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Achieving carbon offsets through blue carbon: a review of needs and opportunities relevant to the Australian seafood industry

Mat Vanderklift[1*], Andy Steven[2], Raymundo Marcos-Martinez[3], Daniel Gorman[1]

[1] CSIRO Oceans & Atmosphere, Indian Ocean Marine Research Centre, Crawley, WA, 6009.

[2] CSIRO Oceans & Atmosphere, Queensland Biosciences Precinct, St Lucia, QLD, 4057

[3] CSIRO Land & Water, Black Mountain, ACT, 2601

*Email: mat.vanderklift@csiro.au

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The Fisheries Research and Development Corporation plans, invests in and manages fisheries research and development throughout Australia. It is a statutory authority within the portfolio of the federal Minister for Agriculture, Fisheries and Forestry, jointly funded by the Australian Government and the fishing industry.

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Executive summary

Several stakeholders within the Australian seafood industry have demonstrated strong leadership by developing carbon neutral business practices. In 2017, participants in the National Seafood Industry Leadership Program challenged the industry to become carbon neutral by 2030. In response, the Fisheries Research and Development Corporation (FRDC) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) hosted a workshop that invited key stakeholders and thought leaders from industry, government and nongovernmental organisations to discuss the overall attitudes of the Australian seafood industry to the concept of carbon neutrality, and to gauge aspirations for investment in coastal "blue" carbon offsets as a way of achieving carbon neutrality.

Globally, the principal driver of efforts to reduce carbon emissions and enhance sequestration is the need to minimise the impacts of climate change. However, for some buyers of offsets, motivation might be more strongly driven by other associated benefits, such as increased fuel efficiency or enhanced social responsibility. Wider understanding of these benefits, and the risks associated with inaction, would likely lead to greater uptake of low emission practices. In this report, arising from the discussions held at the workshop, we outline a set of recommended actions which the FRDC and its partners can initiate to increase industry awareness, including synthesising and promoting the potential benefits of reducing emissions.

Actions can be taken to reduce emissions, but some emissions are inevitable — for example, boats need fuel to operate. A range of options are available to offset these unavoidable emissions, but the subject can be confusing and alienating, especially for those unfamiliar with the language used. A plain language guide to the options available — from calculating emissions to purchasing offsets through to how to do so while also achieving additional benefits to the environment and society — would be useful for the industry.

Blue carbon offsets are not yet available in Australia, including (but not limited to) Australia's Emissions Reduction Fund, but voluntary market opportunities exist overseas. Several Australian businesses are seeking to promote efforts to accelerate their development in Australia. Developing partnerships between the seafood industry and like-minded businesses, to address key uncertainties and knowledge gaps (such as uncertainty over tenure, lack of reliable demonstration sites, absence of key data such as carbon accumulation rates) is likely to be a fruitful option for maximising the future blue carbon opportunities for the seafood industry.

Glossary

Blue carbon: organic carbon stored in seagrass, mangrove or tidal marsh ecosystems in a way that it is not released into the atmosphere

Sequestration: a process in which carbon is removed from the atmosphere, and stored for long periods in plants, soil or geologic formations

Carbon neutrality: achieving net zero carbon emissions by ensuring that carbon released into the atmosphere is balanced by carbon sequestered or emissions avoided

Ecosystem service: benefits that humans receive from natural ecosystems

Emission: release of carbon dioxide (CO_2) or other greenhouse gas into the atmosphere

Gigatonne (Gt): one billion tonnes

Greenhouse gas: a gas that contributes to warming the atmosphere by absorbing infrared radiation

Offset: a reduction in emissions, or an increase in sequestration, that is made to compensate for emissions occurring elsewhere

List of acronyms used in this report	
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FRDC	Fisheries Research and Development Corporation
NCOS	National Carbon Offset Standard
ERF	Emissions Reduction Fund
VCS	Verified Carbon Standard
NGO	Non-Governmental Organisation
ACIAR	Australian Centre for International Agricultural Research
RAC	Research Advisory Committee
GHG	Greenhouse Gas(es)
IPCC	Intergovernmental Panel on Climate Change
IET	International Emissions Trading
JI	Joint Implementation mechanism
CDM	Clean Development Mechanism
UNFCCC	United Nations Framework Convention on Climate Change
NDC	Nationally Determined Contribution
SDM	Sustainable Development Mechanism
ITMO	International Transfer of Mitigation Outcomes
NAMA	Nationally Appropriate Mitigation Action
NAPA	National Adaptation Program for Action
NAP	National Adaptation Plan
REDD+	Reducing Emissions from Deforestation and forest Degradation
ACCU	Australian Carbon Credit Unit
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
IMO	International Maritime Organisation
PES	Payments for Ecosystem Services
VER	Verified Emissions Reduction
VCU	Verified Carbon Unit
AMWRRO	Australian Marine Wildlife Research & Rescue Organisation
DFAT	Department of Foreign Affairs and Trade
DEE	Department of the Environment and Energy
ERM	Environmental Resource Management
NSILP	National Seafood Industry Leadership Program
WAFIC	Western Australian Fishing Industry Council

Preamble

The Australian seafood industry has been developing a robust set of approaches to improve sustainability (defined as ensuring the supply of fish indefinitely and that the environment which produces them remains healthy). The industry is also considering options to achieve carbon neutrality within this broad sustainability agenda — that is, ensuring that the carbon it emits is reduced as much as possible, and that emissions which are unavoidable are offset.

CSIRO and FRDC jointly convened a workshop in July 2018 to discuss how the Australian seafood industry can progress towards carbon neutrality, with particular emphasis on the potential role of blue carbon (organic carbon stored in seagrass, mangrove or tidal marsh ecosystems in a way that it is not released into the atmosphere). In part, this was informed by recommendations arising from the National Seafood Industry Leadership Program, which included an aspiration for the Australian seafood industry to be carbon neutral by 2030. The intent of the workshop was to:

- inform and understand the aspirations of the Australian seafood industry with respect to carbon neutrality,
- map the aspirations against current opportunities in Australia and overseas, and
- identify actions that can be taken by the seafood industry and the FRDC that will help move the industry towards meeting these aspirations.

A summary of the workshop discussion can be found in Appendix 1, a list of the attendees can be found in Appendix 2, and the workshop agenda can be found in Appendix 3.

In this report, we provide a set of recommendations arising from the workshop discussions and a subsequent review of relevant science, policy and actions which can be used as the basis for progress towards the overall goal of a carbon neutral Australian seafood industry. We also describe the broad context, from changes to Earth's climate, the global and Australian policy setting, the role of various types of climate finance (including carbon trading), and current efforts towards restoration of blue carbon ecosystems in Australia.

Future opportunities for the Australian seafood industry

During the workshop conversations, it was evident that not all members of the industry have the same level of awareness of the benefits of becoming carbon neutral, or the same desire for doing so.

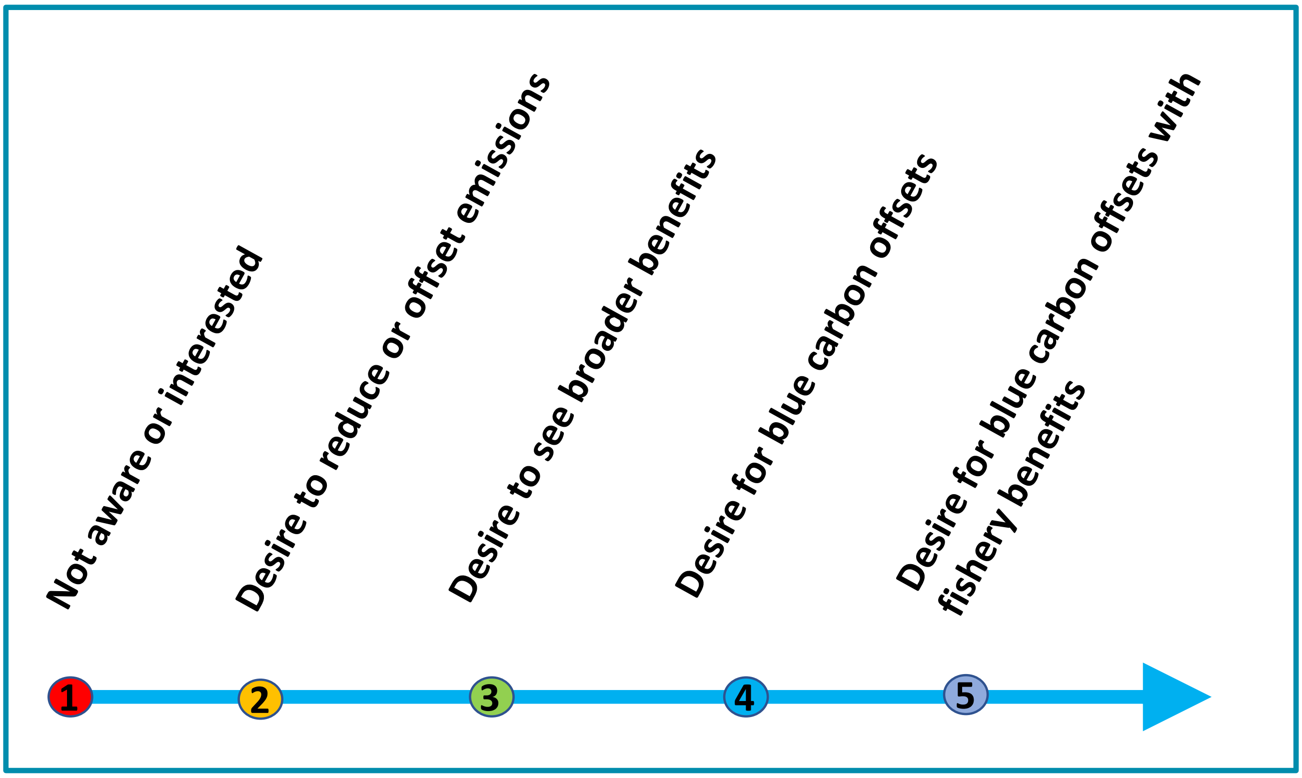

Figure 1 illustrates a representation of the varying levels of awareness and appetite, which we have used to develop the following set of recommendations.

Some progress towards carbon neutrality can be made by adopting practices and technologies that reduce emissions (e.g. increasing fuel efficiency), and our recommendations reflect this. However, some emissions are unavoidable, so the seafood industry would need to offset those emissions; there is some enthusiasm for the idea that this could be done in a way that also benefits the coastal ecosystems which themselves support fisheries through “blue carbon” offsets. A set of our recommendations are focussed on how the FRDC might facilitate steps to make that a feasible option, reinforcing the Australian seafood industry as world leaders in sustainability.

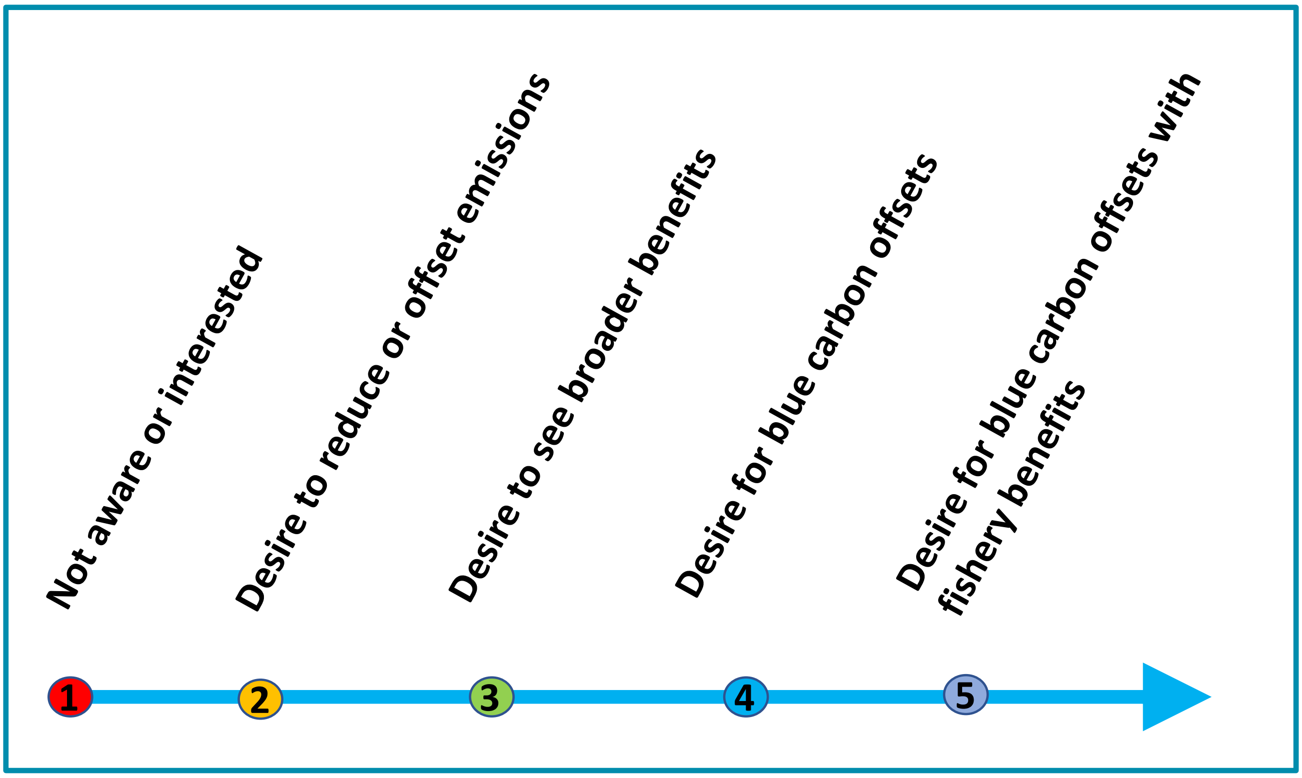

Figure 1: Schematic representation of the range of awareness and appetite for carbon neutrality in general, and blue carbon in particular, in the Australian seafood industry

1. *Low awareness, low desire*. For those in the industry who are largely unaware of the need for, and benefits of, carbon neutrality there is a role for FRDC to play in communicating this information. The FRDC already has some useful relevant resources, such as reports and factsheets on fuel efficiency (e.g. the resources available here: http://www.frdc.com.au/Industry-and-Environment/Climate-change/Fishing-Industry-Opportunities-to-Contribute-to-Mitigation).

However, there are likely to be positive outcomes from developing and synthesising a set of plain-language resources that outline potential benefits to industry members, and the likely future risks associated with lack of action. These include fuel efficiency, but also broader aspects, like greater social acceptability that can in turn improve financial performance. Development of those materials will likely be better informed by research to better quantify the direct and indirect benefits to the Australian seafood industry across the value chain. It might be worth considering adding this to FRDC research priorities. Importantly, developing such materials should not only include compilation of relevant information, but extension and communication of the information in a way that is readily understandable and interpretable to those unfamiliar with the topic.

Recommendation. Locate and compile existing materials relevant to the seafood industry, that describe the need for, and benefits of, carbon neutrality in simple language. Provide a consolidated location for easy access to such materials (the FRDC website is a suitable platform for placing a single point of reference), and communicate this to industry stakeholders (for example, through FISH magazine). Support research that better quantifies the direct and indirect benefits, and risks, to the Australian seafood industry across the value chain.

2. *Desire to reduce and offset emissions, but low awareness of options.* Further along the spectrum, some industry members have broad awareness of the benefits of carbon neutrality, but little awareness of how to go about achieving this. In some cases, they might be primarily interested in just reducing and offsetting emissions (in other cases they might also desire broader benefits, we discuss this next). Similar to (1) above, there might be a role for FRDC to play in developing a set of plain-language materials that outline clearly what the options are, and the steps to take, such as

factsheets (see an example of one produced by the then Department of Resources Energy and Tourism: https://www.austrade.gov.au/ArticleDocuments/5499/RespondingClimateChangeFactsheet.pdf.aspx), or narratives that might resonate with the industry (such as the case study on Austral Fisheries produced by the Department of the Environment and Energy: http://www.environment.gov.au/system/files/resources/7689c180-349d-41ed-8e0c-a2aba798edfa/files/case-study-austral-fisheries.pdf). Such materials should include the main steps towards carbon neutral certification against the National Carbon Offset Standard (NCOS), including through the Emissions Reduction Fund (ERF), but also more broadly (carbon neutral certification against NCOS is possible through multiple avenues). They should contain relevant information about the steps needed to move towards carbon neutrality, such as how to start an audit of emissions. It might be useful to develop a simple tool for members to estimate, for example, the carbon emissions from boats that catch the fish to those associated with generating electricity at land-based facilities, and beyond. Some online calculators exist, such as the Queensland Seafood Industry Association emissions calculator (http://emissionscalculator.qsia.com.au/fisheries/) and the Seafish Emissions Profiling Tool (http://www.seafish.org/GHGEmissionsProfiler/v1/) which are worth reviewing.

For categories 1 and 2, it is worth considering the relative capacity of different members of the seafood industry to engage with this process. The seafood industry is diverse, comprising operators from large integrated companies to small companies and individuals. Each will have a different capacity to maintain awareness and adopt best practice. For smaller operators, it might be beneficial to work together as consortia to reduce per capita transaction costs— we suggest that exploration of how this might work in practice would be worthwhile.

Recommendation. Locate and compile existing materials that describe how to go about achieving carbon neutrality in simple language, including key resources and contacts. Provide a consolidated location for easy access to such materials (the FRDC website is a suitable platform for placing a single point of reference), and communicate this to industry stakeholders (for example, through FISH magazine). Such materials should include advice relevant for all types of industry operators. Support work that investigates how to make carbon neutrality feasible for smaller operators (e.g. through consortia). Review and communicate the availability of simple generic emissions calculators relevant for the Australian seafood industry that will allow interested individuals and businesses to make initial estimates to be made to help guide decisions.

3. *Desire to achieve broader benefits than carbon neutrality alone*. Other members are likely to want benefits that extend beyond carbon neutrality, for example by buying offsets from projects that are certified against standards that demonstrate net social or environmental benefits. As outlined in the section "*Carbon as an ecosystem service*" later in this report, there are several options available, including at least two associated with offsets eligible under the NCOS (i.e. Verified Carbon Standard [VCS] and Gold Standard). Few projects exist in Australia, but there are some, such as the New Leaf Carbon Project (designed to protect native forests on private land from harvesting, and certified by VCS and the Climate Community and Biodiversity Standard), and the Yarra Yarra Biodiversity Corridor (a reforestation project in the Western Australian wheatbelt verified by the Gold Standard). However, numerous projects exist overseas, and these might provide opportunities for the seafood industry, especially if they are in regions within their value chain (e.g. as a supplier of seafood, or as a market for seafood). In this context, the role of the FRDC could be twofold. First, it could play a role similar to that described above by providing materials that outline the broad opportunities, and how it works (e.g. what the co-benefits are, how they are measured and verified, and what the benefits of being associated with them are). Second, together with collaborators who are already working on habitat restoration, consider partnering with one or more of the standards

providers (probably those that can provide carbon offset units eligible under the NCOS) to explore more deeply the types of science-based products that best match the needs of the Australian seafood industry.

Recommendation. Engage with carbon market organisations and standards providers to communicate the needs of the seafood industry, and link market opportunities back to the seafood industry. Work with existing FRDC collaborators so that existing restoration and rehabilitation projects in Australia include relevant actions (including data collection) that advance and enhance efforts towards carbon neutrality. Where the current opportunities don't match industry needs and aspirations, develop relevant priorities for Research and Development investment that address knowledge gaps (e.g. how to define and measure the co-benefits that are most desired by the industry).

4. *Desire to achieve carbon neutrality through blue carbon offsets.* The original rationale for this project was to explore whether blue carbon offsets might be an option for the Australian seafood industry. At the time of writing there are no projects in Australia that produce verified carbon offsets from blue carbon ecosystems. However, there are some VCS projects involving mangrove restoration overseas that fit the broad definition. In addition, there are relatively new methods available through VCS, including "VM0033 Methodology for Tidal Wetland and Seagrass Restoration" (http://verra.org/methodology/vm0033-methodology-for-tidal-wetland-and-seagrass-restoration-v1-0/) that might be applicable, including in Australia, but have not yet been implemented. An important step is to scope the information needed to apply the available methods in an Australian context. This is perhaps best done with explicit reference to a specific location and ecosystem: one example discussed by workshop participants was the possibility of restoring mangroves in places where they have died, such as along the coast of the Gulf of Carpentaria.

Probably the best prospect for immediate progress is through partnering with other agencies or consortia that are working towards similar aims. Within Australia, Qantas Group, several non-governmental organisation (NGOs), and some members of the seafood industry have worked towards identifying potential sites for blue carbon restoration activities. Internationally, some progress could be made through partnering with agencies such as the Australian Centre for International Agricultural Research (ACIAR) to investigate the opportunities for investment into blue carbon offsets overseas. In addition, further development of the relevant standards (including verification and valuation of co-benefits) could be facilitated through partnering with carbon offset standard providers (e.g. VCS/Verra and Gold Standard).

Recommendation. Engage closely with current efforts, including (but not restricted to) the blue carbon roadmap (Department of the Environment and Energy) and efforts led by the business sector (e.g. Qantas Group), representing the interests and expertise of the Australian seafood industry. Invest (or co-invest with other partners) in a scoping project to assess the readiness and applicability of existing blue carbon methods in Australia (such as the VCS tidal wetland method), including identifying information requirements and their potential to generate a market for offsets for the seafood industry. Depending on the results of the scoping study, invest in the collection of relevant data, and review and prioritise potential sites. In parallel to the scoping study, invest in a review of existing standards to assess which have the potential to meet the needs and aspirations of the seafood industry. Depending on this review, partner with one or more standards providers to develop science-based standards which better meet the needs of the seafood industry. Partnering with other groups to establish one or more demonstration sites.

5. *Desire to achieve carbon neutrality with certified benefits to marine ecosystems*. Finally, an aspirational goal for the seafood industry would be to achieve carbon neutrality through carbon offsets that have certified marine biodiversity or fisheries benefits. As outlined later in this report,

certified biodiversity benefits can be associated with tradable carbon offsets (including several that are eligible under NCOS). In principle, these could be applied to blue carbon projects, but in practice this has not yet been done. Nevertheless, such certification does not necessarily mean that the benefits accrue to the species that would be most interesting for fishers, or indeed for consumers of seafood (which might be different). Ultimately, it should be possible to devise or refine standards which can certify marine biodiversity and fishery co-benefits of blue carbon. This field is largely unexplored, and merits investigation.

Recommendation. Seek to partner with standards providers to refine or develop methods for demonstrating co-benefits so that they can be used to unambiguously certify marine biodiversity and fisheries benefits of blue carbon projects. Such an investigation would best be done in association with development of blue carbon offset projects outlined earlier (i.e. demonstration sites), facilitating the relevant research needed to support the development of such standards.

A roadmap for the FRDC

In order to progress towards the aspirations of a carbon neutral seafood industry by 2030, a coordinated approach that includes several of the actions outlined above would be advantageous. This would profit from explicit recognition in the FRDC national priorities. The current focus around the concept of sustainability — "Ensuring that Australian fishing and aquaculture products are sustainable and acknowledged to be so" — is a relevant starting point to promote the idea of carbon neutrality. A relevant resource for this is the Australian Fisheries Healthcheck (FRDC Projects 2014-008 and 2016-060) which include measurement of "carbon footprint" as an indicator. It is likely that as awareness builds, this will be reflected in jurisdictional research priorities managed through the FRDC Research Advisory Committees (perhaps initially focussing on actions towards fuel efficiency or habitat restoration, from which progress towards carbon neutrality can be leveraged). If the appetite of industry grows, it might be relevant to consider a formal structure within the FRDC, such as a subprogram.

During the workshop it was highlighted that some of the future impetus for carbon neutrality is likely to be market-driven by consumers, including chefs. FRDC is well-positioned to leverage its existing relationships with chefs and seafood consumers to understand how these factors are likely to shape their purchasing choices in the future. For example, in some parts of the world celebrity chefs are engaged with government and the fishing industry to communicate via television and books the issues relating to sustainability, influencing some consumers to choose certain seafood products over more vulnerable fish stocks.

Why carbon neutrality?

Earth's climate is changing at an unprecedented rate. Temperature is changing most, and changing fastest. Higher temperatures are in turn causing cascading changes to fundamental parts of Earth's environment, such as rising sea levels and altered rainfall patterns. These changes are now rearranging Earth's biota in diverse ways, from expanding the geographical ranges of disease-bearing mosquitos to causing mass mortalities of key habitats such as coral reefs. In the ocean, changes have included movement of some species' ranges towards the poles, and mortality of species at their warmer range limits. In Australia, mortality (and some localised extinctions) of critical habitat-forming kelps, seagrasses, corals and mangroves has occurred (Thomson et al. 2015, Wernberg et al. 2016, Hughes et al. 2017, Lovelock et al. 2017), alongside episodic mortality events of species valued by fishers (Caputi et al. 2014). The Australian seafood industry has already been adversely affected by these events, and further negative consequences are likely (e.g. Caputi et al. 2016).

Scientists now have very high confidence that the rising global temperatures are directly caused by increasing concentrations of "greenhouse gases" (GHG: so-called because they act like a greenhouse, by absorbing infrared radiation reflected off the Earth's surface, causing the atmosphere to be warmer than it would otherwise be). Carbon dioxide (CO_2) is the biggest single contributor to warming, because it is so abundant in the atmosphere, and concentrations are increasing as a direct result of burning fossil fuels.

In a concerted global effort to minimise the effects of climate change, 195 nations (at July 2018) have signed the Paris Agreement, which set a unified goal of limiting global warming to "well below" 2°C above "pre-industrial" levels (although "pre-industrial" is not actually defined: Schurer et al. 2017), and to make an effort to constrain warming to 1.5°C. By way of reference, Earth is already around 1°C warmer than it was between 1850 and 1900 (IPCC 2018). The Paris Agreement allows each nation to implement their own measures — primarily directed towards reducing the amount of GHG, especially CO_2, emitted into the atmosphere.

However, even if all the currently pledged activities occur as promised, they will not reach the goal of limiting global warming to 2°C, but rather global temperature is likely to increase by 2.6-3°C (Rogelj et al. 2016). There is an estimated emission reduction shortfall of around 11-14 Gt of CO_2e by 2025 (www.climateactiontracker.org). (CO_2e is carbon dioxide equivalent, which means the amount of warming expected from one tonne of CO_2, and which is used as a standardised way of measuring the warming potential of different GHG).

Among the diverse ways that we can address this shortfall, nature-based solutions — using natural ecosystems to help us tackle global problems — play an important role. Such solutions include restoration of degraded ecosystems to increase CO_2 uptake (which happens naturally, because plants need CO_2 for photosynthesis), and reducing rates of habitat loss, which in turn reduces the amount of GHG emitted into the atmosphere. Such solutions have been used on land for some time, for example by planting trees. However, coastal "blue carbon" ecosystems — seagrasses, mangroves and tidal marshes — have been used much less, even though they tend to sequester more carbon than their land-based counterparts and accumulate carbon at a rate that can be up to an order of magnitude higher (McLeod et al. 2011).

Blue carbon is organic carbon that has been sequestered (that is, stored in a way it isn't released into the atmosphere) by seagrasses, mangroves or tidal marshes. These coastal marine plants can grow quickly, and contain a lot of carbon in their roots, rhizomes (which are like underground stems), branches and leaves. When parts of the plants die (say, when leaves fall) some of the dead plant matter is buried in the soil underneath; as the plants grow they accumulate the soil, so that the soil builds upwards. Because of the low oxygen in this waterlogged soil, the carbon decomposes extremely slowly, and so the buried carbon can (if left undisturbed) be stored for millennia, unlike carbon in soils on land which decomposes more rapidly. The low decomposition rates, combined with the accumulation of soil, allow blue carbon habitats to build up carbon stocks that are much higher than those on land.

These same blue carbon ecosystems — seagrass meadows, mangrove forests and tidal marshes — also provide many other benefits. Fishers have known for a long time that these ecosystems provide a nursery in which juveniles of sought-after species can grow, taking advantage of the food available and the shelter they offer. They also protect the coast by dampening the worst effects of storm waves and even tsunamis, and can improve water quality by filtering particles — including plastics and other pollutants. In some places they provide raw materials, like fibres and wood.

Carbon finance

Carbon markets and international climate policy

Carbon markets provide an incentive to reduce carbon emissions by putting a price on them. Carbon markets allow trading of both emission permits (which represent the legal right to emit GHG), and carbon offsets (which represent carbon emissions avoided or removed from the atmosphere). Confusingly, the term carbon credits is loosely applied to both in different circumstances.

Emission permits can be generated via legally-binding commitments (e.g. emission reduction commitments enacted into law by governments) or received as part of cap-and-trade emission reduction schemes. Under a cap-and-trade approach (an example is California in the USA), regulators limit the total volume of emissions allowed (the “cap”), issue emission permits equal to the cap, and allow the permits to be traded.

Carbon offsets can be generated through projects that reduce emissions (such as through renewable energy), or enhance carbon sequestration (such as through reforestation). In these types of market schemes, polluters have economic incentives to implement cleaner technologies.

Carbon market mechanisms were first generated within the context of the Kyoto Protocol (an international treaty adopted in 1997 that commits signatory countries to reduce GHG emissions). Within the Kyoto Protocol three mechanisms were implemented to help countries meet their targets:

- International Emissions Trading (IET), designed to encourage the flow of emission permits and carbon offsets from countries with low costs to countries that have exceeded their emission commitments (an example is the European Union Emission Trading Scheme, which is implemented as a cap-and-trade scheme);
- the Joint Implementation mechanism (JI), designed to allow so-called industrialised countries to invest in emissions reduction projects in other industrialised countries; and
- the Clean Development Mechanism (CDM), designed to promote emission offsetting through projects implemented in developing countries.

Among the Kyoto Protocol mechanisms, the CDM has issued the highest number of certified emission reductions to date (around 1.9 billion tons of CO_2e), with around 8,100 projects in 111 developing countries, and US$300 billion in total investment (UNFCCC 2018). However, the high costs to get a project approved within the CDM, estimated between US$50,000 to US$250,000 (Bayon et al. 2007), have favoured investments in large-scale, low-cost, and long-term emission reduction projects (Wu et al. 2017). As a consequence, around 85% of the projects within the CDM are energy and waste management projects; and around 1% are afforestation or reforestation projects (UNFCCC 2018). Further, CDM projects do not require important provisions like safeguarding principles, local stakeholder engagement, or sustainable development benefits. Opportunities for blue carbon offsets have been rare, with only one project (mangrove afforestation in Indonesia) so far receiving CDM certification (https://cdm.unfccc.int/Projects/Validation/DB/Q94TKNG9V6GRFOTRKPLWDV2GHBCFWW/view.html).

Under the Paris Agreement, all Parties are required to define national emission reduction targets (called Nationally Determined Contributions: NDCs) and implement strategies to achieve them. Three mechanisms are being developed, including the CDM and JI. The third is the Sustainable Development Mechanism (SDM), a market-based platform for the international transfer of mitigation outcomes (ITMO) (Article 6.4). The ITMO is expected to certify that the creation or transfer of emission reductions does not generate a net increase in global emissions or environmental damages, and follow mechanisms to prevent double counting. Negotiators are currently exploring market-based mechanisms under Article 6 of the Paris Agreement, and are also considering provisions to prevent double counting or claiming of emission reductions by multiple entities.

Another relevant international policy framework is the Nationally Appropriate Mitigation Actions (NAMAs), which were introduced at the United Nations Climate Change Conference in Bali in December 2007. NAMAs consist of structured policies and actions implemented by developing countries to reduce GHG emissions and promote sustainable development. Developed countries have committed to support NAMAs through technology transfer, financing and capacity development. Funding has been dispersed through the NAMA Facility and more recently through the Green Climate Fund. While the number of developed NAMAs has been growing, only 9% of the registered NAMAs are in the implementation stage. According to Gardiner et al. (2015) there are not enough projects ready to access available funds. Some countries have included blue carbon conservation and restoration efforts in their NAMAs (e.g. the Dominican Republic) and this option can offer significant opportunities for some countries.

Least developed countries can also submit to the UNFCCC National Adaptation Programs for Action (NAPAs) and National Adaptation Plans (NAPs) detailing the activities needed and implementation strategies to adapt to climate change. Blue carbon ecosystems are part of the adaptation component of multiple NAPs and NAPAs (Herr and Landis 2016).

An additional framework for reducing and avoiding carbon emissions is REDD+ (Reducing Emissions from Deforestation and forest Degradation, which is intended to foster conservation, sustainable management of forests and enhancement of forests carbon stocks), which was introduced and modified over several years from 2005. REDD+ is a framework for forestry-based emission reduction efforts that contribute to climate change mitigation. It has some potential to provide opportunities for blue carbon projects, particularly those that occur in mangrove forests (Ajonina et al. 2014, Ahmed and Glaser 2016). In fact, if a country was to define mangroves as forests, their conservation and restoration could be included in REDD+ (Herr and Landis 2016).

Voluntary carbon markets

Growing awareness and concern about the social and economic costs of climate change have motivated a voluntary market in carbon offsets from entities (e.g. companies, governments, individuals) without legally-binding emission reduction requirements. Almost all offsets traded in voluntary carbon markets undergo third-party verification. The most widely adopted verification standards are: the Verified Carbon Standard (VCS), the Gold Standard, Plan Vivo, and Climate Action

Reserve (Hamrick and Gallant 2017). Once verification is achieved, the standard issues each credit (equivalent to one tonne of CO_2e) a unique identifier. Each registered credit can be traded multiple times (e.g. by resellers) and is labelled as "retired" when a buyer purchases it to offset their emissions (Hamrick and Gallant 2017). While seemingly complicated, this process avoids using the same carbon offset to demonstrate compliance with emission reduction targets by more than one entity (i.e. double counting). Under the Paris Agreement the risk of double counting is higher since all signatory Parties (nations) have agreed to reduce their emissions and maintain a national emission inventory to track their performance against NDCs. In this context, new procedures will be needed to avoid the double counting of voluntary emission reductions within the national emission inventory of project host countries and the emission offsets reported by purchasing nations (Gold Standard 2018).

Carbon offset prices in voluntary markets are influenced by project-specific characteristics (such as cost of implementation, or location), buyers' preferences (such as whether the project meets other socioeconomic or environmental objectives), and transaction volumes (i.e. large-scale transactions typically occur at lower prices than small-scale offsets trading). Historically, offset prices in those markets have ranged between US$0.1 to US$70 per ton of CO_2e, a trend that has continued during the first quarter of 2018 (Hamrick and Gallant 2018).

Voluntary carbon markets have contributed to offsetting around 440 $MtCO_2e$ (million tons of CO_2e) from 2005 until the first quarter of 2018 (Hamrick and Gallant 2018)—this represents around 23% of the total volume of CDM offsets. Compared to compliance markets, voluntary markets are a more flexible alternative for developing new carbon offset technologies and methods. In addition, their low transaction costs have facilitated the development of small-scale projects and a more balanced investment portfolio across multiple sectors (Seeberg-Elverfeldt 2010). Blue carbon financing has originated mainly from these type of markets (Wylie et al. 2016) and voluntary markets currently remain the only option for buyers seeking blue carbon offsets in Australia.

Voluntary markets have channelled around US$380 million per year on average between 2010 and 2016 into carbon offset efforts (Hamrick and Gallant, 2017). However, the value of voluntary offsets has declined since 2011 despite increasing or steady transaction offset volumes.

The Australian context

As a signatory Party to the Paris Agreement, Australia has committed to reduce total emissions by 26-28% below 2005 levels by 2030. As of 2018, the main policy mechanism to achieve this target is the Emissions Reduction Fund (ERF), which provides for carbon offsets (not emission permits). The ERF provides incentives for Australian entities (which can include businesses, farmers, fishers, landholders, local councils and more) to reduce GHG emissions. Domestic emission reduction projects can earn Australian Carbon Credit Units (ACCUs) that can be sold to the Australian government or to other organisations. As of 2017, the ERF had emission offset contracts for 192 $MtCO_2e$ from 438 projects at a cost of AU$2.29 billion (AU$11.97 per tCO_2e) (Department of the Environment and Energy 2017). Around 75% of the total emission reduction comes from vegetation management and agricultural projects. In 2016, the Australian Government established the Safeguard Mechanism to limit the emissions of the 140 largest polluting businesses in the country to guarantee that the emission reduction effort funded through the ERF is not counteracted by increased pollution in other sectors of the economy.

The Australian Government has also developed the National Carbon Offset Standard (NCOS) to guide the measurement, reduction, offsetting, reporting and audit of voluntary carbon market initiatives implemented across multiple sectors. Best-practice guidelines have been developed for organizations (e.g. businesses, cities), products and services, events, precincts and buildings. Multiple Australian organizations (including Austral Fisheries, Qantas and Virgin Australia) have a range of carbon neutral products and services under the NCOS guidelines (Department of the Environment and Energy 2018). The NCOS also offers guidelines for Australian States and capital cities pursuing voluntary emission reduction targets (Energetics 2017).

According to ClimateWorks (Anon 2018a), Australia's 2017 GHG emissions were around 11% lower than 2005 levels, a result of significant reductions in land clearing and increasing afforestation. However, due to increasing industry, building and transport sectors emissions, Australia needs to double its total emission reductions to achieve its commitment to the Paris Agreement. In addition around 90% of the ERF budget has been allocated which highlights the need for additional domestic emission offsetting mechanisms.

International uncertainties and opportunities

So far, neither compliance nor voluntary carbon markets have been able to set prices that are high enough to incentivise meaningful levels of mitigation action. The International Monetary Fund estimates that carbon prices must increase to over US$70 per ton of CO_2e by 2030 to incentivise the investment needed to achieve the Paris Agreement targets (Antonich 2018). Such a price would be a large increase relative to the average prices of around US$5 per ton of CO_2e recorded in voluntary markets during the first quarter of 2018 (Hamrick and Gallant 2018). If carbon prices reflect the social costs of carbon emissions (van den Bergh and Botzen 2014) and reach the levels estimated by the IMF, blue carbon projects could become a significant investment opportunity even for the private sector.

Some additional emission offsets demand could develop over the next few years as a result of several major agreements pertaining to emissions from the transport sector. The International Civil Aviation Organization (the United Nations agency that sets standards for international flights) adopted the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) in 2016 to pursue carbon neutral growth from 2020. Although participation in the scheme is voluntary until 2026, countries representing more than 80% of international air traffic have already signed up (Crooks et al. 2017). CORSIA has potential to mobilise financial resources for climate change mitigation and adaptation projects in other sectors, including blue carbon projects.

In addition, in April 2018 the United Nations International Maritime Organisation (IMO) pledged to reduce GHG emissions from shipping by at least 50% by 2050 relative to 2008 levels. The international shipping industry accounts for around 2.3% of the global CO_2e emissions (slightly higher than the emissions from the aviation industry; Tollefson 2018). The regulatory framework for this target is not expected to be completed until 2023.

Carbon as an ecosystem service

Sequestration of carbon by blue carbon ecosystems is just one of a suite of "ecosystem services" — that is, the benefits that people derive from natural ecosystems. Other services that blue carbon ecosystems provide include enhancement of fisheries production (they provide both habitat and food to numerous species that people eat), protection of shorelines (they tend to dampen the effects of waves and currents that would otherwise erode the shore), and filtering water (by slowing water flow, they allow particles to settle to the bottom).

The fact that a single ecosystem can provide multiple services in this way has led to the development of Payments for Ecosystem Services (PES) as a financial mechanism to allow buyers to make payments to ensure that actions are taken to maintain or enhance the desired service.

PES can be introduced to the market in two distinct ways: bundling and stacking (Jenkins 2011). *Bundling* is when multiple services are combined into a single unit. One advantage of this is that it might generate a higher price. *Stacking* is when services are sold as separate units. An advantage of this approach is that multiple payments can be generated from the same ecosystem, which might also confer some resilience against the risk of declines in any individual market. However, without proper provisions this approach can violate the principle of *additionality* — that is, an action that would not otherwise have occurred — which is an essential criterion for carbon offsetting (Cooley and Olander 2011). In practice, stacking is rare, and bundling benefits is the norm.

There are several standards that exist to verify the carbon, biodiversity or other benefits of a project. In this context, a standard is a set of criteria which must be followed, and which conform to international requirements (in the carbon context, that carbon benefits are real, additional, measurable and verifiable: Hamrick and Gallant 2018). These standards typically provide certificates that provide assurance — say, to buyers of carbon offsets — that the project complies. The seafood industry will be familiar with this general model, because it is applied in the context of fishery sustainability: for example, the Marine Stewardship Council has a series of standards against which fisheries can be certified.

The main contemporary standards for voluntary carbon markets are (in relative order of volume of carbon offsets): Verified Carbon Standard (one of several standards now managed by Verra), Gold Standard, and Plan Vivo (Hamrick and Gallant 2018). Of these, only Verified Emissions Reductions (VERs) issued by the Gold Standard and Verified Carbon Units (VCUs) issued by the Verified Carbon Standard are eligible offset units under Australia's National Carbon Offset Standard.

Gold Standard certification, and VCS when combined with CCB, provides some assurance that benefits will be broader than just carbon, a characteristic that arose from concerns that focus on carbon alone allowed perverse outcomes in which social or environmental outcomes might be reduced in the presence of carbon offsetting (Bernstein et al. 2010). However, typically these social or environmental outcomes are not currently issued separately as tradable commodities, and so are not sold — rather, the standards simply ensure that the methods used in generating the carbon benefits also lead to the additional benefits. One exception is the Gold Standard Averted Disability Adjusted Life Years (ADALY), which is a measure of the increase in health and life expectancy expected from a given action, namely improvements in household cooking fuels and appliances in poor communities; these can be tradable assets in the same way as VERs.

Guidance on the methods used to validate the additional benefits are not typically as prescriptive as the methods used to validate the carbon offsets. In the case of CCB, the biodiversity and social benefits are assessed by methods outlined in Richards (2011) and Pitman (2011). The validation methods have been developed for land-based projects, and their applicability to blue carbon projects remains little explored, although in principle they can be applied. The validation methods do not explicitly account for some of the co-benefits that are likely to be of greatest interest to the Australian seafood industry (e.g. enhanced fish habitat).

Blue carbon projects in Australia

Unlike many of the relatively large efforts to restore blue carbon habitats globally (e.g., Kenya, India, Vietnam, and Madagascar; Erwin 2009) the number and spatial extent of restoration efforts in Australia is typically small. In this section, we review efforts focussed on blue carbon restoration in Australia, with a brief overview of strategies for protection and conservation. Of the 121 studies identified through a preliminary review of the published literature (using Web of Science), government documents and websites, only 50 provided information on the methods (e.g. number of plants or propagules planted), spatial extent (e.g. hectares covered) or gave some measure of successful outcomes (e.g. survival, or restoration of ecosystem function).

Number and extent of activities relevant to blue carbon

Activities to enhance the maintenance or recovery of blue carbon ecosystems can be broadly divided into three main strategies (Figure 2):

- avoidance: preventing further losses of existing habitat through conservation and harm minimisation (i.e., restricting or preventing harmful activities that can adversely affect ecosystems);
- restoration: the process of recovering an ecosystem that has been damaged, degraded, or destroyed through natural or human interference; and
- rehabilitation: the reestablishment of ecosystem processes, services and productivity that does not involve an attempt to restore the ecosystem to its pre-existing state (e.g. establishment of wetlands in areas where they did not previously exist to generate benefits such as fisheries production).

Of these, avoidance is the optimal strategy, because preserving the carbon already stored in these systems is the most effective way of minimising GHG emissions to the atmosphere. The other two strategies involve recovering ecosystem attributes that have been lost or degraded. Restoration can be particularly effective in areas that have been degraded as a result of changes in land-use (e.g. restoration of abandoned aquaculture sites). Together, restoration and rehabilitation encompass a wide range of activities, such as hydrological restoration (e.g. by removing levees) and active revegetation programs (e.g. by planting). The following sections will provide a summary of activities in Australia that relate to these three strategies in the context of blue carbon ecosystems.

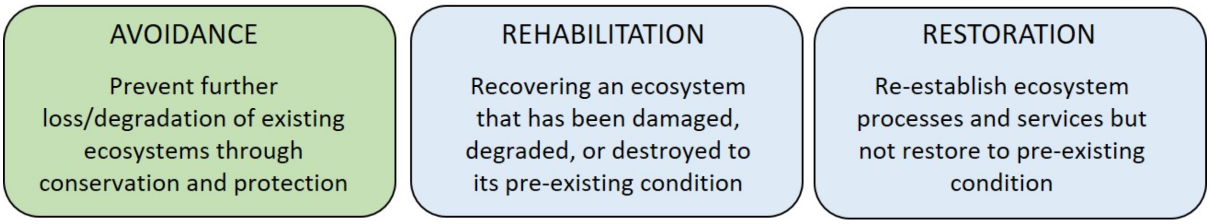

Figure 2: The three strategies for maintaining or recovering blue carbon ecosystems. Green indicates actions that avoid GHG emissions, while blue relates to actions that enhance sequestration of CO_2.

Avoidance and restoration

In Australia, significant steps have been taken toward protecting blue carbon habitats. Avoiding loss can be facilitated by reducing risks (e.g. preventing or reducing activities that can harm ecosystems) or through spatial management approaches, such as protected areas (Barbier et al. 2011). Coastal lakes and estuaries are largely managed by state and territory governments with significant areas of mangroves, seagrass and tidal marsh present in various types of marine and coastal protected areas.

Major losses of coastal wetlands globally have been the result of changes to natural hydrology (e.g. freshwater diversion and the construction of levees) as well as the widespread conversion of coastal land for farming and aquaculture (e.g. see Gorman 2018 for a review of the South American experience). In light of this, one of the more cost effective forms of restoration is the reestablishment of optimal hydrological conditions (e.g. by reducing wave exposure or re-establishing natural tidal flow). This type of intervention has proven particularly effective for aiding the restoration of mangrove forests (Lewis 2005) and tidal marshes (Zedler 2000) because it facilitates natural recruitment and growth. Numerous activities are currently underway, such as the

Reef Trust Investment Strategy (http://www.environment.gov.au/marine/gbr/reef-trust/investments/approach) which includes $5 million to Greening Australia to restore priority wetlands along coastal the Great Barrier Reef. A recent report by the Commonwealth of Australia (Anon 2018b) outlines avoidance and restoration initiatives across the country, including the protection of 600 ha of wetlands including saltmarsh in New South Wales, and upgrades to the water quality of managed wetlands in South Australia to reduce the impacts on nearshore habitats such as seagrass meadows.

Another innovative approach, especially in the context of minimising the environmental footprint of port developments, is the augmentation of wetlands that did not previously exist (akin to terrestrial afforestation). A recent study in Port Hedland, Western Australia involved the construction of a 75 m-long tidal creek (approximately 1000 m^2) into which 800 nursery-raised mangrove seedlings were planted. The survival rate after 3 years was 18%, however there was significant recruitment of another 1171 mangrove seedlings to the site (Erftemeijer et al. 2018). In Queensland, integrated restoration activities that include both mangrove introductions (~7000 seedlings) and saltmarsh protection are being led by indigenous communities groups (e.g. the planned Kolan and Burnett river projects overseen by Gidarjil Development Corporation).

Another action that can increase the resilience of blue carbon ecosystems and aid natural recovery is the removal of certain stressors (Erwin 2009). Restoration of seagrass meadows for example, can benefit from improvements to water quality, such as reducing nutrient (e.g., from agriculture and sewage) and sediment inputs (e.g., from erosion and dredging). One strategy that is aiding the recovery of coastal wetlands in northern Australia is fencing of wetlands to prevent the damaging influence of cattle and feral pigs (Waltham and Schaffer 2017).

Revegetation programs

While avoidance and restoration are major tools in the fight to maintain and recover blue carbon ecosystems, it may be sometimes necessary (or even desirable) to intervene through targeted revegetation (active planting). However, current domestic revegetation efforts are unlikely to meet even moderate increases in the appetite for revegetation in Australia (Figure 3). Most involve small-scale scientific studies lead by universities, NGOs and community or local government groups. Compared to the number of studies involving avoidance or hydrological restoration, active revegetation projects are few (Figure 3). As highlighted earlier, few studies provide the most basic information on the planned and realised size of blue carbon projects which limits assessment of their impact and investment potential.

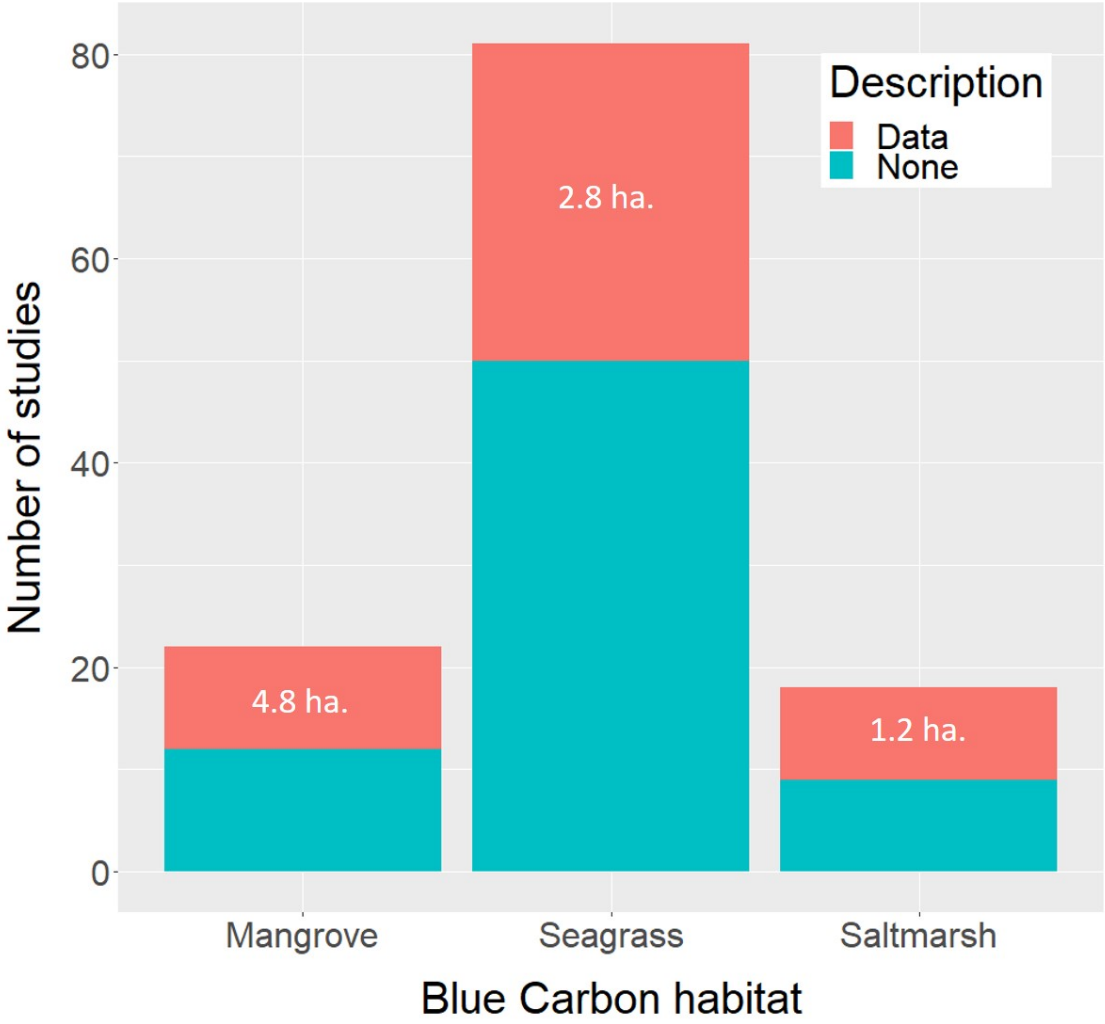

Figure 3: Comparison of the number of restoration studies in blue carbon habitats in Australia that provide a description of outcomes ('Data') versus those that do not ('None'). Numbers inside the bars indicate the mean area in hectares for the subset of studies that explicitly report this.

Restoration and revegetation of blue carbon habitats

Historically the majority of revegetation programs have been situated along the more populated southern coastline of Australia (Figure 4). Western Australia and South Australia have the greatest number of revegetation projects (although this is driven by intense activity at a few selected locations), followed by Victoria and New South Wales, and Queensland (although activities are likely to intensify given renewed focus on reducing damage to the Great Barrier Reef through the Remember the Reef campaign and the Queensland Land Restoration Fund). At present there are no known restoration activities in the Northern Territory.

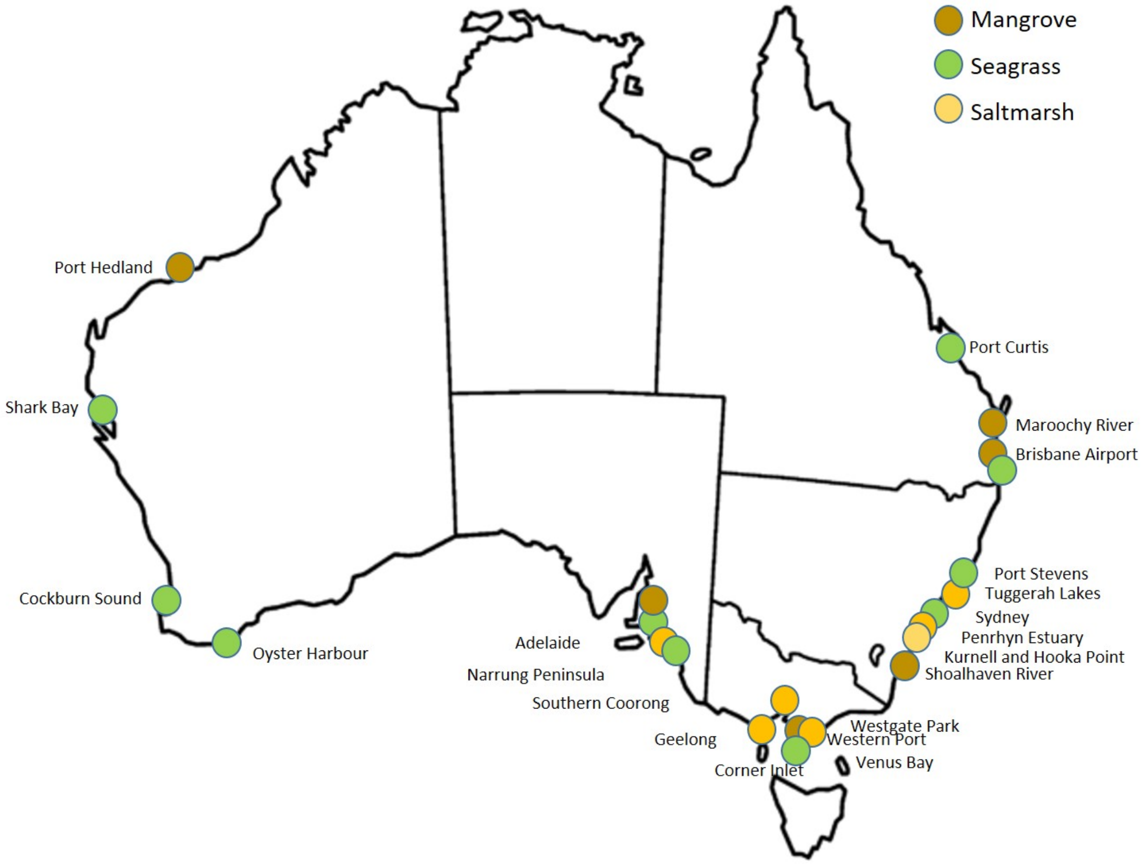

Figure 4: Map of Australia showing sites of significant blue carbon restoration programs

Mangroves

Although mangrove planting has a long history in Australia (at least since the 1970's), most of these early efforts were done with the goal of shoreline stabilisation and/or protection of other habitats (e.g., to conserve seagrass meadows in Western Port Bay; Kirkman and Boon 2012). Probably the most ambitious (but now widely overlooked) project involved the revegetation of ~11 ha of mangrove forest (including 50,000 *Avicennia marina* and *Aegiceras corniculatum*) as part of the Brisbane Airport redevelopment in the 1980's (Saenger 1996). Another more recent project was undertaken in the Port River estuary (north of Adelaide, South Australia) by the Australian Marine Wildlife Research & Rescue Organisation (AMWRRO). This project, supported by industry and government, involved the planting of 500 *Avicennia marina* trees and has successfully revegetated a total area of 3.7 ha (http://www.amwrro.org.au/news/grey-mangrove-revegetation-success).

Seagrasses

The science behind seagrass restoration in Australia is at the forefront of global efforts (particularly in Western Australia) with a number of successes promoted through the Seagrass Restoration Network (https://seagrassrestoration.net/success/). The difficulty in working in a submerged environment however, means that it has remained a challenge to develop single discrete techniques that delivers cost-effective, scalable revegetation (Statton et al. 2012). Because of this, there are a variety of approaches that range from passive recovery (Tanner and Theil 2016), to transplantation (Bastyan and Cambridge 2008) and direct planting (referred to as 'underwater carbon farming'; https://seagrassrestoration.net/thenetwork). Efforts may be targeted within existing unvegetated or degraded habitats or remnant seagrass matte (fibrous material left behind after seagrass dieback). Together these approaches have been used in a variety of programs which have demonstrated small-to-medium scale successes (<1 to 60 ha), some of which have been ongoing for several decades (Marba et al. 2015).

In South Australia, efforts to address the historical loss of ~6,200 ha of seagrass from the Adelaide coast have tested various seagrass restoration approaches (Tanner 2015). Initial efforts with transplantation and the introduction of seedlings yielded limited success, so trials using sand-filled hessian bags to facilitate natural recruitment of *Amphibolis* seedlings were conducted (Wear et al. 2010). Subsequent work trialled a range of different deployment options in 2004, with a standard hessian sack filled with around 20 kg of sand being selected for most subsequent work. These bags can simply be dropped off a boat and do not require any further manipulation by divers, making this approach easy and cheap to deploy (Tanner et al. 2014). Both *Zostera* and *Posidonia* seagrasses have recruited into patches of restored *Amphibolis* providing habitat for fish and crustaceans.

An emerging approach to seagrass restoration mirrors terrestrial broad-scale seeding and has the potential to greatly expand restoration efforts. The approach (headed by researchers at the University of Western Australia) aims to streamline seed collection and processing to produce large quantities of viable seeds that can be deployed to areas earmarked for revegetation programs. Currently, a two-year pilot-scale seeding trial has established seedlings to the juvenile stage (2 years old) with 1-2 plants established every square meter that are showing good development and growth (Figure 5). One advantage of this approach is that it represents a cost-effective way of restoring large areas in remote or technically challenging locations (e.g., northern Australia).

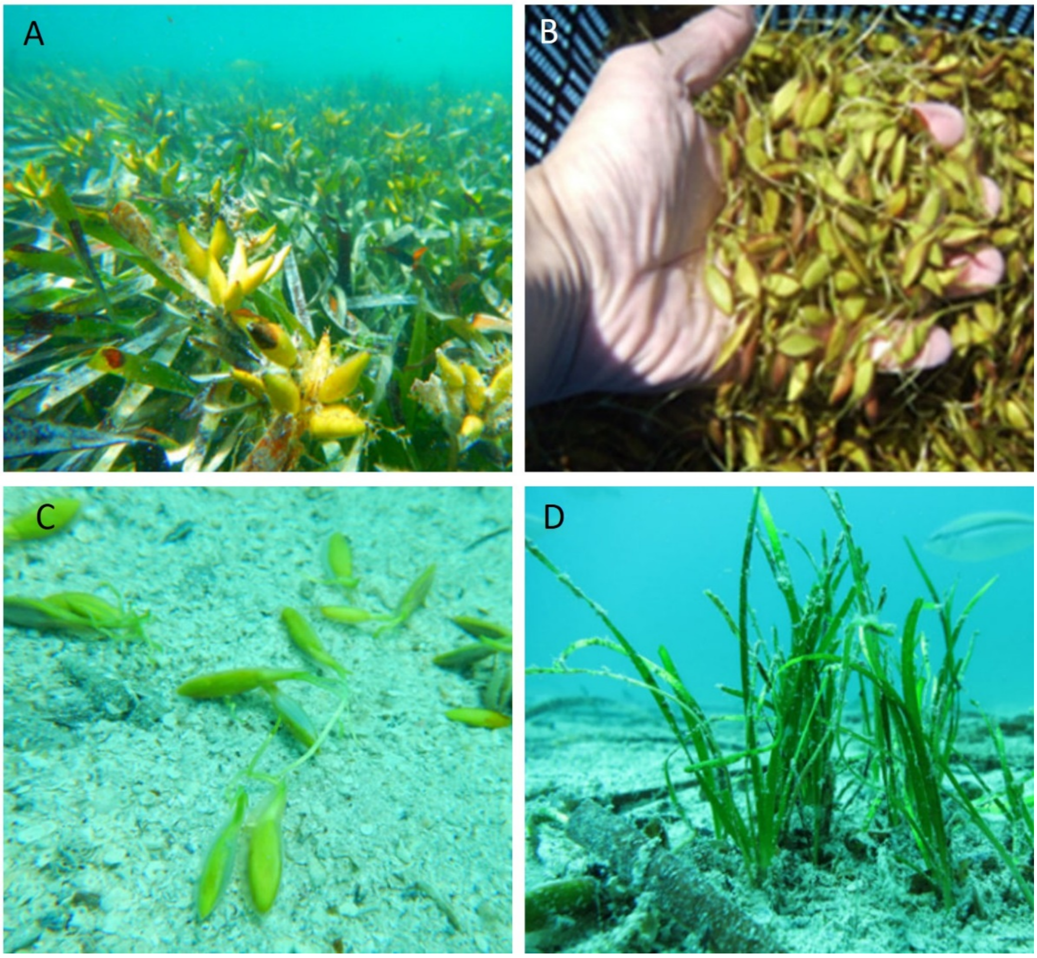

Figure 5: Selected stages of the seed-based restoration of seagrass (*Posidonia australis*) in Cockburn Sound, Western Australia; (A) mature clusters of fruit, (B) collection of clean seeds from an aerated tanks, (C) seedlings with a

developing shoot, and (D) 3-4 month old seedlings. Photos used with permission by John Statton, with figure modified from the 'Seagrass Restoration Network' (SRN) Australasia website (http://seagrassrestoration.net/).

Tidal marsh

Australia's tidal marshes have suffered significant losses but their recently acknowledged capacity for CO_2 sequestration is creating opportunities for protection and restoration (Macreadie et al. 2017). Indeed, Australia's 1.4 million ha of tidal marshes contain an estimated 212 million tonnes of organic carbon in the metre immediately below the surface. This realisation and the relative ease by which actions can be taken to restore them (high tidal elevation) means that these blue carbon systems hold considerable promise as a means of carbon offsets (indeed they have recently been included as part of South Australia's 'Carbon Sequestration strategy': https://www.environment.sa.gov.au/topics/land-management/sustainable-soil-land-management/carbon-sequestration).

Tidal marsh restoration typically involves mitigating the historical damage caused through inappropriate land-use (e.g., grazing or industrial development). Well-documented examples in Australia include revegetation of the Homebush Bay Olympic site (Burchett et al. 1998), Penrhyn Estuary in New South Wales (https://www.portauthoritynsw.com.au/sustainability-and-environment/penrhyn-estuary-rehabilitation/) and protection of existing wetland habitat on Narrung Peninsula indigenous lands in South Australia (https://www.greeningaustralia.org.au/20-million-trees-benefiting-south-australias-environment-and-economy/). Ongoing improvements to the health of saltmarsh ecosystems in both tropical and temperate Australia are likewise being achieved by removing ponded pastures, cattle, weed and feral animals, and by restoring natural saltwater inundation (activities headed by TropWATER in QLD and the Goyder Institute in SA).

State of restoration science

As demonstrated in the previous section, the science underlying blue carbon restoration globally, and in Australia, is advancing rapidly. Survival rates for recent projects are reaching 50% (Erftemeijer et al. 2018). This makes investing in projects less risky and more attractive as an alternative to terrestrial options. A major constraint for investment derives from the uncertainty in potential return on investment (i.e. carbon sequestered per dollar spent), driven by the failure to report the full cost of implementing and monitoring specific projects (including: materials, stock and labour), their scalability (hectares) and success over the medium to long-term (survival and time to maturity).

Discussions during the workshop emphasised the urgent need to begin medium-to large scale pilot studies. Efforts need to be focused on cataloguing potential sites for large-scale pilot studies (and commercial projects) across Australia. Our review also highlights the need for improved data on the outcomes of recovery programs, including on the time taken to generate measurable benefits. The majority of projects have favoured very simple approaches, such as direct planting of a few mangrove species (often in the lower intertidal, where mangroves, do not typically grow naturally). These lower intertidal mudflats are often targeted for rehabilitation because true degraded mangrove forests are frequently linked to tenure issues that require significant effort and investment to resolve, with outcome varying according to habitat, regional and watershed characteristics (Wylie et al. 2016).

Overall, the scale of blue carbon projects in Australia is small (typically <8 hectares) and mostly dominated by hydrological restoration options rather than direct intervention measures (such as planting). Outcomes are typically hard to gauge, given the widespread omission of detailed methods, success rates and total area restored. Many of the active planting initiatives involve a single species (i.e., monoculture) and there have been few efforts to measure the return of ecosystem services. However, restoration science for blue carbon ecosystems is improving and the scale of projects is growing.

Revegetation costs can vary among blue carbon ecosystems, and locations i.e., developed vs. developing countries; Bayraktarov et al. 2016). Projects in developing countries are likely to have significantly lower costs than those in the developed world. The effort and financial costs required for projects will also strongly depend on the habitat considered, issues of tenure, site location (i.e., remoteness) and the availability of cheap labour (Table 1).

Table 1: The mean cost of restoration/revegetation according to blue carbon ecosystems and economy type. Data taken from Bayraktarov et al. (2016), with estimates for Australia taken from the supplementary data table supplied with the online article. Numbers in parentheses are the number of studies from which the estimates were derived.

Cost/ha ($AUD equivalent)		Mangrove	Seagrass	Tidal marsh
Location	Global	$12,465 (109)	$148,534 (64)	$93,375 (73)
	Developing	$ 5,574 (55)	No data	$1,657 (50)
	Australia	$16,314 (5)	$288,080 (16)	$38,216,637 (2)

Acknowledgements

We would like to thank all the participants of the workshop for the free and frank exchange of ideas that contributed to this report and the FRDC, especially Nicole Stubing and Patrick Hone, for supporting the workshop. Brett McCallum was not only an excellent Chair, but provided thoughtful and useful feedback on the draft report. While writing the report, David Shelmerdine (Gold Standard), John Holler (Verra) and Leah Glass (Blue Ventures) generously answered questions, for which we are grateful. Clayton Nelson, Rhys Arangio and Sarah Leugers provided useful comments on the draft report.

Appendix 1: Workshop summary

The "Blue Carbon for the Australian Seafood Industry" workshop was held in Adelaide, South Australia on 19-20 July 2018. The meeting was chaired by Brett McCallum and attended by 15 participants spanning the seafood industry, government departments (DFAT and DEE), NGOs and research (CSIRO). Plenary sessions were held on the two days, with a total of 9 presentations by speakers representing all stakeholder groups. Brett McCallum opened the workshop by posing the question: "Why are we here?", before offering the goal of gauging the level of industry commitment to greater sustainability and contributing toward the generation of a "road map" that could lead to carbon neutrality (as a broader industry goal). There was also discussion on:

"What are the necessary steps to facilitate this goal?",

"How would industry benefit from being carbon neutral?",

"What are the opportunities, risks and benefits?" and

"What are the scale and costs?".

Mat Vanderklift gave the first plenary on the evolution of blue carbon accounting systems in Australia, and how investment in blue carbon is being facilitated in other countries (IPCC, Kyoto, Paris). He then discussed the challenges from rapid climate related changes to blue carbon ecosystems through phenomena such as marine heatwaves (i.e., documented losses of kelp and seagrass). Andy Steven then presented on the need for stakeholders to understand the language of blue carbon and clarified some of the commonly misunderstood terms. Raymundo Marcos-Martinez followed with a presentation on the blue carbon financing mechanisms, highlighting how $350 billion is needed for climate finance, but presently we are not even close to this target (only 52 billion), with most of this being publicly-funded. There was some recognition that carbon off-sets have become cheaper (good for buyers), mainly due to oversupply driving down emission offset prices. In such context, the differentiation of blue carbon offsets (highlighting their co-benefits) could help achieve price premiums.

Prior to breaking for lunch, Patrick Hone asked why carbon neutrality in general, and blue carbon options in particular would be of interest to the Australian seafood industry. He highlighted its importance to sustainability, the potential cost savings (e.g. in energy expenditure), and the value of branding.

Following lunch, Mat Vanderklift provided further background into the certification providers Gold Standard (1 project in Australia) and the Verified Carbon Standard (4 projects in Australia). He also discussed Payment for Ecosystem Services (PES) and the co-benefits. He outlined an example of a Plan Vivo project in Madagascar, where villagers receive payment for revegetating mangroves (need to have social and environmental benefits to fisheries). Mat then reminded delegates that there is currently no scheme that accredits blue carbon offsets in Australia.

Daniel Gorman followed up on this theme with a presentation on current activities in Australia, highlighting the small number of projects and the low scale of revegetation (typically only a few ha). This opened up a discussion about the need to compile a list of potential larger-scale pilot sites nationally as well as engage more with the typically unreported activities being overseen by ERM groups. Sean Harte then gave an overview of Australian Government initiatives, including the Emissions Reduction Fund.

Clayton Nelson gave attendees the background for Austral Fisheries desire to become carbon neutral, noting that it was not easy, and required considerable investment. John Ford, who has recently been involved in the National Seafood Industry Leaders Program (NSILP), discussed how to advance the idea of blue carbon (and habitat protection). He summarised the challenge that the NSILP set the Seafood Industry to be carbon neutral by 2030. John also highlighted the link between blue carbon ecosystems and fisheries habitat restoration.

The remainder of the workshop comprised discussions in plenary, at which the ideas and recommendations produced in this report were discussed.

Appendix 2: Workshop attendees

Brett McCallum (Facilitator)
Patrick Hone (FRDC)
Nicole Stubing (FRDC)
Andy Steven (CSIRO)
Mat Vanderklift (CSIRO)
Raymundo Marcos Martinez (CSIRO)
Dan Gorman (CSIRO)
Stephanie Williams (Sydney Fish Market)
Clayton Nelson (Austral)
Matt Pember (WAFIC)
John Ford
Lowri Price (OceanWatch)
Anissa Lawrence (Tierramar)
Heidi Prislan (DFAT)
Vyt Vilkaitis (DEE)
Sean Harte (DEE)

Appendix 3: Workshop agenda

Blue carbon for the Australian seafood industry

19 – 20 July 2018

Adelaide Meeting Room Hire - Level 5, 97 Pirie Street, Adelaide, Australia

Agenda

	DAY 1 – 19 July 2018
08:45	**Arrival and Registration of Participants – Coffee during registration**
09:00	Welcome: Brett McCallum
09:15	Blue carbon science, policy and finance overview: Andy Steven and Mat Vanderklift
10:00	Blue carbon markets: Raymundo Marcos Martinez
10:30	Break
11:00	FRDC's role and goals: Patrick Hone / Nicole Stubing
11:15	Australian government policy: Department of Energy and the Environment representative
11:45	Presentations from industry Clayton Nelson (Austral) Stephanie Williams (Sydney Fish Market)
12:45	Lunch
13:45	Plenary discussion 1: what does the seafood industry want? Introduced by John Ford
14:45	Report back from plenary discussion 1
15:00	Break
15:30	Blue carbon standards, certification and co-benefits: Mat Vanderklift
16:00	Current activities in Australia: Dan Gorman
16:30	Summary: Brett McCallum
16:45	Close
18:30	Workshop dinner: Singh Thai Noodle Bar and Authentic Thai Restaurant

	DAY 2 – 20 July 2018
08:45	**Arrival and coffee**
09:00	Recap: Brett McCallum
09:15	Plenary discussion 2: what are the gaps, and what are their priority?

10:15	Report back from plenary discussion 2
10:30	Break
11:00	Plenary discussion 3: where to from here?
12:00	Report back from plenary discussion 3
12:15	Summary: Brett McCallum
12:30	Close

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FOR FURTHER INFORMATION

CSIRO Oceans & Atmosphere
Dr Mat Vanderklift
t +61 8 9333 6536
e mat.vanderklift@
w https://people.csiro.au/V/M/Mat-Vanderklift