National Research Vessels

Ship-Time Programme

AggreWind Research Survey Report

Survey Code:	Survey Name:	Chief Scientist/ Institution
CV18034	AggreWind	Jared Peters/ University College Cork

National Development Plan 2007 - 2013

IRISH CENTRE FOR RESEARCH IN APPLIED GEOSCIENCES

University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Centre for Marine and Renewable Energy

Contents

1 Executive Summary

The AggreWind research cruise was conducted on the continental shelf west and south of Ireland from October 17 – 24, 2018. The two primary goals of the cruise were to (1) de-risk offshore construction aggregate mining south of Ireland and (2) de-risk offshore wind farm development south and west of Ireland. A secondary goal of the research cruise was to collect data that may help interpret the behaviour of the last British-Irish Ice Sheet along its western and southern marine-terminating margins. These goals support several research projects including the iCRAG (Irish Centre for Research in Applied Geosciences)-funded AggrePOP (The Integrated Mapping for the Sustainable Development of Ireland's Marine Resource) project and the industry-led Eirwind project, which aim to help facilitate the development of offshore aggregate mining and wind energy production, respectfully.

Two distinct data collection operations were conducted: (1) multibeam echosounder data were collected in areas with little to no existing coverage; and (2) sedimentary data were collected via Shipek grabs and 3-m vibrocores to characterise previously unknown areas of seabed and sub-bottom sediment.

Multibeam data were collected over a period of 62 hours of operation. This work yielded over 400 nautical miles (>740 km) of bathymetric trackline. The vast majority of this was collected from areas with no Irish National Seabed Survey (INSS) or The Integrated Mapping for the Sustainable Development of Ireland's Marine Resource (INFOMAR) coverage that are likely to be relevant to the Eirwind project and future offshore wind farm development.

Sediment data were collected over a period of >46 hours of operation. This work yielded 167 grab samples and 33 vibrocores. Most of these data were collected from previously-unsampled palaeovalleys on Ireland's southern continental shelf. These sampling activities successfully yielded several distinct types of sediment deposits (mud; sand; gravel; shell hash; and compact, gravelly mud) that are likely to provide the basis for new stratigraphic and geographic modelling of the shelf.

The AggrePOP and Eirwind projects are likely to produce results using these data. Both projects have the potential to advance socioeconomic development in Ireland. Thus, this 8-day research cruise is likely to provide a very high cost-benefit ratio.

2 Cruise Details

2.1 Award summary

Title of research survey (survey code):	AggreWind (CV18034)
Co-ordinator/chief scientist:	Andrew Wheeler/Jared Peters
Vessel used for ship time:	Celtic Voyager
Total days at sea:	8
Total of grant-aided ship-time days awarded:	8
Survey dates:	17/10/2018 – 24/10/2018
Mobilisation/Demobilisation ports:	Galway/Cork
Survey personnel:	1 scientist; 1 technician; 5 students
Final Report completed by:	Jared (20/11/2018)

2.2 Science crew summary

Table 1: Science crew summary.

	Name	Institute	Position	Number of days
Scientist	Jared Peters	University College Cork (UCC)	Postdoctoral Researcher	8
Technician	Damien Crean	P & O	Technician	8
Students and Research Assistants	Niamh Connolly	UCC	Research Assistant	8
	Luke O'Reilly	UCC	PhD Student	8
	Kim Harris	UCC	Research Assistant	8
	Stephanie Dunne	UCC	MSc Student	8
	John Appah	UCC	PhD Student	8

2.3 Science crew shift description

During multibeam data acquisition, 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 because following multibeam collection, coring activities were deemed unsafe to crew and equipment at night (sunrise varied from ~08:00 - ~08:10 during the research cruise (Appendix 8.1)). Following multibeam operations, nightshift hours were significantly reduced to leverage the scientific work force (Table 1) for daytime coring operations.

3 Introduction

3.1 Rationale

The AggreWind research cruise generated data for two important projects: AggrePOP and Eirwind. AggrePOP is an Irish Centre for Research in Applied Geosciences (ICRAG) project that is attempting to identify aggregate resources off Ireland's south coast. Eirwind is an industry-led Marine and Renewable Energy Ireland (MaREI) project that is developing a road map for the establishment of Irish offshore floating and fixed windfarms.

New construction and development projects are a vital aspect of improving social wellbeing and sand and gravel are often required for such projects (Sutton, 2008; Sutton et al., 2008). New aggregate resources are particularly vital for Ireland as many Irish cities are working hard to keep up with housing demands (Morgenroth, 2014, 2018; Kitchin et al., 2015). There is a shortage of angular (sharp) sand—vital for concrete production—that could be supplied from offshore sources and the planned enlargement of Cork City by 100,000 new residents will strain this already scarce resource (Morgenroth, 2018). Most construction aggregate is currently sourced from terrestrial locations in Ireland (Sutton, 2008); however, marine aggregates have some benefits over their terrestrial counterparts. From an industry standpoint, marine aggregates are typically cleaner (Prentice, 1990) and less prone to pyritization with improved calcium carbonate contents. From an ecological perspective, mining marine aggregates causes significantly less permanent habitat modification (Sutton, 2008). The AggrePOP project can help provide these critical and potentially more environmentally-responsible resources.

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). These findings highlight the urgency of a recent governmental review of Ireland's progress towards reducing carbon emissions which has pointed out that, 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 appealing because they can be built bigger, they can operate more efficiently, and they practically remove issues with lack of space. Because the benefits of offshore wind energy are scientifically and economically apparent, the Eirwind project is working with industry partners to help facilitate the development of Ireland's offshore wind energy resources through rigorous academic research.

Additionally, the AggrePOP research cruise could help reveal new insights on the extent and behaviour of the last British-Irish Ice Sheet. Recent studies have shown that this ice mass shares key features (e.g. ice-stream fed marine margins and flanking ice shelves) with areas of the modern Antarctic and Greenland ice sheets that are thought to be sensitive to climate change (Peters et al., 2016). Furthermore, the BIIS was likely highly sensitive to climate change due to its relatively small size, low latitude, and abundant marine termini (Clark et al., 2012). Thus, by improving reconstructions of the last BIIS, especially its retreat behaviour, we can help calibrate models of modern ice sheet retreat.

3.2 Study area

The AggreWind research cruise focused on the continental shelf to the west and south of Ireland (Figure 1). Significant bathymetric and geological data gaps exist in these areas, which inhibits resource management and hampers analyses of environmental and climatic change.

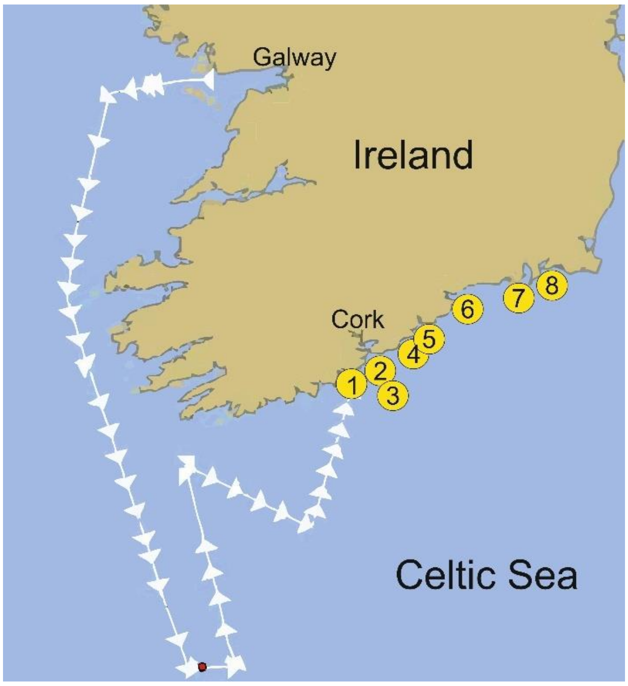

Figure 1: Map of the AggreWind research cruise study area. The vessel mobilised in Galway and demobilised in Cork. The white, arrowed line shows the multibeam survey's trackline and direction. Labelled, yellow dots mark the individual areas targeted for coring activities.

The southern and western Irish continental shelves have 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. Recent 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. These fluvial deposits are often reworked and 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).

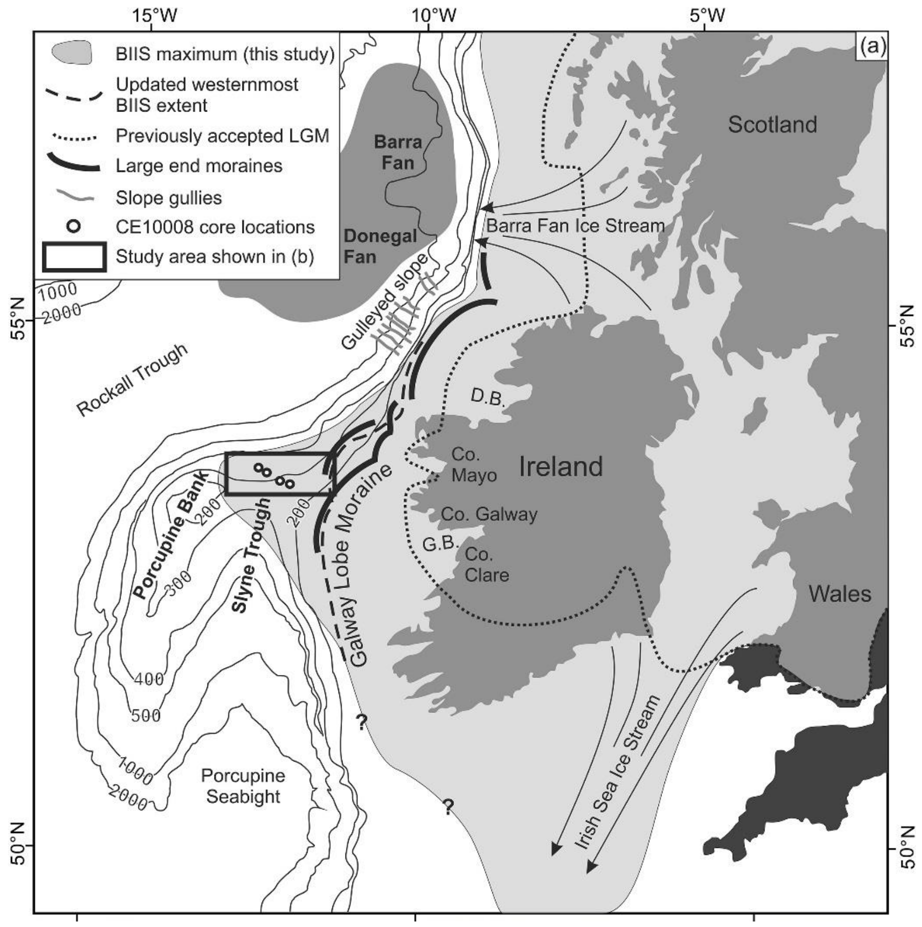

Figure 2: Schematic of the last British-Irish-Ice-Sheet, showing improved ice limits, some major landforms, and large ice streams. Reproduced from Peters et al. (2015) with permission (Elsevier reuse licence #: 4481440580651).

The study area can be delineated as two zones: west and south; in general, multibeam data were collected in the west and sediment samples were collected in the south (Figure 1). Both zones targeted data that would provide more details on the glacial and postglacial conditions described above. Sediment sampling operations targeted a series of palaeovalleys that drained glacial meltwater during the retreat of the last BIIS (Gallagher et al., 2004). It is hypothesised that these drowned valley systems are a source of glaciofluvial sediment suitable for use as construction aggregate and pertinent to offshore wind farm development.

3.3 Objectives

The AggreWind research cruise was designed to supply critical data to the AggrePOP and Eirwind projects (see §2.1 for project details). Specific objectives of the survey include:

- Collect multibeam data in areas with no existing INFOMAR coverage to search for geomorphic markers of BIIS extent and help de-risk Ireland's offshore wind energy development.
- Collect surface sediment samples in and near previously-identified palaeochannels south of Ireland to ground-truth existing multibeam and backscatter data.

- Collect subsurface sediment samples in and near previously-identified palaeochannels south of Ireland to de-risk offshore aggregate mining.
- Ground-truth existing bathymetric data south of Ireland with improved surface-sediment sampling.

4 Methods

4.1 Bathymetric surveying

A Kongsberg EM2040 Multibeam echosounder (MBES; Figure 3) system was used to collect bathymetric and backscatter data. Data were collected at 300 – 400 kHz (Appendix 7.2) at a survey speed of ~8 knots. A Conductivity, Temperature and Depth (CTD) probe was used to measure variability in salinity, temperature and pressure within the water column (cf. Foote et al., 2005). The probe was deployed at intervals dictated by the calibration requirements of the EM2040 system based on user observations of the raw data.

Figure 3: Kongsberg EM2040 Multibeam echosounder hull-mounted array. (Photo credit: Marine Institute, 2014.)

4.2 Sediment sampling

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

A Shipek grab sampler (Figure 4) 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. Some subsamples were also collected and stored in sample bags for potential benthic analyses.

Figure 4: Shipek grab sampler, on its storage stand, used during the AggreWind research cruise (CV18034).

A 3-m vibrocorer (Figure 5) 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.

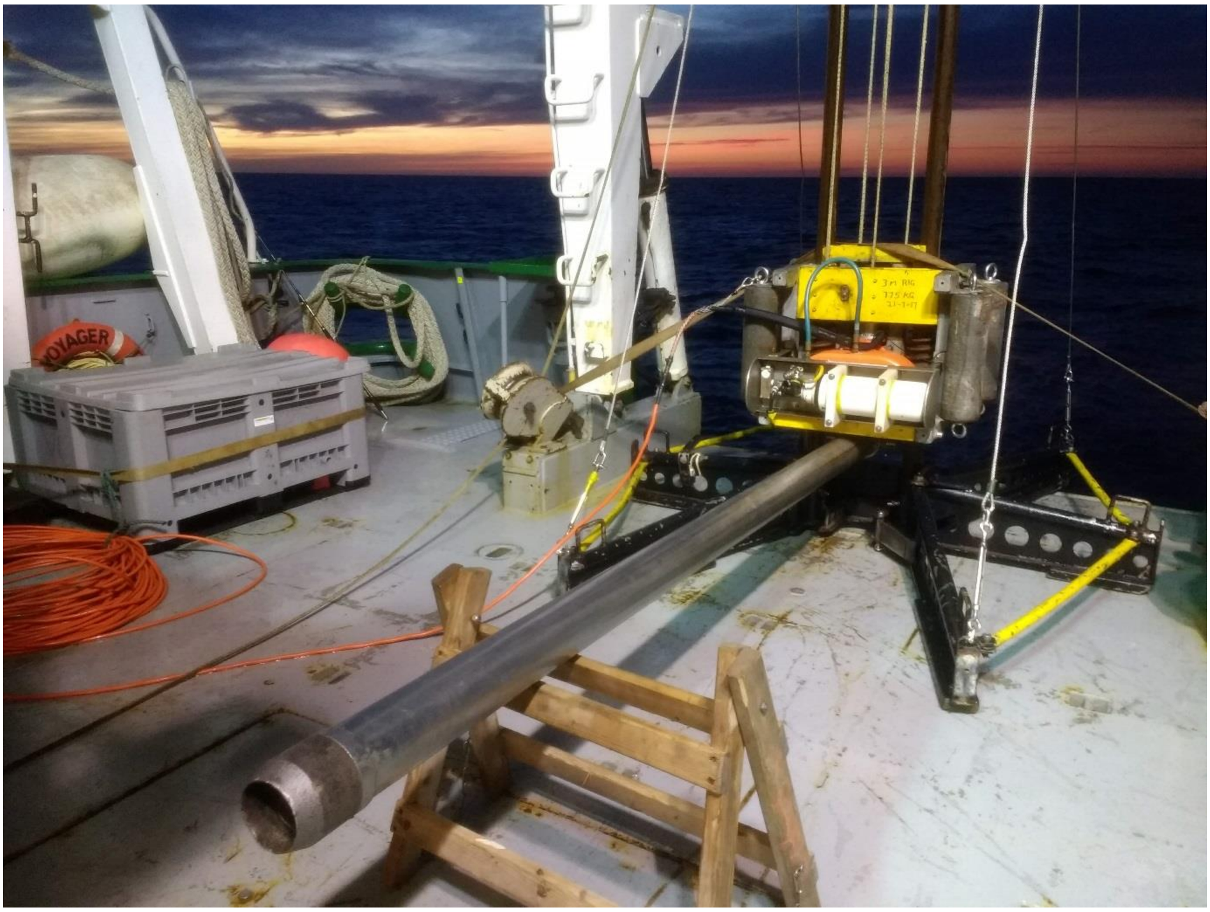

Figure 5: Vibrocorer used during the AggreWind research cruise on the deck of the RV Celtic Voyager. Photo was taken during sediment sampling operations (CV18034). Barrel length is 3 m; barrel diameter is 11 cm.

5 Results

5.1 *Overview of research survey*

5.1.1 Day 1 (17/10/2018)

Science crew arrived at the vessel (*RV Celtic Voyager*) by 14:15. Multibeam echosounder setup and tutorial was carried out by Dr Aaron Lim (UCC) from ~13:50 to ~14:50. Ship safety tour and sign-on paperwork checks were complete by 15:20. The multibeam array (Figure 3) was lowered while transiting westward across Galway Bay at ~24:00.

5.1.2 Day 2 (18/10/2018)

The first Sound Velocity Probe (SVP) data were collected with the CTD at ~01:30. These data allowed calibration of the multibeam and data acquisition started immediately afterwards. Additional SVP data were collected and applied as needed. No significant downtime or disruptions to multibeam operations were experienced.

5.1.3 Day 3 (19/10/2018)

Continued multibeam data collection. SVP data were collected and applied as needed (Appendix 8.2). A slight disruption in data acquisition occurred from 02:29 to 02:51, which resulted in a small gap in the multibeam coverage. No other disruptions to multibeam operations were experienced.

5.1.4 Day 4 (20/10/2018)

Multibeam operations lasted until 04:47 when the survey transect entered an area with INSS coverage. Following this, the multibeam array was raised and the vessel steamed to the first grab sample site.

Sediment sampling operations started at 06:00 in area 1 (Figure 1). Grab sampling was conducted using the Shipek grab sampler (Figure 4) to ground-truth the bathymetric data and refine potential coring sites. Seven vibrocores were collected (cores CV18034_01VC through CV18034_06VC; Appendix 8.4) at areas 1 and 2 (Figure 1, Figure 7) using the 3-m vibrocorer (Figure 5). Sediment sampling operations were completed at 21:30. Following this, nightshift work consisted of report writing and data digitisation.

5.1.5 Day 5 (21/10/2018)

Sediment sampling operations started at 06:00. Grab sampling operations were successful all day in areas 2, 3 and 4 (Figure 1, Figure 6) and several distinct types of seabed sediment were identified. However, after one successful vibrocoring attempt (core CV18034_07VCa, Appendix 8.4), the vibrocorer experienced an unknown technical problem that prohibited its use. Grab sampling continued while an attempt was made to contact a technician that might be able to fix the corer. The vibrocorer was operable again around 14:00 and coring operations were resumed in area 5 (Figure 1, Figure 7). Seven vibrocores were successfully collected (Appendix 8.4).

5.1.6 Day 6 (22/10/2018)

Sediment sampling operations started at sunrise (~07:00) in areas 6, 7, and 8 (Figure 1). Exploratory grab samples were taken to ground-truth the multibeam and backscatter data (Figure 8), but priority was given to vibrocoring operations (Figure 9). Grab sampling operations continued after sunset when coring operations were unsafe to thoroughly characterise the local seabed cover.

Following grab sampling operations at area 7, a long, westward transit was made towards area 3 (Figure 1). This area was skipped previously because the weather conditions excluded coring at the water depth required; however, conditions improved, so another attempt was deemed reasonable.

5.1.7 Day 7 (23/10/208)

Sediment sampling operations at area 3 (Figure 1) started at sunrise (~07:30). Priority was given to vibrocoring operations with minimal grab sampling to ground-truth the seabed. After successful core collection in area 3 (deeper water from 70 – 90 mbsf; Figure 1, Figure 7; Appendix 8.4), coring operations were continued in areas 2 and 1 until core liners were exhausted at 15:40.

After vibrocoring operations were complete, a short transit was made to the edge of the INSS data coverage and multibeam operations started. Lines that parallel the initial multibeam data collected on day 4 (20/10/2018) with a 25% coverage overlap were collected (Appendix 8.2).

5.1.8 Day 8 (24/10/2018)

Multibeam operations continued. Lines that parallel the initial multibeam data with a 25% coverage overlap were collected for as long as possible (Appendix 8.2) until our transit for Cork and demobilisation was required.

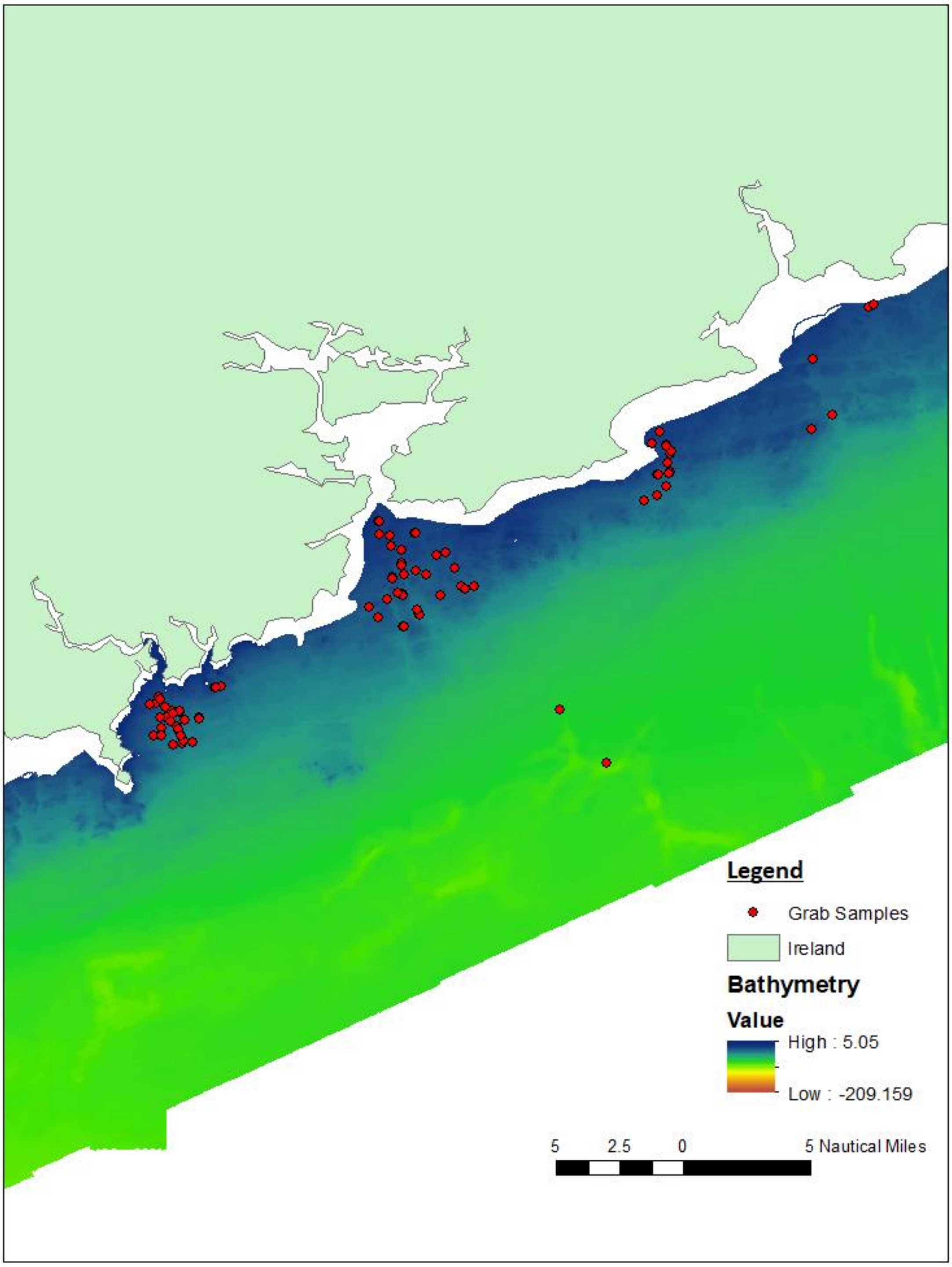

Figure 6: Multibeam bathymetry (INSS data) showing sea floor geomorphology surrounding areas 1, 2, 3, 4, and 5 (see Figure 1). Grab sampling (via a Shipek sampler) stations are shown as red dots. Map credit: Luke O'Reilly.

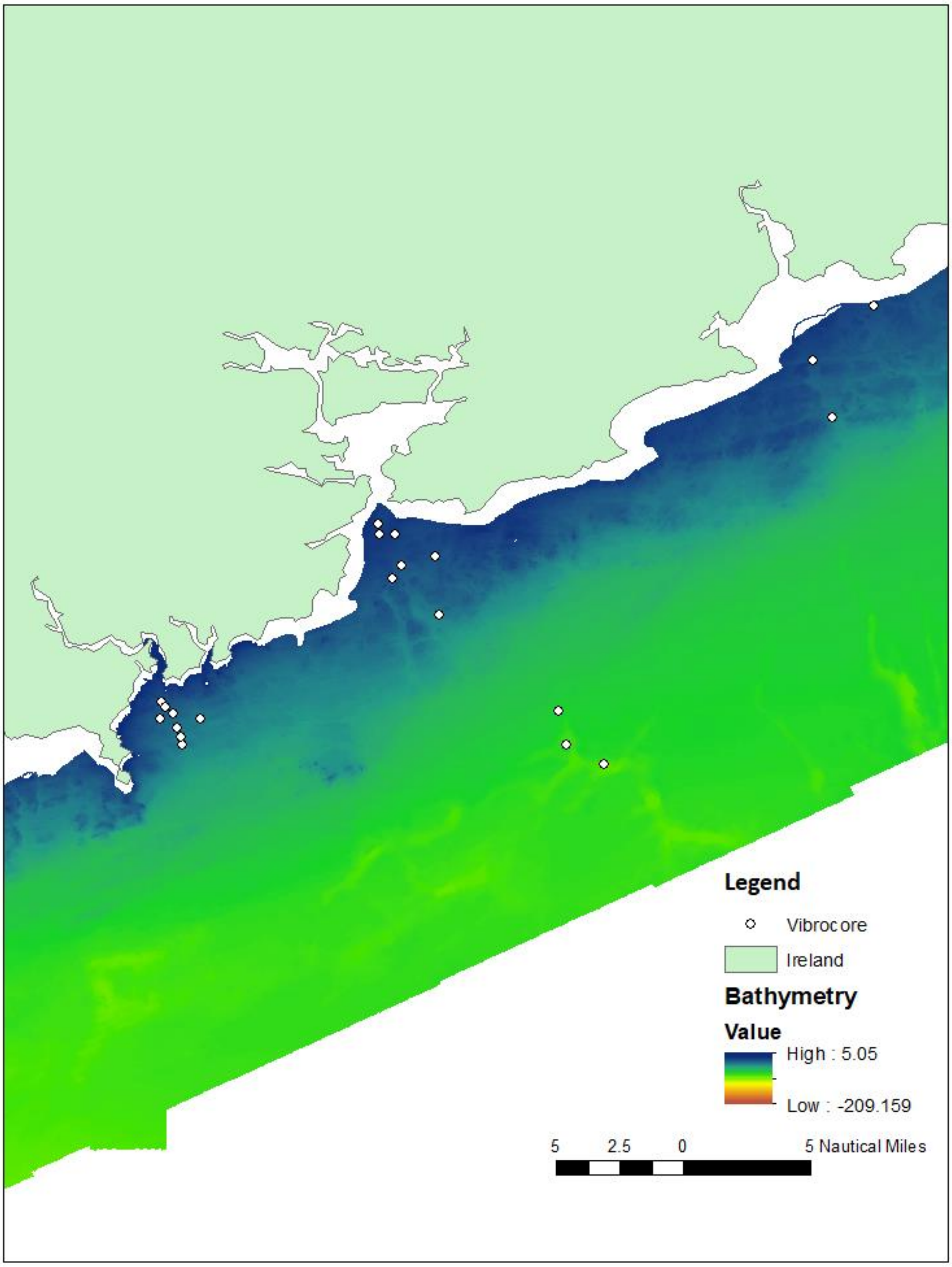

Figure 7: Multibeam bathymetry (INSS data) showing sea floor geomorphology surrounding areas 1, 2, 3, and 5 (see Figure 1). Vibrocoring stations are shown as white dots. (Note: vibrocoring operations were not possible in Area 4 due to abundant fishing gear.) Map credit: Luke O'Reilly.

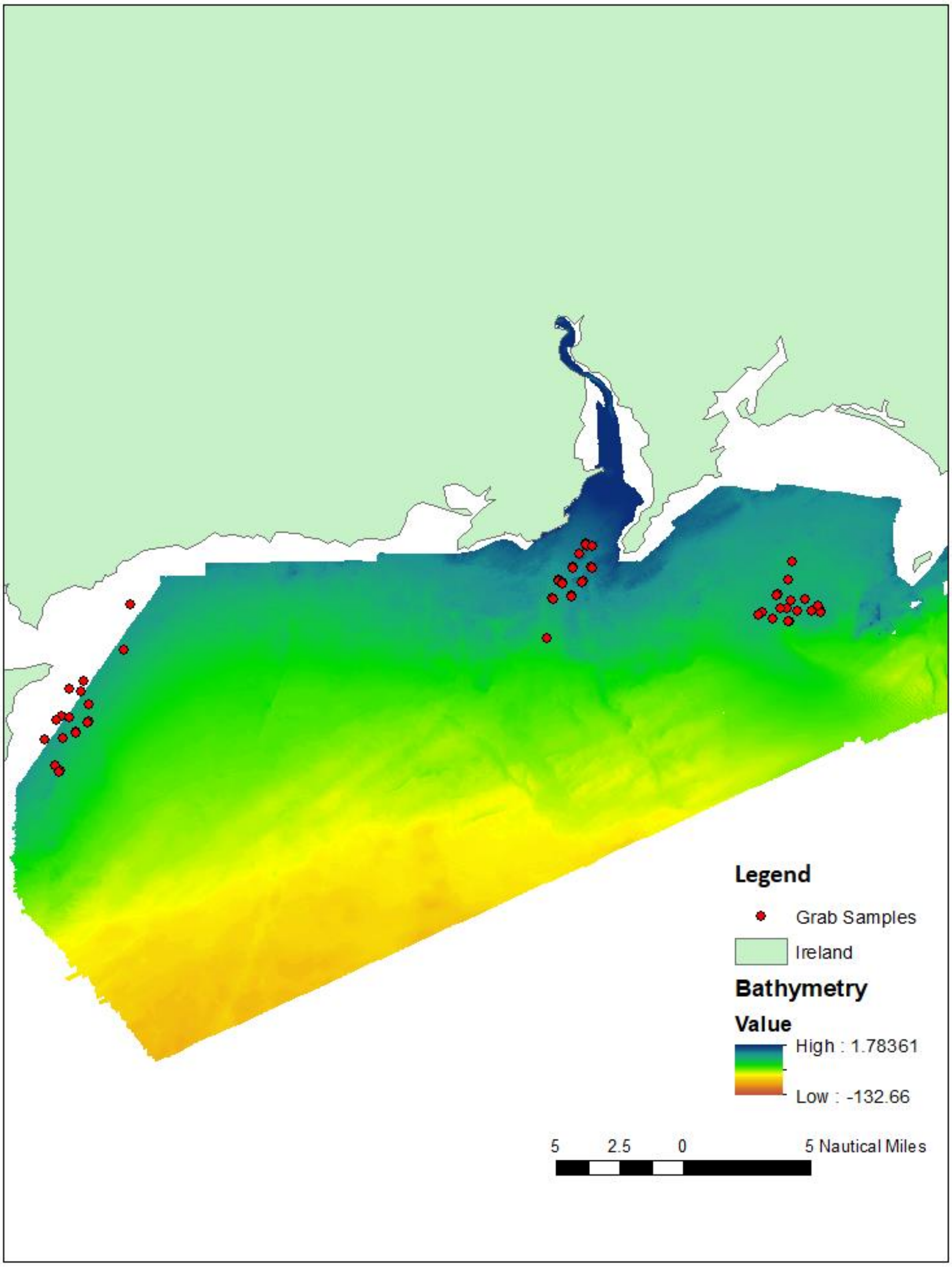

Figure 8: Multibeam bathymetry (INSS data) showing sea floor geomorphology surrounding areas 6, 7, and 8 (see Figure 1). Grab sampling (via a Shipek sampler) stations are shown as red dots. Map credit: Luke O'Reilly.

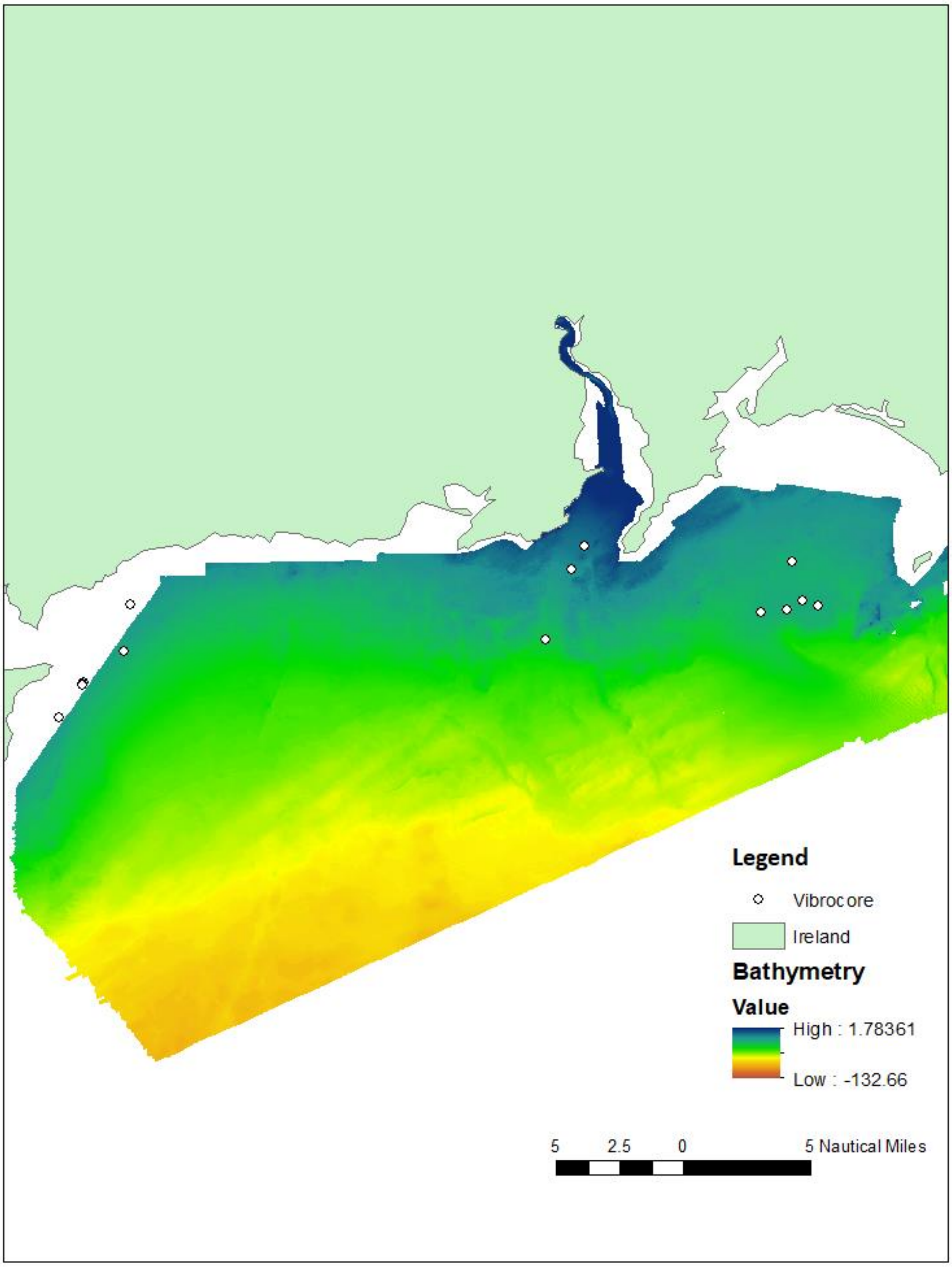

Figure 9: Multibeam bathymetry (INSS data) showing sea floor geomorphology surrounding areas 1, 2, 3, and 5 (see Figure 1). Vibrocoring stations are shown as white dots. Map credit: Luke O'Reilly.

5.1.9 Activity summary

Table 2: CV18034 hourly activity summary. (There was no weather-related downtime.)

Hour breakdown	Hours:minutes	Hourly %
Operational total (hrs)	**156:10:00**	
Crew rest (hrs)	22:14:00	14.35
Transit total (hrs)	19:58:00	12.89
Multibeam ops (hrs)	61:59:00	40.01
Sediment ops (hrs)	46:15:00	29.85
Data management (hrs)	4:29:00	2.89

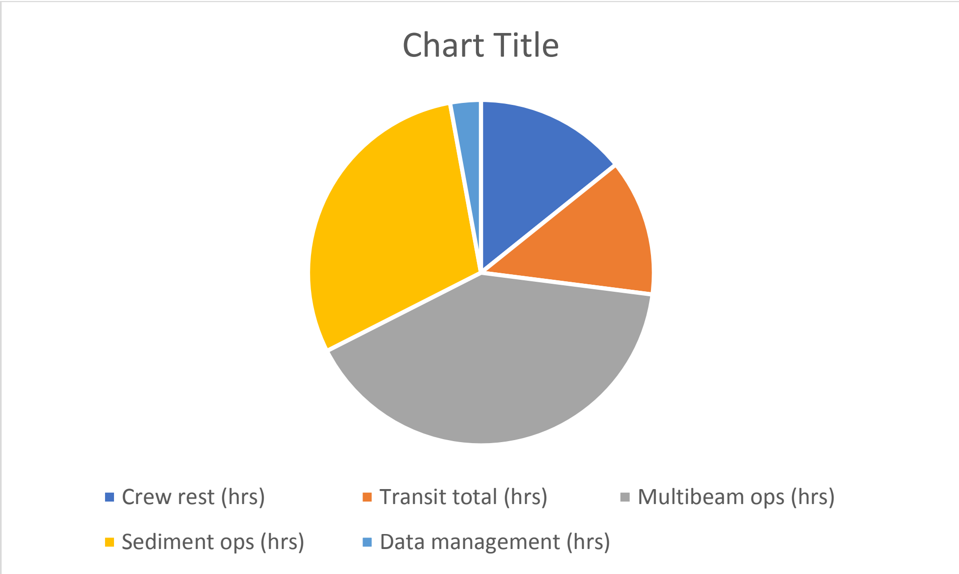

Figure 10: Graphical summary of science crew hourly activity (Table 2).

5.2 Data summary

Multibeam data were collected over ~62 hours of work (Table 2, Figure 10; §4.1.9; Appendix 8.2) resulting in >400 nautical miles of new bathymetric data on the continental shelf west and south of Ireland (Figure 1). Most of this data consists of a single transect covering a ~400-m swath of the sea floor. However, an area of three parallel transects with 25% overlap provides ~1 km wide coverage for a length of trackline south of Ireland.

Sediment sampling operations were carried out over >46 hours (Table 2, Figure 10). 154 grab samples were performed (Appendix 8.3; Figure 6, Figure 8). Every attempt was documented since small or missing returns (which were attempted at least twice) also provide important ground-truthing data. Lithology, sediment properties, and biogenic material content of all results were described. 32 of the successful attempts were sampled in sample bags to establish types samples and enable future analyses.

Thirty-two vibrocores were collected that range in length from ~0.12 m to >2.4 m (Appendix 8.4; Figure 7, Figure 9). The vibrocores sample several distinct strata (mud, sand, shell hash, gravel, and compact gravelly mud).

6 Benefits, impacts and contributions

6.1 Benefits and potential impacts to the Marine Sector

The AggreWind research cruise has produced data that are widely applicable to several national research programmes. The multibeam data are relevant to the industry-led Eirwind project. These data help to explore the bathymetry within several large data gaps west and south of Ireland, areas of focus 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 some 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, 2017). 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 3) has the potential to result in a high cost/benefit ratio through projects like Eirwind and any subsequent offshore wind farm developments.

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. Thus, the sedimentological data provided by the AggreWind research cruise could become an extremely valuable resource for de-risking future mining activities.

Climate change is already affecting our environments 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 AggreWind research cruise, especially the sediment cores, may prove insightful to palaeoglaciological reconstructions of the last BIIS (Clark et al., 2012). These reconstructions are valuable to predictive models for modern climatic and cryospheric changes. Thus, the academic research possible with data collected by the AggreWind research cruise may benefit the economies of Ireland and western Europe if properly considered by policy makers.

6.2 *Benefits and contributions to specific research programmes*

Table 3: CV18034 contributions to specific research programmes.

Programme	Programme duration	Programme partners	Contributions from AggreWind (CV18034)	CV18034 cost to programme	Potential programme benefits to Ireland
AggrePOP	2 years	UCC; iCRAG	Sediment data; ground truthing	Minimal (likely <€1,000)	Construction aggregate sources; improved seabed mapping resolution
Eirwind	2 years	UCC; MaREI; various national and international industry partners	Bathymetric and backscatter data; sediment data; ground truthing	Minimal (likely <€1,000)	Improved site selection for offshore wind farm development

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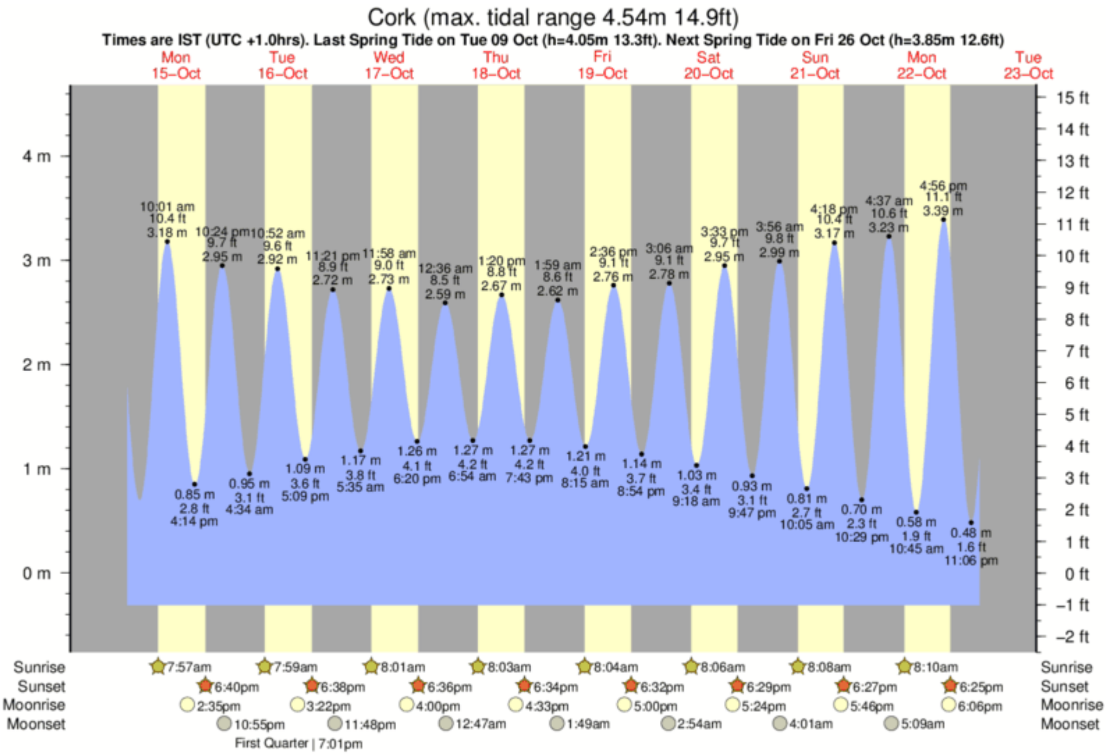
8 Appendix

8.1 Tidal chart



Tidal chart covering the CV19034 cruise dates downloaded from www.tide-forecast.com.

8.2 Multibeam operations log

Date	Time (UTC)	Vessel position		Depth (m)	CTD	Frequency (kHz)
		Lat	Long			
18/10/2018	00:09	53°12.177	09°22.914	34.29	Y	400
18/10/2018	01:35	53°11.765	09°34.473	49.32	Y	400
18/10/2018	01:49	53°11.645	09°34667	50.03		400
18/10/2018	04:22	53°09.626	10°05.406	99.86		400
18/10/2018	04:30	53°09.638	10°05.475	100.02	Y	400
18/10/2018	04:40	53°09.652	10°05.819	100.57		400
18/10/2018	06:35	53°06.911	10°28.266	101.38		400
18/10/2018	06:36	53°06.714	10°28.360	101.2		400
18/10/2018	08:20	52°53.4707	10°33.0020	73.78		400
18/10/2018	08:20	52°53.4707	10°33.0020	73.78		400
18/10/2018	10:01	52°40.4537	10°37.7664	119		400
18/10/2018	10:02	52°52.4537	10°37.7664	120		300
18/10/2018	11:11	52°31.6110	10°40.4098	119		300
18/10/2018	11:11	52°31.6110	10°40.4098	119		300
18/10/2018	12:18	52°23.3119	10°43.7988	108		300
18/10/2018	12:19	52°23.3119	10°43.7988	108		300
18/10/2018	13:17	52°15.8890	10°45.1991	117		300
18/10/2018	13:17	52°15.8890	10°45.1991	117		300
18/10/2018	14:16	52°08.3406	10°46.5757	126		300
18/10/2018	14:16	52°08.3406	10°46.5757	126		300
18/10/2018	15:14	52°00.9776	10°45.9864	91		300
18/10/2018	15:14	52°00.9776	10°45.9864	92		300
18/10/2018	16:19	51°52.6478	10°41.4374	100		300
18/10/2018	16:20	51°52.6478	10°41.4374	101		300
18/10/2018	17:17	51°45.5114	10°37.7372	120		300
18/10/2018	17:17	51°45.5114	10°37.7372	120		300
18/10/2018	17:40	51°42.5316	10°35.6871	-	Y	300
18/10/2018	18:05	51°41.4311	10°34.9851	121		300
18/10/2018	19:11	51°33.3464	10°30.4771	120		300
18/10/2018	19:11	51°33.3464	10°30.4771	120		300
18/10/2018	20:20	51°24.606	10°25.436	135		300
18/10/2018	20:20	51°24.606	10°25.436	136		300
18/10/2018	21:21	51°16.700	10°21.340	136		300
18/10/2018	21:21	51°16.700	10°21.340	136		300
18/10/2018	22:22	51°09.036	10°16.952	138		300
18/10/2018	22:22	51°09.036	10°16.952	138		300
18/10/2018	23:30	51°00.234	10°11.940	128		300
18/10/2018	23:30	51°00.234	10°11.940	128		300
19/10/2018	00:36	50°51.761	10°07.215	125		300
19/10/2018	00:36	50°51.761	10°07.715	125		300
19/10/2018	01:20	50°46.270	10°04.300	126		300
19/10/2018	01:20	50°46.270	10°04.300	126		300

19/10/2018	02:27	50°37.546	10°00.002	140		300
19/10/2018	02:29	50°37.272	09°59.889			300
19/10/2018	02:31	50°37.098	09°59.810	150		300
19/10/2018	02:31	50°37.098	09°59.810	150		300
19/10/2018	02:51	50°34.390	09°58.565	143		300
19/10/2018	04:38	50°20.692	09°50.560	120		300
19/10/2018	04:38	50°20.692	09°50.560	120		300
19/10/2018	05:47	50°11.799	09°45.659	131		300
19/10/2018	05:47	50°11.799	09°45.659	131		300
19/10/2018	05:55	50°10.955	09°45.003	132		300
19/10/2018	05:56	50°10.096	09°44.0865	132		300
19/10/2018	07:25	50°11.0153	09°26.1245	137		300
19/10/2018	07:25	50°11.0153	09°26.1245	137		300
19/10/2018	07:43	50°11.0549	09°22.2759	132		300
19/10/2018	07:43	50°11.0549	09°22.2759	132		300
19/10/2018	09:01	50°20.9982	09°26.8306	135		300
19/10/2018	09:01	50°20.9982	09°26.8306	135		300
19/10/2018	10:14	50°30.6167	09°30.1525	123		300
19/10/2018	10:14	50°30.6167	09°30.1525	123		300
19/10/2018	11:16	50°38.3465	09°33.4208	131		300
19/10/2018	11:16	50°38.3465	09°33.4208	131		300
19/10/2018	12:18	50°46.6037	09°36.6453	120		300
19/10/2018	12:18	50°46.6037	09°36.6453	120		300
19/10/2018	15:16	51°09.2108	09°45.9051	119		300
19/10/2018	15:45	51°08.5277	09°45.5681	120		300
19/10/2018	16:23	51°30.088	09°47.310	110		300
19/10/2018	16:26	51°12.979	09°46.831	110		300
19/10/2018	17:24	51°09.6997	09°36.6232	112		300
19/10/2018	17:24	51°09.6997	09°36.6232	112		300
19/10/2018	18:26	51°06.129	09°24.928	118		300
19/10/2018	18:26	51°06.129	09°24.928	118		300
19/10/2018	19:30	51°02.372	09°12.869	118		300
19/10/2018	19:30	51°02.372	09°12.869	118		300
19/10/2018	20:28	50°59.015	09°02.115	115		300
19/10/2018	20:28	50°59.015	09°02.115	115		300
19/10/2018	21:28	50°55.449	08°50.669	113		300
19/10/2018	21:28	50°55.449	08°50.669	113		300
19/10/2018	22:27	50°57.566	08°43.877	109		300
19/10/2018	22:27	50°57.566	08°43.877	109		300
19/10/2018	23:27	51°03.157	08°41.314	112		300
19/10/2018	23:27	51°03.157	08°41.314	112		300
19/10/2018	23:32	51°03.667	08°41.076	110		
19/10/2018	23:34	51°03.832	08°41.002	110		
19/10/2018	23:42	51°04.646	08°40.641	110		300
20/10/2018	00:40	51°10.073	08°38.143	108		300

20/10/2018	00:40	51°10.073	08°38.143	108		300
20/10/2018	01:40	51°16.267	08°35.021	100		300
20/10/2018	01:40	51°16.267	08°35.021	100		300
20/10/2018	02:40	51°22.402	08°32.402	94		300
20/10/2018	02:40	51°22.402	08°32.402	94		300
20/10/2018	03:40	51°28.696	08°29.211	90		300
20/10/2018	03:40	51°28.696	08°29.211	90		300
20/10/2018	04:40	51°34.367	08°26.534	68		300
20/10/2018	04:40	51°34.367	08°26.534	68		300
20/10/2018	04:47	51°35.132	08°26.143	64		300
23/10/2018	18:00	51°24.235	08°31.580	98	Y	300
23/10/2018	18:14	51°23.152	08°32.290	91		300
23/10/2018	18:18	51°22.616	08°32.509	91		300
23/10/2018	19:27	51°13.511	08°36.734	106		300
23/10/2018	20:36	51°09.624	08°38.683	107		300
23/10/2018	22:22	50°54.962	08°45.589	106		300
23/10/2018	22:31	50°54.504	08°44.923	110		300
23/10/2018	23:22	51°00.873	08°41.901	101		300
24/10/2018	01:10	51°14.958	08°35.225	92		300
24/10/2018	02:05	51°27.490	08°31.641	65		300
24/10/2018	04:27	51°36.228	08°36.228			

8.3 Sediment grab log

CV18034 Grab sample master sheet	Lat (from DataViz)	Long (from DataViz)	Sampled
CV18034_01GS	51° 38' 167''	-08° 28' 501''	N
CV18034_02GS	51° 38' 217''	-8° 27' 881''	N
CV18034_03GS	51° 38' 105''	-8° 29' 110''	N
CV18034_04GS	51° 38' 769''	-8° 29' 882''	N
CV18034_04aGS	51° 38' 778''	-8° 29' 844''	N
CV18034_05GS	51° 38' 822''	-8° 28' 841''	Y
CV18034_06GS	51° 39' 108''	-8° 28' 355''	N
CV18034_07GS	51° 39' 428''	-8° 29' 234''	N
CV18034_08GS	51° 39' 192''	-8° 29' 604''	N
CV18034_08aGS	51° 39' 209''	-8° 29' 570''	N
CV18034_9GS	51° 39' 181''	-8° 29' 964''	Y
CV18034_10GS	51° 39' 739''	-8° 30' 178''	N
CV18034_10aGS	51° 39' 739''	-8° 30' 178''	N
CV18034_11GS	51° 39' 672''	-8° 30' 638''	N
CV18034_12GS	51° 39' 997''	-8° 30' 069''	N
CV18034_13GS	51° 39' 887''	-8° 29' 925''	Y
CV18034_14GS	51° 38' 276''	-8° 28' 479''	N
CV18034_14aGS	51° 38' 283''	-8° 28' 426''	N
CV18034_15GS	51° 38' 682''	-8° 28' 819''	N
CV18034_15aGS	51° 38' 707''	-8° 28' 759''	Y
CV18034_16GS	51° 39' 033''	-8° 29' 251''	N
CV18034_17GS	51° 39' 398''	-8° 28' 744''	N
CV18034_17aGS	51° 39' 450''	-8° 28' 693''	N
CV18034_18GS	51° 46' 930''	-8° 16' 198''	N
CV18034_18aGS	51° 46' 924''	-8° 16' 172''	N
CV18034_19GS	51° 46' 393''	-8° 15' 500''	Y
CV18034_20GS	51° 46' 428''	-8° 16' 149''	N
CV18034_21GS	51° 45' 982''	-8° 15' 428''	Y

CV18034_22GS	51° 45' 790''	-8° 14' 732''	N
CV18034_23GS	51° 45' 281''	-8° 14' 757''	Y
CV18034_24GS	51° 45' 709''	-8° 11' 953''	N
CV18034_25GS	51° 45' 709''	-8° 11' 900''	Y
CV18034_26GS	51° 45' 090''	-8° 11' 347''	Y
CV18034_27GS	51° 44' 847''	-8° 13' 138''	N
CV18034_28GS	51° 45' 021''	-8° 13' 828''	Y
CV18034_29GS	51° 44' 845''	-8° 14' 539''	Y
CV18034_30GS	51° 44' 723''	-8° 15' 287''	N
CV18034_30aGS	51° 44' 704''	-8° 15' 260''	Y
CV18034_31GS	51° 43' 855''	-8° 15' 650''	Y
CV18034_32GS	51° 43' 178''	-8° 16' 226''	N
CV18034_32aGS	51° 43' 176''	-8° 16' 192''	N
CV18034_33GS	51° 42' 804''	-8° 14' 613''	Y
CV18034_33aGS	51° 42' 796''	-8° 14' 586''	Y
CV18034_34GS	51° 43' 301''	-8° 13' 619''	N
CV18034_34aGS	51° 43' 283''	-8° 13' 582''	N
CV18034_35GS	51° 44' 060''	-8° 14' 645''	N
CV18034_35aGS	51° 44' 048''	-8° 14' 610''	N
CV18034_36GS	51° 44' 122''	-8° 14' 936''	Y
CV18034_37GS	51° 44' 023''	-8° 12' 259''	N
CV18034_37aGS	51° 44' 019''	-8° 12' 222''	N
CV18034_38GS	51° 44' 404''	-8° 10' 913''	N
CV18034_39GS	51° 44' 401''	-8° 10' 147''	Y
CV18034_40GS	51° 47' 777''	-7° 59' 385''	Y
CV18034_41GS	51° 47' 961''	-7° 58' 503''	Y
CV18034_42GS	51° 48' 336''	-7° 57' 960''	Y
CV18034_43GS	51° 48' 758''	-7° 58' 517''	N
CV18034_43aGS	51° 48' 765''	-7° 58' 426''	N
CV18034_44GS	51° 48' 899''	-7° 57' 720''	N

CV18034_44aGS	51° 48' 835''	-7° 57' 841''	Y
CV18034_45GS	51° 49' 216''	-7° 57' 858''	Y
CV18034_46GS	51° 49' 614''	-7° 57' 704''	N
CV18034_47GS	51° 49' 709''	-7° 57' 658''	N
CV18034_47aGS	51° 49' 696''	-7° 57' 650''	N
CV18034_48GS	51° 49' 943''	-7° 57' 960''	N
CV18034_48aGS	51° 49' 919''	-7° 57' 955''	N
CV18034_48bGS	51° 49' 900''	-7° 57' 951''	N
CV18034_49GS	51° 50' 004''	-7° 58' 896''	N
CV18034_50GS	51° 50' 450''	-7° 58' 397''	N
CV18034_51GS	51° 50' 558''	-7° 48' 732''	N
CV18034_52GS	51° 50' 541''	-7° 48' 733''	N
CV18034_53GS	51° 51' 099''	-7° 47' 426''	Y
CV18034_54GS	51° 53' 317''	-7° 48' 670''	N
CV18034_54aGS	51° 53' 298''	-7° 48' 682''	Y
CV18034_55GS	51° 55' 366''	-7° 45' 096''	N
CV18034_55aGS	51° 55' 366''	-7° 45' 096''	N
CV18034_56GS	51° 55' 421''	-7° 44' 781''	Y
CV18034_57GS	52° 02' 595''	-7° 30' 257''	Y
CV18034_58GS	52° 01' 233''	-7° 31' 713''	N
CV18034_58aGS	52° 01' 220''	-7° 31' 219''	N
CV18034_59GS	52° 02' 310''	-7° 31' 177''	N
CV18034_60GS	52° 02' 222''	-7° 30' 415''	N
CV18034_60aGS	52° 02' 202''	-7° 30' 448''	N
CV18034_61GS	52° 01' 687''	-7° 29' 985''	N
CV18034_62GS	52° 01' 022''	-7° 29' 974''	N
CV18034_62aGS	52° 00' 998''	-7° 30' 002''	N
CV18034_63GS	52° 00' 631''	-7° 30' 776''	N
CV18034_63aGS	52° 00' 596''	-7° 30' 804''	N
CV18034_64GS	52° 00' 384''	-7° 31' 593''	N

CV18034_64aGS	52° 00' 362''	-7° 31' 628''	N
CV18034_65GS	52° 00' 341''	-7° 32' 750''	N
CV18034_66GS	52° 01' 098''	-7° 32' 020''	N
CV18034_67GS	51° 59' 310''	-7° 32' 096''	N
CV18034_68GS	51° 59' 098''	-7° 31' 834''	N
CV18034_68aGS	51° 59' 059''	-7° 31' 861''	N
CV18034_69GS	52° 04' 107''	-7° 00' 753''	Y
CV18034_70GS	52° 06' 392''	-6° 59' 897''	N
CV18034_70aGS	52° 06' 360''	-6° 59' 903''	N
CV18034_71GS	52° 06' 918''	-6° 59' 008''	N
CV18034_71aGS	52° 06' 891''	-6° 59' 043''	Y
CV18034_72GS	52° 07' 722''	-6° 58' 055''	N
CV18034_73GS	52° 05' 006''	-6° 46' 971''	N
CV18034_74GS	52° 05' 163''	-6° 45' 370''	Y
CV18034_75GS	52° 05' 012''	-6° 43' 201''	N
CV18034_75aGS	52° 04' 991''	-6° 43' 245''	N
CV18034_76GS	52° 05' 240''	-6° 43' 365''	N
CV18034_77GS	52° 06' 990''	-6° 44' 980''	N
CV18034_78GS	52° 06' 282''	-6° 45' 271''	N
CV18034_79GS	52° 05' 690''	-6° 45' 946''	N
CV18034_79aGS	52° 05' 670''	-6° 45' 994''	N
CV18034_80GS	52° 05' 464''	-6° 45' 115''	N
CV18034_81GS	52° 05' 488''	-6° 44' 257''	N
CV18034_82GS	52° 05' 026''	-6° 43' 810''	N
CV18034_83GS	52° 05' 041''	-6° 44' 716''	N
CV18034_83aGS	52° 05' 034''	-6° 44' 716''	N
CV18034_84GS	52° 05' 127''	-6° 45' 763''	N
CV18034_85GS	52° 04' 636''	-6° 45' 270''	N
CV18034_85aGS	52° 04' 632''	-6° 45' 312''	N
CV18034_86GS	52° 04' 730''	-6° 46' 270''	N

CV18034_86aGS	52° 04' 724''	-6° 46' 324''	N
CV18034_87GS	52° 04' 890''	-6° 47' 195''	N
CV18034_88GS	52° 03' 821''	-7° 27' 698''	N
CV18034_89GS	52° 05' 592''	-7° 27' 268''	N
CV18034_90GS	52° 05' 682''	-7° 00' 350''	N
CV18034_90aGS	52° 05' 651''	-7° 00' 314''	N
CV18034_91GS	52° 05' 785''	-6° 59' 097''	N
CV18034_91aGS	52° 05' 759''	-6° 59' 073''	N
CV18034_92GS	52° 06' 279''	-6° 59' 691''	N
CV18034_92aGS	52° 06' 242''	-6° 59' 666''	N
CV18034_93GS	52° 06' 316''	-6° 58' 313''	N
CV18034_93aGS	52° 06' 274''	-6° 58' 463''	N
CV18034_94GS	52° 06' 913''	-6° 59' 031''	Y
CV18034_94aGS	52° 06' 868''	-6° 59' 015''	Y
CV18034_95GS	52° 06' 872''	-6° 57' 811''	N
CV18034_95aGS	52° 06' 845''	-6° 57' 791''	N
CV18034_96GS	52° 07' 419''	-6° 58' 583''	N
CV18034_96aGS	52° 07' 394''	-6° 58' 576''	N
CV18034_97GS	52° 07' 815''	-6° 58' 114''	N
CV18034_97aGS	52° 07' 784''	-6° 58' 148''	N
CV18034_98GS	52° 07' 735''	-6° 57' 735''	N
CV18034_99GS	51° 08' 305''	-8° 4' 735''	N
CV18034_100GS	51° 37' 478''	-8° 1' 735''	N
CV18034_101GS	51° 39' 558''	-8° 4' 735''	Y
CV18034_102GS	51° 43' 565''	-8° 16' 735''	N
CV18034_102aGS	51° 43' 550''	-8° 16' 735''	N
CV18034_103GS	51° 43' 476''	-8° 13' 735''	N
CV18034_103aGS	51° 43' 465''	-8° 13' 735''	N
CV18034_104GS	51° 44' 308''	-8° 10' 735''	N
CV18034_104aGS	51° 44' 292''	-8° 10' 735''	N

CV18034_105GS	51° 45' 203''	-8° 14' 707''	N
CV18034_106GS	51° 45' 605''	-8° 12' 501''	N
CV18034_107GS	51° 46' 469''	-8° 13' 889''	N
CV18034_107aGS	51° 46' 467''	-8° 13' 865''	N
CV18034_108GS	51° 46' 321''	-8° 46' 877''	N
CV18034_109GS	51° 40' 411''	-8° 26' 085''	N
CV18034_110GS	51° 40' 390''	-8° 26' 510''	N
CV18034_110aGS	51° 40' 380''	-8° 26' 462''	N
CV18034_111GS	51° 39' 169''	-8° 27' 508''	N
CV18034_111aGS	51° 39' 151''	-8° 27' 446''	N
CV18034_112GS	51° 39' 316''	-8° 29' 153''	N
CV18034_113GS	51° 39' 583''	-8° 29' 649''	N
CV18034_114GS	51° 38' 485''	-8° 30' 350''	N
CV18034_114aGS	51° 38' 475''	-8° 30' 362''	N
CV18034_115GS	51° 38' 464''	-8° 29' 857''	N
CV18034_116GS	51° 38' 450''	-8° 28' 663''	N
CV18034_116aGS	51° 38' 455''	-8° 28' 632''	N

8.4 Vibrocore log

Date	Time	Station	Lat	Long	Depth (mbsl)	Apparent Penetration (cm)	Core length (cmbsf)
20.10.2018	10:18	CV18034_01VC	51°39.804	08°29.869	24	0	105
20.10.2018	10:47	CV18034_02VC	51°39.112	08°29.946	27	150	81
20.10.2018	11:26	CV18034_03VC	51°38.789	08°28.896	36	0	36
20.10.2018	14:05	CV18034_03aVC	51° 38' 795''	-8° 28' 878''	28	150	100
20.10.2018	14:29	CV18034_04VC	51° 38' 095''	-8° 28' 504''	44	250	207
20.10.2018	16:10	CV18034_05VC	51° 46' 824''	-8° 16' 197''	20	50	115
20.10.2018	17:18	CV18034_06VC	51° 46' 430''	-8° 16' 100''	22	0	77
21.10.2018	07:06	CV18034_07VC	51° 46' 431''	-8° 15' 180''	27	0	0
21.10.2018	07:20	CV18034_07aVC	51° 44' 680''	-8° 15' 286''	27	0	83
21.10.2018	07:55	CV18034_08VC	51° 43' 275''	-8° 12' 305''	40	0	0
21.10.2018	/	CV18034_09VC	51° 51' 027''	-7° 47' 430''	/	0	~12
21.10.2018	14:06	CV18034_10VC	51° 53' 278''	-7° 48' 688''	25	0	39
21.10.2018	/	CV18034_11VC	51° 55' 383''	-7° 44' 775''	23	30	39
21.10.2018	/	CV18034_12VC	52° 02' 564''	-7° 30' 273''	35	0	33
21.10.2018	16:33	CV18034_12aVC	52° 02' 498''	-7° 30' 322''	35	0	13
21.10.2018	16:39	CV18034_12bVC	52° 02' 452''	-7° 30' 357''	35	35 - 40 cm	100
21.10.2018	/	CV18034_13VC	52° 01' 193''	-7° 31' 853''	30	0	164
22.10.2018	07:09	CV18034_14VC	52° 04' 055''	-7° 00' 770''	39	0	12
22.10.2018	07:59	CV18034_15VC	52° 06' 822''	-6° 59' 127''	24	0	~12
22.10.2018	08:21	CV18034_16VC	52° 07' 697''	-6° 58' 205''	20	0	30
22.10.2018	09:32	CV18034_17VC	52° 05' 006''	-6° 47' 021''	34	0	34
22.10.2018	09:58	CV18034_18VC	52° 05' 118''	-6° 45' 420''	33	0	56
22.10.2018	10:36	CV18034_19VC	52° 05' 216'	-6° 43' 410''	32	0	86
22.10.2018	11:24	CV18034_20VC	52° 06' 967''	-6° 45' 036''	33	0	69
22.10.2018	12:20	CV18034_21VC	52° 05' 462''	-6° 44' 347''	32	0	57
22.10.2018	16:25	CV18034_22VC	52° 03' 787''	-7° 27' 686''	24	0	77
22.10.2018	16:48	CV18034_23VC	52° 05' 592''	-7° 27' 264''	27	0	75

23.10.2018	06:55	CV18034_24VC	51° 38' 191''	-8° 04' 320''	85	120 cm	62
23.10.2019	07:37	CV18034_25VC	51° 37' 429''	-8° 01' 893''	93	300 cm	243
23.10.2020	08:24	CV18034_26VC	51° 39' 516''	-8° 04' 773''	77	0	52
23.10.2021	11:30	CV18034_27VC	51° 45' 180''	-8° 14' 700''	35	0	33
23.10.2022	11:52	CV18034_28VC	51° 45' 571''	-8° 12' 561''	23	0	26
23.10.2023	14:10	CV18034_29VC	51° 39' 147''	-8° 27' 406''	39	75 cm	62
23.10.2024	14:30	CV18034_30VC	51° 39' 322''	-8° 29' 100''	32	170 cm	130
23.10.2025	14:50	CV18034_31VC	51° 39' 579''	-8° 29' 624''	23	175 cm	125
23.10.2026	15:40	CV18034_32VC	51° 38' 450''	-8° 28' 600''	41	0	109