2 February 2024

Hon Tanya Pilbersek MP
Minister for the Environment and Water
House of Representatives
Parliament House
Canberra ACT

Dear Minister

Submission on Requests for Reconsideration of Referral Decision: Marine Farming Expansion, Macquarie Harbour, Tasmania (EPBC 2012/6406)

We refer to the public notice, and correspondence received from the Department of Climate Change, Energy, the Environment and Water (**DCCEEW**), inviting submissions on three requests for the reconsideration of the decision made under section 75 of the Environment Protection and Biodiversity Conservation Act 1999 (the **EPBC Act**) in relation to EPBC referral 2012/6406.

We acknowledge the substantive submission provided by Salmon Tasmania on behalf of the major operators in Macquarie Harbour (**Salmon Tasmania Submission**), including Huon Aquaculture Company (**Huon**). Huon confirms that it relies on the Salmon Tasmania Submission and asserts:

a. The existing NCA-PM conditions for EPBC Referral 2012/6406 are appropriate.

b. You should **not** be satisfied that it is warranted to revoke the NCA-PM Decision and to substitute a new decision that the Marine Farming Expansion is a controlled action.

c. None of the asserted grounds relied upon by the Requestors are in fact made out by the information provided in, or referenced by, the requests. Instead, this information fails to meet the required thresholds of establishing that either:

Huon Aquaculture Company Pty Ltd
ABN 86 067 386 109 | Level 13, 188 Collins St, Hobart, TAS 7000 | T 03 6295 8111 www.huonaqua.com.au

- there is substantial new information available about the impacts salmon farming is having (or will have or is likely to have) on the Maugean Skate; or
- there has been a substantial change in circumstances that was not foreseen at the time of the NCA-PM decision and it relates to the impacts that salmon farming is having (or will have or is likely to have) on the Maugean Skate.

Huon further submits that the salmon industry's operations in Macquarie Harbour are critical to the social and economic fabric of Tasmania's west coast, and in particular the community of Strahan.

Huon's Operations in Macquarie Harbour and Strahan

Huon's farms have operated in Macquarie Harbour since 1987. Huon currently has two land-based facilities and three marine leases in the Harbour. Of these leases, only two are currently being utilised - Middle Harbour Gordon and Middle Harbour Strahan.

Huon is proud of its strong record of compliance in Macquarie Harbour (refer to section titled **Compliance History**). Importantly, Huon employs 30FTEs directly related to its operations in the Harbour. A further 50FTEs, in nurseries, hatcheries and processing, are connected to the company's activity in the Harbour.

Compliance History

Huon has a strong compliance history in Macquarie Harbour. As provided with the Salmon Tasmania Submission, the summarised benthic compliance history for Macquarie Harbour demonstrates Huon's 100% compliance at pen bay and compliance sites with respect to its leases at Pelias and Double Bay, and 98% compliance for the Butt of Liberty – noting that the two recorded instances of non-compliance date back to 2016 and 2017.

For recent context, over the past five years Huon has undertaken a total of 546 surveys at compliance sites and pen bay sites across the three leases. Huon has remained 100% compliant at these sites with no significant visual, physico-chemical, or biological impacts noted at these surveys.

These results highlight Huon's strict adherence to the stringent regulatory and environmental conditions related to salmon farming in Macquarie Harbour.

Regulatory Confidence

The current Total Permissible Dissolved Nitrogen Output (**TPDNO**) determinations issued by the EPA Tasmania (which remain in place until 2027) effectively reduce production levels in Macquarie Harbour to the pre-2012 expansion levels. In line with these regulatory requirements, Huon has reduced its production volumes in the harbour by 59% since 2015.

Huon is confident that the TPDNO determinations and additional investment by the operators to address Dissolved Oxygen (DO) levels, through the Macquarie Harbour Oxygenation Project, in partnership with FRDC, will enable salmon farming to continue in the Harbour without adverse impact on the matters protected under the EPBC Act.

This confidence is strengthened by the additional requirements imposed by the Tasmanian EPA within each operator's Environmental Licences. These new conditions require the licence holders to determine and mitigate the impacts of marine finfish farming activities on dissolved oxygen levels at and beyond the boundary of the marine farm leases.

Community Impact

As a final point, Huon notes that the principles of ecologically sustainable development, which underpin the objectives of the EPBC Act, require the balancing of economic advancement and environmental preservation in order to achieve sustainable outcomes.

The EPBC Act requires that any decision-making process under the Act effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.

The role of the salmon aquaculture industry in promoting the economic prosperity of the West Coast (and of Tasmania as a whole) cannot be understated and should be factored into any consideration of environmental matters.

An independent report on the Tasmanian Salmon Industry conducted by Deloitte Access Economics in 2023, found 17% of employment on Tasmania's West Coast is supported by the salmon industry. Further, jobs in the industry pay up to 73.9% more than the average job in this region, which reflects the relatively higher skills and productivity of workers in the industry.

It should be noted, Huon holds grave concerns for the local community, our employees and their families, should a decision be made that in any way reduces or adversely alters salmon farming in Macquarie Harbour.

Huon is a significant contributor to the social and economic vibrancy of the West Coast:

- Of the 30FTEs directly engaged in Huon's Macquarie Harbour operations, 27 employees live in the West Coast LGA and have an average annual salary of $91,259 (including superannuation).
- In the 2022/23 financial year Huon purchased about $300,000 worth of goods and services from suppliers and businesses in the West Coast LGA.
- In the same period, Huon spent more than $20 million on its marine operations in Macquarie Harbour (including wages).
- In total, Huon has invested $60 million of capital expenditure in its operations in Macquarie Harbour during the past 16 years.

In addition, since salmon farming began on the West Coast, Huon has supported countless community groups and initiatives in the region; including breakfast clubs in local schools, funding for community events, product donations to local recreational

groups and financial support for the start-up of a local newspaper, as well as regular shoreline clean up activity.

A report by 3P Advisory (**Appendix 1**) found the salmon industry is recognised by the West Coast community as a "stable, consistent employer, embedded and deeply committed to the local people".

It found:

- Huon contributes to a more diversified economic base for the West Coast, helping mitigate the risks of the cyclic nature of the mining industry or the seasonal nature of the tourism industry.
- Uncertainty and the possible reduction or withdrawal of a major industry, such as salmon, would have an ongoing impact on the local population at a range of levels, including impacts on an aging population and the ability to attract and retain young people, and, more broadly, housing, employment, health, education and other industries and businesses.

Conclusion

In summary, it is Huon's position that none of the Reconsideration Requests establish the necessary statutory grounds required under section 78A(1) of the EPBC Act. Further, the information in the requests is insufficient to satisfy that the revocation and substitution of the NCA-PM Decision is warranted pursuant to s78(1) of the EPBC Act.

Yours sincerely,

Henrique Batista

s. 47F(1)

Huon Aquaculture
CEO

3P ADVISORY
PEOPLE · PLACE · PURPOSE

APPENDIX 1

Western Tasmania and Strahan

The positive social impact of the salmon industry at a local level with local people, starts with understanding the unique and diverse local community of Strahan. The people of the West Coast broadly, including Strahan, have had decades of employment and industry uncertainty due to the volatile nature of the mining industry. Despite this, or maybe because of this, the community have high levels of social cohesion and a strong sense of belonging and identity. This is enhanced by the contribution of Huon through a range of community benefit initiatives that contribute to social cohesion and equity.

The human face of Strahan and the surrounding areas is one of families, deeply connected to the place they live, the people around them, and the industry that employs them.

The long-term impact of the uncertainty relating to the mining industry and the cyclic nature of this industry has been a contributing factor to the challenges the region faces in population decline and overall future sustainability. At an individual and community level, this uncertainty erodes confidence and impacts socially and in areas of health and wellbeing.

The longer uncertainty prevails, the more challenging it becomes to meet local needs such as attracting teaching staff to the local school or a GP to the local medical practice.

The salmon industry is therefore known by local people and those considering moving to the West Coast as the stable, consistent employer, embedded and deeply committed to the local people. This commitment is evident by Huon's critical role in contributing to a range of social and liveability factors to ensure our existing and potential/future workforce can enjoy a good life in their local area. And, these liveability factors help to attract the next generation of teachers, doctors, migrants, artists and entrepreneurs to ensure a strong, vibrant sustainable community.

In addition to the challenges the West Coast faces in short and long-term industry uncertainty with mining and now aquaculture, the dual challenge of both an aging population and a declining population is significant. While Tasmania's population overall has increased by nearly 18% since the mid-1990s, the West Coast region has decreased by 4.5%. At the same time, the median age of the population in this region has increased by over 10 years.[1]

Together, these trends present a considerable risk to the region's long-term sustainability.

Beyond the economic profile, understanding the social & cultural relationships in conjunction with the interdependencies of the close geographical relationships across the West Coast is critical. By understanding these relationships, we can also understand how inter-connected the local people are, socially, culturally and economically. Therefore, any major changes through decision-making that impacts Strahan, has a ripple effect across the people of the West Coast.

This flows into better liveability for local people who benefit from and feel connected to the industry. Although a large and geographically dispersed area with significant distances between population centres, Western Tasmania has strong geographic, economic and social connections.

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[1] Population and dwellings | State Growth Tasmania | Community profile (id.com.au)

While new and long-term industries clustered around the World Heritage Areas and the Tarkine are emerging, including tourism and mountain biking, employment is still reliant and primarily driven by resources and primary industries including mining, forestry, agriculture and the long-term role of the aquaculture industry at a local level.

Local industry and specifically, the salmon industry, brings tangible benefits to the community and the community know and respect the industry for this. Huon contributes to a more diversified economic base, and this mitigates the risks of the cyclic nature of the mining industry or the seasonal nature of the tourism industry. It also positively impacts the confidence of local people that their jobs, their school, their essential services are safe. This confidence is critical not just financially but also for local community members health and well-being.

Uncertainty and the impact of reduction or withdrawal of a major industry that is deeply embedded into the community has an ongoing impact on the local population on a range of levels, beyond just local job losses and health and well-being.

There are impacts on an aging population and impacts on attracting and retaining young people. More broadly, the flow on impact hits areas including:

- Housing
- Employment/Workforces
- Health
- Education
- Other industries and business

<u>About 3P Advisory</u>

3P Advisory undertakes social research through qualitative and quantitative data across Tasmania. Over the last 3 years 3P has undertaken a monthly Tasmanian community sentiment survey testing the sentiment of Tasmanians on a number of social and economic issues. In addition, 3P have undertaken community consultations in communities across Tasmania, including on the West Coast as part of a range of consultancies. 3P Director Kym Goodes also participated in West Coast community consultations in 2023 as part of her role on the Local Government Review Board.

3P Advisory also undertakes community benefit analysis and social impact assessments for a range of industries including renewable energy, primary industries and tourism.

2 February 2024

Hon Tanya Plibersek MP
Minister for the Environment and Water
House of Representatives
Parliament House
Canberra ACT

By email: tanya.plibersek.mp@aph.gov.au
Also lodged via the portal

Submission on Requests for Reconsideration of Referral Decision (EPBC 2012/6406)

Dear Hon Plibersek MP,

This is a representation made pursuant to s. 78B of the *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**).[1]

The Department of Climate Change, Energy, the Environment and Water (**DCCEEW**), invited submissions on three requests purportedly made pursuant to s. 78A of the EPBC Act (**Reconsideration Requests**) on behalf of (hereafter referred to as the **Requestors**):

(a) the Tasmanian branch of The Australia Institute (**The Australia Institute**) dated 8 June 2023 and 31 July 2023;

(b) Fitzgerald and Browne Lawyers on behalf of the Bob Brown Foundation Inc (**BBF**) dated 25 July 2023; and

(c) the Environmental Defenders Office Australia on behalf of the Australian Marine Conservation Society and Humane Society International Australia (**EDO Australia**) dated 23 August 2023 and 20 November 2023.

The Reconsideration Requests seek the review of the Minister's decision in relation to EPBC referral no. 2012/6406, dated 3 October 2012, that the action was "*not a controlled action if undertaken in a particular manner*" (**MH Particular Manner**). The Requestors have sought revocation and substitution of that decision with a new decision that the action is a controlled action.

Petuna Aquaculture Pty Ltd (**Petuna**) holds leases and licences to farm finfish within Macquarie Harbour (**MH**) pursuant to the *Marine Farming Planning Act 1995* (Tas), the *Living Marine Resources Management Act 1995* (Tas) and the *Environmental Management and Pollution Control Act 1994* (Tas). In addition, Petuna is "*a person named in the referral*" in the MH Particular Manner decision and carries out its operations in accordance with that decision.

Petuna supports, and relies on, the Submission of Salmon Tasmania, prepared on behalf of the MH operators (**Salmon Tasmania Submission**). Petuna's submission does not seek to duplicate the detailed analysis in the Salmon Tasmania Submission, but instead elaborates on Petuna's unique perspective and experience in MH.

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[1] Petuna reserves its right to challenge the application of this provision and the lawfulness of the public comment period.

2 EXECUTIVE SUMMARY

2.1 Summary

The following points are made in response to the Reconsideration Requests:

(a) The Tasmanian aquaculture industry currently creates 5,103 full-time equivalent (**FTE**) jobs,[2] has a gross production value of $888 million[3], and is the largest fishery by economic value and volume in Australia.

(b) A cessation of aquaculture in MH would be catastrophic for Petuna, with 50 per cent of its marine operations based in MH. This places the Petuna business at significant risk to a full closure, which would result in 184 job losses across Tasmania. It would also result in potential job losses for the salmon industry of upwards of 400 people from the local West Coast community, with 1 in 3 residents of Strahan being employed in the industry.[4]

(c) The success of the operations in MH is inextricably linked to the environmental conditions. Salmon and trout require good conditions for fish health and performance. Low dissolved oxygen levels impact the production levels of the salmon. Low levels of dissolved oxygen could result in mass mortality incidents; therefore, it makes sense for the salmon industry to ensure that oxygen is well managed in MH.

(d) Petuna has reduced its stocking levels by 57 per cent since 2015 levels, advocated for the move from a biomass cap to a Total Permissible Dissolved Nitrogen Output (**TPDNO**) determination in MH, and is working with Huon Aquaculture Pty Ltd (**Huon**), and Tassal Operations Pty Ltd (**Tassal**) on the Macquarie Harbour Oxygenation Project (**MHOP**) research initiative, which aims to improve the dissolved oxygen levels in MH. This is a great example of aligned and strong cross industry collaboration, with Tassal allowing the use of their assets and Petuna operating those assets in MH.

(e) Since operations have commenced, the operators have monitored and managed the environmental conditions in MH. The operators have worked collaboratively with the Tasmanian government, Institute of Marine and Antarctic Studies (**IMAS**) and Commonwealth Scientific and Industrial Research Organisation (**CSIRO**), local west coast communities and the Tasmanian Environment Protection Authority (**EPA**), to ensure operations are conducted responsibly.

(f) Noting the duality of the Commonwealth and State regulatory regime, the Reconsideration Requests have failed to appreciate that aquaculture in MH is strictly regulated by the Tasmanian EPA by way of an 'adaptive management framework'. The MH Particular Manner decision is explicitly referrable to the Tasmanian Government's regulatory regime acknowledging that the Tasmanian regulator has the experience and expertise in that respect.

It is of note that this can be contrasted with the vast majority of projects subject to the EPBC Act. Projects are normally subject to 'stagnant' regulation by both the Commonwealth and State regulatory bodies. Approvals are issued subject to conditions and the operation proceeds on that basis. MH is unique.

Only two months ago, the Tasmanian EPA revised the conditions of the operators' Environmental Licences (**EL**) in MH pursuant to the *Environmental Management and Pollution Control Act 1994* (Tas) (**EMPCA**). The amendments specifically sought to address concerns with dissolved oxygen levels in MH. This form of regulation ensures that operations in MH are responsive to environmental conditions.

(g) The MH Particular Manner decision has been rigorously considered in Federal Court proceedings *Huon Aquaculture Group Limited v Minister for the Environment* (2018) 160 ALD 292 (***Huon v Minister***). Putting to one side the nuance of the Federal Court's decision, the Commonwealth Government expended considerable resources advocating the lawfulness and appropriateness of the MH Particular Manner decision.

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[2] Deloitte Access Economics (2022), *Socio-economic contribution of the Tasmanian salmon industry*

[3] Tasmanian Agri-food Scorecard, (2020-21): https://nre.tas.gov.au/Documents/Tasmanian%20Agri-Food%20SCORECARD%202020-21.PDF

[4] Deloitte Access Economics (2022), *Socio-economic contribution of the Tasmanian salmon industry*

Petuna submits that the MH Particular Manner decision remains lawful and appropriate.

(h) If the Minister determines to revoke the MH Particular Manner decision pursuant to s. 78C of the EPBC Act, the operations will have to cease immediately. The practical implications of this are incomprehensible. Not only will it result in immediate job loses, but mass euthanasia of current salmon stock in MH giving rise to environmental, biosecurity and animal welfare concerns.

2.2 Legal test – Minister's power to reconsider decision

(a) The Minister's authority to reconsider the MH Particular Manner decision is confined to the statutory requirements of the EPBC Act and *Environment Protection and Biodiversity Conservation Regulation 2000* (**EPBC Regulations**). The EPBC Act creates a complex web of interrelated provisions that establish the 'four walls' of the Minister's decision making.

Reconsideration Requests are not valid

(i) The Reconsideration Requests do not meet the statutory requirements and therefore are not valid.

(ii) In respect of s.78(1)(a) & (aa), the Requestors fail to demonstrate that a "*change in the potential **impacts of the action** is likely to happen **with a high degree of certainty***" as required by regulation 4AA.01(3)(b) and (4)(c) of the EPBC Regulations.

(iii) In respect of s.78(1)(b), the BBF Reconsideration Request does not contain information that establishes that the action is not being taken, or will not be taken, in the manner identified in the MH Particular Manner decision as required by regulation 4AA.01(5) of the EPBC Regulations.

(iv) In the absence of a valid Reconsideration Request, the statutory reconsideration process is not triggered, resulting in:

(A) Section 78B - the public comment period having no statutory imprimatur; and

(B) Section 78C - the Minister is not required to reconsider the MH Particular Manner decision.

(v) In respect of the legal authority of the Minister to reconsider the decision pursuant to s.78 of the EPBC Act, Petuna submits the following:

(A) A valid Reconsideration Request is a prerequisite for s.78 of the EPBC Act to be enlivened; or

(B) In the alternative, if the Minister forms the view that the power to reconsider the request pursuant to s.78 can be enlivened in the absence of a valid Reconsideration Request or that the Requests are valid (erroneously in our view), then in any event, the legal tests under s.78 are not met.

Legal tests under s.78 are not met

(i) Petuna submits that the legal tests under s.78 are not met for the following reasons:

(A) In respect of the Requestors' reliance on s.78(1)(a) & (aa) of the EPBC Act, being 'substantial new information' and 'substantial change in circumstances', the legal test is not satisfied. The legal test requires that the 'substantial new information' and unforeseen 'substantial change in circumstances' relate to **impacts** that **the action** will have or is likely to have on a Maugean skate.

The Minister cannot be satisfied with the information before her that the **impacts** relied on by the Requestors in the Reconsideration Requests are 'impacts' that fall within the scope of the EPBC Act: see 527E(1)(a) and *Environment Council of Central Queensland Inc v Minister for the Environment and Water (No 2)* [2023] FCA 1208[5] (***Environment Council of Central Queensland Inc v Minister***). They are not a direct consequence of the **action**: *Environment Council of Central Queensland Inc v Minister.*[6]

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[5] At [18].

[6] *(No 2)* [2023] FCA 1208 at [73].

The state of expert opinion falls short of the statutory requirements for the Minister to reconsider the MH Particular Manner decision.

The findings of a technical memorandum prepared by Dr Ian Wallis in 2024 (***Wallis 2024***) further refute the assertions of the Requestors and conclude that salmon farms reduce the dissolved oxygen in the top layer by 4 per cent or 0.3 mg/L. Dr Wallis further notes *"This minor decrease would have negligible effect on the survival of the skates in their normal habitat in the top layer near Table Head."*[7]

The IMAS *'Macquarie Harbour Maugean skate population status and monitoring'* on 2 May 2023 (***Interim Report 2023***)[8] is the primary source of new information relied on by the Reconsideration Requests for the purposes of section 78(1)(a) and (aa) of the EPBC Act.[9]

The possible contributory causes of the Maugean skate population decline, is not new information or a change in circumstances. There are a number of possible causes of the decline in the Maugean skate population – all of which have been known since the MH Particular Manner decision.

At its highest, the *Interim Report 2023*[10] is new information about the Maugean skate (*Zearaja maugeana*) (**Maugean skate**) population, not about the impacts of the action on that MNES protected by Part 3 of the EPBC Act. This is a crucial distinction. A distinction that precludes the Minister from reconsidering the MH Particular Manner decision.

(B) The Reconsideration Requests[11] also assert that the new information demonstrates the action **will have or is likely to have** an impact on the Tasmania Wilderness World Heritage Area (**TWWHA**). Noting the scope of the Part 3 controlling provisions relate to the "values" of the TWWHA, the Reconsideration Requests seem to encourage an inference that the dissolved oxygen levels in MH are likely to have an 'impact' on those values. How the 'values' are alleged to be impacted is not articulated in the Reconsideration Requests. This assertion cannot be sustained.

(C) In respect of BBF's reliance on s.78(1)(b)(ii) of the EPBC Act, an alleged failure to conduct the action in accordance with the MH Particular manner decision, Petuna contends:

(1) BBF makes the unfounded assertion, almost in passing, in its Reconsideration Request that the action is not being, or will not be, taken in the manner identified in the MH Particular Manner decision. It is not substantiated with any documentation or particulars that would establish such an allegation; and

(2) Petuna agrees with the position in the Salmon Tasmania submissions that, if the Minister has concerns, as a matter of procedural fairness, it would be appropriate in the first instance for those matters to be put in writing to the operators directly by the Department, for the operators' consideration and response.

2.3 Recommendations

In respect of the Reconsideration Requests, the following recommendations are made by Petuna:

(a) The Minister should determine that the Reconsideration Requests are not valid, and no further

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[7] Wallis, I (2024) *Technical Memo on Dissolved Oxygen in Macquarie Harbour*, Appendix A, p. 23.

[8] IMAS 'Macquarie Harbour Maugean skate population status and monitoring' on 2 May 2023 at p. 1, available: https://imas.utas.edu.au/__data/assets/pdf_file/0007/1655611/Maugean-skate-2021-interim-report-FINAL.pdf/_nocache.

[9] We rely on the Salmon Tasmania submission for a detailed analysis of the other 'information' relied on by the Requestors.

[10] Moreno, D and Semmens, J (2023) Interim Report – Macquarie Harbour Maugean skate population status and monitoring: https://imas.utas.edu.au/__data/assets/pdf_file/0007/1655611/Maugean-skate-2021-interim-report-FINAL.pdf/_nocache (accessed 24.01.24).

[11] EDO Australia 23 August 2023 and Australia Institute dated 31 July 2023.

action is required.

(b) Alternatively, if the Minister forms the view that the Reconsideration Requests are valid, the Minister should confirm the MH Particular Manner decision in accordance with s.78C(1)(b)(i) of the EPBC Act. The legal tests espoused in s. 78(1)(a), (aa) and (b) of the EPBC Act are not met.

(c) If the Minister disagrees (erroneously we say), and determines the statutory requirement(s) are met pursuant to s. 78(1) EPBC Act then:

(i) The decision should be replaced with a new Particular Manner decision.

The operators and the Tasmanian EPA should be consulted about the form of the Particular Manner before the decision is made and the notice is issued pursuant to s. 77A.

(ii) There is no basis for the Minister to be satisfied that the action should be a controlled action pursuant to s.75 of the EPBC Act.

3 Importance of Macquarie Harbour to Petuna

MH is located south of the town of Strahan on the west coast of the State of Tasmania. Aquaculture started in MH in the late 1980s with production steadily increasing over the years, and in May 2012 the proposed expansion of lease areas was approved by the Tasmanian Government. The proposed expansion was referred to the Federal Minister for Environment which resulted in the MH Particular Manner decision.

Petuna is a Tasmanian success story, established by Peter and Una Rockliff from the state's north west in 1949. Originally a fishing company, Petuna diversified into aquaculture in 1990. In 2020, Peter and Una sold their 50 per cent shareholding to their existing business partner, New Zealand company Sealord.

Sealord's Māori ownership – with a focus on preservation of the sea – made it a natural partner for Petuna, allowing the company to grow while staying true to its heritage. Today, Petuna remains true to its core values, recognising aquaculture should complement and co-exist with wild catch activities, both respecting the longevity of the natural environment in which they operate.

Given our farming locations and scale of operations, Petuna has the most to lose from any change to aquaculture in MH. A further reduction in biomass beyond what has already occurred would be catastrophic for the company as its marine farms in MH make up 50 per cent of its entire operation. Petuna would also note that while it has a greater percentage of its total business at risk in MH, Tassal and Huon would also suffer job losses and undoubtedly also be required to make changes in their total operations across their businesses.

The immediate cessation of aquaculture in MH would instantly eradicate the need for 47 direct local jobs Petuna provides in Strahan. The local community of Strahan and surrounding areas would be irrevocably impacted. The importance of the industry to the West Coast of Tasmania cannot be understated. The cessation would also eliminate the need for jobs across all Petuna's operations, including in its hatchery at Cressy, processing facility in Devonport and head offices.

There is also a significant risk that Petuna would be forced to cease to operate all together, resulting in a devastating loss of 184 Tasmanian jobs that Petuna directly employs, spanning the west, north-west and north of the state – largely regional jobs. Additionally, there would be impact on employment in the supply chain that supports Petuna operations, which is far reaching across the state.

4 Importance of Petuna to Macquarie Harbour

The Tasmanian aquaculture industry currently creates 5,103 FTE jobs,[12] has a gross production value of $888 million[13], and is the largest fishery by economic value and volume in Australia.

The MH activities of the operators sustain 395 FTE direct and indirect roles, with 1 in 3 residents of the

[12] Deloitte Access Economics (2022), *Socio-economic contribution of the Tasmanian salmon industry*

[13] Tasmanian Agri-food Scorecard, (2020-21): https://nre.tas.gov.au/Documents/Tasmanian%20Agri-Food%20SCORECARD%202020-21.PDF.

town of Strahan being employed in the industry.[14] For the wider West Coast region of Tasmania, the salmon industry supports 17 per cent of employment in the region.[15]

In 1991, Petuna was the first aquaculture company to farm in MH. Over the past three decades it has consistently responded and adapted to the changing environment of MH, recognising a thriving, balanced and regenerative ecosystem is key to the quality of its fish and the longevity of its business.

Petuna is heavily invested and embedded in the west coast community, contributing a significant amount of financial and in-kind support to a broad range of organisations, events and programs in the region. This includes its own initiatives, such as providing free flu-shots to children in Strahan, marine rescues and shoreline clean ups.

5 Value of Petuna's Macquarie Harbour marine farm

The value of Petuna's MH operations is significant to Tasmania:

(a) Petuna's MH operation generates **$6.2 million** in salaries to local employees each year alone.

(b) The combined operational expenditure totals in excess of $**29.5 million** per annum. The vast majority of which is spent in State.

The value of Petuna's MH operations is also of national significance:

(a) Petuna produces healthy nutritious protein with a low carbon footprint to feed predominantly Australians.

(b) It holds major retail contracts with Coles, Woolworths and Tasmania's leading food retailer, Hill Street Grocer, as well as supplying to high-end restaurants across Australia.

(c) Petuna employs 184 Tasmanians, providing a diversity of job opportunities in regional areas such as Strahan, Devonport, Rowella and Cressy in the state's north and north-west.

(d) The company supports many Tasmanian businesses, with 72 per cent of total spend occurring in the state.

(e) Petuna has attracted and nurtured some of the highest calibre aquaculture experts from around the world to Tasmania. Its immediate-past CEO, Ruben Alvarez, is now Director of Aquaculture for the world's first carbon neutral city and hopes to take the Tasmanian industry's world-class environmental research programs to Saudi Arabia.

6 Environmental Responsibility

The success of the operations in MH are inextricably linked to the environmental conditions. Salmon require good conditions to thrive. Low dissolved oxygen levels impact the production levels of the salmon. Low levels of dissolved oxygen could result in mass mortality incidents, so it is of considerable importance that the operators monitor and manage oxygen levels.

Petuna has been a longtime custodian of the marine environment in MH, going above and beyond its mandatory requirements by adopting conservative stocking densities and supporting reductions of aquaculture biomass, when there have been legitimate concerns raised.

The company has always accepted the determinations of the regulator and it welcomed the Tasmanian Government's decision to transfer responsibility of industry monitoring and regulation from the Department to the EPA.

Since operations have commenced, the industry has monitored and managed the environmental conditions in MH. All industry operators have worked collaboratively with the Tasmanian Government, IMAS and CSIRO and the Tasmanian EPA to ensure operations are conducted responsibly.

Further, the industry has been proactive in addressing concerns relating to the environmental conditions of MH and impacts on the Maugean skate and has taken a leadership role on research initiatives such as the Macquarie Harbour Oxygenation Project.

[14] Deloitte Access Economics (2022), *Socio-economic contribution of the Tasmanian salmon industry*

[15] Deloitte Access Economics (2022), *Socio-economic contribution of the Tasmanian salmon industry*

The Salmon Tasmania submission provides a detailed and thorough overview of the good environmental stewardship of the Salmon Industry in Tasmania. Again, we rely on that submission and do not seek to replicate it here. However, it is relevant to outline the steps that have been led by Petuna, both separately to, and in collaboration with, the other operators including:

(a) Macquarie Harbour Oxygenation Project (**MHOP**)

The MHOP is a $6-million trial of engineering solutions to enhance oxygen levels in a major waterway. The project is being led by the salmon farming industry, in partnership with independent organisations – the Australian Government's Fisheries Research and Development Corporation (**FRDC**), and the IMAS.

Petuna will manage the operation of the equipment that will deliver the industry's MHOP and has, along with the other operators, provided significant funding for the innovative project.

The aim of MHOP is to demonstrate that the engineering solution can assist to improve and regulate oxygen levels in MH, with the end goal of offsetting 100 per cent of the oxygen drawdown of salmon farming in MH.

Petuna would also note that Tassal agreed to allow the use of its assets, which ordinarily would have been deployed in support of its own operations in other parts of Tasmania.

(b) Total Permissible Dissolved Nitrogen Output and biomass reduction

Petuna also called for the EPA to move from a biomass cap in MH to a Total Permissible Dissolved Nitrogen Output (**TPDNO**) determination, bringing it into line with the monitoring regimes of other aquaculture regions in the state.

TPDNO caps allow the EPA to validate feed volumes reported by the companies about the amount of feed they put into the water. It is an objective method of regulating and monitoring impacts of the operation on the marine environment in MH.

Petuna has reduced biomass by 57 per cent in MH since 2015 to the 2022 TPDNO determination.

(c) Commissioning Ian Wallis report 2024

Petuna commissioned a technical memorandum outlining expert opinion from scientists and Dr Ian Wallis in relation to the impact of salmon farming on the levels of dissolved oxygen in MH as that may be relevant to the Maugean skate.

Dr Wallis is a member of the MHOP team and was then also engaged by Salmon Tasmania to prepare a technical memorandum to estimate the demand for oxygen by salmon farms in MH and determine whether the resulting dissolved oxygen drawdown impacts the Maugean skate.

A copy of the Wallis 2024 Report is attached as Appendix A to this submission.

(d) Bathurst Harbour research

Along with Tassal and Huon, Petuna has supported research into the Maugean skate's presence in Bathurst Harbour. This research was funded collectively by the aquaculture industry through FRDC.

6.2 Petuna's commitment to Macquarie Harbour conservation

Petuna's commitment to MH's conservation stretches far beyond its operational responsibilities.

Whale rescues

In September 2020, the Petuna team in Strahan took the lead in scrambling to save stranded long-finned pilot whales in what is believed to have been one of the largest global strandings on record.

Included in the rescue mission were three of Petuna's vessels (two jet boats and a Yakka – heavy works vessel), as well as two cargo nets lined with 32mm mesh for lifting the mammals, several strops and five people to assist in the recovery.

Although tragically nearly 400 whales died, more than 110 were saved, 65 of which were rescued by the Petuna team. In 2022, Petuna once again jumped in to save more than 40 whales that also became stranded.

Perhaps even more commendable was the role Petuna employees played in the gruelling physical and emotional efforts to responsibly dispose of the hundreds of whales that sadly did not survive both stranding events, preventing a potential environmental and public health disaster in the MH.

Despite the significant financial, operational and emotional strain the whale rescues put on the company and its people, Petuna did it because it was the right thing to do.

Raising issues

Petuna has always been proactive in raising issues relating to the health of MH with the Tasmanian Government and the EPA, including heavy metal levels in the marine environment due to the legacy of nearby mining operations.

For many years now, Petuna, and indeed the industry, has also engaged with government, industry and other stakeholders in MH, calling for an integrated management approach to Maugean skate conservation.

7 Environmental credentials

Petuna is the first company in the world to achieve Best Aquaculture Practice (**BAP**) accreditation for two species in a marine environment – Atlantic Salmon and Ocean Trout. More recently, it also became the first company to receive BAP accreditation for both its fresh and saltwater operations.

In 2019, Petuna achieved BAP Four Star accreditation. This top-tier certification means every step in the company's production chain, from hatchery and farms to feed mills and processing plants, complies with the highest best aquaculture practice standards in the world.

7.1 Innovation investment

(a) Petuna's Cressy **III** project represents a $15-million investment in environmental sustainability, with a new state-of-the-art Recirculation Aquaculture System that reuses up to 99 per cent of the water in the hatchery, with 100 per cent of the solid waste planned for use on a nearby agricultural farm for organic fertiliser. This investment occurred to deliver fish for ongrowing in MH with improved fish health and performance outcomes.

(b) In an Australian first, using specially developed cardboard boxes made in Tasmania from sustainably sourced paper-based material, Petuna will progressively avert the use of around 300,000 polystyrene boxes every year, significantly reducing its contribution to landfill as well as CO2 emissions from delivery truck movements.

(c) Petuna has also invested $18 million towards a major enhancement project to improve fish health and performance as well as environmental sustainability at its Rowella salmon farm in the state's north.

7.2 Environmental compliance

Petuna has an established track record of environmental compliance in MH, reflected most recently in the EPA renewing the company's environmental licenses for a further two years. The EPA's decision considers Petuna's 'compliance history and character' as well as advice from science research organisations, non-governmental organisations and both the State and Federal Governments.

Harbour data collected monthly for the EPA from the broadscale water quality monitoring program, which includes in excess of 100 sampling sites, further demonstrates Petuna's environmental compliance.

The EPA Director's renewal of environmental licenses demonstrates environmental management of aquaculture activities in the MH can be managed using the environmental licensing conditions and other regulatory tools in place, such as TPDNO determinations.

7.3 Climate adaptation

Petuna is committed to its Climate Change Action Plan, focused on two key areas – mitigation and adaptation. The Plan sets targets and measures progress to reduce the company's greenhouse gas emissions and carbon footprint through a continuous improvement program spanning its operations. It also sets out strategies to adapt to extreme weather and rising sea temperatures through innovation such as Petuna's world-leading breeding program.

8 The Reconsideration Requests

8.1 Petuna relies on the detailed analysis, critique of, and response to, the Reconsideration Requests outlined in the Salmon Tasmania submission. We do not propose to duplicate that analysis here.

The Reconsideration Requests do not meet the statutory requirements and therefore are not valid.

The Reconsideration Requests were purportedly made pursuant to the following:[16]

(a) section 78(1)(a) of the EPBC Act, it is alleged that there is substantial new information available about the impacts the action is having (or will have or is likely to have) on the Maugean skate and the Tasmanian Wilderness World Heritage Area (being a matter protected by Part 3 of the EPBC Act); and/or

(b) section 78(1)(aa) of the EPBC Act, it is alleged that there is a substantial change in circumstances that was not foreseen at the time of the MH Particular Manner decision and it relates to the impacts the action is having (or will have or is likely to have) on the Maugean skate and the TWWHA (being a matter protected by Part 3 of the EPBC Act); and / or

(c) section 78(1)(b) of the EPBC Act, it is alleged that action is not being, or will not be, taken in the manner identified in the MH Particular Manner decision.

8.2 Do the Reconsideration Requests meet the statutory requirements?

Section 78A provides an avenue for a Reconsideration Request to be made by a person other than a State or Territory Minister. Section 78A(2) requires the Reconsideration Request:

(a) be in writing; and

(b) set out the basis on which the person thinks the decision should be reconsidered; and

(c) any further requirements in the *Environment Protection and Biodiversity Conservation Regulations 2000* (**EPBC Regulations**).

Regulation 4AA.01 of the EPBC Regulations[17] require a Reconsideration Request to *inter alia* contain / include:

(a) Substantial new information:[18]

  (i) any new information that was not considered when the original decision was made; and

  (ii) information that demonstrates that a change in the **potential** impacts of the action is **likely to happen with a high degree of certainty**.

(b) Substantial change in circumstances:[19]

  (i) identifies the changed circumstances; and

  (ii) establishes why the circumstances were unforeseen at the time the original decision was made; and

  (iii) demonstrates that a change in the **potential** impacts of the action is **likely to happen with a high degree of certainty**.

(c) Action inconsistent with Particular Manner requirements:[20]

  (i) information that **established that the action is not being taken**, or will not be taken, in the manner identified in the original decision.

The Reconsideration Requests do not include information that demonstrates that the potential impacts of the **action** on the TWWHA or the Maugean skate are "*likely to happen with a high degree of certainty*".

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[16] EDO Australia dated 23 August 2023 and 20 November 2023; The Australia Institute dated 8 June 2023 at [4] & [8] and 31 July 2023 at [3]; BBF dated 25 July 2023 at p. 2.

[17] Other requirements under 4AA.01 include:

(2) A request must:

(a) identify the ground or grounds in paragraphs 78(1)(a) to (ca) of the Act that are being relied upon to make the request; and

(b) include the source of any information provided; and

(c) provide details of when the information became available.

[18] Regulation 4AA.01(3) of the EPBC Regulations

[19] Regulation 4AA.01(4) of the EPBC Regulations

[20] Regulation 4AA.01(5) of the EPBC Regulations

The legislative framework sets a high threshold for Reconsideration Requests to meet. This is unsurprising given the significant implications of such requests. They expend considerable departmental time and resources and provide uncertainty for project proponents and the community. They should only be made in exceptional circumstances. The wording of the EPBC Regulations reflect this.

The Reconsideration Requests rely on the *Interim Report 2023*, and other publications,[21] to substantiate that aquaculture has the impact of reducing levels of dissolved oxygen in MH and that this is likely to have an impact on the Maugean skate (which we contest). The *Interim Report 2023* does not reach that conclusion and affirms that there are a number of possible causes of the vulnerability of the Maugean skate. This is considered in more detail at sections 9.3 – 9.5 below.

In respect to s.78(1)(b), the BBF has clearly failed to **establish** the action is not being, or will not be, taken in the manner identified. There is no basis for this assertion. See section 9.7 below for a more detailed analysis.

The Requestors have failed to demonstrate the asserted potential impacts on the Maugean skate are as a result of the action or are likely to happen with a high degree of certainty as is required by r. 4AA.01 of the EPBC Regulations.

The implications of the Reconsideration Requests not being valid is that the statutory reconsideration process is not triggered. Section 78 – 79 of the EPBC Act outline the reconsideration process. Following receipt of a valid Reconsideration Request, the Minister is required to provide notice of the request to certain persons.[22] The Minister is then required to publish a copy of the request on the internet and invite public comments.[23] As soon as practicable after receiving all comments, the Minister **must reconsider the controlled action decision**, and either:

(a) confirm the decision; or

(b) revoke the decision and substitute a new decision.

Therefore, if the Reconsideration Requests are not valid:

(a) Section 78B - the public comment period has no statutory imprimatur; and

(b) Section 78C - the Minister is not required to reconsider the MH Particular Manner decision.

While the Minister has invited public comments, this does not establish as a matter of law, that it is done in accordance with s.78B of the EPBC Act. The Reconsideration Requests fail to meet the statutory requirements. Accordingly, the requests are not valid and based on the statutory construction of Division 3 of the EPBC Act, the statutory process has not been triggered. The Minister is not required to take any further action.

9 No legal basis to reconsider the MH Particular Manner decision

9.1 The statutory prerequisites for enlivening the Minister's power to reconsider the MH Particular Manner decision, pursuant s.78(1), have not been met because:

(a) the Reconsideration Requests fail to meet the statutory requirements and a valid request is a prerequisite for s.78 of the EPBC Act to be enlivened. Section 78C provides that the Minister may "*revoke the decision on one or more of the grounds under section 78(1) and to substitute it with a new decision*". Petuna's position is that s.78(1) only arises in the context of a valid Reconsideration Request; or

(b) if the Minister forms the view that the power to reconsider the request pursuant to s.78 can be enlivened in the absence of a valid Reconsideration Request or that the Requests are valid (erroneously in our view), then Petuna's position is that the legal tests under s78 are not met.

Section 78(1) of the EPBC Act outlines when 'substantial new information' or 'substantial change in

21 Australia Institute letter of 31 July 2023 at [7].

22 Section 78B(2) of the EPBC Act

23 Section 78B(6) of the EPBC Act

circumstances' arises. The below table sets out the statutory test for each:

Section 78(1)(a) - Substantial new information	**Section 78(1)(aa) - Substantial change in circumstances**
(a) impacts (b) the action (c) has or will have OR is likely to have; (d) on a matter of national environmental significance (MNES).	(a) was not foreseen at the time of the controlled action decision that relates to the; (b) impacts (c) the action (d) has or will have OR is likely to have; (e) on a matter of national environmental significance (MNES).

BBF asserted in its Reconsideration Request that s.78(1)(b) of the EPBC Act was also a basis upon which the Minister can reconsider the decision. This is similarly disputed, the reasons for which are outlined below at section 9.7.

The requirements for ss. 78(1)(a) and (aa) are largely the same so we address each in turn, below (in order of relevance).

9.2 Matter of National Environmental Significance (MNES) - Protected by Provision of Part 3

The matters nominated in the MH Particular Manner decision as relevant to the action are:

(a) World Heritage properties (sections 12 and 15A);

(b) National Heritage places (sections 15B and 15C); and

(c) Listed threatened species and communities (sections 18 and 18A).

The Reconsideration Requests[24] assert that the impact of the action is on both the TWWHA (which is listed as a World Heritage property and National Heritage place) and listed endangered species, the Maugean skate.

9.3 "Likely" / "is likely to have"

The requirements that the action "*has or will have or is likely to have"* an impact, sets a threshold of certainty as to the impact. At the lower end, the impacts of the action need only be "likely" to occur.

The recent decision of the *Environment Council of Central Queensland Inc v Minister* considered the meaning of "*is likely to have*" in the scope of s. 78 of the EPBC Act.[25]

In that decision, Justice McElwaine held that it was clear from a number of authorities that the natural and ordinary meaning of "*likely*" is intended "*to convey the notion of a substantial – a 'real and not remote' – chance regardless of whether it is less or more than 50 per cent*".[26] His Honour concluded at that the phrase "*is likely to have*" means "*a real or not remote chance or possibility*".[27]

9.4 Action

The MH Particular Manner decision is the decision subject to the Reconsideration Request. The then Commonwealth Minister for Sustainability, Environment, Water, Population and Communities determined that the action would not be a controlled action if undertaken in a Particular Manner. This

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[24] EDO dated 23 August 2023 assert an impact on the TWWHA and the Maugean skate at p. 3; Australia Institute dated 8 June 2023 assert an impact on the TWWHA and the Maugean skate at [13].

[25] *Environment Council of Central Queensland Inc v Minister for the Environment and Water (No 2)* [2023] FCA 1208 at [54] – [59]

[26] *Environment Council of Central Queensland Inc v Minister for the Environment and Water (No 2)* [2023] FCA 1208 at [55]; Citing *Boughey v The Queen* (1986) 161 CLR 10 at 21 (Mason, Wilson and Deane JJ). See also *Clubb v Edwards* [2019] HCA 11; 267 CLR 171 at [58] (Kiefel CJ, Bell and Keane JJ) and *Chan v Minister for Immigration and Affairs* (1989) 169 CLR 379 at 398 (Mason CJ).

[27] *Environment Council of Central Queensland Inc v Minister for the Environment and Water (No 2)* [2023] FCA 1208 at [58] – [59].

decision resulted from the referral of the proposed action, being the expansion of marine farming in MH to the Commonwealth Government by the then Secretary of the Department of Primary Industries, Parks, Water and Environment (**DPIPWE**).

On 25 May 2012 DPIPWE referred the following 'action':

> "*The expansion of marine farming operations, that will occur consistent with the 2012 amendment to the Marine Plan, which will include the following activities:*
>
> (i) *The arrangement and securing of sea pens for fish farming;*
>
> (ii) *The construction of associated water based infrastructure;*
>
> (iii) *The operation of fish farms including:*
>
> (A) *Servicing and maintenance of sea pens and associated water and land based infrastructure;*
>
> (B) *Feeding and managing the health, waste, processing and predators of fish in the farms;*
>
> (C) *Transportation of fish to and from the farms across water and land.*"

An amendment to the *Macquarie Harbour Marine Farming Development Plan October 2005* was made under s.38 of the *Marine Farming Planning Act 1995*. The amendment was approved by the Tasmanian Minister for Primary Industries in May 2012.[28]

The Court held in *Huon v Minister* that the 'action' was "*the expansion of marine farming operations, that will occur consistent with the 2012 amendment to the Macquarie Harbour Marine Farming Development Plan*.....".[29] Noting the governmental authorisation exemption under the EPBC Act,[30] the action is the physical steps taken by the operators (e.g. securing of sea pens) that give effect, and continue to give effect,[31] to the expansion of the operations approved pursuant to the amendments of the *Macquarie Harbour Marine Farming Development Plan October 2005*.

What the 'action' is for the purposes of the EPBC Act is clear. What is not made out is that the action is causing the impact.

9.5 Impact

The legal test requires consideration of the <u>**IMPACT**</u> that the action "*has or will have or is likely to have*" on the MNES. Impact is defined in the EPBC Act at s.527E as follows:[32]

> "*527E Meaning of impact*
>
> *(1) For the purposes of this Act, an event or circumstance is an impact of an action taken by a person if:*
>
> *(a) the event or circumstance <u>is a direct consequence of the action</u>; or*
>
> *(b) for an event or circumstance that is an indirect consequence of the action —subject to subsection (2), the action is a substantial cause of that event or circumstance.*"
>
> [**emphasis added]**

Petuna's submission is that this is the element of the legal test that is not met. The impacts relied on by

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[28] The amendment provided for the increase in area available for salmonid farming in Macquarie Harbour. The amendment provided for the reconfiguration and addition of leasable areas to facilitate increased salmonid production through better growing conditions and/or additional growing areas. The amendment also included changes to management controls within the marine farm development plan.

[29] *Huon Aquaculture Group Ltd v Minister for the Environment* (2018) 160 ALD 292; [2018] FCA 1011 at [35]

[30] Section 524 of the EPBC Act

[31] *Huon Aquaculture Group Ltd v Minister for the Environment* (2018) 160 ALD 292; [2018] FCA 1011 at [220] where Justice Kerr held that the action had not been taken pursuant to s. 78(3) of the EPBC Act.

[32] *Environment Council of Central Queensland Inc v Minister for the Environment and Water (No 2)* [2023] FCA 1208 [51] and also from [153] considered the types of impacts that fall within the scope s. 78 of the EPBC Act. Impacts under the EPBC Act has been the subject of substantial judicial consideration.

the Requestors in the Reconsideration Requests are not 'impacts' that fall within the scope of the EPBC Act.

What must be established for the Minister to be satisfied that s.78 applies, is that the 'new information' or 'substantial change in circumstances' relates to an impact on the Maugean skate and TWWHA that "*is a direct consequence of the action*".[33]

The Minister has before her, considerable information about the dissolved oxygen levels in MH and the decline in the Maugean skate population. What is required in applying the legal test in s. 78 is that the <u>impact</u> to the Maugean skate outlined in the IMAS Report 2023, being the 47 per cent decline in catch per unit effort from 2014 to 2021 indicating a substantial decrease in the relative abundance of the Maugean skate numbers in MH,[34] is a <u>direct consequence</u> of the expansion of marine farming in MH.

MH is a complex system. This is acknowledged by the experts.[35] There are many factors at play in the dissolved oxygen levels in MH. The Reconsideration Requests assert that the decline in the Maugean skate population is due to dissolved oxygen levels and that the aquaculture operations are the cause of the fluctuation in dissolved oxygen levels. There is no conclusive evidence to substantiate:

(a) the aquaculture operations in MH are the primary or major source of the decline in dissolved oxygen level in MH; or

(b) the cause of the decline in the Maugean skate population is due to dissolved oxygen levels in MH.

The Salmon Tasmania submission provides a detailed and thorough analysis of the *Wallis Report 2024* and the *Interim Report 2023*, in addition to other publications relied on by the Requestors. We rely on that analysis but extract below pertinent matters for ease of reference.

The *Interim Report 2023* is the predominate basis upon which the Reconsideration Requests have been made. The Reconsideration Requests, make unsubstantiated assertions such as *"the current scientific evidence is that the Action has had a significant impact on the endangered Maugean Skate"*.[36] The Requestors seem to imply that there is an unequivocal direct impact between the aquaculture operations and the decline in skate population. There is no material, currently before the Minister, to establish that.

The *Interim Report 2023* does not present any new information or change in circumstances about the impacts of the action on the Maugean skate, let alone any substantial new information about such impacts or their likelihood of occurring. The only new information and change in circumstances contained in the *Interim Report 2023* is data regarding the population size, composition and characteristics of the Maugean skate. This is new information / change in circumstances about the Maugean skate population. The Maugean skate population was in decline prior to the *Interim Report*. What is new is the extent of the population decline.

Importantly, as the name suggests, it is an interim report which is expressly stated to be subject to further analysis and noted that the analysis is not definitive.

The possible contributory causes of the Maugean skate population decline is not new information or a change in circumstances. There are a number of possible causes of the decline in the Maugean skate population – all of which have been known since the MH Particular Manner decision. It has long been understood that several factors **<u>may</u>** impact the viability of the Maugean skate in MH including:[37]

(a) the closure of the Mt Lyell mine and the corresponding increase in acids and heavy metals in the Harbour;

(b) predation (for example from fur seals and parasitic sea lice), including in particular a rise in predations of young skate and eggs by introduced species of crab;

(c) low genetic diversity and inbreeding;

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33 See s. 527E(2)(b) of the EPBC Act. Indirect consequence does not arise in situation.

34 *Impact Report 2023* at p.1.

35 *Impact Report 2023* at p.1; Wallis Report 2024 at p. 5.

36 EDO Australia (23 August 2023) Reconsideration Request, p. 6.

37 https://nre.tas.gov.au/conservation/threatened-species-and-communities/lists-of-threatened-species/threatened-species-vertebrates/maugean-skate (accessed 23 January 2024)

(d) habitat changes linked to altered fresh water river flows from hydroelectric production; and

(e) climate change impacts and warming water.

At its highest, this is new information about the MNES and the skate population, it is not about the impacts of the action on that MNES. This is a crucial distinction.

There have been a number of scientific papers relied on in the Reconsideration Requests, which related to the Maugean skate populations and dissolved oxygen levels in MH, including:

(a) Understanding the Ecology of Dorvilleid Polychaetes in Macquarie Harbour (Ross 2016 Report);

(b) Environmental Research in Macquarie Harbour Interim Synopsis of Benthic and Water Column Conditions (Ross 2017 Report);

(c) Vulnerability of the endangered Maugean skate population to degraded environmental conditions in Macquarie Harbour (Moreno 2020 Report);

(d) Macquarie Harbour Oxygen Process model (Wild-Allen 2020 Report); and

(e) Most recently the *Interim Report (2023).*

We reiterate the position put by Salmon Tasmania in its submission[38] that the scientific reports that do attempt to draw a causal link between the action and the vulnerability of the Maugean skate, are based on flawed assumptions that do not reflect modern aquaculture practices employed in MH or outdated data.

Further, *Wallis Report 2024* undertook a review of scientific literature relied upon in the Reconsideration Requests and found that data relied upon, and assumptions made in the literature either did not support the conclusions drawn or overstated the impacts of salmon farming on environmental conditions.

Further, *Wallis Report 2024* concluded, in respect of the relationship between the aquaculture activities, DO levels and impacts on the skate: [39]

(a) the reduction of dissolved oxygen in the top layer of the harbour waters by 4 per cent or 0.3 mg/L from salmon farming "*would have negligible effect on the survival of the skates in their normal habitat…*"; and

(b) Skates appear to avoid areas of low dissolved oxygen including when uplift events occur, by moving to the deeper ocean inflow regions where high dissolved oxygen water is entering (and causing the uplift event).

9.6 Tasmanian Wilder World Heritage Area (TWWHA)

The Reconsideration Requests[40] also assert the *IMAS Report 2023* is new information or change in circumstances about the impact that the action *will have or is likely to have* on the TWWHA. It is unclear if the assertion is the dissolved oxygen levels or decline in the Maugean skate population is alleged to be impacting the 'values' but neither can be substantiated.

Noting the scope of the Part 3 controlling provisions relate to the "values" of the TWWHA, the Reconsideration Requests fail to articulate the 'values' asserted to be impacted or how they would be impacted.

9.7 Not taken in the manner as outlined in the MH Particular Manner decision – s.78(1)(b) of the EPBC Act[41]

Petuna strongly refutes the assertion that the operations are not being undertaken in accordance with the MH Particular Manner decision.[42]

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38 Salmon Tasmania submission at p. 5

39 Wallis, I (2024) *Technical Memo on Dissolved Oxygen in Macquarie Harbour*, Appendix A, p. 23-25.

40 EDO Australia and Australia Institute -

41 Fitzgerald and Browne Lawyers on behalf of the Bob Brown Foundation Inc (BBF) by way of letter dated 25 July 2023 at p. 1.

42 Only BBF rely on s.78(1)(b) of the EPBC Act as a basis to reconsider the decision. However, EDO Australia also allege non-compliance with the MH Particular Manner decision in its Reconsideration Request at p. 1.

BBF provides no particulars in respect of the asserted non-compliance with the MH Particular Manner decision. The MH Particular Manner decision provides a number of detailed and technical conditions, and no attempt is made by BBF to particularise when or how those requirements have been breached by the operators.

The compliance with the MH Particular Manner decision was considered by the Federal Court in the 2018 in *Huon v Minister.* The Commonwealth Government advocated strongly for the maintenance and appropriateness of the MH Particular decision in those proceedings.

In any event, we agree with the position in the Salmon Tasmanian submissions that, if the Minister has concerns, as matter of procedural fairness, it would be appropriate in the first instance for those matters to be put in writing to the operators directly by the Department, for the operators' consideration and response.

10 STATE AND FEDERAL REGULATION – CONSISTENCY REQUIRED

The Reconsideration Requests fail to appreciate that aquaculture in MH is strictly regulated by the EPA.

Huon, Tassal and Petuna hold leases and licences to farm finfish within MH pursuant to the *Marine Farming Planning Act 1995* (Tas) (**MFPA**), the *Living Marine Resources Management Act 1995* (Tas) (**LMRMA**) and EMPCA. This is in addition to the MH Particular Manner decision which lists the operators as "*persons named in the referral*". Therefore, the operations in MH are regulated by the Tasmanian Government and the Commonwealth Government.

The Salmon Tasmania submission provides a detailed and thorough overview of the introduced changes to the regulatory regime. Again, we rely on that submission and do not seek to replicate it here.

10.1 Protection of the Maugean skate

The Maugean skate is listed as endangered under Tasmania's *Threatened Species Protection Act 1995* and the Commonwealth EPBC Act. Therefore, the Tasmanian Government has statutory requirements to ensure protection of the Maugean skate and to take certain measures to achieve that. Those measures include:

(a) **Conservation Action Plan** - The Department of Natural Resources and Environment Tasmania (**NRE**) has developed a Conservation Action Plan (**CAP**) for the species. The CAP identifies priority research and conservation management actions for recovery of the species.

(b) **Total Permissible Dissolved Nitrogen Output** - In September 2022, the EPA issued a TPDNO for MH, to better manage environmental indicators including levels of dissolved oxygen. This determination reduced dissolved nitrogen outputs by approximately 10 per cent compared with 2021 levels. The EPA has also developed dissolved oxygen targets for MH.

In MH, the number of finfish permitted to be held in each lease area by a particular operator was previously set by the Tasmanian regulatory authority. This was known as the Biomass Cap (the tonnage of fish permitted per hectare) and the Biomass Allocation (the percentage of the biomass determination held by each operator), collectively referred to as the Biomass Determination.

Further, the EPA shifted away from the Biomass Determination to measuring TPDNO, which provides a more objective assessment of the output (being nitrogen) rather than the input (being biomass). The challenges for the operators and the regulator with the Biomass Determination was the tonnage of smolt that enter the water is dependent on the conditions. This made it difficult to ascertain an appropriate level of biomass and the impact was less certain. As the regulatory tool has shifted to TPDNO, the EPA can monitor and manage the nitrogen output from the operations.

(c) **Environmental Licences** - Regulating operations through issuing of Environmental Licences pursuant to EMPCA.

10.1 Environmental licences – EMPCA

The operations in MH are regulated consistently and comprehensively to a high environmental standard in accordance with the requirements of the EMPCA, through the issuance of ELs.

On 30 November 2024, Wes Ford, Director of the EPA, issued Environmental Licence Nos. 9888/3, 9890/3, 9891/3 and 9892/3 to Petuna in accordance with s.42ZB(1) of EMPCA. Each EL was renewed for a period of two years, taking effect on 30 November 2023.

The EPA imposed new conditions on each of these EL requiring the licence holders to determine and mitigate the impacts of marine finfish farming activities on dissolved oxygen levels at and beyond the boundary of the marine farm leases to which each EL relates. This is a perfect example of the adaptive and response nature of the regulatory system imposed by the EPA.

The EL renewal process, which ultimately led to the imposition of new conditions on the ELs for MH, considered feedback from scientific research organisations (i.e., CSIRO, IMAS), Non-Governmental Organisations (EDO Australia) and State and Federal Governments. The process specifically considered whether there are any environmental concerns that would cause the Director of the EPA, having regard to his statutory obligations, to not be satisfied that it is appropriate to renew the licence. The Director formed the view that there were no such concerns.

The possible impacts of aquaculture on the Maugean skate were a crucial consideration in the Director determining to renew the ELs for MH.

The enhanced requirements under the State regime means that marine farming in MH is conducted in a manner that exceeds the requirements contained in the MH Particular Manner decision.

11 Revocation of the MH Particular Manner decision

If the Minister determines the statutory requirement(s) are met pursuant to s. 78 EPBC Act (erroneously we say), and decides to revoke the MH Particular Manner decision, it should be replaced with a new Particular Manner decision.

11.1 If the Minister determines it is a controlled action

If the Minister determines to revoke the MH Particular Manner decision pursuant to s. 78C of the EPBC Act, the operations will have to cease immediately as they are expressly prohibited by s.74AA of the EPBC Act. Further, it was held in *Huon v Minister* that the existing use rights were extinguished when the operation was expanded in 2012.[43]

Potential practical implications of the immediate cessation of the operation in MH have been comprehensively addressed in the Salmon Tasmania submission. The practical implications of this are incomprehensible. Not only will it result in immediate job loses, but also the mass euthanasia of current salmon stock in MH, giving rise to environmental, biosecurity and animal welfare concerns. It would also impact on the smolt stock in Petuna's Cressy hatchery, destined for MH.

The continued operation of salmon farming in MH is supported by the Commonwealth opposition, the West Coast Council, Tasmanian Government, the Tasmanian Opposition, and the Tasmanian EPA.

12 Recommendations

In respect of the Reconsideration Requests, the following recommendations are made by Petuna:

(a) The Minister should determine that the Reconsideration Requests are not valid, and no further action is required.

(b) Alternatively, if the Minister forms the view that the Reconsideration Requests are valid, the Minister should confirm the MH Particular Manner decision in accordance with s.78C(1)(b)(i) of the EPBC Act. The legal tests espoused in s. 78(1)(a), (aa) and (b) of the EPBC Act are not met.

(c) If the Minister disagrees (erroneously we say), and determines the statutory requirement(s) are met pursuant to s. 78(1) EPBC Act then:

    (i) the decision should be replaced with a new Particular Manner decision.

    The operators and the Tasmanian EPA should be consulted about the form of the particular manner before the decision is made and the notice is issued pursuant to s. 77A.

    (ii) There is no basis for the Minister to be satisfied that the action should be a controlled action pursuant to s.75 of the EPBC Act.

We would be happy to discuss this submission, or its contents in more detail if it would assist. We would also be happy to provide any further particulars, details or information you might require to assist in

[43] See s. 43B of the EPBC Act; *Huon Aquaculture Group Limited v Minister for the Environment* (2018) 160 ALD 292 at [185]-[186].

considering the Reconsideration Requests.

s. 47F(1)

Doug Paulin

Chief Executive Officer

SEALORD GROUP LTD

s. 47F(1)

149 Vickerman Street, Port Nelson, Nelson, 7010, New Zealand.

APPENDIX A

CONSULTING ENVIRONMENTAL ENGINEERS
Environmental Scientists and Engineers
Unit 4, 150 Chesterville Road, Cheltenham VIC 3192
Phone 03 9553 4787
Email wallis@cee.com.au

Foreword

The purpose of this technical memo is to estimate the demand for oxygen imposed by salmon farms in Macquarie Harbour, Tasmania.

The author, Dr Ian Wallis, is part of the team with the responsibility to trial oxygenation of the deeper waters of Macquarie Harbour, to counter very low levels of dissolved oxygen in the water column.

The Fisheries Research and Development Corporation (FRDC) is funding the project to trial the injection of oxygen into the middle and deeper waters of Macquarie Harbour. The project team includes salmon industry personnel with equipment and experience related to oxygenation of finfish pens and engineers and scientists with State, National and international expertise related to oxygen injection and associated environmental interactions.

There are examples of successful oxygenation of estuaries in Perth, in Scandinavian fjords, and in Chile. Oxygenation at shallower depths is routinely used in wastewater treatment lagoons and water storages throughout Tasmania and elsewhere.

It would assist the team if they had an estimate of the amount of oxygen input that is required to balance the oxygen demand from the salmon farms in Macquarie Harbour and the best locations to add that oxygen.

Salmon farms were first established in Macquarie Harbour in the 1980s. The early farms wee acquired by the three major companies, and Tassal established farms there in 2003, Huon Aquaculture in 2008 and Petuna around 2011. Production increased from 2,000 t/yr in 2010 to around 16,000 t/yr in 2015-2017, but has decreased since then and averaged 9,500 t/yr in 2018-2023.

The main concerns regarding low dissolved oxygen in Macquarie Harbour are:
1. The risk to the survival of the Maugean Skate, which is a threatened species that apparently survives in low numbers only in Macquarie Harbour;
2. The risk to other ecological processes and systems in Macquarie Harbour; and
3. Anoxic or near-anoxic conditions would encourage the movement of metals from the sediments into solution. The metals exist from past mining activities in the catchment and from natural erosion processes.

There is extensive and ongoing research into the hydrodynamics, water quality, benthic chemistry and biological conditions in the harbour by researchers from the University of Tasmania (UTAS), EPA, CSIRO and other institutions. The research is supported by the FRDC and by the State government through the EPA and Department of Primary Industries, Parks, Water and Environment (DPIPWE). The program includes a trial of re-oxygenation of deeper waters at a rate of approximately 1 t/d of oxygen in 2024.

Macquarie Harbour Stratification

Macquarie Harbour is a large estuary on the west coast of Tasmania, 33 km long by 9 km wide, with a surface area of 280 sq km. The main freshwater supply is from the Gordon River which flows into the south of the estuary. The entrance to the sea is an 8 km long, shallow channel in the north-west of the estuary.

The freshwater inflow from the Gordon River, and other smaller rivers and creeks, forms a surface layer that is 5 m to 10 m deep. The depth depends on the river flow, with the surface layer becoming deeper at times of high river flow and shallower at times of low river flow.

Wind mixes the surface layer into the underlying more saline layer. This results in relatively uniform salinity over the top 2 m, and often down to 6 m depth.

There is a strong salinity gradient from 6 m to 11 m depth. From 12 m depth down to the bottom, at around 45 m depth, there is relatively uniform salinity, generally of 30 to 32 parts per thousand (ppt), only about 10 per cent lower than ocean water.

Mixing of incoming ocean water with harbour water just inside the entrance where the dense seawater cascades down the slope into the harbour means that the salinity of the lowest harbour waters is always less than ocean salinity.

Figure 1 shows the monthly salinity profiles at a central station in Macquarie Harbour for 2013-2014 (data provided by IMAS). Lowest salinity is 2 ppt (at the surface) but the salinity in the surface layer (0 to 4 m) ranged seasonally from 2 ppt to 14 ppt. There is a strong salinity gradient between 5 m and 11 m depth. Below 15 m depth there is a very weak salinity gradient from around 28 ppt at 15 m depth to 31 ppt at the bed. The gradient indicates weak vertical mixing (and hence weak currents) in the lower layer of the harbour.

Figure 1. Vertical Salinity Profiles in Macquarie Harbour in 2013-2014

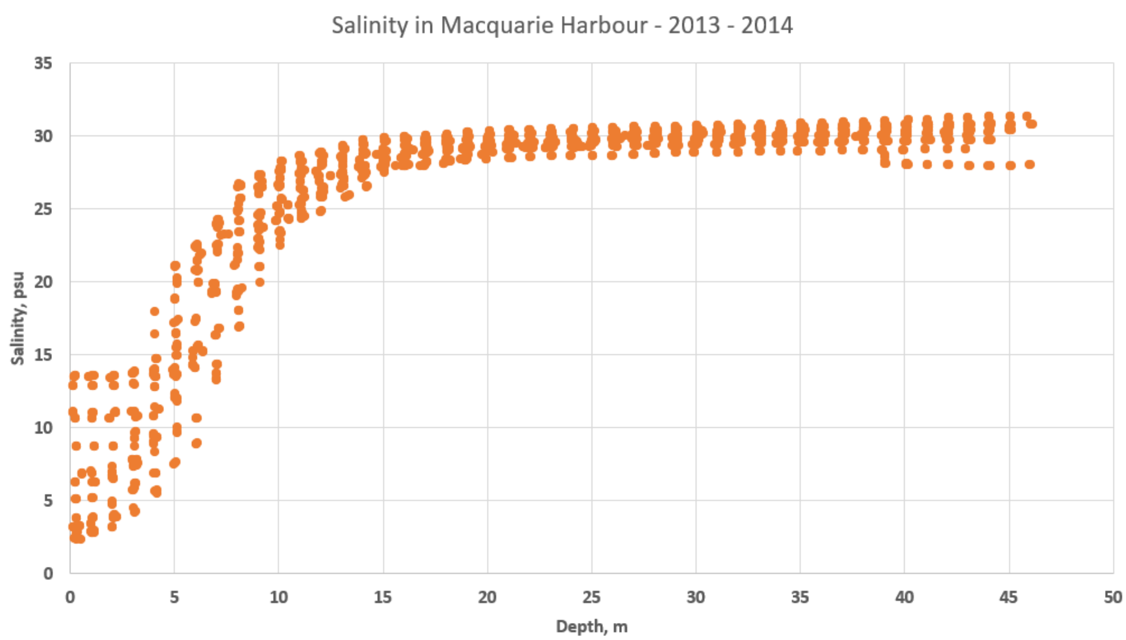


Figure 2 shows the monthly salinity profiles at a central station in Macquarie Harbour for 2018-2019 (data provided by IMAS). There is a single reading of zero surface salinity. The salinity in the surface layer (0 to 4 m) ranged seasonally from 3 ppt to 17 ppt. There is a strong salinity gradient between 5 m and 11 m depth. Below 15 m depth, there is a very weak salinity gradient from around 29 ppt at 15 m depth to 32 ppt at the bed.

Figure 2. Vertical Salinity Profiles in Macquarie Harbour in 2018-2019

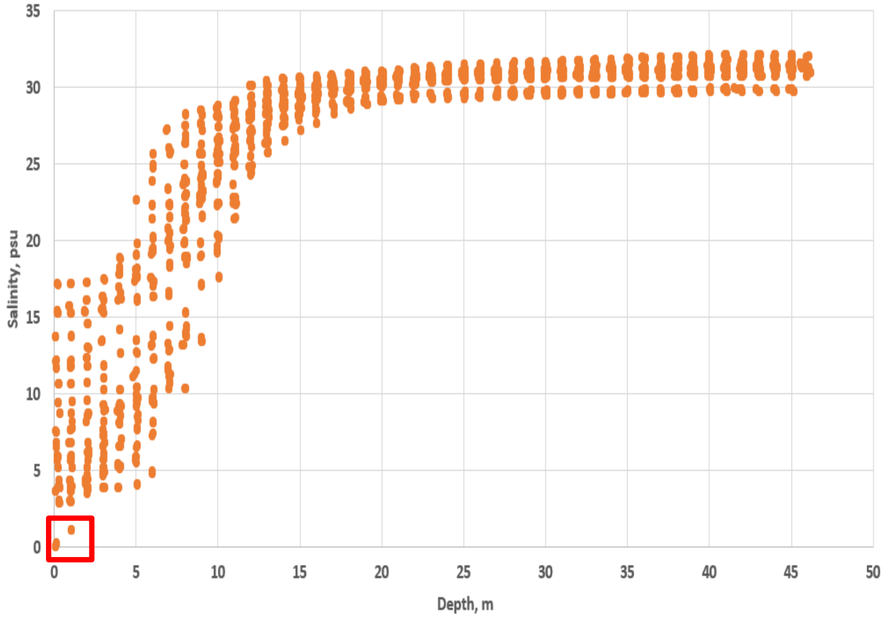
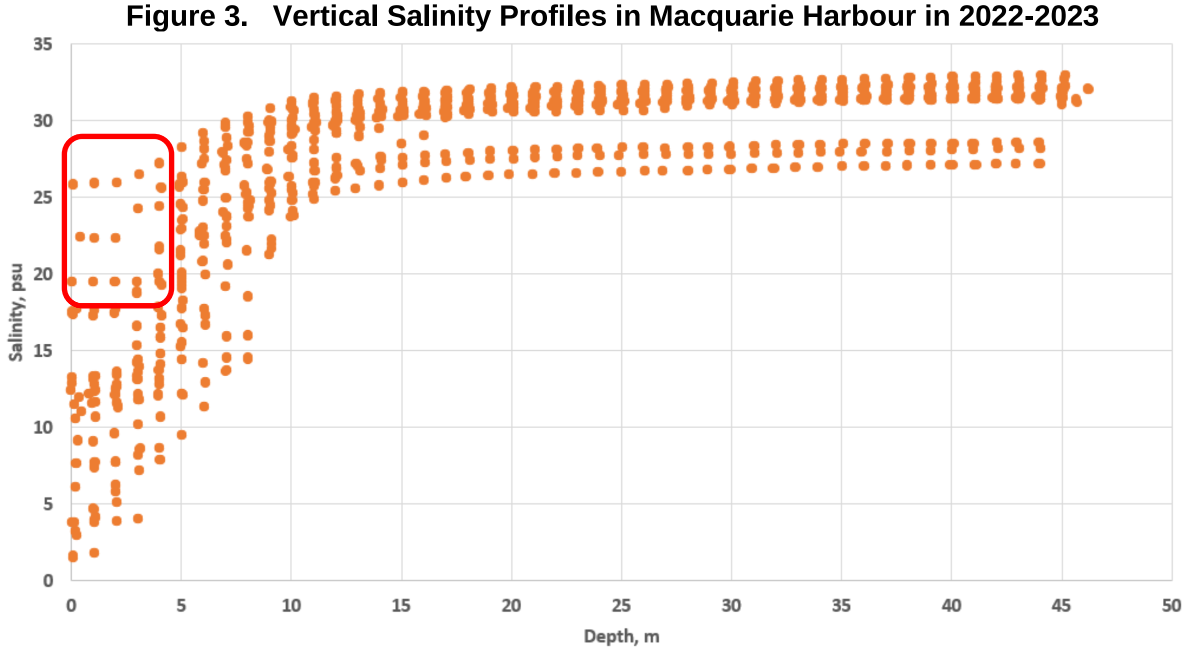


Figure 3 shows the monthly salinity profiles at a central station in Macquarie Harbour for 2022-2023 (data provided by IMAS). This period shows a different pattern, with much higher average and peak salinity in the surface layer (highlighted in the red box). The strong salinity gradient is higher in the water column from 4 m to 9 m depth. Below 11 m depth, there are two lines both showing a very weak salinity gradient from around 26 to 30 ppt at 11 m depth to around 27 to 32.5 ppt at the bed.

Figure 3. Vertical Salinity Profiles in Macquarie Harbour in 2022-2023



The vertical salinity pattern in 2022-2023 is different from the earlier years, with much higher salinity at and near the surface, which indicates a reduction in the river flow during that period, perhaps accompanied by stronger wind mixing. The lower salinity water was deeper in 2022-2023 than in previous years, indicating more ocean water inflow and uplifting of the saline layer.

River Inflow

The major process driving the stratification and circulation in the harbour is the freshwater inflow from the rivers. Koehnken (2005) reported the average annual flow from the Gordon River was 265 m^3/s and the average flow from the King River was 55 m^3/s. Adding minor tributaries such as the Sorell River and Birchs River makes a total freshwater input of around 330 m^3/s. This is sufficient to create a surface layer 0.1 m deep in a day or 4 m deep in a month. *(Note: Mean river inflow for 2017-2018 was 352 m^3/s, Wild-Allen et al, CSIRO, 2020).*

The inflow is, of course, seasonal, and mean monthly flows vary from less than 100 m^3/s in summer and early autumn to 500 m^3/s in late autumn, winter, and spring (Hartstein et al., 2016). Variations in annual rainfall produce higher inflows in wet years and lower inflows during droughts. *(Note: Range of inflow for 2017-2018 was 50 to 2,700 m^3/s, Wild-Allen et al, CSIRO, 2020, p 31).*

There is another important source of variation in the freshwater input to Macquarie Harbour. River flows from the catchments of the Gordon River and King River have been regulated by hydroelectric dams operated by Hydro Tasmania since 1983. Periodic dam releases on the Gordon River make discharges into Macquarie Harbour more variable, and can double the average flow conditions for short periods of time (Hydro Tasmania, 2016).

The freshwater escapes from Macquarie Harbour through the 8 km long entrance at Hells Gates. The mean depth at the narrowest section along the Hells Gates inlet is 4 m (and the entrance channel is approximately 120 m wide). To release the average freshwater input of 330 m^3/s at an average salinity of 8 ppt requires an ebb tide current averaging 1.8 m/s through this constriction.

The mean tidal range in Macquarie Harbour is around 0.5 m (0.2 m for neap tides and 0.9 m for spring tides). The inflow of ocean water to the harbour is restricted by two processes: (1) the large volume of freshwater that must be discharged each tide cycle, limiting the duration of seawater inflow; and (2) the long entrance channel, so that only the seawater that reaches the harbour end of the channel can stay in the harbour – the contents of the channel return to the ocean with the reverse in the current direction.

As an approximation, the seawater input each day corresponds to a net input of about 0.2 to 0.3 m depth of ocean water. As the lower saline layer extends over a depth range of around 40 m, the tidal inflow of seawater takes around 150 to 300 days to replace the water in the lower layer.

Because of this long residence time, a small organic load each day can have a substantial impact on the dissolved oxygen concentration in the lower layer. Low dissolved oxygen concentration in the lower layer should be expected because of the long residence time of water in that layer and the strong stratification which inhibits the transfer of oxygen from the surface to the lower layer.

There are a range of other hydrodynamic processes that influence dissolved oxygen levels, including mixing in the river estuaries, mixing where the incoming seawater cascades down the side of the harbour, seiching and internal waves, wind-driven mixing, surface and halocline slope due to persistent winds and long term variations in ocean water levels. These complicate the prediction of currents, stratification and dissolved oxygen.

According to Hartstein et al, 2019, the tidal water level amplitude is approximately 0.25 m and tides explain only 27% of the water level variation whereas variations in barometric air pressure explained 41% of the observed changes in water level.

Macquarie Harbour Dissolved Oxygen

Oxygen enters Macquarie Harbour continuously with river inflows (which are generally saturated with dissolved oxygen) and surface re-aeration. The ocean water entering the harbour also is generally saturated with dissolved oxygen. Inflows of ocean water are episodic, with regular small inputs at times of spring tides and low river flow, and occasional larger inputs (typically once a year) when the combination of persistent wind and low atmospheric pressure cause a large inflow of ocean water (known as deep layer recharge events).

The waters of Macquarie Harbour are strongly coloured by tannin, so there is low light penetration. Nonetheless, there are phytoplankton living in the harbour (measured chlorophyll-a is around 1 µg/m^3) regularly adding to the oxygen supply. The input of oxygen from macrophytes is very small.

Oxygen is consumed by the decomposition of organic compounds entering the harbour in rivers, local runoff and ocean waters, and by respiration of marine organisms in the water and in the bed. The salmon farms are a source of additional organic material as well as ammonia discharges, which require oxygen for conversion to organic material as well as nitrification to nitrate. Some oxygen is returned by denitrification. The focus of this Technical Memo is to estimate the oxygen demand of the salmon farms.

Figure 4 shows the monthly dissolved oxygen (DO) profiles at a central station in Macquarie Harbour for 2013-2019 (data provided by IMAS). The DO in the top 3 m is always more than 80 % saturated (depicted by the blue colour). Minimum DO occurs at around 30 m depth, and low DO can extend to the bed of the harbour. DO of less than 30 % saturation is depicted by the orange colour. A feature of the DO pattern is the strong gradient, with DO decreasing with depth to around 30 m depth. Periods of low DO in the deep waters correspond to higher river flow in winter-spring, when less seawater comes into the harbour.

Figure 4. Vertical Dissolved Oxygen Pattern in Macquarie Harbour in 2013-2018

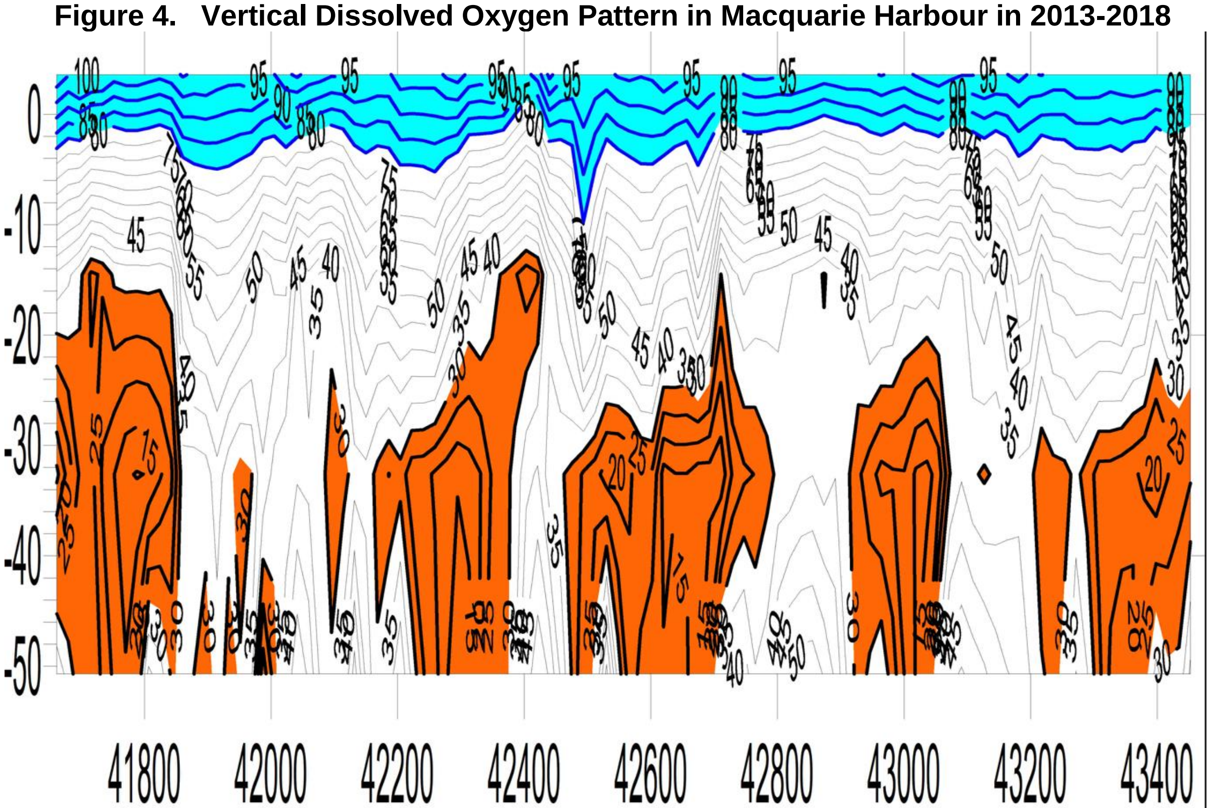


Figure 5 shows the monthly DO profiles at a central station in Macquarie Harbour for 2013-2014 (data provided by IMAS). The well-mixed surface layer extends down to 4 m depth, with the DO level being 95 % to 100 % saturation in this surface layer.

There is a strong gradient of declining dissolved oxygen from around 85 % saturation at 5 m depth to around 20 % saturation at 20 m depth.

Very low DO occurs at times at 25 m to 30 m depth, close to anoxic conditions. From 30 m depth to the bed at 45 m depth, there is a gradual increase in DO. The DO at the bed ranges from 15 % to 45 % saturation, so conditions at the bed are not anoxic.

Figure 5. Vertical Salinity Profiles in Macquarie Harbour in 2013-2014

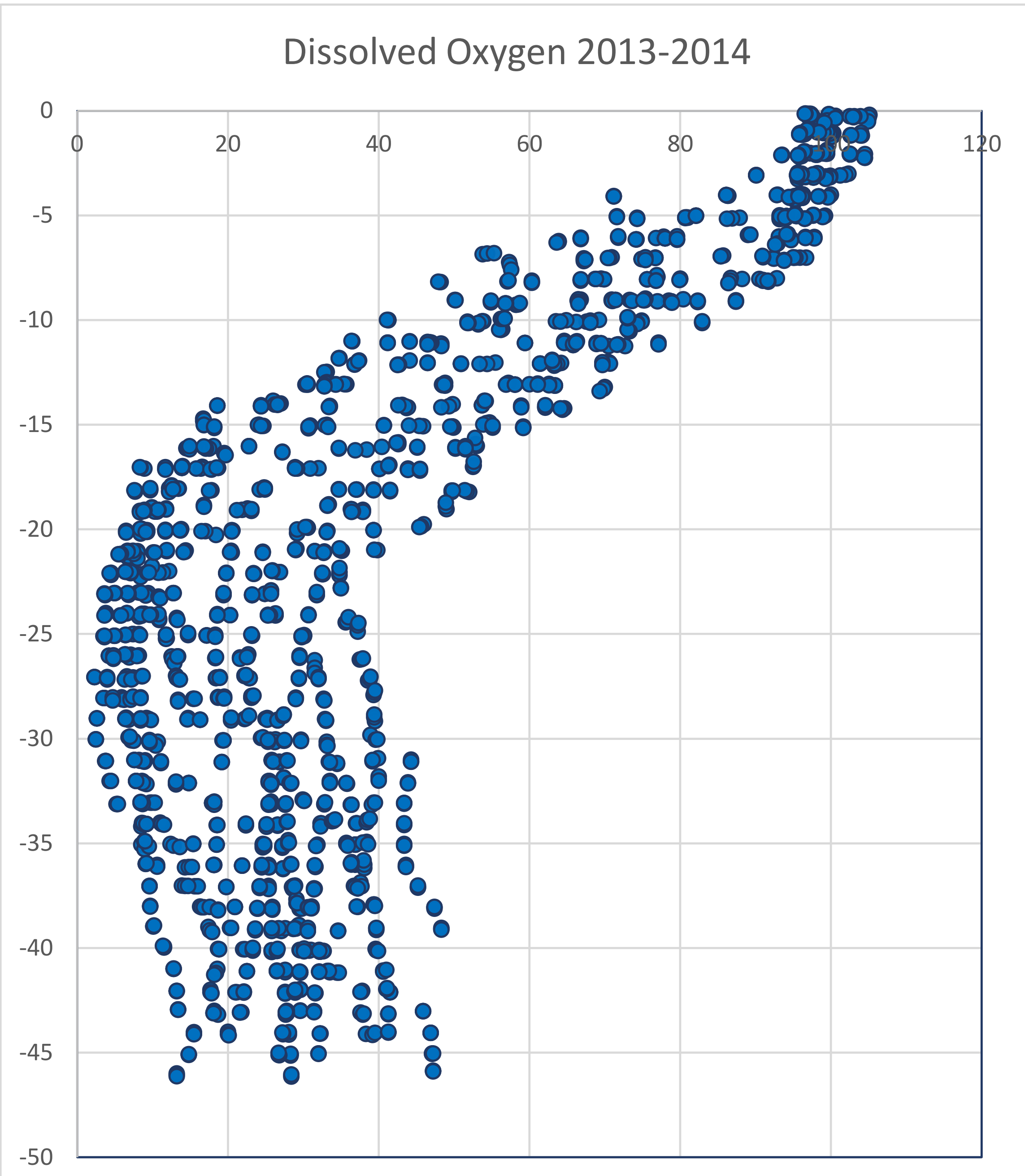


Figure 6 shows the monthly DO profiles at a central station in Macquarie Harbour for 2018-2019. The well-mixed surface layer extends down to 5 m depth, with the DO level being 92 % to 100 % saturation in the surface layer.

There is a strong gradient of declining dissolved oxygen from around 85 % saturation at 6 m depth to around 20 % saturation at 20 m depth. There was one month (January 2019) with lower than usual DO from 6 m to 12 m depth (highlighted with the red box).

Lowest DO occurs at times at 25 m depth, generally in the range of 15 % to 30 % saturation. From 25 m depth to the bed at 45 m depth, there is a gradual increase in DO so that DO at the bed ranges from 18 % to 45 % saturation. There was a smaller range in DO at each depth during 2018-2019 than in the earlier period.

Figure 6. Vertical DO Profiles in Macquarie Harbour in 2018-2019

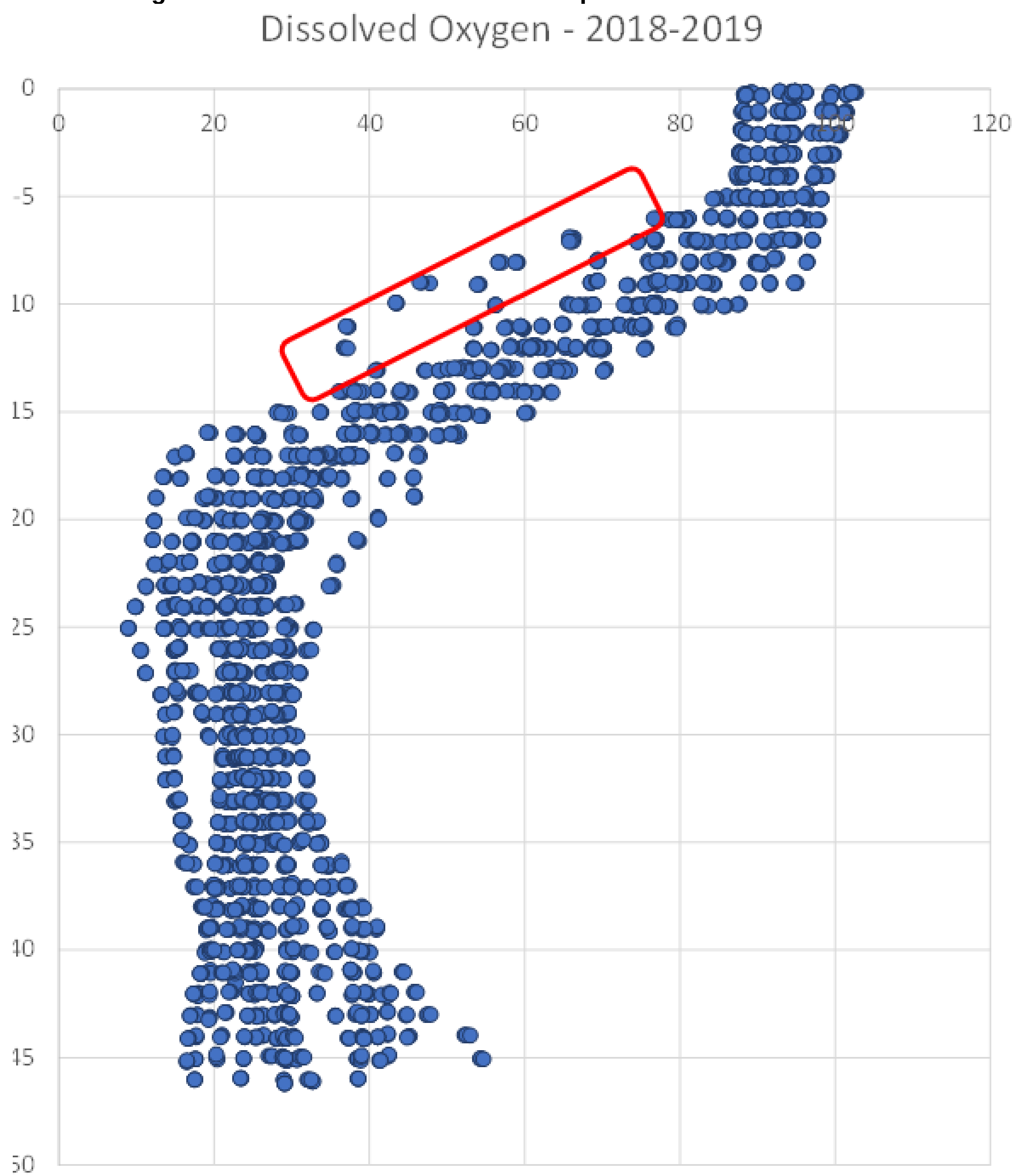
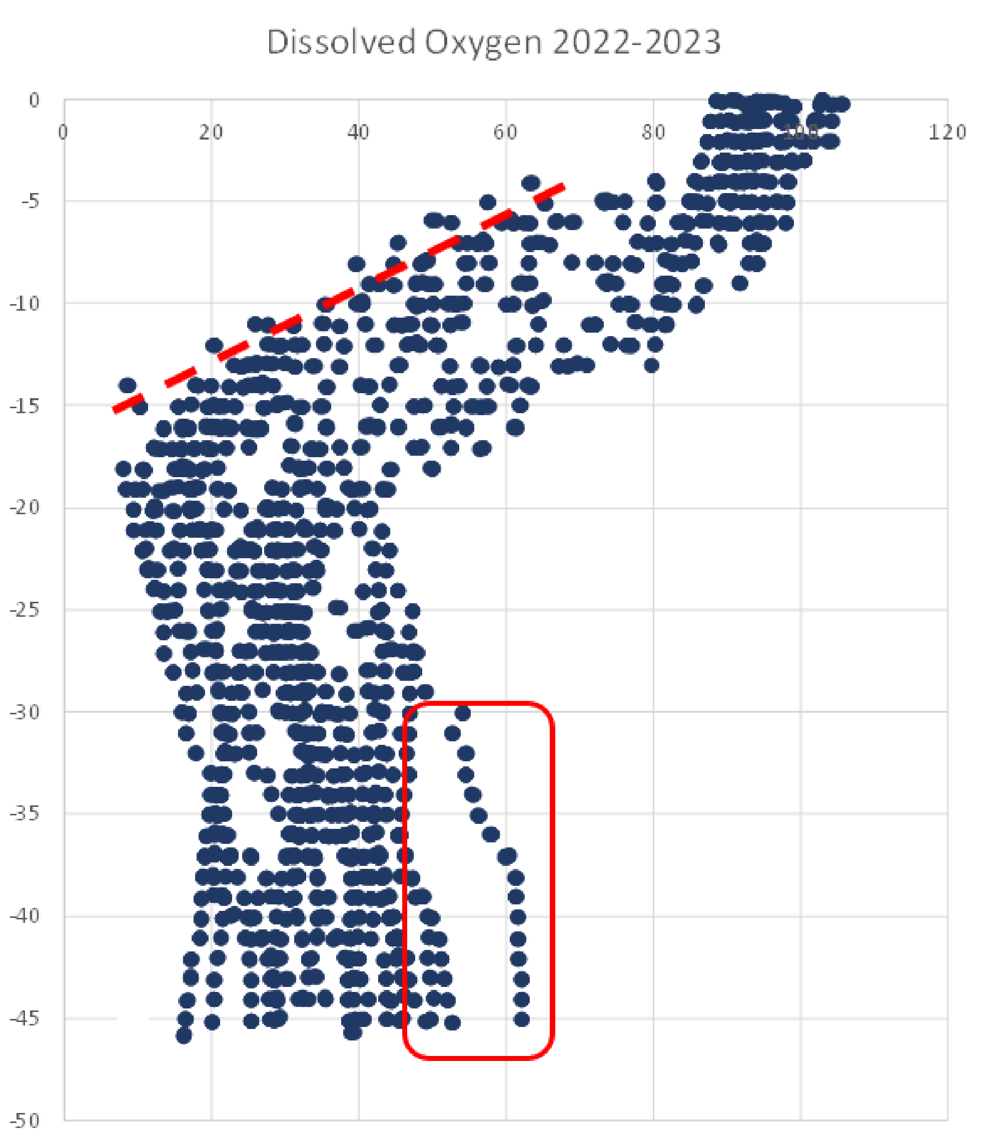


Figure 7 shows the monthly DO profiles at a central station in Macquarie Harbour for 2022-2023. The well-mixed surface layer extends down to 5 m depth, with the DO level being 86 % to 105 % saturation in this surface layer.

DO levels at 5 to 15 m depth were much lower in 2022-2023 than in 2018-2019, showing the water from lower levels had been uplifted in the latter two years. The higher salinity of the surface layer in 2022-2023 corresponds to a reduction in dissolved oxygen in the layer from 5 m to 15 m depth. However, there is not a significant reduction in the surface layer, indicating that surface re-aeration is a dominant process for maintaining high DO levels in the surface layer.

There is a strong gradient of declining dissolved oxygen from 5 m depth to less than 10 % saturation at 15 to 20 m depth. The DO increases slightly from 20 m depth to the bed, evidence that the incoming seawater is an important source of dissolved oxygen to the lower layer. A period when DO in the lower layer exceeded 60 % saturation is highlighted by the red box, indicating an event with a large seawater inflow in January 2022.

Figure 7. Vertical DO Profiles in Macquarie Harbour in 2022-2023



Mortality of Salmon in 2015 and 2019

In May 2015, Petuna reported a mortality event for 3.7 % of their salmon due to low dissolved oxygen near the bottom of the fish pens in Macquarie Harbour (ABC rural, 2015). Other salmon farms in the harbour lost fish as well. The mortality was attributed to a storm lifting low DO water into the shallower waters where the fish are located.

Salmon have a known temperature preference and tolerance, and a known dissolved oxygen tolerance. Salmon actively avoid water warmer than 17 to 18 °C and move to lower depths when the water temperature in the surface layer exceeds 18 °C.

Unfortunately for the salmon, there was a large intrusion of seawater into the harbour in May 2015. Seawater is more dense than the waters in the harbour and moves to the bottom. This displaces the existing bottom layer of water upward and hence each layer in the harbour is uplifted. As a result, water with low dissolved oxygen moves towards the surface.

Uplifting is a hydrodynamic process that occurs throughout the summer low-river-flow period each year. Various combinations of spring tides, onshore winds, low atmospheric pressure and low river flows encourage seawater to enter the harbour. As shown in Figures 1 to 3, the surface layer has an average salinity of 8 ppt. Thus, about 25 % of the outflow from the harbour originates from seawater intruding into the bottom layer. As the river inflow averages 330 m^3/s, the seawater inflow averages 80 m^3/s and the average outflow averages 410 m^3/s.

Salmon are active swimmers and require 50 to 55 % dissolved oxygen in the water to survive. Mortality of salmon occurs when there is a combination of high temperature in the surface layer (so the salmon move down in the water column) and an event of high seawater inflow (which uplifts water with low dissolved oxygen upwards into the bottom of the farm cages).

An event with high seawater inflow occurred in May 2015. Other events occurred in March-April 2019 and January 2022.

A note on terminology. As discussed above, the process that brings waters with low dissolved oxygen closer to the surface is ***uplift.*** *It occurs when a higher-than-usual volume of seawater enters the harbour, cascades down to the bed of the harbour and replaces the bottom layer of water, causing the layers of water above it to move upwards. The process is incorrectly referred to as* ***inversion*** *by Moreno et al (IMAS, 2020) but there is no inversion of the top and bottom layers. An examination of the vertical density profile (see Figure 8) shows that Macquarie Harbour always has a stable density structure with no evidence of an inversion.*

These uplift events are natural occurrences. The influencing parameters are (1) large tidal range; (2) low atmospheric pressure; (3) strong wind conditions; and (4) low river flow (influenced by wet/drought cycles). The operation of hydro-electric storages is another factor that can influent uplift events. Inflow events are reduced when there is higher river inflow.

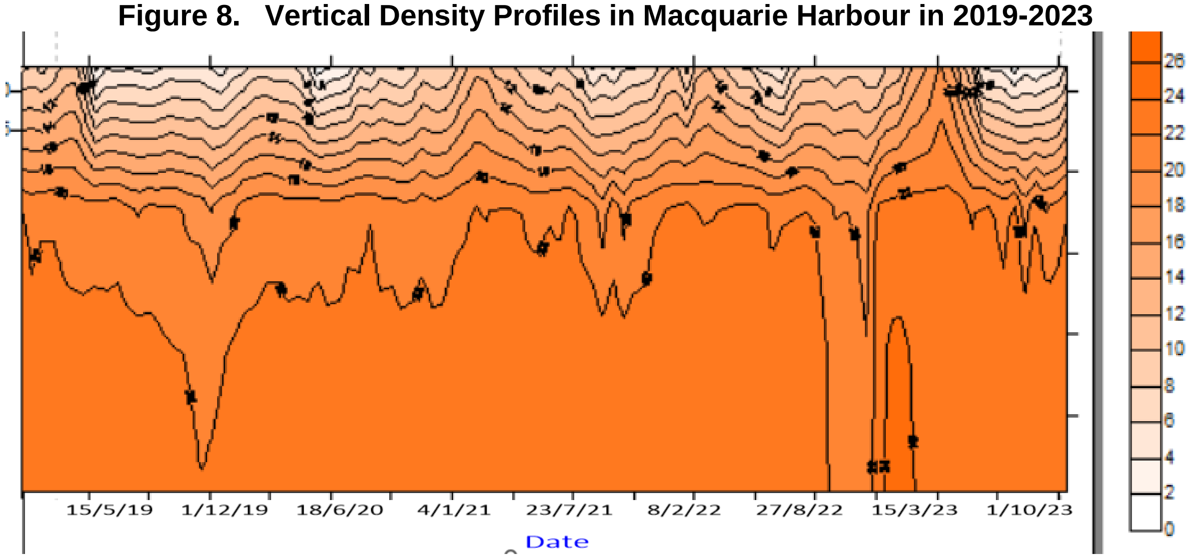
The presence of the salmon farms does not affect the inflow events.

Density Profile of Macquarie Harbour

Figure 8 shows the vertical density profile of Macquarie Harbour (plotted as sigma-T) for 2019 to 2023. The density (sigma-T) of surface waters ranges from near zero (at times of high river inflow) to around 12 kg/m^3 (at times of low river inflow). There is a seasonal pattern, but infrequent floods dominate the surface density.

The vertical profile shows strong stratification from the surface to 20 m depth, with weak stratification at the lower depths. The density stratification is strongly stable, showing that large scale inversions cannot occur. The density near the bed is mostly around 22 kg/m^3, consistent with seawater slightly diluted with freshwater as the ocean inflow cascades down the side of the harbour to the bed.

Figure 8. Vertical Density Profiles in Macquarie Harbour in 2019-2023



The more saline seawater mixes upward into the less saline layers. Thus, over a year, the seawater entering the harbour and settling to the bed slowly mixes upward through the water column, eventually leaves the harbour as part of the brackish surface outflow.

Dissolved oxygen (DO) enters the lowest layer with the seawater (which would normally be 100 % saturated with DO). DO also enters the surface layer with the river inflows (which would also normally be 100 % saturated with DO).

The stratification inhibits the vertical mixing of DO, which is why the lowest DO concentration occurs at 15 to 25 m depth, in the middle of the water column.

It is not obvious from the DO data analysed in this report that there has been *"a marked decline in dissolved oxygen conditions in Macquarie Harbour which are likely to have a significant impact on many resident species, including the Maugean Skate"* Dissolved oxygen was always low in the lower layer. There are certainly significant variations in DO in Macquarie Harbour from month-to-month and year-to-year. Whether or not there is a long term trend of declining DO with time is still an open question, as any trend is difficult to separate from variations in annual and longer term river flows, and events with a large inflow of seawater, due to a coincidence of environmental conditions that encourage such events.

Long period cycles are also likely to be important. As an example, there appears to be a 50-year cycle in the extent of seagrass in Port Phillip Bay, responding to decade-long variations in rainfall (Jenkins, et al, 2015) and similar long cycles may occur in Macquarie Harbour.

Moving from 2-D to 3-D

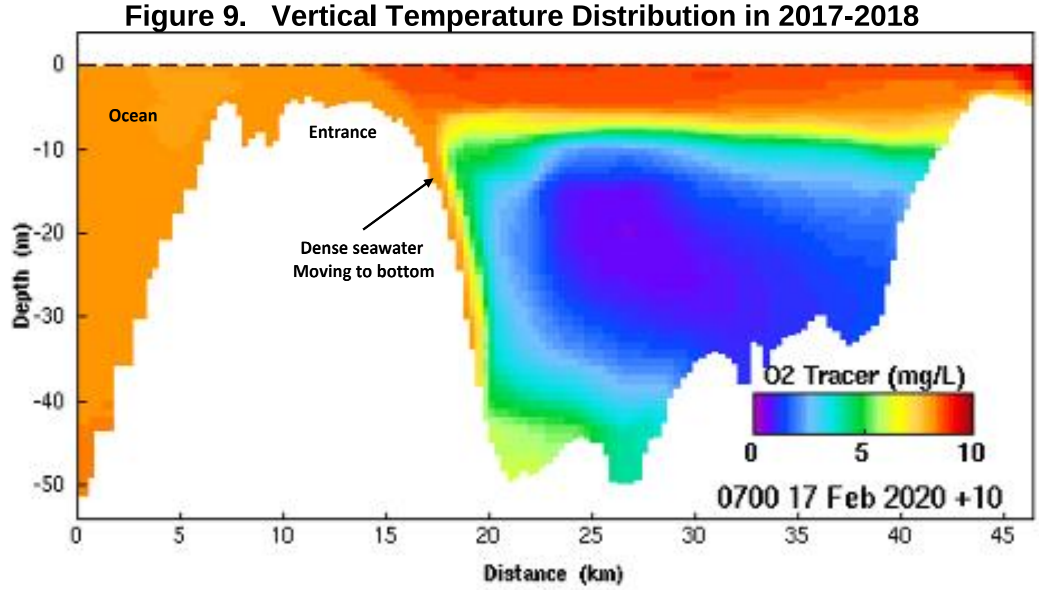
The analysis of vertical profiles of salinity, dissolved oxygen and density is based on a string of monitoring sensors in the middle of the harbour. IMAS maintains the sensors and reported that salinity and density conditions are very similar along the main NW-SE axis of the harbour, based on the correspondence of results for several vertical strings of sensors. The changes over the depth, and with time, are much greater than the changes with distance along the axis of the harbour. Thus, the analysis can be described as a 2-D depiction of conditions.

Conditions near the inlet of the rivers and in the channel connecting the harbour to the ocean differ from the conditions in the bulk of Macquarie Harbour. Near the mouth of the rivers, the freshwater salinity and temperature dominate conditions locally. In the ocean entrance channel, conditions vary over the tide cycle (although river flow rather than tide height dominate the direction of water movement).

In summer, when there is mostly lower river flow, more seawater enters the harbour, and descends down the side to the bed of the estuary. The effect of this plume on temperature is apparent in the summer profiles in Figure 9.

In winter, when there is generally higher river input, the outflow of the surface layer dominates flow in the channel, and there is a smaller inflow of seawater (but some occurs when there is a coincidence of conditions favouring seawater inflow).

Figure 9. Vertical Temperature Distribution in 2017-2018



Source: Wild Allen et al, Macquarie Harbour Oxygen Process model, Fig 2-10, CSIRO, 2020

Uplifting of lower DO waters can occur in suitable conditions, such as persistent strong westerly winds when river inflow is low and the surface layer is shallow (perhaps with higher than usual salinity). The haloclines are tilted and there is an intrusion of marine water causing an uplift of mid layer water with low DO to near the surface at the northwest end of the harbour. In such an event in March 2018, there were large oscillations in the haloclines along the length of the harbour with higher surface salinity and lower dissolved oxygen at sites close to the harbour entrance. After the event, dissolved oxygen was reported to have increased by more than 50 % in the bottom water.

When the wind is aligned along the major axis of the harbour, it sets up oscillations in sea-level that raise and lower the halocline at opposite ends of the harbour. Conditions around the edges of Macquarie Harbour are more variable than in the middle.

Salinity and Temperature Preference of Skates

Moreno and Semmens (IMAS, 2023) reported on the distribution of Maugean Skate eggs in Macquarie Harbour, with particular reference to depth and DO. The distribution of Skates was assessed from multiple net trawls, diver surveys, and tracking of 25 adult Maugean Skates fitted with multi-sensor acoustic tags by 52 acoustic receivers in the Table Head/Liberty Point region of Macquarie Harbour over a 12-month period from Nov 2018 to Nov 2019.

The 25 tagged Maugean Skate were mature individuals ranging from 620 and 820 mm in size. Two of the tagged skate exited the array within a few days of release and were not detected again during the study period. Five individuals exited the array area at 2 to 8 months after release and were not detected again.

Eleven skate (eight males and three females) were assumed to have died during the study period. Seven individuals stayed within the array area for the duration of the study and survived for 12 months. The mortality rate (11 of 25 skates in a year) matches the typical mortality rate for skates (40 % per year, Grant et al, 2022) which predicts the loss of 10 skates per year.

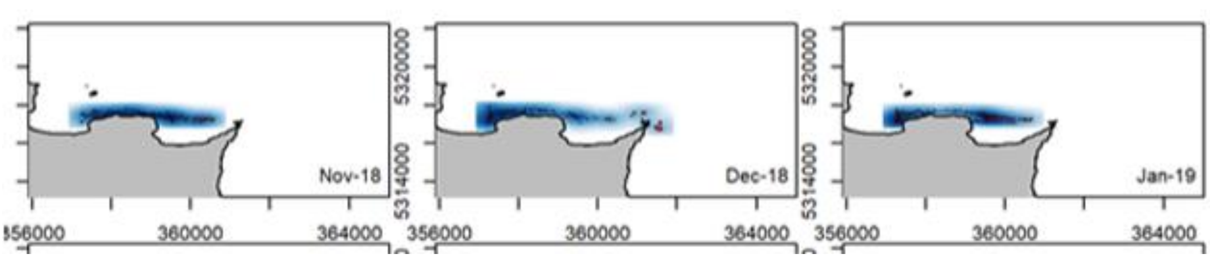
The uplift event in January 2019 has been highlighted earlier in this Technical Memo. The vertical profile for 24 January 2019 showed the DO was at 60 % saturation at 8 m and 50 % saturation at 9 m depth. The salinity at these depths was elevated at 28 ppt at 8 m depth and 28.5 ppt at 9 m depth. This is evidence of a strong salinity uplift event.

The conditions in April 2019 showed a weaker uplift event, with the DO at 60 % saturation at 12 m depth and 50 % saturation at 16 m depth. The salinity at these depths was elevated at 27 ppt at 12 m depth and 30 ppt at 16 m depth.

The location of the mortality events mostly occurred in shallow water (less than 5 m deep) where there was high dissolved oxygen (see Figure 14 of Moreno and Semmens, 2023).

Overall, the skates had small home ranges (< 4 km travel distance, mostly along the depth contours) through which they moved in a consistent manner (see Figure 10). However, at different times of the year, most individuals displayed a change in behaviour where they briefly travelled to sites away from the home range in short excursions (< one week). This travelling was short lived and followed by a return to normal home ranging behaviour.

Figure 10. Travel Paths of Skates at Table Head in 2018-19



The skates had a strong preference for temperatures between 13 to 15°C. During the summer months, when ambient temperatures high in the water column were above that range, individuals spent most of their time at the cooler available sites. The opposite was true during winter, when individuals favoured sites within the preferred range over other much cooler areas.

Figure 11 shows vertical temperature profiles in the 12 months of 2019 with the skates preferred range of 13 to 15°C highlighted. It appears that the temperature in the surface layer (zero to 5 m depth) is too hot in summer and too cold in winter, but just right in spring and autumn. The seasonal variation encourages the skates to move to the 8 m to 15 m depth layer in summer and winter.

Figure 11. Vertical Temperature Profiles in 2019

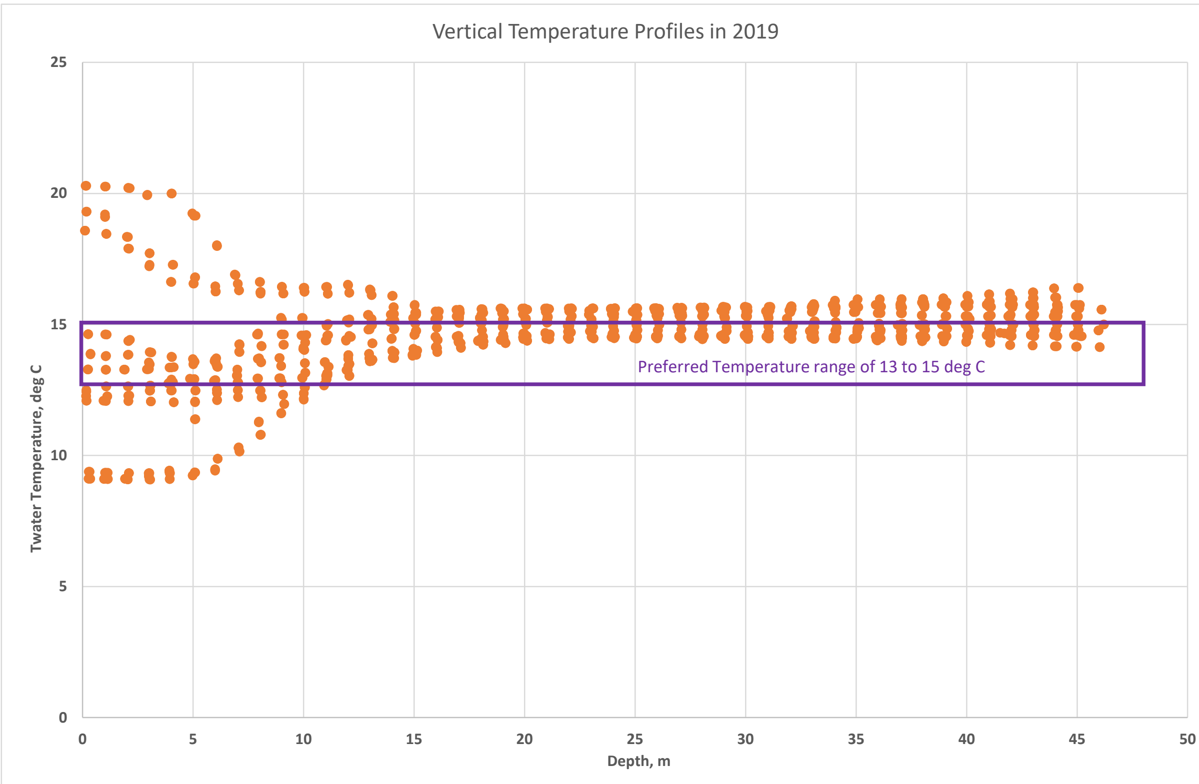


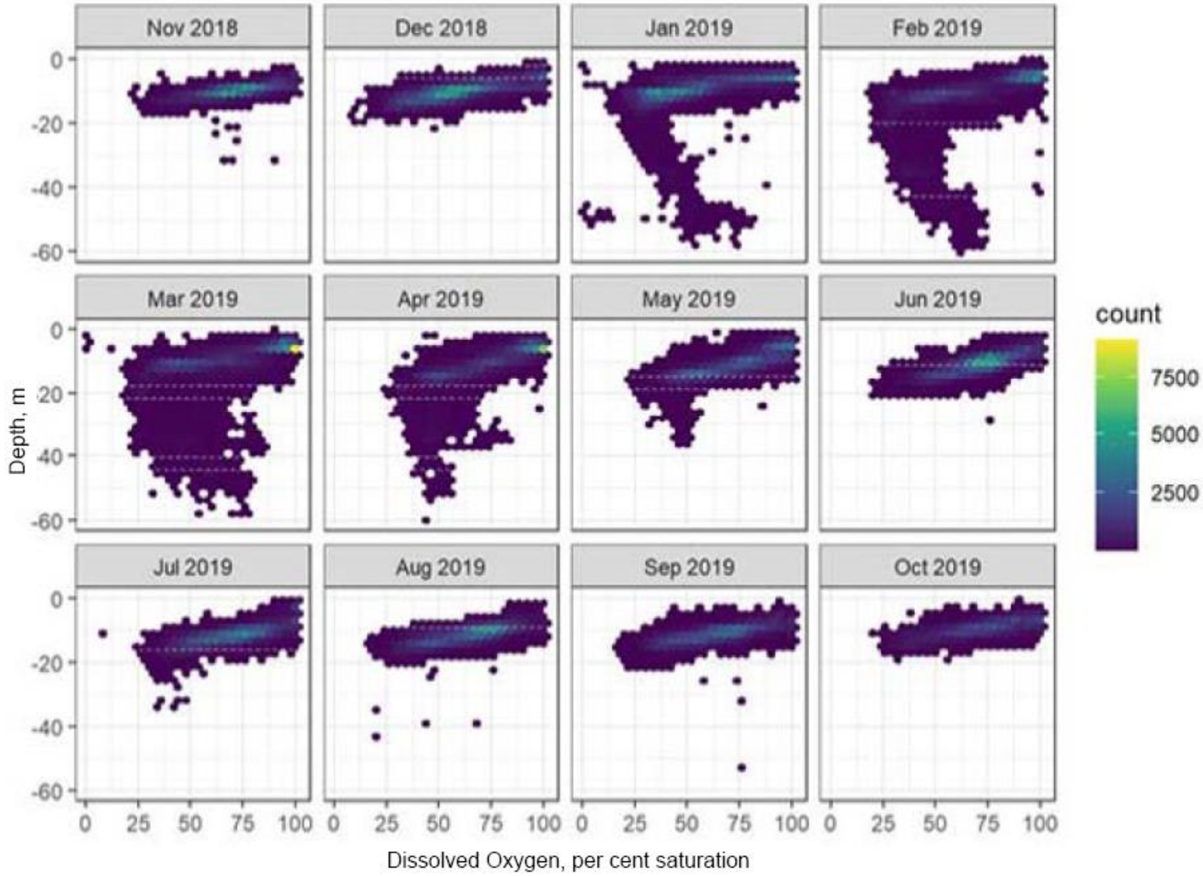
Figure 12 is a plot, month-by-month, of the depths (vertical scale) and DO (horizontal scale) for the monitor records for the seven skate that survived the 12 month monitoring period.

For eight months of the year, the depth range was limited to a maximum of 20 m depth, with most records showing the skate were between 8 m and 15 m depth.

During four months (January to April 2019) the skates were mostly higher in the water column (at 5 m to 10 m depth) but with excursions to 50 m depth (the bed of the harbour). The DO recorded by the monitors ranged from about 30 % at 20 m depth to around 50 % at 50 m depth. These recorded DO conditions are significantly different from the DO recorded by IMAS in the middle of the harbour (see Figure 6). The IMAS sensor string recorded that DO saturation ranged from about 25 % at 20 m depth to around 30 % at 50 m depth.

There is also a large difference between the DO recorded by the skate monitors at 10 m depth (30 % to 100 % saturation) compared to the values recorded by the IMAS sensors in mid-Harbour (mostly 60 % to 80 %, with a single month of 40 %). A possible explanation is that the skates take the opportunity to explore down the slope in the high DO water that occurs during an ocean inflow event.

Figure 12. Vertical Temperature Profiles in 2019



Source: Moreno and Semmens (IMAS, 2023)

This difference is recognized by Moreno and Semmens (IMAS, 2023) who noted that tags attached to skates that died in the study showed different DO levels than the water column sensors at the same depth; suggesting that DO conditions within the skate's preferred habitat appear to fluctuate dynamically by depth and horizontally across relatively small spaces.

Further investigations are necessary to determine why the DO conditions at Table Head differ from those in the rest of the harbour, and why Maugean Skates are concentrated in two relatively small zones (Table Head and Swan Basin) on the west side of the harbour.

The paper suggests "*that the deaths (of tagged skates) may have been related to stress caused (directly or indirectly) by the significant changes in the environmental conditions of the harbour. If this is the case, then recent changes in the environmental health of the harbour (especially dissolved oxygen levels), coupled with the consequences of climate change (including occurrence of extreme weather events), may already be challenging the skate's capacity to cope with the environmental conditions in Macquarie Harbour"*

There is no data in the paper that show that there are changes in the environmental health of the harbour. Thus, there is no basis for this inference. The uplift events that occurred in 2019 and which may, or may not, have contributed to increased mortality of skates are a natural occurrence that occurs regularly (as shown in Figures 4 and 15). Other than this extrapolation, and the conflicting DO results, the Moreno and Semmens (IMAS, 2023) paper is an excellent description of the location and behaviour of skates in Macquarie Harbour, and the wide range of environmental conditions that they experience.

Dissolved Oxygen in Macquarie Harbour

Wild-Allen et al (2020) have set out an oxygen balance for Macquarie Harbour for the years 2017-2018. The published oxygen inputs and losses for that period are set out in Table 1. An updated oxygen balance for the operation of the salmon farms is set out below.

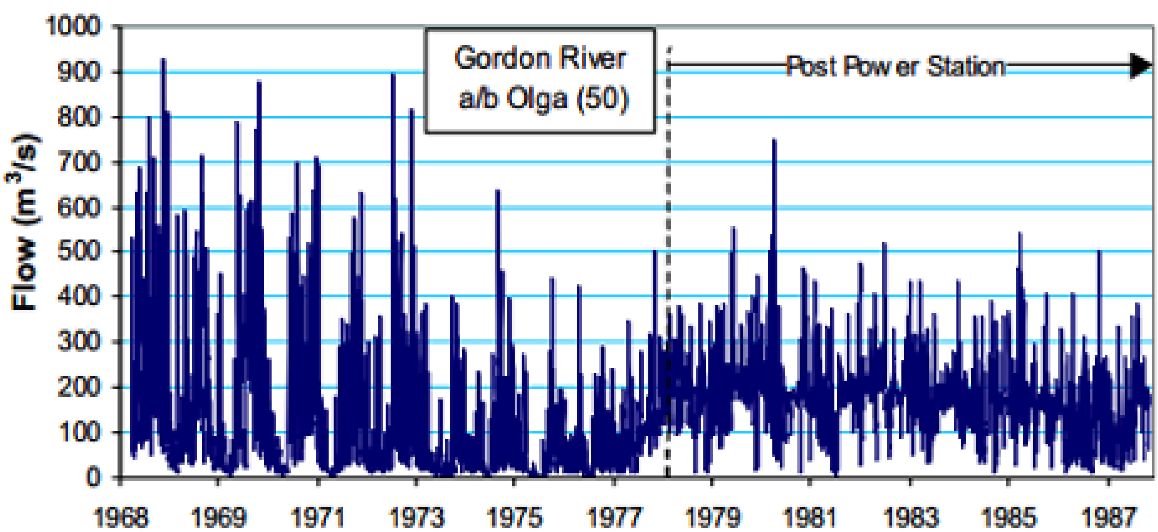
Table 1. Estimated 2017-18 Oxygen Inputs and Losses from Macquarie Harbour

Component	Oxygen, t/yr	Comment
Inputs of Oxygen to Macquarie Harbour		
Oxygen in river inflow	121,000	350 m^3/s at 11 mg/L DO
Oxygen in ocean inflow	14,000	Seems low at 80 m^3/s at 8 mg/L
Re-aeration on surface	11,000	
Phytoplankton and MPB	2,000	
Total inputs of oxygen	***148,000***	
Losses of Oxygen from Macquarie Harbour		
Oxygen in Harbour outflow	129,000	430 m^3/s at 8 mg/L
Accumulation in sediments	12,000	Largely attributed to fish farm solids
Respiration of fish	5,000	50 mg/kg fish per hour for 11,400 t fish
Loss to the atmosphere	2,000	
Total losses of oxygen	***148,000***	

The oxygen balance is dominated by the oxygen that enters the surface layer in river inflow and then leaves as a brackish outflow. The oxygen in ocean water that enters in the channel and descends to the bottom of the harbour involves a smaller amount of oxygen.

The Gordon River power station is the largest power station in Tasmania. The pattern of flow in the river has been changed by the operation of the power station, as illustrated in Figure 13. Flow peaks are attenuated and the base flow rate is increased – this effect can be exacerbated by the requirement to maintain an environmental flow in the rivers. Higher river flow rates correspond to less intrusion of ocean water to the harbour – and less addition of oxygen to the lower layer of the harbour.

Figure 13. Flow Rate in Gordon River – 1968 - 1987



The potential impact of the oxygen demand by salmon farm respiration depends on: (1) the oxygen demand in the vertical profile; and (2) the location of the salmon farms in relation to the areas commonly used by skates.

Vertical Position of Demand

Salmon cages extend from the surface to 13 m depth. The fish move up and down in the cages in response to feeding opportunity, water temperature profile, light, oxygen levels and perceived threats. In winter, salmon can thrive at 2 m to 5 m depth, but in summer they swim at deeper levels (8 m to 11 m) seeking a compromise between lower temperature and lower DO.

I do not have access to data showing a plume of reduced DO near a Macquarie Harbour salmon farm. The measurements of Oldham et al (2018) indicate a reduction of 3 to 5 % in DO in salmon cages in the Huon estuary.

For Macquarie Harbour, a typical salmon farm may be 168 m in diameter with 100 t of fish in a 3 m deep layer. Oxygen demand at 50 mg/kg fish/hr (CSIRO, 2021) is 5 kg/hr.

The flow of water through the school of fish in the cage at a typical velocity of 0.04 m/s is 20 m^3/s or 72,000 m^3/hr. In the surface layer, the DO concentration is 9 mg/L, so the oxygen flux is 650 kg/hr. In the deeper layer, the DO concentration is 6 mg/L, so the oxygen flux is 430 kg/hr. The reduction in DO downstream of a fish cage due to fish respiration is around 1 % or 0.06 mg/L (small).

The depth preferences for skate, reported earlier, shows that the depth range was mostly between 8 m and 15 m depth, so that skate could potentially be affected by the plume from the cages in summer. In winter, the plume of reduced DO water from the salmon farms flows out to the ocean (at undetectably lower concentrations than without salmon farms).

Location of Salmon Farms Relative to Skate Locations

Most skates were found at Table Head, which is around 1.5 km west of the salmon farms. There are five other verified habitats for skates around the perimeter of Macquarie Harbour (DCCEEW, *Conservation Advice for Zearaja maugeana Maugean Skate, 2023*). All are more than 1 km from the nearest salmon pen and the DO in the surface waters at skate sites could not be impacted by respiration of salmon.

Outcome

It is very unlikely that the oxygen demand for salmon respiration can have a direct impact on skates because the reduction in DO is very small at the cages, and even smaller at distance and after the effect of surface re-aeration.

Potential Risk in Bottom Layer DO

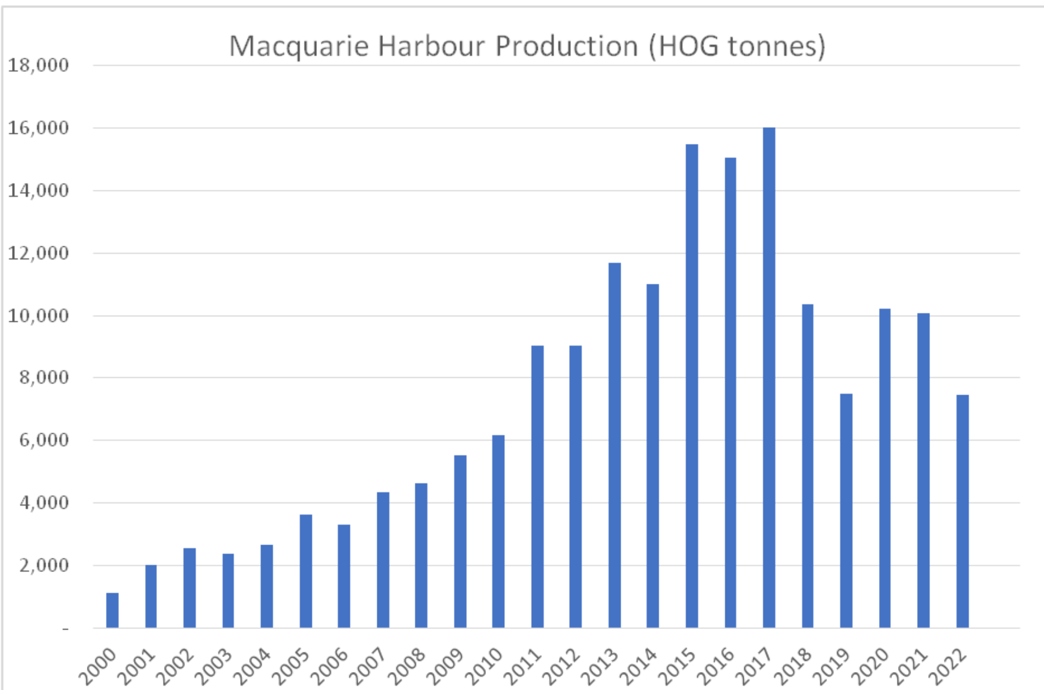
The second consideration is the potential for salmon food and faeces to reduce DO in the lower layer of the harbour from nitrogen and organic solids stimulating bacterial growth in the water column and the sediments with coincident use of oxygen.

The CSIRO model report (Wild-Allen, 2020) estimated that DO load in the sediments due to these processes was 12,000 t/yr, which is close to the estimated input of oxygen from the ocean (of 14,000 t/yr). This is the critical balance that determines the oxygen conditions that skate experience on their deep dives. The model predicted that if the 12,000 t/yr sediment load was removed, DO in the lower layer would increase by around 1 to 2 mg/L at 25 to 35 m depth (Fig 4-40 of CSIRO report). This assumption is checked in this Technical Memo.

Nitrogen and Organics Balance

According to Ross (IMAS, 2022) potential environmental impacts of salmon farms in the water column stem predominantly from the introduction of nitrogen (N) and phosphorus (P). However, carbon addition in fish feed is equally important as respiration of fish coverts a proportion of the carbon supplied to carbon dioxide. Thus an updated nitrogen and carbon balance for salmon farms in Macquarie Harbour is provided in the following section for the year 2023. The mass balance is based on published information, particularly the mass balances published by Wang et al (2013) and Wang and Olsen (2023). The mass balance reflects the lower salmon production in 2018-2023 compared to 2013-2017, as shown in the production plot in Figure 14.

Figure 14. Salmon Farms Production in Macquarie Harbour (t/year)

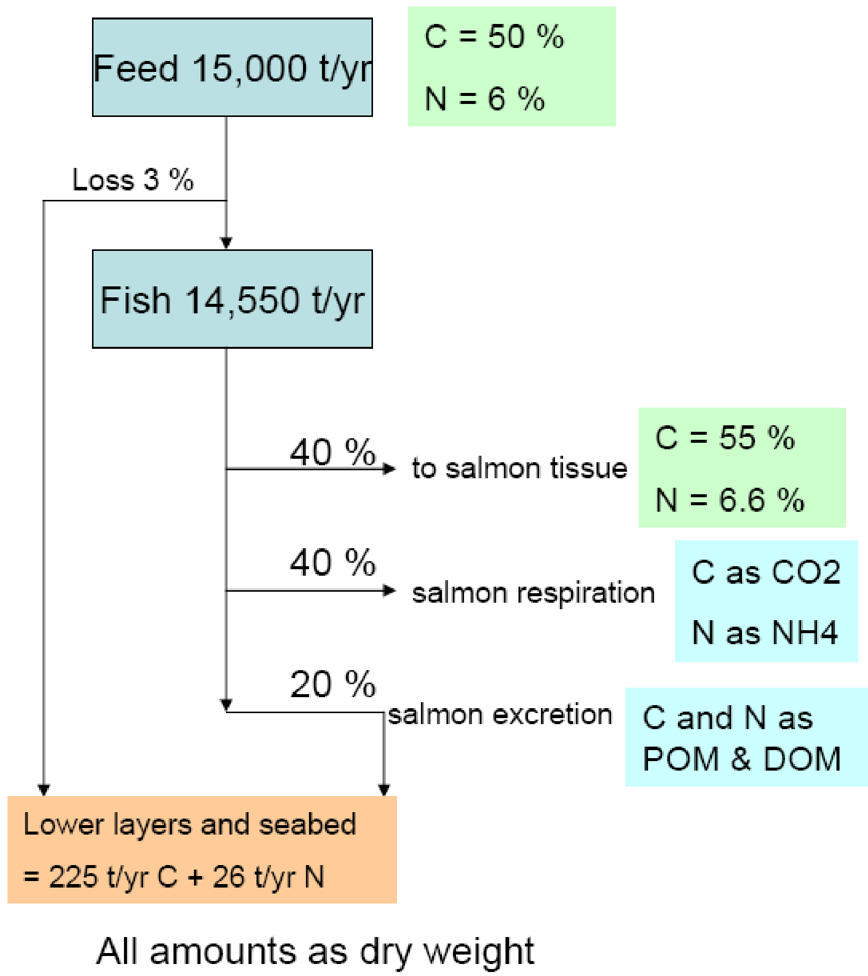


Modern salmon farms are very efficient in their use of feed (97 % of feed is reported to be eaten by the fish and only 3 % escapes the fish cage). The feed is optimized for growth of salmon and 40 % of the feed is assimilated by the fish and converted to salmon mass.

Figure 15 shows the mass balance for fish feed supplied to all salmon farms in Macquarie Harbour. The same pathways apply to carbon and nitrogen, as explained below.

The feed input to salmon farms follows a seasonal pattern with peak input in Oct to Dec each year, and lower inputs in autumn to winter. Total inputs increased steadily from year 2000 to a maximum in 2017 (see Figure 14). Following Harbour wide declines in DO and associated declines in benthic faunal abundance (Ross et al., 2017), the permissible aquaculture biomass in Macquarie Harbour was reduced, and feed input since 2017 has been about half the earlier peak rate. Based on available data, the total input of fish feed in 2023 is estimated to be 15,000 dry tonnes.

Figure 15. Schematic Mass Balance for Fish Feed in Macquarie Harbour



The fish feed (of 15,000 t/yr as dry weight) is assumed to have a carbon content of 50 % and a nitrogen content of 6 % (based on Wang and Olsen, 2023). Other constituents of the fish feed are phosphorus, hydrogen, oxygen and trace elements.

The loss of fish feed through the base of the cages is 3 % or 450 t/yr, which corresponds to 225 t/yr of carbon and 26 t/yr of nitrogen. The fate and related oxygen demand of the lost fish feed is considered in conjunction with salmon excretion.

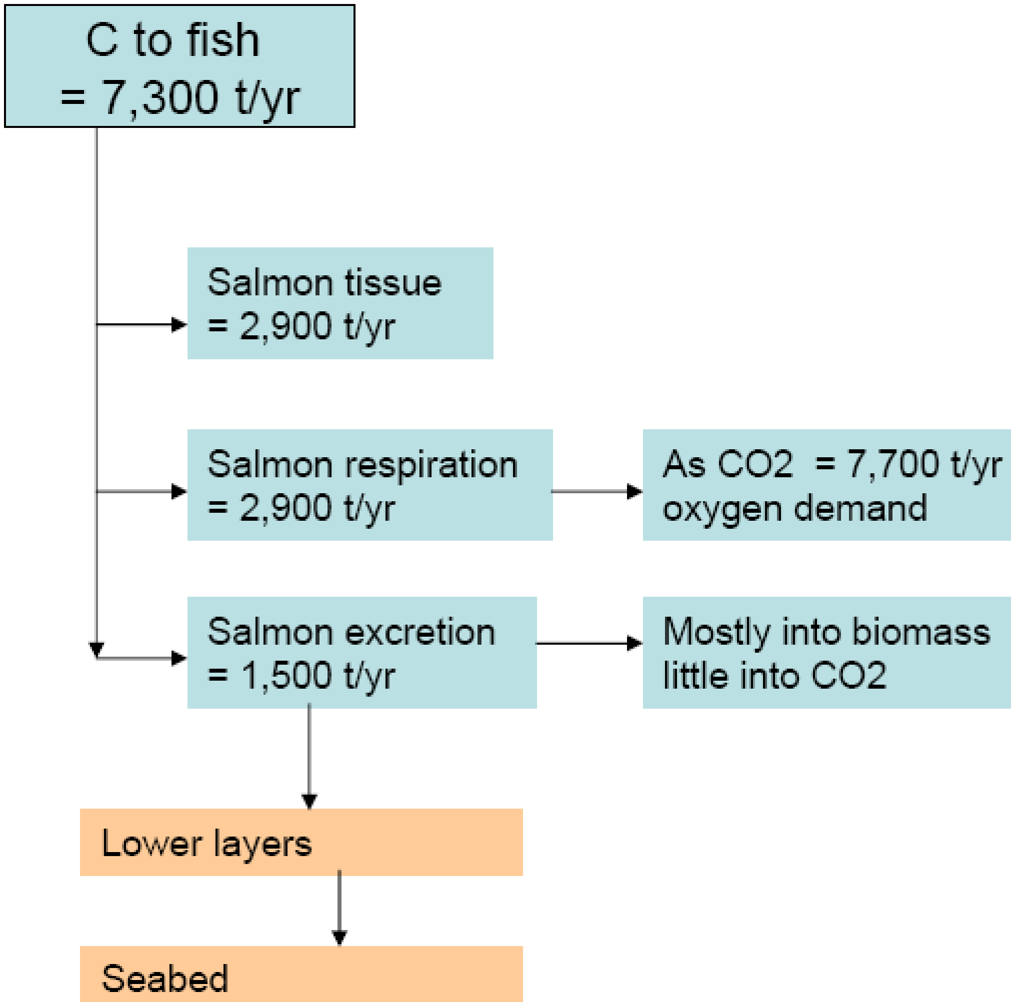
Growth or production of salmon is estimated to be 40 % of the fish feed, as an average over the year. It is recognized that the growth rate varies with the seasonal temperature and other conditions, but the feed rate is altered to adjust for this, and this balance is based on the average conditions over the year.

Salmon use an estimated 40 % of carbon for respiration and also release at the gills an estimated 40 % of nitrogen mostly as ammonia with a small proportion of urea (NH_2CONH_2).

To complete the balance, an estimated 20 % of the feed is assimilated by the fish and excreted as a combination of particulate organic matter (POM) and dissolved organic matter (DOM).

Figure 16 shows the extension of the mass balance for carbon.

Figure 16. Carbon Mass Balance for Fish Feed in Macquarie Harbour



The carbon balance shows the salmon assimilate 7,300 t/yr of carbon. Of this, 40 % goes into salmon growth (2,900 t/yr), 40 % goes into salmon respiration (2,900 t/yr) and 20 % goes into excretion.

Salmon Tissue

Salmon tissue is reported to have a carbon content of 55 %. Thus, the growth of salmon corresponds to 5,300 t/yr of salmon production (2,900 / 0.55 = 5,300). Allowing for 30 % water in adult salmon, the production rate is approximately 7,600 t/yr (which corresponds to the production rate in Figure 14).

Salmon Respiration

Salmon respiration converts 2,900 t/yr of carbon into 10,600 t/yr of carbon dioxide, which involves the fish withdrawing 7,700 t/yr of dissolved oxygen from the waters surrounding them.

Google Earth shows 77 farm cages in Macquarie Harbour, so this corresponds to 100 t oxygen demand/yr/cage. As noted earlier, the flow of water through the school of fish in the cage at a typical velocity of 0.04 m/s is 20 m^3/s or 72,000 m^3/hr. On average, the oxygen demand for respiration of 7,700 t/yr corresponds to 0.16 mg/L reduction in dissolved oxygen.
The peak rate in spring could be up to 0.3 mg/L DO. As surface DO is in the range of 7 to

8 mg/L, this estimate is close to the 3 % to 5 % measured by Oldham et al (2018).

Implications of Respiration on DO

Figures 5 to 7 show the DO at 10 m depth is typically at 60 % to 80 % saturation, reflecting a 2 to 3 mg/L reduction in DO. Most of this reduction can be attributed to the large oxygen demand from river inputs (see Table 1), respiration from the salmon farms also reduced oxygen concentration (albeit much smaller).

There is a strong gradient in DO from the surface to depth in the harbour. Thus, essentially all the oxygen demand in the surface layer by salmon is matched by an input of oxygen from surface re-aeration. Also, some of the oxygen demand is flushed to the ocean in the daily surface outflow.

The DO demand from respiration has no effect on dissolved oxygen levels in the deeper waters (at 15 to 30 m depth).

Salmon Excretion of Carbon

Salmon excreta is a combination of particulate organic matter and dissolved organic matter. Typically, the carbon and nitrogen content of fish excreta is lower than in the feed (Elvines, et al, 2023). Available data suggests that the carbon content decreases from 50 % in the feed to 35 % in the excreta while the nitrogen content decreases from 6 % in the feed to 4.5 % in the excreta. Nonetheless, the 1500 t/yr of carbon shown in Figure 16 is retained for this oxygen consumption analysis.

The excreta is processed by a range of small animals and bacteria in the water column and on the bed of the harbour (if the particles make it to the bed without being consumed). Ultimately the carbon ends up as living tissue in the water column (a small amount) or as sludge on the bed. A minor amount may be transported upward by free-swimming organisms and lost to the ocean in the harbour outflow.

For the calculation of oxygen demand, the following assumptions are made:

- One-third of the excreta is assimilated by organisms in the top layer;
- One-third of the excreta is assimilated by organisms in the lower layer;
- One-third of the excreta is assimilated by organisms in the harbour bed;
- The COD corresponds to complete conversion of C to CO_2;
- The BOD corresponds to a COD/BOD ratio of 2.0, as for similar faecal matter.

On this basis, the following calculations of oxygen demand in the lower layer/bed ensue:

- Total BOD due to carbon excretion is 4,000 t/yr;
- The BOD in the top layer is 1,330 t/yr;
- The BOD in the lower layer is 1,330 t/yr;
- The BOD on the seabed is 1,340 t/yr.

Experience in shallow treatment ponds (2 m to 4 m deep) is that most of the BOD is exerted by organisms on the bed. Macquarie Harbour is much deeper, and the food path and depth ranges for the use of the carbon (and nutrients) is not established as yet, so it is assumed that one third of carbon is assimilated in each of the top layer, lower layer and the bed.

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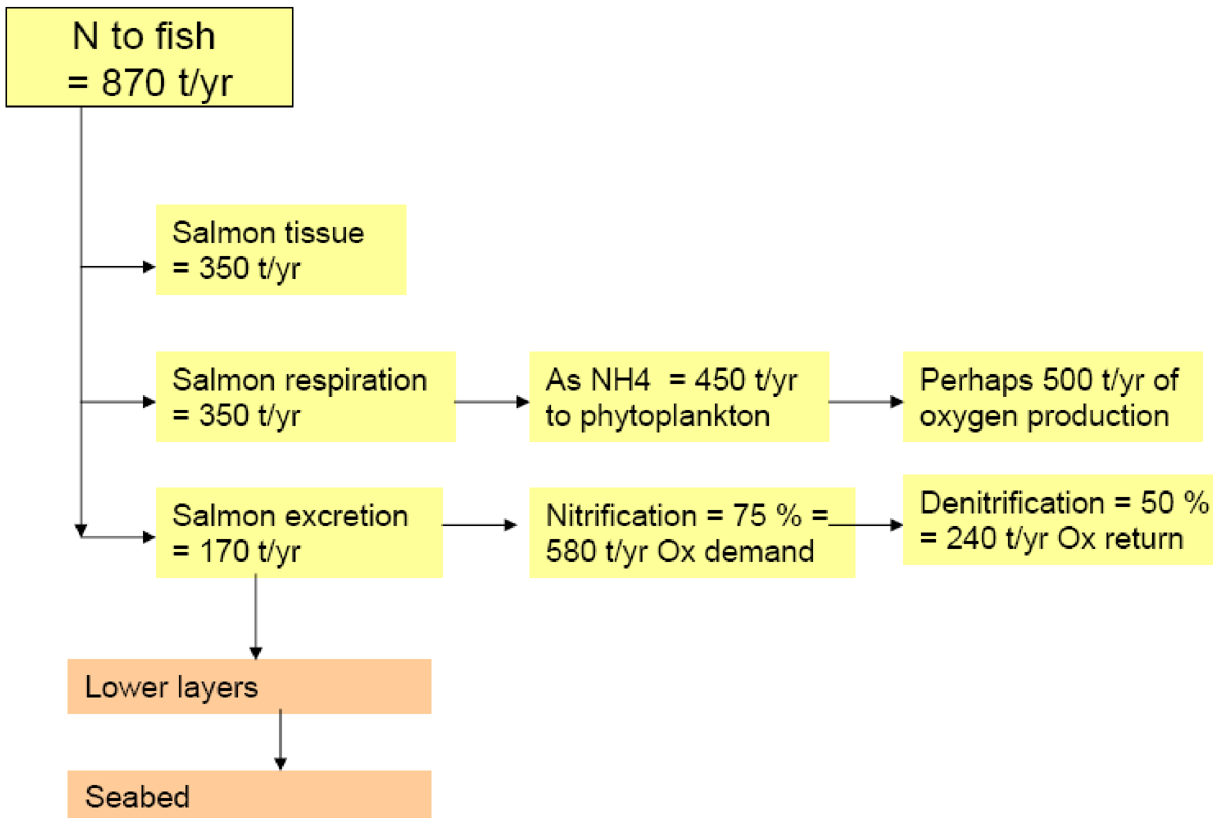
Figure 17 shows the extension of the mass balance for nitrogen, starting with the 870 t N/yr assimilated by the fish.

Figure 17. Nitrogen Mass Balance for Fish Feed in Macquarie Harbour



The nitrogen balance shows that salmon growth uses 350 t/yr of nitrogen. Salmon release excess nitrogen at the gills in the form of ammonia and urea (assumed to be all ammonia). There is 170 t/yr of nitrogen in salmon excreta.

Salmon Tissue

Salmon tissue is reported to have a nitrogen content of 6.6 % (Wang and Olsen, 2023). Thus, the growth of salmon corresponds to 5,300 t/yr of salmon production (350 / 0.066 = 5,300). Allowing for 30 % water in adult salmon, the production rate is approximately 7,600 t/yr (which corresponds to the production rate in Figure 14).

Salmon Release of Excess Ammonia

Salmon release 350 t/yr of nitrogen as ammonia which rapidly dissolves in the seawater in the top layer. In other marine waters, the ammonia would be assimilated by phytoplankton or macrophytes in a few hours. There are no macrophytes near the fish cages, but field surveys have identified that the chlorophyll-a concentration over the top 15 m of the water layer is typically around 1 µg/L which shows there is sufficient phytoplankton habituated to the low light conditions of the harbour to take up the ammonia. The IMAS field surveys also demonstrate that there is no increase in ammonia in the surface waters which confirms that it has been assimilated.

The quantity of phytoplankton supported by a nitrogen discharge (as ammonia) of 350 t/yr is calculated using the Redfield ratio(Redfield, 1958), which states that the average composition of ocean plankton is 106C : 16N : 1 P.

Applying the ratio, the supply of 350 t/yr of ammonia would encourage the growth of around 3,000 t of phytoplankton (8 t/day) which through photosynthesis would supply around 3,600 t of oxygen to the surface layer.

It is not considered that the ammonia release has any effect on dissolved oxygen levels in the deeper waters (at 15 to 30 m depth) as the ammonia is dissolved and assimilated in the top layer.

Salmon Excretion of Nitrogen

As noted above, typically the carbon and nitrogen content of fish excreta is lower than in the feed (Elvines, et al, 2023). Available data suggests that the nitrogen content decreases from 6 % in the feed to 4.5 % in the excreta. Nonetheless, the 170 t/yr of carbon shown in Figure 17 is retained for this oxygen consumption analysis.

The excreta is processed by a range of small animals and bacteria in the water column and on the bed of the harbour (if the particles make it to the bed without being consumed). Ultimately the carbon ends up as living tissue in the water column (a small amount) or as sludge on the bed. A minor amount may be transported upward by free-swimming organisms and lost to the ocean in the harbour outflow.

Nitrification is the natural process that occurs in the environment by a group of specialised bacteria in which ammonia ($NH4^{+}$) is converted to nitrites ($NO2^{-}$) and then to nitrates (NO_3^{-}). The theoretical oxygen demand for this process is 4.57 g O_2/g $NH4^{+}$). The pH in Macquarie Harbour is optimum for nitrification and denitrification.

Denitrification is a related natural process by another group of specialized anaerobic bacteria that convert nitrate to nitrogen gas and release water and oxygen. The theoretical oxygen recovered is 2.86 g O_2/g NO_3^{-} reduced. The overall oxygen requirement for combined nitrification/denitrification is 1.7 g O_2 consumed per g of ammonia.

Neither nitrification nor denitrification is 100 % effective, and both processes are limited by low water temperature (and elevated DO in the case of denitrification). Based on analysis of nitrogen removal in wastewater treatment lagoons at Strahan (TasWater, 2023), nitrification in the region is about 75 % effective and denitrification is about 50 % effective.

For the calculation of oxygen demand, the following assumptions are made:

- Bacteria are assumed to nitrify and denitrify the released nitrogen;
- Oxygen requirement for nitrification is 4.6 g per g of nitrogen;
- The nitrification efficiency is assumed to be 75 %, based on the nitrification efficiency of the adjacent Strahan sewage treatment lagoons;
- Oxygen return from denitrification is 2.8 g per g of nitrogen;
- The denitrification efficiency is assumed to be 50 %, based on the denitrification efficiency of the adjacent Strahan sewage treatment lagoons.
- The remaining 25 % of excreted nitrogen is stored on the bed as dead tissue (sludge).
- One third of carbon is assimilated in each of top layer, lower layer and the bed.

On this basis, the following calculations of oxygen demand ensue:

- The oxygen demand for nitrification is 580 t/yr (factor is 4.6);
- The oxygen return from denitrification is 240 t/yr (factor is 2.8);
- The net oxygen demand in the water column is 340 t/yr.
- The net oxygen demand in the upper layer is 110 t/yr.
- The net oxygen demand in the lower layer column is 110 t/yr.

The remainder of the nitrogen in excreta is converted into tissue of bacteria/fungi and other micro-organisms and accumulated in the bed as sludge.

Lost Salmon Feed

As shown in Figure 15, 450 t/yr of salmon feed containing 225 t/yr of carbon and 26 t/yr of nitrogen falls through the salmon cages.

The most likely fate of the lost salmon feed is that native fish spend time under the cages and assimilate most of the excess feed coming down into their habitat. The remainder experience the fate of salmon excreta.

Alternatively. The lost feed can be consumed by bacteria. Using the same parameters as for the excreta load, the net effect on oxygen demand is as follows:

- Carbon in lost feed assimilated by organisms is 225 t/yr;
- The corresponding COD is 600 t/yr (complete conversion of C to CO_2);
- The corresponding BOD is 300 t/yr (biological conversion of C to tissue).
- One third of carbon is assimilated in each of top layer, lower layer and the bed;
- Oxygen demand from carbon in top layer is 100 t/yr;
- Oxygen demand from carbon in lower layer is 100 t/yr.

- Nitrogen in lost feed assimilated by organisms is 26 t/yr;
- The oxygen demand for nitrification is 72 t/yr (factor is 4.6);
- The oxygen return from denitrification is 36 t/yr (factor is 2.8);
- The net oxygen demand due to nitrogen in feed in the water column is 36 t/yr.
- One third of carbon is assimilated in each of top layer, lower layer and the bed;
- Oxygen demand from nitrogen in top layer is 12 t/yr;
- Oxygen demand from nitrogen in lower layer is 12 t/yr;
- The remainder of the nitrogen in lost feed is converted to sludge in the bed.

Oxygen Balance for Top Layer

The oxygen demand due to salmon farms in the top layer is estimated to comprise:

1. 7,700 t/yr due to salmon respiration;
2. 1,330 t/yr from bacterial demand to convert carbon in salmon excreta;
3. 110 t/yr from net nitrification of salmon excreta;
4. 100 t/yr due to carbon conversion of lost feed;
5. 12 t/yr due to net nitrification of lost feed;
6. -3,600 t/yr of oxygen returned from phytoplankton growth.

The total oxygen demand in the top layer is 5,650 t/yr. This is about 4 % of the estimated oxygen supply to the upper layer of the harbour of 134,000 t/yr (see Table 1). The volume of the top layer (surface to 10 m depth) is 1.8 x 10^9 m^3. The average flushing time is 35 days, and the average DO concentration is about 7.4 mg/L (=134,000 t/yr / 1.8 x 10^9 m^3 / 35 x 365). Measured oxygen levels in the top layer range from 5 to 8 mg/L, which matches the calculated average value of 7.4 mg/L.

The salmon farms reduce the DO in the top layer by 4 % or 0.3 mg/L (=5,650 t/yr/1.8 x 10^9 m^3 / 35 x 365). This minor decrease would have negligible effect on the survival of the skates in their normal habitat in the top layer near Table Head.

Oxygen Balance for Lower Layer

The oxygen demand due to salmon farms in the lower layer is estimated to comprise:

1. 1,330 t/yr from bacterial demand to convert carbon in salmon excreta;
2. 230 t/yr from net nitrification of salmon excreta;
3. 200 t/yr due to carbon conversion of lost feed;
4. 12 t/yr due to net nitrification of lost feed.

The total demand in the lower layer is 1,770 t/yr. This is about 16 % of the estimated oxygen supply from the ocean to the lower layer of the harbour of 11,000 t/yr (from Table 1). Alternatively, the estimated ocean water inflow averaging 80 m^3/s over a year with a DO of 7 mg/L would contribute 17,000 t/yr, and the demand of the salmon farms in the lower layer of water would be around 10 % of the estimated oxygen supply.

Uncertainties

The main uncertainty is the depth at which the conversion of carbon to tissue (requiring oxygen) and nitrogen into nitrate and nitrogen gas (requiring oxygen) occur. This analysis has assumed that most of the conversions occur in the water column, mostly on the basis of the depth of the harbour and the measured oxygen sag at mid-water depth.

If fully saturated, the waters of the lower layer between 15 m and 35 m depth would contain about 10,000 t of dissolved oxygen. The vertical profiles of dissolved oxygen show that about 75 % of the oxygen in this layer is consumed. Assuming a typical residence time of 1 year, the total oxygen reduction in the lower layer is around 7,500 t/yr.

An estimate of the oxygen demand in the lower layer can be made from:

- 5 % of the river inflow oxygen demand (5 % of 121,000 t/yr = 6,000 t/yr);
- Estimated salmon farm demand of 1,770 t/yr;
- Extra 500 t/yr from settlement of native marine organisms in the harbour.

These are approximate estimates that total 8,270 t/yr; the total matches the calculated oxygen reduction of 7,500 t/yr. As a corollary, the calculated oxygen demand from the salmon farms is considered to be approximately correct.

The estimated average effect of the salmon farms is to reduce the dissolved oxygen in the lower layer by around 16 per cent or 1 mg/L. There will be seasonal and spatial variations which can only be explored using a calibrated 3-D model and following further research to gain a better understanding of the biochemical processing involving oxygen and biota in Harbour waters – particularly the lower layer.

This estimate is lower that the prediction by CSIRO that DO in the lower layer would increase by around 1 to 2 mg/L at 25 to 35 m depth if the 12,000 t/yr salmon load (CSIRO estimate) was removed. The load estimated here of 1,770 t/yr is lower because salmon production in 2017 (the year for the CSIRO prediction) was about twice current levels.

The majority of the oxygen demand on the lower layer comes from the river inflow, with organics settling from the top later into the lower layer. On average, organics from river inflows and natural processes are estimated to reduce the DO in the lower layer to around 35 % saturation. The extra load from salmon farms reduces the DO to around 25 % saturation. These estimates match the measured values in the vertical DO profiles presented earlier.

Concerns about Low Dissolved Oxygen

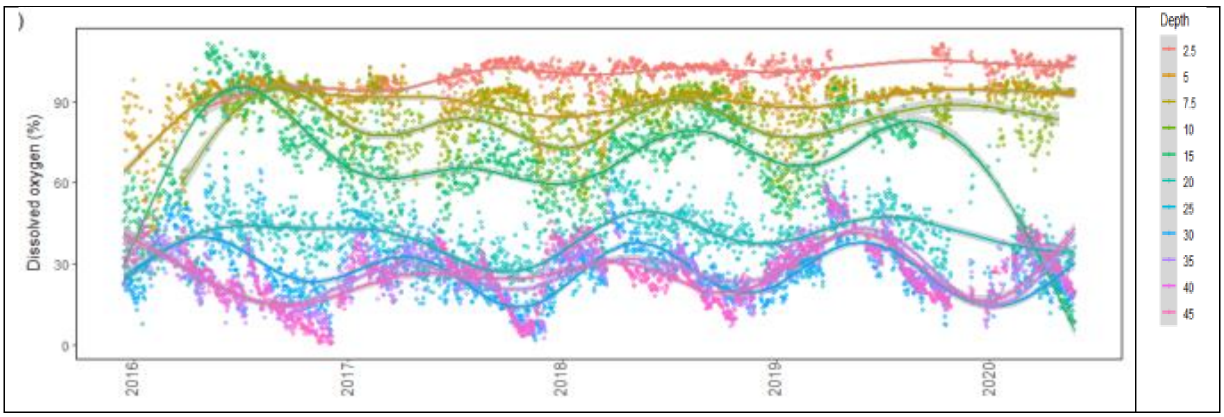
As stated at the beginning of this Technical memo, the main concerns regarding low dissolved oxygen in Macquarie Harbour are:

1. The risk to the survival of the Maugean Skate, which is a threatened species that apparently survives in low numbers only in Macquarie Harbour;
2. The risk to other ecological processes and systems in Macquarie Harbour; and
3. Anoxic or near-anoxic conditions would encourage the movement of metals from the sediments into solution. The metals exist from past mining activities in the catchment and from natural erosion processes.

Implications for Skate Survival

Most records show the skates live mostly between 8 m and 15 m depth with the normal depth range being 2 m to 20 m for eight months of the year. In four months, the skates unexpectedly dived through waters to a depth of about 45 m when the deeper waters had higher DO than the waters at 15 to 20 m depth. Oxygen conditions at Table Head appear to be relatively stable, as shown in Figure 18.

Figure 18. DO at Various Depths at Table Head – 2016-2021



River inflow is the process that determines the extent of ocean water inflow to the harbour, and the oxygen content of the lower layer. High river flows cause less ocean inflow and less oxygen – low river flows result in more ocean inflow and more oxygen in the lower layer.

In the 4000 years since Macquarie Harbour changed from a freshwater lake to a stratified estuary, there must have been many variations in river inflow. It is unlikely that present DO conditions have not been experienced in the past.

The current evidence is that skates normally live in the top layer. Salmon farms reduce the DO in the top layer by 4 % or 0.3 mg/L. This minor decrease would have negligible effect on the survival of the skates in their normal habitat in the top layer near Table Head.

Salmon farms reduce the DO in the lower layer by 10 % to 16 % or 1 mg/L. Skates travel to greater depths at times when the DO at depth is higher than surface levels, so they appear to avoid events with very low DO. Uplift events can reduce DO at 7 to 12 m depth (see Figure 6) but skates appear to avoid this by moving to the ocean inflow region, where high DO ocean water is entering and causing the uplift event.

Implications for Harbour Ecology

Lower DO in the lower layer, combined with higher ammonia and nitrate concentrations inevitably causes a response in ecological conditions in Macquarie Harbour. There will be higher productivity due to the extra available nitrogen.

Ross (2020) notes that conditions in 1999-2003 compared to baseline surveys conducted in 2012 show a change in the broader benthic ecology, as demonstrated by a measurable increase in total abundance, species richness and species diversity. These observed changes include a decrease in burrowing taxa and an increase in more static suspension and deposit feeding tube builders.

DO and Sediments

The DO records show that there is always positive DO below about 30 m from 2018 and below 35 m in 2013-2014. Thus, it is unlikely that precipitated metals will come out into solution. No increase in DO is required at the level of the deep sediments.

Further investigations are required to ascertain the conditions of sediments on the sides of the harbour between 20 m and 35 m depth, and directly under the salmon cages.

Nitrification and TOC

Ammonia is a readily available nutrient and there is some phytoplankton in the upper layers and a range of other micro-organisms that would use the ammonia. It seems very likely that ammonia is being nitrified and converted to nitrate. According to Ross (2022) the conversion of ammonia to nitrate occurs throughout the entire water column, and the increase in nitrate concentration in deeper waters suggests that nitrification is significant in the sediments and the water column. This is consistent with the findings of Ross et al. (2016a) and Maxey et al. (2016) who found that the abundance of ammonia-oxidising archaea and rates of nitrification, respectively, increased markedly with depth in the harbour.

It is noted that the DO minimum in Macquarie Harbour occurs at around 20 to 25 m depth. It may be that most nitrification occurs in that depth range, causing a deficit of oxygen. However, nitrification is expected to occur mostly in the sediments, adding oxygen near the bed.

Total organic carbon (TOC) concentration is highly seasonal in the shallow waters (1, 2 and 5 m) with the highest concentrations occurring in winter and lowest occurring during summer/autumn. In deeper waters (10, 20 and 31 m), TOC is relatively stable. This indicates that most of the organic carbon entering Macquarie Harbour is from riverine sources because concentrations are highest above the halocline in fresh water and the seasonal peaks occur during the cooler months when riverine inputs are greatest. Aquaculture would account for a relatively small fraction of TOC in the harbour.

Conclusion

This analysis has confirmed the findings of previous reviews that river flows control the flushing time of the surface layer and the influx of ocean water into the lower layer. For the foreseeable future, DO conditions in the harbour are controlled by seasonal weather and long period rainfall cycles. Long term, climate change will also have an influence.

The aim of this Technical Memo is to estimate the amount of oxygen input required to balance the oxygen demand from the salmon farms in Macquarie Harbour and the best locations to add that oxygen.

It is concluded that to fully compensate for the salmon farms, the amount of oxygen that would need to be added to the lower layer is approximately **1,770 t/yr**. Further research is required to refine this estimate and to assess whether continual or just seasonal oxygen input would be satisfactory. It is possible that just event-driven input could be optimum.

For the pilot study of re-oxygenation, it would be appropriate to add the oxygen at 30 m depth. It should be noted that an increase in DO of around 1 mg/L is predicted, although that depends on mixing rates (lower mixing rates could allow an increase of up to 2 mg/L) and biological uptake (enhanced biological uptake of the oxygen could result in an increase of only 0.5 mg/L).

TASSAL GROUP LIMITED
ABN 15 106 067 270
GPO Box 1645, Hobart, TAS 7001
1300 660 491
tassal@tassal.com.au
tassalgroup.com.au | tassal.com.au

2 February 2024

Hon Tanya Plibersek MP
Minister for the Environment and Water
House of Representatives
Parliament House
GPO Box 3090
CANBERRA 2601

Dear Minister

REQUEST FOR RECONSIDERATION OF DECISION – MARINE FARMING EXPANSION, MACQUARIE HARBOUR, TASMANIA (EPBC 2012/6406)

Thank you for providing Tassal with the opportunity to consider and provide comment on the reconsideration requests received by yourself, namely requests for reconsideration by:

- The Australia Institute;
- Bob Brown Foundation Inc (BBF); and
- Australian Marine Conservation Society and the Humane Society International

(together the **Requestors**).

Tassal's Position

Tassal completely endorses Salmon Tasmania's submission in respect of this matter and believes that the Minister should confirm that the existing NCA-PM conditions for EPBC Referral 2012/6406 are appropriate.

The Minister should not be satisfied that it is warranted to revoke the NCA-PM Decision and to substitute a new decision that the Marine Farming Expansion is a controlled action.

None of the asserted grounds that are relied upon by the Requestors are in fact made out in the information provided in, or referenced by, the Requestors' documents, specifically:

- there is **no** substantial new information available about the impacts salmon farming is having (or will have or is likely to have) on the Maugean Skate;

- there is **no** substantial change in circumstances that were not foreseen at the time of the NCA-PM decision and it relates to the impacts that salmon farming is having (or will have or is likely to have) on the Maugean Skate.

As a result of our complete endorsement of Salmon Tasmania's submission we do not seek to duplicate the details and analysis in this submission as to why the grounds relied on by the Requestors are invalid. The Salman Tasmania submission is to be relied upon for the legal and technical arguments as to the Requestors' invalid position. Tassal provides this submission to enhance understanding of the industry from Tassal's perspective.

Tassal contends that the adaptive (and proactive) management approach of both the Tasmanian Government, the Environment Protection Agency and the salmon industry over the last 10+ years has sufficiently addressed the nature and extent of environmental impacts in Macquarie Harbour, as and when scientific information has shown the need to adapt its management to suit environmental conditions of Macquarie Harbour.

A cessation of aquaculture in Macquarie Harbour would be catastrophic for Tassal and our employees in that region. The practical implications of this are incomprehensible to our people, the community and animal welfare impacts that would result from mass euthanasia of our salmon stock.

About Tassal, our Industry and the West Coast Community

Tassal Group is an Australian aquaculture leader and leading seafood brand. With more than 35 years' experience and almost 2000 staff, our passion drives our commitment to meet the growing market and customer demand for healthy, sustainable and nutritious food.

In November 2022 Tassal Group was acquired by Cooke Inc which is one of the largest global aquaculture and seafood group of companies and which produces salmon, sea bass, shrimp/prawns, and wild fisheries as its core business. The investment in the Tassal Group by Cooke Inc of $1.7billion also brings into the Tassal Group global experience, expertise, capabilities, innovation and support for the development of Australian aquaculture. International investment in Australian aquaculture needs to be maintained by the proper application of Australia's legal framework to promote investor confidence across Australia's business sectors, including aquaculture.

Our roots however remain grounded in Australia and although based in Tasmania – our farming now extends to Western Australia, Victoria, New South Wales and Queensland. We have expanded and diversified our aquaculture operations to include Atlantic salmon, prawns and barramundi within our species portfolio.

Tassal, our people and the Tasmanian salmon industry support sustainable development while caring for the environment and communities within which we are embedded. We hold the view that healthy functioning waterways are critical ingredients for both our and Tasmania's economic and social prosperity. This is particularly relevant to this submission, especially for the West Coast community and the ongoing environmental management of Macquarie Harbour.

Specifically, Tassal's operations in Macquarie Harbour are critical to our business for the following key reasons:

- This farming region provides important supply to ensure we can maintain critical year-round supply to our key retail and export markets. We have in place retail contracts for up to 3 years supply at any point in time.
- Provides direct employment for 32 FTEs, many of whom both live with their families and attend the local school in Strahan.
- With Tassal's strategy to focus on local suppliers, we spend circa $8.2m per annum directly in the region.

Any pause or reduction in the production of salmon in Macquarie Harbour would have vast and significant economic and social consequences for the West Coast and broader Tasmanian community.

The economic benefits generated by the salmon industry, by virtue of its Macquarie Harbour farming operations, are significant. The industry's operations in Macquarie Harbour employ 395 FTEs (direct and indirect roles). Importantly, 1 in 3 residents in the township of Strahan are employed by this industry.

Salmon farming has developed into a sophisticated and modern industry – our employees are highly skilled and very well trained. The average remuneration of a Tassal employee working in Macquarie Harbour is up to 74%[1] more than other workers in the West Coast region.

Tassal is fully involved with and committed to the social and cultural fabric of the West Coast Community. In practice, this means our workers and their families support local suppliers and shop locally, are members of the local sporting clubs, support the need for local medical care and send their children to local schools. Our active engagement with this community is highlighted through the following programs:

- **Tassal Community Foundation** - supporting a range of local community activities through sponsorships, donations and support in-kind;
- **Strahan Community Aquaculture Forum** – local, community-led engagement platform;
- **Tassal School Breakfast Program** – health & wellbeing program;
- **Mount Lyell Strahan Picnic Day** – regional cultural program;
- **Queenstown Crows Football Club;**
- **Shoreline Clean ups West Coast;**
- **Whale Rescue Support;** and
- **Marine Rescues** - often first responders for vessels in distress.

Environmental Responsibility & credentials

Environmental Responsibility is inextricably linked to the ongoing viability of our operations. We continue to maintain third party certifications of our operations, operate within our licence terms and conditions and have industry leading sustainability reporting and disclosures.

[1] *The Tasmanian Salmon Industry: A Vital Social and Economic Contributor,* Social and Economic Contribution of the Salmon Industry – Salmon Tasmania, 2023

Macquarie Harbour – Renewal of Environmental Licences (2023)

Tassal's Environmental Licences for its three farming leases in Macquarie Harbour were renewed on 30 November 2023 by the Director (Tasmanian EPA). Two key points were included in the Statement of Reasons to endorse the renewal of these licences. These were:

1. That the Director (EPA) was satisfied that it was appropriate to do so and having considered the matters referred to in section 42T of the *Environmental Management and Pollution Control Act 1984* (**EMPCA**); and

2. That the Director (EPA) saw fit to impose new conditions or restrictions on each of these environmental licences requiring all operators in Macquarie Harbour to determine and mitigate the impacts of marine finfish farming activities on dissolved oxygen levels at and beyond the boundary of the marine farm leases to which each environmental licence relates (conditions DO1, DO2, and DO3), to further the objectives of EMPCA. These conditions will be accounted for as part of the Macquarie Harbour Oxygenation Project.

Based on Tassal's compliance history in Macquarie Harbour, the Director (EPA) concluded there is no basis to determine that Tassal is not a fit and proper person to hold an environmental licence.

The Unique and Complex Nature of Macquarie Harbour

Macquarie Harbour is a large unique estuarine system characterised by a narrow sill at the entrance to the ocean and a deep central basin. It is approximately six times the size of Sydney Harbour. The waterway is highly stratified, with a freshwater layer on the surface (due to river inflows to Macquarie Harbour), a mid-layer characterised by older, oxygen-depleted water and a heavier saltwater layer (derived from the influx of O2 rich oceanic water) that lies just above the seafloor.

The environmental conditions in Macquarie Harbour are driven by a range of complex hydrodynamic and meteorological processes – influenced by tides, temperature, wind, freshwater inflows and oceanic recharge events – all of which play a role in Macquarie Harbour's oxygen cycle.

The Macquarie Harbour Dissolved Oxygen Working Group estimates that aquaculture is responsible for 3% -12% of the benthic oxygen demand in Macquarie Harbour (sediments >15 m)[2], with the remaining oxygen demand assumed to be associated with the particulates and detritus in river discharges. Wallis (2024) estimates the oxygen demand due to salmon farms in the lower layer of water in Macquarie Harbour to be approximately 10% -16% of the total oxygen supply from the ocean to the lower layer.

We know the health of Macquarie Harbour reflects historic and current marine and land-based influences from both natural and human sources in a changing environment and a changing climate. We operate in a 'lived estuarine environment' – a unique waterway involving a range of anthropogenic activities including fishing, tourism, introduced marine pest species, logging, over 100 years of mine slurry discharge to Macquarie Harbour and Hydro dam flows and discharges (see image below). Salmon farming is one of many activities which impact on the environmental condition of Macquarie Harbour.

[2] Macquarie Harbour Dissolved Oxygen Working Group. Final Report October 2014.

It is concerning that the Tasmanian EMPCA does not apply to pollution from mining activities that impacts the water quality of Macquarie Harbour. The standard of environmental regulation applied to the salmon industry does not appear to be consistently applied to other contributors of similar or greater impact to Macquarie Harbour.

Picture: Macquarie Harbour following Hydro water discharge through the King River, January 2024.

It is notable that the Macquarie Harbour Status Report (2015)[3] "*highlights river discharge into Macquarie Harbour as a key factor influencing both DO (dissolved oxygen) renewal (hydrodynamics processes) and DO consumption (potential organic carbon load) processes, and also discusses changes to river flow associated with Hydro Tasmania power generation strategies in a broader sense (the "rebuild" from 2008-2012 and the high discharge associated with the carbon price in 2013)*". This report suggests that "*a more detailed investigation into whether any changes in flow regime (flow patterns and flow variability) have influenced hydrodynamics in the harbour may be relevant*".

Also notable is a key urgent action identified in the updated Conservation Advice for the Maugean Skate (September 2023)[4] – "*Reinstate the CSIRO predictive monitoring modelling to inform modification of hydroelectric dam environmental flows*".

The IMAS Assessment of Macquarie Harbour BEMP data from 2011 to 2022 highlights a climate driven increase in bottom water temperatures of 1.5 - 2°C over the past 30 years. This environmentally driven change is also considered to have influenced the observed decline in population abundance of the skate through decreased solubility and increased metabolic rates.

All of these factors, in some way, have shaped, and continue to shape, the environmental condition of Macquarie Harbour.

Whilst there has been a range of comprehensive scientific studies undertaken on environmental elements of Macquarie Harbour, particularly since 2011, Tassal submits that these studies fail to draw direct causal links between salmon farming operations in Macquarie Harbour and the purported declining population status of the Maugean Skate.

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[3] Macquarie Harbour Status Report, Department of Primary Industries, Parks, Water and Environment (2015)

[4] Conservation Advice for *Zearaja maugeana* (Maugean skate). Report for Aust Govt Department of Climate Change, Energy, Environment and Water. (2023).

Tassal contends that a more holistic investigation of the status of the Maugean Skate in Macquarie Harbour should be undertaken prior to any regulatory decision impacting on salmon production. Such an investigation should take account of the full range of environmental variables and anthropogenic impacts that are known to influence the Maugean Skate's habitat abundance and distribution within Macquarie Harbour.

The complex interplay of all the possible impacts that determine the environmental conditions of Macquarie Harbour makes it arguably problematic to draw a causal link between apparent declining population status of Maugean Skates in Macquarie Harbour to impacts from salmon farming.

Populations of Maugean Skate may not necessarily be constrained solely to Macquarie Harbour. This species was first identified in Tasmanian waters in Port Davey in 1989, a waterway where salmon farming or any other significant anthropogenic activity has not occurred. Whilst there have been four confirmed observations of the Maugean Skate in Bathurst Harbour (Port Davey), eDNA studies undertaken by IMAS suggest this species no longer occurs in this location.

One question that must be answered is ***why does the Maugean Skate still exist in Macquarie Harbour, yet its population in the pristine waters of Bathurst Harbour appears to have disappeared?***

The Macquarie Harbour Oxygenation Project (MHOP)

Whilst we acknowledge that salmon farming is one of many activities that impact upon the environmental conditions of Macquarie Harbour, the salmon industry has voluntarily undertaken to reduce its own direct impact on oxygen levels in Macquarie Harbour by supplementing our known oxygen drawdown with oxygenated water (super-saturated) pumped from the surface to depth in the water column.

The *Macquarie Harbour Oxygenation Project (**MHOP**)* is a $6 million collaborative project involving the salmon industry and IMAS, funded through the Australian Fisheries Research and Development Corporation (FRDC), designed to increase the levels of dissolved oxygen in Macquarie Harbour, through utilisation of mechanical/engineering environmental remediation technologies – ***a key urgent action identified in the updated Conservation Advice for the Maugean Skate (September 2023)***.

Initially, the MHOP will be instrumental in understanding the role that mechanical oxygenation of bottom and mid waters can play in remediating oxygen levels more broadly across Macquarie Harbour. This initiative will focus on 3 key elements:

- engineering and operation of the oxygenation plant and delivery system
- measuring the ecosystem response
- modelling to predict plume diffusion and advection at local and broad spatial scales

Even during the recent development of the MHOP in late 2023, there have been significant oceanic recharge of the bottom waters in Macquarie Harbour, with dissolved oxygen concentrations at Tassal's Franklin lease (southernmost lease in Macquarie Harbour) reaching between 4.0 – 5.0 mg/l at 35 metres depth. The extent of this recent recharge event is currently under investigation.

Macquarie Harbour – an Adaptive Management Approach

There have been many scientific and environmental research studies undertaken on Macquarie Harbour, particularly since 2011 when the Tasmanian salmon industry sought to amend the existing Marine Farming Development Plan (MFDP) to reconfigure existing lease areas and add new leases to allow for increased production in Macquarie Harbour.

This expansion program was accompanied by a range of comprehensive studies, monitoring programs and management processes to ensure that the expansion in Macquarie Harbour was undertaken on a sustainable, long-term basis and underpinned by an adaptive management framework. See the studies detailed in Appendix A.

Importantly, and as communicated by the Tasmanian Government to the Federal Government in 2012 – the proposed expansion resulted in the relocation of 59 percent of the previously existing marine farming lease area that occurred in less than 20 meters depth, into the deeper central basins of Macquarie Harbour. This alone effectively reduced farming within lease areas in regions known as the Maugean Skate's preferred habitat.

This adaptive management approach has been informed, and continues to be, by systematic and targeted research and monitoring programs and whole of harbour modelling tools.

"*The ultimate aim of the adaptive management program is to monitor the gradual production increase over time and increase knowledge in relation to the sustainability and feasibility of the proposed amendment. Monitoring any potential adverse environmental effects will be associated with the application of relevant mitigation measures based on the severity of the observed impacts."* (Macquarie Harbour EIS Appendix 2, pg 381).

The research studies listed in Appendix A have contributed to an "evolving" management regime in Macquarie Harbour that has demonstrably changed since the 2012 expansion program was approved by both State and Federal Governments.

The following sequence of management changes below is evidence of the adaptive nature of managing salmon aquaculture in Macquarie Harbour based on a collaborative approach across regulatory authorities, the salmon industry and scientific and research institutions.

Macquarie Harbour – History of Management Changes

In 2012, expansion of finfish aquaculture and reconfiguration of leases within Macquarie Harbour was approved subject to a range of State and Federal environmental requirements. The total allowable lease space increased from 564 ha to 926 ha.

A considerable body of social, economic and environmental information was consolidated into an Environmental Impact Statement that supported the proposed increased production in Macquarie Harbour. Through this process, a maximum sustainable biomass determined for Macquarie Harbour was initially modelled at 29,500 tonnes. Salmonid production in Macquarie Harbour reached a level of 19,200 tonnes in late 2014.

In April 2016, the company wide biomass cap (for all companies) was decreased to 21,500 tonnes for the 2016/2017 production year. However, subsequent biomass determinations from the Tasmanian EPA resulted in lower regulated production amounts for specific periods (i.e. 14,000 tonnes from 14 February to 30 April 2017, 12,000 tonnes for the period 31 May 2017 to 31 May 2018 and 9,500 tonnes per annum between 1 June 2018 to 31 May 2022).

The economic and social impact from these management changes to both Tassal and the West Coast Community has been significant. Between 2015 - 2023, Tassal's production from Macquarie Harbour has declined by circa 50%. Operationally, for Tassal, this has meant that we have had to explore other options to maintain our levels of production, such as in our eastern farming region at Okehampton Bay and Long Bay.

These changes have significant impact on our employees, communities and financial implications. As an example, cost estimates are $20 million for this adjustment alone.

In 2017, the Federal Environment Department undertook an audit of farming practices in Macquarie Harbour to ensure that the 2012 NCA-PM were being complied with. Tassal did not receive any advice that our operations were being undertaken in a manner inconsistent with the 2012 NCA-PM.

From 1 September 2023, a more sustainable management tool for regulating finfish farming in Macquarie Harbour was adopted – moving from a maximum permissible biomass limit of 9,500 tonnes to a Total Permissible Dissolved Nitrogen Output (TPDNO) of 500.1 tonnes, in force for a 2-year period. Effectively, this represented a 10% reduction in the previous production levels, voluntarily agreed to by all companies operating in Macquarie Harbour as a precautionary measure to ensure the sustainable and long-term management of salmon farming in this important farming region.

Summary

In consideration of the points raised in this submission, it is apparent that the current Tasmanian State regulatory framework for salmon farming in Macquarie Harbour is entirely appropriate and can accommodate a sustainable salmon industry in Macquarie Harbour – in a manner that is inclusive of input from research institutions, regulatory authorities, the salmon industry and key stakeholders from the West Coast Community.

There is ample evidence of an effective "adaptive management strategy" for salmon farming in Macquarie Harbour post the expansion approval in 2012, based on sound science, invested heavily by collaborative industry partnerships and frequent engagement with key community stakeholders.

Improved and evolving management arrangements that have bolstered the regulation of salmon farming in Macquarie Harbour, including the development of legally enforceable Environmental Standards in 2023 exceed the original requirements contained in the 2012 NCA-PM, and at significantly lower levels of production than were intended through the initial Macquarie Harbour Expansion Program.

Additionally, measures to improve and better understand the population status of the Maugean Skate, through the recently established Maugean Sate Recovery Team in 2023, and the 2024 Tasmanian Government's Conservation Action Plan, will foster a more consolidated approach to managing interactions between salmon farming and the Maugean Skate – in a manner that ensures “the viable habitat in Macquarie Harbour is available to meet the needs of the Maugean Skate”[5] .

Overall, there is no evidence (scientific or otherwise) of environmental conditions in Macquarie Harbour that connect, or identify, relationships between salmon farming and the population status of the Maugean Skate in Macquarie Harbour.

The revocation of the 2012 NCA-PM decision would result in catastrophic social and economic impacts to the West Coast Community of Tasmania. Tassal considers such an approach is unnecessary and unwarranted given the current robust State regulatory framework for managing salmon farming in Macquarie Harbour according to the principles of ecologically sustainable development – particularly in this instance, when the need to balance social, environmental and economic values is critically important for the West Coast Community and all Tasmanians.

We remain committed to farming responsibility in all areas of our operations.

Tassal appreciates the opportunity to provide a submission as part of this process and looks forward to a prompt decision being made to draw a close to the uncertainty hanging over the heads of our valued employees, families and the West Coast community.

Yours sincerely

s. 47F(1)

Mark Ryan

Managing Director and CEO

[5] Conservation Action Plan. Natural Resources and Environment Tasmania (2024).

APPENDIX A: Key studies that have shaped knowledge of the environmental condition of Macquarie Harbour (post the expansion approval in 2012)

- IMAS Assessment of Macquarie Harbour BEMP data from 2011 to 2020, March 2022
- IMAS Environmental Research Progress Report, February 2020
- IMAS Environmental Research Progress Report, July 2019
- IMAS Progress Report on Macquarie Harbour, December 2018
- IMAS Progress Report on Macquarie Harbour, February 2018
- IMAS Progress Report on Macquarie Harbour, September 2017
- Macquarie Harbour 2013-2016 Nutrient Review May 2017 (Internal Final Draft)
- Macquarie Harbour TWWHA Environmental Status Report, EPA, May 2017
- IMAS Progress Report on Macquarie Harbour, May 2017
- IMAS Technical Report on Macquarie Harbour Condition, Jan 2017
- Understanding oxygen dynamics and the importance for benthic recovery in Macquarie Harbour (FRDC Project no. 2016-067)
- Vulnerability of the endangered Maugean skate population to degraded environmental conditions in Macquarie Harbour (FRDC Project no. 2016-068)
- Managing ecosystem interactions across differing environments: building flexibility and risk assurance into environmental management strategies (FRDC Project no. 2015-024)
- Movement, habitat utilisation and population status of the Endangered Maugean skate (FRDC Project no. 2013-008)
- Atlantic Salmon Aquaculture Subprogram: characterising benthic pelagic interactions in Macquarie Harbour - organic matter processing in sediments and the importance for nutrient dynamics (FRDC Project no. 2012-047)
- The most recent research initiative is the MHOP – the "Macquarie Harbour oxygenation trial" (FRDC Project no. 2023-087)

Salmon TASMANIA
+61 0403 882 283
admin@salmontas.au
salmontasmania.au
83 Salamanca Place,
Battery Point, Tas. 7004

2 February 2024

The Hon Tanya Plibersek MP
Minister for the Environment and Water
Parliament House
Canberra

By email: EPBC.VicTas@environment.gov.au

Dear Minister

Submission on Reconsideration Requests
Marine Farming Expansion, Macquarie Harbour, Tasmania (EPBC 2012/6406)

1 We refer to the public notice, and correspondence received from the Department of Climate Change, Energy, the Environment and Water (the ***Department***), inviting submissions on three requests for the reconsideration of the not a controlled action (particular manner) decision made by the Minister on 3 October 2012 under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (the ***EPBC Act***) in relation to EPBC referral 2012/6406 for the expansion of marine farming operations in the Macquarie Harbour (***Marine Farming Expansion***), the ***NCA-PM Decision***.

2 This submission is a response to the reconsideration requests made by the Tasmanian branch of The Australia Institute (***The Australia Institute***), Fitzgerald and Browne Lawyers on behalf of the Bob Brown Foundation Inc (***BB Foundation***) and Environmental Defenders Office on behalf of the Australian Marine Conservation Society and Humane Society International Australia (together, **AMCS/HSI**), (***Reconsideration Requests***).

3 Salmon Tasmania, provides this submission on behalf and in addition to the submissions made by its member entities, Petuna Aquaculture, Tassal Operations and Huon Aquaculture. In submitting this document, we seek to present the collective perspective of our membership on the matters raised in the Reconsideration Requests.

4 The Reconsideration Requests assert that you should revoke and substitute the NCA-PM Decision, on the basis that there is substantial new information and an unforeseen, substantial change in circumstances in relation to the impacts of the Marine Farming Expansion on the Maugean Skate.

5 The BB Foundation further alleges that the Marine Farming Expansion is not being undertaken in accordance with the particular manner conditions.

6 It is Salmon Tasmania's position that none of the Reconsideration Requests establish the relevant statutory grounds required under section 78A(1) of the EPBC Act. The information in the reconsideration requests is insufficient to satisfy you that the revocation and substitution of the NCA-PM Decision is warranted.

7 Furthermore, Salmon Tasmania and its members reject the unfounded and unsubstantiated assertion made by the Bob Brown Foundation that the Macquarie Harbour Expansion is not being carried out in accordance with the NCA-PM conditions.

8 Salmon Tasmania welcomes the opportunity for further discussion with the Department regarding the contents of our submission.

Yours faithfully

s. 47F(1)

Luke Martin

CEO

Salmon Tasmania

Salmon TASMANIA
+61 0403 882 283
admin@salmontas.au
salmontasmania.au
83 Salamanca Place,
Battery Point, Tas. 7004

Salmon Tasmania Submission

Requests for Reconsideration of Referral Decision:

Marine Farming Expansion, Macquarie Harbour, Tasmania

(EPBC 2012/6406)

Contents

1 Introduction

(a) We refer to the public notice, and correspondence received from the Department of Climate Change, Energy, the Environment and Water (the ***Department***), inviting submissions on three requests for the reconsideration of the decision made under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (the ***EPBC Act***) in relation to EPBC referral 2012/6406.

(b) On 3 October 2012, the then Federal Minister decided that the proposed expansion of marine farming operations in Macquarie Harbour, on the west coast of Tasmania (as described in EPBC Act referral No 2012/6406) (***Marine Farming Expansion***), was not a controlled action provided it is taken in the particular manner specified in the decision (***NCA-PM Decision***).

(c) The matters nominated in the NCA-PM Decision as relevant for the Marine Farming Expansion are:

(i) World Heritage properties (sections 12 and 15A);

(ii) National Heritage places (sections 15B and 15C); and

(iii) Listed threatened species and communities (sections 18 and 18A).

(d) The World Heritage property, National Heritage place and listed threatened species noted to be relevant to EPBC referral 2012/6406 were the Tasmanian Wilderness World Heritage Area (***TWWHA***) and Maugean Skate (*Zearaja maugeana*) respectively.

(e) The entities named in the NCA-PM Decision, being Petuna Aquaculture, Tassal Operations and Huon Aquaculture (together, the ***Operators***), have been carrying out their respective marine farming operations in Macquarie Harbour pursuant to the decision.

(f) Three requests have been made for you to reconsider the NCA-PM Decision in accordance with the process provided by section 78A of the EPBC Act (***Reconsideration Requests***). These requests were submitted by:

(i) the Tasmanian branch of The Australia Institute (***The Australia Institute***) by way of letters dated 8 June 2023 and 31 July 2023;

(ii) Fitzgerald and Browne Lawyers on behalf of the Bob Brown Foundation Inc (***BB Foundation***) by way of letter dated 25 July 2023; and

(iii) the Environmental Defenders Office on behalf of the Australian Marine Conservation Society and Humane Society International Australia (together, **AMCS/HSI**) by way of letters dated 23 August 2023 and 20 November 2023;

(together, the ***Requestors***).

(g) The Reconsideration Requests are each made under section 78A of the EPBC Act and rely in part on common grounds under section 78 (further detail on differences as between the requests is addressed below). By way of summary, the primary submission common to the Reconsideration Requests is that you should be satisfied the revocation and substitution of the NCA-PM decision with a new decision that the Marine Farming Expansion is a controlled action is warranted because:

(i) for the purposes of section 78(1)(a), it is alleged that there is substantial new information available about the impacts the Marine Farming Expansion is having (or will have or is likely to have) on the Maugean Skate (being a matter protected by Part 3 of the EPBC Act); and/or

(ii) for the purposes of section 78(1)(aa), it is alleged that there is a substantial change in circumstances that was not foreseen at the time of the NCA-PM decision and it relates to the impacts that the Marine Farming Expansion is having (or will have or is likely to have) on the Maugean Skate (being a matter protected by a provision of Part 3 of the EPBC Act).

(h) In addition to the above grounds, the BB Foundation requests the revocation and substitution of the NCA-PM Decision under section 78(1)(b) on the basis of an allegation that the NCA-PM Decision requires the Operators not have a significant impact on the Maugean Skate and that the Operators are not complying with this particular manner requirement.

(i) In accordance with section 78C of the EPBC Act, you are required to reconsider the NCA-PM Decision, and to either confirm that decision, or revoke the decision on one or more of the grounds under section 78(1) and to substitute it with a new decision.

(j) This document provides Salmon Tasmania's response to the Reconsideration Requests and addresses the claims and concerns raised in the documentation that forms the basis of those requests.

2 Role of Salmon Tasmania

(a) This submission has been prepared by Salmon Tasmania on behalf of our members, the major operators in Macquarie Harbour, being Petuna Aquaculture, Tassal Operations and Huon Aquaculture.

(b) Salmon Tasmania is a peak industry body representing the interests of Tasmanian salmon farmers, within the Australian aquaculture sector. Salmon Tasmania's members are industry leaders dedicated to sustainable and responsible aquaculture practices within the local salmon farming community.

(c) The Tasmanian salmon and trout farming industry currently creates 5,103 FTE (full-time equivalent) jobs[1], has a gross production value of $888 million[2], and is the largest fishery by economic value and volume in Australia[3].

(d) The positive impact of the industry on the economy spreads well beyond direct employment with the salmon companies, and the flow-on impacts into the broader community are significant. There is a thriving ancillary sector providing imports to the industry such as vessels, pens, nets, feed, training, transport and logistics, and a range of contract and consultancy services.

(e) The industry has a strong record of encouraging training and skills development, creating career paths to attract and retain skilled staff, especially in regional communities.

(f) The Macquarie Harbour activities of the Operators sustain 395 FTE direct and indirect roles, with 1 in 3 residents of the town of Strahan being employed in the industry[4]. For the wider West Coast region of Tasmania, the salmon industry supports 17% of employment in the region[5].

(g) Salmon Tasmania, its members, and workforce are extremely concerned that the Reconsideration Requests be carefully scrutinised and the legislative requirements rigorously applied. A decision to revoke the NCA-PM Decision and make the Marine Farming Expansion a 'controlled action' will have immediate, dire consequences for the Operators and the broader West Coast community (see further in section 8).

[1] Deloitte Access Economics (2022), *Socio-economic contribution of the Tasmanian salmon industry*
[2] Tasmanian Agri-food Scorecard, *https://nre.tas.gov.au/Document2. s/Tasmanian%20Agri-Food%20ScoreCard%202019-20.pdf*
[3] *https://nre.tas.gov.au/Documents/Tasmanian%20Salmon%20Industry%20Plan%202023.pdf; https://www.imas.utas.edu.au/research/fisheries-and-aquaculture/aquaculture/atlantic-salmon-aquaculture-research*
[4] Deloitte Access Economics (2022), *Socio-economic contribution of the Tasmanian salmon industry*
[5] Deloitte Access Economics (2022), *Socio-economic contribution of the Tasmanian salmon industry*

3 Overview of Salmon Tasmania's response to the Reconsideration Requests

Summary

(a) Salmon Tasmania submits the appropriate course is for you to confirm the existing NCA-PM Decision.

(b) You should not be satisfied that it is warranted to revoke the NCA-PM Decision and to substitute a new decision that the Marine Farming Expansion is a controlled action, on the basis of any of the claimed grounds in section 78(1) of the EPBC Act.

(c) None of the asserted grounds under sections 78(1)(a), (aa) or (b) that are relied upon by the Requestors are in fact made out by the information provided in, or referenced by, the Requests.

Any substantial new information about the impacts of the Marine Farming Expansion on the skate?

(d) Central to the each of the Reconsideration Requests is an Interim Report published by the Institute for Marine and Antarctic Studies (***IMAS***) '*Macquarie Harbour Maugean skate population status and monitoring*' on 2 May 2023 (***IMAS 2023 Report***).[6]

(e) The IMAS 2023 Report is relied upon as the primary source of new information by the Reconsideration Requests for the purposes of section 78(1)(a) of the EPBC Act.

(f) The IMAS 2023 Report is an interim report only, which presents newly gathered monitoring data on skate population changes (size composition and relative abundance). The collected data is expressly noted to be subject to further analysis, with the report stating that the analysis of the interim data is not definitive.

(g) The IMAS 2023 Report does not present any information about the impacts of the Marine Farming Expansion on the skate, let alone any substantial new information about such impacts or their likelihood of occurring.[7]

(h) The report recognises that there are numerous anthropogenic activities including mining, forestry, hydro-electricity generation and the general effects of climate change along with marine farming, that have all contributed to a change in the physicochemical conditions in Macquarie Harbour.

(i) Where additional scientific reports are relied upon in the Reconsideration Requests (addressed in section 5 and Schedule 2), those reports do not establish a causal link between impacts of the Marine Farming Expansion and impacts on the skate population.

(j) Moreover, the reports which contend that salmon farming has the impact of reducing levels of dissolved oxygen in the harbour and that this is likely have an impact on the skate, fail to demonstrate these impacts are likely to happen with a high degree of certainty as is required by clause 4AA.01 of the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth) (***EPBC Regulation***).

(k) The reports that do attempt to draw a causal link are based on flawed assumptions that do not reflect modern marine farming practices or outdated data (addressed in section 5 and Schedule 2).

A substantial change in circumstances that was not foreseen at the time the NCA-PM Decision was made, and relates to the impacts of the Marine Farming Expansion on the skate?

(l) The IMAS 2023 Report and the other scientific literature relied upon by the Requestors do not identify a substantial change in circumstances that was not foreseen at the time of the

[6] https://imas.utas.edu.au/__data/assets/pdf_file/0007/1655611/Maugean-skate-2021-interim-report-FINAL.pdf/_nocache

[7] The IMAS 2023 Report and the scientific literature cited within that Report are addressed in greater detail in section 5.

NCA-PM Decision, and which relates to impacts that the Marine Farming Expansion has or is likely to have on the Maugean Skate.

(m) The salmon farming industry accepts that the presence of salmon pens in Macquarie Harbour has an influence on levels of dissolved oxygen in the harbour. This influence was known at the time of the NCA-PM Decision and recognised in the express terms of the NCA-PM Decision notice through requirements imposing obligations for monitoring and management of water quality indicators including dissolved oxygen levels, benthic conditions and physio-chemical impacts.

(n) As such, there is no unforeseen and substantial change in circumstances that relates to the impacts of the salmon farming on the skate.

(o) Furthermore, the Requests fail to demonstrate that some change in the potential impacts of the salmon farming on the skate is likely to happen with a high degree of certainty, as is required by clause 4AA.01 of the EPBC Regulation.

Impacts on dissolved oxygen in Macquarie Harbour from salmon farming operations and implications for the skate?

(p) Salmon farming is one of many anthropogenic factors identified as having an influence on the environmental conditions, including dissolved oxygen levels, in Macquarie Harbour.

(q) The extent of the influence and observed impacts attributable to salmon farming is presented in section 5.4 of this submission, which details the findings of a technical memorandum prepared by Dr Ian Wallis in a 2024 technical memorandum (see Schedule 4) commissioned by Salmon Tasmania.

(r) Salmon Tasmania submits that this expert evidence, which goes directly to the central concern raised by the Requestors, will give you comfort that the NCA-PM Decision remains appropriate and should be confirmed.

(s) Dr Wallis's findings include:

(i) Oxygen is primarily introduced into Macquarie Harbour by river and ocean water inflows and surface re-aeration.

(ii) There is a high level of stratification in the harbour waters. The natural levels of dissolved oxygen in the lower layer are, and always have been, low because of the hydrological processes occurring in the harbour.

(iii) The majority of the oxygen demand on the lower layer comes from the river inflow, with organics settling from the top layer of the harbour into the lower layer. River inflows are continuous, with volumes varying seasonally and following releases from hydroelectric dams upstream in the Gordon and King Rivers.

(iv) River inflow is also the process that determines the extent of ocean water inflow to the harbour, and the oxygen content of the lower layer. High river flows cause less ocean inflow and less oxygen in the lower layer, whereas low river flows result in more ocean inflow and more oxygen in the lower layer.

(v) Natural processes are estimated to reduce the average dissolved oxygen in the lower layer to around 35% saturation. In the lower layer, the extra load from salmon farms reduces the average dissolved oxygen to around 25% saturation.

(vi) In the 4000 years since Macquarie Harbour changed from a freshwater lake to a stratified estuary, there have likely been many variations in river inflow. It is unlikely that present dissolved oxygen conditions have not been experienced in the past.

(vii) Research shows that Skate mostly reside in the top layer of the harbour which has satisfactory levels of dissolved oxygen, and travel into the lower layer only where there is satisfactory dissolved oxygen.

(viii) Salmon farms reduce the dissolved oxygen in the top layer by 4% or 0.3 mg/L. "<u>This minor decrease would have negligible effect on the survival of the skates in their normal habitat in the top layer</u> near Table Head".

(ix) 'Uplift events', where waters with low dissolved oxygen move from the lower layer of the harbour into the top layer, are natural events driven largely by low river flows and, to a lesser extent, by tides, atmospheric pressure and winds. The uplift events are <u>not</u> caused by, or increased by, salmon farms.

(x) There is ample dissolved oxygen (DO) in the top layer due to the supply from the rivers and the atmosphere. The estimated oxygen supply to the top layer of Macquarie Harbour is 134,000 t/yr which corresponds to an average DO concentration of about 7.4 mg/L. Measured oxygen levels in the top layer range from 5 to 8 mg/L, which matches the calculated average value.

(xi) The situation is different in the lower layer, as it cannot receive oxygen from the rivers or the atmosphere. The only supply is from the periodic ocean inflows, which bring in an estimated 17,700 t/yr of oxygen. The residence time for the lower layer is about a year and the natural oxygen demand is around 7,500 t/yr. DO is naturally depleted in the lower layer.

(xii) The biological activities that use oxygen seem to be concentrated at 20 to 35 m depth, and oxygen levels in this depth range are typically only 20 to 40 per cent of saturation.

(t) Dr Wallis concludes that the drawdown of oxygen attributable to salmon farming occurs in a manner that would result in negligible impacts to the Maugean Skate in their observed habitat.

(u) These findings highlight that the cessation of aquaculture in Macquarie Harbour alone without addressing other anthropogenic factors causing environmental degradation including changed river flows and the presence of heavy metals from historic mining activities, would be most unlikely to resolve current low levels of dissolved oxygen.

(v) Dr Wallis also undertook a review of scientific literature relied upon in the Reconsideration Requests and found that data relied upon and assumptions made in the literature either did not support the conclusions drawn or overstated the impacts of salmon farming on environmental conditions (see section 5.4 and Schedule 4).

Whether the Marine Farming Expansion is not being, or will not be taken in accordance with the NCA-PM Decision?

(w) Salmon Tasmania submits that the revocation and substitution of the NCA-PM Decision <u>cannot</u> be warranted on grounds contained in section 78(1)(b) of the EPBC Act. This is because you have not received a properly made request on these grounds.

(x) Moreover, the Operators reject the allegation by the BB Foundation that they are not conducting the Marine Farming Expansion in accordance with the NCA-PM Decision requirements.

(y) The BB Foundation submission provides no detail of a single instance nor any particulars of conduct by an operator that is said to be inconsistent with the measures stated in the NCA-PM Decision to support the allegation. This is contrary to the requirement in clause 4AA.01(5) of the EPBC Regulation – in short, the BB Foundation request on this ground cannot be accepted as being validly made.

(z) In any event, if you or your Department held such concerns, as matter of procedural fairness, it would be appropriate in the first instance for those matters to be put in writing to the relevant operator directly by the Department, for the operator's consideration and response. In the absence of any prima facie basis to accept such an allegation, it is submitted there is no lawful basis for you to accept that a ground is established under section 78(1)(b) to revoke the NCA-PM Decision.

Marine farming environmental requirements, monitoring and adaptive management

(aa) In the event that you are satisfied that the information presented in the Reconsideration Requests does relevantly constitute substantial new information or an unforeseen and substantial change in circumstances, we nonetheless submit that the requirements imposed under the current NCA-PM Decision are the most appropriate protection measures and that Decision should be confirmed.

(bb) The adaptive management principles integrated into the NCA-PM Decision, through requiring compliance with the Tasmanian Government's regulatory regime, including the Macquarie Harbour Marine Farming Development Plan and licencing conditions, are an effective and appropriate framework to identify and address any significant impacts of salmon farming to the Macquarie Harbour environment.

(cc) The adaptive management framework is responsive to developments in technology and scientific research, with the Tasmanian Government amending the State regulatory regime that regulates finfish farming to incorporate international best practices.

(dd) Monitoring, reporting and responding to environmental management conditions, including in relation to dissolved oxygen levels, are already required, and have been complied with, by the Operators since the NCA-PM Decision was made.

(ee) Further, the industry has been proactive in addressing concerns relating to the environmental conditions of Macquarie Harbour and impacts on the Maugean Skate.

(ff) Significant financial and technical contributions have been made by industry to support research and development of marine farming practices including taking a leadership role on research initiatives such as the Macquarie Harbour Oxygenation Project.

(gg) Under the current Tasmanian environmental licencing regime, marine farming in Macquarie Harbour is conducted in a manner that exceeds the requirements contained in the 2012 NCA-PM Decision and at significantly lower levels of production than was intended in 2012. The graph at Schedule 1 demonstrates that production levels in Macquarie Harbour are now less than existed at the time of the NCA-PM Decision in 2012.

(hh) The cessation of marine farming operations in Macquarie Harbour would represent a loss of the largest employer in the region and would result in irreparable damage to the community, both from direct job losses and impacts to businesses that support aquaculture operations.

Alternative submission – NCA-PM with updated requirements

(ii) If you are satisfied that revocation and substitution of the NCA-PM Decision is warranted on any of the grounds under section 78(1), Salmon Tasmania provides an alternative submission for your consideration.

(jj) Salmon Tasmania submits that if the existing NCA-PM Decision is to be substituted, it would be appropriate to take a new decision that the Marine Farming Expansion is not a controlled action if undertaken in a particular manner, and that those requirements of the particular manner be updated.

(kk) Salmon Tasmania in conjunction with the Operators, has convened a technical advisory group to provide recommendations on steps that can be taken to further enhance environmental protection requirements for the Maugean Skate.

(ll) Salmon Tasmania is ready and willing to facilitate engagement by your Department with the Operators, and wider industry stakeholders, in relation to any such proposed measures.

4 Basis of Reconsideration Requests

4.1 Outline

(a) This section summarises the key claims relied upon by the Requestors as the basis of their respective Reconsideration Requests. The purpose of this section is to set out the key matters to which a response will be provided by Salmon Tasmania.

(b) Salmon Tasmania's review and response to each of the claims is contained in section 5 and a technical review of scientific literature relied upon by the Requestors is set out at Schedule 2.

4.2 IMAS 2023 Report

(a) Central to the submissions of each of the Requestors is an Interim Report published by the Institute for Marine and Antarctic Studies (***IMAS***) '*Macquarie Harbour Maugean skate population status and monitoring*' on 2 May 2023 (***IMAS 2023 Report***). [8]

(b) The IMAS 2023 Report is relied upon as the primary basis of the reconsideration requests made under sections 78(1)(a) and 78(1)(aa) of the EPBC Act, by each Requestor.

(c) Each of the Requestors state that this report constitutes:

(i) 'substantial new information' regarding the impacts of the Marine Farming Expansion on the Maugean Skate; and

(ii) identifies a 'substantial change in circumstances that was not foreseen at the time of the controlled action decision' that relates to the impacts of the Marine Farming Expansion on the Maugean Skate.

(d) The report contains initial data and findings resulting from a survey monitoring program that sought to establish the current size and composition of the Maugean Skate population in Macquarie Harbour.

(e) Results from the first year of the survey (2021) were stated to show:

(i) a decline of 47%, in catch per unit effort (***CPUE***) indicating a substantial decrease in relative abundance of the skate in the Harbour (since 2014); and

(ii) that the median size of females had increased (since 2012) while the proportion of juveniles captured had decreased, which was stated to be consistent with recruitment failure.

(f) The report states that there is mounting evidence that low dissolved oxygen conditions are impacting the Maugean Skate population, but relies upon separate scientific literature for that premise.

(g) Separate scientific literature is also used to allege a change in environmental conditions in the harbour, specifically reduced dissolved oxygen levels in deep water (>10m depth).

(h) The report lists marine farming operations as one of various anthropogenic activities including mining, forestry, hydro-electricity generation, and the general effects of climate change, that have 'influenced' a change in the physicochemical conditions in Macquarie Harbour.

(i) The IMAS 2023 Report relies on a 2022 study as the basis of the claim that 'vast majority, if not all, of the remaining Maugean skate live only in Macquarie Harbour' which is said to 'highlight the vulnerability of the species and the need for urgent conservation action'.

[8] https://imas.utas.edu.au/__data/assets/pdf_file/0007/1655611/Maugean-skate-2021-interim-report-FINAL.pdf/_nocache

4.3 The Australia Institute Reconsideration Request

(a) In addition to the IMAS 2023 Report, The Australia Institute relies on a number of additional scientific reports to assert that the Marine Farming Expansion is having a significant impact on the Maugean Skate, such that the NCA-PM decision should be revoked.

(b) These reports include:

(i) *Understanding the Ecology of Dorvilleid Polychaetes in Macquarie Harbour (**Ross 2016 Report**);*[9]

(ii) *Environmental Research in Macquarie Harbour Interim Synopsis of Benthic and Water Column Conditions (**Ross 2017 Report**);*[10]

(iii) *Vulnerability of the endangered Maugean Skate population to degraded environmental conditions in Macquarie Harbour (**Moreno 2020 Report**);*[11] and

(iv) *Macquarie Harbour Oxygen Process model* (***Wild-Allen 2020 Report***).

(c) The above reports are relied upon to support the conclusion drawn by The Australia Institute that the reduced dissolved oxygen levels in the harbour and therefore the impacts being experienced by the skate are attributable to the Marine Farming Expansion.

(d) The Australia Institute states that each of the additional reports constitutes substantial new information and asserts that they establish a substantial change in circumstances relating to the impacts of the Marine Farming Expansion on the Skate.

4.4 AMCS/HSI Reconsideration Request

(a) The AMCS/HSI request relies on similar scientific literature to The Australia Institute to allege a link between the reduced dissolved oxygen levels observed in the Macquarie Harbour and the Marine Farming Expansion.

(b) Substantial new information is also said to consist of:

(i) a report which investigated the existence of Maugean Skate in locations other than Macquarie Harbour, which observed 'low traces of Maugean Skate DNA in Bathurst Harbour' (*Application of environmental DNA to survey Bathurst Harbour (Tasmania) for the Endangered Maugean Skate (Zearaja maugeana)*[12] (***Moreno 2022 Report***); and

(ii) compliance monitoring data maintained by the Tasmanian Environment Protection Authority (***Tasmanian EPA***) that is stated to have documented 'cases of benthic bacterial matting spreading from Tassal's lease MF266'.

(c) Additional research regarding projected increased coastal water temperatures in the coming summer and the impact of these higher temperatures on dissolved oxygen levels is also asserted to constitute evidence of a 'change in circumstances' that should be considered.[13]

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[9] *Understanding the Ecology of Dorvilleid Polychaetes in Macquarie Harbour,* Jeff Ross, Arlie McCarthy, Adam Davey, Andrew Pender and Catriona MacLeod (2016).

[10] *Environmental Research in Macquarie Harbour Interim Synopsis of Benthic and Water Column Conditions*, Jeff Ross & Catriona MacLeod (2017).

[11] *Vulnerability of the endangered Maugean Skate population to degraded environmental conditions in Macquarie Harbour*, David Moreno, Jeremy Lyle, Jayson Semmens, Andrea Morash, Kilian Stehfest, Jaime McAllister, Bailee Bowen and Neville Barrett (2020);

[12] *Application of environmental DNA to survey Bathurst Harbour (Tasmania) for the Endangered Maugean Skate (Zearaja maugeana)*, David Moreno, Jawahar Patil, Bruce Deagle & Jayson Semmens (2022

[13] *Three decades of variability and warming of nearshore waters around Tasmania. Progress in Oceanography*, K.R Ridgway and S.D Ling (2023).

4.5 BB Foundation Reconsideration Request

(a) In addition to relying on the IMAS 2023 Report to establish grounds for the reconsideration request under sections 78(1)(a) and 78(1)(aa) of the EPBC Act, the BB Foundation has additionally sought to rely on the report to seek reconsideration under section 78(1)(b) of the EPBC Act.

(b) The BB Foundation:

(i) has interpreted the conditions of the NCA-PM Decision as requiring the Operators to ensure that their operations in the harbour do not have a significant impact on the Maugean Skate;

(ii) alleges that the results of the IMAS 2023 Report 'demonstrate… that significant impacts are being inflicted upon the Maugean Skate'; and

(iii) concludes that due to these observed impacts, the Marine Farming Expansion is not being conducted in the manner stipulated by the NCA-PM Decision.

5 Response to Reconsideration Requests

5.1 Outline

(a) This section presents Salmon Tasmania's review and response to each of the claims as set out the preceding section 4.

(b) Salmon Tasmania seeks to assist you in your assessment of the Reconsideration Requests in two modes:

(i) Providing an objective review and response to the Requestors' claims, checked against the actual methodology and findings reached in scientific literature cited by the Requestors; and

(ii) Providing you with expert technical opinion from Dr Ian Wallis in relation to the impact of salmon farming on the levels of dissolved oxygen in Macquarie Harbour as that may be relevant to the Maugean Skate.

(c) A technical review of the scientific literature relied upon by the Requestors is set out at Schedule 2. Further, Nautilus Collaboration has been commissioned to undertake a scientific review of the literature relied upon by The Australia Institute (the ***Nautilus Report***). The Nautilus Report is provided with this submission at Schedule 3.

(d) Dr Wallis is a member of the Macquarie Harbour Oxygenation Project (***MHOP***) team and was engaged by Salmon Tasmania to prepare a technical memorandum to estimate the demand for oxygen by salmon farms in Macquarie Harbour and determine whether the resulting dissolved oxygen draw down impacts the Maugean Skate (***Wallis 2024 Report***).

(e) The Wallis 2024 Report has drawn from and commented on the sources relied upon by the Requestors in section 4 above. A copy of the Wallis 2024 Report is attached as Schedule 4 to this submission.

(f) In short, Salmon Tasmania's review highlights that:

(i) None of the scientific literature relied upon by the Reconsideration Requests establishes the requisite causal link demonstrating that the Marine Farming Expansion has caused reduced dissolved oxygen levels that have significantly negatively impacted the Maugean Skate, and does <u>not</u> provide substantiation of the relevant grounds under section 78(1) of the EPBC Act (as described in section 1);

(ii) Nautilus finds that:

(A) Causality of impacts of salmon farming on the skate has not been in fact demonstrated in any of the reference material cited by The Australia Institute; and

(B) The submission of The Australia Institute:

(1) inflates the impact of salmon farming;

(2) fails to discuss or recognise the diminutive attribution of salmon farming to oxygen use in the harbour; and

(3) fails to acknowledge that there is a crucial influence on organic load and enrichment from the river systems from organic deposition;

(iii) Dr Wallis finds that:

(A) For the top layer of harbour waters (surface to depth of approx. 15m) - the reduction of dissolved oxygen in the top layer of the harbour waters by 4% or

0.3 mg/L from salmon farming "would have negligible effect on the survival of the skates in their normal habitat…"; and

(B) For the bottom layer of harbour waters (greater than approx. 15m) - salmon farms reduce dissolved oxygen in the lower layer of harbour waters by 10% to 16%, or 1 mg/L. Skates have been observed to avoid areas of low dissolved oxygen including when uplift events occur, by moving to the deeper ocean inflow regions where high dissolved oxygen water is entering (and causing the uplift event). Uplift events are not caused by, or increased by, salmon farming.

5.2 Response to IMAS 2023 Report

Summary

(a) The salmon farming industry acknowledges the interim Macquarie Harbour data gathered for the IMAS 2023 Report.

(b) The industry rejects however the interpretation of, and conclusions drawn from the report's findings by the Requestors, which can be summarised as:

(i) the reduced environmental conditions, namely reduced dissolved oxygen levels, occurring in the harbour are predominantly caused by salmon aquaculture;

(ii) the reduced dissolved oxygen levels are negatively impacting the Maugean Skate; and

(iii) the sole manner to resolve the impacts identified in the report is the cessation of aquaculture and marine farming in Macquarie Harbour, as is called for in The Australia Institute and AMCS/HSI requests.

(c) To the contrary, no such conclusions can be conclusively drawn from the data or resulting analysis contained in the IMAS 2023 Report, as this goes beyond the scope of the report.

(d) The only novel information contained in the IMAS 2023 Report is data regarding the population size, composition and characteristics of the Skate.

(e) The IMAS 2023 Report does not independently identify marine farming as the dominant cause of reduced dissolved oxygen levels in the harbour, nor does it establish any causal link between the declining CPUE, observed 'recruitment failure' and reduced dissolved oxygen levels in Macquarie Harbour.

(f) Separate scientific literature is referred to throughout the IMAS 2023 Report to establish the changed environmental conditions in Macquarie Harbour, the source of these changes and in turn the impact on the Maugean Skate.

(g) As such, the report does not itself establish any new evidence of Marine Farming Expansion having an impact on the Maugean Skate, as is required under section 78(1) of the Act.

(h) Although the initially reported 47% decline in CPUE since 2014 is notable, as an interim report, data collection for the IMAS 2023 Report remains ongoing. The preliminary nature of the findings is acknowledged in the report, which states that the analysis is not definitive. Following the release of the IMAS 2023 Report, the IMAS researchers have verbally reported the capture of juvenile Maugean Skate in significant numbers compared to historical efforts. This highlights the challenges of basing significant decisions on interim reports, prior to finalisation of populations studies. It also demonstrates the importance of the independent review of the methodology used to estimate population size and distribution which is currently underway via the Maugean Skate recovery process.

(i) Further, it is noted that the Moreno 2020 Report 'reported two environmental events in 2019 that resulted in high mortality (~44%) of [skate] being electronically tracked.' The IMAS 2023 Report attributes the cause of 'the observed declines in relative abundance' of the skate to 'high impact environmental events'.

(j) This coincides with uplift events in the harbour as described by Dr Wallis (see Schedule 4 at page 12).

(k) Notwithstanding, the mortality rate observed in the IMAS 2023 Report is consistent with the known natural mortality rate for skates, which was observed to be 40% per year (Grant et al, 2022) such that the findings of the report cannot be said to be evidence of excessive mortality.

Conclusion

(l) In the absence of final data identifying any conclusive impact on the skate, the sections of the Reconsideration Requests that rely on the IMAS 2023 Report fail to satisfy the requirement under EPCB Regulation 4AA.01 that stipulates that the requests must demonstrate 'a change in the potential impacts of the action is likely to happen with a high degree of certainty.'

(m) On the grounds stated above, Salmon Tasmania and its members reject that the IMAS 2023 Report constitutes:

(i) substantial new information about the impacts that the Marine Farming Expansion has, will have or is likely to have on the Maugean Skate; and/or

(ii) a substantial change in circumstances that was not foreseen at the time of the NCA-PM Decision and relates to the impacts that the Marine Farming Expansion has, will have or is likely to have on the Maugean Skate.

(n) Salmon Tasmania submits that the revocation and substitution of the NCA-PM Decision cannot be warranted based on the information contained in the IMAS 2023 Report, as it does not meet the requisite thresholds under section 78(1)(a) or section 78(1)(aa) of the Act.

5.3 Review of Additional Scientific literature referred to The Australia Institute and AMCS/HMI Requests

(a) A review of additional scientific literature cited by The Australia Institute and the AMCS/HMI Requests is set out in the Technical Review at Schedule 2 and is supplemented by the Nautilus Report provided at Schedule 3.

(b) The authors of the Nautilus Report are Christine Huynh, Andrew Mackay and Elena Contador, being experts with specific experience in advising the aquaculture industry on animal welfare and operations modelling.

(c) Key findings by the Nautilus include:

(i) The comments made by The Australia Institute in their reconsideration requests must be interpreted with caution as the data and information has been taken out of context and infers that there is causality.

(ii) <u>Causality has not been in fact demonstrated in any of the referenced material and the influence of salmon farming is over-stated in each of The Australia Institute requests</u>.

(iii) Wild-Allen (2020) in the FRDC report that found when modelling the removal of salmon farms "a 50 per cent reduction in hypoxic volume, and a 43 per cent increase in healthy water would result from elimination of salmonid farming". What the modelling actually found, was a reduction from 27-28% hypoxic to 14-17% by volume and from 12% to 4-6% by area. The model also used hard definitions of hypoxic as between 1-30% oxygen saturation, which means if the removal of salmon farming increased saturation by 1% and a portion of the water was at 30%, that water volume would now be considered 'intermediate'.

(iv) The Wild-Allen 2020 report findings and budget were based on modelling conditions and farming inputs from 2017 and 2018, which are no longer representative due to changes in salmon farming (decreased biomass limits and nitrogen budgets) and any changes in hydro-electric dam operational management (refer to Schedule 1 for HOG tonnes produced in the harbour).

(v) The referenced material in The Australia Institute letter is considered 'old' evidence. The salmon industry has already considered these pieces of evidence in their adaptive management processes, and since their release, have changed biomass and nitrogen limits to suit the estimated carrying capacity of the harbour. (See discussion of the adaptive management regime under the Tasmanian licensing regime in section 7). This is a statement that applies to all the referenced material, as the models, assumptions and methods need to be updated to incorporate new scientific evidence.

(d) In response to the claim concerning marine lease MF266, this is not new information. MF266 is the southern most lease in the harbour and is impacted by Gordon River flows and related organic matter. This lease sits at the edge of the organic gradient that IMAS research identified. It should be noted that the presence of *Beggiatoa sp*. at sites located well upstream in the TWHA has been observed on a number of occasions and is not related to the impacts of salmon farming.

5.4 Wallis 2024 Report Findings

(a) Key findings of the Wallis 2024 Report include:

(i) that oxygen is primarily introduced into Macquarie Harbour by river and ocean water inflows and surface re-aeration. River inflows are continuous, with volumes varying seasonally and following releases from hydroelectric dams upstream in the Gordon and King Rivers;

(ii) inflows of sea water are responsible for replenishing DO levels of water at the lower layer of the Harbour. The ability of ocean water to enter the harbour is determined by river inflows and is hampered by the large volume of freshwater that must be discharged during a tide cycle and the long channel (8km) from the ocean to the harbour. In periods of higher river flow (generally during winter-spring or following a dam release event) inflow of ocean water is restricted and periods of low DO in deep waters are also observed;

(iii) uplift events where waters with low DO come closer to the surface are natural events driven largely by low river flows and, to a lesser extent, by tides, atmospheric pressure and winds. The events are not caused by, or increased by, salmon farms;

(i) the current evidence is that the Maugean Skate generally live in the top layer of the Macquarie Harbour at a range of 8m to 15m which has satisfactory levels of dissolved oxygen and travel into the lower layer only where there is satisfactory dissolved oxygen.

(ii) salmon pens are located at the surface of the harbour and extend down to approximately 13m depth, with the preferential depth of the fish within the pen varying with temperature changes and DO levels;

(iii) dissolved oxygen demands associated with marine farming operations are 2-fold, being demands from fish respiration and the biological processes associated with lost feed and salmon excreta. When respiration and the net drawdown of oxygen associated with biological processes is considered, 'salmon farms reduce the DO in the top layer [of the harbour] by 4% or 0.3mg/L'. This <u>minor decrease is said to have negligible effect on the survival of the skates in their normal habitat in the top layer</u> near Table Head;

(iv) the drawdown of DO levels associated with marine farming in deeper waters (at 15 to 30 m depth) is estimated to be between 10% and 16% of that supplied by ocean water into the lower layers of the harbour. The DO demand from fish respiration has no effect on dissolved oxygen levels in the bottom layer as salmon pens do not extend to this depth;

(v) the impact of biological processes at depth as a result of salmon farming are minor when considered in the context of the whole harbour. Dr Wallis finds that 'the majority of the oxygen demand on the lower layer' comes from organic material introduced into the harbour as a result of river inflows.

(vi) the natural processes associated with river inflow organics is 'estimated to reduce the DO in the lower layer to around 35 % saturation'. Salmon farming is said to reduce DO levels to around 25%;

(b) Dr Wallis concludes that 'It is not obvious from the DO data analysed in this report that there has been “a marked decline in dissolved oxygen conditions in Macquarie Harbour which are likely to have a significant impact on many resident species, including the Maugean Skate”. Dissolved oxygen was always low in the lower layer … whether or not there is a long term trend of declining DO with time is still an open question…'

5.5 Response to BB Foundation Reconsideration Request

(a) The allegation made by the BB Foundation that the impacts reported in the IMAS 2023 Report indicates that the Marine Farming Expansion is not being undertaken in accordance with the NCA-PM Decision fundamentally misinterprets the function of the decision requirements.

(b) Moreover, the BB Foundation fails to establish, or refer to documentation that establishes, causality between the Marine Farming Expansion, the reported reduced environmental conditions in the harbour and the impacts on the Maugean Skate.

(c) The NCA-PM Decision requires that the Marine Farming Expansion be undertaken in accordance with the Macquarie Harbour Marine Farming Development Plan October 2005 (***MHMFD Plan***) and the measures stated in requirements 1-3 of the decision.

(d) The allegation by the BB Foundation is not supported by any particulars of conduct by the Operators that has occurred in a manner inconsistent with the requirements of the NCA-PM. This is contrary to the requirement in clause 4AA.01(5) of the EPBC Regulation; accordingly the request on the basis of section 78(1)(b) of the EPBC Act is not valid and cannot not be accepted by you.

(e) If you or your Department held any concerns as to compliance with the NCA-PM Decision, as matter of procedural fairness, it would be appropriate in the first instance for those matters to be put by the Department directly to the relevant operators, in confidence, for its consideration and response.

(f) Even if the allegation made by the BB Foundation constituted a properly made reconsideration request, it is submitted there is no factual basis for you to reasonably accept that a ground is established under section 78(1)(b) to revoke the NCA-PM Decision.

6 Addressing environmental impacts, and improving knowledge of the Maugean Skate

6.1 State and Commonwealth Conservation Advice

(a) On 6 September 2023 updated Conservation Advice for Maugean Skate was published by the Department of Climate Change, Energy, the Environment and Water under the EPBC Act (***Conservation Advice***).[14]

(b) The Conservation Advice provides guidance and identifies actions required and research to be undertaken to ensure the conservation and recovery of the Maugean Skate and provides a summary of the current threats to the species.

(c) Several key urgent actions are identified by the Conservation Advice that were recommended to be implemented prior to summer 2023 to ensure the species does not become extinct including:

  (i) increasing the levels of dissolved oxygen in Macquarie Harbour, via a reduction in salmon aquaculture organic loads and/or utilisation of mechanical/engineering environmental remediation technologies;

  (ii) initiation of a captive breeding program, including all appropriate Commonwealth and state permits for collection of Maugean skate adults and eggs; and

  (iii) reinstating the CSIRO predictive monitoring modelling to inform modification of hydroelectric dam environmental flows.

(d) In January 2024, the Department of Natural Resources and Environment Tasmania (**NRE Tas**) released the newly developed Maugean Skate Conservation Action Plan.

(e) The Conservation Action Plan details 5 objectives and actions designed to minimise the extinction risk of the Maugean Skate and support recovery of the skate in the wild.

(f) The first objective of the Conservation Action Plan is to 'ensure that viable habitat in Macquarie Harbour is available to meet the needs of the Maugean skate'. This objective will aim to be achieved through the undertaking of 'Priority Conservation Actions' which for Objective 1 include engineered oxygenation projects supported by the industry.

(g) Both the Federal and State conservation materials identify the role that engineered solutions will need to play in addressing environment conditions within Macquarie Harbour.

(h) The salmon farming industry acknowledges the sensitivities of operating within the unique Macquarie Harbour environment and are alive to the need to develop innovative and effective methods to reduce and mitigate impacts on the environment and to work closely with peak research bodies in order to achieve this.

6.2 Industry Involvement in Research Initiatives

(a) Significant time and resources have been invested by the Operators into addressing these concerns, including providing funding and technical expertise for research and conservation initiatives.

(b) Industry is engaged, consulted and actively participate in research undertaken by peak bodies including the Fisheries Research and Development Corporation (***FRDC***) and IMAS.

(c) Much of the data that underlies the scientific reporting conducted by FRDC and IMAS is collected by the Operators throughout the harbour.

[14] https://www.environment.gov.au/biodiversity/threatened/species/pubs/83504-conservation-advice-06092023.pdf.

(d) Since 2012, the industry has provided financial support for research undertaken in relation to environmental impacts and environmental management relevant to salmon farming in Macquarie Harbour, through projects coordinated by the FRDC including:

(i) Atlantic Salmon Aquaculture Subprogram: characterising benthic pelagic interactions in Macquarie Harbour - organic matter processing in sediments and the importance for nutrient dynamics (FRDC Project no. 2012-047);

(ii) Movement, habitat utilisation and population status of the Endangered Maugean skate (FRDC Project no. 2013-008);

(iii) Managing ecosystem interactions across differing environments: building flexibility and risk assurance into environmental management strategies (FRDC Project no. 2015-024);

(iv) Understanding oxygen dynamics and the importance for benthic recovery in Macquarie Harbour (FRDC Project no. 2016-067); and

(v) Vulnerability of the endangered Maugean skate population to degraded environmental conditions in Macquarie Harbour (FRDC Project no. 2016-068).

(e) Given the high level of involvement of industry in these research efforts the findings arising from these projects are proactively integrated into industry management and operational practices often before the findings are made publicly available.

(f) The most recent initiative is the MHOP – ie the "Macquarie Harbour oxygenation trial" (FRDC Project no. 2023-087) addressed in section 6.3 below.

(g) Extensive technical research has been undertaken by IMAS, again financially and operationally supported by industry, in relation to Macquarie Harbour since 2012, which has informed the Operators' management and practices. This includes the following:

(i) IMAS Technical Report on Macquarie Harbour Condition, Jan 2017;

(ii) IMAS Progress Report on Macquarie Harbour, May 2017;

(iii) Macquarie Harbour TWWHA Environmental Status Report, EPA, May 2017;

(iv) Macquarie Harbour 2013-2016 Nutrient Review May 2017 (Internal Final Draft);

(v) IMAS Progress Report on Macquarie Harbour, September 2017;

(vi) IMAS Progress Report on Macquarie Harbour, February 2018;

(vii) IMAS Progress Report on Macquarie Harbour, December 2018;

(viii) IMAS Environmental Research Progress Report, July 2019;

(ix) IMAS Environmental Research Progress Report, February 2020; and

(x) IMAS Assessment of Macquarie Harbour BEMP data from 2011 to 2020, March 2022.

6.3 Macquarie Harbour Oxygenation Project

(a) The MHOP is a $6 million trial of engineering solutions to enhance oxygen levels in Macquarie Harbour. The project is being led by the salmon farming industry, in partnership with independent organisations - the Australian Government's FRDC, and the IMAS.

(b) The MHOP will be instrumental in demonstrating the role that an engineered solution, being the mechanical oxygenation of bottom and mid waters, can play in improving and regulating the oxygen levels in Macquarie Harbour, as identified in both the State and Federal Conservation documents.

(c) The MHOP will incorporate three packages:

(i) engineering and operation of the oxygenation plant and delivery system;

(ii) measuring the ecosystem response; and

(iii) modelling to predict plume diffusion and advection at local and broad scales.

(d) The pilot trial will progress in a staged approach, with the volume, duration and method of injection progressively scaled based on plume dispersion modelling and detailed water quality and ecosystem observations to ensure that the oxygen is delivered and retained in the bottom waters with no adverse ecological effects.[15]

(e) The MHOP will trial 2 dissolution systems to boost oxygen levels in dissolved-oxygen poor, middle and bottom waters over time:

(i) The first dissolution system works by generating oxygen which is subsequently mixed with water that has been pumped from a depth of 20m. The supersaturated water is then pumped to the high resident marine water that sits beneath the freshwater surface layer at approximately 30m-40m depth; and

(ii) The second employs nano-bubble and micro-bubble technology where oxygen gas will be piped directly to the desired depth where it is injected into the water.

(f) These forms of generation were identified as the best oxygen delivery methods that simultaneously avoid any upwelling or mass water movements in the highly stratified waterway.

(g) This type of technology is regularly used around the world for port and harbour remediation, river and estuarine systems to assist natural water exchange and oxygenation. There is a long serving installation that has been in the Swan River in Perth to assist this naturally low water exchange river and provide oxygen. Internationally, these systems are commercially available and used to boost deep water oxygen levels.

(h) A two-year trial was commenced in Summer 2023/24 which will assess the delivery of oxygen to the deeper water sections of the harbour. These deeper waters of the Macquarie Harbour system have the longest residence time and is where biological oxygen demand from aquaculture, hydro and river systems occurs.

(i) The trial will further determine whether this technology can provide a long-term solution to improve the Macquarie Harbour environment for the Maugean Skate, while responding to the challenge of warming waters.

(j) The impacts of the trial oxygenation activities on the surrounding area will also be assessed to ensure there are no adverse ecological effects as a result of the MHOP project, during the trial period and long-term.

(k) Real-time monitoring will be used to measure oxygen, temperature, salinity levels and turbidity and chlorophyll near the injection location during the trial period. Samples will additionally be collected to test for changes to metals, microbes and nutrients baselines.

(l) The MHOP will be overseen by IMAS scientists, who will independently review and report on the results of the trial to all stakeholders, including the Tasmanian EPA and the Australian Government.

(m) Reports providing updates on the oxygenation trials including a summary of key performance outcomes based on the water column and benthic observations, model outputs and any

[15] FRDC funding application

other relevant findings, will be made publicly available on the FRDC and IMAS websites and in scientific literature publications.

(n) The MHOP has been endorsed by the Maugean Skate National Recovery Task Force as one of the immediate priority actions to support the conservation and recovery of the Maugean Skate as is detailed in the Conservation Advice and Action Plan for the Maugean Skate.

(o) The MHOP has received further endorsement from Senator for Tasmania, Senator Anne Urquhart, who has acknowledged the salmon farming industry's role in pursuing positive outcomes for the harbour.

(p) While we acknowledge that salmon farming is one of many activities that impact upon the environmental conditions of Macquarie Harbour, the industry has voluntarily undertaken to reduce its own direct impact on oxygen levels in the harbour by supplementing the known DO drawdown with oxygenated water (super-saturated) pumped from the surface to depth in the water column.

(q) Salmon Tasmania submits that the two-year trial should be allowed to run its course before any conclusions are reached about its efficacy.

7 Strengthened Tasmanian Government Regime for Marine Farming

7.1 Regulatory framework introduction

(a) Separate to forming the basis of the Reconsideration Requests made under s78A, each of the requests allege that the data contained in the IMAS 2023 Report is evidence that the conditions in the NCA-PM Decision are not sufficient to ensure that the Marine Farming Expansion has no significant impact on the skate.

(b) Salmon Tasmania and the industry reject this allegation as unsubstantiated. The criticisms fail to appreciate the requirements of the NCA-PM Decision and the manner in which they operate in conjunction with the evolution of practices within the industry and the changes to the Tasmanian regulatory regime over time.

(c) The NCA-PM Decision requires that the Marine Farming Expansion be undertaken in accordance with MHMFD Plan and the measures stated in requirements 1-3 of the decision. The conditions require compliance by the Operators with monitoring and reporting requirements as prescribed by the relevant marine farming licence conditions.

(d) Since sampling began in 2012, dissolved oxygen levels have always complied with the set trigger limit for 2 meters (6.82 mg/L). This compliance record for dissolved oxygen incorporates the data from over 100 sampling events (and applies a rolling median).

(e) This evidence of compliance is the same for the other parameters, notably trigger levels set for ammonia at 2 and 20 meters (0.033 mg/L and 0.024 mg/L respectively) and the nitrate trigger set for 2 meters (0.053 mg/L). None of these triggers outlined in the 2012 decision have been breached.

(f) Close supervision of the industry by the Tasmanian Government has resulted in amendments to the regulation of finfish farming and aquaculture at the State level since the NCA-PM Decision was made. A central component of this approach has been the adoption of adaptive management principles.

(g) As a result of changes by the Tasmanian Government, the salmon farming industry is subject to materially more stringent monitoring, reporting and compliance requirements at the State level than were in effect at the time of the 2012 decision.

(h) This is in addition to self-imposed changes by industry in operations and management of salmon farming arising from the results of scientific research and development initiatives.

(i) Significantly, recent amendments to renewed Environmental Licences for Macquarie Harbour farming operations have introduced requirements to monitor and develop mitigation plans relating to dissolved oxygen levels.

(j) The amended regulatory framework has been further bolstered by the State's adoption of modernised impact mitigation measures, introduction of legally enforceable environmental and technical standards and development of key policy documents.

(k) These steps notably include halving the total maximum allowable biomass limits for the harbour, the introduction of Total Permissible Dissolved Nitrogen Output (***TPDNO***) as the metric for managing finfish production, the introduction of *Environmental Standards for Tasmanian Marine Finfish Farming in 2023* and the development of a dedicated Conservation Action Plan for the Maugean Skate.

(l) The enhanced requirements under the State regime means that marine farming in Macquarie Harbour is conducted in a manner that exceeds the requirements contained in the 2012 NCA-PM Decision and at significantly lower levels of production than was intended in

2012. Indeed, as demonstrated in Schedule 1, production levels are now less than existed at the time of the NCA-PM Decision in 2012.

(m) Compliance with environmental licence requirements under the State regime is enforced by the independent environment regulator, the Tasmanian EPA, and for the marine farming leases by the Tasmanian Department of Natural Resources and Environment (***NRE Tas***) - meaning there is further oversight over the industry to ensure compliance with the regulatory regime and appropriate management of environmental impacts.

(n) The further development of the regulatory framework for managing environmental impacts to water quality and aquatic life continues, as evidenced by the release in July 2023 by the Tasmanian EPA of the Interim Default Guideline Values for Aquatic Ecosystems for part of Macquarie Harbour.

7.2 Limiting of Biomass and Introduction of Total Permissible Dissolved Nitrogen Output

(a) Until 2022, biomass caps that determined the maximum allowable biomass of finfish (tonnes per hectare) were implemented under the MHMFD Plan to regulate the number of fish that may be stocked in Macquarie Harbour.

(b) The Marine Farming Expansion included the reconfiguration of leases within Macquarie Harbour to increase the total allowable lease space from 564 ha to 926 ha. A considerable body of social, economic and environmental information was consolidated into an Environmental Impact Statement that supported the proposed increased production in Macquarie Harbour.

(c) The maximum sustainable biomass determined for the harbour was initially modelled at 29,500 tonnes. Salmon production in the harbour reached a level of 19,200 tonnes in late 2014.

(d) In April 2016, the biomass caps for each company were decreased to 21,500 tonnes for the 2016/2017 production year

(e) In 2017 the Tasmanian EPA Director issued determinations to each of the Operators in the harbour, requiring that maximum permissible biomass limits be reduced by half (***2017 Determinations***).

(f) The maximum permissible biomass allowed to be stocked in the Harbour has continued to be progressively lowered since 2017. The total allowable biomass cap for the Harbour was 14,000 tonnes from 14 February to 30 April 2017, 12,000 tonnes for the period 31 May 2017 to 31 May 2018 and 9,500 tonnes per annum between 1 June 2018 to 31 May 2022.

(g) Amendments to the MHMFD Plan on 13 September 2016 conferred the Tasmanian EPA Director with power to determine the total permissible dissolved nitrogen output (***TPDNO***) attributable to licensed finfish marine farming operations in Macquarie for specified periods.

(h) TPDNO limits have been introduced to replace biomass caps as the method for limiting finfish production in Macquarie Harbour.

(i) The first TPDNO determination of 500.1 tonnes was made on 31 August 2022 and applies for the period 1 September 2022 until 31 August 2027.[16] The TPDNO specified in the determination provided for a 10% reduction in production from 2021 production levels.

(j) As a result, current production levels in the harbour are lower than they were at the time of the NCA-PM Decision in 2012.

[16] Determination And Apportionment of Total Permissible Dissolved Nitrogen Output

(k) The introduction of TPDNO is an example of how modern and improved practices are being implemented in the regulation of the salmon farming industry to provide more clarity, transparency and better outcomes for the environment.

(l) The reduced production in Macquarie Harbour as a result of the biomass caps and TPDNO determinations is shown in Schedule 1 .

7.3 New Environmental Licence Conditions

(a) Since the granting of the original licences in 2012, the Marine Licence Conditions (now Environmental Licences) have become more contemporary and includes increased sampling requirements (near and far field).

(b) Industry has also established a real-time sensor network across the system to measure key environmental parameters including oxygen, salinity and temperature.

(c) The strengthened licence conditions have been underpinned by the comprehensive research that has been conducted across Macquarie Harbour allowing the adaptive management of this unique waterway.

(d) On 30 November 2023, following a historical compliance review, the Tasmanian EPA Director decided to renew all environmental licences for leases within Macquarie Harbour for a 2-year period.

(e) This included leases held by Petuna Aquaculture, Tassal Operations and Huon Aquaculture.

(f) In renewing these licences, the Director imposed additional conditions requiring each environmental licence holder to:

  (i) provide the Director with the overall dissolved oxygen demand resulting from finfish activities on their lease;

  (ii) provide and implement a Dissolved Oxygen Mitigation Plan to substantially offset or reduce dissolved oxygen demand from their lease; and

  (iii) develop for approval and implement a Water Quality Monitoring Plan to measure the success of the dissolved oxygen mitigation measures against the interim default guideline values set by the EPA.

(g) The Environmental Licence conditions now require the reporting of oxygen consumption for both fish respiration and biological oxygen demand.

(h) There are also default guideline values that have been developed for 3 segmented zones as determined by EPA across the system. The broadscale water quality monitoring program has remained in place since 2011 and provides a world-class continuous dataset for system wide analysis.

(i) These requirements represent additional measures, in addition to those stated in the NCA-PM Decision, that are undertaken by the Operators in order to address the concerns relating to diminished DO levels in the harbour.

7.4 New Environmental and Technical Standards

(a) In 2023, new Environmental Standards for Tasmanian Marine Finfish Farming were made pursuant to the *Environment Management and Pollution Control Act 1994 (Tas)* (***EMPCA***) and came into effect on 18 October 2023 (***Environmental Standards***).

(b) The standards were introduced as part of the Tasmanian Salmon Industry Plan in support of the regulation and management of the marine finfish farming industry in Tasmania[17]. The Environmental Standards will be enforced by the Tasmanian EPA.

(c) The purpose of the Standards is to set out the environmental management conditions that will be imposed on environmental licences issued to marine finfish farmers, with non-compliance with the Standards being an offence under the EMPCA.

(d) Under the Environmental Standards, the Tasmanian EPA Director is empowered to make determinations as to compliance thresholds, monitoring requirements for marine farming activities and impose conditions relating to environmental outcomes that must be complied with by licence holders.

(e) The Standards also contain standard environmental management conditions that will be imposed on environmental licences issued to marine finfish farmers and are enforced by the Tasmanian EPA.

(f) The Standards are reflective of international industry best practice, and have been developed following a review of international regulatory practices for monitoring the environmental impacts of farming salmonids in net pens by the Tasmania EPA. Input from peak research bodies including IMAS and the Commonwealth Scientific and Industrial Research Organisation (***CSIRO***) also informed the development of the Environmental Standards.

(g) Technical Standards that will that enable the Tasmanian EPA to implement the new Environmental Standards are currently under development. The Technical Standards will contain contemporary, scientifically sound, and auditable methods and are expected to be published by 1 January 2025.[18]

(h) In carrying out the Marine Farming Expansion the Operators are required to comply with the Environmental Standards, and in turn with the forthcoming Technical Standards.

7.5 Conservation Action Plan

(a) The MHOP will play a key role in achieving the first objective of the Maugean Skate Conservation Action Plan, being to 'ensure that viable habitat in Macquarie Harbour is available to meet the needs of the Maugean skate'.

(b) The CAP will be deemed successful if, among other criteria, threats to the skate population and health of Macquarie Harbour generally are better understood and where feasible reduced, and there is an increased understanding of the species' response to anthropogenic impacts within 3 years of the introduction of the Conservation Action Plan.

7.6 Conclusion

(a) The significant work undertaken by the Tasmanian Government and salmon farming industry means that the Marine Farming Expansion is carried out in accordance with international best practice.

(b) Both the Tasmanian Government and the industry are responsive to developments in technology and actionable findings from scientific reports, and incorporate these developments into their licencing requirements and operational practices.

[17] Environmental Standards for Marine Finfish Farming, Tasmanian EPA.
[18] Environmental Standards for Marine Finfish Farming, Tasmanian EPA.

(c) Salmon Tasmania submits that you should take notice that the Tasmanian regulatory regime ensures that the Marine Farming Expansion is being proactively managed in an effective and transparent manner to achieve published standards.

8 Immediate, significant adverse impacts of any revocation of the NCA-PM decision

8.1 Immediate impact on aquaculture activities

(a) Should the outcome of the reconsideration request process lead to a decision that the Marine Farming Expansion in Macquarie Harbour is a 'controlled action', this would result in the activities immediately being expressly prohibited by section 74AA of the EPBC Act until such time as an assessment has been completed and an approval issued.

(b) As such, any revocation of the current NCA-PM Decision and substitution of a controlled action decision would immediately result in the activities being unlawful until approved. All salmon farming industry participants relying on the NCA-PM decision would be required to immediately cease all operations in the Macquarie Harbour, as quickly and practically as possible without compromising animal welfare.

(c) Ceasing operations in Macquarie Harbour would result in major impacts to the local community including a near total reduction in the local workforce.

(d) Should the industry be required to abruptly halt and relocate their activities, it would be highly challenging and cost prohibitive for the industry to restart salmon farming in Macquarie Harbour.

(e) Furthermore, any decision around this matter must consider the immediate animal welfare of the stock of fish currently growing in the harbour. It is not logistically or commercially possible to relocate such large quantities of livestock to other parts of the State, nor is this permitted under the State's biosecurity regime.

(f) The salmon industry considers that any decision that affects the lawfulness of current aquaculture operations in Macquarie Harbour must consider the practical need for fish stock within the harbour to be able to grow out to production size. The only alternative option would be to euthanise the stock.

(g) The Tasmanian EPA Director recognised this constraint in the Statement of Reasons provided for the renewal of Environmental Licences relevant to the Marine Farming Expansion in late 2023. The Director acknowledged that Tasmania does not currently have the capacity to adequately manage the volume of waste that would result from the cessation of aquaculture in the harbour.[19]

(h) Consideration would also need to be had to the handling of the next year class of finfish that are currently being held in freshwater hatcheries waiting to be put into the harbour. The practicality of prematurely destroying infant livestock that cannot be used for production is not something that industry has ever needed to contemplate.

(i) The management of the mortalities from a biosecurity and waste management perspective would require a major undertaking by industry and the Tasmanian Government, with the potential to trigger significant new environmental challenges. Salmon Tasmania urges you to seek advice from your agency and the Tasmanian Government on the environmental risks of such an outcome.

8.2 Impact on member entities

(a) Additionally, if the effect of a new controlled action decision is that the Marine Farming Expansion becomes immediately unlawful (until approved), or conditions imposed on any subsequent approval are unduly onerous and such that it becomes financially unviable, there will be significant flow on effects for Salmon Tasmania's members.

[19] *Statement of Reasons for the Renewal of the Environmental Licences Issued to Petuna Aquaculture Pty Ltd for Finfish Farming Activities in Macquarie Harbour* (2023) page 7.

(b) At a high level, expected likely adverse impacts in the above scenarios include:

(i) environmental considerations in relation to the suspending of operations and decommissioning of the project;

(ii) obligations under employment and remuneration contracts;

(iii) termination of supplier and customer agreements upstream and downstream along the logistics and value chain;

(iv) implications for breach of covenants in agreements with third parties including financiers and suppliers;

(v) risks to certifications held by Operators that affect operations outside of Macquarie Harbour; and

(vi) implications for insurance and inability to obtain further cover.

(c) These effects represent a significant risk to the operating future of our member entities, who are significant employers in the region and would have immediate adverse impacts on our members' workers, their families and the wider community of the West Coast region.

8.3 Impact on the Community and Tasmanian economy

(a) The principles of ecologically sustainable development that underpin the objects of the EPBC Act require the balancing of economic advancement and environmental preservation in order to achieve sustainable outcomes.

(b) The EPBC Act requires that any decision-making process under the Act effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.[20]

(c) The role of the salmon aquaculture industry in promoting the economic prosperity of the region and of Tasmania as a whole cannot be understated.

(d) Deloitte Access Economics analysis in 2022 found:

(i) the Tasmanian salmon farming industry supported 5,103 FTE (full-time equivalent) jobs, and contributed $770 million to the Tasmanian economy.[21] This represents 2.1% of the Tasmanian economy;

(ii) importantly the economic benefit generated by the industry is not concentrated in metropolitan centres but rather in regional areas, where the salmon industry accounts for more than 1 in 4 jobs. In the West Coast region, where Macquarie Harbour is located, the salmon industry supports 17% of employment in the region;

(iii) Macquarie Harbour operations account for 395 FTE direct and indirection roles alone, with 1 in 3 residents of the town of Strahan being employed within the industry; and

(iv) the jobs created by the salmon industry are of high quality with average renumeration being more than double that of the average Tasmanian job and more than 74% of other jobs in the West Coast region. This is in part reflective of the highly technical and skilled nature of the roles involved in the salmon industry.

(e) The positive impact of the salmon industry on the economy spreads well beyond direct employment with the salmon companies, and the flow-on impacts into the broader community are significant.

[20] Section 3A(a) EPBC Act.
[21] Deloitte Access Economics (2022),*'Socio-economic contribution of the Tasmanian salmon industry*

(f) There is a thriving ancillary sector providing inputs to the industry such as vessels, pens, nets, feed, training, transport, fuel and logistics, and a range of contract and consultancy services.

(g) Notably the salmon companies utilise vertically integrated business models, with operations spanning across the whole salmon production lifecycle from hatcheries to salmon processing and distribution. Therefore, any impacts on the aquaculture portion of the business will directly impact the other arms of the Operators' businesses.

(h) The revocation of the NCA-PM decision would result in a devastating loss of jobs across a broad section of the Tasmanian Community.

9 NCA-PM with updated requirements

(a) Should you be satisfied that revocation of the NCA-PM Decision is warranted on any of the grounds under section 78(1), and you are considering what new decision you may take in substitution for the NCA-PM Decision, then Salmon Tasmania makes an alternative submission for your consideration.

(b) Salmon Tasmania submits that if the existing NCA-PM Decision is to be substituted, it would be appropriate to take a new decision that the Marine Farming Expansion is not a controlled action if undertaken in a particular manner, and that those requirements of the particular manner be updated.

(c) Salmon Tasmania in conjunction with the Operators, has convened a technical advisory group to provide recommendations on steps that can be taken to further support environmental protections for the Maugean Skate.

(d) With the benefit of that technical advice, and following consultation with the Operators, Salmon Tasmania is available to put forward for your consideration a set of proposed alternative particular manner restrictions, and requests you to seek technical advice from your Department and engage with industry and the Operators as to additional appropriate, practical and proportionate measures that will further support improved environmental conditions in Macquarie Harbour for the Maugean Skate.

(e) Salmon Tasmania stands ready and willing to facilitate engagement by your Department with the Operators and wider industry stakeholders in relation to the development of any such measures.

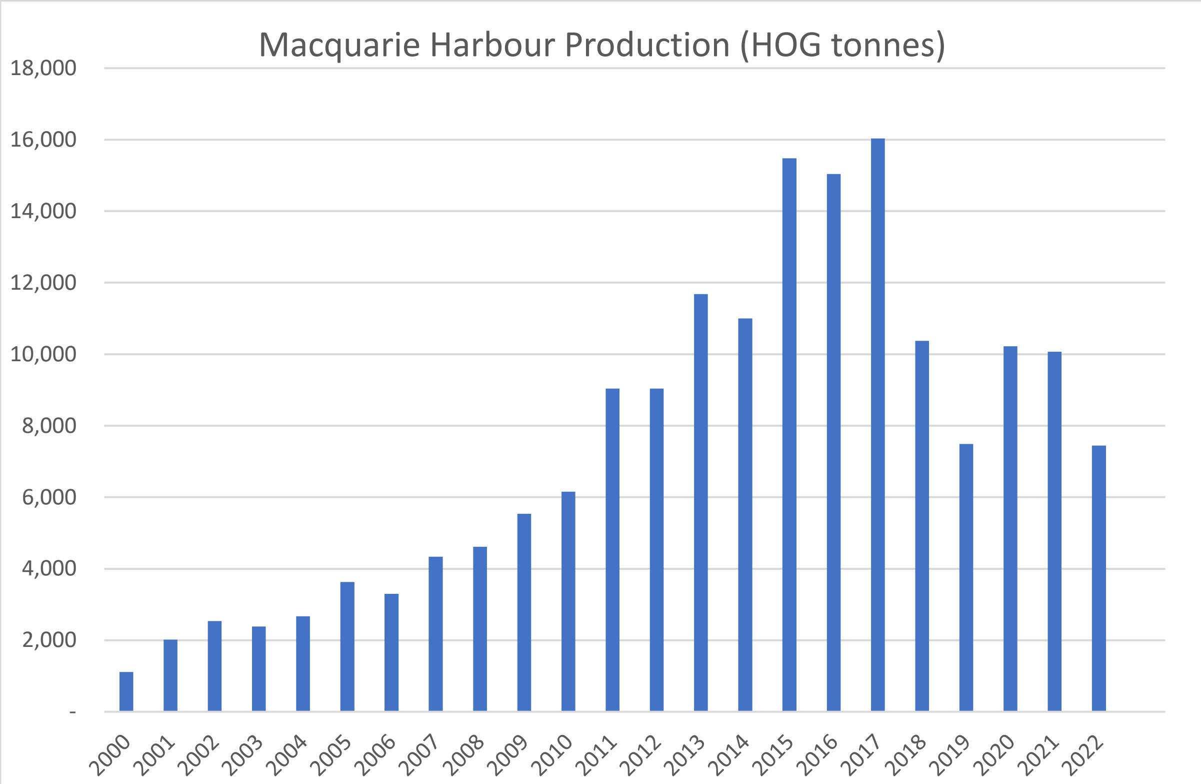
(f) Salmon Tasmania is confident that any discussions on updated particular manner requirements would properly inform a fresh decision that the Marine Farming Expansion is not a controlled action decision if undertaken in accordance with an updated set of particular manner restrictions.

(g) If this alternative proposal is of interest to you and your Department, Salmon Tasmania would welcome the opportunity to engage on the scope and nature of any proposed amended 'particular manner' requirements, to ensure they align with your expectations and comprise a comprehensive set of practical steps to support the recovery of the Maugean Skate in conjunction with sustainable salmon farming in Macquarie Harbour.

(h) In contrast to a fresh NCA-PM decision, any decision that would result in aquaculture in Macquarie Harbour ending without a scientific basis for doing so, that also failed to address other sources of environmental degradation including changed river flows from hydro-electricity generation and the presence of heavy metals from historic mining activities, would be most unlikely to resolve current low levels of dissolved oxygen and that decision made alone would be unlikely to achieve improved environmental conditions in the harbour to support the recovery of the Maugean Skate.

Salmon Tasmania welcomes any questions in relation to this submission and would be pleased to provide further submissions if that will assist your consideration of the matters raised above.

Schedule 1 – Macquarie Harbour salmon farming production



Source: Department of Natural Resources and Environment Tasmania – Aquaculture Branch (public document) Macquarie Harbour Production Data 2000-2022

Schedule 2 – Technical Review

Schedule 2 – Salmon Tasmania Submission on Requests for Request Reconsideration of Referral Decision

Review of scientific reports and papers cited in the Requests from The Australia Institute and the AMCS/HSI

1 Overview

This document presents the findings of the objective review of the Reconsideration Requests and scientific literature referred or and relied upon by the requests. The technical review has been undertaken for Salmon Tasmania by a Technical Advisory Group comprising senior technicians drawn from the Operators, with independent review and findings incorporated from the Nautilus Report (Schedule 3) and the Wallis 2024 Report (Schedule 4). This document is to supplement the primary matters raised in the Submission.

2 Response to The Australia Institute Reconsideration Request

2.1 Salmon Tasmania Submissions

(a) In addition to the IMAS 2023 Report, The Australia Institute relies on the scientific reports outlined in section 4.3 of the Submission in order to assert a causal link between marine farming operations and the observed impacts on the Skate arising from reduced dissolved oxygen levels in Macquarie Harbour.

Substantial new information

(b) Salmon Tasmania submits that individually the reports cited by The Australia Institute fail to establish any causal link between the observed decline in skate population and marine farming operations.

(c) The failure to draw a causal link means that the information relied upon does not demonstrate that a change in the potential impacts of the Marine Farming Expansion is likely to happen with a high degree of certainty, as is required under the EPBC Regulation.

(d) Where cited reports do observe causal links, they overstate the impacts of marine farming operations on dissolved oxygen levels and incorrectly attribute the observed drawdown of oxygen solely or primarily to aquaculture, without considering the hydrological conditions of the harbour and the impacts of other anthropogenic inputs.

(e) The Request by The Australia Institute also restates findings of cited reports in a manner that does not accurately reflect the conclusions of the relevant report.

(f) Moreover, the alleged 'new evidence' extracted in The Australia Institute Letter dated 31 July 2023 (***31 July 2023 Letter***) relies on reports that have already been considered and acted upon by the salmon industry, relevant research partners and regulators.

Unforeseen substantial change in circumstances

(g) The request includes scientific data and statements that support the arguments presented by The Australia Institute, without conducting a discussion of the data or considering the findings via a holistic approach in the context of the changing conditions in Macquarie Harbour or other types of anthropogenic change.

(h) None of the reports relied upon identify circumstances that were not known by the Minister or the industry at the time of the NCA-PM Decision.

(i) There have been significant additional monitoring information collected over time which has supported and improved the understanding of the complexities in managing impacts on the Macquarie Harbour system. However, this further information relating to impacts does not amount to a substantial change in circumstances that was unforeseen – to the contrary the monitoring was anticipated and required of the operators.

2.2 Tasmanian Threatened Species Listing Statement

Summary

(a) The Tasmanian Threatened Species Listing Statement for the Maugean Skate notes that modelling and empirical studies have identified 'river flows and increased nutrient loadings from salmonid aquaculture operations' as playing a 'role in influencing the dissolved oxygen status of the harbour'. River flows were noted to have been altered by 'flows from hydroelectric production' which in turn have also had an impact on 'hydrodynamics and dissolved oxygen status of the harbour'.

(b) These findings are taken from the Ross 2017 Report and the Wild-Allen 2020 Report, discussed below.

2.3 Ross 2016 Report

Summary

(a) The Ross 2016 Report investigated the response of benthic invertebrate communities, specifically *Dorvilleid polychaetes*, to 'organic enrichment' from fish farming in Macquarie Harbour.

(b) The presence of benthic invertebrate communities can be used an indication of deteriorating environmental conditions. Such indicators have been incorporated in monitoring protocols for Macquarie Harbour and the environmental licence monitoring conditions

(c) Having identified a gap in the understanding of the ecology of the benthic communities present in Macquarie Harbour, the report sought to 'determine the reliability of this species as an indicator of sediment condition' and make 'recommendations as to the future use of *Dorvilleids Sp.* in regulatory monitoring of salmon aquaculture in Macquarie Harbour.'

(d) The Report found that there was an increased presence of benthic communities, specifically 2 types of *Dorvilleid Sp.* in the areas immediately surrounding pens used for marine farming. This coincided with decreased dissolved oxygen (***DO***) saturation in the same areas when compared to background levels. DO saturation levels were reported to gradually increase with distance from the pens.

(e) These impacts were more pronounced in lease areas that were further from the oceanic entrance of the harbour and that had been farmed more intensely and for longer periods and determined related background organic gradients across the system.

(f) The Australia Institute relies on these findings as evidence of marine farming operations having an indirect, negative impact on DO levels within the harbour.

Technical Review

(g) Data regarding DO levels taken from the Ross 2016 Report are drawn from periods prior to subsequent salmon biomass determinations which reduced the allowable stock in the harbour.

(h) The production volume and nature of marine farming operations has therefore changed significantly since the data relied upon in the Ross 2016 Report was obtained. Changes to DO levels in the harbour since this time can be observed in Figure 1.

(i) The presence of *Dorvellid Sp.* worms in the area under the salmon pens does not necessarily indicate that salmon farming is having a negative impact on environmental conditions. This conclusion cannot be reached based on the information in the Ross 2016 Report alone.

(j) The presence of benthic communities of this kind are used as an indicator species, in combination with other indicators like benthic diversity and the presence of *Beggiatoa Sp*. mats as an assessment tool for lease management.

(k) Research regarding benthic species has informed industry and regulators of specific indicator species and the role they play during different stages of organic enrichment within the system, which have been incorporated into management and regulatory practices.

(l) Moreover, as sampling for the report was only conducted over one discrete period, the impact of temporal and seasonal cycles on the observed presence of benthic communities and reduced DO levels is stated to be unknown.

(m) The findings contained in the Ross 2016 Report, informed the operation of individual lease areas and stocking practices for different sized fish.

2.4 Ross 2017 Report

Summary

(a) The Ross 2017 Report provides an 'interim synopsis' of the scientific literature that considered the then 'current status of the benthic and water column environments' in Macquarie Harbour.

(b) No causal connections are established by the report, which provides a 'summary of key research projects and their findings' and gaps analysis with recommendations for future research.

(c) Paragraph 12 of 31 July 2023 Letter misattributes the source of the findings regarding potential indirect impacts of salmon farming on the Maugean Skate. This commentary is not contained in the Ross 2017 Report, but rather in a report that forms part of the literature review titled *Movement, habitat utilisation and population status of the endangered Maugean skate and implications for fishing and aquaculture operations in Macquarie Harbour*.[1]

(d) With support from the industry, this report primarily investigated population characteristics and the distribution of the skate within Macquarie Harbour and implications this may have for marine farming operations.

[1] *Movement, habitat utilisation and population status of the endangered Maugean skate and implications for fishing and aquaculture operations in Macquarie Harbour,* Justin Bell, Jeremy Lyle, Jayson Semmens, Cynthia Awruch, David Moreno, Suzie Currie, Andrea Morash, Jeff Ross and Neville Barrett (2016).

(e) An array of acoustic receivers were used to determine the 'distribution, habitat utilisation and movement' of the Skate within the harbour and seasonal biological sampling was undertaken to determine key biological characteristics.

(f) This data was used to establish the preferential habit of the Maugean Skate population within Macquarie Harbour.

(g) Conclusions as to the potential impact of salmonid farming on the Maugean Skate were made by comparing the observed habitat preferences of the skate and the location of marine farming operations.

(h) Paragraph 13 of the 31 July 2023 Letter, contains an extract that details a decline in DO levels in the harbour from 2009 to mid 2014, which continued to the period in which the report was published being 2017.

(i) The section in Paragraph 14 of the 31 July 2023 Letter is extracted from a report entitled *Effect of hypoxia and anoxia on invertebrate behaviour: ecological perspectives from species to community level.*[2]

(j) This report considered the impacts of hypoxia and anoxia on 'a representative spectrum of benthic macrofauna in the natural setting in the Northern Adriatic Sea' and was used to estimate the ecological effect of changing DO levels in Macquarie Harbour on the skate in the Ross 2017 Report, as research specific to the skate was not available.

(k) The Ross 2017 Report states that this approximation was used as 'it is difficult to say for certain what the ecological effect of [variability in bottom water DO levels in Macquarie Harbour] might be' but that some 'insight' may be gained from other research.

(l) 'Figure 28' contained in Paragraph 15 of the 31 July Letter, is also extracted from the same report.

Technical Review

(m) Similar to Ross 2016, data regarding DO levels is taken from the period before salmon stock in the harbour was significantly reduced. The volume and nature of marine farming operations has therefore significantly changed since this data was recorded and the findings that result are unlikely to be reflective of current circumstances.

(n) Recording using the acoustic receivers was only conducted once and not repeated again providing only a single set of data from a discrete time period.

(o) Concerns regarding the size of the sensors used to record the acoustic data and the related mortality rates from the sensors with the related capture and attachment process were also raised in the report.

(p) Salmon Tasmania submits that the usefulness of the extract in Paragraph 13 extract is limited as the cause or source of the reduced DO levels are not stated in the extract or the wider report, and the data regarding DO levels is now over 5 years old.

(q) The report from which the information Paragraphs 14 and 15 is taken relates to a different species in an environment distinct to that of Macquarie Harbour. As such, the conclusions drawn from this data in relation to the Skate are not conclusive.

2.5 Moreno 2020 Report

Summary

[2] *Effect of hypoxia and anoxia on invertebrate behaviour: ecological perspectives from species to community level,* B. Riedel T. Pados ,K. Pretterebner, L. Schiemer, A. Steckbauer, A. Haselmair, M. Zuschin, and M. Stachowitsch (2014).

(a) The Moreno 2020 Report investigated the 'mechanistic links' between the environmental conditions in Macquarie Harbour and the impacts on the skate across multiple life stages. Field surveys, assessments and laboratory studies were conducted to establish findings for the report.

(b) Skate were found to be capable of surviving 'chronic exposure to hypoxic conditions' through entering a depressed metabolic state. This state is noted to not be sustainable in the long term however, and it occurs 'at the cost of other energy intensive life… processes'.

(c) DO levels in bottom waters are stated to 'represent a crucial factor' in the wellbeing of the Skate population.

(d) 'Various' anthropogenic activities are identified as impacting the environmental conditions in Macquarie Harbour, with 'aquaculture, mining, hydro-electricity generation (fluctuating river flows) and coastal development - along with the effects of climate change' all stated to 'play a role in shaping the environmental conditions of this unique system'.

Technical Review

(e) As is identified in the Wallis 2024 Report, the impact of salmon farming on waters in the lower layers of the harbour is minimal. As the nets used on pens in Macquarie Harbour only reach depths of approximately 13m, there is no observed impact on bottom water DO as a result of salmon respiration as no salmon are present at this depth.

(f) Further, the DO draw down associated with biological processes arising from salmon excrement and feed loss on the harbour bed, was found by Wallis to be minimal.

2.6 Wild-Allen 2020 Report

Summary

(a) The Wild-Allen 2020 Report used a biogeochemical and hydrodynamic model to simulate the effects of changes to rivers inflows and a reduction in anthropogenic activities on water quality in Macquarie Harbour.

(b) The model was used to simulate a scenario in which finfish farming was ceased in Macquarie Harbour (by omitting the oxygen drawdown and dissolved and particulate waste attributable to the farms), and then used to predict levels of DO.

(c) Paragraph 22 of the 31 July Letter states that farmed fish reparation accounts for 3% of DO loss in the harbour. In the same 2018 period to which this data relates, this contribution to DO loss is comparable to losses attributable to air sea flux and water column biogeochemistry losses. The greatest loss of DO (87%) for the period was the export of oxygen rich surface water to the ocean. Salmon biomass has decreased and is now regulated via a TPDNO that limits the release of nutrients from farming operations.

(d) The Australia Institute relies upon the model predictions which presented a '50% reduction in hypoxic volume and a 40% reduction in hypoxic sediment area under reduced anthropogenic load' when compared to 2017-18 levels. The modelled reduced anthropogenic load represented the largest reduction in hypoxia when compared to all other modelled scenarios.

(e) The report states that it is the combined effect of river inflows and anthropogenic load that 'ultimately defines the hypoxic condition of the harbour', with the primary source of DO depletion at depth being stratification and 'slow flushing of deep water into the harbour'.[3]

(f) Variations in seasonal releases from hydro dams were also stated to 'impact flushing and harbour oxygen status'.

Technical Review

(g) The central findings of the Wild-Allen 2020 Report, being the modelled removal of salmon farming from the harbour are problematic on a number of fronts:

(i) the key findings (see 2.6(b)) are presented in a manner that overstates the effect of the modelled reduced anthropogenic load. The model predicted a reduction in hypoxic conditions from 27-28% to 14-17% by volume and from 12% to 4-6% by area. When considered in the context of the harbour as a whole, this reduction is not as significant as is represented;

(ii) the ranges used to define the levels of oxygenation are broad and may not provide a true reflection of the relative water conditions in the harbour. For example, if the removal of salmon farming increased oxygen saturation by 1% and a portion of the water was at 30%, the oxygenation of that water volume would be considered 'intermediate'; and

(iii) the baseline data is obtained for the period 2017-2018 which is from the period prior to the biomass caps being implemented, and is therefore not reflective of current operations and stock levels in Macquarie Harbour.

(h) The Wild-Allen 2020 Report estimates the DO load in the sediments due to the oxygen consumption required in biological process associated with the breakdown of salmon food and faeces to be 12,000 t/yr.

(i) The Wallis 2024 Report similarly estimated the DO drawdown associated with these biological processes and determined that the total demand in the lower layer would be 1,770 t/yr.

(j) The differences arise due to the assumptions used in Wild-Allen's modelling being incorrect and not representative of salmon farming practices. The Wild-Allen 2020 Report assumes a feed efficiency of 85%, which in turn assumes a 15% wastage. Currently the industry operations achieve approximately a 3% wastage rate. This difference in assumed wastage rates would significantly change the outputs of the Wild-Allen model and in turn the findings of the report.

(k) The nitrogen content of feed as assumed in the Wild-Allen 2020 Report is also not reflective of current data from improved feed formulations, nor are the biomass figures used in the modelled scenarios.

(l) The estimated average effect of the salmon farms is to reduce the DO in the lower layer by around 16 per cent or 1 mg/L. This estimate is lower than the prediction by CSIRO that DO in the lower layer would increase by around 1 to 2 mg/L at 25 to 35 m depth if the 12,000 t/yr salmon load (CSIRO estimate) was removed. The load estimated here of 1,770 t/yr is lower because salmon production in 2017 (the year for the CSIRO prediction) was about twice current levels.

[3] Pg 6.

2.7 Conclusion

(a) The findings and analysis contained in the Ross 2016 Report and Ross 2017 Report do not fully consider the impact of the Marine Farming Expansion on the Maugean Skate.

(b) The Marine Farming Expansion resulted in the relocation of 59% of the previous marine faming lease area that occurred in less than 20m depth into the deeper central waters of the Harbour. This effectively reduced the lease area where the Maugean Skate preferred habitat occurred.

(c) As noted above, the Ross 2016 Report findings are not 'new' to the industry and in accordance with the adaptive management principles, changes to how industry manages biomass and nitrogenous inputs, as well as in-field data (e.g. benthic surveys) and system-wide monitoring were made as a result of the findings.

(d) Wallis notes in his 2024 Report at page 17 that:

(i) '*In response to harbour wide declines in DO levels and declines in benthic faunal abundance that was observed in the Ross 2017 Report, the total permissible biomass limits for the harbour were reduced. Present day feed inputs are now approximately half the earlier peak rate …*'

(ii) 'Further modern marine farming practices achieve high rates of feed consumption (97%) with very minimal fallout of around 3%.

(e) As discussed above, the Ross 2017 Report relies on related scientific literature to draw parallels to potential impacts of reduced DO levels on the Skate. The secondary or 'indirect' impacts stated in the report (and relied upon by The Australia Institute) are speculative and not based on data collected for the report.

(f) Though the Moreno 2020 Report establishes that reduced DO levels in bottom waters may negatively impact the skate, aquaculture is one of many anthropogenic sources stated as having an impact in the conditions of the harbour, based on other research.

(g) Salmon aquaculture was found in the Wallis 2024 Report to have a minor impact of DO levels in the bottom of the harbour, given the location of the salmon pens in the top layer of the harbour (to a depth of about 15 metres).

(h) Great care should be taken when having regard to the Request by The Australia Institute, as it repeatedly extracts various report sections and restates conclusions of the of scientific reports in a manner that does accurately reflect the findings of the cited report.

(i) Paragraph 9 of the Letter Dated 8 June 2023 states that Tasmanian Threatened Species Listing Statement 'concludes that the Maugean skate is at risk from the aquaculture industry'. This fundamentally overstates the conclusions drawn in the Statement as extracted in section 2.2(a). Further, as is discussed above, the reports relied upon by the Listing Statement to draw these conclusions are also flawed.

(j) The recommendation extracted from Paragraph 10 of the Letter Dated 8 June 2023 does not form part of any recommendations from the Senate Environment and Communications References Committee and is actually contained in the Australian Greens' Dissenting Report.

(k) Paragraph 15 of the 31 July Letter, states that aquaculture is a factor contributing to the environmental conditions contained in the harbour, however it is noted to be one of many anthropogenic factors that impacts Macquarie Harbour and no causal link that supports this claim is established in the Moreno 2020 Report.

(l) For the reasons set out above, Salmon Tasmania submits that the literature relied upon in the Request by The Australia Institute does not constitute substantial new information or an substantial change in circumstances that was unforeseen at the time of the NCA-PM Decision in 2012 that relates to the impacts of the Marine Farming Expansion on the Maugean Skate.

(m) As the information does not satisfy the criteria in section 78(1) of the EPBC Act it cannot warrant the revocation and substitution of the NCA-PM Decision.

3 Response to AMCS/HSI Reconsideration Request

3.1 Salmon Tasmania Submission

(a) We have considered the additional material relied upon in the AMCS/HSI Reconsideration Request and in conjunction with the Wallis Report.

Substantial new information

(b) Salmon Tasmania asserts that the information presented in the reports does not establish any causal link between the declining skate population and reduced dissolved oxygen conditions attributable to marine farming operations. Therefore the stated impacts cannot be said to be likely to occur with a high degree of certainty.

(c) The reports that do try to establish a causation, overstate the impacts of marine farming operations on dissolved oxygen levels.

Unforeseen substantial change in circumstances

(d) The alleged unforeseen changes in circumstances do not specifically relate to impacts the Marine Farming Expansion will have on the Maugean Skate, as is required under section 78(1)(aa). Rather the findings relate to broader circumstances such as climatic changes separate to salmon aquaculture, that may impact the environmental conditions in the harbour or the viability of the skate population.

(e) As such the information relied upon fails to satisfy the criteria in section 78(1)(a) or 78(1)(aa) of the EPBC Act and therefore cannot warrant the revocation and substitution of the NCA-PM Decision on either grounds.

3.1 Moreno 2022 Report

Summary

(a) Using eDNA the Moreno 2022 Report conducted surveys to determine the presence of Maugean Skate in Bathurst Harbour.

(b) Insufficient concentrations of Maugean Skate DNA were found in Bathurst Harbour to allow for positive identification alone. The report concludes that this data suggests 'the vast majority, if not all' of Maugean Skate live in Macquarie Harbour.

(c) The AMCS/HSI submit that the as the Macquarie Harbour population of skate are likely the last population of skate any risks to the population must receive heightened attention.

Technical Review

(d) Hydrological processes will affect the dispersal and persistence of eDNA, especially water flow and in general, temperature.

(e) As such, additional temporal sampling points should be considered to account for the impacts of hydrological processes to the DNA material.

(f) Monitoring at additional depths would also improve the likelihood of capturing the presence of the Maugean Skate in both Bathurst harbour and Macquarie Harbour.

(g) Populations of Maugean Skate may not necessarily be constrained solely to Macquarie Harbour. This species was first identified in Tasmanian waters in Port Davey in 1980's (a waterway where salmon farming or any other anthropogenic activity has occurred). Previous survey work to detect Maugean Skate eDNA in Bathurst Harbour has proved inconclusive. Sampling in Macquarie Harbour in November 2021 (Moreno *et al.* 2022), also failed to detect the species (where a resident population exists) but was successful in February 2022. This suggests movement of the Skate population may be seasonal and indicates that more scientific assessment work needs to be done in this space.

3.2 Wild-Allen 2020 Report

(a) AMCS/HSI relies upon the same data as the Australia institute from the Wild-Allen 2020 Report to support their claim, namely that the modelled absence of fish farming resulted in a' 50% reduction in hypoxic volume and a 40% reduction in hypoxic sediment area under reduced anthropogenic load'.

(b) The summary and technical review in section 2.6 apply.

3.3 Ridgway Report 2023

Summary

(a) The AMCS/HSI request relies upon the Ridgway Report 2023 which finds inshore bays including Macquarie Harbour 'unequivocally… show heightened seasonal changes (warmer in summer and cooler in winter).'

(b) This information considered in conjunction with other climatic data suggests higher than normal water temperatures will be experienced in Macquarie Harbour this summer which will impact DO levels due to reduced dissolvability and increases to BOD processes.

Technical Review

(c) The potential impacts of a warming climate have been known for over 30 years.

(d) The IMAS Assessment of Macquarie Harbour BEMP data from 2011 to 2022 highlights a climate driven increase in bottom water temperatures of 1.5-2^{O}C over the past 30 years.

(e) A warming climate is considered to be one of the many influences on the observed decline in population abundance of the Maugean Skate through decreased oxygen solubility and increased metabolic rates.

(f) This climatic information is not new to environmental managers and does not present an unforeseen change in circumstances in relation to the impacts of the action on the skate. This impact on DO is not related to marine farming operations and cannot be controlled by the Operators.

3.4 Conclusion

(a) For the reasons set out above, Salmon Tasmania submits that the information relied upon in the AMCS/HSI Reconsideration Request does not constitute substantial new information or a substantial change in circumstances that was unforeseen at the time of the NCA-PM Decision in 2012 that relates to the impacts of the Marine Farming Expansion on the Maugean Skate.

(b) The AMCS/HSI Reconsideration Request states that the Moreno 2022 Report constitutes 'substantial new information', however the findings of the report only provide new information in regard to the uncertainty about Maugean Skate still residing in Bathurst Harbour and not the impacts of marine farming on the skate.

(c) There is again a failure by the cited scientific reports to draw conclusions as to the casual linkages by which the impacts of Marine Farming Expansion on the Maugean Skate will occur with a high degree of certainty.

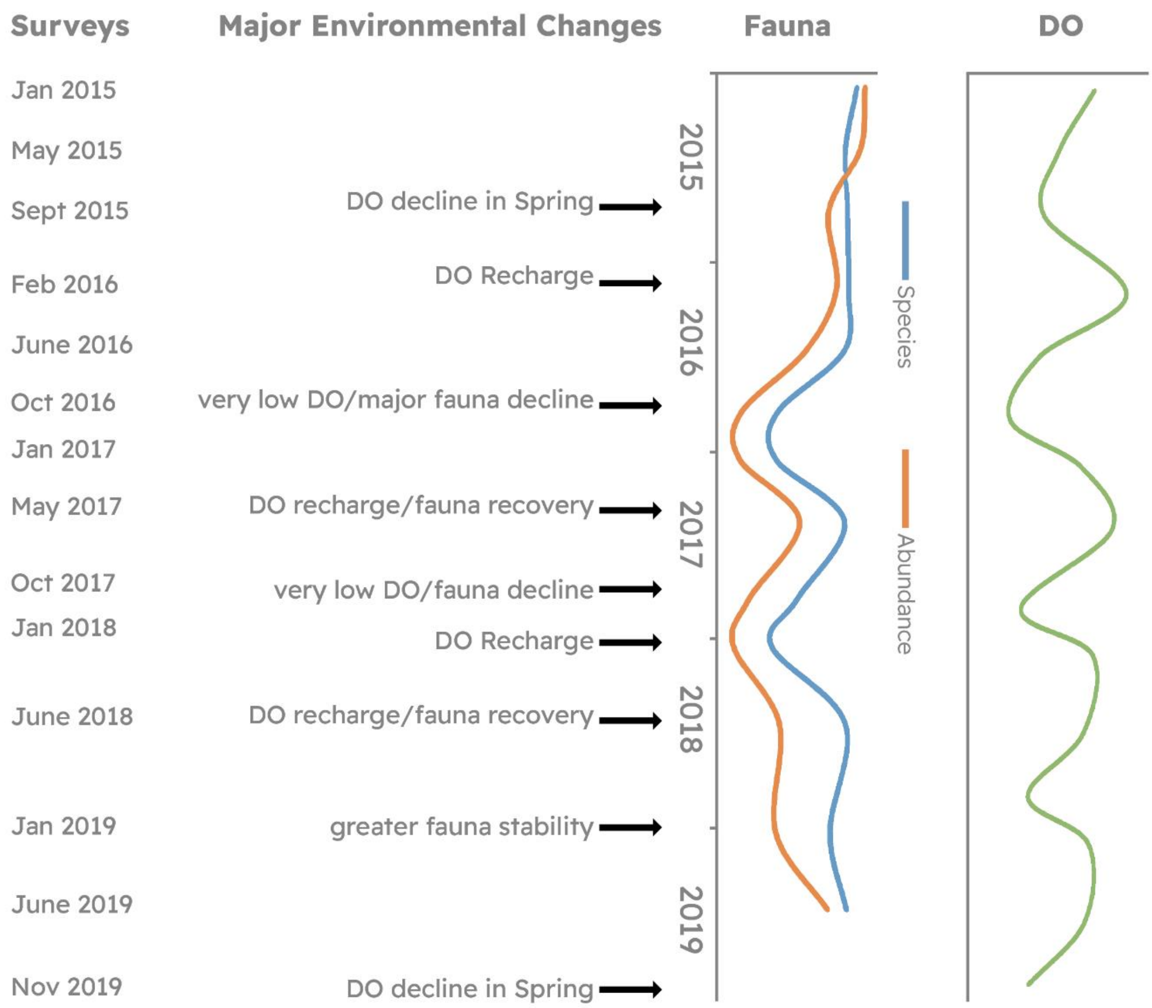
(d) The criticisms of the Wild-Allen 2020 Report assumptions detailed above again apply.

(e) The AMCS/HSI Reconsideration Request states that the information provided in Ridgway Report 2023 amounts to an unforeseen change in circumstances.

(f) The findings relate to climatic changes and therefore do not relate to the impacts of the Marine Farming Expansion on the skate, moreover the circumstances referred to are outside of the control of the Operators.

(g) As the information does not satisfy the criteria in section 78(1) of the EPBC Act it cannot warrant the revocation and substitution of the NCA-PM Decision.

Figure 1



Source: FRDC 2016/067: Understanding oxygen dynamics and the importance for benthic recovery in Macquarie Harbour (Progress Report)

Schedule 3 – Nautilus Collaboration (2024)

NAUTILUS COLLABORATION

Scientific opinion– Australian Institute reconsideration request

The Australian Institute (AI) reconsideration request has selected information which is outdated, to support their arguments against aquaculture in Macquarie Harbour (MH). All of the information/data that the Australian Institute references, were reports that were supported by the salmon industry. The salmon industry commissioned these important research projects, to improve scientific knowledge and understanding, and to incorporate any new evidence/findings into adaptive management techniques to better manage farming practices in the harbour (refer to the 'Acknowledgement' section in these reports).

The comments made by the AI in their reconsideration requests must be interpreted with caution as the data and information has been taken out of context and infers that there is causality. Causality has not been in fact demonstrated in any of the referenced material and the influence of salmon farming is over-stated in all AI submissions.

In reference to the letter from the Australian Institute dated 31 July 2023:

In a previous letter dated 8 June 2023, there was recognition from the Australian Institute that the conditions in the harbour have changed markedly, with the influence of anthropogenic activities (including mining, forestry, hydro-electricity generation, and marine farming operations). AI have since, left out these references and scientific discussions in their updated letter.

Firstly, the referenced material in the AI letter is considered old evidence. The salmon industry has already considered these pieces of evidence in their adaptive management processes, and since their release, have changed biomass and nitrogen limits to suit the estimated carrying capacity of the harbour. This is a statement that applies to all of the referenced material, as the models, assumptions and methods need to be updated to incorporate new scientific evidence.

The AI letter inflates the impact of salmon farming and fails to discuss or recognise the diminutive attribution of salmon farming to oxygen use in the harbour. There is a need to assess the impacts holistically, in terms of an updated oxygen budget and balance (Wallis 2024).

Science is a field that requires input from many different perspectives, and it is encouraged to ensure that critical thinking is exercised to maximise research quality. Therefore, the comments received from AI are acknowledged. It is acknowledged that not all research is made available in real-time, and therefore, unless there is active involvement in these projects, most evidence will be read and considered retrospectively.

(8-10) Ross 2016:

AI rely on this report to support their argument that salmon farming in the harbour is causing detrimental effects, but in fact, the dorvilleid species that are described, were being assessed as an environmental indicator and the report was commissioned by the salmon industry to further understand the significance of the dorvilleid worms and their response to the level of organic enrichment. It was found that there were two species of worms, and their respective presence reflected different levels of organic enrichment. The dorvilleid worms, could then be incorporated into monitoring programs (alongside *Beggiatoa*), to further the industry's understanding of harbour-wide changes and direct effects within a farming lease. The AI letter fails to acknowledge that there is a crucial influence on organic load and enrichment, from the river systems from organic deposition.

It is also noted that the benthic and environmental conditions when the surveys occurred, have changed dramatically due to the adaptive management strategies employed by the salmon industry and EPA. Additionally, the survey was performed in a single period and does not take into account seasonal/temporal changes.

The report played a crucial role in the industry's stocking strategy, fallowing periods and modifying operations within an individual lease. The salmon industry, after commissioning and supporting the research in-kind, used the results to improve environmental management practices across the harbour.

(11-16) Ross 2017:

The report provided a summary of the available research (until October 2016) which assisted at the time, to interpret benthic and water column observations. This report was helpful as a discussion document to understand knowledge gaps and further research opportunities. The authors highlighted a number of key questions/issues on page 33-36 which provided recommendations and work packages for the salmon industry to consider.

The discussion of "current status" where the AI draws its conclusions, is out-dated as it uses data that is over 7 years old. Biomass and nitrogen limits have since been changed, and the AI have not taken this into account in their letter. The report does not conclude that there is any causal relationship between the population dynamics of the skate; or dissolved oxygen draw-down and salmon farming.

(17-21) Moreno 2020:

There are large gaps in our knowledge of skate reproductive behaviour and physiology. Due to the scarce amount of research available it is difficult to understand the cumulative influences of:

- Exposure of chronic low dissolved oxygen to reproductive capacity
- Influence of available heavy metals to reproductive capacity – including gamete quality and quantity and egg/larval survival (which are present from mining activity and erosion)
- Fluctuation in water chemistry and quality from seasonal weather patterns, rainfall, hydro-electric dam release, and mining

It is evident from the research conducted that the skate can modify its metabolic state to survive in environments with hypoxic conditions. The AI letter suggests that salmon farming may affect the available dissolved oxygen where the skate reproduce/reside. Salmon school in the upper layers of MH, where there is ample dissolved oxygen from river inflow and brackish water outflow. The Wild-Allen 2020 oxygen balance/budget calculations detailed that the reduction associated with salmon respiration in the upper and mid- water column was replenished by surface gas exchange and water exchange in the harbour.

The bottom waters of MH will not only be influenced by the biological oxygen demand from salmon farming, but also river inflow, and organic deposition. Salmon farming accounts for approximately 10% of the dissolved oxygen use in bottom waters (Wallis 2024).

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It is important to recognise that there are other environmental processes that can influence the reproductive outcomes of the skate; as well as egg and larval development- and there is not enough information and knowledge about the species to be able to definitively state causality.

(22-26) Wild-Allen 2020:

Wild-Allen (2020) in the FRDC report that found when modelling the removal of salmon farms " a 50 per cent reduction in hypoxic volume, and a 43 per cent increase in healthy water would result from elimination of salmonid farming". What the modelling actually found, was a reduction from 27-28% hypoxic to 14-17% by volume and from 12% to 4-6% by area. The model also used hard definitions of hypoxic as between 1-30% oxygen saturation, which means if the removal of salmon farming increased saturation by 1% and a portion of the water was at 30%, that water volume would now be considered intermediate.

Wild-allen 2020 also states that the "...oxygen budget analysis found the largest influx of oxygen to the harbour was from rivers (66%), marine input (10%) and air-sea flux (6%); the greatest loss terms were from export to the ocean (87%), biogeochemical remineralisation processes in the sediment (8%) and estimated farmed fish respiration (3%)." And "... around 60% of fish farm nitrogen is exported to the ocean and this likely enhances local algal blooms (evident in remotely sensed images of Macquarie Harbour plumes)".

The Australian Institute's request for reconsideration claims the Interim report – Macquarie Harbour Maugean skate population status and monitoring attributes the decline in dissolved oxygen is caused by "anthropogenic inputs' being the large-scale development of salmonid aquaculture.". In this case, anthropogenic is defined as '(chiefly of pollution or environmental change) originating in human activity.'. These statements must be explored further with context.

"While anthropogenic activities since European colonisation have long impacted the harbour, in the past 15 years altered river flows (growing reliance on hydroelectric generation and production demand) and large-scale development of salmonid aquaculture have resulted in considerable changes to the environment.". The report does not claim that the salmonid farming is the only cause of lower dissolved oxygen. There are other reports that discuss the state of the harbour, such as the MHDOWG (2014) which also should be considered in their assessment. The MHDOWG 2014 states, "There have been a number of significant changes over the period from 2009-present. River flow was historically low between 2009-12 and historically high in 2013. This period also coincides with a major expansion of salmon aquaculture". Additionally, there significant influences in total organic carbon load which is associated with river discharge into MH 'around 100 times that of salmon production in the harbour' – these statements were made in the MHDOWG 2014 report, with data from when salmon farming biomasses were higher than they are today.

The MHDOWG 2014 report states that "...based on the data available from recent in situ measurements aquaculture is estimated to be responsible for between 3 and 12% of the benthic BOD in Macquarie Harbour (for sediments deeper than 15 m). The remaining benthic BOD is presumably associated with particulates in river discharge and detritus derived from biological production within the harbour. "- These percentages have further reduce since this report was written due to the reduction in farming biomass.

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Additionally, it was found that "...representing 2.3% of the benthic area (> 15 m), the cage and buffer area account for approximately 5% of the total benthic BOD".

The Wild-Allen 2020 report findings and budget were based on modelling conditions and farming inputs from 2017 and 2018, which is no longer representative due to changes in salmon farming (decreased biomass limits and nitrogen budgets) and any changes in hydro-electric dam operational management (refer to Figure 1 for HOG tonnes produced in the harbour).

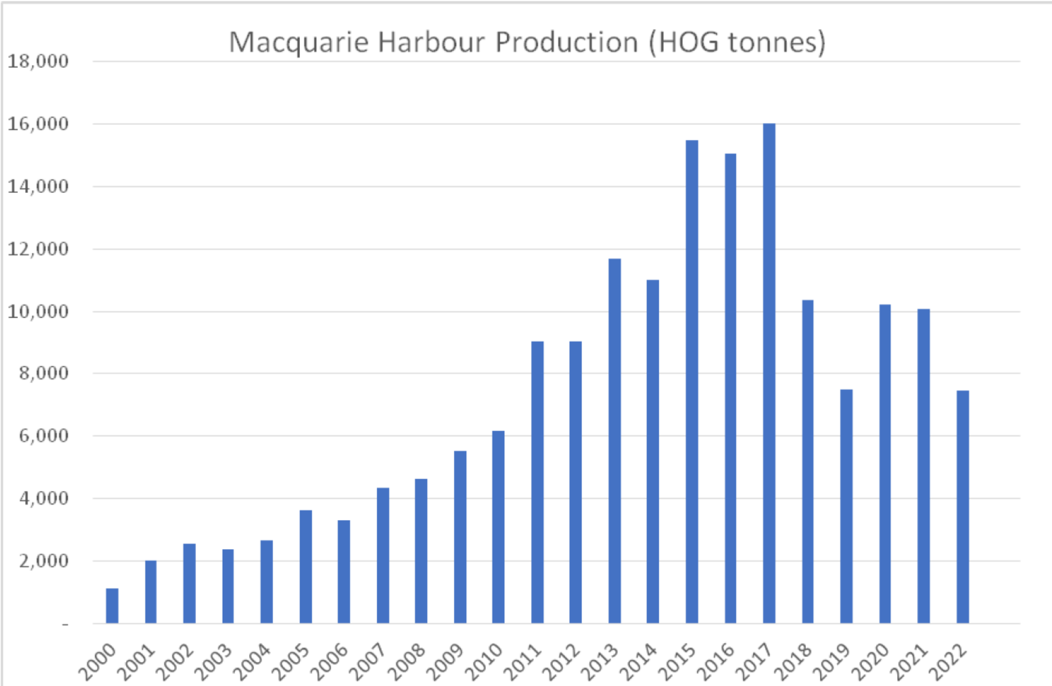

Figure 1: Macquarie harbour production tonnage (HOG tonnes) - noting that from 2018 onwards, there has been a significant reduction in harvested biomass from the harbour

Additionally, there are newer references which have been published Wang 2013 and Wang and Olsen 2023 which are both required to update the oxygen balance and budget.

The following updates need to be made, and are used in Wallis's oxygen budget memo (2024):

Nitrogen	Wang Et al 2012	Wang Et al 2013
DIN (%) Dissolved inorganic nitrogen	0.45	0.39
DON (%) Dissolved organic nitrogen	0.0225	0.03
PON (%) Particulate organic nitrogen	0.153	0.15
Fish Gain	0.38	0.43

Carbon	Wang Et al 2012	Wang Et al 2013
Resipired (%)	0.48	0.4

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DOC (%) Dissolved organic carbon	0.03	0.03
POC (%) Particulate organic carbon	0.19	0.19
Fish Gain	0.3	0.38

This changes totals by 5.92% reduction in overall total oxygen demand.

NAUTILUS COLLABORATION

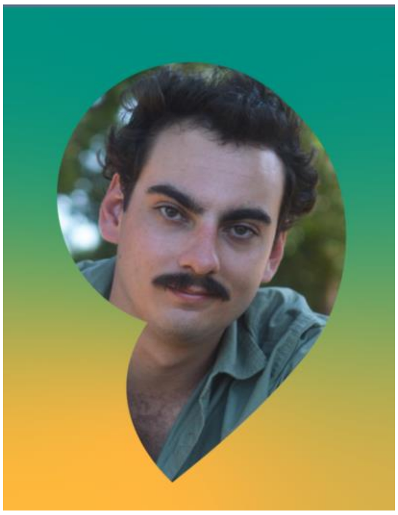
Author biographies

Christine Huynh

Managing Director and Senior Veterinarian

Christine completed a Bachelor of Veterinary Science at the University of Sydney. She has been working in the aquaculture industry since, and consults internationally, offering technical management services that support global best practice.

Specialises in: production medicine, aquatic animal welfare, biosecurity management, technical strategy, technical due diligence



Andrew Mackay

Data Scientist

Andrew holds a Bachelor of Science degree from Monash University majoring in Mathematics with minors in Computational Science and Mathematical Statistics. Andrew has held production roles in Aquaculture and has experiences ranging from data analysis to running grow out operations.

Specialises in: Statistics & Modelling

Elena Contador

Aquatic animal health consultant

Elena, a Chilean veterinarian, holds a Master's in Fish Pathology from Canada's Ontario Veterinary College. With 16 years of expertise in diagnosing fish diseases, her experience ranges from fish farms to wild (native) and exotic species in Canada. In Chile, she served as a laboratory manager and fish histopathologist for 3 years. She then spent 3 years in Malta, contributing to fish stock health in RAS settings.

Specialises in: Diagnostics and fish health and biosecurity management systems

Schedule 4 – Dr Ian Wallis (2024)

CONSULTING ENVIRONMENTAL ENGINEERS
Environmental Scientists and Engineers
Unit 4, 150 Chesterville Road, Cheltenham VIC 3192
Phone 03 9553 4787
Email wallis@cee.com.au

Foreword

The purpose of this technical memo is to estimate the demand for oxygen imposed by salmon farms in Macquarie Harbour, Tasmania.

The author, Dr Ian Wallis, is part of the team with the responsibility to trial oxygenation of the deeper waters of Macquarie Harbour, to counter very low levels of dissolved oxygen in the water column.

The Fisheries Research and Development Corporation (FRDC) is funding the project to trial the injection of oxygen into the middle and deeper waters of Macquarie Harbour. The project team includes salmon industry personnel with equipment and experience related to oxygenation of finfish pens and engineers and scientists with State, National and international expertise related to oxygen injection and associated environmental interactions.

There are examples of successful oxygenation of estuaries in Perth, in Scandinavian fjords, and in Chile. Oxygenation at shallower depths is routinely used in wastewater treatment lagoons and water storages throughout Tasmania and elsewhere.

It would assist the team if they had an estimate of the amount of oxygen input that is required to balance the oxygen demand from the salmon farms in Macquarie Harbour and the best locations to add that oxygen.

Salmon farms were first established in Macquarie Harbour in the 1980s. The early farms wee acquired by the three major companies, and Tassal established farms there in 2003, Huon Aquaculture in 2008 and Petuna around 2011. Production increased from 2,000 t/yr in 2010 to around 16,000 t/yr in 2015-2017, but has decreased since then and averaged 9,500 t/yr in 2018-2023.

The main concerns regarding low dissolved oxygen in Macquarie Harbour are:

1. The risk to the survival of the Maugean Skate, which is a threatened species that apparently survives in low numbers only in Macquarie Harbour;
2. The risk to other ecological processes and systems in Macquarie Harbour; and
3. Anoxic or near-anoxic conditions would encourage the movement of metals from the sediments into solution. The metals exist from past mining activities in the catchment and from natural erosion processes.

There is extensive and ongoing research into the hydrodynamics, water quality, benthic chemistry and biological conditions in the harbour by researchers from the University of Tasmania (UTAS), EPA, CSIRO and other institutions. The research is supported by the FRDC and by the State government through the EPA and Department of Primary Industries, Parks, Water and Environment (DPIPWE). The program includes a trial of re-oxygenation of deeper waters at a rate of approximately 1 t/d of oxygen in 2024.

Macquarie Harbour Stratification

Macquarie Harbour is a large estuary on the west coast of Tasmania, 33 km long by 9 km wide, with a surface area of 280 sq km. The main freshwater supply is from the Gordon River which flows into the south of the estuary. The entrance to the sea is an 8 km long, shallow channel in the north-west of the estuary.

The freshwater inflow from the Gordon River, and other smaller rivers and creeks, forms a surface layer that is 5 m to 10 m deep. The depth depends on the river flow, with the surface layer becoming deeper at times of high river flow and shallower at times of low river flow.

Wind mixes the surface layer into the underlying more saline layer. This results in relatively uniform salinity over the top 2 m, and often down to 6 m depth.

There is a strong salinity gradient from 6 m to 11 m depth. From 12 m depth down to the bottom, at around 45 m depth, there is relatively uniform salinity, generally of 30 to 32 parts per thousand (ppt), only about 10 per cent lower than ocean water.

Mixing of incoming ocean water with harbour water just inside the entrance where the dense seawater cascades down the slope into the harbour means that the salinity of the lowest harbour waters is always less than ocean salinity.

Figure 1 shows the monthly salinity profiles at a central station in Macquarie Harbour for 2013-2014 (data provided by IMAS). Lowest salinity is 2 ppt (at the surface) but the salinity in the surface layer (0 to 4 m) ranged seasonally from 2 ppt to 14 ppt. There is a strong salinity gradient between 5 m and 11 m depth. Below 15 m depth there is a very weak salinity gradient from around 28 ppt at 15 m depth to 31 ppt at the bed. The gradient indicates weak vertical mixing (and hence weak currents) in the lower layer of the harbour.

Figure 1. Vertical Salinity Profiles in Macquarie Harbour in 2013-2014

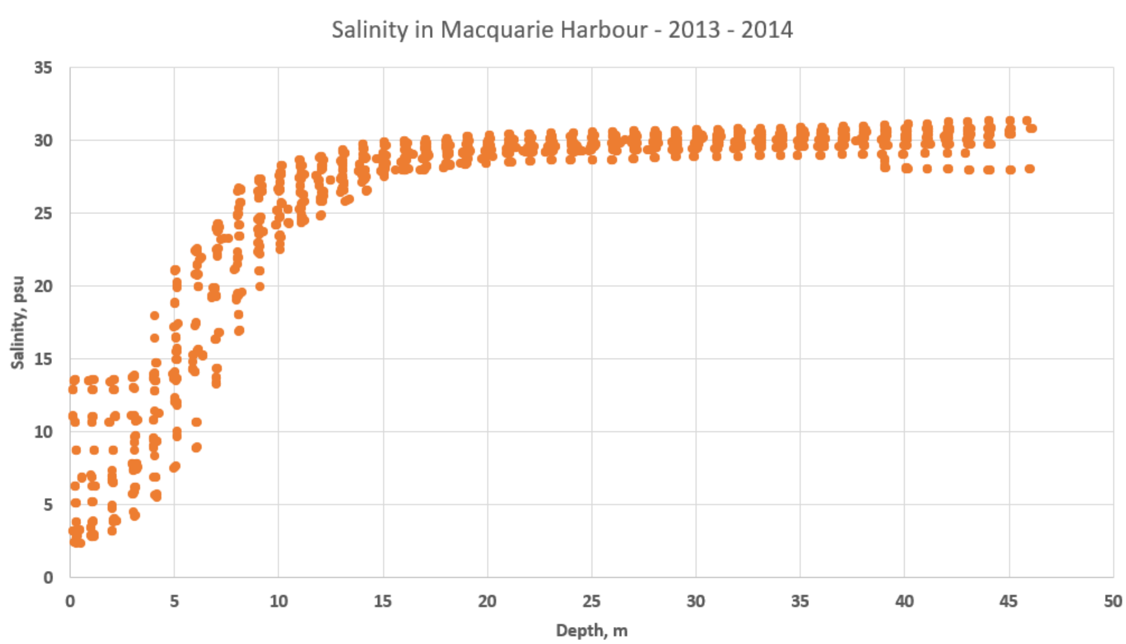


Figure 2 shows the monthly salinity profiles at a central station in Macquarie Harbour for 2018-2019 (data provided by IMAS). There is a single reading of zero surface salinity. The salinity in the surface layer (0 to 4 m) ranged seasonally from 3 ppt to 17 ppt. There is a strong salinity gradient between 5 m and 11 m depth. Below 15 m depth, there is a very weak salinity gradient from around 29 ppt at 15 m depth to 32 ppt at the bed.

Figure 2. Vertical Salinity Profiles in Macquarie Harbour in 2018-2019

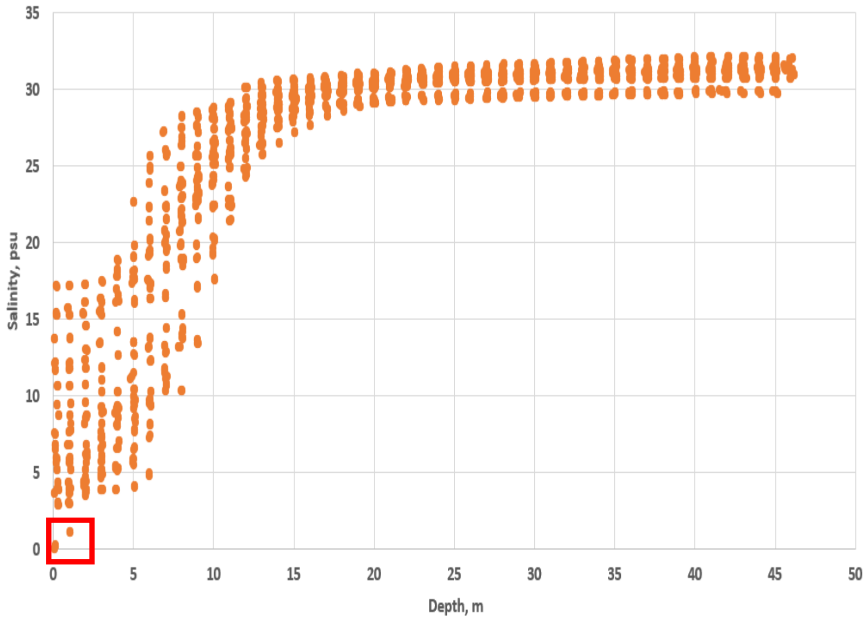
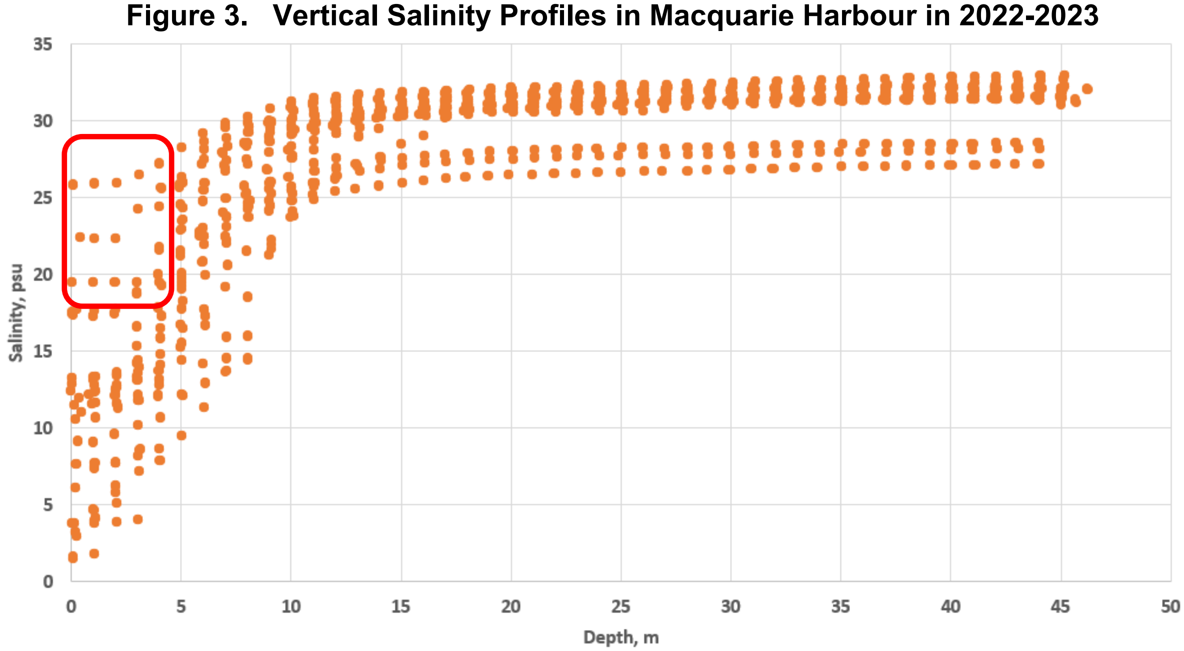


Figure 3 shows the monthly salinity profiles at a central station in Macquarie Harbour for 2022-2023 (data provided by IMAS). This period shows a different pattern, with much higher average and peak salinity in the surface layer (highlighted in the red box). The strong salinity gradient is higher in the water column from 4 m to 9 m depth. Below 11 m depth, there are two lines both showing a very weak salinity gradient from around 26 to 30 ppt at 11 m depth to around 27 to 32.5 ppt at the bed.

Figure 3. Vertical Salinity Profiles in Macquarie Harbour in 2022-2023



The vertical salinity pattern in 2022-2023 is different from the earlier years, with much higher salinity at and near the surface, which indicates a reduction in the river flow during that period, perhaps accompanied by stronger wind mixing. The lower salinity water was deeper in 2022-2023 than in previous years, indicating more ocean water inflow and uplifting of the saline layer.

River Inflow

The major process driving the stratification and circulation in the harbour is the freshwater inflow from the rivers. Koehnken (2005) reported the average annual flow from the Gordon River was 265 m^3/s and the average flow from the King River was 55 m^3/s. Adding minor tributaries such as the Sorell River and Birchs River makes a total freshwater input of around 330 m^3/s. This is sufficient to create a surface layer 0.1 m deep in a day or 4 m deep in a month. *(Note: Mean river inflow for 2017-2018 was 352 m^3/s, Wild-Allen et al, CSIRO, 2020).*

The inflow is, of course, seasonal, and mean monthly flows vary from less than 100 m^3/s in summer and early autumn to 500 m^3/s in late autumn, winter, and spring (Hartstein et al., 2016). Variations in annual rainfall produce higher inflows in wet years and lower inflows during droughts. *(Note: Range of inflow for 2017-2018 was 50 to 2,700 m^3/s, Wild-Allen et al, CSIRO, 2020, p 31).*

There is another important source of variation in the freshwater input to Macquarie Harbour. River flows from the catchments of the Gordon River and King River have been regulated by hydroelectric dams operated by Hydro Tasmania since 1983. Periodic dam releases on the Gordon River make discharges into Macquarie Harbour more variable, and can double the average flow conditions for short periods of time (Hydro Tasmania, 2016).

The freshwater escapes from Macquarie Harbour through the 8 km long entrance at Hells Gates. The mean depth at the narrowest section along the Hells Gates inlet is 4 m (and the entrance channel is approximately 120 m wide). To release the average freshwater input of 330 m^3/s at an average salinity of 8 ppt requires an ebb tide current averaging 1.8 m/s through this constriction.

The mean tidal range in Macquarie Harbour is around 0.5 m (0.2 m for neap tides and 0.9 m for spring tides). The inflow of ocean water to the harbour is restricted by two processes: (1) the large volume of freshwater that must be discharged each tide cycle, limiting the duration of seawater inflow; and (2) the long entrance channel, so that only the seawater that reaches the harbour end of the channel can stay in the harbour – the contents of the channel return to the ocean with the reverse in the current direction.

As an approximation, the seawater input each day corresponds to a net input of about 0.2 to 0.3 m depth of ocean water. As the lower saline layer extends over a depth range of around 40 m, the tidal inflow of seawater takes around 150 to 300 days to replace the water in the lower layer.

Because of this long residence time, a small organic load each day can have a substantial impact on the dissolved oxygen concentration in the lower layer. Low dissolved oxygen concentration in the lower layer should be expected because of the long residence time of water in that layer and the strong stratification which inhibits the transfer of oxygen from the surface to the lower layer.

There are a range of other hydrodynamic processes that influence dissolved oxygen levels, including mixing in the river estuaries, mixing where the incoming seawater cascades down the side of the harbour, seiching and internal waves, wind-driven mixing, surface and halocline slope due to persistent winds and long term variations in ocean water levels. These complicate the prediction of currents, stratification and dissolved oxygen.

According to Hartstein et al, 2019, the tidal water level amplitude is approximately 0.25 m and tides explain only 27% of the water level variation whereas variations in barometric air pressure explained 41% of the observed changes in water level.

Macquarie Harbour Dissolved Oxygen

Oxygen enters Macquarie Harbour continuously with river inflows (which are generally saturated with dissolved oxygen) and surface re-aeration. The ocean water entering the harbour also is generally saturated with dissolved oxygen. Inflows of ocean water are episodic, with regular small inputs at times of spring tides and low river flow, and occasional larger inputs (typically once a year) when the combination of persistent wind and low atmospheric pressure cause a large inflow of ocean water (known as deep layer recharge events).

The waters of Macquarie Harbour are strongly coloured by tannin, so there is low light penetration. Nonetheless, there are phytoplankton living in the harbour (measured chlorophyll-a is around 1 µg/m^3) regularly adding to the oxygen supply. The input of oxygen from macrophytes is very small.

Oxygen is consumed by the decomposition of organic compounds entering the harbour in rivers, local runoff and ocean waters, and by respiration of marine organisms in the water and in the bed. The salmon farms are a source of additional organic material as well as ammonia discharges, which require oxygen for conversion to organic material as well as nitrification to nitrate. Some oxygen is returned by denitrification. The focus of this Technical Memo is to estimate the oxygen demand of the salmon farms.

Figure 4 shows the monthly dissolved oxygen (DO) profiles at a central station in Macquarie Harbour for 2013-2019 (data provided by IMAS). The DO in the top 3 m is always more than 80 % saturated (depicted by the blue colour). Minimum DO occurs at around 30 m depth, and low DO can extend to the bed of the harbour. DO of less than 30 % saturation is depicted by the orange colour. A feature of the DO pattern is the strong gradient, with DO decreasing with depth to around 30 m depth. Periods of low DO in the deep waters correspond to higher river flow in winter-spring, when less seawater comes into the harbour.

Figure 4. Vertical Dissolved Oxygen Pattern in Macquarie Harbour in 2013-2018

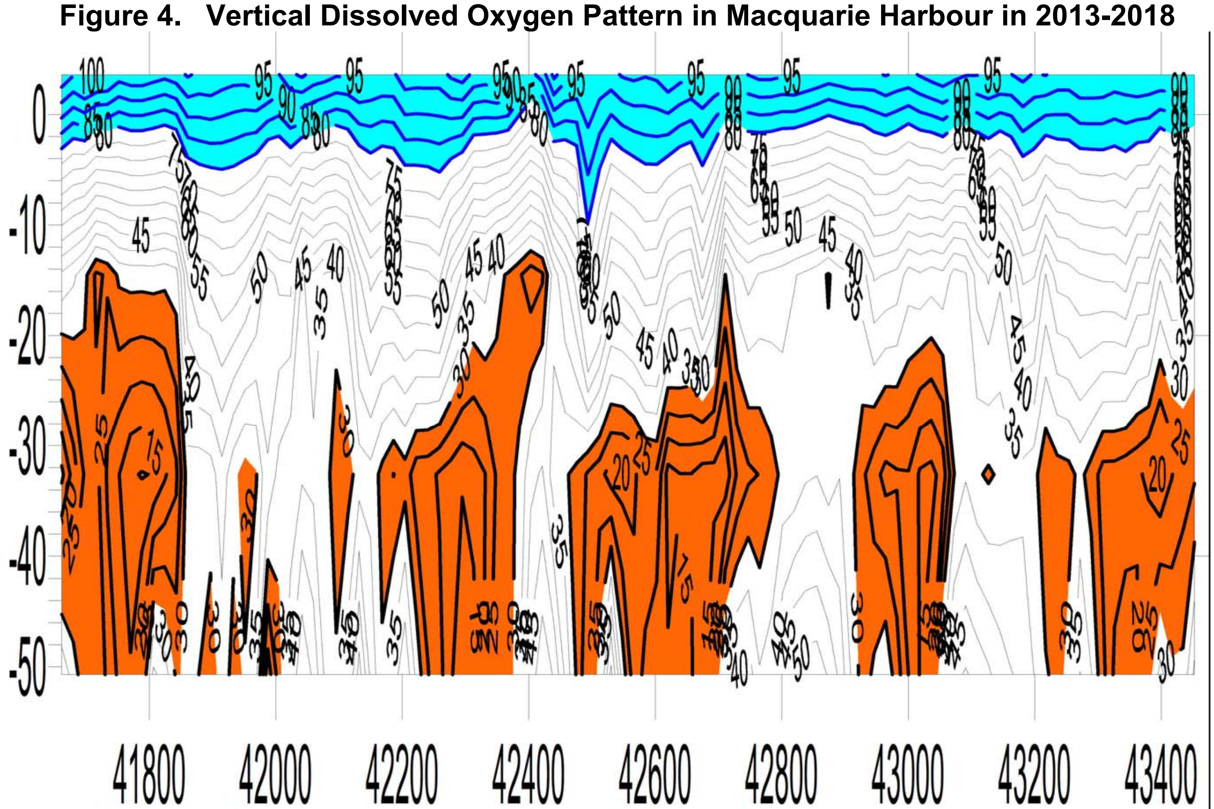


Figure 5 shows the monthly DO profiles at a central station in Macquarie Harbour for 2013-2014 (data provided by IMAS). The well-mixed surface layer extends down to 4 m depth, with the DO level being 95 % to 100 % saturation in this surface layer.

There is a strong gradient of declining dissolved oxygen from around 85 % saturation at 5 m depth to around 20 % saturation at 20 m depth.

Very low DO occurs at times at 25 m to 30 m depth, close to anoxic conditions. From 30 m depth to the bed at 45 m depth, there is a gradual increase in DO. The DO at the bed ranges from 15 % to 45 % saturation, so conditions at the bed are not anoxic.

Figure 5. Vertical Salinity Profiles in Macquarie Harbour in 2013-2014

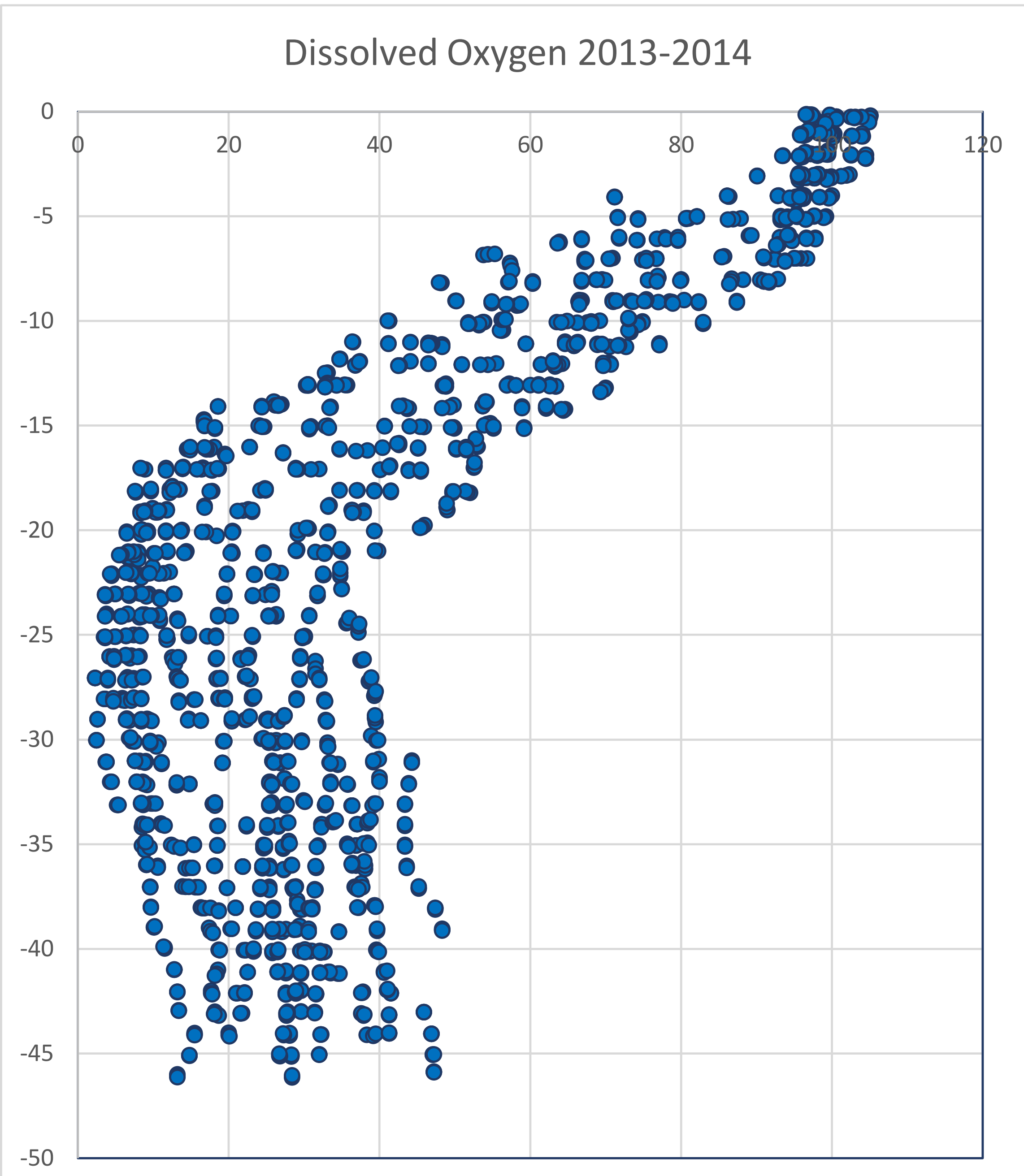


Figure 6 shows the monthly DO profiles at a central station in Macquarie Harbour for 2018-2019. The well-mixed surface layer extends down to 5 m depth, with the DO level being 92 % to 100 % saturation in the surface layer.

There is a strong gradient of declining dissolved oxygen from around 85 % saturation at 6 m depth to around 20 % saturation at 20 m depth. There was one month (January 2019) with lower than usual DO from 6 m to 12 m depth (highlighted with the red box).

Lowest DO occurs at times at 25 m depth, generally in the range of 15 % to 30 % saturation. From 25 m depth to the bed at 45 m depth, there is a gradual increase in DO so that DO at the bed ranges from 18 % to 45 % saturation. There was a smaller range in DO at each depth during 2018-2019 than in the earlier period.

Figure 6. Vertical DO Profiles in Macquarie Harbour in 2018-2019

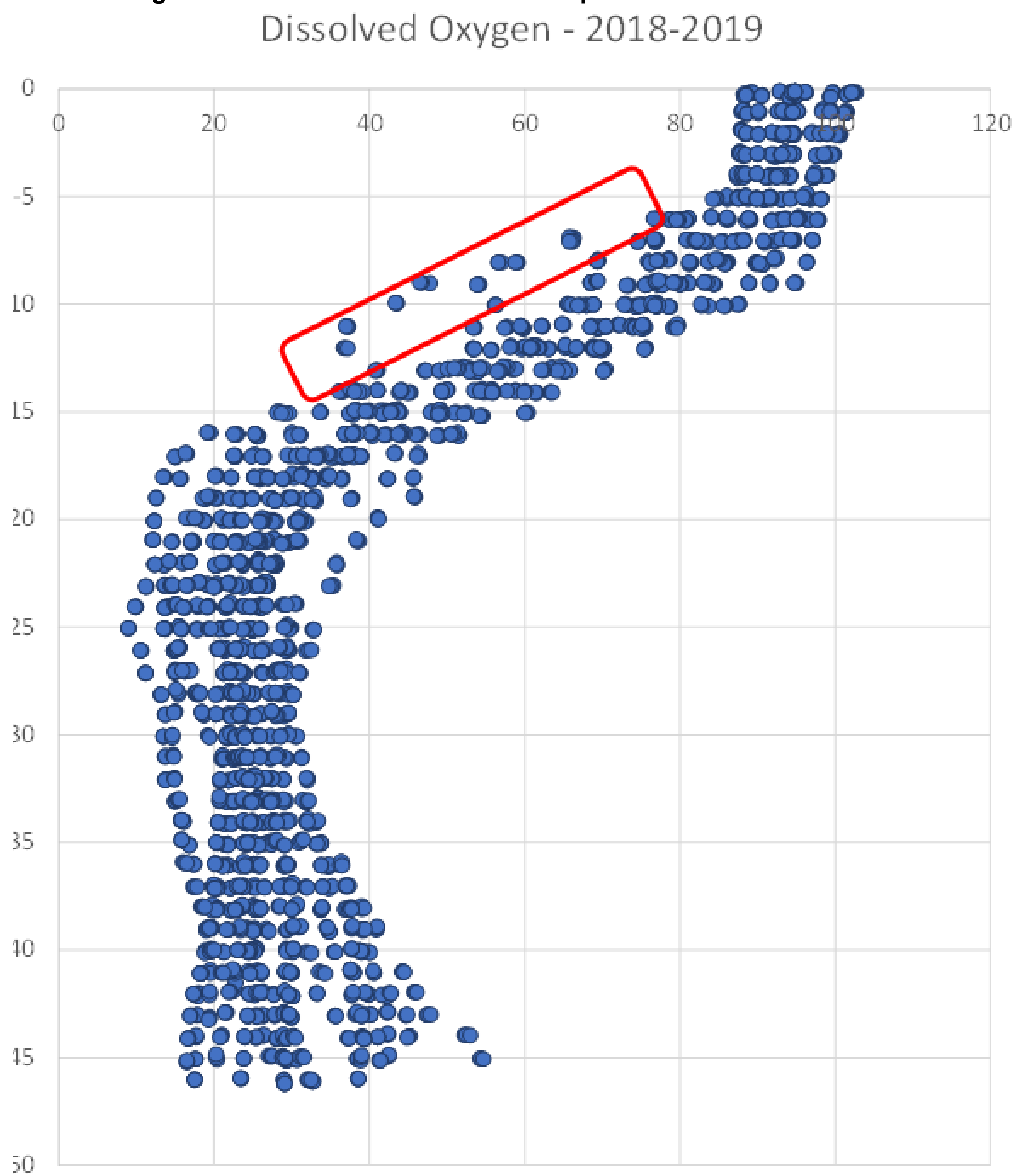
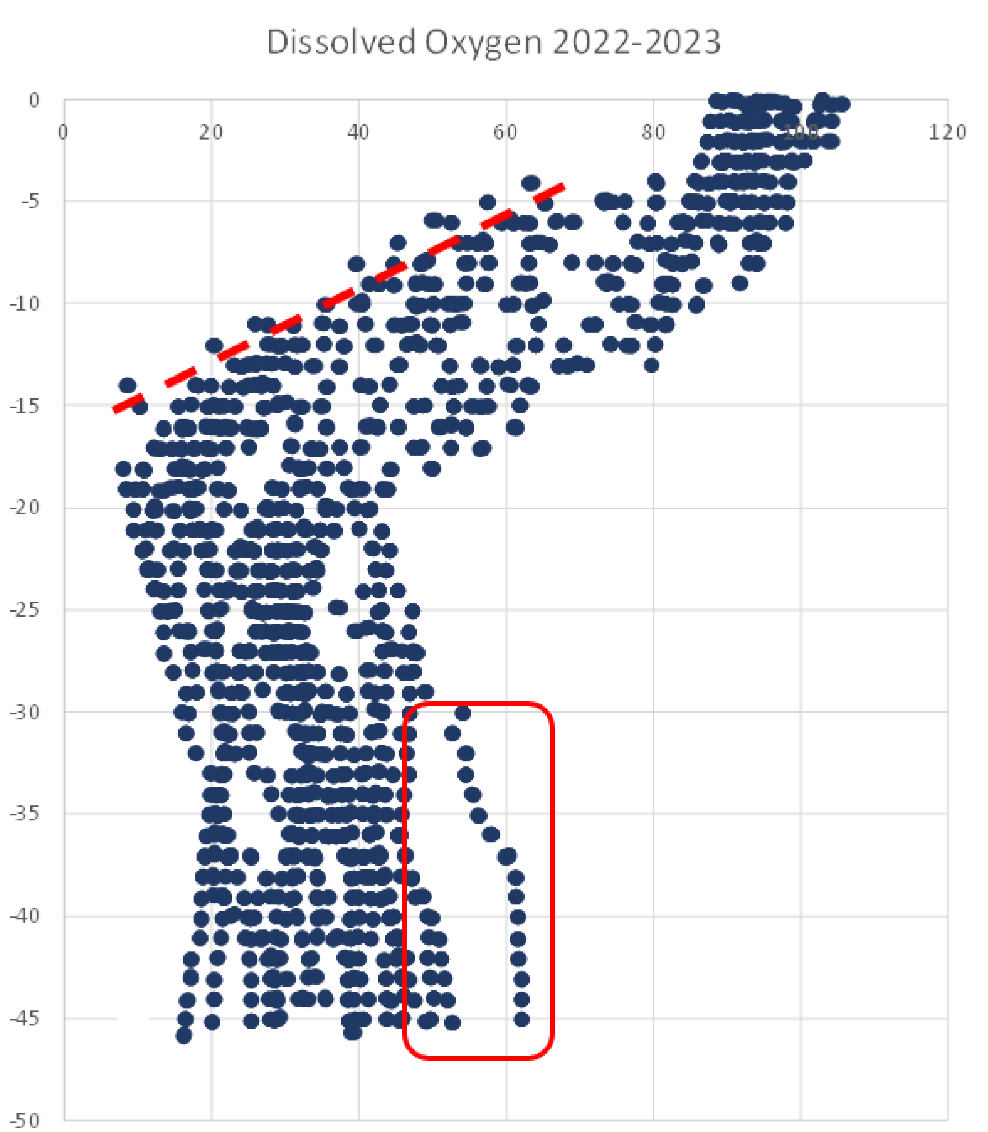


Figure 7 shows the monthly DO profiles at a central station in Macquarie Harbour for 2022-2023. The well-mixed surface layer extends down to 5 m depth, with the DO level being 86 % to 105 % saturation in this surface layer.

DO levels at 5 to 15 m depth were much lower in 2022-2023 than in 2018-2019, showing the water from lower levels had been uplifted in the latter two years. The higher salinity of the surface layer in 2022-2023 corresponds to a reduction in dissolved oxygen in the layer from 5 m to 15 m depth. However, there is not a significant reduction in the surface layer, indicating that surface re-aeration is a dominant process for maintaining high DO levels in the surface layer.

There is a strong gradient of declining dissolved oxygen from 5 m depth to less than 10 % saturation at 15 to 20 m depth. The DO increases slightly from 20 m depth to the bed, evidence that the incoming seawater is an important source of dissolved oxygen to the lower layer. A period when DO in the lower layer exceeded 60 % saturation is highlighted by the red box, indicating an event with a large seawater inflow in January 2022.

Figure 7. Vertical DO Profiles in Macquarie Harbour in 2022-2023



Mortality of Salmon in 2015 and 2019

In May 2015, Petuna reported a mortality event for 3.7 % of their salmon due to low dissolved oxygen near the bottom of the fish pens in Macquarie Harbour (ABC rural, 2015). Other salmon farms in the harbour lost fish as well. The mortality was attributed to a storm lifting low DO water into the shallower waters where the fish are located.

Salmon have a known temperature preference and tolerance, and a known dissolved oxygen tolerance. Salmon actively avoid water warmer than 17 to 18 °C and move to lower depths when the water temperature in the surface layer exceeds 18 °C.

Unfortunately for the salmon, there was a large intrusion of seawater into the harbour in May 2015. Seawater is more dense than the waters in the harbour and moves to the bottom. This displaces the existing bottom layer of water upward and hence each layer in the harbour is uplifted. As a result, water with low dissolved oxygen moves towards the surface.

Uplifting is a hydrodynamic process that occurs throughout the summer low-river-flow period each year. Various combinations of spring tides, onshore winds, low atmospheric pressure and low river flows encourage seawater to enter the harbour. As shown in Figures 1 to 3, the surface layer has an average salinity of 8 ppt. Thus, about 25 % of the outflow from the harbour originates from seawater intruding into the bottom layer. As the river inflow averages 330 m^3/s, the seawater inflow averages 80 m^3/s and the average outflow averages 410 m^3/s.

Salmon are active swimmers and require 50 to 55 % dissolved oxygen in the water to survive. Mortality of salmon occurs when there is a combination of high temperature in the surface layer (so the salmon move down in the water column) and an event of high seawater inflow (which uplifts water with low dissolved oxygen upwards into the bottom of the farm cages).

An event with high seawater inflow occurred in May 2015. Other events occurred in March-April 2019 and January 2022.

*A note on terminology. As discussed above, the process that brings waters with low dissolved oxygen closer to the surface is **uplift.** It occurs when a higher-than-usual volume of seawater enters the harbour, cascades down to the bed of the harbour and replaces the bottom layer of water, causing the layers of water above it to move upwards. The process is incorrectly referred to as **inversion** by Moreno et al (IMAS, 2020) but there is no inversion of the top and bottom layers. An examination of the vertical density profile (see Figure 8) shows that Macquarie Harbour always has a stable density structure with no evidence of an inversion.*

These uplift events are natural occurrences. The influencing parameters are (1) large tidal range; (2) low atmospheric pressure; (3) strong wind conditions; and (4) low river flow (influenced by wet/drought cycles). The operation of hydro-electric storages is another factor that can influent uplift events. Inflow events are reduced when there is higher river inflow.

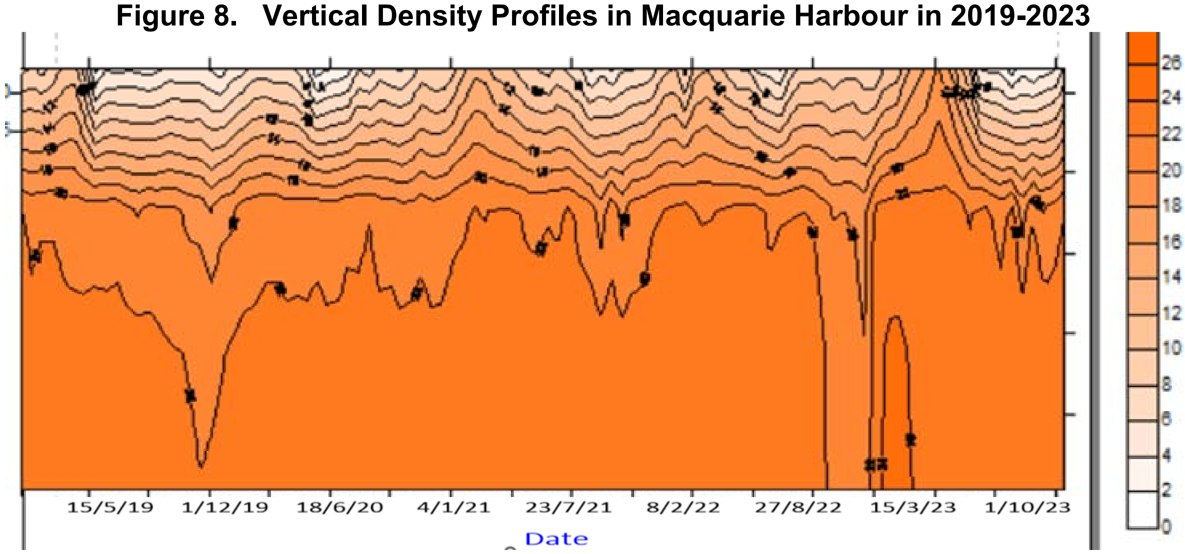
The presence of the salmon farms does not affect the inflow events.

Density Profile of Macquarie Harbour

Figure 8 shows the vertical density profile of Macquarie Harbour (plotted as sigma-T) for 2019 to 2023. The density (sigma-T) of surface waters ranges from near zero (at times of high river inflow) to around 12 kg/m^3 (at times of low river inflow). There is a seasonal pattern, but infrequent floods dominate the surface density.

The vertical profile shows strong stratification from the surface to 20 m depth, with weak stratification at the lower depths. The density stratification is strongly stable, showing that large scale inversions cannot occur. The density near the bed is mostly around 22 kg/m^3, consistent with seawater slightly diluted with freshwater as the ocean inflow cascades down the side of the harbour to the bed.

Figure 8. Vertical Density Profiles in Macquarie Harbour in 2019-2023



The more saline seawater mixes upward into the less saline layers. Thus, over a year, the seawater entering the harbour and settling to the bed slowly mixes upward through the water column, eventually leaves the harbour as part of the brackish surface outflow.

Dissolved oxygen (DO) enters the lowest layer with the seawater (which would normally be 100 % saturated with DO). DO also enters the surface layer with the river inflows (which would also normally be 100 % saturated with DO).

The stratification inhibits the vertical mixing of DO, which is why the lowest DO concentration occurs at 15 to 25 m depth, in the middle of the water column.

It is not obvious from the DO data analysed in this report that there has been *“a marked decline in dissolved oxygen conditions in Macquarie Harbour which are likely to have a significant impact on many resident species, including the Maugean Skate”* Dissolved oxygen was always low in the lower layer. There are certainly significant variations in DO in Macquarie Harbour from month-to-month and year-to-year. Whether or not there is a long term trend of declining DO with time is still an open question, as any trend is difficult to separate from variations in annual and longer term river flows, and events with a large inflow of seawater, due to a coincidence of environmental conditions that encourage such events.

Long period cycles are also likely to be important. As an example, there appears to be a 50-year cycle in the extent of seagrass in Port Phillip Bay, responding to decade-long variations in rainfall (Jenkins, et al, 2015) and similar long cycles may occur in Macquarie Harbour.

Moving from 2-D to 3-D

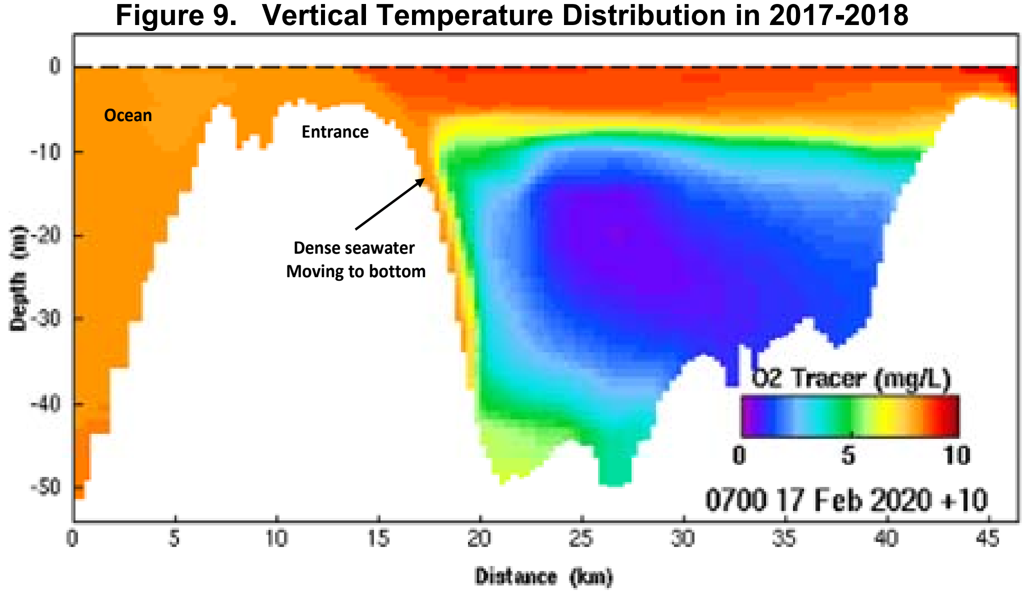
The analysis of vertical profiles of salinity, dissolved oxygen and density is based on a string of monitoring sensors in the middle of the harbour. IMAS maintains the sensors and reported that salinity and density conditions are very similar along the main NW-SE axis of the harbour, based on the correspondence of results for several vertical strings of sensors. The changes over the depth, and with time, are much greater than the changes with distance along the axis of the harbour. Thus, the analysis can be described as a 2-D depiction of conditions.

Conditions near the inlet of the rivers and in the channel connecting the harbour to the ocean differ from the conditions in the bulk of Macquarie Harbour. Near the mouth of the rivers, the freshwater salinity and temperature dominate conditions locally. In the ocean entrance channel, conditions vary over the tide cycle (although river flow rather than tide height dominate the direction of water movement).

In summer, when there is mostly lower river flow, more seawater enters the harbour, and descends down the side to the bed of the estuary. The effect of this plume on temperature is apparent in the summer profiles in Figure 9.

In winter, when there is generally higher river input, the outflow of the surface layer dominates flow in the channel, and there is a smaller inflow of seawater (but some occurs when there is a coincidence of conditions favouring seawater inflow).

Figure 9. Vertical Temperature Distribution in 2017-2018



Source: Wild Allen et al, Macquarie Harbour Oxygen Process model, Fig 2-10, CSIRO, 2020

Uplifting of lower DO waters can occur in suitable conditions, such as persistent strong westerly winds when river inflow is low and the surface layer is shallow (perhaps with higher than usual salinity). The haloclines are tilted and there is an intrusion of marine water causing an uplift of mid layer water with low DO to near the surface at the northwest end of the harbour. In such an event in March 2018, there were large oscillations in the haloclines along the length of the harbour with higher surface salinity and lower dissolved oxygen at sites close to the harbour entrance. After the event, dissolved oxygen was reported to have increased by more than 50 % in the bottom water.

When the wind is aligned along the major axis of the harbour, it sets up oscillations in sea-level that raise and lower the halocline at opposite ends of the harbour. Conditions around the edges of Macquarie Harbour are more variable than in the middle.

Salinity and Temperature Preference of Skates

Moreno and Semmens (IMAS, 2023) reported on the distribution of Maugean Skate eggs in Macquarie Harbour, with particular reference to depth and DO. The distribution of Skates was assessed from multiple net trawls, diver surveys, and tracking of 25 adult Maugean Skates fitted with multi-sensor acoustic tags by 52 acoustic receivers in the Table Head/Liberty Point region of Macquarie Harbour over a 12-month period from Nov 2018 to Nov 2019.

The 25 tagged Maugean Skate were mature individuals ranging from 620 and 820 mm in size. Two of the tagged skate exited the array within a few days of release and were not detected again during the study period. Five individuals exited the array area at 2 to 8 months after release and were not detected again.

Eleven skate (eight males and three females) were assumed to have died during the study period. Seven individuals stayed within the array area for the duration of the study and survived for 12 months. The mortality rate (11 of 25 skates in a year) matches the typical mortality rate for skates (40 % per year, Grant et al, 2022) which predicts the loss of 10 skates per year.

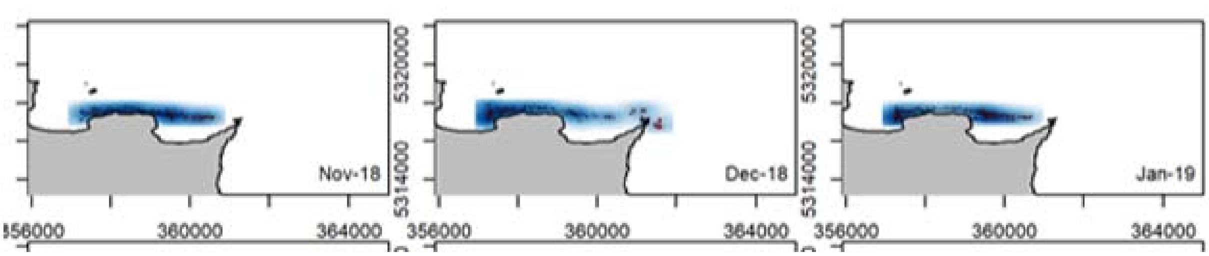
The uplift event in January 2019 has been highlighted earlier in this Technical Memo. The vertical profile for 24 January 2019 showed the DO was at 60 % saturation at 8 m and 50 % saturation at 9 m depth. The salinity at these depths was elevated at 28 ppt at 8 m depth and 28.5 ppt at 9 m depth. This is evidence of a strong salinity uplift event.

The conditions in April 2019 showed a weaker uplift event, with the DO at 60 % saturation at 12 m depth and 50 % saturation at 16 m depth. The salinity at these depths was elevated at 27 ppt at 12 m depth and 30 ppt at 16 m depth.

The location of the mortality events mostly occurred in shallow water (less than 5 m deep) where there was high dissolved oxygen (see Figure 14 of Moreno and Semmens, 2023).

Overall, the skates had small home ranges (< 4 km travel distance, mostly along the depth contours) through which they moved in a consistent manner (see Figure 10). However, at different times of the year, most individuals displayed a change in behaviour where they briefly travelled to sites away from the home range in short excursions (< one week). This travelling was short lived and followed by a return to normal home ranging behaviour.

Figure 10. Travel Paths of Skates at Table Head in 2018-19



The skates had a strong preference for temperatures between 13 to 15°C. During the summer months, when ambient temperatures high in the water column were above that range, individuals spent most of their time at the cooler available sites. The opposite was true during winter, when individuals favoured sites within the preferred range over other much cooler areas.

Figure 11 shows vertical temperature profiles in the 12 months of 2019 with the skates preferred range of 13 to 15°C highlighted. It appears that the temperature in the surface layer (zero to 5 m depth) is too hot in summer and too cold in winter, but just right in spring and autumn. The seasonal variation encourages the skates to move to the 8 m to 15 m depth layer in summer and winter.

Figure 11. Vertical Temperature Profiles in 2019

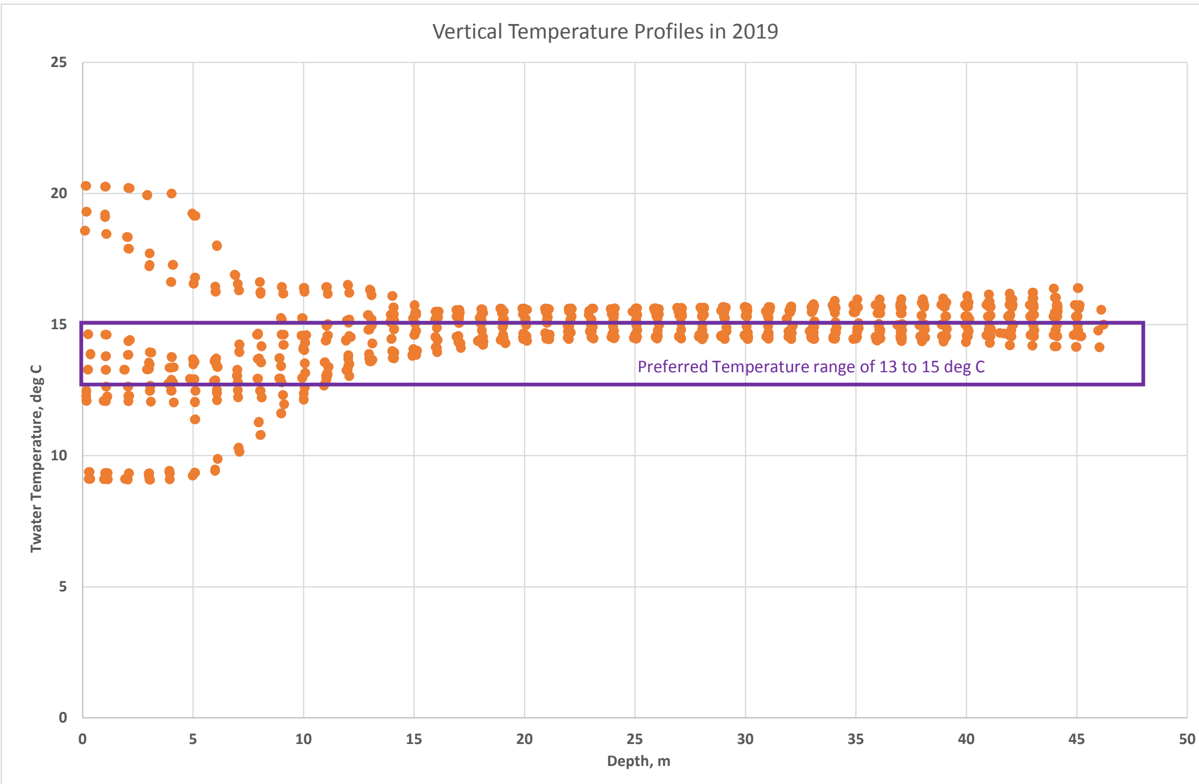


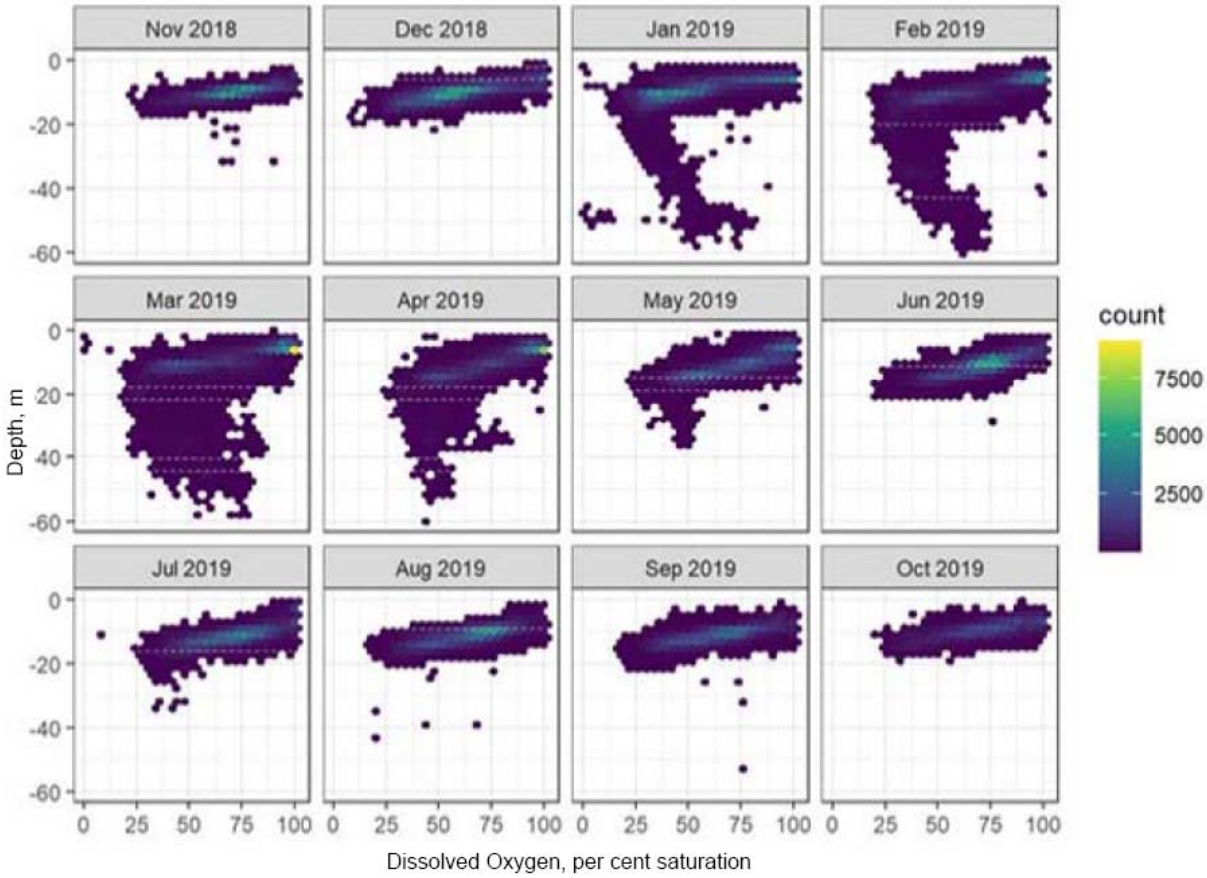
Figure 12 is a plot, month-by-month, of the depths (vertical scale) and DO (horizontal scale) for the monitor records for the seven skate that survived the 12 month monitoring period.

For eight months of the year, the depth range was limited to a maximum of 20 m depth, with most records showing the skate were between 8 m and 15 m depth.

During four months (January to April 2019) the skates were mostly higher in the water column (at 5 m to 10 m depth) but with excursions to 50 m depth (the bed of the harbour). The DO recorded by the monitors ranged from about 30 % at 20 m depth to around 50 % at 50 m depth. These recorded DO conditions are significantly different from the DO recorded by IMAS in the middle of the harbour (see Figure 6). The IMAS sensor string recorded that DO saturation ranged from about 25 % at 20 m depth to around 30 % at 50 m depth.

There is also a large difference between the DO recorded by the skate monitors at 10 m depth (30 % to 100 % saturation) compared to the values recorded by the IMAS sensors in mid-Harbour (mostly 60 % to 80 %, with a single month of 40 %). A possible explanation is that the skates take the opportunity to explore down the slope in the high DO water that occurs during an ocean inflow event.

Figure 12. Vertical Temperature Profiles in 2019



Source: Moreno and Semmens (IMAS, 2023)

This difference is recognized by Moreno and Semmens (IMAS, 2023) who noted that tags attached to skates that died in the study showed different DO levels than the water column sensors at the same depth; suggesting that DO conditions within the skate's preferred habitat appear to fluctuate dynamically by depth and horizontally across relatively small spaces.

Further investigations are necessary to determine why the DO conditions at Table Head differ from those in the rest of the harbour, and why Maugean Skates are concentrated in two relatively small zones (Table Head and Swan Basin) on the west side of the harbour.

The paper suggests "*that the deaths (of tagged skates) may have been related to stress caused (directly or indirectly) by the significant changes in the environmental conditions of the harbour. If this is the case, then recent changes in the environmental health of the harbour (especially dissolved oxygen levels), coupled with the consequences of climate change (including occurrence of extreme weather events), may already be challenging the skate's capacity to cope with the environmental conditions in Macquarie Harbour*"

There is no data in the paper that show that there are changes in the environmental health of the harbour. Thus, there is no basis for this inference. The uplift events that occurred in 2019 and which may, or may not, have contributed to increased mortality of skates are a natural occurrence that occurs regularly (as shown in Figures 4 and 15). Other than this extrapolation, and the conflicting DO results, the Moreno and Semmens (IMAS, 2023) paper is an excellent description of the location and behaviour of skates in Macquarie Harbour, and the wide range of environmental conditions that they experience.

Dissolved Oxygen in Macquarie Harbour

Wild-Allen et al (2020) have set out an oxygen balance for Macquarie Harbour for the years 2017-2018. The published oxygen inputs and losses for that period are set out in Table 1. An updated oxygen balance for the operation of the salmon farms is set out below.

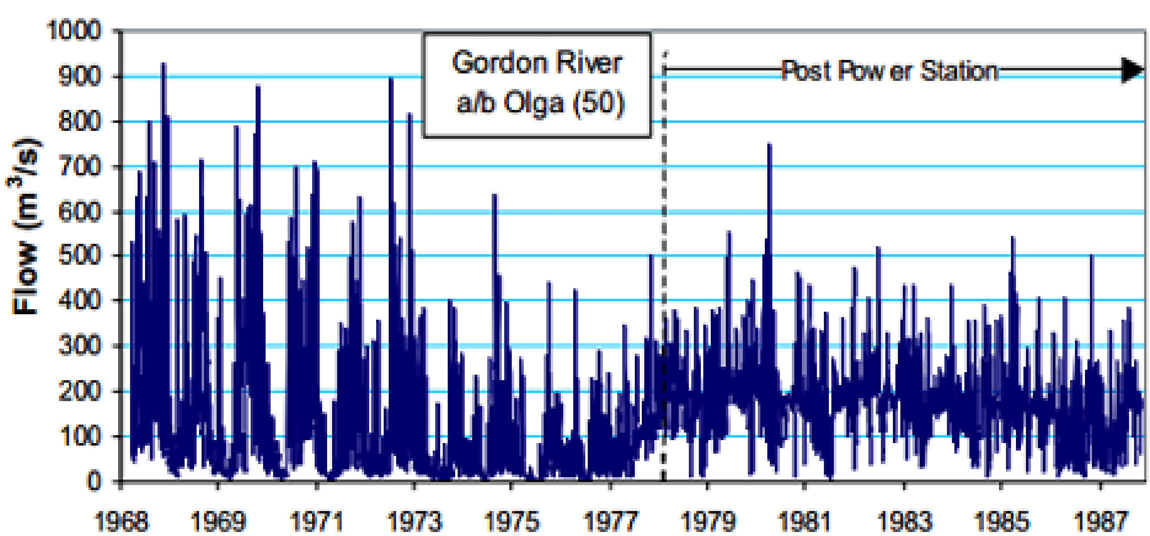
Table 1. Estimated 2017-18 Oxygen Inputs and Losses from Macquarie Harbour

Component	Oxygen, t/yr	Comment
Inputs of Oxygen to Macquarie Harbour		
Oxygen in river inflow	121,000	350 m^3/s at 11 mg/L DO
Oxygen in ocean inflow	14,000	Seems low at 80 m^3/s at 8 mg/L
Re-aeration on surface	11,000	
Phytoplankton and MPB	2,000	
Total inputs of oxygen	***148,000***	
Losses of Oxygen from Macquarie Harbour		
Oxygen in Harbour outflow	129,000	430 m^3/s at 8 mg/L
Accumulation in sediments	12,000	Largely attributed to fish farm solids
Respiration of fish	5,000	50 mg/kg fish per hour for 11,400 t fish
Loss to the atmosphere	2,000	
Total losses of oxygen	***148,000***	

The oxygen balance is dominated by the oxygen that enters the surface layer in river inflow and then leaves as a brackish outflow. The oxygen in ocean water that enters in the channel and descends to the bottom of the harbour involves a smaller amount of oxygen.

The Gordon River power station is the largest power station in Tasmania. The pattern of flow in the river has been changed by the operation of the power station, as illustrated in Figure 13. Flow peaks are attenuated and the base flow rate is increased – this effect can be exacerbated by the requirement to maintain an environmental flow in the rivers. Higher river flow rates correspond to less intrusion of ocean water to the harbour – and less addition of oxygen to the lower layer of the harbour.

Figure 13. Flow Rate in Gordon River – 1968 - 1987



The potential impact of the oxygen demand by salmon farm respiration depends on: (1) the oxygen demand in the vertical profile; and (2) the location of the salmon farms in relation to the areas commonly used by skates.

Vertical Position of Demand

Salmon cages extend from the surface to 13 m depth. The fish move up and down in the cages in response to feeding opportunity, water temperature profile, light, oxygen levels and perceived threats. In winter, salmon can thrive at 2 m to 5 m depth, but in summer they swim at deeper levels (8 m to 11 m) seeking a compromise between lower temperature and lower DO.

I do not have access to data showing a plume of reduced DO near a Macquarie Harbour salmon farm. The measurements of Oldham et al (2018) indicate a reduction of 3 to 5 % in DO in salmon cages in the Huon estuary.

For Macquarie Harbour, a typical salmon farm may be 168 m in diameter with 100 t of fish in a 3 m deep layer. Oxygen demand at 50 mg/kg fish/hr (CSIRO, 2021) is 5 kg/hr.

The flow of water through the school of fish in the cage at a typical velocity of 0.04 m/s is 20 m^3/s or 72,000 m^3/hr. In the surface layer, the DO concentration is 9 mg/L, so the oxygen flux is 650 kg/hr. In the deeper layer, the DO concentration is 6 mg/L, so the oxygen flux is 430 kg/hr. The reduction in DO downstream of a fish cage due to fish respiration is around 1 % or 0.06 mg/L (small).

The depth preferences for skate, reported earlier, shows that the depth range was mostly between 8 m and 15 m depth, so that skate could potentially be affected by the plume from the cages in summer. In winter, the plume of reduced DO water from the salmon farms flows out to the ocean (at undetectably lower concentrations than without salmon farms).

Location of Salmon Farms Relative to Skate Locations

Most skates were found at Table Head, which is around 1.5 km west of the salmon farms. There are five other verified habitats for skates around the perimeter of Macquarie Harbour (DCCEEW, *Conservation Advice for Zearaja maugeana Maugean Skate, 2023*). All are more than 1 km from the nearest salmon pen and the DO in the surface waters at skate sites could not be impacted by respiration of salmon.

Outcome

It is very unlikely that the oxygen demand for salmon respiration can have a direct impact on skates because the reduction in DO is very small at the cages, and even smaller at distance and after the effect of surface re-aeration.

Potential Risk in Bottom Layer DO

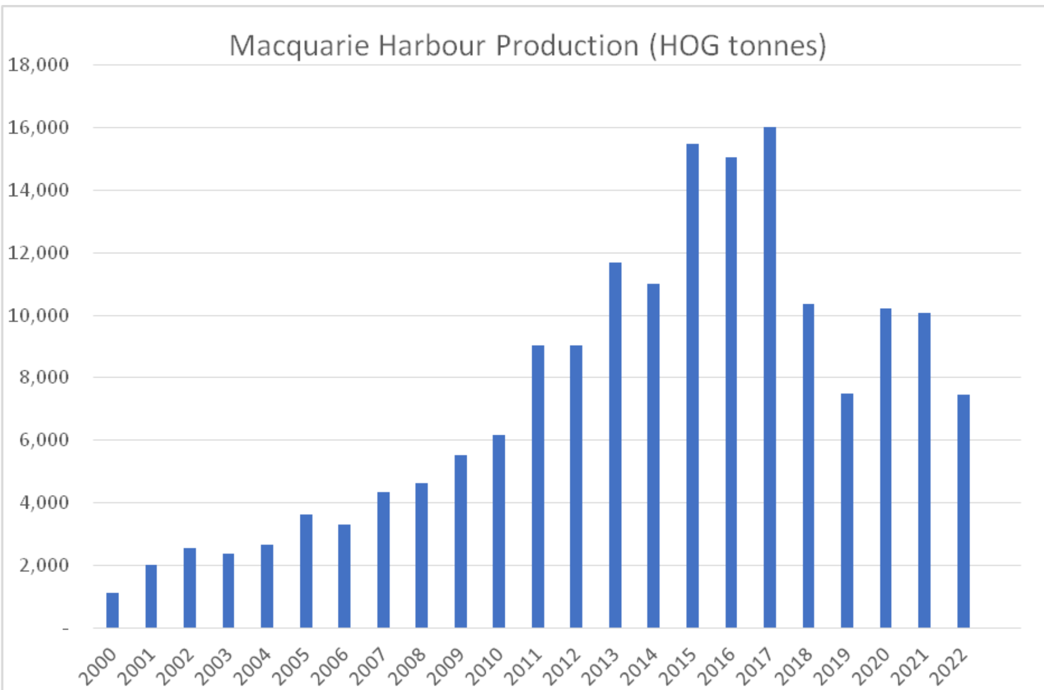
The second consideration is the potential for salmon food and faeces to reduce DO in the lower layer of the harbour from nitrogen and organic solids stimulating bacterial growth in the water column and the sediments with coincident use of oxygen.

The CSIRO model report (Wild-Allen, 2020) estimated that DO load in the sediments due to these processes was 12,000 t/yr, which is close to the estimated input of oxygen from the ocean (of 14,000 t/yr). This is the critical balance that determines the oxygen conditions that skate experience on their deep dives. The model predicted that if the 12,000 t/yr sediment load was removed, DO in the lower layer would increase by around 1 to 2 mg/L at 25 to 35 m depth (Fig 4-40 of CSIRO report). This assumption is checked in this Technical Memo.

Nitrogen and Organics Balance

According to Ross (IMAS, 2022) potential environmental impacts of salmon farms in the water column stem predominantly from the introduction of nitrogen (N) and phosphorus (P). However, carbon addition in fish feed is equally important as respiration of fish coverts a proportion of the carbon supplied to carbon dioxide. Thus an updated nitrogen and carbon balance for salmon farms in Macquarie Harbour is provided in the following section for the year 2023. The mass balance is based on published information, particularly the mass balances published by Wang et al (2013) and Wang and Olsen (2023). The mass balance reflects the lower salmon production in 2018-2023 compared to 2013-2017, as shown in the production plot in Figure 14.

Figure 14. Salmon Farms Production in Macquarie Harbour (t/year)

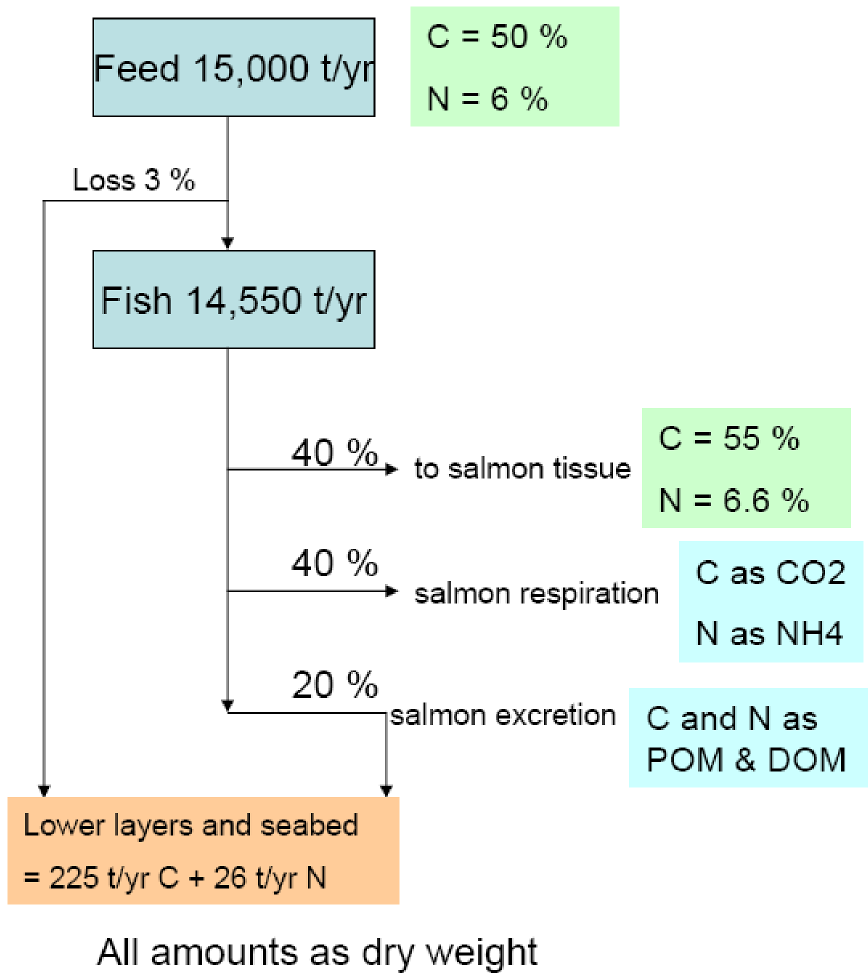


Modern salmon farms are very efficient in their use of feed (97 % of feed is reported to be eaten by the fish and only 3 % escapes the fish cage). The feed is optimized for growth of salmon and 40 % of the feed is assimilated by the fish and converted to salmon mass.

Figure 15 shows the mass balance for fish feed supplied to all salmon farms in Macquarie Harbour. The same pathways apply to carbon and nitrogen, as explained below.

The feed input to salmon farms follows a seasonal pattern with peak input in Oct to Dec each year, and lower inputs in autumn to winter. Total inputs increased steadily from year 2000 to a maximum in 2017 (see Figure 14). Following Harbour wide declines in DO and associated declines in benthic faunal abundance (Ross et al., 2017), the permissible aquaculture biomass in Macquarie Harbour was reduced, and feed input since 2017 has been about half the earlier peak rate. Based on available data, the total input of fish feed in 2023 is estimated to be 15,000 dry tonnes.

Figure 15. Schematic Mass Balance for Fish Feed in Macquarie Harbour



The fish feed (of 15,000 t/yr as dry weight) is assumed to have a carbon content of 50 % and a nitrogen content of 6 % (based on Wang and Olsen, 2023). Other constituents of the fish feed are phosphorus, hydrogen, oxygen and trace elements.

The loss of fish feed through the base of the cages is 3 % or 450 t/yr, which corresponds to 225 t/yr of carbon and 26 t/yr of nitrogen. The fate and related oxygen demand of the lost fish feed is considered in conjunction with salmon excretion.

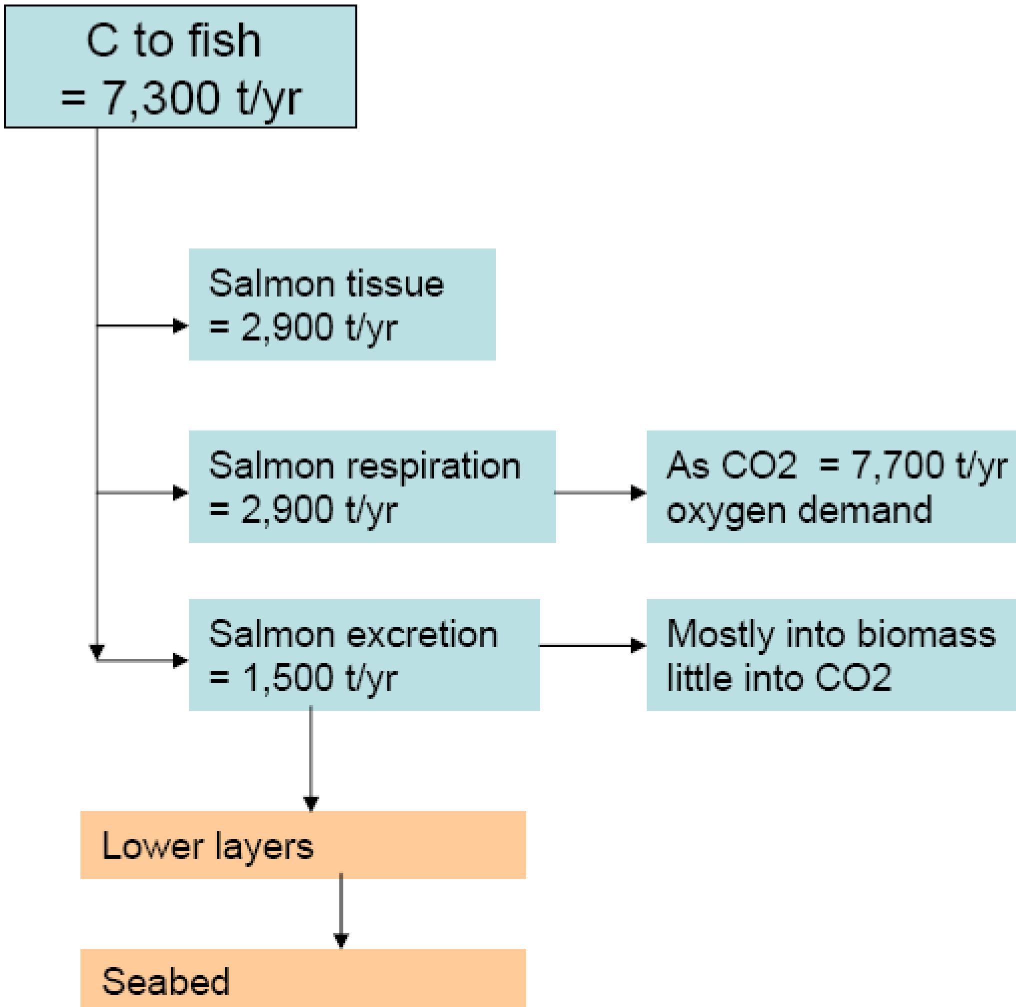
Growth or production of salmon is estimated to be 40 % of the fish feed, as an average over the year. It is recognized that the growth rate varies with the seasonal temperature and other conditions, but the feed rate is altered to adjust for this, and this balance is based on the average conditions over the year.

Salmon use an estimated 40 % of carbon for respiration and also release at the gills an estimated 40 % of nitrogen mostly as ammonia with a small proportion of urea (NH_2CONH_2).

To complete the balance, an estimated 20 % of the feed is assimilated by the fish and excreted as a combination of particulate organic matter (POM) and dissolved organic matter (DOM).

Figure 16 shows the extension of the mass balance for carbon.

Figure 16. Carbon Mass Balance for Fish Feed in Macquarie Harbour



The carbon balance shows the salmon assimilate 7,300 t/yr of carbon. Of this, 40 % goes into salmon growth (2,900 t/yr), 40 % goes into salmon respiration (2,900 t/yr) and 20 % goes into excretion.

Salmon Tissue

Salmon tissue is reported to have a carbon content of 55 %. Thus, the growth of salmon corresponds to 5,300 t/yr of salmon production (2,900 / 0.55 = 5,300). Allowing for 30 % water in adult salmon, the production rate is approximately 7,600 t/yr (which corresponds to the production rate in Figure 14).

Salmon Respiration

Salmon respiration converts 2,900 t/yr of carbon into 10,600 t/yr of carbon dioxide, which involves the fish withdrawing 7,700 t/yr of dissolved oxygen from the waters surrounding them.

Google Earth shows 77 farm cages in Macquarie Harbour, so this corresponds to 100 t oxygen demand/yr/cage. As noted earlier, the flow of water through the school of fish in the cage at a typical velocity of 0.04 m/s is 20 m^3/s or 72,000 m^3/hr. On average, the oxygen demand for respiration of 7,700 t/yr corresponds to 0.16 mg/L reduction in dissolved oxygen.

The peak rate in spring could be up to 0.3 mg/L DO. As surface DO is in the range of 7 to 8 mg/L, this estimate is close to the 3 % to 5 % measured by Oldham et al (2018).

Implications of Respiration on DO

Figures 5 to 7 show the DO at 10 m depth is typically at 60 % to 80 % saturation, reflecting a 2 to 3 mg/L reduction in DO. Most of this reduction can be attributed to the large oxygen demand from river inputs (see Table 1), respiration from the salmon farms also reduced oxygen concentration (albeit much smaller).

There is a strong gradient in DO from the surface to depth in the harbour. Thus, essentially all the oxygen demand in the surface layer by salmon is matched by an input of oxygen from surface re-aeration. Also, some of the oxygen demand is flushed to the ocean in the daily surface outflow.

The DO demand from respiration has no effect on dissolved oxygen levels in the deeper waters (at 15 to 30 m depth).

Salmon Excretion of Carbon

Salmon excreta is a combination of particulate organic matter and dissolved organic matter. Typically, the carbon and nitrogen content of fish excreta is lower than in the feed (Wang et al, 2023). Available data suggests that the carbon content decreases from 50 % in the feed to 35 % in the excreta while the nitrogen content decreases from 6 % in the feed to 4.5 % in the excreta. Nonetheless, the 1500 t/yr of carbon shown in Figure 16 is retained for this oxygen consumption analysis.

The excreta is processed by a range of small animals and bacteria in the water column and on the bed of the harbour (if the particles make it to the bed without being consumed). Ultimately the carbon ends up as living tissue in the water column (a small amount) or as sludge on the bed. A minor amount may be transported upward by free-swimming organisms and lost to the ocean in the harbour outflow.

For the calculation of oxygen demand, the following assumptions are made:

- One-third of the excreta is assimilated by organisms in the top layer;
- One-third of the excreta is assimilated by organisms in the lower layer;
- One-third of the excreta is assimilated by organisms in the harbour bed;
- The COD corresponds to complete conversion of C to CO_2;
- The BOD corresponds to a COD/BOD ratio of 2.0, as for similar faecal matter.

On this basis, the following calculations of oxygen demand in the lower layer/bed ensue:

- Total BOD due to carbon excretion is 4,000 t/yr;
- The BOD in the top layer is 1,330 t/yr;
- The BOD in the lower layer is 1,330 t/yr;
- The BOD on the seabed is 1,340 t/yr.

Experience in shallow treatment ponds (2 m to 4 m deep) is that most of the BOD is exerted by organisms on the bed. Macquarie Harbour is much deeper, and the food path and depth ranges for the use of the carbon (and nutrients) is not established as yet, so it is assumed that one third of carbon is assimilated in each of the top layer, lower layer and the bed.

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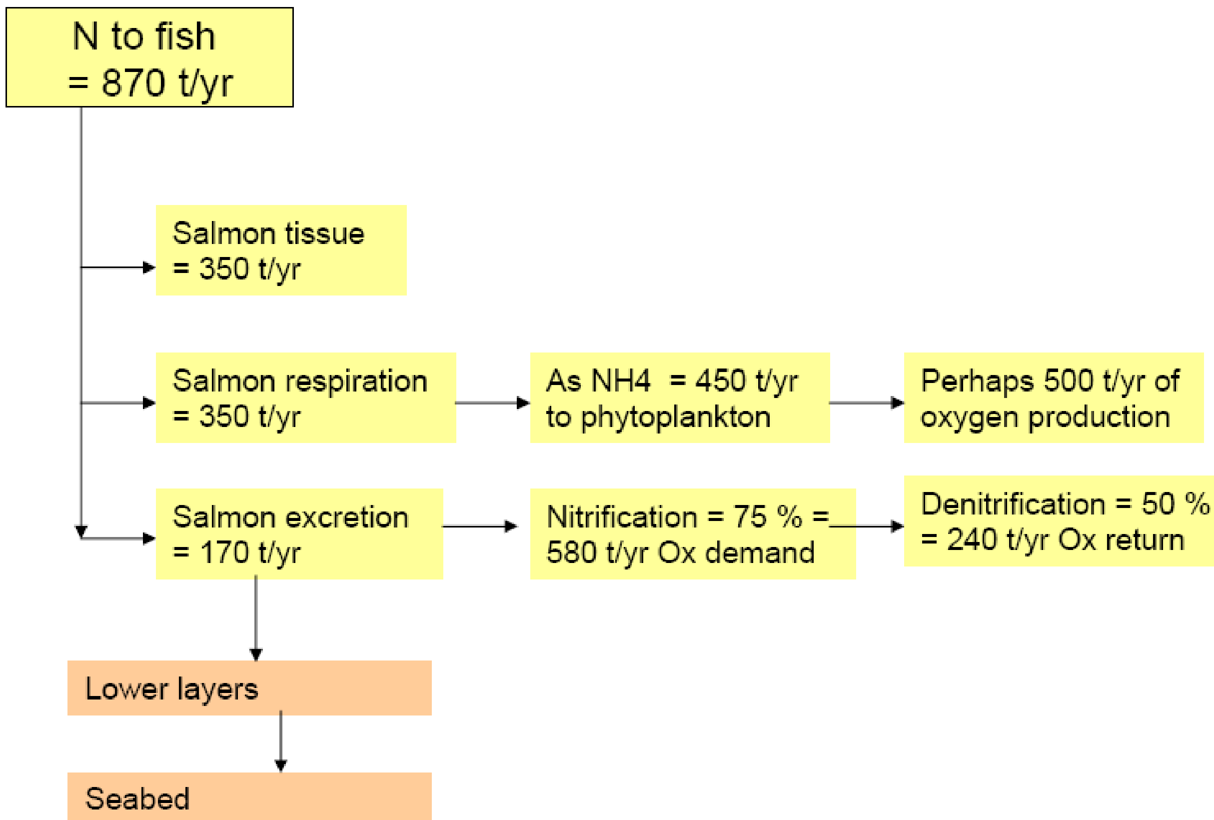
Figure 17 shows the extension of the mass balance for nitrogen, starting with the 870 t N/yr assimilated by the fish.

Figure 17. Nitrogen Mass Balance for Fish Feed in Macquarie Harbour



The nitrogen balance shows that salmon growth uses 350 t/yr of nitrogen. Salmon release excess nitrogen at the gills in the form of ammonia and urea (assumed to be all ammonia). There is 170 t/yr of nitrogen in salmon excreta.

Salmon Tissue

Salmon tissue is reported to have a nitrogen content of 6.6 % (Wang and Olsen, 2023). Thus, the growth of salmon corresponds to 5,300 t/yr of salmon production (350 / 0.066 = 5,300). Allowing for 30 % water in adult salmon, the production rate is approximately 7,600 t/yr (which corresponds to the production rate in Figure 14).

Salmon Release of Excess Ammonia

Salmon release 350 t/yr of nitrogen as ammonia which rapidly dissolves in the seawater in the top layer. In other marine waters, the ammonia would be assimilated by phytoplankton or macrophytes in a few hours. There are no macrophytes near the fish cages, but field surveys have identified that the chlorophyll-a concentration over the top 15 m of the water layer is typically around 1 µg/L which shows there is sufficient phytoplankton habituated to the low light conditions of the harbour to take up the ammonia. The IMAS field surveys also demonstrate that there is no increase in ammonia in the surface waters which confirms that it has been assimilated.

The quantity of phytoplankton supported by a nitrogen discharge (as ammonia) of 350 t/yr is calculated using the Redfield ratio(Redfield, 1958), which states that the average composition of ocean plankton is 106C : 16N : 1 P.

Applying the ratio, the supply of 350 t/yr of ammonia would encourage the growth of around 3,000 t of phytoplankton (8 t/day) which through photosynthesis would supply around 3,600 t of oxygen to the surface layer.

It is not considered that the ammonia release has any effect on dissolved oxygen levels in the deeper waters (at 15 to 30 m depth) as the ammonia is dissolved and assimilated in the top layer.

Salmon Excretion of Nitrogen

As noted above, typically the carbon and nitrogen content of fish excreta is lower than in the feed (Elvines, et al, 2023). Available data suggests that the nitrogen content decreases from 6 % in the feed to 4.5 % in the excreta. Nonetheless, the 170 t/yr of carbon shown in Figure 17 is retained for this oxygen consumption analysis.

The excreta is processed by a range of small animals and bacteria in the water column and on the bed of the harbour (if the particles make it to the bed without being consumed). Ultimately the carbon ends up as living tissue in the water column (a small amount) or as sludge on the bed. A minor amount may be transported upward by free-swimming organisms and lost to the ocean in the harbour outflow.

Nitrification is the natural process that occurs in the environment by a group of specialised bacteria in which ammonia ($NH4^+$) is converted to nitrites ($NO2^–$) and then to nitrates ($NO_3^–$). The theoretical oxygen demand for this process is 4.57 g O_2/g $NH4^+$). The pH in Macquarie Harbour is optimum for nitrification and denitrification.

Denitrification is a related natural process by another group of specialized anaerobic bacteria that convert nitrate to nitrogen gas and release water and oxygen. The theoretical oxygen recovered is 2.86 g O_2/g NO_3^- reduced. The overall oxygen requirement for combined nitrification/denitrification is 1.7 g O_2 consumed per g of ammonia.

Neither nitrification nor denitrification is 100 % effective, and both processes are limited by low water temperature (and elevated DO in the case of denitrification). Based on analysis of nitrogen removal in wastewater treatment lagoons at Strahan (TasWater, 2023), nitrification in the region is about 75 % effective and denitrification is about 50 % effective.

For the calculation of oxygen demand, the following assumptions are made:

- Bacteria are assumed to nitrify and denitrify the released nitrogen;
- Oxygen requirement for nitrification is 4.6 g per g of nitrogen;
- The nitrification efficiency is assumed to be 75 %, based on the nitrification efficiency of the adjacent Strahan sewage treatment lagoons;
- Oxygen return from denitrification is 2.8 g per g of nitrogen;
- The denitrification efficiency is assumed to be 50 %, based on the denitrification efficiency of the adjacent Strahan sewage treatment lagoons.
- The remaining 25 % of excreted nitrogen is stored on the bed as dead tissue (sludge).
- One third of carbon is assimilated in each of top layer, lower layer and the bed.

On this basis, the following calculations of oxygen demand ensue:

- The oxygen demand for nitrification is 580 t/yr (factor is 4.6);
- The oxygen return from denitrification is 240 t/yr (factor is 2.8);
- The net oxygen demand in the water column is 340 t/yr.
- The net oxygen demand in the upper layer is 110 t/yr.
- The net oxygen demand in the lower layer column is 110 t/yr.

The remainder of the nitrogen in excreta is converted into tissue of bacteria/fungi and other micro-organisms and accumulated in the bed as sludge.

Lost Salmon Feed

As shown in Figure 15, 450 t/yr of salmon feed containing 225 t/yr of carbon and 26 t/yr of nitrogen falls through the salmon cages.

The most likely fate of the lost salmon feed is that native fish spend time under the cages and assimilate most of the excess feed coming down into their habitat. The remainder experience the fate of salmon excreta.

Alternatively. The lost feed can be consumed by bacteria. Using the same parameters as for the excreta load, the net effect on oxygen demand is as follows:

- Carbon in lost feed assimilated by organisms is 225 t/yr;
- The corresponding COD is 600 t/yr (complete conversion of C to CO_2);
- The corresponding BOD is 300 t/yr (biological conversion of C to tissue).
- One third of carbon is assimilated in each of top layer, lower layer and the bed;
- Oxygen demand from carbon in top layer is 100 t/yr;
- Oxygen demand from carbon in lower layer is 100 t/yr.

- Nitrogen in lost feed assimilated by organisms is 26 t/yr;
- The oxygen demand for nitrification is 72 t/yr (factor is 4.6);
- The oxygen return from denitrification is 36 t/yr (factor is 2.8);
- The net oxygen demand due to nitrogen in feed in the water column is 36 t/yr.
- One third of carbon is assimilated in each of top layer, lower layer and the bed;
- Oxygen demand from nitrogen in top layer is 12 t/yr;
- Oxygen demand from nitrogen in lower layer is 12 t/yr;
- The remainder of the nitrogen in lost feed is converted to sludge in the bed.

Oxygen Balance for Top Layer

The oxygen demand due to salmon farms in the top layer is estimated to comprise:

1. 7,700 t/yr due to salmon respiration;
2. 1,330 t/yr from bacterial demand to convert carbon in salmon excreta;
3. 110 t/yr from net nitrification of salmon excreta;
4. 100 t/yr due to carbon conversion of lost feed;
5. 12 t/yr due to net nitrification of lost feed;
6. -3,600 t/yr of oxygen returned from phytoplankton growth.

The total oxygen demand in the top layer is 5,650 t/yr. This is about 4 % of the estimated oxygen supply to the upper layer of the harbour of 134,000 t/yr (see Table 1). The volume of the top layer (surface to 10 m depth) is 1.8 x 10^9 m^3. The average flushing time is 35 days, and the average DO concentration is about 7.4 mg/L (=134,000 t/yr / 1.8 x 10^9 m^3 / 35 x 365). Measured oxygen levels in the top layer range from 5 to 8 mg/L, which matches the calculated average value of 7.4 mg/L.

The salmon farms reduce the DO in the top layer by 4 % or 0.3 mg/L (=5,650 t/yr/1.8 x 10^9 m^3 / 35 x 365). This minor decrease would have negligible effect on the survival of the skates in their normal habitat in the top layer near Table Head.

Oxygen Balance for Lower Layer

The oxygen demand due to salmon farms in the lower layer is estimated to comprise:
1. 1,330 t/yr from bacterial demand to convert carbon in salmon excreta;
2. 230 t/yr from net nitrification of salmon excreta;
3. 200 t/yr due to carbon conversion of lost feed;
4. 12 t/yr due to net nitrification of lost feed.

The total demand in the lower layer is 1,770 t/yr. This is about 16 % of the estimated oxygen supply from the ocean to the lower layer of the harbour of 11,000 t/yr (from Table 1). Alternatively, the estimated ocean water inflow averaging 80 m^3/s over a year with a DO of 7 mg/L would contribute 17,000 t/yr, and the demand of the salmon farms in the lower layer of water would be around 10 % of the estimated oxygen supply.

Uncertainties

The main uncertainty is the depth at which the conversion of carbon to tissue (requiring oxygen) and nitrogen into nitrate and nitrogen gas (requiring oxygen) occur. This analysis has assumed that most of the conversions occur in the water column, mostly on the basis of the depth of the harbour and the measured oxygen sag at mid-water depth.

If fully saturated, the waters of the lower layer between 15 m and 35 m depth would contain about 10,000 t of dissolved oxygen. The vertical profiles of dissolved oxygen show that about 75 % of the oxygen in this layer is consumed. Assuming a typical residence time of 1 year, the total oxygen reduction in the lower layer is around 7,500 t/yr.

An estimate of the oxygen demand in the lower layer can be made from:
- 5 % of the river inflow oxygen demand (5 % of 121,000 t/yr = 6,000 t/yr);
- Estimated salmon farm demand of 1,770 t/yr;
- Extra 500 t/yr from settlement of native marine organisms in the harbour.

These are approximate estimates that total 8,270 t/yr; the total matches the calculated oxygen reduction of 7,500 t/yr. As a corollary, the calculated oxygen demand from the salmon farms is considered to be approximately correct.

The estimated average effect of the salmon farms is to reduce the dissolved oxygen in the lower layer by around 16 per cent or 1 mg/L. There will be seasonal and spatial variations which can only be explored using a calibrated 3-D model and following further research to gain a better understanding of the biochemical processing involving oxygen and biota in Harbour waters – particularly the lower layer.

This estimate is lower that the prediction by CSIRO that DO in the lower layer would increase by around 1 to 2 mg/L at 25 to 35 m depth if the 12,000 t/yr salmon load (CSIRO estimate) was removed. The load estimated here of 1,770 t/yr is lower because salmon production in 2017 (the year for the CSIRO prediction) was about twice current levels.

The majority of the oxygen demand on the lower layer comes from the river inflow, with organics settling from the top later into the lower layer. On average, organics from river inflows and natural processes are estimated to reduce the DO in the lower layer to around 35 % saturation. The extra load from salmon farms reduces the DO to around 25 % saturation. These estimates match the measured values in the vertical DO profiles presented earlier.

Concerns about Low Dissolved Oxygen

As stated at the beginning of this Technical memo, the main concerns regarding low dissolved oxygen in Macquarie Harbour are:

1. The risk to the survival of the Maugean Skate, which is a threatened species that apparently survives in low numbers only in Macquarie Harbour;
2. The risk to other ecological processes and systems in Macquarie Harbour; and
3. Anoxic or near-anoxic conditions would encourage the movement of metals from the sediments into solution. The metals exist from past mining activities in the catchment and from natural erosion processes.

Implications for Skate Survival

Most records show the skates live mostly between 8 m and 15 m depth with the normal depth range being 2 m to 20 m for eight months of the year. In four months, the skates unexpectedly dived through waters to a depth of about 45 m when the deeper waters had higher DO than the waters at 15 to 20 m depth. Oxygen conditions at Table Head appear to be relatively stable, as shown in Figure 18.

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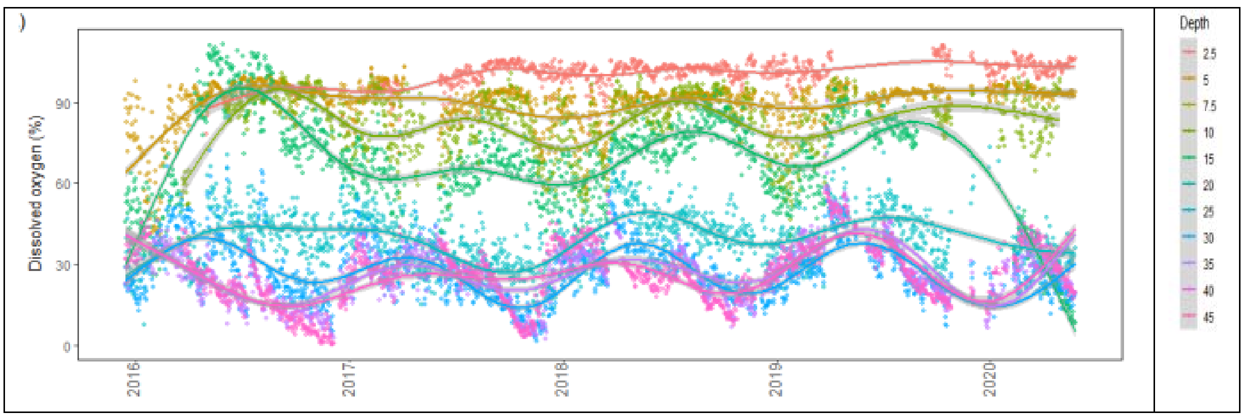
Figure 18. DO at Various Depths at Table Head – 2016-2021



River inflow is the process that determines the extent of ocean water inflow to the harbour, and the oxygen content of the lower layer. High river flows cause less ocean inflow and less oxygen – low river flows result in more ocean inflow and more oxygen in the lower layer.

In the 4000 years since Macquarie Harbour changed from a freshwater lake to a stratified estuary, there must have been many variations in river inflow. It is unlikely that present DO conditions have not been experienced in the past.

The current evidence is that skates normally live in the top layer. Salmon farms reduce the DO in the top layer by 4 % or 0.3 mg/L. This minor decrease would have negligible effect on the survival of the skates in their normal habitat in the top layer near Table Head.

Salmon farms reduce the DO in the lower layer by 10 % to 16 % or 1 mg/L. Skates travel to greater depths at times when the DO at depth is higher than surface levels, so they appear to avoid events with very low DO. Uplift events can reduce DO at 7 to 12 m depth (see Figure 6) but skates appear to avoid this by moving to the ocean inflow region, where high DO ocean water is entering and causing the uplift event.

Implications for Harbour Ecology

Lower DO in the lower layer, combined with higher ammonia and nitrate concentrations inevitably causes a response in ecological conditions in Macquarie Harbour. There will be higher productivity due to the extra available nitrogen.

Ross (2020) notes that conditions in 1999-2003 compared to baseline surveys conducted in 2012 show a change in the broader benthic ecology, as demonstrated by a measurable increase in total abundance, species richness and species diversity. These observed changes include a decrease in burrowing taxa and an increase in more static suspension and deposit feeding tube builders.

DO and Sediments

The DO records show that there is always positive DO below about 30 m from 2018 and below 35 m in 2013-2014. Thus, it is unlikely that precipitated metals will come out into solution. No increase in DO is required at the level of the deep sediments.

Further investigations are required to ascertain the conditions of sediments on the sides of the harbour between 20 m and 35 m depth, and directly under the salmon cages.

Nitrification and TOC

Ammonia is a readily available nutrient and there is some phytoplankton in the upper layers and a range of other micro-organisms that would use the ammonia. It seems very likely that ammonia is being nitrified and converted to nitrate. According to Ross (2022) the conversion of ammonia to nitrate occurs throughout the entire water column, and the increase in nitrate concentration in deeper waters suggests that nitrification is significant in the sediments and the water column. This is consistent with the findings of Ross et al. (2016a) and Maxey et al. (2016) who found that the abundance of ammonia-oxidising archaea and rates of nitrification, respectively, increased markedly with depth in the harbour.

It is noted that the DO minimum in Macquarie Harbour occurs at around 20 to 25 m depth. It may be that most nitrification occurs in that depth range, causing a deficit of oxygen. However, nitrification is expected to occur mostly in the sediments, adding oxygen near the bed.

Total organic carbon (TOC) concentration is highly seasonal in the shallow waters (1, 2 and 5 m) with the highest concentrations occurring in winter and lowest occurring during summer/autumn. In deeper waters (10, 20 and 31 m), TOC is relatively stable. This indicates that most of the organic carbon entering Macquarie Harbour is from riverine sources because concentrations are highest above the halocline in fresh water and the seasonal peaks occur during the cooler months when riverine inputs are greatest. Aquaculture would account for a relatively small fraction of TOC in the harbour.

Conclusion

This analysis has confirmed the findings of previous reviews that river flows control the flushing time of the surface layer and the influx of ocean water into the lower layer. For the foreseeable future, DO conditions in the harbour are controlled by seasonal weather and long period rainfall cycles. Long term, climate change will also have an influence.

The aim of this Technical Memo is to estimate the amount of oxygen input required to balance the oxygen demand from the salmon farms in Macquarie Harbour and the best locations to add that oxygen.

It is concluded that to fully compensate for the salmon farms, the amount of oxygen that would need to be added to the lower layer is approximately **1,770 t/yr**. Further research is required to refine this estimate and to assess whether continual or just seasonal oxygen input would be satisfactory. It is possible that just event-driven input could be optimum.

For the pilot study of re-oxygenation, it would be appropriate to add the oxygen at 30 m depth. It should be noted that an increase in DO of around 1 mg/L is predicted, although that depends on mixing rates (lower mixing rates could allow an increase of up to 2 mg/L) and biological uptake (enhanced biological uptake of the oxygen could result in an increase of only 0.5 mg/L).

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CV of Dr Ian Wallis

CONSULTING ENVIRONMENTAL ENGINEERS

UNIT 4, 150 CHESTERVILLE RD, CHELTENHAM, VICTORIA, 3192
Phone 03 9553 4787 Email wallis@cee.com.au

Ian G Wallis, B.E., M.Eng.Sc., Ph.D., - Environmental Engineer

Qualifications:
Bachelor of Engineering (Honours)
Master Engineering Science
Doctor of Philosophy, Monash University

Summary of Professional Experience:

1970-72	Lecturer in Hydraulics and Fluid Mechanics
1972 73	Research Fellow Oceanography, University of Southampton (UK)
1973	Modeller, Water Pollution Research Laboratory (UK)
1974-77	Senior Investigations Engineer, Brown & Caldwell (USA)
1977-80	Principal Engineer, Caldwell Connell Engineers
Since 1981	Director, Consulting Environmental Engineers

Memberships:
Institution of Engineers, Australia
International Association for Hydraulic Research
Australian Water Association
Registered Professional Engineer Queensland RPEQ 11212
National Professional Engineers Register CP12204

Professional Experience:
Dr Wallis has extensive experience in environmental assessments, water quality, oceanographic studies, and is recognized as one of Australia's experts in these fields. Dr Wallis was a lecturer in hydraulics and fluid mechanics at Swinburne University and at Monash University. He was awarded the Alexander Stewart Fellowship which allowed periods of work at the UK Water Pollution Research laboratory and at Resources for the Future in Washington DC.

At the Water Pollution Research Laboratory, he modelled fish populations in the North Sea and the envelope of response of fish to toxins.

He was part of the team that prepared the Air Quality Policy for Victoria, and developed the Plume Calculation Procedure for the Victorian EPA. He has extensive experience in the use of AERMOD, Ausplume and Auspuff, and in the design, collection and analysis of data from meteorological stations States.

Dr Wallis has served as a member of several expert panels including the Expert Panel on Dredging of Darwin Harbour and the SA Desalination Panel of Experts.