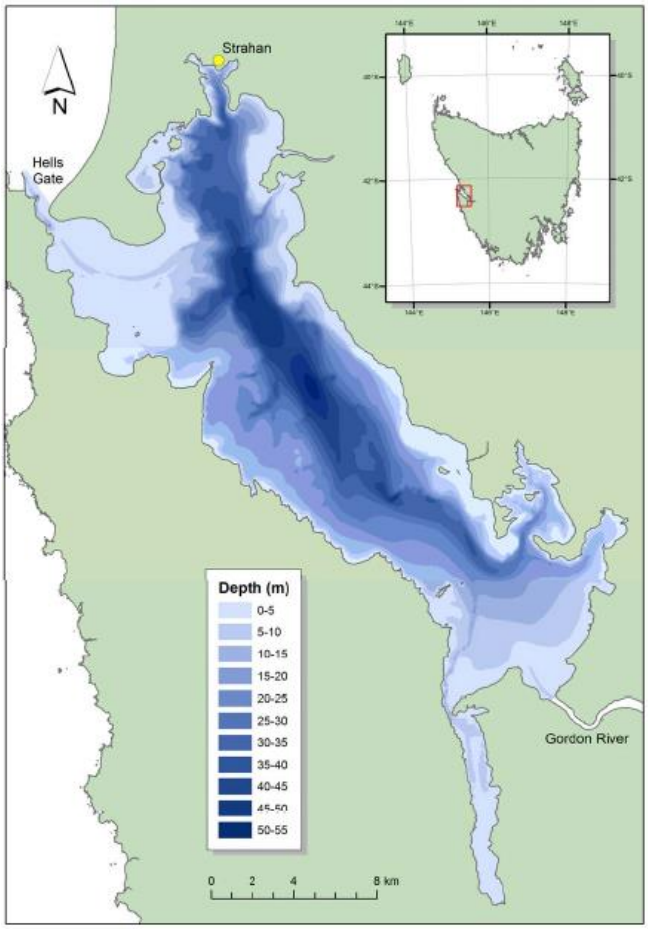
Macquarie Harbour is a large estuary supplied with freshwater from the Gordon and King Rivers (see figure below). Oceanic bottom waters mix with large amounts of freshwater and the water column in the harbour is typically three-layered: fresh, marine, and intermediate. The Harbour is approximately 33 km long and 9 km wide with a total surface area of 276 km². The total space occupied by all marine leases within Macquarie Harbour is 3.3%.

The Harbour has many factors that can influence water quality including: historic mining runoff and legacy pollution to sediments, Hydro Tasmania fresh water pulses for power generation, continual flood events, aquaculture production, oceanic influences and high exposure to predominantly westerly weather patterns.

While the Harbour's maximum depth is around 50 m, a shallow sill at its mouth (< 5 m) restricts exchanges with the ocean. This isolation of deep water in the Harbour has resulted in a naturally depleted dissolved oxygen (DO) environment with low natural biodiversity. The dark colour of the water is typical of waterways throughout the southwest of Tasmania and is caused by naturally occurring tannins in the water.

DO levels fluctuate within the bottom waters and have a direct impact on the benthic management of aquaculture leases in the Harbour. These fluctuations can impact levels of aquaculture production.



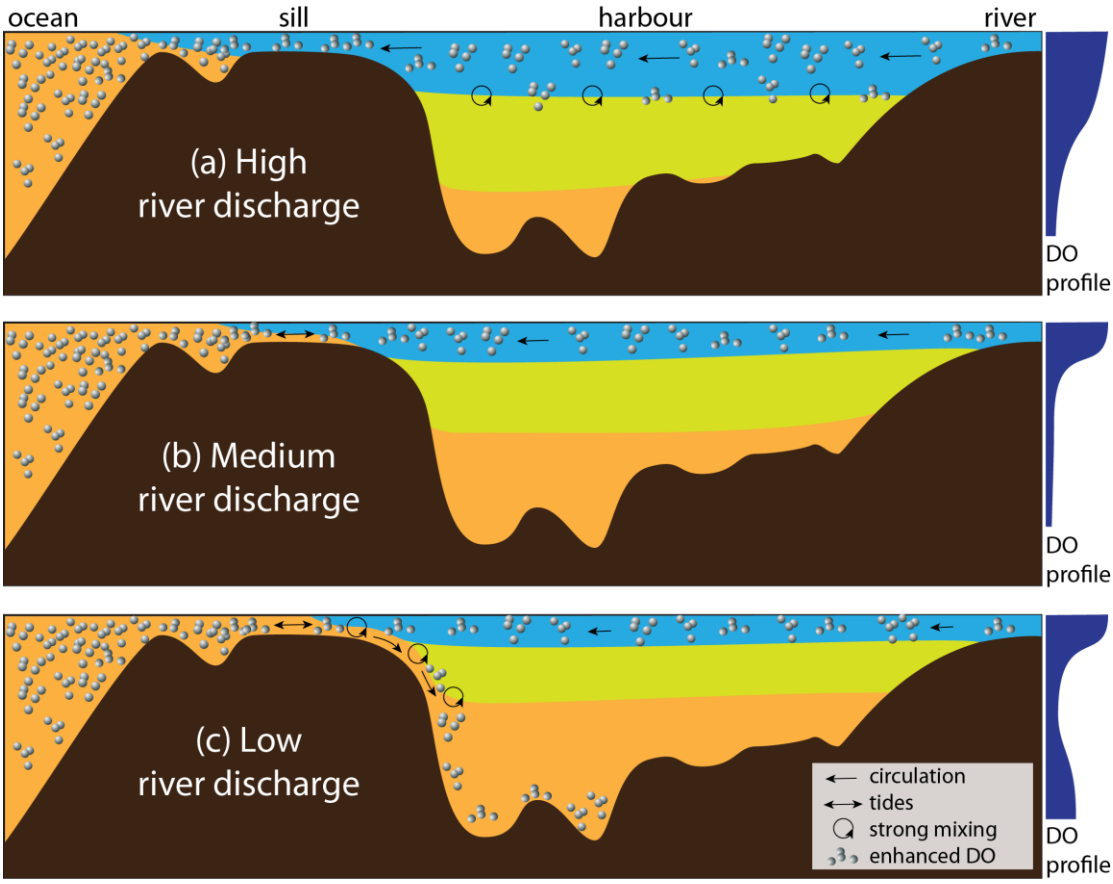
DO in Macquarie Harbour is generally replenished through two mechanisms:

1. Mixing with higher DO surface waters
2. Higher DO waters coming in over the sill 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 that the Harbour has fluctuating DO levels in the bottom waters that are dependent on natural processes. The EPA have 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 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.

The diagram below shows the influence river discharge to the system plays in DO recharge and profile to bottom waters:



The complexity of the drivers to this system mean that none of the marine leases within this unique system are exactly the same, and for this reason need 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.

Adaptive management applied to marine farming requires farmers to 'move with the system' and farm to the conditions relevant to their lease at any particular time. Examples of this adaptive approach to environmental change in Macquarie Harbour would be the need to respond to external influences such as Hydro discharges, the dynamic nature of water recharge over the sill and weather events e.g. drought as seen in 2015/2016.

Compliance:

As previously mentioned Macquarie Harbour is a dynamic system with a range of inputs, including both fresh water and organics derived from river systems. Marine leases within the system are managed on an individual basis as their proximity to oceanic exchange, fresh water flows and placement around the deep basin sections within the system all play an integral part in environmental management. Assimilation capacity of individual leases within the system is known to vary and again the management of leases is on a site by site basis for this reason.

Tassal has reduced biomass over the past few years on specific lease sites to manage benthic impacts at our sites in the system. There has been amplification of farming footprints and related indicator species seen in some farming locations and Tassal has fallowed specific sections of leases in response to this. Research is starting to help us understand these interaction mechanisms and responses but some still remain unpredictable.

Tassal conducts benthic compliance work in line with government licencing requirements on all active marine leases. As of July 2016 the environmental management of the salmon industry is the responsibility of the Environment Protection Authority (EPA). Video footage of the benthic environment is collected at compliance points using a remotely operated vehicle (ROV) both within and outside of each lease area determined by the EPA. ROV footage along with a report and biodiversity database is then supplied to the EPA for assessment and review. Results from observational work are used in conjunction with depositional modelling as a management tool to predict and minimise organic deposition footprints.

Industry regulation uses a range of indicators listed in licence conditions, an example of these is *Beggiatoa* (bacteria) which is an indicator of organic enrichment (potentially caused by fish feed and faeces) being present in the benthos. *Beggiatoa* is a filamentous bacteria, reliant on the availability of sulphide, and is typically found in low oxygen conditions. *Beggiatoa* is a naturally occurring bacterial formation and is often also found in areas of high organic input that is not fish farm-derived. It is regularly observed in waterways after high rainfall where sediment runoff has ensued and also areas where macroalgae has been deposited post storm events.

Tassal's Macquarie Harbour sites have had good compliance history across the Middle (MF214) and Gordon (MF219) leases. Since 2013, the Middle lease has had a compliance of 98.64% overall. The Gordon lease follows suite with 94% compliance historically.

The Franklin lease (MF266) has had a compliance of 87% since the lease was commissioned in 2013 until August 2016. Recent observational work conducted in September produced unusually large amounts of bacterial matting. This resulted in a recent benthic compliance of 54% for this lease.

In light of recent findings, Tassal commissioned independent environmental scientists to investigate a range of potential causative factors and recommendations for additional monitoring into the future. It is now known from recent industry findings that a large component of oxygen consumption in

Macquarie Harbour is within the World Heritage Area (WHA). It is no coincidence that this area is subjected to the largest organic input as particulates flow down the Gordon River and into the Harbour. Tassal and researchers believe that the recent formation of bacterial mats could be related to increases in organic material from the Gordon River catchment, influencing the Franklin lease. It is also known that this area of the Harbour system is the last to see oceanic recharge to bottom waters due to the bathymetry of the system. The main basin in the central area of the Harbour and where most of the marine leases are located is generally the first area to be recharged with oceanic water.

In addition, drought conditions occurred in the late part of 2015, followed by double the average rainfall from May-July 2016. It is suspected that previous periods of low dissolved oxygen bottom water are in part due to an increase in organic material (mostly sourced from river runoff), which has resulted in the presence of bacterial matting at some locations within Macquarie Harbour. Tassal has looked into a range of potential influences such as rainfall records at Strathgordon (Gordon power station), relationship between dissolved organic carbon (nutrients) and river flow, current flow into and out of Macquarie Harbour and dissolved oxygen content across a range of depths near the Franklin lease and at different points around the Harbour.

As a management response to recent results, Tassal is fast-tracking harvest of the Franklin lease, therefore reducing organic input from our farming operations and increasing fallow periods. This will give the sediment extended time to recover. Tassal is of the belief that there is a need to 'move with the system' to maintain sustainable farming in this important waterway. This means working with scientists to continually improve our understanding of the system and complying with the direction of the regulator. Maintaining compliance is critical to Tassal and maintaining our ASC (Aquaculture Stewardship Council) certification.

Fish Health:

A direct measure of fish health is clearly survival. Our 2015 year class (YC) has had excellent survival; even better than previous years. On its current trajectory, the 2015YC are on track for >90% survival which is world's best practice. This is primarily due to improved husbandry, smolt quality and a better understanding of our lease characteristics. Indirect measures of fish health are used throughout the production cycle.

- Feed rates are monitored daily, an early indicator of fish health.
- Biological Feed Conversion Ratio (FCR) is an indication of how well our fish are able to convert feed into growth. Biological FCR is directly impacted by health and is hence used as a long-term measure of wellness.
- We have not seen our biological FCR deteriorate over our time in the Harbour. Even through the hottest summer on record in 2015/16, our biological FCR for that year class is still tracking well, and is better in comparison to previous year classes.
- Our surveillance program aims for early detection of disease. It is a passive surveillance program where we regularly collect diagnostic samples from fish throughout their production cycle to understand their health and what issues may be present.

Exceptions with the 2014YC:

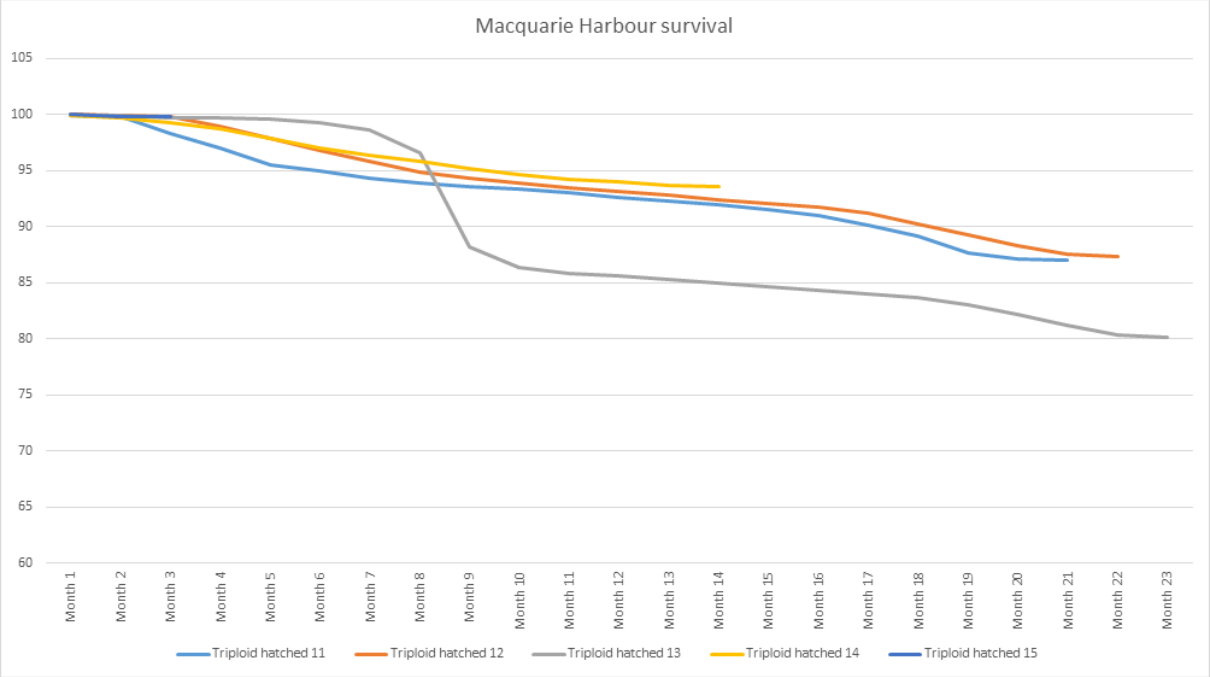
- Tassal suffered mortalities in the 2014YC due to issues with smoltification.

Smoltification is a complicated process where fish undergo changes to their osmoregulatory capacity. New diagnostic tests are continually being developed to better understand this process. Tassal has invested in research and development (R&D) to continually improve our diagnostic capabilities in this area.

Fish Health Best Practice in Macquarie Harbour

- Sourcing stock from recirculation aquaculture systems free from disease.
- Increased smolt size to reduce time at sea.
- Improved smolt quality.
- R&D into smolt readiness.
- New reporting/escalation strategies for early detection of health issues.

See graph below for Macquarie Harbour fish survival and performance.

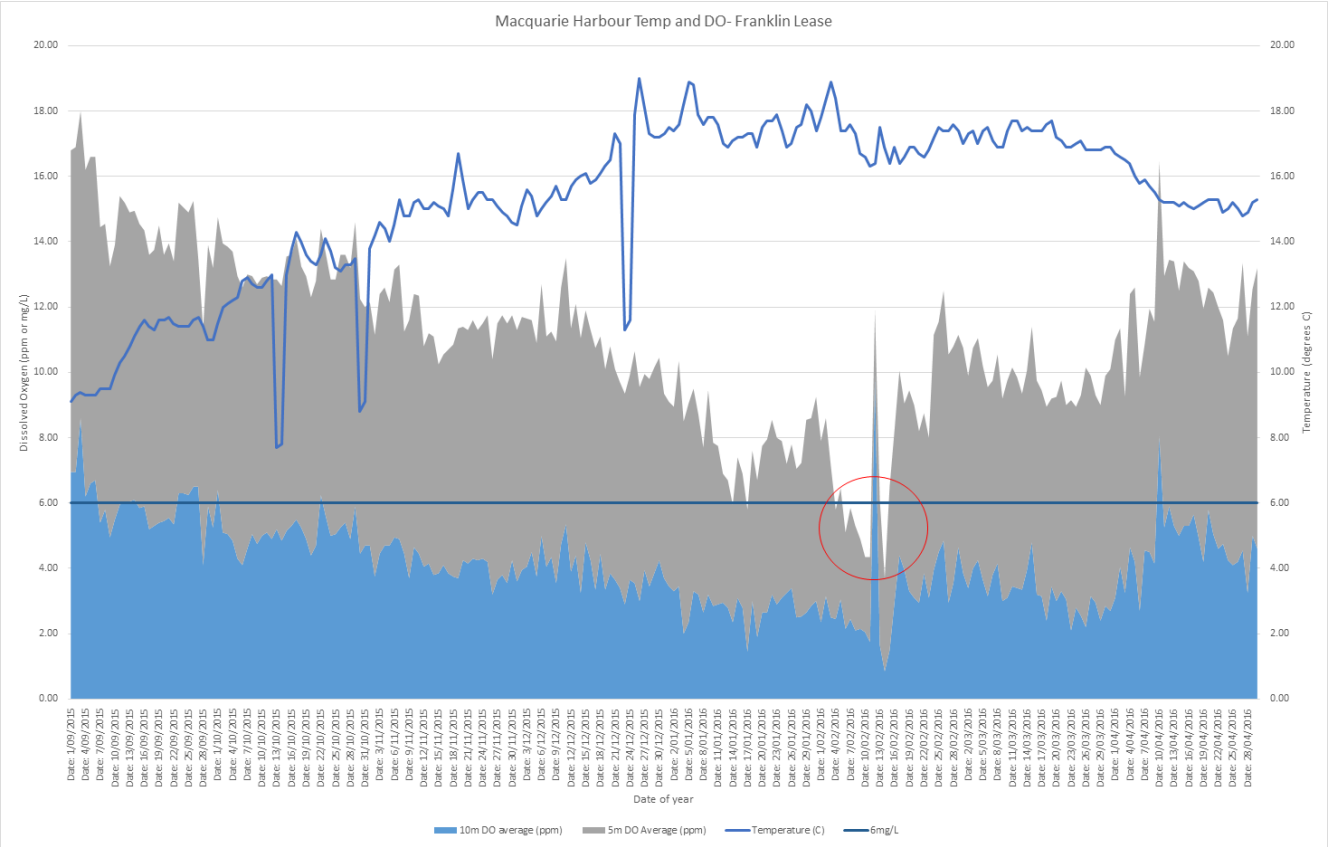


Summer 2015/16 - higher temperatures and lower dissolved oxygen

The graph below is an overlay of 5m and 10m dissolved oxygen profiles with a temperature line graph based off on-site data from Tassal's Franklin lease in Macquarie Harbour.

- Suboptimal levels of dissolved oxygen were only an issue for our fish for less than a week, and there were management strategies put in place e.g. reducing stocking density and feed management to reduce the impact on fish welfare.
- Areas above the 5m mark had higher dissolved oxygen concentrations
- Stocking densities were 4-5kg/m3 through the Jan-Feb period on average calculated on cage volume, hence a maximum density of 10kg/m3 if half the volume of the cage was available
- Temperatures of >18 degrees were observed for periods of no more than 3 days at a time
- Our fish behaviour is monitored by underwater cameras
- Despite the recent, difficult weather conditions, we are experiencing good survival this year which is a combination of thermal tolerance and best practice husbandry practices

The red circle highlights when there were suboptimal ranges for fish to survive and grow – this was discussed in Dempster et al. (2016).



Management Approaches to Low Dissolved Oxygen Periods:

Typically, dissolved oxygen (DO) shares a negative correlation with water temperature, therefore increasing water temperature results in decreasing DO. The likelihood of low DO throughout the water column is increased during the summer months. Tassal utilises a range of both proactive and reactive strategies to mitigate low DO at marine leases.

Management Controls

In-cage biomass is reduced prior to summer by splitting cages into two or more populations. This decreases the DO demand for each individual cage, in turn reducing stress on stock. In addition, these biomass splits occur into larger size mesh nets to maximise water flow. Stock transactions are monitored carefully using multiple DO probes in recipient and donor cages. DO is maintained using liquid oxygen and air stone racks throughout this high stress event.

Dive frequency is increased during summer months, with a focus on net scoring and mortality retrieval. Divers are trained to assess the level and type of biofouling on nets which feeds into high frequency, low volume net cleaning regimes. Cleaner nets allow for higher water exchange and flowthrough.

Tassal uses specific summer diets throughout warmer months. These diets contain increased antioxidant capacity, with the aim of reducing stress and increasing disease tolerance. Research is undertaken in this area for continual improvement.

DO probes are contained within every Tassal pen, continuously feeding information back to a centralised feed barge. A fish not only requires additional oxygen whilst burst swimming for feed, it also utilises oxygen in metabolic processes post-feeding. It is for this reason that minimum DO limits are set for feeding and if exceeded, feeding is ceased until DO rises to an acceptable level. This aims to reduce stress on stock, reduce oxygen consumption and mitigate against potential mortalities due to insufficient DO. There is also a greater focus on DO probe calibration to ensure accuracy of readings.

Daily algal monitoring is conducted, allowing farms to determine algal species diversity and abundance. This assists with the early identification of potential algal eutrophication events which may decrease DO. These events are rare, especially in Macquarie Harbour due to fresh water influence.

Proactive Controls

Tassal uses stock sourced from an industry-owned Selective Breeding Program (SBP). Based on traditional breeding principles, Tassal selects for a range of desirable traits using traditional techniques. Tassal recognises the importance of thermal tolerance in stock, which is why this trait is given special consideration in the SBP process.

Tassal is investing in research of thermal stress markers with the aim of assisting with future breeding and nutritional work is ongoing.

Dorvilleids:

The current regulation controls in Macquarie Harbour were developed based on farming practices and conditions in the south east of the state – these two farming areas are now known to be materially different in their reaction to farming inputs.

Targeted research by IMAS is ongoing in relation to understanding the role of Dorvilleids as a visual indicator in Macquarie Harbour. While this research is continuing, the regulatory authority has determined that the presence of this indicator alone in and around marine leases does not constitute a significant visual impact.

The response of dorvilleids in Macquarie Harbour to organic enrichment from salmon farming has been inconsistent with predictions drawn from other comparable species found in the South East. This difference has highlighted the need for focussed research in relation to the ecology and system response to organic enrichment in Macquarie Harbour. As mentioned, this research is ongoing and to date has discovered the presence of two separate species living in the Harbour system. There is a report on this 12 month study on the FRDC website along with a range of other aquaculture research that Tassal has been involved in.

Skate:

Macquarie Harbour is one of only two areas known to be occupied by the Maugean skate. A recently completed IMAS study has established that the skate is distributed throughout Macquarie Harbour, with a clear preference for the shallow regions (mainly 5-15 m depth). Tracking of individual skate has demonstrated that while many spend much of their time occupying relatively small home ranges they may also disperse over relatively large distances, occasionally into the deepest areas of the harbour, before returning to their home range. Skate feed mainly on a diet of crustaceans and show no evidence of feeding on fish pellets. The IMAS study also concluded that the population is considerably larger

than previously assumed and that, because of their depth preferences, there was relatively limited overlap in preferred habitat and marine farm lease areas.

Tassal are currently in discussions with IMAS to develop a research proposal to continue the research into this species. This next step in the skate research will focus on how the skate respond to and cope with the varying environment conditions within the Harbour system.

Next Steps:

For the upcoming summer (2016/2017) Tassal is commissioning several work packages with International experts in relation to risk identification and adaptive management of the Tassal leases. This work will review past and current information sources.

As widely documented the Harbour is a unique, somewhat unpredictable system with not all areas of the system behaving the same. This means that conditions on one lease may not be the same as those seen on another, nearby lease. By assessing the areas that influence the system we can better predict risks and implement best management practices for fish health and environmental management.

The Tassal summer risk assessment work this year will cover the following:

- Production of an updated risk assessment to examine a number of different scenarios that may occur this summer. This component of the research will focus on the direct risk to the fish at Tassal's three leases.

- Examination of the existing climate forecasts for the next 6 months through both Australian and New Zealand bureau's to determine reliability of seasonal outlook.

- Undertake regression analysis between different influencing parameters i.e. dissolved oxygen, temperature, organic material, river flow etc. and assess correlations. By looking at past conditions an examination will be done around the evolution of oxygen and temperature across the Harbour and how this has developed over the last few years.

- Assessment of methods to collect quality weather/ climate data for Macquarie Harbour. This will improve future predictive capability and accuracy and also track how the system is changing over time.

- Investigation into the risk of overturning/ inversion events happening as a result of strong river flow after low rainfall events and dry periods.

- Collaboration with CSIRO and Industry to calibrate existing hydrodynamic model for Macquarie Harbour in order to determine why different leases behave so independently of each other.

Additional Work:

Tassal are also working on the following areas of research within Macquarie Harbour due to recent findings from the compliance work conducted at the Franklin Lease. This site is the first in the Harbour to see the huge fresh water pulses deriving from the river systems and the last to see oceanic inputs across the sill at Hell's Gates. We are currently increasing our knowledge of what

these key input drivers mean for our operations and environmental management at this end of the Harbour:

- Dissolved organic carbon inputs compared with Gordon River flows
- Dissolved organic carbon concentration from Gordon River discharges (comparison with previous years)
- Dissolved organic carbon budgets in the entire system
- Rainfall records at Strathgordon (Gordon river catchment)
- Gordon River discharge rates and fluxes
- Gordon River flows compared with actual rainfall records
- Current flow at Hell's gate (determine level of marine water and dissolved oxygen exchange and therefore recharge of system waters)
- Updated depositional modelling (DEPOMOD) for Franklin Lease
- Possible impacts of low lake levels on organic matter deposition to the system
- Installation of a real time Acoustic Doppler Current Profiler (ADCP) at the Franklin feed barge, capable of displaying and recording water movements throughout the entire water column
- Ongoing funding for Sense-T dissolved oxygen probes deployed through the water column

In Summary:

- Tassal has always been compliant with biomass limits prescribed by the regulator
- Tassal voluntarily adjusts and lowers stocking density as conditions change
- Last summer heat stress was an issue due to abnormal weather conditions. Tassal experienced similar conditions at all our leases, across the State.
- Although fish were lethargic over this time period, Tassal fish health were excellent in the harbour and survival rates were above other areas in the state
- Our monitoring shows recharge events of dissolved oxygen levels in Macquarie Harbour and we continue to track this
- Latest forecasting predictions show this coming summer to not be as warm as last summer so conditions should continue to improve
- Not all farming sites in the harbour are the same in relation to water quality or environmental assimilation of organic matter
- Tassal has developed a Mass Mortality plan for the EPA in conjunction with the TSGA; however Tassal already had a well-established, emergency response plan in place. This is a standard farming practice and should not be interpreted that Macquarie Harbour is unsustainable and not suitable for salmon farming.