APPLICATION FOR CONSENT TO CONDUCT MARINE SCIENTIFIC RESEARCH IN AREAS UNDER NATIONAL JURISDICTION OF
ICELAND

Date: 29/12/2022

1 - GENERAL INFORMATION

1. Cruise name and/or number:

1.2. Sponsoring institutions:

Funding agency: Ministerio de Ciencia e Innovación de España
Funding programme: Programas Estatales de Generación de Conocimiento y Fortalecimiento Científico y Tecnológico del Sistema de I+D+i y de I+D+i Orientada a los Retos de la Sociedad
Name and reference of the project: Far-reaching impacts of dense water overflows in the North Atlantic Ocean and the Mediterranean Sea (FAR-DWO)
Reference: PID2020-114322RB-I00
Country: Spain

1.3. Scientist in charge of the projects and legs:

Dr. Anna Sanchez-Vidal
Dr. David Amblas

1.4. Scientist from Iceland involved in the planning of the project:

Dr. Solveig Rosa Ólafsdóttir, Marine and Freshwater Research Institute (Iceland)

1.5. Submitting officer:

Name: Dr. David Amblas
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2 - DESCRIPTION OF THE PROJECT

2.1. Nature and objectives of the project:

FARDWO-DS1 cruise aims to study the Denmark Strait overflow, the physical processes involved in its propagation, its capacity to erode, transport and deposit sediment and, through the use of high frequency proxy reconstructions in marine sediment cores, to unveil its variability through time.

Dense water overflows (DWOs) are buoyancy-driven currents that are formed in a few temperate and polar areas by cooling, evaporation or freezing of surface ocean layers. Once denser than surrounding waters, these waters sink and move downslope along the seabed as near-bottom gravity flows. This process contributes to deep-ocean ventilation, plays a role in the global thermohaline circulation (and hence global climate), and involves large-scale transfer of energy and matter from shallow to deep waters, including sedimentary particles, organic carbon and pollutants. The large volumes involved in DWOs can result in appreciable sediment transport and erosion and cause drastic impacts in deep-sea ecosystems and in demersal fisheries. This has been observed in the NW Mediterranean by the FAR-DWO research team through a pioneering work implying more than two decades of observations in the Cap de Creus Canyon (CCC) with instrumented mooring lines equipped with sediment traps, currentmeters and temperature sensors.

FAR-DWO is bringing the knowledge of DWOs behaviour and far-reaching impacts a step forward by intensifying, amplifying and diversifying the CCC monitoring effort, and combining it with the monitoring of the DWOs in Denmark Strait (DS). The two target zones, one temperate and one polar, provide the ideal frame to investigate the physical and biogeochemical evolution and imprint of DWOs, as both are main actors in the oceans themohaline circulation system.

The DWO in the DS is a main driver of the Atlantic Meridional Overturning Circulation and the DWO in the NW Mediterranean it is for the Mediterranean Thermohaline Circulation. The research objectives and the methodological setup in both study areas will be comparable and consist on (i) the deployment of mooring lines that will provide information on the variable hydrography and sedimentology associated to DWOs over the monitored period; (ii) the acquisition of water column information through CTD casts deployed during the research cruises that will allow to investigate the DWOs structure and biogeochemical characteristics; (iii) the acquisition of high-resolution bathymetric and very shallow seismic data that will allow to determine the physical imprint of DWOs on the seafloor and subseafloor; and (iv) the extraction of seafloor sediment samples that will provide a detailed characterization of the DWOs geochemical and sedimentological imprint in the sedimentary record. Such a multidisciplinary strategy has never tackled before in DS, nor with this level of detail in the CCC. The obtained field measurements in both settings are being combined with a tailored process-based hydro-sedimentary numerical model that will provide, for the first time, a quantification of the capacity of DWOs to shape the seafloor. Beyond the study of the present-day DWOs in DS and CCC, FAR-DWO envisages the analysis of its variability in response to the ongoing and past climate changes. This is being achieved through: (i) the examination of historical observations and reanalysis of ocean and atmospheric models to study the interannual variability and trends of DWOs in the NW Mediterranean and North Atlantic during the last decades; and (ii) the use of sedimentological and geochemical proxies in marine sediment cores to reconstruct the physical and biogeochemical evolution of the DWOs in DS and CCC along key past climatic scenarios

2.2. Relevant previous or future research cruises:

At the moment of writing this document one research cruise, named FARDWO-CCC1, has been done in the framework of the FAR-DWO project (the project started in September 2021). It was from 01/03/2022 to 07/03/2022 in Cap de Creus Canyon study area (NW Mediterranean), onboard RV García del Cid. During the cruise we performed CTD casts, seafloor sediment sampling and deployment of instrumented mooring lines.

In March 2023 we will carry out the second cruise (FARDWO-CCC2) foreseen in the FAR-DWO project at the Cap de Creus Canyon, again onboard RV Garcia del Cid. This time, in addition to CTD casts we will use an Autonomous Underwater Vehicle (AUV) carrying an array of sensors to monitor the seafloor and the water column.

In July-August 2023 we will carry out the first of the two research cruises foreseen in Denmark Strait, in the North Atlantic Ocean, on RV Sarmiento de Gamboa (see below a list and description of the expected methods and target areas). The name of the cruise will be FARDWO-DS1 and its duration will be 25 days (19/07/2023 to 12/08/2023, Reykjavík-Reykjavík). The aims of the cruise will include water column and seafloor sampling and characterization

In summer 2024 (most likely at the end of August) we will have a second and short (8 days) cruise in Denmark Strait, named FARDWO-DS2, on RV Sarmiento de Gamboa,. The focus will be on the study of the water column and on the recovery of the instrumented mooring lines deployed in FARDWO-DS1.

2.3. Previously published research data relating to the project:

The following are the SCI papers published in the framework of the FAR-DWO project (started in September 2021):

Estournel, C.; Mikolajczak, G.; Ulses, C.; Bourrin, F.; Canals, M.; Charmasson, S.; Doxaran, D.; Duhaut, T-; Durrieu de Madron, X.; Marsaleix, P.; Palanques, A.; Puig, P.; Radakovitch, O.; Sanchez-Vidal, A.; Verney, R. (2023). Sediment dynamics in the Gulf of Lion (NW Mediterranean Sea) during two autumn–winter periods with contrasting meteorological conditions. Progress in Oceanography, Volume 210, 2023, 102942. https://doi.org/10.1016/j.pocean.2022.102942

Martí, A.; Portell, J.; Amblas, D.; de Cabrera, F.; Vilà, M.; Riba, J.; Mitchell, G. (2022). Compression of Multibeam Echosounders Bathymetry and Water Column Data. Remote Sens. 14, 2063. https://doi.org/10.3390/rs14092063

PhD Theses (running):

Luisa Freitas, thesis from University of Barclona (supervisors: A. Sanchez-Vidal, D. Amblas), started in January 2023. Physical imprints of dense water overflows in the Northern Atlantic Ocean and the North-western Mediterranean Sea.

Irene Llamas, thesis from University of Barcelona (supervisors: A. Sanchez-Vidal), started in November 2022. Impact of dense water formation in biogeochemistry and diatom floristics in the Northern Atlantic Ocean and the North-western Mediterranean Sea.

3 - METHODS AND MEANS TO BE USED

3.1. Particular of vessel:

MAIN RESEARCH VESSEL

Name: SARMIENTO DE GAMBOA
Nationality: Spanish
Owner: CSIC
Operator: CSIC, UTM
Type of vessel: **Oceanographic Research Vessel**

Year built and country: **2007 by CNP Freire, Spain**
Length / width **70,5 m**
Length p.p.: **62,0 m**
Design Draught: **4,60 m**
Scantling Draught**: 4,90 m**
Depth to main deck: **5,00 m**
Tonnage: Gross = **2630 GT**
Dead weight: **850 tpm**
Maximum Speed: **14,5 knots**
Prop. Power: **2400 kW**
Fuel: **528 m3**
Endurance: **40 days**
Accommodation (crew + research) **16+26**
Classification society: **Bureau Veritas, +HULL Special Service Oceanographic and Fishing Research/Unrestricted Navigation/+MACH+AUT-UMS, AUT-CCS, ALM SDS COMF-1, SYS-NEQ 1 DYNAPOS AM/AT**
Register port: **Vigo**
Call code: **E A K F**
Phone:
INMARSAT: +870773931000
VSAT: +34.911.930.357 (Captain)
VSAT: +34.911.930.359 (Bridge)
Cellular: +34.679.510.317
Email: capitan.sdg@utm.csic.es

Name of master :
Miguel Angel Menéndez
David Arenas
Number of crew: 16
Number of scientists on board: 26

3.2. Aircraft or other craft to be used in the project: None

3.3. Particulars of methods and scientific instruments:

			Distance to shore		
Provide a list of the main scientific equipment that is going to be used, saying the waters where it will be used / installed	*Fisheries research within the established fishing limits*	*Research related to the continental shelf beyond the limits of the coastal state*	*Within 12 nautical miles*	*Within 12 and 50 nautical miles*	*Within 50 and 200 nautical miles*

CTD rosette equipped with: - 24 sampling bottles (12 litters) - SeaBird SBE911 (Conductivity Depth Temperature Oxygen), - 2 LADCP (Acoustic Doppler Current Profiler) - Turbidimeter			x	x	x
Seafloor sediment sampling using: - Van Veen grab sampler - Gravity/Piston corer - Multicorer - Monocorer					x
Geophysical equipment for the watercolumn, seafloor and sub-seafloor characterization: - Multibeam echosounder Atlas Hydrosweep DS-3 - Sound velocity profiler Applied Microsystems SV Plus V2 - Doppler Teledyne RD Instruments ADCP Ocean Surveyor 75 y 150 kHz (hull mounted) - Parametric echosounder Parasound P-35					x

3.4. Indicate whether harmful substances will be used:
No

3.5. Indicate whether drilling will be carried out:
No

3.6. Indicate whether explosives will be used:
No

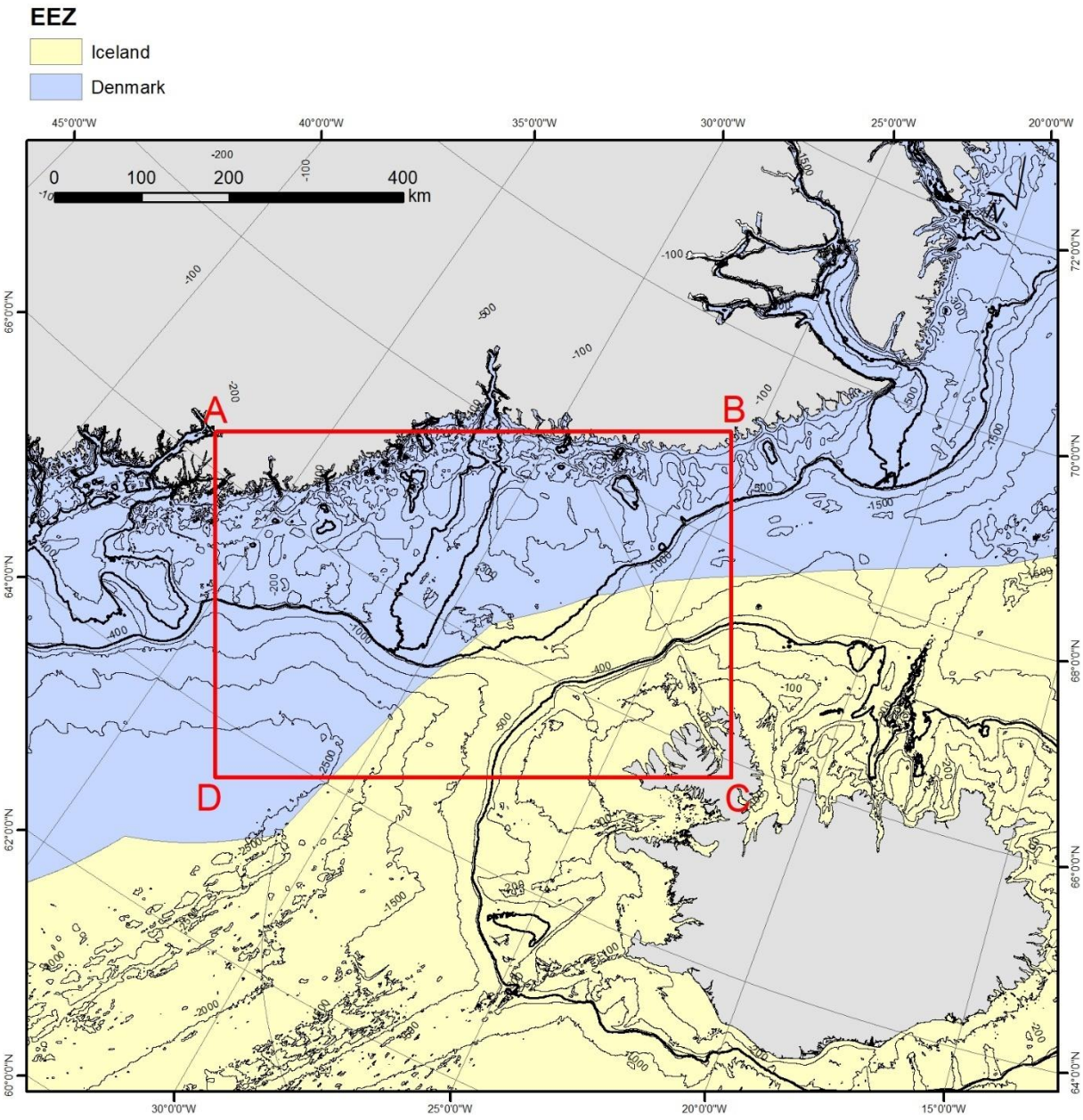
4 - INSTALLATIONS AND EQUIPMENTS

Equipment to be used from the vessel:
- CTD rosette equipped with 24 sampling bottles (12 litters, a SeaBird SBE911 (Conductivity Depth Temperature Oxygen), a LADCP (Acoustic Doppler Current Profiler), and a Turbidimeter. This equipment will be used to monitor the physic-chemical characteristics of

water masses with depth (red dots in the chart in section 5.2).
- Van Veen grab sampler, gravity/piston corer, multicorer and monocorer- will be used to obtain sediment samples of the seafloor in specific stations (some of the red dots in the chart in section 5.2).
- Geophysical equipment hull mounted on the vessel including a multibeam echosounder Atlas Hydrosweep DS-3, a Doppler Teledyne RD Instruments ADCP Ocean Surveyor (75 and 150 kHz), and a parametric echosounder Parasound P-35 will be used to characterize water column and seafloor and sub-seafloor:

5 - GEOGRAPHICAL AREAS

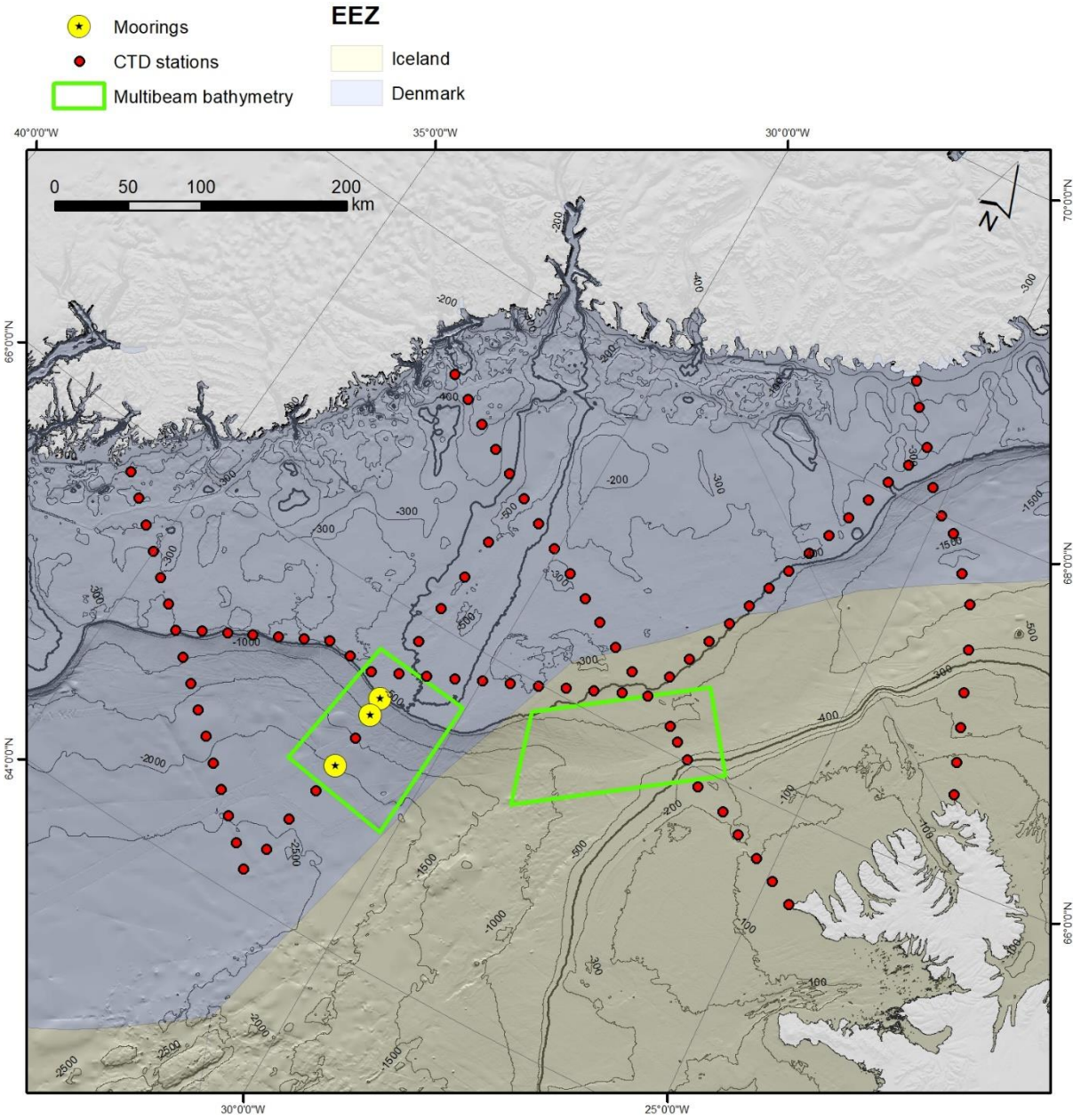
5.1. Indicate geographical areas in which the project is to be conducted (with reference in latitude and longitude):



Latitude and longitude (in decimal degrees) of the bounding box corners:

A (-37.35, 66.30)
B (-25.69, 69.03)
C (-22.06, 65.85)
D (-32.69, 63.49)

5.2. Attach chart(s) at an appropriate scale showing the geographical areas of the intended work and, as far as practicable, the positions of intended stations, the tracks of survey lines, and the locations of specific equipments or facilities:



Red dots correspond to CTD stations. Approximately one fourth of the CTD stations will

include water sampling and monocorer-sediment sampling.

The green polygons highlight the areas where high resolution bathymetric data (i.e. multibeam bathymetry) and high resolution shallow seismic profiles will be acquired.

Yellow dots correspond to the position of the three mooring lines that will be deployed, at 500, 1000 and 2000 m water depth. The moorings will be monitoring the near-seabed (from 0 to 100 m above sea floor) water column physico-chemical and sediment transport characteristics. Seafloor sampling will be carried out inside the green polygon areas. The final position of the sampling stations will be decided according to the information given by the high resolution seafloor map and the very shallow seismic profiles.

6 - DATES

6.1 Expected dates of first entry into and final departure from the research area of the research vessel:

1. Entry in Iceland EEZ date : 19/07/2023

2. Departure from Iceland EEZ date : 12/08/2023

6.2 Indicate if multiple entry is expected:

We will be entering and leaving Iceland EEZ waters in multiple times during the research cruise as the study areas are comprised in between Danish and Icelandic waters, in Denmark Strait.

7 - PORTS CALLS

7.1. Dates and names of intended ports of call in Reykjavik:
19/7/2023 Reykjavík – 12/8/2023 Reykjavík

7.2. Any special logistical requirements at ports of callA :
None

7.3. Name/Address/Telephone of shipping agent (if available):
Not designated yet

8 - PARTICIPATION

8.1. Proposed dates and ports for embarkation/disembarkation:

Start: Reykjavik (Iceland) date: 19/07/2023

End: Reykjavik (Iceland) date: 12/08/2023

9 - ACCESS TO DATA, SAMPLES AND RESEARCH RESULTS

9.1. Expected dates of submission of preliminary reports which should include the expected dates of submission of the final results:

A preliminary cruise report will be sent to Iceland authorities within one months after the end of the cruise. The final cruise report will be sent within three months after the end of the cruise. Note that the data acquired by the moored instruments will not be available for the research team until summer 2024.

9.2. Proposed means for access by the Iceland scientific and public entities, to data and samples:

The final processed data will be made available through the means mentioned in section 9.3. Preliminary data will be distributed to Iceland scientists and authorities on request.

9.3. Proposed means of making research internationally available:

All FAR-DWO data will be findable, accessible, interoperable and reusable (FAIR), following the principles of the EC-programmes H2020 and Horizon Europe to ensure it is soundly managed. Processed and meta-data will be uploaded in international open-access data repositories. The seawater and suspended particulate data generated during this project will be submitted to the BCO-DMO (http://bco-dmo.org/data/), which serves as a data management office for different oceanographic programs. For down-core sediment data, results will be submitted to (https://www.pangaea.de/). The high-resolution bathymetric data obtained in DS will be uploaded to the Arctic and North Pacific Ocean Regional Center of the SEABED2030 project for the updating of the IBCAO map.

Oral or Poster presentations in international conferences and symposia (e.g. Ocean Sciences, AGU Fall Meeting, EGU General Assembly, Goldschmidt …).

The scientific results of FAR-DWO will be published in specialized, high impact, peer-review scientific journals and specialised books.

ANNEX

List of the scientific team

1. David Amblas (University of Barcelona, Spain)
2. Anna Sanchez-Vidal (University of Barcelona, Spain)
3. Leo Pena (University of Barcelona, Spain)
4. Galderic Lastras (University of Barcelona, Spain)
5. Jaime Frigola (University of Barcelona, Spain)
6. Antoni Calafat (University of Barcelona, Spain)
7. Ricardo Silva-Jacinto (IFREMER, France)
8. Technician (IFREMER, France)
9. Xavier Durrieu de Madron (CEFREM, France)
10. Jacobo Martín (University of Barcelona, Spain)
11. M.Dolores Pérez-Hernández (University Las Palmas de Gran Canaria, Spain)
12. Scientist (MFRI, Iceland)
13. Luisa Freitas (University of Barcelona, Spain)
14. Marc Cerdà (University of Barcelona, Spain)
15. Marta Arjona (University of Barcelona, Spain)
16. Irene Llamas (University of Barcelona, Spain)
17. Stina Wahlgren (Univ. Gothenburg, Sweden)
18. Maria de la Fuente (University of Barcelona, Spain)
19. Scientist TBC (University of Barcelona, Spain)
20. Scientist TBC (University of Barcelona, Spain)
21. Technician (Marine Technology Unit, UTM, CSIC, Spain)
22. Technician (Marine Technology Unit, UTM, CSIC, Spain)
23. Technician (Marine Technology Unit, UTM, CSIC, Spain)
24. Technician (Marine Technology Unit, UTM, CSIC, Spain)
25. Technician (Marine Technology Unit, UTM, CSIC, Spain)
26. Technician (Marine Technology Unit, UTM, CSIC, Spain)