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Full Length Research Paper

Interactions between short-beaked common dolphin (*Delphinus delphis*) and the winter pelagic pair-trawl fishery off Southwest England (UK)

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During offshore and onshore studies (2004 to 2009), the interactions between pair-trawls and short-beaked common dolphins (*Delphinus delphis*) were studied to better understand the impact of bycatch. A 'hotspot' area where pair-trawls overlapped with high dolphin abundance was identified. We made comparisons between boat-based data collected in absence and presence of pair-trawlers. The relative abundance and group-size of dolphins was significantly higher in the presence of pair-trawlers. Dolphins were observed associating with towing and hauling procedures. Significantly, more carcasses occurred in areas with hauling-activity than those without. Body-temperatures obtained from carcasses found near operating pair-trawlers indicated that bycatch mostly occurred at night. During necropsy studies, difficulties were encountered in identifying the fishing-gears responsible. Strandings data highlighted that the number of dead stranded dolphins was probably much higher than previously reported and there was a significant difference in the age and gender-composition of carcasses. Mature/sub-adult males appeared at greater risk from entanglement in pair-trawls offshore, whilst females with young appeared more vulnerable to inshore gillnets. Our findings show that the overlap between pelagic fisheries and the common dolphin hotspot is causing direct mortality through bycatch and, together with recent range-shifts, may have contributed to a localised decline of this species in this winter hotspot since 2007.

Key words: Bycatch, common dolphin, *Delphinus delphis*, pair-trawl fishery, gillnets, strandings, English Channel, conservation, abundance, trawling, mortality.

INTRODUCTION

Globally, much is unknown about interactions between fisheries and cetaceans (Read et al., 2006). Incidental catch in fishing gear (bycatch) forms a major threat to the conservation of cetaceans in European waters (Parsons et al., 2010). This has long been acknowledged by inter-governmental bodies such as ASCOBANS (regional agreement on the protection of small cetaceans of the Baltic and North Seas), DEFRA (the UK Department for Environment, Food and Rural Affairs), ICES (International Council for the Exploration of the Sea) and Non-Governmental Organisations such as WDCS (Whale and Dolphin Conservation Society) and Greenpeace (ASCOBANS, 2000; Ross and Isaacs, 2004; DEFRA,

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Abbreviations: NFR, Non-fisheries related; **FR,** fisheries related; **PO,** platform of opportunity; **BSS,** Beaufort Sea State; **CSIP,** Cetacean Strandings Investigation Program.

2009; Parsons et al., 2010). In the eastern Atlantic and western Mediterranean, the common dolphin (*Delphinus delphis*) is the most frequently bycaught dolphin. This species is one of the most abundant dolphin in these areas, although, following a recent decline, not so common anymore in most of the Western Mediterranean (Bearzi et al., 2003). The fisheries responsible for bycatch include tuna driftnets, pelagic trawls, bottom set-nets, beach seine-nets and long-lines (Morizur et al., 1999; Silvani et al., 1999; Silva and Sequeira, 2003; Tudela et al., 2005; Rogan and Mackey, 2007; Fernández-Contreras et al., 2010; Goujon, 1996; Tregenza et al., 1997). With pelagic drift nets now prohibited, pelagic trawls and bottom-set gill-nets pose the main threat to common dolphins in European waters (working report from ICES, 2005). Increases in reported bycatch lead to the adoption of new EU council regulations aiming to reduce cetacean bycatch (EC, 2004). These regulations also require observer programs to monitor cetacean-fisheries conflicts and study the use of pingers in certain fisheries for larger vessels in EU-waters (for example, North Sea, English Channel, Celtic Sea and Baltic; Parsons et al., 2010).

During the winter months, common dolphins move from their summer offshore habitats to aggregate in the western approaches of the English Channel (western Channel) and in particularly off the West and South coasts of Ireland and Southwest England. Densities in these winter areas are much higher than in summer (MacLeod et al., 2008; de Boer et al., 2008; Evans, 1992; Pollock et al., 1997; ICES, 2005; Macleod and Walker, 2004). Aggregations of dolphins in the western Channel also occur whilst this area is heavily exploited by fisheries using different gear including lines, traps, bottom-set gillnets, trammel-nets, bottom and pelagic trawls (López et al., 2003; Silva and Sequeira, 2003; Fernández-Contreras et al., 2010; Northridge et al., 2006). Indeed, the western Channel is reported to have some of the highest fishing pressures in UK waters (Witt and Godley, 2007; Lee et al., 2010).

During winter there is high pair-trawl effort in the western Channel which mainly targets sea bass (*Dicentrarchus labrax*) which come to the area to spawn (ICES, 2005). Pair-trawlers tow a large funnel-shaped net between two boats; the net has a very wide opening both horizontally and vertically. Within the region, most research regarding cetacean bycatch has focused on static gear such as gillnets and more recently on acoustic devices (pingers) to decrease the bycatch of dolphins in fishing nets (for example trammel-, gill- and pelagic trawl-nets) (Leeney et al., 2007; Gazo et al., 2008; Berrow et al., 2009). Conversely, fewer studies have been carried out on cetacean bycatch in trawl fisheries. Twenty-five cetacean species have been reported killed in trawl-gear worldwide (Fertl and Leatherwood, 1997). Other studies have focused on foraging associations between cetaceans and trawl-fisheries (Waring et al., 1990; Couperus, 1993, 1994, 1997; Fertl and Leatherwood, 1997; Morizur et al., 1999; Chilvers and Corkeron 2001; Fortuna et al., 2010). Cetacean bycatch has been reported in pair-trawl gear in the Celtic Sea and English Channel (Northridge et al., 2006) and more recently also in the northern Adriatic Sea (Fortuna et al., 2010) and off northwest Spain (López et al., 2003; Fernández-Contreras et al., 2010).

Common dolphin strandings in the Northeast Atlantic have shown a consistent spatial and seasonal pattern with pronounced winter peaks in the UK, Ireland, and the Atlantic coasts of France, Spain and Portugal (Simmonds, 1997; López et al., 2002; Silva and Sequeira, 2003; Leeney et al., 2008; Peltier et al., 2012; Tregenza and Collet, 1998; Sabin et al., 2004; ICES, 2005). Fishing gear is rarely found on stranded cetacean carcasses; however, traumatic lesions such as abrasions, amputations, penetrating wounds, fracture of limb bones, and mandibles or missing teeth are often visible (Kuiken, 1994; Kuiken et al., 1994; Garcia Hartman et al., 1994). Stranded cetaceans with such lesions can therefore be used as evidence of cetacean bycatch; however, they neither provide estimates of total bycatch nor, in most cases, which gear type was responsible. The reasons are that: (1) only a small percentage of bycaught carcasses are washed ashore with the remainder sinking or decomposing at sea (Williams et al., 2011; Peltier et al., 2012); (2) many stranded carcasses may also go unrecorded due to the length and remoteness of the coastline concerned; and 3) not all carcasses can be retrieved or are fresh enough for necropsy to confirm the cause of death and, in the case of bycatch, the type of fishing gear responsible.

Following a record number of common dolphin strandings in Southwest England in 2003 (Sabin et al., 2004), dedicated cetacean surveys were launched to study the overlap in distribution of common dolphin and their interactions with fisheries in winter. To this end: (1) additional shore-based studies (2006 to 2009) were carried out targeting those remote coastal areas where stranded cetaceans could possibly go unrecorded; and (2) boat-based studies were carried out offshore (winters 2004 to 2005) in order to monitor the pelagic pair-trawl fisheries. This allowed us to observe the entire fleet and study cetacean-fisheries interactions as they occurred, and to collect and study stranded animals that might have otherwise gone unrecorded. Our at-sea surveys differ from observer programs which take place onboard fishing vessels, which do not allow for density comparisons between dolphins that associate with fisheries and those that do not.

The main objectives of this study are: (a) to study the winter distribution of the common dolphins and their interactions with pelagic pair-trawl fisheries in the western Channel; (b) to identify those areas where pelagic pair-trawl fisheries overlap with common dolphin ‘hotspots’; (c) to compare the age and genders of common dolphin

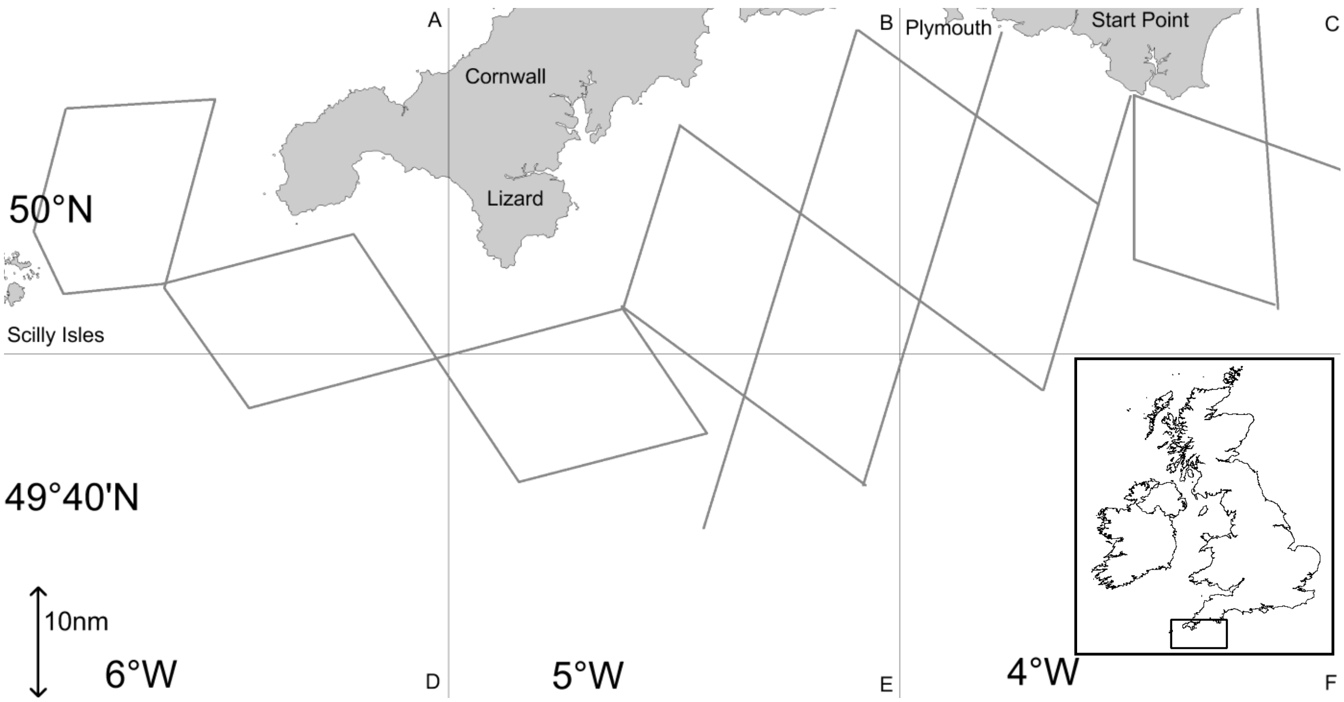

Figure 1. Study area with 6 strata (A to F) and predetermined line-transect design (grey lines) in the Western Approaches of the English Channel.

carcasses found onshore to those offshore; (d) to determine the proportion of unrecorded stranded carcasses; and (e) to examine stranded carcasses for lacerations indicative of bycatch. Given that both fishermen and dolphins are likely to target areas of high fish abundance, we hypothesize that dolphin abundance is higher and hence interactions are more likely in areas with pair-trawl activity compared to areas where such activity does not occur.

METHODOLOGY

Boat-based surveys

Surveys were carried out during winter between 21 January and 8 March 2004 and 17 February and 26 March 2005 in the western Channel. The main study area (23,761 km^2) was between 49°20'N and 50°20'N, and 3°20'W and 6°10'W (Figure 1). The Greenpeace vessel MV Esperanza (72.3 m in length) was employed in either a fisheries monitoring role or a dedicated research role (following predetermined line-transect survey lines) in order to estimate the abundance of common dolphins (de Boer et al., 2008). During search-transits and fisheries monitoring, the vessel was used as a Platform of Opportunity (PO) vessel (without control over ship's route or speed). Survey effort continued throughout all daylight hours and was suspended when Beaufort Sea State (BSS) exceeded 4 or visibility dropped to < 1 nmile. Observations were conducted from the outer bridge wings at an eye height of 11.3 m. Two observers (one on each side) scanned a 180° in front of the ship (de Boer et al., 2008). The group-formation of the dolphins were classified as 'tight' (one group of animals which remain within one body length from each other), 'loose' (one group of animals which are more than 2 to 5 body lengths from each other), 'groups loose' (different groups are in the area, but each group is loosely grouped) or 'groups tight' (different groups are in the area, but each group is tight). The behaviour of the dolphins was recorded, for example 'bow-riding' (gliding/swimming on pressure wave in front of boat), 'breaching' (lifting the whole body above surface and hitting the surface with the lateral body surface) and 'approach' (approaching the vessel up to a few meters) (de Boer et al., 2004). The group-size was recorded as a maximum and minimum estimate on which we based a best estimate (not accounting for animals underwater). Any changes in group composition (groups joining or leaving) were recorded to ensure that the best estimate of group size related to the group first sighted.

Effort was carried out in the absence of fisheries (Non-Fisheries Related effort, NFR) and during fisheries monitoring (from this point onwards called Fisheries Related effort: FR) with pelagic trawlers present in the general area (within 2 km). The position of pelagic pair-trawlers was recorded during hauling and subsequent launching operations (24 h). FR effort also took place in areas where pair-trawlers were not engaged in either hauling or launching, but were solely engaged in trawling activities. When the research vessel was within good visual range of fishing operations any sightings with dolphins and trawler-positions were repeatedly plotted and apparent interactions monitored. Survey effort consisted of pre-determined transects and PO effort (straight tracks) when the vessel was in searching mode or in transit. The same survey protocols were used during FR and NFR effort. Survey speed was on average faster during NFR compared to FR effort (7.0 vs 5.2 nautical mile h^{-1}), When possible, survey efforts continued during high sea states (BSS > 4); however, recorded sightings were regarded as incidental and are not included in the analysis.

In order to confirm if dolphins were entangled in fishing gear, a RIB (rigid-hulled inflatable boat) was used to monitor (non-dedicated) the nets within 100 to 200 m of the trawlers before, during and after hauling (during slight sea conditions, BSS < 4 and good visibility only).

Dead dolphins found offshore

Dead dolphins found floating were collected, identified to species and photographed. The maturity status of common dolphins was based on length [dolphins < 1.88 m are considered immature; derived from Murphy et al. (2009) and in some cases corroborated through necropsy]. Basic body measurements, assessment of decomposition state (as defined in DEFRA, 2002), body temperature measurements and detailed morphological external examinations were carried out. Bycatch casualties were diagnosed following the criteria proposed by Kuiken et al. (1994), including (1) clean amputated fin or fluke, (2) incision wound in abdominal cavity, (3) circumscribing skin abrasions on beak, fin or fluke, (4) skin indentations or incisions apparently produced by net material or a sharp instrument, (5) loss of superficial slices of tissue/skin on edges of fins. In addition, blood or froth discharge from mouth and blowhole, skull fracture, tooth rake marks and skin infections were noted (Stockin et al., 2009). In order to determine if carcasses found at sea had recently died, the body temperature was measured using a digital thermometer inserted via the anus, with a non-flexible 17 cm probe (810-926 ETI-Ltd; until 6 February 2004) or a flexible 100 cm probe (MM2050/TM-electronics; from 14 February 2005 onwards). Carcasses collected at sea were secured for later necropsy studies and stored in a container maintained at -10°C. These were subsequently sent to the veterinary laboratories of the Institute of Zoology, London. When freezer storage availability became scarce, the carcasses were deposited back to sea, together with all carcasses which were already in advanced states of decomposition. To avoid double reporting and recording, carcasses were measured, photographed and where possible tagged around the tailstock before depositing. The tags were made of metal showing a tag-ID and a contact telephone number to which recovered bodies could be reported.

Data analysis (Winters of 2004 and 2005)

The relative abundance was measured as the number of individuals per km effort. A grid of 10 min latitude by 10 min longitude cells was used, totaling 54 cells. Those cells with a survey effort < 5 km were excluded from analysis. We employed statistical tests using the statistical package PASW for windows (SPSS, Inc., version 18) in order to adequately answer the following basic questions. Firstly, potential differences in data collected in the two winters were studied by segregation of the relative abundance per grid cell by survey year. No significant difference was detected between the two winters (Mann-Whitney's U = 1,215.500, p = 0.088) and in subsequent analysis the two data sets were pooled.

To determine whether the dolphins were randomly distributed throughout the survey area or if they appeared to aggregate in particular grid cells, a one-sided Kolmogorov-Smirnov goodness-of-fit test was used to check if the relative abundance of the dolphins differed from a uniform distribution. To compare the relative abundance of dolphins in presence (FR) and absence of trawlers (NFR), a Mann-Whitney's non-parametric test was used. In order to compare the group-size of dolphins between the two winters and between the presence and absence of pair-trawl fisheries (FR *vs* NFR) an independent sample t-test was preferred as the Mann-Whitney's non-parametric test is less powerful and the group-size data fitted a (log) normal distribution. To determine whether the carcasses were randomly distributed over the survey area or were concentrating in particular grid cells, a Chi-squared goodness of fit test was used to investigate whether the observed number of carcasses differed from an expected Poisson distribution. We used a Chi-squared goodness of fit test to check if the sex ratio of the dead dolphins found offshore and onshore differed from the expected unity.

Systematic coastal surveys

Systematic coastal surveys were conducted during the winter months between 11 January to 24 April 2006, 4 December 2006 to 22 March 2007, 8 January to 27 February 2008, and 17 January to 5 March 2009. Remote coastal areas were specifically targeted where, during the winter months, human visitation was expected to rarely occur, as opposed to the more frequently visited beaches where strandings were more readily reported to the UK Cetacean Strandings Investigation Program (CSIP). The coastal sites that we targeted had various degrees of remoteness which depended not only on topography and tidal time windows but also on weather conditions and daylight hours which could make access very difficult for a member of the public who was not motivated or properly equipped to enter such a remote area. Wind speed / direction and other variables were recorded for each coastal survey. A total of 37.6 km of remote coastline was divided into 35 coastal sites which were systematically and repeatedly surveyed following spring tides and favourable weather conditions.

Stranded cetacean carcasses

Each cetacean carcass located was examined and photographed on site. When a carcass was found to be relatively fresh, and evacuation was possible, it was secured for necropsy and transported to the Veterinary Lab (VLA) in Truro (Cornwall). Carcasses not secured for necropsy were left *in-situ* and marked with a unique black plastic-tie secured around the tailstock for future identification and prevention of double reporting. At the end of each survey period, all strandings data was compared to that from the CSIP to determine which of the strandings would have otherwise gone unrecorded. Details of those ‘unrecorded’ carcasses were then forwarded to the UK-stranded cetacean database.

RESULTS

Boat-based surveys

NFR survey effort occurred over 2,122.9 km and FR effort over 404.7 km (16% of total effort). Overall, less effort was carried out in 2005 (NFR: 348.0 km, FR: 56.7 km) due to persistent bad weather. Common dolphins were frequently encountered with 269 NFR sightings of 1,392 dolphins and 41 FR sightings of 386 dolphins. Although incidental sightings were not included in the analysis, it is worth noting that 21 incidental sightings (98 dolphins) occurred in presence of operating pair-trawlers and 161 sightings (1,871 dolphins) in absence of this fishery (BSS > 4; Figures 2 and 3).

Fisheries vs. non-fisheries

The dolphins were not uniformly distributed throughout the survey area (*K-S* D_{max} = 3.21; p < 0.001). Most NFR effort was carried out over the entire study area and concentrated South of Start Point and Southeast of the

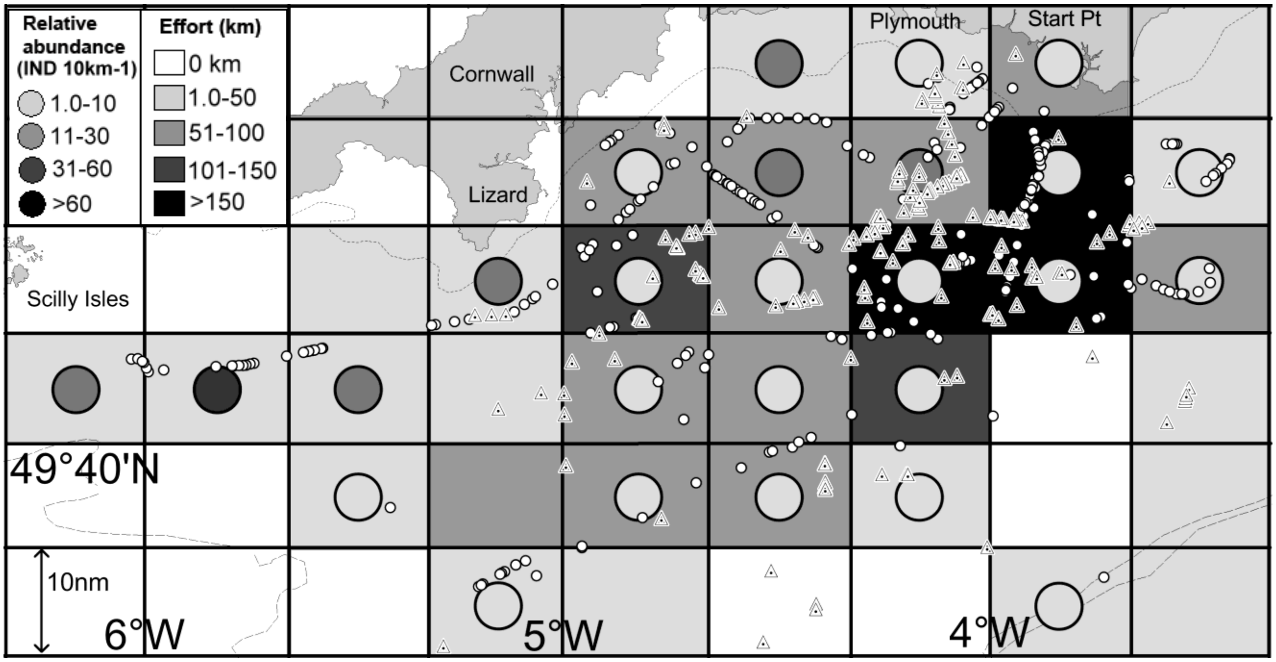

Figure 2. Distribution of NFR effort and spatial distribution of common dolphin relative abundance. Common dolphin sightings are plotted as dots and incidental sightings are plotted as triangles. Depth-contours: 50 m (dotted); 100 m (dash-line).

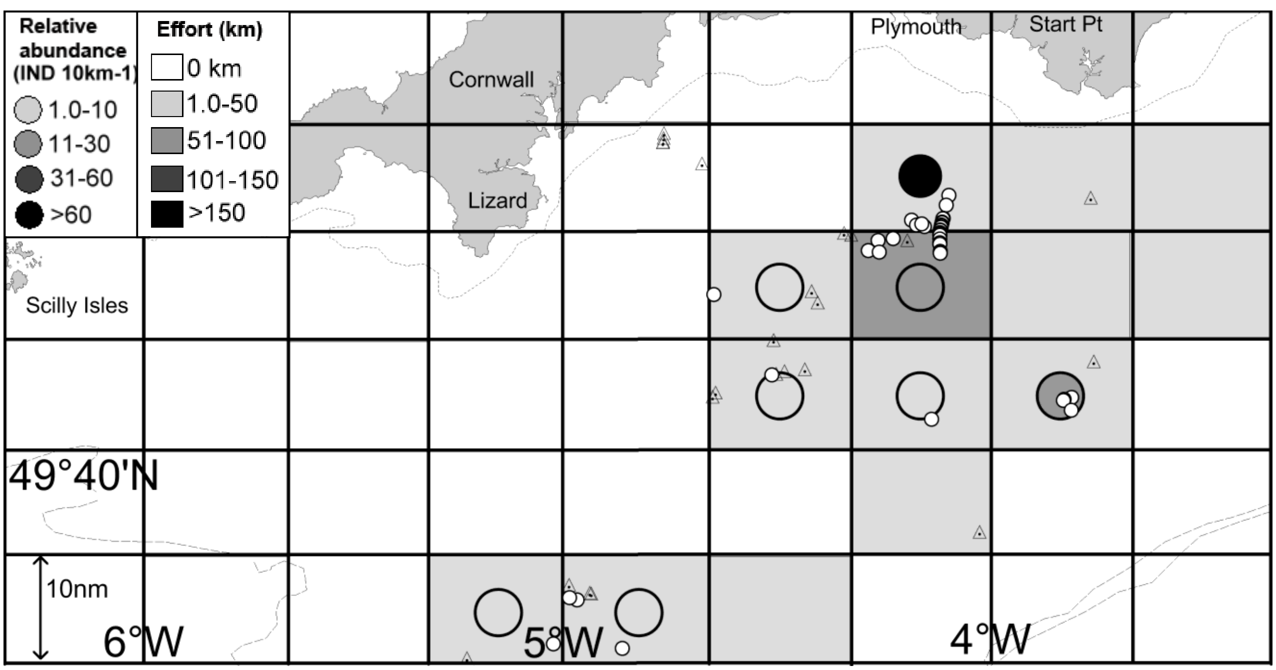

Figure 3. Distribution of FR effort and spatial distribution of common dolphin relative abundance. Common dolphin sightings are plotted as dots and incidental sightings of common dolphins in vicinity of fishing vessels are plotted as triangles. Depth-contours: 50 m (dotted); 100 m (dash-line).

Lizard (Figure 2), whereas FR effort was concentrated in the eastern part of the survey area (Figure 3). The highest NFR relative abundance for common dolphins was measured Southeast of the Scilly Isles (3.2 dolphins km^{-1}), South of the Lizard (2.6 km^{-1}) and Southwest of Start Point (1.7; Figure 2). The highest FR relative abundance for common dolphins was measured Southwest of Start Point (6.8 dolphins km^{-1}; Figure 3).

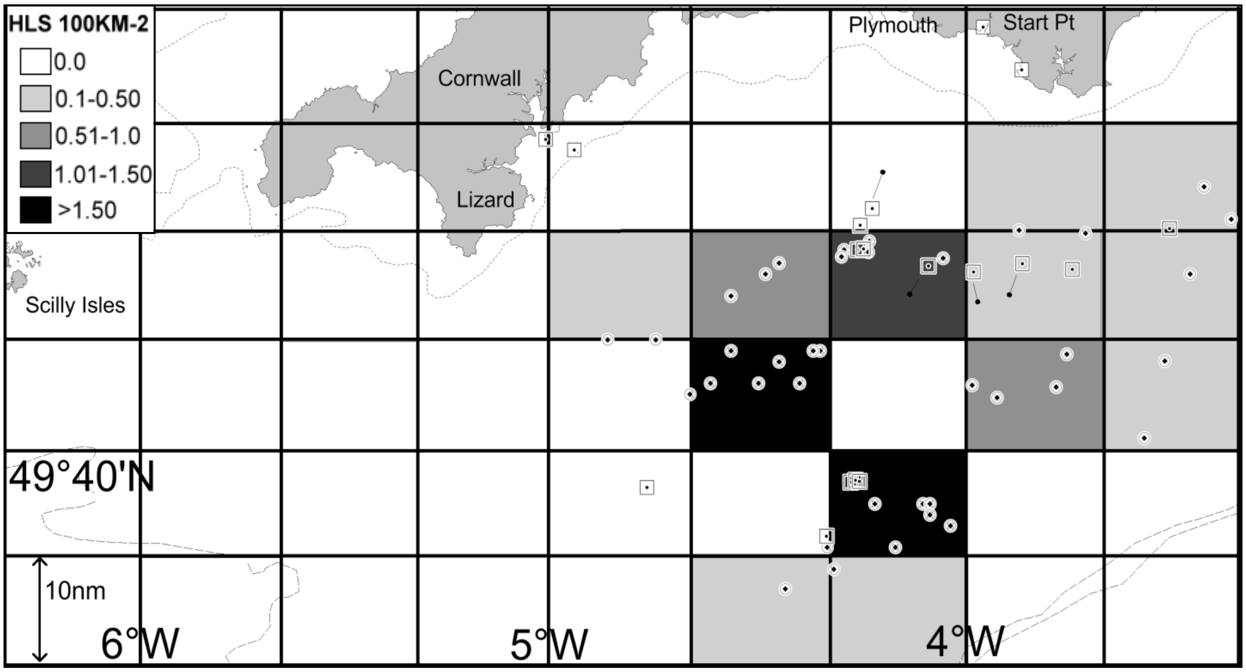

Figure 4. Position of pair-trawlers during hauling (2004 to 2005; open dots). Dead dolphin locations (pointed squares) and tagged dead dolphins (flagged). Depth-contours: 50m (dotted); 100 m (dash-line).

The overall relative abundance for FR dolphins (1.0dolphins km^{-1}) was found to be significantly higher than that of NFR dolphins (NFR: 0.7; Mann-Whitney's U = 1,993.00, p = 0.000). When only focusing on those grid cells where NFR and FR effort overlapped, the relative abundance for common dolphins was still found to be higher during FR effort (1.0 dolphins km^{-1}) compared to NFR effort (0.6 dolphins km^{-1}), however, this was no longer significant (Mann-Whitney's U = 127.50, p = 0.089).

There was no significant difference between the estimates of relative abundance for carcasses found floating at sea in those areas where FR and NFR effort overlapped (0.02 carcasses km^{-1} for FR, 0.003 carcasses km^{-1} for NFR effort; Mann-Whitney's U = 82.50, p = 0.870). Also, when taking the whole survey area into account, no significant difference regarding the relative abundance for carcasses was found (p = 0.685).

The average group-size of FR common dolphins was significantly higher (9.41, SD 11.25, n = 41; Student's T-test, p = 0.032) compared to the average group-size of NFR dolphins (5.44, SD 5.36, n = 269). Overall, the average group-size differed between the two winters, with a significantly higher group-size (NFR + FR) in 2004 (6.96 SD 7.99 n = 162) compared to 2005 (4.78, SD 4.78 n = 148; Student's T-test, p = 0.002).

Interactions

The hauling positions of pelagic pair-trawlers (in all weather conditions; Figure 4) mainly occurred in those grid cells where dedicated FR effort took place. The highest number of hauls per 100 km^2 were recorded to the southwest of Start Point (>0.5 hauls per 100 km^2, Figure 4). In 2004, pair-trawlers were observed hauling their nets at an average distance of 43.7 km (SD = 12.33, n = 18) from the coast whilst in 2005 this was 53.81 km (SD = 19.45, n = 23). The difference in closest distance to the coast of the hauling positions did not significantly differ between the two survey years (Mann-Whitney's U = 144, p = 0.098).

Interactions between the fisheries operations and dolphins were noted on ten occasions. These interactions included 'Approach', 'Bow-riding', and 'Breaching' (between the pair trawlers). The dolphins were also observed surfacing in the vicinity of the nets or approaching these during setting or hauling, or just before the hauling procedure. However, no dolphins were observed entangled in nets.

A total of 23 dolphin carcasses- of which 21 were identified as common dolphins and two unidentified - were found drifting (Appendix Table 1 and Figure 4). Eleven common dolphin carcasses were found during dedicated effort of which seven were found during FR effort. In addition, 12 carcasses were found during bad weather (BSS > 4), of which eight were found in presence of pair-trawlers. Four carcasses were tagged and deposited at sea but none were ever reported as stranded. Most carcasses located in 2004 were found drifting in an area ranging from 26 to 40 km south of Plymouth and southeast of Start Point (Figure 4). In

2005, six carcasses were found in an area ranging from 37 to 77 km south of Plymouth, one carcass was reported near Falmouth and two carcasses were found in the French Channel (Appendix I). The mean distance to shore of the carcasses found in 2004 (excluding those carcasses found floating within 2 km's of the coast) was 32.78 km (SD = 10.37, n = 12), whereas the 2005 data revealed carcass locations to be significantly further offshore (excluding those found in the French Channel; 64.44 km, SD = 16.65, n = 6; Student's T-test, $p < 0.001$). A Chi-Square test considering those carcasses found in the survey area (irrespective of their effort status) showed a significant higher observed number of carcasses than expected, especially in areas with hauling activity ($\chi 2$ = 11.17, df = 2, p = 0.004).

Other species

Occasionally other cetaceans were observed in presence of pair-trawlers, including harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus)*, minke whale (*Balaenoptera acutorostrata)* and *Balaenoptera* sp*. (*probably *Balaenoptera physalus*). On two occasions basking sharks (*Cetorhinus maximus*) were seen in direct vicinity of operating pair-trawlers.

Systematic coastal surveys

A total of 1,364 surveys targeting remote coastal sites between the Helford Estuary on the Lizard Peninsula and Pendeen (Figure 5) were carried out during the winters of 2006 to 2009 over 675.5 h of effort. The wind direction during the 2006 to 2009 winters was mainly from the southwest. Most carcasses were found during periods of prevailing SW to SE (56%) winds. In particular, the 2009 winter period was affected by persistent northwesterly winds and was characterised by a relatively low number of strandings (Appendix Table 2). A total of 41 cetacean carcasses were located stranded (Appendix Table 2), including 19 common dolphins, 9 harbour porpoises and 13 unidentified dolphins (Table 1 and Figure 5). Three carcasses were secured for necropsy studies whilst the remainder of the carcasses were either too decomposed or found in areas where removal was logistically not feasible. Of the 41 cetacean carcasses found during this study, 22 carcasses were found on the more remote coastal sites and as a consequence were never reported to the CSIP. This represents 36.7% of the total number of strandings occurring within the area over the course of this study (n = 60; Table 1).

External and necropsy examinations

During the coastal studies, lacerations on 13 of the total 19 stranded common dolphins were indicative of bycatch. During boat-based surveys, dead dolphins 1 to 5 were found as a group (Appendix Table 1 and Figure 6f). A large piece of heavy netting (approximately 35 m in length) was found near the carcasses. Dolphins 6, 7, 9 and 10 were advanced decomposed. Dolphin 8, 9, 10 and 12 were tagged and deposited to the sea. Dolphins 5 and 11 could not be recovered. Dolphins 1 to 4, 16 and 19 to 21 had body temperatures well above the ambient sea water temperature of 9.4°C (mean body temperature was 20.6°C, range was 14.9 to 30.1°C, Appendix: Table 1). The external examinations of dead dolphins found offshore revealed the following injuries: severe wounding to the rostrum including deep lacerations (Figure 6c), distorted jaws/missing teeth, fluid/froth protruding from mouth and blowhole (Figure 6b), cuts in dorsal-fins, flippers and flukes (Figure 6d).

All eleven necropsies performed on dolphins found offshore revealed injuries consistent with bycatch. Interestingly, dolphins 19 to 21 (Appendix: Table 1) were found close to pair-trawlers that had finished hauling and showed injuries due to partial eviscerations which affected the temperature readings (Figure 6a). All dolphins were in very good nutritive conditions and recently had ingested prey. Necropsy reports provided no other evidence for cause of death other than bycatch. Some external netmarks were believed to be of thinner material than those expected from pelagic trawl-gear. During coastal studies, three common dolphins were secured for necropsy (Figure 5 and Appendix Table 2). The reports concluded that two carcasses were too autolysed and thus the cause of death could not be determined yet one dolphin displayed some evidence of physical trauma prior to death. The third dolphin had a poor body condition and suffered from parasitic/bacterial pneumonia.

Gender and maturity

The sex ratio of the dead dolphins found offshore was skewed in favor of males (14 males: 5 females) and was statistically different from unity (χ^2 = 4.263, df = 1, p = 0.039) whereas an even spread of both sexes was observed for onshore strandings (8 males: 9 females; p = 0.808). A higher percentage of common dolphins found stranded onshore were immature (53%) whilst this was lower for carcasses found offshore (33.3%).

DISCUSSION

Data limitations

Given that the at-sea surveys had an opportunistic nature, it is important to point out several limitations which may lead to biased results: (1) unsystematic sampling effort; and (2) variations in survey speed. In this study, there was an uneven amount of FR and NFR effort

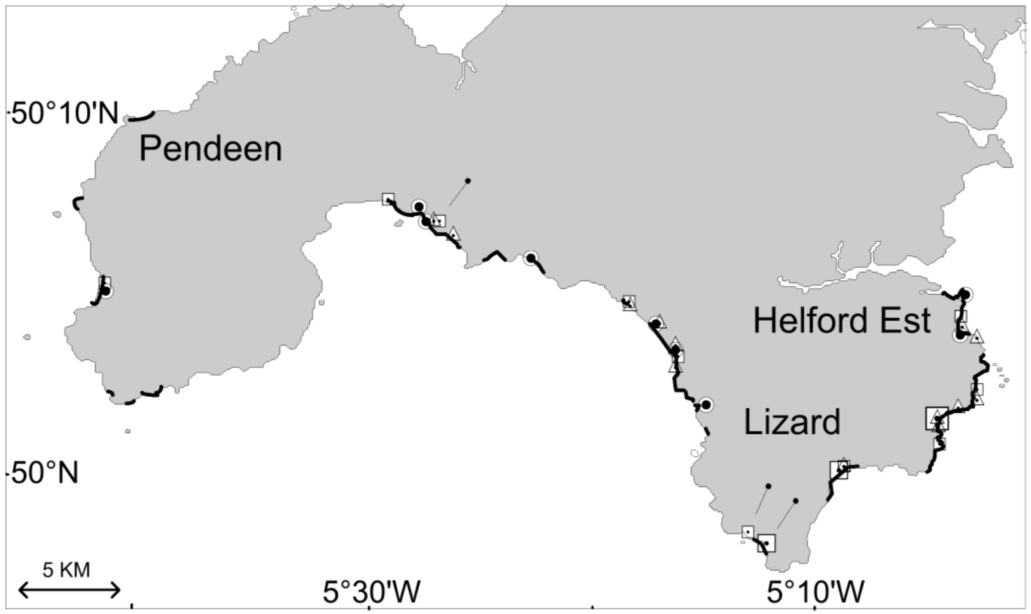

Figure 5. Overview of remote coastal areas (bold black lines) and stranding locations (2006 to 2009). Common dolphin (dotted squares), harbour porpoise (dotted circles) and dolphin sp. (dotted triangles). Common dolphins secured for necropsy are flagged.

Table 1. Overview of carcasses found during coastal studies (2006 to 2009) and those classified as unrecorded. Information on cause of death (bycatch) and total number of carcasses reported to the CSIP are included (columns C and D).

Species	Systematic coastal study (low human visitation)			Study area (all areas)	
	A	B	C	D	E
	Total carcasses found	Total classified as unrecorded carcasses	Suspected bycatch (of A)	Carcasses reported to CSIP (relevant to study area)	Total carcasses in study area (B + D)
Common dolphin	19	11	13	24	35
Harbour porpoise	9	4	3	10	14
Dolphin sp.	13	7	1	2	9
Other	0	0	0	2	2
Total	41	22	17	38	60

which may have caused bias (Williams et al., 2006). However, the sampling effort in this study was independent of the dolphin distribution and we assume that the bias in this data-set is probably low. The average survey speed during FR effort was lower compared to NFR effort (5.2

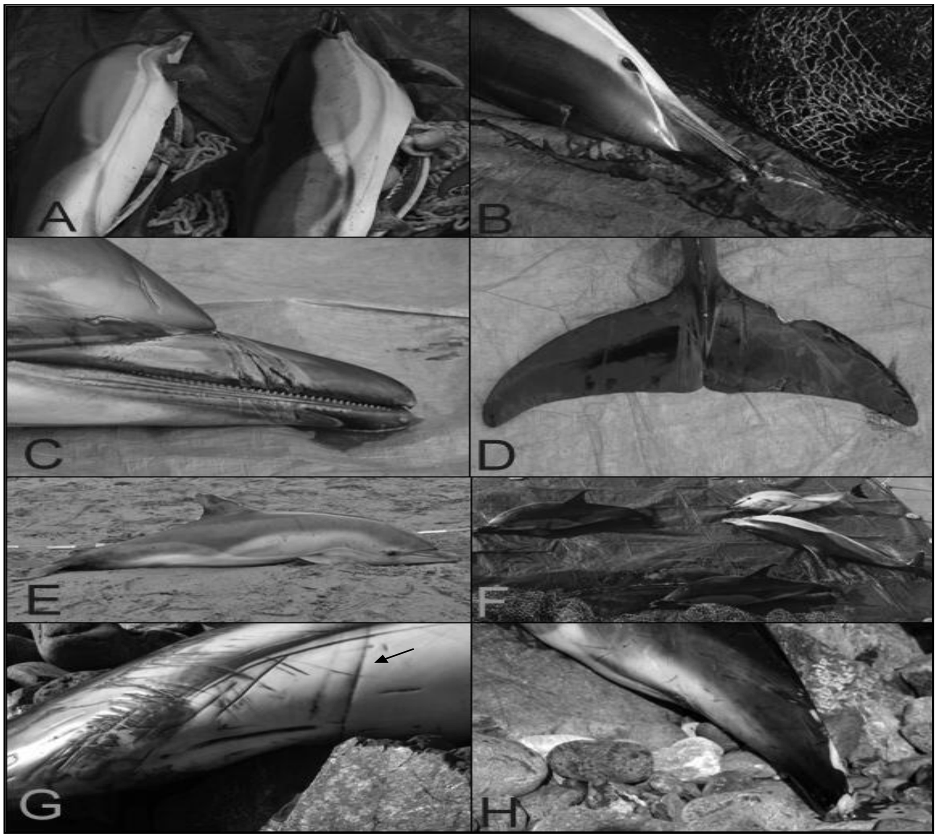

Figure 6. Lacerations indicative of bycatch. (A) Partial evisceration; (B) froth protruding from blowhole; (C) lacerations surrounding rostrum; (D) severed fluke; (E) stranded juvenile common dolphin; (F) four carcasses recovered at sea; (G) deep lacerations surrounding body; and (H) amputated fluke.

Table 2. The number of common dolphins, dolphin groups and the average group-size recorded in the different survey strata (A to F; Figure 1) during NFR and FR effort.

Strata	NFR			FR		
	Number of dolphins/ stratum	**Number of groups/ stratum**	**Average group-size/ stratum**	**Number of dolphins/ stratum**	**Number of groups/ stratum**	**Average group-size/stratum**
Stratum A	0	0	0	0	0	0
Stratum B	426	69	6.66	5	1	4.33
Stratum C	631	133	4.64	341	30	11.89
Stratum D	172	25	6.86	0	0	0
Stratum E	111	29	4.34	10	5	2.00
Stratum F	52	13	8.29	30	5	6.00

vs. 7.0). Different survey speeds are thought to influence the degree of responsive movement of common dolphins (de Boer et al., 2008; NFR line-transect data). It was found that there was a strong responsive movement towards the boat being more pronounced for faster speeds. Because the relative abundance of dolphins appeared higher in FR areas (surveyed with relatively slower survey speeds), any bias from different survey speeds could not have caused the higher estimated differences from FR effort.

Boat-based surveys

Previous studies concerning interactions between cetaceans and pair-trawl fisheries have used observers' onboard fishing-vessels (Morizur et al., 1999; López et al., 2003; Fernández-Contreras et al., 2010). This study revealed that by using a fisheries monitoring vessel, we were able to study the entire pair-trawl fleet which operated within the study area (17 pair-trawlers from two nationalities: France and Scotland). We compared the group-size and relative abundance of the dolphins in the presence and absence of pair-trawlers, and observed any interactions that occurred. The disadvantages of this approach were that no observations could be carried out during hours of darkness and that bycatch could not be observed directly.

The common dolphins observed in the present study aggregated within a relatively small but heavily fished 'hotspot' (10,300 km^2). Most FR effort occurred in the eastern part of the study area where the highest relative abundances were found. Importantly, the relative abundance for common dolphins to the south (French Channel) was reported to be ten times lower (de Boer et al., 2008). The summer density of common dolphins in western shelf waters is estimated as 0.056 dolphins/km^2 (CV 0.61; SCANS-II, 2008) which is an order of magnitude lower than the winter density reported for this area (0.74 dolphins/km^2; CV 0.39; de Boer et al., 2008). We conclude that the apparent 'hotspot' in the eastern part of the survey area presents a main winter feeding ground for common dolphins and that this is where pair-trawl fisheries mainly occur. The highest aggregation of operating pair-trawlers in this hotspot comprised of French vessels, with ten pair-trawlers (20 vessels) operating alongside each other (March 2005). The identified hotspot corresponds with a previously described main winter fishing-ground for seabass (Pawson et al., 2007).

In January 2005, a ban came into force stating that UK pelagic pair-trawlers could not operate within the UK 12-nmile limit (DEFRA, 2009). The geographical distribution of UK pair-trawl effort in 2005 may therefore differ from that in 2004. The effect of this is difficult to assess although the Scottish pair-trawl winter fishery prior to the ban typically operated around the 12-nmile limit from January onwards (Northridge et al., 2005). Moreover, the banning of this fishery within the UK 12 nmile limit was not extended to those vessels of other EU-Member States (such as France) which continued to operate between 6 and 12 miles (DEFRA, 2009).

In the present study, the average distance to shore of the carcasses found at sea in 2005 was significantly further offshore compared to 2004. However, the distance to shore of hauling pair-trawlers did not significantly differ between the two winters.

Fisheries vs. non-fisheries

The relative abundance of common dolphins and their mean group-size were significantly higher in the presence of operating pair-trawlers (Table 2). Common dolphins were observed in significantly smaller groups in 2005 compared to 2004. Similar observations were made during the experimental-mitigation work onboard the UK pair-trawlers, where the mean group-size of bycaught dolphins was also reported lower in the 2004/2005 winter compared to previous winters (Northridge et al., 2005). The formation of larger groups probably benefits the predation on large patches of prey, where prey is abundant enough for each member of the group to profit (Neumann, 2001). It is therefore likely that the prey was distributed over many small patches in 2005 which resulted in the dolphins separating into smaller groups to make foraging more effective.

Interactions

This study provided the first index of abundance for offshore dolphin carcasses (FR: 1.73 carcasses/km) with significantly more carcasses recorded in areas with high hauling-activities. Interactions with fishing operations were reported on ten occasions with dolphins mainly associating with hauling and towing procedures. Other studies have reported that the hauling procedure of trawls increases the chance of cetacean bycatch (Waring et al., 1990; Couperus, 1993, 1994, 1997; Fertl and Leatherwood, 1997; Morizur et al., 1999; Pierce et al., 2002; Fernández-Contreras et al., 2010). Interactions between trawlers and foraging dolphins as well as other cetaceans occur during towing, hauling and discarding activities (Couperus, 1994, 1997; Chilvers et al., 2003; Gonzalvo et al., 2008; Fortuna et al., 2010). Common dolphins have been reported to enter pelagic pair-trawl nets apparently feeding on fish whilst facing into the oncoming water stream (SMRU, 2004). Common dolphins in European waters have been reported to mainly feed on Gadidae (whiting *Merlangus merlangus* and *Trisopterus* sp.), Gobiidae, horse mackerel (*Trachurus trachurus*) and Atlantic mackerel (*Scomber scombrus;* De Pierrepont et al., 2005). It is therefore likely that the common dolphins in the present study were not feeding on sea bass but rather on smaller pelagic fish species such as sardines (*Sardina pilchardus*) and mackerel.

During those times when conditions were suitable to allow for close-up monitoring of the hauling of the nets (using the RIB), no bycaught dolphins were observed entangled in the nets. It may be that most dolphins became bycaught during darkness when close-up monitoring was not feasible. Indeed, it has been reported that cetacean bycatch in trawlers (Northeast Atlantic) occurs particularly at night (Morizur et al., 1999; López et al., 2003. Conversely, most common dolphin bycatch observed in Spain occurred during day-light trawling activity (Fernández-Contreras et al., 2010). In the present study, carcasses were recovered with relatively high body-temperatures indicating recent death.

In order to relate carcass body-temperature to time after death we used the study of Cockcroft (1991). He investigated the post-mortem cooling rate of a striped dolphin (*Stenella coeruleoalba*), which is similar in shape and size to common dolphin, left in waters with a temperature of 15°C. The body-temperature dropped 10°C (from ~35 to 25°C in approximately 4 h). The cooling rate for dolphins in this study was probably faster because the sea water temperature was lower (9.4°C) compared to that in Cockcroft (1991). Therefore, we suggest that the 'hottest' carcasses (both found in the morning hours with core body temperatures of 26.9 and 30.1°C; Appendix Table 1) recovered in 2005 behind pair-trawlers, and following hauling, had been dead for only a few hours. This would confirm that in the present study the dolphins were typically bycaught during darkness.

Coastal surveys

A total of 22 dolphin and porpoise carcasses were located within the study area on the more remote sites and these 'unrecorded' carcasses represented 36.7% of the total number of strandings (*n* = 60; Table 1). This indicates that the actual strandings figures for the study area were much higher than the current database would suggest. Cetacean stranding monitoring programs typically rely on reports from the public or, in the case of some countries (Portugal, Belgium), monthly or bimonthly dedicated coastal surveys. This study facilitated the first comprehensive effort-related shore-based survey covering the more remote shorelines within the UK. Further, it is worth noting that due to the challenging nature of the Cornish coastline, we believe many more potential, yet largely inaccessible, stranding sites exist (based on high-resolution topographical maps) and as such the percentage of unrecorded strandings could be as high as 50%.

External and necropsy examinations

The thin lacerations surrounding the rostrums of stranded carcasses located during coastal studies were likely indicative of entanglement in gillnetting. Common dolphins were indeed observed in the vicinity of this inshore fishery. The deep lacerations and broken rostrums observed on some of the stranded carcasses may have been inflicted by heavier fishing gear. It seems unlikely that these were related to pair-trawl fisheries as this fishery had moved beyond the12-nmile limit. However, trawlers (not paired) did operate closer to shore and are believed to also contribute to common dolphin mortality (Northridge and Kingston, 2009). Three separate fisheries might thus be involved in the bycatch of dolphins in the area.

All necropsy reports of carcasses found offshore confirmed bycatch as cause of death. However, the results highlight the difficulty of interpreting the type of fishing gears involved. The lacerations found on three dolphins in 2004 and three dolphins in 2005 were considered more suggestive of gillnets. It may be possible that pair-trawlers occasionally 'scoop-up' gill or tangle-nets which already contain dead dolphins, or dead dolphins previously caught in such gear, as the study area is the most intensive fishing-ground in the UK. Nonetheless, it does seem unlikely that this would be the case for six of the carcasses collected over the two consecutive winters. Four of these carcasses had high body temperatures (Appendix: Table 1) suggesting a relatively recent death. Importantly, those carcasses recovered in 2005, which had evidently been dead for only a few hours, were found directly behind operating pair-trawlers which had recently hauled their nets. The fresh carcasses recovered at sea proved very valuable for necropsy studies. At the time of the necropsy examinations, the CSIP had never before examined fresh carcasses confirmed to have been bycaught in pelagic pair-trawl gear in order to establish definitive signs (de Boer et al., 2004).

Detailed analysis of digital images taken at the 'find scene' proved a valuable tool in recording lacerations on carcasses. One carcass secured for necropsy appeared to have deteriorated significantly within a 24-h period and so even deep lacerations surrounding the flanks were apparently largely masked. This carcass also had an amputated fluke which is a traumatic lesion specific for bycatch (Kuiken et al., 1994; Figure 6g to h). The CSIP therefore reclassified this carcass as bycaught after receiving digital images taken at the 'find scene' from this study. This was the first occasion within the UK where the cause of death was re-classified as 'bycatch' using digital images following a necropsy examination from which no internal/external evidence was forthcoming. Our findings suggest that all carcasses should be accompanied by detailed digital images from the 'find scene' in order to help ensure the accuracy of future necropsies. Indeed, in the Netherlands and Belgium digital images from the 'find scene', and those taken prior to necropsy, have been used as evidence to aid properly classifying the causes of death (Haelters et al., 2004; Leopold and Camphuysen, 2006).

In the present study, none of the four tagged and released dolphin carcasses (at shore-distances of 32.6 to 36.1 km) were reported stranded along the Southwest coast. Tagging experiments on bycaught cetaceans off the French Atlantic coast (41 ± 31.5 km from the coast) recovered only 8 cetaceans of a total of 100 tagged carcasses (Peltier et al., 2012). In Galician waters (NW Spain), 26.7% of tagged common dolphin carcasses were recovered stranded after drifting between 27 and 320 km (Martinez-Cedeira et al., 2011). The probability of a carcass washing ashore is dependent on the distance of the fishery from shore, depth of water and prevailing current, weather and sea conditions and presence of scavengers. Advanced stages of decomposition (where gas fills up the body interior) will also enhance the wind-drifting capacity of a carcass. We conclude that the tagged carcasses in the present study either did not strand or were not found and reported. However, it does indicate that strandings may only reflect bycatch closer to the coast in this particular area, due to prevailing currents and wind directions, and are not very indicative of offshore deaths.

Gender and maturity

Mixed-age groups of live common dolphins were observed further inshore, whereas groups without calves were seen further offshore. Similar observations have been made for Mediterranean common dolphins; however, it is not known why groups with calves prefer shallower waters (Cañadas and Hammond, 2008). The difference in the age/gender composition of dead common dolphins indicated that mature males and sub-adult males appear at risk from bycatch in pair-trawl gear further offshore, whereas closer inshore females with young appear at risk, most likely from inshore gillnets. Other studies also report that in gillnet fisheries calves and juveniles appear most vulnerable to bycatch (Ferrero and Walker, 1995; Silvani et al., 1999; Rogan and Mackey, 2007). A predominance of bycaught male common dolphins in pair-trawl fisheries has also been reported in other studies (Morizur et al., 1999; Fernández-Contreras et al., 2010) and when aged, most of these were immature (ICES, 2005; Northridge et al., 2006; Fernández-Contreras et al., 2010). A similar predominance of male common dolphins has been found in gillnet and other fisheries (Ferrero and Walker, 1995; Rogan and Mackey, 2007; Westgate and Read, 2007). This male-bias can be explained by possible differences in the habitat-use of common dolphins and diet known to occur among sexes and/or sexual maturity classes (Meynier et al., 2008; Viricel et al., 2008; Quérouil et al., 2009; Van Ganneyt et al., 2003). Indeed, a well-known male bias in the interaction between dolphins and boats (non-fishing vessels) has been reported off the Azores (Quérouil et al., 2009). Such differences could influence the respective chances of dolphins to become bycaught and best explain our findings.

Decline of common dolphins

Within the study area, the UK pelagic pair-trawl fisheries observed a total of 428 common dolphins bycaught between 2001 and 2006 giving a mean bycatch estimate of 200 dolphins per annum (Northridge and Kingston, 2009). The annual bycatch estimate is much higher when taking into account other trawl fisheries that operate in the Channel and Biscay (620 bycaught animals, December 2003 - May 2005) and the French bass fishery (680 animals, 2000 to 2003; Northridge et al., 2006). Based on current bycatch rates, there is a risk in winter of local common dolphin depletion within the Channel (de Boer et al., 2008). Since 2007, there is an apparent decline in stranded carcasses (Deaville and Jepson, 2010; Pikesley et al., 2011) (Appendix Table 2) which may have been effectuated, or at least in part, by the12-nmile ban. A decline in observed bycatch in UK pair-trawl fisheries is also reported since 2007, following the introduction of pingers as a mitigation device (Northridge and Kingston, 2009). Trials with pingers used by French trawlers indicated a 70%-reduction in common dolphin bycatch (Morizur et al., 2008). However, at-sea trials off Ireland indicated that pingers may not provide a consistently effective deterrent signal for common dolphins (Berrow et al., 2009). Low bycatch figures reported since 2007 may also be explained by less fishing-effort from 2007 onwards due to high fuel prices and low sea bass availability (Northridge and Kingston, 2009). Alongside the decline in strandings and bycatch, a decline is also apparent in (live) common dolphin sightings since 2007 (Figure 7). Recent boat-based studies in the region (English Channel/Biscay) confirm this trend and a decline were noted in summer sightings of common dolphins [T. Brereton/Biscay Dolphin Research Programme, unpublished data in Robinson et al. (2010)]. As of now, reasons for the observed decline are uncertain.

Common dolphins have been reported to occur in localised hotspots of abundance with likely spatial and temporal (seasonal and interannual) variations (Cañadas and Hammond, 2008). Recent studies have shown a strong increase in common dolphin abundance towards areas of higher chlorophyll concentrations which in turn may reflect schooling pelagic fish concentrations (Cañadas and Hammond, 2008; Moura et al., 2012). Other studies suggest that sea temperature affects the distribution of common dolphins (Neumann, 2001; Lambert et al., 2011). Common dolphin numbers have increased in Scottish waters (MacLeod et al., 2005; Weir et al., 2009; Robinson et al., 2010) and this range-expansion has been suggested to be attributed to rising sea temperatures (MacLeod et al., 2008; Lambert et al., 2011; Brereton et al., 2010). It is likely that when range-expansion occurs a simultaneous decline may be seen elsewhere (Robinson et al., 2010). However, if the increase of common dolphins in Scotland is indeed related to increasing temperatures, than the abundance in the western channel is expected to increase, due to the northward migration of the dolphins from the western Iberian Peninsula where the highest abundance of common dolphin within European waters is found (Bearzi et al., 2003; Pierce et al., 2010). Range-changes of pelagic dolphins will ultimately move the problem as

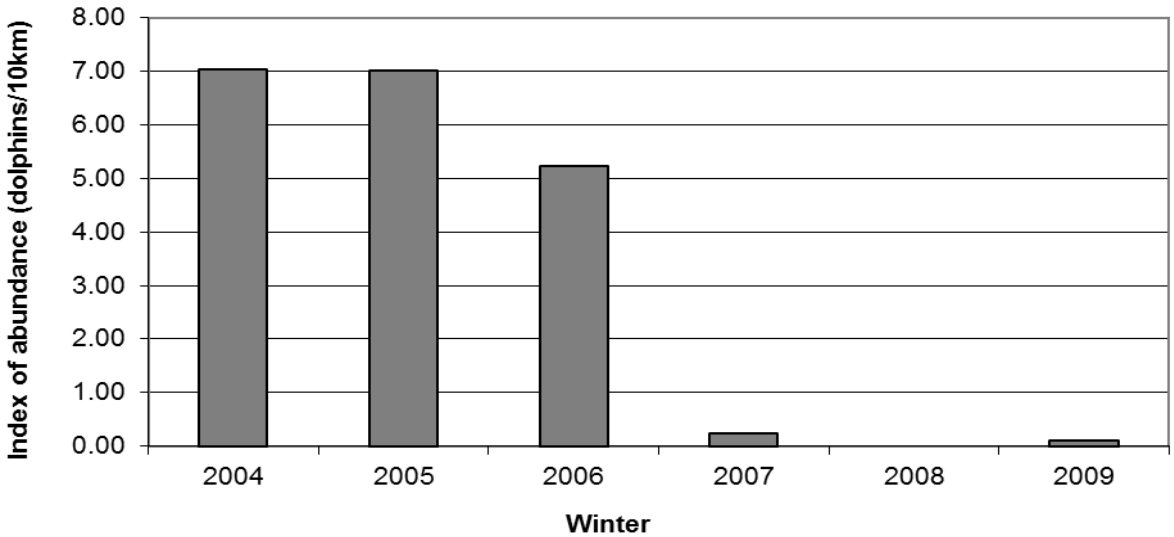

Figure 7. Common dolphin abundance index (NFR + FR; 2004 to 2005) together with additional data collected by the author during boat-based surveys (NFR; 2006 to 2009) within the study area.

potential cetacean and trawl-fishery interactions are likely to occur elsewhere when spatial and temporal habitat-uses coincide.

In the Mediterranean, the common dolphin has declined over a relatively short period coincident with an increase in fishing effort (Bearzi et al., 2003; Cañadas and Hammond, 2008; Piroddi et al., 2011). The same may be true for the Western Channel although it is not clear what the impact of this will be on a wider population level.

Common dolphins are often seen in large groups and are, therefore, at risk of simultaneous entanglement. Further research is therefore required to investigate the interactions of common dolphins with pair-trawl fisheries and the related effect on community structure. It is evident that different types of fisheries are operating in offshore and inshore waters and are incidentally catching groups of dolphins which differ in age and gender. The consequences of this are potentially serious since specific gender/age group-compositions in bycatch contribute more to population growth-rate compared to random removal of individuals (Mendez et al., 2010).

Our findings show that there is a significant overlap between human pelagic fisheries and the common dolphin hotspot which is causing direct mortality through bycatch. This, together with recent range-shifts, may have contributed to a rapid but localised decline of this species in this winter hotspot since 2007. This study highlights the importance of rapidly introducing mitigation measures and we recommend that a closer examination of common dolphin mortality is made within UK waters both through observers' onboard fishing vessels, and through collection of at-sea data. This should also include increased efforts to recover many more fresh carcasses, preferably at sea, for detailed analyses. Given that there are likely to be strong spatial and temporal (seasonal and inter-annual) variations in the distribution and abundance of both common dolphins and fisheries, introducing biological factors into the analysis would lead to a clearer picture of how common dolphins use their habitat. This not only improves our understanding of the ecology of the species, but should also lead to more effective conservation measures.

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APPENDIX

Table 1. Dead dolphins found offshore.

Dolphin	Date	Time	Position	Species	Sex	Length (cm)	Body temperature (°C) (probe length)	Bycatch
1	06.02.2004	11:16	49°58.137 N 004°14.527 W	*D. delphis*	♂	199	16.4 (17.0 cm)	Confirmed
2	06.02.2004	11:20	49°58.215 N 004°14.690 W	*D. delphis*	♂	190 Immature	22.4 (17.0 cm)	Confirmed
3	06.02.2004	11:20	49°58.215 N 004°14.690 W	*D. delphis*	♂	229	20.1 (17.0 cm)	Confirmed
4	06.02.2004	11:20	49°58.215 N 004°14.690 W	*D. delphis*	♂	170 Immature	17.8 (17.0 cm)	Confirmed
5	06.02.2004	11:20	49°58.215 N 004°14.690 W	*Dolphin* sp.*	?	n/a	n/a	n/a
6	08.02.2004	11:59	50°00.092 N 003°30.017 W	*D. delphis*	♂	210	n/a	Suspected
7	08.02.2004	14:26	49°56.362 N 003°44.238 W	*D. delphis*	♂	220	n/a	Suspected
8	14.02.2004	12:27	50°01.929 N 004°13.425 W	*D. delphis***	♂	199	10.1 (41 cm)	Suspected
9	15.02.2004	08:50	49°56.651 N 004°05.228 W	*D. delphis***	♂	205	n/a	n/a
10	16.02.2004	10:25	49°56.120 N 003°58.625 W	*D. delphis***	♂	180 Immature	n/a	n/a
11	16.02.2004	17:40	50°07.283 N 004°56.891 W	*Dolphin sp**	?	n/a	n/a	n/a
12	07.03.2004	13:01	49°56.857 N 003°51.505 W	*D. delphis***	♂	225	12.7 (49 cm)	Suspected

Table 1. Contd.

13	27.03.2004	n/a	50° 18.5' N 3° 57.2' W	*D.delphis*	♀	197	n/a	Confirmed
14	27.03.2004	n/a	50° 14.6' N 3° 51.6' W	*D. delphis*	♀	191 Immature	n/a	Confirmed
15	22.02.2005	09:13	50°00.379 N 004°15.150 W	*D. delphis*	♂	219	9.5 (68 cm)	Confirmed
16	08.03.2005	08:33	49°31.954 N 004°20.075 W	*D. delphis*	♀	198	30.1 (60 cm)	Confirmed
17	11.03.2005	11:31	48°45.551 N 005°52.908 W	*D. delphis*	?	n/a	n/a	n/a
18	11.03.2005	15:52	48°16.481 N 004°55.918 W	*D. delphis*	?	n/a	n/a	n/a
19	15.03.2005	08:40	49°36.888 N 004°16.546 W	*D. delphis*	♂	183 Immature	26.9 (65 cm)	Confirmed
20	15.03.2005	09:11	49°37.048 N 004°15.869 W	*D. delphis*	♀	197	14.9 (65 cm)	Confirmed
21	15.03.2005	09:19	49°36.965 N 004°15.295 W	*D. delphis*	♂	185 Immature	15.8 (70 cm)	Confirmed
22	17.03.2005	14:05	49°36.404 N 004°46.291 W	*D. delphis*	♂	221	10.7 (10 cm)	Suspected
23	26.03.2005	10:15	50°08.233 N 005°01.062 W	*D. delphis*	♀	183 immature	13 (13 cm)	Suspected

Dolphins 17 to 19 had a partial evisceration of the abdomen affecting temperature readings. Sea surface temperature was 8.9 to 10.4°C. *, Dolphins not examined due to weather. **, Tagged dolphins deposited at sea.

Table 2. Stranded cetaceans located within the survey area (2006 to 2009).

ID	Date	Time	Latitude	Longitude	Species	Sex	Length (cm)	State of decomposition	Bycatch
1	13/01/2006	14:57	50.0333	-5.2600	HP?	n/a	n/a	Advanced	n/a
2#	15/01/2006	15:51	50.0267	-5.0950	CD	♀	197	Moderate	Suspected
3	20/01/2006	14:52	50.0550	-5.2800	CD	♀	199	Moderate	Suspected
4	29/01/2006	10:12	50.0683	-5.0790	HP?	?	84*	Advanced	n/a
5#	29/01/2006	10:23	50.0683	-5.0770	D	n/a	155*	Advanced	n/a
6#	29/01/2006	13:05	50.0033	-5.1650	CD	♂	172 (imm)	Moderate	Suspected
7#	06/02/2006	16:21	50.0317	-5.0800	D	♂	n/a	Advanced	n/a
8#	07/02/2006	13:27	50.0350	-5.0667	D	♂	199	Advanced	n/a
9	08/02/2006	09:54	50.0583	-5.2817	D	n/a	n/a	Advanced	n/a
10#	13/02/2006	14:05	50.1233	-5.4650	HP	n/a	n/a	Advanced	n/a
11#	14/02/2006	11:19	50.0033	-5.1650	CD	♀	177 (imm)	Slight	Suspected
12#	14/02/2006	12:50	49.9750	-5.2300	CD	♀	167*	Slight (pm)	Confirmed
13	18/02/2006	12:19	49.9700	-5.2166	CD	♂	157 (imm)	Slight (pm)	Suspected, physical trauma
14	03/03/2006	11:14	50.0633	-5.0667	D	n/a	n/a	Indeterminate	n/a
15	13/03/2006	09:27	50.0050	-5.1617	CD	♂	131 (imm)	Slight	Suspected
16	14/03/2006	11:57	50.0267	-5.0950	CD	♀	169 (imm)	Moderate	Suspected
17	14/03/2006	12:37	50.0150	-5.0933	CD	♂	218	Slight	Suspected
18#	20/03/2006	14:14	50.0050	-5.1617	D	n/a	154*	Advanced	n/a
19	14/04/2006	12:57	50.1167	-5.4500	CD	♂	210	Slight (pm)	No (starvation)
20#	15/04/2006	15:21	50.0883	-5.6880	HP	♂	143 (imm)	Advanced	n/a
21	04/12/2006	11:22	49.9700	-5.2167	CD	♀	174 (imm)	Moderate	Suspected
22	21/12/2006	10:45	50.0250	-5.0940	D	n/a	n/a	Indeterminate	n/a
23	27/12/2006	14:36	50.0267	-5.0950	D	n/a	n/a	Indeterminate	n/a
24	06/01/2007	17:01	50.0700	-5.2950	HP	n/a	n/a	Indeterminate	n/a
25#	08/01/2007	13:29	50.1167	-5.4600	HP	♀	114 (imm)	Moderate	Suspected
26#	11/01/2007	16:21	50.0883	-5.6890	CD	n/a	162 (imm)	Advanced	n/a
27	13/01/2007	15:33	50.1100	-5.4400	D	n/a	86*	Advanced	n/a
28#	21/01/2007	10:56	50.2283	-5.3900	CD	♀	158 (imm)	Moderate	Suspected
29	26/01/2007	15:27	50.0550	-5.2700	D	n/a	152 (imm)	Advanced	n/a
30	07/02/2007	14:06	50.0733	-5.0783	CD	♂	227	Moderate	Suspected
31	22/02/2007	12:06	50.0400	-5.0667	CD	n/a	n/a	Indeterminate	n/a
32#	13/03/2007	10:03	50.0800	-5.3140	D	n/a	107*	Advanced	n/a
33#	14/03/2007	09:37	50.0700	-5.2940	D	n/a	124*	Advanced	n/a
34#	17/01/2008	14:15	50.0583	-5.2820	HP	♂	141 (imm)	Moderate	Suspected
35	13/02/2008	14:32	50.0833	-5.0750	HP	n/a	84*	Advanced	n/a
36#	14/02/2008	14:38	50.0267	-5.0950	CD	♂	187 (imm)	Slight	n/a

Table 2. Countd.

37	20/02/2008	10:45	50.0733	-5.0783	CD	♀	193	Moderate	Suspected
38	27/02/2008	17:53	50.0800	-5.3150	CD	♀	203	Moderate	Suspected
39	18/01/2009	15:31	50.1167	-5.4540	D	n/a	210	Advanced	n/a
40#	20/01/2009	13:07	50.1000	-5.3850	HP	♀	122*	Moderate	Suspected
41#	27/01/2009	09:00	50.1267	-5.4867	CD	♂	200	Advanced	n/a

Length (beak-fluke notch), length* (length of incomplete carcass), state of decomposition (pm = necropsy). #, indicates strandings classified as recorded. HP=harbour porpoise; CD = common dolphin; D = dolphin sp.