NOTIFICATION OF PROPOSED

RESEARCH CRUISE

PART A: GENERAL

1. NAME OF RESEARCH SHIP Le Commandant Charcot — CRUISE NO. O070922

2. DATES OF CRUISE — From September 7, 2022 — To October 1, 2022

3. OPERATING AUTHORITY: PONANT

   TELEPHONE: +47 23411080 / +881 677 105 461

   TELEFAX: N/A

   TELEX: N/A

4. OWNER (if different from no. 3)

5. PARTICULARS OF SHIP:

   Name: Le Commandant Charcot
   Nationality: French
   Overall length: 149.9m
   Maximum draught: 10.2m
   Net tonnage: 9384 UMS
   Propulsion e.g. diesel/steam: -LNG
   Call sign: FMNB
   Registration port and number (if registered fishing vessel)

6. CREW

   Name of master: Patrick Marchesseau, Etienne Garcia

   Number of crew: 216

7. SCIENTIFIC PERSONNEL

Name and address of scientist in charge:
Dr Marion Fourquez
Research Scientist/Biogeochemist
Mediterranean Institute of
Oceanography
UMR 110 AMU - 7294 CNRS
163 avenue de Luminy - Bât.
OCEANOMED
13288 Marseille cedex 09 – France
Tel : + 33 (0)767 324 231

Sponsoring Institution:
Aix Marseille University
Mediterranean Institute of
Oceanography
UMR 110 AMU - 7294 CNRS

Director of the lab:
Valérie Michotey, *Professeure AMU*
Bat Océanomed
Campus de Luminy
134288 Marseille FR
33(0)486090555

MIO, UMR 110 AMU - 7294 CNRS - 235
IRD – UTLN

Sites principaux : Marseille-Lumiy et
Toulon-La Garde

https://www.mio.osupytheas.fr

Statement :
Duke University, on behalf of Pr Nicolas Cassar as the scientist in charge, will handle permits request for the waters off Greenland, Canada and Canada for the completion of the rest of the expedition.

Name of address of scientists:

Nicolas Cassar
Nicholas School of the Environment
Duke University
Durham, NC 27708
USA

Ariana de Souza
Nicholas School of the Environment
Duke University
Durham, NC 27708
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Perrin Hagge
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Marion Fourquez
Mediterranean Institute of
Oceanography
UMR 110 AMU - 7294 CNRS
163 avenue de Luminy - Bât.
OCEANOMED
13288 Marseille cedex 09 – France

No. of scientists:4

8. GEOGRAPHICAL AREA IN WHICH SHIP WILL OPERATE (with reference to latitude and longitude)
South Iceland (62°N – 56°N / 5°W – 25° W)

9. BRIEF DESCRIPTION OF PURPOSE OF CRUISE Because of polar amplification, the effect of climate change is most pronounced in polar regions, particularly the Arctic, where sea ice extent has been decreasing by 13.2% per decade (McMillan et al. 2016). Sea-ice retreat and increased meltwater flux is leading to profound perturbations of marine ecosystems, impacting light availability (Arrigo et al., 2008), water-column stratification, and nutrient inventories/biogeochemistry (Arrigo et al., 2012; 2017; Boetius et al., 2015). We propose to deploy high-resolution underway instruments to study how glacial melt influences the flow of energy and matter across Arctic oceanic ecosystems. We have two objectives: 1) How does ice melt influence net community production in the Arctic, and 2) Does using high frequency and real-time measurements reveal significant BNF in the Arctic, proving past assumptions about BNF incorrect.

10. DATES AND NAMES OF INTENDED PORTS OF CALL
Reykjavik, Iceland. Departure September 7, 2022
Nome, Alaska. Arrival October 1, 2022

11. ANY SPECIAL REQUIREMENTS AT PORTS OF CALL

No special requirements.

NOTIFICATION OF PROPOSED RESEARCH CRUISE

1. PART B: DETAILS

1. NAME OF RESEARCH SHIP Le Commandant Charcot CRUISE NO. O070922

2. DATES OF CRUISE From September 7, 2022 To October 1, 2022

3. a) PURPOSE OF RESEARCH

Because of polar amplification, the effect of climate change is most pronounced in polar regions, particularly the Arctic, where sea ice extent has been decreasing by 13.2% per decade (McMillan et al. 2016). Sea-ice retreat and increased meltwater flux is leading to profound perturbations of marine ecosystems, impacting light availability (Arrigo et al., 2008), water-column stratification, and nutrient inventories/biogeochemistry (Arrigo et al., 2012; 2017; Boetius et al., 2015). We propose to deploy high-resolution underway instruments to study how glacial melt influences the flow of energy and matter across Arctic oceanic ecosystems.

b) GENERAL OPERATIONAL METHODS (including full description of any fish gear, trawl type, mesh size, etc.)

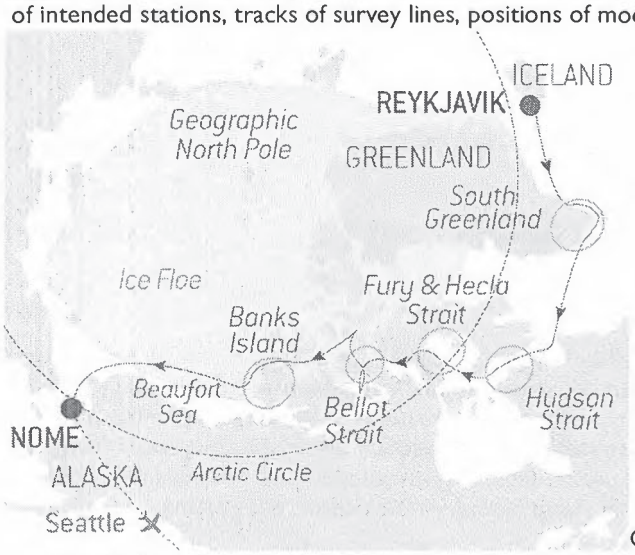
There is increasing evidence that biological events at the ocean surface are episodic and spatially heterogeneous, and that discrete observations cannot capture this patchwork. The methods we have developed allow us to sail with a biogeochemical compass to constrain the fluxes of energy and matter at unprecedented resolution (Cassar et al. 2009, Huang et al. 2013, Huang et al. 2015, Cassar et al. 2012, Cassar et al., 2018). Our sampling does not require any additional ship-time, and samples are collected while the vessel is in transit.

O2/Ar: Ecosystem energetic-Redox balance, biological O2, and Net Community Production: Because of the central role O2 plays in biological redox reactions at the ocean surface, the biological O2 budget reflects the net energetic balance of ecosystems. Ecosystems where the photochemical energy input is greater than the loss of potential energy have a positive internal energy balance. Our measurements estimate NCP at high resolution, where NCP is equal to gross primary production minus community respiration. Equilibrator Inlet Mass Spectrometry (EIMS): Seawater from the ship's underway system will be pumped through a gas equilibrator, the headspace of which will be connected to a quadrupole mass spectrometer for continuous pCO2 and O2/Ar ratio measurements, from which the biogenic O2 supersaturation will be estimated. From the O2/Ar supersaturation, the piston velocity, and the O2 concentration at saturation, NCP will be calculated as in Cassar et al. (2009), correcting for vertical mixing using N2O observations using the calculation methods presented in Cassar et al. (2014).

N2 fixation: Our real-time method will allow us to capture the sensitive variations that lead to the heterogeneity in BNF to further elucidate the biogeography of marine N2 fixation. Flow-through Acetylene Reduction Assays by CRDS (FARACAS): In our real-time method, underway seawater goes through a flow-through incubation chamber for acetylene reduction estimates of N2 fixation. We will use the underway line with the Charcot's peristaltic pump, which is less damaging to cells than the centrifuge pump. Prior to the chamber, high-purity acetylene is continuously added to the flowing seawater. Downstream of the incubation chamber, a contactor cell is used to strip the ethylene out of solution and into the CRDS (Cassar et al. 2012, Cassar et al. 2018).

Bacterial respiration: Organisms of all trophic levels contribute to ecosystem respiration, but respiration by bacteria is known to act as the quantitatively most important pathway accounting for about 50-90% of the total respiration in the oceans (Robinson 2008). Yet, despite its pivotal role in oceanic CO_2 sequestration, microbial respiration remains the major area of ignorance in our understanding of the global carbon cycle. The consumption of O_2 by microbes will be monitored in the dark for the total community (unfiltered seawater, dark community respiration) and the bacterial respiration only (fraction-size <0,8µm, BR) with non-invasive O_2 sensors (Presens). For continuous measurements, O_2 concentration will be recorded every 4 min for up to 7 days. Additional incubations will be performed on the fraction-size <0,8µm with glucose addition (10µM) to follow C utilization by the cells in relation to O2 consumption (Fourquez et al. 2020).

4. ATTACH CHART showing (on an appropriate scale) the geographical area of intended work, positions of intended stations, tracks of survey lines, positions of moored/seabed equipment, areas to be fished



Circled areas mark potential stops and visits by small boats launched from the ship. Underway sampling would occur along the whole route, where we have permission.

a) TYPES OF SAMPLES REQUIRED (e.g., geological/water/plankton/fish/radionuclide)

5. Seawater sampling

b) METHODS OF OBTAINING SAMPLES (e.g., dredging/coring/drilling/fishing, etc. When using fishing gear, indicate fish stocks being worked, quantity of each species required, and quantity of fish to be retained on board).
Seawater samples would be obtained through the ship's underway line as well as through a diaphragm pump from the moonpool of the ship. No dredging, coring, drilling, or fishing would be involved.

6. DETAILS OF MOORED EQUIPMENT This section is not applicable to the sampling we will be doing

Dates Laying	Recovery	Description	Depth	Latitude	Longitude

7. ANY HAZARDOUS MATERIALS (chemicals/explosives/gases/radioactives, etc.)
(Use separate sheet if necessary)

a) Type and trade name
Chemical: Calcium Carbide
Chemical: Mercuric (II) Chloride
Chemical: Hydrochloric Acid
Gas: Isotopically labeled Nitrogen gas

b) Chemical content (and formula)
Calcium Carbide: CaC_2
Mercuric (II) Chloride: $HgCl_2$
Hydrochloric Acid: HCl
Nitrogen Gas: $^{15}N_2$
Glucose: $^{13}C_6H_{12}O_6$

c) IMO IMDG code (reference and UN no.)
Calcium Carbide: UN 1402 (Airgas reference)
Mercuric (II) Chloride: UN 1624 (Carl Roth referencce)
Hydrochloric Acid: UN 1789
Nitrogen Gas: UN 1066

1066	NITROGEN, COMPRESSED	2.2	-	-	-	120 m3	P200	-	-

Reference: IMDG Code International Maritime Dangerous Goods Code Volume 2
13-Glucose: Not a hazardous substance or mixture according to Regulation (EC) No 1272/2008, no UN number.

d) Quantity and method of storage on board
Calcium Carbide: 4 kg
Mercuric (II) Chloride: 200 mL
Hydrochloric Acid: 500 mL
Nitrogen Gas: 1 L
All stored at room temperature. Calcium carbide will be stored in double containers to be kept away from moisture. Mercuric (II) chloride will be handled with gloves and stored in double containers in an appropriate hazardous materials cabinet.
13-Glucose: 1g, stored at 4°C.

e) If explosives give dates of detonation
- Method of detonation
- Position of detonation
- Position of detonation
- Frequency of detonation
- Depth of detonation
- Size of explosive charge in kg.

8. DETAIL AND REFERENCE OF

a) Any relevant previous/future cruises
EXPORTS (North Atlantic/ May 2021) Community production in the North Atlantic

SWINGS (Southern Ocean/Jan-March 2021) Community respiration in the Southern Ocean. Marion Fourquez responsable for microbial measurements.

Palmer LTER (Antarctica/ December 2018-February 2019)

BLOOFINZ (Indian Ocean/ January 2022-March 2022) Nitrogen fixation in the Indian Ocean
Yr3: Nicolas Cassar Chief Scientist on cruise testing N2 fixation method in Sargasso Sea (R/V Atlantic Explorer / August 2017) (Chief Scientist)

ACE Expedition (Antarctica / R/V Akademik Treshnikov / December 2016 – January 2017). Marion Fourquez responsable for trace metal clean sampling and isolation of microbes // Nicolas Cassar responsible for NCP measurements.

EDDY cruise, part of the V02-IN2016 voyage on R/V Investigator. Bacteria/phytoplankton interactions in eddy-ecoystem.

ArcticNet (CCGS Amundsen / July-August 2013). Primary production in the Labrador Sea and the Canadian Arctic

ARK-XXVI/3 (R/V Polarstern / August-October 2011). Carbon fluxes and production under and in Arctic sea ice

KEOPS2 (R/V Marion Dufresne October-December 2011). Investigate the impact of natural iron fertilization on the biogeochemical cycles in the Southern Ocean. Marion Fourquez in charge of Fe uptake rates measurements.

Australian Antarctic Division Southern Ocean Cruise (Aurora Australis / February-April 2005). Measurement of dissolved gases and dissolved inorganic carbon by membrane inlet mass spectrometry (MIMS) and isotope dilution MIMS

Southern Ocean Iron Experiment (SOFeX) Cruise (R/V Roger Revelle / January-February 2002). Photosynthetic carbon assimilation in response to iron fertilization

N2O cruise (R/V KA`IMIKAI-O-KANALOA / July 19-26 1999)

b) Any previously published research data relating to the proposed cruise

Lory, C., F. Van Wambeke, M. Fourquez, and others. 2022. Assessing the contribution of diazotrophs to microbial Fe uptake using a group specific approach in the Western Tropical South Pacific Ocean. ISME Commun. **2**: 41. doi:10.1038/s43705-022-00122-7

Berthelot, H., Duhamel, S., L'Helguen, S., Maguer, J.-F., Cassar, N. 2021. Inorganic and organic carbon and nitrogen uptake strategies of picoplankton groups in the northwestern Atlantic Ocean. Limnology and Oceanography, https://doi.org/10.1002/lno.11909.

Siegel et al. 2021. Overview of the EXport Processes in the Ocean from RemoTe Sensing (EXPORTS) Northeast Pacific Field Deployment. Elementa, https://doi.org/10.1525/elementa.2020.00107.

Tang, W., Garcia, E., Berthelot, H., Polyviou, D., Wang, S., Baylay, A., Whitby, H., Planquette, H., Mowlem, M., Robidart, J., Cassar, N. 2020. New insights into the distributions of nitrogen fixation and diazotrophs revealed by high-resolution sensing and sampling methods. The ISME Journal, https://doi.org/10.1038/s41396-019-0489-6.

Shiozaki, T., Fujiwara, A., Inomura, K., Hirose, Y., Hashihama, F., Harada, N. 2020. Biological nitrogen fixation detected under Antarctic sea ice. Nature Geoscience: 13, 729-732 doi: 10.1038/s41561-020-00651-7

Fourquez, M., M. Bressac, S. L. Deppeler, M. Ellwood, I. Obernosterer, T. W. Trull, and P. W. Boyd. 2020. Microbial Competition in the Subpolar Southern Ocean : An Fe – C co-limitation Experiment. Front. Mar. Sci. **6**: 776. doi:10.3389/fmars.2019.00776

Tang, W., Li, Z., Cassar, N. 2019. Machine learning estimates of global marine nitrogen fixation. JGR-Biogeosciences, https://doi.org/10.1029/2018JG004828.

Cassar, N., Tang, W., Gabathuler, H., Huang, K. 2018. Method for high frequency underway N2 fixation measurements: Flow-through incubation Acetylene Reduction Assays by Cavity ring down laser Absorption Spectroscopy (FARACAS). Analytical Chemistry, 90 : 2839-2851.

Fourquez, M., I. Obernosterer, D. M. Davies, T. W. Trull, and S. Blain. 2015. Microbial iron uptake in the naturally fertilized waters in the vicinity of Kerguelen Islands: phytoplankton–bacteria interactions. Biogeosciences Discuss. **11**: 15053–15086. doi:10.5194/bgd-11-15053-2014

Cassar, N., Wright, S. W., Thomson, P., Trull, T. W., Westwood, K. J., de Salas, M., Davidson, A., Pearce, I., Davies, D. M., Matear, R. J. 2015. The relation of net community production to phytoplankton community composition in the Southern Ocean. Global Biogeochemical Cycles, doi: 10.1002/2014GB004936.

Fourquez, M., A. Schaumann, A. Gueneugues, T. Jouenne, and I. Obernosterer. 2014. Effects of iron limitation on growth and carbon metabolism in oceanic and coastal heterotrophic bacteria. Limnol. Oceanogr. **59**: 1–14. doi:10.4319/lo.2014.59.1.0000

9. NAMES AND ADDRESSES OF SCIENTISTS OF THE COASTAL STATE(S) IN WHOSE WATERS THE PROPOSED CRUISE TAKES PLACE WITH WHOM PREVIOUS CONTACT HAS BEEN MADE

Not applicable

10. STATE

a) Whether visits to the ship in port by scientists of the coastal state concerned will be acceptable (Yes/No)
No

b) Participation of an observer from the coastal state for any part of the cruise together with the dates and the ports for embarkation and disembarkation
No

c) When research data from the intended cruise are likely to be made available to the coastal state and by what means
The results from the cruise will be published in scientific journals, and the data will be also made freely accessible via ISAAFFIK and Zenodo.

PART C. SCIENTIFIC EQUIPMENT

Complete the following table using a separate page for each coastal state

Coastal state Iceland

Port of call Iceland

Dates September 7-8, 2022

Indicate "YES" or "NO"

				DISTANCE FROM COAST		
List scientific work by function e.g.	Water column including sediment sampling of the seabed	Fisheries research within fishing limits	Research concerning the natural resources of the conti-nental shelf or its physical characteris-tics	Within 3 nm	Between 3-12 nm	Between 12-200 nm
Magnetometry	No	No	No	No	No	No
Gravity	No	No	No	No	No	No
Diving	No	No	No	No	No	No
Seismics	No	No	No	No	No	No
Seabed sampling	No	No	No	No	No	No
Bathymetry	No	No	No	No	No	No
Trawling	No	No	No	No	No	No
Echo sounding	No	No	No	No	No	No
Water sampling	Yes	No	Yes	Yes	Yes	Yes
U/W TV	No	No	No	No	No	No
Moored instr.	No	No	No	No	No	No
Towed instr.	No	No	No	No	No	No

Dated May 15, 2022

(On behalf of the Principal Scientist)

NB IF ANY DETAILS ARE MATERIALLY CHANGED REGARDING DATES/AREA OF OPERATION AFTER THIS FORM HAS BEEN SUBMITTED, THE COASTAL STATE AUTHORITIES MUST BE NOTIFIED IMMEDIATELY