OPPORTUNITIES AND ASSOCIATED VALUE IN CARBON NEUTRAL CERTIFICATION AND ENVIRONMENTAL ACCOUNTS

STRATEGIC REPORT FOR THE AUSTRALIAN OYSTER INDUSTRY

2022

FRDC Project 2021-032

Opportunities and associated value in carbon neutral Certification and environmental accounts
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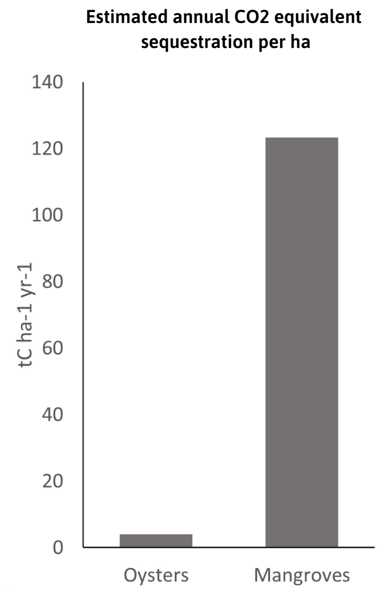
Executive Summary

Now, more than ever, there is a collective desire amongst the community and regulators to see industries move toward more sustainable and integrated production systems and reduce industry carbon footprints where possible. This drive is underpinned by the Australian Government's Paris agreement obligation to reduce net emissions as well as a community expectation that industries reduce their environmental impact footprint as seen most through consumer choice metrics. In order to influence the movement to more sustainable, carbon neutral operations, there are several regulated and non-regulated (voluntary) market mechanisms and certification pathways available to industries. In some instances these mechanisms can provide an industry with additional revenue as a 'payment for carbon capture and storage' and 'payment for ecosystem services'. In all instances they provide an ability to appeal to environmentally conscious consumers.

The Australian seafood sector has been challenged to work towards carbon neutrality and sustainable practices with carbon neutral and sustainability goals included in industry strategic plans. Navigating the regulatory and political landscape for carbon and climate change policy and its application to the seafood industry can be challenging and overwhelming, making it difficult to identify the regulatory need, value for money, return on investment, and subsequent pathway to implementation. Most efforts and approved carbon sequestration, carbon neutral, or ecosystem accounting programs have been land based, despite the value that marine ecosystems are known to play in carbon capture and provision of services. The is due to several factors most notably the complexities in calculating and accurately recording the cradle-to-gate and cradle-to-grave carbon footprints due to marine ecosystem interactions and complexities. However, 2021 saw the first regulatory developments in the coastal carbon space ('blue carbon'), with the Australian Government Emission Reduction Fund (ERF) program announcing funding towards the development of Australia's first 'blue carbon' method for restoring mangroves and tidal marshes which was subsequently approved in January 2022 after a twelve month consultation and method development process. Blue carbon has also been highlighted as a priority area for further development in 2022 which may help provide direction to other marine based projects looking to analyse carbon footprints and sequestration potential.

Oyster farming in Australia has been touted as an area for climate positive investment in sustainable aquaculture, involving zero supplementary feeding, low waste and low GHG emissions per 100g of protein. In addition, it has been widely discussed that the formation of oyster shells may serve as a permanent carbon sink. Oysters consume particulate carbon from their surrounding waters to enable the growth of their outer shells which are made from calcium carbonate, thus removing, concentrating, and storing carbon from the surrounding environment. Regardless of whether the oyster is harvested and consumed, or eventually dies and falls to the ocean floor, carbon is permanently stored within the shell which has contributed to the assumption that 12% of the shell mass can be attributed to carbon sequestration. However, Oysters can also be net-additive where they also release carbon into the surrounding waters through processes such as shell erosion, respiration, and by-products of shell calcification. Because of these ecosystem interactions, there is currently insufficient evidence to support the notion that 12% of the shell mass can be directly linked to a net storage of carbon dioxide linked to the atmosphere. In addition, even if we were to use the 12% figure to estimate potential carbon credit units (1 tonne equivalent of CO_2 removed or avoided) using known harvest quantities across various farms and species in Australia, the volume of reduced emissions is significantly lower than wetland and intertidal systems (such as mangrove rehabilitation) where carbon is both sequestered annually as well as stored in high density in the soil.

Consequently, the development of an ERF method for carbon sequestration through oyster aquaculture is unlikely to be identified as a priority area in the near future. The ERF has, however, identified a focus on carbon capture use and storage, including the production of construction materials like concrete which has direct relevance to the oyster industry through shell waste recycling. This demonstrates that there may be some alternative opportunity in the carbon offset space but it importantly highlights the requirement for the oyster industry itself to compile the information required to asses carbon flows and accurately determine carbon sequestration in oyster shells to better inform opportunities.



Looking beyond carbon offsets, we discuss other opportunities related to sustainability and reducing and offsetting product and supply chain emissions to become carbon neutral and the benefits of acquiring carbon neutral certification. Whilst these independent certifications do not provide for payments to oyster growers through a carbon offset market, they do present value through their ability to influence consumer choice, encourage supply chain and operational efficiencies to reduce emissions whilst providing confidence to the investment market on sustainability and stewardship.

This report also identifies and discusses other opportunities that can leverage the oyster industry's strong position of being a no feed, no waste seafood industry that offer broader ecosystem services and benefits such as supporting habitat and ecosystem interactions and improving water quality through nutrient removal from the water column. We discuss the difference between ecosystem valuation (which is a way of assigning an economic value to a service provided by an environmental asset i.e. nutrient removal, severe weather protection, materials); payment for ecosystem services (translating positive ecosystem services into monetary terms); and environmental condition accounting (provides standardised, quantifiable assessments of the physical state of "environmental assets" and determines a trend in environmental condition over time).

Oyster farmers who wish to demonstrate the sustainability of their product as well as the low impact nature of their operations on the surrounding environment, the Australian 'Accounting for Nature Framework' provides a certified avenue to support these claims and to also enable a record of management over time. Examples where this could be beneficial include:

- Creating a long term dataset of how oyster aquaculture and associated operations interacts with the surrounding environment which is becoming increasingly important along with increasing demand for low emissions protein sources from the sea.
- Operating in protected areas where key assets within the lease areas can be monitored and documented over time (i.e seagrass, benthic diversity) to ensure no adverse impact.
- Complimenting nitrogen reduction offsets through the monitoring and management of water quality along with other environment assets key to the regional ecosystem.
- Maintaining comprehensive data demonstrating sustainable, low impact practices is more likely to assist in future production expansion, green financing, and impact investing.

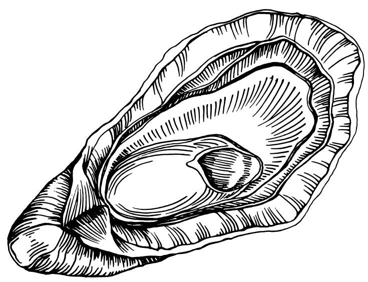
The increasing demand for sustainable food to support growing populations means there is the ever increasing need to look at our ability to advance industries with greater positive environmental and social influence. Whilst oysters themselves are small in size, they are one of the most sustainable no feed, no waste aquaculture operations on the planet which provide additional environmental benefits through the provision of numerous ecosystem services to the environment and regional communities. Further, actively accounting for the positive effects of oyster aquaculture on ecosystem assets and services, could provide a broader and more accurate valuation of the full range of effects the industry might have at successive scales of influence (local, regional and global), and emphasise its link to healthy ecosystems.

We also highlight the potential for oyster growers to benefit from the Australian government's recent funding commitments to biodiversity programs. While there are currently no specific programs targeted to sustainable aquaculture, the growth and development of the Australian oyster industry, particularly in regional areas is likely to align with several criteria across these funding areas. Particular areas of value include environmental performance, and the role oyster farms play in the provision of ecosystem services and regional economic development. Subsequently, it would be worthwhile for growers to engage with their state and local governments to assess the opportunity for funding in line with these focus areas with a goal of ensuring that the programs are expanded to include aquaculture projects.

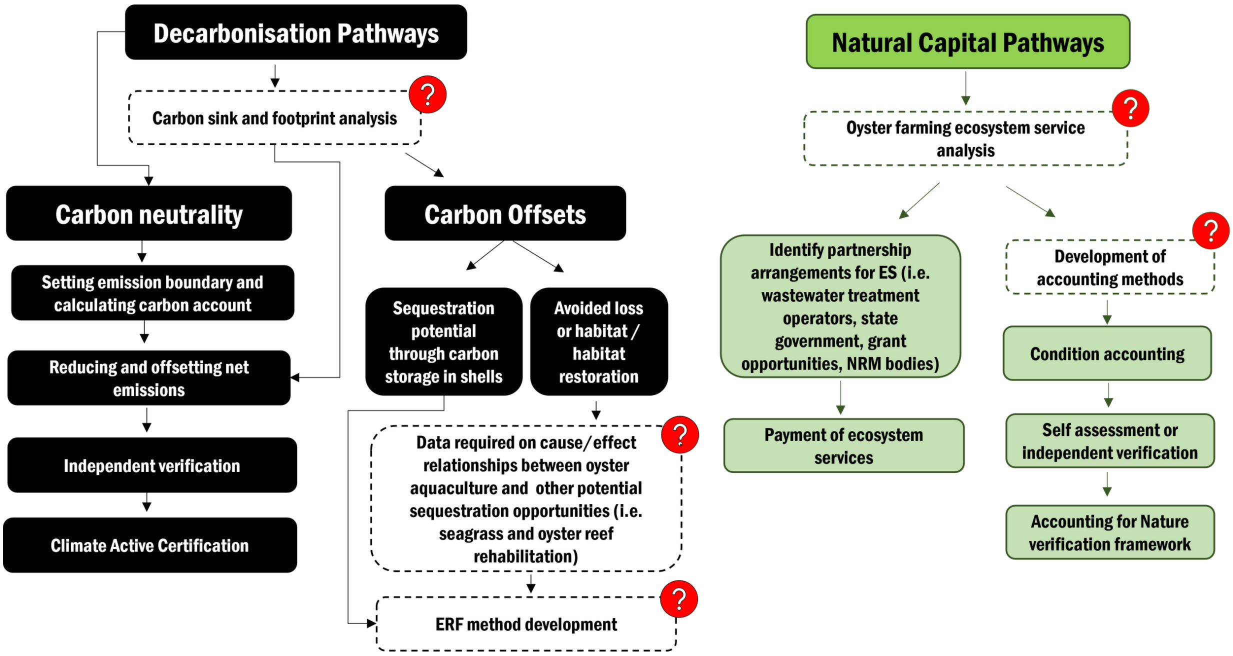
This report describes the benefits and value of both decarbonisation and natural capital certification pathways with a specific focus on two frameworks - Climate Active and Accounting for Nature. These two frameworks were highlighted due to their robust and scientific foundation, uptake by Australian businesses and organisations (particularly regarding food production), alignment with best practice approaches, transparency, and requirement for technical assessment ensuring credibility and confidence to the market. Both certification options discussed allow for the development of scoping options and full certification, enabling entities to investigate its suitability without a full commitment or incurring full certification costs. This flexibility allows entities to:

a) understand the costs and value specific to their business;
b) determine the level of complexity required for data collection and assessment; and
c) develop a plan for implementation over future years for consideration in budget and productivity planning.

In outlining the respective pathways, this report also identifies areas requiring further investigation to more accurately understand and quantify the carbon footprints, ecosystem services and benefits that oyster aquaculture operations provide to assist the development of asset specific methodologies and to to ensure integrity and transparency of claims.



Decarbonisation and natural capital pathways

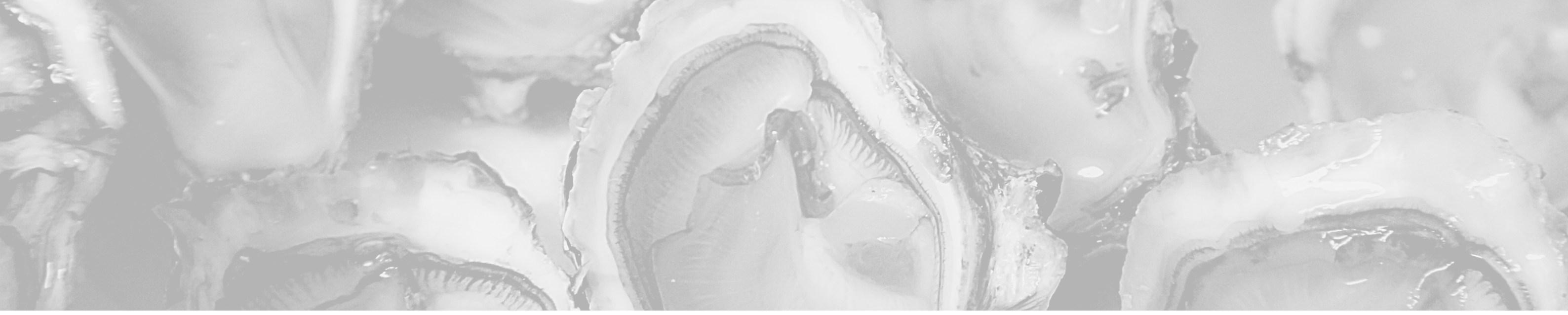


*Red circles indicate areas requiring further investigation and development.

More specifically, the following areas of research have been identified as being of high value in addressing the knowledge gaps that are impeding the development of blue carbon methodologies and ecosystem service valuation of oyster aquaculture in Australia.

- Understanding the carbon balance of oyster production
- Environmental impacts of large-scale oyster aquaculture expansion
- Ecosystem services – cause and effect relationships
- Ecosystem services – maximising ecosystem effects
- Impact of sustainability and carbon neutrality claims /certification on oyster marketability

Addressing the above research priorities will allow the Australian oyster industry to better position themselves to identify, leverage and foster new opportunities with both government and private bodies in areas of decarbonisaiton, environmental stewardship, and environmental and food sustainability in the future.



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Introduction

A person's diet is a significant part of their individual carbon footprint, and food production and consumption make up a significant portion of the carbon footprint of a country. In Australia, 'agriculture' contributes around 14% of our greenhouse gas emissions each year, which are predominantly generated by the land based agricultural sector. The sector has subsequently attracted significant investment by both state and commonwealth governments in research and programs to lower emissions and the development of offset methodologies that utilise land for carbon sequestration. The Australian seafood industry has, similarly, been developing a set of strategies and approaches over the last 5 years to improve sustainability, consumer trust and confidence,(1).

In 2017, CSIRO partnered with FRDC to host a workshop with industry and government stakeholders to discuss the overall attitudes of the Australian seafood industry to the concepts of carbon neutrality and investment in coastal 'blue' carbon offsets as a way of achieving zero net carbon emissions and to identify future opportunities for the Australian seafood industry(2). The workshop was driven in part 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 workshop resulted in the (simplified) recommendations shown in the figure below.

Objectives aside, navigating the regulatory and political landscape in climate change and ecosystem policy is challenging and understanding the opportunities and value for a specific industry can be somewhat overwhelming, particularly when it comes to marine and coastal industries. This is evidenced by the fact that most efforts and approved carbon sequestration, carbon neutral, or ecosystem accounting programs have been land-based, despite the enormous potential for these programs in the marine environment.

This is due to a number of factors, most notably the complexities in calculating and accurately recording the cradle to gate carbon footprint in a marine ecosystem. However, 2021 saw the first regulatory developments in the coastal carbon space, with the Australian Government announcing funding towards the development of Australia's first 'blue carbon'* for restoring mangroves and coastal marshes, which was approved in January 2022. This method may help to provide direction to other marine based projects looking to analyse carbon footprints and sequestration potential. In addition, in 2021 DAWE launched a 5 year, blue-carbon ecosystem restoration program which will see the restoration of four degraded wetland systems. The projects will use integrated environmental economic accounting to measure and value the benefits to climate, biodiversity and livelihood. Whilst these programs are focused on wetland ecosystems, it is a nod toward the importance of measuring and valuing not only carbon but other climate, biodiversity and social outcomes when evaluating the benefits of a marine project.

LOCATE

- Locate and compile existing materials relevant to the seafood industry, that describe the need for, and benefits of, carbon neutrality in simple language.
- Locate and compile existing materials that describe how to go about achieving carbon neutrality in simple language, including key resources and contacts. 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.

ENGAGE

- 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.
- Engage with current efforts, i.e. blue carbon* roadmap and efforts led by the business sector, representing the interests and expertise of the Australian seafood industry. Invest in a scoping project to assess the readiness and applicability of existing blue carbon methods in Australia, including identifying information requirements and their potential to generate a market for offsets for the seafood industry.

PARTNER

- 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.

***What is Blue Carbon?**
Blue carbon is carbon emissions sequestered by the world's coastal ecosystems.

Oyster farming in Australia, has been touted as an area for climate positive investment in sustainable aquaculture practices for a number of reasons. First, oysters have a lower average carbon footprint than all other forms of farmed animal protein, including protein from land animals, farmed fish, farmed crustaceans and is comparable to many vegetables and plant-based proteins such as tofu. Second, as most live oysters produced in Australia are sold domestically, the carbon footprint associated with the supply chain is relatively small. Finally oyster shells have attracted attention across industry as a possible means for producing carbon offsets for the carbon market and attracting additional revenue.

The natural function of oysters as filter feeders in addition to the low-impact design and function of oyster farm infrastructure has also contributed to the discussion on the provision and valuation of the oyster industries' ecosystem services. Understanding and valuing the role of services such as nutrient removal, habitat protection, food production, genetic diversity, and socio-economic services are important in 'proving' sustainability claims, supporting future industry growth and will influence the 'social licence' of the industry in Australia

This report discusses these opportunities which leverage the oyster industry's strong position of being a no feed, no waste seafood industry and which align with Oysters Australia 2020 – 2025 Strategic Plan - Programl, 2 and 4 as well as the FRDC Blue Carbon Report in progressing investigations into opportunities for sustainable and carbon neutral aquaculture.

Aims and Objectives

The primary objective of this report is to provide strategic advice to Oysters Australia - identifying opportunities and associated value for the Australian Oyster Industry in Carbon Neutral Certification and Environmental Accounts.

To achieve this, this report provides the following:

1. A high-level review and positioning of the oyster industry in the Australian climate policy and emission reduction space through undertaking a review of:
    - Marine offset and carbon neutral principles in the Australian legislative framework
    - Carbon offset certification pathway in Australia and relevance to the oyster industry
    - Research consensus of carbon flows in oyster farming practices and identification of knowledge gaps required to address uncertainties.

2. A high level analysis of the opportunity for carbon neutral certification in the Oysters Australia through:
    - Providing an overview of the Australian Carbon Neutral Certification Framework and key attributes which align with Oysters Australia's strategic vision
    - Review of existing carbon flow data from literature
    - Climate Active Framework road map to certification including consultation with the Clean Energy Regulator
    - Discussion of benefits and opportunities to the Australian Oyster Industry, such as marketing, leveraging consumer choice.
    - Identification of high value research areas.

3. A high-level review of the opportunity for environmental accounting and payment for ecosystem services through undertaking a review of:
    - Overview of environmental accounting and application to the Australian oyster industry, including direct and indirect benefits, and development areas.
    - High level review of benefits and examples of ecosystem payments
    - Identification of challenges in research and regulatory approvals
    - Identification of high value research areas.

1.0 Carbon policy context

The Carbon Context - Carbon dioxide emissions, offsets, and carbon neutral principles in the Australian legislative framework

In international environmental policy, market-based instruments such as 'cap and trade' and 'offsets' use markets, price, and other economic variables to provide incentives for polluters to reduce or eliminate detrimental environmental emissions, most commonly carbon dioxide emissions. These instruments have proven effective because they place a tangible value on the pollutant and can be a cost-effective method for achieving pollutant reductions. The most attractive characteristic of market-based instruments is that the incentives provide a vehicle for shifting pollution management effort to those areas that can make the largest net gain in reducing pollutant loads into the receiving environment at the lowest cost whilst achieving additional "co-benefits" to the environment and region.

Carbon offsets are a crucial component of international climate mitigation strategies. They are the principal incentive mechanism of the global carbon market which aims to reduce emissions in a cost - effective way by setting limits on emissions and enabling the trading of emission units (representing emission reductions). Carbon offsets also enable flexibility and financial motivation for businesses to transition to a low carbon industrial base by utilising best practice approaches delivering a net gain for climate change mitigation. However, carbon offsets also allow companies to continue to emit if it is more cost-effective to offset rather than reduce the activity and/or use alternative technologies. The decision to offset verses invest in more energy efficient practices predominantly depends on the current carbon price which is influenced by market factors such as demand and regulatory requirement.

Since 1992, Australia has participated in the United Nations Framework Convention on Climate Change and is currently party to the Paris Agreement which came into force in 2016. Under the Paris Agreement, Australia must submit emissions reduction commitments known as Nationally Determined Contributions (NDCs) which include the following targets(3):

- Committed to net zero by 2050
- Inscribed low emissions technology stretch goals
- Committed to reduce emissions by 26 to 28% below 2005 levels by 2030

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Regulated Mandatory reduction

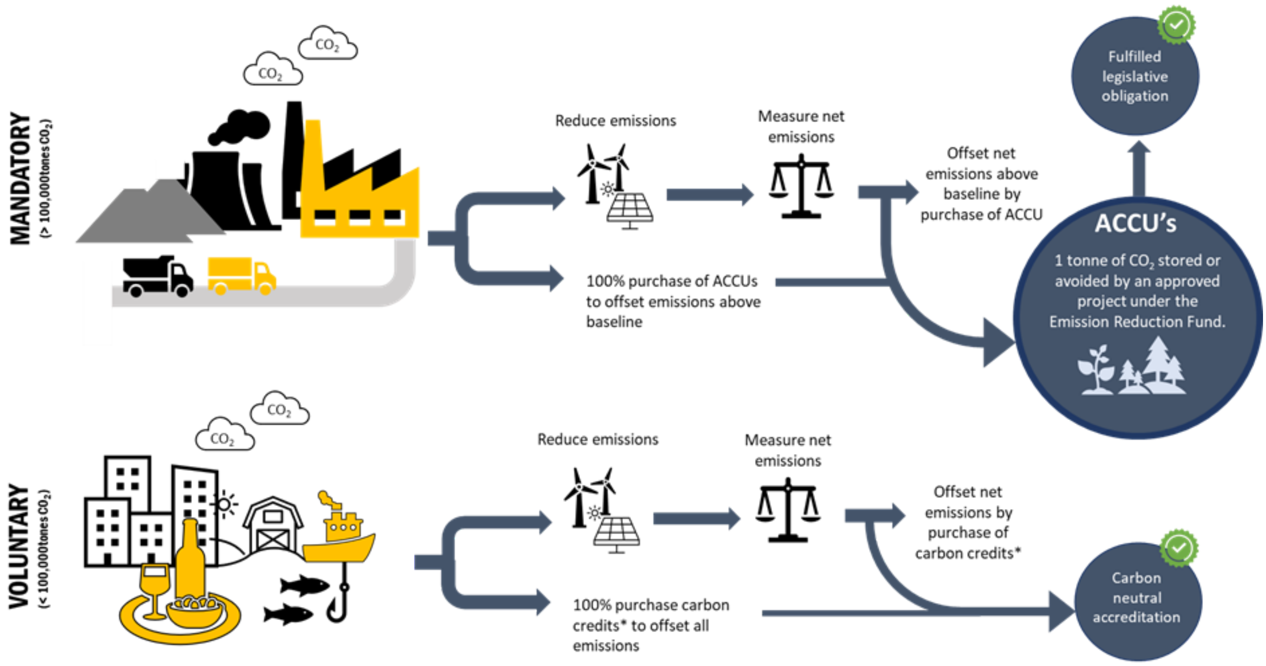
Australia's principal approach to reducing greenhouse gas emissions is through the safeguard mechanism which commenced in 2016 and requires Australia's largest emitters to keep emissions within baseline levels. It applies to large businesses that have facilities with direct emissions of more than 100,000 tonnes of carbon dioxide equivalents (t CO_2-e) a year (approximately 140 businesses), covering around half of Australia's emissions. Reported baselines are determined based on historical high points between 2009-10 and 2013-14 and Calculated baselines are determined based on an independently audited forecast of production and apply to new facilities only. Flexible compliance arrangements give designated large entities access to a range of options for meeting safeguard obligations including a 'net emissions' approach that will allow businesses to use Australian Carbon Credit Units (ACCUs) to offset emissions above the baseline.

ACCU's are issued by the Clean Energy Regulator where each credit represents one tonne of carbon dioxide equivalent (tCO_2-e) stored or avoided by a project undertaken as part of the Australian Government's Emissions Reduction Fund. The issuance of ACCUs is governed by the CFI Act 2011, the Carbon Credits (Carbon Farming Initiative) Regulations 2011(CFI Regulations 2011) and the Carbon Credits (Carbon Farming Initiative) Rule 2015 (CFI Rule 2015). ACCU's are sold to the Australian Government through a carbon abatement contract where they are then auctioned to those wanting to offset their carbon emissions. Generally, the demand for ACCU's dictate the auction price. Recent surges in new participants entering the market due to both mandatory compliance buying and voluntary investment has seen the current ACCU spot price reach $40.00 in December 2021 and it is expected to continue to increase along with demand. 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(4).

Voluntary Reduction

For entities that are not required through legislation to offset their GHG emissions, there are options available to reduce a companies carbon footprint through the voluntary offset market where companies can offset their footprint by investing in domestic ACCU's and/or in high-quality domestic and international carbon reduction projects referred to as Certified Emission Reductions (CERs). CERs are tradeable certified emission reduction units issued outside Australia in accordance with the Kyoto rules. CERs are issued for projects registered under the Clean Development Mechanism (CDM), which operates in countries that are non-Annex I Parties to the United Nations Framework Convention on Climate Change (UNFCCC)(2) and Kyoto Protocol (developing country Parties). The ability to purchase international carbon credits provides freedom for companies to purchase credits from projects that align with the company's ethos and commitment to the UN sustainability goals, i.e. projects which have additional benefits such as biodiversity, education, jobs, food security, clean drinking water and positive health outcomes.

Figure 1 Diagram showing mandatory and voluntary carbon offset pathways.
(*) voluntary carbon reduction pathway's can use either ACCUs or CERs for carbon footprint reduction verification.



Relevance to the Australian oyster industry

Primary production industries in Australia are increasingly under pressure to invest in minimising or counterbalancing their carbon footprints and contribute to Australia's net emission targets. While beef production is at the forefront of emission reduction research and approaches (5), the publication of carbon emissions data comparing different agricultural and aquaculture products is becoming more common (figure 2). Such comparisons have historically been focused on terrestrial horticulture and agriculture.

Aquaculture production is one of the fastest growing primary industries in the world. For the past decade, global aquaculture production has been growing at a rate of almost 8% a year, while in Australia, growth of aquaculture production has been less rapid, averaging 4.3%. In 2019/20 Australia exported AUD$1.6 million worth of oysters and imported AUD$7.05 million of oyster products indicating a significant demand domestically for shellfish and a clear indication that the current supply of domestic oysters is insufficient to meet domestic demand (6). In addition, recent estimates from bivalve production in the USA (11.1 tons of CO2e per ton of protein (40)) indicated emissions from this sector were just 7.6% of the average emissions from terrestrial (beef, pork, and chicken) protein production (41, 42). If these percentages were applied in context of GHG emissions from the Australian agricultural sector, the oyster industry would be responsible for approximately 1.5% of Australia's agriculture emissions.

Consequently, bivalve aquaculture is increasingly discussed as a sustainable, climate-friendly source of nutrient-rich protein production for human consumption and an industry with significant growth potential, presenting an opportunity to review and assess the potential value of integrating net-zero emission approaches for current and future expansion of the industry.

Generally, there are four main driving forces behind interest in emission reduction and carbon offsets in the food production sector in Australia:

- The generation of additional revenue through the Emission Reduction Fund pathway, carbon farming and sale of carbon credit units through the Australian carbon market from 'blue carbon' offset projects.

- Potential opportunities to utilise operations and/or land for carbon sequestration, to enable counterbalancing of carbon emissions to reach carbon neutral status.

- Counterbalancing emissions through the purchase of carbon offsets to obtain carbon neutral certification and increase market potential by appealing to the climate conscious consumer.

- The third driver, particular for oyster growers, is that of social licence. Unlike many other agriculture and aquaculture sectors, oyster farmers lease the water from the crown. Operating in a public space, utilising publicly owned resources, often in visible locations, most growers are acutely aware of the need to maintain community support and the need to look to continually improve. Emission reductions is one way of doing this.

While a number of carbon sequestration options are available to the land-based agriculture sector through the ERF approved project methodologies, progress is slow in the coastal/marine areas. Australia has made progress in this area through electing to include blue carbon ecosystems in its national greenhouse gas (GHG) accounts and funding various blue carbon ecosystem restoration grants, acknowledging the significant sequestration potential of our oceans and marine ecosystems, and future opportunities in sequestration and emission avoidance projects. However, there are significant barriers for blue carbon beyond wetland systems under the ERF.

A technical review conducted by CSIRO in 2017(8) highlighted significant knowledge gaps hindering method development for blue carbon projects, such as limited information on the spatial extent over which the influencing factors operate; natural seasonal fluxes, the mechanisms responsible for altering the magnitude of carbon sequestration or GHG emission avoidance; existing management practices; and the application of legislation. One of the most critical factors identified was the lack of research or case studies relevant to Australian blue carbon ecosystems.

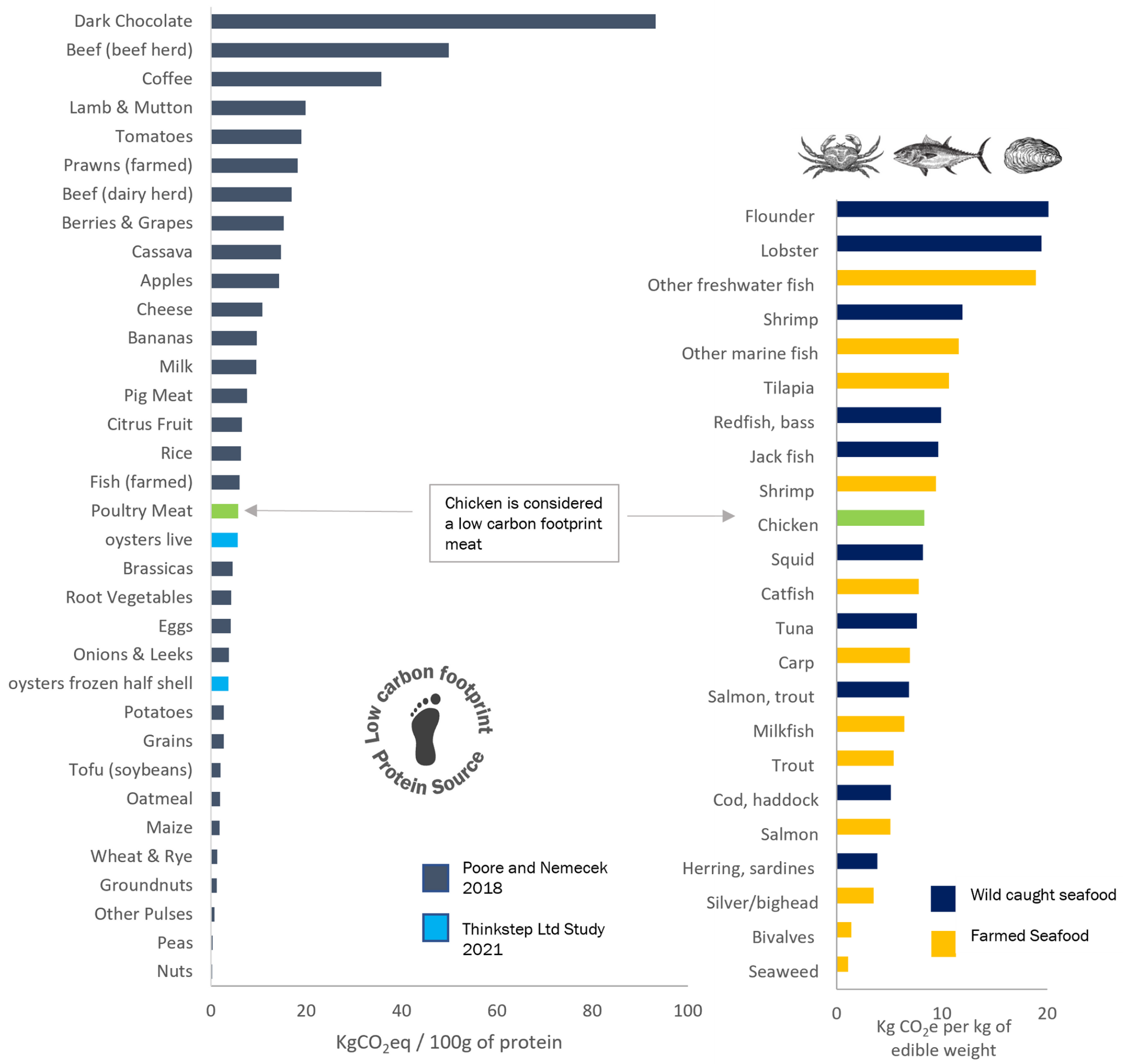
The report pointed to avoidance of vegetation loss as well as regrowth opportunities of mangroves and tidal marshes to improve coastal marine carbon capture as areas for ERF methodology development.

Subsequently, in early 2022, the first blue carbon methodology was released by the Clean Energy Regulator for consultation which focused on creating opportunities to store carbon through restoring mangroves and tidal marshes and reintroduction of tidal flows.

Blue carbon has also been highlighted as a priority area for further development in 2022 as well as a focus on carbon capture use and storage, including the production of construction materials like concrete which has direct relevance to the oyster industry through shell waste recycling. This demonstrates the potential for blue carbon programs in Australia but also highlights the requirement for the oyster industry itself to compile the information required to asses carbon flows and the sequestration potential of shellfish.

Figure 2: Comparison of carbon emissions per 100g of protein and kg of edible weight across common farmed foods

The figures below show the carbon footprint of a variety of farmed foods as well as wild caught seafood. Poultry (chicken) is highlighted in green which is typically regarded as a low emission food source. The foods which produce fewer emissions when compared to poultry are therefore also regarded as foods with a low carbon footprint. In both figures, farmed bivalves (which includes oysters) have comparatively smaller carbon footprints when compared to chicken and significantly smaller footprints when compared to other farmed seafoods.



Sources: (left) Carbon emissions per 100g of protein across common farmed foods. shellfish data provided by ThinkStep Ltd Study, all other data from https:ourworldindata.org. (Right) The carbon footprint of wild and farmed seafood based on a meta-analysis which includes data from 1690 fish farms and 1000 unique fishery records. Measured per kg of edible weight. Source: https:ourworldindata.org (7)

2.0 Carbon Science

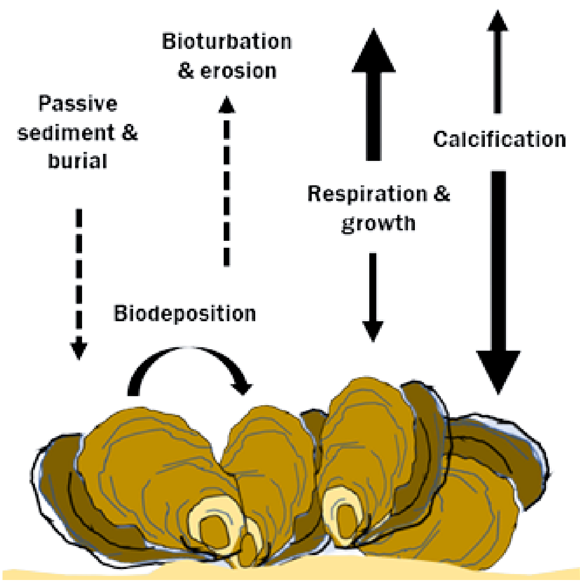
Understanding carbon flows

A handful of published studies in Australia and internationally have considered the cradle-to-grave impacts of shellfish farming, from hatchery or spat collection, to on-going growing, harvesting, depuration and pack-out (9,10). In addition, the carbon uptake potential in shellfish has been studied for comparison to afforestation or reforestation in the hope of the development of blue carbon offsets (11). Understanding both processes is important in understanding both the carbon sinks (-) and carbon sources (+) from farm to plate to determine the total carbon footprint of an oyster farming operation.

Carbon sources and sinks

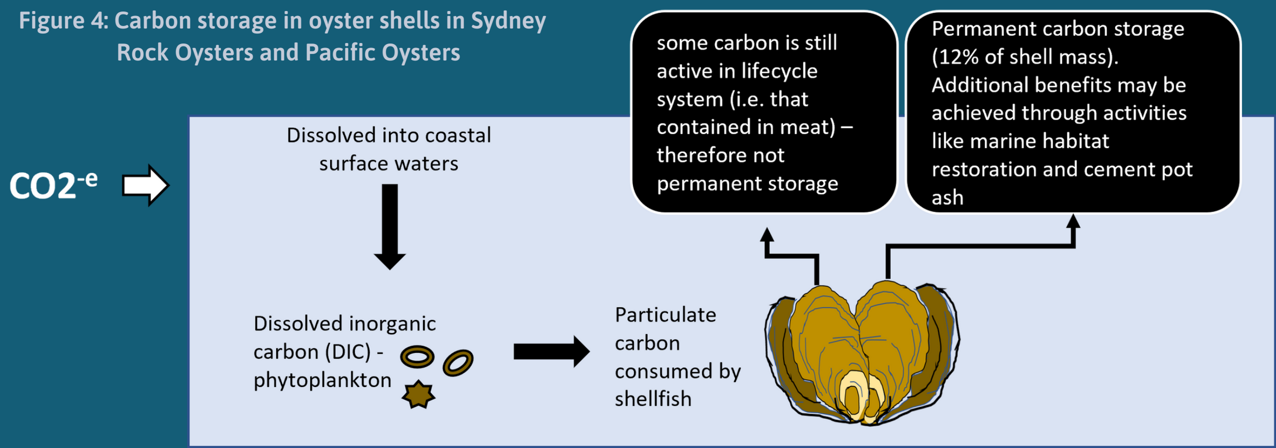
Oysters consume particulate carbon from their surrounding waters to enable the growth of their outer shells which are made from calcium carbonate, thus removing, concentrating, and storing carbon from the surrounding environment. Regardless of whether the oyster is harvested and consumed, or eventually dies and falls to the ocean floor, carbon is permanently stored within the shell which has contributed to the assumption that carbon sequestration has occurred. The scientific consensus to date is that carbon contributes approximately 12g for every 100g shell, or 12% of overall shell mass. However, Oysters can also be net-additive (+) where they also release carbon into the surrounding waters through processes such as shell erosion, respiration, and by-products of shell calcification (Figure 3). Because of these ecosystem interactions, there is not sufficient scientific evidence to suggest that shell formation can be directly linked to a net storage of carbon dioxide linked to the atmosphere and therefore serve as a carbon offset.

Figure 3 Oysters can also be net-additive.
Arrows indicates carbon deposition (downward) or carbon release (upward), arrow size gives qualitative indication of relative size of carbon flow. (12)



Consequently, the use of the 12% shell mass to determine carbon sequestration (Figure 4) through carbon storage should be used conservatively (if at all), acknowledging that there are a number of dynamic factors that would ultimately influence the net carbon balance of an oyster grown in a specific location. Findings from investigations into carbon storage in oyster shells in Pacific Oysters in South Australia and Sydney Rock Oysters in Southeast Queensland are shown in Table 1 below. Similar results have also been reported in oysters farmed in Chesapeake Bay in the USA.

Figure 4: Carbon storage in oyster shells in Sydney Rock Oysters and Pacific Oysters



Harvest : Carbon Assumptions	Sydney rock oysters	Pacific oysters
carbon contributes 12% of shell mass.		
shell % of total weight	75.6% total weight	83.8% total weight
dozen oyster weight avg	0.43kg	1kg average
Avg shell weight (g)	271	698.3
Avg carbon per shell (g)	32.5	83.8

These calculations are based on average harvest numbers of plate grade oysters and do not factor in variabilities in growth rates, spat to harvest success percentages. While these calculations indicate potential revenue attributed to a carbon offset from the carbon stored in the oyster shells, these calculations do not consider the cradle to grave carbon footprint, the waste management of the shells (i.e. burial, repurposing or landfill (42)) nor variances in stocking densities which would need to be measured on a case by case scenario to accurately predict total sequestration potential. The carbon price per hectare per year calculated across the five sites in Table 1 ranged from AUD$60 and $160 depending on stocking density and species. These figures when compared to the sequestration potential of other blue carbon initiatives (such as the restoration of mangrove systems with a annual sequestration figures around 30 tonnes C ha-1 yr-1 (based on a stocking density of 1000 trees per ha and a value of ~ $5,000 per ha per yr) are low and unlikely to be considered by the Clean Energy Regulator for carbon credit methodology development in the near future due to the low volume of reduced emissions.

Table 1 Estimated carbon uptake of Pacific Oysters and Sydney Rock Oysters using stocking density of harvested plate size oysters per hectare. See appendix for calculations

Location	Species	density (per ha)	Harvest period	Carbon sequestered over harvest period (kg)	Carbon sequestered (tC ha-1 yr-1)	Equivalent in carbon dioxide (tC ha-1 yr-1)	Offset revenue per ha per year (based on carbon price of $40)
SA Coffin Bay (Avg across 2 sites)	Pacific Oyster	259,200	2 years	2,167.8	1.086	3.988	$159.43
SA Smokey Bay	Pacific Oyster	195,000	2 years	1,630.9	0.817	2.999	$119.94
SA Ceduna	Pacific Oyster	180,000	2 years	1,505.4	0.754	2.768	$110.72
SA Oyster Bay	Pacific Oyster	260,000	2 years	2,174.5	1.089	3.998	$159.92
QLD Moreton Bay (Avg across 3 sites)	Sydney Rock Oyster	420,000	3 years	3,512.7	0.455	1.670	$66.81
Mangroves**		10,000	25 years	840,000	33.6	123.312	$4,932.48

Source: Pacific Oyster data sourced from Hickey (2004), Moreton Bay farmed Sydney Rock Oysters from NineSquared/University of the Sunshine Coast supplied data (2020).
Note: offset revenue is speculative and does not consider other carbon interactions in the environment.
** source: https://raidboxes.io/wp-content/uploads/2019/05/Carbon-Sequestration-in-Mangroves.pdf

Supply chain carbon sources

There are a variety of activities in the oyster farming supply chain where GHG emissions are produced and are therefore referred to as a carbon source. These are found across the input, production, processing, wholesale, retail and consumption phases or oyster aquaculture. Due to this, oyster farming, whilst considered to be a low carbon footprint protein source, is still a carbon positive (+) activity.

Carbon footprint

The whole-of-life carbon footprint of oysters depends on a number of variables along the oyster production supply chain, such as whether oysters are grown from wild spat collection or supplied from a hatchery, the consumables and infrastructure used, the stocking density, the end product (i.e. shucked or whole oysters, fresh or frozen), and the end destination (i.e. wholesalers, retail market, restaurants, or exported). Understanding the carbon life cycle and subsequent carbon footprint of an oyster aquaculture operation establishes context and is the foundation to exploring opportunities for carbon neutral and other sustainability certifications.

3.0 Overview of Environmental Certifications in Australia

As the requirement for action on climate change becomes increasingly urgent, individuals, organisations, and countries are looking for ways to reduce their carbon footprints and prove that the operations of their organisation and the products or services they provide are done in a sustainable and socially responsible way. To service this need an increasing number of certification options are now available for companies/organisations to 'prove' their commitment to net zero emissions and/or sustainable development goals and environmental stewardship. This can present a challenge to determine the option that presents the most value and impact. The following are the most common certification schemes available in Australia:

Certification		
Climate Active (AUS)	Launched by the Australian Government in 2010, Climate Active is a highly trusted carbon neutral certification that denotes a status of carbon neutrality. The certification can be used to certify organisations, products and services, events, buildings, and precincts. It requires entities to calculate emissions, develop a reduction strategy, and purchase offsets to achieve net zero emissions. Climate Active is the only Australian certification scheme that meets the integrity principles based on the offsets integrity framework for Australian Carbon Credit Units (ACCUs). Certification requires auditing from an independent third party (see section 4). The Climate Active annual certification fee is based on net emissions before offsetting and the number of certifications held. There are four brackets which range from under 2,000 tonnes of carbon emissions to over 80,000 tonnes. A company will pay between $820 to $2,627 annually inc GST for the lowest bracket. Additional expenses are expected for third party validation.	High value, variable cost (medium-high) High initial costs plus <$5,000 pa* *does not include third-party fees
Accounting for Nature (AUS)	Accounting for Nature® Framework measures the biophysical condition of environmental assets (e.g. native vegetation, soils, freshwater, native fauna, marine) in a project area, across an entire property, or within a region, state or even across a nation. The Framework provides an optional paid certification pathway for interested parties to have their environmental accounts recognised as either "Self-verified" or third-party "Certified" by Accounting for Nature Ltd. Only proponents who have had their accounts certified are able to make public claims regarding their Environmental Accounts. Accounting for Nature environmental accounts are widely considered the source of truth and trust for any sustainability claim that is made with respect to landscape or marine conservation and restoration. The framework has been developed to complement other standard and certification systems, such as those for developing carbon offset projects, building and assessing impact investment opportunities (e.g. green bond criteria), pursuing corporate sustainability outcomes and achieving global goals such as the Sustainable Development Goals and Aichi Targets. It is also consistent with the United Nation's Standard for Environmental Economic Accounting (SEEA). Fees range from $2100 to $3,300AUD depending on size of organisation and level of certification (self-verified vs ceritified). These fees exclude the cost of hiring a third party auditor.	High value, medium cost. <$5,000 pa* *does not include third-party fees
The Science Based Targets (INT)	Science-based targets initiative provides a clearly-defined pathway for companies to reduce greenhouse gas (GHG) emissions, helping prevent the worst impacts of climate change and future-proof business growth. Targets are considered 'science-based' if they are in line with what the latest climate science deems necessary to meet the goals of the Paris Agreement – limiting global warming to well-below 2°C above pre-industrial levels and pursuing efforts to limit warming to 1.5°C. The SBTi requires that companies set targets based on emission reductions through direct action within their own boundaries or their value chains. Offsets are only considered to be an option for companies wanting to finance additional emission reductions beyond their science-based target (SBT) or net-zero target. Avoided emissions are also not counted towards SBTs. The target validation fee is USD 4,950* (+ applicable VAT) or USD 1,000* (+ applicable VAT) for SMEs. This includes up to two target assessments. SBTs are predominantly aimed at the corporate sector and large emitters. Whilst SBTs can be used for small scale food production entities, there are likely to be other certifications that are more fit for purpose.	Medium value, low cost <$2000 for SMEs

Certified B Corporation (INT)	B Corporation (also B Lab or B Corp) certification of "social and environmental performance" is a private certification of for-profit companies. B Corp certification is conferred through verification by B Lab, a global non-profit organisation. To be granted and to maintain certification, companies must receive a minimum score from an assessment of "social and environmental performance", integrate B Corp commitments to stakeholders into company governing documents, and pay an annual fee based on annual sales. Companies must re-certify every three years to retain B Corporation status. Certified B Corporations pay certification fees annually based on the organisation's total revenue for the 12 months prior. If the entities total revenue is less than $3 million AUD, the maximum annual fee is $1,800. B Corporation certification is predominantly aimed at large profit making enterprises that want to consider their impact on all stakeholders. The certification enables them to demonstrate a commitment to social and environmental performance, public transparency and legal accountability to balance profit and purpose. Therefore the relevance and value for oysters growers is difficult to ascertain.	Low value, low cost <$1,800pa

Seafood Specific Certification

IGlobally there are dozens of third-party seafood certification programs - below are three of the most well-known. Some retailers (eg. large supermarkets) have procurement policies which require 3rd party certification before a grower can supply products.

Friends of the Seas (INT)	Certification is use to show consumers that the product is sourced from a well-managed capture fishery or aquaculture operation that focus on issues related to the sustainable use of fisheries. Certification criteria include: no impact on critical habit; compliance with water quality parameters; no use of harmful antifouling nor growth hormones; compliance with social accountability; reduction in carbon footprint. There is a specific set of criteria and indicators for certification of farmed shellfish. There are two cost points, the first is an audit cost which depends on the complexity of the operation, number of products and information provided, the second is an annual royalty cost which ranges from 500 – 7000€ for 1-4 products/species depending on annual company revenue (i.e. company revenue 10,000-500,000€ incurs a 500€ royalty fee).	High value, low cost <$2,500 pa
Aquaculture Stewardship Council (INT)	The organisation operates a third party certification and labelling programme for aquaculture around the world. ASC standards address 7 principles and criteria to minimize environmental and social impacts with a key focus on social responsibility. The ASC does not have an emission reduction focus. Every ASC certificate holder must undergo reassessments at regular intervals to remain in the programme. There are two cost points, the first is an audit cost for independent verification and the second is a royalty fee through sales of products displaying the ASC logo.	Medium value, unknown cost
Best Aquaculture Practices (INT)	'BAP' certification is verification that producers are following best practices to deliver farmed seafood safely and responsibly. Best Aquaculture Practices (BAP) is a seafood specific certification program that addresses the four key areas of sustainability—environmental, social, food safety, and animal health & welfare—at each step of the aquaculture production chain. BAP standards are science backed, certification and benchmarked by third parties with the Standards Oversight Committee being a separate entity from BAP comprising of birth academia and industry. There are three cost points: audit, conformity report, and certification.	High value, unknown cost

In the following sections we provide a more in-depth overview of the Australian carbon neutral certification and environmental accounting pathways, highlighting areas of value and areas requiring further development to inform decision making.

4.0 Carbon Neutral Certification

When an entity becomes carbon neutral, it has demonstrated that carbon emissions have been reduced where possible and accounted for the remainder by investing in carbon offsets projects to achieve net zero overall emissions. As described in section 1, offsets are generated from an activity that removes greenhouse gas emissions from being released into the atmosphere. For an industry that is not mandated to offset or reduce emissions, carbon neutral certification is voluntary and is facilitated through the Climate Active Initiative. This initiative is administered and managed by the Australian Government Department of Industry, Science, Energy and Resources.

Whilst there are other certification options that display an organisations commitment to carbon neutral and sustainability objectives, Climate Active is the only Australian certification scheme that meets the integrity principles based on the offsets integrity framework for Australian Carbon Credit Units (ACCUs). This ensures any unit used to offset emissions as part of a carbon neutral claim against the various Climate Active standards represents a genuine and credible emissions reduction.

There are currently two seafood producers in Australia which have achieved carbon neutral certification through Climate Active including Austral Fisheries (since 2016) and Harvest Road (since 2021), with both realised and anticipated benefits in consumer perception and fishing fleet efficiencies.

Identifying opportunities to enable Australian oyster aquaculture to move towards a carbon neutral industry has been identified as a medium priority in the Oysters Australia 2020-2025 Strategic Plan, along with undertaking carbon footprint analysis of oyster farms. In this section we outline the steps involved in becoming carbon neutral certification under the Climate Active framework and opportunities available to the Australian Oyster industry. We also discuss an Australian carbon neutral certified oyster aquaculture operation in Western Australia which applies the methodology in practice.

Climate Active Framework road map to certification

For an entity to be certified under Climate Active, it must meet the Climate Active Carbon Neutral Standard (formerly the National Carbon Offset Standard (13)) which is broadly based on 4 steps: measure emissions; reduce emissions where possible; offset remaining emissions; then publicly report on achievement. The process for certification varies slightly depending on what a business is wanting to certify. For Oyster producers, the most common certification standard is the 'product' certification (14) which provides confidence to the consumer that the carbon emissions attribute to the production of the product have been offset.

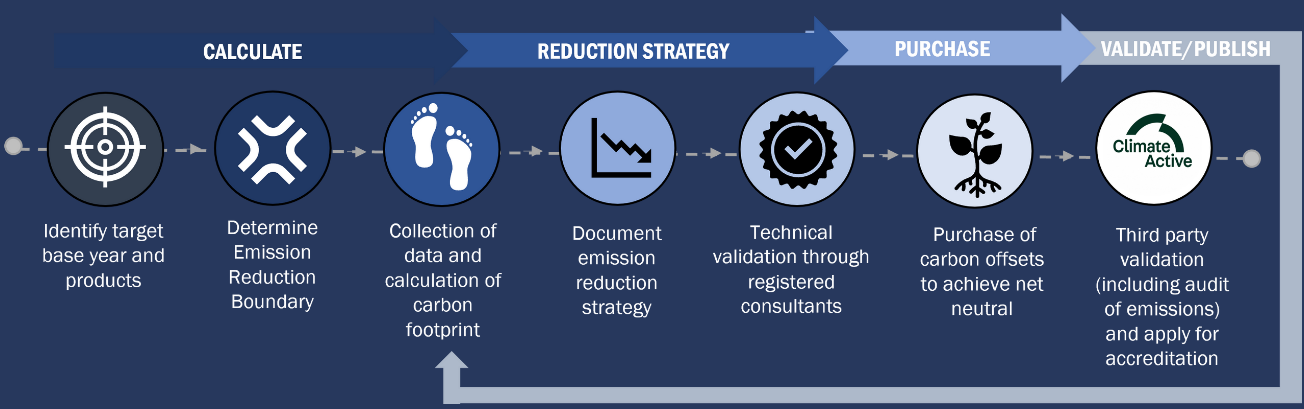
There are two steps in which an organisation typically seeks independent assistance from registered consultants with expertise in technical life cycle assessment, carbon footprint calculations and third-party audits. Whilst, the entity may choose to prepare their own carbon account, most entities engage an independent party to assist in the whole process to certification or to develop an inventory and plan towards future certification to facilitate a basic carbon offset strategy and costs to certification.

Life Cycles (LCA)

A cradle-to-grave life cycle assessment considers the entire life cycle of a product or service, from raw material extraction and acquisition, through to energy and material production and manufacturing, to use and end of life treatment and disposal. If the function of the final product is not known, or there are significant barriers to collecting data, a cradle-to-gate boundary can be defined.

Cradle-to-gate is a partial life cycle inventory, including all emissions and removals from material acquisition through to when the product leaves the responsible entity's gate Thinkstep ANZ provides an excellent example of the carbon lifecycle calculations from spat collection to Oyster harvesting, processing, and distribution (10).

Figure 5: Schematic showing the steps involved in Climate Active certification



Setting the emissions boundary

To estimate the carbon footprint of an oyster production, the first step is to draft the emissions boundary following the product certification standard (4). The emissions boundary refers to the coverage and extent of the carbon account. The boundary is established using a set of criteria to identify emissions sources and decide which of the identified sources are to be included or excluded. An emission boundary can be determined using the following steps:

1. **Define a functional unit**
   A functional unit is a quantified reference unit which conveys the functions of the product or service being certified. For oyster production, the functional unit would most likely describe the finished product at point of sale e.g. a dozen oysters.

2. **Conduct a Lifecycle assessment**
   Mapping the processes involved in producing a product, illustrating the services, materials, and energy needed to move a product through its life cycle. This can either be cradle-to-grave if the final function of the product is known, or cradle-to-gate if unknown.

3. **Identify attributable and non attributable emissions sources**
   Through the life cycle assessment, attributable process will need to be identified:

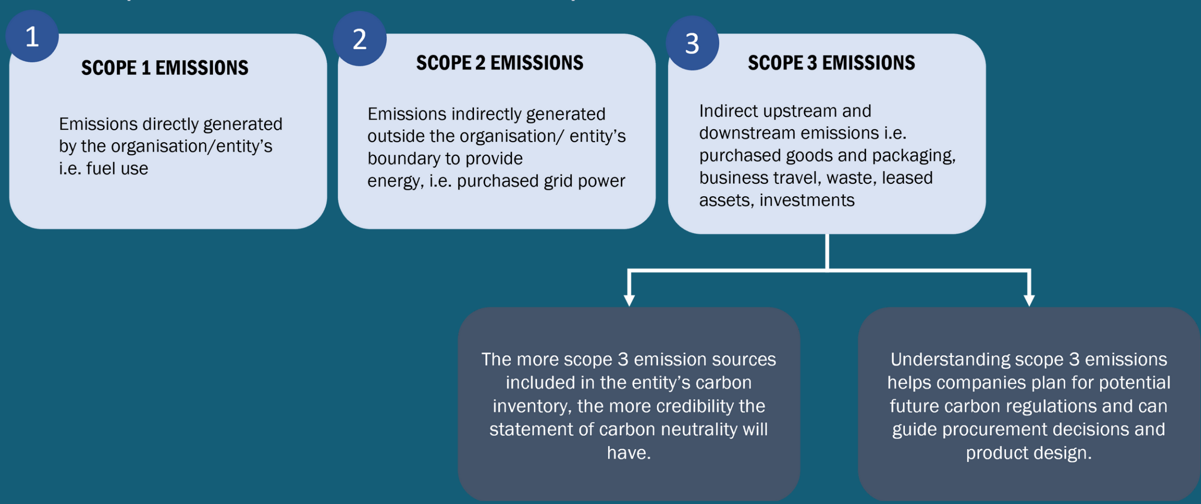
   - Attributable processes are service, material and energy flows that become the product, make the product, and carry the product through its life cycle.

   - Non-attributable processes are services, materials, and energy flows which are not directly connected to the product or service during its lifecycle because they do not become the product or service, make the product or service, or directly carry the product or service through its life cycle (15). Non-attributable emissions may be within the emission boundary and contribute to the footprint liability, or they may be considered outside of the emission boundary. An example of a non-attributable emission source for a wine product is the food sold in the winery restaurant because it is not directly related to the production of the wine.

Scope of Emissions

Attributable processes often cut across multiple direct and indirect emissions due to the complex nature of supply chains. To help delineate between direct and indirect emissions sources, emissions included within the emissions boundary may be classified into the following scopes:

Figure 6: To take responsibility for the entire lifecyle emissions associated with shellfish products, emissions across scope 1,2 and 3 should be considered where quantifiable.



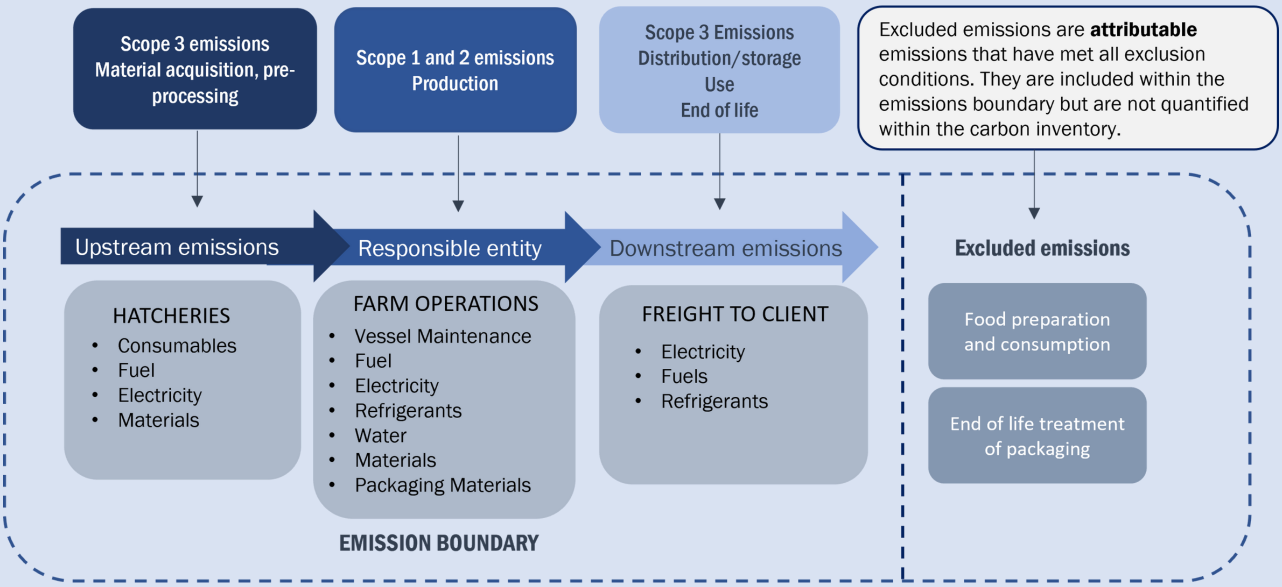
All attributable processes must be included in the emissions boundary of the product or service unless they fulfil all the conditions for exclusion:

- A data gap exists because primary or secondary data cannot be collected (no actual data).
- Extrapolated and proxy data cannot be determined to fill the data gap (no projected data).
- The emissions from the process are not expected (for example though an estimation) to be material (constitute more than 1 per cent to the total carbon account).

Example of an oyster production emission boundary

Through following the above criteria and steps, a high level emission boundary for the production of oysters can be developed (Figure 7) illustrating the services, materials and energy needed to produce oysters through their product life cycle. The diagram shows emissions that are considered attributable but may be excluded on the provision that they meet the exclusion criteria listed above.

Figure 7: An example of an emission boundary and emissions sources attributed to upstream and downstream components of supply chain and operations.



Caluculating the carbon account

The responsible entity must calculate greenhouse gas emissions attributable to the product or service unless the source is identified as excluded. Emissions sources should be catalogued in such a way that allows them to be traced back to their place in the process map.

The carbon account must include emissions of carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3).

Accounting for carbon neutral supply chains

If the carbon account includes an activity or product in its supply chain that has been certified as carbon neutral against any other categories of the Climate Active Carbon Neutral Standard (see Box 1), the activity or product is considered to contribute zero emissions to the carbon account. This is because the emissions of the activity or product have already been accounted for and offset.

The use of the activity or product must still be reported (in the form of activity data) to ensure transparency and completeness of the carbon account. The activity data should be recorded as having an emission factor of zero.

Offset selection and purchase

Where possible, emissions should be avoided whilst maintaining/driving profit. Subsequently, purchasing offsets should be the last resort in a carbon management strategy. Under the Climate Active Framework, any remaining emissions must be compensated each year through cancelling (also known as retiring) an equivalent number of eligible offset units. Carbon offsets are often selected based on an organisation's circumstances, budget and alignment with the organisation's values.

Two approaches to offsetting are allowed under the Climate Active Framework Product & Service Standard:

1. Forward offsetting: this involves estimating emissions for the coming reporting year and cancelling that number of eligible offset units at the start of the year. This must be followed by an annual true-up process to ensure that the number of cancelled eligible offset units is at least equal to actual emissions.
2. Offsetting in arrears: this involves cancelling offset units for the claim period after it has finished.

Independent consultants can help identify suitable carbon offsets, and help the organisation go to market for the most suitable carbon offsets and most cost-effective offset provider.

Cost and cost variables

Costs associated with certification vary depending on the use of technical experts, the types of offsets used and auditing services. Technical advice may include developing a carbon account and having your carbon neutral claim and data independently validated. Offset costs will depend on how many are required and the types of offset units purchased. These costs are separate to the certification fee, are set by the market and vary across the industry

There are four typical fee components along the certification pathway for Climate Active certification . These are outlined below:

Step	Variables	External costs
Determine Emission Boundary and carbon footprint calculation	The extent to which a consultant is required will depend on the availability and readiness of emission data for use in LCA and baseline development. More comprehensive and accurate data and records will reduce potential independent consultant costs. However, it is likely that an independent consultant will be required to assist for the baseline year and establish the company's account. This work is carried out by a registered consultant. It is not mandatory to use a registered consultant in this step.	Possible and highly variable
Third Party Validation	Must be conducted by a third party validation provider to verify the work done by the registered consultant. Verification costs also increase with the complexity and size of the organisation. It is likely that verification providers will charge a higher fee if the company chooses not to engage a registered consultant.	Yes and will vary depending on step 1 approach
Offset Purchase	Purchase of suitable carbon offsets, price varies depending on where offsets are purchased. Offsets can range from $2 to 30.	Yes
Climate Active certification	The Climate Active annual certification fee is based on net emissions before offsetting and the number of certifications held. There are four brackets which range from under 2,000 tonnes of carbon emissions to over 80,000 tonnes. A company will pay between $820 to $2,627 annually inc GST for the lowest bracket which is likely to cover most oyster aquaculture companies in Australia. If the footprint is greater than 80,000 tonnes, the fee is $18,911 inc GST annually. These fees increase by 2.5% every year.	Yes

Pathway Options

There are several factors that would influence a decision for an organisation to apply for carbon neutral certification with the Climate Active Framework. Whilst carbon neutral certification has been available since 2010 in Australia, focus has largely been placed on the large-scale emitters and food producers. Recent years however has seen a voluntary shift across industries as they publicly commit to sustainability and social values, anecdotally supported by consumer choice and preference. However, there is currently no publicly available data that shows consumer preference towards carbon neutral seafood products over noncertified products in Australia or abroad. Despite this, organisations choose to become certified to:

- Safeguard their future operations from the possible risk of emission regulatory reform,
- Ensure future access to overseas export markets that have more stringent trade emission targets (i.e EU)
- Participate in net zero seafood industry targets
- Product stewardship from cradle-to-grave
- Differentiate their product in the marketplace
- Demonstrate environmental credentials and build social licence

For organisations/entities that are interested in understanding the best approach towards certification but are not ready to commit to full climate active certification and associated costs, entities can request a scoping study from registered consultants to help map the product carbon footprint and establish a data management plan and basic carbon reduction and offset strategy for implementation in future years. This approach would enable an options analysis to reveal the best value for money approach and strategy, i.e as a single entity vs forming a co-op of growers.

Benefits and opportunities to the Australian Oyster Industry, such as marketing, leveraging consumer choice and long term financial benefits from improved operational efficiencies

The Lowy Institute found that 6 in 10 Australians perceive climate change as serious and pressing problem with 8 in 10 Australians supporting a net-zero target for 2050, suggesting they seek firmer commitments by the Australian Government in developing policy and incentives to progressively reduce carbon emissions as soon as possible (16). Eighty—five percent of Australian customers also want brands to be more transparent about the sustainability of their products with 9 in 10 Australian consumers more likely to purchase ethical and sustainable products (17).

There is an increasing focus on environmentally sustainable seafood, which creates a potential for segmentation in the seafood market with research in Europe showing that environmental concern does sway preference in consumers (18). In addition, consumers in Vietnam are showing preference for aquaculture that carries an independent, third-party sustainability certification (19). For the carbon conscious consumer, choosing foods that are able to show that they have a low carbon footprint is a common approach to lowering an individual's carbon footprint and a way individuals can contribute to climate change action.

There is opportunity for the oyster industry is to use the certification programs to highlight the relatively low footprint of farmed bivalves such as oysters and mussels (figures 7) as well as the additional ecosystem service benefits such as nutrient removal from the water of oyster production. This could then be used as a marketing tool when promoting oyster consumption.

In addition to consumer benefits, focusing on long term improvements in supply chain and operational efficiencies to reduce an entities carbon footprint (such as vessel fuel usage) can also produce financial benefits. For example, Austral Fisheries completed a refit program in 2018 on their largest fishing vessel which saw a 38% reduction in fuel usage in its first year. "Given that around 80 per cent of our emissions are from diesel use, it shows the significance of the project and is a major achievement that has environmental and financial benefits. Done correctly, being carbon neutral can be a profit centre, not a cost centre" (Austral Fisheries commenting on their Climate Active carbon neutral certification).

"Eighty—five percent of Australian customers also want brands to be more transparent about the sustainably of their products with 9 in 10 Australian consumers more likely to purchase ethical and sustainable products."

HARVEST ROAD

LEEUWIN COAST

CASE STUDY

Harvest Road Oceans (HRO) became the first Australian Shellfish Aquaculture company to become certified carbon neutral under the Australian Climate Active Framework in 2021 for its oyster production. The driving force behind the certification was alignment with Harvest Road's aim of producing sustainable food, demonstrating this to the community, and improving production efficiency whilst reducing emissions. The product disclosure statement (PDS) represents the base year for Harvest Road Oceans Climate Active certification which sets a benchmark for comparison over time. The information presented in this case study is from the PDS (20) and consultation with Harvest Road and is focused on oyster aquaculture.

The PDA outlines the company's approach to measure scope 1,2 and 3 emissions in a reporting year, however as HRO only took ownership of their oyster farms in Albany in 2020, and oysters take a number of years to reach market size, they were unable to attribute energy use (and calculate emissions) per reference unit (1 dozen). As a result, their total emissions for the base year attributed to oyster farming was only 48 t CO2-e which is expected to climb in future years and estimates will be updated over time as data management and recording is refined.

Life Cycle Assessment

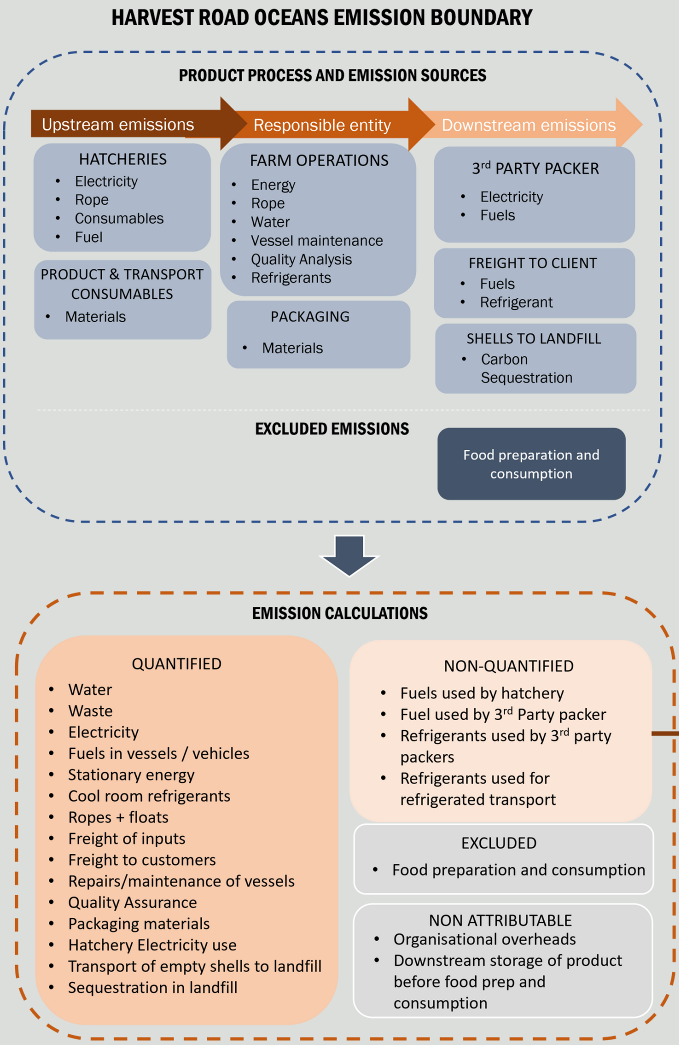
The assessment estimated the greenhouse gas intensity for the functional unit of "1 dozen Rock Oysters / Akoya supplied to customers". The assessment was carried out in accordance with the Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Protocol (38), including:

- the carbon emissions from a third-party hatchery,
- the fuel used in the boats to the pre-processing of the materials used in the packaging, through to freight of the product to the customer and;
- disposal of the empty shells

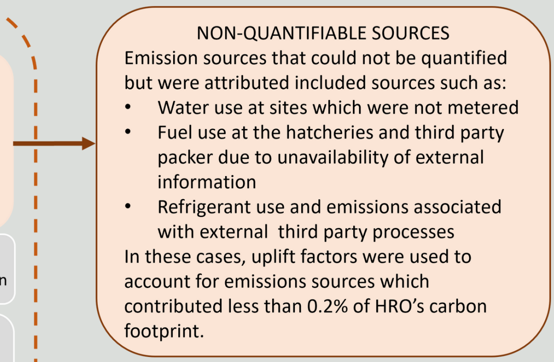
The product process diagram and emission boundary is shown in Figure 8. For emission sources where there is no actual or projected data available to quantity emissions in the carbon inventory, an uplift factor (upwards adjustment) was applied in accordance with the Climate Active Technical Guidance Manual (21). The uplift factor is used to increase the estimated emissions from an activity by a risk-adjusted proportion or percentage. In line with the GHG Protocol Product Standard, organisational overheads were not included within the emission boundary (e.g. capital goods, corporate activities, employee commuting).

image sources: Leeuin Coast | Harvest Road

Figure 8: Cradle-to-grave life cycle of shellfish products and the emission sources considered (including those quantified, non-quantified and those that were not attributed).



"Carbon neutral certification is part of our organisation-wide commitment to sustainability. Certification will allow us to showcase sustainable aquaculture and enables consumers to purchase sustainable shellfish, without compromising their values. Our employees can also feel proud that Harvest Road is committed to being carbon neutral."



Emission Reduction Strategy

Key emission reduction strategies employed by HRO include:

- Increased vessel capacity, increasing efficiency reducing diesel needs and usage
- Integrated product development reducing local freight and staff travel demands
- Investing in more efficient oyster handling technology reducing vessel time on lease per production unit

Environmental Stewardship approaches

- Replacement of lead lines with ceramic lines
- Switch from polystyrene to polypropylene boxes which are re-usable/recyclable
- Reducing seabed disturbance through investing in floating infrastructure
- Environmentally friendly hydraulic oil

Carbon Offsets

Offsets are forward-purchased based on the assessment for the completed year and next year's estimated sales volume. After each reporting period, a true-up will occur and any additional credits will be procured as needed. If HRO has pre-purchased more credits than required, then any surplus credits are carried over (banked) to the next reporting period. HRO chose to purchase credits with significant 'co-benefits' aligning with overarching sustainability goals beyond carbon emission reductions. HRO purchased offsets from the Fortaleza Ituxi REDD project in Brazil, mitigating deforestation in the Amazon in Brazil along with an additional equal number of credits from the Western Australia Yarra Yarra Project with a focus on long-term sustainability and recovering woodland in the Wheatbelt region. The Yarra Yarra credits will not be available until 2022 so it is likely this will result in surplus credits will be banked towards their next account.

5.0 Beyond Carbon: Ecosystem Valuation, Ecosystem Services and Environmental Accounts

Overview

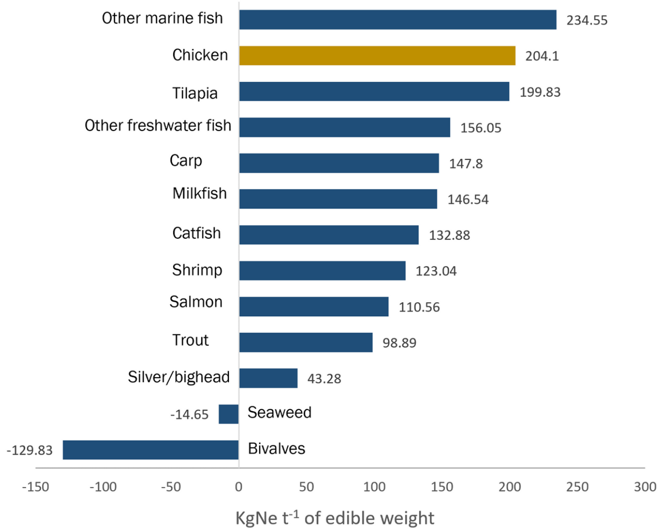
This report has outlined the value in taking measures to reduce an entity's carbon footprint from a sustainable stewardship, social responsibility, and an organisational risk perspective. However, decarbonisation approaches are focused on carbon and contributing to national and global emission reduction targets. In this section we discuss other opportunities available to the Australian Oyster Industry to highlight the broader environmental benefits of the industry.

Aquaculture is one of the fastest growing food production systems in the world, developing rapidly over the last 50 years in estuarine, coastal, and marine seascapes (22). Progress has been made over the last several decades toward the development of ecologically sustainable aquaculture practices, with growing recognition of how aquaculture can return positive ecosystem effects. The progress has been supported by regulation and policies and a growing understanding of the economic value provided by aquaculture through the provision of ecosystem services (23,24). As described earlier, the farming of bivalves when compared to other aquaculture practices, generates some of the lowest amounts of life cycle greenhouse gases, even when compared to wild caught bivalves. In addition, along with seaweed, they are one of the few farmed seafoods with negative nitrogen emissions (figure 9). These results are not surprising for filter-feeders that require no supplementary feeding. These results do however highlight how the oyster industry can easily outperform many other sources of land-based protein when viewed from an environmental stress perspective and enhance the potential opportunities and role that the oyster industry could play within sustainable diets and shifting demand from relatively high to low stressor foods.

To demonstrate this benefit there is a need to both quantitatively and qualitatively measure how environmental elements of an industry add/detract value and how they change overtime. This has been the focus of the development of ecosystem services and environmental accounting principles over the last decade.

Several valuation methods have been developed to help measure and quantify these ecosystem effects and values, each providing their own potential unique value to the Australian oyster industry through certification , transparent stewardship, or even payment for ecosystem services. We provide a high-level summary of these approaches below:

Figure 9: Farmed Aquaculture nitrogen emissions (KgNe t-1) showing bivalves (including oysters) as one of the few farmed seafoods with negative nitrogen emissions.



source: Gephart J.A et al 2021 (25). Chicken is highlighted yellow for comparison as a 'low emission/low impact' land based farmed protein.

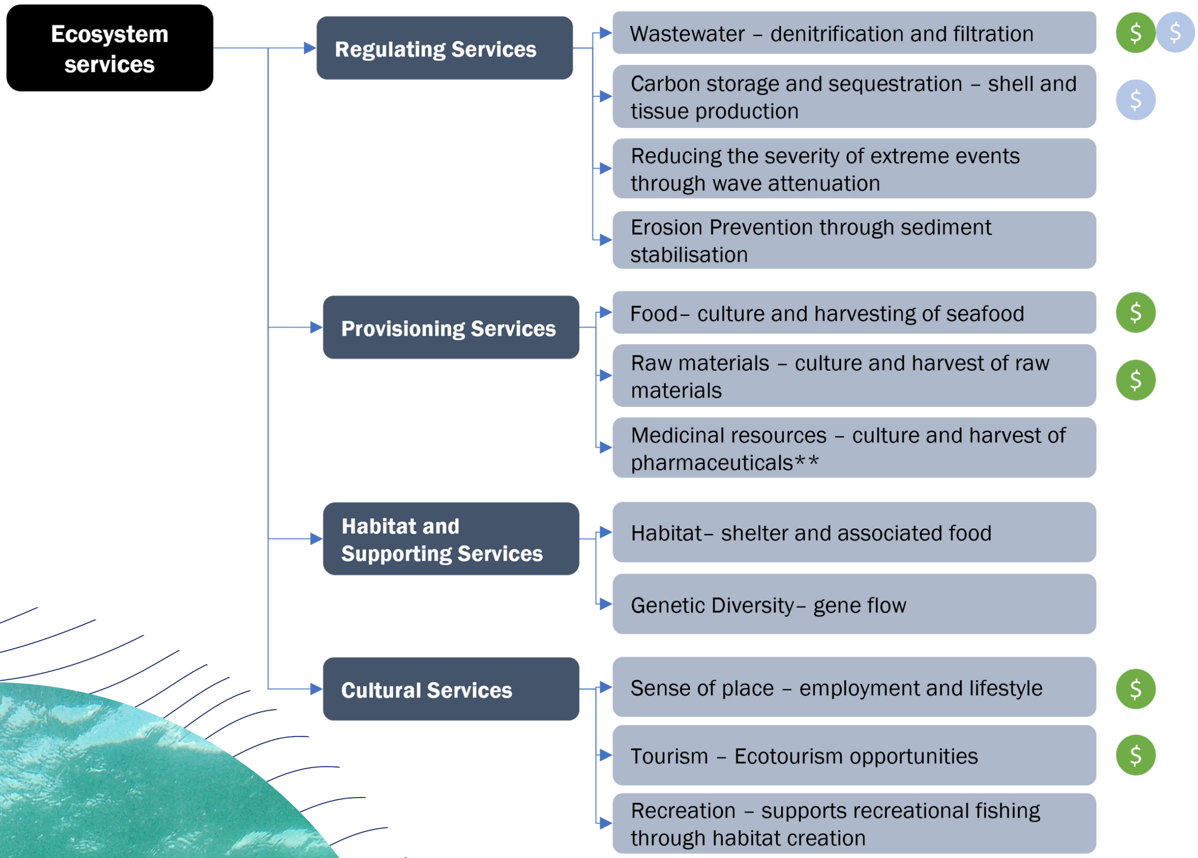
Ecosystem Services (ES)

Ecosystem service (ES) accounting was established to provide a finance-based platform for quantifying nature's goods and services, to draw attention to the crucial role biodiversity plays in global economic benefits as well as the significance of its loss (26) as well as promising solution to halt the degradation of ecosystems through payments for ecosystem services (PES). A growing body of scientific evidence indicates that the commercial cultivation of oysters can deliver valuable ecosystem goods and services beyond generating a food product for human consumption, including provision of new habitats for fish and mobile invertebrate species. A recent literature review of studies focusing on habitat-related interactions associated with bivalve and seaweed aquaculture found that bivalve aquaculture were associated with higher abundance and species richness of wild, mobile macro-fauna when compared to both seaweed farms and reference sites (39).

These services (Figure 10) are referred to as "provisioning services" and "habitat supporting services". In addition, oyster farming plays an important role in nutrient cycling, assimilation, removal; water filtrations; and the attenuation and stabilisation of wave energy. By reducing excess anthropogenic nutrients, the shellfish aquaculture can help to combat eutrophication (27). These services are referred to as "regulating services". Further, aquaculture can provide cultural services through preserving the individual and collective physical and spiritual connections with the marine environment and resources. Shellfish farming has been shown across Australia as a means for traditional and indigenous communities to maintain and preserve customary access to ways of life in a sustainable way whilst achieving income. The provision of employment opportunities can also serve to provide a sense of place, particularly in regional areas and provide alternative employment opportunities for those affected by losses in wild fisheries.

Food tourism is also an emerging industry that can be important in sustaining and building regional community identity and create employment opportunities (28). Individual aquaculture operators may be able to provide farmgate experiences to interact with their business, and regional hubs or collectives of tourism or education-oriented activities can showcase operations across the value chain (i.e. spat production, farming, harvesting, marketing, transport). Notably, aquaculture operators who develop value-added activities as a part of their business and link production to other ecosystem services generally adopt broader socioecological principles resembling an ecosystem-centric approach to aquaculture. For example, the use of oyster infrastructure and exclusion areas in marine protected areas avoids additional recreational fishing pressure whilst allowing the rehabilitation of sub-tidal ecosystems such a sea grass and protection of juvenile fish species. When paired with food processing and educational experiences, oyster operations can support provisioning, habitat, cultural and regulating services.

Figure 10 Shellfish Aquaculture can provide a range of goods and services across four service categories, ($) indicate services where revenue opportunities currently exist (green) or may exist in future (blue). ** Australian aquaculture oysters are currently not used for pharmaceutical products



Source: adapted from Alleway et al (2019).

Payment for Ecosystem Services (PES)

Payment for Ecosystem Services (PES) translate these positive attributes into monetary terms, rewarding ES providers for their conservation efforts using positive and conditional economic incentives, thereby aiming at internalising market externalities. Over the last two decades, publications addressing PES have increased dramatically, paralleled by a growing interest by national governments and organisations looking at conservation and sustainable development goals such as poverty reduction, as well as implemented PES programs (29). However, valuation methods are viewed critically because the measurement and calculation of ES is often difficult, e.g., due to incomplete information and scientific uncertainties regarding ecosystem functioning, which like carbon, is arguably complex in the marine environment compared to terrestrial landscapes (30).

The removal of anthropogenic nutrients from the water through the aquaculture of shellfish, however, has been a growing area showing promise for potential PES schemes. Nutrient removal through assimilation by aquacultured shellfish with the goal of offsetting terrestrial nutrient sources has been proposed, modelled, or piloted in various scenarios and across many locations (31,32):

- The effect of blue mussel farming on nitrogen cycling was modelled in Sweden in 2005 where the ability of mussels to act both as sustainable food production and as a cost-effective method to improve coastal water quality was evaluated. The Swedish study demonstrated that the production of 2800 tonnes of mussels would result in the removal of 28 tonnes of nitrogen. When attributing a nitrogen removal revenue and income tax, the study estimated that the net cost for society would only amount to 1USD for each kg of nitrogen removed which is far more cost effective that alternative nitrogen removing technologies.
- In Australia, a 2005 study investigating nitrogen bio-assimilation in pearl oysters found that each tonne of pearl oyster material harvested, removed 7.5kg/t of nitrogen from the waters of Port Stephens. Increasing farm production from ~10 t/yr, to ~500 t/yr would be sufficient to balance nitrogen loads entering Port Stephens from a small sewage treatment plant (37).
- A 2017 study investigating the potential for oyster aquaculture to complement existing wastewater management measures in urban estuaries in Long Island Sound, USA, found that up to 1.31% and 2.68% of incoming nutrients could be removed by current and expanded production respectively (32). The value of removed nitrogen was conservatively estimated using alternative management costs (e.g., wastewater treatment, agricultural and urban BMPs) as well as replacement cost methods (i.e. if oysters no longer existed), showing ecosystem service values of USD$8.5 and $17.4 million to $469 million per year for current and maximum expanded production, respectively. Note that these costs are proxy for the value of N removal through bioextraction.

When compared to other nitrogen removal methods and offsets such as riparian and wetland construction, oyster farming is less intensive and more cost efficient to establish and operate whilst also achieving sustainable food production and employment benefits. A study conducted in 2016 in North Queensland's Tully catchment determined through consultation with industry that wetland construction costs are typically between AUD$30,000 - $40,000 per ha, depending on the nature of the terrain, access and design purpose with an annual estimated maintenance cost of 2% of the initial construction cost (33). Unlike oyster production, wetlands also do not offer employment opportunities or a sustainable commodity that can be harvested. Nutrient offsets presents an opportunity for oyster producers that has the potential to generate income beyond food production(34).

Various payment/trade mechanisms have been proposed in Australia particularly with the aim of improving water quality objectives and outcomes on the Great Barrier Reef (i.e. "Smart Market" (33), Reef Credits). Whilst these market approaches are yet to gain sufficient traction for there to be a tangible opportunity for the Australian oyster industry, there are state policies (in all states/territories except NT and Tasmania) which enable flexible options for environmental offsets to assist with managing point source pollution (particularly nitrogen). However, in lieu of a 'nitrogen credit market' and 'approved methodologies" (like the carbon credit units) an offset proposal would need to be directly linked to an emission producer, most likely through a partnership arrangement, and assessed by the respective state's environmental regulator.

The key challenges in PES schemes in Australia are:

Conditionality: meaning that payments to ES providers are only made if the provision of the ES can be contractually secured, making clearly defined and enforced property rights and good monitoring necessary

Spatial scales: The role of spatial scales for the environmental and social effectiveness of PES programs has not been sufficiently examined in the literature. One often mentioned issue addresses the distinction between the scale of ES provision versus the scale of ES benefits.

Regional vs national: local and regional schemes provide a range of advantages compared to national or international schemes. There are indications that local scale PES programs are more effective. In practice, most PES schemes operate at local or regional scales anyhow, while international PES programs appear to be rare.

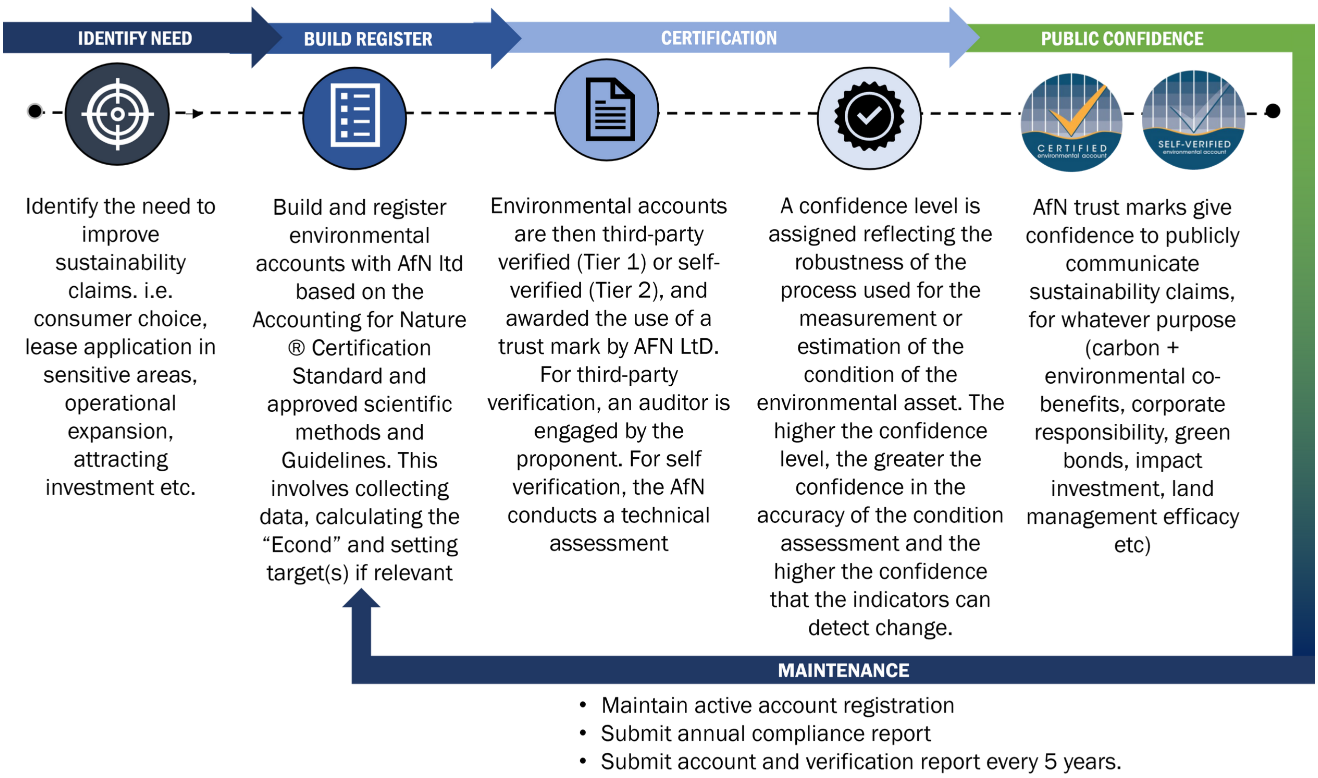
Natural capital Accounting and Certification

Accounting is a long-established and well understood format for organising information with built-in checks and balances. It is used for tracking value through time and space. While national accounts report on the economy, on the whole measures of human, social, and natural capital do not register in these accounts.

Environmental condition accounting provides standardised, quantifiable assessments of the physical state of "environmental assets" such as agricultural soils, native vegetation and wildlife, rivers and marine ecosystems. This enables natural resource managers, policy makers, investors and customers to link the condition of environmental assets with economic decision making. Environmental accounting focuses on establishing the condition of environmental assets within a defined area (e.g. farm or protected area) or at a regional (ecosystem) scale. Importantly, environmental accounting also seeks to determine the trend in environmental condition - that is, to show whether (or not), and at what rate a resource management activity and underlying investment is making a real and measurable difference on the ground. The Australian environmental accounting standard is managed by the Accounting for Nature® Framework which is free to be used by any organisation or individual to measure the biophysical condition of their environmental assets over time. The Accounting for Nature® Framework has been developed so that it complements other standards and certification systems, such as those for developing carbon offset projects, building and assessing impact investment opportunities (e.g. green bond criteria), pursuing corporate sustainability outcomes and achieving global goals such as the Sustainable Development Goals and Aichi Targets. It is also consistent with the United Nation's Standard for Environmental Economic Accounting (SEEA). Similar to a framework for financial or carbon accounting, the Accounting for Nature® Framework offers a system of rules and processes designed to ensure integrity and transparency of environmental accounts, no matter the environmental asset being measured. The Accounting for Nature Framework has been tried and tested over a decade from 2008 to 2018 at both property (enterprise) and ecosystem (regional) scales and is at the forefront of environmental accounting both nationally and internationally. Through reviewed and approved methodologies, the framework allocates an 'Econd' which is the condition of an environmental asset at time of measurement. An Econd is established by comparing the current condition of a set of indicators against their reference condition. The benchmarks for these reference states must closely approximate the natural or unmodified condition of native vegetation (through the use of a historical record, observation at a reference site, robust modelling or expert opinion).

Unlike the Climate Active Framework, third party verification of the environmental account is not mandatory but is recommended to ensure confidence (Figure 11).

Figure 11: Steps involved in obtaining and maintaining Accounting for Nature certification



The Accounting for Nature methods contain detailed measurement and reporting requirements for specific environmental assets in specific regions, ecosystems, or sub-regions. In preparing an Environmental Account, proponents must select a Method they will follow in preparing their accounts. Parties who wish to have their Environmental Account certified have three options in selecting Methods, depending on the measurement and monitoring requirements of their project and what they want to use it for. They can:

- Download and use an AfN approved "open" Method;
- Request to review a "licensed" Method, which may require a licensing fee of $1,000 per project;
- Develop their own Method, either independently or in collaboration with Accounting for Nature Ltd, and submit it to the Standards & Accreditation Committee for accreditation and approval for use under the Framework

A confidence level is then assigned to the method which reflects the robustness of its processes for the measurement and estimation of a condition (examples are shown in Figure 12 below).

Figure 12 shows an example from the Accounting for Nature Claims Guide which shows the different confidence levels awarded for individual assets in an example Environmental Account. *A Level 1 (Very High) confidence level applies to Methods that include a comprehensive set of indicators and are likely to have very high accuracy (≥95%) when measuring the condition of environmental assets and detecting change in their condition through time. A Level 2 (High) confidence level applies to Methods that include a relatively comprehensive set of indicators and are likely to have high accuracy (≥90%) when measuring the condition of environmental assets and detecting change in their condition through time. A Level 3 (Moderate) confidence level would apply to Methods that include a limited set of indicators and are likely to have moderate accuracy (≥80%) when measuring the condition of environmental assets and detecting change in their condition through time (35)

Figure 12 - Accounting for Nature confidence level illustration

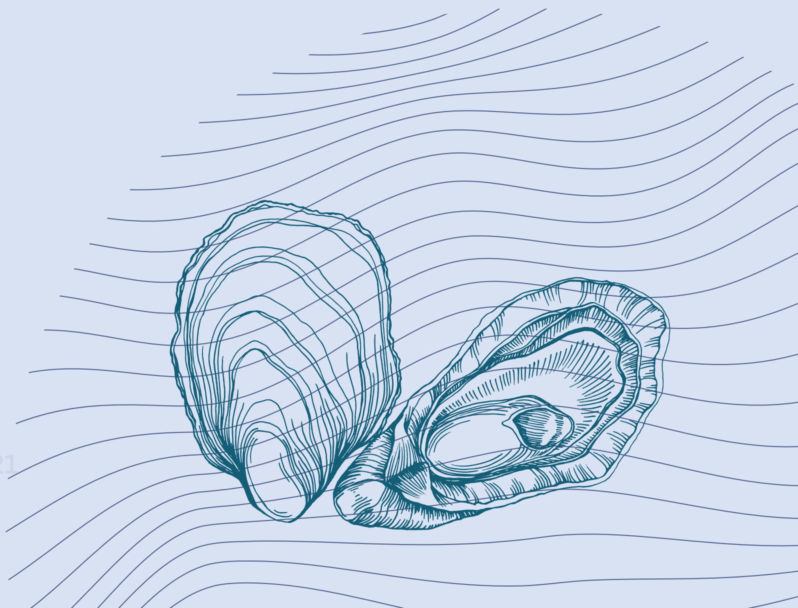
Asset Class	Econd® 2020	Econd® Trend 2010-2020	Confidence level*	Status
SOIL	76	Econd® +20 Since 2010	LEVEL 1	CERTIFIED ACCOUNTING for NATURE
FRESH WATER	52	Econd® Stable Since 2010	LEVEL 2	CERTIFIED ACCOUNTING for NATURE
NATIVE VEGETATION	24	Econd® -15 Since 2010	LEVEL 3	CERTIFIED ACCOUNTING for NATURE

Methods for establishing an environmental account should be selected based on the confidence level required to support the intended use of the environmental account. For example, the proponent may decide to use Methods with a Level 1 confidence level where they wish to participate in any environmental market, Level 2 for helping to support public sustainability claims, and Level 3 for gaining an initial understanding of environmental change over time for internal business purposes

For oyster farmers who wish to demonstrate the sustainability of their product as well as the low impact nature of their operations on the surrounding environment, the Accounting for Nature Framework provides a certified avenue to support these claims and to also enable a record of management over time. Examples where this could be beneficial include:

- Creates a long term dataset of how oyster aquaculture and associated operations interacts with the surrounding environment which is becoming increasingly important along with increasing demand for low emissions protein sources from the sea.
- Operating in protected areas where key assets within the lease areas can be monitored and documented over time (i.e seagrass, benthic diversity) to ensure no adverse impact.
- Compliments nitrogen reduction offsets through the monitoring and management of water quality along with other environment assets key to the regional ecosystem.
- Comprehensive data demonstrating sustainable, low impact practices is more likely to assist in future production expansion, green financing, and impact investing.

The costs for certification are likely to be similar to carbon neutral certification under the Climate Active Framework, however, as there are no existing approved marine methods, resources would need to be allocated to developing the methods for the chosen assets through collaboration with Accounting for Nature. Once the methods are developed, they can be widely used with/without a licence fee depending on the agreement with the method developer. A practical and cost effective approach may be for Oysters Australia, or other entity, to investigate the development of a subset of methods that may be applicable to a number of oyster farms in Australia for trial.



Summary of Ecosystem Services

The increasing demand for sustainable food to support growing populations means there is the ever increasing need to look at our ability to advance industries with greater positive environmental and social influence. Whilst oysters themselves are small in size, they are one of the most sustainable no feed, no waste aquaculture operations on the planet which provide additional environmental benefits through the filtration of nutrients whilst providing economic and social benefit to the regions in which they occur. Further, actively accounting for the positive effects of oyster aquaculture on ecosystem assets and services, could provide a broader and more accurate valuation of the full range of effects the industry might have at successive scales of influence (local, regional and global), and emphasise its link to healthy ecosystems.

In order to more accurately understand and quantify the ecosystem services and benefits that oyster aquaculture operations provide, there are several areas that require further investigation to assist the development of valuation and accounting methodologies and to ensure integrity and transparency of claims. These include understanding the interacting factors between oyster farms and their surrounding habitats (cause and effect relationships) to better understand how beneficial ecosystem effects can be maximised (see recommendations in Part 6).

6.0 Summary and Recommendations

Now more than ever, the global community has an expectation that industries demonstrate practices that align with community values and benefits particularly in the food production industry. Governments around the world are incentivising industries to progress towards lower emissions and more sustainable production, including the taxation of imports from countries with less proactive emissions regulations. This is placing increasing pressure on the Australian Government to develop more proactive emission reduction targets and policies into the future. This, combined with the existing need to meet current emissions targets and the community's desire for trust, respect, and value (also known as the social licence) highlight the driving forces the oyster industry's growing appetite to demonstrate its sustainability credentials. Further, the FRDC strategic 2020-2025 vision of "Fish forever 2030; Collaborative vibrant fishing, and aquaculture, creating diverse benefits from aquatic resources, and celebrated by the community" identifies these areas as being of strategic priority for the Australian government.

This report has outlined several certification opportunities available in Australia for parties voluntarily wishing to prove their commitment to sustainability and net zero objectives and their application and potential benefits to the Australian Oyster Industry. We have conducted a high-level summary and value assessment of seven of the most common certification options in table 2 and have discussed in detail the Australian Government carbon neutral certification framework "Climate Active" and the Accounting for Nature ® environment accounting certification framework.

These two frameworks were highlighted due to their robust and scientific foundation, uptake by Australian businesses and organisations (particularly regarding food production), alignment with best practice approaches, transparency, and requirement for technical assessment ensuring credibility and confidence to the market. Both certification options discussed allow for the development of scoping options and full certification, enabling entities to 'lean in' without a full commitment or incurring full certification costs. This flexibility allows entities to a) understand the costs and value specific to their business; b) determine the level of complexity required for data collection and assessment; and c) develop a plan for implementation over future years for consideration in budget and productivity planning. Where appropriate, we have also used case studies to demonstrate certification steps and data which communicates the potential value of measuring and validating ecosystem benefits.

Expanding terrestrial biodiversity and green infrastructure funding opportunities to the coastal environment

The report has also highlighted the potential for oyster growers to benefit from the Australian government's recent funding commitments to biodiversity programs. While there are currently no specific programs targeted to sustainable aquaculture, the growth and development of the Australian oyster industry, particularly in regional areas is likely to align with several criteria across these funding areas. Particular areas of value include environmental performance, and the role oyster farms play in the provision of ecosystem services and regional economic development.
Subsequently, it would be worthwhile for growers to engage with their state and local governments to assess the opportunity for funding in line with these focus areas with a goal of ensuring that the programs are expanded to include aquaculture projects.

At the national scale, the Australia government has invested millions of dollars into carbon and biodiversity stewardship programs over the last few years, with particular focus on land-based agriculture. Recently, 2020 saw the Australian government invest in a range of programs that aim to assist agricultural landowners manage their natural resource base through the Agricultural Biodiversity Stewardship Package committing AUD 34 million to help develop market arrangements and kick start private investment in farm biodiversity and other sustainability opportunities. Whilst the program is currently in pilot phase and focused on terrestrial systems only in high value regions, similar biodiversity benefits could be realised in oyster lease infrastructure with benefits to water quality and habitat through the maintenance of intertidal habitats (such as seagrass, seaweed, benthic composition) and restoration of natural oyster beds. However, consultation with the Department of Environment noted that the program is, at this time, terrestrially focussed. Whilst research gaps exist in understanding the ecosystem interactions between aquaculture infrastructure and natural habitats, particularly across seasonal and spatial scales, ecosystem benefits have been well documented for consideration in extending the vision of such programs to include sustainable aquaculture industries. This program perhaps presents the most promising opportunity for FRDC and Oysters Australia to engage with the Department of the Environment to identify potential opportunities and program criteria that would enable the Department to consider extending the program to facilitate a stewardship pilot trial in oyster aquaculture.

High value research areas

Through this review, the following areas of research have been identified as being of high value in filling the knowledge gaps hindering the development of blue carbon methodologies and ecosystem service valuation in oyster aquaculture in Australia:

Understanding the carbon balance

Part 2 of this report highlighted the challenge in obtaining consensus on whether carbon sequestration can be directly attributed to the quantity of carbon measured in the oyster shells due to ecosystem interactions. We have also discussed that the potential carbon sequestration from oyster production is of low monetary value and therefore unlikely to be prioritised for method development under the Emission Reduction Fund. There is, however, some value in understanding the net carbon impact of an oyster for use in developing net zero strategies. Therefore, the need remains for more conclusive research with the objective of accurately determining the net CO2 impact of each oyster produced.

Impact of sustainability and carbon neutrality claims on oyster marketing

As highlighted through this report, future impetus for carbon neutrality is likely to be driven by consumers and the wholesale and retail markets, including restaurants and chefs. However, limited market research has been conducted and published to date that shows data or tends in consumer choice related to the purchase of carbon neutral products in the market. Therefore, it would be beneficial to leverage the relationship that Oysters Australia has with industry and FRDC to understand how carbon neutral certification and/or environmental accounting certification may influence purchasing choice in the future through both a passive and proactive approach.

Environmental impacts of large-scale expansion

Part 3 of this report discussed the potential opportunities for the Australian oyster industry in ecosystem services (ES) and payment for ecosystem services (PES) and the benefits of expanding seafood industries that are low emission, low stress, and low impact. Additional research is needed to understand the total environmental impacts of large-scale expansion of oyster production, especially for system-specific impacts. Increasing production also requires the creation of appropriate incentives, reducing barriers for producers and technological interventions that improve production efficiencies and mitigate risks (including disease management). Research and findings need to be available to the public to ensure knowledge and technology transfer to all farmers despite farm size, and adoption of practices that lead to the growth of sustainable industries with low environmental stress.

Ecosystem Services - cause and effect relationships

There is a need to evaluate cause and effect relationships and to generate primary data on interactions between fundamental factors, such as biogeochemical cycles, species, and surrounding habitats. For instance, how farm design (eg. infrastructure type, stocking densities) and sector-wide operational standards (eg. controls and maintenance standards adopted to reduce biosecurity or aquatic animal health issues) influence the ecosystem services provided and the extent to which any negative impacts might undermine the benefits.

Maximising ecosystem effects

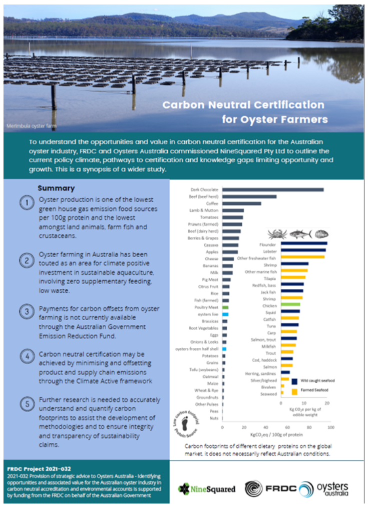
Oyster production ideally should support many of the goods and services provided by natural shellfish ecosystems. Due to dwindling naturally occurring oyster reef ecosystems, there may be instances in which oyster aquaculture is an effective method for supporting and restoring these natural ecosystem functions, such as the provision of shellfish for food and introduction of a large mass of filter feeders to increase water filtration. More research is needed to understand how oyster production can be best designed, to maximise ecosystem effects in relation to oyster reef rehabilitation, as well as identifying any risks in doing so (i.e. disease risk).

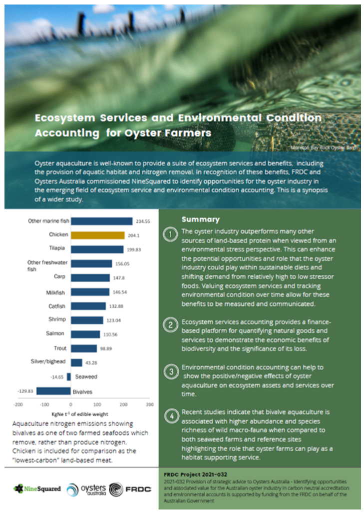
7.0 Extension and Adoption

Project materials

This project developed the following materials which are available via the Oysters Australia website.

1. Opportunities and associated value in carbon neutral Certification and environmental accounts: Strategic report for the Australian Oyster Industry (this report).
2. Communication handout - Carbon Neutral Certification for Oyster Farmers.
3. Communication handout - Ecosystem Services and Environmental Condition Accounting for Oyster Farmers.





Presentations

1. Webinar chaired by Oysters Australia on the 5th May 2022, presented by Dr Rachael Marshall from NineSquared. Recorded webinar available via the Oysters Australia Webpage www.oystersaustralia.org
2. Conference presentation at NSW Oysters conference, Batemans Bay 18-20 May 2022. "Carbon credits, carbon neutral certification and environmental accounts". Presented by Dr Rachael Marshall

Media

1. ABC radio - NSW Country Hour interview 19 May 2022 12:00pm
2. ABC South East (article): Researchers, farmers investigate carbon neutral accreditation for Australian oysters - ABC News. 20 May 2022

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Appendix

Consultation record

Climate Active	Australian Government backed carbon neutral accrediation framework
Harvest Road	First shellfish producer to become certified carbon neutral accredited in Australia
Accounting for Nature	Environmental accounting certification pathways in Australia
100% Renewables	Consultancy with extensive experience in the Climate Active accreditation processes
DAWE	Deparment of Agriculture, Water and the Environment - Ag Stewardship program

Reference/Calculations

The below assumptions were used for to estimate the average CO_2 for oysters and mangroves in table 1.

Oyster shell weights and carbon percentages

	Sydney Rock Oysters	Pacific Oysters
Shell % of total weight	75.6%	83.8%
weight of a dozen oysters (kg)	0.43	1.0
Average shell weight (Kg)	0.0271	0.0968
Average C per shell (Kg)	0.00325	0.00838

Source: Pacific Oyster data sourced from Hickey (2004), Moreton Bay farmed Sydney Rock Oysters from NineSquared/University of the Sunshine Coast supplied data (2020).

Carbon Calculations

The data below is taken from table 1 to demonstrate the calculations.

Location	Species	density (per ha)	Harvest period	Carbon sequestered over harvest period (kg)	Carbon sequestered (tC ha-1 yr-1)	Equivalent in carbon dioxide (tC ha-1 yr-1)	Offset revenue per ha per year (based on carbon price of $40)
SA Coffin Bay (Avg across 2 sites)	Pacific Oyster	259,200	2 years	2,167.8	1.086	3.988	$43.36

1. The ratio of CO_2 to Carbon was calculated based on the atomic weights of each molecule

$$3.67 = \frac{(12 + 16 + 16)\ \text{(Atomic weight of CO2)}}{12\ \text{(atomic weight of C)}}$$

2. Multiply this ratio with the amount of C per hectare to obtain the amount of CO_2 sequestered per hectare of oyster farm and mangrove forest over the growth period. To calculate the annual CO_2 offsets, we divided the total amount of CO_2 per hectare by the the harvest period or growth life.

$$3.988\ \text{t of CO2 per ha} = 3.67 * \left\{ \frac{\text{Carbon sequestered over harvest period}}{2\ \text{years}} \right\}$$