

Southwest England

Grey seal colonies in this area are almost entirely in caves, or on remote wave-swept rocks making surveys difficult and imprecise.

Republic of Ireland

The most recent published estimate of pup production in the Republic of Ireland dates from 1966.

France

A small number of pups are now born every year in the Brittany area.

Table 1. Published estimates of seal abundance in the Study Group's area. Note that the quality of these estimates is highly variable and the estimates do not necessarily correspond to the values given in the Appendix tables.

COUNTRY	AREA	YEAR	ESTIMATE	SOURCE
GREY SEAL				
Russia	Barents Sea coast	1986–1992	3 400	Haug *et al.*, in press
Norway	Finnmark	1986–1992	640–700	
	Tromsø	1986–1992	136	
	Nordland	1986–1992	900	
	Nør–Trøndelag	1979	230	Wiig, 1986
	Sør–Trøndelag	1979	1 400	
	Rogaland	1986	120	
	Baltic	1992	5 000	WP2
Germany	Wadden Sea	1992	31–40	Vogel and Koch, 1992
Netherlands	Wadden Sea	1992	178	Reijnders *et al.*, 1992
United Kingdom	Northeast Coast	1991	8 200	Hiby *et al.*, 1993
	Orkney	1991	29 000	
	Shetland	1983	3 500	
	Outer Hebrides (including Scottish mainland)	1991	41 000	
	Inner Hebrides	1991	8 700	
	Wales	1992	5 000	Baines, 1993
	Southwest England	1973	350	
Republic of Ireland		?	2 000	Lockley, 1966

COUNTRY	AREA	YEAR	ESTIMATE	SOURCE
HARBOUR SEAL				
Norway	Barents Sea coast	1977–1989	195	Bjørge, 1991
	West coast		3 341	
	Kattegat/Skagerrak	1991	3 897	Heide-Jørgensen *et al.*, 1992
	Baltic	1990	200	Helander and Bignert, 1992
Denmark	Limfjorden	1992	750	ICES, 1993
	Wadden Sea	1992	1 170	
Germany	Wadden Sea	1992	5 115	
Netherlands	Wadden Sea	1992	970	
United Kingdom	East coast England	1991	1 551	Hiby *et al.*, 1993
	East coast Scotland	1991	1 663	
	Orkney	1989	7 137	
	Shetland	1991	4 784	
	Outer Hebrides	1974	1 300	
	West coast Scotland	1988–1991	8 205	
	Northern Ireland	1978	585	Summers *et al.*, 1980
Republic of Ireland		1978	1 248	
RINGED SEAL				
	Bothnia Bay	1990	2 497	Härkönen and Lunneryd, 1992

3.5 Species Reviews: Small Cetaceans

3.5.1 Harbour porpoise *Phocoena phocoena* (Appendix Table 4)

Baltic and Kattegat/Skagerrak

Estimates of abundance are available only for a large part of ICES Area IIIc. There is some evidence from morphometric analysis that porpoises in the Baltic and Kattegat/Skagerrak are genetically different. The reported by-catches from this area appear high in relation to the apparent size of the population. For example, the reported by-catch from the Bay of Kiel in 1991 was 25 animals, the estimate of porpoise abundance for the same year was 207 (Heide-Jørgensen *et al.*, 1993). The SCANS survey will provide more information on porpoise abundance in the Kattegat/Skagerrak and western Baltic, but these estimates are likely to have low precision because few animals will be sighted. **The Study Group recommended that there was a need for better data on by-catch in this area, preferably collected by independent observers.**

Central North Sea

The SGSSC welcomed the data on porpoise by-catch in the Danish gill net fishery for cod and turbot which had been provided by the Danish Institute of Fisheries and Marine Research. WP3 was a preliminary report and analysis of an investigation into by-catch levels of harbour porpoise in that fishery, which accounts for approximately 50% of total North Sea landings using this method. The Study Group noted that a full report of the study would be submitted to the 1994 Statutory Meeting. Danish and UK registered vessels account for about 80% of all landings made using this method in the North Sea. The by-catch in the cod and turbot fisheries had been investigated using observers from the Danish Institute of Fisheries who spent 3–7 days on board vessels on a total of 51 trips and examined all by-caught animals. Most of the observed by-catch occurred along the North Sea coast of Denmark and in the central North Sea. It was estimated that the annual by-catch in the Danish gill-net fishery for cod, turbot and sole was 4629 porpoises. UK data on effort and fish landings by similar English fisheries (accounting for approximately 30% of the total catch) are available for the same period as the Danish study. **The Study Group recommended that relevant UK data should be integrated with the Danish data to estimate the potential by-catch of harbour porpoise in the central and southern North Sea, and that the Danish study should be extended to the plaice, hake, and inshore fisheries.**

Information on porpoise abundance in the area where these fisheries operated will come from the SCANS surveys. However, there were some data on abundance in the Danish North Sea and the German Bight (Danielsen *et al.*, in press). Although these surveys covered only part of the area where the gill net fishery operated, the estimated by-catch appeared high in proportion to porpoise abundance and the Study Group expressed concern about its impact on this population.

Quantified effort data from land-based observers at a number of sites around the southern North Sea suggest that local densities declined during the 1980s but they may now be recovering (Evans, 1992; Camphuysen and Leopold, 1993).

Northern North Sea

New estimates of porpoise abundance will come from the SCANS surveys. In the past, there had been a significant by-catch of porpoises in the Norwegian salmon drift net fishery. This fishery has now closed, but **the Study Group recommended that data on the by-catch in other passive gear fisheries in the northern North Sea should be collected.**

Celtic Sea

Independent observer studies of by-catch in the Irish and English gill net fisheries have recently been completed and a report will be available by mid-1994. It is known that porpoises are the principal by-catch in this fishery. The area where the fishery operates will be covered by an extension of the SCANS survey in the summer of 1994.

3.5.2 Bottlenose dolphin *Tursiops truncatus* (Appendix Table 5)

There are a number of small, apparently resident, coastal populations of bottlenose dolphins in the area covered by the Study Group. Bottlenose dolphins are also observed at lower densities offshore throughout the area, but no estimates of abundance are available. Many of the resident populations are now being studied intensively.

3.5.3 Killer whale *Orcinus orca*

No information on trends in killer whale numbers is available.

3.5.4 Other small cetacean species (Appendix Table 5)

The Study Group noted the results of the French study of dolphin by-catch in the albacore drift net fishery in the Northeast Atlantic (see Goujon *et al.*, 1993). The combination of independent observer data on by-catch and sightings surveys had made it possible to estimate a feasible range for the mortality caused by the by-catch. The Study Group commended this study as a model of the way in which data on the effects of by-catch should be collected.

The Study Group also noted that some white-beaked dolphins are by-caught in the Danish gill net fishery (see WP3).

The Study Group was informed that there was a directed take of common and spotted dolphins around the Azores. Dolphins were taken to feed bait fish in the tuna longline fishery.

Since the end of 1992 a research programme has been carried out by the Netherlands Institute for Fisheries Research in IJmuiden to quantify the by-catch of cetaceans in the Dutch pelagic fisheries. A fleet of a dozen large freezer trawlers fishes for herring, mackerel and horse mackerel in the North Sea and around the British Isles. So far, an observer has made 5 trips of 4 weeks each on different vessels. Only during the last trip, in February 1993, was a by-catch (of 1 common dolphin and 2 whitesided dolphins) observed. At the same time, skippers are asked to fill in forms to document by-catches and to land a limited number of cetaceans for further research. For this purpose, 7 dolphins (4 common dolphins, 2 whitesided dolphins, 1 whitebeaked dolphin) were landed in 1992. In 1993 so far 24 dolphins were landed for post-mortem analysis: 21 whitesided dolphins, 2 bottlenose dolphins, and 1 common dolphin. The bulk of the by-catch appears to occur in an area off southern Ireland.

4 FACTORS AFFECTING REPRODUCTION AND SURVIVAL RATES

4.1 Introduction

The Study Group agreed to limit its discussion to the way different factors affect survival and fecundity rates, rather than the way in which they may influence the survival and reproduction of individual marine mammals.

A large number of factors have been implicated in changes in survival and reproduction. Their effects can conveniently be divided into those that act directly on survival and reproduction, and those that have an indirect effect (for example, by increasing vulnerability to fatal infection, or by reducing foraging efficiency). These effects are summarized in Table 2.

The effects can also be classified into those which can, in principle, be modified rapidly through changes in human behaviour (deliberate killing, by-catch, and disturbance), and those where the response of the ecosystem to change may be slow or non-existent (pollution, food availability, disease).

Many factors may have little effect on their own, but may become important when other factors change. For example, the effects of pollution may only be evident when an animal is in poor condition as a result of changes in food availability or when it is challenged by a disease agent. The effects of disturbance may only be important when food availability is low.

Because of the synergistic way in which these factors act, it is not possible to determine their relative importance, as requested in the terms of reference. Rather, it is necessary to consider the situation of each population on a case-by-case basis. Detailed investigation is only likely to be worthwhile in situations where a population is known to be declining, or where a population is believed to be particularly vulnerable to the effects of one, or more, of the factors described below. However, identification of these effects is often hampered by the lack of baseline information on "normal" values of biological parameters for marine mammals which have not been affected by these factors. **The Study Group therefore recommended more research on low cost methods for monitoring the abundance and population characteristics of marine mammals.** The SGSSC noted that the sampling of by-caught animals is an excellent way of collecting much of this information, particularly if the by-catch is investigated by independent observers who also collect sightings information. Studies of this kind can provide baseline information on reproductive rates, contaminant levels, body condition, and diet.

The way in which the different factors can act on survival and reproduction, and specific research which is required to clarify these effects, is described below.

4.2 Deliberate Killing

Deliberate killing, either for commercial purposes or to reduce perceived damage to fishing gear or catches, is an additional source of mortality. Since natural mortality rates are low for many marine mammal species, even apparently small amounts of additional mortality can have significant effects on population dynamics. The tendency of marine mammals to aggregate in particular areas, and the vulnerability of seals when they are on land, means that high mortality rates can be imposed even when a species is relatively rare. Deliberate killing can make animals wary and, therefore, more vulnerable to the effects of disturbance.

Table 2. Direct and indirect effects of different factors on survival and reproduction.

FACTOR	DIRECT EFFECTS	INDIRECT EFFECTS
Deliberate killing or predation	Decreased survival	Disturbance leading to reduced fecundity
By-catch	Decreased survival	
Disease	Decreased survival Decreased fecundity	
Pollution	Reduced reproduction	Reduced resistance to disease
Food availability		Emigration, Decreased foraging efficiency leading to reduced fecundity or juvenile survival
Disturbance	Injury leading to decreased survival, Separation of mother and young leading to decreased juvenile survival	Emigration, Decreased foraging efficiency, Increased stress leading to reduced reproduction and reduced resistance to disease

4.3 By-Catch

By-catches have exactly the same effects on population dynamics as deliberate killing. Recent shifts in fishing practice to the use of passively fished gear have led to a significant increase in the numbers of cetaceans, and seals in some areas, which are caught in fishing gear. In most cases, levels of by-catch are poorly documented. At its last meeting, the SGSSC concluded that voluntary or postal surveys were the best method to identify fisheries where by-catch was likely to occur. The numbers of by-caught animals and the additional mortality rate which this imposes is best estimated using independent observer schemes and sightings surveys.

4.4 Disease

The mass mortalities of seals and dolphins in the North Sea, the Mediterranean Sea, and the east coast of the USA since 1987 have indicated that disease can cause significant additional mortality in some marine mammal populations. However, such events may not occur sufficiently frequently to be an important factor in the dynamics of these populations. The rapid recovery of harbour seal populations around the North Sea since 1988 suggests that disease may have only a short term effect. However, long distance movements of domestic animals and humans have become much more frequent in recent years. This has increased the risk that novel disease agents will be introduced into naïve populations where they may cause significant mortality. Such events may pose a threat to species or local populations which are already at very low levels. Reliable baseline data on the previous exposure of populations to disease is required. Sampling from by-caught and stranded animals can provide some of this information.

4.5 Live Strandings

Death after live strandings is a component of natural mortality in cetacean populations. The Study Group concluded that they are not a threat for any population in its area.

4.6 Pollution

Marine mammals, as top predators, are vulnerable to the effects of bioaccumulating pollutants, particularly those (like the organohalogens) which are fat soluble. Organochlorines and some heavy metals are known, from experimental studies of other mammals, to have an effect on reproduction and the immune system, but sensitivity to these effects varies widely between species. In marine mammals, these pollutants accumulate in tissues where they are normally relatively inactive. Their effects may only become obvious when the animals are stressed (for example, due to changes in food availability, because of disturbance, or after lactation, or exposure to disease). It is often hard to identify these effects because of the lack of good baseline data on "normal" conditions. In particular, there are no good indices of body condition available for most small cetaceans. **The Study Group therefore recommended the continued monitoring of contaminant levels in marine mammal populations, particularly those where high contaminant levels have been reported in the past, and of the possible effects of these compounds.** Such monitoring can provide information on changes in environmental levels over wide geographical areas and may provide the first evidence of the occurrence of novel compounds in the environment. In addition, further studies of the biochemical action of contaminants in marine mammals are required to provide an index of their physiological impact and the way this may vary from species to species. The basic pathways through which these compounds act is well documented in other mammal species, but the situation is complicated in marine mammals because many compounds are only mobilized under certain conditions.

4.7 Food Availability

Changes in food availability may affect marine mammal populations in a variety of different ways. In general, a decrease in availability below some threshold will reduce the efficiency of foraging and, thus, net energy intake per day. Species may respond by emigrating, by slowing their growth rate, or by economizing on some aspect of reproduction. Animals in poor condition as a result of reduced energy intake are likely to be more vulnerable to the effects of accumulated contaminants and to disease. The effect of El Niño events on seal populations in the Pacific has clearly demonstrated the consequences of large scale changes in food availability (Trillmich and Ono, 1991). The Study Group stressed the need for baseline information on body condition in marine mammal populations and for further studies of the characteristics of critical habitats for marine mammals.

4.8 Disturbance

The potential effects of disturbance on seal populations has been reviewed by Reijnders *et al.* (1993). It can directly contribute to mortality through injury caused by boat traffic, damage to seal birth lairs caused by icebreakers, and disruption of the bond between mothers and their young. The mortality caused by these events can, in theory, be measured and its impact on a population's dynamics estimated. The success of sanctuary areas for harbour seals in Denmark, Germany, and Sweden has shown how a reduction in disturbance (and hunting pressure) can allow populations to recover from low levels.

However, the indirect effects of disturbance are more difficult to evaluate. They are likely to be similar to those related to changes in food availability: disturbed animals are likely to forage less efficiently, and to be more vulnerable to the effects of pollution and disease through increased stress. Again the lack of baseline data on the "normal" behaviour of marine mammals is a handicap to evaluating the effects of disturbance. **The Study Group recommended further studies of the movements and foraging behaviour of marine mammals under disturbed and undisturbed conditions.**

5 SEALS IN THE BALTIC

5.1 Harbour Seal

The numbers of harbour seals in the Baltic are undoubtedly very much lower than they were at the beginning of the century. As noted in Section 3, there are two apparently distinct populations of harbour seals in the Baltic. The population in ICES Area IIId is small and genetically distinct (see Section 3.5.1). The population in ICES Areas IIIb and IIIc has not recovered from the effects of the 1988 phocine distemper epidemic (Helander and Bignert, 1992). Levels of contaminants in all Baltic harbour seals are relatively high (Blomkvist *et al.*, 1992), and there is a by-catch of harbour seals in the Danish and Swedish drift net fisheries for salmon (see WP2). Although the official statistics suggest that only a few animals are killed each year, these by-catches might be a significant factor in slowing down the recovery of the numerically small Baltic population.

5.2 Ringed Seal

There is considerable uncertainty about the total numbers of ringed seals in the Baltic because no information has been available for the Gulf of Finland, which holds an appreciable part of the population, since 1984. However, an aerial survey of the Gulfs of Finland and Riga is scheduled for April 1994. Regular aerial surveys of ringed seals in the Bothnian Bay commenced in 1984. These suggest that numbers have increased, although this may be the result of immigration by seals from the Gulf of Finland in response to the greatly reduced ice cover during the last five winters. At present, there are about 3000 animals in the Bothnian Bay. Durant and Harwood (1986) estimated that there may have been at least 300 000 ringed seals in the Baltic at the beginning of the century from catch statistics and an estimate of population size in the 1970s. This analysis needs to be repeated with a wider range of demographic parameter values to provide an estimate of the range of initial population sizes which are consistent with the catch history and recent survey results. Nevertheless, it is clear that the present population represents only a small fraction of the historic level. Until the 1960s, hunting was the major cause of the marked decline in the numbers of ringed seals in the Baltic Sea. However, the decline continued after hunting pressure was reduced, due to reduced population fecundity which may have been caused by pollution.

There is a by-catch of ringed seals in the fixed-net fishery for salmon. This mortality appears to be low (<1% per annum), but its impact on the recovery of the population should be evaluated.

High levels of contaminants were found in Baltic ringed seals in the 1960s and 1970s. In addition, a large proportion of the adult females had uterine occlusions (Helle *et al.*, 1976), resulting in reduced fecundity (when only one horn was occluded) or sterility (when both horns were occluded). There are signs that the levels of DDT and PCBs in the blubber of ringed seals are decreasing (Blomkvist *et al.*, 1992) and there has also been a reduction in the incidence of uterine occlusions (Helle, pers comm.). The proportion of young (ages 1–4) animals taken during the spring hunt has started to increase, which provides indirect evidence of an increase in population fertility.

5.3 Grey Seal

1300 pups were counted at colonies in Estonia in 1992. The historic population was undoubtedly much larger. A figure of 100 000 has been proposed in the literature (Almkvist, 1978; 1982) but the basis for this is unclear. However, catch statistics are available and an estimate of numbers at the beginning of the century could be back-calculated using the approach described by Durant and Harwood.

The reported by-catch for the last three years has averaged 90 animals (WP2). This represents an annual mortality of 2–3%.

High pollution levels were found in Baltic grey seals in the 1960s and 1970s. Uterine occlusions were also common, although the incidence was only about half that recorded for ringed seals. There has been a reduction in the levels of DDT in grey seal blubber, but PCB levels have not changed significantly (Blomkvist *et al.*, 1992). PCB levels in grey seals may have remained relatively high if there has been a shift in the diet of the seals from white fish to fatty fish in response to recent changes in prey availability.

5.4 Recommendations

The Study Group on Seals and Small Cetaceans in European Seas recommended that there should be further modelling studies of the population dynamics of all three seal species in the Baltic Sea. This should include an investigation of the effect of current reported by-catches on the recovery of the ringed and grey seal populations, and back calculations of popu-

lation size at the beginning of the century. If these calculations indicate that the by-catch is having a significant effect, efforts should be made to obtain more reliable estimates of the extent and timing of the by-catch so that the effectiveness of management measures can be evaluated.

The vulnerability of the small, but genetically distinct, west Baltic harbour seal population to extinction should be investigated.

6 PURPOSE AND TIMING OF FUTURE MEETINGS

The Study Group on Seals and Small Cetaceans in European Seas recommended that it should meet again in December 1995, when the results of the SCANS surveys would be available and it would be possible to evaluate the impact of a number of cetacean by-catches.

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ANNEX 1

ICES STUDY GROUP ON SEALS AND SMALL CETACEANS IN EUROPEAN SEAS

Cambridge, England, 15–18 March 1994

AGENDA

1. Chairman's introduction
2. Appointment of rapporteurs
3. Comprehensive review of current and historical population sizes
   - 3.1 Estimation methods
   - 3.2 Population identity
   - 3.3 Format for presenting information
   - 3.4 Species reviews: seals
     - 3.4.1 *Phoca vitulina*
     - 3.4.2 *Pusa hispida*
     - 3.4.3 *Halichoerus grypus*
     - 3.4.4 Other species
   - 3.5 Species reviews: small cetaceans
     - 3.5.1 *Tursiops truncatus*
     - 3.5.2 *Phocoena phocoena*
     - 3.5.3 Other species

4. Factors affecting reproduction and survival
   - 4.1 Relative importance of:
     - 4.1.1 Disturbance
     - 4.1.2 Pollution
     - 4.1.3 Disease
     - 4.1.4 Food availability
     - 4.1.5 By-catches
     - 4.1.6 Other factors
   - 4.2 Research requirements
     - 4.2.1 Disturbance
     - 4.2.2 Pollution
     - 4.2.3 Disease
     - 4.2.4 Food availability
     - 4.2.5 By-catches
     - 4.2.6 Other factors

5. Seals in the Baltic
   - 5.1 Population size
   - 5.2 Population condition in relation to:
     - 5.2.1 Contamination
     - 5.2.2 By-catch

6. Recommendations

7. Agreement of report

ANNEX 2

STUDY GROUP MEMBERSHIP AND LIST OF MEETING PARTICIPANTS

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ANNEX 3

ACTION LIST AND RECOMMENDATIONS

Population Status

1. The Study Group expressed some concern about the decline in the number of harbour seals counted in Strangford Lough, Northern Ireland, given the high levels of contaminants which have been recorded in harbour seals and other marine mammals from the Irish Sea.

2. The Study Group recommended that there is a need for better data on the by-catch of harbour porpoises in the Baltic Sea and the Kattegat/Skagerrak, preferably collected by independent observers.

Factors Affecting Survival and Reproduction

1. The Study Group recommended more research on low cost methods for monitoring the abundance and population characteristics of marine mammals. The sampling of by-caught animals is an excellent way of collecting much of this information, particularly if the by-catch is investigated by independent observers who also collect sightings information.

2. The Study Group recommended the continued monitoring of contaminant levels in marine mammal populations, particularly those where high contaminant levels have been reported in the past, and of the possible effects of these compounds. Such monitoring can provide information on changes in environmental levels over wide geographical areas and may provide the first evidence of the occurrence of novel compounds in the environment. In addition, further studies of the biochemical action of contaminants in marine mammals are required to provide an index of their physiological impact and the way this may vary from species to species.

3. The Study Group stressed the need for baseline information on body condition in marine mammal populations and for further studies of the characteristics of critical habitats for marine mammals in order to assess the effects of changes in food availability.

4. The Study Group recommended further studies of the movements and foraging behaviour of marine mammals under disturbed and undisturbed conditions.

Seals in the Baltic

1. The Study Group recommended that there should be further modelling studies of the population dynamics of all three seal species in the Baltic Sea. This should include an investigation of the effect of current reported by-catches on the recovery of the ringed and grey seal populations, and back calculations of population size at the beginning of the century. If these calculations indicate that the by-catch is having a significant effect, efforts should be made to obtain more reliable estimates of the extent and timing of the by-catch so that the effectiveness of management measures can be evaluated. The vulnerability of the small, but genetically distinct, west Baltic harbour seal population to extinction should be investigated.

Future Meetings

The Study Group on Seals and Small Cetaceans in European Seas recommended that it should meet again in December 1995, when the results of the survey of Small Cetacean Abundance in the North Sea will be available and it will be possible to evaluate the impact of a number of cetacean by-catches.

ANNEX 4

LIST OF WORKING PAPERS
(submitted to, or prepared at, the meeting)

WP1	Harwood, J.	Report of the Workshop on Factors Affecting Marine Mammal Abundance
WP2	Helle, E.	By-catch of seals in the Baltic as reported to HELCOM
WP3	Hoffmann, E., and Vinther, M.	Preliminary information on the by-catch of harbour porpoise (*Phocoena phocoena*) in the Danish North Sea gill-net fishery

APPENDIX TABLES 1–5

THE FOLLOWING APPENDIX TABLES SUMMARIZE THE DATA ON THE CURRENT AND HISTORICAL SIZE OF SEAL AND SMALL CETACEAN POPULATIONS IN EUROPEAN SEAS WHICH WERE AVAILABLE TO THE STUDY GROUP

THE FOLLOWING CODES ARE USED TO INDICATE THE SURVEY METHOD WHICH WAS USED:

A. Single count of grey seal pups (see Section 3.1.1). These figures are usually multiplied by a correction factor to obtain an estimate of the total number of pups born during the season. Confidence limits for these numbers cannot be calculated. The way in which this factor has been obtained is not always clearly specified, so the figures shown are the actual number of pups counted.

B. Estimate of grey seal pup production obtained from a series of counts made during the breeding season (see Section 3.1.1). These estimates are inherently more accurate than those obtained using method A. Confidence limits can be calculated.

C. Counts made from aerial survey of seals hauled out in a particular area during the moult (see Section 3.1.2). Harbour seals spend much of their time out of the water during the moult, thus a large proportion (probably around 60%–Thompson and Harwood, 1990; Härkönen and Heide-Jørgensen, 1990) of the population can be counted in surveys conducted at this time. Confidence limits are available for locations where more than one survey has been made in a year.

D. Estimates of abundance based on aerial survey of ringed seal density, scaled up to provide an estimate of population size (see Section 3.1.2). Confidence limits can be calculated for these estimates.

E. Counts of seals hauled out made from boat, land or air at times other than the moult. Such counts are often made over a number of years, thus there may have been movement of animals between areas (see Section 3.1.3). No confidence limits are available.

F. Line transect survey of cetacean abundance (see Section 3.1.4). Such surveys provide estimates of the density of cetaceans in the area of the survey. These can be adjusted to take account of animals missed on the track line, and are scaled up to provide an estimate of total population size in the area surveyed. Confidence limits can be calculated.

G. Estimation based on photo-identification (see Section 3.1.5).
G1 Number of individuals in the photo-identification catalogue.
G2 Capture-recapture estimate.

H. Back-calculation of population size from catch records (see Section 3.1.7).

In the Tables, the column labelled "Directed Take" contains official statistics on the number of animals killed each year for commercial purposes or fisheries protection. The absence of figures for directed take and by-catch does not mean that there was no take or by-catch, only that figures are not available.

APPENDIX TABLE 1
HARBOUR SEAL

BARENTS SEA COAST

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS or COMMENTS	DIRECTED TAKE	BY-CATCH
1964–1966	180	E	Does not include Russia		
1977–1989	195	E	Does not include Russia		

WEST COAST OF NORWAY

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1964–1966	3 670	E	–		
1977–1989	3 341	E	–		

OSLOFJORD

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1964–1966	190	E			
1977–1989	93	E			

KATTEGAT / SKAGERRAK

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1988	2 901	C	2 497 – 3 305		
1989	3 146	C	2 823 – 3 469		
1990	2 820	C	2 247 – 3 393		
1991	3 897	C	3 157 – 4 636		

APPENDIX TABLE 1
HARBOUR SEAL

BALTIC

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS or COMMENTS	DIRECTED TAKE	BY-CATCH
1989					8
1990					5
1991					10
1992	367	E+C	120 in Denmark		
1993	269	E+C	Does not include Denmark		

LIMFJORDEN

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1976	90	C			
1977	200	C			
1978	330	C			
1979	326	C			
1980	300	C			
1981	440	C			
1982	420	C			
1983	588	C			
1984	639	C			
1985	657	C			
1986	710	C			
1987	682	C			
1989	490	C	229 - 752		
1990	498	C	426 - 570		
1991	628	C	345 - 910		

APPENDIX TABLE 1
HARBOUR SEAL

WADDEN SEA – DENMARK

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1976	389	C			
1977	410	C			
1978	332	C			
1979	421	C			
1980	671	C			
1981	656	C			
1982	789	C			
1983	924	C			
1984	853	C			
1985	958	C			
1986	1 261	C			
1987	1 477	C			
1988	–	C			
1989	868	C			
1990	1 048	C			
1991	1 097	C			
1992	1 168	C			
1993	1 433	C			

APPENDIX TABLE 1
HARBOUR SEAL

WADDEN SEA – SCHLESWIG-HOLSTEIN

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1951	1 200	C		88	
1952	1 200	C			
1953	1 275	C		94	
1954	1 350	C		109	
1955	1 700	C		172	
1956	1 200	C		166	
1957	1 650	C		194	
1958	1 700	C		254	
1959	1 420	C		270	
1960	1 410	C		261	
1961	1 720	C		272	
1962	1 400	C		256	
1963	1 210	C		206	
1964	1 420	C		276	
1965	1 620	C		273	
1966	1 660	C		277	
1967	1 605	C		226	
1968	1 560	C		265	
1969	1 710	C		261	
1970	1 647	C		230	
1971	1 490	C		178	
1972	1 500	C		195	
1973	1 600	C		93	
1974	1 544	C		31	
1975	1 749	C		39	
1976	1 653	C		36	
1977	1 806	C		25	
1978	1 795	C		10	
1979	1 919	C		12	
1980	2 202	C		15	
1981	2 200	C		20	
1982	2 350	C		35	

APPENDIX TABLE 1
HARBOUR SEAL

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1983	2 500	C		25	
1984	2 700	C		24	
1985	3 300	C		11	
1986	3 195	C		15	
1987	3 793	C		17	
1988	4 209	C			
1989	1 741	C			
1990	1 974	C			
1991	2 313	C			
1992	2 861	C			
1993	3 285	C			

WADDEN SEA – NIEDERSACHSEN

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1958/1959	1 827	?		365	
1959/1960	1 936	?		368	
1960/1961	2 250	?		482	
1961/1962	2 165	?		377	
1962/1963	2 238	?		286	
1963/1964	1 899	?		282	
1964/1965	1 695	?		318	
1965/1966	1 670	?		268	
1966/1967	1 744	?		245	
1967/1968	1 665	?		180	
1968/1969	1 541	?		185	
1969/1970	1 347	?		142	
1970/1971	1 299	?		97	
1971/1972	1 282	?		72	
1972/1973	1 441	?		47	
1973/1974	1 276	?		7	
1974/1975	1 240	?		10	
1975/1976	1 121	?		7	
1976/1977	1 163	?		4	
1977/1978	1 140	?		5	
1978/1979	1 228	?		11	
1984	1 870	C			
1985	1 929	C			
1986	2 032	C			
1987	2 245	C			
1988	–	C			
1989	1 400	C			
1990	1 620	C			
1991	1 924	C			
1992	2 255	C			
1993	2 482	C			

APPENDIX TABLE 1
HARBOUR SEAL

WADDEN SEA – NETHERLANDS

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1900	16 000	H			
1960	1 250	E			
1961	1 250	E			
1962	1 375	E			
1963	1 500	E			
1964	1 515	E			
1965	1 450	E			
1966	1 245	E			
1967	890	E			
1968	920	E			
1969	975	E			
1970	965	E			
1971	665	E			
1972	650	C			
1973	540	C			
1974	530	C			
1975	520	C			
1976	480	C			
1977	485	C			
1978	505	C			
1979	545	C			
1980	515	C			
1981	585	C			
1982	654	C			
1983	710	C			
1984	740	C			
1985	775	C			
1986	800	C			
1987	1 055	C			
1988	975	C			
1989	535	C			
1990	560	C			

APPENDIX TABLE 1
HARBOUR SEAL

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1991	750	C			
1992	960	C			
1993	1 075	C			

DELTA – NETHERLANDS

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1900	11 500	H			
1953	1 000	E			
1954	900	E			
1955	800	E			
1956	590	E			
1957	560	E			
1958	515	E			
1959	435	E			
1960	350	E			
1961	330	E			
1962	310	E			
1963	325	E			
1964	290	E			
1965	250	E			
1966	180	E			
1967	135	E			
1968	30	E			
1969	10	E			
1970	15	E			
1992	18	E			

FRANCE

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
	30	E			

APPENDIX TABLE 1
HARBOUR SEAL

WASH

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1968	1 468	C			
1969	1 722	C			
1970	1 662	C			
1971				315	
1972	1 632	C		385	
1973				395	
1974				1	
1975				1	
1976					
1977					
1978	2 176	C			
1980	2 191	C			
1988	3 026	C			
1989	1 576	C			
1990	1 531	C			
1991	1 551	C			
1992	1 645	C			
1993	1 721	C			

APPENDIX TABLE 1
HARBOUR SEAL

NORTHEAST COAST OF SCOTLAND

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1971				66	
1972				70	
1973				59	
1974				105	
1975				50	
1976				121	
1977				40	
1978					
1979					
1980				5	
1981				3	
1988	Moray Firth 1 249	C		30	
1989	Moray Firth 1 118	C			
1990	Moray Firth 1 103 Tay 467	C			
1991	Moray Firth 1 166 Tay 670	C		5	
1992	Moray Firth 1 308 Tay 773	C		1	

APPENDIX TABLE 1
HARBOUR SEAL

ORKNEY

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1971				12	
1972				116	
1973				198	
1974				198	
1975				86	
1976				96	
1977				17	
1978					
1979					
1980				28	
1982				2	
1985	6 600	C			
1989	7 100	C			
1993	7 983	C			

SHETLAND

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1971	2 500	E			
1978	4 000	E			
1984	4 800	E		4	
1985				3	
1986				10	
1987				12	
1988				23	
1991	4 797	C			
1993	6 000	C			

APPENDIX TABLE 1
HARBOUR SEAL

OUTER HEBRIDES

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1974	1 300	E		15	
1975				50	
1976				42	
1977				39	
1992	2 278	C			

NORTHERN IRELAND

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS or COMMENTS	DIRECTED TAKE	BY-CATCH
1977	348	E	Stangford Lough only		
1978	585	E	Strangford Lough = 332		
1988	1 112	E	Strangford Lough only		
1989	784	E	Strangford Lough only		
1990	898	E	Strangford Lough only		
1991	718	E	Strangford Lough only		
1992	603	E	Strangford Lough only		

APPENDIX TABLE 1
HARBOUR SEAL

REPUBLIC OF IRELAND

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1972				176	
1973				68	
1974				52	
1975				117	
1976				38	
1978	1 248	E			

APPENDIX TABLE 1
HARBOUR SEAL

WEST COAST OF SCOTLAND

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1971				267	
1972				230	
1973				250	
1974				235	
1975				190	
1976				208	
1977				211	
1978				340	
1979				350	
1980	5 900	E		350	
1981				350	
1982				3	
1983					
1984					
1985				1	
1986				22	
1987					
1988				44	
1989	8 044	C			

APPENDIX TABLE 2
RINGED SEAL

BALTIC

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS or COMMENTS	DIRECTED TAKE	BY-CATCH
1900	300 000	H			
1975	3 000	D	Gulf of Bothnia only		
1984	2 000	D			
1989	2 500	D	± 17%		
1991	2 970	D			24
1993	3 140	D			24

APPENDIX TABLE 3
GREY SEALS

NOTE: THESE ARE COUNTS OF PUPS NOT TOTAL NUMBERS

KOLA PENINSULA

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1960s	200	A			
1986	233	A			
1987	230	A			
1990	203	A			
1991	328	A			

FINNMARK

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1990	39	A			

TROMSO

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1986	27	A			
1991	17	A			

NORDLAND

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1976	130	A			
1977				70	
1987				324	
1989	105	A		32	
1991	171	A			

APPENDIX TABLE 3
GREY SEALS

NOTE: THESE ARE COUNTS OF PUPS NOT TOTAL NUMBERS

NORD-TRØNDELAG

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1979	47	A		27	

SØR-TRØNDELAG

<table>
<tr><th>YEAR</th><th>ESTIMATE</th><th>METHOD</th><th>95% CONFIDENCE LIMITS or COMMENTS</th><th>DIRECTED TAKE</th><th>BY-CATCH</th></tr>
<tr><td>1974</td><td>97</td><td>A</td><td>Froan only</td><td>27</td><td></td></tr>
<tr><td>1978</td><td>118</td><td>A</td><td>Froan only</td><td rowspan="6">310</td><td></td></tr>
<tr><td>1979</td><td>228</td><td>A</td><td></td><td></td></tr>
<tr><td>1982</td><td>114</td><td>A</td><td>Froan only</td><td></td></tr>
<tr><td>1983</td><td>172</td><td>A</td><td>Froan only</td><td></td></tr>
<tr><td>1985</td><td>173</td><td>A</td><td>Froan only</td><td></td></tr>
<tr><td>1986</td><td>167</td><td>A</td><td>Froan only</td><td></td></tr>
<tr><td>1986</td><td>167</td><td>A</td><td>Froan only</td><td></td><td></td></tr>
<tr><td>1987</td><td>141</td><td>A</td><td>Froan only</td><td></td><td></td></tr>
</table>

BALTIC

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1989					73
1990					70
1991					123
1992	1 300	A			

APPENDIX TABLE 3
GREY SEALS

NOTE: THESE ARE COUNTS OF PUPS NOT TOTAL NUMBERS

WADDEN SEA – NETHERLANDS

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1985	2	A			
1986	2	A			
1987	5	A			
1988	6	A			
1989	6	A			
1990	6	A			
1991	9	A			
1992	21	A			
1993	25	A			

WADDEN SEA – SCHLESWIG-HOLSTEIN

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1993	7	A			
1991	6	A			
1990	7	A			
1989	3	A			
1988	9	A			

FRANCE

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1993	2	A			

APPENDIX TABLE 3
GREY SEALS

NOTE: THESE ARE COUNTS OF PUPS NOT TOTAL NUMBERS

NORTHEAST COAST OF BRITAIN

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1956	751	B	complete counts		
1957	854	B			
1958	869	B			
1959	898	B			
1960	1 020	B			
1961	1 141	B			
1962	1 118	B			
1963	1 259	B			
1964	1 439	B			
1965	1 404	B			
1966	1 728	B			
1967	1 779	B			
1968	1 800	B			
1969	1 919	B			
1970	1 987	B		6	
1971	2 041	B		17	
1972	1 617	B		1 329	
1973	1 678	B		20	
1974	1 668	B		9	
1975	1 617	B		1 467	
1976	1 426	B		8	
1977	1 243	B		343	
1978	1 162	B		175	
1979	1 620	B		217	
1980	1 617	B		93	
1981	1 531	B		226	
1982	1 637	B		190	

APPENDIX TABLE 3
GREY SEALS

NOTE: THESE ARE COUNTS OF PUPS NOT TOTAL NUMBERS

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1983	1 238	B		28	
1984	1 325	B		37	
1985	1 711	B		37	
1986	1 834	B		31	
1987	1 867	B		13	
1988	1 556	B			
1989	1 921	B			
1990	2 341	B		18	
1991	2 368	B		13	
1992	2 354	B		13	

APPENDIX TABLE 3
GREY SEALS

NOTE: THESE ARE COUNTS OF PUPS NOT TOTAL NUMBERS

ORKNEY

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1964	2 204	B			
1965	2 332	B			
1966	2 467	B			
1967	2 602	B			
1968	2 826	B			
1969	2 520	B			
1970	2 712	B		731	
1971	3 018	B		975	
1972		B		699	
1973	2 835	B		341	
1974	2 964	B		975	
1975	3 016	B		1 050	
1976	3 606	B		1 020	
1977	3 686	B		841	
1978	4 136	B		1 067	
1979	4 334	B		1 015	
1980	4 842	B		1 195	
1981	5 422	B		1 219	
1982	5 656	B		1 184	
1983				8	
1984	4 908	B	± 10%	2	
1985	5 571	B	± 10%	1	
1986	5 926	B	± 10%	2	
1987	6 819	B	± 10%	21	
1988	6 264	B	± 10%		
1989	7 016	B	± 10%		
1990	7 336	B	± 10%		

APPENDIX TABLE 3
GREY SEALS

NOTE: THESE ARE COUNTS OF PUPS NOT TOTAL NUMBERS

1991	8 375	B	± 10%		
1992	9 116	B	± 10%	1 ad	

SHETLAND

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1970				60	
1971				39	
1972				30	
1973	578	A		49	
1974				73	
1975				68	
1976				72	
1977	700	A		10	
1978				59	
1979				37	
1980				40	
1981				40	
1982				49	
1983				1	
1984				1	

APPENDIX TABLE 3
GREY SEALS

NOTE: THESE ARE COUNTS OF PUPS NOT TOTAL NUMBERS

OUTER HEBRIDES

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1961	2 960	B			
1966	3 122	B			
1967	3 075	B			
1968	3 219	B			
1970	4 829	B			
1971		B		11	
1972	4 757	B		7	
1973		B		386	
1974	5 926	B		868	
1975	6 667	B		754	
1976	6 892	B		600	
1977	6 030	B		718	
1978	6 012	B		85	
1979	6 417	B		200	
1980	7 733	B		7	
1981	7 857	B		2	
1982	7 536	B			
1983		B			
1984	7 637	B	± 10%		
1985	8 123	B	± 10%	5	
1986	8 160	B	± 10%		
1987	8 689	B	± 10%	15	
1988	8 715	B	± 10%		
1989	9 429	B	± 10%		
1990	9 810	B	± 10%		
1991	10 684	B	± 10%		
1992	11 458	B	± 10%		

APPENDIX TABLE 3
GREY SEALS

NOTE: THESE ARE COUNTS OF PUPS NOT TOTAL NUMBERS

INNER HEBRIDES

YEAR	ESTIMATE	METHOD		DIRECTED TAKE	BY-CATCH
1984	1 278	B	±10%		
1985	1 324	B	±10%		
1986	1 755	B	±10%		
1987	2 080	B	±10%		
1988	1 989	B	±10%		
1989	2 044	B	±10%		
1990	2 241	B	±10%		
1991	2 495	B	±10%		
1992	2 723	B	±10%		

WALES

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1977	645	A			
1992	1 450	B			

SOUTHWEST ENGLAND

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1973	107	A			

APPENDIX TABLE 4
HARBOUR PORPOISE

BALTIC

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1819–1892	50 000	H		≈ 1 035 per year	
1916–1919				≈ 500 per year	
1941–1944				≈ 320 per year	

ICES AREA IIIc

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1992	1 196	F			

KATTEGAT/SKAGERRAK + DANISH NORTH SEA COAST

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1987	7 000	F	2 800 – 11 200		
1988 (Jan./Feb.)	7 600	F	3 500 – 11 700		
1988 (April/May)	12 800	F	6 300 – 25 900		
1980–1981					1 000 – 3 000[1]
1990					750[2]
1993					7 000[3]

[1] based on interviews with Danish fishermen
[2] based on interviews with Danish fishermen in one harbour
[3] estimated by-catch in Danish turbot and cod gill net fishery

APPENDIX TABLE 4
HARBOUR PORPOISE

GERMAN BIGHT

YEAR		ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1992	January/ February	8 800	F	5 200 - 15 000		
	April/ May	17 000	F	8 400 - 34 600		

SOUTHWEST IRELAND

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1989	19 210	F	6 408 - 32 012		

NORTHERN NORTH SEA

YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
1989	82 600	F	42 740 - 121 460		

APPENDIX TABLE 5
OTHER SMALL CETACEANS

BOTTLENOSE DOLPHIN

AREA	YEAR	ESTIMATE	METHOD	BY-CATCH
NORTHEAST SCOTLAND	1991	78 – 95	E+G1	
BRITANY	1993	30	E+G1	
MONT ST MICHEL	1993	60	E	
ARCACHON	1993	6	G1	
SADO ESTUARY		?		
CORNWALL	1991/1993	15	E	
DORSET		?		
CARDIGAN BAY	1991	14 – 106	G1	
SHANNON ESTUARY		?		
GALWAY BAY		?		
CLEW BAY		?		

KILLER WHALE

AREA	YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
NORTHERN NORTH SEA	1989	7 029	F	3 400 – 14 400		
NORTH NORWAY	1991/ 1992	475	G2			

DELPHINIDAE (MAINLY WHITE-BEAKED DOLPHIN)

AREA	YEAR	ESTIMATE	METHOD	95% CONFI-DENCE LIMTS	DIRECTED TAKE	BY-CATCH
NORTHERN NORTH SEA	1989	26 665	F	CV=71%		
	1990	16 781	F	CV=85%		

APPENDIX TABLE 5
OTHER SMALL CETACEANS

COMMON DOLPHIN

AREA	YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
NORTHEAST ATLANTIC	1992					410*
	1993	61 888	F			419*

* data from French albacore fishery only

STRIPED DOLPHIN

AREA	YEAR	ESTIMATE	METHOD	95% CONFIDENCE LIMITS	DIRECTED TAKE	BY-CATCH
NORTHEAST ATLANTIC	1992					1 193*
	1993	73 843	F			1 152*

* data from French albacore fishery only