Section A: Award Summary

Title of Research Survey and Survey Code:	CE20009: Constraining the Impact of Arctic Amplification in the Nordic Sea: A biogeochemical approach	
Co-Ordinator/ Chief Scientist:	Dr. Audrey Morley	
Vessel used for ship-time:	*RV Celtic Voyager* ☐ *RV Celtic Explorer* **x**	
Total number of days at sea:	23	
Total number of grant-aided ship-time days awarded:	23	
Dates of survey:	24th of August – 16th of September 2020	
Mobilisation/Demobilisation Ports	Killybegs, County Donegal/ Galway	
Survey Personnel:	*No. of Scientists* *10*	*No. of Students* *1*
Final Report Completed by:	*Audrey Morely and Janina Buescher*	**Date**:

Section B: Description of the Research Survey

B1 Overview of survey personnel

Names	***Institute/ Department/ Course***	***Position (undergraduate/ post graduate etc)***	***Number of Days***
Scientists			
Audrey Morley	*NUIG (Ireland)*	*Lecturer*	*23*
Peter Croot	*NUIG (Ireland)*	*Professor*	*23*
Ulysses Ninnemann	*University of Bergen (Norway)*	*Professor*	*15*
Julie Meilland	*MARUM (Germany)*	*Post-Doc*	*23*
Pål Tore Morkved	*University of Bergen (Norway)*	*Technician*	*15*
Tali Babila	*NOC (UK)*	*Post-Doc*	*23*
Jessica Crumpton-Banks	*NUIG (Ireland)*	*Post-Doc*	*23*
Janina Büscher	*NUIG (Ireland)*	*Post-Doc*	*23*
Aedín McAleer	*NUIG (Ireland)*	*Technician*	*23*
Steven Churchett	*-*	*Film Maker*	*23*
Students			
Malin Lunde	*University of Bergen (Norway)*	*Msc Student*	*15*

B2 Objectives

The central theme of Cruise CE20009/CIAAN was to monitor and capture the signal transfer of modern climate system (temperature, salinity, and the carbonate system) and biogeochemical (Nutrients, Oxygen, CDOM) parameters into climate/oceanic archives. The analysis of datasets collected will enable us to extend our short observational records beyond preindustrial conditions. Specifically our central objectives were to:

(1) Monitor current hydrographic conditions in the Nordic and Greenland Seas. One of our key objectives was to collect an extensive hydrographic dataset for surface and deep waters including T, S, Nutrients, DIC, TA, and climate relevant dissolved

gases. This objective complemented work carried out by the Ocean Climate S Rockall Trough cruises that facilitate long-term monitoring of the deep-water environment to the west of Ireland, VOCAB, and scientific objectives of the GO-SHIP (line) A02. *Ship-based operations and data collected during the survey allowed us to meet this objective.*

(2) Determine Biogeochemical processes in the upper ocean. To assess the biogeochemical processes pertinent to pico and nanoplankton distributions our main objectives were to (i) Map the distribution and concentration of Colour Dissolved Organic Matter (CDOM), nitrate, nitrite, silicate and phosphate and oxygen. (ii) Determine the O_2/Ar ratio in the upper water column and measure dissolved DMS (dimethyl sulphide) concentrations. (iii) Determine how biogeochemical processes affects light absorption and fluorescence through the water column. *Ship-based operations and data collected during the survey allowed us to meet this objective.*

(3) Determine the climate signal in the geologic archive. Here we proposed to improve our understanding of how ocean acidification and warming are recorded in marine archives by combining the hydrographic survey with the ***development of new palaeoceanographic tools***. Specifically we *assessed the transfer of modern hydrographic conditions into Arctic planktonic foraminfiera Neogloboquadrina pachyderma (NP)* using specimen collected from (1) vertically stratified plankton nets and (2) multicore tops collected from the Nordic Seas. The combination of tows and multicore tops, will allow us to determine the importance of phenology, ecology, the mobility of NP in the water column during their life cycle, and how these are linked to the climate signal recorded in geologic archives. *Ship-based operations and data collected during the survey allowed us to meet this objective.*

(5) Constraining the transfer of salinity into the geologic archive. Oxygen isotopes ($\delta^{18}O$) in foraminifera is a well-established tool to assess past ocean physical property changes. Samples for water column isotopes (δD and $\delta^{18}O$) and salinity were collected at each station where foraminifera were collected in order to provide contemporaneous salinity- $\delta^{18}O_w$ water information for determining the signal transfer of these properties into foraminifera. *Ship-based operations and data collected during the survey allowed us to meet this objective.*

(6) Constrain the transfer of the carbonate system into the geologic archive. To determine the carbonate system using planktonic foraminifera it is necessary to constrain two parameters of the carbonate system, alongside temperature and salinity. Boron isotopes ($\delta^{11}B$) is a proxy for seawater pH and B/Ca is related to borate / dissolved inorganic carbon (DIC) of seawater. Since DIC is primarily composed of bicarbonate [HCO_3^-] at typical seawater pH values, the combination of $\delta^{11}B$ and B/Ca allows for quantification of seawater CO_2 [16]. Here we aimed to improve empirical calibration equations for $\delta^{11}B$ and B/Ca on foraminifera collected from plankton tows and multicore tops to 1) extend the B/Ca dataset [20] for NP to low carbonate values inherent of Arctic environments, 2) better constrain proxy sensitivities and 3) improve our understanding of boron incorporation into foraminiferal calcite. *Ship-based operations and data collected during the survey allowed us to meet this objective.*

(7) Constraining natural vs. anthropogenic carbon cycling using NP. The uptake of fossil fuel CO_2 by the oceans is apparent in the rapid decline of oceanic carbon isotopes, termed the $\delta^{13}C$-Suess effect [21] Marine calcifiers record these changes, as well as natural carbon cycle changes, in the isotopic values ($\delta^{13}C$) of their tests. We will determine the $\delta^{13}C$ of foraminifera (water column and sediment surface) as well as water $\delta^{13}C_{DIC}$ in order to establish the determinants for the signal transfer of carbon isotopes into NP. *Ship-based operations and data collected during the survey allowed us to meet this objective.*

(8) Investigate the variation in cetacean and seabird species between Irish waters and Nordic waters in the survey area. Irish and Nordic waters are ecologically important for many species of seabirds and cetaceans. Irish waters are important migratory corridors for species such as fin and blue whales [22] where they migrate from their northern feeding grounds to their breeding grounds in the south. Changes in climate is likely to affect cetacean and seabird distribution, range, migration patterns and reproductive success [23]. We expected to carry out visual observations for both seabirds and cetaceans from the point of sailing to the return, *however due to a significantly reduced Science party from 21 to 11 Scientists, we were not able to meet this objective.*

B3 Overview of research survey

24th Aug: At 10:30 a.m. the scientific party embarking in Ireland boarded the RV *Celtic Explorer* in Killybegs, County Donegal. After all scientists were sent to their cabins to have a shower and change clothes as a safety measure with regard to COVID-19, a safety induction training was organized by the 2nd officer. After lunch, we set up our equipment for the survey and made sure to secure everything tight. Unfortunately, the refrigerated container that was set up on the deck of the vessel for climate-controlled experiments, could not be opened from the inside, representing a safety issue in that persons who work in there for long hours are not able to escape without somebody from outside letting them out. At 6:30 p.m. the RV *Celtic Explorer* departed on time with activated underway systems (EK60, 320 2040 multibeams).

25th Aug: Despite escaping the Irish territories on our way towards our first destination, Bergen, Norway, and seeking shelter in the passage between Scotland and the Hebrides, we felt the back end of storm *Francis* with swells of 2 metres plus omnidirectional / mixed seas. At 10 a.m. we gathered for a first science meeting to discuss deployment procedures of the different scientific instruments, sampling order and labelling regime. Film maker Steven Churchett, who is joining us to record our activities during this survey, started to interview all scientists on board with regard to their scientific objectives for the CIAAN survey.

26th Aug: During passage, interviews continued while we were trying to get accustomed to the rocky sea conditions.

27th Aug: In the morning, we arrived in Bergen's coastal waters. At 7 a.m. (8 a.m. local time in Norway) the pilot boarded the RV *Celtic Explorer* and at 9 a.m. (10 a.m. local time) we docked in Bergen port on time to collect the Norwegian scientists and further scientific equipment. After the safety induction for the Norwegian's and a short briefing, the complete science crew gathered together to finalize science operations and sampling procedure. In the afternoon, the chemistry container was set up and equipment was secured. We left Bergen port on time, but stopped outside the fjord to adjust the gravity core (GC) on the starboard side of the RV *Celtic Explorer*. After about an hour we headed towards our first station further north in the Norwegian Sea (see map, Fig. 1).

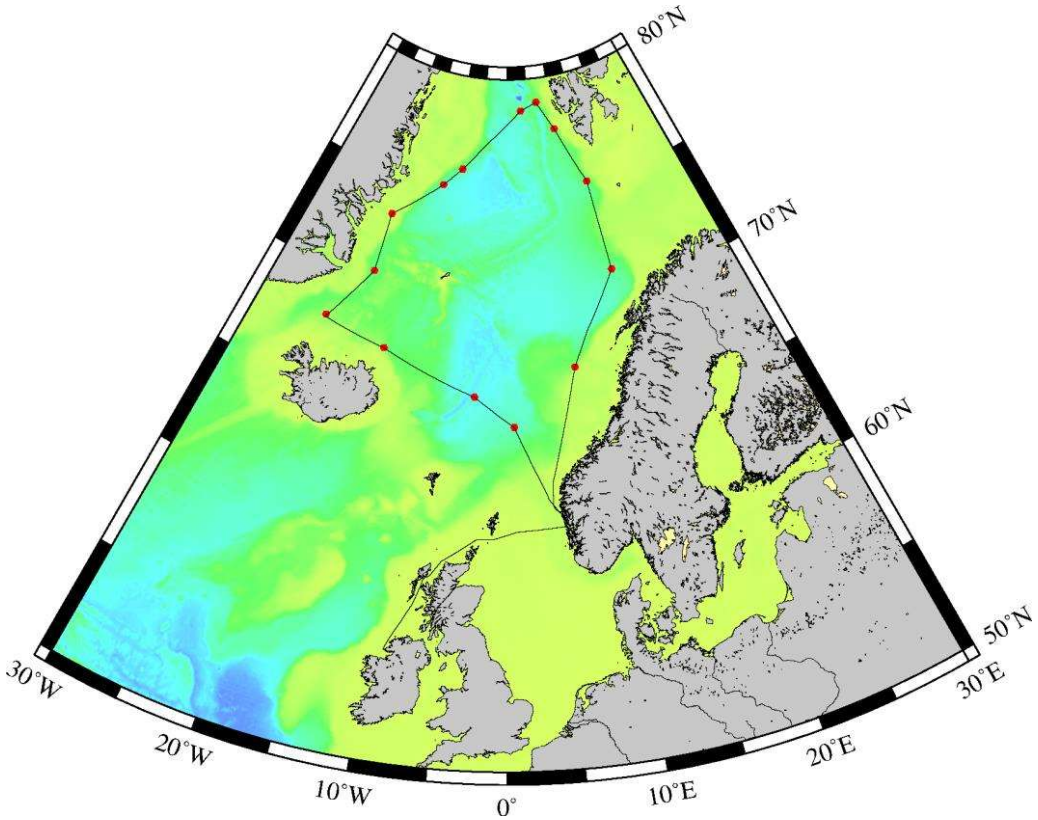

Figure 1 Map of cruise track and Stations sampled during Project CIAAN provided by Prof Peter Croot.

28th Aug: The day before our arrival at station 1 (Fig. 1) we prepared for the first sampling events. Weather has calmed down and so we were ready for equipment trials and further strategy planning of sampling, Delta Ray isotope Analyser and Multicore drilling.

29th Aug: We arrived on **Station 1** at 6:18 a.m. and started with the vertical Multinet (MN-vertical; 7:31 a.m., St. 01-01) right away. After one hour the first event was successfully finished with a slight delay because of a scroll faulty. Afterwards, the CTD was deployed (7:31 a.m., St. 01-02), but was delayed due to software issues that would not allow to fire the bottles. As some bottles did not fire when the CTD was recovered and back on deck at 9:05 a.m. and sample depth could not be determined, the collected water was not sampled and it was decided to repeat the CTD cast. First, however, the GC was deployed (9:32 a.m., St. 01-03) and successfully recovered with a 4.35 m deep penetrated sediment core (6 m barrel) that was immediately subsampled, stored, and refrigerated. Afterwards, a CTD test run was conducted with the CTD being lowered only a couple of metres to fire the bottles. After this was successful, the CTD was deployed once more, but unfortunately, the deployment had to be stopped due to an error on the main unit caused by a short due to a water leakage in the conducting cable. Thus, the CTD had to be retrieved again without samples collected. At 12:10 p.m., the multicore (MUC; St. 01-04) was deployed but came up empty (without any sediment) at 12:50 p.m. Two more trials (1:04 p.m. and 2:04 p.m.) with the MUC failed as well even though more weights were added in the last run, so that at 03.25 p.m. a small box core (Rheineck; St. 01-06) was deployed as alternative sediment sample gear. The last event for this day was the Multinet-oblique tow which was deployed at 04:05 p.m. (MN-oblique, St. 01-05), which was successful. By 04:55 p.m. we finished operations on station 1 and were on our way to station 2.

30th Aug-31st Aug: While transiting towards **Station 2** porewater sampling of the sediment core collected at station 1 and slicing of the box core was carried out in the wet lab. At 8:42 p.m. we arrived at station 2. The MN-vertical was deployed right away (8:58 p.m.; St. 02-01) and successfully brought up samples at 9:42 p.m., however living foraminiferans were only found in the upper 50 m. Afterwards, the CTD was tested for transmissometer voltage and fluorescence signal and deployed at 10:00 p.m. (St. 02-02). The CTD cable had been reterminated after St 1. with the main control unit exchanged also for the backup system. The CTD reached bottom at 10:52 p.m. and was back on deck at 00:03 a.m. All bottles fired successfully, however one bottle (#16) was leaking as it didn't close properly on the lower end. The GC was deployed at 0:26 a.m. on 31st Aug (St. 02-03) and recovered successfully at 1:30 a.m. with a 3.70 m sediment core. At this rather deep station the MUC was not deployed again. Instead, the box core was deployed (St. 02-06), which failed due to implosion of the frame. Last device for this station was the MN-oblique (St. 02-05) deployed at 04:25 a.m. By 04:50am operations finished at Station 2 and we were on our way to station 3. During the day, sample processing took place (i.e. pore water sampling from GC, oxygen measurements).

1st Sept: **Station 3** was reached at 5:54 a.m. and the usual event procedure started with deployment of the MN-vertical (St. 03-01 at 06:05 a.m.). It was recovered at 7:00 a.m. with samples, but unfortunately one of the nets broke as well as the cod-end. After the CTD transmissometer test the CTD was deployed at 7:14 a.m. (St. 03-02). CTD recovery was successful with all bottles fired except one, after which the GC was deployed straight away (St. 03-03), which brought up a 4.30 m sediment core about an hour later. Afterwards, the MUC (St. 03-04) was tried again after modifications were applied (damper demounted, which failed, so that the repaired box core was deployed instead (St. 03-06). However, also the box core did not bring up any sediment sample, so the assumption was made that the currents were too strong and the wire angle too slant to properly sink into the sediment. At around 14:00 p.m. we therefore headed towards the next station further north (Station 5) (Note: station 4 was skipped due to time shortage and as stations 4 and 5 are fairly close to each other). The MN-obliquè was skipped at this station as there was only few foraminifera found in the MN-vertical and the strong currents would have put the multinet frame at risk of damage.

2nd – 3rd Sept: When arriving at **Station 5** at 5:15 a.m. the standard sequence of operations started once more with the MN-vertical being deployed (St. 05-01; 5:25 a.m.). It brought up foraminifera from the first 100 m water depth at 6:15 a.m. Cold water species were rare and instead foraminifera assemblages were representative of warmer surface waters typically found further south. The CTD went in at 6:30 a.m. (St. 05-02) and all except one Niskin bottle fired. The GC brought up a 4 m sediment core. (St. 05-03), after which the MUC was tried again (St. 05-04). This site was shallower at 1296m and bottom currents

were weaker, which resulted in the successful recovery of the MUC. All four tubes were filled for the first time during this survey. The MN-oblique was deployed at 10:25 a.m. (St. 05-05) and back on deach at 10:46 a.m., after which we started steaming towards station 6 (Fig. 1), passing the beautiful west coast of Spitsbergen (Svalbard archipelago). At 7:10 p.m. we arrived at **Station 6** the most northerly station west of Svalbard and started our routine sampling procedure. MN-vertical went in the water at 7:31 p.m. (St. 06-01), the CTD at 8:10 p.m. (St. 06-02), followed by the GC (St. 06-03), which brought up a 4.25 m sediment core. Two trials with the MUC failed most likely due to pre-trigger issues. Therefore, the box core was deployed (St. 06-06) which did not trigger at all. The MN-oblique was deployed at 1:58 a.m. on the 3rd September (St. 06-05) and successfully retrieved with samples. We were on the way at 02:21 a.m.

3rd Sept: At 9:00 a.m. we arrived at **Station 7** with 25 kn northerly winds and quite some swell compared to yesterday. After solving some issues with the winch, the MN-vertical was deployed at 9:28 a.m. (St. 07-01), but unfortunately one of the nets broke again. The CTD went in the water at 10:12 a.m. (St. 07-02) and was lowered more slowly than usual due to the rougher weather conditions. Since this station is also the deepest one with 2520 m, it took about an hour to reach the bottom (11:11 a.m.) and came back on deck at 12:25 a.m. The GC was deployed (St. 07-03) and came back on deck with a 3.21 m long sediment core. Due to the rough weather conditions, MUC was not deployed and instead, the box core was used (St. 07-06) but unfortunately it did not trigger. The MN-oblique was skipped at this station because of the rough weather. Thus, we started heading towards station 8 as soon as everything was secured after the box core (5:07 p.m.).

4th Sept: We arrived on **Station 8** at around 5 a.m., but as the weather conditions prevented us from deploying research equipment and the weather forecast promised worse conditions later on, we continued transiting to the next station. Arriving on **Station 9** at 2:35 p.m., we delayed the MN-Vertical due to weather and instead began operations with the CTD (St. 09-02) at 2:49 p.m. The CTD was retrieved at 4:35 p.m. with one of the Niskin bottles coming up with a broken lid. The GC was deployed next (St. 09-03; 4:55 p.m.) bringing up a 5.10 m sediment core. Afterwards, only the box core was deployed (St. 09-06), successfully bringing up a sample. The MUC was not deployed, however a shallow vertical tow was deployed down to 100m at 20:01 p.m. only to prevent damage given the rough weather conditions. By 20:18 operations were complete at Station 9 and we were on our way.

5th Sept: Arriving at **Station 10** at 5 a.m. the standard sequence of operations began with the deployment of the MN-vertical (St. 10-01). Due to a winch failure it could only be deployed to 40 m water depth and had to be recovered. The CTD was deployed afterwards (St. 10-02; 05:28 a.m.) and retrieved at 06:55 a.m. (one bottle not closed properly). The MN-vertical was deployed once more at 07:35 a.m. (St. 10-01), bringing up lots of NPS, the polar foraminifera species *Neogloboquadrina pachyderma* looked for all along. Afterwards, the GC went in (St. 10-03) The retrieved sediment core was 4.81 m long. As wind conditions were good today and the sea surface very calm, the MUC was deployed (St. 10-04) and successfully brought up 4 tubes full of sediment. At last, the MN-oblique was lowered at 12:38 p.m. (St 10-05), after which we steamed towards station 11 straight away at 1:25 p.m.

6th – 7th Sept: We arrived on **Station 11** at 3:40 a.m. and deployed the MN-vertical at 04:21 a.m. (St. 11-01). As the water depth is so shallow at this station (287 m), the net was only lowered to 100 m. The CTD went in the water at 5:48 a.m. with a little delay due to issues with the DP system (St. 11-02). Bottle #9 was not fired when the CTD came up at 5:59 a.m. Afterwards, the instruments were deployed in the following order: GC (St. 11-03), Box core (St. 11-06), MUC (St. 11-04), and MN-oblique (St. 11-05); all successful even though we were on the shelf with harder bottom structure. The GC brought up a 0.58 m sediment core and the MUC came up with all four tubes filled. By 08:15 operations were complete and we left station 11. We arrived at **Station 12** at 10:21 p.m. and started the usual sequence of operations with the MN-vertical (St. 12-01). Unfortunately, the nets did not fire as the nets were not opened before deployment. In expectance of bad weather conditions, the MUC was deployed next (St. 12-03; 23:50 p.m.), successfully coming up with 4 sediment filled tubes. At 02:03 a.m. on the 7th September, the CTD was deployed (St. 12-02) with all bottles fired. The MN-vertical was repeated afterwards at 02:47 As last event for this station, the GC was deployed (St. 12-04; 3:30 a.m.). At 10:07 p.m. we arrived at **Station 13** with choppy sea from 12-15 m/s wind speeds. However, the swell and wind calmed down since the last hours and so we tried our luck with the CTD as first event of this

rather shallow station (St. 13-02; 10:20 p.m.). Due to increasing high swell, deployment of any other instruments was not possible and we steamed towards station 14 at 01:35 a.m. on 08/09/2020.

8th Sept: At approximately 8 p.m. we arrived at **Station 14**. Due to very rough weather conditions (high swell and strong winds), only the CTD could be deployed, which went in the water at 8:24 p.m. (St. 14-01) followed by usual water sampling procedures. At 11 p.m. the station was finished and we headed towards station 16 (while skipping station 15 due to lack of time and the close proximity of stations 15 and 16).

10th Sept: We arrived on **Station 16** at 5:00 a.m. and started with the CTD (St. 16-02), as the swell was too high for net tows. After the CTD was back on deck at around 7:45 a.m., the GC was deployed (St. 16-03; 1.61 m sediment core). Afterwards, the MUC went in the water (St. 16-04), which failed at the first attempt and was deployed once more. The second time, it was successful and brought up four filled tubes. Since the weather conditions did not change in our favour for net deployments, we finished station work after the MUC and headed towards our last station of this survey, station 17.

11th Sept: We arrived on **Station 17** at 02:30 a.m. and started with the MN-vertical at 02:47 a.m. (St. 17-01), as weather conditions permitted to tow the net. At 03:32 a.m. the usual sequence of operations continued with CTD deployment (St. 17-02). The GC was deployed (St. 17-03), but failed. Another trial was attempted, which unfortunately caused the GC tube to bend. The MUC was thus not deployed at this station. The MN-oblique was also not deployed due to high swell. Therefore, we finished station work and started heading towards Bergen at 10:00 a.m.

12th Sept: Around lunchtime we arrived at the Norwegian coast close to Bergen and halted for about an hour to bring the GC frame in. At ca. 2:20 p.m. the pilot arrived on board and around 4:45 p.m. we arrived in Bergen's town centre to disembark our Norwegian colleagues including their research equipment.

16th Sept: At 5 a.m. we moored in Galway port and all scientific staff and equipment disembarked around 9 a.m. End of CIAAN survey.

Table 1 Summary of CIAAN station location, water depths, and operations. MN (vert.) refers to the deployment of the vertical Multinet frame down to 500 m water depth, GC refers to the 6 m long Gravity Core, MUC to the 4-tube Multicore, BC to the Rheineck Box Core and MN (Obl.) to the obliquely towed multinet frame at fve equally distant depths in the upper 100m. (y) indicates when deployment of equipment and recovery was successful (n) when deployment was cancelled or failed.

Station ID	Date	Lat	Long	Depth [m]	MN *(vert.)*	CTD	GC	MUC	BC	MN *(obl.)*
CE20009-01	29/08/20	66°58.10'N	07°38.2'E	1050	*y*	*n*	*y*	*n*	*y*	*y*
CE20009-02	30/08/20	70°55.27'N	14°21.5'E	2170	*y*	*y*	*y*	*n*	*n*	*y*
CE20009-03	01/09/20	74°59.76'N	13°56.9'E	1742	*y*	*y*	*y*	*n*	*n*	*n*
CE20009-04	*cancelled due to bad weather*									
CE20009-05	02/09/20	77°37.19'N	09°56.8'E	1296	*y*	*y*	*y*	*y*	*y*	*y*
CE20009-06	02/09/20	78°54.88'N	06°46.55'E	1490	*y*	*y*	*y*	*n*	*n*	*y*
CE20009-07	03/09/20	78°35.06'N	03°04.36'E	2520	*y*	*y*	*y*	*n*	*n*	*n*
CE20009-08	*cancelled due to bad weather*									
CE20009-09	04/09/20	75°49.93'N	08°11.12'W	1985	*y*	*y*	*y*	*n*	*y*	*n*
CE20009-10	05/09/20	75°00.00'N	11°85.28'W	2637	*y*	*y*	*y*	*y*	*y*	*y*
CE20009-11	06/09/20	73°09.41'N	18°04.48'W	287	*y*	*y*	*y*	*y*	*y*	*y*
CE20009-12	07/09/20	70°29,57'N	17°55,49'W	1674	*y*	*y*	*y*	*n*	*n*	*n*
CE20009-13	07/09/20	67°51,59'N	21°46,24'W	779.5	*n*	*y*	*n*	*y*	*y*	*n*
CE20009-14	08/09/20	67°20,15'N	14°12,06'W	1008	*n*	*y*	*n*	*n*	*n*	*n*
CE20009-15	*cancelled due to bad weather*									
CE20009-16	10/09/20	65°48,07'N	03°29,35'W	2890	*n*	*y*	*y*	*y*	*n*	*n*
CE20009-17	11/09/20	64°31,01'N	00°44,08'W	2647	*y*	*y*	*n*	*n*	*n*	*n*

B4 Benefits, impact and contribution of the outputs to marine research and the marine sector in general.

The cruise supports efforts to define a more comprehensive description of Nordic Seas ecosystem and will provide transformative insight into how ECVs are recorded in geologic archives. These will aid our understanding of short and long-term processes linked to current and past climate change and their impact on Arctic ecosystems. The innovative methodologies and unique research strategy employed to decipher the geochemical signature recorded in foraminifera will provide a major advancement in the field of palaeoceanography, material to guide the development of future funding (Horizon Europe, Blue Growth), and expand our collaborative networks. Furthermore, we expect that the application of our calibrations to past changes in arctic climate will improve validation experiments with general climate models to calibrate the response of the climate system to high magnitude changes in the Arctic. This is relevant to Ireland and NW Europe in general because there is growing consensus that current trends in Arctic amplification will increase the frequency of extreme weather events over northern mid-latitudes. The associated changes in atmospheric circulation are also likely to influence ocean circulation and upper ocean properties [43] resulting in a weaker subpolar gyre circulation, which in turn allows warmer and saltier waters to reach the west coast of Ireland and thereby impact the distribution of primary producers and economically important fisheries. Our efforts to constrain the magnitude of arctic climate change in response to global climate events is thus timely and of key importance when considering the development of adaptation strategies on land (e.g. flooding) and the marine environment (marine habitats/ fisheries).

To maximise the impact of our findings, results will be disseminated through several key pathways in accordance with the European Commission's 'Dissemination & Exploitation of Results' guidelines (H2020 Manual). First, open-access publication of results in high-profile journals and presentation at international conferences are the most appropriate routes for ensuring data, methodological innovations, and results provided by the cruise reach their intended scientific audience. Second, this work will generate several datasets and sample collections that, in addition to being published, will be accessible to other researchers via PANGAEA a data publisher for Earth & Environmental Sciences. Third, the survey will enhance the direct flow of new climate knowledge within the lead applicant's institution via research group meetings and incorporation of findings into outreach activities. A key outcome of this knowledge transfer will be the development of new, focused climate research initiatives led by the all applicants. Fourth, aligned with the EU strategy of science-informed decision making for adaptation to climate change, we will share our data on North Atlantic abrupt climate change via the Science Hub Communities of the European Commission's Joint Research Centre (JRC).

B5 Data

Sea Water via CTD & Rosette: samples were taken to asses temperature, Conductivity, Pressure, Oxygen, Turbidity, and Fluorescence, pH, Alkalinity, DIC, Nutrients, Chlorophyll, Salinity, Trace elements, Boron Isotopes, Oxygen and Carbon Isotopes).

Plankton via Multinet deployment: Samples were taken to assess foraminifera abundance and species distribution, by depth. Further, Trace elements, Boron Isotopes, Oxygen and Carbon Isotopes analysis will be performed on foraminifera tests.

Marine Sediments were collected via Multicore and Rheineck Box cores to collect the most recent geolgic archives and via gravity cores for long term archives of foraminifera.

Pore Waters of recovered sediments were sampled via Rhizons for temperature, salinity, pH, Oxygen, Carbon Isotopes, Nutrients, Trace elements, and Boron Isotopes.

Upon scientific publishing, we intend to share our dataset in the publicly accessible disciplinary repository, PANGAEA, using descriptive metadata as required/provided by that repository. The information system PANGAEA is operated as an Open Access library aimed at archiving, publishing and distributing georeferenced data from earth system research. The system guarantees long-term availability of its content through a commitment of the hosting institutions the Alfred Wegener Institute, Helmholtz Center for Polar and Marine Research (AWI) and the Center for Marine Environmental Sciences, University of Bremen (MARUM). Each dataset can be identified, shared, published and cited by using a Digital Object Identifier (DOI Name). PANGAEA also allows data to be published as supplements to science articles or as citable data collections in combination with data journals like ESSD, Geoscience Data Journal, Scientific Data, or others.

B6 Contribution to marine research programmes

Outline specific National/EU/International research programmes this survey supported. Please include the funding sources for these programmes as well as the total amount of funding leveraged (Repeat the table below, if necessary).

National/EU/International Research programme(s):	Marine Institute Post-Doctoral Fellowship programme 2019
Total Programme cost:	*€292,713*
Value to Irish partners:	*€292,713*
Project duration:	*Three years*
Contract no.:	PDOC/19/05/02
Project partners:	*Dr Audrey Morley, Prof Ulysses Ninnemann, Prof Gavin Foster*
Project web address:	*https://www.morpalaeolab.com/research*

National/EU/International Research programme(s):	Irish Centre for Research in Applied Geoscience (iCRAG) Research Grant from Science Foundation Ireland (Grant-Aid Agreement No. 13/RC/2092). Cofunded under the European Research Development Fund and by PIPCO RSG.
Total Programme cost:	*€29,453*
Value to Irish partners:	*€29,453*
Project duration:	*6 months (iCRAG 1 2015-2020)*
Contract no.:	13/RC/2092
Project partners:	*Prof Peter Croot*
Project web address:	*https://www.icrag-centre.com/*

National/EU/International Research programme(s):	JPI Climate & JPI Oceans 2019 Joint Call on Next Generation Climate Science or Oceans
Total project cost:	*€2.5M*
Value to Irish partners:	*€400,000*
Project duration:	*3 years*
Contract no.:	PDOC/19/05/02
Project partners:	*Atlantic International Research Centre (AIR Centre), Portugal; Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC), Italy; Intergovernmental Oceanographic Commission (IOC), UNESCO; Instituto Superior Técnico (IST), Portugal; Laboratoire d'Etudes en*

	Géophysique et Océanographie Spatiales (LEGOS), France; Institut de Recherche pour le Developpment (IRD), France; Latvijas Hidroekoloģijas institūtā. (LHEI), Latvia; Latvijas Universitate, Latvia; Marine & Freshwater Research Institute (MFRI), Iceland; Marine Institute (MI), Ireland; Norsk institutt for vannforskning (NIVA), Norway; NORCE, Norway; University of Liege, Belgium
Project web address:	*https://www.ce2coast.com/*

National/EU/International Research programme(s):	Marine Research Programme 2014-2020
Total project cost:	*€649,983*
Value to Irish partners:	*€649,983*
Project duration:	*3.5 years (includes COVID extension)*
Contract no.:	PBA/ME/16/01
Project partners:	*Marine Institute (Dr Evin McGovern)*
Project web address:	*https://www.nuigalway.ie/science-engineering/school-of-natural-sciences/disciplines/earth-ocean-science/research/vocab/*

National/EU/International Research programme(s):	The Nansen Legacy (Arven etter Nansen; AeN); Norwegian funded coordinated research effort on the changing Barents Sea.
Total Programme cost:	*740 million NOK (˜73 million Euros)—half from Research Council Norway, half in-kind from partners*
Value to Irish partners:	*€15,000*
Project duration:	*Six years, 2018-2023*
Contract no.:	Research Council Norway (Norges forskningsråd) 276730 & Ministry of Education and Research
Project partners:	*Professor Ulysses Ninnemann (link between CIAAN and AeN); AeN is a consortium of 10 different research institutions.*
Project web address:	*https://arvenetternansen.com/*

Appendices

Please number and attach any relevant Appendices here.