National Research Vessels

SHIP-TIME PROGRAMME

RESEARCH SURVEY REPORT

Survey Code:	Survey Name:	Chief Scientist/ Institution
CE23011	SiTrAc: Signal Tracking to unveil Arctic Climate variability	Audrey Morley

Section A: Award Summary

Title of Research Survey and Survey Code:	***SiTrAc:*** *Signal Tracking to unveil Arctic Climate variability. CE23011*	
Co-Ordinator/ Chief Scientist:	Audrey Morley	
Vessel used for ship-time:	*RV Celtic Voyager* ☐ *RV Celtic Explorer* ☒	
Total number of days at sea:	30	
Total number of grant-aided ship-time days awarded:	31	
Dates of survey:	21/07/2023-20/08/2023	
Mobilisation/Demobilisation Ports	Killybegs / Galway	
Survey Personnel:	*No. of Scientists* *10*	*No. of Students* *8*
Final Report Completed by:	Audrey Morley	**Date** 03/10/2023

Section B: Description of the Research Survey

B1 Overview of survey personnel

Names	***Institute/ Department/ Course***	***Position (undergraduate/ post graduate etc)***	***Number of Days***
Audrey Morley *Brian Ward* *Elwyn De La Vega* *Thomas Weiss* *Alessio Fabbrini* *Avery Fenton* *Allison Jacobel* *Nil Irvali* *Nicolaas Glock* *Alan*	*University of Galway* *University of Galway* *University of Galway* *University of Galway* *University of Galway* *University of Galway* *Middlebury College* *Bergen University* *University of Hamburg* *Self-Employed*	*Lecturer* *Lecturer* *PDRA* *PDRA* *PDRA* *RA* *Assistant Professor* *PDRA* *PDRA* *Artist*	*30*
Hridya Krinshnakumar *Kevin McGraw* *Adele Westgard* *Freya Sykes* *Simon Lefevre* *Anjaly Govindankutty Menon* *Apolonia Arellano* *Ashley Rodriguez*	*University of Galway* *University of Galway* *The Arctic University of Norway* *The Arctic University of Norway* *Bergen University* *University of Hamburg* *Columbia University* *Middlebury College*	*PhD Student* *PhD Student* *PhD Student* *PhD Student* *PhD Student* *PhD Student* *PhD Student* *Undergraduate Student*	*30*

B2 Objectives

Our understanding of critical climate tipping points and their impact on future Arctic and global climate remains limited due to the shortness of our observational records and our inability to quantify past changes in sea surface temperatures and the carbonate system in Arctic or Subarctic Oceans. Project SiTrAc addresses this critical gap by pioneering a new holistic multidisciplinary approach to palaeoceanographic proxy development that considers foraminifera as a living organism and not just as a proxy carrier. Using innovative biogeochemical techniques and micro-structural analyses of polar foraminifera *Neogloboquadrina pachyderma* (**NP**), which is the dominant and often only species present in surface waters below 4˚C, SiTrAc will track essential climate variables via the living proxy into the archive (i.e., marine sediments). The main objective for survey CE23011 was to quantify biological and physiochemical processes, that influence how geochemical tracers of climate are recorded in NP.

To do so we set out the following cruise objectives:

(1) Characterize the modern habitat range of NP via a hydrographic survey in the Western Nordic Seas, Irminger Sea, and Labrador Sea, recording essential climate variables of the water column (e.g.,T, S, Nutrients, Oxygen, Trace Elements, stable oxygen, carbon and boron isotopes, pH, TA, DIC, and CO_2 fluxes).
(2) Capture living NP specimens from a wide range of hydrographic gradients via multinet sampling for onboard respiration experiments and onshore microstructural and geochemical analysis.
(3) Capture sinking and recently dead specimens via multicore tops and deepwater tows for an assessment of crust formation and dissolution.
(4) Recover Marine Climate Archives to provide crucial insight into Arctic climate variability, the magnitude of change, and its impact on global climate.

These overall objectives have not changed from the original proposal.

Additional Objectives in line with SiTrAc:

(5) Investigate the impact of diet on growth and mortality, and eventual shell geochemistry, in the subpolar to temperate foraminifera *Globigerina bulloides* **(GB),** via onboard culturing experiments**.**
(6) Analyse the individual intracellular nutrient storage (e.g. phosphate) of living planktic and benthic foraminifera from high latitudes and measure respiration rates of benthic foraminifera from Sermilik Fjord (Greenland).
(7) Upscale the individual benthic foraminiferal nutrient storage, using total living abundances at the sampling locations.

B3 Overview of research survey

The table below provides a detailed account of research activities and timelines for each of the stations targeted during the survey. Important acronyms for equipment deployed include:

CTD Stands for Conductivity, Temperature and Depth and refers to a package of electronic instruments that measure these properties. CTD was attached to a large metal frame called a rosette, which held 24 water-sampling (Niskin) bottles that are used to collect water at different depths.

MUN Stands for "Multinet". The type used during this survey is a Hydrobios Multi Plankton Sampler MPS 92B. It has the ability to sample plnkton at 5 different depth per deployment.

MUC Stands for Multicore. The type used during this survey is a 4-core multicore, model 71.500 manufactured by KC Denmark. It was further equipped with extension legs to permit deployment in deep waters. Cores are 60cm long permitting the recovery surface sediments from the sea bed.

GC Stands for the 6-meter gravity core deployed to recover sediment archives from the sea floor.

BC Stands for the Rhieneck Box corer. This corer was used as a back-up for the Multicorer. It can collect a 10x20x30cm box of surface sediments from the seafloor.

Station ID	Date	Event	Time [IN]	Time [OUT]	Comment
Killybegs	21/07/23		23:00		Survey starts
Station 0	22/07/23		10:54		On Station at 55˚5.120N, 11˚7.230W - Collection of seawater for foraminifera culturing experiments at Station 1
	22/07/23	CTD1	10:57	11:12	All bottles fired at 200m to collect water for culturing experiment
	22/07/23		11:15		Station Complete - transit to station 1
Station 1	22/07/23		22:05		On Station at 55˚38.880N;14˚0.530W - No ASIP due to swell
	22/07/23	CTD1	22:23	00:17	Full depth CTD to 2554m all bottles fired at 10 depths
	23/07/23	MUN1	00:43	01:05	All nets fired at 90-80m, 80-70m, 70-60m, 60-50m, 50-40m
	23/07/23	MUC1	01:47	03:15	Successful (recovery 19.5-21.0cm)
	23/07/23	GC1	03:36	05:04	Successful (recovery 2.7m)
	23/07/23	MUN2	06:12	06:30	The nets did not fire, battery was out of place
	23/07/23	MUN3	07:19	07:25	Deployed to 70m, fired at: 60m, 50m, 40m, 30m, 20m
	23/07/23		07:34		Station complete - transit to Station 2
Station 2	27/07/23		23:20		On Station at 71˚37.650N; 8˚25.080W
	27/07/23	ASIP	23:30	06:26	ASIP Deployed and recovered
	28/07/23	CTD	23:59	01:28	Full depth CTD to 1946m all bottles fired at 10 depths
	28/07/23	MUN1	01:34	01:57	Deployed to 150m and fired at 150-80, 80-60, 60-40, 40-20, 20-0m
	28/07/23	MUC1	02:19	03:21	Successful (recovery 41.5-43.5cm)
	28/07/23	GC1	03:37	04:45	Successful (recovery 3.6m)
	28/07/23		06:34		Station Completed - transit to Station 3
Station 3	29/07/23		04:02		On Station at 74˚28.180N; 1˚33.720W
	29/07/23	ASIP	04:08	13:18	ASIP Deployed and recovered
	29/07/23	CTD	04:45	07:12	Full depth CTD to 3280m all bottles fired at 10 depths
	29/07/23	MUN1	07:18	07:55	Issues with depth sensors. Deployed to 150m and fired at 150-80, 80-60, 60-40, 40-20, 20-0m
	29/07/23	MUC1	08:10	10:05	successful (recovery 42-45cm)
	29/07/23	GC1	10:20	12:12	Successful (recovery 3.6m)
	29/07/23		12:31		Station Complete - transit to Station 5
Station 5	30/07/23		22:50		Station 4 is covered in drift ice, heading to station 5 instead. Station 5 is covered in Drift Ice - new coordinates are:78˚24.5'N; 003˚19.5W
	30/07/23	ASIP	19:51	01:42	Deployed off station to avoid collision with sea ice (78˚22.2'N; 002˚23.5W)
	30/07/23	CTD	22:56	23:28	Full depth CTD to 2227m all bottles fired at 10 depths
	30/07/23	MUN1	23:30	23:43	Deployed to 150m and fired at 150-80, 80-60, 60-40, 40-20, 20-0m
	31/07/23		01:53		Due to drift ice,, we completed the station after MUN as further deployments were deemed to risky. Also both MUC and GC are available for this station from CE20009/CIAAN.-Transit to Station 4
Station 4	31/07/23		13:46		Station 4 is still covered in drift ice and so is Station 6. There is a need for healthy NP for respiration experiments. We are therefore dropping the MUN in promising locations on the way to Station 7 to find NP.
Station 4.1	31/07/23	MUN1	14:00	14:10	Station 4.1 at 77°04.16N, 01°54.38W. MUN deployed to 150m and fired at 150-100, 100-75, 75-50, 50-25, 25-0 - Only dead or unhealthy specimen recovered.
	31/07/23	CTD	14:15	14:30	CTD deployed to 200m, no bottles fired
	31/07/23		14:31		Transit to Station 4.2
Station 4.2	31/07/23		19:16		On Station 4.2 at 76°34.240N, 2°5.077W
	31/07/23	MUN1	19:25	19:50	MUN deployed to 150m and fired at 150-100, 100-75, 75-50, 50-25, 25-0 - Only dead or unhealthy specimen recovered.
	31/07/23	CTD	19:59	20:11	CTD deployed to 200m, no bottles fired
	31/07/23		20:15		Transit to Station 4.3
			23:10		On station 4.3 at 76°21.031 N, 4°26.707 W

Station ID	Date	Event	Time [IN]	Time [OUT]	Comment
Station 4.3	31/07/23	MUN1	23:15	23:20	MUN deployed to 150m and fired at 150-100, 100-75, 75-50, 50-25, 25-0 – Only dead or unhealthy specimen recovered.
	31/07/23	CTD	23:32	23:45	CTD deployed to 200m, no bottles fired
	31/07/23	23:45			Transit to Station 4.4
Station 4.4	01/08/23	02:29			On station at 78°07.9 N, 8°00.2 W
	01/08/23	MUN1	02:34	03:12	Deployed to 150m and fired at 150-100, 100-75, 75-50, 50-25, 25-0 - healthy NP in Nets 3 & 4 recovered
	01/08/23	CTD	03:28	03:52	CTD had to be cut short due to encroaching ice. Only the sample at a depth 500m was able to be collected (bottles 1+2).
	01/08/23	03:52			Station Complete - Transit to Station 7
Station 7	01/08/23	08:29			On Station at 75˚49.840N; 8˚10.910W
	01/08/23	ASIP	05:42	17:31	ASIP Deployed at 74˚15N, 010˚03.7W and recovered
	01/08/23	CTD	08:40	10:12	Full depth CTD to 3140m all bottles fired at 10 depths
	01/08/23	MUN1	10:15	10:30	Deployed to 100m and fired at 100-75, 75-50, 50-25, 25-0m
	01/08/23	MUC1	10:49	11:50	Successful (recovery 36.0-43.5cm)
	01/08/23	GC	Not deployed but a GC is available here from CE22009 - CIAAN		
	01/08/23	12:00			Station Complete - Transit to Station 8.1
Station 8.1	02/08/23	05:37			Station 8.1 is in an alternative position because the original Station 8 was covered in drift Ice. New coordinates are 74°15.013N; 10°4.079W
	02/08/23	ASIP	05:42	17:31	ASIP Deployed and recovered
	02/08/23	CTD	06:03	07:57	Full depth CTD to 3150m all bottles fired at 10 depths
	02/08/23	MUN1	08:05	08:51	Deployed to 150m and fired at 150-80, 80-50, 50-20, 20-0
	02/08/23	MUC1	09:09	10:51	Successful (recovery 39.0-43cm)
	02/08/23	GC1	11:15	13:19	Successful (recovery 4.25m)
	02/08/23	MUN2	14:22	15:50	Oblique Multinet deployed to 100m and towed at 100 x2 75m and 50m
	02/08/23	17:38			Station Complete - Transit to Station 9
Station 10	04/08/23	07:21			Station 9 was bypassed because our diplomatic clearance for Greenland had expired. This happened due to a reversal of the cruise track, not taken into account. A full station work-up, CTD, MUN, MUC, and GC are available from CE20009 – CIAAN. On station 10 at 70˚29.830N, 17˚5.658W
	04/08/23	ASIP	07:35	23:53	ASIP Deployed and recovered
	04/08/23	CTD1	00:00	09:19	Full depth CTD to 1710m all bottles fired at 10 depths
	04/08/23	MUN1	09:25	09:38	Deployed to 150m and fired at 150-80, 80-50, 50-20, 20-0
	04/08/23	MUC1	09:54	10:49	Successful (recovery 44-46cm)
	04/08/23	GC1	11:00	11:58	Successful (recovery 4.41m)
	04/08/23	MUN2	13:06	14:12	Oblique tow, 15min at 3knt at 125m, 75m x2, 50m
	04/08/23	14:15			Station Complete - transit to station 10.1
Station 10.1	04/08/23	16:10			On Station 10.1 at 70°24.65 N, 18°56.72W. Three additional stations were added to collect benthic foraminifera from the continental slope and shelf.
	04/08/23	CTD	16:14	16:47	Full depth deployed to 714.8m no water samples taken
	04/08/23	MUC1	17:00	17:20	successful (recovery 19-20cm but only top 10cm sampled)
	04/08/23	17:26			Station Complete - transit to station 10.2
Station 10.2	04/08/23	18:00			on Station 10.2 at 70°24.14N, 19°08.930
	04/08/23	CTD	18:01	18:21	Deployed to 441m, no water samples taken
	04/08/23	MUC1	18:25	18:45	Successful (recovery 20+ cm but only top 10cm sampled)
	04/08/23	18:46			Station Complete - transit to Station 10.3
Station 10.3	04/08/23	19:15			on Station 10.3 at 70˚23.58N, 19˚19.87W
	04/08/23	CTD	19:16	19:37	Deployed to 380m bottles fired at 7 depth
	04/08/23	MUC1	18:50	19:12	no recovery
	04/08/23	MUC2	19:15	19:37	no recovery - move 0.5NM to find a a softer substrate
	04/08/23	MUC3	20:27	20:49	new position: 70°23.6N; 019.°18.2W: (recovery 20+ cm but only top 10cm sampled)

Station ID	Date	Event	Time [IN]	Time [OUT]	Comment
	04/08/23	2050			Station Complete - transit to Station 11
Station 11	05/08/23	18:10			On Station at 67˚52.040N; 21˚45.920
	05/08/23	ASIP	18:14	21:53	ASIP Deployed at 67˚52.12N; 021˚45.79W and recovered
	05/08/23	CTD	18:20	19:00	We had to move off station slightly because of ASIP drifting toward the boat - CTD deployed to 796m bottles fired at 8 depths
	05/08/23	MUN1	19:14	19:26	Deployed to 200m and fired at 200-150, 150-100, 100-50, 50-0m
	05/08/23	MUC1	19:36	20:11	Moved back on Station for MUC e.g., 67 52.0N; 021 45.9W - Failed
	05/08/23	MUC2	20:20	20:55	Failed – hard grounds? - site abandoned too risky for Gravity Corer
	05/08/23	21:55			Station Complete - transit to Station 12
Station 12	06/08/23	19:41			On station at 65˚24.980N; 28˚19.930W
	06/08/23	ASIP	Not deployed due to weather		
	06/08/23	CTD	19:46	20:33	Deployed to 1049, bottles fired at 9 depth
	06/08/23	MUN1	20:38	20:49	Deployed to 160m and fired at 160-120, 120-70, 70-40, 40-0m
	06/08/23	MUC1	20:51	21:30	failed - redeployed with additional weights
	06/08/23	MUC2	21:44	22:19	failed - redeployed with additional weights
	06/08/23	GC1	22:27	23:01	Bent but recovery of 80cm - hard grounds
	06/08/23	23:55			Station complete - transit to station 13
OFF Station	07/08/23	ASIP	22:58		Deployed offshore 20NM before heading to Sermilik Fjord. This was to prevent the collision of ASIP with Sea ice, and ice bergs
Station 13.1	08/08/23	06:30			Station 13 was covered by drift ice so we stopped 1 NM away from it at 65˚33.3N; 038˚11.7W
	08/08/23	CTD	06:39	07:10	Deployed to 600m bottles fired at 6 depths
	08/08/23	MUC1	07:15	07:44	failed
	08/08/23	07:45			Station complete - drift ice moved so we can now move onto station 13
Station 13	08/08/23	08:10			On Station 13 - at 65˚34.6N; 038˚12.9W
	08/08/23	MUC1	08:11	08:30	failed
	08/08/23	MUC2	08:39	09:05	failed
	08/08/23	BC1	09:15	09:36	Rheineck Box Corer deployed to test seafloor sediments. Result: mud, over penetration, so we tried again with MUC
	08/08/23	MUC3	09:53	10:13	successful (29-45.5cm) - note one of the cores lost material
	08/08/23	GC1	10:28	10:52	Successful (1.63m)
	08/08/23	CTD	11:26	11:58	Deployed to 621m, bottles fired at 8 depths
	08/08/23	12:00			Station Complete - transit to Station FOXOIG
FOXOIG	08/08/23	14:02			On Station - 300meters away from planned site at 65°34.6N; 38°12.9W
	08/08/23	MUC1	14:17	14:50	failed - hard grounds?
	08/08/23	MUC2	15:00	15:50	failed - hard grounds?
	08/08/23	MUC3	15:52	16:20	failed - hard grounds?
	08/08/23	16:20			Station abandoned due to failed recovery and drift ice - transit to Station 14
Station 14	08/08/23	19:51			Arrived on Station at 65˚21.1N, 038˚54.8W - deployed MUC first to see if we have recovery
	08/08/23	MUC1	19:55	20:20	failed - hard grounds?
	08/08/23	MUC2	20:22	20:44	failed - hard grounds?
	08/08/23	20:57			Station abandoned due to failed recovery and drift ice - transit to recovery ASIP
OFF Station	08/08/23	ASIP	23:20		Recovery of ASIP at 65˚06.2N; 038˚17.2W then head towards Station 16. Station 15 was skipped due to sea ice and difficulty in recovering sediments on the shelf.
Station 16	09/08/23	14:00			On station 16 at 62˚45.170N; 37˚30.500W
	09/08/23	CTD	14:00	15:25	Deployed to 2069m, bottles fired at 9 depths
	09/08/23	MUN1	15:33	15:56	Deployed to 150m and fired at 150-100, 100-70, 70-40, 40-0m
	09/08/23	MUC1	16:06	17:05	failed - hard grounds? Redeployed with higher speeds.

Station ID	Date	Event	Time [IN]	Time [OUT]	Comment
	09/08/23	MUC2	17:41	18:35	recovery of 1-2cm of very compact clay with some IRD, poorly sorted, coarse grains, lots of planktonic foraminifera
	09/08/23		18:49		Station abandoned - too risky for Gravity Core - transit to Station 17
Station 17	10/08/23		10:50		On Station at 60°10.52N, 34°07.50W, No ASIP due to swell
	10/08/23	CTD	10:55	13:10	Deployed to 1068m, bottles fired at 9 depths
	10/08/23	MUN1	13:18	13:32	Deployed to 150m and fired at 150-100, 100-60, 60-30, 30-0m
	10/08/23	MUC1	10:56	13:32	failed: Triggered at the surface due to swell - too dangerous to redeploy switch to GC.
	10/08/23	GC1	14:10	15:50	Successful (recovery 4.93m)
	10/08/23		16:30		Station complete - Transit to Station 18
Station 18	11/08/23		16:22		On Station at 58˚15.140N; 45˚38.390W
	11/08/23	ASIP	16:22	02:16	ASIP deployed
	11/08/23	CTD	16:33	18:18	Deployed to 2310m, bottles fired at 9 depths
	11/08/23	MUN1	18:22	18:32	Deployed to 150m and fired at 150-90, 90-60, 60-30, 30-0m
	11/08/23	MUC1	19:02	20:15	Successful (recovery 18.5-21cm)
	11/08/23	MUC2	21:05	22:16	failed
	11/08/23	BC1	23:15	01:09	Did not fire - goal here was to recover living benthic foraminifera for respiration experiment
	12/08/23		01:10		Station Complete - transit to Station 19
Station 19	12/08/23		12:40		On Station at 57˚33.060N; 48˚31.110W - no ASIP due to swell
	12/08/23	CTD	12:47	15:01	Deployed to 3550m, bottles fired at 8 depths
	12/08/23	MUN1	15:06	15:20	Deployed to 150m and fired at 150-75, 75-50, 50-25, 25-0m
	12/08/23	MUC1	15:45	17:47	Successful (recovery 26-27cm)
	12/08/23	GC1	18:00	18:55	Successful (recovery 5.53m)
	12/08/23		20:30		Station complete - transit to Station 20
Station 20	15/08/23		22:40		On Station at 56˚21.830N; 27˚53.300W - No ASIP due to wind & Swell
	15/08/23	CTD	22:46	00:35	Deployed to 2787m, bottles fired at 10 depths
	16/08/23	MUN1	00:44	01:01	Deployed to 150m and fired at 150-100, 100-50, 50-25, 25-0m
	16/08/23	MUC1	01:20	02:26	Successful (recovery 43-46cm)
	16/08/23	GC1	02:38	04:03	Successful (recovery 5.28m)
	16/08/23		04:41		Station Complete - transit to Station 21
Station 21	17/08/23		23:00		On Station at 53˚32.290N; 20˚17.490W - no ASIP due to swell & wind, No MUN since it would have been too late for respiration experiments
	17/08/23	CTD	23:04	00:34	Deployed to 2172m, bottles fired at 9 depths
	18/08/23	MUC1	00:47	01:52	Successful (recovery 19-27cm)
	18/08/23	GC1	02:03	03:07	Successful (recovery 4.88m)
	18/08/23		03:51		Station Complete - transit to Station 22
Station 22	18/03/23		10:40		On Station at 53˚13.290N; 18˚53.210 - no ASIP due to swell & wind, No MUN since it would have been too late for respiration experiments
	18/03/23	CTD	10:57	11:36	Deployed to 2402m, bottles fired at 9 depths
	18/03/23	MUC1	12:51	14:15	Successful (recovery 25-30cm)
	18/03/23	GC1	14:27	15:39	Successful (recovery 5.00m)
	18/03/23		16:12		Station Complete - transit to Galway
Galway	20/08/23		09:00		In port

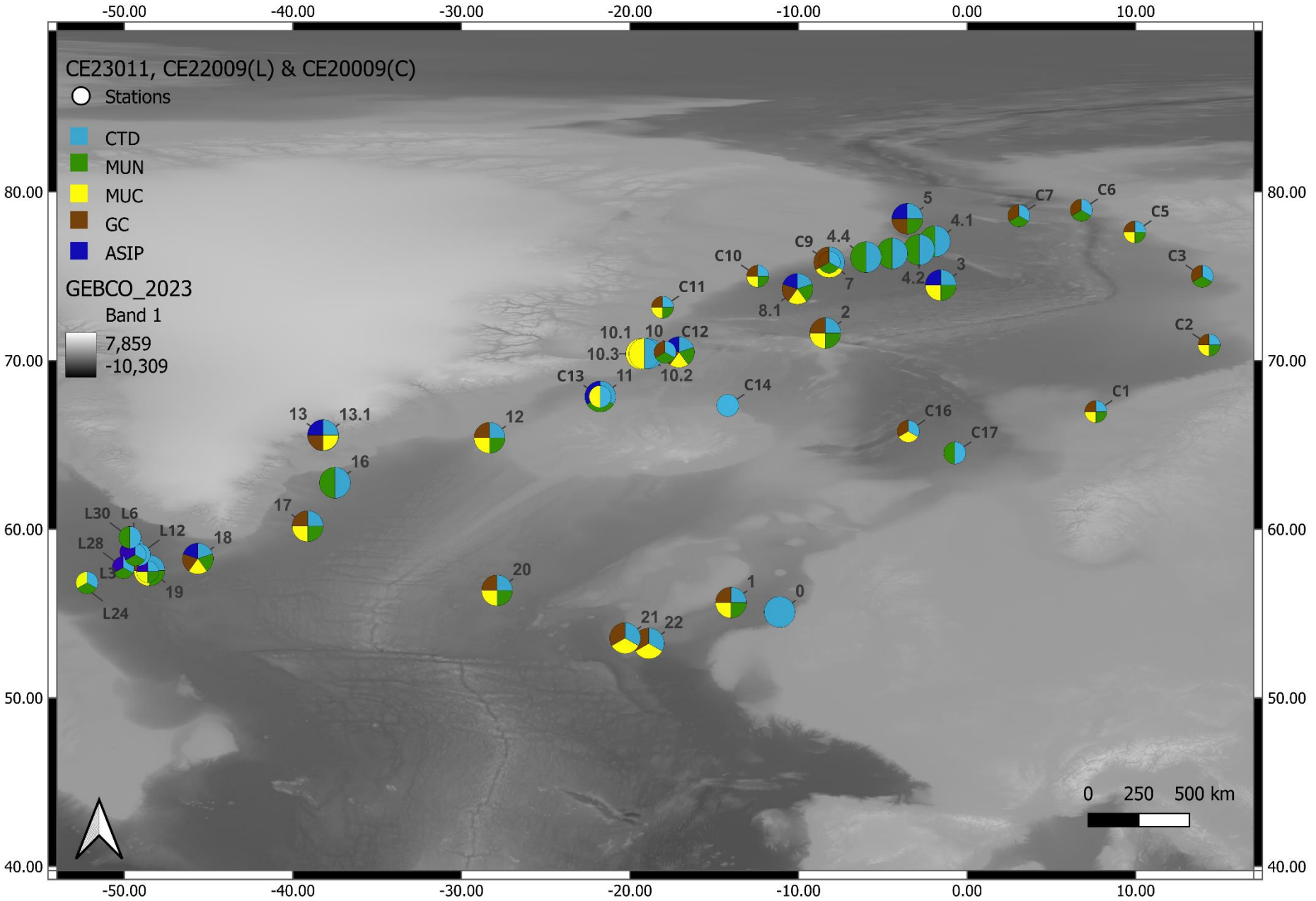

Figure 1 Overview Map of samples collected during CE23011 (large circles). Also shown are stations and samples from survey CE20009 (CIAAN – marked with a C) and survey CE22009 (LabSea – marked with an L) all contribute to the overall objectives of project SiTrAc.

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

SiTrAc presents an ambitious new approach to assess geochemical tracers in modern and fossil NP using interdisciplinary methods developed in ecology, micropaleontology, biomedical engineering, and geochemistry to significantly advance (Paleo)climate research. The holistic vision of tracing geochemical proxies from the living NP into the archive is conceptually unique and in sharp contrast to traditional proxy development. This type of cross-disciplinary research opens new research avenues and has the potential to create an entirely new set of tools for paleoclimatic research that is not limited to a single species, high-latitude cold environments, or a specific geologic period.

i. Contribution to knowledge

SiTrAc provides the blueprint for quantifying vital effects, early diagenesis, and secondary environmental controls for all planktonic foraminifera species and can be applied to test outstanding climate hypotheses and debates globally. Fundamental new knowledge on NP growth and metabolic rates will detail how Arctic Climate change impacts the rate at which organic material is converted to inorganic calcite at the cellular level. As such, SiTrAc provides the baseline for new research on carbon export and storage to the deep ocean, and carbon cycle feedbacks on multiple timescales and climatic boundary conditions. Beyond the field of Palaeoceanography, we expect that the application of SiTrAc and specific insights gained from climate reconstructions will provide a crucial reference for validation experiments with general climate models to simulate the impact of Arctic climate change for future greenhouse gas scenarios and hypothesized tipping points.

ii. Impact on Research Capacity and Capability Building

The provision of trained graduates, postgraduates and Postdoctoral Researchers is essential to underpin Ireland's use of national aquatic resources, as outlined in the *Marine Knowledge, Research and Innovation Strategy and the National Marine Research & Innovation Strategy 2017–2021*. The SiTrAc survey provided *7 PhD students, 1 Undergraduate student, and 5 PDRAs* with a unique opportunity to be involved in international, collaborative, and interdisciplinary research. Cruise participants represented 10 nationalities from six research institutions located in Ireland, Norway, Germany, and the USA. We thereby addressed recommendation of the *Ostend Declaration* and *Key Action 28* of *Harnessing Our Ocean Wealth*. The inclusion of international partners and focus on collaborative (maturity level 4) as well as Translational (maturity level 5) research also supports several national strategies and policy directives (e.g., Nordic Strategy, National Marine Research & Innovation Strategy 2017–2021) and lays the foundation for Northern Periphery and Arctic Interreg and H2020 bids.

iii. Contribution towards sustainable management

Given the growing consensus in the scientific community that current trends in Arctic amplification will increase the frequency of extreme weather events over northern mid-latitudes including Ireland, we anticipate that our findings will have *immediate implications for future climate scenarios relevant to Ireland, Europe, and beyond.* The proposed work will thus be of key relevance to Climate-ADAPT (*European Climate Adaptation Platform)* and provide a more comprehensive understanding of how the Arctic Ecosystem responds to abrupt changes in climate and radiative forcing.

iv. Promoting Multidisciplinary / Inter-Institutional Research

This cruise brought together 6 international institutions from 4 different countries placing Irish research in a global context. The cruise was truly multidisciplinary combining elements of geology, oceanography, ecology, and biogeochemistry. Exposure to different disciplines and early trans-European networking opportunities are crucial for early career researchers to build their future collaborative networks. Furthermore, the data and samples generated will contribute to final year projects across disciplines at the University of Galway. Providing final year projects based on funded science programmes is highly inspiring to undergraduate students and can motivate the best students to compete successfully for postgraduate funding.

B5 Data

WP1 Hydrographic Survey: For the collection of water samples at different depths, we deployed a CTD equipped with Niskin-X bottles. Following collection, water samples were taken for Temperature, Salinity, O_2, $\delta^{18}O$, $\delta^{13}C_{DIC}$, DIC, Nutrients and Trace Elements to be measured after our return. Alkalinity was measured on board using an AS-ALK3 system. Once analysed the data is backed-up on the University Institutional server. For a complete station list of CTD deployments and water samples please consult **Appendix 1.1** and **1.2.**

WP2 ASIP and CO_2 fluxes: ASIP is an autonomous vertically rising ocean profiler. It was deployed from the ship a total of 7 times during the duration of the cruise. Descending through the water column by the action of electrically driven thrusters to a maximum of depth of 120m, it subsequently rises by its own buoyancy towards the surface during which various oceanographic data instruments record the environmental conditions. Sensors equipped on ASIP are: Conductivity, Temperature, Depth, microscale conductivity, microscale temperature, microscale turbulence, PAR (photosynthetic available radiation), chlorophyll fluorescence, acoustic doppler velocimetry, and oxygen concentrations. For a complete list of ASIP deployments please consult Appendix 2. The eddy covariance flux system is mounted on a 9m mast which is located at the bow of the R/V Celtic Explorer. It measures the vertical velocity of wind and the CO_2 concentration in the atmosphere. Secure data storage is ensured via cloud storage, which has redundant version backup and which allows for ease of sharing data with collaborators.

WP 3 Collection of NP via Multinet vertical and oblique tow deployment: Plankton tows of 100 µm mesh size were deployed at 17 stations at 4 or 5 distinct water depths with a maximum winch speed of 0.3 m/s using a MultiNet frame. Vertical as well as oblique tows were performed to collect sufficient sample material for respiration and geochemical analysis. For a complete list of foraminifera recovered from each Multinet deployment please see **Appendix 3.1**. Upon towing, live NP specimens were placed in culture cells for at least 6h to rest. thereafter their respiration was assessed with a nano-respiration system. Alongside the respiration rates, a pH microsensor measured the *associated changes in pH within the microenvironment.* After analysis, individual foraminifera were placed in slides and photographed. For a full list of samples analysed please see **Appendix 3.2**. The remaining plankton tows were frozen at -80°C and transferred to a -80C freezer at the University of Galway for further processing onshore, including specimens stored individually for genetic analysis. In addition, two vertical plankton tows of 63 µm net size were deployed at station 1. Live juvenile specimens of GB were picked from the sampled material and placed into filtered seawater in either culture cells or 75ml falcon flasks. All specimens were kept at 13°C and fed every other day. Daily observations and photography were carried out to record growth and mortality. Water chemistry was monitored throughout the experiment. Further GB were also collected at later stations with 100 µm net size to compliment the culturing. Upon death each individual was picked, placed in slides and photographed. Specimens were taken back to UiT – The Arctic University of Norway.

WP 4 Collection of NP from the geologic archive via Multicore and Gravity Core. The collection of sediments by multicores ensured the recovery of sediment with their overlaying bottom waters and therefore an intact water-sediment interface. The multicore was successful at 15 stations. At 12 stations, two tubes were subsampled for pore-water characterization ($\delta^{13}C$, $\delta^{11}B$, pH, O_2, Alkalinity, DIC, Nutrients, TE) using rhyzons, the others were sliced at 0.5cm resolution and frozen at -20°C on board. The collection of gravity cores was successful at 10 stations. Gravity cores were cut into 1 m sections. Core opening and subsampling of sediment for past climate reconstructions will occur onshore at NUI Galway For a summary of cores recovered during the survey please see **Appendix 4**.

WP 5 Collection of benthic foraminifera from sediment samples. For the determination of total living abundances of benthic foraminifera, we fixed the top 5 cm of four multicores from four different stations (one was sampled until a depth of 10 cm). At station 13 the top 7 cm of the Rheineck boxcore were sampled, using a pushcore with a diameter of 8.8 cm. For the sampling, the sediment was gently pushed out of the tubes and sliced into subsections of 1 cm height. For the extraction of the intracellular nutrient content in foraminifera, we took 6 monospecific samples of benthic foraminifera and 2 monospecific samples of planktic foraminifera. In addition, we measured respiration rates for 12 benthic foraminifera from Station 13 (Sermilik Fjord Estuary).

B6 Contribution to marine research programmes

National/EU/International Research programme(s):	*Marine Institute Post-Doctoral Fellowship 2022 – MERRACC: Marine Ecosystem Response to Rapid Arctic Climate Change*
Total Programme cost:	€394,882
Value to Irish partners:	€394,882
Project duration:	*01/01/2024 to 31/12/2027*
Contract no.:	PDOC/23/01/03
Project partners:	*Dr Julie Meilland – MARUM, Bremen University (DE)* *Dr Mohamed EZAT - UIT, the Arctic University of Norway in Tromsø (NO)* *Dr Michael Siccha - MARUM, Bremen University (DE)* *Dr Alessio Fabbrini – University of Galway (IE)*
Project web address:	*TBD*

National/EU/International Research programme(s):	SFI Frontiers for the Future Project - SiTrAc: Signal Tracking to unveil Arctic Climate variability.
Total Programme cost:	*€615,716.80*
Value to Irish partners:	*€615,716.80*
Project duration:	*01/12/2023 – 31/11/2027*
Contract no.:	21/FFP-P/10261
Project partners:	*Prof Gavin Foster – National Oceanographic Centre/ University of Southampton (UK)* *Prof Ulysses Ninnemann – Bjerknes Centre for Climate Research/ Bergen University (NO)* *Prof Peter Croot – University of Galway (IE)*
Project web address:	*https://www.morpalaeolab.com/research*

National/EU/International Research programme(s):	iCRAG 2 - PostDoctocral Fellowship - Constraining the Impact of Ocean Acidification on Arctic Foraminifera
Total Programme cost:	*€154,590*
Value to Irish partners:	*€154,590*
Project duration:	*01/01/2023 - 31/12/2024*
Contract no.:	13/RC/2092_2 / 4-PD1-1.3.2
Project partners:	*Prof Gavin Foster – National Oceanographic Centre/ University of Southampton (UK)* *Prof Ulysses Ninnemann – Bjerknes Centre for Climate Research/ Bergen University (NO)* *Prof Peter Croot – University of Galway (IE)*

Project web address:	*https://www.morpalaeolab.com/research*

National/EU/International Research programme(s):	iCRAG2 – PhD fellowship - The Impact of Upper Ocean Turbulence and Air-Sea Fluxes on the Onset of a Phytoplankton Bloom Position (Unique Identifier: 8-PhD-1.1.4)
Total Programme cost:	*€123,270*
Value to Irish partners:	*€123,270*
Project duration:	*01/10/2022 - 30/09/2026*
Contract no.:	13/RC/2092_2 /8-PhD-1.1.4
Project partners:	*Dr. Erin Bertrand, DAL* *Dr. Stephanie Kienast (Dal)* *Dr. Carolyn Buchwald (DAL)* *Dr. Uta Passow (MUN)* *Doug Wallace (Dal)* *Dariia Atamanchuk (Dal)* *Julie LaRoche (Dal)* *Zoe Finkel (Dal)* *Andrew Irwin (Dal)* *Katja Fennel (Dal)* *Heather Reader (MUN)*
Project web address:	*https://nwa-bcp.ocean.dal.ca/*

National/EU/International Research programme(s):	Southern Ocean Carbon and Heat Impact on Climate (SO-CHIC)
Total Programme cost:	*€7,989,925*
Value to Irish partners:	*€243,670*
Project duration:	*01/11/2019 - 31/10/2026*
Contract no.:	821001
Project partners:	*France, Germany, UK, Ireland, Sweden, Norway, Switzerland, Italy, Netherlands, and South Africa*
Project web address:	*http://www.sochic-h2020.eu/*

Appendices

Please number and attach any relevant Appendices here.

Appendix 1: CTD station list and Water sampling

Appendix 2. ASIP Deployments and profiles

Appendix 3.1. Multinet deployments and sample recovery

Appendix 3.2. Respiration rate experiments

Appendix 4. Gravity and Multicore recovery during CE23011

Table 1 Appendix 1.1 CTD station list

Cruise	Station no.	CTD ID	Date	Lat N (Dec Deg)	Long E (Dec Deg)	Sounding [m]	Start Time UTC (hh:Mm)	Time End UTC (hh:mm)
CE23011	0	CE23011_CTD1	22/07/2023	55.085	11.121	2681	09:57	10:12
CE23011	1	CE23011_CTD2	22/07/2023	55.648	14.009	2550	21:23	23:16
CE23011	2	CE23011_CTD3	27/07/2023	71.628	8.418	1946	23:59	01:27
CE23011	3	CE23011_CTD4	28/07/2023	74.470	1.562	3300	04:45	07:09
CE23011	5	CE23011_CTD5	30/07/2023	78.409	3.548	2227	22:56	23:28
CE23011	4.1	CE23011_CTD6	31/07/2023	77.070	1.906	3000	13:15	13:29
CE23011	4.2	CE23011_CTD7	31/07/2023	76.571	2.846	2603	18:59	19:11
CE23011	4.3	CE23011_CTD8	31/07/2023	76.351	4.445	3000	23:32	23:44
CE23011	4.4	CE23011_CTD9	31/07/2023	76.132	6.003	2770	03:22	03:51
CE23011	7	CE23011_CTD10	01/08/2023	75.831	8.182	2032	07:48	09:12
CE23011	8.1	CE23011_CTD11	02/08/2023	74.250	10.068	3150	06:03	07:57
CE23011	10	CE23011_CTD12	04/08/2023	70.497	17.094	1710	08:06	09:17
CE23011	10.1	CE23011_CTD13	04/08/2023	70.411	18.945	736	15:14	15:44
CE23011	10.2	CE23011_CTD14	04/08/2023	70.402	19.149	441	17:01	17:21
CE23011	10.3	CE23011_CTD15	04/08/2023	70.393	19.331	396	18:16	18:37
CE23011	11	CE23011_CTD16	05/08/2023	67.867	21.765	796	17:19	17:59
CE23011	12	CE23011_CTD17	06/08/2023	65.416	28.332	1068	19:46	20:22
CE23011	13.1	CE23011_CTD18	08/08/2023	65.556	38.196	600	05:39	06:08
CE23011	13	CE23011_CTD19	08/08/2023	65.577	38.215	625	10:25	10:58
CE23011	16	CE23011_CTD20	09/08/2023	62.753	37.508	2060	13:02	14:24
CE23011	17	CE23011_CTD21	10/08/2023	60.176	39.126	2750	09:56	12:08
CE23011	18	CE23011_CTD22	11/08/2023	58.252	45.640	2310	15:33	17:18
CE23011	19	CE23011_CTD23	12/08/2023	57.551	48.519	3550	11:46	14:00
CE23011	20	CE23011_CTD24	15/08/2023	56.364	27.888	2823	22:46	00:35
CE23011	21	CE23011_CTD25	17/08/2023	53.538	20.292	2198	23:04	00:34
CE23011	22	CE23011_CTD26	18/08/2023	53.222	18.887	2425	10:57	11:36

Table 2 Appendix 1.2 Water sampling

Station	Sample No.	Bottles	Depth (m)	Temp (C)	Salinity
1	2	1-2	2,540	2.52	34.931
1	3	3-4	1600	3.79	34.934
1	4	5-6	800	8.08	35.257
1	5	7-8	400	9.9	35.329
1	6	9-10	100	11.27	35.457
1	7	11-12	75	11.5	35.464
1	8	13-14	40	12.06	35.4
1	9	15-16	30	14.27	35.4
1	10	17-18	20	14.55	35.38

Station	Sample No.	Bottles	Depth (m)	Temp (C)	Salinity
1	11	19-24	5	14.6	35.38
2	12	1-2	1898	-0.82	34.917
2	13	3-4	1200	-0.5	34.914
2	14	5-6	600	-0.08	34.895
2	15	7-8	300	0.29	34.877
2	16	9-10	150	0.37	34.844
2	17	11-12	100	0.97	34.844
2	18	13-14	75	0.7	34.79
2	19	15-16	50	0.07	34.652
2	20	17-18	25	1.09	34.18
2	21	19-24	5	4.43	33.814
3	22	1-4	3280	-0.87	34.918
3	23	5-6	2000	-0.7	34.915
3	24	7-8	1000	-0.2	34.902
3	25	9-10	500	0.22	34.913
3	26	11-12	200	0.9	34.913
3	27	13-14	150	1.88	34.948
3	28	15-16	100	2.75	34.944
3	29	17-18	40	3.41	35.005
3	30	19-20	20	5	34.855
3	31	21-24	5	6.93	34.715
5	32	1-2	500	1.65	34.953
5	33	3-4	300	3.13	35.005
5	34	5-6	200	3.69	34.999
5	35	7-8	100	5.1	35.038
5	36	9-10	50	5.69	35.042
5	37	11-12	40	5.86	35.046
5	38	13-14	30	6.1	35.039
5	39	15-16	20	7.77	35
5	40	17-18	10	7.76	34.955
5	41	19-24	5	7.48	34.802
6	42	1-2	1971	-0.85	34.905
6	43	3-4	1000	-0.19	34.905
6	44	5-6	500	0.8	34.934
6	45	7-8	300	1.22	34.907
6	46	9-10	150	2.02	34.923
6	47	11-12	100	2.16	34.89
6	48	13-14	60	1.39	34.53
6	49	15-16	40	-1.09	34.15
6	50	17-18	20	-1.24	33.823
6	51	19-24	5	1.82	31.965
8.1	52	1-4	3085	-0.86	34.917

Station	Sample No.	Bottles	Depth (m)	Temp (C)	Salinity
8.1	53	5-6	2000	-0.72	34.914
8.1	54	7-8	1200	-0.24	34.911
8.1	55	9-10	500	0	34.905
8.1	56	11-12	300	0	34.913
8.1	57	13-14	120	0	34.875
8.1	58	15-16	75	1.14	34.842
8.1	59	17-18	40	1.2	34.673
8.1	60	19-20	20	3.47	34.108
8.1	61	21-24	5	4.66	31.945
10	62	1-2	1661	-0.65	34.915
10	63	3-4	1000	-0.23	34.908
10	64	5-6	700	0.1	34.899
10	65	7-8	500	0.5	34.903
10	66	9-10	200	1.28	34.873
10	67	11-12	150	1.53	34.856
10	68	13-14	100	-0.15	34.627
10	69	15-16	50	-0.84	34.133
10	70	17-18	20	2.67	33.751
10	71	19-24	5	4.23	32.95
10.3	72	1-2	380	0.85	34.89
10.3	73	3-4	250	1.64	34.824
10.3	74	5-6	150	-0.8	34.18
10.3	75	7-8	100	-1.63	33.701
10.3	76	9-10	50	-1.68	32.8
10.3	77	11-12	20	-0.3	31.332
10.3	78	13-14	5	1.82	29.325
11	79	1-2	796	-0.29	37.909
11	80	3-5	250	0.39	34.797
11	81	6-8	175	1.39	34.772
11	82	9-11	125	2.36	37.795
11	83	12-14	75	3.28	34.768
11	84	15-17	50	4.07	34.7
11	85	18-20	20	5.1	33.576
11	86	21-24	5	4.75	32.31
12	87	1-3	1049	4.3	34.959
12	88	4-6	600	5.49	34.991
12	89	7-9	400	6.19	35.021
12	90	10-12	200	7.07	35.068
12	91	13-15	140	7.26	35.067
12	92	16-18	100	7.46	35.066
12	93	19-20	60	8.92	35.07
12	94	21-22	20	10.86	35.09

Station	Sample No.	Bottles	Depth (m)	Temp (C)	Salinity
12	95	23-24	5	11.85	35.092
13.1	96	1-3	482	4.39	34.799
13.1	97	4-6	240	4.26	34.59
13.1	98	7-9	120	-0.24	34.432
13.1	99	10-13	40	-0.54	32.203
13.1	100	14-16	20	3.3	30.72
13.1	101	17-19	5	2.57	29.458
13	102	1-3	612	4.41	34.798
13	103	4-6	300	4.21	34.664
13	104	7-9	150	1.05	33.782
13	105	10-12	125	2.09	33.631
13	106	13-15	100	-0.48	33.163
13	107	16-18	40	0.32	31.683
13	108	19-21	25	4.18	31.067
13	109	22-24	5	2.97	29.776
16	110	1-3	2040	2.23	34.887
16	111	4-5	800	3.61	34.88
16	112	6-7	400	4.65	34.927
16	113	8-10	200	5.87	34.993
16	114	11-13	125	6.38	35.005
16	115	14-16	80	6.75	35.025
16	116	17-19	50	7.24	35.03
16	117	20-22	20	10.26	34.98
16	118	23-24	5	11.03	34.956
17	119	1-3	2733	1.18	34.882
17	120	4-5	2000	3.04	34.924
17	121	6-7	800	3.46	34.864
17	122	8-9	400	4.08	34.896
17	123	10-12	150	4.93	34.932
17	124	13-15	80	5.33	34.912
17	125	16-18	50	5.82	34.909
17	126	19-21	15	10.12	34.789
17	127	22-24	5	10.58	34.803
18	128	1-3	2279	1.97	34.886
18	129	4-5	1000	3.51	34.897
18	130	6-7	400	4.16	34.893
18	131	8-10	200	4.74	34.918
18	132	11-13	100	5.16	34.906
18	133	14-16	75	5.35	34.871
18	134	17-19	45	7.48	34.793
18	135	20-22	20	9.99	34.61
18	136	23-24	5	10.24	34.615

Station	Sample No.	Bottles	Depth (m)	Temp (C)	Salinity
19	137	1-3	3544	1.45	34.885
19	138	4-6	2500	2.85	34.92
19	139	7-9	1500	3.28	34.869
19	140	10-12	600	3.47	34.826
19	141	13-15	85	4.76	34.89
19	142	16-18	60	4.85	34.866
19	143	19-21	35	5.4	34.778
19	144	22-24	10	9.32	34.518
20	145	1-3	2787	2.56	34.96
20	146	4-6	1500	3.44	34.899
20	147	7-8	600	5.2	34.983
20	148	9-10	300	7.22	34.931
20	149	11-12	150	8.95	35.046
20	150	13-14	125	9.08	35.02
20	151	15-16	75	9.98	35.113
20	152	17-18	45	12.97	35.035
20	153	19-20	30	13.48	35.009
20	154	21-22	10	13.92	35.045
21	155	1-3	2172	3.23	34.933
21	156	4-5	1200	4.56	34.991
21	157	6-8	650	8.74	35.241
21	158	9-10	300	11.08	35.466
21	159	11-13	90	11.6	35.46
21	160	14-16	60	12.26	35.562
21	161	17-19	30	14.28	35.475
21	162	20-22	20	25.67	35.402
21	163	23-24	5	15.76	35.405
22	164	1-3	2402	2.41	34.924
22	165	4-6	1750	3.55	34.934
22	166	7-9	1000	5.39	35.069
22	167	10-12	600	8.26	35.232
22	168	13-14	300	10.28	35.328
22	169	15-16	150	10.96	35.382
22	170	17-18	60	11.82	35.442
22	171	19-20	30	13.52	35.397
22	172	21-22	5	15.33	35.333

Table 3 Appendix 2 ASIP Deployments

Date [ddmmyy]	Station #	Latitude [N]	Longitude [E+,W-]	Number of Profiles	Depth [m]
290723	3	74.46	-1.56	54	80
300723	5	78.38	2.35	52	50
020823	8.1	74.22	-10	77	100
040823	10	70.49	-17.93	132	75
050823	11	66.5	-28	26	75
080823	13	65.22	-38.15	116	60
110823	18	58.25	-45.66	61	100

Table 4 Appendix 3 Multinet deployment and Sample recovery

Station	Lat	Long	Species	Number	Depth (m)
CE23011_1	55.648	14.009	*G. bulloides*	143	70 – 0 m
			N. incompta	30	60 – 0 m
CE23011_2	71.628	8.418	*N. pachyderma*	60	60 – 40 m
			N. pachyderma	30	80 – 60 m
			N. pachyderma	80	Various depths
CE23011_3	74.470	1.562	*T. quinqueloba*	31	80 – 40m
			N. pachyderma	35	60-40
CE23011_5	78.409	3.548	*N. pachyderma*	24	20-0
			T. quinqueloba	34	40-20
CE23011_4.1 – 4.3			N/A	0	N/A
CE23011_4.4	76.132	6.003	*N. pachyderma*	37	75-50
			N. pachyderma	34	50-25
CE23011_8.1	74.250	10.068	*N. pachyderma*	83	150-80
			N. pachyderma	4	80-50
			N. pachyderma	5	80-50
			N. pachyderma	13	50-20
CE23011_10	70.497	17.094	*N. pachyderma*	55	150-100
			N. pachyderma	99	100-50
CE23011_11	67.867	21.765	*N. pachyderma*	52	150-100
			N. pachyderma	13	100 - 50
			N. pachyderma	15	50 - 0
CE23011_12	65.416	28.332	*N. pachyderma*	37	70-40
			N. pachyderma	102	40-0
			N. incompta	8	40-0
			T. quinqueloba	6	40-0
			G. bulloides	7	40-0
CE23011_16	62.753	37.508	*N. incompta*	9	70-40
			N. incompta	44	40 – 0
			N. pachy/incompta (sin)	4	40-0
			G. bulloides	2	40-0
CE23011_17	60.176	39.126	*N. pachy/incompta*	97	60-30
			T. quinqueloba	18	60-0
CE23011_18	58.252	45.640	*N. pachy/incompta*	43	60-30

Station	Lat	Long	Species	Number	Depth (m)
			N. pachy/incompta	63	30-0
			T. quinqueloba	31	
			N. pachyderma	69	50-25
			N. incompta	17	50-25
CE23011_19	57.551	48.519	*N. pachyderma*	35	25-0
			N. incompta	5	25-0
			G. bulloides	4	50-0
			N. incompta	25	100-50
CE23011_20	56.364	27.888	*N. incompta*	42	50-0
			G. inflata	52	100-0
			G. bulloides	2	100-0

Table 5 Appendix 3.2. Respiration experiments

Cruise Station #	Lat N (Dec Degrees)	Long E (Dec Degrees)	Taxon	Temp [C]	Nr of profiles [O_2]	Start	Finish	Microslide #
CE23011_1	55.65	14.01	*N. incompta*	13	*21*	23/07/23	24/07/23	1-7
CE23011_2	71.63	8.42	*N. pachyderma*	1	*18*	28/07/23	29/07/23	8-12
CE23011_5	78.41	3.55	*N. pachyderma*	7	*5*	01/08/23	01/08/23	13-14
CE23011_4.4	76.35	4.45	*N. pachyderma*	2	*5*	01/08/23	01/08/23	15-16
CE23011_7	75.83	8.18	*N. pachyderma*	3	*10*	01/08/23	02/08/23	17-20
CE23011_8.1	74.25	10.07	*N. pachyderma*	1, 3.5	25	02/08/23	04/08/23	21-27
CE23011_10	70.50	17.09	*N. pachyderma*	0.5	30	04/08/23	05/08/23	28-34
CE23011_11	67.87	21.77	*N. pachyderma*	2.5	*12*	05/08/23	06/08/23	35-39
CE23011_12	65.42	28.33	*N. pachyderma*	10	*19*	07/08/23	08/08/23	*40-46*
CE23011_16	62.75	37.51	*N. pachyderma/N. incompta*	10	18	10/08/23	10/08/23	51-56
CE23011_17	60.18	39.13	*N. pachyderma*	6	30	11/08/23	11/08/23	57-62, 65-68
CE23011_18	58.25	45.64	*N. pachyderma*	7.5	12	12/08/23	13/08/23	63-64, 69-70
CE23011_19	57.55	48.52	*N. pachyderma/N. incompta*	6	24	13/08/23	14/08/23	71-78
CE23011_20	56.36	27.89	*N. pachyderma/N. incompta*	14	15	16/08/23	17/08/23	79-83

Table 6 Appendix 4 Gravity and Multicore recovery

					Multi Core Length (cm)						
Date	Station #	Lat (DDS)	Long (DDS)	Depth (m)	A	B	C	D	ALK	NUT, $\delta^{13}C$, TE	Gravity Core (m)
27/07/23	CW2301_1	55.09	14.01	2,550	19.5	20.5	21.5	20.5	A	B	2.7
27/07/23	CW2301_2	71.63	8.42	1,946	41.5	41.5	43.5	42.5	B	A	3.6
29/07/23	CW2301_3	74.47	1.56	3,300	42.0	41.5	43.0	43.0	C	B	-
08/01/23	CW2301_7	75.82	8.20	2,032	42.5	36.0	43.5	43.0	D	A	-
08/02/23	CW2301_8.1	74.25	10.07	3,150	42.0	42.5	40.0	41.5	C	A	4.25

Date	Station #	Lat (DDS)	Long (DDS)	Depth (m)	Multi Core Length (cm)						Gravity Core (m)
					A	B	C	D	ALK	NUT, $\delta^{13}C$, TE	
08/04/23	CW2301_10	70.50	17.09	1,710	45.0	-	43.5	43.5	D	C	4.41
08/04/23	CW2301_10.1	70.41	18.95	736	-	-	-	-	-	B	-
08/04/23	CW2301_10.2	70.40	19.15	441	-	-	-	-	-	B	-
08/04/23	CW2301_10.3	70.39	19.33	396	-	-	-	-	-	B	-
08/06/23	CW2301_12	65.42	28.33	1,068	-	-	-	-	-	-	0.8
08/08/23	CW2301_13	65.58	38.22	625	44	31	-	39.5	D	B	1.63
08/10/23	CW2301_17	60.18	39.13	2,750	-	-	-	-	-	-	4.93
08/11/23	CW2301_18	58.25	45.64	2,310	21	21	18.5	20	B	A	-
08/12/23	CW2301_19	57.55	48.52	3,550	25.5	23.5	25.5	24.5	D	B	5.53
15/08/23	CW2301_20	56.36	27.89	2,823	42	43.5	47	43	C	A	5.28
17/08/23	CW2301_21	53.54	20.29	2,189	26	25.5	18	25	B	A	4.88
18/08/23	CW2301_22	53.22	18.89	2,425	23.5	23.5	27	26.5	D	A	5