Marlborough Salmon Farm Relocation Advisory Panel. Information to Decline Application

H. Janssen
Ecosystem Scientist
Adaptive Resource Management Ltd

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From 9.30 am

RECOMMENDATION

It is recommended the Marlborough Sounds Farm Relocation Advisory Panel

Decline the application for the following reasons:

1. The decision and ruling established a THRESHOLD of a MAXIMUM of TWO salmon farms (Waitata and Richmond) in the WAITATA REACH, conditional upon monitoring.
2. **This renewed application process disregards the entire previous expert witness tribunal process and decisions and the judge's ruling that:**
    a. **An expert panel-conducted effective monitoring regime has to be put in place to assess baselines and any adverse effects on the Sounds' environment, and that**
    b. **Thresholds are set to trigger remedial action before the effects become damaging and that**
    c. **Possible effects can be remedied before they become irreversible.**
3. King Salmon's exceptionally high salmon death rate is due to the fact that the Sounds are unsuitable for salmon:
    ⇨ The waterbody environment is too warm, too calm and there is too little exchange
    ⇨ and that farming salmon is cruel to a top trophic layer migratory fish species.
4. The death of salmon in farms predicts precisely what will happen to the Sounds environment, if unnatural practices at this scale were to be continued.
5. **Placing existing farms in high-flow areas would amplify the already skewed monitoring and reporting set-up, as less impact will result under high flow farms and consequently more ADVERSE EFFECTS be EXTERNALISED upon the receiving and unmonitored wider Sounds' environment, resulting in:**
    a. **Proliferation of Harmful Algal Blooms (HAB) =>,**
    b. **Collapse of native fish stocks and spawning grounds =>**
    c. **Overabundance of anoxic sludge worms under cages**
    Proliferation of plankton-feeding jellyfish elsewhere =>,
    d. **Collapse of mussel farming=>**
    e. **Collapse of Sounds' life supporting capacity etc.**
6. Sounds' ecosystem collapse. The catastrophic shift in Sounds' functional integrity cannot be reversed as easy as it was degraded, as the trajectory of recovery is very different from the pathway of decline**.**

7. The Sounds' Ecosystems are globally significant, as they comprise the hub of one of the planet's 34 BIODIVERSITY hotspots. The proposal would foul the fast flow sites of highest endemic biodiversity value!
8. New Zealand's endemic and endangered Hector's dolphin habitats are the high-velocity marine environments with highest biodiversity value that KS would foul by attempting to shift salmon farming where NZ's Hector dolphins live.
9. Endemic biodiversity is not just of global significance; evolved biodiversity is also vital to sustain ecosystem productivity long-term and yield for human use (refer to J. Banks' quote 1770). One cannot persist without the other!
10. Should existing fish-farms be operated simultaneously, the probability is high for irreversible adverse effects of high potential impact from an already functionally compromised Sounds ecosystem to a severely degraded state to occur. The Sounds would lose the capacity to sustain trophic structural complexity and with it, the life supporting capacity for people, the local economy and future generations.

Contents

PRECEDENT:

This renewed application process disregards the entire previous expert witness tribunal process and decisions and the judge's ruling that an expert panel-conducted effective monitoring regime has to be put in place to assess baselines and any adverse effects on the

Sounds' environment[1] **(*not just the cages*!)**, and that thresholds are set to trigger remedial action before the effects become damaging and that possible effects can be remedied before they become irreversible.

The outcome of the previous application process was conditional upon that monitoring proved that there were to be no adverse effects on the environment and the use of public space, as the applicant never provided any evidence on adverse, cumulative or potential effects of EXISTING salmon farming operations on the Sound's environment, let alone an estimate on adverse effects of his earlier proposal.

This renewed application disrespects the outcome of the previous application process.

The applicant (& the MSWG):

1. Ignores panel's decision and judge's ruling and because of this
2. Fails once again to provide any information on adverse, potential and cumulative effects on the Sounds' environment and on public space.

As it stands, the earlier decision with regard to the applicant's use of public space is a compromise in favour of the applicant, as it should have been the applicant's obligation to prove BEFORE any farms were to be established that there were to be no adverse effects on the environment and the use of public space.

The standing ruling states that baseline and environmental monitoring of the cage vicinity AND the wider Sounds environment (*as opposed to salmon-farm operational monitoring*) MUST accompany granted farms to prevent any potential-, cumulative-, and adverse effects on the Sounds' environment and on occupied public space.

The requirements of the RMA Ss 5-7 are that if independent environmental monitoring establishes adverse effects of salmon farm pollution-induced toxic algal blooms and jellyfish proliferation as indicators of degradation, that all existing farms must immediately be closed and dismantled, and the site cleaned up to maintain environmental integrity and public safety.

The decision and ruling established a THRESHOLD of a MAXIMUM of TWO salmon farms (Waitata and Richmond) in the WAITATA REACH !

> Julian Ironside: " There is the potential for any new farm establishing in the Waitata reach to undermine and have a confounding effect on the integrity of the monitoring effort required for the Waitata and Richmond farms. To maintain the integrity of that monitoring effort, it first needs to be established that the Waitata and Richmond farms can operate to the maximum levels of discharged feed authorised under the

[1] [181] After considering the principles applied in these cases for adaptive management to be appropriate in this instance we must be satisfied that:
[a] There will be good baseline information about the receiving environment;
[b] The conditions provide for effective monitoring of adverse effects using appropriate indicators;
[c] Thresholds are set to trigger remedial action before the effects become overly damaging; and
[d] Effects that might arise can be remedied before they become irreversible.

Using his assumptions we calculate the population equivalents for the maximum feed levels in the three regions would be 58,950, (Port Gore) 141,470 (QCS) and 200,420 (Pelorus Sound) respectively or a total of an additional 400,480 people for Sounds people. This figure is very close to Dr Schuckard's estimate and usefully illustrates the scale of the proposal.

conditions of consent for the two farms, before any new farm could be allowed to establish in the Waitata reach."

"Further the board's decision in relation to the White Horse Rock site illustrates the fact that the board itself considered that a THRESHOLD of 2 new farms was the LIMIT of further salmon farming development for the Waitata Reach…. the board was not prepared to grant consent for a further salmon farm in the Waitata Reach…!"

Despite ruling and known knowns Rosewarne proclaimed: "The 130-tonne Waitata Reach barge would hold 240 tonnes of salmon feed, or one to two weeks' worth of feed. The farms' current feed capacity of 100 tonnes a week would double!"

KS-NZ: The Worldwide Highest Salmon-farming Death Rate

⇨ An Omen for the SOUNDS!

According to KS figures, King Salmon has highest death rate at > 16 % of any salmon farming operations[2] worldwide and their main goal is to reduce that to 10 %, by "reducing feeding stress and constant feed input (100 times per day).

The exceptionally high salmon death rate is due to the fact that the Sounds are unsuitable for salmon:

1. The waterbody environment is too warm, too calm and there is too little exchange
2. and that caging salmon is cruel to a top trophic layer migratory fish species.

The death of salmon in farms shows exactly what will happen to the Sounds environment if such unnatural practices are continued.

[2] This exceptional death-rate despite as yet no issues with sea lice or other "diseases" that prompted other operations to have to use ANTIBIOTICS in NATURAL ENVIRONMENTS !

JELLYFISH Proliferation and Harmful Algal Blooms

Scientific Evidence of Salmon Farming's Adverse Effects (Actual, Potential & Cumulative).

Salmon farm under cage fouling – results from just 10% of fossil-fuelled pollution (Not "*enrichment*") being added to the waterbody. 90 % of pollution typically disperses throughout the shallow Sounds' waterbody.

The 90 % pollution accumulate in the many low-flow bays in the Sounds such as Onapua Bay and result in many more death zones throughout the Sounds, over and above the operational monitoring derived death zones underneath the salmon cages[3].

KS incorrectly refer to their operational farm monitoring to reduce salmon deaths as "Adaptive Management".

Adaptive Management has been developed and is based upon **environmental monitoring**, which KS fails to do for 90 % of its effluent. Their monitoring and reporting instead rests on merely 10 % of their farms' impact underneath and immediately next to their cages ("the toxic worm-sludge footprint"), while ignoring monitoring and reporting potential and cumulative adverse effects of 90 % of the impact of their operations on the wider Sounds environment.

If the full 100 % of their operations' adverse effects were monitored, proper Adaptive Management could be implemented and which, according to the ruling, must encompass the option to shut down old and new farms before monitoring confirms damage to environment and public spaces through salmon farm-effluent induced harmful algal blooms and jellyfish overabundance

Placing <u>existing farms in high-flow areas</u> will amplify the already skewed monitoring and reporting already in place, as less impact will result under high flow farms and consequently <u>more adverse effects</u> will be <u>externalised upon the receiving and unmonitored wider Sounds environment</u>.

Jellyfish overabundance and toxic algal blooms already demonstrate that environmental tipping points have been breached and collapse of the Sounds ecosystem might be imminent just with existing salmon farming operations.

[3] The concept of adaptive management was developed to monitor input responses to ecosystem integrity and thus to recognise mismanagement early on and prevent ecosystems reaching tipping point of no return.

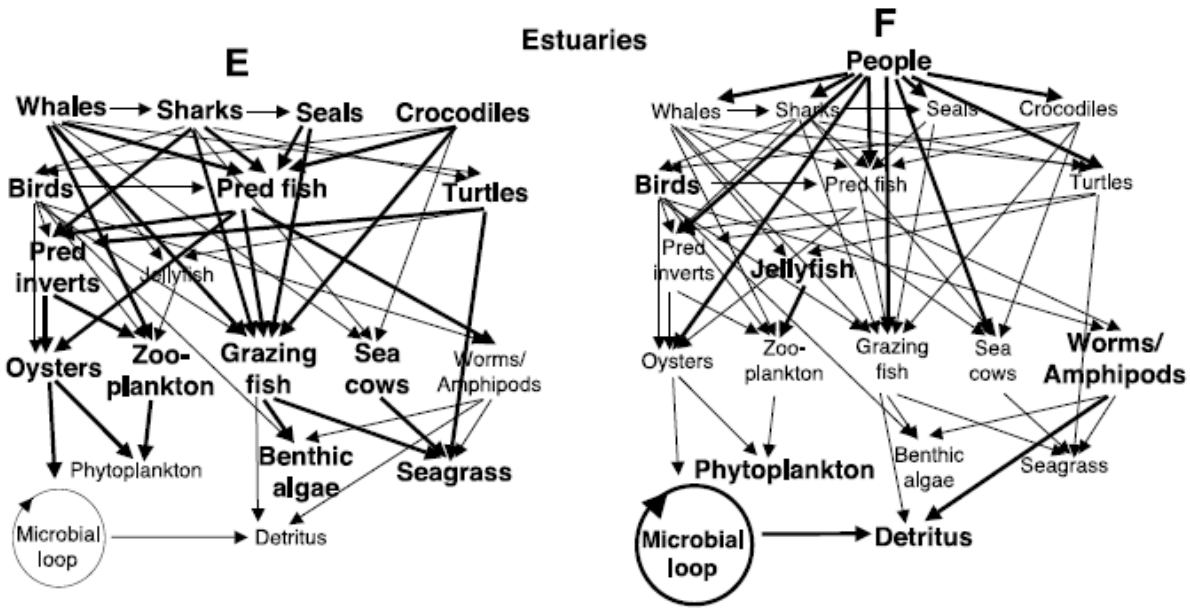


Figure 1: Cumulative impact of people on tropical estuaries. Remove tropical species to visualise impact in Sounds.

The proposed feed-derived pollution levels approach the original proposal. The following graphs demonstrate the potential effect, that led to the decision and the judge's ruling to limit new farms to TWO in Waitata reach accompanied with monitoring of the adverse effects of effluent input (10 % under cage AS WELL AS 90% to wider receiving Sounds environment !)

Eutrophication and Harmful Algal Blooms: A scientific Consensus!

(Heilser et al. 2008[4])

The proposal adversely affects the integrity and natural productivity of the Sounds' environment and thereby the very existence of its people, communities and future generations in the upper South Island.

[4] References: Please refer to Statement of Evidence HJ 2012

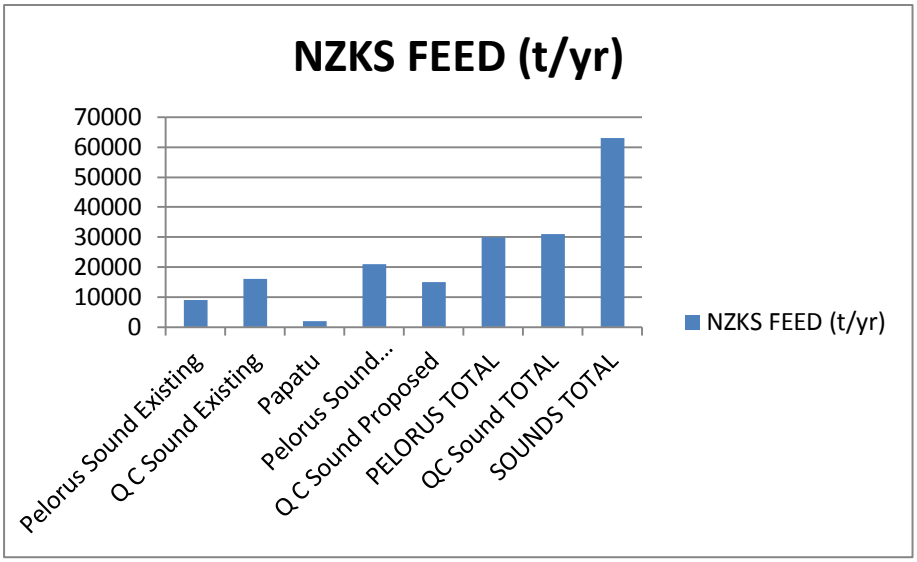


Figure 2 Sounds' existing and proposed loading of fish feed in dry-weight t/yr.

Peak feeding in summer and autumn. Weight eq. total: 10,000 pilot whales (wet weight) decomposing each in Pelorus Sound AND Queen Charlotte Sound every year or 400 Blue whales stranding annually.

1. Organic nutrients have been shown to be important in the development of blooms of various "Harmful Algal Bloom" (HAB) species, in particular cyanobacteria and dinoflagellates (e.g., Paerl 1988) and the importance of this phenomenon is beginning to be documented around the world (e.g., Granéli et al. 1985 , 1999, Berman 1997, 2001, Berg et al. 2003).
2. **Both chronic and episodic nutrient delivery promotes HAB development.** (Heilser et al. 2008)

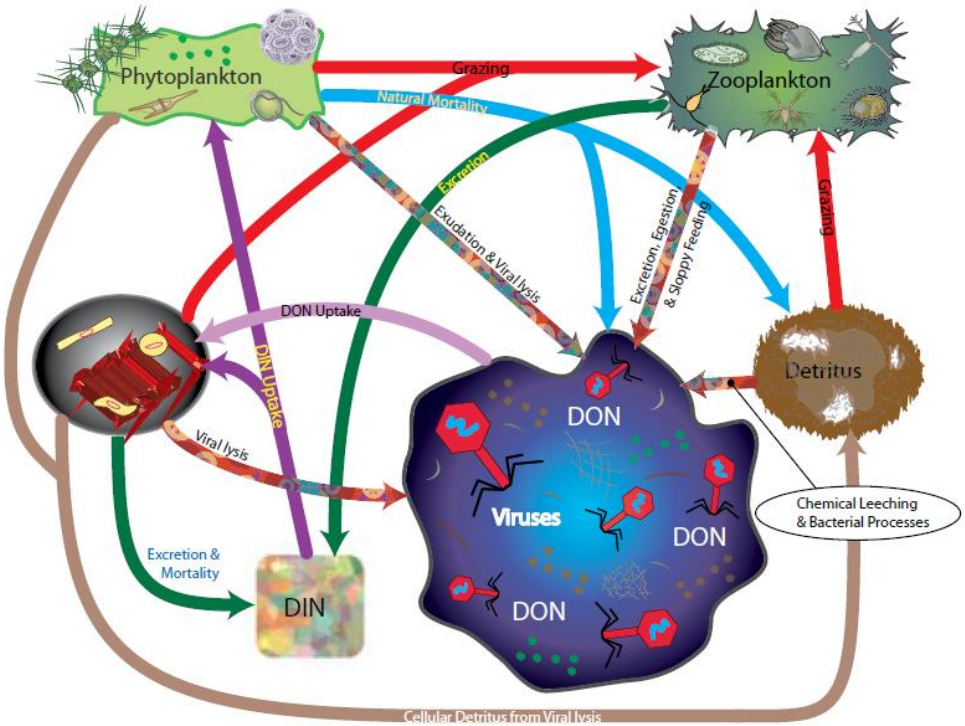


Figure 3 A schematic diagram of a nitrogen-based model of mixed-layer plankton and nitrogen cycling showing the flow of nitrogen among compartments.
University of Maryland Center for Environmental Science, www.ian.umces.edu.

Effluent Flushing and Accumulation in Sounds' Native Fish Spawning Grounds

1. **Fish farm effluent accumulates in calm stratified water columns of interior Sounds. Native fish spawning grounds and mussel farms would be replaced with Harmful Algal Blooms and jellyfish (compare Figure 9).**

2. Faecal detritus and nutrient release from existing and proposed fish farms **significantly alters the natural balance** of dissolved organic nitrogen (DON) and dissolved inorganic nitrogen (DIN= ammonia, nitrate, nitrite) nutrient pools, resulting in chaotic cascades within and between trophic layers, with **peak inputs** during HAB-hazardous **summer and autumn** periods.
3. Carbon: 20% excreted as faeces
4. Nitrogen:
    a. **50% excreted as DIN** => ***readily available to fuel HABs!***
    b. 25% excreted as faeces => DON temporary N store
    c. merely 25% is metabolised by salmon,
5. Phosphorus:
    a. 65 % excreted as faeces - dissolved organic phosphorus (DOP)
    b. 30% excreted as dissolved inorganic phosphorus (DIP)

    (*Data from models by **Neil David Hartstein***)

6. Based on (Maita 1993) and an assumption of nutrient rich upwelling waters from Cook straight entering the Sounds at 30 milligram/ m^3 and an average depth of 30 m, **the 34428 ha Pelorus Sound water body should, in its natural, unpolluted state contain 310 t of dissolved inorganic Nitrogen DIN** as one of the nutrients that through balanced input forms the basis for the growth of a diverse range of phytoplankton species, which sustains the natural productivity of the Sound's upper trophic layers.
7. KS developments just about **doubles the DIN input into Pelorus Sound** by its reactivated Pelorus fish-farms, releasing 924 t /yr DIN plus 462 t/year of DON, which over time will add extra DIN into the unnatural / polluting pool.
8. An unnatural input of such magnitude and skewed Redfield ratio is set to entirely collapse the Sound's phytoplankton dynamics and its natural trophic structure.

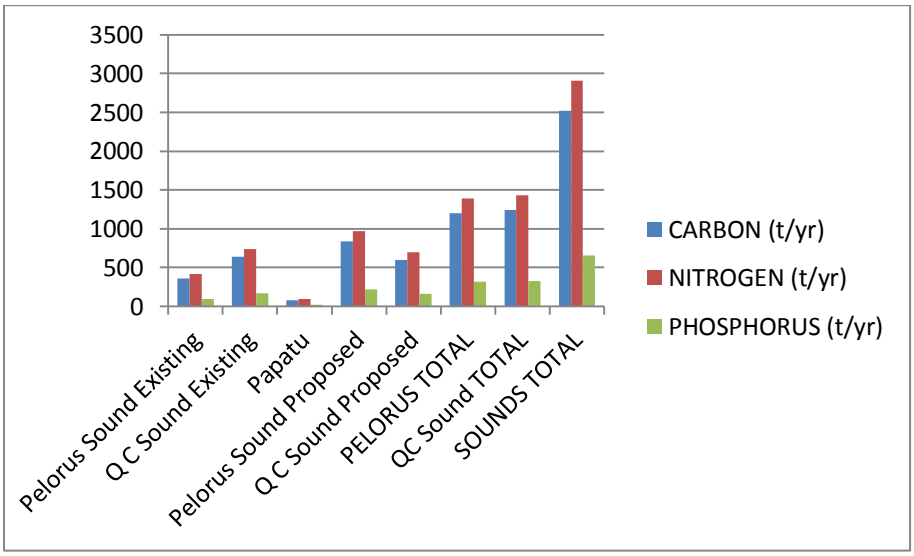


Figure 4 Salmon farm effluent C/N/P Redfield ratio 3.8 : 4.4 : 1

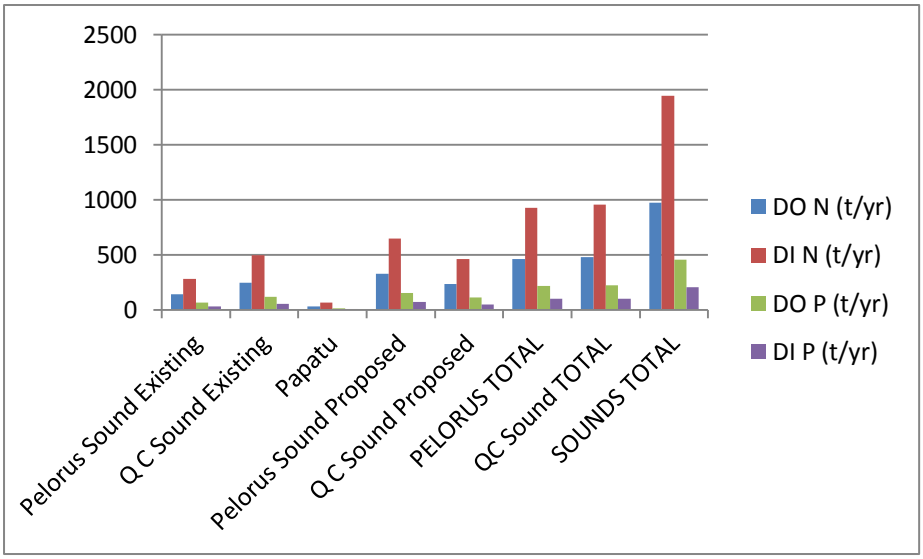


Figure 5 Compare natural DIN input to Pelorus of 310 t/yr with salmon-farmed Pelorus total DIN pollution of > 900 t/yr plus 462 t/yr N pool available to fuel toxic algal blooms. Salmon farm effluent ratio: C/DIN/DIP 12.4 : 9.6 : 1

Unseasonal and Industrial-scale Nutrient Input is the Cause of Toxic Algal Blooms!

The majority of bio-available dissolved organic nitrogen (DIN) from salmon farms is released into the water column peaking during the summer months.
This is contrary to natural DIN and phytoplankton cycles, where, in early spring, diatom phytoplankton rapidly assimilates any nutrient reserves, built up over winter, feeding into a healthy trophic structure of zooplankton and fish.

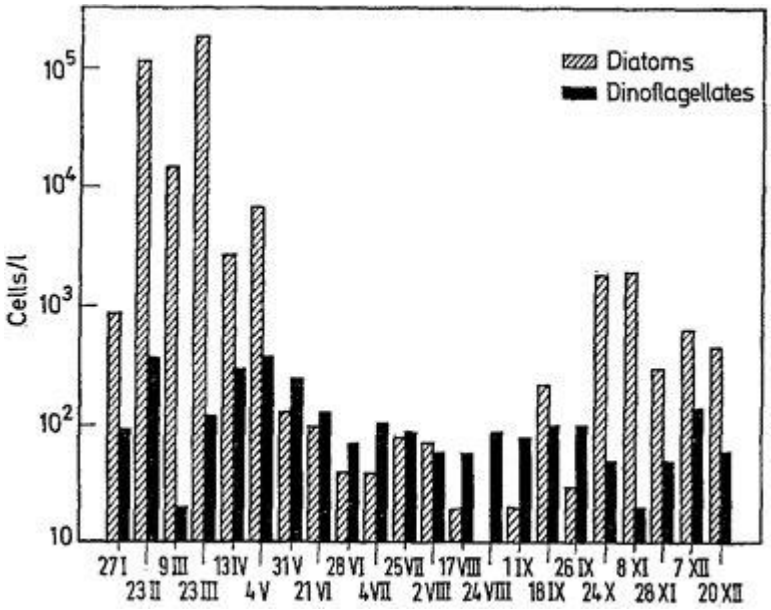


Figure 6 Note: Natural N_r reserves are depleted in spring predominantly by diatoms. Summer and autumn: Naturally low N_r (DIN) and therefore low phytoplankton cell counts. Northern hemisphere histogram showing the seasonal changes in net plankton diatom and dinoflagellate populations (Ignatiades, 1969). The latitude is comparable to the Sounds.

1. **Fish-farming therefore results in three significant adverse effects on the Sounds' natural nutrient and phytoplankton cycles**:
    a. Significant unnatural (fossil-fuelled) increase of DIN and chronic N release from accumulating dissolved organic nitrogen (DON) and detritus pollution of the marine ecosystem

b. An unnatural, seasonally skewed peak DIN input in summer and autumn, when, under natural conditions, DIN is low and DON reserves are used up.

c. Unnatural C/N/P ratios (4:4:1 and 12:10:1 for N_r) of nutrients released, considerably exceeding background terrestrial nutrient flux from the Sound's natural forested catchments (C920:N30:P1) and a marine Redfield ratio of (C106:N16:P1), typically entering as tidal current through Tory Channel or Waitata reach. (Miyajima, et al. 2007)

2. **Therefore the proliferation of Harmful Algal Blooms (HAB) <u>will increase</u> with fish-farms already in existence.**
    a. **Their proposed placement in high-flow areas will result in an increase of flushed effluent through the Sounds.**

3. **Salmon farm relocations are set to tip a threshold of biological capacity resulting from failure to assimilate effluent harmlessly into the Sounds' trophic structure.**
    a. **This is likely to devastate the Sounds' marine ecosystems beyond recovery.**

Peak fish-farms' input of DIN in summer will result in a non-linear ecosystem response by way of Harmful Algal Blooms (HAB) that <u>will</u> result in persistent harmful algal blooms starting in summer and autumn, with corresponding on-going adverse effects for anyone visiting or living and working in the Sounds and beyond.

RESULT:

a. Dying waterbody (Harmful Algal Blooms);
b. collapse of the Sounds' native fish populations and spawning grounds (HABs)
c. => Proliferation of plankton-feeding jellyfish
    i. => Collapse of mussel-farming
    ii. => Collapse of Sounds' life supporting capacity
d. => King salmon will proclaim as "uneconomic" its use of a dying waterbody, the Sounds' public space, and will attempt to take their shareholder business to as yet unspoilt frontiers…
e. => Leaving their mess for Marlburians to sort over many future generations.

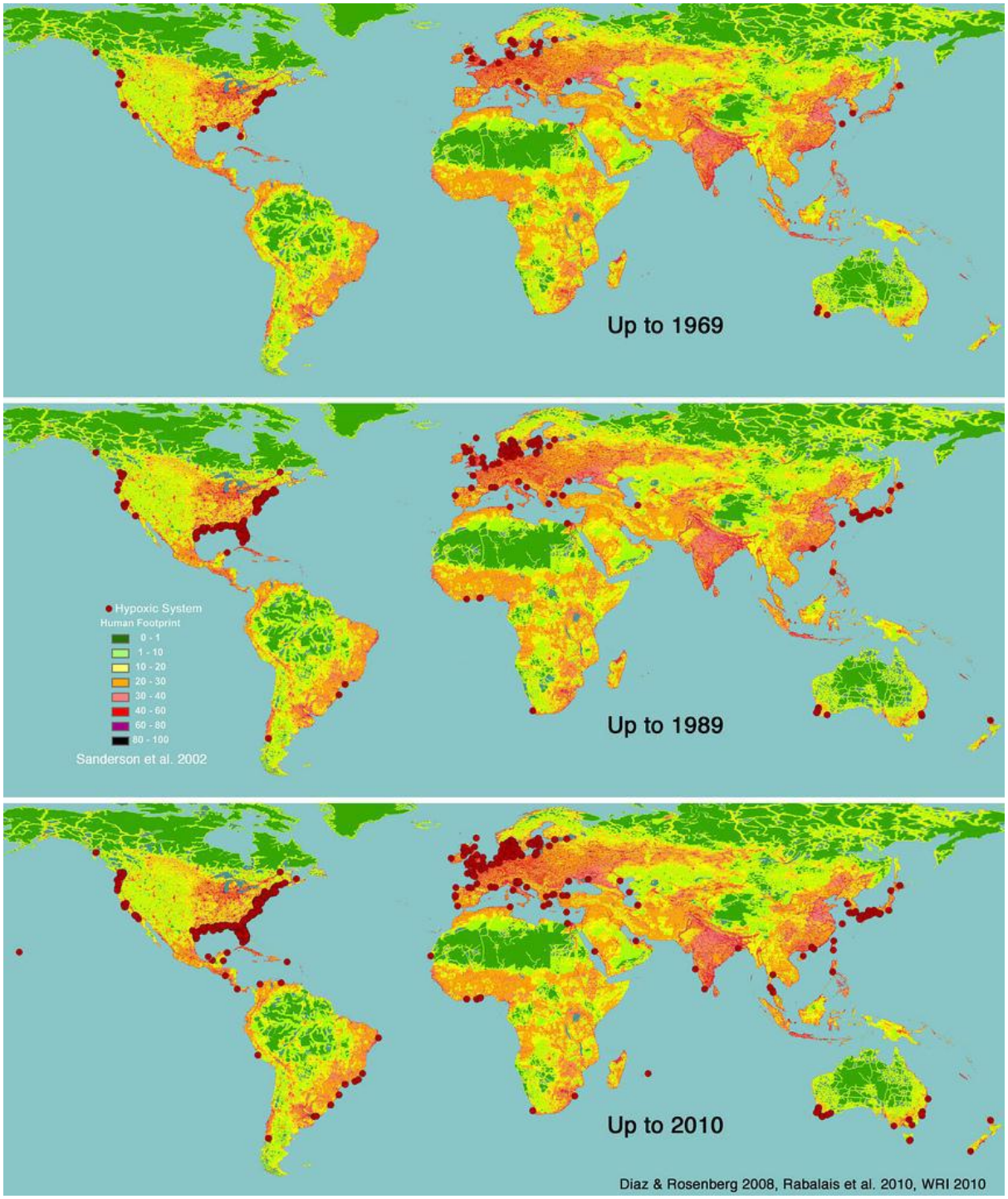


Figure 7: Rapid increase of marine Dead Zones from N_r induced phytoplankton blooms. Note 2 dead-zone events in NZ. Dead-zones result from fossil-fuelled N_r irrespective of effluent source – intensive food production / urban / fish-farm!

Figure 7, graphic of 2010, depicts the second marine dead-zone in New Zealand. An associated case study: Nutrient Loads to Protect Environmental Values in Waituna Lagoon, Southland NZ (Scanes, 2012) describes the consequence of a catastrophic ecosystem collapse affecting an enclosed NZ water-body as follows:

The catastrophic shift cannot be reversed by a correspondingly small reversal of the parameter variable; i.e. the trajectory of recovery is very different from the pathway of decline (*Petraitis and Dudgeon 2004, Lester and Fairweather 2008*). (References in my EIC)

In simple terms:
If the system tips, the causal factor needs to be changed by a large amount to bring it back – this means that it is much more expensive and difficult to restore than it is to protect.
This fossil-fuelled Tide of Death must never be allowed into the Sounds!

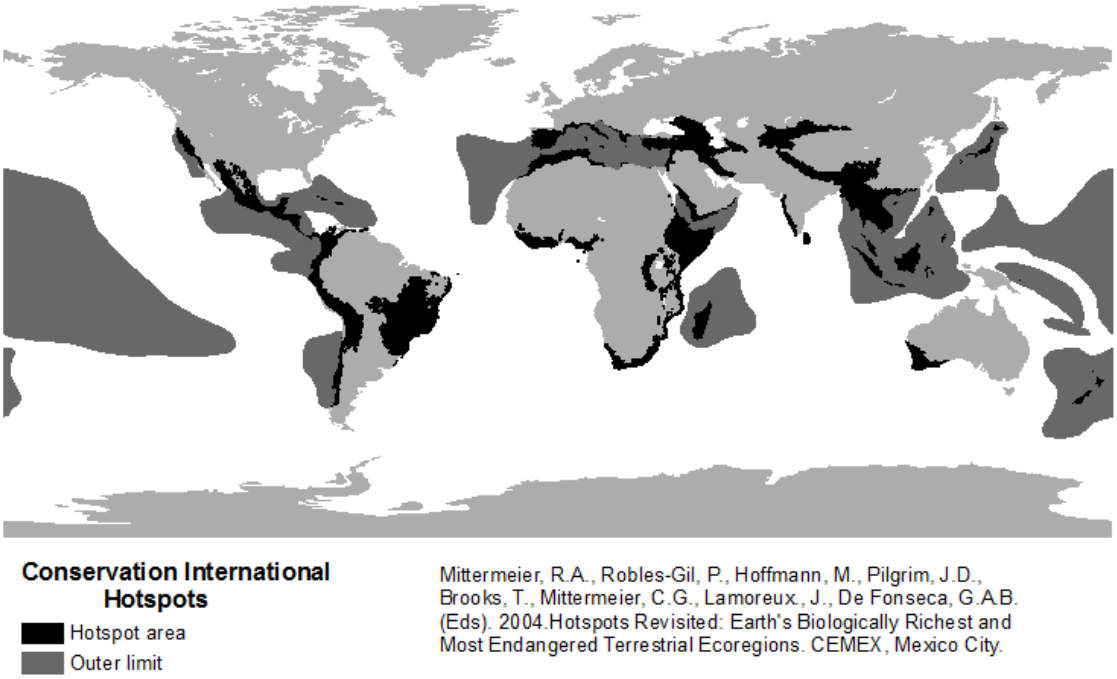
As keen kayaker I can tell you from close up observation within the more natural parts of the Sounds that jellyfish already have taken over where there was an abundance of native fish populations before. Fish that once sustained one of the highest fishing hunter-gathering population densities world-wide (50 E / sqkm) and left earlier European mariners astounded and return numerous times to restock supplies and describe Sounds' natural biodiversity and productivity as:

> "…caught 18 species of fish in a seine net one afternoon yielding more than enough to feed the entire crew for the duration of our stay" (Joseph Banks 1770).

Biodiversity Hotspot of Global Significance

As human developments' cumulative adverse effects are projected to increase the rate of species extinctions from 1000 times in the 20th century, to 10,000 times this century, relative to the background global extinction rate (Mace et al.2005) –

- the moral and legal responsibility to ensure the survival of endemic biodiversity by protecting the functional integrity of ecosystems is of topmost priority.



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- **Figure 8: Marlborough Sounds - the Hub of a Biodiversity Hotspot of Global Significance. One of Earth's biologically richest and most endangered ecoregions.**

1. The Sounds' Ecosystems are globally significant, as they comprise the hub of one of the planet's 34 biodiversity hotspots. Biodiversity hotspots are defined quantitatively as those areas where:

a. there are more than 1500 species (greater than 0.5 per cent of the world total) of endemic species (species that occur only here, nowhere else)
b. at least 70 per cent of the original habitat has been lost.

2. About half of our marine environment's flora and fauna are yet to be discovered (Gordon, MacDermaid, 2010).
3. Resulting from **physiographic complexity** and isolation:

    a. 84 % of terrestrial species
    b. 44% of marine species (108 fish *spp*)
    c. 86 % of bivalves
    d. 75% of sea squirts
    e. 66% of penguins, cormorants and shags.
    f. 90% of freshwater fish species

    …are **endemic**.

Endangered Hector's Dolphin.

Marlborough Sounds' Marine Habitats: Sanctuary or Casualty

Endemic biodiversity is not just of global significance; evolved biodiversity is also vital to sustain ecosystem productivity long-term and yield for human use. One cannot persist without the other!

Endangered Hector's dolphin is an endemic indicator species, responding to pressures on marine ecosystems. Its refuge and sole north-eastern South Island stronghold is the indigenous high-velocity marine environment 58 and now to a lesser degree environment 64. The very same environments are used by King Salmon in its salmon farming operations, both existing and the proposed fish-farms are located in this refuge habitat of hectors dolphin. It is highly probable that that fish-farms' adverse effects will exterminate this local population and divide eastern and western South Island populations, pushing this endemic species towards critically endangered status.

1. The Sounds' biodiversity is of global and national significance. Fractal dimensional complexity of terrestrial and marine environments and thus habitat opportunities at organism scales (10^{1} to 10^{-6} m) are outstanding nationally and globally.
2. Three of the four marine environments (MfE, 2005) where endemic Hector dolphin populations (*Cephalorhynchus hectori*) remain around NZ can be found in the Marlborough Sounds. These environments of endangered Hector dolphin populations (IUCN status - Reeves et al, 2008) are:
    a. The Sound's Hector dolphin stronghold **MEC 58:** Northern South Island's preferred coastal marine high-velocity habitat type for **Hector's dolphin** (Figure 1: light yellow). A local population lives around Oruawairua (Bluemine Island) and Tory Channel. Another pod of this northern South Island population lives in the remainder of the same marine environmental habitat in Cloudy Bay and Clifford Bays (Dawson et al. 2004). Small groups of the local

QC Sound and Tory Channel population do venture out to frequent this habitat type (**MEC 58**) in Waitata reach and Tawhitinui reach.

i. King Salmon already have <u>5 existing salmon farms in MEC 58.</u>
ii. <u>This proposal would shift Salmon farms</u> to this habitat stronghold of the remaining northern South Island Hector's dolphin population.

b. Another high-velocity and high nutrient habitat type (**MEC 64** - Figure 1: green) is frequented by **Maui dolphin** (*Cephalorhynchus hectori maui*) up north and by the Hector dolphins' largest remaining population on the west coast of the South Island (Slooten et al, 2004, 2005). With dwindling numbers over the past decades, sightings are rare nowadays in Marlborough's MEC 64 habitat.

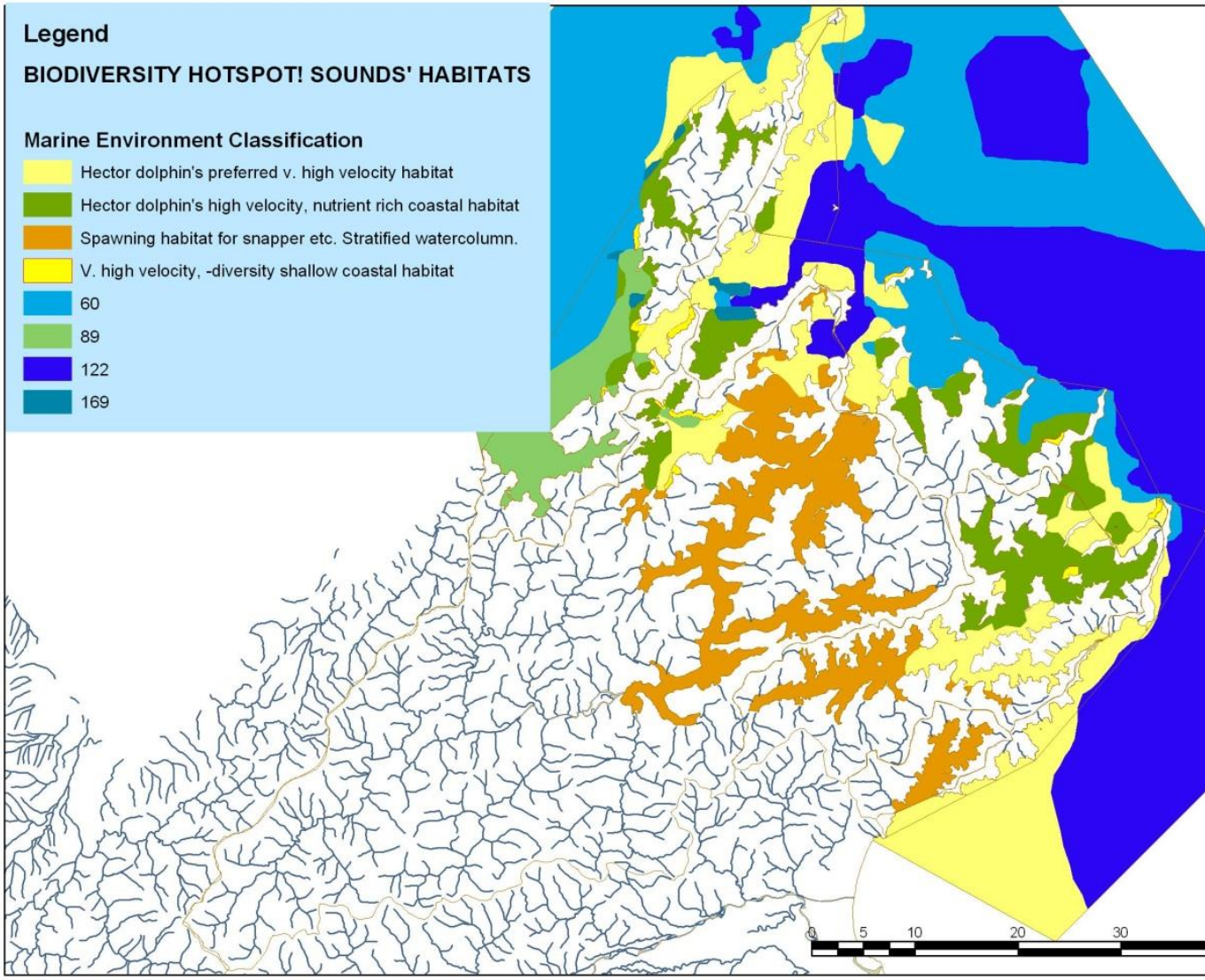

Figure 9 Marlborough Sounds' Marine Environments (MfE, 2005); Globally and Nationally Significant Habitat Biodiversity. Habitat of endemic and endangered Hector's dolphin.

Fish farm effluent accumulates in calm stratified water columns of interior Sounds (<u>ORANGE habitat type</u>). Native fish spawning grounds and mussel farming would be replaced with Harmful Algal Blooms and jellyfish!

Site fidelity of Hector dolphins is high, as most individuals range over less than 60 km, with the highest recorded range being 106 km (Dawson, 2009). Hector's

dolphins live in groups of 2-8 and may aggregate to form groups of up to 50 dolphins (Jefferson et al, 1993).

The total South Island's East Coast Hector's dolphin population (from Farewell Spit to just south of Otago Pensinsula) has collapsed to 20% of the 1970 population with less than 2000 remaining, while the entire, North Island population collapsed from more than 2000 in 1970 to less than 80 today (Slooten, 2009). This North Island's Maui dolphin subspecies is isolated on the northern Taranki coast and critically endangered.

c. Original numbers of Hector's dolphins in Tasman Bay and Golden Bay until about 1970 are estimated to have been around 500 individuals. Less than 100 are estimated to remain today (E Slooten, pers. com.). The lower velocity eastern habitat type of Canterbury's Hector's dolphin population (Rayment et al, 2010; Dawson et al, 2004) also exists in Tasman Bay (**MEC 89** – Figure 1: light green) from Rangitoto ki Te Tonga, Croiselles Harbour to Golden Bay. Surveys could not find any remaining Hector's dolphins here (Dawson et al, 2004). Thus far, major expansion of commercial gillnetting since the 1970s is the main reason for this dramatic decline (Slooten, 2007). Fish-farm resultant habitat degradation of Hector dolphin's north-eastern South Island refuge could sever the life-line between eastern and western South Island Hector dolphin populations, as, with **high probability,** the Sounds population would go extinct.

The distribution today is a reflection of current and past threats as well as habitat suitability. In the past, Hector dolphins would have also frequented the interior Sounds habitat MEC 130. Today they are rarely seen in Grove arm, Port Underwood and the inner Pelorus Sound, presumably because of cumulative effects from various human activities resulting in this environment to now be sub-optimal to sustain local groups long-term. However, a **Hector dolphin sighting** (photographic evidence by Danny Bolton) was made on July 2nd 2012 up **the inner Pelorus Sound**, indicating that a small group had ventured out of QC Sound, past Long Island, via Port Gore, to habitat type (**MEC 58**) in **Forsyth Bay and Waitata reach**, then continuing on past Tawero Point to Pelorus Sound's interior marine environment (**MEC 130).** Eight existing salmon farms are on this route..

The refuge stronghold of the north-eastern Hector's dolphin population is the Sounds' high velocity habitat MEC 58 (Dawson, 2004, E.Slooten pers com).

Considering Hector dolphin's relative site fidelity and the population collapse since the 1970s, the Sound's MEC 58 population is under immense pressure of being fragmented and isolated from both West Coast and East Coast populations (Dawson, 2004). Conversely, this north-eastern MEC 58 Hector's population provides a critically important connective linkage between east and west coast populations.

This northern population link is to be restored and strengthened, not threatened by the range of well-established adverse effects from fish-farming on the Sounds in general and marine environments 58 and 64 in particular.

Figure 10 New Zealand's endemic Hector's dolphin (*Cephalorhynchus hectori*). High Velocity Marine Environment (MEC 58) is where most fish farm proposals are sited. MEC 58 is also the refuge habitat of northern South Island's population of this endangered dolphin species.

PROPOSITION

1. **Ecosystem-based Aquaculture** is based entirely on people optimising productive potential by understanding, aligning with-, and enhancing ecosystem processes, local energy and material cycles.

    a. Importantly it connects today's potential with aspirations and proven practices of cultures that practiced kaitiakitanga in time before cumulative effects of exploitation resulted in desertification, establishing realities that sealed the demise of any irresponsible culture, incapable to adapt life-styles to the life-supporting capacity of their ecosystems.

2. High levels of production are indeed possible where communities focus on optimising potential use, cycling and storage of local ecosystem-derived energy and nutrients and thus evolve an ecosystem-based culture of high resilience and strong sustainability.
3. Kaitiakitanga and the concept of rahui reflect ancient evolved practices in some ecosystem-based cultures. Ecosystem-based cultures adhere to ethics that protect biodiversity, are aligned with a region's biological capacity and apply principles that enhance ecosystem functions and productivity.