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Summary

Within the framework of ARICE WP3 "Educating a new generation of polar researchers and professionals", APECS organised an "Early Career Technicians and Engineers Training". The online training sessions began on 30 March and concluded on 14 April 2021 and covered six training modules with a total duration of 13.5 hours. The objective of this training was to convey an insider's view of technical operations on research icebreakers, provide a platform for interactive knowledge exchange and maximise the practical experience possible using the online meeting format. An important element is the multidisciplinary character that this training activity was able to take thanks to the contributions of consortium partners. The six modules as listed below are covering a wide spectrum of operational, scientific and technological topics, namely:

1. How to Build a Deep Sea Robot, 2. Polar Marine Robotics, 3. Mooring Operations in Polar Waters, 4. Atmospheric Measurements Aboard Research Ships, 5. Technical Science Support at the British Antarctic Survey, and 6. Lab Management - My Lab is Moving!

Technical training modules (TTMs) were presented by experts in their respective fields.

The technical training was advertised through the ARICE, APECS and World Ocean Council outreach channels including websites and social media. We successfully generated a huge interest with 985 registrations in total. Participation was generally between 30-50 % of registrants, depending on the module. Audience expectations and satisfaction were evaluated before and after the training. The training reached the target audience as approximately half of the participants were junior/early career scientists or engineers. Participants came from all continents with the majority indicating the European Union (EU) as their current residence. Satisfaction with the course organisation, the training platform and the trainers was generally high.

Recordings of the training are available on the ARICE and APECS website as a training legacy of the ARICE project.

1. Online Technical Training Series

The Early Career Technicians and Engineers Training was initially conceived to take place aboard research vessels to facilitate practical knowledge by hands-on applications of scientific support technology on board. Despite several attempts for in-person training and due to the COVID-19 pandemic, organising the training on an icebreaking vessel was not possible. Instead, WP3 leads and the ARICE steering board members agreed that the deliverable should be facilitated as an online training and a project amendment was submitted accordingly. The project amendment was approved by the EC in November 2020 (4th Amendment). In January 2021, potential lecturers for the training were contacted. In the course of the following weeks, commitments to facilitate six training modules were secured. The objective of these modules was to provide an insider's view of technical and science support activities aboard research vessels, provide elements for implementation of new measurements and use of the ship as multidisciplinary/multi-domain observing platform, facilitate interaction and knowledge exchange.

a. Training module overview

The following section provides an overview of the technical training modules (TTMs), including brief presenters' profiles, as well as course content. The recordings of the TTMs are collected on the APECS Vimeo channel.

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TTM1: How to Build a Deep Sea Robot

The course was held on 30 March 2021, 8:00-11:30 GMT. It offered an introduction into the engineer's approach for developing scientific subsea technology. Emphasis was on enhancing understanding and communication between engineers and scientists in polar marine research. In addition to the theoretical part which included principal considerations and limitations, construction design and 3D modeling, participants used this knowledge to design a marine robot themselves.

The course was taught by Elena Schiller who is a construction engineer at the Alfred Wegener Institute and part of the HGF-MPG joint research group for deep sea ecology and technology.

The trainer provided the following course outline:

1. Introduction: Who even builds deep sea robots and why?
2. The steps of doing magic: From a scientist's demand to a diving science machine
    a. How to find out what a scientist wants
    b. Where to start
    c. Principal decisions and outlines
    d. Construction design - or how to make it work
    e. 3D modelling - or how to show a scientist what you intend to build
    f. Technical drawings and manufacturing - or how to make it real
    g. Assembly and tests - or how not to panic
    h. Deployment at sea - or how not to totally panic
3. Question & Answer session
4. Practical part: Design a deep sea robot! Starting off on a typical scientist's demand (like "I want to take sediment samples in close proximity of this particular type of coral in 4000 m depth" or "I need a seasonal cycle of water samples in 4000 m depth" or "I want a 1-week time lapse visual footage of this oyster bank at 300 m depth"), participants had the unique chance to brainstorm in small groups. During ~45 minutes of interdisciplinary exchange they discussed technical solutions presented in 2.c and d, and sketched a design idea for a technical solution to their scientist's demand. The course concluded with a discussion of the results in the larger group.

The course recording is available here and has been watched 83 times as of 29 September 2021.

TTM2: Polar Marine Robotics

The course was held on 12 April 2021, 8:00-11:30 GMT. This course offered a historical overview of polar marine robotics, considerations and experiences for robot design in cold environments, operational and logistic aspects and experiences from the activities of the National Research Council of Italy (Consiglio Nazionale delle Ricerche, CNR). Participants applied the knowledge gained in the course to plan a hypothetical campaign for a semi-submersible vehicle to acquire data and samples at the ice-water-air interface.

The course was taught by Massimo Caccia, the research director at the National Research Council of Italy (CNR), Angelo Odetti, a researcher at the CNR and Raffaella Beroldo, an administrative assistant in charge of campaign logistics at CNR.

The trainers provided the following course outline:

1. Historical overview of polar marine robotics: an introduction to the topic

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2. CNR marine robotics activities in Ny-Ålesund /Svalbard
    a. Scientific motivations
    b. Operational and logistic requirements
    c. "Polar-impact" on robot design
    d. Previous Arctic and Antarctic experiences (i.e. SESAMO, POLE, RAISE & e-Robot projects)
    e. Field campaigns: from at-field proof-of-concept demonstration to consolidated technology

        - 2015 Campaign: Robotics-supported data & samples collection - at field proof of concept demonstration: Shark USSV and the trimaran

        - 2017 Campaign: Cooperative heterogeneous UxVs for data & samples collection - at field validation: Proteus USSV and UAVs

        - 2018 Campaign: Custom-adaptation of robots for data & samples collection: Proteus USSV, winches and multi-sampler design

3. Interactive Work
    a. Planning of a one week campaign in Ny-Ålesund with an autonomous semi-submersible vehicle to acquire data and samples at the ice-water-air interface

The course recording is available here and has been watched 29 times as of September 2021.

TTM3: Mooring Operations in Polar Waters

This course was held on 13 April 2021, 9:00-10:30 GMT. The focus of the course were ocean moorings, widely used fixed platforms for long-term observations of the marine environment. After an overview on how to plan, design, equip and operate a mooring, the course explored mooring operations in the demanding, ice-covered polar areas. These operations are linked to unique challenges, related both to the platform design (instrumentation and mooring hardware) and to the manner of deployment and recovery from an icebreaker in conditions of partial or even full sea ice cover.

The course was led by Hanne Sagen, Senior Researcher, Nansen Environmental and Remote Sensing Center (NERSC), Norway, and Agnieszka Beszczynska-Möller, Senior Researcher, Institute of Oceanology of the Polish Academy of Sciences (IOPAN), Poland.

The trainers provided the following course outline:

Part I Mooring operations in polar water – a general introduction (Agnieszka Beszczynska-Möller)

1. Mooring as a platform for long-term measurements.
2. Environmental constraints for mooring measurements in polar waters.
3. Different types of moorings used for applications in the Arctic – open ocean and fjords.
4. Overview of moored instruments used for physical, biogeochemical and biological observations and their applicability to operate in polar waters.
5. Mooring hardware and localization equipment (acoustic pingers, Argos/Iridium beacons, avalanche beacons).
6. Mooring design and requirements for operations in ice-cover waters (MDD Toolbox, distribution of mooring components and buoyancy, ice avoidance, etc.).

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7. Deployment procedures (anchor first and anchor last methods, ship equipment).
8. Recovery procedures and possible challenges.
9. Examples of moorings and moored arrays in the Arctic Ocean and a future vision.
10. Discussion

Part II Mooring operations in polar water – a case study of the CAATEX experiment in the Arctic Ocean (2019-2020) (Hanne Sagen)

1. The scientific plan and design of the CAATEX experiment.
2. Design of CAATEX moorings for deployment and recovery in ice.
3. Field experiment planning (sea ice information, route planning, logistics) and changes to the plan.
4. Deployment procedure (drift tests, bathymetric survey, deployment procedure).
5. Positioning of moorings and transponder network.
6. Mobilization prior to recovery of under-ice moorings.
7. Recovery under normal conditions in the Nansen Basin (daylight in July)
8. Recovery in cold and dark conditions in the Beaufort Sea (Arctic night in late November)
9. Lessons learned and summary and discussion

The course recording is available here and has been watched 14 times as of 29 September 2021.

TTM4: Atmospheric Measurements Aboard Research Ships: Needs, Opportunities and Challenges

The course was held on 13 April 2021, 16:00–18:30 GMT. This course explored the challenges of taking atmospheric measurements on research ships. A team of experts introduced and moderated a discussion of relevant topics, the opportunities arising from new technologies and concrete examples of best practices. The overall aim was to communicate the opportunities arising by considering the ship as an observing platform for domains of the climate system other than marine sciences organizing research vessel expeditions in such a way that they significantly contribute to close the large observational gap of atmospheric ground-based measurements over the sea. This is an important and necessary step in building an observing system (both at polar and global level) that is able to monitor occurring climate changes and at the same time supply information useful to elucidate the most important mechanisms and processes that drive the climatic system.

The training was led by Vito Vitale, Director of Research at the Institute of Polar Sciences (ISP) of the National Research Council of Italy. Invited speakers included Christian Lanconelli (EU Joint Research Centre), Laura Riihimaki (NOAA Earth System Research Laboratories), Robert Weller (Woods Hole Oceanographic Institution), Aki Virkkula (Finnish Meteorological Institute) and Chris Fairall (NOAA Physical Sciences Laboratory).

The trainers provided the following course outline:

1. Short introduction: motivations and targets; practical arrangements
2. Research ship: a multi-disciplinary platform to close a gap, introduction to scientific needs for atmospheric measurements over the sea, also in connection with satellite observations; relevance for polar regions; general consideration on challenges for these measurements, needs for new technologies and also adaptation of methodologies

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3. Challenges in the observation of radiation fluxes over land and ocean;
   radiation budget as fundamental input for many marine processes, instrument calibration, data acquisition and analysis practices, observing methods in use on land and at sea, discussion on challenges in observations, in particular over titling platforms, discussion of land and maritime communities' active cooperation scenario
4. ASIMET – a modular system for surface meteorological observations
5. Modular instrument systems for high quality meteorological observations from buoys, research ships, and volunteer observing ships
6. Observation of the marine boundary layer, climate-quality near-surface meteorological variables for computation of air sea fluxes and boundary layer information, boundary-layer profiling systems
7. Aerosols observations at surface and in the atmospheric column
8. Discussion

The course recording is available here and has been watched 13 times as of 29 September 2021.

TTM5: Technical Science Support at the British Antarctic Survey

This training was held on 14 April 2021, 8:00-9:30 GMT. This course presented an overview of BAS's equipment options, offered a first-hand account on what spare parts to bring, the operations aboard BAS vessels, followed by a discussion on best practice.

The training was led by Bjorg Apeland, a marine technician at the British Antarctic Survey.

The training consisted of the following parts:

1. Equipment options and preparing for failure
2. Ship operations and challenges
3. Best practices for polar marine technicians
4. Career advice

The course recording is available here and has been watched 10 times as of 29 September 2021.

TTM6: Lab Management: My Lab is Moving!

This course was held on 14 April 2021, 13:00-14:30 GMT. The course focused on laboratory management aboard polar research vessels. This included the complex licensing and permitting requirements which are part of every aspect of work on board. Laboratory use on board a moving platform poses challenges through rough seas, seasick lab users, and tight mobilisation and demobilisation schedules laboratory managers must navigate. These topics were explored using the polar research vessels of the British Antarctic Survey as an example.

The course was led by Aisling Smith and Natalie Ensor, laboratory managers on board the RRS Sir David Attenborough, the British Antarctic Survey's new polar research vessel.

The trainers provided the following course outline:

1. Challenges of research at sea, preparation, equipment, and hazardous chemicals.
2. Permitting and licencing in unique environments
3. New research platform: RRS Sir David Attenborough

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The course recording is available here and has been watched 7 times as of 29 September 2021.

b. Advertising for the course

Once the programme for the training was agreed upon, the training was advertised through different mailing lists (i.e. cryolist), the ARICE and APECS websites, the APECS and ARICE newsletters and social media (Facebook, Twitter, Linkedin, Instagram). In addition, we reached out to the World Ocean Council, which advertised the training to their early career network.

c. Audience surveys

In order to gather information about the registrants and help the trainers prepare their courses, we conducted an audience survey before the training began. During the training, participants were also asked to fill out a short poll. After the training concluded, we asked the registrants to evaluate the training modules they attended.

The meta-statistics of the survey outcomes are evaluated in this Deliverable report D3.4 whereas the training quality will be evaluated in the frame of the Deliverable report D3.9 (Training Assessment Report).

2. Outcomes

a. Registration and Participation

A total of 984 registrations were recorded. The actual attendance was not recorded as the meeting format was chosen (instead of a webinar format which collects participation statics in zoom) in order to allow maximal interaction between trainers and audience. However, the participation in the individual modules can be approximated by the number of responses to the poll questions that were asked during the meeting even though not all participants answered the poll. Therefore, the number can be considered an underestimation. On average, each course received 164 registrations.

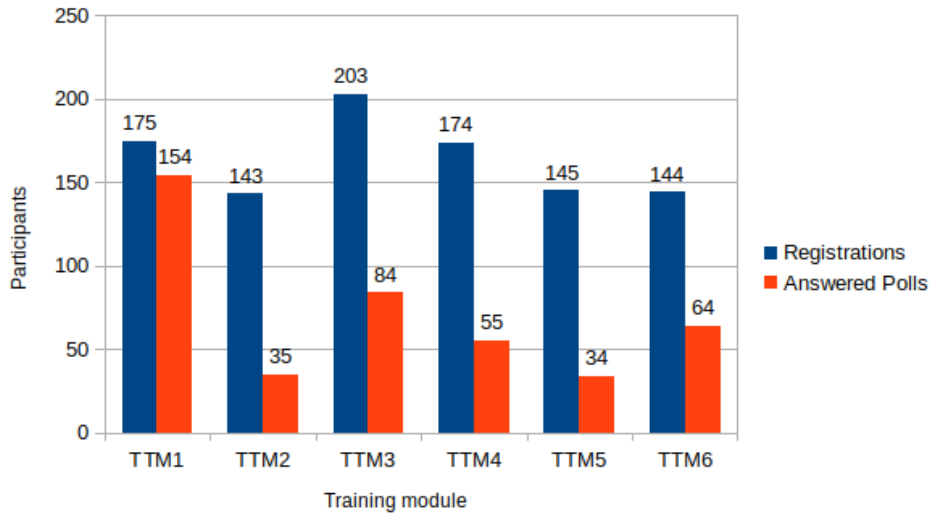

Figure 1. Number of registrations for each technical training module (TTM: 1. How to Build a Deep Sea Robot; 2. Polar Marine Robotics; 3. Mooring Operations; 4. Atmospheric Measurements Aboard Research Ships: Needs, Opportunities and Challenges; 5. Technical Science Support at the British Antarctic Survey; 6. Lab Management: My Lab is Moving!)

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The largest proportion (n = 200, 20 %) of participants registered target-oriented for a single module, and to a lesser degree for 2, 3, 4 and 5 courses (n = 164, 147, 116 and 75, respectively, or 8.3 %, 5.0 %, 3.0 %, and 1.5 %, respectively). 47 participants (4.8 %) registered for all six training modules.

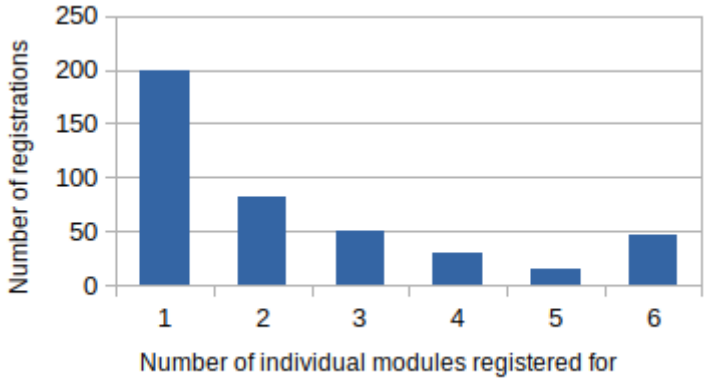

Figure 2. How many courses did registrants register for? The graph shows that the largest proportion registered for one course only.

b. Advertising

The audience survey conducted prior to the training provides insight into how the participants found out about the training. The APECS website and general social media combined had the biggest impact, followed by word of mouth.

Colleague/Friend	36.84 %
APECS Newsletter/Website	30.53 %
Social Media	13.68 %
Cryolist	7.37 %
ARICE Newsletter/Website	3.16 %
Other channels	8.42 %

c. Course evaluation participation and audience retention

The audience survey - conducted before the training started - received 98 responses, while the training evaluation survey received 85.

In this report, we focus on the responses provided in 85 answers of training evaluation surveys, unless stated otherwise. Introductory questions asked respondents to select the courses they were providing feedback for, as well as whether they had completed the audience survey and for which portion of the training they were present.

Table 1. Responses to the audience evaluation survey grouped by the technical training module evaluated.

Technical training module (TTM) evaluated	Number of responses	Percentage of total
1	13	15.3 %
2	12	14.1 %
3	14	16.5 %
4	9	10.6 %
5	14	16.5 %
6	11	12.9 %
1, 3	1	1.2 %
2, 3	1	1.2 %
1, 2, 3, 4	2	2.4 %
1, 2, 3, 5	1	1.2 %
2, 3, 4, 6	1	1.2 %
2, 3, 5, 6	1	1.2 %
3, 4, 5, 6	1	1.2 %
1, 2, 3, 4, 5	1	1.2 %
1, 2, 3, 5, 6	1	1.2 %
1, 2, 3, 4, 5, 6	2	2.4 %
Total number of respondents	85	100 %

The proportion of participants attending the whole course (i.e. audience retention) ranged from 50-94 %. In most cases participants remained for the full duration of the course. Figure 3 clearly indicates how the community of the forefathers obviously belongs primarily to the marine sciences. In any case, it is important that messages and information concerning not only marine sciences have also been conveyed to this community. The scientific communities are, despite all efforts, still quite separate. Among the tasks, that these courses and these training activities must pursue there is certainly also that of ensuring that communities, and especially young researchers, can interact and exchange information and ideas.

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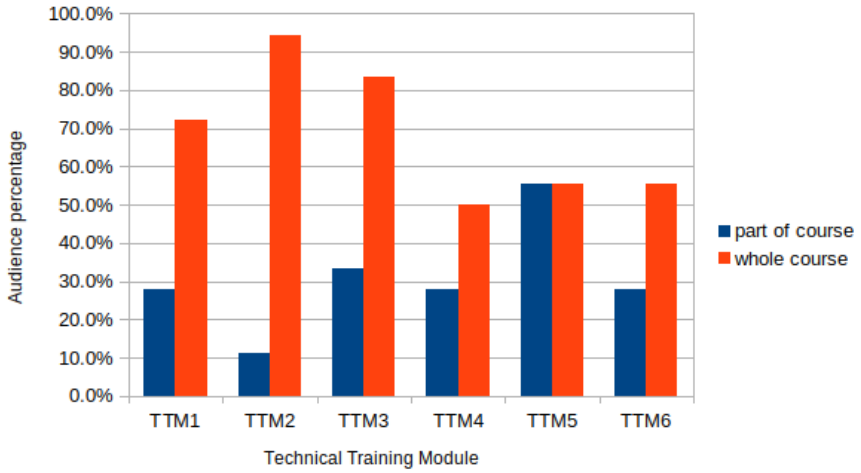

Figure 3. Attendant retention of individual modules as indicated by the audience survey.

d. Demographics

In the evaluation survey demographic information was queried in terms of gender, age, current country of residence, professional background, career and education level.

Gender

Out of 85 respondents, 45 (53.6 %) identified as a man, 38 (45.2 %) as woman, and 1 (1.2 %) preferred not to answer. None have identified as non-binary. Noteworthy, 63.2 % of participants in TTM1 identified as women whereas in other courses men tended to be in the majority with the exception of TTM6 where there men and women were represented equally.

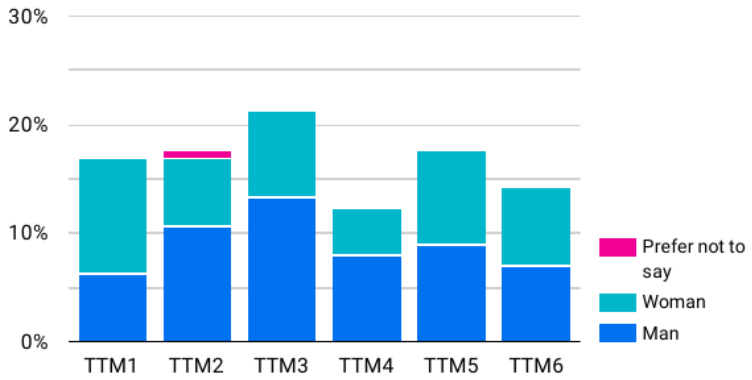

Figure 4. The gender of participants as the percentage of total responses grouped by training module (TTM: 1. How to Build a Deep Sea Robot; 2. Polar Marine Robotics; 3. Mooring Operations; 4. Atmospheric Measurements Aboard Research Ships: Needs, Opportunities and Challenges; 5. Technical Science Support at the British Antarctic Survey; 6. Lab Management: My Lab is Moving!)

Country of residence

The training drew a very international audience with participants from all continents (except Antarctica). 37.3 % participants were EU based (Portugal: 5.7 %, Finland: 4.6 %, Germany: 3.5 %, Poland: 2.3 %, and France, Romania, Spain and Sweden: 1.1 %), followed by the United Kingdom (22.9 %). Participants from Chile, Norway and Russia contributed 4.8 % of participants each; Brazil and Malaysia 3.6 % each; Canada, Iceland, New Zealand, South Africa 2.4 % each; and Australia, Egypt,

India, Mexico, Turkey, UAE and Uzbekistan 1.2 % each. This result is largely driven by two factors: 1) The ability to reach the possible interested parties, 2) the convenience compared to the time of day in the respective areas and the time at which the module took place. Some significant shortcomings are however evident: There is no significant participation of researchers from the United States; we also note the absence of both Japanese and Koreans. An in-depth look at the recordings could help us understand if this unsatisfactory result is more the result of less effectiveness in distributing news of webinars or the inconvenience for time zones. In the case of the North American continent, one cannot fail to point out that the lack of US researchers is offset by the Canadian participation (2.4 %).

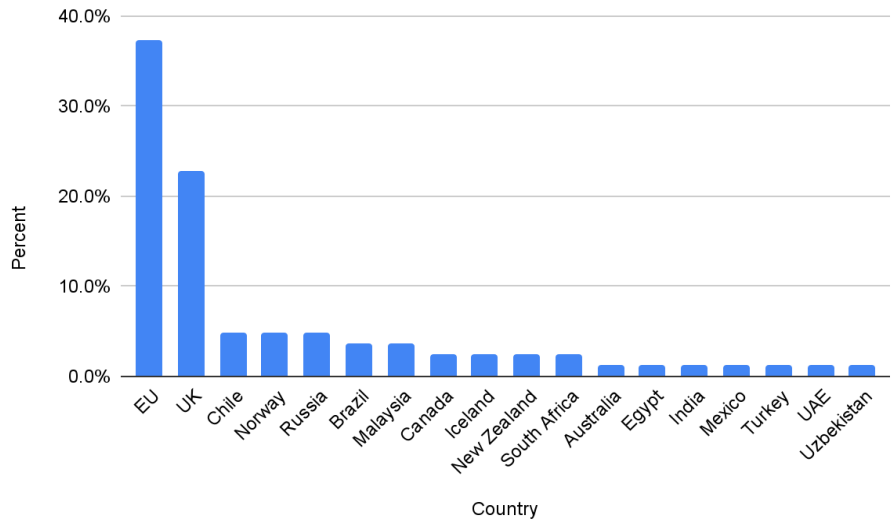

Figure 5. Course participant country of residence based on the evaluation survey responses as the percentage of total responses.

Education level

Overall, 35.3 % held a PhD degree or higher. The distribution varies across the modules, however. Approximately half of the participants in TTM3 held a PhD or higher, while 35 % of participants in TTM1 held either a bachelor's degree or a high school diploma.

Table 2. Results of education level query in the evaluation survey grouped by technical training module.

Module	n	PhD or higher	PhD Student	Masters	Bachelor	High School	Other
TTM1	20	25.0 %	0.0 %	30.0 %	25.0 %	10.0 %	10.0 %
TTM2	21	38.1 %	4.8 %	33.3 %	14.3 %	4.8 %	4.8 %
TTM3	25	48.0 %	0.0 %	32.0 %	12.0 %	4.0 %	4.0 %
TTM4	15	26.7 %	0.0 %	53.3 %	6.7 %	6.7 %	6.7 %
TTM5	21	28.6 %	4.8%	52.4 %	9.5 %	0.0 %	4.8 %

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TTM6	17	41.2 %	0.0 %	47.1 %	5.9 %	0.0 %	5.9 %
Total	119	35.3 %	12.6 %	4.2 %	1.7 %	5.9 %	0.0 %

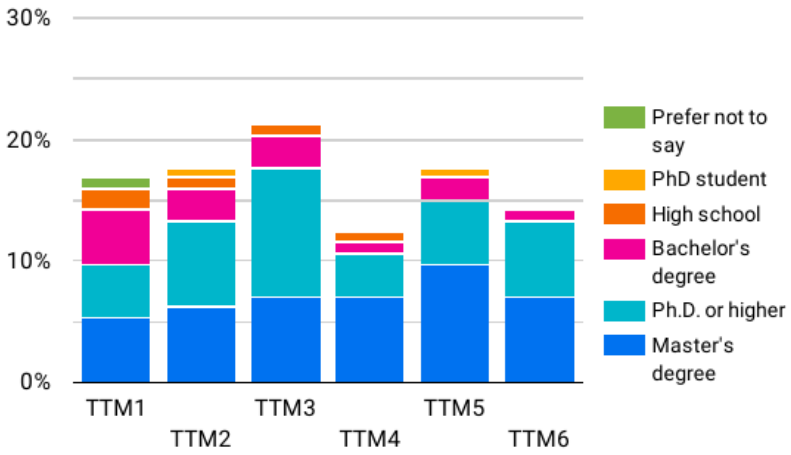

Figure 6. Education level of participants grouped by training module.

Career level

The career level of participants reflected the target audience for the training. Typically more than half of the participants were junior/early career scientists or engineers or in between junior and senior.

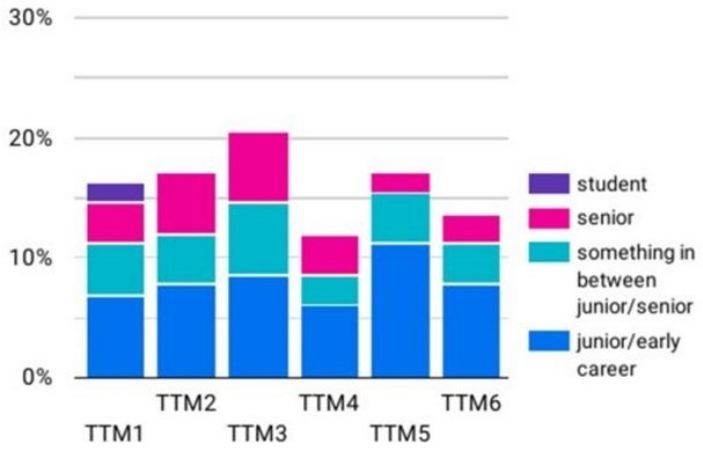

Figure 7. Career level of participants across different modules as reported in the course evaluation survey.

Professional background

The question on professional background in the course evaluation survey allowed participants to select multiple options. These were distributed to the different categories in the table below and thus the sum is greater than the number of respondents of the survey. Participants with a science background typically constituted the bulk of the attendees (~55.6 %), followed by technical support and engineering (11.3-6.0 %).

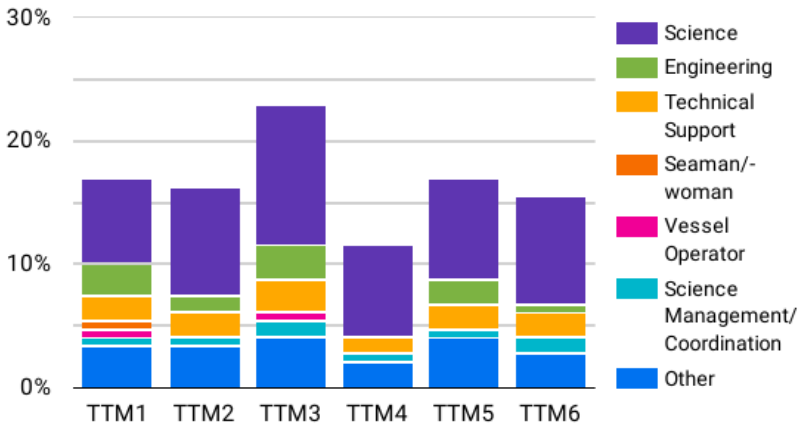

Figure 8. Professional background of participants as reported in the course evaluation survey.

Participants' age

The majority of participants across the courses were in the 26-35 age group (47.0 %). There are some differences among the modules; TTM1 drew the youngest audience, while the age group of 46-55 comprised a significant part of the audience in TTM3. In fact, TTM3 drew most attendees in the 46-55 demographic (3.4 %).

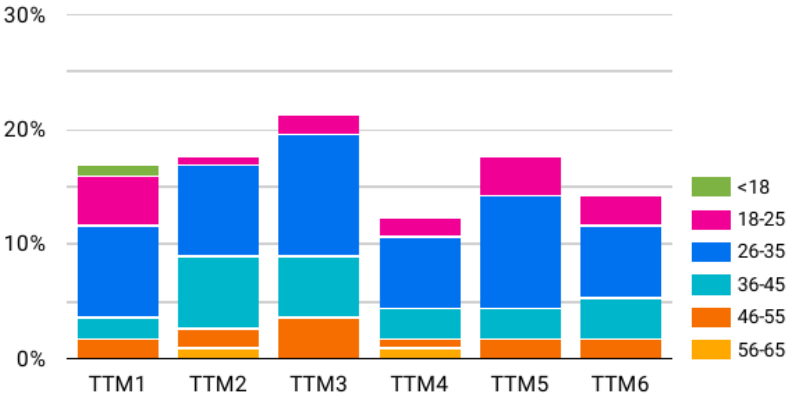

Figure 9. The age of training participants grouped by module.

Audience feedback

Nineteen participants provided comments and other thoughts on the training. The majority expressed appreciation for the training organisation in the digital format because it enabled participation. Other participants expressed a desire for more detailed, technical courses in the future. Some requested more structure in the delivery of the training, better practical and networking facilitation, lastly, the respondents wished for more online and in person training in the future.

Lessons learned

It became apparent that there is great demand for technical training courses considering the high number of registrations (984). The digital platform allows participation regardless of location, while the recordings of the training represent a lasting resource for early career professionals and the public at large.

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Most participants registered for one course only, indicating a very specific interest. Therefore, it is important to know the needs of the community and to be aware of technical advances in order to provide relevant content.

The audience also expressed a desire for future courses to be organised in this way, but some also would have liked more structure.

Despite the reference community was mostly in marine science, all the six modules were well received and convey a lot of interest with a high number of registrations and a sufficiently consistent real participation. The multidisciplinary and multi-domain aspect of the Training Course was well received and should be further developed in the future.

By relying on the APECS website and social media, the course advertising was successful in reaching the target audience. Early career professionals consistently comprised the majority of the audience. In addition, the training format enabled even more junior attendees, such as high school students.

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