Topic	H2020 – INFRAIA-2018-2020
Short Title	EurofleetsPlus
Title	An alliance of European marine research infrastructures to meet the evolving requirements of the research and industrial communities
Project Number	824077
Delivery Date	31.01.2023
Deliverable No	D 6.6
Lead Beneficiary	UGOT
Dissemination Level	Public

Blue Skills Labs

Document information	
Document Name	D6.6 Blue Skills Labs
Document ID	Eurofleets+_D6.6_Blue skills Labs_V1
Revision	Version 1
Revision Date	01/02/2023
Author	Andrea Caburlotto (OGS), Niklas Andersson (UGot), Nicolas Nowald (UB)
Security	Public

Approvals			
	Name	**Organisation**	**Date**
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Activity Coordinator	Niklas Andersson Nicolas Nowald	UGOT UB	31/01/2023
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History			
Revision	**Date**	**Modification**	**Author**
V 1.0	31.01.2023	Final	Andrea Caburlotto

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1 Introduction

Over the last ten years' new technologies have remarkably extended the scope of marine research and now offer exciting novel perspectives for pioneering research. Unmanned underwater vehicles reached a high degree of reliability as they develop towards standard equipment on modern research vessels. However, the technical complexity of the systems and their integrated scientific payload is a challenge for both the operational team and the scientists. This is addressed through proposed dedicated training courses to enable the next generation of marine researchers to fully utilize the possibilities offered by the kind of scientific instrumentation onboard European research vessels. Applications for the Eurofleets+ Blue Skills Labs were evaluated based on the scientific/technical experience of the applicants and coherency between their studies and topics. The participation of people from less equipped countries and to women scientists was encouraged throughout.

Applicant assessments were carried out by a team that included course organisers and the coordinator of the Eurofleets+ "Education and Training" work package for each course. The evaluation was based on the following criteria:

- Quality of the application
- Curriculum of applicants
- Recommendation letter
- Relevance - Research interest matches with cruise objectives

The following Blue Skills Labs were foreseen to achieve these goals:

- 2 AUV Labs at UGOT
- 2 ROV Labs at University of Bremen (c/o MARUM)
- 2 Seismic Labs at OGS

At the end of all the courses a certificate of completion has been delivered to all participants.

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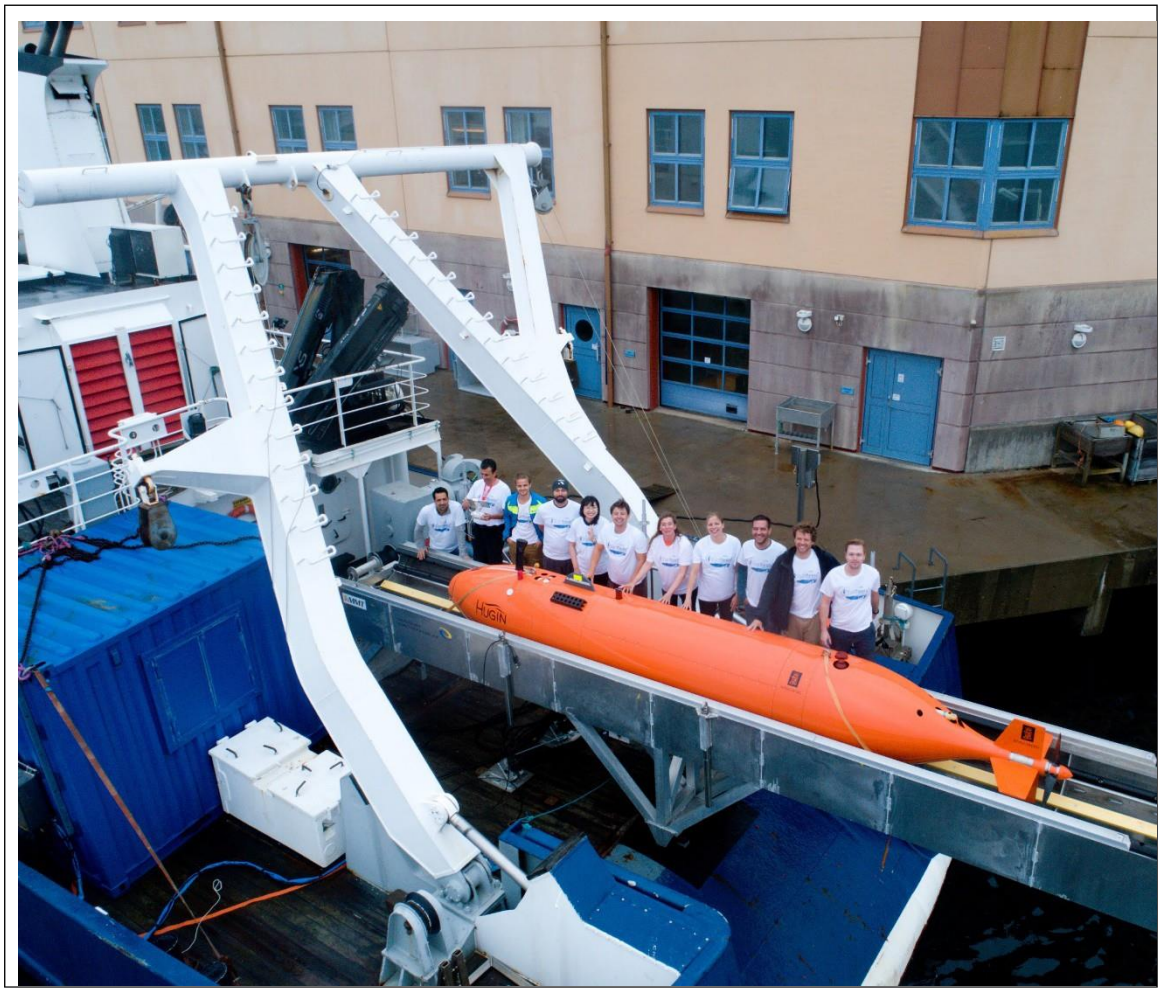
2 AUV Blue Skills Labs

Two workshops were delivered on AUV and Sea-Glider operations at the Robotics Lab workshop of Gothenburg University (UGOT) in collaboration with the Swedish Marine Robotics Centre (SMaRC) including participation of industry (Marine Mätteknik, MMT). Course elements included technical preparation of Autonomous Underwater Vehicles, mission planning preparation, integration of scientific payload, data acquisition and post-processing of various types of sensors with emphasize on hydroacoustic sensors (multibeam, sediment profiling, ADCP). Theoretical course elements were practically applied on a boat trip in the Baltic Sea.

2.1 1st AUV Blue Skills Lab at University of Gothenburg, Sweden – August 2019



Participants at the 1st AUV course in front of the UGOT field station on Kristineberg

The first Worksop took place from the 18 to 23rd[th] of August 2019 at the Robotics Lab workshop of Gothenburg University (UGOT) in collaboration with the Swedish Marine Robotics Centre (SMaRC) including participation of industry (Marine Mätteknik, MMT) and focus on AUV operations.

It was offered to European PhD and post-graduate students (students of all nationalities enrolled at European universities). The call and application form were published on the Eurofleets+ website in June 2019, and remained open until July 8[th]. The course received 11 applications, from which 10 candidates of 7 nationalities were selected.

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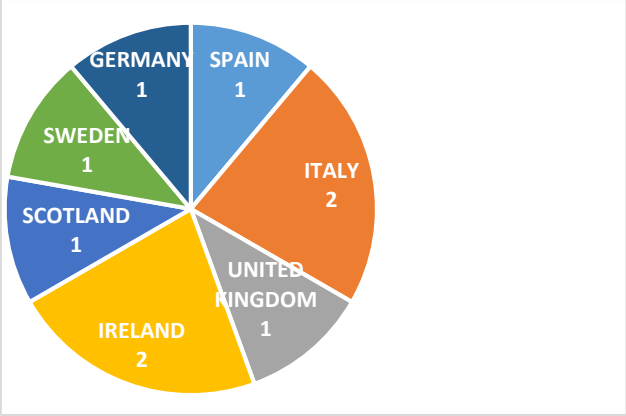

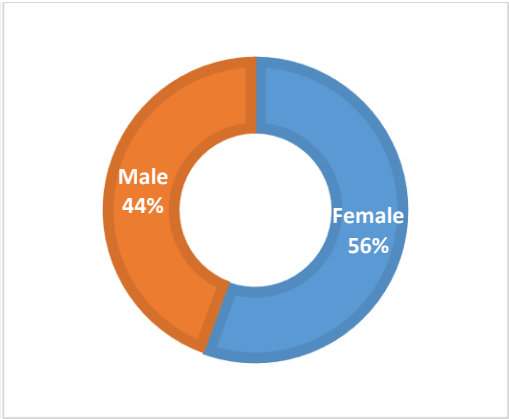

The aim of the course was to teach young scientists how to use one of the larger AUV systems available, a Kongsberg 'Hugin' AUV. Course elements included technical preparation of Autonomous Underwater Vehicles, mission planning preparation, integration of scientific payload, data acquisition and post-processing of various types of sensors with emphasis on hydroacoustic sensors (multibeam, sediment profiling, ADCP). Theoretical course elements were applied practically in a one-day boat trip in the Baltic Sea. All applicants were successful in securing a space on the course which was delivered over six days.

Infrastructure used/shown during the workshop:

The AUV at The University of Gothenburg – called Ran – has good navigation accuracy and carries high resolution acoustic sonars and other mapping instruments. There are only a few AUVs in the world with Ran's capacity, accessible to science. Thanks to the navigational properties, it can accomplish under-ice missions, and it has been used successfully in Antarctica and under ice in Baltic sea coastal waters. Ran is a part of the national research infrastructure MUST (Mobile Underwater System Tools), financed bythe Knut and Alice Wallenberg Foundation. The infrastructure is open for external users for research purposes. Ran can also, under certain circumstances, be rented by commercial companies.

See **Annex 1** for the Eurofleets+ 1st AUV Blue Skills Lab report.

2.2 2nd AUV Blue Skills Lab at University of Gothenburg (UGot), Sweden - November 2022

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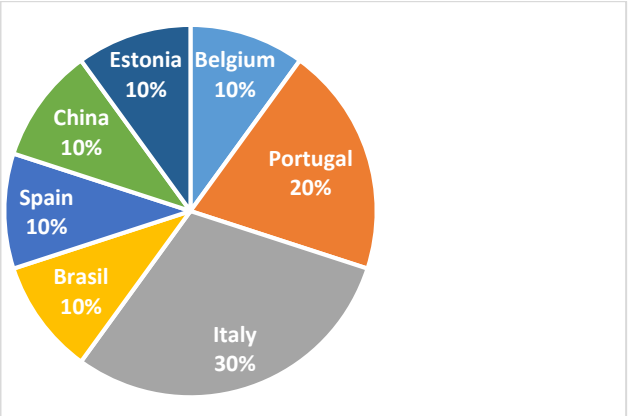
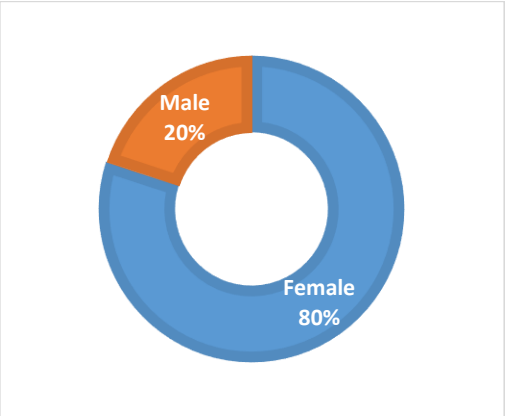
Participants at the 2nd AUV course in front of the UGOT field station.

The AUV workshops / training on AUV operation, organized within the Eurofleets+ training program, was held at the Robotics Lab workshop of Gothenburg University (UGOT) at the field station Kristineberg, from 31st October to 4th November 2022.

It was offered to European PhD and post-graduate students (students of all nationalities enrolled at European universities). The call and application form were published on the Eurofleets+ website on September 2nd, and was open until September 22nd. 11 applications were received of which 10 were accepted and one was put on a reserve list. One of the accepted applicants cancelled and the one from the reserve list was accepted and participated in the course. The 10 students are residents in 7 different European countries and are 8 different nationalities. Of the 10 students 8 were female and 2 male.





This AUV workshops / training on AUV operation was held at the Robotics Lab workshop of Gothenburg University (UGOT) at the field station Kristineberg.

Course elements included technical preparation of Autonomous Underwater Vehicles, mission planning preparation, integration of scientific payload, data acquisition and post-processing of various types of sensors with emphasize on hydroacoustic sensors (multibeam, sediment profiling, ADCP). Theoretical course elements were applied practically on board the RV Skagerak.

Infrastructure used/shown during the workshop:

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The AUV at The University of Gothenburg – called Ran – has good navigation accuracy and carries high resolution acoustic sonars and other mapping instruments. There are only a few AUVs in the world with Ran's capacity, accessible to science. Thanks to the navigational properties, it can accomplish under-ice missions, and it has been used successfully in Antarctica and under ice in Baltic sea coastal waters. Ran is a part of the national research infrastructure MUST (Mobile Underwater System Tools), financed by the Knut and Alice Wallenberg Foundation. The infrastructure is open for external users for research purposes. Ran can also, under certain circumstances, be rented by commercial companies.

See **Annex 2** for the Eurofleets+ 2nd AUV Blue Skills Lab report.

3 ROV Blue Skills Labs

Two onshore training courses were held at MARUM, focusing on the specific requirements of scientific ROV deployment at sea. Topics included cruise preparation, mobilisation and operation at sea. Workshops as well as exercises on various manipulators and training missions in a ROV simulator and in test tank with ROV MARUM -Squid (a powerful, lightweight work-class ROV for operations in water depths of up to 2000 metres) were conducted.

3.1 1st ROV Blue Skills Lab at MARUM, Germany – November 2019

The ROV workshops / training, organized within the Eurofleets+ training program, was held at MARUM-University of Bremen, from 19th to 21st November 2019.

Participants of the ROV Lab from left to right: J. White, N. Georgiou, N. Mauromatis, C. Katlein, S. Schillai, L. Manousakis, N. Nowald, V. Ratmeyer and E. Kallergis. Not in the image: H. Preuß, C. Seiter

It was offered to European PhD and post-graduate students (students of all nationalities enrolled at European universities). The call and application form were published on the Eurofleets+ website on August 8th, and remained open until October 7th 2019. Seven participants from three European Institutions (Greece, Sweden, Germany) successfully applied. The course was designed for eight. Most participants had a technical background and were familiar with ROV operations for several years.

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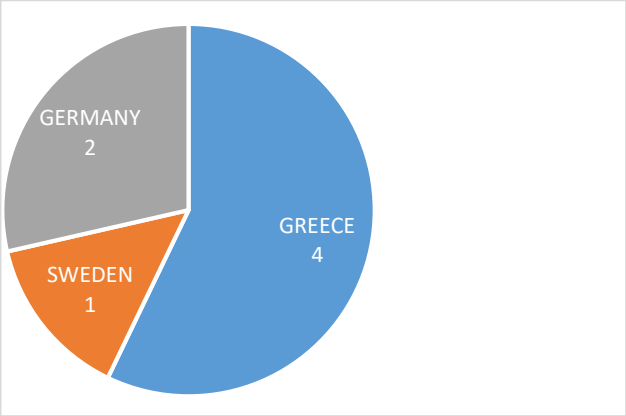
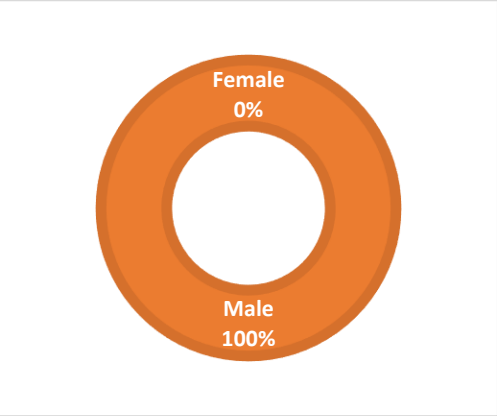
Others were just starting into the ROV business hence, expertise in ROV operations ranged from little to very experienced. Eleven applications were received all together out of which seven were selected and considered as "suitable". Five more applicants missed the deadline or could not join due to temporal reasons. Mrs. Schillai from MARUM joined the course outside Eurofleets+ to fill the 8th place but thus, received no Eurofleets+ certificate of completion. In terms of gender, seven males and one female participed.





Scientific ROV Teams not only need a solid technological background and detailed understanding of their system, but also need to handle the special requirements of scientific ROV operations and requests of the scientific community. Scientific ROV operations differ decisively from those in the oil and gas industry in terms of cruise/dive planning, payload integration, post dive procedures to name but a few. The Eurofleets+ ROV Lab was aimed at the specific demands of scientific ROV diving in several Class-Workshops and hands on practice which are usually not covered by offshore ROV training courses. The course was offered to ROV Pilots/Technicians with no or basic experience of ROV operations and divided into three Class-Workshops and practical training.

The aim of the Class-Workshops was to give an comprehensive overview of what needs to be considered in the run-up of the cruise (e.g. working area, payload integration, etc.), during mobilization (adaptation, power conditioning, etc.) and operation at sea (deployment procedures, Vessel - ROV coordination, etc.).

The aim of the practical exercises was to train the participants on basic flying and navigating a ROV, to handle a manipulator and to take samples, Pilot to Co-Pilot coordination and to pre-dive check a

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system prior to diving. Unfortunately, the planned training dive with ROV-Squid could not be carried out, due to a failure in the slipring of the ROV winch.

Infrastructure used/shown during the workshop:

- Orion 7P manipulator training stand
  The training stand consists of a hydraulic power unit, two Pan & Tilt units with color zoom cameras, the Orion 7P, fully proportional, hydraulic manipulator and the corresponding master arm to operate the unit. The training stand requires two pilots. One is operating the arm, while the other is moving the cameras so that the arm operator can fully focus on the sampling and has good visuals on the arm and objects to be sampled.
- ROV Marum-Quest (4000 m)
  Quest was presented as an example for a work-class ROV, designed for heavy deep-sea research. The system was also used to troubleshoot a ground leak of a 24V device.
- ROV Marum-Squid (2000 m)
  The 2000 m light work-class ROV Squid was also presented as an example for a smaller ROV system. In addition, the entire group performed a pre-dive check on the vehicle. As already stated, the planned training dive in the test-tank could, unfortunately, not be carried out.
- Quest-SIM, ROV training simulator
  The training simulator is a 1:1 copy of the MARUM-Quest control van in which scientific dives can be carried out in a virtual environment. It consists of the simulation running on a dedicated computer with projection screens for cameras, additional monitors and computers for navigation and sonar, a master arm controller for the virtual Orion 7P and input devices to fly the ROV. Several scenarios can be loaded into the simulation, like a Black Smoker vent field. Apart from navigating and flying the ROV, objects can be manipulated to train e.g. scientific sampling.

See **Annex 3** for the Eurofleets+ 1st ROV Blue Skills Lab report.

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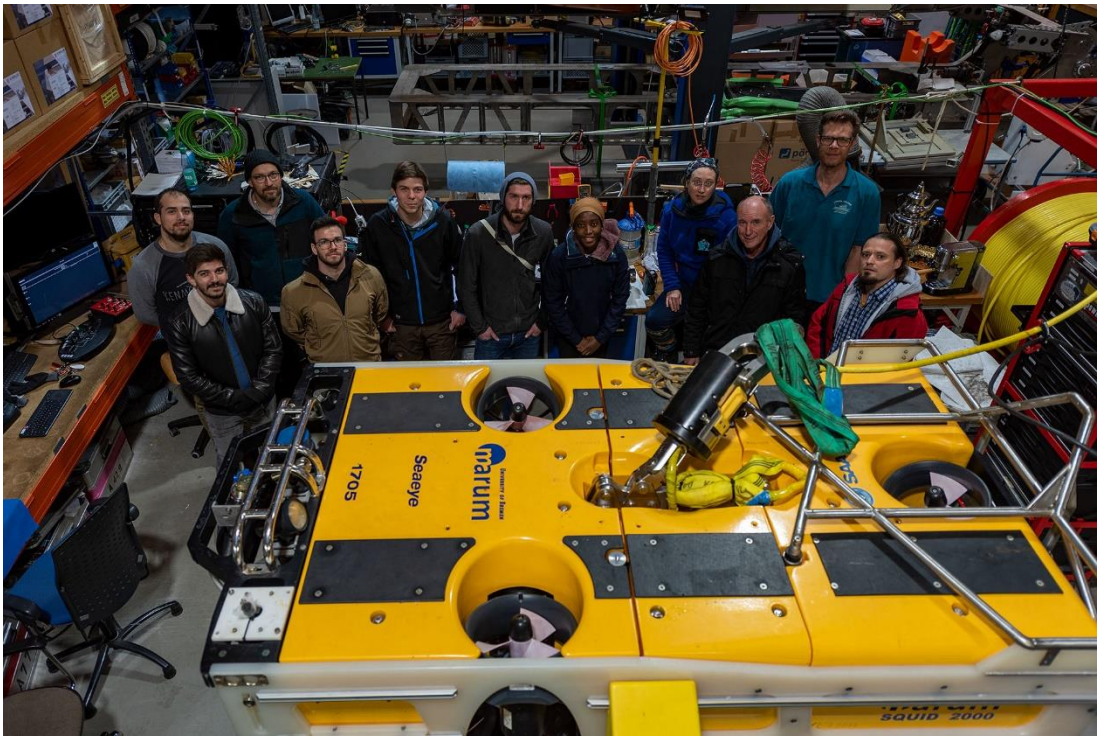
3.2 2nd ROV Blue Skills Lab at MARUM, Germany – November 2022



Participants/Instructors of the ROV Lab from left to right: V. Vittori, S. Dimech, T. Leymann, A. Menegatos, C. Engler, T. Fleischmann, N. Sililo, S. Schillai, A. Peirano, N. Nowald and I. Kuprijanov

The 2nd ROV workshops / training, organized within the Eurofleets+ training program, was held at MARUM-University of Bremen, from 22nd to 24th November 2022. It was offered to European PhD and post-graduate students (of all nationalities enrolled at European universities). The call and application form have been published on the Eurofleets+ website on September 23rd , and was open until October 28th 2022.

Fourteen applications were received from which six were selected and considered as "suitable". The chosen participants were from Greece, Malta, Italy, Estonia and Nigeria. However, the participant from Nigeria cancelled its participation on short notice because it was not possible to issue a Visa in time. As the course was designed for eight, two technicians from Marum joined the course (total of 7 participants, 5 via EF+, 2 from MARUM). Most applicants had no experience in piloting an ROV or experience with ROVs in general. This led to a rejection of many applications, because they did not belong to the target group of this course. In terms of gender four males and one female participants took part (EF+ applicants only).

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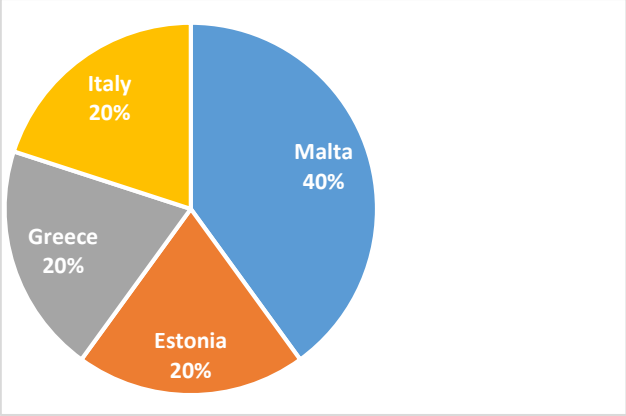
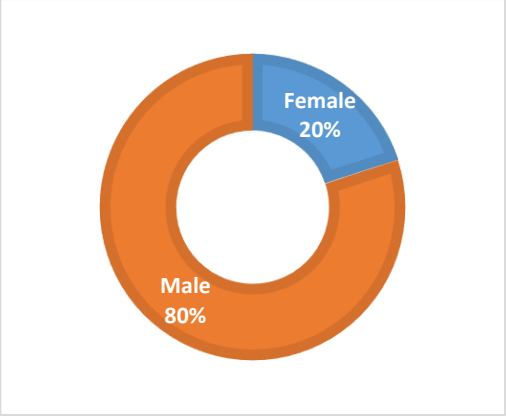
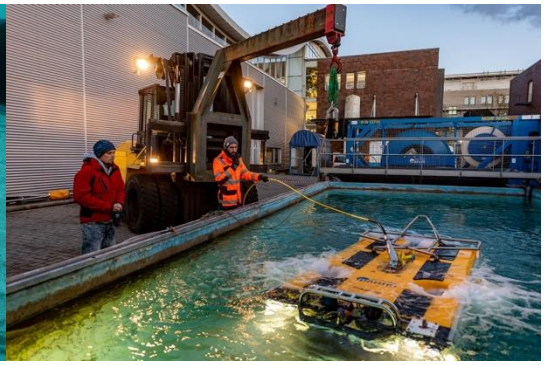




The aim was to show and share knowledge of how MARUM operate ROVs, prepare cruises and everything related to it. The Class-Workshops took place with all participants in a MARUM seminar room. Class-Workshops gave a comprehensive overview of the considerations in the run-up to a cruise (e.g. working area, payload integration, etc.), during mobilization (adaptation, power conditioning, etc.) and operation at sea (deployment procedures, Vessel - ROV coordination, etc.)

Two groups were created (Group 1 & Group 2) for practical training lessons as well as for the class workshops. For technical reasons, the first part of Class I - Operation at Sea: Dive preparation took place for all participants on Day 1. The aim of the practical exercises was to train the participants on basic flying and navigating a an ROV, to handle a manipulator and to take samples, Pilot to Co-Pilot coordination and to pre-dive check a system prior to diving. Compared to the first ROV Lab in 2019, we changed the agenda to have one QUEST-SIM training session and one ROV-Squid dive for each of the two groups (see Course Agenda). Previously, there was only one QUEST-SIM session and one MARUM-Squid dive in the test tank for all groups together. The new setup would ensure to have more time for each participant during these two units.



<u>Infrastructure used/shown during the workshop:</u>

- Orion 7P manipulator training stand
  The training stand consists of a hydraulic power unit, two Pan & Tilt units with color zoom cameras, the Orion 7P, fully proportional, hydraulic manipulator and the corresponding master arm to operate the unit. The training stand requires two pilots. One is operating the arm, while the other is moving the cameras so that the arm operator can fully focus on the sampling and has good visuals on the arm and objects to be sampled.
- ROV MARUM-Quest (4000 m)

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ROV Quest was presented as an example for a work-class ROV, designed for heavy deep-sea research. The introduction to the system was also meant as a preparation for the QUEST-SIM.

- ROV Marum-Squid (2000 m)

  The 2000 m light work-class ROV Squid was also presented as an example for a small work-class ROV system. The introduction to the system was also meant as a preparation for the training dive with ROV-Squid in the testtank.

- QUEST-SIM, ROV training simulator

  The training simulator is a 1:1 copy of the MARUM-Quest control van in which scientific dives can be carried out in a virtual environment. It consists of the simulation running on a dedicated computer with projection screens for cameras, additional monitors and computers for navigation and sonar, a masterarm controller for the virtual Orion 7P and input devices to fly the ROV. Two scenarios can be loaded into the simulation: a Black Smoker vent field and an area with bacterial mats. Apart from navigating and flying the ROV, objects can be manipulated to train e.g. scientific sampling.

See **Annex 4** for the Eurofleets+ 2nd ROV Blue Skills Lab report.

4 Seismic Blue Skills Labs

Two 3-day workshops were organized in the Seislab at OGS about scientific and technological aspects of seismic data acquisition, processing and interpretation.

The two seismic workshops were originally planned for 2020 and 2022 respectively. Unfortunately, due to the Covid 19 pandemic, the first seismic workshop could not take place in 2020 or even 2021. Consequently, there should have been two courses in 2022 (the last year of the project), but there was insufficient time to implement both. Therefore, a solution was proposed to the Eurofleets Project Management Board to run two different courses, focused on seismic: a seismic lab and a seismic borehole lab, which were run consecutively in the same week and thus offered applications the possibility to participate in both courses. Three of the selected participants took part in both courses.

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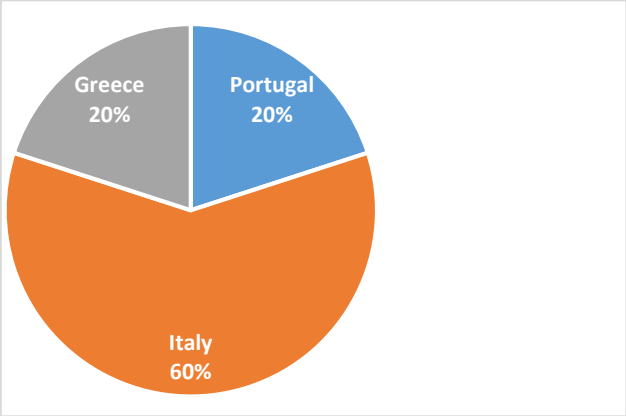
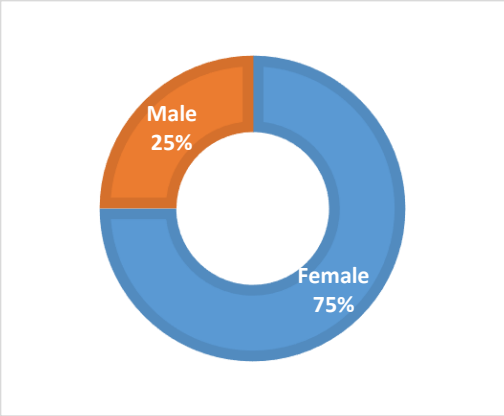
4.1 Seismic Blue Skills Lab at OGS, Italy – October 2022

Participants of the Eurofleets+ Seismic Lab

The Seismic Lab workshop, organized within the Eurofleets+ training program, was held at OGS, National Institute of Oceanography and applied Geophysics, from 10th to 12th October 2022. It was offered to European PhD and post-graduate students (of all nationalities enrolled at European universities). The call and application form have been published on the Eurofleets+ website on August 8th, and was open until September 15th 2022.

Five applications were received in total and all were selected and considered as "suitable". The chosen participants were from Greece, Italy, Morocco and Portugal. However, the participant from Morocco cancelled its participation on short notice for personal reasons.





This course was aimed at early career marine researchers with no or only basic experience and knowledge of multichannel seismic data acquisition and processing and who use and/or will use

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geophysical data in their research projects. The aim was to introduce seismic data acquisition and processing, and to familiarise participants with procedures to better understand and "read" geophysical data. The classroom activities were based on the presentation and explanation of the theory of seismic waves properties and the processing of raw data; in addition, the participants attended two lectures on Tomography and numerical modelling of seismic data, which gave them an overview of the potential and advantages of these tools.

On the second day, participants went on board the OGS R/V Laura Bassi, where a geophysical technician showed and explained the ship's multi-channel seismic data acquisition system and procedures.

The practical sessions took place with all the participants in the OGS SeisLab room. Here, participants were trained in the use of Seismic Unix for processing seismic data and carried out exercises on a seismic profile. The participants also learned and practised how to process seismic data in a virtual research environment.

Infrastructures used during the EF+ Seismic Lab:

- **On board R/V Laura Bassi** - Seismic data acquisition on board: Air Compressors, GI Gun, Streamer and SERCELL acquisition software.
- **SeisLab** - is a hardware/software infrastructure that provides an environment for the integration of software and geophysical data. Based on the concept of hardware virtualisation, Seislab supports the user in carrying out part or all of the processing and analysis phases foreseen in the workflow. The seismic numerical modelling codes are already implemented in Seislab and are available to users. Rock physics codes for calculating the seismic and electromagnetic properties of partially saturated media and theoretical AVO curves are also available in OGS.
- **Seismic Unix** – an open source seismic utilities package that provides instant seismic research and processing environment (running on Unix or Unix like operating system), dedicated to education, and permit the processing of 2D seismic.
- OGS **COLLA** (Collaborative Toolkit for Scientific Project development) – Is a Virtual Research Environment aiming to support and foster collaborative activities among member of a working group, by concentrate server side all information needed to be available. It allows to host on the same web portal many projects. Data remain isolated from project to project on a user account based policy.

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See **Annex 5** for the Eurofleets+ 2nd ROV Blue Skills Lab report.

4.2 Borehole Seismic Blue Skills Lab at OGS, Italy – October 2022

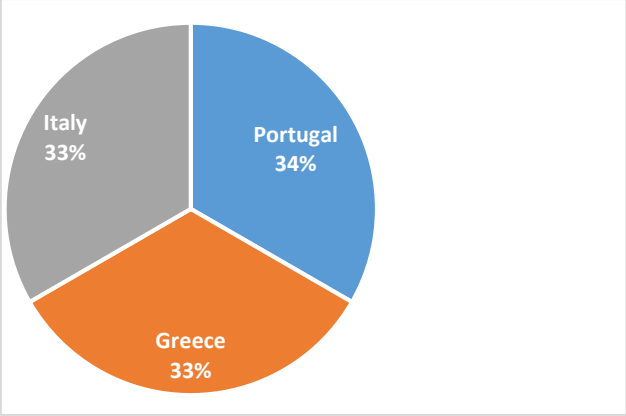
The Borehole Seismic Lab workshop is organized as part of the EurofleetsPlus training program and will be held at OGS, National Institute of Oceanography and applied Geophysics in Trieste (Italy). The three days' workshop (October 12-14, 2022) is offered to Marine sciences related researchers with no or only basic experience and knowledge of Borehole Seismic data acquisition and processing.

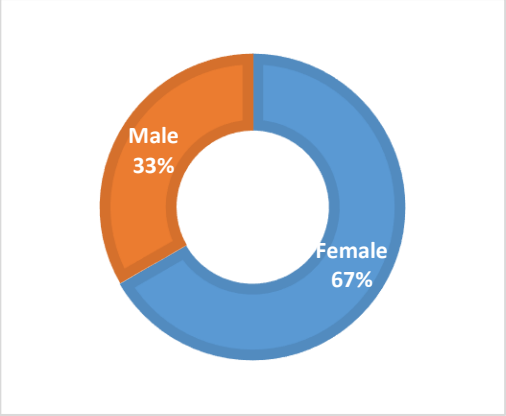
Participants of the Eurofleets+ Seismic Lab

The workshop is closely related to ECCSEL-ERIC (European Research Infrastructure for CO_2 Capture, Utilisation, Transport and Storage (CCUS))and to the ECCSELERATE project (an EU-funded Horizon 2020 project aimed at increasing the use and ensuring the long-term sustainable operation of the ECCSEL ERIC RI), as the test site PITOP, where on-field activities will take place, is part of ECCSEL.

The call and application form were published on the Eurofleets+ website on August 8th, and remained open until 15 September 2022. Four applications were received and all were selected and considered as "suitable". The chosen participants were from Greece, Italy, Morocco and Portugal. However, the participant from Morocco cancelled its participation on short notice for personal reasons.

This project has received funding from the EU H2020 research and innovation programme under Grant Agreement No 824077





This course was aimed at early career marine researchers with any or only basic experience and knowledge of borehole seismic data acquisition and processing and who use and/or will use geophysical data in their research projects. Our aim was to introduce them to the procedures of borehole data acquisition and processing, and to introduce them in the application of this methods. The classroom activities were based on the presentation and explanation of the principle of well logging and the different type of logging.

The aim of class lectures was to give a comprehensive overview of the principles of obtaining seismic borehole data, the standard procedures for processing the data, and the use and application of borehole logging.

On the second day, the participants were in the PITOP Geophysics test site, where OGS technicians conducted a vertical seismic profile (VSP) survey at Piana di Toppo (PITOP) to showcase the latest advances and techniques in borehole geophysics.

Infrastructures used during the EF+ Borehole Seismic Lab:

- **Well Geophysics facility PITOP** - The test site covers an area of approximately 22,000 m^2 and was designed and developed by OGS with the aim of providing a facility for the study and testing of innovative geophysical methods, technologies, and well / surface tools under realistic conditions, due to the presence of 4 wells between 150 and 420 m deep, instrumented with accelerometers, geophones and optical fibers (DAS). Furthermore, there are two sensor lines (geophones and DAS), buried about 50 cm deep. The facility has permanent laboratories equipped with instrumentation for recording and processing data in real-time. The site is a resource for seismic and seismological studies, and acoustic well

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methodologies for the national and international scientific community. The site is part of the ECCSEL - ERIC consortium, which includes the main centers of excellence on CO_2 separation, transport and confinement (CCS) from 9 European countries and represents a unique scientific test site in Italy.

See **Annex 6** for the Eurofleets+ 2nd ROV Blue Skills Lab report.

5 Concluding Remarks

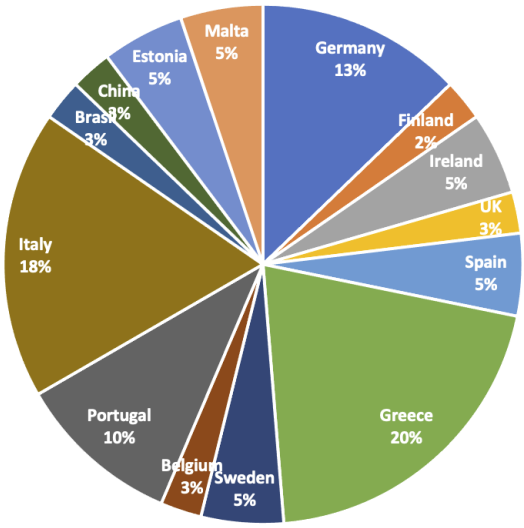
Even though new and sophisticated technologies and instruments are increasingly found on board European research vessels, their technical complexity is a challenge for both the operational team and the scientists.

There are no courses for marine technicians in mainstream training programmes. Therefore, skills can only be acquired on-the-job, during cruises and in shore-based workshops, and to some extent by attending courses offered by equipment manufacturers. The increasingly complex IT systems on board research vessels are also part of the equipment that needs to be looked after by marine technicians.

The Blue Skills Labs, by their nature and purpose, represented an innovation in international training and filled a gap in knowledge of advanced marine science instrumentation.

The Blue Skills Labs were open to marine scientists to give them the opportunity to fully exploit the possibilities offered by this type of scientific instrumentation on board research vessels.

However, applications for these courses came from a very diverse range of people in across marine science domains: from postgraduates to scientists and technicians in the early stages of their careers (junior and senior managers). This is a pleasing result for the Blue Skills Labs, showing that there is a high level of interest in these topics from a variety of marine science staff.



Across all Blue Skills Labs, 57 applications were received for the 41 positions, which shows the demand for hands on training. Participants came from 14 different countries, with a significant number of women (46%).

The Blue Skills Labs were very well received by the participants. The feedback was very positive, and suggested that more course should be provided in the future.

This project has received funding from the EU H2020 research and innovation programme under Grant Agreement No 824077

6 Annexes

This project has received funding from the EU
H2020 research and innovation programme
under Grant Agreement No 824077

Annex 1: 1st AUV Blue Skills Lab

This project has received funding from the EU
H2020 research and innovation programme
under Grant Agreement No 824077

EUROFLEETS+ Blue Skills Labs

"AUV courseLab"

at UGOT - University of Gothenburg

Gothenburg, 18th - 23rd of August 2019

Scientific Participants

Anna Wåhlin (UGOT, instructor)

Johan Rolandsson (UGOT/MMT, intstructor)

Gunnar Svensson (UGOT/MMT, instructor)

Niklas Andersson (UGOT, administrator)

Matthias Obst (UGOT, instructor)

Yixi Zheng

Silas Dean

Gioannis Morfis

Raisa Turja

Mathias Roltz

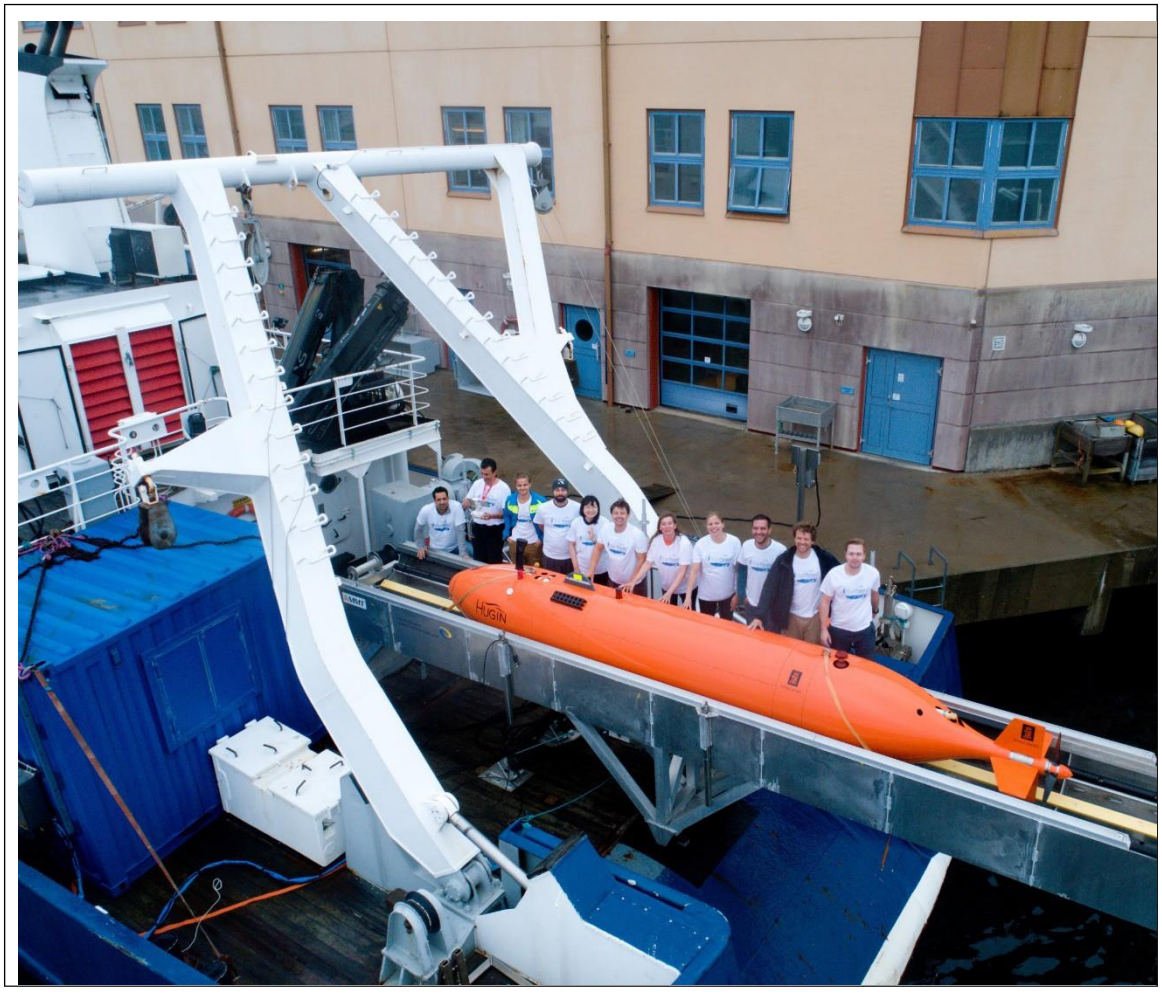
Sebastian Ritz

Jose-Maria Cordero Ros

Niklas Conen

This projecthasreceivedfundingfr omthe EU H2020

Course objectives



Participants of the AUV course in front of the UGOT field station on Kristineberg

Autonomous underwater vehicles (AUVs) have been observing the ocean independently for more than 30 years. The potential of using AUVs in oceans with rough sea condition and extreme weather has been well shown in the last decades. The aim of this course was to teach young scientists in the use of one of the larger AUV systems available, a Kongsberg 'Hugin' AUV. The detailed course schedule can be found in Appendix 1, and two selected course reports are found in Appendix 2 and Appendix 3. Scientists participating in this workshop will learn to:

- Learning (-by-doing) the logistical challenges and advantages with AUVs as research tools
- Acoustic methods for biotope classification and GIS charting
- Limitations and opportunities of AUVs as platforms
- Importance of the AUV sensor suite

This projecthasreceivedfundingfr omthe EU H2020

1) Introduction day (Aug 19th)

The participants met in the Big Lecture Hall at Kristineberg field station. They were divided into two groups and everyone made sure the software (HuginOS) and necessary maps were installed on their laptops. Those that needed to borrow laptops or other equipment were given that. The goal of the first day was to get acquainted with the mission planning software and agree on small number of missions that the group wanted to perform. At the end of the day everyone assembpled and the missions were brought up on the big screen and quality-controlled with respect to risk factors, payload requirements etc. The evening assignment was that the two groups merge their missions into four joint missions that would be performed over the coming days.

2) First field day (Aug 20th)

Participants met in the morning on RV Skagerrak, after which we wnet over to Lysekil to load the AUV. A lecture on acousitc methods for identifying biotopes was given by Matthias Obst, and one lecture on Basics of multibeam and sidescan processing was given by José Maria Cordero Ros. Due to difficulties with loading of the AUV, the first mission was postponed until Wednesday morning. Workshop participants worked on a common guide to post processing of the course data (Appendix 4).

3) Second field day, first AUV mission (Aug 21st)

AUV launched for its first mission. Workshop 'huddles' and completes post processing guide (Appendix 4). Revision of mission plans for second mission and download of data from first mission. Participants participated in launch, guard keeping over emergency messages, and recovery.

4) Third field day, second AUV missions (Aug 22nd)

AUV launched for its second mission. Workshop participants wrking on data post processing from first mission and report writing. After recovery, data from second mission Revision of mission plans for second mission and download of data from first mission. Participants participated in launch, guard keeping over emergency messages, and recovery. Arrival at port late at night.

5) Last day, post processing and data analyses

Participants working on report: describing a question, method, limitation or advantage of using AUV, optimal frequency for your application, or similar. Wrapping up on post processing document.
Post processing:

Infrastructure used/shown during the workshop:

The AUV at The University of Gothenburg – called Ran – has good navigation accuracy and carries high resolution acoustic sonars and other mapping instruments. There are only a few AUVs in the world with Ran's capacity, accessible to science. Thanks to the navigational properties, it can accomplish under-ice missions, and it has been used successfully in Antarctica and under ice in Baltic sea coastal waters.

Ran is a part of the national research infrastructure MUST (Mobile Underwater System Tools), financed by the Knut and Alice Wallenberg Foundation. The infrastructure is open for external users for research purposes. Ran can also, under certain circumstances, be rented by commercial companies.

This projecthasreceivedfundingfr omthe EU H2020

Basic data:

Model: Hugin (Kongsberg)

Length: 7.5 metres

Weight: 1850 kg (dry)

Speed: 1-7 knots, cruise speed 4 knots

Maximum dive depth: 3000 metres

Maximum dive length and time: 300 km and 36 h

Sensor suite:

multibeam echo sounder, Multibeam Kongsberg EM2040, 200-400 kHz, 0.7° x 0.7° beam width, swath coverage sector up to 140°

conductivity, temperature and depth sensor (CTD), dual systems SeaBird 911 19plusv2

oxygen sensor, SeaBird SBE43 (dual system)

carbon dioxide sensor, Contros HydroC

nitrate sensor, SeaBird Deep SUNA

chlorophyll/turbidity sensor, SeaBird WetLabs ECOtriplet (FLBBCD)

side scan sonar (= acoustic ”camera”), EdgeTech 2205. Frequencies 75/410 kHz (1-6 km range)

bottom-penetrating sonar (= acoustic ”X-ray camera”), EdgeTech DW216 with configurable chirp

navigation system: DVL-supported Honeywell Hg9900, gives accuracy of better than 0.08% of distance travelled

acoustic communication below surface, 2-3 km between ship and AUV

satellite, radio and WiFi communication in surface mode

Concluding remarks

We believe that the course was a success. Feedback was very positive and we are confident, that the next course will be a success as well. Many people have already shown their interest of joining the upcoming AUV workshop this summer. We will keep the general structure and content of the course, because we believe that it is good that way

This projecthasreceivedfundingfr omthe EU H2020

Eurofleets AUV workshop / curse, detailed plan

Group A:
Yixi Zheng
Silas Dean
Gioannis Morfis
Raisa Turja

Group B:
Mathias Roltz
Sebastian Ritz
Jose-Maria Cordero Ros
Niklas Conen

During field work, each group takes turn being 'on shift'. Two persons from each group are outside, two persons inside (then you rotate).

Monday:
Meet in large lecture hall at 10.00 - everyone should have HuginOS installed on a laptop and tested
Each group produces one or several mission plans for Koster Fjord. Save them as .mp files. Monday afternoon (starting at 15.00) we will bring the mission plans up on the screen and have a look together. Then we will discuss how to merge these plans into one or two. Monday night groups work to merge the plans, and the goal is to launch Tuesday morning / lunchtime near the mission area. The missions should be planned so that we minimize the number of launch and recovery operations, but still allow resting time for the crew and technical staff. For example one launch in the morning and recovery early night, or if we need two missions in one day perhaps aim at launch early morning, recover at lunch, launch after lunch and the recovery in time to get a good nights sleep.

Tuesday: On RV Skagerrak. Meet in mess at 9.00
Missions and some lectures. Matthias Obst: Acousitc methods for identifying biotopes
José Maria: Basic of multibeam and sidescan processing
Planning wednesday missions

Downloading data and starting with the post-processing
Google doc for post processing:
https://docs.google.com/document/d/1nHQVdNetEJ8HMSiGWhOyHfPbSxn99W-RVRszcdPgZtg/edit?usp=sharing
Everyone fills in their tips and tricks for post processing

Wednesday: On RV Skagerrak. Meet in mess at 9.00
Missions and some lectures. Matthias Obst: Acousitc methods for identifying biotopes
Student 'huddles': Post processing - fill in Google docs (https://docs.google.com/document/d/1nHQVdNetEJ8HMSiGWhOyHfPbSxn99W-RVRszcdPgZtg/edit?usp=sharing)
Planning thursday missions
Downloading data and starting with the post-processing

Thursday: On RV Skagerrak. Meet in mess at 9.00. Returning to Kristineberg at night
Missions and post processing
Downloading data and working with the post-processing

Friday:
9.00 : Summary discussion on post processing. Meet in mess at 9.00
Wrapping up: Make sure you have all the data you need and have done all the post processing steps you need. Start writing your report. Diploma.
Report: 2-5 pages describing a question, method, limitation or advantage of using AUV, optimal frequency for your application, or similar. One take-away message from the week. Reports are due Aug 30th but if possible try to finish them on the flight back - they should not be extensive (but comprehensive)

Post processing:
Google docs where you can share tips and tricks (and let each other know who has what software):
https://docs.google.com/document/d/1nHQVdNetEJ8HMSiGWhOyHfPbSxn99W-RVRszcdPgZtg/edit

Comparison between Measurements from Ship-based and Hugin-based Sensors for Temperature and Salinity

Yixi Zheng[1] and Anna Wåhlin[2]

1. *Centre for Ocean and Atmospheric Sciences, School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom*
2. *Department of Marine Sciences, University of Gothenburg, Gothenburg Sweden*

Abstract

Hugin AUV has the potential to be used in regions with the worst environments. A Hugin AUV named Ran went below the Thwaites Ice Shelf (TIS) and measured the properties of water beneath TIS where no hydrographic data has been made before. As a newly-launched scientific observation platform, an assessment of the performance of Ran's scientific sensors has not yet been made by any third party. This study uses data from two short missions in an estuary in Västra Götaland County, Sweden collected by both ship-based and Ran-based hydrographic sensors to make a comparison between these two sensor-sets. As the ship-based CTD sensor do not have a correct record of time in these missions, the time lag of the measurements cannot be thoroughly evaluated. Further investigation is required to accurately assess the errors. However, in general, Ran achieves a very good accuracy according to the ship-based CTD data.

1. Introduction

Autonomous underwater vehicles (AUVs) have been observing the ocean independently for more than 30 years. The potential of using AUVs in oceans with rough sea condition and extreme weather has been well shown in the last decades (e.g. Griffiths et al., 1998; Dowdeswell et al., 2018; Stone et al., 2018)

In February 2019, a team from the University of Gothenburg working under the Thwaites-Amundsen Regional Survey and Network (TARSAN) project made the very first deployment of AUVs below the Thwaites Ice Shelf. Ran, the Hugin AUV built by Kongsberg for the University of Gothenburg, dove into the ice cavity and measured the properties of water beneath ice shelf. This ground-breaking dataset will help us to better understand the circulation and water masses exchange below the Thwaites Ice Shelf which are almost completely unknown. However, Ran is Kongsberg's first Hugin to be made for scientific research and the first Hugin equipped with conductivity-temperature-depth (CTD) sensors - as a newly-operated observing system, it has not yet been assessed by any third party.

In August 2019, Eurofleets+ Hugin AUV training course cruise took place on the R/V Skagerak in an estuary in Västra Götaland County, Sweden. We obtained ship-based CTD measurements and deployed Ran in two test missions. Some measurements from ship-based CTD and Ran were collected at about the same time and same place which allows us to compare the performance between the hydrographic sensors in ship and Ran. The CTD data collected by both sensor sets are then analysed and a basic comparison is made. This study aims to contribute to the assessing and calibration of hydrographic data collected by Ran.

2. Data

The observations were obtained on 20-21 August 2019 from the Swedish R/V Skagerak under the Eurofleets+ Hugin AUV training course in an estuary in Västra Götaland County, Sweden (fig 1). We deployed Ran twice and the ship-based CTD three times during this short cruise. Station 1 was measured on the 20th of Aug and station 2 and 3 were measured on the 21st. The ship-based CTD measurements were obtained with Sea-Bird Scientific SBE 911 tool with a CTD

sensor and Ran is equipped with a dual Sea-Bird SBE-19 plus V2 sensors.

The temperature and salinity data collected by Ran with two CTD sensors passed a low-pass median filter (with cut-off frequency 0.5 Hz) separately and were averaged and binned into 2-second interval. The data collected by the ship-based CTD sensor has binned by pressure with 0.25-dbar interval and we only use downcast profiles here.

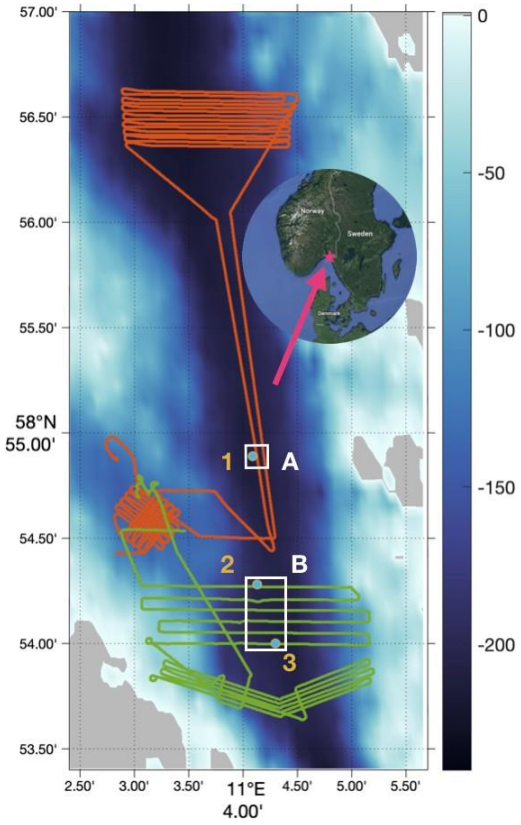


Fig 1. **Map of the study region.** Trajectories of Ran are indicated by the green line (mission on the 20th of Aug) and the orange line (mission on the 21st Aug). Ship-based CTD stations are marked in blue dots with station numbers in yellow. Bathymetry data from EMODnet (EMODnet Bathymetry Consortium, 2018) is shaded in colour scale on the righthand side with grey patches indicating the land. White rectangles indicate the data that would be presented in fig.2 and fig.3. Insect map shows the location of the estuary in Västra Götaland County (obtained on the 4th of Nov, 2019, Google Maps).

3. Results

Here we only compare the data collected by Ran in regions close to the ship-based CTD stations (see fig.1, white rectangles).
The data from region A are shown in fig. 2.

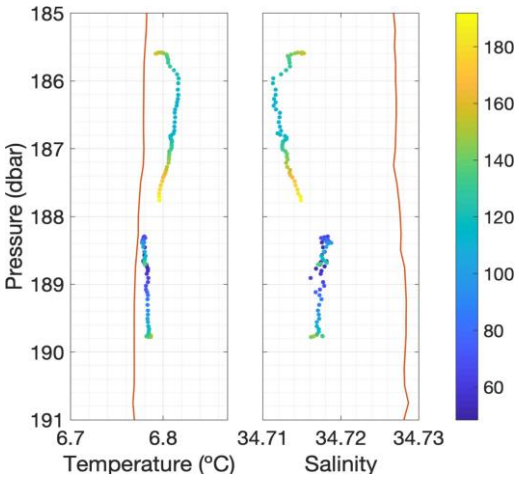


Fig 2. **The comparison between Ran's data and the data collected in ship-based CTD station 1.** Data collected by Ran are indicated by the dots coloured by the distance (in meter) away from CTD station 1. Profile collected by ship-based CTD profile is presented by the orange line.

There are two green lines inside region A. Ran dove to 188-190 dbar (shown in fig.2 as the dots concentrate in deeper level) along the line closer to CTD station 1 and 185-188 dbar (shown in fig.2 as the dots concentrate in shallower level) along the line further away from CTD station 1.

The difference among the dots along the same line does not have a significant pattern. Considering that the water is flowing along the channel, and the sensitivity of sensors, this difference is negligible. Near CTD station 1, the differences are generally smaller along the green line that is closer to CTD station. Within 100 meters away from CTD station, Ran's temperature difference is about 0.03 ºC higher than the ship-based CTD data and salinity is about 0.01 lower than the ship-based CTD data.

The data from region B are shown in fig.3. Note that, in fig. 3 Ran's data are coloured by the distance away from the zonal line where

CTD station 3 (profile coloured in purple) locates. Dots that are shaded in dark blue indicate the measurements that were made close to the station 3 (southmost) and dots in bright yellow indicate the measurements that were made close to station 2 (northmost).

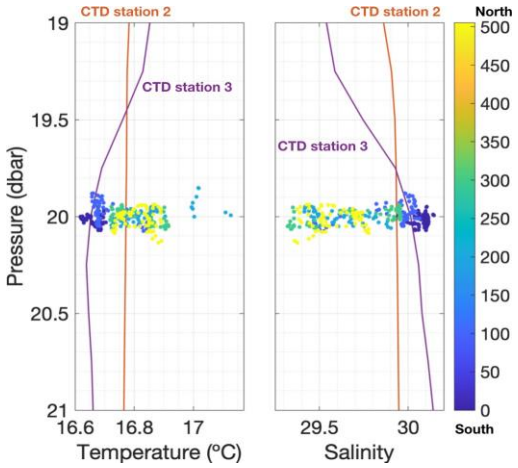


Fig 3. The comparison between Ran's data and the data collected in ship-based CTD station 2 and 3. Data collected by Ran are indicated by the dots coloured by the distance (in meter) away from the zonal line where CTD station 3 locates. Profiles collected by ship-based CTD are presented by the orange line (station 2) and the purple line (station 3).

The water is warmer and fresher in the north than in the south. As we can see from this fig. 3, strangely, while the dots in dark blue have very similar value with the purple profile, showing that at Ran's data being consistent with ship-based CTD's data well in the south; dots in bright yellow have higher temperature and lower salinity compare to the orange profile, suggesting the same pattern of the systematic error as region 1, but in a greater value. The salinity difference is higher in region B than in region A. This could be explained by the rainfall that we encountered on the 21st of Aug as there was a time lag between the time when we made the CTD cast, and the time when Ran passed this region, which allows the freshwater to accumulate. However, Ran's data show a warmer sign of water in the north which is not shown in ship-based CTD data. This might be caused by the temporal variation of water but more test mission is needed to achieve a better answer.

4. Discussion

The limitation of this study is that the CTD casts do not have a correct time record, as the student (Yixi…) mishandled the SBE toolbox. As the result, error induced by the temporal variation of the water in the study region cannot be properly evaluated. The results shown in region A might suggest a systematic error between sensors from Ran and Skagerak which should be calibrated before next mission. The results from region B seen quite suspicious – the water in the north is much warmer than ship-based CTD measurements - more investigation n. After all, Ran's data and ship-based CTD's data are very similar and show the same pattern (warm and fresh water near the sea surface, cold and saline water near the seabed). Ran obtained good measurements.

5. References

Dowdeswell, J.A., Evans, J., Mugford, R., Griffiths, G., McPhail, S., Millard, N., Stevenson, P., Brandon, M.A., Banks, C., Heywood, K.J. and Price, M.R., 2008. Autonomous underwater vehicles (AUVs) and investigations of the ice–ocean interface in Antarctic and Arctic waters. Journal of Glaciology, 54(187), pp.661-672.

Stone, W., Richmond, K., Flesher, C., Hogan, B. and Siegel, V., 2018. Sub-ice Autonomous Underwater Vehicle Architectures for Ocean World Exploration and Life Search. In Outer Solar System (pp. 429-541). Springer, Cham.

Griffiths, G., Millard, N.W., McPhail, S.D., Stevenson, P., Perrett, J.R., Peabody, M., Webb, A.T. and Meldrum, D.T., 1998, April. Towards environmental monitoring with the Autosub autonomous underwater vehicle. In Proceedings of 1998 International Symposium on Underwater Technology (pp. 121-125). IEEE.

6. Acknowledgement

Special thanks will be given to Anna, Filip, Gunna (wrong spelling...), the crew members and all students! <3

Bathymetry data are downloaded from EMODnet Bathymetry Consortium (2018): EMODnet Digital Bathymetry (DTM), see http://doi.org/10.12770/18ff0d48-b203-4a65-94a9-5fd8b0ec35f6 for details.

Title Multi-scale and Multi-agent Geomorphological Landform and Stratigraphy Detection using AUV acoustic sensors

Name: Silas Dean

Affiliation: University of Pisa

Abstract

Training missions in Skagerrak offshore Bohuslän, SW Sweden with the University of Gothenberg and Eurofleet's Kongsberg Hugin AUV "Ran" demonstrate this platform's viability to simultaneously detect geomophological land forms at different scales created by different formation agents. The study area is an uplifting Precambrian granite peneplain dominated by joint-valleys and rocky hills in both submerged and emerged zones, and as such the fjords and areas between islands offer a high range of slopes and environments to gather data with sub-bottom profiler, sidescan sonar, and multibeam echo-sounder. Features detected included large-scale fjord slopes underneath sediment via CHIRP, underwater debris slides/flows and detailed images of granite rocks with sidescan sonar, and striations and sediment accumulations with multibeam. Both the multibeam and sidescan were even able to detect microscale anthropogenic features in the form of trawl marks.

1. Introduction

Bohuslän is located in SW Sweden, opposite Denmark, between which runs the Skagerrak strait. This area of Scandinavia is a peneplain of Precambrian rocks preserved under later sediments then subsequently exhumed in the Paleogene or Neogene (Lidmar-Bergström 1995). Bohuslän is typified by Bohus granite dating to the Sveconorwegian orogeny ~920 Ma, and the emerged landscape is dominated by joint-valleys, often infilled with up to 40 m of Quaternary sediments and glaciomarine clays (Johansson, Migon, and Olvmo 2001). Estimates based on models and observations agree on an isostatic rebound or uplift rate of between 2-3 mm/a; a steady but decreasing rate of relative sea-level drop since 15 ka from 120 m asl to present levels, though gaps in observational data exist, and GIA models do not account for tectonic inputs. (Peltier, Argus, and Drummond 2015).

The Gullmar fjord runs NE to SW ~20km and generally 1-2 km across. High productivity in this and other fjords results in organic rich sediments and hypoxic environments (Polovodova Asteman and Nordberg 2013), which rapidly infill fjords and other near-shore channels. The high sedimentation rate of organic-rich clay sediments provides a high-resolution record for palaeoclimate research, in which centenniel scale fluctuations such as the Medieval Warm Period (Polovodova, Nordberg, and Filipsson 2011; Harland, Polovodova Asteman, and Nordberg 2013) and more recent, shorter-term climate changes (Filipsson and Nordberg 2004) are archived.

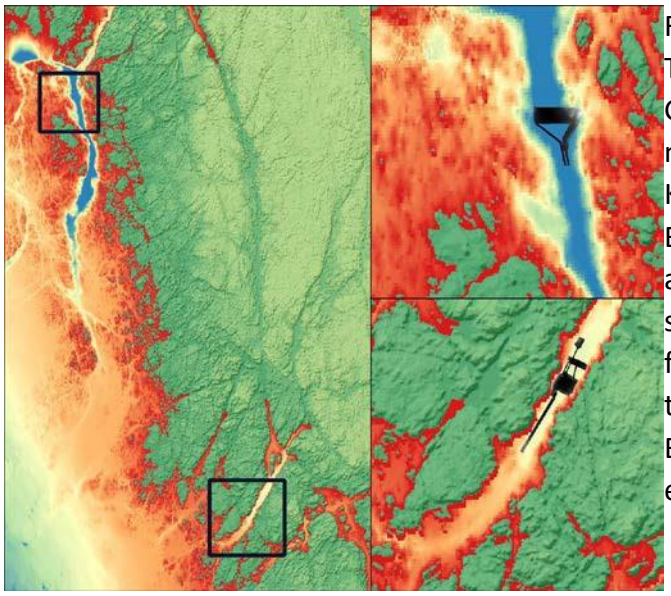


Figure 1. Study area. The southern box is Gullmar fjord. The northern box is Koster channel. Black represents areas of bathymetric surveys. Topography from SRTM and terrestris; Bathymetry from emodnet.eu.

2. Methods

The AUV launched from an inclinable holding frame mounted on the aft deck of the University of Gothenberg's R/V Skagerrak, a 38 m long, 9 m beam, steel-hulled platform for marine science applications with a single screw and bow thruster. The AUV was positioned 15m above the sea floor for these surveys, generally at a speed of 2 m/s. Survey data was collected using Kongsberg EM2040 bathymetric multibeam in 400 kHz and 300 kHz frequencies, and an Edgetech 2205 with sidescan sonar capable of 75 kHz to 1600 kHz frequencies and CHIRP sub bottom profiler capable of 500Hz to 24 kHz frequencies. After extensive post processing, multibeam bathymetry was analyzed with QGIS 3.4.11, while sidescan and CHIRP profiles were viewed using Edgetech Explorer and Kongsberg Reflection.

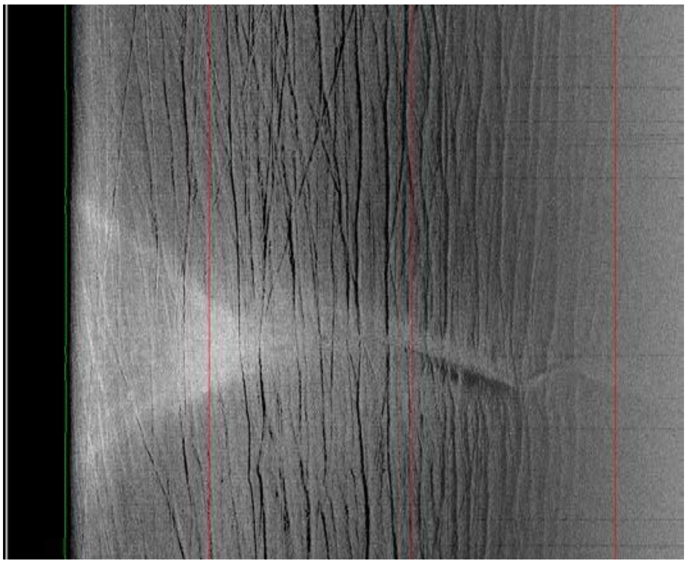
3. Results

The surveys produced a number of results, despite challenges imposed by sea conditions which restrict AUV insertion/extraction locations and therefore increase ship-to-target travel times, and software malfunctions on Mission 1 which prevented the AUV from collecting any sidescan or CHIRP data. The multibeam bathymetry resulted in digital elevation maps of resolutions approximately 1 m after extensive post-processing by subject matter experts. Sidescan images were likely of even higher resolution, while CHIRP data offered exciting glimpses into the stratigraphic record. The types of land forms that could be mapped by the different sensors are presented in the following table, with discussion of some of the most notable finds below. Note that all interpretations of CHIRP data should be subject to additional expert analysis before conclusions are drawn.

Scal e		
Larg e		
Larg e		
Medium		
Medium		

4. Discussion

Due to concerns with Ran's collision avoidance capabilities as well as its ability to capture good bathymetric data in extremely high relief areas, mission plans did not include areas of shallow, rocky hills and bedrock stuctures. Instead, deeper areas of the Gullmar fjord and Koster trench were scanned. In Gullmar fjord, the AUV did lengthwise and athwart transects of the fjord channel at the approximate location of one of the deeper cores taken there by previous researchers – core 9004 (Filipsson and Nordberg 2010), though this core was only 8.5 m long and additional post processing and expertise with CHIRP data is necessary to detect high resolution sedimentary sequences. A brief discussion of some of the more



interesting finds from the acoustic sensors follows below.

Figure 2. Sidescan sonar image of submerged landslide in Gullmar fjord. This structure is perpendicular to a fluvial outlet in the fjord wall and lies underwater between 0-100 m depth. The feature is well defined and with proper post processing, accurate measurements of size and morphometric parameters would be possible. Of particular interest is the higher reflectivity of the material in the debris fan at the left side of the image. This area and others like it could provide a sediment record of different resolution and characteristics than the deeper area of the fjord. Since this region is uplifting and the bottom sediments are soft marine silts/clays, this feature presumably formed underwater from higher energy inputs by the valley abutting the fjord at this location. Note also over cutting the feature apparently deep striations parallel with fjord orientation, and trawl marks at oblique angles in sets of two.

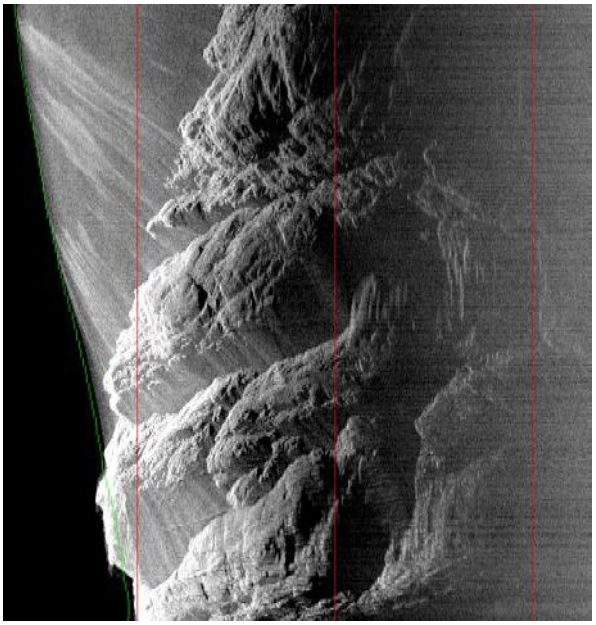


Figure 3. Exposed bedrock/granite hill in Koster channel. The sidescan sonar records these features in great detail despite the high relief, and shows the granite peneplain partially covered by marine sediments. In Gullmar fjord, sidescan images also showed scour patterns of marine sediments around similar rocky residual hills.

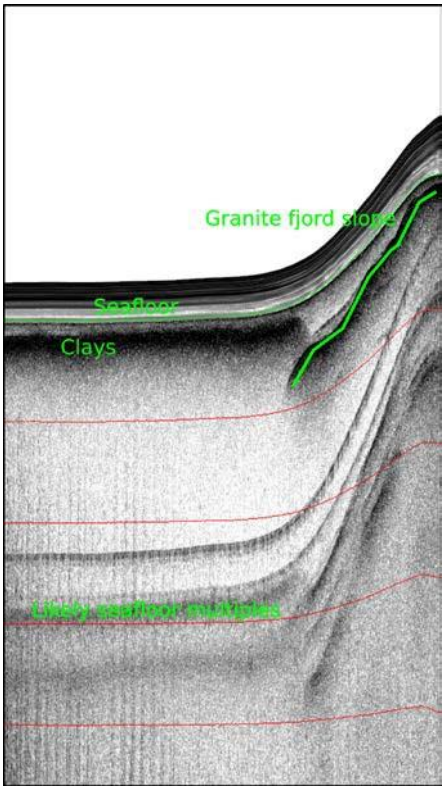


Fig4. CHIRP of half of lateral transect across Gullmar fjord. In all CHIRP illustrations, red lines are 50ms intervals, which should correspond approximately to 37.5 m assuming a 1500 m/s speed of sound. The CHIRP image, at least without further post processing and changes to gain, does not immediately illustrate a detailed sediment sequence down to bedrock. Bedrock is only visible at the periphery (right side) of the fjord, since the bottom lines in the image are presumably seafloor multiples. In the middle of the channel, a poorly delineated but distinct return, seen in the image as a thick, diffuse line seems to occur at about 10 ms below the surface. Whether this is truly a distinct lithological unit, or merely a result of the increasing sediment density due to compaction as depth increases in these types of sediments (Gyllencreutz, Jakobsson, and Backman 2005) is unclear. The Gullmar fjord Core 9004 (Polovodova, Nordberg, and Filipsson 2011) at 8.5m max depth may not penetrate deep enough for a full comparison, and core lithology examined was relatively homogeneous with sand fraction between 0-9 %., aside from a clay/silt/sand horizon at 404-407 m depth, which Polovodova et al. (2011) ascribe to the Medieval Warm Period (MWP). A distinct lithological unit does seem to appear above the bedrock but beneath the sea floor on the right side of the image.

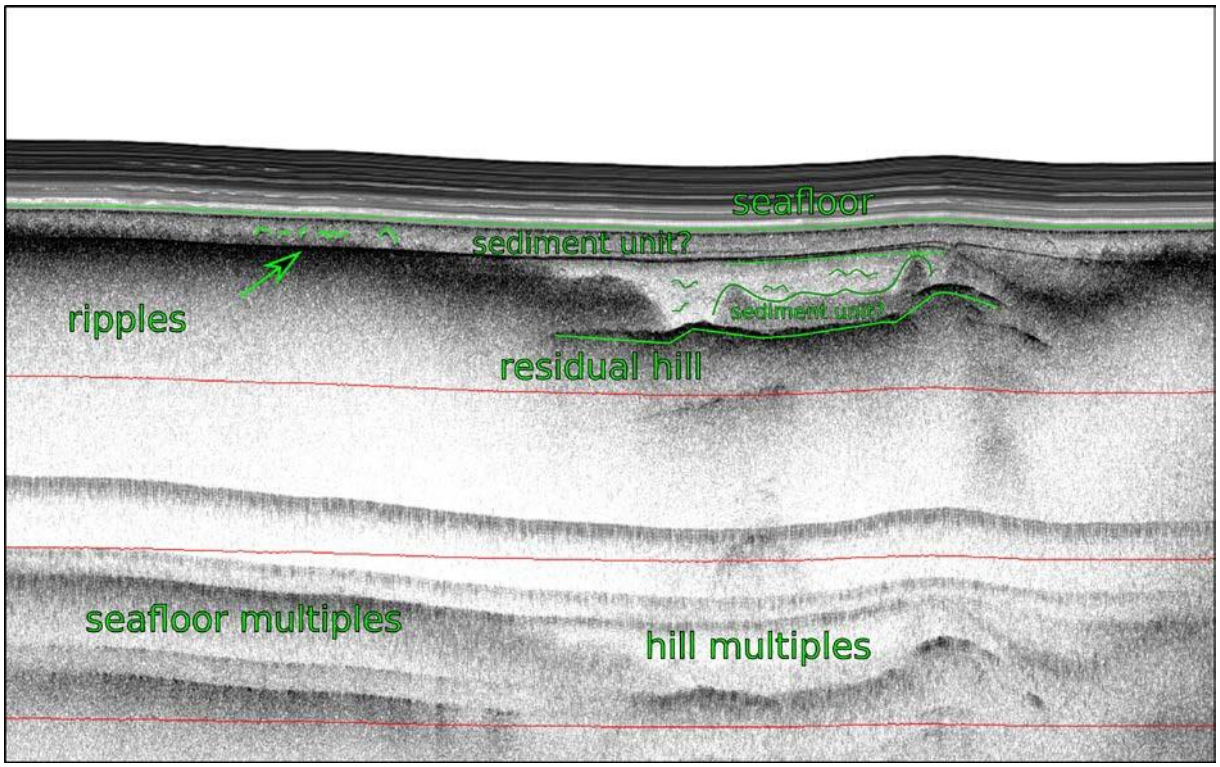


Fig 5. CHIRP of small portion of lengthwise transect through Gullmar fjord, with residual hill from granite peneplain. This piece of the transect passes by a partially exposed residual granite hill, and Ran's CHIRP is able to detect a complex, irregular rippled stratigraphy which may result from the complex depositional environment forced by scouring and currents around the hill. A very thin, distinct reflection is detected at approximately 10ms again. Whether this corresponds to the MWP horizon at ~4m depth detected by Polovodova et al (Polovodova, Nordberg, and Filipsson 2011) or another, deeper unit is unclear.

In the more distal environment of the Skagerrak strait, 4 distinct sedimentary units were detected (Gyllencreutz, Jakobsson, and Backman 2005) above the bedrock or a dense layer of till/diamicton, with the topmost two units being attributed to postglacial sediments. Gullmar likely has a much higher sedimentation rate, so no significant lithological discontinuities were discovered in the 8.5m core 9004 spanning some 2500 years (Polovodova, Nordberg, and Filipsson 2011) it seems likely that the reflections visible in these images represent only a small portion of the Holocene stratigraphy.

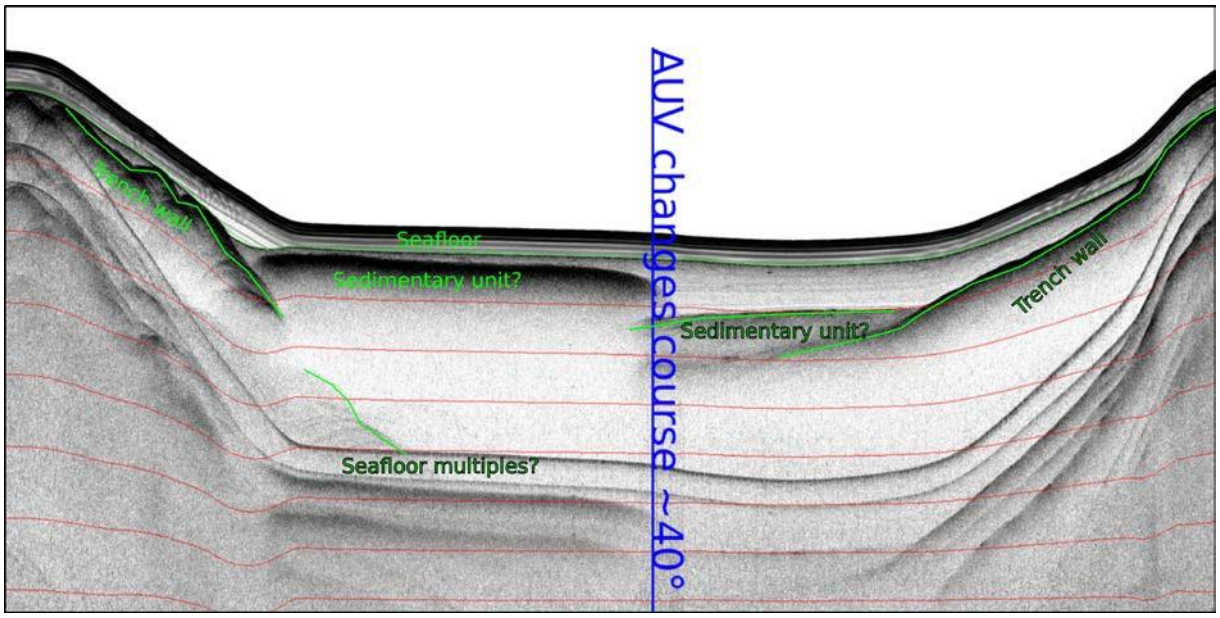


Fig 6. CHIRP transect of Koster trench. Koster trench indicates similar characteristics to Gullmar, but as the trench is deeper and more distal from the coast, a lower energy environment can be assumed. Nevertheless, rippled reflections (too small to be visible in this image) can also be observed in the topmost unit. It is possible these ripples are the result of bioturbation by organisms living in the soil, or by trawling.

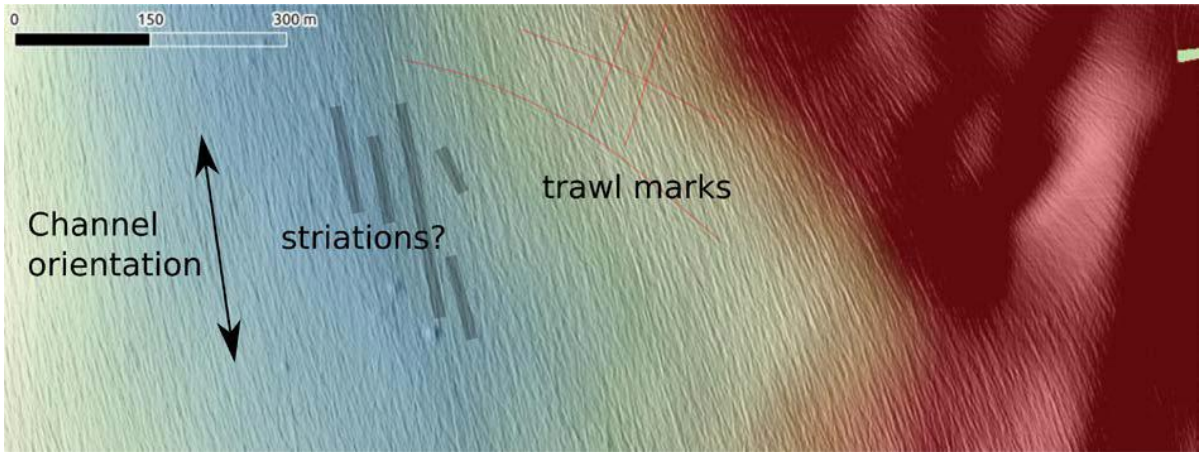


Fig 7. Multibeam bathymetry of Koster trench showing sediment mounds on right side, possibly with rocky hills underneath. CHIRP data was not available from this mission. Long, linear forms going in directions oblique to the channel orientation are certainly trawl marks. More frequent striations (a few are highlighted in the image, but they occur throughout the sea bed) in the soft marine sediment that follow channel orientation may be natural due to current/deposition processes, if not also caused by trawling activity. Study and comparison with the bottom morphology in the marine protected area nearby Koster, where trawling is not allowed, is necessary to assess this. Such study would help determine the rates at which both sedimenation and recovering benthic ecosystems can efface anthropogenic traces and impact bottom morphology.

Overall, the trainning missions demonstrate the excellent capabilities of the “Ran” AUV to supplement existing research and concurrent projects with bathymetric and sub-bottom data, as well as opening up possibilities for multi scale morphometric analyses.

5. References

Filipsson, Helena L., and Kjell Nordberg. 2004. “Climate Variations, an Overlooked Factor Influencing the Recent Marine Environment. An Example from Gullmar Fjord, Sweden, Illustrated by Benthic Foraminifera and Hydrographic Data.” *Estuaries* 27 (5): 867–81. https://doi.org/10.1007/BF02912048.

———. 2010. “Variations in Organic Carbon Flux and Stagnation Periods during the Last 2400 Years in a Skagerrak Fjord Basin, Inferred from Benthic Foraminiferal δ ^{13} C.” *Geological Society, London, Special Publications* 344 (1): 261–70. https://doi.org/10.1144/SP344.18.

Gyllencreutz, Richard, Martin Jakobsson, and Jan Backman. 2005. “Holocene Sedimentation in the Skagerrak Interpreted from Chirp Sonar and Core Data.” *Journal of Quaternary Science* 20 (1): 21–32. https://doi.org/10.1002/jqs.892.

Harland, Rex, Irina Polovodova Asteman, and Kjell Nordberg. 2013. “A Two-Millennium Dinoflagellate Cyst Record from Gullmar Fjord, a Swedish Skagerrak Sill Fjord.” *Palaeogeography, Palaeoclimatology, Palaeoecology* 392 (December): 247–60. https://doi.org/10.1016/j.palaeo.2013.09.006.

Johansson, Magnus, Piotr Migon, and Mats Olvmo. 2001. “Development of Joint-Controlled Rock Basins in Bohus Granite, SW Sweden.” *Geomorphology* 40 (1–2): 145–61. https://doi.org/10.1016/S0169-555X(01)00042-3.

Lidmar-Bergström, Karna. 1995. “Relief and Saprolites through Time on the Baltic Shield.” *Geomorphology* 12 (1): 45–61. https://doi.org/10.1016/0169-555X(94)00076-4.

Peltier, W. R., D. F. Argus, and R. Drummond. 2015. “Space Geodesy Constrains Ice Age Terminal Deglaciation: The Global ICE-6G_C (VM5a) Model.” *Journal of Geophysical Research: Solid Earth* 120 (1): 450–87. https://doi.org/10.1002/2014JB011176.

Polovodova Asteman, I., and K. Nordberg. 2013. “Foraminiferal Fauna from a Deep Basin in Gullmar Fjord: The Influence of Seasonal Hypoxia and North Atlantic Oscillation.” *Journal of Sea Research* 79 (May): 40–49. https://doi.org/10.1016/j.seares.2013.02.001.

Polovodova, I., K. Nordberg, and H.L. Filipsson. 2011. “The Benthic Foraminiferal Record of the Medieval Warm Period and the Recent Warming in the Gullmar Fjord, Swedish West Coast.” *Marine Micropaleontology* 81 (3–4): 95–106. https://doi.org/10.1016/j.marmicro.2011.09.002.

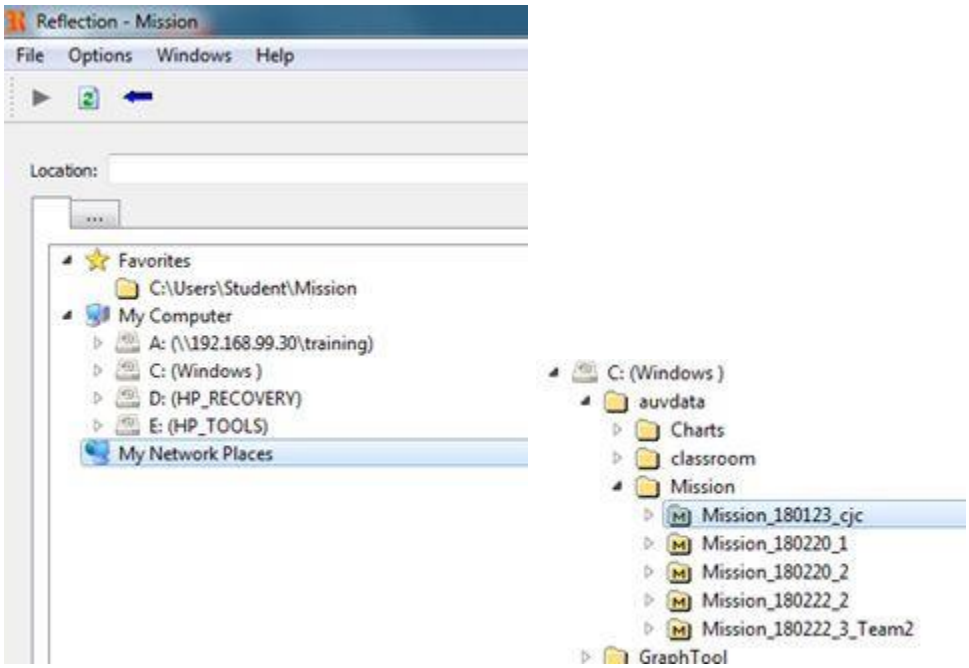
Post processing of acoustic sensor data from Hugin

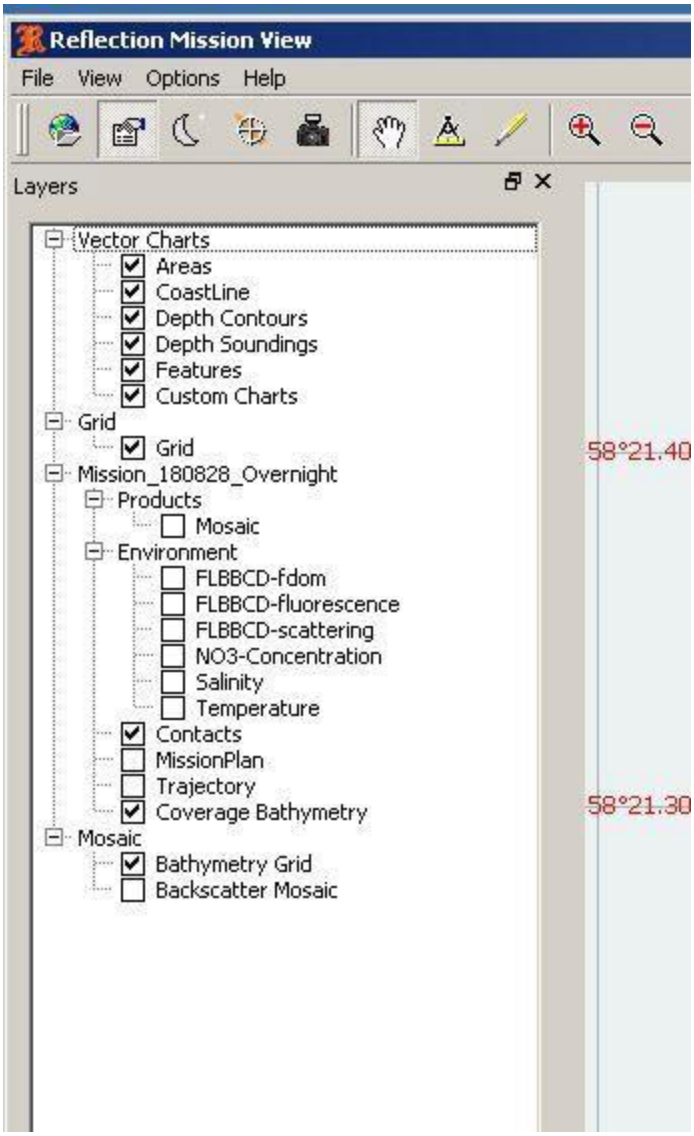
Hardware:
Multibeam: Kongsberg EM2040
Side Scan Sonar: Edgetech 2205
Sub Bottom Profiler: Edgetech 2205

Software:
Reflection
Caris
EIVA

Reflection:
Very user-friendly software that you can install on your laptop and use provided you are connected to the license server (switch in the 'CTD room'). However, only useful to get a first quick view of data - can not export any gridded products or anything.
Download installation media here:
https://www.dropbox.com/s/esfz2d7ypesfjk8/Reflection.zip?dl=0

To get a first view of data, mark the mission folder and then chose the type of data you want to look at (if no choice is made, several types of data is displayed simultaneously)





Exctract depth contours:

1. Right-click in 'Mosaic' menue Bathymetry Grid, chose 'Extract depth contours'

2. Right-click again: 'Save Depth contours'

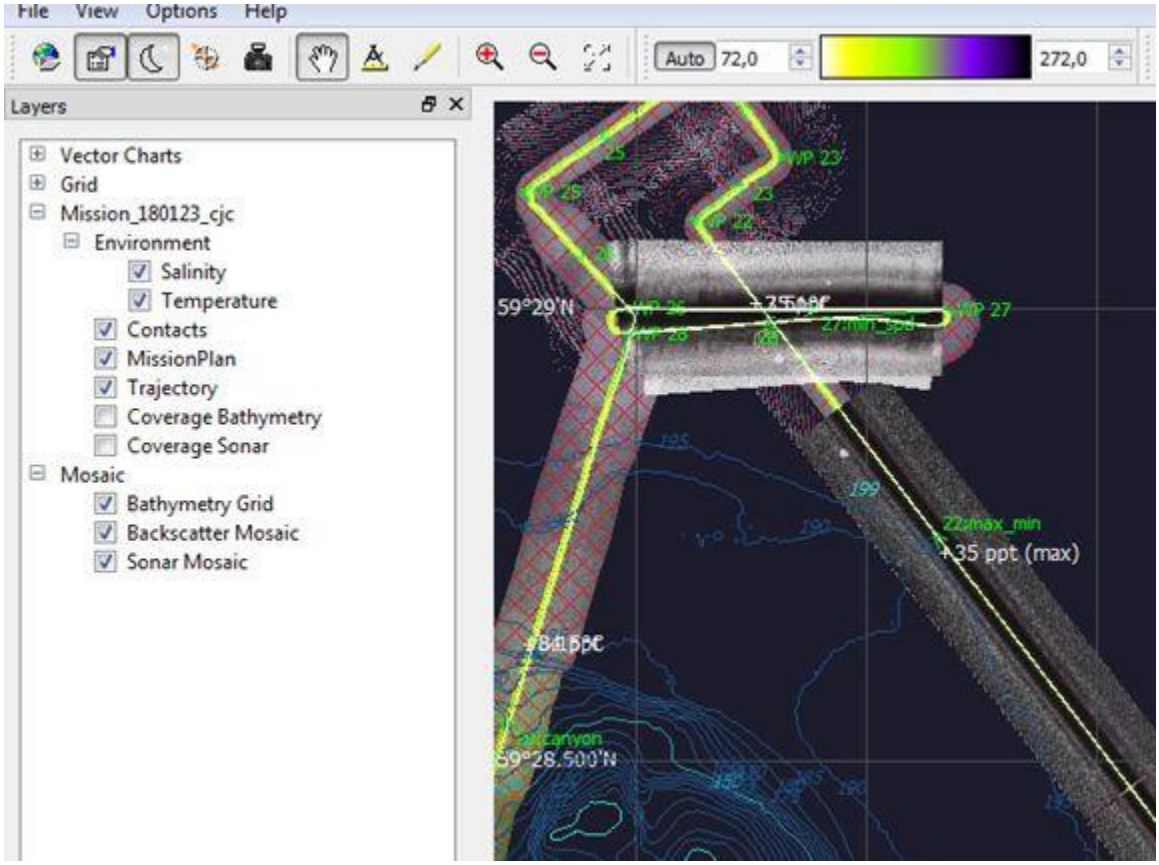
Save depth contours in 'products' folder belonging to that mission

Double-click in movie => target view. Can go closer, go to 3D view etc

Generate report

Environment sensors:

To get a first view, check boxes for environment sensors



GLOBE

GLOBE (GLobal Oceanographic Bathymetry Explorer) is a free application developed by IFREMER for processing and displaying oceanographic data. GLOBE offers processing and display solutions of multi-sensor data within a single 3D environment represented as a globe. Currently, the software is mainly used for processing, analyzing and displaying acoustic data, as well as moving tectonic plates.

Developed in Java, GLOBE is a multiplatform application (Windows, Linux, Mac) whose architecture allows users to develop and add with ease new modules for processing bathymetric data , generating digital elevation models and correcting for tides.

The software is used by the European project EMODnet Hydrography for manipulating and creating digital elevation models.

https://www.flotteoceanographique.fr/en/The-Fleet/Shipboard-software/GLOBE

MBSystem

MB-System is an open-source software package for the processing and display of bathymetry and backscatter imagery data derived from multibeam, interferometry, and sidescan sonars.It is a collaborative effort between the Monterey Bay Aquarium Research Institute (MBARI)

The source code for MB-System is freely available (for free) by anonymous ftp (including "point and click" access through these web pages). A complete description is provided in web pages accessed through links below.

https://www.mbari.org/products/research-software/mb-system/

EIVA Navisuite

EIVA NaviSuite is a software suite for offshore survey and construction operations. It provides acquisition, processing and visualization of multibeam and LIDAR datasets.

Academic licenses, free of charge, can be obtained by accessing the following link https://www.eiva.com/products/special-offers.

Annex 2: 2nd AUV Blue Skills Lab

This project has received funding from the EU
H2020 research and innovation programme
under Grant Agreement No 824077

EUROFLEETS+Blue Skills Lab

"AUV workshop"

at UGOT - University of Gothenburg

Fiskebäckskil, November 2022

Scientific Participants

Anna Wåhlin (UGOT, Instructor)

Filip Stedt (UGOT, Instructor)

Niklas Andersson (UGOT, Administrator)

Participant list

Last name	First name	Nationality	Institute
Serimozu	Cem	Belgian	IMS METU, Turkey
Cavalinhos	Rita	Portuguese	UALG, Portugal
Varzi	Andrea Giulia	Italian	UNIMIB, Italy
Garzia	Angela	Italian	UPdM, Italy
de Oliveira	Larissa	Brazilian	UCC, Ireland
Amblas	David	Spanish	UB, Spain
Ribeiro	Clara	Portugal	UALG, Portugal
Yuan	Xiaohan	Chinese	UGOT, Sweden
SALM	KAI	ESTONIAN	TalTech, Estonia
Porrino	Roberta Saul	Italian	Uniparthenope, Italy
Enzmann-Horvath	Richard	Hungarian / British	Robotics planet, at own expense

This project has received funding from the EU H2020 research and innovation programme under Grant Agreement No 824077

Course objectives

An AUV workshops / training on AUV operation, organized within the Eurofleets+ training program, was held at the Robotics Lab workshop of Gothenburg University (UGOT) at the field station Kristineberg. The workshop had a duration of 5 days and was offered to European PhD and post-graduate students (students of all nationalities enrolled at European universities). Course elements included technical preparation of Autonomous Underwater Vehicles, mission planning preparation, integration of scientific payload, data acquisition and post-processing of various types of sensors with emphasize on hydroacoustic sensors (multibeam, sediment profiling, ADCP). Theoretical course elements were applied practically on board the RV Skagerak.

The participants in this workshop learnt:

- Learning (-by-doing) the logistical challenges and advantages with AUVs as research tools
- Acoustic methods for biotope classification and GIS charting
- Limitations and opportunities of AUVs as platforms
- Importance of the AUV sensor suite

11 applications were received of which 10 were accepted and one was put on a reserve list. One of the accepted applicants cancelled and the one from the reserve list was accepted and participated in the course. The 10 students are residents in 7 different European countries and are 7 different nationalities. Of the 10 students 8 were female and 2 male.

This project has received funding from the EU H2020 research and innovation programme under Grant Agreement No 824077

Course log and use of infrastructure

Oct 30th – Arrival at Kristineberg station

Oct 31st – The participants met in the computer lab room at Kristineberg field station. They were given a short background on the Eurofleets project and the infrastructure to be used. They were divided into four groups, and everyone made sure the software (HuginOS) and necessary maps were installed on their laptops. The goal of the first day was to get acquainted with the mission planning software and agree on a small number of missions that the group wanted to perform. At the end of the day everyone assembled, and the missions were brought up on the big screen and quality-controlled with respect to risk factors, payload requirements etc. The evening assignment was that the groups merge their missions into four joint missions that would be performed over the coming days. Skills learned included set-up software, installing maps, plan draft mission, pre-mission procedures and QC of mission plan.

Nov 1st – First field day. Participants met in the morning on RV Skagerak with the AUV on board. On-board lectures were given during transit times. First mission was done successfully. Participants participated in launch, guard keeping over emergency messages, and recovery. Simultaneous use of RV Skagerak's multibeam was done by some of the students.

Nov 2nd – Second field day

AUV launched in the morning from RV Skagerak. Workshop 'huddles' and completes post processing guide. Participants participated in launch, guard keeping over emergency messages, and recovery. Simultaneous use of RV Skagerak's multibeam was done by some of the students.

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Nov 3rd - Third field day - AUV launched for its mission. Workshop participants working on data post processing from previous mission and report writing. After recovery, data from third mission was downloaded and quality controlled and plans for fourth mission was finalized. Participants participated in launch, guard keeping over emergency messages, and recovery. Simultaneous use of RV Skagerak's multibeam was done by some of the students.

Nov 4th – data post-processing and course report preparation. Participants working on report: describing a question, method, limitation or advantage of using AUV, optimal frequency for your application, or similar. Wrapping up on post processing document.

Infrastructure used/shown during the workshop:

The AUV at The University of Gothenburg – called Ran – has good navigation accuracy and carries high resolution acoustic sonars and other mapping instruments. There are only a few AUVs in the world with Ran's capacity, accessible to science. Thanks to the navigational properties, it can accomplish under-ice missions, and it has been used successfully in Antarctica and under ice in Baltic sea coastal waters.

Ran is a part of the national research infrastructure MUST (Mobile Underwater System Tools), financed by the Knut and Alice Wallenberg Foundation. The infrastructure is open for external users for research purposes. Ran can also, under certain circumstances, be rented by commercial companies.

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Basic data:

Model: Hugin (Kongsberg)

Length: 6.5 metres

Weight: 1850 kg (dry)

Speed: 1-7 knots, cruise speed 4 knots

Maximum dive depth: 3000 metres

Maximum dive length and time: 300 km and 36 h

Sensor suite:

multibeam echo sounder, Multibeam Kongsberg EM2040, 200-400 kHz, 0.7° x 0.7° beam width, swath coverage sector up to 140°

conductivity, temperature and depth sensor (CTD), dual systems SeaBird 911 19plusv2

oxygen sensor, SeaBird SBE43 (dual system)

carbon dioxide sensor, Contros HydroC

nitrate sensor, SeaBird Deep SUNA

chlorophyll/turbidity sensor, SeaBird WetLabs ECOtriplet (FLBBCD)

side scan sonar (= acoustic ”camera”), EdgeTech 2205. Frequencies 75/410 kHz (1-6 km range)

bottom-penetrating sonar (= acoustic ”X-ray camera”), EdgeTech DW216 with configurable chirp

navigation system: DVL-supported Honeywell Hg9900, gives accuracy of better than 0.08% of distance travelled

acoustic communication below surface, 2-3 km between ship and AUV satellite, radio and WiFi communication in surface mode

RV Skagerak

On board RV Skagerak the students did CTD measurements to compare and quality control AUV data. They used the ship’s Kongsberg multibeam to compare with the AUVs multibeam.

Preliminary results

No results can be presented due to the nature of the course.

Evaluation of student learning

No tests were conducted as the course. The students’ final group reports were all up to standard.

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Students course evaluation

Like the last course from 2019, we received mainly positive feedback.

	Number of votes	
Feedback question	Yes	No
Did you find the organisers helpful during preparations?	7	0
Do you feel the course was well organized?	5	2
Was the course content interesting?	7	0
Did you get better knowledge on what scientific platform that fits best for different research questions?	7	0

Comments:
"I only suggest that you develop a guide on all mission preparation and even processing software in order to be easier to understand "

"Knowing how to solve problems and communicate with the vessel crew during the AUV mission felt very important. However, all the communication between the lead scientist and crew members to solve issues and plan missions was done in Swedish. We understand it is a Swedish vessel therefore Swedish will be spoken. But we felt a bit left out in most of the situations, especially the situations dealing with technical issues, because we could not understand the language. We would have appreciated it if the communication between Prof Anna, the captain, or Philip for example, were done in English so we could get more involved in the mission and therefore get a further understanding of the AUV deployment. "

„I would have liked to have a little more time to post process the data. Maybe two days instead of one. "

Concluding remarks

Overall, the students would have liked to have a little more time for their tasks. It was also obvious that the less experienced students did not get as much out of the course as the more experienced ones. The time on board when the AUV was doing the other group's project was spend curiously exploring the possibilities on the research vessel by the more experienced students while the less experienced were not able to take own initiatives to the same extent. If the course is to be run again, we should consider not enrolling less experienced students or prepare more hands-on tasks for them.

The course was an incredible opportunity for UGOT to showcase the possibilities on board our RV Skagerak and with the AUV to a broader group of students.

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Annex 3: 1st ROV Blue Skills Lab

This project has received funding from the EU
H2020 research and innovation programme
under Grant Agreement No 824077

EUROFLEETS+Blue Skills Lab

"ROV Lab"

at MARUM - University of Bremen

Bremen, 19th - 21st of November 2019

Scientific Participants

Nicolas Nowald (MARUM, Instructor)

Volker Ratmeyer (MARUM, Instructor)

Christian Seiter (MARUM, Instructor)

Emmanouil Kallergis (HCMR, Participant)

Leonidas Manusakis (HCMR, Participant)

Joel White (UGot, Participant)

Christian Katlein (AWI, Participant)

Nikos Mauromatis (Uni. Patras, Participant)

Nikolaos Georgiou (Uni. Patras, Participant)

Henrich Preuß (IOSB AST, Participant)

Sophia Schillai (MARUM, Participant)

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under Grant Agreement No824077

Course objectives

Participants of the ROV Lab from left to right: J. White, N. Georgiou, N. Mauromatis, C. Katlein, S. Schillai, L. Manousakis, N. Nowald, V. Ratmeyer and E. Kallergis. Not in the image: H. Preuß, C. Seiter

Scientific ROV Teams do not only need a solid technological background and detailed understanding of their system, but also need to handle the special requirements of scientific ROV operations and requests of the scientific community. Scientific ROV operations differ decisively from those in the oil and gas industry in terms of cruise/dive planning, payload integration, post dive procedures to name but a few. The EurofleetsPlus ROV Lab was addressing to the specific demands of scientific ROV diving in several Class-Workshops and hands on practice which are usually not covered by offshore ROV training courses. The course was offered to ROV Pilots/Technicians with no or basic experience of ROV operations and divided into three Class-Workshops and practical training:

Class-Workshops:

Class-Workshop I: Mobilization, Setup, Telemetry

Class-Workshop II: Operations at sea:

- Dive preparation
- Dive operation
- Post dive procedures

Class-Workshop III: Cruise preparation

Aim of the Class-Workshops was to give an comprehensive overview of what needs to be considered in the run-up of the cruise (e.g. working area, payload integration, etc.), during

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mobilization (adaptation, power conditioning, etc.) and operation at sea (deployment procedures, Vessel - ROV coordination, etc.)

Practical training:

Training with the Schilling Robotics Orion 7P manipulator

Troubleshooting

Scientific training mission in the Quest-SIM

Pre-Dive check on ROV Squid

Training dive with ROV Squid

Aim of the practical exercises was to train the participants on basic flying and navigating a ROV, to handle a manipulator and to take samples, Pilot to Co-Pilot coordination and to pre-dive check a system prior to diving.

Unfortunately, the planned training dive with ROV-Squid could not be carried out, due to a failure in the slipring of the ROV winch.

Seven participants from three European Institutions (Greece, Sweden, Germany) have successfully applied for the ROV Lab. The course was designed for eight. Most participants have a technical background and were into ROV operations since several years, even decades. Others were just starting into the ROV business hence, expertise in ROV operations ranged from little to very experienced. We received eleven applications all together out of which seven were selected and considered as "suitable". Five more applicants missed the deadline or could not join due to temporal reasons. Mrs. Schillai from MARUM joined the course outside EF+ to fill the 8th place but thus, received no EF+ certificate of completion. In terms of gender we had seven male and one female participant.

Nature of the course and work carried out on the course

Our intention was to show and to share our knowledge of how we at MARUM operate ROVs, how we prepare our cruises and everything related to it. We showed and explained course related Powerpoint slides and moderated them to initiate discussion as well as the exchange of experience. The Class-Workshops took place with all participants in a MARUM seminar room.

During the practical exercises, the participants were divided into two or three groups, depending on the exercises.

Three groups were arranged for the Orion 7P manipulator training and the introduction to ROV Quest and ROV Squid.

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Two groups were arranged for ROV-Squid Training dive and the ROV-Quest simulator. As already stated, the training dive with ROV-Squid could not be carried out due to the broken slipring of the winch. The time was used to systematically search the error, as one would do offshore, which turned out to be a good exercise for the group.

All members were present during the pre-dive check of ROV-Squid.

Infrastructure used/shown during the EF+ ROV Lab:

- Orion 7P manipulator training stand
  The training stand consists of a hydraulic power unit, two Pan & Tilt units with color zoom cameras, the Orion 7P, fully proportional, hydraulic manipulator and the corresponding master arm to operate the unit. The training stand requires two pilots. One is operating the arm, while the other is moving the cameras so that the arm operator can fully focus on the sampling and has good visuals on the arm and objects to be sampled.

- ROV Marum-Quest (4000 m)
  Quest was presented as an example for a work-class ROV, designed for heavy deep-sea research. The system was also used to troubleshoot a ground leak of a 24V device.

- ROV Marum-Squid (2000 m)
  The 2000 m light work-class ROV Squid was also presented as an example for a smaller ROV system. In addition, the entire group performed a pre-dive check on the vehicle. As already stated, the planned training dive in the test-tank could, unfortunately, not be carried out.

- Quest-SIM, ROV training simulator
  The training simulator is a 1:1 copy of the MARUM-Quest control van in which scientific dives can be carried out in a virtual environment. It consists of the simulation running on a dedicated computer with projection screens for cameras, additional monitors and computers for navigation and sonar, a master arm controller for the virtual Orion 7P and input devices to fly the ROV. Several scenarios can be loaded into the simulation, like a Black Smoker vent field. Apart from navigating and flying the ROV, objects can be manipulated to train e.g. scientific sampling.

Course Log

1st day (19th of November 2019)

In the morning, all participants gathered in a seminar room at MARUM. After the welcome, we presented the workshop program. In the run-up of the course, we asked the participants to prepare a 10 minutes presentation about their Institute, the ROVs they are operating and their activities. The participants from the HCMR for example, were very experienced pilots and operating ROVs since the mid-90ies. We also asked everyone what they expect from the workshop. Some started more or less from scratch in terms of ROV operations, the more experienced participants were interested of how we organize and operate our systems.

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After the introduction, we started with the first Class-Workshop:"Mobilization, Setup, Telemetry". Slides were shown of what needs to be considered during mobilization. Especially the challenges when mobilizing on different vessels, the adaptation of LARS to the lifting gear of the vessel or the power supply. Also, organizing the 2 to 3 days lasting procedure was explained.

After the lunch break around noon, the participants were divided into three groups.

The first group got an introduction to the 4000m Work-Class ROV MARUM-Quest. The second group was introduced in parallel to the 2000 m depth rated, light Work-Class ROV MARUM-Squid. The two systems were shown and explained, their technical specifications and also their different field of application. The third group was trained on the Orion 7P manipulator training stand. The training stand is operated by two pilots. One is operating the arm, while the other moves the two cameras which are installed on individual pan and tilt units. We explained the manipulator and showed how to operate the arm via the master controller. In the next step, the participants were trained to grab and to place objects. Also the usage of a more complex tool, like a temperature lance dummy, was trained. One major goal of the session was to demonstrate, how important it is that both pilots need to coordinate actions and work together in order to be able to successfully take samples. After 1.5h the groups were switched.

C. Seiter (far right) explaining sampling techniques with the Orion7P manipulator to N. Mauromatis (left) and H. Preuß (middle)

2nd day (20th of November 2019)

At 09:00 the second Class-Workshop was held: *Operations at Sea*. This workshop was split into three sub-sessions. In the *Dive preparation* session, we explained in detail of how we prepare each dive. Special focus was put on the pre-dive check of the ROV, which is the most crucial procedure prior to the deployment. In addition, we showed several documents such as a Dive Plan from the science party or bathymetrical maps of different study areas that serve as the base for navigation. Furthermore, we talked about evaluating weather conditions or how to organize shifts for the pilots during longer dives.

In the *Dive operation* session we described the deployment and recovery procedures of our ROVs or how to coordinate a tethered ROV system with a vessel. Furthermore, we discussed decision making for aborting a dive or not during failures and how we recover a "dead vehicle" when control over the system is lost.

Post dive procedures covered everything that needs to be done after a dive such as the treatment of the recorded data and videos or how to organize repairs on a vessel in case something on the ROV is broken.

After the lunch break, the entire group performed a pre-dive check on ROV-Squid, using the pre-dive checklist shown in the previous session. During this procedure, every single component (cameras, thrusters, etc.) of the ROV is checked for full functionality. Before powering up the system, the participants were

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asked to install sampling tools (Markers and Nets) inside the ROVs sample drawer box. After powering up the vehicle, we observed that one the three phases supplying the vehicle with electricity, showed different values compared to the other two. As the pre-dive check could not be continued because the system was not running, we used the time to systematically locate the error. Together, we pinned the error down to the winch slipring. The continuity check on one phase failed and the slipring was uninstalled and shipped to the manufacturer for repairs after the ROV Lab course.

L. Manousakis, E. Kallergis, N. Nowald and J. White (from left to right) preparing the installation of tools inside the sample tool box of ROV Squid before the pre-dive check.

At 15:30, we all gathered back in the seminar room for the last Class-Workshop: *Cruise preparation*. During this session, we described what needs to be discussed with the scientific team before an expedition such as the working area, expected weather conditions or the payload that needs to be adapted to the ROV.

3rd day (21th of November 2019)

We assembled at 09:00 in the morning. Unfortunately, Mr. H. Preuß got sick and could not participate. Usually it was planned to prepare ROV-Squid with the entire group for the training dive in the outside test-tank. Because this was not possible, we decided to train the participants of how to troubleshoot a ground leak of a 24V device. For this purpose, a camera was modified to generate bad resistance values on the 24V Line Insulation Monitoring system of ROV-Quest. The participants were asked to locate the bad device with help from our side.

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J. White, L. Manousakis, E. Kallergis and V. Ratmeyer (from left to right) troubleshooting a bad device on ROV MARUM-Quest

After this exercise, one group started with the simulated training dive in the Quest-SIM. The other group received an additional manipulator training on the Orion 7P in parallel instead of diving with ROV Squid. Groups were switched after ~2.5h. During the simulated dive, the participants were introduced in the controls (input devices), displays and control system of ROV-Quest. In the Quest-SIM, the trainees navigated to and through a Black Smoker vent field. The usage of tools with the virtual manipulator was also part of the simulated dive. Apart from flying and manipulation, we pointed out the importance of the coordination between pilot and co-pilot.

C. Katlein and S. Schillai in the Quest-SIM container

Afterwards we assembled in the seminar room for concluding discussion and handed over the certificates of completion. The workshop ended around 18:00.

Preliminary results

No results can be presented due to the nature of the course. (No sample collection and/or analysis)

Evaluation of student learning

No tests were conducted as the course was designed to e.g. share our experiences during ROV operations or to demonstrate how to operate a manipulator - not to teach educational knowledge in the classical sense or way. Testing the participants within our course structure was not applicable.

Students course evaluation

Feedback from the participants was extremely good. Unfortunately, not all participants filled out the evaluation form. One participant checked the very unsatisfying box several times, but we believe that this

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was a mistake. In the feedback module same participant stated, that he benefited from the course and that it was a "good presentation" and a "nice workshop with ROV Quest and Squid".

Referreing to Q6 and Q7 on the feedback module	Number of votes				
Course Element	Very satisfying	Satisfying	Neutral	Unsatisfied	Very unsatisfied
Class-Workshop I: Mobilization, Setup, Telemetry	4	1			1
Class-Workshop II: Operations at sea	5				1
Class-Workshop III: Cruise preparation	4				1
Manipulator training	5				1
Quest-SIM	4	1			1
Troubleshoot (replaced the training dive with Squid)	2	1		1	

Feedbacks stated in Q11 (comment highlights & lowlights) were all the way positive, for example "Everything was perfect", "Great workshop" or "Very friendly and professional people". Some participants would even recommend a longer duration/extension of the course.

Concluding remarks

We believe that the course was a success. Feedback was very positive and we are confident, that the next course will be a success as well. Many people have already shown their interest of joining the upcoming ROV Lab.

We also believe that the participants liked the way of how we presented and organized the course. We did not pretend that the way we organize and operate ROVs is the right way. We just showed how we at MARUM do it.

This allowed a lively, very open discussion and conversation even during the class-courses. In that respect we have to say, that we also learned a lot from the participants.

We will keep the general structure and content of the course, because we believe that it is good that way. However, minor tweaks on the Class-courses, especially the slides, will be done.

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Annex 4: 2nd ROV Blue Skills Lab

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EUROFLEETS+Blue Skills Lab

"ROV Lab"

at MARUM - University of Bremen

Bremen, 22nd - 24th of November 2022

Scientific Participants

Nicolas Nowald (MARUM, Instructor)

Vincent Vittori (MARUM, Instructor)

Tom Leymann (MARUM, Instructor)

Sophia Schillai (MARUM, Instructor)

Marcel Schröder (MARUM, Instructor)

Namate Sililo (AquaBiotechGroup, Malta, Participant)

Sean Dimech (AquaBiotechGroup, Malta, Participant)

Ivan Kuprijanov (Department of Marine Systems, Estonia, Participant)

Alexandros Menegatos (Department of Geology, Greece, Participant)

Andrea Peirano (Marine Environment Research Centre, Italy, Participant)

Christian Engler (MARUM, Participant outside EF+)

Timo Fleischmann (MARUM, Participant outside EF+)

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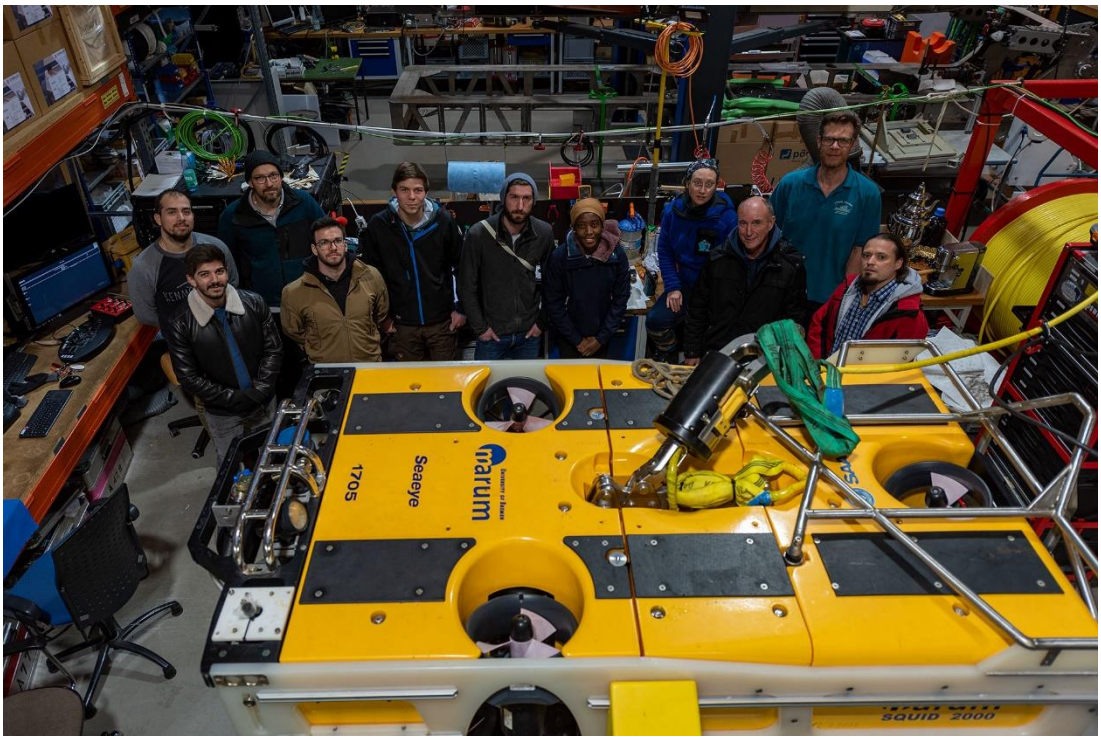

Participants/Instructors of the ROV Lab from left to right: V. Vittori, S. Dimech, T. Leymann, A. Menegatos, C. Engler, T. Fleischmann, N. Sililo, S. Schillai, A. Peirano, N. Nowald and I. Kuprijanov

Course objectives

Scientific ROV Teams do not only need a solid technological background and detailed understanding of their system, but also need to handle the special requirements of scientific ROV operations and requests of the scientific community. Scientific ROV operations differ decisively from those in the oil and gas industry in terms of cruise/dive planning, payload integration, post dive procedures to name but a few. The EurofleetsPlus ROV Lab was addressing to the specific demands of scientific ROV diving in several Class-Workshops and hands on practice which are usually not covered by offshore ROV training courses. The course was offered to ROV Pilots/Technicians with basic experience of ROV operations and divided into three Class-Workshops and practical training:

Class-Workshops:

Class I: Operation at sea:
- Dive preparation
- Dive operation
- Post dive procedures

Class II: Mobilization, Setup, Telemetry

Class III: Cruise preparation

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Aim of the Class-Workshops was to give a comprehensive overview of what needs to be considered in the run-up of the cruise (e.g. working area, payload integration, etc.), during mobilization (adaptation, power conditioning, etc.) and operation at sea (deployment procedures, Vessel - ROV coordination, etc.)

Practical training:

- Training with the Schilling Robotics Orion 7P manipulator
- Scientific training missions in the QUEST 4000 Simulator (QUEST-SIM)
- Training dives with ROV MARUM-Squid

Aim of the practical exercises was to train the participants on basic flying and navigating a ROV, to handle a manipulator and to take samples, Pilot to Co-Pilot coordination and to pre-dive check a system prior to diving. Compared to the first ROV Lab in 2019, we changed the agenda to have one QUEST-SIM training session and one ROV-Squid dive for each of the two groups (see Course Agenda). Previously, there was only one QUEST-SIM session and one MARUM-Squid dive in the test tank for all groups together. The new setup would ensure to have more time for each participant during these two units.

We received fourteen applications altogether out of which six were selected and considered as "suitable". The chosen participants were from Greece, Malta, Italy, Estonia and Nigeria. However, the participant from Nigeria cancelled its participation on short notice because it was not possible to issue a Visa in time. As the course was designed for eight, we decided to invite two technicians from Marum (total of 7 participants, 5 via EF+, 2 from MARUM). Most applicants had no experience in piloting an ROV or experience with ROVs in general. This led to a rejection of many applications, because they did not belong to the target group of this course. In terms of gender we had four male and one female participant (EF+ applicants only). Most participants had already some experience with scientific ROVs which made them perfect candidates.

Nature of the course and work carried out on the course

Our intention was to show and to share our knowledge of how we at MARUM operate ROVs, how we prepare our cruises and everything related to it. We showed and explained course related Powerpoint slides and moderated them to initiate discussion as well as the exchange of experience. The Class-Workshops took place with all participants in a MARUM seminar room.

We created two groups (Group 1 & Group 2) for the practical training lessons as well as for the class workshops. For technical reasons, the first part of Class I - Operation at Sea: Dive preparation took place for all participants on Day 1.

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Day 2 and Day 3 had the same course content. Group 1 would have a QUEST-SIM session and Class Courses on Day 2, while Group 2 would go in the test tank with ROV Squid. On Day 3 the groups were switched (see Course Agenda)

Infrastructure used during the EF+ ROV Lab:

- Orion 7P manipulator training stand
  The training stand consists of a hydraulic power unit, two Pan & Tilt units with color zoom cameras, the Orion 7P, fully proportional, hydraulic manipulator and the corresponding master arm to operate the unit. The training stand requires two pilots. One is operating the arm, while the other is moving the cameras so that the arm operator can fully focus on the sampling and has good visuals on the arm and objects to be sampled.

- ROV MARUM-Quest (4000 m)
  ROV Quest was presented as an example for a work-class ROV, designed for heavy deep-sea research. The introduction to the system was also meant as a preparation for the QUEST-SIM.

- ROV Marum-Squid (2000 m)

  The 2000 m light work-class ROV Squid was also presented as an example for a small work-class ROV system. The introduction to the system was also meant as a preparation for the training dive with ROV-Squid in the testtank.

- QUEST-SIM, ROV training simulator

  The training simulator is a 1:1 copy of the MARUM-Quest control van in which scientific dives can be carried out in a virtual environment. It consists of the simulation running on a dedicated computer with projection screens for cameras, additional monitors and computers for navigation and sonar, a masterarm controller for the virtual Orion 7P and input devices to fly the ROV. Two scenarios can be loaded into the simulation: a Black Smoker vent field and an area with bacterial mats. Apart from navigating and flying the ROV, objects can be manipulated to train e.g. scientific sampling.

Andreia Afonso from the Portugese Task Group for the Extension of the Continental Shelf (EMEPC), operating ROV Luso, asked if she could participate during the Class courses. We established a Zoom-Meeting so their group was could join in as well.

Course Log

DAY 1 - (22nd of November 2022)

In the morning all participants gathered in a seminar room at MARUM. After the welcome, we presented the workshop program. In the run-up of the course, we asked the participants to prepare a 5 minutes presentation about their Institute, the ROVs they are operating and their activities. All of them worked with small sized ROVs in rather shallow depths for scientific surveys and observations.

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In addition, we also asked everyone what they expect from the workshop. All participants wanted to increase their ROV skills and were very interested in how we organize and operate our systems.

After the introduction, we started with the first Class-Workshop I: Operation at sea. This workshop was split into three sub-sessions:

Dive Preparation (Day 1)

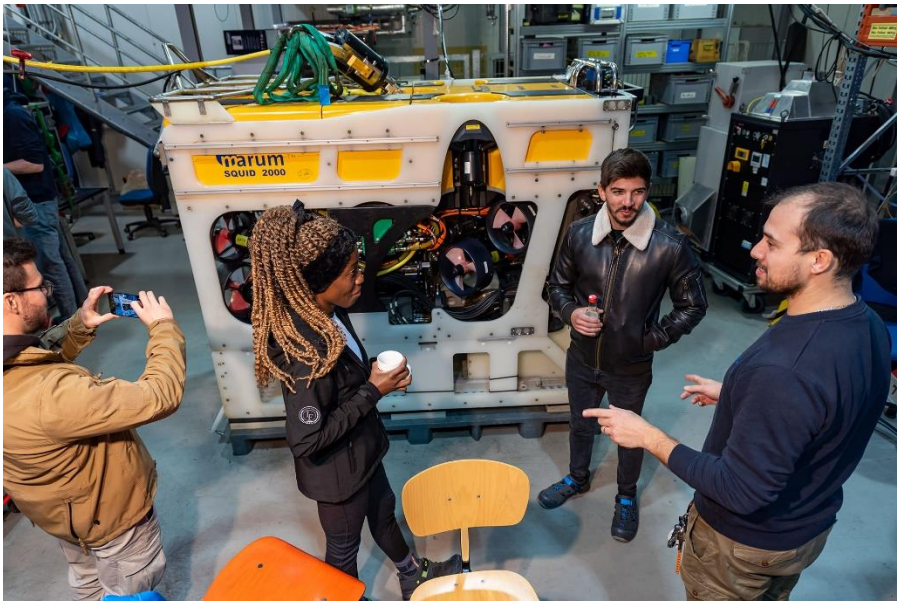
Dive Operation (Day 2 & 3)

Post Dive Procedures (Day 2 & 3)

In the Dive preparation sub-session, we explained in detail of how we prepare each dive with focus being put on the pre-dive check. In addition, we showed several documents such as a Dive-Plan from the science party or bathymetrical maps of different study areas that serve as the base for navigation. Furthermore, we talked about evaluating weather conditions or how to organize shifts for the pilots during longer dives.

After the lunch break around noon, the participants were divided into the two groups: Group 1 was trained on the Orion 7P manipulator arm. Group 2 got an introduction to ROV Quest and ROV Squid. Groups were switched after 2.5 – 3h.

The Orion 7P manipulator training stand is operated by two pilots. One pilot is operating the arm, while the other moves the two cameras which are installed on individual pan and tilt units. We explained the manipulator and showed how to operate the arm via the master controller. In the next step, the participants were trained to pick up and to place/store objects. One major goal of the session was to demonstrate, how important it is that both pilots need to coordinate actions and work together in order to be able to successfully take samples.



Vincent Vittori (right) introducing Alexandros Menegatos, Namate Sililo and Sean Dimech to ROV-Squid

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In preparation for the QUEST SIM Dive and the ROV Squid training dive taking place on Day 2 and Day 3, the participants were introduced to the ROVs MARUM-Quest and MARUM-Squid to familiarize with the systems ROV controls, the camera displays, technical specifications and so on. After Day 1, all candidates were on the same skill level in the use of the arm and knowledge of the ROV controls and thus, ready for the upcoming dives in the QUEST-SIM and testtank.

Namate Sililo (front) and Sean Dimech practising with the ORION 7P manipulator

DAY 2- (23rd of November 2022)

Group 1:

After the gathering in the morning, Group 1 went into the QUEST-SIM for scientific training missions. Before the actual mission started, the participants were introduced to the input devices, displays and control system. In the first mission, the ROV has to navigate to an elevator that is placed on the seafloor, containing tools. The task here is to pick up a small sensor platform from the elevator with the Orion Manipulator and then place it on a bacterial mat. In the second scenario, the ROV has to navigate through a black smoker vent field and place a temperature sensor on the top of a black smoker. Apart from flying, navigating and manipulation, we pointed out the importance of the coordination between pilot and co-pilot.

Around 02:30 pm, the session in the QUEST-SIM ended and Group 1 continued with Class Course I – Operation at sea, with the sub-sessions Dive Operation and Post Dive procedures. In the Dive Operation session we described the deployment and recovery procedures of our ROVs or how to coordinate a tethered ROV system with a vessel. Furthermore, we talked about how to navigate in an area of scientific interest or how to best position the ROV in order to get the scientific tasks done. We also discussed decision making for aborting a dive or not during failures and how we recover a "dead vehicle" when control over the system is lost. The last sub-session, Post dive procedures, covered everything that has to

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be done after a dive such as the treatment of the recorded data and videos or how to organize repairs on a vessel in case something on the ROV is broken.

After a short break we continued with Class II: Mobilization, Setup, Telemetry. Slides were shown of what needs to be considered during mobilization. Especially the challenges when mobilizing on different vessels, the adaptation of LARS to the lifting gear of the vessel or the power supply. Also, organizing the 2 to 3 days lasting procedure was explained.

The last session for Group 1 of this day was the Class III: Cruise preparation. During this class workshop, we described what needs to be addressed to the scientific team before an expedition starts such as the working area, expected weather conditions or the payload that needs to be adapted to the ROV.

Group 2:

Group 2 started with the pre-dive check of ROV Squid for the dive in the testtank. The participants ran through the pre-dive check list to get the vehicle ready for launch. During this procedure, every single component (cameras, thrusters, etc.) of the ROV is checked for full and proper functionality. After the check, the vehicle was rolled out of the maintenance hall to the testtank with the large forklift. Participants were asked to operate the winch to payout the umbilical in parallel. After the deployment in the testtank, the participants had to familiarize with the controls and to get a “feeling” for the vehicle´s behavior whilst flying. The second task was to approach a diorama that has been prepared and deployed in the tank. Corals (real ones and 3D-printed) and a cold-seep chimney with emitting air bubbles were placed on 2 x 2m grid to simulate an area of interest.

Image taken with ROV-Squid´s stills image camera inside the testtank during the training dive, showing the diorama with several objects

After approaching and parking the vehicle in front of diorama, the participants had to take proper images and video recordings. They also had to carefully reposition the ROV in order to get good images from another perspective of the diorama. The last task was to pick up stones with the manipulator and to store

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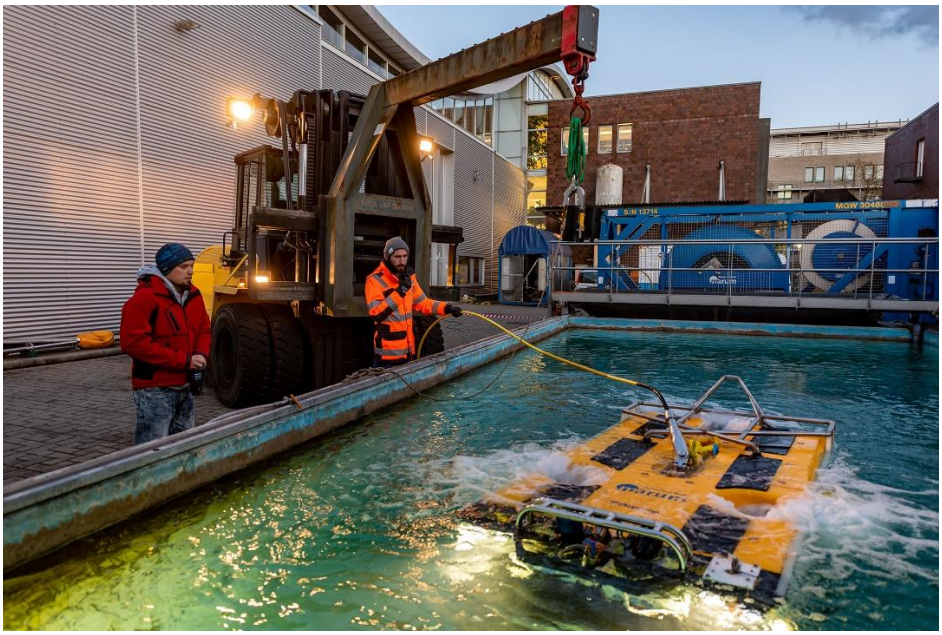
them in the sample box of the ROV. Around 5pm the vehicle was recovered and moved back into the maintenance hall.



Ivan Kuprijanov and Timo Fleischmann during the recovery of ROV Squid

DAY 3 - (24th of November 2022)

On Day 3, Goups 1 and 2 were switched. Group 2 went into the QUEST-SIM and had Class Courses after, while Group 1 was planned to go in the testtank with ROV-Squid.

Timo Fleischmann and Andrea Peirano in the QUEST-SIM

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During the pre-dive check in preparation of the training dive in the testtank, we observed that the voltage on the 500V bus on the system was not correct. Because there was something not properly working with the ROV we had to abort the dive. Instead, Group 1 repeated training sessions with the Orion manipulator. Alexandros Menegatos attended in removing and opening the ROV transformer to search for the failure which was a valuable lesson for him. Later on, we showed the group other additional underwater videos from the MARUM ROVs in the seminar room.

Around 5pm, we all gathered in the seminar room for concluding discussion. The participants were given time to fill out the evaluation sheets and after this, we handed over the certificates of completion. The workshop ended around 18:00.

Preliminary results

No results can be presented due to the nature of the course. (No sample collection and/or analysis)

Evaluation of student learning

No tests were conducted as the course was designed to e.g. share our experiences during ROV operations or to demonstrate how to operate a manipulator - not to teach educational knowledge in the classical sense or way. Testing the participants within our course structure was not applicable.

Students course evaluation

Like the last course from 2019, we got very positive feedback. The participants were “very satisfied” with the course and found it “very beneficial”. Many would like to see additional training days.

Referreing to Q6 and Q7 on the feedback module	**Number of votes**				
Course Element	Very satisfying	Satisfying	Neutral	Unsatisfied	Very unsatisfied
Class-Workshop I: Mobilization, Setup, Telemetry	5				
Class-Workshop II: Operations at sea	5				
Class-Workshop III: Cruise preparation	5				
Manipulator training	5				
Quest-SIM	4	1			
Training dive with Squid)	2	3			

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Concluding remarks

We believe that the course was a success as the feedback we received right after, and already during the course, was very positive. The participants were very excited as they had the opportunity to have “hands on” on a large portion of the ROV related infrastructure here at MARUM.

We also believe that the participants liked the way of how we presented and organized the course. We did not pretend that the way we organize and operate ROVs is the right way – we just showed how MARUM does it. This allowed a lively, very open discussion and conversation during the three days.

Having the Class Courses online, to make the content available for interested people that cannot come to Bremen, could be considered. Andreia Afonso from Portugal stated, that it was very helpful for her group to join in online.

In terms of course content, we might put more focus on sampling techniques (with cameras or manipulator) and reduce technical content like how to mobilize an ROV in possible future courses.

We at MARUM were also very excited in having the chance to share our knowledge with other ROV operators from Europe. We are very thankful that EF+ gave us this great opportunity.

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Annex 5: Seismic Blue Skills Lab

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EUROFLEETS+ Blue Skill Lab

"SEISMIC Lab"

At OGS, Trieste (Italy), October 10th-12th 2022

Participants

Davide Gei (OGS, Instructor)

Favrizio Zgur (OGS, Instructor)

Flavio Accaino (OGS, Instructor)

Gualtiero Bohm (OGS, Instructor)

Edy Forlin (OGS, Instructor)

Biancamaria Farina (OGS, Instructor)

Paolo Diviacco (OGS, Instructor)

Alessandro Busato (OGS, Instructor)

William Toson (OGS, IT support)

Alexandros Menegatos (Uni. Patras, Participant)

Sara Rodrigues (Royal Holloway Uni. London, Participant)

Nora Markezic (Uni. Trieste, Participant)

Roberta Saul Porrino (Uni. Napoli Parthenope, Participant)

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Course objectives

Figure 1- Participants of the Eurofleets+ Seismic Lab

Marine Seismic exploration, is a geophysical method that aims to image the subsurface, i.e., to reconstruct the geological structures and to estimate the rock properties. Seismic waves are produced by artificial sources and the echoes from the subsurface layers are recorded by receivers located in the proximity of the earth's (or sea) surface. Seismic data acquisition, processing and interpretation require a good knowledge of the principles governing the wave propagation.

The Seismic Lab workshop is organized as part of the EurofleetsPlus training program and was held at OGS, National Institute of Oceanography and applied Geophysics in Trieste (Italy).

The three-day workshop (10-12, October 2022) was aimed at early career researchers in the field of marine sciences who have no or only basic experience and knowledge in the acquisition and processing of multichannel seismic data. Seismic Lab addressed the specific requirements of scientific multichannel seismic data acquisition and processing in several class-workshops and practical sessions:

Class Lectures:

- Basic of wave propagation
- Marine seismic data acquisition (Sources and geometry)

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- Seismic data processing
- Seismic tomography and application to marine data
- Seismic numerical modelling

Class lectures aimed to give a comprehensive overview on the principles governing the acquisition of seismic data and the standard procedure to process the seismic data.

Practical sessions:

- Visit on board OGS R/V Laura Bassi
- Seismic data processing with Seismic Unix
- Seismic data processing with OGS "COLLA" Virtual Research Environment

The practical sessions gave the participants the opportunity to observe the marine seismic infrastructures on board the R/V laura Bassi and the opportunity to practice in processing seismic data by their own.

Five applications have been received, and all oft hem have been considered suitable. The participants were from Italy, Portugal, Greece and Morocco. Unfortunatelly, the participant from Morocco cancelled its participation one week before the start of the workshop, for personal reasons.

In terms of gender, we had three females and one male.

Nature of the course and work carried out on the course

This course was aimed at early career marine researchers who have no or only basic experience and knowledge of multichannel seismic data acquisition and processing and who use and/or will use geophysical data in their research projects. Our aim was to introduce them to seismic data acquisition and processing, and to familiarise them with the procedures so that they can better understand and "read" geophysical data. The classroom activities were based on the presentation and explanation of the theory of seismic waves properties and the processing of raw data; in addition, the participants attended two lectures on Tomography and numerical modelling of seismic data, which gave them an overview of the potential and advantages of these tools.

On the second day, the participants went on board the OGS R/V Laura Bassi, where a geophysical technician showed and explained the ship's multi-channel seismic data acquisition system and procedures.

The practical sessions took place with all the participants in the OGS SeisLab room. Here, they were trained in the use of Seismic Unix for processing seismic data and carried out exercises on a seismic profile. The participants also learned and practised how to process seismic data in a virtual research environment.

Infrastructures used during the EF+ Seismic Lab:

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- **On board R/V Laura Bassi** - Seismic data acquisition on board: Air Compressors, GI Gun, Streamer and SERCELL acquisition software.
- **SeisLab** - is a hardware/software infrastructure that provides an environment for the integration of software and geophysical data. Based on the concept of hardware virtualisation, Seislab supports the user in carrying out part or all of the processing and analysis phases foreseen in the workflow. The seismic numerical modelling codes are already implemented in Seislab and are available to users. Rock physics codes for calculating the seismic and electromagnetic properties of partially saturated media and theoretical AVO curves are also available in OGS.
- **Seismic Unix** – an open source seismic utilities package that provides instant seismic research and processing environment (running on Unix or Unix like operating system), dedicated to education, and permit the processing of 2D seismic.
- OGS **COLLA** (Collaborative Toolkit for Scientific Project development) – Is a Virtual Research Environment aiming to support and foster collaborative activities among member of a working group, by concentrate server side all information needed to be available. It allows to host on the same web portal many projects. Data remain isolated from project to project on a user account based policy.

Course Log

1st day (10th October 2022) – OGS meeting room

In the morning all participants gathered in the meeting room. After the welcome, we presented the workshop program.

After the introduction, we started with the first lecture on “Basic of seismic wave propagation”. After the coffee break , the second lecture was devoted to “Marine Seismic Data Acquisition”, where the participant were introduced to the different type of sources and receivers, the acquisition system, the acquisition geometries and also the field quality control.

In the afternoon, the participants attended the lecture on “Seismic Data Processing”, that gave them an introduction on the different step needed to reduce all the type of noise and increase the signal/noise ratio (Automatic Gain Control, spherical divergence correction, statistical and deterministic deconvolution, velocity analysis and stack, spectral analysis and F-K removal of water bottom multiple, and migration).

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Last lectures of the first day was devoted to “Seismic Tomography and application to marine data”, focused on the concept of tomography, methods and algorithms, geophysical applications using tomographic method and examples of real cases.

2nd day (11th October 2022) – OGS R/V Laura Bassi and OGS Seislab

In the morning the participant made a visit on board the OGS R/V Laura Bassi. They were greeted on the bridge by the captain, that gave some information of the Vessel and described the activities on board during the navigation. Subsequently, a technician took them to visit the other part of the shio and then to see the instrumentation that is used for the acquisition of seismic data. The participants were introduced to the procedures for the deployment and recovery of seismic tools, and look at the air compressors for the seismic sources (Air Gun and GI gun), the 1,5 km streamer and the seismic data acquisition room.


After lunch, they move to OGS in the SeisLab for a hand-on practice seismic data processing session with Seismic Unix. They have been introduced to the software and taught on how it works. A seismic raw data and the script to elaborate “correctly” a seismic raw profile. Was available to the students on a common user’s folder, and they start the processing by their own, step by step with the supervision and help of the instructors. After the practical session, the students attended a lecture on “Seismic numerical modelling”, that gave them an overview different seismic models (direct, integral-equation and ray-tracing methods), numerical modelling issues and an example of acoustic propagation.

3rd day (12th October 2022) – OGS Seislab

The third day started in the OGS Seislab, where the participants make the seismic processing on their own (under the supervision of OGS personnel): they start with the raw data and , based on the lectures and the practical session they attended in the previous days, they were asked to make a standard elaboration.

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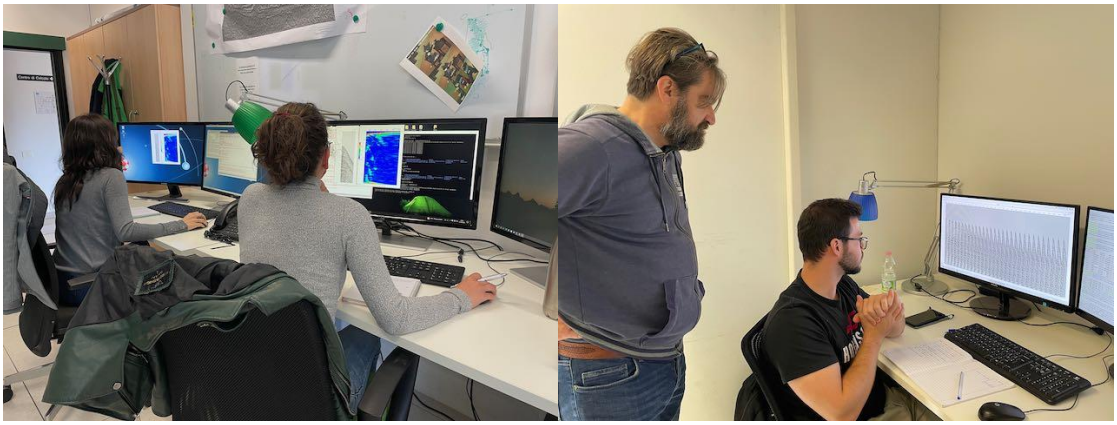
After the coffee break, we started another practical session focused on the Virtual Research Environment COLLA: the participants have been introduced on the COLLA environment, and on how to make the processing of seismic data by remote and how to share their elaboration within a work group.
The Seismic Lab ended around 1 pm.



Preliminary results

No results can be presented due to the nature of the course. (No sample collection and/or analysis)

Evaluation of student learning

No tests were conducted as the course was designed to e.g. share our experiences during ROV operations or to demonstrate how to operate a manipulator - not to teach educational knowledge in the classical sense or way. Testing the participants within our course structure was not applicable.

Students course evaluation

The participants were “very satisfied” with the course and they think that this experience will be “very beneficial” for their studies and future career.

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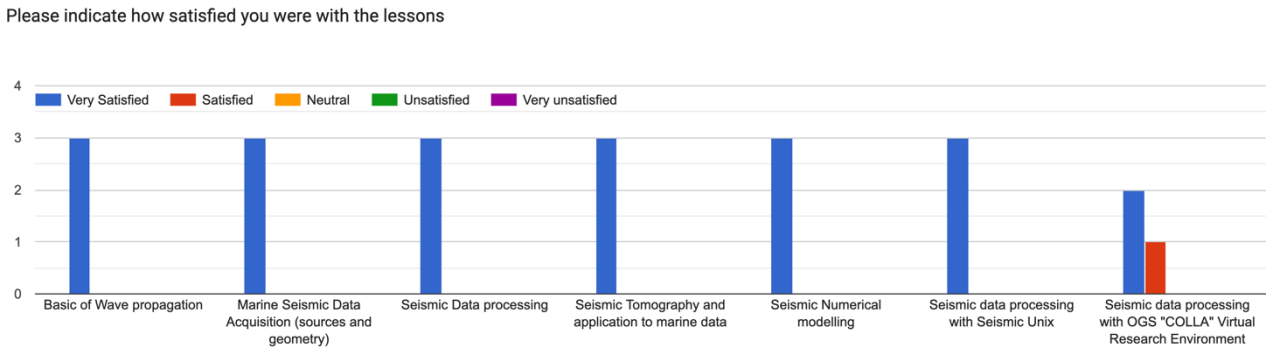

The students highlighted that the practice with Seismic Unix was very useful, and they suggest increasing the time devoted to it.

Concluding remarks

Based on the feedback of the participants and on our feeling during the workshop, this course has been successful.

During the classroom lectures, we showed the principles of the seismic data acquisition and processing, and moderate to them to initiate discussion, insights as well as exchange of experiences: this interaction was very appreciated from the students.

The practical sessions in these types of courses are necessary in our and attender's opinion, as demonstrate by their feedback. It helps the students to better understand the principles and procedures presented in the classroom activities.

We are aware that it is not possible to cover all the knowledge on seismic data acquisition and processing in such a short time, but the participants confirmed that this is a good starting point and it was very useful for them to better use seismic data in their studies and careers.

Appendix

- Seismic Lab course Agenda
- Course evaluation statistic

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Eurofleets+ Blue Skill Lab - Seismic Workshop

OGS-Istituto Nazionale di Oceanografia e Geofisica Sperimentale

Borgo Grotta Gigante 42/c

34010 Sgonico (Trieste)

From 10 to 12 October

AGENDA

DAY	TIME	PROGRAMME	VENUE
10 Oct	09:00 – 09:30	Welcome Speech	Conference Room "Michelato"
	09:30 – 10:30	Basics of waves propagation *Davide Gei*	
	10:30 – 11:00	Coffee Break	OGS Bar
	11:00 – 13:00	Marine seismic data acquisition (sources and geometry). *Fabrizio Zgur*	Conference Room "Michelato"
	13:00 – 14:00	Lunch	OGS Bar
	14:00 – 16:00	Seismic Data Processing *Flavio Accaino*	Conference Room "Michelato"
	16:00 – 16:20	Coffee Break	Conference Room "Michelato"
	16:20 – 17:30	Seismic Tomography and application to marine data *Gualtiero Bohm*	Conference Room "Michelato"
11 Oct	09:00 – 12:00	Visit onboard RV Laura Bassi	RV Laura Bassi
	12:00 – 13:00	Lunch	TBD

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	13:00 – 14:00	Seismic numerical modeling *Biancamaria Farina*	SeisLab
	14:00 – 16:30	Seismic data processing with Seismic Unix *Davide Gei, Edy Forlin*	SeisLab
	16:00 – 16:20	Coffee Break	OGS Bar
	16:20 – 17:30	Seismic data processing with Seismic Unix *Davide Gei, Edy Forlin*	SeisLab
DAY	**TIME**	**PROGRAMME**	**VENUE**
12 Oct	09:00 – 10:30	Seismic data processing with Seismic Unix *Davide Gei, Edy Forlin*	SeisLab
	10:30 – 11:00	Coffee Break	OGS Bar
	11:00 – 12:00	Seismic data processing with Seismic Unix *Davide Gei, Edy Forlin*	SeisLab
	12:00 – 13:00	Seismic data processing with OGS "COLLA" Virtual Research Environment *Paolo Diviacco, Alessandro Busato*	SeisLab
	13:00	End of Activities & Lunch	OGS Bar

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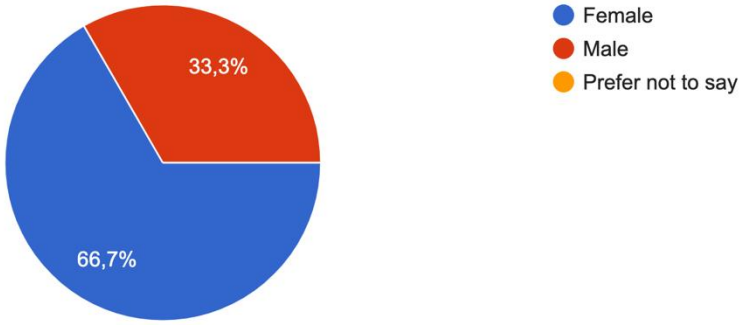
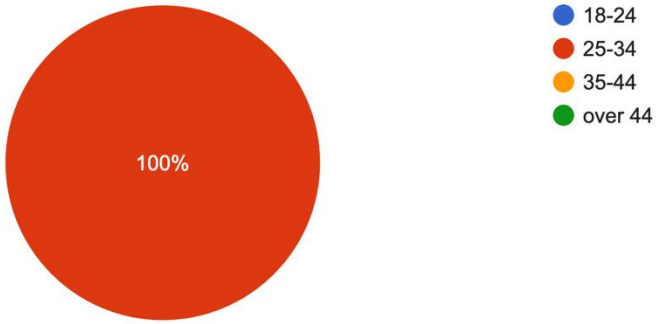
Please indicate your gender

3 risposte



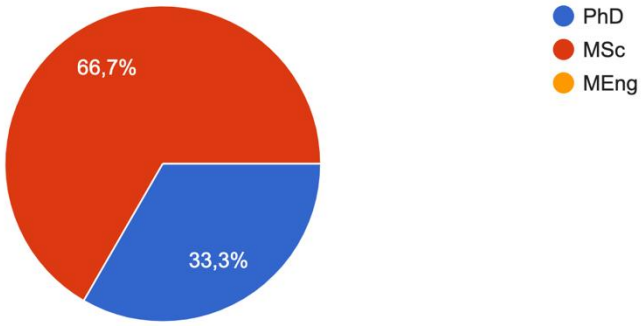
Please indicate your age group

3 risposte



Which of the following best describes your current academic profile?

3 risposte



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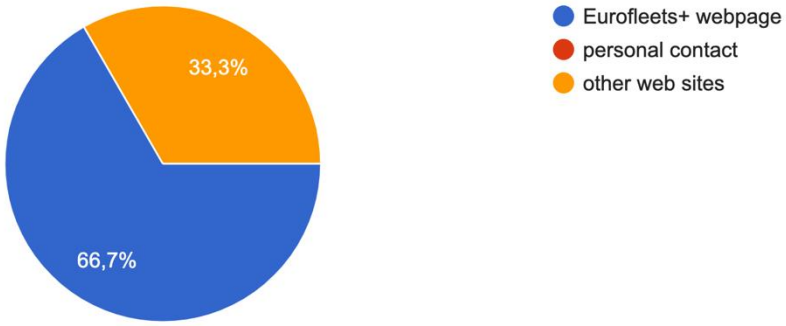
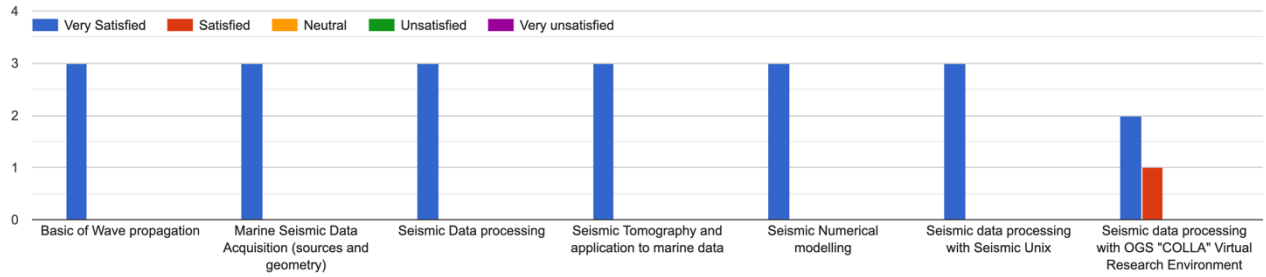
How did you know about the Seismic Lab?

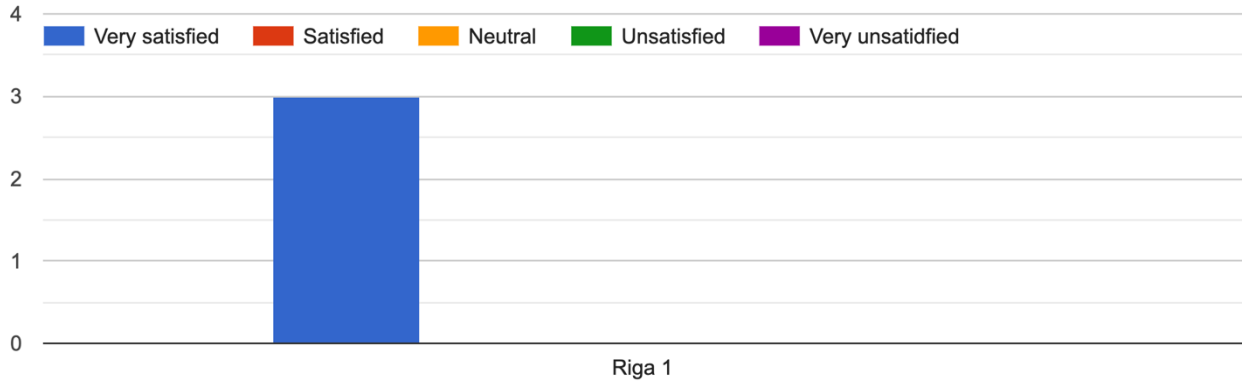
3 risposte



Please indicate how satisfied you were with the lessons



Overall how satisfied were you with the delivery of the Seismic Lab?



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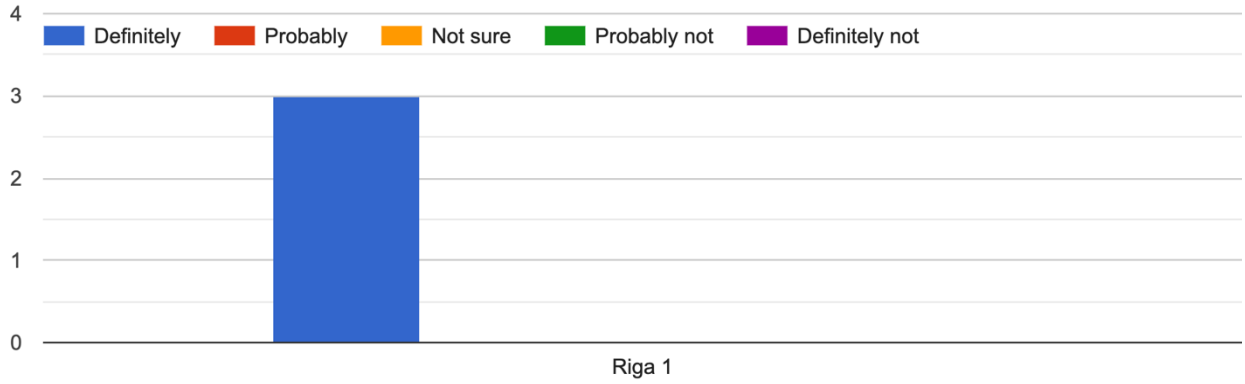
Do you believe the Seismic Lab experience will benefit your studies and future career?



Please feel free to comment on the highlights and/or lowlights of the Seismic Lab workshop

The seismic unix processing was one of the highlights, as well as the VSP

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Annex 6: Borehole Seismic Blue Skills Lab

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EUROFLEETS+ Blue Skill Lab

"BOREHOLE SEISMIC Lab"

At OGS, Trieste (Italy), October 12th-14th 2022

Participants

Cinzia Bellezza (OGS, Instructor)

Giorgia Pinna (OGS, Instructor)

Fabio Meneghini (OGS, Instructor)

Erika Barison (OGS, Instructor)

Piero Corubolo (OGS, Instructor)

Biancamaria Farina (OGS, Instructor)

Andrea Schleifer (OGS, Instructor)

Valentina Volpi (OGS, Instructor)

William Toson (OGS, IT support)

Alexandros Menegatos (Uni. Patras, Participant)

Sara Rodrigues (Royal Holloway Uni. London, Participant)

Nora Markezic (Uni. Trieste, Participant)

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Course objectives

Figure 1- Participants of the Eurofleets+ Borehole Seismic Lab

The Borehole Seismic Lab workshop is organized as part of the EurofleetsPlus training program and will be held at OGS, National Institute of Oceanography and applied Geophysics in Trieste (Italy). The three days' workshop (October 12-14, 2022) is offered to Marine sciences related researchers with no or only basic experience and knowledge of Borehole Seismic data acquisition and processing.

The workshop is closely related to ECCSEL-ERIC (European Research Infrastructure for CO_2 Capture, Utilisation, Transport and Storage (CCUS))and to the ECCSELERATE project (an EU-funded Horizon 2020 project aimed at increasing the use and ensuring the long-term sustainable operation of the ECCSEL ERIC RI), as the test site PITOP, where on-field activities will take place, is part of ECCSEL.

This workshop addressed the specific requirements of acquisition and processing of borehole seismic data in several class-workshops and and a field trip on a geophysics well test site:

Class Lectures:

- Vertical Seismic Profiling (VSP): an overview and application for CCS
- Instruments for borehole geophysics
- ECCSEL: the European Research Infrastructure for CO2 Capture, Utilisation, Transport and Storage (CCUS) - ECCSELERATE Transnational Access project

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- Electrical methods in well and at surface
- Well logging – an overview
- Seismic modeling application to borehole exploration
- VSP data processing with Vista (Schlumberger Software)
- VSP data processing with Seismic Unix

The aim of class lectures was to give a comprehensive overview of the principles of obteining seismic borehole data, the standard procedures for processing the data, and the use and application of borehole logging.

Field trip:

OGS technicians conducted a vertical seismic profile (VSP) survey at Piana di Toppo (PITOP) to showcase the latest advances and techniques in borehole geophysics.

Four applications have been received, and all oft hem have been considered suitable. The participants were from Italy, Portugal, Greece and Morocco. Unfortunatelly, the participant from Morocco cancelled its participation one week before the start of the workshop, for personal reasons.

In terms of gender, we had two females and one male.

Nature of the course and work carried out on the course

This course was aimed at early career marine researchers with any or only basic experience and knowledge of borehole seismic data acquisition and processing and who use and/or will use geophysical data in their research projects. Our aim was to introduce them to the procedures of borehole data acquisition and processing, and to introduce them in the application of this methods. The classroom activities were based on the presentation and explanation of the principle of well logging and the different type of logging.

On the second day, the participants were in the PITOP Geophysics test site, wher they had the opportunity to attend a well logging survey.

Infrastructures used during the EF+ Borehole Seismic Lab:

- **Well Geophysics facility PITOP** - The test site covers an area of approximately 22,000 m^2 and was designed and developed by OGS with the aim of providing a facility for the study and testing of innovative geophysical methods, technologies, and well / surface tools under realistic conditions, due to the presence of 4 wells between 150 and 420 m deep, instrumented with accelerometers, geophones and optical fibers (DAS). Furthermore, there are two sensor lines (geophones and DAS),

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buried about 50 cm deep. The facility has permanent laboratories equipped with instrumentation for recording and processing data in real-time. The site is a resource for seismic and seismological studies, and acoustic well methodologies for the national and international scientific community.The site is part of the ECCSEL - ERIC consortium, which includes the main centers of excellence on CO_2 separation, transport and confinement (CCS) from 9 European countries and represents a unique scientific test site in Italy.

Course Log

1st day (12th October 2022) – OGS meeting room

After lunch, all participants gathered in the meeting room. After the welcome, we presented the programme of the workshop. They attended a series of presentations on an overview and application of Vertical Seismic Proflies (VSP) to Carbon Capture and Storage (CCS), the tools used in borehole geophysics, and were introduced to the European Carbon Capture, Conversion, Transport and Storage (ECCSEL) research infrastructure and transnational access ECCSELERATE.

2nd day (13th October 2022) – Field trip to OGS well geophysics facility PITOP

In the early morning the participants met at OGS and drove to the well geophysics test site PITOP.

As part of the Eurofleets+ Borehole Seismic Workshop 2022, OGS conducted a demo Vertical Seismic Profile (VSP) survey at Piana di Toppo on October 13 to showcase the latest advances and techniques in borehole geophysics.

Among all the participants, the following members of the Borehole Geophysics Group were present: Andrea Schleifer (Senior Field Engineer), Cinzia Bellezza (Geophysicist), Fabio Meneghini (Field Engineer), Stefano Maffione and Andrea Palermo (Field Technicians).

After the presentation of the main site facilities and equipment, Schleifer and Meneghini explained in detail all the preparation steps the technicians were into, which was followed by a short introduction to the functioning principles of the main downhole tool, as well as the active seismic source used to inject energization in the ground, which in this case is the portable vibroseis *Elvis VII.*

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3rd day (14th October 2022) – OGS meeting room

The third day began in the OGS Michelato meeting room, where participants followed the lecture on downhole and surface electrical methods, focusing on resistivity theory, data acquisition layout and geometry, and the instruments used.

The second lecture was dedicated to an overview of borehole logging; it focused on the classification and use of borehole logging as well as on the different measurement methods (lithological, resistivity and porosity measurements). The last lecture introduced the participants to seismic modelling in borehole exploration, which aims to reproduce the behaviour of seismic waves travelling in the formations around the borehole.

After these presentations, an example of VSP data processing with "Vista" (Schlumberger software) and with Seismic Unix was shown in the SeisLab.

The Borehole Seismic Lab ended at 16.00.

Preliminary results

No results can be presented due to the nature of the course. (No sample collection and/or analysis)

Evaluation of student learning

No tests were conducted as the course was designed to e.g. share our experiences during ROV operations or to demonstrate how to operate a manipulator - not to teach educational knowledge in the classical sense or way. Testing the participants within our course structure was not applicable.

Students course evaluation

The participants were overall “very satisfied” with the course and they think that this experience will be “very beneficial” for their studies and future career.

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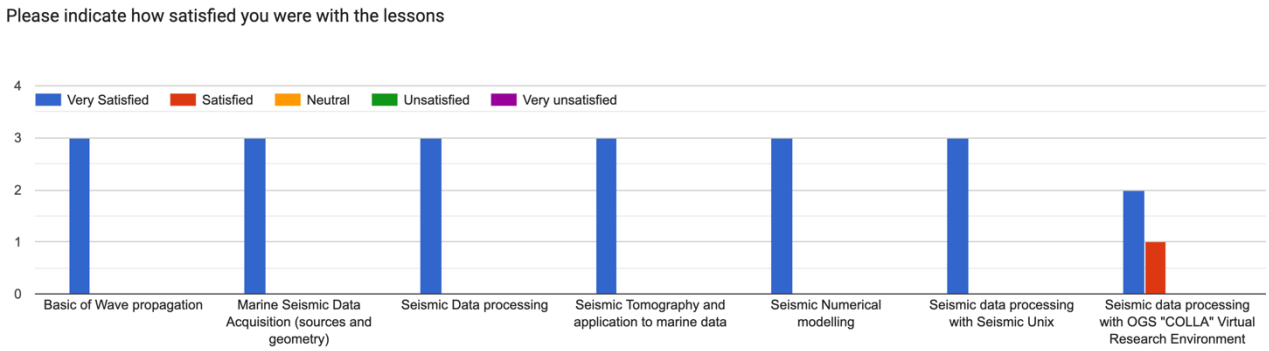

The students in particular appreciated the VSP data acquisition on field and highlighted that the demonstration of VSP data processing with "Vista" and Seismic Unix were very useful.

Concluding remarks

Based on the feedback of the participants and on our feeling during the workshop, this course has been successful.

During the classroom lectures, we showed the principles of the VSP seismic data acquisition and processing, and moderate to them to initiate discussion, insights as well as exchange of experiences: this interaction was very appreciated from the students.

The acquisition of VSP data on field was very interesting and useful, as demonstrate by their feedback. It helps the students to better understand the principles and procedures presented in the classroom activities, and they suggest being more involved in this field activity.

"Allowing the participants to perform some of the tests themselves (such as the borehole VSP or on-site processing) would be extremely helpful to understand how the methods work and are quality controlled. This could be done under careful guidance of the researchers involved, as well as the expert technicians."

Overall from our side and based on the the participants comments, we can confirm that this is a good starting point and it was very useful for them to better use this tools in their studies and careers.

Appendix

- Borehole Seismic Lab course Agenda
- Course evaluation statistic

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34010 Sgonico (Trieste)

From 12 to 14 October

AGENDA

DAY	TIME	PROGRAMME	VENUE
12 Oct	14:00 – 15:30	Vertical Seismic Profiling (VSP): an overview and application for CCS *Cinzia Bellezza*	Conference Room "Michelato"
	15:30 – 15:50	Coffee Break	OGS Bar
	15:50 – 16:30	Instruments for borehole geophysics *Andrea Schleifer/Fabio Meneghini*	Conference Room "Michelato"
	16:30 – 16:50	ECCSEL: the European Research Infrastructure for CO2 Capture, Utilisation, Transport and Storage (CCUS) ECCSELERATE Transnational Access project *Valentina Volpi*	Conference Room "Michelato"
13 Oct	09:00 – 16:00	VSP data acquisition on field	Geophysical Test Site "PITOP" Piana di Toppo (PN)
14 Oct	9:00 - 9:45	Electrical methods in well and at surface. *Erika Barison*	Conference Room "Michelato"
	9:45 – 10:30	Well logging – an overview *Giorgia Pinna*	Conference Room "Michelato"

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	10:30 – 10:50	Coffee Break	OGS Bar
	10:50 – 11:20	Seismic modeling application to borehole exploration *Biancamaria Farina*	Conference Room "Michelato"
	11:20 – 13:00	VSP data processing with Vista (Schlumberger Software) *Piero Corubolo*	Building "E" Room 46
	13:00 – 14:00	Lunch	OGS Bar
	14:00 - 16:00	VSP data processing with Seismic Unix *Cinzia Bellezza*	SeisLab
	16:00	End of Activities	

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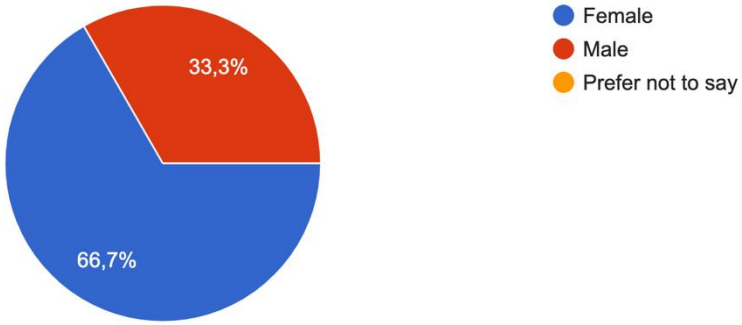
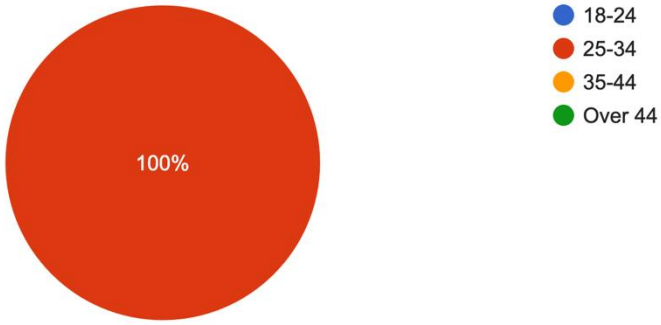
Please indicate your gender

3 risposte



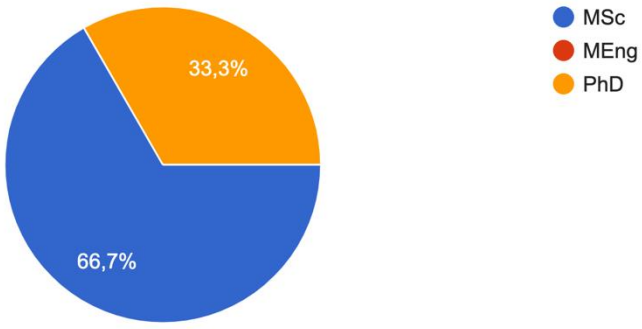
Please indicate your age group

3 risposte



Which of the following best describes your current academic profile?

3 risposte



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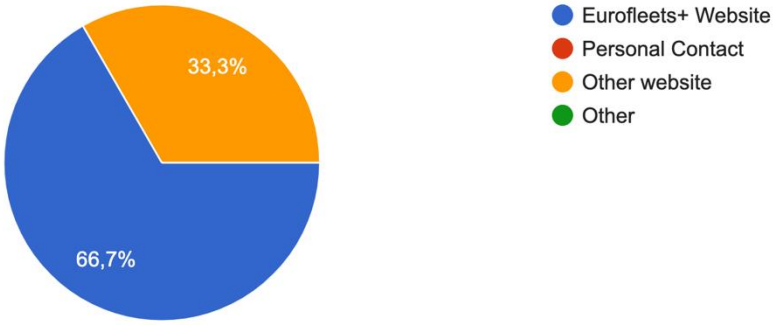
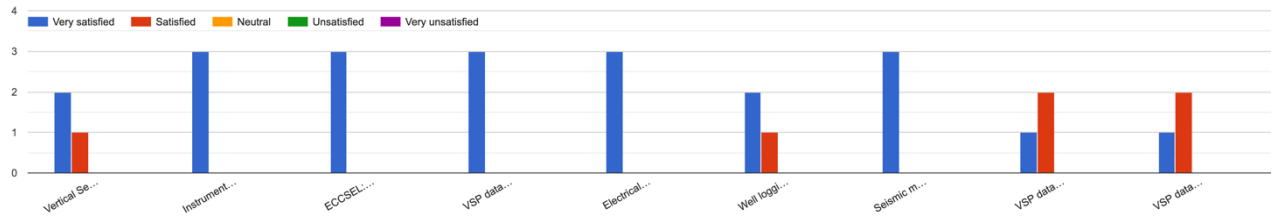
How did you know about the Seismic Lab?

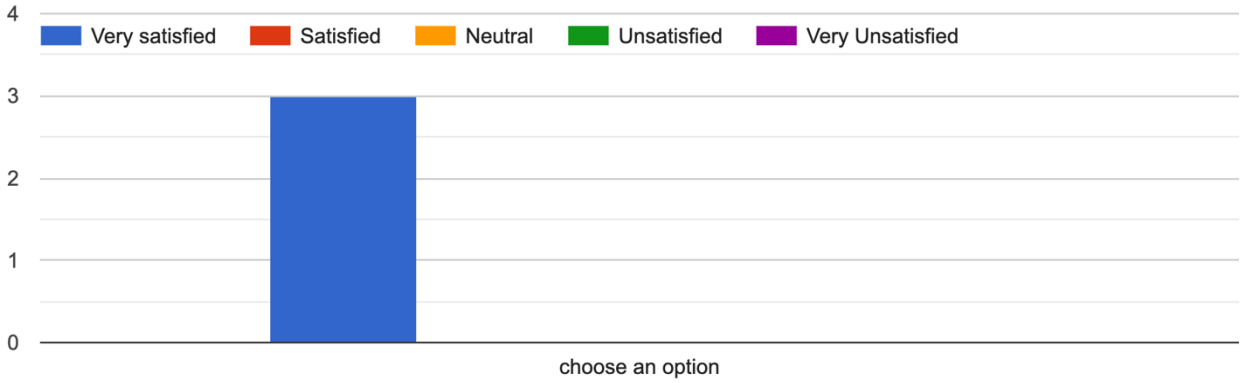
3 risposte



Please indicate how satisfied you were with the lessons



Overall how satisfied were you with the delivery of the Borehole Seismic Lab?



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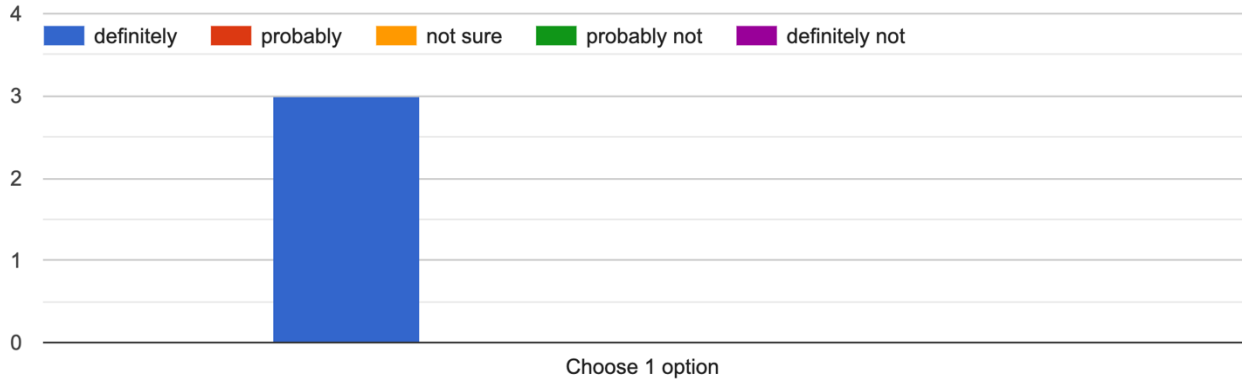
Do you believe the Borehole Seismic Lab experience will benefit your studies and future career?



Please feel free to comment on the highlights and/or lowlights of the Borehole Seismic Lab workshop

It was a really interesting workshop that give us the key component to link surface measurements with the reservoir data acquired in the well provide high resolution geological and geomechanical measurements vital to calibrate and constrain the processing of surface seismic and other data across the field.

The lecturers showed that the VSP is incredibly important to develop a time (ms) to depth (m) conversion, highlighting that it is an extremely powerful tool for academia and industry involved in seismic and well data acquisition / interpretation. During the well logging presentation, the lecturer should highlight better the importance of each log for applications or geological interpretations (especially those that are being currently used in research and industry), rather than give an extensive list of all the possible methods and well logs.

Everything was good

Please, outline any recommendations you may have for future Blue skill labs programme

Allowing the participants to perform some of the tests themselves (such as the borehole VSP or on-site processing) would be extremely helpful to understand how the methods work and are quality controlled. This could be done under careful guidance of the researchers involved, as well as the expert technicians.

Everything was good

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