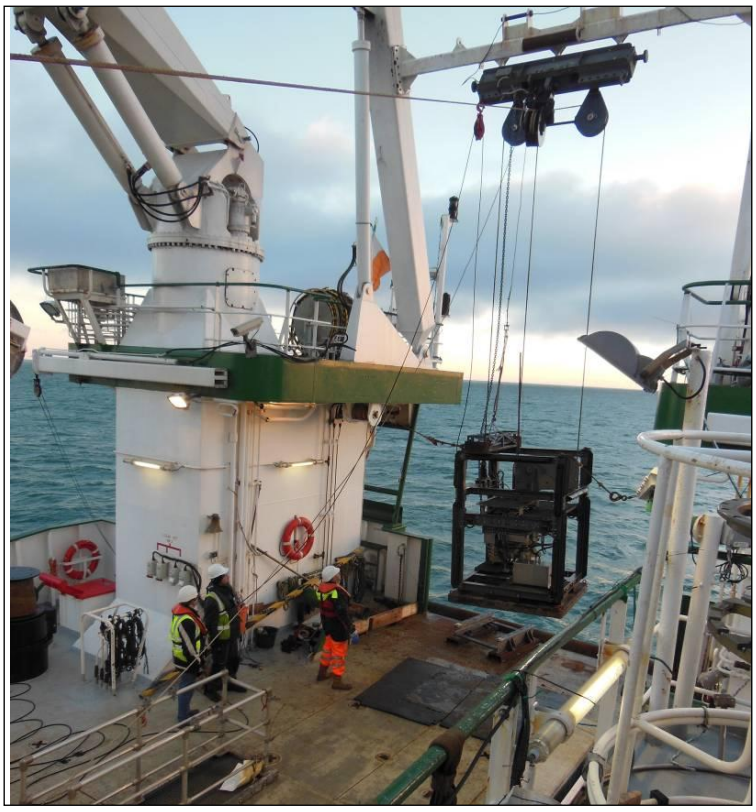
Cruise Report CE14001:

Developing Geotechno-stratigraphies (Leg 2)

NW & Central Irish Sea

RV Celtic Explorer



10th to 17th January 2014

Professor Andy Wheeler (Chief Scientist) and Mark Coughlan
School of Biological, Earth & Environmental Sciences,
University College Cork, Ireland

BEES
School of Biological, Earth & Environmental Sciences at University College Cork, Ireland

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Marine Institute
Foras na Mara

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1 EXECUTIVE SUMMARY

This is the second part of a two part survey to define offshore stratigraphies. The initial survey (CE13003) concentrated on NW Celtic Sea and offshore Dungarvan- the Saltees, collecting cores and seismic data for palaeoenvironmental and geotechnical studies. The overall objective to understand the control of palaeoenvironments on sedimentary sequence development and how, in turn, this controls geotechnical sub-seabed properties.

The purpose of this survey was to perform in situ Cone Penetration Testing (CPTu) in order to groundtruth previously collected seismic data and obtain geotechnical data regarding the nature of sediment at depth. This involved a collaborative effort undertaken by University College Cork, MARUM (University of Bremen), the Marine Institute and Gaelectric Developments Ltd. The main area of focus was the north-western Mudbelt area of the Irish Sea; a large area earmarked for offshore renewable energy development. The Lambay Deep area was also the subject of a seismic survey to identify buried tunnel valleys and one site for CPT deployment.

Under a 24 hour work routine, **17 sites** were surveyed using the MARUM designed and built Geotechnical Offshore Survey Tool (GOST). In total some **306.17 m** of good, in situ sub-seabed geotechnical data was collected identifying a succession of inferred glacial layer overlaying bedrock, in turn overlain by an unconsolidated marine mud layer. Thickest accumulations of sediment were found towards the centre of the area with bedrock and glacial sediments occurring close to the surface in the west and south.

In the Lambay Deep area, 66.3 km of sparker lines were shot imagining three valley structures. Two infilled and showed a complex fill history. The third was open and part of the Lambay Deep system.

2 BACKGROUND

The development of the Pleistocene sedimentary sequences in the Irish Sea is complex and records episodes of glacial and glaciomarine deposition, fluvioglacial erosion and deposition, marine transgressive surfaces and sea level high stand marine sedimentation. Understanding the history of Irish Sea Pleistocene deposition provides us with a fuller understanding of British-Irish Ice Sheet dynamics and palaeoenvironmental responses to Pleistocene climate and sea level change. By understanding the dynamics of Irish Sea environments in the past, we can appreciate the dynamics of future climate and sea level responses in the Irish Sea.

Although numerous studies on coastal exposures have revealed valuable information, these settings are peripheral to the Irish Sea proper which house, at least in the last glacial, a significant surging Ice Stream and has repeatedly cut major meltwater channels.

Accessing these sequences, which are often buried 10's of metres in costly. Building of previous studies, both by UCC over the last 10 years and the BGS in the 1970s and 80s, this survey focussed on the seismic investigation of deeps marking former meltwater channels and the groundtruthing of previous seismic studies using an Iin situ cone penetrometer (GOST-CPT) that provides geotechnical and inferred sediment composition data has cm resolution down to 40 m.

In addition, the GOST-CPT data is of interests to offshore renewable energy developers who can use this data to assess potential foundation device solution for offshore energy devices. Ireland has one of the best offshore renewable energy resources in the world. The development of this sector has the potential to yield thousands of new jobs as well as providing Ireland with future energy security.

The siting of wind farms, tidal turbines and near-shore wave energy converters requires significant consideration of foundation design - foundation easily taking up one third of overall investment. Although it is theoretically possible to these technologies anywhere offshore with sufficient resource, different substrates (and sub-substrates) require different foundation designs (e.g. monopile, tripod, gravity base, steel jacket) and installation approaches (e.g. driving and/or drilling, or suction caissons). An early-development foundation design allows for a tailor-made installation strategy, and thus reduces the costs of transportation, associated crane capacity and the very substantial equipment on the Jack-Up vessels usually required to put these foundations in place. The conditions of the seabed also define where Jack Up vessels best rise on their jack-up legs.

3 SURVEY RATIONALE AND OBJECTIVES

The key objectives of the proposal are:

(1) to determine the sub-seabed stratigraphy (the succession of sedimentary layers below the seabed) in high probability areas for renewable energy farm development with particular relevance to the industry's requirements: the lateral extent and variability in e.g. variation in strata thickness, depth, internal sedimentary unit properties (boulders!) and acoustic reflectivity; thus to advise the industry on optimised foundation designs in target areas

(2) to obtain physical samples from the sub-seabed for geotechnical analysis e.g. shear strength, load capacity, internal friction, density, cohesion

(3) to obtain and analyse physical samples from the sub-seabed to determine the palaeo-environmental development of the seabed and submerged coastline and low-lying terrestrial areas through time

(4) to map the spatial distribution and morphological characteristics of sedimentary bedforms and collect physical samples to advance our understanding of seabed mobility in key areas and to advise the industry on optimised cable emplacement strategy in target areas

(5) to provide this data as (a) base-line data to both government bodies and industry for both site selection and future environmental assessment, and (b) key data to allow for realistic financial modelling for cost-effective installations and maintenance of offshore renewable energy farms.

These objectives will be achieved at several sites off the south coast that are potential areas of identified windfarm development.

The data from this project feeds into the existing PhD programmes of Marian McGrath and Mark Coughlan as well as proposed PhD and post-doctoral researcher through the SFI Research Areas call (pending).

4 EQUIPMENT

4.1 Research Vessel - RV Celtic Explorer

The Celtic Explorer is a 65.5 m multi-purpose research vessel. The vessel has wet, dry and chemical laboratories, which are permanently fitted with standard scientific equipment and can accommodate 20-22 scientists along with 13-15 crew who are highly skilled with the handling and deployment of scientific equipment. It has a maximum endurance of 35 days. The Celtic Explorer is equipped with two Trimble 300-D GPS and has Dynamic Positioning.

On the aft deck is a 25 tonne A-frame with 4m outward and inward reach in addition to a 3m, 10 tonne starboard T-frame. The ship also comprises of a midship, forward and aft crane as well as a 6 tonne CTD winch.

4.2 GOST Cone Penetration Test System

The Geotechnical Offshore Seabed Tool (GOST), designed and developed at the MARUM Institute, University of Bremen in Germany, is an innovative geotechnical tool used to characterise the subsoil by means of "push-in tools" such as cone penetration testing or CPT. It is designed to operate from the seafloor in water depths of up to 4,000m with a penetration depth of 6-40m. Its primary focus is as an offshore site investigation tool in aid in foundation design, cable/pipeline route surveys and environmental mapping.

During continuous operations, GOST can be slightly lifted from the seafloor during transit times and so allow for maximum use of valuable shiptime as there is no need for full recovery and subsequent redeployment at new sites.

The GOST itself weighs between 2 and 8 tonnes depending on the addition of weighted plates for extra stability. It has its own mobile winch with a mobile hydraulic power unit allowing for easy and quick deployment using a three point suspension. It has 8,000kg of hydraulic push power with infinitely variable hydraulic pressure of 0-200bar. The cone tip has a cross section of 5cm^2 and is composed of hardened stainless steel. Recording measurements such as tip resistance, sleeve friction, differential pore pressure, inclination and acceleration, it has a resolution of 0.06 MPa allowing for a range up to 120MPa. Additionally, it was be fitted with sensors for heat conductivity. Exact control on push velocity during penetration allows for data to comply to the highest international including DIN 4904 requirements. The interface is a digital one of industrial RS485 BUS using direct A/D converting of a measured variable with overvoltage and reverse protection.

4.3 Geo-Source 400 Sparker Seismic system

The Geo-Source 400 sparker seismic system of the Marine Institute was used during the survey. This sparker seismic system consists of the Geo-Spark 6 kJ pulsed power supply which emits a pulse to the sparker source which is towed behind the vessel. The source comprises four electrode modules that are evenly spaced in a planar array. The return signal is picked up in Geo-Sense single channel hydrophone array. The system provides high resolution (<30cm) seismic profiles of the Shallow subbottom strata. The device achieves this level of accuracy due to its multi-tip array of sparker nodes, which are evenly spaced and set in-phase producing a very strong downward projection of acoustic energy. The system which is designed to be towed on or just below the water-surface. High resolution seismic profiles of up to 300m depth can be imaged using the Geo-Spark 200 depending on the composition of the water column, sea conditions and the nature of the underlying geology

4.4 Sound Velocity probe

The AML SV Plus is a shallow water sound velocity profiler recording sound velocities and pressure through the water column.

5 TECHNICAL DIFFICULTIES AND DOWNTIME

Saturday 11th January 2014

03.45 - For CPT site **CV14001_001**, the rod broken and 27m of rod was left in the seabed. We think that was because the soft mud in the upper 16m did not support the rod allowing it to excessively flex when it hit bedrock and snap. Down time was incurred as we had to prepare a new rod and then rebuild the rod before deployment (4 hrs lost).

10.09 - At CPT site **CV14001_002A**, a stone was encountered at 3.3m. The hole was abandoned, the GOST removed from the seabed and the site shifted a few m away and retested.

10:37 - At CPT site **CV14001_002B**, the sensor produced anomalous readings at 75cm either in error or possibly another stone. The hole was abandoned, the GOST removed from seabed & checked for damage to cone by monitoring the cone whilst in the water column. Cone readings were erroneous in the water column so the cone was recovered. The cone had split and the outer sieve came away exposing the sensor fully to the water. The sensor was replaced with a more robust sensor.

*Damaged cone with outer sleeve completely removed after stone impact at **CV14001_002A**.*

Sunday 12th January 2014

02:38 - DP bow thruster tripped. RV Celtic Explorer deviates slightly from course on transit. Lost DP for 10 minutes but OK as in transit.

03:09- Just prior to redeployment of GOST. Technical issues arise. Rods have become parted during transit. When the DP failed, the prop had to be used which vibrated the GOST. When the rods were lost the GOST winch wiped the cable out which damaged the cone. The GOST is recovered for maintenance.

03.09 – Main winch sprung a hydraulic leak. Leak fixed and hydraulic fluid mopped up.

03.10 - 22.32: Poor sea state and weather condition at Force 8 inhibit operations.

Monday 13th January 2014

12.27: Transit between stations under DP with 15m of GOST in the water did not work. There was excessive vibration on the GOST which caused 2.5 turns on the rods. The transit was aborted before the rods unscrewed and were lost. Also the main winch under vibration hopped its sleeve (this was fixed relatively easily). The main tension winch was also experiencing spooling problems with the cable becoming wrapped on the drum. A new spooling arrangement was put into place. It is not clear why this transit under DP with the GOST in the water was not working this time when the previous night it worked very well. Recover was prudent as the transit was scheduled for 5 hrs in this mode. This will incur a few hours downtime as the rods have to be dismantled and rebuilt. The wire to the sensor is vulnerable also during this operation.

Tuesday 14th January 2014

02:23- Discovered that cone tip was not communicating and had to be replaced. This was because some water got into the data cable.

21.20 – GOST impacted with force on the seabed as it caught a large wave just as it reached h bottom. The seabed at Station 16 is firmer than elsewhere. As a result, the cone was damaged and electrically dead. On recovery it was discovered that the cone had been sheared off.

21.57 – Dynex hauling cable slipped out of the GOST sieve during hauling. It must have been running on the rim when hauling commenced. Tension was released from the cable by lower GOST to the seabed and the cable put back in the sieve. Total operation took 20 minutes credit to the bosun and deckhands.

Thursday 16th January 2014

09.50-13.30 – Sea-state marginal to poor for Sparker

Survey Narrative

Friday 10th January 2014

Calm, cloudy and occasional drizzle.
Wind speed 7 m s-1. Wind direction 270^{o}. Swell 0.5m

08.00 - Start mobilisation of GOST system to modified deck and modified A-frame. Progress good with a few setbacks overcome.

20.00 - Depart Dublin Port for the Northern Irish Sea Mudbelt. All heavy lifting complete, final checks to GOST system and construction of GOST personnel gantry completed on route.

Saturday 11th January 2014

Calm, Wind speed 10 m s-1 .Direction 230^{o}. Swell 0.5m.

00.03 - Arrive on station for first CPT deployment (**CV14001_001**) in the middle of the mudbelt. Dynamic positioning took 15 minutes to fine tune and stabilise ships position.

02.32 – 30 m of rod constructed on GOST and starting to push into seabed

03.35 – 30 m penetration achieved (**CV14001_001**).

03.45 – On recovery it was discovered that the rod broke, only 3m of rod recovered.

04.05 – GOST system recovered on deck. Transit to most NWerly CPT site.

05:30 - Arrive on station (Station 2, originally Station 6). Maintenance of GOST continues.

09:00 - Deployment of the GOST began in earnest. 10 rods used.

10:00 - GOST began collecting data at Station 2 (**CV14001_002A**).

10:09 - the push was halted due to the probable presence of a stone or cobble. It was decided to retrieve the rod to the seabed, move the GOST a few metres to the side and begin again in hopes of going deeper without causing possible damage to the probe. Hence Station 2 is divided into Station 2a and 2b.

10.23 - GOST began collecting data at Station 2 again (**CV14001_002B**).

10:37 – GOST aborted as hit a stone at 75cm at Station 2B

10:47 – Cone damaged so GOST returned to surface to replace the cone. Cone was tested in the water column which confirmed damage.

11.35 – GOST on deck and damaged cone inspected and replaced with a more robust cone but with decreased data quality.

15.40 – GOST began collecting data at Station 2 again (**CV14001_002C**).

15.45 – Started to push **CV14001_002C** into seabed at 15MPa per second

15.54 – Aborted **CV14001_002C** at 3.3m (Unit E) due to high resistance as in **CV14001_002B**.

16.15 - Transit 1.5 nm to Station 3 at 1.9 kts

17:14 – GOST on the bottom of Station 3 (**CV14001_003**). Started to push cone into seabed. Limit was set at 20mPa and exceeded this limit at 3.75m so the limit was increased to 30mPa. There is a break in the data where the limit was reset so will show as files 3_1 and 3_2. When the 30mPa limit was applied and penetration started it peaked again at 3.75m.

17.45 – GOST aborted at 3.75m at 30 MPa due to concern on the GOST system's limit. GOST was then taken up and with the top few metres of rod decoupled and the system held just in the water tight to the stern. This arrangement enabled us to transit at 3 kts in the dark in an area of potential crab pots.

18.00 – Transit to station 4 at 3 kts commenced.

20.55 - Arrive at Station 4 and start lower GOST to seabed.

21:22 – GOST on the bottom of Station 4 (**CV14001_004**). Started to push cone into seabed. A depth of 3.38 m was reached before the push was aborted when 30 mPa was reached and the GOST recovered and secured to the back of the ship for transit.

22.16 – Began transit to next station (Station 5) at 3 kts.

23.12 - Arrive at Station 5 and start lower GOST to seabed.

23:38 – GOST on the bottom of Station 5 (**CV14001_005a**). Started to push cone into seabed. During recording data was split into 2 files. A stone was encountered at 10 m reaching a peak of 10 mPa. The push was discontinued at 00:12 (Sunday 14th); the GOST

raised from the seabed and moved 2/3 m (station 5b) in order to try again.

Sunday 12th January 2014

Calm, Wind speed 19 m s-1, wind direction 141^{o}. Swell 1.0m deteriorating to Wind Speed = 28.0 m s-1 but gusting 38 m s-1, wind direction = 160°, swell height 2.7m. Gale force 8.

00:45 – Second push started at Station 5 (**CV14001_005B**). A peak of 30mPa in the data was encountered at 2.6 m, subsequently the data was divided into 2 parts (A and B). 8 m saw an increase of up to 2 mPa which gradually increased further. At 01:08 the limiter peak of 30 mPa was encountered and so the push stopped. The GOST was recovered. As it was discerned that trawling had recently taken place in the area and hence there was little likelihood of encountering static gear, the GOST held 6 m above the seafloor and moved to the next station (Station 6) at a speed of 1 knot initially. At this stage the sea-state began to noticeably pick up.

01:39 - Began transit to next station (Station 6_aborted).

02:38 - DP bow thruster tripped. RV Celtic Explorer deviates slightly from course on transit.

03:06- On site at Station 6_aborted.

03:09- Just prior to redeployment of GOST. Technical issues arise. Rods have become parted during transit. A cone and some rods are lost. The GOST is recovered for maintenance. Poor and deteriorating weather inhibits redeployment: bow thrusters would not be able to hold position, excessive pitch on the aft deck makes deployment and recovery dangerous, GOST heave compensator would be under severe strain.

11.00 - Weather update:
Bad weather throughout Sunday morning so can not deploy CPT. Wind Speed = 28.0 m s-1 but gusting 38 m s-1, wind direction = 160°, swell height 2.7m. Gale force 8. Weather should improve after 20.00.

18.00 – Weather update:

20:00- After consultation with the bridge and Bosun it was decided to wait until 21:00 to try and deploy the GOST.

21:00- Sea state greatly improved. Decision was taken to deploy GOST

21:02 - On station (new Station 6)

21:18- GOST deployed off the stern. Some initial issues with the gangway were solved by some gentle persuasion from Jimmy and his hammer. Rod string being constructed.

21.30 - Weather update:
Wind Speed = 11.0 m s-1, wind direction = 231°, swell height 1.5m.

22.32 - GOST on the bottom of Station 6 (**CV14001_006**). Started to push cone into seabed. Penetration down to 23.5m into till eventually.

Monday 13th January 2014

Sea progressively calming in the early morning. Wind speed 13 m s-1. Wind direction 209. Swell 1.5 m.

00.44 - Began transit to next station (Station 7) at 1kt initially to see how the GOST system performs in the water. Speed increased to 1.2 kts.

02.01 - On station (new Station 7)

02.06 - GOST on the bottom of Station 7 (**CV14001_007**).

03.30 – Left station 7 (**CV14001_007**). Now on route to next station (**CV14001_008**).

04:17- On station (Station 8)

04:24- GOST on Seabed (**CV14001_0078**)

04:36- Started pushing (**CV14001_008**)

05:18- Stopped pushing at a depth of 19 m. No till was encountered with cone resistance values staying relatively low (<2 mPa). Recovery of the GOST began.

06:06- GOST lifted off the seabed and transit to next station began (Station 9)

06:58- Arrived at Station 9 and GOST was deployed.

07:07- GOST on the seabed at Station 9 (**CV14001_009**)

07:15- Push started

07:57- Pushed stopped having reached a depth of 19 m (**CV14001_009**)

08:04 - GOST lifted off the seabed and move to Station 10 started.

10.17 – GOST deployed at station 10 (**CV14001_0010**). Penetrated to 20m and hit bedrock.

2121.07 – GOST lifted off the seabed and move to Station 11 started on DP at 1.5-2 kts.

12.27 – Vibration on the GOST was too high even at 1.5 kts and unsustainable. GOST recovered on deck.

15.00 - Left station 11 on route to next station 12 at 7 knots.

15.50 - Arrived at Station 11. GOST rods to be built to 30m.

17.01 - GOST deployed at station 11 (**CV001_0011)**.Penetrated to 26.5m and hit probable bedrock.

17.10 – GOST lifted off the seabed and move to Station 12 started on DP at 1.4 kts.

20.09 - GOST deployed at station 12 (**CV001_0012)**.

21.14 – Push stopped. Penetration to 26m.

22:13-GOST lifted off the seabed and move to Station 13 started on DP at 1.5-2 kts.

Tuesday 14th January 2014

Calm. Wind speed 17 m s-1 peaking at 30 m s-1 by afternoon. Wind direction 283. Swell 1- 1.5 m rising to 2m by afternoon

00:20- Arrived on site (Station 13)

00:32- GOST on seabed and pushing begins (**CV001_0013).**

01:43- Pushing stopped having reached a depth of approximately 30 m (**CV001_0013)** (this is the world record for the GOST system). Retrieval of the GOST begins.

02:23- As the GOST is retrieves it is discovered that the cone tip has been lost electronically. Therefore, the GOST must return to deck to have a new cone fitted.

04:25- GOST back on deck to have cone replaced and electronics tested. Some water is believed to have gotten into the data cable so will be cleaned. No big deal. Transit to next site (Station 14) begins.

04:55- On site at Station 14. GOST continues to be serviced on the deck.

05:25- Some bended rods. Data cable was replaced on deck.

08:15- GOST redeployed at Station 14 having been mended.

09:27- GOST on sea bed and started pushing with a limit of 15mPa (**CV001_0014).** At 26m there is more sand so the CPT was increased to 20mPa.

10:34 – GOST stopped at 26.7m as passed the 20mPa limit. GOST recovered from seabed, rods dismantled on way up.

13.51 – GOST on deck and sensor changed. Transit to Station 15 at 7 kts.

15.00 – On station 15 (**CV001_0015)**

15.51 – GOST deployed over the stern, rods being built up to 20 m.

16.59 – GOST is on the seabed (**CV001_0015)** and started pushing. Penetration to 18.32m where we hit a stone or bedrock.

17.58 – GOST system retrieved from seabed and brought up above the water line aft of the vessel to allow transit Station 16 which is a second attempt at Station 3.

19.41 – Start transit to Station 16 (**CV001_0016)** with the GOST tight against the stern of the vessel at 9.2 kts.

21.20 – GOST lowered to the seabed to start (**CV001_0016).**

21.43 – Due to an unfortunate wave we hit the seabed with some force and damaged the cone. CV001_0016 aborted.

21:57- During hauling the cable hopped out of GOST sleeve. Therefore, GOST is returned to the seabed to rectify.

22.15 – Sieve fixed and GOST recovery continued.

23:14 – GOST recovered on deck and fixed. Transit to Station 17 (Lambay) 30 nm away at 9 kts.

Wednesday 15th January 2014

Calm. Wind speed 13 m s-1. Wind direction 207. Swell 1- 1.5 m

02:12- On site (Station 17).

02:22- GOST deployed.

03.31 – GOST on the seabed and started pushing (**CV001_0017).** Penetrated to 20m.

04.22 – GOST system recovery started.

06:26- GOST back on deck and transit back to Dublin begins at 5 kts.

09.30 – tie up in Dublin Port and commence demobilisation of the GOST system.

Thursday 16th January 2014

Moderate. Wind speed 21 m s^{-1}. Wind direction 177. Swell 1.5 – 2.0 m. Dropping during the day

07:58 – Leave Dublin Port and transit to Station 18 at 9 kts.

07.15 – Marine Mammal Observations commences prior to soft-start of the sparker seismic system.

08:27- SVP was deployed in the water but not fully due to strong tides. As a result, it was retrieved, the ship went off DP and allowed to drift to find an easier position.

08:34- SVP was redeployed, this time with an added weight on the line. Currents at 3 kts so vessel but on drift with DP hold drift back to allow SVP to go down as vertical as possible.

08:44- SVP taken (**CE001_0018**) and back on board. Ship moved 2 miles to allow for configuration of Sparker system prior to starting first line.

09.50. - Marine Mammal Observations cease and sparker soft start commences.

09.50-13.30 – Sparker data very poor due to weather hampering configuration. Eventually decent data quality achieved on falling sea, after several configurations of sparker and streamer and different setting reasonable geology is seen. Weather conditions still marginal. Head for SOL.

Weather update: *Wind speed 14 m s^{-1}. Direction 198. Swell 2.5m.*

13.59 – SOL **CE001_0019** at 2kts.

15:20- EOL **CE001_0019**

15:31 – Sparker equipment retrieved onboard. Started steaming for next line (Station 19) at 7 knts.

16.15 – Marine Mammal Observations commences prior to soft-start of the sparker seismic system.

17.00 – Sparker deployed and soft start protocol commenced. Continue transit at 6 kts.

17.30 – Soft start complete. Marine Mammal Observations complete.

19.47 – SOL **CE001_0020** at 4 kts.

20.16 - EOL **CE001_0020.** Transit to next line at 6 kts.

20.36 - SOL **CE001_0021** at 4 kts.

21.14 - EOL **CE001_0021.** Transit to next line at 6 kts

21.27 - SOL **CE001_0022** at 4 kts.

21.14 - EOL **CE001_0022.** Transit to next line at 6 kts.

22.44 - SOL **CE001_0023** at 4 kts.

23.15 - EOL **CE001_0023.** Transit to next line at 6 kts.

22.44 - SOL **CE001_0024** at 4 kts.

Friday 17th January 2014

Weather Update (00.30): Moderate. Wind speed F2. Wind direction NNW. Swell ~1m; Slight sea.

00:54- SOL **CE001_0025** at 5.2 kts

01:30- EOL **CE001_0025**. Transit to next line at 5 kts.

02:04- SOL **CE001_0026** at 5.6 kts.

03:37- EOL **CE001_0026**. Transit to next line was slowed by a ferry crossing nearby.

04:12- SOL **CE001_0027**.

05:09- EOL **CE001_0027**. Transit to next line at 4.8 kts.

05:36- SOL **CE001_0028** at 4.9 kts.

06:18- EOL **CE001_0028.** Transit to next line at 4.3 kts.

06.31- SOL **CE001_0029** at 4.9 kts.

06:57- EOL **CE001_0029.**

07.04 – Sparker system recovered. Transit to Howth.

09.00 – Scientific party disembark at Howth via tender Tom Creen.

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6 WEATHER REPORT

Date	Time	Wind Direction	Beaufort	Visibility	Sea state	Air Pressure (hPa)	Comments
10/01/14	22.45	W-NW	F5	Good	-	-	-
11/01/14	02.00	W-SW	F4	Good	Calm	1011.7	-
11/01/14	04.00	W	F4	Good	Calm	1012.8	-
11/01/14	05.45	W	F5	Good	Moderate	-	-
11/01/14	08.00	W-NW	F3	Good	Moderate	1016.0	-
11/01/14	14.00	W	F1	Good	Calm	1019.5	-
11/01/14	16.00	W	F2	Good	Calm	1020.1	-
11/01/14	19.00	SW	F2	Good	Moderate	-	-
11/01/14	20.00	SW	F2	Good	Moderate	1020.0	-
11/01/14	22.21	S-SE	F5	Good	-	-	-
12/01/14	01.39	SE	F6/7	Good	Moderate	-	At 02.38 the DP bow thruster tripped due to adverse sea state and winds
12/01/14	04.00	S-SE	F7	Good	Rough	1014.1	Unable to deploy due to adverse weather
12/01/14	04.25	S-SE	F7	-	Rough	-	Unable to deploy due to adverse weather
12/01/14	05.55	SE	F7/8	-	Rough	-	Unable to deploy due to adverse weather
12/01/14	08.00	SE	F8	Good	Rough	1010.0	Unable to deploy due to adverse weather
12/01/14	10.38	SE	F8	Good	Rough	-	Unable to deploy due to adverse weather
12/01/14	12.00	SE	F8	-	Rough	-	Unable to deploy due to adverse weather
12/01/14	14.00	SE	F8	Good	Rough	1001.4	Unable to deploy due to adverse weather
12/01/14	16.00	SE	F7/8	Good	Rough	998.8	Unable to deploy due to adverse weather

Date	Time	Wind Direction	Beaufort	Visibility	Sea state	Air Pressure (hPa)	Comments
12/01/14	17.30	SE	F7/8	Moderate	Rough	-	Unable to deploy due to adverse weather
12/01/14	19.58	W	F4/5	Moderate	Moderate	995.0	Unable to deploy due to adverse weather. Redeployed at 21.00.
13/01/14	02.01	SW	F5	Good	Moderate	1000.8	-
13/01/14	04.00	SW	F5	Good	Moderate	1000.1	-
13/01/14	08.00	S	F4	Good	Moderate	998.0	-
13/01/14	12.07	S	F4	-	-	-	-
13/01/14	14.00	SW	F3	Good	Calm	995.7	-
13/01/14	16.00	W	F3	Good	Calm	996.2	-
13/01/14	18.00	W	F3	Good	moderate	-	-
13/01/14	20.08	W-NW	F3	Good	Moderate	-	-
14/01/14	02.00	NW	F3	Good	Calm	1000.5	-
14/01/14	04.00	W-NW	F4	Good	Calm	1001.3	-
14/01/14	07.00	W	F2	Good	Moderate	-	-
14/01/14	08.00	W	F2	Good	Moderate	1002.0	-
14/01/14	11.58	S	F4	-	-	-	-
14/01/14	14.00	S	F5	Moderate	Moderate	998.5	
14/01/14	1600	SSW	F6	Moderate	Night Sea	996.1	
14/01/14	1800	SSW	F5	-	Moderate	-	
14/01/14	2000	SSW	F3	Clear		995	
14/01/14	2359	S	F5	-	-	-	-
15/01/14	0200	S	F6	Moderate	Slight Sea	992.6	
15/01/14	0400	S	F6	Good	Slight Sea	991.2	
15/01/14	0800	S	F4/5	-	Moderate	988	
15/01/14	22.02	S	F4	-	-	-	
15/01/14	23.58	SSW	F4	-	-	-	
16/01/14	0200	S	F5	Good	Slight Sea	985	
16/01/14	0400	SSW	F5	Good	Slight Sea	984.3	
16/01/14	0600	S	F4/5	Clear	Moderate Sea	-	

Date	Time	Wind Direction	Beaufort	Visibility	Sea state	Air Pressure (hPa)	Comments
16/01/14	1045	SSE	F5	-	-	-	Sea state adversely affected sparker data
16/01/14	1217	S	F5	-	-	-	Sea state adversely affected sparker data
16/01/14	13.59	S	F4	Good	Slight Sea	-	Sea state adversely affected sparker data
16/01/14	15.00	S	F4	Good	Slight Sea	979.2	Sea state adversely affected sparker data
16/01/14	16.00	S	F4	Good	Slight Sea	979	
16/01/14	18.00				Low swell	979	
16/01/14	21.30	ESE	F4				

Appendices

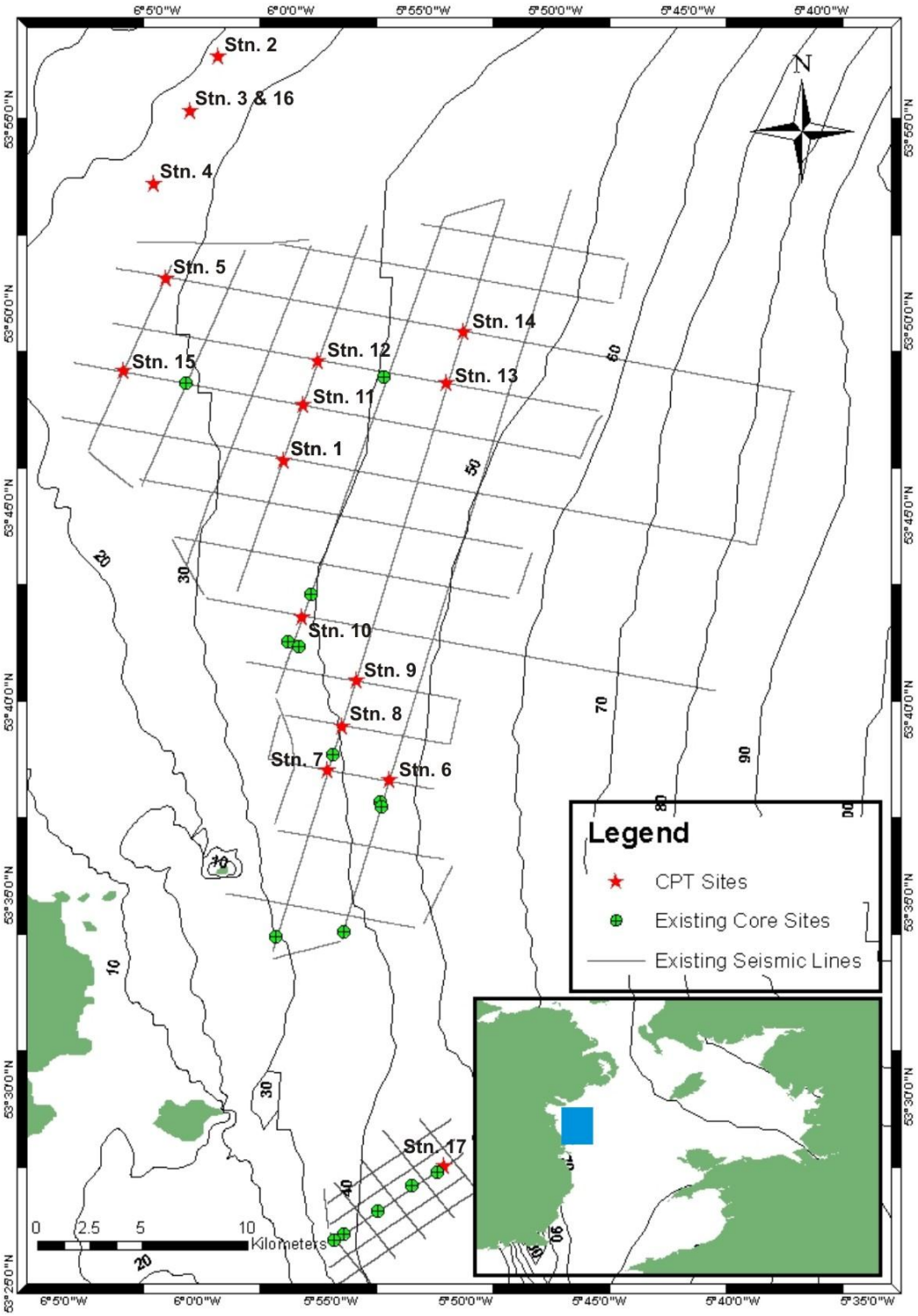
I. PERSONNEL

Ship' crew	Scientific Party
Denis Rowen *Master*	Prof. Andy Wheeler *Chief Scientist (UCC)*
Mark Ivory *Chief Engineer*	Prof. Dr. Tobias Mörz *Scientist/GOST team leader (MARUM)*
Basil Murphy *1st Mate*	Mark Coughlan *Geologist – Night watch leader (UCC)*
John O'Regan *2nd Mate*	Marian McGrath *Geologist - Day watch leader (UCC)*
Ted Sweeney *2nd Engineer*	Aaron Lim *Geologist (UCC)*
Paul Wray (10th -15th Jan) Dave Stuart (15th – 17th Jan) *ETO*	Wolfgang Schunn *Technician/GOST operator (MARUM*)
Frank Kenny *Bosun*	Christian Bathmann *Scientist/GOST operator (MARUM)*
Shane Horan *Bosun's Mate*	Johannes Brock *Scientist/GOST operator (MARUM)*
Michelin Faherty *AB Deckhand*	André Kahl *Scientist/GOST operator (MARUM)*
Martin Goggin *AB Deckhand*	Daniel Otto *Scientist/GOST operator (MARUM)*
Tom Gilmartin *AB Deckhand*	Antoinette McCarthy (10th -15th Jan) *Student (UCC)*
Jimmy Burke *AB Deckhand*	Brennus Voarino (10th -15th Jan) *Student (UCC)*
Philip Gordon *Technician*	
Jimmy Moran *Cook*	
Mark Masson *Assistant Cook*	
Daniel Rose *Engineer Cadet*	

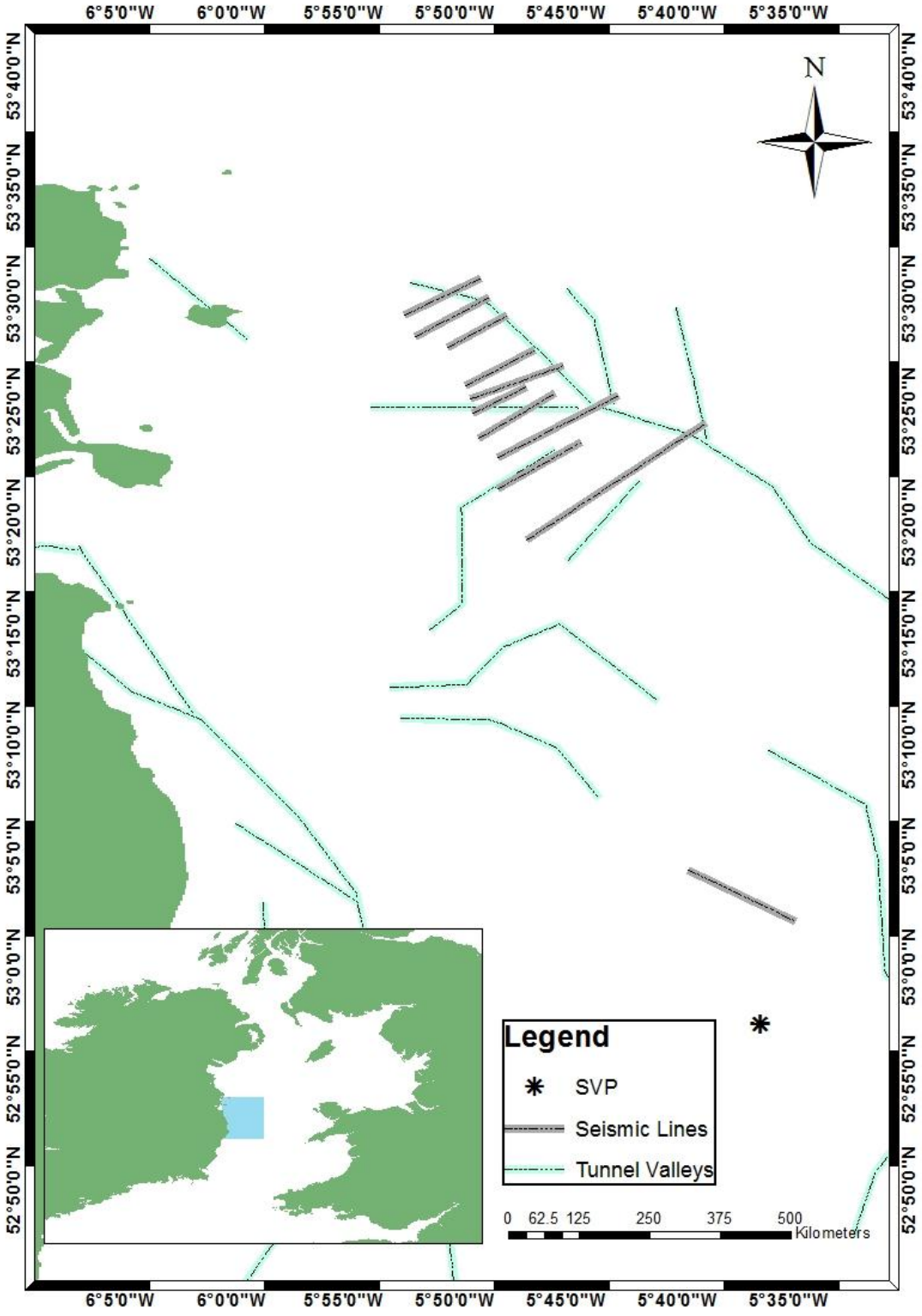
CE14001 shipbased party

II. AREA MAPS: COVERAGES AND SAMPLE LOCATIONS

NW Irish Sea station map



Central Sea station map



III. CPT STATIONS

Survey	Station No.	Area	Date	Time UTC	Latitude (Deg)	Latitude (Dec Min)	Longitude (Deg)	Longitude (Dec Min)	Water Depth (m)	Depth of GOST penetration (m)
CE14_001	1	Mudbelt			53	46.2545	5	59.0872	31.6	30
CE14_001	2a	Mudbelt			53	56.6689	6	2.658	22.1	3.3
CE14_001	2b	Mudbelt			53	56.669	6	2.659	21.3	0.75
CE14_001	2c	Mudbelt			53	56.682	6	2.652	20	3.3
CE14_001	3	Mudbelt			53	55.261	6	3.551	21.4	3.75
CE14_001	4	Mudbelt			53	53.375	6	47.091	29.1	3.65
CE14_001	5a	Mudbelt			53	50.937	6	4.015	28.6	10
CE14_001	5b	Mudbelt			53	50.9346	6	4.01	27.1	8.7
CE14_001	6	Mudbelt			53	37.994	5	54.266	48.8	21.2
CE14_001	7	Mudbelt			53	38.284	5	56.577	36.8	16
CE14_001	8	Mudbelt			53	39.418	5	56.158	37.7	19
CE14_001	9	Mudbelt			53	40.573	5	55.768	43.4	19
CE14_001	10	Mudbelt			53	42.248	5	57.914	37.5	20
CE14_001	11	Mudbelt			53	47.706	5	58.502	32.7	26.5
CE14_001	12	Mudbelt			53	48.819	5	58.045	35.3	26
CE14_001	13	Mudbelt			53	48.309	5	58.231	43.9	30
CE14_001	14	Mudbelt			53	49.58	5	52.701	44.1	26.7
CE14_001	15	Mudbelt			53	48.491	6	5.373	24.3	18.32
CE14_001	16	Mudbelt			53	55.25	6	3.54	23.1	0 (Aborted)
CE14_001	17	Lambay			53	28.0659	5	51.115	37.9	20

IV. SPARKER SEISMIC LINES & SVP

Survey	Station No.	Line No.	Area	Date	Time UTC	Latitude (Deg)	Latitude (Dec Min)	Longitude (Deg)	Longitude (Dec Min)	Water Depth (m)	Comment
CE14_001	18		W. St. George's Channel	16.1.14	08.34	52	57.396	5	36.271	72	SVP
CE14_001	19	1	W. St. George's Channel	16.1.14	13.59	53	2.048	5	34.726	95.5	SOL
CE14_001	19	1	W. St. George's Channel	16.1.14	15.20	53	4.330	5	39.551	-	EOL. Two files
CE14_001	20	2	Lambay	16.1.14	19.47	53	27.844	5	50.353	49.2	SOL
CE14_001	20	2	Lambay	16.1.14	20.16	53	29.256	5	47.650	75.7	EOL
CE14_001	21	3	Lambay	16.1.14	20.36	53	30.070	5	48.486	73.1	SOL
CE14_001	21	3	Lambay	16.1.14	21.14	53	28.303	5	51.808	37.4	EOL
CE14_001	22	4	Lambay	16.1.14	21.27	53	29.259	5	52.290	42.6	SOL
CE14_001	22	4	Lambay	16.1.14	22.01	53	30.956	5	48.847	64.6	EOL
CE14_001	23	5	Lambay	16.1.14	22.44	53	27.719	5	46.438	71.0	SOL
CE14_001	23	5	Lambay	16.1.14	23.15	53	26.087	5	49.520	42.9	EOL
CE14_001	24	6	Lambay	16.1.14	23.46	53	23.721	5	48.967	44.8	SOL
CE14_001	24	6	Lambay	16.1.14	00:26	53	25.7957	5	45.5019	66.2	EOL
CE14_001	25	7	Lambay	17.1.14	00:54	53	23.588	5	44.3280	62.4	SOL
CE14_001	25	7	Lambay	17.1.14	01:30	53	21.4918	5	48.086	43.6	EOL
CE14_001	26	8	Lambay	17.1.14	02:04	53	19.1780	5	46.8267	30.9	SOL
CE14_001	26	8	Lambay	17.1.14	03:37	53	24.4436	5	38.7441	53.4	EOL

Survey	Station No.	Line No.	Area	Date	Time UTC	Latitude (Deg)	Latitude (Dec Min)	Longitude (Deg)	Longitude (Dec Min)	Water Depth (m)	Comment
CE14_001	27	9	Lambay	17.1.14	04.12	53	25.6940	5	42.6492	57.3	SOL
CE14_001	27	9	Lambay	17.1.14	05.09	53	22.8755	5	48.0861	44.7	EOL
CE14_001	28	10	Lambay	17.1.14	05.36	53	24.851	5	49.2460	41.6	EOL
CE14_001	28	10	Lambay	17.1.14	06:18	53	27.045	5	45.1628	65.2	EOL
CE14_001	29	11	Lambay	17.1.14	06.31	53	26.0443	5	46.7910	67.8	EOL
CE14_001	29	11	Lambay	17.1.14	06.57	53	25.5464	5	49.3307	41.3	EOL

V. MARINE MAMMAL OBSERVER REPORT

MARINE MAMMAL OBSERVER REPORT

R.V. Celtic Explorer

CE14001

Developing Geo-Stratigraphies

Part 2

North West Irish Sea

10th - 17th January 2014

MMO: Marian McGrath

Introduction

Ireland's Exclusive Economic Zone (EEZ) has one of the most important marine mammal habitats in Europe. All marine mammal species in Irish waters are protected by the 1976 wildlife act (and wildlife amendment act 2000). The National parks and Wildlife Service (NPWS) has set aside Special Areas of Conservation (SACs) and Special Protected Areas (SPAs) under this wildlife act to ensure no operations can take place in areas where an abundance of marine mammals are present. Such operations include seismic surveys, multi-beam and side-scan sonar which have been set aside in a code of practice published by the NPWS (Anon. 2007).

Marine Mammal Observers (MMO) are required by law to be aboard any vessel which is carrying out seismic surveys within Irish waters. It has been recognised that the sound generated by seismic sources has the potential to cause both disturbance and injury to marine mammals (JNCC, 2010).

The aim of the cruise CE14001 was to carry out geotechnical Cone Penetration Testing and to collect 3D Sparker seismic data from the North West Irish Sea. The objective of the cruise was to identify the depth of bedrock and the thickness of over lying sediment layers in order to better understand desirable sites for offshore renewable energy infrastructure.

Date & Location of Survey

10TH TO 17TH JANUARY 2014

North West Irish Sea

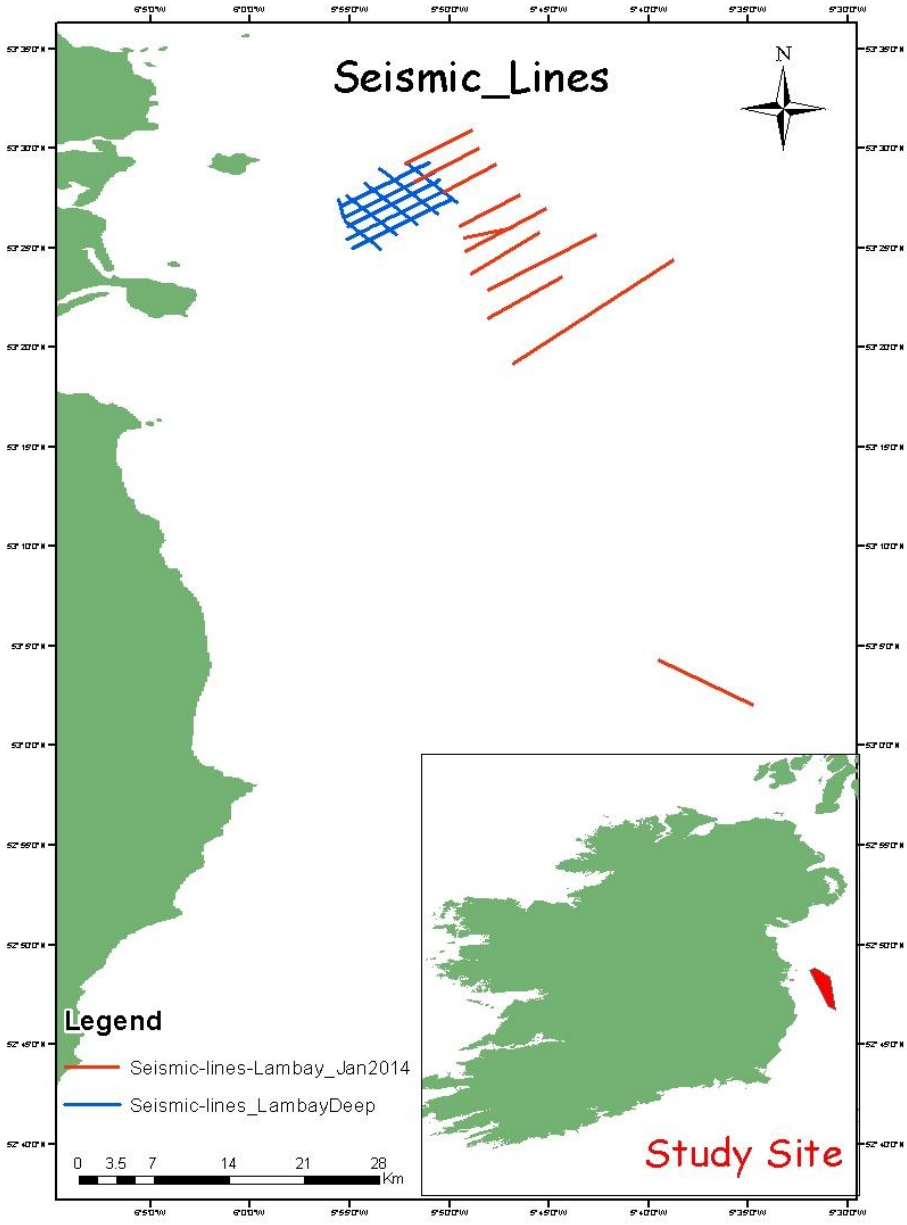
Survey Vessel

R.V Celtic Explorer

Marine Mammal Observers/Qualifications

- Qualified MMO: Marian McGrath
- Casual Observations: Bridge and deck crew

Survey Areas



Seismic Lines collected on CE14001 survey are shown in red.

ACOUSTIC SURVEY EQUIPMENT

During the cruise the following equipment were used:

- Sparker System operating between 120 Hz to 2 kHz

MARINE MAMMAL OBSERVATIONS

Marine mammal observations were carried out from the bridge and on the bow of the ship. These areas gave the best view point of both sides and in front of the vessel. Prior to commencement of the acoustic survey a 30 minute observation was done either on the bow of the ship or on the bridge depending on the weather. Weather conditions were favourable during MMO watches apart from a shower which made visibility poor for 10mins.

Observations were undertaken using a reticular binoculars and also by the naked eye. Distance to marine mammals is determined using this reticular binoculars and height above sea level. To determine the range one of the divisions present in the binoculars is placed on the horizon. A formula is then used to determine the distance of the mammal from the ship. The formula is:

Distance (m) = (height of eye above sea level (m) x 1000/ no. of mils down from horizon)

No marine mammals were spotted during this survey.

Pre-Shoot Searches

As detailed in the NPWS code of Practice, a 30 minute watch was carried out prior to shooting the Sparker for mammals within 1000m range of the equipment. If marine mammals were spotted within this area, Sparker would have to be halted for a certain period of time or the vessel would have to move to a different area of the survey. If no marine mammals were seen within the 30 minute watch then a soft start would commence. A Sparker soft start was carried out each time the acoustic equipment was switched on.

A normal soft start comprises of a ramp up of source power of acoustic emission over at least

30 minutes until full power is reached. The Sparker was stopped during transit between study areas so soft starts were carried out each time it was re-started. The Sparker was always started during daylight hours to allow for MMO watches to be carried out prior to soft starts. The MMO watch was continued till the Sparker reached full power. Watches do not need to be carried out once the Sparker is

already operating on full power. Throughout the duration of this survey no marine mammals were seen during the 30 minute watches prior to the soft starts.

References

Anon. 2007. Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters. National Parks and Wildlife Service.

JNCC. 2010. Joint Nature Conservation Committee guidelines for minimising the risk of disturbance and injury to marine mammals from seismic surveys

RECORD OF OPERATIONS FORMS

MARINE MAMMAL RECORDING FORM - RECORD OF OPERATIONS

Ship: RV Celtic Explorer **Client:** UCC **Seismic Contractor:** UCC **PAD No:** N/A

Complete this form every time the airguns are used, including overnight, whether for shooting a line or for testing or for any other purpose.
(Times should be in GMT)

Once the Sparker was started it was kept running during transit between short lines. It was turned off during longer transits and an MMO watch was carried out before each re-start

Date	Seismic activity						Pre-shooting search					Action necessary		
	Time when soft start began	Time when airguns reached full power	Time of start of line	Time of end of line	Time output reduced to 150 dB (if relevant)	Time when airguns stopped	Who carried out a search for marine mammals? (Job title)	Time when pre-shooting search for marine mammals began	Time when search for marine mammals ended	Was there any reason why marine mammals may not have been seen? (e.g. dark, fog, swell, etc.)	Were hydro-phones used?	Were marine mammals present before the airguns began firing?	If yes, give time when marine mammals were last seen	If marine mammals were present, what action was taken? (e.g. delay shooting)
16/01/2014	09:50	Stopped due to technical problem				10:05	MMO	08:15	10:40	No	No	No		
16/01/2014	10:10	10:40	13.59	15.20			MMO	08:15	10:40	No	No	No		
16/01/2014	17:00	17:30	19.47	06.57 17/01/14		07:00 17/01/14	MMO	16:15	17:30	No	No	No		