Carbon and Nitrogen Marine Offset Synergies in Australia's regulatory framework

Opportunities for seaweed and shellfish aquaculture | 2020

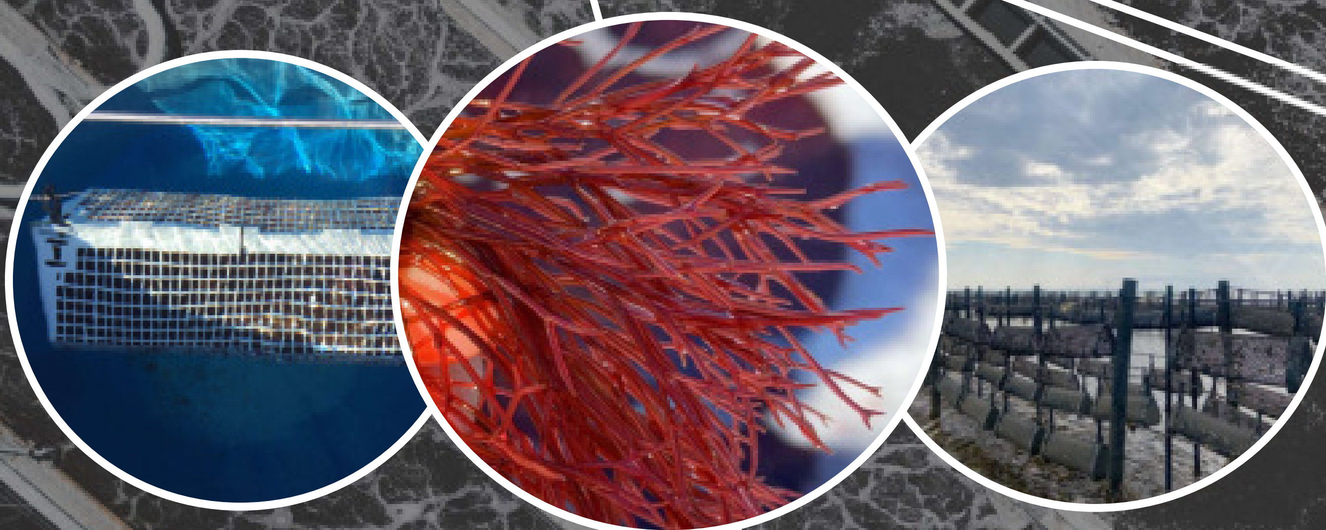

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Table of Contents

Figures

Abbreviations and Acronyms

SeaSets	Seaweed Shellfish Offsets Project
CO2-e	Emission of carbon dioxide
GHG	Green House Gas
IPCC	Intergovernmental Panel on Climate Change
UNFCC	United Nations Framework Convention on Climate Change
REDD+	Reducing emissions from deforestation and forest degradation
UNEP	United Nations Environment Programme
IUCN	International Union for Conservation of Nature
ACCU	Australian Carbon Credit Unity
CSF	Climate Solutions Fund
ERF	Emissions Reduction Fund
CSIRO	The Commonwealth Scientific and Industrial Research Organisation
Tg C	Teragram of carbon
STP	Sewerage Treatment Plant
ANAO	Australian National Audit Office

Acknowledgements

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1. Executive Summary

In 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. These instruments have proven effective because they place a tangible value on the pollutant requiring abatement and can be a cost-effective method for achieving pollutant reductions, particularly resulting from negative externalities associated with profit-maximising enterprises. 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.

Market-based instruments are employed around the globe across a range of pollutants, most recently in the area of anthropogenic carbon emissions through a 'cap and trade' system. This system was adapted in Australia to a baseline and credit mechanism. Similar systems have also been implemented in several Australian states as a way of managing water quality pollution from point-source discharges and diffuse catchment pollution. Cap and trade systems through trading or approved offsets offer flexible options for licensed, point-source operators to meet their water emission discharge requirements in a more cost-effective way that maximises the ecological benefits and whole of catchment outcomes.

The use of offsets provides an avenue to reduce the overall cost of achieving a given emission target particularly when the cost of the offset is less than the cost of on-site mitigation. Emitters purchase credits supplied by offsets from approved abatement projects. In Australia, this is facilitated through the Emissions Reduction Fund (ERF). A by-product of the ERF is the potential for projects to deliver incentives and sustainability benefits beyond the offset objective through the development of technology, alternative income streams, biodiversity protection or restoration, and overall consumer behavioural change. To date, most offset projects in Australia have focused on terrestrial programs in vegetation such as reforestation and biodiversity conservation, agricultural stock management, savannah burning programs under approved ERF methodologies. The international community (including Indonesia, Cost Rica, Australia) is progressively interested in exploring offset project potential in coastal or marine ecosystems with key focus across coastal wetlands, mangroves, seagrass and seaweeds. So called 'Blue Carbon' (carbon captured by coastal and marine ecosystems) has been shown to have much greater carbon sequestration potential than terrestrial systems. However, considerable steps need to be taken in understanding and estimating the carbon storage potential in specific coastal ecosystems (in particular permanence) before such methodologies can be approved under these existing frameworks.

Similarly, interest is growing in the use of marine offsets for the treatment of nutrients, primarily nitrogen, attributed to point source pollution from sewage treatment plants and diffuse catchment pollution. The use of marine plants such as seaweed has been touted as one of the most effective biological means for treating nutrients. Seaweed has been used in aquaculture systems around the world as a biofilter to remove nitrogen from the aquatic environment. Seaweed is also grown extensively across the Indo-Pacific for the generation of food, gels and agricultural products, yet seaweed is not currently farmed in Australian coastal waters. As governments and industry look to more ecologically-balanced solutions for the management of waste streams, seaweed farming presents an opportunity for nutrient credits and/or offsets. This opportunity could be generated using existing aquaculture systems with the corresponding growth of a sustainable domestic industry with minimal waste generation.

Whilst offset projects are well regarded for creating additional environmental and socio-economic co-benefits[1], only one offset is typically recognised for consideration even if there are multiple offsets of potential financial value i.e. sustainable aquaculture farming that offsets both carbon and excessive nitrogen in water catchments. Whilst this is not unique to Blue Carbon, the quantification of carbon sequestration and permanent storage in coastal ecosystem is more challenging when compared to terrestrial environments and has subsequently slowed progress towards identifying and accepting Blue Carbon methodologies. The complex nature of the Blue Carbon concept, however, combined with the need to address growing water quality concerns in the shadow of booming coastal populations in Australia, has led to unprecedented collaboration across disciplines, where scientists, conservationists and policy makers have interacted intensely to advance shared goals and increase flexibility in approaches to sustainability and climate mitigation.

Whilst we demonstrate that there is both environmental and financial benefit in both carbon and nitrogen offset opportunities, we demonstrate that nitrogen offsets have an offset value twice that of carbon per tonne of harvest, and traceable environmental and economic benefit at the local and regional scales, and the potential for greater renumeration through an offset market mechanism. Irrespective of the aquaculture method (e.g. oysters or seaweed), the value of nitrogen (per tonne of seaweed) is twice that of carbon, based

[1] Green and Minchin (2012) The co-benefits of carbon management on country. Nature Climate Change 2, 641-643

on existing nitrogen treatment costs (globally) and current carbon market prices. For example, with a carbon market price of AUD$12 per tonne, harvested seaweed (dry) and oysters (shells only) could attract additional revenue of between AUD$2.00-$3.00 and between AUD$1.44- $5.22 per tonne per harvest respectively through the sale of Australian Carbon Credit Units. Storage permanence and sequestration periods, however, remains an issue and further research needs to investigate the cradle to the grave carbon lifecycle to accurately quantify and track carbon sequestration. Nitrogen, on the other hand, at a current treatment cost of between AUD$10-40 per kg, has the potential to attract between AUD$50-200 per tonne of oysters and AUD$200-$800 per tonne of dried seaweed through trading nitrogen credits. In both circumstances the cost of production of seaweed and oysters remain similar, meaning that the relative financial value of the nitrogen offset could be substantially greater than the carbon offset.

Through this paper, we demonstrate an opportunity to integrate both nitrogen and carbon pollution management through sustainable aquaculture systems that would enable the growth and diversification of commercial products to traditional markets as well as the potential trading of nitrogen and carbon on offset markets. We consider the market-based mechanisms utilised for both carbon and nutrient pollution in Australia; the regulatory framework that facilitates them; the non-regulatory pathways and their incentives; the role of both the communities and business interests (suppliers and investors) at the opposite ends of the offset value chain across spatial scales; and the overarching benefits and constraints for combining carbon and nitrogen offset activities in coastal aquaculture.

2. Introduction

Offsets are measures that compensate for the residual impacts of an action on the environment, after avoidance and mitigation measures are taken. They are designed to ensure that when a negative environmental impact is expected from an activity, there is no net loss to the environment because an equivalent net benefit to the environment will occur elsewhere in the system. Compensating for environmental impacts in the form of offsets has become an important component of an environmentally sustainable development framework. They are used widely both to compensate for impacts of development and to compensate for negative externalities that result from industrial processes, such as excessive CO_2 emissions. As the prevalence of environmental offsetting grows, so does the challenge of translating no-net-loss goals to workable policy.

The overarching objective of environmental offsets is to deliver a 'no net loss' of a particular component of the environment. This objective is typically enabled through policy frameworks and the use of metrics, which quantify the amount and type of environmental impacts to be incurred through a development on one or more components of the environment, and also what an equivalent offset would be to compensate for that impact. A best-case scenario delivers a net gain. This same concept applies to offsets for many different pollutants including carbon and Nitrogen.

Carbon offsets represent a system of addressing negative externalities related to greenhouse gas emissions. Carbon offset activities are designed to counterbalance the unavoidable emission of carbon dioxide (CO_2-e) into the atmosphere as a result of industrial processes and other human activity through allocating carbon offset proceeds towards carbon mitigating projects such as preventing rainforest deforestation. The key issue with negative externalities is that the total cost of the activity is not borne by the consumers of the activity. The most prevalent example is the generation of power in a coal fired power station where the power plant incurs a cost for coal is uses to produce electricity but does not incur the full cost of the production of the electricity which also includes the costs borne by others due to the pollution and climate change impacts. The concepts of carbon taxes and cap and trade systems seek to replicate the full cost of the production of greenhouse gasses though equalling the value of the negative externalities.

Consequently, carbon offsets are a crucial components of international climate mitigation strategies in that they are the principal incentive mechanisms of the global carbon market which aims to reduce emissions cost-effectively by setting limits on emissions and enabling the trading of emission units (representing emission reductions). Carbon offsets in theory represent the means by which businesses are given flexibility and financial motivation to transition to a low carbon industrial base by utilising best practice approaches deliver a net gain for climate change mitigation. However, carbon offsets are also a means to allow companies to continue to emit if it is more cost-effective to offset rather than reduce the activity and/or use alternative technologies.

Most carbon offset initiatives are focused on carbon capture in terrestrial environments with projects predominantly in vegetation (i.e. reforestation and conservation initiatives), agriculture (stock management) and savannah burning (prescribed burning to reduce old growth vegetation loss). No registered Australian carbon offset activities presently involve carbon sequestration in aquatic environments[2] ('Blue Carbon') which are extremely efficient at sequestering and storing carbon, particularly in coastal wetlands, which are under ever increasing threat from population growth and development. The challenge in approving 'Blue Carbon' mythologies and subsequent projects lies in the ability to accurately quantify carbon capture and guarantee storage in perpetuity in dynamic environments with tenure challenges.

In contrast to carbon, nitrogen in wastewater (and in general, nutrients) offset policy is in its infancy and designed and implemented at the state level in Australia as a way of meeting water quality improvement objectives. Nitrogen offsets (also referred to as water quality trading), like carbon, are designed to ensure a net gain in nitrogen abatement in the receiving environment through a market based approach that provides for innovation and flexibility in how regulations are met, thereby potentially lowering regulatory compliance and abatement costs in comparison to the carbon approach of fixed emission limits for each individual emitter[3]. Whilst substantial international policy has been adopted on carbon offsets and mechanisms for valuing carbon, nitrogen offset policy remains localised to state regulatory frameworks in Australia, with few examples worldwide and few examples of attributing a trade value to nitrogen pollution and subsequent nitrogen market.

This paper outlines the Australian regulatory frameworks for carbon and nitrogen offsets and their potential application to the development of oyster and seaweed industries in Moreton Bay, South East Queensland. It

[2] Australia's carbon project registry. Carbon Market Institute, accessed 5/12/2019 http://marketplace.carbonmarketinstitute.org/registry/

[3] Smart et al (2016) A tradeable permit scheme for cost-effective reduction of nitrogen runoff in the sugarcane catchments of the Great Barrier Reef. Tropical Water Quality Hub, National Environmental Science Programme.

discusses existing mechanisms and markets and opportunities for further development utilising both international and domestic examples. We identify the key knowledge gaps that are inhibiting development of aquatic sequestration methodologies for both carbon and nitrogen at the science/policy interface in Australia and draw on synergies between carbon and nitrogen offset opportunities in the aquatic environment.

2.1 Australian environmental offset pathways for carbon and nitrogen

Australia is an enthusiastic adopter of environmental offsetting, with policies in all states and territories and at the federal level most notably with a focus on biodiversity and CO_2-e abatement. Whilst there is some policy on nitrogen offsetting in Australia, it is managed at the state government level alone and assessed on a case by case basis, most commonly used to achieve water quality improvements through offsetting excess nitrogen from point source emitters such as sewage treatment facilities (also known as water quality trading).

Regardless of the target of an offset, whether it be biodiversity, carbon or nitrogen, environmental offsets are principally only considered after available avoidance and mitigation have been exhausted and aim to deliver a no net loss outcome for the environmental asset which is protected. Universally, offsets must be targeted according to the priority asset/s impacted; be beyond existing requirements; achieve a like-for-like or better outcome; and must be enforceable through legislation, agreements or contracts.

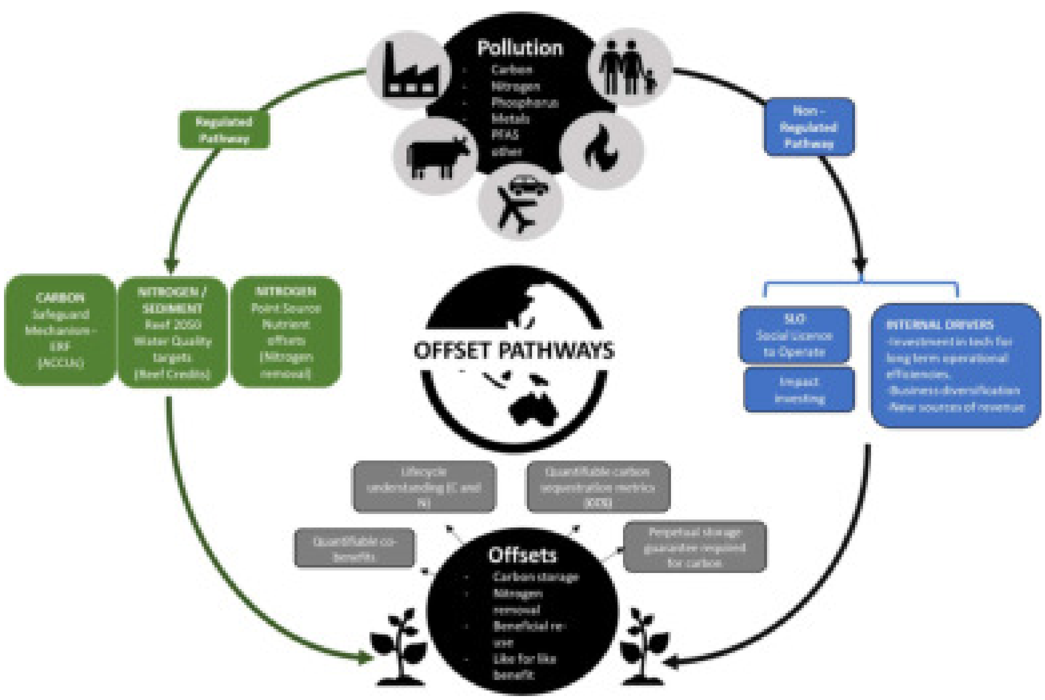

Figure 1: Overview of regulatory and non-regulatory pathways for offsetting carbon and nitrogen pollution in Australia. Grey boxes indicate general requirements of offsets in order for them to meet nationally accepted best practice offset principles.

Whilst clear regulatory mechanisms and voluntary markets exist for carbon and some nitrogen offsets, there are also non regulatory/market incentives to encourage the adoption of practices that emit less carbon and nitrogen into the environment. As shown in figure 1 below, these can include internal drivers such as investing in technology for longer term operational efficiencies which in Australia may be eligible to receive funding from the Clean Energy Infrastructure Fund, or through business diversification, environmental ethics/ethical consumerism and accreditation (i.e. carbon neutral, social licence to operate) and to a lesser extent, impact investing. Impact investing is where consumers make purchasing decisions based on a product's social and ethical positioning. It is on the rise as consumers look to drive change by adjusting where and what they spend their dollars on. The UK's Ethical Consumer Report (2018) shows that the young are turning towards more sustainable solutions with 49% of those under 24 avoiding products or services due to negative environmental impacts[4]. This behavioural trend is also growing within Australia indicating a significant appetite to address individual environmental impacts through consumer choice.

[4] Ethical Consumer Markets Report (2018) - Ethical Consumer.

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3. Carbon offsets framework principles

Greenhouse gas (GHG) or carbon offsets (CO_2-e equivalents) have long been promoted as an important element of a comprehensive climate policy approach, primarily by land-based re- or afforestation and preservation.

Offset programs can reduce the overall cost of achieving a given emission target by enabling emission reductions to occur through cap and trade programs, incentives to shift to renewables, or where companies purchase offsets from approved abatement projects such as Australia's Emissions Reduction Fund (ERF). A by-product of many of these programs is the potential for projects and incentives to deliver sustainability benefits beyond the offset objective through the development of technology, re-investment through grant schemes, alternative income streams, biodiversity protection or restoration, and overall consumer behavioural change. Carbon offsets can also develop human and institutional capacity for reducing emissions in sectors and locations not included in a cap and trade or a mandatory government policy, further facilitating carbon abatement outside the direct regulatory pathway where incentives exist for abatement quantification through voluntary and compliance ecosystem service market mechanisms (i.e. Queensland Reef Credits Scheme).

Offsetting can also be viewed as a transitional measure designed to facilitate incremental changes in industry toward low carbon economic practices. By establishing price signals on specific production outcomes (i.e. case GHG emissions) regulatory agencies encourage companies to find alternative business models; less carbon-intensive activities become more financially attractive, and thus viable investment propositions. This approach is used by both the Australian SafeGuard Mechanism and most recently, the Australia's Clean Energy Innovation Fund.

Protecting existing carbon stocks is critical to avoiding substantial additional carbon emissions, but meaningful mitigation requires sequestering carbon from past and ongoing emissions. However, there are inherent limitations to restorative practices in offsetting; most notably, available space or habitat on land (e.g., forests) and water and the challenge of permanence.

3.1 Australian Carbon policy chronology and 2019 position

Since 1992, Australia has actively participated in the United Nations Framework Convention on Climate Change, including signing the Kyoto Protocol in 1998, which remained unratified until 2007 (Figure 2). A range of measures aimed to reduce Australia's greenhouse gas emissions have been on the agenda at the Federal and State level for the last two decades. Until recently, successive Australian governments have been committed to the introduction of a carbon price or an emissions trading scheme designed to mitigate climate change. In July 2014 however, under the Abbott Coalition government, the eight 'carbon tax repeal' bills were passed by the Senate, coming into effect on 1 July 2014, resulting in Australia becoming the first nation to reverse action on climate change (Appendix 1).

In place of a carbon price, the Coalition introduced the Direct Action Plan[5] and Emissions Reduction Fund to cut emissions to 5% below 2000 levels by 2020 and to 26 to 28 per cent below 2005 levels by 2030. The Plan comprises an element to credit emissions reductions, a fund to purchase emissions reductions, and a safeguard mechanism (see also Figure 3). It is built on the concept that crediting and purchasing elements will lower national emissions, while funding businesses to undertake projects that will improve their productivity, for example through more efficient industrial processes, improved household and commercial energy efficiency and improved soil productivity[6]. Figure 2 (below) illustrates the key pivots in Australia's carbon policy history against international convention milestone and corresponding carbon emissions trends. The figure illustrates the following key points:

- The introduction of the National Greenhouse and Energy Reporting Act in 2007 and ratification of the Kyoto Protocol under the Labor government resulted in a steady reduction of Australia's total GHG emissions.
- The implementation of a carbon price in 2012 aligned with international climate mitigation approaches and reinforced the downward emission trend.
- The downward trend in total emission production slowed dramatically in 2014, coinciding with the repeal of the carbon price by the Coalition Government.
- Total GHG emissions have been slowly rising since 2016.

[5] The Government's Direct Action Plan, also referred to as "The Coalition's Direct Action Plan" (2013)

[6] The Safeguard Mechanism – overview. Department of the Environment. https://www.environment.gov.au/climate-change/government/emissions-reduction-fund/publications/factsheet-erf-safeguard-mechanism

- The latest report from the Clean Energy Regulator shows Australia's greenhouse gas emissions are still increasing, driven by rising emissions across several sectors of the economy including transport and liquefied natural gas production. Recent figures show emissions rose by 1.1m tonnes of carbon dioxide equivalent, or 0.2%, in the year to March 2019. Whilst emissions across electricity and agriculture sectors were down, increases were attributed across all other sectors.
- Based on the current trajectory, to meet its first abatement target under the Paris Agreement, Australia will be required to reduce total projected emissions by at least 840 Mt CO2-e over the period 2021–2030[7]

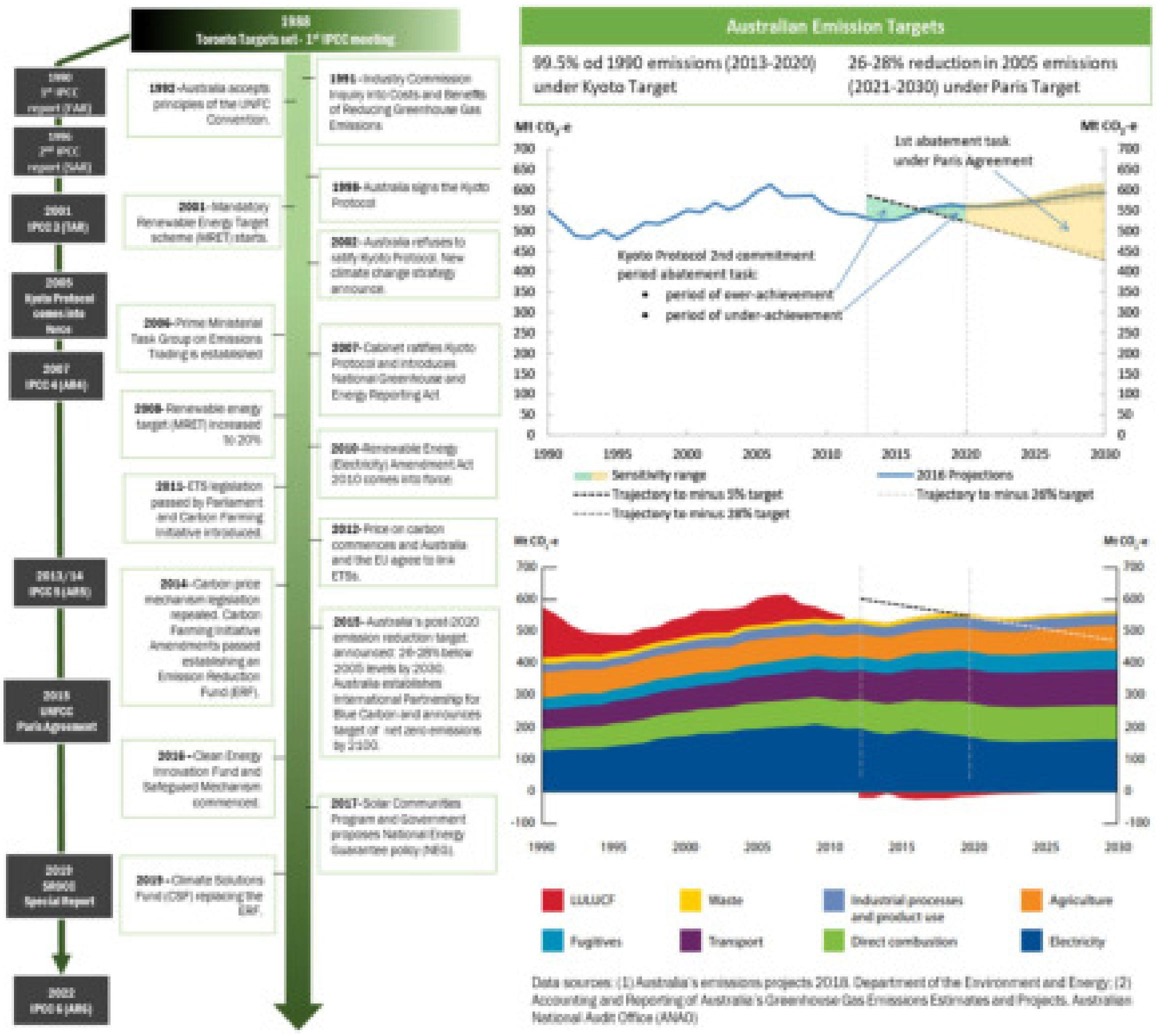

Figure 2: Key pivots in Australia's carbon policy history against international convention milestones and corresponding carbon emissions with existing and predictive trends against ratified targets.

3.1.1 Australia's carbon emissions safeguard mechanisms

The legislative framework for the safeguard mechanism is set out in the National Greenhouse and Energy Reporting Act 2007 (the Act), through amendments included in the Carbon Farming Initiative Amendment Act 2014. The safeguard mechanism is also supported by amendments to related legislative instruments,

[7] Accounting and Reporting of Australia's Greenhouse Gas Emissions Estimates and Projects. Australian National Audit Office (ANAO)

including the National Greenhouse and Energy Reporting Regulations 2008 and the National Greenhouse and Energy Reporting (Audit) Determination 2009.

The safeguard mechanism commenced on 1 July 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 CO2-e) a year (approximately 140 businesses), covering around half of Australia's emissions. The entity with operational control of a facility is responsible for meeting safeguard requirements, including that the facility must keep net emissions at or below baseline emissions levels. There are four main types of baselines: Reported baselines; Calculated baselines; Production-adjusted baselines; and Benchmark baselines. 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 or production and apply to new facilities only. Production-adjusted baselines are determined based on actual production levels where original baselines can be re-assed and Benchmark baselines are based on benchmark emissions intensities which are based on the least emissions intensive standard for production. Both calculated baselines and benchmark baselines are determined using forecasts of production and can be replaced with a production-adjusted baseline that reflects actual production from the facility. A facility must exceed the 100,000t CO2-e threshold to be covered by the safeguard mechanism. A baseline cannot be set below this level.

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.

Whilst the SafeGuard Mechanism is a key element of the Government's current climate change policy suite, findings from the Carbon Market Institute's (CMI) Australian Climate Policy Survey (2018) found that 92% of Australian business and industry respondents believed that current climate and energy policies were insufficient to meet Paris Agreement targets[8] and needed to evolve. The survey results suggest strong support for transitioning the existing SafeGuard Mechanism towards a Baseline and Credit Emissions Trading Scheme (BCS) enabling a scalable, multi sector mechanism that utilises the existing SafeGuard Mechanism Framework. Transitioning the Safeguard to a BCS would involve placing a clear limit on absolute emissions covered under the scheme through the adjustment of baselines. CMI suggests the emissions reduction trajectory required under Australia's Paris Agreement targets should guide how emissions baselines set under the Safeguard will decline and reduce (cap) absolute emissions in alignment with other policies across the economy[9].

3.1.2 Commonwealth Approach: Emissions Reduction Fund

The Emissions Reduction Fund is a voluntary scheme that aims to provide incentives for a range of organisations and individuals to adopt new practices and technologies to reduce their emissions. It is enacted through the Carbon Credits (Carbon Farming Initiative) Act 2011, the Carbon Credits (Carbon Farming Initiative) Regulations 2011 and the Carbon Credits (Carbon Farming Initiative) Rule 2015.

A number of activities are eligible under the scheme and participants can earn Australian Carbon Credit Units (ACCUs) for emissions reductions. One ACCU is earned for each tonne of carbon dioxide equivalent (tCO2-e) stored or avoided by a project. Projects must satisfy criteria under the ERF and be an approved methodology to enable ACCUs to be sold through auction (Section 3.2). ACCUs can be sold to generate income, either to the government through a carbon abatement contract, or in the secondary market. Market updates are produced by the Clean Energy Regulator each quarter (since December 2018) and more recently outlines opportunities by new emerging sources of demand from voluntary and state/territory participants, as well as the continued purchasing through the ERF. In late February 2019 the Australian Government announced an additional $2 billion in funding for the Emissions Reduction Fund (ERF), rebranding the scheme the Climate Solutions Fund (CSF). The additional funding tranche for the ERF is predicted to provide $200 million over 10 years, bringing total investment to $4.55 billion since the commencement of the scheme in 2014/15. To register and bid in an ACCU auction, a project must be able to identify delivery terms and schedules for carbon abatement, the quantity of ACCUs and be able to audit the project throughout its delivery period and qualify as an approved ERF method. As of mid-2019, ERF approved methods were predominantly limited to the areas of energy efficiency, agriculture, vegetation (i.e. forest protection and restoration), savanna burning, transport and waste related approved projects.

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[8] Carbon Market Institute, Australian Climate Policy Survey (2018).

[9] Carbon Market Institute, Transitioning the Safeguard Mechanism to a Baseline and Credit ETS. Design Options for Consideration – Discussion paper (2019)

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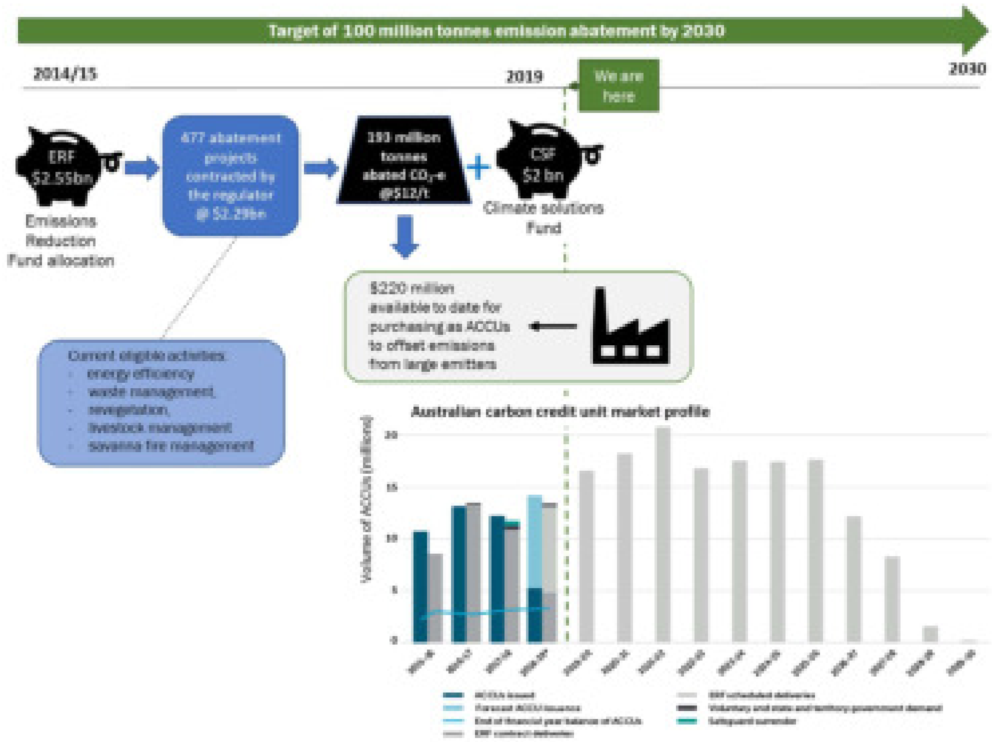

Figure 3: Timeline indicating the combined figures from eight Emissions Reduction Fund auctions, funded by the Federal Government allocations through the Emissions Reduction Fund and later renamed Climate Solutions Fund in 2019. Data obtained from the Clean Energy Regulator.

3.1.3 State Approach Example: Queensland's Land Restoration Fund

Queensland, due to its large land mass and natural ecology, has a comparative advantage in carbon farming to generate carbon offsets which is an identified action under the Queensland Climate Transition Strategy and has seen approximately 250 carbon farming projects under the Australian Government's ERF. Independent analysis conducted by Energetics in 2017 indicates that Queensland has an opportunity to generate between $1.4 and $4.7 billion from land and agriculture offsets cumulatively by 2030, abating between 32 and 104 million tonnes (with further abatement up to 502 million tonnes under various growth scenarios) and creation of up to 21,000 jobs[10]. The assessment was conservative and assumed low demand in the short term and some strengthening of the Safeguard Mechanism over time. The significant benefit of a carbon farming industry to the state of Queensland through regional job creations and valuable environmental co-benefits saw the creation of the Land Restoration Fund in 2018 to continue to grow the industry through a $500 million investment.

The Land Restoration Fund differs to the ERF because it aims to reduce greenhouse gas emissions while also valuing the positive social, economic and environmental outcomes associated with carbon farming—the co-benefits—that are created by land sector carbon farming projects. Initial investment priority areas include:

- Priority 1 - land restoration to improve the health of wetlands and coastal ecosystems, including the Great Barrier Reef.
- Priority 2- land restoration for threatened species and biodiversity
- Priority 3 - Land restoration for social and economic sustainability

To be eligible, projects must be located in Queensland and be a carbon farming project eligible for registration under the ERF. Projects are assessed against a list of criteria to determine merit, with a core focus on the delivery of co-benefits and contribution to one or more of the investment priorities.

[10] Energetics, Unlocking value for the Queensland economy with land and agriculture offsets (2017). Department of Environment and Heritage Protection, Queensland Government.

The Land Restoration Fund currently mirrors the ERF in project scope where all current approved and funded projects are focused on agricultural methods (cropping, soil and livestock), savanna burning and vegetation methods for carbon capture. However, the Land Restoration Fund differs in that it is heavily investing in pilot projects that aim to catalyse land manager participation; demonstrate how carbon farming activities can generate co-benefits; generate and collate data that measures co-benefits and growth of new environmental markets; and form a basis to enable the first investments of the Land Restoration Fund. In 2019, two 'Blue Carbon' projects were funded which looked at the opportunities for carbon sequestration in coastal systems through: (1) identifying 'Blue Carbon' opportunities in Queensland, including the mapping of carbon stocks and modelling sequestration rates under various management regimes; and (2) 'Blue Carbon' and cane land restoration through restoring tidal connectivity, resulting in the collection of data on natural resources, farm productivity and profitability both pre and post intervention. These pilot projects will be integral in identifying carbon sequestration potential in coastal systems, quantifying co-benefits and mobilising and accrediting future 'Blue Carbon' projects in Queensland.

3.2 Blue Carbon

The majority of environmental carbon farming projects have been terrestrial due to approved ERF methodologies. Currently, none have been in coastal systems. The discussion around 'blue carbon', or atmospheric carbon captured by coastal ecosystems, has gained momentum since 2009 through focused reports by the United Nations Environment Programme (UNEP)[11] and the International Union for Conservation of Nature (IUCN[12]), as well as extensive scientific literature. The international community is becoming progressively more interested in exploring the potential of coastal ecosystem conservation for their role in climate change mitigation. This was reflected in the Manado Oceans Declaration signed by countries in 2009 which recognises that healthy and productive coastal ecosystems have a growing role in mitigating the effects of climate change on coastal communities and economies. This declaration emphasised the importance of the scientific community's ongoing development of reliable scientific information on the roles of coastal wetlands, mangrove, algae, seagrass, and coral reef ecosystems in reducing the effects of climate change[13].

The 2009 UNEP Blue Carbon report[14] stated that 55% of atmospheric carbon captured by all living organisms is captured by marine organisms, of which, between 50-71% is captured by vegetated marine habitats (i.e. mangroves, seaweed, seagrass, saltmarshes), which account for less than 0.5% of the seabed, and are further disappearing at an alarming rate. The report states that coastal vegetated habitats sequester between 1.6 and 4.6% of total anthropogenic carbon emissions (equating to 7,200 teragrams of carbon per year). Due to their high carbon sequestration potential, there is growing interest in exploring the potential of including Blue Carbon in existing and emerging climate change frameworks. However, considerable steps need to be taken in understanding and estimating the carbon storage potential in coastal ecosystems before such methods can become approved methodologies under these frameworks.

In 2015, Australia announced that it would establish an International Partnership for Blue Carbon at the Global Landscapes Forum in Paris[15]. The partnership recognised the value and importance of coastal blue carbon ecosystems and its role in motivating a range of activities to better manage blue carbon resources, including the UNFCC REDD+ program (reducing emissions from deforestation and forest degradation in developing countries) , Nationally Appropriate Mitigation Actions (NAMAs), voluntary carbon markets and post 2020 Intended National Determined Contributions. It also recognises that some countries had already commenced work towards including coastal blue carbon ecosystems in their national greenhouse inventory through implementation of the IPCC supplementary guidance on wetlands. The International Partnership for Blue Carbon seeks to scale up and amplify such efforts through supporting countries in the Asia-Pacific to build their capacity to protect coastal blue carbon ecosystems. This includes a $6 million Pacific Blue Carbon Initiative and a $2 million Indonesia-Australia Program. Both programs will strengthen blue carbon knowledge and data, support integration of blue carbon into national greenhouse gas accounting and climate policy and encourage public and private sector investment.

3.2.1 Blue carbon opportunities

Australia has elected to include blue carbon ecosystems in its national greenhouse gas (GHG) accounts. Consequently, Australia is also considering extending its domestic policy instruments to reduce national GHG emissions to include blue carbon opportunities. These instruments include potential methods that allow for

[11] Blue Carbon: the role of healthy oceans in binding carbon (2009) UNEP report.

[12] Management of Blue Carbon sinks (2009) IUCN report.

[13] Manada Ocean Declaration adopted 14 May (2009), in Manado.

[14] Nellemann, C., Corcoran, E., Duarte, et al. (2009). Blue Carbon. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal,

[15] Media Release - Australia establishes International Partnership for Blue Carbon. 6 Dec (2015). The Hon. Greg Hunt MP.

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sequestration and emissions avoidance projects specifically in blue carbon ecosystems under the ERF. This has included contracting CSIRO to undertake a Technical review of opportunities for including blue carbon in the Australian Government's Emissions Reduction Fund. This report was published in early 2017[16], and identifies potential carbon abatement opportunities and barriers for blue carbon under the ERF.

A pre-requisite to incorporating Australia's blue carbon ecosystems into the broader framework of the nation's carbon economy is an assessment of the potential for anthropogenic management activities to sequester carbon and avoid GHG fluctuations (avoiding emission of GHGs expressed as carbon dioxide equivalents, CO2-e) against a business as usual scenario. The CSIRO technical review identifies significant knowledge gaps, such as limited information on the spatial extent over which the influencing factors operate; the mechanisms responsible for altering the magnitude of carbon sequestration or GHG emission avoidance; existing management practices; and legislation. One of the most critical factors is the lack of research or case studies relevant to Australian blue carbon ecosystems. The report points to avoidance of vegetation loss as well as regrowth opportunities of mangroves and tidal marshes to improve coastal marine carbon capture as potential areas for ERF methodology development. The technical report does not discuss the concept of controlled farming of coastal marine vegetation in an abatement focused activity, alternatively focusing largely on rehabilitation of marine ecosystems and reduction in loss through development and urbanisation.

3.3 Developing Methods under the Emissions Reduction Fund

The Minister for Energy and Emissions Reduction determines the priority activities and methods for development under the Emissions Reduction Fund. The priorities are informed by a set of questions that are outlined in the Emissions Reduction Fund White Paper[17]. Approved methods become legislative instruments. They define what activities are eligible to earn carbon credits, and how emissions reductions are to be measured, verified and reported. It is the role of the Department of the Environment and Energy to develop these methods. The Department scopes the activity, works with scientists, industry, technical experts, and potential end users of the methods. The Minister must then seek advice from the independent Emissions Reduction Assurance Committee on whether proposed methods meet the offset integrity standards set out in the Carbon Credits (Carbon Farming Initiative) Act 2011[18].

[16] Technical review of opportunities for including blue carbon in the Australian Govern

[17] Emissions Reduction Fund White Paper, April (2014). Commonwealth of Australia.

[18] Carbon Credits (Carbon Farming Initiative) Act 2011. Commonwealth of Australia.

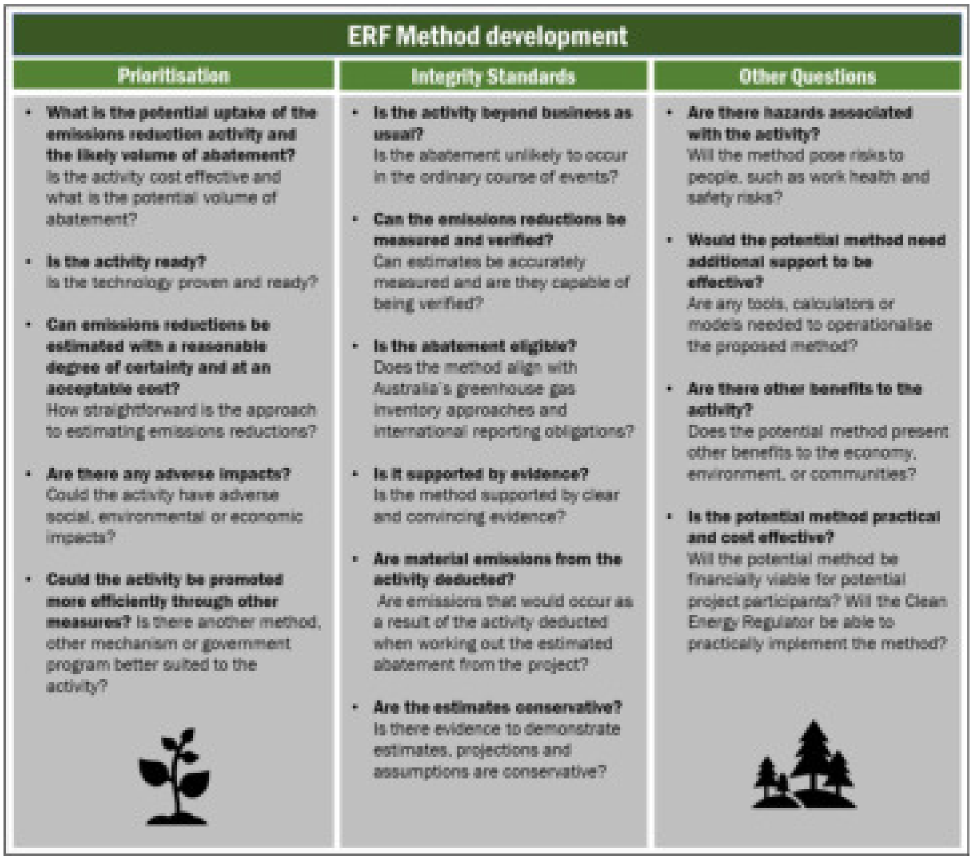

Figure 4: Outline of method development under the ERF. It explains the process, key questions, and legislative requirements considered as part of this process.

3.4 The challenge of permanence

When emissions are avoided or reduced by switching from coal to wind energy for example, or preventing deforestation, these are avoided emissions that would have otherwise been generated. Provided the baseline is accurately determined, it can be credibly stated that a business as usual tonne of carbon dioxide of GHG was not emitted for that year. It is a permanent abatement of the emission. When an abatement action involves the revegetation or reforestation of an area, whereby carbon dioxide is removed (sequestered) from the atmosphere through photosynthesis, the carbon is stored as biomass. In other words, the carbon still exists but is being stored and therefore still vulnerable to deforestation or ecosystem impact and destruction. When this occurs, the beneficial effects of the carbon sequestration have been reversed.

Concerns about "reversals" have challenged reforestation and afforestation as a practical approach to climate change mitigation. Carbon offset markets (e.g., California's cap-and-trade system) employ technical fixes like "buffer accounts" to reduce the risk of over-crediting (i.e. paying for the predicted carbon storage than the actual carbon storage), given the risks of reversal. However, concerns around permanence continue and may limit both financial and political investment into restoring ecosystems for climate benefits[19]. Concerns around permanence apply to all "enhancements" of natural carbon stocks, because of their physical vulnerability. All actions to improve natural carbon stocks carry real risks of reversal through human disturbance, whether through reforestation, afforestation, in soils, in terrestrial non-forest ecosystems, or with coastal blue carbon (e.g., construction of wetlands).

A well referenced study conducted by Krause-Jensen and Duarte (2016) suggests that deep sea kelp forests may act differently in that the authors estimated that 90% of the sequestered carbon dioxide taken up by the worlds known kelp and macroalgae ecosystems is moved through the Dissolved Organic and Particulate

[19] Kelp and carbon sequestration: bringing terrestrial carbon accounting to the deep sea (2018). The Carbon Institute.

Organic Carbon pools, and transported to the deep sea in perpetuity[20]. When the authors reviewed the existing data on kelp and other macroalgae to develop an estimate of kelp sequestration quantities, they estimated approximately 634 million tonnes of carbon dioxide per year (173 Tg C) was being removed from the atmosphere which is greater than the total emissions of Australia.

The Krause-Jensen and Duarte study provides an example of a potential blue carbon method that may transcend the permanence issues that complicate sequestration for forests, other terrestrial ecosystems, and other blue carbon ecosystems due to the sediments of the deep sea having little human contact compared to the majority of other ecosystems being considered for carbon sequestration. Whilst this study serves to increase focus on kelp/seaweed sequestration performance as a novel climate mitigation strategy, it must be emphasised that this method focuses on optimising carbon capture and ensuring permanent storage through ecosystem enhancement/restoration. It is important however, that this concept be clearly separated from discussion on carbon sequestration opportunities in kelp/seaweed cultivation practices which we address in this paper, as such activities require significant investigation into the carbon lifecycle through 'cradle to the grave' carbon analysis and will vary significant depending on the fate of the harvested seaweed. Seaweeds have various commercial uses: as a gel (hydrocolloid industry), as food products, an energy source, in pharmaceuticals, in fertilizers, and for invertebrate aquaculture (e.g., abalone, shrimp, sea urchins). However, to be economically efficient, research would need to quantify how cultivation methods and harvest timing affect carbon release compared to a natural growth baseline. The processing and product pathway would also need to be assessed to determine whether the carbon capture efficiently offsets the energy required during the production process as well as the end state of the product as to whether the carbon is permanently stored or whether it re-enters the atmosphere through other pathways (i.e. human food, aquaculture feed).

3.5 International examples

3.5.1 USA algae farms – in the wake of biofuels

Between 2005 and 2012, significant investments were made on the promise of algae-based biofuels (i.e. ethanol), most notably in the USA where industry advocates claimed that commercial algae fuels were within near-term reach ensuring the delivery of billions of gallons of biofuels by 2012. Nothing close to 1 million gallons was ever produced. Due to a lack of competitive pricing and underdeveloped drying and conversion technology, the investment of $450 million USD, whilst substantial, was not nearly enough to develop the US market for biofuels and maintain momentum in the industry. The silver lining sits in the investment in the algae farming infrastructure, development of technology and the opportunity to diversify into other industry areas such as pharmaceuticals, cosmetics, food, stock feed and carbon capture.

An example of one those farms that have diversified in the wake of the biofuel's failure, is Qualitas in New Mexico. Qualitas New Mexico is one of the largest microalgae farms in the world, specialising in *Nannochloropsis*, or omega-3 supplements, with 48 ponds in production over 50 acres. However, the new hope for algae across the USA algae farms is that they could rebalance the global carbon equation as a food source and through carbon capture, not a fuel. To grow large amounts of algae quickly, farmers must inject CO2 directly into their crop, turning the algae farms into vast CO2 sponges. As a result, there is renewed interest in industry/farm partnerships where algae farms are positioned with coal-fired power plants (and other emitters) to consume the CO2 produced through industry operations resulting in a mutually beneficial system. Methodologies for carbon accounting, however, remain one of the challenges in receiving regulatory approval as a credible carbon sequestration methodology which would in turn allow payment of tax credits, not dissimilar to the Australian ACCU system. The methodology that most accurately accounts for CO2 moving through a respective system is the Life-Cycle Analysis (LCA) Model which has been adopted international as the cornerstone of climate strategies. The LCA method essentially evaluates environmental impacts from the cradle to the grave (or cradle to the farm gate in primary productivity) including resource extraction, production, distribution, use and disposal phases in calculating net CO2 capture and benefit[21]. Defining LCA methodology, inputs, and assumptions is a challenge depending on the technology pathway, type and location of the farm and is arguably why a methodology for carbon capture has not been approved as yet[22].

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[20] Dorte Krause-Jensen and Carlos M Duarte (2016) Substantial role of macroalgae in marine carbon sequestration. Nature Geoscience 9, 737-742.

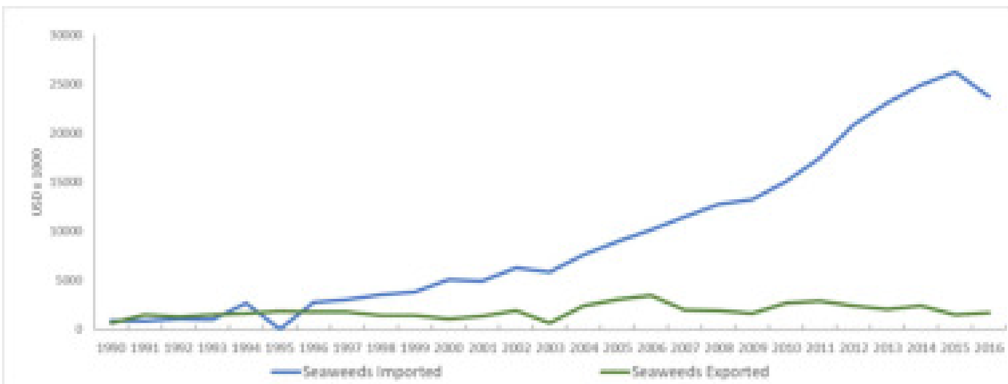
[21] Baumann, H.; Tillman, A.-M. The Hitch Hicker's Guide to LCA; Studentlitteratur: Lund, (2004).

[22] US Department of Energy (2017) Algae Cultivation for Carbon Capture and Utilisation Workshop Summary Report

3.6 Blue Carbon growth potential in a developing the aquaculture industry in Australia

Carbon offsetting has become part of the portfolio of solutions to mitigate carbon emissions through policy and voluntary markets, primarily by land-based re- or afforestation and preservation. However, land is limiting, creating interest in a rapidly growing aquaculture and permaculture farming sector, particularly in seaweed and shellfish aquaculture. The aquaculture of finfish, crustacea, shellfish, and seaweed is one of the fastest growing food sectors on the planet, with seaweed aquaculture demonstrating the fastest growth at 8% per year with additional interest in using seaweed aquaculture to combat GHG emissions growing rapidly[23]. Whilst at a large scale, seaweed and shellfish culturing is extremely unlikely to offset global agriculture and industrial GHG emissions, it appears to be more feasible at a regional level, especially in areas with strong climate policy[24] where the farming of seaweed and shellfish could offset more localised emissions such as from local agriculture and the overall food sector.

In 2016, Australia imported over $10 million (USD) and exported over $3.6 million (USD) in oyster products and imported over $23 million (USD) and exported under $2 million (USD) in seaweed products indicating increasing domestic consumer trends in both markets, particularly for seaweed products (figure 5). With seaweed developing into a $6 billion market globally, there is substantial opportunity for Australia to increase productivity and exports due to suitable climate range leading to a diversity of seaweed species, and available technology. The limiting factors in Australia are processing infrastructure, streamlining of the farm to market process, testing sites for species productivity and marketing potential in both domestic and international markets.



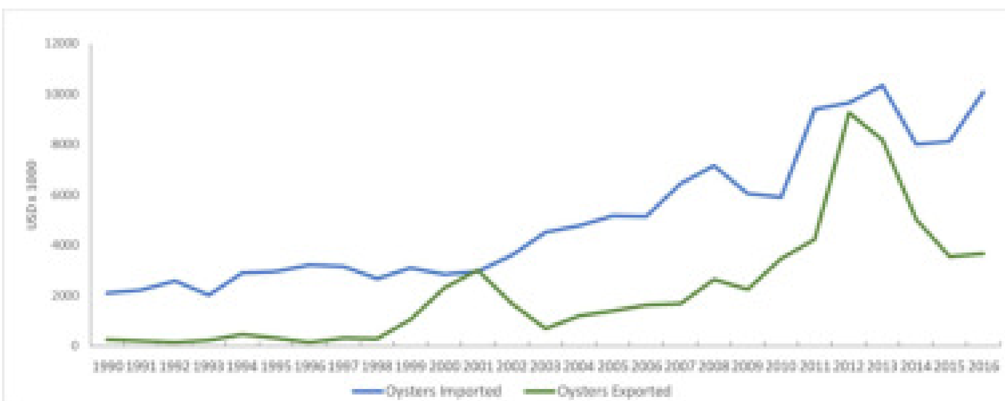


Figure 5: Australian seaweed and Oyster commodity data (USD dollars) reported to the FAO 1990-2016 (Food and Agriculture organisation of the United Nations). Data reflects totals and does not delineate between seaweed fit for human consumption and seaweed not fit for human consumption.

23 Duarte et al (2017) Can seaweed farming play a role in climate change mitigation and adaptation? Marine Science 4:100

24 Froehlich et al (2019) Blue growth potential to mitigate climate change through seaweed offsetting. Current Biology 29, 1-7.

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Most of the Seaweed exported from Australia is from storm-cast seaweed with few cultivation farms growing at commercial capacity. Trials and early phases of both onshore and in water aquaculture are underway in Australia in Port Lincoln, South Australia and Tasmania. Seaweed farming that utilises aquaculture systems are not only heralded as a sustainable extractive aquaculture industry due to being a zero-waste food production practice with additional water quality benefits, but in many cases, a proposed strategy for climate change mitigation in terms of carbon capture. The World Bank Group estimates that 1 tonne of seaweed can absorb 0.27 tonnes of carbon annually, offering the potential of using carbon credits to improve the profitability of the seaweed business[25]. At AUD$12.00^{-t} carbon price, this would equate to an addition $3.24 per tonne of seaweed per harvest, with multiple harvest's per year, if it could be clearly demonstrated that the carbon sequestered was stored in perpetuity (for example, through biochar application). In comparison, over a two-year period, plate size Pacific Oysters from South Australia can absorb 0.12 tonnes of carbon per tonne of harvested oysters based on the assumption that 12% of the shell mass is composed of carbon deposits, stored indefinitely[26]. Similar results have also been reported in oysters farmed in Chesapeake Bay[27]. At the aforementioned carbon price, this would equate to AUD$1.44 per tonne per harvest. Slightly higher estimates have been reported from the Scottish produced intertidal Pacific Oyster reporting 0.441 tonnes of carbon per tonne per harvest[28] equating to AUD$5.28. It's important to note however, that whilst these calculations indicate a much greater potential for seaweed to sequester carbon, these calculations do not consider the cradle to grave carbon footprint nor variances in stocking densities which would need to be measured on a case by case scenario to accurately predict total sequestration potential. Furthermore, it is also critical to understand that the carbon sequestration potential is reliant on the ability for the carbon to be stored in perpetuality, which is impossible when products are consumed as food which allows the carbon to be reused and the carbon cycle continues.

Seaweed has been investigated as a livestock feed modification method for reducing methane emissions from ruminant livestock, such as cattle. Ruminant enteric methane is responsible for approximately 10% of greenhouse gas emissions in Australia and is 28 times more potent than carbon dioxide over a 100-year timeframe. One species of seaweed, a red macroalga, *Asparagopsis taxiformis,* has been shown to even mitigate the production of methane in the rumen without compromising other gut health indicators at an inclusion rate of ≤2%[29,30]. Studies conducted by CSIRO and James Cook University in collaboration with the Australian Government and Meat & Livestock Australia (MLA) have been investigating the most economic and practical methane reduction options for cattle in Australia since 2016 and have demonstrated that *Asparagopsis* is not only the most effective seaweed to inhibit methane production, but by doing so improves gut health, improves meat flavour through additional Omega-3, and may improve growth and productivity of the livestock[31]. The challenge in Australia and in the commercialisation of this methane reduction approach is the ability to mass produce *Asparagopsis* at a scale to provide supplementation to livestock, including the most appropriate method for processing and feeding to livestock systems. Producing enough *Asparagopsis* to feed 10% of the almost 1 million feedlot and 1.5 million dairy cattle in Australia would require approximately 300,000 tonnes a year. With typical seaweed production rates at 30-50 tonnes of dry matter per hectare per year, this suggests that to supply 10% of the Australian livestock industry will require at least 6,000 hectares of seaweed farms[32].

The development and expansion of both the seaweed and oyster aquaculture industries in Australia presents several potential economic, environmental and social benefits. The culmination of these benefits could provide additional incentives for continued growth and development in the industry including the investment and development of new technologies associated with farm operations, consumer products and sustainable applications which is being seen worldwide.

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[25] Seaweed Aquaculture for Food Security, Income Generation and Environmental Health. World Bank Group.

[26] Hickey (2004) Carbon Sequestration Potential of Shellfish. University of South Australia. https://thefishsite.com/articles/carbon-sequestration-potential-of-shellfish

[27] Higgins et al. (2011) Nutrient Bioassimilation Capacity of Aquacultured Oysters: Quantification of an Ecosystem Service. Journal for Environmental Quality. 40:271-277

[28] Scottish Aquaculture Research Forum https://www.aquaculturealliance.org/advocate/beefing-up-seaweed-production-to-green-up-beef/

[29] Kinley et al (2015) The red macroalgae Asparagopsis taxiformis is a potent natural antimethanogenic that reduces methane production during in vitro fermentation with rumen fluid. Animal Production Science 56(3) 282-289

[30] Magnusson et al (2016) Dose-response effects of Asparagopsis taxiformis and Oedogonium sp. on in vitro fermentation and methane production. Journal of Applied Phycology 28(2) 1443-1452

[31] Rogue et al. (2019) Effect of the macroalgae Asparagopsis taxiformis on methane production and rumen microbiome assemblage. Animal Microbiome 1:3

[32] CSIRO FutureFeed Program https://research.csiro.au/futurefeed/why-future-feed/

4. Nitrogen Offset – Nutrient Trading Framework

4.1 Nitrogen from watershed pollution sources

Nutrients in waterbodies are essential for the growth of algae and aquatic plants that are an important food source for many small invertebrates and fish and therefore integral to the healthy function of an ecosystem. The main nutrients in waterways come in the form of inorganic nutrients called nitrogen (N) and phosphorus (P). However, only small amounts of each are required in a natural ecosystem and any additional increase of these nutrients in waterways can be problematic, causing eutrophication, soil siltation and chemical deterioration leading to excessive algae and plant growth, causing negative overall impacts on waterway ecosystem health and productivity. Increases in nutrients are nearly always as a result of land use activities and runoff (diffuse) or direct discharges from industry (point source). In Australia, point source dischargers are regulated across each state by the relevant Environmental Protection Authorities through licencing and approval mechanisms whereas diffuse water pollution predominantly relies on voluntary non-regulatory approaches to manage water entering waterways except in Queensland under new Reef Regulations affecting Great Barrier Reef Catchments. The relative lack of progress with reducing diffuse source pollution reflects the complexities of controlling multiple pollutants from multiple sources, their high spatial and temporal variability, associated transaction costs, and limited political acceptability of regulatory measures[33].

4.1.1 Diffuse pollution

Given the relatively short agricultural history, long lead times and low population density, diffuse source water quality problems are only now emerging in Australia where the Great Barrier Reef, Gippsland Lakes, Peel-Harvey Inlet and the Murray-Darling system are all notable examples amongst many others[34]. Diffuse pollution involves multiple pollutants from multiple sources accumulating. It is hard to regulate because factors such as spatial and temporal variability, physical features of individual sites and climatic conditions make it difficult to identify, measure and attribute individual emissions[35]. This in turn makes it difficult to utilise the traditional pollution abatement mechanisms of liability and enforcement which have been very successful in reducing point-source pollution, such as industrial waste from a pipe or drain.

Several options addressing diffuse pollution in agricultural have been broadly identified including:

- *Education and information initiatives*
  Including campaigns; training, information from suppliers; soil and water monitoring.
- *Voluntary instruments*
  Industry codes of practice; environmental management standards; voluntary agreements.
- *Economic Instruments*
  Input taxes or levies on fertilisers or pesticides; tradeable nutrient quotas; audits, financial compensation for creating vegetation buffers and riparian zones to reduce runoff
- *Regulatory Instruments*
  Compulsory adoption of environmental management plans; placing cap on polluting emissions; fertiliser application controls; banning risk farm operations; compulsory disposal methods for on farm waste.
- *Planning Instruments*
  Rezoning land to exclude agriculture; land retirement contracts; land management contracts.

Some of these have been implemented across Australia, particularly in Queensland through the Reef 2050 Water Quality Improvement Plan which builds on 15 years of efforts by governments, landholders, natural resource managers, industry and research organisations to improve water quality entering the Great Barrier Reef through prioritised investment, incentive programs (such as Reef Credit), adaptive management

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[33] OECD, Diffuse Pollution, Degraded Waters (2017),

[34] Roberts and Craig (2014) Regulatory reform requirements to address diffuse source water quality problems in Australia: learning from US experiences. Australasian Journal of Environmental Management 21(1): 102-115

[35] Cunningham and Sinclair (2008) Policy instrument choice and diffuse source pollution. Journal of Environmental Law 17(1)

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campaigns and regulation (Reef Protection Regulations and amendments). The challenge with identifying mechanisms for the management of diffuse water pollution is the need to develop specific performance criteria and indices for effectiveness and efficiency across both economic and environmental areas. To date, little consensus exists on what criteria a successful regulatory strategy should satisfy,[36] namely due to the inability to measure the pollution from a specific source which prevents regulatory action from non-compliance. The most applied strategy internationally is to implement nutrient management plans across agricultural industries that incorporate recommended technologies and environmental practices with the aim of meeting pre-determined nutrient loadings, depending on the type of land and agricultural activity [37] [38]. In countries such as Denmark and the Netherlands, authorities utilise statutory powers to mandate the adoption of process standards due to the highly concentrated agricultural sectors that are confronting extreme levels of agricultural pollution[39]. Process standards influence the ways in which things are done, as opposed to defined performance outcomes, or the adoption of specific technologies (although there is some overlap with the latter). As such, they attempt to generate a greater awareness of environmental issues on the part of landholders, and a more systematic way of approaching those issues. At the same time, they provide considerable flexibility for farmers to tailor solutions to their individual circumstances.

4.1.2 Point source pollution

In all Australian states and territories, wastewater from a point source can only be disposed of as permitted by a license under the relative Environmental Protection Act. For example, in Queensland, under the Environmental Protection Act 1994, wastewater must be treated, or contaminants removed before it can be discharged to waterways. Under the Act, local governments administer approvals and licenses for environmentally relevant activities (ERAs) involving wastewater releases that might have a local impact. The Department of Environment and Science administers approvals and licenses to ERAs involving wastewater releases that might have a regional or statewide impact such as large treatment facilities. Generally, all states and territories in Australia, unless otherwise identified, adhere to this same EPA licensing process as sewerage treatment systems are identified as a schedule activity under each state/territory's respective EPA Act.

If the overall nutrient load entering a waterway can be reduced from any source, the market seeks out the cheapest, which is generally the diffuse sources (as low as $5 per kg nitrogen)[40]. It is usually much more expensive to reduce pollution at heavily regulated point sources (such as WWTPs) because they already operate at a very high technical level of pollution control. There can be stipulations on trading, such as environmental equivalences, to ensure that what is reduced from diffuse sources is equal in environmental impact to what is discharged at point sources. Typically, this means that diffuse discharge reduction must be *at least* 1.5 times greater than the treatment that would have occurred at the facility. For example, there may be a trading ratio where 3 kilograms of nitrogen reduced at diffuse sources is equal to 1 kilogram of nitrogen discharged at the point source. This allows for some uncertainty in relative environmental impact and facilitates a net reduction in nutrients in the waterway. Various pilot studies have taken place around Australia including South Creek, NSW and Beaudesert in Queensland under the respective states EPA legislation and nutrient mechanisms.

4.1.3 Queensland innovative approaches for nitrogen offsets

Queensland has seen significant development in identifying more innovative methods for reducing point-source pollution to improve overall waterway health. This has included investigating opportunities for the provision of alternative investment options for licensed point source operators to meet their water emission discharge requirements under the EPA Act 1994 for nitrogen and phosphorus. Some of these concepts are outlined in the box in Figure 6 below.

Most water quality offsets across Queensland to date have focused on treating diffuse water pollution through activities that reduce the amount of sediment entering waterways through runoff and improving the on-farm application of fertiliser to reduce excess nitrogen and phosphorus entering the catchment. These

[36] Cunningham and Sinclair (2008) Policy instrument choice and diffuse source pollution. Journal of Environmental Law 17(1)

[37] Department of Food and Agriculture, Ireland, Rural Environment Protection Scheme. Department of Food and Agriculture, (2003)

[38] Department for Environment, Food, and Rural Affairs, Existing Policy Instruments that Impact on Diffuse Water Pollution from Agriculture (2002) Department for Environment, Food, and Rural Affairs.

[39] Dwyer at al (2002) Policy mechanisms for the control of diffuse agricultural pollution, with particular reference to grant aid (Report No 455)

[40] O'Sullivan, D (2002) Creating markets for nutrients and other water pollutants, Coast to Coast Conference, 4–8 November 2002, Tweed Heads, NSW, Australia.

offset activities aim to reduce overall catchment water quality pollution that cannot be regulated due the anonymity of the source (except for the Great Barrier Reef Catchments). Recently, industry has been advocating for flexibility in meeting their point-source water emission discharge requirements and obligations for incremental upgrades or production through an alternate investment option (i.e. offsets), while achieving improved water quality in the receiving environment.

The *Flexible options for managing point source water emissions: A voluntary market-based mechanism for nutrient management* was developed in 2014 by the Department of Environment and Heritage Protection and is currently being updated to the Draft *Point-Source Water Quality Offsets Policy.* The development of the mechanism[41] was originally proposed by water service providers in South East Queensland to address increasing sewage treatment costs linked to regional population expansion and targets nitrogen and phosphorus pollution. The draft policy aims to:

- Deliver a net improvement to catchment receiving waters by providing offset solutions to production increments under existing or new EAs from environmentally relevant activities (ERAs).
- Provide voluntary alternative investment options that may provide more cost-effective solutions for ERAs to meet EA conditions.
- Allow for growth and innovative development, while improving water quality across the catchment/sub-catchment receiving waters, depending on the offset's type/location, in accordance with local and national water quality standards.
- Maximise ecologically sustainable whole of catchment outcomes under regional planning frameworks
- Maximise the benefit of an investment for improved waterway health by co-locating offsets works, where relevant, under this Policy with that required under other legislative or policy instruments.
- Minimise transaction costs and regulatory burden.
- Partner with proponents in developing offsets proposals in accordance with the Policy to provide confidence in the offset approach: a) discussing technical requirements including identifying appropriate sites and required site assessments, and b) considering joint marketing and publicity to demonstrate the benefits of offsets to the broader environment and affected communities.

The guideline and offsets are primarily focused on the reduction of sediment entering the waterways through natural filtration buffers such as wetlands and riparian zones; development of treatment technology; or through the mitigation of erosion from the land source. The guideline primarily provides information on delivering a water quality offset between a point source regulated entity and a diffuse source provider using riparian streambank restoration and wetland management. The stream banks and wetlands are assumed to become sinks for the excess nutrients in the water.

Importantly, in order to use the mechanism, the proponent must be able to demonstrate that any proposed nutrient increases at the point source that are to be counterbalanced by alternative nutrient reduction actions (i.e. an offset), must not create an unacceptable impact to the receiving waters. This aligns with the very definition of an offset where the impact must be offset as "like for like, or better". The nutrient reduction action must address the same pollutant as the water quality parameter being licenced (P or N) and at a ratio of 1.5:1. If water quality improvements are to be actioned at an alternative point source (i.e. a water treatment plant exceeding its discharge limit could pay another treatment plant with lower treatment costs to reduce their discharge), a ratio of 1.5:1 is applied. This ensures that a nutrient reduction at one point, corresponding with discharges at another point source, generates a water quality improvement.

Point source discharges are typically simple to quantify. Quantifying load reductions from diffuse sources however is more challenging as noted above, and the efficacy of actions can be difficult to quantify at different locations. In order to assess the proposed load reduction, the proponent will be required to demonstrate the worth of the nutrient reduction action which may include using appropriate catchment and receiving water quality models. A nutrient reduction ratio of 1.5:1 is also applicable for point source / diffuse offsetting action plans. For example, to counterbalance the impact of an additional six tonnes of total nitrogen from a treatment plant, an identified wetland construction offset action must remove nine tonnes of total nitrogen for the license to be approved.

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[41] A mechanism refers to a system arrangement to support the licensing systems for regulated point sources and achieve overall improvement in waterway health.

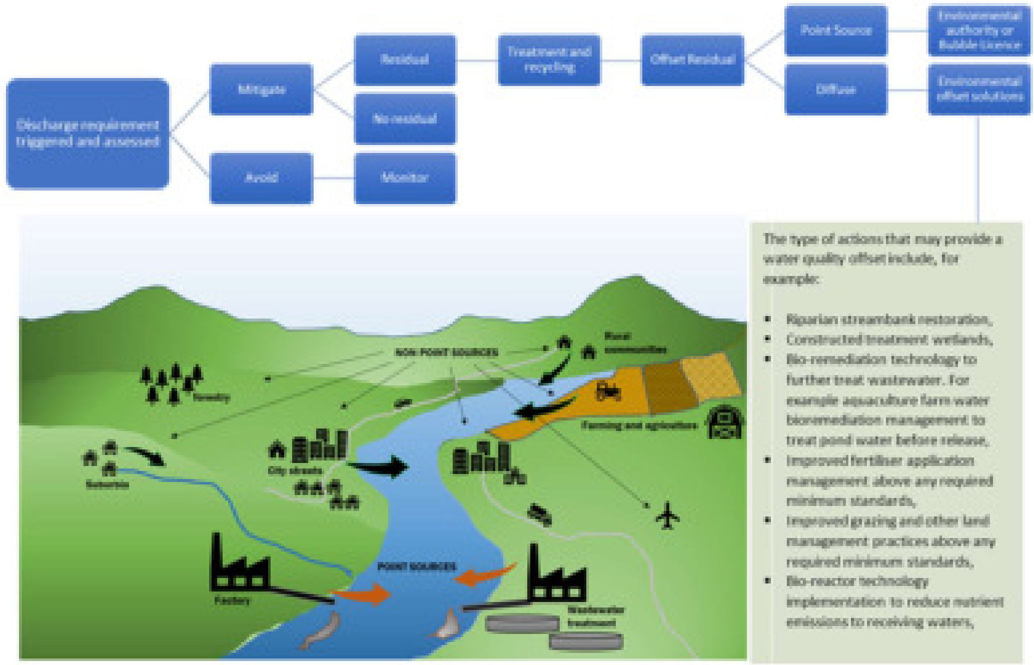

Figure 6 Queensland Point Source (PS) pollution process and examples of offset actions

4.1.4 Queensland offset case study examples

- Urban Utilities Logan River Offset

The QUU Beaudesert Pilot Program was the first in Queensland to use the earlier version of the 2014 Policy "Flexible options for managing point source water emissions: A voluntary markets-based mechanism for nutrient management". The pilot commenced in 2014 and used an innovative approach to nutrient offsets by using the "point source to diffuse source" offsets option. At a cost of approximately $1 million, the pilot was developed to provide a lower cost alternative to meeting the Beaudesert Wastewater Treatment Plant license conditions using riverbank restoration rather than a more expensive treatment plant upgrade. It identified in the modelling that the total annual sediment load entering the Logan River was 13,771 tonnes/year for the section identified. Soil analysis and in-stream modelling techniques were employed to establish an annualised amount of nitrogen and phosphorous.

- Unity Water – Yandina Creek Wetland

In another example in Queensland, Unity Water is pursuing nutrient offsetting as a low-cost alternative to treatment plant upgrades. Unity Water purchased two lots of former cane farming land (191 hectares) in 2016 on the Maroochy River as part of a larger program to improve the health of the rivers and creeks in the area which will offset the amount of nutrients discharged to the Maroochy River following treatment of the local community's sewage. Unity water carried out a cost comparison of using the wetland as a nutrient offset versus constructing a traditional sewage treatment plant. It showed that over a 25-year period, Unity water would save approximately $1 million through the wetland option. It is estimated that the wetlands will remove 5.3 tonnes of total nitrogen per annum from the water downstream from the treatment plant.

Both schemes are designed to reduce the amount of nitrogen in specific rivers / estuaries and while they are designed to deal with diffuse source pollution the key point source polluter in the catchment has been identified and is paying for the mitigation measures.

4.1.5 "Smart Market" Model – tradeable permit scheme

In 2016, the Australian Rivers Institute and Griffith Business School proposed a tradeable permit scheme for cost-effective reduction of nitrogen runoff in the sugarcane catchments of the Great Barrier Reef. The scheme involved a fixed cap on the total amount of emissions, and a tradeable allocation of emission permits among polluters and targeted non-source polluters such as cultivation operations in Tully catchment in Queensland[42]. The buying and selling transactions then reallocate emissions under the cap to harness market forces to promote cost efficiency in emissions reductions. Like the Point Source water quality offset mechanism, the approach encourages innovation and flexibility in how regulations are met, thereby potentially lowering regulatory compliance and abatement costs.

The 'Smart Market' involves the buying and selling of N-permits on the centralised 'Smart' Market, with a uniform initial free allocation of 120kg N/ha, which is the upper limit of Nitrogen application required to reduce dissolved inorganic Nitrogen (DIN) loads by 50% to meet Reef Plan targets. The 'Smart' market then accepts modestly priced offers to supply N-permits and then sells those permits to buyers who entered high bids for N-permit purchases. This matches overall N-permit supply with N-permit demand, whilst still ensuring that permit trading does not infringe the overall load cap at Tully Heads. Smart Market action ensures that N-permit purchasers can buy additional N-permits at the lowest price consistent with securing an adequate supply of permits from N-permit sellers. N-permit sellers also gain from trading because they receive the highest price consistent with matching their supply of N-permits to permit purchasers' demand for N-permits.

Market simulations are extended to include N-credits from constructed wetlands in a common pool with sales and purchases of N-permits. As the DIN load cap at Tully Heads is tightened, the market-clearing price for N-permits and N-credits increases. Higher N-prices under tight DIN load caps are enough to persuade some landowners to convert their less productive cane paddocks to constructed wetlands. These landowners – on the less productive land – find that they can make more money by selling N-credits from their constructed wetlands than they could from growing sugarcane. Selling N-credits from wetlands provides landowners with an alternative source of income, easing their transition out of cane on low productive soils.

This theoretical tradeable permit scheme is like the Queensland *voluntary market-based mechanisms for nutrient management* where two or more point sources managed by the same regulated entity can combine discharge limits to meet an overall reduced discharge limit, commonly referred to as a 'bubble licence'. Two or more point sources that are not managed by the same regulated entity can also enter into a nutrient reduction action arrangement—where one point source reduces its limit below that specified on the environmental authority, so that the other/s may increase their discharge load accordingly, effectively trading their nutrient allowance.

4.2 Potential offset methodologies for point source discharge

4.2.1 Seaweed

Coastal seaweed aquaculture offers a unique and timely solution to complex waste challenges from point source polluters such as water treatment facilities and diffuse polluters alike. Seaweed farming is a 'no-feed´ form of aquaculture; it is zero waste, cost effective and low impact making it compatible with marine conservation zoning requirements as well as with existing aquaculture infrastructure such as oyster farming. Seaweed acts as a sponge, removing nitrogen and phosphorus from the aquatic environment, accumulating those materials in their tissues. Those nutrients generally are stored in the form of pigments and amino acids that can be used later for seaweed growth.

The biological treatment of effluents by seaweeds is not a new concept and has been used in fish farm water treatment[43] based on the concept that the residues of one organism provide food for others. In such systems, the seaweed utilises the metabolic wastes from the animals as fertilizer, absorbs CO_2 and releases O_2 to the environment[44], whilst filtering the water before returning to fish tank systems. In the same way, seaweed could be utilised *in situ* or in-catchment water treatment scenarios where seaweed is grown in an oyster aquaculture system or in the receiving catchment of point-source or diffuse discharge to achieve water quality improvements.

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[42] Smart et al. 2016 Tradeable permit scheme for cost-effective reduction of nitrogen runoff in the sugarcane catchments of the Great Barrier Reef

[43] Devi and Gowri (2007) Biological treatment of aquaculture discharge waters by seaweeds. Journal of Industrial Pollution Control 23(1): 135-140

[44] Neori (2007) Essential role of seaweed cultivation in integrated multi-trophic aquaculture farms for global expansion of mariculture: an analysis. Nineteenth International Seaweed Symposium: Proceedings of the 19th International Seaweed Symposium

Seaweeds grow quickly and strip nutrients from the water column, draw down carbon dioxide and can remove pollutants such as heavy metals. The importance and productivity of seaweeds in water treatment for multi-trophic aquaculture farms has clearly been demonstrated[30]. At more than 25 million tonnes per year, seaweed is the largest marine crop in the world, and can be utilised for water treatment, food consumption, fertilisers and stock feed yet none is currently grown domestically through aquaculture in Australia (refer to section 3.5). As governments and industry look to more ecologically-balanced solutions for the management of waste generation, seaweed farming presents an opportunity that with further investigation and consideration into nutrient credits and/or offsets could provide new income streams, diversification of existing aquaculture systems and the growth of a sustainable domestic industry with minimal waste generation. Based on conservative estimates that 100kg of dried seaweed removes at least 1 kg of Nitrogen from the water column (higher estimates of 3kg reported by Mišurcová 2012[45]), and 1ha produces 10 tonnes of dried seaweed annually (higher estimates of 30 tonnes reported in literature), with a current industry treatment value of between AUD$10 and $40 per kg,[46],[47],[48] of Nitrogen, we can determine a conservative average value of removing nitrogen from the water column of AUD$100 - $400 per tonne of dried seaweed harvested. Variations will be attributed to existing treatment costs of localised facilities.

4.2.2 Shellfish (Oysters / Mussels)

Another potential biological treatment method for wastewater, and one that presents an important comparison to seaweeds, is the cultivation of filter feed organisms such as oysters and mussels. These invertebrates remove nitrogen while generating food of high nutritional value, fodder and agricultural fertiliser, thus recycling nutrients from sea to land. This is a service to society and the environment that is somewhat unrewarded and unacknowledged by most environmental authorities. In environmental economics, the nitrogen-removal service that mussel farms provide is known as an “external benefit” to society[49] as the key objective of farming mussels is to supply food for human consumption. Subsequently the nutrient removing potential is not quantified or financially valued but does present an opportunity for consideration as another methodology for nutrient offsetting.

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[50-51]. The effect of blue mussel farming on nitrogen cycling was modelled in Sweden in 2005[51] 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 when modelled, 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 similar study[52] investigating nitrogen bio-assimilation in pearl oysters found that up to 7.5kg of nitrogen was currently being removed from the waters of Port Stephens by pearl oysters and demonstrated that increasing existing farm production by 50 times per year could balance existing nitrogen loads entering Port Stephens from a small sewage treatment plant.

While shellfish farming does not display the same potential of removing nitrogen from the water as seaweed, both practices are less capital intensive than other existing nutrient offsets such as wetland and riparian construction which are costly during the initial phase and require significant land area. A recent study conducted in 2016[53] in North Queensland’s Tully catchment determined through consultation with industry that wetland construction costs are currently typically between $30k - $40k per ha, depending on the nature

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45 Mišurcová, (2012). Chemical composition of seaweeds, pp. 173–192, in: Se-Kwon Kim. Handbook of Marine Macroalgae. Wiley Blackwell, West Sussex, UK.

46 Pollack et al. (2013) Role and Value of Nitrogen Regulation Provided by Oyster (Crassostrea virginica) in the Mission-Aransas Estuary, Texas USA. PLOS ONE 8(6)

47 NEIWPCC (2015) Final Report - Low Cost Retrofits for Nitrogen Removal at Wastewater Treatment Plants in the Upper Long Island Sound Watershed

48 Newell at al. 2005) Influence of eastern oysters on nitrogen and phosphorus regeneration in Chesapeake Bay, USA. In: The comparative Roles of Suspension Feeders in Ecosystems. R Dame and S.
Olenin (Eds.) Vol 47 NATO Science Series: IV - Earth and Environmental Sciences. Springer, Netherlands. P 93–120.

49 Pearce and Turner (1990) Economics of Natural Resources and the Environment. John Hopkins University Press.

50 Cerco and Noel (2007) Can oyster restoration reverse cultural eutrophication in Chesapeake Bay? Estuaries Coasts 30:331–343

51 Lindahl et al (2005) Improving Marine Water Quality by Mussel Farming: A profitable solution for Swedish Society. Ambio 34(2): 131-138.

52 Gifford et al. (2005) Quantification of in situ nutrient and heavy metal remediation by a small pearl oyster (Pinctada imbricata) farm at Port Stephens, Australia. Marine Pollution Bulletin 50(4) 417-22

53 Smart et al. 2016 Tradeable permit scheme for cost-effective reduction of nitrogen runoff in the sugarcane catchments of the Great Barrier Reef

of the terrain, access and design purpose with an annual estimated maintenance cost of 2% of the initial construction cost. Wetlands also do not offer employment opportunities or a sustainable commodity that can be harvested. The aquaculture of both seaweed and oyster/mussels presents a unique opportunity in water treatment, nutrient offsets, sustainable primary industry development and diversification, and the potential for greater income generation.

4.2.3 The opportunity

The variety of availability data and literature on the nitrogen removal potential of shellfish in aquaculture presents an opportunity for comparison with seaweed which is a more recent aquaculture practice that is therefore lacking in comparable data but is attracting attention from scientists in wastewater treatment due to its rapid growth rates and uptake of nitrogen. Queensland presents an exciting opportunity to investigate both the regulatory and physical viability of nitrogen offsets for the treatment of water quality as it aligns with the states focus on water quality improvement demonstrated in the Reef 2050 Water Quality Improvement Plan and policy development in the point source offsets area. Moreton Bay, located on the doorstep of Brisbane, Queensland's largest city with an average population growth rate of 3.17%, presents a unique opportunity to test the *in-situ* feasibility of nitrogen offsetting through aquaculture. The opportunity is unique due to three factors: (1) Moreton Bay lies adjacent to the city of Brisbane with a population of 2.56 million, as the city continues to grow, it will place subsequent pressure on treatment infrastructure; (2) Moreton Bay has an established oyster farming industry with potential to grow and diversify with 354 hectares[54] of approved oyster areas (with only 30% actively farmed[55]); and (4) Oyster leases are contained within the Moreton Bay Marine Park, regulated by the Marine Parks Regulation 2006 and managed by an administrative framework with clear conditions pertaining to infrastructure and cultivation methods, and provides clear guidelines for any condition alterations and permit modifications i.e. to allow for the farming of seaweed .

Moreton Bay water quality condition is ranked as excellent by Healthy Land and Water[56], maintaining a B – A+ overall condition quality since 2015 and considers a number of indicators including turbidity, total nitrogen, total phosphorus, chlorophyll-a and various habitat indicators such as wetlands, seagrass and mud content. Whilst Total Nitrogen levels remain low, data between 2012-2019 indicates an upward trend across the Inner, Central and Western Bay areas (Figure 7).

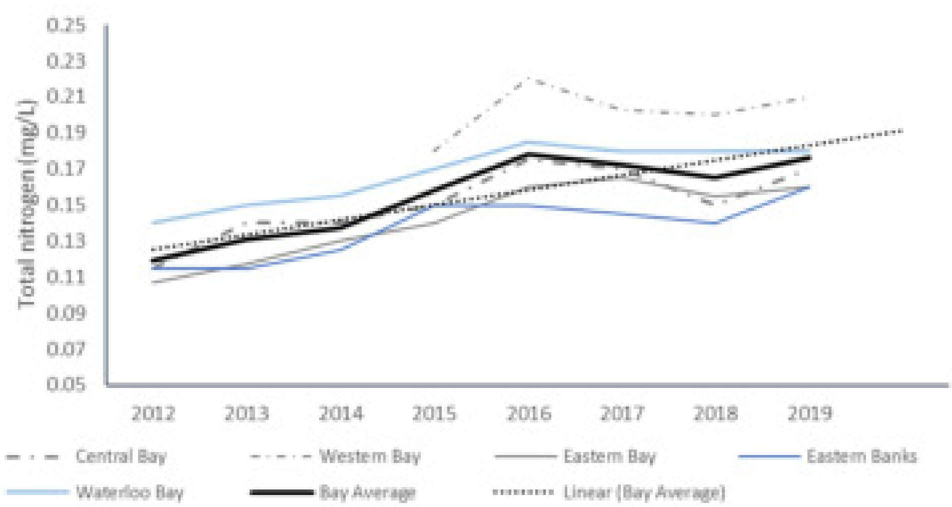

Figure 7 Total nitrogen reported by Healthy Land and Water yearly water quality condition report cards

To assess the feasibility of nitrogen offsets from aquaculture, a comparison across various plausible aquaculture scenarios is required, which investigates the operational and capital costs and revenue associated with the farming operations in order to produce the yields required to present a viable nitrogen offset. These costs would include for example, marginal costs of producing additional units to an existing

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54 Dexter (2015) Oyster industry plan for Moreton Bay Marine Park. Fisheries Queensland, Department of Agriculture and Fisheries.

55 Personnel conversation September 2019 (Queensland Oyster Growers Association)

56 Healthy Land and Water report card results, accessible https://hlw.org.au/

industry; costs of establishing a new industry; average cost of overall productions; and total costs of investment. The farming scenarios that should be investigated include:

1) expanding the shellfish industry.

2) developing new stand-alone seaweed aquaculture opportunities in Australia, or

3) utilising existing aquaculture facilities to harvest both shellfish and seaweed to capitalise on existing production and markets, diversify the product and access opportunities for water quality offsets.

Critical to investigating these scenarios will be

1) Developing an understanding of the regulatory process to enable Offsets to be generated by seaweed/shellfish. Subsequently understanding the requirements for mythology development. This will differ considerable between carbon and nitrogen.
2) Giving consideration to developing an approach for linking proposed offsets with diffuse pollution sources and funding mitigation measures.

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5. Synergies between Carbon and Nitrogen Offsets

Sections three and four have demonstrated the opportunity to link nutrient and carbon abatement through sustainable aquaculture systems that enable both growth and diversification of a physical product to market as well as the potential trading of carbon and nitrogen on offset markets. The challenge is in engaging with both the public and private sectors more effectively across the carbon and nitrogen value chain in our coastal oceans and strengthening the regulatory mechanisms and incentives to support the growth of sustainable aquaculture industries with de-risked investment opportunities for the private sector in carbon and nitrogen capture in aquatic systems.

Academic literature and discussion have historically focused on two areas: science and to a lesser extent economics[57], across both blue carbon and water quality realms. If blue carbon and waterway nitrogen offsets are to be considered in commercial terms, it is necessary to consider the role of both the communities and business interests (suppliers and investors) at the opposite ends of the offset value chain. These stakeholders are crucial in getting the carbon and nitrogen to 'market', through identifying the need, the costs and real benefits to those positioned along the value chain. Whilst there is some focus in the literature on market-based mechanisms for offsets, this focus is predominantly on large, broadscale public approaches to carbon and nitrogen capture. A lack of clarity exists around types of financing opportunities to encourage long term implementation of sustainable practices across spatial scales and environments, particularly in the area of local industry development.

The primary consideration in commercial decision-making is the question of financial risk and return. The availability of capital, transaction costs, legitimacy of project methodology, governance issues, offset price trends and existing markets are key factors in financial analysis of all tradeable offset projects. Projects in coastal and marine systems are further complicated by those issues unique to ecosystem-based activities. For example, investment in blue carbon and water quality offsets is constrained by factors including biophysical issues such as yield variability, measurement uncertainty due to localised and seasonal variation, logistical challenges, lifecycle analysis including energy inputs from infrastructure and operations, land tenure concerns and long-term reliability of legislative frameworks[44,58]. Furthermore, one of the most challenging obstacles as mentioned in section 3.3 is the issue of permanence where natural resources can be damaged and destroyed by natural events such as storm surges, cyclones, and disease outbreak, as well as security of tenure and ability to ensure the carbon and nitrogen is sequestered permanently.

The sequestration permanence, however, is where nitrogen and carbon offsets deviate. Projects that sequester carbon from the atmosphere must ensure that carbon is stored permanently requiring extensive understanding and quantification of the carbon life cycle. Nitrogen, however, once sequestered by the organism is removed from the environment thereby reducing total dissolved inorganic Nitrogen (DIN) in the water body. If the organism is then consumed, the nitrogen will re-enter the nitrogen cycle and will be either treated through human waste water treatment plants or if used as fertiliser may be absorbed into the soil or filter back through the catchment as runoff only to be taken up again through DIN removal processes in the waterbody (Figure 8).

[57] Thomas (2014) Blue carbon: Knowledge gaps, critical issues and novel approaches. Ecological Economics 107:22-38
[58] Alongi (2011). Carbon payments for mangrove conservation: ecosystem constraints and uncertainties of sequestration potential. Environ. Sci. Pol. 14 (4), 462–470.

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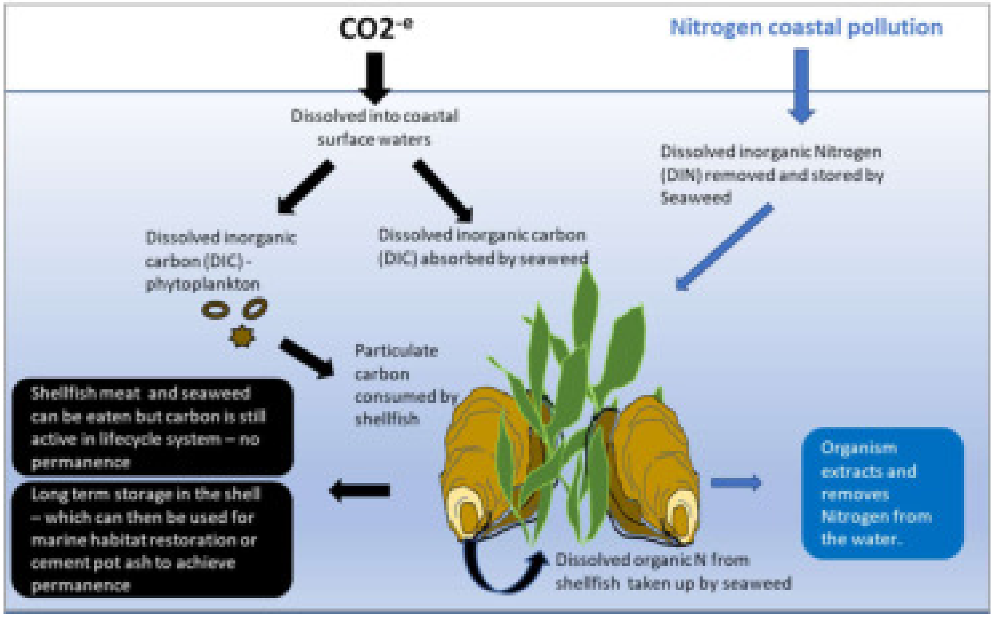

Figure 8: Carbon and nitrogen pathways in seaweed and shellfish illustrating the difficulty of quantifying carbon sequestration without guaranteed permanence compared to nitrogen uptake.

To date, projects addressing multiple offset areas i.e. targeting both nitrogen and carbon sequestration for the purpose of creating sustainable aquaculture, diversification of products and increase in potential revenue through tradeable offsets units (ACCUs and kilograms of Nitrogen) have not been considered. This is most likely due to challenges inherent to blue carbon where quantification of carbon storage has proved historically challenging[59] and the diffuse nature of nitrogen pollution. The complex nature of the Blue Carbon concept, however, combined with the need to address growing water quality concerns in the shadow of booming coastal populations in Australia has led to unprecedented collaboration across disciplines. Scientists, conservationists and policy makers have interacted intensely to advance shared goals and increase flexibility in approaches to sustainability and climate mitigation in our oceans. Understanding the economic values of marine and coastal ecosystems and the opportunities for sustainable investment in our natural resources is important to support and contribute to a shift towards more sustainable and positive practices. Whilst studies have investigated the economic feasibility of Blue Carbon approaches, including considerations for economic models and incentives under a variety of strategies, discussion is lacking on the opportunity for existing sustainable aquaculture practices to support offset opportunities through growth and diversification.

The aquaculture industry in Australia presents a unique opportunity to grow an existing industry with benefits to food and nutrition security; economic and social development in regional areas; and ecosystem services such as carbon sequestration and nitrogen removal. However, economic modelling is essential in order to determine the feasibility of the concepts discussed in this paper and to present to regulatory bodies and the private sector for consideration. An economic model will need to consider the opportunities for additional revenue from tradeable environmental offsets (or combination of) and other social, environmental and economic co-benefits, against the costs of diversifying and growing the industry to encompass seaweed and shellfish.

To sufficiently understand the feasibility of these concepts to a) present for consideration by the appropriate regulatory authorities, and b) address investment potential and risk to the private sector, an economics assessment and business case will be developed. This assessment will not only involve financial analysis and consideration of economic indicators, but also address other social, environmental and socio-economic costs and benefits in Australia when considering environmental offsets.

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[59] Lovelock and Duarte (2019) Dimensions of Blue Carbon and emerging perspectives

6. Next Steps

6.1 Understanding the Science to support an economic model

Integral to conducting a feasibility study on the utilisation of aquaculture systems for nitrogen and carbon offsets is ensuring the scientific data is accurate and representative of the ecosystem being assessed. This requires a high-level review of the nitrogen and carbon pathways supported by local data specific to the area being assessed and considered for offset potential. As discussed throughout this paper, a clear understanding and quantification of carbon and nitrogen storage and life cycles are critical for an offset methodology to be endorsed by the regulator and be considered a low risk venture by potential private investors.

To achieve this, we must investigate the value of nitrogen and carbon offsets across potential seaweed farms and existing shellfish operations, utilising a case study approach to gather input and output data. We must also consider potential impacts of a seaweed farming industry on ecosystem dynamics in a case study area to determine if the diversification of oyster leases to incorporate seaweed farming is both environmentally acceptable based on ecosystem principals and financially feasible.

The project will consider the existing regulatory framework discussed in this paper, the carbon and nitrogen capture opportunity based on case study site sampling, and the potential opportunity for offset investment by polluters through consultation. From here we can design a financial model which assesses the potential financial return on nitrogen and carbon capture for the aquaculture operators and assess against the costs of the development of a seaweed industry in the case study region.

6.2 Economic viability and model development

Ultimately, the decision to proceed with a given project should be based on a thorough feasibility study and cost benefit analysis that considers location, site characteristics, environmental parameters, available technologies, financial and human resources, environmental impacts, market opportunities and risk factors. Furthermore, the results of a feasibility study, in terms of return on investment, cost of start-up or diversification, time to see financial benefit, will assist the producers, regulators and potential investors in making well informed decisions that support both financial and environmentally sustainable investment in the growth of the project. Lastly, the results can be used by government and industry as a tool to captivate interest in the aquaculture sector and assist in unlocking financial support mechanisms for further development, based on sound economic and sustainability principles.

Along with the model, we will develop a user guide to support the model user, operator and/or financial institutes with a summary and explanation to the workings of the financial models and projected financial outcomes.

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7. NineSquared's Approach

NineSquared is an economic and commercial advisory service with expertise in providing data-driven advice and developing economic models for government and the private sector. We value a cross disciplinary approach to finding solutions to complex economic and environmental problems facing our current generation and those to come.

We view multidisciplinary approaches as being paramount to conceptualising, challenging and implementing these solutions; answering the economic questions surrounding environmental offsets; and believe there is enormous opportunity in Australia to further investigate opportunities utilising market mechanisms such as offset "cap and trade" systems which holistically benefit both industry and the environment. Through our partnership with the University of the Sunshine Coast, one of Australia's leading innovative hubs with an emphasis on industry collaborations, we have extensive outreach and engagement with industry. These partnerships enable us to fill knowledge gaps through research so we can develop evidenced based, realistic and adaptable economic models to help us move towards more market-based sustainability systems.

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8. APPENDIX

8.1 Australian Carbon emission policy chronology

Year	Event	Description
1979	First international conference on climate change in Geneva	discussing the link between human activities and climate.
Hawke-Keating Government take office March 1983		
1988 (Jun)	First global emissions reduction targets (the 'Toronto targets'	At the Toronto conference on climate change a target of 20% reduction in greenhouse gas emissions by 2005 on 1988 levels is proposed.
	First meeting of the Intergovernmental Panel on Climate Change (IPCC)	The IPCC is an international working group of experts tasked with reviewing and synthesising peer-reviewed research publications on climate change.
1989	First Australian greenhouse gas emissions reduction proposal submitted to Cabinet	Senator Graham Richardson submits to Cabinet a proposal for a 20% reduction in 1988 Australian greenhouse gas emissions levels by 2005
1990 (Aug)	IPCC releases its First Assessment Report (FAR)	The IPCC FAR notes with certainty that: a natural greenhouse effect warms the Earth and that human activities contribute to atmospheric concentrations of greenhouse gases. Several predictions are made about the effect of an enhanced greenhouse effect on the climate
1990 (Oct)	Australian Government adopts the 'Toronto targets' with provisos	Senator Richardson's 20% target, which had originally been rejected, is accepted and announced on 11 October 1990 as an 'Interim Planning Target' with the proviso that the reduction would not be at the expense of the economy (the 'no regrets' strategy).
1990 (Dec)	First global treaty on climate change established (UNFCCC)	Prompted by the IPCC FAR, negotiations begin for a global treaty responding to climate change. This treaty later becomes known as the United Nations Framework Convention on Climate Change (UNFCCC).
1991 (Nov)	The Industry Commission Inquiry Report, Costs and Benefits of Reducing Greenhouse Gas Emissions	The report resulted from an Industry Commission public inquiry, in response to a request from the Commonwealth Government, into the costs and benefits to Australia of participating in a possible international consensus to reduce emissions by the year 2005 to a level 20 per cent lower than in 1988
Keating Government takes office – 20 December 1991		
1992 (June)	Australia signs the UNFCCC at the UN Conference in Rio de Janeiro, Brazil. Australia ratifies UNFCC in December.	The UNFCCC aims to stabilise atmospheric greenhouse gas concentrations in time to protect ecosystems, food security and economic development from the threat of climate change. By signing the treaty Australia indicates its acceptance of the principles of the Convention.

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1992 (Dec)	The National Greenhouse Response Strategy (NGRS) released	The NGRS is endorsed by the Commonwealth, state and territory Governments at a COAG meeting. The NGRS is a mechanism to audit and facilitate national approaches to limit greenhouse gas emissions so that Australia can meet its commitments to the UNFCCC
1995	Government introduces Greenhouse 21C plan:	The 'Greenhouse 21C plan' supplements the NGRS with several additional measures to curb greenhouse gas emissions. One of these is the Greenhouse Challenge program, a voluntary scheme for major companies and industry sectors to reduce greenhouse gas emissions.
1995 (Dec)	IPCC releases its second assessment report (SAR)	The IPCC SAR states that "there is a discernible human influence on global climate".
Howard Government takes office - March 1996		
1996	The National Greenhouse Advisory Panel releases the results of a major review of the NGRS:	The report indicates that the "NGRS had little if any effect in achieving the necessary policy coordination and integration within and between jurisdictions; with few exceptions, greenhouse issues have not been considered"
1997(Nov)	Prime Minister Howard introduces the 'Prime Minister's package	Funding is provided for strategies outlined in Australia's second national communication to the UNFCCC. A target of an additional 2% of electricity to be sourced from renewable sources by 2010 is made.
1997 (Dec)	Third UNFCCC COP held in Kyoto, Japan – Kyoto Protocol adopted.	The Kyoto Protocol is adopted after two years of negotiations. Australia secures a controversial concession to include land-use change and forestry as part of the net emissions in the 1990 baseline (later known as the 'Australia clause').
1998 (Apr)	The Australian Greenhouse Office (AGO) is established	Australia is the first country to establish a government agency dedicated to reducing greenhouse gas emissions The AGO is responsible for managing the 'Prime Minister's package'.
1998 (Apr)	Australia signs the Kyoto Protocol	Australia signs the Kyoto Protocol, along with 20 other countries. However, Australia does not ratify the Kyoto protocol and therefore the targets are not legally binding.
1999 (Mar)	The AGO releases the first of four discussion papers on emissions trading	The first discussion paper, 'Establishing the Boundaries' of the National Emissions Trading series, details the principles and framework for how an emissions trading system (ETS) might operate
1999 (May)	Measures for a Better Environment' package is announced	New funding is announced in the 2000-01 Budget for reductions in greenhouse gas emissions and to encourage the uptake of renewable energy. More than half of this funding is dedicated to the Greenhouse Gas Abatement Programme to 'support activities that are likely to result in substantial reductions in greenhouse emissions or substantial enhancement of carbon sinks and are consistent with ecologically sustainable development'.
2000	'The heat is on Australia's Greenhouse Future' Senate Committee report released. Recommendations were rejected by the Government in 2001.	The report criticises the Government for a lack of commitment to climate change policy. More than 100 recommendations are made
2001	IPCC releases its third assessment report (TAR)	The IPCC TAR details the growing scientific evidence that global temperatures have increased over the 20th century. Temperatures are predicted to increase by 1.4–5.8°C over the next century.

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2001	Mandatory Renewable Energy Target scheme (MRET) starts.	The MRET commences under the Renewable Energy (Electricity) Act 2000. It mandates, as initially proposed in the Prime Minister's Package, that by 2010 electricity retailers and other large electricity buyers source an additional 2% (above 2001 levels of about 8%) of their electricity from renewable or specified waste-product energy sources. Annual targets are defined.
2002	Australia refuses to ratify the Kyoto Protocol	The Howard Government outlines to the Australian Parliament that ratifying the Kyoto Protocol is not in the nation's interest.
2002 (Aug)	New climate change strategy announced - 'Global greenhouse challenge: the way ahead for Australia'	The Challenge is a four-pronged policy response designed to meet Australia's Kyoto target and anticipate adaptation needs.
2003 (Jan)	Greenhouse Gas Reduction Scheme implemented by the NSW Government	The Greenhouse Gas Reduction Scheme (GGAS) is the world's first mandatory emission trading scheme. The GGAS employs a baseline and credit system (rather than a cap-and-trade system).
2004	Securing Australia's Energy Future White paper released	The paper proposes renewable energy initiatives, including an overhaul of the fuel excise program and funding for research and development. It reaffirms that ratifying the Kyoto Protocol is not in the national interest, but that Australia is on track to meet its target anyway.
2005 (Feb)	Kyoto Protocol comes into force	Ninety days after both conditions are met the Kyoto Protocol's 2012 targets become enforceable
2005 (Aug)	The International Energy Agency (IEA) urges Australia to consider an ETS	The IEA releases Energy policies of IEA countries - Australia 2005 review, which notes that Australia's emission intensity is one of the highest in the world. It urges Australia to consider an ETS
2006	Prime Ministerial Task Group on Emissions Trading is established	Prime Minister John Howard announces the creation of a task group to provide advice on designing an ETS for Australia.
2007 (May)	IPCC releases its fourth assessment report (AR4):	The IPCC AR4 affirms with 90% certainty that increases in global temperatures since the mid-20th century is driven by anthropogenic greenhouse gasses.
2007 (May)	Shergold Report' released	The Prime Ministerial Task Group on Emissions Trading releases the 'Shergold Report' which recommends Australia develop an emissions trading scheme.
2007 (Sep)	National Greenhouse and Energy Reporting Bill 2007 receives royal assent	The National Greenhouse and Energy Reporting Bill 2007 requires industry to report its greenhouse gas emissions, abatement actions, energy consumption and production.
2007 (Oct)	Cabinet rejects proposal to ratify the Kyoto Protocol	Malcolm Turnbull, Minister for the Environment and Water Resources, urges Cabinet to ratify the Kyoto Protocol but is unsuccessful.
Rudd Government takes office November 2007		
2007 (Dec)	The Department of Climate Change and Water is established, and Australia ratifies the Kyoto Protocol.	The Department of Climate Change is established within the Prime Minister and Cabinet portfolio.

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2008 (Feb)	Garnaut Review interim report released. Final report released in September)	The interim report for the Garnaut Climate Change Review submits that Australia is particularly vulnerable to the impacts of climate change. It also proposes that Australia should establish effective climate policies, the centrepiece of which should be an ETS.
2008 (Dec)	Carbon Pollution Reduction Scheme: Australia's Low Pollution Future' released	The White paper outlines the final design of an Australian ETS. It also outlines new 2020 emissions reduction targets: 5% below 2000 levels without any conditions, but 15% below 2000 levels if there is a 'global agreement where all major economies commit to substantially restrain emissions and all developed countries take on comparable reductions to that of Australia
2009	Renewable energy target (RET) increased to 20%	The Renewable Energy (Electricity) Amendment Bill 2009 received royal assent. It amends existing legislation, replacing the MRET with the Renewable Energy Target (RET). The RET has a more ambitious renewable energy target of 20% (45,000 GWh) by 2020. The Solar Credits scheme is also introduced it provides multiple credits for the installation of household rooftop solar.
2010	Adapting to Climate Change in Australia – An Australian Government Position Paper' released	This Position paper sets out the Government's role in and strategies for adapting to climate change
Deputy Prime Minister Julia Gillard becomes Prime Minister after internal party challenge – 24 June 2010		
2011 (Jan)	The RET scheme is split into two parts	The Renewable Energy (Electricity) Amendment Act 2010 comes into force. It separates the RET scheme into the Large-scale Renewable Energy Target and the Small-scale Renewable Energy Scheme.
2011 (May)	Government launches Climate Commission	his independent commission is designed to provide expert advice and information on climate change to the Australian public.
2011 (Mar)	Legislation is introduced for a carbon offset to create incentives for carbon avoidance projects in the land sector	The Carbon Credits (Carbon Farming Initiative) Bill 2011 creates the Carbon Farming Initiative which is the first scheme of its kind globally. The Carbon Farming Initiative came into force in September.
2011 (Nov)	ETS legislation is passed by Parliament	The Clean Energy Act 2011 is a package of 18 Bills that provides the framework for an ETS starting with a three-year fixed-price phase.
2012 (Jun)	$10 billion Clean Energy Finance Corporation (CEFC) legislated	Legislation is passed for the CEFC, a $10 billion fund dedicated to investing in clean energy.
2012 (Jul)	Price on carbon comes into effect and the Climate Change Authority and Australian Renewable Energy Agency formed	An unlimited number of carbon units become available for purchase at a fixed price of $23. Part of the profit from the carbon price will be used to compensate householders as a 'low income tax offset'.
2012 (Aug)	Australia and the EU agree to link ETSs	Australia links its ETS with the EU's ETS, sharing a portion of permits. Initially the link is unilateral allowing the purchase of EU permits within Australia but not the inverse. The link is intended to become bilateral by mid-2018. This deal removes Australia's carbon price floor. The deal also foreshadows Australia joining a second period under the Kyoto Protocol.
Labor Member Kevin Rudd becomes Prime Minister after internal party challenge – 26 June 2013		
2013	Government announces intention to move to a full ETS in 2014	The Government cites the high cost of living as a reason to bring forward by one year the transition from a fixed price to an ETS.

Abbott Government takes office – September 2013		
2013 (sep)	Dismantling of four climate change programs begins and climate change functions moved into Department of Environment	The government begins drafting legislation to repeal the Clean Energy Act 2011 The government abolishes the Climate Commission Treasurer orders the CEFC to cease investments Environment Minister announces plans to abolish the CCA
2013-2014	IPCC progressively releases its fifth assessment report (AR5)	The AR5 included clearer definitions of the risk of climate change affecting agriculture, human health, national security and the environment as well as increased evidence supporting human-induced climate change.
2013 (Oct)	Climate Council replaces Climate Commission:	Funded by $900,000 in private donations, the Climate Council is launched to continue the work of the disbanded Climate Commission
2013 (Nov)	Government introduces legislation to repeal ETS, CCA and CEFC. Repeal bill was voted down.	The Clean Energy Legislation (Carbon Tax Repeal) Bill 2013 is one of a package of 11 Bills repealing the ETS and some related bodies and instruments.
2013 (Dec)	Government releases Emissions Reduction Fund Green Paper	The Green Paper describes the design of the Emission Reduction Fund, focusing on low-cost emission reductions and streamlined administration.
2014 (Feb)	Targets and Progress Review—Final Report released	The Climate Change Authority reviews Australia's progress and recommends a minimum reduction of 15% in greenhouse gas emissions from 2000 levels by 2020.
2014 (Apr)	Emissions Reduction Fund White Paper released	The ERF White Paper sets out the final design of the ERF, with a reduced emissions target of 421 million tonnes of CO2-e over the period to 2020, compared to 431 in the Green Paper.
2014 (Jun)	The Government introduces the first Direct Action legislation - Carbon Farming Initiative Amendment Bill 2014	The Carbon Farming Initiative Amendment Bill 2014 establishes the Emissions Reduction Fund, the keystone of the Direct Action Plan.
2014 (Jul)	Carbon Price Mechanism repealed	The eight 'carbon tax repeal' bills are passed by the Senate, coming into effect on 1 July 2014. Australia becomes the first nation to reverse action on climate change.
2014 (Nov)	Australia and China sign climate change cooperation MOU	Under the MOU, Australia and China will cooperate to deliver practical climate change outcomes, including through energy efficiency; technology cooperation; and improved emissions data reporting.
2014 (Nov)	Carbon Farming Initiative Amendment Bill 2014 passes both houses	The first legislation of the Direct Action Plan will commence the following day. In December, Climate Change Authority releases Carbon Farming Initiative Review: The CCA finds that the CFI achieved some real emissions reductions, but participation was lower than expected.
2014 (Apr)	First Emissions Reduction Fund Auction	The first Emissions Reduction Fund auction in April 2015 saw 47 million tonnes of carbon abatement contracted at an average price per tonne of abatement of $13.95. Through this auction, the Government committed $660 million to projects that will reduce emissions in Australia. The emissions reductions from these projects will be delivered over the next 10 years, which means that reductions purchased in the first auction will contribute not just to Australia's 2020 target, but to its post-2020 targets as well.

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2015 (May)	Renewable Energy Target released	The RET is announced as 33,000 gigawatt hours, or 23.5%, of the estimated electricity generation for 2020.
2015 (Aug)	Australia's post-2020 emission reduction target announced:	The nation will aim to reduce greenhouse gas emissions by 26-28% below 2005 levels by 2030. Setting Australia's post-2020 target for reducing greenhouse gas emissions final report released in August.
Minister Malcolm Turnbull becomes Prime Minister after internal party challenge – 14 September 2015		
2015 (Nov)	Australia elected to head Green Climate Fund Board	The UNFCCC fund supports small developing island states to mitigate the impacts of climate change.
2015 (Nov)	Twenty-first UNFCCC COP held in Paris, France	The Paris Agreement is adopted by 195 nations, the first universal, legally binding climate change agreement. The Agreement aims limit the increase in global temperature to 1.5°C and to reach peak carbon emissions as soon as possible.
2015 (Dec)	Australia's National Climate Resilience and Adaptation Strategy released	The Strategy sets out how Australia is managing climate risks for the benefit of the community, economy and environment.
2015 (Dec)	Australia establishes International Partnership for Blue Carbon	The partnership is designed to accelerate action on the use of 'blue carbon' ecosystems, such as mangroves, sea grass beds and salt marshes.
2015 (Dec)	Government announces target of net zero emissions by 2100	Prime Minister and Environment Minister both announce at COP21 that Australia has a net zero emissions target by 2100.
2015 (Dec)	National Energy Productivity Plan 2015-2030	The NEPP provides a framework and an initial economy-wide work plan designed to accelerate delivery of a 40 per cent improvement in Australia's energy productivity by 2030.
2016 (Mar)	Clean Energy Innovation Fund	The Australian Government established a $1 billion Clean Energy Innovation Fund to support emerging technologies make the leap from demonstration to commercial deployment. Jointly managed by the Clean Energy Finance Corporation (CEFC) and the Australian Renewable Energy Agency (ARENA). Starting with $100 million in 2016- 17, an additional $100 million will be available each subsequent year up to the $1 billion total.
2016 (Jul)	Safeguard Mechanism Commenced	The safeguard mechanism (part of the ERF) commenced on 1 July 2016 and requires Australia's largest emitters (> 100,000 tonnes of carbon dioxide per year) to keep emissions within baseline levels.
2017 (Jan)	Solar Communities Program	The Australian Government's $5 million Solar Communities Program provides funding for community groups in selected regions across Australia to install rooftop solar photovoltaic, solar hot water and solar-connected battery systems at their facility to reduce emissions, reduce their electricity costs and support renewable energy.
2017 (Jun)	Low Emissions Technology Roadmap (CSIRO)	The Low Emissions Technology Roadmap provides an independent, science-based analysis of the technology options in the energy sector that can help Australia meet its 2030 emissions reduction target and create new opportunities for local industry
2017	The National Carbon Offset Standard and carbon neutral certification	The National Carbon Offset Standard (the Standard) is a voluntary standard to manage greenhouse gas emissions and to achieve carbon neutrality. It provides best-practice guidance on how to measure, reduce, offset, report and audit emissions for organisations, products & services, events, precincts and buildings

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2017 (Dec)	2017 Climate Policy Review	the Government reviewed its climate change policies to ensure they remain effective in achieving Australia's 2030 target and Paris Agreement commitments. A final report was released on 19 December 2017
2017 (Dec)	National Energy Guarantee (NEG)	An energy policy proposed by the Turnbull government in late 2017 to deal with rising energy prices in Australia and lack of clarity for energy companies to invest in energy infrastructure. The policy specifically targets energy companies in the National Electricity Market and large energy users to have a reliability obligation as well as emissions reduction obligations. The NEG will need the support of the Australian states signed up to it to activate the scheme.
Minister Scott Morrison becomes Prime Minister after internal Party Challenge – 24 August 2018		
2019	Climate Solutions Fund	The Climate Solutions Fund added a further $2 billion to continue the success of the Emissions Reduction Fund. This funding will boost agricultural productivity, support jobs for Indigenous communities and improve biodiversity and water quality and reduce greenhouse gas emissions.
2020 (Jan)	Federal / NSW bilateral energy agreement	The plan involves NSW receiving $960 million in federal funding to upgrade the energy grid and invest in emissions reductions initiatives. The state and federal governments agreed to jointly underwrite the grid upgrades in the HumeLink interconnector from Snowy Hydro to southern NSW, as well as the Queensland-NSW interconnector. The plan also promises financial support for a new pilot renewable energy zone in the Central West to help large-scale renewable generators pump energy into the grid. As of Jan 2020, the plan did not specify the reduction in emissions it aims to deliver.

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8.2 Australian Nutrient Offset Pollution Current Policy Overview and case studies

Mechanism	Year	Description	WQ/nutrient Offset framework present?
National			N/A
National Water Quality Management Strategy	2018	The National Water Quality Management Strategy (NWQMS) is a long-term plan of action developed by the Federal, State and Territory Governments in 1992 to ensure a sustainable and nationally consistent approach to water quality management. The NWQMS promotes the development of appropriate action plans for waters in regions subject to development pressures. The action plans are based on the Framework for Marine and Estuarine Water Quality Protection. These incorporate national guidelines and recommendations for monitoring and reporting approaches. Action plans aim to improve or sustain the quality of all waters in selected catchments by providing for the development of Water Quality Objectives and better management.	
NSW			Yes
Environmental Protection Act	1979	Overarching Act under which environmental protection policies are developed.	
Green Offsets for Sustainable Development	2002	sets out the rationale for using offsets and how they might be implemented in NSW. Since then, the Department of Environment and Conservation (DEC) has gained practical experience by developing and implementing a number of pollution offset programs	
Western Sydney South Creek Nutrient Offset pilot	2005	South Creek catchment was the site of the first pollution offset scheme to be trialled in NSW (EPA 2005). In this project Sydney Water and Landcom have been able to offset nutrient loads by reducing pollution at locations outside (but within the catchment) of their STP sites.	
Protection of the Environment Operations Act 1997 (POEO Act)	2005	Under section 69 of the amended POEO Act (2005) the EPA can now impose conditions on environmental protection licenses, which allow participation in green offset schemes or works.	
Queensland			Yes
Environmental Protection Act	1994	Overarching Act under which environmental protection policies are developed.	
Voluntary market-based mechanism for nutrient management	2014	flexible options for managing point source water emissions. The purpose of the mechanism is to provide an alternative investment option for licensed point source operators to meet their water emission discharge requirements under the Environmental Protection Act 1994, while delivering an improvement in water quality in the receiving environment (DEHP, 2014).	

Draft Point Source Water Quality Offsets Policy	2017	The Draft Point Source Water Quality Offsets Policy is an update of the 2014 policy. The purpose of the policy is to offer an alternative investment option for regulated point source operators to manage their water emission requirements under the Environmental Protection Act 1994, while improving water quality.	
Victoria			Yes
Environmental Protection Act	1970	Overarching Act under which environmental protection policies are developed.	
Stormwater offsets program – for developments	1999	Urban Stormwater: Best Practice Environmental Management Guidelines (1999) / State Planning Policy Framework / State Environment Protection Policies. Stormwater quality offsets are calculated on a sliding scale according to the percentage of best practice that is achieved on the site. Nitrogen is the currency for the contribution as it is typically the limiting pollutant (e.g. if nitrogen targets are achieved, then phosphorus and suspended solids objectives are also achieved). A specific contribution rate (based on rainfall) has been established for areas within Melbourne and is expressed in $/ha	
Water Quality Offsets Framework	2015	Consistent with regulatory best practice the Draft SEPP (Waters) includes reforms aimed at reducing the costs of pollution abatement by better enabling licensees to adopt economic measures or "offsets" which enable them to offset actions or activities that have the potential to degrade environmental quality (e.g. wastewater discharges) with actions which enhance environmental quality, provided a net environmental benefit can be achieved. First example occurred in 2016 when Goulburn Valley Water received EPA approval to upgrade its wastewater management facility at Killmore, incorporating a water quality offset. Also captured in SEPP (waters).	
Western Australia			Yes
Environmental Protection Act	1986	Overarching Act under which environmental protection policies are developed.	
Busselton Environmental Improvement Initiative example	2002	$200,000 per year for 5 years as part of a state-wide commitment of $1.75million over 5 years to reduce nutrient losses from catchments, to complement upgrading of wastewater treatment facilities. Projects include 30 dairy waste management projects, fertiliser management projects, groundwater denitrification trenches, and waterway fencing.	
South Australia			Yes
Environmental Protection Act	1993	Overarching Act under which environmental protection policies are developed.	
Environment Protection (Water Quality) Policy	2003	Provides the structure for regulation and management of water quality in South Australian inland surface waters, marine waters and groundwaters. The main objective of the Water Quality Policy is linked to the Environment Protection Act to ensure that all reasonable and practicable measures are taken to protect, restore and enhance the quality of the environment while having regard to the principles of ecologically sustainable development.	
A tradeable rights instrument to reduce nutrient pollution in the port waterways (EPA)	2005	Bubble Licencing - several large point sources enter into a self-contained trading scheme within a restricted area. Individual sources within the bubble can adjust their pollution loads if they do not exceed the aggregate discharge limit (or water quality target) Formal offset schemes - A formal offset trading scheme achieves cost-effective pollution reduction through allowing dischargers to reduce their pollution load by purchasing credits from an 'offset bank' in order to meet their allocation.	

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		Negotiating licencing offsets – principally a bubble licensing scheme but with some allowances for diffuse-source pollution abatement via offsets, where possible.	
ACT			No
Environmental Protection Act	1997	Overarching Act under which environmental protection policies are developed.	
Water Quality Environmental Protection Policy (EPP)	2008	This EPP provides guidance on meeting these legislative requirements, including the need to adopt the general environmental duty as specified in the Act to prevent or minimise environmental harm.	
ACT Water Strategy 2014-2044	2014	A water quality strategy that focuses on healthy catchments and waterbodies; a sustainable water supply; a community that values and enjoys clean, healthy catchments. Discusses ways to reduce excess nutrients entering water bodies but does not discuss in the context of offsets.	
NT			No
Environmental Protection Act	1982	Overarching Act under which environmental protection policies are developed.	
Water Quality Protection Plan for Darwin Harbour		The aim is to ensure that Water Quality Objectives are maintained and that community's values for waterways are protected. No water quality offset framework exists.	
Tasmania			No
Environmental Management and Pollution Control Act	1994	The primary environment protection and pollution control legislation in Tasmania. Its focus is the prevention, reduction and remediation of environmental harm, particularly from pollution and waste.	
Emission limit guidelines for sewerage treatment plants that discharge pollutants into fresh and marine waters	2001	No offset mechanism	

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