Understanding the contribution of Flanders' public marine data to society

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Executive summary

This paper describes how marine data made available by public repositories based in Flanders benefit Belgian society and the global community. Key findings from an OECD survey of the repositories' users are discussed and several recommendations are provided for policymakers looking to build upon the provision of public marine data.

Data are required for marine sciences, the operation of ocean economic activities and the effective management of marine space, much of it collected through different types of observing systems and made available for reuse through public data repositories. Flanders' public marine data repositories adhere to open data policies, are free-to-use and many do not require login credentials for data access. As a result, limited information is collected automatically from users and bespoke studies are required to understand how societal value is generated from their uses of the data.

The OECD aims to provide the evidence policymakers require to assess the societal benefits of sustained marine data infrastructures by collaborating with different data communities. The current OECD project improves understanding of the economics of public marine data by surveying repository users and analysing the responses to construct conceptual value chains of their data uses. The Flanders survey follows-on from a similar survey conducted in the United Kingdom in 2020-2021.

Flanders provides an interesting case study in understanding the societal value of the reuse of public marine data because a collection of national and international repositories are based there. Open data policies of the Government of Flanders have encouraged multiple Flemish organisations, including Flanders Marine Institute (VLIZ) and Flemish Hydrography, to make marine data publicly available through dedicated repositories. In addition to its national repositories, Flanders is home to a relatively large number of international repositories important for global data provision. Flanders' public marine data repositories involved in the OECD survey are listed in Annex B.

Responses to the OECD survey reveal how Flanders' repositories enable the reuse of marine data across a range of sectors, contribute to improved decision making, and generate benefits for wider society. The following key points can be drawn from analysis of the responses:

- *Flanders' repositories have a large and varied international user base.* Some 74% of respondents reported working in countries other than Belgium with a total of 58 different countries represented. They work in diverse occupations: scientists, public officials, business managers and many others. They come from sectors beyond the government/policy sector which tends to fund repositories' activities.

- *Individual users of Flanders' repositories frequently use multiple repositories and would struggle to complete their tasks without them*. They access marine data from across the spectrum of parameter disciplines such as physical oceanography and human activities and combine different data types to generate the information they require for their analyses.

- *Reuses of data from Flanders' repositories are plentiful, complex and have effects on a broad range of ocean economic activities from traditional industries such as fishing to emerging activities such as marine renewable energy generation*. The benefits associated

with these reuses reaffirm Flanders' role in providing easy access to quality public marine data at near-zero cost to the user.

The many value chains presented in the analysis of the OECD survey responses show how reuses of public marine data from Flanders' repositories go far beyond the purposes for which the data were originally collected:

- The value chains link specific marine data parameters to the actions taken with them in particular fields to the ocean economy industries that are affected. An example of a high scoring value chain from the "Academia/research centre" sector links data from the "Biological oceanography" discipline used to "Conduct research and development" in the field of "Marine science" with effects on the "Biodiversity conservation" industry.

- Other value chains are good examples of the wide variety of uses of public marine data. A less common value chain from the "Industry/commercial" sector links data from the "Chemical oceanography" discipline used to "Target investments" in the field of "Weather forecasts and predictions" with effects on the "Offshore wind and marine renewable energy generation" industry.

- Considering the value chains alongside respondents' sectors reveals interesting differences in data types used and the actions, fields, and industries for which they are used between different areas of the economy. For example, data on "Human activities" is more important in the group of respondents working in the "Consultancy" sector than other sectors. The analysis they conduct with this data affects a range of ocean economy industries such as "Finance and marine insurance" and "Offshore wind and marine renewable energy generation". The latter is also an important industry affected by analysis of marine data conducted by respondents from the "Government/policy" and "Industry/commercial" sectors, albeit through different parameters, actions and fields. More examples such as these are given in the paper.

Respondents report numerous positive effects emanating from these public marine data value chains which are related to the sustainable development of the ocean economy. OECD analysis of the response data suggest the top three societal benefits relate to improving environmental outcomes such as informing policy decisions affecting the marine environment through spatial planning, conservation, management, biosecurity, and others.

Flanders has also developed a unique position in the global provision of public marine data due to the number of important international repositories based there. The collection of expertise required to manage both the national and international repositories in a relatively small geographical area could drive improvements if the appropriate networks between organisations are created. The benefits of this agglomeration could include opportunities for learning, resource sharing, and further sources of productivity increases in all organisations involved.

In conclusion, public marine data made available by repositories based in Flanders are the basis for a large number of complex value chains that stretch the societal value associated with the data beyond the original scope of the repositories involved as well as Belgium's national borders. The OECD survey demonstrates how the provision of public marine data in Flanders increases the likelihood that the full potential value of marine data to society is realised and how important ocean-related institutions in Flanders are committed to realising the objectives of open data policies of the Flemish Government. Nonetheless, there are further opportunities to be realised by improving access to data, fostering further collaboration between data repositories, and working towards a fuller understanding of users' data needs. Recommendations for how these may be achieved are provided in the concluding section of the paper.

During the OECD Science and Technology Policy Ministerial 2024, member countries committed to developing transformative science, technology, and innovation agendas to help achieve the sustainable use of the ocean. The OECD stands ready to support countries as they endeavour to do so, including through the implementation of evidence-based policies in support of public marine data provision.

1 Flanders: An interesting case study for understanding the societal value of the reuse of public marine data

Marine observations generate raw data which can be stored in repositories that provide access to datasets, metadata and data-products so that the data may be reused by any member of the public. This paper introduces public marine data repositories in Flanders and summarises the results of a survey of the users of these repositories.

Flanders is the Dutch-speaking northernmost region of Belgium containing the entirety of Belgium's 67 kilometres of North Sea coast. The Flemish coastline and Belgian marine space are used for a variety of ocean economic activities including recreation and conservation, fishing and aquaculture, and offshore wind electricity generation. These ocean economic activities contribute a great deal to the overall economy of Flanders. Flemish ports alone, which include Europe's second largest seaport the Port of Antwerp-Bruges, enabled 29.1 billion euros of economic activity in Flanders' economy in 2018 which is equivalent to 11% of the region's gross domestic product (Government of Flanders, 2021[1]).

Given these connections to the ocean, Flanders has invested in multiple data repositories that curate, store and make available marine data for public reuse. It is also home to a relatively large number of international repositories that archive and make global marine data available to the public.

In general, Flanders' repositories are free-to-use and often do not require the entry of login credentials when data are accessed. This means relatively little information is collected about the users of the data from Flanders' public marine data repositories and especially the uses to which they put the data that they access. Understanding the value of the data that flow from Flanders' repositories is therefore difficult without bespoke studies that collect this type of information.

The OECD project on the value chains of public marine data project contributes to filling this knowledge gap by surveying the users of public marine data repositories and collecting information on their data uses. The Flanders survey follows on from a similar survey conducted in 2021/22 of the users of marine data archive and management centres in the United Kingdom's Marine Environmental Data and Information Network (MEDIN) (Jolly et al., 2021[2]). The lessons learned in survey design from the UK study were incorporated into the questions and questionnaire in the Flanders' survey. See Annex A for key details of the survey design.

The paper is split into three other sections. In Section 2, the policy context under which Flanders' repositories have developed is briefly summarised. Section 3 outlines analysis of the survey responses and gives some analysis of the results. A discussion of the key insights drawn from this analysis and the policy context in which public marine data is provided by Flanders' repositories is in Section 4 as well as several related recommendations for policymakers.

Box 1. Summary of the results of an OECD survey of the users of marine data archive and management centres in United Kingdom

The original pilot study for the OECD value chains of public marine data project was conducted on the users of data repositories that are members of the United Kingdom's Marine Environmental Data and Information Network (MEDIN). The OECD survey shed new light on the various groups of users, the breadth of uses and reuses, and the benefits derived from marine observations and data management infrastructures.

With dozens of expert data and archive centres (DACs), the UK marine data landscape is diverse and complex and public marine data are accessed via many different routes. Users visit DACs for downloading raw datasets, running database searches, and for accessing data products. A notable share of survey respondents indicated they also link to marine data through tools such as Application Programming Interfaces (APIs).

The majority of survey respondents were marine scientists with half of respondents working in academia and research centres, 21% in the private sector, 20% in government/policy areas, 12% in consultancy services, and 9% in industry. Physical oceanography was the most highly downloaded category of data (43% of data types used), the second was human activities (21%) and biological oceanography the third highest (20.5%).

In the commercial/industry sector, the main fields of use included marine science services, offshore wind, marine renewable energy, offshore oil and gas, and marine archaeology. Within this group, respondents revealed marine data informed operations, contributed to spatial planning decisions and supported risk analysis. In the offshore wind field, for example, the top actions for industry/commercial data users were to inform operations, analyse risk, validate data from other sources, and inform marine planning decisions.

Respondents reported the various economic and societal benefits generated through the knowledge provided by the data included cost savings and cost avoidances from the sale of marine information products and the productivity gains, improved environmental performance and better ocean governance more generally.

Source: Jolly et al. (2021[2]), *Value chains in public marine data: A UK case study*, OECD Science, Technology and Industry Working Papers, No. 2021/11, OECD Publishing, Paris. https://doi.org/10.1787/d8bbdcfa-en

2 Marine and data policy context in Belgium and Flanders

Belgium is a federal country with considerable powers delegated to subnational governments. Beyond the Federal Government are three Regional Governments (Brussels, Flanders and Wallonia) and three Community Governments of Flemish, German and French speaking areas. In general, Regions control policy areas related to the territory (such as environment, transport and other public infrastructures). Community powers relate to competences linked to persons (such as culture, education, preventive health care and language). The Federal Government manages the national public finances and additional competences which are not those of Regions or Communities (such as curative health care, defence, judiciary, international trade). All federated entities have a responsibility for research and can act at the international level within the remit of their own competences.

The policies governing Belgium's marine space and the provision of public marine data are affected by multiple layers of government. While the entirety of the Belgian coastline is in the Flanders Region, the Belgian portion of the North Sea is not a part of the Region and is thus under the control of the Federal Government. The competence for maintenance of waterways, shipping at sea, ports, coastal protection, fisheries and other elements of marine governance are a Regional competence. Belgium must also adhere to the directives and regulations of the European Union and is a signatory to multiple global international agreements.

Marine and maritime policies of the Government of Belgium and its international commitments

Multiple ocean economic activities take place in the relatively limited marine space of Belgium's portion of the North Sea. Unless managed appropriately, these activities are likely to compete for marine space and create unnecessary environmental harms. In order to reduce the potential for these negative effects to occur, the Belgian Ministry of Environment created a first marine spatial plan (MSP) in 2014 for the period 2014 to 2020. The Belgian MSP process includes consultations with stakeholders including businesses, government bodies, interest groups including non-governmental organisations and citizens. Enacted under the national Marine Environment Act, it stipulates the areas in which certain activities may take place and has ensured the protection of 37% of the total surface area available for birds and other marine wildlife. A second MSP is currently in force for the period 2020 to 2026 and Belgium's recent Marine Protection Act stipulates that the MSP is evaluated every eight years and changed where necessary.

In addition to enforcing the Marine Environment Act and the MSP created under it, Belgium must also adhere to directives and regulations of the European Union (EU). EU Directives affecting Belgian waters include the Habitats Directive, the Birds Directive and the Marine Strategy Framework Directive while the Water Framework Directive affects coastal and transitional waters. Belgium is also a signatory to international agreements including the OSPAR Convention for the North-East Atlantic Ocean and the United Nations Convention on the Law of the Sea (UNCLOS). Relatedly, Belgium is a member of the International Seabed Authority (ISA). Finally, as a signatory to the International Maritime Organisation's

Safety of Lives at Sea convention, Belgium, through Flemish Hydrography, is committed to collecting and publishing hydrographic data.

Data policies of the Flemish Government

Flanders has pursued open data policy initiatives for at least the past decade. In 2011, the Flemish Government released a concept note outlining guidelines on data reuse, source authentication, open standards and their administration (Flemish Government, 2011[3]). In 2018, the *Smart Flanders* programme was launched to support the implementation of a common open data policy across 13 Flemish cities (Figure 1) based on a set of 20 principles published in an *Open Data Charter* (Flemish Government, 2018[4]). In 2020, the *Open Data Action Plan 2020-2024* was launched to encourage the re-use of public data including through the creation of a Flemish Government Open Data Portal and legal support for open data licensing (Flemish Government, 2020[5]).

In addition to creating the framework conditions for opening government data and encouraging digital cities, Flanders has supported the provision of open research and scientific data. In 2018, the Flemish Interuniversity Council (VLIR) released a white paper outlining some of the challenges faced by Flemish researchers attempting to open their research data and providing recommendations for policies to improve open data provision (Flemish Interuniversity Council, 2018[6]). In published plans for their 2019-2024 term, the current Flemish Government stated that "…scientific research funded from public funds should be publicly accessible as soon as possible according to the principle, *as open as possible, as closed as necessary.* This applies both to access to publications as well as for access to the underlying research data" (Flemish Government, 2020[7]).

Figure 1. Cities participating in the Smart Flanders programme include the coastal city of Ostend and the port city of Antwerp

Source: Walravens (2019[8]) *Smart Flanders Program*. https://oascities.org/wp-content/uploads/2019/11/Smart-Flanders_SCEWC2019.pdf

To realise the open data policy, the Flemish Government created the Flemish Open Science Board and charged it with investing five million euros in initiatives for open research data each year between 2019 and 2024 (de Bal, 2023[9]). In 2020, the board established a governmental institution for coordinating initiatives on open data called the Flemish Research Data Network (FRDN). FRDN brings together 36

Flemish research organisations including the Flanders Marine Institute (VLIZ) to build the infrastructure required to achieve findable, accessible, interoperable, and reusable (FAIR) research data (Flemish Government, 2023[10]). It also includes the Flemish science funding agencies and the regional nodes of the European Strategy Forum on Research Infrastructures (ESFRI).

A key objective of the FRDN is to accelerate innovation in society through the reuse of quality research data. To encourage reuse, the Flanders Research Information Space (FRIS) makes available the most recent information about researchers, research groups, publicly funded projects and publications in Flanders (Flemish Government, 2019[11]). It also contains information about patents, infrastructure and datasets. A key objective of FRIS is to "make research data publicly available, so that everyone can use it freely". For instance, FRIS research data can be accessed freely by students, researchers and organisations through open automatic programming interfaces (APIs) (Flemish Government, 2019[11]).

Box 2. Intersection between data policies of the Flemish Government and public marine data in Flanders

The Government of Flanders has long recognised the importance of data for evidence-based policymaking and to improve the transparency of decision making. It was an early supporter of publishing data and progressing towards the 'open data' concept. Today, the Government of Flanders has an 'Open Data' policy which applies to all of its departments and agencies. Organisations in Flanders now have a track-record of publishing marine data as demonstrated by the examples of Flanders Marine Institute (VLIZ) and Agency for Maritime and Coastal Services (MDK).

Flanders Marine Institute (VLIZ)

VLIZ acts as the coordination and information platform for marine and coastal-related scientific research in Flanders and serves as an international contact point. It has the mission to provide technologies and tools to scientists and policymakers, making high-quality data and information accessible to a wide range of marine sciences, while implementing a FAIR (Findable, Accessible, Interoperable, and Reusable) and Open data policy.

From its inception in 1999, VLIZ has focused on rigorous marine data management with a view to enable data reuse. VLIZ thus has become an early adopter of an 'open data' culture. Supported by the Government of Flanders, VLIZ made this expertise also available to a broad spectrum of external marine data users. Key milestones on this VLIZ journey are:

- **2005**: Start of the VLIZ Open Marine Archive (OMA) to make Flemish-Belgian scientific output digital and publicly available and VLIZ becomes the host of the IOC/UNESCO Project Office for the International Oceanographic Data and Information Exchange (IODE) programme
- **2007**: VLI joined the 'Open Archive Initiative' (OAI), setup of the Marine Data Archive (MDA) and the VLIZ Aphia database of VLIZ morphs from a local initiative for storing and distributing information on marine species of the Belgian part of the North Sea to serve as the core IT platform for the highly successful World Register of Marine Species (WoRMS)
- **2008**: a worldwide service for real-time sea level monitoring data becomes continuously active, an initiative that, after the 2004 Christmas tsunami, sprang from the need for better tsunami preparedness. This initiative was developed in cooperation with GLOSS (Global Sea Level Observing System) and IOC (Intergovernmental Oceanographic Commission)

- **2011**: Census of Marine Life data start to be hosted by IODE project office in the form of the Ocean Biogeographic Information System, since renamed the Ocean Biodiversity Information System
- **2013**: Flanders starts to host the Secretariat of the European Marine Observation and Data Network (EMODnet) at VLIZ
- **2022**: VLIZ acts as host for the EMODNet central portal after a years-long project to integrate the multiple thematic portals of EMODnet

The Government of Flanders has, in close cooperation with VLIZ, supported the strategy to embed and foster VLIZ capabilities and infrastructures by their linkage with relevant international networks. The periodic review of VLIZ' performance in this area has confirmed that this strategy has made VLIZ, in particular the VLIZ Marine Data Centre, a strong international partner (IDEAConsult, 2021[12]).

Many parts of the VLIZ (data) infrastructure now benefit from interconnections at European or global scale. An example of an ESFRI infrastructure in which VLIZ participates is LifeWatch. WoRMS there forms part of the "LifeWatch Species Information Backbone". The VLIZ participation in LifeWatch supports the maintenance of WoRMS, the European Tracking Network (ETN), the geo-data portal Marine Regions and the European participation in OBIS, EurOBIS. VLIZ thus has the ability to continue to build on systematic investments in core marine data systems that have a global significance.

Agency for Maritime and Coastal Services (MDK)

The Agency for Maritime and Coastal Services is part of the Government of Flanders. Its Flemish Hydrography team has a long history recording data, including bathymetry, oceanography and meteorology in marine and coastal settings.

In 2004 data were first published through an online data portal. Recognising the added value for end-users, over time additional data portals were developed and in 2014 the bathymetric data portal was launched providing access to all bathymetric survey data in high resolution. The bathymetric data portal hosts all bathymetric data for the Belgian EEZ, and the approaches to Flemish inland ports (Antwerp, Ghent). Users can download data or use webservices to visualise the data in their own applications.

Since 2013 bathymetric data are also shared with the European EMODnet initiative, allowing users to access and integrated low-resolution bathymetric grid of European sea areas. Oceanographic and meteorologic data were first made available in 2004 through the Monitoring network Flemish Banks website. Over time the functionality of the data portal has developed and since 2013 users can access oceanographic and meteorological data back to 1974. Since 2018 users can make use of webservices to use the data in their own applications. Since 2007 data are also shared in the context of the North West European Shelf Operational Oceanographic System (NOOS) and later also through the EMODnet portal.

Under the Open Data policy in place today within the Flemish Government, the Agency for Maritime and Coastal Services continues to develop its web portals to meet the developing requirements and enable further opportunities for re-use of its data.

Links between Flemish open data policies and Belgian ocean economic activity

The North Sea is one of the world's most frequently traversed sea areas in the world with Belgium's federal jurisdiction covering the southernmost part (ESPON, 2013[13]). According to Belgium's Marine Spatial Plan 2020-2026, the Belgian portion of the North Sea is used for a variety of purposes including the fisheries, aquaculture, transportation, offshore wind farms, oil and gas extraction, sand and gravel extraction, tourism and leisure activities, and the siting of cables and pipelines. It also contains cultural and natural heritage

sites, conservation areas for the protection of wildlife and marine ecosystems, and is the subject of much marine research.

Flanders' public marine data repositories provide data required to facilitate the activities outlined in Belgium's Marine Spatial Plan 2020-2026. With the aid of maintenance dredging, Belgian waters are in certain areas deep enough to allow large ships to pass through to the Port of Antwerp-Bruges, the North Sea Port and the Port of Ostend. Trawling fishing methods are often employed by Belgian and international fishers along shallow subtidal sandbanks and mud fields. Mineral resources such as sand are extracted from marine areas through dredging. Multiple sites for offshore wind electricity generation production are expected to generate more than five gigawatts of renewable energy in the future. And pipelines for gas, electricity, and telecommunications cables are bundled into established corridors.

The provision of public marine data in Flanders by institutes committed to the Flemish Government's open data policies helps users to understand the marine space in which these activities are conducted. It also ensures those carrying them out have the information required to navigate Belgian waters safely. For example, the Flemish Agency for Maritime and Coastal Services' Bathymetric Portal offers depth and nautical data of the Flemish Hydrography so that users can better understand marine features and their context. The Flemish Banks Monitoring Network gathers and publishes oceanographic and meteorological data to inform mariners about the conditions at sea and allow safe navigation and maritime operations. Flanders' Wreck Database provides information on the location of shipwrecks and other sites of marine archaeological interest for hobbyists and professionals alike. Flemish repositories also provide data on corridors for cables and pipelines increasing confidence in the safety of operators' assets.

Flanders' important role in the provision of international public marine data

The Flemish Government alongside the Flanders Marine Institute (VLIZ) has taken broad international responsibilities for marine data provision. The UNESCO/IOC International Oceanographic Data and Information Exchange (IODE) Project Office was established in Ostend, Flanders, in 2005 with substantial support from the Flemish Government and the Flanders Marine Institute (VLIZ). Since then, the European Marine Board (EMB) and the Secretariat of the European Marine Observation and Data Network (EMODnet) have been co-located in Flanders with VLIZ. Since 2022, VLIZ and its international partners have been based at the InnovOcean Campus, a state-of-the-art facility and built by the Flemish Government in Ostend to headquarter VLIZ and the marine facilities of the Flanders Research Institute for Agriculture, Fisheries and Food (ILVO).

In addition to public marine data repositories focused on the Belgian-portion of the North Sea and adjoining areas, Flanders hosts a large number of international repositories. In 2000, the European Register of Marine Species sought a new host institution after its first project was completed and key experts recommended the newly established VLIZ for the role (Box 2). VLIZ then expanded the scope of ERMS to include global data through the development of the World Register of Marine Species (WoRMS) (WoRMS, 2023[14]). Today, the international repositories also based in Flanders include EMODnet BIOLOGY, the European Ocean Biodiversity Information System, European Tracking Network (ETN), LifeWatch, Marine Regions, and the Sea Level Station Monitoring Facility (more information on each of these repositories is available in Annex B).

3 The broad and beneficial reuses of public marine data from Flanders' repositories

The survey collected responses via online questionnaires available in both English and Dutch between September 2022 and February 2023. The English language questionnaire was answered by 269 people and the Dutch language version was answered by 102 people. The survey therefore attracted a combined total of 371 completed responses.

Users are located in a large number of countries

The highest number of respondents from a single country (93) were based in Belgium. But 74% of respondents are based in 58 other countries, including more than ten respondents each from United Kingdom, France, Netherlands, and People's Republic of China. All six inhabited continents are represented by respondents. Table 1 below displays the total number of unique respondents from each country and the share of the total that this number represents for the top ten countries represented.

Table 1. Respondents to the survey are based in 59 different countries on six continents

Top ten countries in which respondents are based professionally

	Country	Number of unique respondents	Share of total unique respondents
1	Belgium	93	26.0 %
2	United Kingdom	76	21.2 %
3	France	21	5.9 %
4	Netherlands	21	5.9 %
5	People's Republic of China	16	4.5 %
6	Germany	9	2.5 %
7	Italy	8	2.2 %
8	Mexico	8	2.2 %
9	Brazil	7	2.0 %
10	Australia	6	1.7 %

Note: The remaining countries in which respondents' are based are (number of unique respondents in parentheses): Austria (5), Canada (5), New Zealand (5), Spain (5), Cuba (4), Norway (4), Portugal (4), Denmark (3), Greece (3), Russia (3), Bulgaria (2), Chile (2), Colombia (2), Ethiopia (2), Finland (2), India (2), Ireland (2), Japan (2), Korea (2), Peru (2), Romania (2), South Africa (2), Sweden (2), Algeria (1), Argentina (1), Bangladesh (1), Colombia (1), Dominican Republic (1), Ecuador (1), Egypt (1), Fiji (1), Hungary (1), Iceland (1), Italy (1), Luxembourg (1), Mauritius (1), Namibia (1), Nicaragua (1), Pakistan (1), Poland (1), Samoa (1), Saudi Arabia (1), Senegal (1), Serbia (1), Seychelles (1), Slovenia (1), Taiwan (1), Thailand (1), and Venezuela (1).

Users work in diverse occupations: scientists, public officials, business managers and many others

Respondents were asked to give their occupation and a total of 367 unique respondents chose to do so. The list of occupations available for selection by respondents was created by the survey team based on common jobs associated with the ocean economy. There were 48 options on the list and 39 were selected at least once. The highest number of respondents for a single occupation (81) selected "Marine scientist (marine biology and ecology)". The second largest option was "Other", which was selected by 49 respondents. The first non-scientist occupation that is not "Other" is tied between "Academic, teaching associate, education officer" and "Environmental scientist/engineer" which were both selected by 18 unique respondents.

The occupations list detailed seven specific types of marine scientist. If these different types of marine scientist are grouped together under one category, they represent 131 unique respondents and make up 36% of the total. For comparison, the second largest category "Other" makes up 13% of the total. The "Other" occupations include "taxonomist and museum curator", "chemist specialised in chemical warfare agents", and "emergency management – tsunami warning centre".

Table 2. A broad range of ocean economy occupations is apparent in the survey results with marine scientists making up the largest group of respondents

Top ten occupations in which respondents work

	Occupation	Number of unique respondents	Share of total unique respondents
1	Marine scientist (marine biology and ecology)	81	22.1 %
2	Other	49	13.4 %
3	Marine scientist (marine conservation/environmental protection)	19	5.2 %
4	Academic, teaching associate, education officer	18	4.9 %
5	Environmental scientist/engineer	18	4.9 %
6	Engineer	17	4.6 %
7	I download data as part of a hobby	17	4.6 %
8	Student	17	4.6 %
9	Retiree	16	4.4 %
10	Civil servant/public official	12	3.3 %

Note: The remaining occupations selected by respondents are (number of unique respondents in parentheses): Marine scientist (geology and geophysics) (12), Digital, data and technology specialist/manager (10), Marine scientist (oceanography, ocean modelling and forecasting) (9), Computer information and systems specialist/manager (8), Marine scientist (biogeochemistry and ecosystems dynamics) (6), Information specialist (5), Seafarer (5), Archaeologist/historian (4), Conservationist (4), Environmental consultant (4), Nature guide (4), Nature watcher (4), Marine geomatics specialist (3), Marine science manager (3), Construction (2), Economist (2), Fisheries manager (2), Marine scientist (hydrographic surveying) (2), Marine scientist (palaeoceanography) (2), Merchant marine officer (2), Port operative/harbour pilot (2), Armed forces professional (1), Business services, auditing specialist/manager (1), Commercial diver (1), Marine spatial planner (1), Marine/naval architect (1), Political scientist (1), Regulator (including inspection services) (1), and Sales, marketing and development specialist/manager (1).

Users come from sectors beyond government/policy areas which tend to fund repositories' activities

In addition to their occupation, respondents were asked to reveal the economic sector in which they work. The list of options available contained 10 sector categories including 'Other' and all 10 were selected at least once. The largest sector represented is 'Academia/research centre' which makes up just over 49% of total responses to the question. The second largest sector is 'Recreational user' with 15% of the total.

Figure 2 below depicts the total number of unique respondents that selected each sector as a percentage of the total number of responses to this question.

Figure 2. Nearly half of respondents work in academic/research settings

Percentage of total number of respondents selecting each sector
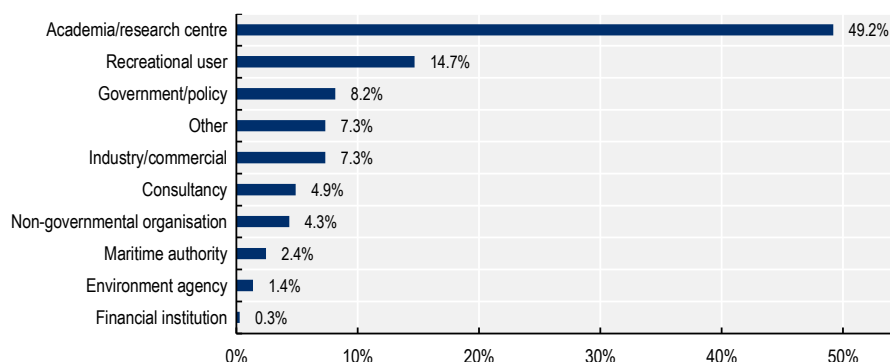
Each occupation in the occupation list could be carried out in multiple sectors in the sector list. Viewing the occupations that are common in particular sectors provides an indication of differences and similarities in the types of jobs that respondents' carry out across different areas of the economy. 'Marine scientists', for example, are highly prominent in the 'Academia/research centre' sector but also in the 'Environment agency', 'Government/policy', 'Industry/commercial', and 'Non-governmental organisation' sectors. 'Digital, data and technology specialist/manager' appear prominently in the 'Government/policy', 'Industry/commercial', 'Maritime authority' and 'Non-governmental organisation' sectors. Figure 3 below gives the top five occupations in each sector revealed by the survey.

Individual users frequently use multiple repositories and would struggle to complete their tasks without them

Respondents were asked to select the public marine data repositories they use from a list of 14 specific repositories based in Flanders (Annex B contains descriptions of Flanders' based repositories involved in the survey). A total of 343 unique respondents answered this question. All 14 repositories were selected by at least one respondent. Most respondents (184) selected a total of one repository but 55 respondents selected four or more repositories. One respondent selected all 14 repositories on the list. On average, respondents selected 2.2 repositories.

The repository selected by the highest number of unique respondents is "World Register of Marine Species (WoRMS)" which was selected a total of 190 times. "Sea Level Station Monitoring Facility", "LifeWatch", "Flemish Hydrography – Bathymetric Portal", and "Marine Regions" were selected by more than 77 respondents and each represents 10 per cent or more of the total number of selections.

Flanders plays an important role in the global ocean information system by hosting multiple international data centres. The list of public marine data repositories in Flanders includes those that are focused on Belgian territorial waters as well as several international data centres that process, store and make available global data. Figure 4 below counts the respondents using each Flanders' based repository.

A total of 107 unique respondents selected at least one nationally focused repository and 327 selected at least one internationally focused repository. A certain number of respondents selected only nationally focused or only internationally focused repositories. In total, 16 respondents selected exclusively nationally

focused repositories, 236 respondents selected only internationally focused repositories and 91 unique respondents selected both nationally and internationally focused repositories.

Figure 3. Different occupations are carried out by respondents from the same sector

Top five occupations in each sector by normalised count of unique respondents
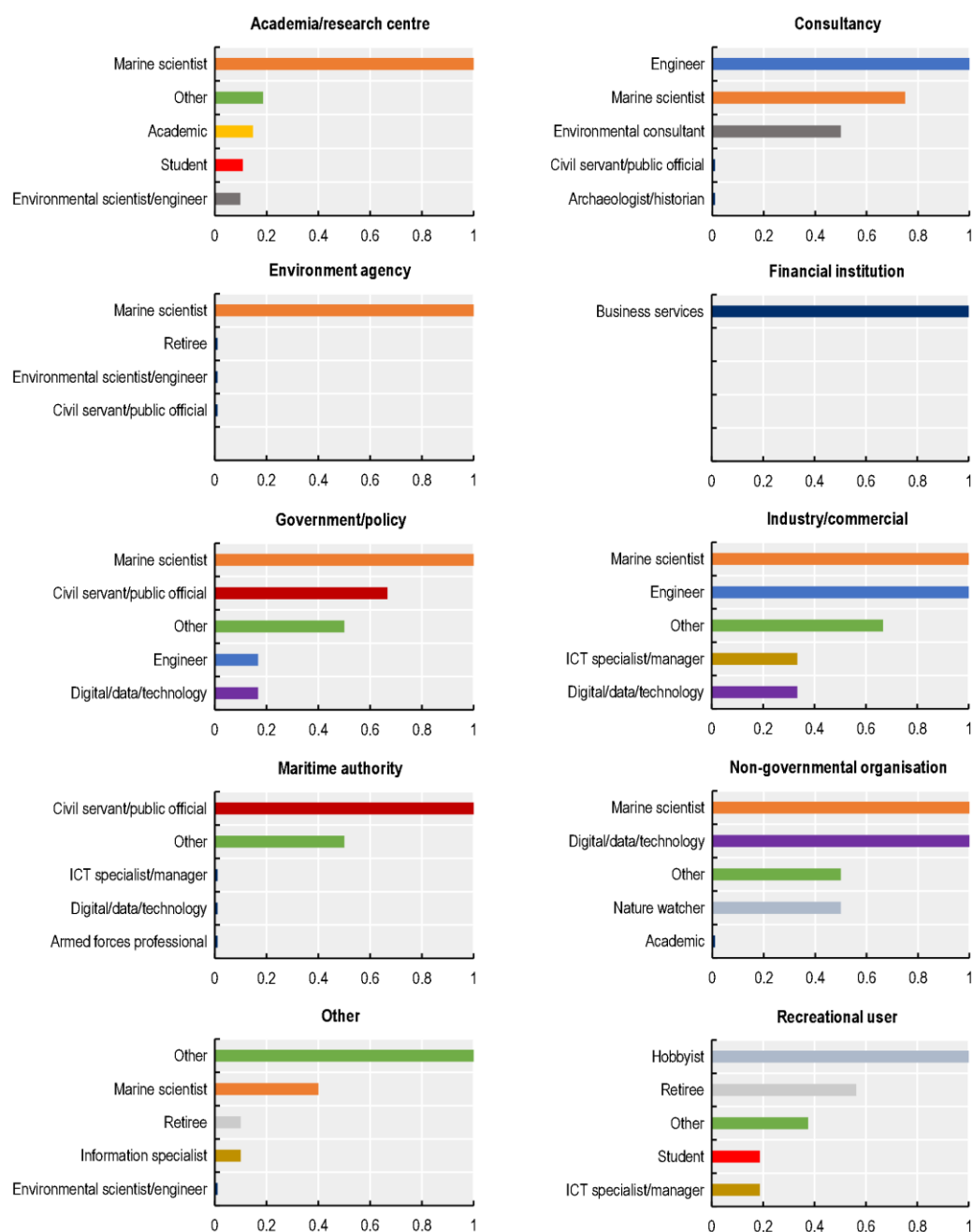
Note: The chart displays the top five occupations in each sector revealed by the survey. Less than five occupations are displayed if less than five occupations were selected by respondents from a particular sector. The occupation count for each sector has been normalised to emphasise the relative importance of each occupation in each sector.

Figure 4. Survey respondents use both nationally and internationally focused Flanders based repositories

Total number of unique respondents selecting each repository
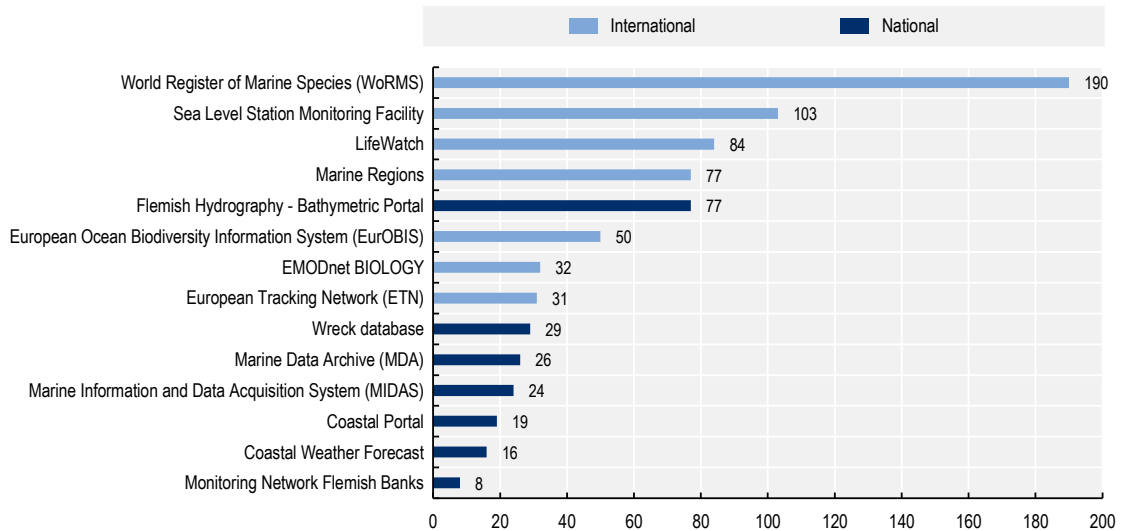
Note: The chart depicts the total number of times each repository was selected by respondents. Light blue bars represent internationally focused repositories based in Flanders and dark blue bars represent nationally focused repositories.

Figure 5. Most respondents use Flanders' public marine data repositories on a monthly or more frequent basis

Percentage of total number of responses selecting each level of frequency of use of Flanders' repositories
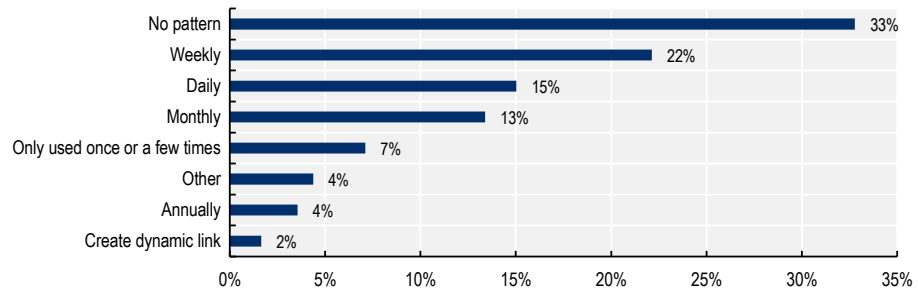
A total of 366 unique respondents selected the frequency with which they used the data they access through public marine data repositories based in Flanders. The largest category was "No pattern" which 120 respondents selected. Combining the "Weekly", "Daily", and "Monthly" categories reveals that 185 unique respondents use the data on a monthly or more frequent basis. A total of six unique respondents selected "Create dynamic link" meaning they access the data automatically via web services. Figure 5 above gives the percentage of total responses to the question for each category of frequency.

Respondents were asked what they would do if public marine data repositories based in Flanders did not exist and 354 did so. The most selected option was "Make decisions based on available next-best data" which was selected by 180 unique respondents. The least selected option was "Purchase the data privately" which was selected only 27 times. Figure 6 below reports the results of this question. The options "Make decisions based on available next-best data", "Make direct request to the organisation to obtain the

data", "Collect the data in the field", "Duplicate efforts to create or derive data" and "Use data modelled by myself" could all be pursued by respondents if Flanders' repositories were not available to them. The results suggest using Flanders' repositories is preferred to each of these alternative options because the net benefits associated with use of the repositories are greater than the net benefits associated with each alternative option.

Figure 6. Users would need to make alternative, potentially more costly, arrangements if Flanders' repositories did not exist

Percentage of total number of responses selecting each alternative to Flanders' repositories
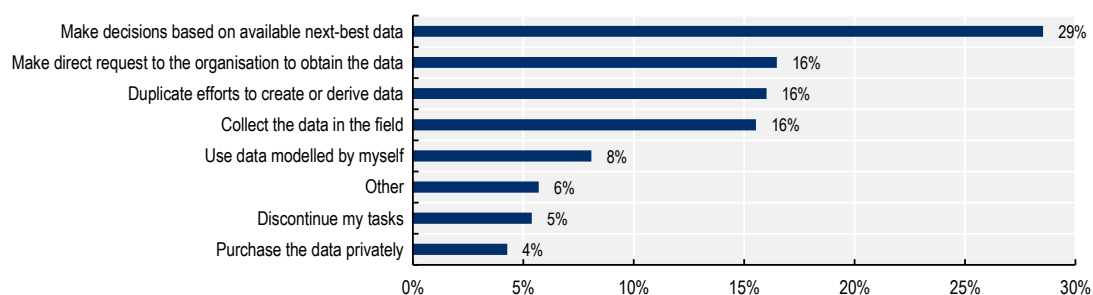
Individual users access marine data from across the spectrum of parameter disciplines

Respondents were asked to select the variables they use from Flanders' based public marine data repositories. The list of options was taken from a controlled vocabulary provided by SeaDataNet's P03 Agreed Parameter Groups which contains 52 individual categories of parameter group.

In total, 308 people responded to this question. On average, they selected 4.2 parameter groups per person. A total of 97 respondents selected one parameter group only, the most frequent number of parameter groups selected. Most people selected fewer than six parameter groups but 13 people selected more than 10 parameter groups and five people selected more than 20 parameter groups. One person selected all 52 parameter groups.

The most frequently used parameter group among the respondents is "Sea level", which was used by 104 people and represents 8 per cent of the total number of parameter groups selected. The second largest parameter group was "Fish" with 73 selections or 6 per cent of the total selected. A total of 22 parameter groups were selected by more than 20 unique respondents.

The controlled vocabularies provided by SeaDataNet have a loose hierarchical structure whereby each parameter group in SeaDataNet's P03 list belongs to at least one category provided by the SeaDataNet P08 Parameter Discipline list. This hierarchy has been edited so that each parameter group belongs to only one parameter discipline to form a strict hierarchy of nine parameter disciplines.

Of the top 10 parameter groups in terms of number of selections by unique respondents, four belong to the parameter discipline "Physical oceanography" and four belong to the parameter discipline "Biological oceanography". Overall, the largest parameter discipline selected from is "Biological oceanography" from which 394 parameter groups were selected. The second largest parameter discipline is "Physical oceanography" which was selected from 311 times.

The parameter disciplines in the SeaDataNet controlled vocabulary contain different numbers of parameter groups. The largest discipline, "Biological oceanography", has 12 parameter groups associated with it. "Human activities" and "Marine geology" both have 11 parameter groups associated with them, "Physical

oceanography" has 7, "Chemical oceanography" has 6, and "Administration and dimensions", "Atmosphere" and "Terrestrial" all have 1.

The ranking of parameter disciplines implied from the results may therefore be biased by the number of parameter groups available for selection from within each parameter discipline. One simple way to account for this potential source of bias is to divide the count of parameter groups selected for a particular discipline by the number of groups available to select from that discipline. Figure 7 below reveals the result of this calculation.

Figure 7. Respondents use data from Flanders' repositories that span the range of common marine parameter disciplines

Count of parameter disciplines weighted by the number of parameter groups available to select from each parameter discipline
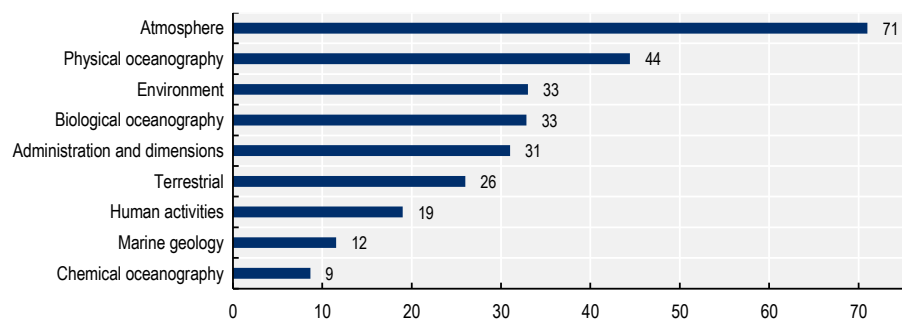
Users combine marine data types from different parameter disciplines to generate the information they require in analysis

Many of Flanders' based repository users access data from multiple parameter disciplines. While just over half the respondents to the parameters question selected parameter groups from only one parameter discipline, 144 respondents selected parameter groups from more than one parameter discipline. Of the 36 possible combinations of parameter disciplines, 34 are positively correlated meaning that respondents who pick more/less of one tend to pick more/less of the other.

A more detailed analysis of the relationships between parameter disciplines would consider all connections between all parameter disciplines in the response data. The multilateral relationships between parameter disciplines can be viewed as a network whereby parameter disciplines represent nodes and the connections between them - formed when a unique respondent selects parameter groups from two parameter disciplines at the same time - form the edges.

Modelling the parameter response data as a network helps to highlight the importance of particular parameter disciplines in the work of users that rely upon multiple parameter disciplines in their analyses. One method for assessing the importance of a particular node in a network is to calculate the number of edges it has with other nodes on the network. The larger the number of edges, the more important the node is. In this case, parameter disciplines that are selected alongside many other parameter disciplines by respondents would be more important than parameter disciplines that are selected by respondents uniquely.

Figure 8. Respondents often reported using data accessed via repositories from multiple parameter disciplines

Relationships between parameter disciplines selected by unique respondents
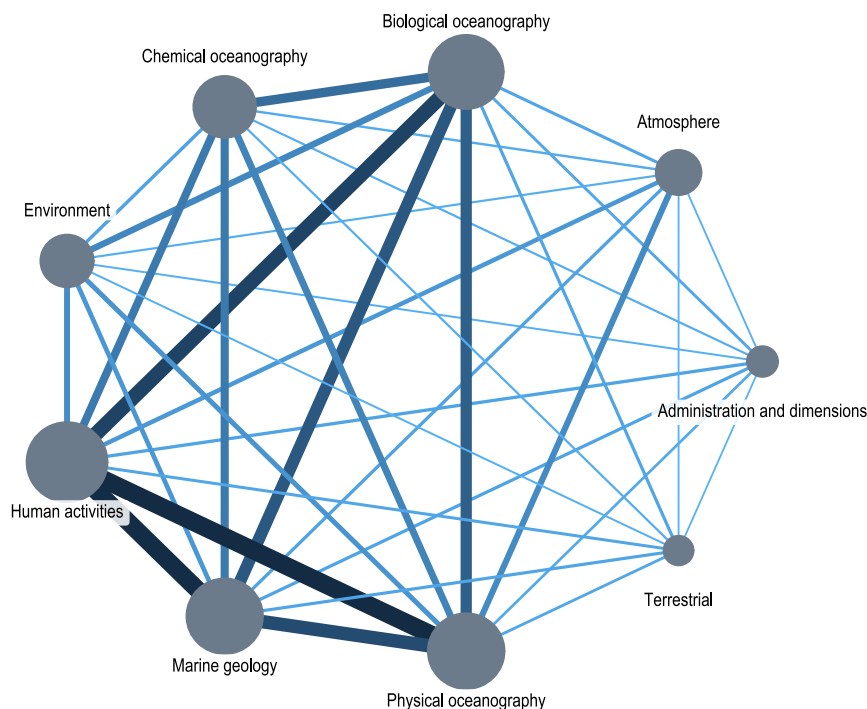
Note: The size of the points (nodes) represents the importance of the parameter discipline in terms of the number of times parameter groups from it were selected alongside those from other parameter disciplines by unique respondents. The thickness of the lines (edges) represents the number of times parameter groups from the parameter disciplines linked by the line were selected by the same respondent.

The response data suggest that the largest node on the network - the most important parameter discipline in terms of the number of connections it has with other parameter disciplines - is "Human activities". Parameter groups from "Human activities" were selected alongside parameter groups from other parameter disciplines 2 319 times in total. The parameter discipline that achieved the highest count of parameter groups selected, "Biological oceanography", is placed fourth in terms of its importance. "Atmosphere", the most selected parameter discipline when the weighted count is used, is in seventh position. "Physical oceanography", the second placed parameter discipline in both the unweighted and weighted counts, is also in second position in terms of its importance to the network here. The least important parameter discipline according to this analysis is "Terrestrial" with a total of 273 connections.

The network diagram in Figure 8 above charts the relationships between parameter disciplines estimated in this manner. The sizes of the points (nodes) reflect the number of connections (edges) each node has with other nodes. Parameter disciplines with more edges are larger than those with fewer edges. The thicknesses of the edges reflect the frequency with which parameter groups from each parameter discipline are selected together by unique respondents. For example, the thick line between "Human activities" and "Marine geology" represents an edge of 600 instances of parameter groups from each of those disciplines being selected together and the thin line between "Biological oceanography" and "Atmosphere" represents an edge of 57 instances.

Box 3. Case studies: Use of Flanders public marine among national and international organisations

As shown in the survey data, the public marine data provided by Flanders' data repositories is deployed by a wide user audience ranging from professional end-users from the ocean economy, marine researchers and passionate citizens. Once downloaded, these data are therefore not only used for front-line analysis, but also find their way into further use cases and broader applications, giving the data a second and even a third life. In addition, a trend is seen in the increase in machine to machine – rather than in person – downloads. To make the breadth of the day-to-day use of the data a bit more tangible, two use cases provided by public marine data experts in Flanders are briefly elaborated below.

Digital twin for Port of Antwerp-Bruges (POAB)

Port of Antwerp-Bruges is Europe's second largest port. With connections to more than 800 destinations, it connects the European continent with the rest of the world. Port of Antwerp-Bruges provides 106 320 direct jobs and as much as 29 billion euros of added value per year. Data are in general important for the Port's operations and the Port is currently developing a digital twin of the harbour. The bathymetric data hosted in the Flemish repositories are used to analyse risk and inform operations and business decisions. Specific activities and operations can then include managing dredging operations, inform infrastructure works and inform daily port and navigation operations. A direct link between the repository and other systems ensures the use of the latest available bathymetric data by all users.

UNESCO Tsunami Unit saves lives

The UN International Oceanographic Commission's (IOC) Tsunami Programme aims at reducing the loss of lives and livelihoods that could be produced worldwide by tsunamis. To accomplish this, the IOC Tsunami Unit supports IOC Member States in assessing tsunami risk, implementing Tsunami Early Warning Systems (EWS) and in educating communities at risk about preparedness measures. The Global Sea Level Observing System (GLOSS), a component of the Global Ocean Observing System (GOOS), is establishing a well-designed, high-quality sea level observing network to support a broad research and operational user base.

The main data repository used is the worldwide Sea Level State Monitoring Facility (SLSMF). The data downloaded from the SLSMF or from secondary data centers is used for tsunami and storm-surge warnings, research and propagation modelling, station maintenance and troubleshooting, planning of the observational capacity. After additional processing and integration with additional data, the data are used for coastal erosion research and coastal protection studies, global sea-level rise (IPCC, JASL) and localized sea-level change studies. Data are downloaded constantly and in real-time. During tsunami events the real-time data downloads can easily increase a hundred-fold. A total of 3.6 billion web hits from users and machines were registered for 2021, and approximately 7.9 terabytes of data was downloaded during 2021. Both measures grew by 10-20% in 2022.

Source: ADD AUTHOR'S NAMES

In addition to considering the links between parameter disciplines, the network analysis can be extended to connections between the parameter groups themselves. In this case, the largest node – the most important parameter group in terms of the number of connections it has with other parameter groups – is "Sea level" which was selected alongside other parameter groups 578 times in total. The remaining four parameter groups in the top five most important nodes are "Currents" with 527 connections, "Meteorology" with 469, "Habitat" with 435, and "Water column temperature and salinity" with 420. "Sea level", "Currents", and "Water column temperature and salinity" belong to the parameter discipline "Physical oceanography". "Meteorology" belongs to the parameter discipline "Atmosphere". And "Habitat" is from the parameter discipline "Environment". The combination of parameter groups that were selected most frequently is "Sea level" and "Waves" with 63 unique respondents selecting these parameter groups together.

Reuses of public marine data are plentiful and have effects on a broad range of ocean economic activities

Respondents were asked to reveal the actions they take with the data they access through Flanders' based repositories from a list of options pre-selected by the project team. In total, 310 people responded to this question. On average, they selected 2.2 actions per person. A total of 66 respondents selected three actions. As respondents were able to select up to three actions from the options list, they were also asked to rank the importance of each of the selected actions in their overall activities. This ranking has been used to manipulate the count of selections to ensure that actions of lesser importance weigh less heavily on the total than actions of greater importance.

Figure 9 below gives the results from the question on actions taken. The top three actions taken with the data after weighting for the importance of each in the overall activities of respondents are: "Conduct research and development" with 155 weighted selections, "Validate data from elsewhere" with 72 weighted selections, and "Raise awareness and education" with 71 weighted selections.

Respondents were then asked to reveal the fields in which they take the actions with the data revealed by the previous question from a list of options pre-selected by the project team. In total, 336 people responded to this question. On average, they selected 2.1 per person. A total of 148 respondents selected three fields. As respondents were able to select up to three fields from the options list, they were also asked to rank the importance of each of the selected fields in their overall activities. This ranking has been used to manipulate the count of selections to ensure that fields of lesser importance weigh less heavily on the total than fields of greater importance.

Figure 10 below gives the results from the question on fields in which actions are taken. The top three fields in which actions are taken with the data after weighting for the importance of each in the overall activities of respondents are: "Marine science" with 112 weighted selections, "Education" with 49 weighted selections, and "Conservation of marine environments" with 45 weighted selections.

Respondents were then asked to reveal the industries that are affected by their use of the data from a list of options pre-selected by the project team based on important industries in the ocean economy. In total, 301 people responded to this question. On average, they selected 2 per person. A total of 116 respondents selected three industries. As respondents were able to select up to three industries affected from the options list, they were also asked to rank the importance of each of the selected industries in their overall activities. This ranking has been used to manipulate the count of selections to ensure that industries of lesser importance weigh less heavily on the total than industries of greater importance.

Figure 9. Actions relating to the innovation process were regularly selected by respondents but so were those concerned with education, planning and regulations

Number of times each action was selected weighted by the importance that each unique respondent placed on that selection in their overall activities

Action	Value
Conduct research and development	155
Validate data from elsewhere	72
Raise awareness and education	71
Analyse risk	59
Manage marine resources	46
Inform marine planning decisions	39
Inform business/industry/user decisions (inc.leisure)	38
Inform operations	31
Inform coastal planning decisions	30
Inform policy decisions/regulations	24
Analyse policies	19
Conduct statutory reporting	10
Raise finance	8
Target investments	4
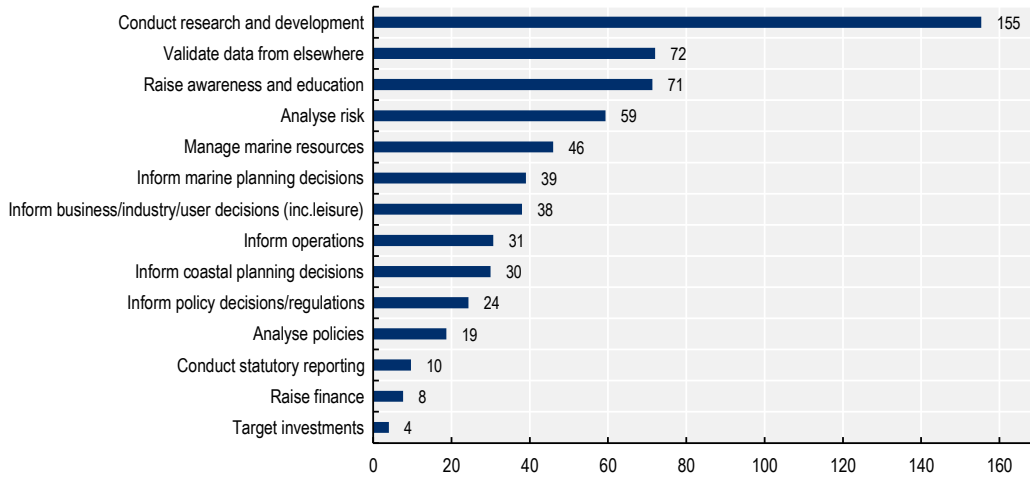
Figure 10. Fields in which actions are carried out go far beyond the fields for which the data are originally collected such as marine science

Number of times each field was selected weighted by the importance that each unique respondent placed on that selection in their overall activities

Field	Value
Marine science	112
Education	49
Conservation of marine environments	45
Citizen science	37
Conservation of marine wildlife	37
Coastal protection	31
Sea state forecasts and predictions	29
Conservation of coastal environments	28
Navigation	25
Leisure activities	22
Climate science	22
Marine area management	20
Weather forecasts and predictions	19
Fisheries scientific advice	17
Fisheries management	15
History	12
Inspection activities	10
Search, rescue and safety of life	5
Policy development	5
Food security	4
Marine archaeology	3
Human health	2
National defence	2
Inert extraction	1

Figure 11. Reuses of public marine data from Flanders' repositories have effects on a wide range of industries associated with the ocean economy

Number of times each industry affected was selected weighted by the importance that each unique respondent placed on that selection in their overall activities
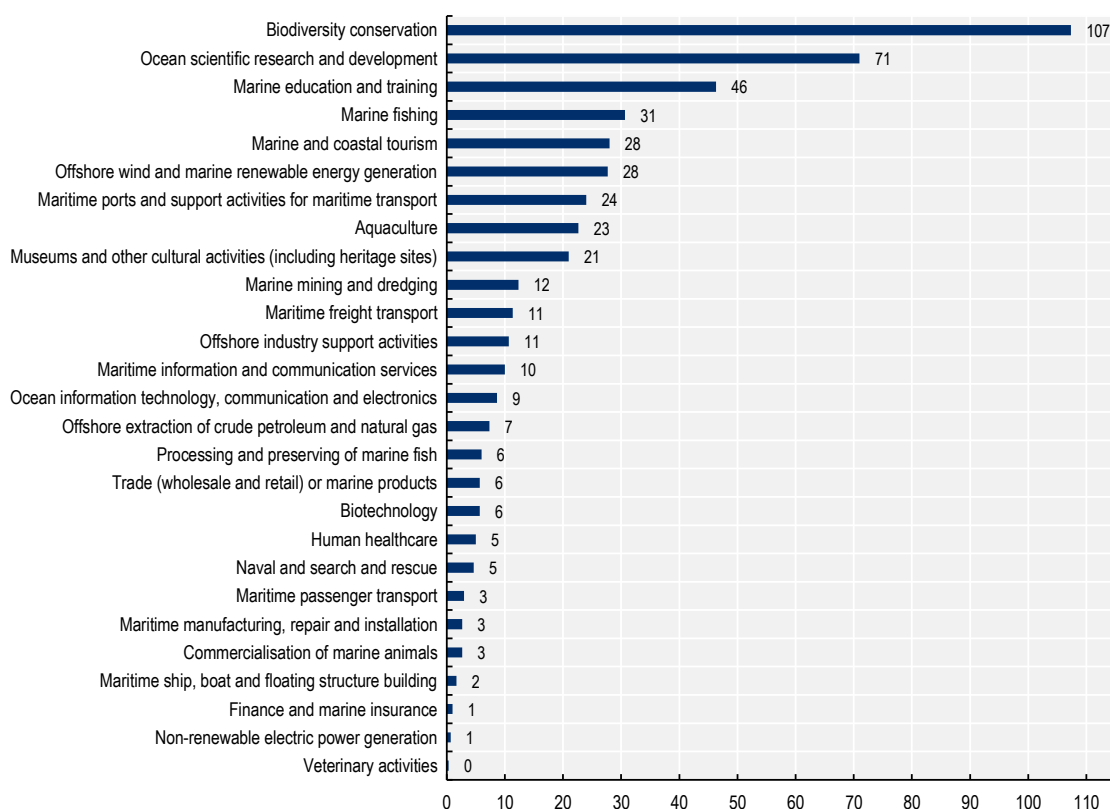
Figure 11 above gives the results from the question on the industries affected by the use of the data. The top three industries affected after weighting for the importance of each in the overall activities of respondents are: "Biodiversity conservation" with 107 weighted selections, "Ocean scientific research and development" with 71 weighted selections, and "Marine education and training" with 46 weighted selections.

Value chains based on data from Flanders' repositories are varied, complex and indicate the broad reach of public marine data reuse

Responses to the questions discussed above can be combined to build an image of the flow of data from action to field to industries affected. Conceptual value chains have traditionally been used to highlight the contribution of different elements to the value created at each stage of a production process. Here, we are trying to understand the contribution of public marine data to the creation of societal value.

A number of steps are taken in order to clearly visualise the marine data value chains revealed by the survey. Firstly, the number of categories of actions, fields and industries are reduced using mappings of survey options available to grouping categories given in Annex C. Then a composite indicator for respondent-specific actions, fields and industries is generated and linked to the parameter disciplines selected by each unique respondent. The composite indicator is calculated by multiplying the rankings of

actions, fields, and industries by each other for each respondent. This reflects the importance of connections between actions, fields and industries in respondents' overall activities for each parameter discipline and results in values ranging from 0 and 1. Identical value chains are then grouped together and the group totals of the values of the composite indicators are calculated.

Figure 12. Conceptual value chains collected by the survey reveal many avenues through which public marine data generate value for society

Visual depiction of the flow of parameter types from the actions taken with data to the fields in which these data are applied to the industries that are affected

Note: The height of each grey box labelled by an action, field, or industry category represents the number of value chains associate with that category. The widths of the lines linking actions, to fields, to industries are scaled by the score for that particular element of the value chain. The categories of actions, fields and industries available for selection by respondents have been grouped together according to the mapping of options in the survey and grouping categories given in Annex C.

This process enables the generation of the conceptual value chains depicted in Figure 12 above. The highest scoring value chain by this analysis links parameters from the discipline of "Biological oceanography" being used for the action "Conduct research and development" in the field of "Marine science" with effects on the "Biodiversity conservation" industry. This takes into account the responses from all respondents even if they did not answer other questions in the survey.

The conceptual value chains can also be considered according to the sector in which respondents work for those that responded to the relevant question on sector. The diagrams in Annex D display the conceptual value chains broken down by the sector that each respondent reported belonging to. Highlights from the sectoral analysis include:

- The highest scoring value chain for respondents in the "Academia/research centre" sector links parameters from "Biological oceanography" being used to "Conduct research and development" in the field of "Marine science" with effects on the "Biodiversity conservation" industry.
- The highest scoring value chain for respondents in the "Recreational user" sector links parameters from "Physical oceanography" being used to "Analyse risk" in the field of "Navigation" with effects on the "Maritime ports and support activities for maritime transport" industry.

Figure 13. Nationally focused value chains are also diverse but reflect differences in the data types made available by Flanders' national and international repositories

Visual depiction of the flow of parameter types from the actions taken with data to the fields in which these data are applied to the industries that are affected

Note: The height of each grey box labelled by an action, field, or industry category represents the number of value chains associate with that category. The widths of the lines linking actions, to fields, to industries are scaled by the score for that particular element of the value chain. The categories of actions, fields and industries available for selection by respondents have been grouped together according to the mapping of options in the survey and grouping categories given in Annex C.
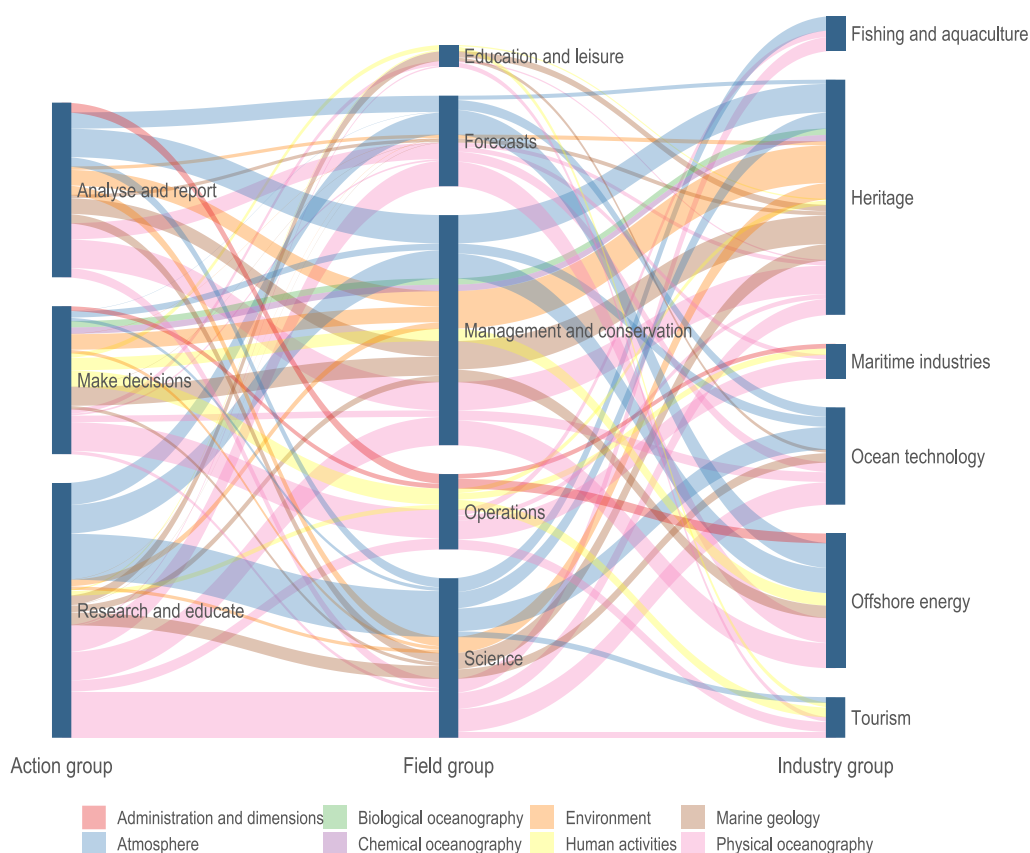
- The highest scoring value chain for respondents in the "Government/policy" sector links parameters from "Atmosphere" being used to "Raise awareness and education" in the field of "Weather forecasts and predictions" with effects on the "Marine and coastal tourism" industry.
- The highest scoring value chain for respondents in the "Industry/commercial" sector links parameters from "Atmosphere" being used to "Inform business/industry/user decisions (including leisure activities)" in the field of "Weather forecasts and predictions" with effects on the "Offshore wind and marine renewable energy generation" industry.

- The highest scoring value chain for respondents in the "Consultancy" sector links parameters from "Biological oceanography" being used to "Validate data from elsewhere" in the field of "Conservation of marine environments" with effects on the "Offshore wind and marine renewable energy generation" industry.
- The highest scoring value chain for respondents in the "Non-governmental organisation" sector links parameters from "Biological oceanography" being used to "Conduct research and development" in the field of "Marine science" with effects on the "Biodiversity conservation" industry.

A key characteristic of public marine data provision in Flanders is that the region hosts both nationally focused and internationally focused marine data repositories. The value chain in Figure 12 above is generated from the results of all respondents from each sectoral grouping and does not account for whether respondents use national or international repositories. However, 16 use only nationally focused repositories and the value chains associated with their use may be qualitatively different to those that use both national and international or only international repositories. Figure 13 above therefore contains the results for respondents that use nationally focused repositories uniquely.

The highest scoring value chain among respondents who use only national repositories links "Administration and dimensions" being used to "Analyse risk" in the field of "Navigation" with effects on the "Marine mining and dredging" industry. The second highest links "Atmosphere" being used to "Analyse policies" in the field of "Policy development" with effects on the "Biodiversity conservation" industry. And the third highest links "Atmosphere" being used to "Analyse risk" in the field of "Policy development" with effects on the "Biodiversity conservation" industry.

Reported use benefits reaffirm Flanders' role in providing easy access to quality data at near-zero cost to the user

The survey question requesting respondents' opinions on the benefits generated from their uses of public marine data allowed for freehand inputs only. The responses therefore provide information that is not uniform across respondents and depends to a large extent on each respondents' interpretation of the meaning of "benefit".

The predominance of marine scientists and other academics among the respondents is perhaps one reason why the provision of accurate and organised data was regularly reported by respondents as being a societal benefit in and of itself. However, other common themes appear when considering the benefit responses as a whole. The three themes of benefits considered by the OECD to appear commonly in the responses are as follows:

- **Building confidence in information**: Reported benefits associated with using public marine data from Flanders' repositories to check, compare and validate existing information.
- **Expanding knowledge**: Reported benefits associated with using public marine data from Flanders' repositories to conduct research and perform science, increase public awareness and educate.
- **Underpinning decision-making**: Reported benefits associated with using public marine data from Flanders' repositories for decision-making in operational settings such as business planning and risk reduction.

Where possible, each freehand response has been associated with one and only one of the above categories. Of the 212 unique responses to this question, 17 could not be associated with one of the categories above either because the response was not clear enough to the authors or no obvious societal

benefit was described. For example, of these 17 non-applicable responses, two revealed that they use Flanders repositories for personal "fun" only.

Table 3. Themes of societal benefits considered to commonly appear in freehand responses are distributed differently among respondents using Flanders' national and international repositories

Count of common themes associated with each freehand response according to respondents using national only, national and international, and international only repositories by total and percentage of respondents using each type of repository

Benefit theme	National	National/International	International	Total
Building confidence in information	2 (25%)	19 (38%)	60 (46%)	**81**
Expanding knowledge	2 (25%)	9 (18%)	42 (30%)	**50**
Underpinning decision-making	4 (50%)	22 (44%)	32 (24%)	**58**

Table 3 above reveals the results of this exercise according to whether respondents use Flanders' national repositories only, Flanders' international repositories only or a mixture of the two. The largest category of common benefit theme relates to "Building confidence in information" which has been associated with a total of 81 unique respondents. This category is also the highest theme for respondents that use only international repositories based in Flanders with 46% of these respondents having been associated with "Building confidence in information". The second highest category overall with 58 respondents – "Underpinning decision making" – is the highest common theme associated with national only and national and international repository users with 50% and 44% of respondents respectively. "Expanding knowledge" is the lowest category of common benefit theme with 50 respondents.

While the costs to the user of accessing public marine data through Flanders' repositories are near-zero, the value of the societal benefits described under each common theme are likely to be considerable should reliable estimates be achieved:

- Examples of specific benefits in responses associated with the "Building confidence in information" theme include providing reliable source data for quality assuring biodiversity datasets, providing access to wind data from higher precision instrumentation than available on consumer markets, and providing the data by which mathematical models of ocean circulation are calibrated and validated.

- Examples of specific benefits in responses associated with the "Expanding knowledge" theme include enabling understanding of processes affecting marine and coastal changes, improving public understanding of ocean swells, and using real time data in university education.

- Examples of specific benefits in responses associated with the "Underpinning decision-making" theme include accurate estimation of environmental conditions for optimising offshore operations, providing the data for models of storms and tsunamis to improve early warning systems and other disaster risk reduction tools, and generating new scientific knowledge for marine spatial planning.

4 Discussion, recommendations and next steps

This paper has summarised the results of an OECD survey of the users of Flanders' public marine data repositories. Its focus is filling knowledge gaps that exist in understanding the value of public marine data by collecting missing information on the reuse of data from users and asking their opinions on the value generated.

The survey is structured so that descriptions of the value chains of data reuse – from the types of data accessed to the benefits generated from their use in analysis – can be realised. For example, a common value chain apparent in the responses to the survey links data from the "Biological oceanography" parameter discipline being used to "Conduct research and development" in the field of "Marine science" with effects on the "Biodiversity conservation" industry. The benefits of this particular value chain taken from the survey range from "Inform[ing] industry for business operations and product development" to "Expand[ing] knowledge for personal use (leisure, hobbies, and others)".

Several factors make Flanders an interesting case study for the value of public marine data. A range of ocean economic activities are well-developed in Belgium but are contained within a relatively small marine space when compared to other important ocean economies. Good governance is therefore paramount and Belgium's Marine Spatial Plans provide the backbone for ensuring that Belgian's portion of the North Sea is used effectively. Many important ocean-related institutions in Flanders are committed to realising the objectives laid out in open data policies for research and scientific data. Furthermore, multiple important international data centres are based in Flanders along with the offices that control them.

The survey therefore represents a good opportunity to consider the provision of public marine data from Flanders repositories in the context of its value to Belgian society and to the global community that are served by the international repositories based there. The OECD and its partners in Flanders have distilled the results of the survey into five discussion points and related recommendations to be considered by policymakers concerned with all aspects of marine and coastal governance.

- **Provision of public marine data in Flanders is helping to realise the Flemish Government's open data objectives, is used to increase knowledge and understanding of marine and coastal spaces in Belgium, and could be considered a model for other coastal regions looking to broaden the reach of public marine data provision in their communities.** The survey reveals the public marine data flowing from Flanders' national repositories are being used in analysis that is beneficial to many users of the Belgian portion of the North Sea and beyond. Uses of the data in searching for appropriate areas for developing ocean economic activity as well as understanding the environmental implications of these developments are present in the response data. Furthermore, the repositories taking part in the survey are all committed to the objectives of the Flemish Government in providing open-access to research and scientific data. In general, the openness of the data was highlighted as a key benefit by respondents to the survey. Together this demonstrates the potential for alignment between the marine data community and public policymakers to prioritise the needs of public marine data users and thereby increase the likelihood that the benefits of reuse are maximised.

- **Reuses of public marine data from Flanders' repositories result in complex value chains that affect a large variety of ocean economic activities globally but more could be done to collect information on these uses from users**. Major actions taken with the data include activities associated with the innovation process such as research and development, the fields in which the data are applied include those with major environmental externalities such as the conservation of marine environments, and the economic activities affected by these uses range across the full spectrum of those considered part of the ocean economy. However, little information is collected from the data users that would help ensure the provision of public marine data remains relevant to their needs. Exploring ways in which this information could be collected while maintaining adherence to the findable, accessible, interoperable, and reusable principles could be considered by repository managers.

- **Flanders' marine data repositories play a fundamental role in enabling the existence of these value chains by ensuring that quality data are available to anybody who wants it at very little cost to the user but some users report facing challenges with data access.** The challenges highlighted by the survey include those that are relatively straightforward to solve such as improving documentation to those that will require potentially substantial resources such as speed improvements. The negative effects of these challenges on users' ability to access data are likely to be compounded for users of Flanders' international repositories in low-income countries where resources are scarce and internet speeds, computing power, and storage space limited. Flanders' repositories are already taking steps to improve access in these areas. The Flemish Government is supporting the UN International Oceanographic Commission's Ocean InfoHub project, for example, that is based on advanced open source tools that enable a faster and more effective search capability that is customisable by different user communities. Such initiatives will improve access domestically and in the rest of the world and should continue to be supported if better access continues to be an objective.

- **Many users of Flanders' public marine data repositories rely upon multiple national and international repositories to access the data they need, which suggests that data aggregators and integrated metadata search engines could be useful tools for optimising access.** Almost half of all respondents accessed multiple repositories regularly and nearly all respondents used a combination of marine data parameters in their analysis. Many of Flanders' repositories already work to organise their data records according to widely agreed standards and to ensure their datasets are findable by users. The next steps are to further invest in improving the semantic and technical interoperability of data and data systems. As a consequence, the use and development of metadata search engines will enable users to search the contents of datasets across all Flanders' repositories and direct them towards the specific repository that meets their needs.

- **Flanders' embrace of international data centres gives it a unique position in the global provision of public marine data and the potential to build upon an agglomeration of marine data expertise.** The large number of international repositories in Flanders and the collection of expertise required to manage them in a relatively small geographical area could be a powerful lever for local productivity increases if networking opportunities are taken advantage of. Agglomeration benefits can also be traded through international collaborations, creating opportunities for learning, resource sharing, and further productivity improvements in all countries involved. Initiatives such as the Flanders Marine Institute's bilateral cooperation agreements with several Latin American countries and the addition of a branch of Marine@UGent to the Ghent University campus in Incheon, Korea, could provide a basis for widening and expanding the international repositories to which Flanders contributes. Other examples of Flemish organisations sharing their knowledge on the development of public marine data infrastructures include contributions to the OceanTeacher Global Academy (OTGA), training sessions for users of the European Ocean Biodiversity Information System (EurOBIS) and the European Marine Observation and Data Network

(EMODnet), financial support for editors to address priority gaps within the World Register of Marine Species (WoRMS) as well as trainings in providing fair, accessible, interoperable and reusable data alongside the European Marine Biological Resource Centre (EMBRC) and the European Strategy Forum on Research Infrastructures (ESFRI).

The results of the survey provide detailed descriptions of the value chains associated with public marine data from Flanders' repositories. The next step in better understanding the value of these data is to quantify in monetary terms the benefits realised at the end of the chains so that they can be compared with the costs of funding them (which tend to be budgeted for and recorded and are usually therefore easier to quantify monetarily). The difference between the benefits and the costs of public marine data systems is one way of measuring their overall value to society. However, monetary valuation of this type is not a simple endeavour. The OECD is currently finalising a project with IOC/UNESCO's Global Ocean Observing System (GOOS) on appropriate methods for monetary valuation of the benefits generated by ocean observations data which are also likely to be relevant for broader marine data types. At the level of the European Union, for example, knowledge of value created through public marine data repositories can help inform investments in the European Ocean Observing System (EOOS).

Finally, the OECD has now conducted three surveys of the users of public marine data repositories in three different countries (Belgium (Flanders), Portugal and the United Kingdom). While the results of the three surveys are not directly comparable, common themes exist in the response data such as the complexity of the value chains emanating from public marine data that go far beyond the initial purpose for collecting the data. The OECD has also been working with experts on the space economy to better understand the societal value of satellite data. Both strands of work could be elaborated upon in an OECD Policy Paper that seeks to provide a high-level overview of the state of open data provision for the ocean economy should the public marine data community confirm its utility.

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Annex A. Brief note on survey design

The objective of the survey was to gather opinions from the users of Flanders-based public marine data repositories so that the value chains associated with the use of the data could be described. The opinions were collected in a structured manner via an online questionnaire that was advertised on the websites of data repositories, in the newsletters of relevant organisations, and via the mailing lists of particular people or organisations.

No information on the demographics of the full population of users of Flanders' marine data repositories was available to the survey team. The target population was therefore unknown and no attempt was made to procure a representative sample beyond the strategic placement of the advertisement. Coverage, sampling and nonresponse errors were not measured as a result. The sample of respondents can therefore be described as a non-probability convenience sample and the results should not be considered representative of the population of the users of Flanders' marine data repositories.

 The survey had 19 individual blocks of substantive questions with a possible total of 51 questions if all branch questions were answered. Different question types were used throughout the survey. For some questions, options were predetermined. The options for the marine environmental variables, for example, were taken from a list of parameter groups belonging to SeaDataNet's P08 controlled vocabulary which can be accessed easily online through a generic web search. For questions on uses, challenges and benefits, open-ended freehand responses were asked for. In each open-ended freehand question, respondents were able to upload files and provide weblinks to documents or examples they felt aided their response.

The survey is similar to an OECD survey conducted in 2020/21. of the users of marine data and archive management centres in the United Kingdom (UK). However, lessons learned from the design of the UK survey were incorporated into the survey of the users of Flanders' repositories. While continuation was ensured for certain parts of the survey, the changes to survey design mean that many of the results of the two surveys are not directly comparable.

Annex B. Flanders' national and international public marine data repositories

Flanders plays an important role in the global ocean information system by hosting multiple international data centres. The list of public marine data repositories in Flanders includes those that are focused on Belgian territorial waters as well as several international data centres that process, store and make available global data for a global user base.

National marine data repositories

Bathymetric Portal

Hydrographic soundings, also called surveys, are three-dimensional measurements (x, y, z) that allow the topography of the seabed and the bottom of rivers to be mapped. To execute these depth measurements, acoustic measuring systems such as "single beam" and "multibeam" devices are used. The measurements can then be processed into depth charts, difference maps, volume determinations, and cross sections. The method of survey and data processing that is used depends on the purpose of the measurement and the requirements of the end user. The depth charts and sea maps of Flemish Hydrography are used to ensure safe navigation, to calculate and control hydraulic infrastructure works, to control dredging, etc. These surveys are executed at sea, on the Scheldt, on the Flemish part of the channel Ghent-Terneuzen, and in the four coastal ports. The acquired data is converted into paper and electronic depth charts.

Coastal Portal

The aim of the Coastal Portal is to provide user-friendly access to information and data products on user functions and monitoring activities in the Belgian part of the North Sea and the coastal zone, including beaches, dunes and polders. The portal offers the possibility to display both static and interactive data products and maps in the form of conveniently arranged GIS layers with the possibility to link to the underlying metadata.

Coastal weather forecast

In our Oceanographic Meteorological Station we produce an exclusive weather forecast for the sea and coast, which is disseminated not only to professional users, such as port authorities and shipping professionals, but also to the general public.

Marine Data Archive (MDA)

The Marine Data Archive (MDA) is an online repository specifically developed to independently archive data files in a fully documented manner. The MDA can serve individuals, consortia, working groups and institutes 1) to manage data files and file versions for a specific context (project, report, analysis, monitoring campaign); 2) as a personal or institutional archive or back-up system 3) as an open repository for data publication.

Marine Information and Data Acquisition Service (MIDAS)

MIDAS provides access to data from the cruises of the research vessel RV Simon Stevin, specifically the registration of research activities during these cruises and the registration of navigational, meteorological and oceanographic parameters en route. All data are organised into cruises and voyages. For each voyage performed, a link to the data en route, stations, research activities and a map of the route is available.

Monitoring Network Flemish Banks

The Monitoring Network is named after the group of irregular sandbanks located in front of the western half of the Flemish coast. These sandbanks complicate navigation in that area. The Flemish Banks Monitoring Network consists of a monitoring network at sea, weather parks ashore, and a computer network in Oostende. The network at sea, consisting of measuring piles and wave measurement buoys, and the meteo parks ashore, are equipped with hydro-meteorological sensors. The central computer network gathers and processes the data and exchanges it with international monitoring networks, research institutes, universities etc.

Wreck database

In the Belgian part of the North Sea, there are many wrecks and obstacles. Wrecks are a particularly special attraction. For fishermen, these are often interesting areas where a good catch can be expected. For divers, wrecks provide a unique under water experience. 'Under water" archaeologists research the wrecks to gain a better idea of life and customs at the time on board these shipwrecks from the distant past.

Wrecks and obstacles may hinder shipping. The task of the Flemish Hydrography is to determine the correct location of these wrecks and to measure their exact depth above the seabed. By using specialised acoustic equipment, such as a side scan sonar or a multibeam, even the smallest part of the wrecks can be mapped. The bigger the difference in absorption of the acoustic signals between the object and its surroundings, the better the obtained image. This results in spectacular images.

International marine data repositories

EMODnet BIOLOGY

The EMODnet biology data portal provides free access to data on temporal and spatial distribution of marine species and species traits from all European regional seas. EMODnet Biology, hosted by VLIZ, is part of the EU funded European Marine Observation and Data Network and is built upon the European Ocean Biodiversity Information System (EUROBIS).

European Ocean Biodiversity Information System

The European Ocean Biodiversity Information System - EurOBIS - is an online marine biogeographic database containing data on all living organisms in seas and ocean. The main objectives of EurOBIS are to centralise the largely dispersed biogeographical data on marine species collected by European institutions, and to make these data freely available and easily accessible. All data undergo a number of quality control procedures before being made available online [see standards], ensuring a minimum level of quality necessary for proper use of the data.

European Tracking Network (ETN)

The European Tracking Network (ETN) data portal gives access to all types of fish telemetry data and provides an interface to manage, explore and download data. The database stores both the occurrences (i.e. detection data) and the metadata related to tags, animals, receivers, deployments and projects.

LifeWatch

The marine observatory, built under LifeWatch, provides data from monthly monitoring campaigns with the research vessel Simon Stevin, as well as data from a sensor network installed in the Belgian part of the North Sea. The LifeWatch data explorer provides open access to these data and facilitates exploratory analysis of all data generated by the local marine freshwater terrestrial LifeWatch observatory.

Marine Regions

Marine Regions is a register of geographical areas and place names. It provides a standard for maritime locations, boundaries and areas, which can be applied to a wide range of map material. Marine Regions provides access to information from the VLIMAR Gazetteer and the VLIZ Maritime Boundaries Geodatabase. The VLIMAR Gazetteer is a database with geographic, mainly marine names such as seas, sandbanks, seamounts, ridges, bays or even standard sampling stations used in marine research. The Maritime Boundaries database represent the Exclusive Economic Zones (EEZ) of the world. Marine Regions is used as the geographic backbone in different data-and information systems.

Sea Level Station Monitoring Facility

Through this website the status and raw, real-time sea level measurements can be consulted for nearly 300 GLOSS measuring stations along the coasts of the Indian and Pacific Oceans, the North-East Atlantic Ocean, the Mediterranean Sea and the Caribbean. In cooperation with the GLOSS data centres of the Permanent Service for Mean Sea Level (PSMSL), the British Oceanographic Data Centre (BODC) and the University of Hawaii Sea Level Centre (UHSLC), additional processing steps are carried out which are necessary for the calculation of the long-term Mean Sea Level (MSL) data at hourly, daily, monthly and annual averages.

World Register of Marine Species (WoRMS)

The World Register of Marine Species (WoRMS) builds an authoritative and comprehensive list of names of marine organisms, including information on synonymy. Although the highest priority is given to valid names, other names in use are also included, so that this register can serve as a guide for the interpretation of taxonomic literature. Aphia, which is part of WORMS, contains valid species names, synonyms and vernacular names, and additional information such as literature-, biogeographical data and ecological characteristics of organisms.

Annex C. Mapping of action, field and industry survey options to diagram grouping categories

Table A C.1. Actions taken with data: Mapping of survey options to grouping categories for diagrams

Option in survey	Grouping category for diagram
Analyse policies	Analyse and report
Analyse risk	Analyse and report
Conduct statutory reporting	Analyse and report
Raise finance	Invest and finance
Target investments	Invest and finance
Inform business/industry/user decisions (including leisure activities)	Make decisions
Inform coastal planning decisions	Make decisions
Inform marine planning decisions	Make decisions
Inform operations	Make decisions
Inform policy decisions/regulations	Make decisions
Manage marine resources	Make decisions
Conduct research and development	Research and educate
Raise awareness and education	Research and educate
Validate data from elsewhere	Research and educate

Table A C.2. Fields in which actions are taken with data: Mapping of survey options to grouping categories for diagrams

Option in survey	Grouping category for diagram
Education	Education and leisure
History	Education and leisure
Leisure activities	Education and leisure
Marine archaeology	Education and leisure
Sea state forecasts and predictions	Forecasts
Weather forecasts and predictions	Forecasts
Coastal protection	Management and conservation
Conservation of coastal environments	Management and conservation
Conservation of marine environments	Management and conservation
Conservation of marine wildlife	Management and conservation
Fisheries management	Management and conservation
Marine area management	Management and conservation
Policy development	Management and conservation
Inert extraction	Operations
Inspection activities	Operations

Navigation	Operations
Search, rescue and safety of life	Operations
Citizen science	Science
Climate science	Science
Fisheries scientific advice	Science
Marine science	Science
Food security	Security
Human health	Security
National defence	Security

## Table A C.3. Industries affected: Mapping of survey options to grouping categories for diagrams

Option in survey	Grouping category for diagram
Finance and marine insurance	Finance
Aquaculture	Fishing and aquaculture
Commercialisation of marine animals	Fishing and aquaculture
Marine fishing	Fishing and aquaculture
Processing and preserving of marine fish	Fishing and aquaculture
Trade (wholesale and retail) or marine products	Fishing and aquaculture
Human healthcare	Health
Veterinary activities	Health
Biodiversity conservation	Heritage
Marine education and training	Heritage
Museums and other cultural activities (including heritage sites)	Heritage
Maritime freight transport	Maritime industries
Maritime information and communication services	Maritime industries
Maritime manufacturing, repair and installation	Maritime industries
Maritime passenger transport	Maritime industries
Maritime ports and support activities for maritime transport	Maritime industries
Maritime ship, boat and floating structure building	Maritime industries
Naval and search and rescue	Maritime industries
Biotechnology	Ocean technology
Ocean information technology, communication and electronics	Ocean technology
Ocean scientific research and development	Ocean technology
Marine mining and dredging	Offshore energy
Non-renewable electric power generation	Offshore energy
Offshore extraction of crude petroleum and natural gas	Offshore energy
Offshore industry support activities	Offshore energy
Offshore wind and marine renewable energy generation	Offshore energy
Marine and coastal tourism	Tourism

Annex D. Value chain diagrams by sector

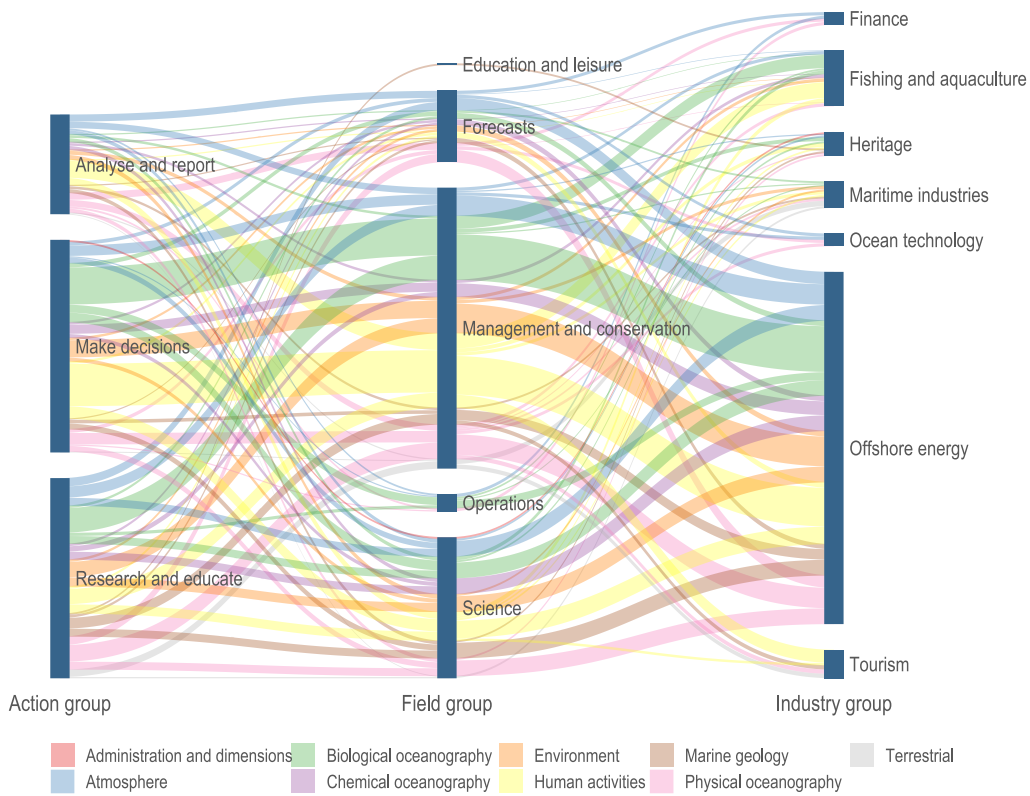## Figure A D.1. "Academia" sector public marine data value chain

Visual depiction of the flow of parameter types from the actions taken with data to the fields in which these data are applied to the industries that are affected for respondents reporting belonging to the "Academia" sector
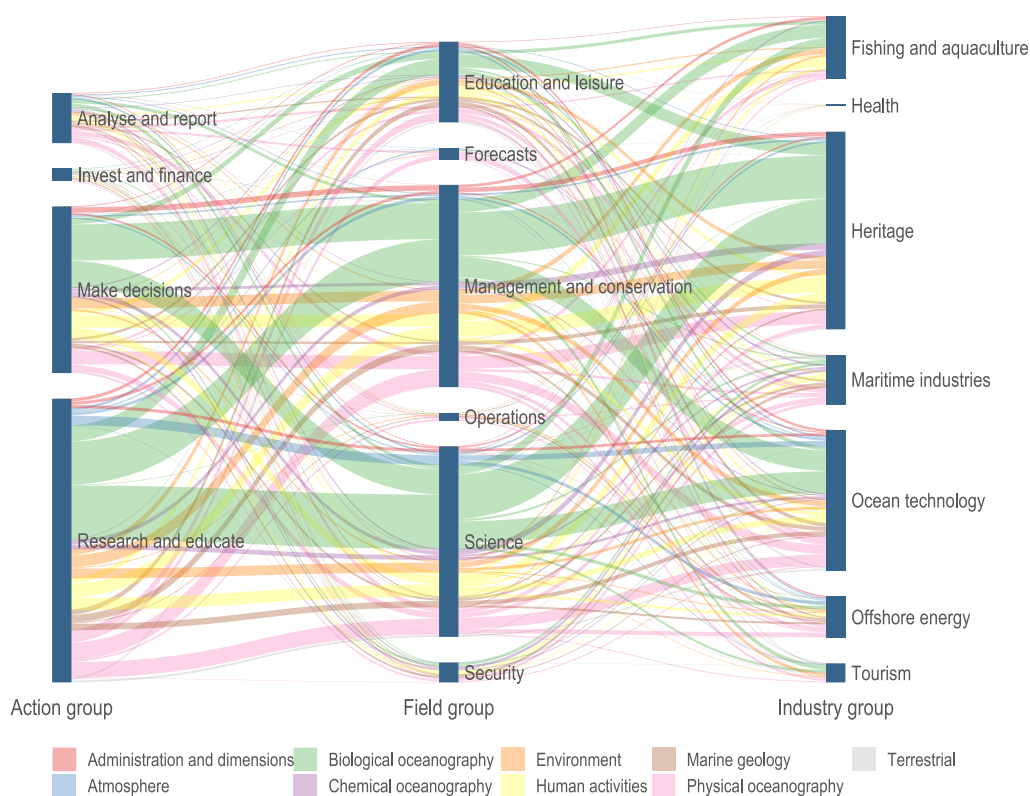
Note: The height of each grey box labelled by an action, field, or industry category represents the number of value chains associate with that category. The widths of the lines linking actions, to fields, to industries are scaled by the score for that particular element of the value chain. The categories of actions, fields and industries available for selection by respondents have been grouped together according to the mapping of options in the survey and grouping categories given in Annex C.

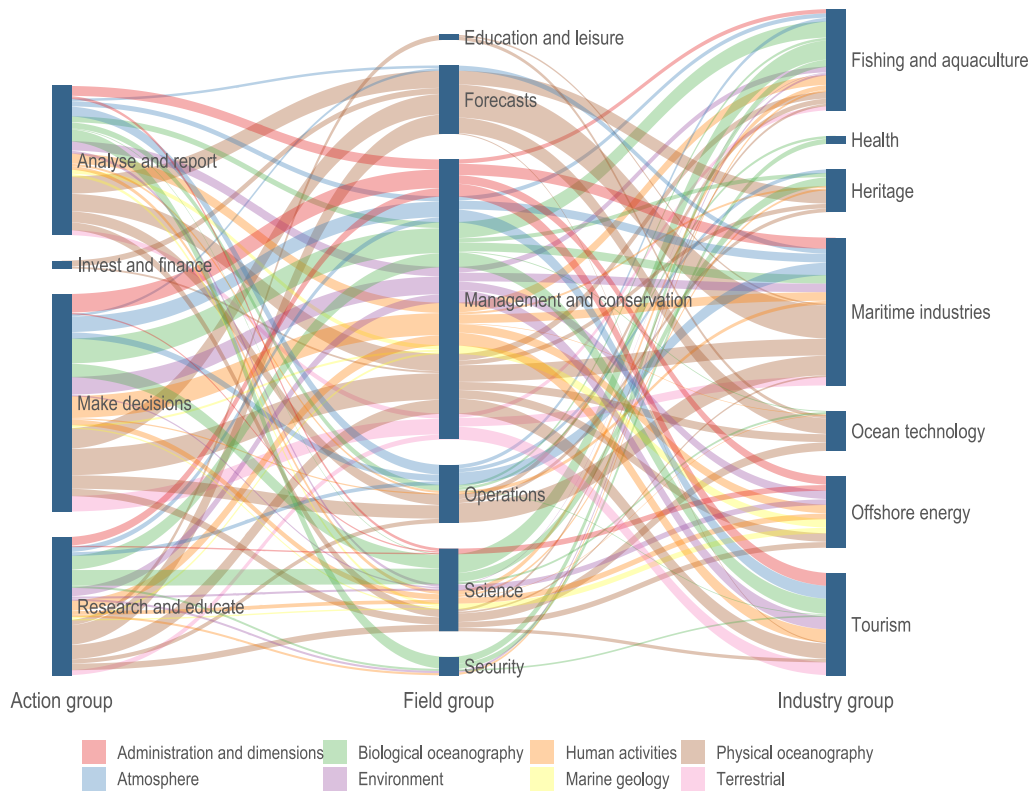## Figure A D.2. "Consultancy" sector public marine data value chain

Visual depiction of the flow of parameter types from the actions taken with data to the fields in which these data are applied to the industries that are affected for respondents reporting belonging to the "Consultancy" sector

Note: The height of each grey box labelled by an action, field, or industry category represents the number of value chains associate with that category. The widths of the lines linking actions, to fields, to industries are scaled by the score for that particular element of the value chain. The categories of actions, fields and industries available for selection by respondents have been grouped together according to the mapping of options in the survey and grouping categories given in Annex C.

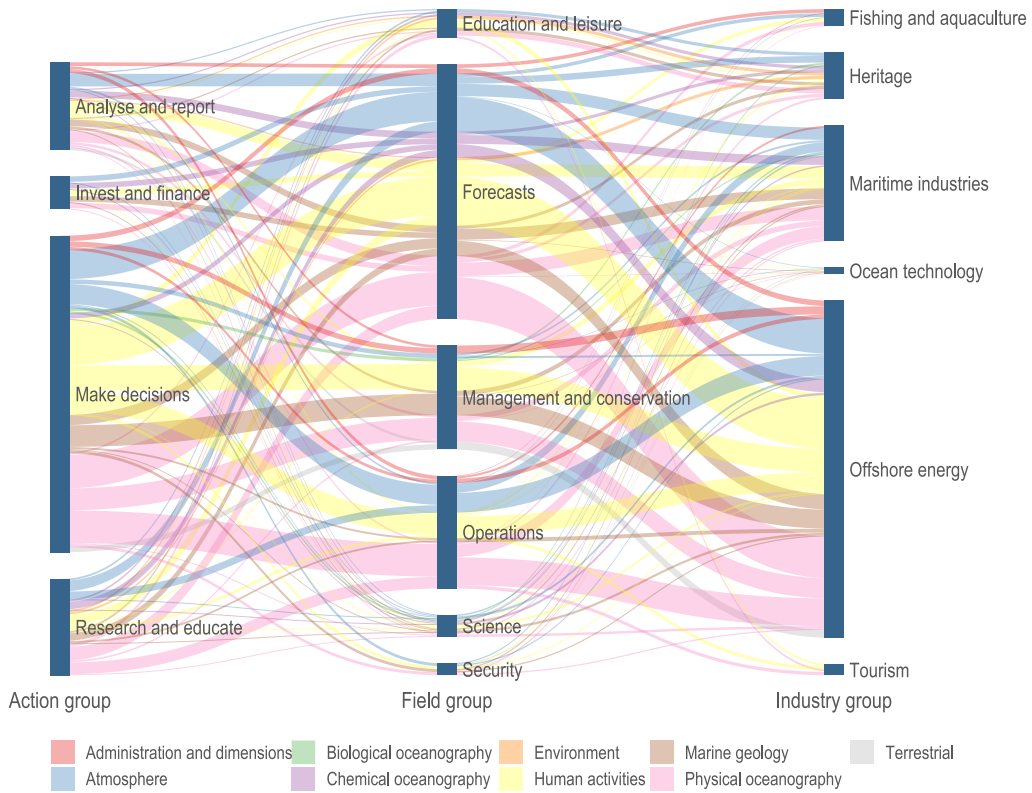## Figure A D.3. "Government" sector public marine data value chain

Visual depiction of the flow of parameter types from the actions taken with data to the fields in which these data are applied to the industries that are affected for respondents reporting belonging to the "Government" sector

Note: The height of each grey box labelled by an action, field, or industry category represents the number of value chains associate with that category. The widths of the lines linking actions, to fields, to industries are scaled by the score for that particular element of the value chain. The categories of actions, fields and industries available for selection by respondents have been grouped together according to the mapping of options in the survey and grouping categories given in Annex C.

Figure A D.4. "Industry" sector public marine data value chain
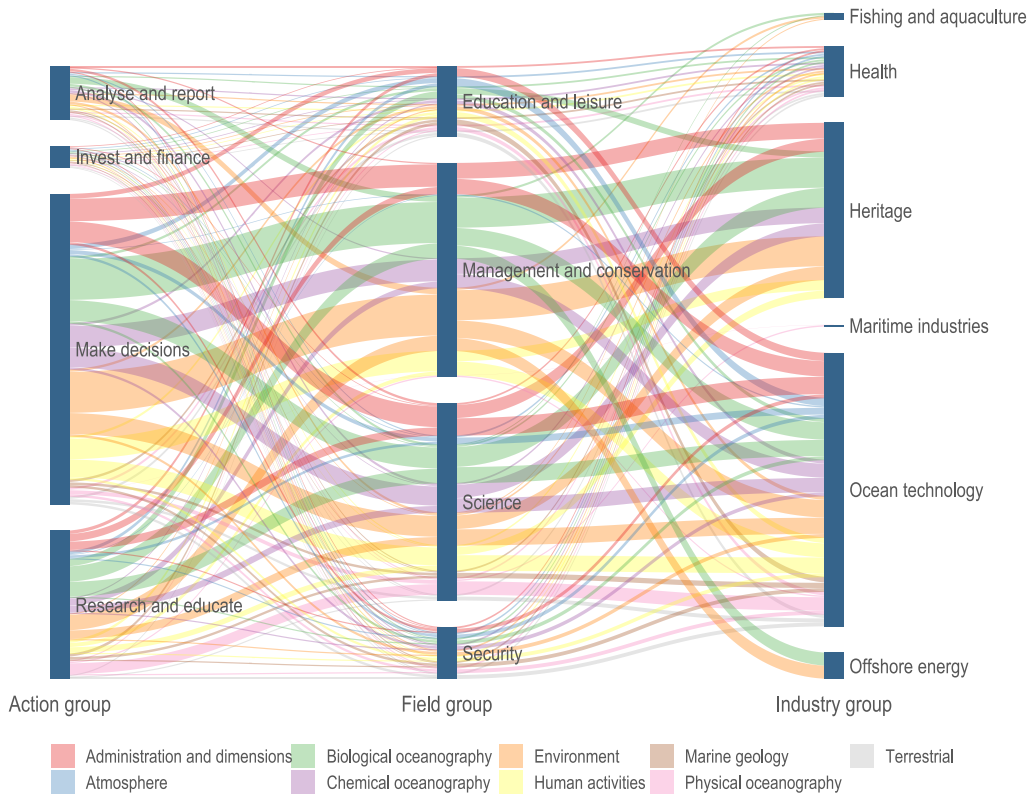
Visual depiction of the flow of parameter types from the actions taken with data to the fields in which these data are applied to the industries that are affected for respondents reporting belonging to the "Industry" sector

Note: The height of each grey box labelled by an action, field, or industry category represents the number of value chains associate with that category. The widths of the lines linking actions, to fields, to industries are scaled by the score for that particular element of the value chain. The categories of actions, fields and industries available for selection by respondents have been grouped together according to the mapping of options in the survey and grouping categories given in Annex C.

Figure A D.5. "Non-governmental organisation" sector public marine data value chain
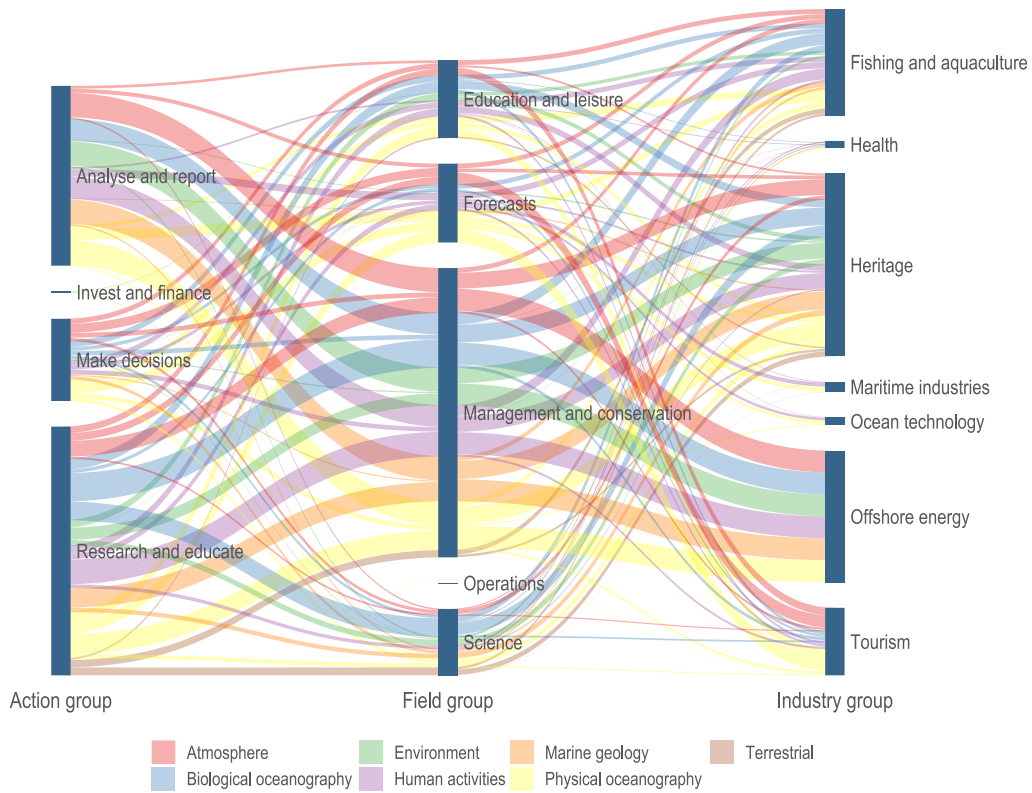
Visual depiction of the flow of parameter types from the actions taken with data to the fields in which these data are applied to the industries that are affected for respondents reporting belonging to the "Non-governmental organisation" sector

Note: The height of each grey box labelled by an action, field, or industry category represents the number of value chains associate with that category. The widths of the lines linking actions, to fields, to industries are scaled by the score for that particular element of the value chain. The categories of actions, fields and industries available for selection by respondents have been grouped together according to the mapping of options in the survey and grouping categories given in Annex C.

Figure A D.6. "Recreational" sector public marine data value chain

Visual depiction of the flow of parameter types from the actions taken with data to the fields in which these data are applied to the industries that are affected for respondents reporting belonging to the "Recreational" sector

Note: The height of each grey box labelled by an action, field, or industry category represents the number of value chains associate with that category. The widths of the lines linking actions, to fields, to industries are scaled by the score for that particular element of the value chain. The categories of actions, fields and industries available for selection by respondents have been grouped together according to the mapping of options in the survey and grouping categories given in Annex C.