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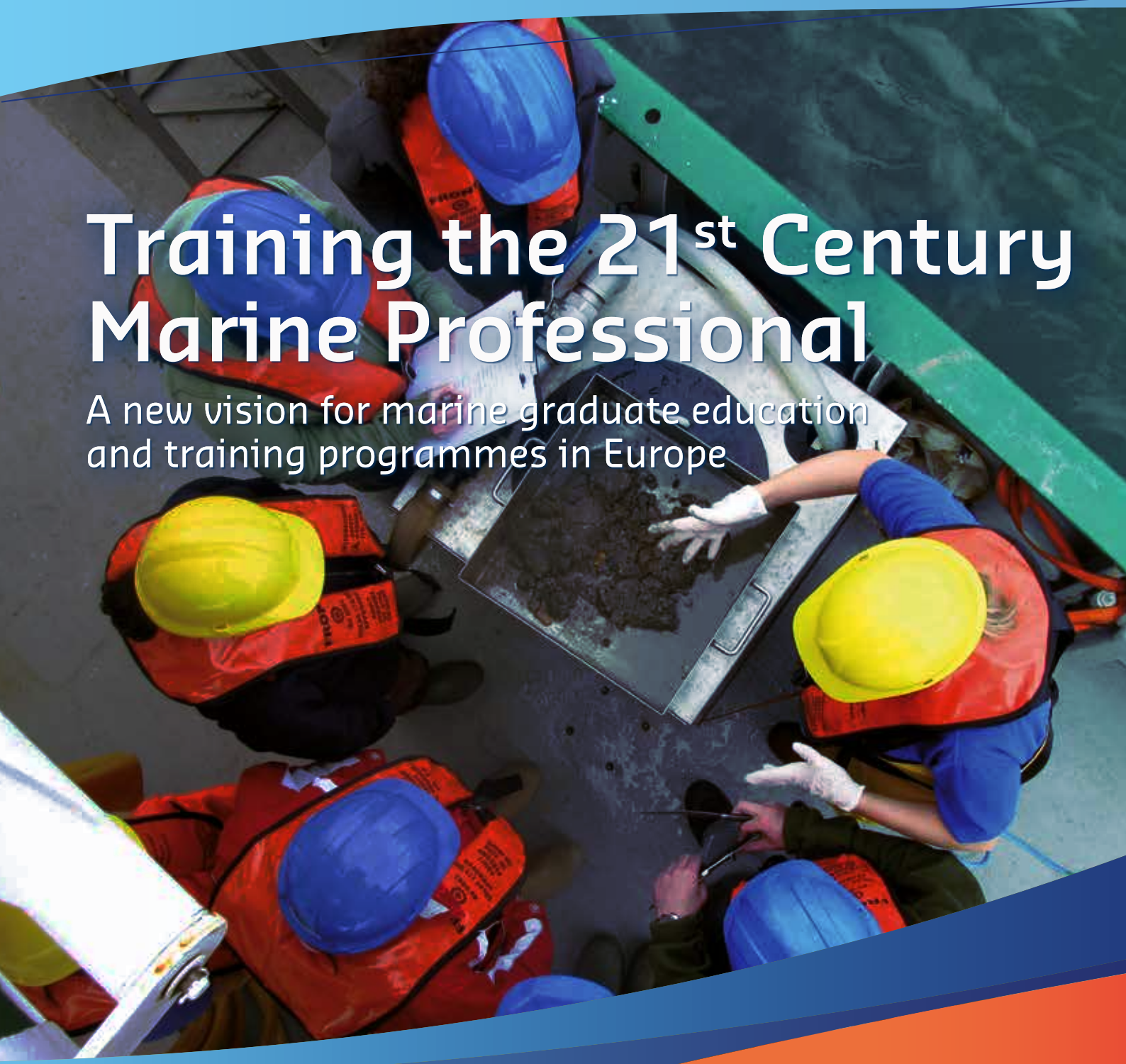

Training the 21st Century Marine Professional

A new vision for marine graduate education and training programmes in Europe

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Advancing Seas & Ocean Science

European Marine Board IVZW Future Science Brief 2

The European Marine Board provides a pan-European platform for its member organizations to develop common priorities, to advance marine research, and to bridge the gap between science and policy in order to meet future marine science challenges and opportunities.

The European Marine Board was established in 1995 to facilitate enhanced cooperation between European marine science organizations towards the development of a common vision on the strategic research priorities for marine science in Europe. Members are either major national marine or oceanographic institutes, research funding agencies, or national consortia of universities with a strong marine research focus. In 2018, the European Marine Board represents 32 Member Organizations from 18 countries.

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European Marine Board IVZW Future Science Brief 2

This future science brief is a result of the work of the European Marine Board Expert Working Group on Marine Graduate Training (WG Training - see list of WG members on page 47).

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Cover Picture: SMART Training, Ireland. Credit: Pauhla McGrane

Foreword

Publishing a paper on marine graduate training and education is a step away from the European Marine Board's traditional focus on core marine science topics, however it is a logical one. In 2013, EMB expanded its membership to welcome national or regional university consortia with a strong marine focus, and in 2016 these university consortia launched an official EMB Panel, the University Consortium Panel (UCP), dedicated to addressing areas of mutual interest. This naturally brings the wider concerns of marine training and education for the future well within the remit of the European Marine Board.

The working group on Marine Graduate Training (WG Training) was launched in 2014, in the wake of the European Commission publishing its 2012 Blue Growth Strategy. The marine and maritime sciences have a significant role to play in supplying high-quality graduates through training programmes and initiatives which are designed to address the needs of industry, science and policy. In order to facilitate the growth and job expansion envisioned by this initiative, a skilled workforce is required, comprised of graduates from many different levels of the educational system. Education and research are, therefore, central components of the Blue Growth and wider European and international strategies, especially the UN 2030 Agenda for Sustainable Development. It is recognized that training itself, and the delivery of high-quality graduate programmes, is a key part of the engine which will drive innovation, sustainability and technology development in maritime sectors. The aim of the working group was to provide a strong vision for the future marine science education and training, identifying ways in which to improve and broaden the skills and capabilities of the next generations of graduates. The document outlines high-level proposals towards improving the educational landscape of marine sciences in Europe and creating a coherent framework for the training of 21st century marine experts.

This topic continues to be current, making this publication timely. A new Erasmus+ -funded project MATES[1] (Maritime Alliance for fostering the European Blue economy through a Marine Technology Skilling Strategy) kicked off in January 2018, showing the ongoing importance of this topic to funders, industry, policy and the marine community alike. Many other examples of related initiatives are highlighted in this document. In fact, the importance of delivering industry- and policy-relevant education and training in an increasingly diverse job market is likely to continue to grow into the future.

On behalf of the EMB membership, I would like to extend my sincere thanks to the members of the EMB Marine Graduate Training expert working group (Annex 1) for their dedication and hard work in producing this excellent document. My thanks also go to the members of the EMB Secretariat, past and present, who have been involved in this publication, in particular to Noémie Wouters, Nan-Chin Chu, Paula Kellett, Kate Larkin, Niall McDonough and Sheila Heymans. Updating the complex marine graduate landscape will require close collaboration between all relevant stakeholders, but the rewards promise to be significant for both science and society.

Jan Mees
Chair, European Marine Board
April 2018

[1] http://www.projectmates.eu/

Contents

Executive summary

This publication is primarily aimed at three key stakeholder groups in Marine Graduate Training: Higher Education Institutes (HEI's), the marine and maritime industries, and National and European research funders. It will also be of interest to the wider marine and maritime research and policy community.

The main aim of the publication is to propose a new vision for marine graduate training in Europe, looking beyond the more traditional silo-based approaches to education. To achieve this, we must improve the capabilities of the next generation of marine scientists and engineers to work at a systems level, applying multi-disciplinary knowledge to address complex marine issues which cut across scientific, environmental and social systems. To achieve this, it is necessary to examine the very complex educational landscape that currently produces our professional marine experts, identify some of the key issues and challenges faced by educators, and make recommendations on how to improve marine higher educational training in Europe.

This document outlines the context of marine graduate training in Europe, highlighting the current mismatch between the needs of policy and industry in a changing world, and the typically more traditional approach to educating graduates within the University system, and therefore the needs that are arising. It then presents a more detailed mapping of the marine graduate landscape in Europe, exploring its current strengths and weaknesses to identify key gaps and needs which should be addressed. These challenges and opportunities are then discussed in the context of the 7 Innovative Doctoral Training Principles[2], proposing approaches to develop, expand and modernise current schemes, with relevant examples.

The European Commission's Expert Group on the skills and career development in the Blue economy has identified 3 key areas of importance for their discussions, namely education-industry cooperation, Ocean Literacy, and lifelong learning, mobility, education programs[3]. These three topics are also directly addressed in this document, as they represent increasingly important facets of marine training and education that perhaps have not been so prominent in the past.

The publication then presents clear recommendations to achieve a modern vision of marine graduate training, identifying the key actors and enablers as well as the steps towards implementation.

The main recommendations of this publication are to:

1. Modernise all marine graduate training programmes;
2. Develop training content by engaging the wider marine community across academia, government (policy & funding) and industry;
3. Maximise recruitment of students and professionals to take an interest in marine graduate training and blue careers;
4. Advance the European Higher Education Area for marine science and technology – structuring the landscape;
5. Deliver relevant policy support initiatives to address the gap between marine graduate training and Blue Growth;
6. Establish long-term, flexible funding instruments and national and EU level to support innovative marine training.

[2] https://euraxess.ec.europa.eu/belgium/jobs-funding/doctoral-training-principles, https://cdn4.euraxess.org/sites/default/files/policy_library/sghrm_idtp_report_final.pdf

[3] https://webgate.ec.europa.eu/maritimeforum/en/node/4139

The recommendations are presented in more detail in Chapter 4. The figure below indicates the required collaborations between the main actors and stakeholders in marine graduate training in order to implement these recommendations:

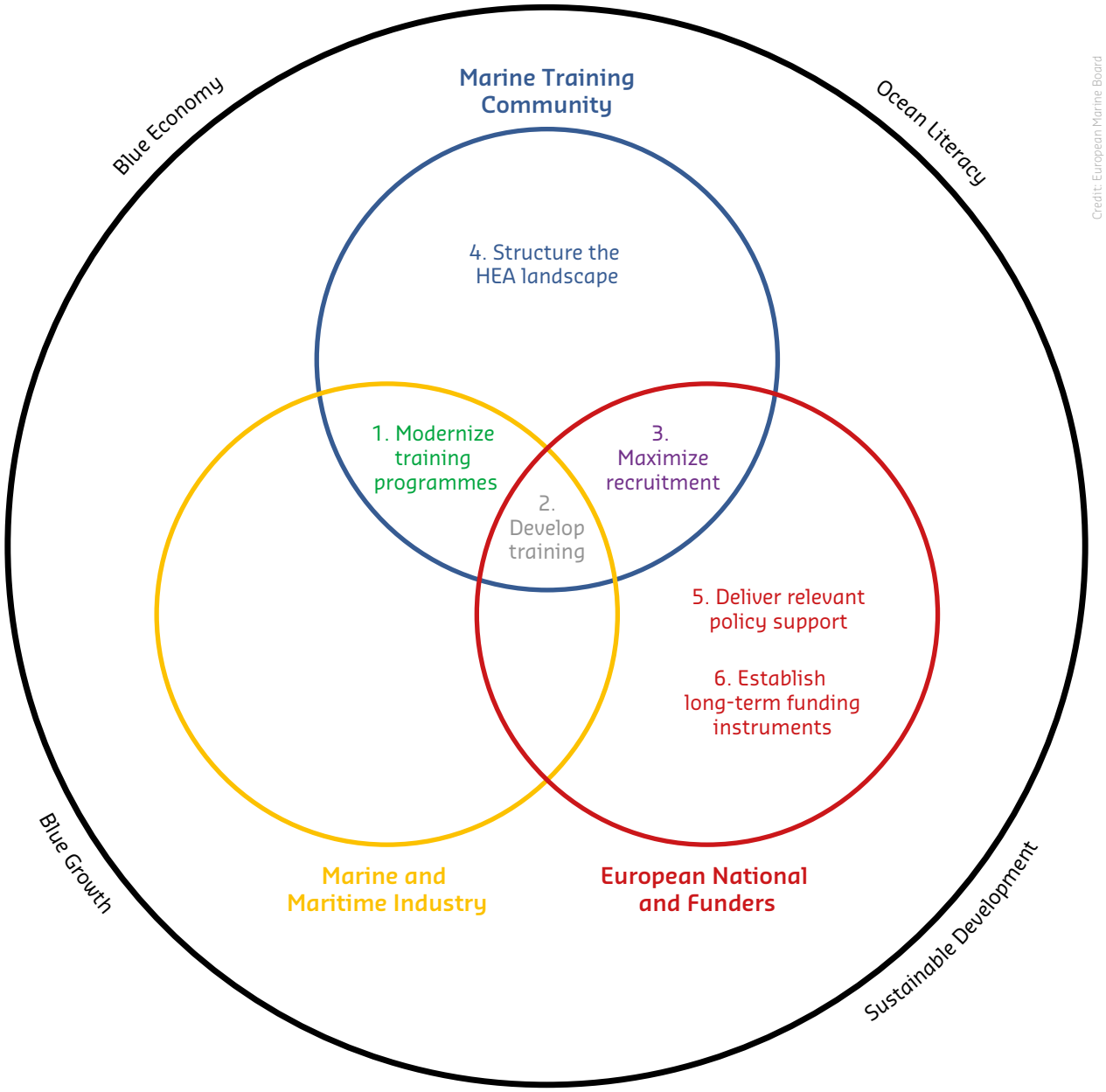


Figure 1.1: Key recommendations for marine graduate training showing key actors, set within the wider marine landscape,

1 Marine graduate training and Blue Growth in Europe

The EU has set strong targets for growth in the maritime economy - also known as "Blue Growth" - but managing human activities in the marine environment presents unique challenges. For Europe to realize the potential of a sustainable blue economy, skilled marine and maritime graduates are required with a specialized knowledge across multiple fields.

Marine graduate training should take full advantage of the major changes in graduate training (including Masters and Doctorates[4]) that have spread across Europe in recent years. This will ensure that in the future, marine graduate training will involve academia, industry and wider stakeholders to stimulate attractive career pathways across existing and emerging blue sectors.

1.1 Discovering, understanding, sustainably using and managing the last planetary frontier

The ocean is our last planetary frontier. Covering 71% of the earth's surface, it contains 97% of the planet's water and is such a crucial component of the earth and climate systems that it has been referred to as the planet's life support system. We only get 2% of our calories and 15% of our proteins from the ocean, although almost 50% of the global primary production takes place there (Scientific Advice Mechanism 2017). The ocean plays a fundamental role in climate regulation and is home to more than 40 ecosystems, of which at least 30 are open ocean or deep sea (Scientific Advice Mechanism 2017; Bertness *et al.* 2014). It provides by far the largest biosphere on the planet, supporting an enormous but largely unknown, and certainly the most extensive genetic diversity on earth (Heip *et al.* 2009). In recent decades, greater awareness of the importance of Earth's marine ecosystems in combination with major technological advances to assist our exploration and understanding of its properties, functions and vulnerabilities, make it clear that unsustainable exploitation is a notion of the past. Additionally, the Ocean Literacy movement has sought to bring this awareness and appreciation to a wider public, to ensure a more informed society.

Blue Growth has become the accepted terminology in Europe for the development and expansion of the maritime economy. Opportunities in Blue Growth are immense. The ocean harbours significant resources that can help to address the major challenges presented by a rapidly rising global population. This includes provisioning ecosystem services such as food from fisheries and aquaculture, water (through desalination), energy (both renewable and non-renewable) and raw materials including valuable minerals, ores and aggregates. The ocean is also a crucial medium for tourism, transport and commerce, and provides regulating services such as protecting coastlines and regulating climate, cultural services such as sense of beauty and space, and supporting ecosystem services such as the maintenance of habitats, food webs and biodiversity (Lange *et al.* 2014). However, human populations in coastal areas and economic activity in coastal seas are rising rapidly. In addition, activities such as oil and gas extraction, fisheries and marine mining are moving further offshore into deeper waters. Aside from the threats of hazards and accidents, these patterns pose a significant threat of overexploitation and conflicts in use, pollution and habitat destruction.

Credit: Paulita McGrane

Hands-on experience enhances learning

Scientific research and knowledge is central not only to understanding the ocean but also to developing ways in which we can benefit from its services and resources in a sustainable way; providing solutions to today's problems, without compromising the abilities of future generations to solve theirs (Scientific Advice Mechanism 2017; Visbeck et al. 2014). Essentially, understanding the complex relationship between humans and the marine environment is central to implementing sustainability. Blue Growth brings new challenges and responsibilities that require deeper knowledge of the ocean system and a wider appreciation of how to utilize the wealth of the ocean's ecosystem services in a sustainable way (Duffy 2006). As humans place more pressure on the ocean, from its deep sea habitats to coastal interfaces, it is essential that a new generation of marine scientists and engineers are trained in a way that best equips them to handle these complex, real-world challenges.

[4] The term PhD and Doctorate are used interchangeably throughout the document

In 2013, graduate education (Masters and Doctorate) in marine sciences and engineering accounted for only a tiny percentage of university and higher institutional programmes in Europe (European Marine Board 2013) and this has not changed significantly. Significant questions have also been raised about whether the current modes of tertiary training are equipping students with the skills and knowhow they need to enter the modern workplace within and beyond academia.

Recognizing this shortfall (European Marine Board 2014) in combination with an ongoing, EU-wide discussion about the need to restructure graduate training programs to meet 21st century challenges, the EMB convened an expert group. The purpose of the expert group was to assess the following:

- The current marine sciences graduate training landscape in Europe;
- EU-level programmes that support marine sciences graduate training; and
- Mismatches and challenges between supply and growing demand with respect to Blue Growth.

The expert group recognised that this is an opportunity to take advantage of the advances in Early Stage Researcher (ESR) training and education. These changes that have been promoted by the European Universities Association, and the European Commission see graduate training as the opportunity to provide researchers access to taught disciplinary and transferable/generic skills and experience in non-academic environments. The change in approach has been to recognise the fact that the Doctoral research project in itself facilitates the development of a wide range of skills. These include complex problem solving, critical thinking, teamwork, creativity, communication, project management and leadership. These are the very skills that are deemed necessary for employment in all sectors. Moreover, the changes also involve graduate training to engage with the key employers in that sector to ensure that Doctoral candidates have access to training in industry and other non-university placements. There is the opportunity for the main stakeholders in the marine sector to take advantage of the evolution of graduate training and provide focused support to Doctoral candidates that will benefit the Blue Economy.

Credit: Paulha McGrane

Practical training at sea is an important part of marine graduate education

1.2 Out of sync: the mismatch between current graduate training provision and the needs of European Blue economy

In 2014 the European Commission published a communication on Innovation in the Blue Economy (European Commission 2014). The Communication promoted specific elements of the 2012 EU Blue Growth strategy (InfoBox 1.1) which identified key strategic actions to underpin the future development of Europe's marine and maritime economy and set an ambitious target of creating 1.4 million additional blue jobs across a number of growth areas. Of the multiple gaps and opportunities identified by the Blue Growth strategy, particular importance was placed on the need for skilled and suitably qualified graduates in marine, maritime and engineering sciences in order to ensure innovation.

INFOBOX 1.1

Blue Growth

http://ec.europa.eu/maritimeaffairs/policy/blue_growth/

Blue Growth (COM (2012) 494) is Europe's long term strategy to support sustainable growth in the marine and maritime sectors. As a maritime contribution to achieving the goals of the Europe 2020 strategy for smart, sustainable and inclusive growth, the Blue Growth strategy consists of three components:

(1) Development of sectors that have a high potential for sustainable jobs and growth, such as aquaculture, coastal tourism, marine biotechnology, ocean energy and seabed mining.

(2) Provision of new knowledge, legal certainty and security in the blue economy, such as improvement of access to information about the sea, maritime spatial planning that will ensure efficient and sustainable management of activities at sea and integrated maritime surveillance to give authorities a better picture of what is happening at sea.

(3) Development of sea basin strategies to ensure tailor-made measures that will foster cooperation among countries.

Blue Growth aims to harness the potential of Europe's seas and coasts to create jobs and growth that will develop the blue economy, while making efforts to reduce negative environmental impacts of maritime activities, safeguard biodiversity and protect the marine environment.

Innovation across all sectors of the Blue economy will be essential in realising growth and jobs, but also with respect to environmental benefits and sustainability measures. The Blue Growth communication identified underinvestment in knowledge as a key weakness, including insufficient collaboration between public and private sectors on innovation, ineffective mechanisms for transferring research results into commercial applications, and a growing skills and knowledge gap. Fragmented and diffuse interdisciplinary learning was identified as slowing progress. It is in this context that policy makers and educators have begun to examine the current graduate training landscape in general and to look for ways to modify and restructure Masters and Doctoral degree programmes so that they better reflect modern needs both in research (production of new knowledge) and innovation (coupling of scientific knowledge with practical application). The good news is that there are programmes across Europe that do deal with the issues identified above.

The European marine science community itself has recognized this issue. The Rome Declaration (European Marine Board 2014), adopted on 8 October 2014 at the EurOCEAN 2014 Conference, called for "innovation in the provision of undergraduate and postgraduate training and enhancing skill sets and career pathways for marine professionals". The Declaration also stresses the need for education and training to encompass and foster cross-disciplinarity. In fact, across the broad range of marine and maritime sectors, there are currently only a few connections between marine graduate training priorities and the needs and expectations of future non-academic employers. This mismatch between academic training programmes and the needs of employers is not just restricted to marine graduate training and not just to Europe. Research has shown that in a global context (and considering training *sensu lato*), less than half of 18-25-year-old students believe that their education system is providing them with the skills needed to enter the workforce (The Economist Intelligence Unit 2015). There is now the opportunity for marine graduate training to build on the experience of graduate training programmes across Europe that operate so called structured PhDs or Doctoral Programmes. These programmes ensure that graduates are provided with the necessary disciplinary and transferable skills that will be of great benefit to future employers. Moreover, several of these programmes offer placement and training options in industry[5]. However, in general, there is no clarity, transparency and advertisement of the different types of programmes and what they offer in terms of eventual jobs. There is a clear need to give graduates this information, so they can orient themselves on the whole spectrum of possibilities (Nature Editorial 2017).

INFOBOX 1.2

Vasco da Gama Project

http://www.vasco-da-gama.eu/

The Vasco Da Gama initiative was launched by the Conference of Peripheral Maritime Regions of Europe (CPMR) in 2010: see http://cpmr.org/policy-work/maritime/education-training-vasco-da-gama/. One of its achievements is the project Training for Greener and Safer Maritime Transport (TGSMT) (2014-2016), led by the CPMR with a financial support from the European Union. It aimed to promote quality of education and training in the maritime transport sector, and launched the basis for European mobility for students, trainees, instructors and increased cooperation between industry and European educational and training actors to improve seafarers' competences and to adapt to the requirements of the shipping industry. The project also developed its own Masters Programme (January – June 2015) and organized International Summer Schools. The project ended on 3 March 2016, with a final conference held in Brussels.

Elements relating to the preparation of maritime policies post-2020, as stated in Section 2.4 of (CPMR 2017), CPMR's activities in the field of education and training are now grouped together under the Vasco da Gama initiative. Their aim is to develop a maritime strand within the New Skills Agenda (European Commission Directorate General for Emploment Social Affairs and Inclusion 2016).

In the wider context of transferable skills, a 2018 report by the European Commission (European Commission Directorate-General for Research and Innovation 2018, pp. 136) highlighted the needs for transferable skills to address education obsolescence and foster innovation. It notes that "By 2030, it is expected that nearly half of today's jobs will be automated or outsourced, 65% of today's schoolchildren will be employed in jobs that currently do not exist, and more than a third of what are now considered 'core skills' will be different". This clearly requires a forward-looking approach in order to ensure that we are providing relevant education not just for today's needs, but for those of tomorrow as well.

Marine graduate programmes and career pathways also lack the coordination and visibility that is crucial to inspire and recruit the next generation of marine and maritime professionals. Students interested in a Masters or Doctoral degree in marine sciences are often presented with a highly fragmented array of specialized and generalist courses, some of which are explicitly marine, while other opportunities are often hidden within other graduate disciplines (e.g. biology, geology, chemistry, geography, geophysics, physical oceanography, ecology, climate modelling, etc.). There is a real need for the main stakeholders at national and European level to collaborate in order to support dedicated training for marine

[5] The term industry can be interpreted in this document in its widest sense to mean covering all areas of non-academic/research employment.

graduates and also ensure that all training opportunities are well communicated.

In this Future Science Brief on marine graduate training, the objective is to identify and draw attention to both the challenges and opportunities that characterize the training-employment mismatch in marine and maritime sciences and to provide high-level recommendations on actions needed to advance the quality and relevance of training in these sectors, all in the context of Blue Growth.

It is also noted that in light of the UN 2030 Agenda and the Sustainable Development Goals[6] adopted in 2015, the awareness, skills and training needs associated with implementing these goals should also be widely considered.

1.3 Sectoral training needs and Blue Growth

Diverse criteria have been proposed to classify various economic activities directly or indirectly based on the use of the sea, all converging to allow for a better definition of what is meant by 'Blue Growth'. In 2012, the European Commission formulated its Blue Growth strategy (see InfoBox 1.1). It estimates that the blue economy represents roughly 5.4 million jobs[7] and generates a gross added value of almost €500 billion a year. It proposed 5 key areas for growth:

1. Aquaculture;
2. Coastal Tourism;
3. Marine Biotechnology;
4. Ocean Energy; and
5. Seabed Mining.

INFOBOX 1.3

European University Association (EUA)

http://www.eua.be/

The European University Association is the organization of universities and national rectors' conferences in 47 European countries with 850 members. As the voice of Europe's universities, EUA supports and takes forward the interests of individual institutions and higher education sector as a whole. Through its work and contacts with decision makers, such as taking part in the Bologna Process and the European Research Area, the EUA influences EU policies on higher education, research and innovation.

TERMINOLOGY

Marine - Refer *sensu lato* to all natural sciences and engineering, both applied and basic, that focus on oceanic, estuarine and coastal ecosystems and processes of the environment. Examples include biological oceanography, marine biogeochemistry, marine geology, physical and chemical oceanography, marine biology, marine conservation, marine fisheries biology, aquaculture, marine ecology, marine genomics, marine biotechnology, marine microbiology, conservation; including advanced modelling, use of big data and other advanced technologies relevant to the aforementioned areas. Other forms of Masters and PhDs focused on engineering disciplines as applied to marine settings are also included here.

Maritime - Refer to industrial activities including, for example, shipbuilding, shipping, ports, offshore platforms, fisheries, aquaculture, offshore and deep-sea mining, dredging and aggregate extraction, spatial planning and tourism. Some of these areas overlap with marine sciences directly.

Graduate - Within Europe graduates are defined by the Bologna Process[8] as those who have successfully obtained a Masters (or equivalent) or PhD degree. However, in the UK and Ireland, a graduate refers to a student who has been awarded a first academic degree (a Bachelor degree). The experts of WG Training agreed that in this document the term "graduate" shall refer only to those enrolled at Masters and PhD levels.

Early Stage Researchers (ESRs) – Researchers in the first four years of full-time research following their primary degree that have not been awarded a Doctoral degree.

Marine Graduate Training - The scope of this Future Science Brief is marine graduate training and it was agreed by the Working Group that this term will encompass training at the level of Masters and PhD. Some attention is also paid to Continuous Professional Development (CPD) although it is not a central topic of this document.

[6] https://sustainabledevelopment.un.org/post2015/transformingourworld

[7] https://ec.europa.eu/maritimeaffairs/policy/blue_growth_en

[8] http://www.eua.be/policy-representation/higher-education-policies/the-european-higher-education-area-and-the-bologna-process

Most of Europe's economic activity is currently land based, and the size of the blue economy is hard to estimate accurately[9]. However, considering that:

- The ocean occupies two thirds of the Earth's surface and contains vast biological, mineral and energy resources;
- Most of the world's population lives near coastal areas, highly attractive for tourism and leisure activities but also exposed to natural hazards; and
- Maritime transport and shipping activities are expected to increase significantly in the next decades.

One of the main challenges for the 21st century is how we can interact with the sea and benefit from the goods and services it provides for human populations in a sustainable way, ensuring that those goods and services will also be available for the benefit of future generations.

New uses of the sea and the foreseen intensification of marine and maritime activities require re-thinking on how the training of the next generation of marine scientists and technicians should be formulated at the European level to better prepare them for new challenges ahead. This is one of the main issues addressed in this report.

Looking closer at the sectors proposed above, our interaction with the sea falls into three main categories:

1. Its use as a medium for transportation and leisure activities;
2. Its use and vast potential as a major source of living, mineral and energy resources (known and yet to be discovered); and
3. The difficulties we have to manage our interactions with the sea related to highly populated land/sea interfaces which are exposed to natural hazards and the effects of climate change (e.g. sea-level rise).

It is worth noting that, in terms of employment, the most important sectors are currently leisure/coastal tourism and maritime transport. While these are the sectors expected to contribute most to Blue Growth in absolute terms, they will have a low impact on the employment of highly-trained marine graduates because most of their workforce has either a lower level of training or has trained in a field that is not specifically marine or maritime. It is difficult to link the employment of highly qualified graduates with the current activities of the tourism and leisure sector. However, opportunities exist to expand more active science-based tourism products such as marine wildlife safaris, eco-tourism and Citizen Science. Although there seems not to have been a recent significant increase in demand to recruit marine graduates from well established companies operating in this domain, these opportunities are now being seized by young marine graduates by creating their own innovative small companies in this expanding field. For maritime transport, an increasing level of scientific expertise will be required to promote efficiency and reduce harmful environmental impacts. Issues to be addressed include navigation efficiency, monitoring of pollution, fouling and corrosion control, energy saving solutions, better broad-band communications at sea, and a new generation of low noise, efficient and safer "green" ships.

The other two sectors with a significant labour force are fisheries and aquaculture. While these sectors also support a workforce largely comprised of people with medium to low academic qualifications, marine science and technology plays a crucial role in supporting technological innovation; promoting health, safety and traceability; and in formulating knowledge-based policies and management practices for sustainability and environmental protection. According to a recent report (Scientific Advice Mechanism 2017) the main growth potential for aquaculture lies in marine aquaculture, particularly in algae and filter feeders like mussels. These are also labour-intensive activities and they are in need of technological advancement. This also applies to harvesting of lower trophic resources, like zooplankton and mesopelagic fish, which is another potential source of increased harvest from the ocean. as well as understanding the implications of these new food sources for the health of the marine ecosystem.

Credit: European Marine Board

The move to marine renewable energy sources will require highly skilled and trained graduates

[9] https://webgate.ec.europa.eu/maritimeforum/frontpage/225

Gradual replacement of fossil fuels with renewable energy sources is a long-term societal challenge and a key objective of the Blue Growth strategy. It is expected that the production of electricity from renewable energy sources (RES) will increase significantly in the next decades and certain countries can already demonstrate success in using alternative energy sources (e.g. 70% of the electricity demand in Portugal is supplied by renewable energy sources). An important fraction of the RES supply could come from ocean energy including wind, tidal and wave energy (and ocean thermal energy conversion, or OTEC, in some of Europe's outermost regions at lower latitudes). Expanding ocean energy opportunities will require skilled graduates, trained in addressing multi-disciplinary technical, environmental and governance challenges.

A wide range of expertise and complementary sciences is also essential for environmental monitoring and coastal protection. The sustainable use of the seas and ocean requires more knowhow on issues such as marine natural hazards and environmental protection and conservation, taking into account the policy goal of ecosystem based management, fundamental to implementation of the EU Marine Strategy Framework Directive (MSFD). Marine Spatial Planning (MSP)[10] is becoming the unifying umbrella under which marine ecologists, oceanographers, coastal engineers, geologists, economists and social scientists can contribute to evidence-based decision-making which minimizes user conflicts, hazard impacts and environmental degradation.

Extraction of non-living resources and biotechnology are where new knowledge must be acquired and scientific research and innovation will play a crucial role. Extracting aggregates, minerals, rare earth elements and water from the ocean requires a wide range of expertise from geology and geophysics, to engineering, materials science, ocean chemistry, physical oceanography, benthic biology/microbiology and ecology. It will be necessary to devise new exploration and exploitation methods, largely based on innovative robotic solutions, and to predict, assess, mitigate, monitor, inspect and regulate the environmental impacts of such activities.

Marine (blue) biotechnology, is a rapidly expanding sector that is currently more scientifically- than economically-driven, but presents significant potential for development as a Blue Growth sector (Querellou et al. 2010; European Marine Board & Marine Biotechnology ERA-NET 2017).

Looking more specially at the maritime technology sector, a 2016 report (SEA Europe et al. 2016) specifically highlights the need for a highly skilled workforce who can drive industrial innovation.

In summary, the extent to which graduates with Masters and PhD qualifications in marine sciences and engineering can contribute to the blue economy varies substantially across the different sectors. Those areas that require a high degree of technical innovation and new models of regulation and governance are more likely to need and attract these graduates. Indeed, highly-trained marine graduates should be entitled to an expectation of reasonable employment opportunities using the knowledge and skills gained from their training. However, the reality is that this training often fails to provide the suite of multi-disciplinary expertise that will make them attractive to employers outside of academia.

Credit: Paulita McGrane

Marine graduates with multi-disciplinary training will be able to help support the many aspects of the Blue Economy

INFOBOX 1.4

League of European Research Universities (LERU)

http://www.leru.org/

Founded in 2002 as a consortium of some of the most renowned research universities in Europe, LERU advocates for the promotion of basic research at European universities. It aims at furthering the understanding and knowledge of policy makers about the role and activities of research-intensive universities. LERU has become an interlocutor for the European Commission on various research topics (Horizon 2020, the European Research Area, Open Science, etc.) and acts as the voice of European research-intensive universities on topics related to EU research policy. LERU took the initiative for the creation of a Global Council of Research Intensive University Networks to stimulate collaboration on research policies worldwide. Their advice paper "Good Practice Elements in Doctoral Training[11]" (2014) recommended that funders and policymakers promote innovative Doctoral training methods in universities, for example, by encouraging creativity and engaging effective skill development.

[10] http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm

[11] http://www.leru.org/files/publications/LERU_AP_15_Good_practice_elements_in_doctoral_training_2014.pdf

1.4 Existing European policy and funding mechanisms for education and training

For many years there have been various policy initiatives on education and training at the EU level, however it is only since 2006 that there has been a clear focus on Doctoral training. There is now a coordinated EU approach to Doctoral training across the education/training and research sectors. In addition to Member State policies, there are key stakeholder organizations that contribute to policy development including the European Universities Association (EUA – See Infobox 1.3), the League of European Research Universities (LERU – See Infobox 1.4) and Science Europe (SE – See Infobox 1.5).

1.4.1 Policy

The EU already has in place strong policy on the education and training of graduates. This policy straddles the areas of education, research and employment especially as the PhD is the transition point from full-time education to becoming a researcher and then entering the broader workforce. For higher-level training as a whole, a major policy realization consists of the implementation of the Bologna process[12] to promote transparency in European Higher Education and also to facilitate mobility by providing common tools (e.g. European Credit Transfer and accumulation System – ECTS) recognized at European level[13].

A convergence of EU education and research policy on Doctoral training is encapsulated in the Innovative Principles for Doctoral Training (IDTP) (European Commission Directorate General for Research and Innovation *et al.* 2013). These seven principles, developed in 2011, are Research Excellence, Attractive Institutional Environment, Interdisciplinary Research Options, Exposure to industry and other relevant employment sectors, International networking, Transferable Skills Training and Quality Assurance. They encapsulate European policy on doctoral degrees; high quality research but ensuring that the Doctoral candidates are equipped for the widest possible employment opportunities through inter-sectoral mobility and research/transferable skills training.

The Innovative Principles for Doctoral Training were developed in the ambit of ERA policy and integrated into the agenda for the Modernisation of the European Higher Education Area International networking in 2011 (European Commission Directorate General for Education and Culture 2011). They are considered best practice for Doctoral training in the Framework Programmes and are mandatory for Marie Skłodowska-Curie Actions in Horizon 2020. This approach to Doctoral training captures all of the desired features of graduate training in the context of the Blue Growth agenda.

Credit: Karen Hissmann / JAGO Team / GEOMAR

Submersible pilot and microbiology graduate debark from the research submersible JAGO on the deck of the German research vessel M.S.MERIAN after a dive at the methane gas vents off Spitsbergen / Norway. FS MARIA S. MERIAN Expedition MSM 21-4, August 2012, Spitsbergen

[12] http://www.eua.be/policy-representation/higher-education-policies/the-european-higher-education-area-and-the-bologna-process

[13] The doctorate is recognized as the Third Cycle in the Bologna process in contrast to the previous Cycles that focus on learning outcomes. It is characterized by the development of new knowledge through an original body of research which is embodied in the PhD thesis. On the research side of EU policy, the European Framework for Researcher Careers identifies the doctorate as the qualification to become a researcher. In that framework, the Doctoral candidate is a First Stage Researcher (R1).

Any change that will happen in the higher education training landscape will require the support of the heads of academic institutions. In 2005, the EUA (InfoBox 1.3) developed the 10 Salzburg Principles for the Third Cycle (Christensen 2005). These were further developed to fully support the development of structured PhD programmes and Doctoral schools in 2010 (European University Association 2009). From a policy perspective EUA fully support PhDs that incorporate skills training and employer engagement. In 2016 the EUA returned to the Salzburg Principles to focus on a number of aspects of implementation including engaging with employers in the private and public sector (EUA Council for Doctoral Education 2016), stating,

"Experience in non-academic settings gives added value to individual Doctoral candidates. It provides them with first-hand knowledge about career options and different work cultures. Mobility between sectors facilitates the development of the skills and competences of the individual Doctoral candidates and enhances the knowledge and appreciation of university research and researchers by the non-academic sector".

The League of European Research Universities (LERU) is highly active on Doctoral training covering all aspects (InfoBox 1.4). They have produced a number of key policy documents on the PhD including, *"Doctoral degrees beyond 2010: Training talented researchers for society"* (League of European Research Univerities 2010), *"Good Practice Elements in Doctoral Training"* (League of European Research Univerities 2014) and more recently *"Maintaining a Quality Culture in Doctoral Training"* (League of European Research Univerities 2016).

INFOBOX 1.5
Science Europe

https://www.scienceeurope.org/

Science Europe is an association of European Research Funding Organizations (RFO) and Research Performing Organizations (RPO), based in Brussels. Its founding General Assembly took place in Berlin in October 2011.

Science Europe promotes the collective interests of the Research Funding and Research Performing Organizations of Europe. It supports its Member Organizations in their efforts to foster European research. It strengthens the European Research Area (ERA) through its direct engagement with key partners. In doing so it is informed by direct representation of all scientific communities in its reflections on policies, priorities and strategies.

Another important stakeholder is Science Europe that acts as a representative body for research funding agencies across Europe (see InfoBox 1.5). In planning how there can be greater funding support for marine graduate training it will be necessary to engage the cooperation of Science Europe.

One of the aspects of Doctoral training that is stressed by all stakeholders is the need for skills training. This can be to advance the specialist knowledge of graduates in their own discipline. It is also about providing transferable or generic skills training on a range of topics including communication, project management and leadership, fundamentals of entrepreneurship and economics and encouraging young graduates to create their own business opportunities, in particular in high tech and innovative areas. These types of skills are also part of European employment policy as laid out in the New Skills Agenda (European Commission Directorate General for Emploment Social Affairs and Inclusion 2016) that was launched in 2016. The objective of the New Skills Agenda is to:

- Improve the quality and relevance of skills formation;
- Make skills more visible and comparable; and
- Improve skills intelligence and information for better career choices.

While the focus of this policy is on those in the workforce with low level skills, it is highly relevant for marine graduate training.

Credit: Lacey Schmeidler/Marine Photobank

Ensuring that marine graduates will be able to contribute to increasing food from the ocean through fisheries and aquaculture innovation will be important

[14] http://www.eua.be/Home.aspx

INFOBOX 1.6

European Skills, Competences, Qualifications and Occupations (ESCO)

https://ec.europa.eu/esco/portal/home

ESCO is a multilingual classification of European Skills, Competences, Qualifications and Occupations launched in summer 2014. ESCO identifies and categorizes skills, competences, qualifications and occupations relevant for the EU labour market and education and training. It systematically relates the concepts into occupational profiles. ESCO is developed as a building block for practical tools and applications such as job matching platforms, HR systems, career guidance tools or statistical applications.

The aim of ESCO is to establish a common language that bridges the communication gaps between the domains of employment, education and training across countries and languages. It increases transparency of occupations, qualifications, skills/competences and learning outcomes. This transparency and common reference will enable people to exchange information with unambiguous and shared meaning, independent of the language and the electronic systems used.

ESCO is an EU Horizon 2020 project, developed by DG Employment, Social affairs and Inclusion, supported by the European Centre for the Development of Vocational Training (Cedefop) and in close collaboration with stakeholders. It has been developed in an open IT format, is available for use free of charge by everyone and can be accessed and downloaded via the ESCO portal[15]. While 'marine' is a cross-cutting component across the reference groups such as Agriculture, Forestry and Fisheries and Hospitality and Tourism, it is presently not a stand-alone sectoral reference group.

1.4.2 Funding

At European level, there are various competitive funding instruments that are dedicated to investing in human capacity with a focus on training and mobility. These stem from two key European policy areas, education and research.

In terms of education funding, the Erasmus+[16] promotes mobility by enabling (young) Europeans to study in another Member State and then apply those new skills and competences when returning to their country of origin (InfoBox 1.7). However, it should be stressed that there is no requirement to adopt the new developments in graduate training (structured PhD's etc.) within this programme. Apart from regular Erasmus+ mobility there are also the funding schemes under Erasmus Action 2 dealing with joint Masters degrees and capacity building.

Credit: Angel Muñiz Piniella

Students training in oceanographic geology methods

[15] https://ec.europa.eu/esco/portal/escopedia/ESCO_v1

[16] http://eacea.ec.europa.eu/index_en.php

INFOBOX 1.7

Erasmus+

http://ec.europa.eu/programmes/erasmus-plus/index_en.htm

The Erasmus Programme is an EU student exchange programme established in 1987. Erasmus+ is the new programme combining fields of education, training, youth and sport for the period of 2014-2020. A previous version of this (2009-2013) was called Erasmus Mundus, and which is referenced several times in this paper, was a cooperation and mobility programme in the field of higher education.

The Erasmus+ Programme aims to boost skills and employability, as well as modernizing education, training and youth work. The 7-year programme has a budget of €14.7 billion and will provide opportunities for over 4 million Europeans to study, train, gain work experience and volunteer abroad.

The Programme is designed to efficiently use the potential of Europe's human and social capital, while confirming the principle of lifelong learning by linking support to formal, non-formal and informal learning throughout the education, training and youth fields. The Programme also enhances the opportunities for cooperation and mobility with partner countries, notably in the fields of higher education and youth.

The Erasmus+ programme supports cooperation and youth exchanges such as transnational Strategic Partnerships, Knowledge Alliances, Sector Skills Alliances and Capacity Building. The Sector Skills Alliances of the Programme's Key Action 2 aims at tackling skills gaps, by identifying sector specific labour market needs and demand for new skills with regard to one or more occupational profiles, and/or enhancing the responsiveness of initial and continuing VET systems (vocational education and training) to sector-specific labour market needs.

Under the Horizon 2020 research programme, the Marie Skłodowska-Curie Actions (MSCA) target researchers at different stages in their career from PhD candidates to highly experienced researchers. In the period 2014-2020, the MSCA will distribute training, mobility and career development grants (InfoBox 1.8). Over half of the entire MSCA budget is dedicated to Early Stage Researcher (ESR) training with the main focus on Doctoral candidates. While the bulk of the funding supports the individual ESR's, there is a dedicated budget line for training. Moreover, the structured training along with experience outside of academia is a mandatory component of this programme. The application of the Innovative Doctoral Training Principles is mandatory. The purpose is to ensure that Doctoral graduates have much wider employment opportunities than academia and research.

The MSCA programme demonstrates the extent to which the Innovative Doctoral Training Principles are applied across Europe. The Innovative Training Networks (ITNs) bring together consortia of 8-10 organisations across countries and sectors to train Doctoral candidates. Structured training in disciplinary and transferable skills is mandatory. The consortium must have members from industry or other non-academic organizations that host and train PhDs. There is also a specific scheme, the MSCA European Industrial Doctorate (EID). In this case the ESR's must spend at least 50% of their Doctoral research in a partner company. Annually there are over 10,000 organizations in consortia submitting proposals to the MSCA ITN programme. This numbers clearly demonstrate the extent to which this type of Doctoral training is provided across Europe.

INFOBOX 1.8

Marie Skłodowska-Curie Actions (MSCA)

http://ec.europa.eu/msca

The Marie Skłodowska-Curie Actions (MSCA) are part of the Excellence Pillar in Horizon 2020 dedicated to strengthening human resources in all areas of research and innovation. The MSCA will award €6.16 billion in the period to 2020, which is 30% more than the 2007-2013 programme that preceded it (FP7). The Marie Skłodowska-Curie actions (MSCA) provide grants for all stages of researchers' careers - be they Doctoral candidates or highly experienced researchers - and encourage transnational, intersectoral and interdisciplinary mobility. The MSCA enable research-focused organizations (universities, research centres, and companies) to host talented foreign researchers and to create strategic partnerships with leading institutions worldwide.

The MSCA aim to equip researchers with the necessary skills and international experience for a successful career, either in the public or the private sector. The programme responds to the challenges sometimes faced by researchers, offering them attractive working conditions and the opportunity to move between academic and other settings. The Actions that support Early Stage Researchers (Masters or Doctoral candidates) are the Initial Training Networks and the COFUND Doctoral Programme. A requirement for these grants is a highly structured education and training programme for the researchers.

The MSCA are open to all domains of research and innovation, from fundamental research to market take-up and innovation services. Research and innovation fields are chosen freely by the applicants (individuals and/or organizations) in a fully 'bottom-up' manner.

[17] http://ec.europa.eu/research/mariecurieactions/

In summary the MSCA Initial Training Networks have been running for over 20 years and provide an excellent model that could be adapted for the marine sector. The opportunity is for funders of marine research to introduce and fund structured PhD programmes modelled on the Marie Skłodowska Curie ITN. It must of course be kept in mind that the Marie Skłodowska Curie programme represents only about 10% of all Horizon 2020 activities. Under the Blue Growth related areas of the Horizon 2020 Societal Challenges (e.g. SC3 Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy), Doctoral candidates have been and will be sponsored within the funded projects. They will undoubtedly gain experience and a level of training in the marine area however this is not done in a consistent and organised manner. This is an opportunity for further development.

Another source of funding for human capacity building is through European Structural and Investment Funds[18]. These facilitate the development of capacity in key areas of importance to Member States.

EXAMPLES OF MSCA ITN'S

During the current Horizon 2020 programme a number of Initial Training Networks (ITN's) for Doctoral candidates have been funded. In each case there is highly structured education and training programme for each PhD to complement their research project and provide them with the skills for future employment across all sectors, public and private. The list includes:

Bringing the paradigm for marine pelagic production into the 21st century: incorporating mixotrophy into mainstream marine research
http://cordis.europa.eu/project/rcn/211693_en.html

The Algal Microbiome: Friends and Foes
http://cordis.europa.eu/project/rcn/193927_en.html

International training at the Science-Policy Interface for Researchers in Europe, for Nature
http://cordis.europa.eu/project/rcn/211664_en.html

Autonomous Unmanned Aerial Systems for Marine and Coastal Monitoring
http://cordis.europa.eu/project/rcn/193888_en.html

Improving the flow in the pipeline of the next generation of marine bio-discovery scientists
http://cordis.europa.eu/project/rcn/205431_en.html

Brachiopods As Sensitive tracers of gLobal marINe Environment: Insights from alkaline, alkaline Earth metal, and metalloid trace element ratios and isotope system
http://cordis.europa.eu/project/rcn/193989_en.html

Submarine Landslides and Their impact on European continental margins
http://cordis.europa.eu/project/rcn/208794_en.html

Marine Management and Ecosystem Dynamics under climate change
http://cordis.europa.eu/project/rcn/198315_en.html

[18] http://ec.europa.eu/regional_policy/en/funding/

It is recognized that a majority of marine graduates will move from academia into the wider job market. However, they should also be enabled to consider creating their own business opportunities, providing innovative highly skilled services based on sound scientific and technological knowledge not yet currently available in the marine and maritime sector. Marine graduate training of the future must therefore work across academia, industry and wider stakeholders and stimulate attractive career pathways across existing and emerging blue sectors. To address the need for interaction between the full knowledge triangle, namely higher education, research and business, the European Commission organizes both 'Alliances' and 'Fora' on thematic clusters. In 2015 the Blue Economy Business and Science Forum was launched at the European Maritime Day in Greece, which brings together different actors e.g. business, industry, researchers and investors to foster collaboration. There has also been the development of a Knowledge Alliance and Marine Sector Skills Alliance (DG MARE) including frequent calls launched to contribute to ongoing discussions on maritime skills and employment with most recently a call released on proposal on blue careers in Europe in 2016. Further detail on Blue Careers initiatives of the European Commission is provided in InfoBox 1.9.

It is clear that European policy does favour doctoral programmes focused on high quality research that incorporate training and close interaction with the broad employment sector. Moreover, there are programmes in Horizon 2020 that provide funding to support this activity and it is hoped that this will continue going forwards.

INFOBOX 1.9

DG MARE Blue Career Policy

https://ec.europa.eu/maritimeaffairs/policy/skills-career-development_en

The EC Communication on Blue Economy (EC COM (2014) 254 final/2) (European Commission 2014) highlights that *"Growth in the blue economy will require an appropriately skilled workforce, able to apply the latest technologies in engineering and a range of other disciplines. There is currently a skills gap that must be tackled."* The Commission has proposed several initiatives and action plans to tackle this skills gap.

Blue Economy Business & Science Forum (BSF)

The Blue Economy Business and Science Forum was proposed in 2014 (IP/14/536, 8 May 2014) and launched one year later during the European Maritime Day in Athens. The first Summit took place in Hamburg in September 2016 . The Blue Economy Business and Science Forum will be used to bring together scientists and businesses that operate in different sectors to address the common challenges to the development of the blue economy. Participants will also discuss bottlenecks hindering the commercialization of innovative blue technologies in the EU. Innovation is costly and even more so in the marine environment. Therefore, access to finance for innovation will be considered as one of the key issues. Additional objectives are to accelerate bringing scientific results to the market and to promote scientific and technological achievements (Reply of Commissioner Vella to the European Parliament, 2015)[21].

Blue Careers in Europe

On 1 March 2016 DG MARE launched a call for proposal on 'Blue Careers in Europe' under the European Maritime & Fishery Fund (EMFF) (C (2015) 8729 annex)[22]. The allocated budget of up to €5.15 million now funds 7 projects to provide enhanced cooperation between education and maritime business and to implement the actions identified according to the geographical and sectoral needs (e.g. requalification programmes for unemployed but qualified people, designing of new curricula, skills upgrading programmes, etc.). More information on the selected projects can be found online[23].

An informal expert group on Careers and Skills in the Blue Economy has also recently been established[24] "to advise the Commission on matters pertaining to the education, training, skills and career development within the blue economy". The group has a kick-off meeting in 2017 in Brussels, Belgium.

[19] http://europa.eu/rapid/press-release_IP-14-536_en.htm

[20] https://ec.europa.eu/maritimeaffairs/content/blue-economy-business-and-science-forum-1st-summit-%E2%80%93-hamburg_en

[21] http://www.europarl.europa.eu/sides/getAllAnswers.do?reference=E-2015-006249&language=EN

[22] http://ec.europa.eu/dgs/maritimeaffairs_fisheries/contracts_and_funding/annual_work_programme/index_en.htm

[23] https://ec.europa.eu/easme/en/news/european-commission-about-fund-10-new-blue-growth-projects, https://ec.europa.eu/easme/en/emff-projects

[24] https://webgate.ec.europa.eu/maritimeforum/en/frontpage/1145

2 The European marine science and technology training landscape

In order to enable modernization and development of the European marine graduate training, it is first important to understand the current landscape. In the context of this publication, the landscape has been explored using a number of different sources to gain a comprehensive overview.

2.1 Mapping the European marine graduate training landscape

Gaining a clear view on the current landscape for marine graduate training in Europe is a basic requirement for identifying and making statements on potential gaps or areas in need of improvement. This chapter describes, in summary, the broad range of marine training opportunities currently on offer in European higher education institutions and marine research institutions. The methodology used to gather supporting information, some general trends in the data, and a series of specific observations are presented.

A first analysis of the marine training landscape was made under the auspices of the FP7 EuroMarine project[25], which eventually became the EuroMarine network (InfoBox 2.1). Through a short internet survey, it was observed that dedicated marine science programmes account for less than 1% of higher educational (degree) programmes[26]. The survey revealed 210 training offerings of which 60% were Masters programmes, 17% were PhD programmes and the remaining 23% were Bachelor programmes or occasional training events (e.g. summer schools). Lifelong learning initiatives and PhD programmes were largely underestimated in the survey (see also Chapter 12 of (European Marine Board 2013)).

INFOBOX 2.1

European Marine Research Network (EuroMarine)

http://euromarinenetwork.eu/

Launched in 2014, EuroMarine is a European marine science network, initially representing the merger of the communities of three former European Networks of Excellence (EUR-OCEAN, Marine Genomics Europe and MarBEF). It is now a broad-scale network of excellence across academic and research institutions in Europe. The network launches annual calls for proposals from their budget to support research that would help to leverage larger transnational projects. Their identified priority areas are: (i) understanding marine ecosystems for healthy oceans; (ii) building scenarios for marine ecosystems under changing oceans; and (iii) marine science as a provider of new concepts for innovation and technology. Several summer schools and international exchanges have already been supported across a range of marine science fields and topics. EuroMarine plays an important role in advancing the quality, integration and visibility of marine graduate training in Europe.

2.1.1 The Marine Training Portal

In late 2013, as part of the Belgian activities of the ESFRI EMBRC[30] project, it was decided to make a new attempt at compiling an inventory of marine training activities in Europe. This dataset is presented in the European Marine Training Portal[31], a centralized access point for education and training in the field of marine sciences. The main driver for its establishment was the total lack of information and overview for finding marine and maritime Masters programmes in Europe. This could be an opportunity to develop a comprehensive Europe-wide portal as a one-stop-shop for graduate education and training opportunities (Masters and PhD) in Europe.

To allow for proper analysis of the data and to allow for exchange of the data with other web based educational portals, the XCRi-

[25] https://cordis.europa.eu/project/rcn/97379_en.html

[26] http://www.mastersportal.eu

[27] EUR-OCEANS: European research on Ocean Ecosystems under Anthropogenic and Natural Forcings

[28] Marine Genomics Europe was devoted to the development, utilization and spreading of high-throughput genomic approaches for the study of the biology of marine organisms and the functioning of marine ecosystems.

[29] MarBEF (Marine Biodiversity and Ecosystem Functioning) was a platform to integrate and disseminate knowledge and expertise on marine biodiversity, with links to researchers, industry, stakeholders and the general public.

[30] www.embrc.eu

[31] www.marinetraining.eu

Cap standard[32] was used as basic data model for the database. This standard allows for description of both educational programmes as a whole as well as short-term courses. The Marine Training Portal endeavours to describe training initiatives both on the basis of content (title, description, objectives, learning outcomes qualification, academic level, subjects, pre-requisites, etc.) and practical aspects (language, venue, duration, application, contacts, costs, places, etc.).

Population of the dataset was done on a country-by-country basis. For each country, all Higher Education Institutions (HEIs) were investigated through an analysis of study catalogues and prospectuses on their respective websites, by contacting University admissions offices, or by scanning relevant study and training portals. Short-term training offered by non-higher education institutions, such as marine research institutions, were also incorporated in the dataset. Only Masters programmes, Doctoral training programmes and short-term training courses (e.g. summer schools, lifelong learning initiatives) that met at least one of the following three criteria were included:

- The training programme is clearly marine from descriptors in the title (e.g. Maritime Operations Management MSc, Masters degree in Yacht and Cruising Vessel Design);
- The training programme is clearly marine from the overall content point of view, even while the title does not indicate the marine orientation as such (e.g. Masters in Chemical Ecology - Université de Bretagne-Sud);
- The training programme contains a significant amount (defined as at least 30%) of individual courses with a clear marine orientation (e.g. Masters in Ecology, Biodiversity: specialization Biodiversity, Evolution – University of Montpellier).

It is important to note that there are a number of information gaps and shortcomings in the dataset (e.g. in terms of the training programmes catalogued for certain countries), and that it is difficult to obtain accurate and exact data on marine graduate training numbers. Hence the trends discussed later are not presented as hard fact but rather as preliminary insights from a constantly evolving dataset.

Credit: European Marine Board

Panel discussion at the European Maritime Day workshop, "How Can Innovative Training Support Blue Growth", Athens, 28 May 2015. Left to right: Niall McDonough, Paris Sansoglou, Stephen Hall, Óscar Gómez, Pierpaolo Campostrini, Eric Thiébaut and Tim Deprez.

[32] www.xcri.co.uk

[33] http://www.marinetraining.eu/content/statistics

[34] www.euromarinenetwork.eu, see also InfoBox 2.1

Credit: Paulia McGrane

Current statistics on the courses listed on the Marine Training Portal can be found online[33].

2.1.2 The Marine Graduate Training Survey

A Marine Graduate Training survey was carried out by members of the EMB Working Group on Marine Graduate Training in March-April 2015 to collect information and opinions from marine graduates including their study background, marine programme components, current employment status (including PhD involvement), and employment satisfaction. Approximately 460 Masters programmes across 18 European countries from the Marine Training Portal were contacted via email and asked to distribute the survey to their programme alumni. The survey was also distributed via social media, newsfeeds, webpages and via email to various institutions and associations.

2.1.3 Dedicated events

A series of meetings was also organized with marine graduate training stakeholders (graduates, employers, course coordinators, policy makers, consultancies, etc.) to gain further insight into the landscape.

On January 14th 2015, as part of the EMB WG Marine Graduate Training activity, a meeting was organized in Brussels involving European Commission representatives, industry representatives (from the aquaculture, dredging, and biomedical sector) and representatives from the academic sector and members of the EMB Working Group. This meeting focused on identifying mismatches between training and the needs of the employers.

On February 23th 2015 a workshop was organized in Naples focusing on marine Doctoral training. This workshop was co-organized by the EuroMarine[34] network and brought together 27 people involved in PhD research (e.g. as a researcher, supervisor, programme coordinator, etc.).

The 2015 European Maritime Day (EMD) in Athens was the third occasion where views from stakeholders, including employers, were collected. A workshop entitled 'How innovative training can support Blue Growth[35]' was jointly organized by the European Marine Board, JPI Oceans[36] and the EuroMarine Network. Discussions were focused around "Europe's Blue Economy: what skill sets are required and what is the role of marine science?" In total approximately 50 people attended the workshop.

2.2 Overview of the European marine graduate training landscape

This section provides a summary of some of the key trends and findings based on the information available on the Marine Training Portal as of May 2015, which at the time included 522 Masters programmes, 66 Doctoral programmes and 150 short courses. The landscape overview is presented separately for Masters and PhD training.

Based on the input of the survey it was observed that many programmes do not offer topics related to the key areas of the EU Blue Growth agenda or the UN's 2030 Agenda's Sustainable Development Goals.

The table below provides an overview of the typical training typologies which are currently available. The sections below present information specifically on Masters and PhD programmes, which can cover several different typologies, depending on the course design.

Table 2.1 Training typologies across graduate courses

TRAINING TYPE	TRAINING CONTENT	TRAINING CONDUCTED BY WHOM	POTENTIAL JOB MARKET	TRAINING FORMAT
Research-based University degree Courses (Bachelor, Masters, PhD)	Disciplinary and multidisciplinary scientific, curiosity-driven research training. Mostly requiring a research thesis.	University Staff with research and teaching duties	Scientific research, teaching, private sector, industry, science administration	Mostly full-time presence courses, incremented with e-learning
Maritime training for professionals vocational diploma courses	Shipbuilding and repair, operation, pilotage, maritime law, management of shipping affairs	Universities and institutes of further education	Maritime traffic and all aspects of the shipping and offshore industry	Presence teaching and distance learning
Engineering and technology degrees (Bachelor and Masters)	Maritime engineering, ocean engineering, naval architecture, hydrodynamics, marine technology	Technical universities and polytechnics	Engineers and technicians	Mostly full-time presence, work-based training, online and distance learning
Specialized sectorial diplomas, certified courses, vocational training courses (Diploma, Bachelor, Masters)	Sector-specific e.g. tourism management, aquaculture and fishing technology, Marine Protected Areas, marine resource management, marine insurance, coastal management	Industry and certified teaching institutes, (technical) universities, NGOs, profit-seeking and non-profit enterprises	Mid- and high-level management in the corresponding sector	Work-based learning, part- and full-time, presence courses, distance learning, internships
In-house training of professionals diplomas and certificates	Technology, management and other skills defined per industry	External and internal pro-fessional trainers	Career-development within the industry, entry-level and add-on qualifications	Short, targeted offers

[35] http://www.marineboard.eu/sites/marineboard.eu/files/public/Workshop%20EMB%20-%20EMD.pdf

[36] http://www.jpi-oceans.eu/; JPI Oceans also includes Training and Education under the banner of Human Capacity Building and identifies this as a key cross-cutting area in their Strategic Research Agenda 2015-2020 (see http://www.jpi-oceans.eu/library?refid=246303)

2.2.1 Masters programmes

Based on the actual number of graduates of 44 marine programmes and the supplemented data from the number of places offered in 123 marine programmes within the dataset in May 2015, it was estimated that there are between 7,000 and 12,000 graduates from marine Masters programmes across Europe each year. Various trends were identified in 2015 which are still relevant considerations now.

Geographical trends

Not surprisingly most marine training is offered in locations near the coast. When analyzing the number of programmes per country, it was clear that the UK and France offered the largest number of marine-oriented programmes. When looking at the number of graduates it was clear that in the UK the vast majority of the programmes had a lower number of students (ranging between 5-10 per year) while in other countries this was higher (average around 20 per year). An explanation for this phenomenon is the flexible definition of 'Masters Programme'. Countries like Belgium and Germany have the tendency to group different specializations into one programme, while in the UK each sub-discipline tends to be covered by an individual programme. This difference in definition still exists at present.

Language of instruction

Language of instruction is important as it influences the extent to which courses are accessible to international participants. At the time of the analysis, English was clearly the leading language of instruction with 39% of all programmes taught in English when excluding the UK and Irish programmes. This rose to 57% when the UK and Irish training programmes are included. There is still a slight north-south dichotomy evident, whereby a greater number of courses in northern Europe are taught in English compared to southern Europe.

Jointness of programmes

From the overall list of Masters programmes in the Training Portal dataset in May 2015, 34 (or about 7%) were organized in a joint construction (as a collaboration between two or more HEIs). Half of these were international collaborations, of which 9 were set up under the EU Erasmus Mundus programme[37] (see Infobox 1.7), corresponding to 6% of the total number of Erasmus Mundus Programmes financed. On average, 190 students graduated from these programmes each year. Collaborative programmes continue to grow in importance, especially in light of international agendas such as the UN 2030 Agenda and therefore it is hoped that these numbers will significantly increase.

Thematic orientation and course content

Gaining an objective view on the actual content of the available training on offer in Europe is difficult, mainly because of the large differences in availability of descriptive data on each training programme, and differences in language and vocabulary. A basic content analysis revealed that the majority of Masters programmes represented on the Marine Training Portal in May 2015 included content on policy and management (65%), while almost half included biodiversity and ecology (49%), and marine and maritime law (41%). Less than 15% of Masters programmes included content on archaeology, blue energy, coastal and marine tourism, marine planning and naval architecture. Although Europe has always been a

Credit: Paulia McGrane

Understanding the current marine education landscape will help develop the way forward

[37] http://eacea.ec.europa.eu/erasmus_mundus/programme/about_erasmus_mundus_en.php

world leader in polar research, only 8 programmes with a clear polar component could be identified at the time. All of them were taught in English and about half of them were joint programmes and had a very clear international orientation. Few programmes exist with a pure marine/maritime legal orientation (18 programmes lead to a Master of Law title).

The "maritime" sector was well represented in the overall dataset with about 25% of all training belonging to that sector. Major domains here were maritime law, engineering, technology, management and logistics. It is important to note, however, that the majority of programmes in this field were UK-based (>65%). Also, in some countries (e.g. France), maritime training is mostly provided, not in universities, but in advanced engineering schools which were not included in the survey.

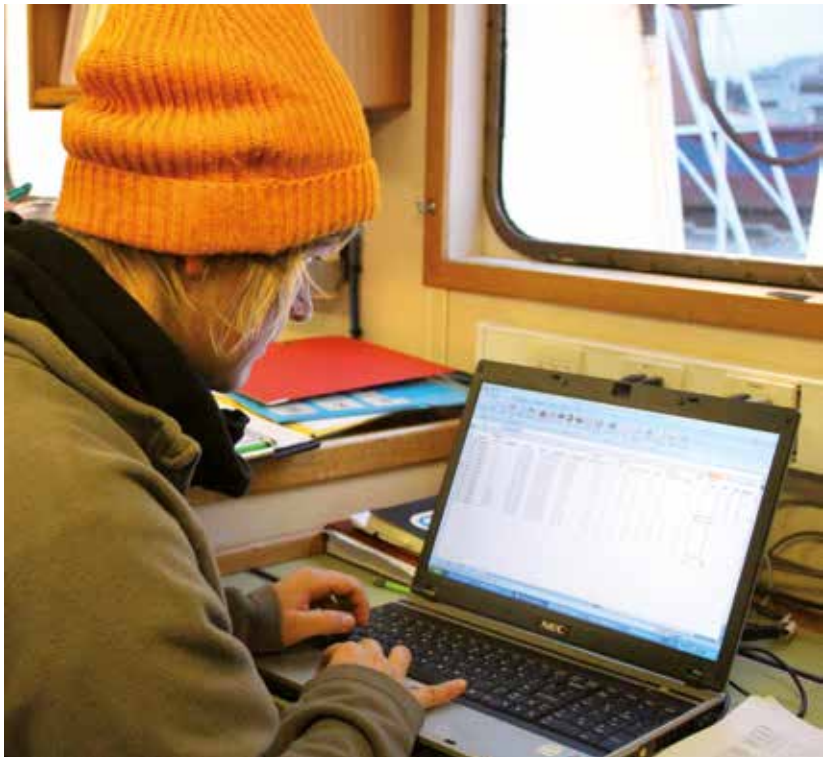
Credit: European Marine Board

Only a very small proportion of Masters courses include content on archeology, blue energy, coastal and marine tourism, marine planning and naval architecture

Training typologies in the programmes

Over 90% of Masters programmes included a thesis or dissertation component, while 70% offered practical or field work within the programme. Other important structural components included laboratory training, research project/project work, internships and language training, offered respectively by 46%, 45%, 44% and 34% of the Masters programmes analysed. The majority of respondents to the marine training survey had undertaken a thesis, internship or language training as part of their Masters training (75%, 64% and 54%, respectively). They considered internships, thesis work, international experiences and transferable skills training as helpful in obtaining their current employment. To gain an insight on employment opportunities for marine training graduates, several questions were included on the survey respondent's current employment situation. It must again be noted that the majority of respondents to the survey were from the natural sciences field. The majority of respondents (>30%) were currently employed either as a PhD researcher (PhD being defined here as employment) or employed elsewhere (approximately 40%). However, 25% of respondents were unemployed and either job seeking or continuing their studies, for example undertaking another Masters degree or a lifelong learning and upskilling opportunity. Almost 60% of graduates gained employment within 6 months of graduating, although around 10% took over 12 months to gain employment and nearly 20% were still searching. Of those respondents that indicated they were employed (not including as a PhD researcher) 20% stated that their current employment was not related to their field of study. When asked the reason for this, the majority indicated that they could not find employment in the related field or it was a combination of factors.

Within the natural sciences field, 69% of respondents were employed, while the others were unemployed (job seeking), studying or other activities. Of those employed, almost 50% were employed as a PhD researcher. This is in contrast with the other fields such as engineering and law, where fewer graduates were employed as PhD researchers.



Credit: Paulia McGrane

PhD programmes must ensure the employability of the graduate, while maintaining their role on the frontier of research

2.2.2 PhD programmes

The Bologna Process, initiated in 1999, aims to create a European Higher Education Area (EHEA) by implementing a comparable three cycle degree system for undergraduates (Bachelor degrees) and graduates (Masters and PhD degrees). In the field of marine education, Masters programmes are relatively well defined and recognized given that the qualification is based on learning outcomes often with an associated thesis. Formal Doctoral training programmes in the marine area are scarcer. The reason is that the PhD is based on a body of original research with the examination based on the thesis alone. That being said it has been recognised across Europe for many years that training in disciplinary and transferable/generic skills is a highly valuable component of the doctorate. The level to which this applied varies across Europe, with the UK[38,39], Germany[40] and Scandinavian countries being among the pioneers. It must be emphasised that this is ever expanding, led by EU, EUA, and LERU policies on Doctoral training.

In April 2018, the Marine Training Portal lists 48 formal Doctoral training programmes, compared to 484 Masters programmes. These Doctoral training programmes typically consist of:

- Fundamental research;
- Advanced course work related to the primary research (Statistics, Modelling, GIS, Programming, Big data, Specialized instrumentation, etc.);
- Research outputs in the form of a thesis/dissertation, peer-reviewed publications stemming from the research, presentations and attendance at high-level scientific conferences in the field; and
- Some training in transferable skills (communication, scientific writing, project planning, time management, integrity/ethics and possibly entrepreneurship).

Based on the stakeholder meetings and feedback from the survey, both in 2015, a series of observations can be made regarding PhD research in Europe.

The focus of most PhD programmes is on research and is designed to train academic researchers through apprenticeship with the emphasis on excellence, creativity and production of new knowledge. There are relatively few links with non-academic sectors (<75 %) mainly because the purpose of the PhD is perceived by both universities and PhD candidates alike as preparation for a career in academic research rather than as preparation for a career in a non-academic sector. At the EU level and in countries across Europe, it has been recognised that more must be done to change this situation and recognise the fact that less than 10% of graduated PhDs will ultimately attain an academic or similar research appointment (The Royal Society 2010). This has been accompanied by a stream of publications on this topic including, *"The disposable academic"* (The Economist 2010), *"Education: The PhD factory"* (David Cyranoski et al. 2011), *"Employment: PhD Overdrive"* (Smaglik 2014), *"How to Build a Better PhD"* (Gould 2015). After graduation a significant proportion of PhDs continue in academia and the pubic research sector (publically funded research laboratories and centres) as postdoctoral researchers. Data indicate that 10 years after the doctorate, 85-90% of graduates will find work outside of academia (Cyranoski et al. 2011).

The discussion now is, on the one hand how to ensure that the PhD degree can open a wider range of employment opportunities, and how to communicate the value of the doctorate beyond the research content of the thesis. On the other hand, the doctorate as a bastion of academic frontier research must maintain its value to secure fundamental system understanding and free space for intellectual excellence. The question is thus how to continually evaluate the profile of the doctorate and even whether the doctorate is the best option for graduates leaving their studies and entering the work-force.

There is also a need for companies to rethink their own perceptions about PhDs and the often-held premise that the classic, research-only, PhD provides little added value as compared with a well-trained and younger Masters graduate.

Although over 50% of the PhD programmes surveyed in 2015 included some form of transferable skills training, the general conclusion is that this is introduced far too late in the educational process. Transferable skills training should start at Masters or Bachelor-levels and continue within the PhD.

[38] https://www.vitae.ac.uk/researchers-professional-development

[39] Review of progress in implementing the recommendations of Sir Gareth Roberts, regarding employability and career development of PhD students and research staff, RCUK 2011 http://www.rcuk.ac.uk/publications/archive/hodge/

[40] Graduiertenkollegs, http://www.dfg.de/foerderung/programme/koordinierte_programme/graduiertenkollegs/

2.3 Strengths and weaknesses in the current European marine graduate training landscape (SWOT analysis)

A summary of this chapter is reproduced below as a SWOT analysis.

STRENGTHS	WEAKNESSES
• Strong research base • Many world leaders in various fields of marine science • Good integration of policy awareness in some courses • Marine education is in itself cross-disciplinary • Broad range of programmes available throughout Europe • Many programmes are offered in English and are open to international communities within and beyond Europe • World class marine research infrastructure and research vessel fleet	• Poor balance between research and attention to long-term employability (either inside or outside the academic sector) • The marine content is often 'hidden' within more general courses, hence not visible • Information about degree programmes is scattered • Insufficient links to non-academic sectors • Difficulty in implementation of cross-disciplinary training due to historical structuring of European universities • EU add-on programmes do little to promote structural change • Lack of data on number of graduates in specific fields and number of graduates needed by employment sector • Training providers such as universities are often rigid and slow to change, while training needs are evolving fast • No coherent marketing of the attractiveness of marine programmes, and their potential job opportunities
OPPORTUNITIES	**THREATS**
• Opportunities for increased collaboration between HEIs • There are many marine infrastructures in Europe that are open access but linking national funding remains difficult in practice • Initiatives like the Marine Training Portal can help in joining forces on training and avoid duplication • Improved advertising for marine-oriented training programmes and how they link to jobs and Blue Growth can help attract new students and trainees • Involvement of industries in academic study programmes increase employment rates of graduates • Capitalise on the experience in structured PhD programmes and Doctoral schools across Europe • Engage more with industry help shape graduate training and provide placements for PhD candidates • National funders of marine research to introduce and fund structured PhD programmes modelled on the Marie Skłodowska-Curie Training Networks	• Legal and practical difficulties with implementation of joint and multi-degree programmes • Workplace experience at sea is expensive and requires secure long-term funding • Short-term funding opportunities for joint initiatives are often more work that they are worth • Availability of marine field stations for advanced courses and research

2.4 Outlook

It is clear that there are many and varied courses and programmes that offer training to Masters and PhD level in Europe. However, it is relatively difficult to find clear trends in the overall offering. This has several causes:

- Information about graduate programmes is often scattered and described in heterogeneous ways. Practical elements are, in most cases, well documented but the theoretical content are often vague. Titles chosen for programmes do not match the actual content of the training programme. To allow for deeper comparison of related programmes in different regions, a common vocabulary is needed.
- The analysis provided here gives a first view of programme offerings across Europe but does not allow for an evaluation of the quality or scope. This is due to a lack of public and open information about performance descriptors and no consistency in application of quality metrics across Europe.
- This analysis shows the clear difference between the UK and continental Europe. Most of the differences can be explained by differing legal and financial models, as well as history and tradition.
- Based upon stakeholder meetings involving both academic and non-academic sectors, it is clear that PhD programmes need to be updated to meet the needs of society, while protecting new knowledge production. Use of placements, internships and mutual involvement in curriculum design would foster training to better fit the needs of all stakeholders.

Credit: Karen Hissmann / JAGO-Team / GEOMAR

GEOMAR researchers look at samples of cold-water corals taken off the coast of Norway by the JAGO submersible, Expedition FS ALKOR AL316, March 2008

3 The future of marine training in Europe: key challenges and opportunities

Looking to the future, marine graduate education and training will increasingly be expected to fulfil the requirements placed on it by societal needs. This however should not be viewed as a burden, but rather as an opportunity to transform current programmes to be fit for the challenges ahead.

3.1 Key targets for marine graduate training in the 21st century

It is important to put the challenges in the marine sector into the more global context of the entire graduate and research community. Since 2001 and the launch of the European Research Area (ERA) there has been a concerted effort at national and EU level to raise the level of investment in R&D towards 3% of GDP. In some countries, Denmark and Ireland for example, this has been expressed as doubling of the number of PhD graduates. From a global perspective the number of researchers has been steadily increasing: since 2007, the total number has risen by 10% to 7.8 million with the highest proportion in Europe at 22%, see UNESCO Science Report - Towards 2030 (UNESCO 2015). The challenge across all disciplines has been to change the approach to Doctoral training to ensure greater employment opportunities where graduates can apply their high level skills. In general, finding a job is not an issue for Doctoral graduates, with employment rates of over 97% (Auriol et al. 2013). However, given that only a small percentage will work as researchers, the real challenge for the marine sector is to ensure that all marine graduates have the opportunity to contribute to the Blue Economy as researchers, working in other employment areas in this sector, or by creating their own business opportunities. The key stakeholders in Doctoral education have risen to this challenge and developed new policies for Doctoral degrees to include formal disciplinary and transferable skills training along with placement opportunities in industry. The size of the marine sector should mean that the main stakeholders can collaborate and focus on this challenge.

At the EU level, the various policies developed by the Member States with the European Commission, involving key stakeholders (including the EUA and LERU) fall under the Innovative Doctoral Training Principles[41] (following on from the EUA Salzburg Principles (European University Association 2005)):

1. Research Excellence
2. Attractive Institutional Environment
3. Exposure to industry and other relevant employers
4. International Networking
5. Interdisciplinary Research Options
6. Transferable Skills Training
7. Quality Assurance

These seven principles were developed specifically for Doctoral programmes.

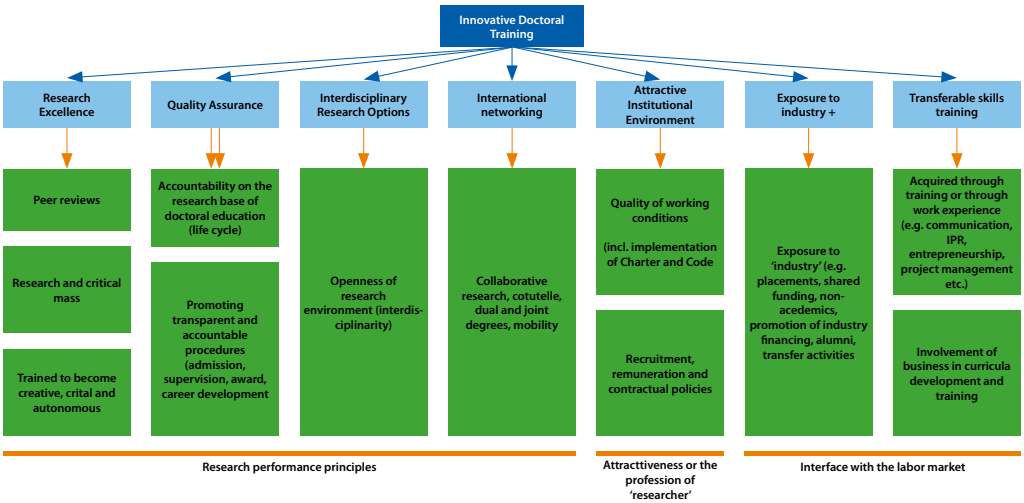


Figure 3.1 The Innovative Doctoral Training "tree" (Remade, source: IDEA Consult based on Report of Mapping Exercise on Doctoral Training in Europe: Towards a Common Approach, 2011) using the 2011 Innovative Doctoral Training Principles (IDTP).

[41] https://euraxess.ec.europa.eu/belgium/jobs-funding/doctoral-training-principles, https://cdn4.euraxess.org/sites/default/files/policy_library/sghrm_idtp_report_final.pdf

INFOBOX 3.1

Strategic Marine Alliance for Research and Training (SMART)

http://www.smartseaschool.com/

The Strategic Marine Alliance for Research and Training (SMART) is an award winning marine education and training programme based in Ireland. SMART specializes in providing applied, research vessel-based training in multidisciplinary ocean science for third-level students of marine-related science and technology. The SMART model relies on collaboration and innovation. Since 2011, SMART partners have pooled infrastructure, facilities and expertise to train over 1,500 students in the practical, cross-disciplinary skills and competencies required to operate and carry out research at sea. Providing access to research vessel infrastructure, along with an array of inter-institutional, accredited courses, delivered by a dedicated team of on-board scientists, is unique internationally and is key to developing the next generation of ocean professionals.

In this section, the key areas for the advancement of graduate training are identified by analyzing the seven IDT Principles in the context of marine disciplines.

3.1.1 Secure and advertise marine research excellence

Marine research has a strong base and there are many world leaders in the various associated disciplines. The core of a Doctoral degree is the development of new disciplinary knowledge. The Doctoral candidates should be trained through their research activities to become creative, critical and autonomous intellectual risk takers, pushing the boundaries of marine research and technology development. In the marine disciplines there is the opportunity of increased collaboration between universities and research organisations to build critical mass. There are many marine infrastructures in Europe that are open access and could be better utilised to host Doctoral candidates as part of their research, for example the Strategic Marine Alliance for Research and Training (SMART) Training Through Research Surveys (TTRS) scheme which facilitate graduate seagoing placements on a range of research surveys on-board the national research vessels. Such on-board placements provide the experience and skills required to work at sea and facilitate career development in ocean science[42] (also see Infobox 3.1).

3.1.2 Create an attractive institutional environment with a clear marine branding

Doctoral candidates should find good working conditions to empower them to become independent researchers, taking responsibility at an early stage for the scope, direction and progress of their project. As shown in Chapter 2, marine graduate training is often hidden within more general graduate programmes. Tailor-made marine training programmes need to be targeted at specific societal challenges, including the Blue Growth priority areas and the needs of the UN 2030 Agenda and the Sustainable Development Goals. In order to recruit more young people for the marine job market, the branding and visibility of marine graduate training needs to be significantly improved and this requires a joined-up and concerted effort across the sector. In addition, furthering Ocean Literacy amongst young people will help to increase understanding of the need for highly-trained marine professionals, further enhancing the image of this being an important and valuable field. It is also important to provide an attractive institutional environment for the trainers (academics, researchers, laboratory technicians, etc.) with sound career pathways and incentives for achieving excellence.

Providing reassurances to applicants to marine programmes is also important. There is a need to address the long-standing problems associated with job-security for early stage researchers, with PhD graduates embarking on successive short-term research contracts with no ultimate guarantee of academic tenure. In this regard it is important to provide career development opportunities, in line with the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers[43]. Doctoral candidates should be made aware that there are many career opportunities outside academia. This can be challenging as career advice by supervisors focuses on academia (Sauermann & Roach 2012).

One way to address this would be to gain a deeper understanding of the career paths of doctorate holders, to use as examples of possible career paths. Career tracking initiatives would also add a valuable feedback loop to education and training providers. Organisations such as Science Connect (under the European Science Foundation) are already starting to initiate such career tracking projects[44]. It is however acknowledged that gathering such data can be extremely difficult and costly.

3.1.3 Incorporate interdisciplinary research options

Marine research and training is in itself cross-disciplinary. This means that marine Doctoral training must be embedded in an open research environment and culture to ensure that any appropriate opportunities for cross-fertilisation between disciplines can foster the necessary breadth and interdisciplinary approach.

The next generation of marine scientists, engineers, high level technicians and other trainees need to be able to work at a systems level, applying multi-disciplinary knowledge to address complex marine and maritime issues which cut across scientific, environmental, economic and social systems. Encouraging broad, multidisciplinary approaches at all stages of training is essential to ensure that trainees and graduates are able to solve the complex issues that are specific to the marine sector.

The marine academic community will need to develop innovative approaches that emphasize not only multi-disciplinarity, networking, and collaboration across sectors, but also create

[42] http://www.smartseaschool.com/TTRS-2017

[43] https://euraxess.ec.europa.eu/jobs/charter

[44] http://www.esf.org/scientific-support/career-tracking-of-doctorate-holders/

links between different areas of expertise and skills. At PhD level in particular, ensuring research excellence while promoting cross-disciplinary problem-solving approaches is a key challenge.

A relevant example would be research in the emerging meta-discipline of Oceans and Human Health (OHH) where close collaboration between the disparate fields of marine and public health / medicine is crucial for understanding the complex interplays between ocean health and human health and wellbeing (Moore et al, 2013).

3.1.4 Expose graduates to industry and other relevant employment sectors

The term 'industry' is used in the widest sense, including all future workplaces, from industry to business, government, NGO's, charities and cultural institutions (e.g. museums). This is important in the context of the Blue Economy given the wide range of employment sectors covered. Exposure can include placements during research training; shared funding; involvement of non-academics from relevant industry in informing/delivering teaching and supervision; promoting financial contribution of the relevant industry to Doctoral programmes; fostering alumni networks that can support the candidate (e.g. mentoring schemes) and the programmes; and a wide array of people/technology/knowledge transfer activities[45].

Professional practice during education can have a positive effect on future employment prospects. Students can achieve competences in a professional setting that providers of higher education cannot offer. Furthermore, as students and graduates rank workplace competencies differently, practice may help develop students' awareness of the importance of graduate competencies (Rainsbury et al. 2002). Studies indicate that candidates with professional experience are more attractive to employers than those without (Lam 2001). Another effect is that professional collaboration promotes student network building, which is important for future career development (Granovetter 1995).

In the future there should be more engagement with employers in the Blue Economy to provide placements for PhD candidates. A good example of this is the UK's Industrial Doctorate Centre in Offshore Renewable Energy (IDCORE) programme[46]. This initiative provides engineering and science graduates with "advanced training in technical skills and competencies as well as transferable skills such as project management, innovation management, and team working", and also provides extensive in-programme placements in industry for which the industry sponsor provides a funding contribution.

3.1.5 Encourage international networking and collaboration

Doctoral training should provide opportunities for international networking, i.e. through collaborative research, co-tutoring, dual and joint degrees. Mobility should be encouraged, be it through conferences, short research visits and secondments or longer stays abroad.

The EU also supports international educational networking through the Erasmus programmes (InfoBox 1.7) and the Marie Skłodowska-Curie Actions (InfoBox 1.8), embedded within consecutive Framework Programmes. These have been highly successful in supporting international mobility and career development for marine graduates over the years but remain narrow in scope and duration (European Marine Board 2013). In addition, the Marie Skłodowska-Curie programme has become highly competitive (with funding success rates of the order of 6%). Thus, only a very small proportion of applicants are able to access funds and a more accessible programme would open up opportunities to a greater number of graduates. However, there is the opportunity for funders in the marine area to develop Doctoral training networks based on the Marie Skłodowska-Curie model and ensure through adequate funding that the success rates are acceptable.

Several examples of regional cooperation to address, amongst other items, the training of future generations already exist. Once such example is the BLUEMED Initiative[47] which was set up in 2014 as a research and innovation initiative to promote the blue economy in the Mediterranean through cooperation. In their 2017 Strategic Research and Innovation Agenda (BLUEMED Initiative 2017), one of their stated aims is "training a new generation of scientists, professionals, technicians and entrepreneurs able to tackle complex ecological, economic and societal challenges in a holistic way, thus creating new and qualified 'sea-based' jobs". The importance and relevance of the BLUEMED Initiative was recognized in the Valletta Declaration on Strengthening Euro-Mediterranean Cooperation through Research and Innovation, released during the Maltese Presidency in 2017 (Union for the Mediterranean 2017).

At a global level, there are many many examples of good collaboration and networking, including the Fulbright Awards[48] which provides grants for educational exchanges for Masters, PhD or post-doctoral candidates. Looking more specifically at marine initiatives, the Partnership for Observation of the Global Oceans (POGO) provides fellowships for shipboard training[49], while the International Oceanographic Data and Information Exchange (IODE) of the Intergovernmental Oceanographic Commission (IOC) of UNESCO Ocean Teacher Global Academy[50] provides training on marine data and other marine topics.

3.1.6 Build in quality assurance

Accountability procedures must be established on the research base of Doctoral education and should be developed separately from the quality assurance in the first and second education cycle. The goal of quality assurance in Doctoral education should be to enhance the quality of the research environment as well as promoting transparent and accountable procedures for topics such as admission, supervision, awarding the doctorate degree and career development. It is important to stress that this not just about the quality assurance of the PhD itself, but also the process or life cycle from recruitment to graduation. This means that the career development beyond graduation of the marine Doctoral candidate begins from recruitment. Their training needs are assessed upon

[45] http://www.eua.be/eua-work-and-policy-area/research-and-innovation/doctoral-education/doc-careers

[46] https://www.idcore.ac.uk/

[47] http://www.bluemed-initiative.eu/

[48] http://www.fulbright.be/awards/

[49] http://www.ocean-partners.org/research-cruise-training

[50] http://classroom.oceanteacher.org/mod/page/view.php?id=2033

CASE STUDY 1: SORCHA CRONIN-O'REILLY

Sorcha Cronin-O'Reilly during her first benthic sampling of the Peel-Harvey Estuary, Western Australia, after being successfully awarded a PhD scholarship from Murdoch University based on her past experience gained through NUIG and SMART.

What is your educational background and how does this relate to your current work?

Level 8 Bachelors degree of Marine Science from the National University of Ireland, Galway. Now pursuing further aquatic research through academia via a PhD at Murdoch University, Perth, Western Australia.

What inspired you to choose this field?

My family comes from a small fishing village in south Ireland and I grew up watching the Atlantic Ocean. We all share a strong bond with the coast and so I found myself quickly applying to a course in Marine Science after secondary school. My love for the field was enhanced by learning more in-depth knowledge of the ocean and its biological, physical and chemical properties.

What training opportunities (marine-related and general skill-related) are or were available to you as a marine graduate?

One of the major training opportunities available was a Field Skills in Marine Science module run by the SMART programme. This provided me with a 'Start to Finish' approach for Marine Science, from survey planning, sample collection using different equipment, through to data analysis, interpretation and communication. It encompassed a two-day training program aboard the RV Celtic Voyager under the context of a hypothetical Environmental Impact Assessment.

Was this training formally recognized (ECTS, professional qualification)?

Yes, it was a listed ECTS module as part of the 4th year curriculum for Marine Science.

How do you feel these training opportunities have helped you?

It provided me with a chance to develop multiple skills that I apply today. I learned how to effectively log data for sites, translate and build project plans through communication and teamwork. It presented me with an opportunity to develop professional liaison abilities as I interacted with many established researchers in Marine Science.

Can you identify marine-related training that would have been useful for your education and current work?

I think opportunities such as the Field Skills in the Marine Science module is greatly required as part of an education in Marine Science. I would love to see the practical element expanded further to include more fundamental maritime skills such as GPS navigation, emergency survival techniques and skipper training for inshore boating.

Can you identify training in transferable/generic skills that would have been useful for your education and current work?

I sought additional practical training in offshore sampling techniques, including a 'Training through Research Surveys Scheme (TTRS)'; an on-board internship programme run by SMART. This provided an opportunity to assist the Marine Institute in its annual Western European Shelf Pelagic Acoustic Survey. This presented me with an integrated multidisciplinary view of how marine research is conducted and how the skills are used across a wide spectrum of research.

How would you like to see your career progressing?

So far, my past has enabled me to secure a PhD scholarship at Murdoch University, Western Australia. I hope that the international training I receive here will broaden both my knowledge and skills foundation so that I can return to Ireland with the aim to further progress Ireland's rapidly developing marine sector.

What training and/or experience would support your career progression?

I believe it is very important that students are presented with multiple opportunities to expand their knowledge and develop research skills. Opportunities such as those provided by SMART allow students to develop skills that cannot be obtained through everyday university attendance, such as professionalism through the pragmatic application of skills and representation of organisations.

arrival and a Personal Career Development Plan (PCDP) is prepared. This contains the details of courses they will follow and various placements in industry and at sea, for example. It should be monitored and constantly updated.

On the level of course accreditation, Higher Educational Institutes (HEIs) have well defined processes based on national legislation and Quality Assurance (QA) processes (European Association for Quality Assurance in Higher Education et al. 2015). There is an onus on other organizations that provide or support training (scientific institutions, private companies, government agencies, NGOs, etc.) to provide proof of the quality of their training before they can be considered equivalent. Accreditation processes can be demanding but are crucial to maximize the standard of training received. Common accreditation processes are especially important in the organization of joint graduate training programmes leading to joint and/or double degrees, delivered across two or more institutions.

A number of methods, although not aligned internationally, already exist to ensure that academic learning programmes, leading to a variety of qualifications, are reviewed against a defined set of learning outcomes that examine the underpinning knowledge, understanding, and skills required by the professional world that most graduates will enter. Accreditation by independent organizations, in particular, can enable students, their parents and advisers to select degree programmes of the standard recognized by the appropriate profession and can confer market advantage to graduates from accredited programmes.

Credit: Adam Corney, IMarEST

Marine training at sea is a valuable addition to a graduate's skill set, but the costs can be significant

3.1.7 Emphasize relevant transferable skills training

According to the European Science Foundation: "Transferable skills are skills learned in one context (e.g. research) that are useful in another (e.g. future employment whether that is in research, business etc.). They enable subject- and research-related skills to be applied and developed effectively. Transferable skills may be acquired through training or through work experience" (European Science Foundation 2010). It is essential to ensure that enough researchers have the skills demanded by the knowledge based economy. Examples include communication, teamwork, entrepreneurship, project management, Intellectual Property Rights (IPR), ethics, modelling, standardisation etc.

The transition from student life to working life is always challenging. New graduates generally perceive their most important competence is the core knowledge they have acquired within their specific discipline or profession. Many do not realize that they have gained valuable transferable skills, such as critical thinking, problem solving, project management, teamwork and communication abilities during their education. Employers tend to value transferable skills more than the educators do (Ryssevik et al. 2011). However, these transferable skills, especially from discipline programmes, are not always communicated to potential employers.

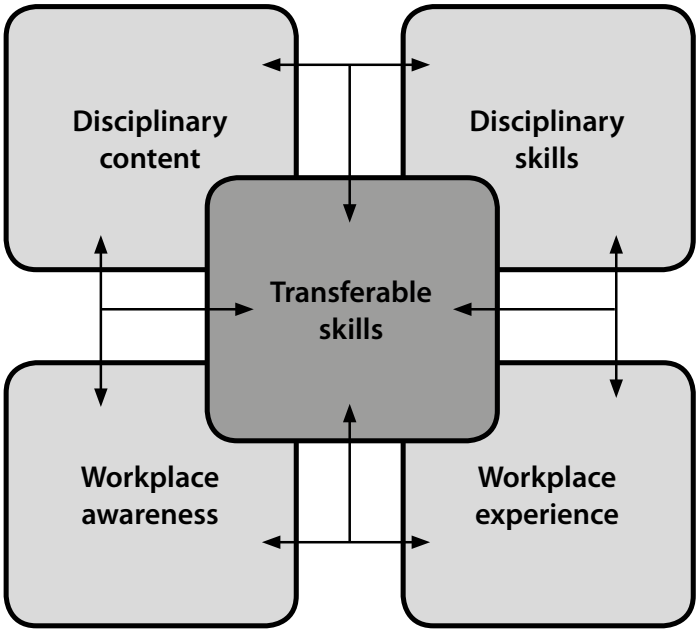


Figure 3.2 Theoretical framework for developing transferable skills in courses and study programmes (Bennett et al. 1999). The model includes five interrelated components, and the central component is transferable (generic) skills. In discipline studies, the two components, "disciplinary content" and "disciplinary skills," generally dominate, while the awareness of the transferable skills is less pronounced, and the "workplace awareness" and "workplace experience" components are small or non-existent.

Transferable skills are seldom emphasized in academic diplomas, course descriptions, or course evaluations. A lack of awareness of their own full competence and potential may hamper newly graduated students in their search for relevant jobs. Increased professional experience may enlighten these students in terms of their skills, and also increase the students' familiarity with the opportunities offered and the competences needed, across relevant professions.

Some universities provide a diploma supplement that formally recognises transferable skills in terms of the courses completed. The diploma supplement is also a policy recommendation from the European Higher Education Area (EHEA) Bologna Follow Up Group (BFUG) on the Third Cycle. Their study[51] showed that across the EHEA, 16 countries already award a diploma supplement for their doctorate degrees. The purpose is to make the PhD degree more understandable for employers without focusing intensively on academic standards or on the progression to post-doctoral programmes.

A number of countries including Ireland have approached this at national level. The Irish Universities' Graduate Skills Statement[52] describes the desired learning outcomes and skills that PhD students will have developed during their Doctoral education and training. The document communicates to employers the skills and attributes of a PhD graduate: including teamwork, leadership, personal effectiveness, entrepreneurship and innovation. This initiative should be emulated by the marine sector: A marine skills statement could be an effective means of communicating the competences and attributes of marine Doctoral graduates.

More generally, as recommended by the European Commission (European Commission Directorate-General for Research and Innovation 2018), there should be clear promotion of the importance of transferable skills among all stakeholders, to increase support for their acquisition and valuation. This activity would be greatly furthered by the development of common transferable skills certification and/or recognition, and common taxonomy and description of those skills.

[51] https://www.ehea.info/cid105340/ad-hoc-wg-third-cycle-2012-2015.html

[52] http://www.iua.ie/publication/view/iua-graduate-skills-statement-brochure-2015/

CASE STUDY 2: ABIGAIL CRONIN

What is your educational background and how does this relate to your current work?

BA Geography and English & MSc in Applied Coastal and Marine Management. I currently work in the Centre for Marine and Renewable Energy Ireland (MaREI) engaging in both fundamental and applied marine research. The MSc equipped me with the necessary knowledge and skills to fit into the Governance and Earth Observation group. My role in the group includes science communications and outreach, project management, and event management. However, I am also interested in in-situ offshore data collection which SMART has allowed me to pursue.

What inspired you to choose this field?

Growing up in Bantry Bay, I gravitated towards water sports and hobbies on or around the sea. I grew curious about the marine environment when out on the water rowing or sailing, and this led me to apply for the MSc in Applied Coastal and Marine Management.

What training opportunities (marine-related and general skill-related) are or were available to you as a marine graduate?

I was aware of the SMART training opportunities throughout my time in UCC, however I began to research further when I started my current role. It is my ambition to lead a multidisciplinary career involving both data collection and science communications and luckily I have a working environment where I'm encouraged to build on these skills. The SMART group provided training opportunities which I could apply for, and luckily I was accepted for the North South Atlantic Training Transect (NoSoAT) and SMART's Training through Research Surveys Scheme (TTRS). These allowed me to increase my time at sea as well as work and network with experts from all over the world.

Was this training formally recognized (ECTS, professional qualification)?

The training was not formally recognised as far as I am aware, however the ship time experience is highly respected in my line of work and has helped me progress in my current role.

How do you feel these training opportunities have helped you?

The NoSoAT transect, organised by POGO, AWI and SMART, was my first time being at sea for more than a day trip so this allowed me to sample this career path without committing to in-situ data collection full time, and also exposed me to areas of ocean research I previously hadn't experienced. Both training transects allowed me to network with professionals who I hope to work with in the future, and collaboration opportunities arising from SMART's TTRS scheme in particular looks promising.

Can you identify marine-related training that would have been useful for your education and current work?

The training on the NoSoAT cruise was very useful, this focused on five subject areas: oceanography, meteorology & climate science, law and governance, remote sensing, and art & science. During the TTRS scheme the hydrographic training was particularly interesting and has opened new doors for me in my line of work. Other training that would have been useful would be the sea survival course.

Can you identify training in transferable/generic skills that would have been useful for your education and current work?

Generic skills useful include project management and event management, however I feel this is separate to ship time training.

How would you like to see your career progressing?

I hope that participation on the SMART training programmes over the past twelve months will allow me to move into more in-situ ocean data collection, preferably in hydrography and perhaps oceanography. progress Ireland's rapidly developing marine sector.

What training and/or experience would support your career progression?

Further oceanographic and hydrographic training would support my career progression, to build on my current skills but also just to network and open up lines of communication with those who I may be able to work with in the future.

3.1.8 Incorporate innovative training methods

Marine graduate training programmes require integration and need to better combine research excellence (particularly at PhD level) with novel approaches in learning techniques (e.g. master classes) (Nurse 2015). In the marine education sector, there are already some very good examples of active learning methods. Short term courses, summer schools, internships and sea-going studies form part of training programmes, but these are mostly ad hoc initiatives and there is a need for tools and processes to support standardization and accreditation and to better reward trainers who invest additional time to provide this training. This of course needs to take into account the variability of resources from different countries. Academics and teachers who are willing to commit extra time and effort to support innovative international training collaborations, need to be recognized and rewarded in terms of career incentives. Currently these initiatives are piecemeal and rely on the good will and dedication of members of the marine science community.

Practical training forms an integral part of marine training and professional practice. If carefully planned and executed, such training can enhance both theoretical learning and practical knowledge, and at the same time foster important transferable skills in students. It is however noted that the level of expense that is often associated with this kind of research, and graduate training at sea, where field campaigns at sea are often part of the research, can be an issue. This places marine applicants at a possible disadvantage, needing to find additional funding to cover relatively more expensive research costs. In addition, marine research and marine graduate training at sea that includes a field element is often high risk research which can be affected by poor weather and equipment failures common in the harsh marine environment. The high risk and cost of marine research and marine graduate training at sea needs to be taken into account in tailoring appropriate support, e.g. for PhD research. There are however some opportunities being provided in this area, such as the on-board training courses that were provided by the Eurofleets 2 project during its activities[53].

At the other end of the spectrum, improved communication between lecturers, students and end-users may create positive synergies for all stakeholders. E-Learning and Massive Open Online Courses (MOOCS) have the capacity and capability to bring expertise to a large audience of professionals at all career stages within an international context (subject to availability of high-quality internet connection).

While independent thinking will always be the hallmark of the successful researcher, leveraging a range of competencies to tackle complex problems will require team work (e.g. the Team Science Approach (Waldrop 2015) and Team-Based Learning (Michaelsen & Sweet 2008)). In addition, active learning methods increase learning outcomes (Deslauriers et al. 2011) and reduce failure rates (Freeman et al. 2014). Improved linkages between industry, marine management agencies and higher education institutions offer the opportunity for mutual benefits by ensuring a more employment-ready graduate who is familiar with the potential opportunities offered in different parts of the marine sector. Internships, industrial placements and guest lectures from industry and policy experts can also add significant value when embedded in training curricula.

Business in the Blue Economy should be more involved in curricula development and Doctoral training so that skills better match industry needs. The marine sector can gain from work in this area done by the University Business Forum[54] and the outcomes of the EUA DOC-CAREERS project[55]. A positive consequence of this type of interaction is that it expands the employment opportunities for marine Doctoral graduates.

3.1.9 Facilitate Continuous Professional Development

Marine graduate training can also contribute significantly to Continuous Professional Development (CPD) for employees in the Blue Economy. CPD is a widely-accepted term that applies to those learning and development activities which contribute to an individual's continued effectiveness as a professional. CPD does not simply involve taking a refresher course or two, but taking part in less structured, more job-specific activities such as on-the-job learning or mentoring. CPD uses the principles of reflective analysis where upfront questions can be asked to determine the value of an activity. Another associated term is 'lifelong learning' which encompasses both formal and informal learning. CPD and lifelong learning courses also play a very important role in adding to existing skills bases, for instance in “marinising” the skills a person already has to enable them to have a career change or move into specialist areas, for example offshore renewable energy or marine communications.

Technology, legislation and the way scientific research is conducted is changing at such a rapid rate that, to remain competitive and employable, individuals must continually update their knowledge and skillsets. Marine and maritime professionals need to be equipped and supported to be adaptable and flexible in an increasingly diverse, mobile and global research and professional environment. Whereas most employers recognise the importance of the need to have a workforce that is continually developing its skills, knowledge and competencies, individuals share the responsibility, and as such need to pro-actively engage in their own personal and career development and lifelong learning. In this regard marine graduate training could be opened up to professionals working in the Blue Economy. This is challenging and will need strong meaningful collaboration between HEIs and Blue Economy employers. It can build on the broad range of training courses available throughout Europe. It will require better information that could be done through the Marine Training Portal. It will also require improved advertising for marine-oriented training programmes and how they link to jobs and Blue Growth that can help attract new students, trainees and professionals.

In the UK in particular, Professional Institutes or Learned Societies such as the Institute of Marine Engineering, Science and Technology[56] (IMarEST), the Royal Institute of Naval Architects[57] (RINA), the Royal Society of Biology[58] and others play a key role in training, and in CPD in particular. Often, university degrees and CPD courses are accredited by the relevant Institute, and in some

[53] http://www.eurofleets.eu/np4/74/

[54] http://ec.europa.eu/education/higher-education/doc1261_en.htm

[55] http://www.eua.be/eua-work-and-policy-area/research-and-innovation/doctoral-education/doc-careers

[56] https://www.imarest.org/

[57] https://www.rina.org.uk/

[58] https://www.rsb.org.uk/

cases the Institute will also offer its own CPD courses and field-relevant training to graduates and professionals. These Institutes, through accreditation and upskilling, may also have a direct role to play in the future direction and development of marine graduate training.

A recommendation made in EMB's Navigating the Future IV publication (European Marine Board 2013) was to promote "Ocean Schools"; clusters of educational schemes, marine stations, museums, aquaria and regional vessels brought together to develop an educational critical mass and regional pool of resources. As well as offering both graduate education and Doctoral education, these Ocean Schools could also serve as centres of life-long learning, providing opportunities for professionals and policy makers to upskill, and refresh and develop knowledge. In 2018 the European Parliament put forward a pilot project to the European Commission to boost ocean literacy in Europe and this could be a good platform to develop a European network of "Blue Schools".

CASE STUDY 3: BJÖRN STOCKHAUSEN

What is your educational background and how does this relate to your current work?

My educational background is a 2007 German Diploma in Biology from the University of Cologne with a focus on ecology including an external diploma thesis in marine ecology at the University in Kiel with the experimental part conducted in Finland. Following graduation, I did a one-semester distance course (certificate) in European environmental law. After a one-year traineeship at the European Commission's Joint Research Centre (JRC) in Italy I started a PhD Thesis at the JRC which is currently ongoing.

What inspired you to choose this field?

I was always interested in Biology and developed during my studies a particular interest for ecology. The interdependent relationships of all processes in ecology, especially in the marine environment, made me stay in this field which I merged over time with my personal interest in environmental legislation and political processes. Nowadays I advocate for legislative changes that lead to healthy and productive European seas in discussions with EU-decision makers based on scientific results and reports.

What training opportunities (marine-related and general skill-related) are or were available to you as a marine graduate?

I took part in training courses offered within the JRC such as on public speaking and economics and in several training courses offered by the International Council for the Exploration of the Sea (ICES).

Was this training formally recognized (ECTS, professional qualification)?

Only few training courses had ECTS points, but all were recognized by an official certificate from the issuing institution.

How do you feel these training opportunities have helped you?

They have helped me a lot to expand my knowledge and understanding in areas related to my main area of work as well as providing soft-skills that are useful in discussions and presentations.

Can you identify marine-related training that would have been useful for your education and current work?

ICES training courses, as mentioned above, are very useful for both my scientific background and my current work. ICES started offering these trainings several years ago and has expanded the scope of these courses since then. Additional useful training courses are for example those on economics or European and international marine laws.

Can you identify training in transferable/generic skills that would have been useful for your education and current work?

These are courses such as on public speaking and media training.

How would you like to see your career progressing?

I would like to continue advocating in the field of environmental policy making, shaping the legislation in Europe.

What training and/or experience would support your career progression?

Leadership training and negotiation skills.

4 Strategic recommendations

In order to achieve the vision of a modern and fit-for-purpose marine graduate training and education landscape in Europe, comprehensive and systematic reform is required by all relevant stakeholders.

4.1 Introduction

Marine graduate training faces challenges if it is to be fit-for-purpose, especially in the context of the Blue Economy. The training currently provided to those undertaking Masters and PhD programmes in the marine sciences in Europe should be updated to address these challenges. PhD training, in particular, is still designed primarily to prepare graduates for an academic career and takes little account of the fact that the significant majority of PhD graduates will leave academia (either immediately following graduation or after several years as a post-doctoral researcher) and pursue a career in another sector, or to create their own business opportunities based on their high skills and holistic vision of the Blue Economy. There have been significant advances to change this approach across Europe through the introduction of Doctoral schools and programmes. These are supported by various national and European funding programmes, such as the Marie Skłodowska-Curie Initial Training Networks that incorporate industry, disciplinary/transferable skills training and professional development.

What is needed is a fundamental rethink on how Masters and PhD courses in the marine sciences are implemented in Europe, with a view to producing graduates with knowledge, competences and skill-sets that are immediately applicable to employers across multiple marine and maritime sectors and that encourages entrepreneurship. To ensure this is in line with the EU goal of a European Higher Education Area, these advances need to happen in a coordinated way, so that opportunities for students to study in different locations across Europe are easily exploited. What is at stake is the possibility for the many thousands of annual Masters and PhD graduates to find attractive employment and/or entrepreneur opportunities in marine and maritime sectors, leading to fulfilling careers and contributing to Blue Growth.

4.2 Recommendations

Based on the information provided in the previous chapters, this final chapter provides a list of high-level recommendations which address some of the most important next steps in advancing marine graduate training in Europe.

One of the complicating factors is the complexity of the landscape and assessing who is best placed and responsible for instigating change and progress. Such progress will depend on the support of, and collaboration between, many different actors including, inter alia, HEIs and their representative bodies at national and European level; national agencies and ministries responsible for education, science, technology and innovation; national accreditation and quality assurance agencies; the European Commission; the European Institute for Technology and Innovation; marine and maritime industries; and various European initiatives dealing with higher education, skills and competences. The marine and maritime communities, many of whom are both educators and researchers, also have a key role to play in driving the process and developing new training models and courses. For each recommendation below, some of the most relevant actors, that could be best placed to respond and drive progress are indicated. These are indicative and not exhaustive.

Credit: European Marine Board

WG Training meets with Stakeholders

1. Modernise all marine graduate training programmes

- Promote the following training content in marine graduate training programmes:
  - **Transferable/generic skills** that have become common across Europe in graduate programmes usually within the context of a structured Doctoral programme. These include communication, project management, teamwork/leadership, entrepreneurship, Intellectual Property Rights, research integrity and ethics;
  - **Marine disciplinary skills** that would cover the 5 blue growth and 6 maritime function areas, as well as marine policy, practical sea-going training courses, basic sea-going skills and other skills related to the Blue Economy;
- Training should be delivered using the most modern methods. These would include embedding active learning techniques and team science approaches within courses and programmes. Where possible, real-world issues, complex marine and maritime challenges should be addressed;
- All course should be accredited with ECTS and formally recognised as part of Continuous Professional Development (CPD);
- Common transferable skills certification and/or recognition, and common taxonomy/description of skills should be developed;
- In addition to providing these courses for marine science and technology students, access should be granted to people working in the Blue Economy (in the public or private sector) as part of their Continuous Professional Development (CPD) and skills need to be more marine orientated.

Employers in the Blue Economy should be involved in advising on skills gaps in industry and course development. They can often help with the promotion of entrepreneurship and the creation of new business opportunities.

Key Actors: HEIs (teachers, training coordinators, university management), national agencies and ministries for education, science and innovation, Professional Institutes.

2. Develop training content by engaging the wider marine community across academia, government (policy & funding) and industry

- Identify (and periodically update) the skills gaps and training needs at EU level across the most important Blue Growth areas, and areas associated with the Sustainable Development Goals;
- Promote best practice exchanges in curriculum development of training programmes between sectors e.g. internships, work experience, practical training, invited lectures;
- Include policy, economic and industrial components (including work placements) in university education;
- Promote centres for marine/maritime graduate and Doctoral training, and life-long learning ("Ocean Schools") focused on research and skills gaps required by the blue economy and wider marine job market, and promote Ocean Schools networks;
- Promote life-long learning and Continuous Professional Development (CPD) for marine and maritime professionals and for non-marine professionals with potential to contribute to the Blue Economy;
- All marine graduate skills should be developed in an Open Education environment,
  - Recognising that there are already developments in this area, future activity must focus on improving the quality and relevance of marine graduate skills;
  - In order that these skills will be internationally portable, marine graduate skills and qualifications must be made more visible and comparable;
  - It must be ensured that marine graduate skills will improve skills intelligence and information to provide Doctoral graduates with better career choices.

Key Actors: HEIs (teachers, training coordinators, university management), national agencies and ministries for education, science and innovation, private sector, NGOs, government agencies and competent authorities for marine issues, Professional institutes.

3. Maximise recruitment of students and professionals to take an interest in marine graduate training and blue careers

- Building on current Marine Training Portal (www.marinetraining.eu), develop a comprehensive Europe-wide portal as a one-stop-shop for graduate training opportunities (Masters and PhD) in Europe;
- Enhance the visibility of marine graduate training courses and marine/maritime career opportunities for Bachelor graduates, school leavers and parents (course prospectus and advertising material); ensure publicity through fora including FINDAPHD.COM and EURAXESS.ORG;
- Develop common blue branding for training courses to employment in Blue Economy and marine management;
- Develop a marine graduate skills statement as an effective means of communicating the competences and attributes of marine Doctoral graduates.

Key Actors: HEIs (teachers, training coordinators, university management), EuroMarine, EMBRC, DG MARE.

4. Advance the European Higher Education Area for marine science and technology – structuring the landscape

- Establish a national marine science and technology network in each country to:
  - o Support the upgrading and modernization of existing graduate training programmes;
  - o Provide an improved alignment of national standards, and positions in education and training;
  - o Ensure that all training in marine science (including sea-going training) is accredited according to national standards; and
  - o Collaborate and form an enhanced European training network for marine science and technology (platform for exchange of knowledge and best practice in dynamic and active learning).

Key Actors: European Marine Board, EuroMarine, Eurofleets and Euopean Research Vessel Operators (ERVO), European Marine Biological Resource Centre (EMBRC), HEIs.

5. Deliver relevant policy support initiatives to address the gap between marine graduate training and Blue Growth

- Ensure graduates of marine sciences are recognized as a key potential contributor to Blue Growth and develop policy actions to ensure best utilization of this significant and valuable human resource;
- Utilize existing EU programmes to reduce the disconnect between marine graduate training and Blue Growth. Options include a marine science and technology Knowledge Alliance, and/or Marine Knowledge and Innovation Community (Marine-KIC);
- Promote the development of a sectoral reference group for the Blue Economy under European Skills, Competences, Qualifications and Occupations (ESCO).

Key Actors: European Commission (DG MARE, DG RTD, DG E&C) European Institute for Innovation & Technology (EIT), ESCO, national marine funding agencies.

6. Establish long-term, flexible funding instruments and national and EU level to support innovative marine training

- Encourage Member States to:
  - o Utilise EU structural funds to support development of marine science and technology training centres of excellence (often in peripheral, coastal locations) and promote their coordination within a national network;
  - o Develop, fund and implement short practical courses (e.g. coastal observatories, research vessels, marine stations, renewable energy devices, etc.) for marine graduate programmes and professional CPD;
  - o Use national marine funding to support marine Doctoral schools based on the Marie Skłodowska-Curie model; and
  - o Develop national or European schemes/centres based on the Marie Skłodowska-Curie European Industrial Doctorates (EID) to forge closer links to the marine employment sector.
- Establish EU funding mechanisms to support the development and implementation of short practical courses (e.g. coastal observatories, research vessels, marine stations, renewable energy devices, etc.) currently not possible within longer-term Marie Skłodowska-Curie and Erasmus+ actions (i.e. long-term mechanisms for short-term training).

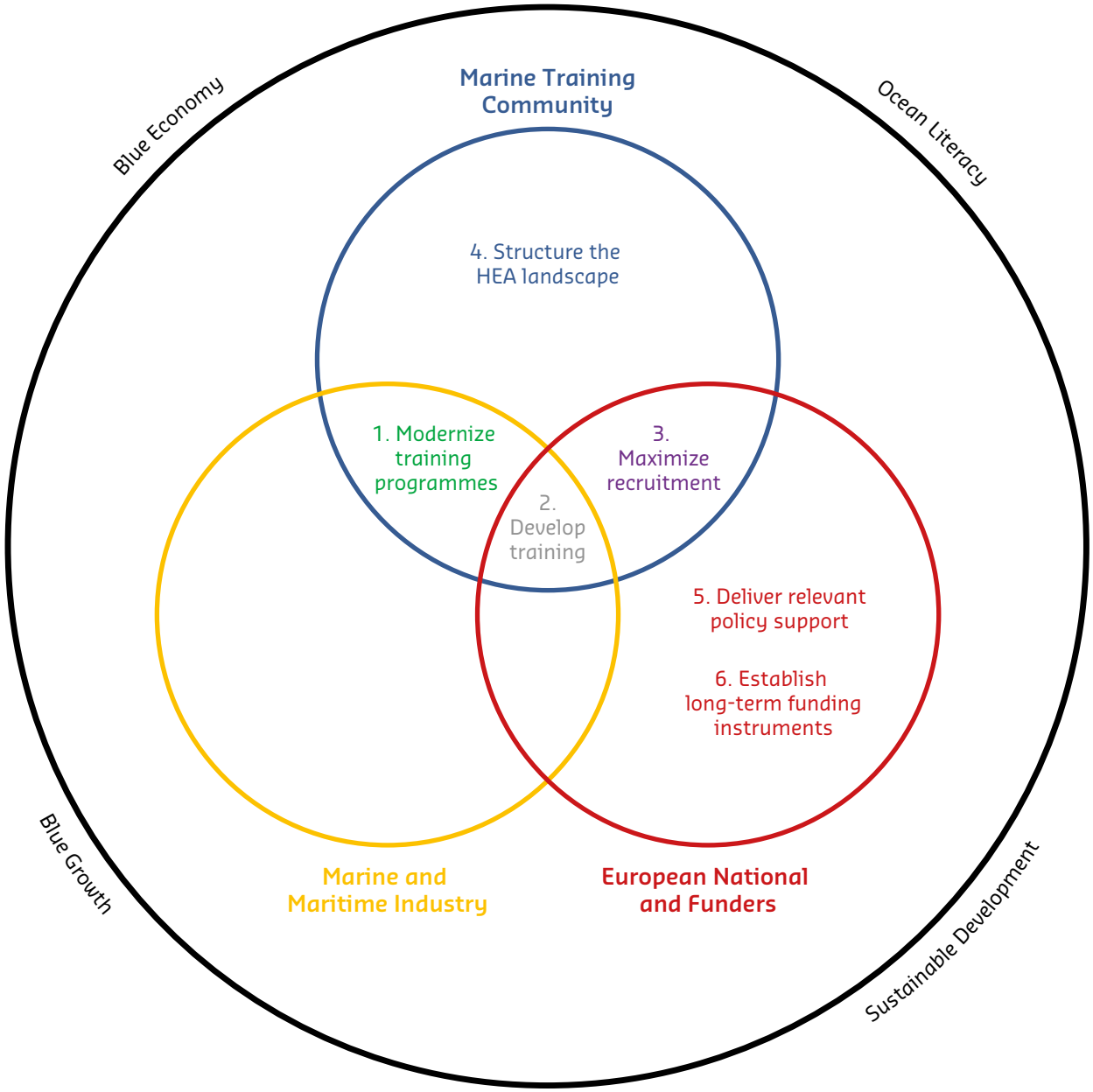
Key Actors: DG Research & Innovation, DG MARE, DG REGIO, EuroMarine, national funding agencies and national authorities (for structural funds).

4.3 Implementation

The six recommendations detailed above set out clear recommendations to achieve a modern vision of marine graduate training in Europe. It is the intention that these Recommendations could be used as input to the ongoing planning of Research Programmes, including the next Framework Programme (FP9), to ensure the training component is further strengthened in future National and European projects.

In terms of Implementation, the six recommendations cover a range of activities that will require the engagement of a wide variety of stakeholders across all sectors. The most effective way to ensure stakeholder input and co-design of the next steps would be to organise an international forum to discuss the recommendations and develop a **roadmap for implementation**. The forum would include representatives from the marine academic, research, industry, funders, government and European communities. A stakeholder-driven, inclusive event would allow each of the six recommendations to be discussed with short-, mid- and longer-term actions for implementation.

The figure below indicates the required collaborations between the main actors and stakeholders in marine graduate training in order to implement these recommendations:



Credit: European Marine Board

Figure 4.1: Key recommendations for marine graduate training showing key actors, set within the wider marine landscape,

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List of Abbreviations and Acronyms

AWI	Alfred Wegener Institute for Polar and Marine Research
BFUG	Bologna Follow Up Group
BSF	Business and Science Forum
CPD	Continuous Professional Development
CPMR	Conference of Peripheral Maritime Regions of Europe
DEME	Dredging, Environmental and Marine Engineering NV
DG	Directorate General (of the European Commission)
DG MARE	Directorate General for Maritime Affairs and Fisheries
DG E&C	Directorate General for Education and Culture
DG REGIO	Directorate General for Regional Policy
DG RTD	Directorate General for Research and Innovation
EC	European Commission
ECTS	European Credit Transfer and accumulation System
EHEA	European Higher Education Area
EID	European Industrial Doctorate
EIT	European Institute for Innovation and Technology
EMB	European Marine Board
EMBRC	European Marine Biological Resource Centre
EMD	European Maritime Day
EMFF	European Maritime and Fishery Fund
ERA	European Research Area
ESCO	European Skills, Competences, Qualifications and Occupations
ESF	European Science Foundation
ESFRI	European Strategy Forum on Research Infrastructures
ESR	Early Stage Researcher
EU	European Union
EUA	European University Association
FP7	7th Framework Programme
GDP	Gross Domestic Product

GIS	Geographic Information System
HEA	Higher Education Area
HEI	Higher Education Institute
ICES	International Council for the Exploration of the Sea
IDCORE	Industrial Doctorate Centre in Offshore Renewable Energy
IDTP	Innovative Principles for Doctoral Training
IMarEST	Institute of Marine Engineering, Science and Technology
IOC	Intergovernmental Oceanographic Commission of UNESCO
IODE	International Oceanographic Data and Information Exchange
ITN	Innovative Training Network
JRC	European Commission's Joint Research Centre
KIC	Knowledge and Innovation Community
LERU	League of European Research Universities
MaREI	Centre for Marine and Renewable Energy Ireland
MATES	Maritime Alliance for fostering the European Blue economy through a Marine Technology Skilling Strategy Project
MOOCS	Massive Open Online Courses
MSc	Master of Science degree
MSCA	Marie Skłodowska-Curie Actions
MSFD	Marine Strategy Framework Directive
MSP	Marine Spatial Planning
NGO	Non-Governmental Organization
NoSoAT	North South Atlantic Training Transect
OECD	Organisation for Economic Co-operation and Development
OHH	Ocean and Human Health
OTEC	Ocean Thermal Energy Conversion
PhD	Doctor of Philosophy
POGO	Partnership for Observation of the Global Oceans
QA	Quality Assurance
R&D	Research and Development

RES	Renewable Energy Sources
RINA	Royal Institute of Naval Architects
RFO	Research Funding Organizations
RPO	Research Performing Organizations
SAM	Scientific Advisory Mechanism
SC	Societal Challenge
SE	Science Europe
SMART	Strategic Marine Alliance for Research and Training
SWOT	Strength, Weakness, Opportunity, Threat
TGSMT	Training for Greener and Safer Maritime Transport Project
TTRS	Training Through Research Surveys
UCP	European Marine Board's University Consortium Panel
UK	United Kingdom
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
VET	Vocational Education and Training
WG	Working Group

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