PReCAST

Galway-Mayo Institute of Technology
Irish Whale and Dolphin Group

Cetaceans on the Frontier Survey 2010

18th February – 1st March 2010

Pilot Whale, Whittard Canyon System. (© Dave Wall)

Survey Team

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1 Introduction

The waters of Ireland's Exclusive Economic Zone (EEZ) are thought to represent one of the most important cetacean (whales, dolphins and porpoise) habitats in Europe. To date 24 species of cetacean have been recorded (Appendix I), with seven of these having been confirmed as calving within the Irish EEZ, while a number of other species are possibly calving (e.g. minke whale and northern bottlenose whale) (Berrow 2001). In recognition of their importance for cetaceans, the Irish government declared all Irish waters (within the EEZ) to be a whale and dolphin sanctuary in 1991 (Rogan and Berrow 1995). Despite this recognition, information on the distribution and relative abundance of cetaceans within the Irish EEZ, especially in offshore waters, is very limited (Wall *et al.* 2006).

The Irish Whale and Dolphin Group (IWDG) have been collecting data on the distribution and relative abundance of cetaceans in Irish waters (including Northern Ireland) since 1991. The IWDG casual and constant effort sightings schemes record data mainly from land-based sightings and surveys (Berrow *et al.* 2001). The IWDG has conducted cetacean surveys on board commercial ferries since 2001 and on board the Irish Marine Institute's offshore research vessel *Celtic Explorer* since 2003.

In 2008, the IWDG in collaboration with the Galway-Mayo Institute of Technology commenced PReCAST, a three-year project (2008-2011) that aims to provide robust scientific data to support conservation policy and provide guidance to state agencies in implementing national and international obligations. PReCAST is committed to gaining a more complete understanding of the seasonal distribution, relative abundance and habitat use of cetaceans within the Irish EEZ.

As part of this project the PReCAST team committed to apply for ship time under the Marine Institute's Ship Time Programme and was successful in 2009, conducting a survey of slope and canyon habitat along the north and west slopes of the Porcupine Bank (Wall *et al.* 2009). In 2010 the PReCAST team applied for further ship time to conduct a similar survey of slope and canyon habitat along the slopes of the southern Porcupine Bank, eastern Porcupine Basin and South-western shelf. The application was made in order to address a number of objectives.

1.1 Visual Cetacean Survey

The main focus of the survey was to conduct a habitat specific survey of deep diving cetaceans, particularly the enigmatic beaked whale species. These whales, of which 5 species have been recorded from Irish waters (Sowerby's, Gervais', True's and Cuvier' beaked whales and the northern bottlenose whale), favour deep waters (in excess of 1000m depth) with complex bathymetry (Macleod C., 2005). Little is known of their distribution or biology, and all were listed as 'data deficient' in the 2007 Irish report on the conservation status of cetaceans in Irish waters (NPWS, 2008). The focus of this survey was on deep-water canyons, which splice the slopes of the Porcupine Bank and Shelf Edge to the west of Ireland.

Detailed multi-beam bathymetry images collected during the Irish National Seabed Survey (INSS) 2000-2006, enabled these canyons to be targeted in a very specific manner for the first time. The survey track was designed to run through the centre of each of the chosen study canyons and the route was further refined during the survey using the *Celtic Explorer's* OLEX™ bathymetry charting system (updated with INSS bathymetry data), which enabled real time visualisation of the vessel's movement above the canyons.

1.2 Acoustic Cetacean Survey

Many deep diving species spend the vast majority of their lives beneath the surface and out of the reach of visual detection. In order to increase the detection rate for these species during the current survey, a number of acoustic survey methods were employed.

1.2.1 Towed Hydrophone Array

Beaked whales belong to one of the marine mammal families that we know the least about. The reason for this is their infrequent encounter rates, offshore (deep water) distribution and extensive deep and long lasting dives (Heyning 2002, Mead 2002, Pitman 2002). The beaked whale family is widely distributed on a global scale (Cox *et al.* 2006, MacLeod *et al.* 2006, Podestá *et al.* 2006) and concentrated in deep-water habitats, continental slopes or submarine canyons (D'Amico *et al.* 2003, Johnson *et al.* 2008, MacLeod and Mitchell 2006, Mead 2002, Reeves *et al.* 2002, Whitened *et al.* 1997, Williams *et al.* 2002). Their general diving pattern limits the time the animals spend on the surface and encounter rates of beaked whales during visual surveys are therefore typically low (ANON 2004, Barlow 1999, Barlow *et al.* 2006).

Several beaked whale species are believed to produce clicks and some species also use whistles as part of their vocal repertoire (Dawson *et al.* 1998, Hobson and Martin 1996, Hooker and Whitehead 2002, MacLeod and D`Amico 2006, Rogers and Brown 1999). Beaked whales use ultrasonic frequency clicks with most of the energy in the 26-50 kHz frequency range. The frequency modulated search clicks are 175 to 270 µs long with inter click intervals (ICI) of between 0.2 and 0.4 sec. (Johnson *et al.* 2008, Johnson *et al.* 2004, 2006, Madsen *et al.* 2005, Zimmer *et al.* 2005).

The potential of using near surface towed hydrophones to detect beaked whales from ships like the RV *Celtic Explorer* is unknown. Preliminary assessment of towed hydrophone array data collected during the Cetaceans on the Frontier survey 2009 yielded no confirmed beaked whale vocalisations, however identification methods and software for beaked whale clicks are still very much under development and recorded audio files will be subject to ongoing analyses for identification of beaked whale clicks and whistles. Recorded data could be very important combined with the dedicated visual and acoustic 2007 CODA survey for cetaceans (CODA 2009). The objective from an acoustic marine mammal perspective is to investigate the potential for collection of passive acoustic data on beaked whales from a large vessel and to generate data on distribution, abundance and habitat use of beaked whales and other cetacean species.

1.2.2 Bottlenose Dolphin Vocalisations

Acoustic data from bottlenose dolphin encounters will be provided to a PhD study (based in University College Cork and funded by IRCSET), which aims to describe the variability of bottlenose dolphin (*Tursiops truncatus*) vocalisations in Irish waters. To do this, passive acoustic techniques were used to sample vocalisations, initially from resident dolphins in the Shannon estuary and coastal transients. Photo identification techniques were used to look the degree of association within and between these communities to identify any overlapping ranging patterns. Data from a parallel study will also be used in which genetic sampling through biopsy provides information on relatedness within and between the studied communities (study funded by SFI).

The vocal repertoire of dolphins includes pulsed sounds and tonal whistles. Pulsed sounds can be divided into click trains and burst pulses and are used for echolocation and communication purposes. Burst pulse calls are often described as cries, barks, grunts or squeals since even though these are composed of individual clicks the repetition rate is so high that the clicks are indistinguishable to the human ear and the sound is like a continuous noise. Burst pulses are produced by most toothed whales and are associated with feeding and close range social interactions (Blomqvist and Amundin, 2004).

The whistle repertoire of dolphins varies between species, geographically separated populations (Azevedo and Van Sluys, 2005; Morisaka et al., 2005b), different groups within populations (Rendell et al., 1999) and between individuals (Janik et al., 2006). Such variation in may be the result of physiological or environmental factors such as body size or ambient background noise levels (Morisaka et al., 2005; Rendell et al., 1999). The presence of eavesdroppers (e.g. predators or prey) may also contribute to variation between social groups or individuals (Deecke and Janik, 2005). Variation may also arise from related individuals sharing similar whistles (Bazua-Duran and Au, 2004) or through distinct repertoires being used within associating groups and thus result in the development of dialects (Tyack, 1986). Dialects are well known in birds (Baker, 1987) but rare among cetaceans, two examples are the calls of killer whales (Orcinus orca) (Ford, 2002) and the codas of sperm whales (*Physeter macrocephalus*) (Weilgart and Whitehead, 1997).

1.3 Cetacean Photo-ID and Biopsy

To better understand the status of the whales and dolphins found in Irish waters, and identify whether (and what) additional conservation measures are required, it is essential to clarify issues related to stock structure, movements and abundance. A number of scientific tools have been used to assist in determining stock structure and movement and it is generally agreed that information from a suite of techniques is required. Without such an understanding it is difficult, if not impossible to devise an appropriate conservation and monitoring strategy.

The most commonly used techniques are analyses of individual identification data (photographs), genetic analyses of population structure and analysis of satellite telemetry data. All approaches have strengths and weaknesses, and a number of respected international scientific bodies (e.g. the Scientific Committee of the International Whaling Commission, the IUCN Western Grey Whale Advisory Panel) recommend and use data from all three approaches to obtain as clear an understanding as possible.

During this survey it was hoped to obtain photo-ID images of target species (fin, humpback, and sperm whales, bottlenose dolphins and pilot whales) in Irish waters. To date the IWDG have photo-identified 20 bottlenose dolphins in offshore waters within the Irish EEZ.

1.4 Visual Seabird Survey

By surveying seabirds at sea using a standardised ship-based method (following European Seabirds At Sea (ESAS) recommendations (Tasker et al. 1984; Komdeur, Bertelsen and Cracknell 1992; Camphuysen et al. 2004) during this research cruise, it was planned to record and then map the distribution, abundance, and density of seabird species occurring over the slopes and canyons of the Porcupine Bank, Porcupine Seabight, and southwest shelf of the North Atlantic. This data would supplement current knowledge of seabird distribution in the waters of Ireland's Atlantic margin (e.g. Pollock et al. 1997; Mackey et al. 2004), and would be combined with the results of seabird surveys carried out during the 2009 Cetaceans on the Frontier research cruise which took place in August 2009. Thus, summer and winter seabird distributions may be compared for this region.

As well as providing insights into the biology of particular seabird species, seabirds at sea data can also shed light on how bird distribution relates to physical and biological aspects of the marine ecosystem. Seabirds at sea data are key to identifying the requirements of marine birds outside the breeding season (e.g. Ballance 2007) and marine areas requiring special protection. Long-term data can indicate where changes in the marine environment are occurring (Cairns 1987; Croxall 1987; Monaghan 1996; Furness and Camphuysen 1997), for instance with regard to pollution, fisheries practice, or climate change (González-Solis and Shaffer 2009; Grémillet and Boulinier 2009).

1.5 Plankton and Oceanographic Survey

Due to recent intensive mapping work by the Irish National Seabed Survey, the location and extent of many continental slope canyons in the Irish EEZ have become apparent. Studies in other regions have demonstrated that similar canyons may affect the distribution or production of phyto- and zooplankton (Allen *et al.* Can. J. Fish. Aquat. Sci. 58: 671–684, 2001). Such concentrations may in turn lead to concentrations of predators such as fish and cetaceans. The purpose of the present investigation was to determine if there was any evidence to suggest that zoo- or phytoplankton was more concentrated near canyons along the slopes of the Porcupine Bank, Porcupine Seabight or shelf edge and if any features in the physical oceanography of the canyon systems would favour increased production or concentration of planktonic organisms.

Studies have shown that deep-water canyons and slopes, such as those to the west and southwest of Ireland, may influence the abundance and distribution of phytoplankton and zooplankton (N. Skliris et al, 2005). Such aggregations of plankton over these areas may also be linked to cetacean activity along the shelf edge and in the region of canyons

The objective of the plankton study during this trip was to map the distribution of both zooplankton and phytoplankton in relation to deep-sea canyons. In addition, in relation to gelatinous zooplankton, the study aimed to determine the vertical distribution of various gelatinous zooplankton species in deep water (>1000m).

Because the primary purpose of the cruise was to record the distribution of cetaceans using visual and acoustic techniques, oceanographic work was conducted only after sunset.

The collection of underway sea surface temperature data will enable cetacean sightings to be related to sea surface temperatures. Temperature is thought to be a significant factor affecting the distribution of some cetacean species and concern has been raised as to the possible effects of global warming on cetacean populations in northwest Europe (Learmonth *et al.*, 2006).

1.6 Stable Isotope Analysis of Krill

Despite their widespread occurrence here, very little is known about the diet and migrations of the six species of baleen whale in Irish waters. Such information is essential if Ireland is to fulfil its legal conservation obligations for these species. To date, there has been no systematic analysis of baleen whale diets in Irish waters by conventional methods due to the difficulty in obtaining useable stomach samples.

Stable isotope analysis (SIA) can be used to obtain these data. Using SIA to infer trophodynamics is based on the principle of preferential accumulation of heavier isotopes (δ15N, δ13C, δ18O) over lighter ones (δ14N, δ12C, δ16O) due to differential excretion (called fractionation). Stable isotopes, namely carbon, nitrogen and oxygen occur in all living organisms. These are derived from diet and are incorporated into the tissues of a predator in a predictable manner. Stable isotopes thus record faithfully the origin of diet in the predator via the lower trophic levels.
Nitrogen stable isotopes increase by 3‰ per trophic level and are therefore used to infer trophic level in a predator. The carbon isotope is not enriched for each trophic level and is used to infer the geographic location as it is thought to become more depleted with increasing latitude. Oxygen isotopes are indicative of the temperature of the environment from which they were acquired. Such is the complexity of the technique, that baseline stable isotope data are required from each trophic level.

Current evidence suggests that Euphausiids comprise the primary consumer in the Fin Whale food chain. The whales probably feed on them directly and indirectly (via Herring or sprat). Their feeding habits may change depending on season. Analysis of skin/blubber biopsies and baleen plates from fin and humpback whales is in progress.

1.7 Marine Megafauna Survey

In addition to visual sightings data on cetacean and bird species, it was planned to collect data on the distribution of other marine megafauna, including sharks, seals, turtles and sunfish. Basking shark and marine turtle sightings data are collected and held by the IWDG in an effort to map the seasonal distribution of these species in Irish waters and to monitor their numbers. Offshore seal sightings are collected on behalf of the National Parks and Wildlife Service (NPWS) in an effort to help identify important offshore feeding areas for seals in Irish waters. Sunfish sightings are collected for a project being run in the Coastal Marine Resources Centre at University College Cork.

1.8 Deployment of ARGO Oceanographic Buoy

ARGO is an international collaboration that collects high-quality temperature and salinity profiles from the upper 2000m of the ice-free global ocean and currents from intermediate depths. The data come from battery-powered autonomous floats that spend most of their life drifting at depth where they are stabilised by being neutrally buoyant at the "parking depth" pressure by having a density equal to the ambient pressure and a compressibility that is less than that of sea water. At typically 10-day intervals, the floats pump fluid into an external bladder and rise to the surface over about 6 hours while measuring temperature and salinity. Satellites determine the position of the floats when they surface, and receive the data transmitted by the floats. The bladder then deflates and the float returns to its original density and sinks to drift until the cycle is repeated. Floats are designed to make about 150 such cycles.

2 Methods

The survey was conducted on board the Marine Institute's R.V. *Celtic Explorer* as a dedicated survey between 18th February and 1st March 2010. The survey area covered waters over the Porcupine Bank, Porcupine Seabight, Whittard Canyon System and Celtic Shelf. The survey track was predominantly designed to target deep-water canyon and slope habitat (fig. 1).

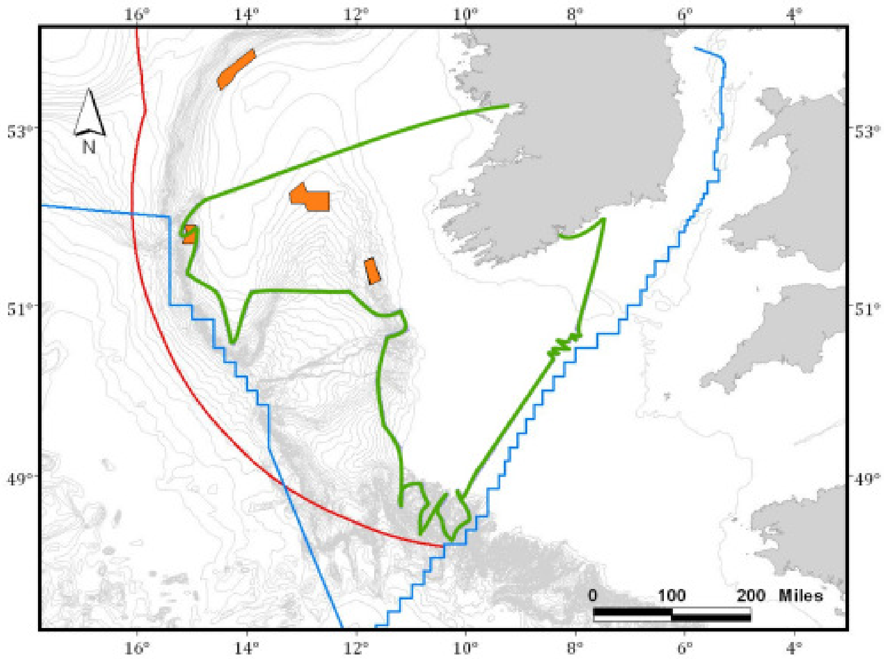

Fig. 1 *Survey transects (green line) for the 2010 Cetaceans on the Frontier research cruise. Orange areas denote Special Areas of Conservation.*

The survey transects cut across the Southwest Porcupine SAC and a permit to conduct research within the SAC was applied for and granted by the National Parks and Wildlife Service of the Department of the Environment.

The survey vessel travelled at an average speed of 8 knots while on transect, except in heavy swell. The ship spent from 08:30 – 18:30 each day on visual and acoustic transect, and from 20:30 – 08:30 altered between steaming at 8 knots and being stationary while conducting CTDs, water sampling and plankton hauls.

2.1 Visual Cetacean Survey

A double platform cetacean survey design, based on methods used during the SCANS II and CODA surveys (Hammond & Macleod, 2006) was employed. The method was a combination of line-transect distance sampling and mark-recapture methods. Three types of survey mode were used during the survey. In sea states up to sea state 4, double platform survey mode was used. In sea states of 5 and 6, single platform survey mode was employed. In sea states greater than 6, in heavy rain, very reduced visibility or where conditions were unsafe for surveying from the Monkey Island or Crow's nest, a watch was kept from the bridge.

Sightings were identified to species level where possible, with species identifications being graded as definite, probable or possible. Where species identification could not be confirmed, sightings were downgraded (e.g. unidentified dolphin / unidentified whale / unidentified beaked whale etc.) according to criteria established for the IWDG's cetacean sightings database (IWDG 2009).

2.1.1 Double platform survey mode

A team of 6 surveyors was used to survey from two platforms. Two surveyors operated from the primary platform, located on the 'monkey island' 12m above the waterline (fig. 2). The primary platform surveyors scanned the area around the ship, out to a distance of 1000m by eye. Sighting species identification and group size were confirmed with the aid of 8 X 50 binoculars. The port side primary surveyor scanned an arc from 10^o starboard to 90^o port, while the starboard side primary surveyor scanned an arc from 10^o port to 90^o starboard. Angles were read using an angle board placed between the two observers and distances were measured using the aid of a distance measuring stick. Sightings were relayed to the data recorder and duplicate identifier via two-way radio. The second surveyor recorded a duplicate of the sighting data onto paper forms.

Fig. 2 *Position of Cetacean survey and bird survey platforms on R.V. Celtic Explorer.*

Another two surveyors surveyed from the tracker platform, located on the 'crows nest' 17m above the waterline (fig. 2). The tracker platform surveyors surveyed ahead of the ship (500m+) in order to spot animals before they reacted to the presence of the ship and before the primary platform surveyors spotted them. The port side tracker scanned an arc 60° to port and starboard using 8 X 40 Opticron™ binoculars, while the starboard side tracker scanned an arc 40° to port and starboard using 10X40 Zeiss™ binoculars. Angles were read using an angle board placed between the two observers and distances were measured using the aid of a distance measuring stick. Sightings were relayed to the data recorder via two-way radio. The duplicate identifier recorded a duplicate of sighting data onto a paper form. The role of the trackers was to locate animals at a distance from the ship and track them as they approached or passed by the vessel.

The data recorder was positioned on the crow's nest deck within an enclosed survey platform (fig. 2). The recorder logged details of primary and tracker platform sightings into an access database using IFAW Logger 2000™ (IFAW, 2000). The data recorder also logged details of observer rotations, waypoints and changes in environment every 30 minutes or as required.

The duplicate identifier was situated on the crow's nest deck beside, and listening to, the trackers. The duplicate identifier also received details of the primary platform sightings via a two-way radio. The role of the duplicate identifier was to match sightings made by the primary platform with those being tracked by the tracker platform. Sightings matched between the two platforms were termed duplicates and were ranked as definite, probable, possible, remote or not a duplicate.

Primary platform and tracker platform surveyors formed survey pairings, which remained unchanged during the survey. Primary and tracker surveyors swapped from port to starboard every 30 minutes while data recorder and duplicate identifier changed every hour. Primary and tracker platform surveyors acted as data recorder and duplicate identifier in rotation.

2.1.2 Single platform survey mode

A team of 3 surveyors was used to survey using the primary platform. Two surveyors operated from the primary platform, located on the 'monkey island' 12m above the waterline. The primary platform surveyors scanned the area around the ship, out to a distance of 1000m by eye. Sighting species identification and group size were confirmed with the aid of 8X50 binoculars. The port side primary surveyor scanned an arc from 10° starboard to 90° port, while the starboard side primary surveyor scanned an arc from 10° port to 90° starboard. Angles were read using an angle board placed between the two observers and distances were measured using the aid of a distance measuring stick. Sightings were relayed to the data recorder via two-way radio. The second surveyor recorded a duplicate of the sighting data onto paper forms.

2.1.3 Bridge watch mode & auxiliary sightings

Two surveyors (either primary or tracker) kept a watch from the port and starboard wings of the bridge for any animals in the vicinity of the ship. Sightings were logged onto paper forms and were entered in the database as auxiliary sightings.

Sightings recorded at by other time by members of the ships or scientific crew were also entered in the database as auxiliary sightings.

2.2 Acoustic Cetacean Survey

A number of projects to enable the acoustic detection of cetaceans within canyon systems and at sea were conducted during the cruise.

2.2.1 Towed Hydrophone Array

The towed hydrophone setup (fig. 3) onboard the *Celtic Explorer* consisted of a 200m array having two elements separated at 25cm and no depth sensor. This was set up with a MACREC LTD HP-27st bufferbox. A National Instrument DAQ-6255 USB soundcard connected the output from the buffer-box to a laptop. This laptop used PAMQUARD (ver. 1.6.01) Beta software for data acquisition and beaked whale click detection. An external GPS unit provided GPS data to the setup.

A 1 TB hard drive provided storage and backup facility for the data collected. Raw recordings and click files were stored and backed up every day.

2.2.2 Bottlenose Dolphin Vocalisations

Recordings were made using a 200 m array with a set-up as described in section 2.2.1 above.

2.3 Cetacean Photo-ID

A six-meter rigid inflatable boat was carried on board the ship to allow photo-identification of target cetacean species. The species to be targeted were fin whales, humpback whales, bottlenose dolphins, sperm whales, pilot whales and beaked whales.

Fig. 3 *IWDG's 6m RIB, Muc Mhara, being loaded on board the R.V. Celtic Explorer.*

A number of Digital SLR cameras and telephoto zoom lenses were carried on board for the purposes of obtaining photo-identification images of target cetacean species, should the opportunity arise.

2.4 Visual Seabird Survey

Surveys of seabirds at sea were conducted from the R.V. Celtic Explorer between February 19th and March 1st 2010. The ship spent from 08:30 to 18:45 each day on transect, during which the average travel speed was 8 knots, except when heavy swell prohibited this (at which time surveying also stopped). A standardised line transect method with sub-bands to allow correction for species detection bias and 'snapshots' to account for flying birds was used (following recommendations of Tasker et al., 1984; Komdeur, Bertelsen and Cracknell 1992; Camphuysen et al. 2004), as outlined below.

Two observers (a primary observer and a primary recorder), in rotation from a pool of four surveyors, were allocated to survey shifts of two hours, surveying from 08.30 to 18.00 hours (dusk) each day. Environmental conditions, including wind force and direction, sea state, swell height, visibility and cloud cover, and the ship's speed and heading were noted at hourly intervals during surveys. No surveys were conducted in conditions greater than sea state five, when high swell made working on deck unsafe, or when visibility was reduced to less than 300m.

Fig. 4 *Seabird primary observer and recorder surveying from the bridge deck of the R.V. Celtic Explorer (©Maggie Hall). Binoculars were used to confirm species identification.*

The seabird observation platform was the bridge deck, which is 10.5m above the waterline and provided a good view of the survey area. The survey area was defined as a 300m wide band operated on one side (in a 90˚ arc from the bow) and ahead of the ship. This survey band was sub-divided (A = 0-50m from the ship, B = 50-100m, C = 100-200m, D = 200-300m, E > 300m) to subsequently allow correction of species differences in detection probability with distance from the observer. A fixed-interval range finder (Heinemann 1981) was used to periodically check distance estimates. The area was scanned by eye, with binoculars used only to confirm species identification. All birds seen within the survey area were counted, and those recorded on the water noted as 'in transect'. All flying birds within the survey area were also noted, but only those recorded during a 'snapshot' were regarded as 'in transect'. This method avoids overestimating bird numbers in flight (Tasker et al. 1984). The frequency of the snapshot scan was ship-speed dependent, such that they were timed to occur at the moment the ship passed from one survey area to the next. Any bird recorded within the survey area that was regarded as being associated with the survey vessel was noted as such (to be excluded from abundance and density calculations). Survey time intervals were set at 5 minutes. Additional bird species observed outside the survey area were also recorded and added to the species list for the research cruise, but these will not be included in maps of seabird abundance or density.

2.5 Plankton and Oceanographic Survey

Zooplankton samples were collected using a 1m ring net with a mesh size of 280µ and another of 700µ. At each station a CTD profile was carried out on arrival. Following this the 1m ring net was deployed to a maximum depth of 1000m and hauled at a rate of 2ms-1. A phytoplankton net was also deployed to 50m at each station. At the Labadie Bank two zooplankton tows were carried out using Bongo nets (mesh size 700µ). This net was towed for 20mins at a speed of 2knots from stations 23 and 27.

During vertical profiles (carried out at stations 4, 6 and 22) the 1m ring net was consecutively deployed to 1000, 800, 600, 400, 200 and 50m. All samples were fixed and stored in 4% formalin-seawater solution for further analysis.

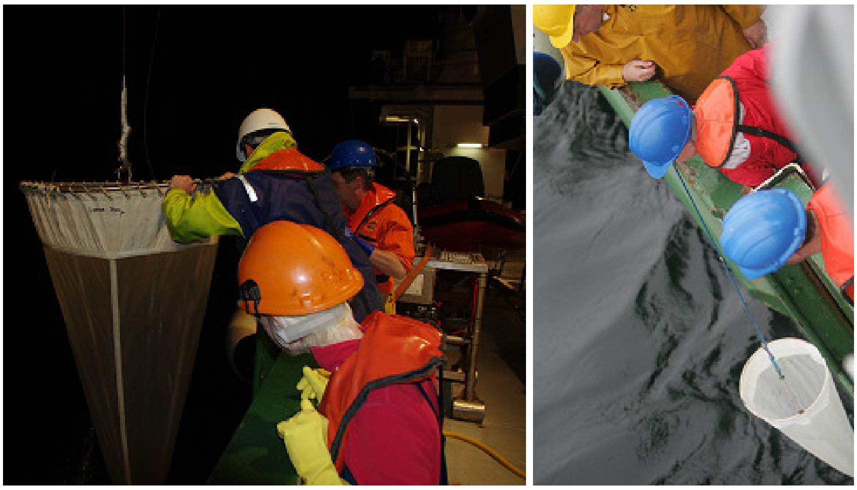

***Fig. 5** Sampling using a 1m ring net and a 20µ net.*

28 oceanographic stations were sampled (fig. 6). Due to the time taken to conduct vertical profiles of zooplankton at some stations, CTDs were not conducted at all stations but at least one CTD was conducted at each canyon/location. CTDs were conducted at 29 stations. Due to surface currents and poor weather it was not possible to conduct zooplankton hauls at all stations.

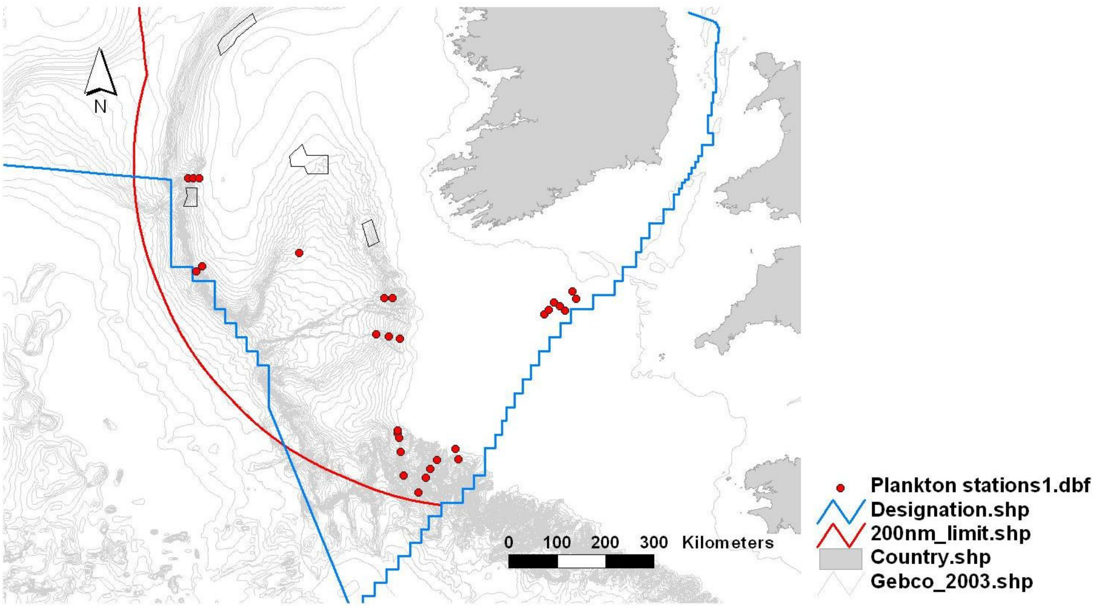

***Fig. 6** Location of 29 stations sampled for zooplankton and/or CTD.*

Salinity, temperature and fluorescence were measured under way using the ship's onboard fluorometer and CTD. This data has been logged and will be used to construct maps of surface distribution of these variables. Once a day pumped seawater from the ships non toxic supply was filtered through a 20 μ net for 45 minutes to collect surface phytoplankton. The sample was preserved using Lugol's Iodine for examination on shore.

28 oceanographic stations were sampled (fig. 8), of these 14 were in or near canyon systems along the southwest slopes of the Porcupine Bank, the east slopes of the Porcupine seabight and the Whittard Canyon system. Eight stations were sampled for comparative purposes, one over the Porcupine Seabight and seven over inter-canyon slopes in the Whittard Canyon System. Another seven stations were conducted over along the Labadie Bank some 70nm south of the Cork coast. At each station, temperature salinity, density and light transmission were measured from in water depths from 200m – 3000m. Water samples were collected at some stations. These samples were preserved in Lugol's Iodine for cell counting on shore. Extensive surface data was obtained on a 24 hour basis, including seas surface temperature.

The Simrad™ EK 60 echo sounder was turned on during CTD/Plankton work and when steaming between plankton/oceanographic stations (it could not be used when hydrophones were deployed due to acoustic interference with the hydrophone recordings). This gave an initial estimate of zoo- and even phytoplankton density along the main axes of several canyon systems.

2.6 Stable Isotope Analysis of Krill

Vertical plankton hauls were made at various stations where high densities of Fin Whales are known to occur. The complete water column was sampled using a 280μm (ø=100cm) plankton net. Sampling was carried out at night when net-avoidance by larger zooplankton is thought to be less problematic. Euphausiids (*Meganyctiphanes norvegica*, and *Thysanoessa* spp.) and Copepods (*Calanus* spp.) were removed from the samples and stored at -20OC for stable isotope analysis. Samples will be freeze-dried, ground to a powder, carbonates and lipids will be removed before being analysed using a mass spectrometer.

2.7 Marine Megafauna Survey

Any marine megafauna data was collected during cetacean visual surveys, was collected using methods as described in section 2.1 above.

2.8 Deployment of ARGO Oceanographic Buoy

The ARGO buoy was deployed at a location in the Porcupine Seabight and will continue to collect data for a number of years. As the float ascends a series of typically about 200 pressure, temperature, salinity measurements are made and stored on board the float. These are transmitted to satellites when the float reaches the surface (fig. 7).

For most floats in the Argo array the data are transmitted from the ocean surface via the Système Argos location and data transmission system (see also Service Argos Inc.). The data transmission rates are such that to guarantee error free data reception and location in all weather conditions the float must spend between 6 and 12 hrs at the surface. Positions are accurate to ~100m depending on the number of satellites within range and the geometry of their distribution.

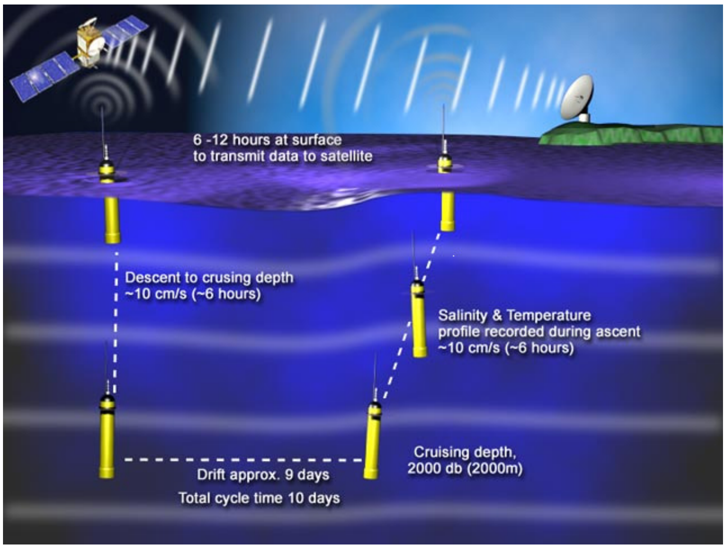

Fig. 7 *Diagram of ARGO float operating cycle.*

Data is relayed and made publicly available within hours after collection and the float forms part of a current network of 3351 ARGO floats (see: http://www.argo.net/).

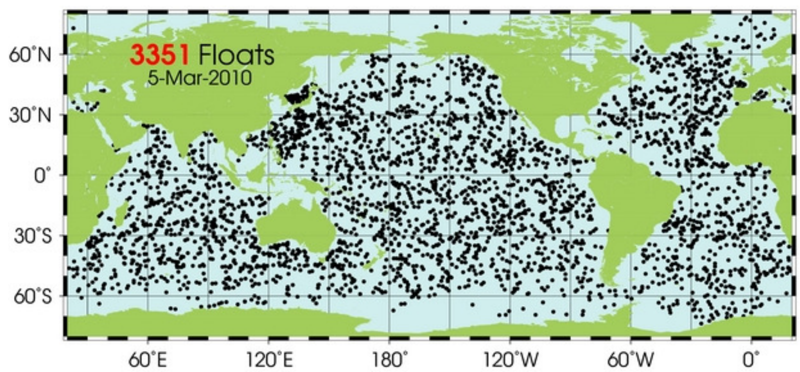

Fig. 8 *ARGO float network (5/3/2010).*

3 Results

3.1 Environmental Conditions

Environmental data was collected at 231 stations. Sea state was ≤3 at 21.6% of environmental stations, ≤4 at 60.2% of stations and ≤5 at 89.2% of stations. Visibility was >5km at 93.1% of stations, 1–5km at 5.2% of stations and <1km at 1.7% of stations. Swell of 2m+ was recorded at 35.1% of stations. Rainfall was recorded at 11.3% of stations (fig. 11). One full visual survey day and one half-day were lost due to due to bad weather (gales, dense fog or heavy rain).

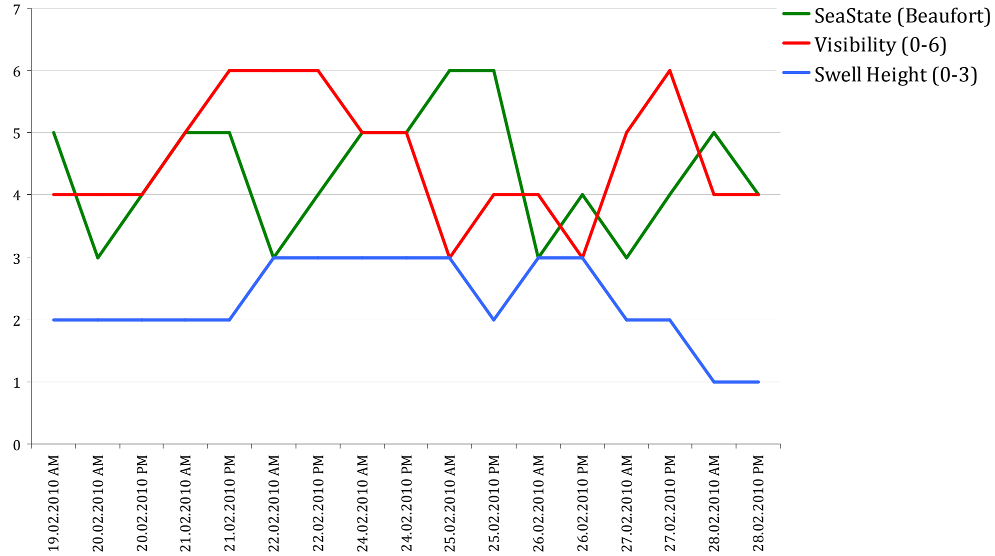

Fig. 9: *Sea state, swell conditions and wind speed recorded twice daily during the survey.*

3.2 Visual Cetacean Survey

80.6hrs of on-effort survey time were logged with 20.7% (16.7hrs) of this at Beaufort sea state three or less; 58.5% (47.15hrs) at Beaufort sea state four or less and 88.6% (71.4hrs) at Beaufort sea state five or less. Additional time was spent watching from the bridge during poor weather, however these data were considered off-effort and sightings from these watched were logged as auxiliary sightings. 25.6hrs of double platform survey effort, 27.5hrs of single platform survey effort and 27.5hrs of bridge watching were logged (fig. 10).

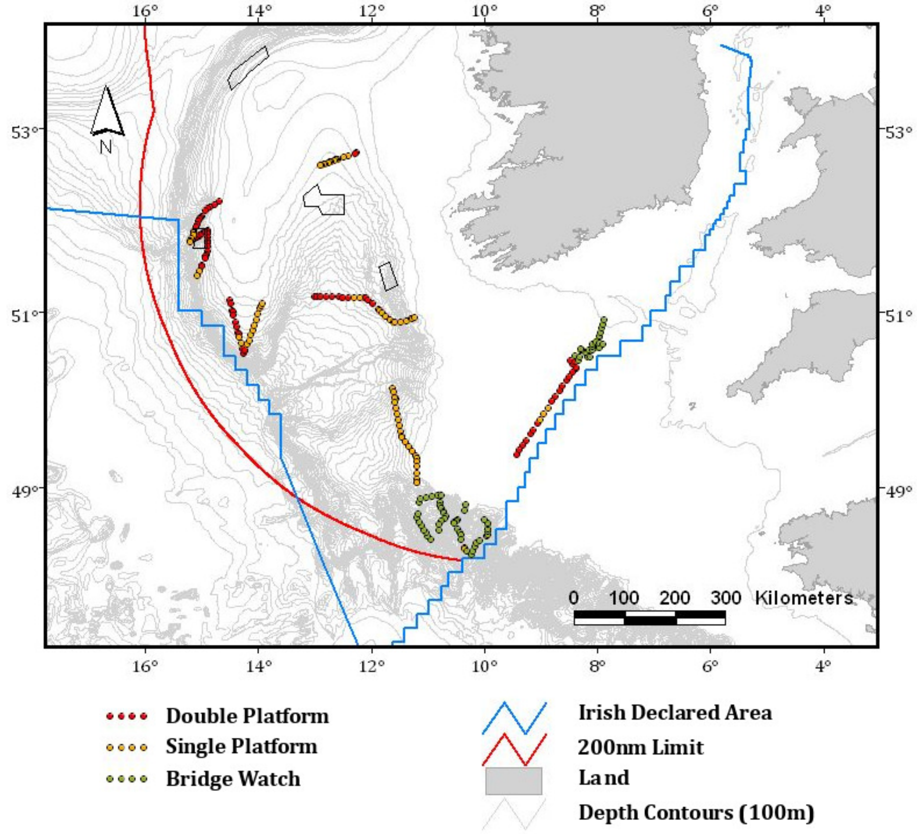

Fig. 10: *Double, Single and bridge watch survey effort collected during the survey.*

94 sightings of at least five cetacean species, totalling 750 individuals were recorded (figs. 13 – 18 show distribution and group sizes of sightings for each species).

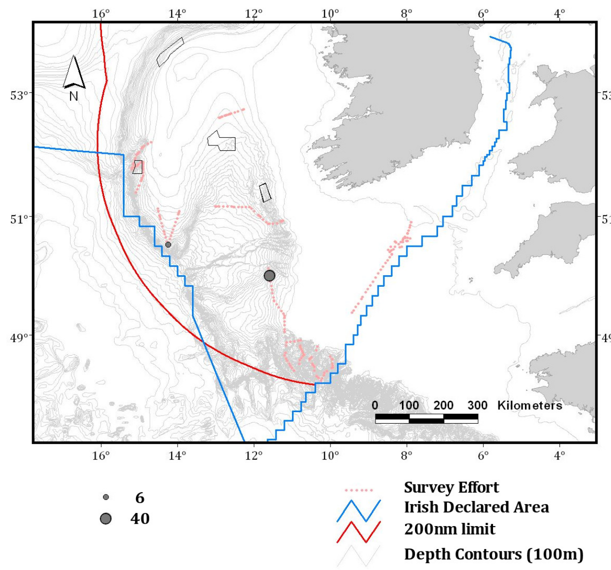

Fig. 11 *Bottlenose Dolphins*

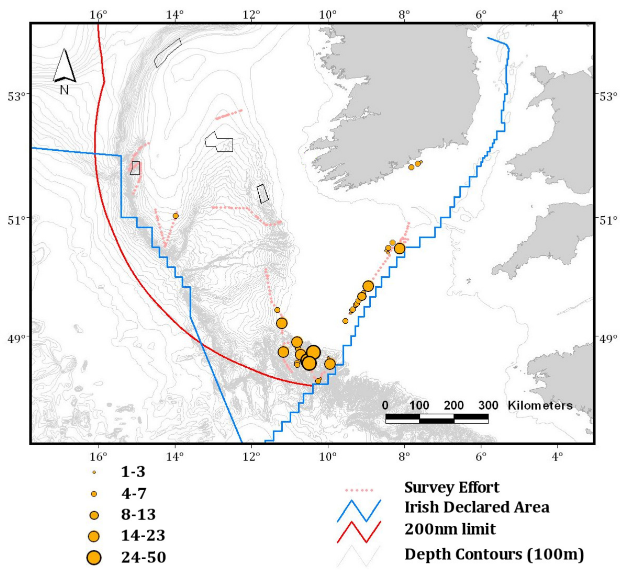

Fig. 12 *Common Dolphins*

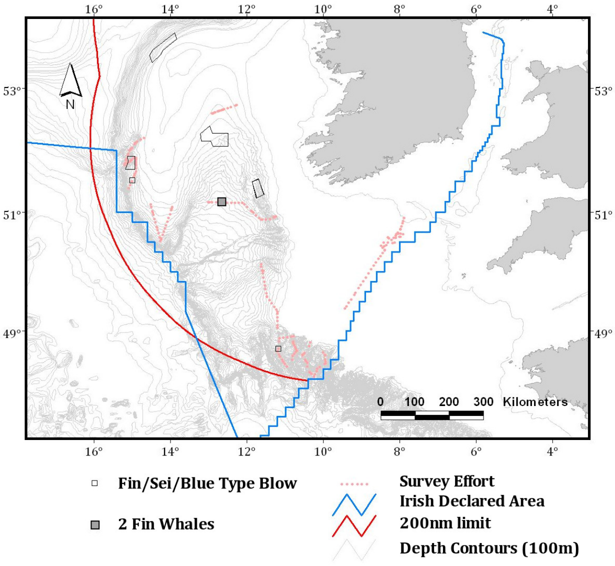

Fig. 13 *Fin Whales & Fin/Sei/Blue Type Blows*

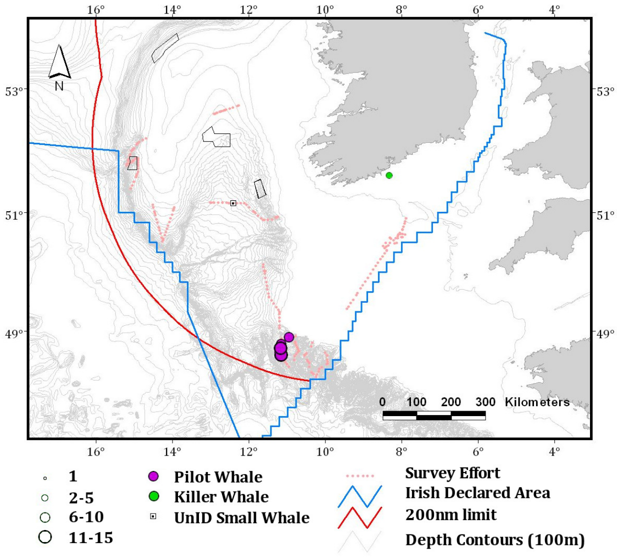

Fig. 14 *Pilot Whales, Killer Whales and Unidentified Small Whale.*

Fig. 15 *Melanistic Common Dolphin (© Patrick Lyne)*

Identified cetacean species were fin whale (*Balaenoptera physalus*), long-finned pilot whale (*Globicephala melas*), bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*) and killer whale (*Orcinus orca*). All sightings of unidentified whale blows were thought to be of fin whales but were classed as fin/sei/blue according to the IWDG's cetacean sightings database classification scheme (IWDG 2010). No beaked whales were seen.

Common dolphins were the most commonly encountered and abundant species recorded during the survey (table 1), encountered group sizes were small with 75.6% of encounters involving group sizes of less than 10 animals.

Table 1: Sightings, counts and group size ranges for cetaceans sighted during the survey.

Species	**No. Sightings**	**No. Individuals**	**Range of Group Size**
Bottlenose dolphin	2	46	6 - 40
Common dolphin	82	649	1 - 50
Killer whale	1	2	-
Fin whale	1	2	-
Long-finned pilot whale	7	58	1 - 15
Fin/sei/blue (blows)	2	2	-
Unidentified cetacean	1	1	-
Unidentified dolphins	1	3	-
Unidentified small whale	1	1	-

A group of 35-40 bottlenose dolphins was encountered on the 24th February on the eastern slopes of the Porcupine sea bight. The ship was diverted to approach the group, to confirm species identification, obtain photo-identification images (see section 3.4) and record vocalisations (see section 3.3.4). The group included at least two calves.

The majority of sightings were made over the Whittard Canyon system, with common dolphins also being commonly encountered in small groups over the Celtic Shelf.

3.3 Acoustic Cetacean Survey

3.3.1 Towed Hydrophone Array

130.25 hours of recordings from the hydrophone array were collected. This data underwent preliminary analysis, resulting in a total of 367 identified acoustic detection events involving at least 4 species. As these results were based on a preliminary analysis of the data, changes in the final dataset should be expected. From the acoustic data and associated visual sightings, 2 detection events were identified as bottlenose dolphins, 42 as common dolphins, 8 as long-finned pilot whales, 18 as sperm whales, 91 as unidentified dolphin clicks and 206 as unidentified dolphin whistles. The acoustic data will undergo further in depth analysis, which may reveal more information on source species, number and duration of detection events. A copy of the acoustic files was also sent to the Sea Mammal Research Unit in St. Andrew's University in Scotland where researchers are looking at the potential and problems in using towed hydrophone arrays to monitor beaked whales.

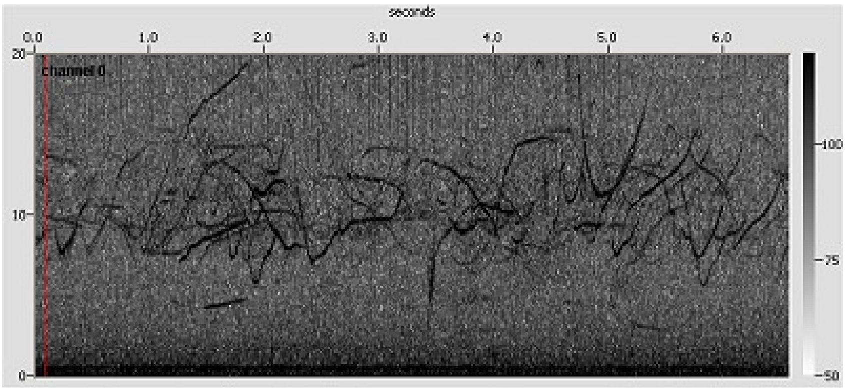

__Fig. 16__ An example of whistle spectrogram recorded from a common dolphin acoustic detection event.

Sperm whales were the most commonly encountered acoustic detection events during the survey. Sperm whales were encountered in the slopes and canyons of the southwest Porcupine Bank and the eastern Porcupine Sea Bight. Pilot whales were encountered in canyons on the east slopes of the Porcupine Sea Bight and the Whittard Canyon System (fig. 17).

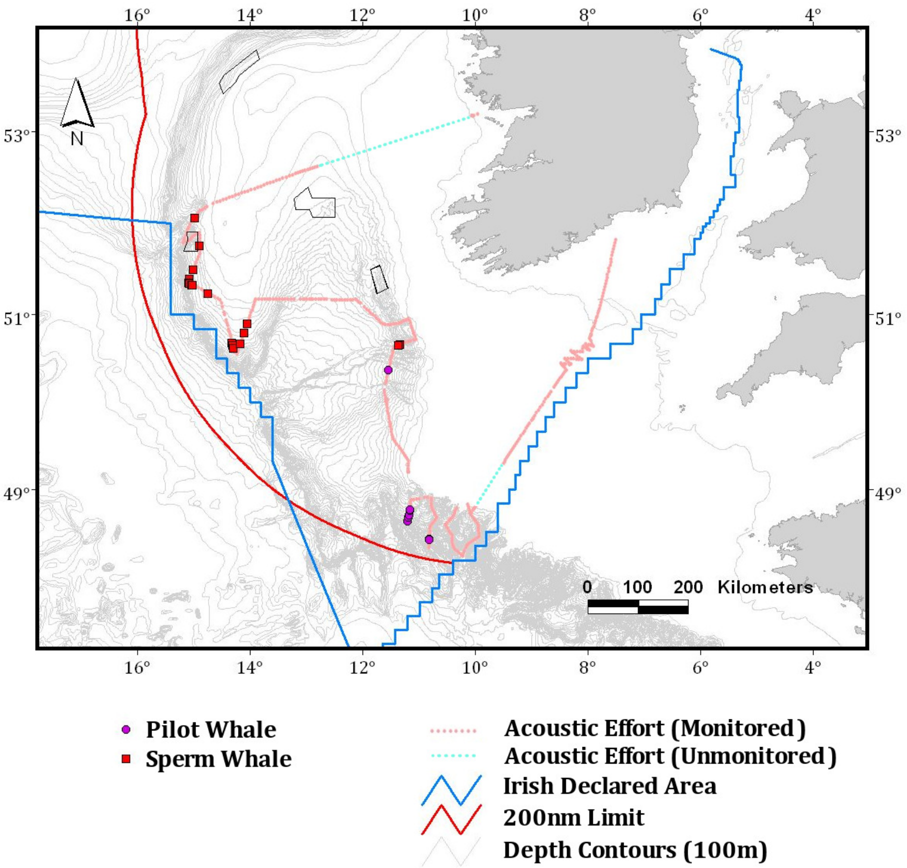

__Fig. 17__ Distribution of acoustic detections of sperm whales and pilot whales recorded during the survey.

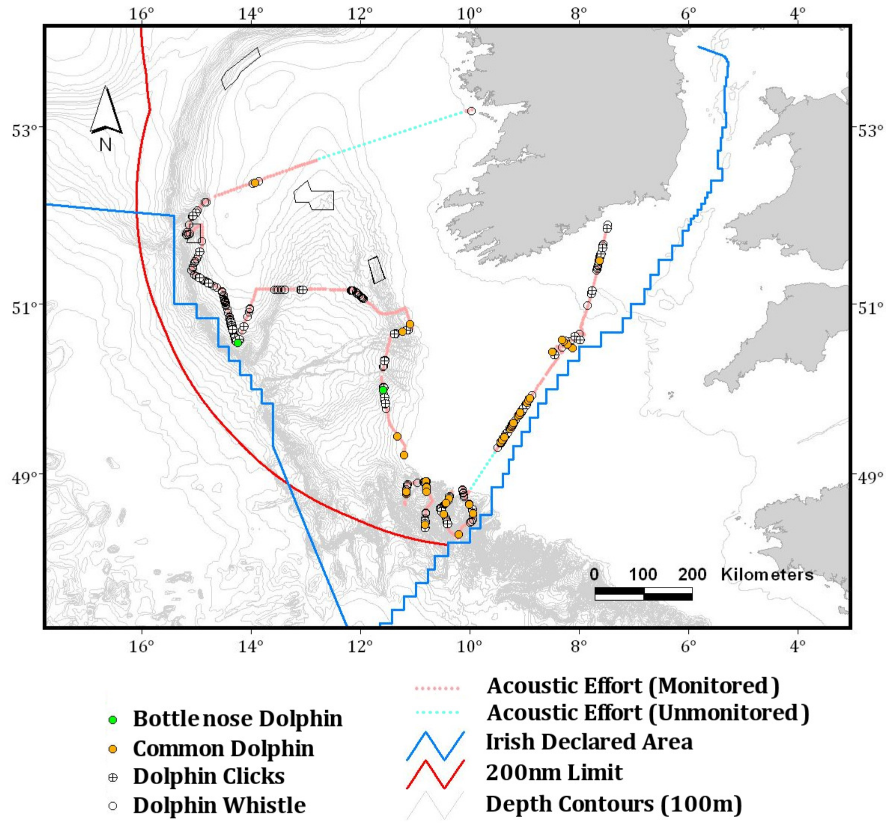

Fig. 18 *Distribution of acoustic detections of common, bottlenose and unidentified dolphin species recorded during the survey.*

Dolphin acoustic detections were commonly recorded in slopes and canyon habitat along the southern slopes of the Porcupine Bank, the Whittard Canyon and the eastern slopes of the Porcupine Sea Bight (fig. 18). Dolphin detections were also common over the Celtic Shelf. Dolphin whistle detections were almost continuously detected in some areas of the survey route, though it is difficult to interpret how far away the vocalising animals were. Generally dolphin clicks appeared to be only recorded when the animals were within a few hundred meters of the array.

3.3.2 Bottlenose Dolphin Vocalisations

Participation in the Cetaceans on the Frontier survey provided a valuable opportunity to sample vocalisations of offshore bottlenose dolphins to compare with inshore recordings. Recordings were successfully made during some of the encounters with bottlenose dolphins during the survey cruise. Recordings were made using the 200m towed array, having a frequency range between 2 kHz and 96kHz sampling at 96kHz, 24bit (48kHz effective bandwidth).

3.4 Cetacean Photo-ID

Due to weather conditions during the survey it was not possible to launch the IWDG RIB for use in photo-identification on the days that bottlenose dolphins were encountered.

An encounter with a group of 40 bottlenose dolphins occurred on the slopes of the southwest Porcupine Bank (fig. 11) on the 24th February 2010. During that encounter the ship approached the group for the purposed of confirming species identification and at this time some of the group approached the ship to bow ride. The interaction enabled the collection of photographic images for the purpose of conducting photo-identification studies.

Following processing of these photographs, nine new bottlenose dolphin photo-identification images were obtained (fig. 19). These images will be catalogued and available on the photo-identification section of the IWDG website (www.iwdg.ie).

Fig.19 *Photo-identification images obtained from a group of 40 bottlenose dolphins encountered on the 24th February 2010.*

Photo-identification images obtained during the encounter will be compared with existing catalogues of bottlenose dolphin fins from Ireland and Europe to attempt to determine whether these are part of an inshore population, a resident group (e.g. Shannon Estuary) or are from a distinct population of offshore dolphins.

During an encounter with a group of 20 pilot whales on the 25th February 2010, eight photo-ID images (fig. 20) of animals carrying identifying scars or breastplate patterns were collected. These images will be catalogued and available on the photo-identification section of the IWDG website (www.iwdg.ie).

Fig.20 *Photo-identification images obtained from a group of 20 pilot whales encountered on the 25th February 2010.*

3.5 Visual Seabird Survey

The seabird survey data collected during the cruise will be input and related to positional data (latitude and longitude) logged by the ship's onboard GPS system. Geo-referenced, processed seabird data will be made available to the partners of the voyage in order to explore possible relationships between cetacean, plankton, seabirds and physical characteristics of the canyon systems.

Survey effort (km2 surveyed), seabird abundance (birds per km travelled), and seabird density (birds per km2) will be mapped per ¼ ICES square (15˚ latitude x 30˚ longitude), allowing comparison to the results of previous seabird surveys in Irish waters (e.g. Pollock et al. 1997; Mackey et al. 2004). All birds recorded on the sea or in flight within the survey area will be used to calculate abundance, while only birds in flight recorded during a snapshot scan are added to birds on the sea for calculating density. Species-specific correction factors from Stone et al. 1995 and Pollock et al. 2000 will be applied to birds recorded on the sea.

Approximately 83 hours of seabirds at sea ship transect data were collected in suitable conditions, between 19th and 28th February inclusive. Only on 23rd February did the weather (force 8) prevent surveying from the bridge deck. In conjunction with birds recorded outside the transect survey periods, surveys yielded a list of 12 bird species encountered during the cruise. At the time of writing this report the input and processing of survey data has yet to be completed. However, northern fulmar, northern gannet and black-legged kittiwake were clearly the most abundant species encountered. A preliminary account of each bird species recorded during the cruise follows.

Northern Fulmar *(Fulmarus glacialis)*

Fulmars were abundant (as expected: Mackey *et al.* (2004) found peak relative abundance of this species occurred in February), and seen daily. However, their abundance did vary over the course of the survey. Pollock *et al.* (1997) reported peak densities of fulmars from February to March in areas with sudden changes in bathymetry, and it will be interesting to see whether our results, once mapped, are consistent with this. The majority of fulmars we saw were light morphs, but a dark morph was noted on 20th February (Fig. 21).

Fig. 21 *Light and dark fulmar morphs were seen (© Maggie Hall).*

Great Shearwater *(Puffinus gravis)*

Two great shearwaters were seen on the morning of 20th February, when we were over the slopes of the Porcupine bank. This compares to a single bird of this species recorded in January in ESAS data collected between 1980 and 1997 in the Atlantic west of Ireland (Pollock *et al.* 1997), and none recorded in winter or spring during surveys of this area conducted between July 1999 and Sept. 2001 (Mackey *et al.* 2004). We were not expecting to see great shearwaters in the North Atlantic at this time of year, as these summer migrants breed on islands in the South Atlantic.

Fig. 22 *Great shearwater (© Dave Wall).*

Sooty Shearwater *(Puffinus griseus)*

A single sooty shearwater was seen from the bridge on the morning of 21st February. At this time we were over the south of the Porcupine bank. This bird was later observed being harassed by a great skua.

Sooty shearwaters were only recorded in the Atlantic west of Ireland between May and November by Mackey *et al.* (2004), and between July and October by Pollock *et al.* (1997). Members of this species typically move out of the area in autumn, to breed in the southern hemisphere. However, the waters west of Ireland are thought to be important as feeding grounds for non-breeders (Warham 1996).

Fig. 23 *Sooty shearwater (© Dave Wall).*

European storm-petrel *(Hydrobates pelagicus)*

A single European storm-petrel was seen during the evening of 24th February (in the hours of darkness), skimming over the surface of the water close to the plankton net as it was hauled in. Pollock *et al.* (1997) report only nine storm petrels observed in Irish waters in December, and none between January and April, but Mackey *et al.* (2004) recorded small numbers of this species in March. Storm petrels winter off southern Africa and are typically summer visitors to the waters around Ireland, with Inishtooskert, County Kerry thought to represent the world's largest breeding colony of this species (Mitchell *et al.* 2004).

Fig. 24 *European storm petrel (© Dave Wall).*

Northern gannet *(Morus bassanus)*

Gannets were seen daily. They were particularly abundant on the afternoon of February 22nd as we surveyed across the Porcupine Seabight and down its eastern slopes, when they were seen plunge-diving and sitting on the water "snorkelling". Gannets were also noticeably more numerous than fulmars on 24th February, as we tracked southwest across the Goban Spur, skirting the shelf edge. We recorded 2nd-, 3rd- and 4th-winter birds, as well as adults throughout the cruise.

This species breeds at a few, very large colonies in the North Atlantic (Wanless 1987), with approx. 80% of the European population breeding in Ireland and Britain (Mead 2000). During the winter months gannets are widely dispersed, some remaining in Irish waters while others (particularly immature birds) migrate south as far as west Africa (Cramp *et al.* 1974; Lloyd *et al.* 1991), before beginning to return to breeding colonies in January (Pollock *et al.* 1997).

Fig. 25 *Northern gannet flying above the R.V. Celtic Explorer (©Maggie Hall).*

Great skua *(Stercorarius skua)*

At least one great skua was seen every day of the survey until 28th February, when they were absent (at this stage we were tracking back north across the Celtic shelf towards inshore waters). Four great skuas associated with the ship during bad weather on 23rd February. We observed kleptoparasitic attacks by this species on northern gannets and a sooty shearwater.

Most great skuas present in the area in winter are likely to be adults, as immature birds are thought to disperse further south (Furness 1987). In spring great skuas migrate north towards their breeding colonies. Almost 60% of the NE Atlantic population breeds in Shetland and Orkney, but a few pairs have recently been discovered breeding in west Ireland (Mitchell *et al.* 2004).

Fig. 26 *Great skua (© Dave Wall).*

Lesser black-backed gull *(Larus fuscus)*

Lesser black-backed gulls were not seen during the first four days of surveys, but once we travelled further south were recorded daily between 23rd and 28th February, usually occurring in small groups of three to five. During the bad weather on 23rd February larger numbers were seen associating with the ship, as part of a mixed group with herring gulls that numbered ca. 40 birds in total. On 28th February larger groups (of ca. 20) were also seen.

Lesser black-backed gulls move north from their wintering grounds between mid-February and early April (Hutchinson 1989), and are widely dispersed south of Ireland in spring (Pollock *et al.* 1997).

Great black-backed gull *(Larus marinus)*

Great black-backed gulls were recorded on the first day of surveying (19th February), and on 22nd, 23rd, 25th, 27th and 28th February (single birds or pairs). They are considered more marine than lesser black-backed and herring gulls.

Fig. 27 *Great black-backed gull (front) and Lesser black-backed gull (behind). (© Dave Wall).*

Herring gull *(Larus argentatus)*

Herring gulls were recorded on 22nd, 23rd (with lesser black-backed gulls- see above), and daily from 26th to 28th February, generally in small groups.

Pollock *et al.* (1997) recorded the highest numbers of herring gulls in winter (November to February), but few were seen at this time southwest of Ireland.

Fig. 28 *Herring gull. (© Dave Wall).*

Black-legged kittiwake *(Rissa tridactyla)*

Kittiwakes were seen daily, often associating with the ship. A high proportion of these were 1st-winter birds.

Pollock *et al.* (1997) recorded the highest density of kittiwakes in February and March, and interestingly (like fulmars) high densities appeared to coincide with the steep slopes of the shelf break (also Webb *et al.* 1990; Bloor *et al.* 1996). Mackey *et al.* (2004) also recorded a peak in abundance in February.

Fig. 29 *Black-legged kittiwake (© Maggie Hall)*

Common guillemot *(Uria aalge)*

The first sighting of any auk species during this cruise was made as we tracked back north over the Celtic shelf on 27th February, when four individuals were seen fleetingly during surveys. One of these was identified as a common guillemot, but we were unable to confirm the identification of the others to species level. Another guillemot was positively identified on 28th February, plus two further “auks” (too distant for species identification).

Previous studies have found common guillemots to be virtually absent from deep offshore waters (Mackey *et al.* 2004), although Pollock *et al.* (1997) report small numbers occurring along the shelf break west of Ireland between October and February.

Atlantic puffin *(Fratercula arctica)*

Two puffins were recorded on 28th February, as we tracked north over the Celtic Shelf.

In winter puffins disperse widely, adopting a pelagic lifestyle. At this time they may feed more on plankton than they do during the summer months (Harris 1984a, b), and may occur at low densities in deep Atlantic waters (Pollock *et al.* 1997). However, in late winter they undergo a complete body moult (mostly between January and March), before returning to their breeding colonies (Harris and Yule 1977). This contrasts with other auk species which moult after the breeding season. Pollock *et al.* (1997) recorded no puffins in February in the waters around Ireland, but in March they appeared off the south coast at low density. Mackey *et al.* (2004) recorded relatively low abundances in February.

3.6 Plankton & Oceanographic Survey

3.6.1 CTD Profiles

Results from the CTD indicated that the water both around canyons and on the shelf edge was very well mixed with no visible thermocline until a depth of approximately 600m. The lowest temperature recorded, 2.8°C, was within the canyons at 3000m. Surface temperatures increased as the survey moved south with a maximum water temp of 11.6°C in the Whittard Canyon. See Appendix I for CTD profiles at each station.

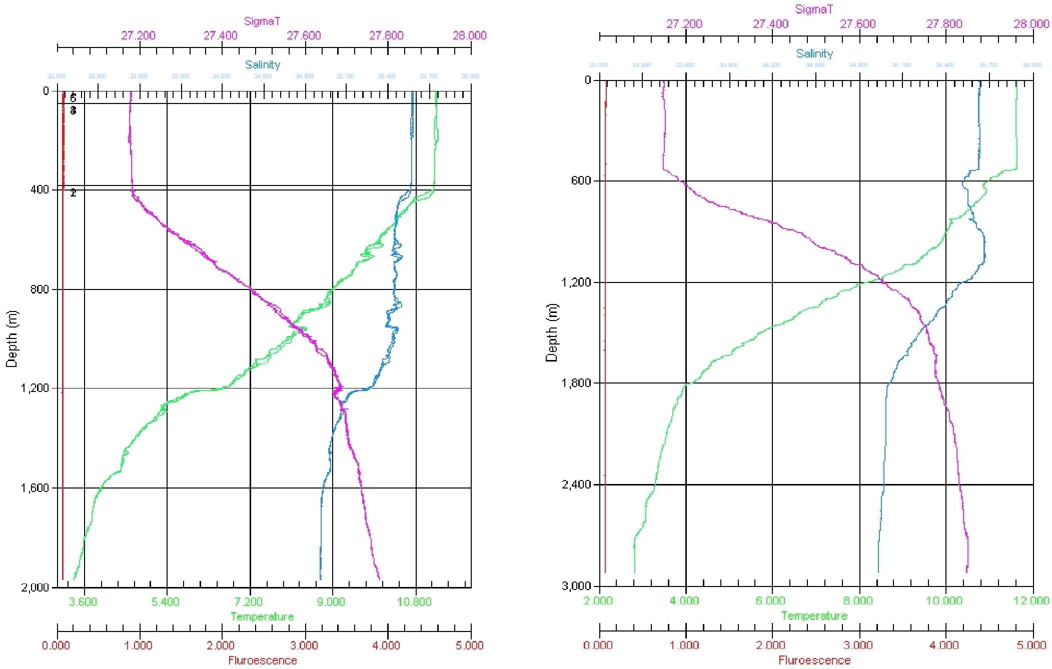

Fig. 30: *Two deep water CTD's. Left: Station 4; right: Station 16.*

3.6.2 Phytoplankton

Initial results indicated very little phytoplankton in the water. This is consistent with existing studies which indicate phytoplankton blooms as occurring during the warmer summer months. An Simrad ER60 scientific echo sounder was used to assess plankton biomass in the water column at each station and between night time stations (fig. 31).

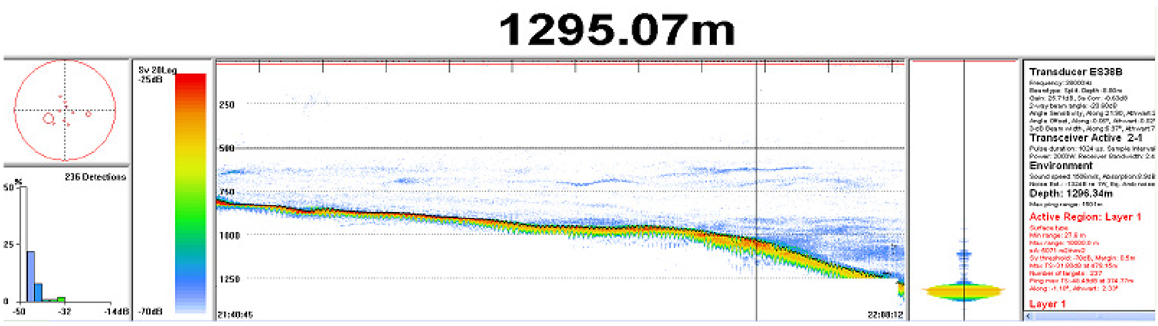

Fig. 31: *Simrad ER60 sounder image of typical distribution of plankton biomass in the water column, with very little phytoplankton in the upper 200m and zooplankton biomass predominantly below 600m.*

3.6.3 Zooplankton

Due to poor weather conditions and/or strong surface currents zooplankton samples could not be taken at every station. A total of 31 zooplankton samples were collected.

Within the canyons there was no visible differences between the shallow and deep areas of the canyons. The only distinction between such areas was the presence of deep-sea zooplankton in deep hauls (>800m). Species such as the deep red jellyfish, Periphylla sp., and also red deepwater crustaceans such as Gnathophausia sp. and Acanthephyra sp. among others were recorded at these stations.

Fig. 32: *A selection of specimens collected during the cruise. Clockwise from top left, Gnathophausia sp., pipefish, Acanthephyra sp., Aglantha digitale, Clio sp.*

The vertical profiles carried out at stations 4, 6 and 22 illustrated the distribution of the zooplankton within the water column. Chaetognaths, siphonophores, pteropods and hydromedusae were observed in hauls between 800 and 1000m, but were rarely found in shallower samples (above 600m). Small copepods, euphausiids and amphipods were present in all samples however very little biomass was observed in hauls shallower than 200m. Pipefish were also present at stations 6 and 7, approximately 15 individuals were recorded over 5 hauls.

The Labadie Bank area was notably different from the other sites surveyed. Here large numbers of chaetognaths, amphipods and copepods were recorded. The hydromedusa, *Aglantha digitale*, not previously observed, was present in all samples taken over the Labadie Bank. A number of large euphausiids and the pelagic larval stage of the cushion star were also observed at all stations on the bank.

Underway temperature, salinity and fluorescence data was collected during the trip and will be obtained from the Marine Institute after the cruise. The sea surface temperature data will be related to cetacean sightings and its effects on cetacean species distribution will be analysed as part of ongoing work by the IWDG/GMIT and the University of Aberdeen.

3.7 Marine Megafauna Survey

No seals, turtles, sharks or sunfish were encountered during the survey.

3.8 Stable Isotope Analysis of Krill

Samples from the Labadie Bank and within 5nm of the southeast coast, where Fin and Humpback whales were known to be feeding at that time (observed from shore by IWDG) were also taken. Fin and blue whales (Wall *et al.*, 2009) are believed to feed on high concentrations of krill along the continental shelf edge of Ireland. These samples will provide a baseline stable isotope profile for baleen whale prey in this region in order to test the hypothesis that whales are feeding directly or indirectly on these species in Irish waters. The zooplankton samples obtained in this survey will be used as a baseline in trophic modelling of baleen whale diets. These samples add value to those collected in September 2009 from the R.V. Celtic Voyager from the Labadie Bank as they will enable a comparison of Spring and Autumn samples to look for seasonal variability in isotope signatures.

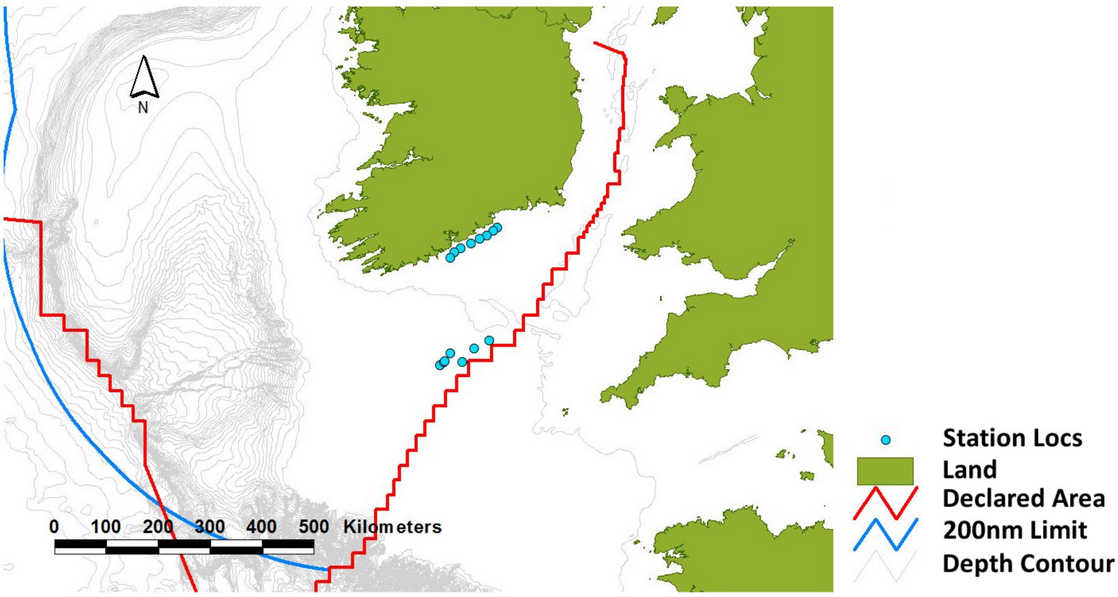

Fig. 32 *Locations of plankton sampling stations for stable isotope analysis.*

3.9 Deployment of ARGO Float

The ARGO float was deployed on the 22nd February in the Porcupine Seabight. By the 18/05/2010 the float had completed 10 recording cycles in 95 days since deployment (fig. 33). The buoy will continue to gather data until its power supply runs down.

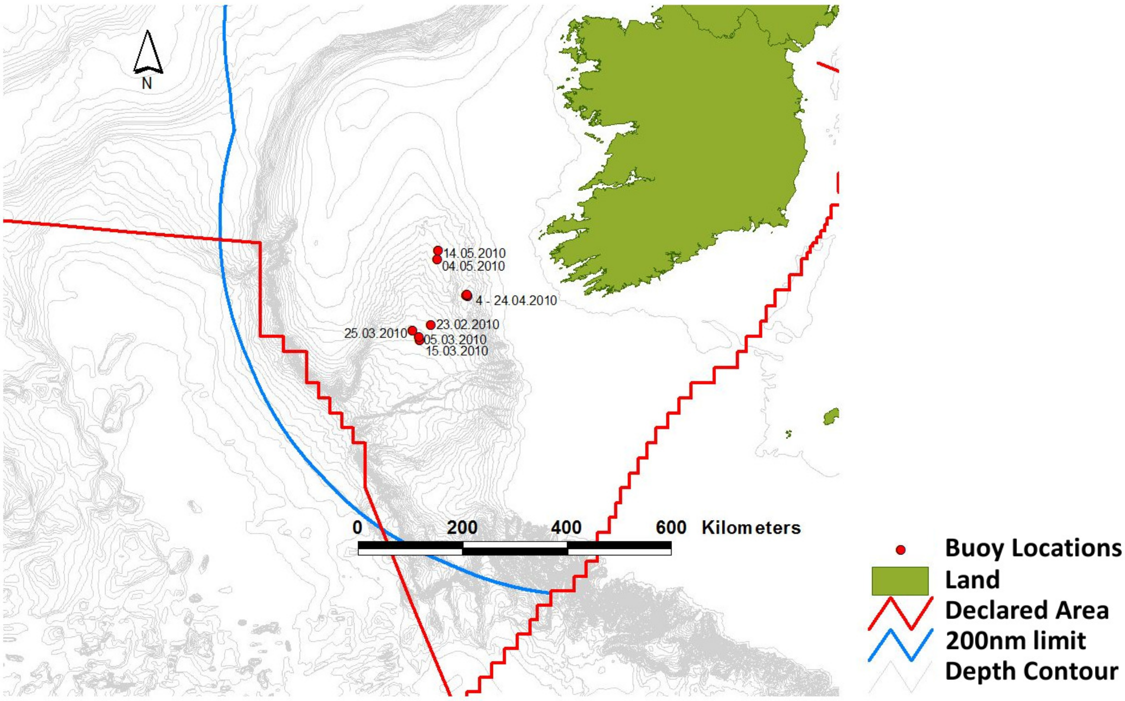

Fig. 33 *ARGO float locations between 23/2/2010 and 14/5/2010.*

Fig. 34 *ARGO float being brought on deck for deployment over the Porcupine Seabight.*

4 Acknowledgements

We would like to thank Captain Denis Rowan and the crew of the R.V. *Celtic Explorer* for their help and professionalism during the course of this survey. To Aodhán Fitzgerald, Barry Kavanagh, Carol Maloney and Bill Dwyer for their assistance during the planning of the survey.

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Access to the R.V. *Celtic Explorer* was granted to IWDG/GMIT through the National Marine Research Vessels Ship-Time Grant Aid Programme 2010, which is funded under the Science Technology and Innovation Programme of National Development Plan 2007-2013

PReCAST is funded under the Sea Change strategy with the support of the Marine Institute and the Marine Research Sub-Programme of the National Development Plan 2007–2013 (Grant Aid Agreement No. PBA/ME/07/005 (02)).

Finally thanks to the Cetaceans on the Frontier 2010 Survey Team for making the trip both enjoyable and productive…

Cetaceans on the Frontier Survey Team 2010

Back row left to right:

Maggie Hall, Joanne O'Brien, Dave Williams, Hilary Healy, Conor Ryan, Laura Kavanagh, Lucy Hunt, Rossa Meade, Sophie Hansen, Darren Craig and Patrick Lyne.

Front row left to right:

Fien de Raedemaecker, Jackie Hunt, Jane Kelleher, Mary Coleman, Dave Wall and Alex Borawska.

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Appendix II: List of cetacean species recorded within the Irish EEZ and adjacent waters.

Atlantic White-Sided Dolphin	*Lagenorhynchus acutus*
Beluga	*Delphinapterus leucas*†
Blue Whale	*Balaenoptera musculus*
Bottlenose Dolphin	*Tursiops truncatus*
Common Dolphin	*Delphinus delphis*
Cuvier's Beaked Whale	*Ziphius cavirostris*
False Killer Whale	*Pseudorca crassidens*
Fin Whale	*Balaenoptera physalus*
Gervais' Beaked Whale	*Mesoplodon europaeus**
Harbour Porpoise	*Phocoena phocoena*
Humpback Whale	*Megaptera novaeangliae*
Killer Whale	*Orcinus orca*
Minke Whale	*Balaenoptera acutorostrata*
Northern Bottlenose Whale	*Hyperoodon ampullatus*
Northern Right Whale	*Eubalaena glacialis*
Pilot Whale (long-finned)	*Globicephala melas*
Pygmy Sperm Whale	*Kogia breviceps*
Risso's Dolphin	*Grampus griseus*
Sei Whale	*Balaenoptera borealis*
Sowerby's Beaked Whale	*Mesplodon bidens*
Sperm Whale	*Physeter macrocephalus*
Striped Dolphin	*Stenella coeruleoalba*
True's Beaked Whale	*Mesplodon mirus*
White-Beaked Dolphin	*Lagenorhynchus albirostris*

*† Vagrant * Recorded only from Stranding*