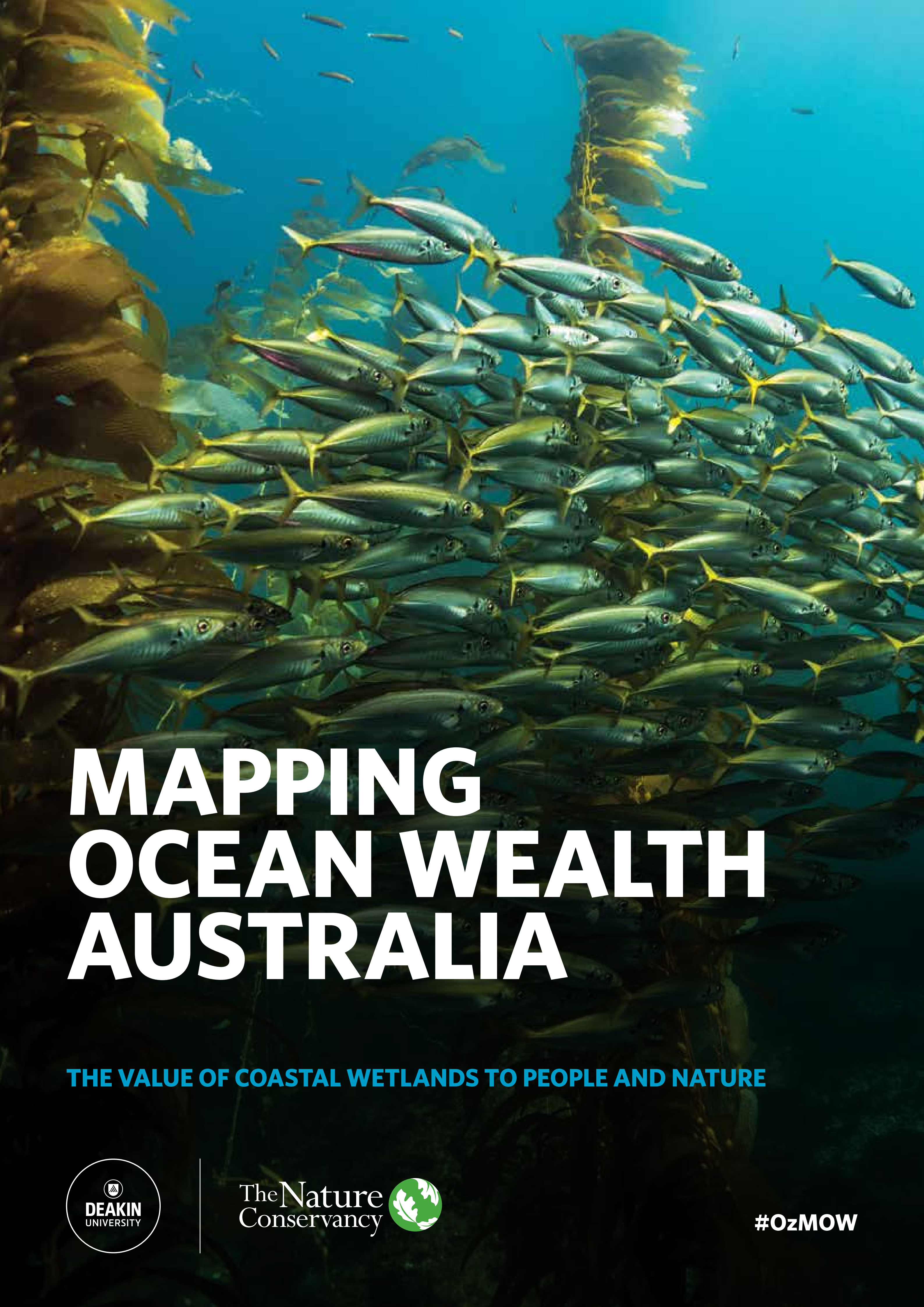

MAPPING OCEAN WEALTH AUSTRALIA

THE VALUE OF COASTAL WETLANDS TO PEOPLE AND NATURE

DEAKIN UNIVERSITY

The Nature Conservancy

#OzMOW

ABOUT MAPPING OCEAN WEALTH

The Australian Mapping Ocean Wealth project represents three years of marine ecosystem service research, spatial mapping and communication for coastal wetlands in south-eastern Australia by several of Australia's leading marine science and conservation institutions. The Australian project is funded and supported by The Nature Conservancy, Deakin University, The Thomas Foundation, HSBC Australia, The Ian Potter Foundation, Victorian Government, NSW Government and a Linkage Grant (LP160100242) from the Australian Research Council.

Photo © Deakin University

The project is active across seven global geographies including the United States, Caribbean, Indonesia, Micronesia and Australia and has been used to improve spatial planning, protected areas, fisheries management, tourism and education. Further information on the global Mapping Ocean Wealth program can be found at **oceanwealth.org**

Developed by The Nature Conservancy with support from The Lyda Hill Foundation and The World Bank (Caribbean), Mapping Ocean Wealth is a global research and communication program that seeks to move away from global averages for ecosystem services towards more specific local information, allowing us to evaluate nature as a social and economic asset at a scale relevant to regional decision making.

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Photo © Deakin University

Ecosystems that fringe our coastlines – saltmarshes, mangrove forests and seagrass meadows – provide a bounty of benefits for Australians. These often-neglected ecosystems support livelihoods, provide a wonderland for recreation and enable mitigation and adaptation to the perils of a changing coastline.

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COASTAL WETLANDS

HOW THEY WORK

Their physical structure and position in the landscape provide food, shelter and physical protection for people and nature

WHO BENEFITS

Coastal communities, fishers, seafood providers, carbon emitters, visitor economy

COASTAL WETLAND

Saltmarsh

Mangroves

Seagrass

MEASURABLE BENEFITS

FISHERIES

TOURISM & RECREATION

BLUE CARBON

COASTAL PROTECTION

APPLICATION

Environmental accounting, marine spatial planning, coastal risk hazard assessment, and cost-benefit and return on investment analyses

Photo © Ashley Missen

KEY FINDINGS

Ecosystems that fringe our coastlines – saltmarshes, mangrove forests and seagrass meadows – provide a bounty of benefits for Australians. These often-neglected ecosystems support livelihoods, provide a wonderland for recreation and enable mitigation and adaptation to the perils of a changing coastline.

Whilst some of these benefits are difficult to quantify in tangible social or economic terms, the value of several of their most common benefits have been quantified for the first time in south-eastern Australia through Mapping Ocean Wealth.

Here we present our most significant findings of relevance to decision-makers and the community.

1

COASTAL WETLANDS POWER AUSTRALIA'S FISHERIES

These wetlands provide food and habitat that are essential for the survival and growth of important commercial and recreational fish and marine invertebrates, supporting coastal livelihoods and businesses:

- Coastal wetlands in south-eastern Australia contribute $35.5 million per year to Australia's nearshore commercial fisheries.
- Coastal wetlands provide 61% of the food that sustains and grows fish species targeted by commercial and recreational fishers.
- Seagrasses in south-eastern Australia produce on average 207 kg more fish per hectare compared to areas without seagrass. With an estimated 72 thousand hectares of seagrass in south-eastern Australia, this equals an estimated average of 14 million tonnes more fish produced by seagrass each year.

2

COASTAL WETLANDS ARE RECREATIONAL HOTSPOTS

South-eastern Australia's coastal wetlands are a wonderland for locals and visitors to enjoy, relax and unwind:

- Seagrasses are a haven for fish targeted by recreational fishers. As a preferred location for recreational fishing, seagrass in Melbourne's two most popular coastal bays, Port Phillip and Western Port, provide a non-market recreational benefit estimated at $33.1 million per annum.
- Mangroves and saltmarshes provide recreational values for birdwatchers at an average of $158 per visit in non-market value (time and travel), which can vary spatially from a value of near-zero in areas with no saltmarsh or mangrove to extremely high (as much as 12 times the average) in areas with coastal wetlands.

3 COASTAL WETLANDS ARE AUSTRALIA'S MOST EFFICIENT CARBON SINK

Coastal wetlands are Australia's most efficient carbon sink, storing carbon for millennia and providing natural climate solutions to address elevated atmospheric CO_2:

- Carbon sequestration in coastal wetlands in Victoria and New South Wales store 36,000 tonnes of CO_2 per year, equivalent to removing 7,826 cars from our roads.
- Australia's blue carbon stocks have diminished since European settlement yet restoration is a powerful method of recovering blue carbon. For example, restored mangroves in the Richmond River, NSW, are capturing an impressive 11.5 tonnes of CO_2 from the atmosphere per hectare per year in the first 25-40 years.
- Allowing coastal wetlands to naturally retreat with sea-level rise in Victoria could sequester 1.6 million tonnes of carbon by 2050 with a value of $65 million.
- New sampling methodologies using drone technology developed by Mapping Ocean Wealth, can map carbon stocks in plant biomass 500-times faster than using traditional on-ground methods.

4 COASTAL WETLANDS ARE OUR FIRST LINE OF DEFENSE

Mangroves, saltmarsh and seagrasses have stood guard over Australia's coastlines for millennia. Their root structures and physical presence hold shorelines in place reducing erosion and wave damage, helping to preserve valuable shoreline assets and infrastructure:

- Coastal wetlands reduce wave energy by 37-71%, protecting property across south-eastern Australia (to the value of $2.7 billion).
- Coastal wetlands protect 1.02 million people from relocation and could lower damages by 11.3%, potentially saving the economy $3.6 billion by 2090.

5 ACCOUNTING FOR OCEAN WEALTH

The use of accounting principles to measure and quantify ecosystem services can improve the way we understand the benefits, monitor and invest in coastal wetlands into the future:

- The United Nations' System of Environmental-Economic Accounting (SEEA) sets out the accounting principles for measuring the relationship between the environment and people and can be applied to coastal wetlands in south-eastern Australia.
- Combined economic values for five services (carbon sequestration, commercial fisheries, recreational fisheries, recreational fishing and birdwatching) in Port Phillip and Western Port are worth $36.5 million per year, with carbon stocks and coastal protection valued at $526 million.

IMPLICATIONS FOR DECISION-MAKERS

New analyses by the Mapping Ocean Wealth project has demonstrated that we can apply social, ecological and economic values to seagrass, mangrove and saltmarsh ecosystems.

This new data provides decision-makers with more relevant and detailed information on coastal ecosystems that can be applied to planning and management. Importantly, such information can be more easily appreciated and integrated into economic decision-making processes and understood by a broader audience than the typical environmental language of biodiversity. We provide below several examples of how decision-makers can apply this new information in a management context:

Enhanced communication to coastal stakeholders on the societal benefits of protecting, managing or restoring coastal wetlands as *natural infrastructure*

Mapping Ocean Wealth has demonstrated that coastal wetlands provide coastal communities and visitors with tangible goods and services such as food, recreation and shoreline protection, supporting livelihoods and growth of the blue economy. We can thus consider coastal wetlands as valuable public assets which can be managed and valued in the same way as *built infrastructure* like roads or jetties.

This is particularly true in the case of the coastal defence service they provide, effectively acting as living seawalls (Chapter 4). By treating natural infrastructure as analogous to built infrastructure, we can more easily justify comparable management actions (to improve or protect natural infrastructure) and greater expenditure to preserve the flow of goods and services to the community and blue economy.

Improved benefit-cost and return on investment analyses for protection or restoration management options

By assigning quantitative benefits in a spatial context, benefit cost-analyses for management actions can be calculated. For example, Chapter 1 provides data on the value of coastal wetlands for commercial fisheries production. This information can be used to calculate the anticipated payback period of an investment to restore or protect coastal wetlands for the purpose of enhancing fish populations harvested by commercial fishers. The cost of protection or restoration of coastal wetlands can then be compared to alternative fisheries management actions such as fish restocking.

More detailed planning for managing recreational access to and use of coastal wetlands

Information that ties site preferences and economic value of using coastal wetlands for recreation can support management decisions associated with maintenance, site access and use. For example, Chapter 2 provides information on where birdwatchers like to go and how much they are prepared to travel to go birdwatching. This information can support coastal managers by identifying the most popular destinations near Melbourne where consideration of visitation infrastructure and management access could maximise opportunities and positive experiences for birdwatchers.

Expenditure relating to maintenance of existing sites, or restoration of degraded sites for the purpose of increasing bird foraging areas, can be matched to popular locations. Collectively, this information can help grow birdwatching tourism in Victoria, providing greater incentives for land managers to protect and manage important coastal areas to ensure migratory birds can sufficiently forage and remain healthy during their stay whilst providing greater opportunities for birdwatching.

Provide quantitative economic information on the opportunity cost of using coastal wetlands for alternative uses

Coastal wetlands, like any other land type, can be used for alternative purposes, with many wetlands in the past drained or filled for agriculture or development. The combined value of ecosystem services for coastal wetlands (Chapter 5) or information on individual benefits can be used to assess the economic trade-offs for alternative land uses or new developments.

For example, Chapter 3 provides information on the carbon benefits of allowing coastal wetlands to naturally retreat with sea-level rise. Here, the value of retaining coastal buffer areas for natural coastal retreat as carbon sinks in the future versus developing these areas for alternative uses, can be economically assessed.

Advanced spatial planning and risk reduction of coastal wetlands according to uses and ecosystem service benefits

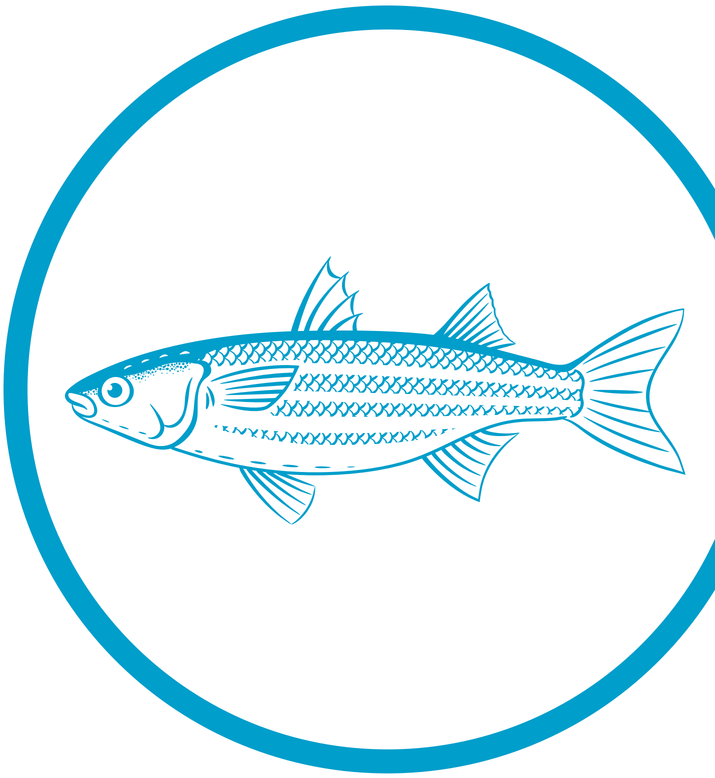
Coastal waters near major population centres can often be heavily used by many industries including transport, aquaculture, recreation and energy. Information on areas with high ecological values such as fish nursery grounds (Chapter 1) can help identify the most ecologically and economically important natural areas for management. When integrated into approaches such as marine spatial planning and coastal and risk hazard assessments, the management and protection of coastal waters for different uses and risk reduction can be optimised.

Applying these methods elsewhere

The methods used by Mapping Ocean Wealth to undertake quantitative assessments of ecosystem benefits and display these in a spatial format can be applied globally, as shown through the Mapping Ocean Wealth mapping portal **https://maps.oceanwealth.org/**.

Coupled with the use of the UN System of Environmental-Economic Accounting (Chapter 5), the combination of methods used for Mapping Ocean Wealth demonstrates a flexible approach to environmental economic assessment and reporting.

We believe that the approaches used for Mapping Ocean Wealth Australia can be applied in other regions and for other ecosystems, enhancing our capacity to capture the tangible benefits of ecosystems and report these in a format accessible to decision-makers.



INTRODUCTION
MAPPING OCEAN WEALTH IN AUSTRALIA

Marine coastal ecosystems, such as saltmarshes, mangroves, and seagrasses – collectively referred to in this report as 'coastal wetlands' – are Australia's under-appreciated ecosystems.

Yet coastal wetlands provide many benefits, or 'ecosystem services', including sustaining commercial and recreational fisheries, protecting our coastlines from ocean-related threats like storm surges and sea-level rise, sequestering and storing carbon (known as blue carbon), and providing natural places for nature-based tourism and recreational activities. These benefits are vital not only for our health and wellbeing, but they also play a significant role in supporting the blue economy and coastal communities, particularly in regional areas. They underpin coastal-based industries such as wildcatch fisheries, recreational fisheries, marine aquaculture and marine tourism, in addition to providing other 'non-market' benefits such as improving culture and health. Whilst these benefits are often intrinsically known, the true social, cultural and economic value derived from coastal wetlands remains largely unquantified. As a result, nature's enormous wealth is often left unaccounted for or undervalued in decision-making, depriving managers, planners and economists of important information that can be used to support smarter decisions.

The Mapping Ocean Wealth project is a global project developed by The Nature Conservancy and seeks to calculate and describe – in quantitative and spatial terms – the ecosystem services provided by marine and coastal ecosystems. The Mapping Ocean Wealth project has brought together some of Australia's best marine researchers from The Nature Conservancy and Deakin University, along with other universities and the Victorian and New South Wales governments, to quantify and communicate the many benefits provided by coastal wetlands in south-eastern Australia. The ecosystems (seagrasses, saltmarshes and mangroves) and related ecosystem services (fisheries, tourism and recreation, coastal protection and carbon sequestration) reported here were prioritised as the most important for decision-making by policy experts and coastal managers at the commencement of the project.

We have examined only four of the benefits provided by coastal wetlands in south-eastern Australia. Although the economic values we have ascribed are significant, we have inevitably underestimated their value, even when combined (Chapter 5). Indeed, these ecosystems **are irreplaceable** – no built infrastructure can replace the suite of benefits they provide. Rather, our estimates highlight just some of the tangible benefits which flow to communities and businesses from healthy coastal wetlands.

The maps and associated data developed through Mapping Ocean Wealth highlight that benefits such as fisheries, carbon storage, coastal protection and recreational activities are socially and economically significant, can be economically valued and are not evenly distributed across the coastal seascape.

The detailed methods supporting Mapping Ocean Wealth can be found on the Mapping Ocean Wealth website, mapping portal and in associated scientific publications (Box1).

The outcomes of Mapping Ocean Wealth have shifted our knowledge-base from previous global estimates of marine and coastal ecosystem services to site-specific, locally applicable information that managers, financiers and policy-makers can use to improve decision-making.

Figure 1: *South-eastern Australia highlighted in orange, the focal states for Mapping Ocean Wealth in Australia - New South Wales and Victoria.*

BOX 1: LOCATION OF SUPPORTING INFORMATION AND ASSOCIATED DATA FOR MAPPING OCEAN WEALTH

Mapping Ocean Wealth Website: **https://oceanwealth.org/**

Mapping Ocean Wealth Australia page: **https://oceanwealth.org/project-areas/australia/**

Mapping Ocean Wealth Mapping Portal: **http://maps.oceanwealth.org/**

Catalogue of scientific publications related to Mapping Ocean Wealth:
https://oceanwealth.org/project-areas/australia/

This project has focussed on the coastlines of Victoria and New South Wales. For some services, existing datasets with sufficient data for economic modelling were restricted in spatial scale and smaller scale geographies have been examined. For other services, data existed at much broader scales, so state-wide or nation-wide analyses and valuations were possible. All $ values are in AUD in year 2019 unless stated otherwise.

Photo © Susan Zentay

CHAPTER 1
COASTAL WETLANDS POWER AUSTRALIA'S INSHORE FISHERIES

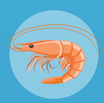
Coastal wetlands provide food and habitat that are essential for the survival and growth of commercial and recreationally important fish and marine invertebrates. They are the food bowl for our coastal fisheries.

- **Coastal wetlands provide 61% of the food for coastal fisheries in south-eastern Australia.**

Value:
$35.6 million per year

CONTRIBUTION TO DIET

NSW

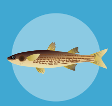


PRAWNS 86%
Valued at $20.3 million per year from 2 species

CRABS 73%
Valued at $2 million per year from 2 species

FISH 62%
Valued at $10.6 million per year from 5 species

VIC



FISH 24%
Valued at $2.4 million per year from 12 species

NURSERY HABITAT

148 fish species use seagrass as nursery habitat, **25** of these are caught by commercial or recreational fishers (e.g. tarwhine, yellowfin bream, sea mullet, yellowfin leatherjacket, luderick)

1 HECTARE of seagrass in south-eastern Australia can produce on average **207 KG** more fish per year than the equivalent area of seafloor without seagrass

South-eastern Australia's seagrass meadows contribute an estimated **$25,364 PER HECTARE** per year to wildcatch fisheries

With an estimated **72,000** hectares of seagrass in south-eastern Australia: scales to an estimated **14 MILLION** tonnes of fish per year

COASTAL WETLANDS ARE A SMORGASBORD FOR FISH

Many of southern Australia's most sought after and valuable fish and invertebrate species such as prawns, whiting, bream and snapper forage for food in coastal wetlands. Without coastal wetlands, these popular species cannot adequately forage for food and grow into adulthood. In order to determine just how important coastal wetlands are to sustaining fish populations we used two different but common approaches.

Firstly, we assessed the contribution of coastal wetlands to the diet of fish and invertebrates and found that mangroves, seagrass and saltmarsh (combined) contribute on average 61% to the diet of these fish and invertebrate species from estuarine and nearshore coastal ecosystems in Victoria and New South Wales. For species that are commercially caught (e.g. prawns, crabs, mullet, whiting) this dietary contribution equates to thousands of tonnes (biomass) of fish and invertebrates per year (Table 1) and equivalent to at least $35.6 million per year in commercial fisheries value in Victoria ($2.6 million) and New South Wales ($33 million). The reliance of coastal fisheries on these ecosystems means that loss or degradation of coastal wetlands will also impact coastal fisheries production.

Table 1: *Top five fisheries-specific mean annual production values in dollars per year from coastal wetlands and other coastal ecosystems in New South Wales and Victoria. Table has been ordered by species-specific average annual catch value (highest to lowest) and reports both the catch in tonnes attributable to the ecosystems, the corresponding value ($) and the area of saltmarsh, mangrove and seagrass in each state.*

SPECIES	ANNUAL PRODUCTION VALUES ATTRIBUTABLE TO ECOSYSTEMS (T YR-1 AND $ YR^{-1} (IN BRACKETS))				
NEW SOUTH WALES	SALTMARSH (13,225 HA)	MANGROVE (16,651 HA)	SEAGRASS (23, 850 HA)	SALTMARSH, MANGROVE AND SEAGRASS	OTHER ECOSYSTEMS
Eastern king prawn (*Melicertus plebejus*)	178 ($4,323,974)	20 ($496,615)	361 ($8,795,220)	559 ($13,615,808)	90 ($2,168,324)
School prawn (*Metapenaeus macleayi*)	481 ($2,117,835)	62 ($531,913)	249 ($4,079,331)	456 ($6,729,078)	98 ($815,721)
Sea mullet (*Mugil cephalus*)	1289 ($3,960,772)	689 ($2,119,376)		1978 ($6,080,098)	1199 ($3,675,374)
Yellowfin bream (*Acanthopagrus australis*)	99 ($1,227,265)	113 ($1,405,740)		212 ($2,633,005)	169 ($2,094,821)
Giant mudcrab (*Scylla serrata*)	46 ($838,432)	25 ($441,893)		71 ($1,280,325)	31 ($558,341)
VICTORIA	SALTMARSH (43,457 HA)	MANGROVE (5,672 HA)	SEAGRASS (48,207 HA)		
King George whiting (*Sillaginodes punctatus*)	10 ($198,055)	10 ($198,055)	45 ($877,100)	66 ($1,273,210)	96 ($1,853,228)
Black bream (*Acanthopagrus butcheri*)			39 ($459,270)	39 ($459,270)	39 ($459,270)
Rock flathead (*Platycephalus laevigatus*)	3 ($21,284)	3 ($21,284)	25 ($200,678)	31 ($243,246)	61 ($480,411)
Snapper (*Pagrus auratus*)	3 ($28,072)	3 ($28,072)	11 ($102,930)	17 ($159,074)	84 ($776,654)
Southern sea garfish (*Hyporhamphus melanochir*)	2 ($17,187)	2 ($17,187)	8 ($74,475)	12 ($108,849)	53 ($464,038)

The second method assessed the importance of coastal wetlands as nursery grounds for fish. Coastal wetlands can act as nurseries where baby fish and invertebrates can both hide from predators and forage. Analyses from the Mapping Ocean Wealth study show that one hectare of seagrass in south-eastern Australia can produce on average 207 kg more fish per year than the equivalent area of seafloor without seagrass.

With an estimated 72 thousand hectares of seagrass in south-eastern Australia, this could equate to an estimated 14 million tonnes of additional fish produced by seagrass compared to an equivalent unvegetated area. Of the 148 fish and invertebrate species included in this Mapping Ocean Wealth study, 25 of these are species caught by commercial or recreational fishers (e.g. tarwhine, yellowfin bream, sea mullet, yellowfin leatherjacket, luderick). Incorporating the price per kilogram for these species yielded an average value estimate of south-eastern Australia's seagrass ecosystems at $25,364 per hectare, per year. While the fish do not have this value until they are caught, this is a way of putting the value of fish biomass into context.

NOT ALL SEAGRASS BEDS ARE CREATED EQUAL

Seagrass in Port Phillip provides important habitat for King George whiting as they grow from juveniles to adults. However, fishers and managers alike have always wondered if there were some areas that fish such as King George whiting prefer over others. By analysing data from field surveys of King George whiting juveniles, the Mapping Ocean Wealth team created the first map displaying hotspots of King George whiting nursery grounds (Figure 2). The 11 km stretch of seagrass between Clifton Springs and Port Arlington is a pivotal nursery ground for King George whiting, with one hectare of seagrass supporting up to 30,000 juvenile whiting.

By combining the King George whiting abundance throughout the study period in Port Phillip (2003-2014), the average fish production was estimated at almost 11 million fish per year, equivalent to 1.2 million kg per year of adult biomass. Knowing the areas of critical importance to young King George whiting is important when considering the management of existing seagrass meadows such as identifying priority areas for restoration and protection.

METHODS

Mapping Ocean Wealth researchers from Deakin University, New South Wales Department of Primary Industries, Victorian Fisheries Authority and The Nature Conservancy, brought together existing information across Australia and calculated the value of mangroves, saltmarsh and seagrass to Australia's commercial fisheries using two aspects important to fish populations: food (diet), and provision of baby fish to the fishery (nursery habitat).

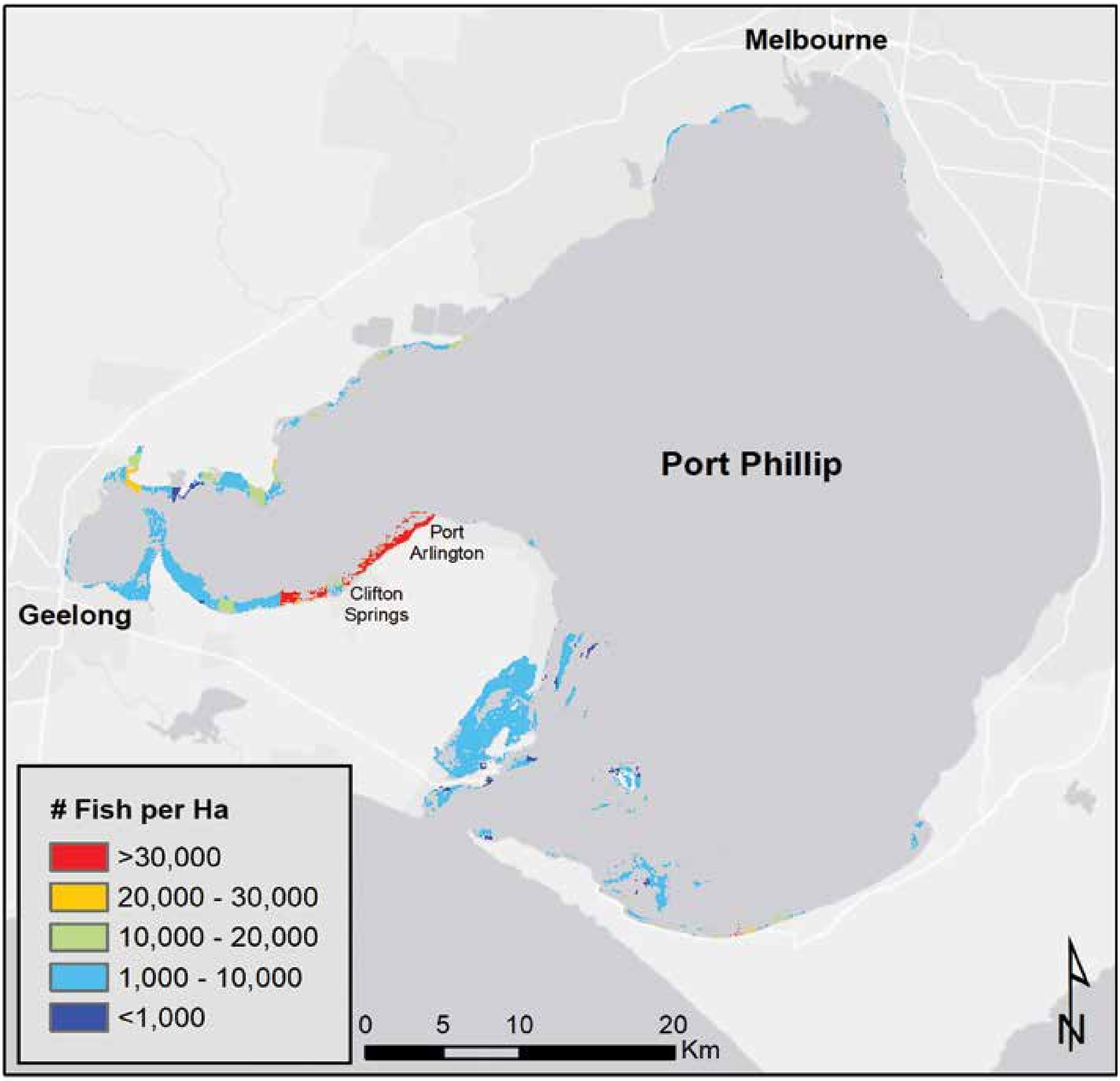
To assess the contribution of diet, the team collated existing studies from across Australia that identified the contribution from mangroves, saltmarsh, seagrass and seaweeds to the diet of a range of fish and invertebrate (crabs and prawns) species targeted by commercial fisheries. These existing studies used measurements of common isotopes such as carbon, nitrogen, oxygen and sulphur (stable isotopes) that are present in fish and invertebrates. The analyses quantified the proportion of the fish species' diet that contained plant material, either directly or via the food-web, allowing the team to identify how important each wetland plant is to the growth of specific fish and invertebrate species. Annual reports of landing values of commercially relevant species were obtained from state-specific fisheries reports. We used the most recent 3 years of commercial catch data that was publicly available.

To assess the value of nursery habitat, the Mapping Ocean Wealth team brought together information from previous research and undertook a new analysis that compared the numbers of juvenile fish found in areas with saltmarsh, mangrove and seagrass to areas without these ecosystems. These calculations were based on published field surveys of 148 fish species from across Australia. To value this nursery function to fisheries, we converted the adult fish biomass enhanced by coastal ecosystems to a dollar value using per kilogram market values of economically relevant fish.

To determine spatial variation in King George whiting density, we utilised an existing systematic long-term dataset of the number of juvenile King George whiting in seagrass beds around Port Phillip. Fish densities from seagrass beds were combined with novel machine learning methods to predict fish densities across the whole of Port Phillip. Fish densities were then combined with modelling to estimate the biomass of adult fish.

Coastal ecosystems enable fish to grow providing livelihoods and protein to humans

Figure 2: *King George whiting juvenile density per hectare per year in Port Phillip. The extent of seagrass has been mapped along the shoreline of the bay (total 6665 ha). Colour coding indicates average fish densities per hectare of seagrass.*



CHAPTER 2
COASTAL WETLANDS ARE RECREATIONAL HOTSPOTS

Spending time in nature is great for our health and wellbeing, with activities like recreational fishing and birdwatching are great ways for us to unwind. These nature-based activities rely on healthy coastal ecosystems and this dependence can be economically valued.

BIRDERS

- **Extensive areas of saltmarsh provide birdwatching hotspots, attracting birds and birdwatchers alike, with an estimated average value of $158 per trip.**

FISHERS

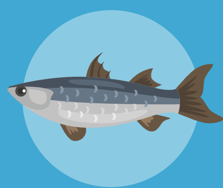
- **Fishers prefer to travel to areas near or in seagrass, because of the higher likelihood of catching a feed. The extra travel costs associated with fishing in seagrass can be valued at $13-85 per fishing trip.**

BENEFIT

Areas with more wetland = more birds that are prized by birdwatchers

BENEFIT

Areas with more seagrass are highly valued by recreational fishers

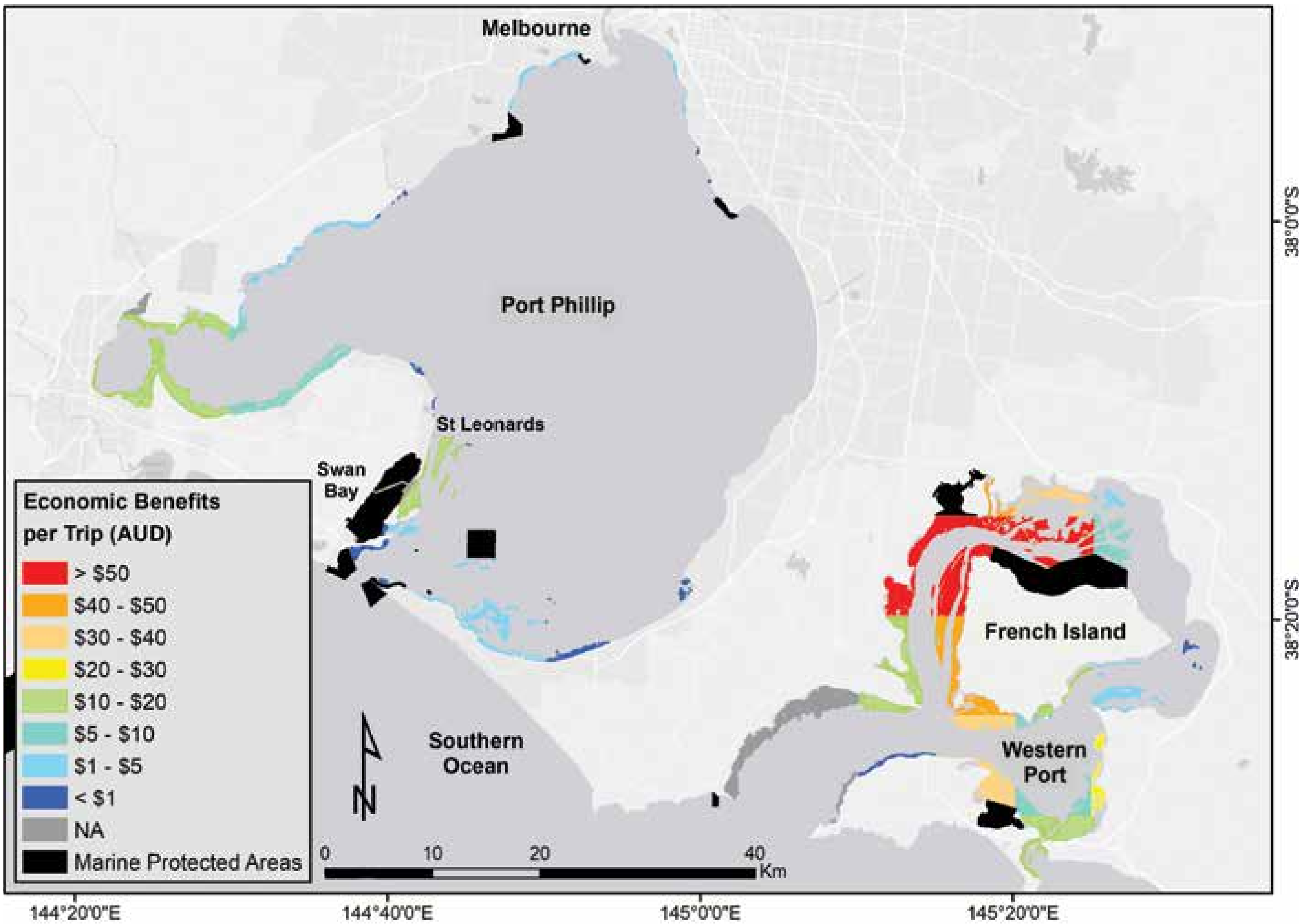


SEAGRASS MEADOWS SUPPORT RECREATIONAL FISHING

Recreational fishing is one of the most popular pastimes in Victoria, with an estimated three million trips per year on Port Phillip and Western Port alone. Seagrass beds are particularly important to fishing. Species of flathead, whiting and calamari squid can be found in abundance in and adjacent to seagrass areas. Our analyses found that recreational fishing catch is positively associated with seagrass abundance, with seagrass areas highly valued by recreational fishers. As would be expected, when given the option, fishers prefer to fish in areas closer to home. Yet we found recreational fishers were also willing to travel further to reach areas with abundant seagrass because catch rates may be higher compared with areas closer to home (Figure 3). This results in a higher economic value for seagrass meadows, as fishers expend more resources travelling and accessing these areas.

The recreational value of seagrass can be estimated per fishing trip – up to $13 in Port Phillip and $85 in Western Port, (Figure 3). With an estimated three million recreational fishing trips in Port Phillip and Western Port, this adds up to over $33.1 million per annum ($7.6 million per year in Port Phillip, and $25.5 million per year in Western Port).

Figure 3: *Value per recreational fishing trip corresponding to the current value of seagrass coverage in Port Phillip and Western Port; NA (in dark grey) refers to areas where there is seagrass, but no fishing activity was recorded by surveys conducted by the Victorian Government. Marine Protected Areas boundaries (Marine National Parks and Marine Sanctuaries, where no fishing is allowed) are shown in black.*



BIRDWATCHERS, JUST LIKE MIGRATORY SHOREBIRDS, TRAVEL FROM FAR AND WIDE TO ACCESS COASTAL WETLANDS

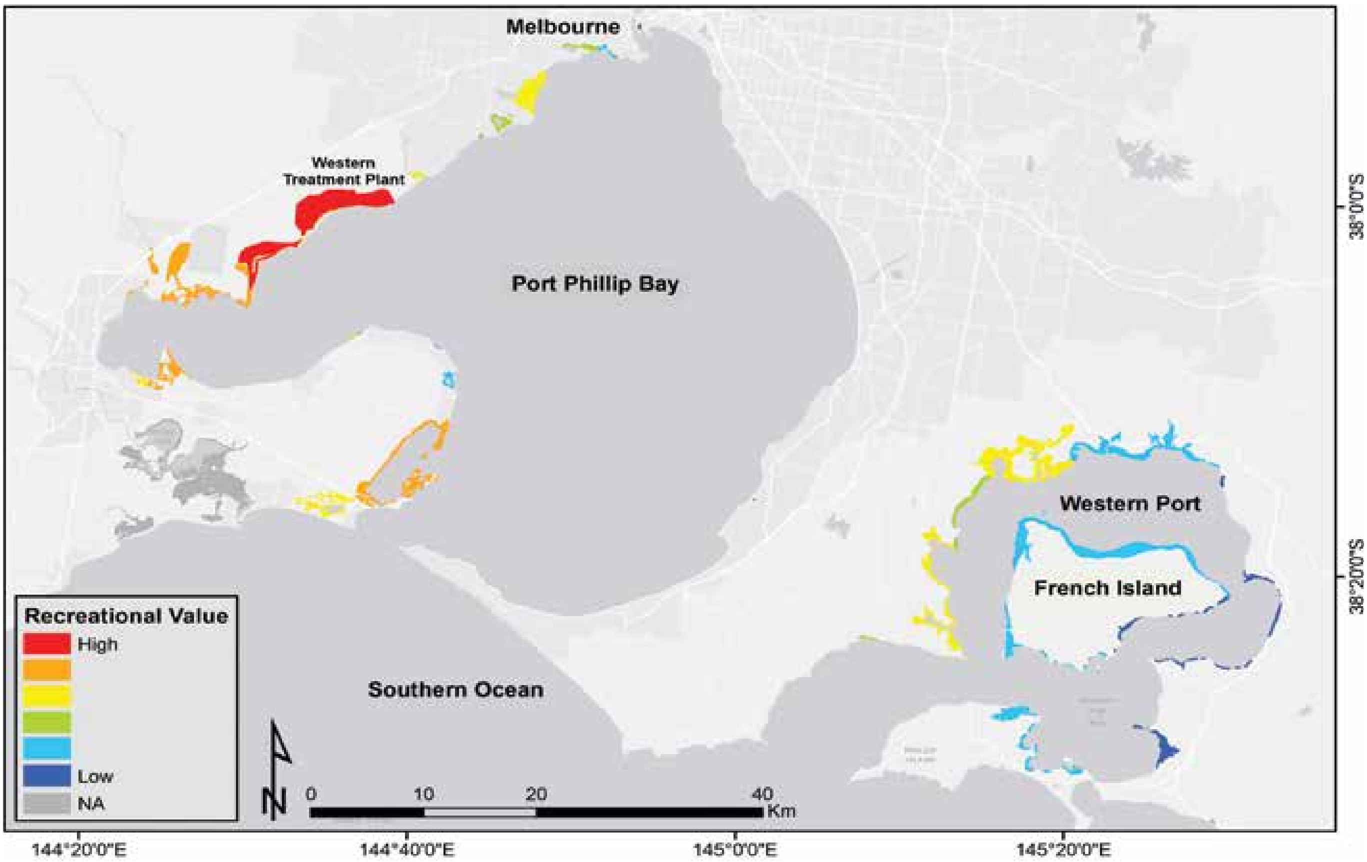
Each summer, large flocks of migratory shorebirds land exhausted on the shores of Port Phillip and Western Port, with some like the tiny red-necked stint or huge eastern curlew having travelled from as far away as Siberia and Russia. Others, like the Critically Endangered orange-bellied parrot, migrate to Victoria's coastal areas over winter from closer destinations, such as Tasmania. Regardless of whether these birds come from near or far, what attracts them to Victoria's coastline is the abundance of food found in saltmarshes, seagrass meadows, mangroves and tidal mudflats. Migratory shorebirds feast for months until they have enough energy to survive the long trip home and come back again the following year. Largely hidden and secretly viewing this annual migration are thousands of birdwatchers hoping to catch a glimpse of these increasingly threatened migratory birds. Locations where it is possible to see greater numbers of migratory shorebirds, attract more birdwatchers and are therefore valued over locations where birds are less abundant or harder to see.

Using a similar approach to the analyses conducted for recreational fishing, we quantified the recreational benefit of saltmarsh and mangrove ecosystems for birdwatching based on survey data and published birdwatching lists on eBird, a citizen science platform (https://ebird.org/).

Our analyses found that mangroves and saltmarshes provide non-market values for birdwatchers at an average of $158 per visit, which can vary spatially from a value of near zero in areas with no saltmarsh or mangrove to extremely highly valued areas in areas adjacent to coastal wetlands.

For example, regions with extensive natural areas of saltmarsh, mangroves and tidal mudflats such as Swan Bay in Port Phillip (shown in orange in Figure 4), have a higher economic contribution compared to other regions because the area is further away from a major metropolitan region and requires longer travel time at a greater cost to the individual. Yet some birdwatchers are prepared to make this visit because of the area's natural amenity and likelihood of seeing more shorebirds. Locations closer to major metropolitan centres can also be highly valued because easier access and shorter travel times mean more people are prepared to visit the site. This example can be seen for the Western Treatment Plant, on the western shore of Port Phillip (shown in red in Figure 4), which is a combination of water treatment ponds derived from historical saltmarsh habitat, natural saltmarsh and other coastal ecosystems. The area is a Ramsar-listed wetland of international importance due its extraordinary values for birdlife, and is a world-renowned birding location, with an estimated 10,000 visits per year by birdwatchers[1].

Figure 4: *Recreational value per birdwatching trip of coastal wetlands in Port Phillip and Western Port; NA (in dark grey) refers to areas not included in this analysis.*



[1] Data provided by Melbourne Water

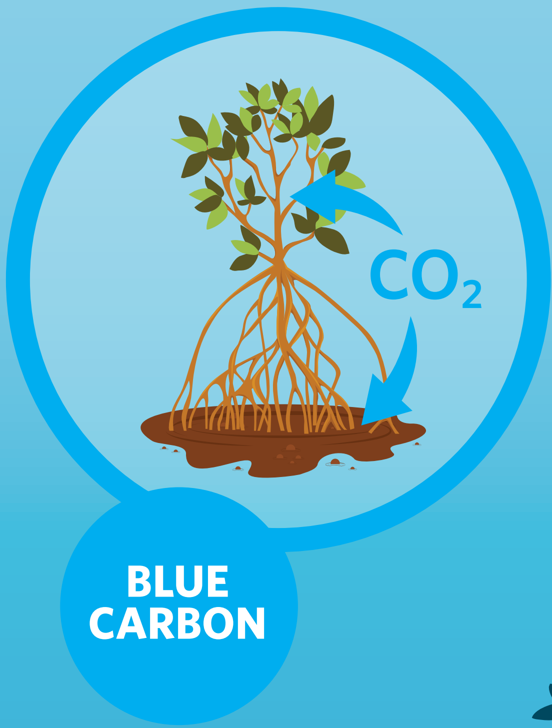
METHODS

To determine the value of recreational fishing and birdwatching trips, our analysis was based on how willing people were to travel further from home in order to undertake their preferred activity, which is a measure of how much they value a location. The economic value associated with coastal wetlands can be estimated through the costs of travel and the time it takes to get there (as they say, 'time is money'). These costs (travel and the value of a person's time) are used to estimate recreational value in dollars. This is a non-market measure of value, based on people's preferences about how and where they spend their time. It is not, for example, how much they spend on fishing gear, though other studies show that equipment expenditure is also substantial[2].

Researchers from Deakin University, Victorian Fisheries Authority, eBird and The Nature Conservancy, used a number of data sets to inform the analysis for fishing and birdwatching, including 1) information on locations where people like to visit for recreational fishing and birdwatching, 2) extent of each of the coastal wetland types, and 3) where people have travelled from to access these areas. We then used these data to estimate the benefits of coastal wetlands per fishing or birdwatching trip. These data were analysed using a choice modelling approach – Random utility maximisation (RUM) framework – that evaluates non-market goods (such as recreational fishing, swimming and hunting) to infer the value of natural ecosystems.

[2] Ernst & Young 2015. Economic study of recreational fishing in Victoria. VR Fish, Melbourne.

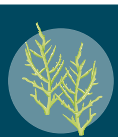
CHAPTER 3
COASTAL WETLANDS ARE AUSTRALIA'S MOST EFFICIENT CARBON SINK



Coastal wetlands capture carbon dioxide from the atmosphere and store this in their plant biomass. They also create the perfect environment for storing carbon captured within the wetland vegetation and from the surrounding environment. This puts them among the most powerful carbon sinks on the planet.

- **Coastal wetlands in Victoria and New South Wales currently capture 36,000 tonnes of carbon each year, equivalent to the annual emissions of 7,826 cars. In Victoria, this could rapidly expand to 1.6 million tonnes of carbon by 2050 if coastal wetlands are allowed to naturally retreat.**
- **Coastal wetlands converted to alternative land uses emit 20% of their stored carbon, whilst restored wetlands can recapture between 2 and 11.5 tonnes of CO_2 per ha per year, equivalent to the CO_2 emitted by 0.5–2.5 cars annually.**

HOW MUCH CARBON CAN BE STORED?



1 HECTARE SALTMARSH
can sequester **2,100** kg per year

1 HECTARE MANGROVES
can sequester **4,800** kg per year

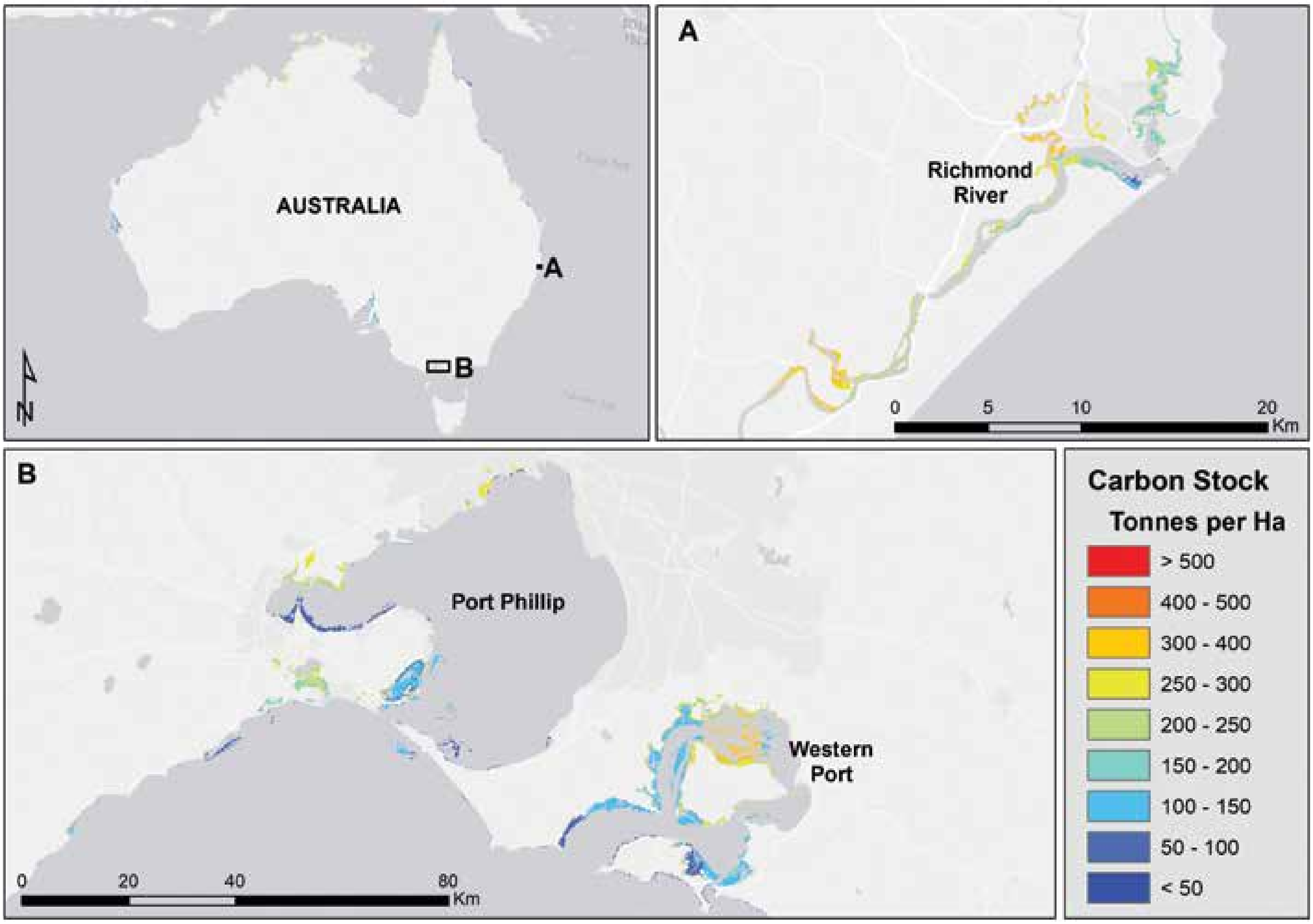
1 HECTARE SEAGRASS
can sequester **1,700** kg per year

COASTAL WETLAND CARBON STOCKS MAPPED FOR THE FIRST TIME

Previous studies have shown that coastal wetlands can sequester carbon up to 40 times faster than rainforests and it can remain in their sediments for thousands of years. The questions we sought to ask were: 1) Where is all this carbon stored?, 2) Have restoration projects led to more blue carbon?, and 3) Where should we restore coastal wetlands to store more carbon?

Saltmarshes, mangroves and seagrasses in Victoria and New South Wales sequester each year an estimated 36,000 tonnes of carbon, equivalent to the annual emissions of 7,826 cars. The carbon already stored in coastal wetland soils can range from 40 to 600 tonnes of carbon per hectare with an estimated 26 million tonnes of carbon stored in mangroves, saltmarsh and seagrass across both Victoria and New South Wales. Mangrove ecosystems store the largest amount of carbon followed by saltmarsh and seagrass. To determine the spatial extent of this stored carbon, the Mapping Ocean Wealth team mapped coastal wetland carbon stocks across Victoria and New South Wales at a resolution useful for state and local agencies, with examples provided in Figure 5.

Figure 5: *Examples of soil carbon stocks (tonnes of organic carbon per hectare) in saltmarsh, mangrove and seagrass ecosystems mapped across Victoria and New South Wales. State-wide and national maps can be accessed from the Mapping Ocean Wealth portal.*



CHANGING LAND USE CONTRIBUTES TO ATMOSPHERIC CARBON STOCKS

Australia may under-represent its emissions accounting if it does not record emissions from the loss of coastal wetlands. For example, the Mapping Ocean Wealth project investigated sites that were once mangroves and converted to other land uses in the Richmond River, NSW. We found these sites had on average 20% less carbon in the soils, suggesting that 75 tonnes of carbon per hectare were released when converted to other land uses. Instead of sequestration, by removing mangroves and disturbing the soil, carbon dioxide is remineralised as a gas which counts as a carbon emission. This is equivalent to an extra 60 cars on the road for a year for every hectare converted to alternative land uses, in addition to lost sequestration potential. Our research provides further evidence for increased protection of coastal wetlands to avoid emissions of carbon dioxide in our atmosphere.

RESTORATION OF COASTAL WETLANDS CAN DELIVER CLIMATE CHANGE MITIGATION FROM RAPID SEQUESTRATION AND STORAGE OF ATMOSPHERIC CARBON

Restoring coastal wetlands is the reverse process of digging up and burning coal or oil because healthy coastal wetlands take greenhouse gases out of the atmosphere and put them into the ground. This process is known as biosequestration and is the same process that created fossil fuels millions of years ago.

The Mapping Ocean Wealth project has shown that over 25-40 years, mangrove restoration in the Richmond River estuary of NSW can store 11.5 tonnes of CO_2 equivalents per hectare per year, with 3.1 tonnes in the soil and 8.4 tonnes stored in the trees. In Port Phillip, saltmarsh rehabilitation projects sequester on average 2 tonnes of CO_2 equivalents per hectare per year in the soils. The projects in Victoria were were originally undertaken to restore critical orange-bellied parrot habitat and are an example of restoration achieving multiple ecosystem benefits.

HOW CAN WE MANAGE OUR COASTS TO SEQUESTER MORE BLUE CARBON?

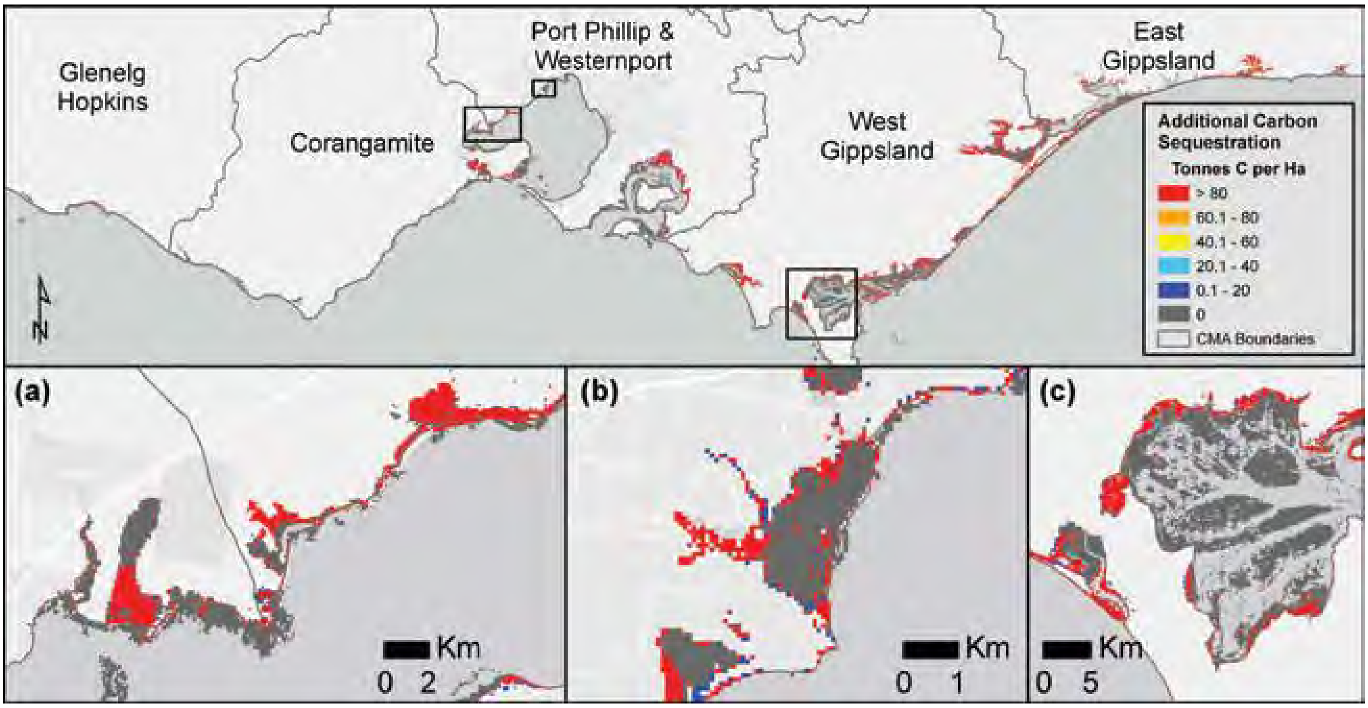
What can we do to harness the power of coastal wetlands to combat climate change? To help answer this question, Mapping Ocean Wealth used possible future management actions or inactions, that would lead to expansion or contraction of coastal wetlands across the state of Victoria to determine how much carbon will be sequestered (or lost) with the change in wetland extent. We assessed three scenarios: 1) reinstate tidal flow under current conditions by breaching levees that currently prevent natural tidal exchange, 2) a 'managed retreat' scenario which models the natural retreat of wetlands in a landward direction with future sea-level rise, and 3) a 'net wetland loss' scenario which modelled an overall decline in wetlands in areas with above-median risk of coastal erosion.

Removing levees now and allowing natural tidal exchange to occur would provide an additional 1.65 million tonnes of carbon sequestration (Figure 6), valued at $67 million using current average carbon prices paid via the Australian Emission Reduction Fund (ERF[3]). Allowing blue carbon ecosystems to naturally colonise into landward areas (that will be inundated by sea-level rise in the future) would sequester 1.6 million tonnes of carbon by 2050, which would be worth $65 million. This would increase to 5.7 million tonnes and be worth $159 million by 2100. This scenario is mapped across Victoria (Figure 6). While sea-level rise will inundate a greater area than targeted levee removal, the levee removal strategy would allow for restoration to begin sooner in some locations, generating up to 14 thousand additional tonnes of sequestration and $2.9 million in ERF value by 2030.

In the coastal wetland loss scenario, if future erosion removes coastal wetlands and no action is taken to allow natural retreat, the carbon released from soils would exceed any sequestration gain from the remaining coastal wetland. By 2100, erosion of Victoria's blue carbon ecosystems would release a net 6.3 million tonnes of carbon into the atmosphere, after accounting for sequestration by remaining ecosystems. These emissions equate to $8.5 billion using the ERF price. While this study presents outcomes for the same management actions or inactions to the whole coast of Victoria, future coastal wetland distribution in any given region will likely be a mosaic of these management scenarios.

[3] Now known as the Australian Climate Solutions Fund.

***Figure 6:** Carbon gained from 2020 to 2100 by restoring coastal wetlands in areas inundated by levee breaching and sea-level rise at (a) Avalon Coastal Reserve to Point Wilson; (b) Point Cook; and (c) Corner Inlet and Shallow Inlet. Sequestration was modelled using the InVEST Blue Carbon model. Additional sequestration was measured as tonnes of carbon gained when allowing newly inundated areas to transition to coastal wetlands compared to a scenario of allowing sequestration to continue only in areas with existing coastal wetlands. Grey patches indicate where coastal wetlands already exist, and carbon sequestration would not differ between the two management actions. CMA = Catchment Management Authority.*

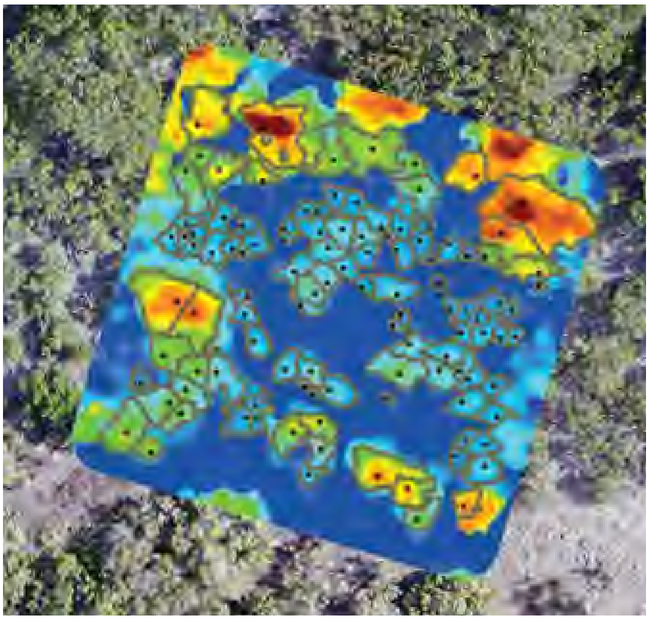


NEW DRONE TECHNOLOGY ALLOWS FOR RAPID ASSESSMENT OF CARBON STOCKS

Measuring above ground carbon stocks in mangroves and saltmarshes can often be tedious and expensive with traditional methods requiring each tree to be measured by hand. New technology developed by Deakin University uses Unmanned Aerial Vehicles (UAVs), more commonly known as drones, to measure above ground carbon stocks remotely, resulting in considerable cost savings and faster assessments compared to traditional methods (Figure 7).

Two people can cover an area the size of a football field in about an hour, 500 times faster than if they were to cover the same area using traditional methods. This results in a cost savings of up to $25,000 per hectare. A video showcasing the new methods and end product is available online https://www.youtube.com/watch?v=fiM8zy1466E.

***Figure 7:** Canopy Height Model showing individual tree locations (black dots) and associated tree crown diameter (yellow line) using new Unmanned Aerial Vehicles mapping technology.*



METHODS

Prior to this project, data on carbon stocks in coastal wetlands consisted of soil core information from point locations throughout Victoria and New South Wales. By linking location data with environmental indicators, we filled gaps in knowledge of the distribution of carbon stocks across the coastal areas of Australia. We developed a model to predict soil carbon stocks based upon climatic, vegetation, topographic and hydrologic properties. Using this model, the Mapping Ocean Wealth team estimated the soil carbon stock within any mangrove, saltmarsh or seagrass ecosystem across Victoria and New South Wales. A total of 13 environmental and anthropogenic variables were used to develop these carbon stock maps across the coastal zone. The top four drivers of carbon stock included ecosystem type, geomorphology, annual rainfall, and land use impacts. By using available maps capturing the variability of these drivers across Victoria and New South Wales, the Mapping Ocean Wealth team was able to accurately predict the distribution of carbon stocks where no information previously existed.

In the Richmond River, the Mapping Ocean Wealth team collaborated with the NSW Department of Primary Industries to measure the amount of carbon stored in mangroves at several rehabilitated and old-growth sites and compared these to sites that have been converted to other land uses. Soil cores (50 cm) were taken to measure soil carbon stocks. Mangroves were measured by the team in the field in four 10 x 10 m plots at each site. Equations were then used to convert these measures to mangrove biomass and carbon stocks. Saltmarsh carbon sequestration rates were measured in Port Phillip at a site managed and recently restored by Melbourne Water. Soil cores were taken to measure carbon stocks and sequestration rates.

The Mapping Ocean Wealth team used the InVEST Coastal Blue Carbon Model to estimate soil carbon sequestration from 2020 to 2100 in Victoria for the following future scenarios of coastal wetland distribution:

1. No Net Change scenario: Current coastal wetland distribution remains the same until 2100
2. Sea-Level Rise scenario: coastal wetlands are allowed to transition in all areas inundated by gradual sea-level rise
3. Levee Removal scenario: Coastal levees are removed and all areas within 1 km behind the former structure and less than or equal to 1 m of elevation above present sea level are restored to coastal wetlands
4. Erosion scenario: Coastal wetlands in areas with above-median risk of coastal erosion are lost[4]

The net present value of carbon sequestration was based on the December 2018 Emissions Reduction Fund auction payment for one metric tonne of carbon dioxide, $13.87, and a 1.5% discount rate. The mapping and analysis of CO_2 sequestration does not take into account for any potential losses from conversion of terrestrial ecosystems to coastal wetlands that may occur.

The drone mapping was achieved by using computer software to merge thousands of overlapping images into a 3D reconstruction, with a ground resolution of less than 1 cm from sets of overlapping images. This 3D reconstruction consisted of a surface model of the canopy height and a model of the land surface. Finally, tree canopy height and other measures were generated by subtracting the modelled land model surface values from the surface (canopy) height values. A segmentation algorithm was used to identify individual trees from the images and extract their height, canopy diameter and tree width where possible. These numbers get combined into equations for estimating the above-ground biomass and carbon stocks. These drone-derived estimates were then compared with the field-based estimates of biomass.

[4] DELWP 2015. Coastal Climate Change Risk Assessments – Vol 1 and 2. Coastal Services Improvement Team, Department of Environment, Land, Water and Planning, Melbourne.

These ecosystems trap and store CO_2 from the atmosphere for thousands of years

CHAPTER 4
COASTAL WETLANDS ARE OUR FIRST LINE OF DEFENCE

Mangroves, saltmarsh and seagrasses have stood guard over Australia's coastlines for millennia. Their root structures and physical presence hold shorelines in place and protect them from erosion and storm surge, preserving valuable infrastructure behind them.

BENEFIT

- **Coastal wetlands reduce wave energy by 37-71%, protecting property across south-eastern Australia (to the value of $2.7 billion).**

VALUE

- **Coastal wetlands protect 1.02 million people (nationally) from relocation and could lower damages by 11.3%, potentially saving the economy $3.6 billion by 2090.**

COASTAL WETLANDS REDUCE WAVE ENERGY

We investigated two ways in which coastal wetlands protect coastlines: 1) their physical structures reduces wave energy and decreases erosion from waves and 2) their ability to maintain elevation with sea-level rise, increasing the height of shorelines. New data from the Mapping Ocean Wealth project reveals that saltmarshes, mangroves and seagrasses reduce wave energy by 37-71% in Victoria. Across Australia, we mapped the role that the current distribution of coastal wetlands plays in reducing storm surge impacts (Figure 8).

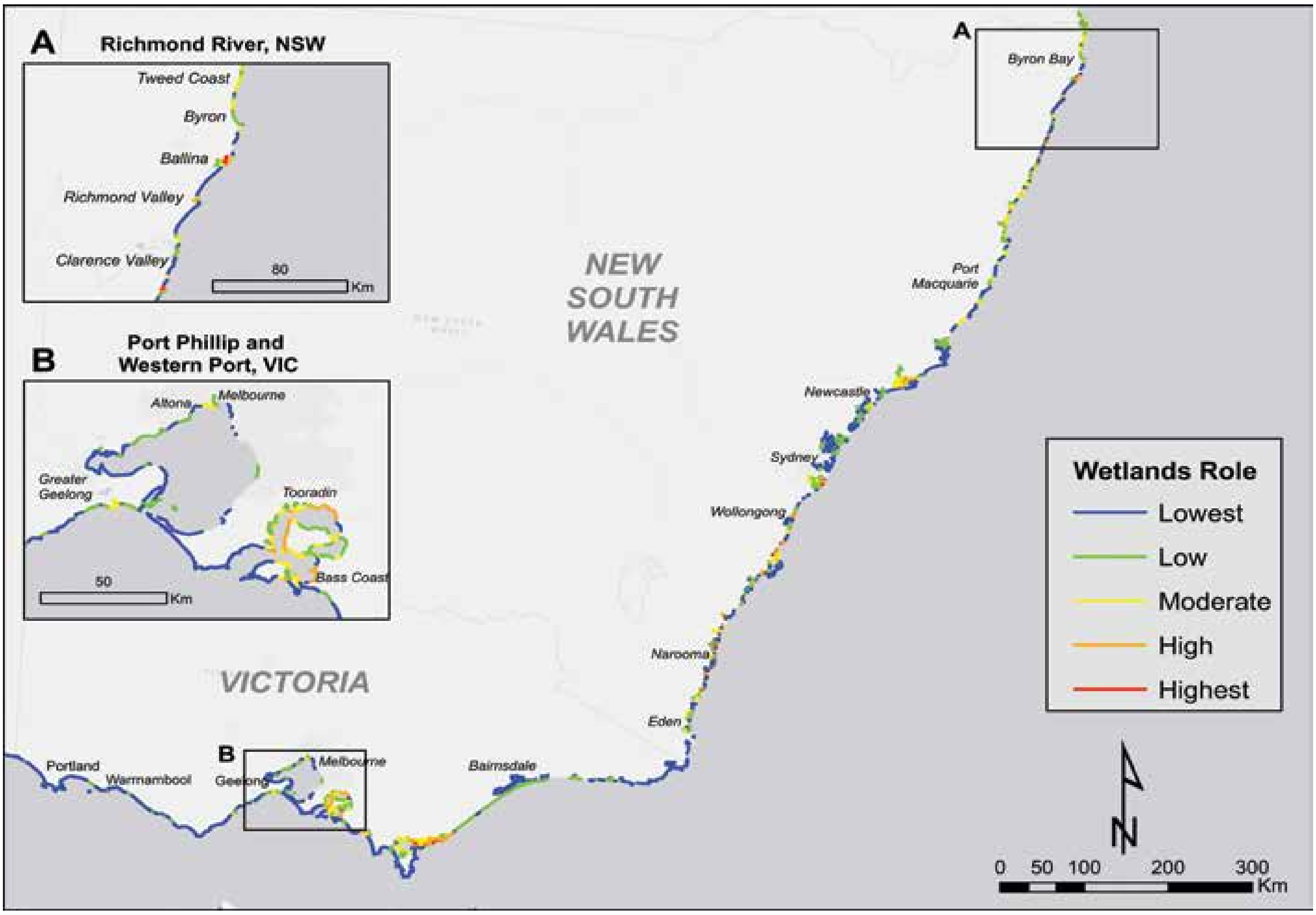
Coastal wetlands protect millions of dollars of coastal infrastructure from the effects of waves and erosion. Across south-eastern Australia, coastal wetlands are protecting up to $2.64 billion of infrastructure (replacement cost), comprising $1.86 billion from mangroves, while for saltmarsh and seagrass this is $702 million and $82.7 million, respectively[5]. This is derived from the value of property within 1 km of the coastline where the presence of coastal wetlands reduces the impacts of inundation from storms.

PROTECTING AGAINST SEA-LEVEL RISE

Australia's coastlines are facing a new threat in the form of sea-level rise, which will result in more frequent and intense erosion and flooding. Different scenarios (Representative Concentration Pathways: RCPs) reflect alternative futures, depending on policies adopted by governments and choices we make. For example, they range from continuing with business as usual with emissions continuing to rise (RCP 8.5) or if we transitioned quickly to renewable energy and improved emissions from transportation (RCP 2.6).

Based on sea-level rise scenario (RCP 8.5), new data from the Mapping Ocean Wealth project suggests that without coastal wetlands, an estimated 1.02 million people would need to be relocated from Victoria and New South Wales by 2090. This would also result in an estimated $31.9 billion in total damages across south-eastern Australia. However, the current distribution of coastal wetlands could lower the damages by 11.3%, potentially saving the economy $3.6 billion in 2090 (Figure 9). This analysis does not assume a change in the distribution of coastal wetlands, which is likely with sea-level rise (see Chapter 3).

Figure 8: *Ranking (lowest to highest) of the role of coastal wetlands (saltmarsh, mangroves and seagrass) in reducing storm surge and sea-level rise across south-eastern Australia. The maps highlight areas in which there would be impacts from waves or sea-level rise if coastal wetlands were not present. Figure 9 displays the value of the property being protected by this service.*



[5] This does not account for increases in property prices or inflation. This is also restricted to property within 1 km of the coast.

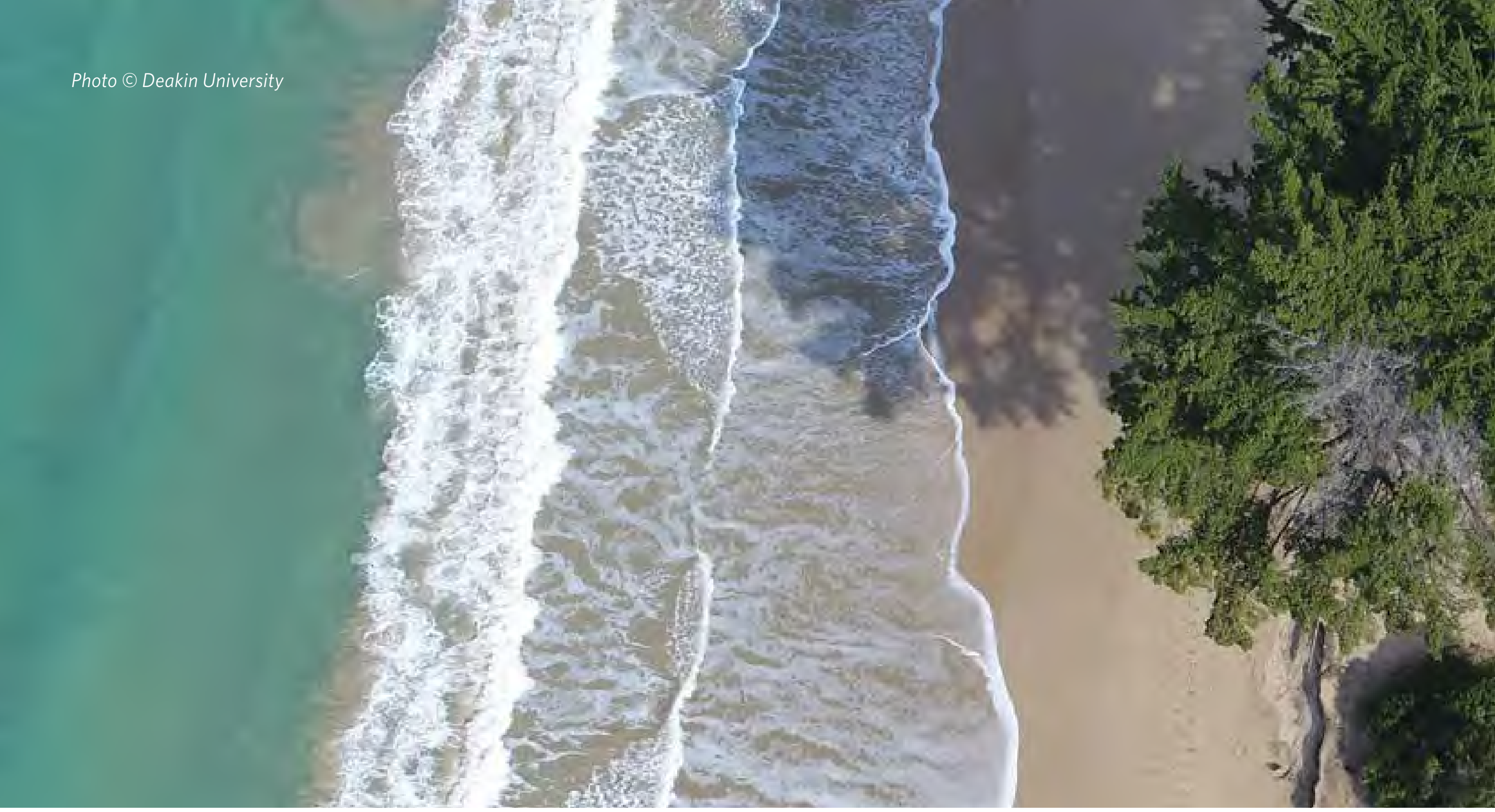
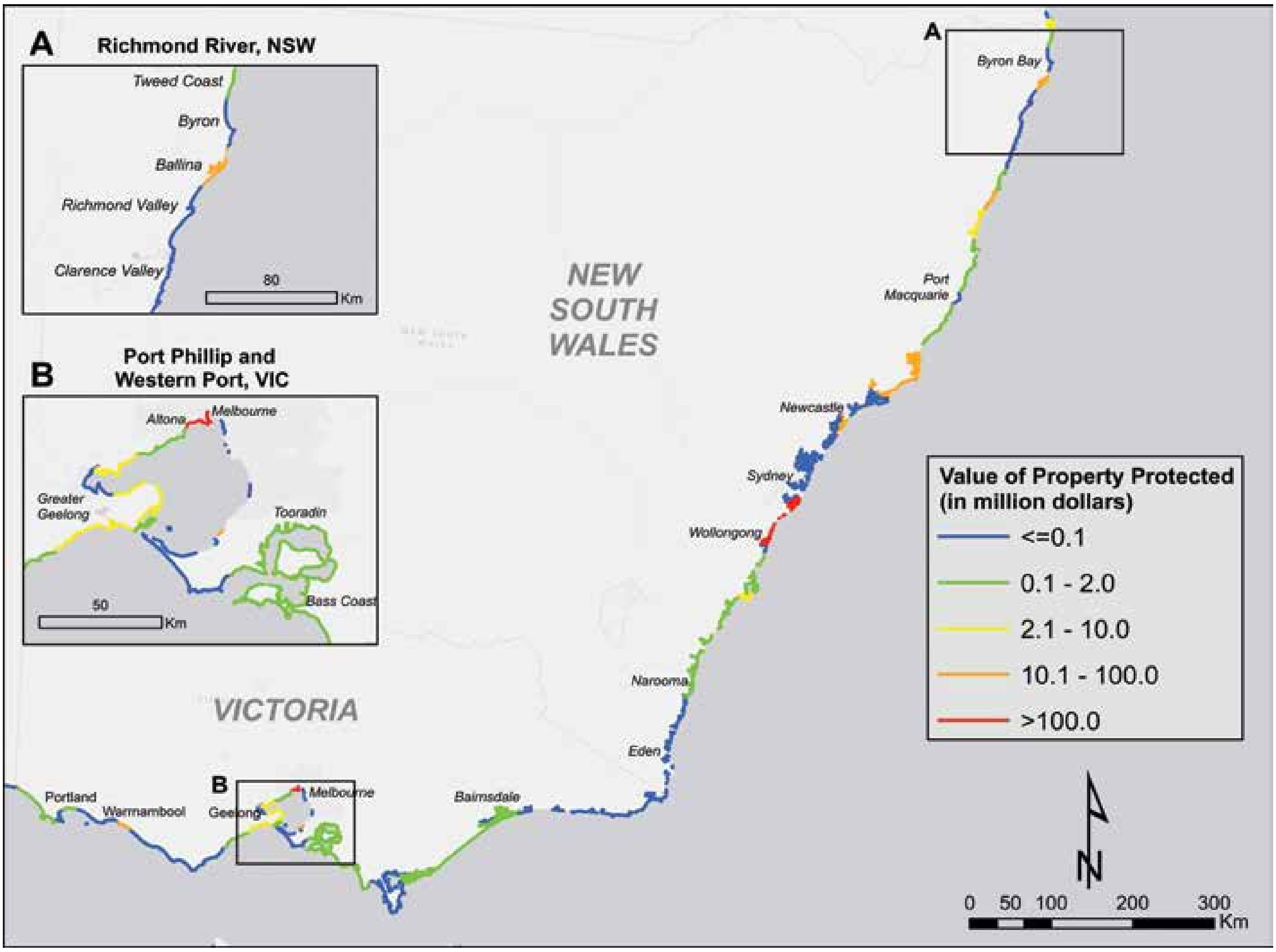


Figure 9: *Estimated cost savings (in million dollars) attributed to present coastal wetlands (vs no wetlands) based on UNISDR GAR15 (Global Exposure Dataset). Estimation of the value of property protected by coastal wetlands within 1 km of the coastline (the area potentially impacted) are summed up at each coastal local government area.*



METHODS

For the first time, the economic value of the protection role of coastal wetlands has been measured and mapped across south-eastern Australia and nationally by the Mapping Ocean Wealth team.

Pressure sensors were deployed in front of and behind coastal wetlands, measuring the wave reduction achieved by these ecosystems in Port Phillip and Western Port in Victoria. Researchers used RBR Solo3 D|wave16 loggers to record pressure data every 20 minutes with frequency of 4 Hz until it reached 2048 samples of data (approx. within 8.5 minutes). Six sites across Port Phillip and Western Port were sampled with a maximum deployment period of 15 days at one site. Vegetation characteristics were also measured including tree/shoot density, tree height, canopy width, stem diameter and the density of pneumatophores of mangroves.

InVEST Coastal protection toolbox: (Natural Capital Project)[6] and coastal protection models were used to map coastal protection across the country. The InVEST toolbox provides a user-friendly first-pass assessment of the coastal protection potential by coastal wetlands at national scales. Cost savings associated with sea level rise were calculated using the InVEST models and following the methods of a study that conducted a similar analysis across the entire United States coastline[7].

[6] https://naturalcapitalproject.stanford.edu/invest/

[7] Following the method of Arkema KK, Guannel G, Verutes G, Wood SA, Guerry A, Ruckelshaus M, et al. 2013. Coastal habitats shield people and property from sea-level rise and storms. Nature Climate Change 3: 913–918.

CHAPTER 5
ACCOUNTING FOR OCEAN WEALTH

Pulling it all together

The use of accounting principles to measure and quantify ecosystem services can improve the way we understand the benefits, monitor and invest in coastal wetlands into the future.

CONNECTING NATURE TO PEOPLE

The United Nations' System of Environmental-Economic Accounting uses **four** steps to connect nature to people:

STEP 1 ASSET EXTENT: involves measuring the area covered by an ecosystem asset (e.g. a seagrass meadow)

STEP 2 ASSET CONDITION: quantifies the ecological quality or health of an ecosystem asset

STEP 3 SERVICES: records the flows of services generated by ecosystem assets (e.g. the benefits that an area of seagrass meadow supplies to people)

STEP 4 BENEFITS: describes the ways in which these services contribute to peoples' wellbeing

- **The United Nations' System of Environmental-Economic Accounting sets out the accounting principles for measuring the relationship between the environment and people and can be applied to coastal wetlands in south-eastern Australia.**
- **Combined economic values for five services (carbon sequestration, fishery production value, recreational fishing and birdwatching) in Port Phillip and Western Port are worth $36.5 million per year, with carbon stocks and coastal protection valued at $526 million.**

A NEW APPROACH FOR ENVIRONMENTAL-ECONOMIC DECISION MAKING

The United Nations' System of Environmental-Economic Accounting (SEEA) provides a new method for organising and integrating environmental information on the extent, condition and ecosystem services of ecosystems including coastal wetlands. SEEA applies accounting principles that are standard in government economies (like national accounts) to the environment, overcoming a traditional 'language' barrier between environmental managers and economists.

By adopting an environmental accounting system that mirrors a traditional accounting system, decision-makers can compare the social and economic benefits of investing in the management and restoration of natural infrastructure (ecosystems) in the same way that they can compare the social and economic benefits of investing in built infrastructure – traditional developments like a ports, jetties or marinas.

The SEEA uses a four-step process to link the extent and condition of ecosystems to social and economic benefits:

1. **Assess extent** – involves defining and measuring the area covered by an ecosystem (in accounting terms an 'ecosystem' like a seagrass meadow is called an 'asset');
2. **Determine condition** – involves defining the ecological quality or health of an ecosystem asset using a standardised method (e.g. index of seagrass condition);
3. **Quantify services** – involves calculating the ecosystems services derived from the asset (e.g. kilograms of fish produced per hectare of seagrass);
4. **Value benefits** – involves measuring the social or economic value which contribute to peoples' wellbeing (e.g. $15 per kilogram of whiting derived from commercially selling fish).

An advantage of the SEEA system is that it can be used to measure and communicate in accounting terms how both ecosystem assets and ecosystem services can increase or decrease over time and how different management interventions affect these. This allows decision-makers to understand the social and economic trade-offs and opportunity costs of different environmental management (e.g. grazing of saltmarshes versus carbon storage). Most importantly, SEEA uses a standard approach which allows comparison over time, with other assets (including human built) and with local, state, national and international economic accounting practices.

SEEA CASE STUDY FOR PORT PHILLIP AND WESTERN PORT, VICTORIA

The IDEEA Group and Mapping Ocean Wealth team used the information collected over several of the Mapping Ocean Wealth studies to develop an environmental economic account for Port Phillip and Western Port, Victoria, using the SEEA framework. The case study was applied to coastal wetlands (assets) and five ecosystem services as a per year value: carbon sequestration, commercial fisheries (catch value), recreational fisheries (catch value) recreational fishing (time and travel value) and birdwatching (time and travel values).

The current extent and ecosystem services and values were calculated for each asset (Table 2) and 'stacked' to provide a total value for each asset. This resulted in a combined value of $36.5 million per year for coastal wetlands (including the three ecosystem types).

The combined carbon stocks (which are released if the carbon stocks are disturbed) and coastal protection value (the replacement cost of the infrastructure the ecosystems protect from inundation) is worth an additional combined $526 million (Table 3).

This initial assessment provides a snapshot of only a few of the social and economic values for each asset and while it lacks information on ecosystem asset condition, it provides an example of how ecosystem services can be combined to derive a cumulative value of benefits. The data for recreational fishing catch was limited to survey data from 2000[8], with recreational catch likely to have increased since then with a number of Victorian Government initiatives to increase recreational fishing participation.

Additionally, the data on the number of birdwatching trips is limited to those that have registered their trips on the eBird app, which would be a small fraction of the total number of birdwatching trips in the region. Improved or more recent data on these recreational activities would greatly enhance the value estimates made here.

***Table 2:** The five ecosystem services and values that have been assessed on a per year basis in Port Phillip and Western Port as part of the Mapping Ocean Wealth project.*

		PORT PHILLIP			WESTERN PORT		
		SEAGRASS	MANGROVE	SALTMARSH	SEAGRASS	MANGROVE	SALTMARSH
ECOSYSTEM ASSET	HECTARES	6,788	4	2,492	10,505	1,726	2,672
SOIL CARBON SEQUESTRATION	TONNES YR^{-1}	11,336	26	5,975	17,543	11,046	6,413
	$\$YR^{-1}$	157,230	355	82,873	243,326	153,214	88,946
COMMERCIAL FISHERIES (CATCH)	TONNES YR^{-1}	29.85	0.03	2.09	46.20	10.95	2.24
	$\$YR^{-1}$	264,732	218	17,693	409,695	93,894	18,971
RECREATIONAL FISHERIES (CATCH)	TONNES YR^{-1}	97	0.04	4	160	19	7
	$\$YR^{-1}$	522,523	240	20,901	860,161	103,680	40,394
RECREATIONAL FISHING (TIME AND TRAVEL)	TRIPS YR^{-1}	1,429,864	-	-	794,340	-	-
	$\$YR^{-1}$	7,617,361	-	-	25,509,069	-	-
RECREATIONAL BIRDWATCHING (TIME AND TRAVEL)	TRIPS YR^{-1}	-	13	956	-	372	645
	$\$YR^{-1}$	-	470	296,222	-	9149	13,238
TOTAL	$\$YR^{-1}$	8,561,846	1,283	417,689	27,022,251	359,937	161,559
	$\$/HA\ YR^{-1}$	1,261	321	168	2,572	209	60

[8] Henry G and Lyle J 2003. The national recreational and indigenous fishing survey, Project No. 1999/158. Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

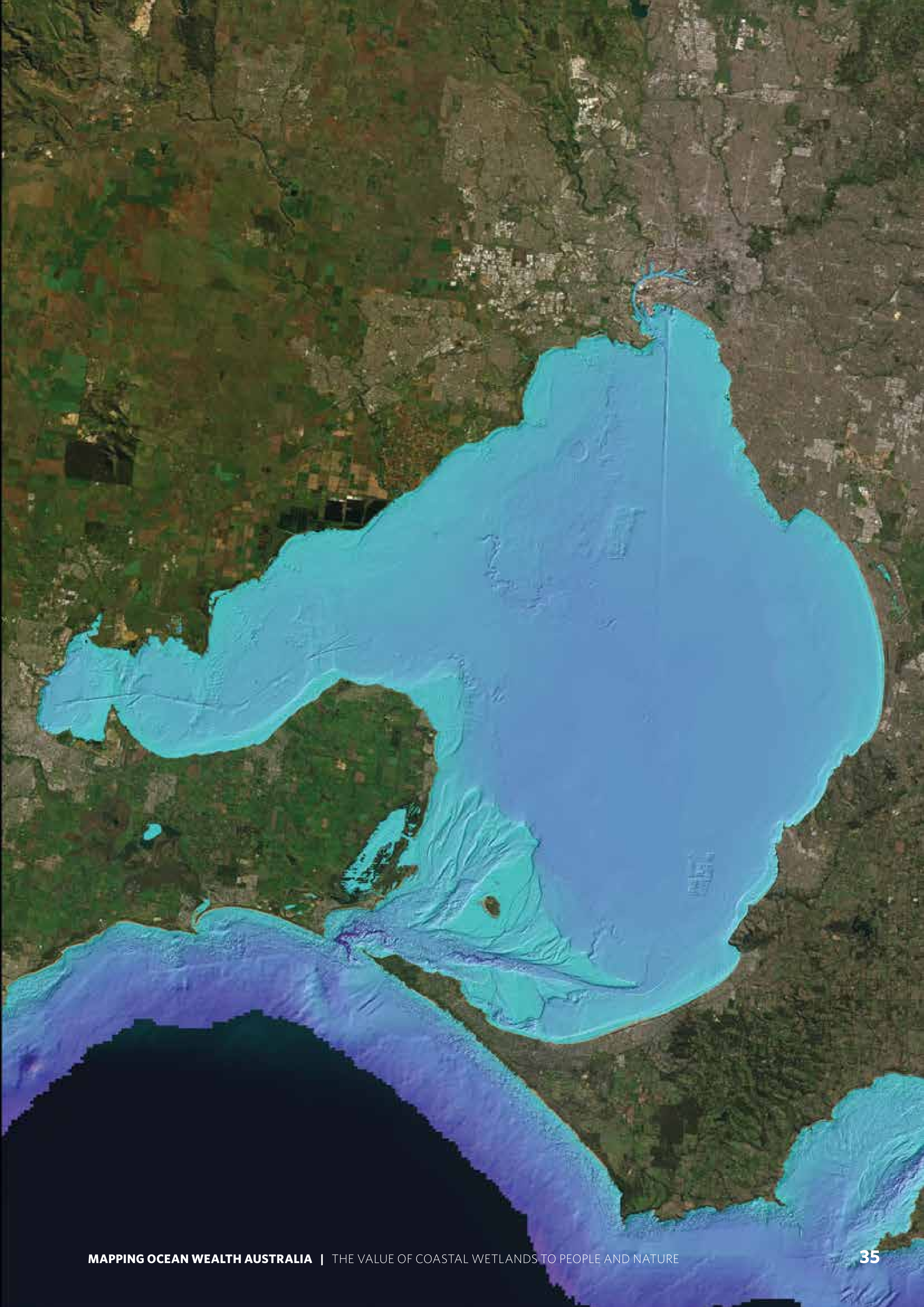



Photo © Deakin University

Future assessments planned by Mapping Ocean Wealth (to be published in 2020) will contain more detailed information including: scenario planning to enable evaluation and comparison of social and economic impacts over time with different management interventions and information on the condition of ecosystem assets. Future versions of the economic account could incorporate other ecosystem services such as nutrient cycling, education and research, cultural values and habitat for endangered species, amongst others.

METHODS

The stacking (combining) of ecosystem services and benefits requires the attribution of physical (e.g tonnes, number of visitors) and monetary quantities of ecosystem services for each ecosystem type within the study area. Depending on the information source, attribution to an ecosystem is either top-down (identical values for each ecosystem type across the study area) or bottom up (different values that vary based on location in the study area for each ecosystem type).

Due to the different spatial scales of the data used in the project, both methods were employed. The top down approach was utilised for physical and monetary estimates of soil carbon sequestration (per hectare quantities based on field estimates), commercial fisheries (per hectare quantities based on state-wide average contributions) and recreational fisheries (per hectare quantities for different species based on state-wide average contributions). The bottom up approach was utilised for physical and monetary estimates of recreational fishing in seagrass ecosystems and carbon storage in all ecosystems.

The challenges faced with developing the environmental-economic accounts, as with most accounts in the early phase of adopting the process is the disparate nature of data and lack of standard measures or reference levels of condition. This study has helped to identify future needs, framing and calls for a standardised approach to collecting and collating ecosystem service and asset condition data.

Table 3: *Carbon storage and coastal protection assessed for Port Phillip and Western Port as part of the Mapping Ocean Wealth project, these values are which are not expressed as a per year value but as the stock or asset value of the ecosystem.*

		PORT PHILLIP			WESTERN PORT		
		SEAGRASS	MANGROVE	SALTMARSH	SEAGRASS	MANGROVE	SALTMARSH
ECOSYSTEM ASSET	HECTARES	6,788	4	2,492	10,505	1,726	2,672
CARBON STORAGE	TONNES	2,393,167	3,389	1,157,112	3,337,504	492,143	892,162
	$	33,193,226	47,005	16,049,143	46,291,180	6,826,023	12,374,287
COASTAL PROTECTION	PEOPLE	53,413	12,123	179,369	965	5,922	2,389
	ASSET VALUE $	89,010,000	20,200,000	298,880,000	470,000	2,910,000	1,170,000
TOTAL	$	122,203,226	20,247,005	314,929,143	46,761,180	9,736,023	12,374,287
	$/HA	18,003	5,061,751	126,376	4,451	5,641	4,631

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CONCLUDING REMARKS

Throughout this report, we have displayed and quantified a few of the most important social and economic benefits provided by Australia's coastal wetlands.

The data provided extends our knowledge of ecosystem service benefits and how these vary across geographies at a scale that allows decision-makers to make more accurate and informed management decisions. The information can be used to support marine spatial planning, benefit-cost analysis of different management interventions and land uses, and prioritisation of restoration and protection.

While the job of truly valuing these ecosystems is far from complete, Mapping Ocean Wealth has laid out a compelling array of information to support the case for further investment in quantifying coastal wetland benefits and strengthens the case for their protection and restoration. Failing to do this threatens not only biodiversity, but also the lives and livelihoods of hundreds of thousands of people along Australia's treasured south-eastern coastline.

Ecosystems that fringe our coastlines – saltmarshes, mangrove forests and seagrass meadows – provide a bounty of benefits for Australians. These often-neglected ecosystems support livelihoods, provide a wonderland for recreation and enable mitigation and adaptation to the perils of a changing coastline.

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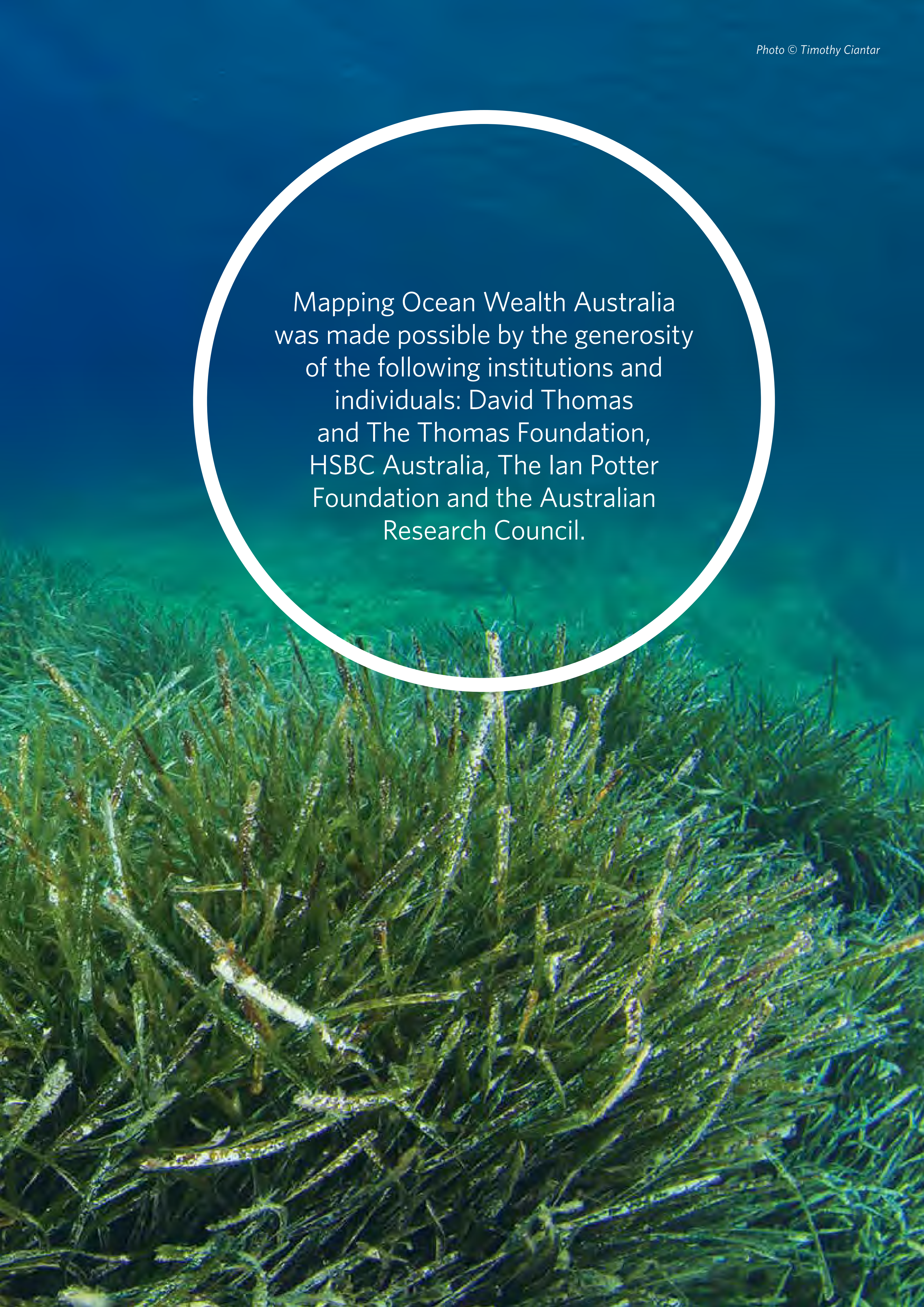

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