ENVIRONMENTAL AND FARMED STOCK MANAGEMENT IN MACQUARIE HARBOUR, TASMANIA

Mark Ryan
Tassal Group Limited
GPO Box 1645
HOBART TASMANIA 7000
tassal@tassal.com.au
www.tassal.com.au

**Name:** Tassal’s response to the draft determination set out by the EPA for the period commencing 1 May 2017 and proposed stocking strategies for the 2016 and 2017 salmon input years in Macquarie Harbour and how Tassal proposes to deal with the quantity of salmon held on leases 214 and 219 supported by the use of fish waste capture and removal trials.

**Location:** Waters of Macquarie Harbour, Tasmania

Tassal is a vertically integrated company that includes freshwater hatcheries, saltwater aquaculture, primary processing and value adding. Tassal is committed to taking a leadership role in sustainable aquaculture production and seafood sourcing. In 2015, Tassal acquired De Costi Seafoods to establish additional distribution networks for meeting a growing national and international demand for sustainable seafood products. Tassal is a publicly listed company on the Australian Stock Exchange.

Tassal is Australia’s largest producer of fresh salmon products and currently harvests approximately 25,000 tonnes of Atlantic salmon (*Salmo salar*) per annum, with all the stock produced in Tasmania.

Tassal was established in 1986 with the installation of marine infrastructure in Port Esperance and the development of a hatchery in Tasmania’s Central Highlands. The company’s first harvest was in 1987 and yielded 53 tonnes of Atlantic salmon. Tassal now contributes 50% of Australia’s total Atlantic salmon harvest each year, and employs over 1200 staff, 90% of whom are based in Tasmania, with a majority in rural areas.

The production of farmed salmon at approximately 20 leases in six regional areas within Tasmania links to 4 processing facilities (all in Tasmania) providing branded products through an owned retail outlet and over 3,300 points of retail presence.
The service and transport industries, including electrical and mechanical services, refrigeration, metal fabrication, logistics, concreting and construction, rely heavily on Tassal for employment opportunities within a spread of regional networks throughout Tasmanian communities.

Tassal’s strategic priority is to deliver sustainable long term returns to shareholders selling highly recognised, ethical, valued brands and products (Salmon and Seafood) to Australian consumers and retailers, while operating in a Zero Harm environment. This approach complements the “Your Marine Values” study undertaken by IMAS in 2012-13 which identified the important values relating to the waters of the D’Entrecasteaux Channel and Huon Estuary for the range of communities and stakeholders with a direct interest in the health of the marine system.

In 2014, Tassal achieved full certification for all its Marine Farms in Tasmania to the Aquaculture Stewardship Council (ASC) Salmon standard.

Tassal currently holds licences in multiple marine farming regions in four different Marine Farming Development Plan (MFDP) areas throughout Tasmania (D’Entrecasteaux Channel, Huon Estuary and Port Esperance, Tasman Peninsula and Norfolk Bay, Okehampton Bay and Macquarie Harbour). Farming within these diverse regions allows Tassal to contribute to shared State economic value and social wellbeing, particularly at the regional community level within Tasmania.

Tassal maintains and possesses the financial, physical and human resources required to support this project and has the express approval of the Tassal Board to engage with the EPA and to fund the projects outlined in this proposal.

Tassal Group Limited
ACN 106 067 270
GPO Box 1645
HOBART TASMANIA 7000
tassal@tassal.com.au
www.tassal.com.au
Executive Summary

Tassal continues to work extensively with EPA, IMAS (scientists), DPIPWE, Government, Petuna and our consultants with respect to Macquarie Harbour.

This submission focussed on how Tassal proposes to deal with the quantity of salmon held on leases 214 (Middle Harbour) and 219 (Gordon) - while Franklin lease recovers - including the use of fish waste capture and removal trials to assist in sediment remediation and recovery. Further we set out our position with respect to the draft determination set out by the EPA for the period commencing 1 May 2017 (i.e. the 14,000 tonnes of maximum permissible biomass) and proposed stocking strategies for the 2016 and 2017 salmon input years in Macquarie Harbour providing a well-articulated and factually supported/evidenced.

Pleasingly we have seen dramatic improvements in Macquarie Harbour, as previously reported. The EPA and IMAS have received and are currently reviewing the underlying data from our survey results. It is likely that a determination from the EPA will be made shortly on Macquarie Harbour given the 1 May date, and at this time data will be made publicly available.

Our position with the EPA has, and continues to be, as summarised below:

- Sustainable salmon farming must balance positive economic, environmental and social outcomes. While Tassal concedes prematurely harvesting the 2016 salmon input year would deliver a limited environmental gain, we do not believe this to be commensurable with the resulting negative economic and socio-economic impacts and fish welfare outcomes, which will be both material (economic and socio-economic [i.e. societal value]) and inhumane (to fish), respectively

- We understand the EPA must consider economic, environmental and social outcomes and it is Tassal’s intent to farm with 100% compliance to marine farming license conditions, rules and regulations that underpin its operations. Our ASC salmon standard process fundamentally underpins this intent

- Macquarie Harbour is integral to Tassal’s production cycle, with planning processes more than 30 months in the making. Going forward, Tassal supports a lease by lease approach to salmon farming in Macquarie Harbour, and given the unpredictability of the Harbour’s system, biomass should be reviewed annually

- Recent compliance results have reinforced to all operators in Macquarie Harbour that not every hectare of this system will yield the same environmental performance. In fact, benthic compliance is also dependent on a marine lease’s location in the Harbour and external influences. Copper contamination and riverine influences have been determined as the major contributors to the health or otherwise of Macquarie Harbour
• As you are aware, Tassal has a long history of strong marine compliance, with our 2016 results demonstrating 96% compliance, and 99.9% compliance to date in 2017 across all South-East sites. While we strive for 100% compliance, we remain a recognised global leader when it comes marine stewardship and transparency.

• The latest environmental surveys show leases 214 and 219 are fully compliant, while lease 266 has made a significant recovery per April 2017 survey results with now only three potential non-compliances (down from 14 non-compliances). Tassal predicts 100% (full out of lease) compliance at the May 2017 Compliance Survey.

• To support short term biomass goals, Tassal will further minimise the environmental impacts of salmon farming in the Harbour, through the deployment of innovative waste capture and recovery technologies.

• Tassal is committed to establishing an adaptive environmental and operational regime for Macquarie Harbour to underpin sustainable salmon farming for the region, which supports economic vitality for the community and broader State.

• Economic modelling demonstrates the immediate removal of Tassal operations from Macquarie Harbour delivers the following consequences:
  o Retrenchment of 39 permanent employees, impacting hundreds of indirect jobs associated with the operation across Tasmania;
  o $259.3 million Gross State Product (GSP) deficit to the state economy; and
  o $1.78 million loss in payroll tax revenue.

• Our research highlights there is no economic or socio-economic rationale for the EPA to justify such a decision based on the science and our current understanding of the complex systems within the Harbour.

• Strengthened by the fact Tassal leases 214 and 219 demonstrate full compliance, with lease 266 predicted to return to full compliance at the May 2017 survey, Tassal is seeking permission for a temporary allowance to exceed the 14,000T standing biomass cap within the Harbour for a period of eight months. This would see the 2016 salmon input year (2016 year class) through to harvest, safely and humanely, with the understanding that environmental compliance must also be maintained for this period.
The above graph demonstrates the period where Tassa is seeking a temporary licence to exceed the 14,000T standing biomass cap for a period of 8 months, with impacts mitigated through the deployment of innovative waste capture and recovery technologies.

- Tassal acknowledges the conditions of Macquarie Harbour have changed and we must farm responsibly to these conditions. However, drawing a correlation between the expansion of fish farming in the Harbour and declining environmental conditions is simplistic, not correct and does not adequately address the relevant causal factors.

- There are natural and anthropogenic influences in the Harbour and they contribute to the overall, current environmental conditions. Recent POD work discusses the contribution of riverine and oceanic inputs as drivers in this complex system. Historic operations (i.e. mining), recent events (i.e. hydro-electric water discharges and drought conditions) and fish farming, have further modified the Harbour. MHDOWG work in 2014 estimated the fish waste was responsible for between 3 -12% of the benthic BOD in the Harbour.
• Based on preliminary measurements collected in December 2016 farm POD rates would equate to approximately 4% of the total oxygen in the harbour below the halocline.

• Benthic oxygen removal due to the presence of fish farms has been recently calculated to be less than 0.35 percent of the total oxygen consumption in the harbour.

• We asked the question (using the science we have available): What would be the environmental impact to the Harbour of holding 18,000 mt of fish for an additional eight months versus 14,000 mt (the proposed biomass limit). Our calculations demonstrate the general magnitude of the sources of DO draw down. Combine this with the known copper contamination, we are putting forward that our additional 4000 mt for an additional eight months has a relatively small contribution to the condition of the Harbour – about a 1% increase in oxygen demand.

• The Harbour’s unique nature has meant traditional compliance monitoring techniques have been tested. There is currently a range of research and monitoring programs being undertaken in Macquarie Harbour and it is Tassal’s position that not all leases are equal. There is also a gradient of response in the Harbour, and due to recent weather conditions, April 2017 sampling is indicating an increase in infaunal abundance. Tassal supports the IMAS research focused on examining the gradient of impact on the abundance and diversity of infaunal assemblages, particularly in respect to complementing the underwater visual compliance surveys with more quantitative ecological assessments.

• In addition we are seeing a very rapid recovery rate for our Franklin site – indicating the impacts are reversible. We are putting forward that with our proposed waste capture the additional environmental impact of our 2016 salmon input year would be negligible however the social and economic benefit of growing out the 2016 salmon input year would be large and significant.

• We do understand there needs to be a greater understanding of the infaunal populations and the contribution salmon farms are having towards their population structure, however as we are progressing in an adaptive manner in the Harbour, we ask that the biomass limit be reconsidered annually as new information and understanding comes to light.

• Tassal takes a long-term sustainable view of all its operations, including Macquarie Harbour – this allows us to invest in our infrastructure, environmental management, our employees and the communities in which we operate. This also provides broad opportunities in terms of improved capacity building in regional communities and the remediation of historic environmental problems. In the
Harbour’s modified environment, where legacy issues associated with mining have created substantial environmental liabilities for the State, Tassal’s operations provide an opportunity to leverage the data collected and financial resources available to assist in remediation work.

- Sustainable salmon farming must be defined and supported by balancing positive economic, environmental and social outcomes. To ensure that balance is maintained, it is critical Tassal is allowed to reduce its biomass in Macquarie Harbour in an orderly, rational and humane way – which means it is allowed to grow out its 2016 salmon input year fish and stock its 2017 salmon input year fish to 1 million smolt.

- Tassal entered its 2016 year class fish into the Harbour (spring 2016) when our biomass limit was 33.58 tonnes per hectare - which would have meant that we were in compliance with the limit at the time of input and forecast ongoing compliance with the limit.

- Tassal strongly believes there is a need for an adaptive, environmental management regime in Macquarie Harbour, which will support ongoing, sustainable salmon farming for the region. This must be underpinned by a standardised policing process across all marine leases in Tasmania, with a penalty framework and publicly transparent report card process that motivates a continued high level of compliance across the whole industry. Tassal recognises additional resources would be required within the EPA to appropriately police marine leases across Tasmania and would be prepared to assist with an industry funded model. The ASC standard/framework should be the process applied.

- During our surveys in March and April we have also found signs of biological recovery in the benthic communities demonstrating that Macquarie Harbour is not a dead zone and is responding well to the changing natural conditions.

To restate our position, Tassal is seeking permission for a temporary allowance to exceed the 14,000T biomass cap within the Harbour for a period of 8 months to see the 2016 salmon input year through to harvest with the understanding that compliance must be maintained. Tassal is proposing to support compliance and to minimize environmental impact through the deployment of innovative waste capture and recovery technology.
SECTION 1 – INTRODUCTION AND SUPPORTING INFORMATION

Tassal is in agreement that there is a need for an adaptive, environmental management regime in Macquarie Harbour that will support ongoing, sustainable salmon farming for the region. Sustainable salmon farming must be defined and supported by balancing positive economic, environmental and social outcomes. To ensure that balance is maintained, it is critical that Tassal is allowed to reduce its biomass in Macquarie Harbour in an orderly, rational and humane way.

The purpose of this submission is to detail how Tassal will transition to the new biomass limit in a way that will not compromise the environment, fish welfare or the community. Using scientific research and demographic data, Tassal has worked through to a preferred proposed approach that limits both environmental impacts and social disruption. Tassal is proposing to pull forward its harvesting to December 2017, when the fish can be safely and humanely harvested and taken to market. This will result in an exceedance of the proposed biomass limit for a period of eight months. Historic environmental monitoring indicates this can be achieved with full environmental benthic compliance at lease 214 and lease 219. However due to the proposed biomass restrictions (15.12 tonnes per Ha), two fish waste management procedures are being proposed to remove fish waste from the Harbour. While Tassal concedes that prematurely harvesting the 2016 salmon input year would have a limited environmental gain, our position is that these gains are not commensurable with the resulting socio-economic impacts and fish welfare outcomes which will be both material and inhumane.

Submission summary

This submission details how Tassal proposes to transition to the proposed biomass limit in a balanced, orderly, rational and humane way. In this submission, Tassal has worked through various scenarios and settled on a proposal that best balances environmental, social and economic factors. The proposal has synthesised expert scientific research, detailed demographic findings and the specifics of the salmon production cycle.

The issues covered include:

- Tassal’s proposal to grow out the 2016 salmon input year which will result in an exceedance of the proposed limit of 15.12 tonnes per Ha for a total of eight months, noting when these fish were entered into the Harbour their forecast biomass would have fallen within the determined biomass limits
- The importance of a ‘lease-by-lease’ approach to adequately manage stocking densities
- The capture and removal of solid waste from fish farming operations on lease 214 and lease 219. Options considered include an in-water collection system
designed to capture waste as it falls through the pens and/or a recovery system to remove solid emissions from the sea floor within the leases

- Defining the impacts of the natural and anthropogenic influences on the Harbour’s environmental condition. In particular, the role of riverine and fish farm derived organic matter and Dissolved Oxygen (DO) and metal dynamics in the Harbour and the relative risk contribution of each to the system

- The results of recent environmental surveying and improvements in environmental lead indicators. Compliance surveys of lease 214, lease 219 and lease 266 showing recovery between January and April 2017. This improvement is measurable via the increase in dissolved oxygen levels, a decrease in extent and density of *Beggiatoa* and an increase in infaunal abundance

- The social and economic impacts resulting from Tassal’s reduction in production capacity and/or withdrawal from operations in region

**Background**

In Tassal’s submission dated 22 December 2016, Tassal requested that it be authorised to transition to the new biomass determination in an orderly manner and grow its 2016 salmon input year in the Harbour through to harvest weight. In your letter dated 8 March 2017, Tassal was directed to lay out a clear pathway for dealing with the fish currently held on lease 214 and lease 219. The purpose of this submission is to detail of how Tassal proposes to transition to the new biomass limit in a way that will not compromise the environment, fish welfare or the community.

Under current production conditions, Tassal will begin to exceed the EPA’s new, proposed maximum permissible biomass (15.12 tonnes per Ha) target in June 2017. This means Tassal is proposing to grow out the 2016 salmon input year, which will result in an exceedance of the proposed limit of 15.12 tonnes per Ha for a total of eight months, until which time (December 2017) these fish will commence their harvesting period. After this point Tassal will be operating, ongoing within the new proposed maximum biomass allocation of 15.12 tonnes per Ha.

Tassal is therefore seeking permission for a temporary allowance to exceed the 14,000T biomass cap within the Harbour for a period of eight months to see the 2016 salmon input year through to harvest with the understanding that environmental compliance must also be maintained for this period. Tassal proposes to achieve compliance and will further minimize the environmental impacts of salmon farming in the Harbour through the deployment of innovative waste capture and recovery technologies.
The input of the 2016 salmon input year onto lease 214 and lease 216 was conservative and was 20% lower than the biomass limit set in May 2016. The subsequent determinations, lowering biomass limits, have led to a situation whereby the new limits will be exceeded by the existing fish in the water, noting when these fish were entered into the Harbour their forecast biomass would have fallen within the determined biomass limits. This potential exceedance is a function of the length of time required in planning salmon production cycles and the time needed to ensure an orderly transition to new limits.

The proposed harvest start date of December 2017 represents an accelerated harvest plan. Optimally, Tassal had planned, prior to the draft determination, to harvest the 2016 salmon input year starting in February 2018 (i.e. the accelerated plan represents a loss to Tassal of [underline 0]).

Macquarie Harbour is an important part of Tassal’s production cycle:

- Our production planning is more than 30 months in the making. The final stage of production involves the harvest of fish. Our humane harvesting strategy (in line with the RSPCA’s protocol) involves harvesting fish at 4 plus kgs
- Due to biosecurity restrictions specific to Macquarie Harbour these fish cannot be relocated to SE marine farms
• A reduction as proposed, would indeed lead to a mass level of destocking and would be logistically challenging, monopolizing our harvest boat and crew to the detriment of harvest plans in SE and challenging the capacity of our rendering plant and composting options. It would mean euthanising the fish in liners with a drug and then weeks of trucking dead fish out of Strahan, utilising multiple trucks, every day for the better part of a month
• A rapid destocking would lead to an immediate loss of jobs in the region without time to reassign workers in a humane fashion
• The 2016 salmon input smolts in the Harbour fill a very specific and important niche in our harvest program. They were amongst the last smolt put to sea with the intention of allowing enough time for them to make market weight
• To pull the 2016 salmon input year forward any further would mean:
  o Average harvest weight below the market expectations and creating difficulty in selling
  o Fish would be culled and it would be challenging to do this humanely
  o Creating a gap in our production whereby we would have limited fish to supply the market
  o Putting the financial viability and sustainability of Tassal at risk
• The 2016 salmon input year fish at MH are triploids. Triploids are challenging to grow but they are valuable in that they don’t mature. Triploids fill a specific period in our harvest program after the diploids from the previous generation have been harvested (before they mature) and before the next generation is of market size
• For every reduction in biomass there is an million loss to the company

Tassal takes a long-term view of all its operations, including Macquarie Harbour – this allows us to invest in our infrastructure, environmental management, our employees and the communities in which we operate. And this provides broad opportunities in terms of improved capacity building in regional communities and the remediation of historic environmental problems. In the Harbour’s modified environment, where legacy issues associated with mining have created substantial environmental liabilities for the State, Tassal’s operations provide an opportunity to leverage off the data collected and financial resources available to assist in remediation work.

Environmental lead indicators

Tassal has approached recent compliance monitoring surveys with a heightened level of urgency to better understand how the Harbour responds to short-term changes within the system (such as marine water recharge events, riverine flooding events or the effects from particular weather patterns), all of which appear to provide a unique layer of complexity which may be considered specific to Macquarie Harbour. It also provides Tassal with a more immediate capacity to advise the EPA with an assessment of environmental and biological conditions within the Harbour.
This proposal is also supported by recent environmental lead indicator results, with visual compliance at lease 214 and lease 219 showing recovery and compliant. In January 2017, lease 2014 and lease 219 had two non-compliances each (four in total). These sites showed full recovery in the March 2017 surveys and remain compliant at the 10 April 2017 surveys, overall these points were non-compliant in January, compliant in March and continue to be compliant in April.

Pictured above is regulatory extent mapping undertaken by Tassal at Franklin Marine Lease (MF266) showing the extent of *Beggiatoa* that has been mapped around the lease area from January to April 2017 Note the dramatic reduction in *Beggiatoa* extent in the April 2017 sampling.

The CSIRO hydrodynamic model is pictured beside this and was developed for the Macquarie Harbour system. The hydrodynamic output is shown with high resolution current directionality flows in and around MF266. This shows the directionality of flows in relation to MF266 and the south westerly direction of these water movements across the shallower south western end of this lease area. These current flows are for waters down through the water column for 3m, 5m, 10m, 15m and 20m depth ranges.

There are a series of factors that influence hydrodynamic flows at this end of the system including: depth, distance from the franklin basin, oceanic penetration, river flows, rainfall and weather influences.

The January benthic survey results at MF266 showed *Beggiatoa* to be present outside of lease boundaries extending the furthest at this south western end of the Marine Lease. The significant and rapid recovery displayed in the last four months in this area of the system is understood as being a combination of factors including dissolved oxygen recharge in bottom waters (oceanic exchange through hells gates...
and wind-driven vertical mixing both playing a major role), as well as reduced fresh water flows (and reduced organic input) from the Gordon and King rivers over summer months.

Following on from the January 2017 results the Harbour received several significant oceanic recharges. These recharges were large enough to register in bottom waters at MF266 on real time monitoring equipment and were seen to fluctuate for several days. Ultimately contributing to a rapid and visually decisive reduction in *Beggiatoa* and based on the most recent evidence from April surveys Tassal is predicting full out of lease compliance at the May surveys.

**MF214 Middle, MF219 Gordon and World Heritage Area 2017 summary**

Tassal intensively monitors all its marine farming operations in line with EPA requirements. There is currently a range of research and monitoring programs being undertaken to assess the environmental effects associated with salmon farming operations and other input sources to the Macquarie Harbour system. One of these projects investigates ‘control’ sites throughout the World Heritage Area (WHA).

Industry monitoring has recorded observations of *Beggiatoa* historically at several WHA monitoring sites, which did not appear to have a relationship with distance to the farming precinct. These observations are summarised in Table 2. Tassal hypothesises that presence of *Beggiatoa* at the WHA sites is primarily due to organic loading and associated biological oxygen demand from the Gordon and King River systems.

Periodic benthic compliance footage was taken of points as determined by the EPA at both Middle Harbour 214 and Gordon 219 leases in January 2017. These surveys showed the presence of *Beggiatoa* to be existing at two of the out of lease compliance dives for each lease, which may be the result of organic enrichment to sediments outside of the lease boundaries. Details of these non-compliances and subsequent management controls can be seen in Table 1. Internal intermediate work was conducted in two discrete events during March and April focusing on these non-compliances. This work involved diving both the existing compliance points and points relating to the furthest known extent identified at the January survey work. Results from March and April confirm that there are no further out of lease non-compliances at either Middle Harbour or Gordon.

Tassal will continue to monitor all leases in line with regulatory requirements, along with internal intermediate survey work on a site-by-site basis within the Harbour.
Table 1. 214 Middle Harbour and 219 Gordon 2017 compliance record.

<table>
<thead>
<tr>
<th>2017</th>
<th>214 Middle</th>
<th>219 Gordon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observations</td>
<td>Management Controls</td>
</tr>
<tr>
<td>January</td>
<td>Visible impacts of farming detected at CP5.1 (200m) and CP7 (50m).</td>
<td>Positions 7 and 8 (pens in closest proximity to the non-compliances) relocated to 1 and 20 as a precaution.</td>
</tr>
<tr>
<td>February</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>March</td>
<td>CP5.1 and CP7 surveyed. No impacts of farming detected.</td>
<td>No additional controls required.</td>
</tr>
<tr>
<td>April</td>
<td>CP5.1 and CP7 surveyed. No impacts of farming detected.</td>
<td>No additional controls required.</td>
</tr>
</tbody>
</table>
Table 2. Historic Beggiatoa observations within the World Heritage Area from January 2016 to April 2017.

<table>
<thead>
<tr>
<th>World Heritage Area Dive No.</th>
<th>39</th>
<th>42</th>
<th>43</th>
<th>44</th>
<th>45 (Gordon River mouth)</th>
<th>56</th>
<th>57</th>
<th>58</th>
<th>59</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to centre of main farming area (km)</td>
<td>5.8</td>
<td>7.8</td>
<td>9.8</td>
<td>11.8</td>
<td>14</td>
<td>7.2</td>
<td>9.3</td>
<td>11.3</td>
<td>12.4</td>
</tr>
<tr>
<td>Distance to mouth of Gordon River (km)</td>
<td>11.2</td>
<td>9.3</td>
<td>7.4</td>
<td>5.4</td>
<td>3</td>
<td>9.8</td>
<td>8</td>
<td>7.6</td>
<td>5.7</td>
</tr>
<tr>
<td>January 16</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Patchy</td>
<td>Patchy</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Not Detected</td>
</tr>
<tr>
<td>May 16</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Patchy</td>
<td>Patchy</td>
<td>Patchy</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Not Detected</td>
</tr>
<tr>
<td>September 16</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Patchy</td>
<td>Patchy</td>
<td>Thick patches</td>
<td>Not Detected</td>
<td>Patchy</td>
<td>Patchy</td>
<td>Patchy</td>
</tr>
<tr>
<td>January 17</td>
<td>Patchy</td>
<td>Patchy</td>
<td>Patchy</td>
<td>Not Detected</td>
<td>Thin mat</td>
<td>Not Detected</td>
<td>Patchy</td>
<td>Patchy</td>
<td>Patchy</td>
</tr>
<tr>
<td>April 17</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Thin mat</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>Thick patches</td>
<td>Not Detected</td>
</tr>
</tbody>
</table>

**Note:** Green shaded area shows latest survey results from WHA in relation to *Beggiatoa* (confined to upper reaches of WHA around the Gordon River mouth). This can be related to discussion further in the document regarding system influences. WHA site 45 (Gordon River mouth) is a high flow and shallow (7 metres) site. *Beggiatoa* is regularly observed on the lee side of the undulated sediments indicating that organics from the river system are being deposited here along with *Beggiatoa* colonisation.
Recent infaunal sampling events undertaken by Tassal in March (MF 214) and April 2017 (MF219 and MF 266) have shown promising signs of biological recovery, with an obvious recruitment of the Heart urchin (*Echinocardium cordatum*) recorded along study transects at each of the three leases.

The extent of recovery is shown below in Table 3 for Tassal’s MF 219 and MF 266 leases in Macquarie Harbour. Estimates of infaunal abundance for June 2016 and October 2016 have been taken from Ross and Macleod (2017) ‘Interim Synopsis of Benthic and Water Column Conditions in Macquarie Harbour’. The same sites were sampled by Tassal in April 2017 to complement the March 2017 sampling at MF 214 – which showed the first evidence of biological recovery in the Harbour.

### Table 3. Average abundance of infaunal animals (numbers/m²) collected by IMAS (published results) and Tassal (April 2017) from MF Leases 219 and 266 at Macquarie Harbour

<table>
<thead>
<tr>
<th>Lease</th>
<th>June 2016</th>
<th>October 2016</th>
<th>April 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF 219</td>
<td>839</td>
<td>145</td>
<td>448</td>
</tr>
<tr>
<td>MF 266</td>
<td>550</td>
<td>Nil</td>
<td>94</td>
</tr>
</tbody>
</table>
Whilst the April 2017 infaunal sampling at the IMAS study sites shows that the abundance of individuals within the sediments has not reached previous levels of abundance, there has nevertheless been a three-fold increase in abundance between October 2016 and April 2017 at MF 219, which is situated in the middle of the Harbour. This level of recovery was not observed at MF 266, located at the southern end of the Harbour, however there was a noticeable increase in abundance at this end of the Harbour since the October 2016 survey, which showed no evidence of live fauna within 500 m from the farm cages. Interestingly, abundance estimates for the northern transects at MF266 were much higher than those recorded from the southern transects (approximately 155 individuals/m² compared to 32 individuals/m² in the south). In addition, samples collected at the southern sampling sites showed increased amounts of organic detritus within the samples, and this may reflect the proximity of MF 266 to river inflows from the Gordon River.

The biological recovery shown at MF 219 and MF 266 in recent months is most probably a result of the marine water recharge events in early 2017, where bottom water DO concentrations have increased significantly from the critically low levels observed by IMAS in October 2016. This spatial extent of this benthic response also seems to be related to distance from the Harbour entrance.
Recovery of salmon farm leases after fallowing

The dominant source of benthic organic matter enrichment associated with salmon farming comes from the deposition of fish faeces and uneaten fish feed. This deposition results in changes to sediment chemistry and macrofaunal assemblages in and around farm sites (Black 2001). In extreme cases the volume of organic matter deposited on to the sediments surpasses the sediment microbial community’s ability to assimilate and metabolize the organic matter using aerobic means leading to the production of substances such as NH$_4^+$ and H$_2$S.

Generally, degradation to the sediments is limited to the immediate footprint of the fish cages and some surrounding buffer zone. Fallowing a lease area is a common method used to reverse the effects of organic matter deposition to the benthos, and this involves rotational farming or the temporary or permanent cessation of farming at a particular site. There is no set standard for how long fallowing should take place, nor are the recovery periods for a particular lease areas and/or sites predicted with a high degree of precision.

In theory, sediments begin to recover as soon as fallowing (i.e. cessation of farm derived organic matter inputs) begins. Specific definitions of recovery vary but the essence of the concept is the reversibility of sediment conditions from their post-farm state to some pre-farmed state or to a similar condition of a nearby undisturbed reference site. Two types of post-farming benthic recovery were defined by Brooks et al. (2000).

1. **Chemical recovery of the sediment:** Chemical recovery can be defined as the reduction of accumulated organic matter with associated decreases in H$_2$S and increases in DO in the sediments under and adjacent to the salmon farms. These sediment chemistry parameters must return to levels at which more than half of the reference area taxa can recruit into the area.

2. **Biological recovery of the sediment:** Biological recovery in the sediments can be defined as the restructuring of the macrobenthic community to include those taxa found to make up at least 1% of the total invertebrate abundance at some appropriate reference station. The majority of literature suggests that full recovery to some reference condition takes place over several years (some examples are Karakassis et al 1999, Morata et al 2014, Keely et al 2014; Salvo et al 2017). In the case of Macquarie Harbour background conditions and influences must be considered.

The time needed for full chemical and biological recovery depends on several factors including:

- the duration and amount of organic matter deposited to the seabed (Brooks et al 2003, 2004)
• the hydrologic regime of the system
• the natural sediment characteristics of the site
• the season fallowing begins (Zhulay et al 2015)
• the natural dominant benthic taxa
• the duration of fallowing (Pereira et al 2004).

The chemical recovery of sediments usually occurs on time scales of weeks to months after fallowing (Brooks et al 2000). Biological recovery of the seabed starts after the commencement of chemical recovery. Recruiting of opportunistic macrofauna back into the former cage footprint begins with the decrease in $\text{H}_2\text{S}$ and increase in redox potential. This is followed by a succession of other species returning with improved conditions and availability of food sources.

Again, depending on the hydrological regime and the reference conditions used to define recovery, biological resotration of the seabed can occur on timescales of a few months (high energy sites, Brooks 1993, Ritz et al. 1989, Brooks et al. 2000, Zhulay et al. 2015) to years (Mahnken et al 1993). Most studies show that rapid improvement in sebed conditions occurs within the first few months after fallowing, but full biological recovery often requires longer as seen in studies from Karakiniss et al (1999), Brooks et al (2004), Macleod et al. (2006), Aguado-Giménez et al. (2012), Keeley et al (2014), Morata et al (2014), Salvo et al. (2017).

Despite the time period needed for full biological recovery in the myriad of studies listed above, Macquarie Harbour sediments in the southern Harbour may be quick to recover chemically to their pre-farming state due to the paucity of benthic fauna before the implementation of intensive fish farming.

Several studies over the last 25 years indicate that much of the central Harbour has repeatedly had a paucity of benthic fauna (Talman et al 1996, Hartstein et al 2010, Hartstein et al 2011 and others). Several others have also observed that the world heritage and or central areas of the Harbour have a history of low oxygenated sulphide rich sediments that are often associated with low numbers of benthic invertebrates; this will be discussed in more detail in the following sections.

Seabed flows in the system can be episodically energetic which will lead to relatively rapid recovery times. Some evidence for this can be seen in the rapid reduction of *Beggiatoa* matting in around the Table Head Lease and more recently at the Franklin lease.

It may be years, if it is even possible at all, for the southern leases to biologically recover to pre-mining and pre-Gordon damming baselines (and currently there is no record to our knowledge of what this baseline might be) even without the presence of the fish farms. Sediments in the southern portions of Macquarie Harbour are likely always in a state of change/flux, shifting from hypoxic/anoxic conditions to normoxic conditions with changes in Gordon River organic matter depositions and flow regime.

If baseline conditions are defined as the conditions immediately before the Franklin Lease began stocking fish, then the chemical recovery of the seabed may occur over
a matter of months (until the next large organic matter load is deposited into the Harbour from the Gordon River), while biological recovery may always be suspended at a successional stage dominated by opportunistic fauna.

**History of organic matter deposition and presence of *Beggiatoa* in the Harbour**

Industry regulation uses a range of indicator species such as *Beggiatoa* (bacteria) to determine whether organic enrichment is occurring in the sediment. It is well published that *Beggiatoa* are filamentous bacteria, reliant on the availability of sulphide, and are typically found in low oxygen environments at the thin interface between oxic surface waters and sulphide-rich, anoxic sediment pore water (*Jørgensen and Nelson 2004, Page et al. 2005*). *Beggiatoa* is a naturally occurring bacterial formation and is often also found in areas of high organic input. (*Teske and Nelson 2006*). It is regularly observed in waterways after high rainfall where land based sediment runoff has ensued and in basins where large quantities of organic matter have been deposited (*Williams and Reimers 1983, Graco and et al 2001, Fenchel and Bernard 1995*).

The presence of *Beggiatoa* is not necessarily an indicator of organic enrichment from marine farms, but of organic matter enrichment in general. In areas of high organic matter inputs and low oxygen availability, like the southern portion of Macquarie Harbour, *Beggiatoa* matting is likely a natural, but ephemeral phenomenon. Mat formation disappears as oxygen and H$_2$S levels naturally recover throughout the greater Macquarie Harbour system.

Tassal has conducted underwater filming in different waterways around the state where fish farming does not currently (or historically) occur. Evidence of organic enrichment in the form of *Beggiatoa* matting was found in the Prosper River, on the east coast, potentially from the accumulation of particulate organics after June and October flood events in 2016. *Beggiatoa* has also been observed within the WHA (albeit in sparse, low density amounts), and recorded up to 13 kilometres away from the nearest marine farming lease. Observations of *Beggiatoa* within the WHA have been recorded prior to the most recent expansion of fish farming in Macquarie Harbour and periodically through continual monitoring. Evidence for the presence of sulphide-rich sediments, indicative of organic enrichment, was even found in 1989 (*Carpenter et al. 1991*) and 1995 (*Teasdale et al 2003*) in southern and middle Harbour sampling sites.

The most recent underwater video surveys undertaken by Tassal have shown significant and rapid recovery in sediment condition (and a corresponding decline in *Beggiatoa*) at the Franklin lease. On 17 March 2017, the Tasmanian EPA publicly stated that the presence of *Beggiatoa* in the WHA does not represent a significant or direct environmental impact from finfish aquaculture in the broader Harbour system ([http://epa.tas.gov.au/pages/News.aspx?newsstory=3691](http://epa.tas.gov.au/pages/News.aspx?newsstory=3691)).

The World Heritage area and central areas of the Harbour have had a history of low oxygenated sulphide rich sediments. As mentioned above, *Carpenter et al (1991)*
undertook experiments looking at the chemistry of trace elements, humic substances, and sedimentary organic matter within the Harbour. Sampling took place in February 1989 and observed evidence of previous anoxic conditions within the surface sediments situated in the middle of the Harbour. Specifically:

"Higher concentrations of biomarkers indicative of anaerobic microorganisms including sulfate-reducing bacteria, were found in the Mid station sediments".

A 1995 sampling program by Teasdale et al. (2003), also observed that sulphate reducing reactions were occurring in sediment at both the middle and southern ends of the Harbour (towards the Gordon River). Specifically, they observed “black ooze that smelled strongly of sulphides”. Such ooze was linked to the deposition of organic material sourced from the Gordon River. In 2010, an EMP study commissioned by Petuna Aquaculture reported observed Beggiatoa north of Bryan’s Bay (which is now part of the existing Franklin lease operated by Tassal).

Several benthic surveys conducted in 2010 and 2011 also observed very low numbers of benthic invertebrates and high levels of organic material usually associated with seabed sulphides (Hartstein et al. 2011). A Talman et al (1996) study also recorded very low numbers of individual invertebrates and species richness across much of the Harbour (i.e. what they define as zone 1). The number of invertebrates measured during these surveys are similar in number to those observed during the recent 2017 IMAS survey’s (i.e. less than 10 individuals observed per meter squared). Dissolved oxygen profiles collected during these surveys (particularly the June 2011 survey) also indicated that dissolved oxygen in the lower part of the water column reached levels below 2mg/L just west of the World Heritage area (Hartstein et al. 2011). The low number of benthic invertebrates along with the high volume of organic material and low dissolved oxygen were attributed to the deposition of organic material from the Gordon River.

In September 2016 a number of observations of Beggiatoa were made in several lease areas as well as several hundred metres from the edge of the Franklin Lease. In addition Beggiatoa was observed in the World Heritage area several kilometres from the nearest farm.

While fish farming activity can be assumed to be directly contributing to the Beggiatoa mat formation in and closely around the Franklin Lease, it is unlikely to affect the seabed characteristics thousands of meters away from the farm due to the bathymetry of the southern Harbour, as the sinking organic material would need to travel upslope. Hydrodynamic modelling (Terry et al. 2001, DHI 2009, DHI 2010) along with numerous ADCP deployments indicates that there is also a net flow of water towards the north due to the inflow of water from the Gordon River (located at
the southern end of the Harbour) escaping over time via Hells Gate (towards the northern end). Again, this makes it unlikely that farm derived organic matter will travel kilometres south of the farms against gravity and predominate flow direction.

Over the last two years there has been large variations in climatic forcing's (i.e. summer temperature, rainfall) in West Tasmania. These forcing's have had an impact on the discharge of organic material into the Harbour as well as impacting on marine recharge events through Hells Gate. Higher temperatures have also had an adverse impact on surface oxygen in the Harbour.

In the summer of 2016 Hydro Tasmania ran the Gordon dam to the lowest levels on record (Figure 3). When the water level within a dam reduces, it promotes the discharge of organic material into the river system beneath the dam, along with water that is generally lower in dissolved oxygen (Skinner et al., 2014, MHDOWG, 2015). Organic material was observed to be depositing near the mouth of the Gordon River on what were previously sandy beaches during summer of 2016 industry monthly monitoring. In addition, the summer of 2016 was one of the driest if not the driest on record in several parts of Western Tasmania (Bureau of Meteorology; Figure 13).

![Figure 3: Records of Lake Gordon level from 2011 to 2016.](image)

The hydrodynamic impacts of the flow regulation along the Gordon River have also been alluded to in several literature sources concerning the Harbour’s marine water intrusions once being able to supply meromictic lakes well upstream of the Gordon River (King and Tyler 1982, Hodgson and Tyler 1996, Terry et al. 2001).

Following this period of very dry, hot weather there was a sudden increase in rainfall (Figure 13). Multiple riverine flood events occurred in the north of the State during this period (Pers. Comm. TasPorts February 2017). These rainfall events increased both river flow and the volume of organic material to enter the harbour.
Numerous peer review publications report a link between an increase in organic deposition/input, oxygen consumption and changes to seabed chemistry (Rabouille et al. 2008, Rabalais et al. 2002, Gray et al. 2002).

Based on regression analysis comparing the Gordon River flow data and the concentration of dissolved organic material (DOC) at the river mouth, it is shown that the greater the river flow the higher the concentration of DOC (Figure 4). In April, May and July of 2016, it was estimated that approximately 14,000, 33,000 and 9,000 tonnes of organic material has entered and stayed within the harbor for the respective months (Figure 5 and Figure 6). The deposition of an estimated 33,000 tonnes of organic material in a single month is the largest on record (though the record only goes back 33 months). It should be noted that estimates of organic matter are based on measurements taken from the mouth of the Gordon River, several stations within the Harbour and within Hells Gate.

Figure 4: Regression plot of DOC vs river flow at the Gordon River.
A combination of low dam levels/drought and high temperatures, followed by flooding has led to an increase in organic material entering Macquarie Harbour during 2016.
As microbes break down organic matter large amounts of oxygen are consumed until either the supply of oxygen or organic matter is exhausted. If the supply of oxygen is exhausted first, resulting in anoxic conditions occurring in the sediment water interface, microbes will use other substrates such as nitrate and sulphate present in the overlying water column and sediment pore waters (as mentioned in Hargrave et al. 2008).

The reduction of these species of N and S result in the accumulation of toxic NH$_4^+$ and H$_2$S in the sediments, as was reported in the Teasdale et al. (2003) surveys. This is especially notable at the southern end of the Harbour which is closest to the source of Gordon River organic deposition. Anoxic conditions have resulted in changes to the seabed composition (Figure 7 and Figure 8), within Macquarie Harbour (i.e. promoting the growth of the sulphide oxidizing bacteria *Beggiatoa* and reducing the number of benthic invertebrates) as well increasing the consumption of oxygen in both Harbour bottom and mid waters and effectively changing the salmon farms receiving environment.
Figure 7: Harbour Conditions During Periods of Low River Organic Loading.

Figure 8: Harbour Conditions During Periods of High River Organic Loading.
As previously outlined, currently oxygen levels in parts of the world heritage are very low and can be attributed to this increase in organic matter deposition. Due to the distance the world heritage/Franklin basin is from Hells Gate there is less of an impact from oxygen recharge via ocean recharge. Oxygen recharge in the world heritage area is observed after flood events, but these riverine recharges also bring substantial organic matter loads that later enhance POD/oxygen consumption after the initial DO increase.

Tassal has been filming the TWWHA sites on behalf of industry (9 of 18 industry managed broad scale sites) over several years. Throughout this period Tassal have collected four monthly data on the presence of *Beggiatoa* throughout the upper reaches of the WHA monitoring sites. These findings are far removed from any potential impacts from farming and have been observed to have a relationship with river flow and rainfall. *Beggiatoa* primarily exists at the mouth of the Gordon River in 7m of water. At this location it has been observed in light densities deposited on the back of the undulations at this high flow interface between the narrow river output and greater Harbour system.

The instances where *Beggiatoa* has been recorded within the TWWHA, including the mouth of the Gordon River in shallow depths (i.e. approx. 7 m) appear to be more related to a different set of biological and physical dynamics than those which may be generally attributed to fish farm induced *Beggiatoa* observations. The recent complex (and unusual) interplay between hydrological, climatic and anthropogenic (i.e. mining and aquaculture) dynamics affecting environmental conditions within the Harbour (observed as very low DO concentrations in bottom waters) has resulted in detectable harbour-wide ecosystem changes. The presence and extent of *Beggiatoa* at a range of sites within the harbour (including within the TWWHA) supports this assertion.

During the more recent flood events of winter 2016 *Beggiatoa* was observed to move further down the system from the river interface and vary in mat density. This is thought to be a result of both increased river flow and associated organic loadings in conjunction with the unregulated catchments to the WHA end of the system.

Tassal has engaged a third party consultant to determining the statistical relationship that exists between rainfall and river discharges (and associated organics) to the system and the presence and density of *Beggiatoa* from the upper reaches of the WHA. This work is aiming to show the relationship that exists between distribution and density of recorded *Beggiatoa* throughout the WHA and fresh water flows coming into the Harbour.

Tassal will continue to collect this visual and database data from the WHA area (in line with regulatory survey requirements) within MH to continually build on this system understanding and add confidence to relationships that exist and fluctuate across differing climatic conditions.
*Beggiatoa* within the WHA has rapidly declined since the January survey results with the presence of *Beggiatoa* only at monitoring locations situated at the mouth of the Gordon River and West of Pine Point (WHA sites 45 and 58).

**Environmental Significance of Tassal growing out the 2016 salmon input year on the Harbour**

The impacts of transitioning the 2016 salmon input year can be broken down into both soluble impacts and impacts to the seabed (benthic community and seabed chemistry).

**In regard to soluble impacts:**

An examination of the nutrient trigger levels vs individual measurements does indicate the ammonium trigger levels have not been exceeded over the last five years (since measurements began) (see figure 9 and figure 10) other than four outlying samples. Fish directly release ammonium into the water column as part of the digestion process.

In the case of ammonium more than 1000 measurements have been taken within the Harbour since October 2012 and the trigger has been exceeded only 4 times in total. Each time these exceedances appear to be outliers (other samples collected at the same time are all under the trigger).

During the five years of sampling, fish biomass has at times been close to 20,000 tonnes and ammonia levels have not exceeded trigger levels. In this regard based on this evidence, a proposed biomass of 14,000 tonnes should not result in ammonium levels exceeding the Macquarie Harbour ammonium trigger.

Nitrate levels have oscillated towards 2 meter rolling trigger levels in late 2014 and 2015 and have since come down even though stocking was at a similar level in late 2015 (approx. 17500 mt) and early 2016 (approx. 14800 mt).
Figure 9: Ammonia measurements vs trigger level at 2m within Macquarie Harbour from October 2010 to February 2017.

Figure 10: Ammonia measurements vs trigger level at 20m within Macquarie Harbour from October 2010 to February 2017.

One of the key factors to understanding the impact of keeping fish at both the Gordon and Middle Harbour leases for an additional 8 months is predicting the distribution of resulting faeces and feed waste (farm debris) on the surrounding seabed.
To best make this prediction numerical modelling is required. Unfortunately to date due to the complex nature of the Harbour, numerical modelling has been unable to successfully predict the changes observed in seabed habitat in recent months, particularly in relation to the spread of *Beggiatoa*.

The refinement of DEPOMOD will use lab based trials to determine factors including diet digestibility and the sinking rates of faeces, and use these calculations to refine how modern day diets react. This work will update the existing assumptions within the DEPOMOD package in conjunction with real-time ADCP data collected continuously at each lease Tassal will be using the improved DPOMOD package as a management tool for the 2016 salmon input year of fish at Middle Harbour and Gordon leases.

A review and update of the original DEPOMOD ([Cromey et al. 2002](#)) and AUTODEPOMOD in 2016 (called new DEPOMOD) has indicated that the old version of the model underestimated the spread of the falling faeces (SAM/004/12, 2016).

Current thinking is that the existing DEPOMOD package “overestimated the volume of faeces accumulating under the cages. The main reason for the underestimation of the spread of the falling faeces is the behaviour of the faeces after they have been deposited onto the seabed. The previous assumptions used in the modelling of faeces (i.e. how sticky they are) appear to have overestimated the stickiness of the faeces and their interaction with the existing seabed.

Previous modelling has also estimated that much of the farm debris (faeces and fish food) would fall beneath the farm. Remodelling with the new set of assumptions indicates that faeces will tend to fall further a-field which is similar to the observations made of farm debris in Macquarie Harbour particularly in regard to the spread of *Beggiatoa*.

The implications are also that the volume of farm debris thought to have an adverse impact on the seabed has reduced. But the extent of this reduction is still unknown. Based on our observations of *Beggiatoa* around the Franklin lease we suspect that very small volumes of farm faeces can lead to quite significant changes in seabed habitat due to the unique characteristics of Macquarie Harbour. In short, farm related impacts are amplified by the volume of organic material deposited inside the Harbour from the Gordon River. As has been stated several times previously the volume of this river discharge in May and June 2016 was much greater than the typical average loading.

Specifically, the southern portion of the Harbour exists in a state of perpetual regime shift between normoxic and hypoxic states due to the decomposition of large organic matter inputs from the Gordon River outfall and paltry up-estuarine migration of DO rich ocean water as a result of the regulation of Gordon River outflow. During periods of high river flow, even small additions of organic matter derived from fish farm could move the localized (lease) seabed towards a hypoxic state.
To improve the assumptions in regard to sediment re-suspension when modelling deposition in Macquarie Harbour, Tassal will work with consultants to review the results of these (New Depomod) experiments as a starting point for future modelling (in regard to re-suspension). Experts are currently looking at the falling rates of faeces, with binding and non-binding agents, which will assist in understanding how changes in feed composition (especially digestibility since the initial Cromey et al 2001 work) impact on the behaviour of fish faeces. As mentioned a binding agent will also be tested which will act to stop the faeces from re-suspending once it is deposited on the seabed. This agent will also make the faeces fall faster and hence close to the cage. This information can also be utilised for future modelling.

In addition, our proposed trials looking to collect fish faeces before they hit the seabed will provide important information that can be included in the depositional modelling re-work.

Tassal understands the universally accepted environmental effects of finfish aquaculture on marine and estuarine systems – yet the environmental conditions in Macquarie Harbour have confounded the expected environmental response to finfish farming activities, particularly in recent years when extreme weather events have played a significant role in depressing DO concentrations within the bottom waters of the Harbour.

Tassal acknowledges that the conditions of the Harbour have changed and we must farm responsibly to these conditions. However, drawing a correlation between the expansion of fish farming in the Harbour and declining environmental conditions is simplistic and does not adequately address the relevant causal factors. In this submission we explore delineates the impacts of the natural and anthropogenic influences in the Harbour and their contribution to overall, current environmental conditions. This work indicates that the contribution of riverine and oceanic inputs are drivers in this complex system. Historic operations (i.e. mining), recent events (i.e. hydro-electric water discharges and drought conditions) and fish farming have further modified the Harbour.

The Harbour’s unique nature has meant that traditional compliance monitoring techniques have been tested. There is currently a range of research and monitoring programs being undertaken in Macquarie Harbour. Some of these activities relate to monitoring for industry compliance purposes, whereas other scientific studies have involved targeted investigations into specific areas of interest (i.e. such as understanding the ecology of Dorvilleid polychaetes, or the collection of real time dissolved oxygen data using sensor nodes).
Effect of Organic Matter on Copper and Metal Cycling

Under anoxic conditions some metals in sediments are bound into insoluble, stable metal-sulphide precipitates (called Acid Volatile Sulphide or AVS) during the process of sulphate reduction. This binding process is reversible and sensitive to the oxidative condition of the sediments as well as the oxygen conditions. When DO conditions improve, AVS binding breaks down and the metals are mobilized back into pore waters and the overlying water column. I.e. it is the sulphide in the sediments formed during anoxic conditions that binds metals in an inert form. When the sediments are oxygenated the sulphides are oxidized and the metals are mobilized back into the pore waters and water column.

To what degree the remobilization of metals results in adverse impacts (accumulation and degree of toxicity) to benthic fauna depends on many factors including the feeding method and ecology of the organisms in question. Note that Tassal’s fish are tested by the food safety department for heavy metal contamination and we continue to find levels that are well below food safety limits.

The Macquarie Harbour seabed shifts from states of hypoxia (and sometimes anoxia) to normoxia regularly (particularly in the northern and central parts of the Harbour), and this could also result in the regular mobilization of metals into the sediment porewater and overlying water column, and thus into benthic and epibenthic macrofauna, especially given their regular supply from the King River. Dejong et al. (2012) also showed concern for the remobilization of metals into macrofauna with improved oxygen conditions:

“*Our results demonstrate that increasing O₂ conditions can result in faster metal accumulation [into benthic fauna] from AVS-rich sediments in aquatic invertebrates living at the sediment/water interface.*”

Further adding to the complexity of the role of organic inputs and further specifically salmon farm inputs in the Harbour system, a number of studies (see below) also indicate that copper concentrations in both the water column and surface sediments have reached levels in Macquarie Harbour that can adversely impact on benthic communities.

Rygg (1985) studied the correlation of benthic fauna diversity and the sediment concentration of heavy metals and organic matter in Norwegian fjords. The results indicate that stations with sediment copper concentrations of more than 200 µg Cu g⁻¹ showed significantly low benthic fauna diversity. This concentration was chosen as benchmark because it is approximately 10 times higher than background values and correlates with a 50% reduction in diversity. The author also categorised each benthic species based on their tolerance to copper concentrations in sediment. Based on the 1996 studies by Talman and Koehnken a large portion of the Harbour has nearly 3x this value of copper in the sediments.

Statistical analysis in an experimental field study by Morrisey et al. (1996) suggested that copper-treated environment results in changes on the abundance and
composition of benthic fauna over a period of 6 months, although the changes varied among taxa.

Table 4: Benthic fauna susceptibility to sediment copper concentrations. Summarized from Rygg (1985).

<table>
<thead>
<tr>
<th>Category</th>
<th>Taxonomic Group/Species</th>
</tr>
</thead>
</table>
| Non-tolerant species, absent from stations with sediment copper concentrations above 200 µg Cu g\(^{-1}\) | **Annelida**  
Glycera rouxii  
Phylo norvegica  
Laonice cirrata  
Diplocirrus glaucus  
Polyphysia crassa  
Scalibregma inflatum  
Ophelina cylindricaudata  
Ophelina norvegica  
Ophelina modesta  
Ophelina acuminata  
Rhodine loveni  
Rhodine gracilior  
Sosane gracilis  
Terebellides stroemi |
| Non-tolerant species, only occasionally found at stations with sediment copper concentrations above 200 µg Cu g\(^{-1}\) | **Crustacea**  
Eudorella emarginata  
Eriopisa elongata  
Calocaris macandreae |
| | **Mollusca**  
Nucula sulcata  
Ennucula tenuis  
Abra nitida |
| | **Annelida**  
Paraphinome jeffreysii  
Lumbrineris spp.  
Paraonis gracilis  
Prionospio cirrifera  
Spiophanes kroeyeri.  
Melinna cristata |
| | **Mollusca**  
Thyasira equalis |
| | **Echinodermata**  
Amphiura chiajei  
Amphiura filiformis |
Moderately tolerant species, present at some of the stations with sediment copper concentrations above 200 µg Cu g\(^{-1}\)

<table>
<thead>
<tr>
<th>Annelida</th>
<th>Ceratocephale loveni</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nephtys paradoxa</td>
</tr>
<tr>
<td></td>
<td>Nephtys ciliata</td>
</tr>
<tr>
<td></td>
<td>Prionospio malmgreni</td>
</tr>
<tr>
<td></td>
<td>Tharyx marioni</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mollusca</th>
<th>Thyasira flexuosa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thyasira sarsi</td>
</tr>
<tr>
<td></td>
<td>Corbula gibba</td>
</tr>
</tbody>
</table>

Highly tolerant species, common at the most copper-polluted stations

<table>
<thead>
<tr>
<th>Annelida</th>
<th>Pholoe minuta</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eteone longa</td>
</tr>
<tr>
<td></td>
<td>Anaitides groenlandica</td>
</tr>
<tr>
<td></td>
<td>Nereimyra punctata</td>
</tr>
<tr>
<td></td>
<td>Ophiodromus flexuosus</td>
</tr>
<tr>
<td></td>
<td>Glycera alba</td>
</tr>
<tr>
<td></td>
<td>Gonniada maculata</td>
</tr>
<tr>
<td></td>
<td>Polydora spp.</td>
</tr>
<tr>
<td></td>
<td>Scoloplos armiger</td>
</tr>
<tr>
<td></td>
<td>Cirratulus cirratus</td>
</tr>
<tr>
<td></td>
<td>Chaetozone setosa</td>
</tr>
<tr>
<td></td>
<td>Cossura longocirrata</td>
</tr>
<tr>
<td></td>
<td>Capitella capitata</td>
</tr>
<tr>
<td></td>
<td>Heteromastus filiformis</td>
</tr>
</tbody>
</table>

The effects of dissolved copper concentration in different degrees of oxygen condition were studied on benthic amphipod *Corophium volutator* (Eriksson & Weeks, 1994). Results showed that elevated copper concentrations in seawater led to higher total body copper concentrations and lower percentage of egg production in amphipod. Mortality rate of amphipod was significantly higher in anoxia condition (19% saturation) coupled with elevated ambient copper concentrations (100 µg Cu L\(^{-1}\))
Figure 11: Effects of exposure of different copper and oxygen concentrations in seawater (Eriksson & Weeks, 1994).

In Macquarie Harbour, Stauber et al. (1996) found that the concentrations of dissolved copper in water collected in October and December 1995 ranged from 10 to 42 µg Cu L\(^{-1}\), with the highest concentrations found immediately below the outflow of the King River. Koehnen et al. (2005) reported that the total copper concentrations ranged from 5 to 1,000 µg Cu L\(^{-1}\) (such concentrations are higher than the tolerance levels of many benthic invertebrates) in the course of more than 10 years of water quality monitoring in the Harbour.

Water sampling conducted by Teasdale et al. (2003), in June 1995, indicates copper concentrations in the Harbour ranged from 4 to 560 µg Cu L\(^{-1}\).
Dejonge et al. 2012 found that increases in DO led to metal mobilization out of the sediments resulting in higher concentrations of metals in epibenthic species like amphipods. This means that elevated DO may result in the accumulation and increased toxicity of previously bound metals into other epibenthic fauna. With the episodic variation in DO along the bottom of Macquarie Harbour, the mobilization of metals due to the breakdown of AVS binding may be a significant mechanism of faunal die offs.

Teasdale et al (2003) conducted sediment sampling in Macquarie Harbour in June 1995. They observed a distinct north-south gradient in several sediment quality parameters including dissolved copper concentrations, presence of sulphide, and AVS. They found sediments close to the King River delta contained significantly more copper than further sites and little indication of sulphide or AVS formation. Sites closer to the Gordon River contained much less copper, but much more Sulphide and associated AVS. The authors attributed these trends to differences in organic loading from the somewhat “denuded” catchment of the King River and the nearly pristine but heavily organic enriched catchment of the Gordon River.

Organic rich sediments, such as those forming near the Gordon River mouth, may be especially good at sequestering copper through AVS binding. DeJong et al. 2012 set up an experiment whereby surface water DO was manipulated to test the effects changing sediment redox conditions may have on the release of metals into the water column. They found that while some metals were released when oxygen conditions in the overlying water column improved (breaking down AVS binding), Cu was less prone to re-mobilisation, to which the authors give the following explanation:

"[S]trong Cu-AVS binding can directly be related to the extremely low solubility product of CuS (Ksp = 10^{-36}), compared to around 10^{-26} for PbS and ZnS (Caetano et al., 2003; Kelderman and Osman, 2007). As a consequence of the high affinities between Cu(II), Cu(I) and S(-II), very stable precipitates (e.g. chalcocite and covellite) can be formed in anoxic media (Huerta-Diaz et al. 1998). Additionally, Cu is known to have a high affinity for organic matter (Kelderman and Osman, 2007). Organic substances in the sediment might have captured freshly released Cu ions following the breakdown of CuS."

Organic matter from the Gordon River thus helps to bind copper both directly through binding with humic substances dissolved in the water column (Eriksen et al., 2001) and with particulate organic matter in southern Harbour sediments, and indirectly through AVS binding due to natural formation of sulphides in southern Harbour sediments. However, the southern Harbour is not the major sink of copper from the system as it was calculated that 2.1 tonnes year^{-1} is deposited in the southern reaches of the Harbour. In comparison, the King River delta and surrounding area have an estimated 750 tonnes of copper deposited yearly into sediments (Teasdale et al. 2003). The remainder of the copper load is flushed out of the system through Hells Gates.
With the closure of the copper mine at Queenstown there has been a reported reduction in the mediation works that act to reduce the volume of copper entering the King River. Over the last two years sediment plumes from the King River have become much more noticeable. Over this period there have been numerous small oxygen recharges that have impacted on the bottom water of the Harbour. Sense T, growers’ loggers, and the monthly monitoring all clearly show rapid changes from anoxic to normoxic conditions (especially in the northern and central areas of the Harbour. These rapid changes in the system can also affect benthic conditions.
A ‘lease-by-lease’ approach

It is Tassal’s position that not all leases are equal and there is a gradient of response in the Harbour and due to recent weather conditions April sampling is indicating an increase in infaunal abundance. In addition, Tassal is seeking a better understanding if whether recent flooding events may have resulted in an increase in the release of dissolved copper from the sediments in the King River delta zone to the water column, and whether such a release may have impacted on infaunal abundance within the Harbour. There is an enhanced focus on understanding the response of infaunal assemblages to changing environmental conditions. Tassal supports the IMAS research focused on examining the gradient of impact on the abundance and diversity of infaunal assemblages, particularly in respect of complementing the underwater visual compliance surveys with more quantitative ecological assessments.

Tassal currently have the 2016 salmon input year (2016 year class) evenly distributed between lease 214 and lease 219. Both leases currently have no out of lease non-compliances (last checked week of 10 April 2017) and we are managing them onsite to minimize pen bay impacts. Due to the location of these sites and our historic experience with farming them, we are confident we can manage the sites until harvest, under full environmental compliance. In fact we have observed recent improvements in pen bay recovery compared to previous years.

Tassal’s proposed approach falls in line with a ‘lease-by-lease’ management approach as lease 214 and lease 219 have very different biomass capabilities than lease 266. This is mostly due to their location in the Harbour and our local ecological knowledge of these sites as we have farmed lease 214 and lease 219 for a decade. As Tassal has stated in previous letters to the State Government, a ‘lease-by-lease’ management model in Macquarie Harbour is more appropriate than a Harbour-wide determined maximum sustainable biomass model.
Set out below is a summary of the historic salmon input years (pre 2015 salmon input year) and the current forecast (2015 salmon input year harvesting), 2016 salmon input year (in water at present) and 2017 salmon input year (at 1 million input) and the future forecast (i.e. 2018 salmon input year onwards) as a comparison.

<table>
<thead>
<tr>
<th>Lease #</th>
<th>Historical Max MT/Ha</th>
<th>Current Forecast Max MT/Ha</th>
<th>Future Forecast Max MT/Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Further to the above and set out below is a forecast fallow strategy based on site characteristics and compliance history.

<table>
<thead>
<tr>
<th>Lease</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Overview of Pelagic Oxygen Demand (POD)**

A study commissioned by the TSGA in late 2015 aimed to improve the understanding of the major drivers of bottom water Dissolved Oxygen (DO) in Macquarie Harbour. Oxygen is biologically removed from the water column by both microbial oxygen demand and direct respiration from fish and other aquatic life. Part of this study involved improving the understanding of the oxygen draw down rates due to microbes in the water column or what we term Pelagic Oxygen Demand (POD). POD is comprised of two major DO removal pathways (organic matter respiration and nitrification) whose combined effects are measured as changes in DO in a fixed volume of water over time.

POD was measured in Macquarie Harbour 3 times over the past 12 months: once in April 2016, again in December 2016, and finally in February 2017. POD was measured from water collected throughout the Harbour including water taken directly in and under farm cages, at the two major river mouths (Gordon and King Rivers), and in several reference sites located in all major Harbour basins. To address any variation in POD that might occur due to the depth, samples were collected from the surface, in the halocline, below the halocline, and 2 meters from the seabed.

The greatest POD rates measured in the Harbour were from the King River during the December 2016 and February 2017 sampling events. In December 2016 POD consumed 0.033 mg O$_2$ L$^{-1}$ h$^{-1}$ and in February 2017 POD consumed 0.018 mg O$_2$ L$^{-1}$
POD rates at the King River mouth in April 2016 were much more modest (0.0025 mg O$_2$ L$^{-1}$ h$^{-1}$). In comparison, the greatest rates observed beneath fish cages in the Harbour was 0.024 mg O$_2$ L$^{-1}$ h$^{-1}$. At the mouth of the Gordon River, POD rates also varied with season, but reached as high as 0.019 mg O$_2$ L$^{-1}$ h$^{-1}$ in February 2017. High POD rates associated with fish cages were localized to the immediate area surrounding the lease due to the diffuse nature of dissolved substances in the water column.

Clearly the influence of organic matter entering the Harbour from the Gordon and King Rivers has thus far been underestimated as a major driver of POD in the system. The results of the POD study show that the river endmembers can and do transport POD into the system rivalling and exceeding rates measured under farm cages.

Concerns about the influence riverine organic matter might have on DO drawdown in the Harbour were mentioned in the 2014 Macquarie Harbour Dissolved Oxygen Working Group report (MHDOWG, 2015). This report highlighted several key knowledge gaps associated with attribution of low bottom water DO in the system. Chief among these knowledge gaps are:

“the absence of reliable estimates of labile organic carbon fluxes associated with river discharge and export to the ocean, and levels of pelagic BOD [biological oxygen demand]”

In that report, it was suggested that DO levels in the Harbour are maintained by a combination of physical drivers including both episodic deep water intrusion from the ocean and riverine mixing events. While rivers do bring in relatively DO rich water, they also introduce organic matter into the Harbour that when decomposed (by bacteria) removes DO.

MHDOWG, 2015 mentions that high river discharge events following periods of drought may deliver larger amounts of accumulated organic matter from the catchment into the system. But had reservations about what contribution these sources might make to the total oxygen demand in the system:

“It is important to note that this is problematic for catchment inputs due to the absence of information on the proportions of refractory and labile catchment organic carbon and the volume of catchment organic carbon leaving though Hell’s Gates. These uncertainties are particularly significant given the magnitude of the source (~100 fold greater than fish farm organic carbon).”

The summer of 2015-2016 (especially Jan 2016) had one of the lowest periods of rainfall in recorded history (Australian Bureau of Meteorology; Figure 13). April
2016 POD measurements captured POD in the Harbour close to the end of the drought period periods were river flows were low, and just before the flood events of May and June POD was subsequently measured in December 2016, during more typical rainfall and organic loading periods, with the King River endmember showing the greatest amount of DO consumption measured in the Harbour thus far.

![Rainfall at Strathgordon (Gordon Power Station)](image)

**Figure 13: Average Rainfall at Strathgordon Station Compared to Rainfall in 2016.**

It is clear that while fish farming does deliver labile organic matter to the Harbour bottom, and causes an increase in POD in the water column in and around the cages, the influence of the rivers’ organic matter deposition must also be taken into account.

The southern portion of Macquarie Harbour is historically prone to hypoxic conditions and formation of sulphide in the sediments. Teasdale et al. (2003) cite heavy organic matter loading from the Gordon River as the reason for heavy sulphide presence (and the reason for copper binding) in Harbour sediments from cores taken as far back as 1995. A number of other studies have also observed sulphides in the sediments. In short, there appears to be a history of large riverine loads of organic matter which may import large loads of POD into the Harbour.

**Contribution of Fish farm and Riverine POD to DO Budgets**

MHDOWG, 2015 provides estimates of benthic oxygen consumption (the amount of DO removed by the seabed from the water column) under fish cages and non-farmed portions of the Harbour. It was estimated that the decomposition of fish farm derived wastes would be responsible for up to 13% of the total theoretical benthic oxygen
demand in the Harbour. They estimate that sediments beneath farm cages would remove approximately 0.025 g m\(^{-2}\) month\(^{-1}\) from water below the halocline (15 meters). Based on fluxes of dissolved inorganic carbon (a conservative proxy used to derive DO fluxes) they estimated 1.21 tonnes of O\(_2\) day\(^{-1}\) would be removed from the water column by fish farm sediments and 24.78 tonnes of O\(_2\) day\(^{-1}\) by the whole seabed.

The major driver of oxygen consumption in Macquarie Harbour is the water column rather than the sediments, as the volume of water column (approximately 4.2 billion m\(^3\)) is relatively large compared to its sediment surface area.

![Cumulative Volume (cubic meters)](image)

**Figure 14: Hypsography of Macquarie Harbour. Based on MSL bathymetry.**

During periods of normal rainfall (and following a significant period of flooding in the middle of 2016, POD rates observed in the Gordon River reached 0.456 g m\(^{-3}\) day\(^{-1}\) and rates in the King River reached 0.792 g m\(^{-3}\) day\(^{-1}\). In February 2017, the average sub-halocline POD measured under the most heavily stocked fish farm cages in the Northern and Southern Leases was 0.192 g O\(_2\) m\(^{-3}\) day\(^{-1}\). The maximum POD ever measured under any cage in the Harbour was 0.576 g O\(_2\) m\(^{-3}\) day\(^{-1}\).

During high rainfall events, King River daily average flows can reach 80 cumecs which would import an oxygen demand of **5.5 tonnes of O\(_2\) consumption day\(^{-1}\)** into the Harbour. Gordon River daily average flows can reach 1,680 cumecs during high rainfall events, equating to an oxygen demand of **66.2 tonnes of O\(_2\) consumption day\(^{-1}\)** entering the Harbour (**Figure 15**).

During high rainfall events, King River daily average flows can reach 80 cumecs which would import an oxygen demand of **5.5 tonnes of O\(_2\) consumption day\(^{-1}\)** into the Harbour. Gordon River daily average flows can reach 1,680 cumecs during high rainfall events, equating to an oxygen demand of **66.2 tonnes of O\(_2\) consumption day\(^{-1}\)** entering the Harbour (**Figure 15**).

Compared to the estimated farm induced benthic oxygen demand from MHDOHG **2015**, the oxygen demand imported by the rivers during high rainfall periods is
approximately 56 times greater. The oxygen demand imported by the Gordon River alone is 52 times greater than the estimated benthic oxygen demand.

MHDOWG, 2015 calculated the area of the seabed that is covered by cages (and a 50-meter buffer area). This total area of 0.66 km² (area directly under the fish cages) and 2.05 km² (50m buffer around the cage area) equate to about 2.71 million m². Assuming an average depth of 30 meters under the cages in the Harbour this equates to a water volume of approximately 81.3 million m³.

Based on the mean POD measured under Northern and Southern leases in February 2017, from their most heavily stocked cages, and assuming all cages and leases under the farm were as densely stocked, it would mean 15.6 tonnes O₂ day⁻¹ would be removed from the sub-halocline waters due to all farming operations in the Harbour. Based on the highest POD ever measured under a farm, from the most heavily stocked cage, and assuming all cages and leases under the farm were as densely stocked, it would mean 47 tonnes O₂ day⁻¹ would be removed from the Harbour. Clearly, assuming all cages on the leases are stocked equally, and all POD under the lease is uniform will certainly overestimate pelagic DO consumption due to fish farming.

The total volume of water in the Harbour below 15 meters is approximately 1.6 billion m³. A characteristic POD rate measured in non-farmed reference sites is approximately 0.168 g m⁻³ day⁻¹. If the non-farmed area of the Harbour water column is approximately 1.48 billion m³, then the total DO consumption of the Harbour excluding the farm areas is approximately 249 tonnes of DO day⁻¹. Total POD in the water column below 15 meters (water under lease + water not under leases) would be 264 tonnes of O₂ day⁻¹. Thus, if all water under the lease had the same POD rate as the highest stocked cage (an overestimation) then farm POD in the system would make up approximately 4.3% of the total Harbour oxygen demand below 15m.

We estimate that during the February 2017 POD sampling the total Harbour biomass was approximately 16,000 tonnes. This means that for every ton of fish 0.975 kg O₂ will be removed day⁻¹. If the Harbour was holding 14,000 tonnes of fish the total oxygen drawdown will be 13.65 tonnes O₂ day⁻¹ or 3.8% of the total oxygen demand below 15 meters. If the Harbour was holding 18,000 tonnes of fish this consumption increases to 17.55 tonnes O₂ day⁻¹ or 4.8% of the total oxygen demand below 15 meters.
During high rainfall periods, like those observed in May and June 2016, the proportion of total Harbour POD due to the cages would be smaller as the proportion of total Harbour POD due to the river derived POD would increase. Based on the measurements collected in December 2016 which occurred during more average river flow/rainfall conditions (i.e. not a drought or severe flooding) then the farm POD rates would equate to approximately 4% of the total POD. **Farm benthic oxygen removal would be less than 0.35 percent of the total oxygen consumption in the Harbour (Figure 3).**

The ADS POD surveys were not designed to characterise the spatial variation of pelagic POD under farm leases, but were instead designed to take a snap shot of the POD under the highest stocked cages. In order to adequately characterize POD under the leases it will be necessary to measure POD under each cage at multiple depths on a frequent (monthly) basis, and compare the values to POD from rivers measured on a similarly frequent basis.
Economic & Social

As previously stated, it is critical we reduce our biomass in Macquarie Harbour in an orderly and rational way – and to a sustainable level – with sustainability defined as a balance of economic, environmental and social outcomes, particularly socio-economic.

We very much want to mitigate the loss of economic value to the region and mitigate and minimise the loss of jobs. We believe we can do this – but require an additional 8 months to transition. We can however, do this whilst maintaining environmental compliance with both Leases 219 and 214 and reducing overall tonnage in the Harbour during that period.

Tassal will start to exceed your new, proposed maximum permissible biomass (15.12 tonnes per Ha) target in June 2017. Growing out of this 2016 salmon input year in accordance with safe operating and personnel practices will result in an exceedance of your above proposed limit of 15.12 tonnes per Ha for a total of 8 months until which time (December 2017) these fish will commence their harvesting period. After this point Tassal will be operating, ongoing within your new proposed maximum biomass allocation of 15.12 tonnes per Ha.

The lost economic value from reducing Tassal’s capacity in Macquarie Harbour at a quicker rate than we are proposing will impact in regional areas around Tasmania. Tassal has commissioned a professional, social and economic impact study looking at the impacts of reducing capacity in Macquarie Harbour. The scope of this study is considering the economic impacts of management and/or regulatory decisions which affect the current production cycle and the following production cycles.

Over 100 jobs rely directly on Tassal’s Macquarie Harbour production, including:

- Feed manufacturing (Cambridge);
- Hatcheries (Wayatinah, Russell Falls and Ranelagh);
- Logistics (State-wide);
- Fish farming (Strahan);
- Processing (East Devonport and George Town); and
- Value-adding (Huonville and Margate).

It is an important fact that most of these areas have lower employment rates and lower educational attainment than the Tasmanian averages and it is estimated that 577 jobs result from Tassal’s Macquarie Harbour operations across Tasmania.
Aquaculture (and the associated supply chain) is an ideal industry in these areas, given the relatively low skill levels required for most jobs, potential for training and education to be provided by Tassal and other companies, and career paths that can be created. Further, aquaculture is able to grow in Tasmania, subject to robust environmental regulation to ensure its sustainability, as its supply chain is highly specialised and generally does not displace other industries.

At current production levels from Leases 214 and 219, Tassal’s Macquarie Harbour operations directly contribute $106 million per annum to the Tasmanian economy and 39 direct jobs on the West Coast.

The multiplier effect of the economic impact is a further $77 million per annum contribution to Gross State Product. If Tassal is able to harvest the 2016 salmon input year when the fish are fully grown and then reduce its future stock levels to 1.0 million fish (Scenario 1), its economic contribution to GSP will still be $86.4 million lower over the two years.

It is important to reinforce that the impact of rapidly reducing our current volumes of 2016 salmon input year to 1 million fish (Scenario 2) by mid-2017 will result in Tassal’s economic contribution being lower by $77 million immediately. This is a direct negative impact of $77 million to the economy not to mention the material, negative economic impact to the company. This dollar amount reflects the loss of value from harvesting non-marketable fish. This would result in a loss of 20 direct jobs immediately.

Due to the extreme timelines of the proposed reduction, there is no clear way for Tassal to compensate the loss organically for the company or the State economy. The impact of this loss will lead to Tassal’s withdrawal from Macquarie Harbour as it will be challenging to justify continued operations in the region post a massive financial loss; compounded by the uncertainty surrounding the stocking of the 2017 salmon input year. This would result in a loss of 39 direct jobs.

From an economic perspective as foreshadowed above, the worst-case scenario is that Tassal withdraws from Macquarie Harbour, with a GSP $259.3 million negative impact.

If Tassal withdraws from Macquarie Harbour, this will be completed after the remaining 2016 salmon input year is harvested in early 2018. Assuming other companies are unable to stock Tassal’s former leases 214 and 219, the economic value lost is projected to be $182.3 million in real terms in 2018-19 and future years.
Tassal paid $205,000 in payroll tax for its Macquarie Harbour operations in 2015-16, and its liability in the year to date is $159,000. The economic modelling performed allows for quite a large multiplier effect (577 jobs) based on associated jobs per $1 million turnover. However, even if a modest three indirect to one direct job multiplier is used; the impact on Tasmania is still material at 120 jobs and resulting payroll taxes relative to the baseline scenario if Tassal withdraws from Macquarie Harbour. These jobs cannot be replaced easily or quickly, whether by expanding in other marine areas or in other industries.

Figure 16: Tassal stocking scenarios Macquarie Harbour.

Tassal currently directly employs 39 people (including casuals) at Macquarie Harbour. It recently restructured its working and shift arrangements, with an explicit objective to invest in long-term stability for its locally-based staff and their skills and reduce the reliance on drive in-drive out staff. Tassal’s internal data shows that 46 per cent of its Macquarie Harbour staff are locally-based, compared to 21 per cent in September 2015. Over time, this proportion of locally-based staff should increase as the current staff gain more operational experience and undertake further training. Across the company, Tassal’s staffing profile is consistent with long-term job stability and strong local connections, highlighting the longer-term potential for the company as it develops its Macquarie Harbour workforce (Tassal, 2016).

Tassal’s training system provides opportunities for skill transfer in the community. The company also employs many tradespeople — directly and indirectly — across the State, which ensures that they can provide services in their communities, where trade
shortages may otherwise occur. To support the year-round specialised logistics operations required by the aquaculture industry, the State government and major companies have made substantial investments in infrastructure, particularly roads and marine, in regional areas around the State. Other supporting infrastructure includes telecommunications and energy. These assets and related services are generally available to the relevant communities, subject to safety considerations. Clearly, the positive impact of Macquarie Harbour presents the counter-risk that reductions in Tassal’s Macquarie Harbour stocking capacity will have a detrimental effect across regional areas in Tasmania, particularly if it withdraws.

The economic benefits of having a significant and long-standing employer in remote communities include career opportunities, ongoing training and workforce development for local employees and support for community organisations and local small businesses.

These economic benefits are also associated with well-established social benefits such as:

- Health and education services provided by both the public and private sectors are more sustainable with larger employment bases.
- Permanent and locally-based employees provide a core for local sporting clubs and community organisations. Around 20 per cent of West Coast residents actively volunteer for community organisations (source: ABS Census of Population and Housing). Tassal contributed over $120,000 to community groups across the State in 2014-15.

Typically, stable populations and lower rates of long-term unemployment — along with access to education and health services and employer and employee engagement in the community — partly mitigate the social consequences of challenges such as:

Stability in the aquaculture workforce has been identified as a factor that offsets the loss of mining jobs in the region, particularly while Mt Lyell is under care and maintenance. Over time, if Tassal (and other aquaculture companies) remain as
strong and viable businesses in Macquarie Harbour, and mining employment increases, it is reasonable to expect that measures of social outcomes on the West Coast would show material improvements. However, these gains would likely be placed at risk if Tassal and/or other producers withdraw from Macquarie Harbour. In this scenario, the social and economic burdens would be placed on the broader Tasmanian community.

Aquaculture is moving into a significant leadership position within the Tasmanian economy. The economic and social effects of losing Tassal’s Macquarie Harbour operations would be significant, particularly given uncertainty in the mining sector, and could transfer a significant burden onto the Tasmanian community. For further detail please see the attached...
17: Value chain illustration - Tasmania’s farmed salmon industry.
Mitigating negative social and environmental impacts

In reference to your letter dated 8 March 2017 and as set out in detail below, culling the fish now to achieve a very small, whole of Harbour environmental offset will have serious economic, social and fish welfare outcomes. These fish are not a size to be harvested and cannot be relocated as mentioned previously, in order to take a precautionary approach and to find a solution for all parties Tassal has been investigating waste recovery and capture methods. However we want to be clear, in our willingness to take this step is not indicative of a problem and we believe that lease 214 and lease 219 can be farmed successfully into the future using traditional farming methods.

Tassal is also committed to remediating lease 266 (Franklin) as an additional, positive environment offset for the Harbour. In fact, Tassal is proposing to use lease 266 as a test site for sediment remediation research, including the innovative removal of waste and an academic research project to understand natural remediation in the Harbour. It is well understood globally that salmon farms will naturally remediate to background conditions and there is a range of remediation times and influences. Tassal is proposing to remediate the site as a way to further improve overall Harbour conditions in the short term and to potentially accelerate a whole of Harbour recovery.

To restate our position, Tassal is seeking permission for a temporary allowance to exceed the 14,000T biomass cap within the Harbour for a period of 8 months to see the 2016 salmon input year through to harvest with the understanding that compliance must be maintained. Tassal is proposing to achieve compliance and to minimize environmental impact through the deployment of innovative waste capture and recovery technology.

We have considered the options as set out in your letter dated 8 March 2017:

1. Transferring salmon to leases held by either Petuna or Huon Aquaculture.
2. **Acquiring a portion of Total Permissible Dissolved Nitrogen Output (TPDNO) from either Petuna or Huon Aquaculture to allow the fish to be grown on either lease 214 or lease 219.** Noting this approach will require the setting of a TPDNO for the harbor.

3. **The capture and removal of solid waste from fish farming operations on lease 214 and lease 219.**
   
   **This is Tassal’s preferred option.**
   
   This may be from an in-water collection system designed to capture waste as it falls through the pens. Alternatively, it may include a recovery system to remove solid emissions from the sea floor within the leases. Please see following detail.

4. **Accelerated harvesting of fish commencing in June to ensure the peak biomass is not exceeded.**
   
   The proposed harvest start date of December 2017 represents an accelerated harvest date. Optimally, Tassal had planned, prior to the draft determination, to harvest the 2016 salmon input year starting in February 2018 (i.e. which represents a loss to Tassal of [redacted]).
   
   In June 2017, the fish will be too small to handle and harvest using humane methods. In addition the cost of harvesting the fish at this size would be greater than the return so effectively harvesting at this time would be equivalent to culling and it would be more humane to cull. Tassal is proposing to bring the harvest forward to December 2017 and thus harvesting at a lower average weight than would be economically optimal.

5. **A cull of the 2016 salmon input year fish to reduce biomass so that the allocation is not exceeded.**
   
   Culling the 2016 salmon input year or any material part thereof, is not an option for Tassal. It would put our business at [redacted] Tassal question the need for such a radical approach that will result in large negative economic, social and fish welfare impacts and in our opinion, minimal environmental returns. This is not a strategy Tassal wishes to entertain and
thus we are willing to invest significant funds to find an alternative and innovative method to offset any potential environmental impacts.
SECTION II – THE PROPOSED PROJECT

Option 3: Tassal’s preferred option for consideration

Tassal is proposing to remove the solid faecal output from all stock in excess of (Tassal’s apportionment of 14 000mt) held on lease 219 and 214 throughout the growing cycle of the 2016 salmon input year of fish. Tassal has identified two techniques to accomplish this proposal and plan to further investigate both techniques to ascertain which technique, or a combination of both, we will propose to implement on a commercial scale.

Tassal is prepared to provide regular and real time monitoring together with transparent reporting to relevant stakeholders throughout the duration of the trials and any subsequent up-scaled operations.

The two techniques can be categorised as follows:

1. Remove fish waste from the seabed within the marine leases
2. Capture and remove fish waste within fish nets

1. **Remove fish waste from the seabed within the marine leases**

   to adapt existing skills, techniques and infrastructure to remove fish waste from the seabed within lease areas. It was identified in early discussions with both that an area of major concern with removing organic waste from beneath salmon cages is the risk of sediment re-suspension, and importantly in the context of Macquarie Harbour, the risk of re-suspension of heavy metals present from historic mining operations. has vast experience in removing contaminated sediments from mine tailing dams across the world, the infrastructure they propose to use for this project has been proven to be able to operate in a manner which will not disturb sediments to a degree that would create a significant plume and risk large scale re-suspension within the system.

For this operation to be viable the sediments must be de-watered once removed from the seabed, the process of extracting the sediments
Initial steps have been taken by [redacted] to determine if the proposed de-watering technology can separate the solids from the sediment. A box-grab sediment sample was taken from beneath a stocked cage within lease 214 in Macquarie Harbour and sent to the [redacted] The results from this trial were positive and [redacted] was able to successfully separate the solids from the sediment sample. After the separation process, both the solids sample and the water discharge sample were sent to a NATA accredited lab for analysis. Results from the analysis [redacted] have entered into an official Heads of Agreement to formalise the intent of all parties to engage in the trial.

**Description:** Remove waste material from bottom

**Location:** Marine Lease 266 (Franklin) Macquarie Harbour

**Quantity of waste to be removed:** [redacted]
<table>
<thead>
<tr>
<th>Process</th>
<th>Risk</th>
<th>Risk Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Table 1:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring Pre waste removal</td>
<td>Monitoring During waste removal</td>
<td>Monitoring Post waste removal</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Determine waste quantity</td>
<td>Chemically characterise waste and mud</td>
<td>Chemically characterise sludge</td>
</tr>
<tr>
<td>Sediment cores (thickness of waste/organisms versus mud)</td>
<td>Metals and metalloids (totals and dissolved) REDOX Nutrients TOC</td>
<td>Metals and metalloids (totals and dissolved) REDOX Nutrients BOD COD DO TOC</td>
</tr>
<tr>
<td>Area/extent of waste using ROV</td>
<td>Water Quality</td>
<td>Water Quality</td>
</tr>
<tr>
<td></td>
<td>(pre waste removal or at appropriately located control site)</td>
<td>Use ROV and ADCP (and other observations) to determine flow rate and direction.</td>
</tr>
<tr>
<td></td>
<td>Physico-chem (vertical profile, 1m intervals) turbidity, pH, conductivity, DO, temperature</td>
<td>Based on flow observations, locate sample and monitoring sites “down-current” of waste removal operations collecting samples and measurements along a transect from area of impact to area of no impact</td>
</tr>
<tr>
<td></td>
<td>Nisken samples bottom, middle, top &amp; analyse for nutrients (dissolved and total), metals (dissolved and total), turbidity (to confirm field measurement), TOC &amp; DOC</td>
<td>Grab samples bottom, middle, top &amp; analyse for nutrients, metals (dissolved and total), turbidity (to confirm field measurement)</td>
</tr>
<tr>
<td>Sludge</td>
<td>Sludge</td>
<td>Sludge</td>
</tr>
<tr>
<td>Consider bench tests to determine likely rate of sediment settlement</td>
<td>Consider bench tests to determine likely rate of sediment settlement</td>
<td>Consider bench tests to determine likely rate of sediment settlement</td>
</tr>
<tr>
<td>ROV</td>
<td>ROV</td>
<td>ROV</td>
</tr>
</tbody>
</table>
i. **Capture and remove fish waste within fish nets**

On 8 March 2017 Tassal installed a waste capture system on a stocked cage at lease 219 in Macquarie Harbour. The purpose of this installation was to ascertain whether fish waste could be captured within a net and removed for on-processing on land. Together with wanting to understand the operational effectiveness of this technique, Tassal also initiated a monitoring program to help understand if this technique was going to show beneficial results in relation to benthic impact underneath the fish cage. The monitoring program consists of 3 sites:

- Video footage from under the site of the containment system before installation
- Video footage from under a site that has had similar feed inputs but won’t be having a containment system installed
- And, video footage of a site that is currently being fallowed with no stock planned to be introduced

To date, this trial has successfully shown that faeces waste is able to be effectively captured within a salmon net and then extracted to the surface to be further processed on-board a vessel.
Tassal plans to continue monitoring the three sites to gain an understanding of any improvement to the extent of benthic impact which the waste capture technique may provide.

The trial has highlighted various operational deficiencies of the waste capture system. As a next step, Tassal plan to continue the Research and Development of the waste capture system to address these issues. Several contracting groups, including specialist fish net manufactures, are being engaged to develop a system with the aim of producing a containment system that can be implemented across multiple cages.

To determine the effectiveness of the waste capture system, Tassal is requesting permission to conduct a field trial which will involve installing the containment system on 4 stocked cages, together with using de-watering infrastructure and methodology to process the waste once extracted. The tables below identify and describe the process, associated risks, and operational responses to manage identified risks associated with waste removal and further incorporates and addresses the EPA’s and Tassal’s environmental monitoring plan which will identify impacts (positive or negative) of the trial.

**Location:** Marine Lease 219 (Gordon) Macquarie Harbour.  
**Quantity of waste to be removed:** Dependant on time vs feed amount for the fish cages which the containment system is installed.
<table>
<thead>
<tr>
<th>Process</th>
<th>Risk</th>
<th>Risk Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disinfection of all equipment before shipping as per Tassal’s biosecurity protocols.</td>
<td>Biosecurity.</td>
<td></td>
</tr>
<tr>
<td>Effluent spill into waterways.</td>
<td>De-watering facility designed in way that any effluent spill can be contained on land without release into waterways.</td>
<td></td>
</tr>
<tr>
<td>Removal of fish waste from in-net waste containment system.</td>
<td>Resuspension of fish waste containing organics. Potential for spread into WHA or neighbouring farm sites.</td>
<td>Slow controlled suction of fish waste from containment system. Process to be monitored by divers within the cage and stopped if excessive pluming is occurring.</td>
</tr>
<tr>
<td>Loading and transport of effluent for de-watering on land.</td>
<td>Release of sediment/effluent into the Harbour.</td>
<td>Slow controlled suction of waste/effluent from the waste containment system. All effluent securely loaded and transported using 1000L IBC’s. Spill response equipment available on-board vessel.</td>
</tr>
</tbody>
</table>

Table 2: Process, risk and risk mitigation measures for waste capture and recovery trials Macquarie Harbour.
<table>
<thead>
<tr>
<th>Monitoring pre waste capture</th>
<th>Monitoring During waste capture</th>
<th>Monitoring Post waste capture</th>
<th>Monitoring Other</th>
<th>Trial success to be measured by:</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Determine benthos condition</strong>&lt;br&gt;Pre-condition of benthos beneath cage using ROV</td>
<td><strong>Waste settlement</strong>&lt;br&gt;Record settlement time of uneaten food and faeces into capture device.</td>
<td><strong>Determine benthos condition</strong>&lt;br&gt;Post condition of benthos beneath cage using ROV</td>
<td><strong>Other</strong></td>
<td>No 'new 'waste on harbor bottom</td>
<td>It is understood that food types may be varied to optimise waste capture. Separate trials are likely to be needed to test the impact of feed types on efficacy of waste capture.</td>
</tr>
<tr>
<td><strong>Water Quality</strong>&lt;br&gt;(control site &amp; fallow site)&lt;br&gt;Physico-chem (full vertical profile, 1m intervals) turbidity, pH, temperature</td>
<td><strong>Determine effectiveness of waste capture</strong>&lt;br&gt;With capture device in place: ROV of fixed cameras on the outside of the cage Sediment traps&lt;br&gt;At a stocked control site with no capture waste device: ROV of fixed cameras on the outside of the cage Sediment traps</td>
<td><strong>Chemically characterise sludge</strong>&lt;br&gt;Metals and metalloids (totals and dissolved) REDOX Nutrients BOD COD DO TOC&lt;br&gt;<strong>Physically &amp; Chemically characterise cake</strong>&lt;br&gt;Volume</td>
<td><strong>Cake classified and disposal approval</strong>&lt;br&gt;Supernatant classified and disposal approval&lt;br&gt;Measurements of faeces vs uneaten food capture</td>
<td>Faeces and uneaten food capture approaching 100%</td>
<td>Trial objective is to maximise waste capture.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Measurement of waste capture (as a % of feed input)</td>
<td>In determining whether the trial is a success and whether this waste extraction approach can be extended to other lease areas, the trial outcomes must inform the following:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- estimates or measure volume of the waste that is currently escaping pens&lt;br&gt;- measure of waste that is captured expressed as a % of feed input&lt;br&gt;- calculate O₂ consumption of the waste material assuming no capture (i.e. status quo)&lt;br&gt;- calculate (reduction of) O₂ consumption assuming complete capture of waste</td>
<td></td>
</tr>
<tr>
<td>Water Quality</td>
<td>Metals and metalloids (totals)</td>
<td>No serious, material environmental harm, or environmental nuisance.</td>
<td>- calculate (reduction of) O₂ consumption based on waste captured in the trial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------------------</td>
<td>-------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physico-chem (full vertical profile, 1m intervals) turbidity, pH, DO, conductivity, temperature</td>
<td>REDOX</td>
<td>Analyse for: Nutrients (total &amp; dissolved) fine particulates TOC DOC</td>
<td>Findings are to be presented in terms of a conceptual model of the Harbour. In particular it may be useful to present conceptual models without waste removal and with waste removal.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grab samples “down-current” but immediately adjacent to the cage. Collect samples at depths 0m, 10m, 20m, 30m (Needs to try and capture stratification and density)</td>
<td>Nutrients TOC</td>
<td>Physically and Chemically characterise supernatant</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pending the results from further research and development trials, and in liaison with the EPA, Tassal may seek the relevant government approvals to broaden the application of this technique to remove the solid faecal salmon waste from all stock in excess of (Tassal’s apportionment of 14 000mt) held on lease 219 and 214 throughout the growing cycle of the 2016 salmon input year of fish.

Although Tassal initially plans to have a single waste capture system built and installed at the Gordon lease, through this process Tassal will also be gathering supply timelines and costings for multiple waste capture systems to be built and installed. We also plan to gain approval from the Board on the expenditure required to build multiple waste capture systems if required.

Tassal has engaged [Redacted] as waste management consultants to review the options for the disposal of both fish waste scenarios. The Lab analysis results from the [Redacted] desktop experiment were supplied to [Redacted] for use as an indicator of the waste composition for the option of removing fish waste from the seabed.

[Redacted] and [Redacted] have reviewed the analysis results for both the [Redacted] and [Redacted] scenarios.

Further testing will be required for either of the options to be pursued.

1. For landfill disposal, leachable metal testing to see if leachable levels are lower and offer a better disposal option, or
2. For land application, the full Biosolid Classification needs to be determined (Inc. stabilisation grade) tested in accordance with the procedures described in TBRG.

The [Redacted] was below limits and suitable for discharge to sewer.

As a next step to further define the suitability of the waste for either landfill or land spreading, further sampling will be conducted to evaluate the spade-able quality of the [Redacted].
Samples of the captured fish waste from within the liner have been taken and supplied to [blank] for analysis. These results will also be supplied to [blank] to explore all available disposal options as per the process with [blank].
OUTLINE OF THE PROPOSED LOCATION OF THE PROJECT

The below map of Macquarie Harbour highlights marine leases 214 (Middle Harbour), 219 (Gordon) and 266 (Franklin). Tassal’s 2016 salmon input year of 1.9 million fish are currently stocked at leases 214 and 219. This proposed project will encompass all three leases mentioned above with regards to the [REDACTED] technique. The waste capture and removal technique is proposed to be implemented at Leases 214 and 219.

Figure 18: Marine farm leases within Macquarie Harbour.
THE PHYSICAL ENVIRONMENT THAT MAY BE EFFECTED BY THE PROJECT

The Environmental Characteristics of Macquarie Harbour

Marine farming activities and management controls in Macquarie Harbour are covered under the Macquarie Harbour Marine Farming Development Plan October 2005 – the physical extent of which includes all those waters within the Harbour outside of the Tasmanian Wilderness World Heritage Area (TWWHA) (see Figure 3 below).

The Macquarie Harbour Marine Farming Development Plan October 2005 identifies 10 marine farming zones within the plan area, providing for a total of 564 hectares of lease area.

Macquarie Harbour is one of Australia’s largest estuaries. It has a maximum depth of around 50 metres, is approximately 33 km long and 9 km wide encompassing an area of 276 km\(^2\). The catchment area for the Harbour is estimated to be 6,900 km\(^2\), with almost 90% of this area contained within the Gordon and King River catchments (Koehnken 2002). The total area occupied by all marine leases within Macquarie Harbour is 3.3% of the total Harbour.

Many studies have been undertaken over a number of years to characterise the various complex interactions between the unique estuarine features of the Harbour (similar to the natural conditions of Bathurst Harbour in Port Davey) and the significant environmental effects from over 100 years of mine slurry discharged into the King River (Cresswell et al. 1989), as well as intermittent regulation of river inflows from the Gordon and King River catchments for the purpose of hydro-electric power generation.

Based on the unique physical attributes of the Harbour, the water column is highly stratified due to the significant freshwater inputs from the King and Gordon Rivers, the low level of water exchange at the mouth of the Harbour and a long residence time for water at about 20 metres depth. Above this depth, water quality characteristics are driven mainly by surface water run-off and seasonal heating and cooling, and below this depth in the deeper basins, denser marine waters predominate. (Cresswell 1989).

The recent industry expansion approved in 2012 was also accompanied by a range of comprehensive scientific and environmental monitoring programs investigating the water quality and seabed characteristics of the Harbour. A synthesis of these studies and their findings is included in Ross and Macleod (2017) – “Environmental Research in Macquarie Harbour –Interim Synopsis of Benthic and Water Column Conditions”. The water quality monitoring program initiated in 2011 confirmed a decline in dissolved oxygen within the bottom waters of the Harbour in 2013. Since
this time, the effect of dissolved oxygen on water quality and sediment condition of the Harbour has been the main focus of industry’s research efforts.

In addition, declining dissolved oxygen levels have also been addressed through regulatory management determinations on biomass limits within the Harbour. The EPA is in the process of consolidating a position on the sustainable development of the aquaculture industry in Macquarie Harbour, including management options to prevent environmental degradation within the water column and seafloor ecosystems. This proposal seeks to provide ongoing options for remediating the effects of finfish farming within the Harbour as well as attempting to capture, remove and treat solid waste emissions instead of the current practice where solid emissions are naturally assimilated on the seafloor.
**Proposal Specific**

This proposal includes the development of fish waste capture and recovery systems through:

i. Deployment of in-water liners beneath stocked cages
ii. Removal of organic sediments from the seafloor

Initially, it is proposed that pilot trials be undertaken to ensure that the environmental effects associated with both activities do not have a significant impact upon fish health and/or the biophysical attributes of the Harbour.

All trials will be restricted to within the lease boundaries of MF 214 (Middle), MF 219 (Gordon) and MF 266 (Franklin). The deployment of in-water liners beneath stocked cages will capture faecal waste associated with finfish production within active leases, whereas the removal of organic sediments from the seafloor will only be undertaken during pen falling, or to assist in the environmental recovery of MF 266 which has been removed from production planning until further notice.
Figure 19: Waters designated under the MHMFDP 2005.
KEY ENVIRONMENTAL, HEALTH, ECONOMIC AND SOCIAL ISSUES IDENTIFIED TO DATE

Environmental

The key environmental issue associated with the current ongoing marine farming within Macquarie Harbour is fluctuating dissolved oxygen levels within the water column leading to changes in ecosystem structure and function. A range of scientific studies have confirmed that the isolation of deep water in the Harbour has resulted in a naturally depleted dissolved oxygen environment with low natural biodiversity. However, natural replenishment in dissolved oxygen levels occur periodically through:

1. Mixing with higher DO surface waters
2. Higher DO waters coming in over the mouth of the Harbour and descending as a plume through the bottom of the system

The second of these two recharge mechanisms has several key drivers that influence the duration and extent of the DO recharge including: air pressure, weather, depth of the sill, wind and fresh water flows to the system. This means the Harbour has fluctuating DO levels in the bottom waters that are dependent on natural processes. The EPA has records of these patterns dating back several decades and prior to salmon farming expansion.

The surface sections of the water column (which the salmon occupy) has naturally high levels of DO due to the pulsing fresh water (FW) inputs from both the Hydro flows and other unregulated inputs (rivers) and wind driven surface or ‘top down’ recharge. These DO levels are generally higher than all other salmon growing areas around the State.

Figure 4 below shows the influence river discharge to the system plays in DO recharge and profile to bottom waters:
The unpredictable nature of the drivers to this system, combined with complex patterns of water stratification within the Harbour mean that none of the marine leases within this waterway are exactly the same, and for this reason there is a strong imperative for marine farms to be managed on a lease by lease basis. This differs from other farming regions in the State where conditions within the regions are generally more uniform.

Current management controls applied to marine farming in Macquarie Harbour are more tailored towards a system-wide approach as opposed to managing site-specific environmental conditions, which fluctuate significantly, both spatially and temporally, across the Harbour.

The summary of the role riverine and farm-derived organic matter may have on dissolved oxygen and metal dynamics in Macquarie Harbour is based on previous investigations of system process rates, findings in the literature, and industry monthly monitoring surveys.

- The results of the 2016/2017 POD (water column oxygen) study indicates that the river endmembers can, and do, transport POD into the system rivalling and exceeding rates measured under farm cages.
• While fish farming does deliver labile organic matter to the seabed causing an increase in POD in the water column in and around the cages, the influence of the rivers’ organic matter deposition must also be taken into account.

• Based on the preliminary measurements collected in December 2016 farm POD rates would equate to approximately 4% of the total oxygen in the Harbour below the halocline.

• Benthic oxygen removal due to the presence fish farms has been calculated to be less than 0.35 percent of the total oxygen consumption in the Harbour: based on the measurements collected in December 2016, which occurred during more average river flow/rainfall conditions (i.e. not a drought or severe flooding) then the farm POD rates would equate to approximately 4% of the total POD. The Macquarie Harbour seabed constantly shifts from states of hypoxia (and sometimes anoxia) to normoxia regularly. Such changes can mobilise metals from the sediments into pore water and the water seabed interface. Thus, increases in seabed dissolved oxygen can result in an increase in metal accumulation and possible toxic impacts on benthic invertebrates.

• A number of studies have also stated that copper concentrations in both the water column and surface sediments have reached levels in Macquarie Harbour that can adversely impact on benthic communities.

• Rapid changes in DO may also have attributed to the sharp drop in benthos observed in 2016-2017 along with increases in copper entering the Harbour (due to a lack of mediation at the Queenstown copper mine as it closed approximately 2 years ago). Over the last two years sediment plumes from the King River have become much more noticeable.

• Several benthic surveys conducted over the last 25 years have observed very low numbers of benthic invertebrates and high levels of organic material usually associated with seabed sulphides. The number of invertebrates measured during these surveys are similar in number to those observed during the recent 2017 IMAS survey.

• Over the last two years there have been large variations in climatic forcing’s (i.e. summer temperature, rainfall) in Western Tasmania. These have had an impact on the discharge of organic material into the Harbour as well as impacting on marine recharge events through Hells Gate.
• A combination of low dam levels/drought and high temperatures, followed by flooding has led to a significant increase in organic material entering Macquarie Harbour during May and June of 2016.

• This organic matter lead to higher oxygen consumption in the Harbour bottom and mid-waters and increased the prevalence of anoxia within the Harbour. These conditions promoted the growth of the sulphide oxidizing bacteria *Beggiatoa* and reduced the number of benthic invertebrates.

• Based on our observations of *Beggiatoa* around the Franklin lease we suspect that very small volumes of farm faeces led to quite significant changes in seabed habitat due to the large influx of riverine organic material in May and June 2016.

• While fish farming activity contributes to *Beggiatoa* mat formation in and around the Franklin Lease, it is unlikely to affect the seabed characteristics thousands of meters away from the farm due to the bathymetry of the southern part of the Harbour, as the sinking organic material would need to travel upslope. Hydrodynamic modelling with numerous ADCP deployments indicates there is also a net flow of water towards the north due to the inflow of water from the Gordon River which would also restrict the movement of fish faeces in the southward (up estuary and up slope) direction.

• Surveys and studies proposed or underway in relation to the key issues in Macquarie Harbour.

**Relevant Ongoing Studies**

There is currently a range of research and monitoring programs being undertaken in the Macquarie Harbour. Some of these activities relate to monitoring for industry compliance purposes, whereas other scientific studies have involved targeted investigations into specific areas of interest (i.e. such as understanding the ecology of Dorvilleid polychaetes, or the collection of real time dissolved oxygen data using sensor nodes).

The compliance monitoring programs (such as the monthly water quality and ROV underwater surveys) have added valuable insight into environmental trends in the Harbour, whereas the detailed scientific studies have provided a greater conceptual understanding of ecosystem structure and function in the Harbour, particularly physical processes within both sediments and the water column that facilitate nutrient cycling.

In addition, Harbour-wide environmental surveys have been undertaken annually since 2016 to detect broad-scale changes in benthic condition. The sampling
schedule was designed to complement concurrent studies carried out by IMAS. A variety of survey methodologies and analyses were implemented to assess seabed condition including underwater filming (ROV), sediment chemistry, particle size, C:N ratio, heavy metal analysis, organic content and benthic infauna. The methodologies used in these surveys are in accordance with Schedule 3B Harbour Wide Survey Macquarie Harbour. Survey sites included those sampled during previous baseline studies undertaken in 2012 and sites sampled by IMAS in January 2015 as part of FRDC funded surveys. The raw data arising from the surveys will be incorporated into a detailed assessment of seabed condition across Macquarie Harbour, to be carried out by IMAS.

The Sense-T Macquarie Harbour Salmon Project, involving the use of moored sensor arrays, commenced in late 2015 and established fish-borne telemetered DO tags and the deployment of sensor strings to monitor ambient DO levels in real-time within the Harbour. Sensors were placed in 2 sentinel fish pens within an existing marine farming lease as well as three environmental sensor strings deployed along the edge of 3 marine farming leases along the central Harbour. These real-time sensor arrays have enabled scientific personnel and managers to develop a more intimate understanding of stratification processes in the water column on a more frequent basis than would otherwise be detected through monthly water quality monitoring. In addition, the deployment of CSIRO’s environmental profiler has also collected valuable water column information for use in the development of a near real time hydrodynamic model of the Harbour.

FRDC Project 2015-024 “Managing ecosystem interactions across differing environments: building flexibility and risk assurance into environmental management strategies” undertaken by IMAS is also positioned to contribute significantly to a better understanding of the key recovery response principles and benthic condition criteria in the Harbour. Specifically, this project (which is ongoing) will develop site specific performance criteria and benthic monitoring strategies for Macquarie Harbour.

Industry has also supported a body of research undertaken by ADS and IMAS to investigate Pelagic Dissolved Oxygen (POD) in Macquarie Harbour. The aim of this work is to identify the discrete processes and cycling components that contribute to DO consumption within the pelagic water column. Overall, this project (ongoing) will provide a better understanding of the key processes driving POD, as well as an identification of the likely sources of significant DO drawdown. Early results indicate the River Systems (Gordon and King) are having a larger contribution to POD that previously thought.
Most importantly though, is the proposed FRDC funded research study (to be undertaken by IMAS) entitled “Understanding oxygen dynamics and the importance for benthic recovery in Macquarie Harbour” which incorporates the findings of previous research studies into three discrete work packages targeting:

i. Benthic recovery in the Harbour
ii. Development of a real time dissolved oxygen network
iii. Oxygen transport modelling

These initiatives are integral to the development of a better understanding the drivers and dynamics of low DO water at both local (e.g. lease) and Harbour wide scales. The integration of sensor networks with a near real time hydrodynamic model incorporating oxygen transport will greatly assist in managing (and regulating) benthic and water column condition in the Harbour and how it relates to ongoing management and monitoring programs. This study is due to commence in early 2017.

Proposal Specific Studies/Surveys

The trialling of innovative waste capture and recovery technologies identified in this proposal will be supplemented by specific scientific survey methodologies to assess and determine any potential environmental impacts resulting from these activities, as well as an assessment of the potential environmental benefits associated with their use. Tassal will liaise with the EPA and Analytical Services Tasmania to refine specific methodologies and testing regimes.

Table 3 shows the proposed survey methodologies for measuring and monitoring the potential impacts associated with these trials. The proposed surveys will involve (but are not limited to):

**Waste Capture**
- assessment of the efficacy of in-water liners to capture faecal matter
- determination of waste composition (i.e. N, C and P) and comparison with feed input composition
- water quality testing (i.e. nutrients/DO impact and control sites)
- assessment of sediment condition and recovery (using traditional sediment survey techniques (i.e. cores, Van Veen Grabs, ROV and sediment trap deployment). Analyses to include redox, sulphides, infauna, C:N and metals)
- ongoing gradient of impact monitoring (IMAS)

**Waste Recovery**
- pre and post sediment remediation assessment (using ROV)
• pre and post water quality testing (using Niskin bottle to collect bottom water samples)
• analysis of emissions (solid and water) for nutrients and heavy metals
• monitoring of sediment condition and recovery (using traditional sediment survey techniques (i.e. cores, Van Veen Grabs, ROV and sediment trap deployment). Analyses to include redox, sulphides, infauna, C:N and metals)
• ongoing gradient of impact monitoring (IMAS)

PROPOSED TIMETABLE FOR THE PROJECT

If permission is granted, it is Tassal’s expectation that the trials will be completed. A full implementation timetable will be dependent on the outcome of the trials. An indicative implementation timetable will be developed in the next two weeks.

The specific activities relating to this proposal in the short-term relate to trials which will not affect the natural environment of Macquarie Harbour in any significant manner. Monitored trials will be undertaken in the field to assess the efficacy of potential waste capture and remediation trials, but these small-scale trials will be subjected to rigorous monitoring and environmental surveillance. Testing will be undertaken on sediments/emissions which will be removed from lease areas, tested and disposed of in an appropriate manner using approved land-based waste facilities.

If the waste capture and recovery trials detailed in this document prove successful, any activities that relate to the removal of sediments from the seafloor will be assessed in terms of the potential for these activities to impact on Maugean Skate populations. Direct interactions between Maugean Skate and aquaculture operations appear to be limited (IMAS interim report prepared for EPA and DPIPWE January 2017). Tassal has liaised with recognised experts in Maugean Skate ecology.
CONCLUSION

At the beginning of this submission Tassal stated that there is a need for an adaptive, environmental management regime in Macquarie Harbour that will support ongoing, sustainable salmon farming for the region. Sustainable salmon farming must be defined and supported by balancing positive economic, environmental and social outcomes. To ensure that balance is maintained, it is critical that Tassal is allowed to reduce its biomass in Macquarie Harbour in an orderly, rational and humane way.

We have also examined the potential risks to the environment, the fish and the community in culling 50% of our current 2016 salmon input year in order to immediately meet the new biomass determination. Our conclusion is that the overall, additional environmental impact to the Harbour is small while the social and economic impact is very large.

Our review shows that harvesting the 2016 salmon input year would have a very limited environmental gain; our position also is this gain is not commensurable with the resulting socio-economic impacts and fish welfare outcomes which will be both catastrophic and inhumane. Removing 50% of our 2016 salmon input year before they are ready for harvest will result in less than a 2% reduction in environmental impact, a loss of Gross State Product (GSP) of $259 million to the economy and a million loss to Tassal. However, the commercial implication of this scenario is that

We asked the question (using the science we have available): What would be the environmental impact to the Harbour of holding 18000 mt of fish for an additional eight months versus 14,000 mt (the new determined biomass limit). Although one could argue that our calculations are crude, they very much demonstrate the general magnitude of the sources of DO draw down. Combine this with the known copper contamination, we are putting forward that our additional 4000 mt for an additional eight months has a relatively small contribution to the condition of the Harbour – about a 1% increase in oxygen demand.

In addition we are seeing a very rapid recovery rate for our Franklin site – indicating that the impacts are reversible. We are putting forward that with our proposed waste capture the additional environmental impact of our 2016 salmon input year would be negligible however the social and economic benefit of growing out the 2016 salmon input year would be large and significant.
We do understand that there needs to be a greater understanding of the infaunal populations and the contribution salmon farms are having towards their population structure, however as we are progressing in an adaptive manner in the harbour we ask that the biomass limit be reconsidered annually as new information and understanding comes to light.

Sustainable salmon farming must be defined and supported by balancing positive economic, environmental and social outcomes. To ensure that balance is maintained, it is critical Tassal is allowed to reduce its biomass in Macquarie Harbour in an orderly, rational and humane way – which means it is allowed to grow out its 2016 salmon input year fish and stock its 2017 salmon input year fish to 1 million smolt.

The above graph demonstrates the period where Tassal is seeking a temporary licence to exceed the 14,000T standing biomass cap for a period of 8 months, with impacts mitigated through the deployment of innovative waste capture and recovery technologies.

Going forward, Tassal supports a lease by lease approach to salmon farming in Macquarie Harbour, and given the unpredictability of the Harbour’s system, biomass be reviewed annually.
Tassal strongly believes there is a need for an adaptive, environmental management regime in Macquarie Harbour, which will support ongoing, sustainable salmon farming for the region. This must be underpinned by a standardised policing process across all marine leases in Tasmania, with a penalty framework and publicly transparent report card process that motivates a continued high level of compliance across the whole industry. Tassal recognises additional resources would be required within the EPA to appropriately police marine leases across Tasmania and would be prepared to assist with an industry funded model.

To restate our position, Tassal is seeking permission for a temporary allowance to exceed the 14,000T biomass cap within the Harbour for a period of 8 months to see the 2016 salmon input year through to harvest with the understanding that compliance must be maintained. Tassal is proposing to support compliance and to minimize environmental impact through the deployment of innovative waste capture and recovery technology.
REFERENCES


