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Ralph Rayner, Carl Gouldman & Zdenka Willis

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# The Ocean Enterprise – understanding and quantifying business activity in support of observing, measuring and forecasting the ocean

Ralph Rayner<sup>a,b</sup>, Carl Gouldman<sup>b</sup> and Zdenka Willis<sup>b</sup>

<sup>a</sup>London School of Economics and Political Science, London, UK; <sup>b</sup>National Oceanic and Atmospheric Administration, Silver Spring, MD, USA

## ABSTRACT

Sustained ocean observations, measurements and models provide a wide range of societal benefits underpinning the safety, operational and compliance needs of beneficiaries that operate around, on and under the ocean (In the context of this paper, the term ‘ocean’ is defined as encompassing the global ocean, enclosed seas and the US Great Lakes.) They also provide an essential input to ocean scientific research and the effective protection of the marine environment. Delivering the means to collect and use ocean data and information on a sustained basis constitutes a significant business undertaking. The companies that enable sustained ocean observation, measurement and forecasting, and deliver its benefits as commercial services, combine to create a unique and growing industry cluster; the Ocean Enterprise. Ocean Enterprise businesses underpin the ability to provide societal benefit from sustained ocean observations, measurements and models, as well as delivering significant economic and employment benefits in their own right. In this paper, we describe a systematic evaluation of the scale, scope and characteristics of the Ocean Enterprise in the United States. We explore the ways in which this industry cluster interacts with the US Integrated Ocean Observing System and how the United States Ocean Enterprise compares to that of the United Kingdom.

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## KEYWORDS

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## Introduction

The ocean is a key source of food, energy and minerals. It provides the primary medium upon which global trade takes place. Approximately 40% of the world’s population lives in coastal regions and three quarters of the world’s large cities are located on the coast. Coastal waters and regions are the locations of a large proportion of the global tourism and recreational industries.

Ecosystem services provided by the ocean play a pivotal role in human society (Spalding et al. 2016). Hundreds of millions of people depend directly on the ocean for their food and livelihoods. We all depend on the ocean for the provision of much of the oxygen that we breathe and for its controlling and moderating role in weather and climate.

In its report on the ocean economy, the Organisation for Economic Cooperation and Development (OECD 2016) estimates that 2010 economic activities associated with the ocean amounted to around US\$ 1.5 trillion, or approximately 2.5% of world gross value added, with direct full-time employment in the ocean economy amounting to around 31 million jobs. The OECD report projects rapid growth in economic activity associated

with the ocean, with ocean-based industries having the potential to outperform the growth of the global economy as a whole, both in terms of value added and employment. Their projections suggest that between 2010 and 2030, the ocean economy could more than double its contribution to global value added, reaching over US\$ 3 trillion per annum.

The marine and maritime industries delivering this economic activity continue to undergo a profound transition. As well as the traditional industries of shipping, capture fisheries, tourism and marine recreation; there is now extensive industrial activity associated with exploitation of offshore oil and gas, the harnessing of marine renewable energy and aquaculture based food production, as well as emerging new activities, such as ocean mining and marine biotechnology.

In contrast to the terrestrial environment, the ocean represents a difficult and harsh environment in which to operate. Much of the economic activity around, on and under the ocean would not be possible without data, information and knowledge derived from sustained ocean observations, measurements and forecasts which underpin safe, cost-effective and environmentally acceptable marine and maritime activity.

**CONTACT** Ralph Rayner  [ralph.rayner@noaa.gov](mailto:ralph.rayner@noaa.gov)  1315 East-West Highway, Silver Spring, MD 20910, USA

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In addition to underpinning economic activity in the ocean sustained ocean observations, measurements and models provide an important input to weather forecasts and climate projections, delivering socioeconomic benefits far inland.

The ocean environment is subject to a complex range of pressures. Foremost are those related to ocean health; over-exploitation of marine resources, pollution, rising ocean temperatures and levels, ocean acidification and loss of biodiversity. Unsustainable use of the ocean and its resources threatens the basis on which much of the world's welfare and prosperity depends. Here too ocean observations, measurements and forecasts play a fundamental role in underpinning the scientific basis for protection of the ocean and the ecosystem services they provide as well as the means for monitoring environmental policy compliance and effectiveness.

It is clear that the economic and societal benefits underpinned by ocean observations, measurements and forecasts are large. However, they are difficult to quantify. There have been no comprehensive global attempts to value these benefits, although numerous case studies have attempted to quantify components of the benefit accruing from the collection and use of such data. In aggregate, the cost of obtaining and using such data is almost certainly only a small percentage of the value of the benefits derived.

Delivering the means to collect and use ocean data and information on a sustained basis constitutes a significant business undertaking. The companies that enable sustained ocean observation, measurement and forecasting, and deliver its benefits as commercial services, combine to create a unique and growing industry cluster; the Ocean Enterprise.

Ocean Enterprise businesses underpin the provision of societal benefit from sustained ocean observations, measurements and models, as well as delivering significant economic and employment benefits in their own right to the nations in which such business activity takes place.

Due to the diversity of businesses that operate in this space, accurately assessing their financial impact, employment, location, and business challenges is a complex task. Prior to the study described in this paper, the only national assessment of the Ocean Enterprise that had been conducted was that for the United Kingdom (Society of Maritime Industries 2018). This annual survey provides a time history of the development of the Ocean Enterprise in the United Kingdom over the period since 2009.

In this paper, we describe a systematic study of the scale, scope and characteristics of the Ocean Enterprise in the United States; drawing comparisons with the

work undertaken in the United Kingdom and exploring how this industry cluster interacts with the activities of the US Integrated Ocean Observing System (US IOOS®).

## Stakeholders and beneficiaries

Before describing the methodology used in the Ocean Enterprise study it is important to clearly define the scope of business activity intended to be encompassed by this term. To define the scope of the Ocean Enterprise we adapted a framework of ocean observation, measurement and forecasting stakeholders described during the US IOOS Summit held in 2012 (Rayner 2012). This framework divides the stakeholders in ocean observation, measurement and forecasting into three main groups:

**Providers** of the infrastructure making possible observations and measurements of the ocean environment;

**Intermediaries** who use ocean data or information as an input to the production of information products and services underpinning economic or societal benefits;

**End-users** whose activities or businesses derive benefit from ocean data and information products and services.

Providers of ocean observation and measurement infrastructure include manufacturers of sensors, instruments and platforms; providers of the cyber infrastructure that interconnects and communicates ocean data; and organisations that develop and maintain the data management systems, software tools and models that are used to turn data into useful information. Intermediaries are organisations that add value to ocean data and information, tailoring it for specific end-uses. End-users are the ultimate beneficiaries of ocean observations, measurements and models. They use value-added products and services generated, in whole or in part, from such data and information as an input to their activities to derive specific scientific, societal or business benefits.

A large proportion of operational ocean observations and measurements are made by public organisations. In the United States, these include federal and state organisations as well as universities. The National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation, and the U.S. Navy, purchase the majority of instrumentation and associated infrastructure for this purpose, either directly or indirectly, through funding to external grant recipients. NOAA has the responsibility for sustained ocean observation, measurement and forecasting, for civil applications. NOAA, within the National Ocean Service (NOS), hosts the US Integrated Ocean Observing System Program Office. The US IOOS is a coordinated effort of 17 federal agencies, 13 non-federal regional and functional

associations, as well as advisory and action bodies. It supports the collection and dissemination of high quality, interoperable oceanographic data, information and models to support maritime commerce and safety, improved predictions of weather and climate, resource management and the protection of the marine environment.

In addition to this public sector activity, many private sector, business end-users of ocean observation, measurement and forecast information products commission their own data collection to support operational needs which cannot be met using publicly available ocean data and information. In these instances, end-users generally place contracts with intermediaries who undertake such work on their behalf.

The largest component of such private sector end-user commissioned ocean observation and measurement relates to hydrographic, geophysical and geotechnical survey.

The Ocean Enterprise Study described in this paper set out to evaluate the scale, scope and characteristics of United States provider and intermediary business activity associated with meeting the data and information needs of end-user beneficiaries of ocean observations, measurements and models. It also explored the ways in which these provider and intermediary businesses interact with the US IOOS.

### Ocean enterprise study methodology

As a fundamental step in the study, the first component of work was devoted to obtaining and compiling lists of companies who were potentially engaged in the Ocean Enterprise. Lists of companies were obtained from a variety of sources including; professional organisations, industry-specific email and contact lists, professional and industry conferences, Federal agencies and US IOOS stakeholders. Each list provided a variable amount of information ranging from company name only, up to full contact information including a contact person, website URL, email, phone, and address.

In addition, the study, and the planned online questionnaire and survey to be employed in gathering data, were promoted through a variety of professional and trade publications inviting companies to participate and to provide contact details via the IOOS website. The online survey also included a question for respondents to identify other companies working in the Ocean Enterprise sector as providers or intermediaries, so they could be added to the study database.

The resulting database represented a broad range of organisations, not all of which were involved in Ocean Enterprise related business activity. Accordingly, the

database was refined by reference to the content of the websites of each listed company and through review by experts closely involved with the Ocean Enterprise industry space. The final reviewed pool of target businesses comprised 410 companies.

Initial qualitative interviews were conducted with nine of these, representing both Providers and Intermediaries, as well as varied company sizes and geographical locations. The results of these interviews informed the content of a quantitative survey instrument and provided context for the quantitative survey results. These interviews took place during the fall of 2014.

The survey of the 410 identified companies was conducted by means of a web questionnaire. The survey instrument used for this purpose is shown in [Table 1](#). Initial outreach efforts designed to inform companies of the upcoming survey were conducted through announcements in industry publications, information posted on the US IOOS website, and presentations at industry meetings and conferences. In early April 2015, the web-survey announcement and link were sent to the targeted companies. Reminder emails were sent out to non-responders two weeks after the initial survey mailing, and weekly thereafter. The survey concluded in late June 2015. The final survey database comprised 159 respondents, representing a response rate of 39%.

### *The Ocean Enterprise business scale, scope and characteristics*

As defined above, the survey sought to categorise respondents' activity between Providers of infrastructure for ocean observation, measurement, or forecasting and Intermediaries that make use of ocean, coastal, and Great Lakes measurements, observations, and models as an input to the creation or enhancement of value-added information products in support of specific end-uses. [Figure 1](#) provides a breakdown of the survey results across these two types of business activity.

The majority of respondent firms (64%) were Providers, involved solely in developing infrastructure and equipment applicable to the Ocean Enterprise space. Twenty per cent of respondents identified themselves as solely performing activities as an Intermediary; using ocean data and information to create or enhance value-added data products in support of end-user requirements. Twenty per cent indicated they performed both functions, yielding a combined 80% of respondents performing activities as a Provider and a combined 36% providing services as an Intermediary.

[Figure 2](#) shows the distributions of employment numbers for both the survey respondents and the United States economy as a whole (US Census Bureau 2018).

**Table 1.** The Ocean Enterprise study survey instrument.

- 
1. Please select the answer choice(s) below that best describes your business: (select all that apply)
    - We provide infrastructure for ocean measurement, observation, or forecasting purposes (e.g. platforms, instruments, sensors, data communications, IT infrastructure, instruments for navigation and positioning, etc.)
    - We use ocean measurements, observations or forecasts to create or enhance a value added data product offered for commercial sale (e.g. to provide a survey product, power a weather or surf forecast service, evaluate ocean hazards, support fish locating, etc.)
    - We don't provide ocean measurement, observation, or forecasting infrastructure or use ocean measurements, observations or forecasts <SURVEY WILL GO TO THANK YOU/EXIT SCRIPT>
  2. How long has your business provided ocean measurement, observation or forecast infrastructure or related value added services?
    - Less than 1 year
    - 1 through 3 years
    - through 5 years
    - More than 5 years
    - Unknown
  3. Currently, how many employees in your business are located in the U.S.?
    - 1–4
    - 5–9
    - 10–24
    - 25–49
    - 50–99
    - 100–249
    - 250–499
    - 500–999
    - 1000 or more
  4. Currently, how many employees in your business are at your current location?
    - We only have one location
    - 1–4
    - 5–9
    - 10–24
    - 25–49
    - 50–99
    - 100–249
    - 250–499
    - 500–999
    - 1000 or more
  5. In the next 12 months do you anticipate your company:
    - Growing
    - Staying the same
    - Decreasing
    - Not sure
  6. Is your company a subsidiary, and if YES, what is the name of the holding company and in which country is it registered?
    - Not a subsidiary
  7. How many discrete locations does your company or your parent company have? (multiple buildings on a single campus counts as one location)
 

Yes, we are a subsidiary of \_\_\_\_\_, and based in (Country) \_\_\_\_\_.

    - 1
    - 2
    - 3
    - 4
    - 5
    - 6–9
    - 10 or more
  8. How many of these locations are outside the U.S.?
    - All
    - None
    - 1
    - 2
    - 3
    - 4
    - 5
    - 6–9
    - 10 or more
  9. What were your company's gross revenues for the past year?
    - a) Subsidiary revenues (if subsidiary)
    - b) Overall company revenues
  10. What share of your revenue is due to Maritime activities or business?
    - 0% or None
    - 1% to 24%
    - 25% to 49%
    - 50% to 74%
    - 75% to 100%
    - Don't Know
- 

*(Continued)*

**Table 1.** Continued

- 
11. What share of your maritime revenues is due to business or activities associated with providing ocean observation, measurement or forecasting infrastructure or provision of value added data products based in whole or in part on ocean observation, measurement or forecast data?
- 0% or None
  - 1% to 24%
  - 25% to 49%
  - 50% to 74%
  - 75% to 100%
  - Don't Know
12. What percentage of your ocean observation, measurement or forecasting related revenues from Question 10 is from sales outside the U.S.?
- 0% or None
  - 1% to 24%
  - 25% to 49%
  - 50% to 74%
  - 75% to 100%
  - Don't Know
13. In the next 12 months, do you anticipate your ocean observation, measurement and forecasting related business revenue:
- Growing
  - Staying the same
  - Decreasing
  - Not sure
14. From which of these market areas does your company, or your parent company (if it is U.S. registered) receive significant ocean observation, ocean measurement or ocean forecasting business related revenue (greater than 5%) (Select all that apply):
- Australia/New Zealand
  - Other Asia-Pacific
  - Japan
  - China
  - Taiwan
  - South Korea
  - Africa
  - Middle East
  - East Europe/Russia
  - Continental Europe
  - UK/Ireland
  - USA
  - Canada
  - Mexico/Central America
  - Non-U.S. Caribbean
  - South America
  - Other:
15. What are your main market sectors? (select all that apply)
- Academic research
  - Defense
  - Maritime Security
  - Ports/harbors
  - Coastal protection
  - Environmental monitoring
  - Renewable energy
  - Oil/gas
  - Maritime security
  - Fishing industry
  - Hydrographic Surveying
  - Construction Surveying
  - Water and water quality
  - Biotechnology
  - Engineering
  - Weather and ocean forecasting
  - Cargo shipping
  - Cruise ships/passenger ships
- Other:
16. (Providers only) What kind of ocean measurement, observation, or forecasting infrastructure (e.g. platforms, instruments, sensors, data communications, Information Technology infrastructure etc.) do you sell? (select all that apply)
- Hydrographic survey sensors/instruments/systems
  - Shallow geophysical survey sensors/instruments/systems
  - Geotechnical measurement/sampling, sensors/instruments/systems
  - Physical oceanographic sensors/instruments/systems
  - Chemical oceanographic sensors/instruments/systems
  - Biological oceanographic sensors/instruments/systems
  - Navigation and positioning sensors/instruments/systems
  - Platforms such as towed systems, remote or autonomous underwater vehicles
  - Data communications and Information Technology infrastructure
  - Other
- 

(Continued)

**Table 1.** Continued

- 
17. (Intermediaries only) If you utilize "IN SITU" ocean observations or measurements in your data products (ie data generated from observations or measurements conducted within or upon the ocean) what kind of data do you use? (select all that apply)
- Bathymetric data
  - Geophysical data
  - Geotechnical data
  - Physical oceanographic data
  - Chemical oceanographic data
  - Biological oceanographic data
  - Other
  - We do not utilize IN SITU data
18. (Intermediaries only) If you utilize "REMOTELY SENSED" ocean observations in your product (e.g. satellites, airplane observations, high frequency radar), what kind of data do you use? (select all that apply)
- Aircraft observations
  - Satellite observations
  - Shore observations
  - Other
  - We do not utilize REMOTELY SENSED data
- The following questions relate specifically to your interaction with the US Integrated Ocean Observing (IOOS).*
19. Are you aware of the Integrated Ocean Observing System (IOOS) and, if so, do you contribute to IOOS infrastructure or utilize IOOS coordinated data? (Select all that apply)
- We are unaware of the IOOS <SURVEY WILL GO TO THANK YOU/EXIT SCRIPT>
  - We are aware of IOOS
  - We contribute to IOOS infrastructure
  - We make use of IOOS coordinated data
20. Which of the following do you consider issues or barriers to working with IOOS that impact your business? (select all that apply)
- Local regulations or restrictions
  - Limited access to data streams
  - Structure of IOOS data streams limits usability
  - Lack of documentation on IOOS data streams
  - Difficulties or limitations with adapting new technology into the existing ocean observing system
  - Limited knowledge about future investment and development plans for the IOOS system
  - Data does not adequately cover the geographical needed
  - Hard to find employees who can work with the IOOS data
  - Hard to find employees who can work with the IOOS infrastructure
  - Other:
  - None of the above
  - Don't know
21. In the future, we plan to: (select all that apply)
- Develop new products that utilize IOOS data
  - Expand the capabilities of our current product that utilizes IOOS data
  - Provide additional infrastructure for IOOS
  - Provide additional services for IOOS
  - Eliminate some products or services we provide
  - None of the above
22. What areas do you think could be improved with regard to working with IOOS? (select all that apply)
- Better information and data stream standardization
  - More openness to opportunities for new innovations
  - Greater focus on the interests of small or new enterprises engaged in ocean observation, measurement, and forecasting or the use of ocean data
  - Greater focus on the interests of large or established enterprises
  - Other: (please describe) \_\_\_\_\_
  - None of the above
23. Do you feel your current or future workforce could benefit from specific training related to working with IOOS data or providing IOOS infrastructure?
- Yes: please explain:
  - No
  - Don't know
24. Is there anything that would make it easier to provide services, products, or infrastructure to NOAA and the IOOS system?
- Yes: please explain:
  - No
  - Don't know
25. Is there anything that would make it easier to utilize the IOOS data and incorporate it into a product?
- Yes: please explain:
  - No
  - Don't know

## OPTIONAL RECOMMENDATION QUESTION:

Can you recommend other recipients for this survey? These could be subsidiaries of your company, or other qualified companies?

If yes, please list below (name of company and contact if available):

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When compared with the United States economy as a whole, mid-sized businesses are more proportionally represented in the respondent distribution.

Examination of employment by company function (Figure 3) reveals that Intermediaries were more likely to be in both the very smallest and largest employment



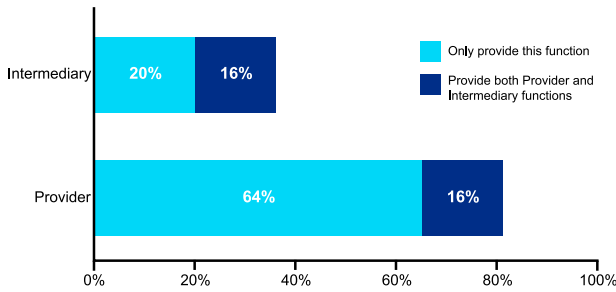


Figure 1. Business functions of respondent companies.

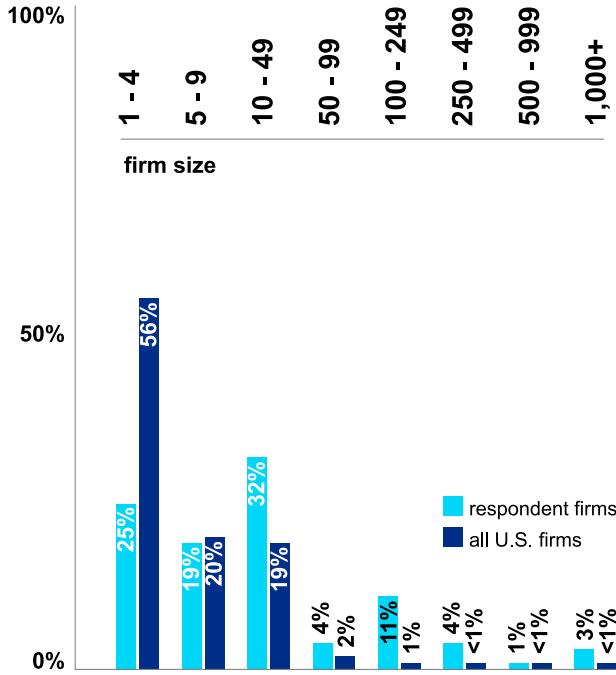


Figure 2. Total employment of respondent companies compared to United States average.

categories as compared to Providers. For example, 29% of Intermediaries had between one and four employees, compared to 22% for Providers and, 4% of Intermediaries had greater than one thousand employees, compared to 1% for Providers.

The number of locations from which each respondent company operated is shown in Figure 4. Slightly less than half of all the surveyed companies operate from a single establishment. Not surprisingly two and three-establishment companies are the next most common arrangements, with the exception of highly complex businesses with ten or more locations.

Figure 5 shows the number of overseas locations operated by respondent companies. With 45% of respondents indicating they are one-establishment companies, it is not surprising that over half (58%) of respondents report their company operates solely within the United States.

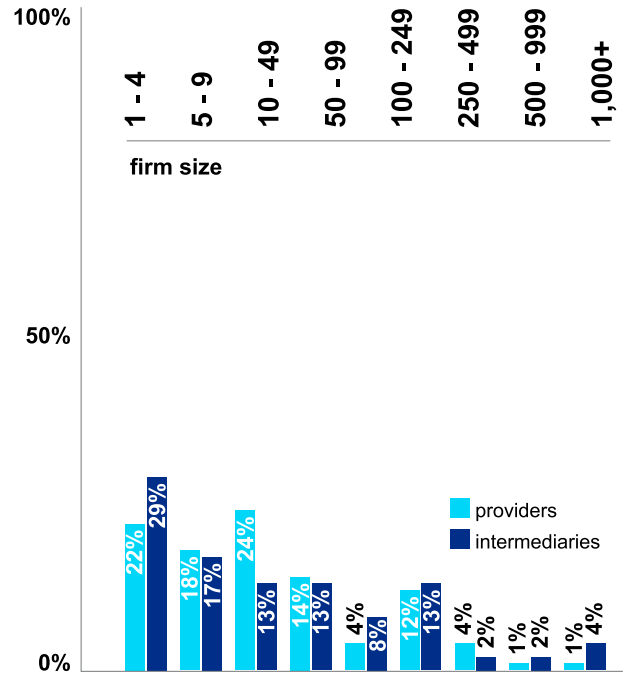


Figure 3. Employment numbers of respondent companies by business function.

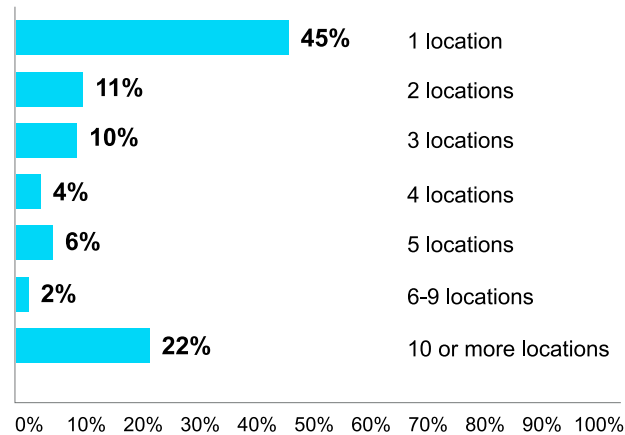
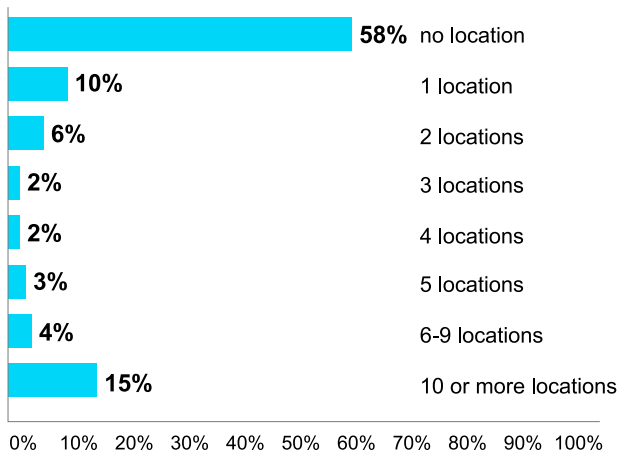


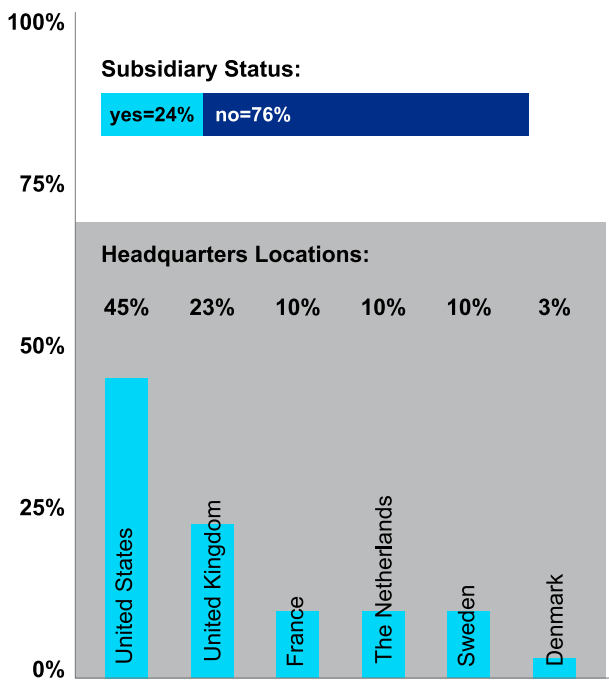
Figure 4. Number of locations operated by respondent companies.

However, among those that do have foreign operations, a marked 'U' shape reflects a characteristic distribution. A combined 16% of respondents report one or two foreign location(s). This drops to 2% with three foreign locations. Then, the percentage begins to rise, with the caveat that choices above six locations were associated with ranges, until 15% of respondents reported ten or more foreign locations. These results emphasize just how different the Ocean Enterprise community is from the general national economy. For all United States businesses in the most recent Business Dynamics Survey (US Census Bureau 2018), 0.6 per cent of businesses had





**Figure 5.** Number of overseas locations operated by respondent companies.



**Figure 6.** Subsidiary status and location of ultimate headquarters of respondent companies.

ten or more locations anywhere. In the Ocean Enterprise community, 15% had 10 or more locations outside the United States.

With this level of business complexity, it is not surprising that a significant share of respondents reported that they were subsidiaries of a larger corporate family. Nearly one in four (23%) indicated that they were such a subsidiary. Figure 6 indicates the national locations of these respondents' corporate headquarters. The most common response for these more complex businesses, as would be expected, was the United States, which

hosts the headquarters of 45% of multi-country respondents' companies. The UK was the second most common host, with seven headquarters, while France, the Netherlands, and Sweden hosted three headquarters each. Finally, Denmark was the location of one of the respondents' headquarters. It is important to note that there were instances of multiple respondents belonging to the same ultimate corporate parent. In those cases, the parent location for each subsidiary was counted in the analysis.

Figure 7 shows the United States metropolitan location of the companies identified as within scope and eligible to take part in the survey. They spread over 36 States. The location distribution is markedly different from that for the United States Economy as a whole. Part of the explanation is an obvious one; proximity to the ocean is a distinct (but not necessarily required) advantage in the markets encompassed by the Ocean Enterprise. However, even aside from this general principle, there are interesting patterns within the location data. Major Ocean Enterprise hubs can be seen in the Boston and Houston regions, the Bay Area-to-San Diego corridor, Florida, and the Pacific Northwest.

Companies largely reported relatively extensive experience in the ocean measurement, observation, and forecasting sector. Almost nine in ten respondents reported at least 5 years' experience in the market (Figure 8). A mere 2% were new to the market (1 year or less of experience). Providers tended to have been in Ocean Enterprise-related business longer than Intermediaries. This is not surprising given the pace of relatively recent developments in data and information processing, distribution and presentation which have supported the more recent emergence of a growing number of Intermediary companies.

Although obtaining a true economic impact measure for the Ocean Enterprise was outside the scope of the study, one of the goals was to provide estimates of revenues based on the self-reported data from the sample of survey respondents and other public sources of information. Survey respondents were asked to report the revenue of their organisation. Since respondents were permitted to omit any questions they did not feel comfortable answering, a proportion did not provide this information, or the accompanying requested information regarding share of revenue attributable to maritime business, share of maritime revenue attributable to the Ocean Enterprise, and what proportion of Ocean Enterprise revenues was from sales outside the United States. In these cases, and for companies that did not respond to the survey, every effort was made to obtain this information through secondary sources.

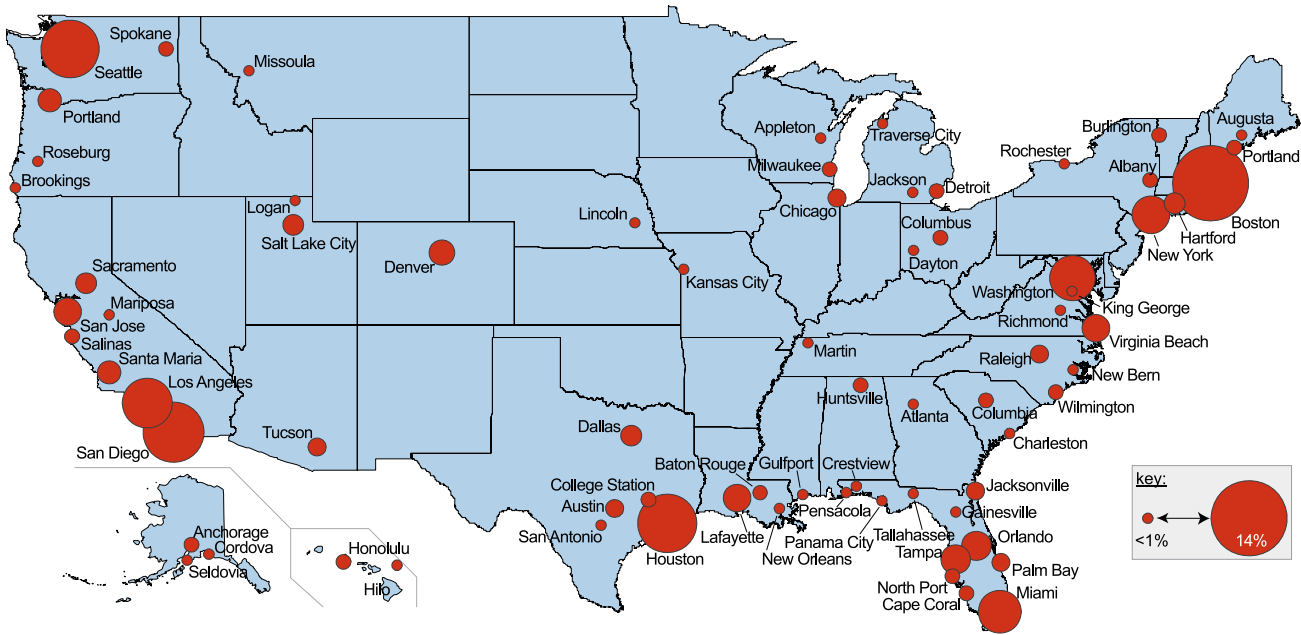


Figure 7. Location of surveyed companies.

These sources include web searches for publicly available information and purchasing organisational information from data brokers.

It was consensus that even after the best efforts to identify all United States companies involved in the Ocean Enterprise and include them in population of businesses eligible to be surveyed, up to 20% of the organisations potentially involved in the Ocean Enterprise in the United States may have been missed. Although there are no objective means of verifying whether this weighting of the survey results is a realistic one, it is consistent with the comparable study conducted

in the United Kingdom (Society of Maritime Industries, 2018) which applied an effective weighting of the same order.

This process makes the assumption that the missing companies had the same basic properties as those surveyed. Although the 20% uplift in revenues associated with unidentified companies is considered to be realistic, it can also be viewed as a measure of the range of error associated with the overall revenue estimate.

The aggregate proportion of total revenue attributed to maritime and Ocean Enterprise activity is shown in Figure 9. Over half of respondents (58%) reported that the majority (75–100%) of their revenues were from maritime business (top pie chart in Figure 9). When asked what proportion of their maritime revenue was associated with Ocean Enterprise activities, just under half (46%) reported that Ocean Enterprise revenues accounted for the majority (75–100%) of their overall maritime activity (middle pie chart in Figure 9). Respondents were further asked to report what proportion of their Ocean Enterprise-related revenue was from export sales. A minority, 27% of respondents, reported that foreign sources accounted for at least half of their Ocean Enterprise-related revenues, while 49% reported that export sales contributed to less than one-quarter of their total Ocean Enterprise related business (bottom pie chart in Figure 9). One-fifth reported that overseas customers accounted for none of their Ocean Enterprise related revenue.

Figure 10 provides the overall estimates of revenues for businesses that have Ocean Enterprise activities.

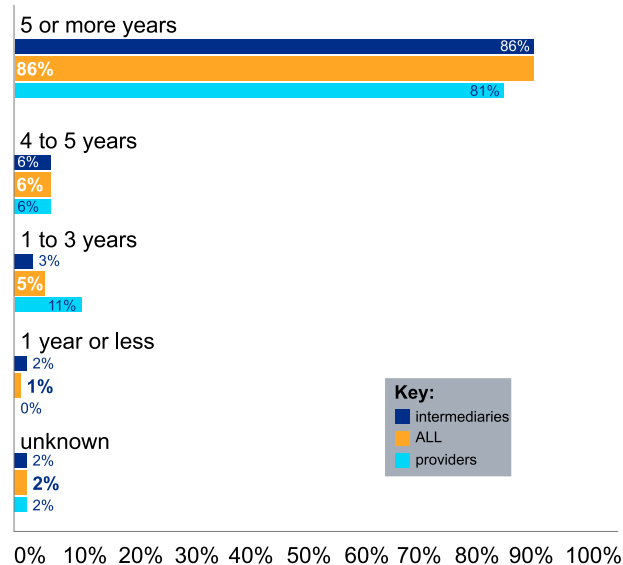
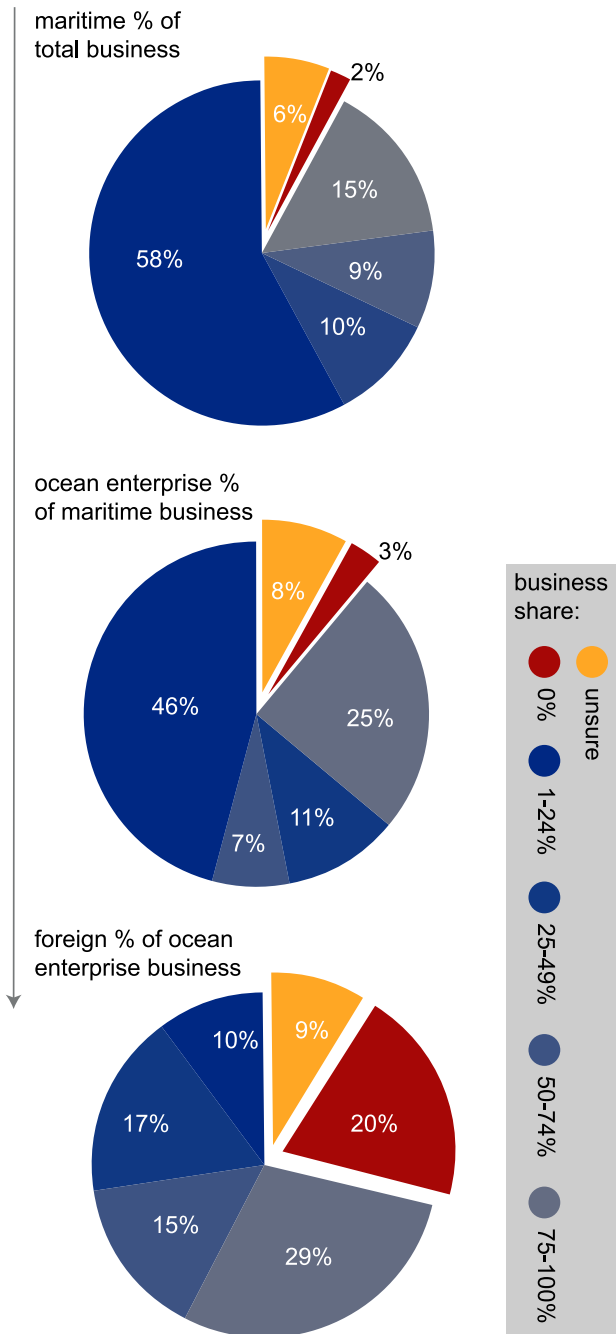
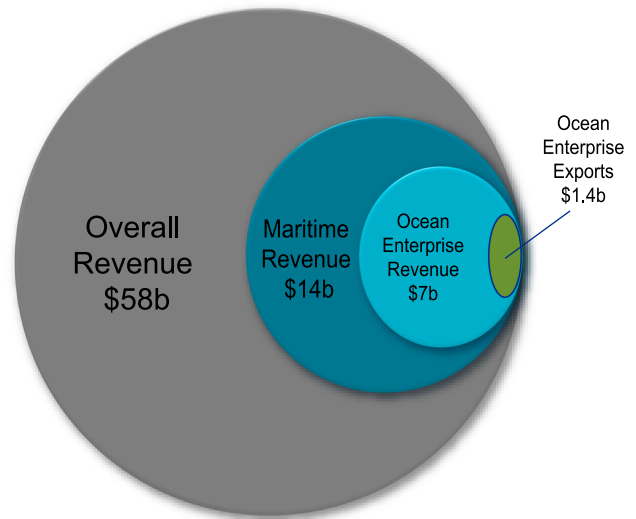


Figure 8. Experience in Ocean Enterprise related activity.

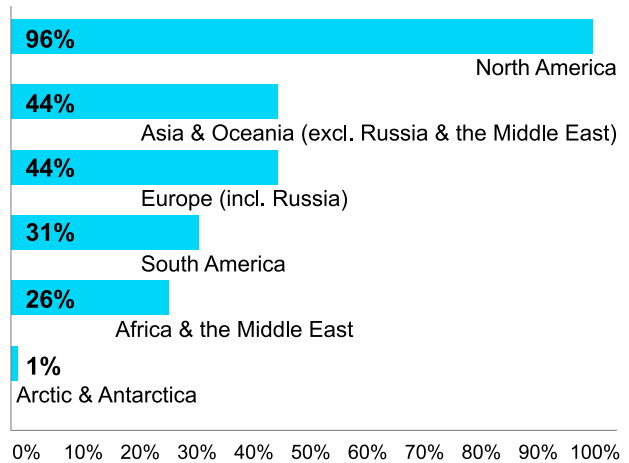


**Figure 9.** General maritime, Ocean Enterprise and overseas Ocean Enterprise shares of revenue.

Total revenue for these businesses is estimated at \$58 billion, with \$14 billion of these overall revenues being attributable to maritime-related activities, and \$7 billion of these maritime revenues being attributable to Ocean Enterprise business activities. Finally, it is estimated that \$1.4 billion of Ocean Enterprise revenue is associated with export activity. The survey results indicate that companies that functioned as both Provider and Intermediary accounted for the majority of export revenue (\$1 billion) which accounted for almost 35% of their Ocean Enterprise revenue (\$3 billion). These dual



**Figure 10.** Overall revenues.



**Figure 11.** Markets that represent at least 5% of revenues.

role businesses tended to be larger and more diversified than those which served only one function.

Respondents with Ocean Enterprise export activity were asked to identify the geographical markets that are a source of at least 5% of revenues for their businesses and were allowed to select as many markets as applied. Unsurprisingly, the most mentioned market was North America. Nearly all firms (96%) report customers in North America, with 93% of those reporting customers in the United States. Of particular interest in the responses about foreign markets is the equal importance of Europe and Asia and the Pacific Rim, with 44% reporting sales in both regions. Summary results for the analysis of the export markets for survey respondents are provided in Figure 11.

Respondents were asked to report the employment levels of their organisation. Using a similar methodology

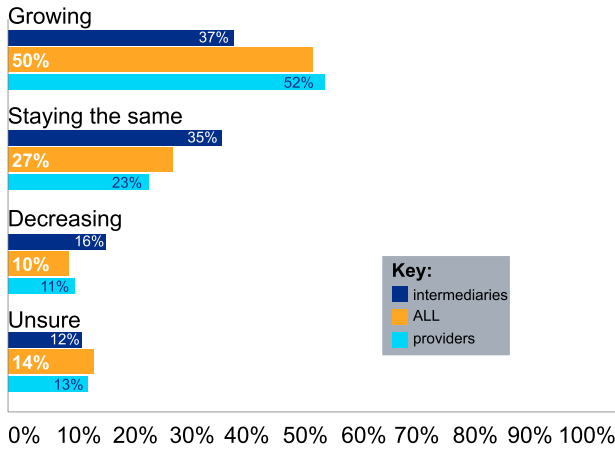


Figure 12. Business expectations.

to that used for revenues, the employment data from the 159 survey respondents were supplemented with data from secondary sources to project employment for all businesses thought to be involved in the Ocean Enterprise. The total employment is estimated to be between 223,000 and 268,000 employees in the United States. This employment estimate is for all business activity of companies who identified that they are active in provision of Ocean Enterprise-related products and services.

The survey asked a series of questions that related to expectations about the future. Respondents were generally optimistic with regard to growth of their Ocean Enterprise related business activities in the forthcoming twelve months. As shown in Figure 12, half of the respondents expected growth for the Ocean Enterprise related market sectors of their business. Intermediaries were less likely to project growth as compared to Providers, and more likely to predict their Ocean Enterprise-related business would decrease or stay relatively the same. This optimistic outlook for Ocean Enterprise-related revenue mirrors the projections for growth of the overall ocean economy.

Respondents were asked to report the market sectors with which their company is engaged. As shown in Figure 13, the Ocean Enterprise space is incredibly diverse in the end-use markets that it serves. Three end-uses are a target for at least half of the respondents (environmental monitoring, academic research, and offshore oil and gas), and a further seven are foci for at least one-third of respondents. The 25% threshold was associated with 12 different market sectors.

Analysis of the gross number of companies engaged in certain market activities does not necessarily reflect employment representation. For example, a hypothetical company engaged in the ‘defence’ market sector could potentially represent more gross employment than all

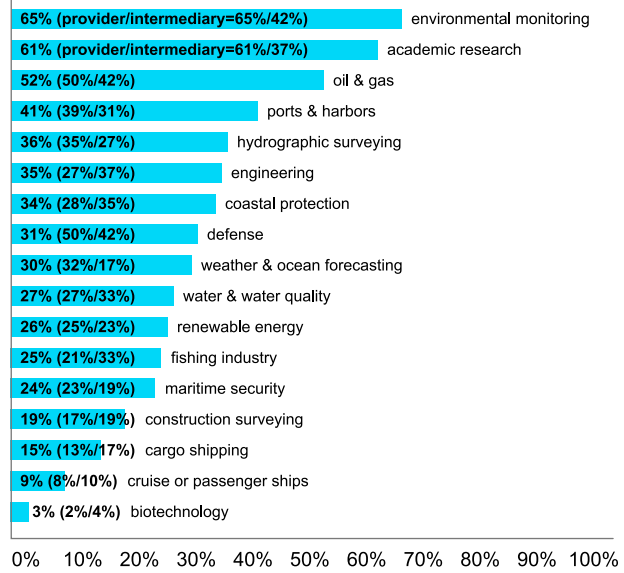


Figure 13. Market sectors.

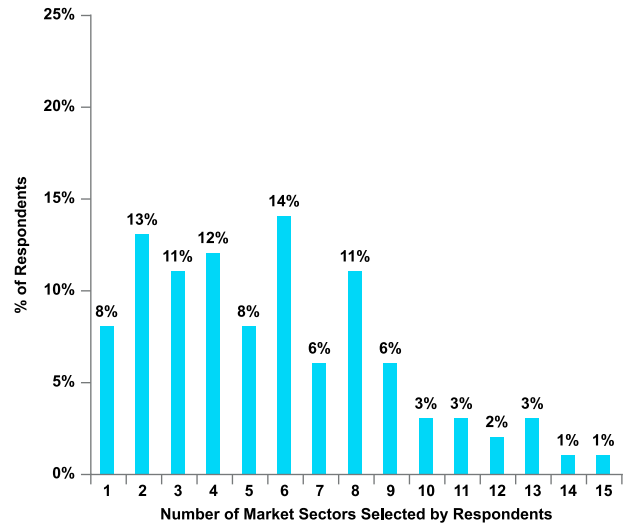


Figure 14. Number of market sectors served.

firms engaged in environmental monitoring combined. Accordingly, although fewer firms are engaged supporting ‘Cargo and Shipping’, it is possible that their employment representation has a far greater impact than some sectors that have more participation, but from many smaller firms.

The number of market sectors chosen by respondents provides an indicator of diversity of function. As shown in Figure 14, 14% of respondents reported their company was engaged in six of the listed market sectors. A combined 48% of respondents reported their company was engaged in more than five of the listed market sectors. Only 8% of respondents reported their company was engaged in only a single listed sector.

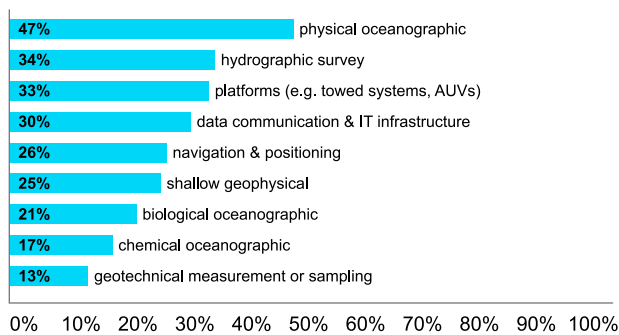


Figure 15. Types of Ocean Enterprise infrastructure sold.

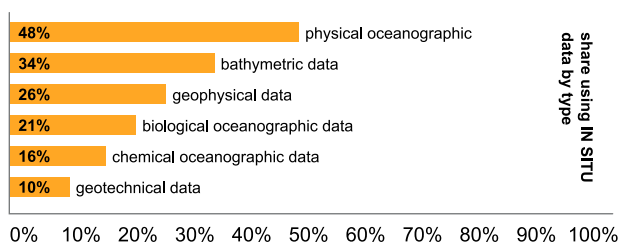


Figure 16. Use of in-situ data by data type.

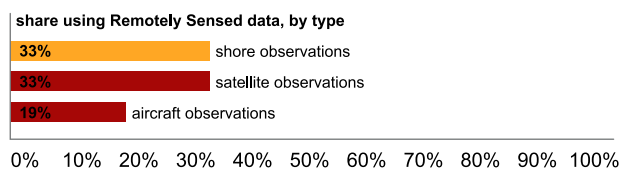


Figure 17. Use of remotely sensed data by data type.

Respondents who indicated they filled the role of a Provider of infrastructure for ocean observation, measurement and forecasting were asked a question regarding the types of infrastructure they sold. Nearly half (47%) provide physical oceanographic products of some type (Figure 15). Approximately one-third offer hydrographic survey products. These results are consistent with what might be expected from the more mature mission areas associated with mapping, charting, tide prediction, and general oceanography.

Organisations that indicated they were Intermediaries were asked a series of questions regarding their use of *in-situ* and remotely sensed data types. As shown in Figure 16, nearly half use physical oceanographic data, with one-third using bathymetric data and one-quarter reliant on geophysical data streams. The widespread use of physical oceanographic data is not surprising given that most Intermediaries would need this information to combine with other data to serve their service or product purposes.

Use of remotely sensed data is less common than *in-situ* data. Remotely sensed data is often not as easy to access or utilise and is applied to more specialised versus general purposes as compared to *in-situ* data. While approximately two-thirds of Intermediaries rely on *in-situ* data, 41% employ data that is remotely sensed. As shown in Figure 17, shore and satellite observations are both used by one-third of respondents, while airborne observations are used by just less than one-fifth.

## Comparison with the United Kingdom study

For the same survey year (2015), the number of companies identified in the United Kingdom was just under one quarter of the number of companies in the United States Ocean Enterprise. Annual Ocean Enterprise revenue for the United Kingdom was estimated at £1.8 billion (\$2.75 billion at the average exchange rate in 2015), compared with \$7.0 billion for the United States; consistent with the smaller number of companies. Export activity represented a far larger proportion of the revenue for United Kingdom companies than for the United States companies at £778 million (\$1.2 billion at the average exchange rate for 2015) or 43% of total revenue, compared with \$1.4 billion or 20% of total revenue.

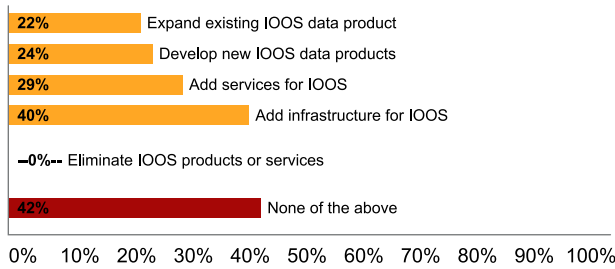
Overall the characteristics of the two countries Ocean Enterprise business activity are similar. Both have significantly more Producers than Intermediaries and provide services to similar markets with academic research, defence, offshore oil and gas and ports being the top four for each. Both studies point to the global nature of the Ocean Enterprise with North America, Europe and Asia-Pacific identified as major markets. In both studies, more than 65% of companies have 50 or fewer employees and over 80% of the companies report they have been in Ocean Enterprise related business activities for five or more years.

The principal difference between the results of the two studies is the relative level of export activity, with United Kingdom exports being a far larger proportion of total revenue and having an absolute value close to that for the United States. This reflects the large differences in scale of the domestic markets in each country.

## Awareness of IOOS

A further purpose of the Ocean Enterprise study was to assess respondents' awareness of the US IOOS. Seventy per cent of respondents indicated they were familiar with IOOS. This is a surprisingly high level of awareness, given that a significant proportion of the Providers





**Figure 18.** Future plans for working with IOOS.

would not necessarily be expected to have had direct dealings with the US IOOS.

Respondents who were aware of the US IOOS were asked to indicate their future plans with respect to the IOOS and IOOS data.

As shown in Figure 18, with regard to the provision of services and infrastructure, 40% planned on supporting new IOOS infrastructure and 29% intended additional services to the system. For use of IOOS data to support and develop products, 24% planned for new products that utilise IOOS data and 22% planned an expansion of existing products that utilise IOOS data. None of the respondents indicated that they planned to eliminate IOOS related products and services. By inference, the remaining 42% evidently plan to continue providing the same mix of IOOS-related products and services unchanged.

Reported barriers to working with IOOS are displayed in Figure 19. It is immediately apparent that perceived barriers to working with IOOS differed greatly by company function. For example, Intermediary businesses were far more likely to report that the data they utilise

did not adequately cover their target geographical use areas or that the structure of data streams limits their usability. This is not surprising given that the role of Intermediary companies is to use ocean observation data to enhance or create an information product. As would be expected, Providers were more likely to be concerned with development plans for the IOOS system itself.

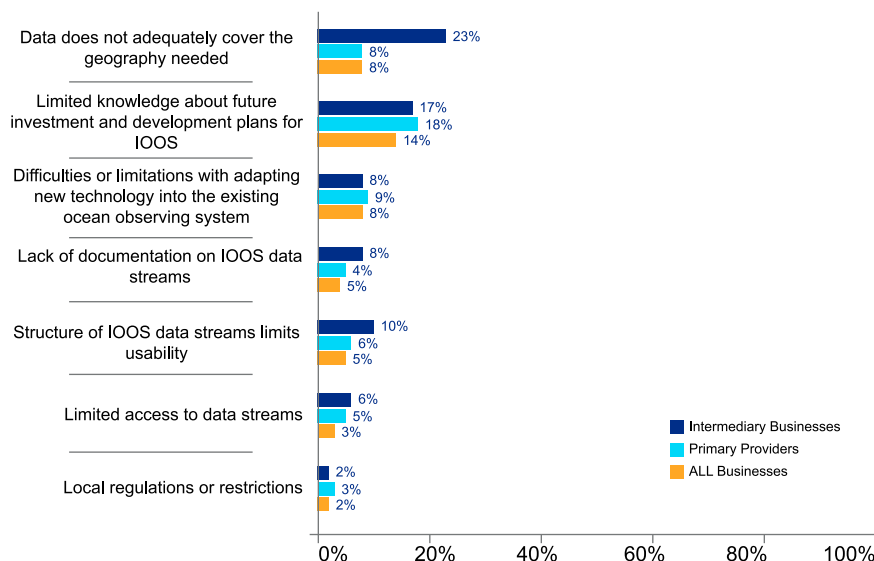
Respondents were also asked questions about access to suitably qualified employees. None cited this as a barrier for their business.

### Summary and next steps

The results of the Ocean Enterprise study identify a diverse and dynamic business cluster, delivering significant economic and employment benefits. Given the projected growth of the ocean economy over the coming decades the sector has considerable potential for further growth in the United States and elsewhere.

The revenues of Ocean Enterprise businesses in the United States could range as high as \$58 billion, with revenues due to maritime activities as high as \$14 billion and revenues due to Ocean Enterprise activities as high as \$7 billion. The total employment impact of businesses with Ocean Enterprise activities may range as high as 223,000–268,000 employees in the United States.

The business outlook as reported by respondents is one of optimism, with many companies reporting they will be developing new Ocean Enterprise products and finding new uses for ocean data and information. The potential for new business for existing companies and



**Figure 19.** Barriers to working with IOOS.

opportunities for new entrants is large, as the Ocean Enterprise business sector responds to the needs of a rapidly growing ocean economy and the pressing needs for protection of the ocean and coastal environment.

This study represents a first attempt to capture the scale, scope and characteristics of the Ocean Enterprise within the United States. As with all such early endeavours, the limitations of the study must be recognised. The execution of the study revealed the inherent issues with even identifying businesses involved in the Ocean Enterprise. Although there was some considerable success identifying target organisations through a concerted effort to compile lists from industry organisations, government sources, and through word of mouth from known businesses, there is no doubt that a significant proportion will have been left unidentified.

Other limitations of the study include possibly unreliable revenue reporting, lack of precision between reporting for entire organisations and subsidiaries, and the tendency of some respondents to omit some critical financial information.

Important lessons were learned with regard to the design of future survey instruments for similar research. For example, asking respondents to provide more detailed employment breakdowns, such as employment by revenue source, would enable detailed estimates of specific maritime-related employment. This would help to separate maritime and Ocean Enterprise activity levels for companies that also conduct business in non-maritime markets.

Next steps may include a more in-depth economic impact study, further investigation of the uses of and access to ocean observation data streams and regular update as undertaken in the United Kingdom. More study may also be warranted in examining service-demand gaps for potential new ocean information products and services.

The United States and United Kingdom studies provide a framework which could be used for corresponding work in other countries; leading to a consistent global assessment of the Ocean Enterprise.

It is hoped that valuable lessons learnt will be carried forward into subsequent studies and that future surveys will permit tracking the growth and development of the Ocean Enterprise in the United States and elsewhere.

## Acknowledgements

The Ocean Enterprise Study described in this paper represents a first of its kind evaluation of the extent of United States private sector, commercial activity in support of ocean measurement, observation and forecasting and the sale of ocean information to underpin safety, economic and environmental benefits. Work on the Ocean Enterprise Study was supported by The Maritime Alliance, San Diego, CA and Eriss Corporation, San Marcos, CA.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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