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## Risks to the Tasmanian Abalone Fishery from further expansion of the Salmonid Industry

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**Dean Lisson**  
**Chief Executive**  
**Tasmanian Abalone Council Ltd**  
262 Argyle Street, Hobart, Tasmania  
Phone; 03 62 311955  
Fax; 03 62 311966  
Email; [deanlisson@tassie.net.au](mailto:deanlisson@tassie.net.au)  
[admin@tasabalone.com.au](mailto:admin@tasabalone.com.au)  
Web; [www.tasabalone.com.au](http://www.tasabalone.com.au)  
[www.abalonecouncil.com.au](http://www.abalonecouncil.com.au)  
[www.australianwildabalone.com.au](http://www.australianwildabalone.com.au)

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## Risks to the Tasmanian Abalone Fishery from further expansion of the Salmonid Industry

September 2014

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Please note that this is a preliminary document that sets forth the general position of the Tasmanian Abalone Council Ltd (TACL) with regard to the risks associated with further expansion of the salmonid farming industry. This initial submission will be updated and extended with further detail pending the supply of more information from a range of sources.

### **Executive Summary**

Tasmania's wild harvest Abalone industry has been generating wealth and creating jobs in Tasmania for over half a century and will continue to do so forever provided the fishery is harvested sustainably and the inshore marine habitat where abalone thrive remains pristine.

Valuable export revenue generated by the abalone industry (\$100 million per annum) generates some \$300 million of associated economic activity (via economic multipliers) into the state's economy and employs over 800 Tasmanians in regional and coastal communities around Tasmania. (<http://tasabalone.com.au/about%20the%20industry/>) The total capitalised value of the industry exceeds \$750 million taking into account the value of abalone quota plus fishing, processing and exporting infrastructure.

The industry's peak body, the Tasmanian Abalone Council Ltd (TACL), has recently engaged in a series of meetings with Tasmania's two largest salmonid producers - Tassal Group Ltd (Tassal) and Huon Aquaculture P/L (HAC).

These meetings have been prompted by the publicly stated intention of both companies to double the size of the salmonid industry by 2030 and to expand their activities out to inshore oceanic waters. This is a deviation from past practises where salmon cages have been located within sheltered estuarine harbours, channels and embayments.

Tassal Ltd has recently confirmed its intention to apply for expanded salmonid lease sites between Dover and Southport in the lower D'Entrecasteaux channel – cage systems at these sites will contain 1.7 million salmon when fully stocked. These sites are adjacent to productive abalone and rock lobster habitat.

Huon Aquaculture P/L (HAC) has recently confirmed its intention to apply for four lease sites offshore from North Bruny Island near Cape Queen Elizabeth. HAC have stated on their website that they hope to be able to farm the amended lease sites of North Bruny from early 2015 – cage systems at these sites will contain up to 4 million salmon when fully stocked. These sites are adjacent to productive abalone and rock lobster habitat.

**The potential expansion of salmonid farming activities into inshore oceanic waters adjacent to productive wild abalone beds poses a number of risks to the Tasmanian commercial Abalone industry. These risks relate to reduced resource productivity and increased bio-security, navigational and dive safety risks.**

It is a widely acknowledged fact that Salmon farming has a detrimental affect on water quality and substrate characteristics in close proximity to farming operations. The degree to which these impacts occur depends on the intensity of the farming (i.e. stocking density and fish

feed inputs) and the capacity of the receiving marine environment to buffer or assimilate these impacts.

Tasmania's burgeoning salmonid industry has been impacting the marine environment in the D'Entrecasteaux Channel in Tasmania's southeast for 30 years.

There is a commonly held and unequivocal view amongst commercial abalone divers who harvested abalone in the D'Entrecasteaux Channel during the seventies, eighties and nineties that the benthic community in some sections of the lower Channel has altered in a way which is less supportive to habitation by abalone and other benthic reef dwellers which were once abundant in this area.

During the last decade abalone divers have regularly reported a fine layer of "milky dust" covering some parts of the inshore benthic community – they also report a change in the type and form of algae that grows in some of the bays and around the shoreline of the lower Channel.

Tasmania's 120 Abalone divers have averaged over 27,000 hours underwater per year for the last 10 years (aggregated total figure based on DPIPWE catch data). This puts them in a unique position as the "sentinels" of Tasmania's inshore oceanic environment simply because they witness with their own eyes almost all of Tasmania's coastline which is 4882kms long (including islands).

By virtue of their affinity with the ocean, their general concern for its well being and the fact that they spend so much time underwater, Tasmania's abalone divers are "early detectors" of any short, medium or long term changes to the underwater environment.

The following underwater video recorded on the 30<sup>th</sup> of August 2014 provides visual evidence of the impact of salmonid farming on the marine environment – please click on the below weblink:

<http://youtu.be/aUrvhSIJ76A>

**The primary risk to the wild abalone fishery in Tasmania from any oceanic expansion of the salmonid sector relates to long-term environmental degradation of inshore abalone habitat by sustained nutrient and sediment inputs from finfish farming activities.**

The Tasmanian Abalone Council calls on the Tasmanian Government to take the following actions:

1. Impose a moratorium on salmonid farm expansion into oceanic waters until a comprehensive review of the environmental effects of salmonid farms on inshore Tasmanian oceanic benthic environments can be properly and comprehensively conducted. This review should focus on the local and broadscale environmental effects and bio-security risks of salmon farming on oceanic benthic flora and fauna and should examine the impact on the structure and bio-diversity of reef systems in response to sustained nutrient and sediment inputs from salmonid farming systems. **Tasmania's two most valuable and iconic wild fishery resources – abalone and rock lobster - should not be subjected to environmental risks from the expansion of the salmonid sector into oceanic waters.**

2. In order to protect productive abalone and rock lobster beds in the Lower D'Entrecasteaux Channel, the Government impose a permanent ban on any salmonid farming activities south of a straight line between Scotts Point on the southern side of Port Esperance (Dover Bay) and the northern tip of Partridge Island.
3. In order to protect inshore productive abalone and lobster beds in Storm Bay, any future salmonid cage systems to be established no closer than 4 nautical miles from the shoreline. This would move the salmon cages towards the centre of Storm Bay and create a buffer zone which will significantly reduce the risk of the inshore benthic flora and fauna being adversely affected by salmon farm inputs.
4. The *Broadscale Environmental Monitoring Program* (BEMP) be reviewed by the Government and relevant Marine Research institutions for data gaps and expanded to include oceanic reef sampling and monitoring sites in the lower Channel and Storm Bay - i.e. additional sampling sites that include pristine oceanic reef habitat - these sites to monitor macro-faunal communities, micro and macro algal structure/abundance/distribution as well as water and sediment quality. The underlying BEMP data to be made available to the abalone industry to conduct its own regular review and analysis.

**Additional “recommendations for action” are outlined at the end of this paper.**

#### KEY RECOMMENDATION FROM THE TASMANIAN ABALONE INDUSTRY

The primary recommendation of the Tasmanian Abalone Council is that future expansion of the Salmonid sector in Tasmania should feature the use of offshore cage systems that are located four (4) or more nautical miles away from inshore oceanic reef habitat. An environmental buffer zone of this magnitude will provide adequate protection to the *inshore reef habitat* around Tasmania's pristine coastline which is of immense cultural, recreational and commercial value to the citizens of Tasmania and the world. This habitat should be continuously monitored for ecological changes and the **precautionary principle** should be adopted by the Government in any decisions regarding its future.

From Wikipedia, the free encyclopedia

The **precautionary principle** or precautionary approach states that if an action or policy has a suspected risk of causing harm to the [public](#) or to the [environment](#), in the absence of [scientific consensus](#) that the action or policy is not harmful, the [burden of proof](#) that it is *not* harmful falls on those taking an action.

The principle is used by policy makers to justify discretionary decisions in situations where there is the possibility of harm from taking a particular course or making a certain decision when extensive scientific knowledge on the matter is lacking. The principle implies that there is a [social responsibility](#) to protect the public from exposure to harm, when scientific investigation has found a plausible risk. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result.

**The abalone fishery depends on complex environmental factors to replenish and maintain healthy stock levels. Many of these factors are not completely understood nor do we have control over them. The consequences of environmental disturbance in a wild fishery can be devastating and extremely difficult or impossible to reverse and as such the *precautionary principal* should be adhered to whenever possible.**

**This paper outlines the initial concerns of the TACL regarding the proposed expansion of salmonid farming activities into oceanic waters where wild abalone thrive within a healthy inshore benthic reef ecosystem.**

### **Tasmania's iconic wild Abalone fishery**

Tasmania has the world's largest wild abalone resource – the Tasmanian commercial abalone fishery produces a staggering 25% of total global production of *wild caught* abalone and generates approximately \$100 million of annual export revenue for the state.

The foresight, innovation and responsible custodial attitude of abalone stakeholders over the past 5 decades has created and sustained a valuable export industry that injects substantial income into the Tasmanian economy in many diverse ways creating employment in regional and coastal communities around the state.

Fundamental and substantial restructuring of the abalone industry in the early nineties has seen more and more Tasmanians investing directly and participating in the industry. Approximately 83% of Tasmanian abalone quota is currently owned by Tasmanian family businesses – many of these businesses are located in regional Tasmania providing crucial "local" economic stimulus within small coastal communities. The total capitalised value of the industry exceeds \$750 million taking into account the value of abalone quota plus fishing, processing and exporting infrastructure.

On a broader scale, Abalone industry stakeholders provide many areas of Tasmanian commerce with vital and solid investment capital – this capital supports important infrastructure in other industries/businesses such as agriculture, viticulture and wine making, retail, wholesale, property development and tourism.

Inbound Chinese tourist numbers have increased by 14.2% since 2012/2013 (<http://www.tourism.australia.com/statistics/10455.aspx>) and an increasing number of them are visiting Tasmania and seeking out seafood related experiences.

*"Survey results released on Wednesday (23/9/14) show Tasmania's visitor numbers grew to a record 1.06 million in the 12 months to June. The biggest international growth market was China, up 61 per cent from the year before."*

(<http://www.themercury.com.au/lifestyle/tasmanian-casino-lays-out-the-welcome-mat-to-chinese-visitors/story-fnj64obd-1227071971788>)

Wild abalone is the most revered food in Chinese cuisine and as such there is much potential for Tasmania tourism and food & beverage businesses to capitalise on this growing opportunity by featuring abalone (and other premium Tasmanian seafood) as a part of the visitor experience.

Tasmania will produce 1932 tonnes of live weight abalone during the 2014 quota year with 95% of this exported principally to China, Hong Kong, Singapore, Taiwan and Japan and 5% consumed within Australia. All Tasmanian abalone export premises must comply with strict export standard food safety regulations.

Tasmanian wild abalone is harvested from one of the world's most pristine marine environments, has a high nutritional value and is a 100% natural and organic product.

Because it is "hand-harvested" in a sustainable manner, there is negligible environmental impact on the reef ecosystem.

The Tasmanian Abalone fishery was one of the first fisheries in Australia accredited as 'sustainable' under the Commonwealth *Environment Protection & Biodiversity Conservation Act 1999*.

Australian (and Tasmanian) wild abalone is recommended for consumption by the World Wildlife Fund (WWF) because they recognise and acknowledge that it is harvested from well

managed sustainable fisheries and is harvested in an ecologically friendly way. ([http://awsassets.wwfhk.panda.org/downloads/wwfhk\\_seafood\\_guide.pdf](http://awsassets.wwfhk.panda.org/downloads/wwfhk_seafood_guide.pdf) ).

The industry is continually investing in a range of R&D projects and initiates and funds millions of dollars worth of research much of which is conducted right here in Tasmania by UTAS, CSIRO and IMAS.

Approximately 95% of annual production is exported and is sold in an increasingly sophisticated and highly competitive global market. Tasmanian abalone exports are subjected to various tariff and non-tariff barriers across a number of global markets – these trade barriers present an ever-changing and complex series of challenges to our exporters.

Despite these challenges, the Tasmanian abalone industry has grown from very humble beginnings in the mid sixties to an industry with a conservative capitalised value of around \$750 million that generates \$300 million of economic activity annually – it has achieved all of this with no subsidisation from the Tasmanian Government. The industry is a net provider of revenue to the Tasmanian Government and has paid over \$150 million in licence fees and royalties over the last 30 years.

For further information please refer to:

[www.tasabalone.com.au](http://www.tasabalone.com.au)

[www.abalonecouncil.com.au](http://www.abalonecouncil.com.au)

[www.australianwildabalone.com.au](http://www.australianwildabalone.com.au)

In addition to the commercial harvest of abalone, the wild abalone fishery also supports significant indigenous and recreational fishing activities.

### **The Tasmanian Salmonid industry – good for the economy but not so good for the marine environment**

No one would dispute the very significant positive contribution that the salmon farming industry has made to the Tasmanian economy since its inception.

In recent times, salmon farming enterprises have worked hard to improve their operational practices in a genuine attempt to lessen their impact on the marine environment from which they derive their income. They have also worked hard and invested significant capital into improving their environmental credentials – this is an investment in their *social licence* to enable them to continue to operate and to also expand beyond their currently constrained production limits.

In any broad discussion of the merits or otherwise of the salmon farming industry, the following facts should not be forgotten or overlooked:

- The salmonid industry adds \$190 million to the Tasmanian State Gross Product and employs 1500 Tasmanians (<http://www.tsga.com.au/history/> )
- Salmon farming poses a number of ecological and bio-security risks to the marine environment and its activities degrade a public resource that many other businesses and resource users rely upon
- Salmon farming generates localised amenity impacts such as noise and visual pollution, boating & navigational hazards and reduces waterway area available for general unrestricted use
- Tasmania's salmon farming relies on the propagation of an *introduced species* sustained with *artificial food* in *man-made structures*

- It is a widely acknowledged fact that Salmon farming (as previously and currently practised in Tasmania) has a detrimental effect on water quality and substrate characteristics in close proximity to farming operations. The degree to which these impacts occur depends on the intensity of the farming (i.e. stocking density and fish feed inputs) and the capacity of the receiving marine environment to buffer or assimilate these impacts. The salmonid industry and State and Federal Governments have invested significant resources into understanding the near-farm environmental effects of salmonid production.
- The broadscale and long-term environmental impacts of salmonid farming on the marine environment are less well understood.
- There is a general lack of research regarding the environmental impacts of salmonid farming on inshore Tasmanian oceanic benthic flora and fauna communities.
- Environmental monitoring of the *near-farm* effects of the salmonid industry is undertaken by the salmon growers themselves thereby raising concerns regarding *conflict of interest/lack of independence*.
- Environmental monitoring of the *broad-scale* effects of the Salmonid industry in the Huon and D'Entrecasteaux regions is undertaken by an independent contractor but this contractor is *paid* by the salmon growers themselves thereby raising concerns regarding *conflict of interest/lack of independence*.

### **Expansion plans of the Tasmanian Salmonid industry**

As mentioned above, the Tasmanian Abalone Council Ltd (TACL) have engaged in a series of meetings with Tassal and Huon Aquaculture (HAC) in recent months. These meetings have been prompted by the publicly stated intention of both companies to double the size of the salmon industry in Tasmania by 2030 and to expand their marine farming activities into oceanic waters.

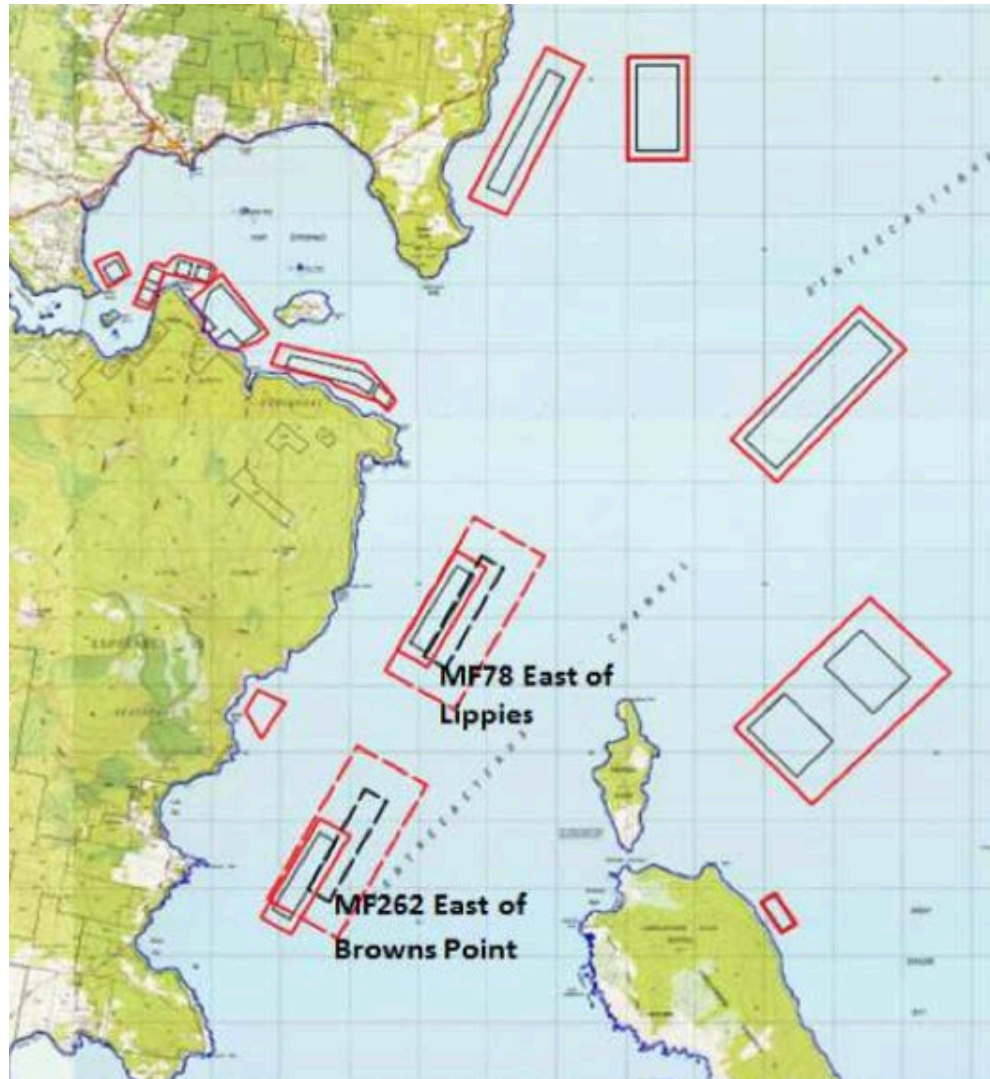
Tassal has recently confirmed its intention to apply for expanded lease sites between Dover and Southport. These lease sites are called Lippies and Browns (refer below map) and will be sited close to the centre of the D'Entrecasteaux Channel – cage systems at these sites will contain 1.7 million salmon when fully stocked.

Huon Aquaculture (HAC) has confirmed its intention to apply for lease sites offshore from North Bruny near Cape Queen Elizabeth. HAC plans to place five pens on the existing lease in Trumpeter Bay in September 2014. HAC claims that this will in effect be a “mini-lease” which will allow them to undertake rigorous monitoring and testing of new infrastructure and systems in a production setting.

HAC will be applying to the Tasmanian Government to split the Trumpeter Bay lease into four sub leases (each 50ha) and move them further out from shore (refer below map). HAC have stated on their website that they hope to be able to farm the amended lease sites of North Bruny from early 2015 – cage systems at these sites will contain up to 4 million salmon when fully stocked.

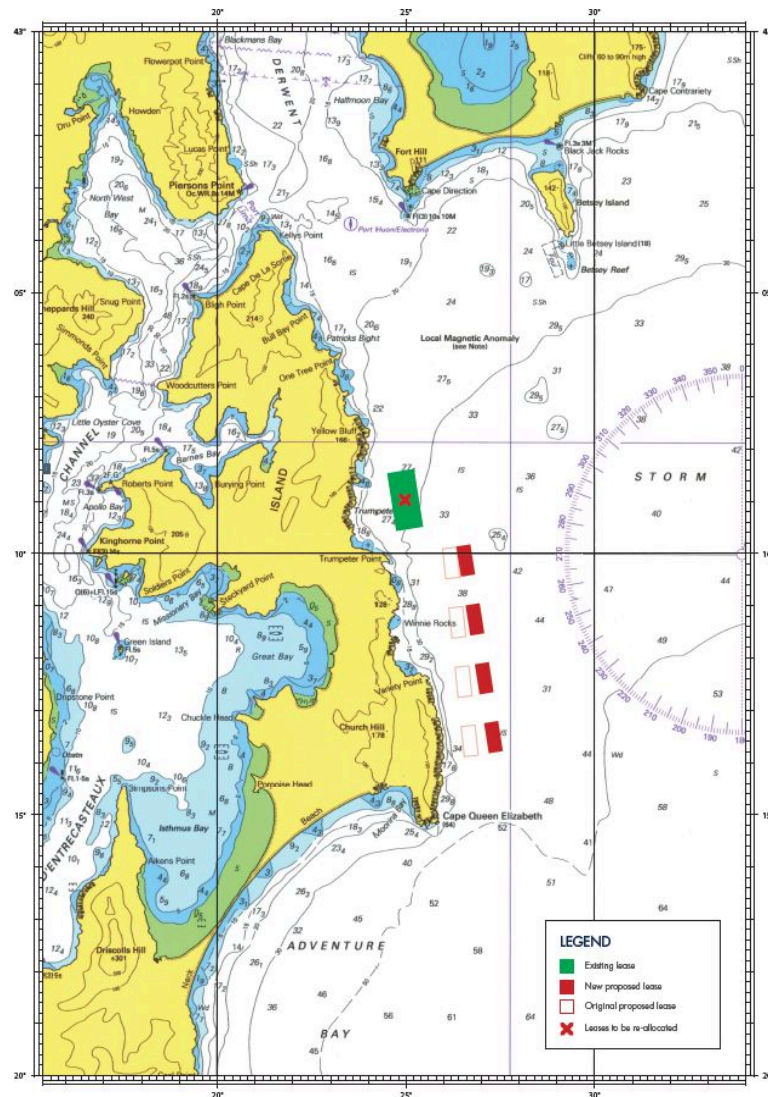
Both companies have stated that these applications are merely the first stages in a significant expansion phase into oceanic waters around Tasmania.





Tassal's proposed "Lippies" and "Browns" lease sites south of Dover





Huon Aquaculture proposed lease sites offshore from North Bruny Island

### **The known detrimental effects of Salmonid farming on the marine environment**

The principal *ongoing risk* to the abalone industry is degradation of the marine environment upon which the resource and the industry depend – localised and broad-scale habitat degradation due to anthropogenic impacts – i.e. human activity that impacts the marine environment such as pollution, sedimentation from run-off, the effects of global warming and the introduction of exotic diseases may ultimately lead to a reduction in the health and productivity of the abalone fishery.

Salmon farming is one anthropogenic activity that poses a risk to the Tasmanian wild abalone fishery. This risk increases when salmon farming is conducted in close proximity to the benthic reef communities that abalone inhabit.

It is a widely acknowledged fact that Salmon farming (as previously and currently practised in Tasmania) has a detrimental affect on water quality and substrate characteristics **in close proximity** to farming operations. The degree to which these impacts occur depends on the intensity of the farming (i.e. stocking density and fish feed inputs) and the capacity of the receiving marine environment to buffer or assimilate these impacts.

Salmon farm inputs potentially detrimental to abalone habitat include the *principal* inputs of artificial fish feed and fish excreta plus the *incidental* inputs such as anti-foulants, heavy metals (principally copper and zinc), fuel & oil spills, rotting and/or dead fish, fish escapees, recoverable and non-recoverable farm debris and cleaning chemicals. Other detrimental impacts may occur as a result of the restriction of wave action and water flow around and through cage systems to neighboring marine habitats. This list is by no means exhaustive.

The *principal* inputs of *fish feed* and *salmon excreta* introduce soluble and insoluble components into the water column around and underneath salmon cages. The soluble component (principally fish excreta) is nutrient rich and is dispersed by water movement through and around the cages. The insoluble component sinks to the seabed and creates a layer of sediment that builds up under the cages. Near-farm water quality testing and ROV monitoring of sediment accumulation under the cages is used to determine when to move the cages to new sites and allow *fallowing* of the original site – *fallowing* is the process whereby the salmonid companies relocate cage systems from time to time so that the marine environment within their lease footprint is given time to assimilate - i.e. “break down” the organic components of the farm inputs. Tidal currents and bottom currents may disperse the sediment beyond the salmon farm lease boundary – indeed, abalone divers regularly report a fine layer of sediment covering inshore reef systems that are adjacent to salmonid farms.

In stark contrast to salmon farming, bivalve farms (mussels & oysters) are fed by naturally occurring nutrients and food sources within the water column – being filter feeders, mussels and oysters filter out suspended solids and remove excess nitrogen from the water column thereby reducing the likelihood or extent of harmful algal blooms or anoxic conditions.

*Farmed Atlantic Salmon however are sustained using industrial scale quantities of artificially manufactured feed.*

While oyster and mussel farms remove excess nitrogen, salmon farms dump excess nitrogen into the marine ecosystem (hence the need for a nitrogen “cap” that limits salmonid production capacity in the D’Entrecasteaux Channel). Artificial salmon feed residues and salmon excreta in high concentrations can lead to eutrophication within the water column – i.e. nutrient overload which in turn can lead to hypoxia (oxygen depletion) and phytoplankton blooms. Eutrophication causes a severe reduction in water quality and generally promotes excessive plant growth and decay, favouring simple algae and plankton over other more complex marine plants such as the macro-algae that mature abalone feed on.

### **Risks posed to the wild abalone fishery by inputs from salmon cage systems**

Abalone are grazing animals, eating marine algae using a serrated “tongue” as they move across the ocean floor. To support a healthy comprehensive age range of animals a complex assortment of feed is required. Large brown algae such as cray weed, giant kelp and bull kelp along with some species of red algae including the encrusting corallines are necessary. Juvenile abalone graze on rock encrusting coralline algae, diatoms and bacterial films. As they grow they increasingly rely on red and brown macro-algae.

Sustained nutrient loads from salmon farms or other sources may alter the types and proportions of algae that grow within pristine and healthy marine ecosystems ([Kraufvelin et al. 2010](#)) – the type where wild abalone thrive. Sustained nutrient loads change the balance of macro algal species in the environment in turn changing reef community structure and biodiversity. Species of algae that thrive under regular and increased nutrient loads *may not* support an ecosystem with healthy populations of wild abalone, lobster and other species of marine fauna.

Abalone are localised spawners and are at their most vulnerable during the early stages of their life cycle – localized anoxic conditions due to physico-chemical changes in the sediment and/or nutrient overload in the water column (whether sustained or periodic) may have a deleterious effect on larval growth, larval settlement and the early grow-out stages of the lifecycle ([James and Barr 2012](#)) leaving abalone stunted and unfit for harvest.

Sustained nutrient input from salmonid farming systems and its potential effect on the structure and bio-diversity of Tasmanian inshore oceanic reef communities is one obvious research project that warrants attention by Marine scientists.

Abalone have been shown to be particularly sensitive to sedimentation even at low levels, potentially affecting all life stages. Larval abalone have shown significant reductions in settlement in response to low level sedimentation ([Onitsuka et al. 2008](#)). Sediment has also been shown to indirectly increase the mortality of juvenile abalone through displacement from their cryptic refuges by sediment accumulation to seek out sediment free exposed areas which leaves them more exposed to predation - vulnerability to predation is then increased further as sedimentation also results in a decreased ability for juvenile abalone to “hold fast” to surfaces and impedes abalone’s righting response resulting in higher abalone mortality in areas where sediment is present ([Chew et al. 2013](#)).

The effect of sediment on abalone was recently canvassed at the 6<sup>th</sup> National *Trans Tasman* Abalone Convention in Queenstown, New Zealand on the 6 - 8<sup>th</sup> August 2014. New Zealand has a commercial abalone industry based on a species of abalone called *haliotis iris*, commonly referred to as *paua*. A presentation at the convention by Dr Norman Ragg of the Cawthron Institute in Nelson, New Zealand entitled “*Fighting for breath: how does oxygen exchange limit abalone performance in a changing coastal environment?*” focused on the gill structure of paua and how it struggles to respire under sediment loads; (<http://abalonecouncil.com.au/wp-content/uploads/2014/08/14-RAGG-Fighting-for-breath.pdf> )

Dr Ragg concluded his presentation by stating the following:

- paua are absolutely dependent on their gills for oxygen uptake
- The gill surface of paua may be damaged (directly or indirectly) by sedimentation events
- Paua gills appear to have a limited capacity to clear sediment or associated mucus

Clearly then, there is robust scientific evidence that abalone do not cope well under seasonal or sustained sediment loads. This fact may explain why abalone divers have witnessed fewer abalone on reefs adjacent to salmonid farming systems which are known to introduce significant and sustained sediment loads into the marine environment.

Sustained sediment input from salmonid farming systems and its potential effect on:

- the settlement of larval abalone,
- the vulnerability of juvenile abalone to predation and
- the ability of abalone gills to properly respire

is another obvious research project that warrants attention by Marine scientists.

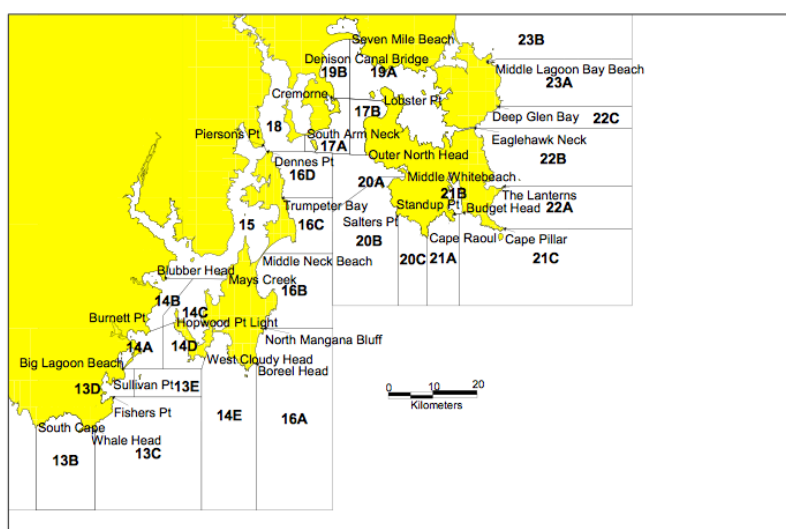
In short, any input that causes degradation to the health of the inshore benthic community which wild abalone and other marine fauna inhabit *must be* regarded as a risk. It is commonly accepted that benthic molluscs (such as abalone) serve as the “canary in the coal mine” when it comes to sensitivity to environmental changes within oceanic reef communities.

It is also an accepted fact that significant loss of benthic biodiversity and localised changes in the physico-chemical properties of sediments occur in close proximity to salmon farms.

**The risk for the wild abalone industry relates primarily to the broader-scale medium to long-term environmental degradation caused in part or wholly by sustained nutrient and sediment inputs from salmonid farming.**

**Loss of productivity from abalone fishing block 14 - has salmon farming been a factor?**

Interaction between salmon farming operations and the wild capture abalone industry commenced in the mid eighties when salmon farming leases were initially granted within the D’Entrecasteaux Channel. Abalone catch-reporting block 14 encompasses the southern end of the D’Entrecasteaux Channel and the southern coast of Bruny Island (south of Blubber head to Boreel Head).



Map showing abalone catch reporting blocks for South East Tasmania

There is evidence that some sections of the inshore benthic community in the lower D’Entrecasteaux channel have changed since the introduction of salmon farming in the eighties.

Abalone divers spent 27,507 hours underwater harvesting abalone around Tasmania’s coastline during 2013 (aggregated total figure based on DPIPWE catch data). They have been averaging over 27,000 hours underwater every year for the last 10 years. This puts them in a unique position as the “sentinels” of Tasmania’s inshore oceanic environment simply because they witness with their own eyes almost all of Tasmania’s coastline which is 4882kms long (including islands).

By virtue of their affinity with the ocean, their general concern for its well being and the fact that they spend so much time underwater, Tasmania’s 120 abalone divers are “early detectors” of any short, medium or long term changes to the underwater environment.

There is a commonly held and unequivocal view amongst commercial abalone divers who harvested abalone in abalone sub-blocks 14b and 14c and block 15 during the seventies, eighties and nineties that the benthic community in some sections of the lower Channel has altered in a way which is less supportive to habitation by abalone and other benthic reef dwellers which were once abundant in this area. During the last decade, divers have regularly

reported a fine layer of “dust” covering some parts of the inshore benthic community – they also report a change in the type and form of algae that grows in some of the bays and around the shoreline of the lower Channel.

They have also witnessed a significant reduction in the biomass of wild abalone.

Over the last 30 year period, there has been an alarming loss of productivity from abalone block 14. In the 5 year period between 1981 and 1985, the average annual harvest by divers from block 14 was 276 tonne. In the five year period between 1996 and 2000, this had fallen to an average harvest of 125 tonne per annum. In the five year period between 2006 and 2010, the harvest averaged 69 tonne per annum. In total block 14 has experienced a 75% reduction in productivity since the mid eighties (when salmon farming commenced) in the lower D’Entrecasteaux Channel.

If block 14 was as productive now as it was in the seventies and early eighties, the abalone harvested would be adding some \$7 million dollars in export revenue to Tasmania’s economy each and every year. As it is today, much lower productivity combined with harvesting restrictions due to regular and sustained toxic algal bloom events have reduced this valuable component to a “mere shadow” of its former self with abalone harvested in block 14 during 2013 worth less than one tenth of its former value at \$600,000 (cf \$7 million).

Whilst it would be easy to “point the finger” at the burgeoning salmonid industry and its unwanted inputs into the marine ecosystem of the lower D’Entrecasteaux Channel, it must be said that there are other sources of anthropogenic inputs that may also be having a deleterious effect – effluent from sewerage systems, organic and inorganic inputs from fertiliser usage, sediments from farming and forestry “run off” etc etc .....

Determining the localised and broadscale anthropogenic & environmental inputs/factors that have caused this reduction in productivity of the wild abalone resource in catch-reporting blocks 14b, 14c and 15 is another area of research worthy of attention by Marine scientists – whilst not “pointing the finger” solely at the salmonid sector, it is not unreasonable to suggest that salmon farming may be a **significant factor** in the changing benthic ecology of some parts of the lower D’Entrecasteaux Channel.

#### **A new underwater video provides visual imagery of the impact of salmonid farming on the marine environment**

On the morning of the 30<sup>th</sup> of August 2014, a team of abalone divers and underwater videographers launched their dive vessel at Dover (Port Esperance) with the objective of recording video footage of three dive sites in South East Tasmania – these sites all had one thing in common – they feature benthic reef habitat containing seaweed and wild abalone. The sites were as follows:

1. Site 1 – Hope Island in the entrance to Port Esperance near Dover. This site is close to a finfish farm owned by Tassal – Tasmania’s largest producer of Atlantic Salmon and Ocean Trout.
2. Site 2 – Actaeon Island – this is arguably the most productive reef system for abalone in the world – it lies 11 nautical miles to the south of Port Esperance.
3. Site 3 – Lady Bay – this is close to a finfish farming lease that Tassal have yet to utilise. It lies 4 nautical miles to the south of Port Esperance.

The resultant video featuring underwater footage at each site has been loaded onto YouTube.  
– this video may be viewed at:

<http://youtu.be/aUrvhSIJ76A>

**Site 1** adjacent to the Tassal finfish farm shows very clearly how the benthic habitat is covered by a fine film of milky sediment. The seaweed does not look healthy and there are few abalone at this site.

**Site 2** features some of the most productive abalone beds in the world – the seaweed looks healthy, there are plenty of abalone from juveniles to adults and there is no sediment film.

**Site 3** features healthy seaweed and there is very little sediment – there are small and large abalone at this site.

**The fear that abalone divers have is that if Tassal install new salmon cages near Site 3 (Lady Bay) it will look like Site 1 (Port Esperance) a decade from now with lower abundance of abalone and a fine layer of sediment choking the benthic flora and fauna.**

**Please check out the following YouTube link as well which very clearly demonstrates the impact that King Salmon farming has had on the benthic ecology of the iconic Marlborough Sounds in New Zealand:**

<http://www.youtube.com/watch?v=Ds7TPeWGVA4>

**The abalone fishery depends on complex environmental factors to replenish and maintain healthy stock levels. Many of these factors are not completely understood nor do we have control over them. The consequences of environmental disturbance in a wild fishery can be devastating and extremely difficult or impossible to reverse and as such the *precautionary principal* should be adhered to whenever possible.**

This is in contrast to a farmed fishery that can be replenished with fresh stock at will. Any risk to the salmon industry doesn't carry the same consequences because the environment that the fish live in is controlled, they can be easily replenished in huge numbers and their cages can be relocated to a "clean" site.

### **Toxic algal blooms in the D'Entrecasteaux Channel**

*Gymnodinium Catenatum* bloom events have been occurring for many years in South East Tasmania and a particularly large and enduring algal bloom in late 2010/early 2011 resulted in export restrictions on abalone harvested from blocks 14 and 15. These restrictions were due to the risk of Paralytic Shellfish Toxins (PST's) accumulating in the tissues of wild abalone potentially at a level toxic to humans. A subsequent "significant" bloom event occurring approximately 12 months later created further management "headaches" for the wild abalone industry following tissue sampling from sites within the lower D'Entrecasteaux Channel (Garden and Partridge Islands).

Harvesting restrictions in abalone blocks 14 and 15 have been in place "on and off" ever since.

From a broader perspective, a recent risk assessment conducted by the South Australian Research & Development Institute (SARDI) has declared that algal bloom bio-toxins are a very



low risk for Australian (& Tasmanian) wild abalone. The abalone bio-toxin risk assessment will be used to ensure ongoing access to our international markets.

Even though the risk assessment has declared that algal bloom bio-toxins are low risk, the abalone industry is still required to implement a management plan for future algal bloom events. This plan will culminate in a coordinated monitoring and response strategy involving the Tasmanian Abalone Council, the Tasmanian Departments of Human Health and Primary Industry and the Commonwealth Department of Agriculture.

The plan will require ongoing testing of abalone tissue samples at considerable expense to the abalone industry. Based on recent history, it appears likely that toxic algal blooms will continue to occur into the future and that there will be further trade restrictions placed on abalone block 15 and some sections of abalone block 14.

Algal bloom events require a certain mix of environmental conditions – one of which is high levels of nutrients in the water column.

In the *Institute of Marine and Antarctic Studies* (University of Tasmania) report entitled “*Evaluation of Broadscale Environmental Monitoring Program (BEMP) data from 2009 to 2012*” – page 4, Ross and McLeod, clearly identify fish farms as one of the major sources of nutrients in the Huon/D’Entrecasteau region:

*“Catchment inflows, fish farms and oceanic inputs are the major sources of nutrients, particularly nitrogen, but they vary in the form of nitrogen they input to the system.”*

<http://dpipwe.tas.gov.au/Documents/Ross---MacLeod-BEMP-Data-Review-2009-2012-.pdf>

The Kingborough Council acknowledges finfish farming inputs in its recent document entitled “*Snapshot of the state of the D’Entrecasteaux Channel & Lower Huon Estuary*”

*“The largest human- induced sources of nutrients to the waterways are fish farms and catchment inputs via river water. A long term increase in phytoplankton (microalgal) biomass across the region is evident and toxic algae are a concern for the region.”*

[http://www.kingborough.tas.gov.au/webdata/resources/files/Snapshot%20of%20the%20D'E%20ntrecasteaux%20Channel%20and%20Huon%20Estuary%20\\_approved\\_.pdf](http://www.kingborough.tas.gov.au/webdata/resources/files/Snapshot%20of%20the%20D'E%20ntrecasteaux%20Channel%20and%20Huon%20Estuary%20_approved_.pdf)

It would not be an unreasonable assumption therefore that salmonid farming activity may be “feeding” toxic algal blooms with nutrients thereby helping to ensure they occur regularly and across an expanded temporal and spatial horizon.

Also, it would probably be no surprise to find that the reported incidence of algal blooms in the lower D’Entrecasteaux channel aligns with the introduction of the salmon farming industry into the same area. Research needs to be conducted to determine if there is a causal link between the establishment (and expansion) of the salmonid industry in the D’Entrecasteaux Channel and the incidence of toxic algal blooms.

### **The Actaeons – a truly remarkable abalone reef system**

Lying immediately to the south of abalone catch-recording block 14 lies sub block 13E. This abalone fishing block is regarded as the most productive abalone reef system in the world in terms of sustainable productive capacity and commercially harvestable biomass. It is truly the “jewel in the crown” of the Tasmanian wild abalone resource.

Abalone sub block 13E (which contains the Actaeons reef system) is producing about 220 tonne per annum of premium grade wild abalone prized for live export to China. It has (so far) maintained this level of productivity since the commercial abalone industry commenced in the mid sixties.



At current prices, this sub block generates about \$10 million each year in export revenue for Tasmania.

The proposed new salmon cage lease sites between Dover and Southport (“Browns” & “Lippies” - Tassal) if approved, will bring the salmon farming industry and its detrimental effects on the marine environment closer to the world’s most productive wild abalone reef system which lies only 11 nautical miles south of existing Tassal salmonid cage systems in Port Esperance.

This same reef system also supports recreational and commercial rock lobster fishing.

*Is this a risk worth taking?*

In order to protect productive abalone and lobster beds, the TACL are seeking a permanent ban on any salmonid farming activities south of a line between Scotts Point (at the southern edge of Port Esperance) and the northern tip of Partridge Island. The future establishment of any new salmonid cage systems south of this line would only **increase** the risk of potential damage to valuable benthic ecosystems including the Actaeons reef system.

### **The obligations of the Tasmanian Government and the Primary Industry Minister**

The legislation that underpins marine farm planning is the Marine Farm Planning Act 1995. The purposes and objectives of that Act are as follows:

*MARINE FARMING PLANNING ACT 1995 - 4. Purpose and objectives*

- (1) The purpose of this Act is to achieve well-planned sustainable development of marine farming activities having regard to the need to –*
- (a) integrate marine farming activities with other marine uses; and*
  - (b) minimise any adverse impact of marine farming activities; and*
  - (c) set aside areas for activities other than for marine farming activities; and*
  - (d) take account of land uses; and*
  - (e) take account of the community's right to have an interest in those activities.*

*The definition for sustainable comes from clause 2 of schedule 1:*

- 2. In clause 1(a), sustainable development means managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural well-being and for their health and safety while –*
- (a) sustaining the potential of natural and physical resources to meet the reasonably foreseeable needs of future generations; and*
  - (b) safeguarding the life-supporting capacity of air, water, soil and ecosystems; and*
  - (c) avoiding, remedying or mitigating any adverse effects of activities on the environment.*

Clearly the Primary Industry Minister has many statutory obligations with regard to Marine Farming activities as clearly enunciated within the *Marine Farming Planning Act 1995 (MFPA)*.

The MFPA was drafted to ensure well-planned sustainable development of marine farming activities having regard to the need to integrate marine farming activities with other marine

uses such as fishing, and minimise any adverse impact of marine farming activities. Sustainable development means managing the use, development and protection of natural and physical resources, while safeguarding the life-supporting capacity of the water and marine ecosystems, including those that support wild abalone, rock lobster and other marine fauna and flora.

**The MFPA and associated processes are required to sustain the potential of the natural resources to meet the future needs of the community. Potentially adverse effects of marine farm activities on the environment, including the impact to important natural resources such as abalone and lobster, should be investigated to the fullest extent. If the effects are shown to be potentially adverse, then existing and future marine farming developments must be managed to avoid, remedy or mitigate such adverse effects on the environment.**

### **Environmental Monitoring of Tasmania's Salmonid Industry**

Below is an excerpt from a Tassal document made available recently to the Tasmanian Abalone Council (*Information for the Abalone Council regarding proposed amendments to Tassal leases in the D'Entrecasteaux Channel* – emailed to the TACL from Tassal on the 21<sup>st</sup> February 2014).

The document describes “in Tassal's own words” what the environmental impacts of their farming operations are and how they monitor them:

- *“Approximately 5% of the total feed input is released into the environment as a form of nitrogen, of which 85% is released as dissolved nitrogen and 15% in particulate form. Most of the dissolved nitrogen is excreted by fish as ammonium, which is a preferred source of nitrogen for phytoplankton and other marine plant species.*
- *In the marine environment, nitrogen is assumed to be the limiting nutrient (hence Nitrogen Cap being used as a primary environmental management tool by DPIPWE), so its availability in dissolved form dictates the amount of primary production that will occur in the water column.*
- *Marine farming impacts upon the marine environment. These impacts are largely restricted or localised within close proximity to the lease boundaries. **However, broadscale impacts such as those attributable to soluble emissions are known to occur within 500 m of sea cages.** (my highlighting)*
- *Impacts at the fine spatial scale (i.e. sedimentation from uneaten feed and faeces) are closely monitored and managed. Management controls regulated by DPIPWE require regular ROV monitoring to ensure that there are no significant visual, physico-chemical or biological impacts at or extending beyond 35 metres from the boundary of the lease area.*
- *Broadscale impacts are also monitored through the Broadscale Environmental Monitoring Program (BEMP), an industry-funded water quality and sediment monitoring program that commenced in 2009. Over 70 sampling events have been completed in the D'Entrecasteaux Channel and Huon Estuary at 15 sites extending from North West Bay to Recherche Bay (control site).”*

Below is an excerpt from the *D'Entrecasteaux Channel Marine Farming Development Plan February 2002* which details the environmental compliance expectations of the regulator – i.e. the Marine Farming Division of DPIPWE:

### “3.1 General controls for all marine farming zones

*Finfish 3.1.1 There must be no unacceptable environmental impact, to the satisfaction of the Secretary, 35 metres outside the boundary of the marine farming lease area. Relevant parameters must be monitored in the lease area, 35 metres from the boundary of the marine farming lease area and at any control sites(s) in accordance with the requirements specified in the relevant marine farming licence.”*

Furthermore, an example of a Marine Farm Licence condition (schedule) applied to salmonid leases is as follows:

*“There must be no significant visual, physico-chemical or biological impacts at or extending beyond 35 metres from the boundary of the Lease Area. The following impacts may be regarded as significant. Visual impacts:*

- *Presence of fish feed pellets*
- *presence of bacterial mats (e.g. *Beggiatoa* spp.)*
- *presence of gas bubbling arising from the sediment, either with or without disturbance of the sediment*
- *presence of numerous opportunistic polychaetes (e.g *Capitella* spp., *Dorvilleid* spp.) on the sediment surface.*

*In the event that a significant visual impact is detected at any point 35 metres or more from the lease boundary, the licence holder may be required to undertake a triggered environmental survey or other remedial activity determined by the Director.”*

(The above example of a licence condition was taken from the following document:

[http://www.edotas.org.au/wp-content/uploads/2013/10/2012conf\\_ford\\_marine\\_farm\\_planning\\_tas.pdf](http://www.edotas.org.au/wp-content/uploads/2013/10/2012conf_ford_marine_farm_planning_tas.pdf) )

It is clear from the above excerpts that the regulator of marine farming in Tasmania (DPIPWE) may trigger an environmental survey or “other remedial activity’ determined by the Director if there are significant visual, physico/chemical or biological impacts at or extending beyond 35 metres from a lease boundary.

It is worth noting that whilst the regulator insists on an environmental impact compliance limit of 35m from the lease boundary, Tassal admit that “*broadscale impacts such as those attributable to soluble emissions are known to occur within 500m of sea cages*” (refer to highlighted sentence above).

This rather obvious inconsistency raises concerns regarding the environmental compliance protocols encapsulated in Marine farming legislation and regulations in Tasmania – perhaps it is time for a legislative and regulatory review?

Broadscale monitoring of the D’Entrecasteaux Channel and Huon Estuary commenced in March 2009, and is currently undertaken by all marine finfish farm licence holders in the D’Entrecasteaux Channel and Huon River/Port Esperance Marine Farm Development Plan (MFDP) areas. Fifteen sites within the MFDP areas are monitored throughout the year to assess spatial and temporal patterns of water and sediment quality; this includes a broad suite of parameters capturing the physical, chemical and biological characteristics of the system.

Below is a map showing the BEMP sample sites: from Ross, D. J. and Macleod, C. K. (2013). *Evaluation of Broadscale Environmental Monitoring Program (BEMP) data from 2009-2012. IMAS Technical Report 140pp.*

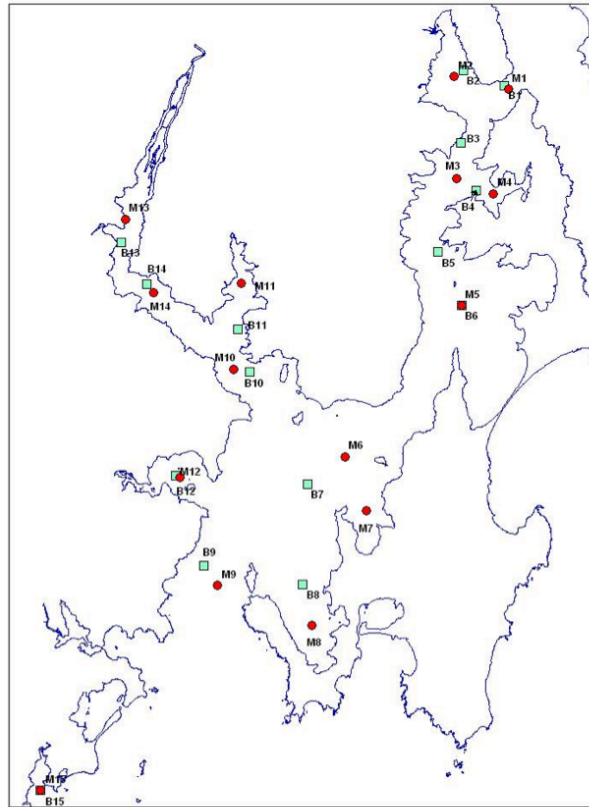


Figure 1.1: Map showing location of monitoring sites in the D'Entrecasteaux Channel and Huon Estuary. Sediment assessment sites (B1-B15) and water quality monitoring sites (M1-M15). Note that the control site at Recherche Bay is located in the bottom left corner of the map (B15/M15).

Below are some initial comments regarding the BEMP from the point of view of the Tasmanian Abalone industry. These comments are generated from a preliminary review of the Ross and MacLeod (2013) report *Evaluation of Broadscale Environmental Monitoring Program (BEMP) data from 2009-2012. IMAS Technical Report 140pp* :

1. Currently, abalone is not on the “radar” of the BEMP. The word “abalone” does not appear once in any of the BEMP reports.
2. There are no oceanic reef sample sites within the BEMP. The BEMP has been designed to monitor broad scale changes within the D'Entrecasteaux Channel and the Huon Estuary. The BEMP has never monitored oceanic rocky reef and macro algal communities that are of interest to the abalone (and lobster) industries. It is important to monitor and minimise adverse environmental impacts to wild fisheries such as abalone and lobster, because they are more fragile than salmon in a pen.
3. If conditions near a salmon pen become anoxic, the pen may be moved to a cleaner site or the salmon may be destocked and relocated to another pen at a cleaner site. Abalone cannot be “moved” to a cleaner site – they rely on a healthy ecosystem undamaged by anthropogenic inputs. There are no BEMP sites on North Bruny near the proposed new Huon Aquaculture oceanic lease sites. The BEMP sampling sites closest to productive abalone and lobster beds at the southern end of the Channel (BEMP sites B9 and M9) are towards the centre of the channel (near Browns Point) rather than near the edge of the channel where abalone and lobster live.

4. Environmental monitoring conducted by or on behalf of the salmonid companies appears to be primarily configured to bring adverse water quality and sediment impacts to just above the point where salmon start seeing significant adverse effects.
5. Environmental monitoring of the *near-farm* effects of the salmonid industry is undertaken by the salmon growers themselves thus raising issues of conflict of interest/lack of independence.
6. Environmental monitoring of the *broad-scale* effects of the Salmonid industry in the Huon and D'Entrecasteaux regions via the BEMP is undertaken by an independent contractor but this contractor is paid by the salmon growers themselves thus raising issues of conflict of interest/lack of independence.
7. The BEMP review conducted by Ross & MacLeod in 2013 identifies the lack of a Hydrodynamic Model for the D'Entrecasteaux Channel as a significant shortcoming of the BEMP. It seems obvious that such a model should have already been developed given the importance of having a comprehensive understanding of water flows in any analysis of anthropogenic inputs into this important region.

#### Other issues of concern

- **Navigation:** The Tassal lease sites Lippies and Browns will be sited almost in the centre of the D'Entrecasteaux Channel between Browns Point and Partridge Island. This is the narrowest section of the Channel and at the moment is entirely clear of any navigational hazards. The insertion of salmon cage systems near the centre of the Channel as proposed by Tassal will create a *significant navigational hazard* for all vessels transiting the Channel. The risk of collision will remain significant – particularly for vessels transiting the area at night. Recreational boaters are currently not required to have radar skills as part of their qualifications. To navigate through the ever-increasing maze at night or in adverse weather conditions i.e. heavy rain, is becoming increasingly dangerous without the use of radar. Similarly, the proposed Huon Aquaculture leases near Cape Queen Elizabeth on North Bruny will also present a major navigational hazard for ALL vessel users. This section of coastline is subject to heavy commercial and recreational boat traffic.
- **Risk of shark interactions:** The proposed siting of salmon cages adjacent to productive abalone reef systems increases the risk of shark interactions as far as abalone divers are concerned. Excreta plumes created by millions of salmon in cage systems are likely to attract large oceanic predators – sharks will be attracted to the cages by the presence of seals and massive quantities of salmonid body fluids, excreta/faeces and uneaten food residues. This is a potentially a significant safety issue for any abalone diver wishing to work the shoreline between Cape Queen Elizabeth and Trumpeter bay on North Bruny. These risks would also apply to recreational divers. There is plenty of evidence that Great White sharks are attracted to finfish cage systems - Please refer to: [www.frdc.com.au/research/Documents/Final\\_Reports/2002-040-DLD.pdf](http://www.frdc.com.au/research/Documents/Final_Reports/2002-040-DLD.pdf) and [www.whitesharktrust.org/media/salmonfarm/documents/salmonfarming.pdf](http://www.whitesharktrust.org/media/salmonfarm/documents/salmonfarming.pdf)
- **Bio-security:** There are also bio-security risks – i.e. transmission of disease from farm-reared salmon to the broader marine ecosystem. Although this risk is acknowledged as “very low” it cannot be ruled out with 100% certainty.

## Where to from here?

The Tasmanian Abalone industry calls on the Tasmanian Government to take the following actions:

1. Impose a moratorium on salmonid farm expansion into oceanic waters until a comprehensive review of the environmental effects of salmonid farms on inshore Tasmanian oceanic habitat can be properly and comprehensively conducted. This review should focus on the local and broadscale environmental effects and bio-security risks of salmon farming on oceanic benthic flora and fauna and should examine the impact on the structure and bio-diversity of reef systems in response to sustained nutrient and sediment inputs from salmonid farming systems. **Tasmania's two most valuable and iconic wild fishery resources – abalone and rock lobster - should not be subjected to environmental risks from the expansion of the salmonid sector into oceanic waters.**
2. Whilst the moratorium is in place, the Government and the Salmonid industry complete a comprehensive Risk Assessment of;
  - a. navigational risks posed to all waterway users by salmon cage systems sited in oceanic waters and
  - b. predator risk to commercial and recreational divers due to increased prevalence of sharks attracted to oceanic salmon cage systems
3. In order to protect productive abalone and rock lobster beds in the Lower D'Entrecasteaux Channel, the Government impose a permanent ban on any salmonid farming activities south of a straight line between Scotts Point on the southern side of Port Esperance and the northern tip of Partridge Island.
4. In order to protect inshore productive abalone and lobster beds in Storm Bay, any future salmonid cage systems to be established no closer than 4 nautical miles from the shoreline – i.e. a minimum of 4 nautical miles between the low tide mark and the edge of the salmonid lease boundary. This would move the salmon cages towards the centre of Storm Bay and create a buffer zone which will significantly reduce the risk of the inshore benthic flora and fauna being adversely affected by salmon farm inputs.
5. The BEMP to be reviewed by the Government and relevant Marine Research Institutions for data gaps and expanded to include oceanic reef sampling and monitoring sites in the lower Channel and Storm Bay - i.e. additional sampling sites that include pristine oceanic reef habitat - these sites to monitor macro-faunal communities, micro and macro algal structure/abundance/distribution as well as water and sediment quality. The underlying BEMP data to be made available to the abalone industry to conduct its own regular review and analysis.
6. The Government to commission the appropriate Marine Research Institute to develop Hydrodynamic Models for the lower Channel region and for Storm Bay – these models to be utilised in any future planning for marine farming in these areas. The Hydrodynamic models to be 3D with particle tracking to determine the fate and distribution of sediment fallout from salmon cage systems (at least 12 months of hydrodynamic data should be obtained prior to any consideration of new salmon cage sites).
7. An independent comprehensive scientific review to be commissioned to:

- a. determine if there is a causal link between the establishment (and expansion) of the salmonid industry in the D’Entrecasteaux Channel and the regular incidence of toxic algal blooms in the same area.
  - b. to examine the impact of sustained (salmonid) sediment input and its effect on (1) the settlement of larval abalone, (2) the vulnerability of juvenile abalone to predation and (3) the ability of abalone gills to properly respire.
  - c. to examine the localised and broadscale anthropogenic & environmental inputs/factors that have caused the reduction in productivity of the abalone catch blocks 14b, 14c and 15.
8. The Government in conjunction with the salmonid industry to conduct a full analysis of the alternatives available for future expansion of the industry without the need to establish near-shore oceanic farming systems – i.e. offshore oceanic farming systems and onshore farming systems. The inshore oceanic sites currently sought by Tassal and HAC have the potential to adversely affect the health of nearby marine benthic communities.

#### KEY RECOMMENDATION FROM THE TASMANIAN ABALONE INDUSTRY

The primary recommendation of the Tasmanian Abalone Council is that future expansion of the Salmonid sector in Tasmania should feature the use of offshore cage systems that are located four (4) or more nautical miles away from inshore oceanic reef habitat. An environmental buffer zone of this magnitude will provide adequate protection to the *inshore reef habitat* around Tasmania’s pristine coastline which is of immense cultural, recreational and commercial value to the citizens of Tasmania and the world. This habitat should be continuously monitored for ecological changes and the **precautionary principle** should be adopted by the Government in any decisions regarding its future.

From Wikipedia, the free encyclopedia

The **precautionary principle** or precautionary approach states that if an action or policy has a suspected risk of causing harm to the **public** or to the **environment**, in the absence of **scientific consensus** that the action or policy is not harmful, the **burden of proof** that it is *not* harmful falls on those taking an action.

The principle is used by policy makers to justify discretionary decisions in situations where there is the possibility of harm from taking a particular course or making a certain decision when extensive scientific knowledge on the matter is lacking. The principle implies that there is a **social responsibility** to protect the public from exposure to harm, when scientific investigation has found a plausible risk. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result.

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