

REPORT OF THE

**Working Group on Marine Mammal Population
Dynamics and Habitats**

By Correspondence
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International Council for the Exploration of the Sea

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1 INTRODUCTION

1.1 Participation

The following members of the Working Group on Marine Mammal Population Dynamics and Habitats (WGMMPH) participated in producing this report (see Annex 1 for addresses):

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1.2 Terms of Reference

A set of terms of reference for the Working Group was agreed at the 88th Statutory Meeting of ICES. Unfortunately, due to changes in circumstance of the designated Chair and Co-chairs, it proved impossible to meet as agreed in the ICES Council Resolution. In addition, the European Commission made an urgent request to ICES for advice on the by-catch of marine mammals in certain fisheries. Further to extensive advice on this topic, this advice was requested and given in 2001. As a consequence, the agreed terms and conditions were replaced by the following:

The Working Group on Marine Mammal Population Dynamics and Habitats [WGMMPH] (Acting interim chair: Mark Tasker, UK) will meet by correspondence to:

- a) Develop further the basis for advice to the European Commission on cetacean by-catch and mitigation measures in EU Fisheries [EC DG FISH]:
 - i) Update information on by-catches of cetaceans by species, gear, and area;
 - ii) Update information on sizes and distribution of cetacean populations against which by-catches can be counted;
 - iii) Details of gears, areas, and times associated with effective closures;
 - iv) Potential advantages and disadvantages of a generalised use of pingers in fixed gear; technical specifications affecting the effectiveness of pingers;
 - v) Potential advantages and disadvantages of a generalised use of pingers or other deterrents in pelagic trawls; updated information and technical specifications;
 - vi) Technical details of any other possible mitigation measure.
- b) Make recommendations for the future chairing of WGMMPH and suggest terms of reference for 2003.

WGMMPH will report on Term of Reference a) at the latest by 31 May (if possible earlier) to the Advisory Committee on Ecosystems (ACE) and both Terms of Reference by 31 July to ACE and the Marine Habitat and Living Resources Committees.

1.3 Justification of Terms of Reference

The first Term of Reference is based on a request for urgent advice sent by the European Commission in February 2002. It is worth noting that the group did not consider the by-catch of seals. This does not mean that there is no by-catch or necessarily that seal by-catch is not important. The group may address seal by-catch in the future.

1.4 Acknowledgements

We thank Dick de Haan, DLO-Netherlands Institute for Fisheries Research, for provision of a copy of the CETASEL report. Sharon Robertson (JNCC) helped with typing.

2 NEW INFORMATION ON BY-CATCH OF CETACEANS

2.1 Introduction

WGMPH reviewed the impact of fisheries on marine mammals in European waters in 2001 (ICES, 2001). A report produced by a working group of the European Commission's Subgroup on Fishery and Environment (SGFEN) of the Scientific, Technical and Economic Committee for Fisheries (STECF) also reviewed by-catch both in the ICES area and the Mediterranean (CEC, 2002). The latter report included information that became available after ICES (2001) was written. Relevant new information from CEC (2002) is summarised below, along with information that has become available even more recently, updating ICES (2001).

2.2 Gillnets

Figures for by-catches of harbour porpoises in the dogfish, crayfish, and skate gillnet fisheries for the period 1995–1999 in seas to the west of Scotland were presented in CEC (2002). Estimated numbers of harbour porpoises in the by-catch varied annually between 209 and 22 (Table 2.2.1) and have declined recently due to the collapse of the crayfish tangle net fishery. The total recorded effort (days at sea) in all locally based UK set-net fisheries west of Scotland has declined from 1256 to 697 days between 1995 and 2000, with the crayfish component going from 882 days to 53 days. There is, however, a significant gillnet fishery operating in deep water along the shelf edge, which has not been sampled, and for which, therefore, there are no estimates of mammal by-catch.

Table 2.2.1. Estimates of harbour porpoise by-catch to the west of Scotland (S. Northridge, pers. comm.). These estimates are for all locally based set-net fisheries, excluding the offshore freezer-netters, and are derived from individual estimates for each of the fisheries in each area.

Year	Extrapolated numbers by-caught	95 % confidence interval
1995	165	82–365
1996	156	74–349
1997	209	95–475
1998	45	34–83
1999	22	14–39

Updated estimates of the by-catch of porpoises in Danish gillnet fisheries for cod, hake, plaice, sole and turbot in the North Sea were provided by Vinther and Larsen (2002). Total estimates range from a low of 3,887 in the most recent year's data (2001) to 7,366 in 1994. These estimates, however, do not take account of the mandatory use of pingers in the cod wreck net fishery during the third quarter of the year since 2000. Vinther and Larsen (2002) estimated that the third quarter cod wreck net fishery would have been responsible for 570 porpoise entanglements in 2000 and 405 in 2001. Assuming that the effect of pingers may have been to eliminate porpoise by-catch, the most recent estimate of total mortality of 3,887 in 2001 may, therefore, be an overestimate by as much as 405 animals.

Table 2.2.2. Estimated harbour porpoise by-catch by fishery and season (quarter of year) for Danish bottom-set gillnet fishing in the North Sea (Vinther and Larsen, 2002).

Fishery	Season	1987	1988	1989	1990	1991	1992	1993	1994
Cod, wreck	1,2 and 4	97	99	89	104	102	117	116	123
	3	276	405	383	173	291	386	606	555
Cod, other	1 and 3	1410	1342	1217	919	1076	1307	1603	1578
	2 and 4	236	323	294	401	386	443	428	456
Hake	all	119	160	212	268	405	541	697	493
Turbot	2 and 3	2719	3229	2547	3067	3033	2577	2245	2534
Plaice	all	465	380	231	260	1018	1172	1014	1627
Sole	all	0	0	0	0	0	0	0	0
All	all	5322	5938	4973	5191	6312	6543	6709	7366

Fishery	Season	1995	1996	1997	1998	1999	2000	2001	Mean
Cod, wreck	1,2 and 4	117	121	130	148	126	106	67	111
	3	568	475	587	738	511	570*	405*	462
Cod, other	1 and 3	1546	1472	1514	1943	1705	1420	950	1400
	2 and 4	435	445	538	565	411	413	261	402
Hake	all	381	189	119	142	217	181	158	285
Turbot	2 and 3	2366	1999	1402	1034	737	985	1144	2108
Plaice	all	1325	1292	1018	636	521	475	903	822
Sole	all	0	0	0	0	0	0	0	0
All	all	6737	5991	5308	5206	4227	4149	3887	5591

* By-catch in this fishery is overestimated, as the effect of the use of pingers has not been taken into account.

Reijnders (pers. comm.) noted that some information on harbour porpoise by-catch in Dutch coastal waters exists. During 1997 and 1998, amongst the (on average) 50 dead porpoises annually recovered through a stranding network, around 50 % were diagnosed as being by-caught.

2.3 Tuna Driftnets

A ban on the use of these nets came into effect at the start of 2002, partly because of the scale of earlier dolphin by-catch. If fishing with this metier has ceased so, presumably, has the related dolphin by-catch.

2.4 Pelagic Trawls

Pierce *et al.* (2001) observed 73 days at sea in the UK pelagic fishery (including the North Sea and areas west of the UK) with no recorded by-catch in 69 hauls.

By-catch in the Irish experimental pair pelagic trawl fishery for albacore was observed in 1999 off western Ireland and the southern Bay of Biscay (BIM, 2000). A total of 313 hauls over 160 days were observed. A total of 145 cetaceans of four species of cetacean were caught (Table 2.4.1); more than 2/3 of these were taken in just ten hauls, with one haul accounting for 30 animals. Ninety percent of the hauls had no cetacean by-catch. This highly clustered pattern of by-catch is not unusual in pelagic trawls, probably due to the cohesive nature of dolphin social groups (Fertl and Leatherwood, 1997).

Table 2.4.1. By-catch in Irish experimental pair trawls off western Ireland and in the Bay of Biscay in 1999 (BIM, 2000).

Species	Number caught
Common dolphin	127
Striped dolphin	8
Atlantic white-sided dolphin	2
Long-finned pilot whale	8

In the UK, the Sea Mammal Research Unit (SMRU) has also monitored 195 days at sea on UK-registered pelagic trawlers during 1999–2001, covering 210 fishing operations. Target species included mackerel, herring, bass, sprats, pilchards, blue whiting, and anchovy. Of these 210 operations, cetacean by-catch (53 common dolphins) was observed in 11 hauls, all of which were in the bass fishery in the Channel (S. Northridge, pers. comm.).

2.5 Other Fisheries

Silva *et al.* (2002) observed by-catch in the pole-and line-tuna fishery off the Azores that targets tuna, mostly bigeye. A total of 617 fishing trips were monitored during the three-year study, with a total of 6554 fishing events recorded. Since there are no data on the number of fishing events per trip, the total tuna landings per trip was used as a measure of the fishing effort of the whole fleet to estimate the capture rates of cetaceans (Table 2.5.1). All the animals caught (hooked) were released alive (by cutting the fishing line), although it was impossible to know if they survived the interaction. This difficulty in assessing effect has been addressed in the USA with a set of guidelines to assess whether or not injuries sustained are “serious”.

Table 2.5.1. By-catch estimates for Azores (Silva *et al.*, 2002). Note that all of these animals were released alive after capture.

By-caught species	Fishery target	Gear	Season	Years	By-catch estimates	95 % confidence interval
Common, striped, and bottlenose dolphins	Tuna	Pole-and-line	May to October	1998	38	16.91–59.06
				1999	55	19.55–89.55
				2000	16	11.74–20.19

3 NEW INFORMATION ON CETACEAN POPULATIONS

3.1 Most Recent Abundance Estimates

There have been no recent comprehensive studies on cetacean abundance or population size in the ICES area. The most recent abundance estimates are shown in Table 3.1.1. Note that the estimate of cetacean abundance in a specified survey region is not equivalent to an estimate of population size, as biological populations may extend over wider areas, or conversely be contained within a sub-area of the survey region. Abundance estimates are usually snapshots of animal density and abundance over a short period of time. With highly mobile species such as cetaceans, the actual density or abundance of animals within a survey region may vary considerably, either seasonally or inter-annually, if those animals range outside the survey area. For animals with seasonal migrations, an estimate of abundance in one part of the range should not be used as an indication of abundance throughout the year. Mark-recapture techniques usually take longer to obtain and often result in average estimates of numbers covering longer time periods.

The variance that occurs between techniques and time of year was illustrated by Baines *et al.* (2002) for the bottlenose dolphins in Cardigan Bay. The average abundance May–September 2001 was 135 (95 % CI = 85–214) using ship-based line transect and 213 (95 % CI = 183–279) using photographic mark-recapture. However, in the centre of this period (May to mid-July 2001), the equivalent figures were 128 (67–245) using ship-based line transect and 112 (82–116) using photographic mark-recapture. There were fewer animals estimated using ship-based line transect later in the season (mid-July–September 2001), 52 (80–287), but about the same number, i.e., 211 (CI 169–304) using photographic mark-recapture.

The summed estimates of abundance of bottlenose dolphins listed here probably comprise the majority of these animals in the nearshore Atlantic waters of Europe. This species (along with harbour porpoise) is listed on Appendix II of the

EU Habitats Directive (Council Directive 92/43/EEC) as requiring special conservation measures. There is cause for concern that this “population” is low and declining (see Wilson *et al.*, 1999) and therefore requires particular measures to ensure that it suffers no further anthropogenic mortality.

Table 3.1.1. Abundance estimates of small cetacean populations in EU waters within the ICES area.

Species	Year of estimate	ICES Area	Abundance estimate	95 % Confidence limits	Method	Reference	
Harbour porpoise	1994	IIIa + b	36,046	20,276–64,083	Ship-based line transect	Hammond <i>et al.</i> , 2002	
	1995	IIIc	588	240–1,430			
		24+25 Kiel & Mecklenberg Bights	599 817	200–3,300 300–2,400	Aerial survey, line transect	Hiby and Lovell, 1996	
1994	IVa IVb + c VIIIf+g+h+j	98,564 169,888 36,280	66,679–145,697 124,121–232,530 12,828–102,604	Ship-based line transect			Hammond <i>et al.</i> , 2002
Bottlenose dolphin	1992	Moray Firth (southwestern IVa)	129	110–174	Photographic mark-recap. Photographic identification or direct observation	Wilson <i>et al.</i> , 1999 C. Liret, pers. comm. R. Gaspar, pers. comm. ICES 1996	
	2001	French coasts VIIe, VIIla	250–300	na na			
	2001	Sado Estuary	34	na			
	1991/3 1994–95	Cornwall Dorset	15 5	na	Ship-based line transect Photographic mark-recap.	White and Webb, 1995 Baines <i>et al.</i> , 2002 Ingram, 2000 ICES, 1996	
	2001	Cardigan Bay	135	85–214			
			213	183–279			
1999 1995	Shannon Estuary Dingle Bay	113 12	94–161 na				
White-beaked and Atlantic white-sided dolphins	1994	IVa	1,685	690–4,113	Ship-based line transect	Hammond <i>et al.</i> , 2002	
		IVb	9,242	5,344–15,981			
		VIIIf+g+h+j	833	159–4,360			
Atlantic white-sided dolphin	1998	Faroes-Shetland channel	21,371	10,000–45,000	Ship-based line transect	Macleod, 2001 O’Cadhla <i>et al.</i> , 2001	
	1998	VIa (N)	74,626	35,000–160,000			
	2000	parts of VI a&b, VII b/c, VIIj&k	5,490	1,134–10,015			
Killer whale	1989	IIa, IVa,b	7,057	3,400–14,400	Ship-based line transect	Øien, 1993	
Common dolphin	1994	VIIIf+g+h+j	75,449	22,900–284,900	Ship-based line transect	Hammond <i>et al.</i> , 2002 O’Cadhla <i>et al.</i> , 2001	
	2000	parts of VI a&b, VII b/c, VIIj&k	4,496	2,414–9,320			
Long-finned pilot whale	1987	V (parts of) VI	29,198 5,392		Ship-based line transect	Buckland <i>et al.</i> , 1993 Sanpera and Jover, 1987 Buckland <i>et al.</i> , 1993.	
	1989 1981–84	V (parts of) Bay of Biscay	80,867 9,739				
	1987–89 1987–89	VIII (E. of 15°W) VIII (W of 15°W)	12,235 128,080				3,924–38,148 45,241–362,640
Striped dolphin	1993	Bay of Biscay	73,843	36,113–150,990	Ship-based line transect	Goujon <i>et al.</i> , 1993	
Common dolphin	1993	Bay of Biscay	61888	35,461–108,010	Ship-based line transect	Goujon <i>et al.</i> , 1993	

4 POSSIBLE LIMITATIONS ON USE OF GEAR, TIME/AREA CLOSURES

4.1 Background

Limitations to gear use range from the complete banning of a gear type or metier, as has occurred with driftnets for large pelagics in EU waters, through partial banning on a season or area basis, to limits on fishing effort – for example, limiting the length of driftnets to 2.5 km. Additionally, the imposition of technical measures as discussed below could also be required on a seasonal or area basis, as is the case in the Danish wreck net fishery for cod.

It is important to realise that limitation on the use of fishing gear, whether total or partial, is likely to result in a redistribution of fishing effort, either into other metiers, or into adjacent areas. Any such restriction needs to target a specific goal in terms of by-catch reduction, and the effects of any likely displacement need to be considered prior to imposing the limitation if the strategy is to achieve that goal. Thus, the complete closure of a metier may eradicate by-catch by that metier, but if effort is displaced to another metier that also has a significant level of by-catch then the overall goal of minimising by-catch of a species of concern may not be achieved. Similarly, if an area of high by-catch is closed to a specific metier, but effort is redistributed to adjacent areas, the total by-catch level may not be reduced to the target level.

For seasonal or area restrictions to work, the by-catch rate within the closure should be significantly higher than the by-catch rate elsewhere. In this context, “significant” means that it should be high enough such that total by-catch will meet the management goal if fishing effort is redistributed elsewhere away from the season or area of closure or restriction. Furthermore, the difference in by-catch rates inside and outside of the season or area of closure must be consistent from year to year.

It is evident that, in order for such times or areas to be identified, there must be comprehensive by-catch observation schemes that are run from year to year. There have only been a few such observation schemes in EU waters, despite the fact that schemes are required under the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (known as the Habitats Directive). The lack of observation schemes means that it is generally not possible to define useful times or areas for closure. Furthermore, the limited nature of current observation schemes has the unfortunate effect that closures and effort limitations have been restricted to those fisheries where participants have consented or allowed observer schemes on their fleets.

The USA, in accordance with the Take Reduction Plan for harbour porpoise under the Marine Mammal Protection Act, has implemented a series of time and area closures to reduce porpoise by-catch in the Gulf of Maine multispecies gillnet fishery and Mid-Atlantic coastal gillnet fishery (Appendix to Read, 2000; Murray *et al.*, 2000).

4.2 Celtic Sea Bottom-Set Gillnets

Northridge *et al.* (2000) addressed the by-catch of porpoises in the UK and Irish Celtic Sea hake gillnet fisheries, where they postulated a requirement of a 70 % reduction in by-catch rate. They examined the observed by-catch rates by area, but could find no suitable potential areas (or seasons) for closure that might achieve this goal.

4.3 Western Channel / Bay of Biscay Pelagic Trawls

In the western English Channel and northern Bay of Biscay, there have been repeated incidents of common dolphins and other species washing up dead in late winter and early spring. In some years, there have been several hundreds of corpses, most clearly diagnosed as having died through capture in fishing nets. The origin of these animals is unclear, but the pathology of many is consistent with drowning in trawl nets. Morizur *et al.* (1999) studied by-catch using an independent observer scheme in eleven separate pelagic trawl fisheries in this area and recorded by-catch in four of them (Dutch horse mackerel, French hake, French tuna, and French sea bass). Observer effort was limited in other pelagic trawl fisheries in this area and others have arrived in the area since the study period (1993–1995).

The effect of these by-catches on the local population or populations is unknown, as is the total annual mortality. Many corpses would not wash ashore, this being dependent on variable winds and currents, and we know almost nothing about the population structure of common dolphins in this area. We cannot, therefore, easily say what proportion of the population is affected or whether the by-catch is sustainable in population terms, but there is a sufficient number of corpses washing ashore to cause considerable public and political concern.

In the first quarter of 2002, there was again considerable public concern over the numbers of dead, by-caught dolphins arriving on beaches in England and France, and several sources blamed the pelagic trawl fisheries for bass. There was,

however, no direct evidence on which to base this claim and, in addition, the greatest numbers of corpses were washed ashore before the start of the main bass fishery (in other words, other fisheries than the one for bass are also catching dolphins). These public concerns have led to calls for precautionary bans on pelagic trawling for bass in the English Channel, or bans on all pelagic trawling by vessels above a certain size. These arbitrary measures are unlikely to achieve the desired goal as they may result in shifts of effort to fisheries that occur further offshore where evidence of continued cetacean by-catch would be less obvious, as discussed above. Furthermore, there is evidence (Morizur *et al.*, 1999) that cetacean by-catch in this area is not general among all pelagic trawl metiers, so that blanket restrictions on all pelagic trawls would be regarded as inequitable by the industry. Clearly, there is an urgent need for comprehensive monitoring of the numerous trawl fisheries active in this region before we can be precise about mitigation requirements.

4.4 Eastern Central North Sea Wreck Fisheries

Vinther (1999, and pers. comm.) conducted observations on the Danish set-net fisheries. A clear peak in harbour porpoise by-catch was identified in the wreck net fishery in the period August–October. This elevated by-catch rate is the reason for the Danish wreck net fishery in this period having been selected for mandatory use of acoustic alarms. If this scheme using acoustic alarms fails (although the results so far indicate success), then this fishery might be suitable for closure in August–October. However, the utility of such a measure would depend on the specified target for by-catch reduction. Vinther and Larsen (2002) estimated that the third quarter cod wreck net fishery would have been responsible (with no pinger deployment) for just 570 porpoise by-catch deaths out of a Danish North Sea total of 4,149 porpoises (14 %) in 2000 and 405 of 3,887 (10 %) in 2001. It is not clear whether such a reduction would be sufficient, given the lack of an international management framework for porpoise by-catch reduction in the North Sea. The effect of a total seasonal closure would then also need to be weighed against the possibility of a subsequent increase in effort in areas outside the North Sea (for example in ICES area VIa) during this period as a consequence. It would also seem only fair that any restrictions on this fishery should apply not just to Danish fishers, but also to all others from other nations carrying out wreck-net fishing during August–October in this area, even though no such peak in by-catch has been observed in the by-catch rates of UK vessels fishing slightly further south and east (Northridge and Hammond, 1999).

4.5 Kattegat

The recorded by-catch in the Swedish fishery in the Kattegat and eastern Skagerrak was two harbour porpoises in 2001 (Börjesson, 2002). This is a six-fold decrease since 1996 and corresponds well with the reduction of total gillnet effort in the same period—from 60.8 million m*hours in 1996 to 10.6 million in 2000. Analysis of the distribution of 112 by-catches during the 1990s shows no clear concentrations that could be used for time/area closure. There is no new information on the Danish fishery in the same area.

4.6 Baltic Sea

It is widely agreed that the population of harbour porpoises in the Baltic Sea is seriously depleted compared with former times (e.g., Berggren *et al.*, 2002a). It is uncertain precisely why this is, but climatic problems (cold winters) and by-catch in fisheries are both implicated. A recent workshop held at Jastarnia, Poland (ASCOBANS, 2002) to draft a recovery plan concluded that, regardless of cause, urgent measures were required to allow recovery, and that a current severe pressure was by-catch. It further concluded that, as a matter of urgency, every effort should be made to reduce the porpoise by-catch towards zero as soon as possible. There was no agreement as to the precise balance of measures required (the workshop was only drafting the recovery plan for later consideration by the Parties to ASCOBANS). Nevertheless, tools available include reduction in fishing effort in certain fisheries, changing gear types away from those carrying a higher risk of by-catch, and the introduction of a pinger programme (at least on a short-term basis). Insufficient information on the distribution of either porpoises or fisheries meant that key areas of overlap cannot be suggested for effort restriction or closure at this time.

5 GENERAL USE OF PINGERS IN FIXED GEAR

5.1 Background

Pingers are acoustic deterrent devices that have relatively low acoustic source levels (typically less than 150 dB re 1 μ Pa at 1m) (Reeves *et al.*, 2001) and that can be run for periods of months or years with a small battery pack. These low power devices are not the same as the higher power acoustic devices (or Acoustic Harassment Devices) with source levels greater than 185 dB re 1 μ Pa at 1m that are used to protect coastal aquaculture sites from seal, and sometimes dolphin, predation. These latter generally require large power sources that need frequent recharging, and which are therefore unsuitable for deployment in gillnet and active gear fisheries.

Pingers were first shown to successfully reduce cetacean by-catch in Canada, primarily as a means to reduce baleen whale entrapment in coastal set-nets and traps (Lien *et al.*, 1992). These “whale pingers” operated at 2.5 kHz and were later applied experimentally to gillnets in the Bay of Fundy, where they appeared to minimise harbour porpoise by-catch (Trippel *et al.*, 1999).

Lien adapted the original design, using a higher frequency to deter porpoises from gillnets in the Northern Gulf of Maine in the early 1990s. Subsequently, a U.S. electronics company designed a commercial device which was tested successfully in a carefully designed gillnet fishing experiment in the Gulf of Maine (Kraus *et al.*, 1997). This device operated at 10 kHz with harmonics at higher frequencies, and is highly effective in reducing porpoise by-catch. Current US National Marine Fisheries Service regulations were subsequently introduced and these specify a harbour porpoise by-catch reduction pinger (300 ms pulses of a 10 kHz tonal pulse repeated at 4-second intervals with a minimum source level of 132 dB re 1 μ Pa) (Baur *et al.*, 1999). This U.S. technical specification was arrived at empirically but the statistical results of a series of observer-based studies confirm that the pingers are nevertheless effective.

Tests with captive porpoises in Holland and in Denmark suggest that more aversive acoustic signals exist than the sinusoidal tone pulses specified in the USA. Wide-band pulses with a dynamically changing spectrum (frequency sweep) were shown to be significantly more aversive than single tones (Lockyer *et al.*, 2001) in captive animals. These features have been incorporated into a pinger design employing digital signal synthesis (a programmable microcontroller) developed by Loughborough University in the UK (Newborough *et al.*, 2000). The device emits a variety of wide-band frequency-sweep type signals with randomised inter-pulse intervals. Prototypes of this design worked successfully in a trial in the Danish North Sea cod gillnet fishery in 1997 (Larsen, 1999). An improved version of this prototype is presently commercially available as AQUAmark100. More recent designs by a Dutch company (Cuckoo) incorporate a wider range of frequency sweeps in an acoustic deterrent device that is intended to mask echolocation clicks, rather than simply to deter animals. The design also includes a replaceable sealed battery pack that can be removed from the rest of the device and replaced without detaching it from the net.

5.2 Principles for the Use of Pingers

There are a number of fundamental principles that need to be addressed before any widespread introduction of pingers to a fishery or an area. These were considered by the Scientific Committee of the International Whaling Commission at its annual meeting in 1999 (IWC, 2000).

Pingers are best targeted (for cost effectiveness and efficiency) at times/areas considered most likely to have overlap between “high” porpoise densities and intensive use of nets posing a risk to the cetaceans (hotspots).

An appropriate observer programme to ensure that pingers are being properly used at sea should accompany pinger implementation.

Appropriate by-catch monitoring should continue.

5.3 Potential Advantages and Disadvantages of a Generalised Use of Pingers in Fixed Gear

The advantages of pingers are: 1) they seem to be very effective in reducing by-catch, at least in the short term; 2) they are immediately available; and 3) they allow fishing to continue. A more generalised use would also be expected to result in more competition between different manufacturers and in lower costs. However, some potential side-effects of pinger usage affect their potential suitability as mitigation devices.

5.3.1 Ease of use by fishers

There are a number of issues to be considered here, including methods of attachment, robustness, effects on fishing operations, and battery life and replacement. Cost is also a significant issue. If any of these issues result in significant operational problems, there are likely to be consequent problems with implementation and effectiveness. Several of these issues were examined in detail by SMRU *et al.* (2001) and WGMPH has not reviewed this issue in depth. There are advantages and disadvantages to all of the various devices currently on the market, with some being easier to attach to nets than others, and some having better battery life than others. Given the range of fishing strategies and gear types used even within the gillnet sector, it seems unlikely that there is any one ideal design, and a danger of being too prescriptive in device type is that this will stifle further technical innovation in the devices. The issue of the cost of devices has been addressed in the Danish fishery by the Danish Fishermen’s Association buying a stock of the devices for use by its members. An education/information programme for affected fishers on the proper use of the pingers should accompany any widespread introduction of devices.

5.3.2 Effects on targeted fish species

Although effects on targeted fish species are a concern of some fishers, there have been no indications of decreased fish catches due to the use of pingers in any of the European fisheries studied so far. It is generally thought that most fishes, other than clupeids, are unable to detect acoustic signals at the frequencies (>10 KHz) and source levels that are typically employed in acoustic deterrents. However, any widespread introduction of pingers should be accompanied by a research (and subsequent information) programme to determine any effect on fish catches. Such research could accompany necessary monitoring of the effects of pingers on cetacean by-catch.

5.3.3 Exclusion of cetaceans from habitat

Concern has been expressed that widespread use of pingers could lead to small cetaceans being excluded from habitat critical for the viability of the populations. This would be of particular concern where the cetaceans are specifically exploiting the same resources in the same areas as those used by the fishers.

There have been several studies of the effects of pingers on the use of areas by cetaceans (Koschinski and Culik, 1997; Stone *et al.*, 1997; Goodson *et al.*, 1997; Laake *et al.*, 1998; Gearin *et al.*, 2000; Culik *et al.*, 2001; Cox *et al.*, 2001; Berggren *et al.*, 2002b). In most of these studies, cetaceans were tracked visually (and sometimes also by sound) in an area containing one or more pingers. The distribution and movement of the animals were then compared when pingers were on or off. Typically, harbour porpoises were observed less frequently in areas out to between 100–500 m distant from the pingers. For example, Berggren *et al.* (2002b) studied the use of pingers on a simulated net and found that pingers (Dukane NetMark 1000™) significantly reduced the number of porpoise clicks detected within 500 m of a net. This could be partly due to movement away from the net or from reduction in click rate due to the pinger (or both), as has been noted in other studies (Cox *et al.*, 2001). The studies of Berggren *et al.* (2002b) showed that mean surfacing distance from the net in a bay (maximum offshore distance 1900 m) changed from 431 m when the pingers were off to 752 m when they were on, though some sightings were still made very close to the sound source. In general, it is likely that the area over which cetaceans are deterred from entering and/or there is a reduction in click rate will be affected by sound transmission properties of the area and ambient noise levels.

Larsen and Hansen (2000) made a rough estimate of the amount of sea that might be affected by the use of pingers if all Danish bottom-set gillnets in the North Sea were equipped with pingers. Their results suggest that, on average, only a few percent of the North Sea would be unavailable to porpoises, but this is obviously affected by assumptions on the effective range of the pingers used. Detailed spatial information on pinger usage and area affected would be required to develop this modelling further. Further research would be required to determine the long-term effects at the population level of a widespread use of pingers. Such research would be very difficult, as a small reduction in viability of a large proportion of a population could have seemingly little consequence to an individual (and therefore be difficult to detect), but have a significant effect at the population level.

Concern has been expressed that pingers lost in the sea would continue to emit signals for a considerable period and thus unnecessarily add to the areas from which small cetaceans were excluded (CEC, 2002). To avoid this risk, it would be technically feasible for some pinger types to be programmed to stop transmitting after a pre-set period of submergence. It should also be noted, however, that continued pinger activity on lost gear may facilitate its eventual recovery.

5.3.4 Habituation

None of the experimental trials to examine the effects of pingers on marine mammal behaviour has continued over typical periods or schedules that fishers might use commercially. Habituation may occur after prolonged use. Cox *et al.* (2001) tested for this and found that there was an initial avoidance response by harbour porpoises similar to those observed elsewhere, but after a few days (in one test 2.8 days, in another 8.5 days) avoidance distance had waned by 50 %. Nevertheless, the pingers continued to prove effective at keeping porpoises away from the net over the two weeks of experimental noise. Habituation will presumably occur at the individual level, and therefore will only happen if these individuals are repeatedly exposed to the pinger. It would therefore be likely that habituation effects would vary depending on the use that cetaceans make of an area. A resident group might be expected to habituate more readily than a transient group. The effect of habituation may therefore be simply to reduce the effective acoustic “exclusion zone” with time – if this becomes too small, it could result in a return to previous by-catch rates.

5.4 Technical Specifications Affecting the Effectiveness of Pingers

Several features that influence the effectiveness of pingers have been mentioned above. Characteristics of existing available pingers are shown in Table 5.4.4.1 (from Reeves *et al.*, 2001).

5.4.1 Signal

As noted above, wide-band pulses with a dynamically changing spectrum (frequency sweep) are assumed to be significantly more aversive than single tones. Random pulses (within a limit) appear to be more aversive than regular pulses. However, it is not clear that maximal aversion is the optimal strategy to adopt if the objective is to minimise by-catch while simultaneously minimising the potential area of exclusion.

5.4.2 Reliability and longevity

Pingers should be regularly checked to ensure that they perform adequately. Issues such as length of time that pingers can operate without significant maintenance (such as battery changing) are obviously important. This issue will also affect inter-pinger distance on nets (and therefore the number of pingers and their total cost). A common problem is mechanical damage to pingers when nets are set at high speed. Improved attachment arrangements and pingers that are more robust are a priority for future development.

5.4.3 Ease of use and cost

The most important feature of any implementation of pingers on nets is their acceptance by the fishers asked to deploy them. Without such acceptance, the difficulties of enforcement and monitoring are such that their effectiveness will be seriously compromised. This plainly is not solely a technical issue, but unless pingers are relatively inexpensive (or free) and do not add significantly to the workload of a fisher, then it seems doubtful that they will be readily adopted.

5.4.4 Spacing of pingers

Some redundancy is required in spacing on a net, but the work of Berggren *et al.* (2002b) suggested that most recommended net spacings (Table 5.4.4.1) were probably too close for the Dukane pinger. The louder the acoustic signal, the fewer pingers need be applied per unit net length to achieve total deterrence, but the greater the power requirement of the devices will be, and the greater the exclusion zone around the net will be. The spacing of pingers also needs to take account of the likely failure rate, and the greater this is thought to be, the more safety margin is required. Recommended distances are typically 100–200 m intervals, but effective distances will probably be defined empirically in future, and are likely to be further apart. Plainly, the reliability of pingers is an important factor.

5.4.5 Enforcement

The problem of enforcement needs to be addressed during the implementation of any statutory pinger scheme. Enforcement procedures could either involve hauling a net to check proper deployment of pingers, or the remote acoustic sensing of pingers (though these both assume that net owners can be identified), or could be port-based assuming that appropriate legislation could be framed. Some of the newer micro controller-type pingers that are able to transmit an ID code might assist in determining the owner of deployed nets.

5.4.6 Balancing technical specifications

There is probably no such thing as an ideal pinger for all fisheries. There are trade-offs between factors that affect energy consumption on the one hand and longevity on the other, especially for attachment methods which require small pinger housings. One of the most important results from the EU-funded EPIC (Elimination of harbour porpoise incidental catches) project was the realisation that signal length can be reduced considerably without reducing aversiveness, thus reducing energy consumption. Another aspect of prime importance for the effectiveness of pingers is appropriate use, e.g., appropriate attachment, particularly where it relates to sound propagation.

Table 5.4.4.1. Characteristics of pingers (from Reeves *et al.*, 2001).

Manufacturer	Dukane Corp. (discontinued)	Aquatec Sub-Sea Ltd (C)	Fumunda (C)	Lien – L1 (H)
Models	Net Mark 1000 TM (a); Netmark 2000 (b)	Aquamark 100 TM (a); Aquamark 200 (b); Aquamark 300(c)	FMP 332	Gearin (L2); McPherson (L3)
Source level max/min (dB re 1µPa @1m)	150–130	145	134–130	132–110
Battery	4 × “AA” alkaline	1 × “D” alkaline	1 × lithium	4 x PP3 alkaline
Fundamental frequency	10 kHz (US)	(a) 20–160 kHz frequency sweeps (DK); (b) similar to (a) but the frequency sweep tuned for dolphins (DK); (c) 10 kHz tonal (US)	10 kHz (US)	(L1) 2.5 Hz; (L2)3.5 kHz; (L3) 3.5 kHz
High-frequency harmonics	Yes	Yes	Yes (Barlow); no (Goodson)	Yes (sometimes!)
Pulse duration (nominal)	300 msec	300 msec	300 msec	300 msec
Inter-pulse period	4 seconds (regular)	(a, b) 4–30 seconds (randomised); (c) 4 seconds (regular)	4 seconds (regular)	<2 (L1) (regular)
Life (continuous operation)	~ 5 weeks	(a, b) 18 months to 2 years	12 months	3–4 weeks
Wet switch	(a) no, (b) yes	Yes	No	Yes
Battery change	Yes	No (option available soon)	Yes	Yes
Environmental (battery disposal)	None	20 % discount for returned units against replacements	None	None
Spacing along nets (maximum recommended)	100 m	200 m	100 m	<50 m

Notes: C = commercially available; H = home-made but used extensively in trials; L = derivative of Jon Lien’s original design for baleen whales; US = emissions specified for regulated U.S. fisheries; DK = Type 1 emissions specified for regulated Danish fisheries. Note: PICETM is not listed here, as the commercial AQUAmark 100TM is an improved derivative that transmits the same wide-band randomised acoustic signals.

5.5 Summary

Pingers have been demonstrated to be effective in mitigating small cetacean by-catch in fixed gear both in controlled experiments and in fishing operations. However, pingers have only been tested on a few small cetacean species so far. The behaviour of small cetaceans varies, which can affect the reasons why they are caught in nets (Cockcroft, 1994). Therefore, the efficacy of pingers is likely to vary between species, and it should not be assumed that pingers will be equally effective among all species and in all situations. For this reason, the Scientific Committee of the IWC recommended controlled experimental trials prior to implementing pingers in a management framework to test their efficacy in new fisheries and with different species. Even when their ability to limit by-catch has been proven, sea trials were also recommended in any proposed fishery to ensure that there are no unforeseen technical or operational problems in implementation. Furthermore, the IWC Scientific Committee also recommended that pingers should not be deployed in an uncontrolled manner, but that there should be a monitoring programme to accompany any widespread deployments of pingers to ensure that their efficacy is monitored and to guard against failures in the technology, in the management practices, or in the deterrent value of the devices as a result of habituation. The cost of enforcement will reduce the cost-effectiveness of the technology.

5.6 Recommendations

5.6.1 Western English Channel and Celtic shelf

Based on the current levels of by-catch (see ICES, 2001, and Section 2 of this report, above), it is apparent that mitigation measures are required in the gillnet fisheries of the western English Channel and the Celtic shelf. Northridge *et al.* (2000) found no “hotspots” for closure of the hake gillnet fishery. No other mitigation measure than the use of pingers is presently available that is known to be effective in these waters, apart from an overall major reduction in gillnet fishing effort. We thus recommend that a generalised use of pingers be implemented in bottom-set gillnet fisheries within the known current range of harbour porpoises in this area. This is likely to approximately cover all shelf waters south of Ireland and west of Britain and France. The eastward limit in the English Channel and southward limit to the west of France require some further research, but the limits are likely to extend at least as far as 2°W in the Channel and north of 47°N in the Bay of Biscay. Work remains to be done to establish whether mandatory pinger use by all gillnet vessels operating in these waters can be enforced, or whether a sufficient reduction in by-catches could be achieved by targeting only boats above a certain size. This latter option would limit pinger use and enforcement to the boats using the most netting, and minimise pinger deployment among some of the hundreds of small vessels working in these waters

5.6.2 Baltic Sea

The harbour porpoise population of the Baltic Sea is heavily depleted. As a consequence, ASCOBANS is drafting a recovery plan (ASCOBANS, 2002). Its current main recommendations in relation to mitigation of this by-catch are that:

- pinger use be made mandatory in Baltic high-risk gillnet fisheries, on a short-term basis (2–3 years), in at least ICES Fishing Areas 24, 25, and 26;
- trials of fish traps, fish pots, and longlines be initiated immediately, with the long-term goal of replacing gillnets in the cod fishery, particularly in areas where porpoises are known or expected to occur frequently;
- serious consideration be given to replacing driftnets with longlines in areas where porpoise by-catch is known or likely to occur.

This mix of pinger use and replacement of gear was reviewed and generally supported at the meeting of the Scientific Committee of the International Whaling Commission in 2002. It is important to note that both the ASCOBANS drafting group and the IWC Scientific Committee (IWC, 2002) consider that pinger deployment should be considered as a short-term approach to meet the objective of allowing this harbour porpoise population to recover. The rapid development of medium- and long-term approaches to mitigation (e.g., reduced fishing effort in “high risk” areas, conversion to fishing gear and practices likely to result in considerably less by-catch) is crucial and should not be compromised. Multiple mitigation measures are typically required elsewhere in meeting by-catch reduction objectives (e.g., Dawson *et al.*, 1998).

6 GENERAL USE OF PINGERS OR OTHER MODIFICATIONS IN PELAGIC TRAWLS

Although this term of reference refers to pingers or other deterrents, we have chosen to generalise this to include devices that might exclude cetaceans from trawls also. There have been two European tests of devices that might exclude cetaceans.

6.1 CETASEL

De Haan *et al.* (1998) reported on a three-year project (1995–1997) entitled CETASEL, co-funded by DG XIV (now DG Fisheries). This project aimed to understand dolphin behaviour near to (and within) pelagic trawl nets. It then aimed to test the effects of a series of ropes hung within the pelagic trawl net to determine if such ropes would prevent the entry of dolphins further into the net. Considerable technical difficulties meant that an effective dolphin-tracking system was not developed so that only limited insights were made on dolphin behaviour near pelagic trawl nets. Trials of the ease of rigging the ropes within the net were completed and were reasonably successful. Tests of behaviour near equivalent sets of ropes suspended into a pool containing dolphins found that they would swim through them. However, it is not possible to generalise from this captive situation to actual situations at sea. It is not possible on the basis of the results of CETASEL to draw any conclusions on the possible effectiveness of sets of ropes used as exclusion devices.

6.2 UK Tests in 2001/2002

Trials of an excluder device by the UK's Sea Mammal Research Unit were undertaken in cooperation with Scottish pair trawl fishermen in the bass fishery in early 2002 under funding from the UK Government. This device is an exclusion grid similar to those used in many other trawl fisheries to exclude larger unwanted by-catch, and consists of a steel grid placed in the extension piece of the trawl, with an escape hatch covered by a small meshed net immediately in front of the device. The preliminary tests were intended to ensure that the device would not hinder fishing, and that bass could still be caught with a grid in place. Although a power analysis suggested a high probability of also observing dolphins in the trawl during the projected 8-day trial, based on by-catch rates in 2001, in fact very few dolphins were observed at all in 2002, so no direct evidence of how dolphins would react to the grid was obtained. Nevertheless, the grid performed well in other ways, though it is still clearly in need of some refinements. The effectiveness of this device remains unproven as yet, but further work is planned.

6.3 Use of Pingers

The use of pingers in pelagic trawl nets has been suggested in several places (e.g., de Haan *et al.*, 1998). Given the width of opening of pelagic trawls, it would not be sensible to place pingers around the mouth of the trawl. De Haan *et al.* (1998) suggested that it would be more sensible to place pingers around the "sharks teeth" where the net mesh narrows. De Haan *et al.* (1998) further suggested that sounds could be turned on selectively as trawls are hauled or turned. These suggestions are based on the idea (yet unproven) that many dolphin catches occur during these phases of fishing. Such usage would possibly also reduce habituation by dolphins. Until such suggestions are better supported and a clear need is demonstrated, it is not possible to assess this suggestion.

De Haan *et al.* (1998) also suggested placing pingers on all vessels and netsondes in a fleet operating pelagic trawl gear in order to deter dolphins from a wide area of sea. This suggestion cannot be supported by any existing data on widespread deterrence of dolphins from an area. The sound levels required to keep animals out of a large area may in fact place any dolphins near the source at risk of acoustic damage.

6.4 Time of Day

There has been some suggestion that dolphin by-catches in pelagic trawls are more common at night (Baird, 1996), or during evening and early morning (de Haan *et al.*, 1998). As a result of this, guidelines were established for some New Zealand pelagic trawl fisheries to minimise dolphin by-catch, which involved minimising certain activities during hours of darkness. There is little evidence in European waters to support any of the suppositions behind these guidelines, however, and observations in the bass fishery demonstrate that by-catches of common dolphins are frequent during daylight tows (S. Northridge, pers. comm.). It seems likely that dolphin by-catch modalities will be different in different areas, different fisheries and with different species, so that a standard set of guidelines is probably inappropriate.

6.5 Conclusions

There is, at present, insufficient information to justify the deployment of pingers on pelagic trawl nets in anything other than experiments. Further experiments are required before excluder devices can be recommended for pelagic trawls. There is insufficient information, mostly due to lack of independent observer schemes, to be certain which pelagic trawl fisheries pose the greatest risk to cetacean populations, or to the scale of that risk. WGMPH noted that proper evaluation of cetacean by-catch (that would therefore use such observer schemes) is mandatory under existing EU legislation and recommends that effective enforcement of this requirement would help considerably.

7 OTHER POSSIBLE MITIGATION MEASURES

7.1 Mitigation Plans for Individual Fisheries

Experience throughout the world has shown that the most effective ways of reducing by-catch need to be tailored for individual fisheries and circumstances. This tailoring is best done by a combination of the fishers, relevant scientists, and gear technicians. In the U.S., where by-catch reduction is mandatory in a number of fisheries, take reduction teams are established to develop overall mitigation strategies. These teams include a wide range of stakeholders, such as managers, representatives of environmental groups, and residents of areas affected by the fisheries, along with those listed above (Read, 2000). The teams are pressured by there being a default option by which the Secretary of Commerce will impose a plan if no consensus is reached.

This model may not be suitable for the substantially more complex, multinational fisheries in EU waters, but the principle of bringing relevant scientists and fishers together should not be lost if any mitigation is to be effective. Similarly, the principle of timetabled default management options in the absence of effective implementation of mitigation measures is also something that could usefully be adopted in a European context, if by-catch reduction across national fleets is to be effective.

7.2 Protected areas

Marine Protected Areas (MPAs) are conceptually different from fishery time-area closures in that they are established for conserving marine life (and sometimes landscapes) rather than specifically to deal with fisheries impacts. In the European Union, the Habitats (92/43/EEC) and Birds (79/409/EC) Directives require establishment of areas to protect certain marine life. Under the Habitats Directives, species requiring such protection include the harbour porpoise and bottlenose dolphin. Management plans are required for these areas in order to maintain the “interest” of the site. For those sites established for harbour porpoises or bottlenose dolphins, there will inevitably be a consideration of the management of fisheries. At present, there are few and relatively small areas proposed for protection under these Directives for these small cetaceans. Such sites may be more effective in safeguarding the relatively local groups of bottlenose dolphins listed in Table 3.1.1, but it is difficult to see how the more wide-ranging harbour porpoises might be better protected without establishing very large areas.

Examples from elsewhere illustrate the type of management plan that might be drawn up. Zoning plans for multiple-use marine protected areas can be modified to accommodate concerns regarding the impacts of fishery by-catches on marine mammals. This approach has been adopted within the Great Barrier Reef Marine Park (GBRMP) and the Hervey Bay Marine Park, both in Queensland, Australia. There, two levels of “Dugong Protection Areas” (DPAs) were established in 1997 in an attempt to reduce fishery-related mortality (Marsh, 2000). Fishery regulations were modified to prohibit most netting within one tier of DPA, and regulations regarding net attendance were strengthened in the other tier of DPA. Despite occupying a small portion of the GBRMP (less than 5000 km² in an MPA of nearly 350,000 km²), the DPAs offer some protection to approximately 60 % of the dugong population in the region (Marsh, 2000).

7.3 “Reflective” gillnets

An alternative to the use of acoustic alarms on gillnets is the development of nets that have a lower probability of entangling cetaceans. One approach would be the development of net that would be more detectable to an echo-locating marine mammal. Larsen *et al.* (2002) described a study to test whether gillnets made from monofilament impregnated with iron oxide catch fewer harbour porpoises. The trial was conducted in the Danish North Sea bottom-set gillnet fishery in 2000 and recorded a 20 % reduction in cod catch relative to nets made from conventional materials. Eight porpoises were caught in control nets and none were taken in the iron-impregnated nets, a significant reduction in by-catch. Surprisingly, acoustic testing indicated that there were no significant differences in the acoustic target strength of modified and control nets (the manufacturers considered that there was an 11 % increase in reflectivity), suggesting that the reduction in by-catch was not caused by an increase in acoustic reflectivity. It seemed likely that the modified nets caught fewer porpoises (and cod) because they were stiffer than conventional nets. If this is true, modification of net stiffness offers the potential for an inexpensive means of reducing by-catch, although this benefit may be tempered by reduced catch of target species and heavier and more bulky nets.

Further preliminary tests have been conducted in Canada and the USA, but the results of these tests have yet to be fully published (Trippel *et al.*, 2000). Undoubtedly further tests are required, but if such nets prove to be effective in reducing the by-catch of small cetaceans in gillnet fisheries, *and* do not reduce the catch of target fish species, they hold great promise as a mitigation tool. The nets are unlikely to be significantly more expensive than traditional nets and, unlike pingers, do not require additional maintenance. If some change to the physical properties of monofilament gillnets results in a lower by-catch rate of dolphins and porpoises, this modification has potential as a mitigation measure.

7.4 Lost Nets

A large number of gillnets are lost during ordinary fishing operations. It has been demonstrated that such nets capture fish for long periods of time, in the order of years (Anon., 2000; Santos *et al.*, 2001). This means that they can be a hazard for cetaceans, also. Harbour porpoises, searching for food using a “bottom grubbing” technique (Lockyer *et al.*, 2001), may also be exposed to lost fishing nets that have sunk to the bottom. The loss frequency is estimated at 10 % per year or more in some fisheries (Anon. 2000; Santos *et al.*, 2001; F. Larsson, pers. comm.). With the long active life of such lost nets, they add a substantial part to the total risk of by-catch due to the gillnet fishery. An organised recovery of lost nets should be regarded as an additional possible mitigation measure.

8 FUTURE WORK OF THE WGMMPH AND RECOMMENDATIONS

8.1 Future Work of the WGMMPH

It is likely that the demand for advice from ICES client commissions and others on marine mammal issues will continue and will grow in future years. Despite difficulties this year ICES, therefore, still requires a working group dealing with marine mammal issues. This should continue to be parented by the ICES Advisory Committee on Ecosystems. In order to reflect the width of the marine mammal remit, we therefore recommend that the group title be changed to either Working Group on Marine Mammals, or Working Group on Marine Mammal Ecology (the latter reflecting the titles of ICES working groups on seabirds and benthos).

8.2 Recommendation for Future Meeting

The Working Group on Marine Mammal Ecology [WGMME] (Chair: Gordon Waring, USA) will meet from 26–29 March 2003 at the AZTI Fisheries and Food Technological Institute, Pasajes (Guipuzcoa), Spain to:

- a) develop further the response to the European Commission standing request regarding fisheries that have a significant impact on small cetaceans and other marine mammals:
 - i) review any new information on population sizes, by-catches or mitigation measures and suggest relevant advice,
 - ii) provide a comprehensive overview of the background information available to set limits for anthropogenic removals of marine mammal populations,
 - iii) provide a scientific evaluation and critical review of the background information under i),
 - iv) simulate the consequences and risks associated with alternative levels of removals.
- b) in response to a request from HELCOM [HELCOM 2002/2]:
 - i) develop advice for the establishment of a monitoring programme for Baltic Sea seal populations, taking into account the requirements of the proposed HELCOM Seal Project,
 - ii) provide advice on harmonisation of monitoring and estimating procedures across the Baltic region,
- c) further develop EcoQs for marine mammals in the North Sea including current, reference, and suggested target levels. Developments should include:
 - i) review simulations of the maximum rate of increase and develop limits for anthropogenic removals for harbour porpoises and other small cetaceans,
 - ii) estimate maximum rate of increase and develop limits for anthropogenic removals of seals based on a thorough risk analysis incorporating life history parameters,
 - iii) incorporate Toxic Equivalent Units in the EcoQO for body burden of contaminants in marine mammals,
- d) review preliminary findings from the 2002 seal epizootic event around Sweden and review the role of such events in population regulation;
- e) review census techniques for seals, and statistical analysis of resulting data (including correction factors);
- f) review the effects of interspecific competition, particularly population effects of habitat exclusion, on expanding grey and harbour seal populations;
- g) prepare a case for a WGMME Workshop on Marine Mammal Health in relation to Habitat Quality.

The WGMME will report by 11 April 2003 to ACE, and the Marine Habitat and Living Resources Committees.

8.3 Justification

- a) This is further work in relation to a European Commission request for an increase in ICES efforts to provide information and advice in relation to the by-catch of marine mammals in commercial fisheries and means to decrease such by-catches.
- b) This is a request from the Helsinki Commission for 2002.

- c) This is further work in relation to an OSPAR request for recommendations for appropriate Ecological Quality Objectives for North Sea marine mammals, and the preparation of provisional estimates for the current, reference, and target levels for the proposed EcoQO indices.
- d) The scale of this epizootic is unknown at present. Previous epizootic events have caused population crashes as well as considerable public concern.
- e) There has been some standardisation of seal census techniques, but a further review would help in delivering reports on, e.g., EcoQOs in European waters, or trends in populations in the ICES area.
- f) There is considerable interest in many quarters as to the carrying capacity of the marine environment for seals. A review of worldwide harbour and grey seal population growth rates and a determination of carrying capacity for these species would be useful. A workshop being held in Woods Hole in January 2003 should provide material for this review.
- g) There is a need to interpret marine mammal health in relation to marine mammal habitats, as identified in the past by WGMMHA, WGMPH and in the current OSPAR request.

9 REFERENCES

- Anon. 2000. Report of FANTARED, EU study contract no. 94/095. Incidental impact of gill-nets. DG Fisheries, European Commission, Brussels.
- ASCOBANS. 2002. Draft recovery plan for Baltic harbour porpoises. Document AC9/Ddoc. 7.(S). ASCOBANS, Bonn.
- Baines, M.E., Reichelt, M., Evans, P.G.H., and Shepherd, B. 2002. Comparison of the abundance and distribution of harbour porpoises (*Phocoena phocoena*) and bottlenose dolphins (*Tursiops truncatus*) in Cardigan Bay, UK. 16th Annual Conference of the European Cetacean Society, Liege, Belgium.
- Baird, S. J. (comp.) 1996. Non-fish species and fisheries interactions Working Group Report. New Zealand Fisheries Assessment Working Group Report, 96/1. 27 pp. + appendix.
- Baur, D.C., Bean, M.J., and Gosliner, M.L. 1999. The laws governing marine mammal conservation in the United States. *In* Conservation and management of marine mammals, Chapter 3. Ed. by J.R. Twiss, Jr and R.R. Reeves. Smithsonian Institution Press, Washington, DC. 471pp.
- Berggren, P., Carlström, J., and Tregenza, N. 2002b. Mitigation of small cetacean by-catch; evaluation of acoustic alarms (MISNET). Final report to European Commission. Stockholm University, Stockholm.
- Berggren, P., Wade, P.R., Carlström, J., and Read, A.J. 2002a. Potential limits to anthropogenic mortality for harbour porpoises in the Baltic region. *Biological Conservation*, 103: 313–322.
- BIM. 2000. Diversification trials with alternative tuna fishing techniques including the use of remote sensing technology. Final report of EU Contract 98/010, Bord Iascaigh Mhara (BIM), Dun Laoghaire, Ireland.
- Börjesson, P. 2002. Ph.D. thesis.
- Buckland, S.T., Bloch, D., Cattanach, K.L., Gunnlaugsson, Th., Hoydal, K., Lens, S., and Sigurjónsson, J. 1993. Distribution and abundance of long-finned pilot whales in the North Atlantic, estimated from NASS-87 and NASS-89 data. Report of the International Whaling Commission Special Issue, 14: 33–49.
- CEC. 2002. Incidental catches of small cetaceans. Report of the Subgroup on Fishery and Environment (SGFEN) of the Scientific, Technical and Economic Committee for Fisheries (STECF). Commission Staff Working Paper, Brussels. SEC (2002) 376.
- Cockcroft, V.G. 1994. Is there a common cause for dolphin capture in gillnets? A review of dolphin captures in shark nets off Natal, South Africa. Report of the International Whaling Commission (Special Issue 15): 541–547.
- Cox, T.M., Read, A.J., Solow, A., and Tregenza, N. 2001. Will harbour porpoises (*Phocoena phocoena*) habituate to pingers? *Journal of Cetacean Research and Management*, 3: 81–86.

- Culik, B.M., Koschinski, S., Tregenza, N., and Ellis, G.M. 2001. Reactions of harbour porpoises *Phocoena phocoena* and herring *Clupea harengus* to acoustic alarms. *Marine Ecology Progress Series*, 211: 255–260.
- Dawson, S.M., Read, A., and Slooten, E. 1998. Pingers, porpoises and power: uncertainties with using pingers to reduce by-catch of small cetaceans. *Biological Conservation*, 84: 141–146.
- de Haan, D., Dremière, P.Y., Woodward, B., Kastelein, R.A., Amundin, M., and Hansen, K. 1998. Prevention of the by-catch of cetaceans in pelagic trawls by technical means. CETASEL. Final Report to DG XIV of contract number AIR III-CT94–2423 1994–1997. DLO – Netherlands Institute for Fisheries Research, IJmuiden. 204 pp.
- Fertl, D., and Leatherwood, S. 1997. Cetacean interactions with trawls: A preliminary review. *Journal of Northwestern Atlantic Fisheries Science*, 22 219–248.
- Gearin, P.J., Goshko, M.E., Laake, J.L., Cooke, L., DeLong, R.L., and Hughes, K.M. 2000. Experimental testing of acoustic alarms (pingers) to reduce by-catch of harbour porpoise, *Phocoena phocoena*, in the state of Washington. *Journal of Cetacean Research and Management*, 2: 1–10.
- Goodson, A.D., Amundin, M., Mayo, R.H., Newborough, D., Lepper, P.A., Lockyer, C., Larsen, F., and Blomqvist, C. 1997. Aversive sounds and sound pressure levels for the harbour porpoise (*Phocoena phocoena*): an initial field study. *ICES CM 1997/Q:17*. 5 pp.
- Goujon, M., Antoine, L., Collet, A., and Fifas, S. 1993. Approche de l'impact écologique de la pêche thonière au filet maillant dérivant en Atlantique nord-est. Rapport IFREMER – RI.DRV-93.034. 47 pp.
- Hammond, P.S., Berggren, P., Benke, H., Borchers, D.L., Collet, A., Heide-Jørgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F., and Øien, N. 2002. Abundance of the harbour porpoise and other cetaceans in the North Sea and adjacent waters. *Journal of Applied Ecology*, 39: 361–376.
- Hiby, L., and Lovell, P. 1996. Baltic/North Sea aerial surveys – final report. (Unpublished). 11 pp.
- ICES. 1996. Report of the Study Group on Seals and Small Cetaceans in European Seas. *ICES CM 1996/N:1*.
- ICES. 2001. Report of the Working Group on Marine Mammal Population Dynamics and Habitats. *ICES CM 2001/ACE:1*.
- Ingram, S. 2000. The ecology and conservation of bottlenose dolphins in the Shannon estuary. Ph.D. thesis, University College, Cork.
- IWC. 2000. Section 5.3 of the Report of the Sub-committee on Small Cetaceans. *Journal of Cetacean Research and Management*, 2: 239–243.
- IWC. 2002. Report of the IWC Scientific Committee on its 54th meeting, Shimonoseki, Japan. International Whaling Commission, IWC/54/4.
- Koschinski, S., and Culik, B. 1997. Deterring harbour porpoises (*Phocoena phocoena*) from gillnets: observed reactions to passive reflectors and pingers. Report of the International Whaling Commission, 47: 659–668.
- Kraus, S. D., Read, A.J., Solow, A., Baldwin, K., Spradlin, T., Anderson, E., and Williamson, J. 1997. Acoustic alarms reduce porpoise mortality. *Nature*, 388: 525–526.
- Laake, J., Rugh, D., and Baraff, L. 1998. Observations of harbour porpoise in the vicinity of acoustic alarms on a set gill net. U.S. Department of Commerce, NOAA Technical Memorandum NMFS/AFSC-84, January 1998.
- Larsen, F. 1999. The effect of acoustic alarms on the by-catch of harbour porpoises in the Danish North Sea gill net fishery: a preliminary analysis. Paper presented to the Scientific Committee of the International Whaling Commission, Grenada, June 1999, SC/51/SM41.

- Larsen, F., and Hansen, J.R. 2000. On the potential effects of widespread use of pingers in the North Sea. Paper presented to the Scientific Committee of the International Whaling Commission, Adelaide, June 2000, SC/52/SM28. 12 p.
- Larsen, F., Eigaard, O.R., and Tougaard, J. 2002. Reduction of harbour porpoise by-catch in the North Sea by high-density gillnets. Paper presented to the Scientific Committee of the International Whaling Commission, Shimonoseki, May 2002, SC/54/SM30. 12 pp.
- Lien, J., Barney, W., Todd, S., Seton, R., and Guzzwell, J. 1992. Effects of adding sounds to cod traps on the probability of collisions by humpback whales. *In* Marine Mammal Sensory Systems, pp. 701–708. Ed. by J.A. Thomas, R.A. Kastelein, and A.Y. Supin. Plenum, New York.
- Lockyer, C., Amundin, M., Desportes, G., and Goodson, A.D. 2001. The tail of EPIC. Final report of EPIC, Elimination of harbour porpoise incidental catches. EU Project DG XIV 97/0006. 249 pp.
- Macleod, K. 2001. The spatial and temporal distribution of cetaceans off the west coast of Scotland in relation to environmental factors: implications for marine management. Unpublished Ph.D. thesis, University of Greenwich, London.
- Marsh, H. 2000. Evaluating management initiatives aimed at reducing the mortality of dugongs in gill and mesh nets in the Great Barrier Reef World Heritage Area. *Marine Mammal Science*, 16: 684–694.
- Morizur, Y., Berrow, S.D., Tregenza, N.J.C., Couperus, A.S., and Pouvreau, S. 1999. Incidental catches of marine mammals in pelagic trawl fisheries of the northeast Atlantic. *Fisheries Research*, 41: 297–307.
- Murray, K.T., Read, A.J., and Solow, A.R. 2000. The use of time/area closures to reduce by-catches of harbour porpoises: lessons from the Gulf of Maine sink gillnet fishery. *Journal of Cetacean Research and Management*, 2:135–141.
- Newborough, D., Goodson, A.D., and Woodward, B. 2000. An acoustic beacon to reduce the by-catch of cetaceans in fishing nets. *Journal of the Society for Underwater Technology*, 24: 105–114.
- Northridge, S.P., and Hammond, P.S. 1999. Estimation of porpoise mortality in UK gill and tangle net fisheries in the North Sea and west of Scotland. Paper presented to the Scientific Committee of the International Whaling Commission, Grenada, May 1999, SC/51/SM42.
- Northridge, S., Tregenza, N., Rogan, E., and Hammond, P. 2000. Spatial aspects of porpoise by-catch in UK and Irish Celtic Shelf gillnet fisheries. Paper presented to the Scientific Committee of the International Whaling Commission, Adelaide, June 2000, SC/52/SM31.
- O’Cadhla, O., Burt, M.L., Borges, A.L., and Rogan, E. 2001. Summer distribution and abundance of cetaceans in western Irish waters and the Rockall Trough. Paper presented to the International Whaling Commission, London, June 2001, O:15.
- Pierce, G., Santos, B., Eggleton, J., Kelly, E., Whomersley, P., Young, I., Newton, A., Robb, A., Tregenza, N., Palenzuela, J.T., Pardo, P.C., Tranchero, P.O., Alfaya, C.L., López, A., Figueiredo, P.C., Barreiro, A., Cedeira, J.A.M., Fontañá, V.T., and Otero, M.G. 2001. Pelagic fisheries in Scotland (UK) and Galicia (Spain): observer studies to collect fishery data and monitor by-catches of small cetaceans. Draft final report of EU study project 2000/27.
- Read, A.J. 2000. Potential mitigation measures for reducing the by-catches of small cetaceans in ASCOBANS waters. Report to ASCOBANS, December 2000. Duke University, North Carolina. 34pp. + appendices.
- Reeves, R.R., Read, A.J., and Notarbartola-di-Sciara, G. 2001. Report of the workshop on interactions between dolphins and fisheries in the Mediterranean: evaluation of mitigation alternatives, Roma, 4–5 May 2001. ICRAM, Rome. (Presented also to International Whaling Commission Scientific Committee, as paper SC/53/SM3.) 44 pp.

- Santos, M.N., Erzini, K., Gaspar, M.B., and Montiero, C.C. 2001. FANTARED II – a study on ghost fishing in European waters. Poster to NAFO Deep Sea Fisheries Symposium, September 2001. NAFO SCR Doc. 01/97.
- Silva, M.A., Feio, R., Prieto, R., Gonçalves, J.M., and Santos, R.S. (in press 2002). Interactions between cetaceans and the tuna-fishery in the Azores. *Marine Mammal Science*, 18(4): xxx - xxx.
- SMRU, UCC, CFPO, and ISWFO. 2001. Reduction of porpoise by-catch in bottom set gillnet fisheries. Report to the European Commission, Study Contract 97/095.
- Stone, G., Kraus, S., Hutt, A., Martin, S., Yoshinga, A., and Joy, L. 1997. Reducing by-catch: can acoustic pingers keep Hector's dolphins out of fishing net? *Marine Technology Society Journal*, 31: 3–7.
- Trippel, E.A., Palka, D., Potter, D., Merrick, R., Holy, N.L., King, D., Conway, J.D., and Shepherd, T. 2000. Testing of acoustically reflective gillnets as a management tool to reduce incidental mortalities of harbour porpoise in northwest Atlantic gillnet fisheries. Paper presented to the Scientific Committee of the International Whaling Commission, Adelaide, June 2000, SC/52/SM26. 8 pp.
- Trippel, E.A., Strong, M.B., Terhune, J.M., and Conway, J.D. 1999. Mitigation of harbour porpoise (*Phocoena phocoena*) by-catch in the gillnet fishery in the lower Bay of Fundy. *Canadian Journal of Fisheries and Aquatic Science*, 56: 113–123.
- Vinther, M. 1999. By-catches of harbour porpoises (*Phocoena phocoena* L.) in Danish set-net fisheries. *Journal of Cetacean Research and Management*, 1: 123–135.
- Vinther, M., and Larsen, F. 2002. Updated estimates of harbour porpoise by-catch in the Danish bottom set gillnet fishery. Paper presented to the Scientific Committee of the International Whaling Commission, Shimonoseki, May 2002, SC/54/SM31. 10 pp.
- White, R., and Webb, A. 1995. Coastal birds and marine mammals of mid Dorest. Joint Nature Conservation Committee, Peterborough, UK. 48 pp.
- Wilson, B., Hammond, P.S., and Thompson, P.M. 1999. Estimating size and assessing trends in a coastal bottlenose dolphin population. *Ecological Applications*, 9: 288–300.
- Øien, N. 1993. Abundance of killer whales (*Orcinus orca*) in waters off Norway. Working paper for the NAMMCO Working Group on Killer and Northern Bottlenose Whales, Reykjavik, 24–25 November 1993.

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