Australian Government

Australian Institute of Marine Science

THE AIMS INDEX OF MARINE INDUSTRY 2020

Deloitte Access Economics undertook this analytical work for AIMS. Drawing on experience in developing and updating the AIMS Index of Marine Industry in the past, Deloitte Access Economics also drew on its in-house Deloitte Access Economics Regional Input-Output Model (DAE-RIOM) to estimate the flow-on and total economic contribution of the marine industry.

Front cover: Fishing Boats, Success Boat Harbour, Fremantle WA, by Chris King, unsplash.com

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Glossary

Acronym	Full name
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
AIMS	Australian Institute of Marine Science
ANZSIC	Australian and New Zealand Standard Industrial Classification
FTE	Full-time equivalent
GBR	Great Barrier Reef
GDP	Gross Domestic Product
IOIG	Input Output Industry Group
IPCC	Intergovernmental Panel on Climate Change
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
nfd	Not further defined
NSW	New South Wales
NT	Northern Territory
QLD	Queensland
RCP	Representative Concentration Pathway
SA	South Australia
SSP	Shared Socioeconomic Pathways
TAS	Tasmania
TRA	Tourism Research Australia
VIC	Victoria
WA	Western Australia

Foreword

Welcome to the eighth instalment of the Australian Institute of Marine Science (AIMS) Index of Marine Industry. This project began back in 2008, and considered data going back to 2001. Since then, working with Deloitte Access Economics, we have issued the Index every two years, to provide a regular update of the value of Australia's blue economy. Previous editions of the Index have confined their focus to economic output and value add of marine-based sectors, allowing comparison with other sectors of the Australian economy. The Index continues to evolve and improve. This year, Deloitte has updated the methodology for calculating value add in key sectors, making the numbers even more dependable. In addition, for the first time, this new edition includes breakdowns of key marine industry sub-sectors by state or territory and discusses the possible effects of climate change on future economic output and value add from the Great Barrier Reef. The ninth edition will be published in 2022, coinciding with AIMS' 50th anniversary, and will continue to provide a detailed look into one of the most important, vital, and fastest growing parts of Australia's economy.

Australia's population is concentrated near the coast, with more than 85% living within 50 km of the ocean. More than 70% of Australia's territory lies beneath the ocean. The sea is part of our national identity, and of deep cultural significance to Indigenous Australians. It is home to a wondrous and amazing diversity of life, including our iconic coral reefs. As Australia's tropical marine research agency, AIMS' mission is to provide the research and knowledge of Australia's tropical marine estate required to support growth in its sustainable use, effective environmental management and protection of its unique ecosystems. The Institute's research supports government in development of marine policy, enables evidence-based decisions by the public and private sectors, works in partnership with the Traditional Owners of our coastline and sea country, and provides trusted advice to the community at large about the state of our unique tropical marine ecosystems.

As the Index shows, our 10 million square kilometre marine estate is also a significant and growing source of wealth for all Australians. In 2017-18 (the most recent available data), the output of Australia's blue economy was valued at $81.2 billion - a four-fold increase over the last two decades. Australia's marine industry provided jobs for hundreds of thousands of people and contributed $62.9 billion of economic value to the economy. And while this analysis does not include environmental and social values (which are considerable), it does show just how important the oceans are, in an economic sense, to our island-continent nation. Growth in the sustainable use of our oceans is vital to Australia's future prosperity. AIMS is here to help ensure that this occurs in a way that also preserves and protects our oceans' unique ecosystems now and in the future.

Dr Paul Hardisty
Chief Executive Officer, Australian Institute of Marine Science

Executive summary

Introduction

Australia's 'blue economy' spans a wide range of activities that add significant economic value and employ many Australians across a number of sectors. The AIMS Index of Marine Industry (the Index) assesses the economic output and value-added economic contribution of Australia's marine industry to the nation's economic bottom line.

The Index adds a new time point to a growing time-series of available economic data about activities related to the marine environment. The analysis follows a well-established economic framework to allow comparison with other economic sectors.

This 2020 version is the eighth edition of the Index. In addition to an update of the economic output and value added economic contribution of the marine industry to the Australian economy, this analysis has been extended to assess state-based output in key marine industry sub-sectors to show how economic activity is geographically distributed across the nation. The report also includes a qualitative discussion of the potential impacts COVID-19 pose for the marine industry, which are anticipated to be measurable and reported in future editions.

This update also considers the broader economic, social and environmental values provided by marine assets through a sample analysis of the values provided by the Great Barrier Reef specifically and the risks to these from climate change.

Study Approach

This study assesses the economic output and value-added economic contribution of the Australian marine industry based on 2017-18 data, the latest financial year for which data are published across most major marine sub-sectors. This update to 2017-18 represents two additional years of data presented since the 2018 edition of the Index, which contained estimates to 2015-16.

This update follows the same general methodology as the 2016 and 2018 editions of the Index in which the definition of marine industry was broadened relative to pre-2016 editions.

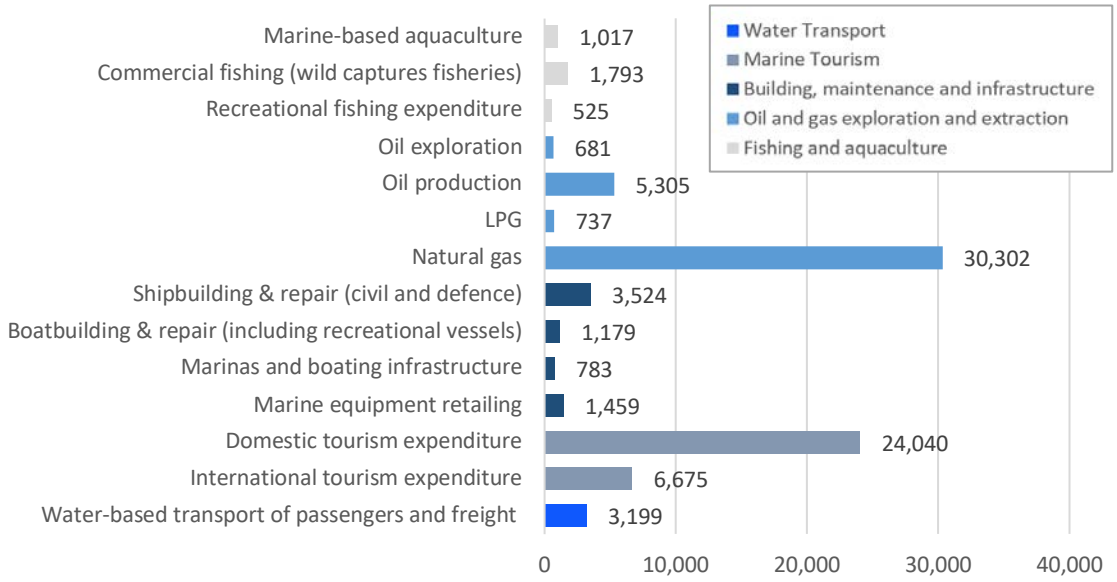
This Index edition updates the methodology for calculating economic sub-sector output in some areas including recreational fishing, marine tourism and gas production. Methodological updates reflect new data sources and information for these marine sub-sectors, allowing more accurate estimation of economic output.

In addition to the economic output of the marine industry, which is the income that is directly earned by the marine industry, the Index considers the flow-on and total economic contribution of the marine industry to the national economy. This recognises that activities in the marine industry stimulate demand for inputs from the upstream supply chain. The size of these impacts is related to factors such as the extent to which domestic inputs are used to produce outputs of the marine industry. By analysing both the marine industry sub-sectors and their supply chain, the Index provides a comprehensive estimate of the overall size and importance of the marine industry.

The economic output of Australia's marine industry

The economic output of the marine industry in Australia is estimated at $81.2 billion in 2017-18. This is based on the revenue of economic activities in 14 marine industry sub-sectors, including water-based transport, domestic and international tourism, marinas and boating infrastructure, boatbuilding and repair, ship building and repair, marine equipment retailing, oil exploration, oil production, liquefied petroleum gas (LPG) production, natural gas production, marine-based aquaculture, commercial fishing, and recreational fishing. The economic output from these marine-related activities in 2017-2018 is shown in Chart i.

Chart i: The economic output ($m) from marine-related activities in 2017-18.



Data source: Various government publications and industry reports, see Appendix A.

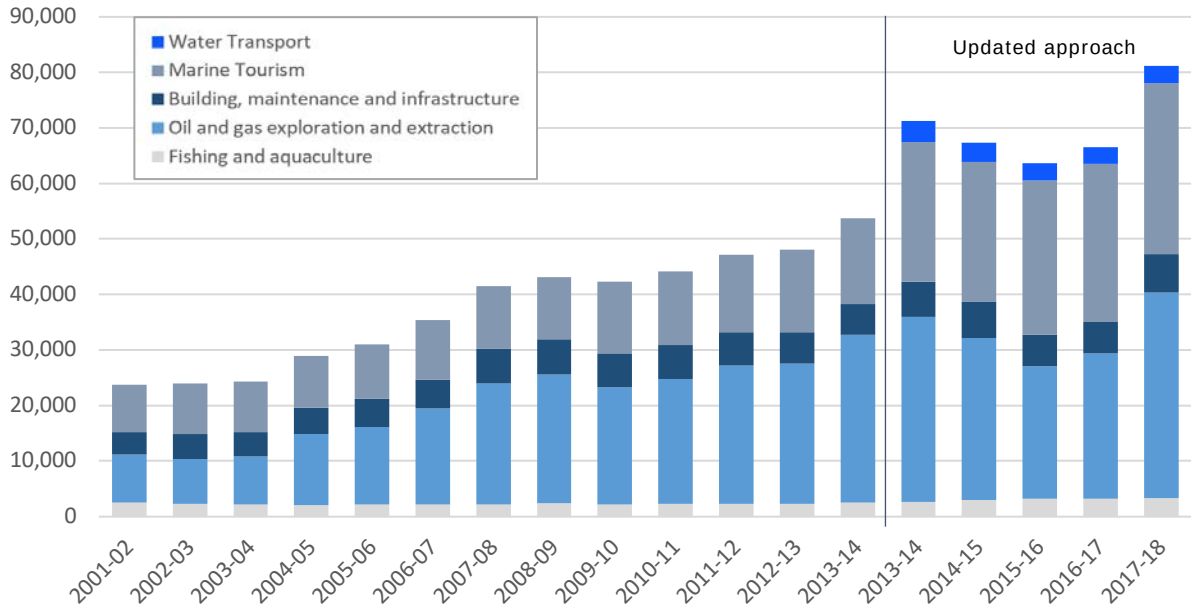
The economic output of the marine industry in 2017-18 of $81.2 billion represents a substantial increase compared with 2015-16 ($63.6 billion[1]). This increase is primarily driven by:

- A large increase in the output of Australian natural gas production, particularly from offshore production in Western Australia. The value of output from offshore natural gas production is estimated to have increased by 79% from $16.9 billion in 2015-16 to $30.3 billion in 2017-18.
- A 57% increase in the value of output in ship building and repair, from $2.3 billion to $3.5 billion, driven by activity in South Australia and Western Australia.
- Strong growth in both international and domestic marine tourism, increasing by 11% from $27.8 billion to $30.7 billion.

The time-series of economic output from marine-related activities since 2001-02 is shown in Chart ii. Where methodological updates were applied, economic output estimates have been back-cast to 2013-14 which is the first year that the Index used current sub-sector definitions.

[1] The economic output of the marine industry in 2015-16, as reported in the previous edition of the Index, was $68.1 billion. However, as discussed in section 2.2 and Appendix C of this Index, the methodology adopted to assess economic output for some sub-sectors has been refined and updated to improve accuracy and reflect the availability of new data. This figure of $63.6 billion reflects a back-casting using the updated methodology adopted in this Index.

Chart ii: Time-series of economic output ($m) from marine-related activities since 2001-02.



Source: Deloitte Access Economics modelling.

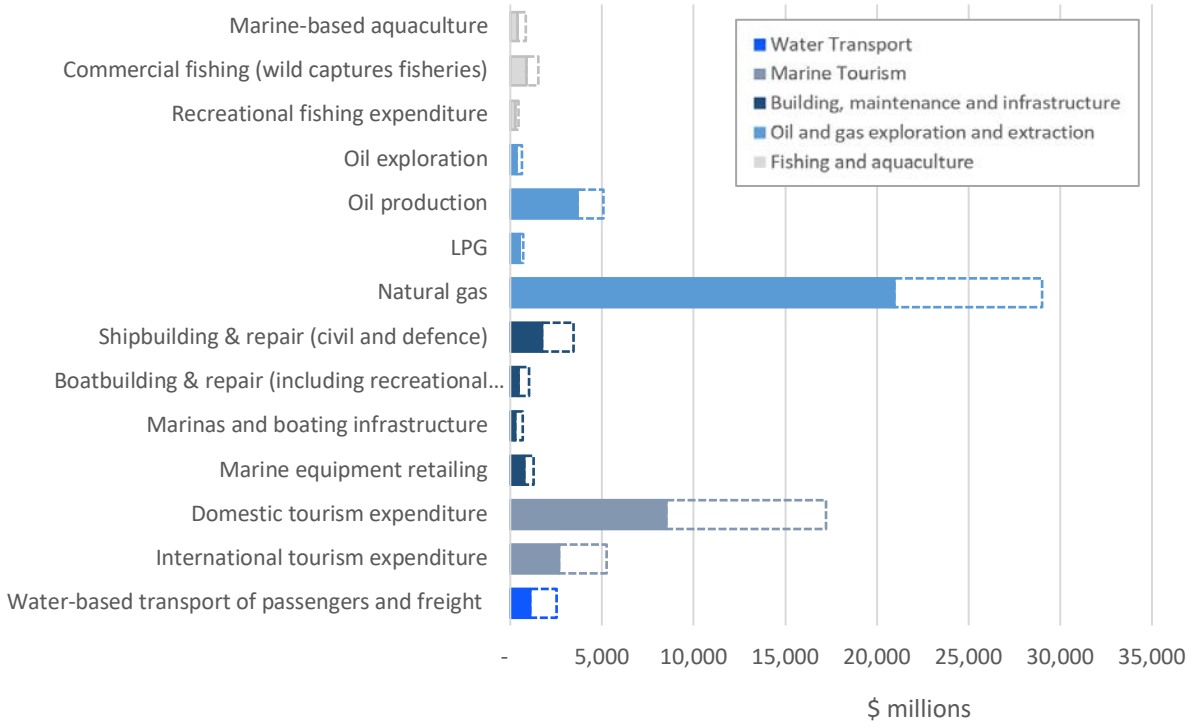
The economic contribution of Australia's marine industry

The total economic contribution of the marine industry is measured by value added and employment. Value added is a different concept to output. It is commonly used to measure economic contribution because the output of one industry, measured by the value of production, often becomes the input of another. This can lead to double-counting and give a misleading estimate of an industry's true contribution to the economy. In contrast, an industry's value added does not include the value that is created by upstream industries. An industry's value added is measured by the value of what it produces, net of inputs from other industries, and is therefore smaller than its total output. The value add for each industry are summed to measure Gross Domestic Product (GDP), which is the primary indicator of the size of a country's economy. This approach avoids double-counting outputs that flow between industries.

The marine industry directly contributed $42.4 billion in value added to the economy in 2017-18, with a further $26.8 billion of indirect value add in upstream industries. This amounts to a total economic contribution of $69.2 billion in value added, or 3.7% of national gross domestic product.[2] The direct and indirect contribution of marine-related activities in 2017-2018 is shown in Chart iii.

[2] Based on Australian GDP of $1.85 trillion in 2017-18. Source: Australian Bureau of Statistics (2019b).

Chart iii: Direct (solid colour) and indirect (dashed line) value added ($m) by marine sub-sector in 2017-18.



Source: Deloitte Access Economics modelling, using various government publications and industry reports (see Appendix A).

The marine industry's total employment was estimated as 338,974 FTE workers. Of these, 191,286 FTE workers were directly employed in the marine industry, with a further 147,688 FTE workers in employment in upstream industries.

In the previous version of the Index, the blue economy was estimated to contribute $71.4 billion in direct and indirect value added and support 393,011 FTE workers in 2015-16. However, the reduction in value added (from $71.4 billion to $69.2 billion) and employment (from 393,011 to 338,974 FTE workers) between 2015-16 and 2017-18 are unlikely to reflect a fall in the economic contribution of the blue economy over this period. Instead, they are the result of the availability of new data that allow better estimation of economic contribution in this version of the Index report. Specifically, new data has enabled better identification of marine tourism, who marine visitors are, how much and what they spend their money on. This, in turn, has allowed for more accurate estimates of expenditure and economic contribution from marine tourism.

Climate change impacts on Great Barrier Reef values

The Great Barrier Reef (GBR) is a globally significant marine asset that provides a variety of values for society. Climate change is impacting the GBR now, evidenced by three mass bleaching events in the period 2016 to 2020. Continued ocean warming and acidification, and potentially more severe cyclones, will place GBR values at growing risk. Current emission-reduction pledges would see the world warm more than 2°C relative to preindustrial levels this century with a high likelihood of exceeding 1.5°C already by year 2040. Improved climate-change mitigation strategies will reduce risks to the GBR in the long term, helped further by adaptation strategies for ecosystems, people and industries.

COVID-19 and the marine industry

The COVID-19 pandemic has brought unprecedented disruption to many areas of the economy and Australia's marine industry is no exception. The next Index edition to be published in 2022 will access data for 2019-20, and this will allow us to begin to quantify the impact of COVID-19 on the blue economy. It is worth noting at this stage that the marine industry will be affected due to:

- Border closures and stay-at-home restrictions forcing many tourist operators to partially or fully suspend operations depending on where in Australia they are located.
- Significant reduction in oil and gas prices as a result of broad global economic recession caused by the pandemic.
- Reduction in demand for certain fish products, in particular high-end products, such as lobsters, oysters and bluefin tuna.[3]
- Anticipated reduction in expenditure on luxury items such as recreational vessels as consumers become more cautious in their discretionary spending.

[3] Organisation for Economic Co-operation and Development (2020)

1 Introduction

1.1 Purpose of this study

AIMS has commissioned this analysis - the eighth edition of the AIMS Index of Marine Industry - as part of the Institute's effort to demonstrate the economic importance of Australia's marine estate to this nation. This update of the Index provides the addition of 2017-18 data to the time-series overview of the blue economy since 2001-02, capturing the economic value of activities in the marine industry and their contribution to the national economy and employment. For the first time, and where data exists, the Index also assesses state-based output in key marine industry sub-sectors to show how economic activity is geographically distributed across the nation.

As well as an added time point to the time-series of economic output and analysis of the economic contribution of the marine industry to the national economy, this update has been expanded to include discussion of the risks that climate change pose to a greater range of economic, social and environmental values of the Great Barrier Reef (GBR). Specifically, continued warming and ocean acidification in combination with storms and sea level rise represent significant risks to the GBR and marine industries that depend on its ecosystem services. Climate mitigation in combination with adaptation measures will be critical to sustaining GBR values, economic and otherwise.

As this update of the Index pertains to the marine industry in 2017-18, the impact of the COVID-19 pandemic on the marine industry is not reflected in the analysis. Nevertheless, the Index provides a brief qualitative assessment of potential impacts of the pandemic on different components of the marine industry which are likely to be evident in the next version of the Index.

1.2 Approach to the valuation

The economic contribution framework is the most suitable tool to demonstrate the economic importance of Australian marine assets. The framework values economic activities associated with marine assets, using data on industry structure and trade relationships provided in industry Input-Output tables.[4] The economic contribution framework focuses on the flow value of Australian marine industries in terms of their contribution to the national economy and employment. This approach is consistent with the National Accounting Framework adopted by the Australian Bureau of Statistics to measure Gross Domestic Product and Gross State Product, thus allowing the value of the marine industry to be compared to other industries in the economy.

It is acknowledged that the flow value, measured through an economic contribution framework, is not the only way to value Australian marine assets. The stock value is another way to value Australian marine assets. While the flow value estimates the marine industry's contribution to the national economy in a period of time (i.e. a year), the stock value reflects marine assets' total contribution to the welfare of society at a point in time. The stock value captures not only the economic value but also social, environmental and other intangible values of the marine environment. Leaving the marine assets for future generations to enjoy is an example of an intangible value captured under the stock value. Although estimating the stock value of Australian marine assets is not in the scope of this edition of the Index, the impact of climate change on the GBR is qualitatively discussed with regards to a range of values, including those provided by marine assets beyond their economic contribution.

1.3 Structure of the Index

This edition of the Index is structured as follows:

- Chapter 2 discusses the economic output of marine activities among key marine industry sub-sectors. The approach to defining marine activities and the associated economic output is also discussed in this chapter.

[4] Australian Bureau of Statistics (2020a)

- Chapter 3 discusses the economic contribution of marine activities, in terms of value added and employment. The approach to estimating the economic contribution of marine activities is also discussed in this chapter.
- Chapter 4 discusses the impact of climate change on the use and non-use values of the GBR.

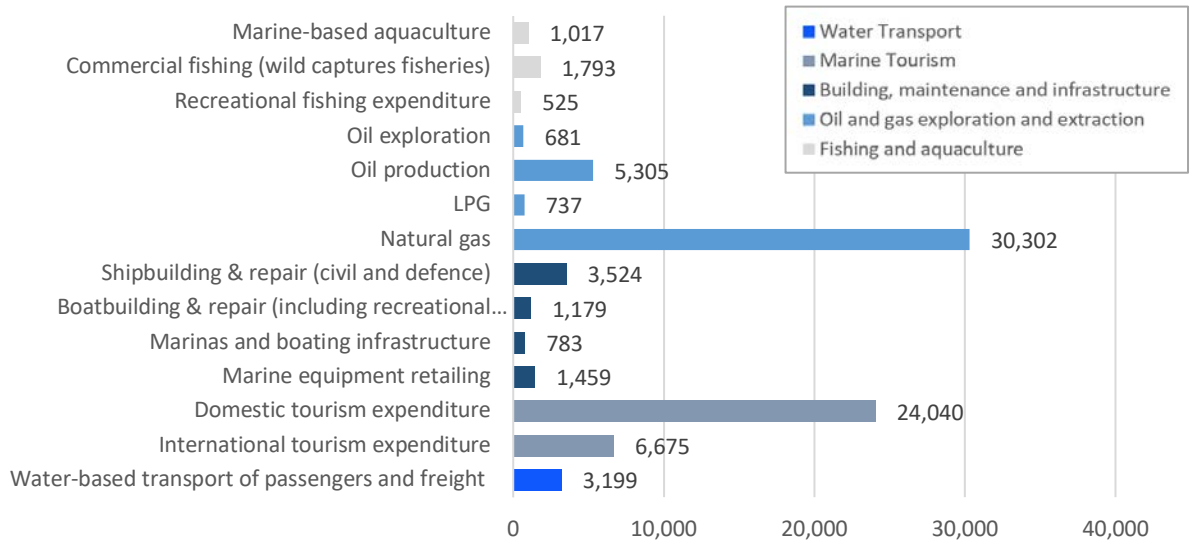
2 The economic output of Australia's marine industry

2.1 Economic Output in 2017-18

We define the Australian marine industry as comprising 14 sub-sectors: water-based transport, domestic and international tourism, marinas and boating infrastructure, boatbuilding and repair, ship building and repair, marine equipment retailing, oil exploration, oil production, liquefied petroleum gas (LPG) production, natural gas production, marine-based aquaculture, commercial fishing, and recreational fishing.

In 2017-18, the economic output attributable to the marine industry in Australia was $81.2 billion. The economic output of marine-related activities in 2017-2018 is shown in Chart 2.1.

Chart 2.1: Economic output ($m) from marine-related activities in 2017-18.



Data source: Various government publications and industry reports – see Appendix A.

By way of comparison with key land-based industries, in 2017-18:

- The economic output of all agricultural production in Australia was $58.9 billion.[5]
- The economic output from coal mining totalled $69.7 billion.[6]
- The economic output from primary metal and metal product manufacturing totalled around $53.0 billion.[7]
- The economic output from heavy and civil engineering construction totalled around $68.5 billion.[8]

It should be noted that the economic output estimates provided do not capture all values of the marine industry. This is because data is unavailable for some marine activities, such as marine environment management, and there are non-economic values, such as the cultural value to

[5] Australian Bureau of Statistics (2019d)
[6] Australian Bureau of Statistics (2019e)
[7] Australian Bureau of Statistics (2019e)
[8] Australian Bureau of Statistics (2019e)

Aboriginal and Torres Strait Islander communities and the icon value to the Australian brand, which are not captured by this approach.

2.2 Changes over time

A time-series overview is provided in Chart 2.2. and enables assessment of changes to economic output of marine sub-sectors over time. As outlined in detail in Section 2.3, there are updates to the economic output estimation methodology for several sub-sectors (i.e. marine based aquaculture, recreational fishing, marine tourism, natural gas and LPG production). To appropriately compare the economic output of the marine industry over time, the updates to output estimation have been applied to previous periods (estimates are back-cast to 2013-14 which is the first year that the Index used current sub-sector definitions and undertook value added economic contribution analysis for the marine industry).[9]

Using the marine industry definition used prior to the 2016 edition of the Index, between 2001-02 and 2013-14, the value of marine industry output has more than doubled. Since then, this upward trend has continued, undergoing a particularly substantial increase between 2015-16 and 2017-18 data sets.

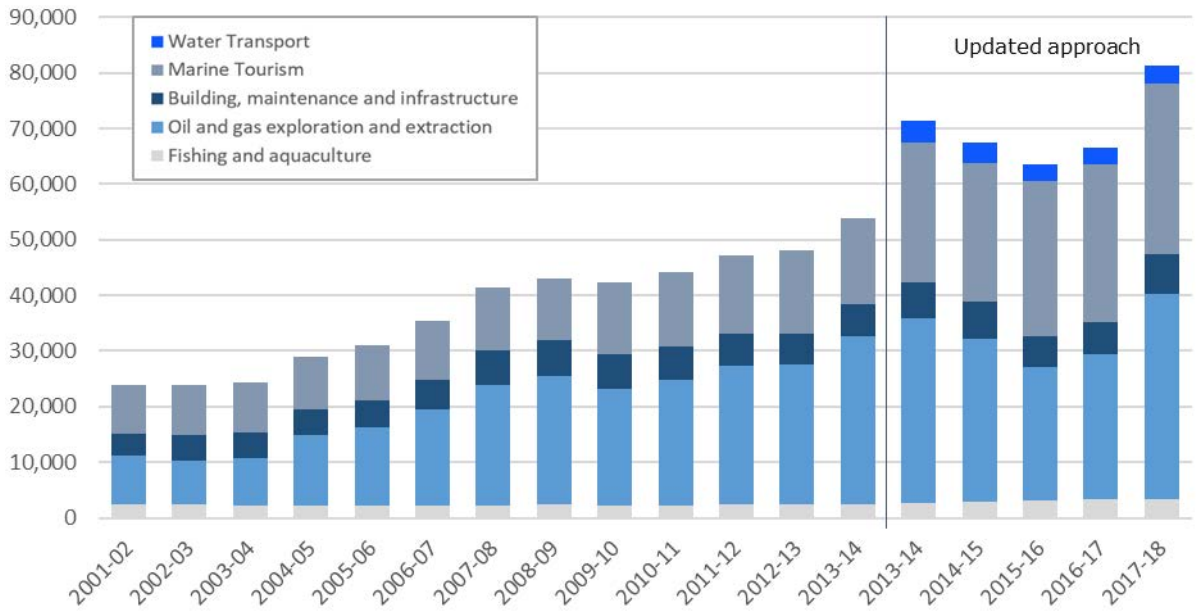
This increase over the period was primarily driven by:

- Large increases in the economic output of offshore oil and gas production, in particular in the value of Australian natural gas production. This is mostly driven by increases in production volume rather than prices, particularly from increased production capacity of offshore gas facilities in Western Australia. The economic output from offshore natural gas production increased from $16.9 billion in 2015-16 to $30.3 billion in 2017-18.
- A 57% increase in the value of output in ship building and repair from $2.3 billion to $3.5 billion, driven by production in South Australia and Western Australia.
- Strong growth in both international and domestic marine tourism expenditure, increasing by 11% from $27.8 billion to $30.7 billion.

Moderating these increases over the same period was a decrease in economic output for oil and gas exploration, which fell 47% from $1.3 billion to $681 million. However, this decrease in oil and gas exploration is heavily outweighed by the increase in oil and gas production.

[9] Refer to Table A.6 in Appendix D for a detailed description of the methodological updates for several marine subsectors.

Chart 2.2: Time-series of economic output ($m) from marine-related activities since 2001-02.



Data source: Various government publications and industry reports – see Appendix A. Note that to ensure comparability the values shown in this figure from 2013-14 onwards reflect calculations using updated methodologies described in this Index. They are therefore not the same as those shown in the 2018 edition of the Index.

Appendix A contains a table (A.5) with detailed data of economic output for each marine sub-sector from 2001-02 to 2017-18.

2.3 Marine industry sub-sectors

The following sections discuss each of the marine industry sub-sectors and provide state-based breakdowns of economic output by sub-sector for 2017-18.

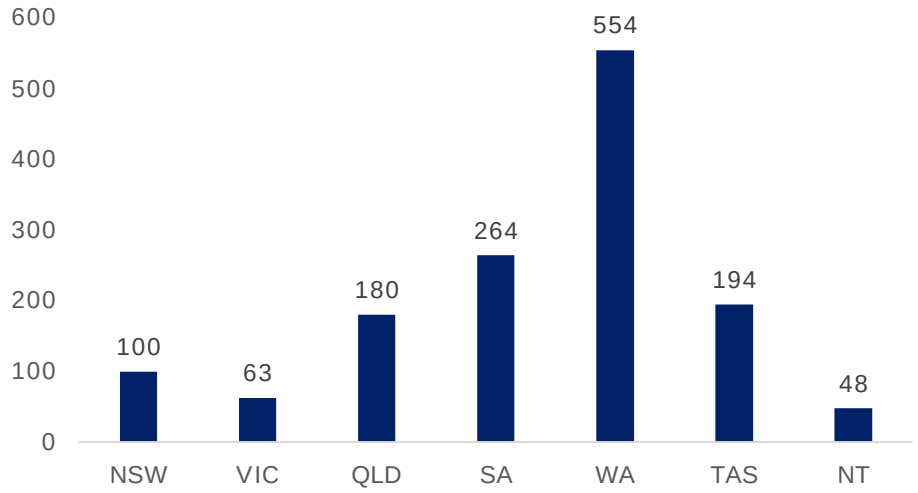
2.3.1 Commercial fishing and aquaculture

In 2017–18, the economic output of wild-catch fisheries in Australia was estimated at $1.8 billion. Rock lobsters, prawns, and abalone were the most valuable wild-caught species, together accounting for 64% of the economic output of all wild-catch fisheries.[10]

The three-leading wild-catch jurisdictions in 2017–18 in terms of value of production, were Western Australia ($554 million), Commonwealth marine areas ($390 million) and South Australia ($264 million). Commonwealth marine areas are any part of the sea, within Australia's exclusive economic zone and/or over the continental shelf of Australia, that is not in state or Northern Territory waters.[11] The Commonwealth marine area stretches from three to 200 nautical miles from the coast.

[10] Australian Bureau of Agricultural and Resource Economics and Sciences (2020)
[11] More information of Commonwealth and state waters can be found at the following link: https://www.environment.gov.au/epbc/what-is-protected/commonwealth-marine-areas#:~:text=The%20Commonwealth%20marine%20area%20is,nautical%20miles%20from%20the%20coast.

Chart 2.3: Economic output ($m) of commercial fishing in 2017-18.



Note: The national direct economic output of commercial fishing also includes activities in Commonwealth waters. Commercial fishing in Commonwealth waters is estimated at $390 million. Source: *ABARES* (2020)

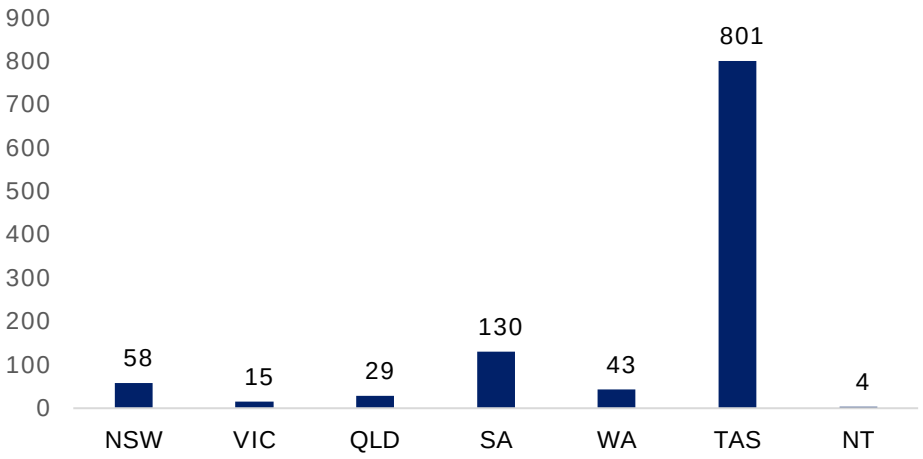
Aquaculture in Australia can be carried out in freshwater, brackish water or marine water. This analysis is limited to marine-based aquaculture. The economic output of marine-based aquaculture is estimated by multiplying the value of aquaculture production, published in the *Fisheries and Aquaculture Statistics 2018* with the share of offshore aquaculture employment, collected in the Census.[12] As outlined by the Census, 72% of aquaculture employment occurs offshore (employment reported against 'aquaculture nfd' is excluded since it is unclear whether employment in this non-defined category occurs onshore or offshore). It is acknowledged that some inland aquaculture operations use salt water, but these have not been captured in this analysis due to lack of data.

The economic output of the Australian aquaculture sector in 2017-18 was $1.4 billion (*Fisheries and Aquaculture Statistics 2018*). It is estimated that approximately $1.0 billion (72% of total aquaculture) was marine based. Salmonid, tuna, and oyster production contributed the most to the economic output of marine-based aquaculture.

Tasmania was by far the top marine aquaculture producing state or territory in Australia in 2017-18 with an economic output of around $800 million.

[12] Australian Bureau of Agricultural and Resource Economics and Sciences (2020) and Australian Bureau of Statistics (2016).

Chart 2.4: Economic output ($m) of marine-based aquaculture in 2017-18.



Source: *ABARES* (2020), *ABS* (2016).

2.3.2 Recreational fishing

Quantifying the economic value of recreational fishing activities is challenged by difficulties in collecting and comparing data about activities which occur in a relatively informal way and across a fragmented sector. For example, the fish caught by recreational fishers represent an economic value, but they are not part of a market transaction and hence are not part of the economic valuation of the sub-sector.

Currently, the only data available about recreational fishing's economic impact is for fishing-related expenditure, such as expenditure on fishing gear or bait. This also includes activities which are considered under the tourism sub-sector (such as travel and accommodation) and marine equipment retailing (expenditure on vessels used for recreational fishing).

Previously the Index estimated fishing expenditure based on the *2003 National Recreational and Indigenous Fishing Survey* that reported 3.36 million Australians engaged in recreational fishing, spending $1.9 billion in 2000-01 and escalating this value to current day prices.[13] In this edition of the Index, this methodology has been updated to better reflect changes to fishing preferences, national population and wage increases in Australia.

Although the *2003 National Recreational and Indigenous Fishing Survey* was the last national level survey that estimated the value of recreational fishing there are several (more recent) studies that have been conducted; however, these are for one particular state or region and occur at different time periods.[14] Given that almost all states and territories have an appropriate (more recent) study we use these studies to gauge updated fishing participation levels and, in some cases (Tasmania and Northern Territory) fishing expenditure.

This allows us to better capture recent expenditure trends and recreational fishing behaviour. Where gaps exist (such as expenditure habits not being included in the state-based study) we draw on the *2003 National Recreational and Indigenous Fishing Survey* study, as in some cases this still provides the most recent data. In addition, we use population growth and wage growth to scale fishing populations and expenditure to 2017-18.

Further updates to the methodology involved excluding several expenditure items which are likely to be counted in other marine industry sub-sectors, such as tourism. Previously these items were

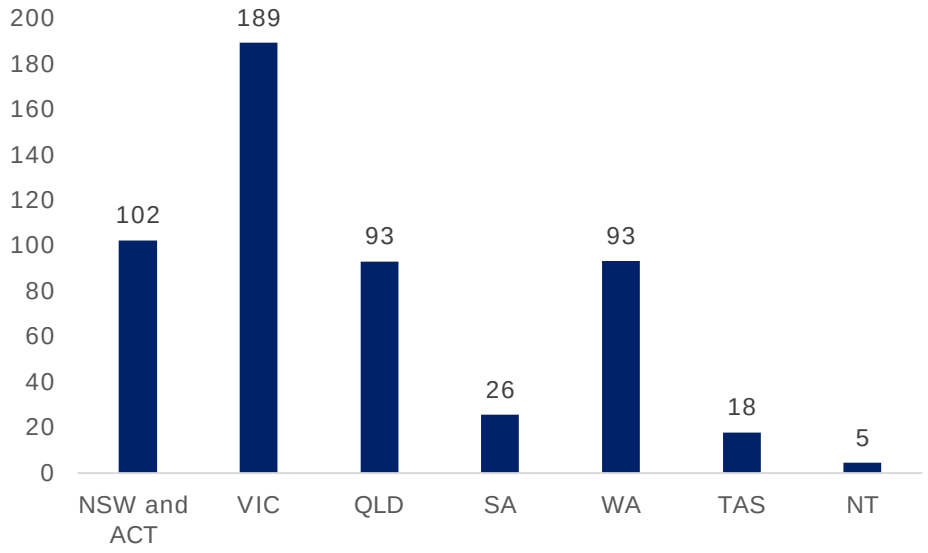
[13] Department of Agriculture, Fisheries and Forestry (2003).
[14] Information on the most recent state-based surveys can be found at: https://www.agriculture.gov.au/abares/research-topics/fisheries/fisheries-and-aquaculture-statistics/recreational-fishing#commonwealth-waters.

not excluded, and their removal significantly reduces the value of expenditure. In addition, the portion of fishers who are tourists is excluded to remove double-counting of expenditure in the tourism sub-sector; this is determined through estimates from Tourism Research Australia.

Marine fishing (offshore, coastal and estuary) accounts for 82% of the total estimated harvest (which also includes rivers and lakes/dams), which is taken into account in the final expenditure estimate.

In 2017-18, the marine-based recreational fishing sub-sector was valued at $526 million. Using both the state-based studies and the *2003 National Recreational and Indigenous Fishing Survey* which disaggregated expenditure by state, enabled a comparison of expenditure presented in Chart 2.5. The most valuable marine-based recreational fishing states and territories in 2017–18 were Victoria ($189 million), New South Wales/Australian Capital Territory ($102 million), and Queensland ($93 million) and Western Australia ($93 million). The variation in expenditure among states and territories is mostly driven by population differences.

Chart 2.5: Economic output ($m) from marine recreational fishing activities in 2017-18.



Source: Various state-based studies and *DAFF* (2003).

2.3.3 Indigenous fishing

Native fishing is linked to core cultural values and beliefs in Aboriginal and Torres Strait Islander communities. While Indigenous people are included in the population basis used to calculate the number of recreational anglers, Indigenous fishermen that live in Indigenous communities and fish for cultural or food reasons are not included in the estimates of the recreational and commercial fishing industries of this study. DAFF (2003) remains the most recent source for data on Indigenous fishing. It is estimated that there are 37,000 Indigenous fishers who spent 420,000 fishing days in 1999-2000.

2.3.4 Offshore oil and gas exploration and production

The offshore exploration and production of oil, LPG, and natural gas is the largest contributor to economic output of the blue economy in 2017-18. In addition to the value arising from domestic or export sales, which is reliably reflected in production statistics, there is substantial activity generated through exploration and the development and ongoing maintenance of infrastructure (e.g. pipelines).

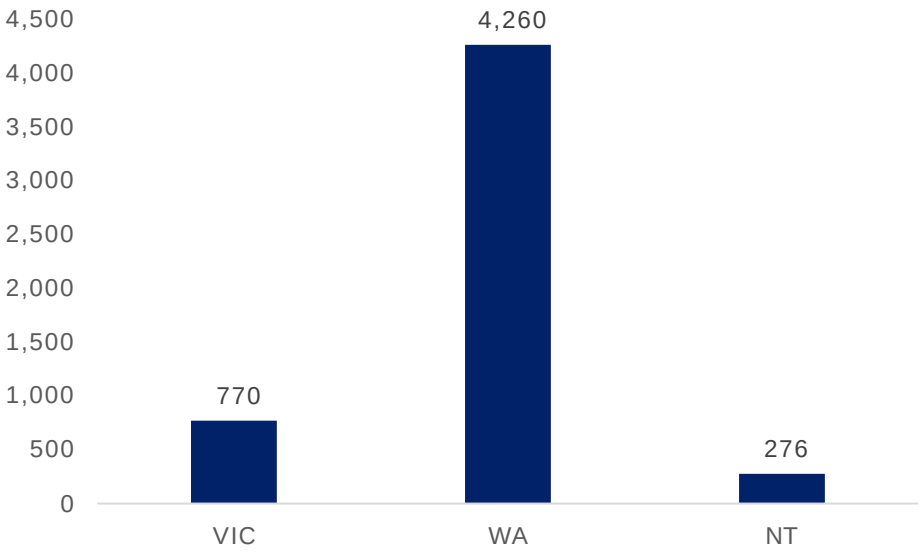
Oil and gas exploration occurs both onshore and offshore in Australia and the offshore expenditure component is delineated in the *Mineral and Petroleum Exploration statistics*.[15] The value of offshore

[15] Australian Bureau of Statistics (2020d).

oil and gas exploration is provided only at a national level and in 2017-18 this value was $681 million.

In 2017-18 offshore Australian oil production was valued at $5.3 billion. Estimates for oil production are derived from using *Annual Financial Survey 2017-18* for $AUD/barrel and *Australian Petroleum Statistics* for offshore production volume (in barrels).[16] Production is attributed to particular basins enabling broad delineation of offshore production by state and territories. Western Australia was the main contributor to the value of offshore oil production in 2017-18 ($4,260 million).

Chart 2.6: Economic output ($m) of oil production in 2017-18.



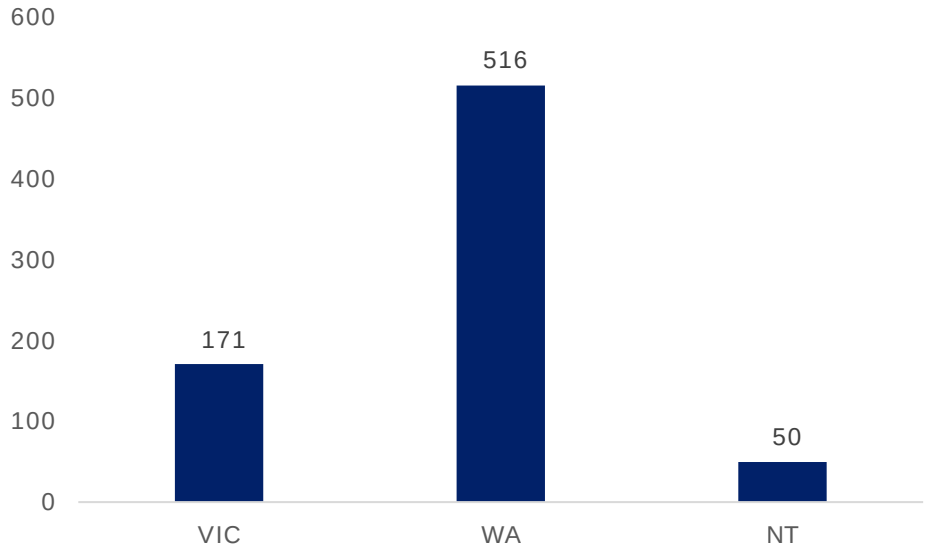
Source: *APPEA* (2019) and *Department of the Environment and Energy* (2019b).

The value of production of LPG and natural gas in Australia in 2017-18 was $46.0 billion.[17] Based on production volumes at the basin level, the value of offshore LPG extraction is estimated at $737 million and the value of offshore natural gas production is estimated at $30.3 billion.[18]

The LPG production attributable to states or territories was determined by the shares of Australian conventional gas production volume from the *Australian Energy Update*.[19] Western Australia is the largest contributor to offshore LPG production in Australia. In 2017-18, the value of Western Australian LPG production was $516 million.

[16] Australian Petroleum Production & Exploration Association (2019) and Department of the Environment and Energy (2019b).
[17] Australian Bureau of Statistics (2019a).
[18] Department of the Environment and Energy (2019a).
[19] Department of the Environment and Energy (2019a).

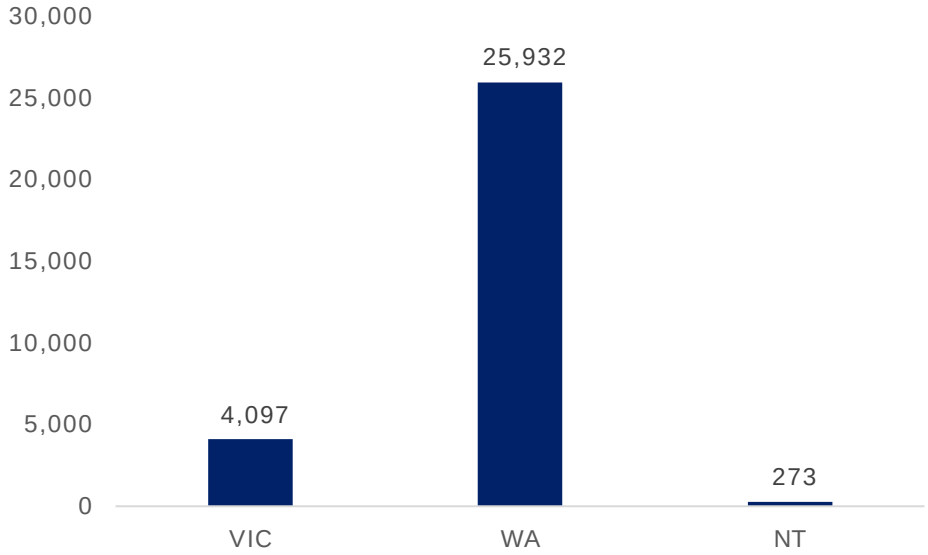
Chart 2.7: Economic output of offshore LPG production ($m) in 2017-18.



Source: *ABS* (2019a) and *Department of the Environment and Energy* (2019a).

Natural gas production attributable to states or territories was determined by production volume share per offshore basin in Australia from the *Australia Energy Resource Assessment*.[20] Similar to LPG, Western Australia was the largest contributor to natural gas production in Australia with production valued at $25.9 billion.

Chart 2.8: Economic output ($m) of offshore natural gas production in 2017-18.



Source: *ABS* (2019a), *Department of the Environment and Energy* (2019a) and *Geoscience Australia* (2019).

2.3.5 Other resource extraction

A number of existing and emerging marine activities have been identified but are not reflected in this edition of the Index due to a lack of available data. These activities include desalination, carbon capture, biotechnology, sea salt production, sand extraction and tidal power.

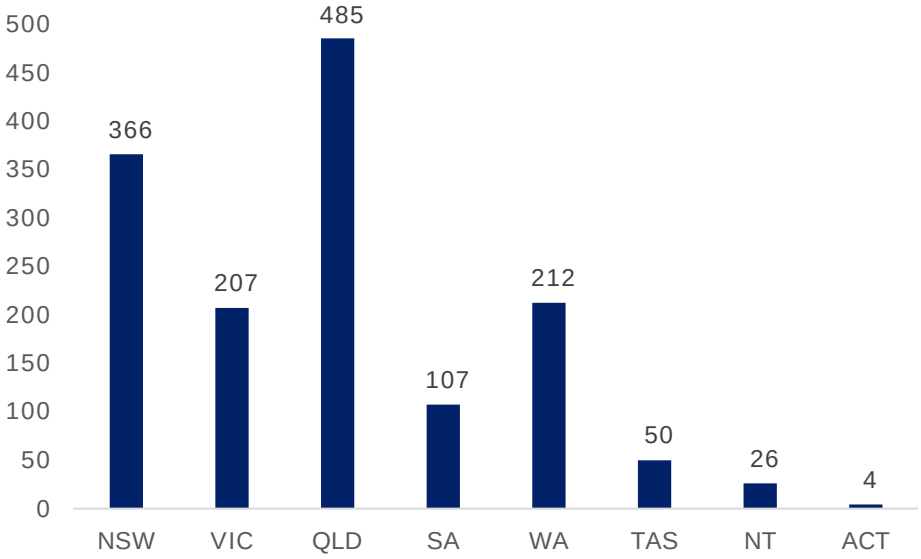
[20] Geoscience Australia (2019).

2.3.6 Boat and ship building and maintenance equipment, services and infrastructure

The ANZSIC manufacturing division includes marine equipment and supplies such as the manufacture of winches, diving equipment, marine engines, acoustics equipment, sails and marine flooring. However, the economic output from these marine-related activities is not currently separated out from general transport-related manufacturing.

Marine equipment retailing (ANZSIC 4245) is an important contributor to this marine industry sub-sector and consists of mainly retailing related to new or used boats and boating accessories. The value of marine equipment retailing is reported in the *Marine Equipment Retailing Report*.[21] In 2017-18, the value of marine equipment retailing in Australia was $1,457 million. Using marine equipment retailing employment, collected in *the Census* we estimated the contribution of this sector by state and territory.[22] In 2017-18, Queensland was the largest retailer of marine equipment ($485 million), followed by New South Wales ($366 million) and Western Australia ($212 million).

Chart 2.9: Economic output ($m) of marine equipment retailing in 2017-18.



Source: *IBISWorld* (2020) and *ABS* (2016).

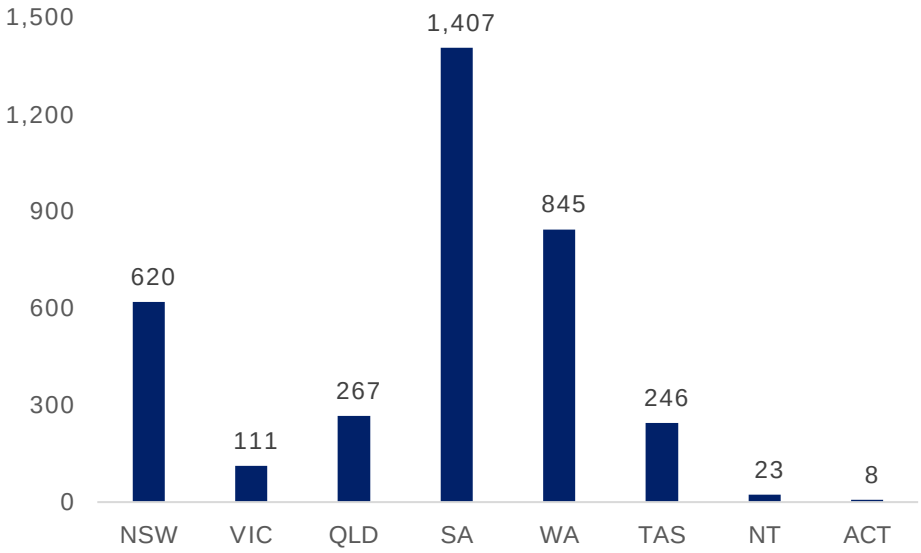
Other large contributors to this marine category include ship building and repair, and boat building and repair. Ship building mainly consists of manufacturing or repair of vessels of over 50 tonnes displacement, whereas boat building represents vessels under 50 tonnes. The *Australian Industry Statistics* report the value of sales and service income (production value) from both civilian and non-civilian activity.[23]

In 2017-18, production of ship building and repair services was valued at $3,524 million and boat building and repair services was valued at $1,179 million. State- or territory-based attribution of economic output is estimated using ship building and repair services, and boat building and repair services employment collected in *the Census*.[24]

In 2017-18, ship building and repair services output was largest in South Australia ($1,407 million), followed by Western Australia ($845 million) and New South Wales ($620 million).

[21] IBISWorld (2020).
[22] Australian Bureau of Statistics (2016).
[23] Australian Bureau of Statistics (2019e).
[24] Australian Bureau of Statistics (2016).

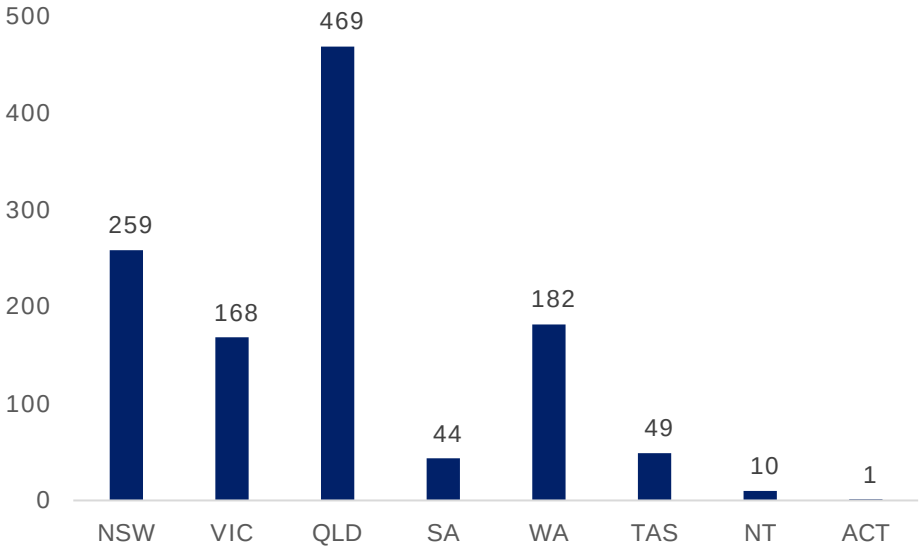
Chart 2.10: Economic output ($m) of ship building and repair activities in 2017-18.



Source: *ABS* (2019e) and *ABS* (2016).

In contrast, in 2017-18, the three most valuable boat building and repair services production states or territories were Queensland ($469 million), New South Wales ($259 million) and Western Australia ($182 million).

Chart 2.11: Economic output ($m) of boat building and repair in 2017-18.



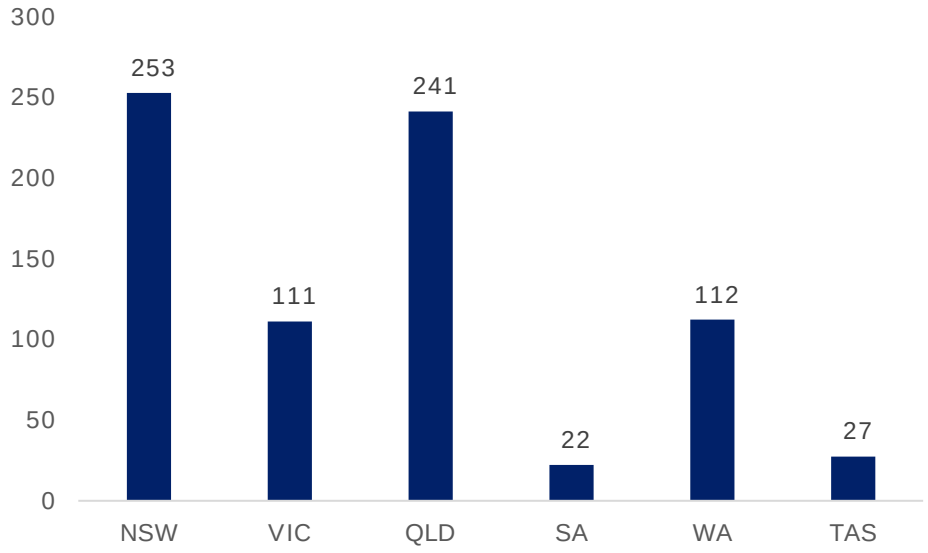
Source: *ABS* (2019e) and *ABS* (2016).

The boat and ship building and maintenance equipment, services and infrastructure sub-sector also includes activities in marinas and boating infrastructure. Indexing data provided in the *2016-17 Health of the Marina Industry Survey* by the increase in the CPI, the economic output from marina and boating infrastructure is estimated to be $783 million in 2017-18.[25] Economic output is separated by state and territories, which shows New South Wales ($253 million) and Queensland

[25] The Recreational Marine Research Centre (2017).

($241 million) contributing most economic output to this sub-sector, followed by Western Australia ($112 million) and Victoria ($111 million).

Chart 2.12: Economic output ($m) on marinas and boating infrastructure activities in 2017-18.



Note: The value of marinas and boating infrastructure at the national level also includes marinas in Northern Territory and the Australian Capital Territory. Both territories were excluded from the state breakdown for confidentiality reasons.

Source: *The Recreational Marine Research Centre* (2017).

2.3.7 Marine tourism

Assessing the value of marine tourism is perhaps the most challenging part of assessing the output of the marine industry. At the same time, the very substantial contribution of this sector to the economies of marine and coastal communities means that its importance should be recognised.

Desktop research and literature scan suggests that there is no single framework for consistently identifying the portion of tourism attributable to marine-based activities. Internationally, approaches to define the 'marine' components of tourism vary considerably. In this edition of the Index, the value of domestic and international marine-based tourism is estimated as the total expenditure of trips that involve marine-based activities.[26] Domestic marine tourism is determined by the addition of domestic overnight marine tourism and domestic day trip marine tourism. Total visitor nights and number of domestic day trips are determined for domestic visitors to a coastal region that partake in marine activities (i.e. visiting the beach or undertaking a water-based activity). These numbers are then multiplied by the average spend per night for domestic overnight tourists to coastal regions and by average spend of domestic day trip visitors to coastal regions.

International marine tourism is estimated using the same methodology as described for domestic marine tourism. Total visitor nights from international visitors who visit a coastal region and partake in marine-based activities are multiplied by average spend per night of international overnight tourists to coastal regions.

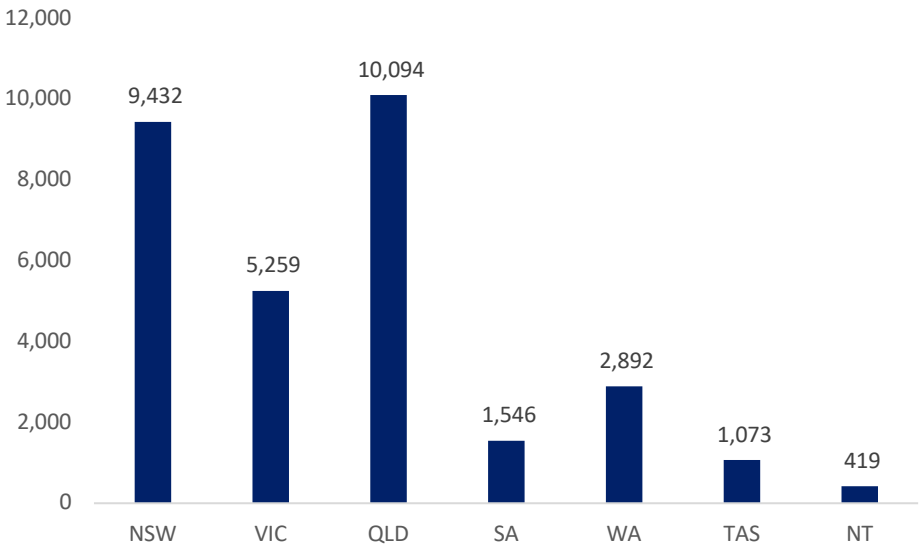
This is an updated approach to how marine tourism expenditure was estimated in previous Index editions. Previously marine tourism expenditure was determined by using total domestic and international tourism expenditure, assuming that marine tourism comprised of 40% and 19% of domestic and international tourism expenditure respectively.[27] The methodological update used in this edition of the Index reflects more up-to-date data on tourism trips and expenditure.

[26] Australian Bureau of Statistics (2019c).
[27] Review Committee on Marine Industries, Science and Technology in Australia (1989).

In 2017-18, domestic marine-based tourism expenditure is estimated to be $24.0 billion and international marine-based tourism expenditure is estimated to be $6.7 billion. Expenditure by state is estimated by the geographical classification of the coastal regions.[28]

The three states with the highest domestic marine-based tourism output in 2017–18 were Queensland ($10.1 billion), New South Wales ($9.4 billion), and Victoria ($5.3 billion).

Chart 2.13: Economic output ($m) of domestic marine tourism in 2017-18.

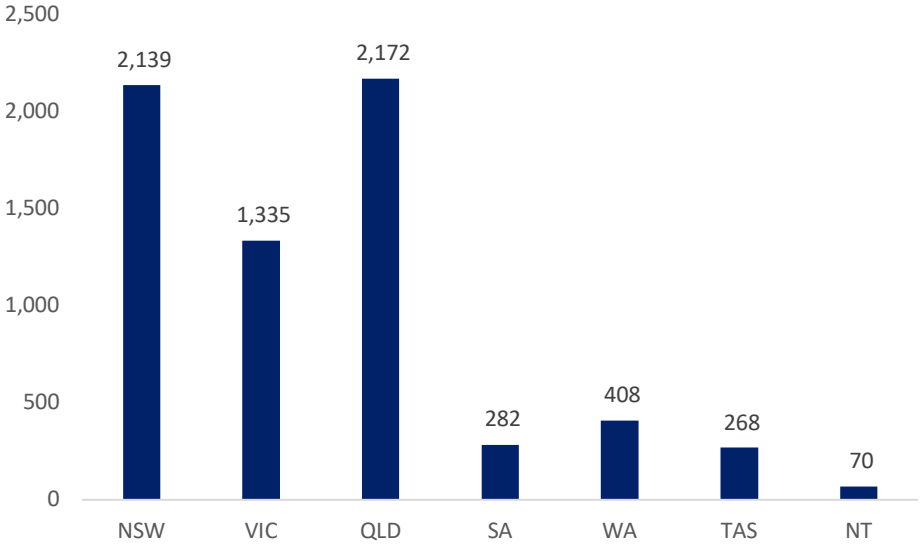


Source: ABS (2019c) and TRA (2018)

Economic output of international marine-based tourism in 2017–18 was greatest in Queensland ($2.2 billion), New South Wales ($2.1 billion) and Victoria ($1.3 billion).

[27] Tourism Research Australia (2018).

Chart 2.14: Economic output ($m) of international marine tourism in 2017-18.



Source: *ABS* (2019c) and *TRA* (2018).

2.3.8 Water transport, services to water transport and ports

The challenge of capturing and appropriately attributing the value of all water-based passenger and freight transport activities that strictly occur in Australian waters is considerable, given the frequently multinational nature of transport operators.

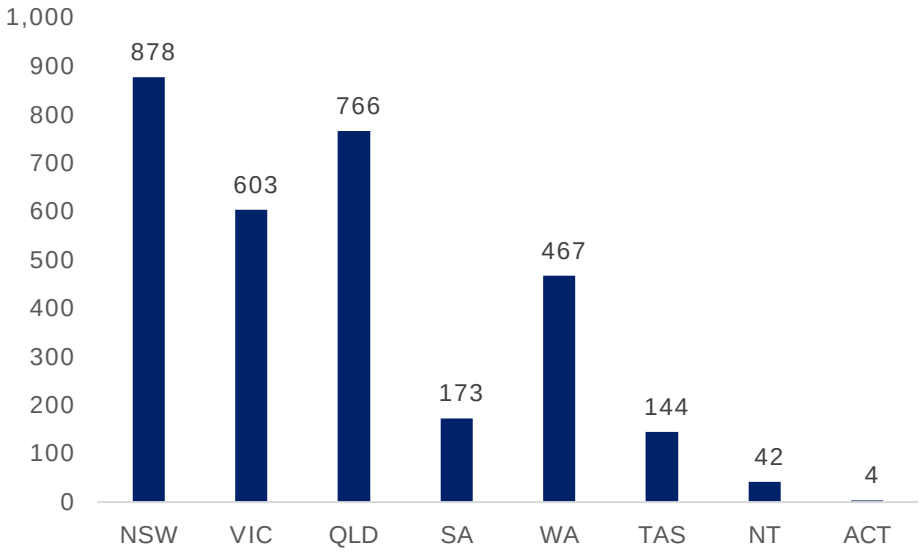
In order to avoid double-counting and to present a reliable baseline, this sector is restricted to include only the industry sub-sectors for which the ABS collects and publishes data on the gross value of production.[29] In terms of freight activity, the sector includes coastal sea freight services between domestic ports, international sea freight transport between domestic ports and international ports, harbour and ferry freight and river transport. 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 economic output of water-based transport is published by the *Australian Industry Statistics.*[30] State- and territory-based output is determined by the share of water transport employment by state or territory collected in *the Census*.[31]

In 2017-18, water-transport production was greatest in New South Wales ($878 million), Queensland ($766 million) and Victoria ($603 million).

[29] ANZSIC 2006 Subdivision 48: Water Transport.
[30] Australian Bureau of Statistics (2020c).
[31] Australian Bureau of Statistics (2016).

Chart 2.15: Economic output ($m) of water transport activities in 2017-18.



Source: *ABS* (2020c) and *ABS* (2016).

2.3.9 Marine safety and environment management

This grouping includes activities which provide management services for the marine environment, including scientific research and development and knowledge transfer, the establishment and operation of environmental management programs, and marine safety activities. In general, the major challenge to establishing the level of activity in this area is that it often occurs in a relatively diffuse way, spread across research institutes, universities, and the national, state, and even local levels of government. The operating budgets of some key institutions of this sub-sector are included in Appendix A.

2.4 Impact of COVID-19 on the marine industry

The COVID-19 pandemic has brought unprecedented disruption to society at large, causing enormous damage to our health, and economic well-being. In the absence of a vaccine or an effective treatment being available to the wider population, social distancing and border closure are among the most effective measures to contain the spread of the virus and protect people's health and lives. These measures, however, come with an enormous cost to society. Many industries across the world have been severely impacted, and some have even come to a near complete halt. The marine industry is no exception.

Some marine activities bear the immediate consequence of travel and social distancing restrictions. The tourism sector is at the front line and among the most vulnerable industries to the COVID-19 pandemic. Border closures and stay-at-home restrictions mean that many operators have been forced to close operations to varying degree depending on where they are located in Australia. A 30% decline (276,000 people) in accommodation and food services employment was observed nationally between February and May 2020, and more specifically, visitation to the entire Great Barrier Reef Marine Park during financial year 2019-20 was only 70% of the level for the preceding year.[32,33]

Other marine sub-sectors have experienced significant declines in demand from downstream industries and consumers. Oil and gas prices have fallen significantly as a result of the global

[32] Australian Bureau of Statistics (2020b).
[33] Great Barrier Reef Marine Park Authority. See http://www.gbrmpa.gov.au/our-work/reef-strategies/visitor-contributions/numbers

recession, and this has contributed to a substantial decline in employment of roughly 9,000 people in the oil and gas extraction sector between February and May 2020.[34]

Similarly, the closure of restaurants and cancellation of events have resulted in a collapse in demand for certain fish products, in particular high-end products, such as lobsters, oysters, bluefin tuna.[35] Aquaculture employment declined by 44% - approximately 3,700 jobs - between February and May 2020.[36] Changes in preferences and spending habits are likely to weigh upon luxury items such as boats as consumers become more cautious in their discretionary spending. This is likely to impact the boatbuilding sub-sector, as well as marine equipment retailing.

The next edition of the Index to be published in 2022, will access data from 2019-20, and this will allow us to begin to quantify the impact of COVID-19 on the marine industry and how various sub-sectors have fared. This will also give an indication of whether COVID19 has materially affected the expectation that the marine industry can achieve the goal of contributing $100 billion to the Australian economy in 2025 – as outlined in the National Marine Science Plan 2015-2020.

[34] Australian Bureau of Statistics (2020b).
[35] Organisation for Economic Co-operation and Development (2020).
[36] Australian Bureau of Statistics (2020b).

3 The economic contribution of Australia's marine industry

3.1 Economic contribution analysis

While the economic output of the marine industry (discussed in Chapter 2) is a useful metric, it does not represent the contribution of the marine industry to the Australian economy. This is because many inputs to the marine industry are directly imported from overseas or are made up of imported components which do not contribute to Australia's GDP and, therefore, living standards. Additionally, the level of revenue is influenced by the value of intermediate inputs; thus, a higher level of revenue may simply reflect the value of intermediate input used, rather than the value created by the industry.

The economic contribution of the marine industry, 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 valued added from other industries. Components of value added, and revenue are demonstrated in Figure 3.1:.

Figure 3.1: Value added and revenue components.

Source: Deloitte Access Economics.

3.2 Methodology

The economic contribution of the marine industry can be split into direct and indirect components.

- The direct economic contribution of the marine industry measures the value added created directly as a result of economic activities within the marine industry.
- The indirect economic contribution calculates the value added created by the businesses that produce inputs for the marine industry, that is the profits and wages that are generated through the marine industry's expenditure on inputs. The indirect contribution acknowledges that production activities in the marine industry stimulate demand in upstream industries. For example, fishermen need to purchase inputs such as baits as part of their operation. Commercial fishing activities, therefore, stimulate demand and value added in the bait industry.
- The total economic contribution to the economy is the sum of the direct and indirect economic contributions.

The economic contribution of the marine industry in this edition of the Index is estimated based on the national Input-Output tables 2017-18 published by the ABS.[37] Many of the marine-related sub-sectors represent a proportion of a larger Input Output Industry Group (IOIG). For instance, the IO

[37] Australian Bureau of Statistics (2020a).

industry "Oil and gas extraction" includes both offshore and onshore gas and oil extraction. The offshore oil and gas extraction sub-sectors are, therefore, a subset of the larger IOIG. The report assumes that each marine 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.

The following example demonstrates how the expenditure for a representative sub-sector, in this case the commercial fishing sector, is calculated. The Input-Output table provides information on how much the *Fishing, and hunting and trapping* industry spends on each other industry as a percentage of total production. These ratios are then multiplied by the total production value of the commercial fishing sub-sector to provide a breakdown of expenditure on intermediate inputs that the commercial fishing sub-sector pays to their upstream providers. The profile of intermediate input expenditure is used to estimate the indirect contribution of the commercial fishing sub-sector. A further discussion of the methodology is provided in Appendix B.

3.3 Economic contribution results

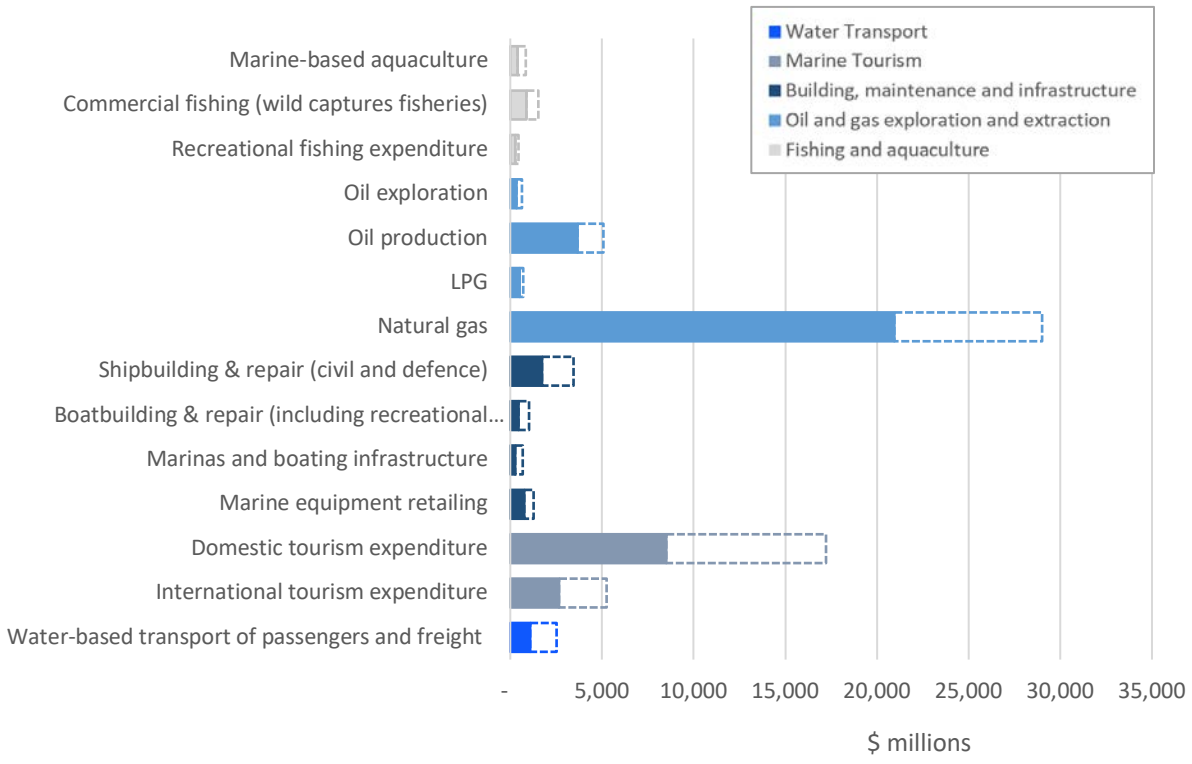
3.3.1 Value added

3.3.1.1 Value added by marine sub-sector

The first step in determining the economic contribution of the marine industry involved estimating the direct value added based on the data presented in Chart 2.2, which provided the total measurable output from marine-related activities in 2017-18. Table 3.2 below presents both the value of production and the corresponding value added, which is considered to be the marine industry's direct contribution.

Using the approach outlined in Section 3.1, the indirect contribution (expressed as indirect value added) was then calculated for each sub-sector. It is important to note that each sub-sector was analysed separately. Consequently, the indirect values (as shown in the Chart 3.1 below) are not additive, as many of the sub-sectors supply to each other. For instance, the boatbuilding industry supplies its products to the fishing industry. The indirect value added of the fishing industry would, therefore, include some of the direct value added of the boatbuilding industry.

Chart 3.1: Direct (solid colour) and indirect (dashed line) economic contribution ($m) by marine sub-sector in 2017-18.



3.3.1.2 Total value added of the marine industry

In order to determine the total contribution of the marine industry, any potential double-counting had to be eliminated. An estimation was undertaken on the total direct and indirect contribution of the marine industry. This largely followed the methodology established in Section 3.1 above, however, if the expenditure for each industry in question was to another marine sub-sector industry it was removed from the expenditure bundle. This was to avoid double counting of the indirect value added.

In total, the Australian marine industry is estimated to create $42.4 billion in direct value added in 2017-18, with a further indirect value added of $26.8 billion. This amounts to a total contribution of $69.2 billion in value added, as shown in Table 3.2. This represents 3.7 per cent of national gross domestic product in 2017-18.

Table 3.1: Total direct and indirect economic contribution ($m) of the Australian marine industry in 2017-18.

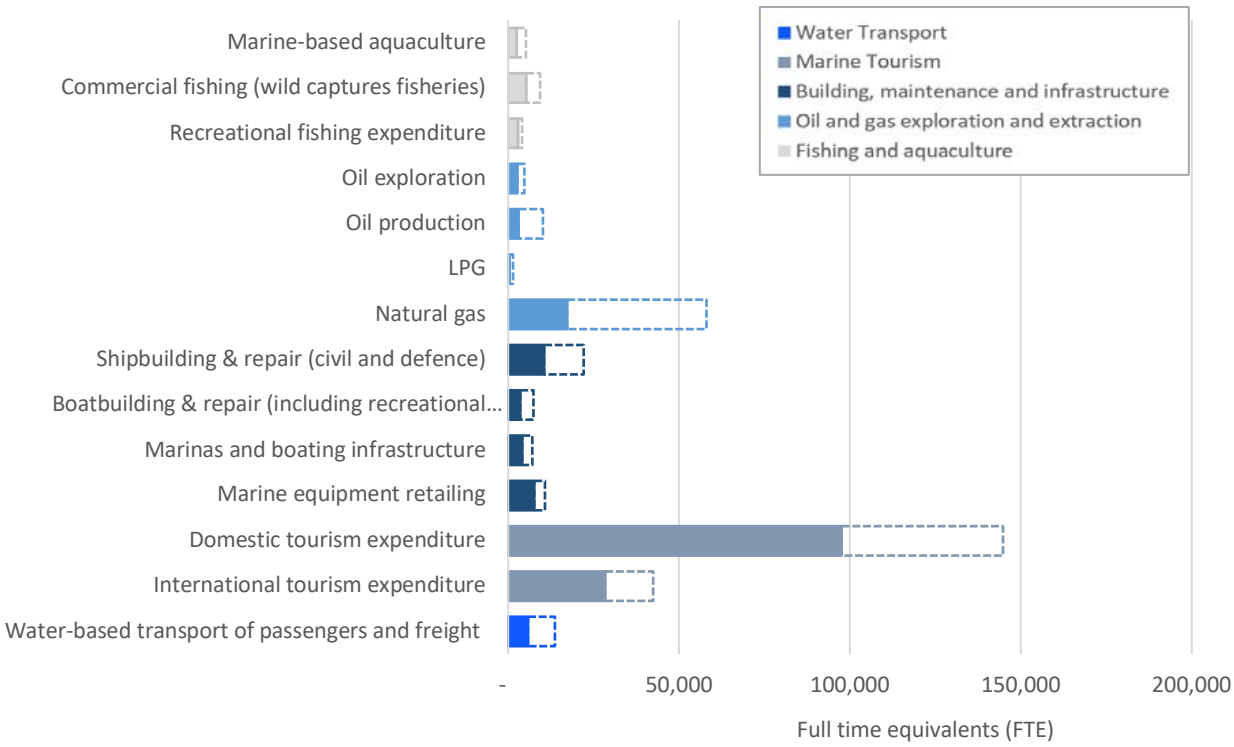
	Direct value of production (output)	Direct value added	Indirect value added	Total value added
All marine industries	81,220	42,449	26,761	69,210

3.3.2 Employment contribution

3.3.2.1 Employment contribution by marine sub-sector

Chart 3.2 below presents an estimation of the direct and indirect FTE employment effects of each marine sub-sector. Domestic consumption of tourism goods and services account for the largest share of employment overall, reflecting the relatively labour-intensive nature of tourism industries.

Chart 3.2: Direct (solid colour) and indirect (dashed line) employment (FTE) by marine sub-sector in 2017-18.



3.3.2.2 Total employment contribution of the marine industry

In total, Australia's marine industry directly employed approximately 191,286 FTE workers in 2017-18.

Again, indirect employment in the different sub-sectors, as presented in Chart 3.2, was not additive. Hence, the same approach as for value added was applied to determine total indirect employment. As shown in Table 3.2 below, the marine industry supported a further 147,688 FTE workers in indirect employment (considering upstream industries only), amounting to a total employment contribution of 338,974 FTE workers.

Table 3.2: Total direct and indirect employment (FTE) contribution of the Australian marine industry in 2017-18.

	Direct employment (FTE)	Indirect employment (FTE)	Total (FTE)
All marine industries	191,286	147,688	338,974

In the previous version of the Index, the blue economy was estimated to contribute $71.4 billion in value added and support 393,011 FTE workers in 2015-16. The reductions in value added (from $71.4 billion to $69.2 billion) and employment (from 393,011 to 338,974 FTE workers) between 2015-16 and 2017-18, however, are unlikely to reflect that the economic contribution of the blue economy has reduced over the period. Instead, they are the result of the availability of new data that allow better estimation of economic contribution.

The key driver of the reductions in value added and employment contribution is the domestic tourism sub-sector. New data has enabled better identification of marine tourism, who marine visitors are, how much and what they spend their money on. This, in turn, has allowed for better estimates of tourism expenditure and economic contribution for a given dollar of expenditure.

The reduction in tourism value added, to a large extent, is offset by the increase in value added of the oil and gas production sub-sector. Nevertheless, as the oil and gas production sub-sector is not as labour intensive as the tourism sub-sector, the fall in total employment is larger than the fall in value added.

4 Climate change impacts on Great Barrier Reef values

The blue economy provides a significant contribution to Australia's prosperity and supports a diverse range of economic activities. Australians value marine assets for the economic opportunities they provide, but also for their beauty, significance in Australian culture and identity, and value as part of the natural environment.

Climate change poses a significant risk to the Australian economy and the economic values provided by marine assets and industries. Recent analysis from Deloitte Access Economics suggests that by 2070 the economic losses of unmitigated climate change on the Australian economy could amount to $3.4 trillion in present value terms – or 6% of GDP.[38] These losses could result in 880,000 jobs lost to the economy in 2070.[39] The analysis does not consider other values provided by marine assets (environmental, social and cultural) also at risk from climate change.

This chapter is a high-level discussion of the risks that climate change poses to Australian marine assets and the broader values they provide, exemplified by the Great Barrier Reef (GBR).

4.1 Environmental impact of climate change on the GBR

The GBR is the world's largest coral reef ecosystem, a globally significant marine asset, and a World Heritage Area.[40]

The economic, social and icon asset value of the GBR approximates $56 billion. In 2015-16, the GBR supported 64,000 jobs and contributed $6.4 billion to the Australian economy.[41]

The GBR ecosystem and the services and values it provides to society are at growing risk from climate change.[42] Climate change is impacting the GBR now, most prominently as mass bleaching events,[43] which are a modern phenomenon for reefs globally.[44] In 2020, the GBR saw its fifth such mass bleaching event (1998, 2002, 2016, 2017 and 2020).[45]

4.1.1 Warming

The magnitude of climate change risks to the GBR and coral reefs globally are driven by the global carbon-emissions trajectory.[46] In the short term, the most ambitious scenario for global mitigation efforts will be insufficient to prevent continued warming.[47]

For GBR ecosystems, heat waves represent greater risk than average warming trends.[48] As heat waves drive coral bleaching events, they transform coral species composition,[49] as well as the species composition of associated biodiversity, including fish and invertebrates,[50] and ultimately impact on ecosystem services.[51]

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[38] Deloitte Access Economics (2020)
[39] Deloitte Access Economics (2020)
[40] Commonwealth of Australia (2018)
[41] Deloitte Access Economics (2017)
[42] Great Barrier Reef Marine Park Authority (2019), Hardisty et al. (2019), Anthony et al. (2020)
[43] Hughes et al. (2019)
[44] Hoegh-Guldberg (1999)
[45] Australian Institute of Marine Science (2020)
[46] Gattuso et al. (2015), Hoegh-Guldberg et al. (2017)
[47] Intergovernmental Panel on Climate Change (2018), Rogelj et al. (2016), Jackson et al. (2018)
[48] King et al. (2017)
[49] Hughes et al. (2018)
[50] Hoey et al. (2016), Byrne (2011)
[51] Stoeckl et al. (2011), Stoeckl and Anthony (2019)

Risks to the GBR from heatwaves are partly represented by how much summer temperatures exceed historical norms.[52] Under continued global warming, the amount of such heat stress experienced by GBR corals may double under 1.5°C global warming, triple under 2°C warming, and increase six-fold under 3°C warming relative to preindustrial levels.[53]

4.1.2 Ocean acidification

Potential impacts of ocean acidification, a consequence of CO2 emitted to the atmosphere – and of which about a third is absorbed by the ocean – include reduced reef growth,[54] weakening of reef structures and reduced rates of replenishment of coral and fish following disturbances.[55] In combination, these impacts contribute to lowered resilience of the GBR to climate change.[56] Because the loss of resilience due to ocean acidification is gradual and does not occur as dramatic events, significant loss of resilience may go un-noticed before action is called for.

4.1.3 Cyclones

While heatwaves are the central factor in climate risk projections for the GBR, impacts of cyclones in a warming world are significant but uncertain risk co-factors. Physical damage of corals by cyclones have historically accounted for around half of the reported coral mortality on the GBR,[57] and they are a major disturbances for seagrasses.[58] Projected cyclone risks in the south-western Pacific suggest that the GBR could experience stronger and wetter, but less frequent, storms.[59] Flooding during storms drive run-off from catchment into the inshore GBR,[60] adding to risks of physical damage during storms.

4.1.4 Sea-level rise

Global ocean warming will also drive sea-level rise due to thermal expansion and the melting of polar ice caps.[61] While the growth of modern coral reefs has kept up with sea level rise, the capacity of tropical shallow-water coral reefs to do so in the future may be compromised under continued and intensified climate change.

The combination of increased heat stress, reduced reef growth under ocean acidification, and impacts from storms may overwhelm the capacity of corals in some areas to keep up with future sea-level rise.[62] However, where, when and to what extent this will occur is uncertain.

4.1.5 Climate change pathways and uncertainties

Impacts of climate change have until now occurred within an envelope of approximately 1°C global warming since pre-industrial levels.[63] Global warming projections under strong climate change mitigation (Representative Concentration Pathway (RCP) 2.6 by the Intergovernmental Panel on Climate Change (IPCC)) would see the world warm another 0.5 to 1.0 °C this century. Current emission-reduction pledges, however, are insufficient in limiting warming to this level, and unless further reductions in emissions are achieved the world is projected to warm 2.3 to 3.5°C relative to pre-industrial levels.[64]

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[52] For example, Hughes et al. (2018)
[53] Lough et al. (2018)
[54] Doney et al. (2009), Mollica et al. (2018)
[55] Madin et al. (2012), Munday et al. (2010)
[56] Albright et al. (2016), Anthony (2016)
[57] De'ath et al. (2012)
[58] Coles et al. (2015)
[59] Knutson et al. (2020)
[60] Brodie et al. (2012)
[61] Intergovernmental Panel on Climate Change (2014)
[62] Field et al. (2011), Woesik et al. (2015)
[63] Information can be found at: https://www.ncdc.noaa.gov/sotc/global/201913
[64] Rogelj et al. (2016), WMO (2020)

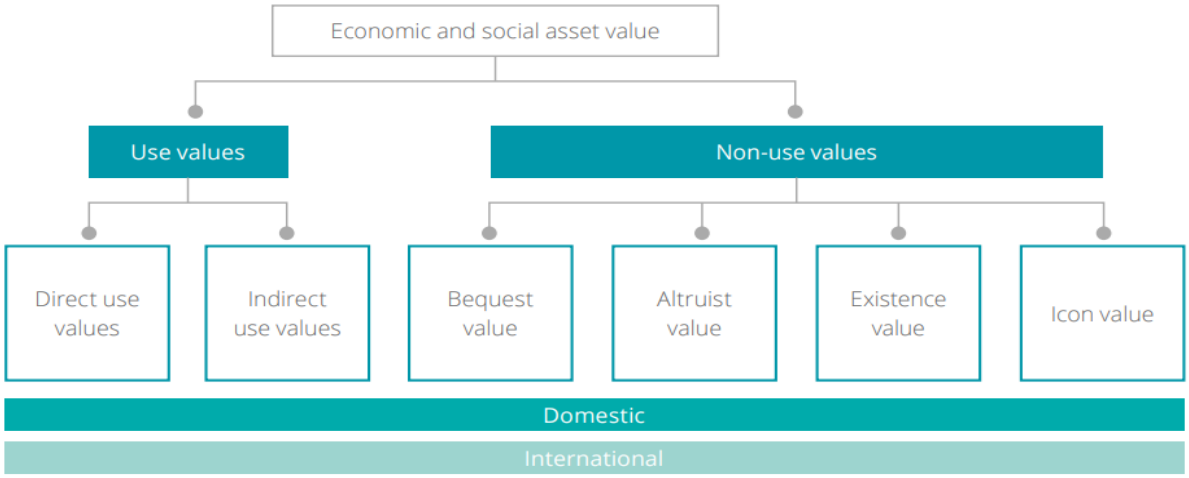
Importantly, the likelihoods that different climate-change pathways will unfold vary. The 'business as usual' pathway that, if realised, would lead to more than 4°C warming this century (RCP 8.5) is increasingly unlikely because market forces, in part, would counteract it.[65] Conversely, the pathway aspired to by the Paris Accord (RCP 2.6),[66] which would keep global warming below 1.5°C relatively to pre-industrial levels, is also increasingly unlikely given mitigation pledges.[67] Intermediate climate change pathways are likely to be most relevant for decision makers managing climate change risks on the GBR.

Lastly, the new Shared Socioeconomic Pathways (SSP) used in the IPCC's next assessment report will improve the line of sight between global climate change mitigation efforts and risks to ecosystems and society.[68] In the context of the GBR, this means that both the risks of unmitigated emissions and opportunities of mitigated emissions become clearer. Moving to a future warmer than 1.5°C relative to pre-industrial levels, which could be realised by 2040 under the current warming trend,[69] will mean continued and elevated risks to sensitive GBR ecosystems and an urgent need for adaptation measures for reefs, people and industries.[70]

4.2 Impact of climate change on values provided by the GBR

Environmental assets, including marine assets, provide a wide variety of values to society. The Total Economic Value framework is widely used in studies that aim to capture the full economic value of an environmental asset.[71] This framework has also been recognised by the Productivity Commission in its guide to environmental non-market valuation.[72] The Total Economic Value framework is illustrated below in Figure 4.1:.

Figure 4.1: Total economic value measurement framework



Source: Deloitte Access Economics

The Total Economic Value framework is broader than the scope of the economic contribution analysis discussed in the previous chapters. The Total Economic Value framework captures not only the value of market transactions but also non-market values such as value of the GBR in providing ecosystem services and the value that people place on the GBR for its existence. Additionally, consumer surplus derived from market transactions is also captured under the Total Economic Value framework while

[65] Hausfather and Peters (2020)
[66] United Nations Framework Convention on Climate Change (2016)
[67] Raftery et al. (2017)
[68] Riahi et al. (2017)
[69] Intergovernmental Panel on Climate Change (2018)
[70] Hardisty et al. (2019)
[71] This framework has been used in major studies domestically performed by the CSIRO (2018), Deloitte Access Economics (2017), Oxford Economics (2009) and many academic publications
[72] Baker and Ruting (2014)

consumer surplus is not captured under the economic contribution analysis. The values of tourism and recreation activities in this section, therefore, differ from and are not comparable to the values discussed in earlier chapters.

The value categories under the Total Economic Framework are used to discuss the impact of climate change on a number of values provided by the GBR and are outlined below.

4.2.2 Use value

Direct use values measure the value derived from market and non-market uses of the GBR such as tourism, fishing (recreational and commercial), recreation, research, indigenous uses, amenity and aesthetic values. Society also indirectly uses the GBR through benefiting from the ecosystem services it provides.

- Tourism: Since the 1890s, the GBR has drawn tourists based on its reputation as the world's largest and best-known coral reef ecosystem with spectacular and diverse species. Deloitte Access Economics has estimated that the total direct use benefit to domestic tourists of the GBR is valued at $29 billion.[73] Activities include visiting beaches, swimming, snorkelling and sightseeing around the GBR.
  - Tourism values of the GBR are likely to be impacted by marine heatwaves and cyclones, potentially exacerbated by ocean acidification. Marine heatwaves and the mass coral bleaching events they can drive directly reduce the quality of the tourism experience. Further, extreme weather events directly affect tourism with increased evacuations, negative media coverage and impacts on tourism infrastructure.[74] Indirectly, reducing tourist numbers long term leads to reduced funds for maintenance of infrastructure, such as pontoons and marinas.

- Recreation: Many of the residents that live in the GBR region use the GBR for recreational activities such as visiting an island, snorkelling, diving, sailing, boating and fishing. Deloitte Access Economics estimated that total direct-use benefit of the GBR to recreational visitors is $3.2 billion.[75]
  - Recreation activities, such as fishing, are primarily impacted by marine heat waves and storm events. These extreme events impact the outdoor use of the reef by locals for recreational purposes.

- Commercial fishing: Commercial fishing production in the GBR region provided over $162 million in value added to the economy in 2015-16.[76] Species such as coral trout, cod, emperor, barramundi, sharks, mackerel, mud crab, blue swimmer crab, spanner crab, prawns, scallops, and bugs are all commercially harvested on the GBR.[77]
  - Under an unmitigated emissions scenario, global catch could potentially decline by approximately 40% in the tropics from 2005-2055, but substantially increase at higher latitudes[78]. Climate change, particularly warming and climate extremes such as cyclones, is already directly affecting commercial fishing. The sector has observed an expansion of locally invasive species, increased disease outbreaks, and reduced species which have introduced the need to fish elsewhere.

- Ecosystem services: The ecosystem services of the GBR, for example, produce food, maintain water quality and provide fisheries habitat. The GBR also provides important storm protection for the Queensland coast. The value of GBR coastal protection has been estimated at $10

[73] Deloitte Access Economics (2017)
[74] QLD Department of State Development, Tourism and Innovation, Strategic Assessment (2014), Galloway McLean et al. (2020)
[75] Deloitte Access Economics (2017)
[76] Deloitte Access Economics (2017)
[77] QLD Department of State Development, Tourism and Innovation, Strategic Assessment (2014), Townhill et al. (2019)
[78] Holbrook and Johnson (2014)

billion.[79] Coral reefs disperse 97% of the wave energy that can impact the coastline and reduce damage to ecosystem habitats, land and infrastructure from storm surges and extreme events.[80]

Climate change places the value of these ecosystem services at risk.

4.2.3 Non-use value

Non-use values capture the value that people place in the GBR for its existence (existence value), for other people to use (altruist value), and for later generations to use (bequest value). In addition to these values, the GBR is also significant to Aboriginal and Torres Strait Islander Traditional Owners and to Australia's brand.

The total existence (aesthetic, heritage, cultural) value of the GBR to Australians is highlighted through a moral and ethical willingness to protect the reef and preserve it for future generations, and acknowledgement of the GBR as a prime Australian icon. These values have been estimated by Deloitte Access Economics to equate to $24 billion.[81] This is the cumulative amount the Australian population is willing to pay for the protection of the reef, regardless of their relationship to it (directly via geographical proximity, recreational use, or indirectly through associated industries). Climate change poses an existential challenge to the GBR and thus places at risk significant value derived by Australian society.

This high-level discussion illustrates the diversity of economic and non-economic value that marine assets, exemplified by the GBR, provide to Australia. Preserving the value of Australia's marine estate into the future is highly uncertain, particularly considering the significant risks from climate change to marine assets such as coral reefs. As the state of the marine environment is closely linked to growth of the blue economy, it is imperative to continue to adopt best practice environmental management - informed by high quality research and monitoring of Australia's unique marine ecosystems.

[79] Oxford Economics (2009)
[80] Ferrario et al. (2014)
[81] Deloitte Access Economics (2017)

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Appendix A: Data tables

Summary statistics for Australian marine sub-sectors

A summary of the major and most recent available data regarding marine industry activities in Australia, from publicly available sources, is outlined in Table A.1 below.

The information summarised in the table shows that there are a number of categories for which there is no suitable data available (shown as n/a). For sub-sectors where data is available, comparable and reliable, the values have been aggregated to provide a total measurable value for 2017-18.

Table A.1: Summary statistics for Australian marine sub-sectors in 2017-18.

	Industry Value added (2017-18 $m)	Value of Production (2017-18 $m)	Industry employment (2017-18)	Other
Marine resource activities and industries				
Fishing				
Marine-based aquaculture[82]	n/a	$1,017	n/a	-
Commercial fishing (wild capture fisheries)[83]	n/a	$1,793	n/a	-
Recreational fishing[84]	n/a	$525 (expenditure)	n/a	Estimated 3.73 million fishers in 2017/18, 82% marine fishing
Indigenous fishing[85]	n/a	n/a	In 2000-01, around 37,000 indigenous people participated	2000-01 harvest: 1.89 million fish, 0.84 million crustaceans, 1.15 million molluscs, 0.93 million others
Offshore oil & gas exploration and extraction				
Oil exploration[86]	n/a	$681	n/a	-
Oil production[87]	n/a	$5,305	n/a	-
LPG[88]	n/a	$737	n/a	-
Natural gas[89]	n/a	$30,302	n/a	-
Marine-related service activities and industries				
Boat/ship building, repair & maintenance services and infrastructure				
Ship building & repair (civil and defence)[90]	$1,728	$3,524	10,430 employees	-
Boatbuilding & repair (including recreational vessels)[91]	$447	$1,179	6,010 employees	-

[82] Australian Bureau of Agricultural and Resource Economics and Sciences (2020) and Australian Bureau of Statistics (2016)
[83] Australian Bureau of Agricultural and Resource Economics and Sciences (2020)
[84] Department of Agriculture, Fisheries and Forestry (2003)
[85] Department of Agriculture, Fisheries and Forestry (2003)
[86] Australian Bureau of Statistics (2020d)
[87] Australian Petroleum Production & Exploration Association (2019) and Department of the Environment and Energy (2019b)
[88] Australian Bureau of Statistics (2019a) and Department of the Environment and Energy (2019a)
[89] Australian Bureau of Statistics (2019a), Department of the Environment and Energy (2019a) and Geoscience Australia (2019)
[90] Australian Bureau of Statistics (2019e)
[91] Australian Bureau of Statistics (2019e)

	Industry Value added (2017-18 $m)	Value of Production (2017-18 $m)	Industry employment (2017-18)	Other
Marinas and boating infrastructure[92]	n/a	$783	3,576 employees (2016-17)	-
Marine equipment retailing[93]		$1,459	3,250 employees	-
Marine tourism and recreational activities				
Domestic consumption of tourism goods and services[94]	n/a	$16,577	n/a	-
International consumption of tourism goods and services[95]	n/a	$4,741	n/a	-
Aquaria[96]	n/a	n/a	n/a	2006-07: $304 million retail sales, $233m gross value of production.
Water transport				
Water-based transport of passengers and freight[97]	$1,081	$3,199	7,000 employees	-
Marine safety and environment management				
Australian Maritime Safety Authority (AMSA)[98]	n/a	n/a	384 employees (2014-15)	Operating expenditure $201.3 million
Royal Life Saving Australia[99]	n/a	n/a	n/a	Operating expenditure $4.7 million
Australian Volunteer Coast Guard	n/a	n/a	n/a	-
Great Barrier Reef Marine Park Authority (GBRMPA)[100]	n/a	n/a	203 employees	Operating expenditure $68.2 million
National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)[101]	n/a	n/a	126 employees	Operating expenditure $31.7 million

[92] Recreational Marine Research Centre (2017)
[93] IBISWorld (2020)
[94] Australian Bureau of Statistics (2019c) and Tourism Research Australia (2018)
[95] Australian Bureau of Statistics (2019c) and Tourism Research Australia (2018)
[96] Fisheries Research and Development Corporation /Department of Agriculture, Fisheries and Forestry (2008) This figure includes $129 million in ornamental fish sales, $171 million in accessories sales (tanks, filters, lights, etc.) and $4 million in 'other' sales (live rock, coral and aquatic plants).
[97] Australian Bureau of Statistics (2020c)
[98] Australian Maritime Safety Authority (2015) and Australian Maritime Safety Authority (2018).
[99] Royal Life Saving Australia (2018)
[100] Great Barrier Reef Marine Park Authority (2018)
[101] National Offshore Petroleum Safety and Environmental Management Authority (2018)

Economic contribution results – value added

Table A.2: Direct and indirect value added ($m) by marine sub-sectors in 2017-18.

	Direct value of production	Direct value added	Indirect value added	Total value added
Marine resource activities and industries				
Fishing				
Marine-based aquaculture	1,017	399	446	845
Commercial fishing (wild captures fisheries)	1,793	880	650	1,530
Recreational fishing expenditure	526	273	174	447
Offshore oil & gas exploration and extraction				
Oil exploration	681	337	299	635
Oil production	5,305	3,667	1,411	5,078
LPG	737	509	196	705
Natural gas	30,302	20,947	8,061	29,007
Marine-related service activities and industries				
Boat/ship building, repair & maintenance services and infrastructure				
Ship building & repair (civil and defence)	3,524	1,728	1,721	3,449
Boatbuilding & repair (including recreational vessels)	1,179	447	576	1,023
Marinas and boating infrastructure	783	263	416	678
Marine equipment retailing	1,459	758	513	1,271
Marine tourism and recreational activities				
Domestic tourism expenditure	24,040	8,506	8,715	17,221
International tourism expenditure	6,675	2,656	2,598	5,254
Water transport				
Water-based transport of passengers and freight	3,199	1,081	1,444	2,525

Note: Each sub-sector was analysed separately. Consequently, the values in the 'indirect value added' column are not additive. Total indirect contribution was estimated by removing expenditure associated with marine sub-sectors to avoid double-counting.

Table A.3: Direct and indirect value added ($m) of all marine industries, 2017-18.

	Direct value of production (output)	Direct value added	Indirect value added	Total value added
All marine industries	81,220	42,449	26,761	69,210

Economic contribution results – employment

Table A.4: Direct and indirect employment (FTE) by marine sub-sectors in 2017-18.

	Direct employment (FTE)	Indirect employment (FTE)	Total (FTE)
Marine resource activities and industries			
Fishing			
Marine-based aquaculture	2,417	2,766	5,183
Commercial fishing (wild captures fisheries)	5,260	4,063	9,323
Recreational fishing expenditure	2,866	1,178	4,052
Offshore oil & gas exploration and extraction			
Oil exploration	2,673	2,055	4,728
Oil production	3,017	7,139	10,156
LPG	419	992	1,411
Natural gas	17,233	40,780	58,013
Marine-related service activities and industries			
Boat/ship building, repair & maintenance services and infrastructure			
Ship building & repair (civil and defence)	10,500	11,572	22,071
Boatbuilding & repair (including recreational vessels)	3,513	3,871	7,384
Marinas and boating infrastructure	4,099	2,951	7,050
Marine equipment retailing	7,606	3,144	10,750
Marine tourism and recreational activities			
Domestic tourism expenditure	97,539	47,233	144,772
International tourism expenditure	28,360	14,049	42,410
Water transport			
Water-based transport of passengers and freight	5,783	7,880	13,663

Note: Each sub-sector was analysed separately. Consequently, the values in the 'indirect employment' column are not additive. Total indirect employment was estimated by removing activity associated with marine sub-sectors to avoid double-counting.

Table A.5: Direct and indirect employment (FTE) contribution of all marine industries in 2017-18.

	Direct employment (FTE)	Indirect employment (FTE)	Total (FTE)
Marine industries	191,286	147,688	338,974

Changes in output over time

Table A.5: Economic output from marine-related activities, 2001-02 to 2017-18.

Marine resource activities and industries														*New figures*				
Value of output ($m, nominal)	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14 (old)	2013-14 (new)	2014-15 (new)	2015-16 (new)	2016-17 (new)	2017-18 (new)
Fishing																		
Marine-based aquaculture	731	709	725	634	742	806	868	867	878	954	1,054	1,053	994	744	872	969	1,002	1,017
Commercial fishing (wild capture fisheries)	1,784	1,656	1,499	1,490	1,461	1,446	1,363	1,393	1,335	1,317	1,302	1,361	1,503	1,514	1,616	1,749	1,742	1,793
Commonwealth Fisheries														-	-	-	-	-
Recreational fishing expenditure														456	473	491	509	525
Total fishing	2,515	2,364	2,224	2,125	2,203	2,252	2,231	2,470	2,213	2,271	2,356	2,356	2,498	2,713	2,961	3,209	3,253	3,335
Offshore oil & gas exploration and extraction																		
Oil exploration	720	922	791	830	938	1,727	2,541	3,318	2,746	2,559	2,246	3,430	3,512	3,512	2,537	1,278	949	681
Oil production	4,441	3,473	4,899	7,867	7,570	9,230	12,124	8,638	9,412	8,465	9,708	6,978	9,145	9,509	7,254	4,968	3,907	5,305
LPG	856	981	717	861	1,037	1,038	1,182	1,044	1,105	1,068	971	1,088	1,265	960	816	699	604	737
Natural gas (export revenue)	2,613	2,607	2,174	3,199	4,416	5,220	5,854	10,079	7,789	10,437	11,950	13,741	16,305	19,239	18,589	16,936	20,652	30,302
Total offshore oil & gas	8,630	7,983	8,581	12,757	13,961	17,215	21,701	23,078	21,051	22,529	24,875	25,238	30,226	33,220	29,195	23,882	26,113	37,025
Boat/ship building, repair & maintenance services and infrastucture																		
Shipbuilding & repair (civil and defence)	1,796	1,839	1,696	1,721	1,797	1,777	1,954	1,997	2,724	2,722	2,825	3,098	2,966	2,966	3,231	2,251	2,285	3,524
Boatbuilding & repair (including recreation vessels)	818	1,037	1,108	1,251	1,488	1,688	1,829	1,869	1,207	1,203	1,055	1,048	1,235	1,235	1,138	1,154	1,176	1,179
Marinas & boating infrastructure														699	712	719	767	783
Marine equipment retailing	1,412	1,633	1,670	1,710	1,744	1,805	2,487	2,559	2,167	2,149	2,055	1,460	1,393	1,538	1,516	1,502	1,480	1,459
Total boat/ship services	4,026	4,509	4,474	4,682	5,029	5,270	6,270	6,426	6,098	6,074	5,935	5,606	5,594	6,438	6,597	5,627	5,708	6,945
Marine tourism and recreation activties																		
Domestic tourism expenditure	7,337	7,784	7,726	7,909	8,326	9,012	9,554	9,345	11,048	11,236	11,949	12,639	13,128	20,241	19,752	21,668	22,182	24,040
International tourism expenditure	1,272	1,292	1,377	1,420	1,469	1,612	1,725	1,799	1,964	204	2,065	2,294	2,337	4,886	5,361	6,097	6,334	6,675
Total tourism	8,609	9,076	9,102	9,329	9,795	10,624	11,279	11,143	13,011	13,279	14,013	14,933	15,465	25,127	25,113	27,765	28,516	30,715
Water transport																		
Water based transport of passengers and freight														3,817	3,481	3,142	2,903	3,199
Total water transport																		
TOTAL	**23,780**	**23,932**	**24,381**	**28,892**	**30,988**	**35,361**	**41,480**	**43,118**	**42,373**	**44,153**	**47,179**	**48,133**	**53,783**	**71,315**	**67,347**	**63,625**	**66,492**	**81,219**

Note: The last five columns reflect methodological updates to the industry structure of the marine industry that occurred in the 2016 AIMS Index of Marine Industry as well as methodological changes to some output sub-sectors in this edition of the Index.

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 the table below).

Table B.1: Definitions of economic contribution estimates:

Estimate	Definition
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

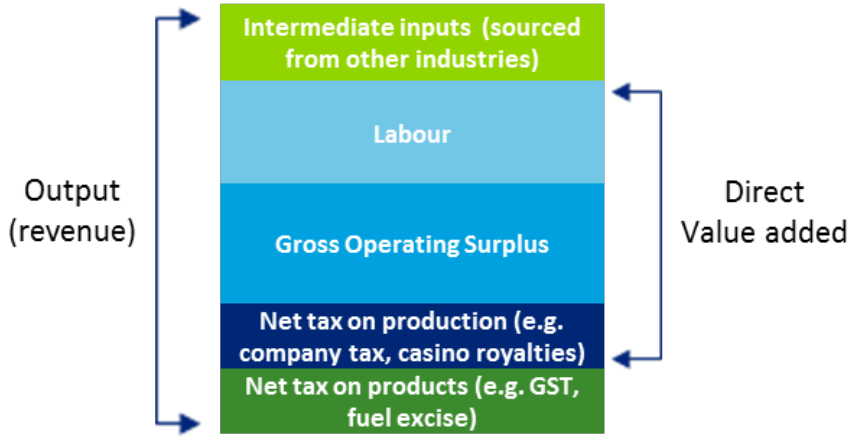
relationship to GDP, the value added measure can be thought of as the increased contribution to welfare. Value added is the sum of:

- 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.

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 (ABS 2020a).

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:[102]

> 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 (2020a). 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.

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[102] Productivity Commission (1999)

Appendix C: Methodology updates to output estimates

In order to ensure that the Index is as accurate and up to date as possible, new data sources and approaches are reviewed as they become available to estimate the contribution of the Australian marine industry. The table below summarises methodological updates since the last edition of the Index in 2018.

Table C.1: Detailed description of updates to the output estimation methodology of selected marine sub-sectors.

	Approach in the 2015-16 report	Approach in this 2017-18 report
Marine-based aquaculture	Aquaculture output is reported by ABARES' *Australian Fisheries and Aquaculture Statistics.* This figure was used as an estimate of marine-based aquaculture output.	This report combines aquaculture output published in ABARES' *Australian Fisheries and Aquaculture Statistics* with the share of offshore aquaculture employment provided by *the Census* (ABS 2016) to isolate marine-based outputs.
Recreational fishing expenditure	Recreational fishing expenditure was estimated by adjusting the result of the national recreational fishing survey conducted by DAFF (2003) for inflation. The share of harvest of marine species relative to all harvest (82%) was applied to isolate marine fishing.	This report utilises more up-to-date data on the number of Australians who participate in recreational fishing and their expenditure as provided by various state-based surveys. The following refinements have been made in estimating recreational fishing expenditure: • Expenditure items which are likely to be counted in other marine sub-sectors, such as, tourism and marine equipment are excluded to avoid double counting • If state-based surveys were conducted before 2017-18, wage growth (for expenditure) and population growth (for fishing populations) are used to estimate the number of fishers and their expenditure in 2017-18. • The share of harvest of marine species relative to all harvest (82%) was applied to isolate marine fishing.
LPG and natural gas	The estimate of natural gas was the export revenue published by the Department of the Environment and Energy (2019b) – Australian Energy Update.	Two refinements are made in this report: • Value of natural gas production published by the ABS (2019a) - Energy Account is used to better reflect the production for domestic use. • To isolate offshore extraction activities, we attribute production to individual basins based on the Department of the Environment and Energy (2019a) - *Australian Energy Update.*
Domestic and international tourism expenditure	Marine tourism output was estimated by multiplying the output provided by Tourism Research Australia (2018) – *State Tourism Satellite Account* with the share of marine tourism. Domestic and international marine tourism were estimated as 40% and 19% of total domestic and international tourism expenditure. This methodology was first established	Estimate of marine tourism expenditure is based on the expenditure of visitors who participated in beach or water-based activities in their trip. This data is collected by Tourism Research Australia's National Visitor Survey and International Visitor Survey. Data from these surveys suggest that: • It is estimated that 18% of domestic visitors and 68% of international visitors undertook beach or water activities in their trips in 2017-18.

	by the Review Committee on Marine Industries, Science and Technology in Australia (1989)' Oceans of Wealth.	• The number of visitors who undertook beach or water activities are multiplied with their average length of stay in coastal regions and average spend per night to estimate marine tourism expenditure.

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