National Research Vessels

Ship-Time Programme

De-risking Offshore Wind Energy Development Potential in Irish Waters (DOWindy)

Leg 2

Survey Code:	Survey Name:	Chief Scientist/ Institution
CV19026	DOWindy	Jared Peters University College Cork

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1 Executive Summary

The De-risking Offshore Wind Energy Development Potential in Irish Waters, or "DOWindy" research cruise (leg 2), was carried out to add to the data collected during the first leg of the same cruise (CV19023). The research goals for these two cruises were identical; thus, the data collected and the cruise reports describing the two expeditions, are also quite similar.

Research was conducted aboard the *RV Celtic Voyager* offshore of Ireland from October 16 – 20, 2019 by scientists from University College Cork (UCC) and the Centre for Marine and Renewable Energy (MaREI); however, poor weather delayed the start of the cruise by ~2.5 days. The data collected was primarily geological and was acquired from the submerged Irish continental shelf for use in improved offshore wind farm development and site selection models. Data were collected in the Atlantic Ocean and the Celtic Sea.

This research cruise is motivated by interest from offshore wind energy developers and the ever-increasing evidence of climate change's detrimental impacts, which may be curbed by decreasing carbon emissions. Armed with this information, global and European leaders have set goals for limiting the use of carbon emissions from fossil fuels. Renewable energy sources, like offshore wind, will play a critical role in achieving these fossil fuel reductions. Ireland has made commitments to these clean energy goals but is thus far failing to meet them. By improving the offshore data relevant to wind farm development, we hope to help achieve these goals.

The data collected during the DOWindy (leg 2) cruise consists of: multibeam echosounder measurements of the seabed bathymetry; sediment grabs of seabed surface geology; a sediment core that reveals deeper stratigraphy; and seismic sub-bottom profiles that reveal information on the entire sediment package overlying the bedrock. A total of 63 nm (117 km) of seismic sub-bottom data were collected. These dub-bottom transects will enable assessments of large areas of stratigraphy and overall sediment depth to the underlying bedrock. These stratigraphic data will be added to the data collected during the first DOWindy leg, and together they will be used to model seabed conditions for offshore wind farm developments. All told, the two research cruises produced one sediment core, 21 sediment grabs, and ~496 nm (~919 km) of seismic sub-bottom data.

These data are widely applicable to several national research programmes. They will primarily be used by the EirWind (UCC, MaREI) research consortium to improve assessments of offshore wind development scenarios. The iCRAG-funded AggrePOP programme, which intends to map and quantify potential offshore construction aggregate sources south of Ireland, may also benefit from these data. Additionally, the information provided by the DOWindy cruise could be used to improve insights to palaeoglaciological reconstructions of the last British-Irish Ice Sheet and associated postglacial benthic adaptations. Thus, the academic research possible with data collected by the DOWindy research cruise may benefit the economies of Ireland and western Europe.

2 Cruise Details

2.1 *Award summary*

Title of research survey (survey code):	DOWindy Leg 2 (CV19026)
Co-ordinator/chief scientist:	Andrew Wheeler/Jared Peters
Vessel used for ship time:	Celtic Voyager
Total days at sea:	5
Total of grant-aided ship-time days awarded:	5
Survey dates:	16/10/2019 – 20/10/2019
Mobilisation/Demobilisation ports:	Galway/Dublin
Survey personnel:	6 scientists; 1 technician
Final Report completed by:	Jared Peters (2019)

2.2 *Science crew summary*

Table 1: Science crew summary.

	Name	Institute	Position	Number of days
Chief Scientist	Jared Peters	University College Cork/MaREI (UCC)	Postdoctoral Researcher	13
Scientist	Luke O'Reilly	UCC	PhD Researcher	13
Scientist	Evan O'Mahony	UCC/iCRAG	MSc Researcher	13
Scientist	Jochelle Laguipo	MaREI	Research Assistant	13
Scientist	Odhran McCarthy	UCC	PhD Researcher	13
MMO	Jessica Giannoumis	UCC/MaREI	PhD Researcher	13

2.3 *Science crew shift description*

Operations were conducted 24-hours a day using 12-hour shifts. Shift changes took place at 20:00 and 08:00 to maximise day-shift operations during sunlight hours since sediment sampling activities were deemed unsafe at night.

3 Introduction

3.1 Rationale

Anthropogenic climate change is a dangerous and expensive phenomenon and some predictions for its progression are dire (IPCC, 2014). New and ongoing research agrees with the long-running scientific consensus that carbon emissions need to be drastically curbed to preserve human safety and wellbeing (Pachauri et al., 2014). Thus informed, the European Union has set out ambitious renewable energy goals (EU Renewable Energy Directive (2009/28/EU)) that aim to minimise climate change impacts. These goals promote the continuing global trend of increasing renewable energy production (International Energy Agency, 2019).

Unfortunately, Ireland is not yet among the nations to join this trend. Instead of reducing carbon emissions by its goal of 1 million tonnes/yr, Ireland's emissions are currently increasing by 2.1 million tonnes/yr (Climate Change Advisory Council, 2018). Furthermore, unless serious steps toward mitigation are enacted, Ireland will "…miss its 2030 EU Effort Sharing Regulation cumulative emissions reduction target by 92 million tonnes…" (ibid). The need for additional mitigation efforts is critical. Wind power generation is one such effort and offshore wind farms are a good option because they can be built bigger, they can operate more efficiently, and they remove many issues with lack of space. Because the benefits of offshore wind energy are scientifically and economically apparent, the DOWindy cruise is endeavouring to provide new data for offshore wind development in the Irish EEZ. The Eirwind project (EirWind, 2019) will use these data by working with industry partners to help facilitate the development of Ireland's offshore wind energy resources through rigorous academic research.

3.2 Study area

The DOWindy research cruise focused on the Irish continental shelf offshore of western, southern, and eastern Ireland (Figure 1). Significant bathymetric and geological data gaps exist in these areas, which inhibit resource management and hampers analyses of environmental and climatic change.

Moreover, the Irish continental shelf is geologically complicated. It has been glaciated multiple times through the Quaternary (the past 2.6 million years) in response to climate oscillations, leaving the present seabed a palimpsest signature of the last glaciation and postglacial tidal and current reworking. Several studies provide evidence for extensive grounded BIIS ice on what is now the submerged continental shelf (e.g. Ó Cofaigh et al., 2012; Peters et al., 2015; Figure 2). Following deglaciation of the Irish shelf, lower relative sea levels (Brooks et al., 2008) allowed fluvial erosional and depositional processes to modify the now-submerged landscape. The ancient fluvial and glacial deposits are often reworked and/or overlain by marine sediment recording sea-level transgression (a relative rise in sea level) (Peters et al., 2015). The upward-fining, shell-rich signature of transgression is often overlain by bioturbated sand deposits that occasionally grade upwards to muddy sand or sandy mud, marking the transition to modern neritic sedimentation (cf. Chang et al., 2006).

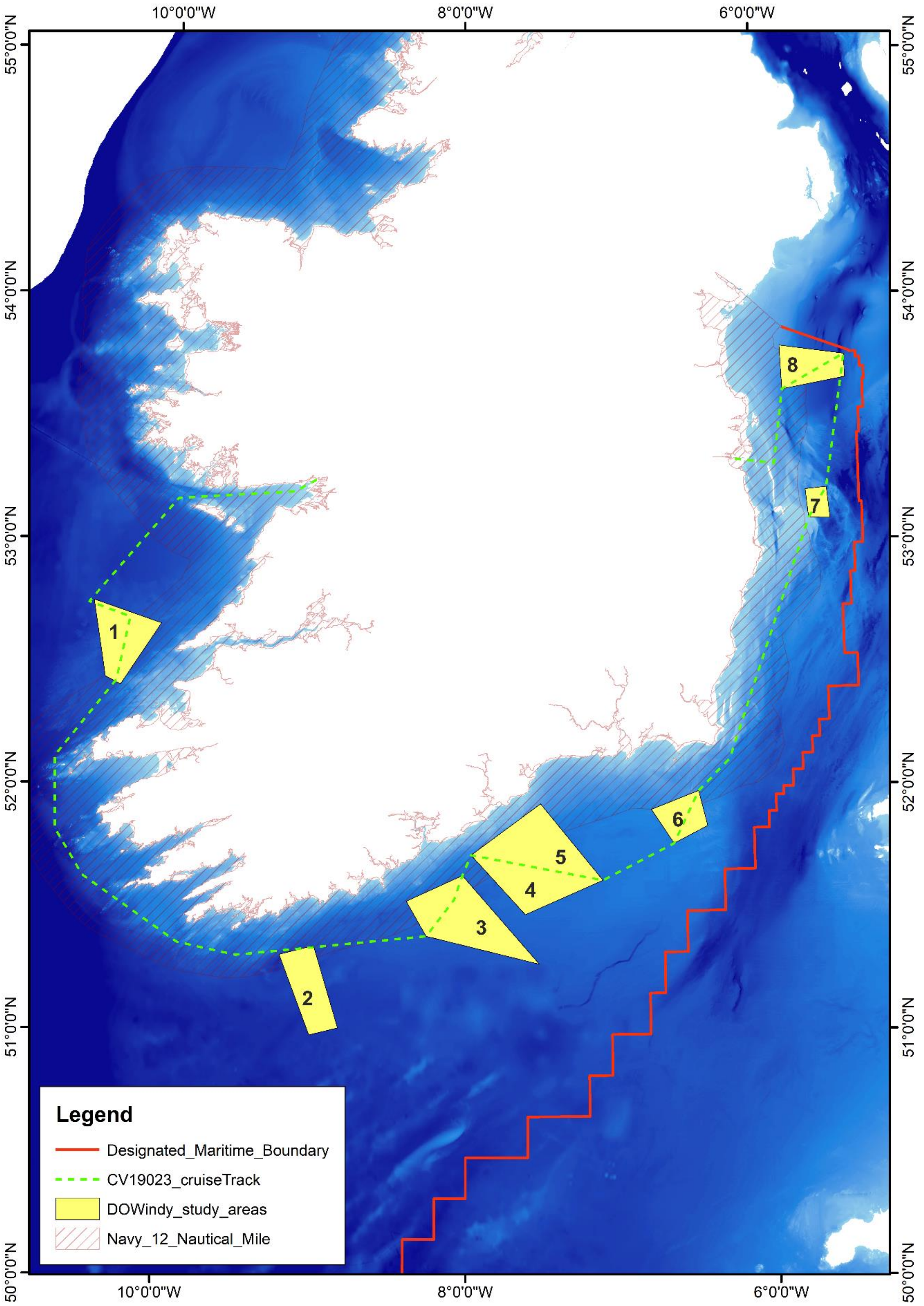

Figure 1: Map of cruise track and study areas (labelled yellow boxes). Note: only areas 2 and 3 were surveyed during the second leg of DOWindy (CV19026).

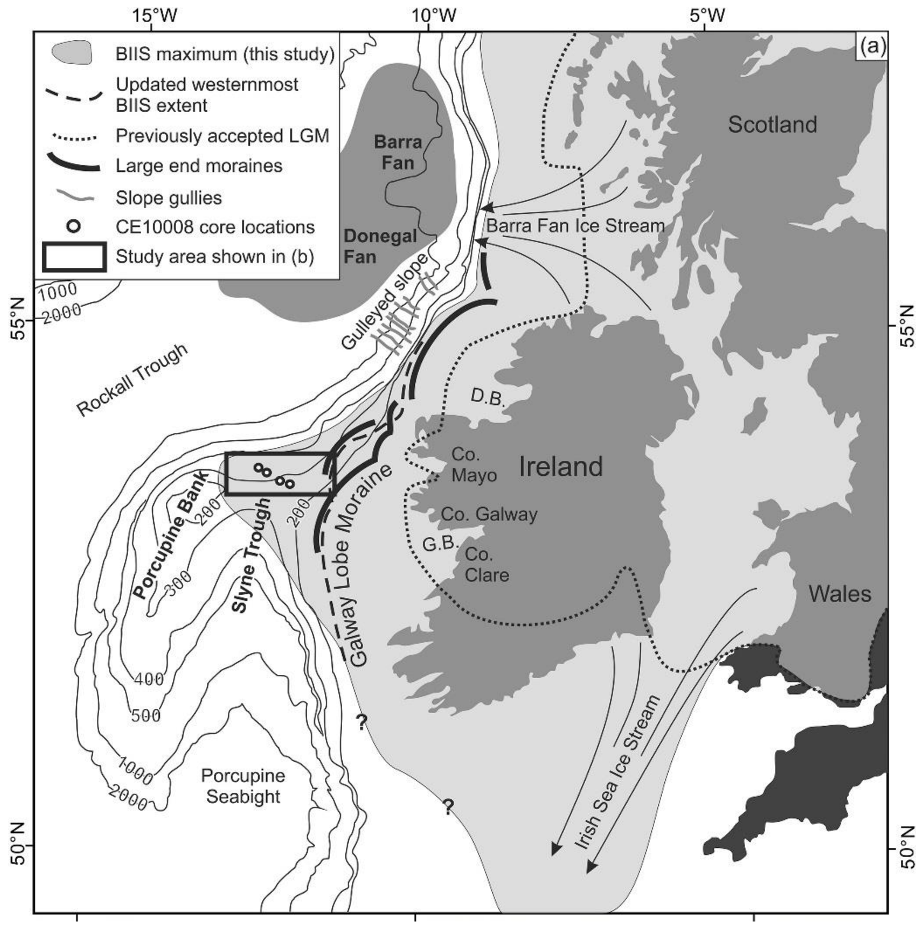

Figure 2: Schematic of the last British-Irish-Ice-Sheet, showing improved ice limits, some major landforms, and large ice streams. Reproduced from Peters et al. (2015) with permission (Elsevier reuse licence #: 4481440580651).

3.3 Objectives

The DOWindy research cruise was undertaken to supply critical data to the Eirwind project (EirWind, 2019; see §3.1 for project details). The data targets are the product of one year of collaborative planning from a diverse team of researchers at the MaREI Centre and ten industry partners. Specific objectives of the survey include:

- Collect multibeam data that can be used to model sediment mobility and improve existing bathymetric coverage.
- Collect seismic sub-bottom data using a sparker acoustic system to identify stratigraphic characteristics and the thickness of the seabed sediment (i.e. depth to bedrock) in key areas.
- Collect surficial sediment samples that will help ground truth seabed/benthic terrain models and assess sediment mobility.
- Collect subsurface sediment samples using a 3-m vibrocorer to ground truth the seismic stratigraphy and improve models of seabed sediment composition.
- Ground-truth existing bathymetric data south of Ireland with improved surface-sediment sampling.

4 Equipment and Methods

4.1 RV Celtic Voyager

The *RV Celtic Voyager* is a multi-purpose research vessel measuring 31.4 m long with a 4-m draught. It has wet and dry laboratories and can remain at sea for up to 14 consecutive days. Some of the Celtic Voyager's equipment that the DOWindy cruise made use of are the large a-frame for deployment of the vibrocorrer off the aft; the port-side wench for deployment of the grab samplers, and the hull-mounted EM2040 Multi-beam echosounder.

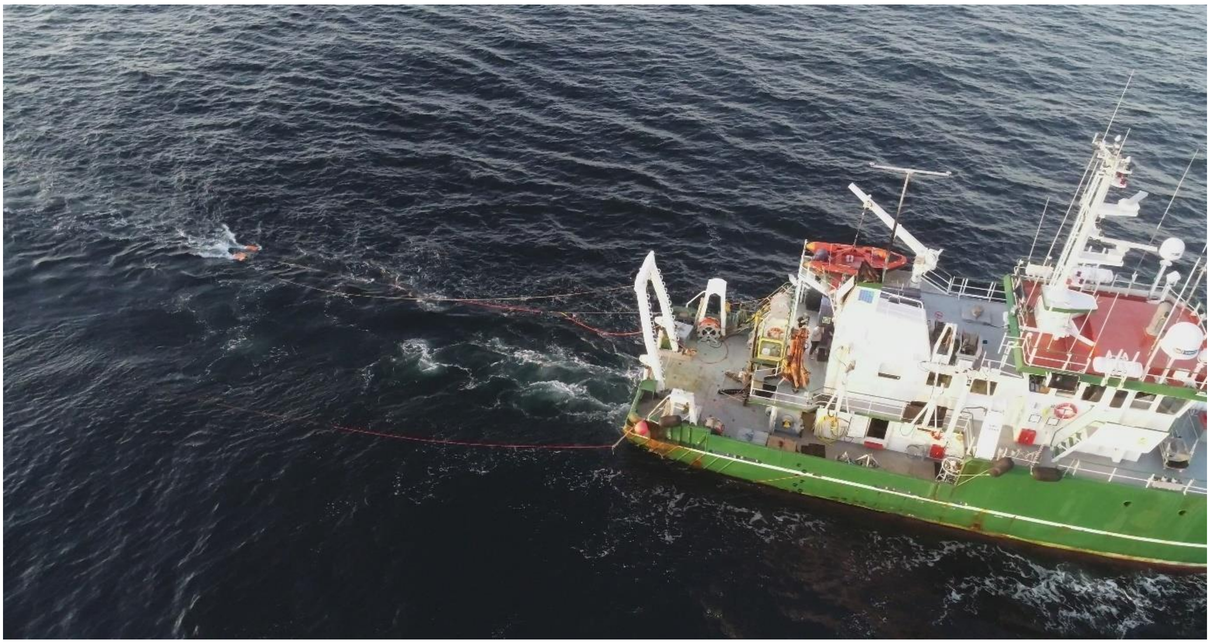

Figure 3: Drone photograph of the RV Celtic Voyager, a 31.4 m, multi-purpose research vessel capable of oceanographic and environmental data collection, towing the Sparker system during the CV19023 cruise. Photograph credit: Marine Institute.

4.2 Seismic data acquisition

Seismic transects were chosen based on a series of considerations deemed important by the EirWind Consortium (Peters, 2019; EirWind, 2019). Primary planning considerations included: data coverage (i.e. filling data gaps), distance from shore, water depth, restriction zones (e.g. special areas of conservation, shipwrecks), distance to potential electrical grid connections, and distance to ports with the potential to support future operation and maintenance activities (cf. Irish Maritime Development Office, 2019). Planning consideration also considered geomorphological characteristics from any existing bathymetry and an evaluation of regional geological history (§3.2).

Seismic sub-bottom data were collected using a hull-mounted pinger and a Geo-Source GeoSparker200 sparker system. The sparker system used was a Geo-Source GeoSparker200 system. This sub-bottom profiler consists of a Geo-Spark 6 kJ pulsed power supply and a Geo-Sense single channel hydrophone array. Both are towed behind the vessel during operation. The power supply emits a signal from the bang box (Figure 4) to the sound source, which consists of four evenly-spaced electrodes in a planar array suspended from a catamaran (Figure 5). After reflection/refraction from interaction with the water column and seabed, the return signal is detected by the hydrophone array while it is suspended just below the water surface (Figure 6). This system provides high-resolution (<30 cm) seismic sub-bottom profiles in water depths up to 500 m, depending on seabed characteristics (Geo-Marine Survey Systems, 2019). Data acquisition is controlled via a CODA DA2000 system.

Figure 4: Sparker system bang box in the wet lab of the *RV Celtic Voyager*.

Figure 5: Geo-Source GeoSparker200 catamaran.

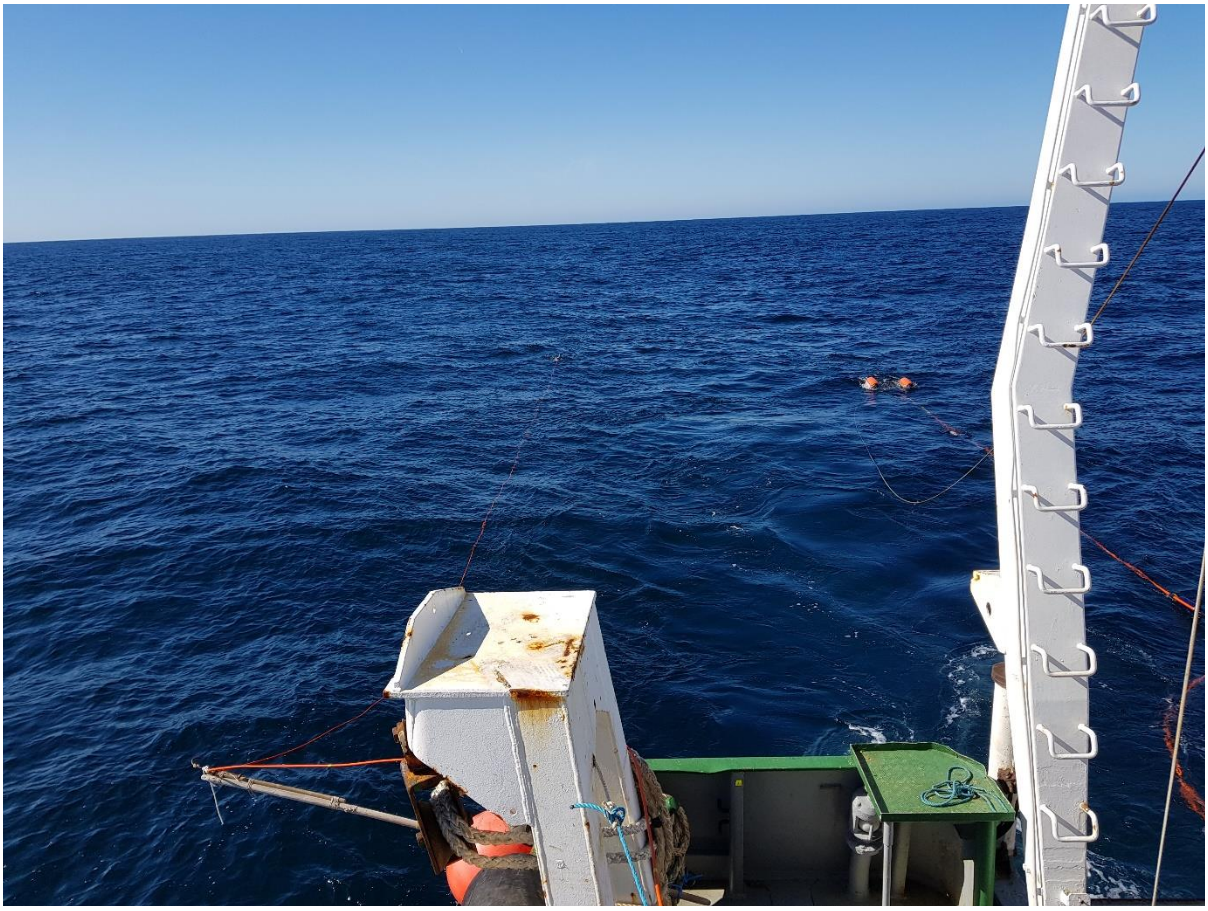

Figure 6: The Geo-Source GeoSparker200 hydrophone (thin orange stringer on left, deployed from a boom), and the sparker source catamaran on the right, deployed and ready for use. See also Figure 3.

4.3 Sediment sampling

Initial sample site locations were informed by geomorphic analyses, regional Quaternary geological history (§2.2), and analyses of existing INFOMAR multibeam bathymetry and backscatter data. These locations were further refined during the cruise using sea-floor data collected "on the fly," prior to sampling operations.

A Shipek grab sampler (Figure 7) was used to collect surface sediment samples. These samples were used to ground-truth geological analyses and inform site selections for coring operations. Ship position and water depth when the sampler reached the sea floor was recorded. Subsamples were collected and stored in sample bags for potential benthic analyses and/or quantified grain size analyses.

Figure 7: Shipek grab sampler, on its storage stand aboard the *RV Celtic Voyager*.

A 3-m vibrocorer (Figure 8) with an 11-cm barrel was used to collect subsurface sediment samples. The maximum water depth for safe operation of this corer from the *RV Celtic Voyager* was 100 m. Sediment cores were recovered in 1-m sections and labelled immediately. Recovered samples were stored upright and near the centre of the ship to minimise disturbance to unconsolidated sediments during continued operations, transit, and demobilisation activities.

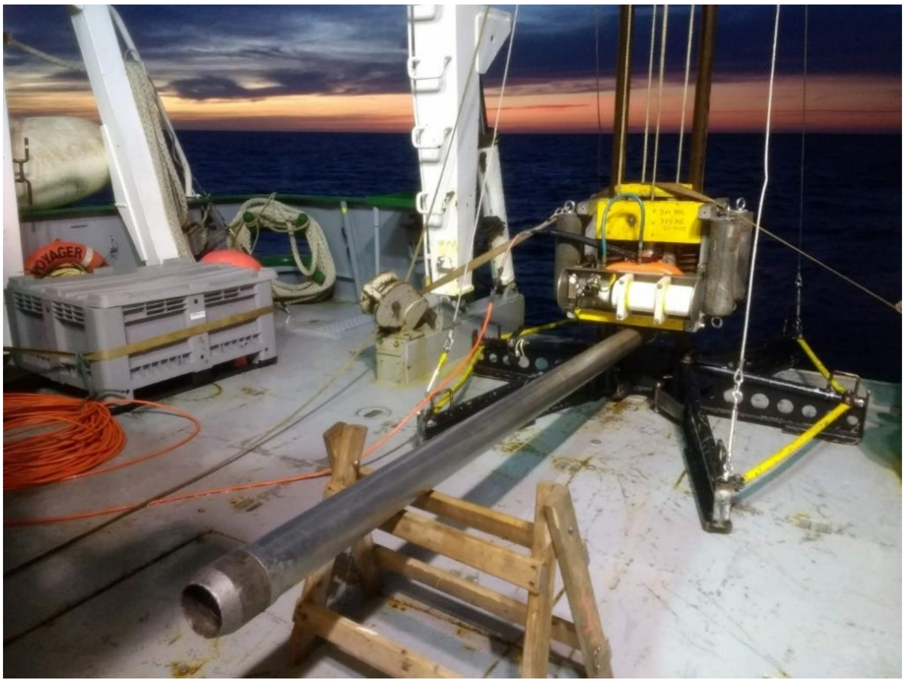

Figure 8: Vibrocorer used during the DOWindy (CV19023) research cruise on the deck of the *RV Celtic Voyager*. Barrel length is 3 m; barrel inside diameter is 11 cm.

5 Activity Overview

5.1 Overview of research survey

Times referred to in this section are GMT. A detailed log of ship activities was also kept (Appendix 9.2).

5.1.1 Day 1 (16/10/2019)

Weather delay.

5.1.2 Day 2 (17/10/2019)

Weather delay.

5.1.3 Day 3 (18/10/2019)

The ship was prepared for the DOWindy scientists (equipment and consumables were loaded; sparker was connected; coda was switched from pinger acquisition to sparker acquisition). Science crew arrived at the vessel (*RV Celtic Voyager*) by 14:30. Science crew boarded the ship, presented documents and identification, and took the safety tour by 16:20.

We sailed from Galway Docks at 18:30 on the evening tide. Transit lasted the rest of the night.

5.1.4 Day 4 (19/10/2019)

We arrived on station in Area 2 at 13:30 and started the MMO watch. At 14:00 two dolphins were spotted and another 30-minute MMO watch was started (Appendix 9.3, 9.4). Soft start commenced at 14:30.

Sparker seismic data were acquired using 500 – 700 J of power based on water depth and assessments of the raw data quality. Sweep time was adjusted for 1,600 m/s in ~100 m of water. The GeoSense gain filter box was adjusted to improve raw data clarity; settings are shown in Figure 9. TVG and scale were adjusted as required to monitor the raw data during acquisition.

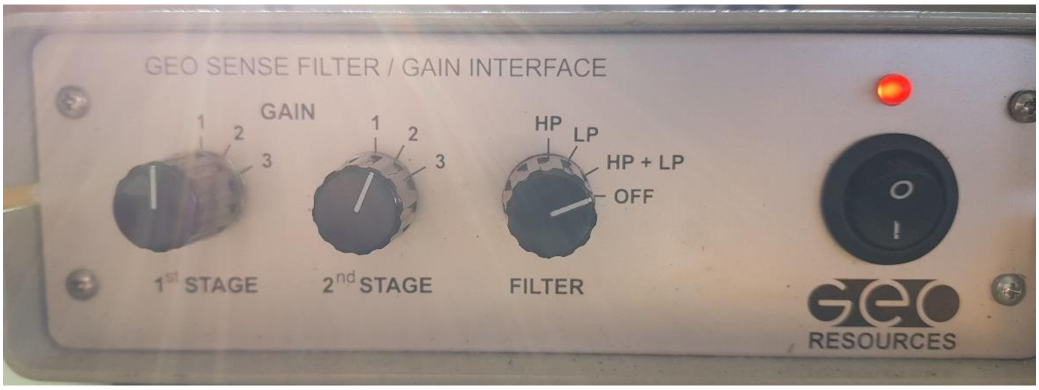

Figure 9: Photo of the GeoSense filter/gain interface box with the settings used during CV19026. Settings are: 1st stage gain set to 1; 2nd stage gain set to 2; filter set to HP+LP.

The sparker boom box stopped firing several times, which required a manual restart. This didn't typically result in much loss of data. The Coda Octopus software also crashed three times due to some "memory exception" that caused a software error. A prompt from the program requested that Coda technical support be contacted.

5.1.5 Day 5 (20/10/2019)

Sparker data acquisition continued. At 06:50 the power was changed to 700 J to try to improve signal penetration. At 08:20 the survey was ended and transit towards Area 3 began.

In Study Area 3 (Figure 1), sediment grabs were collected along seismic transects from the first DOWindy leg (CV19023). Seven grabs were attempted using the Shipeck sampler (Figure 7) from 12:30 – 14:20. Only three of these attempts yielded samples that were suitable to bag for future analysis. It seemed that the poor weather conditions (force 5; Appendix 9.1) were likely causing the sampler to drag along the seabed, followed by too much motion during retrieval through the water column (Murdoch & MacKnight, 1994).

5.2 Activity summary

Table 2: CV19023 hourly activity summary (see also Figure 10).

Activity	Time (hours:minutes)	Hourly %
Sediment collection	1:50	1.8
MMO watches	3:40	3.5
Seismic data acquisition	15:10	14.6
Transit	23:10	25.8
Weather standby	56:30	54.3

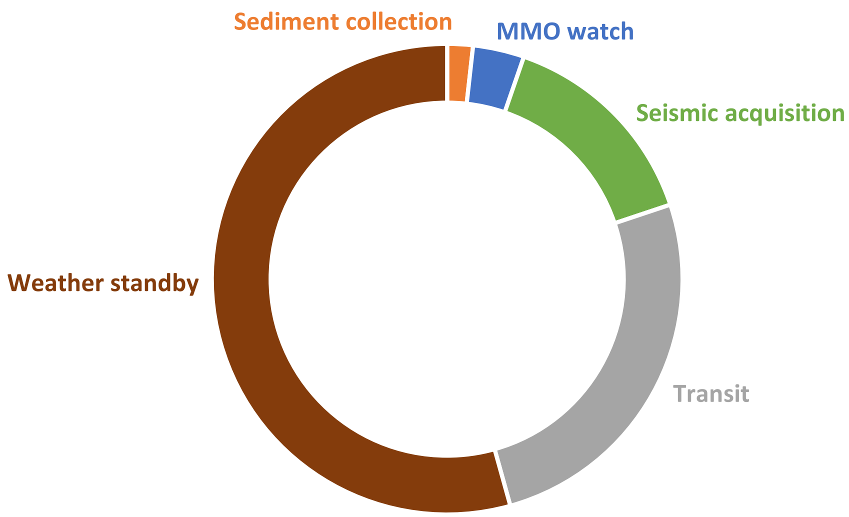

Figure 10: Doughnut graph of major cruise activities as percentages of total operational time (see also Table 2).

6 Results and data summary

6.1 Study Area 2 results

Just over 63 nm (~117 km) of sparker sub-bottom seismic data were collected from Area 2 (Figure 11). These data reveal geological information from ~10-25 nm offshore of County Cork, about 40 nm west of Cork Harbour, which was identified as a potentially suitable port for OWE O&M activities (Irish Maritime Development Office, 2018). Sediment bedforms overlying nearby bedrock were targeted during this survey because they probably record some of the Quaternary depositional history of the Irish continental shelf (cf. Gallagher et al., 2004; Peters et al., 2016). This information will likely be beneficial to offshore development as well as palaeoclimate and palaeoglacial research.

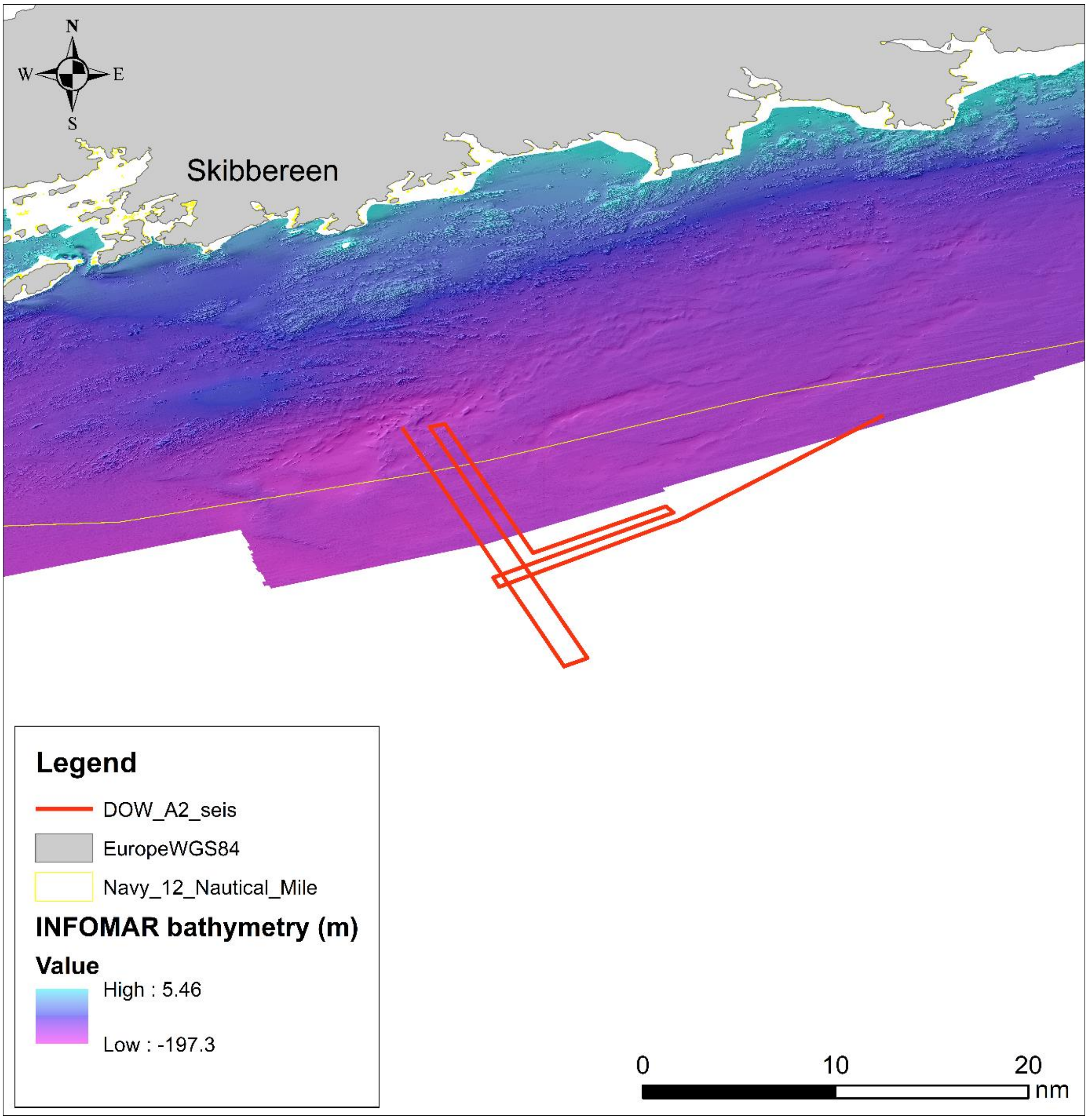

Figure 11: Map of study area 2 showing the 63 nm of sparker seismic data collected. Hillshaded bathymetric DEM is made from INFOMAR data and has a 10-m resolution; white map areas have no INFOMAR data coverage

6.2 Study Area 3 results

Seven grab samples were attempted in Study Area 3. Sample sites were selected based on the location of sparker data collected during the first leg of the DOWindy cruises (CV19023) and the palaeovalley geomorphology revealed by INFOMAR data (Figure 12). Three samples from in and near a complex palaeovalley system, mapped in Figure 13, provided enough recovery for bagging. The other four attempts were either failed or extremely small recoveries (i.e. practical failures).

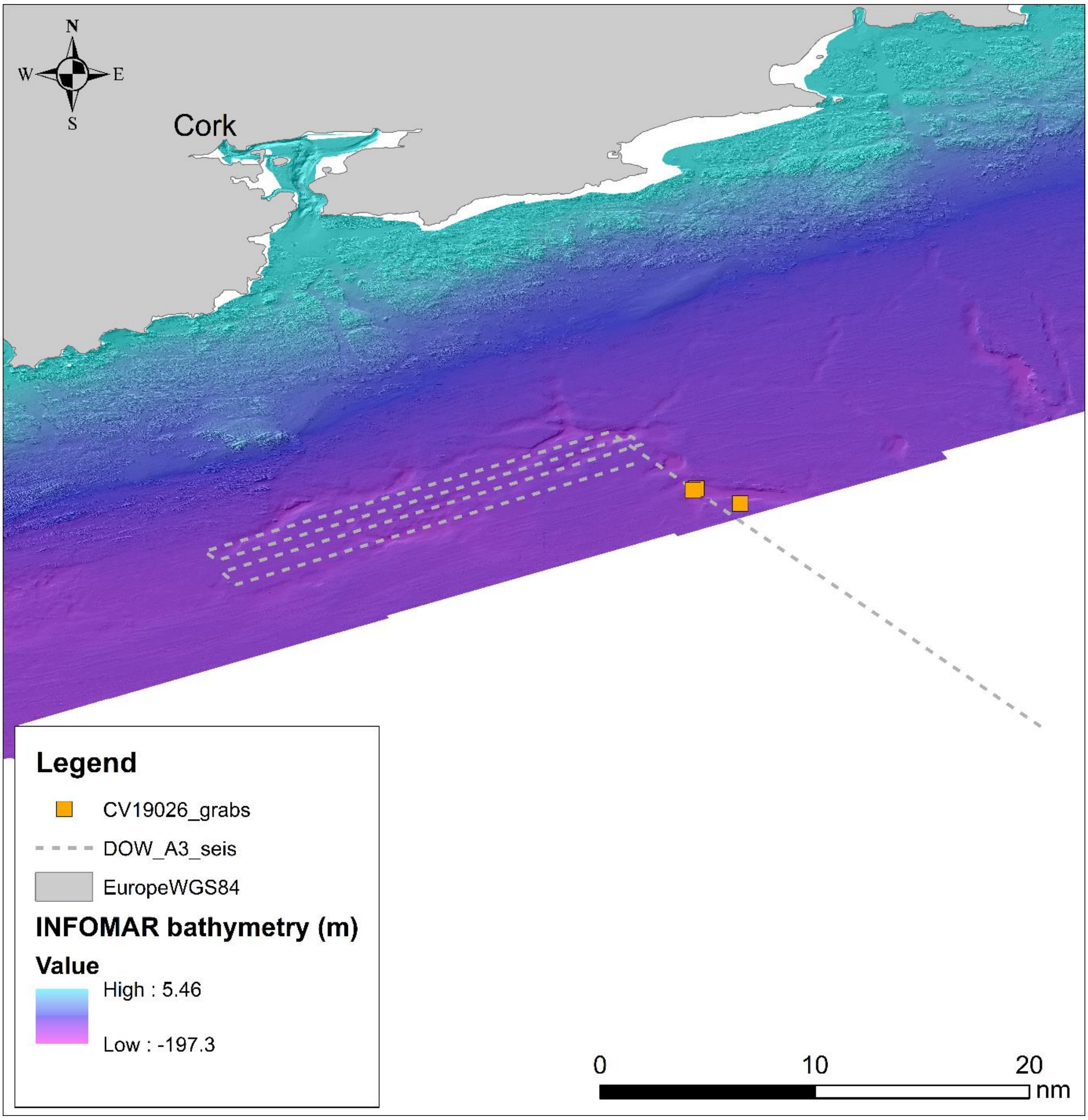

Figure 12: Map of the three successful sediment grabs collected in Area 3, near the seismic transect from the first leg of the DOWindy cruises (CV19023). See Figure 13 for a detailed view (large scale/small area) of the sample locations.

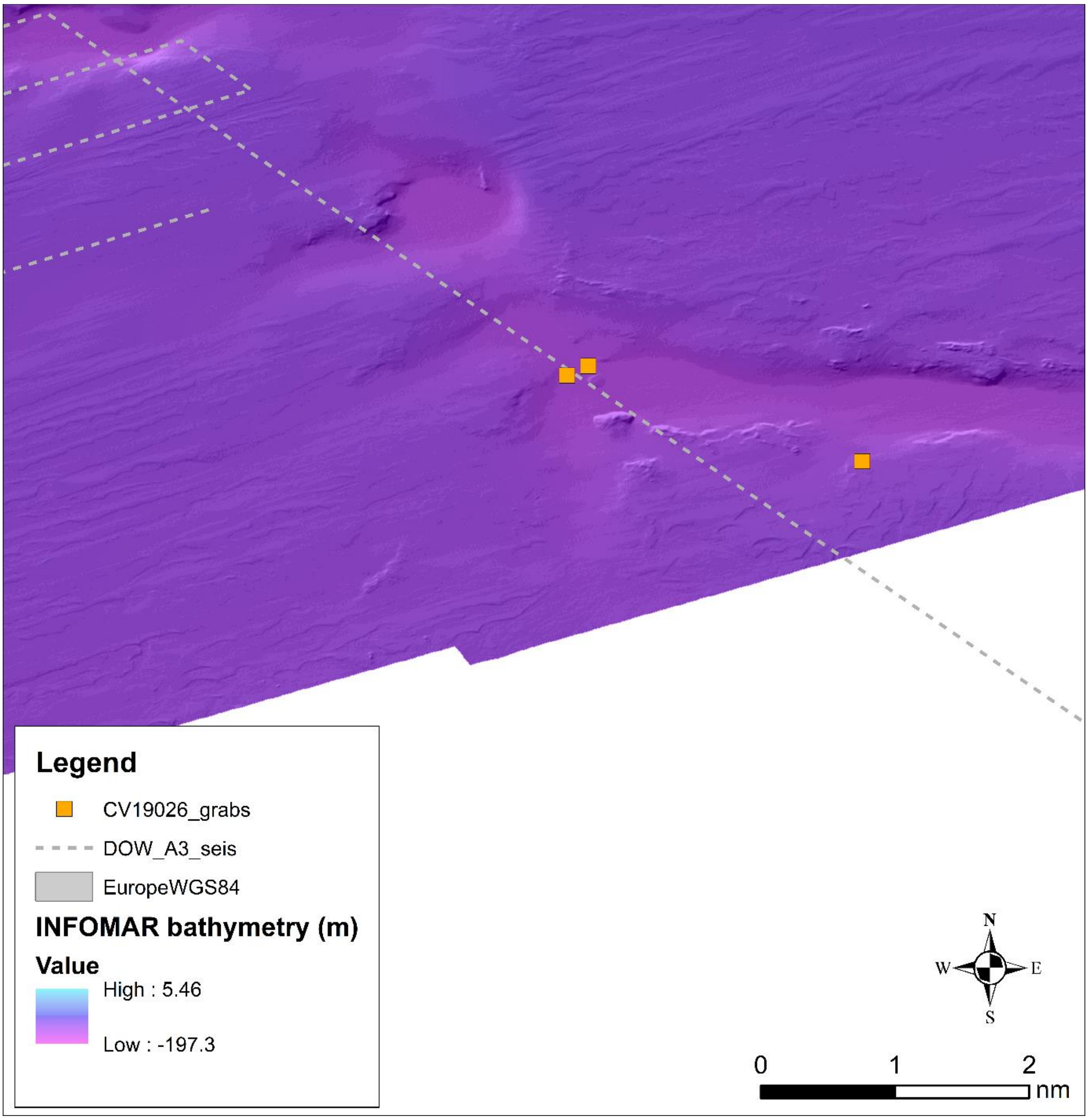

Figure 13: Map of the three successful grab samples collected in Area 3, showing detail of the sample locations within the palaeovalley system. See Figure 12 for regional location.

6.3 Data summary

A total of 63 nm (117 km) of sparker seismic data were collected in Study Area 2 (Figure 11). Six grab samples were attempted in Study Area 3 (Figure 12, Figure 13); three of these attempts were successful (Table 3).

Table 3: Sediment grabs.

Study Area	Sample number	Latitude	Longitude
3	01_G	51°34.103'	07°57.797'
3	02_G*	51°34.470'	07°58.330'
3	02a_G*	51°34.406'	07°58.321'
3	02b_G*	51°34.305'	07°58.513'
3	03_G	51°34.812'	07°57.838'
3	03a_G	51°34.741'	07°57.996'

*Failed attempts.

7 Benefits, impacts and contributions

7.1 Benefits and potential impacts to the Marine Sector

The following section is taken from the CV19023 (DOWindy Leg 1) cruise report.

The DOWindy research cruise has produced data that are widely applicable to several national research programmes. The research was designed for, and by, the industry-led Eirwind project. These data help to improve bathymetric and geologic information within several large data gaps that occupy areas of interest for the development of Ireland's offshore wind energy industry. The new bathymetric data reveal seabed characteristics like bedrock outcrops and mobile-sediment landforms that are important for de-risking aspects of offshore wind farm development (Kallehave et al., 2015).

Ireland is rich in untapped offshore wind energy (Gallagher et al., 2016) and many European nations are already benefiting from offshore wind energy production. In 2017, offshore wind farms in the UK experienced an 8% increase in financial investors (The Crown Estate, 2018). These investments seem to be paying off, since the debt-to-equity ratio for financing these projects has risen from 70:30 to 75:25 (ibid). Considering these facts, the relatively small investment for this research cruise from a variety of academic and industry partners (Table 4) has the potential to result in a high cost/benefit ratio through projects like Eirwind and any subsequent offshore wind farm developments.

Another potential benefit of the sediment data collected by the DOWindy cruise is insights into marine aggregate potentials. Building materials are essential to continued socioeconomic development in Ireland (Paul et al., 2006), a nation with an appetite for construction aggregate that is approximately four times higher than the mean European Union per capita demand (~30 tonnes per person/yr in 2005; Sutton et al., 2008). Approximately 33 million tonnes of aggregate were mined for use as construction material in Ireland during 2017 (Irish Concrete Federation, 2018). These materials help drive Ireland's construction industry, which represents a large portion of the GNP (Paul et al., 2006) and offshore aggregate resources are particularly economically viable (Sutton et al., 2008). Despite these facts, the stratigraphy of palaeovalley infill sequences offshore of Ireland, which could consist of sand and gravel, have not been thoroughly investigated. The iCRAG Centre, a Science

Foundation Ireland programme, is currently working with UCC to investigate the viability of offshore marine aggregate sources. Thus, the sedimentological data provided by the DOWindy research cruise could add information that benefits other research programmes and helps de-risk future mining activities.

Climate change is already affecting our environment and economy (Pachauri et al., 2014), and projections for Ireland predict a temperature increase of 2° by 2100 (Christensen et al., 2007). These changes are exacerbating the vulnerability of coastal areas (Flannery et al., 2015) and some analyses predict irregular and serious issues from even small changes in Ireland's climate (e.g. Lennon, 2015). The data collected by the DOWindy research cruise, especially the sedimentary data, may prove insightful to palaeoglaciological reconstructions of the last BIIS (Clark et al., 2012) and postglacial benthic adaptations. These reconstructions are valuable to predictive models for modern climatic and cryospheric changes because they enable comparative assessments of model validity. The sediment data from the vibrocore and seismic data could also be used to assess palaeoenvironmental changes since the last glaciation, thereby providing insightful context for any research on modern benthic habitats on the Irish continental shelf. Thus, the academic research possible with data collected by the DOWindy research cruise may benefit the economies of Ireland and western Europe if properly considered by policy makers.

7.2 Benefits and contributions to specific research programmes

Table 4: CV19023 contributions to specific research programmes.

Programme	Programme duration	Programme partners	Contributions from DOWindy (CV19023)	CV19023 cost to programme	Potential programme benefits to Ireland
Eirwind	2 years	UCC; MaREI; various national and international industry partners	Bathymetric and backscatter data; sediment data; ground truthing	Minimal (<€1,000)	Improved site selection for offshore wind farm development
AggrePOP	2 years	UCC; iCRAG	Sediment data; ground truthing	Minimal (<<€500)	Construction aggregate sources; improved seabed mapping resolution

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9 Appendix

9.1 Weather report

Day 1 (16/10/2019):

Lost to weather.

Day 2 (17/10/2019):

Lost to weather.

Day 3 (18/10/2019):

16.00 Calm with high clouds (In Galway Docks).

Day 4 (19/10/2019):

08.00 Northerly wind at 17 knots. 2 m swell with 1.5 m wind waves. Force 5. High cloud cover; good visibility.

12.00 North-westerly wind at 12 knots. 1.5 m swell with 0.7 m wind waves. Force 4. Sunny, some high clouds, good visibility.

16.00 Northerly wind at 11 knots. 1 m swell with 0.3 – 0.5 m win waves. Force 4. Sunny, partial cloud cover, good visibility.

20.00 Northerly wind at 9 knots. 1.5 m swell with 0.5 m. wind waves. Force 4. Dark. Partial cloud cover, poor visibility.

24.00 Northerly wind at 10 knots. 1.5 m swell with 0.5 m. wind waves. Force 4. Dark. Partial cloud cover, poor visibility.

Day 5 (20/10/2019):

04.00 Northerly wind at 17 knots. 0.8 m swell with 0.2 m. wind waves. Force 4. Dark. Partial cloud cover, poor visibility.

08.00 Northerly wind at 17 knots with gusts over 30 knots. ~0.5 – 1 m swell with 1-m wind waves. Many large white caps; force 5. High clouds; good visibility.

12:00 Northerly wind at 18 knots with gusts up to 20 knots. Force 5. 0.7 m swell with 1.2 m wind waves. Many large white caps. Force 5. High clouds, moderate visibility.

9.2 Activity log

Times are GMT.

DAY	DATE	ACTIVITY	START TIME	END TIME	DURATION (HRS)
1	16/10/2019	Weather delay			24
2	17/10/2019	Weather delay			24
3	18/10/2019	sail	18:30:00	18:30:00	00:00:00
3	18/10/2019	Transit	18:30:00	00:00:00	05:30:00
4	19/10/2019	Transit	00:00:00	13:30:00	13:30:00
4	19/10/2019	MMO watch started. Catamaran deployment.	13:30:00	16:30:00	03:00:00
4	19/10/2019	MMO soft start	16:30:00	17:10:00	00:40:00
4	19/10/2019	Sparker survey.	17:10:00	00:00:00	06:50:00
5	20/10/2019	Sparker survey.	00:00:00	08:20:00	08:20:00
5	20/10/2019	Transit.	08:20:00	12:30:00	04:10:00
5	20/10/2019	Sediment sampling.	12:30:00	14:20:00	01:50:00
5	20/10/2019	Transit into Cork to demob.	14:20:00	18:00:00	03:40:00

9.3 MMO log

The following tables were supplied by Jessica Giannoumis and modified for inclusion in this report.

Regulatory reference number	CV19026	
Ship/ platform name	RV Celtic Voyager	
Date	19/10/2019	20/10/2019
Time soft start/ ramp-up began (UTC)	13:28	
Time of full power (UTC)	14:26	
Time of start of line (UTC)	14:26	
Time of end of line (UTC)		7:20
Time airguns/ source stopped (UTC)		7:20
Time pre-shooting search began (UTC)	12:31	
Time search ended (UTC)	13:28	
Was it day or night in the period prior to firing?	d	d
Was any mitigating action required?	y	
Comments	delayed softstart due to marine mammal detection	line finished next day

9.4 MMO Report

The following report was provided by Jessica Giannoumis (the DOWindy MMO). Where possible, it was shortened without significant loss of content (with context supplied by this research cruise report) and it's formatting and figure references were modified for inclusion into this document.

Marine Mammal Observer Report

R.V. Celtic Voyager

Marine Institute

CV19026

Derisking Offshore Wind Energy Development Potential in Irish Waters (DOWindy)

Celtic Sea

18th - 20th of October, 2019

Contents

2. Introduction

Irish waters are among the most important in Europe for a wide range of marine mammals, including cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals) which are present regularly or seasonally. The 1976 Wildlife Act (NPWS, 1976) and the subsequent Amendments (2000, 2005, 2010, and 2012) provide a legal framework extending to Ireland's Territorial Sea (i.e. the 12 nautical mile limit from the baseline) for the protection of marine mammal species and their habitats in Irish waters. Under the Wildlife Act, it is an offence to hunt and injure (unless licences or Ministerial permits have previously been obtained), disturb, or destroy breeding places of protected species. The Habitats Directive further states that all marine mammals normally occurring within Ireland's 200 nautical mile limit must be given protection (DAHG, 2014). In Ireland, 24 cetaceans and 2 pinnipeds can be found, some of these marine mammals are abundantly spread throughout Irish waters, while others are rarely encountered (Berrow, 2001).

Man-made sound, such as sound generated by seismic surveys, can have life-threatening effects on marine mammals, hence, any acoustic introduction into the marine space needs to be carefully considered and monitored (Weilgart, 2007). Any geophysical acoustic surveys should use the minimum acoustic source level to achieve the desired result. The undertaking of geophysical acoustic surveys carried out by vessels within Irish waters require Marine Mammal Observers (MMO) to be present. Prior to any seismic operations, MMOs will carry out 30 minute pre-shoot watches in waters up to 200 meter deep, followed by a 40 minute soft start. If any marine mammals during the pre-shoot watches within the mitigation zone (1000 metre of the acoustic source) have been detected, seismic operations are to be halted until the marine mammal has moved away. Seismic operations may only start once the marine mammals had sufficient time to leave the area (30 minutes from when the marine mammal was last seen). Soft starts will slowly introduce acoustic emissions to the environment, achieving maximum or desired sound output after 40 minutes.

This document serves to meet the reporting requirements as outlined in the Department of Arts, Heritage and the Gaeltacht's Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters, January 2014 (DAHG, 2014) for geophysical surveys.

3. Date and Location of Survey

The CV19026 survey was planned for October 18th – 20th, 2019 in the Celtic Sea.

4. Survey Vessel

R.V. Celtic Voyager (call sign: EIQN; Figure 3), 31.4 m in length and 4 m draught, is a multi-purpose vessel and is equipped with wet, dry, and chemical laboratories which are permanently fitted with standard scientific equipment. The vessel accommodates 15, depending on the survey between 6-8 scientists and 7-9 crew members, highly skilled in handling and deploying the scientific equipment. The Celtic Voyager has a maximum endurance of 14 days.

Key features of the R.V. Celtic Voyager include EM2040 Multi-beam echosounder, Ixsea Gaps USBL System, ideally suited to towed Underwater TV operations, Capable of beam and pelagic and demersal otter trawling, CTD work to 1000 m, and full oceanographic services.

5. Survey Equipment

The Geo-Source 200 sparker seismic system of the Marine Institute was used during the survey. This sparker seismic system uses a 6kJ (max 5,600 V) pulsed power supply which emits a pulse to the sparker source which is towed behind the vessel. The return signal is picked up in Geo-Sense single channel hydrophone array at frequencies ranging from 200 – 1,500 kHz. The Geo-Spark 200 provides high resolution seismic profiles of up to 300 m depth, depending on the composition of the water column, sea conditions, and the underlying seabed. A multi-tip array of sparker nodes are evenly spaced in planar array which enhances the downward projection of the acoustic energy. The Geo-Source 200 is designed to float on or just below the water-surface.

6. Marine Mammal Observers/Qualifications

MMO: Jessica Giannoumis

Address: Douglas, Co. Cork, T12 Y7FV, Ireland

Email: Jessica.Giannoumis@ucc.ie

Academic Qualifications:

- M.Sc. in International Environmental Studies, Norwegian University of Life Sciences, 2017

Specialised in the regulation of mitigation procedures of anthropogenic sound in marine environments in the United States

- BA in Media Studies and Human Geography, University of Oslo, 2015
- Diploma in Environmental Impact Assessment and Natural Disasters, University of Hong Kong, 2014

Training and Certifications:

- IWDG Marine Mammal Observer course (2019)
- JNCC Marine Mammal Observer Training (2019)
- 5yr+ of marine mammal observation and detection of marine wildlife in European waters and Puget Sound

Recent Marine Mammal Survey Experience (accounting for at least 6 weeks):

- Marine Mammal Observer

R.V. Celtic Voyager, CV19023, Atlantic, Irish, and Celtic Sea, Ireland – marine mammal observation for geophysical seismic survey (September 2019 2 weeks)

- Marine Mammal Observer

Charter boats varied in West Cork, Ireland – using marine mammal observation techniques to detect marine wildlife (May – September 2019 3 weeks)

- Marine Mammal Observer

Celtic Mist, SW Ireland, IWDG – using marine mammal observation techniques to survey humpback whales along 100 m contour line (August 2019 1 week)

- Marine Mammal Observer

Vessels varied and were provided by local dive centres and fisher people on Faial island, Azores, Portugal – research project in collaboration with the University of the Azores, documenting the effects of man-made sound introduction and marine megafauna (July – August 2016 6 weeks)

Casual observations: bridge and deck crew - there were sightings of marine mammals by other crew on board which always were verified by the MMO.

7. Survey Areas

The survey was undertaken to increase the understanding of seabed and sub-seabed conditions in areas of good grid connectivity (west, south, and east coasts) at the 12 mile limit where offshore windfarms are most likely to be developed.

- To repeat multibeam bathymetric and backscatter mapping to assess seabed dynamics
- To collect spark seismic data to assess sub-seabed conditions e.g. depth to the rock
- To collect seabed sampling to collect sediment grab samples

8. Marine Mammal Observations

Observations for marine mammals, and turtles were conducted by a specialized MMO with previous mitigation experience (see Section 3) and were made from the bridge deck (height: 5.5 m) at a height of 7.2 m above sea level. Observations were conducted around the vessel from the bridge which offered a near 360° view with only minor visual obstruction to the stern where a life-raft was stored. The MMO searched for blows, splashes, or disturbances to the sea surface. Data were recorded on JIP22 forms.

In addition to naked eye observations, reticular binoculars (7 x 50 mm) were used and pre-calibrated with the specific conditions of work (height from sea level and eye height of the observer). To determine the range between the Sparker and marine mammals, one of the divisions present in the binoculars is placed on the horizon. The following formular was used to determine the distance between the vessel and the marine mammal.

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

As detailed in the "Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters" (DAHG, 2014), prior to commencement of the acoustic surveys, 30 minute watches in unprotected areas and in waters up to 200 m depth within 1000 m range of the sparker equipment were carried out. Pre-shoot watches were only carried out when weather conditions were below sea state 4 or Beaufort Scale force 4 and during day light hours. If marine mammals were spotted in the area, the soft start procedure was halted for 30 minutes from the time the marine mammal has left the 1000 m mitigation zone or was last seen. If no marine mammals were detected during the pre-watch, a sparker soft start was carried out.

A normal soft start comprises of a ramp up of source power of acoustic emission over at least 40 minutes until the sparker reached full power. During transit between the different study areas the sparker was stopped.

Once the sparker reached full operating power, there is no need for further MMO watches.

9. Pre-Shoot Watches

Visual monitoring was conducted on October 19th when the R.V. Celtic Voyager reached the survey area, during daylight, and when weather conditions were favourable to safely carry out pre-shoot watches.

Visual monitoring while acoustic source was inactive amounting to 1 hour and 55 minutes (71 %), visual monitoring while acoustic source was active amounting to 24 minutes (29 %).

10. Results of Operations

The acoustic source was soft started once over the course of the survey in order to commence full volume survey operations. The soft starts were conducted starting with the sparker emitting sound at low frequency of 100 Hz where gradually more energy was added until the sparker reached full power.

At the start of the first seismic survey, technical issues between the Quincy and CODA programs caused the soft start period to be extended to approximately one hour. MMO protocols were adhered to throughout this period.

The acoustic source was active for a total of 18 hours 50 minutes throughout the project. This includes testing and soft start of the sparker and full power.

11. Marine Mammals Effort Sightings

Visual monitoring conducted during the sparker survey resulted in a total of 6 sightings of marine mammals.

These sightings comprised of six sightings of short-beaked common dolphins (Delphinus delphis). There were no sightings of sea turtles though mitigation was extended to turtles.

During the survey there were a total of 6 sightings of marine mammals. Of the 6 sightings, two occurred during a pre-shoot watch, 1 sighting occurred while the source was active, and 5 sightings occurred while the source was inactive (Appendix II).

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