2 SMALL CETACEAN BY-CATCH IN FISHERIES

Request

The request from the European Commission, Directorate General for Fisheries, in February 2002 concerning by-catch of cetaceans states:

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. Potential advantages and disadvantages of a generalized use of pingers in fixed gear; technical specifications affecting the effectiveness of pingers.*
iv) *Potential advantages and disadvantages of a generalized use of pingers or other deterrents in pelagic trawls; updated information and technical specifications.*
v) *Technical details of any other possible mitigation measure.*

Source of information

The 2002 Report of the Working Group on Marine Mammal Population Dynamics and Habitats (WGMMPH) (ICES CM 2002/ACE:02).

2.1 Information on by-catch of cetaceans

2.1.1 Introduction

The ICES Working Group on Marine Mammal Population Dynamics and Habitats (WGMMPH) reviewed the impact of fisheries on marine mammals in European waters in 2001. This material was reviewed by ACE and used as a basis for preliminary advice to DG FISH (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 summarized below, along with information that has become available even more recently, updating ICES (2001). It is worth noting that we cannot include information on those fisheries that have not been studied.

2.1.2 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 2.1.2.1) 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 days 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 2.1.2.1. Estimates of harbour porpoise by-catch to the west of Scotland. 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) (Table 2.1.2.2). Compared to previous estimates for these fisheries, the new estimate uses an extrapolation method where changes in fish catch per unit effort have been taken into account. 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.

ICES (2002) noted that some information on harbour porpoise by-catch in Dutch coastal waters exists. During 1997 and 1998, amongst the on-average 50 dead por-

Table 2.1.2.2. 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	all	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	5192	6311	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	all	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	6738	5993	5308	5206	4228	4150	3888	5590

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

poises annually recovered through a stranding network, around 50 % were diagnosed as being by-caught.

2.1.3 Tuna driftnets

A ban on the use of tuna driftnets in EU waters and by EU vessels operating elsewhere came into effect at the start of 2002, partly owing to the scale of earlier dolphin by-catch. If fishing with this metier has ceased, so presumably has the related dolphin by-catch.

2.1.4 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 pelagic pair 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 2.1.4.1); more than 2/3 of these were taken in just ten hauls, with one haul accounting for 30 animals. Ninety percent of hauls had no cetacean by-catch. This highly clustered pattern of by-catch is not unusual in pelagic trawls, probably due the cohesive nature of dolphin social groups (Fertl and Leatherwood, 1997).

Table 2.1.4.1. 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 eleven hauls, all of which were in the bass fishery in the Channel.

2.1.5 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 6,554 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 2.1.5.1). All the animals caught (hooked) were released alive (by cutting the fishing line), although it was impossible to know whether they survived the interaction. This difficulty in assessing effect has been addressed in the U.S.A. with a set of guidelines to assess whether or not injuries sustained are "serious".

2.2 New information on cetacean populations

2.2.1 Most recent abundance estimates

There have been no recent comprehensive studies on cetacean abundance or population sizes in the ICES area. The most recent abundance estimates are shown in Table 2.2.1.1. 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 may 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 technique estimates 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, Wales. The average abundance in 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 a 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), namely, 152 (80–287), but about the same number, i.e., 211 (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's 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.

2.3 Possible limitations on use of gear, time/area closures

2.3.1 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 seasonal 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 realize that a 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 minimizing the 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.

Table 2.1.5.1. By-catch estimates for Azores (Silva *et al*., 2002). Note that all of these animals were released alive after capture.

By-catch 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 1999 2000	38 55 16	16.9 – 59.1 19.6 – 89.6 11.7 – 20.2

For seasonal or area restrictions to be effective, 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, then 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.

2.3.2 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.

2.3.3 Western Channel/Bay of Biscay pelagic trawls

In the western English Channel and the 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 other fisheries 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, as this is 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.

2.3.4 Eastern central North Sea wreck fisheries

A clear peak in harbour porpoise by-catch was identified in the Danish wreck net fishery in the period August–October (Vinther, 1999). 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 other fisheries during the period of closure. It seems inconsistent that any restrictions on the cod wreck fishery should apply just to Danish fishers. However, wreck net fishing during August–October by UK vessels fishing slightly further south and east of the Danish fishing grounds had no peak in by-catch (Northridge and Hammond, 1999).

Table 2.2.1.1. Abundance estimates of small cetacean populations in EU waters within the ICES area.

Species	Year of estimate	ICES Area or geographical locality	Abundance estimate	95 % Confidence limits	Method	Reference
Harbour porpoise	1994 1995 1994	IIIa + b IIIc 24+25 Kiel & Mecklenberg Bights IVa IVb + c VIIf+g+h+j	36,046 5,850 599 817 98,564 169,888 36,280	20,276–64,083 3,749–9,129 200–3,300 300–2,400 66,679–145,697 124,121–232,530 12,828–102,604	Ship-based line transect Aerial survey, line transect Ship-based line transect	Hammond *et al*., 2002 Hiby and Lovell, 1996 Hammond *et al*., 2002
Bottlenose dolphin	1992 2001 2001 1991–1993 1994–1995 2001 1999 1995	Moray Firth (southwestern IVa) French coasts VIIe, VIIIa Sado Estuary, Portugal Cornwall Dorset Cardigan Bay, Wales Shannon Estuary, Ireland Dingle Bay, Ireland	129 250–300 34 15 5 135 213 113 12	110–174 na na na na 85–214 183–279 94–161 na	Photographic mark-recap. Photographic identification or direct observation Ship-based line transect Photographic mark-recap.	Wilson *et al*., 1999 ICES, 2002 ICES, 2002 ICES, 1996 White and Webb, 1995 Baines *et al*., 2002 Ingram, 2000 ICES, 1996
White-beaked and Atlantic white-sided dolphins	1994	IVa IVb VIIf+g+h+j	1,685 9,242 833	690–4,113 5,344–15,981 159–4,360	Ship-based line transect	Hammond *et al*., 2002
Atlantic white-sided dolphin	1998 1998 2000	Faroes-Shetland channel VIa (N) parts of VI a&b, VII b/c, VIIj&k	21,371 74,626 5,490	10,000–45,000 35,000–160,000 1,134–10,015	Ship-based line transect	Macleod, 2001 O'Cadhla *et al*., 2001
Killer whale	1989	IIa, IVa,b	7,057	3,400–14,400	Ship-based line transect	Øien, 1993
Common dolphin	1994 2000	VIIf+g+h+j parts of VI a&b, VII b/c, VIIj&k	75,449 4,496	22,900–284,900 2,414–9,320	Ship-based line transect	Hammond *et al*., 2002 O'Cadhla *et al*., 2001
Long-finned pilot whale	1987 1989 1981–1984 1987–1989 1987–1989	V (parts of) VI V (parts of) Bay of Biscay VIII (E of 15°W) VIII (W of 15°W)	29,198 5,392 80,867 9,739 12,235 128,080	 3,924–38,148 45,241–362,640	Ship-based line transect	Buckland *et al*., 1993 Sanpera and Jover, 1987 Buckland *et al*., 1993
Striped dolphin	1993	Bay of Biscay	73,843	36,113–150,990	Ship-based line transect	Goujon *et al*., 1993
Common dolphin	1993	Bay of Biscay	61,888	35,461–108,010	Ship-based line transect	Goujon *et al*., 1993

2.3.5 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 m*hours 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.

2.3.6 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 what is the cause, 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.

2.4 General use of pingers in fixed gear

2.4.1 Background

Pingers are acoustic deterrent devices that have relatively low acoustic source levels (typically less than 150 dB re 1 μPa 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 μPa 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 minimize 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 U.S. 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 μPa) (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 the Netherlands and in Denmark suggest that more aversive acoustic signals exist than the sinusoidal tone pulses specified in the U.S.A. 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 randomized 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 available commercially 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 echo-location 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.

2.4.2 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 (IWC) 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.

2.4.3 Potential advantages and disadvantages of a generalized 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 generalized 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.

2.4.3.1 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 WGMMPH 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.

2.4.3.2 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.

2.4.3.3 Exclusion of cetaceans from habitat

Concern has been expressed that widespread use of pingers could lead to small cetaceans being excluded from habitats 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 the 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 the 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.

2.4.3.4 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 happen only 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.

2.4.4 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 2.4.4.1 (from Reeves *et al*., 2001).

2.4.4.1 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 minimize by-catch while simultaneously minimizing the potential area of exclusion.

2.4.4.2 Reliability and longevity

Pingers should be regularly checked to ensure that they perform adequately. Issues such as the 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.

2.4.4.3 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 is plainly 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.

2.4.4.4 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 2.4.4.1) were probably too close for the Dukane pinger. The louder the acoustic signal, the fewer pingers need to 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. 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.

2.4.4.5 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 enforcement 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.

2.4.4.6 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 realization 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.

2.4.5 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

Table 2.4.4.1. 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™ (a); Netmark 2000 (b)	Aquamark 100™ (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 × PP3 alkaline
Fundamental frequency	10 kHz (U.S.)	(a) 20–160 kHz frequency sweeps (DK); (b) similar to (a) but the frequency sweep tuned for dolphins (DK); (c) 10 kHz tonal (U.S.)	10 kHz (US)	(L1) 2.5 kHz; (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 second (regular)	(a, b) 4–30 second (randomized); (c) 4 second (regular)	4 second (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; U.S. = emissions specified for regulated U.S. fisheries; DK = Type 1 emissions specified for regulated Danish fisheries. Note: PICE™ is not listed here, as the commercial AQUAmark 100™ is an improved derivative that transmits the same wide-band randomized acoustic signals.

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.

2.4.6 Areas suitable for pinger scheme implementation

ACE lists below those areas of EU waters that have by-catches of porpoises that appear to be likely to be adversely affecting porpoises at the population level. In doing this, the definition recommended by ACE in 2001 (ICES, 2001) was used: "*Using the objective of rebuilding populations to 80 % of carrying capacity, or maintaining them there, and an* R_{max} *of 4 %, an annual by-catch mortality rate of 1.7 % of a small cetacean population is the maximum that could be sustained. This value is accepted as the basis for scientific advice until improved estimates of maximum population growth rates are available for these populations, or different* *management targets are adopted.*" This also reflects Table 3.6.1 of ICES (2001) listing fisheries that give the greatest concern due to harbour porpoise by-catch. With the exception of a generalized reduction in bottom-set gillnet fishing effort (net*km*hours), no other mitigation measure than the use of pingers is presently available that is known to be effective in these waters.

2.4.6.1 Western English Channel and Celtic Shelf

Based on the current levels of by-catch, 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. Pingers should thus be implemented in bottom-set gillnet fisheries within the known current range of harbour porpoises in this area. This is likely to cover approximately 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 minimize pinger deployment among some of the hundreds of small vessels working in these waters.

2.4.6.2 Channel and Southern Bight of the North Sea

This is an area holding few harbour porpoises, but known to be depleted relative to former times. Any by-catch in this area would represent a barrier to recovery. However, given the rarity of harbour porpoises, particularly in the central part of the area (eastern Channel), little is known of the most risky fisheries, and whether all fisheries carry risk to harbour porpoises. It would, therefore, be more appropriate to deploy pingers at each end of this area (see Sections 2.4.6.1 and 2.4.6.3) in order to minimize by-catch in those areas that are likely to provide the source of any recovery. This situation should be reviewed if the status of harbour porpoises or by-catch changes in this area. The Bergen Declaration by North Sea Ministers in March 2002 committed North Sea States to drafting and implementing a recovery plan for North Sea porpoises. The Channel and Southern Bight could be the main area to benefit from such a plan.

2.4.6.3 Central/southern North Sea (including coastal)

By-catch in this area is likely to exceed rates considered to be sustainable for the population of the area. As a consequence, pingers are presently deployed in the fishery believed to have the highest by-catch per unit effort: the Danish wreck fishery for cod in the months August–October. It is, however, inconsistent that other nations carrying out similar fisheries in the same area should not apply pingers.

As indicated in Table 2.1.2.2 though, the greatest absolute by-catch by a single fishery in this area is by the turbot fishery. Pinger deployment in this fishery (both Danish and those of other nations) in this area has the potential to reduce overall by-catch by around one third. The turbot fishery is relatively small (defined from days at sea, landings by weight, and value), with a proportionally high cetacean by-catch, and ACE therefore gives a mandatory pinger use in the turbot fishery the highest priority. The Danish turbot fishery is characterized by large meshes (mainly 270 mm) and a very long soaktime. Depending on the area, turbot or monkfish is the target species. The Danish fishers also target lumpsucker by gears similar to the turbot net. The UK also has fisheries, using large meshes and long soaktimes, for turbot, monkfish, rays, and skates. For a clear definition, ACE proposes that pingers should be mandatory in all bottom-set net fisheries using large meshes. The EC regulation 850/98 uses 220 mm as the minimum mesh size for the (fish) by-catch regulation relevant to the fisheries mentioned, so ACE proposes mandatory pinger use for all fisheries using meshes ≥220 mm.

The next most numerous by-catch comes from cod fisheries other than around wrecks. However, there will probably be an effort reduction in the cod fishery as part of the "North Sea cod recovery plan" and, taking the expected major by-catch reduction in the ≥220 mm set-net fisheries into account, ACE considers that the effort reduction will be a sufficient mitigative strategy at present.

Pinger deployment could thus occur in the cod wreck fishery in the months August–October and in the ≥220 mm set-net fisheries, with a review of the situation after two years to determine the overall effect on by-catch rates. The precise geographical limits of pinger deployment need to be reviewed, but should take account of the need to particularly safeguard porpoises in the area just north of the Southern Bight (see Section 2.4.6.2).

2.4.6.4 Northern North Sea

Information on the set-net effort and by-catch level in this area is limited, mainly due to missing information from the major set-net fishing nation (Norway) in the area. To avoid effort redistribution in the cod fishery to this area, pinger use should be mandatory in the wreck fishery in the northern North Sea as well. Likewise, to prevent effort redistribution in the turbot fishery to a more northerly monkfish and turbot fishery, pingers should also be mandatory in this area for the ≥220 mm set-net fisheries.

2.4.6.5 Skagerrak, Kattegat, and the Belt Seas

Information on by-catch indicates that in the period from 1996 to 2001 there has been a six-fold decrease in by-catch and effort in the Swedish cod fishery in the Kattegat and the eastern Skagerrak. Information on the Danish fisheries is based on a sampling effort much lower than that for the North Sea, but data indicate in general a much lower by-catch except for the lumpsucker fishery. Both Sweden and Denmark have had a significant effort reduction in the cod fishery due to declining cod stocks and TAC, probably resulting in a by-catch decrease. However, the Kattegat and Belt Seas are immediately adjacent to the Baltic Sea, whose population of harbour porpoise is heavily depleted. The Baltic population structure and its connection to adjacent waters are still under debate, but a recovery might be more rapid with a supply of animals from adjacent waters. However, considering the effort reduction in the cod fishery, the apparently low by-catch, and the very high SCANS estimate of porpoise density in the Belt Seas, the need for a significant by-catch reduction from a generalized pinger use is not urgent, and will not help the Baltic porpoise population very much. The by-catch in the lumpsucker fishery might, however, be significant.

2.4.6.6 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).

2.5 General use of pingers or other modifications in pelagic trawls

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

2.5.1 CETASEL

De Haan *et al*. (1998) reported on a three-year project (1995–1997) entitled CETASEL, co-funded by DG XIV. 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 whether 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 generalize 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.

2.5.2 UK tests in 2001/2002

Trials of an excluder device by the UK 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 eight-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.

2.5.3 Use of pingers

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.

2.5.4 Time of day

There has been a 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 minimize dolphin by-catch that involved minimizing certain activities during the 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 (ICES, 2002). 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.

2.6 Other possible mitigation measures

2.6.1 Overall effort reduction

Any reduction in fishing effort will reduce by-catch. For several years, ICES has advised reductions in directed effort for many fisheries in the EU zone. To the extent that these advised effort reductions are allocated to static net or pelagic trawl fisheries, particularly ones with high by-catches, the effort reductions themselves will contribute directly to reduced by-catch of small cetaceans, and will continue to do so in the future. ACE notes the new proposals by the European Commission to further reduce effort in nearly all fisheries in EU waters (COM (2002) 181 and COM (2002) 185).

2.6.2 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.

2.6.3 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 Directive, 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 2.2.1.1, but it is difficult to see how the more wide-ranging harbour porpoises might be better protected without establishing very large areas.

2.6.4 "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 could be the development of a 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 U.S.A, 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, they 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.

2.6.5 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; ICES, 2002). 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 overall effort reduction is probably the most efficient way to reduce the amount of lost gears. Pinger application might help as well as a means to localize lost nets, owing to the economic value of recovered pingers. An organized recovery of lost nets should be regarded as an additional possible mitigation measure.

2.6.6 Technical measures with regard to gear specification and deployment

Factors such as reducing the numbers and lengths of nets deployed per fisher, sizes of mesh and twine, and soak duration, have been found effective in reducing the by-catch of small cetaceans in static net fisheries in the U.S. (Read, 2000). However, the U.S. results suggest that the effectiveness of the technical measures on both the by-catch of small cetaceans and impacts on gear efficiency for target species must be evaluated on a case-by-case basis before specific recommendations can be made. The effectiveness of specific technical measures for specific EU fisheries has not been investigated systematically within the Northeast Atlantic. Each fishery is more or less unique with respect to gear specification and fishing practice and most parameters, such as mesh size and twine thickness, are moreover highly correlated. Therefore, in addition to data from existing observer programmes, substantial field work using various mesh sizes, twines, hanging ratios, etc., is required to analyse the effect of one parameter.

2.7 Recommendations

1) ICES advises that monitoring programmes, using independent observers, for obtaining information on by-catch of cetaceans should be extended to all fisheries with a potentially high risk of by-catch. Without full information, it is impossible to make a full assessment of the impact of fisheries on cetacean populations.

2) Noting that the regulation EC 1543/2000 for the national collection of data in the fisheries sector does not mention cetacean by-catch, while requiring (at sea) sampling of fish discards, ICES recommends that discards sampling should be done primarily by independent observers and, where possible, be combined with sampling of marine mammal by-catch.

3) Noting that proper evaluation of cetacean by-catch (that would, therefore, use such observer schemes) is mandatory under existing EU legislation (Directive 92/43/EEC), ICES recommends effective enforcement of this requirement.

4) ICES advises that any reduction in overall fishing effort is likely to reduce by-catch and, therefore, be an effective measure.

5) Limitation on the use of fishing gear, whether total or partial, is likely to result in redistribution of fishing effort, either into other metiers, or into adjacent areas. Whether or not this results in an overall reduction in by-catch will depend on the by-catch rates of the metiers receiving the redistributed effort. Therefore, ICES does not in general recommend spatial and temporal closures on a small scale, without overall effort reduction, as an effective mitigation strategy.

6) ICES considers that the use of pingers is a short- or medium-term mitigation measure, but because the effectiveness and effects on distribution are still uncertain, pinger application must be monitored and

evaluated. Notwithstanding the concerns mentioned in Section 2.4, to contribute to a reduction in the by-catch of cetaceans in the short term, ICES recommends that the use of pingers be made mandatory in the following fisheries:

- bottom-set gillnet fisheries within the known current range of harbour porpoises in the western English Channel and Celtic Shelf (see Section 2.4.6.1 for further details) unless and until evidence is available to discriminate between by-catch in the various fisheries using the area;

- bottom-set gillnet fisheries used in the cod wreck fisheries in the months August–October and in set-net fisheries using mesh sizes ≥220 mm in the North Sea;

- bottom-set gillnet fisheries for lumpsucker in the Skagerrak, Kattegat, and Belt Seas, unless observer schemes can validate a low by-catch.

7) For pelagic trawls, ICES recommends that more research be conducted on pingers and other devices to exclude cetacean by-catches before they can be recommended as mitigation measures.

8) There is insufficient information on by-catch in pelagic trawl metiers, mostly owing to a lack of independent observer schemes, to know the relative risk that those fisheries pose to cetacean populations, or the scale of that risk. ICES recommends observer programmes for all pelagic trawl metiers.

9) In addition to observer programmes in the commercial fishery, ICES recommends that further investigations be carried out to determine the effect of gear specification and fishing practice on by-catch, to be able to understand which factors induce high by-catch rates and provide a basis for the development of alternative gears.

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