UNIVERSITY of TASMANIA

IMAS

Institute for Marine and Antarctic Studies

Aquaculture Environment Review Series

General Introduction

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May 2025

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Introduction

As the global aquaculture industry continues to grow, knowledge of how this industry interacts with the environment is key to ensuring long-term economic and environmental sustainability.

All forms of aquaculture will interact with the environment along numerous pathways, with potential effects positive, negative or neutral. The form of aquaculture, prevailing environmental conditions, and ecosystem structure and function are important factors that determine response, vulnerability and resilience of the receiving environment.

In Tasmania, aquaculture is a vital industry for the economy, providing direct financial benefits, employment opportunities and indirect opportunities across the state. It is a growth industry, with sustainability key to long term prosperity for the state.

The Department of Natural Resources and Environment Tasmania (NRE Tas) has commissioned the University of Tasmania's Institute for Marine and Antarctic Studies (IMAS) to perform an independent review of literature relating to marine farming interactions with the environment.

The series is intended to support the planning and regulation of marine farming in Tasmania, as well as providing a reference source for people with an interest in Tasmanian aquaculture, including proponents of aquaculture developments, resource managers, and the general public.

It is intended to cover all forms of existing or proposed marine-based aquaculture within Tasmanian state waters, and will be regularly updated and revised to consider new scientific information.

Background

Worldwide aquaculture production now exceeds that of wild fisheries, with the trend set to continue as the aquaculture industry continues to grow (FAO 2020).

Aquaculture occurs in multiple forms across different trophic levels and taxonomic groups, including seaweeds, crustaceans, molluscs, echinoderms and finfish.

In 2018, marine animal aquaculture comprised 37% (30.8 million tonnes live-weight) of the global aquaculture production (FAO 2020). Molluscs were the dominant biomass produced at 56% of marine production, with crustaceans and finfish making up most of the remaining production. Global seaweed production was at 32.4 million tonnes in 2018, tripling since 2010, mainly out of Asia.

Although Australia is a minor contributor to global aquaculture production (FAO 2020), aquaculture contributes significantly to Australia's economy (Tuynman et al. 2023). The economic worth of aquaculture ($1.94b GVP) is more than the worth of its wild capture fisheries ($1.51b GVP) (Tuynman et al. 2023).

Salmonid, tuna, pearl and oyster production are the highest-value contributors, and are among over 40 species grown in Australia (Table 1). Projections are for aquaculture production to increase, reaching $2.21b GVP by 2028-29, due to production increases across a range of species, but primarily driven by the salmonid industry (Tuynman et al. 2024).

The Tasmanian seafood industry is highly valuable to the state economy, with the value of aquaculture, specifically salmonids, now exceeding that of wild fisheries (Rust & Ogier 2021, Tuynman et al. 2023). Other commercial aquaculture species grown in Tasmania include Pacific oysters, blue mussels, abalone and seahorses. Salmonids and oysters are considered the key aquaculture species, contributing more than $650m and $35m (gross value added) respectively to the Tasmanian economy (Rust & Ogier 2021). Salmonid production is forecast to increase in coming years (Tuynman et al. 2024). Abalone, blue mussels and seahorses are Tasmanian industries with only small-scale operations, while seaweed farming in Tasmania is in a research and development stage[1].

1 https://nre.tas.gov.au/aquaculture/aquaculture-species-in-tasmania

Table 1: Aquaculture species in Australia (listed) and Tasmania (in blue) (sourced from ABARES)

Classification	Aquaculture sector	Species farmed	
Feed-added	Finfish	» **Atlantic salmon** » **Rainbow/Ocean trout** » Tunas » Silver Perch » Barramundi » Yellowtail kingfish	» Eels » Aquarium species » **Seahorses** » Grouper » Mulloway
Extractive	Shellfish	» **Oysters (various species)** » **Abalone**	» **Blue mussels** » Pearl oysters
Mixed	Crustaceans	» Prawns	» Mud crab
Extractive	Seaweed	» **Various species**	
Mixed	Other taxa	» Marine sponges » Sea urchins	» Sea cucumber

Most aquaculture in Tasmania occurs within five nautical miles of the coastline (Figure 1). In terms of the major species, salmonid aquaculture takes place in estuarine and marine systems, with key growing regions being the D'Entrecasteaux Channel/Huon River, Storm Bay and Tasman Peninsula in the south-east and Macquarie Harbour on the west coast. Pacific oyster farming takes place in both subtidal and intertidal environments with key growing regions on the north, east and south coasts.

There are many pathways of interaction between aquaculture and the environment (Figure 2). The presence of artificial structures in the marine environment can modify local hydrodynamics and act as an attractant to wild fauna and flora (Callier et al. 2018).

The culture species can also modify existing physiochemical regimes, such as nutrient dynamics, ecosystem metabolism and carbon flow (Buschmann et al. 1996, Sara 2007, Bouwman et al. 2013, White et al. 2019). There is also potential for flow-on effects from aquaculture across habitats through factors such as nutrient exchange, transfer of disease, genetic flow from cultured to wild populations and invasive species (Grigorakis & Rigos 2011, Naylor et al. 2021). How these interactions manifest will depend on multiple factors including where aquaculture is sited, the density of farming and the biomass of production, along with the nature of the receiving environment.

The classification or form of aquaculture (feed additive vs extractive) will also influence environmental interactions. Feed additive or "fed" aquaculture refers to the practice of farming aquatic organisms by providing them with formulated feeds.

In contrast, extractive aquaculture refers to aquaculture that relies solely on natural food sources within the environment (Chopin et al. 2012). Production of feed-additive species generally carries higher environmental risk compared to extractive species, due to the addition of feed-associated nutrients into the system. If not managed appropriately these additional nutrients can overstimulate primary production, exceeding the carrying-capacity of an ecosystem (Sara 2007, Price et al. 2015). Nutrient enrichment from extractive species is typically mild and more localised in comparison, since nutrients already in the system are utilised. While the extraction of nutrients can deplete natural food sources available to native species, this may equally have a positive effect on nutrient cycling, including biomineralization in some systems (Nielsen et al. 2016, Weitzman et al. 2019). The ability of certain extractive species to assimilate particulate or dissolved nutrients creates potential for them to offset nutrient enrichment from feed-additive aquaculture within co-culture systems (Chopin et al. 2012, Gentry et al. 2020). Although different aquaculture sectors share broad ecological interactions, the nature of actual and potential effects varies among species, culture systems and environments in which they are grown.

Figure 1: Marine farming licenses for finfish (yellow), non-finfish (red) and land-based facilities (green) (sourced from NRE Tasmania)

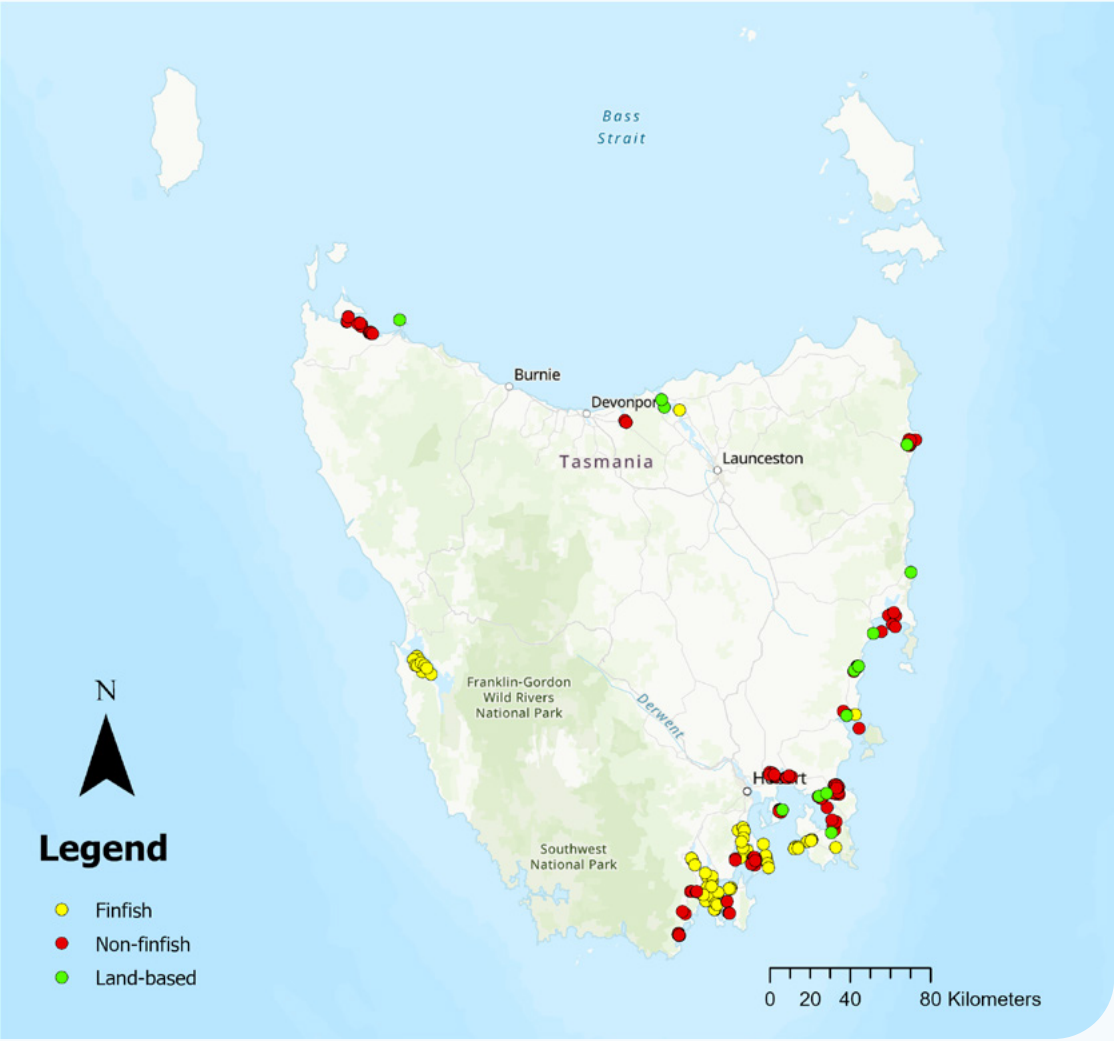
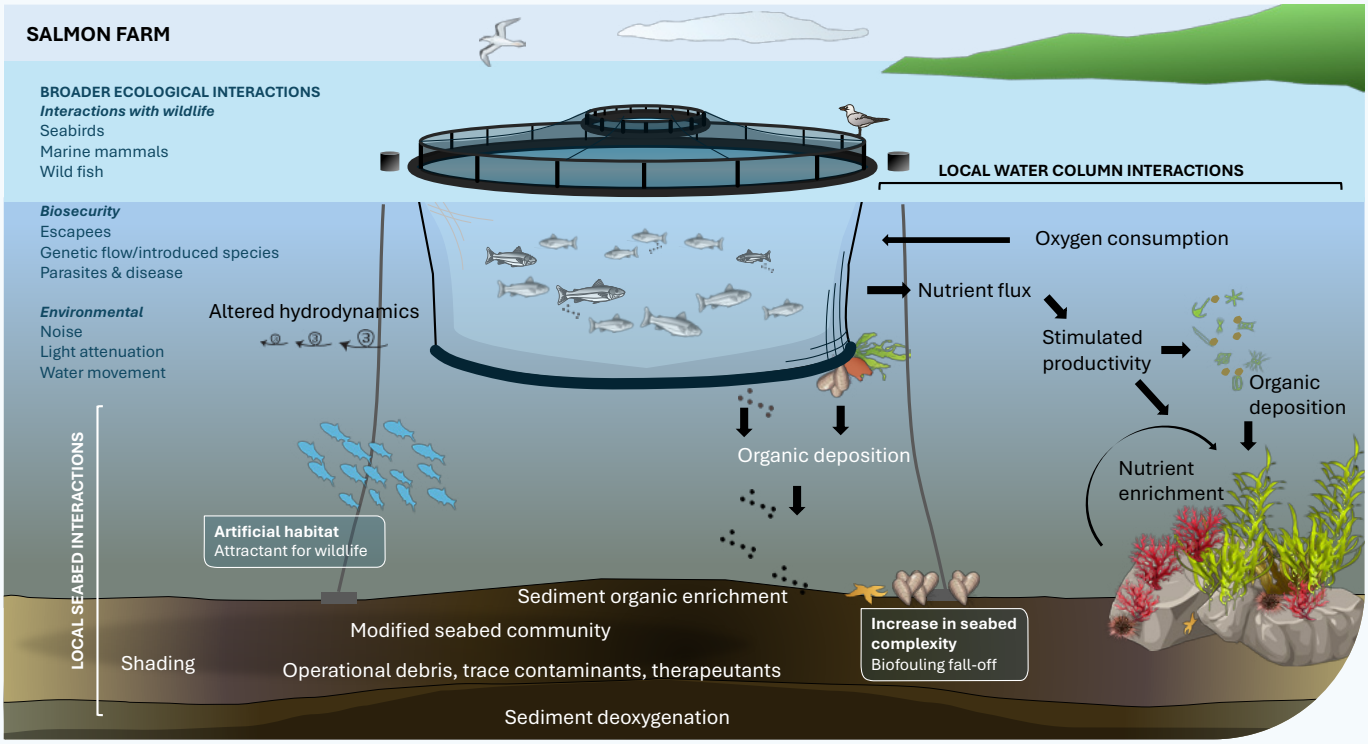


Figure 2: Broad overview of ecological interactions

Feed additive aquaculture — finfish



Extractive aquaculture — shellfish

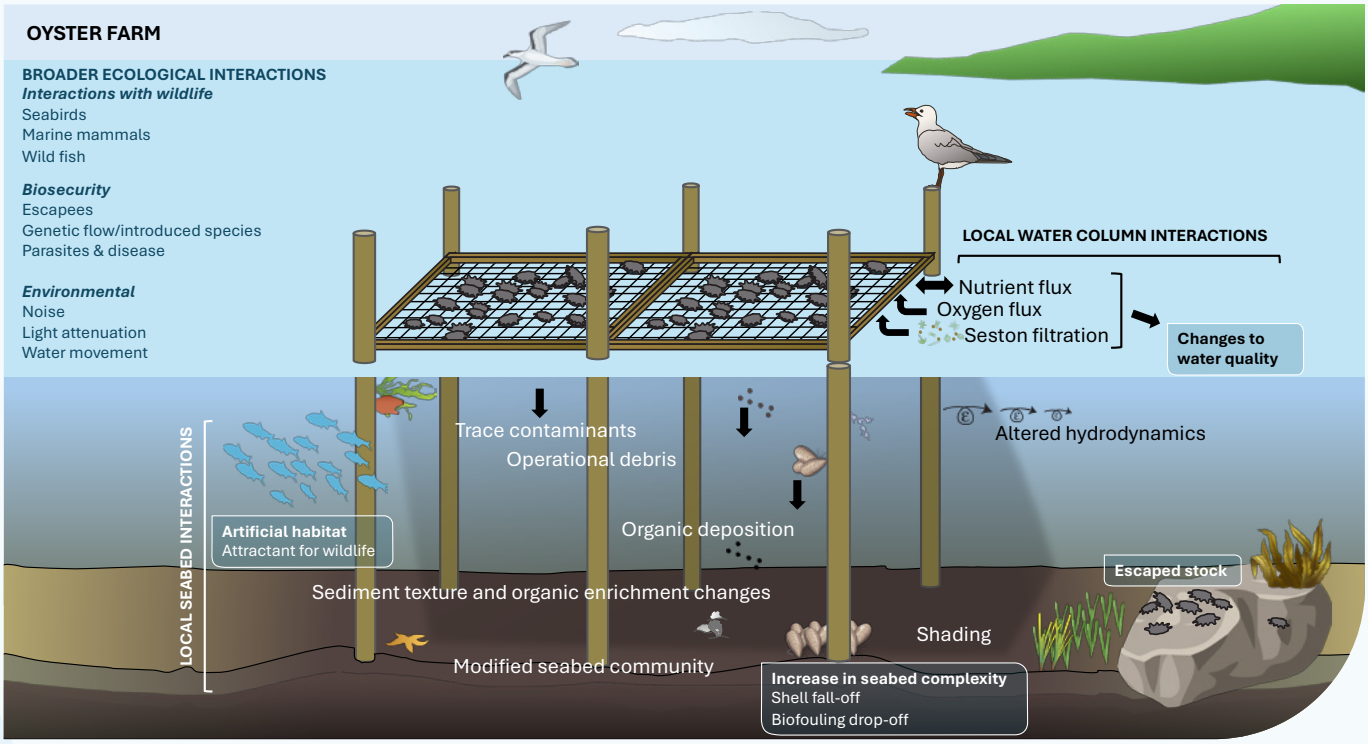
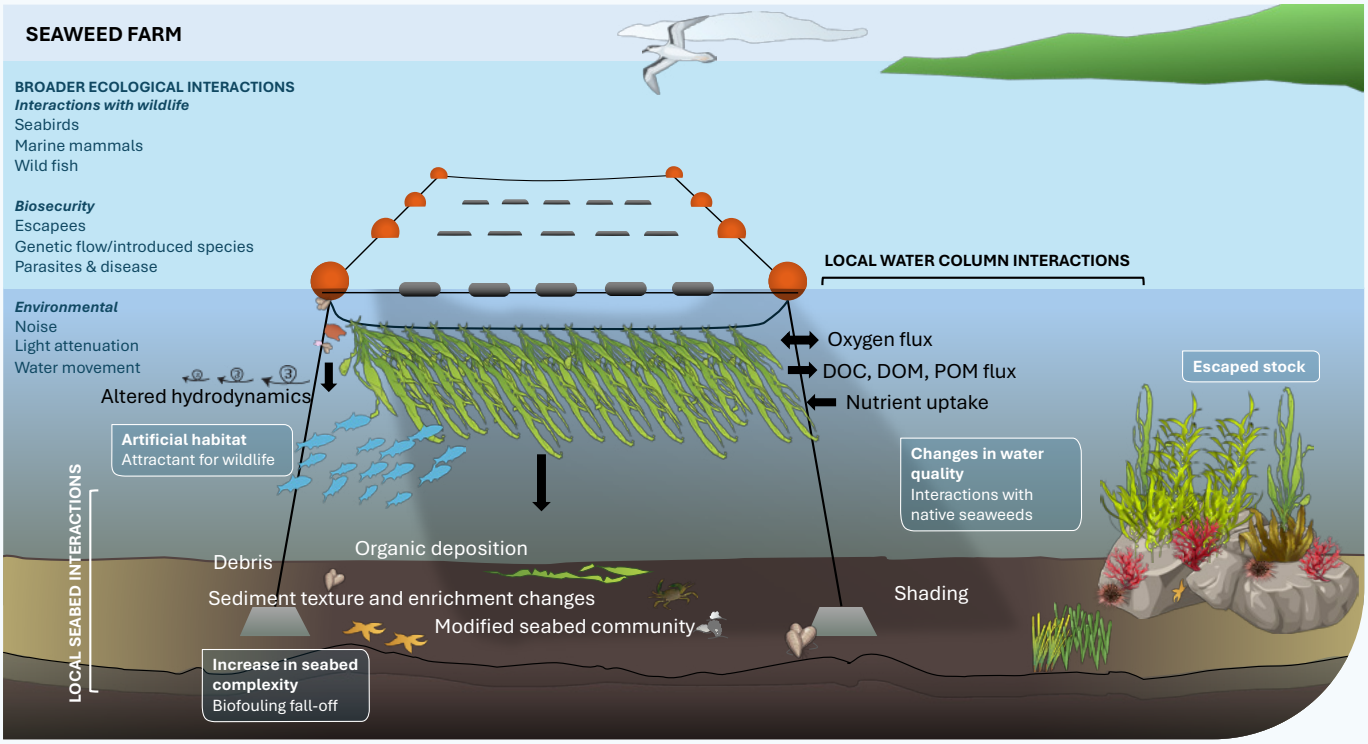


Figure 2: Broad overview of ecological interactions (continued)

Extractive aquaculture — seaweed



Tasmania has a complex coastline with oceanographic conditions that extend from estuarine to oceanic, and support ecosystems that are biologically significant on a global scale. Marine ecosystems include intertidal estuaries and sand-shore environments, along with submerged benthic habitats including seagrass, oyster reef, sponge beds, rocky reef with macroalgal beds, deep reef, and soft sediment expanse in shallow, continental and deeper waters (TPC 2009, Parsons 2011).

The East Australian Current brings warmer, nutrient-poor waters primarily to the eastern coastal regions, while the Zeehan Current flowing across Australia's south coast brings cooler and relatively more nutrient-rich waters to the western and southern regions of Tasmania.

The cold and nutrient-rich Antarctic Circumpolar Current also has an influence in the southern areas and it is the convergence of these currents that creates a hotspot for biodiversity (Ridgway 2007, Parsons 2011).

Tasmania's 2024 State of Environment report recognised habitats and species within Tasmania's waters that are under threat, including giant kelp forests and species of marine mammals, birds and fish (TPC 2024). In addition to aquaculture, other identified pressures on Tasmania's marine natural values included climate change, fishing, chemical, silt and nutrient run-off from urbanisation and other catchment activities, invasive marine species moving in, and modification of the coastal zone (TPC 2024). Accordingly, interactions from aquaculture must be understood and managed with other environmental stressors to minimise the potential for cumulative or synergistic effects.

Regulatory landscape

Legislation and administration

There are three overlapping legislative acts under which aquaculture in Tasmania is regulated. These are the *Marine Farming Planning Act 1995* (MFPA), *Living Marine Resources Management Act 1995* (LMRMA) and *Environmental Management and Pollution Control Act 1994* (EMPCA), summarised on page 12. Together, these acts form part of Tasmania's Resource Management Planning System (RMPS), established in 1994 to achieve sustainable outcomes for the use and development of Tasmania's natural and physical resources. Another key piece of legislation affecting aquaculture activities is the *Biosecurity Act 2019* (BA). The RMPS helps inform and guide decisions pertaining to site selection, monitoring and other aspects associated with establishing, operating and regulating marine farming. The objectives of the Tasmanian RMPS are embedded in its key Acts and can be used to underpin and develop mitigation and management measures for aquaculture proposals.

Responsibility for administration of the EMPCA lies with the Minister for Environment (or delegate[2]). The Minister for Primary Industries and Water (or delegate[3]) oversees the BA, while the Minister for Business, Industry and Resources has carriage of the MFPA and LMRMA.

Marine farm planning and regulation

The licensing process for aquaculture involves several steps, including planning, assessing environmental impact and environmental licensing (Appendix 1). In summary, a marine farming development plan (MFDP) is required for new aquaculture developments or any significant modifications to existing aquaculture operations.

An Environmental Impact Statement that considers and assesses the potential consequences of an aquaculture development is required when preparing a new MFDP, or where substantive changes to an existing MFDP are proposed (Appendix 1). A MFDP designates a region within which aquaculture can take place. Smaller zones exist within a MFDP region to delineate where aquaculture is allowed to take place, and what constraints apply there. The planning processes leading to creation of and changes to marine farming development plans are overseen by NRE Tas.

To operate a marine farm in one of those zones, aquaculture proponents need to be granted a marine farming lease, usually for a term of 30 years, and a marine farming licence which is renewed annually. Finfish aquaculture also requires an environmental licence which sets out monitoring and reporting requirements. The Environment Protection Agency (EPA) is the principal oversight agency for environmental licensing processes related to finfish aquaculture, including reviewing the monitoring outcomes and taking enforcement action if required.

2 Delegate is The Director of the Environment Protection Authority

3 Delegate is The Secretary of the Department of Natural Resources and Environment Tasmania

Overview of the legislation related to planning and regulation of aquaculture in Tasmania

Marine Farming Planning Act 1995

This Act governs planning for marine farming development, and is administered by the Minister (or delegate) for Business, Industry and Resources. The purpose of this Act is to achieve well-planned sustainable development of marine farming activities to:

- integrate marine farming activities with other uses
- limit adverse impacts
- set aside areas for activities other than for marine farming activities
- take account of land uses
- take account of the community's right to have an interest in those activities.

Living Marine Resources Management Act 1995

This Act governs marine farming through establishing instruments including permits, fisheries rules and licenses, and is administered by the Minister (or delegate) for Business, Industry and Resources. This Act also includes provisions relating to developing and enforcing various regulations.

Environmental Management and Pollution Control Act 1994

This Act is performance-based legislation with the fundamental intent to prevent, reduce and remediate environmental harm, including environmental nuisance. This Act includes provisions for environmental licences used to regulate finfish farming, and empowers the Environment Protection Authority (EPA) to assess and regulate the environmental impacts associated with finfish farming. This Act is administered by the Minister for Environment (or delegate).

Biosecurity Act 2019

This Act sets out the overarching legal concepts, principles, functions and legal machinery to support biosecurity management in Tasmania. This Act is administered by the Minister for Primary Industries and Water (or delegate).

Environmental standards

Aquaculture Standards are being developed by NRE Tas, in conjunction with EPA, to facilitate consistent regulation of aquaculture across Tasmania. They are developed under key legislation described earlier in this section, and build on existing regulatory and voluntary management of the aquaculture industry.

Three aquaculture standards have recently been developed for:

- **Marine farming operations**, which aims to standardise aquaculture management controls across all aquaculture sectors, state-wide
- **Biosecurity (finfish aquaculture)**, which relates to biosecurity risk management of the finfish aquaculture sector
- **Environmental Standards for Tasmanian Marine Finfish Farming**, which aim to improve consistency around environmental regulation of finfish aquaculture (DNRET 2023a, 2023b). This sets out environmental management conditions and requirements for finfish aquaculture license and lease holders. It outlines broad environmental practices and minimum information requirements needed to effectively regulate and assess certain environmental interactions. The Environmental Standards are to be supported by **Technical Standards**, which will set out specific methodologies and practices including, but not limited to, measuring environmental interactions. Technical Standards will also include environmental threshold or trigger values to inform the management of these interactions.

Further information about Aquaculture Standards is available on the NRE Tas website (Appendix 1).

Purpose of the review series

The purpose of this review series is to provide a scientifically rigorous source of information on the interactions of aquaculture with the marine environment, with context as to how these interactions are managed and measured.

The series intends to support aquaculture planning and regulation in Tasmania, as well as provide a reference source for people with an interest in Tasmanian aquaculture.

Resource managers may use the information to inform and underpin aquaculture planning processes, while proponents of aquaculture developments may find it a useful reference source to draw from when preparing public planning documents, such as environmental impact statements.

Scope of the review series

Finfish, shellfish and seaweed are dominant groups cultured in Tasmania. As the salmonid industry is the largest in Tasmania, the first reviews completed have focused on finfish environmental interactions, with the anticipation that reviews on interactions from shellfish and seaweed aquaculture will be released in the future.

The first release of literature reviews include the series introduction and cover the following ecological themes:

1. Ecological effects of finfish aquaculture on soft sediments
2. Ecological effects of finfish aquaculture on the water column
3. Ecological effects of finfish aquaculture on rocky reefs

The key focus of each review is on the present understanding of environmental interactions, both known and potential, within the above ecological themes. The management and monitoring of these interactions are also reviewed and succinctly presented. Each report in the series follows the structure below:

- **Introduction** – background information on the ecological theme as it is relevant to aquaculture and Tasmania
- **Known and potential environmental effects** – a description of the major environmental interaction pathways within the ecological theme, reflecting the most up to date understanding, including that specific to the Tasmanian context
- **Management** – a summary of the key actions through which interactions are managed, including avoidance, minimisation or mitigation, with a particular focus on Tasmania
- **Monitoring** – an overview of the key approaches and techniques used to measure ecological interactions, both globally and in Tasmania.

Key literature informing the technical reviews is drawn from peer-reviewed research articles, as well as reports related to commercial and government sectors, either published directly or commissioned to consultancy organisations. The origin of the generalised literature used is global, but the review emphasises literature drawn from Tasmania. New Zealand literature also has a strong representation in some reviews, due to the comparable temperate marine area and the similarities in aquaculture activities and their management.

Overall, the sustainability of the aquaculture industry depends on the capacity of marine ecosystems to recover, which is a key goal of management and regulatory frameworks. If managed appropriately, any unwanted interactions following the removal of the aquaculture activity can be expected to reverse over time.

Managing a growing industry while maintaining or reducing the environmental footprint represents a challenge, with the aquaculture industry expected to be a dominant source of seafood and marine products into the future. This review series is intended to be an important tool in managing environmental interactions with aquaculture, and a valuable resource for sectors into the future.

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Appendix 1

Quick resources for key processes and information relating to aquaculture planning and management, Tasmania

Topic	Resource
Overview	An overview of key processes and information relating to planning and management of aquaculture in Tasmania can be found on the Aquaculture pages of the NRE Tasmania website: https://nre.tas.gov.au/aquaculture
Aquaculture Standards	An overview of Aquaculture Standards as set out by NRE Tas: https://nre.tas.gov.au/aquaculture/industry-strategy-and-innovation/aquaculture-standards
Licensing	A central information source about the regulatory framework for finfish aquaculture NRE Tas: https://nre.tas.gov.au/Documents/Tasmanian%20Regulatory%20Framework%20for%20Finfish%20Aquaculture.pdf
Environmental Impact Statement	Guidance for the preparation of an EIS for consideration by the EPA Board – environmental licence: https://epa.tas.gov.au/Documents/Guidelines%20for%20Preparing%20an%20Environmental%20Impact%20Statement.pdf
	Guidance for the preparation of an EIS to accompany an application for a marine farming development plan (or a draft amendment to a marine farming development plan): https://nre.tas.gov.au/aquaculture/aquaculture-regulation-and-planning/marine-farming-development-plans (scroll to EIS)
Environmental Standards	A detailed explanation on the background and process for developing and implementing Environmental Standards: https://nre.tas.gov.au/aquaculture/industry-strategy-and-innovation/aquaculture-standards/environmental-standards

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