ARCTIC 2022 – IMPLEMENTED PROJECTS

GOOD-OARS-IMDOS

LEAD INSTITUTION

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ABSTRACT

We propose participating in three cruise legs, Iceland-Longyearbyen (3-15 June) and two Longyearbyen-Longyearbyen legs (15 – 23 June, 28 June – 8 July, Fig.1), and to initiate a 5-year PONANT-based monitoring program in the Atlantic sector of the rapidly changing Nordic Seas.

Figure 1: Proposed cruise legs

The Arctic is one of the most rapidly warming regions on the planet. Warming and freshwater input from melting inland and sea ice lead to enhanced stratification and associated changes in ocean ventilation and circulation (Fig.2), whereas reductions in sea ice (Fig.3) allow for increased levels of solar radiation and hence photosynthesis in the ocean's surface layer. This affects marine ecosystems in this ocean region with extraordinary high planktonic and benthic biodiversity, large flocks of migratory seabirds, some of the world's largest fish stocks as well as a diverse community of sea mammals. Current threats include: overfishing, climate change via direct warming, Greenland meltwater run-off and loss of sea ice, petroleum development, ship transport, long range pollution, radioactivity, aquaculture and introduction of alien species.

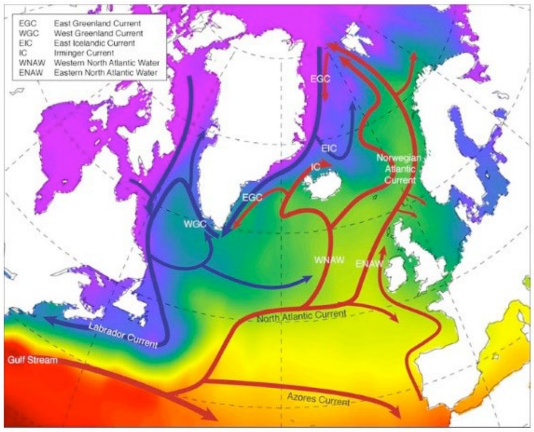


Figure 2: Surface circulation pattern (0-1000m) in the Arctic Atlantic sector. Blue arrows denote cold current from polar regions while red arrows warm currents from the subtropical gyre (from Gonzales-Pola et al., 2019).

As a result of warming, freshening, disappearing sea ice melts, as well as deoxygenation and ocean acidification, species composition and seasonal cycles of organic matter production and export out of the surface layer will change (van Appen et al., 2021). This can alter the whole marine food chain impacting also on biodiversity of higher trophic levels. The combined effects of ocean currents, atmospheric transport and river drainage result in the Arctic Ocean being a “sink’ for long-range pollution such as heavy metals and marine litter (Denisenko et al., 2004).

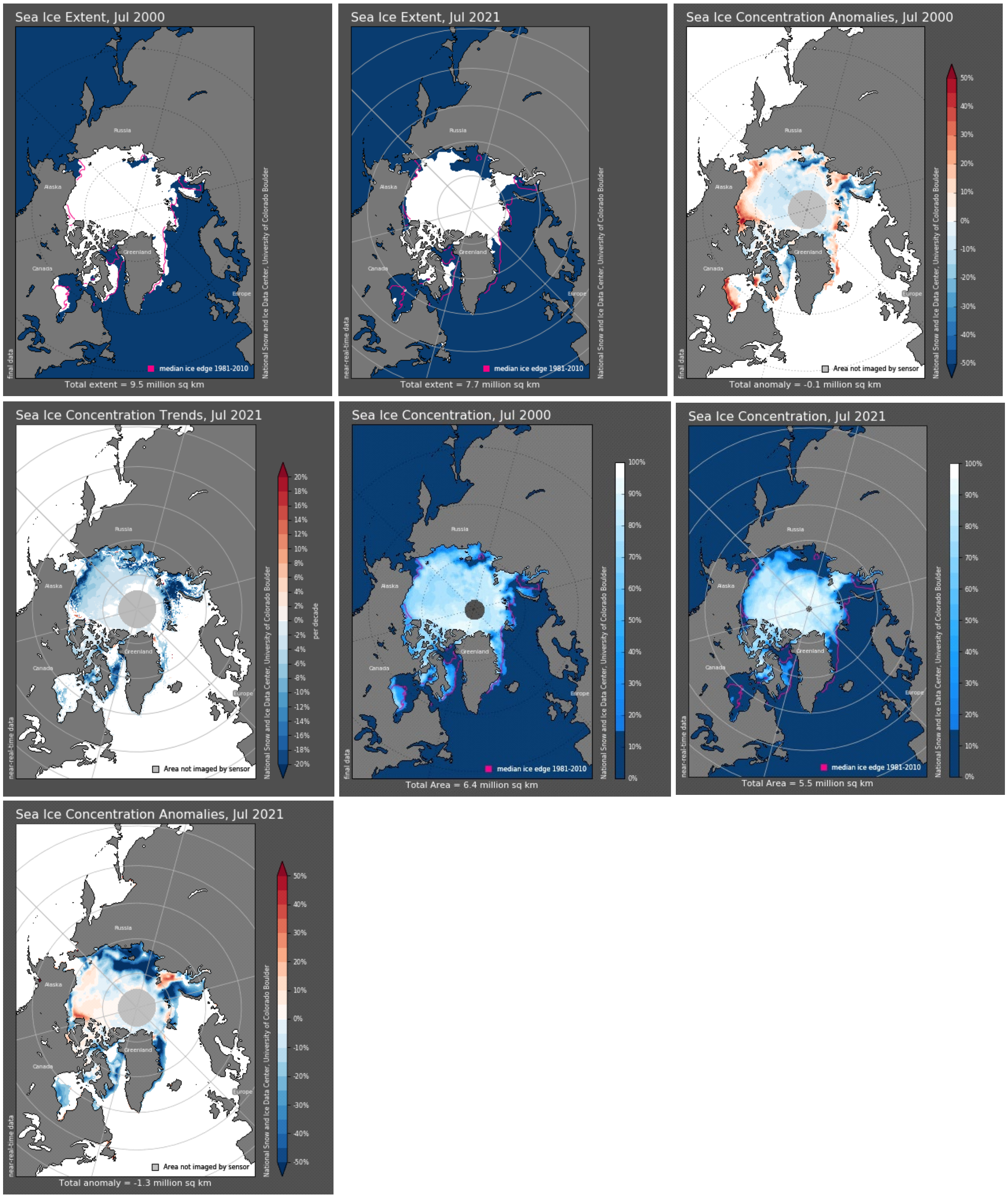


Figure 3 : Monthly sea ice extent, concentration, anomalies in July 2000 and 2021 and trends in Juy 2021 (source:https://nsidc.org/data/seaice_index) Credit: National Snow and Ice Data Center)

We will focus here on the role of climate change and ocean pollution in the Atlantic sector of the Arctic Ocean, in particular on the role of warming and meltwater on upper-ocean stratification, deoxygenation and acidification and the resulting impacts on marine ecosystems. A 5-year strategic observing program via Ponant Science on Le

Commandant Charcot would contribute to the UN Decade of the Ocean for Sustainable Development endorsed programmes GOOD (Global Ocean Oxygen Decade), OARS (Ocean Acidification Research for Sustainability), and those of the Global Ocean Observing System (GOOS, here focusing on expanding global observations of marine litter as part of the Integrated Marine Debris Observing System, IMDOS). The latter will correspond to a feasibility study during the 1st year, either by GEOMAR or IFREMER. IFREMER has underway y a stand-alone research proposal to be submitted to Ponant Science, investigating the broader life cycle of plastics in the environment.

Research objectives

1/ Assess the role of warming and meltwater input on upper ocean oxygen levels on the east Greenland shelf, in the East Greenland Current and around Spitsbergen (Nordvest Spitsbergen National Park, Nordaust and Soraust Svalbard Nature Reserves)

2/ OARS scientific objective is to assess ocean acidification (OA) data targeting SDG 14.3 and address the impacts due to climate change, such as warming, increased freshwater from melting glaciers, sea ice and increased landriver runoff, and permafrost melting due to climate change.

3/ Monitor the biomass and taxonomic composition of zooplankton (the crucial trophic link between primary producers and higher trophic levels) in relation to changing environmental parameters.

4/ Document the distribution of microplastics during the upcoming summer 2022 Ponant cruise campaigns

5/ Demonstrate that innovative user-friendly tools may underpin a sustainable citizen Oceanography 3.0 providing critical new knowledge on global plankton ecology, morphology and genetics.

Methodology

1/ Core hydrography (e.g. salinity, temperature, dissolved oxygen) will be acquired in the upper 500 m on as many stations via CTD-O_2 profiles, in case of sea-ice cover from above-ice melt ponds, at the below-ice ice-water interface and in the surface mixed layer beneath. Air-sea gas exchange will be computed following Islam et al. (2017).

2/ OARS sampling methodology: water sampling from CTD-Niskin rosette (from 2023) in the water column, surface water, and ice-water interface for the analyses of the OA parameters dissolved inorganic carbon (DIC), total alkalinity (AT), pH, as well as calculations of calcium carbonate saturation states and partial pressure of CO_2 (pCO_2), following methods in Fransson et al. (2015, 2016) and Chierici et al. (2019). Continuously measured pCO_2, salinity and temperature at the ship water intake at about 5 meters will be performed using HydroC C CO_2 sensor for surface water pCO_2, and sensors for salinity and temperature (from 2022). Additional sensors for dissolved oxygen and pH are planned in 2023/2024.

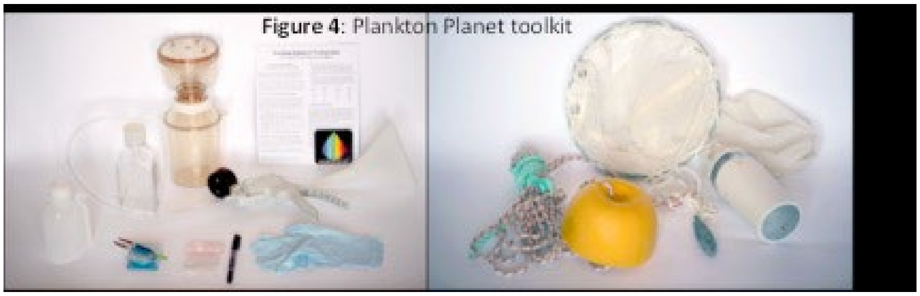
3/ A novel self-contained underwater imaging system (PISCO) recently developed at GEOMAR will acquire highresolution images of zooplankton in a large sample volume. This imaging approach permits to study a diversity of species over a wide size range (approx. 0.2 mm to several cm) in their natural environment, resolving small-scale variability (e.g. vertical distribution and migration of organisms) by non-invasive data collection (allowing studies of fragile gelatinous species). Data on spatiotemporal patterns of species distributions will be used to study foodweb functioning and sensitivity of Arctic ecosystems to a changing ocean environment.

4/ Microplastics will be sampled by an appropriate sampling gear (e.g. Manta trawl net) and the Commandant Charcot crew will be trained to perform the sampling on subsequent cruises. Engaging passengers in performing the sampling will be an ideal example of citizen science for long-term monitoring. After the cruise completion, data will be analysed and publicly shared through the GOOS/IMDOS channel.

Pending a successful test with microplastic sampling in these June-July 2022 cruises, a dedicated proposal for regular monitoring of microplastics on Ponant cruises could be drafted by GOOS as a contribution to the globally harmonised effort, part of a future Integrated Marine Debris Observing System (IMDOS). Future research projects on marine plastics (currently in the pipeline) could include the support for the analysis of data coming from future regular monitoring from the Ponant cruises.

5/ A toolkit of simple, scientifically relevant instruments (Figure 4) for citizen-based assessments of marine biodiversity (https://planktonplanet.org/about/values-vision/) will be deployed in 2022. This simple kit does not require chemicals or electricity. Plankton samples can be shipped dried to the lab. Total DNA will be extracted from these samples, millions of DNA barcodes will be sequenced. These data will allow detection and quantification of total plankton communities from the Arctic Ocean. Once a rosette and Niskin bottles will be installed onboard RV Commandant Charcot for the 2023 and subsequent cruises, samples will be also collected for pigment determination in the top 100 m of the water column through filtration of water samples and kept in a freezer at -20°C until delivery to the lab on land to be analyzed using HPLC techniques.

Figure 4: Plankton Planet toolkit



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