



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

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

Date: 20/01/2025

1 - GENERAL INFORMATION

1.1. Cruise name and/or number:

MIXSED2

1.2. Sponsoring institution:

Funding agency: Deutsche Forschungsgemeinschaft (DFG) & Agencia Estatal de Investigación (AEI).

Funding programme: bilateral Spanish and German call by the MICIU/AEI/10.13039/501100011033 and by the European Union.

Name and reference of the project: Denmark Strait – Mixing and Sediment Dynamics (DS-MIXSED). Projektnummer 541914507 and grants PCI2024-155022-2 and PCI2024-155084-2

Country: Germany and Spain

1.3. Scientist in charge of the project:

Dr. María Dolores Pérez Hernández (University of Las Palmas de Gran Canaria)

Dr. David Amblas (University of Barcelona)

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

There is no plan for a participation from Greenland or Denmark to the cruise, however a member of the Háskóli Islands (University of Iceland) is part of the research team.

1.5. Submitting officer:

Name: Dr. María Dolores Pérez Hernández

Address: Despacho F-103. Departamento de Física Edificio de Ciencias Básicas

Campus de Tafira, Universidad de Las Palmas de Gran Canaria

Phone +34 928 45 4491

2 - DESCRIPTION OF THE PROJECT

2.1. Nature and objectives of the project:

The boundary of the oceans – their bathymetry or topography – sets both the geometry of ocean basins (depth and width), and also guides the shape of the large-scale ocean circulation (gyres and currents). Smaller scale features (i.e., coastline shape, straits, submarine sills, cross-shelf troughs, ridges and

canyons) further steer the ocean circulation and drive mixing. The Denmark Strait (DS) is one of several chokepoints in the large-scale Atlantic circulation, where a narrow (290 km) and shallow sill (650 m) separates the Arctic ($>65^{\circ}\text{N}$) from the wider Atlantic basin, affecting the rate at which dense waters formed in the Arctic can enter the North Atlantic, and influencing how those dense waters are mixed. At the DS, the overflow of dense water is a bottom-intensified current. Here, the bathymetry-flow interaction operates in two directions: (1) with the topography steering the flow or providing drag to induce shear and, subsequently, mixing in the flow, and (2) with the intense flow and its variations in space and time contributing to shaping the seabed. In this project, we propose to assess flow-topography interactions to understand their role in ocean mixing at the submesoscale (1–10 km), and their contribution to transporting sediments and shaping the seabed.

Therefore the cruise MIXSED2 (embedded on the DS-MIXSED project) aims to maintain the long-term mooring observations located in the Denmark Strait (1 German mooring, 1 Icelandic), to recover a high-resolution submesoscale mooring array deployed in May 2026 by the German ship Maria S Merian, south of Denmark Strait, at two locations (one near the sill maintained by the German partners and one nearly 200 km south of the sill maintained by the Spanish partners) and to deploy a year-long low-resolution mooring array at the downstream site. In addition, the cruise plans involve carrying rosette profiles with CTD casts to calibrate the instruments and locate the main flows, water samples for salinity calibration and isotopes as tracers of age and water masses, turbidity measurements, zooplankton measurements and velocity measurements. During the navigation we will simultaneously acquire water column acoustic data, multibeam bathymetry data and very shallow seismic data to study the physical imprint of DSO on the water column, seafloor and sedimentary record.

2.2. Relevant previous or future research cruises:

Upcoming:

- MSM142. Research cruise: Maria S Merian. Nuk, St Johns, Reykjavik 26 March to 11 May 2026. Dr Fehmi Dilmahamod (GEOMAR Helmholtz Centre for Ocean Research Kiel)
- MSM. Research cruise: Maria S Merian. 2027. Dr. Joel Bracamontes Ramirez (University of Hamburg)
- MSM. Research cruise: Maria S Merian. 2028. Dr Eleanor Frajka-Williams (University of Hamburg)

2.3. Previously published research data relating to the project:

In particular written by the project's participants we have the following publications:

Sun, Y., and Coauthors, (2025). Reduced Transport of Overflow Water in the West Greenland Boundary Current System: The Role of Upstream Entrainment. *J. Phys. Oceanogr.*, 55, 2119–2139, <https://doi.org/10.1175/JPO-D-25-0024.1>.

Holliday, N. P., Bacon, S., Cunningham, S. A., Gary, S. F., Karstensen, J., King, B. A., Li, F., & McDonagh, E. L., (2018). Subpolar North Atlantic Overturning and gyre-scale circulation in the summer 2014 and 2016. *Journal of Geophysical Research: Oceans*, 122. <https://doi.org/10.1029/2018JC013>

A.Ruiz-Angulo, E. Portela, C. de Marez, A. Macrander, S.R. Ólafsdóttir, T. Meunier, S. Jónsson, and M.D. Pérez-Hernández. Stratification and Mixed Layer Depth around Iceland, characterization and interannual variability. *Ocean Science*. Under Review : <https://doi.org/10.5194/egusphere-2025-2102>

Sanchez-Vidal, A., Amblas, D., & DS2 Shipboard Party. (2025). Oceanographic Cruise FARDWO-DS2 Report (2024). *Zenodo*. <https://doi.org/10.5281/zenodo.14618610>

Amblas, D., Sanchez-Vidal, A. and FARDWO-DS1 shipboard party (2023). Oceanographic Cruise FARDWO-DS1 Report. *Zenodo*. 78 pp. <https://doi.org/10.5281/zenodo.10581882>.



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

- 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>
- M. Casanova-Masjoan, et al.(2020). Alongstream, seasonal and interannual variability of the North Icelandic Irminger Current and East Icelandic Current around Iceland. *Journal of Geophysical Research-Ocean.* 125, e2020JC016283. doi:10.1029/2020JC016283

Other relevant publications:

- Fu, Y., et al., (2023). Seasonality of the Meridional Overturning Circulation in the Subpolar North Atlantic, *Nature Communications*, doi: 10.1038/s43247-023-00848-9.
- Li, F., Lozier, M.S., Bacon, S. et al. (2021). Subpolar North Atlantic western boundary density anomalies and the Meridional Overturning Circulation. *Nature Communications* 12, 3002. <https://doi.org/10.1038/s41467-021-23350-2>
- Fu, Y., F. Li, J. Karstensen, C. Wang,(2020). A stable Atlantic Meridional Overturning Circulation in a changing North Atlantic Ocean since the 1990s. *Science Advances*, 6, 48, eabc7836, DOI: 10.1126/sciadv.abc7836
- Oltmanns, M., J. Karstensen, K. Moore, S. Josey, (2020). Rapid North Atlantic cooling initiated by surface freshwater, *Geophysical Research Letters*, 10.1029/2020GL08720
- Lozier, M.S., et al. (2019). A Sea Change in Our View of Overturning – First Results from the Overturning in the Subpolar North Atlantic Program, *Science*, 363, 516–521, February 1, doi: 10.1126/science.aau6592
- Schaffer, J., Kanzow, T., Jochumsen, K., Lackschewitz, K., Tippenhauer, S., Zhurbas, V. M., & Quadfasel, D. (2016). Enhanced turbulence driven by mesoscale motions and flow-topography interaction in the Denmark Strait Overflow plume. *Journal of Geophysical Research: Oceans*, 121(10), 7650-7672.
- Jochumsen, K., Moritz, M., Nunes, N., Quadfasel, D., Larsen, K. M., Hansen, B., ... & Jonsson, S. (2017). Revised transport estimates of the Denmark Strait overflow. *Journal of Geophysical Research: Oceans*, 122(4), 3434-3450.

PhD Theses (running):

- Luisa Freitas, thesis from University of Barcelona (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.
- Mara Navarro Buigues, thesis from University of Las Palmas de Gran Canaria (supervisors: Dolores Hernández-Perez, Anna Sanchez Vidal), started in 2023. Deep Water of the Denmark Strait; physical characteristics and interaction with geomorphology. Universidad de las Palmas de Gran Canaria, 2023-2027.
- Helena Fos Serdà, thesis from University of Barcelona (supervisors: David Amblas, Anna Sanchez-Vidal), started in March 2024. Atmospheric and oceanographic conditioning factors involved in the formation of dense waters in the Mediterranean and the North Atlantic, 2024-2027.

3 - METHODS AND MEANS TO BE USED

3.1. Particular of vessel:

Name	RV Odón de Buen
Nationality	Spanish
Owner	CSIC (Consejo Superior de Investigaciones Científicas) / Instituto Español de Oceanografía (IEO-CSIC)
Operator	CSIC / IEO-CSIC
Type of vessel	Oceanographic Research Vessel
Year built and country	2024, Spain (Astilleros Armon, Vigo)
Length / width	84.30 m / 17.80 m
Length p.p.	77.40 m
Design Draught	6.54 m
Scantling Draught	5.2–5.5 m (operational draught)
Depth to main deck	5.60 m
Tonnage (Gross)	4,595 GT
Dead weight (DWT)	~10,700 t
Maximum Speed	14.5 knots
Prop. Power	2 × INDAR 1700 kW electric motors
Fuel	Diesel + LNG dual-fuel generators



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Endurance	40 days (diesel), 10 days (LNG)
Accommodation (crew + research)	58 (20 crew + 38 scientists/technicians)
Classification society	Lloyd's Register, notation: 100A1 Oceanographic & Fishing Research, Ice Class PC7
IMO	9962914
Register port	Vigo, Spain (home port)
Call code	EABT
VSAT	+34911930378
Cellular	+34 610583701
Email	capitan.odb@utm.csic.es
Name of master	Adrian Gerpe Olivera Alejandro Marín Portillo
Number of crew	20
Number of scientists on board	38

3.2. Aircraft or other craft to be used in the project:

Small drone (model DJI Mini 4 Pro) for video documentation



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

3.3. Particulars of methods and scientific instruments:

List of all major marine scientific equipment it is proposed to use.	Fisheries research within fishing limits	Research concerning continental shelf out to State's margin	Waters in which equipment will be deployed		
			between <12 NM	between 12-50 NM	between 50-200 NM

a. vessel mounted systems					
Vessel mounted ADCP (38kHz , & 150 kHz)	NO	YES	NO	YES	YES
Meteorological station data (wind, humidity...)	NO	YES	NO	YES	YES
Multibeam echosounders (EM124 and EM712)	NO	YES	NO	YES	YES
Echosounder EK80	NO	YES	NO	YES	YES
Permanent surface water sampling / analysis (incl. Thermosalinograph)	NO	YES	NO	YES	YES
Multisensor MVP-200	NO	YES	NO	YES	YES
AUTOSAL	NO	YES	NO	YES	YES
b. mobile equipment					
Rosette with: CTD, turbidimeter, water samples, lowered ADCP & UVP-6	NO	YES	NO	YES	YES
WP2	NO	YES	NO	YES	YES
Argo and APEX floats	NO	YES	NO	YES	YES
Multicorer, monocorer, boscoring	NO	YES	NO	YES	YES
Current meter and hydrography/biogeochemistry moorings, for positions see next section	NO	YES	NO	YES	YES
Instrumented mooring lines: - ADCP Teledyne RD Instruments 300 kHz - Sediment trap Technicap PPS3 (3) - Current meter Nortek Aquadopp (3) - Buoys Nautilus (20) - Seabird SBE37 (3)	NO	YES	NO	YES	YES

3.4. Indicates whether harmful substances will be used:



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

No

3.5. Indicate whether drilling will be carried out:

No

3.6. Indicate whether explosives will be used:

No

4 - INSTALLATIONS AND EQUIPMENTS

Details of installations and equipments (dates of laying, servicing, recovery, exact locations and depth):

Equipment to be used from the vessel:

- **CTD rosette** equipped with 24 sampling bottles (12 liters, a SeaBird SBE911 (Conductivity Depth Temperature Oxygen), a **LADCP** (Acoustic Doppler Current Profiler), a Turbidimeter and a UVP-6. This equipment will be used to monitor the physic-chemical characteristics of water masses with depth (blue dots in the chart in section 5.2).
- Geophysical equipment hull mounted on the vessel including multibeam echosounders Kongsberg EM124 and EM712, 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.
- Multicorer, boscorer and monocorer will be used to retrieve seafloor sediments

Equipment to be recovered, after 1 months of deep-sea monitoring:

- 2 mooring lines will be recovered at m water depth in the slope off Greenland (see chart in section 5.2).
 - FD-DS-A: 1370 m water depth (65°14.637'N, 31°19.060'W)
 - FD-DS-B: 1870 m water depth (65°01.610'N, 31°22.209'W)The moorings include ADCP, currentmeters and sediment traps to monitor water column physico-chemical and sediment transport characteristics.
- Recovery of the high-resolution mooring array located south of Denmark strait (see map, red triangular shape)
- We will also anticipate maintenance tasks for a mooring stationed at the Denmark Strait sill, which is operated by the University of Hamburg (Germany).

Equipment to be deployed:

- The 2 moorings named FD-DS will get back in the water and stay for a year sampling the deep flow in low-resolution.
- We will deploy ARGO and APEX floats in key locations to sample eddies shed from the strait. These floats measure temperature, salinity and velocity of the water column.

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 Degrees, Minutes, Seconds) of the bounding box corners:

- (A) 63°44'11"N, 32°28'25"W;
- (B) 65°59'12"N, 34°37'59"W;
- (C) 67°45'56"N, 31°28'10"W;
- (D) 68°17'19"N, 26°40'14"W; and
- (E) 64°50'31"N, 24°12'2"W

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:

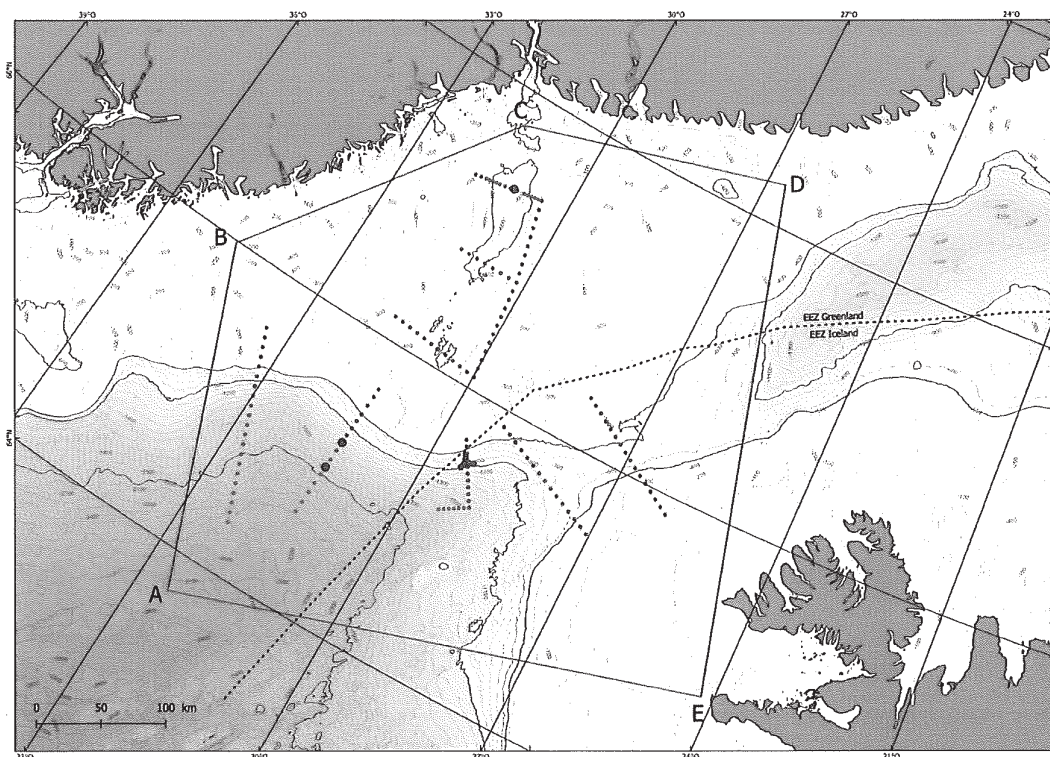


Figure 1: letters A to E indicate the geographical area to survey, black dots the boundary between the Icelandic and Greenlandic EEZ, blue dots CTD stations and red dots moorings.



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

6 - DATES

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

Entry: Iceland EEZ	date :	June 30rd 2026
Entry: Greenland EEZ	date :	July 3rd 2026
Entry: Iceland EEZ	date :	July 5st 2026
Entry: Greenland EEZ	date :	July 9st 2026
Entry: Iceland EEZ	date :	July 19st 2026

We aim to sample the Látrabjarf section first, then the mooring in the Kangerlussuq Trough, then sample downstream of Denmark Strait. However, this plan is weather dependent and we might need to change the sampling order.

6.2 Indicate if multiple entry is expected:

We will enter and leave Iceland's EEZ waters multiple times during the research cruise, as the study area is situated between Danish and Icelandic waters, in the Denmark Strait.

7 - PORTS CALLS

7.1. Dates and names of intended ports of call in Lisbon:

01/07/2026 Reykjavík – 22/07/2026 Reykjavík

7.2. Any special logistical requirements at ports of call:

No

7.3. Name/Address/Telephone of shipping agent (if available):

Not yet designed

8 - PARTICIPATION

8.1. Proposed dates and ports for embarkation/disembarkation:

Start Reykjavik

date : July 1st 2026

End: Reykjavik

date : July 22nd 2026



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

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 month after the end of the cruise. The final cruise report will be sent within six months after the end of the cruise.

9.2. Proposed means for access by the Icelandic/Greenlandic 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 DS-MIXSED 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. The cruise report, and the processed and metadata will be uploaded in international open-access data repositories (e.g. Zenodo). The seawater and suspended particulate data generated during this project will be submitted to the BCO-DMO (<http://bcodmo.org/data/>), which serves as a data management office for different oceanographic programs. 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. Argo data is instantaneously available online through the Argo network (e.g. <https://www.argoespana.es/argo-espana/>). Oral or Poster presentations will take place at international conferences and symposia (e.g. Ocean Sciences, AGU Fall Meeting, EGU General Assembly, Goldschmidt or the ASOF workshop). The scientific results of MIXSED2 will be published in specialized, high impact, peer-review scientific journals and specialised books.



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

ANNEX

List of the scientific team



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

		Institution
1	María Dolores Pérez Hernández	Universidad de Las Palmas de Gran Canaria, Spain
2	David Amblas Novellas	Universitat de Barcelona, Spain
3	Anna Sanchez Vidal	Universitat de Barcelona, Spain
4	Mara Navarro Buigues	Universidad de Las Palmas de Gran Canaria, Spain
5	Alberto González Santana	Instituto Español de Oceanografía, Spain
6	Angel Ruiz Angulo	University of Iceland, Iceland
7	Student	University of Iceland, Iceland
8	Jose María Landeira or a PhD student working with him	Norwegian University of Science and Technology, Norway
9	Nuria Casacuberta or a PhD student working with her	ECTZS, Switzerland /ICM-CSIC, Spain
10	Eleanor Frajka-Williams	University of Hamburg, Germany
11	Joel Bracamontes Ramírez	University of Hamburg, Germany
12	Ilmar Leimann	University of Hamburg, Germany
13	Andreas Welsch	University of Hamburg, Germany
14	Isabelle Schmitz	University of Hamburg, Germany
15	Chiara Monforte	University of Hamburg, Germany
16	Yves Sorge	University of Hamburg, Germany
17	Laura Moscat Martínez	Universitat de Barcelona, Spain
18	Marc Cerdà Domènech	Universitat de Barcelona, Spain
19	Oriol Uviedo Palomas	Universitat de Barcelona, Spain
20	Antonio Calafat Frau	Universitat de Barcelona, Spain
21	Galderic Lastras Membrive	Universitat de Barcelona, Spain
22	Jonathan Mette	Universitat de Barcelona, Spain
23	Helena Fos	Universitat de Barcelona, Spain
23	Scientist TBC	Universitat de Barcelona, Spain
25	Scientist TBC	University of Gothenburg
26	Scientist TBC	University of Stockholm
27	Technician for rosette & CTD	Unidad Tecnologica Marina, CSIC, Spain



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

28	Technician for rosette & CTD	Unidad Tecnologica Marina, CSIC, Spain
29	Technician for rosette & CTD	Unidad Tecnologica Marina, CSIC, Spain
30	Technician for echosounders	Unidad Tecnologica Marina, CSIC, Spain
31	Technician for IT	Unidad Tecnologica Marina, CSIC, Spain
32	Technician for deck operations	Unidad Tecnologica Marina, CSIC, Spain
33	Technician for deck operations	Unidad Tecnologica Marina, CSIC, Spain
34	Technician in training	Unidad Tecnologica Marina, CSIC, Spain
35	Technician in training	Unidad Tecnologica Marina, CSIC, Spain
36	Technician in training	Unidad Tecnologica Marina, CSIC, Spain