A Review of the Direct and Indirect Impacts of Fishing Activities on Marine Mammals in Welsh Waters

Peter GH Evans & Kirsten Hintner

CCW Policy Research Report No. 12/5

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Review of the Direct and Indirect Impacts of Fishing Activities on Marine Mammals in Welsh Waters

Peter G.H. Evans & Kirsten Hintner

A Report to Countryside Council for Wales

October 2010

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Executive Summary

Eighteen species of cetacean and two species of seal have been recorded in Welsh waters in recent times. However, only six species can be considered relatively common, occurring regularly. These are harbour porpoise, bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, minke whale, and Atlantic grey seal. Although all six species can be found in Welsh waters at any time of year, several species show seasonal changes in distribution. Some, such as short-beaked common dolphin and minke whale appear to largely move out of the region in winter, whilst recent research shows that the bottlenose dolphin changes its habit from being mainly coastal in small groups during summer, particularly in Cardigan Bay, to dispersing over wider regions in winter forming much larger groups. Grey seals aggregate at specific localities to breed during autumn and moult during winter and spring, hauling out at other times for shorter periods at a wider range of sites. River otters are increasing in Wales, and are now more frequently seen along the coast.

The diets of the grey seal, and four of the five species of cetaceans, are dominated by fish, the exception being the Risso's dolphin, which is almost exclusively a cephalopod feeder. However, all the other species have catholic diets, which may include some cephalopods as well as crustaceans. Preferred fish taken varies with marine mammal species both in terms of prey size and species although they tend to encompass a range of common pelagic, demersal and benthic fish, for example herring, mackerel, cod, whiting, sea bass, sprat, sandeel, and flatfish such as sole and flounder. Bottlenose dolphins also take a variety of other fish that are predominantly coastal, such as salmonids, eels, and mullet. Coastal otters feed upon shellfish and inshore shallow water fish.

Fisheries in Wales are predominantly inshore involving small vessels engaged in potting and other shellfisheries. Beam trawling targeting plaice or sole is conducted particularly off North Wales but also South-west Wales. Scallop dredging has been mainly south and west of the Isle of Man, but in 2007, intensified within Cardigan Bay. Demersal trawling (using otter trawls for plaice, sole and rays through the summer, and whiting during winter) takes place mainly off South-west Wales. Light demersal trawls for shrimp occur in a few areas, such as the Dee Estuary and in Carmarthen and Cardiff Bays. Beach seining catches bass or mullet in a number of localities around North Wales. There are no established pelagic trawl fisheries around the coasts of Wales. Hand lining and rod and line fishing are widespread and occur both commercially and recreationally in inshore waters, as is the use of set nets targeting particularly sea bass in summer but also rays and other species throughout the year. Other than sea fish, migrating salmon and sea trout are the main target for net fisheries. Potting for shellfish is the most frequently used and widespread fishing gear used in Welsh coastal waters. Aquaculture is practised particularly for mussels, but also crabs and oysters.

The main fisheries known to directly impact marine mammals through entanglement are trawls, static fishing gear, driftnets and seine nets. Since the ban on driftnets, most marine mammal mortality in the British Isles has come from either pair trawling or bottom-set gillnets. However, certain species, notably baleen whales such as the minke and humpback whale, may suffer mortality by entanglement in creel lines or mooring ropes. All marine mammal species suffer entanglement from lost or discarded netting.

A reduction in fishing activities using gear that are known to result in cetacean by-catch, along with the use of acoustic deterrent devices such as pingers and exclusion grids, has probably resulted in the reductions in by-catch observed in various parts of Northern Europe, including the British Isles. In Wales, cetacean by-catch appears to be low, and involve mainly harbour porpoise. Over the last ten years, numbers of stranded porpoises that have been identified as by-catch has not exceeded five per year. Although actual by-catch numbers will almost certainly be larger than this, there is no indication that it has any significant impact upon the porpoise population, which in the Irish Sea is estimated to exceed 15,000 individuals (and more than this if the Celtic Shelf area is included).

Indirect effects of fisheries upon Welsh marine mammals are more difficult to ascertain because of the lack of information on the regional diets of most of the species. Competitive relations are often very complex and involve understanding the spatial coincidence of fishing and marine mammals, their respective consumption rates, as well as interactions between prey species. Scallop dredging, for example, if intensively repeated over important seabed habitats, could have a detrimental effect upon bottlenose dolphins, although present regulations are likely to reduce any effects. Trawling and net fisheries for species such as sole, plaice, whiting, and sea bass potentially overlap the diets of several of the marine mammal species found in Welsh waters. With activities occurring mainly in the inshore sector, they are more likely to affect bottlenose dolphin, harbour porpoise and grey seal, although as yet, for reasons given above, the level of impact cannot be established.

Crynodeb Gweithredol

Yn ddiweddar mae deunaw math gwahanol o greadur morfilaidd a dau fath gwahanol o forlo wedi'u cofnodi yn nyfroedd Cymru. Fodd bynnag, dim ond chwe rhywogaeth y gellir eu hystyried fel bod yn rhai cymharol gyffredin sydd i'w gweld yn rheolaidd. Y rhain yw llamidyddion, dolffiniaid trwyn potel, dolffiniaid cyffredin, dolffiniaid Risso, morfilod pigfain a morloi llwyd. Er bod modd dod o hyd i'r chwe rhywogaeth hyn yn nyfroedd Cymru unrhyw adeg o'r flwyddyn, mae newidiadau tymhorol i'w gweld yn nosbarthiad sawl rhywogaeth. Mae rhai, megis dolffiniaid cyffredin a morfilod pigfain, fel pe baent yn mynd y tu allan i'r rhanbarth yn ystod y gaeaf. Ymhellach, mae gwaith ymchwil diweddar yn dangos bod dolffiniaid trwyn potel yn newid eu harferion yn ôl y tymor – yn ystod yr haf maent yn aros mewn grwpiau bach o gwmpas yr arfordir, yn arbennig ym Mae Ceredigion, gan wasgaru dros ardaloedd ehangach yn ystod y gaeaf a ffurfio grwpiau llawer mwy. Gwelir bod morloi llwyd yn ymgasglu mewn mannau penodol i fridio yn ystod yr hydref a bwrw'u blew yn ystod y gaeaf a'r gwanwyn, a'u bod yn gorffwyso am gyfnodau byrrach ar adegau eraill o'r flwyddyn ar amrywiaeth ehangach o safleoedd.

Pysgod yw prif fwyd morloi llwyd a phedair rhywogaeth o blith y creaduriaid morfilaidd. Yr eithriad yw dolffiniaid Risso, sy'n bwydo fwy neu lai yn llwyr ar seffalopodau. Fodd bynnag, mae gan yr holl rywogaethau eraill ddiet eang sy'n gallu cynnwys rhywfaint o seffalopodau yn ogystal â chramenogion. Mae hoff bysgod y gwahanol greaduriaid yn amrywio o rywogaeth i rywogaeth, o safbwynt maint a rhywogaeth y prae, er eu bod yn tueddu i fwyta amrywiaeth o bysgod pelagig, dyfnforol a benthig, er enghraifft penwaig, mecryll, penfreision, gwyniaid môr, draenogiaid môr, corbenwaig, llymrïaid, a lledod megis lledod chwithig a lledod mwd. Ymhellach, mae dolffiniaid trwyn potel yn bwyta amrywiaeth o bysgod eraill sydd i'w cael yn bennaf o amgylch yr arfordir, megis pysgod eogaidd, llysywod a hyrddod.

Pysgodfeydd y glannau a geir yng Nghymru yn bennaf lle gwelir llongau bach yn pysgota gyda chewyll, yn ogystal â chregynbysgodfeydd eraill. Defnyddir treillrwydi traws, yn enwedig oddi ar arfordir Gogledd Cymru a hefyd yn Ne-orllewin Cymru, i bysgota lledod coch neu ledod chwithig. I'r de a'r gorllewin o Ynys Manaw y gwelir treillio am gregyn bylchog yn bennaf, ond yn 2007 gwelwyd mwy o hyn yn digwydd ym Mae Ceredigion. Mae treillio dyfnforol (sef defnyddio treillrwydi estyllod i bysgota lledod coch, lledod chwithig a morgathod trwy'r haf, a gwyniaid môr yn ystod y gaeaf) i'w weld yn bennaf oddi ar arfordir De-orllewin Cymru. Defnyddir treillrwydi dyfnforol ysgafn i bysgota berdys mewn ambell ardal, megis Aber Afon Dyfrdwy, Bae Caerfyrddin a Bae Caerdydd. Defnyddir rhwydi sân traeth i ddal draenogiaid môr neu hyrddod mewn nifer o ardaloedd o amgylch Gogledd Cymru. Nid oes pysgodfeydd treillio pelagig wedi'u sefydlu o amgylch arfordir Cymru. Mae defnyddio leiniau pysgota, ynghyd â physgota â gwialen a lein, yn arferion cyffredin sydd i'w gweld o amgylch y glannau at ddibenion masnachol a dibenion hamddena, ac mae'r un peth yn wir am ddefnyddio rhwydi gosod sy'n targedu draenogiaid môr yn yr haf a morgathod a rhywogaethau eraill drwy gydol y flwyddyn. Ar wahân i bysgod môr, eogiaid a siwin yw prif dargedau pysgodfeydd rhwydi. Cewyll ar gyfer dal cregynbysgod yw'r offer pysgota mwyaf cyffredin a ddefnyddir amlaf yn nyfroedd arfordirol Cymru. Rhoddir dyframaeth ar waith hefyd, yn arbennig ar gyfer cregyn gleision, ond hefyd ar gyfer wystrys a chrancod.

Treillrwydi, offer pysgota sefydlog, drifftrwydi a rhwydi sân yw'r prif bysgodfeydd y gwyddys eu bod yn effeithio'n uniongyrchol ar famaliaid môr gan fod yr anifeiliaid yn mynd yn sownd yn y rhwydi. Ers i ddrifftrwydi gael eu gwahardd, mae marwolaethau mamaliaid môr yn Ynysoedd Prydain yn digwydd gan amlaf oherwydd treillio yn y bar neu rwydi drysu a ddaw i gysylltiad â gwely'r môr. Fodd bynnag, gall rhai rhywogaethau arbennig – morfilod walbon megis morfilod pigfain a morfilod cefngrwm – farw ar ôl mynd yn sownd mewn rhaffau cewyll neu raffau angori. Mae mamaliaid môr o bob math yn mynd yn sownd mewn rhwydi a gollwyd neu rwydi a daflwyd ymaith.

Mae'n debyg bod lleihad mewn gweithgareddau pysgota y gwyddys eu bod yn sgil-ddal creaduriaid morfilaidd, ynghyd â defnyddio dyfeisiadau ataliol acwstig fel 'teclynnau tincial' ("pingers") a gridiau dan waharddiad, wedi lleihau sgil-ddaliadau mewn gwahanol rannau o Ogledd Ewrop, yn cynnwys Ynysoedd Prydain. Yng Nghymru, ymddengys mai rhywfaint yn unig o greaduriaid morfilaidd sy'n cael eu sgil-ddal, a'r llamhidydd yw'r anifail sy'n cael ei ddal yn y fath fodd gan amlaf. Yn ystod y deng mlynedd diwethaf nid yw niferoedd llamidyddion sydd wedi mynd yn sownd ar y lan oherwydd eu bod yn sgil-ddalfa wedi codi'n uwch na phump y cant. Er bod gwir niferoedd sgil-ddaliadau yn debygol iawn o fod yn uwch na hyn, ni cheir unrhyw arwydd fod hyn yn cael effaith sylweddol ar boblogaeth llamidyddion. Amcangyfrifir bod mwy na 15,000 o lamidyddion ym Môr Iwerddon (mwy, yn wir, os caiff ardal gwely'r Môr Celtaidd ei chynnwys).

Mae'r effeithiau anuniongyrchol a gaiff pysgodfeydd ar famaliaid môr Cymru yn anos i'w pennu oherwydd diffyg gwybodaeth am ddiet rhanbarthol y rhan fwyaf o'r rhywogaethau. Gall perthnasau cystadleuol fod yn gymhleth a rhaid deall yr effaith a gaiff pysgota ar famaliaid môr, eu cyfraddau bwydo, a hefyd y berthynas rhwng mathau gwahanol o brae. Os caiff treillio am gregyn bylchog ei ailadrodd yn ddwys dros gynefinoedd pwysig ar wely'r môr, gallai gael effaith andwyol ar ddolffiniaid trwyn potel, er bod y rheoliadau presennol yn debygol o leihau unrhyw effeithiau. Mae yna bosibilrwydd y gall treillrwydo a physgodfeydd rhwydi orgyffwrdd â diet nifer o famaliaid môr sydd i'w cael yn nyfroedd Cymru. Gan fod y gweithgareddau'n digwydd yn bennaf yn y sector sy'n pysgota'r glannau, maent yn fwy tebygol o effeithio ar ddolffiniaid trwyn potel, llamidyddion a morloi llwyd; ond hyd yn hyd, ni ellir pennu lefel eu heffaith am y rhesymau a nodir uchod.

1. INTRODUCTION

In many parts of the world, the incidental capture of non-target marine species in fishing gear is a significant management issue facing fishermen, fisheries managers and marine conservationists alike. In its simplest sense, ‘by-catch’ can be described as the taking of unwanted, untargeted animal species by commercial fishing operations. These species may be other fish, but they can also include a suite of invertebrate or vertebrate taxa such as turtles, seabirds, seals, and cetaceans.

Besides direct impacts by drowning due to net entanglement, marine mammals and fisheries may conflict with one another where they compete for food, or where a fishing activity modifies the habitat sufficiently to change the local ecosystem and thus the prey available to marine mammals.

This report reviews current literature on the direct and indirect impacts of fishing activities upon marine mammals, and identifies any gaps in knowledge. Those fisheries undertaken in Welsh territorial waters that are most likely to impact upon marine mammals are identified. From this review, a pilot or test sensitivity matrix will be developed for the cetacean species regularly occurring in Welsh waters, and applied to different types of fishing activity. Previously, Hall *et al*. (2008) have produced sensitivity indices for marine benthic habitats in Wales. This report will review potential impacts of fisheries upon marine mammals, with special attention to Welsh waters.

Information on marine mammal behaviour, distribution and abundance in Welsh waters is necessary to support environmental stewardship and help to determine appropriate mitigation measures so that anthropogenic impacts can be minimised. As a first step to address those needs, an Atlas of Marine Mammals of Wales (Baines & Evans, 2009[1]) was produced for the Countryside Council for Wales, and the results of that will be used here to summarise status and distribution of the major marine mammal species occurring in Welsh waters, along with other biological information synthesised from research on marine mammals within the UK. That information will then be utilised to assess the impacts of different fishing activities on those marine mammal species regularly occurring in the region.

1.1 Project Objectives

The overall aim of this project is to determine the sensitivity of marine mammals to the different fishing gear types used within the 12 nautical mile boundary of Welsh territorial waters and, thereafter, to propose a methodology for visually representing such sensitivity.

The principal objectives of the project are to:

1) Collate, compile and review the literature on the direct and indirect impacts of interactions between marine mammals and fishing activities. This should draw upon

[1] A second edition with new maps has been published in 2012

information from elsewhere, particularly northern Europe. Identify which fishing activities undertaken in Welsh territorial waters may interact with the marine mammals found there.

2) Categorise the effects of already defined (by CCW) fishing activities (shown in Appendix 1) on marine mammal behaviour and activity within the 12 nm boundary of Welsh waters.

3) Demonstrate consideration of how other factors e.g. seasonal differences and prey availability may also influence the effects of different fishing activities on marine mammals.

4) Use this information to create a sensitivity matrix (or equivalent approach) for assessing the sensitivity of marine mammals to different types and intensities of fishing.

This literature review will address the first three of these objectives.

2. MARINE MAMMAL SPECIES OF WALES

Eighteen species of cetacean and two seal species have been recorded in Welsh waters since 1990. Six species are relatively common and occur regularly. These include one seal species, the Atlantic grey seal (*Halichoerus grypus*), and five cetacean species: harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*), and minke whale (*Balaenoptera acutorostrata*). Rare species include fin whale (*Balaenoptera physalus*), killer whale (*Orcinus orca*), and long-finned pilot whale (*Globicephala melas*), and as casual visitors to the region: the harbour seal (*Phoca vitulina*), humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), pygmy sperm whale (*Kogia breviceps*), northern bottlenose whale (*Hyperoodon ampullatus*), Cuvier's (*Ziphius cavirostris*), Sowerby's (*Mesoplodon bidens*) and Blainville's beaked whales (*Mesoplodon densirostris*), striped dolphin (*Stenella coeruleoalba*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), and white-beaked dolphin (*Lagenorhynchus albirostris*) (Baines & Evans, 2009).

The status, distribution, behaviour and diet of the six common species are summarised in subsequent sections. Emphasis is placed upon those aspects that are relevant to assessing potential interactions with fisheries, and their likely impacts. This includes evaluating population sizes and trends, habitat preferences, and in particular, diet and foraging behaviour. Tables of diet are detailed in Appendix 2.

2.1 Harbour Porpoise *Phocoena phocoena*

2.1.1 Status & Distribution

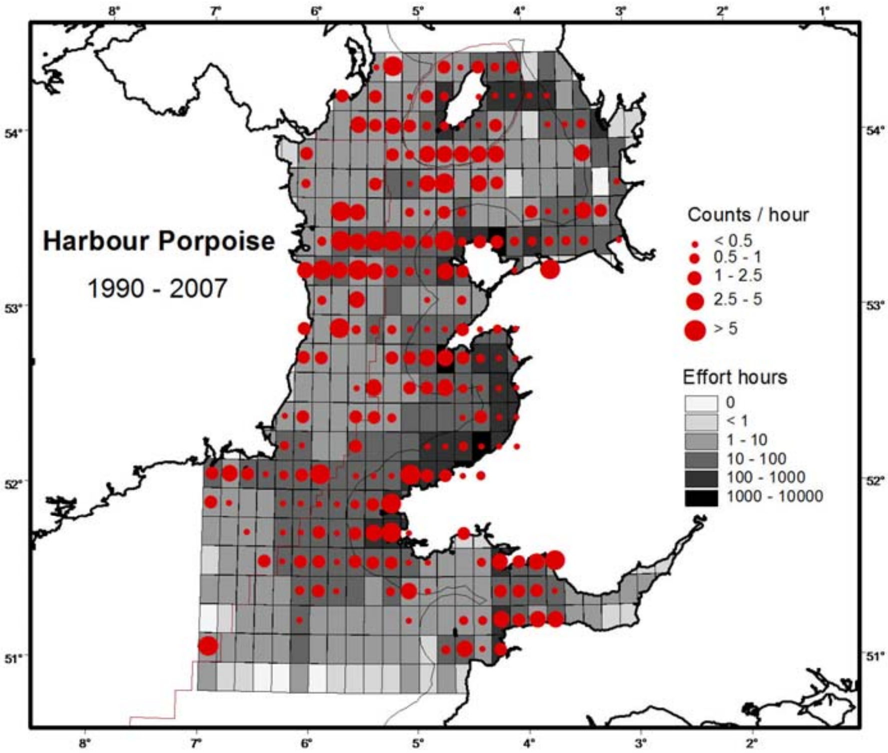
Britain's smallest cetacean, the harbour porpoise is the commonest and most widespread species both in UK and Welsh waters (Hammond *et al*., 2002; Evans *et al*., 2003; Reid *et al*., 2003; Evans *et al*., 2008; Hammond, 2008). In the Irish Sea, porpoises are not evenly distributed. Hot spots can be identified around Anglesey and off the Pembrokeshire coast, and to a lesser extent off the south coast of the Llyn Peninsula, in southern Cardigan Bay, and in the Bristol Channel off the south coast of Wales (around the Gower Peninsula and in Newport Bay) (Baines & Evans, 2009; see Fig. 1). These areas of higher density have generally persisted over the long-term.

2.1.2 Abundance & Trends

From line transect surveys in July 1994 (Hammond *et al.*, 2002), an overall population estimate of 341,000 porpoises (CV=0.14; 95% CI: 260,000-449,000) was made, with the following regional estimates: the North Sea (c. 250,000), Baltic region (36,600 in Kattegat/Skagerrak/Belt Seas/Western Baltic Sea), Channel (0), and Celtic Shelf (36,300).

A repeat survey in July 2005 (SCANS II), covering a wider area (continental shelf seas from SW Norway, south to Atlantic Portugal), gave an estimate of 385,600 (CV = 0.20) (Hammond, 2008), with regional estimates: North Sea (c. 231,000), Baltic (23,000 in Kattegat/Skagerrak/Belt Seas/Western Baltic Sea), Channel (40.900), and Celtic Shelf (58,400).

a) Long-term mean sightings rates overlying effort



b) Interpolated long-term mean sightings rates

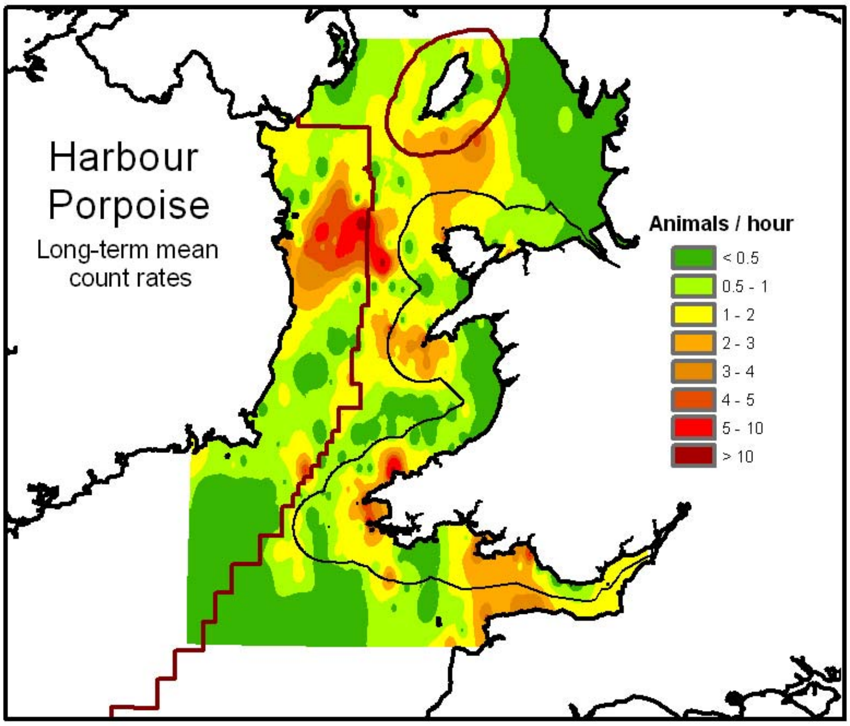


Figure 1. Long-term mean sightings rates (counts per hour) of harbour porpoise (Baines & Evans, 2009[1])

[1] ***Editor's Note***: *A 2nd edition with new maps was published in 2012*

The abundance estimate calculated from the July 2005 SCANS II survey for the Irish Sea was 15,200 (CV=0.35) (Hammond, 2008). In Cardigan Bay, line transect surveys of the SAC indicate that the harbour porpoise population has been slightly increasing over the period 2001 and 2008 (Pesante *et al*., 2008), whilst sightings rates show a significant increase since the 1980s (Evans *et al*., 2003).

2.1.3 Habitat

Harbour porpoises favour cool temperate shelf seas (mainly 11-14^{o}C) of 20-100m depth. The species is commonly found in coastal bays and estuaries, around headlands, and within tidal channels (Reid *et al*., 2003; Evans *et al*., 2003, 2008).

2.1.4 Annual Cycle

Porpoises are present year-round in Welsh waters, although they are probably under-recorded in winter, and acoustic monitoring using T-PODs indicated that the species was present in Cardigan Bay at a higher frequency in winter than in summer (Pesante *et al*., 2008; Baines & Evans, 2009). Porpoise calves occur throughout the region, with births occurring mainly in May-July (Evans *et al*., 2008). In British waters (as elsewhere), the species is usually solitary or in small loose groups of 2-10, although larger ephemeral aggregations up to one hundred or more may occur seasonally, particularly between July and October (Evans *et al*., 2003, 2008).

2.1.5 Diet & Feeding Behaviour

Porpoises feed primarily on small (mainly 75-200 mm in length), schooling fish, found in the water column or on the sea floor. Small cephalopods (mainly Sepiolidae) are also consumed, but less frequently than fish. Their diet can vary both geographically and seasonally. Analyses of tissues from porpoises by-caught at four Scandinavian localities (from North Sea to Barents Sea), using stable isotopes and the trace element cadmium, correlated well with both bathymetry and latitude, indicating a shift in feeding habits from pelagic prey species in deep northern waters to more coastal and/or demersal prey in the relatively shallow waters of the North Sea and Skagerrak (Fontaine *et al.* 2007b.)

In France, analyses of stomach contents reveal mainly blue whiting, scad, and hake (Desportes 1985; Spitz *et al*., 2006). In Germany, the diet was mainly sole and cod (Lick 1991) or sandeels (Ammodytidae) and sole (Benke & Siebert 1996). Herring, sprat and gadoids (particularly cod and whiting) predominated in large samples from Denmark and Scandinavia respectively (Aarefjord *et al*. 1995; Berggren 1996; Børjesson & Berggren 1996; Santos *et al*. 2005); gadoids (particularly whiting and *Trisopterus* spp.), sandeel and gobies Gobiidae predominated in large samples from the UK (Martin 1996); whilst gadoids (mainly whiting) and gobies were the main species in a sample from the Netherlands (Santos *et al*. 2005). In Scotland (mostly the east coast), the main prey were: whiting and sandeels, although there were differences between regions, seasons and years (Santos *et al*. 2004). Off Ireland, the diet was mainly *Trisopterus* spp., whiting, and herring (Berrow & Rogan, 1995). Echosounder surveys of porpoise-prey associations in Shetland found significant spatio-temporal associations only with sandeel, despite an abundance of gadoid fish (whiting & saithe), which presumably were not favoured when sandeels were abundant (Evans, 1996).

In much of the North Sea, herring became much scarcer than they had been in the 1970s and before. Where herring are present, they frequently form a major component of the diet (Lindroth 1962, Rae 1965, 1973, Recchia & Read 1989, Aarefjord *et al*. 1995, Gannon *et al*. 1998), presumably because they are fatty and energy-rich (Evans, 1990). In parts of the North Sea and in the Baltic, stomach contents include gobies as well as cephalopods (Sepiolidae), crustaceans, polychaetes and other molluscs (Lick 1991, Benke & Siebert 1996, Malinga & Kuklik 1996, Santos *et al.* 2005).

Little is known of how porpoises find and catch their prey in the wild, although there have been several recent captive studies (Kastelein *et al*. 1997; Verfuß *et al*. 2005). There is circumstantial evidence that seasonal movements into coastal waters of the British Isles, and longer-term status changes in the North Sea, are related to the timing of spawning of herring, sandeels and gadoids (Evans 1990, 1996a; Reijnders 1992; Evans *et al*., 2008).

The food requirements of individuals are not well understood; preliminary studies with captive animals suggests that adult porpoises require a daily ration of 4-9.5%, and juveniles up to 15%, of body mass (Koga 1991, Kastelein *et al*., 1997, Lockyer *et al*., 2003). Porpoises increase their food consumption in late summer and increase their body weight, reaching a peak weight with increased blubber and fat storage in mid-winter (Lockyer *et al*., 2003, Lockyer 2007). This aids insulation in the cold months and provides a temporary energy surplus.

In Danish waters, 14 porpoises with satellite linked dive recorders averaged 29 dives per hour between April-August, and 43 during October-November (Teilmann *et al*., 2008). Dives occurred day and night, but with peak activity during daylight hours, spending 55% of time in the upper 2m during April-August. Maximum dive depths were to the sea bottom (30-50m) in the Belt seas and Kattegat, and 132m in the deeper Skagerrak, with most frequent depths of 14-32m. Maximum dive durations were typically 4-6 mins, but possibly up to 10-15 mins (Teilmann *et al*., 2008).

2.1.6 Interactions with Humans

As the most common cetacean within 10km of the coast, it is exposed to a variety of human activities. In UK, cause of death, where known, has been primarily from entanglement in fishing gear, infectious disease or bottlenose dolphin attack, although incidences of starvation have been increasing (Jepson, 2005; Deaville & Jepson, in press). In Wales, mortality due to fisheries by-catch is lower than elsewhere in the UK, and the most common cause of death is bottlenose dolphin attacks (Jepson, 2005; Deaville & Jepson, in press).

Key:

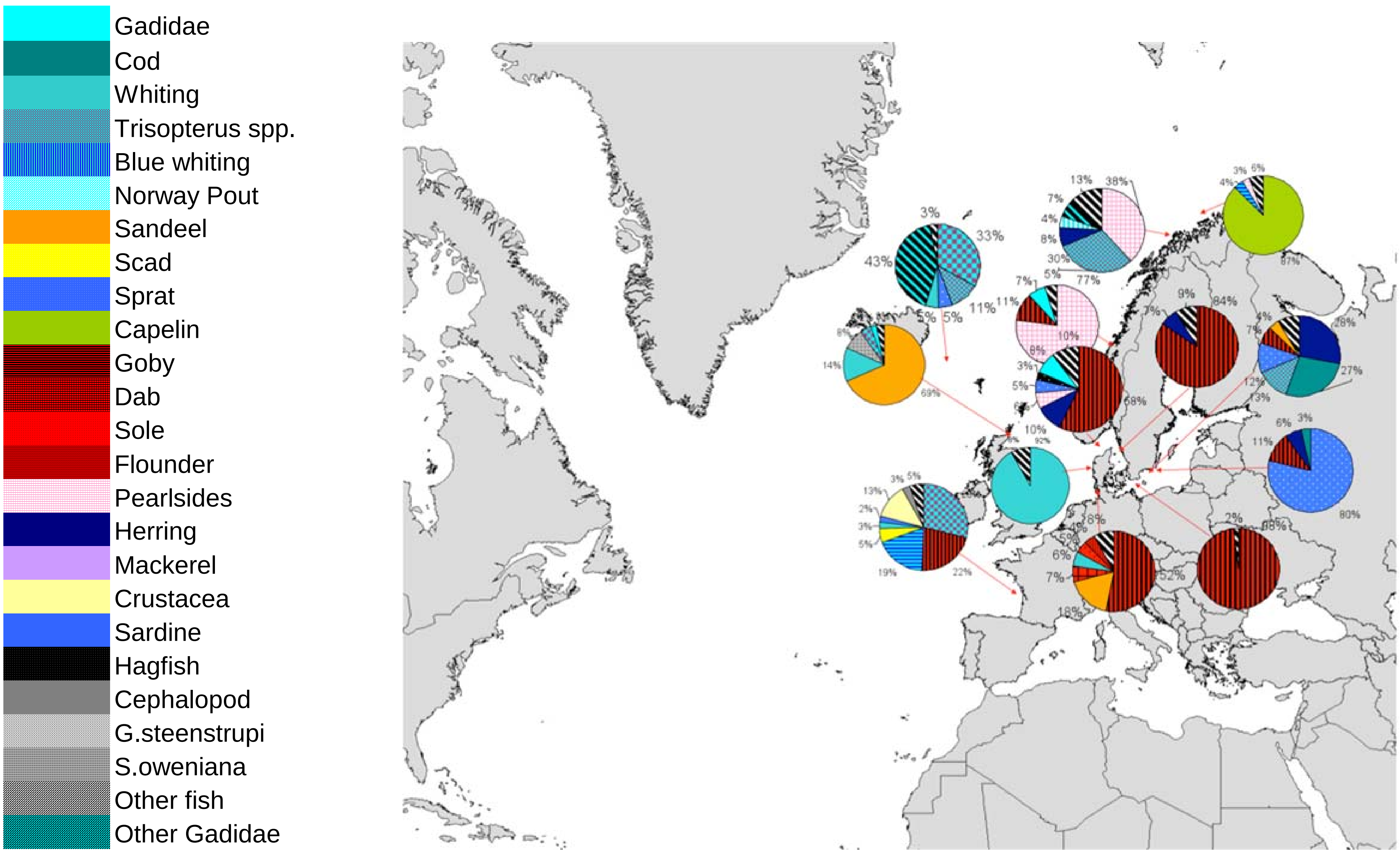


Figure 2: The diet of harbour porpoise by number (%) in the North east Atlantic

Key:

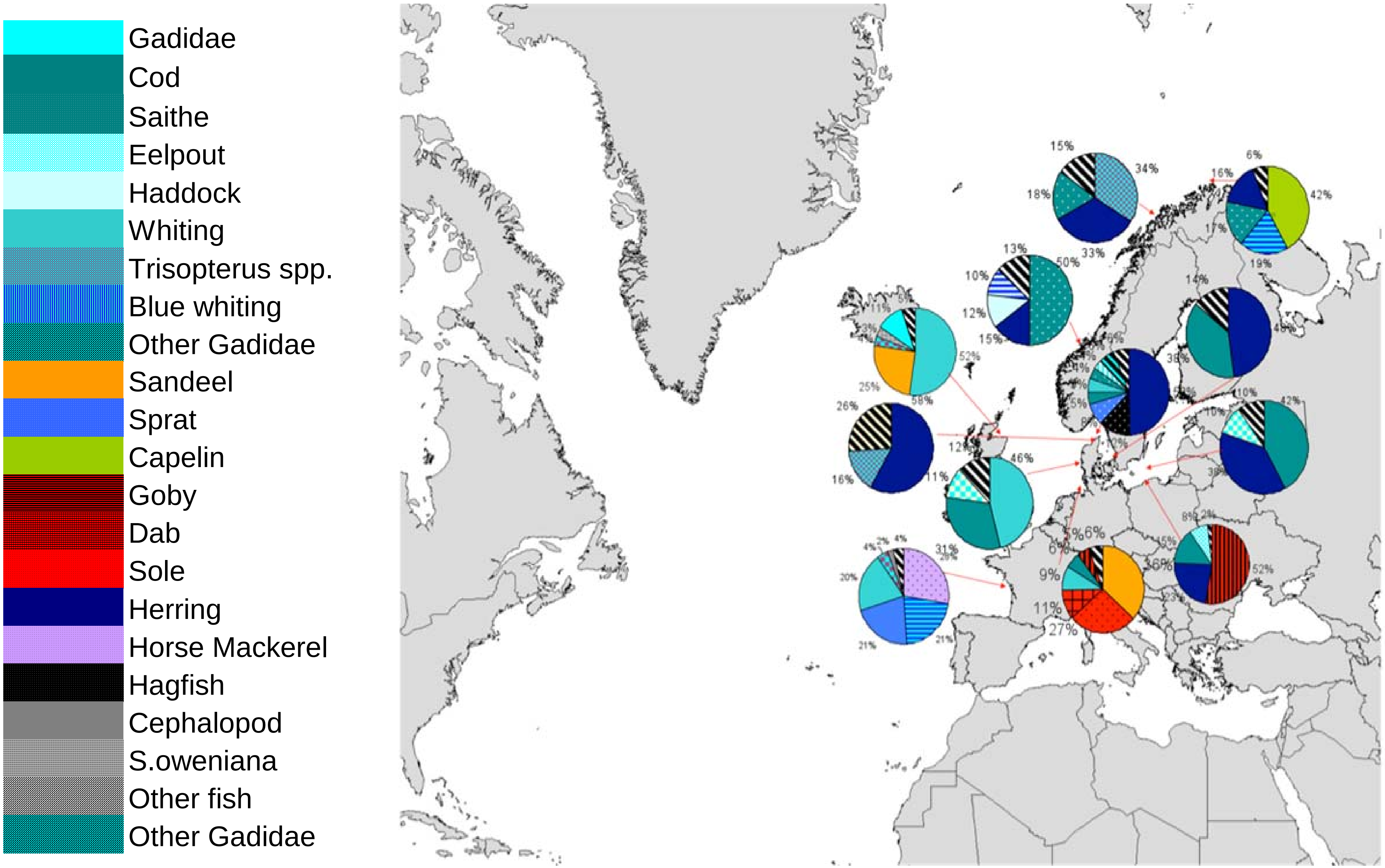


Figure 3: The diet of harbour porpoise by weight (%) in the North east Atlantic

2.2 Bottlenose dolphin *Tursiops truncatus*

2.2.1 Status & Distribution

The bottlenose dolphin has a worldwide distribution in tropical and temperate seas in both hemispheres. Along the Atlantic seaboard of Europe, the species is locally fairly common near-shore off the coasts of Spain, Portugal, north-west France, western Ireland (particularly Galway Bay and the Shannon Estuary), East Scotland (particularly Moray Firth south to the Firth of Forth), South-west Scotland, in the Irish Sea (particularly Cardigan Bay and North Wales), and in the English Channel (Hammond *et al*., 2002; Evans *et al*., 2003; Reid *et al*., 2003; Hammond, 2008).

In Welsh waters, the bottlenose dolphin is the next most frequently recorded cetacean species, with a predominantly coastal distribution, although low densities have been recorded offshore, particularly in St George's Channel and the southwest sector of the study area (Baines & Evans, 2009; Fig. 4). The main concentrations of sightings occur in southern Cardigan Bay and further north in Tremadog Bay although the species may also be found off the north coast of Wales, particularly north and east of Anglesey.

2.2.2 Abundance & Trends

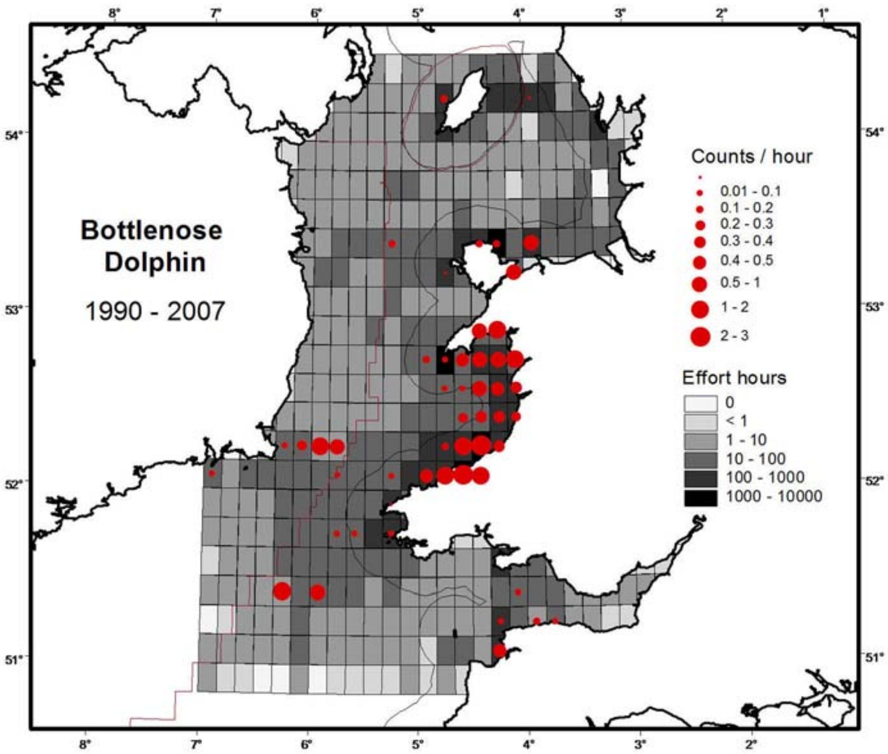
Coastal populations of bottlenose dolphins tend to be small (Wilson, 2008). Abundance estimates (mainly using photo-ID and mark-recapture) exist for both of the principal coastal populations in the UK. An estimated 129 (95% CI = 110-174) animals live in the Moray Firth (Wilson *et al.*, 1999), whilst the population in the Cardigan Bay SAC has been estimated from 2001-09 to vary in any particular year between 121 and 210 bottlenose dolphins (using a closed population model), and for the entire Cardigan Bay (between 2005-09, and using an open population model) has varied between 154 and 248 (Pesante *et al*., 2008; Sea Watch, unpublished data). Neither the Moray Firth nor the Cardigan Bay population is confined to those areas nor is closed, and individuals may join up for periods of time from elsewhere.

In Western Ireland, estimates of between 113 and 140 individuals have been reported as occupying the Shannon Estuary (Ingram 2000; Ingram and Rogan, 2003, Englund *et al*., 2007, 2008).

SCANS II surveys of Northwest European shelf waters in July 2005 gave an overall abundance estimate of 12,600 (CV=0.27), most of which were close to the shelf edge (Hammond, 2008), and, further offshore, the CODA survey (July 2007) yielded an abundance estimate, uncorrected for g(0) and responsive movement, of 19,300 (CV=0.25) (P.S. Hammond, *pers. comm.*). These highlight the significant offshore population(s) of this species. The SCANS 2 estimate for the Irish Sea was 235 individuals (CV=0.75) (Hammond, 2008).

There was indication of a slight but non-significant increase in the Cardigan Bay bottlenose dolphin population between 2001 and 2007, but from 2008 onwards, has either been stable or declined (Pesante *et al*., 2008; Sea Watch, unpublished data), whilst the Moray Firth population remains stable (Thompson *et al*., 2004).

a) Long-term mean count rates



b) Interpolated long-term mean count rates

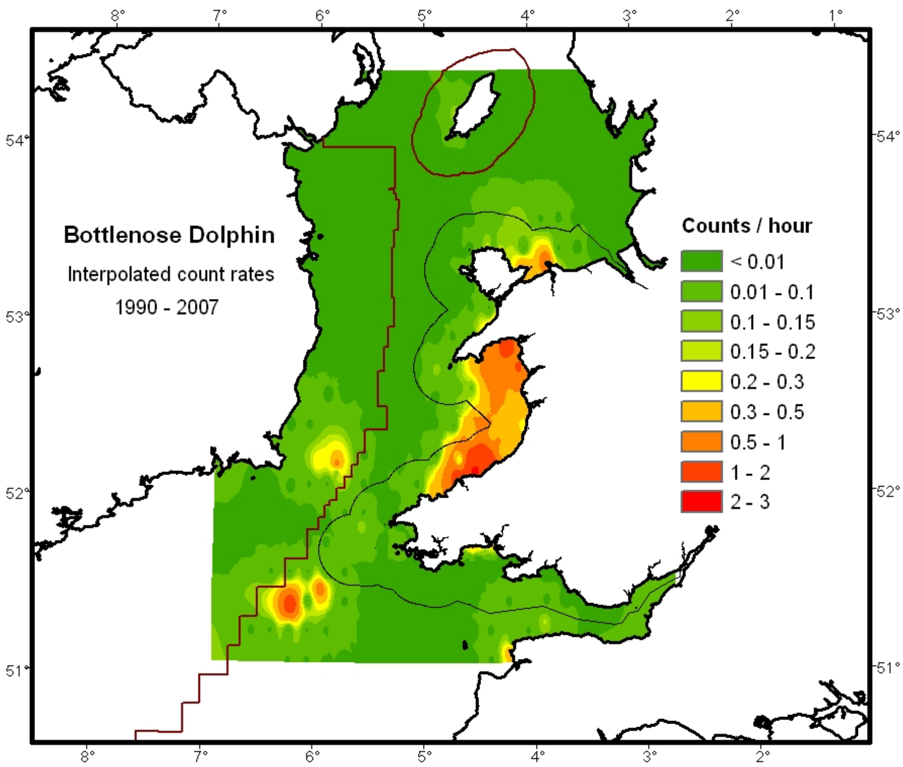


Figure 4: Long-term sightings rates (no. of individuals per hour) of bottlenose dolphins (Baines & Evans, 2009)

2.2.3 Habitat

Inshore distribution of bottlenose dolphins includes estuaries and harbours with brief forays into fresh water where areas of strong tidal currents and steep bottom relief are particularly favoured (Lewis & Evans, 1993; Liret *et al*., 1994; Wilson *et al*, 1997; Ingram & Rogan, 2002; Evans *et al*., 2003; Wilson, 2008). In coastal waters, they often associate with headlands or sandbanks where there is uneven bottom relief and/or strong tidal currents, but a significant population also exists along the continental shelf edge (Evans *et al*., 2003; Reid *et al*., 2003; Hammond, 2009). Little is known about the ecology of offshore animals though they frequently co-occur with long-finned pilot whales *Globicephala melas*. The relationship between offshore and coastal bottlenose dolphins is unknown.

2.2.4 Annual Cycle

Bottlenose dolphins breed throughout their Welsh range, with calves observed in most months of the year (Pesante *et al*., 2008). However, in Welsh waters, there is an apparent peak in newborn calves in summer with 60% of birth estimated to occur in July-August, and 92% between May and September (Sea Watch, unpublished data). In the Moray Firth, newborns were also seen in most months of the year, but mainly between July and September (Grellier, 2000).

Seasonal differences in group size and dispersion have been observed, with dolphins in summer occurring mainly in small groups typically of 2-10 individuals near the coast, centred upon Cardigan Bay, dispersing more widely and generally northwards, where they may form very large groups numbering up to 100 individuals in winter (Pesante *et al*., 2008a, b). However, the species can be seen at any time of the year throughout Welsh coastal waters (Baines & Evans, 2009). Bottlenose dolphins frequently bow-ride vessels, and engage in aerial activity.

2.2.5 Diet & Feeding Behaviour

This species is generally considered to be an opportunistic feeder with diet including a wide variety of benthic and pelagic, solitary and schooling, fish and cephalopods (Wilson, 2008; Figs. 5 & 6).

Individuals may specialise on particular prey species or switch as availability changes particularly with area and season. Documented prey of ten bottlenose dolphins from Scottish waters included gadoids (cod, saithe, whiting, haddock), salmon, sprat, sandeels, flatfish and cephalopods (Santos *et al.,* 2001). Although there have been no analyses of stomach contents of Welsh bottlenose dolphins (since very few animals strand and they generally have empty stomachs), animals have been directly observed taking a variety of prey, including sea bass, salmon, conger eel, garfish, sandeel, and small shark species (Pesante *et al*., 2008; Sea Watch, unpublished data).

Elsewhere, in Western Ireland, a total of 36 prey species were identified in eight bottlenose dolphin stomachs (82% fish, 17% cephalopods, and <1% crustaceans) (Hernandez-Milan & Rogan, 2010). Amongst fish, gadoids (mainly whiting, blue whiting, pollack, saithe, haddock, and pouts *Trisopterus* spp.) were the most commonly recorded species (87.5%). Amongst cephalopods, oceanic species (62.5%) such as *Teuthowenia megalops* and *Gonatus* sp.) were the principal prey in one carcass.

In France, Spitz *et al*. (2006) recorded 25 fish species, three cephalopod species and a crustacean from the stomachs of 25 bottlenose dolphins. Fish largely dominated by both number (94%) and mass (91%). Hake was the most important prey (20% by number and 41% by mass). Scads and mullets represented 13% and 12% by reconstructed biomass and 15% and 5% by number, respectively. Secondary fish species included pouts *Trisopterus* spp., sea bass, sea bream, and sardine. Blue whiting and sprat represented respectively 13% and 11% by number but owing to their very small body size (9 and 12cm), less than 1% by mass. Prey sizes ranged from 18 to 667mm (mean = 228mm), with 41% being <160mm, 44% of 160-320mm length, and 16% being >320mm.

In Galician waters, the most important prey recorded in 82 stomachs were blue whiting and hake (Fernández *et al*., 2006), as was the case from nine stomachs collected from bottlenose dolphins along the Asturian coast (Arronte *et al*., 2009). In the latter case, blue whiting represented 85% by number and 50% by mass, whilst hake constituted 9% by number and 39% by mass. The oceanic cephalopod, *Todarodes sagittatus*, was the most important cephalopod prey (4.8% by mass).

In the Adriatic Sea, sea-breams (family Sparidae) were found to be the most abundant fish in 25 bottlenose dolphin stomachs from the Croatian coast, both in term of percentage frequency and percentage occurrence (Kovacic & Bogdanovic, 2006). However, the species appeared to be feeding predominantly on cephalopods in the central Adriatic but primarily on fish in the northern and southern Adriatic.

The bottlenose dolphins examined from around the Iberian Peninsula and in the Bay of Biscay appear to have been feeding predominantly on pelagic fish. Two of the bottlenose dolphins from France were known from photo-ID to have been resident in coastal waters. One of these had only poor cod (*Trisopterus* spp.) and squid (*Alloteuthis* sp.) in its stomach, whereas the other had mainly mullet (family Mugilidae), but also *Trisopterus* spp. and squid (*Loligo* sp.) (J. Spitz, *pers. comm.*).

Observations of bottlenose dolphins in Cardigan Bay suggest that during summer they form small groups that occupy areas very close to the coast where they make vertical dives, apparently feeding off or close to the seabed (Pesante *et al*., 2008; Sea Watch, unpublished data). At times, however, they will feed on more pelagic prey either offshore or around river estuaries such as the Teifi, and have been found to associate with herring and mackerel in those situations. In North Wales, particularly between November and April, they form larger groups and tend to be found associated with sea bass, whiting, herring or mackerel (Sea Watch, unpublished data).

2.1.6 Interactions with Humans

Only small numbers have been recorded stranding (Baines & Evans, 2009), and, rarely is cause of death established (Jepson, 2005; Deaville & Jepson, in press). Direct physical injury from boat strikes and underwater explosions, as well as drowning due to entanglement in fishing gear have been reported in various parts of the world (Wilson, 2008) including Wales (Pesante *et al*., 2008), whilst levels of PCBs in UK strandings are disturbingly high (Jepson, 2005; P.D. Jepson, *pers. comm*.).

Key:

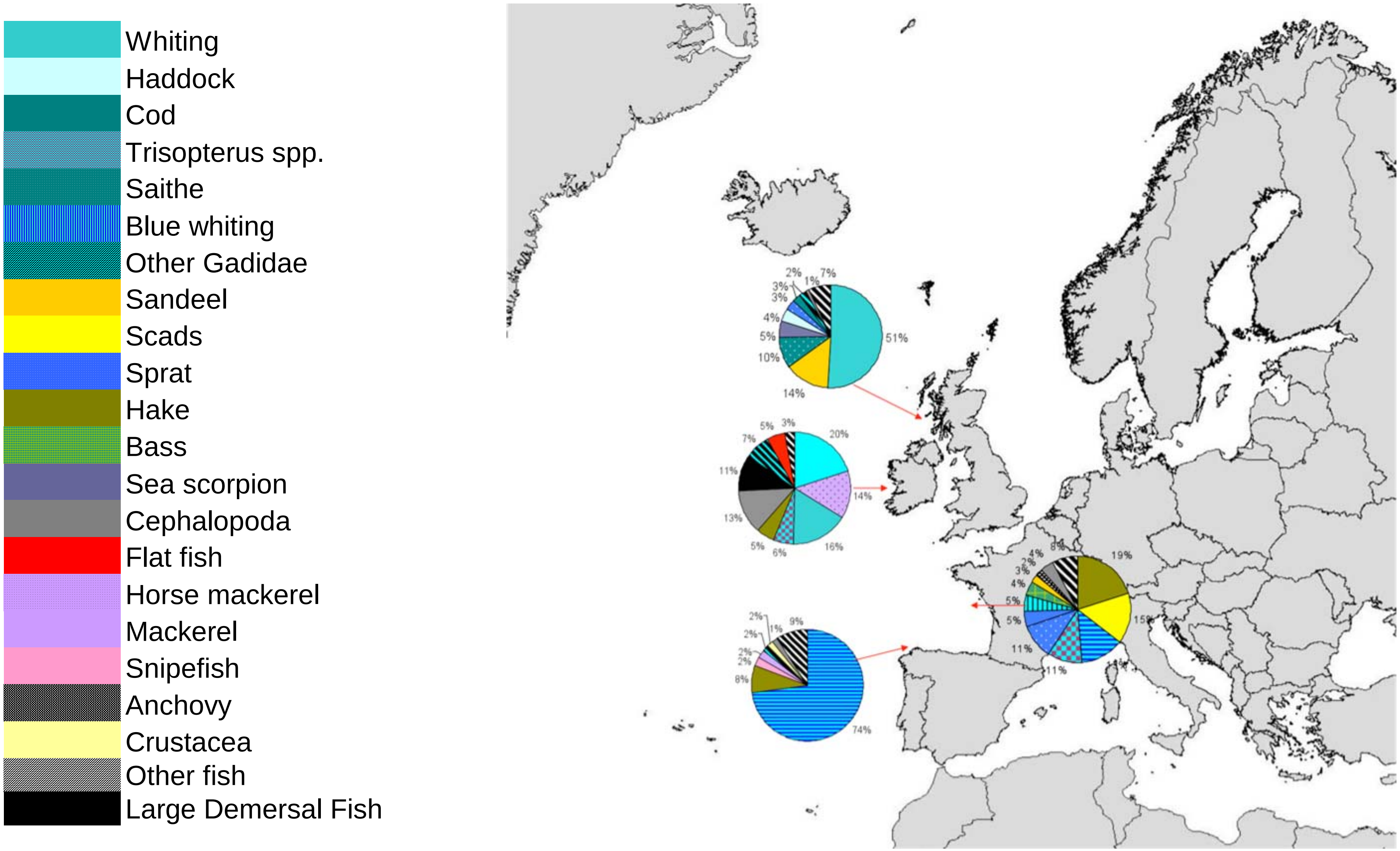


Figure 5: The diet of bottlenose dolphins by number (%) in the North east Atlantic

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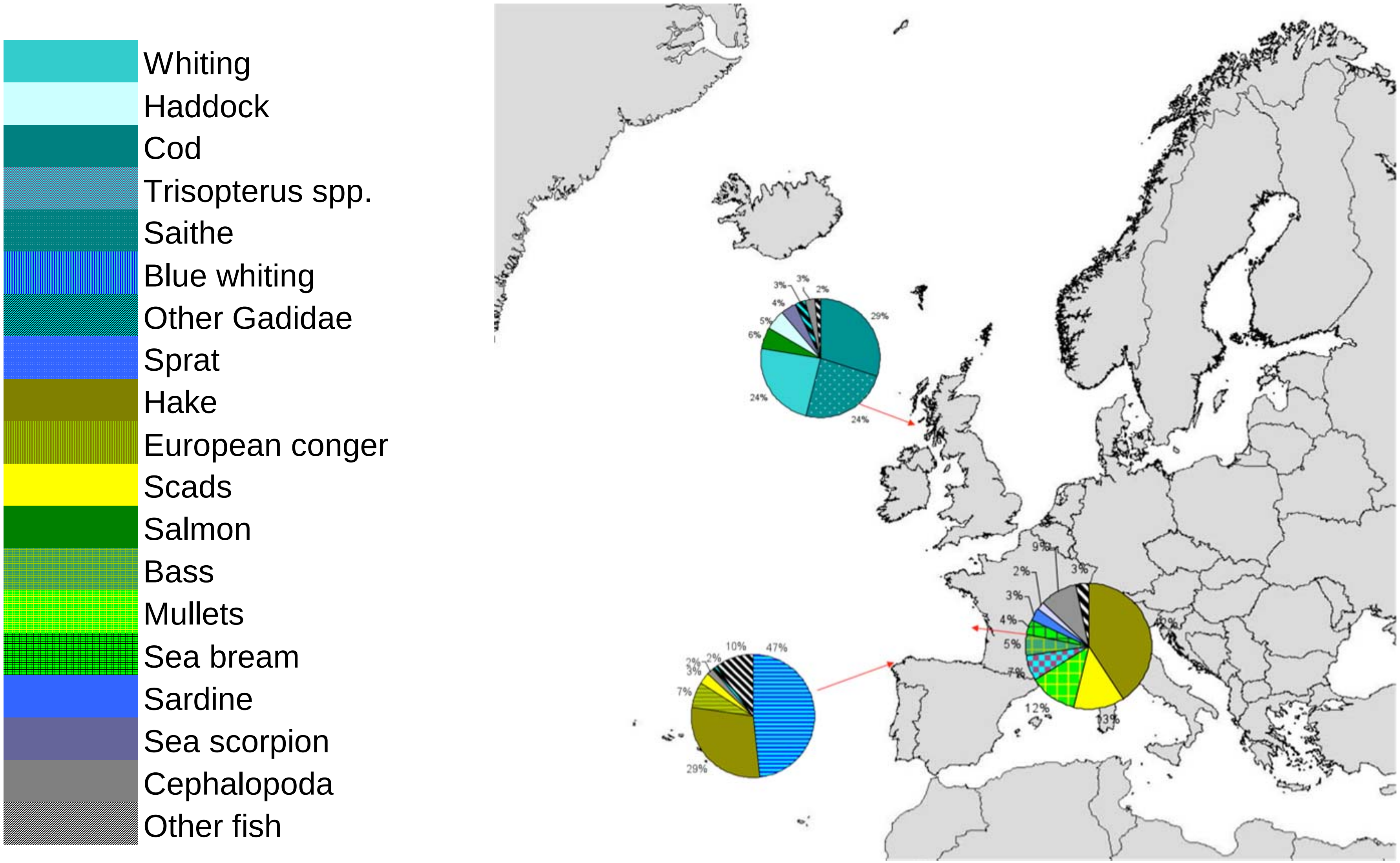


Figure 6: The diet of bottlenose dolphins by weight (%) in the Northeast Atlantic

2.3 Short-beaked Common Dolphin *Delphinus delphis*

2.3.1 Status & Distribution

The short-beaked common dolphin has a worldwide distribution in oceanic and shelf-edge waters of tropical, subtropical and temperate seas, occurring in both hemispheres. It is abundant and widely distributed in the eastern North Atlantic, mainly occurring in deeper waters from the Iberian Peninsula north to the Faroe Islands (Reid *et al*., 2003; Murphy *et al*., 2008).

On the UK continental shelf, the species is common in the western half of the English Channel and the southern Irish Sea, and further north in the Sea of Hebrides and southern part of the Minch (Evans *et al*., 2003; Reid *et al*., 2003). It is also common south and west of Ireland, whilst off the edge of the continental shelf it can be found north to a latitude of about 65^{o} N (though rare north of 62^{o} N). In some years, the species occurs further north and east in shelf seas - in the northern Hebrides, around Shetland and Orkney, and in the northern North Sea. It is generally rare in the central and southern North Sea and eastern portion of the English Channel, but is abundant in the Bay of Biscay (Evans *et al*., 2003; Reid *et al*., 2003).

In Welsh waters, the species has a largely offshore distribution centred upon the Celtic Deep at the southern end of the Irish Sea, where water depths range from 50-150 metres (Baines & Evans, 2009; Fig. 7). This high-density area extends eastwards towards the coast and islands of west Pembrokeshire. Elsewhere in the Irish Sea, the species occurs at low densities mainly offshore, in a central band that extends northwards to at least the Isle of Man. Similar patterns of distribution have occurred across the four time periods examined. (Baines & Evans, 2009)

2.3.2 Abundance & Trends

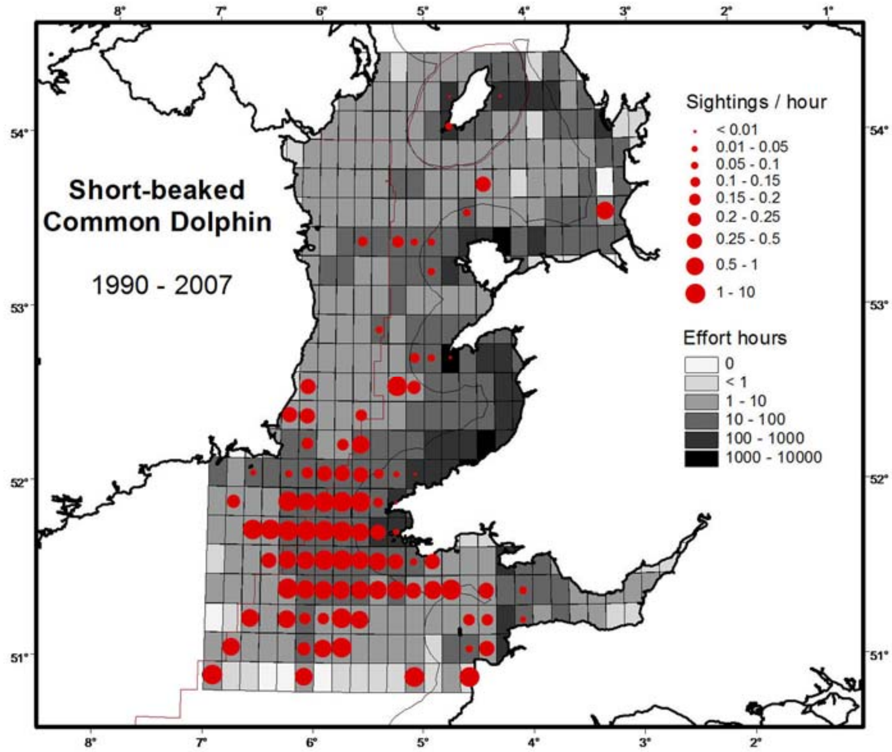
Several surveys using line transect methods have estimated population abundance levels in the NE Atlantic. The MICA survey in the summer of 1993 estimated the population at 61,888 (95% C.I.: 35,461–108,010) in the area where the French tuna driftnet fishery operated (Bay of Biscay, continental shelf W to c. 20°W, and S to c. 43°N) (Goujon *et al*., 1993).

The SCANS survey in July 1994, included the Celtic shelf to approximately 11°W and 48°S, and gave an estimate of 75,450 (CV = 0.67; 95% C.I.: 23,000–249,000) (Hammond *et al*., 2002). Where the two surveys overlapped in area along the shelf edge (11°W-51°N to 8°W-48°N), the total summer population was estimated at c. 120,000 (Goujon, 1996).

During August 2002, the ATLANCET aerial survey covered 140,000 km^2 of continental shelf and shelf break in the Bay of Biscay overlapping with the SCANS survey area in the Southern Celtic Sea, gave an estimate of 17,639 (95% C.I.: 11,253-27,652) (Ridoux *et al*., 2003, WGMME, 2005).

The NASS ship-based survey, in summer 1995, by the Faroese covered two large areas to N and W of Ireland (NASS east and NASS west), and gave an estimate of 273,159 (95% C.I.: 153,392-435,104) for the western block (Cañadas *et al*., 2009); further east, the SIAR survey estimated 4,496 (95% C.I.: 2,414–9,320) within an area of c. 120,000 km^2 off W Ireland during August 2000 (Ó Cadhla *et al*., 2003).

a) Long-term mean sightings rate



b) Interpolated long-term mean sightings rate

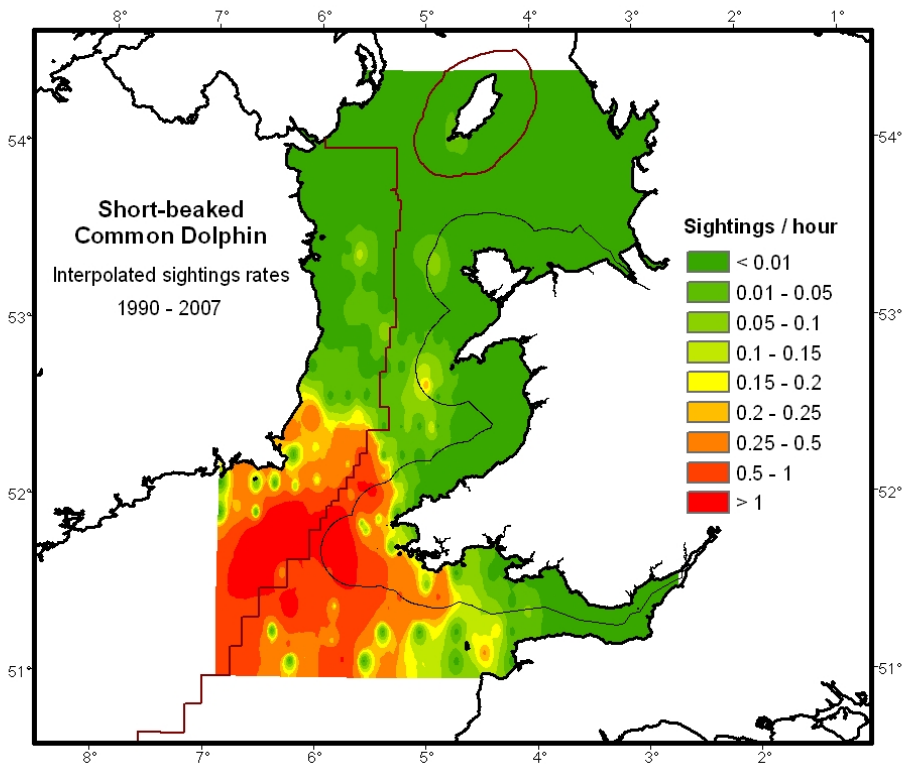


Figure 7: Long-term sightings rates (sightings per hour) of common dolphins (from Baines & Evans, 2009)

The MICA and the SCANS 1994 surveys did not use a double-platform method, nor did they correct for animals missed on track line (g(0)) or for responsive movement. Therefore, abundances estimates from these surveys may be inaccurate.

In 2005, SCANS II survey was undertaken and surveyed the same area as SCANS, 1994, but extended this to include the Irish Sea, waters off western and northern Ireland, western Scotland, and continental shelf waters off France, Spain and Portugal. The total summer abundance for those Northeast Atlantic shelf waters was estimated at c. 50,507 (CV = 0.29) (Hammond, 2008). Within the Irish Sea proper, the estimate was only 825 (CV=0.78) but in the Celtic Sea (which includes most of the St George's Channel as well as shelf seas south and west of Ireland and SW England), it was 11,141 (CV=0.61) (Hammond, 2008).

As part of the EU NECESSITY project, abundance was estimated for a defined management area in relation to pelagic trawl fisheries in the NE Atlantic, which coincides with ICES Areas VI, VII, & VIII. As this area was not covered by a single survey, it was necessary to combine data from various surveys (including SIAR, SCANS I & II; MICA, NASS-95 E block, ATLANCET & PELGAS - see Burt, 2007). For surveys where the probability of detection on the track-line could not be estimated, it was assumed that $g(0)$ equals one. Responsive variables were latitude, longitude, slope, depth & distance from coast.

The estimated number of common dolphin schools was 28,791 (CV=0.24; 95% CI: 15,370–42,210), and the estimated number of animals was 248,962 (CV=0.18; 95% CI: 161,920–336,000) (Burt, 2007). It should be noted that this abundance estimate is specific to the management area described above, and does not cover the known range of the species. All sightings data used to calculate this abundance estimate were obtained during the summertime. Furthermore, the abundance estimate uses data obtained over a long temporal scale, and assumes that the density and distribution of common dolphins did not change during the 14-year sampling period (1993-2006).

Finally, the CODA offshore survey conducted in July 2007, covering the area beyond the continental shelf from Shetland to NW Spain), estimated a total abundance of 162,300 (CV=0.46) (P.S. Hammond, *pers. comm.*).

In Welsh waters, summer surveys of a portion (area 3,134 km^2) of the Celtic Deep west of Pembrokeshire gave estimates of 1,186 (CV=0.41; 95% CI: 520-2709), 1,644 (CV=0.27; 95% CI: 968-2792), and 2,166 (CV=0.17; 95% CI: 1541-3045), for the years 2004, 2005 & 2006 respectively (Evans *et al.*, 2007).

2.3.4 Habitat

Common dolphin distribution appears to be associated with the Gulf Stream in seas of 10^o to 28^oC surface temperature (Evans *et al.*, 2003; Reid *et al.*, 2003; Murphy *et al.*, 2008). From the Sea Watch database, 75% of sightings in NW European waters occurred at SSTs of 11.5-15^oC (total range including outliers 6-19^oC) (Anderwald, 2002).

The species is often found in association with prominent undersea features such as seamounts and sea escarpments, and continental slope waters, although it has also been recorded in mid-Atlantic (Murphy *et al*., 2008).

2.3.4 Annual Cycle

The short-beaked common dolphin is mainly a summer visitor although persisting in the Celtic Deep at least to November (Evans *et al*., 2007; Baines & Evans, 2009). An influx of juvenile groups may occur in late summer. Most strandings take place along the coasts of Southwest Wales (Baines & Evans, 2009).

In the NE Atlantic, reproduction is seasonal, with mating and calving both occurring between May and September as indicated by both marked seasonal changes in testes mass and cellular activity in males, and the presence of ovulating and recently pregnant females (Murphy 2004, Murphy *et al.*, 2005, 2008).

The species commonly bow-rides and exhibits a variety of above-surface activities. They usually travel in schools of 6–15 individuals, but sometimes much larger concentrations, of hundreds or even thousands, can be seen associated with feeding or large-scale movements (Evans *et al*, 2003, 2007; Reid *et al*., 2003).

2.3.5 Diet & Feeding Behaviour

Common dolphins are opportunistic feeders, (Young & Cockcroft, 1994) taking a variety of fish and squid, although in the North East Atlantic their diet predominately comprises a few main species, which vary depending on season and region (Murphy *et al*, 2009; Figs. 8 & 9).

Horse mackerel, mackerel, Norway pout and sardines were dominant in the stomachs of stranded specimens from the British Isles & Republic of Ireland, but other species included whiting, herring, scad, sprat and sandeel (Berrow & Rogan, 1995; Couperus, 1999; Gosselin, 2001; Kuiken *et al.*, 1994; Pascoe, 1986; Santos, 1998). Cephalopods included mainly *Loligo* spp., *Alloteuthis subulata*, *Ancistroteuthis lichtensteini*, *Todarodes sagittatus. T.eblane* and *Sepiola atlantica*, although other squid species, octopus, and cuttlefish were also consumed.

In French inshore waters, four taxa contributed to the majority of dietary remains including anchovy, sardine, horse mackerel, and *Trisopterus* spp. (Meynier, 2004). Diet displayed strong inter-annual and seasonal variations, reflecting prey availability in the area (Meynier, 2004).

In Portuguese waters, sardine, blue whiting, *Atherina* sp., *Trachurus* and scombrid species comprised 84% of the total estimated weight, with *Sardina pilchardus* being the most important (Silva, 1999).

In Galician waters, blue whiting and sardine together comprised >56% of prey weight consumed. The main cephalopods consumed were *Loligo vulgaris* and *L. forbesi*. There were signs of opportunistic feeding, with higher numbers of sardines consumed in years of higher sardine abundance and lower recruitment of blue whiting. Other species eaten included scad, sandeels, scaldfish, sole, gobies, garfish, and *Atherina* sp. (Santos *et al.*, 2004).

Common dolphins can be deep divers, the maximum dive depth recorded from telemetry studies being 280m (W.E. Evans, 1975). Otherwise, food-herding behaviour has frequently been observed, with apparent co-operation between school members (Evans, 1987, 1990).

2.1.6 Interactions with Humans

Although a mass stranding of the species in Cornwall in June 2008 may have been related to noise disturbance (Jepson & Deaville, 2009), the main cause of conservation concern for the Northeast Atlantic population is large-scale, but poorly documented, incidental capture in fishing nets (Murphy *et al.*, 2008).

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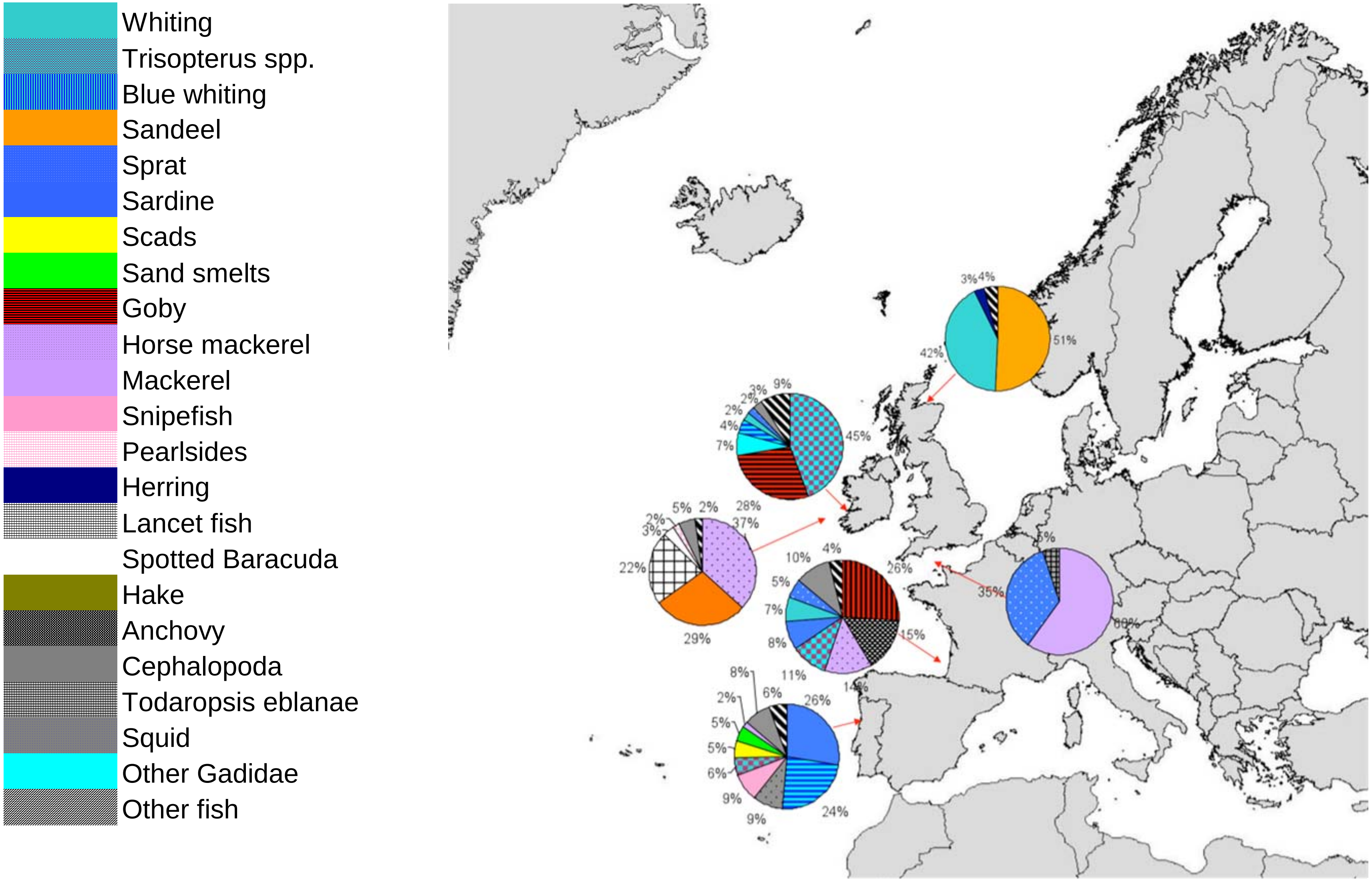

Figure 8: The diet of short-beaked common dolphins by number (%) in the Northeast Atlantic

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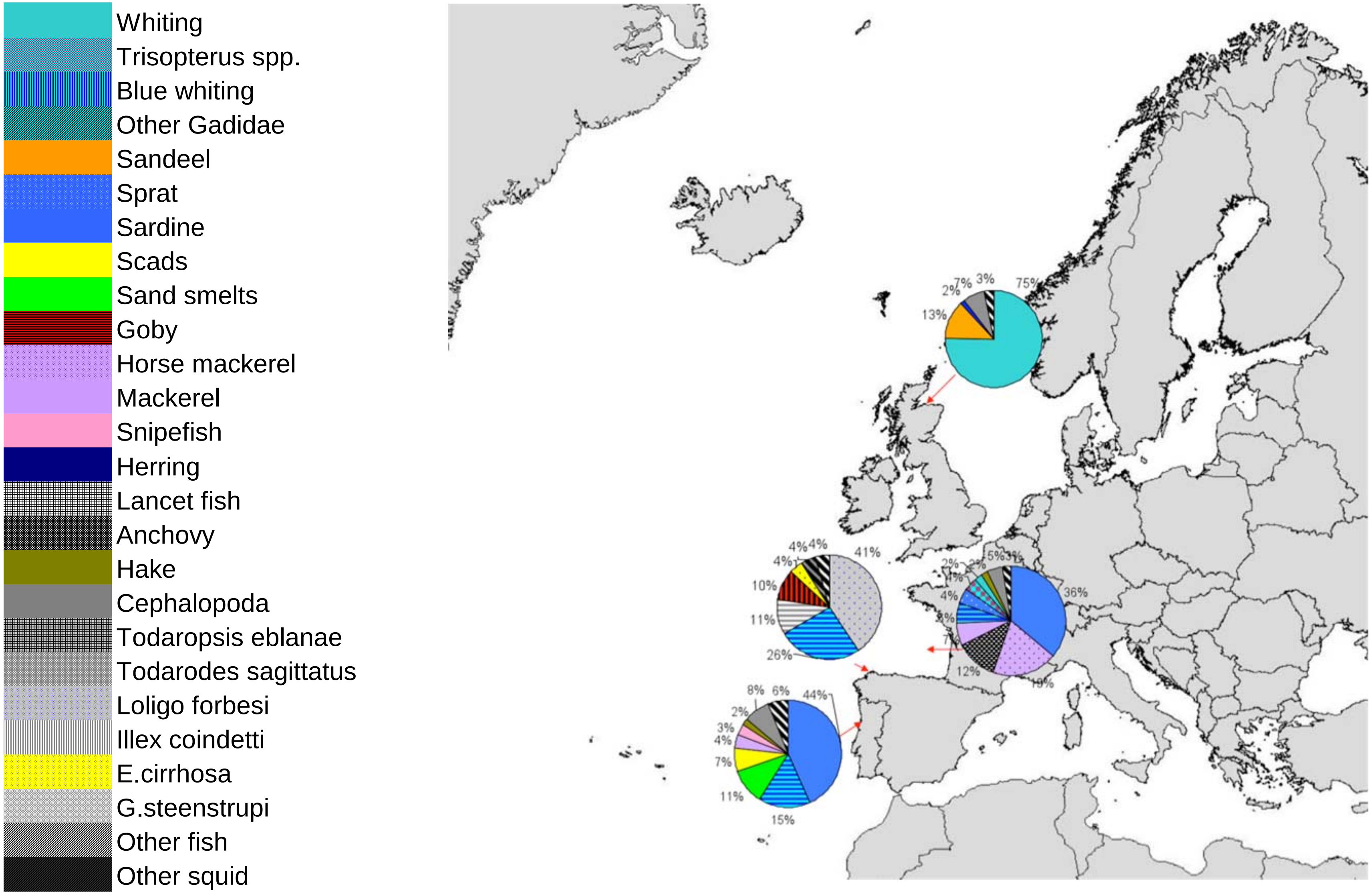


Figure 9: The diet of short-beaked common dolphins by weight (%) in the Northeast Atlantic

2.4 Risso's Dolphin *Grampus griseus*

2.4.1 Status & Distribution

The Risso's dolphin is widely distributed in tropical and temperate seas of both hemispheres (Evans, 2008). It occurs in small numbers along the Atlantic European seaboard from the Northern Isles of Scotland south to the Iberian Peninsula and east into the Mediterranean Sea, favouring continental slope waters (Evans *et al.*, 2003; Reid *et al*., 2003).

The major populations in northern European waters occur in the Hebrides but the species is regular also in Shetland & Orkney, and the Irish Sea, as well as particularly around South-west Ireland. It is rare in the North Sea and all but the western end of the English Channel. Elsewhere, it is present in North-west France, the southern Bay of Biscay, around the Iberian Peninsula, and in the Mediterranean Sea (Evans *et al*., 2003; Reid *et al*., 2003).

In the Irish Sea, it has a relatively localised distribution, forming a wide band running SW-NE that encompasses west Pembrokeshire, the western end of the Llyn Peninsula and Anglesey in Wales, the southeast coast of Ireland in the west, and waters around the Isle of Man in the north (Baines & Evans, 2009; Fig. 10). There have been only a few strandings, mainly in the western parts of Wales (Baines & Evans, 2009).

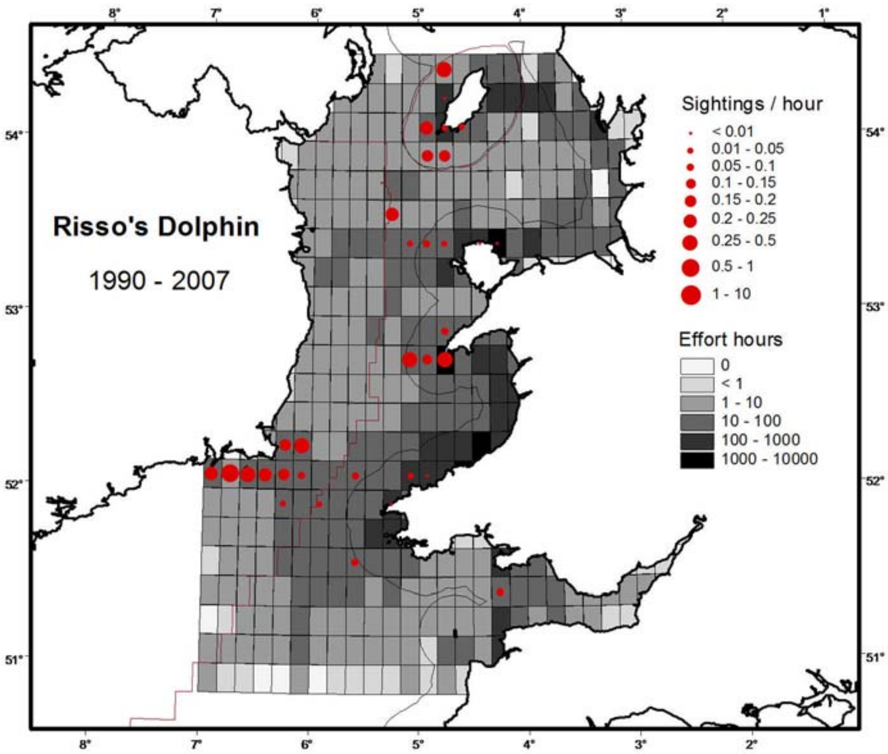
2.4.2 Abundance & Trends

In the Western North Atlantic, a population estimate of 29,000 exists for waters off Eastern USA and 2,700 in the Northern Gulf of Mexico (Waring *et al*., 2001). No population estimates exist for any region in the Eastern North Atlantic. A study in the North Minches, Scotland, identified at least 142 individuals (Atkinson *et al*., 1997, 1998). Similarly, at least 345 individuals have been photo-identified in the NW Mediterranean between 1990-2004 (Gaspari, 2004; S. Gaspari, *pers. comm*). There are no obvious population trends for the species in British waters; numbers visiting the coasts of Wales can vary a great deal between years.

2.4.4 Habitat

Risso's dolphins show a preference for warm waters (ranging from 7.5-28^{o}C, but mainly at 5-20^{o}C, and rarely below 10^{o}C), generally favouring continental slope waters (Evans, 2008). In the Eastern Pacific, the species typically occurs seaward of the 180m depth contour, and is seen in coastal areas only where the continental shelf is relatively close to shore (Leatherwood *et al*. 1980, Kruse 1989). In those areas, the depth averaged 1,000m. Steep sections along the edge of the continental shelf are also identified as high-use areas in Eastern USA and the Gulf of Mexico (Hain *et al*. 1981; Kenney & Winn, 1986, 1987; Baumgartner 1997). By contrast, over the continental shelf around the British Isles, the species is seen mainly over slopes of 50-100m depth.

a) Long-term mean sightings rate



a) Interpolated long-term mean sightings rate

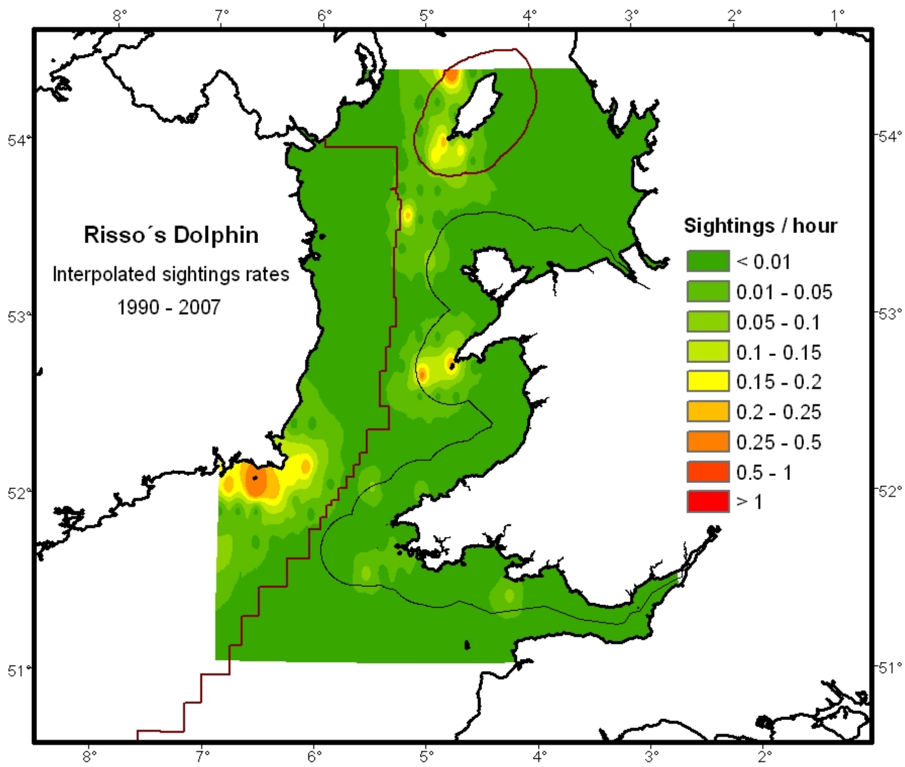


Figure 10: Long-term sightings rates (sightings per hour) of Risso's dolphins (Baines & Evans, 2009)

2.4.4 Annual Cycle

The species is mainly a summer and autumn visitor, with the highest sightings rates in the period July to September. Risso's dolphins breed in the region, and young have been observed wherever groups have been sighted. Calves may be born in most months of the year, although calving seems to peak between March and July (Evans *et al.*, 2003; Evans, 2008). An examination of 51 stranded animals in the NW Mediterranean indicated calving to be between the end of winter and early summer (Raduan *et al.*, 2007), although the number of calves there peaks in July, whilst the proportion of adults to calves largely remains the same throughout the year (Gaspari, 2004). It is possible that calves are born in most months of the year (CETAP, 1982)

Risso's dolphins form small to medium-sized pods of 2–50 animals (most commonly 6–12 in Welsh waters), although they may be seen singly or in some parts of the world, in groups of several hundreds or even thousands (Evans, 2008; Baines & Evans, 2009). They are relatively slow swimmers, 4–12 km/h, but when frightened they can speed up to 20–25 km/h. They are usually slightly wary of vessels, only occasionally bow-riding (mainly juveniles), and regularly engaging in a variety of surface behaviours. In the North Atlantic, Risso's dolphins are sometimes seen swimming with other cetaceans, including long-finned pilot whales, white-beaked, Atlantic white-sided dolphins, common, and bottlenose dolphins (Evans, 1987, 2008).

2.4.5 Diet & Feeding Behaviour

Risso's dolphins are largely cephalopod feeders (Figs. 11 & 12), taking particularly octopus *Eledone cirrhosa,* cuttlefish *Sepia officinalis* and various squid *Todarodes sagittatus, Loligo forbesi* and *L. vulgaris, Gonatus* spp., *Histioteuthis reversa* and *H. bonnellii,Ancistroteuthis lichtensteinii, Sepiola oweniana* and members of the family Cranchiidae. They will also occasionally take small fish (e.g. cod *Gadus morhua*) (Atkinson, *et al.*, 1998; Bello & Pulcini, 1989; Carlini, *et al.*, 1992; Clarke, 1986; Clarke & Pascoe, 1985; Cockcroft *et al.*, 1993; Desportes, 1985; Eggleton, 1905; Mitchell, 1975; Podestà & Meotti, 1991; Tsutsumi, *et al.*, 1961; Wurtz, *et al.*, 1992; Zonfrillo, *et al.*, 1988).

2.4.6 Interactions with Humans

In some parts of the world, the species suffers mortality from net entanglement, but, generally, little is known about causes of death (Evans, 2008).

Key:

- E.cirrhosa
- Ocythoe tuberculata
- Loligo forbesi
- Loligo vulgaris
- R.macrosoma
- S. oweniana
- Histioteuthis reversa
- Histioteuthis sp.
- Histioteuthis bonnelli
- Illex coindetti
- G.steenstrupi
- Cranchiidae
- Todarodes sagittatus
- Ancistroteuthis lichtensteinii
- Other squid

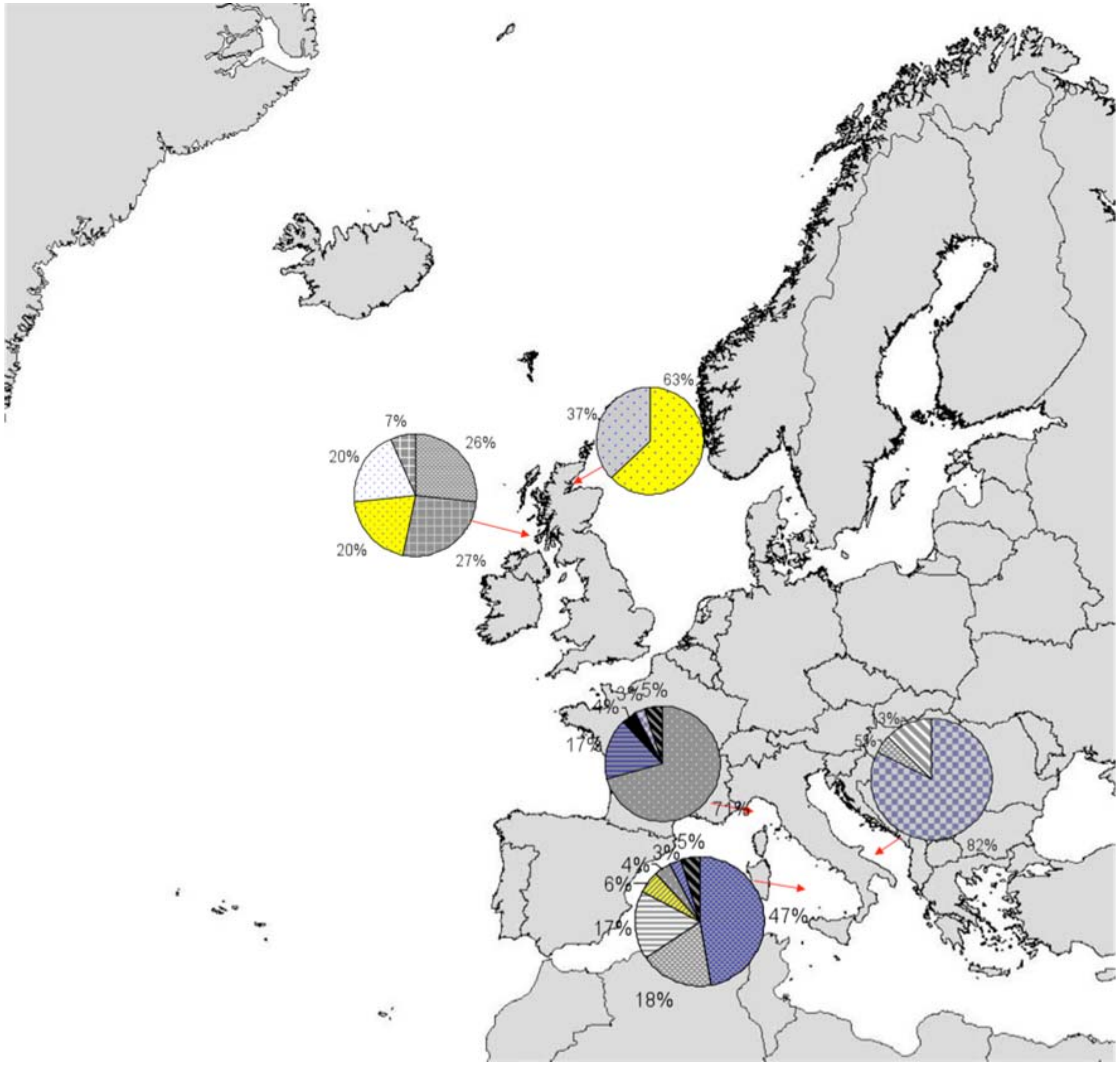


Figure 11: The diet of Risso's dolphins by number (%) in the Northeast Atlantic

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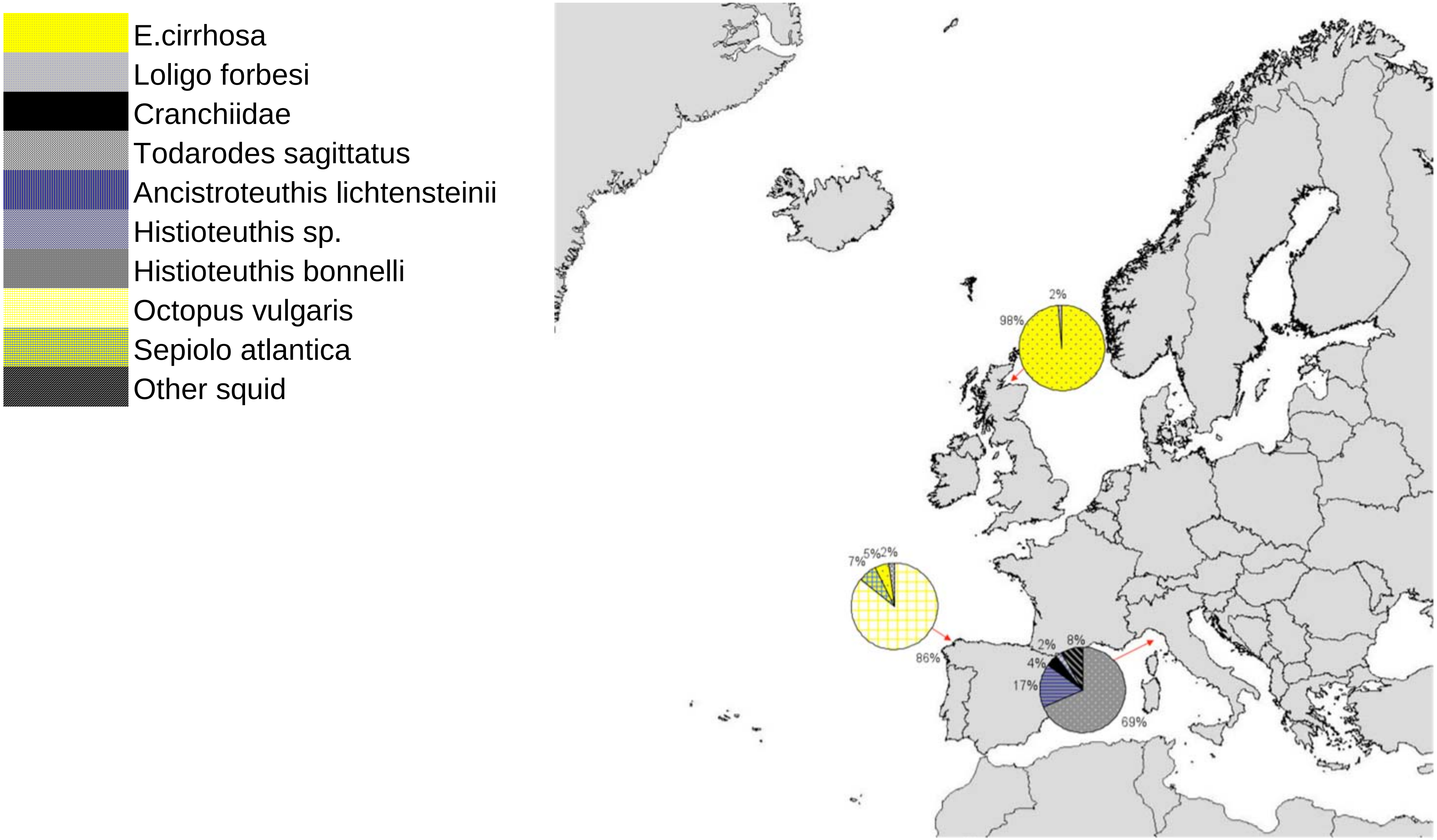


Figure 12: The diet of Risso's dolphins by weight (%) in the Northeast Atlantic

2.5 Minke Whale *Balaenoptera acutorostrata*

2.5.1 Status & Distribution

The minke whale is the commonest baleen whale both in the North Atlantic and around the British Isles.

It occurs in small numbers along the Atlantic seaboard of Europe mainly from Norway south to France, and in the northern North Sea, although abundance is greatest in the north (Evans *et al*., 2003; Reid *et al*., 2003; Hammond, 2008). The species is widely distributed along the Atlantic seaboard of Britain and Ireland, with numbers greatest off the west coast of Scotland and around the Hebrides (where aggregations of up to twenty have been recorded); it also occurs regularly in the northern and central North Sea as far south as Yorkshire, but is rare in the southernmost North Sea and eastern half of the English Channel (Evans *et al*., 2003; Reid *et al*., 2003). In the western English Channel, it is evenly distributed to the continental shelf edge, being largely absent from the deeper parts of the Bay of Biscay.

In the Irish Sea, the minke whale has a largely offshore distribution, with highest densities of sightings occurring in the area of the Celtic Deep, although the species is found also in deeper areas (generally >50m depth) northwards towards the Isle of Man (Baines & Evans, 2009; Fig. 13).

2.5.2 Abundance & Trends

The only published population estimates for minke whales in UK waters are from the SCANS surveys. In July 1994, a survey of the N Sea, English Channel and Celtic Sea estimated 8,450 individuals (95% C.I. 5,000-13,500) (Hammond *et al*., 2002). A more extensive line transect survey (SCANS II) over the NW European continental shelf in July 2005 gave an overall estimate of 16,395 (including 10,500 for the equivalent area as 1994) (Hammond, 2008).

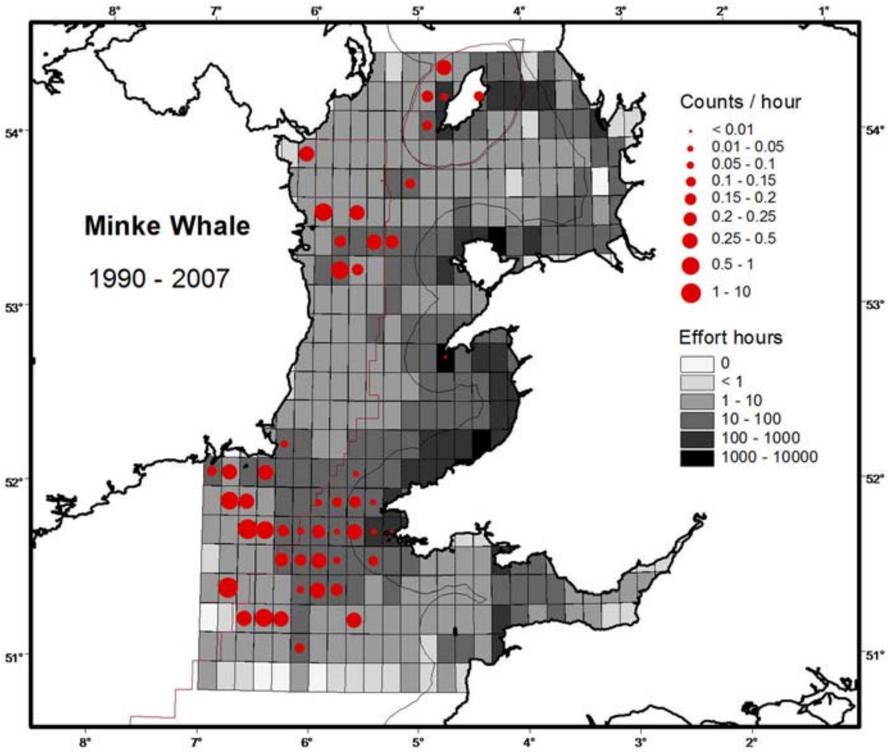
A population estimate for the entire Central and Northeastern North Atlantic (based upon data from 1996-2001) gave 174,000 individuals (95% C.I. 125,000-245,000) (IWC website: www.iwcoffice.org). Previously, the stock seasonally inhabiting the Norwegian and Barents Seas was estimated at 86,700 individuals (95% C.I. 61,000-117,000) (Schweder *et al*., 1993). Assessing minke whale numbers is difficult and controversial, since the species is inconspicuous at sea, and often reacts to survey vessels.

Population changes in the NE Atlantic remain uncertain. Effort-related sightings surveys suggest that the species has increased in UK shelf waters during the 1980s-1990s (Evans 1992; Boran *et al.*, 1999; Evans *et al.*, 2003).

2.5.3 Habitat

Although widely distributed in all the major oceans of the world from tropical to polar seas, minke whales are most abundant in relatively cool waters and on the continental shelf (in depths of 200m or less) (Anderwald *et al*., 2008). The species can be found very close to land, sometimes entering estuaries, bays or inlets, and usually feeding around banks and in areas of upwelling or strong currents around headlands and small islands, primarily during summer (Anderwald *et al*., 2008).

a) Long-term mean sightings rate



b) Interpolated long-term mean sightings rate

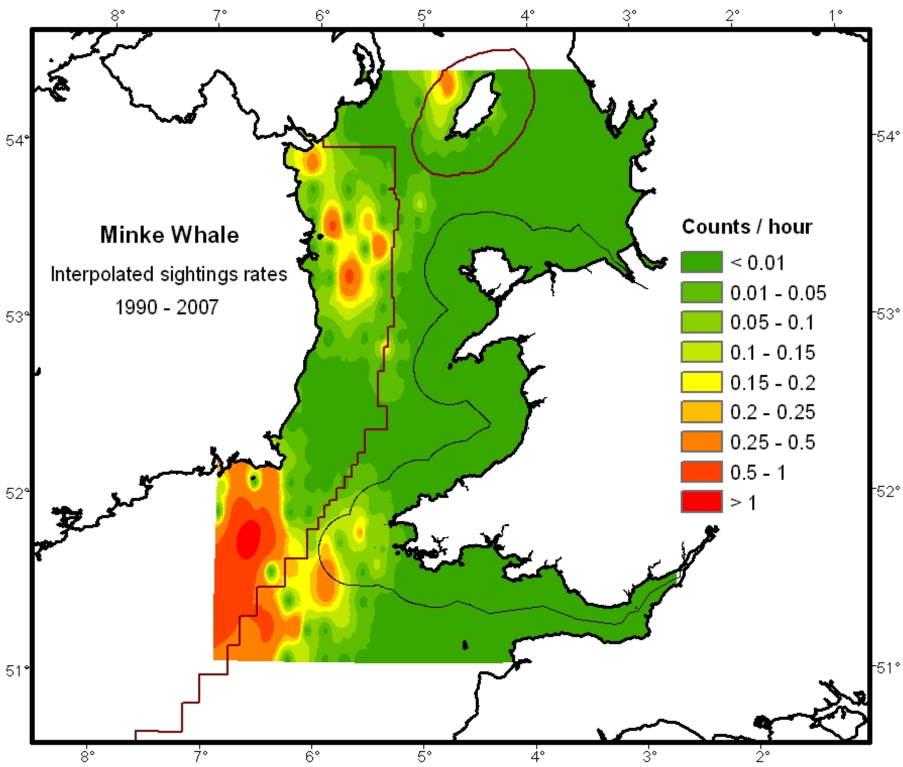


Figure 13: Long-term sightings rates (sightings per hour) of minke whales (Baines & Evans, 2009)

2.5.4 Annual Cycle

The species appears to be a mainly summer visitor to the Irish Sea, with few sightings in winter, although this may partly be due to low effort at that period. There is no evidence as yet that the species breeds in Welsh waters, calves being born during winter months, presumably mainly outside the region (Baines & Evans, 2009). In the Northeast Atlantic, births are mainly around December, probably in temperate offshore waters, but possibly extending to the subtropics (Anderwald *et al*., 2008).

Usually seen singly or in pairs, minkes sometimes aggregate into larger groups of around 10-20 individuals when feeding (Evans *et al*., 2003; Reid *et al*., 2003). The species is a moderately fast swimmer, cruising at 5-26km/hr, and capable of bursts exceeding 40km/hr. It frequently approaches vessels, and will both bow- and stern-ride, whilst breaching is not uncommon (Anderwald *et al*., 2008).

2.5.5 Diet & Feeding Behaviour

The minke whale is the most catholic feeder of all the rorquals (Fig. 14). In the Northern Hemisphere, the species takes more fish (sandeels, herring, sprat, cod, capelin, haddock, saithe and whiting) than the other baleen whales, although euphausiids and pteropods are also taken, especially in higher latitudes (Haug, *et al.*, 1995, 2002; Nordøy, *et al.*, 1995; Neve, 2000; Sigurjónsson *et al.*, 2000; Olsen & Holst, 2001; Born, *et al.*, 2003; Pierce, *et al.*, 2004).

In Scottish waters (mainly east coast), examination of the stomach contents of ten minke whales found only fish, with sandeels forming 66% by number and 62% by weight (standardized for incomplete sampling) (Pierce *et al*., 2004). Clupeids (herring and sprat) formed the next most important category, accounting for 33% by number and 32% by weight of the diet. The estimated size of sandeels eaten ranged from 6cm to 15cm, and the majority of sprats were 10-13cm in length. Other species found in the stomachs included mackerel, *Trisopterus* spp. (Norway pout and/or poor cod), and gobies. On the west coast of Scotland, in late summer, minke whales have been observed feeding on bait balls comprising mainly sprat (but also including herring), whilst during early summer, their distribution suggested an association with sandeel grounds (MacLeod *et al*., 2004; Anderwald, 2009; Anderwald *et al*., in press). No minke whale stomachs have been examined from Welsh waters.

Like humpback and fin whales, minke whales use a variety of feeding methods depending on the nature of the prey: engulfing prey with open mouth from behind, or side- and lunge-feeding using the sea surface to trap fish shoals. Known individuals revisiting the same bank or bay over a period of several years fed at the same site using the same feeding strategy (Hoelzel *et al*., 1989): two types of foraging specializations were observed, used exclusively by individual whales; some fed on ephemeral patches of herring, brought to the surface by feeding auks, others pursued prey in deeper water, herding them against air/water interface. Similar feeding methods have been observed off the west coast of Scotland (Anderwald, 2009; Anderwald *et al*., in press). In British and Irish waters, feeding minke whales commonly associate with flocks of auks, Manx shearwaters, kittiwakes, and various *Larus* gulls (Evans, 1982; Anderwald *et al*., 2008; Anderwald, 2009).

2.5.6 Interactions with Humans

To the north of the British Isles, minke whales are hunted for their meat in Norwegian waters, and to a lesser extent off Iceland and Greenland. Since 2006, the annual catch quota set by the Norwegian government has been 1,052, but the numbers actually caught have been much less (Anderwald *et al*., 2008). However, in UK waters, the main cause of death appears to be entanglement in static fishing gear, mainly gill nets set for salmon, and creel lines (IWC 1994; Jepson, 2005; Northridge *et al*., 2010). There have been a few cases of physical damage from ship strikes (Evans, 2003).

Key:

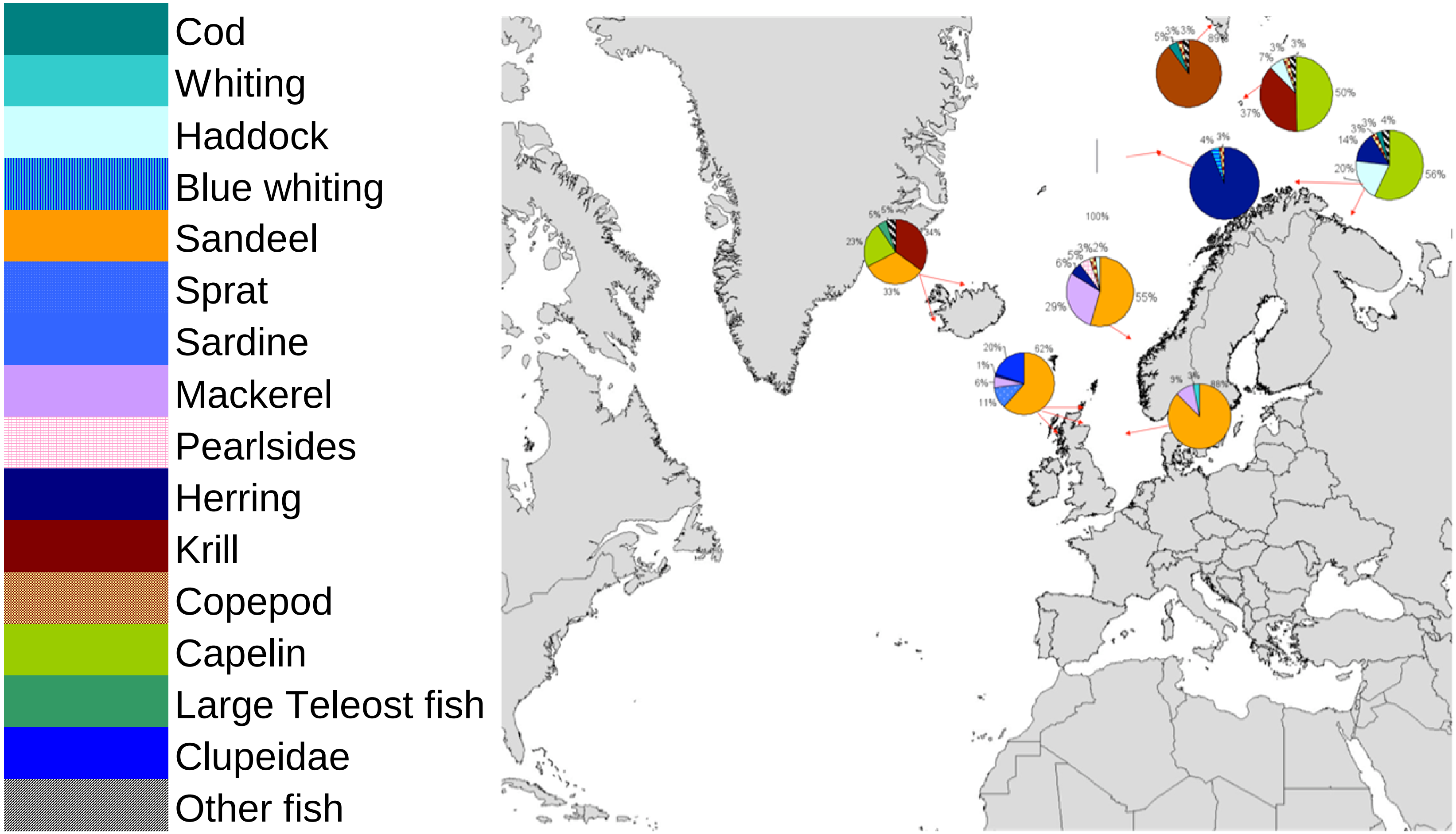


Figure 14: The diet of minke whales by weight (%) in the Northeast Atlantic

2.6 Grey Seal *Halichoerus grypus*

2.6.1 Status & Distribution

The Atlantic grey seal is restricted to the North Atlantic and Baltic Sea In the eastern North Atlantic, it is distributed from Brittany to the White Sea, with breeding locations in Northwest France, around the British Isles and Ireland, the Faroe Islands, Norway (north of Møre), Iceland and the Murmansk coast (Hammond *et al*., 2008).

Outside the breeding season, grey seal distribution is more widespread, and the species can be seen almost anywhere around the British coast, particularly in Scotland (Hammond *et al*., 2008). Studies using satellite telemetry show the distribution at sea to include most of the continental shelf area to the north and west of Scotland, the western North Sea, the Channel, and the Irish Sea (McConnell *et al*., 1999; Matthiopoulos *et al*., 2004).

Pup production in Wales is greatest in NW Pembrokeshire, particularly on Ramsey Island, but extending southwards to Skomer Island and northwards to southern Ceredigion. Smaller concentrations occur around the Llyn Peninsula and the coast of Anglesey. These areas among others are used as haul-out sites during the non-breeding season in addition to other non-breeding haul-outs. Telemetry studies suggest that seals may make foraging trips to very localised areas, with animals from a particular locality tending to remain in that region. Sightings at sea indicate an area of high usage off the North Wales coast that is also shown in the telemetry data, but as there is not even coverage, due to many observers not recording seal sightings systematically, conclusions cannot be drawn across the whole area (Baines & Evans, 2009; Fig. 15).

2.6.2 Abundance & Trends

Most of the Northeast Atlantic population breeds around the British Isles. Indeed, about 45% of the world populations breed here (Hammond *et al*., 2008). The latest population estimate for UK was made in 2009, at 106,200 (95% CI: 82,00-138,700) (SCOS, 2010). Most (c. 90%) of the UK population is in Scotland; the remaining 10% is in England and Wales (Hammond *et al*., 2008). The Irish population has been estimated at c. 4,000 (Ó'Cadhla & Mackey, 2002).

Grey seal pup production has increased markedly over the last 50 years, although the rate of increase may now be slowing down (Hammond *et al*, 2008; SCOS, 2008-10). Trends vary regionally with pup production in the Hebrides levelling off in the mid 1990s, but in Orkney more recently, whilst the North Sea population continues to increase exponentially (SCOS, 2008-10). In Wales, population growth appears to be stable (McMath & Stringell, 2006).

2.6.3 Habitat

The type of terrestrial habitat used by grey seals during the breeding season differs from that used through the remainder of the year, when either moulting or resting. Breeding colonies are typically on remote undisturbed coasts or islands, usually with good access to the open sea. In the British Isles, they tend to be on sandy, shingly or rocky beaches above the high-water mark, or in sea caves (Hammond *et al*., 2008). Where access is available and there is little disturbance, the colonies may spread inland from the coast on to grassy swards, whilst remaining within c. 300m of access to the sea. In some localities they may use gullies or rocky slopes to gain access to the interior of the island.

Outside the breeding season, haul-out sites are much closer to, or below, the high-water mark, and may include intertidal sandbanks, rocky coasts and skerries, sea caves, and sandy, shingle or rocky beaches. Non-breeding haul-out sites are more widespread and much less remote than breeding sites, and numbers here may fluctuate widely from day to day, and between locations (Hammond *et al*., 2008).

The grey seal is the only pinniped species breeding in Wales. It is widely distributed in the region, breeding in caves and small coves on offshore islands, and less populated parts of the mainland coast (Baines & Evans, 2009).

Offshore around the British Isles, the foraging habitat is at or near the seabed in shelf waters, and may include submarine banks of gravely sand, the preferred habitat of sandeels, a major prey item (McConnell *et al*., 1999). On the other hand, the wide variety of prey taken indicates that these seabed foraging habitats also include sand/mud (flatfish) and rocky substrates (gadoids, etc).

2.6.4 Annual Cycle

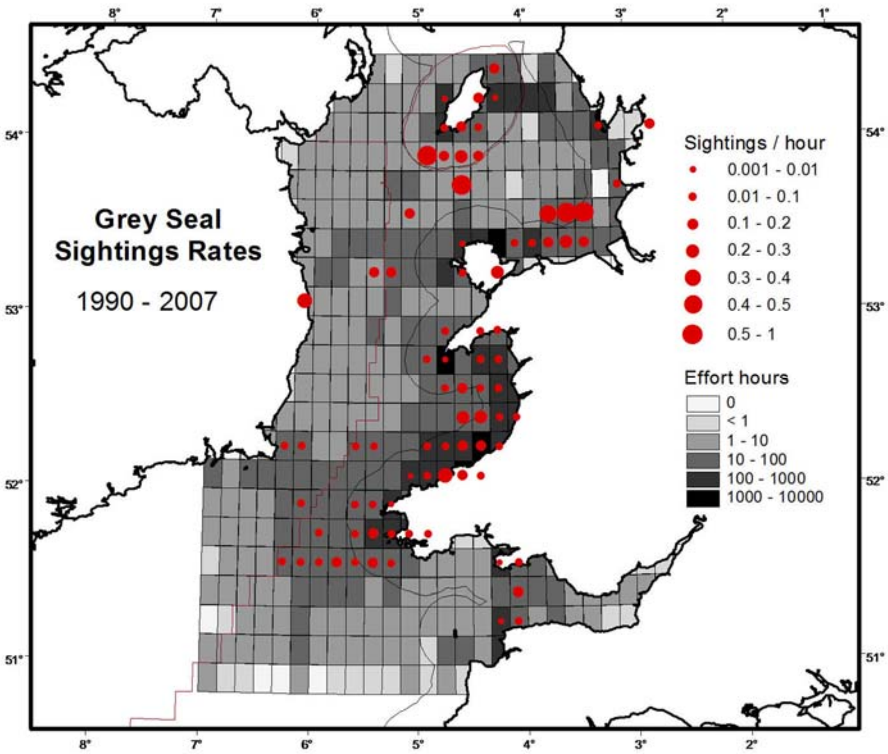
Grey seals come ashore on relatively remote islands and coastlines to give birth to their pups in the autumn (September – October in the southwest, October – November in West and North Scotland, and November – December on the east coast), and to moult in spring, and for shorter periods at other times of year to haul out and rest between foraging trips to sea (Hammond *et al*., 2008; SCOS, 2008-10). Each mature female grey seal gives birth to a single white-coated pup, which is nursed for about three weeks before being weaned and moulting into its adult coat. Births may be reported at other times of year, with some occurring in spring in Wales.

2.6.5 Diet & Feeding Behaviour

Grey seals generally feed on fish, and composition varies seasonally and regionally, but a few species make up most of the diet in any given area and season (Fig. 16). Although a wide variety of fish species are taken, the major prey species include sandeels, gadoids (mainly cod, whiting, haddock, saithe, and ling), and pleuronectids (mainly plaice, sole, and lemon sole) (Hammond & Grellier, 2006; Hammond & Harris, 2006). In some areas, such as the southern North Sea, benthic fish species such as dragonet and sea scorpions are also commonly taken, forming a higher proportion by weight (50%) than sandeels (17.6%) or gadoids (17.5%). Cephalopods are also taken but do not appear to form major items in their diet.

Some notable changes in prey species were observed between the 1980s (mainly 1985) and more recently (2002), with less sandeel and cod but more haddock and plaice, taken in 2002 in the northern North Sea, than in 1985. In West Scotland in 2002, grey seals took also less sandeel, saithe and ling, about the same amount of cod and whiting, but three times more haddock than in 1985 (Hammond & Grellier, 2006; Hammond & Harris, 2006; Hammond *et al*., 2008). These changes presumably reflect changes in prey species availability.

a) Long-term mean sightings rates



b) Interpolated long-term mean sightings rates

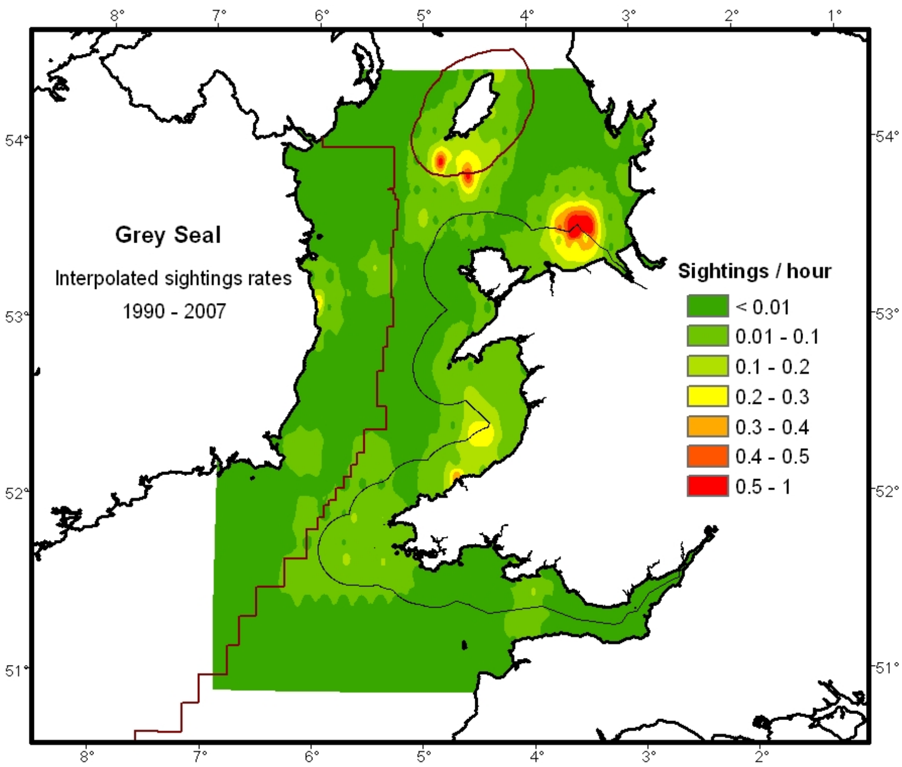


Figure 15: Sightings rates of grey seals 1990–2007
(Baines & Evans, 2009

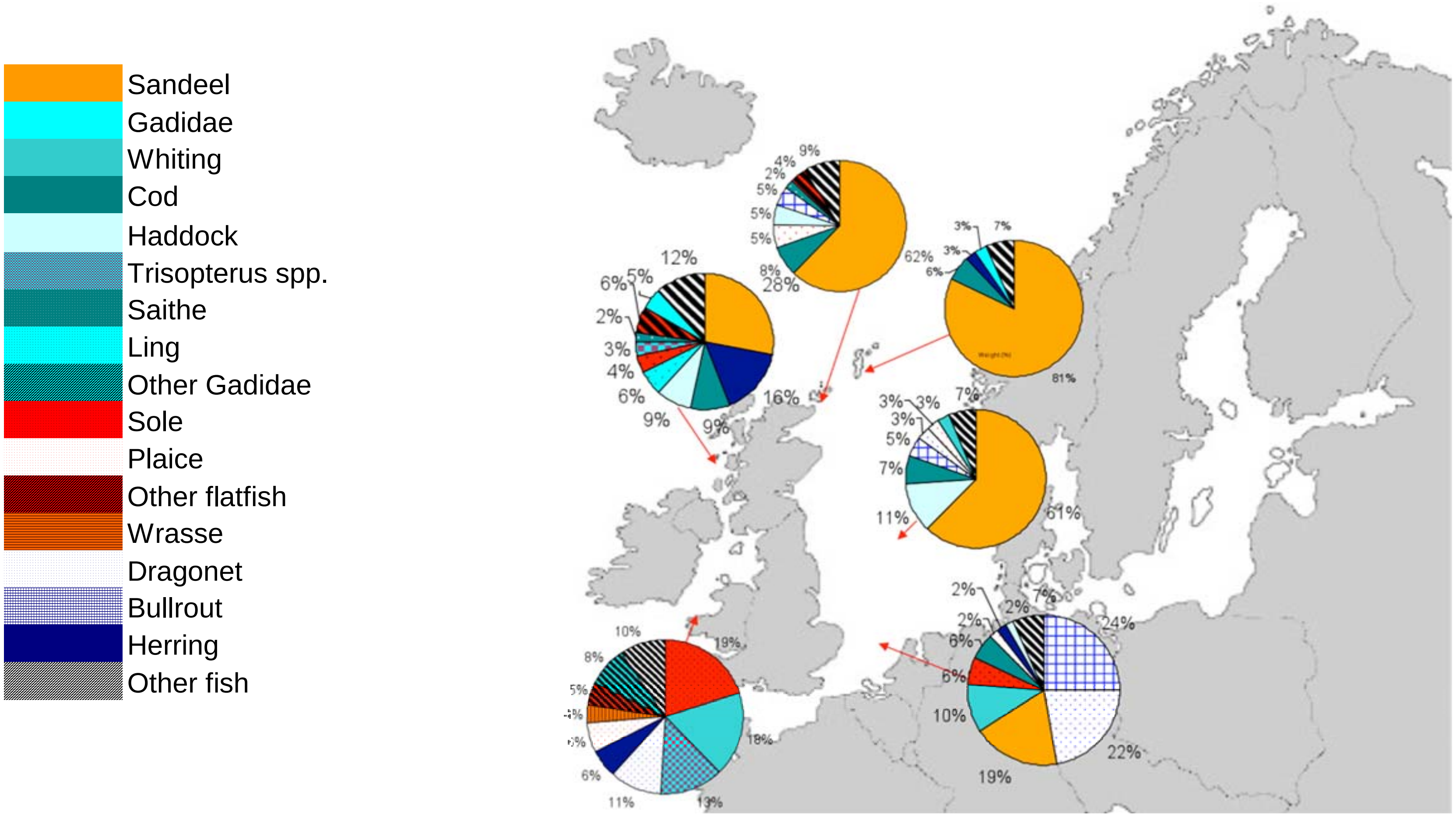


Figure 16: The diet of grey seals by weight (%) in the Northeast Atlantic

Grey seal diet in Wales has been examined from faeces collected at colonies in Pembrokeshire during the 1990s (Strong, 1996). Again, gadoids (mainly whiting and *Trisopterus* species) but also flatfish (mainly sole) dominated the diet, accounting for 70% by weight. In one locality (Cemaes region), herring dominated in the diet sampled. Interestingly, sandeels were virtually absent whereas dragonets contributed 11%.

The species consumes a range of fish sizes including very small fish such as sandeels and gobies, to large gadoids (e.g. cod up to 60cm, and ling up to 70cm). They can sometimes be seen eating large fish at the surface, particularly in river mouths and around fishing nets.

Telemetry studies indicate that foraging trips from haul-out sites will usually last 2-5 days and will target localized areas, generally within 50km of the haul-out site (McConnell *et al.*, 1999). Most dives appear to be to the seabed, implying epibenthic foraging, either by using a 'sit and wait' strategy or 'grazing' the seabed for sandeels. Dives at sea away from the haul-out sites are regular: travelling dives are typically of 3-9 mins duration and either V- or U-shaped in profile. Foraging dives are typically 10 mins duration (sometimes much longer) and involve swimming directly to the seabed but then swimming little whilst at depth. The longest recorded dive was 32 min, and the deepest recorded dive >200m (Hammond *et al.*, 2008). The swim speed underwater has been measured at 1-2m/sec.

2.6.6 Interactions with Humans

Although no longer commercially hunted, fishermen sometimes kill grey seals in attempts to lessen loss or damage to fish, particularly salmon, in their nets. Fixed nets and long lines set for whitefish may also be affected by seal predation (Hammond *et al.*, 2008). Besides shooting, acoustic scaring devices may be employed to deter seals, particularly from around fish farms.

Although whitefish fishermen consider seals as competitors for commercial fish stocks, comparison of estimates of the amount of prey consumed by seals with fish catches have indicated that seal predation is typically an order of magnitude less than commercial catch limits in the North Sea (Hammond & Grellier, 2006), although much higher in the west of Scotland (Hammond & Harris, 2006). Seals occasionally suffer entanglement in fishing gear (including discarded netting) in the UK, but such interactions are greater where longlines or fish traps are deployed widely, as in the Baltic (Lunneryd *et al.*, 2005; HELCOM, 2009).

2.7 River Otter *Lutra lutra*

Although the river otter is not a true marine mammal, brief consideration will be given to this species here because of the coastal habit of some individuals. Otters in Wales have increased and spread in recent decades, following the documented declines in the 1960s and 1970s, attributed to pesticides, human disturbance, and habitat modification (Chanin, 1985; Andrews & Crawford, 1986; Jones & Jones, 2004; Jefferies & Woodroffe, 2008). In Wales, the species can be found in >65% of tetrads, mainly along the Clywd, Wye, Teifi and Cleddau river systems (Andrews & Crawford, 1986; Andrews *et al.*, 1993; Jones & Jones, 2004). In recent years, there have been a number of sightings of otters along the coast of Wales, manly around

Cardigan Bay and in Pembrokeshire (Jones & Jones, 2004; P.G.H. Evans, unpublished data). The population size in Wales was estimated to increase from 210 in 1984–86 to 540 in 1990-94, with a further increase to 760 in 2000-02 (Andrews & Crawford, 1986; Andrews *et al*., 1993; Jefferies, 1997; Jones & Jones, 2004).

The diet of coastal otters has been studied mainly in Scotland, where it comprises salmonids and eels, butterfish, blennies, sea scorpions, and lumpsuckers, as well as shellfish (mainly crabs) (Chanin, 1985; Kruuk, 2006).

Conservation threats facing otters in the past have included human persecution, and organochlorine pollution (Jefferies & Woodroffe, 2008). Nowadays, most human induced mortality appears to come from road kills and in coastal areas, accidental capture in eel fyke nets, lobster creels, and fish traps (Jefferies, 1993; Reuther, 2002; Jefferies & Woodroffe, 2008).

2.8 Cetacean Biodiversity Patterns

Cetacean species diversity is highest around the Celtic Deep. The areas of coastal Wales with highest species diversity are west Pembrokeshire, the western end of the Llyn Peninsula, and west of Anglesey – all those are regions closest to deeper waters and the possible influence of the two major frontal systems in the Irish Sea, the Celtic Sea and Irish Sea Fronts (Baines & Evans, 2009).

3. WELSH FISHERIES

The nature and extent of different fisheries in Wales have both direct and indirect impacts upon marine mammals. In this section, we examine the various fishing activities within the ICES areas VIIa, VIIg & VIIf that make up Welsh waters (Fig. 17). We draw upon a number of reviews of Welsh fisheries: the Wales Fisheries Strategy (WAG, 2008), Welsh Development Agency (2003), CEFAS (Mills & Eastwood, 2005, CEFAS, 2005), as well as more up to date reports from the South & North Wales Sea Fisheries Committees, reports from Coastal Fisheries of England and Wales, and data from the Marine Fisheries Agency, supplemented by information extracted from a CCW report by Thomas (2003) and the Sea Fishing Atlas of Wales (CCW, 2010). Nevertheless, it is important to note that even the most recent publication, the Sea Fishing Atlas of Wales, relies on maps of fishing activity for the period 2000-05, and that summaries of fishing effort are frequently derived from analyses conducted some years previous.

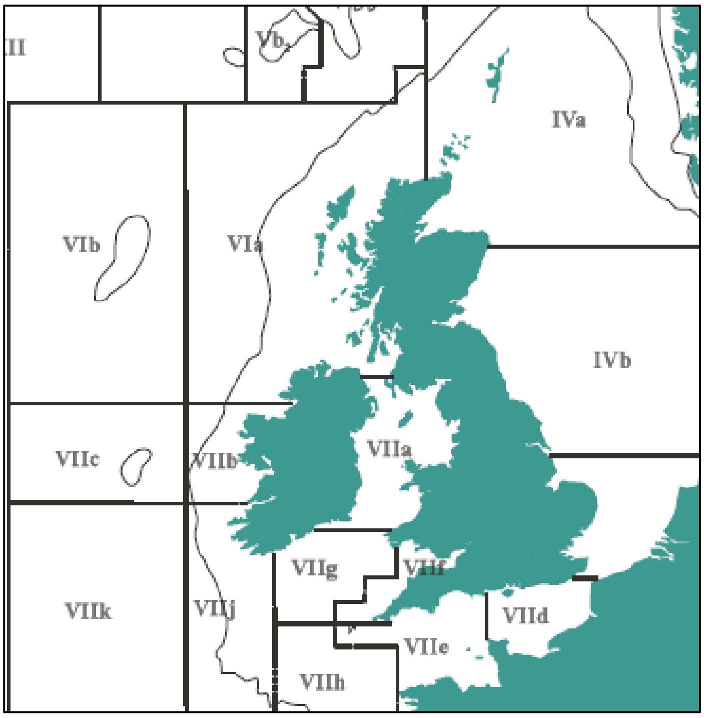


Figure 17: ICES Areas (Mills & Eastwood, 2005)

The Welsh commercial sea fishing sector is a diverse industry based all around the Welsh coastline. The sea-going fleet comprises large offshore vessels targeting prime fish species and shellfish, down to the smaller inshore vessels operating within coastal waters. A large proportion of the vessels target more than one type of fishery (WAG, 2008).

Any fishing vessel wishing to operate commercially within the European Union is required to be licensed by its national fisheries department and to display Port registration Letters and Numbers (PLN). In 1995, there were 560 registered fishing vessels of 10m length or less, working around the Welsh coasts. By January 2003, this figure had fallen to 408. This was a dramatic fall, but actually marked a small increase upon numbers for 2002 (DEFRA, 2002, 2003a) and has increased further, with 400 and 500 operating out of the main fishing port of Milford Haven in 2006-08 (see Table 1). The number of vessels of >10m length has remained low, between 30-40 in recent years (Irwin & Padia, 2009).

Table 1: Welsh fleet operating out of the main fishing port of Milford Haven, 2006-08 (Source Irwin & Padia, 2009)

Milford Haven	2006	2007	2008
10m & under	465	469	436
Over 10m	39	40	34
All vessels	504	509	470

The 3, 6 and 12 nautical mile boundaries provide regulatory boundaries to different sized boats. Generally, the larger boats are not permitted to fish within the boundaries that are closer to shore.

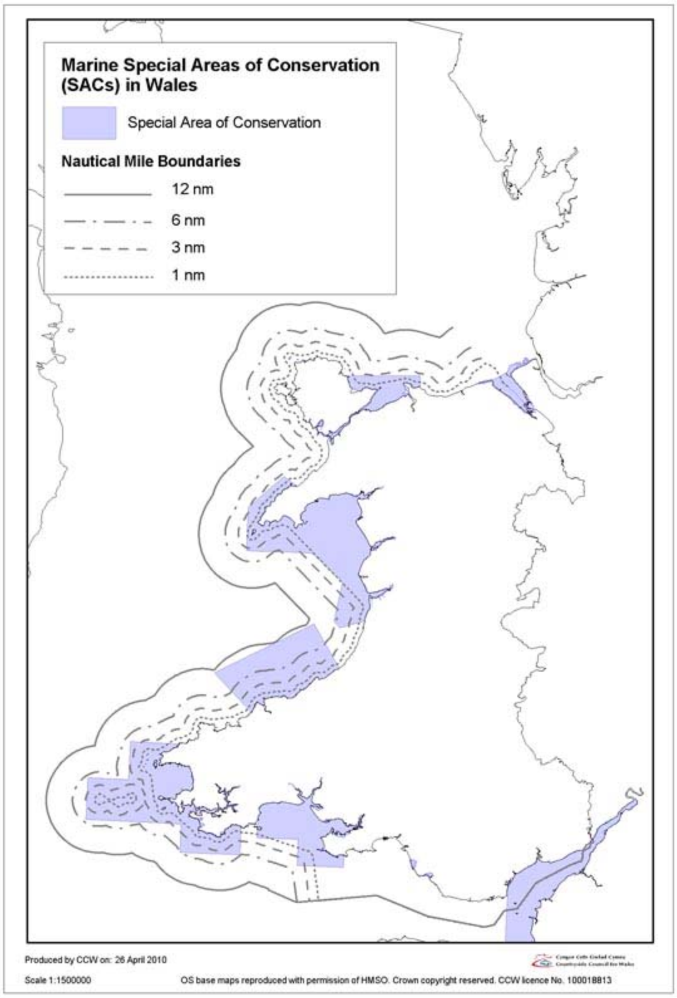


Figure 18: Map showing 1, 3, 6, & 12nm boundaries & SACs in Welsh waters (CCW, 2010)

Table 2: Division of commercial sea fisheries in Wales (adapted from WAG, 2008)

	Sub-Sector	Target Species	Gear Method	Comments & Main Seasons
Offshore	Flagship vessels	Mixed prime fish, Nephrops	Mobile gear-demersal & beam trawls	Very seasonal, but seasons vary depending upon target species and current regulations. Other EU member states flagged in Wales (i.e. AngloSpanish) do not fish in Welsh waters
	Mixed demersal vessels	Mixed prime fish	Mobile gear-demersal & beam trawls	Year round, but low activity
Inshore	Mixed demersal vessels	Mixed prime fish	Mobile gear-demersal & beam trawls. Nets	Year round, but low activity - only scallop dredging and beam trawling for scallops. French, Belgium boats fish year round in Pembrokeshire
	Shellfish	Lobster, edible crab, velvet crab, whelks, prawns	Static gear-lobster pots, whelk pots, nets	Brown shrimp – short autumn season, then another spring season. Prawn – all winter. The rest (lobster and crab artisanal fisheries), mainly April to November; but some fishers operate all year although highly weather dependant. Some super crabbers and super whelkers fish year round offshore, and this is the bulk of whelk fishery in Welsh waters.
		Cockles, mussels, periwinkles, razor clams	Hand gathering	All year but are subject to temporary closures e.g..cockle fisheries from May to August in North Wales. Cockle fisheries are subject to closure at any time if the authority believes it to have become depleted. Razor clams can only be collected at the biggest tides of the year (found at spring low water mark).
	Seasonal fisheries	Scallops	Mobile gear-scallop dredges	Was 1st Nov – 31st May 2008/09 but then shortened to 1st March - 31st May in 2009/10 (likely to become 1st Nov foreshortened to 31st April for 2010/11 season)
		Bass	Rod and line, drift/gill/tangle net	Summer (April – Nov)
		Mullet	Gill/trammel net	Summer (April – Nov)
		Mackerel	Rod and line	Summer
		Herring	Static gear-drift/gill/tangle nets hand	Winter (byelaws are in place that dictate the season for the different fisheries around Wales (e.g. Cleddau fishery is open Jan – April)
		Sprat	Long lining (not applicable to sprat), fine meshed net	Has not been prosecuted, although it may become a target species if fishers decide to diversify in the future

Table. 3: Weight and Value of species (Categorised by Demersal, Pelagic and Shellfish) landed at four major Welsh ports and the overall total for Wales.
(From WAG, 2008; Irwin & Padia, 2009)

Port	Milford Haven		Holyhead		Bangor		Penrhyn		Total	
Species	Weight Tonne	Value £'000	Weight Tonne	Value £'000	Weight Tonne	Value £'000	Weight Tonne	Value £'000	Weight Tonne	Value £'000
Demersal										
2003	1,753	3,144	414	531					2,302	3,956
2006	1,737	3,653	190	270	-	-			1,927	3,923
2008	1,500	3,900							1,500	3,900
Pelagic										
2003	14	10	-	-					14	10
2006	4	2	-	-	-	-			4	2
2008									-	-
Shellfish										
2003	471	900	2,939	1,456					6,796	6,771
2006	597	1,843	2,617	1,901	5,129	193(1)			8,343	5,780
2008	1,600	3,000	2,100	2,100			4,300	1,500	8,000	6,600
Total										
2003	2,238	4,053	3,353	1,987					7,578	6,040
2006	2,338	5,498	2,807	2,170	5,129	193(1)			12,612	7,861
2008	3,100	6,900	2,100	2,100			4,300	1,500	9,500	10,500

(1) Value of 4,965T of Mussels unknown

Table 3 summarises the latest information available on quantity and value of fish landed in the four major Welsh ports: Milford Haven, Holyhead, Bangor and Penrhyn.

There is no statutory requirement for owners of vessels <10m length to declare their catches. However, since 2006, with the introduction of the Registration of Buyers and Sellers (Wales) Order 2006, landed catch information has been gathered for this sector of the fleet. The figures shown above therefore may not be complete for 2003 and 2006, but they do give a good indication of the species contributing to the Welsh fishing economy. For mapping distribution of effort, we have favoured using the data analysed by CEFAS (Mills & Eastwood, 2005) from overflights during the period 1998-2003, supplemented by analyses of VMS (Vessel Monitoring Systems) data from fishing activities around the UK during 2006 and 2007 (Lee *et al*., 2010). Since neither is completely up to date, we have further noted any marked changes in fishing effort reported since then.

The data from overflights are gathered on routine or targeted patrols in sectors of the UK coast. The plane 'watchdog 72' overflies an area and records the position of any vessels it sees, and whether they are fishing or not. However, the overflights provide an incomplete picture. For example, the number of patrols will increase in Cardigan Bay during winter when the scallop fishery is open, but fewer patrols occur in summer when it is closed. VMS is used primarily for fisheries enforcement purposes, but it also provides information on the spatial and temporal distribution of fishing effort. This approach generally shows particular promise as a monitoring tool (Lee *et al*, 2010).

3.1 Overview of Welsh Offshore Fisheries

Since 1st April 2010, the Welsh Assembly Government is now responsible for an extended ‘Welsh Fisheries Zone’, expanding the influence of the Assembly out into the Irish Sea, as far as the median line border with the Republic of Ireland, England, Northern Ireland, and the Isle of Man. This is part of a long-term plan to improve fisheries management and marine enforcement in Wales.

The offshore fleet comprises vessels over 10m that fish both outside and within the 12nm coastal waters around Wales. Only a small number of these are Welsh owned vessels. Some are “Flag-ship” vessels registered and licensed in Wales but beneficially owned and operated by interests outside of the UK (e.g. northern Spain (WAG, 2008).

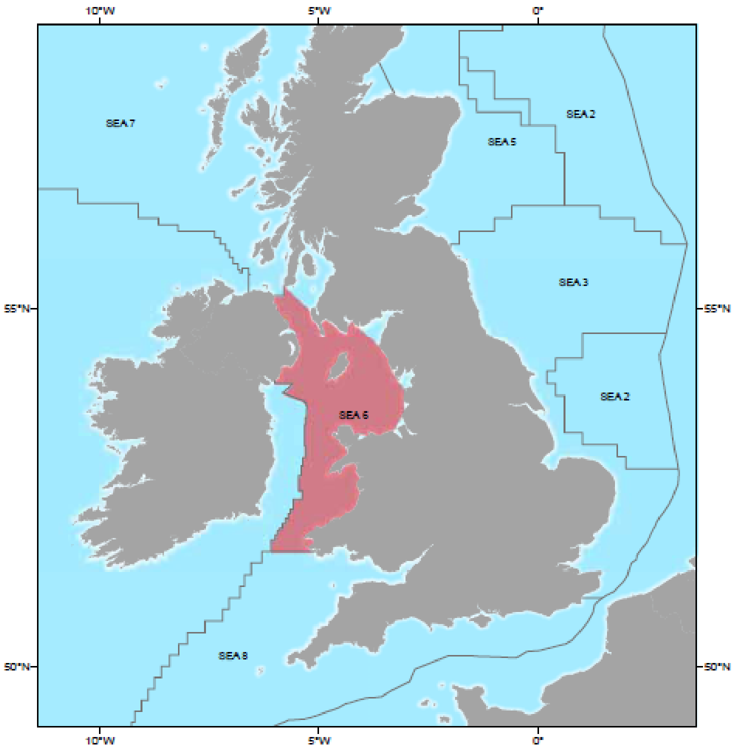


Figure 19: Extent of Area SEA6, (Mills & Eastwood, 2005)

The sea areas around the British Isles have recently been divided up for the purpose of Strategic Environmental Assessments (SEAs), by the Crown Estate. One of these areas (SEA6) encompasses all of West & North Wales, corresponding to the eastern half of the St George’s Channel and Irish Sea (Fig. 19). This region covers a major proportion of the ICES division VIIa, which extends from 52°N (Pembrokeshire) to 55°N (the North Channel). This area supports valuable fisheries (see Table 4), which are widely spread, and include demersal pelagic fish and shellfish. Several of these fisheries are prosecuted by French and Belgian fleets (Mills & Eastwood, 2005).

Some of the more important demersal fish landed include flatfish (e.g. plaice and sole), gadoids (e.g. cod and whiting), and elasmobranchs (spurdog, and skates & rays), and these species are typically caught by beam and otter trawlers. The eastern

Irish Sea is an important spawning and nursery area for several flatfish species, especially plaice and sole, and is the focus of seasonal fisheries. Several of these fish species are taken by marine mammals (see Chapter 2).

Table. 4: SWSFC District landings of finfish and first sale value - 2006 to 2008 (SWSFC, 2008)

	2006		**2007**		**2008**	
	Tonnes	£	Tonnes	£	Tonnes	£
Fin fish	1,462	3,515,041	1,953	4,492,482	1,615	4,227,000

Pelagic species are of lesser economic importance, although certain species (e.g. Manx herring) are important. The status and distribution of those stocks may well affect some marine mammal species such as minke whale and harbour porpoise. The taking of shellfish is particularly important in SEA6, especially scallops and *Nephrops*. The main fishing ground for *Nephrops* is in the western Irish Sea, covering the northwest part of SEA6 and the southernmost part of SEA7. Scallops are taken mainly in the northern Irish Sea between the Isle of Man and Anglesey, and in Cardigan Bay. There are also important coastal fisheries for edible crab and lobster off the Welsh coast (e.g. Cardigan Bay, Llyn Peninsula and Pembrokeshire) (Mills & Eastwood, 2005). Although most shellfish in the region are likely to be taken only occasionally by cetaceans, they can be important components in the diet of grey seals, whilst any bottom dredging activities may affect the habitat of various species such as bottlenose dolphin (see Chapter 5).

The other area (SEA8) that includes Welsh waters covers the national waters off the southern and southwestern coasts of England and Wales, including the Bristol Channel. Important commercial species in the Bristol Channel (ICES area VIIf) include monkfish, cod, hake, plaice, rays, sole and whiting, and the inshore fleet generally uses a variety of gears, ranging from pots (for crab, lobster and whelks), set nets (e.g. for rays) and long-lines (e.g. for porbeagle shark). Pelagic fish are not of high commercial value in the Bristol Channel, although there is a small fishery for Milford Haven herring and an important bass fishery in the Bristol Channel (CEFAS, 2005). The presence of sea bass in the latter region may attract bottlenose dolphin. Otherwise, cod, whiting, sole and plaice all form part of the diet of harbour porpoise, bottlenose dolphin, and grey seal (see Chapter 2).

Further offshore, in the Celtic Sea just south of the St George’s Channel, the deeper waters support valuable fisheries for monkfish, conger eel, ling, pollack, megrim, hake and rays. This area also contains some grounds where *Nephrops* may be fished. Mackerel is the basis of an important pelagic fishery in the South-western Approaches, to the south of Wales (CEFAS, 2005). Mackerel and hake are also taken by short-beaked common dolphins and minke whales, in particular, whilst several of the other fish species form part of the diet of various cetacean species and grey seals (see Chapter 2).

3.2 Overview of Welsh Inshore Fisheries

Historically, the inshore fisheries of Wales have had their own seasonal patterns in activity depending on what species were available at a particular time of year. The annual arrival of the herring shoals, for example, were once the staple resource that kept communities alive along much of the coast, especially in Cardigan Bay (Jenkins, 1991). However, in more recent times, the herring have gone and it is market forces as much as seasonal availability that dictates the fishing activity. As a consequence, there is a trend towards boats carrying a number of different fishing gears.

As trends and the industry in Wales have evolved, there has been a shift of focus from the larger vessels operating out of these central points to the smaller inshore vessels operating from smaller ports and harbours around the whole of the Welsh coastline (WAG, 2008).

The inshore fleet mainly fish close (<6nm) to the coast for a wide range of species including sea bass, crabs, scallops, lobster, prawns, brill, turbot, sole, plaice, rays, cod and whelks. Many of these species are of high commercial value and high quality due to the methods of capture used and short time between capture and landing. These small-scale fisheries contribute most to the Welsh economy in volume and value (WAG, 2008). In many cases, they also form important parts of the diet of various marine mammals (e.g. harbour porpoise, bottlenose dolphin, and grey seal) (see Chapter 2).

From the point of view of equipment and manpower, inshore fisheries are usually prosecuted by small boats under 10 metres in length, and crewed by one or two men. These operate very locally, moving up and down a small stretch of coast, targeting a variety of species and utilising a range of mainly static gear types (Thomas, 2003).

3.3 Types & Distribution of Fishing Activities in Wales

3.3.1 Beam Trawls

Beam trawls (along with scallop dredges) are heavy gear. The larger 12-metre beams (as used by some foreign fleets) are not permitted in UK territorial waters where only 4-metre beams can operate. Irish (Liverpool Bay) and Belgian (Pembrokeshire Peninsula) vessels have historic rights to fish in the 6-12nm zone, but not with 12-metre beams. Fleetwood-based vessels occasionally visit the North Wales coast, and Devon-based boats may fish in Cardigan Bay and off South and South-west Wales (CCW, 2010).

Beam trawlers target demersal fish: in Welsh waters, these are plaice or sole. The three major countries beam trawling in the Irish Sea during 1998-2003, were Belgium (52%), the UK (32%), and France (12%), with sole the main target species. The beam trawl fleet was distributed to the southwest of the Isle of Man and in Liverpool Bay, in Cardigan Bay, and off the coast of South-west Wales (Fig. 20). During this time, there was no noticeable temporal trend in beam trawling effort (Mills & Eastwood, 2005), with similar levels of activity in 2007 (Lee *et al.*, 2010; Fig. 21). Effort has remained relatively consistent throughout the year, with slightly less activity during the autumn (Fig. 22).

Historically, several species of skate and ray of economic importance used to be landed in Wales. Since the 1970s, stocks have been declining steadily owing to over-fishing by the offshore fleet. Only rays are now landed and form a vital part of overall landings, amounting to 80% by value for some Welsh inshore vessels (WAG, 2008).

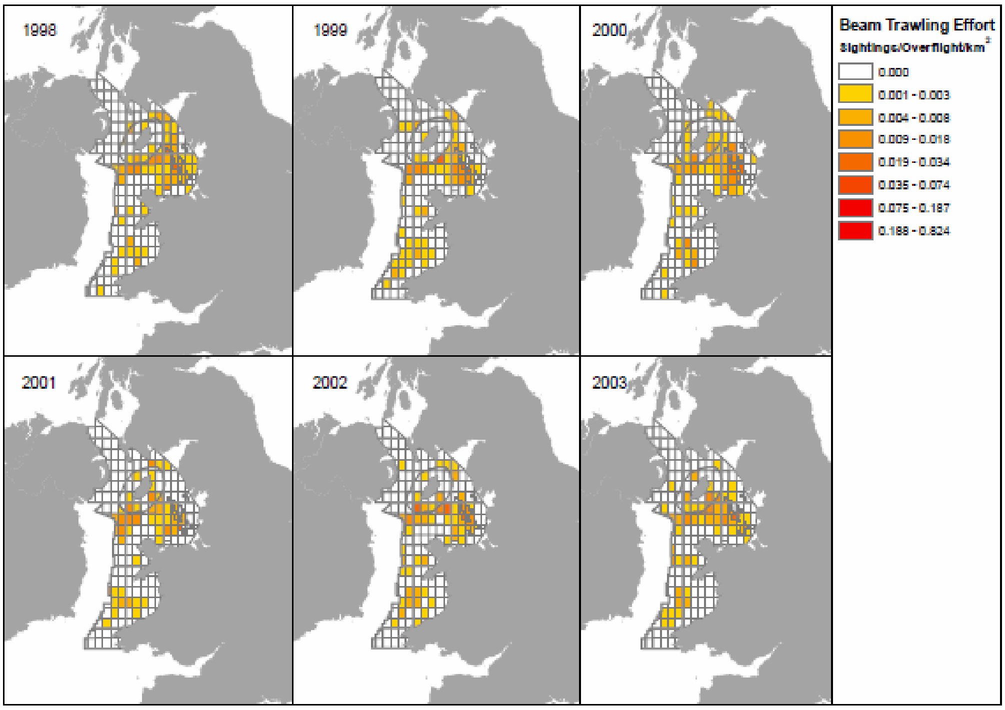


Figure 20: Annual distribution of beam trawling within SEA6 between 1998 and 2003, based on SFI overflight surveillance data (Mills & Eastwood, 2005)

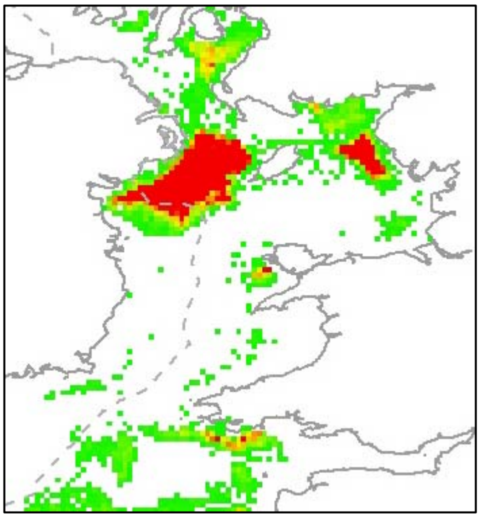


Figure 21: Distribution of beam (Cumbria, Lancashire, North & SW Wales) & *Nephrops* (between Northern Ireland and the Isle of Man) trawls from VMS, 2007 (Lee *et al*., 2010)

Outside of 6 and 12nm zones, European beam trawlers, and more recently, twin-rigged trawlers, have increased their efforts, and are not bound by Sea Fisheries Committee minimum fish size limits (WAG, 2008).

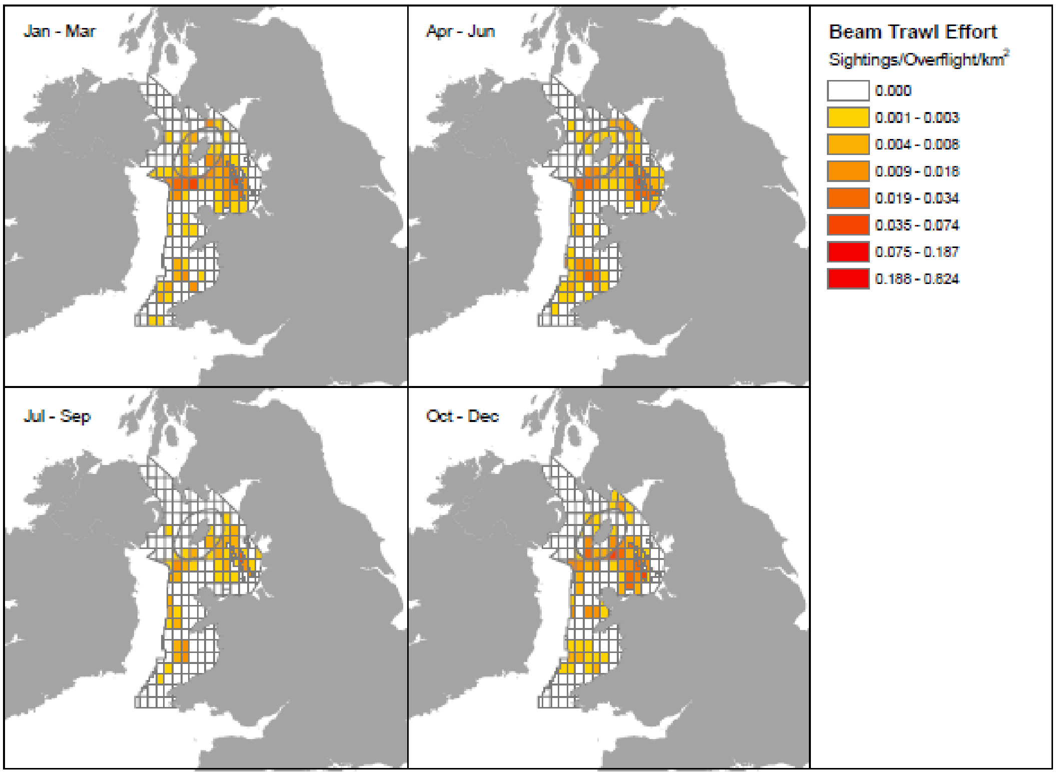


Figure 22: Quarterly distribution of beam trawling within SEA6 between 1998 and 2003, based on SFI overflight surveillance data (Mills & Eastwood, 2005)

3.3.2 Scallop dredgers

Wales has significant stocks of scallops, both King and Queen scallops, and they are in heavy demand, although a high level of effort from large visiting scallop dredgers has been cause for concern over long-term sustainability of the fisheries (WAG, 2008). During the early 1970s, there was little scallop dredging in the UK. In 1976, catches increased greatly, with up to 2-300 vessels moving into Cardigan Bay, dredging for Queen scallops. Catches declined to almost zero due to over exploitation, leading to a pause in the fishery. In the late 1980s, prospecting for scallops started again, and in 2000, King scallops were discovered and a local fishery started. In 2007, scallopers moved into Cardigan Bay from England, having been excluded from locations like Lyme Bay.

Scallop dredgers working around Wales are mainly UK or Isle of Man registered (also Dutch and possibly Belgian), and they can fish in areas subject to the new Scallop Fishing Order 2010 (CCW, 2010). In 2009, the Welsh scallop fishery was due to open for the season 1st November 2009 to 31st May 2010 under the Scallop Fishing (Wales) Order 2005. However, a considerable increase in fishing effort in this fishery over the previous years (due to displacement from the closure of other UK scallop fisheries) led to its controversial closure until the end of February 2010 whilst new regulatory measures were drawn up. The Scallop Fishing (Wales) (No.2) Order 2010 came into force on 1st March 2010 and included both spatial and technical restrictions to reduce the level of scallop fishing effort in Welsh waters. The technical restrictions set a maximum limit on engine power for scallop dredgers accessing the fishery and also set restrictions on the design and number of dredges deployed by vessels. In the main, the spatial restrictions prohibited scallop dredgers from designated areas in Welsh waters featuring vulnerable marine species and habitats although, as a result of survey work specifically undertaken to assess the impact of this fishery, scallop dredging was allowed in one part of the Cardigan Bay Special Area of Conservation. The development of more sustainable management measures for the future of this fishery is still ongoing (CCW, 2010).

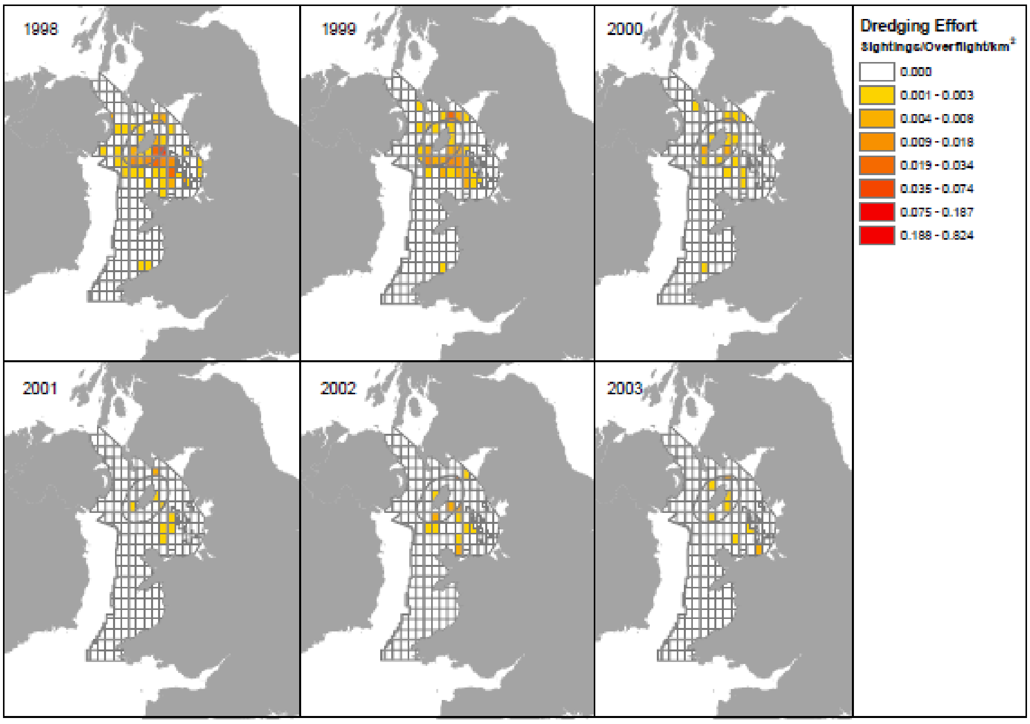


Figure 23: Annual distribution of scallop dredging within SEA6 between 1998 and 2003, based on SFI overflight surveillance data (Mills & Eastwood, 2005)

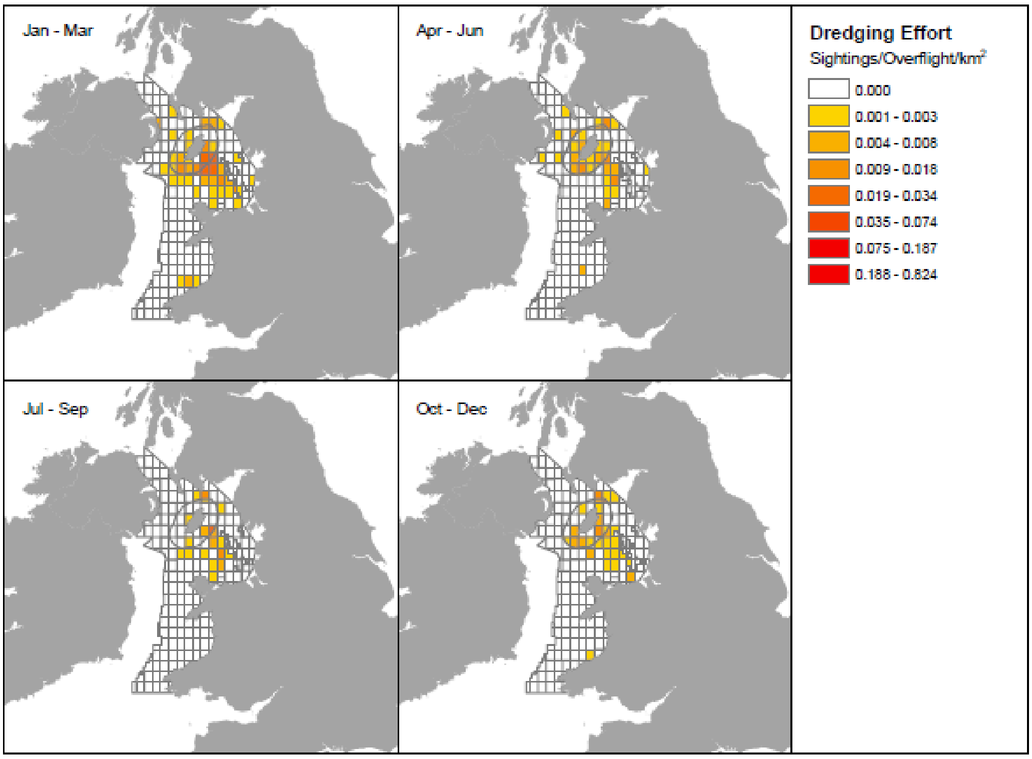


Figure 24: Quarterly distribution of scallop dredging within SEA6 between 1998 and 2003, based on SFI overflight surveillance data (Mills & Eastwood, 2005)

Scallop beds between Anglesey and the Isle of Man have for some years provided the main focus for activity (Fig. 23). On average, effort has been slightly higher over the winter months (Fig. 24). However, measures of effort in this category did not take account of the large number of vessels that take scallops and Queen scallops as by-catch in white fish trawls. During that period, a limited amount of effort also occurred off the coast in Cardigan Bay, although the inshore component of this fishery was subject to a seasonal closure between July and December. There was a noticeable decline in effort over the six-year period, 1998-2003 (Mills & Eastwood, 2005; Fig. 23), but in 2007, vessels from Southwest England moved from Lyme Bay (Dorset) scalloping grounds into Cardigan Bay and started working this area (Figs. 25 & 26).

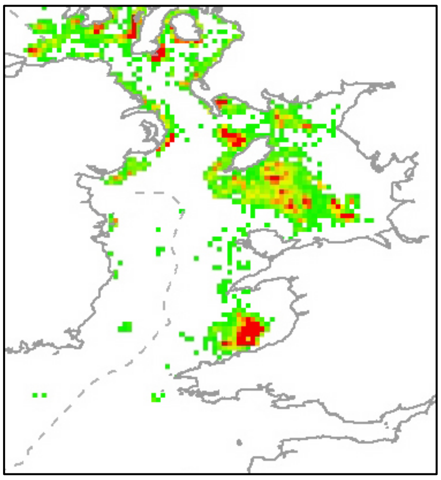


Figure 25: Distribution of dredging effort from VMS, 2007 (Lee *et al*., 2010)

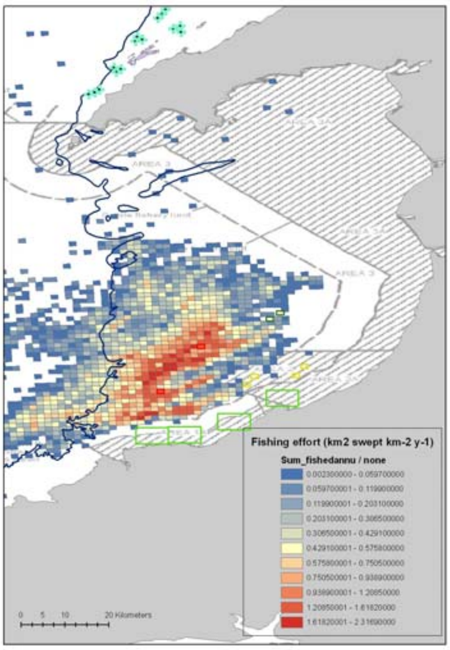


Figure 26: Distribution of scallop dredging effort in Cardigan Bay, 2008
(Source: School of Ocean Sciences, Bangor University)

North Wales has a small number of resident <10 metre scallop dredgers but most are itinerant vessels fishing anywhere between Milford Haven and the Great Orme (CCW, 2010).

There is recognised potential for a diver-caught scallop industry in inshore waters. This gives the product a higher price without the environmental concerns relating to dredge fisheries, so long as the activity is well regulated (WAG, 2008).

3.3.3 Rockhopper Trawls

Rockhopper trawling does not occur in Welsh territorial waters.

3.3.4 Oyster/Mussel Dredging and Prospecting

These activities are seasonal and the areas fished may change from year to year depending on where, for instance, the mussel seed can be located.

Oyster dredging has only been carried out by a few small vessels operating in a limited number of areas around the Welsh coast. These vessels are unlikely to use more than a pair of dredges of limited width (<1 metre) over a limited area – defined by the exploited oyster bed – for a relatively short season each year (CCW, 2010).

Mussel dredges, unlike scallop and oyster dredges, have a fishing bar at the front lower edge of the dredge, which is not toothed, but simply a smooth round bar. The purpose of this bar is to slide across the substrate underlying dense mussel populations, to separate the mussels from the substrate. Seed mussels for commercial cultivation are, or have been, harvested from areas east of the Great Orme, the Caernarfon Bar, and the Burry Inlet in South Wales (CCW, 2010).

Such activities may modify seabed habitats, which could potentially affect some prey species of marine mammals, but are unlikely to have a direct impact through by-catch.

3.3.5 Demersal Trawls

The principal source of fishing effort in the Irish Sea derives from otter trawling (Fig. 27). UK vessels comprise approximately 70% of the fleet, with French and Irish vessels forming the majority of the remainder. Otter trawlers predominantly target whiting, *Nephrops*, and plaice throughout the year. Figure 27 indicates that, in general, fishing effort remained relatively consistent over the period assessed (1998-2003), and the main areas fished were the same in 2007 (Fig. 28; Lee *et al.*, 2010). Effort was distributed to the east and west of the Isle of Man and, to a lesser extent, in the southern Irish Sea off the coast of South-west and South Wales. Those areas coincide with known important foraging locations of harbour porpoise and grey seal (whose diets include whiting, sole, and plaice). The spatial distribution of otter trawlers showed only marginal seasonal differences (Fig. 29; Mills & Eastwood, 2005).

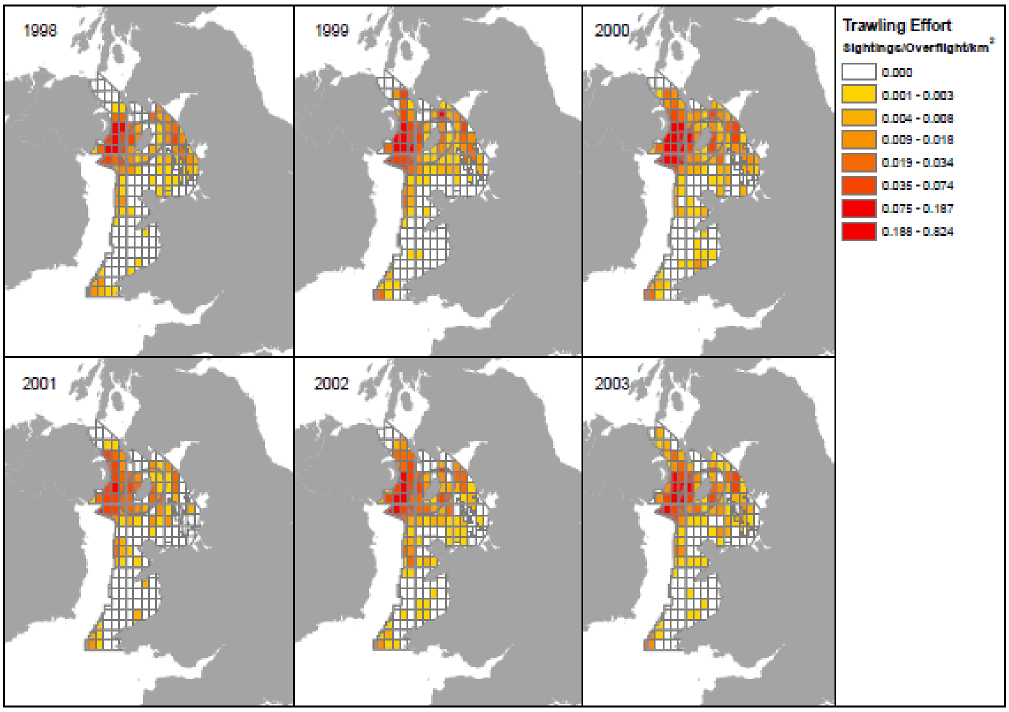
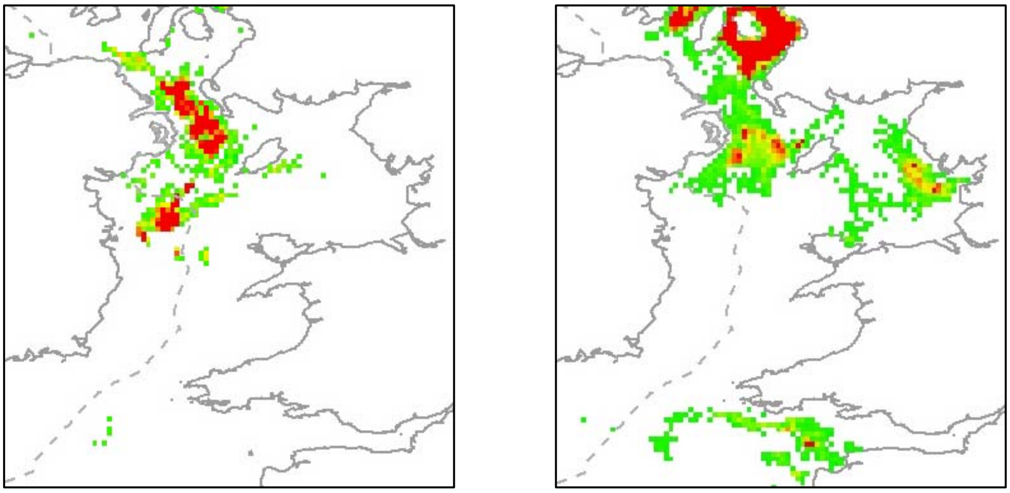


Figure 27: Annual distribution of otter trawling within SEA6 between 1998 and 2003 based on SFI overflight surveillance data (Mills & Eastwood, 2005)



a) Pelagic otter trawls

b) Demersal otter trawls

Figure 28: Distribution of trawling effort from VMS, 2007 (Lee *et al*., 2010)

Throughout much of the region, otter trawlers land plaice, sole, and rays (thornback ray, spotted ray, cuckoo ray, and small-eyed ray) from spring to autumn, and cod and whiting during winter (Mills & Eastwood, 2005; CEFAS, 2005). The last known Welsh record of the huge common skate came from the Llyn Peninsula in 1962. By 1981, the species had been declared commercially extinct in the Irish Sea (Brander, 1981; Moore, 2002).

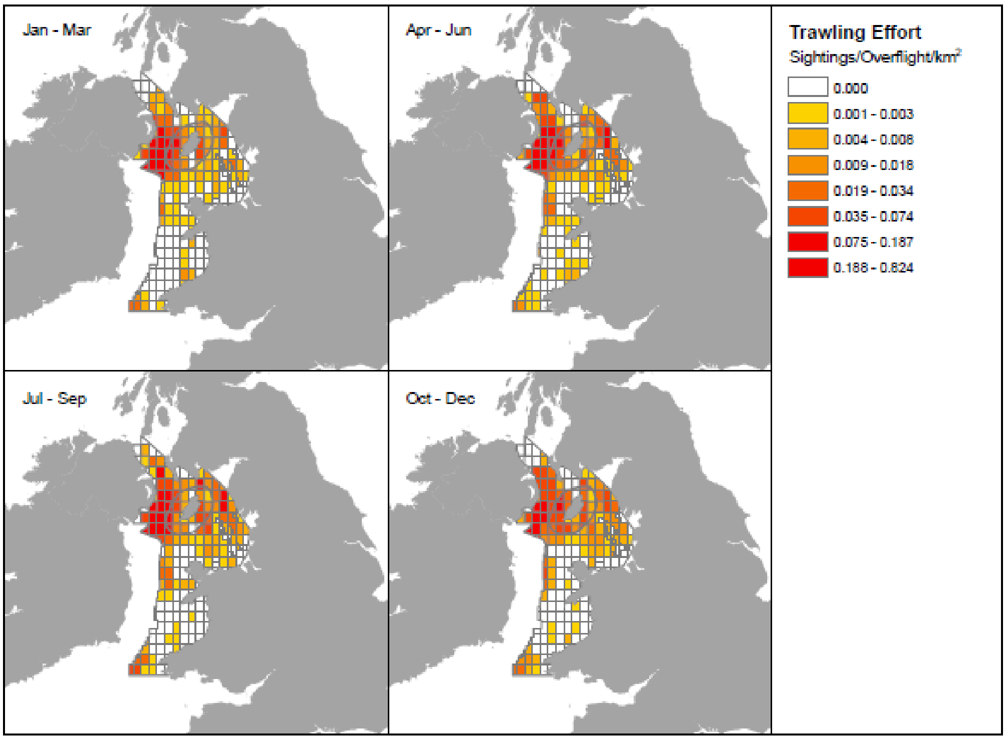


Figure 29: Quarterly distribution of otter trawling within SEA6 between 1998 and 2003, based on SFI overflight surveillance data (Mills & Eastwood, 2005)

3.3.6 Light Demersal Trawls and Seines

This activity is carried out mainly by smaller inshore vessels targeting particular species such as rays, plaice and shrimps, and operating in different areas at different times of the year. It is also an activity used by some fishermen in order to gather bait such as flounder, for lobster and crab pots.

The common characteristic among all these gears is that they are intended to be used by vessels that do not have great engine power; consequently, the gear skims across the seabed (CCW, 2010).

Light otter trawls are used throughout Wales, whereas light beam trawls are used by just a small number of boats in Wales, mostly in South and South-west Wales. Shrimp trawls are a very lightweight version of a lightweight beam trawl but have a smaller cod end mesh and a sorting grid/veil attached. Shrimp fishing occurs in the Dee Estuary, and in Carmarthen and Cardiff Bays. There is currently no Danish or Scottish seining occurring in Welsh waters (CCW, 2010).

Beach seining is commonly used to collect sandeels as bait for rod and line fishing to catch bass (CCW, 2010). Intertidal netting occurs at Conwy, in Red Wharf Bay (East Anglesey), at either end of the Menai Strait, and around the Dyfi Estuary.

Although none of these activities are likely to directly impact on cetaceans, they could remove potential prey of grey seal and coastal otters.

3.3.7 Hydraulic Suction Dredges

Hydraulic dredging for bivalves has occasionally occurred in Carmarthen Bay, until in 2003 when legislation was passed to stop the activity. There was limited activity in other small areas off the Welsh coast, mainly for razorfish (CCW, 2010). Impacts on marine mammals are likely to have been negligible.

3.3.8 Pelagic Trawls, Nets and Lines

There are no established pelagic trawl fisheries around the coasts of Wales (CCW, 2010). Offshore, bottom-set gillnets (the fishing method known to have one of the greatest impacts on marine mammals through by-catch) operate in the Celtic Sea northwards into the St George's Channel, but otherwise are not in use in Welsh waters (Fig. 30).

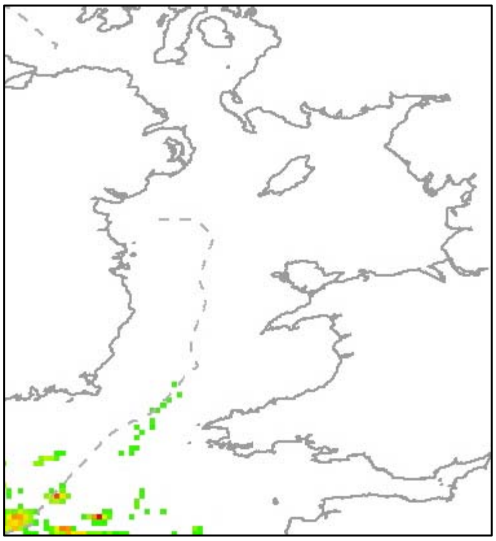


Figure 30: Distribution of bottom set gillnetting in the Irish Sea, 2007 (Lee *et al*., 2010)

Driftnets are used to fish for salmon (Severn Estuary) and bass (widespread). In some areas, bottom-set drift nets are worked for sole, plaice, flounder and bass, for example on Scarweather Bank in Swansea Bay. There is always a boat in attendance with drift nets (CCW, 2010). Some driftnetting for herring has occurred in autumn and winter, although effort was generally low as only small, local markets were supplied (Mills & Eastwood, 2005). Although bottlenose dolphins feed upon several of the fish species targeted by these fisheries, the areas in which they occur rarely coincide. In some locations, however, there could be interactions with grey seals.

Hand-lining / Jigging are carried out by both commercial and recreational fishermen mainly targeting fish, such as mackerel, that occur above the seabed. The method is probably widespread, but not necessarily used frequently, and so is likely to have minimal impact on marine mammals.

Drift lines are sometimes set in South-west Wales to catch pelagic fish (e.g. sharks).

Plugging and fly fishing are carried out by both the commercial and recreational sectors; most fish targeted, such as sea bass, live above the seabed and so loss of line and tackle is minimal (CCW, 2010).

In inshore waters, sea bass (a potentially important prey of bottlenose dolphin) are caught in fixed and drift nets, by rod and line, on long lines and, more recently, in high lift trawls, and increasingly throughout the year. Mullet (another bottlenose dolphin prey species) are sometimes taken as a by-catch in nets. There are numerous restrictions specifying the type of net permitted in certain areas (especially in and around estuaries to protect juvenile bass and salmon and sea trout), length and distance between nets and marking requirements. The bass rod and line fishery has expanded since the late-1980s due to these restrictions, the low cost of fishing gear and high demand for this species. The Burry Inlet, Three Rivers, and several other estuaries are designated as bass nursery areas by national legislation (Bass Specified Order 1990), where fishing for bass from a boat, or with sandeels as bait, is prohibited during May to October inclusive. The popularity of bass angling has increased the demand for sandeels as bait. Enforcement effort has reduced previously high numbers of unlicensed fishermen taking and selling significant quantities of bass (CCW, 2010).

Herring (a popular prey species for harbour porpoise; also minke whale and grey seal) attract a small amount of effort, usually in the form of drift netting in Swansea Bay, and drift and fixed netting in Milford Haven and in areas in North Wales, but demand is low. Mackerel are caught in drift nets and by hand-lining, and the chartered angling sector is highly dependent on mackerel during the summer. Sprats are occasionally taken in mid-water trawls and inshore in gill nets (Walmsley & Pawson, 2007). Both mackerel and sprat are regularly taken by marine mammals (mackerel, particularly by common dolphin and minke whale; sprat, by harbour porpoise, bottlenose dolphin and minke whale – see Chapter 2).

3.3.9 Static Gear - Nets and Long lines

The use of set nets is widespread around the Welsh coasts, mainly by small inshore day boats, which target sea bass in particular during the summer months, but also rays and other species throughout the year (CCW, 2010). There are some vessels using long lines for rays, principally around the North Wales coast, but the activity is not at the intensity it once was (CCW, 2010).

Gill nets can be set to fish at the surface (for salmonids, sea bass and clupeids, mainly left to drift), in mid-water, or on the seabed. Occasionally, they are also anchored intertidally which means they may fish at the surface, mid-water and seabed over the course of each tide (CCW, 2010).

Trammel nets are used to ensnare fish such as cod and plaice, and tangle nets to ensnare larger fish and crustaceans, such as rays and spider crabs (CCW, 2010).

Other than sea fish, migrating adult salmon and sea trout are the main target for net fisheries around the Welsh coast. Activity is restricted to coastal waters and estuaries, where limits can be set regarding the number of net licences issued, the type of net used, and the times of the year when those nets can be fished. These restrictions are operated by the Environment Agency (EA) under the Salmon Act 1986, which was established to protect salmonids (NAFW, 2000; CEFAS, 2006). Whilst salmon stocks are currently seen as low, sewin or sea trout is the most important species to game fishing in Wales, with the River Tywi being regarded as having one of the premier fisheries in the UK (NAFW, 2000). All of these fish species are taken as prey by bottlenose dolphin, as well as by grey seal.

3.3.10 Long lines

The use of long lines has largely gone out of favour among the inshore fleet since the introduction of cheap monofilament netting (CCW, 2010). The method is both labour and bait intensive, as each hook (and even a small 5-6 metre boat might fish 1,000 hooks per day) has to be baited before going to sea, unless it has been fitted with an auto-long line system. By-catch from long lines represents a major problem globally for some seabirds, particularly petrels, shearwaters, and albatrosses (Dunn & Steel, 2001).

Intertidal long lines (trot lines) are set on various habitats intertidally, mainly by recreational fishermen, although those fishermen who regularly set lines do so upon sandy beaches (CCW, 2010). Occasionally, a vehicle is used to attend the lines.

3.3.11 Static Gear – Pots

Potting is the most frequently used and widespread fishing gear in Welsh coastal waters and has a relatively low impact on the environment. Most of the Welsh inshore fleet employ static gear, especially pots. They are mainly small (under 10m) boats that fish close to their home port or harbour; some are launched daily from a beach around the Welsh coast. The species targeted alter throughout the year, and the fishery can be very seasonal in some areas due to weather conditions, which can restrict fishing particularly in the winter months (CCW, 2010). Many fishing ports along the Welsh coast support a small number of boats potting for crab and lobsters out to 6nm. Since the late 1980s, potting for prawns in Cardigan Bay has become increasingly popular, particularly between autumn and spring when the lobster fishery is at a seasonal low (Thomas, 2003). A brown shrimp fishery, pursued between the Dee and Duddon Estuaries, has also run from April through to December (Eno *et al*., 2001).

Live Welsh lobster, edible, spider and velvet crab, as well as prawns (*Palaemon* spp.) are in constant and increasing demand in the UK and further afield, with demand spreading rapidly as far as China and the Middle East. Lobster stocks in Welsh waters have been considerably improved through V-notching programmes, and by 2008 over 59,000 female lobsters had been returned to the sea to contribute to the breeding population, which would have otherwise been removed (WAG, 2008). These shellfish species are taken regularly by grey seals, and also by coastal otters (see Chapter 2).

Inkwell pots are a very traditional style of pot that are used by larger boats fishing offshore mainly for crab (CCW, 2010). They are not particularly efficient, as crustaceans are able to climb out of the pot. Occasionally, non-target species such as conger eel, wrasse and triggerfish, may be caught.

Parlour pots (lobster and brown crab) are more efficient than inkwell pots as the opening and a second inner chamber make it more difficult for the crab or lobster to find its way out (CCW, 2010; see also Fig. 31). They will also retain juvenile animals unless escape slots are fitted. They are typically set between April and November. Brown crabs provide an important resource off the Llyn Peninsula, where boats under 10m-length set pots out to 6nm from the coast (Mills & Eastwood, 2005).

Figure 31: European lobster *Homarus gammarus (left)*, static gear-pots *(right)* (WAG, 2008)

Lobsters provide the main resource for many fishermen operating in Cardigan Bay, as well as around the Llyn Peninsula and Anglesey (Mills & Eastwood, 2005).

The three graphs in Figure 32 illustrate the annual landings and gear used to catch edible crab, spider and velvet crab, respectively, from waters in South Wales in 1980-2008. European lobster *Homarus gammarus* is a valuable species targeted by the Welsh inshore fleet (WAG, 2008). Figure 33 shows the general rise in catches over this same period.

Prawn pots are mainly cylindrical pots made of plastic. The pots are negatively buoyant and do not have additional weight added. Due to the shape and their relatively light weight, they probably tend to roll around on the seabed if they are shot on smooth ground near to rock outcrops rather than on the rock.

Whelk pots are made from almost any form of plastic container. One end is partially removed and partially covered with netting. The rest of the pot is perforated with 25-30 mm holes, and about 25 mm of concrete is set in the bottom to weight the pot. They are fished on sand-gravel substrates (CCW, 2010).

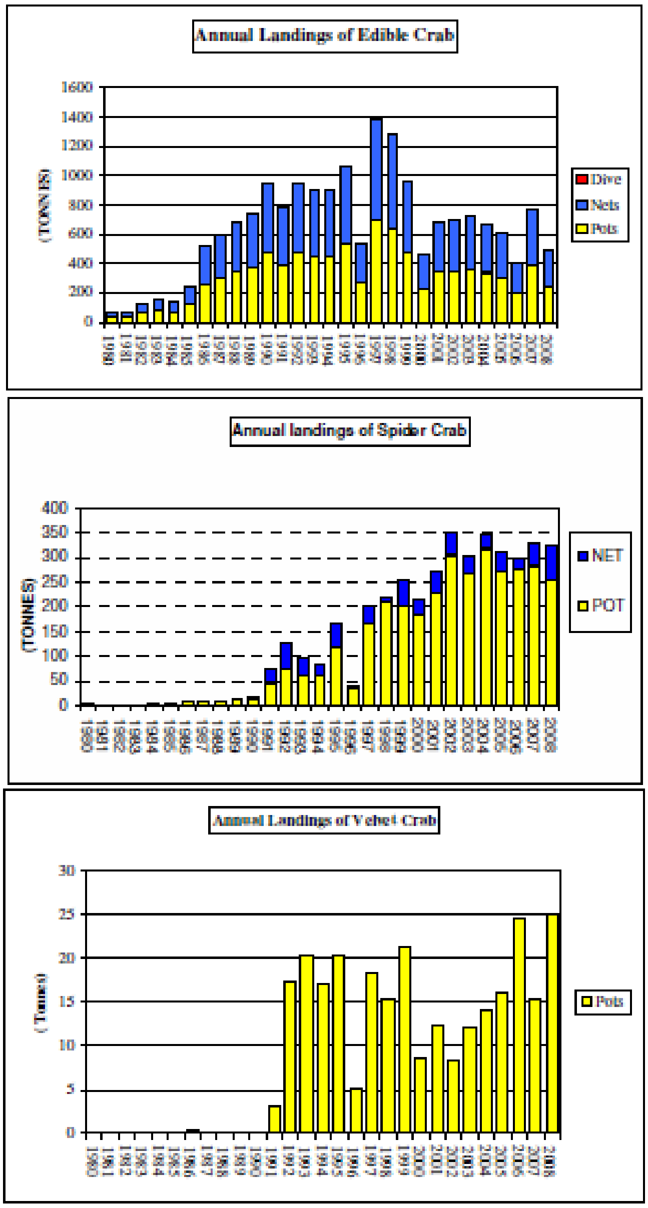


Figure 32: Annual landings of edible crab (top), spider crab (middle) & velvet crab (bottom) (SWSFC, 2009)

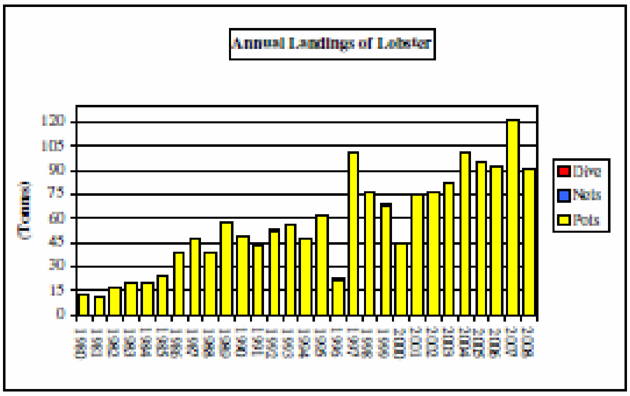


Figure 33: Annual landing of lobster (SWSFC, 2009)

In a number of localities in Europe, pots and traps attract seals and coastal otters, and sometimes these become accidentally caught in the fishing gear. In the Baltic, seals taking shellfish are considered a major problem by fishermen (Lunneryd *et al.*, 2004, 2005).

Between 1998 and 2003, <3% of the vessels sighted during overflights in the Irish Sea were potters, but this probably reflects the relatively short periods of time a potter may spend at sea. Effort was distributed primarily in Cardigan Bay and around Anglesey, but also around Pembrokeshire coast (Fig. 34); it also occurs around the Gower Peninsula. In general, the overall number of sighted potters increased slightly between 1998 and 2003 (Mills & Eastwood, 2005), and this increase appears to have continued through 2007 (Fig. 35; Lee *et al.*, 2010).

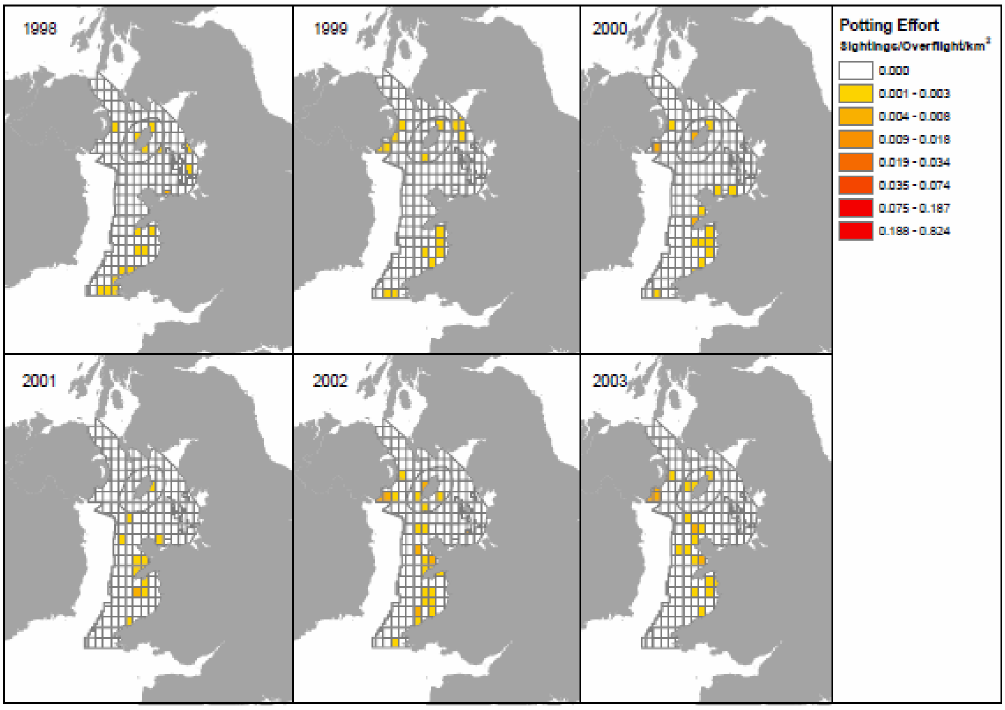


Figure 34: Annual distribution of potting within SEA6 between 1998 and 2003 based on SFI overflight surveillance data. (Mills & Eastwood, 2005)

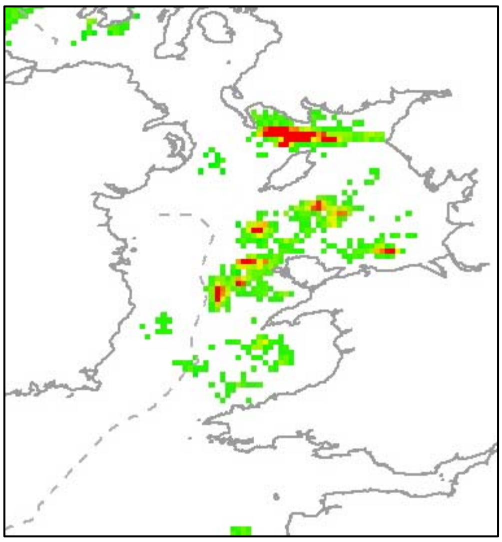


Figure 35: Distribution of Potting from VMS, 2007 (Lee *et al.*, 2010)

Potting occurs year-round, but at slightly higher intensities during the summer and autumn months (Fig. 36).

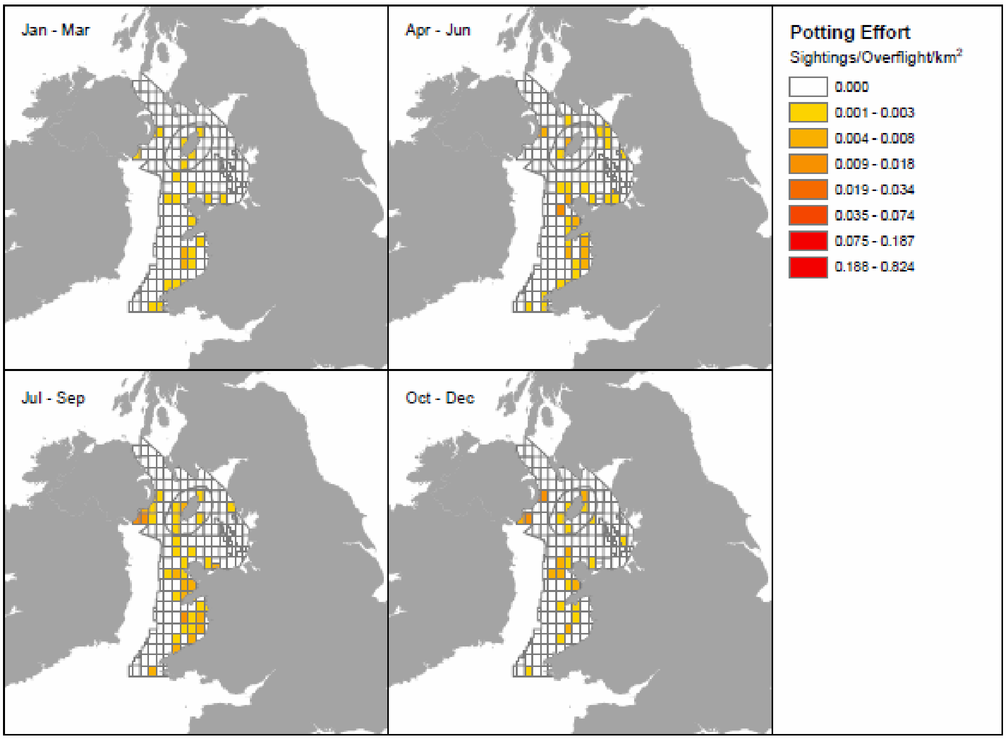


Figure 36: Quarterly distribution of potting within SEA6 between 1998 and 2003 based on SFI overflight surveillance data. (Mills & Eastwood, 2005)

Table 5: SWSFC District landings of crustaceans and first sale value - 2006 to 2008 (SWSFC, 2008)

Crustaceans	2006		2007		2008	
	Tonnes	£	Tonnes	£	Tonnes	£
Lobster	92	989,000	121	1,331,000	91	864,500
Edible crab	200	250,000	385	500,500	247	296,400
Spider crab	297	356,400	329	394,800	325	422,500
Crawfish	.35	12,000	2	56,000	.22	6,600
Velvet crab	25	32,500	15	18,000	25	32,500
Green crab	0	-	0	0	0	0
Prawn	3	51,000	4	68,000	6	120,000
Total	617	1,690,900	856	2,368,300	694	1,742,500

The shellfish fishery is prosecuted throughout the year on all sections of the coast, but especially in the remoter, rugged western areas. The summer months are the most productive when the fishermen are able to supply the tourist market. Winter operations are usually dictated by weather and sea conditions. However, effort may increase around the Christmas season when good prices can be had in supplying the festive market because supply overall is low at this time.

Shellfish caught in pots are of superior quality to those taken in nets. Despite this, tangle netting for spider crab does take place. Historically, the tangle net fishery for crustaceans was prosecuted in Pembrokeshire, its offshore islands, and around Ynys Enlli (Thomas, 2003).

A profitable pot based whelk fishery has also grown up around the Welsh coast in recent years. The main boom was during 1995/96, since which yields stabilised at approximately 1500 tonnes per year, but in the last few years have declined somewhat (Table 6). The majority of whelks are sold to markets in the Far East (WAG, 2008).

Table 6: SWSFC District landings of shellfish and first sale value **-** 2006 to 2008 (SWSFC, 2008)

Shellfish	2006		2007		2008	
	Tonnes	**£**	**Tonnes**	**£**	**Tonnes**	**£**
Cockles-Burry Inlet	1,077	376,770	688	263,710	960	326,000
Cockles-Three Rivers	0	0	410	164,000	20	6,780
Cockles-Three Rivers	0	0	55	30,635	-	-
Mussels (adult)	229	89,300	127	82,804	141	181,000
(seed)	3,720	465,000	5,550	1,110,000	-	-
(crumble)	720	90,000	82	10,660	-	-
Winkles	No Data	-	8	9,000	No Data	-
Oysters	6	12,000	2	4,000	1.54	3,080
Scallops	51	107,100	90	15,000	1726	3,045,000
Whelks	595	357,000	1,038	778,500	721	468,650
Total	**6,398**	**1,497,170**	**8,050**	**2,468,309**	**3,570**	**4,030,510**

3.3.12 Rod and Line hand-fishing

Rod & line are occasionally used by some commercial fishermen, in order to fish for sea bass (CCW, 2010). It is not a principal means of fishing, however, but is used by some fishermen in Wales between setting and lifting set nets. This method of fishing is usually carried out from a boat and has very little contact with the seabed. A small sandeel seine-net fishery has been developed as a result in order to supply bait (Mills & Eastwood, 2005). Interactions with marine mammals are likely to be small.

The remaining types of fishing activity are practised intertidally or in coastal or estuarine situations. As such, they have limited impact on marine mammals. However, they may in certain circumstances cause human disturbance to seals or coastal otters.

3.3.13 Casual hand gathering

Casual hand gathering is the occasional gathering by an individual of shellfish for personal consumption or of one or more species for personal use as bait for angling (CCW, 2010). The activity is very seasonal with the collection of some species restricted for parts of the year. There may be a number of individuals on popular sites at certain times of the year. The main species of shellfish collected for personal consumption are cockles, winkles and mussels by hand, and shrimps that are gathered using a push-net. Bait gatherers target lugworm, ragworm, peeler/soft crabs, limpets, shrimps, butterfish and sandeels.

3.3.14 Professional hand gathering

Shellfish, principally molluscs such as cockles, mussels, scallops, oysters and periwinkles, are hand-gathered usually with the aid of a spade, rake or similar device. A sieve, with an appropriately sized mesh, is often used to separate marketable sized cockles, and in some areas hand-gathering is the only permitted method of harvesting molluscs.

Professional collectors are individuals who work in gangs or alone and gather daily, sometimes twice a day. These individuals gather as much of the target species as possible when the tide recedes and the habitat is exposed. These collectors can either be gathering species for consumption (cockles, mussels, razor fish, winkles) or as use for bait (lugworm, ragworm, peeler/soft crabs, razor fish) for anglers.

There are usually vehicles involved when collection occurs commercially, in order to transport the equipment to the site and for the removal of the targeted species (CCW, 2010).

3.3.15 Aquaculture - Trestles, Ground lays & Traps

In 2005, shellfish cultivation in Wales was valued at c. £12 million. There were 12 registered shellfish farm sites operated by 11 businesses. Mussels, grown on the seabed, made up the bulk of production, the majority of which was exported as live, fresh produce to Europe. Compared to 2001, improved efficiency had led to a doubling of output, from 8,000 to 16,000 tonnes. In fact, Wales is currently the UK leader in seabed mussel production, the larger companies using purpose-built, state of- the-art mussel dredgers. Key to the year on year success of the mussel producers is the availability of seed mussel, obtained locally or from areas outside Wales, in years when supply from local sources are inadequate (WAG, 2008).

Mussels are collected either by hand, which is carried out intertidally, or from a boat with a 'long handled rake'. This method of collection removes the mussels from the 'mussel mud' with very little sediment disturbance and any by-catch is immediately returned to the sea. Vehicles can be used to transport the mussels off the intertidal. Mussels are also 'farmed' on sub-tidal areas called 'lays', usually within a Several Order. Seed mussel is laid on the plots and then gathered when they reach a preferred size, and collected by boats equipped with dredges.

Small quantities of oysters (<20 tonnes per year) are also produced. They are a niche product and are likely to remain so in the near future because market prices continue to remain fairly static. Scallops, clams and abalone are potential new species for cultivation, again for the niche market (WAG, 2008).

Trestles are used mainly in the intertidal zone for Pacific oyster cultivation by hand. The trestles sit on the seabed and the amount of mud from the oysters that could build up on the seabed from the oysters under the trestles depends on the rate of tidal flow.

Pacific oysters are an introduced species, which are gathered by hand. Pacific oyster lays will smother the ground in a similar manner to mussels. They are always intertidal.

Clam lays are most commonly intertidal, in which case the lay is covered with fine-mesh netting to exclude predators (green crabs and birds). Clams can also be cultivated sub-tidally. There are no clam lays currently in Welsh waters although licenses may be awarded in the future.

Peeler crab traps have increased in the estuaries and sheltered shores around the Welsh coast in recent years. Crab traps or 'shelters' are set in mainly muddy habitats. The traps are usually either old car tyres or guttering protruding out of the seabed at an angle. The guttering can be made from plastic, metal or asbestos. In very sheltered deep mud, metal corrugated roofing sheets can be used.

3.3.16 Aquaculture - Cages & Rope Cultivation

Salmonid aquaculture has been tried in the upper reaches of Milford Haven with limited success. The cages are either circular or square which float in the water column, and are anchored to the seabed by a number of anchors. The size can range from 4m x 4m to 25m x 25m (square cages) or from 40m circumference to 150m circumference (round cages) (CCW, 2010).

3.3.17 Suspended Rope Aquaculture

There has been much interest by fishermen in Wales recently to diversify into suspended rope aquaculture to grow mussels. This consists of a length of rope that is held about two metres below the surface by buoys. These are then anchored to the seabed by a number of anchors, or concrete blocks. It is on these ropes that mussel spat settles, and then the seed can either be collected or grown on to marketable size (CCW, 2010).

3.4 Summary and Conclusions

Fisheries in Wales are predominantly inshore, involving small vessels engaged in potting and other shellfisheries. Beam trawling targeting plaice or sole is conducted particularly off North Wales but also South-west Wales. Scallop dredging has been mainly south and west of the Isle of Man, but recently, has intensified within Cardigan Bay. Demersal trawling (using otter trawls for plaice, sole and rays through the summer, and whiting during winter) takes place mainly off South-west Wales, but also between Anglesey and the Isle of Man. It is most intensive in the north-western Irish Sea. Light demersal trawls for shrimp occur in a few areas, such as the Dee Estuary and in Carmarthen and Cardiff Bays. Beach seining catches sea bass or mullet in a number of localities around North Wales. There are no established pelagic trawl fisheries around the coasts of Wales. Hand lining and rod & line fishing are widespread and occur both commercially and recreationally in inshore waters, as is the use of set nets targeting particularly sea bass in summer but also rays and other species throughout the year. Other than sea fish, migrating salmon and sea trout are the main target for coastal net fisheries. Potting for shellfish is the most frequently used and widespread fishing gear in coastal waters. Aquaculture is practised, particularly for mussels, but also crabs, clams and oysters. For detailed maps of activity distribution of fisheries in Welsh waters between 2000 and 2005, see CCW (2010) *Atlas of Fishing in Wales*.

4. FISHERIES & THEIR DIRECT IMPACTS ON MARINE MAMMALS

Most species of marine mammals (even large baleen whales) interact in some way with fisheries, and virtually every species has been known to die from accidental capture in fishing gear (Northridge & Hofman, 1999). Likewise, almost all kinds of fishing operations have at least some impact on marine mammals, whilst some interactions represent a significant threat to marine mammals globally (Reeves *et al.*, 2003).

Modern technology has done much to improve the efficiency of commercial fishing. Fish-finders and sonar have made detection of shoals relatively easy. Synthetic materials, including monofilament fibres for netting, have lessened the chances of breakage or escape once the fish are caught. These improved techniques have led to a resultant increase in by-catch (Northridge, 2009).

There has been much speculation about the mechanisms by which cetaceans are by-caught (see, for example, Goodson, *et al.*, 1994a). Studies have been carried out both in captivity and upon free-ranging animals to observe cetacean responses to different types of net, and to assess their ability to negotiate such obstacles (Hatakeyama *et al.*, 1994; Kastelein *et al.*, 1995a, b, 1997a, b; 2000; De Haan *et al.*, 1997). Debate continues as to whether entanglement occurs because the animals cannot or do not detect the nets, or they do not perceive the net as an impenetrable barrier or threat, or they perceive the threat but become distracted by their prey (Anon., 1965; Goodson, 1993; Goodson *et al*., 1994; Goodson and Mayo, 1995; DEFRA, 2003).

By-catch is of particular concern since interactions with nets are usually fatal, and, thus do not facilitate a learning process. A secondary debate exists as to when it is during fishing operations that cetaceans become caught in the nets, and at what part of the fishing procedure they are most vulnerable (Tregenza *et al.*, 1997a; Couperus, 1997b).

A problem with identifying by-catches as such, arises if by-caught animals are freed from the nets (either by the fishermen or by other causes) and are found floating at sea or stranded on the coast. The diagnosis of by-catch in these animals remains a difficult task. Carcasses are often too decomposed to allow any post-mortem study to be conducted and some net types do not cause net marks on the skin – perhaps the clearest indication of by-catch (Kuiken 1994). Only a proportion of cetaceans found stranded, even if they show signs of physical trauma, can be diagnosed unequivocally as by-catches (Siebert *et al*., 1994, 2001; Jepson, 2005; Deaville & Jepson, 2009, in press; Haelters & Camphuysen, 2009).

Cetaceans that are caught and restrained underwater by fishing gear usually die of asphyxiation. In the case of animals that escape from entrapment, they may suffer the pain and debilitation of injuries for days, months, or even longer. By-caught dolphins, whales and porpoises commonly suffer cuts and abrasions to the skin (see Figure 37). This results from the scraping or incision of rope, netting or twine into the skin as the animal tries to escape. Animals that get caught in very fine and loosely set gillnets, twist or writhe, causing the netting to become more tangled and to tighten around them. By-caught dolphins are commonly recorded with broken teeth, beaks or jaws. These injuries are particularly associated with animals that have been caught in trawl nets, which, as towed gear, are relatively taught and resistant. These animals are trapped within the net rather than entangled, and in trying to find an escape route they appear to try to push their way through the meshes with such force that fractures occur (McLachlan, 1997, 2001; Spencer *et al*., 2000).

Figure 37: Evidence of by-catch in stranded animals: (top left) net marks on snout (upper and lower jaws) (top right) pectoral fin clippings, (bottom left) hyphaema (blood in the eyes) - notice also the net marks. (bottom right) twine wounds on pectoral fins, tailstock and fluke (from Haelters & Camphuysen, 2009)

Table 7: Species / Gear Interactions - fishing gear known to cause accidental entanglement for major European cetacean species (Northridge, 2009)

Species/Gear category	Gill nets	Pelagic trawls	Demersal trawls	Long lines	Pot lines
Harbour porpoise	√		√	√	
Bottlenose dolphin	√	√	√		√
Atlantic white-sided dolphin	√	√			
White-beaked dolphin	√	√			
Short-beaked common dolphin	√	√	√		
Long-finned pilot whale	√	√	√	√	
Minke whale	√	√			√

NOTE: Current sampling based on frequency of records, not significance of possible impact
(see also Appendix 3)

By-caught dolphins can also suffer extreme internal injuries. These include bruising, torn muscles, internal haemorrhaging (bleeding), congestion of organs such as the liver, kidneys and spleen, and punctured and collapsed lungs. The processes that lead to these internal injuries are still a matter of conjecture. However, the muscular tears and haemorrhaging that are frequently recorded are consistent with extreme struggling or thrashing as the animal tries to escape the net, or convulses before death.

Almost any gear can cause entanglement but certain types are known to be more problematic than others. In Northern Europe, four types of fishing gear, which have been operated over the last two decades, are particularly identified as having a cetacean by-catch associated with them (Northridge & Hofman, 1999; Kaschner, 2003; Northridge, 2009).

They are:

- Trawls (active/mobile)
- Static fishing gear
- Driftnets (although these have now been phased out in many regions)
- Seine nets

These will be reviewed below along with various mesh types.

4.1 Trawls

Trawls can broadly be divided into:

- **demersal trawls**, which are towed along the seabed to disturb and catch species such as hake, flatfish, monkfish and various crustaceans. These may include dredging, beam trawling, otter trawling, and rockhopper trawling.

- **mid-water trawls/pelagic trawls**), which are towed through the water above the sea bed, targeting pelagic fish species such as mackerel, herring, pilchard, cuttlefish and anchovies. These may include pair trawling and otter trawling.

While the mesh size of trawls is important in determining the catch compositions, the type of mesh used is of less importance for cetacean by-catch in active fishing gears.

Trawls are usually in the water for 2-4 hours at a time (Sequeira & Ferreira, 1994). With the advent of freezer trawlers, fishing trips can last for up to five months (see, for example, Couperus, 1997b). In the absence of on-board freezer facilities, trawlers are usually at sea for only a few days at a time (Sequeira & Ferreira, 1994). Pumps represent a modern advance in the trawling procedure, used by the larger vessels, and resulting in by-catch of marine mammals usually being underestimated when they are in use (Hartmann *et al*., 1994; Tregenza & Collet, 1998; Morizur *et al.*, 1999). However, although used in UK pelagic trawl fisheries (e.g. for mackerel), they are currently not in use in Wales.

4.1.1 Demersal Trawls

One of the simplest of trawls, although very effective, is the beam trawl (Fig. 38). The beam trawl net is towed over the seabed, and is generally used to catch flatfish. The mouth of the net is held open horizontally by a beam, and there may be ‘tickler’ chains added in front of the ground-rope to disturb flatfish off the bottom as the net approaches.

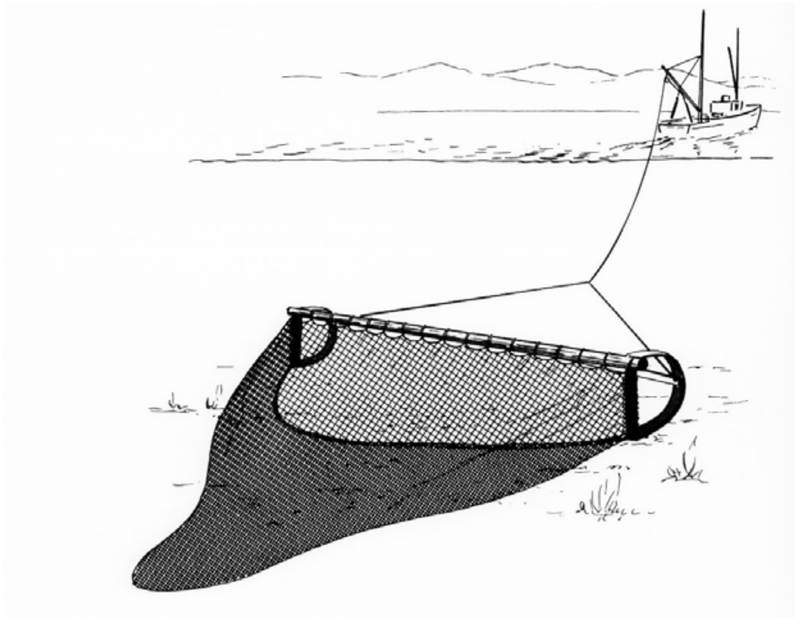


Figure 38: Beam Trawling (NEFSC Photo Archives)

An otter trawl is a demersal trawl where the mouth is held open by otter boards, which are designed to pull away from each other as they are towed and so keep the net open (Fig. 39). A beam is therefore unnecessary.

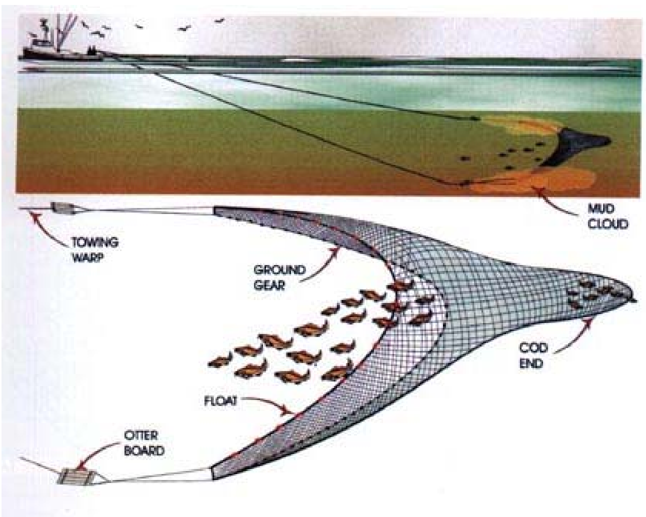


Figure 39: Otter Trawling (Source: R. Amaral)

The more recent development of rockhopper trawls, with large rollers that can travel over seafloor obstructions, has allowed trawlers to fish in more areas than ever before. Rows of rubber tyres or rollers ensure that the footrope remains in contact with the seafloor but also enable it to manoeuvre over seafloor obstacles in areas that may have previously been inaccessible without this gear type. Netting with chafers is used over sandy bottoms, whereas mesh matting is used in rougher conditions.

4.1.2 Pelagic Trawls

Pelagic or mid-water trawls may also be towed by a single large vessel or by a pair of vessels (Fig. 40). In either case, the net is generally very large and has to be towed quite fast.

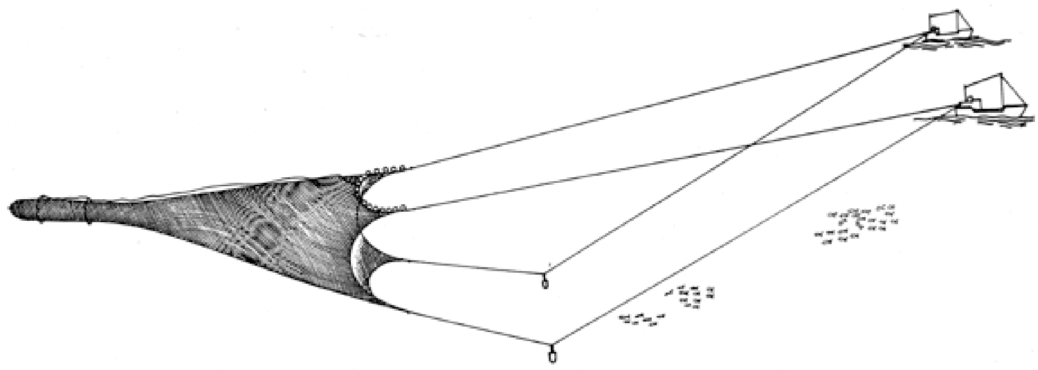


Figure 40: Pair Trawling (Source: Food & Agriculture Organisation: www.fao.org/fishery/fishtech/1006/en)

Direct Impacts

Both trawls and gillnets often have high by-catch mortality associated. One similarity between the two fishing techniques is that they are both targeting marketable species, which are also eaten by cetaceans (Wurtz *et al.*, 1992). However, a fundamental difference between by-catch in trawls and that from gillnets is in the cetacean species that are caught. Dolphins rather than porpoises seem to be mostly associated with by-catch in trawl fishing (Fig. 41).

Besides the engine noise from the boat, several parts of a trawl vibrate when operated – such as the chains and pennants, which strum, causing a high frequency reverberation. Thus, cetaceans are likely to be much more aware of the fishing gear (De Haan *et al.*, 1997). On the other hand, most cetaceans that echolocate do not do so continuously; and within a school, only a few individuals may be echolocating at any one time (Akamatsu *et al*., 2005).

Many trawl fisheries operate at night using lights to lure the target species to the surface (Sequeira & Ferreira, 1994), and it is an interesting feature of cetacean entanglement in trawls that it occurs significantly more frequently at night than in the daytime (Aguilar, 1997; Crespo *et al*., 1997; De Haan *et al*., 1997; Fertl & Leatherwood, 1997). In fact, De Haan *et al*. (1997) observed that cetaceans tend to keep a greater distance from vessels during the daytime and seem less inclined to interact with the trawl. During a study using a hydrophone array to assess the behaviour of dolphins around a simulated trawl, these authors observed that the dolphins seemed attracted to the deck lights used when trawling at night. When the lights were extinguished, the dolphins retreated from the boat and returned again on re-illumination. This area of research merits further investigation.

Figure 41: Atlantic white-sided dolphin from a pelagic trawl (P. Watkinson/SWF)

The major regions and fisheries, where marine mammal by-catch has been identified as significant, are reviewed below.

Multinational Pair Trawl Fisheries in the Celtic Sea and Western English Channel
The first efforts to record by-catch levels from an independent observer scheme in UK waters started in the 1990s in the Celtic Sea (Tregenza *et al*., 1997a, b; Tregenza & Collet, 1998; Northridge *et al*., 2000). Since 2001, by-catch monitoring in set nets has been focused on the southwest of Britain, as has monitoring of the bass pelagic pair trawl fishery during the winter fishing seasons (ICES, 2008). Monitoring of by-catch from UK fisheries is co-ordinated by the Sea Mammal Research Unit, University of St. Andrews.

The number of stranded carcasses of common dolphins and harbour porpoises reported from beaches in South-west England increased three-fold during the 1990s (Kuiken *et al*., 1994a; Kirkwood *et al*., 1997; Bennett *et al*., 2000). A large proportion of these animals were diagnosed as having died in fishing operations, although the proportion varied between years. Many of these deaths were probably due to gillnet fisheries (see section 4.2), but also implicated was the offshore bass pair trawl fishery (DEFRA, 2003), and most strandings were between January and March (Bennett *et al*., 2000). During 2000-04, 61.1% (116 out of 190) of autopsied stranded common dolphins diagnosed as incidentally caught in fishing gear (Jepson, 2005). This high rate of strandings in SW England diagnosed as by-catches has declined in the last few years (Deaville & Jepson, in press; P.D. Jepson, *pers. comm.*).

The offshore pelagic trawl fishery has been predominantly a French fishery, with about three-quarters of annual fishing effort in the western Channel due to French vessels, whilst about one quarter were UK vessels, mainly from Scotland. Thus, estimates of by-catch within the UK fishery from this area may greatly underestimate the total number captured.

It was estimated that between 2000 and 2003, the UK fishery in the Channel took around 90 common dolphins annually (but no porpoises) (Northridge *et al.*, 2003). However, this likely underestimated the total by-catch since annual strandings of common dolphins alone over that period exceeded 90 every year (Jepson, 2005). More recently, common dolphin by-catch estimates in the UK bass pelagic pair trawl fishery were 84 (2005-06) in ICES Area VIIe, 114 (2006-07), and 260 (2009) in ICES Area VIIadefghi (UK National Report to ASCOBANS, 2009; Northridge & Kingston, 2010).

Independent observer schemes targeting the French pelagic trawl fishery in the mid-1990s estimated by-catches of common and striped dolphins between the low hundreds and low thousands per year (Morizur *et al.*, 1996, 1999; Tregenza & Collet, 1998). The latest published estimate, following the introduction of EC Regulation 812/2004 in 2004, indicated a by-catch of 240 common dolphins, 40 striped dolphins, 50 bottlenose dolphins, and 10 long-finned pilot whales in pelagic trawls for 2007 (French Annual Report for 2007 to ASCOBANS, 2009), and of 300 common dolphins and 90 long-finned pilot whales in 2008 (French Annual Report to ASCOBANS, 2010).

So far, the only Irish fishery that has been monitored in detail for cetacean by-catch is the Irish tuna fishery. In 1994 and 1995, monitoring programmes were undertaken in the Irish herring fishery operating in the Celtic Sea. However, no cetaceans were recorded as by-catch in this fishery at that time (Berrow *et al.*, 1998). Currently, work is being undertaken to monitor cetacean by-catch in the Irish mackerel and blue whiting fisheries, but so far during the 2009/10 season, no cetaceans had been reported as by-catch in these fisheries (An Bord Iascaigh Mhara, *pers. comm.*).

Initial investigations into the Irish fishery for albacore tuna were carried out in 1996 and 1998, and it was estimated that in those years respectively, 345 and 2,552 common dolphins were caught incidentally, by the whole fishery (Harwood *et al.*, 1999).

During 1998 and 1999, An Bord Iascaigh Mhara (BIM) and the Marine Institute undertook a major two-year study into developing alternative tuna fishing techniques (BIM, 2004). In 1999, tests on experimental trawls were carried out off Western Ireland and the southern Bay of Biscay, and 313 hauls over 160 days were observed. Results showed that a total of 145 animals, which include four species of cetacean, were incidentally caught (Table 8; BIM, 2005). Ninety percent of hauls had no cetacean by-catch, but 125 common dolphins were caught. However, this occurred in just four pair trawls (BIM, 2000). This highly clustered pattern of by-catch is not unusual in pelagic trawls, and may be as a result of the cohesive nature of dolphin social groups (BIM 2000).

Table 8: Cetacean by-catch from the Irish pair pelagic trawl fishery for albacore tuna (Unpublished data obtained from BIM)

Year	**1998**	**1999**	**2002**	**2003**	**2004**
No. of observed hauls	144	330	113	55	35
No. of cetacean by-catch incidents					
Common dolphin	12	23	5	1	1
Striped dolphin		4			
Atlantic-white sided dolphin		1			
Long-finned pilot whale		4			
Total	**12**	**32**	**5**	**1**	**1**
Mean no. of cetacean incidents per haul	**0.08**	**0.10**	**0.04**	**0.02**	**0.03**
Sum of cetacean by-catch	**No. of by-caught animals**				
Common dolphin	44	125	16	1	2
Striped dolphin		10			
Atlantic-white sided dolphin		2			
Long-finned pilot whale		8			
Total	**44**	**145**	**16**	**1**	**2**
Mean no. of cetaceans per haul	**0.31**	**0.44**	**0.14**	**0.02**	**0.06**

In 1999, a number of other species were also incidentally caught, including striped dolphins, Atlantic white-sided dolphins, and long-finned pilot whales. In more recent years, only common dolphins have been reported as by-catch.

A noticeable decrease in incidental capture of cetaceans in the Irish tuna fishery was recorded between 2002 and 2004 (BIM, 2004; Table 8), suggesting that the decrease in cetacean by-catch may have resulted from a number of improvements in avoidance techniques by the Irish fleet, many of which have been involved in the pair pelagic fishery since it commenced in 1998. These include (1) avoiding fishing operations when cetaceans are active in the area; (2) carrying out a number of practices such as extinguishing stern lights while towing; and (3) dropping the headline to several metres below the surface. These practices are simple to adopt and do not adversely affect fishing for albacore (BIM, 2004). Onboard observer programmes aboard fishing vessels were in operation during 2010 (Marine Institute, MI/BIM), including a dedicated cetacean programme to examine by catch in pelagic trawls in compliance with the EU 812/2004 Directive (McCarthy *et al*., 2011). Towards the end of the calendar year 2010, dedicated observers monitored pelagic trawls targeting albacore tuna and herring. No by catch was observed in these trips.

French Pelagic Trawl Fisheries (in ICES VII and VIII)

In July 2004, the European Project PETRACET started a one-year study to collect data in several fisheries in ICES areas VII and VIII. French fleets included in PETRACET were tuna and bass fisheries in area VII, a bass fishery in area VIII, and the spring and autumn anchovy fisheries. The report showed that in the tuna and bass fisheries alone, the total mortality of common dolphins in European pelagic trawl fisheries (combining UK, Irish, French, Dutch and Danish pelagic trawls) in the two ICES areas was probably around 800 animals per year, although large inter-annual variability was noted in those fisheries (Northridge *et al*., 2006). By-catches of common dolphins are also known to occur in other fisheries including very high vertical opening (VHVO) trawls, bottom trawls, and static nets (ICES, 2005).

Table 9: Total number of hauls observed and number of individuals caught by quarter during 2005 for bottom pair trawlers with very high vertical opening nets (VHVO) in Divisions VIIIa,b,d (ICES, 2005)

	1st quarter	2nd quarter	3rd quarter	4th quarter	Total 2005
Hauls observed	34	9	10	17	70
Hauls with by-catch	2	0	0	0	2
No. of individuals	2 (1,1)	0	0	0	2 (1,1)

The 2005 observations on the VHVO bottom pair trawlers for ICES Divisions VIIIa,b,d, are presented in Table 9. Common dolphin by-catch was recorded in two of 70 (2.85%) hauls. Both incidental takes were in the first quarter of the year (ICES, 2005; Table 9). For 2006, the estimated by-catch from the albacore tuna pair trawl fishery in ICES area VII was 55 common dolphins (ICES, 2008). In 2007, the pelagic trawl fishery in ICES areas VII and VIII had an estimated by-catch of 240 common dolphins; this rose to 300 in 2008, and around 1,000 in 2009, but apparently has declined since then (French Annual Reports to ASCOBANS, 2008-10; Y. Morizur, *pers. comm.*). Most of the by-catch occurs in the winter bass fishery but there is also by-catch in the summer tuna fishery.

Spanish Pelagic Trawl Fisheries in and around the Bay of Biscay

The very high vertical opening (VHVO) bottom pair trawl fishery is the only one in which cetacean by-catch has been observed. These by-catches have only been observed in ICES Divisions VIII a, b and d (ICES, 2005).

Table 10: Monthly distribution of the number of days at sea, hauls observed and by-catch in the VHVO bottom trawl in ICES Divisions VIII a, b and d for year 2000 (ICES, 2005)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Days at sea	0	18	7	6	8	0	0	0	6	4	19	3	71
Hauls observed	0	20	9	7	9	0	0	0	7	5	21	3	81
Hauls with by-catch		1	0	0	0				0	1	2	0	4

In 2001, 118 hauls were observed (2.4% of the total effort in ICES Divisions VIII a, b and d) and only one haul had a cetacean by-catch, in February. Common dolphin was the only cetacean species involved in this by-catch. For this year, 38 hauls were observed in ICES Divisions VII h and j (5% of the total estimated effort in these Divisions) and no cetacean by-catch was recorded in them (ICES, 2005). There has been no reporting of by-catch since then although questionnaire surveys clearly show there continues to be a by-catch in the Spanish fleet (F. Read, *pers. comm.*).

4.2 Static Fishing Gear - Gillnets

All gillnets share the common principle that they are designed to ensnare fish, which swim into them. They form an effective barrier through which fish greater than a certain size cannot pass. They work on the principle that fish trying to pass through the mesh become stuck, and, as they struggle, the twine catches them behind the operculum.

Each net panel consists of a floatline, which holds the net taut in the water when balanced against the weight of the leadline, and the mesh itself. The floatline comprises a series of air-filled chambers that are spaced evenly along the length of the net. The leadline consists either of a continuous length of lead-weighted rope, or a rope with individual weights attached at intervals. These two parts of the net are considered to be the only parts that are substantial enough to facilitate detection by cetacean sonar (Goodson 1993; Goodson *et al*., 1994a, Hatakeyama *et al.*, 1994; Goodson & Mayo, 1995; Nakamura *et al*., 1998). However, the target strengths of the floats used are often fairly weak, and the leadline tends to become buried in the sediment and is thus no longer available as a target for detection (Spencer *et al*., 2000).

4.2.1 Bottom-Set Gillnets and Tangle Nets

Bottom-set gillnets (Figure 42) are fixed to the seabed by means of anchors, and are generally used for fish or groundfish. When very loosely set (i.e. with plenty of slack in the netting), these nets are termed tangle nets as they catch fish or crustaceans by entangling them rather than killing them. Tangle nets tend to be made with multi-monofilament twine. Typically, small boats (<15m length) may operate tangle nets in coastal fisheries, and as a result there is no legal requirement for monitoring by-catch from these, although with large numbers of such vessels in operation, the overall by-catch can be substantial.

In bottom-set gillnets, where the lead-line is set on the seabed, the lead-line becomes buried. In all gillnets, the reciprocal echoes from the knots are very weak, further reduced in intensity if the incident angle of approach departs from 90º (Goodson and Datta, 1992; Goodson *et al.*, 1994; Au, 1994). These characteristics of gillnets are the cause of some conjecture as to whether cetaceans can detect such nets in the water.

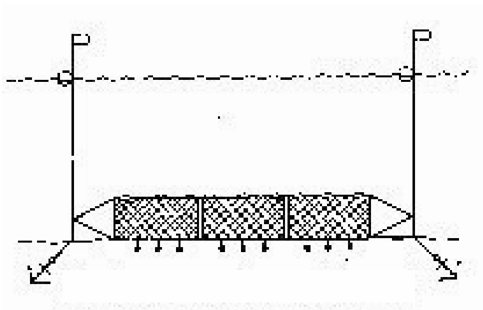


Figure 42: Outline Representing Bottom-set Gillnet or Tangle Net (Thomas, 2003)

Tangle nets are large meshed gillnets that tend to be set in deep water. The stretched mesh for these nets can be as large as 325mm. Their headlines are never weighted, but may on occasion be buoyed. Thus, they hang loosely in the water column, rising only a very short height above the seabed. Rather than catching their prey by the body or gills, these nets wrap themselves around the fish. They are used mainly to take rays and other flatfish, but are also often used to target crustaceans such as spider crab and crawfish. However, when it comes to dealing with crustaceans, tangle nets are acknowledged to be labour intensive and time consuming to clean. Professionally fished, tangle nets can be very effective. On the other hand, their cheapness can encourage poor use and they can easily be lost on poor or rough ground (Pickett & Pawson, 1994).

Wreck nets are multifilament gillnets set over shipwrecks, with steel rings on the leadline used to hold the net in place. A further variation of the gillnet is the monofilament or multi-monofilament trammel net. These nets comprise three layers. Trammel nets operate by trapping fish in a pocket of the inner mesh as they swim through from one side of the outer mesh to the other (Gill, 1999).

Direct Impacts

Evidence suggests that both dolphins and porpoises are capable of detecting gillnets and that, in a heightened state of awareness, they perceive the threat and thus will avoid nets, or at least become entangled less frequently (Hatakeyama *et al.,* 1994; Kastelein *et al.,* 1995b). However, there is also evidence that harbour porpoises may not detect nets until they are too close to avoid entanglement (Kastelein *et al.,* 2000). Detection distance of dolphins and porpoises (i.e. the distance from which they will receive a significant echo) is unknown, whether this distance allows time for an avoidance reaction, and how much the target strength varies with the angle of approach (Au 1994; Kastelein *et al.,* 1995b). Studies showed that a common dolphin should be able to detect a net within 25-55m, but it was concluded that the returning echoes from the nets were probably not sufficient to enable the animal to distinguish it from the 'volume-scattered' echoes of other penetrable barriers such as schools of small fish or the deep scattering layer (Goodson & Datta, 1992; Au, 1994; Kastelein *et al.,* 1995b). This is the basis for the deployment of acoustic alerting devices such as pingers as a mitigation measure.

Two species above all other cetacean species in Northern Europe, appear to be major victims of by-catch from gillnet fisheries. These are the harbour porpoise and short-beaked common dolphin.

Gillnets, tangle nets and trammel nets are all deployed on or near the seabed, targeting demersal species such as cod, turbot, lumpfish, plaice, sole and ray. Probably due to harbour porpoise feeding behaviour on or near the seabed, those gear types are associated with having the highest harbour porpoise mortalities (Northridge, 1988, 1991; Northridge & Hofman, 1999).

A disproportionately high number of juvenile porpoises amongst by-catches have been reported in several fisheries, for example the Danish gillnet fishery (Clausen & Andersen 1988, Kinze 1994) and the German fleet fishing in the Baltic and the North Sea (Kock & Benke 1996). It has been suggested that avoidance of nets could be related to experience, making young animals more vulnerable. Young animals could try to explore and play with the nets and become entrapped and this fact could also put females at risk if they try to rescue their calves (IWC 1994, Kinze 1994). Kinze also pointed out that the existence of age-related segregation in harbour porpoises would make some groups more vulnerable to by-catch. Gaskin & Blair (1977) found sub-adult males segregating from other groups in Canadian waters and staying closer to the coast and thus becoming more frequently entrapped in nets (Santos & Pierce, 2003).

a) Celtic Sea & Western English Channel

In the Western English Channel & Approaches, the only fishery besides the bass fishery in which common dolphin by-catch has been recorded and estimates obtained, is the offshore hake / pollack gillnet fishery. This fishery is prosecuted by both Irish and English vessels, which are usually 15m or more in length. Common dolphin by-catch rates were estimated in this fishery over the years 1992-94 and found to be around 200 animals per year (Tregenza *et al.*, 1997b; Tregenza & Collet, 1998).

Table 11: Quantified common dolphin by-catch observations in static net fisheries, Western English Channel, 1992-2000 (ICES, 2005)

Fishery	Years	No. of hauls observed	Km. hours	No. of common dolphin
Hake gillnets	1992-1994	949	52050	3
Tangle nets	1992-1994	7	1050	0
Hake gillnets	1992-2000	237	18000	2*
Hake gillnets with pingers	1999-2000	181	12400	1

* one common dolphin and one unidentified dolphin species

In 1999-2000, a second study was undertaken, and recorded by-catches of common dolphins at a slightly higher rate than those in 1992-94 (Table 11). All of the dolphins were taken between October and March. The hake gillnet fishery that was monitored in these two studies is distributed well offshore, with boats making trips of several days (Tregenza *et al.*, 1997b; Tregenza & Collet, 1998). Subsequent management action and a decline in the overall effort in this fishery have probably led to the lower by-catch levels observed since then (ICES, 2005).

During an independent observer scheme monitoring by-catch of common dolphins in gillnets, the dolphins seemed to be attracted to the boats during the shooting and hauling of the nets, and one dolphin was caught alive during hauling (Tregenza *et al.*, 1997b). There was also evidence that by-catch occurred particularly at night (Aguilar, 1997; Tregenza & Collet, 1998; Morizur *et al.*, 1999).

The UK & Irish hake fishery also had a significant annual by-catch of harbour porpoises, estimated for 1992-94 at 2,200 (95% CI: 900-3500; with c. 700 in the UK and 1,500 in the Irish fisheries) (Tregenza & Hammond, 1994; Tregenza *et al.*, 1997a). This represented 6.2% of the estimated number of porpoises in the region, a level more than three times the amount that was considered sustainable (Tregenza *et al.*, 1997a).

More recent estimates of porpoise by-catch from gill and tangle nets in the Celtic Sea between 2005 and 2007 gave annual values of 453 (2005) and 728 (2006) from the UK fishery, and 350 (2005-07) from the Irish fishery (ICES, 2008). For 2008, the by-catch estimates of harbour porpoise in gillnet and tangle net fisheries in the Irish and

Celtic Sea areas were 498-1409 and for common dolphins, 279-1019 (SMRU, 2009; UK National Annual Report to ASCOBANS, 2010).

b) North Sea

All countries bordering the North Sea and adjacent waters have reported by-catch in their fisheries. By-catch levels differ in different fisheries, but total mortalities are considered to be unacceptably high in a number of cases (Northridge & Hammond, 1999; Vinther 1999; Northridge *et al*., 2003).

The largest fishery in the region is the Danish bottom-set gillnet and wreck net fisheries targeting cod, hake, turbot, plaice and sole. The most recent estimates of cetacean by-catch come from the years up to 2001-02, presented by Vinther & Larsen (2004). They estimated from the central and southern North Sea an annual by-catch of 5,591-5,817 porpoises. The former figure is based on landings as used by Vinther (1999), and the latter is extrapolated from by-catch rates determined from observers between 1987 and 2001, accounting for fleet effort. By-catch may have been overestimated due to use of pingers in the cod wreck net fishery not being accounted for (Vinther & Larsen, 2004).

Table 12: Fisheries in the North Sea that are most problematic for harbour porpoise (from Eisfeld & Kock, 2006)

Gear type	Location	Country and fishery	Concern criteria
Gillnets (incl. tangle nets)	Central/Southern North Sea, including coastal waters	Denmark, cod, hake and flatfish	1 (high)
		UK, cod and flatfish	1
	Channel and Southern Bight of North Sea	UK, France, Belgium, Netherlands, Denmark	2 (moderate), 4 (low)
	Kattegat, Skagerrak	Denmark, cod and flatfish	2,4
		Sweden, cod, flatfish and herring	1

Between 1995 and 2002, UK set net (gill and tangle nets) fisheries for cod, skate, turbot, sole, monkfish and dogfish in the North Sea, extended in 1997 to cover Scottish vessels fishing on the Scottish west coast. The observer programme estimated the porpoise by-catch in ICES Divisions IVa, b and c, and VIa at approximately 1,000 animals in 1995, reducing to around 600 in 2000 (Northridge & Hammond, 1999; Northridge *et al*., 2003; DEFRA, 2003). The reduction was primarily associated with an overall decline in gillnet fishing effort. This reduction in by-catch appears to have continued since then, although observer effort has been insufficient to accurately determine levels.

Germany has only a small fishing fleet operating in the North Sea, targeting cod, turbot, sole and other demersal fish. Their observer programme yielded an annual estimate of around 25-30 porpoises for the years 2002-03 (Flores & Kock, 2003).

No observer programmes have existed until very recently for Belgian or Dutch fisheries, which generally involve small vessels using bottom-set gillnets for cod and turbot. Information on by-catch has, therefore, had to rely upon postmortem examinations of strandings. In 2006, 92 harbour porpoises stranded on the Belgian coast (89 in 2005). As in the preceding three years most of the strandings (60%) occurred from March to May, although another peak was observed in August 2006 (15%). In May 2005, a relatively high number of decayed harbour porpoise carcasses washed ashore in a short period of time. The most probable cause of death of most of these animals was determined as by-catch (Haelters & Camphuysen, 2009).

Data on by-catch of porpoises in Belgian waters, and of porpoises washed ashore in Belgium, are presented in Figure 43. This figure indicates the number and percentage of stranded animals that definitely, or most probably had died in fishing nets. Since 2003, the annual by-catch rate of porpoises has ranged from 19 to 63% (Haelters & Camphuysen, 2009).

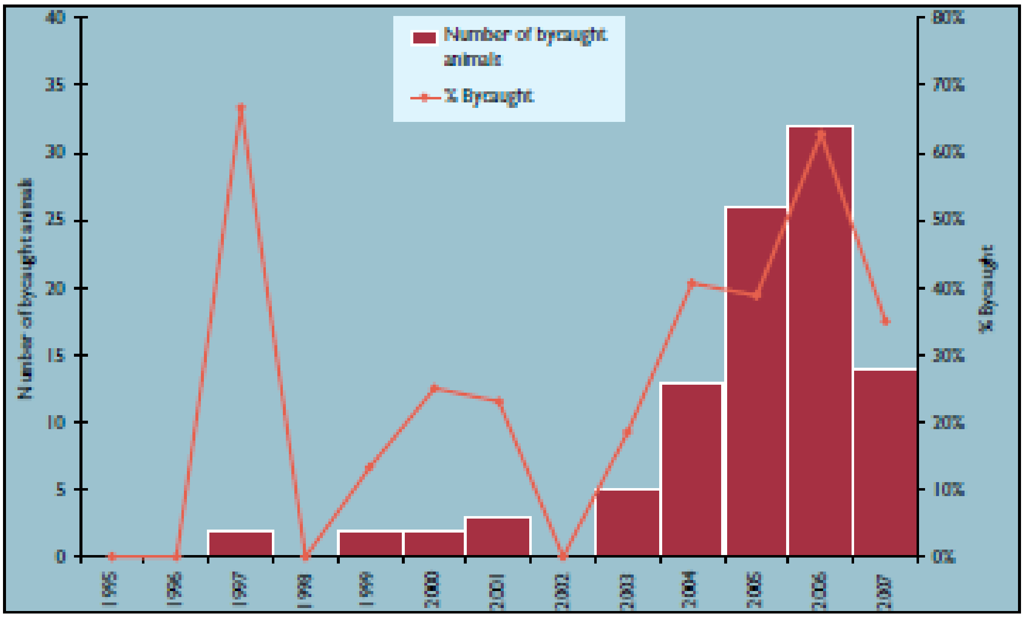


Figure 43: Number and percentage of stranded porpoises that were diagnosed as having been by-caught in Belgium between 1995 and 2007. The percentage was based on all collected animals for which a cause of death could be determined (Haelters & Camphuysen, 2009)

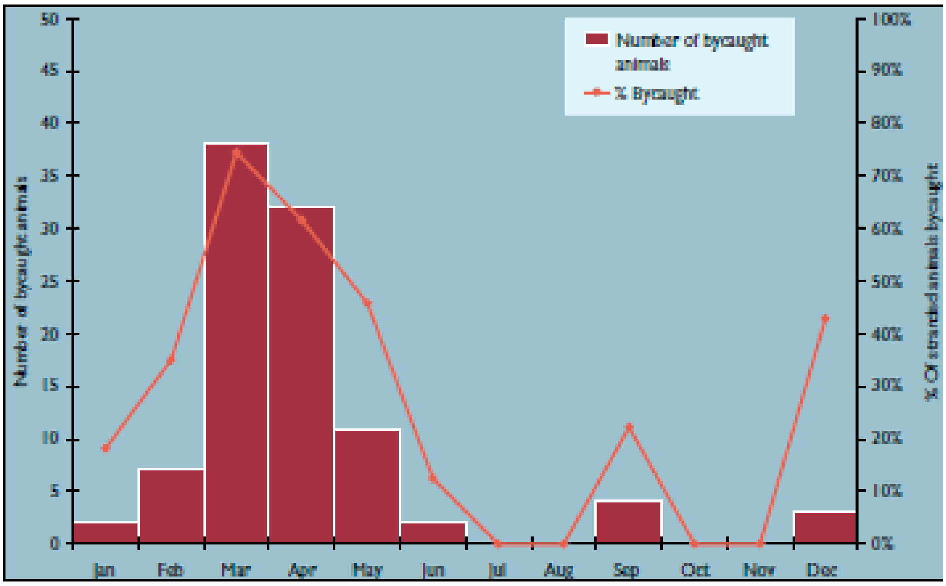


Figure 44: Total number of stranded animals in Belgium diagnosed as having been by-caught per month between 1995 and 2007. The percentage was calculated on the collected animals for which a cause of death could be identified. (Haelters & Camphuysen, 2009)

The number of by-caught animals has increased, together with an increased number of porpoises in the southern North Sea. By-catch was not evenly distributed throughout the year. It predominantly occurred during spring (March-April), when it was identified as the most important cause of mortality in stranded animals in The Netherlands (Leopold & Camphuysen 2006; IMARES/NIOZ, unpublished data) and Belgium (Haelters & Kerckhof, 2006) (see Fig. 44). This is related to a combination of a high density of porpoises during this period, and a high level of fishing with static gear (Haelters & Camphuysen, 2009).

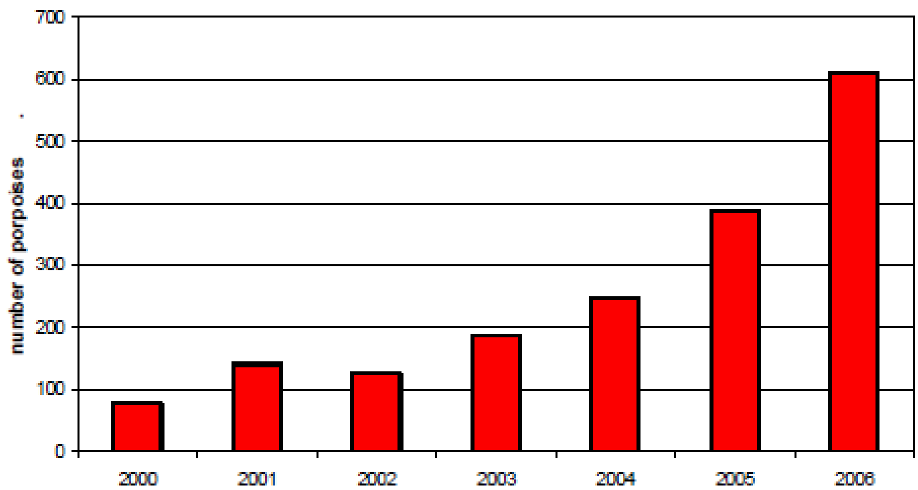


Figure 45: Increase of porpoises stranding on the North French, Belgian and Dutch coasts (combined data) between 2000 and 2006 (ICES, 2007)

In the Netherlands, 509 porpoises stranded in 2006 between January and September, with a peak in spring, of which 64 were necropsied. For those where the cause of death could be established, a minimum of 64% of deaths in fishing nets was reported (Leopold & Camphuysen, 2006). This very high level of strandings (and by-catch) can be compared with total strandings of 207 on average between 2000-06 (ICES, 2007; Fig. 45).

c) Portuguese Fisheries

There has been no dedicated observer scheme to record by-catch in Portuguese fisheries, but Silva and Sequeira (2003) report on 124 by-caught animals noted from 39 separate fishing events between 1975 and 1998. Six different fisheries operating off the Portuguese coastline caught dolphins. Gillnets were responsible for the largest number of occurrences (n = 23, 59%) with a dolphin by-catch exceeding 67% (n = 84). Beach seine nets and trawling operations killed respectively 11% and 9% of the individuals, with the former being only involved in four of the 39 by-catch events (ICES, 2005).

Figure 46: Harbour porpoise captured in recreational fishery (tangle netting) In Shetland (G.K. Stewart/SWF)

d) Norwegian Fisheries

Although the majority of Norwegian fish catches are taken by purse seine (for pelagic fish) and trawl (for demersal fish), marine mammal by-catch from these fisheries appears to be low. On the other hand, about 5,000 commercial small vessels (<15m length) operate a variety of gear types in coastal fisheries (for example the Lofoten fishery for spawning cod, which is one of the world's largest gill net fisheries; a large-mesh net fishery for anglerfish, and a gillnet fishery for lumpsucker).

Table 13: Overview of Norwegian harbour porpoise by-catch (coastal gillnetters) (ICES, 2007)

Species	**Area**	**Incidental Mortality**		
		Observed	**Estimated**	**Source**
Harbour porpoise	ICES area Ia	1	Not avail.	Gill net
Harbour porpoise	ICES area Iiia2	134	Not avail.	Gill net
Harbour porpoise	ICES area IIIa	10	Not avail.	Gill net
Harbour porpoise	ICES area IVa	4	Not avail.	Gill net

In 2006, a monitoring programme for coastal gillnetters in Norwegian waters was initiated. A total of 149 harbour porpoises were by-caught (Table 13). Since then, the scheme has expanded, with two contracted vessels in each of nine domestic fishery statistics areas (A. Bjørge, *pers. comm.*). The annual takes by the contracted vessels were in the low hundreds for harbour porpoise, and less than 100 for harbour seals and grey seals. However, when extrapolated up to the entire fleet, they showed a significant by-catch. Bjorge *et al.* (2011) report estimates of by-catch in Norwegian waters between 2006 and 2008 based on detailed data on effort, catch and by-catch provided by those selected contracted fishers. Models used to extrapolate to the whole fleet predicted a total harbour porpoise by-catch of around 21,000 for the three-year period. The models predicted annual by-catches of 6,900 harbour porpoises in the anglerfish and cod fisheries. The authors noted that the true by-catch is likely to be greater than this when other small-scale gillnet fisheries are considered, including fisheries for lumpsucker, leisure fisheries, and fisheries for mackerel in the North Sea.

e) Baltic Sea

The current harbour porpoise population for the Baltic proper is alarmingly low with less than 1,000 individuals remaining (ASCOBANS, 2009). Historical accounts of population and by-catch levels show that half a century ago the species was both more numerous and ranged further north in the Baltic than now (Lindroth, 1962; Koschinski, 2002). In recent years, the majority of records come from the Polish, Swedish and German sectors.

Table 14: Numbers of dead porpoises reported from the Baltic Sea by member countries to ASCOBANS in 1950–2005. Reported by-catch is given in brackets (Coalition Clean Baltic, 2006)

Years	Sweden	Germany	Poland	Russia	Lithuania	Latvia	Estonia	Finland
1950 - 1959		7(2)	8(5)				5(?)	
1960 - 1969	50(50)	14(?)	8(2)			1(1)	6(?)	259?)
1970 - 1979	7(6)	13(2)	6(3)			1(1)		10(6)
1980-1989	35(27)	36(2)	7(6)	1(1)	1(0)		3(3)	1(?)
1990-1999	17(14)	49(2)	62(45)			1(1)		
2000-2005	16(0)	40(5)	25(18)		3(2)	1(1)		17(0)
Total	**125(97)**	**159(139)**	**116(79)**	**1(1)**	**3(2)**	**4(4)**	**14(?)**	**53(?)**

In 2001, an interview survey estimated the annual by-catch rate to be 89 porpoises caught in gillnets, trammel nets and pelagic trawls and 25 in bottom trawls in the Swedish part of the Skagerrak and Kattegat (Swedish Annual Report to ASCOBANS, 2008). In the German part, most of the 105 recorded, by-caught porpoises in the years 1990 to 2001 were from bottom-set gillnet fisheries, or were stranded with characteristic net-marks (Siebert *et al.*, 2006). While these numbers are considered to be minimum figures, Rubsch & Kock (2004) estimated the annual by-catch in the German set-net fishery to be 57 individuals in the western Baltic Sea, and 25 in the German part of the Baltic proper.

A total of 45 by-caught animals were reported from Polish waters between 1990 and 1999 (Skóra & Kuklik, 2003). Between 1950 and 1989, the average annual number of by-catch reports per decade remained constant at between 0.6 and 1.1 (Skóra & Kuklik, 2003). Since then, it has increased slightly to 4.4/yr in 1990-99 and 2.1/yr in 2000-09 (Skóra & Kuklik, 2003; Kuklik, 2007; I. Pawliczka, unpublished data). Of major concern is that since the introduction of EC Council Regulation 812/2004 on 26

April 2004, many fishermen have refused to report by-catch. The number of by-catch reports has decreased whereas strandings occurring annually have increased (Skóra *et al*., 2010). By-catches from other Baltic states are given in Table 14.

In the German Baltic coast, nine animals were reported by-caught and delivered to local museums: three of them caught in cod-nets, two in gillnets, one in a salmon-net, and three of unknown origin (ICES, 2007).

EU Council Regulation 812/2004 required reporting on by-catch by member states in certain prescribed fisheries by independent observer schemes to start by June 2006. During 2007, the Swedish observer programme, corresponding to 4.6% of the Swedish pelagic trawl and set net fisheries, recorded no porpoise by-catch. However, an unknown number of porpoises are believed to be by-caught in small boat recreational fisheries.

It was also estimated that at least 300 grey seals, 80 ringed seals and 7-8 harbour seals were by-caught in the Swedish Baltic fishery (using static trapnets and gillnets) during the early 1990s (ICES, 1995). More recent estimates indicated over 400 grey seals and 50 ringed seals were by-caught in 2001 reducing to c. 300 grey seals in 2004 (Lunneryd *et al*., 2004, 2005). This represents a 25% reduction since 2001, and is thought to be partly due to the introduction of seal-protected salmon traps and partly to a decreased effort in the gillnet fishery (Lunneryd *et al*., 2005; ICES, 2005a).

Research from Norway by Bjørge *et al*. (2002) indicates that seals are most vulnerable to incidental mortality from fishing gear during the first ten months of a seal's life. The main problems appear to occur in those fisheries using bottom-set nets to target fish. Elsewhere, in the 1980s, catches of seals in the crawfish tangle net fishery of Barra, Outer Hebrides, far exceeded those from anywhere else in the UK, with fishermen claiming that most of the problem related to young seals investigating nets and becoming entangled (Northridge, 1988). However, nowadays seal by-catch in the British Isles appears to be very low (Hammond *et al*., 2008).

4.3 Static gear (fixed gear) – Long lines, Pots & Traps

Other static fishing gear includes long-lines, also deployed passively from a vessel, and gear that is left anchored to the seabed such as weirs, traps or pots.

4.3.1 Long line fishing

Long lines, as their name suggests, consist of a series of hooks each attached to a main line by its own branch line or 'snood'. These hooks are baited and the whole line set, generally near the bottom. The depth at which the hooks are set can be adjusted for local conditions and fish types by the use of floats and weights (Northridge, 1988, 1991).

Long lining is a very effective way of catching fish, and has been reported to achieve higher catches than many other gear types including gillnets (Gill, 1999). They are regularly used in some regions, for example Portugal, to catch sea bass, conger eels, Sargo bream, and various shark species (Sequeira and Ferreira, 1994). However, the return per unit effort is often low, since the deployment of the lines is time consuming. For this reason, many fisheries have replaced their usage with more selective gillnets (Gill, 1999). Although several Northwest European countries engage in long lining, the Norwegian, Icelandic and Faroese fisheries dominate the industry, catching cod, haddock, tusk, ling, blue ling, halibut, wolfish, redfish and sharks on the shelf and shelf edge north of the British Isles (Brothers *et al*., 1999). UK long-liners (mainly small and inshore) target cod and ling, as well as elasmobranch fish (spiny dogfish and rays) (Dunn, 1994; Camphuysen *et al*., 1995). Long lining is generally not practised in Welsh waters.

Direct Impacts
Cetacean by-catch in long lines can be quite high, and indeed the large pelagic long lines deployed in the Gulf of Mexico were declared as a category 1 fishery under the US Marine Mammal Protection Act (MMPA) (NMFS, 1999). Entanglement may occur on the baited hooks or in the line itself (Spencer *et al.*, 2000). High-seas long lines are a particular problem for seabirds, representing a serious conservation threat for albatrosses, petrels and shearwaters (Dunn & Steel, 2001). However, they do not appear to be a major problem for marine mammals around UK.

4.3.2 Fixed Nets, Pots & Traps

Traps used in UK fisheries are predominantly crab and lobster pots, or creels. These consist of a metal or wooden frame surrounded by a mesh, into which is set a funnel shaped entrance. The ‘parlour’ of the trap is baited, usually with rotten fish, and the trap set on the seabed. Crabs or lobsters enter the trap via the funnel entrance and are then unable to find their way out. There are numerous designs of trap.

Cod traps are open-topped mesh boxes, which are about 25m wide on each side. The traps are anchored both to the seabed and to the shore with leader ropes, which deflect the fish towards the trap. Fishing with cod traps is seasonal and takes advantage of the cod run. They are not used in the British Isles.

Pound nets are a special form of fish trap consisting of staked nets arranged so as to form an enclosure with a narrow opening. They reach from the seabed to the surface and are commonly used in inner Danish waters to catch migratory species like herring. They are set close to the shoreline in shallow waters, generally directly in the migration tracks of the fishes. The fish enters voluntarily, but is hampered from coming out. Fishermen visit traps every day, collecting only the captures and leaving the gears set in the same place for the whole season. Pound nets can catch porpoises incidentally, but are not used in the UK.

Fyke nets are cylindrical nets (c. 0.5 m diameter) held in shape by a series of hoops and fixed in their fishing position by stakes. An inverted funnel of netting forms part of the net mouth to aid fish entering the net whilst hindering their escape. There may often be a plain wall of netting several metres long attached to the mouth of the net to act as a ‘leader’ to the net mouth. These nets are most commonly used for eel fishing in rivers, but occasionally are used in estuaries and intertidally. Fyke nets are used in some places in Britain, but they are now more common in Germany, resulting in a significant local by-catch of otters.

Herring weirs are kidney-shaped nets that are secured to the seabed by wooden stakes, with their mouths facing the shore. As with cod traps they have leader ropes anchoring them to the shore, which guide the herring into the traps during their inshore migration.

The fish are collected from the traps with small purse seine nets, and the traps are removed at the end of the season following the conclusion of the juvenile herring migration. Although commonly deployed along the eastern seaboard of the United States, where they frequently result in porpoise by-catch, they are not used in Europe.

Direct Impacts

The setting of traps and pots can also entangle marine mammals. Cetaceans often become caught in the leader ropes rather than the traps themselves, and amongst the more commonly caught species are baleen whales, such as the humpback and minke whale (Lien, 1994; Lien *et al.,* 1995). It is not known why these large whales are particularly at risk of entanglement in the rope lines attached to static nets, pots and traps, but as a result they may even tow the gear away with them – so they may never be recorded.

In the British Isles, there have been a number of cases of baleen whales (mainly minke whales, but also an occasional humpback) being found with mooring ropes or creel lines entangled around them (Northridge, 1988; Evans, 1993; SAC, 2000; Jepson, 2005; Northridge *et al*., 2010; see Fig. 47).

Sometimes, other smaller cetacean species have been recorded entangled in this way. Pierce & Santos (2000), for example, recorded some mortality of common dolphins associated with traps set for various species in Galician waters (NW Spain) in Spain. An interview survey led to an estimate of around 25 animals killed annually by this means.

Figure 47: Minke whale entangled in a creel line in the Hebrides, West Scotland (R. Dyer/SWF)

The harbour porpoise is the cetacean species most commonly recorded as caught in herring weirs, although the numbers involved are generally small (Read & Gaskin, 1988), and it was found that only 39% of those caught were actually killed (Read, 1994). It is thought that porpoises enter the weirs and become trapped simply because they cannot negotiate their way back out. They are usually caught at night (Read, 1994), and the by-catch contains a disproportionately high number of yearlings (Smith *et al.,* 1983). Entrapment in herring weirs has been a particular problem in the Bay of

Fundy and Gulf of Maine, North-eastern United States (Read, 1994). Harbour porpoises are also sometimes captured in Danish pound nets. Mention of these is made because they can cause significant by-catch, but neither gear is currently deployed in the UK.

Amongst other mammals occupying coastal areas, both otters and seals may be by-caught in or around these types of static fishing gear. Statistics come mainly from relatively old studies. During 1975-92, 69 otters were reported as drowned in eel fyke nets, 66 in lobster creels, and one in a fish trap, around the British Isles (mainly Scotland) (Kruuk & Conroy, 1991; Jefferies, 1993); 32 were recorded as drowned in fishing gear around Ireland in the early 1970s (Fairley, 1972); and 36 in the same decade in German coastal waters (Stubbe, 1977). Incidental mortality amongst lobster creels in the Hebrides indicated a preponderance of females (79%) being caught, thought to be due to the small entrance size (Twelves, 1983).

4.4 Driftnets

Driftnets are effectively floating monofilament gillnets and are, therefore, considered also a static fishing technique (Lear and Christensen, 1975; Richards, 1994). These are nets that are set at, or near, the sea surface, hanging in the water column and which drift with the prevailing current for anything from a few hours to overnight. Pelagic fish (like herring, mackerel and pilchard) are caught by their gills, or by enmeshing or entangling (McLachlan, 1997). They are not fixed to the seabed and are most often used when attached to a vessel (which in some coastal fisheries can be a small boat). Whilst driftnets are quite selective, the total amount of net set means that by-catch of non-target fish and non-fish species can be economically significant (Lear and Christensen, 1975; Richards, 1994).

Small driftnets have been used for centuries in coastal waters, traditionally made from hemp or cotton. However, as with other gillnets, the emergence of synthetic nylon netting in post-war years enabled large-scale driftnet fisheries to develop for larger and offshore species such as tuna, squid, and swordfish (Northridge, 1991).

By the 1980's, the use of large-scale driftnets was established in most oceans, with nets of up to 50km in length regularly deployed in the Pacific, and an estimated 50,000km of netting being set each night in the North Pacific alone. The newer synthetic nets appear to be invisible to both the target fish and other marine wildlife, and act as a potential trap to all species that swim into them, the float-line lying at the surface, thus obscuring it. The result has been the capture of very large numbers of non-target animals in the nets (seabirds, turtles, sharks, and cetaceans), consequently dubbed 'walls of death' (Perrin *et al*., 1994; Northridge & Hofman, 1999).

Direct Impacts

Driftnets are effectively floating monofilament gillnets set either offshore to catch pelagic fish like herring, mackerel, pilchard and tuna, and squid, or along the coast in the vicinity of rivers to catch salmon. During the 1980s, the use of large-scale driftnets was established in most oceans, with nets of up to 50km in length regularly deployed in the Pacific. They resulted in very sizeable by-catches in many regions of the world (IWC, 1994), involving not only cetaceans, but also seabirds, turtles, sharks, and other non-target fish species.

In Europe, there were major driftnet fisheries for small pelagic fish in the Mediterranean, in the central Baltic, in the eastern North Atlantic for tuna (French and Spanish fisheries), and along the Atlantic coasts of Norway and Ireland (as well as off West Greenland) for salmon (IWC, 1994). The principal species recorded as by-caught, were porpoises near-shore, and common, striped and Atlantic white-sided dolphins offshore. An independent observer scheme targeting French tuna driftnet fisheries in the Celtic Shelf and Bay of Biscay during 1992-93 estimated by-catch of mainly striped dolphins to be between one and two thousand per year (Goujon *et al.*, 1993).

As the extent of large numbers of cetaceans being caught incidentally and killed in driftnets each year became evident, concern rose globally about their ecological threat. In 1989, the General Assembly of the United Nations passed a resolution recommending that a moratorium be imposed on the use of all large-scale pelagic driftnets by 30 June 1992. Further resolutions followed in 1990, 1991, and 1993. In 1992, the European Union responded to the UN resolution by adopting European Commission (EC) Regulation 345/92 which set a maximum length of 2.5km for driftnets used in EC waters, and by EC vessels. A derogation was then allowed in relation to the north-east Atlantic albacore tuna fishery to use 5km nets until the end of 1993. However, this clearly was insufficient to manage the problem of by-catch in the fishery, and in April 1994, the European Commission proposed a total ban on the use of driftnets to come into force in 1997. This proposal had included the Baltic Sea, and target species more commonly fished in coastal waters such as salmon, and this forestalled the resolution being fully adopted.

With continued conservation concerns, EU fisheries ministers in 1998 adopted EC Regulation 1239/98, banning the carriage or use of driftnets of any length in EC waters and by EC vessels anywhere (except in the Baltic Sea) when intended to target ten fish species and seven fish families. The species covered included tuna, marlin, swordfish, sharks, and cephalopods. The area covered included the Northeast Atlantic and the Mediterranean Sea. This came fully into effect on 1st January 2002. A further EC regulation 812/2004, agreed on 26 April 2004, extended the ban on driftnets used for any species to the Baltic Sea by 2008.

Although driftnets have continued to be deployed in some areas (e.g. the Italian swordfish fishery in the Mediterranean), the ban has largely been observed now.

4.5 Seine Nets

Fish may also be herded by the use of seine nets. There are two main types of seine nets: Danish seines and purse seines. The essential principle is to gather fish over a wide area into the net by encircling them. A Danish seine, also occasionally called an anchor seine, consists of a conical net with two long wings with a bag where the fish collect. Draglines extend from the wings, and are long, so they can surround an area.

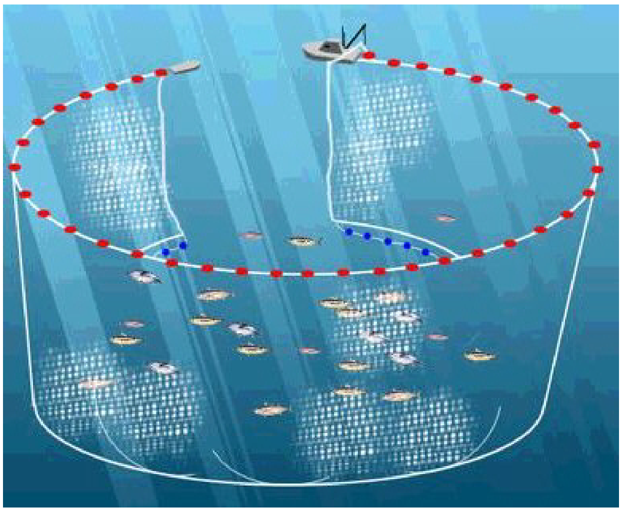


Figure 48: Purse Seine (Source: Europacific Tuna Ltd, 2005)

Purse seines consist of long curtains of netting, which are set in a circle around a shoal of fish (Figure 48). Rather than herding the fish into a bag, the purse seine has a ‘drawstring’ along the bottom of the net curtain, which, once the fish have been encircled, can be drawn in to ‘purse’ the seine. Fish are thus prevented from escaping under the net, and the entire shoal can be brought alongside the vessel in a tightly pursed net. Fish are usually then removed by a pump.

In the UK, most seine netting occurs in the northern North Sea east of Scotland, but a small amount occurs in the eastern Channel and the northern Irish Sea between the Isle of Man and coast of Co. Dublin. No seining presently occurs in Welsh waters (besides intertidal beach seining).

Direct Impacts

Purse seines are probably the types of fishing gear most infamously associated with dolphin mortality, following the much publicised dolphin-tuna problem (see review by Chivers *et al.,* 1989). In the eastern tropical Pacific (ETP), tuna are fished in three ways (Hall, 1994; Perkins & Edwards, 1996), largely due to their tendency for multi-specific associations (Lo *et al.,* 1982; Hall & Boyer, 1987; Au 1991; Northridge & Hofman, 1999; Hall & Donovan, 2001).

‘Dolphin sets’, as deployed in the Pacific, involve setting nets around pods of dolphins, which are associated with tuna, and the catch usually comprises older, larger fish (Punsly *et al.,* 1994; Perkins & Edwards, 1996). ‘Log sets’ involve the setting of nets around inanimate floating objects with which the tuna are associated, and tends to result in the catching of young fish (Hall, 1994; Perkins & Edwards, 1996). ‘School sets’ involve the setting of nets over tuna that are not associated with any other objects, and the catch usually also comprises immature fish (Hall, 1994; Perkins & Edwards, 1996). Because the tuna caught in log and school sets are generally smaller or younger than those caught in dolphin sets, large proportions of the catch are discarded (Punsly *et al.,* 1994). Consequently, using dolphin sets to catch tuna is generally considered better for the tuna stock and for the fishermen (Punsly *et al.,* 1994; Perkins & Edwards, 1996). Although clearly having the potential to be damaging to dolphin populations, this particular mode of fishing is no longer used in the North Atlantic.

4.6 Recreational fishing & "ghost fishing"

Finally, a largely ignored impact on cetacean populations is that caused by recreational fishing (Wells *et al.*, 1998; Fluharty, 2000; Haelters & Camphuysen, 2009). This is considered to be a particular problem for coastal species like bottlenose dolphin (for example, Sarasota Bay, Florida), and in some localities, for harbour porpoise.

As with other gear, fishing lines that are cut loose and discarded continue to cause harm to cetaceans in a way analogous to "ghost-fishing" by discarded nets, which can make up a large percentage of the weight of beach litter in some coastal areas (Spencer *et al.,* 2000). This is also clearly a problem around the British Isles, with cases of minke whales (see Fig. 49), harbour porpoises (see Fig. 60) and grey seals, amongst other species being found entangled in lost/discarded gear (Northridge, 1988; Evans, 1993; PGH Evans *pers. obs*.).

Figure 49: Minke whale entangled in fishing net (F. Ugarte/SWF)

4.7 Mesh Types (Figure 50)

Three types of nylon filament are used for the mesh of netting: monofilament nylon twine, multifilament nylon, and multi-monofilament nylon. Monofilament mesh is made from transparent or blue nylon twine, ranging from 0.2 to 0.7mm in diameter. This netting is generally stronger and stiffer than the other two filament types; it is cheap and is considered to be the best type of twine for enmeshing fish by the gills. Perhaps, most importantly for fishermen, and most problematic for cetaceans, is the fact that monofilament mesh is almost undetectable in the water. Multifilament twine consists of two or more silky filaments spun together. Generally it is more visible in the water than monofilament meshing, it stretches less, and is not quite as strong. Multi-monofilament twine consists of up to ten strands of monofilament twine twisted together. It is strong and is more visible in the water, but is considered better for tangling fish than for enmeshing them by the gills (Gill, 1999).

Figure 50: Different types of net used by gillnet fishermen. Top right: nylon trammel (tangle) net (sole); top left: monofilament trammel (tangle) net (sole); bottom: monofilament gillnet (cod) (from Haelters & Camphuysen, 2009)

4.8 Management of Marine Mammal By-catch

In 1990 and 1991, the Scientific Committee of the International Whaling Commission (IWC) recommended, as the "*highest priority*", the reduction of by-catch for harbour porpoise (IWC 1991, 1992). It also noted the need to improve knowledge of harbour porpoise stock identity and migration, and to obtain reliable figures on by-catches and on abundance. This was further endorsed by ASCOBANS (2000, 2003) who set the limit of unacceptable take at 1.7% of the best available abundance estimate. This subsequently led to EC Regulation 812/2004 of the European Common Fisheries Policy, introducing measures to monitor and reduce by-catch in 2004. These will be elaborated upon in chapter 5.

4.9 Noise Disturbance from Fishing Activities

Little is known currently about the possible disturbance effects of noise from fishing activities. There are three sources of noise to consider:

- Low frequency noise created by the vessel's engine and propeller when travelling
- High frequency noise from use of active sonar (sidescan, echosounders, etc)
- Low frequency noise created by the movement of heavy gear (e.g. dredges, beam trawls)

The larger the engine and propeller, the greater the intensity of sound generated by a vessel. Most fishing vessels in Welsh waters are comparatively small (<15m). Some of the offshore vessels are larger and so potentially could cause noise disturbance However, even those trawlers are sizes of vessel typically generating sound with relatively low source levels of around 150-160dB re 1μPa at 100Hz peak frequency (Richardson *et al*., 1995).

Sidescan sonar produces loud high frequency (between 36 and 500kHz) sounds of less than 1msec duration, with source levels of 220-230dB re 1μPa (Evans, 2003). However, unlike the mid-frequency (typically 2-8kHz) active sonar systems used by the military, which have been associated with mass strandings of cetaceans, particularly beaked whales, the sidescan sonar used by fishing fleets produce much narrower beams (c. 35^{o} in the vertical, and 2.7^{o} in the horizontal component) (Evans, 2003). This results in marine mammals being potentially exposed to these loud sounds only if they happen to be caught in the narrow beam. The same applies even more so to echosounders, which direct sound vertically downwards.

Some fishing activities (e.g. scallop dredging, beam trawling) involve the dragging of heavy gear over the seabed. Little is known of the sound levels that these generate. However, source levels are unlikely to exceed 170dB re 1μPa (Richardson *et al.*, 1995). A variety of studies indicate that porpoises are likely to experience temporary threshold shift (TTS) in hearing at received levels of around 183 dB re 1μPa, and permanent threshold shift (PTS) at received levels of around 193 dB re 1μPa (Southall *et al*., 2007).

4.10 Ship Strikes

Any vessel travelling at speed may cause physical damage to marine mammals if they strike one another (Laist *et al*., 2001; Pesante *et al*., 2002; Evans, 2003). Fishing vessels are no exception. Studies have indicated that the probability of a strike being lethal, increases significantly if the vessel is travelling at speeds exceeding 10 knots (Vanderlaan & Taggart, 2007). Using VMS data, Lee *et al*. (2010) calculated vessel speeds for different fishing activities. Estimated modal speeds were 3 knots during fishing for otter trawls, and 4 knots for beam trawls and scallop dredgers. However, when in transit, those speeds increased to 8 knots for otter trawls, and >10 knots for beam trawls and scallop dredgers (Lee *et al*., 2010).

Lethal ship strikes are therefore only likely to occur when fishing vessels are in transit, and probably pose less of a threat than most other shipping.

4.11 Summary and Conclusions

Gillnets and pelagic trawls are the most significant by-catch threats to small cetaceans in Europe whereas creel lines pose the greatest threat to baleen whales. Discarded netting can entangle any marine mammal species, cetacean or seal. In some areas, such as the Baltic, seals may get caught and drown in traps, and shore-based set nets may incidentally capture coastal otters. Around the British Isles, by-catch rates appear to be highest in harbour porpoise and common dolphin, and during the 1990s, they were considered unsustainable for porpoise populations in the Celtic Sea and North Sea. By-catch rates for both species appear to have declined in the last ten years, probably due mainly to reduced fishing effort. Although overall numbers of baleen whales (mainly minkes, but also fin and humpback whales) recorded as by-caught annually are low, they form a high proportion of post mortem examinations, and therefore could have a significant impact, particularly if local populations exist.

The potential impacts by fisheries of noise and vessel strikes appear to be low.

5. MITIGATION FOR THE REDUCTION OF BY-CATCH

5.1 Introduction

With growing recognition of the potentially adverse effects of by-catches, fisheries managers have worked to document the occurrence, magnitude and impact of this phenomenon. In cases where by-catches were recognised as unsustainable or undesirable, the fishing, environmental and scientific communities have then attempted to develop workable solutions to what represents a pervasive problem (Murawski 1994; Hall 1996; 1998). Progress has been made in reducing by-catches in some fisheries (e.g. Joseph 1994; Hall *et al*., 2000; Hall and Donovan 2001), but much work still remains to be done in most areas of the world (Read, 2000).

This chapter reviews some of the mitigation measures that have been applied globally, but with emphasis upon the UK and other parts of northern Europe.

The need to reduce by-catch for small cetaceans in general, and for the harbour porpoise, in particular, was recognised as a key priority in the Ministerial Declaration of the Fifth International Conference on the Protection of the North Sea (the 'Bergen Declaration') of 20-21 March 2002. In this Declaration, Ministers urged the competent fisheries authorities to take all necessary measures to minimise incidental catches and/or damage of non-target organisms. Ministers also agreed to aim at reducing the by-catch of harbour porpoises to below 1.7% of the best population estimate. On the same basis, they agreed as a precautionary objective to reduce by-catches of marine mammals to less than 1% of the best available population estimate, and they urged the competent fishery authorities to develop specific limits for the relevant species (ASCOBANS, 2003).

In the Danish fishery alone, between 2,000-8,000 porpoises were estimated to have been caught in gillnets between 1990-2000; and in the UK gillnet fisheries, between 400-800 animals were estimated as dying from entanglement (ASCOBANS, 2003). Catches were also known to occur in Dutch, Belgian, German, Swedish and Norwegian gillnet fisheries, although overall estimates of by-catch level were generally unavailable (Kaschner, 2003; Northridge, 2009).

5.2 Legislative instruments

There are a number of European Union regulations that have been put in place to try to deal with the problem of by-catch:

Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora gave strict protective status to cetaceans, and required Member States to undertake surveillance of the conservation status of these species. Member States should also establish a system to monitor the incidental capture and killing of these species, and to take further research and conservation measures as required, in order to ensure that incidental capture or killing does not have a significant impact on the species concerned.

Council Regulation (EC) No. 345/92 restricted the length of driftnets to 2.5 km, and **Council Regulation (EC) No. 1239/98** provided for the phasing out of all driftnets used to catch certain listed species, such as tuna and swordfish.

Council Regulation (EC) No. 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy was to ensure exploitation of living aquatic resources that provide sustainable economic, environmental and social conditions. To this end, the Community should, among other things, minimise the impact of fishing activities on marine ecosystems, and the Common Fisheries Policy should be consistent with other Community policies, in particular with environmental policy.

Council Regulation No. 812/2004, adopted on 26 April 2004, obliged Member States to use acoustic deterrent devices or ADDs (notably pingers) in particular gillnet fisheries, and to implement at-sea observer schemes with annual reports of incidental catch estimates.

Council Regulation No. 2187/2005, adopted on 21 Dec 2005, obliged Member States in the Baltic Sea, the Belts and the Sound, to ensure a scientific assessment of the effects on cetaceans of using, in particular, gill nets, trammel nets, and entangling nets.

Council Regulation No. 520/2007, adopted on 7 May 2007 (Article 29), prohibited the setting of purse seine nets around dolphins.

Council Regulation No. 530/2008, adopted on 12 June 2008, banned the use of purse seine nets for bluefin tuna fisheries in parts of the Atlantic and in the Mediterranean Sea.

5.3 Mitigation Measures

Potential by-catch mitigation techniques can be grouped into three main areas:

- gear modifications (which include acoustic deterrents (pingers), exclusion devices, and reflective nets)
- fisheries management measures (time/area restrictions, reduction in soak time, and/or net lengths & days at sea limitations)
- monitoring of fisheries at sea

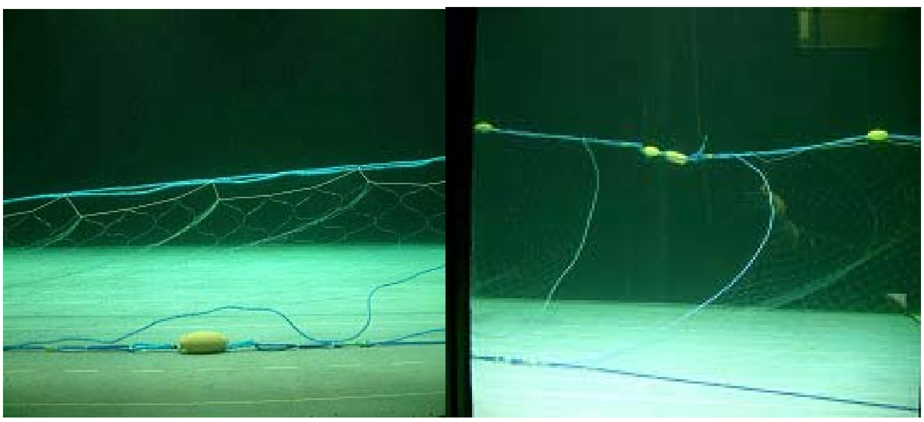


Figure 51: Pinger devices shown on a tangle net (left) and a gill net (right) (Caslake, 2009)

Acoustic deterrent devices in ICES Sub area IV and Division IIIa are mandatory under Council Reg. 812/2004 for:

- Any bottom-set gillnet or entangling net, the combination of these nets, the total length of which does not exceed 400 metres (1st August to 31 October). (= “Wreck net fisheries in the summer”)

- Any bottom-set gillnet or entangling net, with mesh size > 220 mm (= “all tangle net fisheries”), throughout the year

This applies only to boats that are 12m length and over. Nowadays, however, this applies to a very small proportion of the fleet, and therefore is likely to makes only a small impact upon the problem of by-catch (Northridge, 2009).

In ICES Sub Areas VIId and VIIe,, acoustic deterrent devices are mandatory year-round for any bottom-set gillnet or entangling gear.

Acoustic deterrents (better known as ‘pingers’) are small self-contained battery operated devices that are attached to nets (Fig. 51) and emit regular or randomised acoustic signals at a range of frequencies. Typically, they are loud enough to alert or deter animals from the immediate vicinity of fishing gear (Read, 2000; Rihan, 2009). The technical specifications and conditions of use of pingers are specified in Annex II of Regulation 812/2004. This specifies a minimum distance between devices along the net, as well as the frequency characteristics and source levels. For devices that generate the signal digitally, the specified source level is 145dB re 1 μPa @ 1m with a maximum spacing along the net of 200m, with one acoustic device fixed at each end of the net.

Pinger spacing may also be set by national laws. In Denmark, pinger spacing was increased from 200m to 455m, following successful trials with a wider spacing (reported in ICES, 2009). Ireland also issued a derogation in June 2007, allowing an increase in maximum pinger spacing to 500m. The UK has applied for derogation (under Article 3 of Regulation 812/2004) in order to trial an alternative pinger device with different specifications (Northridge & Kingston, 2010).

Within the UK, studies carried out by the Sea Mammal Research Unit (SMRU) within the set net fishery in the Celtic Sea yielded a 92% reduction in by-catch of harbour porpoises in pingered nets compared to un-pingered nets (SMRU, 2001). This work concluded that if a 70% reduction in porpoise by-catch was to be achieved for this fishery, the use of pingers was the only currently viable management option (ASCOBANS, 2003).

Since August 2000, the use of pingers has been mandatory in the Danish cod wreck fishery between August and October. In this case, the effect of pinger use is reported to be close to 100% reduction in by-catch (Larsen *et al.*, 2002; Vinther & Larsen, 2002).

Devices currently used are very much designed to deter harbour porpoises and are known to be effective in set net fisheries, although few trials have so far been carried out in trawl fisheries. Where such trials have been conducted (using different pinger types – notably DDD, Cetasaver, Aquamark 100 & VO2 Marexi devices), Cetasavers in particular were found to cause a significant reduction in common dolphin by-catch, whilst DDD reduced porpoise by-catch (Morizur, 2009). Although the specification in Regulation 812/2004 refers to a narrow range of source levels for pingers, actual received levels can vary considerably (e.g. by 6-10dB at ranges of 100m) due to interference effects from reflections from the sea surface and seabed (Shapiro *et al*., 2009). Louder pingers that could be deployed at wider spacings (e.g. DDD-02 devices from STM 6 products in Italy) have also been tested on gillnets in the UK to investigate effectiveness at by-catch reduction, and also potential for habitat exclusion (ICES, 2009). Further trials including a new model (DDD-03) have continued to show that the DDDs being tested appear to work well in terms of reducing porpoise by-catch, and operational problems are being addressed (Northridge & Kingston, 2010).

However, there remain a number of limitations and concerns about the widespread use of pingers. There are some operational drawbacks, for example: pingers are expensive, they need a high level of maintenance, some types of pingers are prone to failure, and sometimes break so that durability is a problem, and they may cause operational difficulties for fishermen when shooting and hauling nets (see reviews by Read, 2000; Ross & Isaac, 2004, ICES, 2006; CEC, 2009; see Fig. 52). Safety issues related to deployment include chemical leakage from batteries, entanglement in gear, and in some cases, the need for additional crew to attach devices during shooting.

Figure 52: Pinger entangled in fishing gear (left), Durability of pingers is an issue (right)

Other shortcomings include the fact that pingers do not completely reduce the level of by-catch, and there has been an availability issue with only a small number of suppliers (ASCOBANS, 2006). As a result, the effective monitoring and enforcement of pinger use may prove to be difficult.

There have been additional concerns that cetaceans may become habituated to pingers, resulting in an adverse effect; for example, they might progressively realise that a specific sound reveals the presence of a net with entangled fish ("dinner bell" effect). Alternatively, pingers may keep animals away from important feeding sites (Carlström *et al*., 2002; CEC, 2002). These may be the case but have yet to be fully tested, and so remain unproven.

Some of these shortcomings have contributed to overall low levels of compliance with the pinger requirements in Regulation 812/2004. Although there are no official records of the number of vessels using pingers, European Parliament (2010) indicates this amounts to only around eight vessels in Denmark, and five in the UK. Furthermore, under Regulation 812/2004, the fisheries where pinger use is mandatory and the fisheries for which monitoring is required, are different. As a result, there is very little information available on compliance in the use of pingers. The gears specified for mandatory pinger use in ICES Sub Area IV and division IIIa also do not include many of the gear types known to catch porpoises in these areas. Nets of mesh size of smaller than 220mm may still be used without pingers if they are longer than 400m, or between the period of 1 November to 31 July.

Developments such as the *Bycatch Reduction Techniques Database* at (www.bycatch.org), hosted by New England Aquarium (Boston, USA), provide a searchable database of results from studies undertaken to evaluate by-catch mitigation.

Other existing gear modifications include: changes in mesh size, twine thickness, deployment depth, and also attempts to enhance the acoustic visibility of nets either through nets with hollow cores or acoustic reflectors (Goodson *et al*., 1994; Silber *et al*., 1994; Koschinski & Culik, 1997). Nets impregnated with a metal compound such as iron oxide or barium sulphate, so called high-density nets, are also being researched (Larsen *et al*., 2002; Mooney *et al.*, 2003; Trippel *et al.*, 2003). These modifications to nets have a number of advantages relative to pingers:

- No habituation by porpoises
- No noise pollution
- No need for an energy source.

Exclusion devices or selection grids including rigid grids, rope and tunnel barriers, guiding panels, escape panels, are also used in many trawl fisheries around the world to exclude unwanted fish or other animals from the catch (ASCOBANS, 2003). These grids are now widely used, and are even compulsory in many shrimp fisheries around the world (including the EU) to reduce wasteful killing of fish. A variation of the design is also used to exclude turtles from shrimp trawls (ASCOBANS, 2003).

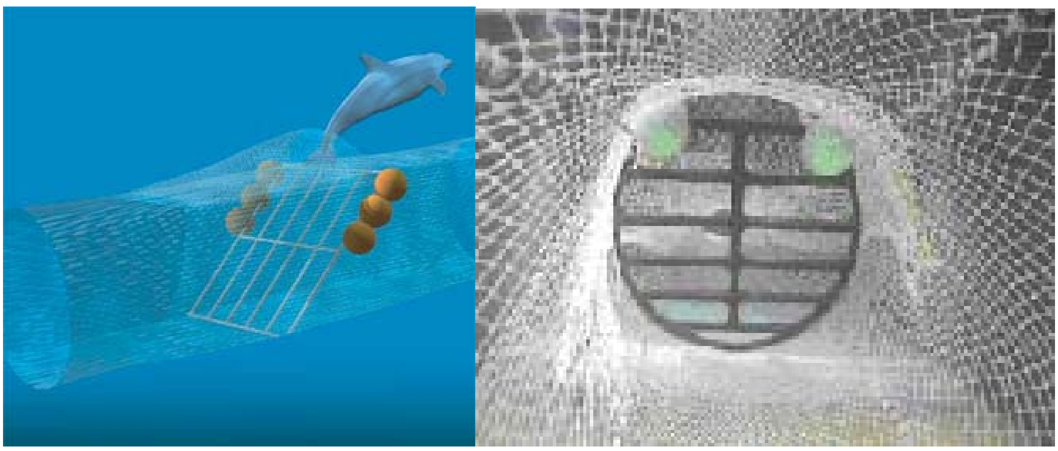


Figure 53: Exclusion devices: Diagram of a selection grid (left) (DEFRA, 2003), and a semi-rigid oval grid (right). (Rihan, 2009)

There are a number of problems associated with excluder devices: most devices are ineffective, with only a 20% reduction at best; the positioning of the grid in the net is critical; they may reduce catches of target species; and they can cause handling difficulties in big pelagic trawls (Rihan, 2009).

In 2001, SMRU was awarded a grant to design and test an exclusion grid to reduce common dolphin by-catch in the UK bass pair trawl fleet. The main method currently under consideration is selection grids (Fig. 53).

Further testing of excluder devices continues where acoustic devices are unlikely to be a solution, for example in Dutch pelagic fisheries (Rihan, 2009).

Other fisheries management measures may include closures by time or by area, which might be triggered by a particular level of by-catch, but closures may simply move the problem into other areas, if not planned effectively (Read, 2000).

5.4 Monitoring of fisheries

Under EC Regulation 812/2004, fisheries to be monitored (and fisheries starting dates) are detailed in Annex III Para 3:

- D: ICES Sub Area IV Driftnets
- E: ICES Sub Areas IIIa and IV Pelagic trawls

Article 4 states that:

- monitoring schemes are required for vessels over 15m…"to provide representative data"
- scientific data should be collected from the same fleets, vessels <15m "by means of appropriate scientific studies or pilot projects."

Monitoring is also mandated under the EU Habitats Directive - Article 12, paragraph 4, which states that:

- Member States shall establish a system to monitor the incidental capture and killing of the animal species listed in Annex IV (a). In the light of the information gathered, Member States shall take further research or conservation measures as required to ensure that incidental capture and killing does not have a significant negative impact on the species concerned.

Monitoring using independent observers is generally the best way to effectively monitor incidental catches of cetaceans, and such proposals have received positive feedback from a number of Member States (CEC, 2009).

There are a number of problems also associated with monitoring. Most important perhaps is that there is a lack of both human resources and financial resources, only 5-10% of fishing effort is covered, and, critically, Regulation 812/2004 includes no requirement to monitor cetacean by-catch for small vessels (<15m). This means that, particularly in inshore fisheries, in areas where porpoise by-catch has already been identified as a significant problem, those vessels are not required to be monitored (Northridge, 2009; CEC, 2009).

In both Norway and Sweden, where significant by-catches of porpoises occur from small vessel inshore fisheries, alternative approaches for monitoring have been piloted: in the case of Norway, this has focused upon contracting vessels (n=18, of <15m length) in the gillnet fisheries for cod and anglerfish, to keep detailed log books of catches (with some independent checks) (Bjorge & Godøy, 2009; Bjørge *et al.*, 2011; A. Bjørge, *pers. comm.*); whilst in Sweden, electronic monitoring using video was tested but found not to be cost-effective (Kônigson, 2009). Sweden attempted to conduct again an experiment in 2010, and nine camera systems to place on board fishing boats were bought for investigating discard as well as marine mammal and bird by-catch, but only one fisherman was willing to cooperate (Swedish Annual Report to ASCOBANS, 2010).

There have been several other trials of electronic monitoring (EM) systems involving video cameras directed at the catch coming into the vessel in order to monitor catch, by-catch, and discards. Archipelago has successfully developed and deployed video based electronic monitoring (EM) on a variety of fisheries, gear, and vessel types (McElderry *et al.*, 2006; McElderry, 2008). Typical systems involve several closed circuit television cameras, a GPS receiver, and a number of sensors. Sensors, such as hydraulic pressure sensors and gear rotation sensors, control the periods for which the cameras record.

Results of a study using the Archipelago video-based system in Denmark during 2008/09 have been described recently by Dalskov & Kindt-Larsen (2009 and Kindt-Larsen *et al.* (2010). The study aimed to provide a complete documentation of nine catches, including discards, from seven vessels, one netter of length <15m, and six vessels between 16 and 31m length. Up to four video cameras were used to view the aft deck, the fish handling areas, and discard chutes. Image quality of the video recordings was sufficient to allow reliable estimates of species and size composition of the catch. The authors note that the system proved reliable and significant cheaper than obtaining the same documentation using onboard observers (even where practical). Video sequences were viewed ashore with on average less than one hour’s data worth of analysis, and image viewing required for verifying one fishing event and the associated catch handling. The other aim of the experiment was to test whether a shift from a landing quota system to a catch quota system (where all catches are counted against the vessels’ catch quotas) will work on small vessels. A more widespread use of CCTV was recommended as a substitute to the observer schemes since these schemes appear to be a much cheaper way of monitoring the fishery (Danish national report, in ICES, 2010b).

The New Zealand Ministry of Fisheries has also evaluated the feasibility of using electronic monitoring for assessing protected species interactions in demersal long-line fisheries (McElderry *et al.*, 2008). Monitoring long-lines may present similar challenges to harbour porpoise by-catch in gillnets where by-caught animals may fall out of the gear before being hauled on board the vessel (see, for example, Tregenza *et al.*, 1997). The trial also used the Archipelago system alongside fisheries observers. The level of agreement between observers and EM varied considerably depending on camera positions and the protected species involved (McElderry *et al.*, 2008).

Electronic monitoring using video systems clearly has the potential to provide the type of data needed to estimate by-catch both from small vessels and larger ones. Camera configurations may require also monitoring the gear in the water so as to observe animals that are not brought aboard. For all such systems, there are trade offs between complexity, reliability, quality of data and cost. However, it is likely that developments in imaging technology, communications and data storage which are moving apace, will result in it becoming increasingly cost-effective. Since cetaceans are large and conspicuous, and take some handling time, this should require less image resolution and lower frame rates (Leaper & Papastavrou, 2010). This smaller data requirement may allow cameras to operate continuously, removing the need for external sensors to be fitted to the vessel. The camera sequences selected for viewing could be based on analysis of GPS data suggesting fishing activity. If power requirements could also be reduced such that the system could be entirely self-sufficient, it would be more realistic to fit to smaller vessels and quicker to install (Leaper & Papastavrou, 2010).

The current costs of EM equipment are relatively high, and there are additional costs associated with viewing video and data analysis. Nevertheless, EM can provide data at lower cost than observers (Dalskov & Kindt-Larsen, 2009), and sub-sampling of EM data could be checked against reports, removing the need for a full analysis of all EM video (Leaper & Papastavrou, 2010). The European Parliament (2010) notes that remote monitoring using CCTV is well suited to monitoring rare events such as cetacean by-catch, and should be considered in the future.

5.5 Summary and Conclusions

Three main approaches to mitigation of marine mammal by-catch are identified. These include: 1) gear modifications (acoustic deterrent devices such as pingers, exclusion devices, and reflective nets); 2) fisheries management measures (time/area restrictions, reduction in soak time, and/or net lengths & days at sea limitations); and 3) monitoring of fisheries at sea. Although each approach has its limitations, some show particular promise. For bottom set gillnetting, pingers have been shown to significantly reduce by-catch of harbour porpoise. Several types exist, but the DDD-03 version currently shows most promise and allows deployment at wider spacings, with consequent improvements in costs as well as a number of practical considerations. Cetasavers (another form of acoustic deterrent device) have proven to be effective in reducing common dolphin by-catch. High-density nets (impregnated with a metal compound such as iron oxide or barium sulphate) may also be useful in particular fisheries, but further research on their effectiveness is needed.

Exclusion devices or selection grids including rigid grids, rope and tunnel barriers, guiding panels, and escape panels, have been used in many trawl fisheries. Selection grids in particular are being trialled in various pelagic fisheries, such as pair trawling for bass, where common dolphins are by-caught. So far, these have not proved to be very successful, with only small reductions in by-catch.

Monitoring of by-catch, particularly for inshore small vessel fisheries, remains a major challenge. A number of approaches such as electronic monitoring by video, independent observers, and vessel reporting schemes have been instigated with varying success. Continued research is likely to make their use increasingly feasible.

6. REVIEW OF INDIRECT IMPACTS OF FISHERIES UPON MARINE MAMMALS

The biological effects of fisheries upon marine mammals encompass all the consequences of the large-scale removal of animal biomass from the marine ecosystem, including, although not limited to, competition for resources between fisheries and marine mammals (Beddington *et al*., 1985; Northridge, 1991; Blix *et al*., 1995; Trites *et al*., 1997; Northridge & Hofman, 1999; Boyd *et al*., 2006; Matthiopoulos *et al*., 2008; Plagányi & Butterworth, 2009). Additionally, some fishing methods (such as dredging and beam trawling) may disturb the seabed to the extent that the benthic communities are destroyed or at least altered, which may then have consequences upon predators such as marine mammals.

Competitive interactions can be direct or indirect. Direct competition occurs when the mammal and the fishery are both taking the same kind of fish (or other prey). Indirect competition includes situations where the fishery and the marine mammal population are taking two different types of fish, but where the removal of one of these fish influences the availability of the other through some competitive or predatory link. Indirect interactions need not be competitive, and sometimes the effect of the fishing industry may be to increase the abundance of the fish community to the detriment or advantage of marine mammals and other predators (Northridge & Hofman, 1999).

It is usually the detrimental aspects of interactions between the fishing industry and marine mammals that are stressed (Blix *et al*., 1995). Increasing marine mammal numbers are often held to be responsible for declining fishery yields, whereas declining marine mammal numbers may be blamed on increased fishing. In almost all cases, there is such a poor understanding of the ecological complexities of the marine environment that demonstrating cause and effect proves difficult or impossible (Boyd *et al*., 2006; Matthiopoulos *et al*., 2008). This problem is generic to marine ecological studies. Rarely is it possible to manipulate the marine environment to test a hypothesis. Moreover, many of the important parameters, such as fish stock size, are subject to considerable variability resulting from environmental factors (Northridge and Hofman, 1999; Boyd *et al*., 2006; Matthiopoulos *et al*., 2008; Plagányi & Butterworth, 2009).

Analysis of these conflicts has usually focused on estimating the quantities of the shared resource removed by each of the competitors (Trites *et al*., 1997). These estimates are then used to make inferences about the likely consequences of particular management actions. Such analyses can provide a broad indication of the potential scale of competition, but they are, at best, an incomplete representation of the interactions that are involved, and at worst, a completely misleading one (Matthiopoulos *et al*., 2008). This is because they provide a static evaluation of the current state of the system, whereas the fundamental questions to be answered in order to understand these interactions all concern the system's structural and spatial dynamics. These are: 1) how will changes in the abundance, demography, and spatial distribution of either of the competitors affect the shared resource; 2) how will changes in the abundance, demography, and distribution of the shared resource affect the competitors; and 3) how will changes in other components of the ecosystem (alternative prey for the predator, alternative target species for the fishery) affect consumption of the shared resource (Matthiopoulos *et al*., 2008)?

Such questions cannot adequately be addressed with the help of simple, single-species population dynamic models, because these do not capture the interactions between the competitors and their resource. Nor can they be addressed with generic simulation models of the entire ecosystem because these models give higher priority to the inclusion of all potentially relevant species than to adding biological detail in the representation of any one species (Matthiopoulos *et al*., 2008). Instead, models are needed that adequately represent the detail of individual, spatial, and temporal heterogeneity that is inherent in wildlife populations, as well as key interspecific interactions. It is also important to be able to investigate the long-term dynamics of a system.

Matthiopoulos *et al*. (2008) further argued that evaluation of the existence, extent and consequences of competition must also entail an examination of 1) the spatial contact rates between the interacting populations; 2) the diet composition of competitors and the effect of all prey on consumption rates; 3) the implications of individual variation within the interacting populations; and 4) the long-term population dynamics of the entire system.

A total of 106 species of marine mammals (74 cetaceans, 31 seals, and the sea otter), out of 127, are known to interact with established fisheries across the world (Northridge, 1984, 1991; Jennings *et al*., 2001). Northridge and Hofman (1999) distinguish between operational and biological interactions. In the context of competition, operational interactions carry the meaning of interference (for example, marine mammals taking fish out of nets) and biological interactions imply competition by depletion of resources, either directly or indirectly via the wider food web (Abrams *et al*, 1996).

The challenge of identifying competition is insignificant compared with the difficulty of measuring its extent, and the consequences for the viability of wild marine mammal populations and fishing fleets. This is because both the intensity of competition and its consequences are likely to be affected in nontrivial ways by the degree of coincidence between the competitors and the influence of other biotic components, either from within the competing populations or from the wider marine community.

The degree of overlap between the spatial distribution of fish and the foraging effort of marine mammals determines the rate of spatial encounters between them, and is a key component in the evaluation of the extent of competition. Similar considerations apply to the distribution of fishing effort. The spatial distribution of fish evidently determines where fish can be caught by predators and fishermen. It can also determine how much prey will be consumed overall, even when predator effort is homogeneous in space (Matthiopoulos *et al*., 2008).

For the most part, the distribution of fishing effort is less constrained than the distribution of marine mammals, although the position of harbours and fish markets may similarly affect the accessibility (and profitability) of certain fishing grounds.

For all these reasons, quantifying competition by simply comparing predator consumption and fisheries catches, is likely to be misleading. Furthermore, in the case of highly mobile prey, competition between marine mammals and fisheries does not necessarily require spatial overlap between them.

At present, there are few marine mammal species where one can begin to assess the degree of potential competition with fisheries: their diets are incompletely known, as are their consumption rates and spatial distribution, not to mention that of the fisheries. One of the better-studied marine mammals is the Atlantic grey seal. The UK population has increased from around 50,000 individuals in 1985 to around 100,000 in 2002 (SMRU, 2005). Concern has been expressed for the impact of grey seal predation on fish stocks, particularly the North Sea population of cod, which is thought to be precariously small (Cook *et al*., 1997). Previous studies have found that the diet of UK grey seals shows significant regional and seasonal variation that are presumed to be related to prey abundance (Prime & Hammond, 1990; Pierce & Boyle, 1991; Hammond *et al*., 1994a, b, 2008; Hall *et al*., 2000).

Incorporating spatial and seasonal availability of prey into models of grey seal consumption rates, Matthiopoulos *et al*. (2008) have investigated functional responses to local prey abundance. Diet data suggest that the seals fed mainly on seven types of prey (immature cod, mature cod, whiting, immature plaice, saithe, ling, and sandeel – see Fig. 16). The availability of each of these prey types to seals was estimated from the overlap between the distribution of prey and the accessibility of different points at sea to seals foraging from different haul-outs. Generalised additive modelling was used to estimate the spatial distribution of each of the seven prey types in the 1980s and 1990s from groundfish survey data (Daan *et al*., 2005). Accessibility of offshore locations to seals foraging from different haul-outs was based on results from Matthiopoulos *et al*. (2004). The functional response parameters were estimated by Bayesian methods to predict consumption by grey seals at UK haul-out sites under three plausible scenarios of prey abundance: 1) fish stocks at 1985 levels, when cod were abundant in the North Sea; 2) fish stocks at 2002 levels, a year in which North Sea stocks were at low levels compared with 1985 (cod stocks on the west coast were reduced to c. 80%, and in the North Sea to c. 50% of 1985 levels); and 3) all fish stocks at one-tenth of their 1985 levels.

Comparison amongst the three scenarios showed that the proportion of cod in the seals' diet was not a simple function of cod availability. The authors therefore converted the diet predictions into gross consumption estimates, and calculated the per capita and thence population energetic requirements of the seals. The resultant estimates were compared with the removal of cod by the fishery, and the total biomass of the stock as estimated for 2002. Predicted cod predation mortality was high in 2002, due to increased seal numbers and the coincidence between low cod stocks and low abundances of alternative prey. However, total seal predation on cod was only 26% of the total biomass of cod taken by fisheries, and 8% of the estimated total biomass of cod in the North Sea (Matthiopoulos *et al*., 2004).

The above exercise is described in detail to illustrate the complexities involved for understanding the nature of competition for resources between marine mammals and fisheries. In theory, a similar approach could be applied to the various cetacean species occurring in the Irish Sea. Unfortunately, very little of the information needed is available. As such, the next available approach to understanding more about the issue of fisheries/marine mammal impacts in the context of Wales is to examine the different fisheries (see Chapter 3) in Wales, and consider the diets of the marine mammals regularly occurring there (see Chapter 2). We will then, at least, have a basic understanding of whether there are potential conflicts between individual species and particular fisheries.

For the remainder of this review, we will concentrate on the six species of marine mammal (harbour porpoise, short-beaked common dolphin, bottlenose dolphin, Risso’s dolphin, minke whale, and grey seal) that occur regularly in Welsh waters, along with the main fisheries currently operated in Wales.

7. EFFECTS OF FISHING ACTIVITIES ON MARINE MAMMAL BEHAVIOUR AND ACTIVITY IN WELSH WATERS

7.1 Direct Impacts upon Marine Mammals in Welsh Waters

In this chapter, we will assess the direct impacts that any fisheries might have on the marine mammals that occur regularly in Welsh waters (harbour porpoise, short-beaked common dolphin, bottlenose dolphin, Risso's dolphin, minke whale, and grey seal), with some reference also to the river otter, as increasingly it appears to be visiting the coast. We will use information from the previous chapters on Welsh fisheries and marine mammal status and distribution, to establish what interactions might occur, the times of the year when interactions may be greatest, and any evidence that exists already in terms of strandings that have occurred showing signs of by-catch.

Two species in particular have been identified as by-caught from stranding post-mortems. These are harbour porpoise and common dolphin.

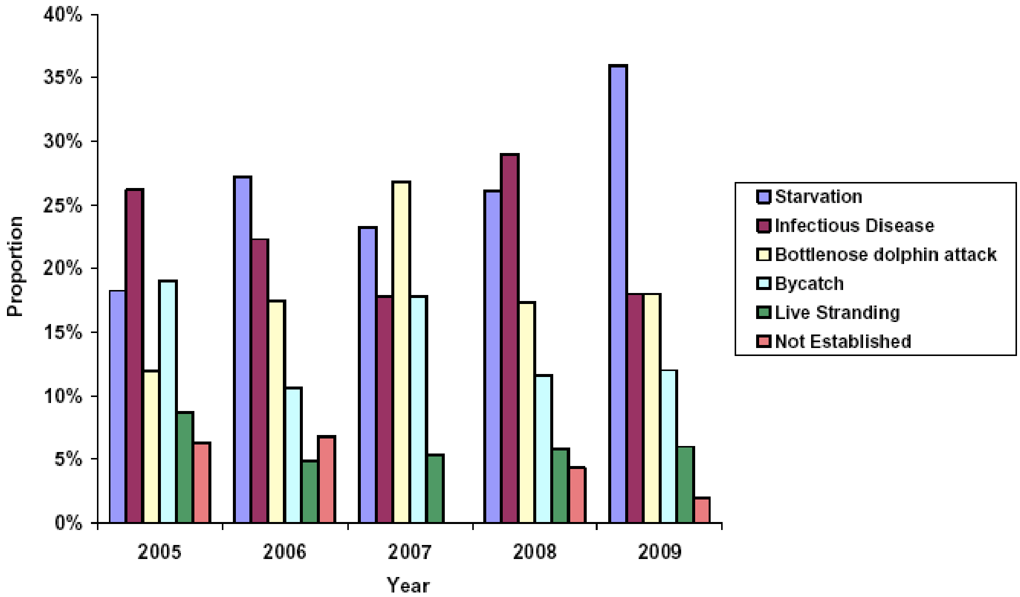


Figure 54: Proportions of major cause of death categories in UK stranded harbour porpoises examined at post mortem 2005-09 (Deaville & Jepson, 2010)

Of 251 harbour porpoise strandings reported in UK (10 in Wales) in 2009, 69 were investigated at post mortem. A cause of death could be established in 49 examined individuals (98% of examined cases). Eighteen (nine of which were neonates) died from starvation, nine died as a result of attack from one or more bottlenose dolphins, six died following entanglement in fishing gear (by-catch), and five died from pneumonias due to combinations of parasitic, bacterial and parasitic infections. A further three porpoises died as a consequence of live stranding, three as a consequence of dystocia, two of generalised bacterial/fungal infections, one from physical trauma of unknown cause, one from a generalised bacterial infection, one died as a result of a heavy gastric parasitic infection, one died as a result of meningitis/encephalitis, one died from a possible coliform endometritis, and one of unknown cause (Deaville & Jepson, 2010). These figures are given as percentages in Figure 54, and compared with previous years, 2005-08.

Figure 55 below illustrates that the number of harbour porpoise by-catches in Wales was higher during the period 1992-97, and then dropped from 2000 onwards, when bottlenose dolphin attacks became more frequent. Coverage over this period was believed to be more or less constant (R. Penrose, *pers. comm.*).

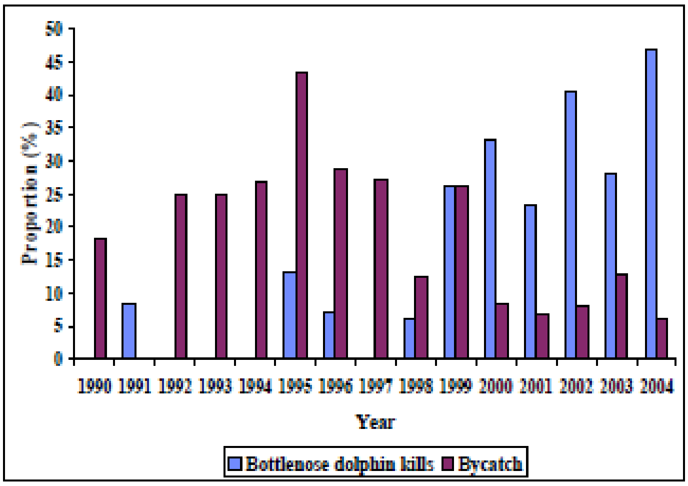


Figure 55: Annual proportion of stranded harbour porpoises diagnosed to be killed by bottlenose dolphins and by-caught in Wales (as % of all post mortem examinations) (Jepson, 2005)

Reports of dead harbour porpoise being washed ashore are relatively common in Wales. Between January 1989 and January 2002, there were 633 strandings recorded along the coast of Wales. This included a steady increase over the last five years of the reported period, from under 60 in 1998 to 120 in 2002 (Penrose, 2003; Thomas, 2003). However, whether this was due to an actual increase in strandings or an increased awareness of reporting procedures by the general public, was unclear (Penrose, 2003). Between 2003 and 2010, there have been 22 strandings of porpoise in Wales where cause of death could be attributed to by-catch (R. Deaville & P. Jepson, *pers. comm.*; Penrose, 2010, 2011; see Table 15, also Appendix 4).

Most (64%) of the 56 stranded porpoises identified as by-catch, came ashore on the coasts of Gwynedd, Ceredigion, or West Glamorgan (Table 15). Unlike the situation in England, where the largest single cause of known mortality is by-catch, in Wales it appears to be much less significant, the most important identified cause of death being bottlenose dolphin kills (Fig. 54).

Of 113 reported common dolphin strandings from UK (four in Wales) in 2008, 29 died as a result of live stranding (26 of which died during a mass stranding event in Cornwall in June - Jepson and Deaville 2009b), four as a consequence of starvation, two following entanglement in fishing gear (by-catch), two from physical trauma of unknown origin, two as a result of trauma resulting from impact with a boat propeller, one from a heavy gastric parasite burden, one starved as a sequel to gastric impaction and a cause of death could not be established in two animals. The number of common dolphins identified as by-catch in 2008, was the lowest number recorded in the UK for 18 years. In the last 5-year period (2004-08), the proportion of UK-stranded common dolphins examined at post-mortem and diagnosed as by-catch decreased from 70% in 2004 to only 5% in 2008 (due in part to the mass live stranding of the species that year (Deaville & Jepson, 2009a, b; see also Appendix 4). Since then, it has increased to 60% in 2009 and then declined to 32% in 2010 (Deaville & Jepson, 2011). The majority of the by-catches have occurred in Southwest England during the winter months, with none recorded from Wales (Jepson, 2005; Deaville & Jepson, 2009a).

Results from the post-mortem examinations in 2009 are shown in Figure 56 below, illustrating the geographical locations of the 16 by-caught & stranded animals; of which five occurred in Wales (two common dolphins, one harbour porpoise, and one bottlenose dolphin. Between 1990 and 2009, by-catch levels in Wales appear to have been about half what has been recorded in England (Fig. 57).

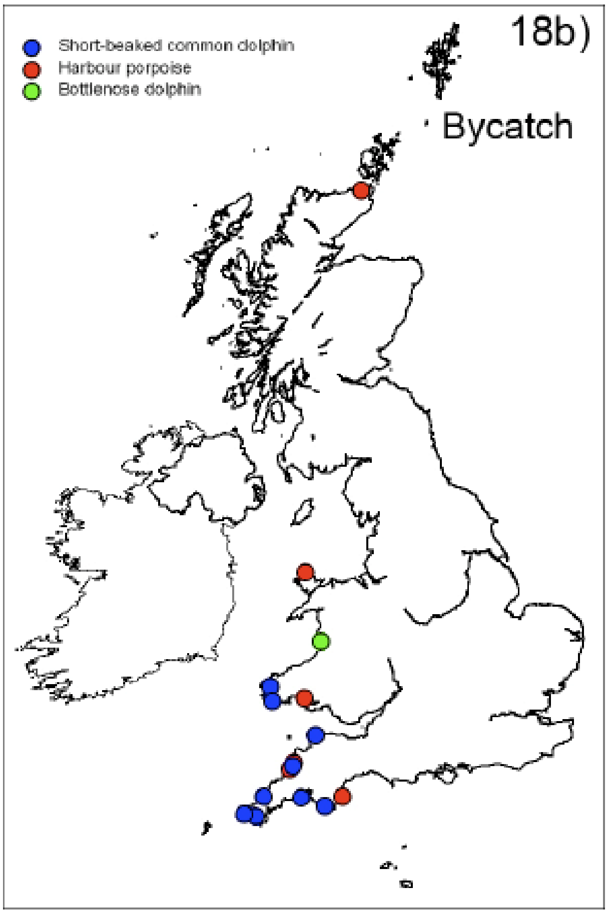


Figure 56: Spatial distribution of cetacean strandings examined at post mortem in 2009 and diagnosed to have died as a result of by-catch and entanglement (n=16) (Deaville & Jepson, 2010)

Table 15: Number of harbour porpoise strandings in Wales proven by post mortem to be by-catch victims (1990-2010)
(Bennett *et al*., 2000; Jepson, 2005; Deaville & Jepson, 2009a, 2011' Penrose, 2010, 2011)

	Flint	Denbigh & Conwy	Mon	Gwynedd & Anglesey	Ceredigion	Carms	Pembs	West Glam	Total
1992					1				1
1993				2					2
1994					1	1	1		3
1995			1	4	3	1	1		10
1996						1	2	1	4
1997		1			1			1	3
1998					1			1	2
1999				1	1	1	1	1	5
2000							1		1
2001									0
2002			1	1				1	3
2003				1				2	3
2004	1	1						2	4
2005				1					1
2006				1				3	4
2007						2	1	2	5
2008				1	1				2
2009				1		1			2
2010		1							1
Total	1	3	2	13	9	7	7	14	56

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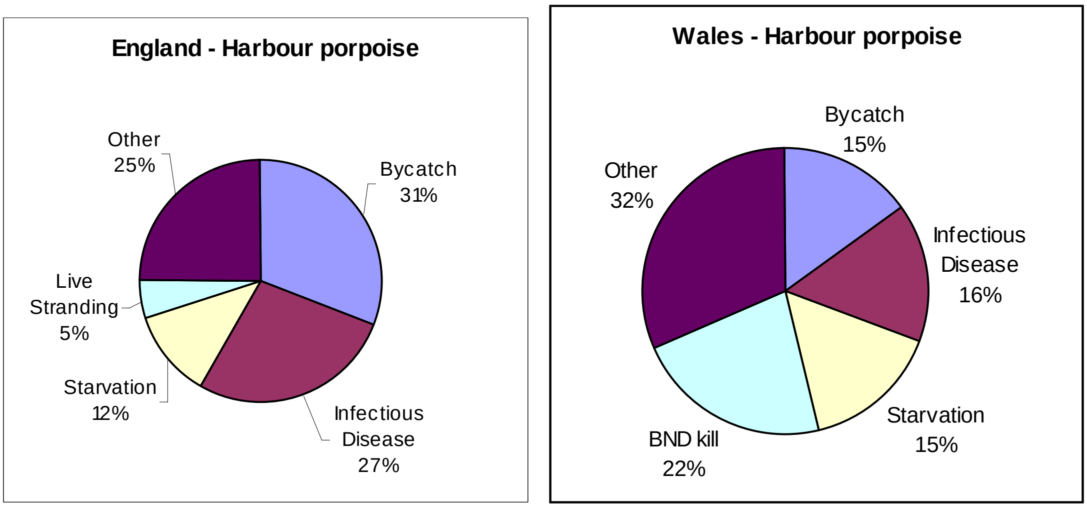
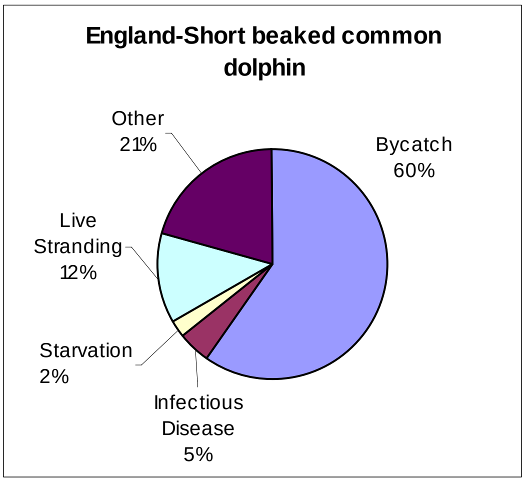


Figure 57: Causes of death of stranded harbour porpoise in England & Wales, 1990-2009, established from post mortem examinations (CSIP, *unpublished data*)

Between 1992 and 2010, only seven common dolphins stranded in Wales that were identified as by-catch, almost all from south or west Wales (Table 16). In contrast to England, where by-catch accounts for 60% of known causes of mortality for the species, in Wales only 10% have been attributed to by-catch between 1990 and 2009 (Figure 58).

Table 16: Number of common dolphin strandings in Wales proven by post mortem to be by-catch victims (1990-2010) (Bennett *et al*., 2000; Jepson, 2005; Deaville & Jepson, 2009a, 2011; Penrose, 2010, 2011)

	Denbigh	Mon	Gwynedd	Ceredigion	Carms	Pembs	West Glam	Total
1992								0
1993								0
1994		1	1					2
1995								0
1996								0
1997								0
1998								0
1999								0
2000								0
2001								0
2002								0
2003					1			1
2004						1		1
2005								0
2006								0
2007						1		1
2008								0
2009								0
2010						2		2
Total	0	1	1	0	1	4	0	7



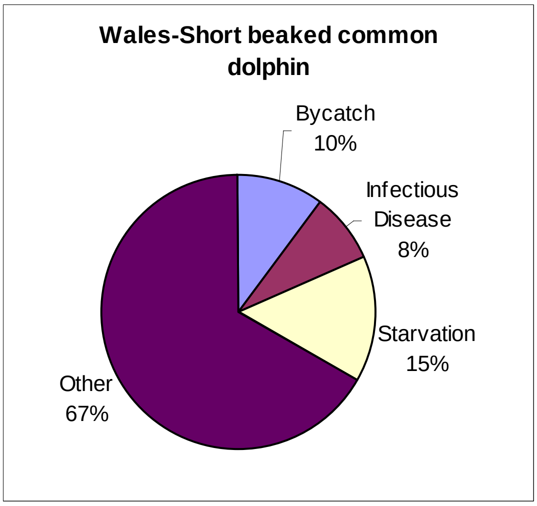
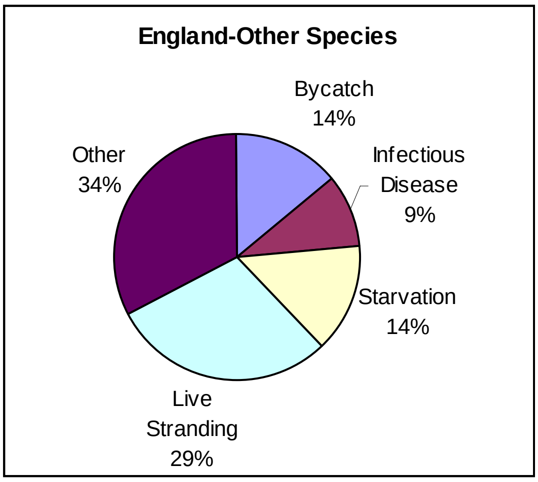


Figure 58: Cause of death of stranded common dolphin in England & Wales 1990-2009 established from post mortem examinations (CSIP, unpubl. data)

Table 17: Causes of Death for Cetaceans Stranding in Wales, 1990-2010, by number (%) (CSIP, unpubl. data)

Species	Strandings	PMEs	BND kill		Starvation		Infectious Disease		Bycatch		Physical trauma		Live Stranding		Others		Dystocia & Stillborn		Boat/ship strike		Not Established		Total
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	%
Harbour porpoise	1425	456	100	21.9	73	16.0	70	15.3	71	15.6	37	8.1	15	3.3	12	2.9	13	2.9			65	14.3	100
Common dolphin	142	53			7	13.2	4	7.5	7	13.2	3	5.7	13	24.5	5	9.4			2	3.8	12	22.6	100
Bottlenose dolphin	35	9					2	22.2	2	22.2											5	55.6	100
Striped dolphin	38	22			2	9.1	3	13.6	2	9.1	3	13.6	2	9.1	5	22.7					5	22.7	100
Long-finned pilot whale	18	2											1	50.0	1	50.0							100
Risso's dolphin	18	7			1	14.3							1	14.3	3	42.9	1	14.3			1	14.3	100
Minke whale	6	3			2	66.7									1	33.3							100
Atlantic white-sided dolphin	5	2			1	50.0							1	50.0									100
Fin whale	3	0																					
Northern bottlenose whale	2	1			1	100																	100
Sowerby's beaked whale	2	1													1	100							100
Blainville's beaked whale	1	1													1	100							100
Cuvier's beaked whale	1	0																					
Pygmy sperm whale	1	1											1	100									100
Humpback whale	1	1			1	100																	100
Unknown	212																						



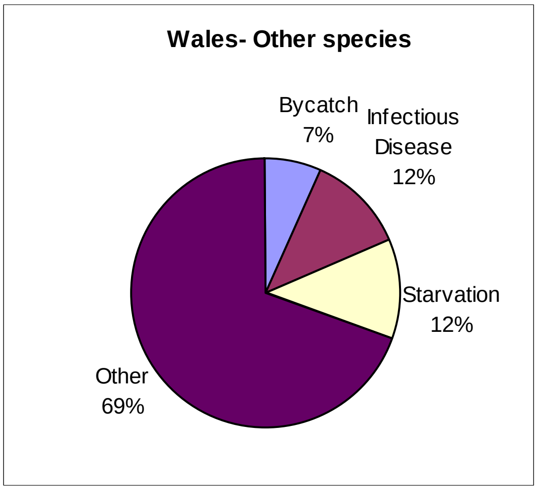


Figure 59: Cause of death of other stranded species in England & Wales 1990-2009 established from post mortem examinations (CSIP, unpubl. data)

For all other cetacean species, by-catch formed less than 10% of post-mortem examinations in Wales over the period 1990 and 2009 (Fig. 59). The only strandings examined post-mortem, where by-catch was attributed as cause of death, were two striped dolphins and a bottlenose dolphin (Table 17). In addition, in early August 2003, a minke whale was found alive but entangled in fishing net, close to New Quay in Ceredigion (see Fig. 49).

More recently, in April 2010, whilst on a trip to North Wales, a family visited Pensarn beach, Abergele, and came across a pile of animals caught up in a net. The net contained: a tope shark, harbour porpoise, spotted dogfish, five mullet, two decomposed unrecognisable fish, and a live dab (see Fig. 60).

Figure 60: Recent evidence of by-catch found on Pensarn Beach, Abergele, North Wales 24th April 2010 animals entangled (left), by-catch from the net (right)

Except after a mass die-off (as, for example, from morbillivirus epizootics), post-mortem examinations of seals do not take place, and so causes of death are rarely established). There are occasional, often unattributable, anecdotal reports of seals being shot or accidentally captured and drowned in fishing gear; the magnitude or importance of such deaths to population dynamics are unknown. Entanglement in persistent synthetic debris (particularly fishing gear debris) causes low-level mortality.

Grey seals also suffer some incidental mortality from entanglement in fishing gear. In the early 1990s, the UK stranding scheme conducted regular post mortems on seals, and between 1990 and 1992, 36 post mortem examinations were carried out from a total of 44 reported strandings in Wales. Of these, five (14%) were identified as by-caught (R. Deaville, IoZ, *pers. comm.*). By-catch clearly continues to this day, with in 2009, two out of five grey seals fitted with GPS phone tags in North Wales being later found by-caught in North Wales and Southern Ireland (M. McMath, CCW, *pers. comm.*), and a number of the grey seals observed around Skomer Island, Pembrokeshire, have signs of past entanglement (Kate Lock, CCW, *pers. comm.*).

Summary & Conclusions

By comparison with some other regional seas around the UK (such as the central and southern North Sea, the Celtic Sea, and Western Approaches to the English Channel, all particularly during the 1990s), the waters around Wales experience low levels of marine mammal by-catch. This is unsurprising given the nature of Welsh fisheries, which is dominated by potting and bottom trawling or dredging for shellfish.

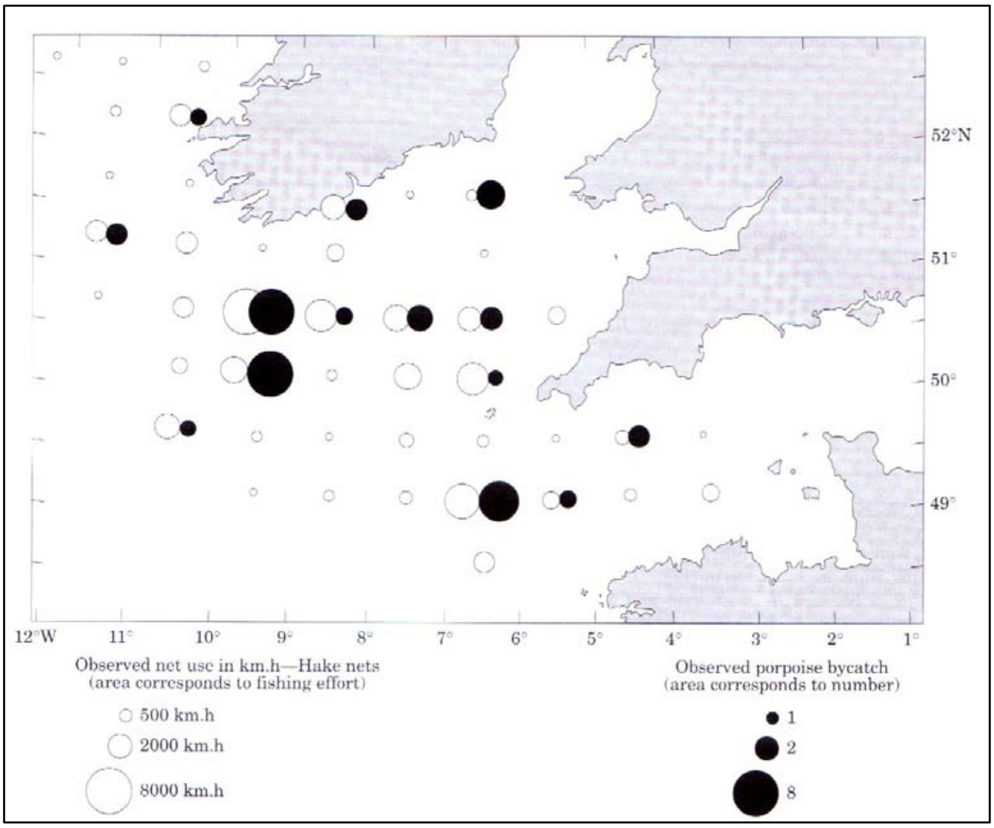


Figure 61: Observed fishing effort and porpoise by-catch in UK and Irish boats, 1992-94 aggregated by ICES rectangles (from Tregenza *et al*., 1997b)

Some of the common dolphins found in Wales as victim of by-catch, may have been drowned outside Welsh waters, and drifted into the region from the south. This could have been the case, particularly during the 1990s when there was a substantial by-catch of common dolphins and harbour porpoise just outside the area, in the Celtic Sea (see, for example, Fig. 61).

In fact, the only species that has been recorded by-caught in any numbers is the harbour porpoise, and even then, most by-catch appears to be due either to local usage by one or two fishermen of gillnets (in some cases thought to be tangle nets) (see, for example, Thomas 2003), or to entanglement from lost or discarded gear (see Figs. 47 & 57). Indeed, the latter is probably the main by-catch threat to marine mammals in Wales. In any event, numbers caught are unlikely to make a significant impact upon local marine mammal populations, given overall abundance estimates.

7.2. Indirect Impacts upon Marine Mammals in Welsh Waters

Whereas in the past, the over-exploitation of pelagic fish such as herring and mackerel, and demersal species such as cod, is likely to have had profound effects on the marine ecosystem which, in turn, could have influenced the status and distribution of many marine mammal species (Evans, 1990; Jennings *et al.*, 2001; Boyd *et al.*, 2006), nowadays, the level of fishing in Welsh waters for competing prey resources is unlikely to be large enough to have a major influence on the main species occurring here.

Although all six of the regular marine mammal species will at times take crustaceans, these generally form minor components of their diet so that the predominant fishing activity of potting probably does not interfere significantly with their life cycles. Risso's dolphins feed almost exclusively upon cephalopods but there is no cephalopod fishery in the region (as yet). The other species take a mixture of benthic, demersal and pelagic fish, the relative amounts varying with species, locality and season. If stocks of salmonids or sea bass are overfished, they could affect the status and distribution of bottlenose dolphins, particularly in the vicinity of the major estuaries such as the Teifi and Dyfi, or in their winter grounds predominantly off North Wales and beyond.

During summer, small groups of bottlenose dolphins, in particular, occupy near-shore sections of Cardigan Bay where their diet includes a number of benthic and demersal prey. Concern has been expressed that repeated scallop dredging occurring in Cardigan Bay could have a long-term impact on the seabed habitats that prey may rely upon, and hence impact prey availability for this dolphin species (Woolmer, 2009). The overlap between fishing activities and important prey habitat may actually be greater than Woolmer (2009) infers because there appears to be greater emphasis by the dolphins on a preference for sedentary prey that depend upon the seabed during summer (from direct observation of feeding behaviour and prey type brought to the surface). This probably relates to the need to have a reliable food source in shallow waters during the period when calves are still dependent upon their mothers. In addition, although sightings are highest during the summer months, at least a portion of the population is present within Cardigan Bay year-round (Pesante *et al.*, 2008a, b). On the other hand, unless legislative measures change in the future, the current technical and spatial constraints implemented by the 2010 Scallop Order seem to be limiting fishing effort to a level and to areas where this activity is unlikely to have a significant impact on marine mammals. The important thing is that scallop dredging should not occur close inshore, and should be restricted to relatively small areas, which are not repeatedly dredged before the benthic communities have had an opportunity to recover fully.

At present, the diet of none of the five cetacean species regularly occurring in Welsh waters is known with any confidence, since dietary studies have not yet been conducted on them in the region. By inference from stomach contents analyses of the different species elsewhere in Britain and around continental Europe (see chapter 2), offshore net fisheries could potentially compete, although the scale of those fisheries is probably not large enough to have a major impact. This will be explored further as sensitivity matrices are developed for each of the marine mammal species.

For the Atlantic grey seal, we have a better idea of their diet through faecal content analyses, as well as of their foraging areas in the Irish Sea through telemetry studies. However, it should be noted that dietary studies were conducted almost twenty years ago, in 1992-93 (Strong, 1996), and as Hammond *et al*. (2008) have shown, diet can change significantly over the long-term depending upon changes in food availability. Those studies were also confined to a limited part of the range of the grey seal. Likewise, the telemetry conducted on a small number of grey seals were from a limited number of sites and so may not necessarily reflect the foraging areas of the Welsh population at large. Despite these caveats, the evidence so far indicates that the main areas of overlap with Welsh fisheries come from the bottom trawl fisheries for flatfish such as sole. Grey seal diet in south-west Wales was dominated by gadoids (particularly whiting or *Trisopterus* species) and flatfish (particularly species of sole), and it is therefore reasonable to assume that this would also be the case in North Wales adjacent to areas that are being more heavily fished.

Minor, temporary, modifications of distribution of seals are routinely caused by various coastal and maritime human activities. There are, for example, historical records of pup deaths (from Skomer and Ramsey Islands) caused by oil spills, whilst on occasions, pupping activity appears to be modified, as seen both by avoidance of sites easily accessible to and often used by humans, and from increasing tolerance of human presence; these influences have opposing effects. The inaccessibility and predominantly winter use of moulting haul-out sites minimises their exposure to human disturbance. On the other hand, anecdotal reports and observations suggest that seals may be becoming increasingly habituated to human presence (CCW, 2009). Nevertheless, recreational fishing by rod and line either from land or offshore in the vicinity of haul-out or breeding sites could cause disturbance to seals at particular locations (e.g. The Skerries, Puffin Island, and the Pembrokeshire islands).

Finally, coastal otters taking salmonids, eels, and shellfish potentially could conflict with inshore fishing activities, but at present only small numbers are likely to be using the coastal zone.

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APPENDIX 1: Categories of Fisheries Activities Used by CCW

(1) Beam trawls and scallop dredges
(2) Rockhopper trawls
(3) Oyster/Mussel dredging and Prospecting
(4) Demersal trawls
(5) Light demersal trawls and seines
(6) Hydraulic suction dredges
(7) Pelagic trawls, nets and lines
(8) Static gear- nets and long lines
(9) Static gear -pots
(10) Rod and line hand-fishing
(11) Casual hand gathering
(12) Professional hand gathering
(13) Aquaculture- trestles, ground lays+ traps
(14) Aquaculture- cages + rope cultivation

APPENDIX 2: Details of the Diet of Marine Mammals

a) Harbour Porpoise

	Scotland (N=188) 1992-2003 (S)		**Scotland** (N=64) 1959-71 (S&BC)	**Germany North Sea** (N=34) 1991-93		**Germany Baltic Sea** (N=27) 1991-93		**Baltic Sea** (N=38) 1960-61	**Ireland & Celtic Sea** (N=26)	**Kattegat and Skagerrak** 1988-1996	**Norwegian Sea Finmark & Troms** 1985-1990 (S&BC)	
Prey Species	**Number (%)**	**Weight (%)**	**Number (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Weight (%)**
Gadidae			**?**									
Merlangius merlangus (Whiting)	13.42	51.73	10	5.7	8.9				4.5	4.8		
Pollachius virens (Saithe)			3.1							4.4	0.8	17
Micromesistius poutassou (Blue Whiting)	0.12	0.22									4	19
Trisopterus spp. (Poor Cod/Norway Pout/Bib)	4.42	3.69							30.1			
Trisopterus minutus (Poor Cod)									10.3			
Gadus morhua (Cod)	0.2	0.59	2		6.2		14.8	3.49				
Haddock, Pollack & Saithe	0.18	6.13										
Melanogrammus aeglefinus (Haddock)	0.21	1.36								4.9	0.4	
Molva molva (Ling)												
Trisopterus luscus (Bib)										3.6		
Trisopterus esmarkii (Norway Pout)			1								0.6	
Gadiculus argenteus (Silvery Pout)												
Lycodes sp. (Eelpout)							8.1					
Other Gadidae	2.07	3.39	3						38.3	6.1	0.8	
Lotidae												
Rockling species	0.02	0.02										
Clupeidae	1.16		21									
Clupea harengus (Herring)	0.43	1.42	10			0.9	22.8	6.19		49.9	2	16
Sprattus sprattus (Sprat)	0.73	0.35	3					78.82	4.7	8.0	0.3	
Sardine pilchardus (Pilchard)												
Other Clupeidae	0.23	0.43										

Ammodytidae												
Ammodytidae (Sandeel)	67.61	24.79	1	17.8	36.6			0.23		1.6		
Carangidae												
Trachurus sp.(Scads)												
Scombridae												
Trachurus trachurus (Horse Mackerel/Scad)												
Scomber scombrus (Mackerel)	0.05	1.50	2									
Osmeridae												
Mallotus villosus (Capelin)											88	42
Gobiidae (Gobies)	0.82	0.03		53.0	4.7	98.0	52.7	11.26				
Merlucciidae												
Merluccius merluccius (Hake)			1.00									
Sternoptychidae												
Maurolicidae (Pearlsides)											3	
Myxinidae												
Myxine glutinosa (Hagfish)										12.4		
Other fish	0.16	0.8		7.7	5.5	1.1	1.6		2.8	4.4	1.4	6
Cephalopoda												
Unidentified Cephalopods			1.00									
Loligo spp.												
Sepiolidae (Unidentified)												
Sepiolidae (Bobtail Squid)	8.13	3.28										
Alloteuthis spp.	0.26	0.16										
Other Cephalopods	0.05	0.01										
Anguilla anguilla (Eel)												
Crustacea	1.58		5.00									
Flatfish			1.00									
Solea solea (Sole)				4.9	27							
Hippoglossoides platessoides (Long Rough Dab)												

Limanda limanda (Common Dab)				6.6	11.1							
Platichthys flesus (Flounder)				4.4								
Other flatfish												
TOTAL	101.85	99.89	64.1	100.1	100.0	100.0	100.0	99.99	90.7	100.1	101.3	100
Source	Santos *et al*., 2004		Rae, 1972	Benke *et al*., 1998		Benke *et al*., 1998		Lindroth, 1962	Berrow & Rogan, 1995	Borjesson *et al*., 2003	Aarefjord & Bjorge, 1995	

a) Harbour Porpoise (cont.)

	Norwegian Sea Nordland 1985-90 (S&BC)		**Norwegian coast - to Swedish border** 1985-90 (S&BC)		**North Sea - Danish west coast** 1985-90 (S&BC)		**Skagerrak** 1985-90 (S&BC)		**Kattegat** 1985-90 (S&BC)		**Baltic Sea** 1985-90 (S&BC)		**France - NE Atlantic, Bay of Biscay & western Channel** (N=29)1988-2003	
Prey Species	**Number (%)**	**Weight (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Weight (%)**
Gadidae														
Merlangius merlangus (Whiting)	0.2		0.1		91	46	3		1		0.9		2.5	20.3
Pollachius virens (Saithe)	2	18	2	50					0.2					
Micromesistius poutassou (Blue Whiting)	2		2	10			0.1		0.2				18.5	21.3
Trisopterus spp. (Poor Cod/Norway Pout/Bib)	1		0.1										28.7	3.9
Trisopterus minutus (Poor Cod)	28		0.2	34	0.1		3	16	0.7		0.9			
Gadus morhua (Cod)	0.3				1	31	0.3		0.7	38	27	42		
Haddock, Pollack & Saithe														
Melanogrammus aeglefinus (Haddock)	2		3	12			0.3		0.1					
Molva molva (Ling)	0.2		0.1								0.9			
Trisopterus luscus (Bib)														
Trisopterus esmarkii (Norway Pout)	4		0.5				2							
Gadiculus argenteus (Silvery Pout)													0.2	
Lycodes sp. (Eelpout)						11					13	10		
Other Gadidae	9		0.8		0.7		5		1					
Lotidae														
Rockling species	0.7						3				2			
Clupeidae														
Clupea harengus (Herring)	7	33	1	15	1		10	58	7	48	28	38		
Sprattus sprattus (Sprat)	2						5		1		12			
Sardine pilchardus (Pilchard)													2.3	21.3

Ammodytidae														
Ammodytidae (Sandeel)	0.2		0.2		0.3		1		0.1		4			
Scombridae														
Scomber scombrus (Mackerel)													0.1	0.9
Carangidae														
Trachurus trachurus (Horse Mackerel/Scad)			0.1											27.6
Trachurus sp.(Scads)													5.2	
Osmeridae														
Mallotus villosus (Capelin)														
Gobiidae (Gobies)	2		11		2		57		83		7		21.5	1.1
Merlucciidae														
Merluccius merluccius (Hake)	0.2		0.4		0.2				1				0.3	1.4
Sternoptychidae														
Maurolicidae (Pearlsides)	35		78				6		2					
Myxinidae														
Myxine glutinosa (Hagfish)							3							
Other fish	4.4	15	0.6	13	0.8	12	0.2	26	0.5	14	1.9	10	5.1	0.5
Cephalopoda														
Unidentified Cephalopods														
Loligo spp.													0.2	0.1
Sepiolidae (Unidentified)													1.7	0.2
Sepiolidae (Bobtail Squid)														
Alloteuthis spp.													0.6	0.5
Other Cephalopods													0.4	0.9
Anguilla anguilla (Eel)							0.1				2			
Crustacea													12.7	0.2
Flatfish														
Solea solea (Sole)														

Hippoglossoides platessoides (Long Rough Dab)					2									
Limanda limanda (Common Dab)														
Platichthys flesus (Flounder)														
Other flatfish														
TOTAL	100	66	100	100	99.1	100	98.9	100	98.5	100	99.6	100	100	100.2
Source	Aarefjord & Bjorge, 1995		Aarefjord & Bjorge, 1995		Aarefjord & Bjorge, 1995		Aarefjord & Bjorge, 1995		Aarefjord & Bjorge, 1995		Aarefjord & Bjorge, 1995		Spitz *et al.*, 2006	

b) Bottlenose Dolphin

	Scotland (N=10) (S&BC) 1990-1999		**Ireland** (N=8) (S) 1994-2008	**Spain** (Northwest), Galacian coast (N=82) (S) 1990-2005		**France** (NE Atlantic,Bay of Biscay & Western Channel) (N=25)1988-2003	
Prey Species	**Number (%)**	**Weight (%)**	**Number (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Weight (%)**
Gadidae			7.1				
Merlangius merlangus (Whiting)	49.1	23.4				0.3	0.1
Pollachius virens (Saithe)	9.4	23.6					
Micromesistius poutassou (Blue Whiting)				72.9	48.3	13.0	0.6
Whiting & Blue Whiting			16				
Trisopterus spp.	3.3	0.7	5.7	1.7	1.3	10.8	6.6
Gadiculus argenteus (Silvery Pout)						4.8	
Gadus morhua (Cod)	2.5	29.6					
Melanogrammus aeglefinus (Haddock)	4.1	5.4					
Molva molva (Ling)	0.1	0.1					
Saithe/Pollack/Haddock			19.7				
Other Gadidae	2.3	2.9					
Clupeidae				0.3	0.2		
Sardina pilchardus (Pilchard)						4.8	3.1
Sprattus sprattus (Sprat)	0.3	0.2				10.6	0.9
Engraulidae							
Engraulis encrasicolus (Anchovy)						2.4	0.2
Ammodytidae							
Ammodytidae (Sandeel)	13.8	0.8		0.9	0.3	2.6	0.1

Scombridae							
Scomber scombrus (Mackerel)				0.2	0.2	0.9	2.3
Scomber japonicus (Chub Mackerel)				2.0			
Gobiidae (Goby)	0.1			0.7		0.3	
Mugil sp. (Mullets)				0.7	6		
Atherina presbyter (Big-scale Sand-smelt)				1.0	0.1		
Myoxocephalus scorpius (Bull-rout)	1	1					
Labridae (Wrasses)	0.3						
Sparidae (Sea-breams)				0.7	1.1		
Carangidae							
Trachurus trachurus (Horse Mackerel/Scad)	0.5	0.9	13.4	2.0	3		
Trachurus sp.(Scads)					3	15.6	13.2
Moronidae							
Dicentrarchus labrax (Bass)						4.2	5.5
Congidae							
Conger conger (European Conger Eel)				0.3	6.8		
Merlucciidae							
Merluccius merluccius (Hake)	0.1	0.1	5.2	8.3	28.8	20.2	40.8
Salmonidae							
Salmo salar (Salmon)	0.4	5.8					
Callionymidae							
*Callionymus sp (*Dragonet)	0.3	0.1					
Centriscidae							
Macroramphosus sp. (Snipefish)				2.5			
Sparidae							
Spondyliosoma cantharus (Black Sea-bream)						2.4	3.8
Other Sparidae (Sea-breams)						0.4	0.8
Eurypterids							
Taurulus bubalis (Sea Scorpion)	4.9	4.1					
Mugil spp. (Unidentified Mullets)						4.5	12.1
Other fish	4	1	2.6	4.5	1.8	1.5	0.7

Cephalopoda							
Unidentified Cephalopods	0.1		13.0	1.5	1.8		
Sepiolidae	0.5					0.1	
Alloteuthis spp.						1.1	
Loligo sp.	0.1	0.3				2.5	9.3
Todarodes sagittatus (European Flying Squid)	0.3	0.6					
Eledone cirrhosa (Horned Octopus)	0.3	1.6					
Other Cephalopods							
Crustacea	0.3			1.8			
Mollusca	0.4			0.1			
Large unidentified demersal fish			10.4				
Flatfish			5.2				
Pleuronectes platessa (Plaice)	0.5	0.3					
Limanda limanda (Dab)	0.1	0.1					
Hippoglossoides platessoides (Long Rough Dab)	0.3	0.1					
TOTAL	99.4	102.7	98.3	102.1	102.7	103.0	100.1
Source	Santos et al., 2001		Hernandez & Rogan, 2001	Santos et al., 2007		Spitz *et al.*, 2006	

c) Short-beaked Common Dolphin

	Scotland 1992-93 (N=1) (S&BC)		**W. Channel** (N=2) (BC) 1982	**France** (Bay of Biscay) (N=71) (S) 1995-2002		**Portugal** (N=42 (23=BC) Jan 1987- Sep 1997		**Ireland** (NW-Inshore) N=76) 1990-2004	**Ireland** (NW-(Offshore) N=58) 1996-1999
Prey Species	**Number (%)**	**Weight (%)**	**Number (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Number (%)**
Gadidae								7.0	
Merlangius merlangus (Whiting)	39.8	79.4		7.0	2.2			2.4	
Haddock/Pollack/Saithe	0.8	1.6							
Micromesistius poutassou (Blue Whiting)					6.0	24.1	15.5	4.0	0.3
Trisopterus spp. (Poor Cod/Norway Pout/Bib)	0.1			10.6	3.9	0.9	0.3	44.5	
Atherina sp. (Sand Smelts)						4.8	11.0		
Clupeidae	2.7	1.7	35						
Clupea harengus (Herring)								1.2	
Sprattus sprattus (Sprat)				5.5				2.3	
Herring/sprat	2.7	1.7			4.2				
All Clupeidea									
Ammodytidae									
Ammodytidae (Sandeel)	47.6	13.5							
Scombridae									
Scomber scombrus (Mackerel)			60	0.6	6.6	0.1	0.3		
Scomber japonicus (Chub Mackerel)						0.9	2.3		
Scomber sp. (Mackerel sp.)						1.1	4.1		
Carangidae									
Trachurus trachurus (Horse Mackerel/Scad)				13.8	19.2			0.9	36.6
Trachurus sp. (Scads)						4.9	6.9		
Clupeidae									
Sardina pilchardus (Sardine)				7.9	36.2	27.4	43.4		
Engraulidae									

Engraulis encrasicolus (Anchovy)				15.2	12.4				
Gobiidae						0.3			
Deltentostheus quadrimaculatus (Goby)						5.7	0.9		
Gobiidae (Unidentified Gobies)				26.1	1.0			27.8	
Merlucciidae									
Merluccius merluccius (Hake)				0.7	2.2	1.4	2.1	0.9	
Centriscidae									
Macroramphosus sp. (Snipefish)						8.5	3.4		
Sternoptychidae									
Maurolicidae (Pearlsides)									2.4
Atherinidae (Sand-smelts)									
Myctophidae									
Myctophum punctatum (Spotted Lantern fish)									28.8
Benthosema glaciale (Glacial Lantern fish)									0.6
Notoscopelus kroyeri (Lancet fish)									21.9
Other Myctophidae									0.6
Paralepididae									
Arctozenus risso (Spotted Barracuda)									3.2
Other fish				2.7	1.6	2.4	3.5	6.0	0.8
Cephalopoda									
Cephalopod	0.1	3.8		10.0	4.5	17.0	7.7	3.0	5
Loligo vulgaris (Common Squid)									
Illex coindetti (Southern Shortfin Squid)									
Eledone cirrhosa (Curled Octopus)									
Todarodes sagittatus (European Flying Squid)									
Todaropsis eblanae			5.0						
Other Cephalopods									
Crustacea	0.3								
Total	94.1	101.7	100.0	100.1	100.0	99.5	101.4	100.0	100.2
Source	Santos *et al.*, 1994		Pascoe, 1986	Meynier, 2004		Silva, 1999		Brophy *et al.*, 2008	Brophy *et al.*, 2008

d) Risso's Dolphin

	Scotland (N=1) (S&BC) 1992-1993		**Scotland** - Argyll (N=1) (S) 1986	**Italy -** Ligurian Sea (N=1) (F) May 1990		**Italy -** Central Tyrrhenian sea (N=2) (F) Jan 1988 & Jan 1991	**Italy -** Lecce (SW Adriatic coast) (N=1) (S) April 1991	**Spain** - Galacian coast (N=3) (S) Jan 1991-March 1993
Prey Species	**Number (%)**	**Weight (%)**	**Number (%)**	**Number (%)**	**Weight (%)**	**Number (%)**	**Number (%)**	**Weight (%)**
Cephalopoda: Squid								
Todarodes sagittatus (European Flying Squid)			26.64			18.1	4.8	2.1
Loligo forbesi (Common Squid)	36.6	1.5						
Loligo vulgaris (European Squid)						2.7		
Gonatus steenstrupi (Atlantic Gonate Squid)			19.98					
Rossia macrosoma (Bobtail Squid)			6.66					
Sepietta oweniana (Bobtail Squid)			26.64					
Illex coindetti (Southern Shortfin Squid)						17		
Cranchiidae (Glass Squid)				4.46	4.6			
Histioteuthis bonnelli (Cock-eyed Squid)				70.7	73	4.2		
Ancistroteuthis lichtensteinii (Angel Squid)				17.2	17.6	1.1	1.6	
Histioteuthis sp.				2.55	2.6		82.5	
Histioteuthis reversa (Reverse Jewell Squid)						47.1		
Octopus & Cuttlefish								
Ocythoe tuberculata (Tuberculate Pelagic Octopus)						5.7		
Eledone cirrhosa (Horned Octopus)	61.7	98.5	19.98					5
Octopus vulgaris (Common Octopus)								
Eledone sp. (Octopus)				1.27	1.3			85.7
Sepia officinalis (Common Cuttlefish)						1.9		
Sepiola atlantica (Little Cuttlefish)								7.2
Sepia sp. (Unidentified Cuttlefish)	0.3							
Other Cephalopods				3.82	7.6	1.7	11.1	
TOTAL	100	100	100	100	106	100	100	100
Source	Santos *et al*., 1994		Zonfrillo *et al*., 1987	Podestà & Meotti, 1990		Carlini et al., 1992	Bello & Pulcini, 1989	Gonzalez *et al.,* 1994

e) Minke Whale

	Scotland(N=10) Apr 1992-Nov 2002	**E. North Sea** (N=22)	**Norwegian Sea** (N=24)	**Iceland** (N=67)	**Spitsbergen** (N=38) May 2000-Jun 2004	**Bear Is.** (N=24) May 2000-June 2004	**S. Barents Sea** (N=101) May 2000-Jun 2004	**Norwegian Sea** (N=10) May 2000-Jun 2004	**W. North Sea** (N=37) May 2000-Jun 2004
Prey Species	**Weight (%)**	**Weight (%)**	**Weight (%)**	**Weight (%)**	**Weight (%)**	**Weight (%)**	**Weight (%)**	**Weight (%)**	**Weight (%)**
Gadidae									
Merlangius merlangus (Whiting)		2.37							0.28
Pollachius virens (Saithe)							1.77		
Micromesistius poutassou (Blue Whiting)						0.6	0.01	3.97	
Gadus morhua (Cod)				0.7	4.79	1.42	2.68		
Melanogrammus aeglefinus (Haddock)					1.4	6.96	20.26		2.42
Other Gadidae					0.01	0.01	0.63		
Clupeidae	20								
Clupea harengus (Herring)	1.34	1.07	100	0.7		0.58	14.32	95.88	6.16
Sprattus sprattus (Sprat)	11.02								
Ammodytidae									
Ammodytidae (Sandeel)	61.71	86.73		32.6			0.46		56.01
Scombridae									
Scomber scombrus (Mackerel)	5.83	9.31							29.72
Merlucciidae									
Merluccius merluccius (Hake)									5.42
Osmeridae									
Mallotus villosus (Capelin)				22.9	1.57	51.15	58.9	0.15	
Other fish	0.1	0.5		3.7	0.02	0.85			
Calanus sp. (Copepod)					2.65	2.66	2.68	2.7	2.72
Euphausiacea (Krill)				34.8	89.59	38.45	0.99		
Large Teleost Fish				4.5					
TOTAL	100	100	100	100	100	102	102.	102	102
Source	Pierce *et al.*, 2004	Olsen & Holst, 2001	Olsen & Holst, 2001	Sigurjónsson *et al.*, 2000	Windsland *et al.*, 2007	Windsland *et al.*, 2007	Windsland *et al.*, 2007	Windsland *et al.*, 2007	Windsland *et al.*, 2007

f) Grey Seal

Prey Species	Southern North Sea Weight (%)	Central North Sea Weight (%)	Orkney Weight (%)	Shetland Weight (%)	Hebrides Weight (%)	West Wales Weight (%)
Gadidae						
Merlangius merlangus (Whiting)	9.6	2.6	1.8	0.4	2.1	18
Haddock/Pollack/Saithe						2.0
Pollachius virens (Saithe)			2.1	1.4	2.3	
Trisopterus spp. (Poor Cod/Norway Pout/Bib)	1	0.3	1.4	0.2	3.2	13.0
Gadus morhua (Cod)	5.2	6.6	7.3	5.9	9.1	3.0
Melanogrammus aeglefinus (Haddock)	1.6	11.7	4.8	0.5	8.5	
Molva molva (Ling)	0.2	0.4	1.5	0.9	5.7	3
Other Gadidae	0.9	1.2	2.3	1.0	5.0	1.2
Clupidae						
Clupea harengus (Herring)	1.9	0.1	0.2	2.6	16.2	6.0
Ammodytidae						
Ammodytidae (Sandeel)	17.6	61.9	60.6	82.7	28.0	0.5
Scombridae						
Scomber scombrus (Mackerel)						0.1
Carangidae						
Trachurus sp.(Scads)						1.0
Clupeidae						0.1
Gobiidae (Gobies)						0.5
Salmonidae						
Salmo salar (Salmon)						0.1
Callionymidae						
Callionymus lyra (Dragonet)	21	3	0.7		1.8	11
Eurypterids						
Taurulus bubalis (Sea Scorpion)						1

Cottidae						
Myoxocephalus scorpius (Bull-rout)	23.6	4.5	4.8	1.0	1.9	0.5
Other fish	0.7	1.2	2.4	2.7	5.4	2.8
Cephalopoda						
Eledone cirrhata (Lesser Octopus)						3
Flatfish						
Pleuronectes platessa (Plaice)	1.9	2.9	5.2		1.5	6
Solea spp (Unidentified Sole species)						20
Solea solea (Dover Sole)	4					
Solea solea Dover Sole & *Microstomus kitt* Lemon Sole	5.7					
Microstomus kitt (Lemon Sole)	1.7	1	0.8	0.4	4.3	0.1
Platichthys flesus (Flounder)						1
Limanda limnda (Dab)						2
Raja sp. (Ray)						2
Other flatfish	3.4	2.3	3.7	1	4.5	2.7
Wrasse						4
TOTAL	100	99.7	99.6	100.7	99.5	104.6
Source	Hammond & Grellier, 2006	Hammond & Grellier, 2006	Hammond & Harris, 2006	Hammond & Harris, 2006	Hammond & Harris, 2006	Strong, 1996

APPENDIX 3: Summary of Fisheries and By-catch Information for North West Europe

Area (& ICES area if known)	Gear type	Target species	Year	Species	By-catch levels	Estimated Mean Annual By-catch	Source	By-catch Investigation approach & Comments
Irish Sea VIIIa-e, VIIh,j,k	Driftnet	Albacore Tuna	1995	CD, SD	Medium	Low 100s	CEC, 2002b	Monitoring scheme By-catch decline with low effort, fishery terminated by EC regs. in 2002
North Sea (offshore) IIa,Iva,Ivb,IVc	Static	Cod, skate, turbot, sole, monkfish, dogfish	1995-1999	HP	High	100s	CEC 2002a,b: Defra, 2001, Northridge & Hammond, 1999; SFPA / SFI, 2001	Monitoring scheme By catch estimate without freezer-netter fleet
North Sea (inshore) Iia,Iva,Ivb,IVc	Static	Cod	1995-1999	HP	Medium	100s	CEC 2002a,b: Defra, 2001, Northridge & Hammond, 1999; SFPA/SFI, 2001	Monitoring scheme Bycatch estimate without freezer-netter fleet
West of Scotland Via	Static	Dogfish, crayfish, skate	1995-1999	HP, CD	Medium	Low 100s	Northridge *pers.comm*. in CEC, 2002a	Monitoring scheme Drastic decline in recent years due to collapse of crayfish fishery
Channel VIId,e	Static	Cod, monkfish, flatfish	-	HP	Low?	-	ASCOBANS, 2003a; CEC, 2002a,b	Opportunistic records

Celtic Sea VIIf-j	Static	Hake, cod, pollack, saithe, ling	1992-1994	HP, CD	Medium-high	100s	CEC 2002a,b: Tregenza *et al.*, 1997; Tregenza & Collet, 1998	Monitoring scheme
Bay of Biscay, Celtic Shelf VIIg-k	Pelagic pair trawl	Albacore tuna	-	CD, SD,AWSD, WBD, LFPW	High?	-	CEC, 2002b	NONE
North Sea & West of Ireland IVa-c, Via,b	Pelagic trawl	Herring, mackerel	1995-1996 & 2000-2001	LFPW, potentially other species	Low?	-	ASCOBANS, 2003a;CEC, 2002a,b; Morizur *et al.*, 1999	Monitoring scheme
Western Channel VIId,e	Pelagic pair trawl	Mackerel, bass, pilchard, blue whiting, & anchovy	1995-1996 & 2000-2001	CD, SD, AWSD, WBD, LFPW	High, mainly CD	-	CEC, 2002; Morizur *et al.*, 1999	Monitoring scheme
North Sea & ? Ivb,c & others?	Demersal trawl	Cod & others?	-	HP	Very low?	-	CEC, 2002b	NONE
Northern North Sea IIa, Iva (parts)	Purse seine	Herring, mackerel	-	Small cetaceans	Low?	-	CEC, 2002b	Opportunistic records
North Sea IVa, IVb, IVc	Fish trap	Salmonids	-	HP	Low?	-	CEC, 2002b	NONE
North Sea IV	Set Nets	Cod, skate, turbot, sole, monkfish, dogfish	1995-2002	HP		439 [371-640]	ASCOBANS, 2004	NONE
Channel & Bay of Biscay VIId,e,f, VIIIa,b& some in IVc	Fixed	Sole, anglerfish, cod, hake, turbot	1995-1996	HP	Low?	<1	ASCOBANS, 2003c;Morizur *et al.*, 1996; CEC, 2002b	
Channel VIId,e	Fixed	?	-	HP	Medium?	>10	Morizur *et al.*, 1996; Swarbrick e*t al.*, 1994	1 HP per boat per year (potentially up to 30 boats)

Celtic Sea VIIe-j	Fixed	Hake & anglerfish	?	HP & other species	High?	-	Morizur pers. comm., in CEC, 2002b	
North Sea VIa,b	Pelagic single or pair trawl	Herring, mackerel & horse mackerel	-	HP, LFPW & small cetaceans	Very low?	-	ASCOBANS, 2003c; CEC, 2002b	NONE
Western Channel (& Celtic Shelf?)	Pelagic single or pair trawl	Blue whiting, mackerel & horse mackerel, herring, sea bass, black sea bream	1994-1995	CD, AWSD, & other species	High for all species but mainly CD	100s	ASCOBANS, 2003c; CEC, 2002a,b; Morizur *et al.*, 1996; Morizur *et al.*, 1999	Independent Observer Scheme
Celtic Shelf & Bay of Biscay	Pelagic single or pair trawl	Hake, tuna, sardine, anchovy, horse mackerel, sea bass	1994-1995	CD, BND	High for all species but mainly CD	100s	ASCOBANS, 2003c; CEC, 2002a,b; Morizur *et al.*, 1996; Morizur *et al.*, 1999	Independent Observer Scheme

Notes:

Key to species

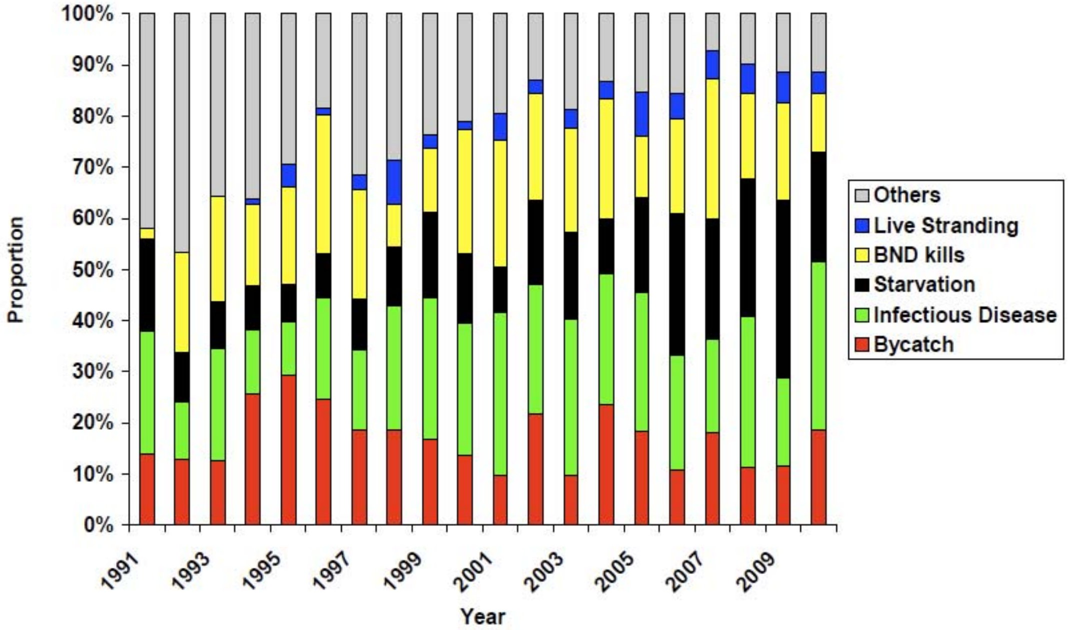
Harbour porpoise	HP
Common dolphin	CD
Bottlenose dolphin	BND
Striped dolphin	SD
Atlantic white-sided dolphin	AWSD
Minke whale	MW
White-beaked dolphin	WBD
Long-finned pilot whale	LFPW

Annual By-catch levels

Rare	Very low
<10/year	Low
10-500 animals/year	Medium
>500 animals/year	High
Several 1000 animals/year	Very high
Potential by-catch levels for fisheries not yet monitored using independent observer programs but alternative sources of information available.	?

APPENDIX 4: Trends in Causes of Death for UK Harbour Porpoise and Short-beaked Common Dolphin, 1991-2010 (from Deaville & Jepson, 2011)

a) Harbour Porpoise



b) Short-beaked Common Dolphin