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HIGH LEVEL PANEL *for*
A SUSTAINABLE
OCEAN ECONOMY

Blue Paper

The future of the workforce in a sustainable ocean economy

LEAD COORDINATING AUTHORS | Leila Ben Hassen, Charles S. Colgan, Mark J. Spalding

OCEAN PANEL COORDINATING AUTHOR | Oliver S. Ashford

CONTRIBUTING AUTHORS | Anthony Castelletto, Helen Ding, Monica Grasso, Philip A.S. James, Kapil Narula, Angelique Pouponneau, Tim Slingsby, Thanos Smanis

oceanpanel.org

About this Paper

Established in 2018, the High Level Panel for a Sustainable Ocean Economy (Ocean Panel) is a unique initiative made up of serving world leaders who are building momentum for a sustainable ocean economy in which effective protection, sustainable production and equitable prosperity go hand in hand. By working collaboratively with a wide array of stakeholders, the Ocean Panel aims to identify bold solutions that bridge ocean health, wealth and equity and accelerate and scale responsive action worldwide.

This Blue Paper was prepared in support of the work of the Ocean Panel to provide a robust science and knowledge base and practical opportunities for action across issues central to building a sustainable ocean economy. The arguments, findings and opportunities outlined in this Blue Paper represent the views of the authors alone. Ocean Panel members have not been asked to formally endorse the Blue Paper and should not be taken as having done so.

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Foreword

We stand at a fork in the road. One path, business as usual, leads towards declining human health and increasing inequality through exacerbation of the triple planetary crises of climate change, biodiversity loss and pollution. The other path, one of a sustainable ocean economy, leads towards healthy, prosperous and equitable societies. This Blue Paper commissioned by The High Level Panel for a Sustainable Ocean Economy (the "Ocean Panel"), provides us with a glimpse of what a sustainable ocean economy may look like for people over the next 25 years, as well as advice on how different stakeholders can work towards this vision. It draws from the best available data and literature, and in-depth expert consultation, to examine the future of employment within a range of ocean sectors.

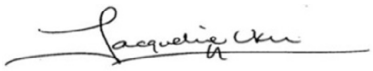
Data on employment in the ocean economy are still diffuse and unstandardised, making them challenging to assess. Previous attempts have underestimated employment in the ocean economy, significantly undervaluing its importance to the global economy. This Blue Paper discusses data from recently published reports to provide a more comprehensive assessment of employment in the ocean economy. It reports that total ocean economy employment in 2019 was at least 133 million. The number is likely to be larger still, given data gaps and the difficulties of estimating informal employment in sectors such as tourism and aquaculture and fisheries. Based on best available data, the paper reports that employment in a sustainable ocean economy could reach 184 million by 2050—an increase of 51 million, or 1.5 percent per year, from a 2019 baseline.

Building upon this through iterative consultation with a diverse team of experts, the Blue Paper identifies both the key drivers that will shape future ocean employment, and the economic sectors they will most likely affect. The results of this suggest that the principal drivers are climate change, access to finance, and the adoption of sustainable practices, whilst the key sectors they will affect are marine renewable energy, aquaculture and fisheries, and offshore oil and gas.

To achieve the potential of a sustainable ocean economy, a just transition that incorporates inclusion and fairness is essential. The Blue Paper identifies critical equity challenges that need to be surmounted, including skills gaps, insufficient training and educational resources (especially in developing nations), regional disparities in infrastructure, and inadequate funding and institutional capacity.

The authors of this Blue Paper, who are internationally recognised subject matter experts, identify immediate priorities for action, and knowledge gaps and strategic recommendations for consideration. Priorities include tackling weak ocean data systems by creating and maintaining national ocean economy accounts, and creating blue skills strategies to expand current capabilities to meet future needs. Knowledge gaps include limited data and understanding of the informal economy and the interactions amongst ocean economy sectors. Key strategic recommendations include strengthening international cooperation on shared ocean resources and expanding social safety nets for workers in the sectors most likely to face significant changes.

As lead experts of the Ocean Panel Expert Group, we call upon the diverse stakeholders of a sustainable ocean economy to embrace the principles and opportunities outlined in this Blue Paper. Together, we can strive for a sustainable ocean economy where effective protection, sustainable production and equitable prosperity go hand in hand. We express our gratitude to the authors, the reviewers and the Ocean Panel Secretariat at World Resources Institute for supporting the production of this valuable resource.



Prof. Peter Haugan, Ph.D.
Institute of Marine Research,
Norway

Dr Judith Kildow, Ph.D.
Director Emeritus of the National
Ocean Economics Program
USA

Dr Jacqueline Uku, Ph.D.
Senior Research Scientist,
Kenya Marine and Fisheries
Research Institute (KMFRI)

Highlights

- The transition towards a sustainable ocean economy presents a wealth of untapped employment opportunities that can drive economic growth whilst ensuring environmental stewardship and social equity. From emerging roles in marine renewable energy, sustainable fisheries and ecotourism, to specialised jobs in marine conservation, data analytics and environmental finance, our analysis suggests that the sustainable ocean economy is poised to become a significant source of employment.
- This paper assembles and synthesises analysis and projections collected from experts and literature on the jobs a sustainable ocean economy could provide.
- We find that the formal ocean economy employs at least 133 million people globally.
- The Expert Panel assembled by this Blue Paper predicts that seven key drivers will shape future ocean employment: climate change, investment access, adoption of sustainable practices, changing demand for ocean goods and services, energy demands, sustainability requirements, and emerging innovative sectors over the near term (2030) and long term (2050). The Expert Panel predicts that the sectors most likely to be impacted by these key drivers are marine renewable energy, aquaculture and fisheries, marine research and innovation, marine transport and ports, tourism and hospitality, offshore oil and gas, and marine management and governance.
- Considering this and the best available information, we report that employment in a sustainable ocean economy may grow by 51 million by 2050 (to 184 million)—an increase of 1.5 percent per year from a 2019 baseline.
- Sectors that combine technological innovation with environmental stewardship may be best poised for growth. The largest sector in the global ocean economy, marine and coastal tourism, employs roughly 79 million people. Fishing and aquaculture is the second-largest employer, supporting an estimated 24 million jobs in 2019. Accounting for subsistence fishing, this estimate may increase to over 120 million. The fastest-growing employment sector of a sustainable ocean economy is projected to be marine renewable energy. It could create 1.2 million jobs by 2050. Traditional sectors like offshore oil and gas face likely employment declines.
- Significant regional disparities exist in the growth of the sustainable ocean economy and the transition to sustainable practices, with developed economies better positioned to capture benefits from emerging opportunities.
- Major skills gaps exist globally between current workforce capabilities and future industry needs, particularly in developing nations and remote coastal communities, and new financial mechanisms and instruments are crucial to protect vulnerable ecosystems and communities and foster a just, inclusive transition towards a sustainable ocean economy.
- Ocean stakeholders, academic institutions, governments and others must collaborate to provide training and capacity-building programmes, create policies and incentives for environmental protection, and promote research and development of sustainable ocean technologies and practices to create new job opportunities while preserving and regenerating ocean resources.

Executive summary

In a world facing climate change, environmental degradation and the urgent need for sustainable development, the global ocean economy is a crucial economic frontier and vital resource that must be protected (Ocean Panel 2020). Choices made today will help determine whether this resource can be developed in ways that foster sustainable production, environmental protection, social equality, new opportunities and better livelihoods for millions of people around the world. Careful management and wise governance are vital for managing ocean resources and developing the workforce in ways that will shape the future of marine ecosystems and dependent coastal communities for generations.

This Blue Paper examines the future of employment within a sustainable ocean economy, providing a comprehensive analysis of current employment patterns, emerging trends and the complex dynamics that will determine the size and characteristics of the workforce in the coming decades. Currently, formal economy jobs span diverse sectors, including fisheries and aquaculture, coastal and marine tourism, maritime transport, offshore energy and emerging industries such as marine biotechnology and renewable energy. Best available data suggest that the ocean economy directly employed approximately 133 million people globally in 2019.

Available data suggest that including subsistence fishing would raise the estimate of ocean economy jobs by roughly 100 million. But we exclude this figure from our baseline estimate because differences in baseline years and data collection methods make comparisons less reliable than for the formal economy. The full contours of ocean-related employment may be only partly understood. But its scale and diversity underscore its importance now and in the future.

The transition to a sustainable ocean economy is more than just an environmental imperative—it demands a fundamental transformation of how we interact with ocean resources, requiring new skills, technologies and approaches to workforce development. Our analysis identifies several key drivers that will shape employment patterns through 2030 and 2050. Climate change, for example, will impact the distribution and characteristics of living resources in the ocean, as well as trends in tourism. Changing energy demands will promote a shift towards marine renewable energy and away from offshore oil and gas. Technological innovation, such as increasing automation, will affect the geographic location of jobs. Our analysis is supported by extensive expert consultation through a comprehensive Delphi process engaging 181 experts across six continents. These experts emphasise that the transformation of the ocean economy will create both opportunities and disruptions, making it essential to prepare the workforce for emerging roles while supporting those in transitioning industries.

Critical challenges and opportunities

Global growth, the structural evolution of sectors and industries, and the requirements of addressing sustainability, will all help shape the ocean economy's future. A more sustainable ocean economy will consist of traditional industries operating in new ways and new industries still emerging, and both will require equipping workers with new skills. This underscores the need to narrow the substantial skills gap between current workforce capabilities and the requirements of emerging sustainable industries (WOI 2022a; Lloyd's Register Foundation 2021). This gap is particularly wide in developing nations and remote coastal communities that lack economic diversity, access to information, training and educational resources, and business opportunities (Issifu et al. 2023). The challenge is compounded by rapid technological change, which requires workers to continuously update their skills and adapt to new ways of working (Spalding 2024).

Regional disparities present another significant challenge. Different regions of the world face varying obstacles in transitioning to sustainable practices. Some do not have the necessary infrastructure,

funding or institutional capacity to support workforce development. These disparities risk creating a two-tier system in which some regions benefit from the transition to new technologies and opportunities for sustainable production, while others fall further behind. Additionally, the impacts of climate change are already threatening traditional ocean-based livelihoods, particularly in vulnerable coastal communities and small island developing states (which have contributed least to the emissions disrupting our planet's climate) (Bindoff et al. 2019).

Social equity is another concern, as the transition must ensure that the benefits of the sustainable ocean economy are distributed fairly and that vulnerable communities are not left behind. This includes addressing gender disparities in ocean-based industries, protecting the rights and livelihoods of Indigenous peoples, and ensuring that workers in declining sectors have access to new opportunities. The challenge of achieving equitable outcomes is particularly acute in regions where traditional ocean-based activities that exclude women (such as wild fish capture) are deeply embedded in local culture and society (Strand et al. 2024).

However, these challenges are matched by significant opportunities that could transform the ocean economy while creating meaningful employment. Emerging industries such as marine renewable energy, sustainable aquaculture and marine biotechnology offer substantial potential for job creation and economic growth. Our research indicates that the ocean economy could nearly double in employment by 2050, particularly in areas that combine technological innovation with environmental stewardship.

The growing demand for expertise in ocean data analytics, marine conservation and restoration, and sustainable resource management creates opportunities for high-skilled employment and career advancement. This includes roles in environmental monitoring, ecosystem restoration and the development of sustainable technologies. The ocean economy also presents opportunities for entrepreneurship and innovation, particularly in areas where sustainable approaches can enhance traditional practices.

The path forward

Success in this transition requires coordinated action in several areas:

- Governments must develop and actively support policy frameworks, such as sustainable ocean plans, that create incentives for sustainable practices, supporting research and development and implementing regulations that promote environmental protection, sustainable production and social equity. They will also need to invest in education and training programmes that prepare transitioning workers and new entrants into emerging employment opportunities.
- Private sector organisations must play a crucial role by further embracing sustainable practices, investing in workforce development and creating new business models that balance profit with environmental stewardship (Woods 2023). The extent of their commitment to sustainability and willingness to invest in human capital will largely determine the success of the transition (Ojiambo 2023).
- Financial institutions must develop innovative funding mechanisms to support the transition, including green bonds, impact investing and other instruments that can channel capital towards sustainable ocean industries (Sumaila et al. 2020). This financial innovation is essential for funding infrastructure development and workforce training programmes.
- Educational institutions must adapt their curricula to meet emerging skill requirements while ensuring that training programmes are accessible to diverse populations. This includes developing new courses and certifications that combine technical knowledge with sustainability principles and creating flexible learning pathways that accommodate working professionals.
- Civil society organisations must provide advocacy and community engagement, as well as monitor progress, to help ensure that the transformation of the ocean economy serves both people and the planet (Bennett et al. 2022). These organisations can be essential champions of social equity and environmental protection throughout the transition.

Our ability to navigate these challenges while seizing emerging opportunities will shape the future of work in the sustainable ocean economy. Success requires technical innovation, financial investment and a commitment to social equity and environmental protection. By taking coordinated action, we can create a future where ocean-based industries thrive while preserving marine ecosystems for generations.

Scope and structure of the report

1. **Current and projected status of employment within the ocean economy.** Presents data on current ocean-related employment across sectors and discusses how this may change towards 2050.
2. **Expert insights: Employment changes in the transition to a sustainable ocean economy.** Presents insights from 181 experts across six continents on anticipated workforce changes, identifying seven key drivers of change and their projected impacts on employment through 2030 and 2050.
3. **Changing employment opportunities in a sustainable ocean economy.** Analyses emerging employment opportunities across various sectors, including marine renewable energy, sustainable fisheries, biotechnology and conservation, while examining required skills and competencies for future workforce development.
4. **A just transition for diversity, equity and sustainability in the ocean economy: Ocean stakeholders' roles and needs.** Outlines specific roles, needs and responsibilities of governments, intergovernmental organisations, the private sector, non-governmental organisations, financial institutions, academia and civil society in supporting workforce transition and development.
5. **Opportunities for action.** Provides detailed, actionable recommendations for creating an inclusive, adaptive and forward-looking workforce capable of supporting a sustainable ocean economy, including specific steps for implementation and monitoring progress.

Through this Blue Paper we aim to provide decision-makers, industry leaders and other stakeholders with the insights and guidance needed to navigate the complex transition towards a sustainable ocean economy while ensuring a skilled, adaptable and inclusive workforce for the future.

Key findings summary

Current employment status

- Base employment estimate of 133 million jobs in 2019.
- Marine and coastal tourism is the largest employer, with 79 million jobs in 2019.
- Fisheries and aquaculture is the second-largest employer, supporting an estimated 24 million jobs in 2019. Accounting for subsistence fishing, this estimate may increase to over 120 million.
- Marine transportation is the third-largest employer, with an estimated 19 million people employed globally.
- Significant data gaps exist in employment tracking across regions and sectors because of weak national data systems or insufficient detail on ocean-related industries.

Future employment trends

- Under the scenario of a sustainable ocean economy, employment could grow by 51 million by 2050, to over 184 million jobs, relative to 2019 baseline data.
- Under the scenario of a stalled transition to a sustainable ocean economy, employment falls relative to the 2019 baseline by nearly 40 million to just over 91 million.
- Marine renewable energy shows the strongest growth potential.
- Traditional sectors like offshore oil and gas face likely employment declines.
- Substantial workforce reskilling and adaptation will be required, particularly in developing regions.
- Digital transformation and technological innovation will create new job categories while potentially displacing others.
- Regional disparities in the pace of transition could exacerbate existing economic inequalities.

Critical challenges

- Substantial skills gaps exist between current capabilities and future needs.
- Access to training and educational resources is limited in developing nations.
- Regions have unequal infrastructure, funding and institutional capacity.
- Social equity and protection of vulnerable communities needs to be improved.
- Data limitations hamper effective workforce planning.

Opportunities for action

Immediate priorities

- Prioritise the creation and/or development of national income-based ocean accounts, including employment estimates, particularly in South Asia, the Middle East, Africa, South America and small island developing states.
- Develop comprehensive blue skills strategies at national and regional levels.
- Strengthen public-private partnerships for workforce development.
- Expand access to technical training and education, particularly in developing regions.
- Create innovative financing mechanisms to support a sustainable transition.

- Improve data collection and monitoring of ocean economy employment, including through the use of uniform metrics.

Knowledge gaps requiring attention

- Limited data on self-employment, subsistence and informal employment in ocean sectors.
- Incomplete understanding of technology impacts on future job displacement.
- Need for better metrics on social equity outcomes in transition.
- Limited research on effectiveness of different training and education approaches.
- Gaps in understanding regional variations in workforce needs and capabilities.
- Gaps in understanding cross-sectorial impacts of changes.

Strategic recommendations

- Develop national income-based, environmental and ecosystem accounts, ocean economy satellite accounts and social accounts, especially for those indicators which track the equitable distribution of economic activity.
- Create training opportunities to support the development of ocean accounts, starting by developing ocean satellite accounts from national income accounts.
- Enhance regulatory frameworks supporting sustainable practices.
- Foster diverse leadership across ocean industries.
- Strengthen international cooperation on shared ocean resources.
- Accelerate digital transformation while ensuring equitable access.
- Expand social safety nets for workers in transitioning industries.
- Create mechanisms to transition informal ocean-related jobs into formal employment.
- Increase funding allocation to Sustainable Development Goal 14 (Life below Water).

Current and projected status of employment within the ocean economy

Differing approaches to defining the blue economy

The term "blue economy" has spread across the globe over the last decade, gaining momentum after the Rio+20 UN conference on sustainable development in 2012 (World Bank Group 2024). But the actions taken have depended on global and local priorities and contexts, creating diverse definitions and plans for enacting a blue economy. In this paper the term "sustainable ocean economy" (SOE) relates the ocean economy to clear principles of sustainability and aligns with the Ocean Panel's definition of the SOE. We define it as a concept that seeks to promote economic growth, social inclusion and the preservation or improvement of livelihoods and jobs while ensuring the environmental sustainability of the ocean and coastal areas (see "Key definitions and glossary").

Three broad and common themes characterise much "blue economy" documentation. Countries that focus attention on the blue economy choose the mixture of these elements appropriate to their circumstances and policy preferences.

1. **The blue economy is defined as the portion of the national economy that can be related to the ocean.** This is usually expressed in the measures used in national accounts, consistent with the UN System of National Accounts, such as gross output (total sales), value added (the difference between gross sales and the cost of inputs) and employment (Colgan 2013).

   The sectors and industries identified as ocean-related vary by country. Industries such as commercial fishing; aquaculture, tourism and recreation; and marine transportation are included in nearly all definitions. Beyond these, industries such as some manufacturing, marine construction and marine services are included either directly or indirectly. Some industries, such as desalination or salt production, are located in only a few countries (Colgan 2018).

2. **The blue economy prioritises sustainable uses of resources.** Sustainability has many different dimensions, including economic, social and environmental ones (Brundtland 1987). But in the case of the blue economy, three major sub-themes have emerged:

   - Use of resources within natural carrying capacity. The traditional example is fisheries which are sustainable when catch is limited to the maximum sustainable yield or less (Andersen 1977). But carrying capacity also includes ecosystem-based carrying capacity for systems such as wetlands or coral reefs. In these cases, sustainability may mean reducing use of the resources from currently unsustainable consumption levels (Moberg and Folke 1999).
   - Adaptation to climate change. Climate change poses major challenges to virtually all uses of the ocean because of changes in ocean temperatures, chemistry, levels or circulation. Sustainability in these cases means finding ways to adapt to these alterations in the baseline conditions. This may mean shifts in the location or types of fishing, alterations in the shoreline or other changes in capital investments or operations (Mills et al. 2023).

- Social sustainability addresses the distribution of the wealth created from the ocean, the processes used to make distribution decisions, whether these include populations historically underrepresented in the allocation and use of ocean resources, and whether these seek to redress past injustices in resource distribution (Jepson and Colburn 2013).

3. **The blue economy encompasses portions of the ocean economy that are focused on technological innovation.** This theme, most prevalent in advanced economies such as North America and Europe, emphasises a leading role for the development of new products and processes related to the ocean. Some of these innovations focus on information and communication technologies, including the development of "big data" to support ocean management. Other areas being explored include biological and chemical technologies that support aquaculture and pharmaceutical development. In addition to their commercial applications as a sector of the ocean economy, technological innovations can contribute to broad efforts to manage the ocean more sustainably (Spinrad 2016).

Defining and measuring employment

Within an ocean economy, there are multiple ways to measure employment:

- **Jobs:** A job is simply one person in an employment relationship. Jobs are usually counted without respect to the period of employment, which might be full time, part time (less than full time each week) or part year (full or part time but only for a limited number of weeks).
- **Full-time jobs**: Full-time jobs are those that meet a defined criterion. This may be 40 hours or 35 hours per week and can vary more widely in some countries.
- **Jobs reported by employers:** Employers and administrative and record-keeping requirements are one source of employment data. For example, unemployment insurance systems usually require employers to report job numbers, though some industries may be exempt from these insurance schemes and not report. Sampled surveys can also gather information from employers.
- **Jobs reported by employees:** Jobs reported by employees will differ from those reported by employers because people may hold multiple positions. The reporting system used may capture these multiple jobs. But some job holders may also be self-employed.
- **Self-employment:** Self-employment means there is no employing organisation and no employment relationship. Self-employment characterises much of the world's fisheries, particularly small-scale fisheries. It is by far the most difficult type of job to count, and measuring it usually requires surveys.
- **Jobs by location:** Jobs can be reported by the location of the employer or the residence of the employee. The first addresses the question of the number of jobs in a specified region. The latter is the number of people in that region with a job. The difference is most often accounted for by commuting, though the rise of remote working makes the measurement even more difficult.
- **Imputed jobs:** For a variety of reasons, jobs known to exist may not be fully accounted for. This may be because of sampling errors or the lack of systematic measurement. However, it can also occur because most statistical databases have rules against the disclosure of employment for single employers and data are not publicly reported. In these cases, statistical procedures have been developed to impute an employment level. Such estimates are imprecise but can still be useful information.

The primary source of ocean economy employment data reported in this Blue Paper is a study by the Organisation for Economic Co-operation and Development (OECD) (OECD 2025). This study is an update and substantial expansion of one released in 2016 (OECD 2016). We also consulted a projection of employment in the ocean economy by DNV (2021) and studies of the global capture fisheries sector by the UN Food and Agriculture Organization (FAO 2024a).

Before proceeding to estimates of employment in the ocean economy, it is important to define the boundaries of what economic activity is to be defined as within the ocean economy for purposes of employment measurement. All employment measures are ultimately rooted in the national statistical systems and the industrial taxonomies used to categorise economic data in those systems. Examples of such taxonomies include the International Standard Industrial Classification, the European Classification System and the NACE (Nomenclature statistique des activités économiques dans la Communauté Européenne). The OECD (2025) study measures employment in seven major sectors:

- Marine and coastal tourism
- Transportation and ports
- Ship building and marine equipment
- Offshore wind / renewables
- Offshore oil and gas
- Fishing and aquaculture
- Trade, transport and R&D services

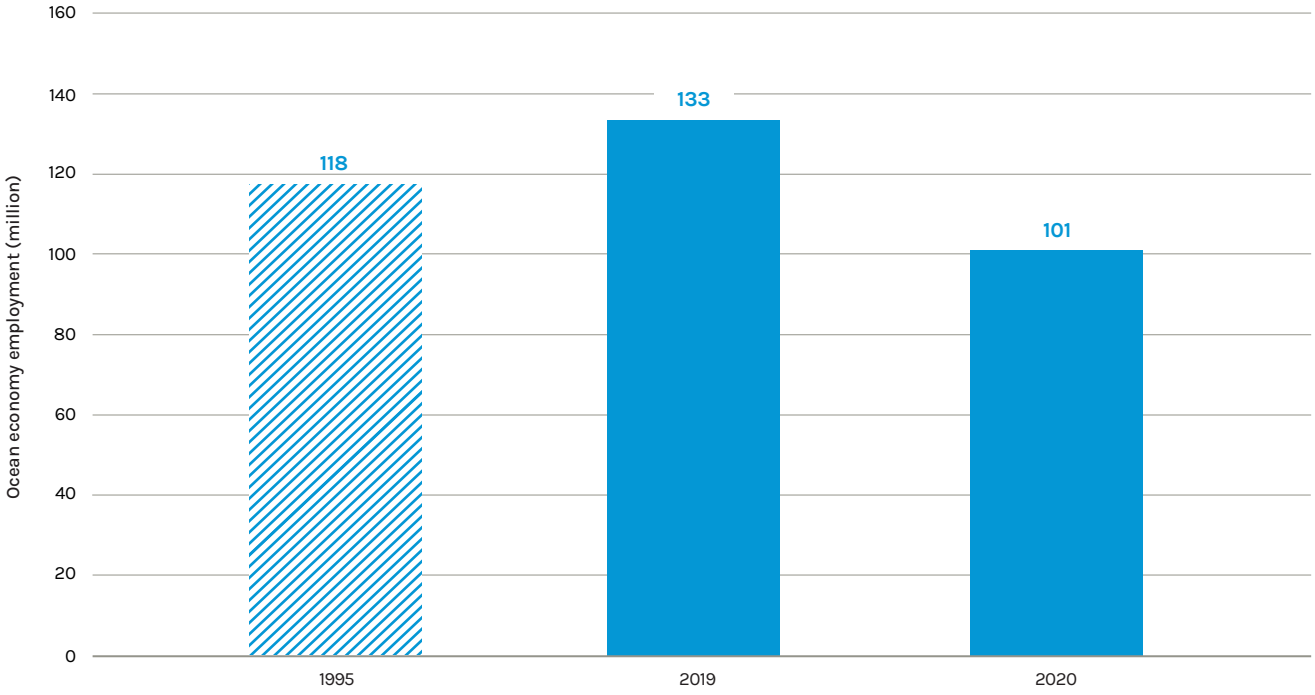
This builds on taxonomies—using some categories as they are and amalgamating others. Ship building, fishing and aquaculture are categories in all taxonomies, for example, whilst others, such as tourism and transportation, are amalgamations of industries such as hotels and restaurants along with others in tourism. Tourism, oil and gas, and renewable industries can be both land- and ocean-located, and measurement requires separating the two using some type of geographic criterion.

The seven OECD sectors cover the majority of ocean-related economic activity, but many types of economic activity are not included. Examples include marine construction, marine research and education, and the ocean-related public sector. Several of these are key to long-term sustainability issues and will be discussed at the end of this section.

Baseline estimates of employment in the ocean economy

Figure 1 shows estimated total ocean-related employment for 1995, 2019 and 2020. The year 1995 was chosen to provide a 25-year retrospective to be

FIGURE 1. **Global ocean economy employment estimates for the years 1995, 2019 and 2020**



Source: Center for the Blue Economy, based on OECD (2025).

compared with 25-year projections (to 2050). Overall, the ocean economy is estimated to have grown from 117.5 million jobs to 133.4 million from 1995 to 2019—or about 14 percent.

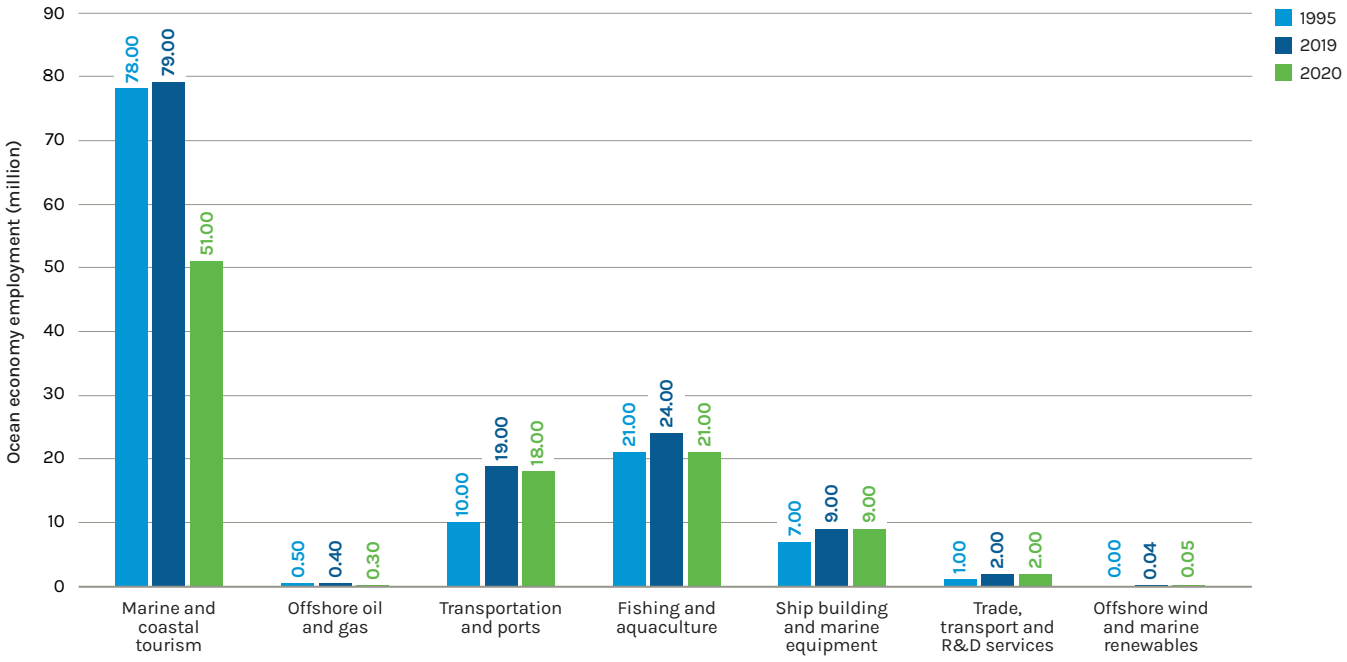
Employment declined sharply from 2019 to 2020, shedding an estimated 32 million jobs for a total of 101.4 million—a drop twice as large in one year as the previous 24 years of increase (Figure 1). This is because of the COVID-19 pandemic, which hit in 2020. The vast majority (87 percent) of the drop in ocean-related employment between 2019 and 2020 was in the marine and coastal tourism sector (Figure 2), a result of COVID-19's restriction of travel worldwide. Some types of economic activity related to ocean tourism, like spending on hotels and restaurants, all but collapsed. The cruise ship industry and its port-side support services ceased operations. Other sectors saw declining employment as well (Figure 2). These included fisheries and aquaculture, which contracted in part because of reductions in fishing effort and in part because of falling demand (Ruiz-Salmón et al. 2021). Transportation and ports also saw an employment loss connected to the overall declines in national economies. Other sectors were stable or only showed small declines (Figure 2). The exception was offshore wind and marine renewable energy, where there was a slight increase in employment because this sector was still in the early stages of growth and largely not dependent on close contact among people.

Choosing 2020 as the baseline year for future projections risks creating substantial distortions in any discussion of the future. We therefore select 2019 as the baseline year and use it to compare projections out to 2050.

For the year 2019, the largest sector by employment by far was marine and coastal tourism, with approximately 79 million jobs globally (Figure 2).

Fishing and aquaculture is the one ocean economy sector that is present in all coastal nations and is the second-largest employer, supporting an estimated 24 million jobs in 2019 (Figure 2). However, the dominance of informal employment in fishing and aquaculture presents some challenges to estimating employment. Fish harvesting can be broadly subdivided into commercial harvesting and subsistence harvesting. The former sells the harvested catch into various intermediate and final markets. The latter splits the catch between

FIGURE 2. **Global ocean economy employment estimates for the years 1995, 2019 and 2020, by sector**



Source: Center for the Blue Economy, based on OECD (2025).
Note: R&D = research and development.

household consumption and the market. Much of the worlds' fishing employment is involved in subsistence fishing, but this sector is not well measured in national or international statistics. A recent study involving surveys deployed in 78 countries estimated subsistence levels at 52.8 million jobs in 2016, with a further estimate of 67.56 million employed in commercial fisheries for a total employed in fishing of 120.4 million. East Asia accounts for 89 percent of the subsistence fisheries total (Virdin et al. 2023).

Marine transportation includes a combination of port activities and vessel operations and is the third-largest sector, with an estimated 19 million people employed globally (Figure 2). Ship building is the fourth-largest sector, with an estimated 9 million people employed in 2019 (Figure 2). This is a function of the large number of employees in the construction of cargo vessels, primarily in Asia, as well as cruise ships, primarily in Europe, and naval vessels in the United States, Asia and Europe.

Trade, transport and research and development services; offshore oil and gas; and offshore wind and marine renewables employed relatively few people in 2019—at 2 million, 400,000, and 40,000 people, respectively (Figure 2).

Projections of ocean economy employment to 2050

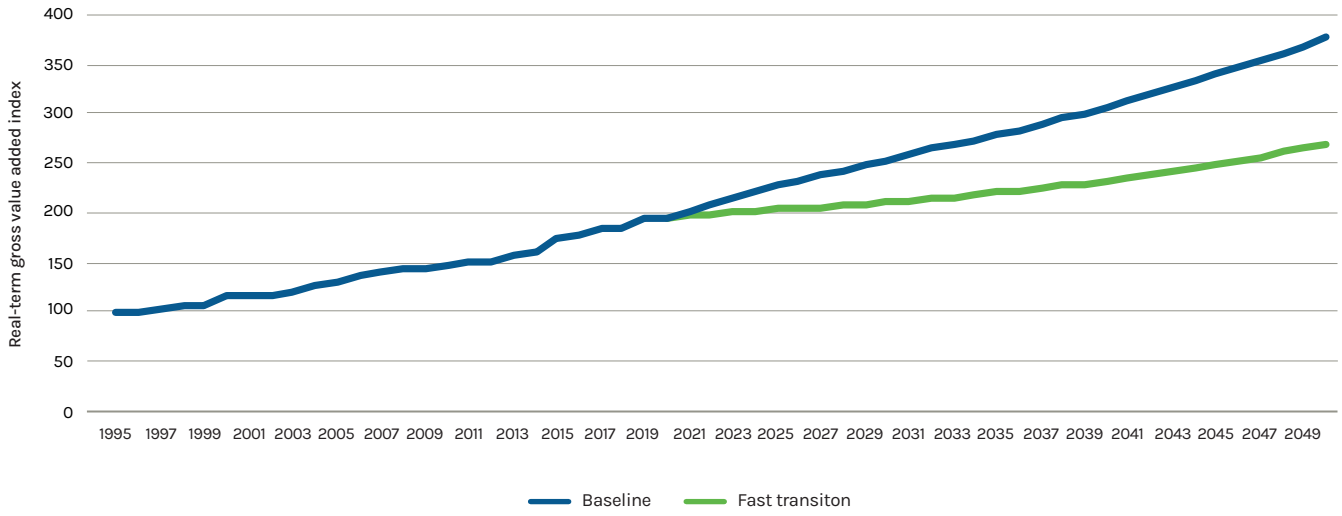
Any projections as far ahead as 25 years inevitably involve profound uncertainties, particularly considering the ecological and economic complexity of the global ocean economy. Inevitably any projections will require simplifying assumptions to control some of the uncertainties and be able to explore the implications of those assumptions. There are many ways to do this, the most common of which is to define key variables, assume certain conditions that create scenarios, and then use models to drive change over time and simulate interactions among driving factors.

The OECD (2025) ocean economy projections are the most reliable published to date, and we refer to them here. They are based on three scenarios. A baseline scenario projects the trends in each sector based on growth patterns among sectors between 1995 and 2019. The other two scenarios are driven by assumptions about the pace at which ocean-related energy production transitions from heavy dependence on offshore oil and gas to much greater dependency on renewable electricity generation—mostly offshore wind. This factor is both the major driver of changes in the industrial composition of the ocean economy and one of the most important factors determining the extent to which the ocean economy becomes more sustainable.

All of the scenarios are driven in part by forecasts of global population and labour force growth along with changes in labour and multi-factor productivity. Other factors shaping growth include climate change, international trade, evolution of the global food system, investments in science and technology, and the overall geopolitical landscape (including international conflicts in the marine space [OECD 2025]).

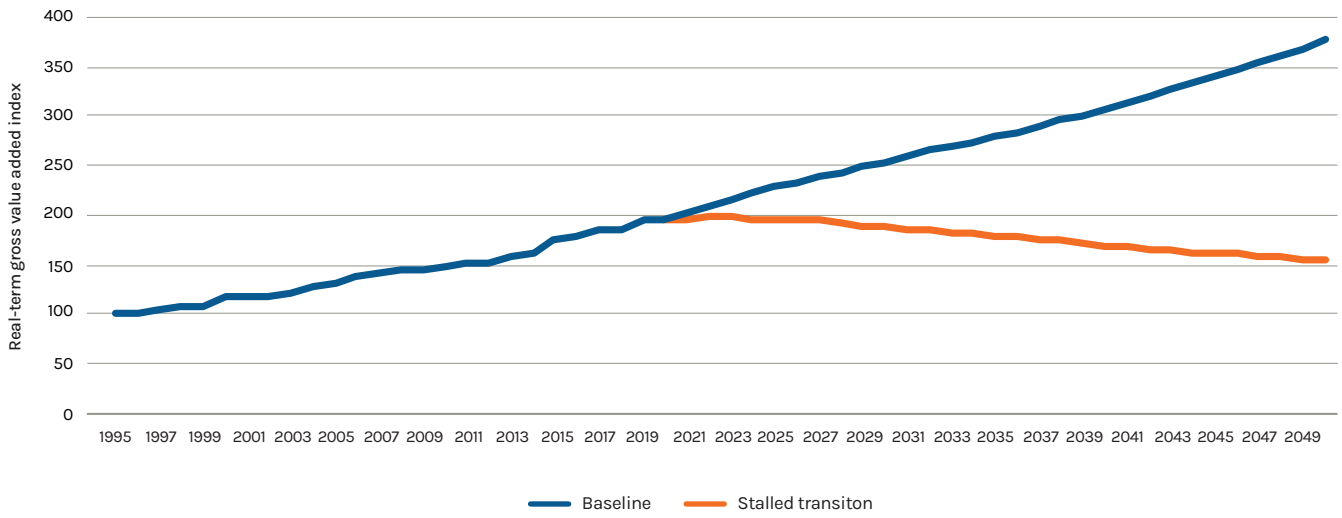
The baseline scenario envisions an increase in total ocean gross value added (GVA) of $1.9 trillion from 2019 to 2050 to $4.1 trillion, a total increase of nearly 90 percent—or 3.6 percent per year.[1] This is an increase in the pace of GVA growth from 2.8 percent per year on average over 1995–2019. The forecast GVA levels imply an employment level of the global ocean economy of 203.4 million in 2050, compared with 134 million in 2019. This is a total growth in employment of 69.7 million, or 1.3 percent per year. However, this is likely to be an overestimate because it does not account for productivity improvements arising from technologies that would reduce demand for labour; nor does it account for changes within the major sectors of the ocean economy that will be needed to improve sustainability. The OECD recognises these limitations and posits two scenarios defined as the fast and the stalled transition scenarios (Figures 3 and 4). "Transition" in this case refers to the shift from fossil fuels to renewable energy. The scenarios are separated by the pace at which the transition is assumed to occur over the next two and a half decades. One scenario is based on a relatively fast transition in which the offshore oil and gas industry declines significantly and is replaced by renewable energy from the ocean, primarily offshore wind. The other assumes that the transition essentially stalls after 2030.

FIGURE 3. **Fast transition to a sustainable ocean economy projection based on gross value added**



Source: OECD (2025).

FIGURE 4. **Stalled transition to a sustainable ocean economy projection based on gross value added**



Source: OECD (2025).

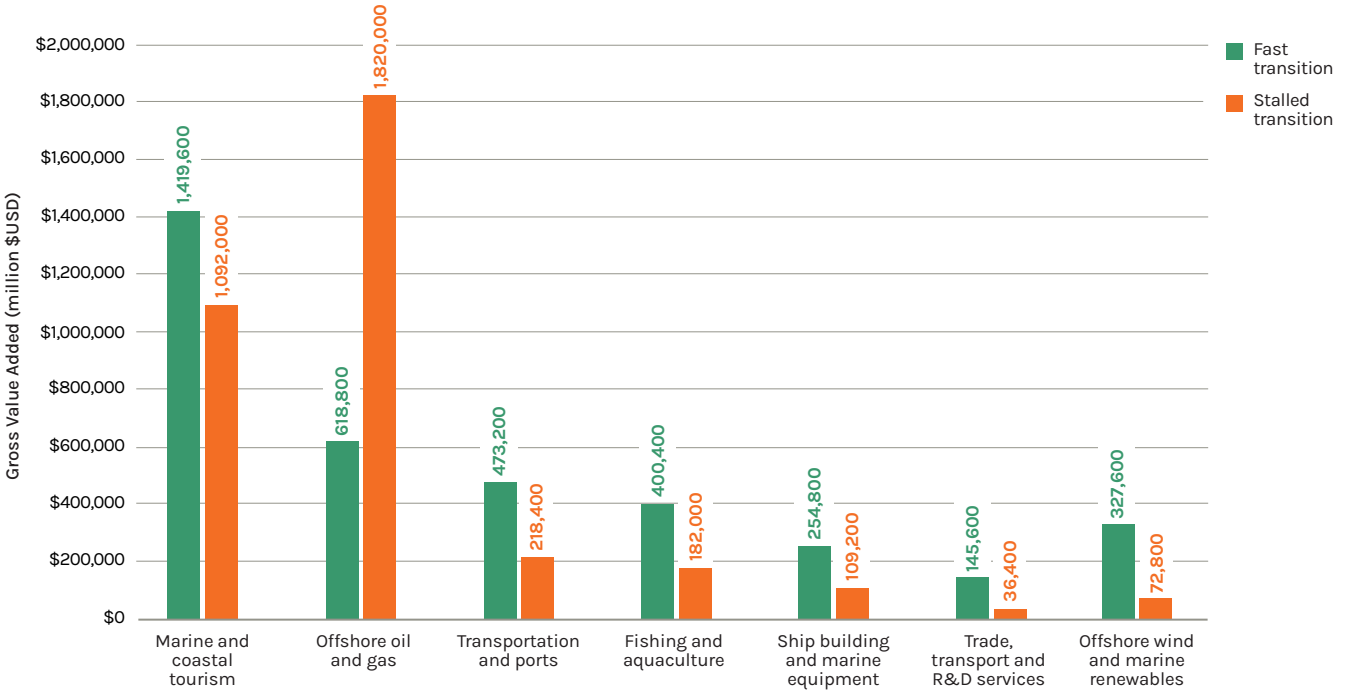
The "fast" transition scenario (Figure 3) envisions continued growth in ocean-related GVA to 2050 but at a much slower pace than in the baseline scenario. In the fast transition scenario, 2050 ocean GVA is $3.64 trillion. This would be a 68 percent increase in GVA from 2019, or 2.7 percent per year on average. It would imply a total employment level of 184 million, an increase of 51 million or 1.5 percent per year from 2019. Key factors in this scenario are continued steady growth in renewable energy and a decline in offshore oil and gas and related industries coupled with steady investments in technologies that offset increasing labour shortages from aging populations but lower employment growth. Geopolitical tensions and trade increase but at slower rates than in the baseline.

The alternate scenario is a "stalled" transition (Figure 4). In this scenario, there is some growth into the late 2020s, but after that there is little growth in renewables while offshore oil and gas continues but at a declining pace because of field exhaustion. The stalled transition sees higher levels of geopolitical tensions and a resulting sharp decline in trade. The increased tensions and declining trade significantly darken the investment climate around the world so that needed investments in renewable energy and continued improvements in ocean industry technologies are not made. The result is that in this scenario 2050 GVA is barely distinguishable from 2019 GVA and employment actually falls relative to 2019 by nearly 40 million to just over 91 million. At that level, employment is below that of the COVID year of 2020.

The implications of the scenarios for the sectors measured by OECD are shown in Figure 5 for GVA and Figure 6 for employment. In the fast transition, GVA is higher in all sectors except offshore oil and gas.

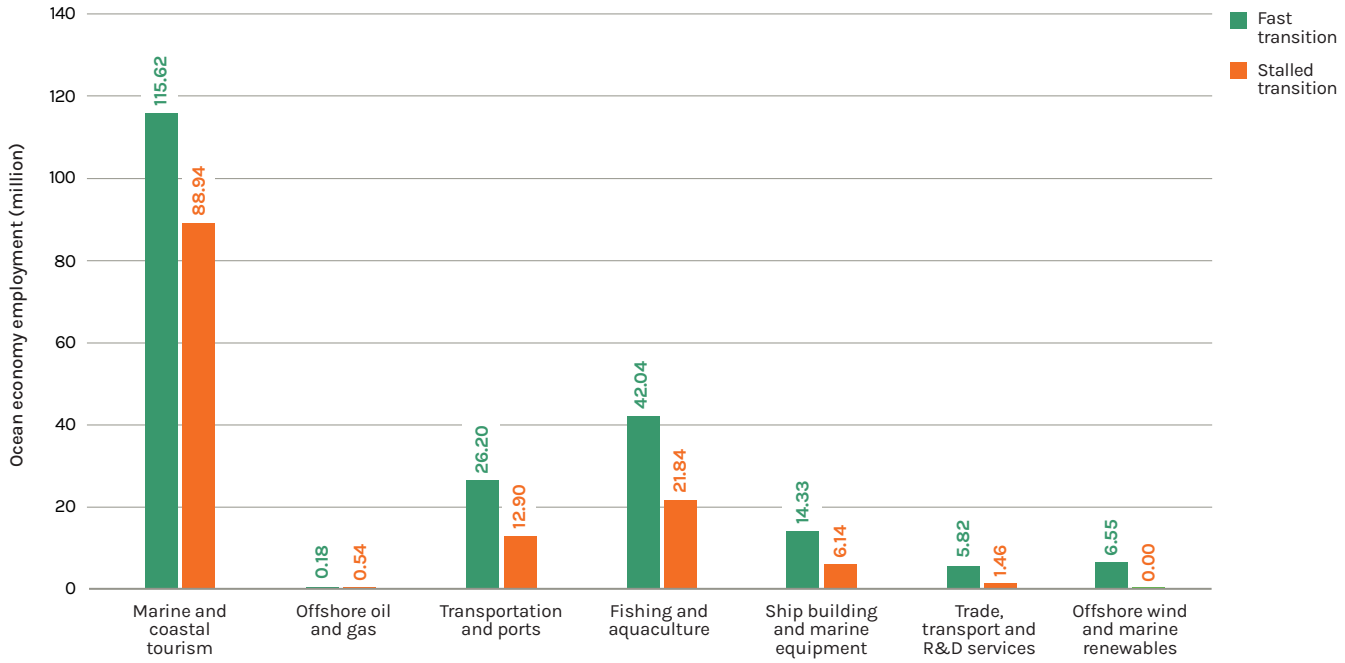
The stalled transition feeds through the other sectors with significant declines in 2050 GVA in every sector except oil and gas. This lower GVA in 2050 across the ocean economy is driven by a number of factors, including much more intense geopolitical conflict with a much more serious drop in international trade. The poorer overall economic climate further suppresses investment in productivity, which drags the overall economy and the ocean economy down considerably relative to the other sectors.

FIGURE 5. **Comparison of 2050 ocean economy gross value added in OECD "fast" and "stalled" transition scenarios**



Source: Center for the Blue Economy estimates based on OECD (2025).
Notes: OECD = Organisation for Economic Co-operation and Development; R&D = research and development.

FIGURE 6. **Comparison of 2050 ocean economy employment in OECD "fast" and "stalled" transition scenarios**



Source: Center for the Blue Economy estimates based on OECD (2025).
Notes: OECD = Organisation for Economic Co-operation and Development; R&D = research and development.

Oil and gas employment in 2050 is considerably higher in the stalled transition than the fast transition, and there is little employment in offshore wind / renewables. The slower growth in the stalled transition spreads throughout employment in the ocean economy.

Which of these three scenarios is most likely to describe the ocean economy in 2050? The most likely is that it will be somewhere between the stalled transition and the baseline projection. Viewed from early 2025, the disruptions in global trade and dramatic reductions in climate mitigation investments that are defining US policy would tend to suggest that the future ocean economy will be much closer to the stalled transition scenario than the baseline scenario or the fast transition.

It may be that the current dislocations in trade and climate policy will be confined to this decade and that the succeeding decades will see a recovery and return to long-term growth. But the result in 2050 will still likely fall short of the fast transition scenario.

Any projections as far ahead as 25 years inevitably involve profound uncertainties, particularly considering the ecological and economic complexity of the global ocean economy.

Expert insights: Employment changes in the transition to a sustainable ocean economy

The transition to a sustainable ocean economy represents a meaningful transformation in global employment patterns. Understanding these employment shifts is crucial for policymakers, industry leaders and workers as they navigate the complex intersection of environmental sustainability and economic development.

To help forecast these changes, we employed a comprehensive Delphi method, directly engaging 181 experts across six continents and multiple sectors, including business, academia, government and non-governmental organisations (NGOs) (Table A-4). The authors, the Secretariat of the Ocean Panel, and the Ocean Panel Expert Group were asked to name leading experts on the ocean economy and especially on the workforce it will require and support. Of the more than 400 invited, we were pleased that over 40 percent participated. For further details, please see Appendix A.

The Expert Panel provided insights into both short-term (2030) and long-term (2050) employment transitions, identifying seven key drivers of change: climate change, investment and access to finance, voluntary adoption of sustainable practices, changing demand for ocean-based goods and services, changing energy demands, increasing regulatory sustainability requirements, and emerging innovative sectors.

Through four rounds of structured questioning and feedback, the Expert Panel considered how these drivers will affect employment across various ocean economy sectors, with particular focus on marine renewable energy, aquaculture and fisheries, marine research and innovation, marine transport and ports, tourism and hospitality, offshore oil and gas, and marine management and governance. This analysis provides crucial insights into the magnitude, timing and regional variations of employment transitions in the sustainable ocean economy. Note that as with all Delphi surveys the goal was to move to consensus and not to do a deep dive into reasoning or evidence for such consensus.

Key factors driving employment changes

The first and second rounds of the Delphi process consisted of questions about what may drive change in the sustainable ocean economy and affect employment, with the aim of identifying consensus on these drivers. For these questions, the sustainable ocean economy was described as the subset of the ocean economy similar to the green business sector, where broad, holistic, sustainable principles are applied and promoted. Otherwise, we did not suggest definitions of any potential driver we listed. We listed exemplar drivers, such as climate change, and invited input on our list and any suggestions the experts had for additional drivers.

FIGURE 7. **Top six drivers of change in employment in a sustainable ocean economy in the short term (by 2030), as revealed by the Delphi process**

Source: Blue Paper authors.

For Rounds 1 and 2, the rankings of top drivers for 2030 and 2050 remained nearly identical.

Figure 7 shows the top six drivers of change in employment in a sustainable ocean economy in the short term (*by 2030*).

Figure 8 shows the top six drivers of change in employment in a sustainable ocean economy in the longer term (by 2050). Because of one difference between the lists, this exercise named seven key drivers to examine in Round 3. Please see Appendix A1 for a full ranking of drivers.

FIGURE 8. **Top six drivers of change in employment in a sustainable ocean economy in the long term (by 2050), as revealed by the Delphi process**

Source: Blue Paper authors.

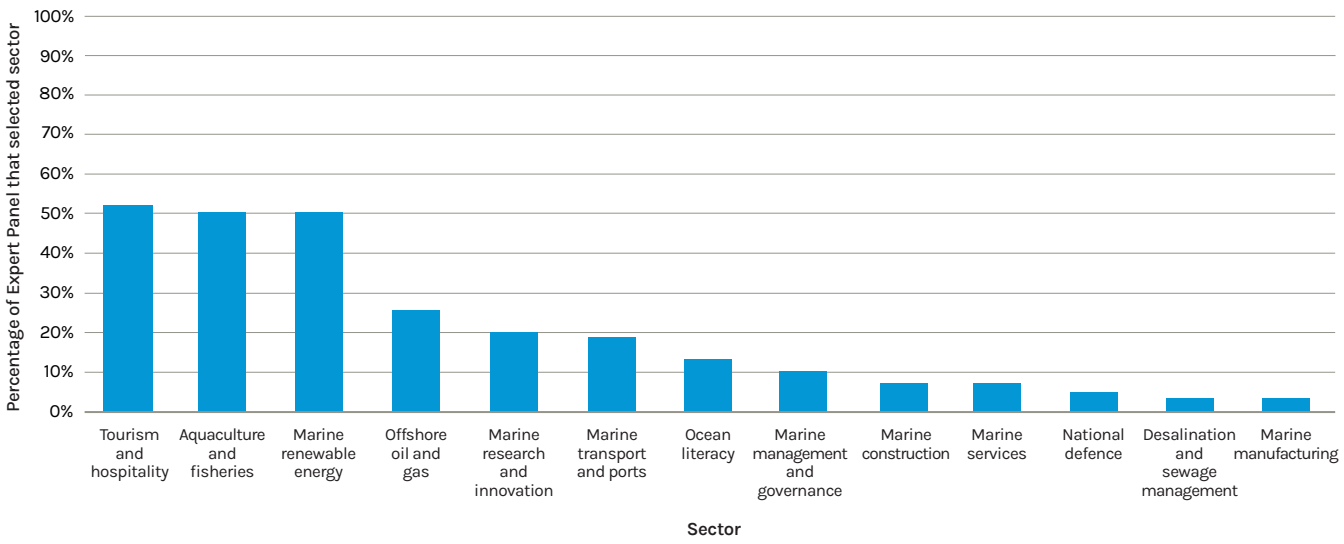
The impacts of these drivers may overlap. For example, the risks posed by climate change could spur demand for sustainability, which could alter practices adopted by industry, government or consumers and shift their demand for ocean-based goods, services or energy sources. This merges high-ranked drivers into one. However, here we wish to tease out the different and subtle mechanisms by which various drivers will affect employment positively or negatively in the future sustainable ocean economy.

Descriptions of the top drivers and their effect on ocean economy sectors

The following paragraphs summarise how the Delphi Process Expert Panel described the seven key drivers of change in employment in the ocean economy. We used artificial intelligence (AI) to synthesise the combined narrative answers to our survey questions, then validated and revised them for logic and readability. We are confident they reflect the "crowdsourced" wisdom of our Expert Panel. We also rank the sectors the Expert Panel most frequently selected as significantly affected by each driver. These were revisited and refined over the survey rounds. For projections the Expert Panel provided, we calculated the median response, then shared the statistical summary with the experts in subsequent rounds to move towards consensus. The anonymous rationales experts shared in their narrative answers indicate that short-term projections are much more robust than longer-term ones.

1. **Climate change** significantly affects employment in ocean economy sectors; particularly aquaculture and fisheries, tourism and hospitality, and marine renewable energy (Figure 9) through changing the abundance and distribution of fish stocks, increasing sea-level rise, affecting the intensity and frequency of extreme weather events and algal blooms, and investment in offshore wind, tidal and solar energy projects. In the search for resilience and in adaptation to climate change impacts, employment may shift from extractive industries towards conservation, low-carbon energy and ecotourism models. Climate policy will trigger changes such as a shift towards a circular economy and regenerative aquaculture (which can lower emissions by reducing demand for raw materials and improving waste management). As these sectors adapt, employment opportunities will expand significantly. For example, investment in marine renewable energy may increase demand for engineers, technicians and project managers, whilst a shift towards the decarbonisation of ships and ports may create demand for engineers trained in hybrid and

FIGURE 9. **Ranking of sectors most frequently selected by the Expert Panel as being significantly affected by climate change**

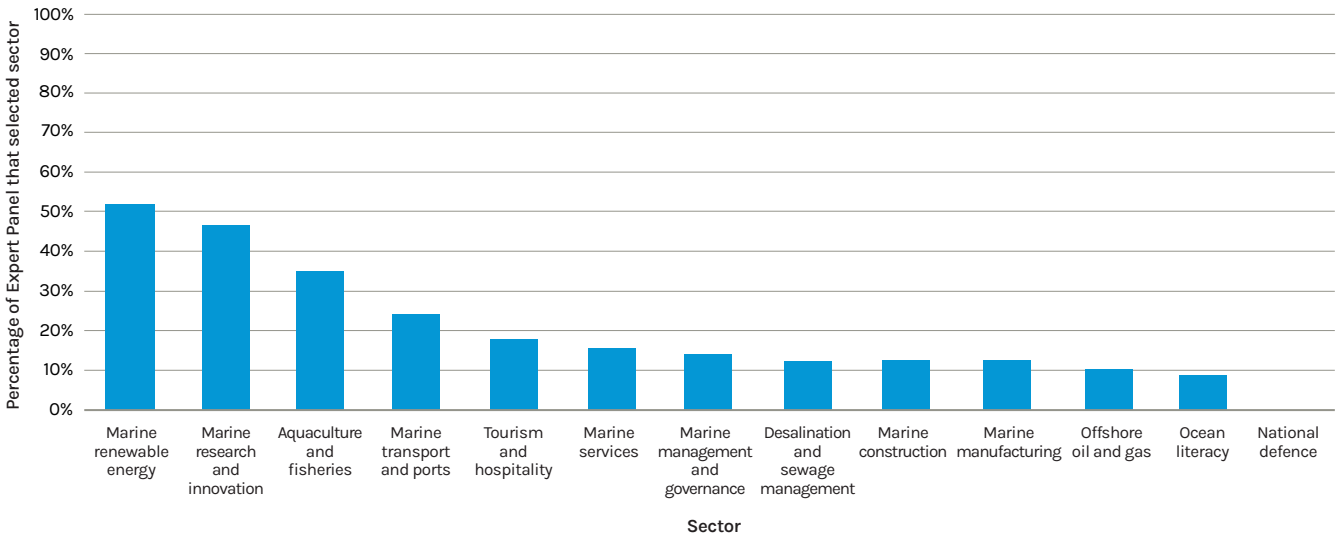


Source: Blue Paper authors and Expert Panel.

alternative fuel engines, or perhaps in electric propulsion technologies. However, there may be inequity between developing countries that have resource constraints when compared to developed countries that have stronger research and innovation capacity.

2. The Expert Panel emphasised the importance of **investment and access to finance** in shaping the ocean economy, highlighting private sector opportunities and best practices. The sectors with the most significant impact on employment will be those that benefit the most from increased finance and investment—particularly

FIGURE 10. **Ranking of sectors most frequently selected by the Expert Panel as being significantly affected by investment and access to finance**

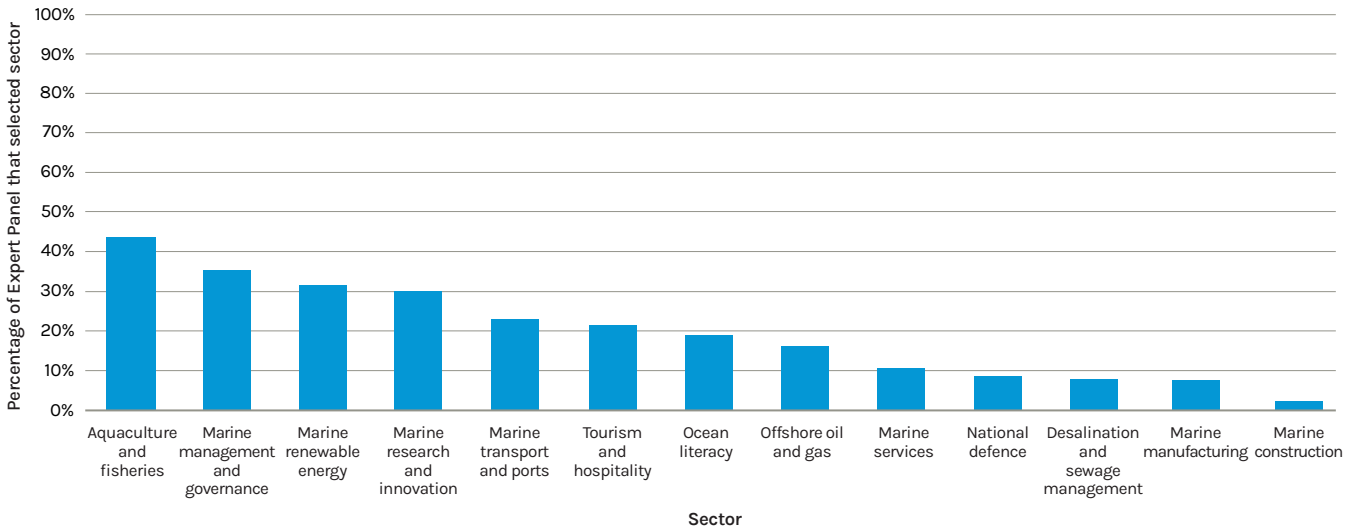


Source: Blue Paper authors and Expert Panel.

marine renewable energy, marine research and innovation, and aquaculture and fisheries (Figure 10). The Expert Panel stressed the need for finance to support a transition towards low-carbon technologies, capacity building and training, as demand for these technologies is expected to increase. For example, transitioning to sustainable fishing and value chains requires investment and financing to upgrade fishing fleets, attract youth and women, and strengthen local rights.[2]

3. The Expert Panel noted the link between **adopting sustainable practices** and significant changes in employment levels, particularly for the sectors of aquaculture and fisheries, marine management and governance, marine renewable energy, and marine research and innovation (Figure 11). The panel members believe that regulatory or consumer-demand incentives could push ocean economy sectors towards sustainable practices, more substantial ecologically and environment-friendly investments and heightened consumer awareness. Ensuring the private sector's offering of sustainable products and services, and employment of relevant staff, is crucial. The Expert Panel emphasised the importance of fair trade, quality food, organic products, cheap energy and clean water as global human rights. The experts also stressed the need for professional training in sustainable practices, local and international regulations to support the adoption of sustainable practices, and job development towards sustainability. The panel highlighted the complex role of industry, government and consumers in achieving this, with the government being the most influential since governments will be essential in setting standards and implementing policies that demand knowledge, education and research and development (R&D) as people adopt sustainable

FIGURE 11. **Ranking of sectors most frequently selected by the Expert Panel as being significantly affected by the adoption of sustainable practices**

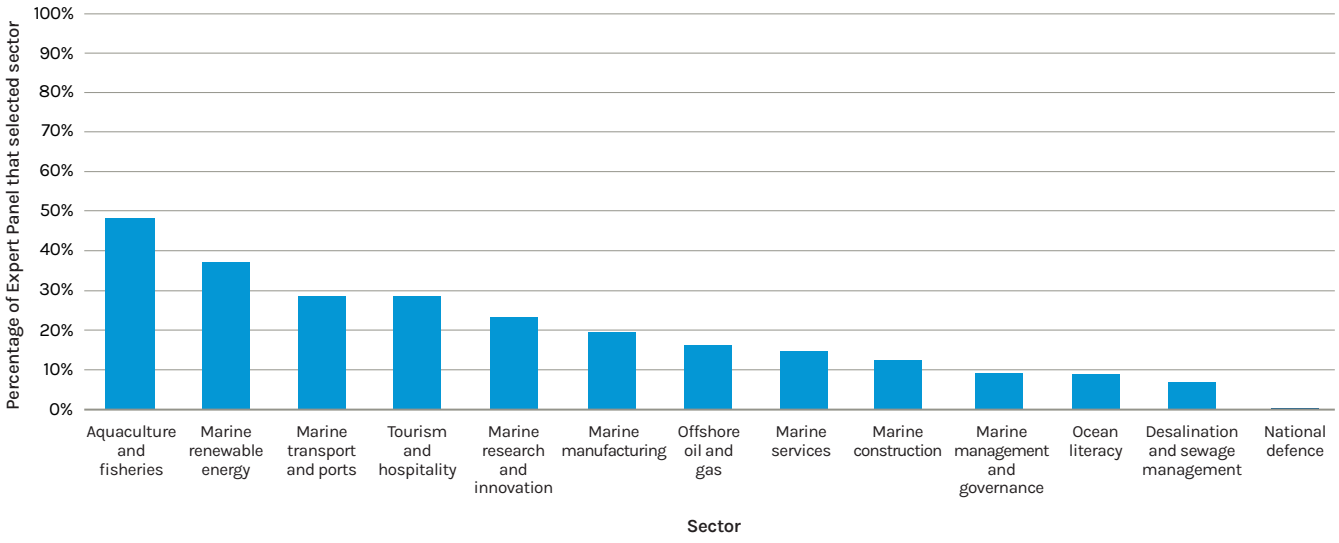


Source: Blue Paper authors and Expert Panel.

practices. Governments in more developed countries currently typically prioritise sustainable practices but may change their approach during less peaceful times. As the sustainable ocean economy grows, more policymakers and enforcers will be needed, and sustainable practices should be supported by policies and schemes that provide social safeguards and economic stability through incentives and tax benefits.

4. The Expert Panel predicts that changing **demand for ocean-based goods and services** will significantly affect jobs in maritime transport and ports, aquaculture and fisheries, marine renewable energy, and tourism and hospitality (Figure 12). For example, a growing demand for marine renewable energy is expected to increase employment opportunities in wind farms and other offshore infrastructure, whilst if global trade in sustainable seafood, other ocean-based goods and sustainable ocean tourism increases, the ports and shipping industries will require increased traffic, logistics, operations and infrastructure jobs. Employment in these sectors will increase in association with innovation, sustainability and adaptation to new market trends. Industry needs foresight to identify business opportunities for new ocean-based goods and services early, and develop job profiles accordingly.

FIGURE 12. **Ranking of sectors most frequently selected by the Expert Panel as being significantly affected by changing demand for ocean-based goods and services**

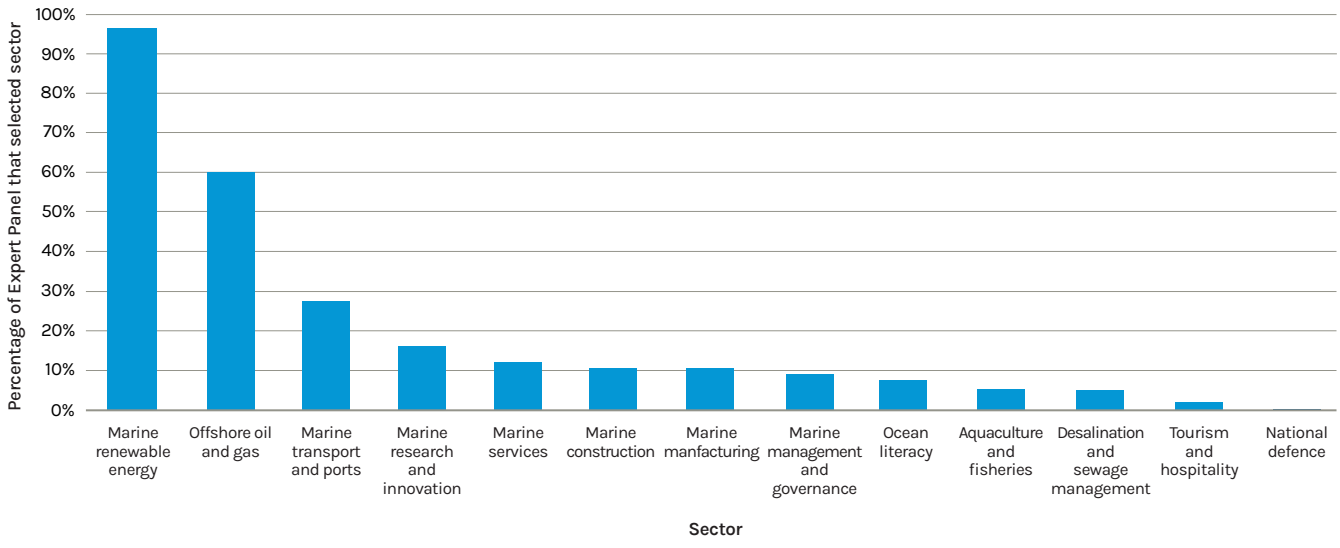


Source: Blue Paper authors and Expert Panel.

5. The Expert Panel noted that **energy demand** is increasing, boosting economic development and employment. This change is driven by population growth and increased per capita consumption of energy. Energy-driven sectors may witness significant changes in employment levels in transitioning to a sustainable ocean economy; the Expert Panel noted that a shift towards renewable sources of ocean energy will particularly impact jobs in the marine transport and ports, marine renewable energy, and offshore oil and gas sectors (Figure 13). For example, the transition to renewable energy in ports is expected to create a modestly positive net employment effect because of the need for capacity in handling low-carbon fuels such as hydrogen, methanol and ammonia. This is despite some job losses in traditional fossil fuel operations. New jobs will emerge in offshore wind construction, maintenance, green fuel bunkering (such as green hydrogen associated with offshore windfarms) and shore infrastructure. Many existing workers can be retrained for roles in alternative fuel handling, electric equipment operation and renewable energy cargo management. The overall workforce transition will likely be gradual, with ports requiring both specialised contractors for decarbonisation projects and permanent staff to operate new green infrastructure. While shared skills and roles between oil and gas and offshore renewables, such as construction and decommissioning, may maintain some consistency in employment, the energy sector leading employment will change. Transitioning to a sustainable ocean economy requires a shift in energy sector corporate leadership.

The Expert Panel noted that a shift towards renewable sources of ocean energy will particularly impact jobs in the marine transport and ports, marine renewable energy, and offshore oil and gas sectors.

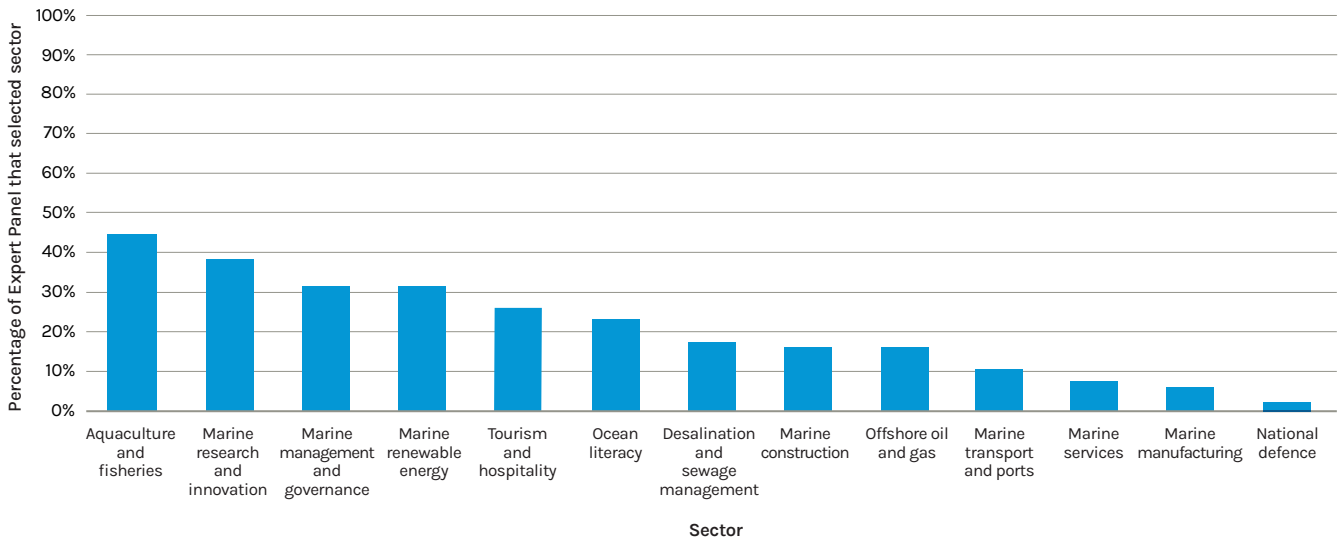
FIGURE 13. **Ranking of sectors most frequently selected by the Expert Panel as being significantly affected by changing demand for energy**



Source: Blue Paper authors and Expert Panel.

6. The Expert Panel noted that the ocean economy is experiencing a surge in **demand from consumers for sustainability and regeneration**,[3] leading to growth in eco-friendly industries and job opportunities in many sectors, but particularly in aquaculture and fisheries, marine research and innovation, marine management and governance, and marine renewable energy (Figure 14). The panel noted that this shift in consumer choices is influenced by younger generations, who drive this revolution and will soon become leaders with real purchasing power. For example, there is growing recognition of the problems of overfishing and illegal, unregulated and unreported (IUU) fishing amongst consumers. This trend towards sustainability and regeneration is partly focused on rewilding, a movement that puts society and the planet above profit. Government and private sector investment is being called upon as part of this demand to create products with less environmental impact and invest in emerging countries to share resources and innovation, promoting a healthier livelihood for people.

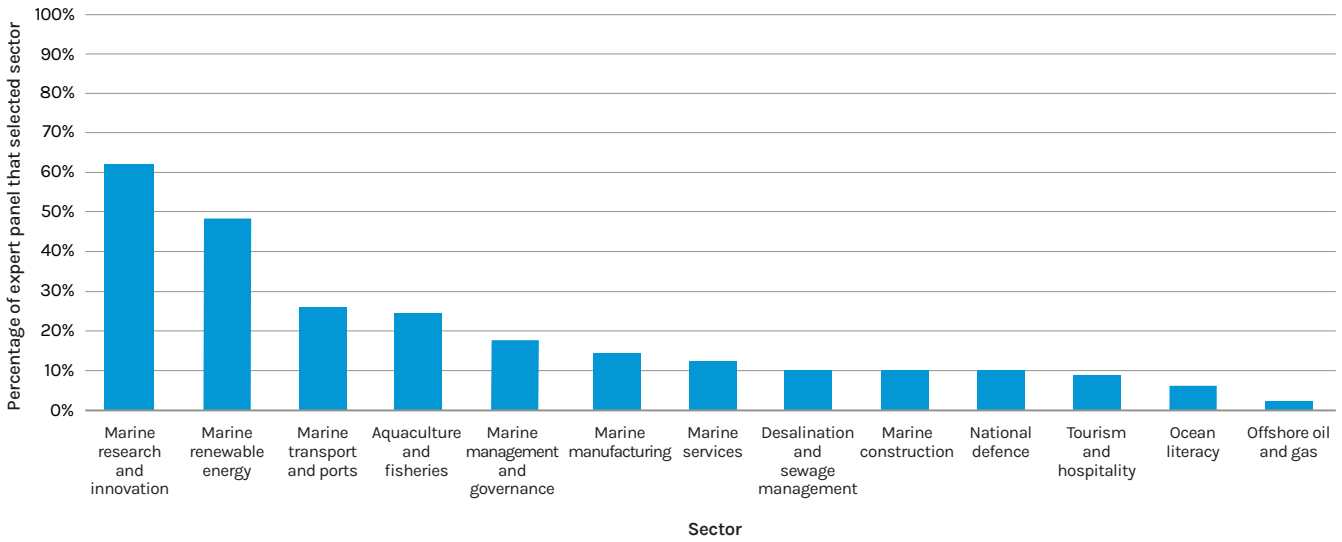
FIGURE 14. **Ranking of sectors most frequently selected by the Expert Panel as being significantly affected by changing demand from consumers for sustainability and regeneration.**



Source: Blue Paper authors and Expert Panel.

7. The Expert Panel noted that **emerging innovative sectors** have significant potential, as they are at the forefront of new industries and are likely to see increased employment. Novel engineering designs and more human-centric operational procedures will drive a need for new suppliers of materials. This may include new technology innovation for aquaculture or specialised port infrastructure to accommodate marine renewable energy (Figure 15). For example, offshore wind projects require ports to adapt by developing new turbine assembly and maintenance facilities. Bioprospecting, an emerging sector, presents real opportunities in marine biotechnology, while artificial intelligence can aid in research and time-management investments.

FIGURE 15. **Ranking of sectors most frequently selected by the Expert Panel as being significantly affected by innovation**



Source: Blue Paper authors and Expert Panel.

What to expect: Expert views on trade-offs, job losses versus gains and choices for sustainability

Based on expert responses to Round 3 of the Delphi process, the sectors of the ocean economy most likely to be impacted by a transition to a sustainable ocean economy are listed in Table 1.

Marine renewable energy was the sector most commonly selected as impacted across the key drivers identified by the Expert Panel, while national defence was the least-chosen sector.

Projected employment changes by sector

Marine renewable energy

According to the narrative answers provided by our Expert Panel members, the marine renewable energy sector (particularly offshore wind energy) is poised for significant growth, driven by climate change concerns and the transition away from oil and gas, with projections indicating 1.2 million new jobs by 2050 and a 6 percent growth in marine engineers and naval architects between 2020 and 2030. The experts proposed that this growth will particularly impact employment in engineering, technical roles and project management across offshore wind, tidal,

TABLE 1. **Ranking of sectors most frequently selected by the Expert Panel as being significantly affected across all seven key drivers identified**

SECTOR	CUMULATIVE PERCENT VOTES	RANK	GROUPING
Marine renewable energy	347.51	1	1
Aquaculture and fisheries	251.54	2	2
Marine research and innovation	235.44	3	2
Marine transport and ports	157.95	4	3
Tourism and hospitality	155.60	5	3
Offshore oil and gas	145.20	6	3
Marine management and governance	124.87	7	3
Ocean literacy (education, communication, culture)	84.89	8	4
Marine services	78.16	9	4
Marine manufacturing	71.42	10	4
Marine construction	69.30	11	4
Desalination and sewage management	62.37	12	4
National defence	25.91	13	5

Source: Blue Paper authors and Expert Panel.

Note: "Cumulative percent votes" reflects the cumulative percentage of survey responses in which a sector was selected across all key drivers. For instance, aquaculture and fisheries were chosen by 50.85 percent of the Expert Panel for the driver "climate change," plus 34.48 percent of respondents for the driver "finance," and so on. The sectors with the largest total percentage value are those most frequently selected by respondents across all the key drivers identified.

Marine renewable energy was the sector most commonly selected as impacted across the key drivers identified by the Expert Panel, while national defence was the least-chosen sector.

wave and solar energy projects. However, the sector's development depends on several factors, including social acceptance (particularly for large offshore wind installations), environmental impact assessments (e.g. concerns on the impact of fixed wind turbines on seafloor communities) and changing ocean conditions (e.g. impact of changing weather conditions on wave energy projects) that could limit ocean-based energy generation.

Financial support and investment will play a crucial role in driving employment growth, particularly in developing, installing, and maintaining renewable energy infrastructure. For example, the Expert Panel noted that the installation of wind turbines at sea requires large capital expenditure. The transition from traditional oil and gas to marine renewables will require workforce retraining (e.g. from capacity in oil and gas prospecting to understanding of the placement of turbines) but is expected to create new job opportunities in emerging energy fields, especially in countries with strong R&D capabilities. This shift is further accelerated by increasing coastal population density and growing demand for sustainable ocean-based goods and services. However, the distribution of these employment benefits will depend on local capacity to advance renewable technologies and implement national energy projects.

Aquaculture and fisheries

Expert Panel members noted that the seafood sector is significantly transforming, shifting from wild capture fisheries to sustainable aquaculture. While this transition may lead to job losses in traditional fishing, particularly in countries dependent on fish protein, it's also creating new employment opportunities in sustainable practices, climate adaptation and regenerative aquaculture. However, the sector faces significant challenges from climate change, which is causing shifting ecosystems, resource scarcity and extreme weather events. Additionally, increasing pollution from plastics, industries and maritime trade raises toxicity levels in fisheries, potentially leading to market collapse and job losses.

Expert Panel members noted that the future of employment in the sector will be heavily influenced by the push for sustainability and the need for better resource management. This creates a demand for skilled workers in ecosystem management, fisheries monitoring and sustainable project development. Financial assistance and investment will be crucial for multitrophic integrated sustainable aquaculture, upgrading fishing fleets, attracting youth and women, and developing sustainable practices. While stricter regulations to combat overfishing and illegal fishing will require more workers skilled in monitoring and enforcement, the overall shift towards environmentally responsible practices may decrease employment numbers in some areas. The sector's growth potential lies in sustainable aquaculture, skilled marine biology work and building sea vessels with sustainable fishing and lower environmental footprint in mind, particularly with proper financial backing for innovation and development.

Marine research and innovation

The consensus of our Expert Panel members is that marine research and innovation employment is primarily driven by increasing investment in understanding and mitigating climate change, developing the blue bioeconomy and transitioning away from oil and gas to marine renewable energy. Growth areas include research positions in marine drugs, oceanographic data analysis, environmental modelling and biotechnology, with new opportunities emerging through the application of artificial intelligence. The push for sustainability and the need for efficient ocean governance are also creating a demand for expertise in innovative solutions and regulatory compliance.

However, the Expert Panel noted that employment growth faces challenges from high data-collection costs coupled with insufficient investment. Success in creating jobs in research and innovation depends heavily on collaboration among educational institutions, government, industry, and communities and investment-sharing formulas that can attract diverse funding sources, including philanthropists and banks. The sector's growth requires increased technological expertise and capability building to support the transformation of ocean industries into sustainable and inclusive systems.

Marine transport and ports

The Expert Panel communicated that the marine transport and ports sector is undergoing a significant transformation driven by multiple factors that will reshape employment patterns, including the impacts

of climate change, changing demand for energy and ocean-based goods and services, and investment and access to finance. While moderate overall growth is expected, digitalisation and automation could replace some jobs, affecting up to two-thirds of positions, according to the Expert Panel. However, this is counterbalanced by new opportunities emerging from decarbonisation initiatives, including roles in ship retrofitting, green port operations and infrastructure development for alternative fuels like methane, hydrogen and electric power systems. The transition to sustainable operations requires workforce reskilling, particularly for engineers and machine repair workers who must adapt to new technologies like hybrid and electric engines.

Experts noted that the sector's employment landscape is further influenced by emerging industries and regulatory changes driving substantial investment over the next two decades. The growth of marine renewable energy, aquaculture and biotechnology is creating demand for specialised infrastructure and logistics services, particularly in offshore wind facility construction and maintenance and specialised cargo handling. Additionally, expanding sustainable seafood trade and ocean tourism is expected to increase the need for logistics, operations and infrastructure personnel. However, these gains may be partially offset by the decline in traditional positions that handle fossil fuel as the industry shifts towards greener alternatives.

Tourism and hospitality

The Expert Panel noted that current mass tourism employment models, such as large coastal resorts, face significant challenges due to climate change, particularly in areas where rising sea levels threaten beaches and coastal infrastructure. This environmental pressure, increased energy demand and reduced financing opportunities are creating pressure to pivot the industry away from traditional mass tourism approaches. The situation may lead to initial job losses in conventional tourism roles as oceanfront sites become compromised and infrastructure deteriorates.

However, the transition towards sustainable tourism also presents new employment opportunities, especially in developing countries. The Expert Panel noted growing demand for nature-oriented and eco-conscious tourism, which creates jobs in sustainable facility construction and maintenance, certified guide services and local cultural experiences. This shift requires workers to develop new skills to support value-added tourism products, sustainable practices and renewable energy systems while focusing on operating within ecosystems' carrying capacities and creating experiences that prioritise environmental regeneration over mass tourism.

Offshore oil and gas

The Expert Panel projects that traditional employment in the offshore oil and gas sector will decline significantly because of climate change concerns and the global push towards sustainability, including decarbonisation and the phasing out of fossil fuels. More specifically, the Expert Panel noted that the primary drivers of this decline include stricter environmental regulations, decarbonisation efforts and growing investments in renewable energy, which will reduce traditional extraction and exploration jobs. While the industry will continue to see demand for oil and gas, employment levels are expected to plateau because of increased automation of operations (e.g. use of robotics for inspection, maintenance and repairs) and shifting to renewable energy supply options.

However, this transition also presents new employment opportunities within the sector. Workers with experience in offshore oil and gas operations are well positioned to transition into emerging roles in carbon capture and storage, decommissioning activities, renewable energy projects and the production of sustainable alternative fuels, such as green hydrogen. Skills common to these roles include working with high-voltage equipment and experience with rigging, crane operations and equipment maintenance. The industry's expertise in energy and offshore operations remains valuable, but there will need to be significant workforce reskilling to align with new technologies and sustainable energy demands. Regulators, countries and multilaterals must work to ensure an equitable transition across developed and developing nations (e.g. by providing retraining opportunities and finance) to address potential unemployment during this transformation.

Marine management and governance

The Expert Panel members noted that increased demands for climate mitigation, sustainability practices and energy needs will significantly shape

the evolving landscape of marine management and governance. As governments prioritise sustainable practices and invest in new species cultivation for food production, there will be a growing need for policymakers, enforcers and researchers to develop and implement transformed governance systems. This expansion is crucial given the sector's vital role in supporting millions of jobs across export, tourism, shipping and transportation industries.

The demand for comprehensive marine management, such as through sustainable ocean plans, will grow as regulatory frameworks become increasingly necessary to oversee sustainable ocean economy activities and balance competing stakeholder interests, particularly in marine renewable energy development versus traditional ocean services. This expansion requires effective communication amongst decision-makers and managers, alongside robust research and innovation. Governments must also develop policies that provide social safeguards and economic stability through incentives and tax benefits while managing potential conflicts in all marine resource allocation and sustainability goals.

Employment forecasts: 2030 and 2050 outlook

The Expert Panel predicts that a transition to a sustainable ocean economy may cause short-term job losses to 2030, resulting from global sociopolitical tensions associated with this transition. By 2050, there will be better potential for sustainable employment growth.

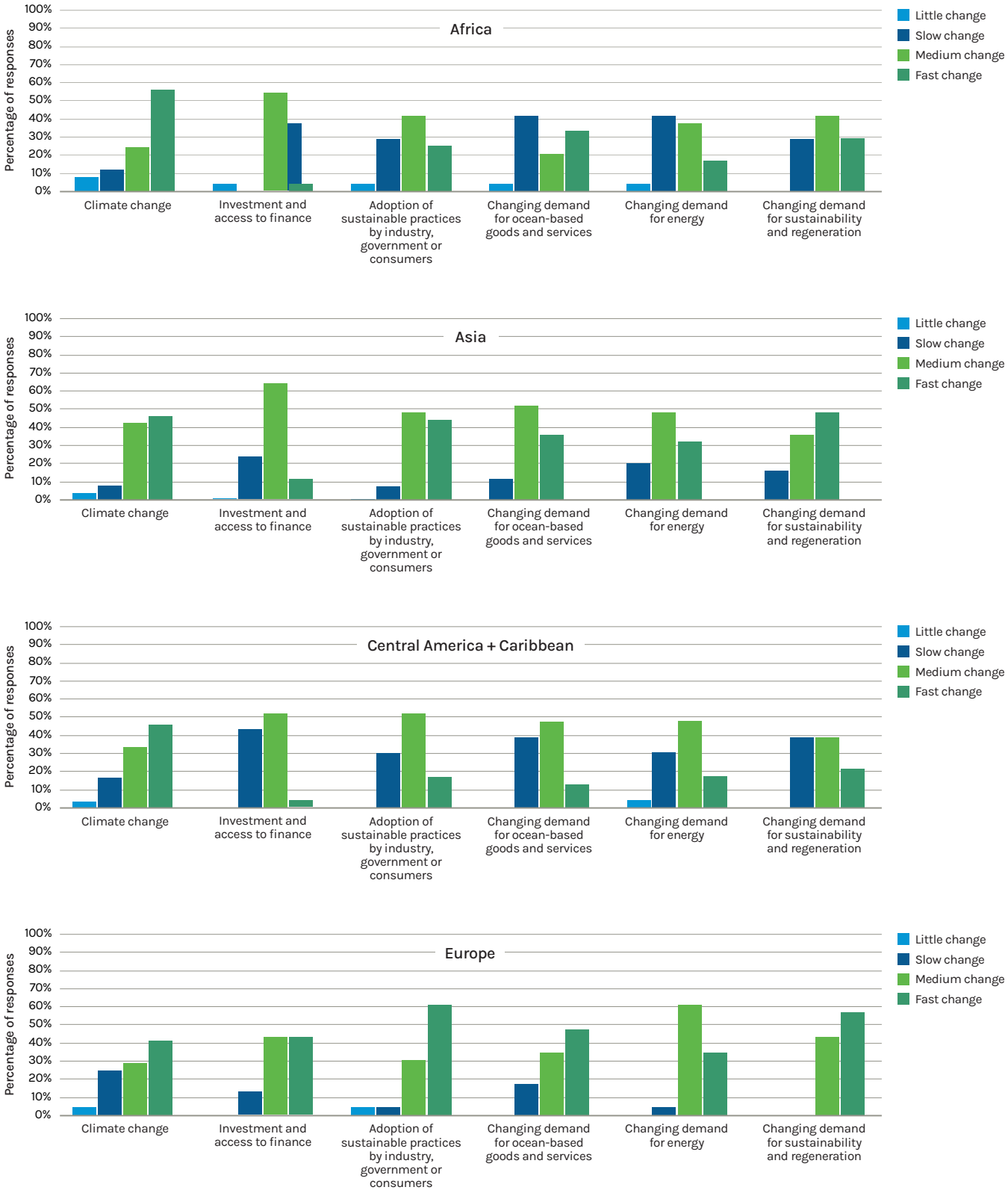
2030 percentage change in employment: Summary of Expert Panel consensus

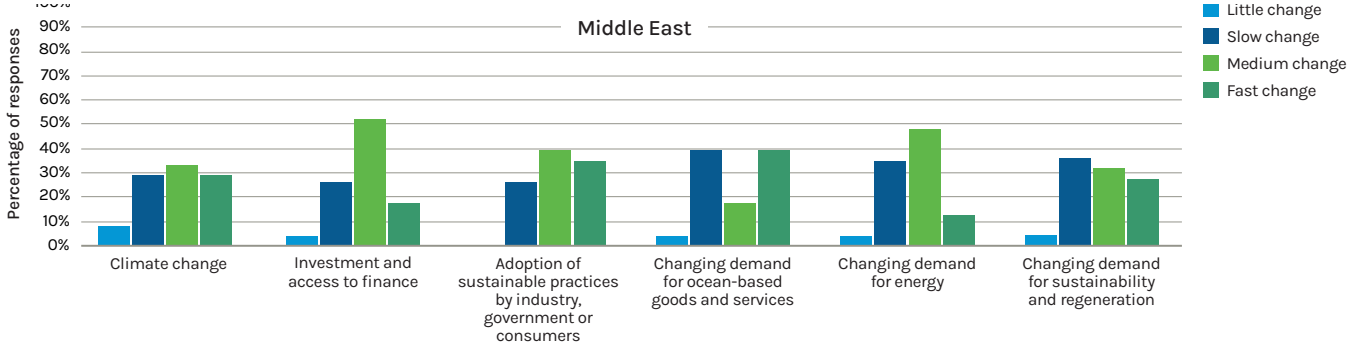
Adopting sustainable practices, shifting supply chains and responding to demands for transparency in reporting may put increased pressure on companies in the short term, with a negative impact on employment. The most substantial shift in jobs will be in the oil and gas industry. Most likely, it will be downwards, with many of these jobs moving to the renewable energy sector. However, the Expert Panel is in consensus that innovation and capitalising on growth opportunities from regeneration can generate meaningful new employment over the short and long term. In particular, ocean economy sectors can significantly contribute to job growth associated with infrastructure development, adoption of electric and hybrid propulsion, and energy storage solutions. However, the panel also reached a consensus that there should be little confidence in predicting the magnitude of the changes. Each driver examined will likely have positive and negative effects on employment, which will differ for different sectors and regions.

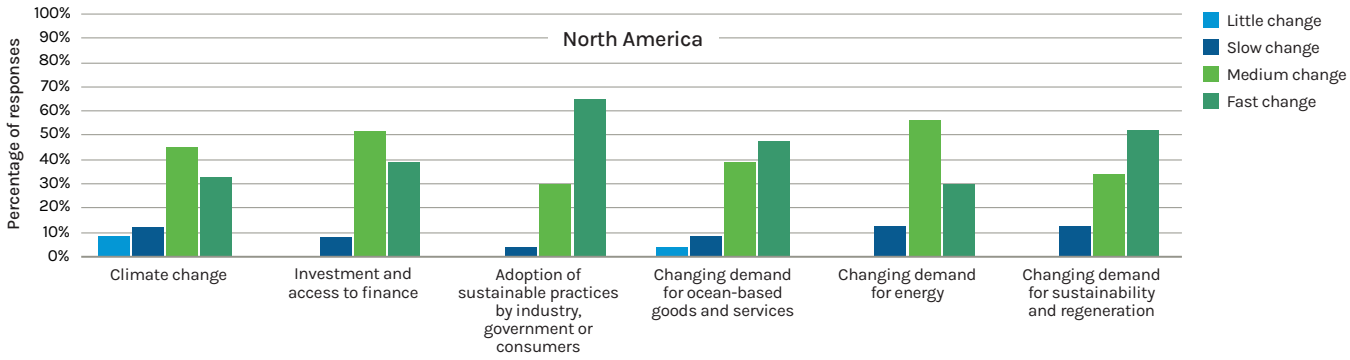
2030 regional pace of change: Summary of expert contributions

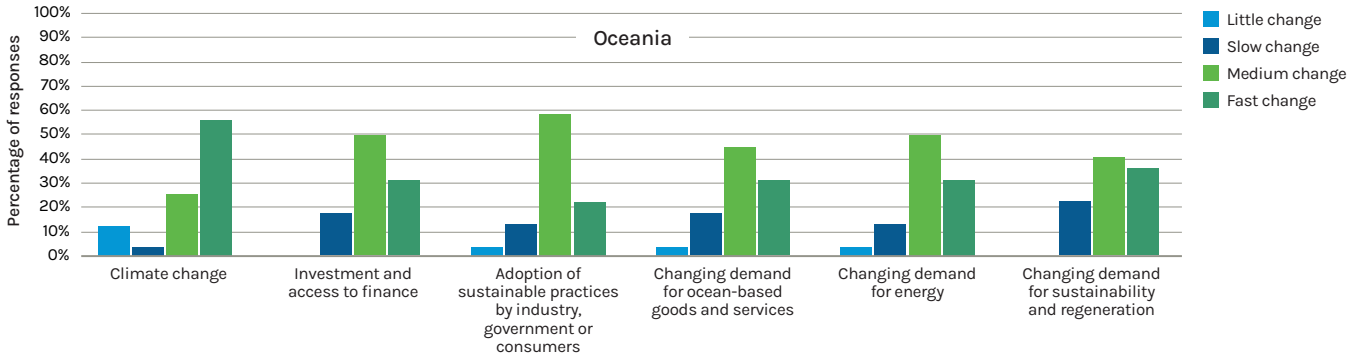
The Expert Panel's consensus was that the regional evolution of the sustainable ocean economy will hinge on the pace and scale of investment in infrastructure, capacity development, and policy development and adoption. Political instability and labour union demands in some parts of the world may hinder the transition to a sustainable ocean economy. Stronger economies will invest in emerging economies, whilst geographic position will create winners and losers in the global ocean economy because of distance to markets or severity of climate change impacts. Small island developing states, including the Pacific islands, might see impacts on jobs from climate due to changes in the distribution of fish stocks and coastal infrastructure losses (Figure 16). They may lack the capacity to adapt, reskill or upskill in the short term until funding and training allow. Many oil- and gas-producing countries continue to put off designing and implementing strict regulations to reduce greenhouse gas (GHG) emissions, delaying the transition to a sustainable ocean economy.

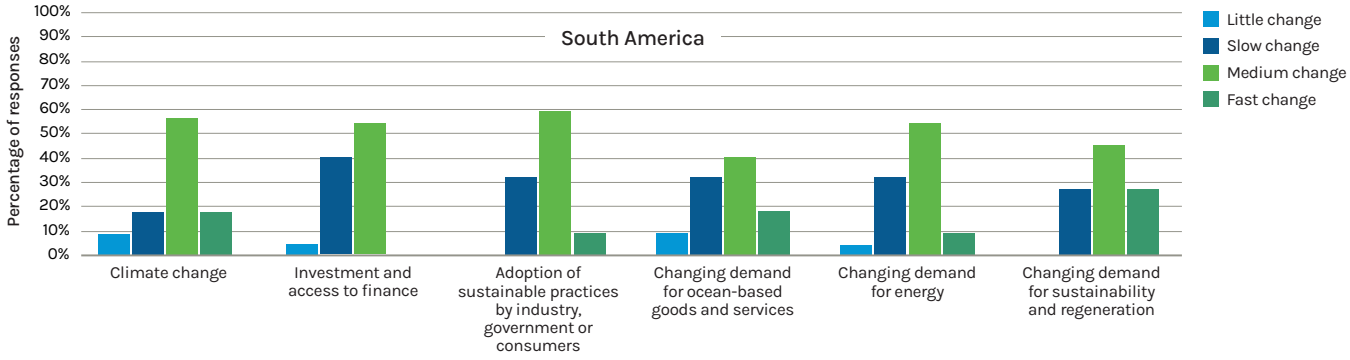
FIGURE 16. **Rate of change in employment in 2030 expected for each of the key drivers at a continent-specific resolution, according to the Delphi Process Expert Panel**











Source: Blue Paper authors and Expert Panel.

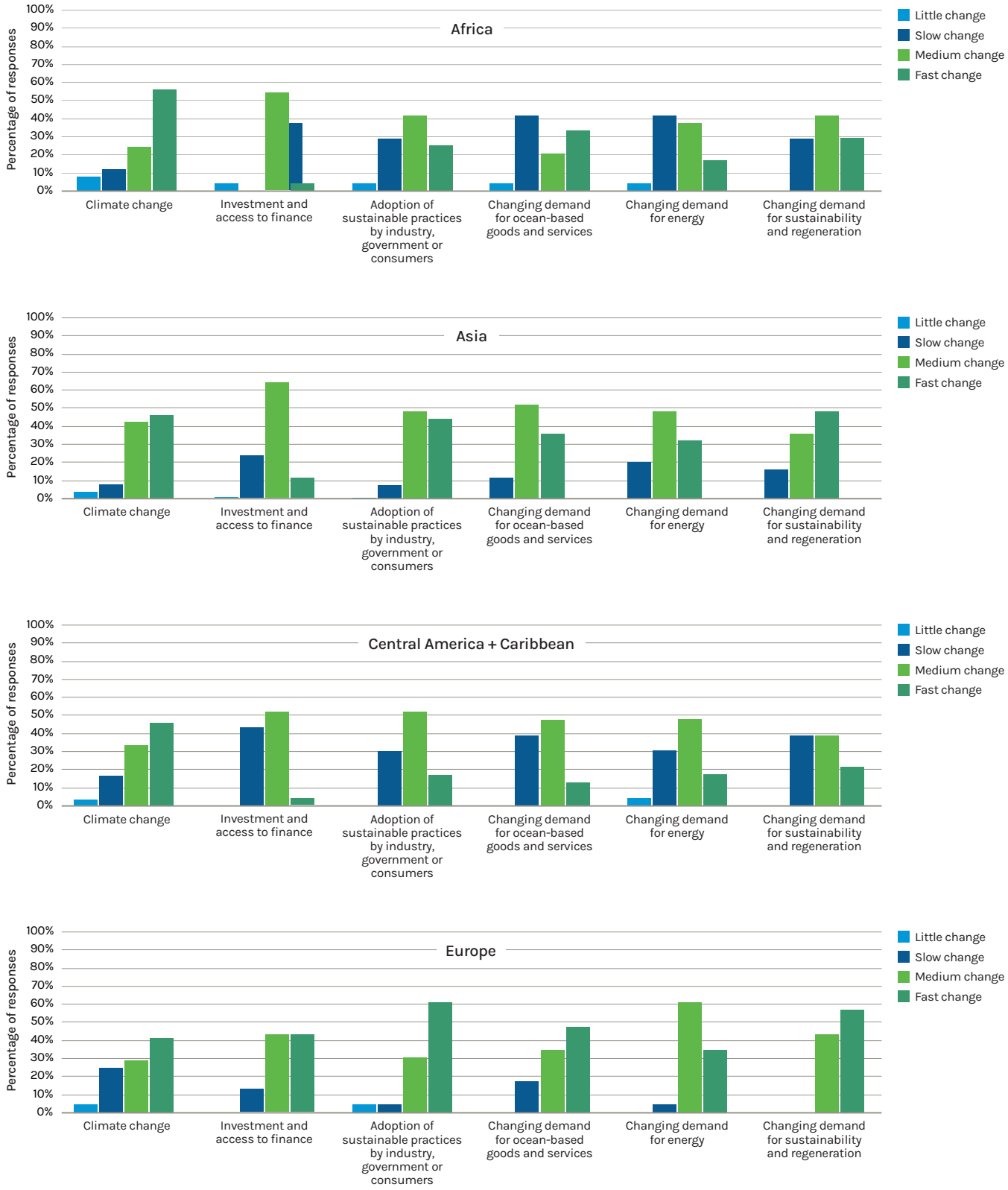
2050 percentage change in employment: Summary of Expert Panel consensus

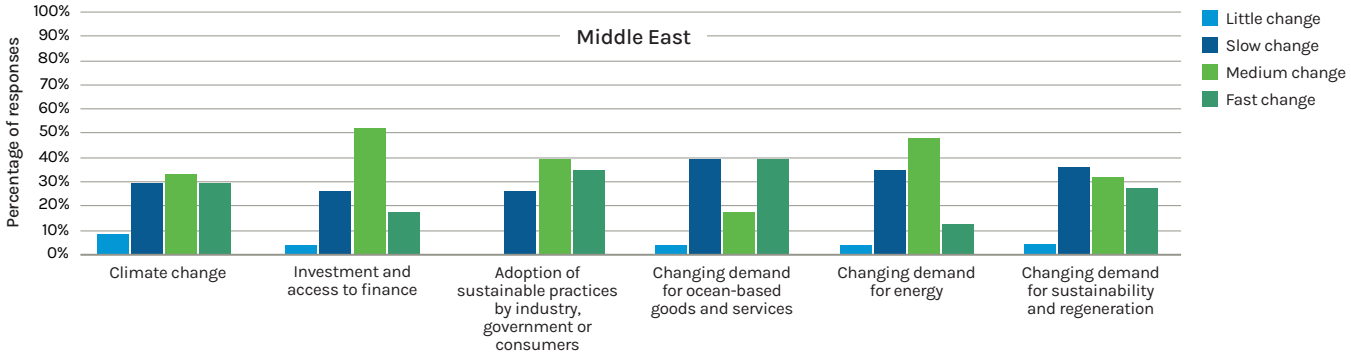
The Expert Panel pointed to uncertainty about the ocean economy's future because so much will depend on the impacts of climate change, government commitments to cut greenhouse gas emissions and the global adoption of sustainable practices. The magnitude of these employment changes is difficult to estimate, and some industry sectors may cease to exist by 2050 because of changes in trade rules, geopolitical conflicts and broader economic factors. The experts generally agreed that while projecting granular changes in employment in the short term is difficult, 25 years into the future becomes pure conjecture. The maritime industry sectors are sure to contribute to a sustainable ocean economy, but accurate responses regarding workforce impacts are impossible because of a lack of employment data. Growth effects may dominate after a transition and job substitution phase, with more companies adopting sustainable practices and shifting supply chains. Sectors focusing on innovation and sustainability might experience growth, while traditional sectors may see employment reductions. The Expert Panel found it particularly challenging to provide percentages to describe the magnitude of job changes due to uncertainties such as regulations, innovation, AI and other factors.

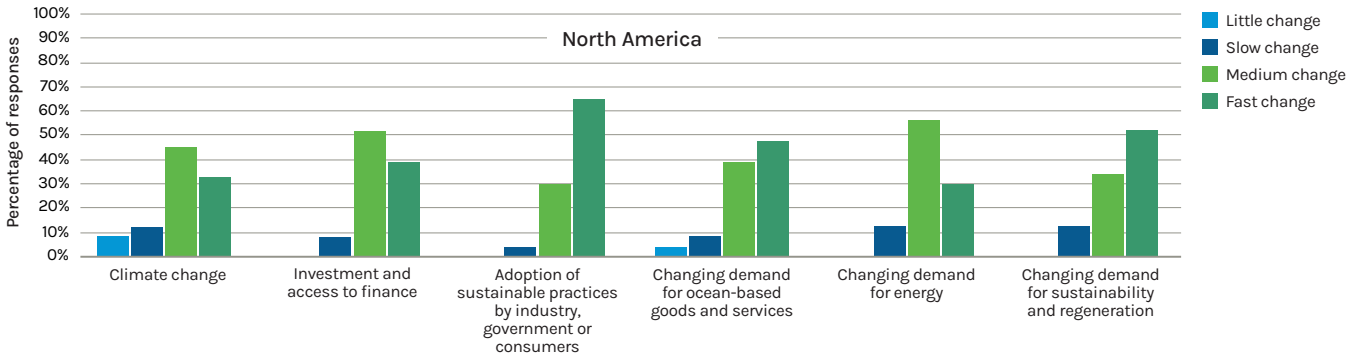
2050 regional pace of change: Summary of expert contributions

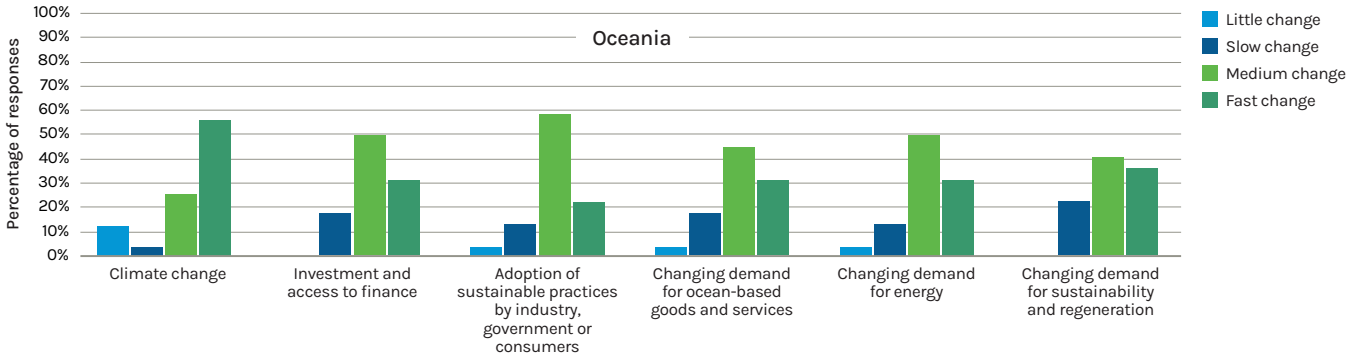
The Expert Panel consensus was that the assessment of job creation in emerging-economy countries is based on economic, environmental and policy factors, with stronger economies having more resources to invest readily. For example, urban population growth will be most significant in Africa, Asia and Latin America by 2050, and to meet environmental, sustainability and economic commitments, the construction and expansion of coastal cities in those geographies will require energy matrices and supply chains that complement fossil fuels, energy efficiency, renewable energy and the local provision of food and resources. The Expert Panel also expects more demand for marine and coastal resources and effective marine spatial planning schemes to reduce stakeholder conflict. After 2030, growth in Asia's maritime economy is expected to slow, whilst Africa will need a mechanism to drive fundamental economic development. The Expert Panel believes that faster changes in the Global South will lead to more environmental refugees, including workers (Figure 17).

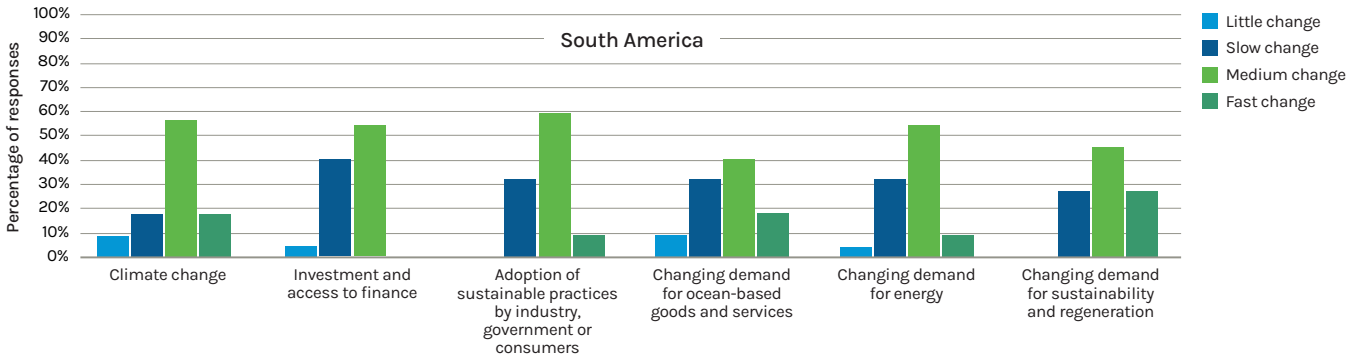
FIGURE 17. **Rate of change in employment in 2050 expected for each of the key drivers at a continent-specific resolution, according to the Delphi Process Expert Panel**











Source: Blue Paper authors and Expert Panel.

Employment transitions: Regional impacts, challenges and opportunities

The transition to a sustainable ocean economy presents both significant challenges and opportunities for global employment. While the Expert Panel emphasises the inherent uncertainty in employment forecasts, particularly beyond 2030, several trends emerge from the Delphi process analysis. Marine renewable energy shows the strongest potential for job growth, while traditional sectors like offshore oil and gas face likely employment declines. The transition will require substantial workforce reskilling and adaptation, particularly in developing regions where access to finance and training resources may be limited.

Regional disparities in the pace and impact of these changes emerged as a critical concern for our Expert Panel. Developed economies with strong research and innovation capabilities may adapt more quickly and capture more benefits from emerging opportunities, while developing nations, particularly small island developing states, face greater challenges in workforce transition whilst also being most vulnerable to climate impacts. This highlights the need for targeted international support and investment to ensure an equitable transition that does not exacerbate existing economic disparities.

The success of this transition will depend heavily on coordinated action across multiple stakeholders, including governments, industry and financial institutions. While short-term job losses may occur in some sectors by 2030, the longer-term outlook suggests potential for net employment growth by 2050, particularly in sustainable sectors. However, realising these benefits will require substantial investment in workforce development, infrastructure and technology, along with strong policy frameworks to guide the transition. Given the inevitability of this transformation, proactive planning and implementation of transition strategies will be crucial for maximising employment opportunities while minimising disruption to affected workers and communities.

Changing employment opportunities in a sustainable ocean economy

The transition towards a sustainable ocean economy presents a wealth of untapped employment opportunities that can drive economic growth whilst ensuring environmental stewardship and social equity. From emerging roles in marine renewable energy, sustainable fisheries and ecotourism, to specialised jobs in marine conservation, data analytics and environmental finance, our analysis suggests that the sustainable ocean economy is poised to become a significant source of employment. The opportunities outlined in this section, sector by sector, support the creation of new jobs and ensure that the transition to sustainable practices is equitable, inclusive and resilient. Embracing these roles will require innovative thinking, investment in skills development, collaboration across sectors and a commitment to integrating traditional knowledge and modern technology, all while preserving marine ecosystems and supporting coastal communities.

Note that the top sectors of the ocean economy most likely to be impacted by a transition to a sustainable ocean economy (as identified in the Delphi process: marine renewable energy, aquaculture and fisheries, marine research and innovation, marine transport and ports, tourism and hospitality, and marine management and governance) are discussed here. For information about additional sectors (marine biotech, ocean data and monitoring, innovative finance, ocean literacy, and desalination and water management), please see Appendix B.

Marine renewable energy

Employment in the offshore renewable energies sector is growing. Today it accounts for around 80,000 jobs and is expected to create between 20,000 and 54,000 new jobs in the five years following the 2021 baseline (2022–27) in Europe alone (RGI 2022).

An estimated 17.3 direct jobs (defined as one year of full-time employment for one person) are created per megawatt (MW) of generation capacity over the 25-year lifetime of an offshore wind project (GWEC 2021)—in other words, around 4,000 job opportunities for a wind farm of 250 MW.

However, with such rapid development, access to skilled labour may become a challenge for the many specialised parts of the supply chains, and offshore-specific training will become more important as the activities at sea grow (Box 1). In this context, the industry will have to address the risks of skill shortages. Twenty-seven percent of companies find it difficult or very difficult to fill the job positions they offer within the marine renewable energy industry, and like other ocean economy sectors, they also face the “brain drain” (UDC 2023).

Current data suggest that the marine renewable energy sector faces a long journey ahead to achieve full societal inclusion. One example is the renewable energy sector gender gap. Women’s underrepresentation in the workforce is most striking in the wind energy sector, where only 21 percent of the workforce is female. Furthermore, women who do hold jobs in the wind energy sector usually work in administrative or low-level management roles (IRENA 2020c).

Employment opportunities

- **Marine engineers and technicians:** Design, develop and maintain marine renewable energy technologies (Shields 2014; Yang and Copping 2017).
- **Renewable energy project managers:** Oversee the planning, development and operation of marine renewable energy projects, ensuring that projects are completed on time and within the allocated budget (Taveira-Pinto et al. 2015).

- **Marine technicians:** Install, operate and maintain marine renewable energy equipment, ensuring that the systems function effectively (Shields 2014).
- **Environmental scientists:** Assess the environmental impact of marine renewable energy projects and develop mitigation strategies to mitigate any negative effects (Soukissian et al. 2017).
- **Policy analysts:** Develop and analyse policies related to marine renewable energy.
- **Grid integration specialists:** Design and implement solutions to connect marine renewable energy to the electricity grid.
- **Finance and investment professionals:** Provide financial support and investment analysis for marine renewable energy projects.
- **Community engagement specialists:** Facilitate communication and collaboration between marine renewable energy projects and local communities.
- **Onshore versus offshore roles**: The distinction between land-based and offshore roles is crucial. Offshore roles, such as wind farm service boat skippers, professional divers and cable installation managers, require specialised training and often involve challenging working conditions. The need for health, safety and environmental staff is particularly important to ensure the safety and sustainability of these operations.
- **Engineering and technology:** Marine engineers, renewable energy technicians and project managers are key roles in the sector.
- **Research and development:** Scientists and researchers are needed to develop new technologies and improve efficiency.
- **Policy and regulation:** Experts in policy development and regulatory compliance are essential for supporting the growth of marine renewable energy.
- **Finance and investment:** Financial analysts, investors and project financiers play a crucial role in funding and supporting marine renewable energy projects.
- **Indirect job creation:** The sector also supports indirect jobs in related industries, such as supply chain, logistics and research.

The sector offers diverse career pathways, from technical and engineering roles to policy, finance and community engagement positions. This diversity not only provides job opportunities across different skill sets but also supports the long-term sustainability of the sector by integrating various perspectives and types of expertise.

BOX 1. Career pathways: Employment opportunities that can be expected in marine renewable energy

ON-LAND / OFFICE WORK

- Health, safety and environmental staff
- Renewable energy project managers and staff
- Project designers
- Researchers and project developers
- Energy information advisers
- Environmental and maritime spatial planning consultants
- Modellers and simulator engineers
- Legal experts and insurers
- Information technology services (website services and designers)

MAINLY OFFSHORE WORK AT SEA

- Wind farm service boat skippers and crew
- Professional divers
- Mechanics and maintenance workers
- Construction workers
- Cable installation managers
- Electricians and technicians
- Oceanographers, marine biologists, hydrologists, geologists, cartographers
- Pilots of remotely operated vehicles

Challenges

- **Policy and regulatory uncertainty:** The combinations of regulatory frameworks and government policies can have a direct impact on project timelines and workforce planning, with uncertainty inhibiting further investment in training and skill development. The regulatory structure needs consistency and some flexibility to allow for shifts in supply chains.
- **Certifications and permits:** A complex web of certifications, permits and standards is required to operate across jurisdictions.
- **Financial resources:** The industry will need to invest in upskilling, reskilling and training programmes, particularly in specialised areas such as offshore engineering and grid integration (IRENA 2020b).
- **Skill shortages:** The marine renewable energy sector requires a diverse range of skills that are in short supply, including engineering, project management, marine science, environmental science and finance (WOI 2022b).
- **Remote locations:** Many marine renewable energy projects are in peripheral areas where securing an adequate skilled workforce is challenging. Skilled workers may be reluctant to move or travel often in these instances, presenting recruitment challenges.

FACTS AND FIGURES

- Job creation: The sector has created 50,000 jobs worldwide, including manufacturing, construction, operations and maintenance (Scassola et al. 2023).
- According to the International Renewable Energy Agency, the global renewable energy sector could create over 42 million jobs worldwide by 2050, with a significant portion attributed to offshore wind, tidal and wave energy technologies (Ferroukhi et al. 2020).
- Global installed capacity: Offshore wind, the most developed marine renewable energy technology, has seen significant growth. Global capacity is estimated to have reached 60 gigawatts in 2024 (IRENA 2024).
- Investment trends: Investment in marine renewable energy has surged, with $20 billion invested globally in 2024 (BloombergNEF 2024).
- Technological advancements: Advances in turbine design, grid integration and cost reduction have made marine renewable energy more competitive (NREL n.d.).

- **Inclusion:** Addressing the gender gap and ensuring inclusivity in the workforce is crucial for the long-term sustainability and diversity of the sector (IRENA 2020a).

Regional trends

- **Europe:** Europe continues to lead in marine renewable energy employment, with countries such as the United Kingdom, Germany and Denmark having established strong industrial bases. Europe's dominance in marine renewable energy is driven by strong policy frameworks, substantial investments and a mature industrial base. The ambitious targets set by the European Union for 2030 and 2050 underscore the importance of continuing to build a skilled workforce to meet these goals (IRENA 2020b).
- **Asia-Pacific:** The Asia-Pacific region is experiencing rapid growth, with countries such as China and Japan creating significant job opportunities. As the Asia-Pacific region ramps up its renewable energy projects, there is potential for significant job creation, particularly in coastal and island nations where marine resources are abundant (WOI 2022b).
- **Americas:** In North America, the focus is on offshore wind and wave energy. The United States and Canada are exploring the potential of these technologies to provide stable and reliable electricity (IRENA 2020a). The development of renewable sources at sea promises to spur new industries and create jobs, aligning with the global energy transition. Latin America, with its extensive coastlines, also has significant untapped potential, particularly in wave and tidal energy (IRENA 2022).
- **Africa:** Africa, particularly Sub-Saharan Africa, has a relatively small share of the global deployment targets for marine renewable energy (IRENA 2022). However, the region's high potential for solar and wind energy can complement marine renewable energy projects. Investments in blue skills and technologies could drive sustainable development and energy security in coastal and island communities (IRENA 2020a). The Middle East and North Africa (MENA) region also shows promise, with opportunities to harness offshore wind and solar power (IRENA 2022).

Aquaculture and fisheries management

The Food Agriculture Organization of the United Nations (FAO) projects an increase in food fish production by 14.8 percent, or an additional 23 metric tons (MT) to reach 181 MT, by 2030 (FAO 2024b). In 2030, 57 percent of the food fish is projected to originate from aquaculture, up from 53 percent in the base period (2018–20), and the global average consumption of fish per capita per year is estimated to be 21.3 kilograms (FAO 2024b). By 2030, it is projected that 90 percent of fish production will be consumed as food, with 8 percent reduced into fishmeal and fish oil, and the remaining 2 percent as other non-food uses (OECD/FAO 2021).

The global number of jobs in fisheries and aquaculture could approximately double from present to reach 90–100 million by 2050 (FAO 2024b), driven by the need for sustainability and food security (WEF 2023). In 2050, spearheaded by new technologies and sustainable practices, aquaculture is expected to play a dominant role in global fish production. Rising consumption and production and the creation of wild and farm fishing alternatives will drive a variety of new business opportunities.

Employment opportunities

- **Governance policies and regulations:** The continuous challenges posed by illegal, unreported and unregulated (IUU) fishing, threats to the preservation of marine ecosystems, and the need for robust legal frameworks will drive the creation of more policies and development, as well as international governance. These demands will become even more pressing due to the accelerating effects of climate change and other ocean health stressors (Costello et al. 2020). With the integration of AI and emerging technologies into fisheries management, new roles will emerge in fisheries blockchain integration, real-time stock assessment, ecosystem monitoring, and traceability systems. This will, in turn, expand employment opportunities in sustainability supply chain audits, certification programmes and regulatory compliance oversight.
- **Marine spatial planning:** Marine spatial planning (MSP), within the context of sustainable ocean plans, is a critical tool in balancing the need to preserve marine resources and the demands of the various traditional and emerging sectors of the ocean economy. Consequently, there will be more need for jobs in MSP, maritime and environmental laws, regulatory compliance, ecological restoration, stakeholder management, and technology development for monitoring and assessment (Stevens et al. 2021).
- **Sustainable fisheries management:** Growing consumer demand for transparency and traceability in seafood sourcing is driving the need for advanced data management, electronic monitoring systems and blockchain-based tracking solutions (FISH 2.0 2015; GDST 2024). This shift will create jobs in fisheries data analysis, AI-powered monitoring, and digital traceability systems, ensuring compliance with sustainability standards. Additionally, as regulatory frameworks strengthen against IUU fishing, roles in marine policy, compliance and certification programmes will expand, reinforcing responsible fisheries management.
- **Sustainable aquaculture:** The increasing pressure to shift to sustainable resources and eco-friendly practices will create more innovative technologies and integration of autonomous systems and operators. Providing transparency will require more expertise in advanced robotics and data management (Underhill 2017). As 2050 approaches, aquaculture will need to evolve as part of an increasingly circular economy, leading to jobs in waste-to-resource management, bioremediation and multi-trophic aquaculture systems (OECD 2016).
- **Alternative fish feed and resource development:** The need for sustainable feed alternatives will create jobs for biotechnologists and drive more research and innovation across the value chain of fish feed, from insects' algae to microbial. In 2050, alternative feeds will become mainstream, and new opportunities will open in biomanufacturing, scaling production and innovation consultancy.
- **Aquaponics:** The integrated system of aquaculture and hydroponics has the potential to revolutionise the future of global food production, especially in urban areas (NOAA Fisheries 2013). It will offer opportunities for different purposes and scales, from small at-home gardening to large commercial farms able to feed a potential global population

of 10 billion people (Searchinger et al. 2019). The expansion of aquaponics will create jobs in the system, including in design, data analysis, food production and distribution. Local economies will benefit from more resilient food production and fewer environmental impacts (Ecolife Conservation 2023).

- **Climate change adaptation:** With the growing impact of climate change on the ocean's health and marine environment, there will be an increased demand for ocean scientists and climate experts to focus on adaptation strategies and disaster management.
- **Local community engagement:** Sustainable fisheries and aquaculture practices will create roles in community outreach, capacity building and education. There will be a demand for sustainable aquaculture educators and community-led innovation project managers (OECD 2016).

Challenges

Several common challenges in the just transition to a sustainable fishing and aquaculture sector will need to be addressed:

- **Reskilling and education:** Substantial investment will be needed in education, reskilling and upskilling to prepare the workforce for the future of sustainable fishing and aquaculture. Without this, the industry may face persistent skills gaps and challenges in adopting new technologies and sustainable practices (EU 2024).

- **Policy and governance:** Effective governance, enforcement, and policymaking will be essential to addressing the sector's challenges. This includes creating supportive regulatory environments, providing incentives for sustainable practices and ensuring that workers are protected and supported through transitions. Effective fisheries management will prevent overfishing and ensure long-term sustainability (FAO 2024b).
- **Adaptation and resilience:** The workforce will need to be adaptable and resilient in the face of environmental, technological and economic changes. Building resilience will require not only technical skills but also social safety nets, access to capital and community support systems (FAO 2024b).
- **Research and development:** Investment in research and development will be critical to address water-related challenges and ensure the long-term viability of the sector (Asche et al. 2013; Alameri et al. 2021).

Regional trends

- **Europe:** The workforce in sustainable fisheries and aquaculture will continue to be shaped by strict environmental regulations and the push for sustainability. The European Union's focus on reducing overfishing and promoting sustainable aquaculture will likely lead to a more skilled and specialised workforce. By 2050, the European workforce may see a significant shift towards high-tech aquaculture and fisheries management. As offshore and technologically advanced aquaculture operations expand, there will be a growing need for workers with expertise in engineering, robotics and data analytics. The traditional fishing workforce may decline, with more emphasis on sustainable practices and ecosystem-based management requiring interdisciplinary skills (European Commission 2025a).
- **North America:** The workforce will likely see a continued trend towards professionalisation and specialisation. The focus will be on sustainable fisheries management, certified aquaculture practices, and advanced technologies. Education and training programmes will emphasise sustainable fisheries management, aquaculture innovation, and environmental stewardship. By 2050, the North American workforce may become

more concentrated in high-tech, sustainable aquaculture operations, with a significant portion of traditional fishing roles becoming automated or phased out. The region may also see more integration of Indigenous knowledge and community-based management practices in fisheries and aquaculture (NOAA 2022).

- **Africa:** By 2030, Africa's workforce in fisheries and aquaculture will continue to expand, as these sectors are seen as vital for food security and economic development. By 2050, the workforce may become more diversified, with a greater emphasis on sustainable aquaculture as a means of enhancing food security and resilience to climate change. The demand for skilled workers in aquaculture technology, environmental management and climate adaptation will increase. There may also be more opportunities for women and youth in these sectors, as efforts to promote inclusive economic development gain traction (Chan et al. 2021).
- **Asia-Pacific:** The workforce in Asia-Pacific's fisheries and aquaculture will continue to be substantial up to 2030, with many rural communities relying on these industries for their livelihoods. However, there will be a gradual shift towards more skilled labour, as the industry adopts new technologies such as automated feeding systems, artificial intelligence and genetic engineering to enhance yields. Training programmes and education initiatives will be crucial to upskilling workers, particularly in major aquaculture-producing countries such as China, Indonesia and Vietnam. By 2050, the number of people employed directly in traditional fishing may decrease significantly due to increased automation and sustainable management practices aimed at reducing overfishing (FAO and NACA 2023).
- **Middle East:** The region will continue to expand its aquaculture sector, particularly in countries such as Saudi Arabia and the United Arab Emirates, where there is significant investment in sustainable fish farming. The dry climate and limited freshwater resources will drive innovation in aquaculture technologies, such as the Recycling the Aquaculture System and brackish water aquaculture. By 2050, the Middle East may see further expansion of aquaculture, with a focus on food security and reducing reliance on imports (van Beijnen and Hoevenaars 2023).

FACTS AND FIGURES

- The Food and Agriculture Organization of the United Nations estimates that there were 59.5 million people engaged directly in the fisheries and aquaculture sectors in 2018 (FAO 2020).
- In 2030, the estimated global number of jobs is 70–80 million, driven by the increase of aquaculture in Asia, Africa and Latin America (FAO 2022).
- By 2050, aquaculture will represent 75 percent of global fish production, up from 53 percent between 2018 and 2020 (FAO 2024b).
- The global number of jobs in fisheries and aquaculture could reach 90–100 million by 2050 (FAO 2024b).

Maritime transport and ports

The future of employment in sustainable maritime transport and ports will be defined by a significant shift towards green shipping and digital roles. Workers in the industry will need to adapt to new technologies and sustainability practices, requiring continuous learning and flexibility. As the industry evolves, traditional roles may decline, and new opportunities will arise to ensure a more sustainable future for maritime transport and ports.

Employment opportunities

The decarbonisation of the global maritime industry could support the creation of up to 4 million green jobs by 2050 (Global Maritime Forum 2024). Key areas of employment opportunities expected in the sector include the following:

- **Green shipping and sustainability**
  - **Decarbonisation experts:** As the International Maritime Organization (IMO) pushes for zero-carbon shipping by 2050, there will be a growing need for professionals with expertise in sustainable energy sources, such as hydrogen and ammonia fuels, and environmental regulations (IMO 2023c).

- **Environmental compliance officers:** Increasing regulations around emissions and marine pollution will drive demand for roles focusing on ensuring that ships and ports meet stringent environmental standards (IMO 2024a).
- **Alternative fuel engineers:** Specialising in the design and operation of engines and ships that run on sustainable fuels, such as hydrogen, will be critical as the industry moves away from fossil fuels (Hoegh-Guldberg et al. 2023).
- **Zero-waste operations coordinators:** Focusing on reducing waste generation and promoting recycling and reuse will require supervisors well versed in innovative technologies and sustainability practices.

- **Automation and digitalisation roles**
  - **Autonomous vessel operators and technicians:** As autonomous ships become more prevalent, new roles will emerge in operating and maintaining these vessels. By 2050, full autonomy could be common, requiring human oversight for fleet operations and system maintenance (Sinay 2024).
  - **Port automation engineers:** Automated cranes, cargo-handling robots and AI-driven systems will reduce manual labour but create high demand for engineers and technicians to design, install and maintain these systems.
  - **Data analysts and AI specialists:** Ports will rely heavily on big data for optimising shipping routes, cargo flow and port operations. Workers trained in maritime data analytics, AI development and smart port management will be in high demand (Marine Digital n.d.).
- **Cybersecurity and information technology professionals**
  - **Maritime cybersecurity experts:** With the rise of digital and automated systems, cybersecurity will become a major concern for both vessels and port infrastructure. By 2050, ensuring the safety of digital operations will be paramount (Marine Safety Consultants n.d.).
  - **Blockchain and supply chain technologists:** With the digitalisation of global shipping, blockchain technology is expected to play a crucial role in secure and efficient documentation and transactions, creating demand for blockchain experts. Jobs in this field require knowledge of autonomous systems, machine learning, robotics and cybersecurity (MarineLink 2024).
- **Supply chain and logistics management**
  - **Smart port managers:** Ports will become increasingly "smart," using AI, "Internet of Things" (IoT) and big data to streamline operations, creating roles in smart logistics and AI-driven management systems (Liu et al. 2025).
  - **Multimodal logistics experts:** Integrating shipping with land, air and rail transport will create new opportunities for professionals in supply chain management who specialise in optimising cargo flow through multiple transport systems.
  - **Digital freight forwarders:** As technology transforms global trade, freight forwarding will rely on digital platforms and AI to optimise shipping routes and schedules.
- **Infrastructure development and civil engineering**
  - **Port infrastructure developers:** New infrastructure will be needed to accommodate larger vessels and adaptation and resilience to rising sea levels and extreme weather events. Engineers and environmental scientists focusing on sustainable construction, climate-resilient port designs and eco-friendly port facilities will be key players.
- **Training and education**
  - **Maritime instructors:** With the increasing complexity of maritime technology and sustainability standards, there will be a growing demand for trainers and instructors to help in upskilling and reskilling and teach new skills to the next generation of maritime workers (Vujičić et al. 2022).
  - **Simulator operators and trainers:** As technology evolves, simulator-based training for both seafarers and port operators will expand, necessitating professionals skilled in running and designing these systems (Sellberg 2017).

- **Legal and regulatory compliance**
  - **Maritime lawyers and policy experts:** As environmental regulations become more complex, there will be an increasing need for maritime legal experts who specialise in international law, environmental compliance and trade agreements (Tsimplis 2021).
  - **Ethical compliance officers:** Managing ethical standards related to labour, environmental protection and sustainable practices will become crucial, creating roles dedicated to ensuring compliance (Wachenfeld et al. 2021).

Challenges

The transition to sustainable maritime transport and ports presents several challenges to employment, particularly in ensuring a "just transition" where workers are not left behind. A just transition requires balancing economic, social and environmental goals, which can create complex labour issues (see section "A just transition for diversity, equity and sustainability in the ocean economy").

- **Job loss:** The transition to sustainability will create jobs in areas like renewable energy and energy efficiency but may also lead to short-term job losses in fossil fuel and traditional maritime sectors. For example, jobs on offshore platforms like drill operators, pipeline technicians and rig engineers may decline as demand for oil and gas decreases. However, growing demand for skills in digitalisation, automation and data analytics could outpace supply, creating workforce shortages. Reskilling programmes will be vital to address these challenges and ensure a smooth transition (Hanson 2023).
- **Regional disparities in employment opportunities:** Not all regions will experience the transition equally. Ports in developing countries may face financial and technical barriers in adopting sustainable practices, limiting the creation of green jobs and leaving workers in traditional roles vulnerable to job insecurity (5% Club and GetZero 2024; UCEM 2025).
- **Decarbonisation pressure:** The International Maritime Organization targets for reducing emissions by 2030 and achieving net zero emissions by 2050 could increase operational costs for shipping companies and ports and put jobs at risk if companies downsize to remain profitable (IMO 2023b).
- **Social inequities and labour rights:** Displaced workers may face unemployment or lower-paying jobs in sectors outside of maritime transport, exacerbating social inequities (European Commission 2020).
- **Labour rights concerns:** As ports and shipping companies adopt new technologies, there are concerns over the erosion of labour rights, particularly if automated systems reduce the demand for unionised labour, or if new green jobs offer less job security and benefits (Dahan et al. 2023).
- **Health and safety considerations:** As ports and ships adopt new technologies and greener practices, workers may be exposed to new health and safety risks. These could range from managing hazardous materials (such as alternative fuels like hydrogen and ammonia) to dealing with the risks associated with new automated systems (Maritime Just Transition Task Force 2024; Safety4Sea 2024).

Regional trends

The regional trends in employment in the maritime transport and port sectors are shaped by several factors, such as the advancement of technology, digital infrastructure, environmental regulation, geopolitical changes and economic growth.

- **Europe:** Europe is leading the transition to green shipping with its commitment to climate neutrality in 2050 and shift to green production, as stipulated in the European Green Deal announced in December 2019. Putting people at the core of this transition, the Just Transition Fund is helping develop new skills to fulfil different roles in the supply chain of offshore renewable energy (European Commission 2025d).
- **North America:** A key player in global trade, particularly with the US-Mexico-Canada Agreement. Ports are increasingly focusing on climate change resilience and implementing AI and IoT technology for port operation, predictive maintenance, and blockchain for supply chain management. This will sustain a high number of

jobs in port management, logistics and customs brokerage, with an increase in upskilling and reskilling (IMO 2024b).

- **Africa:** Many African countries are investing in modernising their ports, which will have a ripple effect on the employment, economic growth and regional trade supported by the African Continental Free Trade Area. The projection of direct employment in African ports is estimated at 2 million to 2.5 million jobs (Ayesu and Boateng 2024). Modernisation usually requires updated rules and regulations, so there will be inquiries for jobs in government institutions, and direct and indirect jobs related to ports and trade. Modern ports will attract more cruises and tourists, which will lead to more jobs in tourism and hospitality (WTTC 2022b).
- **Middle East:** Countries such as the United Arab Emirates, Saudi Arabia and Qatar are heavily investing in expanding their port capacities and maritime infrastructure as part of broader economic diversification efforts. This is creating jobs in construction, logistics and port management. There is also a growing focus on sustainability, with initiatives aimed at reducing the environmental impact of port operations, creating demand for environmental specialists, sustainability managers and engineers.

FACTS AND FIGURES

- Employment in global port operations could see a shift, with an estimated workforce of around 13 to 18 million over the next decade (UNCTAD 2024a).
- Gender distribution: Up to today, the vast majority of seafarers are male, representing 98 percent of the global workforce. Women represent 2 percent, of which 33,000 are mainly in administrative positions or based on passenger ships (IMO and WISTA International 2022).
- The worldwide population of seafarers serving on internationally trading merchant ships is estimated at 1,892,720 (ICS n.d.b).
- The Maritime India Vision 2030 report suggests that investments in port projects could generate over 2 million jobs in India alone (Economic Times 2021).
- By 2050, decarbonisation of the shipping industry could create up to 4 million green jobs worldwide (Global Maritime Forum 2024).

- **Latin America:** Countries such as Brazil, Mexico and Panama (with the Panama Canal) are expanding their port capacities to accommodate growing trade, especially with Asia. This is leading to increased employment in construction, logistics and shipping. As technological development is slow compared to Europe or other regions, this means there is still significant demand for traditional port roles, though there is a gradual shift towards more technical positions (Miller and Hyodo 2021).
- **Arctic:** With climate change and the increase in ice melting, alternative routes for shipping, such as the North Sea, are becoming reliable. This leads to more jobs for icebreakers, climate monitors and experts in sustainable practices in cold environments.

Coastal tourism and hospitality

Coastal and maritime tourism accounts for more than 50 percent of global tourism, contributing $4.6 trillion in revenue and 5.2 percent to global GDP (Nguyen and Cheer 2023). The leisure activities of the sector, such as swimming, diving, surfing and marine wildlife watching, depend largely on a healthy and resilient ocean (Northrop et al. 2022).

A shift towards sustainability will foster job creation that supports environmental protection, a circular economy and renewable energy. There will be fewer jobs linked to mass tourism, such as cruise tourism, with associated climate and pollution impacts (Hoegh-Guldberg et al. 2023). New skills in ocean conservation, marine technology, sustainability consulting, and services rendered by hospitality will be required to fill the new market needs.

Employment opportunities

- **Renewable energy specialists in hospitality:** The shift to renewable energy in the hospitality industry is evolving, so hoteliers will need experts to help them install solar energy systems, for example, to reduce their carbon footprint. Skills in energy management and engineering will be needed (Technology 4 Hotels n.d.).
- **Coastal conservation managers:** Sustainable coastal tourism requires maintenance and restoration of the coastal ecosystem. Hence experts

in conservation management, marine biology and environmental science are needed to manage the protected areas and work closely with local stakeholders (Northrop et al. 2022).

- **Sustainability roles in the value chain:** The pressure of reducing the environmental footprint by 2030, and reaching net zero by 2050, will help create new roles in sustainability across the sector's whole supply chain. This includes designing eco-friendly cruise ships, developing green booking platforms, implementing sustainable procurement practices and managing waste more effectively (Hoegh-Guldberg et al. 2023). Experts in sustainability strategy, implementation, auditing, reporting, certification and data management are becoming increasingly vital.
- **Climate resilience operators and ocean health monitors:** With the continuing negative impacts of climate change, especially on small islands, governments need to deploy experts to draft and implement strategies to protect local communities against natural disasters such as floods, typhoons and hurricanes. The jobs in this field require skills in coastal engineering, natural disaster management and climate science. Additionally, there will be a demand for ocean health monitors to coordinate with the climate resilience operators, manage data and plan accordingly (Mycoo et al. 2022).
- **Virtual reality and augmented reality designers:** As people become more aware of the carbon emissions caused by travelling, there will be an increase in virtual travel experiences. Designers who create virtual reality–based coastal experiences could be in high demand (MIIS 2021).
- **Ecotourism operators and guides:** Public interest in ecotourism is on the rise, driving tourism operators to design experiences that promote wildlife conservation, reef-safe snorkelling and the celebration of cultural heritage. To meet this demand, guides and educators will need effective communication skills and knowledge about the ocean cultural heritage of the local communities (UN Tourism n.d.a). They also will require strong communication skills to effectively engage with holidaymakers, fostering awareness about the importance of protecting both the environment and the cultural identity of the communities they visit. This shift towards sustainable tourism emphasises the need for informed and skilled professionals to inspire responsible travel practices.
- **Sustainable gastronomy chefs:** As consumers increasingly demand sustainable food, chefs will focus on more sustainable gastronomies and promote their menus with sustainable dishes and ingredients, as well as more local fish and seafood. This will require creativity, culinary expertise and knowledge of sustainable food and sourcing (UN n.d.c).
- **Suppliers of eco-friendly souvenirs and handicrafts:** Sustainability-focused travellers are reshaping the souvenir market by prioritising purchases that align with their values. There is a strong preference for locally crafted, sustainably produced souvenirs that celebrate and support local culture, preserve traditions, bolster local economies and minimise environmental footprints (UN Tourism 2018).
- **Experts in sustainable marketing:** As sustainable travellers make their travel destination decisions based on sustainability and eco-friendly products and services, there will be an increased need for suppliers to promote their sustainability footprint, creating a role for marketers who are experts in sustainable tourism and hospitality (EcoCart 2024).

Challenges

By 2050, the jobs that are expected to disappear are related to the following activities:

- Mass market developers and tour operators who focus on mass tourism activities will see their sector shrink as travellers become more focused on sustainable travel and tourism. Any service or product that is not environmentally friendly will be rejected by many. Travellers will actively seek out souvenirs that are locally and sustainably made (UN Tourism n.d.b).
- Fossil fuel use in large marine transportation vessels, such as ships, is expected to decline as cleaner, less-polluting fuels are adopted. The International Maritime Organization is collaborating with shipping companies to achieve net-zero greenhouse gas (GHG) emissions for these vessels by 2050 (IMO 2023a).

- Organisers of large coastal events that damage the environment and harm local communities will face falling demand as travellers prefer to take part in environmentally friendly events (Kaye 2024).
- The global development of tourism infrastructure will face challenges, such as environmental degradation, the displacement of local communities and the need for sustainable management practices to ensure that the natural beauty and resources of coastal areas are preserved for future generations.

Regional trends

- **Europe:** More frequent and severe summer heat waves in Southern Europe will impact travel patterns and trends. Northern Europe will probably attract more tourists in the future, due to the milder climate (Maldonado 2024).
- **Africa:** Coastal tourism will continue to grow in Africa, especially as new destinations emerge in the east and west of the continent. The pristine beaches and cultural heritage will be key attractions for holidaymakers (OECD 2024a).
- **Middle East:** Countries will continue to invest in luxury tourism, with more innovation in sustainability, water management and desalination, which are critical for the region (WTTC 2022a).
- **Caribbean and Pacific:** With the impact of climate change, hurricanes and rising sea levels, more efforts will be deployed to diversify tourist attractions to take pressure off the coastal ones.
- **Asia:** Some countries, such as China and Indonesia, will focus on mega-projects, with big investments in infrastructure making some remote coastal areas more accessible.
- **North America:** Coastal areas, especially in the southern United States, will face increasing challenges related to rising sea levels. This will lead to more investment in infrastructure, including flood-defensive and resilient-adaptive buildings. Trends in experimental tourism will include deep-sea exploration, marine conservation tours and water sports (USGS n.d.).
- **Australia and Oceania:** The region will continue to attract adventure tourists interested in surfing, diving and wildlife tours (Coherent Market Insights 2024).

FACTS AND FIGURES

- In 2019, before the pandemic, travel and tourism accounted for 10.5 percent of all jobs, supporting approximately 334 million jobs globally and 10.4 percent of global gross domestic product (GDP) (US$10.3 trillion) (WTTC 2022b). Tourism accounted for $948 billion in capital investment, or 4.3 percent of total investment worldwide that year (Tippett 2022).
- In 2023, the travel and tourism industry contributed 9.1 percent to global GDP, an increase of 23.2 percent from 2022, and there were 27 million new jobs, a 9.1 percent increase compared to 2022 and only 1.4 percent below the 2019 level (WTTC 2022b).
- The travel and tourism sector is expected to grow by 2.4 percent over the next decade (WTTC 2022b).
- Coastal and maritime tourism accounts for over 50 percent of global tourism and is the largest economic sector for many developing island states (Magni 2023).
- Global coastal tourism could employ between 100 million and 150 million people by 2050 (Northrop et al. 2022; Karl and Soshkin 2024).

Marine innovation and technology

The emerging field of marine innovation and technology presents a wealth of untapped employment opportunities, especially in supporting a just transition to a sustainable ocean economy. As the global focus on ocean health and sustainability intensifies, many emerging sectors are blending environmental stewardship with technological advancements. Traditional sectors are also embracing innovative technologies to adapt to environmental challenges, meet evolving regulatory requirements and access new economic opportunities.

Employment opportunities

- **Artificial intelligence in marine research:** AI is increasingly used to predict ocean patterns, identify species and automate data analysis from sensors and satellite images. This will create a

high demand for AI researchers, machine learning engineers, data scientists and marine ecologists using AI tools (Macdonald and Martin 2024).

- **Marine robotics and autonomous systems:** As ocean exploration expands, underwater drones for deep-sea mapping, autonomous vessels, infrastructure maintenance and resource exploration will require professionals skilled in robotics, mechanical engineering, software development and data science.
- **Blue tech incubators and start-ups:** Innovations in marine technology are often driven by start-ups and incubators that focus on cutting-edge solutions to ocean challenges (1000 OS n.d.). This will drive more opportunities for entrepreneurs, venture capitalists, business development managers, marine engineers and researchers to create new products or services for the market. Start-ups focusing on blue carbon, sustainable fishing practices, underwater robotics and marine IoT solutions will also be required.
- **Earth observation:** This can be used to track marine biodiversity, monitor ocean temperatures and sea levels, and detect illegal fishing or pollution events. For example, the Global Fishing Watch platform uses Automatic Identification System data and machine learning to track and visualise fishing vessel activity around the world. This transparency tool has helped spur international cooperation, in ways critical to fighting illegal fishing, by making data publicly available (Google Sustainability 2018).
- **Marine law, policy and governance:** The rapid growth in marine innovation requires the development of laws and regulations for autonomous shipping and offshore mining, and to comply with international marine treaties and frameworks to protect marine biodiversity. Marine lawyers, policy advisers, regulatory analysts and environmental lobbyists will be needed.

Challenges

- **Skill gaps:** There is a shortage of qualified professionals with the necessary skills and expertise in advanced marine technologies such as AI and automation (World Maritime University 2023). By 2050, increased automation may lead to job displacement, requiring strategies to manage the transition and support affected workers (World Maritime University 2023).
- **Transition:** The rapid pace of technological change requires continuous upskilling and reskilling of the workforce (Di Battista et al. 2023).
- **Workforce diversity:** The industry struggles with low diversity and gender equality, which can limit the pool of talent (Heseltine 2022).
- **Limited funding and investment:** Lack of funding for research and development, including in academic institutions, can hinder innovation and job creation (Katapult n.d.).
- **Regulatory hurdles:** Navigation of complex international regulations can be challenging for companies and professionals (Islam 2024). Governance will need to keep pace with technological changes.

Regional trends

Regional trends in marine innovation and technology will be shaped, in part, by geopolitical priorities, economic conditions and the urgency of addressing climate change. While global cooperation will be crucial to sustainably manage ocean resources, regions will likely focus on their unique marine environments, resources and socioeconomic contexts. Below are some projected regional trends:

- **Europe:** Integration of "digital twin" computer models and AI will enable real-time monitoring and optimisation of marine operations (European Commission 2024a). The shipbuilding and marine resource sectors will adapt to a circular economy (Jansson 2016).
- **North America:** The region will see widespread use of renewable energy sources, including offshore wind (Economist Impact 2023b). The United States and Canada will focus on autonomous and remotely operated vessels' safety and efficiency, and on reducing carbon emissions, as well as cybersecurity to protect data and maritime infrastructure (Jones et al. 2024).
- **Asia-Pacific:** Major ports in China and Singapore will invest in automation and digitalisation to handle increasing trade volumes (Chu et al. 2018). Innovation in sustainable aquaculture technology will help meet the region's high seafood demand.
- **Africa:** Countries will focus on sustainable fisheries, aquaculture and coastal tourism to boost economic growth. They will emphasise training and capacity building to support the adoption of new marine technologies as well as increase technology transfer and collaboration with global partners to enhance marine innovation (Economist Impact 2023b).
- **Middle East:** The region will significantly explore marine renewable energy to diversify the energy portfolio, as well as advanced technologies for the conservation and restoration of marine biodiversity (KAUST n.d.).

FACTS AND FIGURES

- By 2030, the marine innovation and technology sector is expected to contribute millions of new jobs worldwide, driven by the rapid growth of offshore renewable energy, automation in shipping, regenerative aquaculture and blue biotechnology.
- With the global marine robotics market projected to grow at a 13 percent annual rate, the sector is expected to create tens of thousands of jobs in areas such as ocean exploration, defence, shipping and environmental monitoring.
- New research estimates the value of the maritime artificial intelligence market at US$4.1 billion (Macdonald and Martin 2024).

Marine management, protection and restoration

Marine protection and restoration are vital for safeguarding ocean ecosystems, preserving biodiversity and securing the long-term sustainability and resilience of marine resources for future generations. As human activities continue to impact marine environments, effective conservation and sustainable management becomes increasingly important (Fava 2022). In this context, the Kunming-Montreal Global Biodiversity Framework's 30x30 target aims to conserve 30 percent of terrestrial, inland water, coastal and marine areas by 2030. This ambitious goal seeks to halt biodiversity loss, safeguard critical habitats and strengthen the resilience of ecosystems against climate change and human exploitation (WWF and IUCN WCPA 2023).

Employment opportunities

- **Marine biologists and ecologists:** Scientists specialising in marine biology and ecology are essential for understanding and assessing the health of marine ecosystems.
- **Marine conservation specialists:** Experts in marine conservation planning, policy development and implementation are needed to protect and restore marine habitats.
- **Environmental consultants:** Consultants with expertise in marine ecosystems and environmental impact assessment can provide valuable insights to decision-makers.
- **Marine protected area managers:** Professionals responsible for managing marine protected areas, such as national parks and marine sanctuaries, are needed to ensure the continued value of the protected area.

- **Community outreach and education specialists:** Experts in engaging with local communities are needed to raise awareness about marine conservation issues.
- **Marine restoration specialists:** Ecosystem restoration professionals will be needed to restore damaged marine habitats, including coral reefs, seagrass meadows, estuaries and mangroves.

Challenges

- **Funding:** Securing adequate funding for marine conservation and restoration projects remains a challenge. Innovative financing mechanisms, such as the carbon market, blue bonds and public-private partnerships, are being explored to address this issue (Schindler Murray et al. 2023).
- **Climate change:** Climate change poses significant threats to marine ecosystems, requiring adaptive management strategies, including resilience-building measures (IPCC 2023).
- **Illegal fishing and pollution:** Addressing illegal fishing and marine pollution is crucial for effective conservation and restoration. This requires coordinated efforts by governments, enforcement agencies and international organisations. Enhanced monitoring and enforcement capabilities are critical (Widjaja et al. 2020).

Regional trends

- **Caribbean and Pacific:** These regions are home to many coral reef ecosystems that are the focus of significant restoration efforts. Initiatives include coral farming and reef monitoring programmes (NCCOS n.d.).
- **Europe:** Europe has a strong focus on marine conservation and restoration, driven by policies like the EU Marine Strategy Framework Directive and the Habitats Directive. Key initiatives include the establishment of marine protected areas (MPAs) and the restoration of habitats such as seagrass beds and oyster reefs. Untapped opportunities lie in expanding the network of MPAs and enhancing cross-border cooperation for large-scale restoration projects (UNEP 2022).
- **Asia-Pacific:** The Asia-Pacific region is actively engaged in marine conservation, with countries like Australia, Japan and Indonesia leading efforts. Coral reef restoration, mangrove reforestation and the establishment of MPAs are key focus areas. There is significant potential in leveraging traditional ecological knowledge and community-based management practices to enhance conservation outcomes. Improving regional collaboration and data sharing can further support conservation efforts (UNEP-WCMC 2022).
- **Americas:** In North America, marine conservation efforts are robust, with significant investments in MPAs and habitat restoration. The United States and Canada are leaders in marine spatial planning and the restoration of coastal ecosystems (UNEP-WCMC 2022). Latin American countries, particularly Brazil and Mexico, have opportunities to expand conservation initiatives and restore critical habitats like mangroves and coral reefs (Theuerkauf et al. 2019). Enhancing community involvement and integrating conservation with sustainable development goals can unlock further potential (Theuerkauf et al. 2019).
- **Africa:** Key initiatives include the establishment of MPAs and the restoration of mangroves and seagrass beds. The region faces challenges such as limited funding and capacity, but there are opportunities in enhancing regional cooperation and leveraging international support for large-scale restoration projects (Theuerkauf et al. 2019). The Middle East and North Africa region also shows promise, particularly in integrating conservation with climate adaptation strategies (Theuerkauf et al. 2019).

FACTS AND FIGURES

- Global investment: US$3.35 billion has been invested in seascape restoration since 2015, across 237 projects (UNEP-WCMC 2022). Coral reefs have been the most frequent habitat targeted for restoration, followed by mangroves and seagrass beds. However, mangroves received the greatest proportion of the funding. The highest number of projects were found in Western Europe; however, the Asia-Pacific region received the largest amount of funding (UNEP-WCMC 2022).
- Marine protected areas: The number and area of marine protected areas has grown steadily, with about 8.3 percent of the global ocean area protected as of 2024. This represents a significant increase in the area of the ocean under protection in recent years, but continued expansion is necessary to achieve Target 3 of the Kunming-Montreal Global Biodiversity Framework (Metabolic 2024).

A just transition for diversity, equity and sustainability in the ocean economy: Ocean stakeholders' roles and needs

Achieving a just transition

Achieving a just transition for the workforce, whilst requiring significant investment in policy and stakeholder engagement, is critical to creation of a sustainable ocean economy. Integrating diversity, equity and inclusion (DEI) principles is essential to ensuring that vulnerable communities, marginalised groups and historically disadvantaged populations benefit from the transition. Below is a breakdown of what this transition might look like in the short term (to 2030) and long term (2030 onwards).

Short-term goals (by 2030): Laying foundational steps for an inclusive workforce

In the short term, it will be essential to lay the groundwork for a workforce that reflects and respects diversity, equity and inclusion within a sustainable ocean economy (SOE). This includes creating robust policy frameworks that explicitly incorporate DEI principles, so that traditionally marginalised groups—such as coastal communities, Indigenous peoples, women and low-income workers—are not only included but also central to the transition (Khan and Northrop 2022).

Policymakers and industry leaders need to implement comprehensive laws and regulations to safeguard labour rights, ensure equal pay for equal work and maintain safe working conditions for all employees (Österblom et al. 2020). Establishing an inclusive policy environment in these early stages is critical to addressing immediate disparities and creating a foundation for long-term equity in the ocean economy (UNEP n.d.a).

Additionally, fostering active dialogue among governments, employers, workers and marginalised communities is vital to ensuring that these groups have a voice in shaping the future of ocean industries. Involving historically underrepresented voices in decision-making processes can make the transition to a sustainable ocean economy more democratic and responsive to diverse needs (ILO 2015). This collaboration is a cornerstone of a just transition, as it allows different perspectives, including traditional knowledge and lived experiences, to inform policies and practices that will ultimately define the SOE (Blue Marine Foundation 2024).

Educational initiatives are key in empowering marginalised groups to participate fully in emerging SOE sectors. Local workforce education and capacity-building programmes equip vulnerable communities with relevant skills, enhancing their employability and adaptability within the evolving ocean economy.

Tailored STEM (science, technology, engineering and mathematics) and vocational training programmes specifically designed for women, Indigenous communities and youth can open pathways into high-demand areas such as ocean energy, marine technology and conservation (NOAA n.d.a).

Furthermore, education programmes that blend traditional knowledge with sustainable practices enable coastal communities to actively engage in the ocean economy while preserving their rich cultural heritage. These localised initiatives inspire young people to reconnect with their cultural roots, fostering a sense of pride and ownership in their heritage and equipping them to adapt and enhance these time-honoured practices for the future. Beyond

preserving tradition, these programmes prepare communities to embrace new opportunities and cultivate a skilled workforce that embodies the diverse, multigenerational knowledge essential for a sustainable and resilient future (UNESCO-IOC n.d.).

Medium- to long-term goals (2030 onwards): Systemic shifts for equity, inclusive growth and diverse leadership

In the medium to long term, systemic changes will lead to more diverse leadership, equitable job creation and a workforce that reflects the richness of human diversity while advancing sustainability goals (ILO n.d.).

As all industries evolve, intentional hiring and career advancement programmes become crucial to ensuring that women, Indigenous people and other traditionally marginalised groups can access opportunities in the ocean economy (IOC-UNESCO 2020; UNDESA n.d.b). Collective proactive initiatives should be promoted that prioritise equitable hiring, professional development and leadership pathways, and emphasise the need to make jobs in all ocean economy sectors genuinely accessible to all (WOI 2022a).

Community-based enterprises, particularly cooperatives and locally owned ocean ventures such as fisheries, tourism, and conservation and restoration initiatives can contribute to equitable wealth distribution (Schindler Murray et al. 2023). Inclusive governance, equitable participation and amplifying marginalised voices are critical to fostering resilience and fair outcomes, especially in climate-vulnerable regions reliant on ocean resources (UNCC 2021). These enterprises enable communities to retain greater value from ocean resources while driving sustainable, locally led economic growth (Schindler Murray et al. 2023).

It will be important to cultivate diverse leadership across ocean industries by empowering women, Indigenous leaders and community representatives to play key roles in policymaking and industry practices (Kelly and Singh 2021). This inclusive approach ensures that the evolving ocean economy reflects the rich diversity of the communities it serves and is responsive to the needs and values of these groups. Furthermore, diverse leadership in ocean sectors can serve as a model for other industries, demonstrating the value of varied perspectives in driving innovation, sustainability and social responsibility.

International bodies like the United Nations need to establish clear global standards in ocean governance to uphold gender and diversity targets across ocean industries. These standards would help set inclusive benchmarks for multinational corporations, research institutions and government agencies involved in ocean management (Vierros 2017). To encourage compliance, these standards should be paired with incentives, such as access to funding, certifications or trade advantages, motivating businesses and organisations to adopt equitable practices. By promoting such standards and incentives, the SOE can benefit from a more consistent, global approach to inclusivity and equity. This framework enables countries to collaborate on building a just and sustainable ocean economy, where the wealth and resources of the ocean are shared fairly and inclusively (UNGC n.d.b).

Ocean stakeholders' roles and needs to support a just transition to a sustainable ocean economy

Governments

In a just transition to a sustainable ocean economy, governments play a critical role in ensuring that the future workforce is equipped to adapt to emerging industries, technologies and environmental challenges. The roles and needs of national, regional and local government are detailed below and summarised in Appendix C.

National governments

ROLES

- **Policy development and regulation**
    - **Sustainable ocean policies:** Governments establish and enforce policies that promote sustainable use of marine resources, protect ecosystems, reduce environmental impacts, facilitate energy transition and align with international agreements and standards for a sustainable ocean economy (Box 2). This

includes integrating sustainability into all ocean-based sectors (UNDESA n.d.b). Sustainable ocean plans provide a vehicle for such policies (Ocean Panel 2021).

- **Clear legal frameworks:** Governments create frameworks encouraging innovation, while ensuring environmental and social safeguards, including equitable access to ocean resources, full and productive employment, fair labour practices and decent work for all (OECD 2019).

- **Financial support and incentives**
  - **Funding transition programmes:** Governments can provide financial assistance to businesses of all sizes and to workers shifting from traditional ocean industries to more sustainable ones. This could include retraining grants, low-interest loans or direct subsidies (Johnson and Fritsch 2023).
  - **Tax incentives for sustainability:** To encourage companies to adopt sustainable practices (Vivas-Eugui et al. 2022), governments can offer tax credits or subsidies for investing in clean technologies and renewable energy (IEA 2024), and penalise those contributing to pollution (Sumaila et al. 2020).

- **Workforce reskilling and education**
  - **Skills development for new sectors:** Governments should invest in training programmes and vocational education that equip workers with the skills needed in emerging sectors of the ocean economy, such as offshore renewable energy, sustainable aquaculture and marine biotechnology (World Bank Group 2023).
  - **Lifelong learning programmes:** Workers need access to continuous learning opportunities with changing industry demands. Governments can promote partnerships between universities, industries and local communities to ensure accessible education and retraining (Di Battista et al. 2023).
  - **Technical and digital training:** Many sustainable ocean economy jobs in the future will require advanced technical and digital skills (e.g. for monitoring marine environments using AI and satellite technologies). The government can invest in training for these areas (Stevens et al. 2021).

- **Investment in sustainable infrastructure**
  - **Green infrastructure development:** Governments can support the development of ocean-related infrastructure that is sustainable, such as ports adapted for low-emission shipping, marine renewable energy installations and ocean-based tourism facilities that minimise environmental impact (Steven et al. 2020).
  - **Digital infrastructure development:** Governments can invest in digital infrastructure to allow real data collection and monitoring, and provide easy access to online learning platforms, training and upskilling (Daka 2023).

- **Research, innovation and technology**
  - **Support for research and development:** Governments can prioritise R&D funding to explore sustainable ocean technologies (e.g. low-emission shipping technologies, sustainable fisheries practices and ocean ecosystem restoration methods) (Stevens et al. 2021).

- **Encouraging blue innovation:** Promoting innovation hubs and start-ups focused on the ocean economy can create new business opportunities and job growth. This could involve grants, tax incentives or public competitions for innovative ocean solutions (Huay Neo and Meyer 2022).

- **Environmental protection and resilience building**
  - **Marine conservation efforts:** Governments have the power to expand marine protected areas in line with the targets of the Kunming-Montreal Global Biodiversity Framework and support biodiversity conservation initiatives. Healthy ecosystems will support long-term economic activities such as ecotourism, sustainable fishing and aquaculture (WWF n.d.).
  - **Climate adaptation and mitigation:** Governments should ensure that ocean economy activities align with climate goals by adopting low-carbon technologies and practices. This will also involve creating resilient coastal communities to withstand the impacts of climate change (e.g. rising sea levels and ocean acidification) (WOI 2020).

- **Stakeholder engagement and public participation**
  - **Inclusive decision-making:** Governments should engage stakeholders, including local communities, industry leaders, workers and environmental advocates, in decision-making processes to ensure a just and fair transition (see "Achieving a just transition" above). This will help foster trust and long-term buy-in for ocean-related policies (Quesada da Silva et al. 2021).
  - **Public awareness campaigns:** Educating the public about the importance of a sustainable ocean economy and the available opportunities in emerging industries is key to building broad support for change.

- **Partnerships and international collaboration**
  - **International collaboration:** Since the ocean economy is global, governments should collaborate on international agreements, such as UN Sustainable Development Goal (SDG) 14 (Life below Water), and regional fisheries management organisations, to harmonise efforts in conservation and sustainable economic activities.
  - **Public-private partnerships**: Encouraging collaborations between the private sector and public institutions can drive investment in sustainable projects, job creation and innovation in marine technology.

NEEDS

- **Economic diversification strategies:** Governments should develop strategies to diversify ocean-based industries, reduce dependency on unsustainable practices (e.g. overfishing, offshore oil drilling), and foster sustainable alternatives.
- **Access to financial resources:** National governments need access to both domestic and international funding to support the transition to a sustainable ocean economy. This could involve establishing national funds or accessing international financing (such as PROBLUE) for sustainable ocean initiatives (Sumaila et al. 2020).
- **Social safety nets and labour rights protections:** Workers in transitioning industries need protections, such as unemployment benefits, reskilling opportunities and job placement services, to ensure that they are not left behind. Governments need systems to enforce labour standards, ensuring that the ocean economy workforce is treated fairly and equitably (World Bank Group 2018).
- **Strong environmental regulations and enforcement:** To support sustainable practices, national governments need to enforce environmental regulations that limit pollution, overfishing and destructive industrial activities. Adequate enforcement agencies and penalties for violations are critical.

Regional and local governments

ROLES

- **Localised implementation of national policies:** Regional and local governments are key in implementing national ocean sustainability policies at a local level. They enforce environmental regulations, monitor ocean activities and manage local marine protected areas (UNESCO-IOC 2024).

Regional governments should actively engage with coastal communities, including local businesses and civil society, and involve them in decision-making processes...

- **Community engagement and social inclusion:** Regional governments should actively engage with coastal communities, including local businesses and civil society, and involve them in decision-making processes to ensure that the transition is inclusive and responsive to local needs. They should develop mechanisms to incorporate traditional knowledge and community input into workforce development and ocean management policies, ensuring that they reflect local priorities and conditions (Bennett et al. 2021).
- **Workforce development and job creation:** Local governments are responsible for ensuring that education and training opportunities align with the skills required in their regions, particularly for local industries such as fisheries, tourism and marine services. This includes collaborating with vocational schools, universities and local businesses (OECD 2023).
- **Enforcing environmental and labour standards:** Monitor and enforce environmental protections and labour standards within local jurisdictions to ensure compliance with sustainable practices and fair labour rights (OECD 2023).
- **Local economic planning:** Foster local economic planning that prioritises sustainability, such as encouraging sustainable tourism, supporting small-scale fishers or promoting marine conservation projects (UN-HABITAT 2005).
- **Support for small-scale enterprises:** Local economies often depend on micro-, small and medium-sized enterprises (MSMEs) in ocean sectors. Local governments need funding and technical support to help MSMEs transition to sustainable practices.
- **Local research and innovation:** Regional governments should invest in local-level research institutions to foster innovation in sustainable practices that are specific to the environmental and economic characteristics of each region (Ocean Panel 2020).
- **Resilience and adaptation:** Local governments need to plan and support the building of resilience against climate change impacts and other environmental risks through local adaptation strategies that protect coastal infrastructure, livelihoods and biodiversity (NOAA 2010).
- **Public awareness campaigns:** Local governments need resources to promote public awareness of sustainable ocean practices, such as protecting marine biodiversity, reducing pollution and promoting sustainable tourism (UNDESA n.d.a).

NEEDS

- **Climate resilience and adaptation planning:** Local governments need access to funding to support coastal localities to develop infrastructure that is resilient to climate impacts, such as sea-level rise, storms and ocean acidification. This requires long-term planning and access to climate adaptation funds (NOAA 2024a).
- **Capacity building and resources:** Regional and local governments need access to funding, technical expertise and other resources to effectively manage marine resources and support the sustainable workforce transition (Adow et al. 2024).
- **Clear guidelines:** Local governments need clear guidelines and tools to implement national and regional policies related to the ocean economy. They need the capacity to customise these policies to fit local environmental and socioeconomic conditions.
- **Strong communication with national governments:** Regional governments must work closely with national authorities to ensure policy coherence, funding access and technical support for workforce programmes.
- **Support for displaced workers:** Programmes to help workers displaced from traditional industries (e.g. industrial fishing or fossil fuels) transition into new roles in emerging sectors, such as sustainable tourism or renewable energy (Jacquard 2024)

BOX 2. **Government initiative: Canada's Blue Economy Strategy**

Stakeholder: Canadian government
Sectors: Traditional (fisheries and maritime) and emerging (blue technology)
Country: Developed (Canada)

The Canadian government has launched a Blue Economy Strategy to support sustainable growth in its ocean sectors, particularly fisheries, aquaculture and marine conservation. A key pillar of this strategy is workforce development, ensuring that coastal and Indigenous communities have access to training programmes that prepare them for sustainable ocean careers.

- **Training and workforce development:** Through programmes like the Ocean Supercluster and investments in Indigenous guardian programmes, the government is supporting skill-building in ocean technology, sustainable fisheries and marine research.
- **Innovation and digitalisation:** The strategy promotes digital transformation in marine industries, ensuring that workers can transition to sustainable practices.
- **Inclusivity:** Special emphasis is placed on women, youth and Indigenous communities, ensuring that traditionally underrepresented groups have opportunities in the future ocean economy.

Intergovernmental organisations

Intergovernmental organisations (IGOs) play a vital, overarching role in setting direction for the future workforce to achieve a just transition to a sustainable ocean economy. The roles and needs of intergovernmental organisations are detailed below and summarised in Appendix C.

Global institutions

Global institutions include UNB agencies such as the International Maritime Organization (IMO), International Labour Organization (ILO), Intergovernmental Oceanographic Commission (IOC-UNESCO), World Trade Organization (WTO) and World Bank (WB), amongst others.

ROLES

- **Global governance and policy coordination:** IGOs establish global frameworks and agreements such as the UN Sustainable Development Goals, especially SDG 14 (Life below Water), to guide countries towards sustainable ocean practices.
- **Standard setting and regulation:** IGOs develop international standards for sustainable ocean resource management (e.g. fishery practices, maritime regulations, pollution control and offshore energy). They provide policy guidelines to harmonise efforts across borders (e.g. the ILO's guidelines on fair labour practices in the fishing industry).
- **Funding and partnerships:** IGOs provide financial support through organisations such as the World Bank, the Global Environment Facility, other international financing institutions, or partnerships such as the Global Ocean Alliance, which help countries finance sustainable ocean-related projects and workforce development. International institutions should ensure adequate funding through mechanisms to support the transition to a sustainable ocean economy, especially in developing countries.
- **Capacity building and knowledge transfer:** Developing countries and vulnerable coastal communities often lack the technical capacity to transition to sustainable practices, particularly in areas such as marine conservation, renewable ocean energy and sustainable fisheries management. IGOs can provide financial and technical support to develop skills programmes to foster a globally competent ocean workforce through capacity building, training programmes, research and technology transfer (OECD 2020).
- **Monitoring and accountability:** IGOs should monitor global adherence to sustainability goals, track progress and ensure compliance and accountability through reporting mechanisms, international peer review and compliance systems (e.g. the IMO's monitoring of emissions from

the shipping industry). Strong mechanisms for enforcement and compliance are critical (Schmidt-Traub et al. 2015).

- **Regional and international collaborations:** IGOs should strengthen partnerships with existing initiatives and strategies by aligning their efforts through a shared action plan. By contributing their expertise, they can amplify the impact of workshops, webinars and events, creating a multiplier effect that enhances capacity building (Georgeson and Maslin 2018; UNDP 2024).
- **Promoting equity and inclusivity:** IGOs should ensure that the transition is just by focusing on vulnerable populations, including small-scale fishers and coastal communities, to protect their rights and livelihoods (Österblom et al. 2020) (Box 3).

NEEDS

- **Global co-operation and multilateral agreements:** Strong frameworks are needed to facilitate international cooperation, including multilateral agreements that support sustainable ocean economies and promote a just workforce transition (e.g. updates to international maritime conventions) (OECD 2020).
- **Data sharing and transparency:** A robust system for openly sharing data on marine resources, ocean industries and labour markets across countries is essential. International institutions need access to reliable data to create and share accurate models for workforce needs and environmental impacts (Trice et al. 2021).
- **Inclusive decision-making:** International institutions need to ensure that decision-making processes include a wide range of stakeholders, particularly marginalised groups such as small-scale fishers, women and Indigenous communities.
- **Innovation and research funding:** Continuous research into sustainable ocean technologies, practices and ecosystems is required. IGOs must fund research that explores new ocean-based industries (e.g. blue carbon, marine biotechnology) and sustainable practices that create job opportunities.

Regional institutions

Regional institutions include the European Union, African Union, Association of Southeast Asian Nations (ASEAN), Pacific Islands Forum and regional fisheries management organisations.

ROLES

- **Regional policy coordination:** Regional institutions foster regional cooperation by harmonising policies, regulations and enforcement mechanisms across borders for a unified approach to ocean sustainability and workforce development.

A robust system for openly sharing data on marine resources, ocean industries and labour markets across countries is essential.

- **Shared resources and knowledge:** Regional institutions promote the exchange of best practices, technology, data and scientific research across countries within a region to address common challenges, such as illegal fishing or marine pollution.
- **Capacity building, technical assistance and regional projects:** Regional institutions facilitate regional programmes that develop human capacity through skill-building initiatives and technical assistance shared across borders.
- **Fostering trade and innovation:** Regional institutions develop regional trade agreements that promote sustainable ocean-based sectors and incentivise innovation in areas such as blue carbon projects and ocean renewable energy.
- **Managing transboundary resources:** Regional institutions work collaboratively to manage shared marine resources (e.g. fisheries, biodiversity) through collective agreements, ensuring equitable distribution of benefits among regional nations.
- **Equity and social justice:** Regional institutions ensure that marginalised communities, such as Indigenous peoples, are included in policy development and benefit from ocean-based economic opportunities. They also act to support workers transitioning from traditional industries to sustainable ones.

NEEDS

- **Collaboration with national and international bodies:** Regional institutions need effective coordination mechanisms for cross-border collaboration on shared ocean resources. Strong cooperation with higher-level institutions is needed to align local efforts with broader national and international goals for sustainability, and for a just transition.
- **Regional data and knowledge platforms:** Regional institutions need centralised, open access, platforms for data sharing, research collaboration and best practices in sustainable ocean management. Such platforms should also include labour market data to track workforce trends and employment needs.
- **Funding for regional programmes:** Funding is vital for regional projects that address issues such as illegal, unregulated and unreported fishing; pollution; and climate change adaptation. Regional institutions need access to both regional and international financing.
- **Workforce mobility and training programmes:** Regional institutions should promote initiatives that allow workers to gain experience and training across borders. This requires agreements on worker mobility and skills recognition between neighbouring countries.

BOX 3. IGO initiative: The IMO's "Women in Maritime" and green shipping transition

Stakeholder: International Maritime Organization (IMO)
Sector: Traditional (shipping) and emerging (decarbonised maritime transport)
Country: Global

The IMO has several workforce-focused initiatives, particularly its "Women in Maritime" programme and its Green Shipping training programmes.

- **Women in Maritime:** The IMO has established regional associations in Africa, Asia and the Pacific to promote women's career opportunities in the traditionally male-dominated maritime sector.
- **Green shipping and decarbonisation training:** The IMO's GreenVoyage2050 programme helps maritime professionals transition into low-carbon shipping, preparing seafarers for roles in alternative fuels (e.g. liquefied natural gas, hydrogen).
- **Collaboration with academia:** The IMO works closely with maritime universities to integrate sustainability curricula into seafarer training.

Private sector

Through its role as a key employer, the private sector plays a critical role in shaping the future workforce within the framework of a just transition to a sustainable ocean economy. The roles and needs of the private sector are detailed below and summarised in Appendix C.

ROLES

- **Leadership in corporate sustainability**
  - **Sustainable supply chains:** Companies involved in industries such as shipping, fishing or tourism can implement sustainable supply chain practices, which reduce environmental harm while creating demand for skills related to sustainable management, marketing, auditing and compliance (Box 4).
  - **Transparency and reporting:** Through sustainability reporting, data sharing and corporate responsibility initiatives, companies can demonstrate leadership in ocean sustainability, which can inspire similar behaviour across industries, fostering a collective movement towards a just transition (Economist Impact 2023a). Current estimates suggest that only 3 percent of global ocean biodiversity data originates from private companies (HUB Ocean 2024).
- **Capacity building and workforce reskilling and upskilling**
  - **Training programmes:** As the ocean economy shifts towards sustainability, traditional industries (e.g. oil and gas, shipping and unsustainable fishing) will need to reduce their environmental impact or transition into new roles. Private sector employers should establish reskilling and upskilling programmes to ensure that their workforce is equipped for these changes, including areas such as marine conservation, clean energy and sustainable tourism. A dedicated "reskilling revolution" programme for the ocean economy could be one solution to address the skills gaps (WEF n.d.).
  - **Collaboration with educational institutions:** The private sector can collaborate with universities, technical schools and training centres to develop curricula that support capacity, building the skills needed for future ocean jobs, including in STEM subjects like oceanography and environmental science (World Bank Group n.d.a).
- **Supporting regulatory frameworks and policies**
  - **Advocacy and compliance:** Private companies can advocate for and comply with regulations that promote sustainability, such as ones governing marine protected areas, pollution

control and responsible resource extraction. Their support for policies that align with the UN Sustainable Development Goals, particularly SDG 14 (Life below Water), is vital for long-term ocean health.

- **Public-private partnerships:** Through collaboration with governments, civil society and NGOs, the private sector can help design frameworks that balance economic growth with ocean conservation, ensuring that new policies take workforce needs into account (Fritsch 2022).

- **Fostering social responsibility and inclusivity**
  - **Ensuring fair labour practices:** The private sector should promote fair wages, decent working conditions and inclusive opportunities, especially in coastal communities and developing nations where many ocean-related jobs are located (ILO 2013). This will ensure that no one is left behind in the transition.
  - **Gender equality and diversity:** Encouraging diversity in the workforce, especially in industries traditionally dominated by men, can lead to a more inclusive ocean economy. Women and marginalised groups should be included in decision-making and leadership roles to create a more equitable system (IMO 2024b). Current trends suggest that the digital transition will support increased diversity within the maritime workforce.

- **Investing in sustainable industries**
  - Private companies, especially those in traditional ocean-based industries (e.g. fishing, shipping, oil and gas), need to invest in sustainable alternatives and innovations. This includes renewable marine energy (offshore wind, tidal energy), sustainable aquaculture, sustainable fisheries and eco-friendly shipping technologies.

NEEDS

- **Infrastructure and investment**
  - **Access to finance and green investment:** The private sector needs access to financing mechanisms that allow investment in sustainable and scalable ocean industries. Green bonds, impact investing and venture capital for ocean economy innovations can help companies scale sustainable projects, create jobs and develop the future workforce (Economist Impact 2023a).
  - **Funding for new technologies:** The private sector needs capital to develop and deploy technologies that support sustainable ocean economies, such as renewable energy platforms, biodegradable materials for marine use, advanced fisheries monitoring and AI for ocean resource management. Public-private partnerships could become key for sustainable development when investment in research and development drives innovation (Huay Neo and Teleki 2023).
  - **Sustainable infrastructure development:** Companies require infrastructure that supports the transition to a sustainable ocean economy. This includes renewable energy infrastructure, modernised port facilities that accommodate green shipping technologies, and advanced aquaculture systems that minimise environmental harm (Steven et al. 2020).
  - **Digitalisation and data analytics:** The future workforce must be able to harness digital tools such as big data, AI and remote sensing to monitor and manage ocean ecosystems. Companies need access to cutting-edge digital technologies and training programmes that teach workers how to use these tools effectively. Digital infrastructure is crucial to help the transition to the digital era (Leape et al. 2020; Markussen and Teleki 2021).

- **Adopting circular economy models**
  - The private sector should collaborate with governments and non-profits to develop policies that incentivise recycling and waste reduction in ocean industries (Plate et al. 2021; Barona et al. 2023).

- **Ensuring just workforce transitions**
  - Corporations should commit to workforce development programmes, reskilling initiatives and partnerships with educational institutions to create pathways for displaced workers (Laboissiere and Mourshed 2017).

- **Improving transparency and accountability**
  - Private companies need development and enforcement of robust environmental, social and governance (ESG) reporting frameworks that reflect the full impact of business activities on the ocean and its ecosystems (ICS n.d.a).
- **Supporting small-scale and Indigenous communities**
  - Large private sector companies, especially those involved in resource extraction or infrastructure development, need to collaborate with small-scale fishers, Indigenous communities and coastal populations to ensure that they are not marginalised in the transition process. To achieve this, they need policy frameworks and financial mechanisms that ensure equitable profit-sharing, participation in decision-making processes and community-driven conservation efforts (Cohen et al. 2019).
- **Engaging in ocean conservation and restoration**
  - Private companies can contribute to ocean conservation by investing in marine protected areas, marine spatial planning, habitat restoration projects (e.g. coral reefs, mangroves) and biodiversity protection programmes. Hence, they need funding for large-scale conservation initiatives, partnerships with environmental NGOs and alignment with global goals like UN Sustainable Development Goal 14 (Life below Water) (Giron 2024).
- **Promoting research and innovation**
  - The private sector needs collaboration with research institutions and governments to develop cutting-edge technologies that reduce environmental impacts and help adapt to climate change (Lee et al. 2021).
- **Advocating for policy change**
  - The private sector must adapt to evolving consumer demands and shifting habits by offering more sustainable products and services. It should also actively participate in policy dialogues, advocate for stronger ocean governance and support international agreements that promote sustainable ocean management (Petruzzelli 2024).
- **Fostering global and multi-stakeholder partnerships**
  - The private sector needs collaborative platforms for shared learning, investment in joint ventures and cross-sector partnerships to promote sustainable ocean governance (RGI 2022).

BOX 4. Private sector initiative: Prada Group and UNESCO's Ocean Literacy programme

Stakeholder: Prada Group
Sector: Emerging (Sustainable Fashion)
Country: Developed (Italy)

Prada Group, in collaboration with the UN Educational Scientific and Cultural Organization (UNESCO)'s Intergovernmental Oceanographic Commission, launched an educational programme for high school students focused on ocean literacy and sustainability in fashion. This initiative, part of SEA BEYOND, aims to create future ocean-conscious leaders in industries beyond the traditional maritime sector.

- **Youth education:** Engages students worldwide, providing resources on sustainable materials, circular economy principles and ocean conservation.
- **Sustainable workforce integration:** Prada incorporates sustainable ocean knowledge into its workforce, ensuring that employees are trained in sustainable sourcing and material innovation (e.g. recycled ocean plastics in luxury fashion). Collaboration with academia: The IMO works closely with maritime universities to integrate sustainability curricula into seafarer training.

Non-governmental organisations

NGOs play a pivotal role in shaping the future workforce within the context of a sustainable ocean economy. The unique position of NGOs as independent organisations allows them to advocate for policy changes, educate and empower communities, and directly support the development of essential ocean economy skills. The roles and needs of NGOs are detailed below and summarised in Appendix C.

ROLES

- **Advocacy and policy development**
  - **Influencing policy frameworks:** NGOs can advocate for policies that promote sustainable ocean practices, equitable access to marine resources, and the development of a skilled ocean economy workforce. NGOs often serve as intermediaries between local communities, governments and international organisations. They advocate for policies that support sustainable ocean economy practices and ensure that skill development is a priority in national and regional agendas. By participating in policy dialogues and forming strategic partnerships, NGOs help shape a conducive environment for the growth of ocean economy skills (NLA International 2021; Mediterranean Blue Economy Stakeholder Platform n.d.).
  - Promoting international cooperation: NGOs can work to establish international agreements and standards that ensure sustainable and equitable ocean governance.
- **Education and capacity building**
  - **Community outreach:** NGOs can reach out to coastal communities, particularly marginalised groups, to raise awareness of the sustainable ocean economy and its opportunities. NGOs empower communities by providing access to education and training, fostering local entrepreneurship and supporting small-scale fisheries and aquaculture projects. This engagement ensures that the benefits of the ocean economy are inclusive and equitable (Kulkarni 2022).
  - **Skills development programmes:** NGOs can offer training programmes and workshops to equip individuals with the necessary skills for ocean economy careers (Box 5). The Ocean Conservancy (n.d.) and The Nature Conservancy (n.d.) offer various training programmes and educational resources related to marine conservation and sustainable development. NGOs often collaborate with educational institutions and industry experts to develop comprehensive training modules that address current and future skill needs (Blue Generation Project 2018).
  - **Youth engagement:** NGOs can foster interest in the ocean economy among young people, through educational programmes, internships and mentorship opportunities. The Ocean Foundation (n.d.a) and Mission Blue (n.d.) are examples of organisations that focus on youth engagement and education.
- **Research and innovation**
  - **Data collection and analysis:** NGOs can collect and analyse data on marine ecosystems, biodiversity and human activities to inform policy decisions and communities, and to support sustainable practices.
  - **Innovation hubs:** NGOs can establish or partner with innovation hubs to foster the development of new technologies, research and solutions for sustainable ocean management. This partnership helps in developing targeted training programmes and informs policy recommendations. NGOs also pilot innovative projects that demonstrate sustainable practices and new technologies, contributing to the overall knowledge base of the ocean economy (Datta et al. 2023). The Ocean Startup Project (n.d.) and Blue Innovation Labs (n.d.) are examples of initiatives that support innovation in the ocean economy.
- **Sustainable practices and certification**
  - **Promoting and certifying sustainability:** NGOs play a crucial role in promoting sustainable practices and creating market demand for ocean economy skills through certification programmes. These programmes establish standards for various industries and activities

related to the ocean, such as fishing, aquaculture and tourism. By certifying businesses and individuals that meet these standards, NGOs increase consumer awareness, facilitate market access, drive innovation and create job opportunities. The Marine Stewardship Council and the Aquaculture Stewardship Council are well-known certification organisations that set standards for sustainable seafood (Anderson et al. 2021; Olsen et al. 2021).

- **Partnerships and collaboration**
  - **Public-private partnerships:** NGOs can collaborate with governments, businesses and academic institutions to develop and implement sustainable ocean economy initiatives and address market needs. The Ocean Cleanup and the Seabin Project are examples of successful public-private partnerships (The Ocean Cleanup n.d.; Seabin n.d.).
  - **International networks:** NGOs can connect with global networks to share knowledge, resources and best practices. The Global Ocean Forum (2024) is an example of an international network that brings together various stakeholders in the ocean economy.

NEEDS

- **Funding and financial resources:** NGOs often require substantial funding to develop and implement programmes. This includes grants, donations and partnerships with private sector organisations to ensure that they have the financial stability to support long-term projects (Datta et al. 2023).
- **Technical expertise and training:** Access to technical expertise is crucial. NGOs need professionals with knowledge in marine sciences, sustainable fishing practices and marine technology to design effective programmes and provide training to local communities (WRI 2020).
- **Educational tools:** NGOs need materials and resources for training programmes. This includes educational materials, access to online courses and opportunities for hands-on training in sustainable practices.
- **Research and data collection tools:** To support their initiatives, NGOs need advanced tools and technologies for research and data collection. This includes equipment for monitoring marine ecosystems, software for data analysis and platforms for sharing information (WRI 2020), as well as tools for sustainable fishing, marine monitoring and pollution control, which can help make their initiatives more effective and efficient.
- **Community engagement and collaboration:** Effective community engagement is essential. NGOs need resources to organise workshops, meetings and participatory planning processes to involve local communities in their projects. This ensures that initiatives are culturally appropriate and have local support (Datta et al. 2023).

BOX 5. NGO-led training: Caribbean Blue Economy internship program (Caribbean islands)

Stakeholder: Caribbean Blue Economy Initiative
Sector: Traditional (tourism and fisheries) and emerging (marine renewable energy)
Country: Islands (Caribbean)

This initiative, led by regional non-governmental organisations and supported by the World Bank and regional intergovernmental organisations, provides internships and training for youth in island nations, preparing them for sustainable ocean careers in tourism, fisheries and renewable energy.

- **Skills training:** Offers practical experience in marine conservation, ecotourism and offshore wind energy projects.
- **Entrepreneurship support:** Encourages young islanders to develop blue start-ups in sectors like sustainable seafood processing or marine ecotourism.
- **Community impact:** Directly supports local economies by retaining talent in island nations, reducing "brain drain" to other countries.

Financial institutions

Financial institutions have a central role in financing and guiding the just transition to a sustainable ocean economy. They help shape the future workforce by promoting sustainable industries, financing workforce development, supporting traditional sector transitions and ensuring that the benefits of ocean resources are distributed equitably. Through green and blue financing, ESG integration and collaboration with governments and local businesses, they ensure that the future workforce is equipped for a thriving, sustainable and socially just ocean economy (UNEP n.d.d).

Examples of international financing institutions include the World Bank, Asian Development Bank and Inter-American Development Bank. Commercial banks and investment firms include PNB Paribas, Crédit Agricole and Triodos Bank. The roles and needs of financial institutions are detailed below and summarised in Appendix C.

ROLES

- **Financing sustainable ocean industries**
  - **Providing loans and investments:** Financial institutions can drive the shift towards a sustainable ocean economy by directing capital to industries that are environmentally sustainable and socially equitable. Examples include businesses engaged in renewable ocean energy, sustainable fisheries and aquaculture, ecotourism, and marine conservation and restoration (Box 6).
  - **De-risking sustainable projects** by offering affordable credit, green bonds or concessional financing can help businesses develop sustainable ocean-related technologies or infrastructure.
  - **Supporting blue finance initiatives**: Financial institutions can offer financial products and investment strategies aimed at ocean health, resilience and sustainable development.
- **Promoting green and blue bonds**
  - **Issuing green and blue bonds:** Financial institutions can support large-scale sustainable ocean projects while fostering job creation (Thompson 2022). Blue bonds, in particular, are designed to finance marine and ocean-based activities that benefit the environment and create sustainable jobs (IFC 2023). Examples include
    - projects that reduce ocean pollution, such as waste management and plastic recycling initiatives; and
    - initiatives to protect and restore marine ecosystems, such as mangrove conservation, which provide jobs for local communities and contribute to climate resilience.
- **Risk management and insurance**
  - **Offering different insurance products** tailored to the needs of sustainable ocean industries can help mitigate financial risks, promote safety and well-being, support innovation and build resilience against environmental challenges. To achieve this, financial institutions need advanced tools for assessing risks such as sea-level rise, coastal erosion and climate change impacts. This helps in evaluating long-term investments in ocean infrastructure and industries. By protecting both businesses and workers, insurance helps stabilise employment, foster growth in sustainable industries and promote a just transition towards a sustainable and inclusive ocean economy (Wanczeck et al. 2017).
- **Enabling small and local businesses**
  - **Fostering economic inclusion** by offering targeted financial products can support small and medium-sized enterprises (SMEs) and local communities involved in ocean-related industries. This could involve
    - providing microloans and other forms of financial support to small-scale fishers, coastal tourism operators, or local entrepreneurs working in sustainable ocean sectors (Hendriks 2022); and
    - supporting inclusive finance models that offer financial products tailored to underserved communities, helping them access jobs in the sustainable ocean economy.

- **Supporting workforce development and training initiatives**
  - **Funding education and training programmes** enables financial institutions to help prepare the future workforce for roles in the sustainable ocean economy. This includes providing internships, scholarships or loans for students pursuing degrees in marine sciences, ocean engineering or environmental management, as well as supporting technical training in new technologies such as offshore wind or marine conservation.
  - **Investing in industries such as renewable energy, sustainable aquaculture and marine tourism** helps create new jobs. Financial institutions can target investments that promote job growth in regions heavily dependent on the ocean, ensuring that these communities transition smoothly to more sustainable livelihoods.
- **Incorporating ESG criteria**
  - **Comprehensive environmental data:** Financial institutions require access to reliable environmental, social and governance data and standardised ESG metrics for ocean industries to assess the sustainability of ocean-related projects. By incorporating ESG criteria into their lending and investment decisions, they can ensure that businesses adhere to sustainability and social responsibility standards. This involves
    - requiring companies to demonstrate that they are minimising their environmental footprint, respecting human rights and providing fair labour conditions as part of loan agreements or investment deals; and
    - supporting businesses that commit to net-zero emissions goals and demonstrate clear strategies for contributing to marine biodiversity protection and carbon-neutral ocean activities.
- **Collaborating with governments and international organisations**
  - **Collaborating with governments, international organisations and NGOs,** financial institutions can co-finance large-scale ocean sustainability projects and ensure equitable outcomes for the workforce. These partnerships may involve
    - collaboration between the private sector, governments and NGOs in public-private partnerships, which is crucial to ensure large-scale financing for sustainable ocean projects and can provide financial institutions with platforms they need to facilitate multi-stakeholder partnerships that address complex challenges in ocean management and conservation; and
    - engaging in multi-stakeholder dialogues to establish guidelines and standards for sustainable ocean investments, ensuring that the economic benefits of ocean resources are shared fairly with workers and local communities.

NEEDS

- **Collaborative platforms for innovation**
  - **Partnerships with universities and research institutions:** Financial institutions benefit from collaboration with research institutions to stay informed of the latest innovations and breakthroughs in the sustainable ocean economy. These partnerships can help identify emerging investment opportunities in areas such as blue biotechnology, marine renewable energy and sustainable fisheries (UNEP n.d.d).
- **Clear regulatory and policy frameworks**
  - **Stable and consistent regulation:** Financial institutions need clear and predictable regulatory environments to make informed investment decisions. Governments should create policies that support sustainable ocean investments, including clear definitions of sustainable ocean economy sectors and consistent enforcement of environmental regulations (UNEP n.d.e).
  - **Incentives for sustainable investments:** Tax breaks, subsidies and incentives for green and blue finance instruments are necessary to encourage financial institutions to direct capital towards sustainability projects. This helps reduce the risk and increase the profitability of sustainable investments (IFC 2022).

- **Standardisation and certification schemes**
  - **Sustainability certifications for blue economy projects:** Financial institutions need clear standards and certifications that define what constitutes a sustainable ocean economy project. This helps ensure that their investments meet global sustainability goals and attract investors seeking environmental impact alongside financial returns (van Putten et al. 2020).
- **Public awareness and investor demand**
  - **Investor education on blue economy opportunities:** Financial institutions need to build awareness among investors about the opportunities and benefits of investing in the ocean economy. This requires educating clients on the long-term potential of sustainable ocean industries, emphasising both environmental impact and financial returns (IFC n.d.a).
  - **Increased demand for green and blue bonds:** A broader market needs to be cultivated for green and blue bonds. Financial institutions require demand from institutional investors, pension funds and retail investors who prioritise sustainability and are willing to invest in projects that promote ocean health and sustainable livelihoods (IFC n.d.b; Morgan Stanley 2023).

Academia

Academia plays a pivotal role in supporting a sustainable workforce in the just transition to a sustainable ocean economy through advancing knowledge, providing training, conducting research and fostering innovation. This will ensure that the workforce is equipped with the necessary skills, expertise and tools to thrive in an economy that balances economic growth with ocean conservation. The roles and needs of academia are detailed below and summarised in Appendix C.

ROLES

- **Workforce development through education and training**
  - **Curriculum development for emerging ocean industries:** Academia can design and deliver educational programmes that cater to the evolving needs of the traditional and emerging sectors of the ocean economy (Box 7). These programmes can help bridge the gap between academic learning and practical application, ensuring that students acquire the skills and competencies most sought after by employers (Groves and Massena 2024).
  - **Vocational training and technical education:** Educational institutions can also offer technical and vocational training programmes that provide practical skills for ocean-based jobs. These programmes can help equip the workforce

BOX 6. Financial institution: EBRD's Blue Economy Financing (Egypt and Türkiye)

Stakeholder: European Bank for Reconstruction and Development (EBRD)
Sector: Traditional (shipping, ports) and emerging (blue technology, waste management))
Country: Developing (Egypt, Türkiye)

The EBRD Blue Economy Financing initiative supports sustainable job creation in coastal economies by funding projects that drive a greener workforce transition.

- **Green maritime infrastructure:** In Egypt and Türkiye, EBRD has financed sustainable port developments and shipbuilding modernisation to integrate low-carbon and circular economy principles.
- **Workforce training:** ERBD collaborates with local technical institutes to train port workers, shipbuilders and logistics professionals in green shipping and maritime digitalisation.
- **Women in Maritime:** EBRD integrates gender-inclusion policies, supporting women's employment in ocean-related industries.

with the technical expertise needed for tasks such as operating renewable energy equipment, managing sustainable fishing practices and maintaining marine technologies (Charu and Saroj 2023).

- **Short-term certifications for ocean workers:** Offering flexible, short-term certification programmes in areas such as marine technology, ocean data science and environmental conservation can significantly enhance workers' specialisations and employability in the sustainable ocean economy. For instance, programmes like the Oceanographic Science and Technology Certificate and the Ocean Science Graduate Certificate provide targeted education and skills development (University of Rhode Island n.d.). These certifications help workers stay current with the latest advancements and practices in their fields, ensuring that they are well prepared for the demands of the evolving ocean economy.
- **Reskilling and upskilling programmes:** As ocean-based industries transition to more sustainable practices, academia can offer reskilling programmes to help displaced workers transition into new roles (Lubchenco et al. 2020). For example, online learning platforms and professional development courses allow workers in ocean-based industries to continuously update their skills, or reskill. This ensures that the workforce remains adaptable and well versed in the latest technologies and practices in sustainable ocean management.

- **Conducting research and innovation in sustainable ocean solutions**
  - **Marine science and technology research:** Research institutions play a vital role in advancing scientific knowledge and technological innovations that underpin a sustainable ocean economy. Key areas of research include marine renewable energy technologies, marine biodiversity, marine biotechnology, sustainable fisheries and aquaculture systems (UN n.d.b).
  - **Climate change and ocean resilience studies:** Academia can lead research on how climate change impacts ocean ecosystems and coastal communities. By understanding these impacts, research institutions can help develop strategies to build resilience, protect ocean resources and ensure that jobs in the ocean economy are sustainable in the face of environmental change (Yadav and Gjerde 2020).
  - **Interdisciplinary research for policy development:** Academic institutions can bring together economists, ecologists, engineers and social scientists to create holistic solutions for the sustainable ocean economy. Research in this area can help guide governments and industry on policy reforms, governance structures and economic models that support a just transition and equitable distribution of ocean resources (UN n.d.b).

- **Fostering innovation and entrepreneurship**
  - **Incubators and innovation hubs:** Research and academic institutions can create innovation hubs or business incubators to support start-ups and entrepreneurs in the ocean economy. They can also prepare the workforce to address job market needs by encouraging entrepreneurship (e.g. preparation of business plans, bankable projects). These hubs can focus on developing sustainable ocean-based businesses that contribute to job creation while minimising environmental impact (UCSD n.d.).
  - **Collaboration with industry:** Academia can collaborate with private sector companies to drive innovation in sustainable technologies. These partnerships can lead to advancements in renewable energy, marine engineering or waste-reduction technologies, creating high-skilled jobs in the process (Hoegh-Guldberg et al. 2023).

- **Supporting a just transition through social science and policy research**
  - **Research on social equity and workforce inclusivity:** Research institutions can analyse the social dimensions of the ocean economy, ensuring that the benefits of a sustainable ocean economy are shared equitably across different groups (Lubchenco et al. 2020). This includes by
    - investigating the impacts of the transition on vulnerable communities, such as small-scale fishers, Indigenous peoples and women in coastal regions; and

- developing strategies to include marginalised groups in ocean-based industries and decision-making processes, thereby informing policies that ensure a just transition, where economic opportunities are accessible to all and no one is left behind as the economy shifts towards sustainability.

- **Policy development and advising:** Academia can provide evidence-based insights to policymakers and industry leaders, helping shape regulations and frameworks that support a sustainable and equitable ocean economy (UN n.d.a). For example, this includes advising on labour rights and protections for workers in the blue economy. By guiding policy development, academic institutions ensure that workforce needs are considered in the governance of ocean resources.

- **Building global networks and collaborative initiatives**

  - **International collaboration for capacity building:** Academia and research institutions have long been pioneers, and must continue to lead, as global platforms of knowledge sharing, research and best practices for sustainable ocean management. Through partnerships with governments and international organisations, these institutions can

    - develop joint research programmes and international academic exchange initiatives;

    - share expertise on sustainable ocean governance and workforce development; and

    - promote knowledge transfer to developing countries, enabling their participation in the global sustainable ocean economy, thereby ensuring that workforce development is inclusive and benefits coastal communities worldwide (Ocean Tech Hub n.d.).

  - **Public awareness and advocacy:** Education institutions can engage in public awareness campaigns to inform society about the importance of the ocean economy and the need for sustainability. These efforts raise awareness among the workforce, encouraging individuals to pursue careers in ocean-related industries and contribute to the conservation of ocean ecosystems (Education Perfect 2024).

- **Addressing emerging challenges and opportunities**

  - **Research on emerging risks and trends:** As the ocean economy evolves, new risks related to climate change, overfishing and pollution continue to emerge. Collaboration between academic institutions and the private sector is essential to studying these risks and developing innovative solutions. For instance, academics can research to understand the impacts of plastic pollution or ocean acidification on fisheries, while private sector partners can provide real-world data and practical insights, helping to develop mitigation strategies that protect workers, industries and ecosystems (OECD 2016; Martínez-Vázquez et al. 2021). Similarly, research institutions can help prepare the workforce for future ocean industries, such as the development of marine carbon dioxide removal technologies. By identifying future trends and their potential impact on labour markets, academia ensures that the workforce is ready to capitalise on new opportunities sustainably and responsibly (Frost and Teleki 2020).

NEEDS

- **Funding for ocean-focused education and research:** Increased financial resources will enable academia to design and implement specialised programmes in sustainable ocean economy sectors such as marine conservation, renewable energy, aquaculture and oceanic data science (EIB 2025).

- **Capacity building for teachers and researchers:** Professional development opportunities must be enhanced for educators and researchers to keep pace with advancements in sustainable ocean practices and technologies (FMOE 2025).
- **Increased access to technology and infrastructure:** Academia requires modern infrastructure and technological tools, such as marine laboratories, research vessels, ocean monitoring systems and remote sensing technologies (Bauer 2021).
- **Enhanced collaboration with industry and government:** Stronger partnerships between academia, industries and governments will help align education and research with real-world workforce needs. Public-private partnerships, internships and joint research initiatives should be established to bridge the gap between theory and practice in the blue economy (NOAA 2023).
- **Inclusion of local and traditional knowledge**
  - Educational frameworks are needed that incorporate Indigenous and local knowledge about marine ecosystems and sustainable practices.
  - Academia should partner with coastal communities to include their traditional ecological knowledge in academic programmes and research efforts, ensuring relevance and inclusivity (Hiwasaki et al. 2024).
- **Global networking and knowledge sharing**
  - Academia should develop platforms and opportunities to share knowledge, research findings and best practices across borders and institutions.
  - Participation should be encouraged in international collaborations, such as joint research projects, conferences and academic exchange programmes focused on ocean sustainability.
- **Improved data collection and analysis**
  - Academia needs access to accurate, real-time data on marine ecosystems, blue economy activities and labour markets to guide education and workforce development.
  - Partnerships with governments, the private sector and IGOs will enable development of ocean observation systems and open-access databases that support evidence-based learning and research. This will enhance decision-making and curriculum design based on reliable, actionable insights (Greengrove et al. 2020).
- **Focus on social inclusion and equity**
  - Programmes should actively engage women, youth and underrepresented groups in ocean-related education and careers.
  - Academic institutions should provide scholarships, mentorship programmes and outreach initiatives to promote diversity and equity in the ocean workforce (The Ocean Foundation n.d.b).

BOX 7. Academia: World Maritime University blue economy leadership and training

Stakeholder: World Maritime University (WMU)
Sector: Traditional (maritime law, shipping) and emerging (ocean governance, marine renewable energy)
Country: Global

Located in Malmö, Sweden, and founded by the International Maritime Organization, WMU plays a leading role in preparing the next generation of ocean economy professionals through its Blue Economy and Maritime Governance programmes.

- **Blue economy leadership training:** WMU trains government officials, maritime professionals and policymakers on how to transition to a sustainable ocean economy.
- **Innovative ocean sectors:** The university has launched specialised programmes in offshore renewable energy, marine spatial planning and deep-sea mining governance.
- **Global reach:** WMU's graduates lead sustainability initiatives across developed and developing countries, ensuring knowledge transfer in ocean industries.

Societies and the general public

Societies and the public play a critical role in shaping and supporting the ocean economy. Their awareness, engagement and participation are essential for driving sustainable ocean practices, fostering innovation and ensuring that the benefits of the ocean economy are shared equitably. The roles and needs of societies and the general public are detailed below and summarised in Appendix C.

ROLES

- **Consumer awareness and demand**
  - **Informed choices:** Consumers can significantly influence the direction of the ocean economy by making informed choices about the products and services they purchase. By choosing sustainable seafood, marine products and tourism services, consumers can create a market demand for environmentally responsible practices. Consumers need easy access to information about the environmental impact of their choices. This can be through labelling, awareness campaigns and educational initiatives. It is important to encourage consumers to prioritise sustainability over convenience. This shift can be fostered through community programmes, social media campaigns and public endorsements by influential figures. At the same time, businesses must be transparent about their practices, allowing consumers to make truly informed decisions. This can include detailed product histories, sourcing information and environmental impact assessments.
  - **Support for certification programmes:** Endorsing certification programmes such as the Marine Stewardship Council, Aquaculture Stewardship Council and B Corp can help consumers identify sustainable products and services. This, in turn, can encourage businesses to adopt more sustainable practices to meet the rising demand for certified goods (Anderson et al. 2021). Certifications build consumer trust by providing third-party verification of sustainability claims, making it easier for consumers to make responsible choices.
- **Community engagement and participation**
  - **Local initiatives:** Communities can participate in local initiatives to protect marine ecosystems, reduce pollution and promote sustainable fishing practices (McBain 2023). Local events such as workshops, fairs and community activities focused on sustainable marine practices can engage communities directly and foster a collective commitment to the ocean economy.
  - **Interactive platforms:** Apps and online platforms can help consumers track the sustainability of their choices and connect them with eco-friendly options and vendors (Frost 2017; Bushman 2020).
  - **Citizen science:** Individuals can contribute to scientific research through citizen science projects, helping to gather data on marine ecosystems and biodiversity (Kobori et al. 2016).
- **Advocacy and policy influence**
  - **Public pressure:** The public can exert significant pressure on governments and businesses to adopt sustainable policies and practices (OECD 2024b) (Box 8).
  - **Support for NGOs:** The general public can support NGOs working to protect the ocean and promote a sustainable ocean economy. By supporting these organisations through donations, volunteering or advocacy, the public can help to amplify their impact (Crosman 2013).
- **Education and awareness**
  - **Awareness campaigns:** Public awareness campaigns, such as those developed by IGOs, governments or NGOs, play a key role in fostering a culture of environmental stewardship by highlighting the importance of marine conservation and sustainable practices.
  - **Youth engagement:** Engaging young people in ocean conservation and education can foster a new generation of ocean stewards. Youth can participate in educational programmes, volunteer for marine conservation organisations or conduct their own research projects (Fry et al. 2021).

NEEDS

- **Access to information**
  - **Reliable and accessible information**: Societies need easy and quick access to reliable information about the ocean economy, its benefits and the challenges it faces. This includes information on sustainable practices, marine resources and the role of the public in ocean conservation.
  - **Educational resources:** Governments, NGOs and educational institutions should develop and disseminate educational materials and resources on the ocean economy, tailored to different age groups and levels of understanding.
- **Education and training**
  - **Lifelong learning and skills development:** The general public needs opportunities for lifelong learning about ocean-related issues and opportunities. This includes formal education programmes, online courses and workshops on topics such as marine science, fisheries management, aquaculture, marine tourism, sustainable practices and the ocean economy's contribution to economic development.
- **Participation opportunities**
  - **Decision-making:** Societies need opportunities to participate in decision-making processes related to the ocean economy. This includes involvement in policy development, project planning and environmental impact assessments.
  - **Community-based initiatives:** Governments and NGOs should support community-based initiatives that allow local residents to contribute to ocean conservation and sustainable development.
- **Infrastructure and support**
  - **Investment in coastal communities:** Governments and businesses need to invest in infrastructure and support services that enable coastal communities to participate in the ocean economy. This includes improving access to transportation, communication and education.

BOX 8. Societies: Pacific Islands' blue economy and Indigenous knowledge integration

Stakeholder: Local coastal and Indigenous communities
Sector: Traditional (fisheries, tourism) and emerging (blue carbon, marine conservation))
Country: Small island developing states (Pacific islands: Fiji, Vanuatu, Solomon Islands)

Local societies in the Pacific islands are leading efforts to integrate Indigenous knowledge with modern blue economy strategies, ensuring that the workforce transition is both culturally inclusive and sustainable.

- **Community-driven marine conservation and ecotourism:** Coastal communities in Fiji and Vanuatu have developed marine protected areas managed by local fishers, blending traditional ocean stewardship (Tabu areas) with modern marine science.
- **Training the next generation:** Programmes like the Pacific Islands Forum's "Blue Pacific" initiative train local youth in marine conservation, climate adaptation and sustainable fisheries to ensure job retention in their home islands rather than migration abroad.
- **Blue carbon workforce:** In the Solomon Islands, communities are being trained in mangrove restoration and carbon credit projects, turning traditional conservation into income-generating blue economy jobs.

Opportunities for action

Short-term opportunities (1–3 years)

- **Advance ocean literacy and raise public awareness**
  - Implement campaigns to educate communities about the opportunities and benefits of sustainable employment in the blue economy.
  - Engage youth and marginalised groups in discussions about ocean-related careers.
- **Invest in blue skills and workforce development**
  - Launch training programmes for emerging blue economy sectors, such as renewable energy, sustainable aquaculture and ecotourism.
  - Create certification schemes for sustainable ocean-based industries.
- **Enhance public-private partnerships for job creation**
  - Foster collaborations between governments, private sector players and NGOs to fund and implement sustainable employment initiatives.
- **Develop inclusive policy and regulatory frameworks**
  - Establish and enforce workforce policies prioritising equity, inclusivity and sustainable practices in the blue economy while supporting the development of the skills and knowledge needed for the future workforce.
  - Integrate "just transition" principles into national and regional ocean governance.
- **Strengthen social protection for vulnerable workers**
  - Establish social safety nets to support workers displaced by the transition to sustainability, such as those shifting from oil drilling to offshore wind.
  - Promote fair wages, safe working conditions and job security in ocean-based industries.

Mid- to long-term opportunities (4+ years)

- **Accelerate digital transformation in ocean-based industries**
  - Expand digital infrastructure to enable remote work and technology-driven solutions for coastal and maritime communities.
  - Promote the adoption of smart technologies to improve productivity and reduce environmental impacts.
- **Promote sustainable financing and entrepreneurship**
  - Develop innovative financial mechanisms, such as blue bonds and impact investments, to fund sustainable employment initiatives.
  - Empower coastal entrepreneurs, especially women and youth, to create businesses in the blue economy.
- **Build workforce resilience to climate change**
  - Prepare workers for climate-related disruptions through adaptive skills training and capacity-building programmes.
  - Invest in technologies and practices that protect livelihoods in climate-vulnerable regions.
- **Champion gender equity and diversity in the workforce**
  - Ensure that women and underrepresented groups have access to leadership positions and skill-development programmes in the blue economy.
  - Incorporate gender equality metrics into workforce-development policies.
- **Foster global cooperation for equitable workforce development**
  - Encourage international agreements to share resources, knowledge and best practices for creating sustainable employment.
  - Collaborate on global strategies to reduce inequalities in access to ocean-related jobs and opportunities.

Appendix A: Delphi process methods, full ranking of drivers, and membership of Delphi Process Expert Group

Methodology

The Delphi process, also known as the Delphi method, is a robust tool for achieving expert consensus through structured, iterative rounds of questionnaires and controlled feedback (RAND Corporation n.d.). It crowdsources the collective intelligence of experts to address complex problems and forecast future scenarios. It was developed in the 1950s by Norman Dalkey and Olaf Helmer at the RAND Corporation (n.d.) to predict the impact of technology on warfare. It has been widely applied in various fields, including healthcare, business forecasting and public policy (Ludwig 1997; Barrett and Heale 2020; Nasa et al. 2021; Project Management Report 2024).

In a Delphi process, the experts' responses are kept anonymous to prevent dominant individuals' influence and encourage unbiased opinions. Specifically, this approach frees participants from personal biases, minimises the "bandwagon effect" or "halo effect," allows for free expression of opinions, encourages open critique and facilitates admitting errors when revising earlier judgements (von der Gracht 2012). It also dilutes the views of dominant personalities that may not represent the group as a whole. The expert participants in this study have remained anonymous, unless they chose to be revealed as participants (see Table A-4).

The Delphi method involves multiple rounds of questionnaires. After each round, the responses are aggregated, summarised and remarked upon by a facilitator, and this summary is shared back with the panel. Experts are then invited to revise their previous answers in light of the group's feedback. This invitation spurs experts to reconsider their views and move towards a consensus. The process continues until a predefined stopping criterion is met, such as a specific number of rounds, achievement of consensus, or stability of results (Barrett and Heale 2020). The outcome is typically a consensus view or forecast based on the aggregated responses of the experts.

In this Blue Paper, relevant experts were identified and selected by polling the author team and Ocean Panel Secretariat for suggestions. They nominated experts based on their knowledge of and experience in the subject matter. We also drew upon the Ocean Panel Expert Group and Advisory Network. Emphasis was also placed on achieving geographical, sectoral and other diversity criteria (Tables A-1, A-2, A-3).

Our invited panel included 414 experts (51.2 percent male, 48.8 percent female), with composition by sphere, sector and geography, as detailed in Tables A-1, A-3, A-3. Of this invited panel, 183 individuals (46.5 percent male, 53.5 percent female) participated in at least one round of the Delphi process (Tables A-1, A-2, A-3). While there is no standard size for a Delphi panel, it typically ranges from 10 to 50 participants (Akins et al. 2005; Nasa et al. 2021). A larger initial panel can help mitigate the

TABLE A-1. **Composition of the invited and participating Delphi Process Expert Panel by continent**

CONTINENT	INVITED PANEL % COMPOSITION	PARTICIPATING PANEL % COMPOSITION
Europe	35.3	40.2
North America	22.3	22.3
Asia	14.2	9.5
Oceania	11.8	8.9
Africa	7.8	13.4
South America	3.5	4.5
Central America + Caribbean	3.5	0.0
Middle East	1.7	1.1

Source: Blue Paper authors and Expert Panel.

impact of potential dropouts (Shang 2023). It also can help to remove or minimise irrelevant or extraneous information (considered "noise") from a dataset. We also noted that a Delphi study, with its focus on experts rather than a statistical population sampling, offers a unique approach that we believe is crucial for our research. If, instead, we were to seek to survey a statistically significant sampling of the populations across eight continents, it would be nearly impossible because we would have needed a gigantic sample size, perhaps thousands of respondents, to achieve statistical power. We seek to reach a qualitative, not statistical, consensus

TABLE A-2. **Composition of the invited and participating Delphi Process Expert Panel by field**

FIELD	INVITED PANEL % COMPOSITION	PARTICIPATING PANEL % COMPOSITION
Business	29.8	15.2
Academia	20.2	27.5
Government	18.4	12.9
NGO	16.3	19.7
IGO	7.5	6.71
Consultancy	6.0	13.5
Foundation	1.8	4.5

Source: Blue Paper authors and Expert Panel.

TABLE A-3. **Composition of the invited and participating Delphi Process Expert Panel by subject expertise**

FIELD	INVITED PANEL % COMPOSITION	PARTICIPATING PANEL % COMPOSITION
Marine policy	15.0	9.4
Shipping	15.0	7.4
Economics	13.4	20.1
Finance	12.1	10.1
Blue food	11.5	17.4
Environmental protection and conservation	10.2	11.4
Tourism	6.1	4.7
Technology	5.1	4.7
Energy	5.1	4.7
Climate	3.2	2.7
Human health	2.2	5.4
Law	1.0	2.0

Source: Blue Paper authors and Expert Panel.

among experts on the complex and uncertain issues about workforce forecasts for the future rather than describe the characteristics of a larger population (Nasa et al. 2021).

During Round 1 of the Delphi process, a Likert scale was used to score the power of influence of each driver listed by the authors. Experts were also called upon to contribute additional drivers to be listed. The survey of the power of each driver's influence was repeated for the short term (through 2030) and the longer term (through 2050). The survey questions used in Round 1 are available on request (contact author Oliver S. Ashford).

In Round 2, all responses provided in Round 1 were anonymised, aggregated and summarised. This information was shared with the Expert Panel members as a summary of those experts' opinions to encourage further observation, considering all expert participants' replies. Based on the first-round information, this round ranked the drivers from most to least important and called for the Expert Panel to consider reordering them in light of the consolidated opinion from Round 1. The survey questions used in Round 2 are available on request (contact author Oliver S. Ashford).

In Round 3, experts discussed "What to Expect." The Expert Panel was asked for their views on how each of the identified drivers will cause change in employment in key ocean economy sectors. Specifically, we asked how each driver could influence decision-makers towards a more sustainable ocean economy, how each driver will change employment quantitatively (trade-offs / job losses versus gains) and what can be expected for the magnitude and pace of change in employment. The survey questions used in Round 3 are available on request (contact author Oliver S. Ashford).

In Round 4, experts were invited to focus on the top seven sectors identified as being most frequently impacted by the key drivers identified in Rounds 1 and 2. All responses provided in Round 3 were anonymised as a summary of experts' forecasts and reshared to encourage further observation in light of all expert participants' replies. The survey questions used in Round 4 are available on request (contact author Oliver S. Ashford). Analysis of responses received during Round 4 was aided by use of generative AI, Claude 3.5 Sonnet. The outputs of this were read, then compared to the original data for accuracy, omission or loss of meaning.

Key factors driving employment changes

During the first and second rounds of the Delphi process, the Expert Panel was asked what may drive change in the sustainable ocean economy and affect employment, with the aim of identifying consensus on a ranking of the relative importance of these drivers. A full ranking of these drivers is provided below for 2030 and for 2050.

Key drivers to 2030:

1. Climate change
2. Investment and access to finance
3. Adoption of sustainable practices by industry, government or consumers (can be regulatory—through international or national policy—or voluntary)
4. Emerging and innovative industry sectors (such as marine biotechnology, offshore renewable energy, or robotics and automation)
5. Changing demand for ocean-based goods and services
6. Changing demand for energy
7. Changing demand for sustainability and regeneration (in all sectors, including tourism)
8. Increases in scientific understanding of the ocean (including environmental health / human health relationships)
9. Projected economic growth
10. Political instability and geopolitical disputes
11. Digitalisation
12. Artificial intelligence
13. Population growth and changing age structure
14. Population migration
15. Trade volume growth
16. Labour shortages
17. Overexploitation of resources (including fisheries)
18. Change in availability of terrestrial resources (e.g. oil and gas, freshwater and food)
19. Approach to collaboration between organisations and across sectors (including public/private collaboration and data sharing)
20. Development of the circular economy
21. Pollution (e.g. noise, light, chemical, plastics
22. Marine habitat loss
23. Changes in trade patterns
24. Education, upskilling and ocean literacy
25. Urbanisation
26. Just transition and equity
27. Occurrence of global pandemics

Key drivers to 2050:

1. Climate change
2. Adoption of sustainable practices by industry, government or consumers (can be regulatory—through international or national policy—or voluntary)
3. Emerging and innovative industry sectors (such as marine biotechnology, offshore renewable energy, or robotics and automation)
4. Investment and access to finance
5. Changing demand for ocean-based goods and services
6. Changing demand for sustainability and regeneration (in all sectors, including tourism)

7. Changing demand for energy
8. Artificial intelligence
9. Increases in scientific understanding of the ocean (including environmental health / human health relationships)
10. Digitalisation
11. Projected economic growth
12. Population growth and changing age structure
13. Population migration
14. Political instability and geopolitical disputes
15. Change in availability of terrestrial resources (e.g. oil and gas, freshwater and food)
16. Overexploitation of resources (including fisheries)
17. Trade volume growth
18. Labour shortages
19. Development of the circular economy
20. Approach to collaboration between organisations and across sectors (including public/private collaboration and data sharing)
21. Marine habitat loss
22. Changes in trade patterns
23. Education, upskilling and ocean literacy
24. Pollution (e.g. noise, light, chemical, plastics)
25. Urbanisation
26. Just transition and equity
27. Occurrence of global pandemics

Participation in Delphi Process Expert Group

Table A-4 lists all individuals who contributed to the Delphi process for this Blue Paper and gave permission to have their name and affiliation listed.

TABLE A-4. **Membership of Delphi Process Expert Group**

NAME	POSITION AND AFFILIATION
Ms Abby Frank	Associate Vice President, ESG Engagement Analyst—Rockefeller Asset Management
Mr Adam Pool	Adviser—Woods Hole Oceanographic Institute
Miss Adelle Lukes Isechal	Applied Scientist—Palau Government
Mr Adria Jover	President—International Electric Marine Association
Mr Ahmad Alfawaz	Development and Training Manager—Aqaba Company for Operation & Management (Aqaba Port)
Ms Aimee Gonzales	Executive Director—PEMSEA
Ms Aleksandra Dragozet	CEO—Sea Going Green
Mr Alessandro Pititto	Director—Cogea
Mr Alexis Grosskopf	CEO—OceanHub Africa
Ms Alyssa DeFalco	ESG Engagement Analyst—Rockefeller Asset Management
Ms Ana Verónica Garcia Condo	Consultant—Oceanogami
Ms Anastasia Kouvertari	Project Manager—Lloyd's Register
Mr Andreas Merkl	CEO—Centigrade
Mr Andy Hamflett	Co-founder and Director—NLA International
Dr Angel Borja	Principal Investigator—AZTI Foundation

NAME	POSITION AND AFFILIATION
Mr Anil Devli	CEO—Indian National Shipowners' Association
Dr Annika Frosch	Research Fellow—University College London
Mr Aomar Bourhim	Consultant expert on blue economy and maritime spatial planning—Maritime safety and environment protection
Mr Arturo Incerti	Policy Officer—European Commission
Ms Asmaa Benslimane	WIMA Morocco President—WIMA AFRICA
Professor Ayodeji Olukoju	Distinguished Professor of History (Maritime)—University of Lagos
Professor Bruce Maycock	Special Envoy Planetary Health—Asia Pacific Academic Consortium of Public Health (APACPH)
Professor Bruce Prideaux	Professor—Prince of Songkla University, Phuket, Thailand
Miss Celia Murcia	Founder and CEO—Blue-jobs
Dr Chris Wilcox	Principal—Wilco Analytics
Dr Christine Ward-Paige	CEO, Founder—eOceans
Mr Claes Berglund	Director Public Affairs & Sustainability—Stena
Ms Claire Huang	Biologist—NOAA
Mrs Claire Jolly	Head Ocean Economy Programme—OECD
Ms Cynthia Barzuna	Director, Ocean Action 2030—World Resources Institute
Mr David Carter	CEO—Austral Fisheries
Dr David Koweek	Chief Scientist—Ocean Visions
Dr Dennis Fritsch	Nature finance adviser—Minderoo Foundation
Ms Diana Rico	Junior researcher—Euro-Mediterranean University
Dr Divaldo Rezende	CEO—Social Carbon Foundation
Ms Dominique Benzaken	Consultant and researcher—Australian National Centre for Ocean Resources and Security
Mr Duncan Copeland	Co-founder—Free Range Ocean
Professor Elena Ojea	Research professor—University of Vigo
Ms Elisabetta Bonotto	Project Coordinator, International Partnership for Blue Carbon—Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization
Mr Erik Giercksky	Head, Ocean—UNGC
Ms Erika Harms	Global Director of Sustainability—Iberostar Group
Ms Farah Obaidullah	Founder and Director—The Ocean and Us
Dr Felicia Mogo	President/Founder—African Marine Environment Sustainability Initiative (AFMESI)
Dr Felix Addo-Yobo	Deputy Director, SDG Unit—National Development Planning Commission
Professor Finn Gunnar Nielsen	Professor emeritus, University of Bergen

NAME	POSITION AND AFFILIATION
Ms Flavia Rolli	Technologist, Project Manager, Responsible for capacity building and skills development—National Institute of Oceanography and Applied Geophysics—OGS
Dr Francisca Delgado	General Director, Vice President—INIPM-WIMAFRICA
Mr François Mosnier	Head of Ocean team—Planet Tracker
Dr Frank Agyire-Tettey	Senior Lecturer—Ghanaian Government
Mr Frédérick Herpers	CEO—Stratégies Mer et Littoral
Dr Freya Higgins-Desbiolles	Adjunct Senior Lecturer—University of South Australia
Ms Gabriella Gonthier	Senior Monitoring and Evaluation Officer—Department of Blue Economy, Seychelles Government
Dr Gakushi Ishimura	Associate Professor—Iwate University
Dr Georgie Sowman	GP—National Health Service
Mr Gesling Chee	Fisheries Trade Policy Coordinator—University of Papua New Guinea
Ms Gina Casas	Veterinarian—Instituto Tecnológico de la Producción
Ms Hanh Nguyen	Ocean Industries Lead—World Economic Forum
Ms Heba Sami	Head division—ACPOM
Ms Hind Allam	Electronic programmes planning specialist—NORMAL
Mr Hooman Farnejad	Lecturer
Dr Ibon Galarraga	Research professor—Basque Centre for Climate Change (BC3)
Ms Isabel Powell	Community Engagement Specialist—World Economic Forum
Dr Itziar Ruiz-Gauna	Senior Consultant and Environmental Economist—Metroeconomica S.L.
Mr Ivar Engan	Group VP Public Affairs—Kongsberg Group ASA
Honorable James L. Connaughton	Chair—Nautilus Data Technologies
Dr Jan Przydatek	Director of Technologies—Lloyd's Register Foundation
Dr Jean-Baptiste Jouffray	Postdoctoral Fellow—Stanford University
Mr Jean-Paul Adam	Director, Special Adviser on Africa Affairs—United Nations Economic Commission for Africa
Dr Jeff Ardron	Africa Oceans Director—The Nature Conservancy
Ms Jessie Turner	Director—International Alliance to Combat Ocean Acidification
Dr Jimena Rodriguez	DP World
Ms Joan Fulton	Senior Adviser—Ocean Assets Institute
Dr John Virdin	Assistant Professor of the Practice—Duke University Nicholas School of the Environment
Dr Jonathan Spiteri	Senior Lecturer—University of Malta
Mr Joost Pellis	Head of Human Capital—ECHT regie in transitie
Dr Karen Alexander	Assistant Professor Marine Governance and Blue Economy—Heriot-Watt University

NAME	POSITION AND AFFILIATION
Miss Karina Higa	Blue economy consultant—ECOP Programme
Mrs Kelly Hoarea	Research Scholar—University of Tasmania (IMAS) and University of Seychelles (Blue Economy Research Institute)
Dr Khanssa Lagdami	ITF Seafarers Trust Associate Professor of maritime labour law and policy—World Maritime University
Ms Kimberley Kerr	Senior Consultant, Sustainability and Workforce—Education Development Center
Dr Kristine Grimsrud	Senior researcher—Statistics Norway
Ms Laura Bugden	Governance consultant—BGS
Dr Laura Friedrich	Researcher—Norwegian Institute for Water Research
Ms Leila Ben Hassen	CEO—Blue Jay Communication
Ms Linda Etta	Senior Blue Economy Adviser—African Union
Dr Linda Nøstbakken	Statistics Norway
Professor Lisa Levin	Professor Emerita—Scripps Institution of Oceanography
Professor Lora E. Fleming	Emerita Professor—European Centre for Environment and Human Health, University of Exeter Medical School
Ms Lori Kennedy	Co-founder/owner—Sea Food
Dr Lota Creencia	Professor—Western Philippines University
Dr Lucy Woodall	Associate Professor—University of Exeter
Professor Marcel Jaspars	Professor of Chemistry—University of Aberdeen
Ms Maren Hjorth Bauer	CEO—Fynd Invest
Ms Margaret Spring	Chief Conservation and Science Officer—Monterey Bay Aquarium
Professor Marie Antonette Juinio-Meñez	Professor—University of the Philippines Marine Science Institute
Ms Marie-Céline Piednoir	Head of communications—Coral Gardeners
Mr Maris Stulgis	Policy officer Blue Bioeconomy, Algae and Aquaculture—European Commission
Ms Marisa Drew	Chief Sustainability Officer—Standard Chartered Bank
Mr Mark Michelin	Director—CEA Consulting
Mr Martin Exel	Managing Director—SeaBOS
Mr Martin Purves	Managing Director—International Pole & Line Foundation
Dr Martina Gaglioti	Marine expert and educator—IUCN CEC/CCC
Dr Marty Matlock	Professor of Ecological Engineering—University of Arkansas
Ms Melanie Sany	Director Youth, Climate, and Workforce Development—Education Development Center
Dr Melissa Walsh	Head of Nature Finance—Minderoo Foundation
Professor Michael Fabinyi	Professor—University of Technology Sydney

NAME	POSITION AND AFFILIATION
Dr Miguel Ángel Cisneros-Mata	Senior researcher—Mexican Institute for Sustainable Fisheries and Aquaculture
Dr Miguel Marques	CEO—Skipper & Wool
Dr Milena Novy-Marx	Sustainability International Technical Adviser, Visiting Professor of Sustainable Development—Education Development Center and University of Rochester
Ms Minna Epps	Global Ocean Director—International Union for Conservation of Nature
Ms Monica Rojas	Aquaculture Deputy Director—SERNAPESCA
Dr Nallamuthu Godhantaraman	Academic consultant
Ambassador Nancy Karigithu	Maritime and Blue Economy Special Envoy—Office of the President of Kenya
Dr Nathalie Hilmi	Section head environmental economics—Centre Scientifique de Monaco
Mrs Nazli Selek	Senior partner—NSN Law Firm
Mr Nicolas Occhiminuti	President—Waves of Change
Professor Niels Vestergaard	Professor—University of Southern Denmark
Mr Øistein Jensen	Chief Sustainability Officer—Odfjell SE
Mr Olivier Raybaud	Managing Director—SWEN Blue Ocean
Ms Oritsematosan Edodo-Emore	Partner—O. Edodo, Thorpe & Associates
Ms Patricia Huerta Rodríguez	Investigador Asociado C—Área de Protección de Flora y Fauna Laguna de Términos Comisión Nacional de Áreas Naturales Protegidas
Dr Patricia Martí Puig	CEO and Founder—Oceanogami
Dr Paul Sandifer	Director, Center for Coastal Environmental and Human Health—College of Charleston
Dr Peter Schuhmann	Professor—University of North Carolina Wilmington
Professor Philip J. Landrigan	Director, Program for Global Public Health and the Common Good—Boston College
Ms Priscila Petruy	Maintenance Supervisor, Arauco Brazil
Ms Rennie Meyers	Global Ocean Policy Lead, Global Engagement & Thought Leadership, Global Stakeholder Relations—Ørsted
Mr Ross Brooks	General Partner—Katapult Ocean
Mr Sam Selig	Investments—Katapult Ocean
Mr Sam Teicher	Co-founder and Chief Reef Officer—Coral Vita
Dr Samantha Petersen de Villiers	Southwest Indian Ocean Regional Programme Leader—WWF SWIO
Dr Samir Bachouche	Researcher—CNRDPA
Dr Sana Taktak	President—Association of Continuity of Generations (ACG)
Dr Sara Purca	Researcher—Instituto del Mar del Perú (IMARPE)
Ms Sevtap Ozdogan	Project Manager—IMO
Mr Shaun Mann	Senior Tourism Specialist—World Bank

NAME	POSITION AND AFFILIATION
Dr K. Shobha	Director—Nextstep Logistics Management Pvt Ltd
Dr Shreya Some	Postdoctoral Researcher—Technical University of Denmark
Mrs Simone Smith-Godfrey	Chief Researcher—South African International Maritime Institute
Dr Stamatina Rassia	Owner—Le.D.R.A. Group
Mr Stewart Sarkozy	Managing Director, World Ocean Council (WOC), and Co-founder, Okhtapus
Ms Suha Nedhal	Chartering and Logistics Officer—Arab Women in Maritime Association (AWIMA)
Dr Swayamprabha Das	AVP and Lead Policy and Planning—Development Alternatives
Dr Tania Tzelnic	Youth and Workforce International Technical Adviser—Education Development Center
Ms Tess Geers	Research Director—Oceana
Mr Thijs Wullems	CEO—Monkeys by the Sea
Dr Tim Slingsby	Director of Skills and Education—Lloyd's Register Foundation
Mr Tom Bowling	CEO—GenerOcean
Mr Torsten Thiele	Executive Director—Global Ocean Trust
Professor Tracey Sutton	Professor—Guy Harvey Oceanographic Research Center, Nova Southeastern University
Ms Tracy Rouleau	President—TBD Economics, LLC
Dr Uchenna Emenyonu	Founder/Director—Centre for Blue Economy Research and Development Nigeria Ltd/Gte
Ms Ulsía Urrea Mariño	Graduate Research Assistant—Texas A&M University–Corpus Christi
Ms Vera Noon	Founder—ArchiMare consulting
Ms Vicky Maki Honda	Program Director—The Nippon Foundation
Ms Vigdis Hvaal	Director of Communication—HUB Ocean
Ms Violet Williams	President—Maritime
Ms Wangari Theuri	Senior Program Manager, BlueBiz–TechnoServe
Dr Watcharapong Chumchuen	Fishery Biologist—Department of Fisheries, Thailand
Professor William Gerwick	Distinguished Professor—University of California San Diego (Scripps Institution of Oceanography)
Mr Wouter Schalken	Senior Sustainable Tourism Specialist—Asian Development Bank
Mr Yrhen Bernard Balinis	Seafarer—Office of the Youth in Maritime (YIMO)
Dr Zainal Arifin	Research Professor / Principal Researcher—National Research and Innovation Agency (Indonesia)
Dr Zainal Arifin	Research Professor / Principal Researcher—National Research and Innovation Agency (Indonesia)

Source: Blue Paper authors and Expert Panel.

Appendix B: Changing employment opportunities in a sustainable ocean economy: Additional sectors

Marine biotechnology

Marine biotechnology is a rapidly growing field that leverages the unique properties of marine organisms for various applications, including pharmaceuticals, food, cosmetics and environmental remediation (Fleming et al. 2024). The global marine biotechnology market is projected to reach $10.5 billion by 2027, with a compound annual growth rate of 15 percent from 2022 to 2027 (GVR n.d.). As the sector expands, it presents a wealth of untapped employment opportunities.

Employment opportunities

- **Research scientists:** Marine biologists, biochemists and molecular biologists are essential for conducting research and development in marine biotechnology. Bioinformatics specialists and data scientists are becoming increasingly important as the sector leverages big data for genomic research and environmental monitoring (Indeed n.d.).
- **Bioprocess engineers:** Engineers with expertise in biotechnology and process engineering are needed to scale up laboratory discoveries for commercial production (Indeed n.d.).
- **Quality control specialists:** Ensuring the quality and safety of marine-derived products requires skilled quality control professionals.
- **Regulatory affairs specialists:** Navigating complex regulatory frameworks is crucial for commercialising marine biotechnology products.
- **Business development and marketing:** Professionals with expertise in business development and marketing are needed to promote marine biotechnology products and services (Mordor Intelligence 2023).
- **Environmental consultants:** Experts in environmental science and sustainability are required to assess the environmental impact of marine biotechnology activities (Allied Market Research 2023).

Challenges

- **Regulatory hurdles:** Navigating complex regulatory frameworks, designed to ensure human safety, can be challenging for marine biotechnology companies (Collins et al. 2020; Rotter et al. 2021).
- **Sustainability concerns:** Ensuring sustainable sourcing of marine resources and minimising environmental impacts is crucial. The sector must address the overharvesting of marine resources and the potential ecological impacts of marine bioprospecting. Marine protected areas and sustainable harvesting practices are essential strategies to mitigate these concerns (Rampelotto and Trincone 2018; Daniotti and Re 2021).
- **Genetic and biological complexity:** Marine organisms possess unique and complex genetic makeups that are not fully understood. This complexity can hinder efforts to manipulate these organisms for biotechnological applications. For instance, many marine species have intricate biochemical pathways that produce valuable compounds, but understanding and replicating these pathways in a lab setting is challenging (Gov and Arga 2014). Advances in genomics and systems biology are helping to address these issues, but there is still a long way to go (Eren and Delmont 2024).
- **Technological limitations:** Exploring and exploiting marine resources require advanced technologies, such as deep-sea exploration tools, sophisticated bioreactors and high-throughput screening methods. These technologies are often expensive and require specialised expertise to operate and maintain. Moreover, the development of new technologies to access and utilise marine resources is a continuous process that demands significant investment and innovation (Rampelotto and Trincone 2018).
- **Commercialisation pathways:** Bridging the gap between discovery and commercial application involves several hurdles, including scaling up production processes, ensuring product stability and efficacy, and navigating market entry barriers. Many promising marine biotechnological discoveries fail to reach the market due to difficulties in scaling up from laboratory to industrial production (Daniotti and Re 2021). Additionally, the commercialisation process requires significant investment and a clear understanding of market demands and regulatory requirements (Blasiak et al. 2023).

Regional trends

- **Asia-Pacific dominance:** The Asia-Pacific region is the largest market for marine biotechnology, accounting for 40 percent of the global market share. Japan, China and South Korea have made substantial investments in marine biotechnology, focusing on pharmaceuticals and environmental remediation (Precedence Research 2024).
- **Europe:** Europe is a leader in marine biotechnology, with a strong focus on sustainable development and innovation. The region has established networks and collaborations to advance marine biotechnology, leveraging its rich marine biodiversity. Key areas of research include the development of bioactive compounds, bioremediation and the use of marine organisms in pharmaceuticals and cosmetics (Rotter et al. 2020). Untapped opportunities lie in exploring deep-sea resources and enhancing biotechnological applications in aquaculture and fisheries (Rotter et al. 2021).
- **Americas:** In North America, marine biotechnology is focused on the sustainable use of marine resources and the development of new bioproducts. The United States and Canada are leaders in marine genomics and the discovery of novel bioactive compounds (Rotter et al. 2021). Latin America, with its rich marine biodiversity, offers untapped opportunities in bioprospecting and the development of marine-derived products (Theuerkauf et al. 2019). Key areas of growth include marine biomedicine, biofuels and environmental biotechnology.
- **Africa:** Africa's marine biotechnology sector is still emerging, with significant potential for growth. The region's rich marine biodiversity offers opportunities for bioprospecting and the development of new bioproducts. Key areas of focus include the sustainable use of marine resources, bioremediation and the development of marine-derived pharmaceuticals. Investments in research and development, as well as capacity building, are crucial for unlocking the region's potential (Rotter et al. 2021).

Ocean data and monitoring

Ocean data and monitoring play a crucial role in understanding the health of our ocean and informing sustainable management practices. By collecting and analysing data on factors such as temperature, salinity, currents, biodiversity and pollution, scientists and policymakers can make informed decisions to protect marine ecosystems and promote sustainable resource use (Leape et al. 2020; UNESCO 2023).

Employment opportunities

- **Marine scientists and researchers:** Scientists specialising in oceanography, marine biology and related fields are essential for collecting, analysing and interpreting ocean data (UNEP n.d.c).

FACTS AND FIGURES

- Investment in marine biotechnology research and development has been on the rise, with $1.2 billion allocated globally in 2021 (IMBA n.d.).
- The global marine biotechnology market is estimated to have reached $9.5 billion in 2024, with a projected growth rate of 12 percent per year (GVR n.d.).
- Research and development: Investment in marine biotechnology research and development has increased significantly, with $1.2 billion allocated globally in 2024 (IMBA n.d.).
- The sector is expected to create 50,000 new jobs worldwide by 2030 (OECD 2016). These jobs will likely be concentrated in research hubs and regions with strong biotech industries (OECD 2016).

- **Ocean data science and big data analytics:** Ocean data scientists, geographic information system specialists, AI and machine learning experts, and cloud computing engineers will be required to collect and analyse vast amounts of ocean data to improve marine resource management, predict ocean behaviour and mitigate climate change effects (Hoddenbach and Ervin 2024).
- **Technology developers:** Engineers and technicians are required to develop innovative technologies for ocean data collection, monitoring and analysis (ESA 2022).
- **Policy analysts and advisers:** Experts in marine policy and governance are needed to translate scientific findings into effective policies and regulations (Kaiser et al. 2019).
- **Environmental consultants:** Consultants with expertise in marine ecosystems and environmental impact assessment can provide valuable insights to decision-makers.

Challenges

- **Data integration:** One challenge is integrating data from diverse sources and formats into cohesive, actionable insights. Improved data interoperability and standardisation can address this issue.
- **Funding and resources:** Ensuring sustained funding for ocean data initiatives and maintaining up-to-date technologies are crucial for ongoing progress.

- **Public engagement:** Increasing public awareness and engagement in ocean data collection can lead to broader support for marine conservation initiatives (Kelly et al. 2022).

Regional trends

- **North America and Europe:** These regions lead in ocean data collection and monitoring due to their advanced technological infrastructure and research institutions. Programmes such as the European Space Agency's Copernicus Marine Environment Monitoring Service and the US Integrated Ocean Observing System are key contributors (Copernicus n.d.; NOAA n.d.b).
- **Asia-Pacific:** Rapid development in this region is driven by countries such as China and Japan, which invest heavily in ocean monitoring technologies and data analytics to support their extensive maritime activities.
- **Africa:** Africa's ocean data and monitoring capabilities are still developing, with significant opportunities for growth. The region's vast and diverse marine environments require improved data collection and monitoring systems to support sustainable development. Key areas of focus include enhancing coastal and marine observation networks, improving data accessibility and building local capacity for data analysis and interpretation. Investments in technology and infrastructure are crucial for realising these opportunities (von Schuckmann et al. 2024).

FACTS AND FIGURES

- Global investment: Investment in ocean data and monitoring technologies has increased significantly in recent years, reaching $2.5 billion globally in 2024. Investments are often directed towards enhancing data collection and infrastructure, developing new technologies and expanding research capabilities (World Bank Group n.d.a).
- Data volume: The volume of ocean data collected has grown exponentially, with 200 petabytes of data generated annually. These data come from a variety of sources, including satellite observations, buoys, autonomous vehicles and research vessels (European Commission 2024b).
- Technological advancements: Advances in satellite remote sensing, autonomous underwater vehicles and oceanographic sensors have revolutionised data collection capabilities.
- Job growth: The ocean data and monitoring sector has experienced a surge in employment, with 10,000 new jobs created in the past five years (IOC n.d.).

Desalination and water management

With growing water scarcity and increasing demand for freshwater, desalination and water management have become critical areas of focus.

Desalination, the process of removing salt from seawater or brackish water, can provide a reliable source of freshwater, while effective water management practices can help conserve and optimise existing water resources.

Employment opportunities

- **Desalination engineers and technicians:** Experts in desalination technology and plant design and operation are essential for the development and management of desalination facilities (IDRA 2022).
- **Water resource managers:** Professionals responsible for planning, managing and conserving water resources are needed at local, regional and national levels. They work on projects related to water allocation, conservation planning and drought management. They also collaborate with other stakeholders to ensure equitable and efficient water distribution (Dyck 1990).
- **Environmental scientists:** Experts in environmental science and hydrology are needed to assess water quality, monitor water resources and develop sustainable water management strategies. Their work includes monitoring water quality, providing certifications, studying hydrological cycles and evaluating the environmental effects of brine discharge (UNEP n.d.b).
- **Policy analysts and advisers:** Experts in water policy and governance are required to develop and implement effective water management policies and regulations. They analyse data, craft regulations and work with governmental and non-governmental organisations to implement effective water policies (World Bank Group n.d.b).
- **Community outreach specialists:** Professionals are needed to engage with communities to promote water conservation and education. They play a key role in educating the public on water conservation and sustainable practices, developing educational programmes, leading awareness campaigns and fostering community engagement in water management efforts (WaterAid n.d.).

Challenges

- **Energy consumption:** Desalination is an energy-intensive process, requiring significant energy inputs, primarily due to the need to pressurise water for reverse osmosis or heat water for distillation. Research into renewable energy sources and more efficient technologies is crucial for reducing the carbon footprint of desalination processes (Walton 2019).

- **Environmental impacts:** The environmental impacts of desalination, such as brine discharge and energy consumption, need to be carefully considered, as they can harm marine environments by increasing salinity and affecting local marine life. Innovations such as zero-liquid discharge systems and improved brine management practices aim to mitigate these environmental impacts (Lamizana 2019).
- **Water conservation:** Promoting water conservation and efficiency is essential for reducing the demand for desalination (WRI 2024).

Regional trends

- **Middle East and North Africa:** The MENA region, characterised by its arid climate and limited freshwater resources, has a strong dependence on desalination. Countries like Saudi Arabia and the United Arab Amirates have made significant investments in desalination infrastructure and technological development (Abdelraouf 2024).
- **Asia-Pacific:** Rapid urbanisation and population growth in countries like China and India have driven a surge in demand for freshwater, making desalination a viable solution (Dhakal et al. 2022). Investments in new desalination projects and research into energy-efficient technologies are increasing in this region (Energy Recovery 2024).
- **Europe:** European countries are exploring desalination as part of broader water management strategies, particularly in areas facing droughts or where freshwater resources are under pressure (EU n.d.).
- **Americas:** The United States and Canada are investing in advanced desalination technologies and water-reuse systems. Latin America, particularly in coastal areas, has opportunities to expand desalination capacity to support growing urban populations and industries. Enhancing public-private partnerships and leveraging technological advancements can drive further growth in this sector (Fortune Business Insights 2025).

FACTS AND FIGURES

- Global desalination capacity: The global desalination capacity has increased significantly in recent years, reaching 60 million cubic meters per day in 2024 (IDRA n.d.).
- Investment in desalination: Investment in desalination projects has grown steadily, with $10 billion invested globally in 2024. This investment supports the development of new technologies, expansion of existing facilities and improvement of energy efficiency (Global Water Intel n.d.).
- Water scarcity: In 2024, 3.6 billion people faced water scarcity, highlighting the urgent need for both desalination and effective water management. This scarcity affects various regions, particularly those with arid climates or high population densities (World Bank Group n.d.b).
- Energy efficiency improvements: Desalination technology has become more energy-efficient, with a 20–30 percent reduction in energy consumption compared to a decade ago (IDRA n.d.).

Innovative financing

Access to innovative finance is one of the key drivers of change in the sustainable ocean economy, as identified by the Delphi Process Expert Group. It can help to address the economic, technological, environmental and social challenges of transitioning to a more sustainable, inclusive and equitable economy.

Employment opportunities

- **Blue economy investment strategists:** These strategists develop and implement investment strategies focusing on the ocean economy, particularly in one sector, such as renewable energy or marine research and innovation, identifying opportunities and evaluating risks. Strategists will work closely with financial institutions to create portfolios that align with environmental, social and governance (ESG) criteria. The role requires a deep understanding of the sustainable ocean economy, marine ecosystems, ESG principles and financial markets (Morgan Stanley 2023).
- **Marine ecosystem valuation analysts:** Analysts specialise in quantifying the economic value of marine ecosystems, including services such as carbon sequestration, coastal protection and biodiversity. This role requires expertise in environmental valuation techniques to be able to support the development of financial instruments such as blue bonds and ecosystem service credits (Austen et al. 2019).
- **Ocean impact fund managers:** This role requires expertise in impact investing, fund management, and a deep understanding of environmental science and marine ecosystems to be able to assess the sustainability and profitability of the projects, with a focus on the long-term impacts on the ocean environment (Ocean 14 Capital n.d.).
- **Sustainable blue bond advisers:** Professionals in this area are involved in structuring, issuing and managing blue bonds, which are debt instruments specifically designed to fund ocean-related projects like marine conservation, sustainable fisheries and coastal restoration. They need skills and expertise in capital markets expertise, bond structuring, legal and regulatory knowledge, and familiarity with environmental finance (Thoday et al. 2023).
- **Blue tech venture capitalists:** Venture capitalists focusing on ocean technology invest in start-ups that are developing innovative solutions for the sustainable use of ocean resources, such as clean energy, waste management and sustainable seafood production. The skills required for this role are venture capital, technology assessment, start-up incubation and sector-specific knowledge of marine industries (Katapult n.d.; SeaAhead n.d.).

- **Ocean carbon credit brokers:** These brokers facilitate the trading of carbon credits derived from ocean-based carbon sequestration projects, such as mangrove restoration or kelp farming (Schindler Murray et al. 2023). Brokers connect buyers and sellers, helping to price and verify credits (JP Morgan Chase & Co. 2023).
- **Marine insurance innovators:** These professionals develop new insurance products that address the unique risks faced by marine industries, such as climate-related losses or biodiversity impacts. These could include insurance linked to environmental outcomes or parametric insurance for ocean events. This role requires knowledge of insurance, environmental risk assessment and oceanography (Crawford 2023).
- **Data analysts and environmental economists:** Data analysts and environmental economists work on quantifying the economic value of ocean resources and the financial impacts of environmental degradation. They provide data-driven insights that guide investment decisions and policy development in the ocean economy (OECD 2016).
- **Ocean resilience risk managers:** These workers assess and manage risks related to climate change, overfishing and other environmental challenges in ocean-related industries. They help companies and investors develop strategies to mitigate these risks (ORRAA n.d.).
- **Just transition ocean finance specialists:** These specialists focus on ensuring that the financial mechanisms supporting the transition to a sustainable ocean economy are equitable. This includes developing financial products that support vulnerable communities and ecosystems and advising on policies that promote social inclusion. This role requires knowledge and expertise in ocean policy and regulations, social finance and inclusive development (III n.d.).
- **Blue economy regulatory advisers:** These advisers have expertise in international maritime law, regulatory affairs and ocean governance. They guide financial institutions, insurance policies and companies in navigating the complex regulatory landscape related to the ocean economy, ensuring compliance with international, regional and national regulations while promoting sustainable practices (UNECA 2016; EU 2022).
- **Training and capacity-building specialists:** These professionals design and implement training programmes aimed at building the capacity of individuals and institutions involved in the sustainable ocean economy. They have skills in education, training, innovative finance, oceanography and environmental landscapes (World Bank Group 2023).

Challenges

- **High-risk perception:** Investments in the ocean economy are often perceived as high-risk compared to land-based investments. They also tend to have longer gestation periods and may require patient capital. Convincing investors and stakeholders to commit to these projects demands not just financial expertise but also strong communication and negotiation skills (OECD 2016).
- **Defining impact metrics:** Unlike traditional financial sectors, the sustainable ocean economy places a strong emphasis on environmental, social and governance factors. Professionals need to develop and implement robust systems for measuring non-financial impacts, such as biodiversity gains or carbon sequestration (Janulis 2022).
- **Lack of investable projects:** There is a scarcity of high-quality, investable projects that meet the risk-return profiles required by investors (Sumaila et al. 2021).
- **Regulatory and policy barriers:** Inconsistent or weak regulatory frameworks can hinder the development and implementation of innovative financial solutions (Fletcher et al. 2021).
- **Skill gaps:** Specialised skills in blue finance are limited (IFC 2022). Existing workforce development programmes often do not cover the niche technicalities needed to structure innovative financial solutions for sustainable ocean projects. Innovative finance often requires scalable solutions, such as ocean-based carbon sequestration or marine energy projects. This requires knowledge of finance, technology and marine environmental ecosystems.
- **Collaboration and coordination:** Effective collaboration between various ocean stakeholders and financial institutions is often lacking. It requires a workforce that is not only technically skilled but also adept at navigating complex geopolitical and legal environments.
- **Lack of digital infrastructure:** Many regions, especially coastal communities, lack the digital infrastructure needed for access to information, awareness of the importance of a sustainable ocean economy, data collection, monitoring and reporting (Stevens et al. 2021).

Addressing these challenges requires ongoing investment in workforce development, education and cross-sector collaboration to align finance, science and sustainability goals for a thriving ocean economy.

Regional trends

Regional trends will be influenced by factors such as access to capital, regulatory environments, educational infrastructure and proximity to marine resources.

- **Europe:** The European Union's Green Deal emphasises the importance of the blue economy (European Commission 2025c). The European Union is expected to increase funding for sustainable ocean projects, including renewable marine energy (offshore wind and tidal energy). Europe is leading in the development and issuance of blue bonds, especially in Nordic countries, to finance marine conservation and sustainable projects (Muchira n.d.). EU funding programmes such as Horizon Europe finance ocean research and support marine-sustainable practices (European Commission 2025b).

- **North America:** The United States and Canada are seeing an increase in venture capital investments in ocean tech start-ups, focusing on innovations like marine carbon dioxide removal, sustainable seafood alternatives and marine biotech. Employment opportunities are emerging in R&D, start-up management and impact investing (ISED Canada 2019). With increasing consumer demand for sustainable seafood, there is a push towards developing and financing sustainable fisheries and aquaculture practices, particularly in Canada and coastal US states (SeaChoice 2009).
- **Latin America and the Caribbean:** With its rich marine ecosystems, Latin America is focusing on marine conservation through innovative financing mechanisms such as blue bonds and debt-for-nature swaps. This creates jobs in environmental finance and project management. Regions such as the Caribbean are experiencing a trend towards community-based financing for small-scale fisheries and coastal protection projects, providing employment in local project coordination and finance (Conservation Finance Alliance 2021). Sustainable marine tourism is a key sector, with financing directed towards eco-friendly tourism infrastructure, particularly in countries such as Costa Rica and Belize. This is generating employment in tourism management, environmental consultancy and finance (Northrop et al. 2022).
- **Africa:** In Africa, innovative financing is increasingly focused on sustainable fisheries, given the reliance on marine resources for food security. Employment opportunities are growing in sustainable fisheries management, supply chain innovation and finance. Countries such as Kenya and South Africa are advancing their blue economy strategies, focusing on sectors including maritime transport, renewable ocean energy and marine biotechnology, creating jobs in policy development, environmental engineering and finance (AU-IBAR 2019).
- **Middle East:** The Middle East, particularly the Gulf states, is investing in sustainable marine infrastructure and shipping, with a focus on reducing the environmental impact of oil- and gas-related maritime activities. This trend is creating jobs in environmental compliance, engineering and finance. Given the arid environment, there is a focus on financing sustainable desalination technologies and creating employment opportunities in engineering, project finance and environmental science. There is growing interest in marine conservation, particularly in the Red Sea region, where innovative financing is being directed towards protecting coral reefs and promoting sustainable tourism (Pradeep 2023; Walker 2023).
- **Asia-Pacific:** Asia-Pacific, with its vast coastlines and significant marine biodiversity, is focusing on blue economy investments. Countries such as Indonesia, the Philippines and India are prioritising sustainable fisheries, aquaculture and marine tourism. The region is increasingly leveraging technological innovations like AI and blockchain for sustainable fisheries management and financing, which could create employment opportunities in tech-driven roles (ADB 2022).

FACTS AND FIGURES

- UN Sustainable Development Goal (SDG) 14 (Life below Water) receives the least long-term funding of any of the SDGs. Reports suggest that $175 billion per year is needed to achieve SDG 14 by 2030 (WEF 2022). Yet, between 2015 and 2019, global investments in ocean sustainability and related economic activities amounted to under $10 billion (WEF 2022).
- By 2030: Employment in sustainable financing within the ocean economy could number in the hundreds of thousands globally (WOI 2020).
- By 2050: Employment could reach into the millions, reflecting the growing importance of sustainability in the global economy and the expanding scope of the ocean economy (Konar and Ding 2020).

Ocean literacy

In a just transition to a sustainable ocean economy, ocean literacy is a vital tool for empowering individuals, communities and industries. It ensures that people have the knowledge and skills needed to engage in sustainable ocean-based activities, helps to create equitable economic opportunities and promotes environmental stewardship. Ultimately, ocean literacy supports the development of an inclusive, resilient and sustainable ocean economy where social equity, environmental health and economic prosperity are in balance.

Employment opportunities

- **Ocean literacy policy advocates:** These professionals advocate for policies that integrate ocean literacy into national education systems and ocean economy strategies. This requires cooperation with governments and international organisations to ensure that ocean literacy is recognised as essential to the sustainable management of marine resources (NMEA n.d.).
- **Ocean literacy content creators for blue economy vocational training:** These creators develop vocational training materials and programmes that combine practical blue economy skills with ocean literacy concepts to promote sustainability. Trainers need to collaborate with vocational schools, the private sector and governments to create courses that integrate sustainable practices into training for jobs such as fishing, boat building and tourism.

- **Ocean literacy for climate change resilience trainers:** Literacy professionals train coastal communities on the importance of ocean ecosystems in climate change resilience (e.g. mangroves, coral reefs) and how to protect and restore these systems to adapt to climate impacts. This requires tight collaboration between governments and NGOs to provide training on community-based adaptation strategies, nature-based solutions and sustainable livelihoods that help protect marine ecosystems.
- **Indigenous ocean knowledge facilitators:** Facilitators work with Indigenous communities to document and integrate traditional knowledge into formal ocean literacy programmes and make sure Indigenous knowledge on ocean cultural heritage is included in the ocean economy transition. This will create partnerships between Indigenous communities, governments and educational institutions to ensure that traditional ecological knowledge is recognised and valued in ocean literacy efforts (Strand et al. 2024).
- **Digital ocean literacy platform developers:** With the increase in online learning there is a need for more online developers for the various digital platforms helping the public, students and professionals access information and learning about ocean ecosystems, marine technologies and all the opportunities in the ocean economy. Digital platforms will expand access to ocean literacy education globally, especially for those in remote or underserved areas, and support lifelong learning about ocean sustainability (Kelly et al. 2022).
- **Marine media and communications specialists:** Communication experts require detailed knowledge about the ocean to be able to create and manage content (e.g. documentaries, social media, journalism), raise global awareness of ocean issues and drive behaviour change towards sustainable consumption and environmental protection.
- **Community ocean ambassadors:** These ambassadors serve as a bridge between ocean experts, local communities and stakeholders, helping to raise awareness of ocean sustainability issues and opportunities within the ocean economy. Ambassadors can connect coastal communities to ocean economy job training and resources (The Ocean Foundation n.d.b).
- **Citizen science programme managers:** These professionals develop and lead citizen science initiatives that engage the public in ocean monitoring, data collection and conservation. The programmes help people learn about the ocean while contributing to scientific research. This requires collaboration with universities, research institutes and NGOs, as well as managing volunteer programmes and outreach (Ocean Wise n.d.).

Challenges

- **Lack of public awareness and interest:** Despite its importance, many people are not aware of ocean literacy as a distinct field of study or career path. It is often overshadowed by other environmental concerns, such as climate change and renewable energy, which receive more public attention (Fielding et al. 2019).
- **Lack of funds and resources:** Limited funding can restrict initiative programmes and job opportunities. Many ocean literacy initiatives rely on government, NGO or private sector funding. However, these areas are often underfunded compared to other environmental or education programmes (Payne and Marrero 2021; Lewis et al. 2023).
- **Lack of interdisciplinary skills:** There is an increased need for professionals who have different skills in marine science, communication, education and stakeholder engagement (von Hellfeld et al. 2024).
- **Inconsistent policy support:** Governments may not prioritise ocean literacy in their environmental or educational policies, and policy frameworks for promoting ocean literacy vary widely from country to country (IOC 2021).
- **Geographic disparities in opportunities:** Ocean literacy initiatives tend to be concentrated in coastal regions or countries with strong marine industries. Inland and landlocked regions may not prioritise ocean literacy, leading to fewer local opportunities for employment (Paredes-Coral et al. 2021).

Regional trends

Employment trends will reflect the growing awareness of the ocean's importance in mitigating climate change, ensuring sustainable development and promoting economic equity within the ocean economy. This will vary regionally, based on factors such as geographical location, economic development and political priorities.

- **Europe:** *EU Blue Economy Strategy*—The European Union's blue economy initiatives will lead to an increase in ocean literacy jobs, particularly in education, policy development and sustainability consultancy. Coastal countries like Portugal, Spain and Norway (not an EU Member State) will see the largest growth in marine-based education and citizen engagement programmes (European Commission 2025c). *Marine renewable energy*—Northern Europe, especially the United Kingdom and the Netherlands, will see employment opportunities in ocean literacy related to offshore wind farms and tidal energy projects. Education on sustainable practices and environmental stewardship will be integrated into vocational training for renewable energy jobs (CEDEFOP 2024).

- **North America:** *Education outreach*—In the United States and Canada, there is a strong focus on integrating ocean literacy into both formal and informal education systems (NOAA 2024b). *Blue economy*—Coastal states like California and Alaska, and provinces like British Columbia, will invest in ocean literacy to support their growing blue economies, particularly in renewable energy (offshore wind and tidal energy) and sustainable fisheries (Berendzen 2021).
- **Africa:** *Community-based outreach*—Ocean literacy roles will grow in coastal communities, focusing on local knowledge integration, capacity building and sustainable economic activities such as ecotourism and small-scale aquaculture (IOC-UNESCO 2023). *Sustainable fisheries and marine biodiversity*—Coastal nations, such as Senegal, Kenya and South Africa, will need ocean literacy professionals to support sustainable fisheries practices and marine conservation. Employment will focus on educating fishers and coastal communities about the importance of marine biodiversity (Hendriks 2022).
- **Latin America and the Caribbean:** *Climate migration and resilience*—By 2050, as climate-induced migration affects coastal populations, ocean literacy professionals will play a key role in helping communities adapt to new coastal environments, focusing on sustainable resource use and ocean ecosystem protection. *Renewable energy*—Brazil and other Latin American countries investing in offshore wind and marine renewable energy will see increased employment in ocean literacy roles related to environmental assessments and community education about the blue economy.
- **Asia-Pacific:** *Climate resilience and adaptation*—Coastal areas facing rising sea levels and extreme weather events will require professionals in ocean literacy who can train local communities in adaptation strategies and nature-based solutions, such as mangrove restoration and coral reef conservation. *Indigenous knowledge and ocean governance*—In the Pacific Islands, ocean literacy programmes will increasingly integrate Indigenous knowledge to support sustainable ocean governance, leading to new employment opportunities in education and policy advocacy.

FACTS AND FIGURES

- In 2025, 70 percent of UN Member States are expected to have a national ocean literacy strategy and integrate ocean literacy into the curriculum and education policies of formal education systems (Freitas et al. 2022).
- In 2025, governmental representatives and officials are expected to possess the knowledge, capacity, skills and commitment to incorporate ocean sustainability into local, national and regional policies (IOC 2021).
- The e-learning market is expected to grow by 20.5 percent by 2030.The global e-learning market size was valued at $235.5 billion in 2022 and is expected to grow to $648.6 billion by 2030, with a compound annual growth rate of approximately 13.5 percent over the forecast period 2023–30 (Beyond Market Insights 2024).

Appendix C: Summary table of ocean stakeholders' roles and needs to support a just transition to a sustainable ocean economy

STAKEHOLDER	TIMESCALE	ROLES	NEEDS
National governments	Short term	**Policy development and regulation** —Develop and enforce sustainable ocean policies and clear legal frameworks.	**Policy development and regulation** —Align policies with international standards for sustainability and safeguard social equity.
		Workforce reskilling and education —Launch training programmes for skills in renewable energy, aquaculture and biotechnology.	**Workforce reskilling and education** —Ensure accessible technical and digital training for new technologies like artificial intelligence (AI) and satellite monitoring.
		Financial support and tax incentives —Provide funding programmes (e.g. retraining grants, low-interest loans).	**Financial support and tax incentives** —Offer tax incentives to businesses adopting sustainable practices and penalise polluters.
		Stakeholder engagement and awareness —Engage stakeholders (e.g. communities, industries) in inclusive decision-making.	**Stakeholder engagement and awareness** —Launch public awareness campaigns to promote opportunities in sustainable ocean economies.
		Environmental protection —Expand marine protected areas (MPAs) and support biodiversity conservation.	**Environmental protection** —Implement measures to reduce pollution and align with global biodiversity targets.
	Medium term	**Partnerships and international collaboration** —Strengthen international agreements (e.g. UN Sustainable Development Goal [SDG] 14, regional fisheries management organisations).	**Partnerships and international collaboration** —Promote public-private partnerships to fund and innovate sustainable marine solutions.
		Investment in sustainable infrastructure —Develop green infrastructure (e.g. low-emission ports, renewable energy installations).	**Investment in sustainable infrastructure** —Build digital infrastructure for data collection, online learning platforms and upskilling.
		Support for research and innovation —Fund research and development for low-emission shipping, sustainable fisheries and ocean restoration.	**Support for research and innovation** —Foster innovation hubs and incentivise ocean-based start-ups.
		Climate adaptation and mitigation —Adopt low-carbon technologies and create resilient coastal communities.	**Climate adaptation and mitigation** —Ensure that ocean economy activities align with climate adaptation and mitigation goals.

STAKEHOLDER	TIMESCALE	ROLES	NEEDS
	Long term	**Economic diversification** —Reduce reliance on unsustainable industries like overfishing and oil drilling.	**Economic diversification** —Foster new sustainable sectors like renewable energy, marine biotechnology and ecotourism.
		Strong environmental regulations and enforcement	**Strong environmental regulations and enforcement**
		Social safety nets and labour rights —Establish unemployment benefits, reskilling services and job placement programmes.	**Social safety nets and labour rights** —Ensure equitable treatment and enforcement of fair labour standards in the ocean economy workforce.
Intergovernmental organisations	Short term	**Strengthened global frameworks and standards** —Develop and enforce international standards for sustainable resource management, maritime regulations and pollution control. —Promote Sustainable Development Goal 14 (Life below Water) and align policies with global sustainability goals.	**Global cooperation and multilateral agreements** —Strengthen multilateral agreements that support sustainable ocean economies and just workforce transitions.
		Mobilisation of financial support and partnerships —Provide funding mechanisms (e.g. World Bank, Global Ocean Alliance) to support sustainable projects, especially in developing countries. —Facilitate partnerships to finance workforce development and sustainable ocean-related initiatives.	**Data sharing and transparency** —Create open data-sharing systems on marine resources, industries and labour markets to support informed decision-making.
		Capacity building and knowledge transfer —Launch training and education programmes to equip vulnerable communities with skills for sustainable practices. —Promote knowledge-sharing through workshops, webinars and events to amplify global reach.	
		Monitoring and accountability —Establish mechanisms to monitor global adherence to sustainability goals and ensure compliance with international agreements.	
		Promotion of equity and inclusivity —Ensure fair treatment and representation of vulnerable populations, such as small-scale fishers and coastal communities, in decision-making processes.	

STAKEHOLDER	TIMESCALE	ROLES	NEEDS
	Medium term	**Alignment with existing initiatives** —Strengthen partnerships with ongoing initiatives (e.g. UNESCO Ocean Decade Challenges) to harmonise efforts. —Collaborate to scale successful models for capacity-building and marine conservation programmes.	**Inclusive decision-making** —Engage marginalised groups, such as women, Indigenous communities and small-scale fishers, in decision-making processes.
	Long term	**Funding of innovation and research** —Support research into emerging sustainable ocean industries (e.g. marine biotechnology, blue carbon) and technologies. —Promote innovation hubs and technological advancements in sustainable ocean practices.	
		Enhanced enforcement mechanisms —Develop stronger compliance systems to enforce international agreements and address non-compliance effectively.	
Private sector	Short term	**Leadership in corporate sustainability** —Adopt sustainable supply chain practices to minimise environmental harm. —Increase transparency and reporting through sustainability initiatives.	**Access to finance and green investment** —Provide funding mechanisms (e.g. green bonds, blue bonds, impact investing) for sustainability projects.
		Capacity building —Establish reskilling programmes to transition workers from unsustainable industries to ocean-friendly roles.	**Training and workforce development** —Invest in reskilling and upskilling for sustainable ocean industries.
			Collaboration with education —Partner with academic institutions to create aligned curricula and training programmes.
	Medium term	**Investing in sustainable industries** —Develop and deploy sustainable technologies like renewable energy and eco-friendly shipping.	**Infrastructure development** —Invest in renewable energy platforms, green ports and modern aquaculture systems.
		Social responsibility and inclusivity —Ensure fair labour practices, diversity and inclusion in the ocean workforce. —Support small-scale fishers and Indigenous communities through equitable profit-sharing and participation in decision-making.	**Digitalisation** —Adopt advanced technologies such as AI and data analytics for ocean resource management.
			Circular economy models —Collaborate on policies incentivising waste reduction and recycling in ocean industries.

STAKEHOLDER	TIMESCALE	ROLES	NEEDS
			Global partnerships —Foster international and multi-stakeholder collaborations for sustainable ocean governance.
	Long term	**Advocacy and policy support** —Advocate for and comply with regulations on marine protection, pollution control and sustainable resource use.	**Policy advocacy** —Promote stronger ocean governance and align with international agreements like SDG 14.
		Conservation and restoration —Invest in marine conservation, biodiversity protection and habitat restoration initiatives.	**Research and innovation** —Collaborate with governments and academia to develop cutting-edge solutions for sustainability.
		Global networking —Engage in cross-sector partnerships and collaborative platforms for shared learning and sustainable practices.	**Funding for conservation** —Support marine spatial planning, habitat restoration (e.g. mangroves, coral reefs) and MPAs.
			Transparency and accountability —Adopt robust environmental, social and governance (ESG) reporting frameworks to track environmental and social impacts.
Non-governmental organisations (NGOs)	Short term	**Advocacy and policy development** —Advocate for sustainable ocean practices and equitable access to marine resources. —Influence policies that prioritise workforce development in the ocean economy.	**Funding and financial resources** —Secure grants, donations and private partnerships to sustain programmes.
		Education and capacity building —Launch community outreach to raise awareness about sustainable ocean practices and opportunities. —Offer training programmes for reskilling and upskilling in ocean economy careers.	**Educational tools** —Develop training materials, online courses and resources for workshops and skill-building.
			Community engagement resources —Organise workshops, participatory planning and meetings to engage local stakeholders.
	Medium term	**Research an innovation** —Collect and analyse marine ecosystem data to support policies and sustainable practices. —Partner with innovation hubs to foster sustainable technologies and solutions.	**Research tools** —Invest in monitoring tools, data analysis software and platforms for sharing information.
		Sustainable practices and certification —Promote certification programmes for sustainable fisheries, aquaculture and tourism.	**Technical expertise** —Build access to marine science professionals and technology experts for programme design.

STAKEHOLDER	TIMESCALE	ROLES	NEEDS
			Collaboration with networks —Engage with global networks to share knowledge and develop scalable solutions.
			Public-private partnerships —Collaborate with governments, businesses and academia for sustainable initiatives.
	Long term	**Partnerships and collaboration** —Build international networks to share best practices and foster global cooperation.	**Long-term funding** —Establish diversified, sustainable funding mechanisms for ongoing projects.
		Education and youth engagement —Engage youth through educational programmes and career opportunities in the ocean economy.	**Sustainability standards** —Support the development of global standards and certification systems.
		Ocean governance and restoration —Contribute to marine conservation and restoration efforts through pilot projects and community initiatives.	**Advanced training** —Facilitate internships, mentorships and hands-on training for long-term workforce growth.
			Innovation hubs —Partner with or create hubs to develop and test innovative technologies and sustainable models
			Policy influence —Advocate for international agreements that promote sustainable and equitable ocean governance.
Financial institutions	**Short term**	**Financing sustainable ocean industries** —Provide loans, investments and affordable credit for sustainable fisheries, aquaculture and ecotourism. —Support blue finance initiatives such as green and blue bonds for sustainable projects.	**Collaborative platforms** —Partner with universities and research institutions to identify emerging opportunities.
		Enabling small and local businesses —Provide microloans and inclusive finance models for small and medium-sized enterprises and underserved communities.	**Regulatory clarity** —Advocate for clear, stable policies supporting sustainable ocean investments.
			Standardisation —Develop or adopt certifications defining sustainable ocean economy projects.
			Incentives —Governments to offer tax breaks and subsidies for green and blue financial products.

STAKEHOLDER	TIMESCALE	ROLES	NEEDS
			Public awareness —Educate investors on blue economy opportunities and benefits of green and blue bonds.
	Medium term	**Promoting green and blue bonds** —Issue blue bonds for projects like ocean pollution reduction and marine ecosystem restoration.	**Market demand** —Cultivate investor interest in sustainable bonds through education and awareness campaigns.
		Supporting workforce development —Fund education, internships and scholarships in marine-related fields.	**Risk management tools** —Develop tools for assessing long-term risks (e.g. sea-level rise, climate impacts).
			Technical expertise —Collaborate with experts to design and fund training in marine sciences and new technologies.
			Insurance products —Provide tailored insurance for sustainable industries, supporting resilience and innovation.
	Long term	**Incorporating ESG criteria** —Integrate ESG standards into lending and investment processes, focusing on biodiversity and net-zero goals.	**Data accessibility** —Ensure access to standardised ESG metrics for ocean investments to guide sustainable decisions.
		Collaborating with governments and organisations —Co-finance large-scale sustainability projects through public-private partnerships.	**Public-private partnerships** —Foster platforms for collaboration between governments, NGOs and the private sector.
			Global guidelines —Co-develop global standards for sustainable investments and ensure equitable outcomes.
			Innovation hubs —Partner with institutions to develop new marine technologies and sustainable business models.
Academia	**Short term**	**Workforce development** —Develop curricula for emerging ocean industries to meet evolving job market demands. —Launch short-term certifications in marine technology, ocean data science and conservation practices. —Offer vocational training and upskilling programmes for displaced or transitioning workers.	**Funding and resources** —Increase financial support for specialised education and research programmes. —Provide scholarships, mentorships and outreach for diverse and underrepresented groups.

STAKEHOLDER	TIMESCALE	ROLES	NEEDS
		Research on emerging challenges —Conduct research on climate impacts, overfishing and pollution. —Propose mitigation strategies for risks like ocean acidification and plastic pollution.	**Capacity building** —Train educators and researchers in the latest sustainable ocean practices and technologies.
			Collaboration with industry —Create public-private partnerships for real-world application of knowledge. —Enhance partnerships to ensure that academic programmes align with industry needs.
	Medium term	**Innovation and collaboration** —Establish innovation hubs and incubators to support ocean-based entrepreneurship. —Collaborate with industry to advance marine engineering, renewable energy and waste-reduction technologies.	**Inclusion of local knowledge** —Integrate Indigenous and traditional ecological knowledge into education.
		Interdisciplinary research —Lead studies integrating science, economics and policy for holistic ocean sustainability solutions. —Provide evidence-based insights for policymaking, labour rights and equitable governance.	**Global networking** —Promote cross-border knowledge-sharing platforms and academic exchange programmes.
			Data infrastructure —Develop robust data systems for ocean ecosystems and workforce trends.
	Long term	**Global networks and advocacy** —Build global platforms for capacity building and sharing sustainable practices. —Advocate for public awareness of ocean sustainability and workforce opportunities.	**Technological modernisation** —Invest in infrastructure like research vessels, ocean monitoring systems, etc.
		Sustainable ocean solutions —Advance marine science and technology research in renewable energy, aquaculture and marine biotechnology. —Address emerging opportunities like marine carbon dioxide removal technologies.	**Focus on equity** —Ensure inclusivity in education and research by involving women, youth and marginalised groups.
Societies and the general public	**Short term**	**Consumer awareness and demand** —Choose sustainable seafood, marine products, and ecotourism to drive demand for responsible practices.	**Access to information** —Provide reliable, accessible data about sustainable choices through labels, campaigns and educational materials.

STAKEHOLDER	TIMESCALE	ROLES	NEEDS
		Community engagement and participation —Engage in local initiatives to reduce pollution and promote sustainable marine practices.	**Certification programmes** —Promote awareness and use of certifications like those by the Marine Stewardship Council and the Aquaculture Stewardship Council to encourage sustainable practices.
		Education and awareness —Promote youth engagement in ocean conservation and education.	**Interactive tools** —Develop apps and platforms for tracking sustainable choices and connecting with eco-friendly vendors.
			Citizen science —Encourage participation in data collection for marine research and biodiversity studies.
			Awareness campaigns —Launch campaigns emphasising marine conservation and sustainable practices.
	Medium term	**Advocacy and policy influence** —Apply public pressure on governments and businesses to adopt sustainable practices.	**Support for NGOs** —Encourage donations, volunteering and advocacy to amplify NGO efforts.
			Education and training —Offer lifelong-learning opportunities on ocean-related topics like marine science and sustainable tourism.
			Community-based initiatives —Develop local conservation projects, workshops and fairs to foster collective commitment.
	Long term	**Education and awareness expansion** —Build a culture of environmental stewardship through targeted education and outreach.	**Youth programmes** —Invest in long-term educational programmes to foster future ocean stewards.
			Participation in decision-making —Create platforms for public input on policy, project planning and environmental assessments.
			Coastal investment —Governments and businesses should enhance infrastructure and services for coastal communities to participate in the ocean economy.

Source: Blue Paper authors.

Note: Roles and needs are categorised into short (immediate priorities), medium (2–5 years) and long term (beyond 5 years).

Appendix D: Challenges Ocean Panel members may encounter when undertaking research on employment in the sustainable ocean economy

Writing a Blue Paper on "The Future Workforce for a Just Transition in the Sustainable Ocean Economy" presents significant challenges, given the paper's intended impact on policy, economic development and workforce readiness across a range of ocean-based sectors. The paper must navigate these challenges to produce a comprehensive, actionable document that resonates with high-level policymakers, industry leaders and other key stakeholders. Below are some of the primary challenges we faced in developing this Blue Paper:

Defining complex and interdependent concepts

Defining foundational concepts like "just transition," "sustainability" and "blue economy" is challenging because of the need to address both environmental and socioeconomic dimensions. The paper must carefully balance environmental sustainability goals with the socioeconomic imperatives of job creation, fair labour practices and community resilience. Ensuring clarity and specificity is crucial so that all stakeholders share a common understanding of these terms.

Lack of standardised data and consistent metrics

Reliable, up-to-date data on workforce demographics, skills gaps and employment trends across the wide range of formal and informal workforce distribution in traditional and emerging ocean sectors are often lacking, with significant variability in data collection standards and practices between countries and industries. This inconsistency complicates efforts to establish a baseline understanding of workforce dynamics, making it difficult to identify gaps and recommend targeted interventions. The absence of unified metrics hinders the creation of precise, evidence-based recommendations.

Engaging a diverse range of stakeholders

During the Delphi process, which consists of four survey phases, engaging stakeholders from various sectors and regions—particularly government officials and private sector leaders—proved challenging. Each group brings unique insights and priorities for the future workforce in a sustainable ocean economy, but gathering comprehensive perspectives requires sustained outreach and collaboration. Ensuring representation from all relevant stakeholders across different regions is essential to creating a holistic and inclusive blueprint for workforce development.

Balancing technical rigour with accessibility

Communicating the intricacies of the sustainable ocean economy to a wide audience—including policymakers, industry representatives, community leaders and the general public—requires careful language choices. Editors must distil complex technical information into clear, accessible language without compromising the accuracy or depth of the content. This balance ensures that the paper remains both authoritative and understandable, facilitating broader buy-in and action.

Developing practical, actionable recommendations

High-level policy recommendations are valuable, but they can sometimes lack the specificity required for implementation. It is challenging to bridge the gap between strategic goals and measurable, practical steps that stakeholders can feasibly enact. To maximise the paper's impact, editors need to translate broad objectives into actionable policies and programmes that stakeholders can implement and monitor effectively.

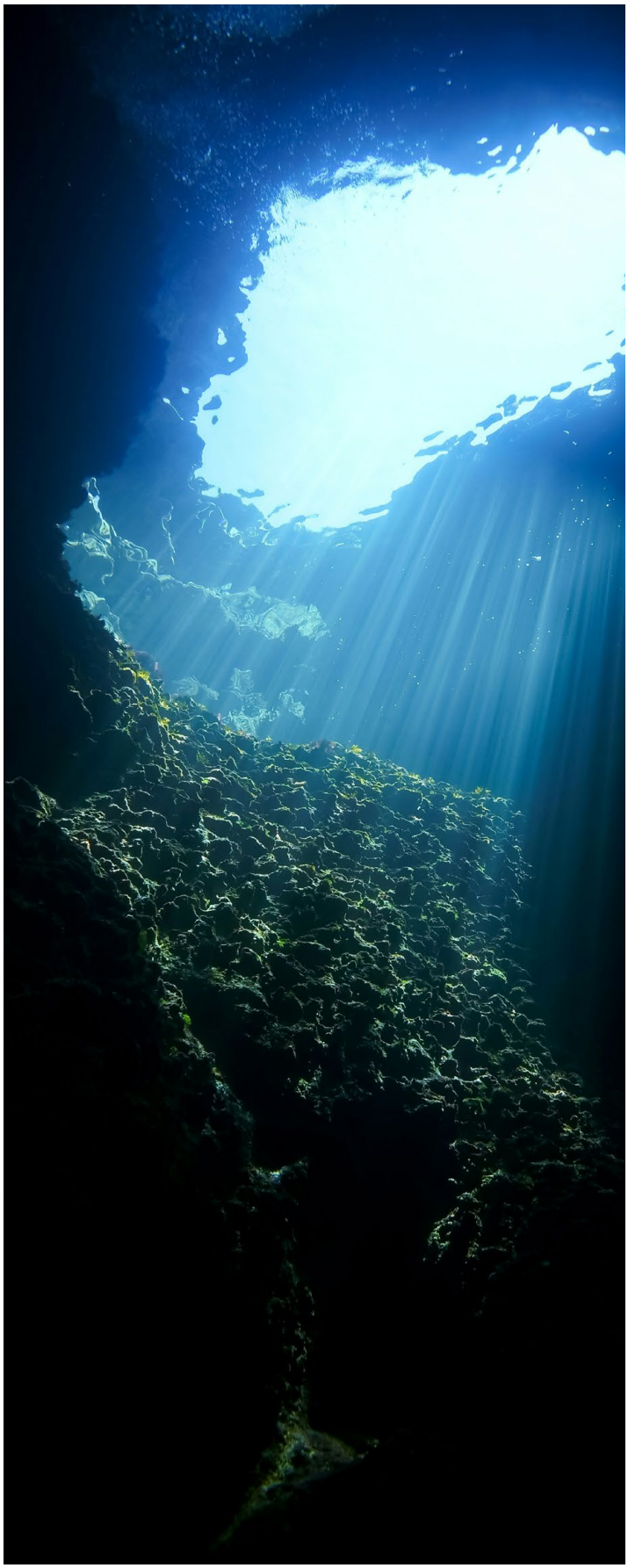
Balancing global strategies with local realities

The paper must offer globally relevant strategies while also addressing local variations, especially in regions with fewer resources and differing regulatory environments. Aligning global recommendations with local contexts, particularly in developing countries, is essential for fostering inclusive, sustainable growth that meets both local and international needs. This dual focus ensures that the paper supports equitable progress across diverse economic and social landscapes.

Navigating uncertainty in future workforce needs

The rapid evolution of ocean sectors, such as marine renewable energy and marine biotechnology, introduces uncertainty into forecasting exact workforce requirements. Editors must account for both current workforce skills and potential future demands, while also considering technological advancements, climate change impacts and shifting economic priorities. This requires a forward-looking yet adaptable approach to workforce planning.

By effectively addressing these challenges, this Blue Paper serves as a strategic and influential resource, empowering stakeholders to build a resilient, skilled and equitable workforce capable of advancing a sustainable ocean economy. This Blue Paper also lays the foundation for an evolving series of reports, offering periodic updates to data, insights and strategic guidance. Each edition will build on the previous one, refining the vision and practical framework necessary to foster a workforce that is not only inclusive and skilled but also adaptable to the dynamic and transformative needs of a sustainable, regenerative ocean economy. Through this iterative approach, the series can continue to be a vital tool for navigating future shifts and ensuring that the ocean economy's growth remains socially and environmentally responsible.



Key definitions and glossary

- *Blue economy*: According to the World Bank, the blue economy is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of the ocean ecosystem" (World Bank Group 2017).
- *Blue growth* tends to focus more specifically on the growth and development of marine and maritime sectors. It emphasises the potential to develop a national strategy for growth, innovation and job creation within the ocean economy (whether it be the sustainable blue economy or other aspects). In practice, as seen in the European Union, blue growth can be seen as a strategy or approach to achieving a sustainable blue economy (Guerreiro 2021).
- *Climate justice* is the principle that the benefits reaped from activities that cause climate change and the burdens of climate change impacts should be distributed fairly. Climate justice means that countries that became wealthy through unrestricted carbon emissions have the greatest responsibility not only to stop warming the planet but also to help other countries adapt to climate change and develop economically with non-polluting technologies (Arcaya and Gribkoff 2022).
- *Environmental justice* is the "fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. This goal will be achieved when everyone enjoys: The same degree of protection from environmental and health hazards; and equal access to the decision-making process to have a healthy environment in which to live, learn, and work" (US EPA n.d.).
- *Just transition*: A just transition incorporates inclusion and fairness. According to the Maritime Just Transition Taskforce, "A Just Transition is a people-centred response to addressing the climate emergency. . . . This means greening the economy in a way that is as fair and inclusive as possible, creating decent work opportunities" (UNGC n.d.a). According to the Just Transition Alliance (n.d.), a "Just Transition is a principle, a process, and a practice. The principle of just transition is that a healthy economy and a clean environment can and should co-exist. The process for achieving this vision should be a fair one that should not cost workers or community residents their health, environment, jobs, or economic assets. Any losses should be fairly compensated. And the practice of just transition means that the people who are most affected by pollution—the frontline workers and the fence line communities—should be in the leadership of crafting policy solutions."
- *Ocean economy*: According to the Organisation for Economic Co-operation and Development, the ocean economy is defined as "the sum of the economic activities of ocean-based industries, together with the assets, goods, and services provided by marine ecosystems" (OECD 2016).
- *Sustainable ocean economy*: The Ocean Panel has described the sustainable ocean economy as a concept that seeks to ensure the environmental sustainability of the ocean and coastal areas whilst promoting economic growth, social inclusion and the preservation or improvement of livelihoods and jobs. It emphasises sustainably managing human activities to ensure that the ocean's resources are used wisely and equitably (Ocean Panel 2020).
- *Transition*: Addressing human disruption of the climate system requires transitioning to a net-zero economy, a journey we must all take together. Investments in various sectors are necessary to mitigate climate change and lower emissions. These efforts will focus on replacing or updating technologies for electricity and heat production, manufacturing, transportation and buildings. They should also include aggressively leapfrogging to the most advanced zero or near-zero emissions options available, especially for emerging markets and developing nations, ensuring that no one is left behind in this crucial transition.

Endnotes

1. All dollar figures are in US dollars adjusted to 2019 prices.

2. Please note that this information does not originate from the Delphi process: A cluster-based industry emerges when interconnected companies, specialized suppliers, service providers and associated institutions concentrate in a particular geographic location. The concept was popularized by Harvard economist Michael Porter, who observed that thriving industries often develop in clusters rather than existing in isolation. These clusters create a robust ecosystem where the whole becomes greater than the sum of its parts. To understand how clusters work, imagine a thriving automotive manufacturing hub. At its core, you have major car manufacturers. Around them, three phenomena can be observed:

   • First, a network of specialized suppliers provides everything from seats to electronics to raw materials. These suppliers are located nearby to reduce transportation costs and enable just-in-time manufacturing.

   • Second, supporting services emerge, specialized law firms handling automotive patents, engineering consultants, marketing agencies with automotive expertise, and technical schools training the workforce.

   • Third, research institutions and universities establish programmes aligned with the industry's needs, creating a pipeline of skilled workers and driving innovation through R&D partnerships.

   Once a cluster gains critical mass, it attracts more related businesses, creating a virtuous growth cycle. Cluster-based industries are uniquely positioned to benefit from increased access to finance and training for clean technology transitions.

   Think of a cluster as an interconnected web where changes can ripple through the entire system more effectively than in isolated industries. When we consider access to finance and training for clean technologies, clusters create a multiplier effect: when one company successfully implements a clean technology solution, the knowledge spreads quickly through formal and informal networks. Engineers meet after work, employees move between companies, etc.

3. Please note that this information does not originate from the Delphi process: "Regeneration" generally refers to the biological process by which living organisms can replace, restore or regrow damaged or lost cells, tissues, organs or even entire body parts. This process varies significantly across species and types of tissue. When discussing environmental or habitat regeneration, the concept shares some core principles with biological regeneration—notably the ability of a system to recover and restore itself after damage or degradation. However, it operates at an ecosystem level rather than a cellular one.

   In environmental contexts, regeneration typically refers to the natural or assisted recovery of an ecosystem to a healthier, more functional state after disturbance or degradation. This might involve

   - the reestablishment of native plant and animal communities;

   - the restoration of natural processes like nutrient cycling and water flow;

   - the recovery of soil health and microbial communities;

   - the reemergence of complex ecological interactions and food webs; or

   - the return of ecosystem services like water filtration or carbon sequestration.

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About the Authors

Lead coordinating authors

Leila Ben Hassen is CEO of Blue Jay Communication and founder and organiser of the Africa Blue Economy Forum. She is an expert in the blue economy, leadership sustainability and communication. She also consults on maritime issues, gender equality and financial inclusion. Leila is based in London.

Contact: leila@bluejaycommunication.com

Charles S. Colgan (PhD) is Director of Research at the Middlebury Institute of International Studies, Monterey, California, and Emeritus Professor of Public Policy at the University of Southern Maine. He has been developing information on the blue economy for over 40 years.

Contact: ccolgan@middlebury.edu

Mark J. Spalding (JD, MPIA), President of The Ocean Foundation, is a Senior Fellow at the Center for the Blue Economy, a member of the UNEP Guidance Working Group for its Sustainable Blue Economy Finance Initiative, and an adviser to various ocean-centric investment funds. He is an expert on international ocean policy, law, philanthropy, finance and investment. Mark is based in Washington, DC.

Contact: mspalding@oceanfdn.org

Ocean Panel Secretariat coordinating author

Oliver S. Ashford (PhD) is a British marine biologist specialising in deep-sea ecology. He is a Program Associate within the Ocean Program at World Resources Institute and a member of the Ocean Panel Secretariat.

Contact: oliver.ashford@wri.org

About the Authors

Contributing Authors

Anthony Castelletto is an American Research Associate at the Center for the Blue Economy of Middlebury Institute of International Studies, Monterey, California.

Contact: acastelletto@middlebury.edu

Helen Ding (PhD) is a Chinese economist who leads WRI's economics research on inclusive development at the Global Centre of Economics. She is also Head of the Centre's Equitable Economics Innovation Team in WRI Europe's regional office in The Hague.

Contact: helen.ding@wri.org

Monica Grasso (PhD) is the US National Oceanic and Atmospheric Administration (NOAA) Chief Economic Advisor. She provides intellectual leadership, analysis and management expertise for NOAA's Blue Economy priorities, Earth observations investments and natural resources policies.

Contact: monica.grasso@noaa.gov

Phil James (PhD) is a British environmental economist specialising in marine ecosystems, coastal community development and the blue economy. He is Co-director of the Centre for Sustainable Development Reform at the University of New South Wales and Secretariat Director of the Global Ocean Accounts Partnership.

Contact: phil.james@unsw.edu.au

Kapil Narula (PhD) is trained as an engineer and economist and works on energy, climate, maritime and global sustainability issues. He works as a Senior Analyst in the UN Climate Champions Team and is based in Dubai.

Contact: kapilnarula@yahoo.com

Angelique Pouponneau is a Blue Economy and Finance Adviser to the Mission of Palau to the United Nations. She has specialised knowledge in enabling legal environments for sustainable ocean economies in small island developing states and previously held the post of CEO of the Seychelles' Conservation and Climate Adaptation Trust.

Contact: angeliquepouponneau11@gmail.com

Tim Slingsby (PhD) is Director of Skills and Education at Lloyd's Register Foundation, an independent global charity that aims to engineer a safer world, and Chair of the Maritime Charities Group, an alliance of major seafaring charities in the United Kingdom.

Contact: tim.slingsby@lrfoundation.org.uk

Thanos Smanis is a Greek Blue Economy consultant at CLIMAZUL, focusing on policy and capacity building and with extensive experience in sea basin strategies and transboundary collaboration.

Contact: tsmanis@gmail.com

Photo Credits

Pg. ii, raulling; Pg. iv, Max Kukurudziak; Pg. 2, Jason Leung; Pg. 6, Ed Wingate; Pg. 13, Insung Yoon; Pg. 15, Markku Soini; Pg. 18, Vassos Kyriacou; Pg. 19, National Cancer Institute; Pg. 20, Sohan Rahat; Pg. 22, Nathan Cima; Pg. 23, Reegan Fraser; Pg. 27, raulling; Pg. 30, Cecelia Chang; Pg. 33, NOAA; Pg. 38, Matt Seymour; Pg. 45, NOAA; Pg. 50, NOAA; Pg. 54, Jason Leung; Pg. 56, Bárbara Cascão; Pg. 65, Damiano Baschiera; Pg. 69, Kanenori; Pg. 97, Geoff Trodd.

HIGH LEVEL PANEL *for*
A SUSTAINABLE OCEAN ECONOMY

10 G Street NE
Suite 800
Washington, DC 20002, USA
+1 (202) 729-7600

oceanpanel.org