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Mussel Farming in Central Pelorus Sound

INTRODUCTION

1 The Kenepuru and Central Sounds Residents Association has serious concerns with the existing level of marine farming in the central Pelorus Sounds area, specifically Beatrix Bay, Clova Bay and Crail Bay, and where marine farming is occurring along the north shore in Kenepuru Sound. Their concern arises from the likelihood that the current level of marine farming poses a credible threat to the ecosystem within Pelorus Sound.

2 This report summarises the science behind the concerns and highlights areas where knowledge is believed lacking.

THE AREA UNDER CONSIDERATION

3 Beatrix Bay, Clova Bay and Crail Bay comprise the Beatrix Basin, with Kenepuru Sound lying further to the south. Marine farming, and more specifically mussel farming, is largely concentrated in these areas of Pelorus Sound and occupies some 2500 ha within the Pelorus area. This is a significant increase from the approximately 1000 ha occupied in 1995.

4 Mussel farming is estimated to occupy approximately 15% of the surface area of Beatrix Bay, ~ 10% of the surface area of Crail Bay, and ~ 20-30% of the surface area of Clova Bay.

5 Beatrix Bay is recognised in Appendix B of the Marlborough Sounds Resource Management Plan (MSRMP) as being an area of king shag feeding habitat and is, as a result, an area of international ecological value (MDC 2003). It is also noted as an area within which lemon sole spawn (Department of Conservation 1990).

6 A large body of data has been collected over the years about the physical and biological environment of Beatrix Bay, with the focus largely being on likely effects on this environment from mussel farms (e.g. NIWA 2001, Mead 2002, Christensen *et al.*, 2003, Davidson and Richards 2011, Davidson 2012a,b), and likely influences on mussel growing from currents, nutrient inputs, and other physico-chemical parameters (e.g. Gibbs and Vant 1997, Gall *et al.*, 2000, Gibbs *et al.*, 2002, Safi and Gibbs 2003, Handley 2015). The robustness of these assessments is variable (MDC 2000), but is largely directed by the suggested protocols outlined in a guideline document prepared by the Department of Conservation (DoC 1995). The majority of assessments of environmental effects carried out for applicants wishing to establish mussel farms have, to date, come to the conclusion that environmental effects will be less than minor.

GENERAL EFFECTS OF MUSSEL FARMING

7 At this point it is worthwhile examining the likely effects of mussel farming on the marine environment. Such effects fall into a number of categories and include biological effects, physical effects and physico-chemical effects, each with varying degrees of influence on the surrounding ecosystem.

Sediment deposition.

8 Deposits beneath marine bivalve aquaculture farms occur as a result of four processes: (a) shell drop, (b) faeces, (c) pseudofaeces, and (d) biofouling, with between 250 and 400 tonnes of sediment being reported to accumulate beneath each hectare of farm per annum (e.g. Hartstein and Rowden 2004, Hartstein and Stevens 2005). Faecal pellets and mucous-bound pseudofaeces have greater sinking velocities than their constituent particles. Thus mussel farms typically increase sedimentation rates under culture sites (Hatcher *et al.*, 1994; Callier *et al.*, 2007; Giles *et al.*, 2006). Such deposits may change the character of substrate beneath farms by covering fine, soft substrate with coarser material (e.g. dead shell or live bivalves) that will ultimately lead to a new suite of fauna living beneath the farm (Mead 2002; Keeley *et al.*, 2009). The shell debris may also promote the accumulation of fine sediment and organic matter by dampening currents and reducing oxygen percolation into the sediment, and in doing so, reduce the rate of mineralisation of organic matter (MPI 2013a). Finer and much lighter deposits, such as faeces and pseudofaeces (particles which have been rejected as unsuitable for food) may gradually sink to the bottom, build up over time, and may eventually lead to anoxic conditions prevailing in fine sediments. This results in an associated change in substrate chemistry and likely change in infaunal composition (Chamberlain *et al.*, 2001; Christiansen *et al.*, 2003). Lastly, biofouling organisms growing on bivalves may, in turn, produce their own

deposits (Kaiser *et al.* 1998) and will also accumulate on sediments beneath mussel farms after being removed during the harvesting process.

Nutrient Stripping and/or addition

9 There have been a number of studies that have shown that marine aquaculture, particularly of filter feeding bivalves, alter the amount of nutrients entering or leaving marine farms (e.g. Waite, 1989; James *et al.*, 2001; Keeley *et al.*, 2009). Bivalves selectively filter out particles in the range of 5 – 500 µm for food and reject as pseudofaeces those particles that are not suitable. Thus water in the lea of a farm may be depleted of nutrients that are associated with phytoplankton, which may have been utilised by organisms downstream. Conversely, as a by-product of metabolism there is a release of nutrients into the water column by the organisms being farmed, usually in the form of nitrogen excreted as ammonia (Keeley *et al.*, 2009). Such excretion from farmed bivalves may influence phytoplankton downstream of a marine farm by providing needed nutrients in the form of nitrates (Broekhuizen *et al.*, 2002).

Plankton depletion (zooplankton and phytoplankton)

10 As with nutrients, there has been considerable research into type and amount of food (plankton) stripped from the water column by aquaculture farms (e.g. Bourgrier *et al.*, 1997; Shumway *et al.*, 1985; Safi and Gibbs 2003). Zeldis *et al.*, (2004) noted that filter-feeding bivalves have the potential to alter the composition of the plankton biomass by differentially clearing phytoplankton and zooplankton. Such stripping has implications for downstream communities in the form of reduced recruitment through the removal of eggs and/or larvae, and reduced food supply.

Effects on benthos under and adjacent to longlines and droppers

11 In addition to the sediment deposition discussed above anchor systems impact on the substrate beneath a farm and on the associated benthic flora and fauna, albeit in a relatively minor way. However, a system that is buried in the substrate (e.g. screw anchors) is likely to have less impact than structures set on the seabed.

Shading

12 Shading by marine farm structures and longlines bearing shellfish droppers have the potential to inhibit the abundance, biomass and species compositions of both benthic microalgae and macroalgae growth by virtue of limiting light (shading) (Huxham *et al.,* 2006; McKindsey *et al.*, 2011). However, this is recognised as a relatively minor issue in all but very densely clustered farms (Keeley *et al.*, 2009, Handley 2015).

Effects on local currents

13 Water currents are a key factor for transport of nutrients, plankton, larvae, and for dispersal of material. Organisms may also have habitat preferences influenced by water speed. Water currents are therefore a key driver of ecological processes (MPI 2013b). It has been well established that marine farm structures influence local water currents by attenuating velocity and/or changing current direction (e.g. Gibbs *et al.*, 1991; Boyd and Heasman 1998; Plew *et al*., 2005, 2006; Morrisey *et al.*, 2006; Plew 2011). Such changes may result in changes to the depositional footprint, and/or changes to the local ecology.

Fouling and biosecurity

14 Fouling by other marine organisms can be a problem for marine farms (Mazouni et al., 2001; Costa-Pierce and Bridger 2002). In New Zealand the invasive tunicates *Styela clava*, and *Didemnum vexillum*, and Japanese kelp *Undaria pinnatifida* are a problem on mussel farms in the Marlborough Sounds and some other areas (Coutts and Forrest 2007; Gust *et al*., 2007).

THE LIKELY ENVIRONMENTAL EFFECTS DUE TO MUSSEL FARMING IN CENTRAL PELORUS SOUND

15 Bivalve aquaculture is a multi-million dollar earner for the New Zealand economy, with most of the revenue generated by the farming of Greenshell™ mussels (*Perna canaliculus*) (Keeley *et al.*, 2009). Despite the earning potential of such industries, one must not lose sight of the wider ecological impacts aquaculture farms may have on immediate or nearby ecosystems.

16 Experimental mussel farming in New Zealand did not start until 1968 (Stead 1971). However, mussel dredging started in about 1962, with dredges 4.5 to 8 ft wide working the beds throughout much of the suitable habitat of the Marlborough Sounds (Stead 1971). As a consequence, large tracts of the soft bottom benthic habitat of the Marlborough Sounds cannot be considered pristine.

17 It is unfortunate that there are few baseline survey data for Beatrix Bay from before 1962, or even prior to 1990 when aquaculture expansion began in earnest, apart from Stead (1971) noting that there were low densities of green lipped mussels (*Perna*) and blue mussels (*Mytilus*) in the lower intertidal and upper sub-littoral zones.

18 The majority of ecological assessments carried out in central Pelorus focus solely on the sea floor immediately beneath and within a few metres of mussel farms. Consequently

there have been relatively few comprehensive descriptions of the biota within the central Pelorus Sound area. Notable excpetions are Mead 2002 and Duffy *et al*. (in prep).

19 It is well known that mussel farms are a source of biodeposits, with up to 400 tonnes of sediment being reported to accumulate beneath each hectare of farm per annum (Hartstein 2005, Hartstein and Stevens 2005). Further, MPI (2013a) recognises that a mussel farm may well produce an impact on other farms and nearby communities, while escaping such impacts itself, with the lightest deposits from mussel farms reaching perhaps in excess of 90 m from a farm (Kuku Mara 2002) and ultimately influencing downstream communities.

20 There is evidence that mussel farms may influence feeding and recruitment for nearby communities by filtering out phytoplankton and zooplankton upstream of a community (e.g. Safi and Gibbs 2003; Plew 2011). There is also evidence that mussel farms alter current regimes that bathe nearby communities (e.g. Gibbs et al., 1991; Plew et al., 2006). Significant reductions of up to 70% in current speed may occur in seawater flow through mussel farms, compromising feeding efficiency and therefore carrying capacity (Gibbs et al., 1991; Boyd and Heasman 1998; Plew et al., 2006).

21 Waite (1989) observed that in the absence of adequate seawater flow through farms, there may be an up to 60% reduction of food occurring due to retardation of flow by farm structures and grazing by mussels. He further noted that longlines have been found to be relatively impermeable to currents and effectively deflect currents to run parallel to them.

22 Handley (2015) in a recent report, noted the likelihood of a "shifting baseline". In such a scenario a gradual change to seafloor habitat through time occurs such that what exists today does not closely resemble historical benthic communities and sediment. Possible drivers of a shifting baseline are thought to include sedimentation derived from land based human activities such as farming and logging, dredging and other harvesting of shellfish, and increased density of aquaculture farms (Handley 2015).

23 It is unfortunate that, as already acknowledged, there is a real paucity of baseline data for many of the areas within which marine farming has flourished. Without such data comparison of current benthic health with past benthic health is largely conjecture. However, a dive video survey carried out in September 2014 that compared benthic flora and fauna on reefs at two sites within Beatrix Bay with a site at a location that is devoid of mussel farms in Miro Bay, Marlborough Sounds, showed that there were differences in community structure at sites adjacent to mussel farms and at sites where mussel farms do

not exist. Results, however, were not clear-cut and the author noted that other environmental factors must be considered (Stewart 2014).

24 The investigations that have been carried out within central Pelorus over the past decade are insufficient to gauge whether or not there has been any impact on soft bottom communities beyond the immediate footprint of existing mussel farms and are certainly insufficient to gauge any effects on hard substrata. What is concerning is that there has been little or no requirement to monitor the wider environment or the sustainability of marine farming.

CUMULATIVE ECOLOGICAL EFFECTS

25 There is an acknowledged gap in knowledge about cumulative effects of mussel farms (Mead *et al.*, 2001, MPI 2013a), and the effect of "fencing off" inshore communities (Keeley *et al*., 2009; MPI 2013a).

26 Within the context of aquaculture development in the marine environment, cumulative effects are defined as:

Ecological effects in the marine environment that result from the incremental, accumulating and interacting effects of an aquaculture development when added to other stressors from anthropogenic activities affecting the marine environment (past, present and future activities) and foreseeable changes in ocean conditions (i.e. in response to climate change) (MPI 2013a).

27 A cumulative effect is referred to in Section 3 of the RMA as an effect which arises over time or in combination with other effects. Peart (in Milne 2008) believes the effects based approach of RMA fails to deal adequately with cumulative effects arising from granting of individual consents. The author of the paper (Milne 2008), however, suggests that the RMA (1991) supplies the tools to deal with cumulative effects but believes the challenge is for local authorities to use the tools available to them before the "horse has bolted". It is worthwhile noting that within the cited paper (Milne 2008) cumulative effects are largely referred to in terms of natural character, landscape, amenity, but not ecology. In my view this is a serious oversight.

28 Examples of cumulative ecological effects include the additive effect of multiple local scale benthic footprints; incremental depletion of phytoplankton and zooplankton as a result of shellfish culture; and spread of pests/diseases among farms that leads to multiple reservoir populations. Cumulative effects of eutrophication can occur gradually over long

time periods (Armitage et al. 2011) and cascading effects to the environment, such as shifts in benthic communities, can last for decades (Herbert and Fourqurean 2008).

29 The potential for shellfish aquaculture to contribute to cumulative effects in the marine environment will be dependent on the size of the culture, density of farms, and environmental characteristics of the area being farmed (e.g. hydrodynamics, phytoplankton biomass, anthropogenic nutrient inputs etc.). Using "sustainability performance indicators", Gibbs (2007) suggests that the retention (flushing) time for a water body should not exceed 5 percent of the clearance time (filtering efficiency) of farmed mussels in order to minimise cumulative effects on the wider ecosystem. According to the Aquaculture Stewardship Council (ASC 2012), where the area of marine farms exceeds 10% of the surface area of a water body, as in Beatrix Bay, the ratio of clearance time over retention time should be >1. Shaw Mead (2015), among others, has calculated that the CT/RT ratio for Beatrix Bay is likely two or even three orders of magnitude less than one. This suggests that the ecological carrying capacity for the bay is already well exceeded.

30 Spatial modelling tools offer a way of estimating the extent to which the cumulative effects of mussel farming may be approaching ecological carrying capacity on "bay-wide" and "regional" scales. However, knowledge gaps are still evident in these models; particularly in the biological aspects (e.g. feeding behaviour and growth of the shellfish) which are still areas of active research. Long-term monitoring of the wider ecosystem is required to validate and improve models and to assess wider cumulative environmental change. Bathymetric and hydrodynamic data are needed for all regions supporting aquaculture, as this provides the basis for understanding waste dispersion and assimilation. The recently completed NIWA model for Pelorus Sound may well help with this.

CARRYING CAPACITY

31 One of the most contentious issues with respect to the development of mariculture throughout the world is the concept of "carrying capacity" (McKindsey. *et al.*, 2006). For bivalve mariculture, Inglis *et al.* (2000) divided carrying capacity into four functional categories:

i) physical carrying capacity — the total area of marine farms that can be accommodated in the available physical space,

ii) production carrying capacity — the stocking density of bivalves at which harvests are maximized,

iii) ecological carrying capacity — the stocking or farm density which causes unacceptable ecological impacts,

iv) social carrying capacity — the level of farm development that causes unacceptable social impacts.

32 Determining ecological carrying capacity for growing waters under its broad definition is difficult because there is no strong foundation for defining limits within a marine ecosystem based on complex ecological processes. Simple modelling techniques limit any findings to a broad, bay-wide scale assessment of ecological carrying capacity and do not incorporate feedback mechanisms such as changes to the flushing regimes induced by structures (Grant & Bacher 2001; Plew et al., 2005) or far-field nutrient enhancement and increased phytoplankton growth (Gibbs et al., 1992).

33 A number of authors have expressed concerns regarding Beatrix Bay and other similarly sheltered waters in the Marlborough Sounds being "over allocated" with respect to aquaculture, with the likely consequence that the carrying capacity of the bay may have been exceeded (Hayden et al., 2000; Mead 2002, 2013). Certainly there has been a steady increase in the area of mussel farm development in Pelorus Sound over time (Handley 2015) (Figure 1).

34 Low mussel growth rates and production in the late 1990s to early 2000s, and more recently, seemed to support the conjecture that production carrying capacity for Beatrix Bay may be being approached. However, there have been periods of strong recovery of mussel yield after low production periods and the work of Zeldis (2008) and Zeldis et al. (2013) suggest that productivity and farming intensity of aquaculture in the Pelorus Sound is, to date, occurring at densities below the production carrying capacity of the system, due to nutrient availability being driven by climate forcing in El Nino years.

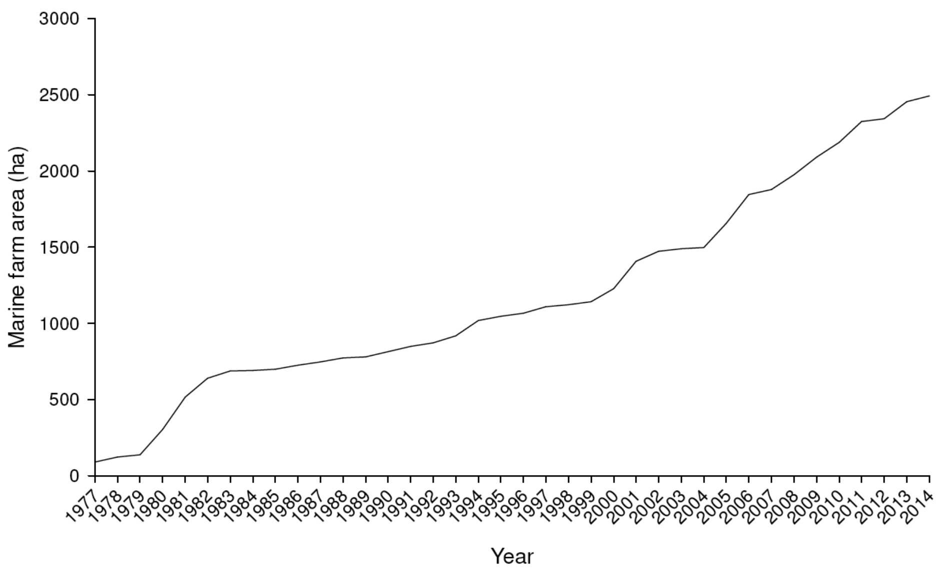

Figure 1 *Cumulative area (ha) of Pelorus Sound marine farms, 1977-2014 (from Handley 2015).*

35 Nevertheless, anecdotal evidence and press clippings from the Marlborough Express from January, April, August and September 2013 suggest that yield fell again during the 2012 - 2013 seasons. This suggests to me that it is entirely possible that the Beatrix Basin and similar areas may be being farmed close to or beyond sustainable production limits during years of naturally low primary production.

36 It is very important to note that production carrying capacity and ecological carrying capacity are not the same. Jiang & Gibbs (2005) concluded that ecological carrying capacity limits are likely to be around 20% of the production capacity limits, so it follows that ecological carrying capacity may be being exceeded by the current level of culture in some areas. Indeed, Mead (2015, Appendix 6) calculated that the ecological carrying capacity of Beatrix Bay may currently be exceeded by an order of 5.

NIWA BIOPHYSICAL MODEL

37 Modelling of the processes involved in and influencing mussel aquaculture is a useful tool in predicting carrying capacity and effects on the environment, or on the cultured species. However, modelling studies have primarily focused on carrying capacity in terms of sustaining farm production, rather than ecological carrying capacity.

38 The Marlborough District Council (MDC) commissioned NIWA to develop a pair of biophysical models for the Marlborough Sounds, one for the Queen Charlotte Sound/Tory Channel system and one for the Pelorus Sound system (Hadfield et al., 2014, Broekhuizen et al.,

2015). The models used current and historic data to assess effects of mussel farming on a number of parameters under three possible scenarios. i.e. (i) no mussel farming, (ii) mussel-farming at the extent revealed by a 2012 aerial survey ('existing farms'), and (iii) mussel farming at the scale implied by all licenses approved (at about Feb. 2014; 'approved farms'). The 'existing farms' scenario was treated as the baseline.

39 Both reports have been extensively peer reviewed and accepted by the MDC. The models provide useful tools for understanding the interaction of physical and biological parameters within the areas under study, and doubtless, the accuracy of each will improve with continued ground truthing (i.e field observations) and with the addition of more data as it comes to hand.

40 As it stands, however, the model for Pelorus Sound raises some issues with regard to effects of mussel farms. Tables 1 and 2 below are based on information provided in Figures 5.13 and 5.14 in Broekhuizen et al. (2015).

Table 1 *Summary of likely changes to water column parameters during summer if mussel farms were removed, as compared to the baseline (existing farms) scenario.*

	Clova Bay	**Beatrix Bay**	**Crail Bay**	**North Side Kenepuru**
Zoo Plankton Levels	10 times more	Up to 10 times more	Up to 10 times more*	Up to 10 times more
Small Palatable Detritus Levels	2 times more	Up to 2 times more	Up to 2 times more	Up to 2 times more
Large Palatable Detritus Levels	4 times more	Up to 4 times more	Up to 4 times more	Up to 4 times more
Ammonium in the water column	60%+ less	Up to 60% less	Up to 60% less	Up to 60% less
Nitrates in the water column	50%+ less	50% + less	50%+ less	50%+ less
Chlorophyll in the water column	Slightly more	Slightly less	Slightly less	Up to 25% less

* *Up to means it is may be less in some parts of the Bay*

Table 2 *Summary of likely changes to water column parameters during winter if mussel farms were removed, as compared to the baseline (existing farms) scenario.*

	Clova Bay	**Beatrix Bay**	**Crail Bay**	**North Side Kenepuru**
Zoo Plankton Levels	3+ times more	2+ times more	2+ times more	8+ times more
Small Palatable Detritus Levels	3 times more	Up to 2.5 times more	Up to 2.5 times more*	3+ times more
Large Palatable Detritus Levels	4 times more	Up to 3 times more	Up to 3 times more	4+ times more
Ammonium in the water column	50%+ less	Up to 50% less	Up to 50% less	50%+ less
Nitrates in the water column	15% less	Up to 15% less	Up to 15% less	Up to 30% less
Chlorophyll in the water column	3 times more	Up to 2.5 times more	Up to 2.5 times more	Up to 2.5 times more

* *Up to means it is may be less in some parts of the Bay*

41 While the elevated ammonium concentrations are well below Australian and New Zealand guidelines for fresh and marine water quality (ANZECC 2000) toxicity guideline concentrations for marine waters the consequences higher in the foodweb of reduced (or elevated) phytoplankton concentration or reduced zooplankton concentration under the 'existing farms' scenario are of more concern. Any organisms will suffer if their foodsupply is sufficiently reduced. Furthermore, as already stated, there may well be downstream effects from reduced larval recruitment (e.g. reduced food supply for organisms higher up the food chain, reduced abundance and/or diversity of settlement). The authors of the model concede that are questions to answer. Dr Breokhuizen states "I suspect that, relative to no mussel and no fish farms, some of the changes predicted by the model are large enough that other aspects of the foodweb may change materially" (Broekhuizen 2015).

42 The relationship between the environment and the growth of Perna canaliculus, which underpins any related ecosystem models, is presently poorly defined (Keeley *et al.,* 2009). A better understanding of the feeding physiology and energetics of Perna species would greatly improve confidence and reduce variance in model outputs, particularly when it comes making predictions for new environments.

DISCUSSION

43 Davidson (2012c) states that "Inappropriate or poorly planned human endeavours have often had a negative effect on the marine environment. This has undoubtedly led to a reduction in the quality and quantity of biological values in the Marlborough Sounds. It is therefore important remaining biological values are not further adversely affected and are well managed."

44 I consider that we simply do not know enough about the marine ecosystems within Pelorus Sound to evaluate the ecological effects of existing farms, or to allow further development of aquaculture in the area, without a comprehensive plan to monitor the ecology of the system. Baseline conditions and the current level of cumulative effects from past and existing developments and activities (including land based) are not well documented or monitored in the coastal environment. Additionally, nutrient inputs to the marine environment from land-derived diffuse (non-point) sources, and natural oceanic sources such as denitrification and burial are not well quantified.

45 Due to uncertainty around the cumulative effects of multiple nutrient inputs in New Zealand's coastal environments, it is difficult to adaptively manage any one activity in response to changes occurring in the wider environment. Hence, a precautionary approach utilising a

number of tools (such as modelling and monitoring) is essential in developing aquaculture in any coastal environment.

46 The precautionary approach, as enunciated in Policy 3 of the NZCPS, seeks to adopt a precautionary approach towards proposed activities whose effects on the coastal environment are uncertain, unknown, or little understood, but potentially significantly adverse.

47 Among the important tools and components of a precautionary approach are:

1. The use of models and existing data to gauge limits to development within the context of a region's assimilation capacity (i.e. ecological carrying capacity).
2. Establishment of wider-ecosystem, long-term monitoring programmes that include establishment of baseline conditions of a region and adoption of limits of acceptable change.
3. Targeted monitoring and research for validating and improving accuracy of predictive models and understanding the role of aquaculture in driving cumulative effects.

48 There is an urgent need for the science to catch up with the industry. Despite what industry stakeholders say about there being a large amount of information available, there has been surprisingly little targeted monitoring done to determine effects of aquaculture on nearby ecosystems or on the wider Marlborough Sounds environment.

49 It is well recognised that there are little baseline data available from before aquaculture was introduced to the Sounds, but of more concern is the fact that there has apparently been little monitoring of any farms once farms are established. As far as I can ascertain there appears to have been little or no adaptive management taking place with respect to environmental issues for any marine farm within the Marlborough Sounds.

50 I would suggest that the requirements for assessing ecological carrying capacity and managing cumulative effects fall beyond the scope of a single consent applicant and are, in my opinion, best led by the industry in partnership with science agencies, local authorities (e.g. Dubé 2003; Hargrave *et al.,* 2005, Zeldis 2008a,b) and central government departments (Morrisey *et al.* 2009; Zeldis *et al*., 2011a,b). It is critical that this task is undertaken in order to develop ecosystem-based management programmes in an adaptive manner.

51 Adaptive management was defined in New Zealand in the Environment Court in the case of Crest Energy Kaipara Limited v Northland Regional Council (Decision A. 130/09).

52 The five features are:

1. that stages of development are set out;
2. that the existing environment is established by robust baseline monitoring;
3. that there are clear and strong monitoring, reporting and checking mechanisms so that steps can be taken before significant adverse effects eventuate;
4. that these mechanisms must be supported by enforceable resource consent conditions that require certain criteria to be met before the next stage can proceed; and
5. that there is a real ability to remove all or some of the development that has occurred at the time if the monitoring results warrant it.

53 It is my belief that the DoC (1995) guidelines for assessing sites for aquaculture and requirements for on-going monitoring are inadequate. Handley and Cole (2000) recommended that appropriate monitoring conditions should include phytoplankton and nutrient availability, current dynamics, species assemblage changes, sediment grain size analysis, nutrient deposition, and visual observations of the benthic epibiota inside and outside the farm at frequencies appropriate to each of the issues. They further recommended that results from all monitoring should be reviewed after 3 and 5 years and assessed by the appropriate consent authority.

54 MPI (2013b) suggest that AEE monitoring is crucial to assessing the effects of a marine farm on the surrounding environment. They advise that a monitoring plan needs to be thought about early on, including whether and what baseline monitoring is needed, and how any ongoing monitoring is undertaken and state that it is important to look at what monitoring already exists to see whether that can be used. In my opinion there is an urgent need to implement a control based monitoring programme for mussel farming within the Marlborough Sounds. Such monitoring is essential to empirically determine the impacts of mussel farming within the Sounds. Without estabilishing the level of effects is it impossible to establish an ecologically acceptable level of mussel farming.

55 There is little doubt in my mind that aquaculture, as practiced in the Marlborough Sounds, results in measurable changes to marine communities in the Sounds and perhaps to the ecosystem as a whole. There are strong indications that the low flush areas of Clova Bay, Crail Bay and Beatrix Bay are being farmed beyond what might be considered an acceptible ecological carrying capacity. It has been said that Beatrix Bay is a “Farming” area as though that somehow validates any ecological changes that ensue from marine farming. If one accepts this and accepts that ecological change is a necessary part of aquaculture, that needs to be recognized and accepted by the wider community. If, however, widespread ecological change

is not accepted, guidelines as to how much change is acceptable, and how to monitor the degree of change, need to be implemented with some urgency.

56 In summary, indications are that ecological carrying capacity is being exceeded in the central Pelorus area. For future mussel farm applications and/or renewals I would suggest that it is imperitive that the applicant be required to show that this is not the case before consents are granted.

Yours faithfully
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