Final Report of a Survey for Harbour Porpoises Conducted from R/V *Song of the Whale* in French and British waters of the English Channel, May to June 2011.

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EXECUTIVE SUMMARY

Due to incidental mortality in fishing gear, possible negative impacts of offshore developments and variation in stranding records and encounter rates, the status of the harbour porpoise (*Phocoena phocoena*) has been of concern in European waters in recent years. There are some reports of fluctuating harbour porpoise distribution within the North Sea, with more animals reported in the southern areas of the North Sea over the last few years. The English Channel contains the busiest shipping lanes in the world, wind farm developments, a large fishing fleet and a high concentration of recreational boating activities. However, the presence and distribution of harbour porpoises in this area are poorly known and rely primarily on opportunistic data collection. MCR International and IFAW carried out a visual and acoustic survey for harbour porpoises between May and June 2011 from IFAW's research vessel, *Song of the Whale*. A total of 4243 km track line was completed, with 2749 km "on track" with at least acoustic effort. Visual effort was impacted by poor sighting conditions due to the weather. Forty encounters with cetaceans occurred during the survey (visual *n*=16, acoustic=24), 34 of which were harbour porpoise encounters (visual=13, acoustic=21 – acoustic and visual detections coinciding for three encounters). The distribution of harbour porpoises in the Channel appears to be linked to depth, with the majority of encounters occurring in depths of 50-100 metres. In addition, most of the harbour porpoise encounters occurred in the western area of the Channel, away from the major shipping lanes and shallow uniform topography of the eastern channel. Sightings and acoustic detections of other cetacean and marine species are also presented.

1. INTRODUCTION

There is considerable concern for the conservation status of harbour porpoises in the North Sea and adjacent waters. This concern has arisen from substantial incidental mortality in fishing operations (Carlström & Berggren, 1997; Lowry & Teilmann, 1995; Tregenza *et al.*, 1997; Vinther & Larsen, 2004), from variation in stranding records (Haelters & Camphuysen, 2008; Smeenk, 1987) and from encounter rates in coastal waters. Porpoises in European waters are protected by both national legislation and international agreements including the EU Habitats Directive and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), and their status has been subject to much discussion and concern within the Scientific Committee of the International Whaling Commission (IWC). In some areas the total bycatch of harbour porpoises has been well above a level deemed acceptable (e.g. ASCOBANS, 1997). Indeed, a marked increase in the number of stranded porpoises showing lesions indicative of bycatch along the Dutch and Belgian coast has been noted in recent years with up to 60% of carcasses showing signs of entanglement (Haelters & Camphuysen, 2008; Leopold & Camphuysen, 2006; Smeenk *et al.*, 2004). Small numbers of porpoises are also bycaught in French waters (Morizur *et al.* 2010). Additional pressures on porpoise populations may be presented by anthropogenic noise, for example the construction noise associated with offshore renewable energy projects (Carstensen *et al.*, 2006; Nedwell & Howell, 2004; Tougaard *et al.*, 2003) and commercial shipping traffic (impacts on other cetaceans are outlined by Gerstein *et al*., 2005; Nowacek *et al*., 2001; Parks *et al*., 2007; Parks *et al*., 2009). Very few dedicated surveys have been conducted across the entire English Channel for harbour porpoises for many reasons including the difficulties posed by the high concentration of ship traffic. Additionally, with recent findings indicating a shift in harbour porpoise distribution (Winship, 2009), a need for dedicated research on the presence and distribution of harbour porpoise in these waters was identified.

1.1 Cetaceans of the English Channel

The three most commonly sighted cetaceans in the English Channel are the harbour porpoise, common dolphin (*Delphinus delphis*) and bottlenose dolphin (*Tursiops truncatus*), all of which occur year around (Kiszka *et al.*, 2007). Harbour porpoises are usually found in shallow, coastal shelf-waters such as those found in the Channel, although sightings occurring beyond the edge of the continental shelf to depths up to 200 metres have occurred in the western English Channel and Bay of Biscay (Kiszka *et al*., 2007). Conversely common dolphins typically have a very broad distribution in west European waters (Reid *et al*., 2003) which has been linked to high topographic relief and on shelf edges, possibly related to prey availability. Bottlenose dolphins are found in all habitats from shelf, to slope to oceans waters with the coastal populations of the English Channel limited mostly to the western areas.

Several other odontocetes are also reported from the Channel including striped (*Stenella coerulealbus*), white-beaked (*Lagenorhynchus albirostris*) and Risso's dolphins (*Grampus griseus*) and long-finned pilot whales (*Globicephala melas*). The less common species such as the Pilot whale and Risso's dolphin are seen seasonally (Kiszka *et al.*, 2007) in the English Channel with the rest of the year spent in deeper oceanic areas (Cañadas and Sagarminaga, 2000). Pilot whales are thought to enter the shallow coastal waters of the English Channel in relation to feeding or reproduction (Kiszka *et al*., 2004) while Risso's dolphins are seen seasonally in the shallow coastal waters of the French Channel. The depth of the Channel is relatively uniform in comparison to the surrounding areas of the Bay of Biscay and the North Sea and this may be a primary reason for the lack of cetacean diversity (Figure 1).

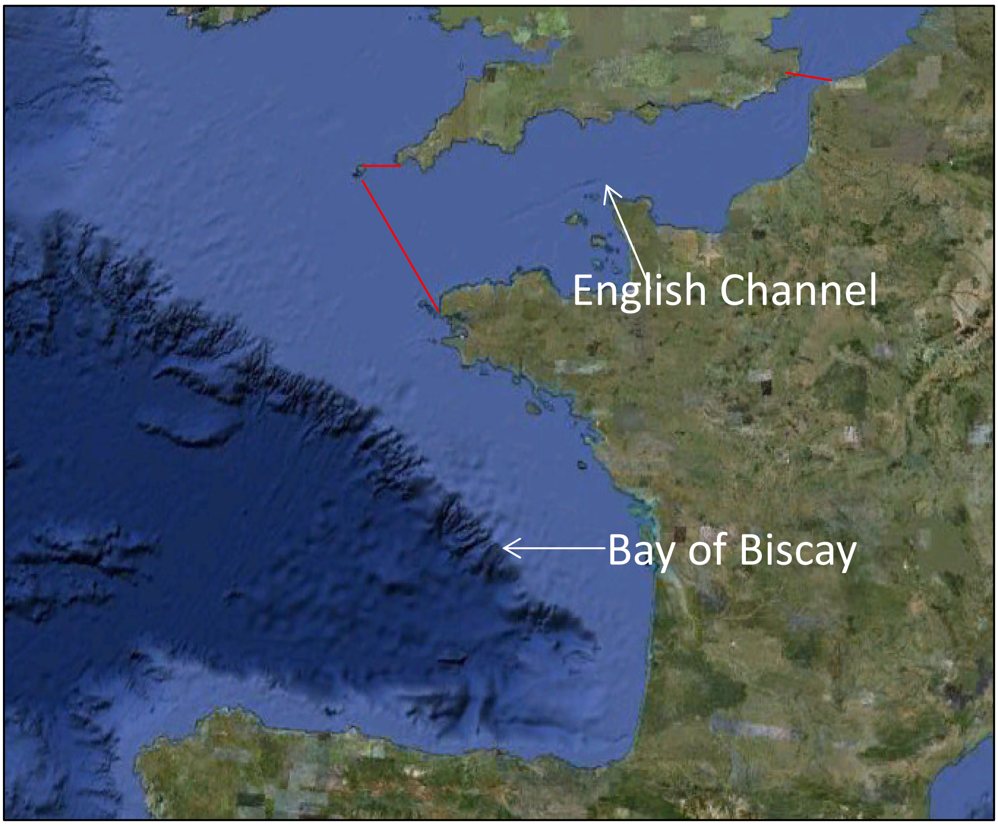

Figure 1: English Channel and surrounding waters, demonstrating the uniform shallow topography within the channel in contrast to the surrounding areas. Red lines represent approximate boundaries of the English Channel, based on ICES management blocks. Source: Google Earth.

1.2 Harbour Porpoises in the English Channel

Following a serious decline in the presence of porpoises in European coastal waters in the first half of the 20th century, sightings and stranding reports increased in the 1990's. In the last few years, some observations and studies indicate a shift of harbour porpoise distribution in European waters, from northern regions of the North Sea to the southern North Sea, English Channel and Celtic Sea (Winship, 2009). This shift may include a return of harbour porpoise to coastal waters of the Netherlands, Belgium and France (Camphuysen, 2004; Jung *et al.* 2009; Thomsen *et al.*, 2006). The European-wide SCANS surveys reported no harbour porpoise sightings in the English Channel in 1994, and just a few isolated sightings of harbour porpoises in the English Channel from aerial surveys in 2005 (Hammond & Macleod, 2006). Conversely, over the last decade opportunistic surveys conducted aboard passenger ferries travelling from the UK to France and across the Bay of Biscay have shown high concentrations of harbour porpoises, especially in the western part of the English Channel and Western Approaches (Kiszka *et al.*, 2007) and off the continental shelf edge in waters <200 metres. In addition, opportunistic research by Jung *et al.* (2009), showed a recent increase of sightings and strandings (between 1997 and 2007) of harbour porpoises in the English Channel and north of Brittany (Kiszka *et al.*, 2007).

Sightings in the English Channel are thought to occur all year around (Jung *et al.*, 2009), with a higher presence of harbour porpoises in the English Channel in summer months (Macleod *et al.*, 2008).

Many environmental and geographical factors have been found to impact harbour porpoise distribution such as daily tidal cycles (Embling *et al*., 2010; Pierpoint, 2008; Calderan, 2003; Johnston *et al*., 2005; Sekiguchi, 1995), fronts, eddies and rips (Johnston *et al*., 2005; Zamon, 2003) and highly sloped regions (Booth, 2010). While many of these features are linked to increased mixing and therefore productivity and higher prey (Wright *et al.*, 2000; Zamon, 2003), it is also thought that harbour porpoises use some of these features for navigation (Pryor, 1990; Booth, 2010). Additionally, from satellite telemetry work, harbour porpoises have been found to occupy small core areas for short periods while ranging over a much larger area (Johnston *et al*. 2005; Teilmann *et al*., 2004).

1.3 Acoustic surveying for Harbour porpoises

As a result of harbour porpoises small size, cryptic surfacing behaviour and often solitary nature, visual detection rates are linked to environmental conditions. Palka (2006) suggests that detection probability of harbour porpoises decreases by 50% between Beaufort 0 and Beaufort 3 and continues to decrease substantially as sea state degrades. As harbour porpoises are believed to echolocate almost continuously while underwater (Verfuß *et al.*, 2005), passive acoustic monitoring can be an effective survey tool complimenting traditional visual surveying techniques (Boisseau *et al*., 2007; Booth, 2010; CODA, 2009; Embling, 2007; Gillespie *et al*., 2005; Gordon *et al*., 2003; Hastie *et al*., 2005; Leaper *et al*., 2000; Hammond, 2002). Acoustic surveys allow for detection of harbour porpoises at night, during most weather states and poor sighting conditions. Acoustic surveys have shown particular worth for harbour porpoise research with acoustic detection rates being as much as eight times higher than visual detection rates (Gillespie *et al*., 2005).

Harbour porpoises produce high-frequency, narrow band clicks with peak frequencies between 115 and 145 kHz (Goodson and Sturtivant, 1996), and maximum source levels (SL) reported between 178-205 dB re 1 µPa @ 1m pp with a mean SL of 191 dB re 1 µPa pp @ 1m (Villadsgaard *et al*., 2007). Their click rates increase (Kastelein *et al.*, 2008, Verfuβ *et al.*, 2005; Verfuβ *et al.*, 2008) and their source levels decrease (Atem *et al*., 2009) as they approach a target.

Due to the ultrasonic nature of harbour porpoise clicks, passive acoustic monitoring has its limitations. Harbour porpoise clicks attenuate quickly in water (Urick, 1983) and can rarely be detected more than 300 metres from the hydrophone (Goodson and Sturtivant, 1996). Additionally, the clicks are highly directional, therefore animals are much more likely to be detected when facing the hydrophone (Goodson and Sturtivant, 1996).

1.4 Aims of the Survey

Marine Conservation Research International (MCR International) and IFAW conducted a visual and acoustic survey to investigate the presence and distribution of harbour porpoises in the Channel during May and June 2011. There have been few dedicated research surveys for harbour porpoises in the English Channel, in part possibly due to high densities of shipping which present a major challenge to navigation and to following pre-determined transect lines. Distribution data for the region are based mostly on opportunistic sightings, bycatch and stranding records, and the SCANS aerial surveys. Thus, survey results from the project reported here will contribute to baseline data on the summer distribution of porpoises in the English Channel, provide novel data to update the SCANS-II survey in 2005, and will supplement on-going research and conservation work in the region (for example, data has already been contributed to the JNCC Joint Cetacean Protocol project to investigate the status of cetaceans within the ASCOBANS area, and the CHARM II dataset). Additionally, as efforts are currently underway to derive abundance estimates from joint visual-acoustic surveys, a further aim was to derive abundance estimates from the survey data using distance-sampling techniques.

Thus, the aims of survey work in the English Channel were to:
1. Detect harbour porpoises both visually and acoustically.
2. Investigate the summer presence and distribution of porpoises and document the presence of other cetaceans and marine wildlife.
3. Collect dual-platform sightings data in areas of high density to estimate g(0).
4. Derive estimates of relative abundance for harbour porpoise.

2. METHODOLOGY

2.1 Data Collection

The survey was conducted in the English Channel between 23rd May and 15th June 2011 from R/V *Song of the Whale,* a 21 metre auxiliary-powered cutter-rigged sailing research vessel, owned by the International Fund for Animal Welfare and operated by Marine Conservation Research Ltd. (MCR Ltd).

The English Channel survey area was treated as two survey blocks to correspond with International Council for the Exploration of the Sea (ICES) fishery subdivisions (essentially bisecting the Channel into eastern and western blocks). Using the programme *Distance 6.0* (Thomas *et al*., 2010), randomly generated tracklines were planned to provide equal coverage probability within each block (see Figure 2). The tracklines crossed perpendicular to the Channel's shipping lanes (coordination with the relevant UK and French Vessel Transport Scheme coordinators was established). While on survey effort a twin-element hydrophone array was towed approximately 100 metres behind the research vessel. Acoustic surveys took place for 24 hrs/day in sea conditions up to Beaufort 6.

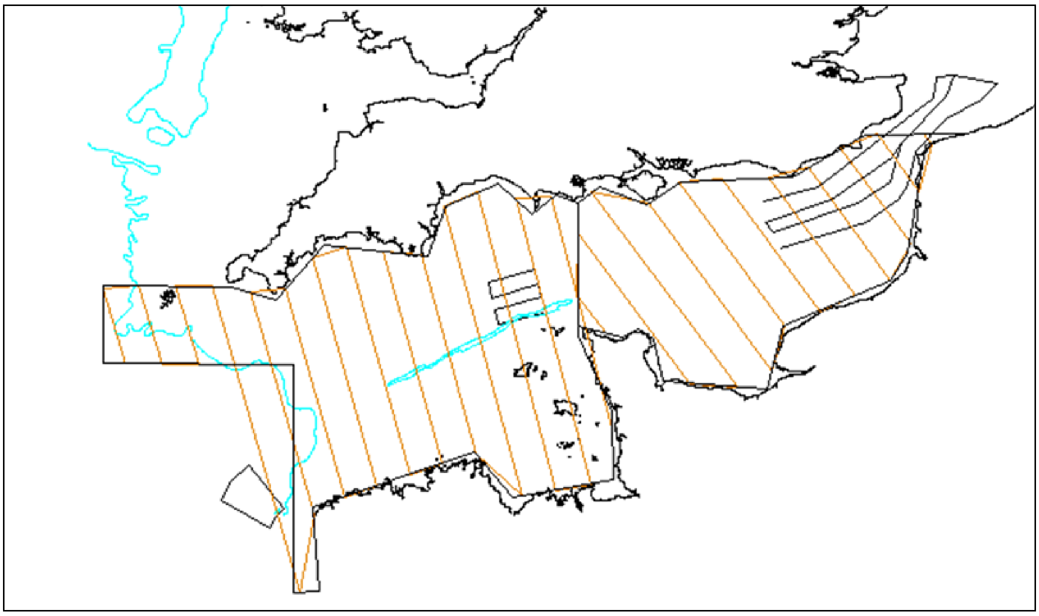

Figure 2: The English Channel was divided into two blocks (displayed as black outlined boxes); an eastern and a western block. Randomly distributed survey tracks (displayed in orange), the Dover, Casquette and Ushant Traffic Separation Schemes (from Right to Left) (displayed as parallel black lines), and 100 metre depth contours (turquoise lines) are displayed.

Observer effort followed distance sampling protocols. In daylight hours and in sea states below four, two visual observers with binoculars were positioned on a platform 5.5 metres above sea level to record any cetacean sightings; observers were not prompted by acoustic cues or deck observers. In higher sea states, observers kept a lookout from deck. Sightings were logged to a database via the Logger software (IFAW). Environmental and GPS data were logged automatically to the same database, including date, vessel position (lat-long), sea surface temperature (°C) and wind speed (knots). Manual updates of other environmental variables (such as sea state, wave and swell height) and survey effort (numbers of observers at which positions) were made hourly to the database.

Visual observers scanned out to 90 degrees either side of the trackline, and from close to the boat out to the horizon with binoculars. Accurate distance and angles to sightings were recorded using reticule / compass binoculars fixed to an adapted monopod, with a camera to record a second measurement of the sighting angle relative to the ships heading (Figure 3). Whenever possible, a third observer took images from the A-frame of porpoise encounters to calculate range independently.

Figure 3: For every sighting from the observation platform a photograph was taken of the lines on the floor while the binoculars were pointing towards the sighting. Therefore an accurate calculation of the bearing to the sighting could be made from the angle of the lines on the A-frame in the photograph.

Seabirds were also logged through visual scans every 15 minutes to provide a snap shot of local distribution.

Acoustic surveys were conducted using a 100 metre towed two-element broadband hydrophone array (SEICHE Ltd.). Continuous stereo 500 kHz recordings were made via a SEICHE buffer box passing signals to a National Instruments USB-6251 sound card. The buffers were configured to give a variable frequency response and the response of the system was 2 to 200 kHz (10 dB resolution). However, in the bandwidth of interest for harbour porpoise clicks (approximately 115 to 180 kHz; (Villadsgaard *et al*., 2006), the response of the system was approximately flat. Recordings were made using PAMGUARD (Passive Acoustic Monitoring Guardianship) and written to hard drive as two-channel 16 bit wav files. As typical harbour porpoise clicks are distinctive high frequency, narrowband signals with a long duration (100 µs), a peak frequency of around 130 kHz, an inter-click interval of around 60 ms and a maximum source level of 172 dB re 1µPa pp @ 1 m (Møhl and Andersen, 1973; Akamatsu *et al*., 1994; Teilmann *et al*., 2002), it is possible to detect and extract potential harbour porpoise clicks from background noise using click detection algorithms. Thus, acoustic signals were monitored in real-time using a PAMGUARD click detector whereby sounds with significant energy (> 8 dB above background noise) in the 100 to 150 kHz band were classified as potential harbour porpoise clicks.

2.2 Data analysis

A more thorough investigation of potential clicks was conducted post-survey on the recorded audio files. During post-processing, clicks were classified as harbour porpoise clicks if they met the following criteria: the click had a peak frequency between 100 to 160 kHz, the energy of the click was at least 5dB above the background noise levels and less than 2ms in duration and if the click had a waveform resembling that of published data for harbour porpoises, with a relatively flat frequency structure revealed in a Wigner plot. Non-porpoise clicks were classified as echo-sounder (with centre frequencies of: 38, 100 and 200 kHz) or unknown (with no identified source). When clicks were automatically identified, they were displayed visually with their bearing, waveform, frequency spectrum and Wigner plot in Pamguard Viewer program window (Figure 4). Each click was then manually checked by an analyst to remove any false detections and separate the clicks into acoustic events. A second analyst independently confirmed these events.

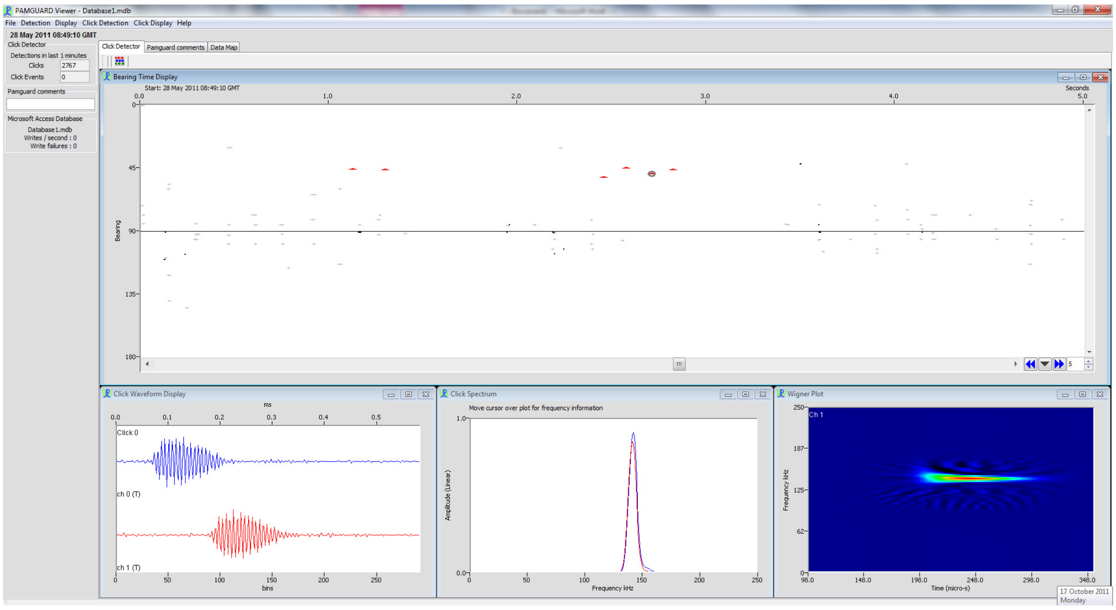

Figure 4. A screen grab of a pamguard viewer display showing a single track harbour porpoise detection (in red triangles) at a bearing of 40 - 50 degrees (recorded on the 28/05/2011 at 08:49:11).

Acoustic events were assessed using the same classification criteria developed for the SCANS-II analysis to allow comparison between results. The SCANS-II criteria are displayed in Table 1.

Table 1: SCANS-II criteria for harbour porpoise acoustic events (SCANS II, 2008).

Event	Description
Porpoise Click	One or two individual clicks
Single Track	A train of porpoise clicks with a clear and defined track from a single animal
Multiple Track	One or more trains of porpoise clicks with a clear defined track from multiple animals
Porpoise Event	A train of porpoise clicks with no clear or defined track

After each event had been separated, an estimate of the number of animals vocalising was given. Animals were thought to be in the same group, therefore creating a multiple track, if the click trains overlapped in time, or if they occurred within 99 seconds (this is the time it takes to cover 300 m when travelling at the average survey speed of 6.2 knots). The time allowed accounts for the time it takes for the vessel to move past a stationary porpoise or cruising porpoise travelling at an average speed of 1.25 knots (Read and Westgate, 1997). Additionally, 300 metres is the likely maximum detection range for the species (Goodson and Sturtivant, 1996). GPS positions were given for each detection by comparing the exact timing of the start of the click train to the Logger GPS database.

Other cetacean detections were also analysed and recorded using PAMGUARD viewer.

3. RESULTS

The total distance logged for the harbour porpoise research cruise was 4243 km of which 2749 km was 'on track' with at least acoustic effort (Figure 5). Of the 397 hours of total cruise time, almost 37% (147 hours) included visual effort; visual effort increased to 44% (100 hours) of the 228 hours spent on the survey track (Table 2).

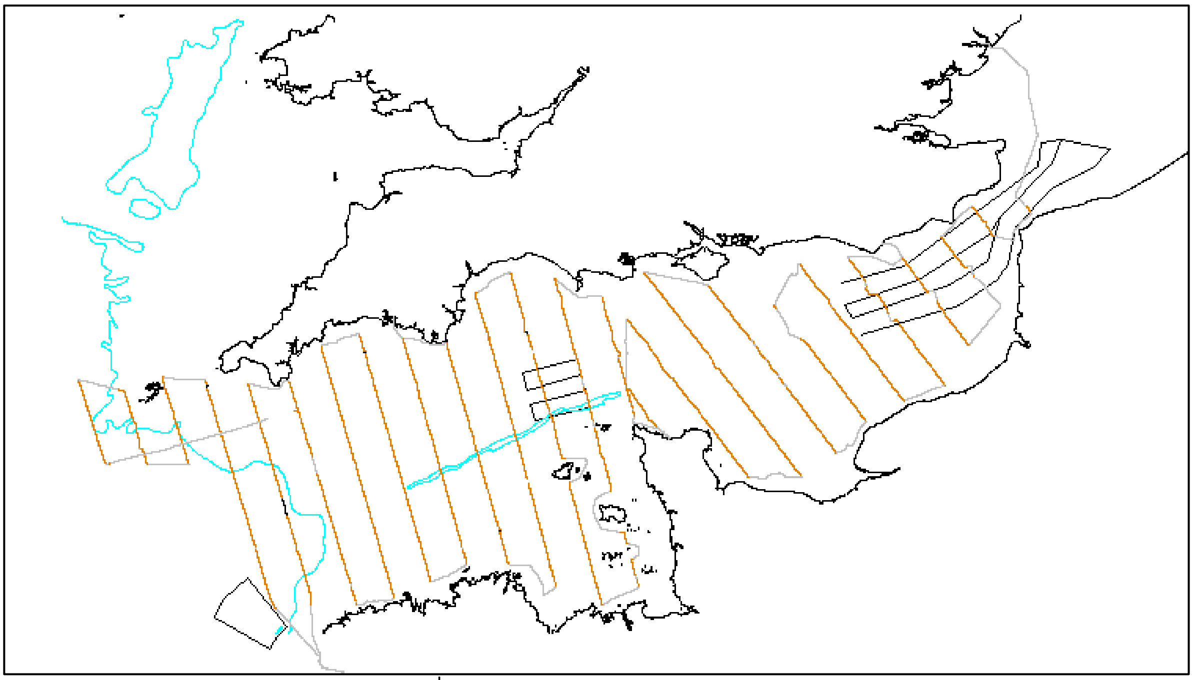

Figure 5: Survey effort from 23rd May to 15th June 2011. The distance logged was 4243 km of which 2749 km was on track with acoustic effort. The orange line shows effort on-track and the grey effort off-track.

Table 2. Summary of research effort during the harbour porpoise survey and ship noise measurements.

	Nautical Miles	Km	Time (hhh:mm)
Total Track	2291	42243	369:10
Passage	209	387	40:45
Passage + acoustic	269	499	44:44
Passage + visual	49	92	7:30
Passage + acoustic + Visual	241	446	38.22
Track + acoustic	828	1523	126:56
Track + visual	8	14	1:07
Track + acoustic + visual	656	1214	98:56
Other	11	21	3:11

3.1. Sightings

A total of three species of cetacean were identified visually in 16 separate encounters both on and off the survey trackline (Figure 6); common dolphins (*n* = 1 sighting), white-beaked dolphins (*n* = 1), harbour porpoise (*n* = 13) and unidentified dolphin (*n*=1). An unidentified shark and turtle were also observed.

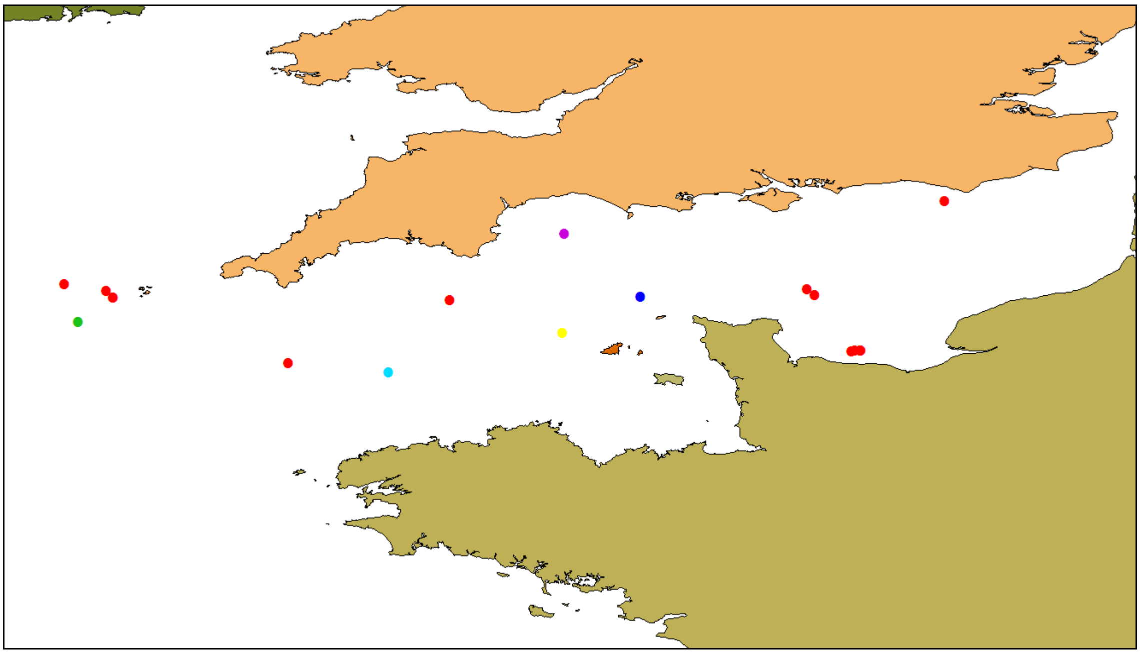

Figure 6: All 18 visual encounters during the survey; harbour porpoise *n*=13 (red), unidentified dolphin *n*=1 (yellow), white beaked dolphin *n*=1 (purple) and common dolphin *n*=1 (turquoise), unidentified turtle *n*=1 (blue), unidentified shark *n*=1 (green).

The number of individuals in each encounter was variable, but typically the harbour porpoises were in small groups of one to two individuals whilst the dolphins were typically in groups of five or more.

Additionally, there was one sighting of an unidentified turtle in the centre of the Channel, close to the Casquettes Traffic Separation scheme. The animal was small and not a leatherback turtle, possibly a loggerhead. A sighting of an unidentified shark species also occurred close to the Isles of Scilly, western Channel. The shark was not a basking shark, which are common around the south west of England during summer months, but thought to possibly be a blue shark due to its pointed dorsal fin and size.

3.2 Acoustic detections

In addition to continuous recording, the signal from the hydrophone array was manually monitored every 15 minutes (approximately 1.6 nautical miles at the average survey speed of 6.2 knots) for animal and ship noise. Very little cetacean acoustic activity was logged. Ship noise was a very obvious factor during the listening periods; however the loudest ship noise was limited to the shipping lanes and approaches to and from the shipping lanes. In total 24 detections were made throughout the survey, 21 harbour porpoise detections, one common dolphin detection and two white-beaked dolphin detections.

A more detailed analysis to identify potential harbour porpoise clicks was completed post-survey. Twelve 'certain' and nine 'possible' harbour porpoise events (Table 3 and Figure 8) were identified using the waveform, time frequency and energy spectrum of the clicks (Figure 7). The peak frequency of the harbour porpoise clicks recorded during this survey was relatively high varying between 130 and 140 kHz, with a duration of approximately 0.15 ms. Multiple track detections of two or more animals were most frequent with the average estimated harbour porpoise group detected being 1.7 animals. Throughout the survey there was a detection frequency of 1.04 harbour porpoises every 100 km surveyed.

Table 3. The harbour porpoise detections from the English Channel Survey with estimated number of porpoises and suggest event type noted.

Date	Time	Event	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Estimated No. of Porpoises	Certainty*
28/05/2011	08:49:00	Single Track	50.173080 N	0.160883 E	1	Certain
04/06/2011	07:05:50	Multiple Track	49.842650 N	2.350250 W	3	Certain
06/06/2011	04:32:31	Multiple Track	49.710300 N	3.038283 W	2	Certain
06/06/2011	04:34:06	Single Track	49.707350 N	3.036884 W	1	Possible
06/06/2011	04:37:20	Porpoise Click	49.700730 N	3.033700 W	1	Possible
06/06/2011	13:52:00	Single Track	48.840950 N	2.675283 W	1	Certain
06/06/2011	15:46:14	Multiple Track	48.798630 N	2.776367 W	3	Certain
06/06/2011	23:11:39	Multiple Track	49.359670 N	3.280450 W	2	Possible
06/06/2011	23:40:55	Porpoise Click	49.417750 N	3.305017 W	1	Possible
08/06/2011	17:33:00	Single Track	49.838970 N	3.871950 W	2	Certain
10/06/2011	16:45:22	Multiple Track	49.017450 N	4.630633 W	3	Certain
10/06/2011	18:42:08	Multiple Track	49.227370 N	4.730967 W	2	Certain
10/06/2011	20:27:06	Multiple Track	49.401770 N	4.811150 W	2	Certain
10/06/2011	21:01:37	Single Track	49.456380 N	4.838283 W	1	Certain
11/06/2011	09:46:00	Porpoise Click	49.348780 N	5.173100 W	1	Possible
13/06/2011	03:01:32	Single Track	48.695700 N	5.242116 W	1	Possible
13/06/2011	06:27:05	Single Track	49.043420 N	5.409433 W	1	Possible
14/06/2011	05:12:53	Single Track	49.880800 N	6.570700 W	1	Possible
14/06/2011	05:53:33	Single Track	49.934080 N	6.626467 W	1	Possible
14/06/2011	11:39:22	Multiple Track	49.653320 N	6.843033 W	2	Certain
14/06/2011	23:46:10	Multiple Track	49.810600 N	5.054850 W	2	Certain

*Certainty refers to the level of certainty that the click detected is a harbour porpoise click and does not refer to the harbour porpoise numbers which are all estimated.

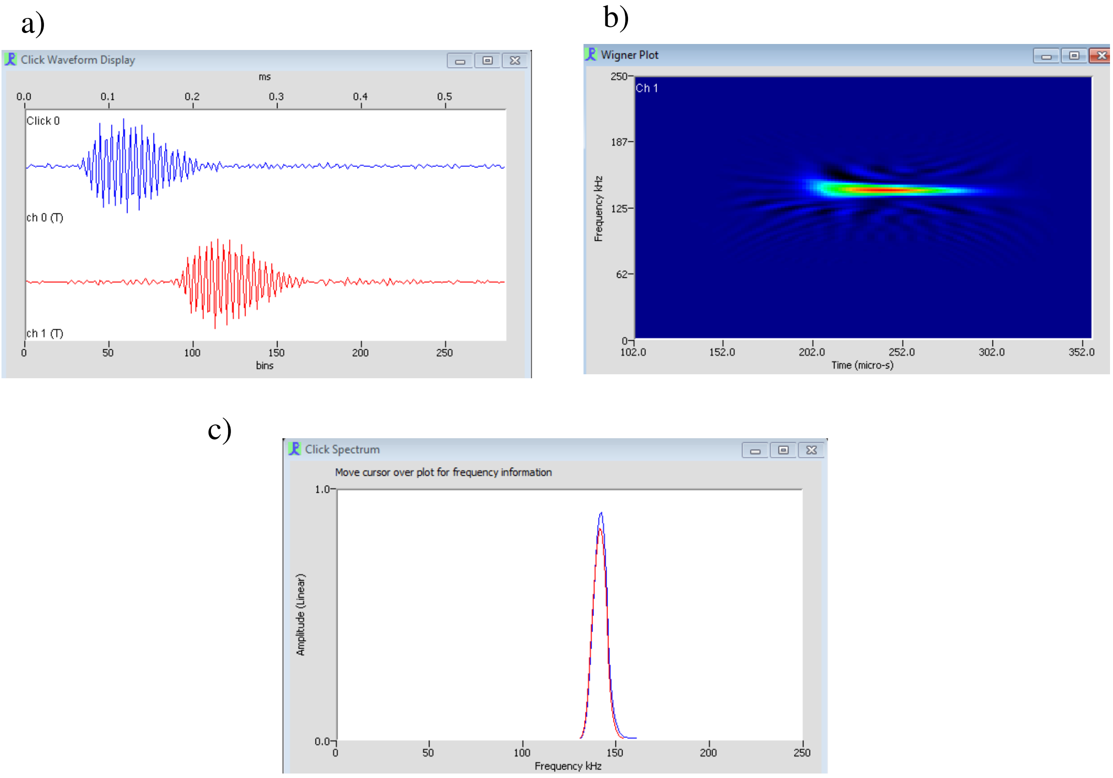

Figure 7. Features typical of a harbour porpoise click (recorded on 08:49:10 on 28/05/11) as shown in a waveform (a), time-frequency Wigner plot (b) and power spectrum (c).

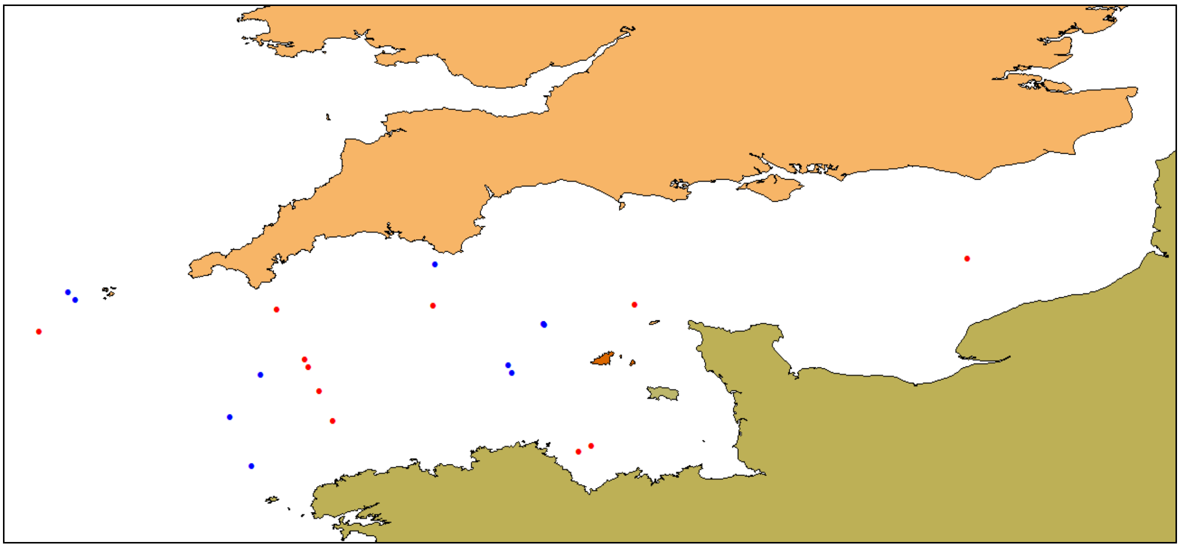

Figure 8: Harbour porpoise detections from the Channel survey: definite detections (marked in red) and possible detections (marked in blue).

Just three of the detections coincided with a harbour porpoise sighting, each of which were rated with “possible” certainty. The white-beaked dolphin and common dolphin detections coincided with the relevant sightings and were classified as definite detections.

As there was not a suitable number of visual or acoustic encounters with harbour porpoises, absolute abundance estimation was not possible.

4. DISCUSSION

Forty encounters with cetaceans occurred during the English Channel survey (visual *n*=16, acoustic *n*=24) with the great majority of encounters being harbour porpoise single animals and groups (*n*=13 visual + *n*=21 acoustic). Only three of the visual harbour porpoise encounters coincided with an acoustic detection, whereas both the common dolphin and white beaked dolphin sightings coincided with acoustic detections.

Harbour porpoise clicks are very high frequency and directional (Goodson and Sturtivant, 1996) therefore the click's energy attenuates quickly (Urick, 1985). This has two repercussions for acoustic research, firstly if the animal is more than 300 metres from the hydrophone (Goodson and Sturtivant, 1996) it is unlikely to be detected acoustically, and secondly if the click is not directed towards the hydrophone there is less chance of detection which may explain the lack of linked visual and acoustic detections. Additionally, harbour porpoises, like all cetaceans do not vocalise continuously when on the surface, therefore when animals were being visually observed, detections cannot always be assumed. However, acoustic survey methods allow continued data collection during poor weather, which was a feature of this study, and allow coverage during the hours of darkness.

Although there were three groups of porpoises within the sightings, two in the west of the eastern block and one in the far west of the western block close to the Isles of Scilly, this clustering is not thought to be representative of distribution due to the poor weather conditions throughout the survey, limiting sightings in other areas. All sightings of harbour porpoises occurred in good weather conditions under sea state 3.5 with the majority (n=11) occurring in conditions under sea state 2.

Both visual and acoustic detections of harbour porpoise encounters were higher in the west of the Channel than in the eastern block. Harbour porpoise distribution has previously been linked to specific depth ranges, although reports vary for different regions; Booth (2010) found harbour porpoise distribution in the Hebrides peaked in waters of between 50 and 150 metres, Caretta *et al*., (2001) demonstrated a decrease in porpoise abundance in depths below 40-60 m, whereas Hammond *et al.*, (2002) found this trend below 200 metres and Read and Westgate (1997) recorded peak harbour porpoise abundance around 98-189 metres. The harbour porpoise encounters in this study showed an increased encounter rate in deeper waters >50 m (although the waters of the Channel are rarely more than 120 metres) with the average depth for an encounter being 75.5 m (Figure 9). There are a few possible explanations of this limited distribution. Many scientists have suggested this distribution limitation is due to harbour porpoises prey species (Hastie *et al*., 2005; Tynan *et al*., 2005), as harbour porpoises need to consume prey regularly in order to meet the requirements of their daily activities, they therefore have to locate themselves close to high densities of prey. Johnston *et al*. (2005) noted that harbour porpoise make foraging decisions on the mesoscale (10-100km) and fine scale (1-

10km) assuming that these animals will remain near a prey patch until it becomes energetically profitable to move on. Although presently poorly understood, it has been hypothesized that harbour porpoises, like other cetaceans, navigate through a number of environmental cues such as land marks, bottom topography, salinity and temperature gradients, currents odours, tastes and sounds. Scientists have also linked depth specific distribution to porpoises diving behaviour with porpoise prey of sand eels and herring often being situated close or near to the seabed and porpoises are routinely recorded to dive up to depths of only 70-100 metres (Otani *et al.*, 2001).

Watts and Gaskin (1985) describe avoidance by harbour porpoises of very shallow areas thought to be due to increased turbulence therefore making it difficult for animals to forage visually or acoustically. The data from this study could not examine this, as the survey transect lines were stopped before very shallow waters (<20 metres) due to the draft of the research vessel with the hydrophone towed.

Additionally highly sloped ground (Booth, 2010) and areas with high tidal (Calderan, 2003; Johnston *et al.*, 2005) and current movement have been linked with high levels of porpoise presence. All three are also thought to be linked to prey abundance, with increased slope leading to upwellings and highly tidal areas leading to increased mixing and therefore both to increased levels of prey. In this Channel survey, the harbour porpoise detections did not obviously correlate with slope due to the Channel being more or less uniform in topography and therefore lacking any steep changes in bathymetry (Figure 9).

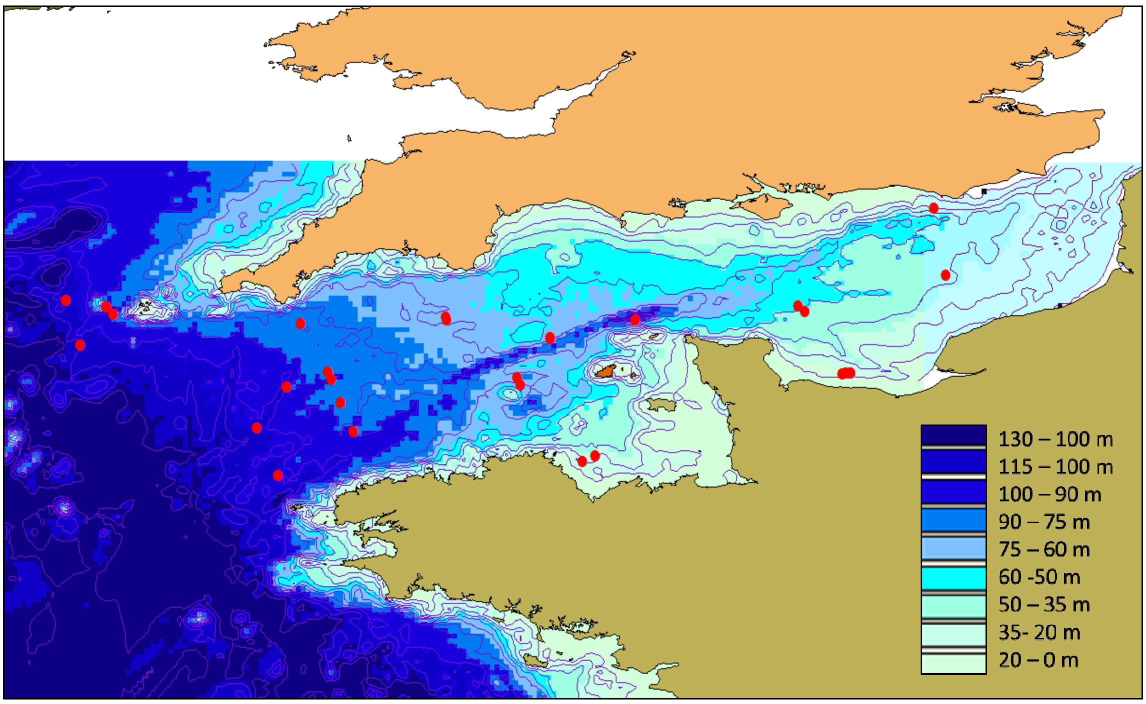

Figure 9: The harbour porpoise encounters (both visual and acoustic) (in red) across the Channel. 10 metre contours are displayed as purple lines. Plot created using depth measurements from GEBCO displayed via ArcView GIS mapping system.

Marine mammals have been shown to have adverse reactions to a variety of loud anthropogenic noises including commercial shipping (Currey *et al.*, 2009; Gerstein *et al.,* 2005; Nowacek *et al.*, 2001) military operations, oil and gas exploration, fishing activities and marine renewables (Carstensen *et al.*, 2006; Madsen *et al.*, 2006). The English Channel contains the busiest shipping lane in the world (http://www.dft.gov.uk/mca/mcga_-_hm_coastguard_-_the_dover_strait), between Dover and Calais, as well as several wind farms, recreational boating and fishing activities within its waters. Future research to analyse the impact of background noise on harbour porpoise presence may go some way to help explain some of the differences in the distribution patterns observed between the western and eastern blocks.

MCR and IFAW collaborated with other organisations (e.g. Association GECC, Marine Life and ORCA) which work in the Channel in order to supplement and compare previous harbour porpoise sightings with the data collected during this survey. Figure 10 shows harbour porpoise encounters recorded from R/V *Song of the Whale* (marked as red dots); these were reported from areas of the Channel which were rarely covered from the other opportunistic surveys (such as from ferry routes etc.). Therefore these encounters demonstrate the importance of a dedicated survey such as this to provide additional data on the status of the harbour porpoise across the entire region.

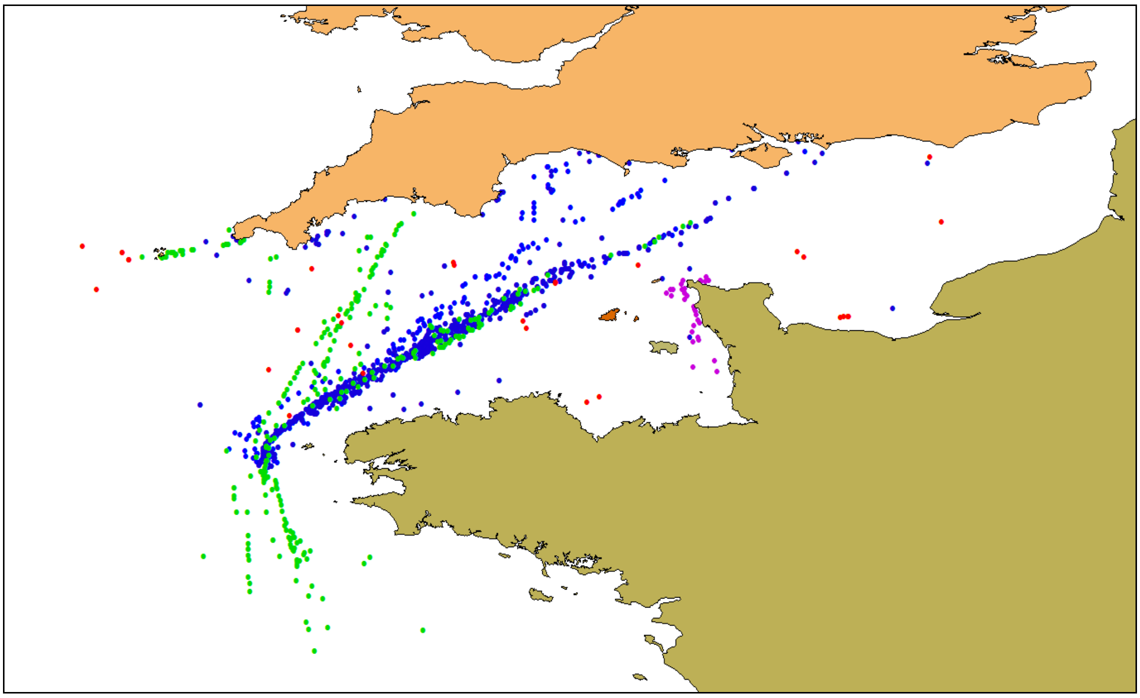

Figure 10: Sightings of harbour porpoise in the Channel from data contributed by ORCA (1998-2010 - marked in green), Association GECC (2008-2011 - marked in purple), MarineLife (2003-2010 - marked in dark blue) and MCR-IFAW's recent harbour porpoise survey (May – June 2011 marked in red – both visual and acoustic encounters shown).

One sighting of white-beaked dolphins occurred within Lyme Bay, Dorset, of five animals which bow-rode the R/V *Song of the Whale*. White-beaked dolphins are common in cooler, deeper (>50m) often more northerly British waters (MacLeod *et al.*, 2008) however, opportunistic sightings of white-beaked dolphins are frequent in Lyme Bay, southern England, year around (Brereton *et al*., 2010). It is thought that Lyme Bay is the most southerly known site that white-beaked dolphins regularly occur and may be one of the most important sites in the English Channel for white-beaked dolphins (Brereton *et al*., 2010), possibly due to the predominantly deep, stratified waters, sandy sediment (Edwards, 2010), high numbers of whiting and reduced fishing fleets (Brereton *et al*., 2010). Pre- and post- sighting, the dolphins were acoustically detected with recordings made of click trains and buzzes (Figure 11). White-beaked dolphins make a variety of whistles up to a frequency of 35 kHz, and clicks with a peak frequency at 115 kHz (Rasmussen and Miller, 2002). The white-beaked dolphin clicks had peak frequencies higher then estimated previously by scientists, with several clicks having peak frequencies around 130 kHz, and the occasional clicks ranging up to 150 kHz.

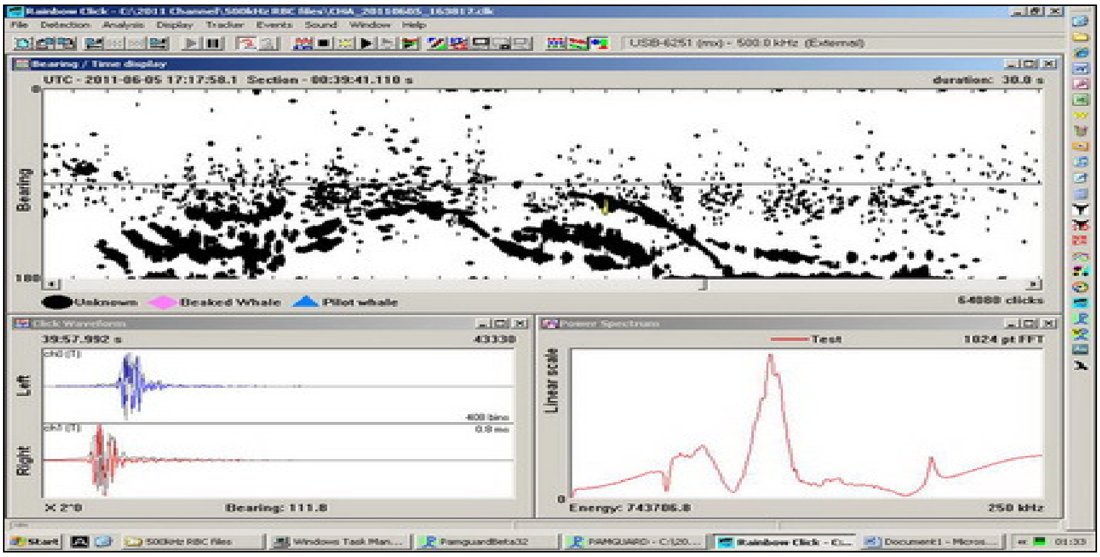

Figure 11: The output from Rainbow Click software displaying some of the clicks recorded from the white-beaked dolphin encounter.

Later in the survey, on the 10th June a single sighting of a group of short-beaked common dolphin occurred in the centre of the western Channel. Between 5 and 10 animals were observed bow riding the survey vessel. The limited number of sightings of common dolphins throughout our survey may be due to summer – winter fluctuations in occupancy between shelf and deeper waters of the Bay of Biscay. Macleod *et al.* (2008) found trends from ferry based data collection indicating increased occupancy of common dolphins in the winter months within the English Channel and low occupancy in summer months, although it should be noted that the ferry routes studied cover very little of the eastern English Channel survey block.

Five species of marine turtle have been recorded in UK and Irish waters (Pierpoint, 2000); however, only one species, the leatherback turtle, *Dermochelys coriacea*, is reported annually and is considered a regular member of British marine fauna. The loggerhead turtle, *Caretta caretta*, and Kemp's Ridley turtle, *Lepidochelys kempii*, occur less frequently, mostly in winter and spring (Pierpoint, 2000) and are thought to be carried north from their usual habitats by adverse currents (Mallinson, 1991; Pierpoint, 2000). Most loggerhead and Kemp's Ridley turtles seen in British waters are juvenile having been washed ashore on the south and south-west coasts following stormy periods. Stormy weather preceded the sighting of a small, unidentified turtle from SOTW.

The data presented here provides some additional information on the presence, distribution and relative abundance of harbour porpoises in the Channel, and further, valuable evidence of the presence of harbour porpoises in the eastern parts of the Channel. Additional dedicated surveys of the English Channel including at different times of the year, would be extremely beneficial to the understanding of cetacean distribution in the area as a whole, as previously, few dedicated boat based surveys have been carried out across the area.

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6. REFERENCES

Akamatsu, T., Hatakeyama, Y., Kojima, T. and Soeda, H., 1994. Echolocation rates of two harbour porpoises (*Phocoena phocoena*). Marine Mammal Science **10**(4): 401-411.

ASCOBANS. 1997. Second Meeting of Parties to ASCOBANS: 17-19 November 1997, Bonn, Germany. ASCOBANS. 67pp.

Atem, A.C.G., Rasmussen, M.H., Wahlberg, M., Petersen, H.C., Miller, L.A., 2009. Changes in Click Source Levels with Distance to Targets: Studies of Free-Ranging White-Beaked Dolphins *Lagenorhynchus Albirostris* and Captive Harbour Porpoises *Phocoena Phocoena*. Bioacoustics-the International Journal of Animal Sound and Its Recording **19**: 49-65.

Boisseau, O., Matthews, J., Gillespie, D., Lacey, C., Moscrop, A., and El Ouamari, N., 2007. A visual and acoustic survey for habour porpoises off North-West Africa: further evidence of a discrete population. African Journal of Marine Science **29**(3):1-8.

Booth, C.G., 2010. Variation in Habitat Preference and Distribution of Harbour Porpoises West of Scotland. PhD thesis submitted at the University of St. Andrews.

Brereton, T., Wynn, R., Macleod, C., Bannon, S., Scott, B., Waram, J., Lewis, K., Phillips, J., Martin, C. and Covey, R., 2010. Status of Balearic Shearwater, White-beaked Dolphin and other marine animals in Lyme Bay and surrounding waters. Marine Life report.

Calderan, S.V., 2003. Fine-scale temporal distribution by harbour porpoise (*Phocoena phocoena*) in North Wales: acoustic and visual survey techniques., In School of Biological Sciences. University of Wales, Bangor, Bangor, Wales.

Cañadas, A., Sagarminaga, R., and Garcia-Tiscar, S. 2002. Cetacean distribution related with depth and slope in the Mediterranean off southern Spain. Deep Sea Research Part I, 49: 2053–2073

Camphuysen, C. J. 2004. The return of the harbour porpoise (*Phocoena phocoena*) in Dutch coastal waters. *Lutra* **47**(2): 113-122.

Caretta, J.V., Taylor, B.L., Chivers, S.J., 2001. Abundance and depth distribution of harbour porpoise (*Phocoena phocoena*) in northern California determined from a 1995 ship survey. Fisheries Bulletin **99**: 29-39.

Carlström, J. and Berggren, P. 1997. Bycatch rates of harbour porpoises (*Phocoena phocoena*) in Swedish bottom set gillnet fisheries obtained from independent observers. European Research on Cetaceans, Proc. 10th Ann. Conf. European Cetacean Society, Lisbon, 11-13 March 1996.

Carstensen, J., Henriksen, O. D. and Teilmann, J. 2006. Impacts of offshore wind farm construction on harbour porpoises: acoustic monitoring of echolocation activity using porpoise detectors (T-PODs). Marine Ecology Progress Series **321**: 295–308.

CODA, 2009. Cetacean Offshore Distribution and Abundance i the European Atlantic (CODA). Report available from SMRU, Gatty Marine Laboratory, University of St Andrews, St Andrews, Fife KY16 8LB, UK. http://biology.st-andrews.ac.uk/coda/, p. 43.

Edwards, D.L., 2010. Habitat Selection of Dolphin Species in Lyme Bay. MSc Dissertation for Bournemouth University, School of Conservation Sciences.

Embling, C.B., 2007. Predictive models of cetacean distributions off the west coast of Scotland, In School of Biology. p. 258. University of St Andrews, St Andrews.

Embling, C.B., Gillibrand, P.A., Gordon, J., Shrimpton, J., Stevick, P.T., Hammond, P.S., 2010. Using habitat models to identify suitable sites for marine protected areas for harbour porpoises (*Phocoena phocoena*). Biological Conservation **143**: 267 - 279.

Gerstein, E.R., Blue, J.E., Forysthe, S.E., 2005. The acoustics of vessel collisions with marine mammals. Oceans 2005, **1-3**: 1190-1197.

Gillespie, D., Berggren, P., Brown, S., Kuklik, I., Lacey, C., Lewis, T., Matthews, J., McLanaghan, R., Moscrop, A. and Tregenza, N., 2005. Relative abundance of harbour porpoises (*Phocoena phocoena*) from acoustic and visual surveys of the Baltic Sea and adjacent waters during 2001 and 2002. Journal Cetacean Research Management **7**(1): 51-57.

Goodson, A.D., Sturtivant, C.R., 1996. Sonar characteristics of the harbour porpoise (*Phocoena phocoena*): Source levels and spectrum. Ices Journal of Marine Science **53**:465-472.

Gordon,J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M.P., Swift, R., Thompson, D., 2003. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal **37**: 16-34.

Haelters, J. and Camphuysen, C. J. 2008. The harbour porpoise in the southern North Sea: Abundance, threats and research- & management proposals. Report commissioned by IFAW (International Fund for Animal Welfare) EU office, 60pp.

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

Hammond, P. S. and Macleod, K. 2006. Progress report on the SCANS-II project. ASCOBANS Advisory Committee, Finland, 6pp.

Hastie, G.D., Swift, R.J., Slesser, G., Thompson, P.M., Turrell, W.R., 2005. Environmental models for predicting oceanic dolphin habitat in the Northeast Atlantic. Ices Journal of Marine Science 62, 760-770.

Johnston, D.W., Westgate, A.J., Read, A.J., 2005. Effects of fine-scale oceanographic features on the distribution and movements of harbour porpoises *Phocoena phocoena* in the Bay of Fundy. Marine Ecology-Progress Series 295, 279-293.

Jung, J-L., Stéphan, E., Louis, M., Alfonsi, E., Liret, C., Carpentier, F-G. and Hassani, S., 2009. Harbour porpoise (*Phocoena phocoena*) in north-western France: aerial survey, opportunistic sightings and strandings monitoring. Journal of the Marine Biological Association of the United Kingdom, **89**: 1045-1050.

Kastelein, R.A., Verboom, W.C., Jennings, N. and de Haan, D., 2008. Behavioural avoidance threshold level of harbour porpoise (*Phocoena phocoena*) for a continuous 50 kHz pure tone. Journal of Acoustic Society of America **123**: 1858-1861.

Kiszka, J., Hassani, S., and Pezeril, S. 2004. Distribution and status of small cetaceans along the French Channel coasts: using opportunistic records for a preliminary assessment. Lutra, **47**: 33– 45.

Kiszka, J., Macleod, K., Van Canneyt, O., Walker, D. and Ridoux, V., 2007. Distribution, encounter rates, and habitat characteristics of toothed cetaceans in the Bay of Biscay and adjacent waters from platform-of-opportunity data. ICES Journal of Marine Science, **64**: 1033-1043.

Leaper, R., Gillespie, D. and Papastavrou, V., 2000. Results of passive acoustic surveys for odontocetes in the Southern Ocean. Journal of Cetacean Research and Management **2**: 187-196.

Leopold, M. F. and Camphuysen, C. J. 2006. Bruinvisstrandingen in Nederland in 2006. Achtergronden, leeftijdsverdeling, sexratio, voedselkeuze en mogelijke oorzaken, IMARES rapport C083/06, NIOZ Report 2006-5, 89pp.

Lowry, N. and Teilmann, J. 1994. Bycatch and bycatch reduction of the harbour porpoise *Phocoena phocoena*) in Danish waters. Report for the International Whaling Commission Special Issue **15**: 203-209.

Macleod, C.D., Weir, C.R., Begoña Santos, M. and Dunn, T.E., 2008. Temperature-based summer habitat partitioning between white-beaked and common dolphins around the United Kingdom and Republic of Ireland. Journal of the Marine Biological Association of the UK, **88**: 1193-1198.

Mallinson, J.J. 1991. Stranded juvenile loggerheads in the United. Kingdom. Marine Turtle Newsletter, **54**: 14-16

Møhl, B. and Anderson, S., 1973. Echolocation: high-frequency component in the click of the harbor porpoise (*Phocoena ph*.L). Journal of the Acoustical Society of America **54**: 1368-1373.

Morizur, Y., Hassani, S., Le Niliot, P., Gamblin, C., Toulhoat, L. and Pezeril, S. 2010. Note on the recent French studies on by catch and pingers in the English Channel (Document 4-16). Presented at the 17th ASCOBANS Advisory Committee Meeting AC17, UN Campus, Bonn, Germany, 4-6 October 2010, 9pp**.**

Nedwell, J. and Howell, D. 2004. A review of offshore windfarm related underwater noise sources, COWRIE report no. 544 R 0308, 57pp.

Nowacek, S.M., Wells, R., Solow, A.R., 2001. Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. Marine Mammal Science 17, 673 - 688

Otani, S., Naito, Y., Kato, A., Kawamura, A., 2001. Oxygen consumption and swim speed of the harbor porpoise *Phocoena phocoena*. Fisheries Science 67, 894-898.

Palka, D., 2006. Effects of Beaufort Sea State on the Sightability of Harbour Porpoises in the Gulf of

Maine. Report of the International Whaling Commission – SC/47/SM26, **46**: 575-582.

Parks, S.E., Clark, C.W., Tyack, P.L., 2007. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. Journal of the Acoustical Society of America **122**: 3725-3731.

Parks, S.E., Urazghildiiev, I., Clark, C.W., 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. Journal of the Acoustical Society of America **125**: 1230-1239.

Pierpoint, C., 2000. Bycatch of marine turtles in UK and Irish Waters, JNCC Report No 310.

Pierpoint, C., 2008. Harbour porpoise (Phocoena phocoena) foraging strategy at a high energy, near-shore site in south-west Wales, UK. Journal of the Marine Biological Association of the United Kingdom **88**: 1167-1173.

Pryor,K.W., 1990. Non-acoustic communication in small cetaceans: Glace, touch, position, gesture and bubbles. In Sensory Abilities of Cetaceans. Eds. J.Thomas, R.Kastelein, pp537-544. Plenum Press, New York.

Rasmussen, M.H. and Miller, L.A., 2002. Whistles and clicks from white-beakd dolphins, *Lagenorhynchus albirostris*, recorded in Faxaflói Bay, Iceland. Aquatic Mammals, **28.1**: 78-89.

Read A.J. & Westgate A.J. 1997. Monitoring the movements of harbor porpoises (Phocoena phocoena) with satellite telemetry Marine Biology **130**: 315-322.

Reid, J.B., Evans, P.G.H., Northrides, S.P., 2003. Atlas of cetacean distribution in north-west European waters. JNCC.

SCANS II, 2008. Small Cetaceans in the European Atlantic and North Sea. Final Report submitted to the European Commission under project LIFE04NAT/GB/000245.

Sekiguchi, K., 1995. Occurrence, behaviour and feeding habits of harbour porpoises (*Phocoena phocoena*) at Pajaro Dunes, Monterey Bay, California. Aquatic Mammals **22**: 91-103.

Smeenk, C. 1987. The harbour porpoise *Phocoena phocoena* (L., 1758) in the Netherlands: stranding records and decline. *Lutra* **30**: 77–90.

Smeenk, C., García Hartmann, M., Addink, M. J. and Fichtel, L. 2004. High number of by-catch among beach-cast harbour porpoises, *Phocoena phocoena*, in The Netherlands. Kolmården, Sweden, European Cetacean Society 18th Annual Conference, 1st April 2004.

Teilmann, J., Miller, L.A., Kirketerp, T., Kastelein, R.A., Madsen, P.T., Nielsen, B.K. and Au, W.W.L., 2002. Characteristics of echolocation signals used by a harbour porpoise (*Phocoena phocoena*) in a target detection experiment. Aquatic Mammals **28.3**: 275-284.

Thomsen, F., Laczny, M. and Piper, W. 2006. A recovery of harbour porpoises (*Phocoena phocoena*) in the southern North Sea? A case study off Eastern Frisia, Germany. Helgoland Marine Research **60(3)**: 189-195.

Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology **47**: 5-14.

Tougaard, J., Cartensen, J., Henriksen, O. D., Skov, H. and Teilmann, J. 2003. Short-term effects of the construction of wind turbines on harbour porpoises at Horns Reef. DDH-Consulting, Roskilde, Denmark, 72pp.

Tregenza, N. J. C., Berrow, S. D., Hammond, P. S. and Leaper, R. 1997. Harbour porpoise (*Phocoena phocoena* L.) by-catch in set gillnets in the Celtic Sea. ICES Journal of Marine Science **54(5)**: 896-904.

Tynan, C.T., Ainley, D.G., Barth, J.A., Cowles, T.J., Pierce, S.D., Spear, L.B., 2005. Cetacean distributions relative to ocean processes in the northern California Current System. Deep Sea Research (Part II): Topical Studies in Oceanography **52**: 145-167.

Urick, R.J., 1983. Principles of underwater sound. Peninsula Publishing, Los Altos, California.

Verfuβ, U., Miller, L.A., Schnitzler, H.-U., 2005. Spatial orientation in echolocating harbour porpoises (*Phocoena phocoena*). Journal of Experimental Biology **208**: 3385-3394.

Verfuβ, U.K., Miller, L.A., Pilz, P.K.D., Schnitzler, H.U., 2008. Echolocation by two foraging harbour porpoises (Phocoena phocoena). Journal of Experimental Biology **212**: 823-834.

Villadsgaard, A., Wahlberg, M. and Tougaard, J., 2006. Echolocation signals of wild harbour porpoises, *Phocoena phocoena*. The Journal of Experimental Biology **210**: 56-64.

Villadsgaard, A., Wahlberg, M., Tougaard, J., 2007. Echolocation signal of wild harbour porpoises, *Phocoena phocoena*. Journal of Experimental Biology **210**: 56-64.

Vinther & Larsen, 200 Vinther, M. and Larsen, F. 2004. Updated estimates of harbour porpoise (*Phocoena phocoena*) bycatch in the Danish North Sea bottom-set gillnet fishery. Journal of Cetacean Resource Management **6**: 19-24

Watts, P. and Gaskin, D.E., 1985. Habitat Index Analysis of the Harbor Porpoise (*Phocoena phocoena*) in the Southern Coastal Bay of Fundy, Canada. Journal of Mammalogy **66**, 733-744.

Winship, A. 2009. Estimating the impact of bycatch and calculating bycatch limits to achieve conservation objectives as applied to harbour porpoise in the North Sea. University of St Andrews, PhD Thesis, 262pp.

Wright, A.J., Aguilar-Soto, N., Baldwin, A.L., Bateson, M., Beale, C.M., Clark, C., Deak, T., Edwards, E.F., Fernandez, A., Godinho, A., Hatch, L.T., Kakuschke, A., Lusseau, D., Martineau, D., Romero, L.M., Weilgart, L.S., Wintle, B.A., Notarbartolo-di-Sciara, G., Martin, V., 2007. Do marine mammals experience stress related to anthropogenic noise. International Journal of Comparative Psychology 20, 274 - 316.

Zamon, J.E., 2003. Mixed species aggregations feeding upon herring and sandlance schools in a nearshore archipelago depend on flooding tidal currents. Marine Ecology Progress Series **261**: 243-255.