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CENTRE FOR MARITIME RESEARCH AND EXPERIMENTATION

Technical Report **CMRE-MR-2022-005**

NREP22 Cruise Report and Data Catalogue

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About CMRE

The Centre for Maritime Research and Experimentation (CMRE) is a world-class NATO scientific research and experimentation facility located in La Spezia, Italy.

The CMRE was established by the North Atlantic Council on 1 July 2012 as part of the NATO Science & Technology Organization. The CMRE and its predecessors have served NATO for over 50 years as the SACLANT Anti-Submarine Warfare Centre, SACLANT Undersea Research Centre, NATO Undersea Research Centre (NURC) and now as part of the Science & Technology Organization.

CMRE conducts state-of-the-art scientific research and experimentation ranging from concept development to prototype demonstration in an operational environment and has produced leaders in ocean science, modelling and simulation, acoustics and other disciplines, as well as producing critical results and understanding that have been built into the operational concepts of NATO and the nations.

CMRE conducts hands-on scientific and engineering research for the direct benefit of its NATO Customers. It operates two research vessels that enable science and technology solutions to be explored and exploited at sea. The largest of these vessels, the NRV Alliance, is a global class vessel that is acoustically extremely quiet.

CMRE is a leading example of enabling nations to work more effectively and efficiently together by prioritizing national needs, focusing on research and technology challenges, both in and out of the maritime environment, through the collective Power of its world-class scientists, engineers, and specialized laboratories in collaboration with the many partners in and out of the scientific domain.

NREP22 cruise report and data catalogue

Pennucci G., Fabbri T., Lewis C. V. W.,
Alvarez A., Russo A., Poulain, P.-M.

This document, which describes work performed under the Project/the Programme SAC000D06 (ASW Environmental Acoustic Support in a Rapidly Thawing Arctic Ocean) of the STO-CMRE Programme of Work, has been approved by the Director.

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NREP22 cruise report and data catalogue

Pennucci G., Fabbri T., Lewis C. V. W., Alvarez A., Russo A., Poulain P.-M.

Executive Summary: The return to great power competition leads the Arctic Ocean to be a fundamental component of the future security space in the Euro-Atlantic zone. Furthermore, the rapid thawing of the Arctic constitutes a major disruptive force to drive potential conflicts in the area. This is already escalating international tensions in the High North region, with unpredictable consequences. Under this scenario, whomever controls the security of the Arctic must rely heavily on undersea dominance. The CMRE research project ASW Environmental Support in a Rapidly Thawing Arctic Ocean resulted from the implementation of the CMRE Arctic Science and Technology Strategy in collaboration with fifteen NATO Nations' research and operational institutions. The project aims to provide sufficient understanding and realistic environmental databases to allow the selection of logical alternative in sensor design, system configuration and signal processing to support future NATO's ASW operation in the Arctic Ocean.

The Nordic Recognized Environmental Picture 2022 (NREP22) sea trial was conducted to collect data and to assess the impact of the environmental conditions on allied Arctic ASW operations, to define the environmental characterization requirements and develop the capabilities to mitigate those impacts. This report describes the oceanographic and acoustic activities conducted during the NREP22 sea trial, as well as a detailed inventory of the collected data. The final aim of this document is to facilitate the exchange and portability of the NREP22 dataset to NATO partners.

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NREP22 cruise report and data catalogue

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Abstract: The Nordic Recognized Environmental Picture 2022 (NREP22) sea trial was performed in the Svalbard Islands area and Greenland Sea from 8th to 27th June 2022. The sea trial was conducted to investigate the impact of ice-covered seas on moored and mobile underwater acoustic communications systems, as well as to conduct sustained monitoring of oceanographic variables and ambient noise levels to assess the Arctic transformation.
This report provides a detailed overview of the oceanographic and acoustic measurements collected by both the NRV Alliance and by autonomous platforms during NREP22, and a summary of the raw and processed data available in the CMRE data repository (isilon).

Keywords: Arctic Ocean, acoustic data, oceanographic data

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1 Introduction

The current geopolitical situation is returning to an era of great power competition. In this global security framework, naval doctrines have refocused on open sea scenarios in addition to littoral theatres. In particular, the Arctic Ocean is expected to be a fundamental component of the future security space in the Euro-Atlantic zone. Furthermore, the rapid thawing of the Arctic due to global warming will be a major disruptive force driving potential conflicts. This is already increasing international tensions in the High North region, with unpredictable consequences for the Euro-Atlantic security. Under this scenario, whomever controls the security of the Arctic must rely heavily on undersea dominance.

The environmental knowledge of the battlefield is a key component to counter near-peer and peer naval adversaries' strategies. The operational concept of Rapid Environmental Assessment (REA) is a current NATO practice for gathering environmental information. REA emerged from NATO's post-Cold War shift towards crisis response in littoral waters. Unfortunately, the extrapolation of littoral REA practices and capabilities to blue water domains like the Arctic Ocean presents new difficulties due to a limited technological scalability. This requires the development of new observing technologies capable to scale to the new dimensions of the battlespace, probably by reinforcing the multisensor character of deployed networks and the determination of novel sampling technologies.

In this scenario, CMRE proposed the CMRE Arctic Science & Technology Strategy (CASTS) with the aim to identify the long-term objectives that CMRE will pursue in the next decade in the Arctic Ocean and the actions necessary to achieve these objectives. The Science & Technology Strategy is intended to address those environmental changes in the Arctic Ocean associated with the global warming that may significantly impact the way Anti Submarine Warefare (ASW) is currently done at this location. Based on a fundamental understanding of the Arctic environmental transformation, the Science & Technology Strategy will result on the identification and requirements to develop Rapid Environmental Assessment (REA) in support of Arctic ASW operations. Specific objectives of this Strategy are: (1) to advance the understanding of variations in the water column stratification and ocean dynamics derived from the climate change, and how these variations will transform the future ASW in the Arctic Ocean; (2) to identify and develop REA requirements, to anticipate future transformation in Arctic ASW.

The realization of the sea trial Nordic Recognized Environmental Picture 2022 (NREP22) campaign led by the Centre for Maritime Research and Experimentation (CMRE) supports the Environmental Knowledge and Operational Effectiveness (EKOE) program outlined in

the Management Plan for the Project *ASW Environmental Support in a Rapidly Thawing Arctic Ocean-SAC000D06* funded by the Allied Command Transformation (ACT).

This report describes the oceanographic and acoustic activities conducted during the NREP22 sea trial, as well as providing a detailed inventory of the collected data. The final aim of this document is to facilitate the exchange and portability of the NREP22 dataset to NATO partners. Moreover, an overview of the cruise area and external participants is detailed. The following Sections describe the oceanographic and acoustic measurements collected during NREP22 and provide a summary of the raw/processed data available in the CMRE data repository (isilon). Specifically, moored autonomous platforms are detailed in Section 2, moving platforms are discussed in Section 3, ship-deployed platforms are described in Section 4, while Section 5 is dedicated to satellite data. Finally, an overall summary of the oceanographic data is presented in Section 6. Details on the acoustic experimentations are provided in Annexes A and B.

1.1 Geographic area and sea trial objectives

The NREP22 sea trial was conducted between June 8th and June 27th 2022 in the Svalbard Islands area and Greenland Sea. Figure 1 shows the NREP22 areas of work: the operational area is indicated by the orange polygon. The white polygon marks the area where several acoustic experiments[1] were performed. Geographical coordinates and additional details are listed in Table 1.

The main objectives of the NREP22 sea trials were:

- To conduct a sustained monitoring of the temperature and salinity characteristics of the Atlantic Water flowing into the region and relate them with the circulation in the North Atlantic.

- To investigate the impact of ice-cover on underwater acoustic communication systems (moored and mobile platforms).

[1] More than twenty-two hours of acoustic transmission were performed during NREP22 over a period of six days. Such acoustic transmissions were carried on under variable ice-coverage conditions and at different transmitter-receiver ranges (between 3 km and 60 km).
Specifically, the first acoustic experiment was performed on the 15th of June 2022 (from 20:00 to 22:30 UTC) at the HYDRA/Wirewalker position (*i.e.* in the white polygon depicted in Figure 1). A second transmission was done on 16th of June from 10:10 to 22:34 UTC. A third acoustic experiment was done on the 17th of June from 7:00 to 17:00 UTC at 30, 27 and 23 km of range eastward from HYDRA. Others acoustic experiments were done 18th June (from 14:23 to 23:26 UTC) and the 19-20 June (from 01:52 to 03:52 UTC). The acoustic transmissions covered different acoustic channel geometries using mobile (*i.e.* the acoustic glider Anna) and moored (*i.e.* the mooring CIO1) platforms as receivers. Details on the acoustic experimentations can be found in Annex A and Annex B.

• To characterize the acoustic propagation under the influence of spiciness[2] potentially induced by the presence of fine structures in the salinity, temperature and sound speed profiles.

• To investigate the capabilities of gliders, drifters and profiling floats tp conduct sustained monitoring of the intensity and directionality of the underwater soundscape. In addition, the collected data will support studies on data fusion to improve underwater navigation.

• To conduct sustained monitoring of oceanographic variables and ambient noise levels to assess the Arctic transformation.

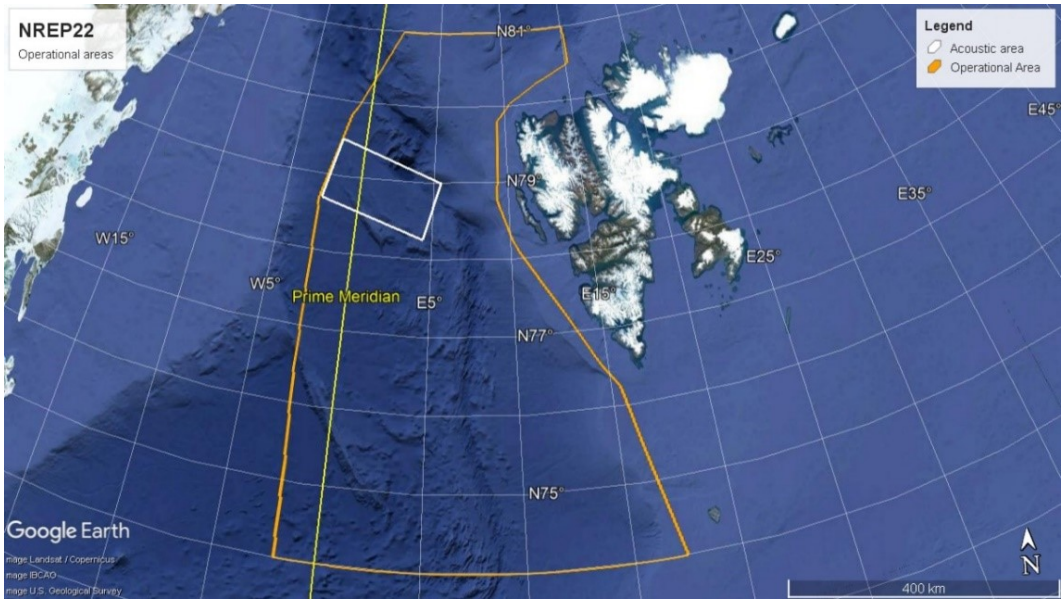

Figure 1: The orange polygon defines the NREP22 operation area while the white polygon defines the area of the acoustic experiments (geographical coordinates are detailed in Table 1).

Table 1: Coordinates of the NREP22 operating area.

Area	Corner Points	Coordinates	
		Longitude	Latitude
NREP22 operational Area (orange)	1	017° 30’ E	74° 00’ N
	2	002° 00’ W	74° 00’ N
	3	002° 40’ W	78° 42’ N
	4	001° 30’ W	79° 50’ N
	5	002° 00’ E	81° 00’ N
	6	015° 00’ E	81° 00’ N
	7	015° 00’ E	80° 30’ N
	8	010° 15’ E	80° 02’ N
	9	009° 18’ E	79° 48’ N

[2] SPICE is defined as the presence of nearly neutrally buoyant oceanographic structure, typically warm salty water adjacent to cool fresher water, with a corresponding large degree of sound speed variability.

	10	009° 16’ E	78° 45’ N
	11	010° 10’ E	78° 15’ N
	12	013° 30’ E	77° 00’ N
	13	015° 30’ E	76° 15’ N
Acoustic Area (white)	1	1° 40.75’ E	79° 29.04’ N
	2	2° 30.10’ E	78° 41.22’ N
	3	4° 25.32’ E	78° 14.62’ N
	4	5° 28.01’ E	78° 59.34’ N

1.2 External Partners

NREP22 involved fifteen partners from six different NATO Nations. The organizations listed below are the Official Partners in NREP22 as detailed in the Trial Plan CMRE-TP-2022-06-NREP22. Official Partners are entitled to have access to the data sets collected during the sea trial after acceptance of the corresponding Memorandum Among Participants-MAP. Access to the NREP22 dataset can also be granted, under request, to other NATO institutions to support defence requirements.

- **CNR/ISMAR:** Consiglio Nazionale delle Ricerche, Istituto delle Scienze Marine (ITA)
- **CNR/ISP:** Consiglio Nazionale delle Ricerche, Istituto delle Scienze Polari (ITA)
- **OGS**: Istituto Nazionale di Oceanografia e Geofisica Sperimentale (ITA)
- **UNIBO:** University of Bologna (ITA)
- **DSTL:** Defence Science and Technology Laboratory (UK)
- **DGA:** French Directorate General of Armaments (FRA)
- **WTD 71:** Bundeswehr Technical Center for Ships and Naval Weapons, Maritime Technology and Research (DEU)
- **APL:** Applied Physics Laboratory, Johns Hopkins University (USA)
- **NRL:** Naval Research Laboratory (USA)
- **AOS:** Applied Ocean Sciences (USA)
- **DRDC:** Defence Research and Development Canada (CAN)
- **NERSC:** Nansen Center (NOR)
- **NPI:** Norwegian Polar Institute (NOR)
- **FFI:** Norwegian Defence Research Establishment (NOR)
- **NMI:** Norwegian Meteorological Institute (NOR)

2
Moored autonomous platforms

During the NREP22 sea trial oceanographic and acoustic moored autonomous platforms were deployed in the operational area. Figure 2 shows the geographical locations of the moored autonomous platforms, and Table 2 provides a summary detailing the time of deployment and recovery. Technical details about the different mooring designs and sensors are provided in the following sections of this report.

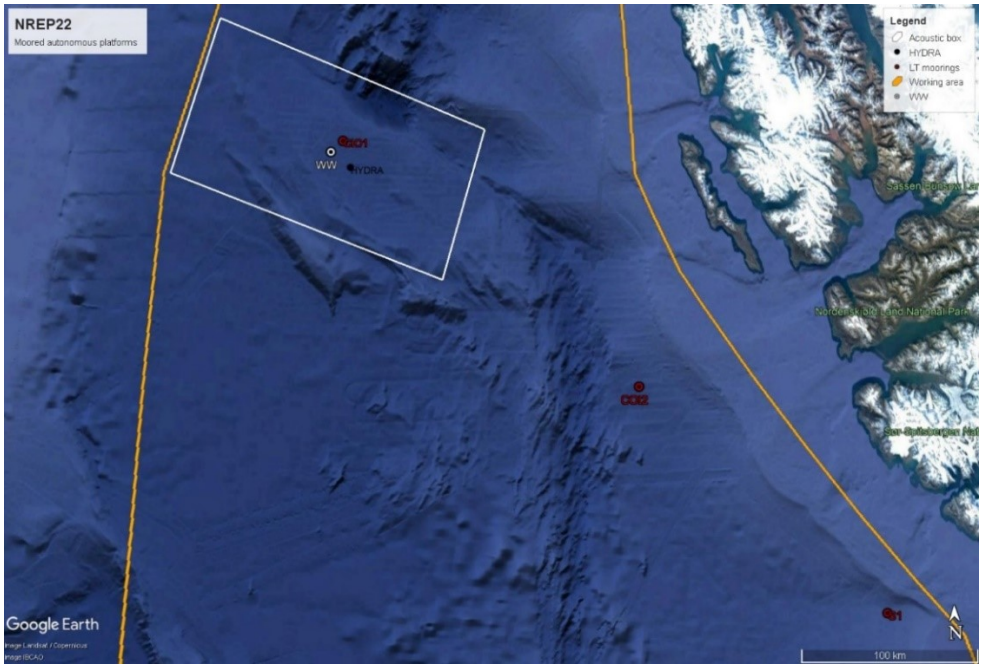

Figure 2: Positions of the moored autonomous platforms deployed during NREP22. Moorings CIO1, CIO2 and S1 are displayed with red points, the wirewalker (WW) in white and Hydra in black (geographical coordinates are detailed in Table 2).

Table 2: Summary of the moored autonomous platforms deployed during NREP22.

Platform name	Time start	Time end	Water depth	Position
CIO1	05/07/2021 23/06/2022	19/06/2022 To be rec. in 2023	2516 m 2506 m	78° 53.660'N 01° 44.574'E 78° 55.986'N 01° 51.046'E
CIO2	04/07/2021	12/06/2022	1720 m	77° 41.266'N 09° 00.496'E
S1	01/06/2021 25/06/2022	11/06/2022 To be rec. in 2023	1038 m 1042 m	76° 26.280'N 13° 56.930'E 76° 26.291'N 13° 57.057'E
HYDRA	15/06/2022	23/06/2022	2500 m	78° 48.060'N 02° 03.952'E
Wirewalker (base & profiler)	14/06/2022 17/06/2022	17/06/2022 20/06/2022(prof) 23/06/2022(base)	2500 m 2500 m	78° 52.555'N 01° 33.414'E 78° 50.177'N 01° 10.007'E

2.1 Mooring CIO1 (CMRE)

The mooring CIO1 was deployed in 2021 during NREP21 and recovered on June 19th 2022 (06:00-11:30 UTC) during NREP22. On June 23rd 2022 it was redeployed at the same general location. The NREP22 CIO1 is equipped with 11 Seabird SBE37 CTD sensors (versus 12 in the NREP21 design), 10 RBR-concerto temperature-pressure sensors (10 also in the NREP21 design), two AANDERAA[3] current-meters (two also in the NREP21 design) and six Loggerhead acoustic recorders (versus seven in the NREP21 design). Figure 3 details the design of CIO1 during the first deployment (2021-2022) while Figure 4 shows the design which has been implemented for the second deployment period (2022-2023).

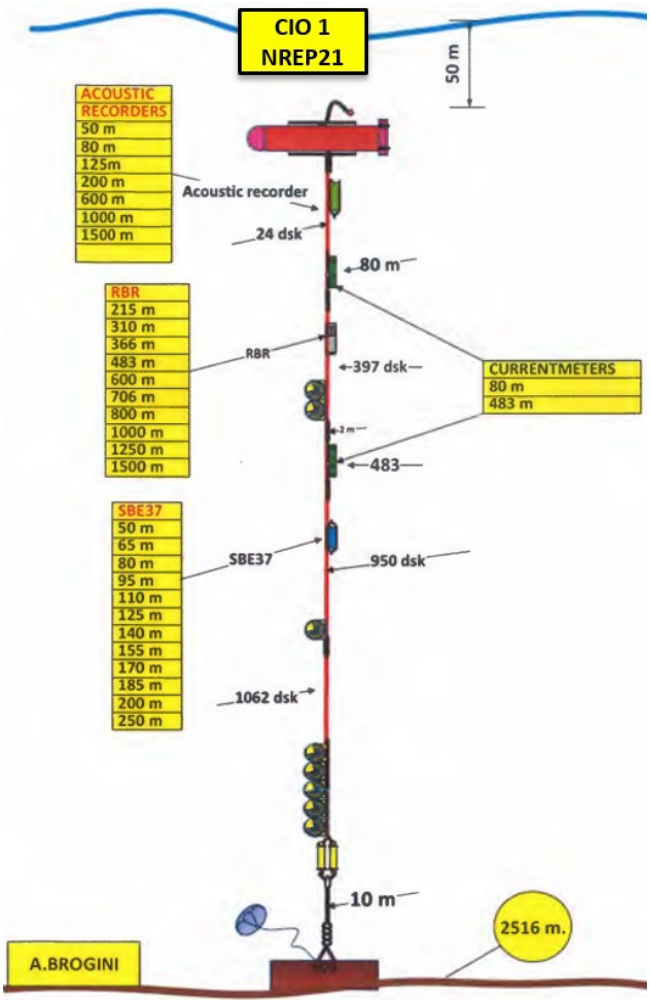

Figure 3: Sensor distribution on the mooring CIO1 during the first sampling period (2021-2022).

[3] Recording Current Meter Model 9 (RCM-9).

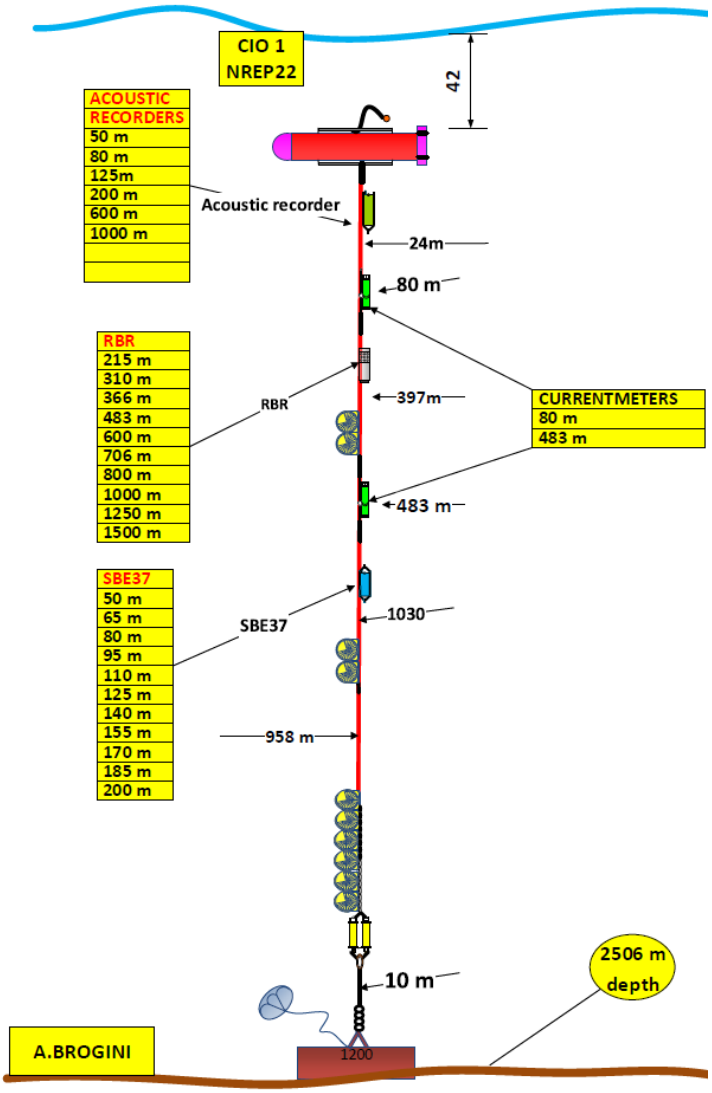

Figure 4: Sensor distribution on the mooring CIO1 during the second sampling period (2022-2023).

Table 3 provides a summary of the available oceanographic and acoustic data collected by CIO1 during the first year period.

Table 3: Summary of the sensors and available data from the first year of the CIO1 deployment[4].

Sensor	Variables and sampling details	Time start	Time end	Files	Size
AANDERAA (RCM9)	temp [ºC]; water current [m/s] 150 pings, 30min, 600ds	05/07/2021	19/06/2022	Level 0 Level 1 (netcdf)	5.44 MB 1.27 MB
		23/06/2022	(2023)	-	-
SBE-37	Cond [mS/cm];temp [ºC];Press [dbar];sea press [dbar];depth [m];sal [PSU];sv [m/s];specific cond [µS/cm]; dens anomaly [kg/m³] 30 sec	05/07/2021	19/06/2022	Level 0 Level 1 (netcdf)	37 MB 20 MB
		23/06/2022	(2023)	-	-
RBR concerto	Temp [ºC]; Press [dbar]; 15min	05/07/2021	19/06/2022	Level 0 Level 1 (netcdf)	911 MB 378 MB
		23/06/2022	(2023)	-	-
Acoustic recorders (Loggerhead)	120 sec, sleep 750, 96 KHz, 2.05 dB 436 ds	05/07/2021	19/06/2022	Level 0 (wav)	1.7 TB
		23/06/2022	(2023)	-	-

[4] **Data access**: NREP21 partners have access to **CIO1** data from 05/07/2021 to 19/06/2022; NREP22 partners have access to data from 10/06/2022 to 19/06/2022 and to the data that will be available in 2023 after the recovery of the mooring CIO1.

2.2 Mooring CIO2 (CMRE)

The mooring CIO2 was deployed during the sea trial NREP21 on June 19th 2021 and it was recovered during the sea trial NREP22 on June 12th 2022. It was equipped with 11 Seabird SBE37 CTD sensors, 10 RBR concerto temperature-pressure sensors, two AANDERAA currentmeters (RCM-9) and eight Loggerhead acoustic recorders (Figure 5). The following table provides a summary of the available oceanographic and acoustic data collected by CIO2.

Table 4: Summary of the sensors and available data from the mooring CIO2[5].

Sensor	Variables and sampling details	Time start	Time end	Files	Size
AANDERAA (RCM-9)	temp [°C]; water current [m/s] 150 pings, 30min, 600ds	19/06/2021	12/06/2022	Level 0 Level 1 (netcdf)	5.55 MB 1.26 MB
SBE-37	Cond [mS/cm];temp [°C];Press [dbar];sea press [dbar];depth [m];sal [PSU];sv [m/s];specific cond [µS/cm]; dens anomaly [kg/m³] 30 sec	19/06/2021	12/06/2022	Level 0 Level 1 (netcdf)	36.7 MB 19.2 MB
RBR concerto	Temp [°C];Press [dbar]; 15min	19/06/2021	12/06/2022	Level 0 Level 1 (netcdf)	984MB 373 MB
Acoustic recorders (Loggerhead)	120 sec, sleep 780, 96 KHz, 2.05 dB 436 ds	19/06/2021	12/06/2022	Level 0 (wav)	2.96 TB

[5] **Data access**: NREP21 partners have access to **CIO2** data from 16/06/2021 to 12/06/2022; NREP22 partners have access to data from 10/06/2022 to 19/06/2022.

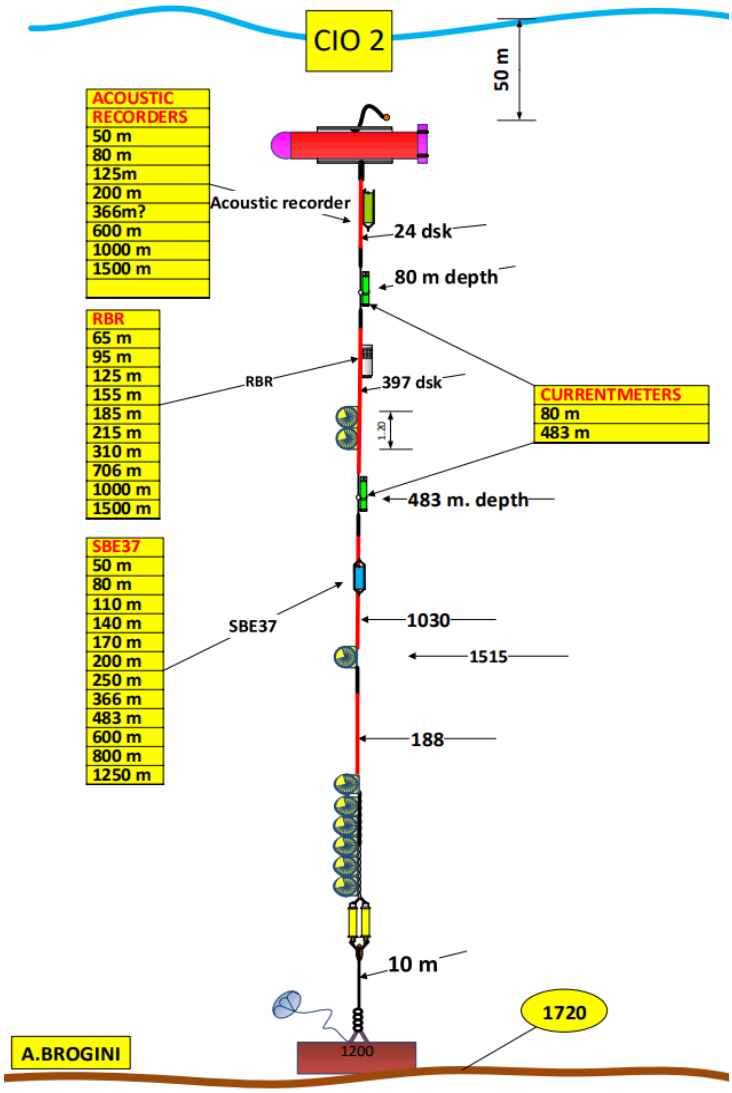

Figure 5: Design of the instrumentations available on the mooring CIO2.

2.3 Mooring S1 (CNR/ISP and OGS)

Mooring S1 was deployed on June 25th 2022 (9.30-13:00 UTC) and will be recovered next year in June-July 2023 during the sea trail NREP23. The mooring incorporates two Loggerhead LSIX acoustic, one SBE-37 CTD and three RBR temperature-pressure recorders provided by CMRE. Figure 6 displays the mooring design. The oceanographic and acoustic data collected will be available after the recovery.

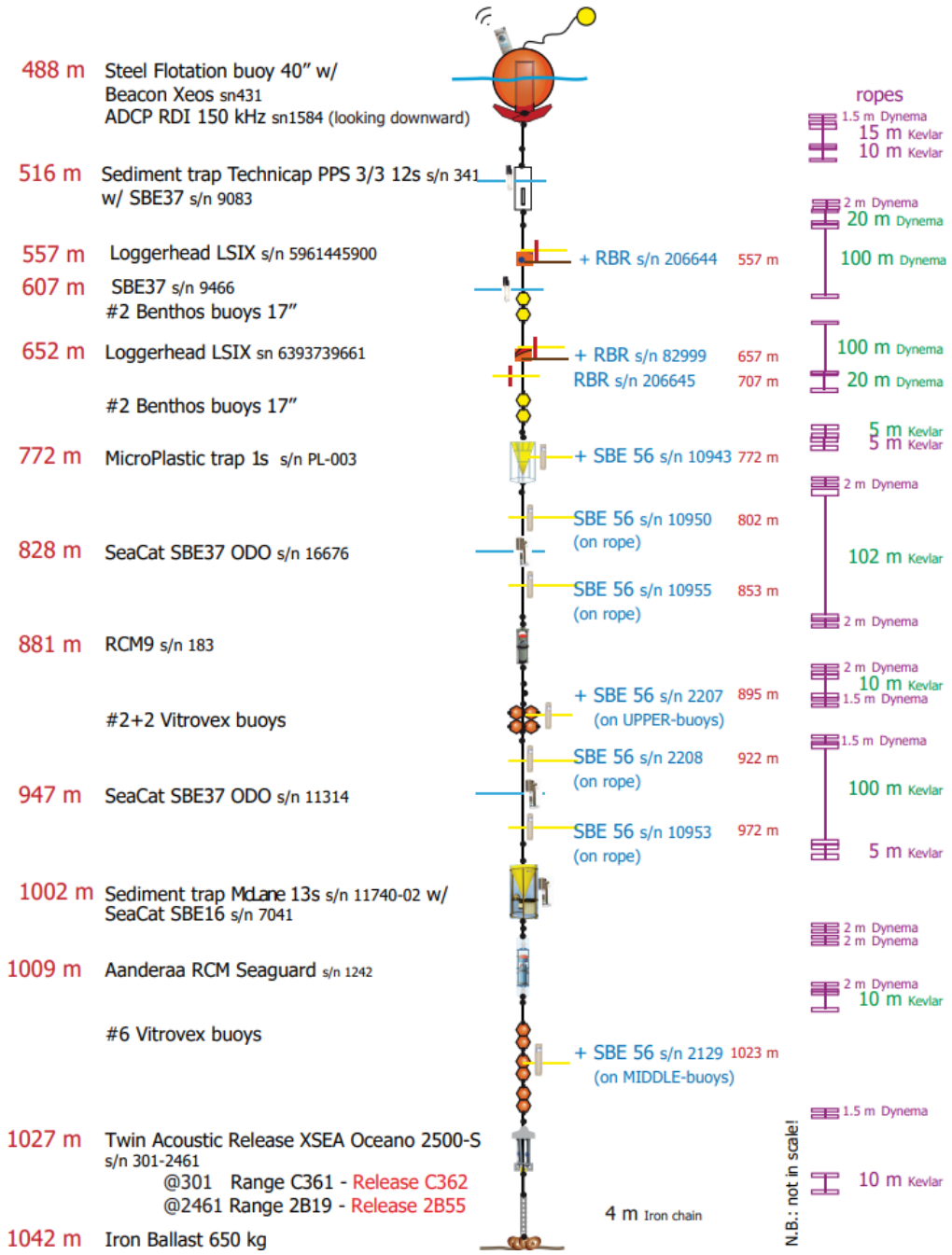

Figure 6: Design of the oceanographic and acoustic instrumentations available on the mooring S1 developed by CNR/ISP and OGS.

2.4 Moored real-time Wirewalker (WW)

During the sea trial NREP22, a moored real-time Wirewalker (WW) was deployed on June 14th 2022. The WW profiler (Figure 7) was equipped with a RBR concerto, a current-meter AANDERAA (RCM-9) and a profiler Nortek ADCP. The WW profiler sampled the water column from near surface to around 300 m depth. It was recovered on June 18th 2022. Table 5 provides a summary of the oceanographic data available from the WW.

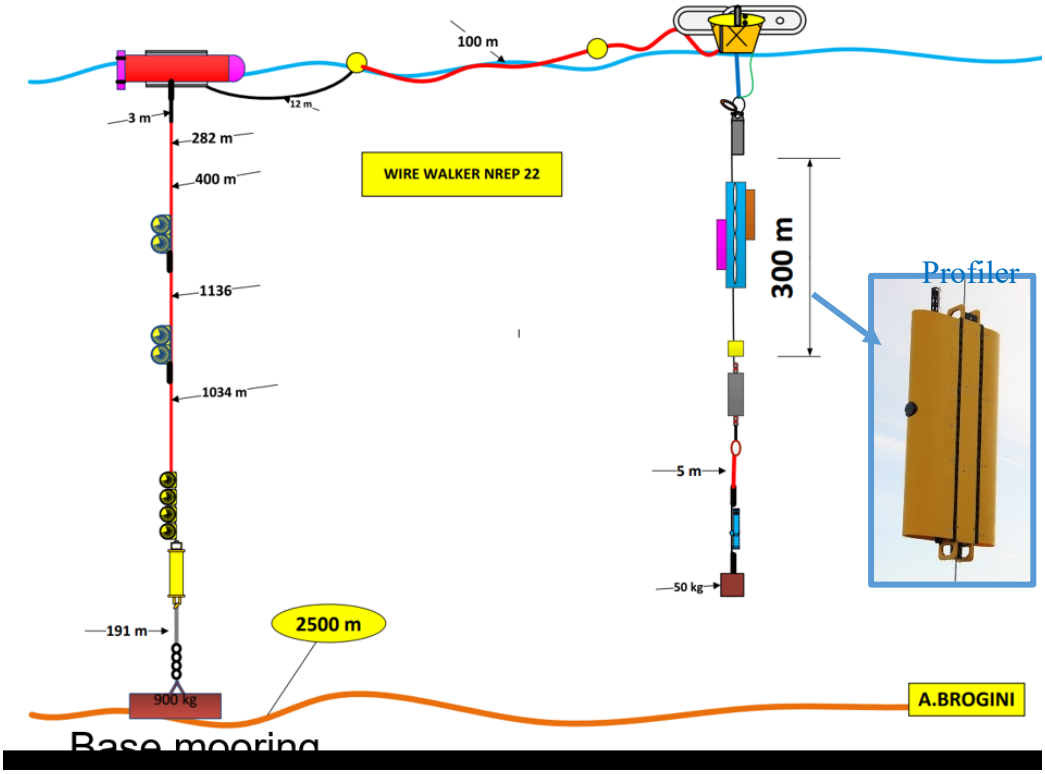

Figure 7: Wirewalker design: the base mooring (on the left) and the profiler (on the right) which was equipped with a RBR, a current-meter (AANDERAA) and an ADCP 100 kHz (Nortek).

Table 5: Installed sensors and available WW oceanographic data.

Sensor	Variables and sampling details	Time start	Time end	Files	Size
RBR concerto	cond [mS/cm]; temp [°C]; press [dbar]; seapress [dbar]; depth[m]; sal[PSU]; sound vel [m/s]; specific cond [µS/cm]; density anomaly [kg/m³]	14/06/22	18/06/22	Level 0 Level 1-2 (netcdf)	311 MB
ADCP 1000kHz (Nortek)	water current [m/s]	14/06/22	18/06/22	Level 0 Level 1-2 (netcdf)	29 GB
(RCM9) Aanderaa	water current [m/s]	14/06/22	18/06/22	Level 0 Level 1-2 (netcdf)	819 KB

No profiles are available from June 15th to June 17th because the WW profiler was covered by the ice. Figure 8, which displays the temperature and the sound speed profiles collected by WW, clearly shows the time period during which the profiles are unavailable.

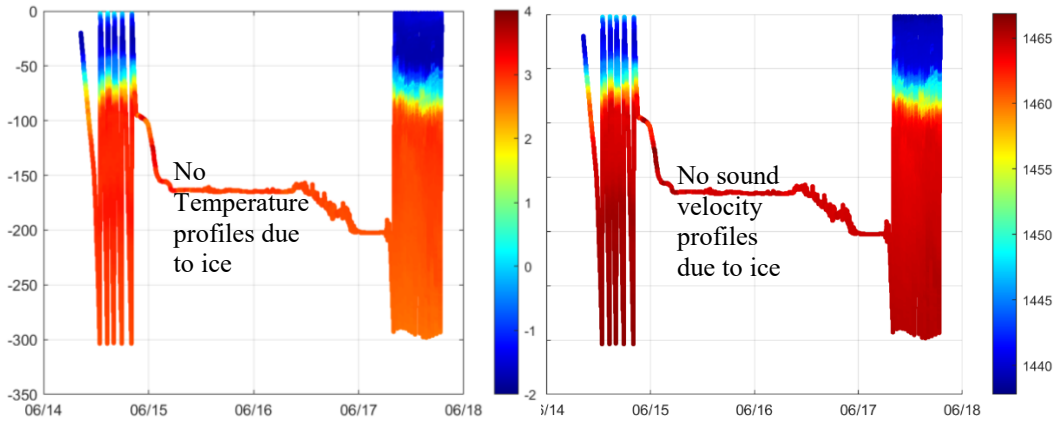

Figure 8: Temperature and sound velocity data available from the WW profiler.

2.5 HYDRA (Line and volumetric array)

The HYDRA mooring was equipped with one Loggerhead acoustic recorder and two acoustic arrays; 1) linear array consisting in eight hydrophones (placed 15 cm apart from each other) and 2) a volumetric 3-dimensional cross array consisting of eight hydrophones. Both arrays mounted an RBR to continuously track their depth. Figure 9 shows the design of the HYDRA mooring. This mooring was deployed on June 15th 2022 and recovered on June 23rd 2022. Table 6 provides a summary of the acoustic data available.

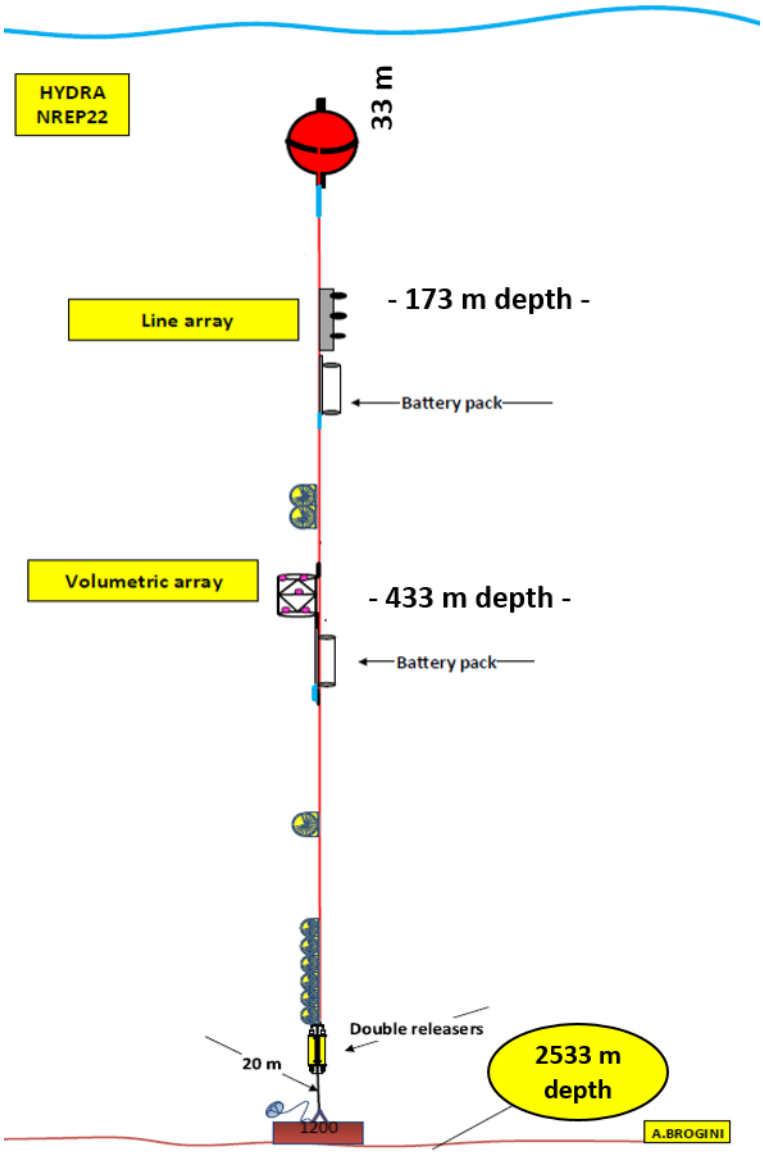

Figure 9: Schematic representation of on the mooring HYDRA and the instruments mounted to it. Real sensors and water depths have been estimated using HiPAP depth measurements.

Table 6: Summary of the available acoustic data[6].

HYDRA	Time start	Time end	Files	Size
Linear array	15/06/2022	17/06/2022	Level 0	1.05 TB
Volumetric array	15/06/2022	17/06/2022	Level 0	1.05 TB
Loggerhead	15/06/2022	17/06/2022	Level 0	129 GB

[6]Temperature-pressure data from RBR are not available due to sensor issues. Acoustic data are available for linear and volumetric hydra and from one loggerhead. Information about depth have been retrieved by the HiPAP system.

3 Moving autonomous platforms

3.1 Drifters

Two Surface Velocity Program (SVP) drifters equipped with three hydrophones (20 m, 25 m and 30 m of depth) were deployed on June 13th 2022 (16:00-20:00 UTC) and recovered on June 14th 2022 (17:00 UTC). During this first deployment two channels (h3+m[7]) were missing for both drifters. The drifters were deployed again on June 15th 2022. One drifter was recovered on June 23rd 2022. For this drifter two channels are available (h1+h2[8]). Unfortunately, the other drifter was lost. Figure 10 displays the drifters' tracks (D1 red and D2 light blue) and a drifter's picture (top-right corner).
Table 7 provides a summary of the oceanographic acoustic data available from the drifters.

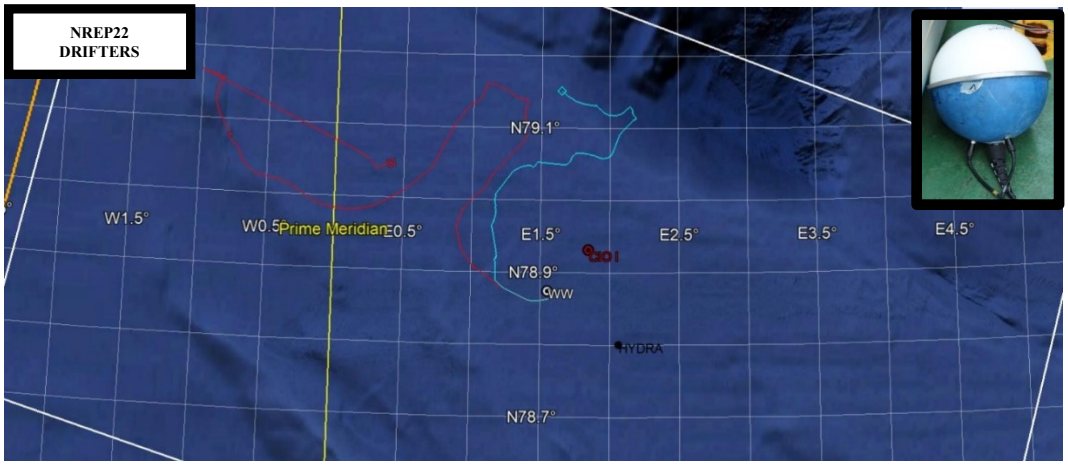

Figure 10: Drifters tracks: D1 in light blue and D2 in red. On the top right hand side a drifter's picture is presented.

Table 7: Summary of the data available from the two drifters.

Drifter	Data type	Date	Files	Size
D1 300534061492040	Acoustic (H1H2[7])	from 11/06/2022 to 17/06/2022 and on 20/06/2022	Level 0 (raw data, wav)	99 GB
	Acoustic (H3M[5])	from 11/06/2022 to 13/06/2022	Level 0 (raw data, wav)	31 GB
	Oceanographic (sst, lat, lon)	from 13/06/2022 to 20/06/2022	Level 0 (raw sbd) Level 1 (netcdf)	170 KB 75 KB
D2 300534061492080	Acoustic (H1H2[7])	from 12/06/2022 to 14/06/2022	Level 0 (raw data, wav)	42 GB
	Acoustic (H3M[5])	from 12/06/2022 to 13/06/2022	Level 0 (raw data, wav)	31 GB

[7] Channel 3 and surface microphone.

[8] Channel 1 and Channel 2

3.2 SLOCUM Gliders

Two SLOCUM gliders were deployed during the NREP22 sea trial:

- Glider Maria (Figure 11): a G2 SLOCUM hybrid (thruster capability) glider with standard oceanographic configuration with pumped CTD, ecopuck 1000m with chlorophyll (CHL) and turbidity sensors.
- Glider Anna: a G3 SLOCUM acoustic glider with single hydrophone and compact Volumetric Array Sensor (cVAS) also equipped with a non-pumped RBR CTD sensor.

The oceanographic glider Maria was deployed on June 12th 2022 (06:00-08:00 UTC). The acoustic glider Anna was deployed on June 16th 2022 (10:30 UTC). The acoustic transmission started on June 16th at 14:00 until 22:00 UTC. Both gliders were recovered on June 23rd (1430-16:00 UTC). Figure 11 shows the gliders' tracks (Anna in yellow and Maria in brown); Table 8 and Table 9 provide a summary of the oceanographic and acoustic data available from these gliders.

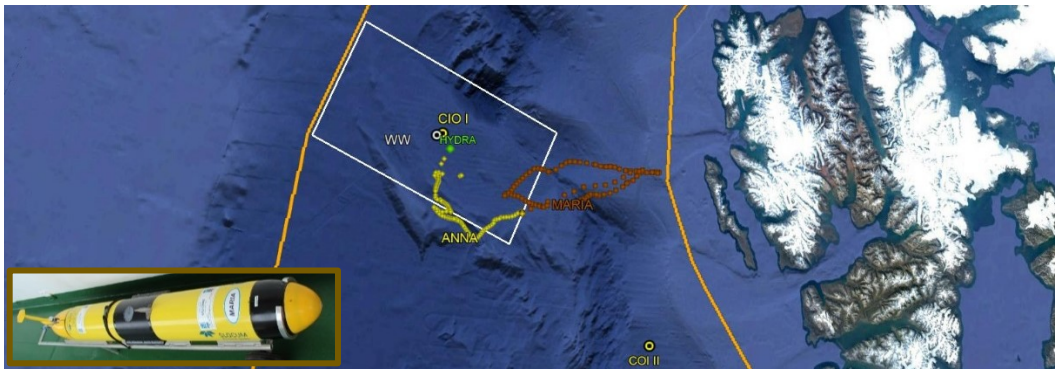

Figure 11: gliders tracks (Anna in yellow and Maria in brown). On the bottom left hand side a picture of the oceanographic glider Maria.

Table 8: Summary of the data available from the glider Maria.

MARIA	Deployment	Recovery	Files	Size
Oceanographic	12/06/2022	23/06/2022	Level 0 (raw data); Level 1-2-3 (netcdf)	1.90 GB

Table 9: Summary of the data available from the glider Anna.

ANNA	Date	Time (UTC)	Files	Size
Acoustic (Single Hydrophone and compact volumetric)	08/06/2022	From 09:00 to 11:00	Level 0 (Wav files and TS video)	417 GB
	16/06/2022	From 06:00 to 23:00		
	17/06/2022	From 00:00 to 23:00		
	18/06/2022	From 00:00 to 23:00		
	19/06/2022	From 00:00 to 23:00		
	20/06/2022	From 00:00 to 07:00		
Oceanographic	16/06/2022	From 00:00 to 23:59	Level 0 (raw data); Level 1-2-3 (netcdf)	1.65 GB
	17/06/2022	From 00:00 to 23:59		
	18/06/2022	From 00:00 to 23:59		
	19/06/2022	From 00:00 to 23:59		
	20/06/2022	From 00:00 to 23:59		
	21/06/2022	From 00:00 to 23:59		
	22/06/2022	From 00:00 to 23:59		
	23/06/2022	From 00:00 to 23:59		

4 Sensors deployed from NRV Alliance

4.1 GPS, METEO and Along-track thermosalinograph (T_S) data

GPS data were logged aboard NRV Alliance, ship meteorology data were available from GILL systems on foremast while T_S data were available from underway CT SBE45 and SBE38 (thermosalinograph) with hull water intake at about 2.5 m below the sea surface. Table 10 provides a summary of the GPS, METEO and T_S data available from the ship while Figure 12 displays the Alliance positions with GPS, meteo and T_S data available.

Table 10: Summary of the GPS, meteo and T_S data available from the ship.

Platform name	Sensor (variables)	Time start (UTC)	Time end (UTC)	Files	Size
NRV Alliance	GPS (depth, speed, heading, lat, lon, time)	01/06/2022 00:00:01	26/06/2022 11:20:05	Level 0 (raw data) Level 1 (netcdf)	800 MB
	METEO	07/06/2022	28/06/2022	Level 0 (raw data)	19.8 MB
	T_S (along track sea water temp, cond, sal, sound vel, lat, lon, time)	08/06/2022 11:56:19	26/06/2022 07:00:37	Level 0 (raw data) Level 1 (netcdf)	180 MB 57 MB

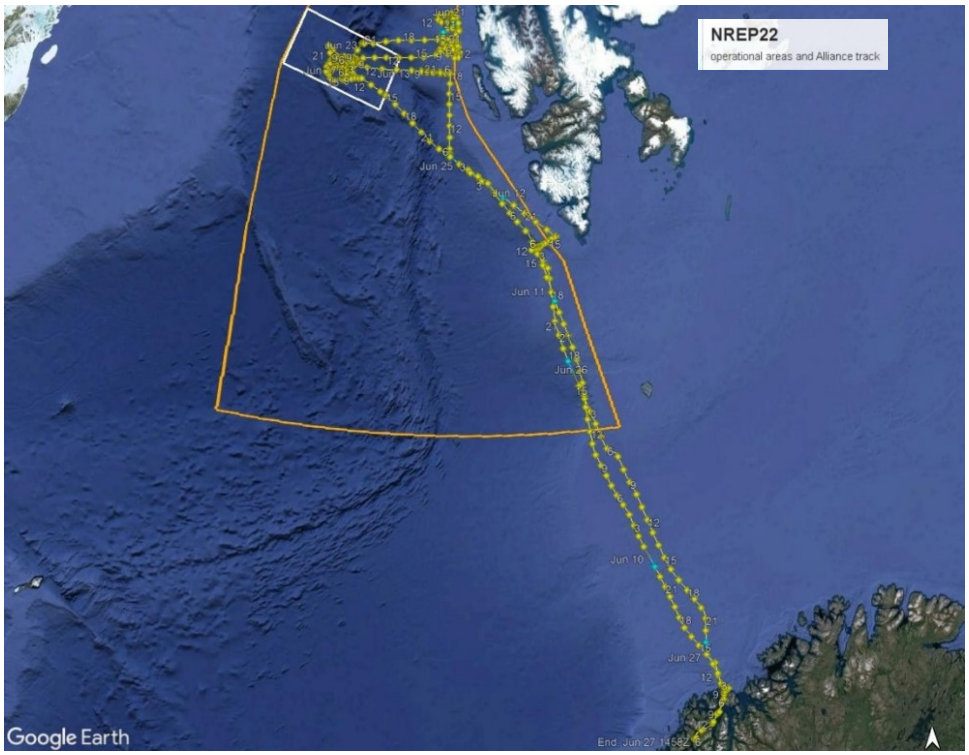

Figure 12: NRV Alliance track with GPS, meteo and T_S data.

4.2 Lowered CTDs and optics (from BB9 – VSF9)

Twenty-seven CTD casts were performed from the NRV Alliance from June 11th 2022 to June 23rd 2022. Sixteen of the casts also included an optical sensor (VSF BB9). Figure 13 shows the lowered CTD Seabird911 system with rosette sampler and ancillary sensors (*i.e.* dissolved oxygen, transmissometer, fluorometer, turbidimeter, altimeter, and optical sensor). Table 11 provides a summary of the available sensors and data while Table 12 details the time and position of each CTD/BB9 profile. Finally, figure 15 shows the CTDs (and BB9) stations sampled.

Figure 13: Picture of the lowered CTD Seabird911 system with rosette sampler and ancillary sensors (*e.g.* dissolved oxygen, transmissometer, fluorometer, turbidimeter, altimeter and optics).

Table 11: Data available from the lowered Alliance system.

Platform name	Sensor (variables)	Files	Size
NRV Alliance (rosette)	CTD (pressure, conductivity, Oxygen, temp, time, turbidity, depth, density, sound velocity)	Level 0 (raw data) Level 1 (netcdf) Level 4 (jpg)	181 MB
	BB9 (fluorescence, pressure, bioluminescence potential)	Level 0 (netcdf) Level 1 (netcdf) Level 2 (netcdf) Level 3 (netcdf)	46 MB

Table 12: Details on the available CTDs and optics underwater profiles preformed during the sea trial NREP22.

Platform name	Sensor ID	Lat	Lon	Time start	Time end
NRV Alliance	CTD001	76.4338	13.9585	11-06-2022 04:07:43	11-06-2022 04:15:57
	CTD002	76.4322	13.9508	11-06-2022 09:34:32	11-06-2022 09:55:48
	CTD003	76.4543	14.1385	11-06-2022 11:06:49	11-06-2022 11:24:15
	CTD004	76.478	14.3548	11-06-2022 12:30:33	11-06-2022 12:41:51
	CTD005 and optics	76.4995	14.5325	11-06-2022 13:43:26	11-06-2022 13:48:14
	CTD006 and optics	76.5188	14.7247	11-06-2022 14:52:42	11-06-2022 14:57:21
	CTD007 and optics	76.5508	14.928	11-06-2022 15:56:15	11-06-2022 15:59:54
	CTD008 and optics	76.5698	15.1085	11-06-2022 16:54:11	11-06-2022 16:57:13
	CTD009 and optics	76.5773	15.192	11-06-2022 17:48:27	11-06-2022 17:50:44
	CTD010	77.6988	8.9787	12-06-2022 05:10:07	12-06-2022 05:40:19
	CTD011 and optics	78.7973	8.9742	12-06-2022 17:16:33	12-06-2022 17:20:29
	CTD012 and optics	78.8633	1.2645	14-06-2022 20:37:11	14-06-2022 20:47:28
	CTD013 and optics	78.791	0.617	15-06-2022 19:27:58	15-06-2022 19:37:12
	CTD014 and optics	78.6223	1.7573	16-06-2022 12:01:22	16-06-2022 12:11:03
	CTD015 and optics	78.606	1.8718	16-06-2022 14:06:35	16-06-2022 14:15:52
	CTD016 and optics	78.684	1.9795	16-06-2022 17:14:17	16-06-2022 17:22:50
	CTD017 and optics	78.719	1.7158	16-06-2022 19:35:14	16-06-2022 19:42:07
	CTD018 and optics	78.7783	1.9518	16-06-2022 21:22:21	16-06-2022 21:28:53
	CTD019 and optics	78.8492	2.7283	17-06-2022 07:07:35	17-06-2022 07:16:33
	CTD020 and optics	78.8898	2.5172	17-06-2022 09:58:37	17-06-2022 10:06:29
	CTD021 and optics	78.9082	2.3597	17-06-2022 13:59:05	17-06-2022 14:07:11
	CTD022	78.9143	1.6518	18-06-2022 14:19:53	18-06-2022 14:57:24
	CTD023	78.868	1.3282	19-06-2022 20:18:25	19-06-2022 20:33:23
	CTD024	78.8952	1.0507	20-06-2022 01:25:31	20-06-2022 01:44:37
	CTD025	79.1327	2.8348	22-06-2022 22:16:13	22-06-2022 23:28:23
	CTD026	78.8953	1.6477	23-06-2022 12:39:48	23-06-2022 12:45:49
	CTD027	76.4410	13.9488	23-06-2022 12:39:48	23-06-2022 12:45:49

4.3 Expendable bathythermograph XBT

19 XBT (Figure 14) profiles were performed on June 22nd 2022 from 8:00 to 12:00 UTC. Table 13 provides details on the available XBT data, while Figure 15 displays the XBT positions (magenta dots).

Figure 14: Picture of a XBT

Table 13: Summary of the data available from the XBT.

Platform name	Sensor (variables)	Files	Size
NRV Alliance	XBT (pressure, temperature, time)	Level 0 (raw data, edf) Level 1 (netcdf)	2 MB

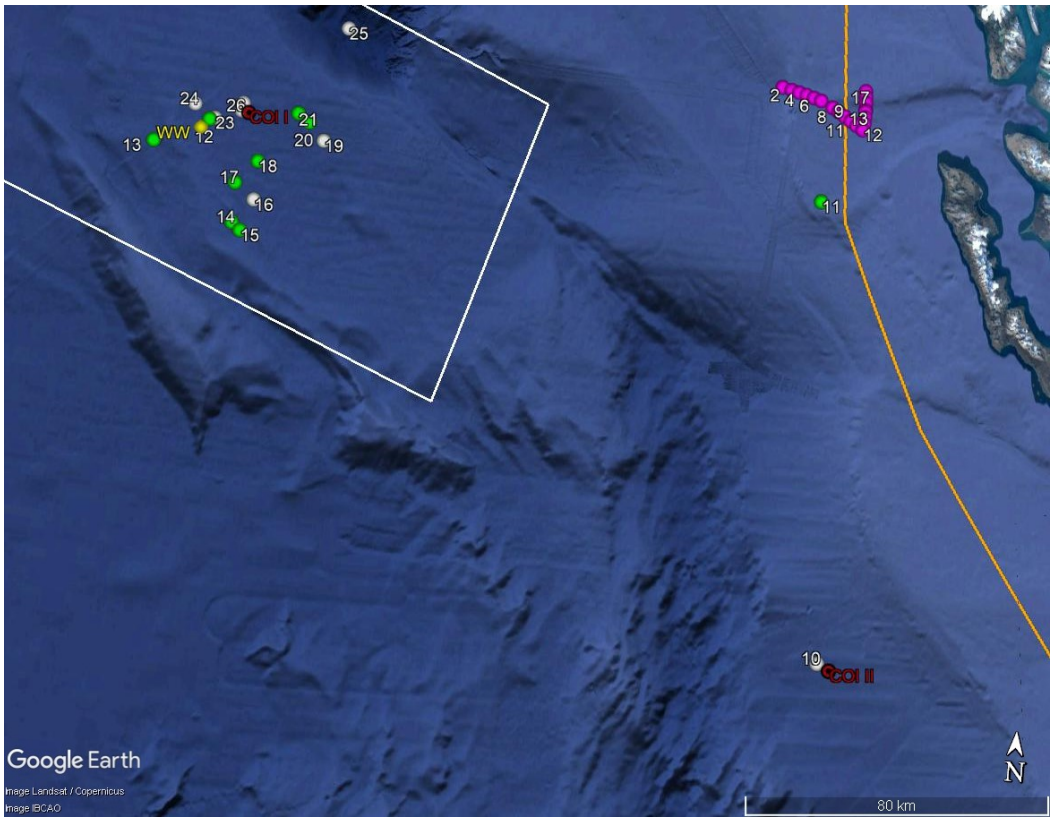

Figure 15: CTD stations position (white point refers to stations with only CTD while the green point represents the stations with CTD and optics) and XBT positions (magenta dots).

Table 14: NREP22 XBTs details.

Platform name	Platform number (and ID)	Lat (North)	Lon (East)	Release time (UTC)
NRV Allance	1 (082546)	79.0765	8.4689	22-06-2022 08:25:46
	2 (083851)	79.07	8.5861	22-06-2022 08:38:51
	3 (084902)	79.0647	8.6845	22-06-2022 08:49:02
	4 (085950)	79.0588	8.7782	22-06-2022 08:59:50
	5 (090815)	79.0524	8.8754	22-06-2022 09:08:15
	6 (092026)	79.046	8.966	22-06-2022 09:20:26
	7 (093859)	79.0297	9.1125	22-06-2022 09:38:59
	8 (094324)	79.0195	9.1911	22-06-2022 09:43:24
	9 (095639)	79.0086	9.2678	22-06-2022 09:56:39
	10 (100533)	78.9978	9.3448	22-06-2022 10:05:33
	11 (101139)	78.987	9.4205	22-06-2022 10:11:39
	12 (102143)	78.9761	9.4983	22-06-2022 10:21:43
	13 (103244)	78.9913	9.5191	22-06-2022 10:32:44
	14 (104157)	79.0074	9.5283	22-06-2022 10:41:57
	15 (105139)	79.022	9.5353	22-06-2022 10:51:39
	16 (110101)	79.0257	9.537	22-06-2022 11:01:01
	17 (110410)	79.0435	9.543	22-06-2022 11:04:10
	18 (111542)	79.058	9.5448	22-06-2022 11:15:42
	19 (112432)	79.0723	9.5434	22-06-2022 11:24:32

4.4 Rapidcast underway profiling CTD (uCTD)

Thirteen uCTDs surveys were performed from the NRV Alliance from June 12th 2022 to June 21st 2022 for a total track of 300 kilometers. Figure 16 shows the rapidcast underway profiling CTD used during the NREP22 sea trial. Table 15 and table 16 provide details on the available data while Figure 17 shows the uCTD tracks (green dots).

Figure 16: Picture of the Rapidcast Underway Profiling CTD (uCTD).

Table 15: Summary of the available[9] uCTD data.

Platform name	Sensor (variables)	Files	Size
NRV Alliance	uCTD (lat, lon chl, density, sound velocity, salinity, conductivity, temperature, pressure, depth, time)	Level 0 (raw data) Level 1 (netcdf) Level 2 (netcdf) Level 3 (netcdf)	629 MB

[9] Unfortunately, some uCTD data were lost due to probe loss just before the downloading phase.

Table 16: NREP 22 uCTDs details.

ID	Start (lat N, lon R)	End (lat N, lon R)	Deployment (UTC)	Recovery (UTC)	track length, # cats (up+down)
175645	78.8014 9.0232	78.8206 6.6403	12-06-2022 17:56:45	12-06-2022 23:57:02	51.45 km, 132
000625	78.8192 6.6219	78.801 8.9018	13-06-2022 00:06:25	13-06-2022 05:33:52	49.23 km, 132
011657	78.7811 1.2921	78.7768 2.2101	14-06-2022 01:16:57	14-06-2022 03:43:45	19.86 km, 46
233124	78.8482 1.264	78.8474 1.7345	14-06-2022 23:31:24	15-06-2022 00:47:27	10.11 km, 24
011402	78.8203 1.7216	78.825 1.2492	15-06-2022 01:14:02	15-06-2022 02:26:23	10.19 km, 22
025831	78.8579 1.2621	78.8572 1.5937	15-06-2022 02:58:31	15-06-2022 03:54:04	7.12 km, 18
234155	78.7767 1.4785	78.7857 2.1938	16-06-2022 23:41:55	17-06-2022 01:31:33	15.5 km, 36
015443	78.8137 2.1686	78.8127 1.4982	17-06-2022 01:54:43	17-06-2022 03:33:38	14.46 km, 32
040740	78.8453 1.5233	78.8474 2.1926	17-06-2022 04:07:40	17-06-2022 05:49:48	14.39 km, 30
201438	78.7818 1.2495	78.7811 2.2219	18-06-2022 20:14:38	18-06-2022 22:38:38	21.03 km, 46
232630	78.8493 2.223	78.8522 1.2233	18-06-2022 23:26:30	19-06-2022 01:52:39	21.49 km, 48
023425	78.9135 1.28	78.9126 2.2479	19-06-2022 02:34:25	19-06-2022 05:05:02	20.69 km, 44
195718	79.3992 9.481	79.1111 8.0383	21-06-2022 19:57:18	22-06-2022 07:27:10	43.82 km, 814

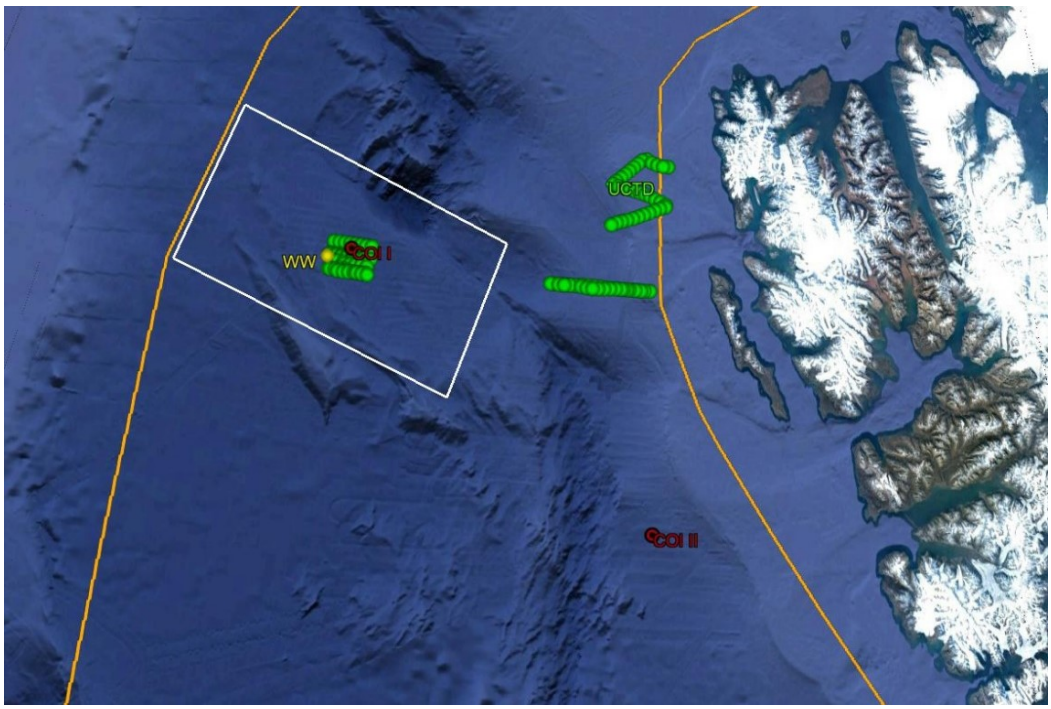

Figure 17: uCTD tracks (green dots).

4.5 HiPAP and MULTIBEAM

The NRV Alliance HiPAP system with six HiPAP pingers and a multibeam were used during the NREP22 sea trial. Details on the data can be found in Table 17.

Table 17: Summary of the available HiPAP and Multibeam data.

Sensor	Start Time	End Time	Files	Size
MULTIBEAM	13/06/2022 14:00	13/06/2022 18:00	Level 0	4.74 GB
	15/06/2022 13:00	15/06/2022 16:00		
	16/06/2022 10:00	16/06/2022 23:59		
	17/06/2022 00:00	17/06/2022 09:00		
	18/06/2022 20:30	18/06/2022 23:59		
	19/06/2022 00:00	19/06/2022 13:00		
	23/06/2022 10:00	23/06/2022 23:00		
HiPAP	14/06/2022 08:00	14/06/2022 22:00	Level 0	291 MB
	15/06/2022 14:00	25/06/2022 15:30		

The Multibeam was used to map the local bathymetry at the mooring locations.
The HiPAP pingers were mounted on different platforms in order to have an estimated location of underwater platforms during different phases of the acoustic experiments. They were mounted on the acoustic source REP11 (detailed in the next Section), on the HYDRA mooring and on the acoustic Slocum glider (Anna).

4.6 Sound source (REP11)

Figure 18 shows the REP11B sources (mounting the transducers MOD40, MOD30 and ITC2010) used during the NREP22 sea trail. Acoustic source details are listed in Table 18.

Figure 18: Acoustic sound source REP11.

Table 18: Acoustic sources details.

Source Name	Frequency [Hz]	Max. Source Level achievable dB re 1 µPa @ 1 m	Max Pulse Length @ max SL seconds	Duty Cycle (%)	SL for continuous transmission dB re 1 µPa @ 1 m
Mod 30	800-1600	205	10	10%	195
Mod 40	79.0647	106	10	10%	196
ITC2010	1000-4000	192	10	10%	182

5 Satellite data

To establish the most suitable positions for the moorings deployments/recoveries in consideration of the sea ice extent, a large number of satellite images of the NREP22 operational area were downloaded, stored and processed.
Specifically, satellite images from AMSR2 and Sentinel-1, available from the Copernicus Marine Environment Monitoring Service (CMEMS), were used to observe the ice extent and drift in the NREP22 operational area. The available CMEMS products are generated from a combination of the sea ice concentration[10] retrieved from the Advanced Microwave Scanning Radiometer 2 (AMSR2[11]) and the Synthetic Aperture Radar (SAR) data (from Sentinel-1). The resulting image is first classified into ice/water at a 40x40m pixel resolution and successively the concentration is estimated from ice area within 1x1km. The two concentrations products are then subsampled to the same 1x1km spatial resolution and merged in an optimal interpolation.
Moreover, IcySea[12] Sea ice concentration SAR images with a spatial resolution of 50 m available from the satellite Sentinel-1 were also used to support operations during the NREP22 sea trial.
Details on the available satellite data archive used during NREP22 are summarized in Table 19. Figure 19 shows an example of the RADARSAT images (*i.e.* 16 swaths) used to monitor ice cover status of the area, the clear blue line is the 10% ice contour retrieved from CMEMS data to detect the ice edge in the operational area.

Table 19: Details on the available satellite data archive used during NREP22.

Provider	Platform	Resolution	Files	Size
CMEMS	AMSR2 and SAR	1 km	Level 3 (netcdf) Level 4 (netcdf)	4.5 GB 1.1 GB
IcySea	SAR	50 m	Level 4 (jpg and kmz)	170 MB

[10] The percentage of an area covered by sea ice

[11] Data produced from the 89 GHz channel with a spatial resolution of 5x5km

[12] https://driftnoise.com/icysea.html (last accessed on October 10th 2022)

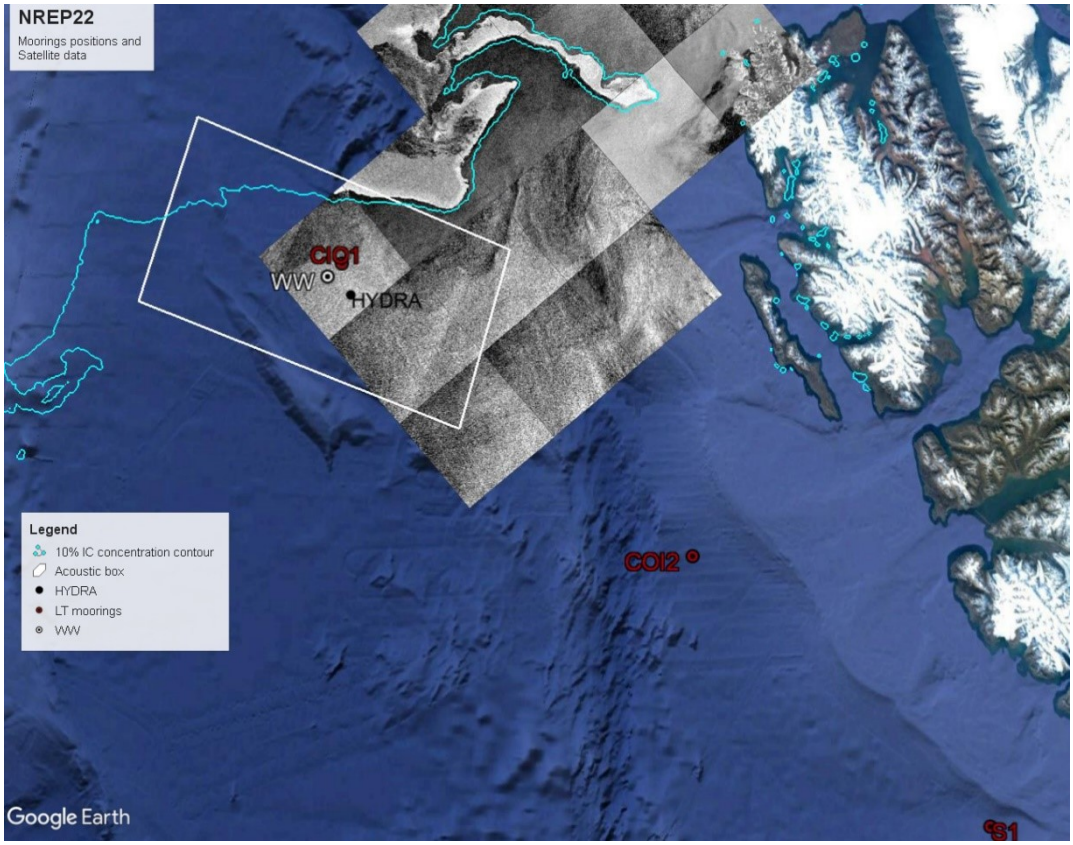

Figure 19: An example of sea ice extent (23rd June 2022) in relation to the moorings positions. The clear blue line shows the 10% concentration contour of the ice (available on the CMRE archive in kml and kmz files).

6 Summary

Figure 20 and Table 20 summarize the NREP22 data collection available in the CMRE data repository (isilon). Details on the acoustic experimentations can be found in Annexes A and B.

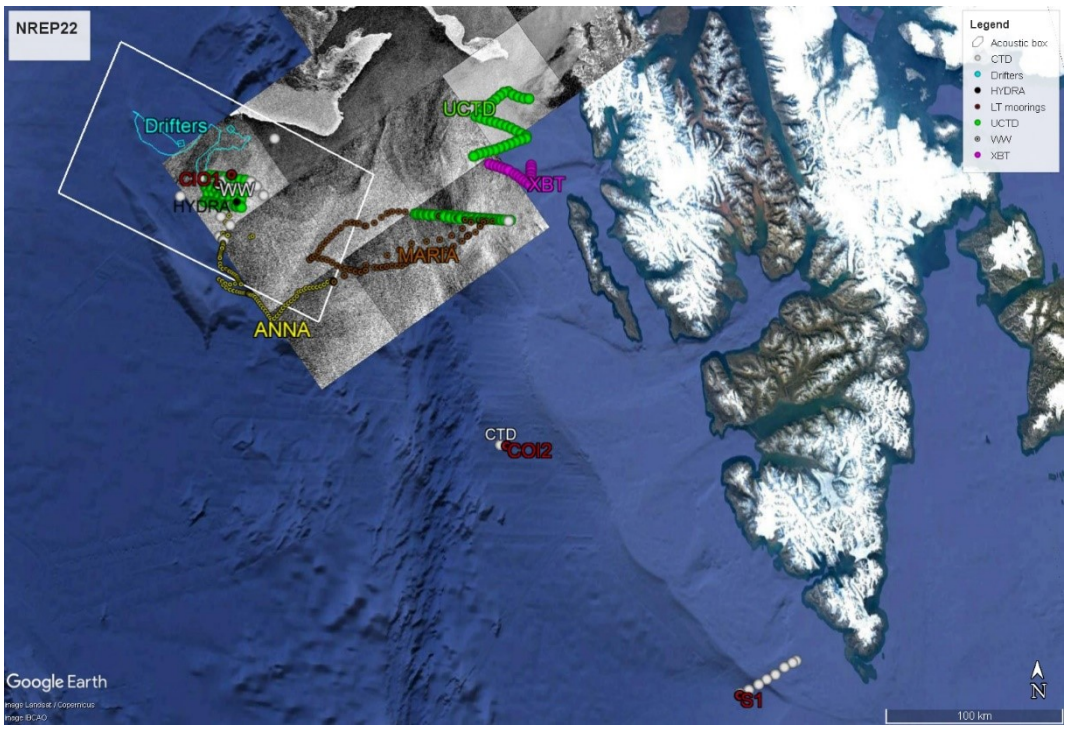

Figure 20: NREP22 oceanographic data summary (gliders, uCTD, CTD, XBT, long term moorings, wirewalker, SAR images and drifters).

Table 20: NREP22 acoustic and oceanographic data summary.

Platform name	Sensor	Time start	Time end
Ship NRV ALLIANCE	CTD; BB9	11/06/2022	23/06/2022
	T_S	08/06/2022	26/06/2022
	Meteo	07/06/2022	28/06/2022
	GPS	01/06/2022	26/06/2022
	uCTD	12/06/2022	21/06/2022
	XBT	22/06/2022	22/06/2022
	Multibeam	13/06/2022	19/06/2022
	REP11	15/06/2022	19/06/2022
	HiPAP	14/06/2022	25/06/2022
CIO1	RBR; SBE; AANDERAA; Acoustic recorders	05/07/2021 23/06/2022	19/06/2022 Recovery planned in 2023
CIO2	RBR; SBE; AANDERAA; Acoustic Recorders	04/07/2021	12/06/2022
S1	RBR; SBE; AANDERAA; Acoustic Recorders	01/06/2022 25/06/2022	11/06/2022 Recovery planned in 2023
WW	RBR; ADCP; AANDERAA	14/06/2022	18/06/2022
Hydra	Linear array; Volumetric array; Loggerhead array	15/06/2022	23/06/2022
Drifter 1	GPS; thermistor; hydrophone	13/06/2022 15/06/2022	14/06/2022 23/06/2022
Drifter 2	GPS; thermistor; hydrophone	13/06/2022 15/06/2022	14/06/2022 23/06/2022
Glider Maria	pumped CTD; ecopuck 1000m with CHL and turbidity	12/06/2022	23/06/2022
Glider Anna	hydrophone cVas; non-pumped RBR; CTD	16/06/2022	23/06/2022
Satellites	AMSR2 ; SAR	2013	2022

References

- Nordic Recognized Environmental Picture 22 – NREP22, Trial Plan, CMRE-TP-2022-06-NREP22.

Annex A: Acoustic experiments details – sequence of events

This Annex details the acoustic experimentations performed during the NREP22 sea trial which covered three main activities:

- ACOMMs[13] : acoustic communications;
- LOC: Glider localization (short range and long range);
- OCEANO: Characterization of the impact of ocean fluctuations on acoustic transmission.

Due to temporal constraints, the three experiments were executed over six days, testing different acoustic channel configurations. The acoustic source was the REP11 and receivers were the HYDRA mooring and the acoustic glider Anna.

The timing of the acoustic transmissions was accurately set in order to give time to the glider to move away from the acoustic mooring (up to ~40 km). The trajectories of the NRV Alliance (acting as the acoustic source) were referenced relative to the locations of the moorings and the glider Anna.

During these five days, acoustic transmissions of soundwaves provided by partners (*i.e.* FFI, DSTL and DGA) involved in the experiment were also performed.

The following tables detail the acoustic transmissions done during each of the six days of acoustic experiments.

The LOC and OCEANO, acoustic experiments were grouped in the same timeslot with the associated name LOCOCEANO. The different colors associated to the label of each experiment or partner (*i.e.* FFI, DSTL and DGA) are used in the next table to help the reader identify the timeslot associated to each of the acoustic transmission. The same color codes are also used in the plots depicting the position of the different assets (*e.g.* acoustic source and receivers) involved in the experiments during different acoustic transmission slots.

In order to be complaint with the marine mammals risk mitigation requirements, each session of acoustic transmission is preceeded by a ramp-up procedure in which the source level of the involved acoustic sources is increased until reaching the maximum allowed level.

The tables below reports not only the acoustic transmission but also the sequence of events that characterized or had an impact on the execution of the acoustic experiments.
It is worth mentioning that due to temporal constraints imposed by bad weather and other activities, the last 3 days (18 – 19 – 20 June) the ACOMMs and LOCOCEANO experiments have been undertaken in a combined way. For this reason the execution presents differences with the planned activities described in the trial plan (Ref. CMRE-TP-2022-06-NREP22).

[13] The goal of the ACOMMs experiment is to record digitally modulated acoustic signals transmitted over different ranges. The specific aims of these signals is to characterize the channel and test adaptive modulation, *i.e.*, match signal parameters to the acoustic link for faster communications.

Day 1: 15th June 2022

Day dedicated to the ACOMMs experiment aiming to record digitally modulated acoustic signals transmitted over different ranges. The specific aims of these signals is to characterize the channel and test adaptive modulation, *i.e.*, match signal parameters to the acoustic link for faster communications.

In this experiment, the acoustic sources involved in are the MOD30 and ITC2010. The MOD40 acoustic source did not work due to issues on a faulty amplifier. The selected soundwaves are reported in Table D of Annex B.

UTC time	Operations	NRV Alliance position
20:20	Acoustic transmission 15 km away from the acoustic mooring HYDRA[14] started – refer to Table D, Annex B.	0.62639 E 78.8073 N
20:23	Start of the ramp-up[15] procedure.	0.6273 E 78.8082 N
20:28	ACOMMs Full power (180 dB re µPa @ 1m) for soundwaves[16]: NREP22-ITC2010-CMRE NREP22-MOD30-CMRE	0.6287 E 78.8097 N
21:30	End of transmission	0.65547 E 78.8256 N
21:35	FFI start soundwaves	0.65834 E 78.8267 N
21:55	FFI end soundwaves	0.66992 E 78.8314 N
22:00	DSTL start soundwaves: C_ITC2010_DSTL – A_MOD30_DSTL	0.67259 E 78.8325 N
22:20	DSTL end soundwaves	0.68526 E 78.8368 N
22:25	DSTL start soundwaves: B_ITC2010_DSTL – D_MOD30_DSTL	0.68865 E 78.8379 N
22:45	DSTL end soundwaves	0.70303 E 78.8421 N
22:50	DGA start soundwaves	0.70678 E 78.8431 N
23:10	DGA end soundwaves	0.71883 E 78.8472 N
23:16	LOCOCEANO start B_LOCOCEANO soundwave	0.7228 E 78.8482 N
23:26	LOCOCEANO end B_LOCOCEANO soundwave	0.73026 E 78.8501 N

No icListen was mounted for this run[17].

[14] The ship drifted during the acoustic transmission starting from an approximate range of 15.5 km and ending at 12 km range from the Hydra mooring.

[15] Details can be found in the Table D of the Trial plan.

[16] Mod40 acoustic source did not work due to faulty amplifier. The amplifier was repaired during the night.

[17] The icListen mounted on the REP11source was not able to record properly the transmissions due to the saturation of the sensor. Starting from the next day of acoustic transmissions, a pre-transmission/pre-recording period with an attenuation of 10 dB is executed at the beginning of each soundwave

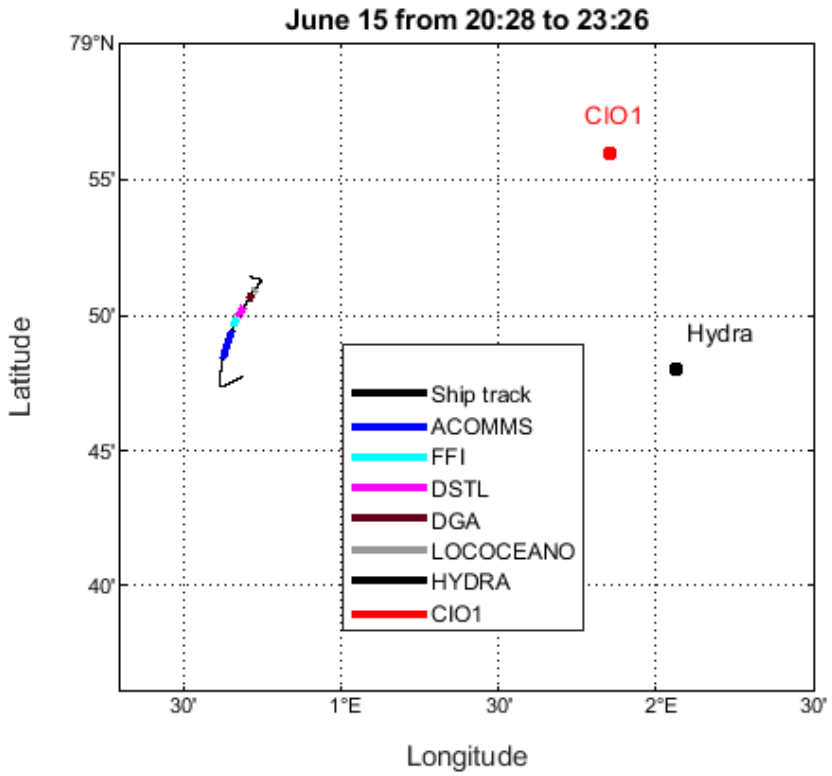

Figure 21: Ship track (black line) with acoustic transmission segments (ACOMMs-blue; FFI-light blue; DSTL-magenta; DGA-brown and LOCOCEANO-gray), ans positions of the moorings CIO1 (red) and HYDRA (black) during the acoustic experiment on June 15th 2022.

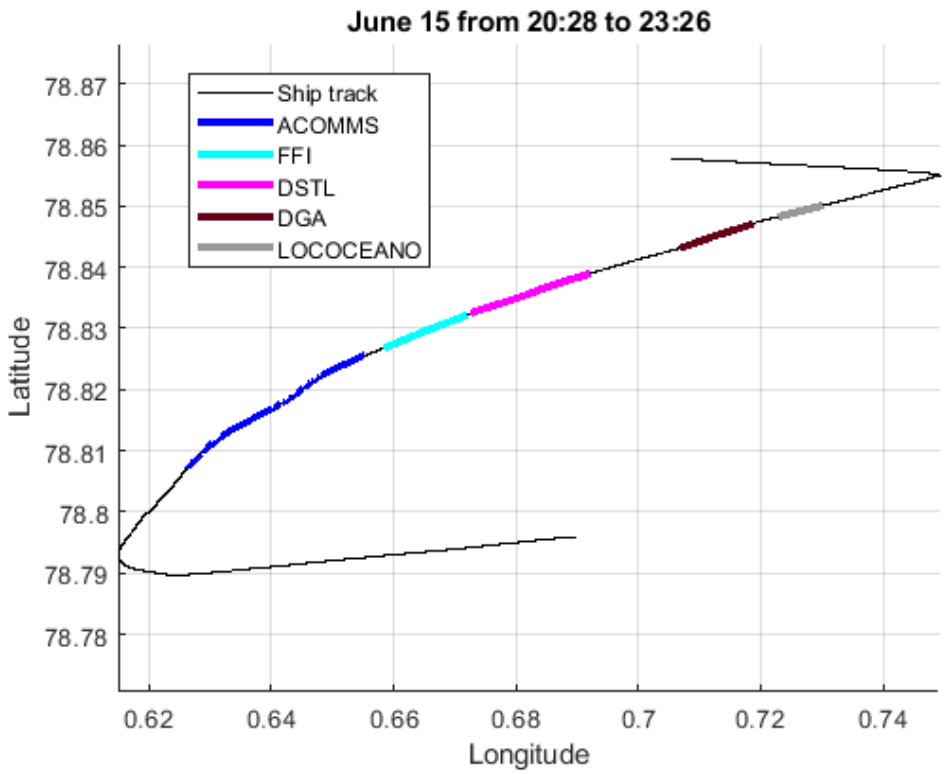

Figure 22: Zoom on the ship track (black) and on acoustic transmission segments (ACOMMs-blue; FFI-light blue; DSTL-magenta; DGA-brown and LOCOCEANO-gray) during the acoustic experiment on June 15th 2022.

Day 2: 16th June 2022

Day dedicated to the LOC: (Glider localization short-medium range) and OCEANO: (characterization of the impact of ocean fluctuations on acoustic transmission) experiments. For completeness purpose, the table below reports the NRV Alliance and acoustic glider Anna locations at different UTC time in order to easily evaluate the distance between the transmitter (NRV Alliance) and the receivers (Anna and acoustic mooring Hydra).

In this experiment, the acoustic sources involved in are the MOD30, MOD40 and ITC2010. The selected soundwaves are reported in Table A and Table B of Annex B.

UTC time	Operations	NRV Alliance position	Glider position
10:10	Approaching the glider deployment point – toward point	1.8351 E 78.6179 N	-
10:30	Delta preparation for deployment	1.8417 E 78.6093 N	-
10:35	Delta in the water – approaching deployment point.	1.8411 E 78.6104 N	-
10:50	Start first test of the Glider – going down	1.8367 E 78.6132 N	1.8258 E 78.6108 N
11:05	Glider back to the surface	1.8316 E 78.6153 N	1.8268 E 78.6102 N
11:20	Maneuvering ship for starting the CTD	1.8264 E 78.6174 N	1.831 E 78.61 N
12:05	CTD until 500 m depth	1.7575 E 78.6226 N	1.8354 E 78.6107 N
13:15	Acoustic glider mission start from G1[18]	1.8163 E 78.6018 N	1.8374 E 78.6126 N
13:34	LOCOCEANO: Source in the water – Start transmission (Table B, Annex B) – Ramp-up	1.8663 E 78.6004 N	1.837 E 78.6114 N
13:47	LOCOCEANO:Acoustic transmission full power (maximum allowed)	1.8697 E 78.6025 N	1.8368 E 78.6108 N
14:41	LOCOCEANO: stop transmission.	1.8758 E 78.6123 N	1.8511 E 78.6147 N
14:46	ACOMMs start soundwaves for 10 minutes	1.8759 E 78.6133 N	1.8575 E 78.6163 N
14:56	ACOMMs stop soundwaves – leaving the acoustic source in the water – maneuvering for the second waypoint W2 – short range localization experiment.	1.8757 E 78.6153 N	1.8597 E 78.6172 N
16:00	LOCOCEANO start transmission – (Table A, Annex B)	1.8647 E 78.6243 N	1.8742 E 78.625 N
16:20	LOCOCEANO stop transmission – maneuvering to WP4	1.866 E 78.6279 N	1.8742 E 78.6265 N
17:12	Arrival at WP4 – CTD @ 500 m	1.9803 E 78.6837 N	1.8636 E 78.6307 N
17:14	Start of ramp-up. (Table B, Annex B).	1.9802 E 78.6841 N	1.8601 E 78.6316 N

[18] HiPAP M46 mounted on glider

17:19	LOCOCEANO – start soundwaves 180 dB (Table B, Annex B)	1.9784 E 78.6852 N	1.8567 E 78.6325 N
18:09	LOCOCEANO – end soundwaves.	1.9433 E 78.6963 N	1.837 E 78.6378 N
18:12	ACOMMs – start soundwaves.t	1.9406 E 78.6969 N	1.837 E 78.6378 N
18:22	ACOMMs – end soundwaves. – maneuvering toward WP6	1.9312 E 78.6991 N	1.8328 E 78.6384 N
19:08	Arrival at WP6 – CTD cast @500 – Ac. source in water – Ramp-up – (Table B, Annex B)	1.7314 E 78.7224 N	1.8042 E 78.6375 N
19:15	LOCOCEANO – start soundwaves max allowed power (Table B, Annex B)	1.7262 E 78.7226 N	1.7971 E 78.6373 N
20:05	LOCOCEANO – end soundwaves; Loading new soundwaves; start ACOMMs soundwaves	1.6851 E 78.7182 N	1.7518 E 78.6358 N
20:15	ACOMMs – stop waves stop. Maneuvering toward WP8	1.6748 E 78.7176 N	1.7463 E 78.6356 N
21:22	Arrival on WP8	1.9525 E 78.7783 N	1.7026 E 78.626 N
21:26	Started the CTD cast @ 500 m– LOCOCEANO:Started the ramp-up	1.9489 E 78.7791 N	1.7034 E 78.6245 N
21:31	LOCOCEANO: start soundwaves max allowed power (Table B, Annex B)	1.9428 E 78.7799 N	1.7034 E 78.6245 N
22:21	LOCOCEANO – stop soundwaves – Loading new soundwaves	1.8707 E 78.7897 N	1.7163 E 78.6174 N
22:24	ACOMMs - start soundwaves.	1.8672 E 78.7902 N	1.7204 E 78.6162 N
22:34	ACOMMs – stop soundwaves.	1.8534 E 78.7918 N	1.7204 E 78.6162 N

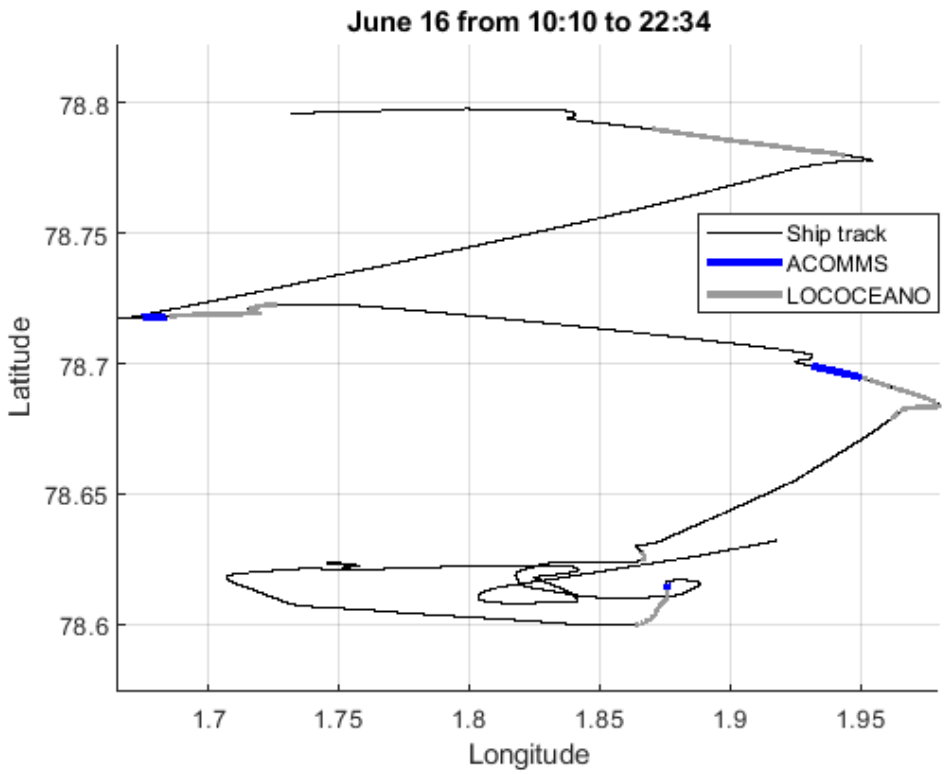

Figure 23: Zoom on the ship track (black) and on acoustic transmission segments (ACOMMs-blue; and LOCOCEANO-gray).

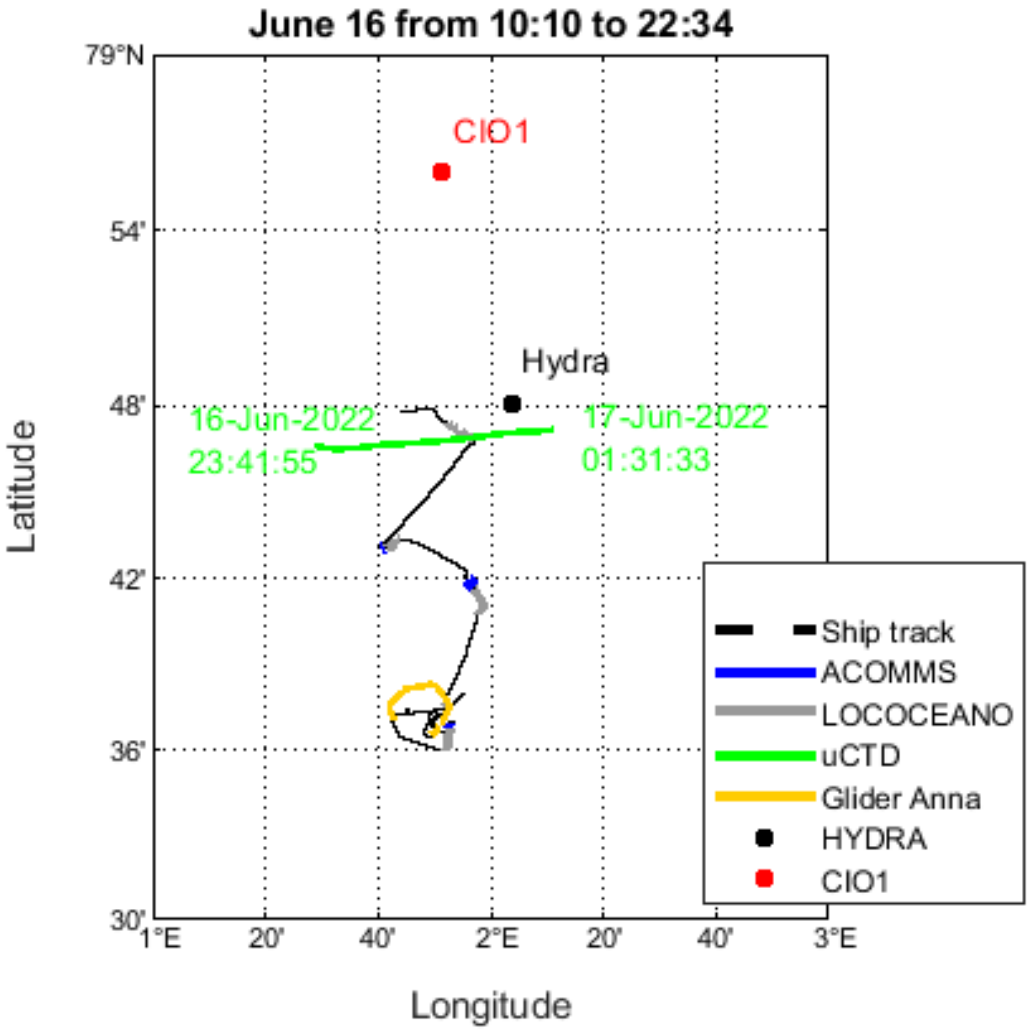

Figure 24: Ship track (black) with acoustic transmission segments (ACOMMs-blue and LOCOCEANO-gray) and positions of CIO1 (red), HYDRA (black), uCTD (green) and Glider Anna (yellow) during the execution of the second acoustic experiment on June 16th 2022.

Day 3: 17 June 2022

Day dedicated to the ACOMMs experiment aiming to record digitally modulated acoustic signals transmitted over different ranges. The specific aims of these signals is to characterize the channel and test adaptive modulation, *i.e.*, match signal parameters to the acoustic link for faster communications.

For completeness purpose, the table below reports the NRV Alliance and acoustic glider Anna locations at different UTC time in order to easily evaluate the distance between the transmitter (NRV Alliance) and the receivers (Anna and acoustic mooring Hydra).

In this experiment, the acoustic sources involved in are the MOD30, MOD40 and ITC2010. The MOD40 acoustic source did not work due to issues on a faulty amplifier. The selected soundwaves are reported in Table E of Annex B.

UTC time	Operations	NRV Alliance position	Glider position
07:15	Start deployment of REP11 acoustic source and marine mammal array and CTD	2.7201 E 78.8515 N	1.8563 E 78.6006 N
07:25	HiPAP deployed	2.7089 E 78.8546 N	1.857 E 78.5999 N
07:26	Start transmission with ramp-up see Table E (Annex B); 30 km range from Hydra - 10dB attenuation to record the signal on the icListen at the source.	2.7079 E 78.855 N	1.857 E 78.5999 N
07:34	ACOMMs: start max allowed power –Also ITC2010 soundwave transmitted	2.6993 E 78.8574 N	1.8576 E 78.5992 N
08:44	ACOMMs: stop transmission.	2.6232 E 78.875 N	1.8675 E 78.5977 N
08:46	FFI - Start transmission (-10 dB)	2.6205 E 78.8755 N	1.8675 E 78.5977 N
08:51	FFI - Stop transmission (-10 dB)	1.1965 E 78.8372 N	1.8391 E 78.517 N
08:52	FFI - Max allowed power	2.6123 E 78.8769 N	1.8675 E 78.5977 N
09:12	FFI – Stop transmission	2.5827 E 78.8812 N	1.8673 E 78.597 N
09:15	DSTL – Start transmission (-10 dB)	2.5783 E 78.8818 N	1.8673 E 78.597 N
09:20	DSTL – Stop transmission (-10 dB)	2.5709 E 78.8828 N	1.867 E 78.5963 N
09:21	DSTL – Start max allowed power	2.5694 E 78.883 N	1.867 E 78.5963 N
09:41	DSTL – Stop transmission	2.5398 E 78.8867 N	1.8664 E 78.5947 N
09:44	DGA – Start transmission (-10 dB)	2.5358 E 78.8873 N	1.866 E 78.5939 N
09:49	DGA – STOP transmission (-10 dB)	2.5294 E 78.8882 N	.8657 E 78.5933 N
09:50	DGA – Start max allowed power – CTD @ 500 m	2.5281 E 78.8884 N	1.8657 E 78.5933 N
10:10	DGA – Stop transmission	2.5056 E 78.8916 N	1.8651 E 78.592 N

10:14	LOCOCEANO – Start transmission (-10 dB) [19]	2.5014 E 78.8921 N	1.8651 E 78.592 N
10:19	LOCOCEANO – Stop transmission (-10 dB)	2.4996 E 78.8926 N	1.8647 E 78.5915 N
10:20	LOCOCEANO – Start max allowed power	2.4994 E 78.8927	1.8647 E 78.5915 N
10:30	LOCOCEANO – Stop transmission	2.4992 E 78.8933 N	1.8675 E 78.5916 N
10:32	ACOMMs – Start transmission (-10 dB)	2.499 E 78.8935 N	1.8646 E 78.591 N
10:37	ACOMMs– Stop transmission (-10 dB)	2.4987 E 78.894 N	1.8675 E 78.5916 N
10:39	ACOMMs – Start max allowed power	2.4987 E 78.8941 N	1.8675 E 78.5916 N
11:49	ACOMMs – Stop transmission	2.4978 E 78.8999 N	1.8711 E 78.5882 N
11:51	FFI – Start transmission (-10 dB)	2.4978 E 78.9001 N	1.8711 E 78.5882 N
11:56	FFI – Stop transmission (-10 dB)	2.4978 E 78.9005 N	1.8711 E 78.5882 N
11:57	FFI = Start max allowed power	2.4978 E 78.9006 N	1.8712 E 78.5876 N
12:17	FFI – Stop transmission	2.4993 E 78.902 N	1.8712 E 78.5869 N
12:19	DSTL – Start max allowed power	2.4994 E 78.9022 N	1.8713 E 78.5863 N
12:39	DSTL – Stop max allowed power	2.5009 E 78.9038 N	1.8718 E 78.5857 N
12:41	DGA – Start max allowed power	2.5012 E 78.9039 N	1.8718 E 78.5853 N
13:01	DGA – Stop max allowed power	2.5034 E 78.9055 N	1.8719 E 78.5848 N
13:04	LOCOCEANO – Start transmission	2.5037 E 78.9057 N	1.8719 E 78.5843 N
13:14	LOCOCEANO – Stop transmission	2.5038 E 78.9065 N	1.8719 E 78.5838 N
13:30	Moving toward 23 km range from Hydra.	2.5054 E 78.9097 N	1.8719 E 78.5828 N
14:08	Arrival at 23 km range from Hydra	2.351 E 78.9092 N	1.8719 E 78.5803 N
14:11	ACOMMs: Start ramp-up	2.3475 E 78.9095 N	1.8719 E 78.5803 N
14:17	ACOMMs: Start max allowed power	2.3403 E 78.9103 N	1.8719 E 78.5803
15:27	ACOMMs: Stop transmission	2.3338 E 78.9153 N	1.867 E 78.5775 N
15:30	FFI: Start max allowed power	2.3344 E 78.9155 N	1.867 E 78.5775 N
15:50	FFI: Stop transmission	2.3379 E 78.9165 N	1.866 E 78.5765 N
15:52	DSTL: Start max allowed power	2.3381 E 78.9166 N	1.8651 E 78.5756 N
16:12	DSTL: Stop transmission	2.3418 E 78.9172 N	1.8642 E 78.5746 N
16:14	DGA: Start max allowed power	2.3422 E 78.9173 N	1.8642 E 78.5746 N
16:34	DGA: Stop transmission	2.3467 E 78.9178 N	1.8626 E 78.5742 N
16:37	LOCOCEANO: Start max allowed power	2.3477 E 78.9177 N	1.8626 E 78.5742 N
16:47	LOCOCEANO: Stop transmission	2.3488 E 78.9174 N	1.8626 E 78.5742 N

[19] From the start of the acoustic experiment until 10:14 the ship was not able to maintain its position and drifted. At 10:14 the ship was already at 27 km range from the Hydra. Wind intensity of 20 knots and sea-state 3 (1 meter wave-height from bridge estimate).

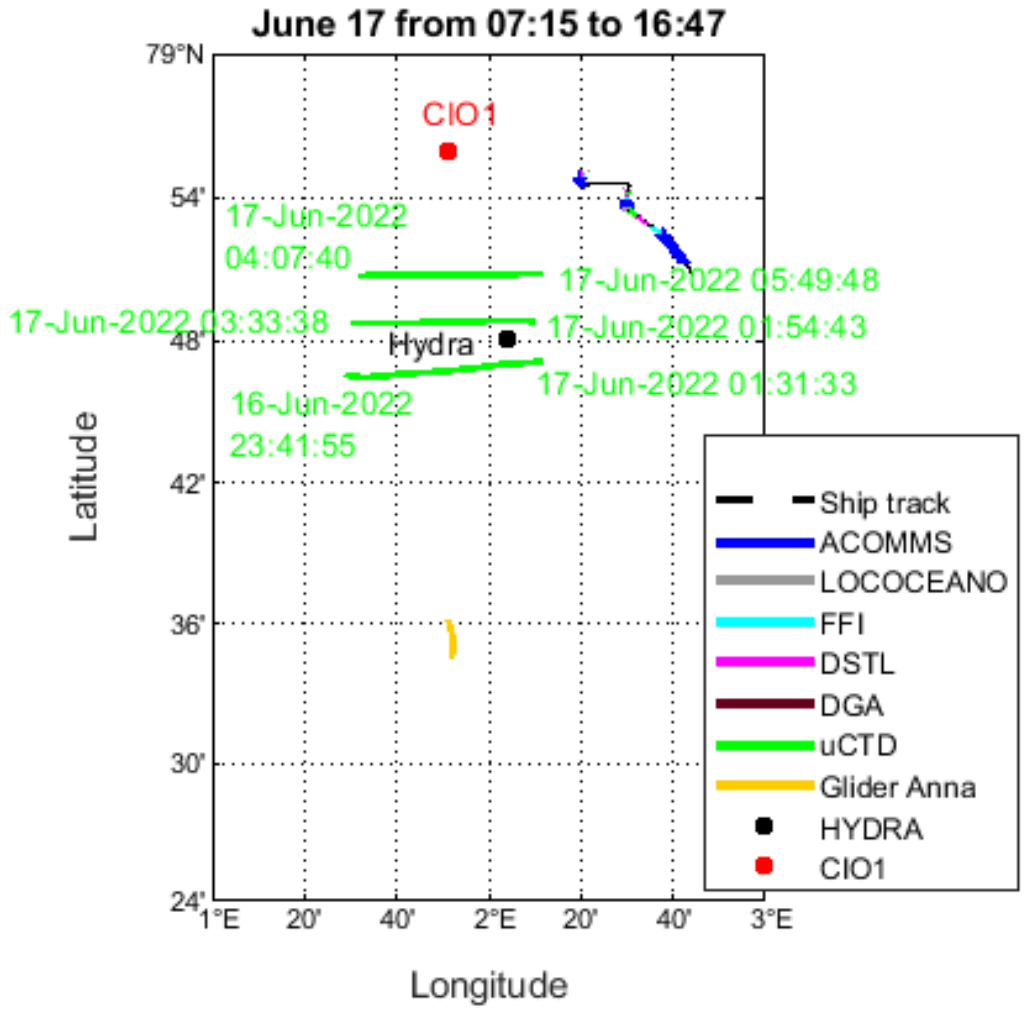

Figure 25: Ship track (black) with acoustic transmission segments (ACOMMs-blue; FFI-light blue; DSTL-magenta; DGA-brown and LOCOCEANO-gray); positions of CIO1 (red), HYDRA (black), uCTD (green) and Glider Anna (yellow) during the execution of the acoustic experiment on June 17th 2022.

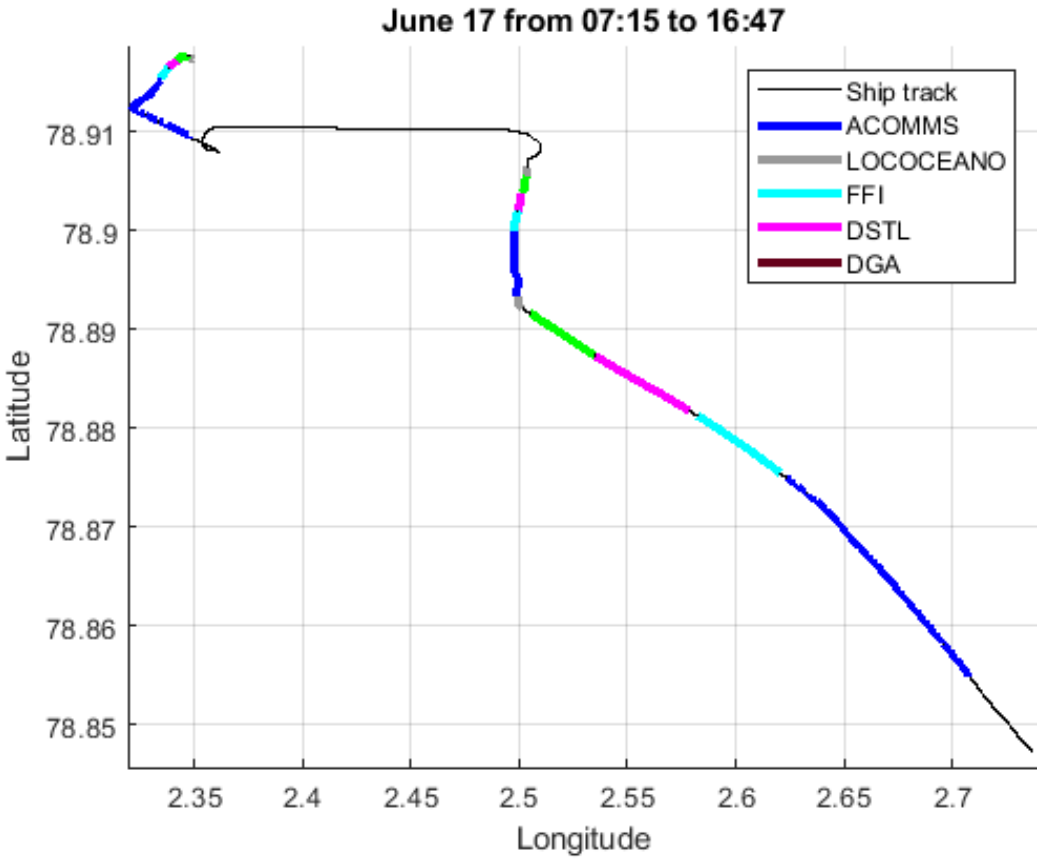

Figure 26: Zoom on the ship track (black) and on acoustic transmission segments (ACOMMs-blue; FFI-light blue; DSTL-magenta and DGA-brown) on June 17th 2022 from 07:34 to 10:10 UTC.

Day 4: 18 June 2022

Day dedicated to the ACOMMs and LOCOCEANO experiments.

In this experiment, the acoustic sources involved in are the MOD30, MOD40 and ITC2010. The selected soundwaves are reported in Table D and Table F of Annex B.

For completeness purpose, the table below reports the NRV Alliance and acoustic glider Anna locations at different UTC time in order to easily evaluate the distance between the transmitter (NRV Alliance) and the receivers (Anna and acoustic mooring Hydra).

UTC time	Operations	NRV Alliance position	Glider position
14:23	CTD @ 2000 m depth	1.6551 E 78.9149 N	1.873 E 78.4791 N
14:42	ACOMMs: Start ramp-up – Table D, Annex B – 11 km from the Hydra	1.6531 E 78.9146 N	1.8873 E 78.4767 N
14:48	ACOMMs: Start max allowed power	1.6478 E 78.9152 N	1.8873 E 78.4767 N
15:48	ACOMMs: Stop transmission	1.6316 E 78.9161 N	1.9185 E 78.471 N
15:51	FFI: Start transmission (-10 dB)	1.6325 E 78.9156 N	1.9256 E 78.4696 N
16:02	FFI: Start max allowed power	1.6366 E 78.9139 N	1.9256 E 78.4696 N
16:17	FFI: Stop transmission	1.6348 E 78.9132 N	1.9327 E 78.4683 N
16:20	DSTL: Start transmission (-10 dB) [ITC2010 – MOD30 – MOD40]	1.632 E 78.9136 N	1.9327 E 78.4683 N
16:25	DSTL: Start max allowed power	1.6267 E 78.9143 N	1.9327 E 78.4683 N
16:40	DSTL: Stop transmission	1.6117 E 78.9165 N	1.9549 E 78.4678 N
16:42	DSTL: Start transmission (-10 dB) [ITC2010 – MOD30]	1.6097 E 78.9168 N	1.9549 E 78.4678 N
16:47	DSTL: Start max allowed power	1.6048 E 78.9176 N	1.9549 E 78.4678 N
17:02	DSTL: Stop transmission	1.5918 E 78.9201 N	1.9659 E 78.4679 N
17:05	DGA: Start transmission (-10 dB) [ITC2010 – MOD30 – MOD40]	1.5893 E 78.9207 N	1.9659 E 78.4679 N
17:12	DGA: Start max allowed power	1.587 E 78.9221 N	1.9768 E 78.468 N
17:27	DGA: Stop transmission	1.5986 E 78.922 N	1.9874 E 78.4681 N
17:31	LOCOCEANO: Soundwave C_LOC_OCEANO from Table F Start transmission (-10 dB)	1.6006 E 78.9216 N	1.9874 E 78.4681 N
17:37	LOCOCEANO: Start max allowed power	1.6032 E 78.9212 N	1.998 E 78.4682 N
18:37	LOCOCEANO: Stop transmission	1.634 E 78.9178 N	2.0365 E 78.469 N
20:14	Start uCTD profiles	1.2451 E 78.7817 N	2.0723 E 78.4632 N
22:38	End uCTD profiles	2.2181 E 78.7811 N	2.1296 E 78.4586 N
23:26	Start uCTD profiles	2.2263 E 78.8492 N	2.1504 E 78.4568 N

NOTE: Anna increased the dive depth to accellerate the speed toward south. Due to adverse sea-current toward north Anna moved slowly during the previous days. Target diving depth was increased to 260 m and during 18/06 it wasincrease again to 270 m. Commanded new mission at 16:40 – 2 hours SE => 2 hours E => SE direction. Required EAST direction to increase distance with possible surface ice.

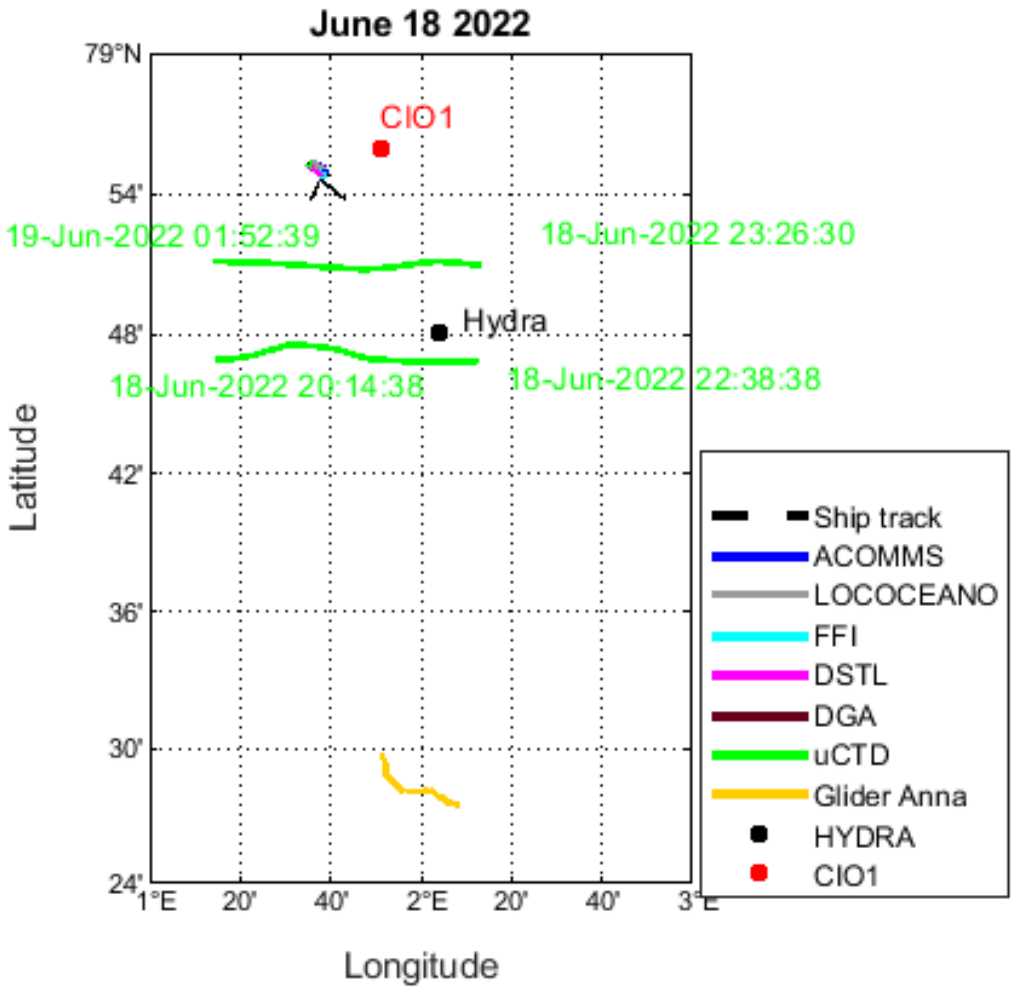

Figure 27: Ship track (black) with acoustic transmission segments (ACOMMs-blue; FFI-light blue; DSTL-magenta; DGA-brown and LOCOCEANO-gray) andpositions of CIO1 (red), HYDRA (black), uCTD (green) and Glider Anna (yellow) during the acoustic experiment on 18th June 2022.

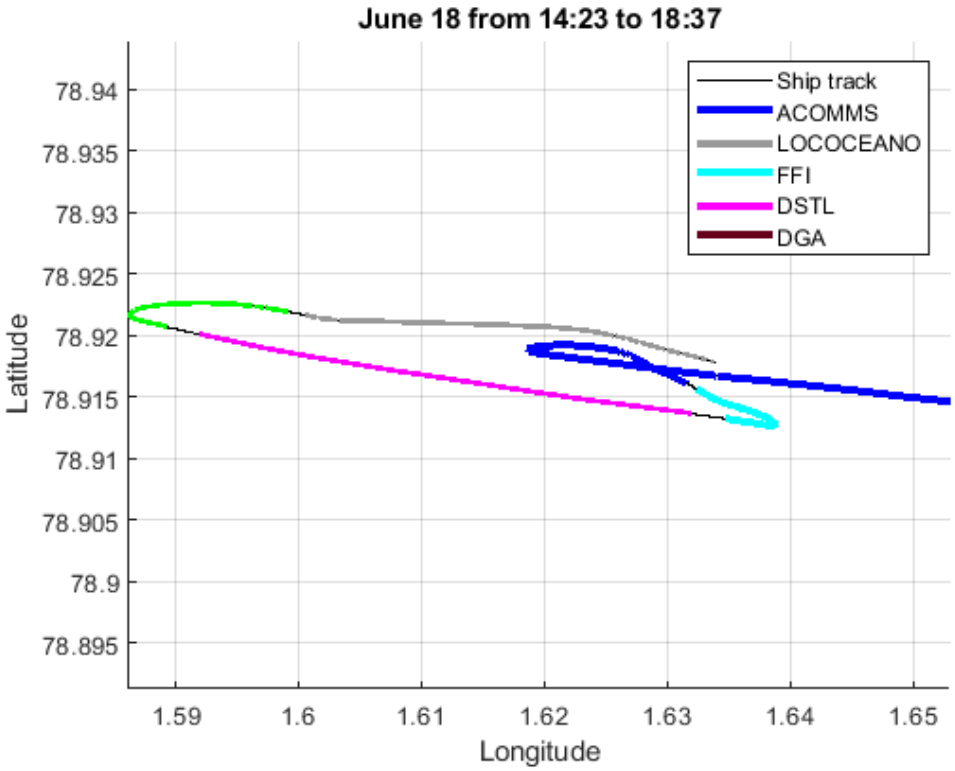

Figure 28: Zoom on the ship track (black) and acoustic transmission segments (ACOMMs-blue; FFI-light blue; DSTL-magenta; DGA-brown and LOCOCEANO-gray) on June 18th 2022.

Days 5-6: 19-20 June 2022

Day dedicated to the ACOMMs and LOCOCEANO experiments.
For completeness purpose, the table below reports the NRV Alliance and acoustic glider Anna locations at different UTC time in order to easily evaluate the distance between the transmitter (NRV Alliance) and the receivers (Anna and acoustic mooring Hydra).
In this experiment, the acoustic sources involved in are the MOD30, MOD40 and ITC2010.
The selected soundwaves are reported in Table D and Table F of Annex B.

UTC time	Operations	NRV Alliance position	Glider position
01:52	End uCTD profiles	1.2275 E 78.8522 N	2.2117 E 78.4514 N
16:40	New waypoint set to Glider	1.0805 E 78.8352 N	2.4171 E 78.4098 N
20:35	ACOMMs: ramp-up started and CTD @ 1000 m depth	1.2919 E 78.8666 N	2.4231 E 78.4041 N
20:44	ACOMMs: Start maximum allowed power	1.2733 E 78.8655 N	2.4231 E 78.4041 N
21:34	ACOMMs: Stop transmission	1.1583 E 78.8612 N	2.3587 E 78.403 N
21:38	FFI: Start transmission (-10 dB)	1.1479 E 78.8611 N	2.3587 E 78.403 N
21:43	FFI: Stop transmission	1.1349 E 78.8609 N	2.3422 E 78.4028 N
21:47	FFI: Start maximum allowed power	1.1243 E 78.8606 N	2.3422 E 78.4028 N
22:07	FFI: Stop transmission	1.0751 E 78.8593 N	2.3107 E 78.4025 N
22:11	DGA: Start transmission (-10 dB)	1.0657 E 78.8591 N	2.3107 E 78.4025 N
22:16	DGA: Stop transmission	1.0536 E 78.8588 N	2.3107 E 78.4025 N
22:18	DGA: Start maximum allowed power	1.0486 E 78.8587 N	2.3107 E 78.4025 N
22:38	DGA: Stop transmission	0.9999 E 78.8585 N	2.2896 E 78.4023 N
22:43	LOCOCEANO: Soundwave C_LOC_OCEANO from Table F	0.9883 E 78.8586 N	2.2786 E 78.4021 N
23:37	LOCOCEANO: Stop transmission[20]	0.8689 E 78.8592 N	2.2191 E 78.398 N
-----	Problems during maneuvering of the ship. Acoustic source left in the water to limit crew work at night. Cable went out from the saddle during the maneuvering of the ship	----------	----------
02:56	(2022-06-20) LOCOCEANO: ramp-up start C_LOCOCEANO soundwave.	.0583 E 78.9048 N	2.0421 E 78.3989 N
03:02	LOCOCEANO: Start max allowed power	1.0506 E 78.9043 N	2.0316 E 78.4001 N
03:52	LOCOCEANO: End transmission	1.0467 E 78.8951 N	1.9905 E 78.405 N

[20] Due to leeway/drift/ice, the ship has drifted up to 9-10 km away from the HYDRA.

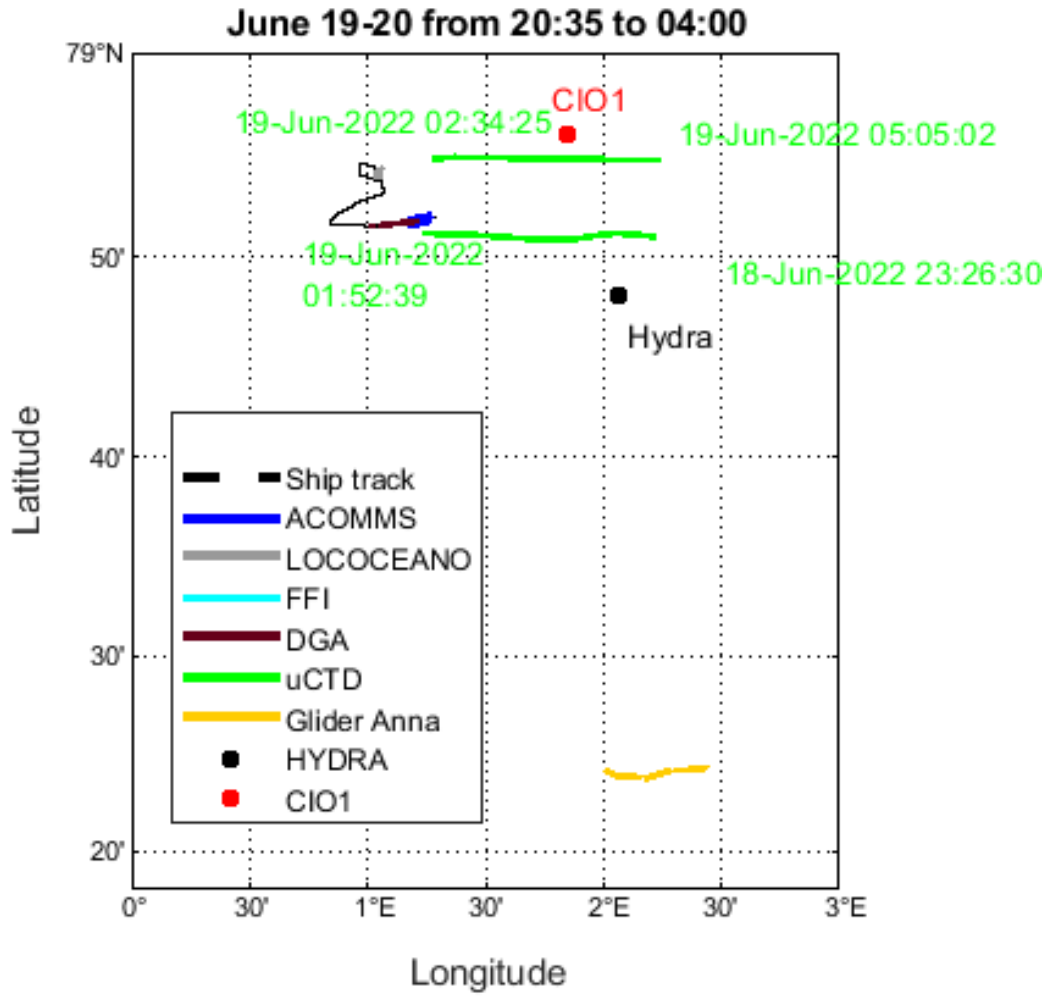

Figure 29: Ship track (black) with acoustic transmission segments (ACOMMs-blue; FFI-light blue; DSTL-magenta; DGA-brown and LOCOCEANO-gray) and positions of CIO1 (red), HYDRA (black), uCTD (green) and Glider Anna (yellow) during the acoustic experiment done on June 19th and 20th 2022.

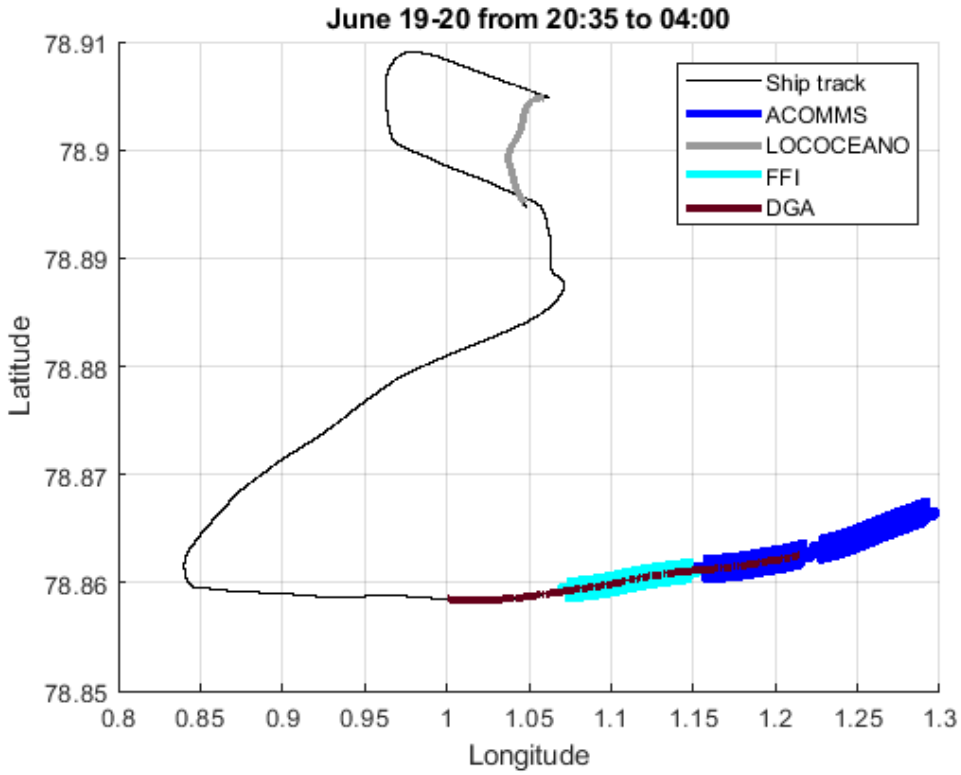

Figure 30: Zoom on the ship track (black) and acoustic transmission segments (ACOMMs-blue; FFI-light blue; DGA-brown and LOCOCEANO-gray) from June 19th (20:35 UTC) to 20th (04:00 UTC).

Annex B: Acoustic experiments details – acoustic transmissions

This Annex reports the details of the transmission signals used for the acoustic experiments executed during the NREP22 sea trial. Specifically, the information is reported below in Tables A, B, C, D , E and F (from trial plan of NREP22).

Tables A, B and F are mostly dedicated to the LOCOCEANO experiments (with a short slot in Tables B and F dedicated to ACOMMs experiment).

Tables C, D and E are mostly dedicated to the ACOMMs and partners (FFI, DSTL and DGA) experiments (with short slot dedicated to ACOMMs experiment).

Additional details can be found in the NREP22 Trial Plan (Ref. CMRE-TP-2022-06-NREP22).

Table A

file name	source	file duration (s)	Repeat (x times)	Total duration (s)
A_LOC_OCEANO_itc_src	ITC2010	60	20	1200
A_LOC_OCEANO_mod30_src	mod30	60	20	1200
A_LOC_OCEAN_mod40_src	mod40	60	20	1200
		Experiment run	**20**	**minutes**
		Total run	20.00	minutes

Table B

file name	source	file duration (sec)	Repeat (x times)	Total duration (s)
A_LOC_OCEANO_itc_src	ITC2010	60	50	3000
A_LOC_OCEANO_mod30_src	mod30	60	50	3000
A_LOC_OCEAN_mod40_src	mod40	60	50	3000
		Experiment run	**50**	**minutes**
NREP22-ITC2010-CMRE	ITC2010	63	9	315
NREP22-mod30-CMRE	mod30	116	5	348
NREP22-mod40-CMRE	mod40	112	5	336
		Experiment run	**10**	**minutes**
		Total run	60.00	minutes

Table C

file name	Source	file duration (sec)	Repeat (x times)	Total duration (s)
NREP22-ITC2010-CMRE	ITC2010	63	47	3000
NREP22-mod30-CMRE	mod30	116	25	3000
NREP22-mod40-CMRE	mod40	112	26	3000
		Experiment run	**50.00**	**minutes**
nrep22_ffi_itc2010	ITC2010	240	5	1200
nrep22_ffi_mod30	mod30	240	5	1200
nrep22_ffi_mod40	mod40	240	5	1200
		Experiment run	**20.00**	**minutes**
DGA_nrep2022_itc_src	ITC2010	64	18	1200
DGA_nrep2022_mod30_src	mod30	64	18	1200
DGA_nrep2022_mod40_src	mod40	64	18	1200
		Experiment run	**20.00**	**minutes**
B_LOC_OCEANO_itc_src	ITC2010	60	10	600
B_LOC_OCEANO_mod30_src	mod30	60	10	600
B_LOC_OCEAN_mod40_src	mod40	60	10	600
	REP11	**Experiment run**	**10**	**minutes**
		Total run	100.00	minutes

Table D

file name	source	file duration (sec)	Repeat (x times)	Total duration (s)
NREP22-ITC2010-CMRE	ITC2010	63	57	3600
NREP22-mod30-CMRE	mod30	116	31	3600
NREP22-mod40-CMRE	mod40	112	32	3600
		Experiment run	**60.00**	**minutes**
nrep22_ffi_itc2010	ITC2010	240	5	1200
nrep22_ffi_mod30	mod30	240	5	1200
nrep22_ffi_mod40	mod40	240	5	1200
		Experiment run	**20.00**	**minutes**
C_ITC2010_DSTL	ITC2010	13	92	1200
A_mod30_DSTL	mod30	63	19	1200
E_mod40_DSTL	mod40	14	85	1200
		Experiment run	**20.00**	**minutes**
B_ITC2010_DSTL	ITC2010	61	19	1200
D_mod30_DSTL	mod30	14	85	1200
		Experiment run	**20.00**	**minutes**
DGA_nrep2022_itc_src	ITC2010	64	18	1200
DGA_nrep2022_mod30_src	mod30	64	18	1200
DGA_nrep2022_mod40_src	mod40	64	18	1200

		Experiment run	**20.00**	**minutes**
B_LOC_OCEANO_itc_src	ITC2010	60	10	600
B_LOC_OCEANO_mod30_src	mod30	60	10	600
B_LOC_OCEAN_mod40_src	mod40	60	10	600
		Experiment run	**10**	**minutes**
		Total run	150.00	minutes

Table E

file name	source	file duration (sec)	Repeat (x times)	Total duration (s)
NREP22-mod30-CMRE	mod30	116	36	4200
NREP22-mod40-CMRE	mod40	112	37	4200
		Experiment run	**70.00**	**minutes**
nrep22_ffi_mod30	mod30	240	5	1200
nrep22_ffi_mod40	mod40	240	5	1200
		Experiment run	**20.00**	**minutes**
A_mod30_DSTL	mod30	63	19	1200
E_mod40_DSTL	mod40	14	85	1200
		Experiment run	**20.00**	**minutes**
DGA_nrep2022_mod30_src	mod30	64	18	1200
DGA_nrep2022_mod40_src	mod40	64	18	1200
		Experiment run	**20.00**	**minutes**
B_LOC_OCEANO_itc_src	ITC2010	60	10	600
B_LOC_OCEANO_mod30_src	mod30	60	10	600
B_LOC_OCEAN_mod40_src	mod40	60	10	600
		Experiment run	**10**	**minutes**
		Total run	140.00	minutes

Table F

file name	source	file duration (sec)	Repeat (x times)	Total duration (s)
C_LOC_OCEANO_itc_src	ITC2010	60	50	3000
C_LOC_OCEANO_mod30_src	mod30	60	50	3000
C_LOC_OCEAN_mod40_src	mod40	60	50	3000
		Experiment run	**50**	**minutes**
NREP22-ITC2010-CMRE	ITC2010	63	9	315
NREP22-mod30-CMRE	mod30	116	5	348
NREP22-mod40-CMRE	mod40	112	5	336
		Experiment run	**10**	**minutes**
		Total run	60.00	minutes

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Title

NREP22 Cruise Report and Data Catalogue

Abstract

The Nordic Recognized Environmental Picture 2022 (NREP22) sea trial was performed in the Svalbard Islands area and Greenland Sea from 8th to 27th June 2022. The sea trial was conducted to investigate the impact of ice-covered seas on moored and mobile underwater acoustic communications systems, as well as to conduct sustained monitoring of oceanographic variables and ambient noise levels to assess the Arctic transformation.

This report provides a detailed overview of the oceanographic and acoustic measurements collected by both the NRV Alliance and by autonomous platforms during NREP22, and a summary of the raw and processed data available in the CMRE data repository (isilon).

Keywords

Arctic Ocean; acoustic data; oceanographic data.

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