Ocean science human capacity

Ocean science thrives when the people behind it thrive

There is a growing understanding of the critical role of the human component in the ocean science enterprise and in the science-to-management and science-to-innovation value chains. There is also an increased recognition of the important contribution of ocean science to a sustainable blue economy, and to sustainable development in general.

National numbers of ocean science researchers vary between <1 to >300 employees per million inhabitants – these ratios do not relate directly to GDP

European countries have the highest ratio of researchers as a proportion of the total population. For example, Norway and Portugal have more than 300 employed researchers per million inhabitants (Figure ES.2). However, if measured in relation to the gross domestic product (GDP), the numbers of ocean researchers in some developing countries (e.g. Benin, Guinea, Mauritania and South Africa) are comparable to or even higher than numbers in some developed countries (e.g. Belgium, Denmark, Ireland and Sweden, Figure ES.3).

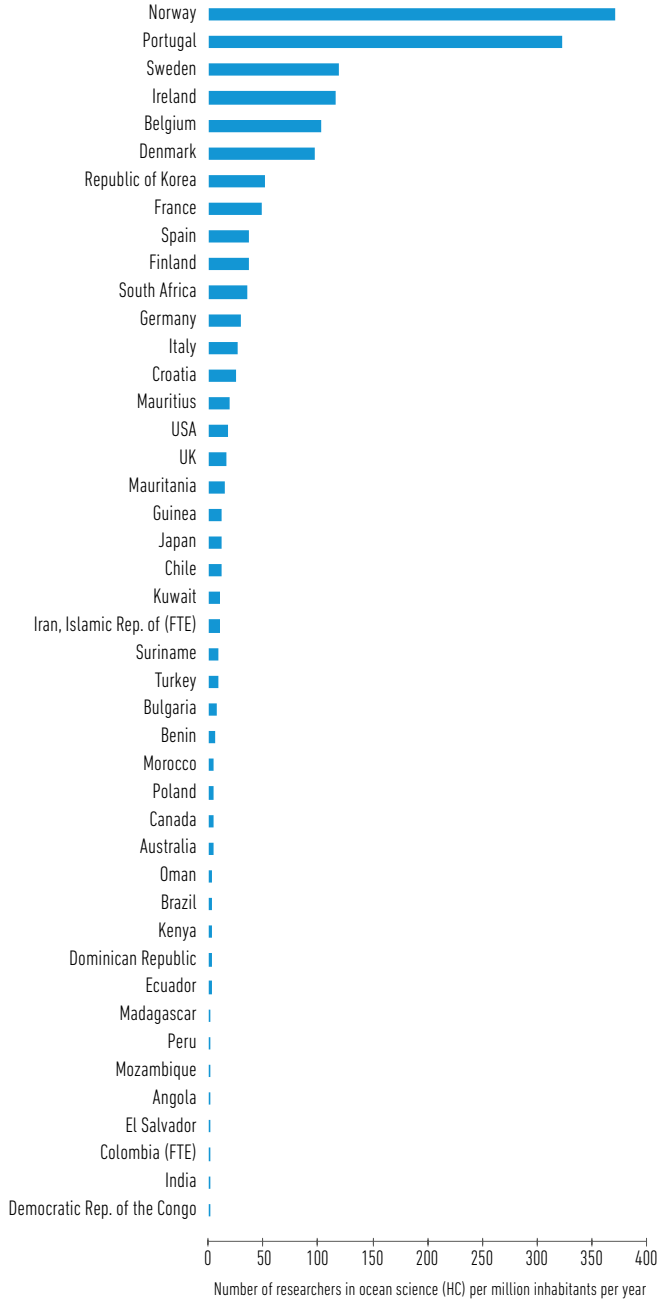

Figure ES.2. Number of national ocean science researchers (headcount – HC; full time equivalent – FTE, for the Islamic Republic of Iran and Colombia) employed per million inhabitants. Based on the subset of data presented in Table 4.1. (see GOSR2020 Chapter 4), researchers employed in ocean science per million inhabitants were extracted for the year indicated for each country.
Sources: Data based on the GOSR2017 and GOSR2020 questionnaires (researchers) and World Bank DataBank (inhabitants).[3]

[3] See https://databank.worldbank.org/source/world-development-indicators (accessed 17 December 2019).

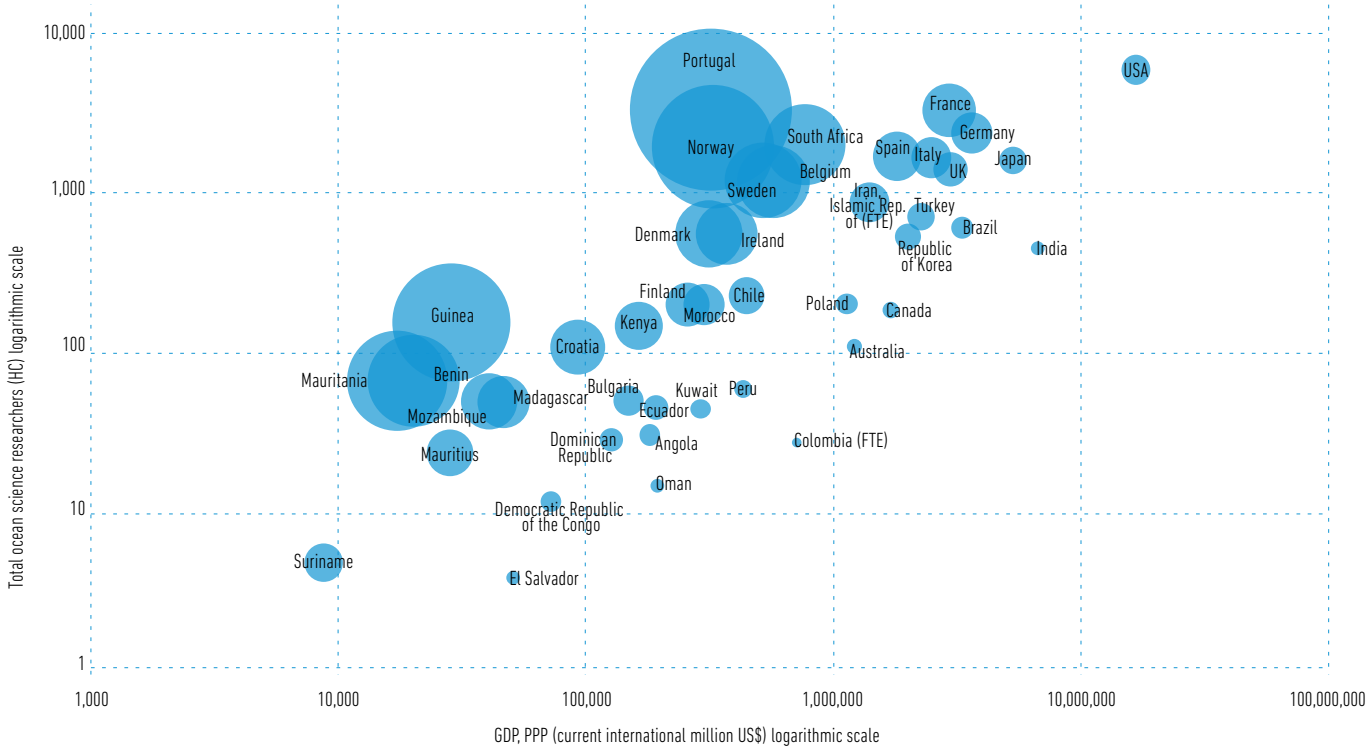

Figure ES.3. Number of national ocean science researchers (HC) in relation to the GDP purchasing power parity (PPP) (current million US$) extracted for each country and year. The size of the bubble is proportional to the ratio of researchers vs GDP for each country.
Sources: Data based on the GOSR2017 and GOSR2020 questionnaires (researchers) and the Global Economic Monitor (GDP, current million US$, seasonal adjustment), available at the World Bank Databank.[4]

[4] See https://databank.worldbank.org/home.aspx (accessed 12 February 2020).

Gender equality in ocean science is far from having been achieved but the challenge to reach it is realistic

Female ocean science personnel range from about 7% (Democratic Republic of the Congo) to 72% (Ireland) of all ocean science personnel, including researchers and technical support staff in the different countries. The global average stands at 37%. The percentage of female ocean science personnel is equal to or higher than 50 in countries such as Angola, Bulgaria, Croatia, El Salvador, Ireland, Poland and Turkey.

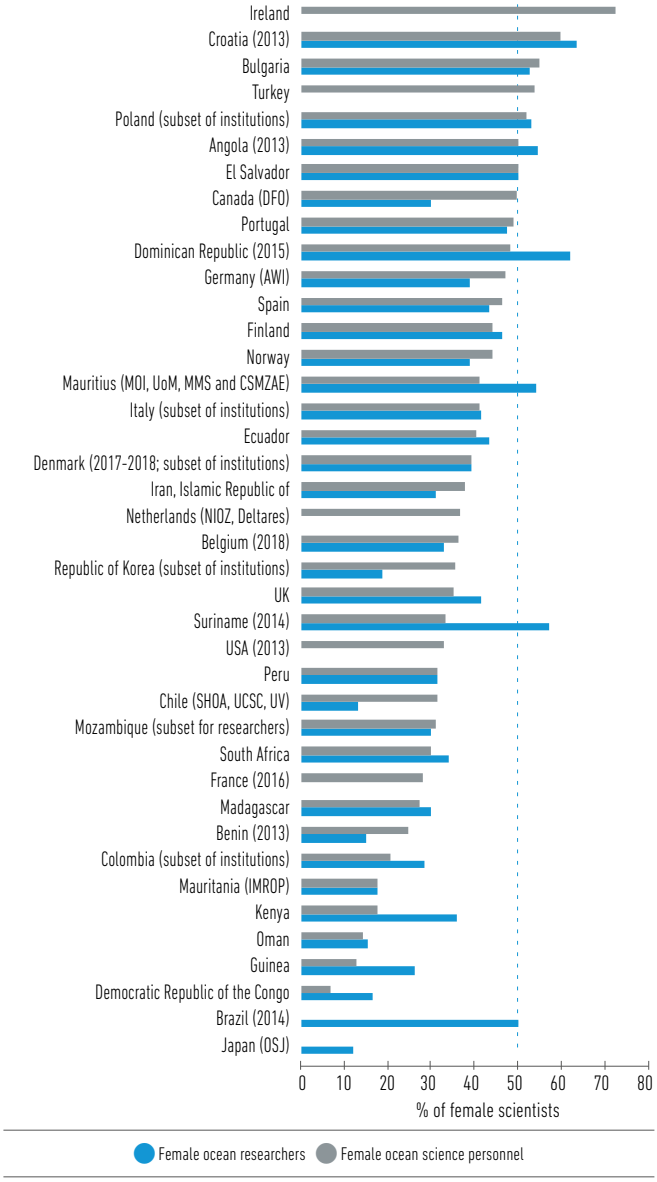

Figure ES.4. Proportion (% of total HC) of female ocean science personnel and female ocean researchers in 2017. In the absence of data for 2017, the latest available year is shown in brackets (see Chapter 4).
Sources: Data based on the GOSR2017 and GOSR2020 questionnaires.

Female researchers account for 39% of global ocean scientists, 10% higher than the global share of female researchers in natural sciences

The percentage of female researchers in ocean science ranges from about 12% (Japan) to more than 63% (Croatia). In Angola, Brazil, Bulgaria, Croatia, Dominican Republic, El Salvador, Mauritius, Poland and Suriname, 50% or more of ocean science researchers are women (Figure ES.4). On average, 38.6% of total ocean science researchers are female – a similar level to that reported in 2017 (38%) and one which remains 10% higher than the global share of female researchers in natural sciences.

Female ocean scientists are increasingly talking to the world

Participation of female scientists in international conferences is another indicator used to assess the involvement of women in ocean science. Female participants account for 29% to 53% of total conference participants, depending on science category and region (Figure ES.5). Compared to the assessment presented in the GOSR in 2017, the number of female participants per category and per region is higher in the GOSR2020 analysis.

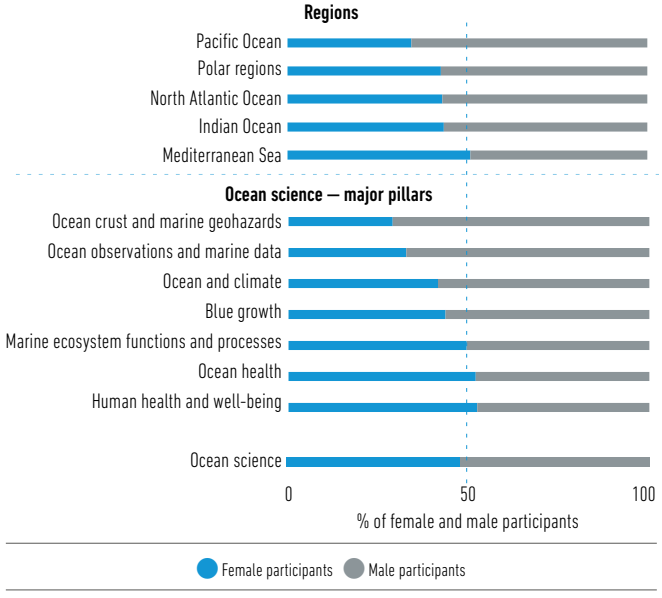

Figure ES.5. Proportion (%) of female and male participants at international scientific conferences/symposia held from 2015 to 2018. Upper section focuses on regional conferences/symposia; lower section on topic-specific conferences/symposia.
Source: Selected lists of participants in international scientific ocean science conferences/symposia held from 2015 to 2018.

Ocean science needs to become younger to open the door for truly innovative transformative solutions

It is important to promote early career scientist networks in the field of ocean science and to facilitate the involvement of young scientists in determining research priorities. To date, only a few countries, developing countries in particular, reported a relatively young community of researchers. Madagascar, for example, reported that more than 50% of their ocean researchers are younger than 34 years. At the same time, Canada, Finland, Italy, Japan and Oman reported that more than 50% of their ocean science researchers are over 45 years old.

Country of origin defines early career scientists' access to international forums

Students from different parts of the world have unequal access to international exchange programmes, e.g. for participation in international conferences. Students from Europe and Northern America account for 69% of the total number of students globally attending ocean science conferences (Figure ES.6).

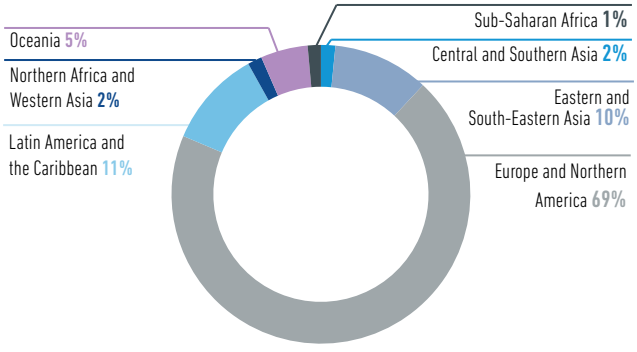

Figure ES.6. Proportion (%) of students per region attending international conferences/symposia, excluding regional conferences from the Pacific Ocean.
Source: Selected lists of participants in international scientific ocean science conferences/symposia held from 2011 to 2018.

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Ocean science generates both knowledge and applications

Global ocean science outputs are continuously rising (with regional differences emerging)

There has been an increase in the number of peer-reviewed ocean science publications, both in absolute and relative terms, in most SDG regions over the past 18 years (Figure ES.7). The most obvious change has been a 10% increase in output from the Eastern and South-Eastern Asia region, largely driven by China, and to a lesser extent by Japan and the Republic of Korea. The publication output in Europe and Northern America did not increase to the same extent, resulting in a relative reduction of its contribution to overall science publications by ~17%, from roughly two-thirds to one-half (Figure ES.8).

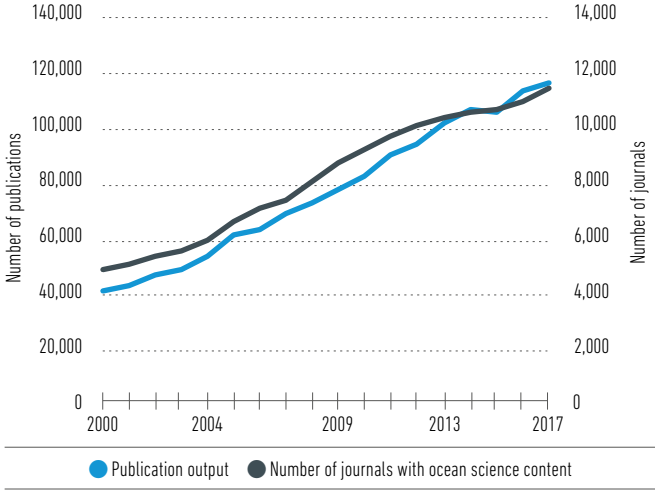


Figure ES.7. Global yearly trend in number of peer-reviewed ocean science publications (blue) and number of journals with content in ocean science (black) between 2000 and 2017.
Source: Authors Chapter 5, based on bibliometric analysis of Scopus (Elsevier) data 2000–2017 by Science-Metrix/Relx Canada.

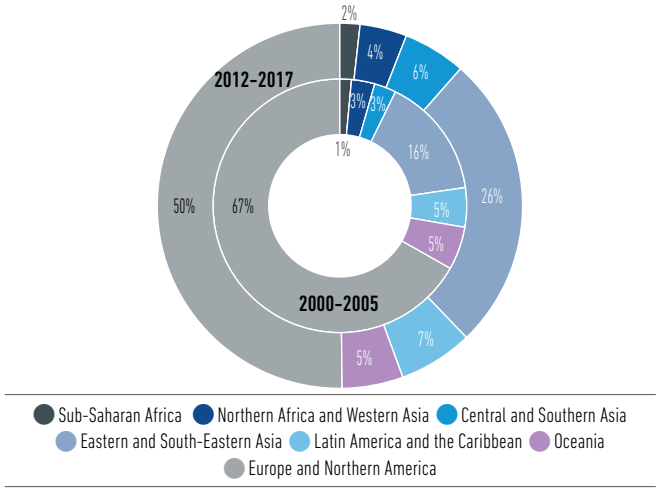


Figure ES.8. Changes in the proportion of global publication output by SDG regions from two different periods: 2000–2005 and 2012–2017.
Source: Authors Chapter 5, based on bibliometric analysis of Scopus (Elsevier) data 2000–2017 by Science-Metrix/Relx Canada.

Competitive ocean science is driven by international partnerships

In the period 2012–2017, 61% of the papers published by ocean scientists globally had at least one co-author from a foreign country, compared with approximately 56% from 2006 to 2011 and 52% from 2000 to 2005 (Figure ES.9). Increased collaboration among scientists from different countries is a sustained trend and should be seen as a very valuable and positive development.

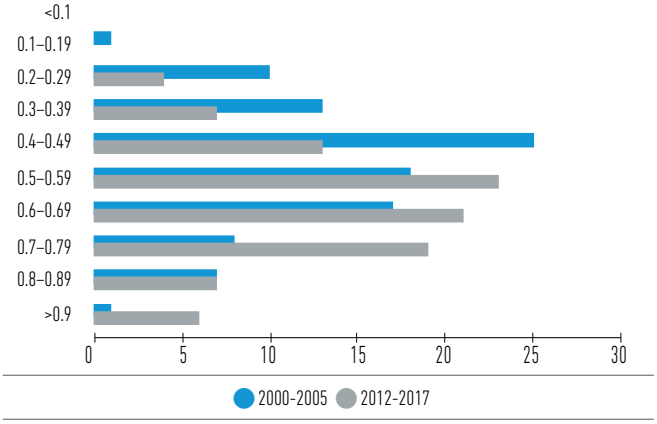


Figure ES.9. Changes in international co-publication rate of the 100 most publishing countries during the periods 2000–2005 and 2012–2017.
Source: Authors Chapter 5, based on the bibliometric analysis of Scopus (Elsevier) data 2000–2017 by Science-Metrix/Relx Canada.

International collaboration results in a higher quality of work

A positive correlation between the average relative impact factor of the publication and the international co-publication rate is reconfirmed (Figure ES.10).

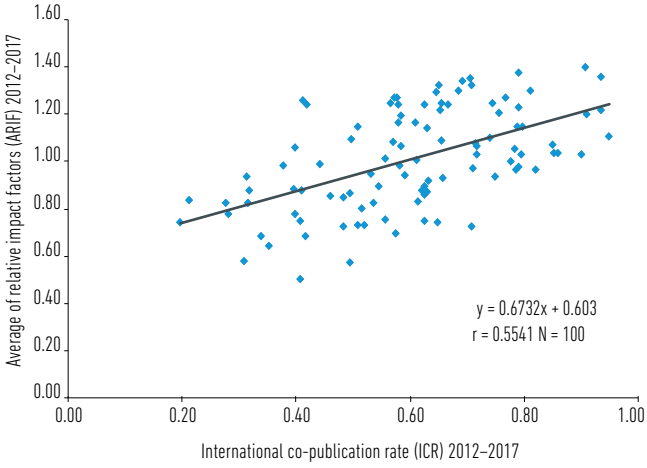


Figure ES.10. Comparison of ICR and average of relative impact factors (ARIF) of the ocean science community and ocean practitioners.
Source: Authors Chapter 5, based on the bibliometric analysis of Scopus (Elsevier) data 2012–2017 by Science-Metrix/Relx Canada.

Ocean science findings are converted into applications for society

'Technologies' or 'Applications for mitigation' or 'Adaptation to climate change' are the most frequent ocean science-related technologies in the Cooperative Patent Classification (CPC) (Figure ES.11). This reflects the increasing recognition of the ocean's role in regulating the climate and the negative impact of anthropogenic change on ocean health. Ocean science discoveries feed into nearly all sectors of the economy.

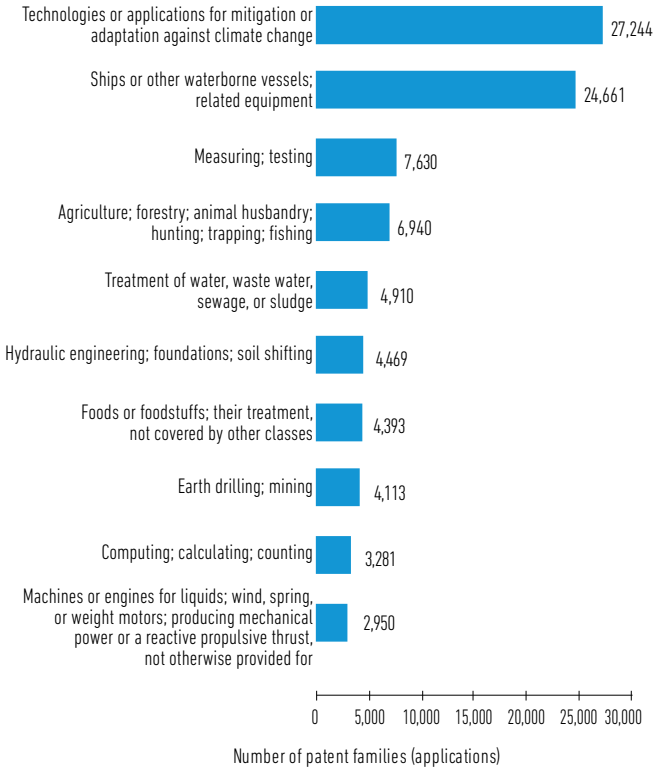


Figure ES.11. Top 10 most frequent CPC technical field classes in the total number of ocean science patent families (applications) using fractional counts.
Source: Based on the technometric analysis of 2000–2018 data provided by the United States Patent and Trademark Office, the European Patent Office, the Korean Intellectual Property Office, the Japan Patent Office and the China National Intellectual Property Administration by Science-Metrix/Relx Canada.

Ocean science in support of sustainable development and management of ocean resources

National priorities and needs guide the focus of ocean science

Nations continue to specialize in particular areas of research reflecting their priorities; these patterns remain consistent over time among the eight considered main ocean science categories (Figure ES.12).

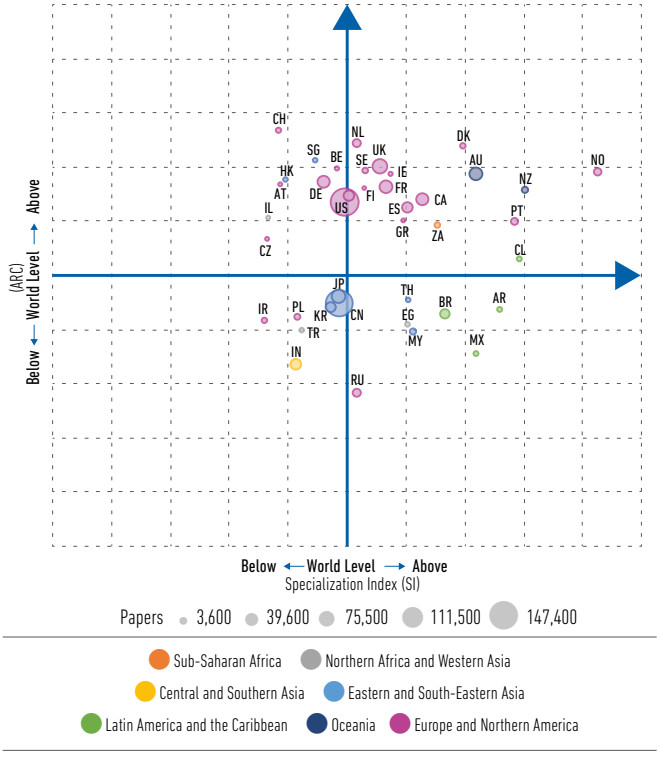


Figure ES.12. Positional analysis for the 40 countries included in the comparison group for ocean science output for the period 2012–2017. This analysis combines three separate indicators: the number of peer-reviewed ocean science publications, the specialization index (SI) and the average relative citation score (ARC). The size of the bubble is proportional to the number of publications for that country over the study period. Abbreviations: Argentina (AR), Australia (AU), Austria (AT), Belgium (BE), Brazil (BR), Canada (CA), Chile (CL), China (CN), China Hong Kong SAR (HK), Czechia (CZ), Denmark (DK), Egypt (EG), Finland (FI), France (FR), Germany (DE), Greece (GR), India (IN), Iran (Islamic Republic of) (IR), Ireland (IE), Israel (IL), Italy (IT), Japan (JP), Malaysia (MY), Mexico (MX), Netherlands (NL), New Zealand (NZ), Norway (NO), Poland (PL), Portugal (PT), Republic of Korea (KR), Russian Federation (RU), Singapore (SG), South Africa (ZA), Spain (ES), Sweden (SE), Switzerland (CH), Thailand (TH), Turkey (TR), United Kingdom of Great Britain and Northern Ireland (GB), United States of America (US).
Source: Based on the bibliometric analysis of Scopus (Elsevier) data 2012–2017 by Science-Metrix/Relx Canada.

Sustainable development is not possible without ocean science

The ocean represents the largest biome on the globe. It provides essential resources supporting human nutrition, health and recreation, and is part of the cultural identity of many coastal communities. Hence, by working towards the achievement of SDG 14, nations also profoundly contribute to attaining all other SDGs.

Many countries lack a specific strategy to measure progress towards the achievement of SDG 14

Of the 37 countries that responded to the related GOSR2020 question, over 70% have strategies and a roadmap to achieve the goals of the 2030 Agenda. However, only 21% reported that they have a specific strategy focusing on the ocean and SDG 14 (Figure ES.13).

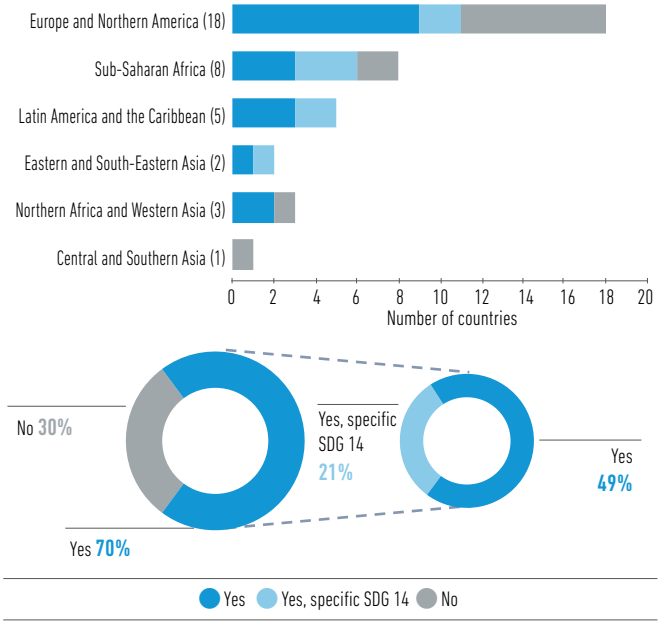


Figure ES.13. Distribution of countries that reported to have a national strategy to achieve the 2030 Agenda ('Yes') and/or SDG 14 within the different regional groups and globally, or not.
Source: Data based on the GOSR2020 questionnaire.

Ocean data and information management

Capacity and infrastructure supporting the management of ocean data and information do not exist in every country but ocean data and information services already support diverse users

Globally, only 57 countries have a designated national oceanographic data centre. The top four services the centres offer to clients are: (i) metadata and data archival; (ii) access to documented methods, standards and guidelines; (iii) data visualization; and (iv) web services (Figure ES.15). The clients and end users of data, products or services represent many sectors of society, reflecting the broad relevance of oceanographic data and information to the economy, research, public administration and, in particular, to businesses. The dominant users of data, products or services are the national and international science communities, students and the private sector, as well as the general public and policymakers.

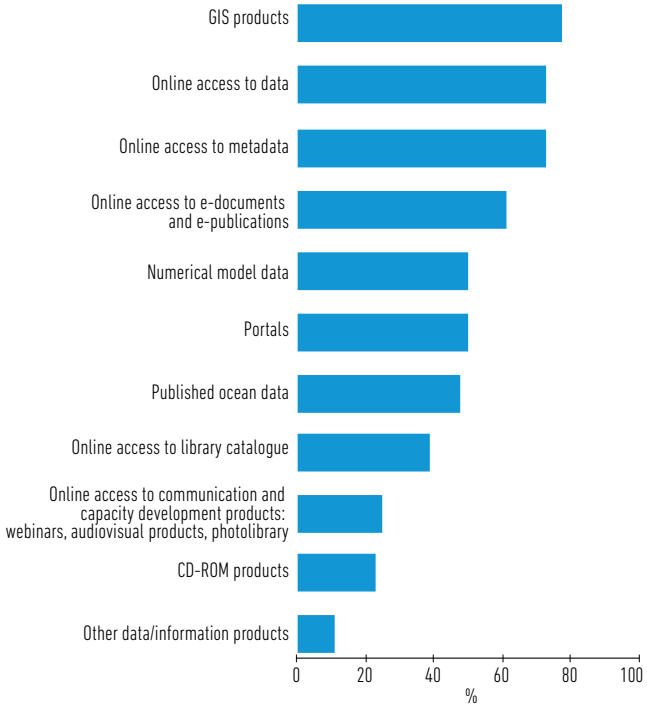


Figure ES.15. Proportion (%) of data/information products and services provided by countries' data centre(s) to their clients (multiple answers possible, 44 submissions).
Source: Data based on the GOSR2020 questionnaire.

Ocean data tend to be recognized as a common good; however, open access to ocean data is still far from being the norm

Data sharing and open access ensure that a variety of societal groups have access to data, data products and services. More than 80% of the countries apply institutional, national or international data-sharing policies. 74% of data centres have established relationships to exchange part of their data and information with other international data systems. This percentage varies greatly among the regions. In Europe and Northern America, for example, more than 90% of data centres have this kind of exchange, while in Latin America and the Caribbean fewer than 50% do (Figure ES.16). While countries reported that 58% of ocean data centres comply with the FAIR principles (Findability, Accessibility, Interoperability and Reusability), 60% of data centres still restrict access to 'certain' data types and 58% of them do so for a certain period of time. Only 16% of data centres apply no restrictions at all to data access (Figure ES.17).

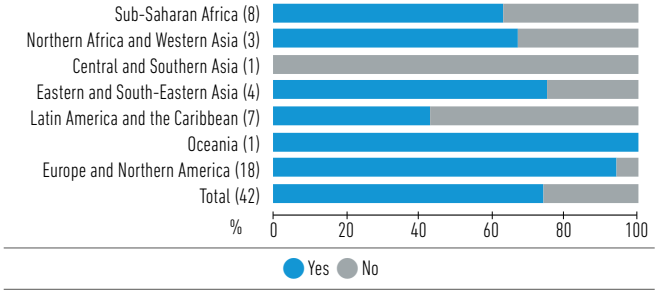


Figure ES.16. Percentage of countries' data centre(s) contributing data and information to international systems such as ICS World Data System, GDACs, WMO Global Telecommunication System (GTS) and others (42 submissions).
Source: GOSR2020 questionnaire.

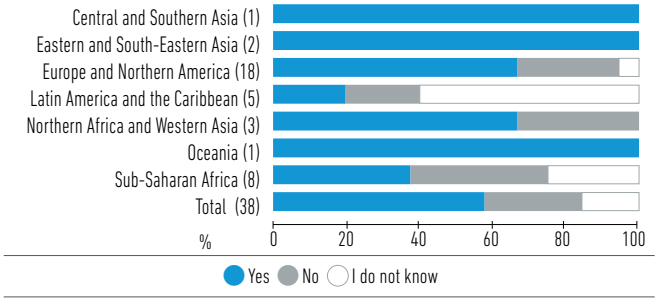


Figure ES.17. Compliance of national data centre(s) with the FAIR data management criteria (percentages based on 38 submissions).
Source: GOSR2020 questionnaire.

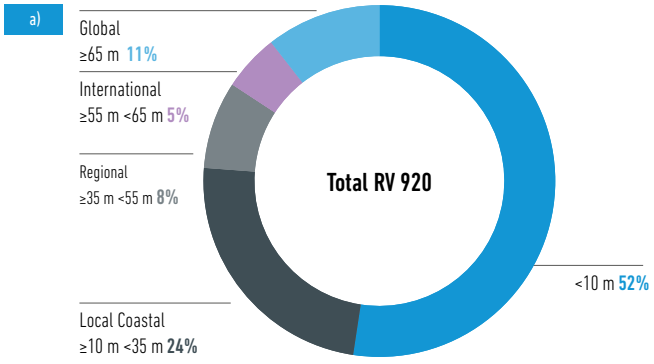
Transfer of marine technology and investments in ocean science

Access to technical infrastructure required for ocean science remains unequally distributed

Information about specific technical equipment used for ocean science was provided by 42 countries. Full access to a wide range of technical infrastructure is reported by five countries from the Northern Hemisphere: USA, Germany, Norway, Japan and Canada. Countries in the southern hemisphere only have limited access to ocean science technologies and infrastructure.

Access to the open ocean is not a given

A total number of 1,081 vessels serve ocean science, comprised of 924 research vessels almost exclusively used for ocean science and 157 ships of opportunity. More than a third of this global research fleet is maintained by the USA. Based on information obtained for 920 research vessels, local and coastal research is the primary purpose of 24% of these research vessels in 35 countries, 8% of the vessels operate at regional, 5% at international and 11% at global scale (Figure ES.18). Vessels plying globally are retained by 23 countries.



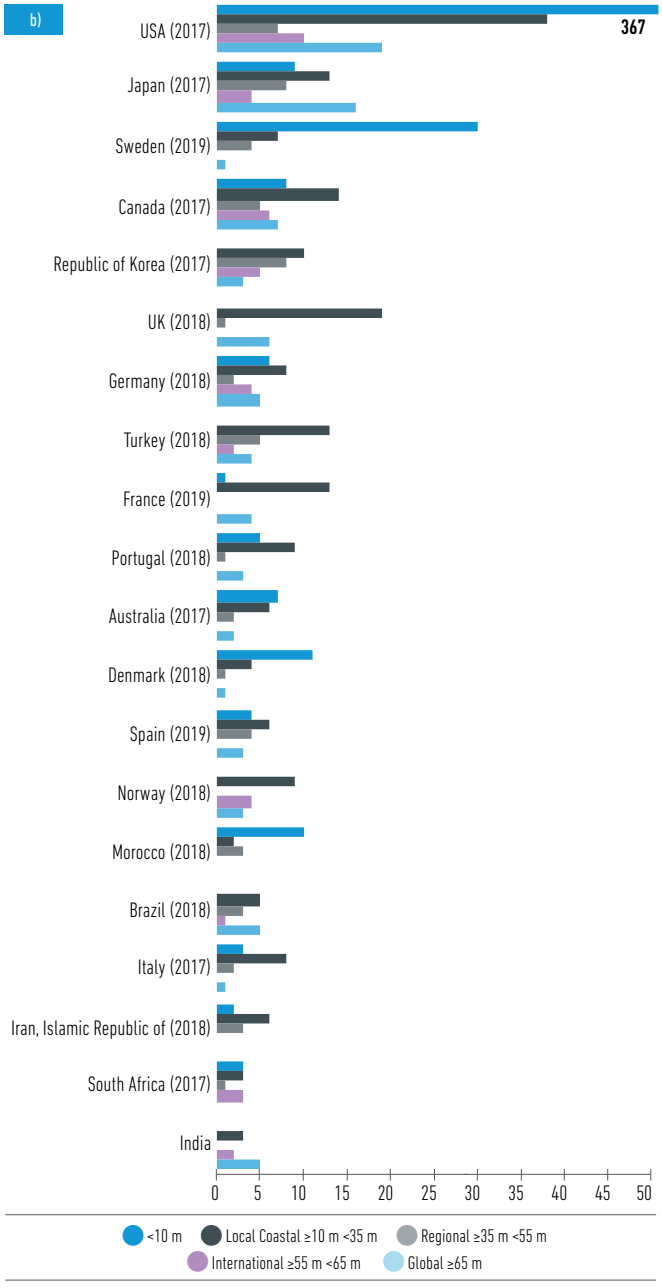


Figure ES.18. Number of nationally maintained RVs (a), classified by ship size. Detailed information is provided for the top 20 countries only (b). *Sources*: Data based on the GOSR2017 and GOSR2020 questionnaires.

There are large differences in countries' investment in ocean research

Overall, the portion of gross domestic expenditure on research and development (GERD) devoted to ocean science is noticeably smaller than for other major fields of research and innovation. On average, only 1.7% of national research budgets are allocated for ocean science, with percentages ranging from around 0.03% to 11.8% (Figure ES.19). This is a small proportion compared to the modestly estimated US$1.5 trillion contribution of the ocean to the global economy in 2010. Some countries are 'punching above their weight' in the field of ocean science, as they allocate a large proportion of their GERD to ocean science, despite having very low overall GERD.

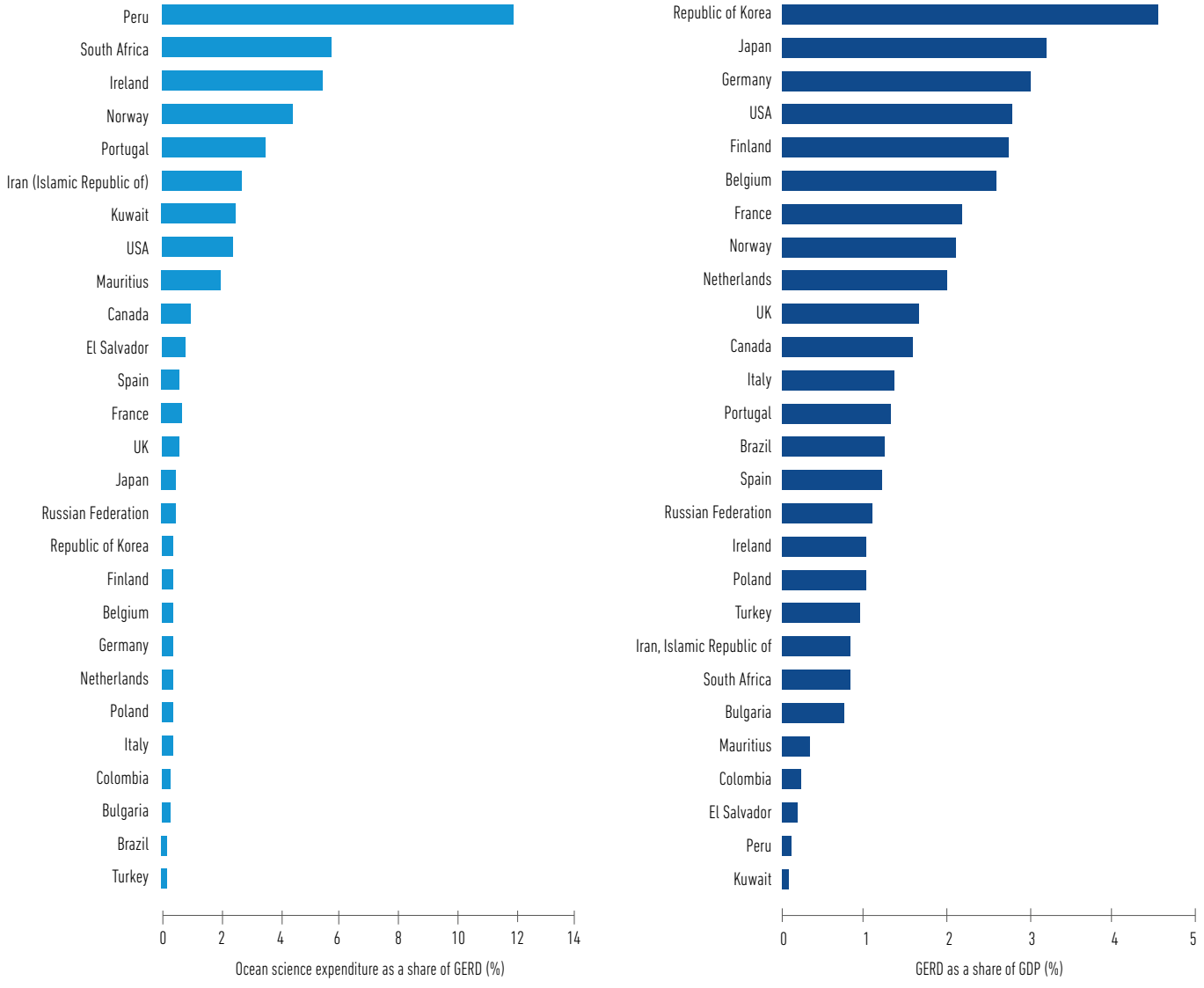


Figure ES.19. Estimates of ocean science funding as a share of GERD and GERD as a share of GDP in 2017.
Sources: Data adapted from GOSR2020 questionnaire and UNESCO Institute for Statistics database. Note that ocean science funding is not identified as such in GERD data and can be found in natural sciences and other categories.[5]

[5] The latest available data for Peru, Portugal and the USA are from 2016. The earliest available data for Iran (Islamic Republic of) and Portugal are from 2014. The latest available GERD data for South Africa are from 2016.

Maintenance and improvement of technical and human capacity in ocean science is at risk

Ocean science budgets vary significantly among countries and over time. Based on the datasets received, 14 countries increased their average budgets between estimates for years 2013 and 2017 (the Russian Federation had the highest annual growth rate, peaking at 10.4%, followed by the UK and Bulgaria), while 9 have reduced their budgets, in some cases quite markedly (particularly Japan, Ecuador, Turkey, Brazil and Italy) (Figure ES.20).

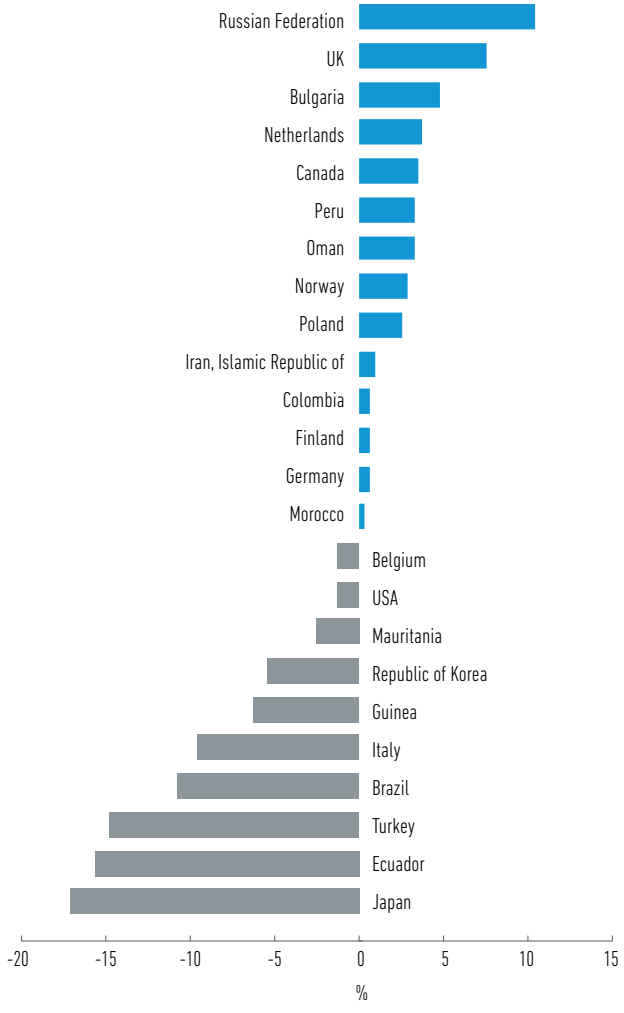


Figure ES.20. Change in % in ocean science expenditure over time based on average annual change of ocean science expenditure in local currency, at constant prices (2010=100), from 2013 to 2017. *Sources*: Data adapted from the GOSR2020 questionnaire and the International Monetary Fund's International Financial Statistics Database.[6]

Funding for ocean science no longer lies exclusively with governments

The sources of funding for ocean science have diversified over the years and today they include national administrations, international programmes, the private sector, foundations and philanthropic organizations. Although the majority of funding for ocean science will certainly remain institutional, private foundations and donors could play a larger role in the funding of small- and large-scale ocean science projects during the next decade. Like other scientific domains, ocean science is also starting to benefit from innovative funding mechanisms. These include transdisciplinary research funds, crowdfunding, lotteries and levies.

International cooperation in ocean science is encouraged by multiple strategies

Partnerships across countries and different sectors are recognized as a key strategy for more effective resource use and increased participation in ocean science, reinforcing its application in policy. Multiple measures are being put in place to encourage the strengthening of international cooperation and exchange, such as financial and in-kind support to facilitate international board memberships, exchange programmes, advisory positions in national and regional bodies, as well as guest researcher positions in the academic sector.

[6] The latest available data for Peru, Portugal and the USA are from 2016. The earliest available data for Iran (Islamic Republic of) and Portugal are from 2014.

Global Ocean Science Report 2020

Charting Capacity for Ocean Sustainability

The world ocean is a life-supporting system for humanity, yet it remains largely unknown. Based on data collected from around the world, the Global Ocean Science Report 2020 (GOSR2020) offers a global record of how, where and by whom ocean science is conducted. By analysing the workforce, infrastructures, equipment, funding, investments, publications, data flow and exchange policies, as well as national strategies, the GOSR monitors our capacity to understand the ocean and seize new opportunities. In its second edition, the GOSR2020 addresses four additional topics: contribution of ocean science to sustainable development; blue patent applications; extended gender analysis; and capacity development in ocean science.

The GOSR2020 is a resource for policymakers, academics and other stakeholders seeking to assess progress towards the sustainable development goals of the UN 2030 Agenda, in particular SDG target 14.a on scientific knowledge, research capacity and transfer of marine technology. The GOSR provides the information for the indicator for target 14.a as the proportion of total research budget allocated to research in the field of ocean science. GOSR2020 not only provides consistent reference information at the start of UN Decade of Ocean Science for Sustainable Development 2021–2030, it evolves as a living product. The global community is given the online facility to submit and update data on the GOSR portal and consult data to regularly assess progress on the efficiency and impact of policies to develop ocean science capacity.

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