Cetaceans and Pelagic Trawl Fisheries in the Western Approaches of the English Channel

The Report of the 2004 WDCS/GREENPEACE Winter Survey

A WDCS SCIENCE REPORT

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EXECUTIVE SUMMARY

The Western Approaches of the English Channel are of importance for whales, dolphins and porpoises. They also support feeding and spawning grounds for a diverse fish fauna including many commercially important species.

These waters are intensively trawled by pelagic fisheries during the winter months from October to May. These fishing activities coincide with relatively highly levels of cetacean strandings. In recent years, several hundred corpses have washed ashore in south west England each winter, most clearly diagnosed as having died through capture in fishing nets. In the case of many of the common dolphin bodies, the external damage is consistent with death in the type of netting used in trawls.

Despite this, little bycatch monitoring has taken place in the pelagic trawl fisheries that operate in these waters, although, in recent years the UK has conducted extensive monitoring of the winter sea bass fishery, which has been found to be responsible for a high rate of cetacean bycatch. Indeed, the UK government recently called upon the European Commission to close the winter sea bass fishery in the western Channel (ICES area VIIe) because of the high level of common dolphin bycatch recorded in the UK fleet. This initiative was unsuccessful.

A joint WDCS/Greenpeace cetacean survey using conventional line-transect techniques and trialling other survey methodologies, was carried out between 21st of January and 8th of March in the Western Approaches of the English Channel, including a brief visit west to the Celtic Shelf. The main aims of this survey were to study the local cetacean populations, to monitor the winter pelagic trawl fisheries there, and also to monitor interactions between these fisheries and the cetaceans.

The results of this survey reveal a high relative abundance of cetaceans (number of sightings per 100km) in the survey area, particularly common dolphins, at this time of year. The cetacean species identified during the survey were: harbour porpoises, short-beaked common dolphins, bottlenose dolphins, Risso's dolphins, striped dolphins, fin whales and minke whales. A total of 469 sightings of approximately 3,707 animals were made during the expedition.

Common dolphins appeared to be widely distributed throughout the whole survey area. However, the relative abundance of this species was lower in the southern (French) part compared to the northern part of the Channel during the survey period. Furthermore, a higher relative abundance was evident for both common dolphins and harbour porpoises in the presence of trawlers.

Taking the whole survey into account, the proportion of common dolphins seen between the coastline and 12 nm was 36%. However, all the periods of fisheries observation where common dolphins were recorded were beyond 12 nm of the coast and this is of potential significance because of the recent closure of the UK's winter sea bass pair trawl fishery within this 12 nautical mile coastal zone.

The group size of common dolphins was also significantly higher during fisheries monitoring (11.5) than other survey modes where trawlers were not present (6.4). During fisheries monitoring, more common dolphins were also found to display behaviour indicative of feeding. These factors merit further investigation, as the group size and foraging strategies are also likely to affect the number of bycaught animals in nets.

Seven interactions between fisheries and cetaceans were recorded and involved common dolphins, harbour porpoises and unidentified dolphins. Common dolphins were seen around trawlers during both hauling and towing procedures. A fin (or sei) whale, a minke whale and several Risso's dolphins were also seen in areas where pelagic trawling was taking place.

The acoustic survey undertaken indicated that the vocalisation activity of dolphins was not distributed evenly across the diurnal cycle. Apparent peaks in the percentage of acoustic detection occurred in the morning, just after sunrise, and in the evening, just after sunset. A low in percentage detections occurred during the midday subdivision. High levels of dolphin detections have been associated with both feeding and social behaviour. Visual surveys are limited to day time, therefore, acoustic techniques, may be able to answer key questions that, at present, remain unanswered including providing a better understanding of the interactions between dolphins and nets.

The post mortems of the dead common dolphins retrieved at sea revealed that several had injuries consistent with being killed in gillnet fisheries. The marked presence of injuries that may have been caused by nets recorded on live common dolphins suggests that some may be wounded during encounters with nets but survive.

The provisional abundance estimate for common dolphins in the entire area surveyed in the Western Channel (8,872 km^2) resulting from this survey was 9,708 animals (95% CI = 4,799-19,639). However, the full designed transect coverage was only achieved in sub-area 'Stratum E' (which covers 4,129km^2 , *see* Chart 1) and this provides the best estimate achieved for common dolphins during this survey using standard line-transect methods: 2,841 (95% CI=169-5,512), although this is subject to potentially large bias related to responsive movement by the dolphins.

These provisional abundance estimates were based on a number of assumptions including that the probability of detecting dolphins on the trackline, *g(0),* is assumed to be one, *i.e.* every animal that surfaces on the trackline is detected. However, this assumption could lead to a slight downward bias in the abundance estimation because in practice some animals may have been undetected.

Another assumption of the line-transect methodology is that the animals do not respond to approaching survey vessels before they are detected. Indeed, the results of the current study highlight the problem of responsive movement for surveys of common dolphins and the use of two different survey speeds enabled comparisons to be made of the way in which responsive movement affects the detection process. The results show that the effects are complex involving changes in both the location of the animal relative to the vessel and the detection probability. For this survey, the assumption that animals were detected before they responded to the vessel was clearly not valid (as there was clear evidence of responsive movement towards the vessel by the dolphins) and this will cause upward bias in the provisional estimates, a factor likely to affect other estimates made for this species.

The high levels of bycatch reported in the Channel area clearly raise both conservation and animal welfare concerns. In conservation terms there is one particularly important question: what is the effect of these removals on the populations of cetaceans in this region. There is clear evidence that many common dolphins and many harbour porpoises are being killed and other cetacean species are also being washed ashore dead. We should not forget that these others may also be significantly impacted. For example, any removals from the small coastal bottlenose dolphin population in the south-west of England, which probably only numbers a few tens of individuals could be highly significant.

However, the data presented here relate mainly to the situation of the common dolphin and the area where bycatch is occurring is on the edge of the usual distribution of this species, bounded by coastlines to the north and south, with very few observations of common dolphins further east in the Channel (Reid *et al*., 2003). If this area is only used by a subset of the total Northeast Atlantic 'stock' of this species, which may be a distinct population which returns each year, then there is, at the very least, a risk of localised depletion within the Channel area. It is not clear if local depletion occurs, whether common dolphins from further away would then start to exploit and re-populate the area. Furthermore, the relatively high encounter rate in this study (the highest rate recorded from any of the relevant surveys in the North Atlantic) shows that the Channel is a very important winter habitat for common dolphins.

The relationship of the common dolphins seen in the winter to others elsewhere in the North East Atlantic is unclear. A large population estimate has recently been generated for a sea area to the west of Ireland based on data from a survey conducted in summer 1995. Simple inference cannot be drawn from this estimate to the bycatch problem seen in the Channel.

A bycatch level of more than 1.7% of the best available estimate of abundance has been deemed in international fora to be unacceptable for small cetaceans, which, based on our abundance estimate for stratum E, would equal 48.3 animals. During the 2003/4 fishing season, a bycatch of 169 common dolphins was recorded in the area in the UK bass fishery alone, producing an extrapolated total estimated mortality for the UK fishery of 439 animals. There is additionally an unquantified mortality in other (*e.g.* gill and tangle net) fisheries, for instance, 200 common dolphins were estimated to be caught annually in the Celtic Sea hake gillnet fishery during the early 1990s (Tregenza & Collet, 1998) and an assumed (but also unquantified) mortality in the French bass fishery - as well as potentially other trawl fisheries.

Overall there is clear evidence of bycatch problems that raise significant welfare concerns and, based on the limited data so far available, significant conservation issues for the common dolphin and probably other species too.

INTRODUCTION

Along the coasts of the Western English Channel and northern Bay of Biscay, there has been a predictable and increasing incidence of dead common dolphins and other species washing ashore, particularly in late winter and early spring. In recent years, there have been several hundred corpses, most clearly diagnosed as having died through capture in fishing nets and, in the case of common dolphins, the external damage on many is consistent with death in the type of netting used in trawls.

The total annual mortality of common dolphins as a result of bycatch is unknown, as is the impact of this bycatch on the affected populations. However, the number and scale of pelagic trawl fisheries that operate in the Celtic Sea, Biscay and Channel area (including UK, Irish, French, Dutch and Danish fleets) and additionally the extensive gillnet and tangle net fisheries that operate in the area, indicate a major risk. This, coupled with the number of bycaught dolphins that strand on surrounding coasts, indicate that the total annual mortality due to bycatch is likely to be in the thousands, possibly many thousands of animals, and is probably unsustainable (Ross and Isaac, 2004).

Ecological diversity

The eastern sector and coastal areas of the English Channel are shallow, with depths rarely exceeding 50m. Depths are greater in the central zone and generally slope from east to west reaching 100m along the western edge, although a trough to the northwest of the Channel Islands reaches a depth of more than 170m. Currents flow eastward, bringing more saline water from the Atlantic (OSPAR, 2000). In winter, the area is exposed to the prevailing south-westerly winds.

The English Channel supports a diverse fish fauna including many commercially important species. The water temperature is a major factor limiting the overall distribution of fish. Cold water species such as cod and herring reach their southern limit in the Celtic Sea and English Channel, whereas northward penetration of warm water species such as sea bass, sardines and anchovies varies periodically according to sea temperature (OSPAR, 2000). Other physical factors, including depth, tidal flow and sediment characteristics, lead to considerable variation in the distribution of each fish species.

The spawning season for mackerel is from March-July (Atlantic) and May-August (North Sea); for blue whiting it is from April-June; and for sea bass it is February-June (*see Annex i*). Recent tagging studies indicate that seasonal patterns of sea bass movements have changed little in the last 20 years, although climatic changes may have lengthened the duration of residence in summer feeding areas (ICES, 2001).

A total of 28 cetacean species have been recorded in the waters off northwest Europe in the last 25 years (Reid *et al*., 2003). Of these, at least 19 species have been sighted or found stranded in the English Channel, including larger whale species, such as fin and sei whales (*see* Table 1). Information on cetaceans usually comes from three sources: strandings data; recent research; and cetacean sightings databases. Based on these sources, the cetaceans most likely to be seen in the English Channel are bottlenose dolphins, harbour porpoises, short-beaked common dolphins, Risso's dolphins, striped dolphins, minke whales, long-finned pilot whales, orcas and fin whales. Other deep water cetaceans (sperm whales and various beaked whales) also visit this area, perhaps when migrating through, and are recorded less frequently.

Species	Common name	Habitat	Presence
Megaptera novaeangliae	Humpback whale	Deep waters	Rare
Balaenoptera acutorostrata	Minke whale	Shallow and deep waters	Frequent
Balaenoptera borealis	Sei whale	Deep waters	Rare
Balaenoptera physalus	Fin whale	Deep waters	Rare
Physeter macrocephalus	Sperm whale	Deep waters	Rare
Kogia breviceps	Pygmy sperm whale	Mainly deep waters	Rare
Ziphius cavirostris	Cuvier's beaked whale	Deep waters	Rare
Hyperoodon ampullatus	Northern bottlenose whale	Deep waters	Rare
Mesoplodon bidens	Sowerby's beaked whale	Deep waters	Rare
Tursiops truncatus	Bottlenose dolphin	Shallow seas	Frequent
Stenella coeruleoalba	Striped dolphin	Mainly deep waters	Rare
Delphinus delphis	Common dolphin	Mainly deep waters	Common
Lagenorhynchus albirostris	White-beaked dolphin	Shallow and deep waters	Rare
Lagenorhynchus acutus	Atlantic white-sided dolphin	Deep waters	Rare
Grampus griseus	Risso's dolphin	Shallow and deep waters	Common
Pseudorca crassidens	False killer whale	Mainly deep waters	Rare
Orcinus orca	Orca	Mainly deep waters	Frequent
Globicephala melas	Long-finned pilot whale	Deep waters	Frequent
Phocoena phocoena	Harbour porpoise	Shallow seas	Common

Table 1. Cetaceans in the English Channel (Sources of data: Reid *et al*., 2003; Walker and de Boer, 2003; Seaquest database; Evans and Scanlan, 1989. Harmer, 1927; Fraser, 1946, 1953, 1974 and Sheldrik, 1989)

Pelagic trawls

In the north east Atlantic region pelagic trawls are used in fisheries targeting a wide range of pelagic and shoaling fish species, including albacore tuna, hake, herring, mackerel, horse mackerel (scad), blue whiting, sea bass, pilchard (sardine) and anchovy (Ross and Isaac, 2004). Monitoring for cetacean bycatch has been conducted in only a few of these fisheries, and most has been at too low a level to be able to deduce bycatch levels. However, high levels of common dolphin bycatch have been recorded in several pelagic trawl fisheries. The only pelagic trawl fishery in the western Channel in which significant cetacean bycatch has been recorded to date is the UK's sea bass fishery (DEFRA, 2003). This fishery is also prosecuted by the French fleet, which is thought to operate around five times more fishing effort than the UK fleet (DEFRA, 2004).

The Western Approaches of the English Channel are intensively trawled by pelagic fisheries during the winter months from October to May, but most fishing effort takes place in late February and March, when sea bass moves offshore to spawn in the mid-Channel region. The UK offshore bass fishery is mostly directed solely at this species but may also have black bream and the small pelagic species, such as mackerel, pilchard and horse mackerel as the main target species with sea bass as a valuable bycatch (ICES, 2001).

Pelagic or mid-water trawling usually involves the towing of a trawl net by either a single vessel or two boats (pair-trawling), The trawl is essentially a bag net with a very wide mouth that gradually tapers to a narrow tube known as the extension piece, leading in turn to the closed end of the net, the 'cod-end', where the fish are collected (*see* Figure 1). The nets typically have large floats on the head line at the mouth of the net to keep the mouth open, and weights on the footrope at the sides, or wing-ends, of the net opening. Nets can be up to 250m in length and consist of very large mesh size at the mouth (up to 18m), gradually decreasing along the net to a small mesh (*e.g.* 4cm) at the cod-end, depending on the size of fish being targeted. Trawl nets can have a vertical opening of between 30m and 60m and the horizontal spread of the wings of up to 200m (Morizur *et al* 1999).

The trawl net is towed at varying depths depending on the target species, and the duration of each tow may vary from five minutes to more then ten hours (*see* Ross and Isaac, 2004).

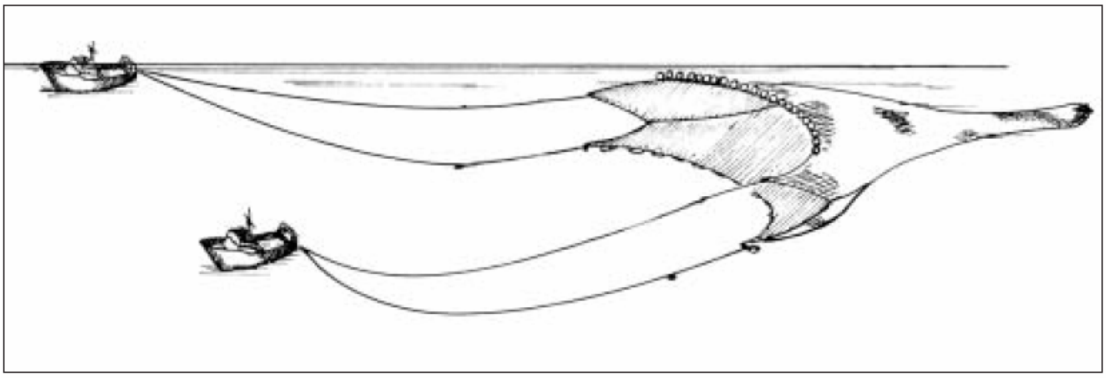


Fig.1. schematic representations of a pair trawl operation (from Northridge, 2003).

Strandings

Records of stranded animals, where they have been subject to post-mortem examination, can be used to identify the existence of a bycatch problem in an area. However, strandings data cannot provide any more than an absolute minimum level of bycatch, as the rate at which bycaught and discarded animals are washed ashore is highly variable and unpredictable (CEC, 2002).

Details of injuries of stranded bycaught animals provide an indication of the type of fishery responsible. For instance, the injuries inflicted by a large-mesh monofilament net will be different to those inflicted by a small-mesh trawl-type netting (Sabin *et al*., 2003). In addition, analysis of stomach contents of bycaught animals show which fish the animals were feeding on when or immediately before they were caught, which may give an indication of the fishery responsible (*e.g.* Kuiken *et al*., 1994). Details of carcasses that are retrieved by onboard observers, such as core body temperature, can also provide useful information as to how and when the animals died (Morizur *et al*., 1999).

Many carcasses discarded from fishing vessels may never reach the shore. There are several factors that will influence the chance of a particular carcase stranding; first, its buoyancy, which will depend on fat and gas content, second wind strength and direction and tidal currents, and third, and perhaps most importantly, the distance to shore. The weather conditions in the north-east Atlantic during the winter months are therefore likely to contribute to high strandings rates. For example, between February and March, 1997, after a period of calm weather, a prolonged westerly storm washed the bodies of 629 cetaceans onto the shores of southern Brittany and Biscay. A total of 74% of these cetaceans showed obvious signs of incidental capture (Tregenza & Collet, 1998). It is also acknowledged that bycatch and, indeed, strandings rates can vary considerably from year to year.

Strandings in the south-west of England typically rise in the December to April period, but commonly peak between January and March. The following histograms illustrate the common winter peaks in strandings of the two species most commonly stranded in the south-west *(see* Fig. 2a & b).

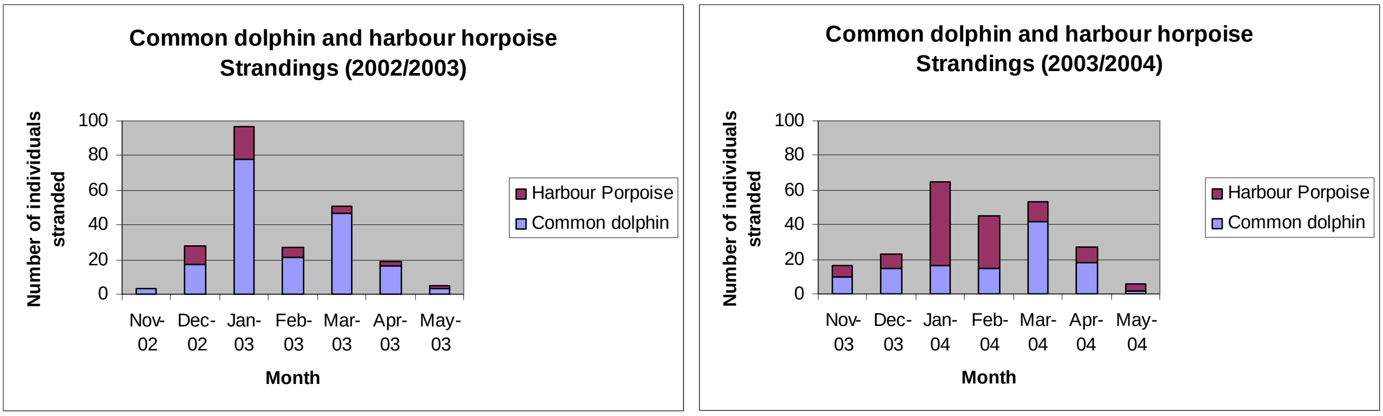


Fig. 2a&b. Overview of strandings of common dolphins and harbour porpoises in Devon and Cornwall during the winter months of 2002/2003 (a) and 2003/2004 (b). Data Source: Devon Biodiversity Records Centre / Cornwall Wildlife Trust.

Although in both the winters of 2002/3 and 2003/4 there is a distinct peak in total cetacean strandings in January, in January 2003 these comprised mainly common dolphins, whereas in January 2004 they are predominantly harbour porpoises. Additionally, a further 69 unidentified small cetacean carcasses were found in this area in the period January to March 2003. Other species that have stranded in Devon and Cornwall in the last two years include white-beaked dolphins, white-sided dolphins, striped dolphins, minke whales and bottlenose dolphins. Although the overall number of strandings of some of these species may be small, in the case of species such as the bottlenose dolphin which has a very small local population, any bycatch or other anthropogenic removals may be highly significant in conservation terms.

It is often difficult to attribute cetacean strandings in a given month of the year to a particular cause. However, the strandings that occur on the coast of south-west England each winter do seem to correspond to the fisheries operating in this region. In 2004, the inshore gillnet fishery, which is thought to be responsible for many harbour porpoise entanglements, lasted into February. This fishery generally finishes in early January, but was extended this year as the bass shoals stayed in-shore for longer (Ruth Williams, Cornwall Wildlife Trust, pers comm.).

Critical values

A number of international bodies have attempted to establish the level at which cetacean bycatch could be considered ‘sustainable’ in conservation terms. It has been agreed internationally that an annual loss of even 1% of a small cetacean population should be a cause of concern that merits investigation as a matter of priority (IWC, 1995). A bycatch level of more than 1.7% has been deemed in international fora to be unacceptable (ASCOBANS, 2000).

In order to place these critical values in the context of real population declines some idea of the size of the cetacean population of concern is needed. Several cetacean surveys have been conducted in the north-east Atlantic in order to estimate abundance. For example, the SCANS (Small Cetacean Abundance in the North Sea) survey of 1994 (Hammond *et al*., 1995) and the MICA (Mesure de l'Impact des Captures Accessoires) survey in 1993 which was focused on the impact of cetacean bycatch in the French albacore tuna driftnet fishery (Goujon *et al*., 1993). However, these surveys took place some years ago and were conducted during the summer months and, therefore, only obtained estimates for cetacean populations at these times. The winter population size and structure of common dolphins and other small cetaceans in the Western Approaches remain very poorly known.

Legislation relevant to bycatch

Cetaceans in European waters are protected by various national and international legal instruments which are briefly described below.

Under the *Common Fisheries Policy (CFP)* competence for fisheries matters lies with the European Community which means that the EC has to mediate changes in fisheries management, including legislation changes. Four regulations with relevance to cetacean bycatch have been introduced so far under the CFP. *Regulation (EC) No 345/92* restricted the length of driftnets to 2.5km and *Regulation (EC) 1239/98* provided for the phasing out of all driftnets used to catch certain listed species such as tuna and swordfish. Both of these regulations apply throughout EU waters, with the exception of the Baltic Sea. *Regulation (EC) No 973/2001* prohibits the encirclement of schools or groups of marine mammals with purse seines, with certain exceptions.

Most recently, *Regulation (EC) No 812/2004* adopted in April 2004 which lays down measures concerning incidental catches of cetaceans in fisheries was adopted. The three main provisions covered by this regulation relate to the use of acoustic deterrent devices (pingers) in gill net fisheries, onboard observer monitoring of bycatch and the phase-out and elimination of driftnets in the Baltic Sea. Whilst undoubtedly an important step forward, the regulation contains critical weaknesses. For example, boats less than 12m long will not be required to use pingers leaving inshore cetacean populations still at risk; those vessels that do carry pingers are not required to carry observers so monitoring of the use and effectiveness of these devices may not occur; and, vessels less than 15m in length are also exempt from the requirement to carry onboard observers leaving a further sector of fishing activity unmonitored.

In mid-2004, the UK Government asked the European Commission to take emergency measures to close the pelagic trawl fishery for sea bass in the western Channel (area VIIe). Monitoring of this fishery by the UK had highlighted a high level of bycatch, potentially of serious conservation concern for the common dolphin, the main species affected. The emergency action proposed by the UK Government comes under the Common Fisheries Policy Framework *Regulation (EC) No. 2371/2002* on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy. Article 7 provides for the Commission to introduce emergency measures "if there is evidence of a serious threat to the conservation of living aquatic resources, or to the marine ecosystem resulting from fishing activities and requiring immediate action"

The European Commission rejected this request on the grounds that the data presented by the UK does not justify an immediate ban. The UK subsequently announced that it would act unilaterally on this issue and ban the pelagic trawl fishery for sea bass within 12nm and restrict the number of UK vessels operating outside this area. Although a positive political gesture, it may do little to reduce the numbers of cetaceans being killed by this fishery each year as fishing effort will continue further offshore.

The *Habitats and Species Directive (92/43/EEC)* places many duties on Member States in relation to the protection and conservation of listed species of Community interest, which include all cetaceans. Of most relevance to bycatch, Article 12 requires Member States to establish a system of strict protection for the animal species listed in Annex IV (a) (which includes all cetaceans), establish a system to monitor the incidental capture and killing of these species and, in the light of information gathered, take further research or conservation measures to ensure that incidental capture and killing does not have a significant negative impact on the species concerned (Article 12.4).

Member States' lack of action on Article 12.4 was acknowledged by the European Commission in a memorandum accompanying its proposal for Council Regulation (EC) No 812/2004 on cetacean bycatch. It is hoped that this Regulation will ensure that Member States are at least moving towards meeting their obligations under the Habitats and Species Directive.

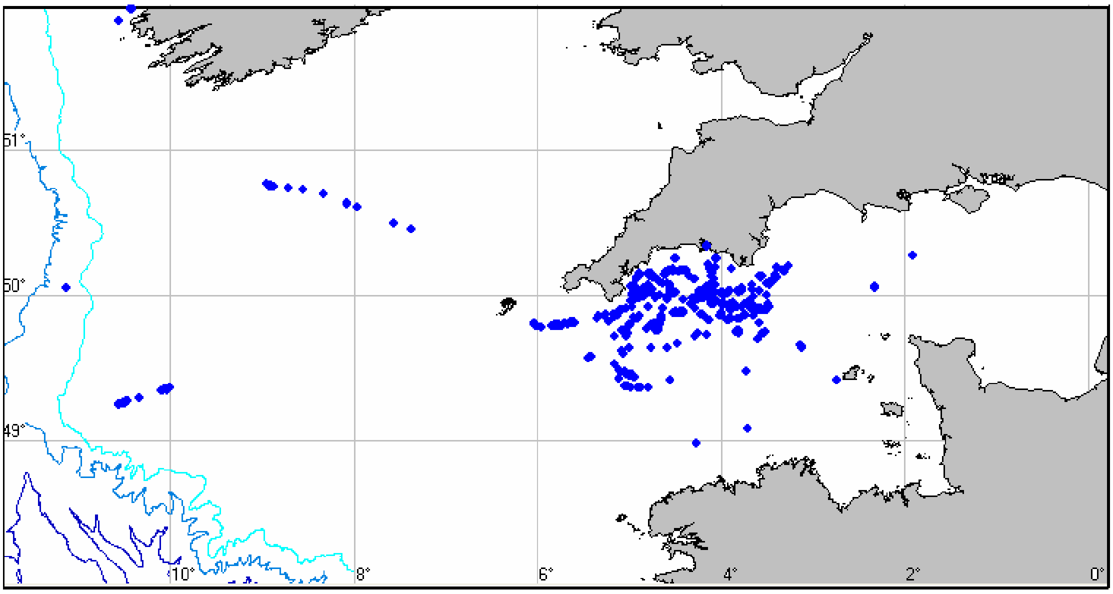
There would seem to be little scope within England and Wales's national legislative regime to tackle bycatch. The *Wildlife and Countryside Act (1981),* the principal piece of legislation that affords protection to species, limits offences relating to the killing and injuring of protected species to 'intentional' acts and defends all acts that are the 'incidental result of a lawful operation and could not reasonably have been avoided'. Recent amendments to the Act as it applies to Scotland (via the *Nature Conservation (Scotland) Act 2004*) may prove helpful as it is now an offence to 'intentionally or recklessly' kill a protected species, and the defence offered to lawful operations has been tightened by adding an additional set of conditions that must be met. It is too early to tell what affect these changes will have. The regulation of inshore fisheries and the work of the UK's Sea Fisheries Committees are also relevant but not reviewed here.

The WDCS/GREENPEACE Survey

WDCS and Greenpeace are very concerned that the current level of small cetacean bycatch in UK and other European fisheries is unsustainable and is therefore threatening cetacean populations. There is also widespread public concern about this issue.

Furthermore, there is a major welfare dimension to this issue. Cetaceans are adapted to remain underwater for prolonged periods of time. Veterinary studies indicate that cetaceans trapped in nets probably remain conscious until they die from lack of oxygen. So, in the case of porpoises, the duration of conscious and painful suffering may be several minutes. Other cetaceans have longer dive times and so the duration of their suffering is likely to be even longer (Ross *et al*., 2001). Evidence from bycaught animals shows signs of extreme struggling including broken teeth and jaws, torn and severed fins and flukes, cuts to the skin, internal bruising and muscular tearing (Kuiken *et al*. 1994).

The above considerations explain the rationale for the 2004 joint survey and the main aims of this survey were to study cetacean populations in the Western Approaches of the English Channel, monitor the winter pelagic trawl fisheries and the interactions between these fisheries and cetaceans.



Distribution of cetaceans sighted during the WDCS/GREENPEACE survey, where one blue dot is one sighting. Dark blue lines represent the 3,000m, blue lines the1,000m and light blue lines the 200m depth contours.

METHODOLOGY

Survey design

One of the most commonly used methods for estimating density and abundance is line-transect sampling, in which the observer travels along a line (transect) recording detected cetaceans and their accurate distances and bearings to the line. The cetaceans may either be individual sightings or clusters of animals. With the collected data, together with covariates that could be affecting the detection of cetaceans, one can then estimate the cetacean density. The density estimate can then be converted to an estimate of abundance using design-based methods (Buckland *et al*., 2001).

In line-transect sampling, the survey design comprises a set of straight lines, spanning the full study area for which an abundance estimate is required. The methodology requires that lines are randomly placed in the study area and that they are placed across known density contours, in order to gain a clearer picture of density and minimise variance in encounter rate (Buckland *et al*., 1993). For shipboard surveys in particular, the study area is often divided into geographic blocks (or strata) and systematic zig-zag transect designs are used to ensure that there is no loss of expensive ship time in traversing from one line to the next. The ship can then continuous search for marine mammals during daylight hours and good weather conditions.

The survey was conducted from the *MV Esperanza*, a 72.3m Expedition/Research vessel which traveled at either a 'fast' average speed of 8.6 knots or a 'slow' average speed of 5.3 knots. Data were collected mainly in the 'passing mode', where the vessel did not deviate from the track-line.

The survey took place between 21st of January and 8th of March in the Western Approaches of the English Channel, including a brief visit to the Celtic Shelf. The main Survey Area (our target area where we placed the survey transects), lay between 49°20'N-50°20'N and 3°26'W-6°10'W (*see* Fig. 3).

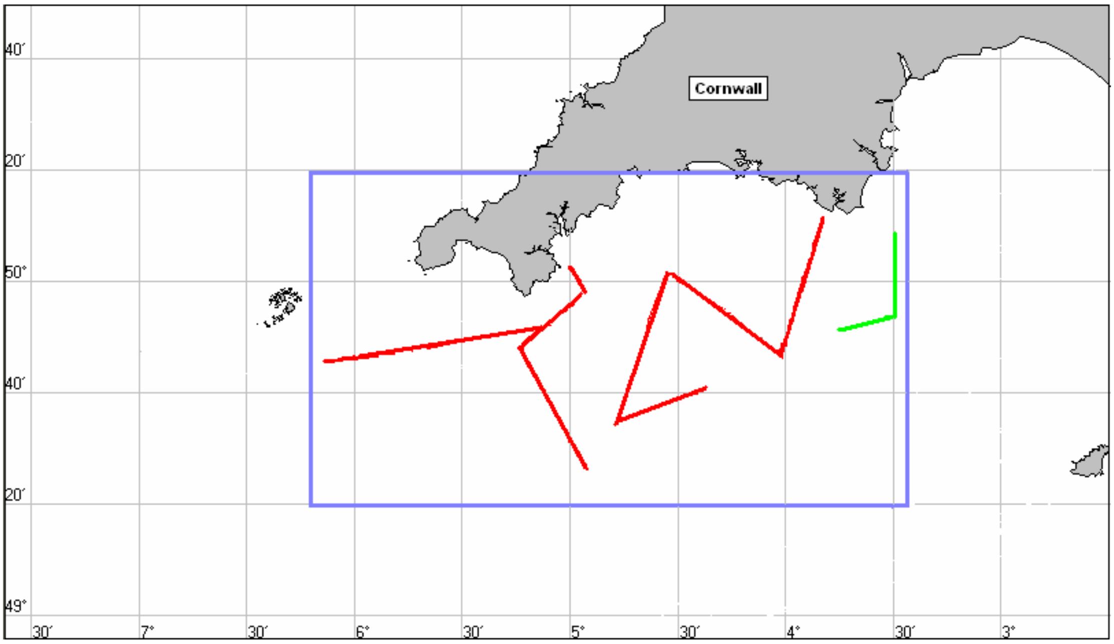


Fig. 3. The main survey area (box) and survey effort ≤4 sea state following pre-determined survey transects at fast speed (thick red lines) and at slow speed (thick green lines).

Cetacean sighting methodology

To facilitate systematic data collection, the data-logging program 'Logger 2000' (developed by IFAW to promote benign, non-invasive research) ran continuously throughout the survey on a laptop computer which was linked to the ship's Global Position System (a Furuno GP-80 satellite navigation system) through an NMEA (National Marine Electronics Association) interface. This program automatically recorded the ship's location every minute and provided a continuous visual display of the vessel's track on a map of the area. Data concerning sightings and the environment were manually entered. The methods used were very similar to those reported in previous studies (*e.g.* De Boer and Simmonds; 2003,. Macleod *et al*., 2003 and Dawson *et a*l., 2004).

All observers were properly trained before taking part in the survey, with some team members staying throughout the survey period to ensure consistent data collection. Two observers were located on the outer bridge deck (which served as the primary platform[1] with an approximate eye-height of 11.3m), one on port and one on starboard. Observers scanned backwards and forwards whilst on watch in a 90 degrees sector (on port and starboard), forming an approximately 180 degrees combined survey area in front of the ship. Scanning was done with the naked eye with occasional scans along the horizon using 7x50 binoculars. A third person acted as the data recorder, entering sighting information and environmental details. Other observers were on break and ready to assist in the photographing or filming of animals. The observers were rotated every hour to avoid fatigue.

Nikon 7X50 marine binoculars with in-built reticule scales were used to measure the angle from the horizon to the sighting. When the sighting was close to the ship, an estimate was made using a 'distance stick'.

The bearing to the sighted animals and the animal(s) headings were determined by using "angle-boards" which were fixed to the ship's railings. These were aligned parallel to the ship's bow and the alignment checked and corrected throughout the survey.

Sightings data recorded included the time, GPS position, bearing, distance, species identification (and degree of certainty ranging from definite-100%, probable-75% to possible-50%), presence of calf and/or juveniles, group size (maximum, minimum and best estimate) and the animal's heading.

The following environmental data were collected every hour, and when conditions changed: ship's position, heading and speed; wind speed and direction (using an OBSERMET Wind meter OMC 939); cloud coverage and amount of glare (in degrees); visibility; swell height; and the Beaufort sea state. The sea surface temperature was measured regularly (every hour whilst on high effort search status) with help of a digital thermometer (810-926 ETI-Ltd). Water depths were obtained using a Furuno Navigational Echosounder (FE-700).

Survey effort

Effort during the survey was divided into several types (*see* Table 2). Survey effort continued throughout all daylight hours but was suspended when the Beaufort sea state exceeded 4.5 or visibility was considered poor. Sightings made during bad weather or when no systematic observations were being conducted (i.e. *low and off effort*), were regarded as incidental sightings. When observers failed to report a sighting which were in fact seen by others (not on watch) were also regarded as incidental.

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[1] Depending on observer availability, a two-independent survey mode protocol was followed, with a secondary team stationed on the monkey-deck (with an approximate eye-height of 14m). However, not enough effort was conducted in this dual survey mode to allow analysis.

Effort mode	Abbreviation	Speed Mode	Description
Transect	T	Fast	Systematic surveys following pre-determined
	TS	Slow	transects
High Effort	S	Fast	Systematic surveys not following pre-determined
	SLOW	Slow	transects whilst on transit
Fisheries	FOF	Fast	Data collected during non-systematic surveys that
Observations	FOS	Slow	were specifically aimed at monitoring fisheries
Low effort	L	n/a	Dedicated observations made during bad weather
			(sea state>4.5) or when visibility was poor
Off effort	X	n/a	No dedicated observers on watch

Table 2. Information and abbreviations for different survey modes conducted at either fast (~8.6 knots) or slow (~ 5.3 knots) speed of the survey vessel.

Interactions with fisheries

During those parts of the survey focussed on monitoring fisheries, and when adequate numbers of trained people were available, 2 additional observers looked towards the stern watching a 180 degrees area to the rear, in order to produce a combined survey area of 360 degrees around the ship. The observer with the best view of the fishing vessels would repeatedly note down bearing and distance to the vessels using reticule binoculars and angle-boards and, when possible, distance using the ship's radars (Furuno and Nucleus2 5000ATA). Only when the *MV Esperanza* was within good visual range of the fishing operations and with cetaceans in the area, would we repeatedly plot sightings of dolphins and trawlers and study any interactions. In addition, a RIB was often on stand-by within several hundreds metres of the fishing vessels, before, during and after the hauling of the nets, in order to monitor by-catch and also to report the presence of dolphins in vicinity of the fishing operations . No dedicated watches were conducted from the RIB, however, and sightings made from the RIB or the main survey vessel during such operations were regarded as incidental. We also recorded information with each sighting, concerning the presence of pelagic trawlers in the general area, noting down bearing and distance to the vessels with help of the ship's radar and monitored any apparent interactions between cetaceans and the fishing operations. Data relating to the fishing vessels themselves are not presented here.

Dead dolphins

On several occasions floating dead dolphins were sighted and, when possible, these were retrieved by the Greenpeace crew for detailed external morphological examinations. When a dead dolphin was sighted, the following data were collected: time, date, position, sea state, swell height, cloud, visibility, wind force, wind direction, bearing and distance to the dead dolphin. To help to retrieve the dolphin, a marker buoy was immediately placed in the vicinity of the animal and a RIB was launched as swiftly as possible. In some cases, the dolphins were brought aboard (animals were lifted onto deck using a belt around the tailstock and the ship's crane). When the animals were already in an advanced state of decomposition, and could not be brought onboard, the animals were sexed, measured, photographed and, when possible, tagged in the water and then left.

For each dead dolphin that was found in a relatively fresh state, the following features were photographed: whole animal, dorsal fin (left and right side), both flippers, head side view, top of the head/blowhole, eyes, close-up of the beak, fluke, flanks, genital regions and any obvious scarring. In addition, those dead dolphins that were recovered and brought onboard were identified to species, sexed and an assessment of the maturity status was made based on length and size. In addition to this, basic body measurements, body temperature measurements and detailed morphological external examinations (based on Tregenza *et al.,* 1997) were carried out. When body temperatures were taken a digital thermometer was inserted via the anus. Two probes of different lengths were used, a 17 cm probe (810-926 ETI-Ltd) and a 50 cm probe (MM2050/TM-electronics).

The animals that were returned to the sea were tagged around the tail stock. Tags were made of metal, showing a tag-ID and a contact telephone number to which recovered bodies could be reported. The tag was attached using a thick plastic cable-tie. The position of drop-off, date and time of tagged dolphins were noted.

Acoustics

From the 13th of February until the 4th of March, the ship towed a two-element hydrophone array. The hydrophone array consisted of two fixed elements 7.5m apart within a 13 metre oil-filled PVC pipe. It was towed on a 300m cable. For safety reasons the length of cable deployed was occasionally decreased to 200 or 100m. A pressure sensor within the hydrophone allowed the depth to be recorded.

The onboard system included signal conditioning equipment, an analogue to digital converter (ADC), and a real-time spectrographic display on a laptop computer. The audio interface, a controller and amplifier of sound, was a Roland UA5 ADC that was linked to the laptop computer using a FireWire connector. The spectrographic display was created and subsequent file analysis carried out by *SeaPro Version 1.2*[2]. The software was set so that a buffer could be recorded instantly, capturing the previous 5 minutes and 49 seconds of data. Files were saved directly onto computer and later saved to CD.

The frequency response of the hydrophones was 40Hz to 60kHz and 100kHz to 250kHz, nominal sensitivity -180dB +/-4 re 1V/¦Pa. The frequency response of the balanced line drivers, the electronics driving the 300m of cable, was 10Hz to 150kHz +/- 1dB. The frequency response of the digital part of the system was DC to 48kHz +/-1dB and the digital equalizer/converter sampled at 96 kHz. The band was limited up to 48kHz for recording and spectrographic display.

The hydrophone was monitored whenever possible by listening to the signal and watching the real-time spectrogram display. Listeners rotated in two or four hour shifts so that listener fatigue was minimised. The display meant that the listener could check the characteristics of the sound that he/she was listening to in order to verify its origin: natural, anthropogenic or cetacean vocalisation. It also allowed the listener to be prompted by a signal that may otherwise have gone unheard. Acoustic activity was noted as a summary of the previous 15 minutes and sound files were recorded when particularly interesting activity was heard. General types of cetacean vocalisation that could be readily identified by the listeners were whistles, squeaks, buzzes and clicks. Cetacean vocalisations were not identified to species. Other data recorded were the time, listener's initials, depth of the hydrophone, length of cable, background noise (0-3), sea state (during day light hours), acoustic event, strength of signal during acoustic event (0-3), whether a sound file was recorded and any notes. All data were recorded onto data sheets.

Listener perspective may be a problem in acoustic monitoring surveys (Michele Manghi, *pers. comm.*) and it is important to minimise the variation between individuals so that the data is scored relative to a consistent protocol. To this accord the listening team spent some time together comparing judgements about particular vocalisations during and before monitoring began.

Photo-identification

Photographs were taken of bottlenose dolphins (*Tursiops truncatus*) and a minke whale (*Balaenoptera acutorostrata*). In addition, many photographs were taken of common dolphins (*Delphinus delphis*).

Analytical analysis

Acoustic analysis

The time during which the hydrophone was monitored was allotted into 15 minute listening periods. Times were synchronised with the visual survey and could therefore be linked to GPS information. From the data files and record sheets, acoustic 'detections' were defined as a listening period during which cetacean vocalisations were detected.

Acoustic survey effort - the track of the ship while the hydrophone was deployed - was then plotted together with the acoustic detections. The survey coverage was deemed to be insufficient to generate comparable detection rates to use across geographical areas. The acoustic effort during different visual survey modes was also extracted and tabulated.

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[2] Software developed by Gianni Pavan © 1998-2003. Distribution by Nauta rcs – Ricerca e Consulenza Scientifica. http://www.nauta-rcs.it/sea.html.

Cetacean vocalisations were not identified to species and only sightings of dolphin species were used. This included sightings of common dolphins, bottlenose dolphins and unidentified dolphin species. The great majority of sightings made during the visual survey were of common dolphins, so it is expected that most of the vocalisations heard were of this species.

'Acoustic detections' give an indication of cetacean presence and absence at any particular time but another method for acoustic analysis is to define 'acoustic encounters'. The latter is used to take into account the fact that the same group of dolphins may be recorded in consecutive listening periods. Encounters can therefore be defined as cetacean contacts separated by a period of time sufficient to assume that the next encounter is of a different (group of) cetacean(s). This technique reduces the number of overall detections and produces a dataset of independent group encounters. This dataset is less affected by the biases of non-independence and is likely to be a more representative sample of the dolphin population in the survey area than a dataset of detections. Because detections are not independent of repetitive contacts with the same group of animals, to use them as the sample here it must be assumed that this non-independence does not significantly affect the conclusions drawn about cetacean presence or absence. However, this could not be assumed if, for instance, differences in group sizes and/or behaviour influenced the attractiveness of the ship to dolphins, in turn, affecting the length of time that any one group of animals remained within detection range next to the ship. Our dataset revealed that the sample size for acoustic encounters from this year's survey was insufficient for analysis and the results presented here are therefore based on acoustic detections only.

Sightings data were compared with the acoustic data. The number of listening periods during which visual effort took place and the number in which sightings were recorded were determined in order to match sightings with detections. Of equal importance, this identified the number of periods, during visual effort, in which detections were made but no sightings recorded and, vice versa, the numbers of periods during which sightings were recorded but no detections were made.

Only sightings of dolphin species were used when comparing acoustic data to sightings data. This included sightings of common dolphin, bottlenose dolphin and unidentified dolphin species. The great majority of sightings made during the visual survey were of common dolphin so it is expected that most of the vocalisations heard were of this species. In fact, cetacean vocalisations were recorded in the presence of common dolphins (as confirmed visually) on a number of occasions.

The possible affect on acoustic data of speed of the vessel was explored. A distinction was made between 'fast' and 'slow' effort for both the visual and acoustic data. Listening periods when the ship was travelling at a speed greater that 6.9 knots were classed as 'fast' and periods when the speed ranged between 4-6.9 knots were recorded as 'slow'. The number of detections during fast and slow periods could then be compared.

The diurnal effect on acoustic detection was explored. Listening periods were categorised into eight subdivisions across the 24 hour day. The number of detections made during each 3 hour subdivision during the day could then be compared. Group size was investigated because it was expected to influence detectability, *e.g.* one might expect larger groups to produce more vocalisations and therefore be more likely to be detected than smaller groups.

Listening periods during fisheries monitoring, *e.g.* with trawlers in the vicinity, were compared to those when no trawlers were in the vicinity. At night, and during periods when no visual effort or reduced visual effort was being carried, out we cannot be certain that there were no trawlers in the vicinity of the ship. Therefore, those 'low effort' modes are excluded from any comparison to test whether there was a higher detection rate when trawlers were in the vicinity of the ship.

No attempt was made to adjust detection rates to account for the effects of background noise or other environmental variables. However, it was expected that the level of background noise would reduce the detection rates. The distance that the hydrophone was deployed from the ship is also likely to affect the background noise and hence detection rates. The signal strength of the cetacean vocalisations and the density of vocalisations have not been investigated and are also not taken into account in this preliminary analysis.

Sightings analysis

Preparing the data

Highest sample sizes were achieved during Transects (T) and High Effort (S).The data analysis presented here, therefore, mainly focus on these survey modes. For comparison, we also give an overview of data obtained during slow speed mode, although the sample sizes are much smaller. Cetacean sightings made during fisheries observations, however, should be regarded as a separate set of data since the presence of trawlers may well influence the behaviour and occurrence of cetaceans.

We pooled probable sightings and definite sightings but excluded possible sightings from further analysis. Re-sightings and duplicate sightings were eliminated from the main data set. Duplicate sightings were identified on the basis of time and sub-sequent re-sightings, species ID, best group size and heading of the animal(s).

The height at which the readings were taken was calculated for each observer by adding the platform height above sea level to the 'height-to-eye' level of each observer. All reticule binocular distances were then converted to radial distances (m) from which perpendicular distances (the right-angle distance between the transect and each detected animal) were calculated.

Radial distances were calculated using the following formula (Buckland *et al.,* 2001):

$$r = \frac{R + v - \sqrt{\{R^2 - r^2\}}}{\tan(\Phi + \Psi)}$$

Where: r = radial distance to sighting (km)
R = radius of the earth ≈ 6,366km
v = vertical height of the binoculars above sea level
Φ = angle between two radii of the earth, one passing through the observer and the other passing through any point on the horizon, as seen by the observer, which is $\cos^{-1}\{(R/R+v)\}$
Ψ = angle of declination between the horizon and the sighting, which is $d \cdot \delta$
d = the number of reticle divisions
h = distance to horizon, which is approximately $h=R \times \tan(\Phi)$
δ = angle of declination between successive divisions on the reticle (radians)

Abundance estimation

Transects were placed over two areas which were similar in size and totalling together 8,872km^2 (between the Scilly Isles and Start Point; *see* Fig. 4). These areas followed the transect design of a previous study during the autumn of 2002 (De Boer and Simmonds, 2003). That particular study was designed to study the distribution and density of small cetaceans along the coasts of Wales and SW England. The survey effort during that survey was stratified according to existing data on distribution, obvious habitat differences, and areas of intrinsic management interest (*see Annex i*). Furthermore, for comparison, the transect design was similar to that of a 'Cardigan Bay survey' conducted in the summer of 2002[3]. Most sampling effort during the autumn 2002 survey was based within 16nmiles. An offshore zone (up to 34 nmiles) was designed during the autumn 2002 survey although no effort was conducted here due to weather conditions. The eastern stratum of this survey coincides with these offshore transects. Both survey strata are depicted in Fig. 4.

Abundance (N) can be estimated as:

$$N = \frac{A \cdot n \cdot s}{2 \cdot L \cdot ESW \cdot g(0)}$$

Where: A = size of study area;
n = number of groups seen;
s = expected group size;

[3] In particular, the 2002-transect design followed transect patterns similar in design to the Cardigan Bay 'snap-shot' survey in summer 2002; Green, pers. comm.)

L = length of transect line surveyed;
ESW = effective half strip width; defined as $1/f(0)$;
$g(0)$ = probability of seeing a group directly on the track line, assumed to be 1.
$f(0)$ = the probability density function (fit to the distribution of perpendicular sighting distances) evaluated at zero distance.

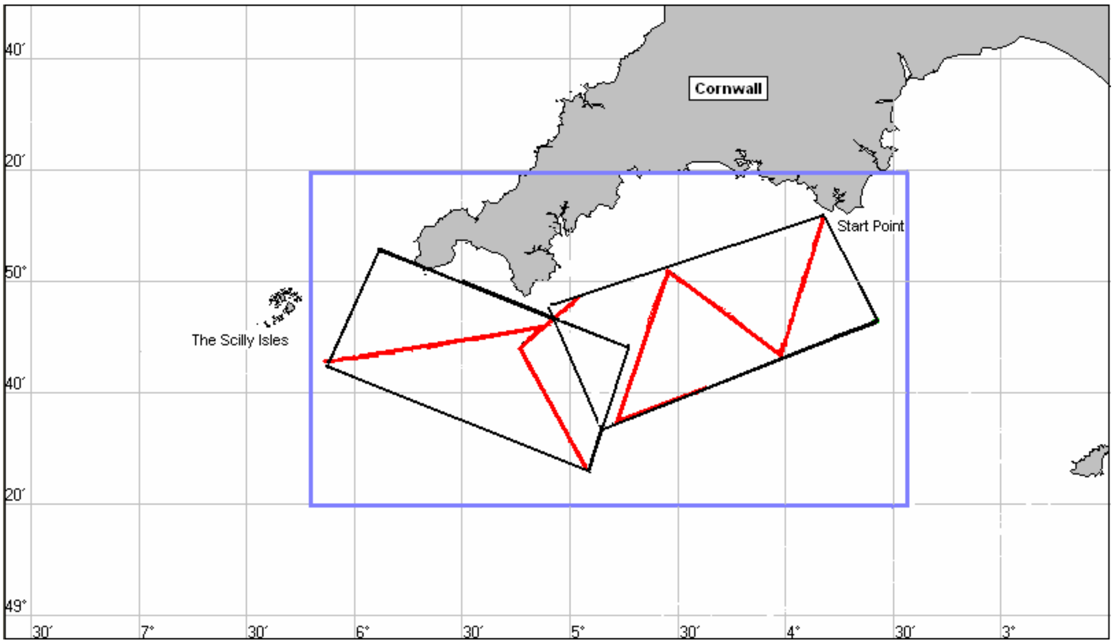

Fig. 4. Map showing the positions of the transect survey design (black boxes) together with plotted transects (red lines) and the main survey area (purple box). [Stratum E is the survey block to the east.]

Assumptions

The line transect method is based on certain assumptions. One of them is that all objects at zero distance from the trackline are detected, that is '*g(0)*' equals one, where '*g(y)*' is the probability that an object at distance *y* from the line is detected. In practise, however, this is likely to not be a valid assumption for cetaceans as they can be missed when spending time underwater. This is the main reason why during line-transect surveys two independent data sets are often collected, because it allows for the calculation of a parameter, *g(0),* to account for animals missed on the trackline. If no correction is made the density estimate and abundance will be negatively biased (Buckland *et al*., 2001; Hammond, 2001).

Another potential problem is that of a 'responsive movement' of the animals to the presence of the survey vessel, since another assumption is that animals do not respond to the surveyor before detection. Common dolphins are known to be attracted to vessels and, if animals respond before detection, this would positively bias the density estimate.

RESULTS

The results from the various parts of the survey (e.g. visual survey, acoustic survey and fisheries observations) are presented below.

Part 1 - Visual survey

Survey effort and summary of sightings

In spite of prolonged periods of bad weather, we were able to conduct systematic survey work (high effort and transects fast survey modes) on 19 days from a total survey period of 48. In addition, fisheries observations were carried out during 19 days.

Systematic surveys following transects lines (T) were conducted for a total of 26:02 hours over 226.1 nautical miles. High effort surveys (S) were conducted for a total of 56:33 hours with 27:18 hours over 232.6 nmiles within the main survey area. Table 3 shows an overview of visual effort during different survey effort modes for the main survey area and elsewhere (*see also Annex i*).

Survey mode		Effort (nautical miles)	Effort (km)	Survey effort (hr:min)	Proportion of Effort (%)
Fast mode	T	226.1	418.7	26:02	3.39
	S	232.6	430.2	27:18	3.56
	S (French Channel)	137.6	254.8	15:26	2.01
	S (Portland)	15.9	29.4	1:53	0.25
	FOF	29.1	53.7	05:16	0.69
Slow mode	TS	25.2	47.1	4:40	0.61
	SLOW	164.2	303.7	25:52	3.37
	SLOW (French Channel)	30.8	57	6:13	0.81
	SLOW (Portland)	26.7	49.6	5:21	0.70
	FOS	68.5	127	16:38	2.17
n/a	Low Effort (Total)	608.9	1127.8	112:10	14.62
	Off Effort (Total)	2260.5	4186.4	369:29	48.16
	Monitoring dead dolphins	25.6	47.4	08:16	1.08
	Other	730.5	1353.4	153:00	19.94
	Total Track	4582.2	8486.2	767:14	100.00

Table 3. Extent of visual effort and tracks lined for various survey modes within the Survey Area unless stated otherwise (*e.g.* the total expedition area (Total), the French part of the English Channel and an area off Portland).

A total of 469 sightings of approximately 3,707 animals were made during the entire expedition. These involved 7 different species. In order of decreasing numbers of detections these included short-beaked common dolphin, harbour porpoise, bottlenose dolphin, Risso’s dolphin (*Grampus griseus*), minke whale, fin whale (*Balaenoptera physalus*) and striped dolphin (*Stenella coeruleoalba*). Of all sightings, 18% remained unidentified. These included 65 sightings of unidentified dolphins (285 animals), 12 unidentified cetaceans (17 animals), 3 ‘like minke whale’, 1 ‘like fin or sei whale’, 1 unidentified baleen whale and 2 unidentified whales.

An overview of sightings made within the survey area during different effort survey modes is depicted in Table 4.

Cetaceans were seen throughout the voyage with a sighting rate of 1.85 sightings/hour during fast modes (T+S). The highest concentration of cetaceans was found in the main survey area where cetaceans were encountered with an average sighting rate of 2.74 sightings/hour during both transect and high effort fast modes. The lowest concentration of cetaceans sighted during the voyage occurred in the French part of the Channel (0.32 sightings/hour) and no sightings were made during high effort (S) in the area off Portland, although an incidental sighting of bottlenose dolphins was reported in Portland harbour.

The highest number of cetaceans seen on a single day during both transect and high effort fast modes (T+S) occurred on the 29th of January 2004 (n=52), between Falmouth Bay and the Scilly Isles. The average sighting rate for that day was 5.78 sightings/hour.

A large proportion of sightings (19%) in the survey area remained unidentified. During the survey, the Beaufort sea state averaged 3.61 (*n*=522, SD 1.72). During transect watches (T) it averaged 1.85 (*n*=43, SD 0.86) and during High Effort (S) it averaged 2.91 (*n*=55, SD 0.9).

FAST MODE			
Species	T	S	T+S
Common dolphin	50 (356)	50 (284)	100 (640)
Harbour porpoise	10 (21)	2 (2)	12 (23)
Bottlenose dolphin	1 (2)	1 (18)	2 (20)
Risso's dolphin	2 (17)	-	2 (17)
Fin whale	-	1(2)	1 (2)
Unidentified dolphin	13 (38)	7 (17)	20 (55)
Unidentified whale	1 (1)	1 (1)	2 (2)
Unidentified cetacean	2 (2)	3 (4)	5 (6)
Total	79 (437)	65 (328)	144 (765)
SLOW MODE			
Species	TS	SLOW	TS+SLOW
Common dolphin	7 (20)	19 (129)	26 (149)
Harbour porpoise	-	4 (16)	4 (16)
Bottlenose dolphin	-	-	-
Fin whale	-	-	-
Minke/bottlenose whale	-	1 (1)	1 (1)
Unidentified dolphin	1 (1)	5 (5)	6 (6)
Unidentified whale	-	-	-
Unidentified cetacean	1 (2)	-	1 (2)
Total	9 (23)	29 (151)	38 (174)
FISHERIES OBSERVATIONS			ALL
Species	FOF	FOS	
Common dolphin	-	30 (346)	156 (1,135)
Harbour porpoise	6(10)	4 (5)	26 (54)
Bottlenose dolphin	-	-	2 (20)
Risso's dolphin	-	1 (20)	3 (37)
Minke whale	-	1 (1)	1 (1)
Fin whale	-	-	1 (2)
Unidentified dolphin	-	5 (37)	31 (98)
Unidentified whale	-	-	2 (2)
Unidentified cetacean	-	-	6 (8)
Total	6 (10)	41 (409)	228 (1,357)

Table 4. Summary of sightings made within the survey area during different effort survey modes, with approximate number of animals in brackets, including the total of sightings during all survey modes within the survey area but excluding incidental sightings (ALL).

Findings per species

The following section summarises main findings for the different species encountered during the survey for different survey modes, followed by a description of mixed-species associations and abundance estimations. Although findings regarding fisheries observations are displayed in tables these are discussed in Part 3 of this report.

Common dolphin

The short-beaked common dolphin was by far the most abundant species seen. Common dolphins are often found in large, active schools with school sizes varying often seasonally and according to the time of day. Schools may range in size from several dozens to over 10,000. Common dolphins typically show active aerial behaviour such as high breaching (leaping high vertically out of the water) and animals are known to bunch tightly together when frightened (Carwardine, 1995).

In the UK, this species is common in the Western Approaches of the English Channel, in the southern Irish Sea (particularly around the Celtic Deep), the Sea of Hebrides and the southern part of the Minches (*see* Evans *et al*., 2003).

Overall, common dolphins comprised 68.4% of all cetacean sightings made within the survey area. A total of 50 sightings were made during transects (T) and an additional 50 sightings during high effort (S; *see* Maps 1-3 in *Annex ii)*. A total of 129 incidental sightings of approximately 1,642 animals within the survey area were also made.

Common dolphins were sighted in waters with an average sea surface temperature of 9.3°C, ranging from 8-10.3, and on average were sighted 14.5 nautical miles from the coast (*see* Table 6). During all pooled effort the proportion of common dolphins seen within 12nmiles was 36%. During fast survey modes this proportion was 48%, whilst during slow survey modes this was 35%. All common dolphins seen during fisheries observations were seen outside the 12nmile zone. Water depths measured at each sighting location averaged 73.62m for this species, ranging from 43.9-93.9m (*see* Table 6).

They were often encountered in groups numbering up to at least 45 animals (best estimate), with an average group size of 6.4, although a group of up to 600 animals (maximum estimate) was reported as an incidental sighting.

Common dolphins often approached the survey vessel to bow or wake-ride, although they were also sometimes seen to remain at a distance, apparently feeding and often accompanied by gannets (*Sula bassana*). During one such 'feeding frenzy', on the 9th of February, a mixed-species association was reported of common dolphins and harbour porpoises.

Only on a few occasions were groups containing juveniles and calves encountered, comprising only 2.34% of all animals seen within the survey area during both Transect (T) and High Effort modes (S).

Natural markings
Photographs were taken during the many encounters with this species and examples of a photo-catalogue showing animals with identifiable features (such as nicks and scars) are included in *Annex iii.*

In addition, photographs are shown of flank markings. Two types were identified; one showing a black lateral stripe continuing into the yellow patch on the flank; whilst the other type did not continue into the yellow patch (*see* Photos 1&2 in *Annex iv*).

The amount of pigmentation on the dorsal fins varied highly with some dolphins having almost completely pale dorsal fins, whilst others had less or no pigmentation at all (*see* Photos 3-4 in *Annex iv*).

Initial sighting cues

During fast survey modes (T+S) 'splash' was reported as an initial cue more than during slow survey modes (SLOW+TS). Also 'back/dorsal' was reported less often during fast modes in comparison to slow survey modes (*see* Table 5).

Initial Cue	T+S %	SLOW+TS %	FOS %
Back/dorsal	44	65	66
Splash	23	4	7
Breach	22	23	7
Underwater	6	8	-
Blank (no cue reported)	5	-	20

Table 5. Percentage of initial cues reported for sightings of common dolphins made during different survey modes, e.g. fast mode (T+S), slow mode (SLOW+TS) and fisheries observations (FOS).

Common dolphin					
Effort mode		**Temperature (°C)**	**Water depth (m)**	**Distance to shore (nmiles)**	**Group size**
Fast (T+S)	*n*	68	85	100	100
	x	9.38	75.82	13.02	6.4
	SD	0.66	8.01	6.05	8.48
	Range	8-10.3	61-93.9	3.29-32.1	1-45
Slow (TS+SLOW)	*n*	19	16	25	26
	x	9.07	66.02	14.31	5.73
	SD	0.67	9.54	6.57	6.97
	Range	8.1-9.9	43.9-81.3	2.8-20.5	1-33
Fisheries Obs. (FOS)	*n*	30	12	30	30
	x	9.36	73.16	19.46	11.53
	SD	0.41	6.7	5.76	12.49
	Range	8-10	67.9-92	14-37.9	1-45
ALL	*n*	117	112	155	155
	x	9.32	73.62	14.51	7.32
	SD	0.61	10.5	6.54	8.27
	Range	8-10.3	43.9-93.9	2.8-37.9	1-45

Table 6. Water temperature, depth, distance to shore of common dolphin sighting location and group size of definite and probable sightings encountered within the main survey area during different effort modes, where 'ALL' represents pooled effort.

Observed behaviour

During fast speed modes (T+S), the most frequently reported behaviour of common dolphins was that of travelling fast (16.67% of all reported behaviours) and porpoising (16.05%, *see* Table 5). Bow-riding comprised about 10.5% of all behaviours and animals were reported either in a tightly grouped composition (9.88%) or as 'Loose' (9.26%, *see* Table 7).

During slow survey modes (SLOW+TS), the most frequently encountered travel speed was slow (27.3%) with animals either in a tightly grouped composition (18.2%) or 'Loose' (18.2%). Furthermore, the animals were actively involved in bow riding the vessel (11.4%, *see* Table 7).

In summary, dolphins were mostly reported travelling fast during fast survey modes and slow during slow survey modes. The amount of porpoising was high throughout the different survey modes, but was exceptionally high during fisheries observations. The dolphins often came to bow-ride, sometimes for extended periods of time, and displayed full breaches (although this was not observed during fisheries observations). Groups of dolphins were mainly 'tight' (*i.e.* closely bunched – see below) or seen in 'loose' formation.

Behaviour		Description	T+S %	SLOW+TS %	FOS %
Travel	*Travel fast*	Fast speed in a given direction	16.67	11.36	11.11
	Travel Medium	Cruising speed in a given direction	9.88	2.27	8.88
	Travel slow	Slow movement in a given direction	6.79	27.27	22.22
	Milling	Slow movement not in any particular direction, showing frequent changes in their heading	1.23	2.27	6.66
Group composition	*Loose*	One group of animals which is loosely grouped, *e.g.* animals are more than 2-5 body lengths from each other	9.26	18.18	2.22
	Tight	One group of animals which remain in a tight group formation, *e.g.* within one body length from each other	9.88	18.18	4.44
	Spread out	No obvious group formations, *e.g.* >5 body lengths from each other	0.62	-	-
	Groups Loose	Different groups are in the area, but each group is loosely grouped, *e.g.* animals within each group are more than 2-5 body lengths from each other	4.94	-	-
	Groups tight	Different groups are in the area, but each group is tight, *e.g.* animals within each group are within one body length from each other	1.23	-	2.22
Surface behaviour	*Porpoising*	High surfacing during fast swimming, with half of body width or more in air	16.05	2.27	24.44
	Full Breach	Lifting the whole body above surface. Noisy re-entry by hitting the surface with the lateral body surface	8.02	4.55	-
	Logging	Motionless at the surface for some seconds, blowhole above surface	0.62	-	-
	Bow ride	Gliding/swimming on pressure wave in front of boat	10.49	11.36	8.88
	Feeding	Dolphins involved in any effort to capture prey as evidenced by chasing fish, co-ordinated deep diving and rapid direction changes	0.62	-	6.66
	Scouting	Brief approach toward the vessel up to a few metres and then moving away	0.62	2.27	2.22
	Spy hop	Head and eyes above water, head vertical	0.62	-	-
	Sharking	Swimming below the surface showing the dorsal fin, often making rapid directional changes	2.47	-	-

Table 7. Percentages of different reported behaviours for common dolphins during fast survey modes (T+S), slow survey modes (SLOW+TS) and during Fisheries Observations (FOS). Grey cells show the behaviours which showed highest percentages of all reported behaviours. Behaviours were reported when dolphins were sighted first and when changes in behaviour occurred these were entered as re-sightings.

Abundance estimate for common dolphin

Sightings made by the primary team were pooled for both survey blocks (strata). Sightings made aft of the beam were excluded from the dataset resulting in a sample size of 44, which, although low, is a sample size that we regarded as adequate to warrant calculation of abundance estimation.

Examining the histograms of perpendicular sighting distance revealed several outliers, which are difficult to model. Sightings beyond 650m were therefore eliminated. This resulted in the loss of only 2 observations (5% of all sightings), falling under the 5-10% truncation levels recommended by Buckland *et al*. (1993).

Using the program Distance (Laake *et al*., 1993) we fitted detection functions to the perpendicular distance data to estimate *ESW*, which is defined as *1/f(0).*

To reduce bias in mean group size estimates due to the potential of a positive relationship between group size and perpendicular distance *(x)*, a regression was performed to show the relationship between the probability detection function, *g(x),* and observed group size (Buckland *et al*., 1993). From this regression, an expected group size was estimated. A Student's *t*-test was performed to test for difference between the actual mean group size and the expected mean group size (p<0.15).

Model	n	ΔAIC	AIC	χ^2	df	p
Half-normal/cosine	42	0.00	143.36	1.8494	4	0.7634

Table 8. Goodness of fit tests statistics and AIC value for models fitted to the transect data with 6 groups and width of 600m.

Akaike's Information Criterion (AIC) was used to select among models fitted to the data. The goodness of fit for different models was assessed using the χ^2 value and its degrees of freedom. Out of the models tested, the half-normal key with cosine adjustment was found to be the best fit (*see* Table 8). The distribution of perpendicular distances and fitted detection function are shown in Fig. 5.

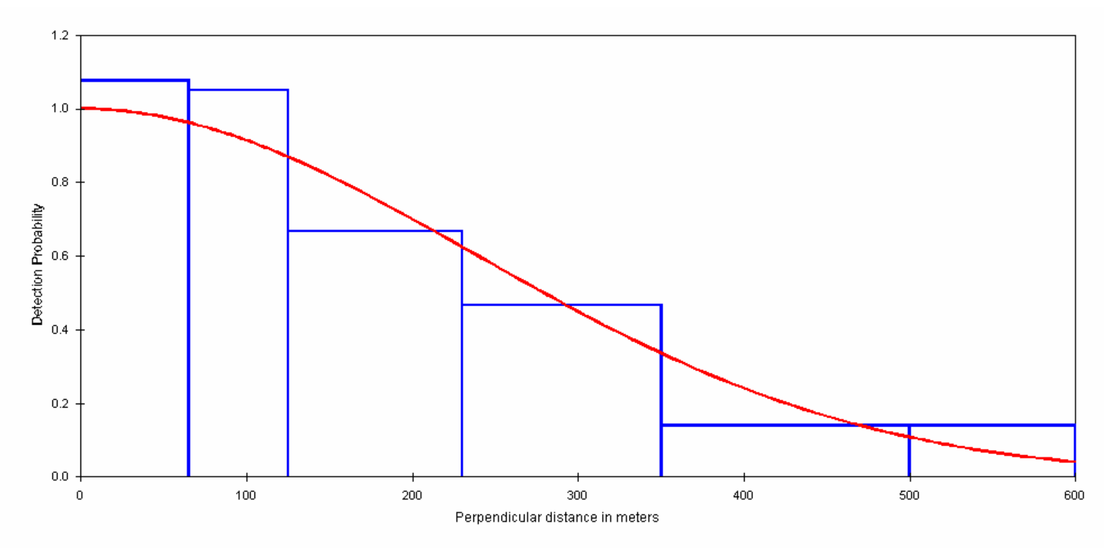

Fig 5. Frequency distribution of sightings within binned perpendicular distances, and fitted detection function for common dolphins during fast transect survey mode.

Having selected a Model, we reviewed the options for variance estimation. Bootstrapping was carried out which incorporates uncertainty in model fitting and model selection was carried out. Although survey effort was achieved in both strata some concerns are given to the western stratum where there were large differences between the designed and the realized cruise tracks (*see* Chart 1). Data for both strata were pooled to calculate the effective half strip width (*ESW*). For the eastern stratum (Stratum E; 4,129 km^2) the designed survey coverage was achieved so the density estimate should not be biased by non-uniform distribution of animals. The combined density estimate for both strata is more sensitive to non-uniform distribution of animals since only a relatively small proportion of the designed survey coverage was achieved in the western stratum. Results are depicted in Table 9.

The estimate of the density of individuals (D) for Stratum E was calculated as follows (Buckland *et al.*, 2001):

$$D = \frac{n \cdot f(0) \cdot s}{2 \cdot L}$$

This revealed an estimate D of 0.688 individuals/ km^2 (*see* Table 9). We calculated the coefficient of variation of estimated density using the formula: $cv(D) = se(D)/D$ where $se(D)=\sqrt{var(D)}$ and where $var(D)=D^2\{cv(n)^2+cv[f(0)]^2 + cv(s)^2\}$

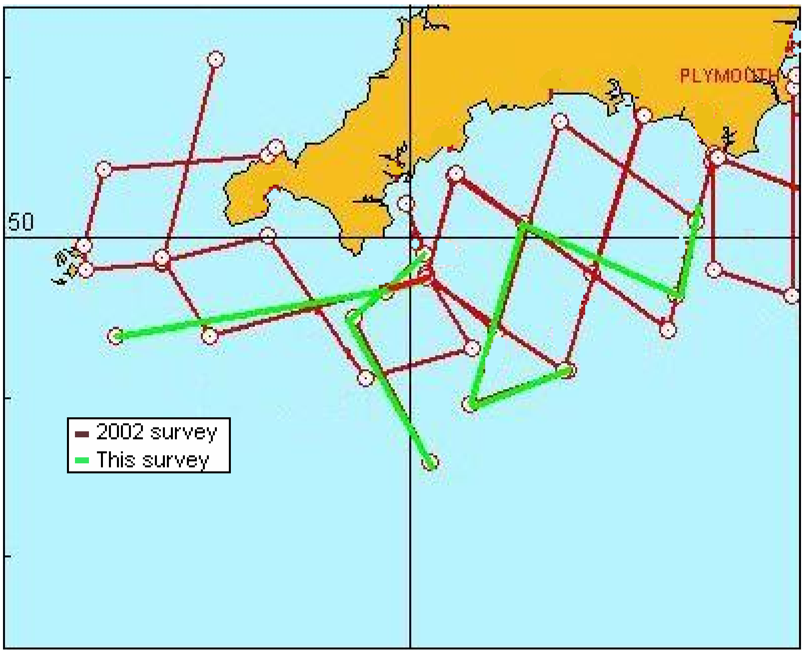

Chart 1. Survey design of the 2002 survey (in red) including survey effort obtained during this survey (in green).

Both strata	Area km^2	Effort *L* (km)	Number of schools *n*	*n*/L	*f(0)*	*ESW*	Expected group size (*s*)	Density (*D*) of individuals (ind/km^2)	Abundance *N*
Estimate	8,872	448.9	42	0.094	3.402	0.294	6.8767	1.094	9,708
%CV				41.76	24.24	12.43	20.52	33.44	33.44
Lower 95% Confidence Limit				0.037	2.099	0.228	4.562	0.541	4,799
Upper 95% Confidence Limit				0.236	5.512	0.377	10.367	2.214	19,639
Stratum E	**Area (km^2)**	**Effort *L* (km)**	**Number of schools *n***	***n*/L**	***f(0)***	***ESW***	**Expected group size (*s*)**	**Density (*D*) of individuals (ind/km^2)**	**Abundance *N***
Estimate	4,129	305.9	18	0.059	3.402	0.294	6.8767	0.688	2,841
%CV				35.23	24.24	12.43	20.52	47.96	47.96
Lower 95% Confidence Limit				0.026	2.099	0.228	4.562	0.041	169
Upper 95% Confidence Limit				0.136	5.512	0.377	10.367	1.335	5,512

Table 9. Estimated model parameters, *f(0)* (the probability density function evaluated at zero distance), Effective half Strip Width (*ESW*), density and abundance of short-beaked common dolphins in the Western Approaches of the English Channel during the winter months (Jan-March 2004) for the total area and for the eastern stratum (Stratum E).

Bias

Conventional line-transect estimates can be biased as a result of responsive movement of the target species (Buckland *et al*., 1993). This is a major issue for common dolphin surveys in general and was evident in our data, which resulted in a very narrow strip width (*ESW* 294m).

We pooled data for sightings of common dolphins in sea state ≤2.5 (to make sure that higher sea states were not affecting the data), excluding re-sightings and sightings aft of the beam during T+S (fast survey mode) and compared these to sightings during slow speed mode (TS and SLOW). Both radial and perpendicular distance plots (*see* Fig. 6&7) show substantial peaks in the first bin (less than 100m), which is likely to be related to responsive movement of the animals to the vessel. The peak is more pronounced at slow speed than at fast speed and this indicates that the effect is related to the behaviour of the animals rather than an observer related effect (which would have resulted in a less pronounced peak at slow speed).

We then explored this responsive movement further by using a vector component of the dolphin's velocity away from the vessels (*i.e.* the cosine of the difference between bearing and heading, where a value of '1' indicates a heading directly away from the vessel, '-1' directly towards and '0' perpendicular). The results, depicted in Figure 8, show a distinct large peak close to '-1', *i.e.* the majority of sightings are approaching the vessel. When excluding closest sightings (< 100m radial distance), the effect is still apparent but is slightly less for the slow speed modes. When only sightings with a distance in the 25 percentile farthest from the boat are included in this analysis, the effect for fast speed mode is still apparent, whilst this effect is no longer significant for slow speed (*see* Figures 9&10).

It appears that there are two effects, one is a 'movement' effect and the other is a 'sightability' effect. The heading data for the fast speed mode indicates that there is no evidence that dolphins were detected before responsive movement. If dolphins were not detected before this response to the vessel, then the abundance estimate is likely to be severely biased to a higher estimate. For slow speed, however, the heading data indicated that dolphins appeared to be detected before responsive movement but because the detection function in itself was more peaked compared to fast speed mode, we conclude that this is probably due to an observational/detectability effect (*e.g.* surfacing behaviour changes your ability to sight an animal). Indeed, it could well be that dolphins that are approaching a fast moving vessel are more likely to surface in the 'middle class' of distances (around 200-300m) whereas dolphins that are approaching a slow moving vessel tend to surface much closer (<100m).

For comparison we have included a graph showing the distribution of headings for all porpoise sightings (*see* Fig. 11). Unlike for the common dolphin, there is no significant attraction to the vessel.

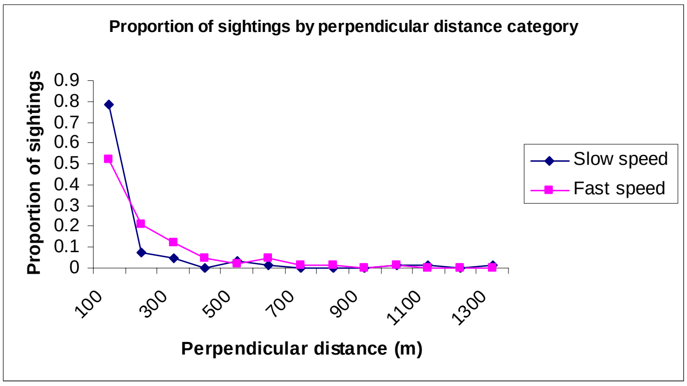

Fig. 6. Proportion of sightings by perpendicular distance category for different speed modes, *e.g.* 'Slow' speed (SLOW+TS) 'Fast' speed (T+S) during survey effort ≤2.5 sea states.

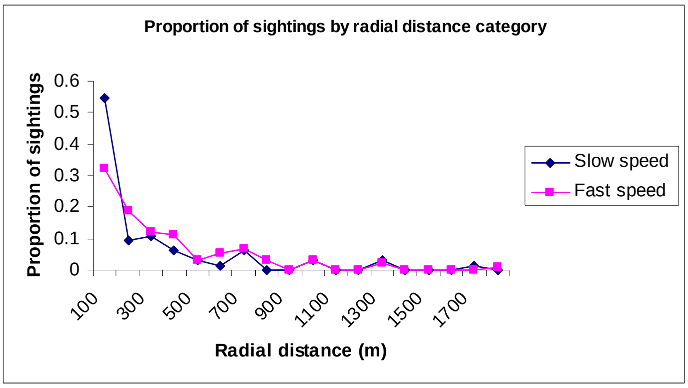

Fig. 7. Proportion of sightings by radial distance category for different speed modes, *e.g.* 'Slow' speed (SLOW+TS) and 'Fast' speed (T+S) during survey effort ≤2.5 sea states.

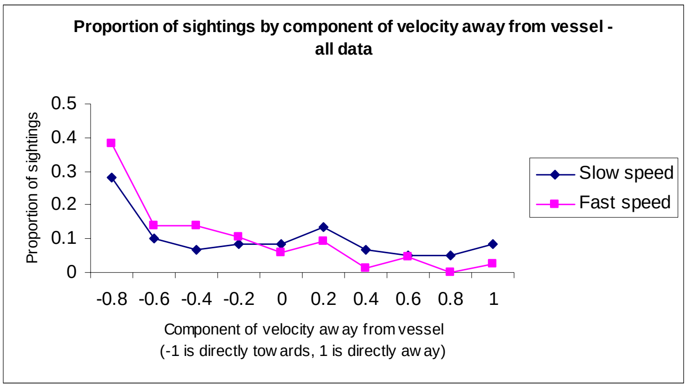

Fig. 8. The proportion of sightings by component of velocity away from the vessel (*i.e.* the cosine of the difference between bearing and heading) during different speed modes, *e.g.* 'Slow' speed (SLOW+TS) and 'Fast' speed (T+S) during survey effort ≤2.5 sea states. Where a value of '1' indicates a heading directly away from the vessel, '-1' directly towards and '0' perpendicular.

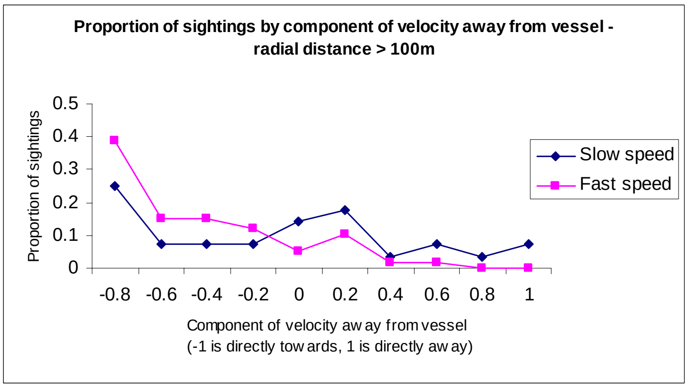

Fig. 9. The proportion of sightings with a radial distance > 100m by component of velocity away from the vessel (*i.e.* the cosine of the difference between bearing and heading) during different modes, *e.g.* 'Slow' speed (SLOW+TS) and 'Fast' speed (T+S) during survey effort ≤2.5 sea states. Where a value of '1' indicates a heading directly away from the vessel, '-1' directly towards and '0' perpendicular.

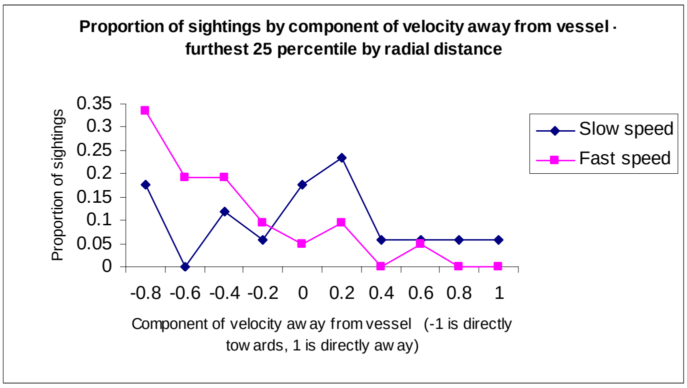

Fig. 10. The proportion of sightings with the furthest 25 percentile of radial distance (520-1,700m) by component of velocity away from the vessel (*i.e.* the cosine of the difference between bearing and heading) during different speed modes, *e.g.* 'Slow' speed (SLOW+TS) and 'Fast' speed (T+S) during survey effort ≤2.5 sea states. Where a value of '1' indicates a heading directly away from the vessel, '-1' directly towards and '0' perpendicular.

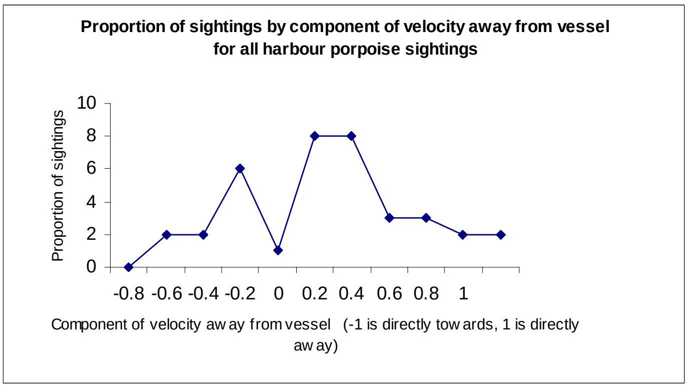

Fig. 11. The proportion of porpoise sightings by component of velocity away from the vessel (*i.e.* the cosine of the difference between bearing and heading) during survey effort ≤2.5 sea states. Where a value of '1' indicates a heading directly away from the vessel, '-1' directly towards and '0' perpendicular.

Harbour porpoise

The harbour porpoise was the second most frequently seen cetacean. This usually timid cetacean tends to travel quite slowly. It has a characteristic swimming pattern of several short, rapid surfacings followed by an extended dive of up to several minutes. Porpoises are typically unobtrusive and very difficult to observe in rough weather (Palka, 1996). Unless sea conditions are virtually flat, porpoise numbers may easily be under-estimated. Unlike many dolphin species, the harbour porpoise is shy and rarely approaches boats. This characteristic is supported by our findings (*see* Fig. 11).

Population estimations of porpoises were made during the Small Cetacean Abundance in the North Sea (SCANS) survey in 1994 (Hammond *et al*., 1995). However, the SCANS estimates are only relevant to summer months and, like other surveys (including our own), are affected by the distribution effort within survey blocks and the weather. The estimate for total surveyed area (the North Sea and Celtic Sea and adjoining waters) was some 340,000 harbour porpoises. A population of this size might be taken as an indication of a secure future. However, the population in the Celtic Sea area, which is thought to be a separate population from that in the North Sea, was estimated to be 36,000 animals. Also, the porpoise has declined or disappeared from many areas around the UK where it was recorded historically. In Cornwall, for example, there has been a suggested 90% reduction in sightings of porpoises over the last 50 years (Tregenza, 1992).

Porpoises accounted for 11.4% of all sightings within the survey area. A total of 12 sightings were made during fast survey mode (T+S) with an additional 10 sightings made during fisheries observations (FOF; *see* Map 4 in *Annex v*).

Porpoises were seen in groups (1-10) with an average group-size of 2.1 (*see* Table 11) although one incidental sighting (made during fisheries monitoring) was of a group of at least 15 animals. The majority of larger groups were assumed to be feeding as seabirds were seen diving nearby. On the 11th of February, an unusually close-knit group of at least 10 animals were seen 6.5 nmiles off Lizard Point. The animals were touching each other whilst surfacing in a rather slow rolling motion, arching their backs but then not disappearing for a deep dive. No birds were interacting with the porpoises and it is not clear whether these animals were feeding or perhaps socialising.

Harbour porpoise					
Effort mode		Temperature (°C)	Water depth (m)	Distance to shore (nmiles)	Group size
Fast (T+S)	*n*	9	11	12	12
	x	9.76	74.56	17.76	1.92
	SD	0.42	4.68	6.46	2.57
	Range	8.9-10.5	65.8-80.4	4.42-26	1-10
Slow (TS+SLOW)	*n*	4	4	4	4
	x	9.5	66.1	4.88	4
	SD	0	4.32	0.54	4
	Range	9.5	63.6-72.5	4.6-5.7	2-10
Fisheries Obs.	*n*	10	3	10	10
(FOS+FOF)	*x*	9.3	77.13	22.42	1.5
	SD	0.5	12.3	6.37	0.85
	Range	8.9-10	68.8-91.2	16.7-39.5	1-3
ALL	*n*	23	18	26	26
	x	9.5	73.1	17.57	2.07
	SD	0.47	7.05	8.26	2.41
	Range	8.9-10.5	63.6-91.2	4.42-39.5	1-10

Table11. Water temperature, depth, distance to shore of harbour porpoise sighting location and group size of definite and probable sightings encountered within the main survey area during different effort modes, where 'ALL' shows the pooled data set of T+S+TS+SLOW+FOS and FOF.

Porpoises approached the survey vessel on just two occasions and both were at the entrance to Dingle Bay (Ireland) during very rough weather. Firstly an adult accompanied by a calf was sighted and later an adult with a juvenile was sighted. For the majority of the time, however, porpoises maintained their course and speed and did not approach the vessel.

Porpoises were seen amongst groups of feeding common dolphins on two occasions on the 9th of February. On one of these occasions they were also accompanied by feeding gannets.

The average surface water temperature for each porpoise sighting location was 9.5°C and the average distance to shore ranged from 4.42 to 39.5 n miles. During slow survey modes (SLOW+TS) porpoises were encountered closer to shore, between 4.6-5.7 nmiles. With group sizes varying between 2-10 animals, porpoises were seen in waters with depths ranging from 63.6 to 91.2m (*see* Table 11).

Only one calf was reported during fast survey modes, although, 1 juvenile and 2 calves were also amongst the incidental sightings.

Bottlenose dolphin

Bottlenose dolphins are very active and curious animals that are capable of travelling at great speed. They are large dolphins and are regularly seen riding in the bow waves and wake of passing vessels. They can also sometimes put on incredible displays of acrobatics. They have a diverse repertoire of hunting techniques that includes the pursuit of individual prey, co-ordinated herding and foraging for discarded fish from fishing vessels (Wells and Scott, 2002).

There are two well-established populations in the UK: the first is in Cardigan Bay, west Wales, and the second in the Moray Firth, northeast Scotland. A third group of bottlenose dolphins has recently been confirmed to exist around the Cornish, Devon and Dorset coasts. This group of dolphins, the 'Cornish group', seemingly "reappeared" on this coastline after having been missing from the area since the 1970s. The Cornish group seem to travel more in spring and summer time than at other times and it is thought that the dolphins occupy a linear range of coast of 650km (Wood, 1998). Bottlenose dolphins are also widespread throughout the Hebrides and around the Channel Islands. Further out at sea, bottlenose dolphins have mainly been reported in the Celtic Shelf area and in the central North Sea (Simmonds *et al*., 1997).

Bottlenose dolphins were reported seven times throughout the survey (*see* Map 5 in *Annex v*). One incidental sighting was made on the 28th of January approximately 4 n miles South of Looe Island comprising of a group of 5 animals. On the 29th of January, a sighting of 2 bottlenose dolphins was made during transect survey at approximately 12.8 n miles SE of the Scilly Isles. The animals were travelling fast and one animal seen half breaching at the stern of the survey vessel.

On the 2nd of February in Dingle Bay, Ireland, an incidental sighting of a group of at least 10 animals, was made in rather heavy seas. A single possible bottlenose dolphin was reported amongst a group of common dolphins during high effort (S) on the 16th of February.

On the 3rd of March in Plymouth Harbour, another incidental sighting was made of at least 12 animals. A group of 18 bottlenose dolphins were then seen on the 7th of March during high effort approximately 11.8 n miles south of Start Point. This group was seen travelling fast and briefly bow riding. One calf was reported in the group. The next day, the 8th of March, a group of at least 25 animals, including 2 calves showing foetal folds were seen in an area SE of Portland.

The average surface water temperature at each sighting location (T+S) was 8.9°C and the distance to shore ranged from 11.86-12.8 n miles. Bottlenose dolphins were seen in waters with depths ranging from 64.8-85.4m (*see* Table 10).

During the encounters photo-identification studies were carried out and examples of a photo-catalogue showing animals with identifiable features is shown in *Annex viii.*

Bottlenose dolphin					
Effort mode		Temperature (°C)	Water depth (m)	Distance to shore (nmiles)	Group size
Fast (T+S)	*n*	2	2	2	2
	x	8.9	75.1	12.33	10
	SD	0.28	14.57	0.66	11.31
	Range	8.7-9.1	64.8-85.4	11.86-12.8	2-18

Table 10. Water temperature, depth, distance to shore of bottlenose dolphin sighting location and group size of definite and probable sightings encountered within the main survey area during different effort modes (T+S).

Risso's dolphin

Risso's dolphins are large robust dolphins without a beak. They are much scarred, probably as a result of social interactions with other Risso's. As the dolphin ages, the number of scratches and marks on the body increases, leading to a change in the overall colour of the body over time, from dark grey when young to almost white in old animals.

Risso's are widely distributed along the West of the UK, including the Western Approaches of the English Channel, the Irish Sea and the Western and Northern Isles of Scotland.

Risso's dolphins were seen twice when surveying transects on the 11th of February (*see* Map 8 *Annex v*). These sightings were made within 10 minutes of each other. Indeed, during the first sighting the dolphins were reported to be widely spread out with small loosely-grouped animals scattered throughout the visual area. A best group size estimate of 15 animals and a maximum of 20 were recorded. The dolphins were highly surface active as frequent high leaps and half breaches were observed. The next sighting, was that of 2 tight dolphins which were travelling at a moderate speed and parallel to the vessel, followed by one dolphin logging at approximately 300m from the vessel.

We also made a sighting of Risso's dolphins on the 10th of February, during fisheries observations (*see* Map 8 in *Annex v*). A group of at least 20 animals were reported to be spread out in no obvious group formations. The animals were highly surface-active and the following behaviours were observed: high leaps, sharking and body slaps. The animals were changing direction frequently and were thought to be feeding. Indeed, they remained submerged for lengthy periods of time. This sighting was made in the vicinity of operating pelagic trawlers. The average surface water temperature was 10.03°C and the distance to shore ranged from 21.3 to 41.4 nmiles. Risso's dolphins were seen in waters with depths averaging 87.7m (*see* Table 12).

Risso's dolphin					
Effort mode		Temperature (°C)	Water depth (m)	Distance to shore (nmiles)	Group size
Fast (T)	*n*	2	2	2	2
	x	10.1	86.55	21.95	8.5
	SD	0	0.64	0.92	9.19
	Range	0	86.1-87	21.3-22.6	2-15
Fisheries Obs. (FOS)	*n*	1	1	1	1
	x	9.9	90	41.4	20
	SD	0	0	0	0
	Range	0	0	0	0
T+FOS	*n*	3	3	3	3
	x	10.03	87.7	28.4	12.33
	SD	0.11	2.04	11.25	9.29
	Range	9.9-10.3	86.55-90	21.3-41.4	2-20

Table 12. Water temperature, depth, distance to shore of Risso's dolphin sighting location and group size of definite and probable sightings encountered within the main survey area during different effort modes (T,FOS and T+FOS).

Fin whale

The fin whale is the second largest whale species and can reach up to 24 metres in length. These whales are usually seen alone or in pairs, although larger aggregations can occur in productive feeding areas. The first sign of a fin whale is usually its tall blow (which can rise up to 8m). They have a variety of feeding techniques and hunt a variety of prey, especially spawning herring, capelin, sand lance and planktonic copepods. These whales are rare in the shallow coastal waters of the UK, although during recent winters they have been regularly observed in coastal areas off southern Ireland, west of Cornwall and in the Celtic Deep. The presence of mother and calf pairs amongst those sightings may indicate that this region may be used as a mating and calving ground, with the mating season peaking in December and January (Evans, 1992).

On the 28th of January, a fin, or possibly a sei, whale (the two being very similar) was incidentally sighted in the vicinity of trawlers near Falmouth, 6 n miles SSE off Dodman Point (*see* Map 7 in *Annex v*). A small group of unidentified dolphins were seen riding the bow wave created by the whale. On the same day, approximately one hour later, one unidentified baleen whale was seen approximately 9.2 n miles SE off Dodman Point, with pelagic trawling operations in vicinity of the animal (*see* Map 6 in Annex). The next day, 2 fin whales were sighted during High Effort (*see* Map 7 in *Annex v*). The animals were seen in waters of 9.5°C and the average distance to shore was 11 n miles SSE off Dodman Point. The whales were seen in waters with a depth of 68.2m (*see* Table 13).

It is interesting to note that a group of fin whales, including 1 calf was also reported in the area on the 14th and 16th of February by the company Orca Sea-faris that operates from Falmouth (K. Reeves, pers. comm).

Fin whale					
Effort mode		Temperature (°C)	Water depth (m)	Distance to shore (nmiles)	Group size
Fast (S)	*n*	1	1	1	1
	x	9.5	68.2	11	2
	SD	0	0	0	0
	Range	0	0	0	0

Table 13. Water temperature, depth, distance to shore of fin whale sighting location and group size of definite and probable sightings encountered within the main survey area during high effort survey mode (S).

Minke whale

The minke whale is the smallest and most commonly encountered baleen whale in the North Atlantic. They are usually encountered singly, but can be seen in pairs and small groups. Minkes can be rather inquisitive and may approach passing or stationary vessels, turning on their sides as they swim by or spy-hopping to take a look.

Minkes are largely absent from deeper parts of the Bay of Biscay. In the Irish Sea, the species occurs mainly on the western side (Evans, 1992; Northridge *et al*., 1995; Evans *et al*., 2003)

One sighting was made of a minke whale on the 10th of February during fisheries observations approximately 35.5 nmiles offshore and in waters of 10°C (*see* Table 14; *see* Map 6 in *Annex v*). The animal was later also seen from a RIB, which the animal approached. The animal was photographed (*see* Photo 1) and showed a distinct nick in its dorsal fin *(see Annex ix*). The animal also swam on its side on approaching the vessel and lifted its head out of the water on one occasion.

Minke-like animals, possibly either a minke or Northern bottlenose whale (both species can be difficult to distinguish when seen from the wrong angle) were sighted on the 10th of February, the 13th of February and one was seen surfacing close to the vessel on the 7th of March (*see* Map 6 in *Annex v*).

Minke whale					
Effort mode		Temperature (°C)	Water depth (m)	Distance to shore (nmiles)	Group size
Fisheries Obs. (FOS)	*n*	1	1	1	1
	x	10	94	35.5	1
	SD	0	0	0	0
	Range	0	0	0	0

Table 14. Water temperature, depth, distance to shore of a minke whale sighting location and group size of this definite sighting encountered within the main survey area during fisheries observations (FOS).

Striped dolphin

The striped dolphin can often be seen leaping clear of the water or moving quickly towards the bow or wake of passing vessels. In the UK, striped dolphins are relatively rare, with most sightings from the Western Approaches of the English Channel between July and September (Evans *et al*., 2003). In recent years, an increase in the number of records along the UK coasts suggests a possible range extension of this species, which may be related to changes in water temperature (Isaksen and Syvertsen, 2002; Collet and Evans, *in press*)

We only sighted one probable striped dolphin on the 28th of January amongst a group of at least 25 common dolphins (*see* Map 6 in *Annex v).* The animal was seen leaping clear out of the water. Bad weather conditions made further observations difficult but it is likely that there were more striped dolphins involved in this mixed-species association but photographs revealed no further positive identifications of this species.

Mixed-species associations

Apart from the striped/common dolphin mixed-species association, three other mixed-species sightings were reported during the survey. On the 29th of January, a group of unidentified dolphins was seen riding the bow wave created by a fin/sei whale. On the 9th of February, during a 'feeding frenzy', a mixed-species association was reported of common dolphins and harbour porpoises and, finally, a single possible bottlenose dolphin was reported amongst a group of common dolphins on the 16th of February.

Photo 1. Minke whale with fulmar (Kate Davison/Greenpeace)

Relative abundance of all species
The relative abundances calculated for different species of cetaceans encountered during different survey modes within the survey area are presented in Table 15.

The common dolphin had the highest combined relative abundance of 12.02 sightings per 100km, which peaked during fisheries observations (22.84). The harbour porpoise was less frequently encountered than the common dolphin. Additional sightings made of porpoises during fisheries observations indicated a more ‘patchy’ distribution for this species, which is reflected in the relative abundance during fisheries monitoring (FOF+FOS; 10.2). The latter was particularly apparent on the 5th of March when, within the space of one hour, a total of 9 porpoise sightings were reported during fisheries observations. The remaining less commonly encountered species were Risso’s dolphin, bottlenose dolphin, fin whale and minke whale. No relative abundance was estimated for striped dolphins, as this species was only encountered once during low effort and its identification was only ‘probable’.

It is worth noting that the relative abundance of common dolphins sighted during fast survey mode in the French part of the Channel was 1.2 sightings per 100km, much lower than that compared to the survey area (*e.g.* northern part of the Channel). Although less effort was conducted here, these findings indicate that common dolphins tend to concentrate in the northern part of the Channel (*see Annex I cont.* for information on effort in the French part of the Channel).

Species	Survey mode	*N*	Effort (km)	*N/L*
Common dolphin	T+S	100	848.9	11.49 (0.23)
	SLOW+TS	31	354.8	8.74 (0.32)
	FOS	29	127	22.84 (0.55)
	ALL	160	1,330.7	12.02
Harbour porpoise	T+S*	11	636.5	1.73 (0.46)
	SLOW+TS*	4	141.8	2.82 (0.88)
	FOS+FOF*	14	137.7	10.2 (0.46)
	ALL*	29	916	3.17 (0.41)
Bottlenose dolphins	T+S	2	848.9	0.24
Risso’s dolphin	T+S	2	848.9	0.24
Fin whale	FOS	1	127	0.79
	T+S	1	848.9	0.12
	ALL	2	975.9	0.2
Minke whale	FOS	1	127	0.79
All cetaceans (including unidentified animals)	ALL	228	1,341.4	16.99

Table 15. The relative abundance (*N/L*) of cetaceans within the survey area measured as the number of sightings per 100km for different survey modes (T+S; SLOW+TS; FOF+FOS;FOS; and ALL for pooled effort). *N* is the number of sightings and the coefficient of variation of each estimate is shown in brackets. * These included survey effort of only sea states ≤2.5 since porpoises are virtually impossible to sight in higher sea states.

Part 2 – Acoustic survey

In addition to the visual survey, acoustic monitoring was carried out by an independent survey team. The hydrophone allowed us to continue to monitor cetaceans during hours of darkness and when environmental conditions were inappropriate to allow for visual observations.

Acoustic effort

The hydrophone was in use for 21 days between the 13th of February and the 4th of March 2004, during which 170 hours of monitoring were possible. Of this, approximately 95 hours of dual acoustic and visual survey were conducted. This included 27 hours during the 'fast' effort modes (S, T and FOF) and 26 hours were conducted during the 'slow' effort modes (SLOW, TS and FOF; *see* Fig. 12). Seventy-five hours were conducted during off effort, when no visual survey was being conducted. A further 42 hours monitoring coincided with incidental effort modes.

The acoustic effort was concentrated in an area to the south of Start Point, west of Jersey and east of Lizard Point. Short transit legs, straight diagonal transect lines, horizontal search patterns and random tracks during fisheries observations are all visible (*see* Fig. 12.). Figure 12 shows that dolphins were detected over much of this area although detections are largely confined to the UK part of the Channel. More effort was focussed here than in French waters, however, and because of this uneven effort coverage it is not possible to make inferences about the spread of acoustic contacts.

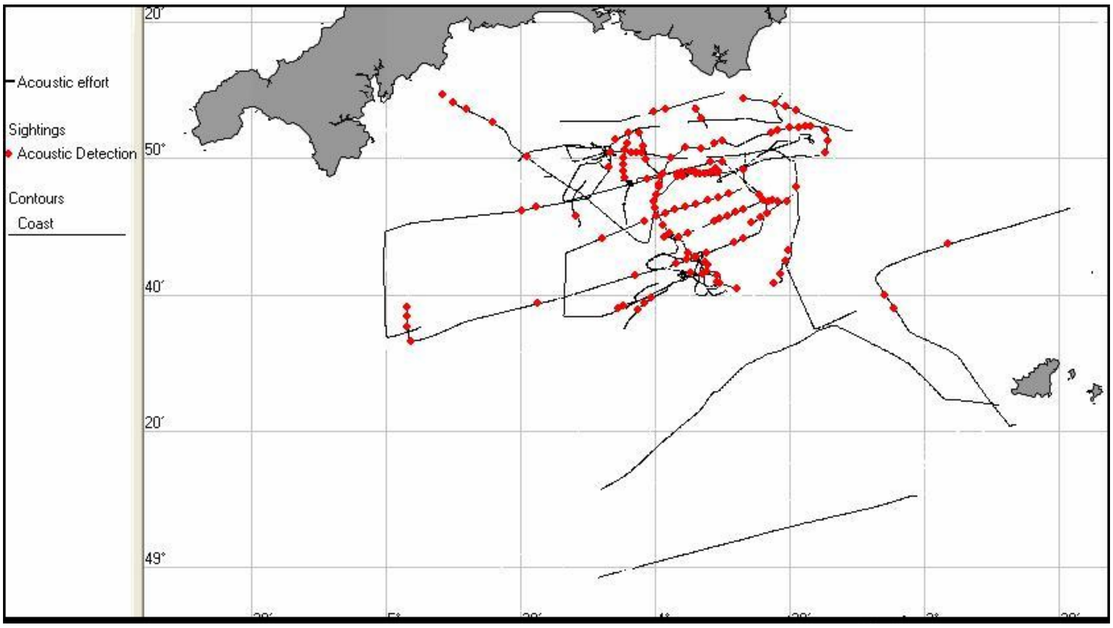

Fig. 12. Acoustic effort with acoustic detections over the survey area.

Comparison to Visual Data

A total of 109 sound recordings were made of which 24 were made during listening periods when visual sightings were made. Figure 13 shows an example of the real-time spectrograph display that 'listeners' could watch while monitoring the signal.

Of the 379 listening periods that were conducted during visual survey effort, 59 periods contained acoustic detections (*see* Fig. 14 & Table 16). Sightings were recorded during 61of these listening periods. Of these, 31 were coincident with acoustic detections whereas 30 sightings occurred when nothing was audible on the hydrophone. Conversely, dolphins were heard during 29 periods while nothing was seen. Some of these 'missed' sightings may be explained by dolphins bow-riding for extended periods of time at the front of the ship. Each sighting was recorded when the animals were first seen but were not reported repeatedly as re-sightings when they remained near the ship.

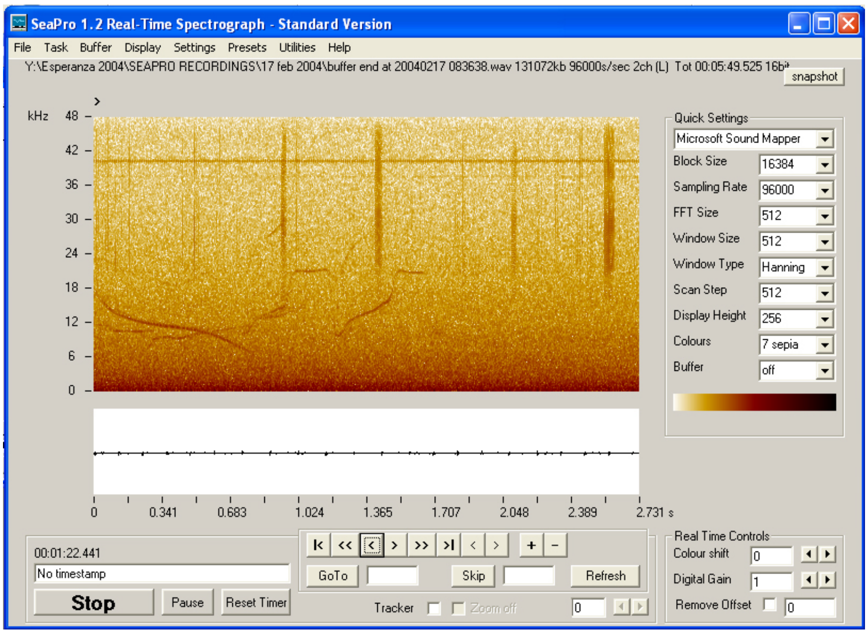

Fig. 13. The screen of the analysis software SeaPro showing the signal from one channel of the hydrophone. The spectrogram illustrates examples of clicks, whistles and a buzz. Note that the contours of the two central whistles are similar.

	S	T	FOF	SLOW	TS	FOS	Incidental	X	Total
Listening periods	80	21	4	47	10	50	167	301	680
Acoustic detections	8	8	0	5	8	6	24	80	139
Acoustic detections with matched visual dolphin sightings	7	4	0	1	4	1	12	2	31
Acoustic detections without a matched visual dolphin sighting	1	4	0	4	4	5	12	78	107
Visual dolphin sightings with no detections	10	1	0	2	0	6	9	2	30

Table 16. The table shows the distribution of listening periods and acoustic detections across different visual effort modes together with information on visual sightings and acoustic detections that matched.

The distribution of listening periods across visual effort shows that most acoustic effort was conducted when the visual survey was ‘Off’ effort (*see* Table 16). This is to be expected as acoustic monitoring may continue into hours of darkness when visual surveys are no longer possible.

During fisheries monitoring, when with trawlers in the vicinity, 15 acoustic detections occurred (*see* Table 17). Four of these had matching sightings and acoustic recordings were made during two of the detections. On the other hand, during 10 listening periods dolphin sightings were made and no detections recorded.

Slightly more listening periods were conducted when no trawlers were in the vicinity and correspondingly more detections were recorded (*see* Table 17). There was no difference in the proportion of acoustic detections during listening periods when trawlers were in the vicinity, compared to periods when no trawlers were in the vicinity (X^2 test for association with Yate’s correction; $X^2 = 3.487$, $p>0.05$, 1 *df*).

The majority of the listening effort, and detections, occurred at times when we cannot be sure whether or not there were trawlers in the vicinity (*e.g.* during night time or during periods of low visibility). During 135 listening periods, trawlers were in the vicinity of the ship but cetaceans were not detected acoustically and in 10 of these dolphins were seen but not heard. This means that neither survey technique recorded each and every cetacean when the survey vessel was in the vicinity of the trawlers.

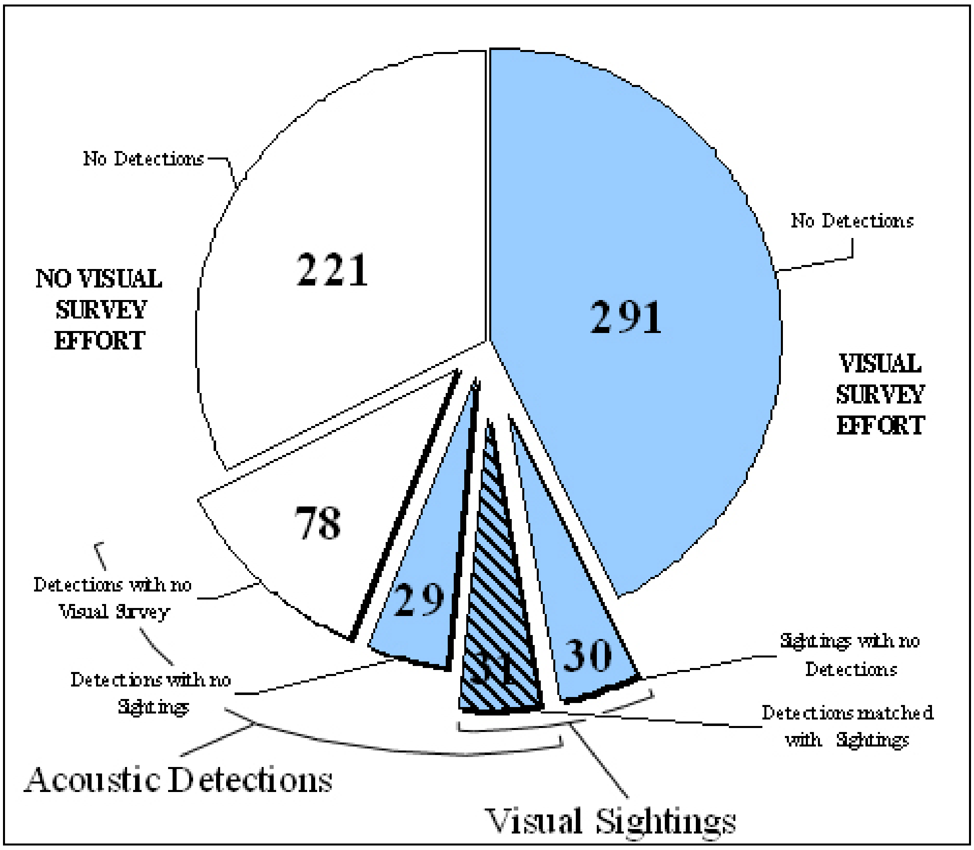

Fig. 14. Chart showing the number of listening periods during visual survey effort (*in blue*) and when no visual survey effort took place (*in white*). Acoustic detections with and without matched sightings during visual and during no visual effort are also shown and are highlighted by text. Note that two sightings occurred during effort mode X, when no visual survey was being conducted, and have been added to the matched sightings pie for the purposes of this diagram.

	Trawlers in vicinity	No Trawlers in vicinity	Incidental	X	Total
Listening periods	150	167	62	301	680
Acoustic detections	15	30	14	80	139
Acoustic detections matched with dolphin sightings	4	16	9	2	31
Dolphin sightings with no acoustic detections	10	13	5	2	30
No acoustic detections and no dolphin sightings	125	124	43	219	502

Table 17. The table compares listening periods and detections during survey effort when fishing trawlers were present and absent near the survey vessel (*see also* acoustic methods).

Group size

Group size did not differ significantly between dolphin sightings during listening periods when they were 'missed' by the listener compared to dolphin sightings during listening periods when detections were made (*Students t-Test*, $p>0.05$).

Effects of vessel speed and diurnal cycle

The proportion of detections during 'fast' and 'slow' vessel speeds did not differ significantly (X^2 test for association with Yate's correction; $X^2 = 0.0046$, $p>0.05$, 7 *df*), indicating that there was no difference in the detection rates between the fast and slow vessel speeds.

The number of listening periods and detections in defined 3 hour subdivisions throughout the day. Acoustic detections were not distributed evenly across the diurnal cycle (X^2 test for association with Yate's correction; $X^2 = 26.34$, 7 *df*, $p>0.001$). Peaks in the percentage of acoustic detection occurred in the morning, just after sunrise, and in the evening, just after sunset (*see* Fig. 15). A low in percentage detections occurred during the midday subdivision.

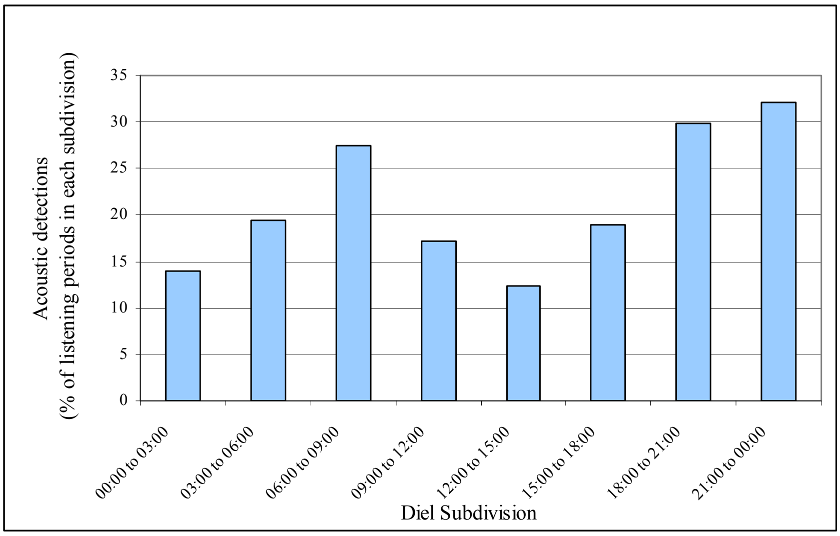

Fig. 15. Acoustic detections as a percentage of the number of listening periods that were carried out in 3 hour subdivisions during the 24 hour day.

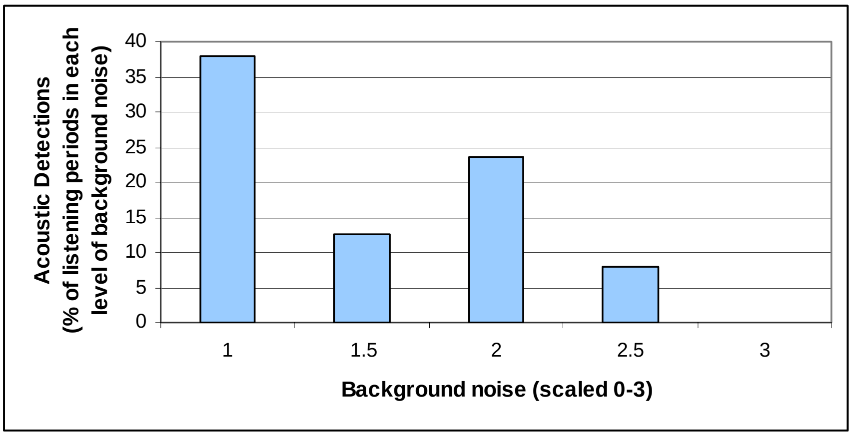

Fig. 16. Acoustic detections as a percentage of listening periods during different levels of background noise, scaled from 1-3, where 3 represents highest level of background noise.

The number of detections appears to decline with increasing background noise (*see* Fig. 16.) and the shorter the distance the hydrophone was deployed from the ship the greater the background noise was judged to be, which is a reflection of the ship's own noise. Further investigation of the effects of sea state and wind speed on detection rates may show that these factors, as might be expected, are also good predictors of background noise.

Part 3 – Fisheries Observations

During the expedition we monitored the winter pelagic trawl fisheries and the interactions between these fisheries and cetaceans. In addition, dead dolphins found floating were taken onboard for detailed external examinations and some dolphins were stored in the ship's freezer to facilitate full post-mortem.

Observation effort and sightings

Throughout the expedition we encountered 19 different operating pairs of trawlers, most of which were monitored for extended periods of time and several of which we encountered up to 5 different occasions during the expedition. Pairs of trawlers that were monitored for a period of longer than one day were entered as a 're-encounter' during the following day, giving a total number of encounters of 37. Vessel name and ID were recorded for 14 of the pairs of trawlers, with 5 remaining unidentified. On the 5th of March, a total of 7 different pairs of trawlers were operating between 49°45N - 50°01N and 3°46W - 3°18W, an area of approximately 13 by 20 nmiles. The average distance to shore of operating pair-trawlers was 20.94 nmiles (SD 8.71) and ranged between 3.1and 44.9 nmiles.

During fisheries observations (FOF+FOS; when monitoring pair-trawlers) a total of 22 hours were spent monitoring fisheries over 97.6 nmiles. A total of 47 cetacean sightings of approximately 419 animals were reported (*see* Table 4). In addition, a total of 48 sightings of approximately 249 animals were reported as incidental sightings during fisheries observations. A summary of all 95 sightings is shown in Table 18. Amongst these were 7 calves and 3 juveniles. The species identified were mainly common dolphins, but also harbour porpoises, Risso's dolphins, minke (and minke-like) whales, baleen whales and a fin/sei whale. Nineteen sightings were unidentified (*see* Table 18).

In this section, we refer to 'group size', 'behaviour' and 'initial cue' for the common dolphin, as presented in tables 5 to 7, in relation to their respective frequency during fisheries observations. When comparing these findings to other effort modes (without the presence of pair-trawlers), some significant differences could be noted, which are described below.

During fisheries observations, the average group size of common dolphins was 11.53, almost double that of survey modes without the presence of fisheries (*see* Table 6). This difference is significant (Student's T-test, $p<0.05$). The group size for harbour porpoises during fisheries observations was slightly lower (1.5) compared to survey modes (T+S and SLOW+TS) without the presence of trawlers (1.9 and 4, respectively), although one incidental sighting made during fisheries observations was that of a group of at least 15 animals. When comparing the differences in group sizes between survey modes, one should note that no other variables/covariates that may influence group size were accounted for.

In the absence of fisheries, common dolphins breached less and the 'underwater' initial cue was not reported (*see* Table 5). During fisheries observations (FOS), the most frequently reported travel speed for common dolphins was slow (22.22%) with animals in mainly 'tight' group formations (4.44%; *see* table 6). Dolphins were also often reported to be porpoising (24.44%) and bowriding. The number of observations of feeding (6.66%) and milling (6.66%) were higher compared to the other survey modes, where these were either not reported or only comprised low percentages. Whereas dolphins did display full breaches during other survey modes, this was not observed during fisheries observations.

Species	Number of sightings	Number of animals	Percentage of sightings (%)
Common dolphin	50	470	53
Harbour porpoise	21	59	22
Risso's dolphin	1	20	1
Fin/Sei whale	1	1	1
Unidentified baleen whale	1	1	1
Minke whale	1	1	1
Minke-like whale	1	1	1
Unidentified dolphin	15	108	16
Unidentified cetacean	4	7	4
Total	95	668	100

Table 18. Overview of all sightings (incidental sightings + effort related sightings) made during fisheries observations, including the approximate number of animals involved and the percentage of sightings for each species.

Interactions with fisheries

Interactions between the fisheries operations and cetaceans were reported 7 times, involving the common dolphin, harbour porpoise and unidentified dolphin species; interactions included bow-riding, breaching between the two trawlers and surfacing in the vicinity of the nets. When cetaceans were seen approaching the fishing operations this was also regarded as a possible interaction. The interactions or possible interactions are briefly described below.

On the 10th of February, at 16:55, a group of 2 unidentified dolphins were seen in the vicinity of two operating trawlers. One animal breached in the space between the two trawlers, the animals then approached the bow of one of the boats where they surfaced briefly. They then re-surfaced in the vicinity of the nets and were not sighted again.

On the 11th of February, at 08:50, common dolphins were seen in the vicinity of operating trawlers. The dolphins were seen in a tight group formation and were seen porpoising and travelling parallel to the fishing vessels.

On the same day, at 10:09, a group of 4 unidentified dolphins were reported porpoising in the vicinity of one of the trawlers that had just started hauling. At 10:23 the trawler had finished hauling, at which point the animals were no longer observed in the area. Subsequently, the fishermen reported that only 4 fish had been caught.

On the 14th of February, at 11:53, a group of at least 10 common dolphins were reported in the vicinity of two operating trawlers. The animals were seen feeding, tail slapping and were also, at times, observed milling. On the same day, at 15:26, a group of porpoises and at least 10 common dolphins were seen approaching the trawlers. The animals were tracked for a period of 20 minutes. The dolphins were at first tightly grouped and seen heading in the direction of the trawlers and, after 7 minutes of tracking, seemed to head towards the area of the net. At this point, the dolphins were more spread out than they had been. They were positioned in different subgroups, each group maintaining a tight formation with a moderate surfacing speed. Seven minutes later, the dolphins were still in the vicinity of the trawlers and travelling at a moderate speed but were then in a more loosely grouped formation. Several minutes later, the dolphins changed course and appeared to be leaving the area.

On the 5th of March, at 07:10 - one hour before the hauling procedure, a group of 4 common dolphins in tight formation were seen next to an operating pair-trawler

Dead dolphins

During the expedition, a total of 12 dead dolphins - of which 10 were identified as common dolphins - were found floating in the water. The information gathered about each of the dead dolphins, including photographs of characteristic markings and details of the tags attached have been reported elsewhere (WDCS, 2004). However, information on date, time, position, species, sex and length are summarized in Table 19.

All but one of the carcasses (Dolphin no. 11) were found in an area of approximately 13-22 nmiles south of Plymouth Harbour and Start Point. The first five dead dolphins (dolphins 1-5) were reported on the 6th of February and were all found close to one another. A large piece of green netting (approximately 35 m in length) was found in the vicinity of the dolphin bodies. These animals were found typically floating on their sides, relatively deep in the water, showing only a little of their bodies above the surface and exposing one flipper. Dolphins 1-4 were brought on deck, sexed, measured, and a temperature reading was taken (*see* Fig 17.). The bodies were then stored in the ship's freezer to facilitate full post-mortem at a later date. The fifth dolphin was lost in the relatively rough seas. Gulls were observed feeding on the carcasses of dolphin 4 and dolphin 9.

Dolphins 6 and 7 (found on the 8th of February at 11:59 and 14:26 respectively) and 9 and 10 (found on the 15th and 16th of February) were all in an advanced state of decomposition and were floating in a belly-up position. These animals were not taken onboard but were photographed, sexed and measured in the water instead. Dolphin 8 was located on the on 14th of February and was brought onboard for detailed external morphological examinations, temperature measurements and was also tagged. Dolphin 11 was located in low light on the evening of the 16th of February and could not be studied or recovered. Dolphin 12, located on the 7th of March, was taken onboard for external morphological examinations, temperature measurements and was also tagged.

Dolphin	Date	Time	Position	Species	Sex	Length (cm)
1	06.02.2004	11:16	49°58.137N 004°14.527W	*D. delphis*	♂	199
2	06.02.2004	11:20	49°58.215N 004°14.690W	*D. delphis*	♂	190
3	06.02.2004	11:20	49°58.215N 004°14.690W	*D. delphis*	♂	229
4	06.02.2004	11:20	49°58.215N 004°14.690W	*D. delphis*	♂	170
5	06.02.2004	11:20	49°58.215N 004°14.690W	*Unknown**	?	n/a
6	08.02.2004	11:59	50°00.092N 003°30.017W	*D. delphis*	♂	210
7	08.02.2004	14:26	49°56.362N 003°44.238W	*D. delphis*	♂	220
8	14.02.2004	12:27	50°01.929N 004°13.425W	*D. delphis*	♂	199
9	15.02.2004	08:50	49°56.651N 004°05.228W	*D. delphis*	♂	205
10	16.02.2004	10:25	49°56.120N 003°58.625W	*D. delphis*	♂	180
11	16.02.2004	17:40	50°07.283N 004°56.891W	*Unknown***	?	n/a
12	07.03.2004	13:01	49°56.857N 003°51.505W	*D. delphis*	♂	225

Table 19. Details on date, time, position, species, sex and length of dead dolphins found floating during the expedition. Where unknown* was lost in relatively rough seas & unknown**only seen in low light and was not recovered or examined.

The conclusions of the post-mortems conducted on the dead dolphins (1-2&4) are presented in *Annex vi.* The main findings were that dolphin 1 (an adult male common dolphin) had a number of findings consistent with entanglement in fishing gear (by-catch). The net and rope marks found on the carcass were all consistent with gillnet-type fishing gear with a monofilament twine diameter of approximately 0.55mm, a mesh size of approximately 267 mm and possibly twin 6 – 8 mm polypropylene headline ropes. The dolphin was in good nutritional condition and there was no evidence to support an alternative cause of death. Dolphin 2 and 4, both juvenile male common dolphins, were also in very good nutritive condition at death. A number of findings consistent with entanglement in fishing gear (by-catch) were found in their post-mortem examinations. These included netmarks, muscle tears and haemorrhage, including some bleeding in the thoracic rete mirabile and evidence of recently ingested prey. The netmarks observed were thinner than those normally found in animals by-caught in pelagic trawl fisheries and were more suggestive of those found in animals by-caught in gillnet fisheries[4]. No evidence to support an alternative cause of death for these dolphins was found.

Cuts, wounds and other scarring
External examination of dead dolphins revealed the following injuries; severe wounding to the rostrum including deep line markings, distorted jaws and missing teeth; fluid/foam protruding from blowhole; and deep cuts in dorsal fins, flippers and flukes (*see* Photo 4-6 in *Annex vii*).

A surprisingly high incidence of wounds and scarring was apparent on some common dolphins that approached the vessel, (*i.e.* during bow or wake riding). These features included missing dorsal fins and partly missing dorsal fins; deep straight cuts; and white patches especially on the dorsal areas (*see* Photo 1-3 in *Annex vii).* Photographs and video footage were taken of common dolphins throughout the survey and these revealed additional records of such scarring and wounds. The different types of scarring on live common dolphins observed throughout the survey are summarized in Table 19. Eleven different types of wounds and scarring were identified (not including the small nicks often present on the trailing edge of dorsal fins or any tooth-rake marks). It is not presently possible to say if these types of scarring result from interactions with nets, although some of the wounds could be regarded as indicative of this. It is also worth noting that according to a whale watch company operating from Falmouth, various types of scarring are frequently seen, especially on common dolphins, and these include those that resemble 'in prints' of netting (K. Reeves, Pers. comm).

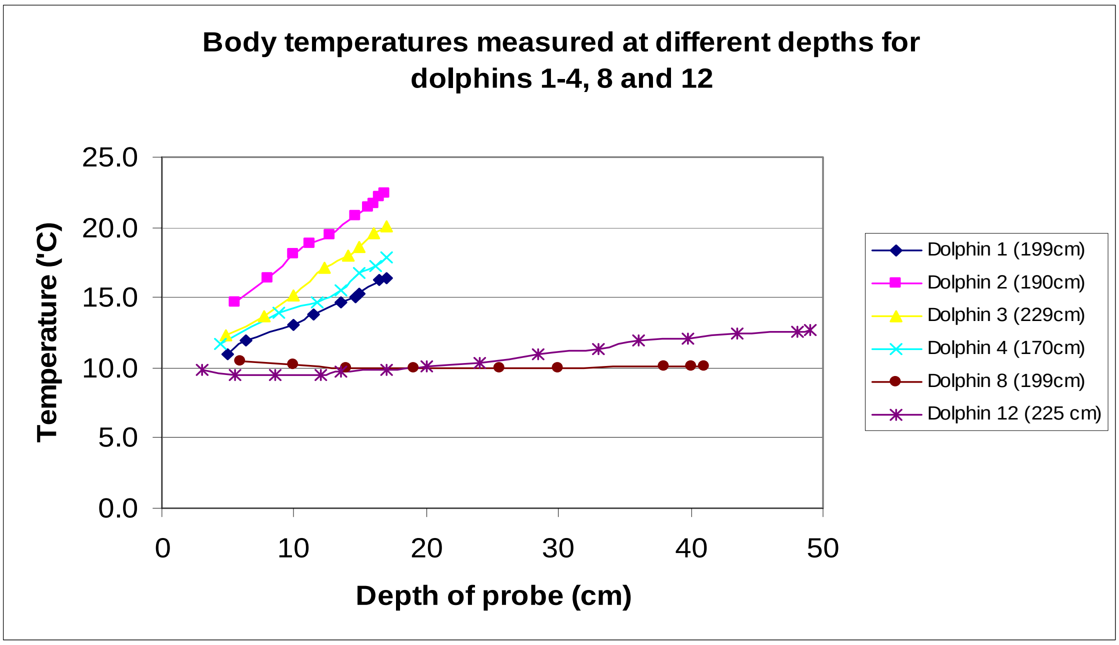

Fig. 17. Measured temperatures (using different probes as outlined in the methodology) taken at different depths for Dolphins 1-4, 8 and 12. Temperatures collected in both ways are regarded as minimum temperatures because the probe did not reach the core of the body *(see* Morizur *et al*., 1999).

Types of scarring	Photo records	Video records	Field records	Total
Cuts to and sections missing from flipper(s)	4	1	-	5
Dorsal fin partially or totally missing	2	-	1	3
Deep straight cut(s) on body	4	1	1	6
Pale wounds behind eye	2	-	-	2
Floppy dorsal fin	1	-	-	1
Cuts near genital area	1	-	-	1
White patches on dorsal area	2	-	2	4
White patches on flippers	1	-	-	1
Damage to dorsal fin on leading edge	2	-	-	2
Large chunks missing from dorsal fin (trailing edge)	5	-	-	5
Severe damage to tailstock	1	1	-	2

Table 19. The different types of scarring on live common dolphins observed throughout the survey.

[4] As this report was going to press, the results of the post mortem of the fourth common dolphin retrieved at sea became available and this animal was also found to be a victim of bycatch in gill nets.

MAIN FINDINGS AND DISCUSSION

Visual survey

The winter cetacean community within the study area can be summarized as follows: The overall relative abundance for all cetaceans was relatively high (16.9 sightings per 100km effort). The common dolphin was the most abundant cetacean with a relative abundance of 12 (per 100km effort). The majority of survey effort and sightings of this species occurred in waters less than 100m deep.

The line-transect survey, from which an estimate of abundance was obtained was carried out between 25 January to 16 February, during the time when pelagic pair trawlers were operating in the same area. The abundance estimate generated is based on a number of assumptions including that the probability of detecting dolphins on the trackline, *g(0),* is assumed to be one, *i.e.* every animal on the trackline is detected. However, this assumption could lead to a slight downward bias in the abundance estimation because, in practice, some animals may have been undetected. Another assumption of the line-transect methodology is that the animals do not respond to the approaching survey vessels before they are detected.

Only very few studies to date have reported the relative abundance of common dolphins in the NE Atlantic or supplied an estimate of density and abundance for them (*see Annex x for a review*) and it is necessary to be very cautious when comparing such estimates, as surveys differ in their distribution of effort, the vessel used, survey methodology and the season in which they are carried out.

In this study, the provisional abundance estimate for common dolphins based on the entire planned survey area (8,872 km^2) in the Western Channel was 9,708 animals (95% CI = 4,799-19,639). However, the full designed transect coverage was only achieved for Stratum E - a sub-area of the full survey area of 4,129km^2 – (see Chart 1) which provides the best provisional estimate achieved for common dolphins during this survey using standard line-transect methods, *i.e*. 2,841 (95% CI=169-5,512) but subject to potentially large bias related to responsive movement.

Responsive movement by common dolphins was evident during this survey and, in fact, the use of two different survey speeds enabled comparisons of the way in which responsive movement affected the detection process. The results show that the effects are complex, involving changes in both the location of the animal relative to the vessel and the detection probability and this is either due to the animals' availability for detection or the strength of the detection cue. For this survey, the assumption that animals were detected before they responded to the vessel was clearly not valid. There was clear evidence of responsive movement towards the vessel which will cause a positive bias in the provisional estimates presented in this report.

Other surveys providing population estimates for common dolphins are likely to have similar problems of bias. For example, during the SCANS survey in Block A, which corresponds to the Celtic Shelf area, a common dolphin abundance estimate of 75,450 (95%CI=23,000-149,000) and a relative abundance (sightings per 100km) index for Block A of 0.94 (Hammond *et al*., 2002) were calculated. The SCANS data were collected from a similar-sized vessel to that used in our survey and abundance estimate calculations were made based on standard line transect methods only. These, therefore, may well also be subject to a positive bias due to responsive movement. There is evidence of this in the SCANS data since the estimated strip width for common dolphins (for the same vessel in the same area) was apparently less than that for harbour porpoise, a surprising result indicating that either responsive movement was the cause of the very narrow strip width or that largely solitary harbour porpoise have a higher detection probability than common dolphins with a mean group size of ten.

The NASS-95 Faroese survey, used the Buckland-Turnock dual platform method (Cañadas *et al., in press)*. This allowed the actual value of *g(0)* to be estimated and, in theory, responsive movement to be taken into account (Cañadas *et al., in press; see Annex x*). This survey was conducted in the Faroese sector, western British Isles and offshore Atlantic during the summer months. Responsive movement was modelled by comparing detections made by the Tracker platform (from which 7x50 binoculars were deployed) and detections by the Primary platform. The detection function based on perpendicular distances for that study shows similar properties to our findings. For instance, Cañadas *et al.* found a rather low Effective Half Strip Width (*see Annex x*). The *g(0)* estimate for the NASS-95 survey was 0.8 (*CV* 0.14) and these researchers found that a standard 'Distance Approach' based on naked eye observations would have resulted in estimates that were positively biased by a factor of 5.9. However, they were not able to establish categorically whether the observers using the high power binoculars were detecting dolphins prior to the animals responding to the survey vessel, so there remains a possibility of bias in this estimate too.

From the WDCS/Greenpeace 2002 autumn survey in an area SW off Cornwall (using similar methods to this survey), a relative abundance for common dolphins was calculated as 2.9 sightings per 100km (De Boer and Simmonds, 2003). This is lower than our current findings for winter (*see Annex x*). The NASS-95 survey area (Block E) yielded a relative abundance of 1.02 sightings per 100km during summer which is comparable to findings from the SCANS survey *(see Annex x*). However, it should be noted that reported bycatch in the trawl fishery was substantially higher in 2003/04 than in previous winters (SMRU, 2004) and this may have been related to an unusually high abundance of dolphins in the Channel in 2003/04.

Nevertheless, our results support the finding of Macleod and Walker (2004), Cresswell and Walker (2003) and Brereton *et al*., (2004) that common dolphins carry out a seasonal movement along the continental shelf and north into the English Channel and Celtic Sea in the winter and southward into deeper waters of the central Bay of Biscay in the summer.

Macleod and Walker (2004) highlighted the variability of common dolphin relative abundance, both temporally and spatially; using data collected from two ferries passing through the area between 1998-2002. For all years combined, their records of relative abundance peaked during winter (encounter rate of 3.5/100km and SD=4.2, where the rate was calculated by ¼ ICES grid squares). They also reported that, during winter, the relative abundance was greatest on the continental shelf (<200m deep), west of the Brittany coast. It was also found to be relatively high in the western English Channel, the area in which our survey was carried out. A considerable between-year variation in the areas that had the highest common dolphin relative abundance was shown and this further supports the need for more seasonally-orientated surveys with a large spatial coverage.

In our study, group sizes of common dolphins ranged between 1 and 45 individuals with a mean of 6.4. However, during periods of fisheries observations it was significantly higher (a mean of 11.53). The SCANS survey found a mean group size of 10.8 in Block A for common dolphins (*see Annex x*) and the NASS-95 survey found a value of 8.29. Macleod and Walker (2004) reported a much higher mean group size of 37.7 (SD 70.8). However, they noted that the mean group size varied seasonally and reported a relatively low mean group size of 16.9 (SD 34.7) during winter, 45.9 (SD 106.8) in spring, and in summer, 39.9 (SD 66.6). The highest mean group size found by these researchers was 78.2 (SD 159.6) during the autumn. The group size of common dolphins is probably influenced by a number of factors, including geographical area and seasonal fluctuations in prey abundance and distribution.

Relatively few common dolphin calves were sighted during the WDCS/Greenpeace survey, although anecdotal reports were made of large groups with young, especially off Lizard Point in early January. It is likely that we mainly encountered groups of males. It is difficult, if not impossible, to sex dolphins in the field, although, in New Zealand the presence of a postanal hump has been reported as a tool to identify sexually mature male short-beaked common dolphins (Neuman *et al*., 2002) and dead mature male common dolphins examined during the survey also showed the presence of a distinct postanal hump, although seemingly not as pronounced as the New Zealand dolphins. Underwater video footage produced good images of postanal humps on live animals, and this technique may well be further developed in future studies in order to help to characterise the school composition of common dolphins in this region.

The harbour porpoise was sighted less regularly than the common dolphin and only a few porpoise calves were reported. These were probably calves from last year as the peak calving period for UK porpoises is believed to be between June and July (Lockyer, 1995).

The bottlenose dolphin was seen further offshore compared to findings reported during an autumn survey along the coasts of Wales and southwest England where the mean distance to shore was 5 km (De Boer and Simmonds, 2003). The presence of young calves in the Channel also indicates the importance of this area for this species.

Our first sighting of a fin or sei whale was made on the 28th of January. A few more sightings followed, including reports on the 14th and 16th of February of fin whales apparently feeding (K. Reeves, pers. comm), confirming that fin whales were still in the area. The fin whales were probably taking advantage of the high local productivity. The presence of a mother and calf pair amongst those sightings supports the suggestion that this region may be used as a mating and calving ground (*see also* Evans, 1992).

Acoustic survey

The hydrophone was in use for a period of 21 days. The listening effort comprised 680 listening periods totalling 170 hours of monitoring. Dolphins were detected in 139 listening periods during monitoring. Detections appeared to be widespread throughout the area although they were largely confined to the UK part of the Channel where more effort was conducted. Although most of the acoustic effort was conducted during the 'off effort' visual survey mode (*e.g.* night time) and other incidental effort modes, 31% of listening periods were in 'dual mode' (*i.e*. conducted simultaneously with high effort visual observations).

The comparisons made between visual survey and acoustic survey illustrate the value of conducting dual visual and acoustic surveys because some records of cetaceans would otherwise have been missed. The characterisation of the types of cetacean vocalisation warrants further study, particularly in the context of sightings data, to help elucidate factors such as behaviour, group size and group composition.

There was no difference in the proportion of acoustic detections made during listening periods when trawlers were in the vicinity compared to periods when no trawlers were in the vicinity. However, the majority of listening effort, and detections, occurred at times when we cannot be sure whether or not there were trawlers in the vicinity (*e.g.* during night time). Furthermore, no significant difference in the detection rates between 'fast' and 'slow' vessel speeds was apparent.

Acoustically, the detectability of larger groups of dolphins was not different to that of smaller groups, despite larger groups having the greater potential to produce more vocalisations. An exploration of call density in relation to group size may further elucidate this matter. Using acoustic detections, as oppose to acoustic encounters, to investigate the detectability of different group sizes may have skewed the result because a pod of dolphins may be more, or less, inclined to stay within detection range of the hydrophone depending on its group size.

Acoustic detections were not distributed evenly across the diurnal cycle. There were peaks in the percentage of acoustic detection in the morning, just after sunrise, and in the evening, just after sunset. A distinct low in the percentage of detections occurred around midday. The spread of detections throughout the day is similar, in some respects, to that reported by Goold (2000). He reported a low in detections around midday for common dolphins off the coast of west Wales, and that the majority of acoustic detections occurred at night. Our survey indicates that acoustic detections showed a crepuscular pattern and the bulk of acoustic activity occurred at night. It must be noted that the patterns illustrated by the data from this survey are not based on a large dataset and a longer period of monitoring, with an unbiased spread of effort, would provide a more representative picture.

There has been some suggestion that common dolphin bycatches in pelagic trawls regularly occur at night (Morrizur *et al*., 1999; Tregenza and Collet, 1998; Aguilar, 1997). Couperus (1996) showed that *Delphinus delphis* and *Lagenorhyncus acutus* were more often caught at night or just before dawn. Vocal activity is indicative of a higher level of activity and has been associated with both feeding and social behaviour (Herzing, 1996). De Haan *et al* (1999) also reported a peak of cetacean activity just before dawn, although most sightings occurred during the day. Visual surveys are limited to day time whereas acoustic surveys are suited to dolphin activity for 24 hours. Therefore, acoustic techniques may be able to help answer key questions that, at present, remain unanswered.

Fisheries observations

During fisheries observations, a total of 95 sightings of cetaceans (of which 50 sightings were common dolphins) were reported. Interactions between fisheries and cetaceans were reported 7 times, including instances when common dolphins were seen around the trawlers during hauling and towing procedures. A fin/sei whale, a minke whale and also Risso's dolphins were also seen in areas where pelagic trawling was taking place. No records apparently exist of Risso's dolphins being bycaught in European pair trawl fisheries, however, reports exist of their bycatch in US pair trawling (Northridge, 2003).

The group size of common dolphins observed during this survey was significantly higher in the presence of trawlers (11.53) than otherwise (6.4). The proportion of observed foraging behaviour was also higher during fisheries observations (6.66%) compared to survey modes without trawlers (0.62%). Silva (1999) studied the diet of common dolphins off the Portuguese continental coast and suggested that common dolphins explore habitats with distinct features and employ various foraging strategies. The success of different foraging strategies probably also depends on group size. For example, when feeding on fish species that form very large schools, it may be more productive to form a larger pod. More research is needed on this topic as group size and foraging strategies are likely to also affect the number of bycaught animals.

The relative abundance of common dolphins was significantly higher during fisheries observations (22.8, *CV* 0.55) compared to other survey modes (11.49, *CV* 0.23 and 8.74, *CV* 0.32) and sightings made of porpoises during fisheries observations indicate a more 'patchy' distribution for this species, which is reflected in the relative abundance during fisheries monitoring (10.2 *CV* 0.46).

Taking into account all survey modes, the total proportion of common dolphins seen within 12nmiles of the coast was 36%, and all the common dolphins seen during the fisheries observations were recorded outside of the 12nmile zone.

The area where most pair-trawlers were encountered during this survey is boxed in blue in Figure 18. This figure also depicts sightings of common dolphins made throughout the expedition (regardless of survey effort) and sightings of dead dolphins. From this chart it can be concluded that the main fishing ground used by pair trawlers during this survey period clearly overlaps with an area used by the common dolphins.

Such overlap of fishing effort and dolphin distribution is likely to increase the risk of bycatch. Indeed, it is this area where 11 of the 12 dead dolphins were found floating on the surface, although several of the dead dolphins have subsequently been shown to be the victims of gillnets. Our findings furthermore indicate a rather low relative abundance of common dolphins in the French part of the Channel.

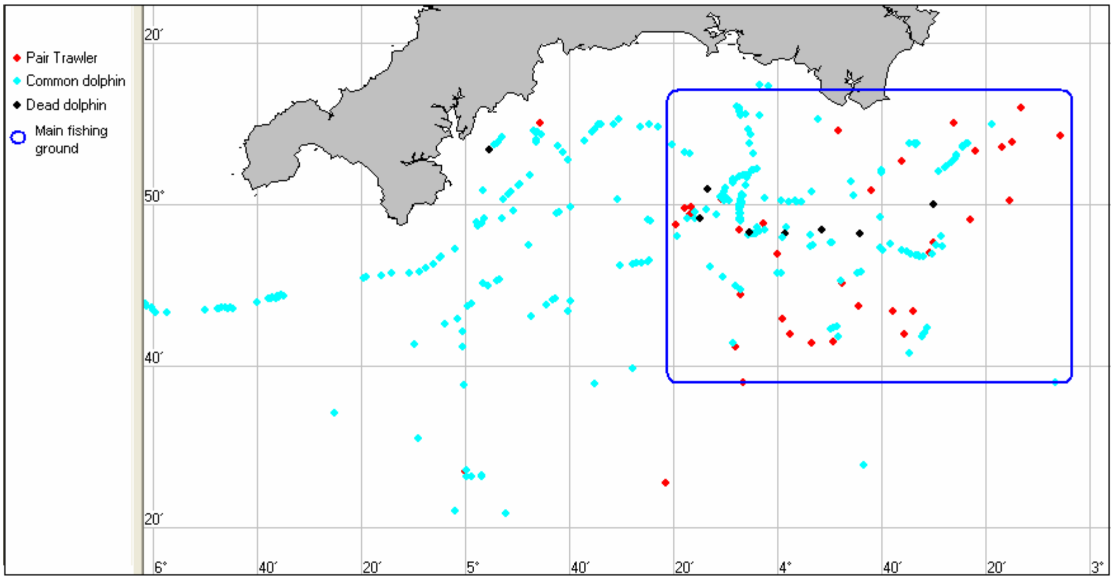

Fig. 18. Sightings of pair trawlers (red dots), dead dolphins (black dots) and all sightings of common dolphins (blue dots; regardless the survey effort) are depicted together with an area identified as the main fishing ground (dark blue box).

All retrieved dead dolphins were males, of which two were juveniles. A predominance of males has also been reported during multiple stranding events in the NE Atlantic (*e.g.* Van Ganneyt *et al*., 2002) and findings of observer studies (Tregenza and Collet, 1998). Although more research is needed, this indicates that mature males are likely to be at higher risk of being bycaught. This may be a result of differential habitat and food utilisation by groups of different social composition (for example differing strategies for adult males and females with young; Van Ganneyt *et al*., 2002).

The post mortem reports of the dead animals retrieved at sea are summarised in the annex. These animals are atypical of the bycaught animals usually presented for post-mortem after they have stranded in that they were retrieved in a fresh state and frozen straight away, allowing a greater amount of forensic information to be obtained and a more confident deduction of cause of death, including gear type (P. Jepson, pers. comm.) The marked presence of injuries recorded on live animals also suggest that some dolphins may be wounded during encounters with nets but survive.

Tagging of bycaught dolphins before discarding them at sea is intended to help establish the origin of stranded animals. We replaced tagged dolphins into the sea at a distance from shore ranging between 17.6 and 19.5 nmiles. However, none of the tagged bodies has been reported stranded to date, although there is a possibility that tags may be lost before the corpses reach the shore.

CONCLUSION

The high levels of bycatch reported in the Channel area clearly raise both conservation and animal welfare concerns and, in conservation terms, there is one particularly important question: what is the effect of these removals on the populations of cetaceans in this region. There is clear evidence that many common dolphins and many harbour porpoises are being killed and other species are also being washed ashore dead. We should not forget that these other species may also be being significantly impacted. For example, any removals from the small coastal bottlenose dolphin population in the south-west of England, which probably only numbers a few tens of individuals, could be highly significant.

Here, however, we focus on the situation of the common dolphin because our observations and results mainly feature this species. The area where bycatch is occurring is on the edge of the usual distribution of this species and bounded by the coastlines to the north and south, with very few observations of common dolphins further east in the Channel (Reid *et al*., 2003). If this area is only used by a subset of the total Northeast Atlantic 'stock' of this species, which may be a distinct population which returns each year, then there is at the least a risk of localised depletion within the Channel area. If local depletion occurs, it is not clear whether common dolphins from further afield would then start to exploit and re-populate the area. Furthermore, the relatively high encounter rate in this study (the highest of all the surveys in the North Atlantic) shows that the Channel is a very important winter habitat for common dolphins.

Inevitably attention will be drawn to the various population estimates that now exist for the common dolphin in the North Atlantic and the relationship between these and bycatch removals. However, great care needs to be taken when making extrapolations or conclusions from such estimates. For example, the relatively large population estimate provided by Cañadas *et al. (in press*), based on data collected in summer 1995, raises a number of issues that are highlighted by the authors themselves. These include an extrapolation from one part of one survey block to the remainder and that the density of animals in this area is high relative to other similar studies. This could represent a particular concentration of animals associated around a particular feature, making extrapolation to a wider area questionable. The authors also note that 'the representativeness of the survey in this block [Block W] is somewhat suspect and the abundance estimate obtained for this block may be biased as a result'. It is also possible that even the special technique used by Cañadas *et al. (in press*) in order to address the responsive movement of the dolphins to the survey vessel was not able to fully address this problem, which could also have caused bias in the population estimate.

Furthermore, the relationship between the common dolphins seen in the area that Cañadas *et al. (in press*) refer to (Blocks E and W to the west of the British Isles) and the common dolphins in the Channel area (the subject of this survey) is unknown. Specifically we do not know if the Channel animals form – or are from - a separate population. Blocks E and W are many hundreds of miles from the English Channel, where the local relatively shallow waters could constitute a significantly different habitat. Indeed, Cañadas *et al. (in press)* comment that their work 'could suggest the existence of a large oceanic population in NE Atlantic, but more work is needed, in these and other north European waters, to assess whether this constitutes a different population to that found in neritic waters [*i.e.* the shallow sea over the continental shelf], or if this high density of animals in the area respond more to behavioural and social structure strategies or to special oceanographic features or prey abundance.'

Moving to the issue of removals, a bycatch level of small cetaceans of more than 1.7% of the best available estimate of abundance has been deemed in international fora to be unacceptable (ASCOBANS, 2000), therefore, based on our provisional abundance estimate (for our stratum E), this would equal some 48 animals. (Note that no correction for responsive movement is made in the provisional abundance estimate.) During the 2003/4 fishing season, a bycatch of 169 common dolphins was recorded in the area in the UK bass fishery alone, producing an extrapolated total estimated mortality for the UK fishery of 439 animals (SMRU, 2004). There is additionally an unquantified mortality in other (*e.g.* gill and tangle net) fisheries, for instance, 200 common dolphins were estimated to be caught annually in the Celtic Sea hake gillnet fishery during the 1990s (Tregenza & Collet, 1998), and an assumed (but also unquantified) mortality in the French bass fishery and potentially other trawl fisheries.

In conclusion, the data from this survey show that the common dolphins in the Channel area (which may or may not be part of a discrete population) could well become depleted as a result of bycatch. We therefore have significant cause from a conservation perspective to be concerned about what is happening to this species in this region. Trawl fisheries and gill nets are implicated in the problem for this species and the latter even more so for bycatch of harbour porpoises.

RECOMMENDATIONS FOR FUTURE RESEARCH

- Other studies have indicated a high variability in common dolphin abundance, both temporally (between seasons and between years) and spatially in the Western Approaches of the English Channel and Bay of Biscay. We strongly recommend continued monitoring of the common dolphin population and fisheries interactions in this region in future years.

- Buckland *et al*. (1993) suggested that an ideal sample size allowing abundance estimations would be 60-80, although 40 may be enough in some circumstances. Obtaining more data via line-transect survey in this region in the winter would improve the provisional abundance estimate provided here as our sample size was near to 40.

- It is still not known at what distance common dolphins may respond to vessels and this is likely to be vessel specific. However, it is likely that dolphins would be able to detect most vessels acoustically at ranges of several kilometres. If the majority of dolphins which detected the survey vessel approached it then this could cause biases in the abundance estimates of an order of magnitude. Studies using high powered 'big-eye' binoculars and recording dolphin heading relative to the vessel may be able to establish the range at which responsive movement occurs for a particular vessel (Palka and Hammond, 2002). It is, however, even possible that responsive movement might be occurring even at the detection range of such binoculars and that, therefore, aerial surveys should be used to resolve this issue.

- Further close-up studies of how the dolphins interact with the fisheries and, in particular, how they behave around the nets could benefit the better understanding of this problem and the development of mitigation measures.

- More information is needed on the fisheries-generated scars on live and dead dolphins. This should include more detailed external examination of in particular fresh dead bodies (using close-up photography) and the use of video and telephoto-equipped cameras.

- In order to obtain more information on the origin of stranded animals, the tagging of dead dolphins found at sea should be encouraged, although the retrieval of bodies can be hazardous and anyone doing this should have guidance and does so at their own risk.

- Future studies should include acoustic data collection and analyses should carefully compare acoustic and visual survey results. This may also help to unearth trends that might otherwise go undetected. Acoustic recordings of cetacean vocalizations in the vicinity of trawlers are rare and the opportunity to collect them should not be missed.

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REFERENCES

Aguilar, A.1997. Inventario de los cetáceos de las aguas atlánticas peninsulares: aplicación de la directive 92/43/CEE. Memoria Final. Departamento de Biologia Animal (Vert.), Facultad de Biologia, Universitat de Barcelona.

ASCOBANS, 200. Resolution on incidental take of small cetaceans. Annex 9c of Proceedings of the Third Meeting of the Parties. Bristol UK.

Brereton, T.M., Williams, A.D., Martin, C. 2004. Ecology and status of the common dolphin Delphinus delphis in the English Channel and Bay of Biscay1995-2002.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L, Borchers, D.L. and L. Thomas. 2001. *Introduction to Distance sampling: estimating abundance of biological populations. Oxford University Press Inc*., New York.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L. 1993. *Distance sampling: estimating abundance of biological populations.* Chapman and Hall, 2-6 Boundary Row, London SE1 8HN.

Cañadas, A., Desportes, G., Borchers, D. *In Press.* Estimation of g(0) and abundance of common dolphins (*Delphinus delphis*) from the NASS-95 Faroese survey. J. Cetacean Res. Manage.

Carwardine, M. 1995. Whales, dolphins and porpoises.. Dorling Kindersley, London, UK 257 pp.

CEC. 2002. Incidental catches of small cetaceans. Report of the second meeting of the subgroup on fishery and the environment (SGFEN) of the Scientific, Technical and Economic Committee for Fisheries (STECF). SEC (2002) 1134, Brussels, 11-14 June, 2002. Commission of the European Communities; 7-14, 33, 40, 63.

Collet, A. and Evans, P.G.H. *in press.* The striped dolphin *Stenella coeruleoalba.In:* New Handbook of British Mammals (ed. S. Harris). Academic press, London.

Couperus, A.S. 1996. Bycatch and discarding in the Dutch pelagic trawl fishery. Chapter 3 in Morizur et al., 1996: 81-97.

Cresswell, G. and Walker, D. 2003. Orca No.2. Incorporating a report on the whales, dolphins and seabirds of the Bay of Biscay and English Channel. Brunton Business Publications Ltd.

Dawson, S., Slooten, E., DuFresne, S., Wade, P., Clement, D. 2004. Small-boat surveys for coastal dolphins: line-transect surveys for Hector's dolphins (*Cephalorhynchus hectori). Fish. Bull.* 201:441-451

De Boer, M.N. and M.P. Simmonds. 2003. WDCS/Greenpeace survey report-small cetaceans along the coasts of Wales and Southwest England. *A WDCS Science Report.*

De Haan, D; Dremière, P.Y; Woodward, B; Kastelein, R.A; Amundin, M; Hansen, K. 1999. *Prevention of the by-catch of cetaceans in pelagic trawls by technical means*. CETASEL Final Report, 1994-1997. DLO-Netherlands Institute for Fisheries Research.

DEFRA. 2003. UK Small cetacean bycatch response strategy. Consultation paper. DEFRA, London, UK.

DEFRA, 2004. Proposed prohibition on pelagic pair trawling for bass. Partial regulatory impact assessment. Defra consultation document 29 October 2004.

Evans, P.G.H. , Anderwald, P., Baines, M.I. 2003. *UK cetaceans status review*. Report to English Nature & Countryside Council for Wales.

Evans, P.G.H. 1992. Status review of cetaceans in British and Irish waters. Report to UK Department of Environment. Oxford, Sea Watch Foundation.

Evans, P.G.H. and Scanlan, G.M. 1989. Historical review of cetaceans in British and Irish waters. UK Cetacean Group. c/o Zoology Dept. University of Oxford, UK.

Fraser, F.C. 1946. *Report on cetacea stranded on the British coasts from 1933 to 1937.* British Museum. (Natural History) No. 12. London.

Fraser, F.C. 1953. *Report on cetacea stranded on the British coasts from 1938-1947*. British Museum (Natural History) No. 13. London.

Fraser, F.C. 1974. *Report on cetacea stranded on the British coasts from 1948-1966*. British Museum (Natural History) No. 14. London.

Goold, J.C. 2000. A diel Pattern in Vocal Activity of Short-Beaked Common Dolphins, Delphinus delphis. *Marine Mammal Science* **16**(1): 240-244.

Goujon, M., Antoine, L., Collet, A., Fifas, S. 1993. Approche de l'impact écologique de la pêcherie thonière au filet maillant dérivant en Atlantique nord-est. Internal report, Department of Living Resources, IFREMER, Plouzané, France. Ref. No. RI.DRV – 93.034. Unpublished.

Hammond, P. 2001. Assessment of marine mammal population size and status. *In*: P.G.H. Evans and J.A. Raga (eds). *Marine Mammals*. Biology and COsnervation. Kluwer Academic/Plenum Publishers. New York. 630pp

Hammond, P.,Berggren, P., Benke, H., Borchers, D.L., Collet, A., Heide-Joergensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F., Øien, N. 2002. Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. *Journal of Applied Ecology* 39:361-376

Hammond, P., Benke, H., Berggren, P., Borchers, D.L., Buckland, S.T., Collet, A., Heide-Joergensen, M.P., Heimlich-Boran, S., Hiby, A.R., Leopold, M.F., Øien, N. 1995. *Distribution and Abundance of the harbour porpoise and other small cetaceans in the North Sea and Adjacent Waters*. LIFE 92-2/UK/027. Final Report, October 1995.

Harmer, S.F. 1927. *Report on cetacea stranded on the British coasts from 1913-1926*. British Museum (Natural History) No. 10. London.

Herzing, D.L. 1996. Vocalisations and associated underwater behaviour of free-ranging Atlantic spotted dolphins, Stenella frontalis and bottlenose dolphins, Tursiops truncatus. *Aquatic Mammals* **22**(2): 61-79.

ICES, 2001. *Report of the Study Group on Sea Bass*. ICES CM 2001: ACFM:25. ICES

Isaksen, K. and Syvertsen, P.O. 2002. Striped dolphins, *Stenella coeruleoalba*, in Norwegian and adjacent waters. Mammalia, 66 (33—41)

IWC, 1995. Report of the Scientific Committee.

Kuiken, T., V.R. Simpson, C.R. Allchin, P.M. Bennet, G.A. Codd, E.A. Harris, G.J. Howes, S.Kenendy, J.K. ,Kirkwood, R.J. Law, N.R. Merret and S.Phillips 1994. Mass mortality of common dolphins (*Delphinus delphis*) in south-west England due to incidental capture in fishing gear. *The Veterinary Record* January, 1994.

Laake, J.L., Buckland, S.T., Anderson, D.R., Burnham, K.P. 1993. Distance sampling: Abundance Estimation of Biological Populations. Distance User's Guide, version 2.1

Lockyer, C. 1995. Investigations of aspects of the life history of the harbour porpoise (*Phocoena phocoena*). In *Biology of the Phocoenids*. IWC Special Issue 16, pp 199-209

Macleod, K. and Walker, D. 2004. Highlighting potential common dolphin-fisheries interactions through seasonal relative abundance data in the western Channel and Bay of Biscay. Poster submitted to the European Cetacean Society, 18th Annual Conference, Sweden.

Macleod, K., Simmonds, M.P., Murray, E. 2003. Summer distribution and relative abundance of cetacean populations off north-west Scotland. *J. Mar. Biol. Ass. U.K.* 83:1187-1192.

Morizur, Y; Berrow, S.D; Tregenza, N.J.C; Couperus, A.S; Pouvreau, S. 1999. Incidental catches of marine-mammals in pelagic trawl fisheries of the northeast Atlantic. *Fisheries research* 41:297-307

Neuman, D.R., Russell, K., Orams, M., Baker, C.S., Duignan, P. 2002. Identifying sexually mature, male short-beaked common dolphins (*Delphinus delphis*) at sea, based on the presence of a postanal hump. Aquatic Mammals. 28(2): 181-187

Northridge, S.P. 2003. Investigations into cetacean bycatch in a pelagic trawl fishery in the English Channel: preliminary results. SMRU Report. SC/55/SM26. Report of the Scientific Committee of the International Whaling Commission, Cambridge, UK

Northridge, S.P., Tasker, M.L., Webb, A., Williams, J.M.1995. Distribution and relative abundnace of harbour porpoises (*Phocoena phocoena* L.), white-beaked dolphins (*Lagenorhynchus albirostris* Gray) and minke whales (*Balaenoptera acutorostrata* Lacepede) around the British Isles. *ICES J. Mar. Sci*. 52:55-66

OSPAR, 2000. *OSPAR quality status report 2000: The regional quality status reports: Executive summaries*. OSPAR Commission for the protection of the marine environment of the north-east Atlantic. www.ospar.org

Palka, D. 1996. Effects of the Beaufort sea state on the sightability of harbour porpoises in the Gulf of Maine. Paper SC/47/SM26 submitted to the Scientific Committee of the International Whaling Commission.

Reid, J.B; Evans, P.G.H; Northridge, S.P. 2003. Atlas of cetacean distribution in north-west European waters. Joint Nature Conservation Committee publication.

Ross, A. and S. Isaac. 2004. The Net Effect? A review of cetacean bycatch in pelagic trawls and other fisheries in the north-east Atlantic. *A WDCS report for Greenpeace*.

Ross, A., McLachlan, H., Simmonds, M. 2001. *The Fishing Industry and Cetacean Bycatch-Time for Action*. Whale and Dolphin Conservation Society, Chippenham, UK

Sabin, R.P., Jepson, P.D., Reid, R.J., Chimonides, P.D.J., Deaville, R., Patterson, I.A.P., Spurrier, C.J. 2003. *Trends in cetacean strandings around the UK coastline and marine mammal post-mortem investigations for the year 2002*. Consultancy report for the Department for Environment, Food and Rural Affairs. Contract CRO238. Natural History Museum, London.

Seaquest database. www.cornwallwildlifetrust.org

Sheldrick, M.C. 1989. Stranded whale records for the entire British coastline, 1967-1986. In: G. Pilleri (ed). *Investigations on Cetacea*.. Vol. XXII, pp. 298-329

Silva, M.A.1999. Diet of common dolphins, *Delphinus delphis*, off the Portuguese continental coast. J. Mar. Biol. Ass. U.K. 79: 531-540.

Simmonds, M. Irish, R., Moscrop, A.1997. The Dolphin Agenda- Whale and Dolphin Conservation Society, Bath, UK.

SMRU, 2004. Report to DEFRA on dolphin bycatch mitigation work in the bass pair trawl fishery. Sea Mammal Research Unit, September 2004.

Tregenza, N.J.C. 1992. Fifty years of cetacean sightings from the Cornish coast, SW England. *Biological Conservation* 59:65-70

Tregenza, N.J.C. and Collet, A. 1998. Common dolphin, *Delphinus delphis*, bycatch in pelagic trawl and other fisheries in the Northeast Atlantic. *Rep. Int Whal. Commn*. 48:453-459.

Tregenza, N.J.C; Berrow, S.D; Hammond, P.S; Leaper, R. 1997. Harbour porpoise (*Phocoena phocoena* L.) by-catch in set gillnets in the Celtic Sea. *ICES Journal of Marine Science* **54**: 896-904.

Van Canneyt, O., Davoust, L. Dabin, W., Ridoux,V. 2002. Population characteristics of the common dolphin, *Delphinus delphis*, during multiple stranding events in the Northeast Atlantic: evidence for by-catch and potential demographic effects. Abstracts European Cetacean Society, 16th Annual Conference, April 7-11, 20002, Liège, Belgium: p.45.

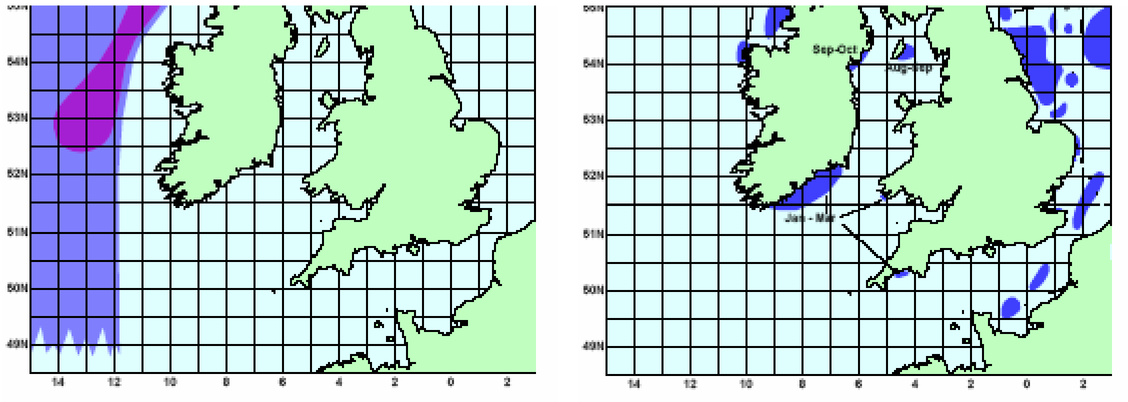
Walker, D and de Boer, M.N.2003. *A guide to the whales, dolphins and porpoises of the United Kingdom.* The first WDCS annual report on the status of UK Cetaceans. Whale and Dolphin Conservation Society, Chippenham, UK.

WDCS. 2004. Dead dolphins in the English Channel. *A report by WDCS for Greenpeace,* June 2004. www.wdcs.org/channelrep.

Wells, R.S. and Scott, M.D. 2002. Bottlenose dolphins. In: *Encyclopedia of marine mammals* (Perrin, W.F., Wuersig, B., Thewissen, J.G.M. (eds). Academic Press, San Diego, 122-127

Wood, C.J. 1998. Movement of bottlenose dolphins around the South-west coast of Britain. *J. Zool. London*. 246, pp 155-16

ANNEX I Information on spawning areas, pelagic fishing effort, migration routes for different fish species and survey effort



A Blue whiting *B Herring*
C Mackerel *D Pelagic fishing effort*

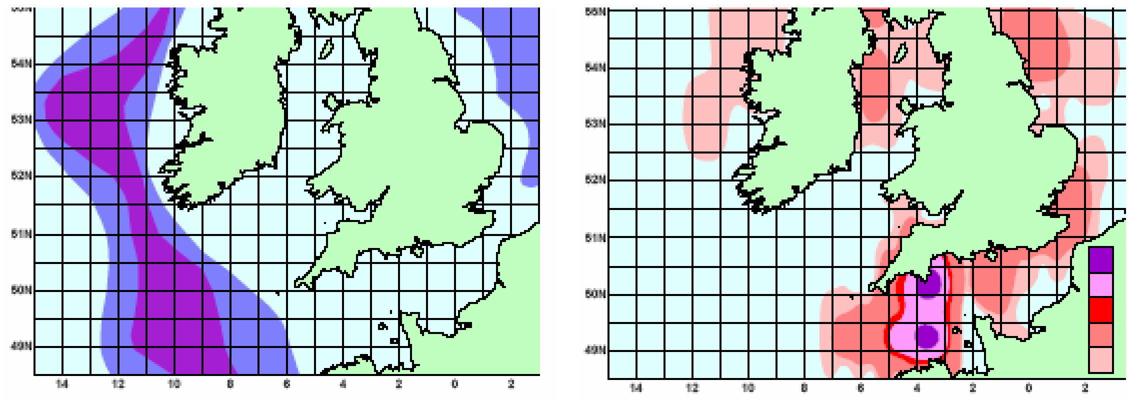


Fig. I. The spawning areas for blue whiting (A), herring (B) and Mackerel (C). The pelagic fishing effort is depicted in figure D, where purple resembles highest effort and where pink resembles lowest effort. From: Coull *et al.,* 1998.

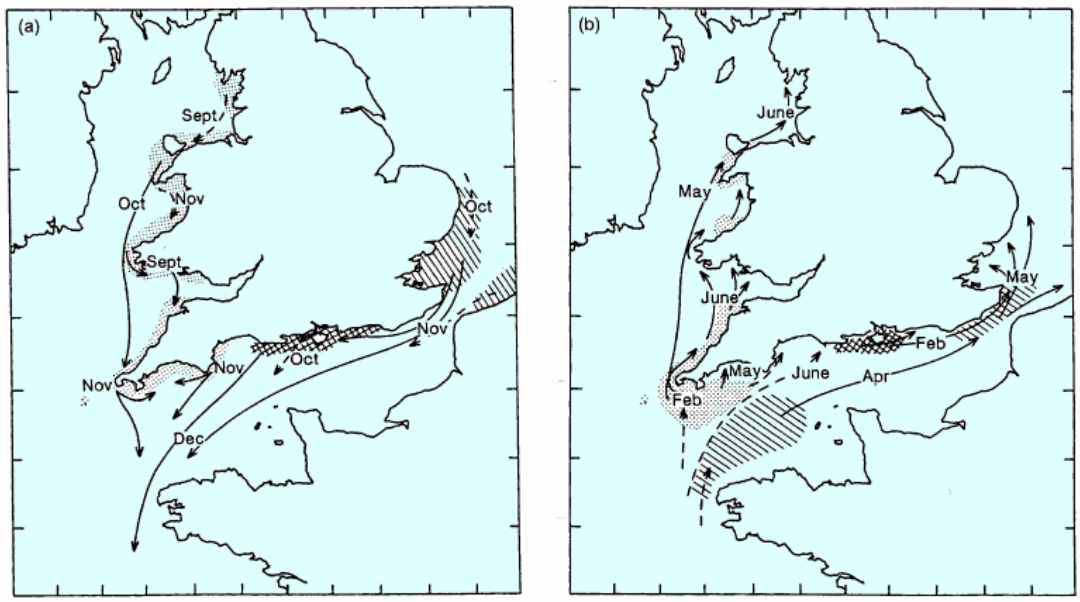
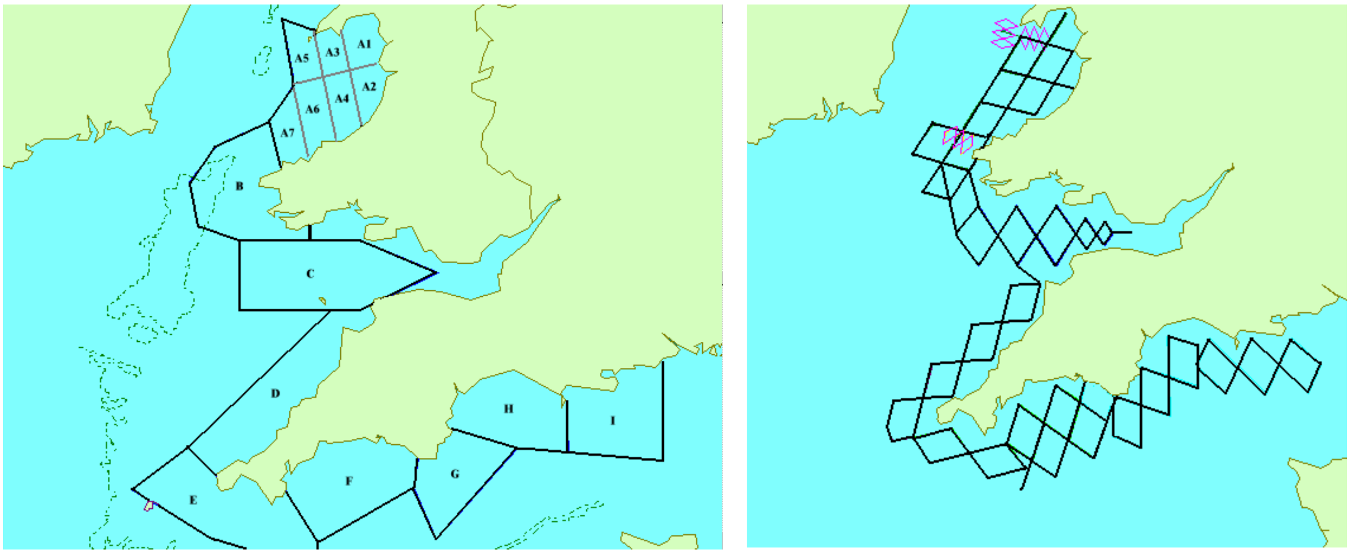


Fig. II. Seasonal movements and migrations of adult sea bass in the 3 main populations around England and Wales indicated by shaded areas: (a) autumn movements from summer feeding areas; (b) spring movements from spawning areas. From: Pawson *et al.* (1987).

ANNEX I – continued (Survey effort)



Maps showing the positions of the different survey strata (A-I) and predetermined transects (black and pink lines) off the coasts of Wales and the Southwest during the WDCS/Greenpeace autumn cruise in 2002 (De Boer&Simmonds, 2003).

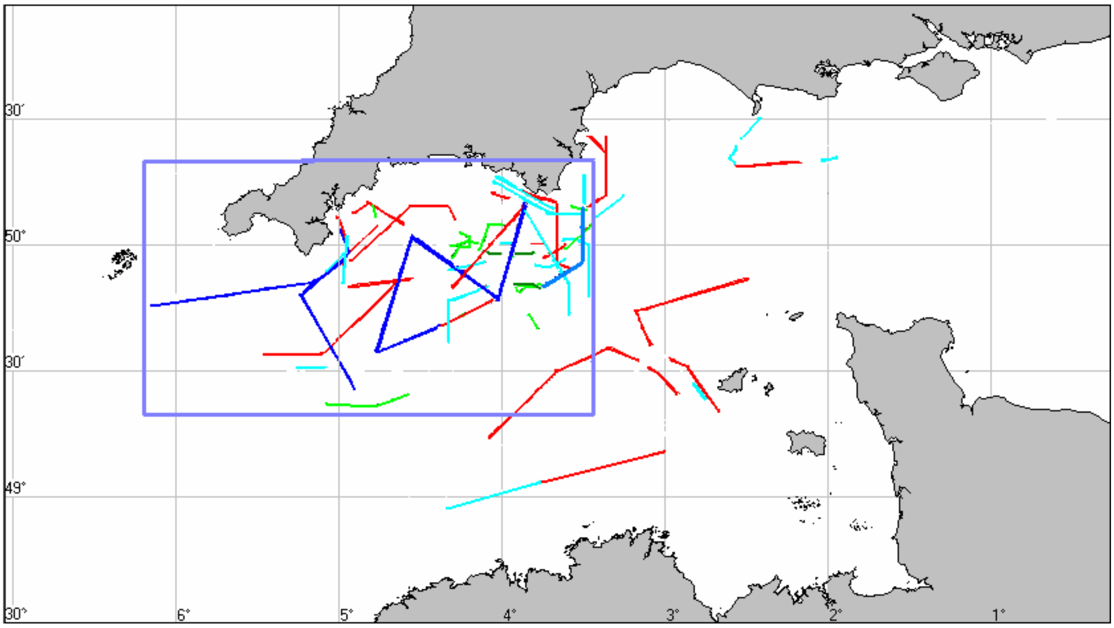
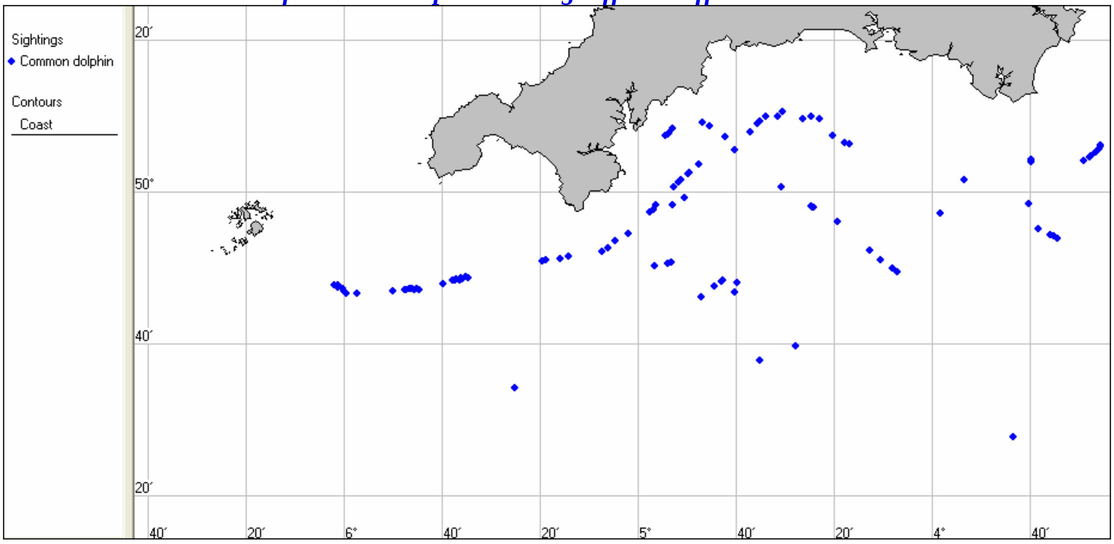
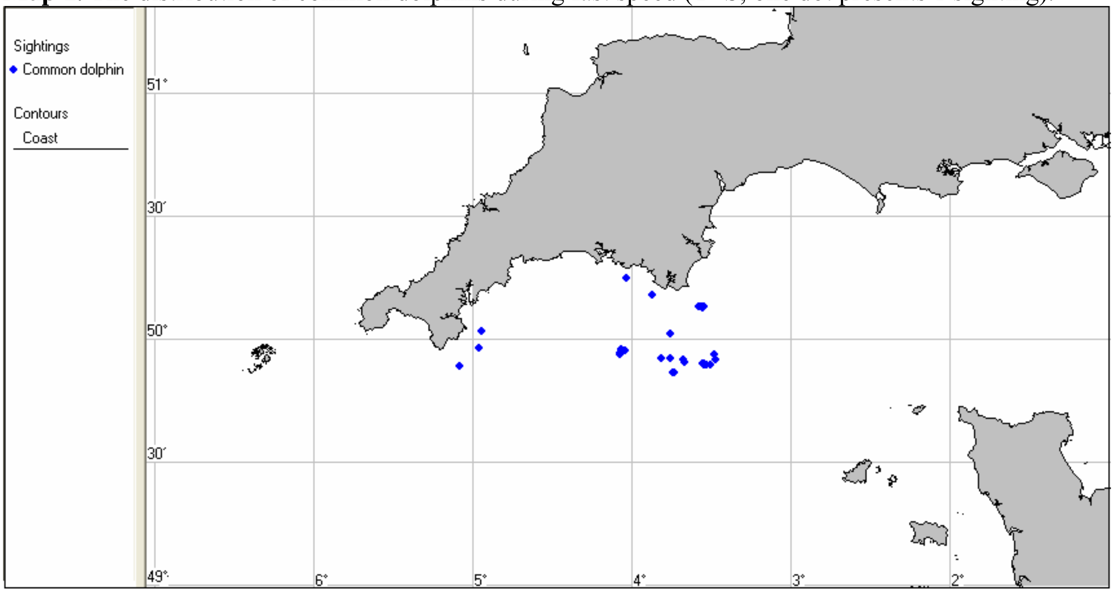


Fig. 1. Survey effort ≤4.5 sea state during transects (T in dark blue & TS in blue); high effort (S in red & SLOW in cyan); fisheries observations (FOS in green & FOF in dark green) with the main Survey Area outlined as a box.

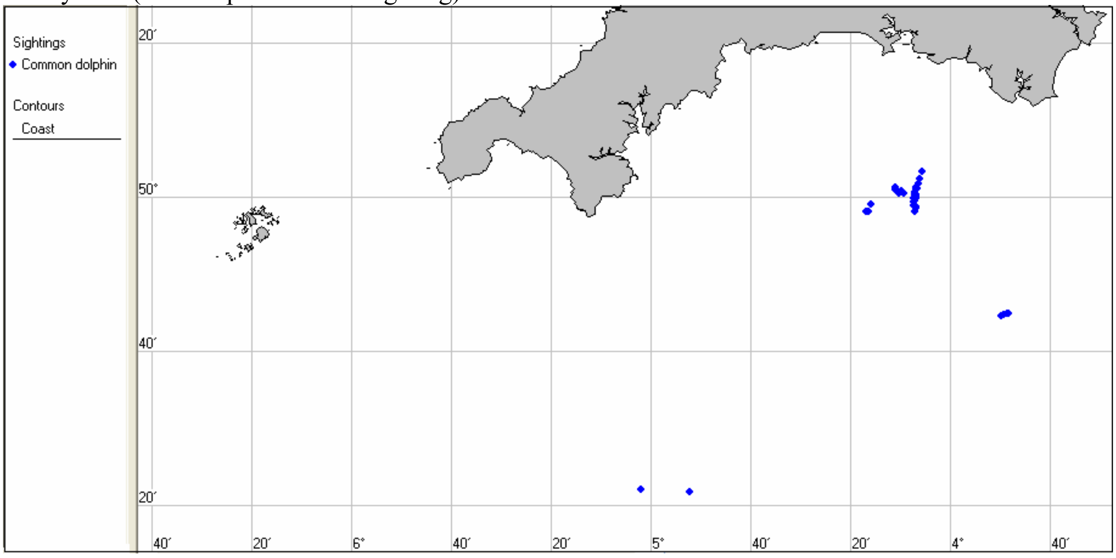
ANNEX II Distribution of common dolphins during different effort modes



Map 1. The distribution of common dolphins during fast speed (T+S; one dot presents 1 sighting).



Map 2. The distribution of common dolphin sightings during slow speed (SLOW+TS) within the survey area (one dot presents one sighting).



Map 3. The distribution of common dolphin sightings during fisheries observations (FOS) within the survey area (one dot presents one sighting).

Annex iii Common dolphin – Photo Id

CD2 (RSD)

CD3 & CD4 (RSD)

CD24 (RSD)

Annex iv Common dolphin – Natural markings

Photo 1. Photo showing the 'Type 1' flank markings on a common dolphin, where a black lateral stripe continues into the yellow side patch.

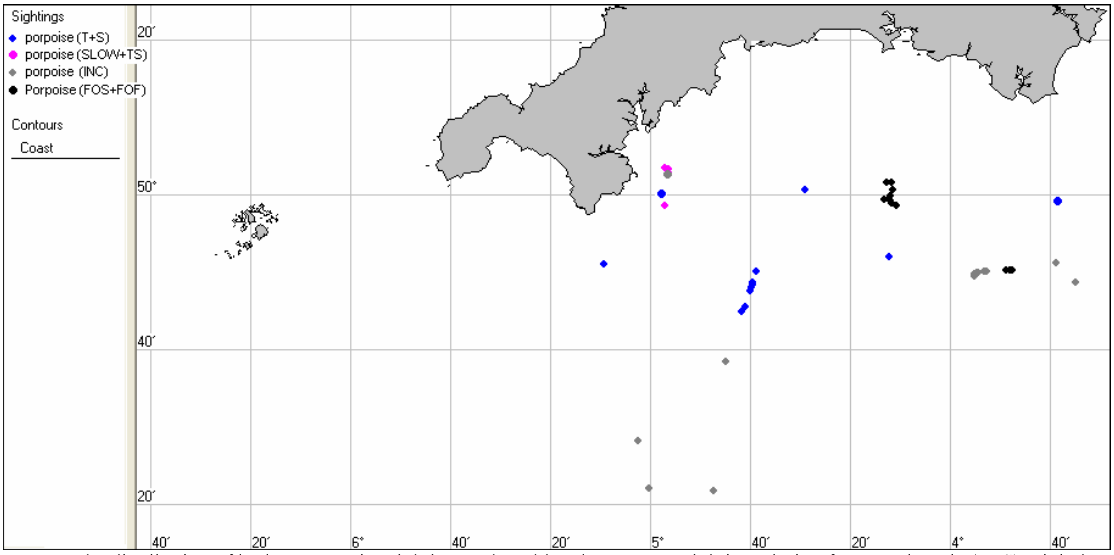
Photo 2. Photo showing 'Type 2' flank markings on a common dolphin, where a black lateral stripe does not continue into the yellow side patch.

Annex iv – continued

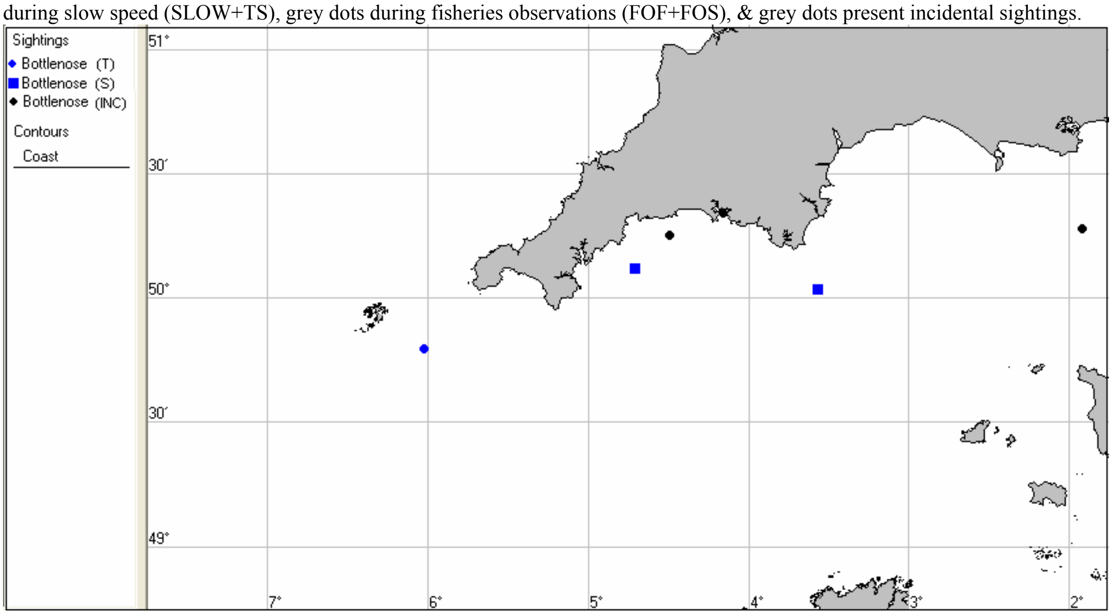
Photo 3. Photo showing a 'partly pale patch' on the dorsal fin of a common dolphin.

Photo 4. Photo showing two common dolphins, the front animal with an almost 'complete pale dorsal fin' and the hind animal with 'no pale pigmentation' on its dorsal fin.

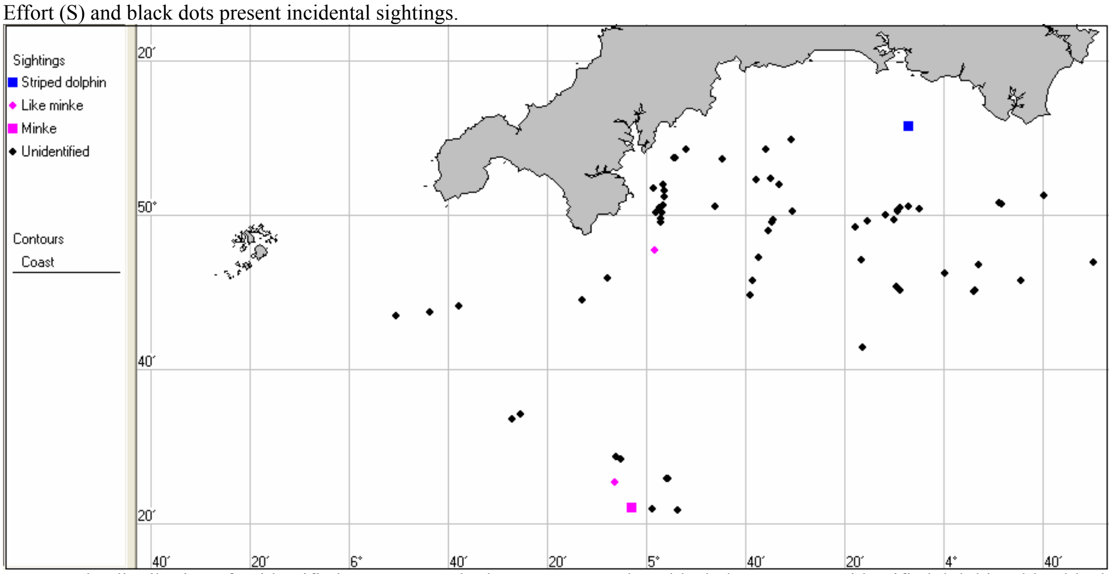
ANNEX v Distribution charts



Map 4. The distribution of harbour porpoise sightings, where blue dots present sightings during fast speed mode (T+S), pink dots during slow speed (SLOW+TS), grey dots during fisheries observations (FOF+FOS), & grey dots present incidental sightings.

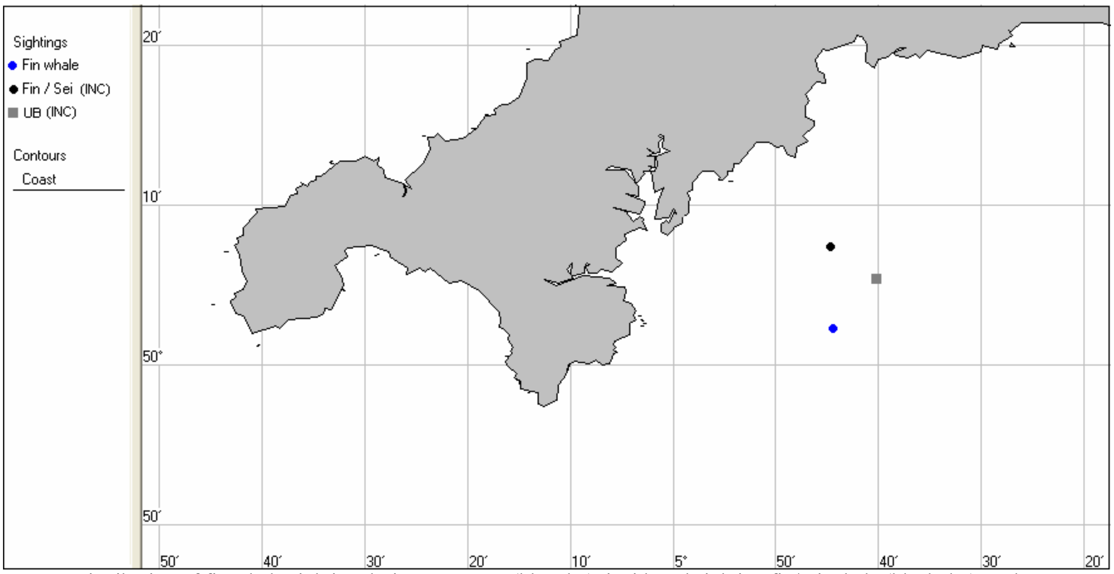


Map 5. The distribution of bottlenose dolphins where blue dots present sightings during Transects (T), blue blocks during High Effort (S) and black dots present incidental sightings.

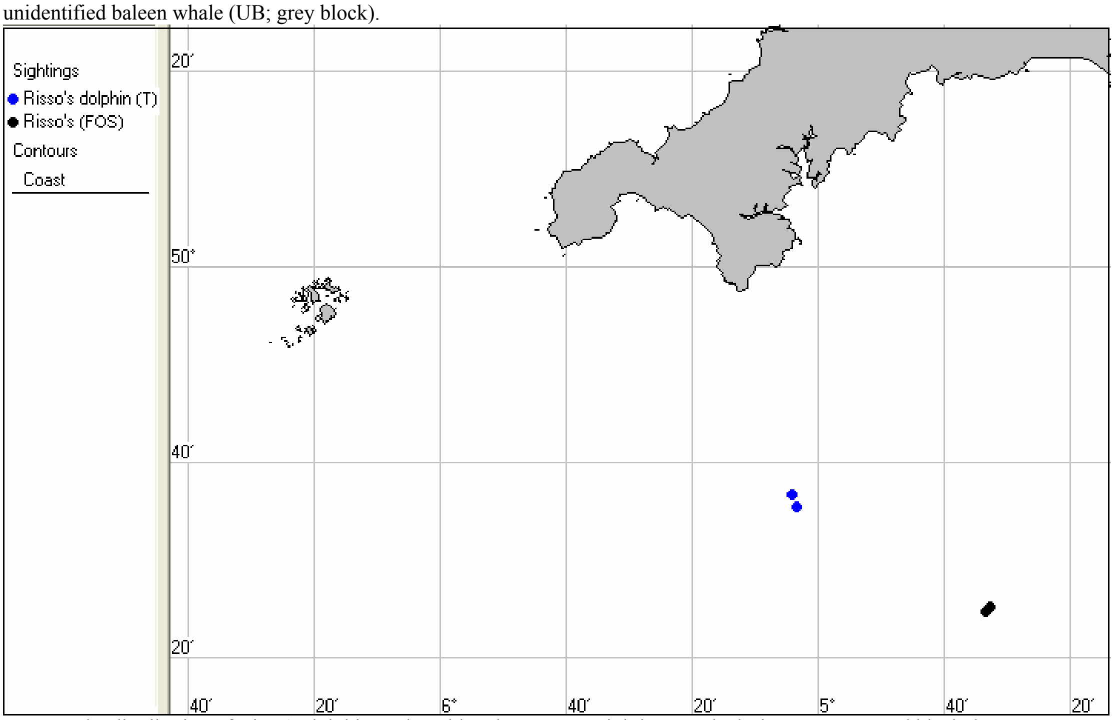


Map 6. The distribution of unidentified cetaceans and other cetaceans, where black dots present unidentified dolphins, blue block presents a striped dolphin, pink block presents a minke whale and where a grey pink dot presents minke-like whales.

ANNEX v Distribution charts-continued



Map 7. Distribution of fin whale sighting during Transects (blue dot), incidental sighting fin/sei whale (black dot) and unidentified baleen whale (UB; grey block).



Map 8. The distribution of Risso's dolphins, where blue dots present sightings made during Transects and black dots present sightings made during fisheries observations.

ANNEX vi Post mortem results

DOLPHIN 1

This male adult common dolphin had a number of findings consistent with entanglement in fishing gear (by-catch). The net and rope marks found on the externa of the carcass were all consistent with gillnet-type fishing gear with a monofilament twine diameter of approximately 0.55mm, a mesh size of approximately 267 mm and possibly twin 6 – 8 mm polypropylene headline ropes. The dolphin was also good nutritional condition and there was no evidence to support an alternative cause of death.

This report is based on gross findings and may be modified after the laboratory findings are known. Laboratory results pending: histology.

Paul Jepson
London, 02/09/04.

DOLPHIN 2

This juvenile male common dolphin was in very good nutritive condition at death. A number of findings consistent with entanglement in fishing gear (by-catch) were found on post-mortem examination. These included netmarks, muscle tears and haemorrhage, some haemorrhage in the thoracic rete mirabile and evidence of recently ingested prey. The netmarks found over the externa were thinner than those normally found in animals by-caught in pelagic trawl fisheries and were more suggestive of those found in animals by-caught in gillnet fisheries. No evidence to support an alternative cause of death was found.

This report is based on gross findings and may be modified after the laboratory findings are known. Laboratory results pending: virology, morbillivirus detection, histology.

Rob Deaville
London, (02/07/04).

DOLPHIN 4

This juvenile male common dolphin was in very good nutritive condition at death. A number of findings consistent with entanglement in fishing gear (by-catch) were found on post-mortem examination. These included netmarks, muscle tears and haemorrhage, some haemorrhage in the thoracic rete mirabile and evidence of recently ingested prey. The netmarks found over the externa were thinner than those normally found in animals by-caught in pelagic trawl fisheries and were more suggestive of those found in animals by-caught in gillnet fisheries. No evidence to support an alternative cause of death was found.

This report is based on gross findings and may be modified after the laboratory findings are known. Laboratory results pending: virology, morbillivirus detection, histology.

Rob Deaville
London, (20/06/04).

ANNEX vii Scarring

Photo1. Partially missing dorsal fin.

Photo 2. Deep straight cut in ventral part.

Photo 3. Damage on head area and dorsal fin.

Photo 4. Dead dolphin with severe woundings of the rostrum

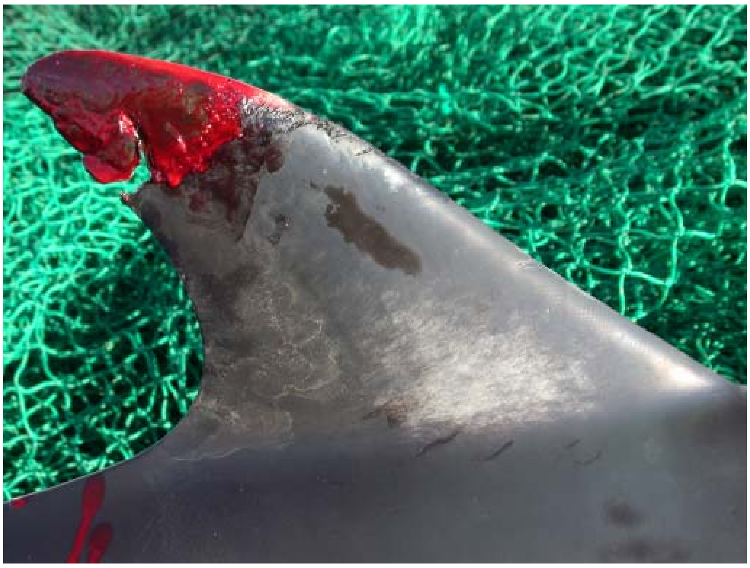


Photo 5. Dead dolphin with a deep cut in the dorsal fin.

Photo 6. Dead dolphin with a deep cut in the flipper.

***Annex viii Bottlenose dolphin* – Bottlenose dolphins in Dingle Bay, Ireland**

BND3 (RSD, front animal),BND4 (RSD, back left animal) & BND2 (back right animal)

BND5 (RSD, back left animal)

BND6 (RSD, back right animal)

ANNEX viii (continued) Bottlenose dolphins (8th March 2004) – Photo ID

BND2 (RSD)

BND6 (RSD)

BND7 (LSD) Calf showing foetal folds

ANNEX ix Minke whale – Photo ID

Right side photo series

Left side photo series

ANNEX X

Study	Season	Area size (km^2)	Effort (km)	Number of sightings (*n* schools)	Location	Relative index of school abundance *n/L* (*n*/100km)	Mean school size (*s*)	Relative index of animal abundance (*n/L * s*)	Estimated half strip width (*ESW*)	Estimated density (*D*) of individuals (ind/km^2)	Estimate of abundance (*N*)
SCANS'94 (Hammond *et al*. 2002)	Summer	201,490	2,974	28	Celtic Sea (Block A)	0.94	10.8	10.2	0.14	0.37[1]	75,450 95%CI=23,000-149,000
NASS'95 (Cañadas *et al., in press*)	Summer	798,681	2,448	25	Faeroes and western British Isles (Block E)	1.02	8.29	8.5	n/a	0.1[2]	77,547 95%CI=25,290-153,831
NASS'95 (Cañadas *et al., in press*)	Summer	371,544	650	49	Off-shore Atlantic (Block W)	7.5	8.29	62.2	n/a	0.74[2]	273,159 95%CI=153,392-435,104
NASS'95 (Cañadas *et al., in press*) – Distance analysis	Summer	371,544	650	45	Off-shore Atlantic (Block W)	6.9	6.87	47.4	0.07	4.30[3]	1,596,400 95%CI=763,920-3,336,200
MICA'93 (Goujon *et al*., 1993)	Summer	370,089	n/a	58	Bay of Biscay	n/a	6.1	n/a	n/a	0.16[1]	61,888 95%CI=35,461-108,010
WDCS/Greenpeace'02 (De Boer & Simmonds, 2003)	Autumn	4,542	241.3	7	Western Channel	2.9	7.81[4] (SD 8.38)	22.6	-	-	-
ORCA (Macleod and Walker, 2004)	Winters (1998-2000)	n/a	n/a	n/a	Western Channel, Bay of Biscay	3.5	16.9 (SD 17.8)	59.2	-	-	-
BDRP (Brereton *et al*., 1999)	Year round	n/a	n/a	n/a	Western Channel, Bay of Biscay	2.7	32 (SD 113)	86.4	-	-	-
This survey	Winter	8,872	448.9	42	Western Channel	9.4	6.9	64.9	0.29	1.09[1]	9,708 95%CI=4,799-19,639
This survey	Winter	4,129	305.9	18	Stratum E	5.9	6.9	40.7	0.29	0.7	2,841 95%CI=169-5,512

Table. x. Information on season, area size (km^2), effort, number of sightings (*n*), location, relative abundance (*n*/100km), mean school size, relative index of animal abundance, estimated strip width, estimated density and estimate of abundance for common dolphins during different surveys in the NE Atlantic, where[1] Standard perpendicular distance analysis assuming *g(0)=1* and no responsive movement;[2] Buckland-Turnock dual platform analysis allowing *g(0)* to be estimated and allowing for responsive movement occurring between detection by Tracker and Primary platforms; [3] Dual platform analysis allowing *g(0)* to be estimated but ignoring responsive movement; and [4] for total area.