ARCTIC Expedition 2021

Cruise Report Project

AdvanCing knowledge on the present Arctic Ocean by chemical-phySical, biogeochemical and biological obServAtioNs to preDict the futuRe chAnges
- CASSANDRA -

29/08/2021, Longyearbyen (NO) – 14/09/2021, Bergen (NO)

PRA

PROGRAMMA DI RICERCHE IN ARTICO

2021

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1- SUMMARY

CASSANDRA project sought to quantify the current state of the physical, chemical, biological and biogeochemical systems of a sub-Arctic historic transect at 75°N (from 75°N 16°E to 75°N 13°W) crossing the Greenland Sea Gyre. As part of the Synoptic Arctic Survey 2020/22 (SAS; https://synopticarcticsurvey.w.uib.no/), CASSANDRA cruise operated with a multidisciplinary approach, making use of common protocols. Emphasis of the CASSANDRA project will be devoted to understanding the major ongoing transformations on the water masses, the marine ecosystem and the carbon cycle.

2- PARTICIPANTS LIST

CASSANDRA cruise started from Longyearbyen on 29 August and ended at Bergen on 14 September 2021 and several scientists were involved (Table 1).

Table 1: CASSANDRA cruise: Participants, Affiliation and Field Activities.

CASSANDRA CRUSIE (29/8–14/9/2021)		
Partecipants	**Affiliation**	**Field Activities**
Facchin Lorenzo	OGS	On board Technologist - Cruise Leader
Coslovich Francesco	OGS	On board Technologist
Cova Andrea	OGS	On board Technologist
Pasotti Jacopo	OGS	Press
Azzaro Maurizio	CNR ISP	Microbial respiration, POC, DOC - Principal Investigator
Bensi Manuel	OGS	Physical Oceanography
Borme Diego	OGS	Zooplankton and Iponeuston (Abundance and diversity)
Cairns Warren R.L.	CNR ISP	Contaminants, $\delta^{18}O$ and δD of H_2O
Diociaiuti Tommaso	OGS	Phytoplankton and Microozoplankton (Abundance and diversity)
Feltracco Matteo	CNR ISP	Contaminants, emerging pollutants, Bioaerosol, $\delta^{18}O$ and δD of H_2O
Giordano Patrizia	CNR ISP	Physical Oceanography
Langone Leonardo	CNR ISP	Physical Oceanography
Mansutti Paolo	OGS	Physical Oceanography
Kovacevic Vedrana	OGS	Physical Oceanography
Monti Marina	OGS	Microzooplankton abundance and diversity
Papale Maria	CNR ISP	Microbial Diversity (Seawater, Bioaerosol and sediment), Biolog, Cultivable bacteria
Rappazzo Alessandro C.	UniVe; CNR ISP	Viral abundance, Microbial abundance (DAPI, Live/Dead, CTC, LPS) and biomass, Chla, Enzymatic activities, Biolog, Cultivable bacteria
Rizzo Carmen	SZN; CNR ISP	Microbial Diversity (Seawater, Bioaerosol and sediment), Biolog
Relitti Federica	OGS	O_2, nitrite and nitrate, phosphate, silicate, total dissolved nitrogen and phosphorous, $\delta^{13}C$-DIC, spectrophotometric pH_T and total alkalinity
Urbini Lidia	OGS	O_2, nitrite and nitrate, phosphate, silicate, total dissolved nitrogen and phosphorous, $\delta^{13}C$-DIC, spectrophotometric pH_T and total alkalinity

3- PARTICIPATING INSTITUTIONS

CNR - National Research Council, Institute of Polar Sciences, Messina/Bologna/Venice (Italy);
OGS - National Institute of Oceanography and Applied Geophysics, Trieste (Italy);
SZN, 'Anton Dohrn' Zoological Station, Messina (Italy);
UniVe - Ca' Foscari University of Venice (Italy).

4- CASSANDRA CRUISE OBJECTIVES

CASSANDRA overarching goal is to contribute to the evaluation of the current state and major ongoing transformations of the Arctic marine system along one of the main gates to the Arctic Ocean. To achieve this scope CASSANDRA pursued 3 key foci: A) Physical and biogeochemical state and variability; B) Microbial Ecosystem response; C) Carbon cycle and Ocean Acidification. The aims of the focal areas are: A1) Depict the distribution and the dynamics of the main water masses in the area of the GSG, and investigate the effects of processes that determine, at different spatial and temporal scales, atmospheric and oceanic circulation patterns; A2) Characterise the water masses biogeochemistry; B1) Evaluate the plankton diversity, abundances, and population structures living in the Greenland Sea Gyre and the northward range expansion of non-indigenous species; B2) Estimate the biomass flux in the analysed ecosystems; C1) Determine the exchanges inorganic carbon along the 75°N transect; C2) Quantify the input and fate of organic carbon; C3) Assess the levels of acidification and possible impacts on the marine biota.

5- DESCRIPTION OF ACTIVITY

During the cruise 28 CTD casts were performed in twenty stations (Fig.1). The station identifications, coordinates and bottom depths are reported in Table 2. Seawater samples were collected by a Rosette sampler equipped with 24 Niskin bottles (capacity 10 L). In addition, meteo parameters (wind speed, wind direction, air temperature, net atmospheric radiation, relative humidity, air pressure) were recorded during the navigation through a shipboard meteorological station and these data have been coupled with some Bioaerosol measurements (diversity and function) in some stations. Ocean current data (velocity and direction) have been collected through a vessel mounted Acoustic Doppler Current Profilers (ADCPs) working at 38 KHz.
In twelve sampling stations (Fig. 1, blue rhombus and red squares; Table 3a) seawater samples were collected for marine chemistry, biogeochemistry parameters (dissolved oxygen, nitrite and nitrate, phosphate, silicate, total dissolved nitrogen and phosphorous, δ^{13}C-DIC, spectrophotometric pH_T and total alkalinity, Particulate and Dissolved Organic Carbon and N, δ^{18}O and δD of H2O) and pollutants. Water samples to carry out salinity measurements with the Autosal Salinometer (model Guildline8400B) for data quality control of the CTD probe were collected in 7 stations, in some cases at multiple levels. At station 30, interstitial water was also collected to measure salinity in the sediment sample from multicorer.
Samples for biological parameters were collected in 6 main stations (Fig. 1, red squares; Table 3b) and have been partially processed to obtain the following measurements along the water column: Viral component (Cytometry); Prokaryotic (Bacteria and Archaea) abundance (also including Live/Dead; cultivable bacteria), biomass (Cytometry, Epifluorescence Microscopy), activity (respiring cells CTC+; Metabolic profiles - Biolog), phylogenetic composition and metabolic potential by next generation sequencing approach; Phytoplankton: Size fractionated chlorophyll (spectrofluorimetric analysis), taxa community composition by microscopy and molecular analysis, optical detection (fluorimeter); Activity in planktonic communities: Microbial community respiration (ETS assay), Enzymatic activities (leucine aminopeptidase, beta-glucosidase and alkaline phosphatase; Fluorimetric assays); Microzooplankton: abundance, biomass, taxa community composition by microscopy, subsamples for molecular analysis. Sampling with WP2 Net were done at the six main stations (Fig. 1, red squares; Table 3b) for Meso- and Macro-zooplankton. Iponeuston

sampling was carried out via manta net. On board samples obtained by plankton nets were split to estimate the biomass and to describe the taxa composition of the zooplanktonic community. Subsamples for biomass estimations were fractioned (fractions:> 2000 µm, 2000-1000µm, 1000-500 µm, and 500-200 µm) and frozen on board. Subsamples for qualitative and quantitative analysis have been preserved both in a seawater-buffered formaldehyde solution (4% final concentration) and in ethanol. Additional water and sediment samples (not foreseen in the original plan) were collected by multi-corer at stations Cass-010 and Cass-030 and will be processed for the analysis of microbial communities.
Unfortunately, the CASSANDRA project program was not fully implemented. In fact, 46 hydrological stations were planned and about half of the stations envisaged biogeochemical measurements. The biological stations alone were made 100% with however a lack of some sampling depths along the vertical. The modification of the original plan was caused both by bad weather conditions and by technical problems with the hydrological cable.

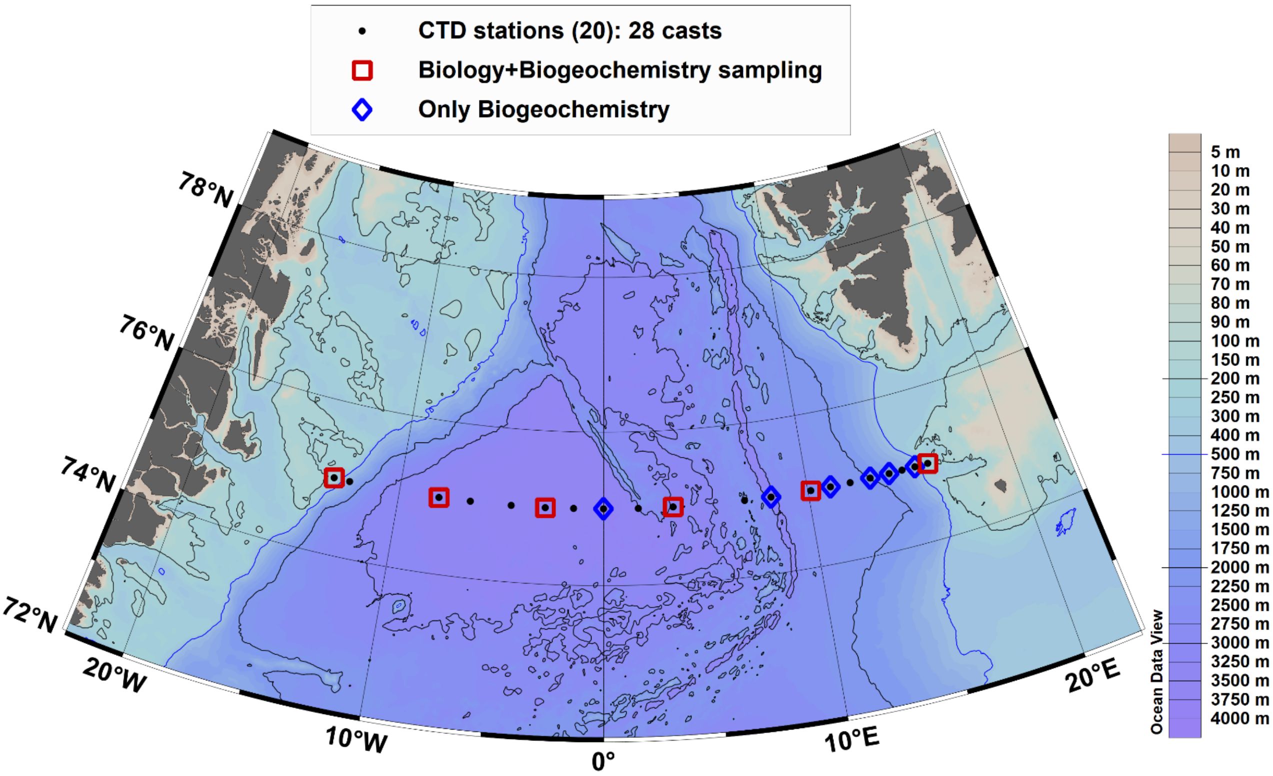

Figure 1 – Study area and sampling stations occupied during the CASSANDRA cruise. Black dots, red squares and blue rhombus indicate the hydrological stations (CTD), biological + biogeochemistry stations, and the biogeochemistry stations, respectively.

Table 2: Station identifications, coordinates and bottom depths revealed by echosounder.

Station	Date	Longitude	Latitude	Bottom Depth [m]
Cass-001	02-09-2022	16.00083°E	75.00034°N	~ 244
Cass-002	02-09-2022	15.35067°E	75.00034°N	~ 863
Cass-003	02-09-2022	14.70067°E	75.00034°N	~ 1286
Cass-004	03-09-2022	14.05050°E	75.00050°N	~ 1684
Cass-006	03-09-2022	13.10883°E	75.00034°N	~ 2007
Cass-007	03-09-2022	12.09917°E	75.00034°N	~ 2233
Cass-008	03-09-2022	11.12950°E	75.00000°N	~ 2436
Cass-010	04-09-2022	10.15017°E	75.00017°N	~ 2495
Cass-013	04-09-2022	8.19967°E	74.99966°N	~ 3445
Cass-015	05-09-2022	6.89817°E	74.99983°N	~ 1920
Cass-020	06-09-2022	3.40083°E	74.99983°N	~ 3495
Cass-023	06-09-2022	1.70117°E	74.99966°N	~ 2916
Cass-025	06-09-2022	0.00183°E	74.99983°N	~ 3707
Cass-028	07-09-2022	1.44934°W	74.99966°N	~ 3614
Cass-030	07-09-2022	2.84283°W	74.99850°N	~ 3642
Cass-032	09-09-2022	4.49750°W	74.99966°N	~3531
Cass-035	09-09-2022	6.49734°W	74.99966°N	~3413
Cass-038	09-09-2022	8.04651°W	74.99983°N	~3341
Cass-045	09-09-2022	12.45667°W	74.99767°N	~1059
Cass-046	10-09-2022	13.22968°W	74.99750°N	~ 220

6- DATA ACQUISITION AND SAMPLE ANALYSIS/DATA STORAGE/AVAILABILITY

Acquired measurements and analysis results will be stored with proper file format. QA/QC (Quality Assurance/Quality Control) procedures will be applied to data from automatic instrumentation. Currently the analysis of the samples is very late due to the administrative delays for the stipulation of the ISP contract with the Arctic Research Program (PRA) and the subsequent passage of the economic resources from ISP to OGS. All datasets will be documented through metadata compliant 19115 standard, and stored in the CNR (http://iadc.cnr.it/cnr/) and OGS (https://nodc.inogs.it/) data centers, which are First Level Nodes of the Italian Arctic Data Center (IADC) funded by Arctic Research Programme (PRA). IADC and its CNR and OGS nodes will provide IT platforms and software (as GeoNetwork and OpenDAP) to assure discovery and access to data by any user following FAIR principles. In particular, thanks to OpenDAP will be possible to distribute csv files in the netCDF format. IADC will offer tools also for integration and deep analysis of acquired datasets.

Table 3a: Chemical and biogeochemical parameters (Bibliographic references for the oceanographic measurements reported in paragraph 7).

Station	Depth	O2	NO2 NO3	PO4	SiO4	TDN	TDP	δ13C-DIC	δ18O δD of H2O	pHT	Total Alkalinity	POC PON	DOC	Hg	Pesticides	Emergent Polluttants
CASS-001	sup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	20	x	x	x	x	x	x	x	x	x	x	x	x	x		
	40	x	x	x	x	x	x	x	x	x	x	x	x	x		
	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
	200	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
	240	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
CASS-002	sup	x	x	x	x	x	x	x	x	x	x					
	20	x	x	x	x	x	x	x	x	x	x					
	40	x	x	x	x	x	x	x	x	x	x					
	100	x	x	x	x	x	x	x	x	x	x					
	200	x	x	x	x	x	x	x	x	x	x					
	500	x	x	x	x	x	x	x	x	x	x					
	870	x	x	x	x	x	x	x	x	x	x					
CASS-004	sup	x	x	x	x	x	x	x	x	x	x	x	x		x	x
	20	x	x	x	x	x	x	x	x	x	x	x	x			
	40	x	x	x	x	x	x	x	x	x	x	x	x			
	100	x	x	x	x	x	x	x	x	x	x	x	x			
	200	x	x	x	x	x	x	x	x	x	x	x	x			
	500	x	x	x	x	x	x	x	x	x	x	x	x			
	1000	x	x	x	x	x	x	x	x	x	x	x	x			
	1500	x	x	x	x	x	x	x	x	x	x	x	x			
	1680	x	x	x	x	x	x	x	x	x	x	x	x			
CASS-006	sup	x	x	x	x	x	x	x	x	x	x					
	20	x	x	x	x	x	x	x	x	x	x					
	40	x	x	x	x	x	x	x	x	x	x					
	100	x	x	x	x	x	x	x	x	x	x					
	200	x	x	x	x	x	x	x	x	x	x					
	500	x	x	x	x	x	x	x	x	x	x					
	1000	x	x	x	x	x	x	x	x	x	x					
	1500	x	x	x	x	x	x	x	x	x	x					
	1999	x	x	x	x	x	x	x	x	x	x					
CASS-008	sup	x	x	x	x	x	x	x	x	x	x					
	20	x	x	x	x	x	x	x	x	x	x					
	40	x	x	x	x	x	x	x	x	x	x					
	100	x	x	x	x	x	x	x	x	x	x					
	200	x	x	x	x	x	x	x	x	x	x					
	500	x	x	x	x	x	x	x	x	x	x					
	1000	x	x	x	x	x	x	x	x	x	x					
	1500	x	x	x	x	x	x	x	x	x	x					
	2000	x	x	x	x	x	x	x	x	x	x					
	2426	x	x	x	x	x	x	x	x	x	x					
CASS-010	sup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	20	x	x	x	x	x	x	x	x	x	x	x	x	x		
	40	x	x	x	x	x	x	x	x	x	x	x	x	x		
	100	x	x	x	x	x	x	x	x	x	x	x	x	x		
	200	x	x	x	x	x	x	x	x	x	x	x	x	x		
	500	x	x	x	x	x	x	x	x	x	x	x	x	x		
	1000	x	x	x	x	x	x	x	x	x	x	x	x	x		
	1500	x	x	x	x	x	x	x	x	x	x	x	x	x		
	2000	x	x	x	x	x	x	x	x	x	x	x	x	x		
	2520	x	x	x	x	x	x	x	x	x	x	x	x	x		
	2528		x	x	x			x		x	x					

Sation	Depth	O2	NO2 NO3	PO4	SiO4	TDN	TDP	δ13C-DIC	δ18O δD of H2O	pHT	Total Alkalinity	POC PON	DOC	Hg	Pesticides	Emergent Polluttants
CASS-013	sup	x	x	x	x	x	x	x	x	x	x					
	20	x	x	x	x	x	x	x	x	x	x					
	40	x	x	x	x	x	x	x	x	x	x					
	100	x	x	x	x	x	x	x	x	x	x					
	200	x	x	x	x	x	x	x	x	x	x					
	500	x	x	x	x	x	x	x	x	x	x					
	1000	x	x	x	x	x	x	x	x	x	x					
	1500	x	x	x	x	x	x	x	x	x	x					
	2000	x	x	x	x	x	x	x	x	x	x					
	2500	x	x	x	x	x	x	x	x	x	x					
	3000															
	3445	x	x	x	x	x	x	x	x	x	x					
CASS-020	sup	x	x	x	x	x	x	x	x	x	x	x	x	x		x
	20	x	x	x	x	x	x	x	x	x	x	x	x	x		
	40	x	x	x	x	x	x	x	x	x	x	x	x	x		
	100	x	x	x	x	x	x	x	x	x	x	x	x	x		
	200	x	x	x	x	x	x	x	x	x	x	x	x	x		
	500	x	x	x	x	x	x	x	x	x	x	x	x	x		
	1000	x	x	x	x	x	x	x	x	x	x	x	x	x		
	1500	x	x	x	x	x	x	x	x	x	x	x	x	x		
	2000	x	x	x	x	x	x	x	x	x	x	x	x	x		
	2500	x	x	x	x	x	x	x	x	x	x	x	x	x		
	3000	x	x	x	x	x	x	x	x	x	x	x	x	x		
	3500	x	x	x	x	x	x	x	x	x	x	x	x	x		
CASS-025	sup	x	x	x	x	x	x	x	x	x	x	x	x		x	x
	20	x	x	x	x	x	x	x	x	x	x	x	x			
	40	x	x	x	x	x	x	x	x	x	x	x	x			
	100	x	x	x	x	x	x	x	x	x	x	x	x		x	
	200	x	x	x	x	x	x	x	x	x	x	x	x			
	500	x	x	x	x	x	x	x	x	x	x	x	x		x	
	1000	x	x	x	x	x	x	x	x	x	x	x	x		x	
	1500	x	x	x	x	x	x	x	x	x	x	x	x			
	2000	x	x	x	x	x	x	x	x	x	x	x	x		x	
	2500											x	x			
	3000	x	x	x	x	x	x	x	x	x	x	x	x			
	3500	x	x	x	x	x	x	x		x	x					
	3698	x	x	x	x	x	x	x	x	x	x	x	x		x	
CASS-030	sup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	20	x	x	x	x	x	x	x	x	x	x	x	x	x		
	40	x	x	x	x	x	x	x	x	x	x	x	x	x		
	100	x	x	x	x	x	x	x	x	x	x	x		x		
	1000	x	x	x	x	x	x	x	x	x	x	x	x	x		
	1500	x	x	x	x	x	x	x	x	x	x	x	x	x		
	2000	x	x	x	x	x	x	x	x	x	x	x	x	x		
	2500	x	x	x	x	x	x	x	x	x	x	x	x	x		
	3642	x	x	x	x	x	x	x		x	x					
CASS-038	sup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	20	x	x	x	x	x	x	x	x	x	x	x	x	x		
	40	x	x	x	x	x	x	x	x	x	x	x	x	x		
	100	x	x	x	x	x	x	x		x	x	x	x	x		
	200	x	x	x	x	x	x	x	x	x	x	x	x			
CASS-046	sup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	20	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
	40	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
	220	x	x	x	x	x	x	x	x	x	x	x	x	x		

Table 3b: Biological parameters (Bibliographic references for the oceanographic measurements reported in paragraph 7).

Station	Depth	Dapi	CTC	Live / Dead	LPS	Biolog	Virus	Prok	Prok DNA	Chla	Respiratory activity	Total Enzymatic Activity	Dissolved Enzymatic Activity	Phytoplankton	DNA Phytoplankton	Micro-zooplankton	DNA Micro-zooplankton	WP2 net Meso-, Macro-zooplankton	Manta Net Iponeuston
CASS-001	sup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0-20 m	0-100 m	sup
	20	x	x	x	x	x	x	x		x	x	x		x					
	40	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	100	x	x	x	x	x	x	x	x	x	x	x		x	x	x			
	200	x	x	x	x		x	x			x	x	x						
	240	x	x	x	x	x	x	x	x		x	x	x			x	x		
CASS-010	sup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0-20 m	0-100 m	sup
	20	x	x	x	x		x	x		x	x	x	x	x					
	40	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	200	x	x	x	x		x	x			x	x							
	500	x	x	x	x		x	x			x	x							
	1000	x	x	x	x	x	x	x	x		x	x	x			x	x		
	1500	x	x	x	x		x	x			x	x							
	2000	x	x	x	x	x	x	x	x		x	x	x			x	x		
	2520	x	x	x	x	x	x	x	x		x	x	x			x	x		
	2528	x	x	x	x	x	x	x	x			x	x						
CASS-020	sup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0-30 m	0-100 m	sup
	20	x	x	x	x		x	x		x	x	x	x	x					
	40	x	x	x	x	x	x	x	x	x	x	x		x	x	x			
	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	200	x	x	x	x		x	x			x	x							
	500	x	x	x	x		x	x			x	x							
	1000	x	x	x	x	x	x	x	x		x	x	x			x	x		
	1500	x	x	x	x		x	x			x	x							
	2000	x	x	x	x	x	x	x	x		x	x	x			x	x		
	2500	x	x	x	x		x	x			x	x							
	3000	x	x	x	x		x	x	x		x	x				x	x		
	3500	x	x	x	x	x	x	x	x		x	x	x			x	x		
CASS-030	sup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0-30 m	0-100 m	sup
	20	x	x	x	x	x	x	x		x	x	x		x					
	40	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	1000	x	x	x	x	x	x	x	x		x	x	x			x	x		
	1500	x	x	x	x	x	x	x			x	x							
	2000	x	x	x	x	x	x	x	x		x	x	x			x	x		
	2500	x	x	x	x	x	x	x				x							
	3642	x	x	x	x	x	x	x	x							x	x		
CASS-038	sup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0-30 m	0-100 m	sup
	20	x	x	x	x	x	x	x		x	x	x		x					
	40	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	200																		
CASS-046	sup	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0-30 m	0-100 m	sup
	20	x	x	x	x	x	x	x		x	x	x		x					
	40	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	220	x	x	x	x	x	x	x			x	x				x	x		

7- REFERENCES

1) Azzaro M., Aliani S., Maimone G., Decembrini· F., Caroppo C., Giglio·F., Langone L., Miserocchi S.· Cosenza A., Azzaro F., Rappazzo A.C., Cabral A.S. Paranhos R., Mancuso M., La Ferla R. (2021) Short-term dynamics of nutrients, planktonic abundances, and microbial respiratory activity in the Arctic Kongsfjorden (Svalbard Islands).Polar Biology, https://doi.org/10.1007/s00300-020-02798-w.
2) Azzaro M., La Ferla R., Maimone G., Monticelli L.S., Zaccone R., Civitarese G. (2012) Prokaryotic dynamics and heterotrophic metabolism in a deep convection site of Eastern Mediterranean Sea (the Southern Adriatic Pit). Continental Shelf Research, 44: 106-118.
3) Azzaro M., La Ferla R., Azzaro F. (2006) Microbial respiration in the aphotic zone of the Ross Sea (Antarctica). Marine Chemistry, 99 (1-4): 199-209.
4) Bensi M., Kovacevic V., Ursella L., Rebesco M., Langone L.,
5) Viola A., Mazzola M., Beszczyńska-Möller A., Goszczko I., Soltwedel T., Skogseth R., Nilsen F., Wåhlin A. (2018) Spitsbergen Oceanic and Atmospheric interactions – SOA. In SESS report 2018- The state of Environmental Science in Svalbard – an annual report. Edited by SIOS. Pp. 130-146.
6) Bensi M., Kovačević V., Langone L., Aliani S., Ursella L., Goszczko I., Soltwedel T. Skogseth R., Nilsen F., Deponte D., Mansutti P., Laterza R., Rebesco M., Rui L., Lucchi R., Wåhlin A., Viola A., Beszczynska-Möller A., Rubino A. (2019) Deep Flow Variability Offshore South-West Svalbard (Fram Strait). Water 2019, 11, 683; doi:10.3390/w11040683.
7) Camuffo D., della Valle A., Becherini F. (2020) Critical analysis of the definitions of climate and hydrological extreme events. Quaternary International, 538: 5-13.
8) Caruso G., La Ferla R., Azzaro M., Zoppini A., Marino G., Petochi T., Corinaldesi C., Leonardi M., Zaccone R., Fonda Umani S., Caroppo C., Monticelli L., Azzaro F, Decembrini F., Maimone G., Cavallo R.S., Stabili L., Todorova N.H., Karamfilov V.K., Rastelli E., Cappello S., Acquaviva M.I., Narracci M., De Angelis R., Del Negro P., Latini M., Danovaro R. (2016) Microbial assemblages for environmental quality assessment: Knowledge, gaps and usefulness in the European marine strategy framework directive. Critical Reviews in Microbiology, doi: 10.3109/1040841X.2015.1087380.
9) Caroppo C., Pagliara P., Azzaro F., Miserocchi S., Azzaro M. (2017) Late Summer Phytoplankton Blooms in the Changing Polar Environment of the Kongsfjorden (Svalbard, Arctic). Cryptogamie, Algologie, 38 (1), 53-72.
10) Catalano G., Azzaro M., Bastianini M., Bellucci L.G., Bernardi Aubry F., Bianchi F., Burca M., Cantoni C., Caruso G., Casotti R., Cozzi S., Del Negro P., Fonda Umani S., Giani M., Giuliani S., Kovacevic V., La Ferla R., Langone L., Luchetta A., Monticelli L.S., Piacentino S., Pugnetti A., Ravaioli M., Socal S., Spagnoli F., Ursella L. (2014) The carbon budget in the northern Adriatic Sea, a winter case study. Journal of Geophysical Research: Biogeosciences, 119 (7).
11) Catalano G., Budillon G., La Ferla R., Povero P., Ravaioli M., Saggiamo V., Accornero A., Azzaro M., Carrada G.C., Giglio F., Langone L., Mangoni O., Misic C., Modigh M. (2006) A global budget of carbon and nitrogen in the Ross Sea (Southern Ocean). In: Liu KK, Atkinson L, Quiñones R, Talaue-McManus L, Eds, Carbon and Nutrient Fluxes in Continental Margins: A Global Synthesis, 450 pp, Global Change, The IGBP Series, Springer, Berlin.

12) Crisafi E., Azzaro M., Lo Giudice A., Michaud L., La Ferla R., Maugeri T.L., De Domenico M., Azzaro F., Pomar M.L.C., Bruni V., (2010) Microbiological characterization of a semi-enclosed sub-Antarctic environment: the Straits of Magellan. Polar Biology, 33 (11): 1485-1504.
13) Decembrini F., Caroppo C., Azzaro M. (2009) Size structure and production of phytoplankton community and carbon pathways channelling in the Southern Tyrrhenian Sea (Western Mediterranean). Deep-Sea Research Part II: Topical Studies in Oceanography 56 (11-12): 687-699.
14) Decembrini F., Bergamasco A., Mangoni O. (2014) Seasonal characteristics of size-fractionated phytoplankton community and fate of photosynthesized carbon in a sub-Antarctic area (Straits of Magellan). Journal of Marine Systems 136 (1): 31-41.
15) Gentile G., Giuliano L., D'Auria G., Smedile F., Azzaro M., De Domenico, M., Yakimov M.M. (2006) Study of bacterial communities in Antarctic coastal waters by a combination of 16S rRNA and 16S rDNA sequencing. Environmental Microbiology, 8 (12): 2150-2161.
16) Ingrosso G., Bensi M., Cardin V, Giani M. (2017) Anthropogenic CO2 in the middle and southern Adriatic Sea. Deep-Sea Research Part I, 123: 118-128.
17) Jones E.P., Swift J. H., Anderson L. G., Lipizer M., Civitarese G., Falkner K. K., Kattner G., McLaughlin F. (2003) Tracing Pacific Water in the North Atlantic Ocean. J. Geophys. Res., 108(C4): 3116-3125.
18) La Cono V., Ruggeri G., Azzaro M., Crisafi F., Decembrini F., Denaro R., La Spada G., Maimone G., Monticelli L.S., Smedile F., Giuliano L., Yakimov M.M. (2018) Contribution of bicarbonate assimilation to carbon pool dynamics in the deep Mediterranean Sea and cultivation of actively nitrifying and CO2-fixing bathypelagic prokaryotic consortia. Frontiers in Microbiology, 9: 3.
19) Luna G.M., Bianchelli S., Decembrini F., De Domenico E., Danovaro R., Dell'Anno A. (2012) The dark portion of the Mediterranean Sea is a bioreactor of organic matter cycling. Global Biogeochemical Cycles, 26 (2), Article number GB2017.
20) Lusher A.L., Tirelli V., O'Connor I., Officer R. (2015) Microplastics in Arctic polar waters: the first reported values of particles in surface and subsurface samples. Scientific Reports, doi: 10.1038/srep14947.
21) Meiners K., Gradinger R., Fehling J., Civitarese G., and Spindler M (2003) Vertical distribution of exopolymer particles in sea ice of the Fram Strait (Arctic) during autumn. Mar. Ecol. Prog. Ser., 248: 1-13.
22) Michaud A.B., Skidmore M.L., Mitchell A.C., Vick-Majors T.J., Barbante C., Turetta C., vanGelder W., Priscu J.C. (2016) Solute sources and geochemical processes in Subglacial Lake Whillans, West Antarctica. Geology (2016) 44 (5): 347–350. doi: 10.1130/G37639.1.
23) Monti M., Minocci M. (2013) Microzooplankton along a transect from northern continental Norway to Svalbard. Polar Res, 32:19306. doi:10.3402/polar.v32i0.19306
24) Monti M., Zoccarato L., Fonda Umani S. (2016) Microzooplankton composition under the sea ice and in the open water in Terra Nova Bay (Antarctica). Polar Biol, doi:10.1007/s00300-016-2016-9.
25) Monti-Birkenmeier M., Diociaiuti T., Fonda Umani S., Meyer B. (2017) Microzooplankton composition in the winter sea ice of the Weddell Sea. Antarctic Science, doi:10.1017/S0954102016000717.

26) Owrid G., Socal G., Civitarese G., Luchetta A., Wiktor J., Nothig E. M., Andreassen I., Schauer U., Strass V. (2000) Spatial variability of phytoplankton, nutrients and new production estimates in the waters around Svalbard (summer 1991). Polar Research, 19(2): 155-171.
27) Papale M., Rappazzo A.C., Mikkonen A., Rizzo C., Moscheo F., Conte A., Michaud L., Lo Giudice A. (2020) Bacterial diversity in a dynamic and extreme sub-arctic watercourse (Pasvik river, norwegian arctic). Water (Switzerland), 12 (11): 1-19.
28) Steinhoff T., Gkritzalis T., Lauvset S.K., Jones S., Schuster U., Olsen A., Becker M., Bozzano R., Brunetti F., Cantoni C., Cardin V., Diverrès D., Fiedler B., Fransson A.,*Giani M.,* Hartman S., Hoppema M., Jeansson E., Johannesson T., Kittidis V., Körtzinger A., Landa C., Lefèvre N., Luchetta A., Naudts L., Nightingale P.D., Omar A.,Pensieri S., Pfeil B., Castaño-Primo R., Rehder G., Rutgersson A., Sanders R., Schewe I., Siena G., Skjelvan I., Soltwedel T., van Heuven S., Watson A. (2019) Constraining the oceanic uptake and fluxes of greenhouse gases by building an ocean network of certified stations: the ICOS-Oceans Network. Frontiers in Marine Science,03 September 2019. https://doi.org/10.3389/fmars.2019.00544.
29) Stefanni S., Stanković D., Borme D., de Olazabal A., Juretić T., Pallavicini A., Tirelli V. (2018) Multi-marker metabarcoding approach to study mesozooplankton at basin scale. Scientific Reports volume 8, Article number: 12085 doi:10.1038/s41598-018-30157-7.
30) Urbini L., Ingrosso G., Djakovac T., Piacentino S., Giani M. (2020) Temporal and spatial variability of the CO2 system in a riverine influenced area of the Mediterranean Sea, the northern Adriatic. Frontiers in Marine Science, 13 August 2020. https://doi.org/10.3389/fmars.2020.00679.
31) Ursella L, Cardin V., Batistić M., Garić R., Gačić M. (2018) Evidence of zooplankton vertical migration from continuous Southern Adriatic buoy current-meter records. Progress in Oceanography, 167: 78-96. https://doi.org/10.1016/j.pocean.2018.07.004.

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