



**The value of Australian seabed  
mapping data to the blue economy**

Geoscience Australia

October 2021

# Executive brief

- Seabed mapping is a little-known activity, but for many key Australian industries, it is **critical to their operations at sea**. Key examples include:
  - **Commercial fishing and aquaculture:** seabed mapping data is required for operators to safely navigate the sea, to guide fishing and aquaculture site selection and to minimise associated environmental impacts.
  - **Offshore energy generation:** Seabed mapping data provides useful information on seabed characteristics that can inform optimal site section, provide evidence to support obtaining environmental and planning approvals and in establishing the required infrastructure (e.g. pipelines and wind turbines).
  - **Tourism:** Seabed mapping is critical for tourism operators to safely navigate the sea and to reduce environmental impacts associated with anchorage and transportation.
- Many government agencies, not-for-profits and commercial operators have been collecting high-resolution seabed mapping data to ensure that economic activities are undertaken safely and sustainability.
- Currently, around **25 per cent of the seafloor within the Australian Exclusive Economic Zone (EEZ)** has been mapped at a resolution suitable to inform sustainable management and use of marine resources.
- Deloitte Access Economics was engaged by Geoscience Australia to undertake an economic analysis to **establish the role of seabed mapping in the Australian economy**, including its supply chain and employment effects.
- The process of producing seabed mapping data directly contributed \$51 million to the Australian economy in 2018-19 and employed over 500 FTEs (full-time equivalent).
- Much of the value of seabed mapping data generates, comes from the wealth of economic activity it enables:
  - In 2018-19, the use of **seabed mapping data directly contributed \$9 billion to the Australian economy and employed over 56,000 FTEs**.
  - This direct contribution is **bigger than the size of the air and space transport sector and rental and hiring services sector**.
  - The use of seabed mapping data also creates demand for upstream activities, contributing a further \$7 billion in indirect value added to the economy in 2018-19.
  - In addition to these figures, there was **\$37 billion of unlocked economic activities** in 2018-19 that is attributable to the use of seabed mapping data during establishment.
- Actions that can maximise the economic dividends of seabed mapping data going forward include:
  - Increase the rate of data acquisition to fill important gaps.
  - Unlock archives of seabed data held by government and industry organisations.
  - Modernise the management of, and online access, to publically available seabed data.
  - Provide seabed mapping data essential for offshore renewable energy and tourism.

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**Geoscience  
Australia**

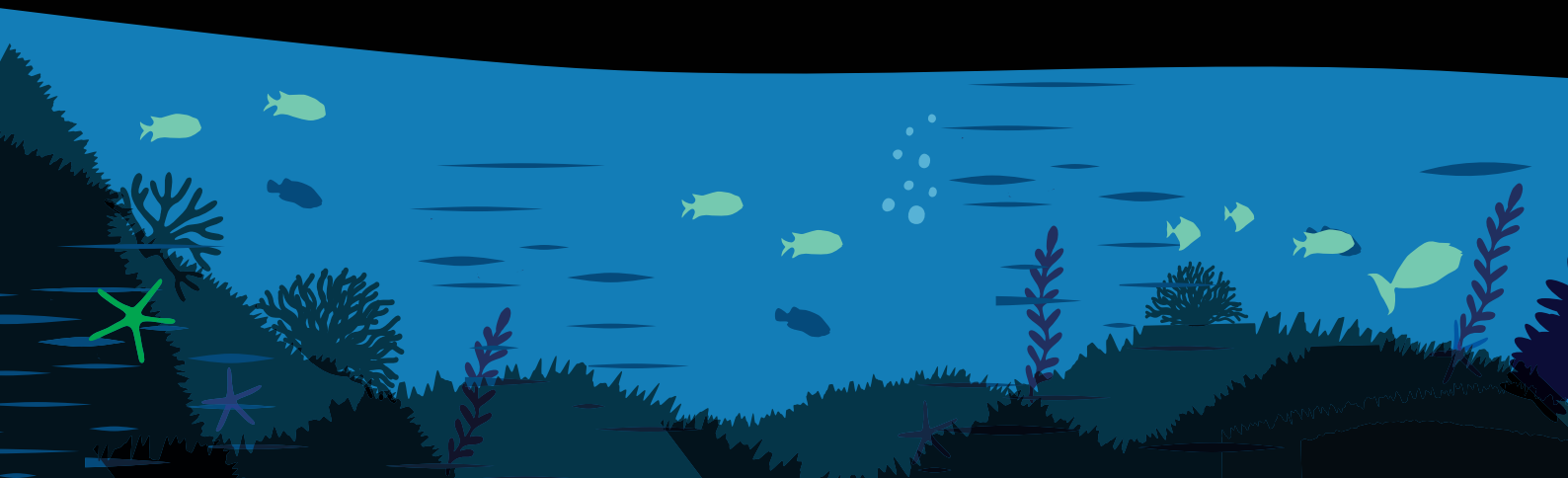
**Australian  
Hydrographic Office**

**The Commonwealth Scientific  
and Industrial Research  
Organisation (CSIRO)**

**Western Australia  
Department of Transport**

# Contents

<b>Acronyms</b>	<b>1</b>
<b>Executive summary</b>	<b>2</b>
<b>1 Introduction</b>	<b>5</b>
1.1 Mapping the Seabed – a Global and National Challenge	6
1.2 This project	7
<b>2 What is seabed mapping?</b>	<b>8</b>
2.1 What is seabed mapping?	9
2.2 How is the seabed mapped?	10
2.3 Where is Australia’s seabed mapped?	10
<b>3 Defining the seabed mapping industry</b>	<b>12</b>
3.1 Seabed mapping supply chain	13
3.2 How seabed mapping creates economic value	14
3.3 Industry survey	15
<b>4 Seabed mapping data producers</b>	<b>16</b>
4.1 Overview	17
4.2 Who produces seabed mapping data?	17
4.3 Survey results on seabed mapping data producers	20



<b>5 Seabed mapping data users</b>	<b>22</b>
5.1 Overview	23
5.2 Who uses seabed mapping data?	23
5.3 Survey results on seabed mapping data users	24
<b>6 Economic contribution of seabed mapping data in Australia</b>	<b>26</b>
6.1 Overview	27
6.2 Data production	28
6.3 Data use	29
<b>7 Broader impact of seabed mapping</b>	<b>35</b>
7.1 Overview	36
7.2 Environmental impact	36
7.3 Social and cultural impact	38
<b>8 Where to from here?</b>	<b>43</b>
8.1 Supporting future growth	44
8.2 Increasing availability and uptake of seabed mapping data	44
<b>Appendices</b>	<b>48</b>
<b>Limitation of our work</b>	<b>58</b>



# Acronyms

<b>Acronym</b>	<b>Full name</b>
ABARES	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
AHO	Australian Hydrographic Office
AIMS	Australia Institute of Marine Science
AMSA	Australian Maritime Safety Authority
APPEA	Australian Petroleum Production and Exploration Association
AUV	Autonomous underwater vehicle
CAGR	Compound annual growth rate
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEM	Digital Elevation Model
EEZ	Exclusive Economic Zone
EU	European Union
FTE	Full time equivalent
GA	Geoscience Australia
GBRMPA	Great Barrier Reef Marine Park Authority
GEBCO	General Bathymetric Chart of the Oceans
HIPP	HydroScheme Industry Partnership Program
IOIG	Input Output Industry Group
LiDAR	Light detection and ranging
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MNF	Marine National Facility
NIWA	New Zealand National Institute of Water and Atmospheric Research
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
SDB	Satellite derived bathymetry
TEV	Total economic value
UN	United Nations
US	United States
USD	United States dollar



# Executive summary



## Current coverage

In today's economy, **data is a driver of growth**. Data can broadly be defined as any information that is collected or created through observation. As such it can take many forms – from sounds, to videos and imagery, sensor and spatial information, and qualitative or quantitative information. Leveraging data can help governments, businesses, scientists, and individuals to better understand their industries and create a competitive advantage. It can inform decision-making, optimise solutions, and enable innovation.

For Australia's blue economy, seabed mapping data is essential to the establishment and operation of many marine industries that significantly contribute to Australia's economic growth.

Over several decades, a wide range of Australian government agencies, universities, not-for-profit organisations and private sector firms have acquired seabed data, motivated through a combination of legal obligations, scientific curiosity, environmental management and commercial interests.

*The process of 'seabed mapping' comprises the collection, compilation, analysis, and interpretation of information on and below the sea floor.*

Australia's blue economy is an area with strong potential for economic growth; however, **three-quarters of the Australian seabed is yet to be mapped** to an adequate resolution to assist businesses and governments in decision making. This data deficit is constraining economic activity and should be addressed to enable Australia's blue economy to thrive.

It is in this context that this project aims to **understand the current economic significance of seabed mapping data in Australia** and the **future benefits** that can be associated with a more comprehensive understanding and application of Australia's ocean resources, as informed by seabed mapping data.

## Current economic value

While the act of **collecting seabed mapping data is an economic activity** within itself, the **commercial outcomes that are driven by the use of seabed mapping data** highlight the true value derived from mapping Australia's seabed.

The applications of seabed mapping are broad, with some of the key uses being:

- Safe marine navigation and anchorage
- Resource exploration and extraction
- Fisheries and other bio-product management
- Recreation and tourism
- Coastal and environmental protection
- Marine search, rescue, and recovery
- Hazard identification and risk modelling
- National defence and marine security
- Infrastructure planning and approvals

Identifying how seabed mapping creates economic value is a case of 'following the money' through the economy. The economic value of seabed mapping data is generated through four channels.

1. **Data production** - The value created through the production and sale of seabed mapping data in Australia.
2. **Data enabling industries (data use)** – activities that are enabled (facilitated) through the use of seabed mapping data. The application of seabed mapping data across these industries varies, and has been split into two categories:
  - Operational seabed mapping data use (used in operations): activities that use seabed mapping data on a regular basis to undertake ongoing revenue generating activities.
  - Unlocked potential (used in establishment): activities that require the use of seabed mapping data in their establishment, but not necessarily ongoing operational use.
3. **Data enhanced industries (data use)** - Industries that use seabed mapping data as part of their usual activities, but these activities are either not core to the industry or seabed mapping data is not essential to them being able to perform these functions.
4. **Non-market benefits** - activities that generate non-market benefits (i.e. environmental, cultural, and social benefits), which do not translate to market activity but are nonetheless valued by society.



The economic contribution of seabed mapping data in Australia in 2018-19 is captured using an input-output analysis methodology.

The process of producing seabed mapping data in itself is an economic activity, which is estimated to have directly contributed \$51 million to the Australian economy in 2018-19 and employed over 500 FTEs. Data production is only a small subset of the value chain of seabed mapping data when compared to the wealth of economic activity unlocked through data use.

*In 2018-19, the use of seabed mapping data directly contributed \$9 billion to the Australian economy and employed over 56,000 FTEs.*

This direct contribution is **bigger than the size of the air and space transport sector** (\$7.3 billion) and rental and hiring services sector (\$8.0 billion)

The use of seabed mapping data also creates demand for upstream activities, **contributing a further \$7 billion in indirect value added to the economy** in 2018-19.

In addition to these figures, there was **\$37 billion of unlocked economic activities** in 2018-19 that is attributable to the use of seabed mapping data during establishment.

### Broader impact

In addition to economic activity, there are also **significant social, cultural, and environmental benefits** that are attributable to the production and use of seabed mapping data.

Seabed mapping data is also often used to understand vulnerability to human impacts, natural hazards such as storm surge, and the physical make-up (geomorphology) of our coastal environments and has been used widely for **environmental management, monitoring, and research**.

Seabed mapping data also holds significant cultural value. It increases traditional owners' **understanding of Sea Country** and can reveal culturally significant events, ranging from drowned landforms that may have been occupied by the ancestors of traditional owners, to historical shipwrecks.

### Growth potential

Marine industries have been able to turn the current coverage of seabed mapping data into a multi-billion-dollar industry. This demonstrates the significant potential this industry has, with over 75 percent of Australia's seabed still to be mapped.

Future growth in the blue economy can be unlocked in two ways. Firstly, through increasing the coverage and usability of high-resolution seabed mapping data and secondly, through increasing the rate at which seabed mapping data is adopted by industries.

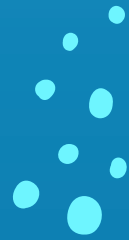
**Increasing the production of seabed mapping data** will create additional activity in the economy through the acquisition of data, as well as providing new coverage of high resolution data to end-users, enabling them to either conduct their usual operations more efficiently or expand their activities to new areas.

The future economic value of seabed mapping data will depend not only on coverage, but on the rate of adoption of new data (as well as existing data). The adoption of seabed mapping data reflects the capability and willingness of an economy's industries to apply seabed mapping data to production, planning and other decision-making processes.

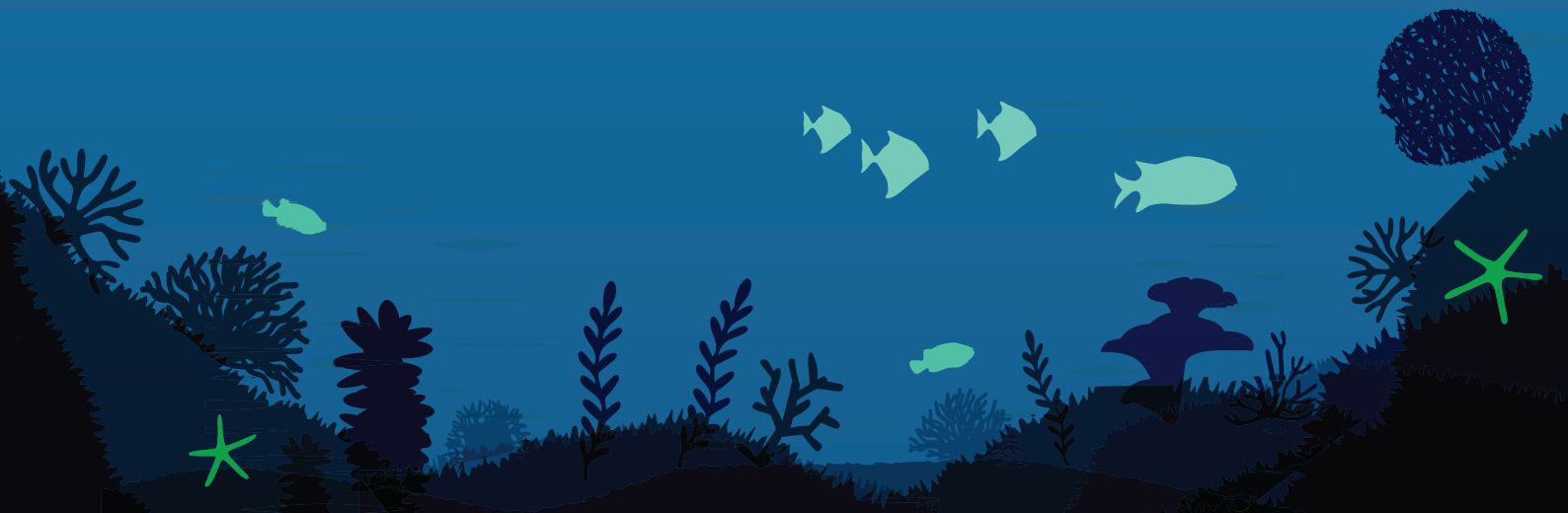
The **benefits and economic contribution of seabed mapping data will increase with a higher utilisation of the data**, as its applications will be broader and attributable to a wider range of economic activity.

New adoption of seabed mapping data also has the ability to unlock new activity, particularly among emerging industries (e.g. offshore renewable energy) where the adoption of the data can inform planning, approvals, construction, and ongoing operations.

Importantly, **areas yet to be mapped likely hold new environmental assets, crucial insights into marine processes, which can generate significant economic potential**.



# 1 Introduction



## 1.1 Mapping the Seabed – a Global and National Challenge

### Background

Access to high-resolution topographic and land-cover data is usually taken for granted because most of the Earth's continents and islands have been well mapped for many decades.<sup>1</sup> However, around 70 per cent of the Earth's surface lies below the oceans and less than half of this area has been mapped in any detail. This huge data and knowledge gap is a legacy of both a lack of awareness of the value of the undersea environment, and the technical challenges posed by measuring the seabed from the ocean surface. Recent advances in marine acoustic technology and computing have enabled much more detailed and rapid mapping of the seabed. However, most nations are still in 'catch up' mode in terms of mapping the seabed of their marine estates and effectively managing the data.

### Recent initiatives

To address major gaps in seabed data, national and international programs have recently started to pull together the available data (e.g. Nippon Foundation GEBCO Seabed 2030 Project<sup>2</sup>), and to plan and implement systematic seabed mapping of national waters (e.g. USA: National Strategy for Ocean Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone; European Union: Marine Observation and Data Network – EMODnet; and MAREANO, the national seafloor mapping programme of Norway). Key drivers of these initiatives are to better inform the management of marine environments and to realise greater benefits from their sustainable use.

### Key challenges

Mapping the seafloor is often driven by commercial interests as much as by government or scientific needs. Both seek to close knowledge gaps and understand seabed characteristics and processes. These often complementary drivers for data acquisition have led to increased volumes of data; however, in the absence of system-wide collaboration and coordination, they have also led to a duplication of effort, varying quality of survey outputs and different formats of data. This situation limits progress towards seamlessly joining up datasets to increase the overall data coverage and quality and improving our knowledge of the seabed.

Currently, around 25 per cent of the seafloor within the Australian Exclusive Economic Zone (EEZ) has been mapped to a resolution suitable to inform its sustainable management and use.<sup>3</sup> The AusSeabed initiative was recently formed to address this national data gap by improving communication and collaboration across Australia's seabed mapping sector, with a shared vision to:

“By 2030, all available seabed mapping data within the Australian Marine Estate will be readily and openly available, and new data acquisition will take into account the needs of a wide range of users. This will facilitate collaborations between government, research institutions and the private sector while contributing to the blue economy and opening up new avenues for scientific investigation.”

– AusSeabed Strategic Plan 2030

To help realise this vision and better support growth in the blue economy, Australian seabed mapping stakeholders have identified the need for an appropriately resourced national mapping program, along the lines of programs now underway in the United States and European Union countries.

Key to these national approaches is complementing and enhancing existing mapping activities, developing a modern system of data processing, management and delivery, and the production of seabed data products that better inform the use and conservation of marine resources.

## 1.2 This project

In recognition of the importance of seabed mapping in understanding Australia's vast and finite marine resources, it is timely to showcase the value of seabed mapping and the role it plays in advancing the economic, environmental, and societal interests of Australia.

It is in this context that Deloitte Access Economics was commissioned by Geoscience Australia to undertake an economic analysis to establish the role of seabed mapping in the Australian economy, including its supply chain and employment effects.

This report seeks to present the current economic and environmental significance of seabed mapping data in Australia and the potential economic benefits that could be unlocked with investment in a national seabed mapping program. Specifically, this report will communicate our research, analysis, and findings through the following sections:

- **CHAPTER 2** | defines seabed mapping in the Australian context and explores how the industry has developed over time.
- **CHAPTER 3** | discusses how seabed mapping is used to create economic value.
- **CHAPTER 4** | defines the industries producing seabed mapping data in Australia.
- **CHAPTER 5** | defines the boundaries of the key industries and businesses that use seabed mapping data.
- **CHAPTER 6** | presents the economic contribution of seabed mapping data facilitated through key industry users and data production activities.
- **CHAPTER 7** | presents the broader social and environmental benefits seabed mapping contributes to Australia.
- **CHAPTER 8** | presents 'what's next' for the seabed mapping industry and how a growing data pipeline, increased adoption rate and new applications of data can further increase the value seabed mapping data contributes to the Australian economy.

## 2 What is seabed mapping?

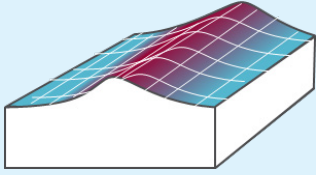

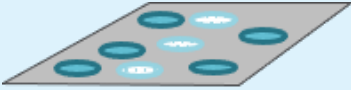
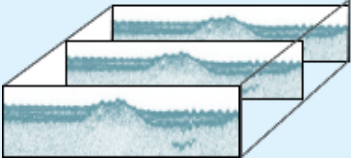

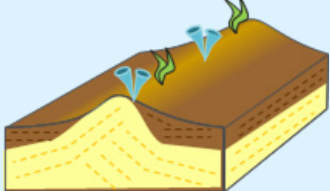


## 2.1 What is seabed mapping?

The definition of seabed mapping captures a complex mix of techniques and activities that all work together to increase our understanding of the undersea landscape. Throughout this report, we will refer to seabed mapping as a process which encapsulates the *“collection, collation, compilation, analysis and interpretation of information on (and below) the ocean floor and includes bathymetry, acoustic backscatter, sediment samples, sub-bottom profiles, and sea floor imagery; and extends to derived interpreted products and information, such as maps of seabed geomorphology, hardness and habitat.”*<sup>4</sup>

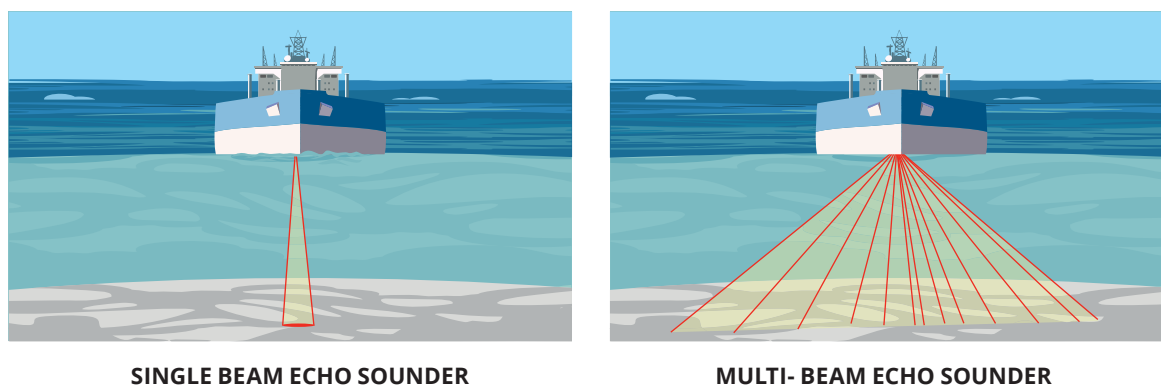
Building a comprehensive understanding of the seafloor requires both acoustic and optical imaging, as well as physical sampling techniques. Layering various types of seafloor data, such as that shown in Table 2.1, allows data producers to offer a range of parameters useful to end-users. For example, seabed backscatter data is often used as a proxy for the hardness of the seabed and water column data can be employed to indicate features (e.g. plankton; fish) and oceanographic processes (e.g. currents).<sup>5</sup>

Table 2.1: Integration of seabed mapping data

<p><b>Bathymetry data</b> is the foundation of seabed mapping. It involves obtaining measurements of the depth of the ocean and is the equivalent to mapping topography on land.</p>	
<p><b>Backscatter data</b> provides information on the ‘hardness’ and ‘roughness’ of the sea floor and is used to differentiate between different types of sea floor material, such as hard rock or soft sediment.</p>	
<p><b>Seabed sediment samples</b> can provide information on grain size (e.g. mud, sand or gravel), mineralogy, fabric and hardness. These samples are collected through a wide range of coring and sampling devices.</p>	
<p><b>Sub-bottom profiles</b> are used to image and characterise geological structure below the sea floor, such as the thickness of seabed sediment.</p>	
<p><b>Biological samples</b> from the seafloor provide information on biodiversity and the relationship between seabed physical features and the lifeforms that it supports.</p>	
<p><b>Integrating</b> these types of seabed mapping data provides insights into seabed structure, composition and habitats.</p>	

Source: Dove, D., Nanson, R., Bjarnadóttir, L.R. et al. 2020. A two-part seabed geomorphology classification scheme:(v. 2). Part 1: morphology features glossary: <http://nora.nerc.ac.uk/id/eprint/528742/1/OR20057.pdf>

Figure 2.1: Illustration of seabed mapping by single and multi-beam echo sounders



Source: Deloitte Access Economics;

## 2.2 How is the seabed mapped?

The seabed is very difficult to directly observe, therefore, seabed mapping is primarily undertaken using an **echo sounder**, which is usually attached to ships, but can also be installed on remotely operated or autonomous underwater and sea-surface vehicles, and deep-tow equipment. An echo sounder measures the depth of the seafloor by emitting a sound pulse into the water then timing how long it takes for that pulse to hit the seabed and return as a reflection.

The simplest technology used for seabed mapping is **single beam echo sounders** that point vertically down beneath the ship to measure the depth of the sea. This technology achieves coverage by continually travelling back and forth in a series of parallel lines so that comprehensive coverage requires a relatively large amount of survey time.

To address the data gaps that arise with the use of single beam echo sounders, many surveyors now use **multibeam echo sounders**. These systems transmit sound to the seabed in a fan pattern that spreads outwards and downwards and can resolve the return echo into many beams (as shown in Figure 2.1). This technology measures the time it takes for the sound to return but can also infer the direction where the sound returns from, providing a measurement of the shape of the seafloor in three dimensions. In addition to bathymetry data, multibeam backscatter data can also be collected at the same time. This data can be used to infer the degree of hardness and/or roughness of the seafloor based on the strength of the returning signals, as well as provide information on features of the water column.

The other commonly used mapping methods are **Airborne LiDAR systems and satellite-derived bathymetry (SDB)**, which are typically used in shallow waters, ranging from several metres down to around 50m (LiDAR). LiDAR systems are mounted in aircrafts and employ wide laser beams to penetrate the water column, while SDB uses reflected light from the seabed that is detected by optical sensors on satellites.

## 2.3 Where is Australia's seabed mapped?

Only around 25 per cent of Australia's EEZ has been mapped with multibeam echosounders. In addition to this, there are also significant gaps in our understanding of seabed characteristics, such as sediment type, underlying geology, and habitats. Complementing bathymetry with this additional information provides a more complete view of the seabed environment. This information is included in our definition of "seabed mapping data": data that describes the depth, shape and composition of the seafloor.

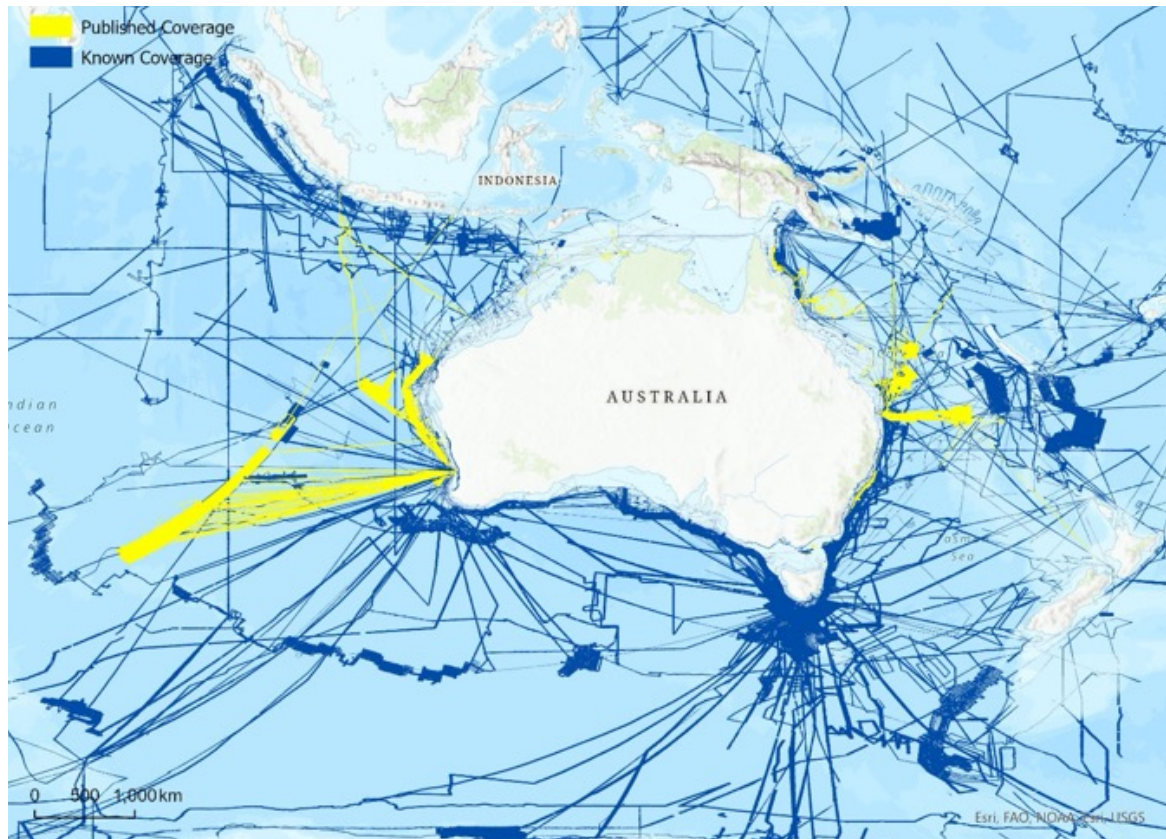
Of the estimated **25 per cent of the seafloor mapped using modern technologies**, the quality and level to which these areas have been mapped is yet to be fully assessed. It is likely that not all of this data would be suitable for all common applications. Most of the areas mapped lie along **major shipping routes**, with large areas in between lacking adequate coverage (refer Figure 2.2).



Areas with greater, consistent coverage have **generally been purposely mapped as part of regionally focused projects**. These areas include the Great Barrier Reef Marine Park, the Southwest Margin (Geoscience Australia's Energy Security Program) and the Great Australian Bight (CSIRO's *Great Australian Bight Deepwater Marine Program*<sup>6</sup>). Other examples include the Southern Ocean to the south of Tasmania, the Indian Ocean southwest of Perth (mapped during the search for Malaysian Airlines flight MH370), and the western continental margin which was mapped to identify seabed characteristics and features and for a future submission to the Law of the Sea – Extended Continental Shelf process.

In addition to these project specific drivers, the Australian Government is investing in seabed mapping to support safe navigation by partnering with the marine industry. The HydroScheme Industry Partnership Program (HIPP) run by the Australian Hydrographic Office has identified, with inputs from the AusSeabed community, priority areas of Australia's EEZ for seabed mapping. These priority areas were identified based on safety and efficiency requirements for a broad range of marine activities, including safety of navigation/shipping routes, tourism, and environmental management. A case study of one of these areas and the economic activity that mapping could potentially unlock are discussed in Chapter 7.

Figure 2.2: Australia's mapped ocean regions



Source: Geoscience Australia (2021)



# 3 Defining the seabed mapping industry



### 3.1 Seabed mapping supply chain

The awareness of, and investment in, seabed mapping within Australia and internationally has steadily increased with the arrival of high-resolution multibeam echosounder technology in the 1970s. Motivated mainly through a combination of scientific curiosity, legal obligations for Australia’s maritime jurisdiction, and commercial interests, a wide range of government agencies, not-for-profit organisations and private sector firms have contributed to mapping the Australian seabed. **In this study, public and private organisations involved in the production of seabed mapping data are termed ‘producers’.**

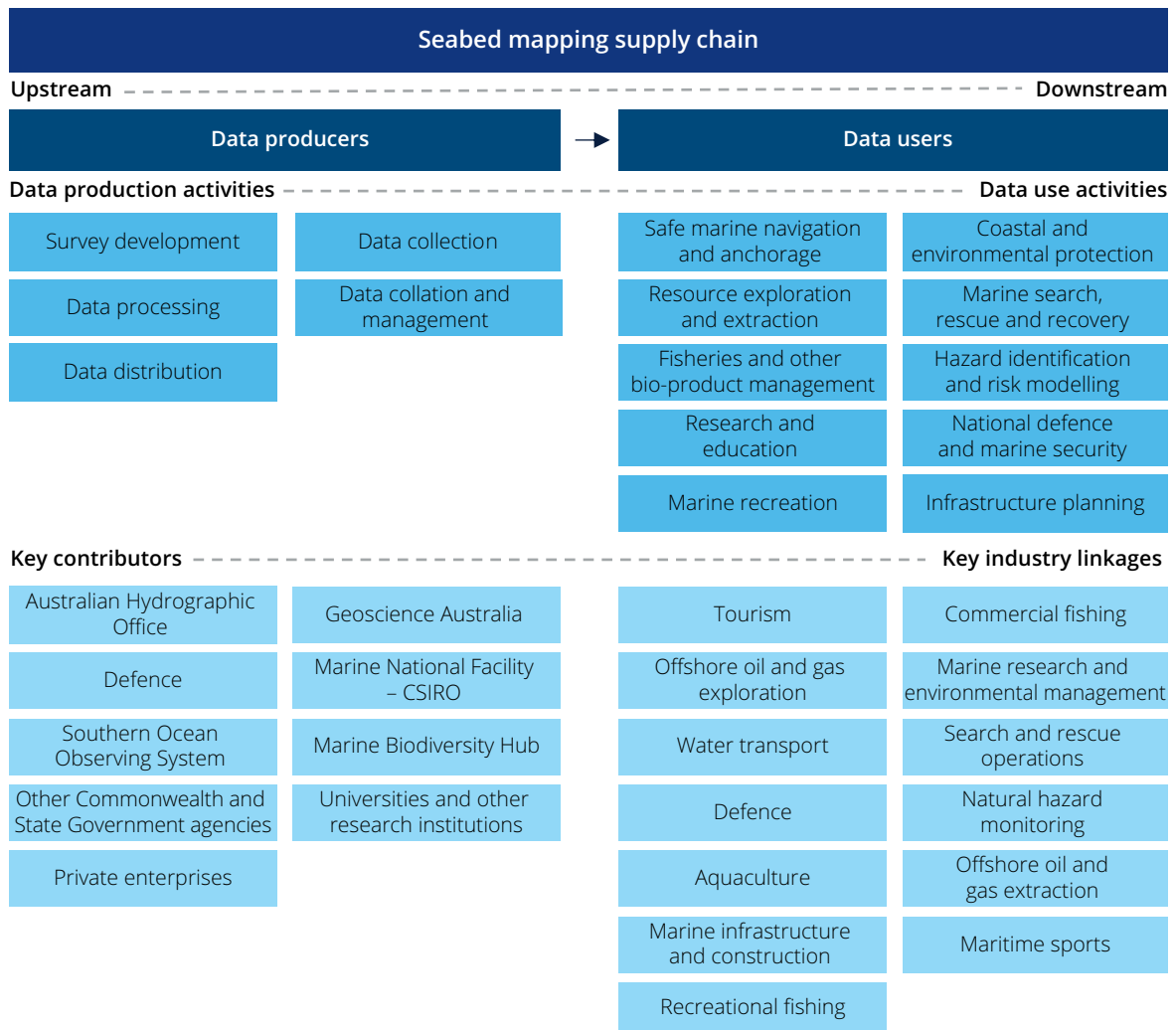
As data producers continue to increase the quality and coverage of seabed mapping data, the mapping technology is used in most of Australia’s marine industries. The applications of seabed mapping are broad, with some of the key uses being:

- Safe marine navigation and anchorage
- Resource exploration and extraction

- Fisheries and other bio-product management
- Recreation and Tourism
- Coastal and environmental protection
- Marine search, rescue and recovery
- Hazard identification and risk modelling
- National defence and marine security
- Infrastructure planning and approvals

The reason for adoption of seabed mapping data use across industries ranges from safety and legal obligations to productivity and efficiency gains. In some cases, seabed mapping even unlocks new opportunities that were not feasible without a better understanding of the sea floor. The seabed mapping data supply chain (refer Figure 3.1) extends the flow of activity from the data production process to the end user activities.

Figure 3.1: Seabed mapping supply chain



## 3.2 How seabed mapping creates economic value

Identifying how seabed mapping creates economic value is a case of 'following the money' through the economy. The economic value of seabed mapping data is generated through four channels:

1. Data production
2. Data enabled industries (data users)
3. Data enhanced industries (data users)
4. Non-market benefits

The distinction between these channels is used to inform the estimate of the economic contribution.

### Channel One: Data production

**The first channel is the value created through the production and sale of seabed mapping data in Australia.** Data producers may collect seabed mapping data for the purposes of selling the data to industry, or they may collect the data for their own use or for the use of others, with intermediate expenses associated with data collection generating additional commercial activity.

### Channel two: Data enabled industries (data users)

Data enabled industries are those whose activities require or are heavily reliant on the use of seabed mapping data. **Seabed mapping data is crucial to the functions of these industries** and businesses would not be able to conduct their usual activities effectively or safely without this data. For example, the water transport sector is required to use official nautical charts, which are derived from seabed mapping data, to safely navigate the ocean. These obligations are stated under the Navigation Act 2012.

The application of seabed mapping data across these industries varies, and has been split into two categories:

- **Operational data use:** Comprised of the activities and organisations that rely on seabed mapping data for regular operational activities. This includes activities such as fishing, sea freight and passenger transport, search and rescue operations, construction of offshore infrastructure, marine research and environmental management.
- **Establishment data use:** Comprised of the activities that rely on the use of seabed mapping data in their establishment, but do not necessarily rely on the data for ongoing operational use. This includes activities that require assessment of potential environmental impact or that rely on seabed mapping for design and engineering for a site to become established, such as in marine infrastructure, oil and gas extraction, and aquaculture.

### Channel three: Data enhanced industries (data users)

Industries that use seabed mapping data as part of their usual activities, but these activities are either not core to the industry or seabed mapping data is not essential to them being able to perform these functions. For example, the use of seabed mapping data is not critical to undertake recreational fishing, however it can be beneficial.

### Channel four: Non-market benefits

In addition to assisting in activities that generate economic output, seabed mapping data also contributes to non-market activities that generate economic value. Seabed data generates environmental, cultural, and social benefits that do not translate to market activity but are nonetheless valued by society. For example, seabed mapping data can be used to monitor the health of marine ecosystems and ensure damage to ecosystems from human activity is minimised, which translates to an improvement in environmental and ecosystem services which has an inherent value.

### 3.3 Industry survey

To obtain a holistic view of Australia's seabed mapping industry, Deloitte Access Economics fielded the *Seabed Mapping Data Users and Data Producers Survey* to a broad range of stakeholder organisations, including AusSeabed collaborators and partners.

#### Seabed Mapping Data Users and Data Producers Survey

The Seabed Mapping Data Users and Data Producers survey was fielded to gain a more holistic view on the seabed mapping activities taking place across the supply chain and to obtain the financial spend and revenue attributable to seabed mapping-related activities. The survey was fielded from 11 March to 23 April, with 32 responses received from a range of industry stakeholders.

The survey was split into two streams: one for seabed mapping data users and one for seabed mapping data producers. Those who are both data users and producers answered both parts of the survey.

The **data user survey** was designed to understand the breadth of seabed mapping data use in Australia across industries and regions, frequency of seabed mapping data use, and the revenue and expenditure derived from seabed mapping data use. It also captured the key sources of seabed mapping data, barriers to seabed mapping data access and use in Australia, and willingness to pay to access data (including higher quality data).

The **data producer survey** was designed to understand the role that seabed mapping data producers play in the capture and distribution of seabed mapping data and to evaluate the resources expended on seabed mapping data production in Australia. The survey also captured the key limitations to greater data collection and distribution in Australia in order to understand the challenges facing the data production industry.

Responses from a representative sample of data producers and data users (refer to Chart 3.1) were collected across a range of government departments, research institutions and the private sector (refer to Chart 3.2). **Over half of the respondents both produced and used seabed mapping data.**

Chart 3.1: Type of respondent

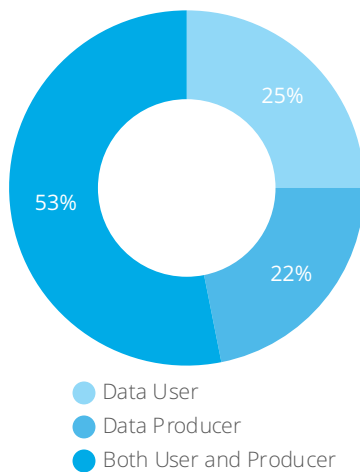
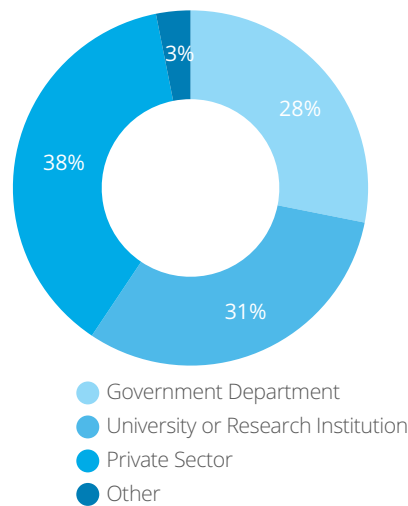


Chart 3.2: Respondent organisation type



Source: Deloitte Access Economics' Seabed Mapping Data Users and Data Producers Survey

# 4 Seabed mapping data producers



### 4.1 Overview

**Seabed mapping data producers include those who are directly involved in acquiring, processing and delivering seabed mapping data; either independently or through collaboration.**

The process of data capture, processing, delivery and utilisation form the data value chain as shown in figure 4.1. The data is provided under commercial or open-access licences and is employed across a wide variety of industries that generate economic activity.

### 4.2 Who produces seabed mapping data?

There are a variety of seabed mapping data producers in Australia, many of which are split between the private and public sector.

#### 4.2.1 Government

The government bodies that contribute to the acquisition of seabed mapping data at a national scale include the Australian Hydrographic Office (AHO), the Marine National Facility (MNF), the Australian Institute of Marine Science (AIMS) and Geoscience Australia (GA).

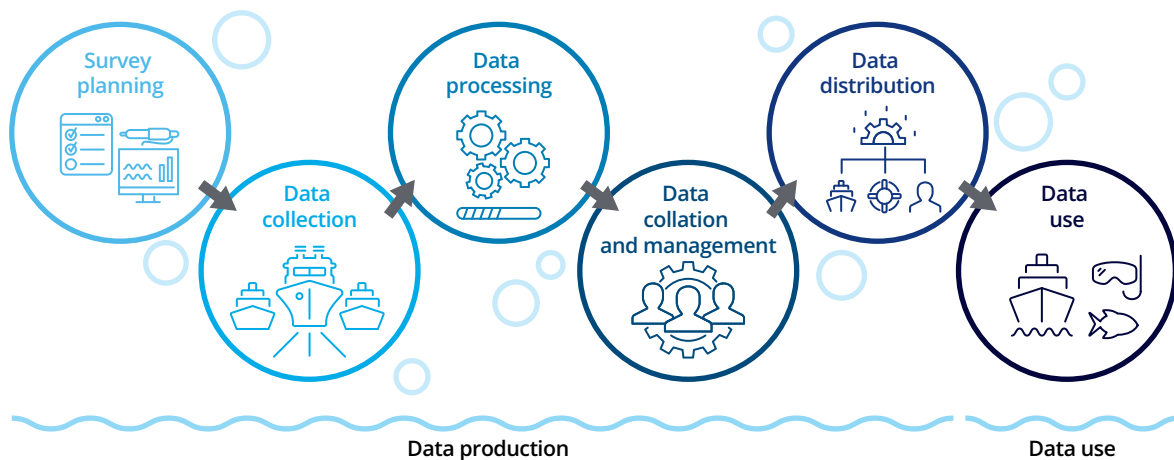
The **MNF is Australia’s dedicated blue-water research facility, which is funded by the Australian Government and operated by CSIRO.** The MNF collects bathymetry data when operating their research vessel (RV) Investigator as part of expeditions that require seabed mapping data as part of a research project, and during transit between survey sites. This allows them to regularly collect seabed mapping data, with nearly 50 per cent of the currently mapped Australian seabed (1.26 million km<sup>2</sup> of 2.54 km<sup>2</sup>) attributable to the MNF.

The **AHO is the national authority on hydrographic matters**, and is responsible for delivering hydrographic services to meet the demands of the maritime community in line with Australia’s obligations under the International Convention for the Safety of Life at Sea, the United Nations Convention on the Law of the Sea and the Navigation Act 2012.

To further contribute to these obligations and their national charting priorities, the HydroScheme Industry Partnership Program (HIPP) was established in early-2020. The HIPP is managed by the AHO and is a commercial acquisition program to efficiently collect bathymetric data to improve Australia’s knowledge of the maritime domain and allow the Royal Australian Navy to concentrate on the military survey function. The program represents a \$150 million Government investment over the first five years with an objective to obtain full, high-quality survey coverage of the Australian Exclusive Economic Zone (EEZ) out to a depth of 200 m by 2050.

The **AIMS acquires seabed data using their research vessels**, in particular RV Solander, as part of their research into the tropical marine environments of Australia. The focus of this seabed mapping is coastal and shelf environments (usually <200m depth).

Figure 4.1 Seabed mapping data value chain



Source: Deloitte Access Economics; AusSeabed Strategic Plan 2030

### **Geoscience Australia acquires seabed mapping data to address specific government information needs,**

including to meet Law of the Sea data requirements; provide environmental context for potential areas of offshore oil and gas exploration; inform marine hazard assessments; and to support national marine conservation priorities. GA harvests and releases data acquired by other research and commercial organisations, including international vessels that operate within Australian waters. GA also leads the AusSeabed initiative, which involves activities that aim to improve national coordination of seabed mapping effort, and the availability and quality of bathymetry data (discussed in 4.2.3).

### **State Governments also have agencies that acquire and provide access to large volumes of seabed data.**

The data is used to support marine research, environmental management and commercial activities within state waters. For example, large areas of Australia's inner shelf have been mapped by the NSW, Victorian and Northern Territory governments, while the Department of Transport in Western Australia has recently been working with AHO to map priority marine areas in WA, as part of the HIPP.

### **4.2.2 Private**

Private sector organisations will often collect seabed mapping data for their own use purposes. This is particularly prevalent in the oil and gas industry, where organisations will collect seabed mapping data in order to undertake oil and gas exploration and extraction activities. Private organisations may wish to keep their data private to maintain commercial advantages over competitors or release the data under an open-access licence (e.g. via the AusSeabed data portal). The private sector offshore renewable energy and telecommunications industries also engage in seabed mapping.

There are also several private sector organisations whose primary activities involve the collection of seabed mapping data (hydrographic surveying). These organisations are contracted by the public and private sector alike to collect seabed mapping data for a range of purposes, depending on client needs. Private sector data collectors include Fugro, iXblue, Acoustic Imaging, EGS Survey, Precision Hydrographic Services, Guardian Geomatics, and EOMAP.

#### **Fugro's role in the search for MH370**

Fugro's expertise, experience and equipment played a key role in the search for the missing Malaysia Airlines flight MH370. Three Fugro specialist survey vessels, equipped with deep water search technology, were involved in the survey and search for the missing Boeing 777 in the Southern Indian Ocean search area.

Malaysian Airlines flight MH370 disappeared on 8 March 2014, prompting the largest and most expensive ocean search ever conducted. Fugro was awarded the contract to conduct bathymetric surveying and the search for the missing plane later that same year.

By January 2017, a total area of 120,000 km<sup>2</sup> was mapped in the Indian Ocean as part of the search efforts for MH370. The search was eventually called off as the plane was not found in the initial and extended search areas, however, the search efforts did provide a wealth of seabed mapping data that is now available on the AusSeabed data portal.

Source: Fugro (2021)

### 4.2.3 AusSeabed

The AusSeabed program is a national collaboration focused on improving the quality of and access to seabed mapping data, and the national coordination of data acquisition. Key activities of AusSeabed and other organisations involved in marine data acquisition and delivery are depicted in Figure 4.2.

To support national coordination, AusSeabed developed a preliminary Survey Coordination Tool<sup>6</sup>, which provides three key functions:

1. a register of upcoming surveys;
2. a map of National Areas of Interest for filling seabed data gaps (Figure 4.3) based on criteria such as: safe navigation; environmental assessment and monitoring; areas of resource competition; areas relevant to pressing policy issues and government decisions; and
3. a tool to request an area to be mapped by the AHO.

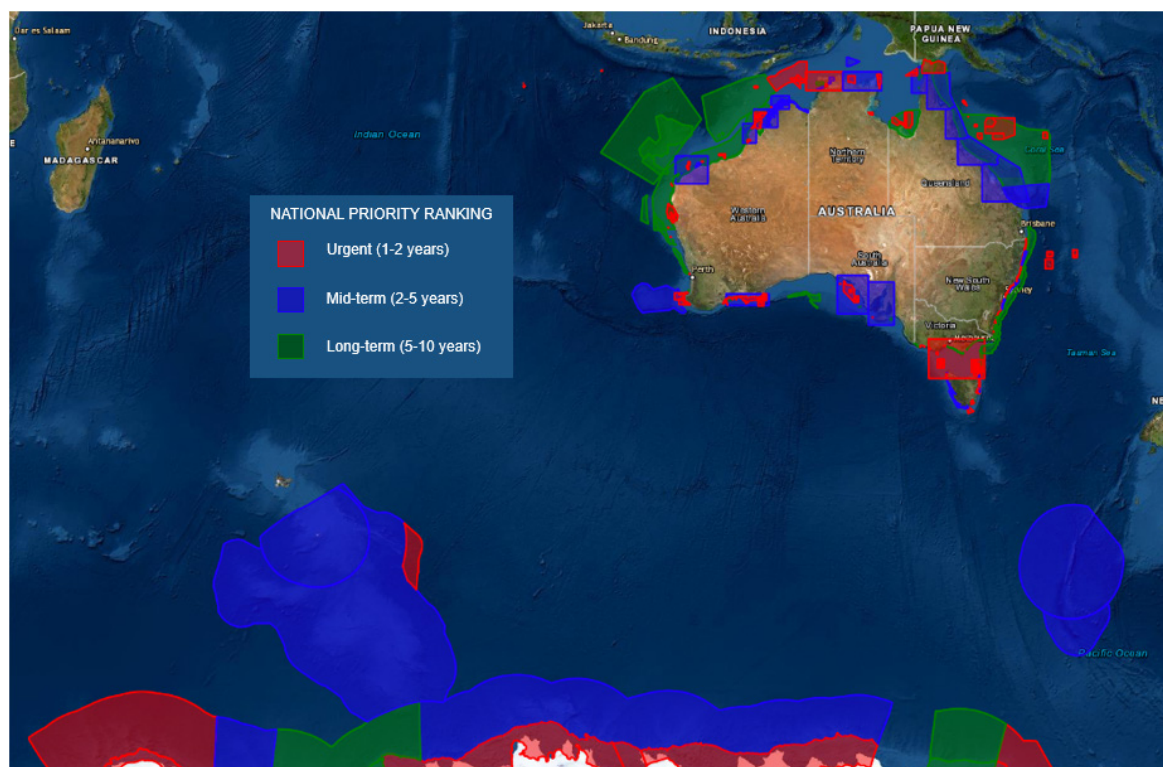
Figure 4.2 Key contributors to the national set of seabed data

		Survey and technology development	Data collection	Data Processing	Data Management	Data Delivery
Water column and seafloor	Southern Ocean Observing System	○				
	Marine Biodiversity Hub	○	○	○		
	Marine National Facility – CSIRO	○	○	○	○	
	Integrated Marine Observing System		○	○		
	Australian Ocean Data Network				○	○
Seafloor	Australian Hydrographic Office	○	○	○		
	Seamap Australia				○	○
	AusSeabed	○	○	○	○	○

Source: AusSeabed Strategic Plan 2030



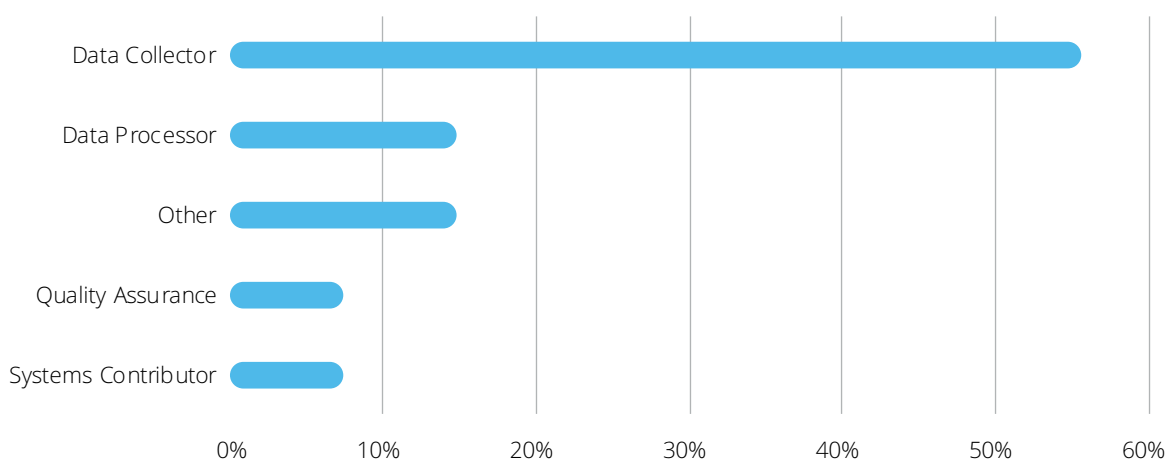
Figure 4.3 AusSeabed Coordination Tool – National Areas of Interest



### 4.3 Survey results on seabed mapping data producers

For the majority of data producers, their primary role in the seabed mapping industry involves the collection of seabed mapping data (refer to Chart 4.1). No organisation's primary role in the seabed mapping data production sector involves survey collaboration. All respondents that are part of the survey collaboration process also play a role in data collection.

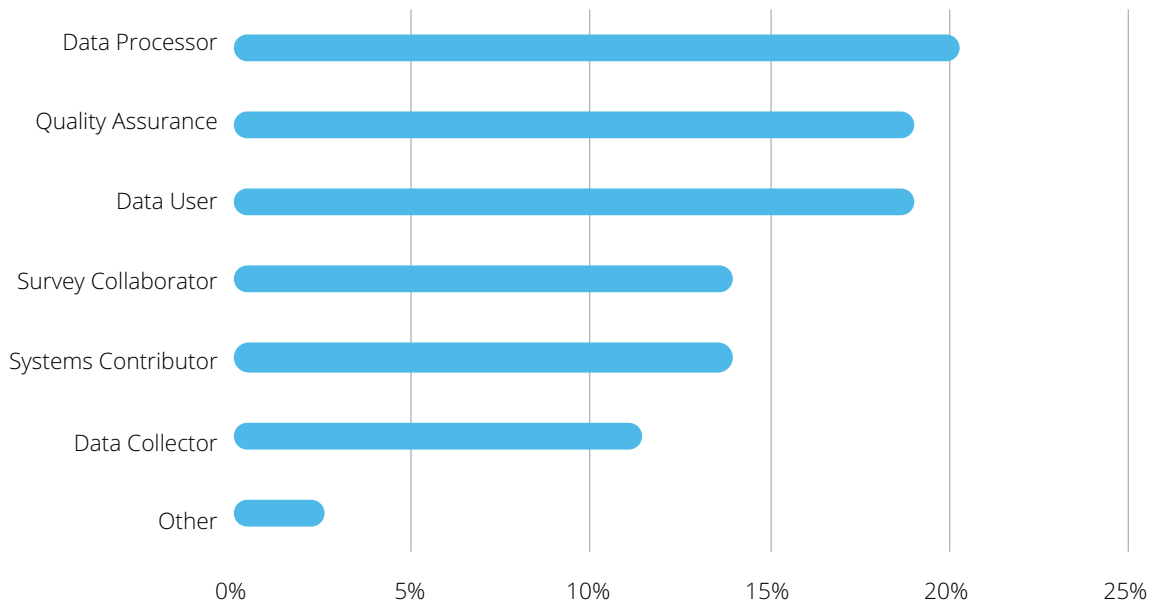
Chart 4.1 Primary role in seabed mapping data production process



Source: Deloitte Access Economics' Seabed Mapping Data Users and Data Producers Survey

Beyond data collection, most data producers also play additional/secondary roles in seabed mapping data production. **Many of the data producers have an active role in the entire seabed mapping data value chain and are engaged in the processing, quality assurance, systems contributor and survey collaboration processes.** Many of the seabed mapping data producers are also data users, and therefore hold an active interest in the further development of the seabed mapping data production process.

Chart 4.2 Secondary role/s in seabed mapping data production process



Source: Deloitte Access Economics' Seabed Mapping Data Users and Data Producers Survey

Data producers are often willing to share their data on open data portals such as AusSeabed, or provide data in-kind to not-for-profit organisations. Private sector data producers are the least willing to freely share their data, as most of these organisations rely on the sale of seabed mapping data and other hydrographic services to generate revenue.

# 5 Seabed mapping data users



## 5.1 Overview

Several sectors of the Australian economy use seabed mapping data to inform decision making processes, improve the safety of workers and civilians, and to understand more about the marine environment. Specifically, it is used to assist with safe navigation and anchorage, to minimise the impacts that marine infrastructure and development have on the surrounding environment, to research ecosystems and marine habitats, to manage resources, and to identify natural hazards.

Seabed mapping data facilitates these activities through fulfilling some legal obligations around safe navigation, while other sectors use the data to unlock efficiencies and enhance the productivity of their commercial output.

## 5.2 Who uses seabed mapping data?

Seabed mapping data is used to varying degrees across all of Australia's marine industries. The data is used across all types of organisations operating in the marine environment, including private sector organisations, universities and research institutions, volunteer organisations and charities, and government departments, including the Defence Force. For the purposes of the economic contribution, Australia's marine industries have been categorised as data enabled industries – those who are reliant on seabed mapping data to carry out activities, and data enhanced industries – those who are less reliant on seabed mapping data but still benefit from using it.

### 5.2.1 Seabed mapping data enabled industries

Data enabled industries include data users and sectors that have developed revenue generation strategies that are heavily or entirely reliant on seabed mapping data to conduct activities.

This may include the requirement to use seabed mapping data for legal and safety reasons, such as the requirement for vessels to be supplied with nautical charts and publications out at sea (which are based seabed mapping data) under the Navigation Act 2012.

### Tourism

Seabed mapping is critical for several tourism-based activities, including those that involve the use of vessels and/or conduct deep sea activities. Vessel operators use seabed mapping data to navigate the seabed safely, minimise disturbance to the underwater ecosystem, identify seabed features of interest, and ensure they can safely anchor.

The following specific tourism activities, as classified by Tourism Research Australia, are considered to involve the use of seabed mapping data:

- Taking a cruise ship, charter boat or ferry
- Scuba diving
- Whale watching
- Visiting or staying on an island
- Reef visits.

There are additional activities that may involve the use of vessels, but it is not always how the activity is undertaken, such as snorkelling. These activities were excluded from the analysis as it was difficult to distinguish the proportion of this activity that involves a vessel and is therefore attributable to seabed mapping.

### Commercial fishing and aquaculture

Commercial fishing and aquaculture use seabed mapping data for several activities, including in the establishment of fishing locations and fish farms, to safely navigate the ocean, and to minimise damage to seabed habitats and fishing equipment. The economic contribution from offshore wild catch fisheries and aquaculture can be attributed to seabed mapping given the use of the data in this industry.

### Oil and gas exploration and extraction

Seabed mapping is a critical component to the process of oil and gas exploration and extraction. It is used in the selection of areas of interest for exploration and the construction of oil and gas extraction infrastructure. Seabed mapping is also essential in assessing the environmental impacts and monitoring risks associated with oil and gas exploration and extraction at a particular site.

The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) is responsible for assessing the environmental and safety plans for oil and gas companies' offshore operations. Oil and gas companies must have comprehensive environmental and safety plans accepted by NOPSEMA before commencing activities in Australian waters – with seabed mapping being a core component in geophysical and geotechnical site surveying.

### Water-based transportation

Seabed mapping data is a crucial data source for water-based transportation, as it assists in safe navigation and anchorage of vessels. Both freight and passenger water-based transportation have been captured in this industry, as both utilise seabed mapping data in their core operations.

### Defence

The Royal Australian Navy seeks to have the best understanding of the entire water column they operate in, including the seabed, to have a strategic advantage. Several naval activities involve deep sea exploration and navigation, and understanding the seabed improves the safety of the naval force.

### Search and rescue operations

Seabed mapping data is a critical input for offshore search and rescue operations. Upon the disappearance of the Malaysian Airlines MH370 flight, bathymetry survey data was collected as part of the search efforts. This allowed an underwater search to be conducted safely, which involved the collection of high-resolution sonar images of the sea floor.<sup>7</sup> Australia's involvement in the search was led by the Australian Transport Safety Bureau (ATSB), who commissioned Fugro to carry out the data collection and Geoscience Australia to further process and manage the data.

While the search for MH370 is one of the most expensive and high-profile ocean search operations, other search and rescue operations carried out on a more regular basis also utilise seabed mapping data, including for safe navigation during rescue operations.

### Marine research and environmental protection

Access to seabed mapping data can assist in research activities and promote better environmental protection. Understanding the benthic environment can allow targeted research into particular habitats or species zones and inform the planning of dedicated conservation areas. Seabed mapping data can also be used to prevent damage to the environment by providing information on seabed structures and habitats that are vulnerable to potential damage from activities such as anchoring and trawling.

### Marine infrastructure and construction

Seabed mapping data is a critical input to understanding the environmental and other impacts that offshore infrastructure and construction activities may have on the seabed. It is also a key input to the engineering and design component of offshore infrastructure planning; for example by providing important environmental context for the selection of sites for pipelines and cables.

### Natural hazard monitoring

Seabed mapping data can be used to monitor the impact on the seabed of marine natural hazards such as severe wind and waves, storm surges and tsunamis. Additionally, seafloor topography, in combination with ocean and tidal current data, is employed in models that predict the impact of hazards such as earthquakes, cyclones and storms on marine infrastructure and the coast.

### 5.2.2 Seabed mapping data enhanced industries

*Data enhanced industries are the industries that benefit from seabed mapping, but using this data is less critical to being able to complete these activities safely and effectively.*

These users can apply seabed mapping data to improve their productivity and facilitate better decision making, however, using this data does not alter their core business model or have an effect on prices. As such, the data enhanced industries are not in the economic contribution analysis, however, the benefits of seabed mapping data to these industries is still discussed qualitatively to provide a holistic picture of the value of seabed mapping data to Australia's blue economy.

- The **recreational fishing** sector can utilise seabed mapping data to navigate the seabed (particularly around rocky seabed and areas of coral cover), avoiding fishing and anchor damage and to identify areas which may deliver a greater fishing yield.
- A number of **sports that take place in marine settings** can benefit from the use of seabed mapping data, such as yacht races, surfing, sailing and open water swimming. These activities can be better planned with a knowledge of the underlying seabed habitats in the locations where these activities are located.

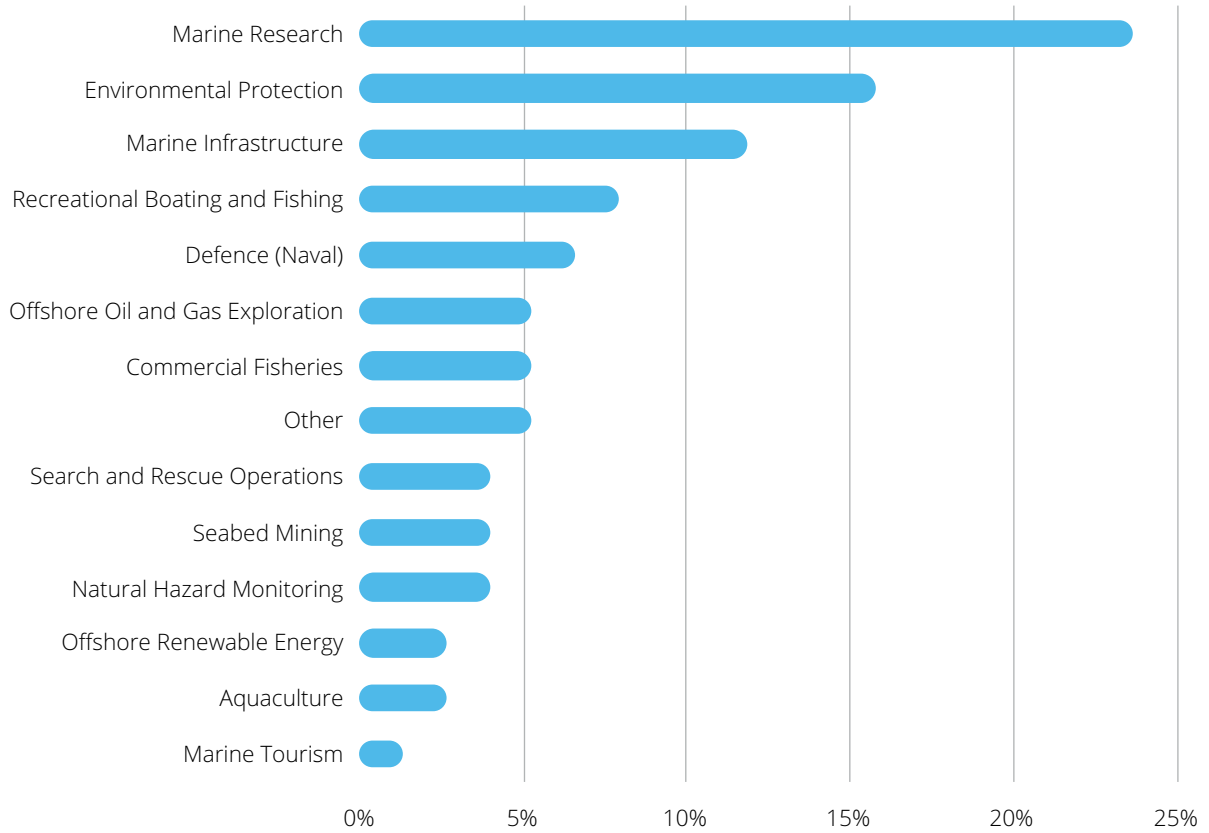
### 5.3 Survey results on seabed mapping data users

The survey respondents operate across a range of industries in all regions of Australia's marine jurisdiction. **Marine research and environmental protection were the most commonly reported activities** for which survey respondents use seabed mapping data (refer to Chart 5.1). This response was seen across marine industries, indicating that seabed mapping data is used by organisations to minimise the environmental impact of their activities.

Survey respondents **undertake seabed mapping-related activities across all regions of Australia**, including offshore Commonwealth territories (refer to Chart 5.2).

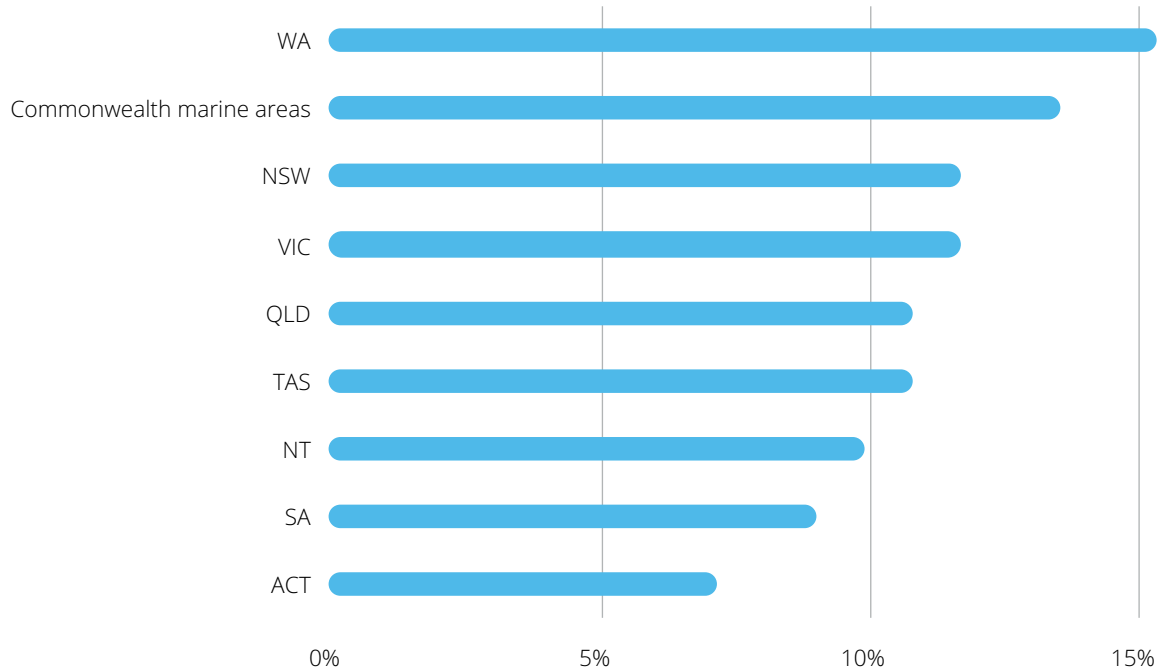
Over 60 per cent of data users source their seabed mapping data from external sources such as the AusSeabed data portal, with the remaining 40 per cent collecting their own data. The most common external sources of seabed mapping data include Geoscience Australia, AHO, state government departments, and university repositories.

Chart 5.1 Number of respondents indicating they use seabed mapping data



Source: Deloitte Access Economics' Seabed Mapping Data Users and Data Producers Survey

Chart 5.2 Number of respondents indicating they use seabed mapping data



Source: Deloitte Access Economics' Seabed Mapping Data Users and Data Producers Survey

# 6 Economic contribution of seabed mapping data in Australia



## 6.1 Overview

The **economic contribution of seabed mapping data in Australia in 2018-19** is captured using an input-output analysis methodology. There are many different roles in the seabed mapping data industry, and the economic contribution analysis has therefore been conducted separately for the data production process and the data use process.

Data producers are the most directly involved in the seabed mapping data industry, as their primary activities are based on the creation and distribution of seabed mapping data. The economic contribution of seabed mapping data use captures the activities in industries that are enabled by the use of seabed mapping data.

### 6.1.1 Economic contribution analysis

The economic contribution of seabed mapping data, both direct and indirect, is expressed in terms of value added and employment.

- Value added consists of the returns to labour in the form of wages and salaries, the returns to capital in the form of Gross Operating Surplus, and net taxes on production. It excludes intermediate inputs as these represent the value added from other industries. The model has been designed to capture only Australian economic activity, and therefore excludes expenditure on imported goods and services.
- Employment consists of the number of jobs supported both directly and indirectly through activities involving the use of seabed mapping data.

### 6.1.2 Key results

- The activities directly involved in **producing seabed mapping data directly contributed \$51 million to the Australian economy** in 2018-19 and created 500 jobs.<sup>8</sup>
- The **direct economic contribution of seabed mapping data use** was \$9 billion in 2018-19.
- The use of seabed mapping data also **directly contributed over 56,000 jobs** (FTEs) to the Australian economy in 2018-19.
- The use of seabed mapping data creates demand for upstream activities, contributing a further **\$7 billion in indirect value added to the economy** in 2018-19.
- In addition to these figures, there was **\$37 billion of unlocked economic activities** in 2018-19 that were enabled by the use of seabed mapping data during establishment.

### 6.1.3 Methodology

The economic contribution of seabed mapping data can be split into direct and indirect components.

- The **direct economic contribution** of seabed mapping data measures the value added created directly as a result of economic activities within industries producing and using seabed mapping data.
- The **indirect economic contribution** calculates the value added created by the businesses that produce inputs for industries producing and using seabed mapping data. The indirect contribution acknowledges that production activities in the seabed mapping data industry stimulates demand in upstream industries. For example, a marine researcher may need to use a vessel as an input to their research activities. This expenditure stimulates demand and value added in the vessel charter industry.
- The **total economic contribution** to the economy is the sum of the direct and indirect economic contributions.

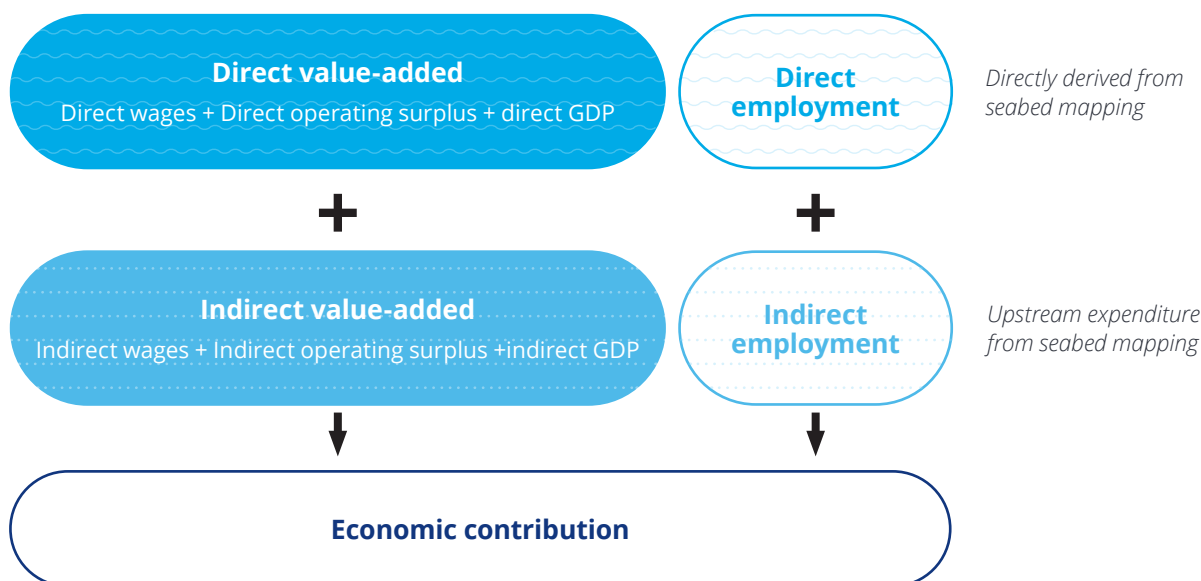
The economic contribution framework is presented in Figure 6.1.

The economic contribution of seabed mapping data in 2018-19 is estimated based on the national Input-Output tables 2017-18 published by the ABS, with consumer prices indexed to 2018-19 price levels. It is assumed that the spend composition of Input Output Industry Group (IOIG) industries did not change significantly from 2017-18 to 2018-19, so the lag in the release of the 2018-19 Input-Output tables should not have a material impact on the economic contribution analysis.

Many of the seabed mapping related sub-sectors in the data user analysis represent a proportion of a larger IOIG, and the seabed mapping-related sub-sector within the broader industry has to be identified. For example, the IOIG 'Exploration and Mining Support Services' includes a variety of activities in the mining industry, however the offshore oil exploration component of this industry is the only component included in the economic contribution analysis due to its use of seabed mapping data. The economic contribution analysis assumes that each seabed mapping-related sub-sector's industrial profile has the same ratios of value added, labour income, input expenditure and FTE per million dollars of output as its larger IOIG. A detailed methodology of how seabed mapping-related activities were carved out of the broader IOIGs is available in Appendix A.



Figure 6.1 Economic contribution analysis



Source: Deloitte Access Economics

In some cases, expenditure on intermediate inputs and labour income, and the subsequent economic contribution figures, were calculated using organisations' annual reports or data collected through the Seabed Mapping Data Producers and Data Users Survey. In the event that an organisation's annual report or the survey data provided a breakdown in expenditure relating to the collection or use of seabed mapping data, this expenditure profile was applied to the economic contribution analysis, rather than the spend profile of the broader IOIG industry.

Refer to Appendix A for further details on the assumptions and identification of seabed mapping industries. Refer to Appendix B for further details on the economic contribution methodology, interpretation of results, and limitations.

## 6.2 Data production

The economic contribution analysis for data producers captures the value-added and jobs generated directly through the act of survey development, data collection, data processing, data collation and management, and distribution of seabed mapping data.

The value-added and jobs created through data production were derived from outputs from the Seabed Mapping Data Producers Survey in addition to consultations with key industry partners.<sup>9</sup> In the event that a data producer did not participate in the survey and/or did not provide any expense information, the producer was not included in the economic contribution analysis due to data constraints. Due to these data constraints we expect the economic contribution figure of seabed mapping data production to be conservative.

Survey respondents included Australia's two largest seabed mapping data producers: Defence and MNF, as well as a range of government departments, research institutions, and private sector firms.

### 6.2.1 Economic contribution of data production

The economic contribution of seabed mapping data production combines the direct and indirect value-added and the employment created through data production. The value-added and employment created through seabed mapping data in 2018-19 is provided in Table 6.1.

### Value-added in the not-for-profit sector

The value-added in an economic contribution analysis is comprised of returns to labour (labour income), returns to capital (gross operating surplus), and net taxes on production. In the not-for-profit sector, gross operating surplus is typically minimal, as generating profit, and therefore having a high gross operating surplus, is not the sole focus of the organisation.

Seabed mapping data producers include several made up of government departments and research institutions whose key focus is not on generating profit. As such, the data production sector has a smaller gross operating surplus as a result.

This smaller gross operating surplus translates to a smaller value-add than what would be seen in a comparable for-profit sector.

Table 6.1 Economic contribution of seabed mapping data production, 2018-19

	Direct	Indirect	Total
Value-added (\$m)	\$51	\$27	\$78
Employment (FTEs)	500	80	600

Source: Deloitte Access Economics. Rounded numbers.

### 6.3 Data use

The economic contribution analysis for data users captures the activities that are enabled through the use of seabed mapping data. The economic contribution of seabed mapping data use has two components:

- **Operational seabed mapping data use (used in operations):** activities that use seabed mapping data on a regular basis to undertake ongoing revenue generating activities.
- **Unlocked potential (used in establishment):** activities that require the use of seabed mapping data in their establishment, but not necessarily ongoing operational use.

Aquaculture and oil and gas extraction are considered to be industries whose revenues are ‘unlocked’ by seabed mapping data, as the data is used in the process of site selection, but less frequently in ongoing revenue generating activities. All other sub-sectors are considered to use seabed mapping data on a regular operational basis.

Both natural hazard monitoring and marine infrastructure are data enabled industries that have been excluded from the economic contribution analysis. For natural hazard monitoring, there was insufficient data available to accurately capture this sub-sector.

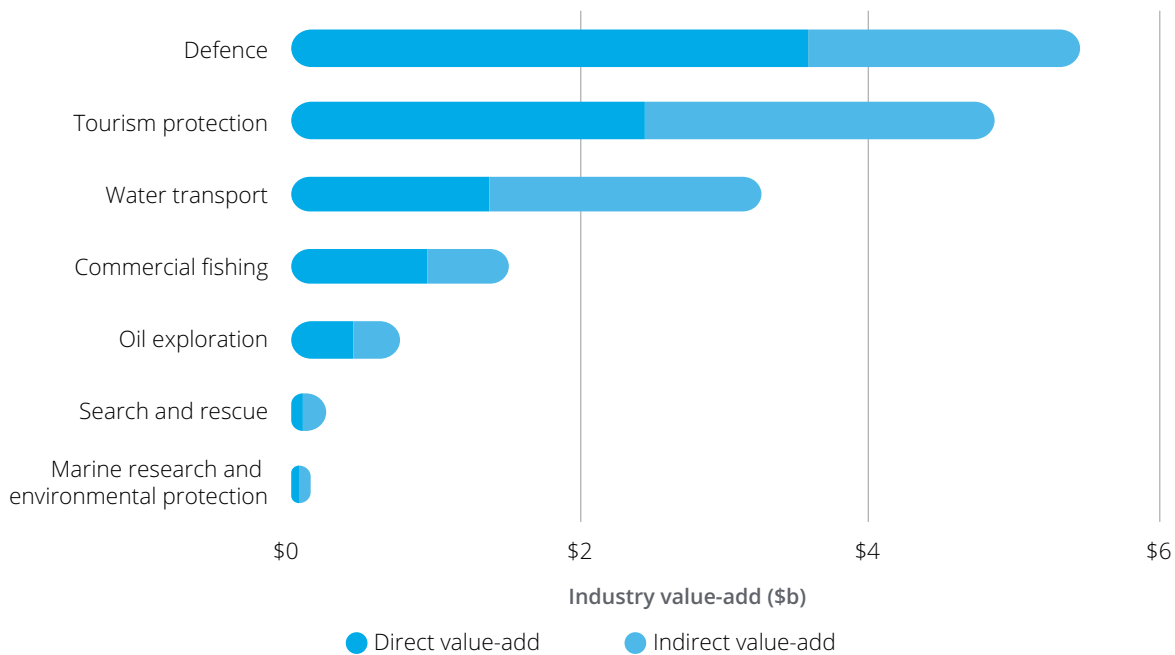
Marine infrastructure and construction was excluded in order to be conservative and ensure that capital expenditure within industries is not double-counted, as capital expenditure is usually captured as an expense through an organisation’s depreciation figure. Marine infrastructure and construction will be an upstream supplier for many of the sub-sectors that are included, and therefore will be indirectly captured in some instances.

#### 6.3.1 Economic contribution by data use sub-sector

To understand the overall economic contribution of seabed mapping data use in Australia in 2018-19, the economic contribution from seabed mapping-related activities was estimated. Chart 6.1 presents the direct and indirect value-add from individual sub-sectors partaking in operational seabed mapping data use, while Chart 6.2 presents the value added from sub-sectors from which seabed mapping data unlocks production potential.

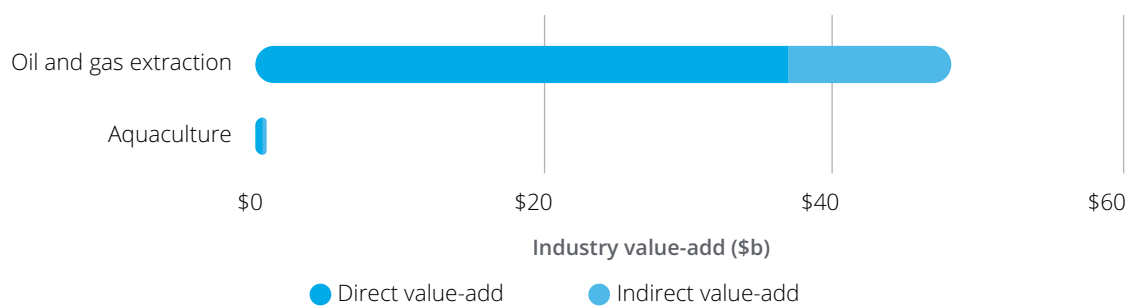
It should be noted that the indirect contribution for each sub-sector was analysed individually, and as a result, the indirect contribution figures are non-additive as many sub-sectors supply each other. The total economic contribution figure (see section 6.3.2) accounts for this.

Chart 6.1 Value added by sub-sectors partaking in operational seabed mapping data use, 2018-19



Source: Deloitte Access Economics

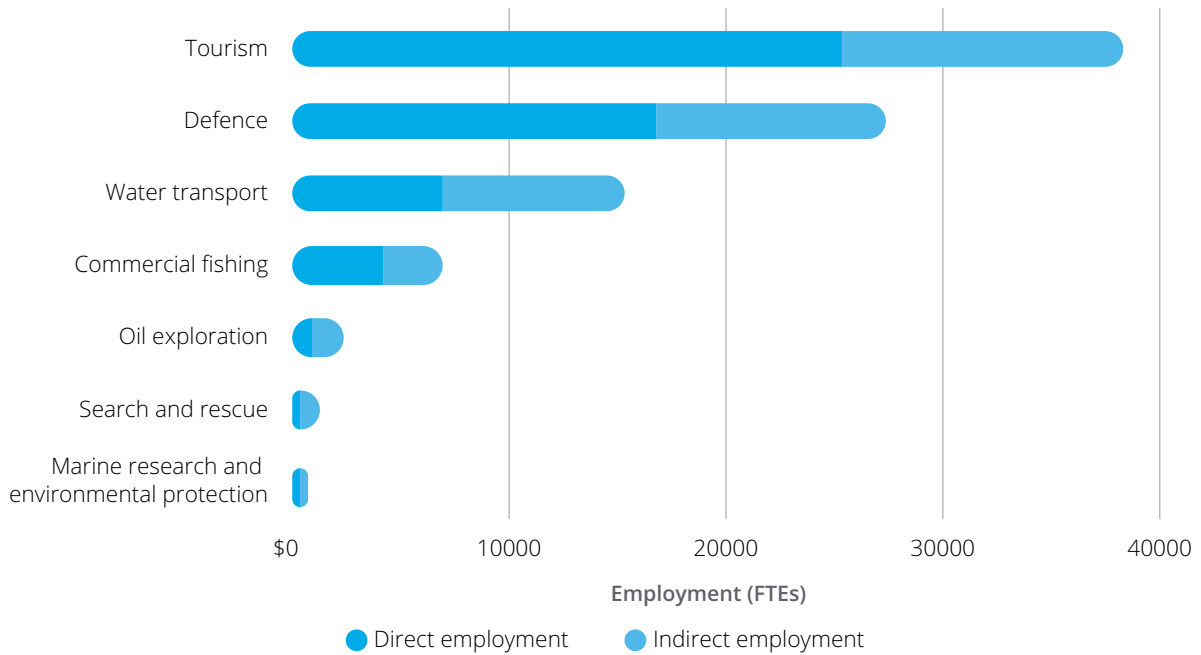
Chart 6.2 Value-added by sub-sectors whose activities are unlocked by seabed mapping data use, 2018-19



Source: Deloitte Access Economics

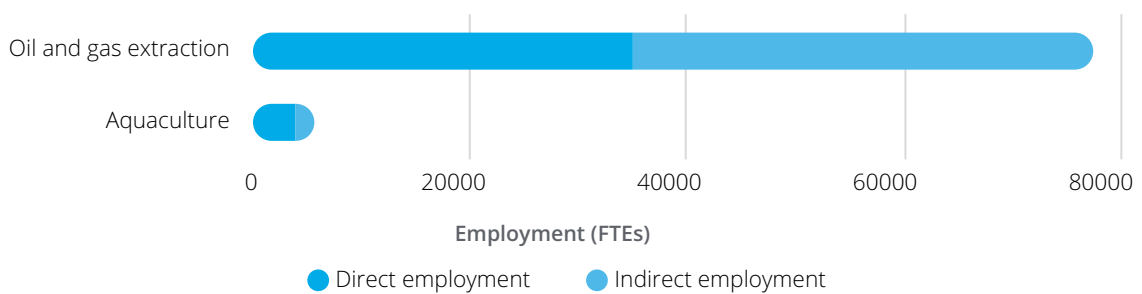
The use of seabed mapping data also stimulates employment in Australia, both directly within industries using the seabed mapping data, and indirectly through industries that are upstream suppliers of goods and services. Chart 6.3 presents the direct and indirect employment from individual sub-sectors partaking in operational seabed mapping data use, while Chart 6.4 presents the employment from sub-sectors for which seabed mapping data unlocks production potential.

Chart 6.3 Employment from operational seabed mapping data use, 2018-19



Source: Deloitte Access Economics

Chart 6.4 Employment from activities unlocked by seabed mapping data use, 2018-19



Source: Deloitte Access Economics

### 6.3.2 Total economic contribution from data use

The total economic contribution figure for data users was calculated using a similar methodology to the sub-sectors' contribution figures, however any potential double-counting between industries was eliminated. Double counting was avoided by removing expenditure between sub-sectors that were directly attributed to seabed mapping. Given seabed mapping activities often represented a small subset of overall activity in an IOIG, only a proportion relevant to seabed mapping was excluded from the expenditure bundle to avoid double counting.

The value added by the use of seabed mapping data in Australia in 2018-19 is shown in Table 6.2.

Table 6.2 Value added from seabed mapping data use in Australia in 2018-19, \$b

	Direct value added	Indirect value added	Total value added
Value-added through <b>operational</b> seabed mapping data use	\$9	\$7	<b>\$16</b>
Value-add <b>unlocked</b> through seabed mapping data use	\$37	\$11.5	<b>\$49</b>
<i>These numbers are best kept separate due to differences in how the use of seabed mapping data has generated industry output.</i>			

Source: Deloitte Access Economics. Numbers may not add due to rounding.

Table 6.3 Employment from seabed mapping data use in Australia in 2018-19, FTE

	Direct employment	Indirect employment	Total employment
Employment from operational seabed mapping data use	56,000	37,000	<b>93,000</b>
Employment unlocked from seabed mapping data use	38,500	44,100	<b>82,600</b>

Source: Deloitte Access Economics. Numbers may not add due to rounding.

### Search and rescue

☆ \$250 M  
Value-added

👜 1,300  
FTEs

### Defence

☆ \$5.5 B  
Value-added

👜 27,800  
FTEs

### Oil exploration

☆ \$740 M  
Value-added

👜 2,400  
FTEs

## Economic cost of seabed data

💡 Sectors using seabed mapping data operationally

☆ \$16 B  
Value-added

👜 93,000  
FTEs

### Marine research and environmental protection

☆ \$120 M  
Value-added

👜 800  
FTEs

### Oil and gas extraction

☆ \$48.4 B  
Value-added

👜 77,000  
FTEs

# Contribution Mapping Use

Sectors unlocked  
by seabed  
mapping data



★ \$49 B  
Value-added

👛 82,600  
FTEs

## Commercial fishing

★ \$1.5 B  
Value-added

👛 7,000  
FTEs



## Water transport

★ \$3.3 B  
Value-added

👛 15,500  
FTEs

## International tourism

★ \$3.1 B  
Value-added

👛 24,700  
FTEs



## Aquaculture

★ \$840 M  
Value-added

👛 5,500  
FTEs



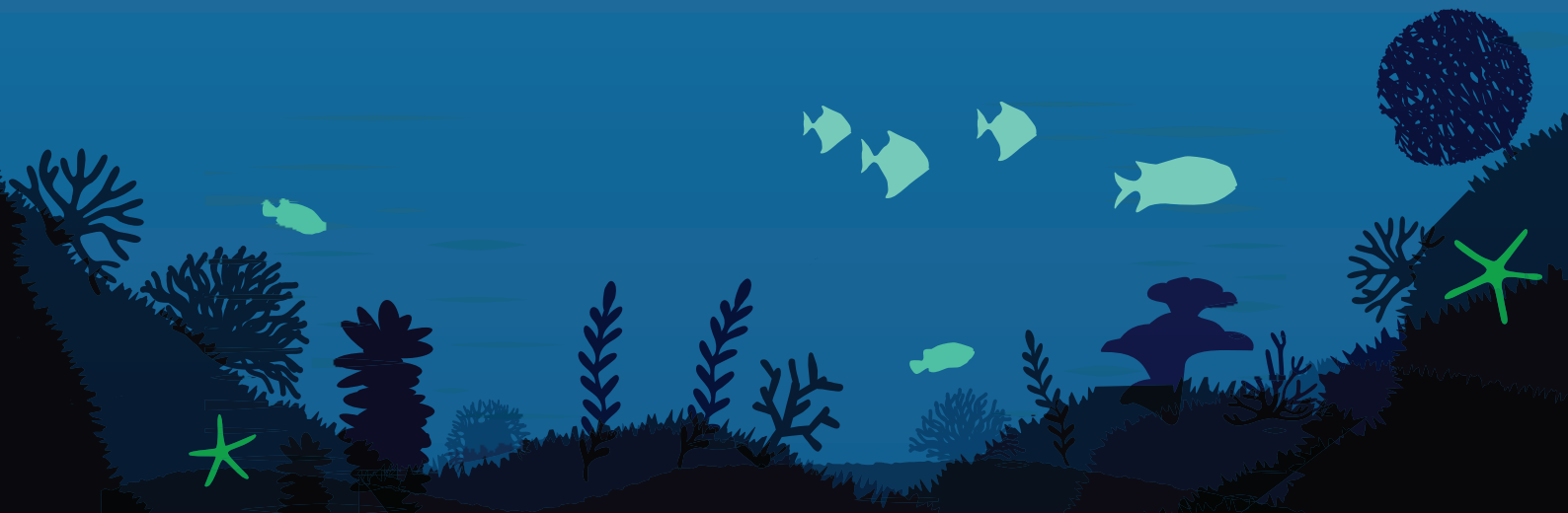
## Domestic tourism

★ \$1.7 B  
Value-added

👛 14,300  
FTEs



# 7 Broader impact of seabed mapping





## 7.1 Overview

The economic benefits delivered by mapping Australia’s seabed extend beyond the economic contribution of market activity. There are additional environmental, cultural, social and sovereignty benefits delivered through mapping Australia’s seabed. Many of these benefits are not captured in normal market activity.

The broader impact delivered by seabed mapping activities in Australia can be captured using a total economic value (TEV) framework. TEV is comprised of direct use value (which includes most market-based activities), indirect use value, and non-use value. These values are summarised in Figure 7.1.

Seabed mapping data delivers benefits in many ways, including through improved environmental outcomes, increased understanding of land and the seabed, safety in marine recreation and by supporting sovereign rights claims.

## 7.2 Environmental impact

*Seabed mapping data is a valuable input into environmental science and research and has been used widely for environmental management and monitoring.*

Seabed mapping data deliver environmental benefits by reducing the impact that marine activities have on ecosystems and marine habitats, and by promoting research efforts that help to protect and restore the marine environment. These environmental benefits yield an increase in indirect use value in the marine environment through improved ecosystem services, carbon sequestration and other environmental services.

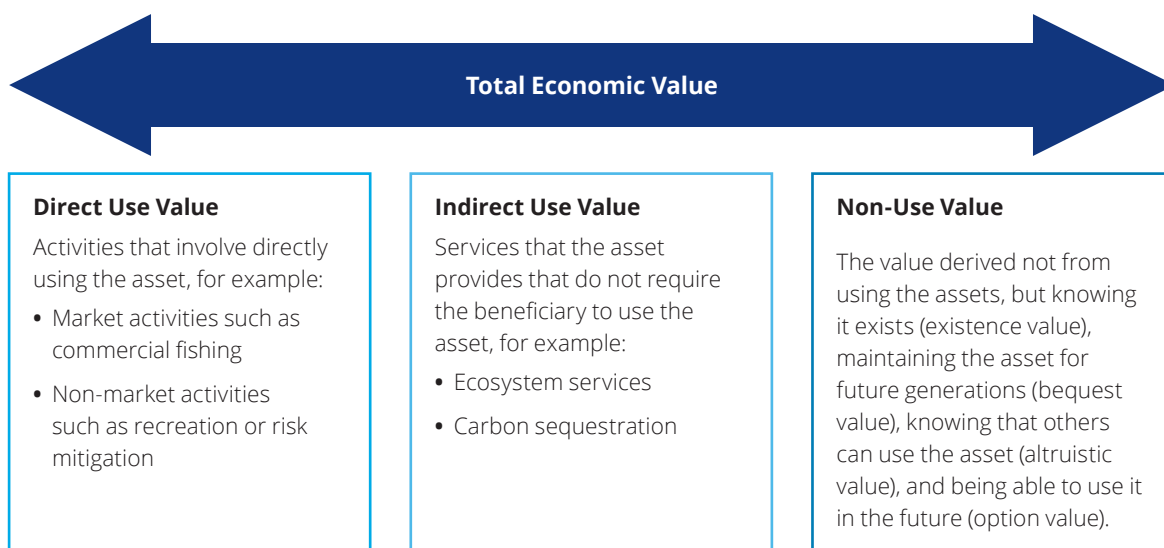
Oceans contribute a significant amount to the protection of our environment. Oceans produce around half of the oxygen in the world and absorb roughly 30 per cent of carbon dioxide emissions resulting from human activity.<sup>10</sup> While environmental and ecosystem services do not directly generate economic output, the value generated from these environmental protection services is vast, and contributes to a significant economic value attributable to the ocean.

It is estimated that Australia’s oceans and coasts will provide \$25 billion worth of ecosystem services, such as carbon dioxide absorption, nutrient cycling, and coastal protection by 2025.<sup>11</sup> Similarly, the carbon sequestration services for the world’s oceans were estimated to be valued at \$4.3 trillion USD in present value terms in 2015.<sup>12</sup>

### 7.2.1 Environmental management and research

Having a greater understanding of the marine environment better informs environmental protection and management strategies. For example, seabed mapping data can assist with ocean navigation and the identification of suitable areas for anchorage, thereby minimising the damage caused to important features such as coral reefs and protected areas. Similarly, data can inform research plans, lead to discoveries of marine assets, and help to identify areas with high levels of biodiversity.

Figure 7.1 **Total economic value framework**



Source: Deloitte Access Economics

### Case Study: Great Barrier Reef

#### Seabed mapping data shows the shape of the Great Barrier Reef in high-resolution, helping scientists better understand the sea floor structure of the Reef.

The Great Barrier Reef is the largest living structure on Earth, located on the north-east coast of Australia. The Great Barrier Reef is the most extensive coral reef system globally, containing hundreds of thousands of different marine species, making it one of the world's most unique and complex ecosystems. As one of the seven natural wonders of the world, it is one of Australia's greatest assets and draws in visitors and researchers from around the world; however, the future of the reef is under threat.<sup>13</sup>

Seabed mapping data provides an essential geospatial framework for research in the Great Barrier Reef region. The data are used to help map coral cover using benthic (habitat) mapping techniques and provide knowledge of the distribution of sea floor structures and sediments. The value of data collation and compilation was demonstrated by the development of a 30 m bathymetry model for the entire Great Barrier Reef, drawing upon multiple data sources and types. This in turn led to a better understanding of the location and extent of reefs in the marine park.<sup>14</sup>

Seabed mapping data can be used to chart coral cover in the marine park, protect areas or species at the greatest risk of decline, and identify areas that might be more suitable for regeneration projects. The data can also improve the safety of life at sea and reduce the impacts of ecotourism during reefs visits, through better navigation around reef structures and anchoring away from reefs.

The AIMS revealed that over 50 per cent of the coral cover in the Great Barrier Reef was lost since 1985 due to storm damage, crown-of-thorns starfish and coral bleaching. While reefs typically do go through periods of growth and decline, long term records show that this severe and sudden decline in coral growth is unprecedented in at least the last 400 years.<sup>15</sup> Climate change and the subsequent coral bleaching is an ongoing threat to the Great Barrier Reef, and a significant amount of research is being conducted to understand how to best identify the spatial extent of bleaching and mitigate these risks.

This smaller gross operating surplus translates to a smaller value-add than what would be seen in a comparable for-profit sector.

#### 7.2.2 Coastal protection and management

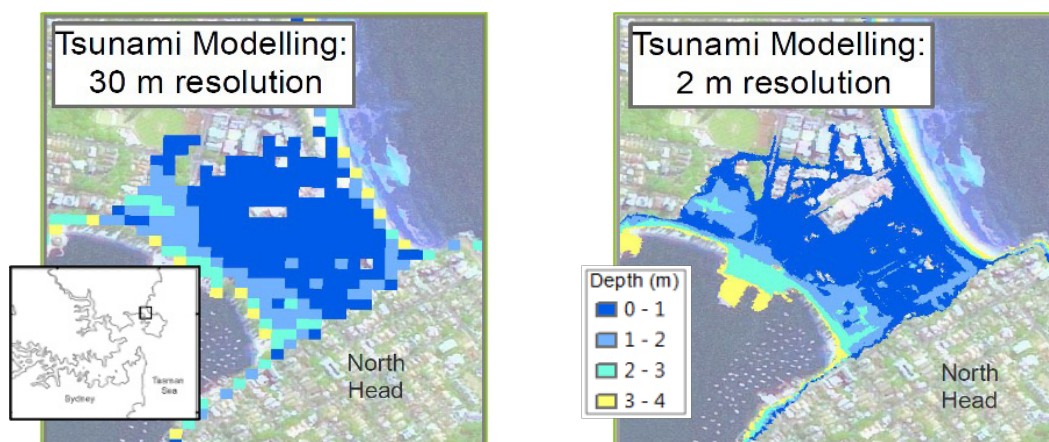
*Seabed mapping data is valuable in understanding hazards, vulnerability, processes, and geomorphology of our coastal environments.*

There is an inherent value associated with identifying hazards early and mitigating the damage they can cause, but this value is not directly captured by an economic contribution analysis. Being able to identify hazards early through the use of seabed mapping data can mitigate the damage done to Australia's coastal communities, potentially saving lives, reducing injuries, and reducing the amount of infrastructure damage caused by these hazards.

In Australia, the annual average cost of natural disasters was estimated to be \$18.2 billion in 2017<sup>16</sup>, though not all costs relating to disasters can be mitigated by early detection, nor can seabed mapping be utilised for all disasters.

Seabed mapping data is employed in models that assess the likely risk associated with a potential storm surge or tsunami and identify whether an area should be evacuated ahead of the event to minimise damage and injuries. Tsunami modelling simulates the run up over a Digital Elevation Model (DEM) made up of bathymetry and topography data, as demonstrated for Manly, NSW in Figure 7.2. There are economic benefits resulting from saving lives and reducing injuries (including a reduced burden on the health care system among many other benefits) and from reducing the damage done to property and the environment.

Figure 7.2 Tsunami modelling in Manly, NSW



Comparison of maximum inundation depth resulting from tsunami modelling using elevation and bathymetric data resolved to 30m and 2m

Source: Picard et al. (2018).

Seabed mapping data can also be used to identify coastline risks, such as areas more susceptible to erosion, and put in preventative measures to reduce the damage caused by such phenomenon.<sup>17</sup> Governments in Australia already incur high costs from natural disasters and develop management plans to reduce the risks of coastal erosion and other damage to the coastline. Following Cyclone Larry and the accompanying storm surge in 2006, the damage to infrastructure and crops in northern Queensland was estimated to be \$500 million.<sup>18</sup> Knowing the risks to the coastline and implementing shoreline protection policies can reduce damage to properties located close to the shoreline and reduce the overall costs of disasters to the economy and environment.

### 7.3 Social and cultural impact

There are many social and cultural benefits derived from the collection and use of seabed mapping data. These benefits range from the value to Australia's traditional owners through understanding the physical characteristics of sea country, to improved safety of life at sea, recreational values, and the discovery of historical artefacts on the sea floor. There are a variety of direct use values (e.g. hazard management) and non-use values (e.g. traditional owner values) associated with data coverage of the seabed.

#### 7.3.1 Traditional Owner value

*Seabed mapping data increases traditional owners' understanding of Sea Country.<sup>19</sup>*

Seabed mapping data is thought to have an intrinsic value to Australia's traditional owners as it increases the knowledge base of their marine areas, and better informs management of the natural environment and resources. Traditional owners may choose to use seabed mapping data themselves to partake in marine activities, thus deriving a direct use value from seabed mapping data. Similarly, they may derive non-use value from the data due to their cultural value of marine sites, and through the development of a greater awareness of these values more broadly.

Aboriginal and Torres Strait Islander peoples have been linked with marine areas, such as the Great Barrier Reef, for tens of thousands of years. Prior to sea level rise and the formation of today's Great Barrier Reef around 7000 years ago, Aboriginal and Torres Strait Islander peoples were custodians of the lands now covered by the sea, and cultural knowledge and value of these sites still remains.<sup>20</sup>

Aboriginal and Torres Strait Islander peoples have provided valuable input into seabed mapping surveys, such as the MNF survey conducted to map the Wessel Marine Park, which lies offshore from the tip of Wessel Islands to Cape Arnhem in the Northern Territory.<sup>21</sup> If made widely available, seabed mapping data has the potential to be utilised by indigenous communities in the various activities they conduct at sea.

### 7.3.2 Maritime safety and risk management

*Seabed mapping data provide governments, businesses, and individuals with the information to successfully navigate risks and hazards in Australian waters.*

Having a greater understanding of the marine environment through the use of seabed mapping data improves the safety of Australians at sea. The Navigation Act 2012 (Cth) requires vessels at sea to be supplied with nautical charts and nautical publications, the provision of which is a core function of the Australian Hydrographic Office.<sup>22</sup> Seabed mapping data has improved the quality of information contained within nautical charts and has contributed to the safer navigation of vessels in Australian waters.

As information at sea has improved and sea navigation has become safer, incidents at sea have become far less common. Of the nearly 9,500 shipwrecks recorded in the Australasian Underwater Cultural Heritage Database, only 138 have been recorded in Australia since 1990, and 38 since 2000. In comparison, 5,712 shipwrecks were recorded in Australia between 1800 and 1900.<sup>23</sup>

Improved safety at sea provides benefits in the form of fewer lives lost and reduced demand for search and rescue operations. This leads to gains to labour productivity, less burden on the health care system, and greater productivity of staff, among many other benefits.<sup>24</sup>

The value from improved safety of life at sea is derived from directly using seabed mapping data, and is therefore considered to be a direct use value.

### 7.3.3 Recreational value

*Seabed mapping data facilitates many recreational activities and ensures that recreational vessels can navigate the sea safely and efficiently.*

For many recreational activities, there is a direct use value associated with undertaking the activity that is not reflected in the estimated economic contribution of seabed mapping (i.e. not captured by market values). Many recreational activities can be done without upfront payments for accessing the activity, and therefore will not be captured in measured economic activity. There are, however, travel costs (e.g. petrol) and equipment purchase costs (e.g. boat hire) that can be used as a proxy for the “price” of the recreational activity.

Recreational fishing is an activity that can benefit from the use of seabed mapping data and is often freely accessible to partake in. For example, regional estimates of the value associated with recreational fishing activities have found that recreational fishing is valued at \$20 million (\$2014) in the Moreton Bay Marine Park each year<sup>25</sup> and \$5.53 million (\$2010) on the Capricorn Coast each year<sup>26</sup>, using the travel cost valuation method.

Additional recreational activities that can make use of seabed mapping data, such as maritime sports (e.g. surfing; sailing), are also sources of recreational value for seabed mapping data.

### 7.3.4 Shipwreck discovery and protection

*Seabed mapping data can reveal culturally significant events, such as the discovery of shipwrecks.*

Seabed mapping activities can lead to the discovery of historical artefacts and shipwrecks, which provide cultural and heritage value – considered non-use values. The discovery of shipwrecks can provide information on Australia’s history – particularly its naval history.

#### Case Study: Shipwreck Discovery

As more of Australia’s seabed becomes mapped, more discoveries of historical artefacts will occur. Deep sea discoveries can be more closely investigated and researched to obtain information on Australia’s voyaging history, which was key to the European discovery, settlement and development of Australia.

During the search for the missing Malaysian Airlines flight MH370, survey imagery enabled identification of what was likely to be a man-made object deep in the southern Indian Ocean in December 2015. To investigate further, Fugro’s Echo Surveyor VII autonomous underwater vessel (AUV) was deployed to perform a high-resolution sonar scan, which revealed that the object was indeed a sunken vessel.

Shipwreck experts based at the Western Australian Museum Shipwreck Galleries reviewed the high-resolution imagery of the sunken wreck and advised that it was likely to be a steel or iron sailing vessel from the turn of the 19th century. This was the second shipwreck to be discovered on the MH370 search, as in May 2015 a previously uncharted shipwreck was discovered at a depth of 3,900 metres.<sup>27</sup>

## 7.4 Sovereign rights

*Seabed mapping data helps with the identification and enforcement of marine boundaries.*

Seabed mapping data can support claims for sovereign rights in the ocean and increase the marine jurisdiction of a nation. Australia was granted an extension of its marine jurisdiction in 2008 by the UN Commission on the Limits of the Continental Shelf after providing seabed and sub-seabed data, acquired in a series of seabed mapping surveys, that show Australia's continental shelf extends beyond 200 nautical miles in several areas.<sup>28</sup>

International law enables a country to be granted sovereign rights over marine territories over 200 nautical miles from the coastline (but only up to 350 nautical miles from the coastline) when the outer limit of the continental shelf goes beyond 200 nautical miles.<sup>29</sup>

Australia received an extension of its marine jurisdiction that covers an additional 2.6 million square kilometres of seabed. With an initial 10.2 million square kilometre marine jurisdiction in its Exclusive Economic Zone (EEZ) and 0.85 million square kilometre marine jurisdiction from overseas territories, the extended continental shelf jurisdiction provides Australia with a total marine jurisdiction of 13.6 million square kilometres.

Owning the sovereign rights in marine areas grants Australia the exclusive rights to explore the marine territory and exploit its natural resources. Other States are not able to undertake the same activities in these areas without express consent of Australia. For Australia, this grants exclusive rights to undertake activities such as oil and gas exploration, fishing, and other activities in its marine jurisdiction.

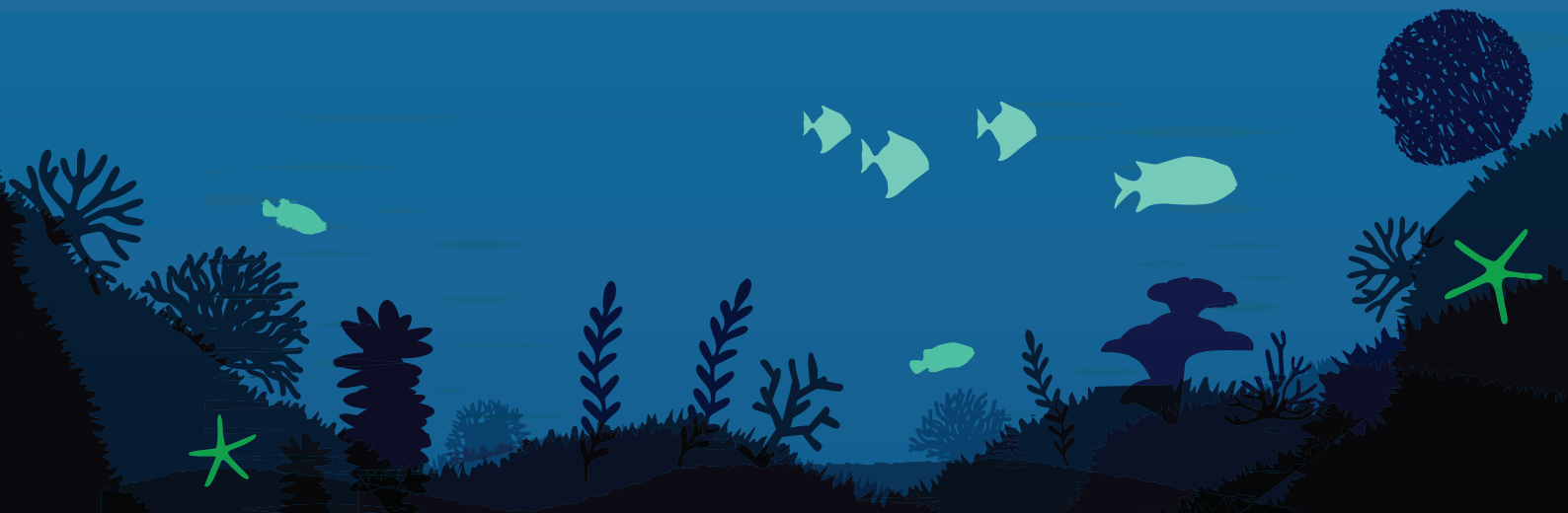
### Case Study: RV Investigator voyage to extend Australia's maritime territory

In January 2020, the CSIRO MNF's RV Investigator vessel departed Perth for a two-month voyage in the Southern Ocean to explore its geology and oceanography, and to establish whether a region of sea floor qualifies to be included in Australia's marine territory. If successful, a potential future claim utilising data acquired on the voyage could lead to the addition of 40,000 square kilometres to the continental shelf recognised as Australia's marine territory.

The voyage involved the mapping of more than 100,000 square kilometres of sea floor approximately 3,000 kilometres to the southwest of Australia. The voyage mapped the entire length of Williams Ridge, defining its continuity with the Kerguelen Plateau and its south-eastern limit for the first time. Kerguelen Plateau includes Australia's territories of Heard Island and McDonald islands, and the sea floor origins of the adjacent William's Ridge was previously unresolved and not included as part of Australia's marine territory.<sup>30</sup>

As part of a future claim, the new sea floor mapping data would be reviewed by the United Nations Commission on the Limits of the Continental Shelf, who are able to grant Australia additional marine territory under the extended continental shelf jurisdiction.

# 8 Where to from here?



## 8.1 Supporting future growth

The economic contribution of seabed mapping data was estimated for 2018-19, prior to the impacts of COVID-19 on the Australian and global economies. As a result of COVID-19 restrictions, economic activity in many of the marine industries that use seabed mapping data were significantly reduced.

As a result, revenue across all major industries that are data enabled decreased by over \$3 billion in 2019-20.<sup>31</sup> As such, **the future growth potential of seabed mapping data must be viewed through a recovery lens.**

**Revenue across marine industries is expected to reach \$69.3 billion over the next 5 years (2024-25).**<sup>32</sup> This is driven by growth in all major data enabled industries, with the exception being oil and gas exploration and extraction. The largest growth potential is expected to come from commercial fishing, marine aquaculture and marine vessel-based tourism.

These forecasts are based on the assumption that seabed mapping data will be available to enable this growth. As new high-resolution data becomes available, it is expected that it will unlock new activity as end-users can effectively plan and strategise around this new information – making seabed mapping data key to the recovery of the blue economy.

## 8.2 Increasing availability and uptake of seabed mapping data

Substantial economic dividends are created by key marine industries, yet only around 25% of the seabed is mapped at a resolution suitable to support these activities. This suggests that there are still significant economic benefits yet to be unlocked as more of the Australian sea floor is mapped.

The Data User Survey identified a number of constraints to the current adoption of seabed mapping data by end users. The majority of these barriers relate to a **lack of coverage in priority areas, low quality of data in particular areas and the high costs of individually acquiring data.**<sup>33</sup>

As such, the future growth of the blue economy can be driven by increasing the amount of new seabed mapping data available to end-users and, importantly, increasing the rate of adoption of this data among end-users.

- **Building the data pipeline:** Increasing the rate of production of new seabed mapping data will create additional activity in the economy through data acquisition, as well as providing new coverage of high resolution data to end-users, enabling them to either conduct their usual operations more efficiently or expand their activities to new areas.
- **Increasing uptake of seabed mapping data:** The rate of adoption of seabed mapping data among 'data enabled' activities is already significant for a number of industries; however there is value in increasing the rate at which these industries adopt new data and how this can be applied to unlocking activity from emerging industries, such as offshore renewable energy generation. Although seabed mapping is not critical to the operations of 'data enhanced' activities, increasing the rate of adoption among these industries can create efficiencies and other economic benefits.

### 8.2.1 Data acquisition

There a number of marine programs that will result in a significant increase in the volume of seabed mapping data that will be acquired in Australia's EEZ in the coming years that can unlock economic activity and efficiencies in marine industries. Some of the major contributors to the future pipeline of seabed mapping data are:

- **AHO's Hydroscheme Industry Partnership Program:** The HIPP will see a major expansion in the volume of bathymetry data acquired annually for the AHO (see Section 4.2.1).
- **MNF's RV Investigator program:** Extension of the MNF's RV Investigator program to 300 days per year operation effectively doubles its data acquisition capability.
- **Australian Antarctic program –** Seabed mapping capability provided by the new icebreaker RSV Nuyina will result in acquisition of extensive new bathymetry and other seabed information, especially for the Southern Ocean and Australian Antarctic Territory.



- **State government agencies** have expanding seabed mapping projects that are providing increasing volumes of high-resolution data for coastal waters (e.g. NSW, Vic, WA) – an essential dataset for seamlessly integrating terrestrial and offshore topography.
- **Offshore industry regulation** is moving towards the submission of environmental data by proponents of developments, including seabed mapping data (e.g. WA).
- A significant volume of data will likely come from the expanding ‘citizen science’ approach to data acquisition, for example from recreational fishers and marine tourism operators.

### 8.2.2 Data management

The diversity of data producers makes it difficult for end-users to source new data, even when it is publicly available, as most end-users don’t have a detailed understanding of what has been mapped to a high-resolution and where it can be accessed. In addition to this obstacle, data producers typically provide seabed mapping data in varying formats, which is not conducive to an end-user being able to effectively use it to inform decisions and drive commercial outcomes.

As such, to maximise the economic dividends of new seabed mapping data, local stakeholders have identified the need for a national data platform from which end-users can access seabed mapping data from various data producers. This could include access to data and services that can be generated from the base data (e.g. seabed geomorphology maps derived from multibeam bathymetry data).

This type of data platform would build on the ‘proof of concept’ data management, processing and delivery systems that have been designed and tested by the AusSeabed program.

Utilising seed funding from its member organisations,

AusSeabed has begun building elements of the data management and delivery systems required. However, to effectively implement these plans and build the required national digital infrastructure requires specific, long-term resourcing.

### 8.2.3 Unlocking data potential

In addition to the new seabed mapping data identified above, there is also a significant amount of data that has been captured but is yet to be unlocked. Data collected by offshore seismic (sound) surveys is a potentially rich source of new bathymetry data. These data exist as multibeam sonar data collected by industry and can also be derived from the seismic records that are used to create detailed images of local subsurface geology.

To build a complete seismic image, the acquisition of high-quality bathymetry data is required as a fundamental seismic-mapping parameter. Over the last several decades, industry seismic surveys have covered approximately 6% (535,160 km<sup>2</sup>) of Australia’s offshore zone, which includes coverage of approximately 11% (229,866 km<sup>2</sup>) of the continental shelf.<sup>34</sup>

Geoscience Australia currently holds the national collection of offshore industry seismic data, which presents a significant opportunity to unlock the bathymetry data contained within these files, and realise additional commercial value. **Geoscience Australia estimates that within their archived seismic files there is around 1 billion dollars’ worth of bathymetry data** that could be generated with additional processing of the data, and subsequently utilised by other marine industries.

*Releasing this bathymetry data and other legacy seabed mapping data held by various government and private organisation can provide a substantial and cost-effective addition to the national set of high-resolution seabed mapping data.*



# How will new seabed mapping data create economic benefits?

The planned areas for surveying as part of HydroScheme Industry Partnership Program in 2021 have been deemed a high priority as they will provide commercial outcomes for numerous marine industries and reduce the safety and environmental risks of undertaking marine activities in these areas. An example of the potential economic benefits that can be unlocked through this new 2021 data pipeline are highlighted by the case study below.

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## Supporting economic activity in Camden Sound, WA



Camden Sound lies at the southern end of the Bonaparte Archipelago, a group of islands in the Kimberley region off the coast of Western Australia. The area was last systematically surveyed between 1947 and 1948, with some additional sparse soundings provided through the National Mapping program from 1974 to 1979.

The new survey data in this area will link a number of previously established shipping corridors that facilitate safe and efficient access to destinations further inshore.

*The availability of this new high-resolution data has the potential to stimulate economic activity through the tourism industry, as tourism operators will be able to offer stopovers to popular inshore destinations within Camden Sound, Brunswick Bay and the Prince Regent River.*

There is already a significant amount of activity occurring in this area, however, the creation of new information and knowledge of the seabed has the potential to unlock safer and more efficient routes, which will support future growth for local operators.

*Capturing new survey data in this area will allow vessels to safely avoid the protected areas of the surrounding marine parks, minimising the environmental risks of economic activities.*

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# Offshore renewable energy generation

Seabed mapping data has the potential to unlock new offshore energy generation activities that are only beginning to be pursued on a commercial scale in Australia. Such activities include wave and tidal energy capture, and offshore wind farming.

The suitability of sites for these activities are limited to specific types of locations due to the site characteristics required to facilitate the effective collection and generation of renewable energy. Seabed mapping data provides useful information on seabed characteristics that can inform optimal site selection, provide evidence to support obtaining environmental and planning approvals and in establishing the required infrastructure (e.g. pipelines, cables and wind turbines).

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## Case Study: Proposed Star of the South – Gippsland Offshore Windfarm



Offshore wind energy is growing rapidly in other parts of the world, but it is yet to take off in Australia. Wind is stronger and more consistent off the coast, making it in many ways a more suitable location for wind energy generation than onshore settings. Energy is generated from wind turbines out at sea, and through a series of cables and substations, the energy is transmitted back to land and to a major connection point for distribution into the electricity grid.

The proposed Star of the South project, located off the shore of Victoria's Gippsland region, would be Australia's first offshore wind farm. At its proposed size, the Star of the South has the potential to provide roughly 20 per cent of Victoria's energy needs. It would exploit a unique weather pattern and profile that includes stronger winds on Bass Strait during heatwaves when energy demand is high, thus the project has the potential to increase the reliability of the grid.<sup>36</sup>

Seabed mapping data is a critical input into the establishment of offshore infrastructure, as it provides key information on the seabed topography, sediment type and distribution, and the benthic environment in the vicinity of the project location. Seabed mapping data will be an input for the environmental impact assessment for the project and it can also help to inform the engineering and design process.

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#### 8.2.4 Data utilisation

The future economic value of seabed mapping data will depend not only on coverage and quality, but on the **rate of adoption of new data** (as well as newly released existing data). The adoption of seabed mapping data reflects the capability and willingness of an economy's industries to apply the data to production, planning and other decision-making processes. The benefits and economic contribution of seabed data will increase with a higher utilisation of the data, as its applications will be broader and attributable to a wider range of economic activity.

**Seabed mapping data is often underutilised in 'data enhanced' activities**, where this information is beneficial, but not essential, to performing these functions. This creates a lack of awareness and adoption of this information, despite it having the ability to create a competitive advantage and efficiency benefits for the user. The increased use of seabed mapping data for these activities also has the potential to have a broader impact, through reducing environmental risks relating to performing these activities.

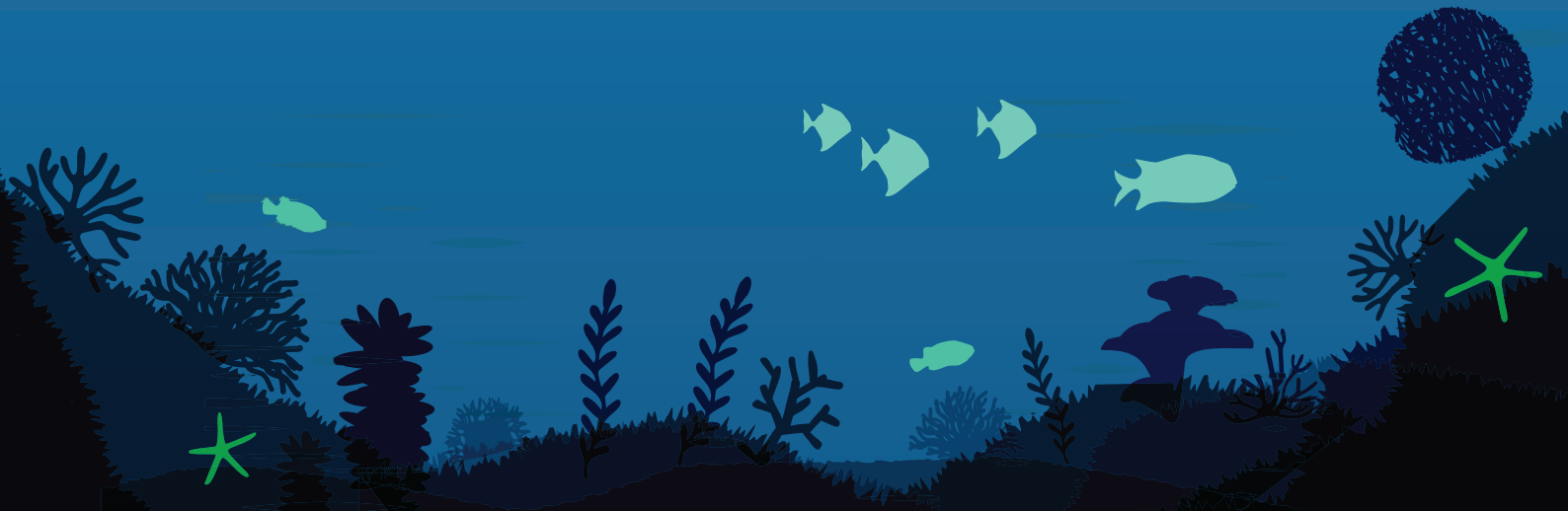
**Utilisation of seabed mapping data among 'data enabled' industries is high** due to obligations around safety and the requirement of the data to facilitate the activity. However, with the release of new and higher quality data to these users, early adoption will maximise the benefits realised from performing their activities (either through safety or efficiency). The creation of a nationally consistent data platform will facilitate rapid uptake of new data, as it will be easier to access and integrate into end-user work programs.

In addition to the activities that were identified as data enabled, seabed mapping also has the ability to **unlock new activity**, particularly among emerging industries where the adoption of the data can inform planning, approvals, construction, and ongoing operations. This has most recently been seen with the emergence of offshore renewable energy, such as offshore wind farming.

The expansion of seabed mapping data production in the Australian economy provides new opportunities for the blue economy, especially given three quarters of the Australian EEZ is yet to be effectively mapped.



# Appendices



# Appendix A

## Economic contribution methodology

### A.1. Assumptions

#### A.1.1. Data producers

The economic contribution attributed to the data production process is based on expenditure data collected from organisations' annual reports and the Seabed Mapping Data Producer Survey. There are many organisations that identify as both a data user and data producer. Questions in the survey requested expenditure figures for activities that use seabed mapping data and an expenditure figure for expenses occurred in collection, processing or distributing seabed mapping data. The data provided by those who are both data users and data producers was carefully considered in the data users and data producers economic contribution analyses in order to avoid double counting.

All data producers were assumed to belong to the professional, scientific and technical services IOIG, as the expenditure profile related to seabed mapping data production is assumed to best reflect the expenditure profile of this industry, regardless of the wider industry an organisation might belong to. For example, while the AHO sits within the Defence industry, the seabed mapping data production activities conducted by the AHO are more likely to reflect similar activities undertaken by a scientific services organisation.

The economic contribution analysis for data producers was constrained by data limitations, as not every data producer responded to the Seabed Mapping Data Producers Survey or provided expenditure data within the survey. There were also limitations in accessing annual reports, as many seabed mapping related activities occur in large organisations that also undertake other activities, or the data was not publicly available in the case of many private sector organisations. In the event that sufficient data was not available for an organisation, it was not included in the economic contribution analysis.

Most of the data provided by seabed mapping data producers was in the form of expenditure, which is treated differently to revenue in an economic contribution analysis. For the organisations where only expense data was available, there was a total of \$136 million of seabed mapping data production expenses in 2018-19. In addition, there was \$31 million in revenue in the economic contribution analysis.

Given the large number of government departments and research institutions who are data producers that are not necessarily looking to make profit, where only expense data was available, it was assumed that revenues were equal to expenses, with minor modifications made to the IO model to account for this.

#### A.1.2. Data enabled industries

##### Tourism

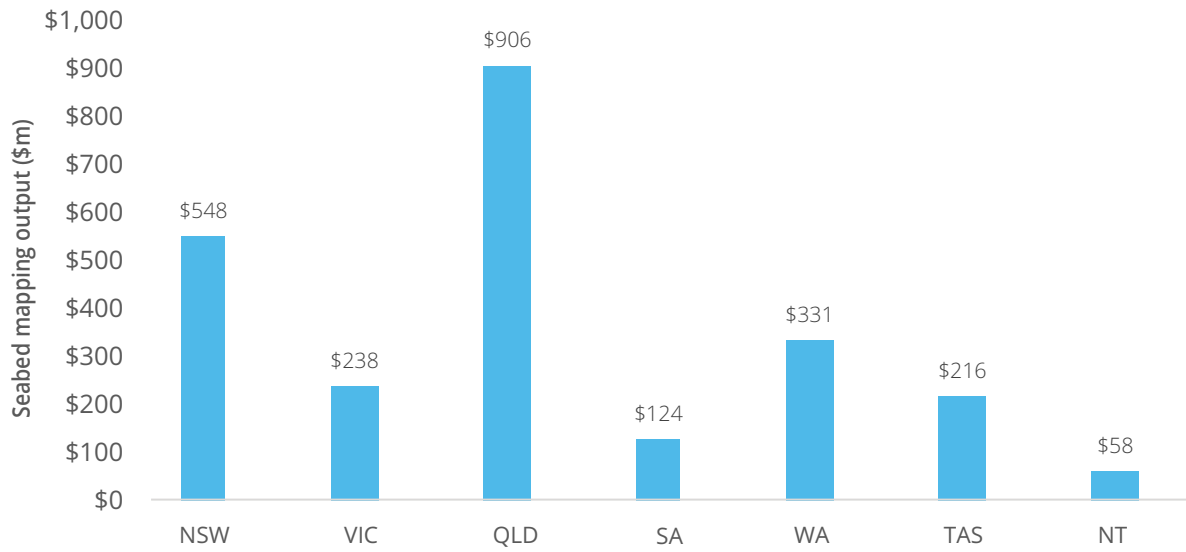
The value of tourism related to activities involving seabed mapping is defined as the total expenditure on the stopover that involves a 'seabed mapping-reliant' activity. For example, a cruise ship needs seabed mapping data to meet legal obligations around safe navigation and therefore this activity was facilitated by the availability of seabed mapping data. Without this data, the activity could not be performed. Therefore, the expenditure on food, accommodation and other tourism-related expenses during the stopover are also attributed to seabed mapping.

There are additional activities that may involve the use of vessels but is not usually how the activity is undertaken. These activities were excluded from the analysis as it was difficult to distinguish the proportion of this activity that involves a vessel and is therefore attributable to seabed mapping.

Domestic tourism involving seabed mapping-related activities is captured by the total number visitor nights (or the total number of visitors for domestic day trips) spent on a stopover involving seabed mapping-related activities. This utilises data published by Tourism Research Australia in their National Visitor Survey that describes the activities undertaken on a stopover (or daytrip). For overnight trips, the number of visitor nights is multiplied by the average spend per night by domestic visitors to provide the total tourism expenditure derived from seabed mapping-related activities. For domestic day trips, the number of visitors is multiplied by the average spend from domestic day trip visitors to obtain their tourism expenditure attributable to seabed mapping.

Direct economic output from seabed mapping-related activities in domestic tourism is greatest in Queensland at \$906 million, followed by NSW at \$548 million (Chart A.1).

Chart A.1 Direct economic output (\$m) of seabed mapping activities in domestic tourism in 2018-19

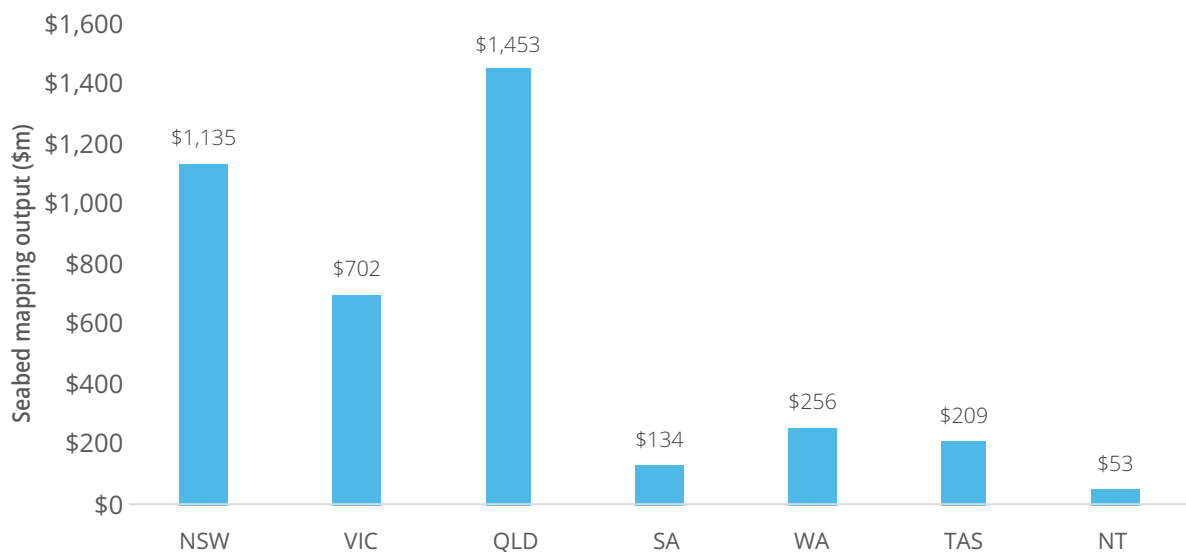


Source: Deloitte Access Economics, Tourism Research Australia (2021)

International tourism involving seabed mapping-related activities is captured by the total number of visitor nights spent on a trip involving seabed mapping-related activities, adjusted to the average length of a stopover for an international holiday visitor. This utilises data published by Tourism Research Australia in their International Visitor Survey. For overnight trips, the adjusted number of visitor nights is multiplied by the average spend per night by international visitors to provide the total international tourism expenditure derived from seabed mapping-related activities.

Direct economic output from seabed mapping-related activities in international tourism is greatest in Queensland at \$1.5 billion, followed by NSW at \$1.1 billion (Chart A.2).

Chart A.2 Direct economic output (\$m) of seabed mapping activities in international tourism in 2018-19



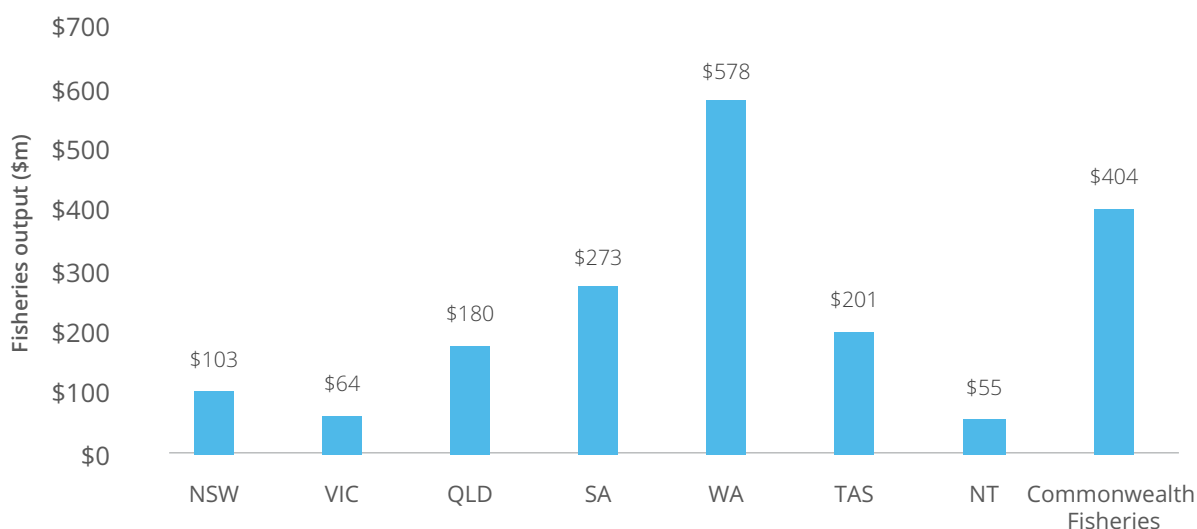
Source: Deloitte Access Economics, Tourism Research Australia (2021)

### Commercial fishing and aquaculture

Value of production was estimated based on the Australian Fisheries and Aquaculture Statistics 2018, with production for the 2018-19 financial year forecast from this data using the three-year CAGR from 2015-16 to 2017-18. Production in the aquaculture sector was apportioned to offshore aquaculture using the proportion of employment in offshore aquaculture relative to onshore (circa. 72% offshore), based on employment in the industry sub-sectors in the 2016 ABS Census of Population and Housing. The value of offshore production from wild catch fisheries was projected to be \$1.9 billion in 2018-19, while the value of production from aquaculture was projected to be \$1.1 billion.

Direct output from fisheries was highest in Western Australia at \$578 million in 2018-19, followed by Commonwealth fisheries at \$404 million (Chart A.3).

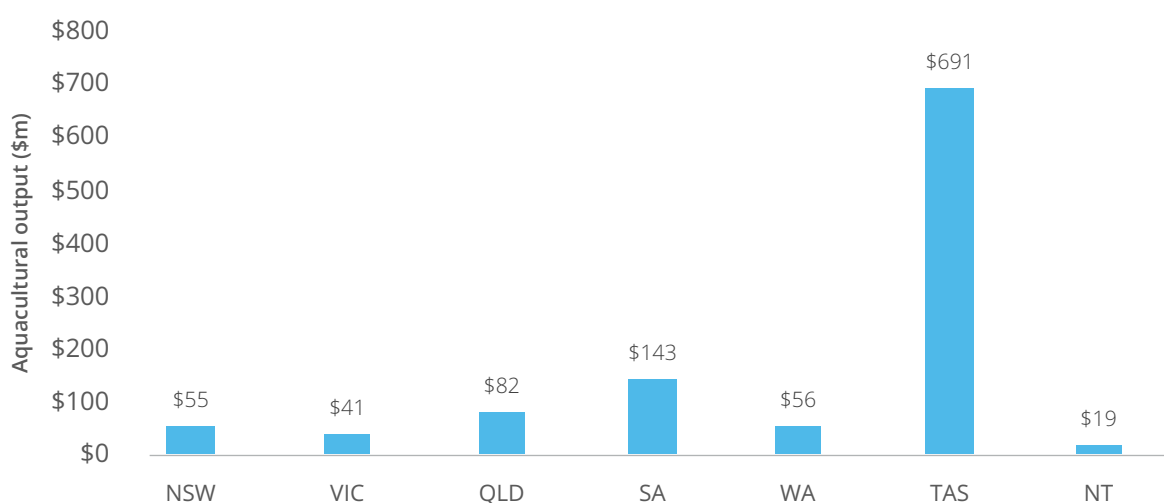
Chart A.3 Direct economic output (\$m) of fisheries in 2018-19



Source: Deloitte Access Economics, ABARES (2018)

Direct output from aquaculture was highest in Tasmania at \$691 million in 2018-19, followed by South Australia at \$143 million (Chart A.4).

Chart A.4 Direct economic output (\$m) of offshore aquaculture in 2018-19



Source: Deloitte Access Economics, ABARES (2018), ABS (2016)

### Oil and gas exploration and extraction

Offshore exploration and extraction of oil, LPG and natural gas is a large contributor to the direct economic output attributable to seabed mapping data. Offshore oil and gas exploration and extraction was captured from a variety of sources, including ABS data on offshore petroleum exploration expenditure, petroleum pricing data from the Australian Petroleum Production and Exploration Association (APPEA), petroleum production from *Australian Petroleum Statistics*, *the Australian Energy Resources Assessment*, *the Australian Energy Update 2020*, *the Australian Energy Market Operator*, and *the ABS' Energy Account Australia*.

Offshore petroleum exploration expenditure is directly available from the ABS on a national level. In the 2018-19 financial year, expenditure on offshore drilling and other oil exploration was \$809 million.

Production from offshore petroleum extraction was derived from Australian Petroleum Statistics and by using APPEA's pricing data. Offshore production in the 2018-19 financial year was estimated to be valued at \$7.6 billion, driven by a strong average price over the year of \$75 per barrel (up from \$63 in the previous year).

Offshore LPG production was estimated using the ABS' Energy Account Australia to gain the overall production value, and the Australian Energy and Resources Assessment to estimate the proportion of LPG extracted from offshore resources. Offshore LPG production in 2018-19 was valued at \$1.2 billion.

Offshore natural gas (LNG) production was estimated using the ABS' Energy Account Australia to obtain the overall production value and used the Australian Energy Update 2020 to estimate the proportion of offshore production – based on the states that have offshore LNG basins. The 2018-19 financial year was a record year for LNG production, which was estimated to be worth \$47 billion in offshore production.

### Water-based transportation

In order to capture only the activities occurring in Australian waters, this sector is including only the industry sub-sectors for which the ABS published data on the gross value of production in *Australian Industry 2018-19*.

In order to avoid double-counting and to present a reliable baseline, this sector is restricted to include only the industry sub-sectors for which the ABS collects and publishes data on the gross value of production.<sup>35</sup>

In terms of freight activity, the sector includes coastal sea freight services between domestic ports, international sea freight transport between domestic ports and international ports, harbour and ferry freight. However, estimates exclude land-based port and water terminal operations and stevedoring services, since the ABS does not publish value-add or income estimates relating to these activities.

The direct economic output of water-based transport is published by the Australian Industry Statistics.<sup>36</sup> The value of production from the water-based transportation industry in 2018-19 is estimated to be \$4.4 billion, with an industry value-add estimated at \$1.4 billion.

### Defence

Given the strategic value of seabed mapping data to the entire Royal Australian Navy, it is assumed that all Australian naval activities use seabed mapping data to some degree. The economic contribution attributed to seabed mapping data from the Royal Australian Navy was obtained from revenue and employment data in the Department of Defence's *Annual Report 2018-19*.

In 2018-19, the revenue granted in the Defence Budget to naval capabilities was \$6.3 billion.<sup>37</sup> This \$6.3 billion comprised 13.9% of the overall budget for the Department of Defence in 2018-19. Any expenditure relating to data production within the Royal Australian Navy was subtracted from the data use figures to avoid double counting.

### Search and rescue operations

The economic contribution of seabed mapping data in offshore search and rescue activities has been carved out on the basis of individual organisations that are primarily involved in offshore search and rescue operations. Organisation data including revenue, expenses and employment was obtained from the 2018-19 annual reports for these organisations. Data was available for the following organisations:

- AMSA
- Australian Volunteer Coastguard
- Marine Rescue NSW
- Marine Rescue QLD
- South Australia Sea Rescue Squadron
- Marine and Safety Tasmania.



While there are additional search and rescue operations occurring in Australia, there is either limited data available on these operations, or these operations sit within a larger organisation (e.g. government departments) with no way of segregating the offshore marine search and rescue activities from wider departmental goals.

Revenue from search and rescue organisations in 2018-19 amounted to a total of \$268 million, with AMSA contributing a significant portion of this revenue at \$235 million. Employment from the search and rescue sector amounted to 425.33 FTEs. It is worth noting that many search and rescue organisations rely on a higher proportion of volunteers than in other industries.

#### Marine research and environmental protection

The economic contribution of seabed mapping data for marine research and environmental protection has been carved out on the basis of organisations whose primary activities involve offshore marine research and environmental protection. Organisational data such as revenues, expenses and employment were obtained from 2018-19 annual reports for the following organisations:

- Great Barrier Reef Marine Park Authority (GBRMPA)
- Great Barrier Reef Foundation
- NOPSEMA.

In addition, survey data was utilised where possible to attribute seabed mapping related activities to research conducted within larger organisations (e.g. AIMS, universities, government agencies, etc.).

Marine research and environmental protection activities attributed to seabed mapping often cannot be segregated from wider research activities conducted by large organisations, leading to likely gaps in the estimation of the true breadth of economic activity resulting from seabed mapping in this sector. Data from the Seabed Mapping Data Users Survey will fill some of the information gaps where annual reports or other organisational information cannot be used to attribute the contribution of seabed mapping data alone.

Survey data provided \$160,000 in seabed mapping data-related revenue in the marine research and environmental protection sector, while annual report data provided \$130 million in revenue for organisations who utilise seabed mapping data for their research and environmental protection activities. This provides a total of \$133 million in revenue relating to the use of seabed mapping data in the marine research and environmental protection sector. Employment from the marine research and environmental protection sector amounted to 369 FTEs in the 2018-19 financial year.

#### Marine infrastructure and construction

The marine infrastructure and construction sector would utilise seabed mapping data to assess sites and, in the design and planning phases of construction. While this is a data enabled industry, it has been excluded from the economic contribution analysis in order to avoid double counting, as organisations' capital expenditure is generally captured as depreciation. Given many seabed mapping-involved industries may have marine infrastructure and construction as one of their upstream, intermediate purchases, it is likely captured in other parts of the economic contribution analysis.

#### Natural hazard monitoring

While seabed mapping data is a key component to natural hazard monitoring, there is limited data available to capture the economic contribution attributable solely to natural hazard monitoring. Such activities are undertaken by large State and Federal Government Departments, however the expenses and employment related to these activities alone is not readily available. As a result, natural hazard monitoring is not captured in the economic contribution analysis.

#### A.1.3. Data enhanced industries

##### Recreational fishing

This industry is not included as a data enabled industry due to limited data, and the inability to identify which recreational fishing activities which require a boat and will be more reliant on seabed mapping data, or those occurring closer to shore that are unlikely to use seabed mapping data to a great extent or at all.

##### Maritime sports

This sector has not been included in the economic contribution analysis due to a lack of data surrounding expenditure and economic output from maritime sports.

##### Shipbuilding / boatbuilding and repair

While the shipbuilding/boatbuilding and repair industry may use purpose-built locations at harbours or elsewhere offshore to assemble new vessels, the use of seabed mapping data in this sector is assumed to be minor and it is therefore not included in the economic contribution analysis.

The shipbuilding/boatbuilding and repair industry is a key supplier to many other industries with higher utilisation of seabed mapping data, and as a result, the inputs from the shipbuilding/boatbuilding and repair sector will largely be captured as an intermediary service.

# Appendix B

## Economic contribution framework

Economic contribution studies are intended to quantify measures such as value added, exports, imports and employment associated with a given industry or firm, in a historical reference year. The economic contribution is a measure of the value of production by a firm or industry.

All direct, indirect and total contributions are reported as gross operating surplus (GOS), labour income, value added and employment (with these terms defined in the table below).

Table B.1 **Definitions of economic contribution estimates:**

<b>Estimate</b>	<b>Definition</b>
Gross operating surplus (GOS)	GOS represents the value of income generated by the entity's direct capital inputs, generally measured as the earnings before interest, tax, depreciation, and amortisation (EBITDA).
Labour income	Labour income is a subcomponent of value add. It represents the value of output generated by the entity's direct labour inputs, as measured by the income to labour.
Value added	Value added measures the value of output (i.e. goods and services) generated by the entity's factors of production (i.e. labour and capital) as measured in the income to those factors of production. The sum of value added across all entities in the economy equals gross domestic product. Given the relationship to GDP, the value added measure can be thought of as the increased contribution to welfare.
Employment (FTE)	Employment is a fundamentally different measure of activity to those above. It measures the number of workers (measured in full-time equivalent terms) that are employed by the entity, rather than the value of the workers' output.
Direct economic contribution	The direct economic contribution is a representation of the flow from labour and capital committed in the economic activity.
Indirect economic contribution	The indirect contribution is a measure of the demand for goods and services produced in other sectors as a result of demand generated by economic activity.
Total economic contribution	The total economic contribution to the economy is the sum of the direct and indirect economic contributions.

Source: Deloitte Access Economics (2016)

## Value added

The measures of economic activity provided by this contribution study are consistent with those provided by the Australian Bureau of Statistics. For example, value added is the contribution the sector makes to total factor income and gross domestic product (GDP).

There are a number of ways to measure GDP, including:

- Expenditure approach – measures expenditure: of households, on investment, government, and net exports; and
- Income approach – measures the income in an economy by measuring the payments of wages and profits to workers and owners.

Below is a discussion measuring the value added by an industry using the income approach.

### Measuring the economic contribution – income approach

Value added measures the value of output (i.e. goods and services) generated by the entity's factors of production (i.e. labour and capital) as measured in the income to those factors of production. The sum of value added across all entities in the economy equals gross domestic product.

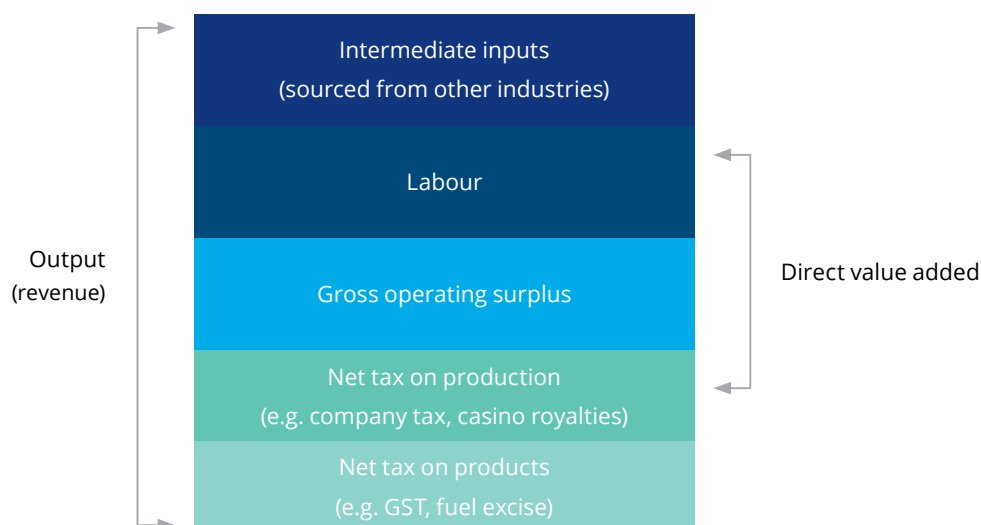
Given the relationship to GDP, the value added measure can be thought of as the increased contribution to welfare. Value added is the sum of:

- Gross operating surplus (GOS) represents the value of income generated by the entity's capital inputs, generally measured as the earnings before interest, tax, depreciation and amortisation (EBITDA).
- Tax on production less subsidy provided for production. Note: given the manner in which returns to capital before tax are calculated, company tax is excluded or this would double-count that tax. In addition, it excludes goods and services tax, which is a tax on consumption (i.e. levied on households).
- Labour income is a subcomponent of value added. It represents the value of output generated by the entity's direct labour inputs, as measured by the income to labour.

Figure B.1 shows the accounting framework used to evaluate economic activity, along with the components that make up output. Output is the sum of value added and the value of intermediate inputs used by the industry.

The value of intermediate inputs can also be calculated directly by summing up expenses related to non-primary factor inputs.

Figure B.1 **Economic activity accounting framework**



Source: Deloitte Access Economics (2016)

Contribution studies generally outline employment generated by a sector. Employment is a fundamentally different measure of activity to those above. It measures the number of workers that are employed by the entity, rather than the value of the workers' output.

### Direct and indirect contributions

The **direct** economic contribution is a representation of the flow from labour and capital in the company.

The **indirect** contribution is a measure of the demand for goods and services produced in other sectors as a result of demand generated by the direct economic activity of an industry. Estimation of the indirect economic contribution is undertaken in an input-output (IO) framework using Australian Bureau of Statistics' IO tables which report the inputs and outputs of specific sectors of the economy.

The total economic contribution to the economy is the sum of the direct and indirect economic contributions.

Other measures, such as total revenue or total exports are useful measures of economic activity, but these measures alone cannot account for the contribution made to GDP. Such measures overstate the contribution to value added because they include activity by external firms or industries supplying inputs. In addition, they do not discount the inputs supplied from outside Australia.

### Limitations of economic contribution studies

While describing the geographic origin of production inputs may be a guide to a firm or industry's linkages with the local economy, it should be recognised that these are the type of normal industry linkages that characterise all economic activities.

Unless there is unused capacity in the economy (such as unemployed labour) there may not be a strong relationship between a firm or industry's economic contribution as measured by value added (or other static aggregates) and the welfare or living standard of the community. The use of labour and capital by demand created from the industry comes at an opportunity cost as it may reduce the amount of resources available to spend on other economic activities. This is not to say that the economic contribution, including employment, is not important. As stated by the Productivity Commission in the context of Australia's gambling industries:<sup>38</sup>

*"Value added trade and job creation arguments need to be considered in the context of the economy as a whole ... income from trade uses real resources, which could have been employed to generate benefits elsewhere. These arguments do not mean that jobs, trade and activity are unimportant in an economy. To the contrary, they are critical to people's well-being. However, any particular industry's contribution to these benefits is much smaller than might at first be thought, because substitute industries could produce similar, though not equal gains."*

In a fundamental sense, economic contribution studies are simply historical accounting exercises. No 'what-if', or counterfactual inferences – such as 'what would happen to living standards if the firm or industry disappeared?' – should be drawn from them.

The analysis – as discussed in the report – relies on a national IO table modelling framework and there are some limitations to this modelling framework. The analysis assumes that goods and services provided to the sector are produced by factors of production that are located completely within the state or region defined and that income flows do not leak to other states.

The IO framework and the derivation of the multipliers also assume that the relevant economic activity takes place within an unconstrained environment. That is, an increase in economic activity in one area of the economy does not increase prices and subsequently crowd out economic activity in another area of the economy. As a result, the modelled total and indirect contribution can be regarded as an upper-bound estimate of the contribution made by the supply of intermediate inputs.

Similarly, the IO framework does not account for further flow-on benefits as captured in a more dynamic modelling environment like a Computerised General Equilibrium (CGE) model.

## Input-output analysis

Input-output tables are required to account for the intermediate flows between sectors. These tables measure the direct economic activity of every sector in the economy at the national level. Importantly, these tables allow intermediate inputs to be further broken down by source. These detailed intermediate flows can be used to derive the total change in economic activity associated with a given direct change in activity for a given sector.

A widely used measure of the spill-over of activity from one sector to another is captured by the ratio of the total to direct change in economic activity. The resulting estimate is typically referred to as 'the multiplier'. A multiplier greater than one implies some indirect activity, with higher multipliers indicating relatively larger indirect and total activity flowing from a given level of direct activity.

The IO matrix used for Australia is derived from the ABS 2017-18 IO tables. The industry classification used for IO tables is based on the Australian and New Zealand Standard Industrial Classification (ANZSIC), with 114 sectors in the modelling framework.

# Limitation of our work

## General use restriction

This report is prepared solely for the internal use of Geoscience Australia. This report is not intended to and should not be used or relied upon by anyone else and we accept no duty of care to any other person or entity. The report has been prepared for the purpose of valuing the economic contribution of seabed mapping data in Australia. You should not refer to or use our name or the advice for any other purpose.

# End notes

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